Stock assessment of Aleutian Islands Region Pollock

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Executive Summary

Development of a detailed age-structured stock assessment for the Aleutian Islands Region pollock began in 2003 (Barbeaux et al. 2003). In this initial study the near shore areas of the main Aleutian chain were isolated and identified as the Near, Rat, and Andreanof Island (NRA) sub-area. This sub-area was further refined to exclude the area east of 174°W to address data consistency issues. The Council supported this proposal and urged continuing development on an age-structured assessment model using data from the area west of 174°W (and omitting deep-water areas where survey data are unavailable).

Comments in the October 2004 SSC meeting on the potential for seasonality of the fishery contributing to the differences in pollock lengths observed between the areas east and west of 174°W longitude were appreciated. This issue was specifically addressed in last year's analysis and perhaps was not documented by the authors as well as needed. The SSC comments suggest that Figure 7 of this assessment would have some bearing on this issue. The authors would like to point out that Figure 7 was meant to demonstrate *inter*-annual differences in data collection months and *not* intra-annual differences, and therefore would have no bearing on an analysis concerning intra-annual differences in length distributions. A new figure (Fig. 8) was included in this assessment to make it clear that there were no large intra-annual differences in fishery data collection months between areas east and west of 174°W longitude, therefore it is our view that our original justification for the geographic split of the commercial fishery data is still valid. However, please note that prior to 1991 most of the length frequency samples were collected after April. Thus the size differences shown in Fig. 6 could potentially be due to stock separation after spawning. The marked similarity between fish east and west of 174°W longitude after 1991 may suggest that fish cross between areas to spawn.

Pollock fishery data collected near the eastern boundary of the Aleutian Islands region (between of 174°W and 170°W) highlight stock structure uncertainty between the Aleutian Islands region, the Aleutian Islands Basin, and the EBS. Consequently, they are excluded from all of the age-structured assessment models presented below. We do, however, recognize that patterns observed from the summer Aleutian Islands bottom trawl (AIBT) survey data from this area are not as clear cut and that substantial uncertainty in the stock structure exists. We therefore have included a model for comparison purposes which includes all of the AIBT survey data including that from the eastern NRA area (NRA area east of 174°W). The results of projections utilizing these data are presented in parallel with the author's recommended model.

The data for this year's assessment differ from last year in that age data from the 1994, 1997, and 2000 bottom trawl surveys became available. Both the AIBT survey data and fishery data have also been refined and recalculated to better reflect the geographic region being assessed. Also, a novel approach to providing estimates of the "effective sample size" for specifying the multinomial likelihood components is provided. This method uses the sample variance in catch-at-age estimates (for the fishery) and population-at-age estimates (from the survey) to provide appropriate statistical weights for fitting these data in different years. This is particularly important for the Aleutian Islands situation where sampling effort has been highly variable between years and between sources of information.

In addition, biomass and size data from the 2004 Aleutian Islands summer bottom trawl survey were available. As with last year's analysis, using the summer trawl survey data at face value (i.e., survey catchability of 1.0) implies unrealistically high exploitation levels during the peak years of the most recent fishery (e.g., the 1995 catch level was over 58 thousand tons yet the 1994 survey biomass estimate was 47.6 thousand tons followed by a 1997 estimate of 57.6 thousand tons). Since past management recommendations (ABC/OFL levels) have been

based on an implied value of 1.0 for survey catchability, we felt that an initial assessment model should begin with a similar assumption. Preliminary model runs under this assumption resulted in a number of problems due to inconsistencies with the data. The fact that the 1995 catch level was considerably more than the 1994 and 1997 survey estimates and that the survey estimates increased after 1997 is inconsistent with the levels of recruitment observed during this period. Relaxing the assumption that the survey catchability was equal to 1.0 was required for exploring model alternatives. This results in (not unexpectedly) higher values of biomass trajectories that are largely a function of prior-distributions specified for the catchability coefficient.

Due to these preliminary modeling results, we investigated alternative sources of abundance indicators for Aleutian Islands pollock. These included 1) evaluating the within-season pollock fishery catch rate patterns for evidence of depletion; 2) examining pollock bycatch rates from the cod longline fishery; and 3) evaluating the pollock bycatch rates in the Pacific ocean perch trawl fisheries. For the depletion study data from 1995 were evaluated since this was the year of the largest catch. During the main 38 days of the 1995 fishery, the catch per vessel-day was stable to increasing suggesting that the overall exploitation rate was relatively low and that pollock were moving into the areas. The Pacific cod bycatch analysis showed that, on average, about 1.3 pollock were caught for every 1,000 hooks fished. Pollock were observed in approximately 27% of the observed Pacific cod longline operations. Trends in pollock bycatch rates from the Pacific cod longline fishery were highly variable. Qualitatively, they suggest an overall increasing trend in pollock abundance through the 1990s. Closer examination of these data showed that they were unsuitable as a quantitative abundance index since the observed data on the Pacific cod fishery varied considerably between years and areas. More comprehensive modeling of these data (e.g., using General Linear Models) may improve this situation. However, the fact that large areas are inconsistently sampled in different years is likely to preclude much improvement as an annual index. The bycatch of pollock in the Pacific ocean perch trawl fishery presented similar problems to that of the longline fishery: irregularly available data by areas and years.

Spatial analyses of fishery, survey, and bycatch data using GIS methods does reveal an important characteristic of pollock in the Aleutian Islands region: concentrations are highly variable and likely evolve quickly within seasons. This result highlights the challenge of evaluating stocks that: are highly mobile, spend variable time associated with the bottom, have patchy distributions, and are likely influenced by neighboring stocks.

ABC and OFL Recommendations

The authors recommend the maximum Tier 3a ABC ($F_{40\%}$) under Model 1 of the assessment which is 27,900 mt and an OFL of 34,200 mt. We understand that this is a low bound estimate which does not include the biomass between 170°W and 174°W longitude, but feel that this is justified given our lack of knowledge of this population. The recommended harvest strategy would be highly conservative and is aimed towards maintaining a precautionary approach in the management of the newly developing Aleutian Islands pollock fishery.

Although we are as confident in the results obtained from Model 1B as those obtained from Model 1, we believe that the maximum allowable ABC under Model 1B to be too high given the early 1990’s catch history, the high degree of uncertainty in the 2002 and 2004 AIBT estimate, and the lack of fisheries data since 1998. We feel the plan team’s recommendation of using the estimated long-term average yield from Model 1B for setting the ABC is another means of achieving a conservative management policy consistent with a precautionary approach and will explore this further in next year’s assessment.

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. This problem was confirmed in last year’s assessment (Barbeaux et al. 2003). Hence, the data used here are organized to cover a region that are 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 considered 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

Catch estimates

Estimates of pollock catch in the Aleutian Islands Region are derived from a variety of data sources (Table 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 current estimates from the blend data. 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 2).

For the period 1977-1984, the foreign reported catch database was used to partition catches between the eastern NRA, western NRA, and basin areas while for 1985-2003, observer data were used. These proportions were then expanded to match the total catch (Table 3; Fig. 1).

The distribution of observed catch differed between the JV years (1977-1989) and the domestic fishery (1989-2002; Fig. 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, we recommended that the Aleutian Islands Region was broken into areas where apparent breaks existed (Fig. 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 4. In the NRA area west of 174°W the fishery tended to concentrate in two distinct locations one on the north side of Atka Island around 174°W and the other near 177°W northwest of Adak Island. While the overall catch level was relatively low, the fishery moved far to the west in the 1998 (Fig. 4).

Fishery length frequency

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 5). However, the differences in the length frequencies appear to be substantial between regions (Fig. 5 and Fig. 6). 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. 7), but inter-annually the fishery was consistent in the time between the eastern and western NRA (Fig. 8). Therefore differences in length distributions observed between these two regions cannot be attributed to differences in time of year the fishery was conducted. Intra-annual differences may show a trend that could be consistent with seasonality differences. The occurrence of larger fish later in the time series is likely due to the fishery targeting on spawning pollock. Pollock average weights-at-age from the early period are lower than the recent period (Fig. 9; Table 6). The observed proportion of females in the catch appeared to show a slight decline over this period (Fig. 10).

Fishery age composition

Catch-at-age composition estimates are made following 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 7). This problem is exacerbated for samples collected from different areas and gears (Table 8). The estimates for catch-age composition are shown in Table 9.

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, 2002 and 2004. 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 10). 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. 11).

All previous RACE Aleutian Islands bottom trawl (AIBT) surveys indicate that most of the pollock biomass has been located in the Eastern Aleutian Islands Area (Area 541) and along the north side of Unalaska-Umnak Islands in the eastern Bering Sea region (~165°W and 170°W). The 2004 Aleutian Islands trawl survey showed that the greatest densities and estimated biomass occur in the Unalaska-Umnak area in the eastern Bering Sea region. If we ignore the biomass estimates from the Unalaska-Umnak area the 2004 AIBT survey showed a very different pattern of biomass abundance than the 2002 survey (Fig. 11). Within the Aleutian Islands Region (Areas 541, 542, and 543) the 2002 AIBT survey indicated the highest densities and biomass were in the Central Aleutian Islands Area (Area 542) followed by the Eastern (Area 541) and Western areas (Area 543). In the 1991-2000 AIBT surveys the highest biomasses for the NRA Areas were estimated in Area 541 followed by Area 542 and Area 543. The earlier RACE AIBT surveys indicated a decline in pollock biomass in the portion of 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. This trend was reversed in the 2002 survey with an estimate of 53,368 mt and in 2004 with an estimate of 111,250 mt (Table 9). In the 1991-2002 surveys a number of large to medium sized tows were encountered throughout the Aleutians indicative of a fairly well distributed population. This is very different from the 2004 survey estimate which indicated a low level of pollock abundance in both Area 542 and Area 543, and a much higher pollock density in Area 541. The 2004 survey revealed very few pollock throughout the NRA, except for a single large tow in Seguam pass. Roughly 100,000 mt of the 111,225 mt estimated for the area east of 174°W can be attributed to extrapolations from this single tow. Without this tow the biomass estimate in the entire NRA would be well below 40,000 mt. Since there has not been a fishery in the Aleutians, the survey has covered roughly the same grounds, and there has not been a change in survey methodology, the large decrease in pollock must be attributed to either a change in catchability due to vertical migration of pollock out of the reach of the bottom trawl, or a migration of pollock out of the surveyed area. Since the AIBT is limited to within the 500 m isobath the survey 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.

Survey Length Frequencies

The 2004 AIBT survey found a large proportion of small fish (between 100 and 250 mm, indicative of 1 or 2 year old fish) in the NRA area west of 174°W, but very few small fish east of 174°W (Fig. 12). The 2002 AIBT survey did not find very many small fish anywhere in the Aleutians. There were a large number of small fish observed in the 1994 and 2000 surveys throughout the NRA (Fig. 12). The large numbers of 1 or 2 year old size pollock observed in the these surveys were assumed to have entered the fishable population in 1996 and 2002, respectively, and should have stabilized or increased pollock biomass in the Aleutian Islands in recent years. In the 2000, 2002, and 2004 AIBT surveys differences in length distribution are apparent between areas east and west of 170°W longitude. Differences in pollock length distributions between the areas east and west of 174°W longitude in the NRA are not as apparent.

In addition to the bottom trawl survey there has been one echo integration-trawl survey in a portion of the NRA. The R/V Kaiyo Maru conducted a survey between 170°W and 178°W longitude in the winter of 2002 after completing a survey of the Bogoslof region (Nishimura et al 2002; Fig. 13). Due to difficulties in operating their large mid-water trawl on the steep slope area they felt their catches in this area were insufficient for accurate species identification and biomass estimation. They did however come up with some preliminary biomass estimations. For the entire area from 170°W and 178°W longitudes they estimated a biomass of 93,000 mt of spawning pollock biomass with between 61,000 mt estimated in the NRA east of 173°W and 32,000 mt in the remainder of the survey area to 178°W longitude (Table 11). The largest aggregations in the NRA area were observed at 174°W longitude north of Atka Island. Most of the pollock echo sign was observed along the slope of the Aleutian Islands relatively near shore.

Analytic Approach

We investigated the use of alternative methods in an attempt to find a reasonable indicator of pollock abundance in the Aleutian Islands. The results of these investigations are provided in the Attachment 1. While this exercise provided new insights on the ephemeral characteristics of pollock distribution and abundance in the Aleutian Islands, further analyses are required prior to including them within the main assessment model.

The 2004 Aleutian Islands walleye pollock stock assessment uses the same modeling approach as last year's model; 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 14-age-groups that are modeled (ages 2-15+). Age-2 recruitment in each year is estimated as deviations from a mean value expected from an underlying stock-recruitment curve (or simple mean). 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 1 –3 provide a description of the variables used, and the basic equations describing the population dynamics of Aleutian Islands pollock and likelihood equations. The model was modified from that of Barbeaux et al. (2003). These modifications include a feature that allows a user-specified age-range for which to apply the survey (or other abundance index) catchability. For example, by specifying the age-range of 6-10 (as was done for Aleutian Islands pollock) means that the average age-specific catchability of the survey is set to the parametric value (either specified as fixed or estimated). Also, in the previous assessment age-1 pollock were explicitly modeled whereas in the work presented here, they were dropped from consideration because they observations of age-1 pollock are irregular, and in trials where they were included, they were found to limit the flexibility to try alternative model specifications such as parametric forms of selectivity functions. The quasi[1] likelihood components and the distribution assumption of the error structure are given below:

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

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

The age-composition components are heavily influenced by the sample size assumptions specified for the multinomial likelihood. Since our (sample) variances of our catch-at-age estimates are available (Dorn 1992), it is "effective sample sizes" ($\dot{N}_{i,j}$) can be derived as follows (where *i* indexes year, and *j* indexes age):

$$\dot{N}_{i,j} = \frac{p_{i,j}\left(1-p_{i,j}\right)}{\mathrm{var}\left(p_{i,j}\right)}$$

where $p_{i,j}$ is the proportion of pollock in age group *j* in year *i* plus an added constant of 0.01 to provide some robustness. The variance of $p_{i,j}$ was obtained from the estimates of variance in catch-at-age. Thompson et al., (2003, p. 137) and Thompson (pers. comm.) show that the above is a random variable that has its own distribution. They show that the harmonic mean of this distribution is equal to the true sample size in the multinomial distribution. This property was used to obtain sample size estimates for the surveys and fishery numbers-at-age estimates:

Fishery data	Year	1978	1979	1980	1981	1982	1983	1984	1985	1987
	$\dot{N}_{i,\bullet}$	246	170	119	215	553	81	296	225	150
	Year	1990	1992	1993	1994	1995	1996	1997	1998	
	$\dot{N}_{i,\bullet}$	199	238	172	327	211	228	30	302	
Survey data										
	Year	1991	1994	1997	2000	2002				
	$\dot{N}_{i,\bullet}$	1*	740	690	831	1124				

*The 1991 value was down-weighted by a factor of 1,000 because the samples collected in that year were not representative of the region considered.

These values represent a refinement to the previous approach where they were held constant at assumed values for each data source.

Parameters

Parameters estimated independently

Natural Mortality

In the current assessment, a natural mortality value of 0.3 was used for all Models. We 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 12). Currently, the assessment model fails to allow for age-specific natural mortality rates. It should be noted that in general, a higher natural mortality rate for age 2 pollock may be more appropriate (e.g., Ianelli et al. 2003) and that this model differs from the Eastern Bering Sea model. In the future, we will be investigating methods to improve AMAK to include age varying natural mortality.

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 estimated for the 1980, 1983, and 1986 AIBT surveys (Table 13). 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, 1994, 1997, 2000, 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 174°W longitude were excluded from the data set for calculating length and weight at age for all but one model. 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 from data collected west of 174°W. These values (Table 6) are important for converting model estimated catch-at-age (in numbers) to estimated total annual harvests (by weight).

Maturity at Age

Maturity at age follows the schedule based on the studies of Wespestad and Terry (1984; Table 14). An updated analysis on maturity-at-age using more recent data is underway and should be available in late 2004.

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

Fishing mortality in all models was parameterized with an age (selectivity) component and was separable with both an age component (selectivity) and a year component. In all models selectivity is conditioned so that the mean value over all ages will be equal to one. To provide regularity in the age component, a 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 selectivity was allowed to vary over time. The model was set with controls selecting the degree to which selectivity is allowed to change.

Survey Catchability

For the bottom trawl survey, survey catchability-at-age follows the parameterization similar to the fishery selectivity-at-age presented above. The catchability-at-age relationship is modeled with a smoothed non-parametric relationship that can take on any shape (with penalties controlling the degree of change and curvature specified by the user). To provide regularity in the age component, a penalty was imposed on sharp shifts in catchability-at-age 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). As noted above, the model allows specification of the age-range over which the catchability parameter is applied. For Aleutian Islands pollock, ages 6-10 were selected to have the average catchability (factoring selectivity components) equal to the catchability parameter value.

Evidence suggests that the average catchability for the summer bottom trawl survey is less than one. These trawl surveys are designed to assess demersal stocks and a significant portion of pollock biomass occurs in the pelagic zone. Also, the bottom trawl survey takes place in the summer when Aleutian Islands pollock densities are considered lower due to seasonal changes. Further confirmation of these patterns can be seen when comparing survey estimates with actual catch levels. In July of 1994 the Aleutian Islands the pollock survey biomass estimate for the NRA area west of 174°W was 47,623 mt. The 1995 fishery, occurring February – April, removed over 58,000 mt of pollock from the same area, exceeding the biomass estimate by more than 20% (Fig. 14). Subsequently, the 1997 survey estimate was over 57,000 tons suggesting that the exploitation rate in 1995 was relatively low (unless unprecedented recruitment occurred—not evident in any of the age composition data).

To further evaluate the possibility of a high exploitation rate occurred in 1995, a separate analysis of pollock catch-rate trends was undertaken. Depletion estimators (Hilborn and Walters 1992) can provide robust estimates of initial stock size provided the assumptions are met and that the exploitation rate is moderate or high. The concept of the method is simple, as fish are removed from an area, the ability to catch fish should become more difficult (i.e., the CPUE should decline). For our analysis we used catch per day as our measure of effort. Preliminary depletion analyses for 1995 fishery for the entire NRA area west of 174°W (Fig. 15) show no apparent decline in CPUE in either the catcher-processor/mothership sector or the catcher vessel sector. Partitioning the analysis by smaller fishing areas revealed similar patterns. However, as these are broken out, there are clear vessel-time of fishing interactions based on the period within the season different vessels operate (Tables 15 & 16). Furthermore, it is unclear whether there is a "partial day" effect occurring (i.e., as vessels depart or arrive on the fishing ground, their initial "catch-per-day" may not include a 24 hour period). An alternative would be to use catch per hour towed. However, tow duration is not recorded for a significant number of hauls and catch per hour may not be as meaningful when fishing on aggregations because this would not include search time. For future studies investigating depletion estimators, partial-days should be taken into account along with available data on catch per hour fished.

Regardless of these issues, the assumption that pollock are homogenously available during the "depletion" period can confound results. It is known that the Aleutian Islands pollock fishery was targeting on pre-spawning aggregations that form fairly dense schools. This schooling aspect can create "hyper stability" in catch rates. That is, as the true abundance declines with fishing, the catch rates remain relatively constant since the density of fish within schools remains the same. In these situations, CPUE can clearly result in a poor index of abundance (unless of course the effort is high enough to deplete nearly all of the aggregations). While our analyses suggest that the exploitation rate in 1995 was probably relatively small, results based on depletion analyses are equivocal.

The biomass estimate from the Bogoslof survey in winter 1995 was about 1.1 million tons while the average from 1992-2003 has been about 0.5 million tons (Ianelli et al. 2003). The recent peak in the Aleutian Islands pollock fishery occurred at around the same time, suggesting that perhaps some environmental phenomena may have occurred that affected pollock distribution and spawning concentrations. Environmental factors affecting adult pollock distributions in the Aleutian Islands are limited. However, Mueter et al. (2004) investigated a number of indices for the Easter Bering Sea (EBS). An examination of their study showed that in 1995, the summer time overlap between adults and juveniles was highest compared to all other years (1982-2003). This anomaly indicates that pollock were distributed differently in the EBS in that year. Perhaps this pattern is indicative of an interaction between the EBS shelf, Bogoslof Island, and Aleutian Islands pollock.

Recruitment

A reparameterized form of the Beverton-Holt stock recruitment relationship based on Francis (1992) was used (Table 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 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 (h) was set at 0.6 or estimated with a prior of 0.7 and CV of 0.2 ,and sigma r was set at 0.6 for all model runs presented here

Model evaluation

The focus of the research leading to this report was to evaluate alternative data sources to better understand processes affecting Aleutian Islands pollock dynamics. Some of these efforts are presented in the attached report on alternative indices. Other indications of stock status are presented above (i.e., a limited Echo-integration trawl survey by a Japanese vessel during the winter, a depletion evaluation during the winter of 1995). For this report , five models are presented: one configuration that assumes survey catchability is 1.0 and steepness is 0.6 precisely, the second that assumes the catchability parameter can be freely estimated and steepness centered on 0.7 with a CV of 0.2 as a (normal) prior distribution, one that assumes the catchability is centered on 1.0 as a (normal) prior distribution with a CV of 0.2 and steepness centered on 0.7 with a CV of 0.2 as a (normal) prior distribution, one with the 1995 fishery catch set at the mean for 1978-1998 and the catchability parameter freely estimated (on request from the BSAI Plan Team) and steepness centered on 0.6 with a CV of 0.2 as a (normal) prior distribution, and the fifth where catchability is assumed to be 1.0, steepness centered on 0.7 with a CV of 0.2 as a (normal) prior distribution, but with survey data for the entire NRA region included (in response to SSC comments).

