Update on Plan Team and SSC requests for the BSAI Blackspotted/rougheye stock assessment

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Introduction

In the December, 2020 meeting of the Statistical and Scientific Committee of the North Pacific Fisheries Management Council, the following requests were made regarding the BSAI blackspotted and rougheye stock assessment:

● *The SSC supports the BSAI GPT recommendation that the authors explore the distribution of the survey samples to evaluate trends by depth, to help determine risk considerations and potentially help inform the industry on how to reduce incidental catch.*

● *Similarly, the SSC recommends an exploration of the spatial footprint of the AI survey and incidental catch fisheries with an eye towards potential mismatches due to untrawlable habitat that might provide context for interpreting conflicting survey abundance and fishery size/ age composition. We note that a graduate research project investigating the survey – fishery alignment along with recent changes in Atka mackerel and POP fishing behavior is underway at Alaska Pacific University. In addition, the SSC pointed out that a NMFS – University – Industry cooperative effort entitled "The Science-Industry Rockfish Research Collaboration in Alaska" being led by Dr. Madison Hall is currently underway. While this effort is primarily focused on GOA rockfish, it may provide important analytical tools and insights for application to the BSAI BS/RE complex.*

● *The SSC supports the BSAI GPT suggestion to explore other survey data (e.g. NMFS and IPHC long-line or ADF&G survey data) to augment abundance and size/ age composition information. We note that a new graduate research project looking at combining data from different surveys and gears is underway at the College of Fisheries and Ocean Sciences at the University of Alaska Fairbanks.*

● *The SSC notes that the values of M used in the AI assessment are very high, especially for a long-lived species, and requests that the authors fully explore the ranges and interactions of catchability and M in the AI assessment model.*

● *The SSC requests an update on work (e.g. genetics) to further refine BS/RE stock structure in the AI.*

● *Given the information regarding shifts in fishing effort to shallower areas provided in public testimony, the SSC requests that the authors investigate the effects of fleet behavior on apparent size/ age compositions, and to what extent this may be influencing fishery selectivity*

● *The JGPT proposed a Council workshop in 2021 to evaluate both the fishing mortality rates by gear associated with different apportionment schemes as well as the management and socio-economic considerations of alternatives. The SSC concurs with the JGPT's note that the area apportionment approach currently used for the BSAI BS/RE complex should be included in the Spatial Management Workshop proposed for 2021.*

The purpose of this report is to address the items above that concern the BSAI blackspotted/rougheye stock assessment and its input data, and present potential options for the 2022 assessment.

1) The distribution of the survey samples to evaluate trends by depth

The sample sizes of the AFSC Aleutian Islands survey hauls is shown in Table 1. Samples between the western Aleutian Islands (WAI), central Aleutian Islands (CAI), and eastern Aleutian Islands (EAI) are relatively evenly distributed, with smaller sample sizes in the southern Bering Sea area (SBS). For all subareas, the largest amount of samples occurs in the 100 – 200 m depth zone, with the relative amount of sampling in the 200 – 300 m depth zone being largest in the EAI and smallest in the SBS. The overall number of stations sampled has increased over time relative to the 1991 and 1994 surveys.

Survey biomass trends by depth and survey subarea are shown in Figure 1, and for the CAI and EAI subareas the trends shown separately for strata north and south of the Aleutian Islands chain. In most subareas, the 300 – 500 m depth zone contains the largest amount of estimated biomass, although the biomass in the 200 – 300m depth zone in the north CAI subarea has been large in some years. In the WAI, biomass in depth zones > 200 m decreased from the 1997 survey to the 2000 survey, whereas biomass in these depth zones in the north CAI increased between these survey years. Biomass in the north CAI subarea and the WAI were at low levels in the 2018 survey relative to previous years, whereas biomass in the deep strata in the south EAI subarea was at a relatively high level.