These models are referred to as:

Model 1: *q* fixed at 1.0 and *h* fixed at 0.6

Model 2: *q* freely estimated, h with prior of 0.7 CV of 0.2

Model 3: *q* estimated with a prior distribution specified as Normal $(1.0,0.2^2)$, *h* with prior of 0.7 CV of 0.2

Model 2A: *q* freely estimated and 1995 catch set at the mean for 1978-1998, *h* with prior of 0.7 CV of 0.2.

Model 1B: *q* fixed at 1.0, *h* with prior of 0.7 CV of 0.2, and input of survey data for the entire NRA

Model 2A was developed in response to comments from the plan team because we thought that the 1995 catch was anomalous and thought that it may have had an adverse affect on the performance of our model. Model 1B was developed for two reasons a) in response to SSC comments on the 174°W data division line and b) the apparent shift of pollock biomass to the east in the 2004 survey. Model 1B only includes survey data from the eastern NRA and does not include fishery data. We strongly believe that the 174°W data division line for the fishery data is essential for the proper characterization of Aleutian Islands pollock stock dynamics.

Results

Abundance and exploitation trends

Key results of fitting the first three models are their differences in biomass trajectories (Fig. 16). Relative differences in fits are shown in Table 17 and stock condition estimates are in Table 18. Even after smoothing the anomalous 1995 catch, Model 2A did not provide a better fit than Model 2 (log likelihood of 99.42 to 91.39), and provided only a minor change in catchability (0.06 to 0.08). By including the survey biomass from the area east of 174°W Model 1B did show a marked improvement in fit from Model 1. This is primarily due to a better fit to the survey index. The NRA wide biomass index has less intra-annual variability with a much smoother trend which allows for a better fit to the model.

For models 1 through 3 and model 2A the fit to the survey data is relatively poor, but not surprisingly so given the estimates of variance for the individual survey point estimates (Fig. 17) and the high intra-annual variability of the estimates. For all five models the fit to the survey age composition data was excellent, except for the 1991 data where for sampling reasons, was given less weight than for the other years (Fig. 18). Results of fits to the fishery age-composition data was much poorer, probably reflecting the different locations and sampling locations for the fishery in different years (Fig. 19). The time-varying selectivity patterns fit by the models show only slight changes for the survey but a relatively large shift (to older fish) after 1990 for the fishery data (Fig. 20).

As presented above, the abundance trend is highly conditioned on the assumptions made about the area-swept survey trawl assumptions on catchability. Even with some assumptions about catchability, the uncertainty on the trend and level is very high (Fig. 21). Bearing in mind the high degree of uncertainty, the stock trend appears to be stable.

Recruitment

For all models estimates of recruitment (at age 2) are estimated with high variance (Fig. 22). The 1978 year-class is the largest, followed by 1989. The extent that recruitment is synchronous with other areas is an open question (e.g., these year classes are also strong in the EBS region, Ianelli et al. 2003). An alternative explanation is that there are episodes of movement from other areas that affect year-class abundance. The extent that adjacent stocks interact is an active area of research.

Markof Chain Monte Carlo Results

Markof Chain Monte Carlo (MCMC) runs were completed for Model 1,Model 1B, and Model 2 to compare the results derived from estimating survey catchability and steepness to those where catchability and steepness were specified. One million MCMC simulations sampled at 200 were conducted for each of the models. Model 1, where catchability was set at 1.00 and steepness was set at 0.6, resulted in an estimated biomass with a very tight distribution about the mean. This is expected since we allow for no uncertainty in catchability or steepness, leaving only the fit to selectivity uncertain. Model 1B where catchability was set at 1.00 and steepness was estimated with a normal prior with mean of 0.7 and CV of 0.2, resulted in an estimate of biomass with a broader, slightly skewed, but roughly normal distribution (Fig. 23). Model 1B was able to provide an estimate of steepness with a mean of 0.62 and a CV of 0.29. The estimates obtained from Model 2 are highly skewed in comparison with Model 1 and Model 1B. The MCMC trace for the catchability parameter in Model 2 shows a one-way downward trajectory (Fig. 24). It is evident that the distribution of catchability in Model 2 is very flat and that the model cannot properly estimate this parameter.

Summary of results

In these analyses, the focus has been to evaluate a key model assumption: the extent to which the NMFS summer bottom trawl survey catchability should be estimated by the available data (resulting in very high stock sizes) or constrained to be close to a value of 1.0 (implying that the area-swept survey method during the summer months reasonably applies to a fishery that will likely occur during the winter). We provide evidence that suggests that fixing the value of survey catchability to 1.0 is unreasonable. However, recognizing that no other information is available to “anchor” the assessment model to an absolute biomass level, the authors are reluctant to proceed with specifying influential prior distributions on catchability values. The effects of the fishery on the pollock population dynamics appear to be poorly determined given the available data. This could be due to a number of factors including: characteristics of Aleutian Islands pollock relative to adjacent regions, poor quality data, and the possibility that the fishing effects are minor relative to other factors. The latter point is likely to be true at least for the recent period where the fishery removals have been minor since 1999. We have therefore selected a fixed catchability value of 1.00 for our preferred alternative models.

We assessed two models with fixed catchability at 1.00, Model 1 and Model 1b. These models differ in the survey data input, Model 1 excludes survey data from east of 174°W longitude, while Model 1b includes these data. Although Model 1b appears to provide a better fit (lower negative logliklihood), these two models should not be compared directly in this manner. Model 1b fits the survey biomass index data better than Model 1, but the data used in Model 1b is highly uncertain (high CV) which appear to have smoother transitions between surveys. As with the fishery data, the survey data from east of 174°W may be significantly influenced by abundance trends in the eastern Bering sea and thus may not be a good index for the western NRA pollock population. Based on our previous analysis of pollock distributions in the Aleutian Islands, we recommend

Model 1 as our reference model. We feel this will be a conservative strategy which will maintain a precautionary approach in the management of the newly developing Aleutian Islands pollock fishery.

Projections and harvest alternatives

For projection purposes we are using the yield projections estimated for two reference models, Model 1 and Model 1B with selectivity set to that of the modeled 2004 Bering Sea estimate for selectivity. Because a directed fishery on pollock has been banned since 1999 we do not believe the selectivity-at-age assumed in the reference model would be relevant to a newly opened directed fishery. For projections we used the selectivity-at-age derived from the 2004 EBS pollock assessment (Ianelli, et al 2003) because a current estimate for selectivity-at-age for a directed pollock fishery in the Aleutians is not available. The selectivity-at-age for the EBS pollock would be applicable if the Aleutian Islands Pollock fishery were again opened to a directed fishery because the fishery would most likely be prosecuted by the same vessels. Both models have catchability fixed at 1.0, Model 1 excludes all data from east of 174°W, while Model 1B only excludes fishery data from east of 174°W. Comparisons of yield predictions for 2005 are provided below:

	AI Model Selectivity		Bering Sea Selectivity	
Projection	Model 1	Model 1B	Model 1	Model 1B
$F_{40\%}$ 2005 Catch (mt)	31,300	94,600	27,900	80,500
$F_{35\%}$ 2005 catch (mt)	38,600	114,700	34,200	99,300

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 spawner biomasses that would be expected under average estimated recruitment from 1978-2004 (Model 1 = 133.8 million age 2 recruits or Model 1B = 191.3 million age 2 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 for Tier 3 of Amendment 56. For our analyses, we selected the following values from Models 1 and 1B:

Female spawning biomass	Model 1	Model 1B
$B_{100\%}$	134,900 mt	192,500 mt
$B_{40\%}$	53,900 mt	77,000 mt
$B_{35\%}$	47,200 mt	67,400 mt

Specification of OFL and Maximum Permissible ABC

For the Reference Models 1 and 1B , the projected year 2005 female spawning biomass (SB_{05}) is estimated to be 54,400 mt and 131,200 mt under the maximum allowable ABC harvest strategy ($F_{40\%}$). The projected 2004 female spawning biomass is above the $B_{40\%}$ value of 53,900 mt for Model 1 placing NRA pollock in Tier 3A, and above the $B_{40\%}$ value of 77,000 mt for Model 1B also placing NRA pollock in Tier 3a. The maximum permissible ABC and OFL values under these two scenarios are:

Model 1 Tier 3A:

Harvest Strategy	FSPR%	Fishing Mortality Rate	2005 Projected yield (mt)
max F_{ABC}	F40%	0.35	27,900 mt
F_{OFL}	F35%	0.45	34,200 mt

Model 1B Tier 3A:

Harvest Strategy	FSPR%	Fishing Mortality Rate	2005 Projected yield (mt)
max F_{ABC}	F40%	0.35	80,500 mt
F_{OFL}	F35%	0.45	99,300 mt

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 is probably less than 1.0, but we have no data to concretely anchor the value at anywhere less than 1.0. We therefore employed a default value for catchability of 1.00 (a conservative estimate). This provides a conservative total biomass estimate.

3) AIBT survey estimates of biomass are very uncertain with an average CV of 0.34. The 2002 and 2004 estimates are especially uncertain with a CV of 0.38 and 0.78 respectively. This therefore shines a considerable amount of uncertainty on our projections.

4) The reference models only have survey and fishery age composition data available for the 1990s, because of the selectivity-at-age assumed in these models we may be underestimating the 1978 year class. The results of the reference model are therefore conservative estimates.

5) All of the differences between our two reference models are due to the inclusion of the survey biomass and survey age data from the NRA area east of 174°W.

ABC Recommendations

The pollock biomass in the NRA appears to be increasing in both models, even in light of the latest low values for the AIBT survey. The total age 3+ biomass for 2005 is expected to be (Model 1) 163,800 mt or (Model 1B) 344,430 mt. The estimated female spawning biomass projected for 2005 is expected to be (Model 1) 54,400 mt or (Model 1B) 131,200 mt. Estimates for Model 1 are above the $B_{40\%}$ level of 53,900 mt, and B35% level of 47,200 mt, and the estimates for Model 1B are also above the $B_{40\%}$ level of 77,000 mt, and B35% level of 67,400 mt. For the year 2005, the maximum permissible ABC alternative based on $F_{40\%}$ for Model 1 is 27,900 mt (F=0.35) and for Model 1B is 80,500 mt. We feel that Model 1B level to be high given the high degree of uncertainty in the 2002 and 2004 AIBT estimate and the lack of fisheries data since 1998 and recommend the Model 1 ABC of 27,900 MT.

Under the tier 5 assessment if we continued to employ a natural mortality of 0.3 the 2005 ABC would be 29,351 mt (130,450 mt x 0.75 x 0.30 = 29,351mt).

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 0.3 and the best available estimate of total (year-end) catch for 2004. 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: Authors recommendation, in all future years, F is set equal to *max* F_{ABC}.

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.)

Scenario 8: In all future years, F is set equal to a constant Catch of 19,000 mt, the maximum TAC currently set by regulation for Aleutian Islands Pollock.

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

Scenario 6: In all future years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be 1) above its MSY level in 2005 or 2) above ½ of its MSY level in 2005 and above its MSY level in 2014 under this scenario, then the stock is not overfished.)

Scenario 7: In 2005 and 2006, 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 2017 under this scenario, then the stock is not approaching an overfished condition.)

Projections and status determination

Model 1

The projected age 3+ biomass at the beginning of 2005 for Model 1 is 163,800 mt and the projected 2005 female spawning biomass is 54,400 mt . The projected yields, female spawning biomass, and the associated fishing mortality rates for the seven harvest strategies for Model 1 are shown in Table 19. For Model 1 under a harvest strategy of $F_{40\%}$ (Scenario 1), female spawning biomass is projected to be above $B_{40\%}$ for the entire 13 year projection (Fig 25 and Fig 26). Female spawning biomass is projected to fall below $B_{40\%}$ when fishing at F_{OFL} (Scenarios 6 & 7, Table 20) for the entire 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 spawner biomass that would be expected under average estimated recruitment from 1978-2003 (133.4 million recruits) and $F = F_{35\%}$, denoted $B_{35\%}$ is estimated to be 47,200 mt. This value ($B_{35\%}$), is used in the status determination criteria. Female spawning biomass for 2005 (54,400 mt) is projected to be above$B_{35\%}$ thus, the NRA pollock stock would be determined to be *above* its minimum stock size threshold (MSST) and is *not overfished*. Female spawning biomass for 2017 is projected to be above $B_{35\%}$ in scenario 7, thus the NRA pollock stock is *not* expected to fall below its MSST in two years and is *not approaching an overfished condition*.

Model 1B

The projected age 3+ biomass at the beginning of 2005 for Model 1B is 344,400 mt, and the projected 2005 female spawning biomass is 131,200 mt. The projected yields, female spawning biomass, and the associated fishing mortality rates for the seven harvest strategies for Model 1B are shown in Table 21. For Model 1B under a harvest strategy of $F_{40\%}$ (Scenario 1), female spawning biomass is projected to be above $B_{40\%}$ for all 13 years of the projection. Female spawning biomass is projected to fall below $B_{40\%}$ when fishing at F_{OFL} (Scenarios 6 & 7, Table 22) in 2008 and remain below for the remainder of the projection. Please note again that the fishing mortality rates are prescribed on the basis of the harvest scenario and the spawning biomass in each year. Thus, fishing mortality rates may not be constant within the projection if spawning biomass drops below $B_{40\%}$ in any run.

The associated long-term average female spawner biomass that would be expected under average estimated recruitment from 1978-2003 (191.3 million recruits) and $F = F_{35\%}$, denoted $B_{35\%}$ is estimated to be 67,400 mt. This value ($B_{35\%}$), is used in the status determination criteria. Female spawning biomass for 2005 (131,200 mt) is projected to be above ½ $B_{35\%}$ (33,700 mt) thus, the NRA pollock stock would be determined to be *above* its minimum stock size threshold (MSST) and is *not overfished*. Female spawning biomass for 2017 is projected to be above ½ $B_{35\%}$ in scenario 7, thus the NRA pollock stock is *not* expected to fall below its MSST in two years and is *not approaching an overfished condition*.

Ecosystem Considerations

Ecosystem considerations for Aleutian Islands walleye pollock are summarized in Table 23.

Ecosystem effects on Aleutian Islands Walleye Pollock

Prey availability/abundance trends

Adult walleye pollock in the Aleutian Islands consume a variety of prey, primarily large zooplankton, copepods, and myctophids. Figure 27 highlights the trophic level of pollock in relation to its prey and preditors. No time series of information is available on Aleutian Islands for large zooplankton, copepod, or myctophid abundance.

Predator population trends

Walleye pollock are consumed by a variety of piscivores, including, marine mammals, and seabirds (Fig. 26). The abundance trend of Aleutian Islands Pacific cod is decreasing, and the trend for Aleutian Islands arrowtooth flounder is relatively stable. Northern fur seals are showing declines, and Steller sea lions have shown some slight increases. Declining trends in predator abundance could lead to possible decreases in walleye pollock mortality. The population trends of seabirds are mixed, some increases, some decreases, and others stable. Seabird population trends could affect young-of-the-year mortality.

Changes in habitat quality

The 2004 Aleutian Islands summer bottom temperatures indicated that 2004 was an average year. This is a warming trend since the 2002 survey was the second coldest year after the 2000 survey. Bottom temperatures could possibly affect fish distribution, but there have been no directed studies, and there is no time series of data which demonstrates the effects on Aleutian Islands walleye pollock.

AI pollock fishery effects on the ecosystem

AI pollock fishery contribution to bycatch

The AI pollock fishery has been closed since 1998, and therefore the actual levels of bycatch in a newly opened fishery will be unknown. Prior to 1998 levels of bycatch in the Atka mackerel fishery of prohibited species, forage, HAPC biota, marine mammals and birds, and other sensitive non-target species was very low compared to other fisheries in the region. Since it is expected that the fishery will primarily be prosecuted by catcher processor vessels in 2005, the bycatch levels will be highly monitored with 2 observers on each vessel.

Concentration of AI pollock catches in time and space

Since the AI pollock fishery is expected to be a winter roe fishery and the distribution of pollock in the winter around the Aleutian Islands is expected to follow that observed in 2002 during the R/V Kiayo Maru EIT survey there is expected to be a concentration of effort in small areas between Steller sea lion critical habitat closures. The impacts of this fishery due to temporal and spatial concentration are not expected be substantial due to the relatively low fishing mortality expected. In addition, less than 25% of the Aleutian Islands shelf area is open to directed fishing for pollock, limiting impacts to a relatively few small areas which have been designated as less important to potentially impacted species, such as the Steller sea lion.

AI pollock fishery effects on amount of large size walleye pollock

The AI pollock fishery in the Aleutian Islands has been closed since 1998. Year to year differences observed in the previous six years can not be attributed to the fishery and must be attributed to natural fluctuations in recruitment. Fishers have indicated that the larger pollock in the Aleutian Islands will be targeted. But the low level of fishing mortality is not expected to greatly affect the size distribution of pollock in the AI.

AI pollock fishery contribution to discards and offal production

The 2005 Aleutian Islands pollock fishery is expected to be conducted by catcher processor vessels. Many of the pollock Catcher processor vessels have fish meal processing plants and therefore very little discard or offal production is expected from this fishery.

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

The effects of the fishery on the age-at-maturity and fecundity of AI pollock are unknown. No studies on AI pollock age-at-maturity or fecundity have been conducted. Studies are needed to determine if there have been changes over time and whether changes could be attributed to the fishery.

Data gaps and research priorities

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

Summary

Reference Model Parameters				
Natural Morality:		$M = 0.3$		
Initial Biomass (1978):	Model 1	$B_0 = 509{,}200$ mt		
	Model 1B	$B_0 = 674{,}900$ mt		
2005 (Tier 3a recommended)				
Maximum permissible ABC:	Model 1	$F_{40\%} = 0.35$	yield =	27,900 mt
	Model 1B	$F_{40\%} = 0.35$	yield =	80,500 mt
	Model 1B LTEY*	**$F_{abc} = 0.20$**	**yield =**	**43,200 mt**
	Tier 5 (M = 0.3)		yield =	29,351 mt
Overfishing (OFL):	Model 1	$F_{35\%} = 0.45$	yield =	34,200 mt
	Model 1B	$F_{35\%} = 0.45$	yield =	99,300 mt
	Model 1B LTEY*	**$F_{OFL} = 0.21$**	**yield =**	**46,600 mt**
	Tier 5 (M=0.3)		yield =	39,100 mt

Equilibrium female spawning biomass

Model 1		Model 1B	
$B_{100\%}$ =	134,900 mt	$B_{100\%}$ =	192,500 mt
$B_{40\%}$ =	53,900 mt	$B_{40\%}$ =	77,000 mt
$B_{35\%}$ =	47,200 mt	$B_{35\%}$ =	67,400 mt

Projected 2005 biomass

Model 1		Model 1B	
Age 3+ biomass	= 163,800 mt	Age 3+ biomass	= 344,400 mt
Female spawning biomass	= 54,400 mt	Female spawning biomass	= 131,200 mt

* LTEY is the Long-term expected yield under Model 1B at $F_{40\%}$ for ABC and $F_{35\%}$ for OFL recommended by the BSAI plan team.

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Literature Cited

Barbeaux, S., J.N. Ianelli, E. Brown. 2003. Aleutian Islands walleye pollock SAFE. In: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Fish. Mgmt. Council, Anchorage, AK, Section 1A:839-888.

Dorn, M.W. 1992. Detecting environmental covariates of Pacific whiting Merluccius productus growth using a growth-increment regression model. Fish. Bull. 90:260-275.

Harrison, R. C. 1993. Data Report: 1991 bottom trawl survey of the Aleutian Islands area. Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., NOAA Tech. Memo. NMFS-AFSC-12.

Hilborn, R. and Walters, C.J. 1992. Quantitative fisheries stock assessment: choice, dynamics, and uncertainty. Chapman and Hall, New York, N.Y. 570 p.

Hilborn, R. and M. Mangel. 1997. The Ecological Detective – confronting models with data. Princeton University Press, Princeton, New Jersey. pp.315

Ianelli, J.N., T. Buckley, T. Honkalehto, N. Williamson and G. Walters. 2001. Bering Sea-Aleutian Islands Walleye Pollock Assessment for 2002. In: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Fish. Mgmt. Council, Anchorage, AK, section 1:1-105.

Ianelli, J.N., S. Barbeaux, T. Honkalehto, N. Williamson and G. Walters. 2002. Bering Sea-Aleutian Islands Walleye Pollock Assessment for 2003. In: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Fish. Mgmt. Council, Anchorage, AK, section 1:1-123.

Ianelli, J.N., S. Barbeaux, T. Honkalehto, N. Williamson and G. Walters. 2003. Bering Sea-Aleutian Islands Walleye Pollock Assessment for 2003. In: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Fish. Mgmt. Council, Anchorage, AK, section 1:1-123.

Kimura, D.K. 1989. Variability in estimating catch-in-numbers-at-age and its impact on cohort analysis. In R.J. Beamish and G.A. McFarlane (eds.), Effects on ocean variability on recruitment and an evaluation of parameters used in stock assessment models. Can. Spec. Publ. Fish. Aq. Sci. 108:57-66.

Lowe, S., J. Ianelli, and H. Zenger. 2003. Assessment of Aleutian Islands Atka Mackerel . In: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Fish. Mgmt. Council, Anchorage, AK, section 14:1-123.

Mueter, F. J., M.C. Palmer, and B.L. Norcross. 2004. Environmental predictors of walleye pollock recruitment on the Eastern Bering Sea shelf. Final Report to the Pollock Conservation Cooperative Research Center. June 2004. 74p.

Nishimura, A., T. Yanagimoto, Y. Takoa. 2002. Cruise results of the winter 2002 Bering Sea pollock survey (Kaiyo Maru), Document for the 2002 statistical meeting, Central Bering Sea Convention, September 2002. Available: Hokkaido National Fisheries Research Institute, Hokkaido, Japan

NMFS. 2002. Alaska Groundfish Fisheries: Draft Programmatic Supplemental Environmental Impact Statement. NMFS, Alaska Region, NOAA, U.S. DOC.

Wespestad, V. G. 1990. Walleye pollock. Condition of groundfish resources in the Bering Sea-Aleutian Islands region as assessed in 1989. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., NOAA Tech. Memo. NMFS F/AKC.

Wespestad, V. G. and J. M. Terry. 1984. Biological and economic yields for eastern Bering Sea walleye pollock under differing fishing regimes. N. Amer. J. Fish. Manage., 4:204-215.

Wespestad, V. G. and J. Traynor. 1989. Walleye pollock. In: L-L. Low and R. Narita (editors), Condition of groundfish resources in the Bering Sea-Aleutian Islands region as assessed in 1988. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., NOAA Tech. Memo. NMFS F/AKC-178.

Wespestad, V. G., J. Ianelli, L. Fritz, T. Honkalehto, G. Walters. 1996. Bering Sea-Aleutian Islands Walleye Pollock Assessment for 1997. In: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Fish. Mgmt. Council, Anchorage, AK, section 1:1-73.

Tables

Table 1. Estimates of the entire Aleutian Islands Region walleye pollock fisheries catch by source, 1977-2003. Units are in metric tons.

Year	Official Foreign & JV Blend	Domestic Blend	Foreign Reported	NMFS Observer Data	Current estimates
1977	7,367		7,827	5	7,367
1978	6,283		6,283	234	6,283
1979	9,446		9,505	58	9,446
1980	58,157		58,477	883	58,157
1981	55,517		57,056	2,679	55,517
1982	57,753		62,624	11,847	57,753
1983	59,021		44,544	12,429	59,021
1984	77,595		67,103	48,538	77,595
1985	58,147		48,733	43,844	58,147
1986	45,439		14,392	29,464	45,439
1987	28,471			17,944	28,471
1988	41,203			21,987	41,203
1989	10,569			5,316	10,569
1990		79,025		51,137	79,025
1991		98,604		20,493	98,604
1992		52,352		20,853	52,352
1993		57,132		22,804	57,132
1994		58,659		37,707	58,659
1995		64,925		18,023	64,925
1996		29,062		5,982	29,062
1997		25,940		5,580	25,940
1998		23,822		1,882	23,822
1999		1,010		24	1,010
2000		1,244		75	1,244
2001		824		88	824
2002		1,156		144	1,156
2003					1,653

Table 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 3. Estimates of Aleutian Islands Region walleye pollock catch by the three management sub-areas. Foreign reported data were used from 1977-1984, from 1985-2003 observer data were used to partition catches among the areas. Units are in metric tons.

Year	East (541)	Central (542)	West (543)	Total
1977	4,402	0	2,965	7,367
1978	5,267	712	305	6,283
1979	1,488	1,756	6,203	9,446
1980	28,284	7,097	22,775	58,157
1981	43,461	10,074	1,982	55,517
1982	54,173	1,205	2,376	57,753
1983	56,577	1,250	1,194	59,021
1984	64,172	5,760	7,663	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
2003	569	758	326	1,653

Table 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. 3 for locations on a map. (*Note: 1977-1984 area assignments are based on foreign reported data, 1985- 2003 are based on observer data).*

	NRA	NRA w/o E	Basin	Basin + E
1977	7,367	2,965	0	4,402
1978	6,283	1,016	0	5,267
1979	9,446	7,959	0	1,488
1980	58,157	29,873	0	28,284
1981	31,258	14,811	24,259	40,706
1982	50,322	3,149	7,863	54,605
1983	44,442	1,669	15,354	57,352
1984	42,901	9,171	39,140	68,424
1985	47,070	870	48,472	57,278
1986	23,810	704	28,003	44,735
1987	26,257	2,720	2,251	25,752
1988	36,864	574	4,339	40,628
1989	10,569	0	0	10,569
1990	79,025	10,477	0	68,548
1991	98,604	561	230	98,043
1992	52,352	8,519	29,455	43,833
1993	57,132	16,162	22,404	40,970
1994	58,659	5,965	26,288	52,694
1995	64,925	58,203	3,015	6,723
1996	29,062	23,187	899	5,875
1997	25,940	25,774	0	166
1998	23,822	23,335	67	486
1999	1,010	631	0	378
2000	1,244	891	0	354
2001	824	575	0	249
2002	1,156	351	1	805
2003	1,653	1,430	0	222

Table 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 6. NRA pollock fishery average weight-at-age in kilograms. Shaded cells had missing observations and were filled with their mean values

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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	0.3392	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	0.3392	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	0.3392	0.4736	0.6609	0.7333	0.7796	0.7954	0.9264	0.9574	1.0146	0.9024	1.1892	1.1496	0.9740	1.1400
1984	0.4260	0.4459	0.6609	0.7419	0.8099	0.8721	0.9680	0.9963	1.2704	1.6431	1.1351	1.2212	1.1943	1.1400
1985	0.4675	0.5656	0.6705	0.6896	0.8028	0.8536	0.8567	1.0909	1.2330	1.5996	1.6644	1.1496	1.6448	1.1400
1986	0.3392	0.5114	0.6019	0.7472	0.8266	0.8698	0.9506	0.9266	1.0137	0.9428	1.0702	0.8963	1.1943	1.1400
1987	0.3392	0.4736	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	0.3392	0.4736	0.6609	0.8013	0.7905	0.8208	0.9279	0.8883	0.9839	0.8933	0.7843	0.7223	0.8976	1.0621
1989	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400
1990	0.3392	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	0.3392	0.4736	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	0.3392	0.4736	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	0.3392	0.4736	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	0.3392	0.4736	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	0.3392	0.5512	0.8471	0.7536	1.1264	1.3303	1.3972	1.3551	1.4333	1.4197	1.5010	1.4466	1.6582	1.3206
1996	0.3392	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	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400
1998	0.3392	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
1999	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400
2000	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400
2001	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400
2002	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400
2003	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400
2004	0.3392	0.4736	0.6609	0.7536	0.8510	0.9260	0.9927	1.0611	1.1106	1.1501	1.1892	1.1496	1.1943	1.1400

Table 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	490	1,013	1,503
1979	124	178	302	611	706	1,317
1980	93	167	260	971	1,183	2,154
1981	124	152	276	2,226	2,556	4,782
1982	564	640	1,204	3,655	4,058	7,713
1983	132	145	277	1,493	1,484	2,977
1984	294	312	606	5,273	5,571	10,844
1985	210	265	475	349	431	780
1986	77	113	190	0	0	0
1987	131	142	273	1,670	2,375	4,045
1988	34	33	67	188	190	378
1989	0	0	0	0	0	0
1990	46	49	95	5,209	7,094	12,303
1991	36	47	83	0	0	80
1992	110	121	231	3,755	3,650	7,405
1993	81	82	163	7,701	5,770	13,471
1994	157	151	308	2,644	2,381	5,025
1995	74	106	180	16,518	12,552	29,070
1996	95	84	179	8,933	6,374	15,307
1997	15	15	30	9,232	8,007	17,239
1998	144	170	314	5,992	4,447	10,439
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 8. Number of individual vessels and hauls sampled by observers in the NRA west of 174W longitude pollock fishery 1990-1998.

	NRA Area 541 West of 174W				NRA Area 542				NRA Area 543			
	Catcher Processor		Catcher Only		Catcher Processor		Catcher Only		Catcher Processor		Catcher Only	
Year	Vessels	Hauls	Vessels	Hauls	Vessels	Hauls	Vessels	Hauls	Vessels	Hauls	Vessels	Hauls
1990	12	50	0	0	16	132	0	0	2	4	0	0
1991	2	3	0	0	2	2	0	0	0	0	0	0
1992	18	126	0	0	4	5	0	0	0	0	0	0
1993	18	195	0	0	6	25	0	0	3	5	0	0
1994	18	76	0	0	3	6	0	0	0	0	0	0
1995	22	200	8	39	15	272	11	77	0	0	0	0
1996	5	12	7	15	25	198	10	38	0	0	0	0
1997	13	66	11	30	14	93	10	60	1	6	0	0
1998	4	6	5	16	3	24	5	19	2	97	4	24

Table 9. Estimated NRA region pollock catch at age (millions). Highest mode for each year is shaded.

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1978	0.01	0.14	0.12	0.07	0.36	0.10	0.14	0.13	0.13	0.06	0.02	0.01		0.00	1.27
1979	0.01	2.18	2.22	2.02	2.43	1.73	0.65	0.63	0.37	0.03	0.22			0.05	12.53
1980	8.20	3.24	2.64	3.71	6.94	4.05	2.47	0.73	1.07	0.53	0.16	0.01	0.14	0.01	33.91
1981		5.72	3.36	2.19	1.65	2.55	2.54	1.93	1.37	0.73	0.20	0.15	0.20	0.04	22.64
1982		0.01	3.00	0.51	0.23	0.31	0.38	0.35	0.15	0.07	0.04	0.03	0.01	0.01	5.10
1983				0.74	0.44	0.17	0.11	0.24	0.23	0.05	0.04	0.01	0.00	0.00	2.04
1984	0.14	3.97		4.12	4.12	1.46	1.10	0.74	0.51	0.34	0.09	0.06	0.03	0.01	16.68
1985	0.01	0.01	0.17	0.06	0.17	0.46	0.20	0.08	0.08	0.04	0.01	0.01	0.00	0.00	1.30
1986															
1987			1.40	0.31	0.23	0.04	0.09	1.01	0.09	0.12	0.00	0.03	0.01	0.04	3.36
1988															
1989															
1990		0.95	0.26	0.96	0.78	0.78	0.93	0.17	1.10	0.34	0.56	0.28	0.13	0.21	7.45
1991															
1992			0.03	0.33	0.60	0.30	0.60	0.12	0.69	0.39	0.52	0.36	1.71	1.91	7.55
1993			0.18	0.47	1.12	1.34	0.54	1.46	0.81	0.88	0.83	0.38	0.70	4.34	13.05
1994			0.07	1.00	0.31	0.42	0.60	0.43	0.33	0.17	0.39	0.10	0.08	1.30	5.20
1995		0.22	0.38	0.00	10.22	1.19	5.10	4.84	1.42	2.36	2.08	3.82	0.77	8.32	40.71
1996		0.17	0.15	0.56	1.42	5.15	1.53	2.09	1.21	0.92	0.64	0.20	0.77	2.00	16.79
1997															
1998		0.05	0.08	5.66	1.65	1.05	0.96	1.71	1.20	1.00	2.40	1.30	1.17	1.49	19.73

Table 10. Pollock biomass estimates from the Aleutian Islands Groundfish Survey, 1980-2002.

	Aleutian Islands Region				
	NRA West (174W-170E)	NRA East (170W-174W)	NRA total	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	137,202	51,644	188,846
1994	47,623	29,879	77,502	39,696	117,199
1997	57,577	39,935	97,512	65,400	158,912
2000	76,613	28,985	105,598	22,462	128,060
2002	121,915	53,368	175,283	181,334	356,617
2004	19,201	111,250	130,451	235,658	366,110

Table 11. Results of the 2002 Aleutian Islands echo integration-trawl survey conducted by the R/V Kaiyo Maru.

	Leg 2-1	Leg 2-2	Leg 2-3	Leg 2-4
Area (km^2)	27,902	10,433	4,045	1,413
Density (mt/km^2)	2.18	1.82	2.46	1.79
Population (10^6)	37	12	6	2
Biomass (10^3 mt)	61	19	10	3
CV	0.31	0.33	0.21	0.76

Table 12. 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 13. Estimated von Bertalanffy growth curve parameters and length-weight regression parameters for walleye pollock sampled during the U.S.-Japan 1980, 1983, and 1986 groundfish surveys and the 1991, 1994, 1997, 2000, and 2002 RACE groundfish surveys.

	L_{inf}	**K**	t_0	**A**	**b**
1980	51.92	0.414	-0.525	0.0132	2.858
1983	53.26	0.383	0.002	0.0178	2.768
1986	51.02	0.443	-0.084	0.0142	2.831
1991	54.55	0.392	-0.361	0.0104	2.912
1994	61.58	0.330	-0.102	0.0069	3.022
1997	61.41	0.286	-0.397	0.0081	2.983
2000	62.58	0.306	-0.048	0.0064	3.019
2002	64.36	0.289	-0.127	0.0066	3.018

Table 14. Average weight-at-age for Aleutian Islands pollock as estimated from NMFS summer bottom trawl survey estimates. Values between survey years (shaded) were set to the mean of the nearest two surveys (or single year for 1978-79, 2003-04).

	Age													
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1978	0.31	0.50	0.65	0.78	0.87	0.93	0.97	1.00	1.02	1.03	1.04	1.04	1.05	1.05
1979	0.31	0.50	0.65	0.78	0.87	0.93	0.97	1.00	1.02	1.03	1.04	1.04	1.05	1.05
1980	0.31	0.50	0.65	0.78	0.87	0.93	0.97	1.00	1.02	1.03	1.04	1.04	1.05	1.05
1981	0.25	0.43	0.60	0.73	0.83	0.90	0.95	0.99	1.01	1.03	1.04	1.05	1.05	1.05
1982	0.25	0.43	0.60	0.73	0.83	0.90	0.95	0.99	1.01	1.03	1.04	1.05	1.05	1.05
1983	0.19	0.37	0.54	0.69	0.80	0.88	0.94	0.98	1.01	1.02	1.04	1.05	1.05	1.06
1984	0.21	0.40	0.56	0.70	0.80	0.87	0.92	0.95	0.97	0.99	1.00	1.01	1.01	1.01
1985	0.21	0.40	0.56	0.70	0.80	0.87	0.92	0.95	0.97	0.99	1.00	1.01	1.01	1.01
1986	0.23	0.42	0.59	0.71	0.80	0.86	0.90	0.92	0.94	0.95	0.96	0.96	0.97	0.97
1987	0.23	0.46	0.64	0.75	0.91	1.01	1.08	1.06	1.10	1.08	1.06	1.04	1.06	1.03
1988	0.23	0.46	0.64	0.75	0.91	1.01	1.08	1.06	1.10	1.08	1.06	1.04	1.06	1.03
1989	0.23	0.46	0.64	0.75	0.91	1.01	1.08	1.06	1.10	1.08	1.06	1.04	1.06	1.03
1990	0.23	0.46	0.64	0.75	0.91	1.01	1.08	1.06	1.10	1.08	1.06	1.04	1.06	1.03
1991	0.22	0.51	0.69	0.79	1.01	1.15	1.26	1.21	1.27	1.21	1.16	1.12	1.16	1.10
1992	0.21	0.51	0.78	0.89	1.08	1.22	1.25	1.33	1.36	1.32	1.35	1.33	1.35	1.22
1993	0.21	0.51	0.78	0.89	1.08	1.22	1.25	1.33	1.36	1.32	1.35	1.33	1.35	1.22
1994	0.20	0.52	0.87	1.00	1.14	1.29	1.24	1.45	1.44	1.43	1.54	1.54	1.54	1.35
1995	0.22	0.48	0.82	0.97	1.07	1.24	1.26	1.38	1.44	1.45	1.53	1.52	1.57	1.47
1996	0.22	0.48	0.82	0.97	1.07	1.24	1.26	1.38	1.44	1.45	1.53	1.52	1.57	1.47
1997	0.25	0.43	0.78	0.95	1.00	1.19	1.29	1.31	1.44	1.47	1.52	1.51	1.60	1.60
1998	0.21	0.47	0.77	0.92	0.95	1.17	1.28	1.31	1.43	1.50	1.62	1.59	1.53	1.65
1999	0.21	0.47	0.77	0.92	0.95	1.17	1.28	1.31	1.43	1.50	1.62	1.59	1.53	1.65
2000	0.17	0.51	0.77	0.89	0.90	1.15	1.26	1.32	1.41	1.52	1.71	1.67	1.47	1.70
2001	0.19	0.49	0.74	1.02	1.03	1.23	1.29	1.43	1.53	1.56	1.74	1.68	1.58	1.67
2002	0.21	0.47	0.70	1.15	1.16	1.32	1.32	1.53	1.65	1.61	1.76	1.69	1.68	1.64
2003	0.21	0.47	0.70	1.15	1.16	1.32	1.32	1.53	1.65	1.61	1.76	1.69	1.68	1.64
2004	0.21	0.47	0.70	1.15	1.16	1.32	1.32	1.53	1.65	1.61	1.76	1.69	1.68	1.64

Table 15. 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 16. Data on catch per day in 1995 for the Aleutian Islands sub-area 541 (west of 174W). The first column is the number of vessels operating, the second is the average catch over all vessels for that day, and the 3rd column is the cumulative catch for this area. Subsequent columns represent the estimated catch by specific vessels during each day. Days (represented by rows) are in sequence.

Number of vessels	Average catch/day	Cumulative catch	**Vessel-specific (columns) catch in 1995 by day in tons**																													
1	29	29											29																			
14	79	1,138	92	52	92			76	47	252		62	92	83				19		100	52	71	18									
12	90	2,218	84	55	111		79	26		146		50	86	31						71	195	146										
9	72	2,867	37				39	70		21			61			80	40			157	143											
7	92	3,513	20				87	95			70					61	75			238												
10	117	4,685					62	101	64	246	70		121			29	99			94	288											
10	87	5,554					44	20	67	68	41		246			36	128			17	202											
9	148	6,886					239	55	67	126	9					162	305			223	147											
7	98	7,571					82	67	44		40					81	200			170												
7	66	8,033		54			58	55			38					51	125			82												
7	79	8,587		72												85	175			120					12	13				76		
5	76	8,967		51			64									92	60			113												
5	41	9,171		16		32	29									69				60												
1	13	9,185																														13
3	93	9,464																								35				211		33
4	82	9,791													1										45	31				249		
6	154	10,714			159																	151			80	88			67	378		
7	63	11,153			131										31							117			65	62		20	13			
4	109	11,591			252																	91					43				51	
4	72	11,881			45																	173					38				34	
2	137	12,154			141																	132										
1	57	12,211																				57										
1	7	12,218																										7				
2	196	12,611																	327													65
3	161	13,093																	143							54				285		
4	157	13,720																	201						65	81				280		
2	153	14,027																							150	157						
1	140	14,167																							140							
1	421	14,588																												421		
1	410	14,998																												410		
1	71	15,069																						71								
		Number of days fishing	4	6	7	1	10	9	5	6	6	2	6	2	2	10	9	1	3	12	6	8	1	1	7	8	2	2	2	8	2	3

Table 17. Data on catch per day in 1995 for the Aleutian Islands sub-area 542. The first column is the number of vessels operating, the second is the average catch over all vessels for that day, and the 3rd column is the cumulative catch for this area. Subsequent columns represent the estimated catch by specific vessels during each day. Days (represented by rows) are in sequence.

Number of vessels	Cumulative catch	Average catch/day	Vessel-specific (columns) catch in 1995 by day in tons																										
1	319	319															319												
1	333	651															333												
2	247	1,146	236														259												
2	262	1,670	250														274												
2	303	2,275	270														335												
6	106	2,910	13						122		129			77		26	268												
4	145	3,488							206		237			87			48												
3	354	4,550							198		437			427															
8	178	5,971	3				95	104	387	36	379			386			31												
4	323	7,262							421		343			487			40												
7	187	8,572						219	259	107	100		28	568			28												
6	259	10,128						227	147	208			430	389			155												
10	223	12,362		498	450	83		154	263	380	30	108	226				41												
12	323	16,236		520	291	193		270	494	391	449	207	360	448	67		184												
15	307	20,835		326	464	194	61	419	425	70	39	293	425	665	424		313		453							27			
15	219	24,121		366	65	108	200	109	404	159	351	170	300	356	251		206		126							114			
4	300	25,322							152		447							569								33			
1	43	25,365																										43	
6	330	27,346																	679	296			54		447		250		255
6	197	28,531																416		63		206	233				96		170
3	91	28,805																				106				73	96		
1	58	28,863																								58			
2	266	29,396																	414		119								
2	166	29,728																	154		178								
1	85	29,813																											85
5	175	30,690																353		105				140	83				196
5	206	31,721																206		254				200	325				46
1	145	31,866																							145				
1	27	31,892																			27								
4	140	32,454																			88	150	88						235
4	157	33,082																			124	150	221						134
	Number of days	fishing	5	4	4	4	3	7	12	7	11	4	6	10	3	1	15	4	5	4	5	4	4	2	4	5	3	1	7

Table 18. Comparisons of fits for the evaluations of Aleutian Islands pollock models 1-3, model 2A and Model 1B.

	Model 1	Model 2	Model 3	Model 2A	Model 1B
Number of Parameters	263	265	265	265	264
Survey catchability	1.00	0.06	0.12	0.09	1.00
Fishery Average Effective N	37	38	38	38	37
Survey Average Effective N	281	388	434	388	217
RMSE Survey	0.660	0.585	0.594	0.584	0.372
-log Likelihoods					
Survey index	24.51	11.90	12.26	11.85	8.57
Fishery age comp	77.71	65.11	64.81	65.34	70.87
Survey age comp	13.83	8.46	8.27	8.37	17.17
Sub total	116.05	85.46	85.34	85.57	96.91
-log Penalties					
Recruitment	-7.80	-11.85	-11.33	-11.82	-13.07
Selectivity constraint	14.23	15.07	15.08	15.00	14.80
Prior	0.00	0.06	9.88	0.06	0.01
Total	129.09	91.39	101.73	91.42	105.48

Table 19. Characteristic results for the evaluations of Aleutian Islands pollock pollock models 1-3, model 2A and Model 1B.