2) An exploration of the spatial footprint of the AI survey and incidental catch fisheries

The spatial overlap between the fishing grounds for blackspotted/rougheye rockfish and the survey trawls was first presented to the BSAI Plan Team in 2013, focusing on the WAI subarea. Figure 2 is a map from the 2013 presentation to the BSAI Plan Team showing survey sampling grids in a portion of the WAI, with untrawlable grids in red and successfully trawled grids in green. The 3 ellipses near 175° indicate areas where fishery trawling effort and blackspotted catch have occurred, but are unsampled by the trawl survey. Confidentiality restrictions prevent presentations of individual fishery tows, but an update of the data indicates that these spatial overlap patterns between the fishery and the survey have also continued since 2013.

Due to the multispecies objectives of the AFSC trawl survey, and the emphasis on representative sampling from all trawlable habitats in the survey area, we would not expect the distribution of survey hauls and CPUE to closely match fishery effort and catch for any species. However, plots of the relative proportion of fishery and survey hauls by longitudinal bins can reveal differences in patterns of spatial effort. The relative proportion of number of survey hauls, by 0.5° longitudinal bins, for the WAI, CAI, and EAI are shown in Figure 3, along with the relation proportion of the number of fishery hauls which had a positive catch of blackspotted/rougheye rockfish. As expected, the survey hauls are roughly evenly distributed throughout this sampling area. The fishery hauls have been concentrated in various locations, and the strength of these concentrations can vary between years. The shaded red bar corresponds to 174.5°- 176°, roughly the area shown in Figure 2, and indicates a low area of survey effort but often a high area of fishery effort (particularly in years 1996-1998, 2001 – 2007, and 2015 – 2021). A similar plot (Figure 4) indicates that the relative portion of fishery catch from this area typically exceeds the relative proportion of survey CPUE.

This particular area of 174.5°- 176° was chosen as an illustrative example, as there are other areas where the fishery and survey distributions of catch and sampling effort do not match each other (i.e., the EAI east of -173°). Finally, it is unclear what effect, if any, these differences in spatial footprints would have on the survey biomass estimates. In any area-swept trawl survey, the density from the areas sampled by the trawl are applied to the areas unsampled by the trawl. If the densities from the sampled and unsampled areas are similar, then the effect on the survey indices would be minimal.

The SIRICA (Science- Industry Rockfish Research Collaboration in Alaska) project being led by Madison Hall is focused on the GOA, and involves conducting standardized trawls using fishing vessels to augment the GOA survey tows. The study will use two types of tows: experimental tows conducted in untrawlable habitats (to further obtain information about density), and calibration tows in trawlable habitat (to estimate relative fishing power between the fishery and survey tows). Field work is underway, and planned to continue through 2025. The objective of the study is to demonstrate the utility of a cooperative data collection program, from which an index of rockfish abundance in untrawlable grounds could be obtained.

Another relevant study is the thesis project of Cara Hesselbach (Alaska Pacific University), who is examining the spatial and temporal overlap of survey and fishery observations of blackspotted and rougheye rockfish in the Aleutian Islands. Some of this work will involve descriptive measures of overlap (similar to what is presented in this update), but will also extend to development of species distribution models. Although this study is ongoing, one notable finding is recognition of consistency between the fishery and survey composition data (i.e., each showing a shift to smaller fish in recent years), and this will be shown later in this document.

3) Exploration other survey data (e.g. NMFS and IPHC long-line or ADF&G survey data)

We examined the survey biomass estimates from the 3 surveys identified in the SSC comment: 1) NMFS longline survey; IPHC longline survey; and 3) ADF&G trawl survey data. Inclusion of multiple indices of abundance can be useful to fill in missing gaps with respect to temporal coverage or sampling of age and length categories. Implicit in the inclusion of multiple survey indices of abundance is that each abundance is representative of a single underlying population, and any differences between the surveys can be attributed to the sampling characteristics (i.e., catchability and selectivity) (Conn 2010). The use of multiple surveys that each cover a portion of the distribution of the stock complicates interpretation, as any differences between indices could represent either differences in sampling characteristics (i.e., the proportion of the stock sampled by the survey could vary between regional subareas), or local differences in abundance trends (Peterson et al. 2021). Hilborn and Walters (1992) recommend that representative surveys cover the entire range of stock, as multiple surveys that each cover subareas of the stock may not necessarily be measuring the same signals (Maunder and Piner 2017). Conn (2010) developed a method for analyzing multiple "noisy" indices of abundance, but recommends screening the individual indices of abundance to ensure that the sampling is spatially balanced.