	Model 1	Model 2	Model 3	Model 2A	Model 1B
Model conditions					
Survey catchability	1.00	0.06	0.12	0.09	1.00
Natural mortality	0.30	0.30	0.30	0.30	0.30
Fishing mortalities					
Max F 1978-2004	0.436	0.082	0.152	0.075	0.334
F 2004	0.040	0.013	0.016	0.014	0.023
Stock abundance					
Initial Biomass (1978; thousands of tons)	509	1,769	1,064	1,293	675
CV	23%	84%	38%	86%	24%
2005 total biomass (thousands of tons)	192	1,116	612	802	436
CV	20%	89%	40%	92%	22%
2005 Age 3+ biomass (thousands of tons)	164	915	505	658	344
1978 year class (at age 2)	229	829	498	604	288
CV	27%	85%	39%	87%	27%
Recruitment Variability	0.64	0.47	0.50	0.47	0.46
Specified Sigma R	0.60	0.60	0.60	0.60	0.60
Steepness (h)	0.60	0.63	0.59	0.63	0.67
Projected catch (unadjusted)					
F50% 2005 catch	20.5	180.6	95.3	128.6	62.9
CV	19%	91%	43%	95%	23%
F40% 2005 catch	31.3	255.4	135.0	182.2	94.6
CV	20%	91%	42%	95%	24%
F35% 2005 catch	38.6	300.2	159.0	214.5	114.7
CV	20%	91%	42%	95%	23%

Table 20 Estimates of pollock fishery, survey and projected fishery selectivity-at-age for Model 1 and Model 1B.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
M1 Fishery	0.012	0.030	0.087	0.262	0.438	0.570	0.650	0.614	0.586	0.598	0.774	1.000	1.000	1.000
M1B Fishery	0.008	0.021	0.595	0.173	0.283	0.371	0.437	0.445	0.479	0.551	0.764	1.000	1.000	1.000
Projected	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
M1 Survey	0.050	0.083	0.128	0.181	0.251	0.342	0.472	0.681	0.999	1.320	1.458	1.526	1.526	1.526
M1B Survey	0.039	0.090	0.187	0.315	0.448	0.574	0.689	0.816	0.994	1.190	1.335	1.413	1.413	1.413

Table 21. Model 1 (left) and Model 1B (left) estimates of pollock biomass with approximate lower and upper 95% confidence bounds for age 2+ biomass. Also included is the age 3+ biomass.

M1	**Total Biomass (age 2+)**			**Biomass**
Year		**LCI**	**UCI**	**Age 3+**
1978	509,180	270,060	748,300	390,752
1979	516,810	290,470	743,150	347,635
1980	613,220	382,100	844,340	433,530
1981	628,180	401,460	854,900	517,264
1982	620,610	406,670	834,550	458,522
1983	607,340	413,484	801,196	441,854
1984	577,790	408,492	747,088	439,640
1985	535,540	390,562	680,518	416,260
1986	502,540	380,370	624,710	375,846
1987	464,750	362,996	566,504	356,831
1988	436,840	352,286	521,394	307,156
1989	417,210	346,566	487,854	321,750
1990	400,150	340,272	460,028	276,039
1991	390,090	339,492	440,688	284,828
1992	385,130	341,186	429,074	303,336
1993	360,180	321,632	398,728	342,435
1994	322,140	287,818	356,462	281,449
1995	297,390	265,124	329,656	294,171
1996	219,700	187,708	251,692	202,438
1997	188,470	154,686	222,254	163,665
1998	151,070	114,796	187,344	129,007
1999	123,450	85,136	161,764	108,394
2000	124,470	84,370	164,570	106,522
2001	127,570	84,348	170,792	104,422
2002	127,690	82,058	173,322	109,936
2003	141,730	91,546	191,914	109,867
2004	171,130	106,438	235,822	128,189
2005	191,800	114,338	269,262	163,759

M1B	**Total Biomass (age 2+)**			**Biomass**
Year		**LCI**	**UCI**	**Age 3+**
1978	674,940	346,800	1,003,080	501,677
1979	679,570	371,910	987,230	445,433
1980	807,620	495,680	1,119,560	554,584
1981	859,660	549,440	1,169,880	664,197
1982	864,020	569,080	1,158,960	593,032
1983	818,750	559,570	1,077,930	571,172
1984	755,940	537,160	974,720	570,046
1985	702,300	516,066	888,534	544,349
1986	652,310	497,486	807,134	486,976
1987	603,500	474,392	732,608	460,426
1988	561,530	454,678	668,382	394,850
1989	529,960	440,556	619,364	407,114
1990	508,730	431,014	586,446	344,947
1991	503,620	433,204	574,036	360,087
1992	504,410	437,034	571,786	386,513
1993	481,620	415,432	547,808	444,677
1994	434,630	370,486	498,774	370,950
1995	403,180	338,400	467,960	391,761
1996	329,040	260,464	397,616	295,808
1997	302,610	226,646	378,574	254,208
1998	279,830	192,308	367,352	222,979
1999	266,870	167,562	366,178	219,052
2000	288,400	173,592	403,208	229,957
2001	317,930	181,254	454,606	245,902
2002	341,070	183,844	498,296	281,466
2003	371,130	203,026	539,234	294,701
2004	409,490	232,930	586,050	317,277
2005	435,540	247,884	623,196	344,430

Table 22. Estimated pollock numbers at age in millions. 1978-2003 based on Model 1 (Top) and Model 1B (bottom).

Model 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	% of 15+
1978	173	141	118	83	73	32	27	20	16	11	7	5	4	9	718	1.2%
1979	229	128	104	86	61	53	23	20	15	11	8	5	4	9	756	1.2%
1980	707	169	94	75	62	43	37	16	14	10	8	6	4	9	1254	0.7%
1981	158	519	122	65	51	41	28	24	10	8	6	5	4	9	1051	0.8%
1982	97	116	379	87	46	36	28	19	16	7	6	4	4	8	852	1.0%
1983	160	72	86	277	63	33	26	20	13	11	5	4	3	9	782	1.1%
1984	149	118	53	63	202	46	24	19	14	10	8	4	3	9	721	1.2%
1985	150	110	87	38	45	144	33	17	13	10	7	6	2	8	670	1.2%
1986	127	111	81	64	28	33	105	24	12	9	7	5	4	8	618	1.3%
1987	98	94	82	60	47	21	24	76	17	9	7	5	4	9	551	1.6%
1988	158	72	69	60	43	34	15	17	55	12	6	5	4	9	560	1.6%
1989	138	117	53	51	44	32	25	11	13	40	9	5	4	9	548	1.7%
1990	117	102	86	39	37	32	23	18	8	9	29	6	3	9	520	1.8%
1991	220	86	75	62	28	26	22	16	12	5	6	19	4	8	592	1.4%
1992	91	163	64	55	46	21	19	16	12	9	4	4	14	9	528	1.7%
1993	76	68	120	47	40	33	15	13	11	8	6	3	3	15	458	3.3%
1994	70	57	50	88	34	28	22	10	9	7	5	4	1	10	394	2.6%
1995	79	52	42	37	64	24	20	16	7	6	5	4	2	8	365	2.2%
1996	53	58	38	30	24	37	12	10	8	3	3	2	1	3	282	1.1%
1997	65	39	43	27	20	15	22	7	6	5	2	2	1	2	255	0.8%
1998	51	48	29	30	17	11	8	11	4	3	2	1	1	1	215	0.5%
1999	40	38	35	20	19	9	6	4	5	2	1	1	0	0	179	0.3%
2000	44	29	28	26	15	14	7	4	3	4	1	1	1	1	175	0.3%
2001	64	32	22	21	19	11	10	5	3	2	3	1	1	1	192	0.4%
2002	39	47	24	16	15	14	8	7	4	2	1	2	1	1	181	0.6%
2003	116	29	35	18	12	11	10	6	5	3	2	1	1	1	248	0.5%
2004	158	86	22	26	13	9	8	7	4	4	2	1	1	2	341	0.5%

Model 1B	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	% of 15+
1978	218	178	148	106	92	41	35	26	21	14	9	7	5	13	915	1.5%
1979	288	161	132	109	77	67	30	25	19	15	10	7	5	14	960	1.4%
1980	895	213	119	96	79	55	48	21	18	13	10	7	5	13	1592	0.8%
1981	205	658	154	84	66	53	37	31	14	12	9	7	5	12	1347	0.9%
1982	126	151	482	110	59	47	37	25	21	9	8	6	5	12	1098	1.1%
1983	210	93	112	352	80	43	34	26	18	15	7	6	4	12	1013	1.2%
1984	197	155	69	82	257	59	31	24	19	13	11	5	4	12	938	1.3%
1985	185	145	114	50	59	185	42	22	17	13	9	8	3	12	865	1.4%
1986	160	137	107	84	37	43	135	30	16	12	10	7	6	11	795	1.4%
1987	122	119	101	79	61	27	31	98	22	12	9	7	5	12	705	1.7%
1988	184	91	88	74	58	45	19	23	70	16	8	6	5	12	699	1.8%
1989	166	136	67	64	54	42	33	14	16	51	11	6	5	13	679	1.9%
1990	150	123	100	49	47	40	31	24	10	12	37	8	4	13	650	1.9%
1991	288	111	90	73	35	34	28	21	16	7	8	25	6	12	755	1.5%
1992	130	213	82	67	54	26	25	20	16	12	5	6	18	12	687	1.8%
1993	102	96	158	60	49	39	19	17	14	11	8	3	4	20	601	3.4%
1994	96	75	71	116	44	35	27	13	12	10	7	5	2	15	526	2.8%
1995	126	71	56	52	85	32	25	19	9	8	7	5	4	11	510	2.2%
1996	94	93	52	40	36	53	19	14	11	5	4	3	2	5	430	1.2%
1997	119	69	69	38	28	24	35	12	9	7	3	2	1	3	419	0.8%
1998	136	88	51	49	26	18	15	20	7	5	4	1	1	2	422	0.4%
1999	107	100	64	37	34	16	11	9	12	4	3	2	1	1	400	0.3%
2000	152	79	74	47	27	25	12	8	6	9	3	2	1	1	447	0.3%
2001	190	113	59	55	35	20	18	9	6	5	6	2	1	2	519	0.3%
2002	128	141	83	43	40	26	14	13	6	4	3	5	1	2	511	0.4%
2003	200	94	104	62	32	30	19	11	10	5	3	2	3	3	577	0.5%
2004	240	148	70	77	46	24	22	14	8	7	3	2	2	4	666	0.6%

Table 23. Estimates of age-2 pollock recruitment (in millions) based on Model 1 (left) and Model 1B (right).

Year class	Index at age 2
1976	172.8
1977	229.1
1978	707.3
1979	157.9
1980	96.9
1981	160.0
1982	148.7
1983	149.8
1984	126.7
1985	97.8
1986	157.7
1987	137.7
1988	117.1
1989	220.3
1990	91.3
1991	76.5
1992	70.0
1993	79.1
1994	53.5
1995	64.6
1996	51.1
1997	39.8
1998	43.9
1999	63.5
2000	39.4
2001	115.6
2002	158.1
2003	83.0
Ave 83-03	132
Med 83-03	107

Year class	Index at age 2
1976	218.3
1977	288.2
1978	895.1
1979	205.2
1980	125.6
1981	209.8
1982	196.7
1983	185.0
1984	160.5
1985	122.4
1986	183.6
1987	166.3
1988	150.4
1989	288.2
1990	130.0
1991	101.8
1992	95.7
1993	126.4
1994	94.1
1995	118.8
1996	135.8
1997	107.2
1998	152.1
1999	190.0
2000	127.5
2001	200.2
2002	240.0
2003	151.7
Ave 83-03	192
Med 83-03	156

Table 24. Estimates of full-selection fishing mortality and exploitation rates for pollock based on Model1 (left) and Model 1B (right).

Model 1

Year	F[a]	Catch/Biomass Rate[b]
1978	0.017	0.017
1979	0.043	0.043
1980	0.112	0.112
1981	0.068	0.068
1982	0.023	0.023
1983	0.018	0.018
1984	0.041	0.041
1985	0.016	0.016
1986	0.016	0.016
1987	0.023	0.023
1988	0.016	0.016
1989	0.013	0.013
1990	0.071	0.071
1991	0.013	0.013
1992	0.065	0.065
1993	0.113	0.113
1994	0.050	0.050
1995	0.410	0.410
1996	0.225	0.225
1997	0.387	0.387
1998	0.436	0.436
1999	0.024	0.024
2000	0.028	0.028
2001	0.021	0.021
2002	0.017	0.017
2003	0.014	0.014
2004	0.040	0.040

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

Model 1B

Year	F[a]	Catch/Biomass Rate[b]
1978	0.016	0.016
1979	0.036	0.036
1980	0.088	0.088
1981	0.054	0.054
1982	0.021	0.021
1983	0.017	0.017
1984	0.034	0.034
1985	0.016	0.016
1986	0.015	0.015
1987	0.021	0.021
1988	0.016	0.016
1989	0.013	0.013
1990	0.058	0.058
1991	0.012	0.012
1992	0.053	0.053
1993	0.092	0.092
1994	0.041	0.041
1995	0.334	0.334
1996	0.171	0.171
1997	0.285	0.285
1998	0.276	0.276
1999	0.017	0.017
2000	0.019	0.019
2001	0.015	0.015
2002	0.013	0.013
2003	0.011	0.011
2004	0.023	0.023

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

Table 25. Projections of Model 1 (with adjusted selectivity) spawning biomass (in thousands of mt), *F*, and catch (in thousands of mt) for NRA pollock for the 8 scenarios. 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*	*Scenario 8*
2004	48.9	48.9	48.9	48.9	48.9	48.9	46.4	48.9
2005	54.4	54.4	56.0	57.7	57.7	53.5	44.6	55.5
2006	53.8	53.8	61.7	71.7	71.7	50.2	50.2	59.3
2007	55.7	55.7	67.4	85.1	85.1	51.3	53.8	64.3
2008	56.8	56.8	71.1	96.7	96.7	51.7	52.7	68.4
2009	57.3	57.3	73.5	106.5	106.5	51.8	52.1	72.1
2010	57.1	57.1	74.5	113.8	113.8	51.4	51.5	74.7
2011	56.5	56.5	74.6	119.1	119.1	50.7	50.7	76.3
2012	56.1	56.1	74.6	123.1	123.1	50.4	50.4	77.5
2013	56.2	56.2	74.9	126.4	126.4	50.6	50.6	78.6
2014	56.7	56.7	75.4	129.1	129.1	51.0	51.0	79.8
2015	56.9	56.9	75.8	131.2	131.2	51.2	51.2	80.8
2016	56.7	56.7	75.7	132.5	132.5	51.0	51.0	81.2
2017	56.1	56.1	75.1	133.0	133.0	50.4	50.4	81.1
F	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*	*Scenario 8*
2004	0.019	0.019	0.019	0.019	0.019	0.019	0.298	0.019
2005	0.349	0.349	0.175	0.000	0.000	0.448	0.285	0.223
2006	0.339	0.339	0.175	0.000	0.000	0.415	0.320	0.213
2007	0.329	0.329	0.174	0.000	0.000	0.404	0.418	0.194
2008	0.321	0.321	0.173	0.000	0.000	0.393	0.398	0.180
2009	0.318	0.318	0.172	0.000	0.000	0.390	0.392	0.176
2010	0.317	0.317	0.171	0.000	0.000	0.389	0.389	0.175
2011	0.317	0.317	0.171	0.000	0.000	0.387	0.388	0.175
2012	0.316	0.316	0.171	0.000	0.000	0.386	0.386	0.175
2013	0.316	0.316	0.171	0.000	0.000	0.386	0.386	0.174
2014	0.317	0.317	0.172	0.000	0.000	0.388	0.388	0.171
2015	0.317	0.317	0.172	0.000	0.000	0.388	0.388	0.168
2016	0.317	0.317	0.171	0.000	0.000	0.388	0.388	0.167
2017	0.316	0.316	0.171	0.000	0.000	0.385	0.385	0.168
Catch	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*	*Scenario 8*
2004	1.6	1.6	1.6	1.6	1.6	1.6	21.1	1.6
2005	27.9	27.9	15.2	0.0	0.0	34.2	18.6	19.0
2006	26.2	26.2	16.5	0.0	0.0	29.2	23.0	19.0
2007	27.3	27.3	18.5	0.0	0.0	30.1	32.7	19.0
2008	28.3	28.3	20.3	0.0	0.0	30.7	31.9	19.0
2009	28.7	28.7	21.1	0.0	0.0	30.9	31.3	19.0
2010	28.6	28.6	21.4	0.0	0.0	30.7	30.8	19.0
2011	28.3	28.3	21.4	0.0	0.0	30.2	30.2	19.0
2012	28.0	28.0	21.3	0.0	0.0	29.8	29.9	19.0
2013	28.0	28.0	21.4	0.0	0.0	29.9	29.9	19.0
2014	28.1	28.1	21.4	0.0	0.0	30.2	30.2	19.0
2015	28.4	28.4	21.6	0.0	0.0	30.5	30.5	19.0
2016	28.3	28.3	21.6	0.0	0.0	30.3	30.3	19.0
2017	28.1	28.1	21.5	0.0	0.0	30.0	30.0	19.0

Table 26. Projections of Model 1B (with adjusted selectivity) spawning biomass (in thousands of mt), *F*, and catch (in thousands of mt) for NRA pollock for the 8 scenarios. 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	Scenario 8
2004	128.5	128.5	128.5	128.5	128.5	128.5	119.3	128.5
2005	131.2	131.2	136.2	141.4	141.4	128.2	96.0	139.3
2006	106.7	106.7	128.2	157.1	157.1	95.9	90.1	144.7
2007	93.8	93.8	121.8	167.9	167.9	81.8	84.8	147.1
2008	86.2	86.2	116.4	175.5	175.5	75.2	76.6	147.8
2009	82.7	82.7	112.6	181.0	181.0	73.1	73.5	148.0
2010	81.0	81.0	109.8	184.7	184.7	72.3	72.3	147.6
2011	80.1	80.1	107.9	187.3	187.3	71.7	71.8	147.1
2012	79.7	79.7	106.7	189.0	189.0	71.5	71.5	146.5
2013	79.5	79.5	106.1	190.2	190.2	71.5	71.5	146.0
2014	79.7	79.7	105.9	191.3	191.3	71.7	71.7	145.8
2015	79.9	79.9	106.0	192.2	192.2	71.9	71.9	145.7
2016	79.7	79.7	105.7	192.5	192.5	71.6	71.6	145.3
2017	79.0	79.0	104.9	192.1	192.1	71.0	71.0	144.5
F	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
2004	0.007	0.007	0.007	0.007	0.007	0.007	0.412	0.007
2005	0.412	0.412	0.206	0.000	0.000	0.544	0.412	0.081
2006	0.412	0.412	0.206	0.000	0.000	0.544	0.412	0.080
2007	0.412	0.412	0.206	0.000	0.000	0.526	0.533	0.078
2008	0.398	0.398	0.206	0.000	0.000	0.491	0.495	0.077
2009	0.390	0.390	0.206	0.000	0.000	0.482	0.483	0.077
2010	0.386	0.386	0.205	0.000	0.000	0.479	0.479	0.078
2011	0.384	0.384	0.205	0.000	0.000	0.476	0.476	0.080
2012	0.384	0.384	0.205	0.000	0.000	0.476	0.476	0.080
2013	0.384	0.384	0.205	0.000	0.000	0.476	0.476	0.081
2014	0.384	0.384	0.205	0.000	0.000	0.476	0.476	0.081
2015	0.384	0.384	0.205	0.000	0.000	0.477	0.477	0.081
2016	0.385	0.385	0.205	0.000	0.000	0.478	0.478	0.081
2017	0.383	0.383	0.205	0.000	0.000	0.474	0.474	0.082
Catch	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
2004	1.6	1.6	1.6	1.6	1.6	1.6	73.1	1.6
2005	80.5	80.5	45.0	0.0	0.0	99.3	55.8	19.0
2006	61.6	61.6	40.8	0.0	0.0	69.1	50.1	19.0
2007	53.4	53.4	38.7	0.0	0.0	56.3	59.4	19.0
2008	48.2	48.2	37.6	0.0	0.0	49.4	51.0	19.0
2009	45.2	45.2	36.2	0.0	0.0	47.0	47.6	19.0
2010	43.8	43.8	35.2	0.0	0.0	46.2	46.3	19.0
2011	43.1	43.1	34.4	0.0	0.0	45.7	45.7	19.0
2012	42.8	42.8	33.9	0.0	0.0	45.5	45.5	19.0
2013	42.7	42.7	33.7	0.0	0.0	45.4	45.4	19.0
2014	42.7	42.7	33.6	0.0	0.0	45.5	45.5	19.0
2015	42.9	42.9	33.7	0.0	0.0	45.8	45.8	19.0
2016	42.9	42.9	33.6	0.0	0.0	45.7	45.7	19.0
2017	42.4	42.4	33.4	0.0	0.0	45.1	45.1	19.0

Table 27. **Ecosystem effects on AI walleye pollock**

Indicator	Observation	Interpretation	Evaluation
Prey availability or abundance trends			
Zooplankton	Stomach contents, ichthyoplankton surveys	None	Unknown
Predator population trends			
Marine mammals	Fur seals declining, Steller sea lions increasing slightly	Possibly lower mortality on walleye pollock	No concern
Birds	Stable, some increasing some decreasing	May affect young-of-year mortality	Unknown
Fish (Pacific cod, arrowtooth flounder)	Pacific cod—decreasing, arrowtooth--stable	Possible decreases to walleye pollock mortality	No concern
Changes in habitat quality			
Temperature regime	The 2004 AI summer bottom temperature was near average. A warming since 2000 and 2002 were coldest and second coldest survey years respectively.	Warming from 2002 could affect apparent distribution.	Unknown

***The AI walleye pollock* effects on ecosystem**

Indicator	Observation	Interpretation	Evaluation
Fishery contribution to bycatch			
Prohibited species	Expected to be heavily monitored	Likely to be a minor contribution to mortality	No concern
Forage (including herring, Atka mackerel, cod, and pollock)	Expected to be heavily monitored, but fishery has been closed since 1998.	Bycatch levels should be low.	Unknown
HAPC biota (seapens/whips, corals, sponges, anemones)	Very low bycatch levels of seapens/whips, sponge and coral catches expected in the pelagic fishery	Bycatch levels and destruction of benthic habitat expected to be minor given the pelagic fishery.	No concern
Marine mammals and birds	Very minor direct-take expected	Likely to be very minor contribution to mortality	No concern
Sensitive non-target species	Expected to be heavily monitored	Unkown given that this fishery has been closed since 1998. Bycatch of other species was very low in fishery prior to 1998.	No concern
Other non-target species	Very little bycatch.	Unknown	No concern
Fishery concentration in space and time	Steller sea lion protection measures may concentrate fishery spatially to very small areas between 20 nm closures	Depending on concentration of pollock outside of critical habitat could possible have affect.	Possible concern
Fishery effects on amount of large size target fish	Depends on highly variable year-class strength	Natural fluctuation	Possible Concern
Fishery contribution to discards and offal production	Offal production—unknown. Fishery in 2005 expected to be conducted by CPs which may have fish meal production capabilities	Unknown	Unknown
Fishery effects on age-at-maturity and fecundity	Unknown	Unknown	Unknown

Figures

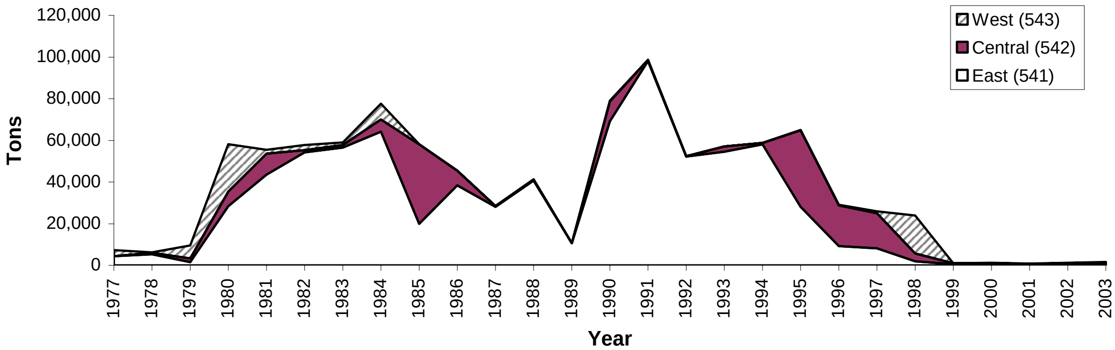


Figure 1. Estimated pollock catch by sub-area of the Aleutian Islands Region, 1977-2003. Units in metric tons.

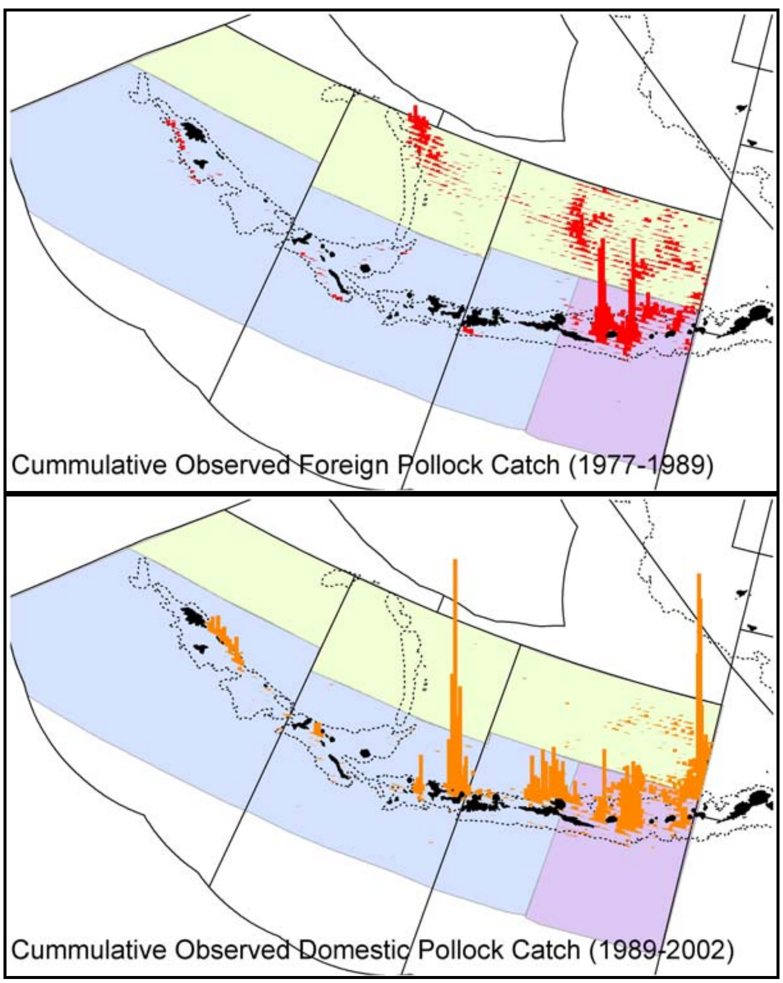


Figure 2. Observed foreign and J.V. (1978-1989), and domestic (1989-2002) pollock catch in the Aleutian Islands Area summed over all years and 10 minute latitude and longitude blocks. Both maps use the same scale (maximum observed catch per 10 minute block: foreign and J.V. 8,000 t and Domestic 19,000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

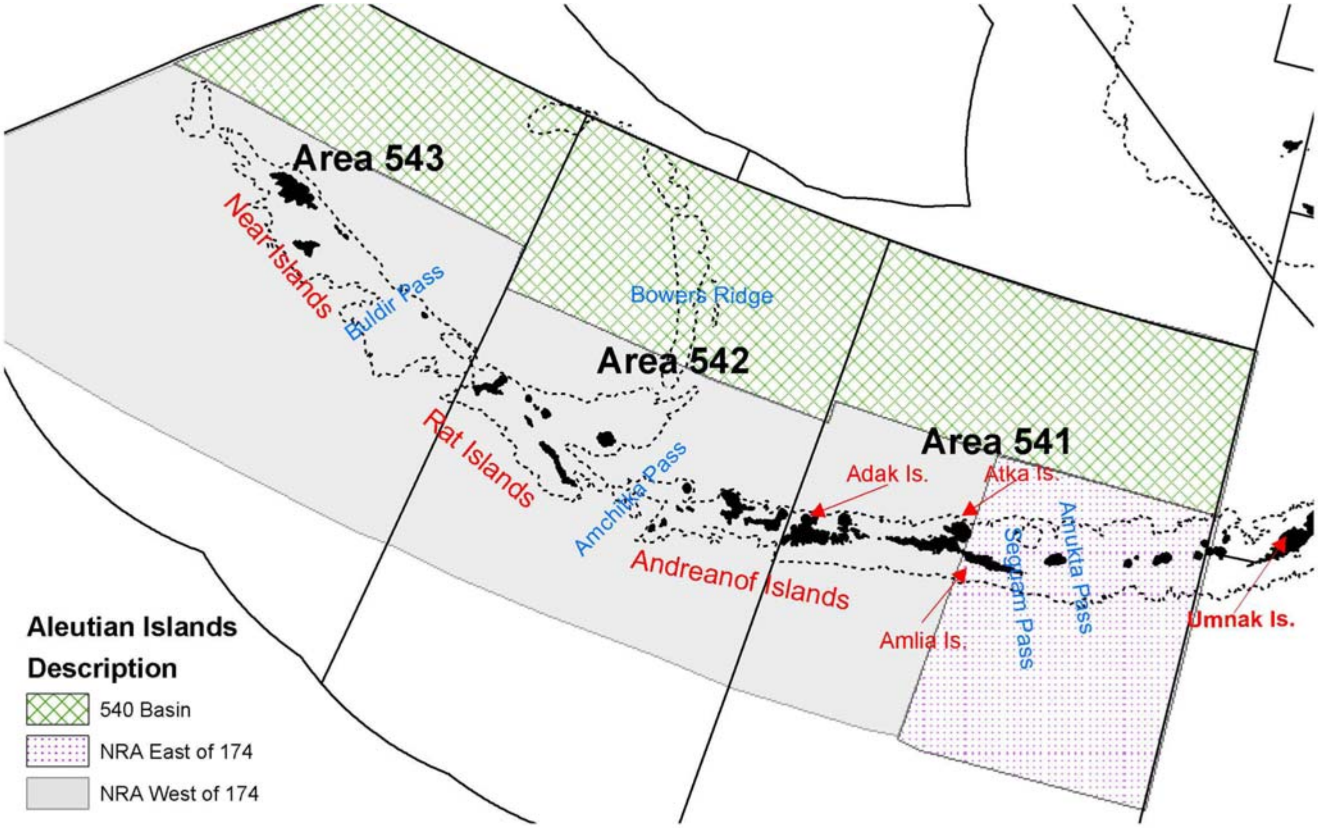


Figure 3. Regions defined for consideration of alternative data partitions for Aleutian Islands Region pollock. The abbreviation "NRA" represents the Near, Rat, and Andreanof Island groups.

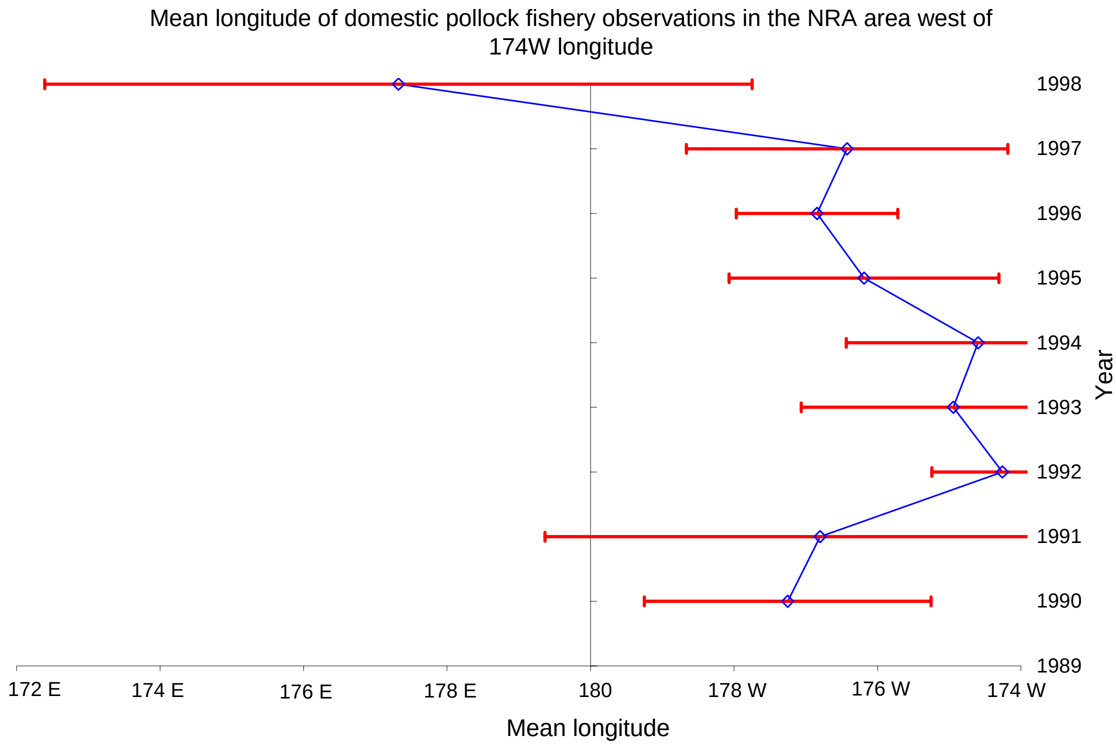


Figure 4. Mean longitude of observed targeted domestic (1990-1998) pollock catch in the NRA west of 174 W longitude. Error bars indicate one standard deviation from the mean.

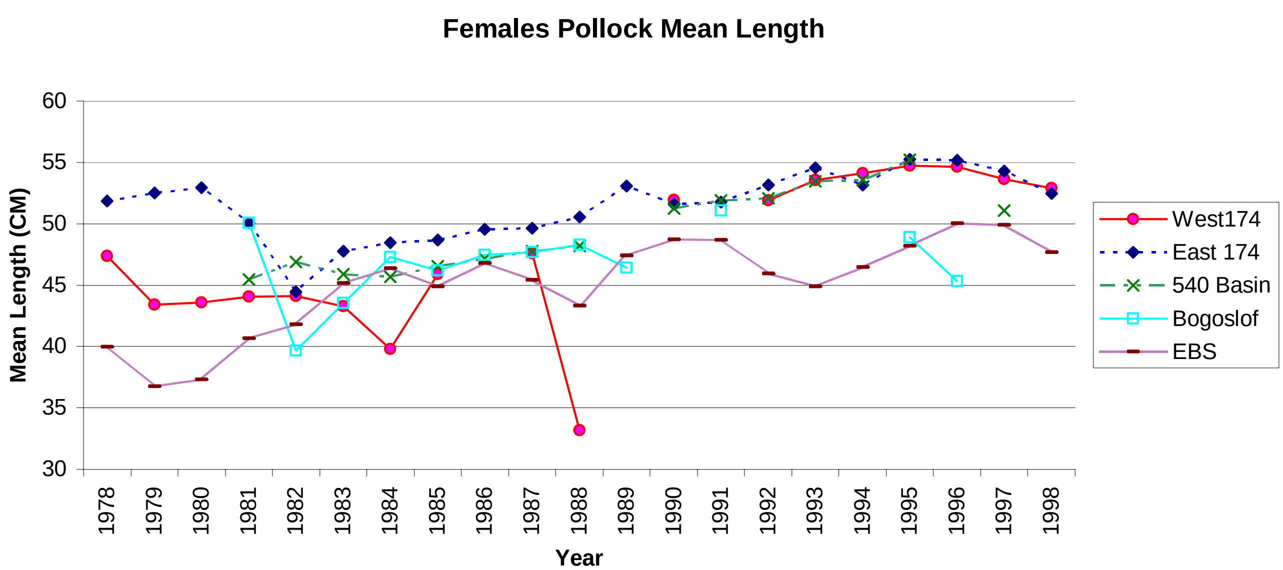


Figure 5. Mean length of female pollock for various areas from observer data.

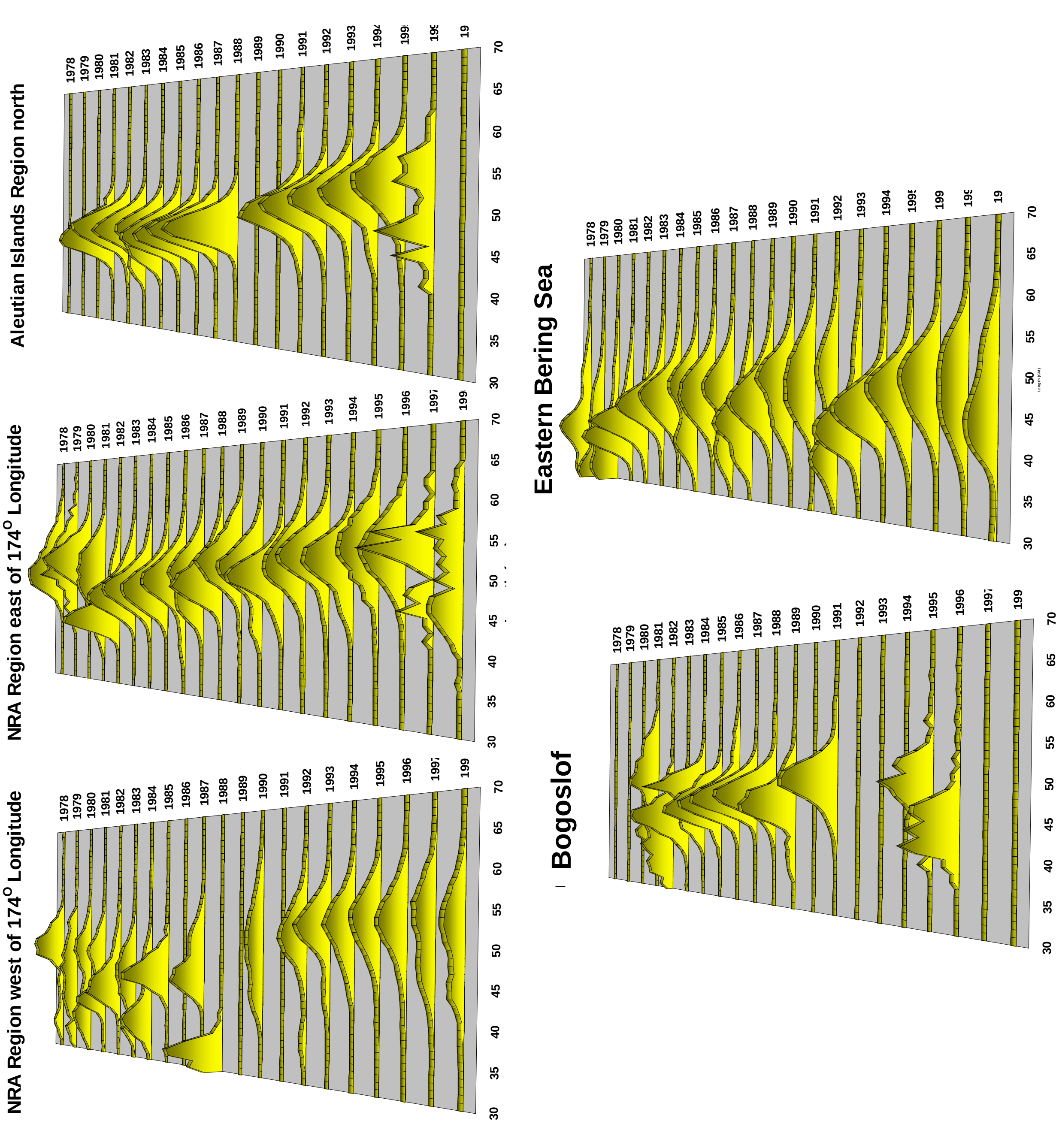


Figure 6. Pollock length frequency distributions by region.

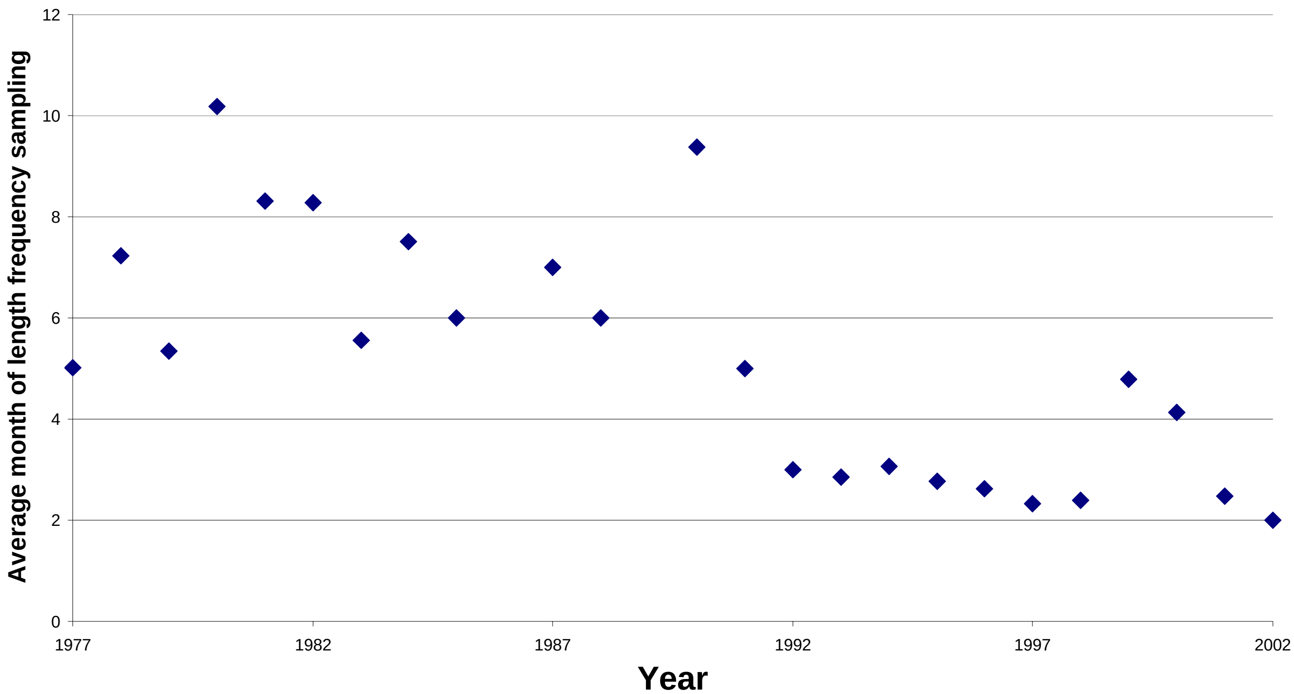


Figure 7. Average month of length frequency sampling (where Jan=1, Feb=2, etc.) for pollock in the NRA region showing that sampling during the early period was from later in the year than during the more recent period.