In the case of rockfish in the Aleutian Islands, none of the potential additional surveys (beyond the AFSC trawl survey) covers the entire range of the Aleutian Islands area defined for the stock, and there is biological and oceanographic data to suggest that the habitats and system structure differs between Aleutian Islands subareas. I begin by discussing the nature of these additional surveys, followed by discussion of the differences between subareas

NNFS longline survey

The AFSC longline survey samples a portion of the Aleutian Islands in even years. Prior to 1996 the survey was conducted cooperatively with Japanese vessels, whereas in 1996 and later the survey was conducted solely by AFSC. Sampling occurs east of 180° longitude in the "NE" and "SE" longline survey strata (Figure 5; from Echave et al. 2013). Although no sampling occurs west of 180° longitude, the Relative Population Number (RPN) estimates for this area (i.e., the NW and SW strata) are produced based on ratios between the east and west Aleutians based on data from the Japanese longline surveys (which ended in 1994).

The correlation between the RPN values in the NE and SE areas is small (R^2 = 0.001); Figure 6). The combined RPNs in the NE and SE longline areas can also be compared to the trawl survey estimates of abundance and biomass in the EAI and the eastern portion of the CAI (strata 32x and 42x). These correlations are also small, with R^2 values for 0.003 for trawl abundance and 0.05 for trawl numbers (Figure 7). Finally, the CVs for the RPN index are consistently larger than those for either the trawl survey index of biomass or abundance (Figure 8).

IPHC longline survey

The IPHC longline survey samples that entire Aleutian Islands area defined as the stock area in the assessment for most of the time series, with the IPHC AI subarea roughly corresponding to the WAI-CAI-EAI subarea of the AFSC trawl survey. IPHC RPN estimates are available beginning in 1998; however, beginning in 2021 the sampling design for this survey was substantially changed, with no sampling in the WAI.

The correlation between the IPHC survey RPN estimates for the AI subarea are generally consistent with the AFSC trawl survey abundance and biomass estimates (R^2 values of 0.71 and 0.44, respectively; Figure 9). However, the data used for these correlations begins in 2000 and includes only years with estimates for each survey, and does not include a period in the late 1990s when the IPHC estimates declined sharply while the AFSC trawl estimates were more stable (Figure 9). Finally, the CV estimates of the IPHC RPN values are generally larger than those of the AFSC trawl survey estimates of either biomass or abundance (Figure 10).

ADFG trawl survey

The ADFG trawl survey extends as far west as Makushin Bay, and the Aleutian Islands stations for this survey correspond to the southern Bering Sea portion of the AI trawl survey. The survey time series begins in 1988, but in recent years the sampling in the AI has been limited to Akutan, Unalaska, and Makushin Bays. Given the limited geographic coverage of this survey, no further analyses were considered.

Spatial complexity within the Aleutian Islands

As mentioned above, differences in survey estimates of abundance or biomass between spatial subareas can be attributed to either sampling characteristics or underlying population characteristics. Comparing the correspondence between subarea estimates within a survey would presumably control for some of the sampling characteristics, and there was little correlation in the RPNs between the Aleutian Islands NE and SE areas of the AFSC longline survey (Figure 6). Similarly, there is relatively little correspondence in the subarea biomass estimates from the AFSC trawl survey (Figure 11), and the two areas with the strongest correlations (WAI and CAI) showed a negative correlation (i.e., in the 1990s the WAI was high and the CAI biomass was low, whereas the two years with the largest CAI abundance showed small estimated biomass in the WAI).