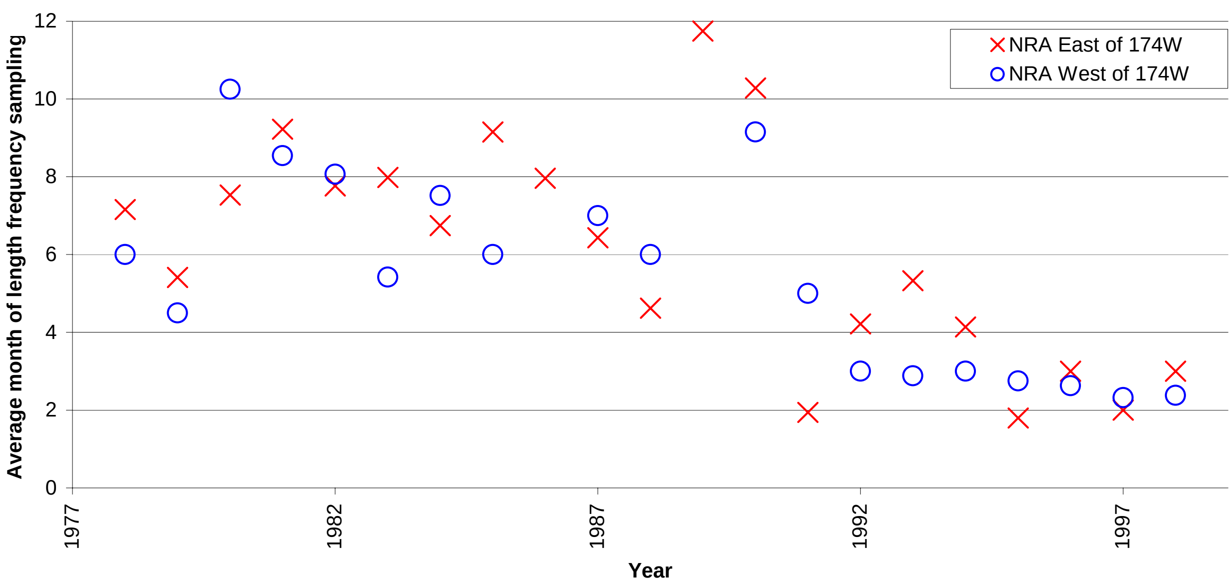


Figure 8. Average month of length frequency sampling (where Jan=1, Feb=2, etc.) for pollock in the NRA region showing that sampling occurred near the same season for both the eastern and western NRA.

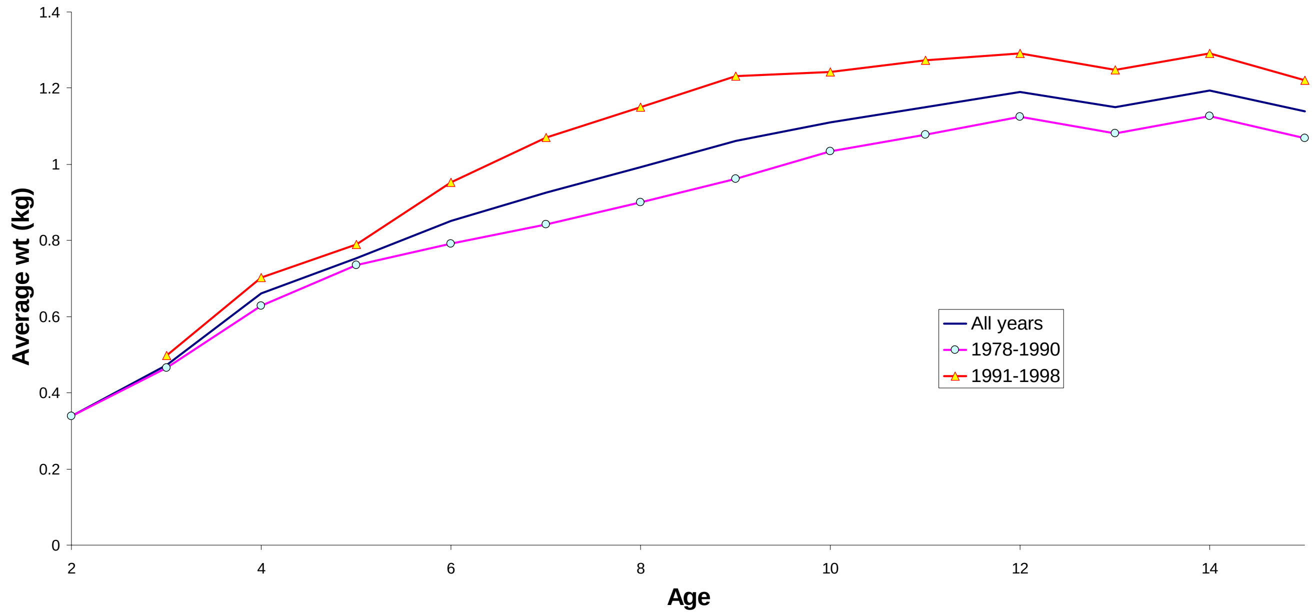


Figure 9. Average weight-at-age for Aleutian Islands pollock for all years combined, 1978-1990, and 1991-1998.

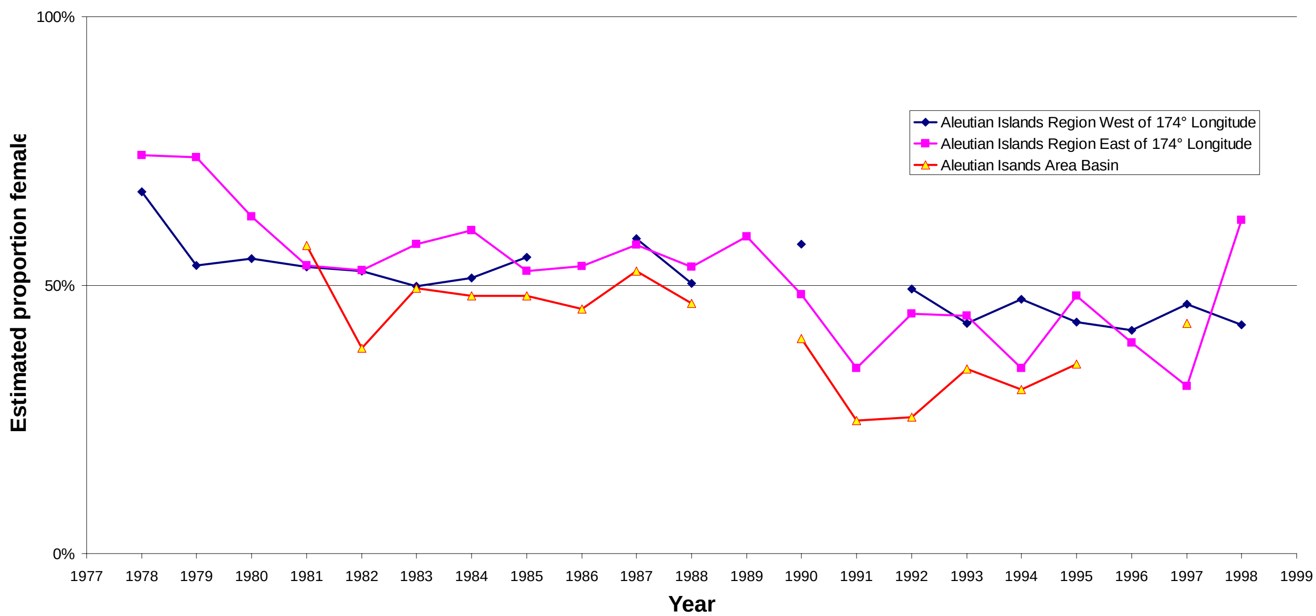


Figure 10. Estimated proportion of female pollock by Aleutian Islands sub-regions, 1977 -1998 based on fishery data.

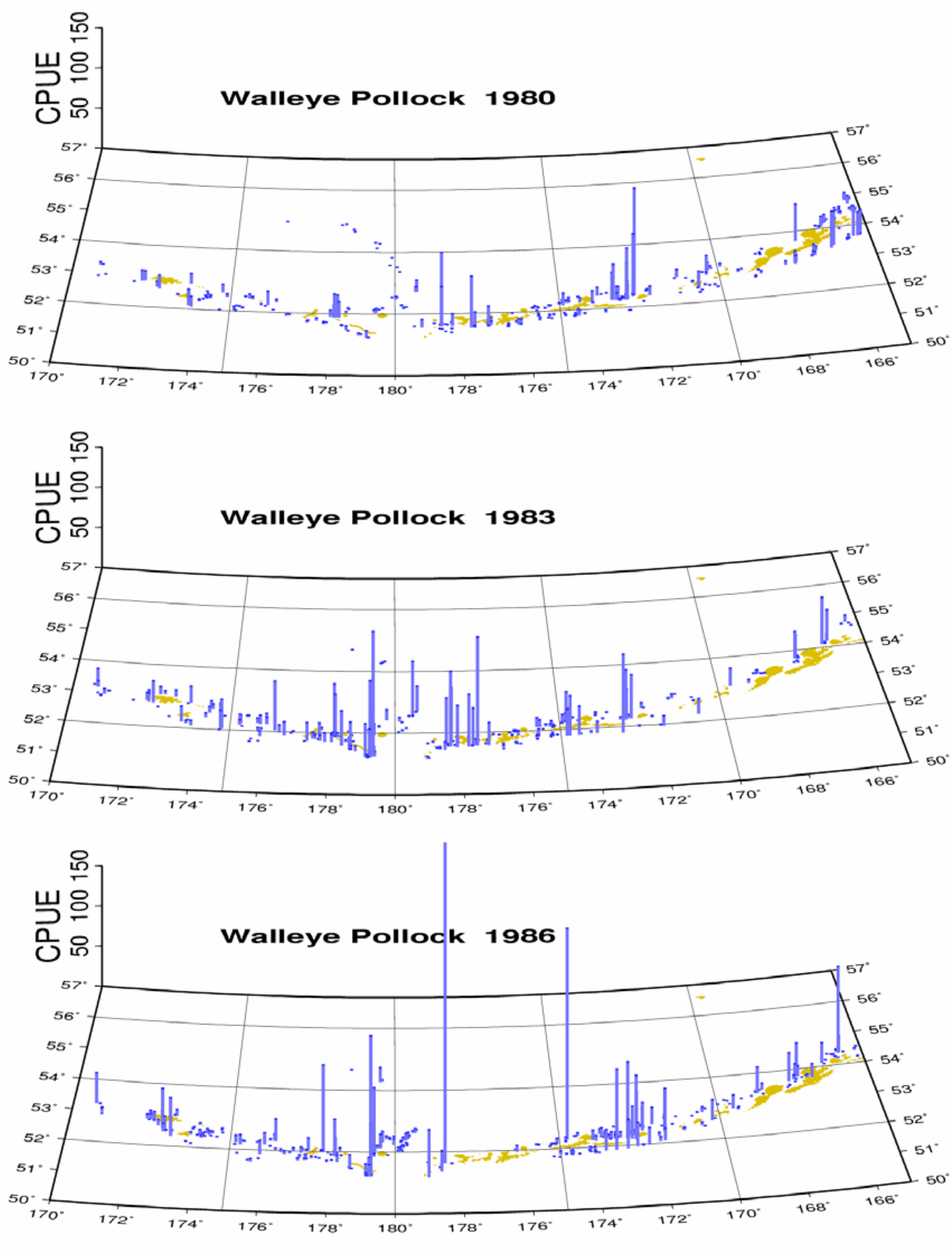
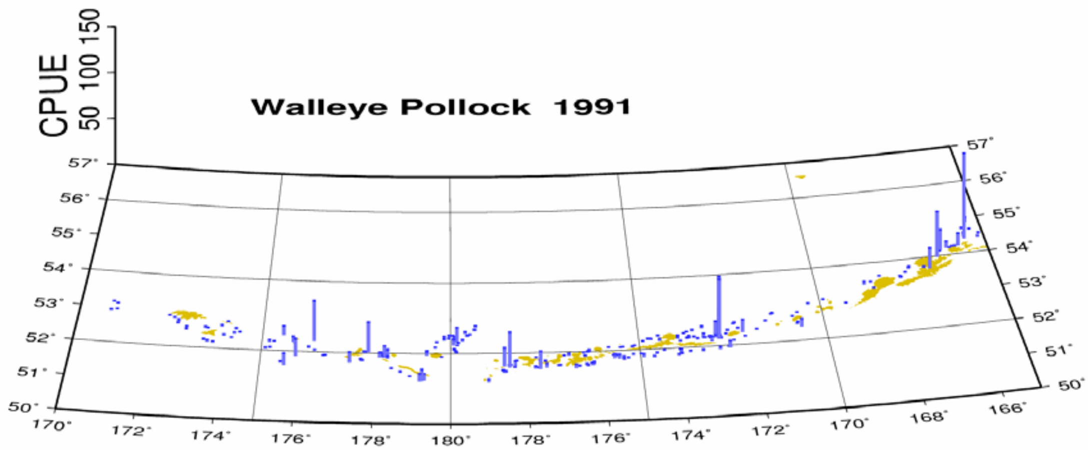
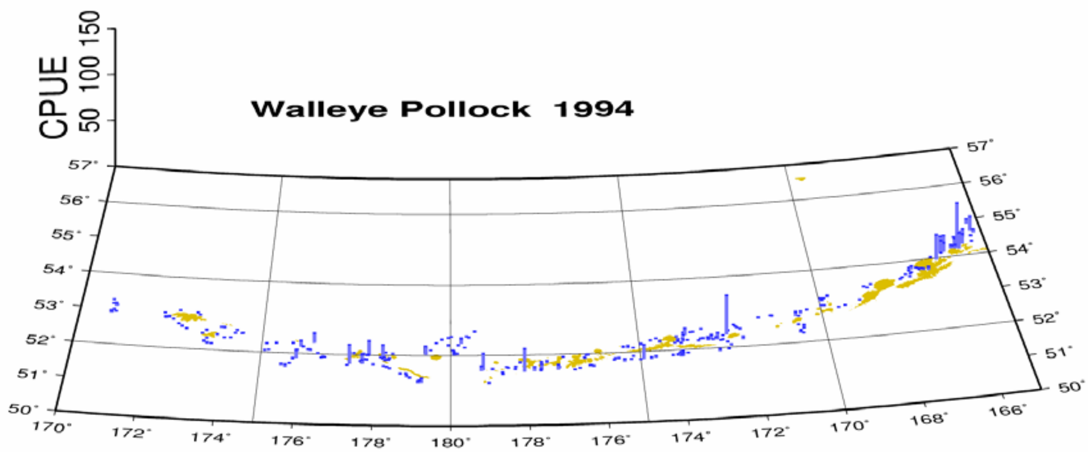


Figure 11. Catch per tow (CPUE) for surveys of pollock in the Aleutian Islands Region and east of 170°W, 1980-2004.





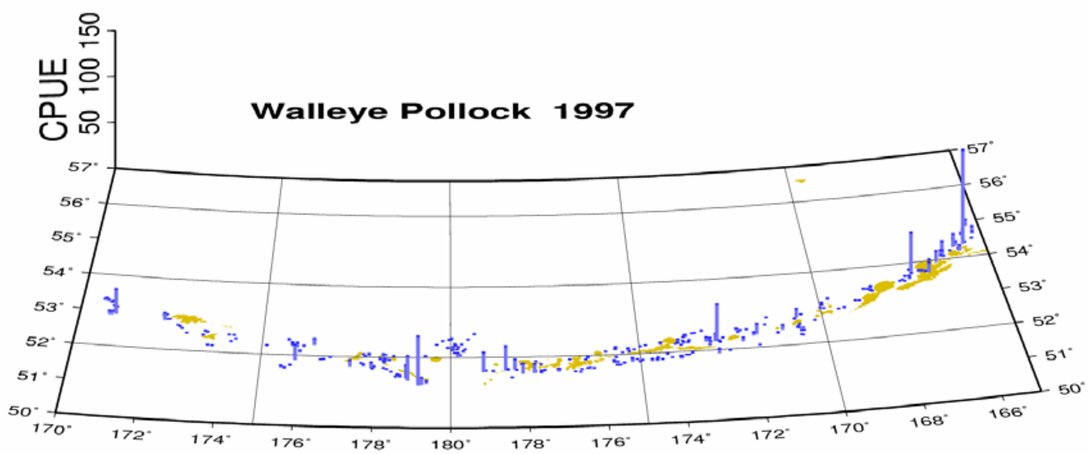


Figure 11. (continued) Catch per tow (CPUE) for surveys of pollock in the Aleutian Islands Region and east of 170°W, 1980-2004.

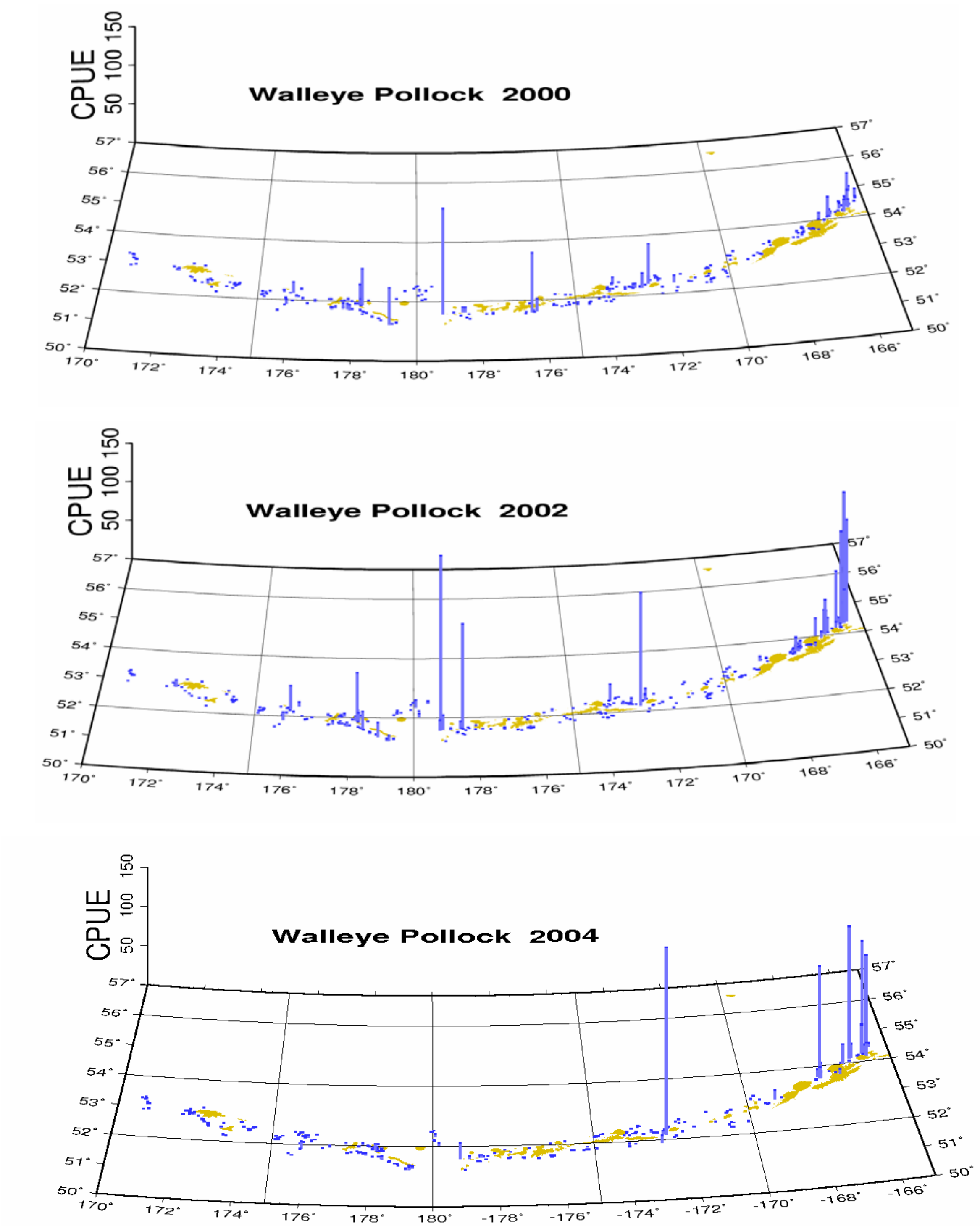


Figure 11. (continued) Catch per tow (CPUE) for surveys of pollock in the Aleutian Islands Region and east of 170°W, 1980-2004.