Given the oceanographic and biological complexity within the Aleutian Islands, it is not surprising that there is variation in trends between regions even within a single survey. The Aleutian Islands Ecosystem status reports recognizes three ecoregions (Ortiz and Zador, 2021), with the WAI subarea are from the trawl survey corresponding to the Western ecoregion, the CAI and EAI subareas from the trawl survey corresponding to the Central ecoregion, and the southern Bering Sea subarea from the trawl survey included in the Eastern ecoregion. These ecoregions were defined in 2011 by a team of ecosystem experts based on the ecological characteristics and oceanography; for example, the western ecoregion is distinct from the central ecoregion with respect to the northward flow of the Alaska Stream through deep passes (Ortiz and Zador 2021).

Given the differences in these ecological regions within the Aleutians, it is likely that underlying population trends differ between AI subareas, and that the spatial patterns cannot be attributed solely to variations in sampling characteristics (i.e., catchability). If surveys that cover a portion of the Aleutian Islands reflect different signals in the underlying population, then trends in one subarea would not be expected to correspond to trends in other areas.

Within AFSC, a team of scientists has been documenting the methodology of the AFSC and IPHC longline surveys, and providing RPN indices for various species. The advice of members of this team was not to use the IPHC longline survey due to the changes in the sampling design that started in 2021. Whereas the IPHC longline survey only recently had a spatial coverage issue in the Aleutian Islands, the AFSC longline survey has never sampled the WAI area. Given the rationale for the not including the IPHC survey, it appears that a stronger argument exists for also not including the AFSC longline survey in the assessment due to a mismatch in the spatial extent of the survey and stock area.

4) Natural mortality estimates

Natural mortality has been the subject of several comments from the BSAI Plan Team and SSC in recent years, as well as a focus of assessment model updates. A brief summary of this history is shown below.

BSAI Plan Team, November 2018 -- *For the next assessment, the Team recommends . . . examining larger bounds on M and investigating a profile of M and its subsequent impacts on model results.*

SSC, December 2018 – *The SSC also supports the PT recommendations for . . . examining larger bounds on M, applying a more rigorous prior on M, and investigating the profile of M.*

September 2020 Plan Team *The Team agrees with the author's recommendation to pursue the following three elements for the November 2020 assessment:*

1. Updating either the natural mortality point estimate or prior distribution using recent literature,

2. updating the ageing error matrix with likelihood-based estimates, and

3. using the Francis method for weighting composition data

SSC, October 2020 - *The PT recommended the updated model use the Then et al. (2015) literature value of M=0.045 as either a mean on the prior distribution for M or as a fixed M. The SSC concurs with the PT recommendation for the December assessment.*

The 2020 stock assessment set the mean of the prior distribution for natural mortality to 0.045, based on research by Then et al. (2015), as was recommended by both the Plan Team and SSC. The estimated *M* was 0.049. Additionally, a profile on the natural mortality parameter was presented.

SSC, December 2020 -- *The SSC notes that the values of M used in the AI assessment are very high, especially for a long-lived species, and requests that the authors fully explore the ranges and interactions of catchability and M in the AI assessment model.*

The methodology for obtaining the prior distribution of M was documented in the 2020 BSAI blackspotted-rougheye rockfish stock assessment (Spencer et al. 2020), and is based on three natural models developed by Then et al. (2015) based on maximum age, which Then et al. (2015) recommend as the preferred methodology. The observed maximum age t_{max} for BSAI blackspotted/rougheye rockfish is 134, and estimates of natural mortality for each model were obtained from values of t_{max} ± 25 years are shown below and ranged from 0.033 to 0.067:

		Maximum Age		
Method	Model	109	134	159
Then_{1parm}	$M = a/t_{max}$	0.047	0.038	0.032
Then_{lm}	$\log(M) = a + b * \log(t_{\max})$	0.049	0.040	0.033
Then_{nls}	$M = at_{max}^{b}$	0.067	0.055	0.047

The average from this table is 0.045, which is larger than the currently estimated value for Gulf of Alaska blackspotted/rougheye rockfish (0.034; Sullivan et al. 2021). However, a mean of the prior of 0.045, and an estimated parameter of 0.049 is consistent with other north Pacific stocks of blackspotted and rougheye rockfish. For example, a range of 0.035 – 0.055 was analyzed for British Columbia blackspotted and rougheye rockfish (DFO, 2020). Natural mortality was an estimated parameter in the stock assessment of rougheye and blackspotted rockfish along the ES west coast (Hicks et al. 2014). Despite using a prior distribution with a median of 0.034, the estimated natural mortality was 0.042, with a 95% confidence limit of 0.035 – 0.049.

The estimated natural mortality for Gulf of Alaska blackspotted and rougheye rockfish is lower than estimated values for the BSAI, British Columbia, and the US west coast, and is lower than estimates obtained from the more recent analyses of Then et al. (2015). The most recent assessment for GOA rougheye and blackspotted rockfish noted these differences, and stated that the authors plan to revisit natural mortality in future assessments (Sullivan et al. 2021).

5) Temporal changes in depth of fishery effort, and potential influences on age and size compositions

The mean depths of fishery trawl hauls, by AI subarea and year, are shown in Figure 12, with red dashed lines the unweighted mean depths of all observed hauls that caught any blackspotted and rougheye rockfish, and the mean depths weighted by the extrapolated number caught in the haul shown in the solid red line. In the WAI, the unweighted mean depths increased from 155 m in 2002 to 270 m in 2013, and declined to 186 m in 2022. The weighted mean depth (i.e., the depths reflecting the locations where fish are captured by the trawl fishery) follows a similar trend, although not declining as rapidly in recent years as the unweighted mean depth. The pattern in the EAI is similar but with more temporal change, where the unweighted mean depths increased from 181 m in 2004 to 418 m in 2010 before declining to 192 m in 2022, and in recent years the unweighted and weighted mean depths are very similar. In the CAI, both the weighted and unweighted mean depths are have been relatively stable since the early 1990s.

It is useful to also compare the fishery mean depths to those from the trawl survey, as this would give an indication of the characteristics of the population. As expected, the unweighted mean depths in the survey are generally flat over time, and any changes in the unweighted mean depths is likely attributable to changes in allocation of survey tows between depth strata. However, in both the WAI and CAI, the weighted mean depth (in this case, weighted by numerical CPUE) has shown more temporal variability than the unweighted mean depth, and has decreased over time. In the WAI, the weighted mean survey depth of blackspotted and rougheye rockfish has decreased from 277 m in 1997 to 207 m in 2018, and in the CAI the weighted mean depth has decreased from 337 m in 2006 to 226 m in 2018. In the EAI, the weighted mean depth has decreased from 336 m in 2004 to 246 m in 2014, and increased to 292 m in 2018.

In summary, the mean depths of the fishery and the survey have each shown decreases over time. Shifting of fishery effort to shallower depths could contribute to the fishery pattern but would not explain the pattern in the survey mean depths. The decreases in the survey mean depths could be explained by changes in the age/size structure (i.e., age/size groups that occur at shallower depths have increased their relative proportion in the population over time).

Similarly, any change in the fishery length distributions over time could either reflect changes in selectivity that result from changes in fishing behavior, or changes in the underlying population. Comparisons between the fishery and survey size compositions can help disentangle these factors, and are shown in Figure 13 by area for different time periods. Each of the time periods shows the combined size composition for multiple years of survey populations and fishery catch for relatively short time blocks. In general, the fishery and survey populations correspond relatively closely to each other, with only a few exceptions (i.e., CAI from 2010 – 2012, WAI from 2004 – 2006). Both the survey and fishery length compositions have shifted to smaller sizes over time. Using the WAI as an illustrative example, from 2000 – 2002 the proportion of fish exceeding 40 cm was 86% in the survey ad 82% in the trawl fishery, and from 2016 – 2018 these proportions decreased to 34% in the survey and 29% in the trawl fishery. Thus, while the depth of fishery effort has varied somewhat over time, the length compositions in the fishery has largely tracked the length compositions in the trawl survey.