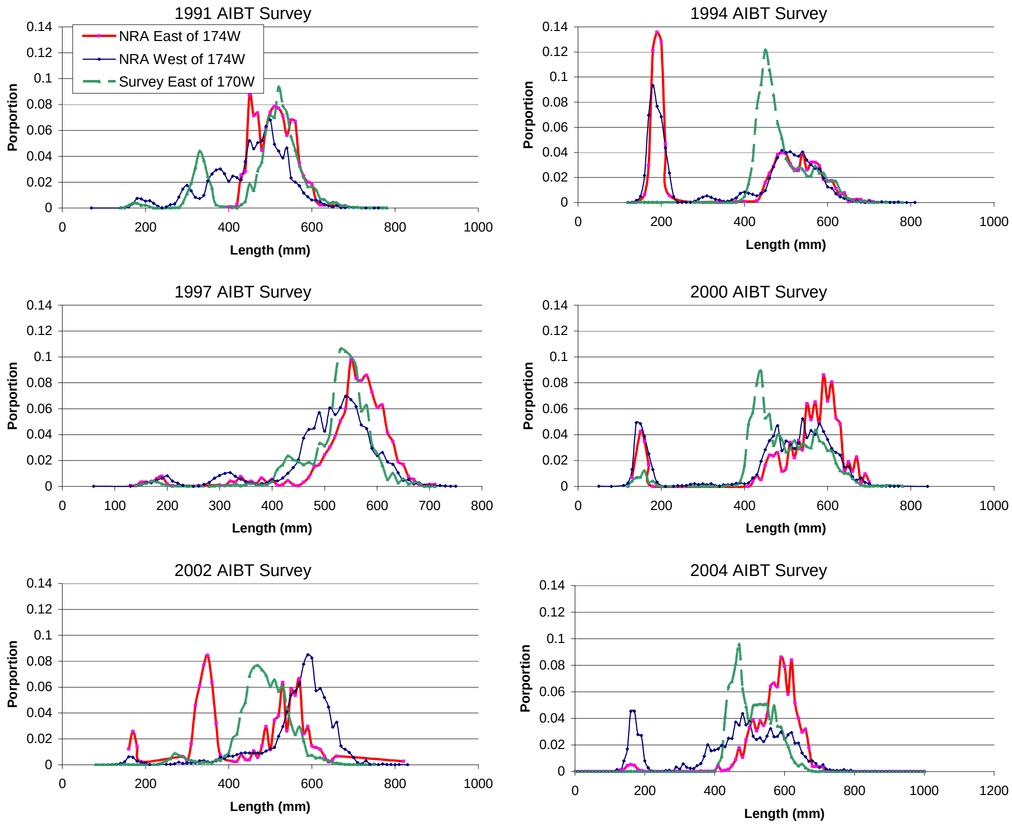


Figure 12. Length-frequency from Aleutian Islands Bottom trawl surveys (AIBT) 1991-2002 showing measurements from the NRA East of 174W, NRA West of 174W, and from the AIBT surveys East of 170W.

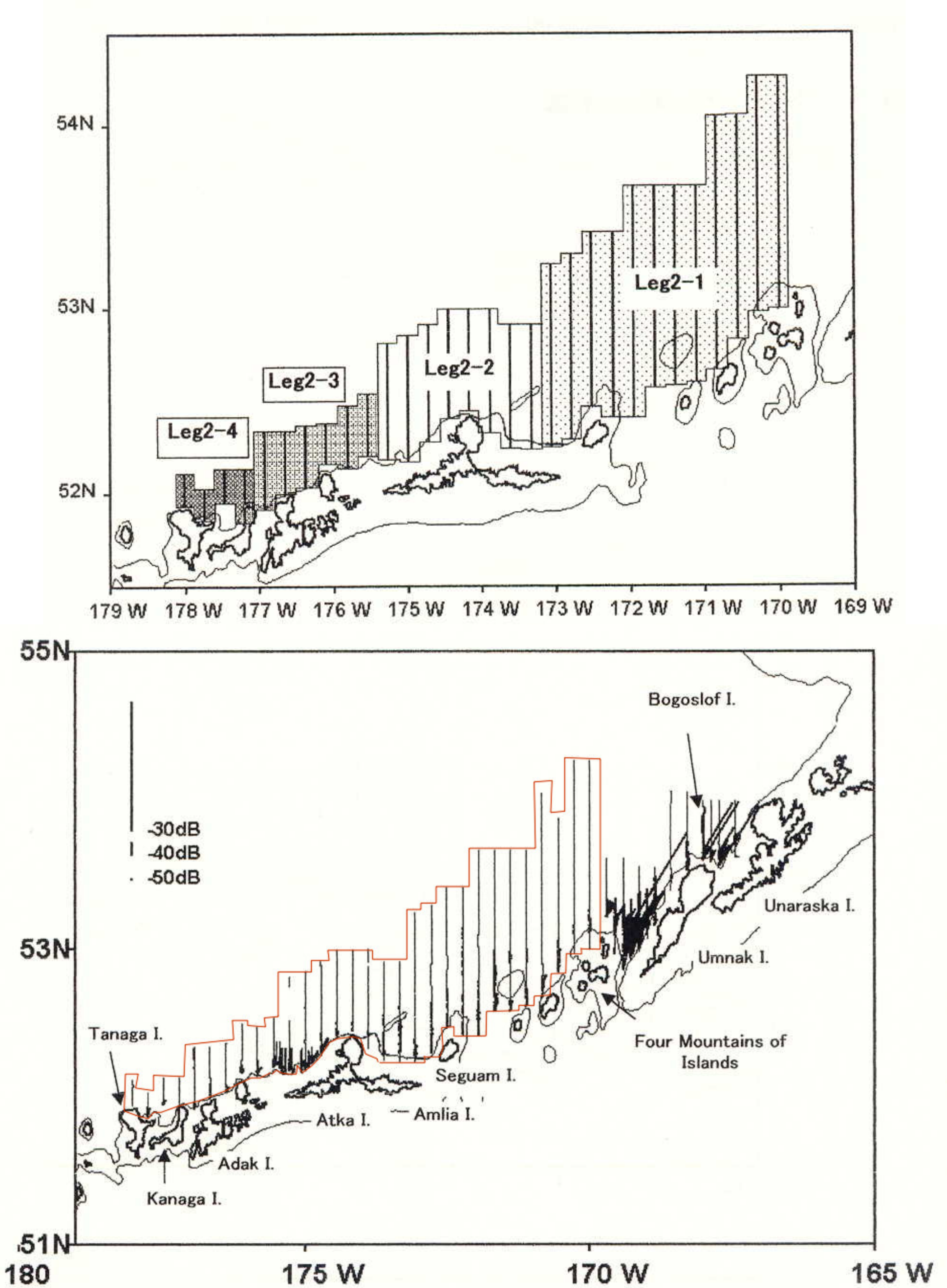


Figure 13. R/V Kaiyo Maru 2002 echo integration-trawl survey (above) strata for leg2 and below observed S_A in both legs. Please note that in the bottom picture the encircled area is leg 2.

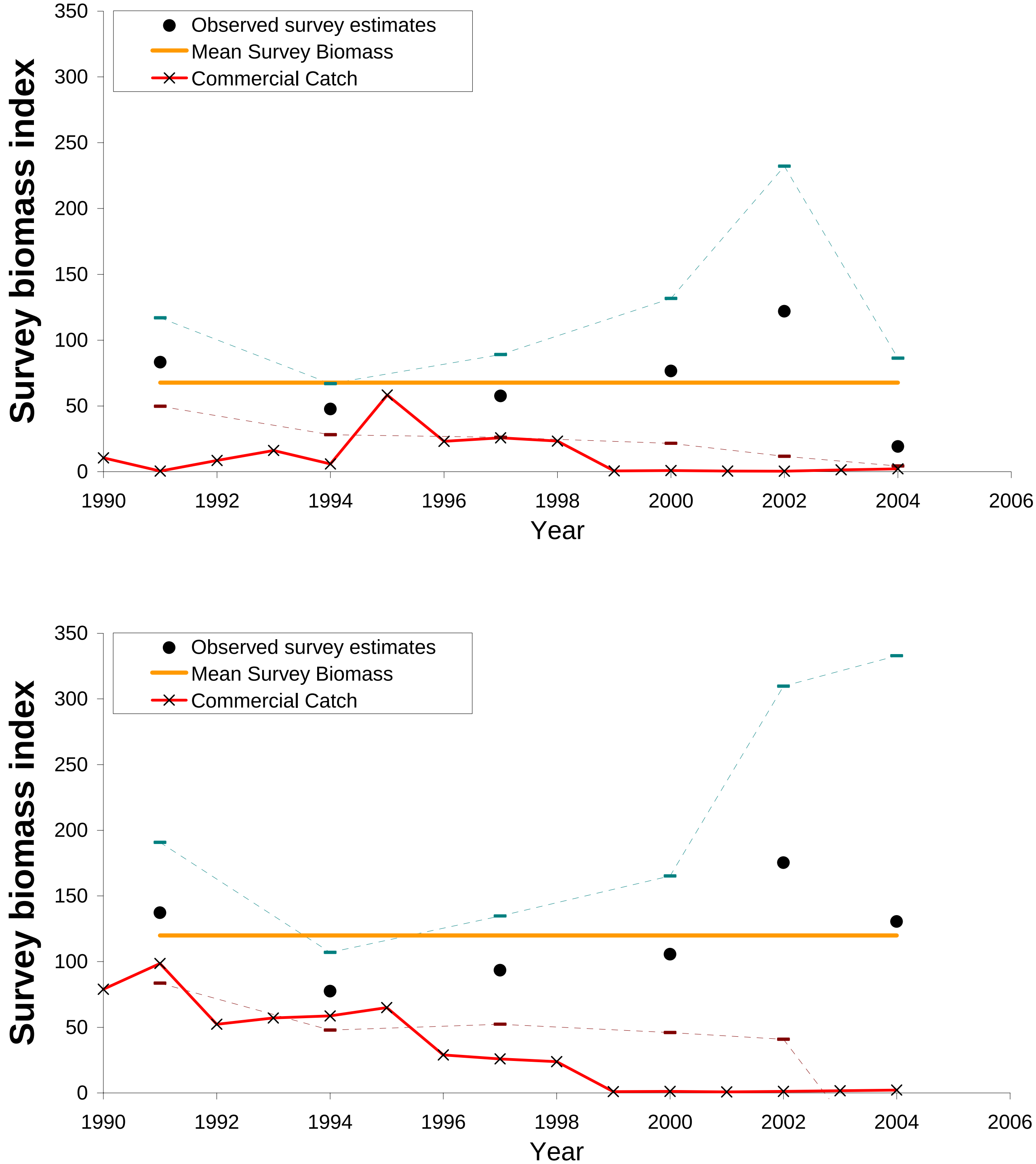


Figure 14. Aleutian Islands bottom trawl survey biomass estimates and total pollock catch for the NRA area west of 174 W longitude (top) and entire NRA (bottom).

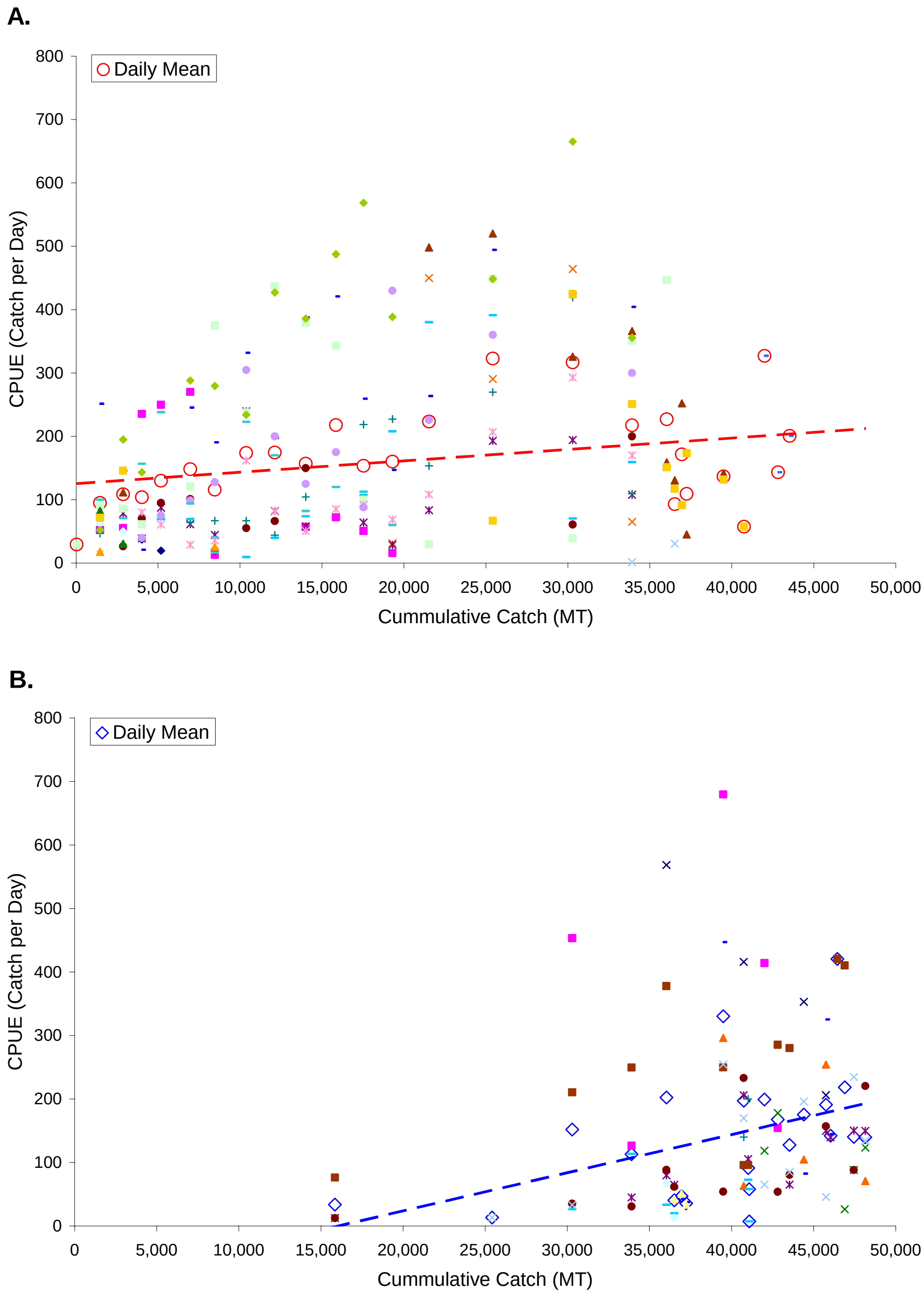


Figure 15. CPUE and cumulative catch of pollock in the 1995 NRA west of 174W Longitude for the catcher-processor and mothership fleet (A.) and catcher vessel fleet (B.). Symbols vary according to individual vessel.

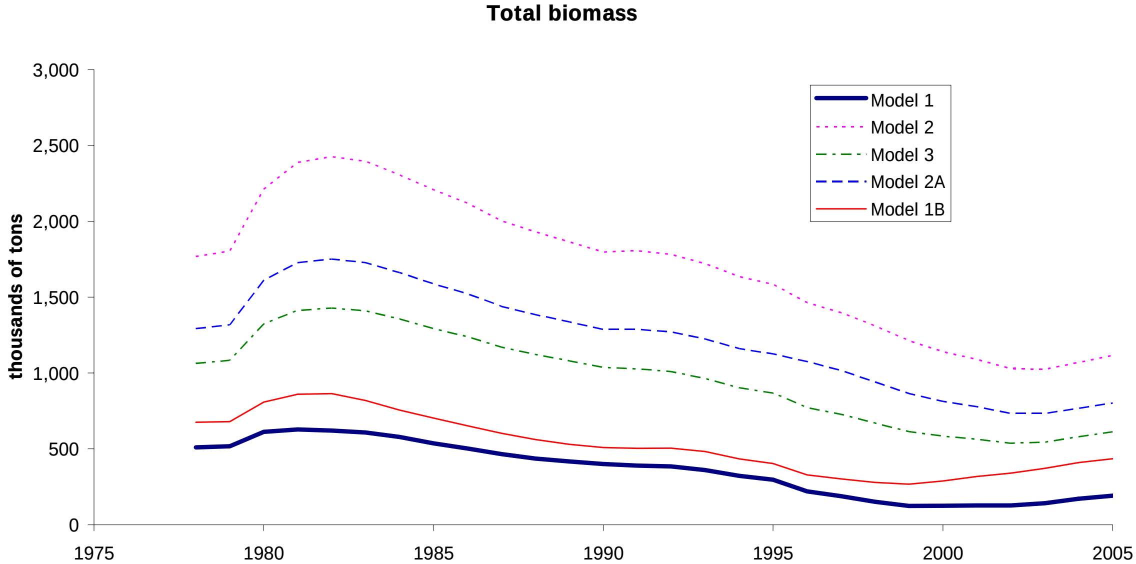


Figure 16. Biomass trajectories under four alternative model specifications: Model 1 with *q* fixed at 1.0, Model 2 with *q* freely estimated, Model 3 with *q* estimated but with a prior distribution on *q* specified as Normal(1.0,0.2^2), Model 2A configure as Model 2, but with 1995 catch estimates set at the mean catch for 1978-1998, and Model 1B configured as Model 1, but including survey biomass index estimates for the entire NRA area.

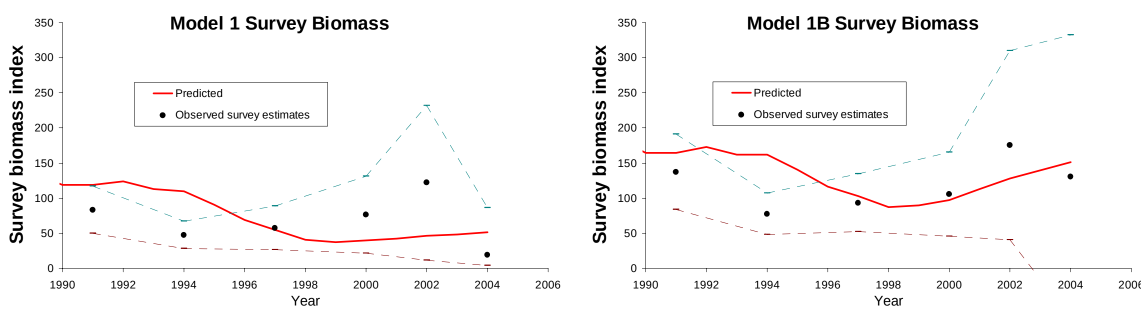


Figure 17. Fit (solid line) to NMFS summer trawl survey (dots) for Model 1 and Model 1B. Dashed lines represent upper and lower confidence bounds of survey estimates.

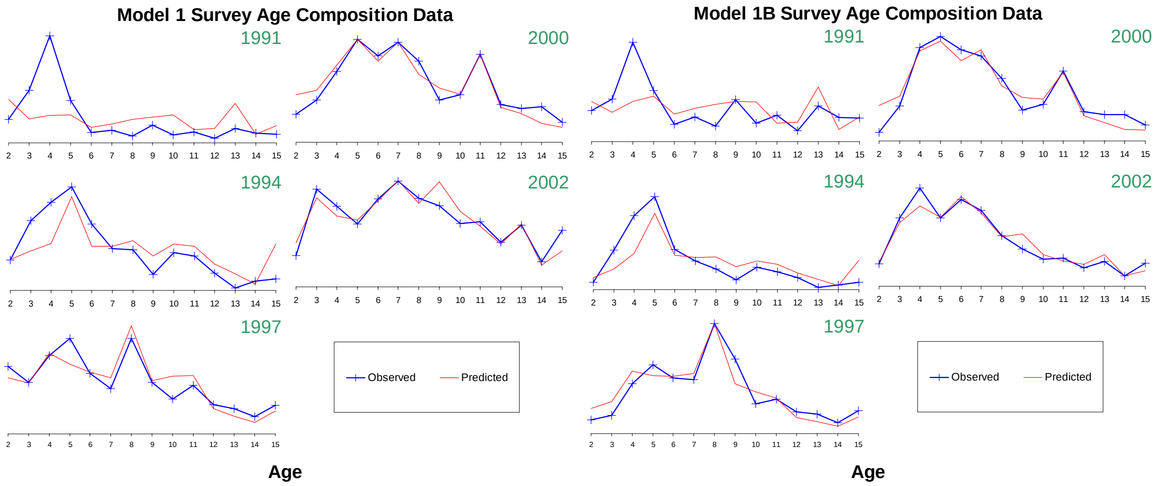


Figure 18. Fit to NMFS summer trawl survey age composition data for Model_3 for Aleutian Islands (NRA west assessment area) pollock.

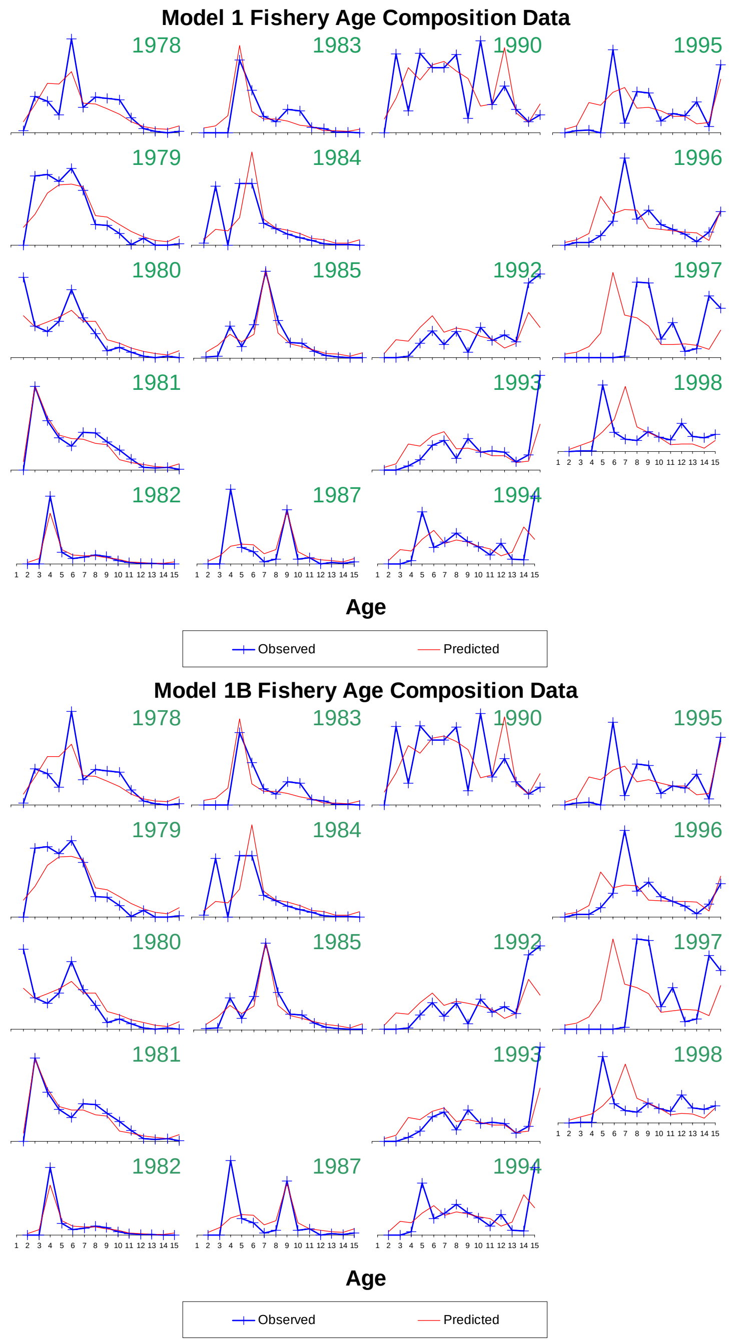


Figure 19. Fit to fishery age composition data for Model 1 (top) and Model 1B (bottom) for Aleutian Islands (NRA) pollock.

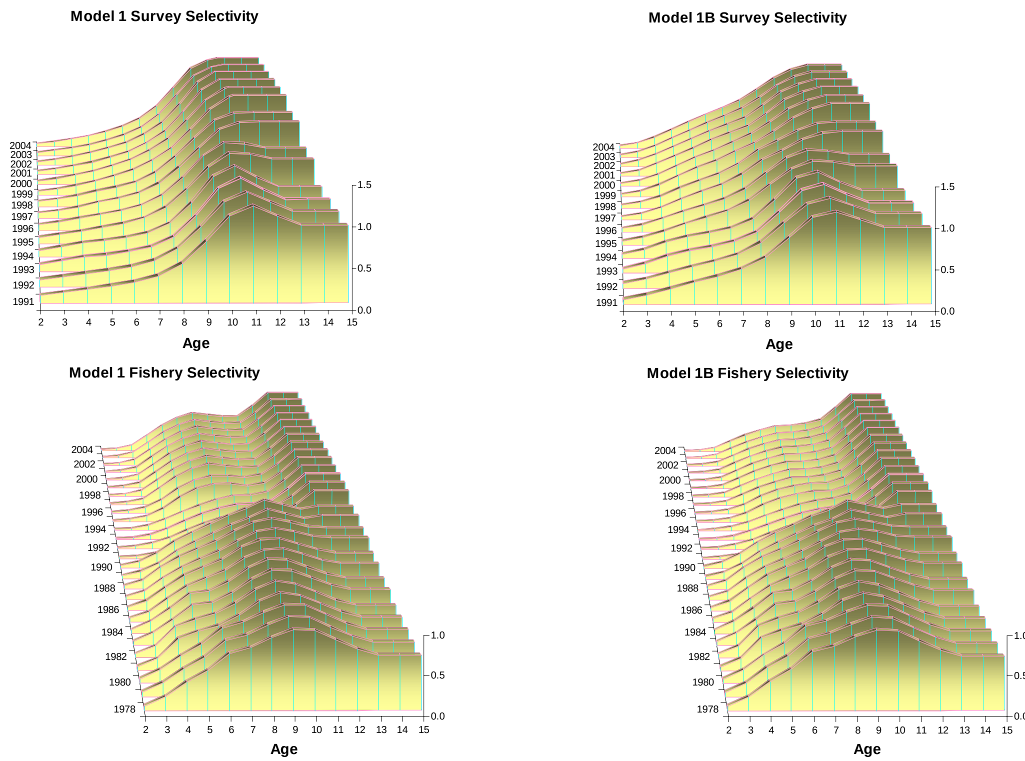


Figure 20. Selectivity estimates for Aleutian Islands pollock for the bottom trawl survey (top panel) and the fishery (bottom panel) for Model 1 (left) and Model 1B (right).

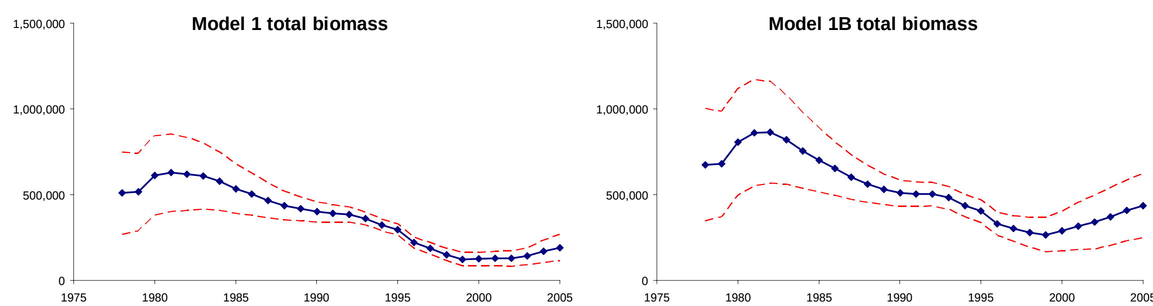


Figure 21. Model1(right) and Model 1B (top) estimates of Aleutian Islands pollock total biomass (in tons); dashed lines represent approximate upper and lower confidence bounds.

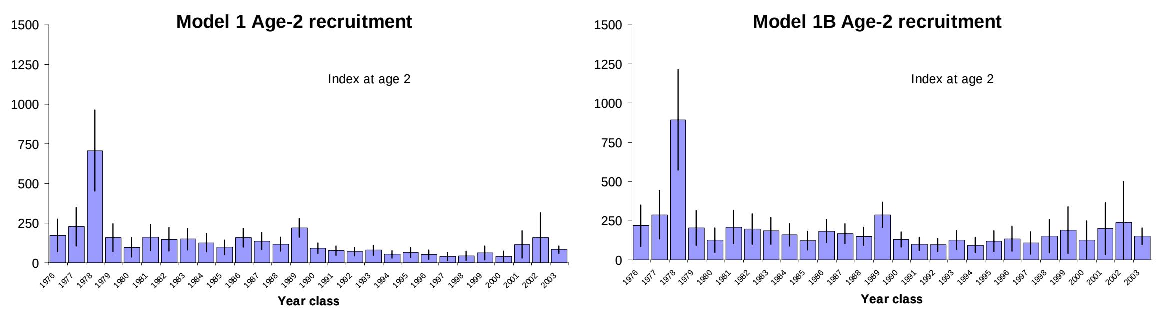


Figure 22. Model 1 and Model 1B estimates of Aleutian Islands (NRA assessment area) pollock year-class estimates; vertical bars represent approximate upper and lower confidence bounds.

MCMC 2005 Biomass Distribution for Model 1 and Model 1B

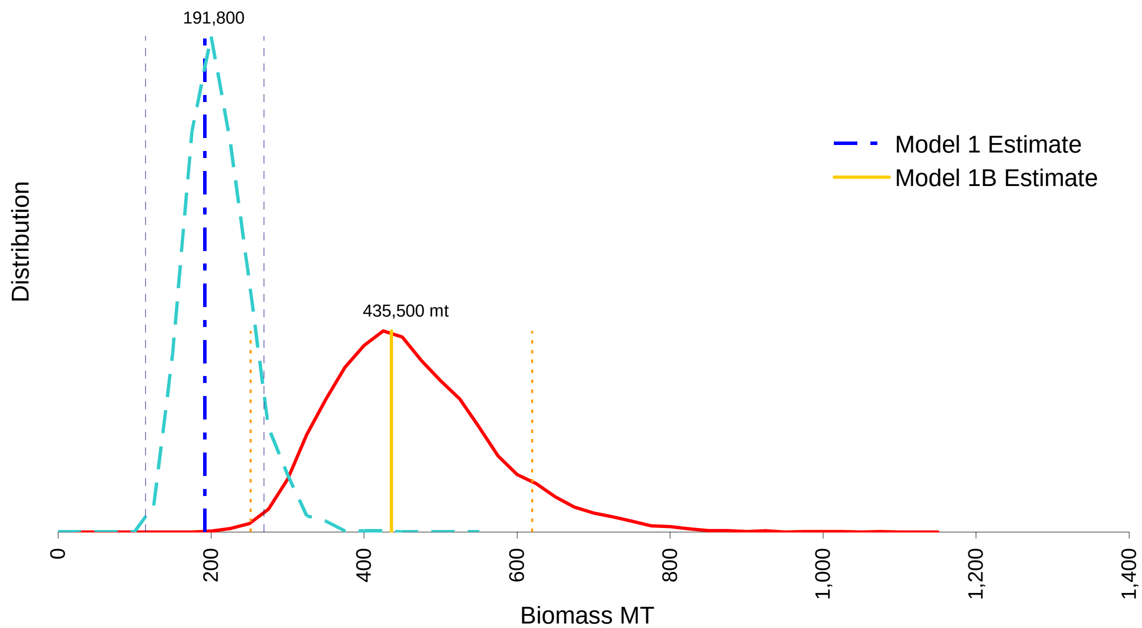


Figure 23 Biomass distributions from MCMC runs of Model 1 and Model 1B. Error bars are 2 standard deviations from the point estimate. Distributions were generated through 1,000,000 MCMC simulations sampled every 200 simulation.

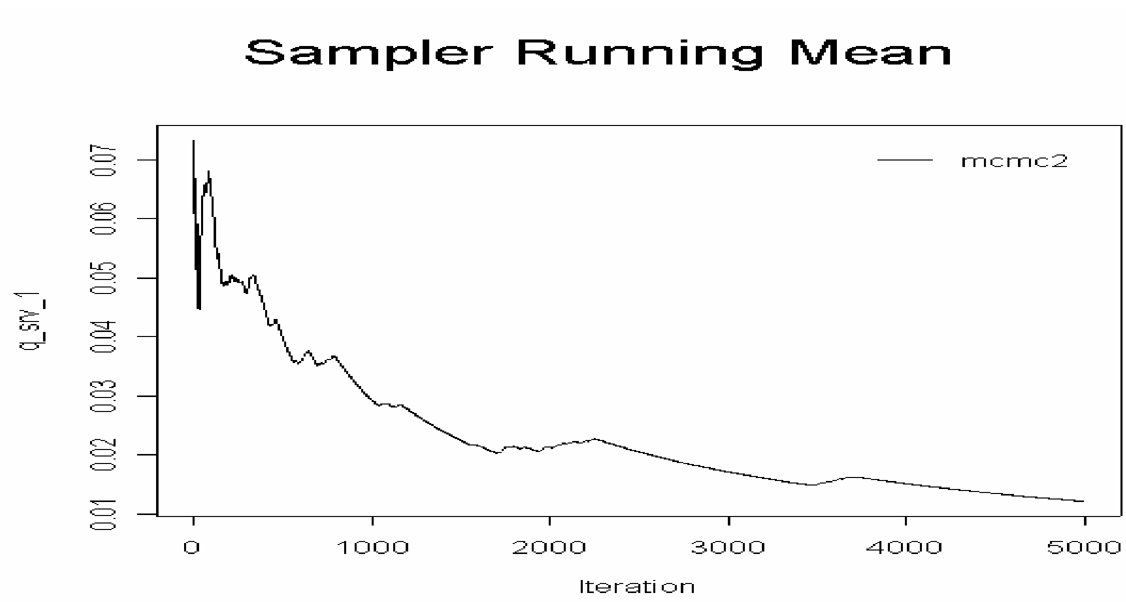


Figure 24 Running mean of catchability (Q) from MCMC simulations generated through 1,000,000 simulations sampled every 200 simulation.

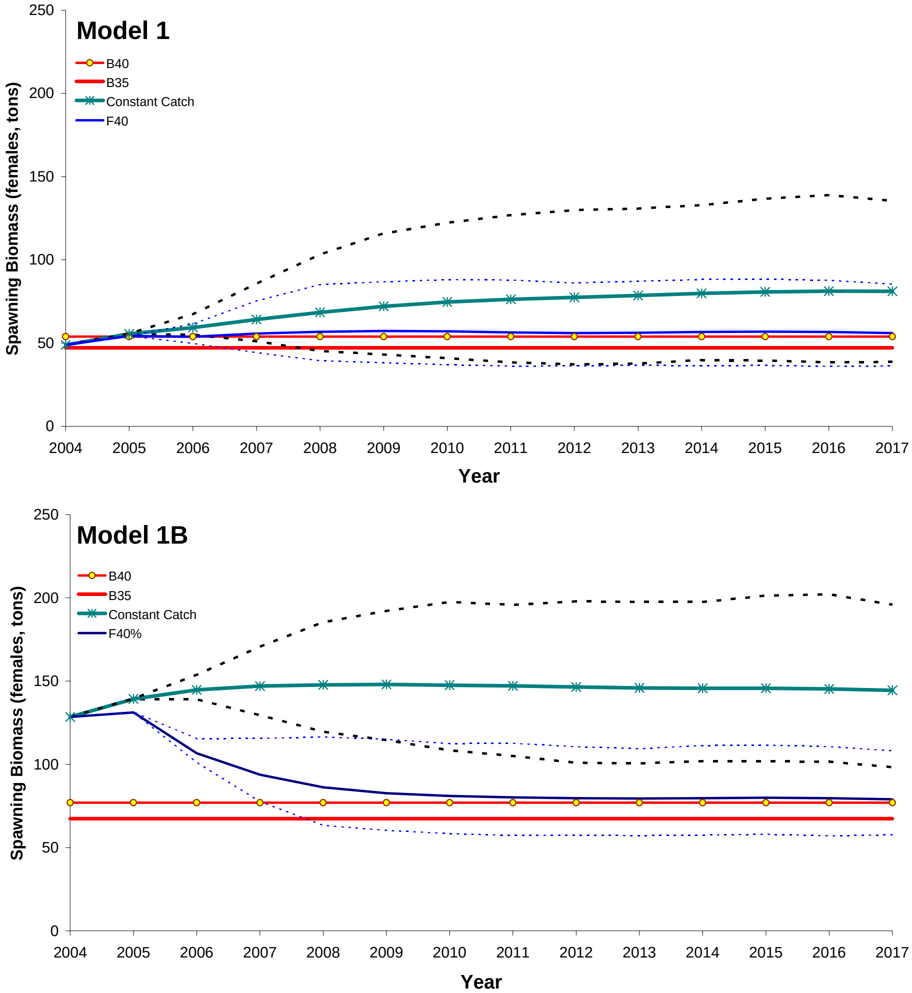


Figure 25 Projected spawning biomass for $F_{40\%}$ and constant catch (19,000 mt) ABC scenarios from Model 1(top) and Model 1B (bottom) with adjusted selectivity-at-age.

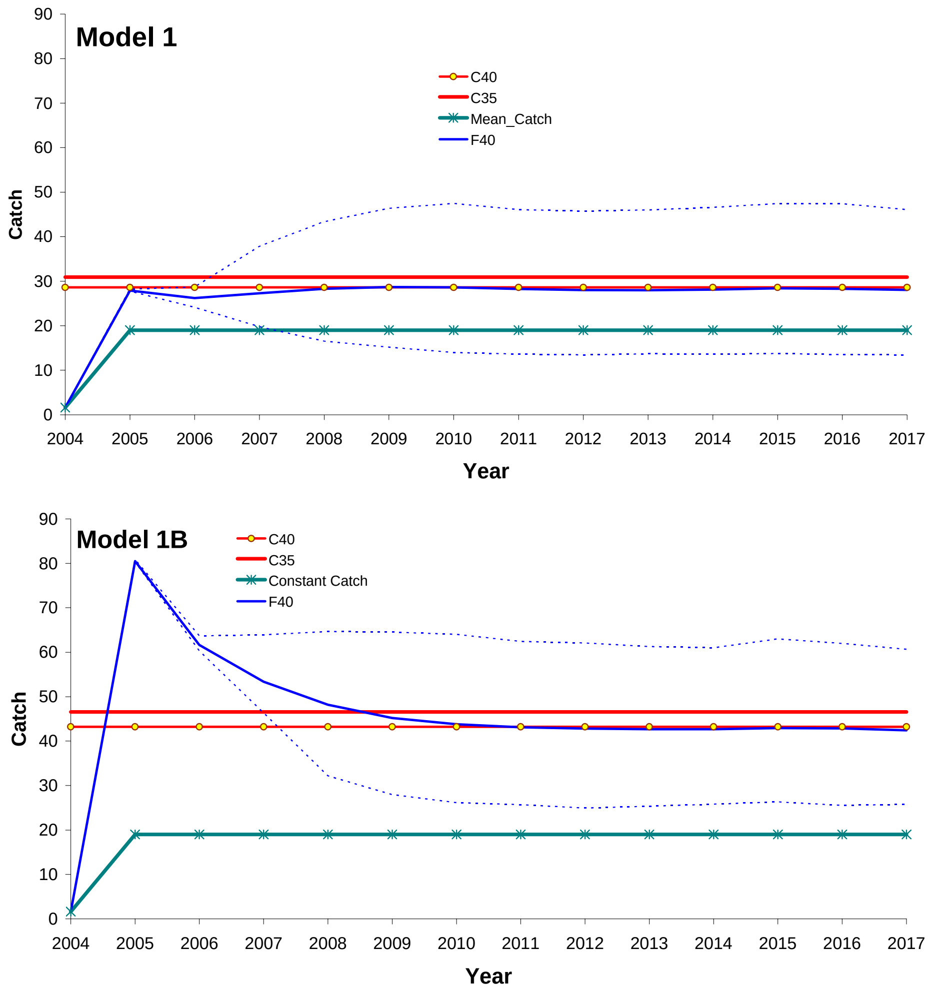


Figure 26 Projected catch for $F_{40\%}$ and constant catch ABC scenarios from Model 1 (top) and Model 1B (bottom) with adjusted selectivity-at- age.

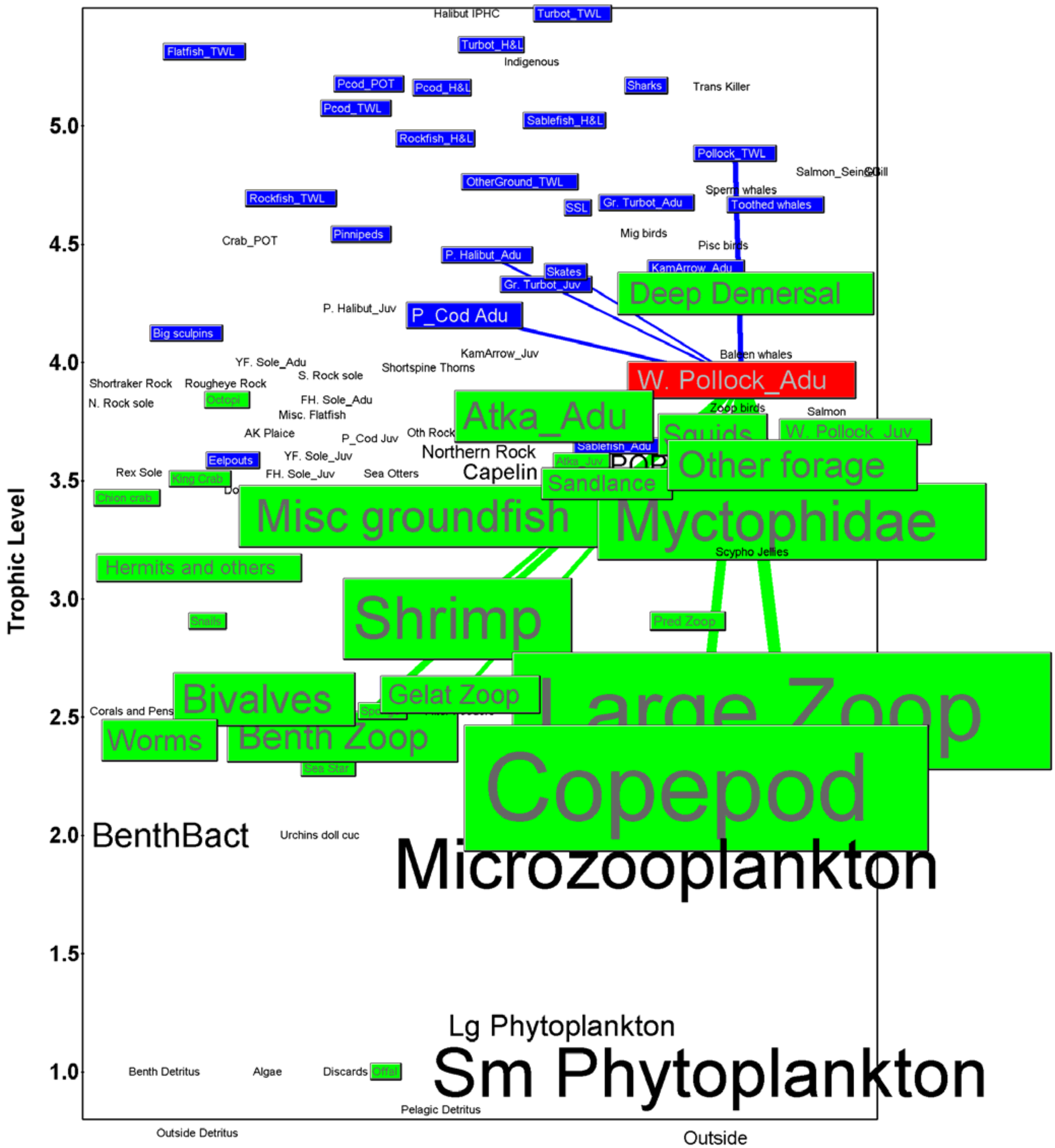


Figure 27 Aleutian Islands ecosystem trophic level map in relation to adult walleye pollock. Everything that consumes pollock is in blue (dark), everything consumed by pollock is in green (light). The size of the box indicates relative abundance in the Aleutian Islands, location on the y-axis indicates trophic level. Figure provided by Sarah Gaichas.