Summary, and recommendations for November 2022 assessment

A team of scientists within AFSC that has reviewed the IPHC longline survey and produced RPN estimates for groundfish stocks do not recommend use of the IPHC survey RPN estimates, largely because the changes in sampling effort in 2021 resulted in the much of the western Aleutian Islands being unsampled (Jane Sullivan., AFSC, pers. comm.). Whereas the IPHC longline survey only recently had a reduction in spatial coverage, the AFSC longline survey has never sampled the WAI area; thus, a stronger argument exists for also not including the AFSC longline survey in the assessment due to a mismatch in the spatial extent of the survey and stock area. None of the additional candidate surveys covers the entire Aleutian Islands, and the observed differences in trends between subareas (both within a given survey, and between separate survey series) could reflect some combination of both sampling characteristics (i.e. catchability and selectivity) and underlying differences in population signals. The ecological differences between Aleutian Islands subareas recognized in the Aleutian Islands ecosystem report (Ortiz and Zador 2021) reflects potential habitat differences that would be expected to affect subarea productivity and population dynamics. Finally, both the AFSC and IPHC longline surveys have higher CVs for the RPNs than the CVs for the abundance or biomass estimates from the AFSC trawl survey.

Length compositions between the trawl fishery and the AI survey are largely consistent with each other, indicating that recent increases in the proportion of small fish is not primarily a function of changes in the depths of fishery effort. Given this observation, it is unclear what effect modeling time-varying fishery selectivity would have on the model results, although this could be explored for the November 2022 assessment.

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Table 1. Number of the AFSC Aleutian Islands trawl survey hauls, by year, subarea, and depth

	WAI					CAI					EAI					EAI					AI Survey
Year	0 - 100 m	100 - 200 m	200 - 300 m	300 - 500 m	WAI total	0 - 100 m	100 - 200 m	200 - 300 m	300 - 500 m	WAI total	0 - 100 m	100 - 200 m	200 - 300 m	300 - 500 m	WAI total	0 - 100 m	100 - 200 m	200 - 300 m	300 - 500 m	WAI total	total
1991	6	31	10	9	56	16	44	20	11	91	14	66	28	21	129	30	19	2	4	55	331
1994	15	33	12	9	69	22	49	24	19	114	18	62	30	23	133	31	26	4	3	64	380
1997	15	50	22	10	97	26	53	30	22	131	21	61	42	28	152	31	17	6	3	57	437
2000	16	57	30	10	113	23	39	28	20	110	13	46	55	24	138	28	17	8	5	58	419
2002	25	51	18	13	107	29	45	23	17	114	16	47	43	27	133	30	16	7	9	62	416
2004	23	62	25	14	124	31	48	30	21	130	15	42	33	22	112	33	8	4	8	53	419
2006	22	47	23	21	113	32	35	21	22	110	12	31	28	23	94	21	12	4	8	45	362
2010	32	55	22	9	118	48	47	21	12	128	21	55	33	12	121	27	14	5	5	51	418
2012	23	57	31	9	120	26	42	32	14	114	14	59	47	13	133	26	16	8	5	55	422
2014	24	70	33	7	134	25	43	32	10	110	15	55	44	9	123	19	12	9	4	44	411
2016	24	75	30	6	135	25	49	30	10	114	15	58	45	9	127	18	13	8	4	43	419
2018	25	73	25	6	129	34	52	24	10	120	18	61	39	8	126	20	14	7	4	45	420

Figure 1. Estimated biomass from the AFSC Aleutian Islands trawl survey, by year, depth, and subarea

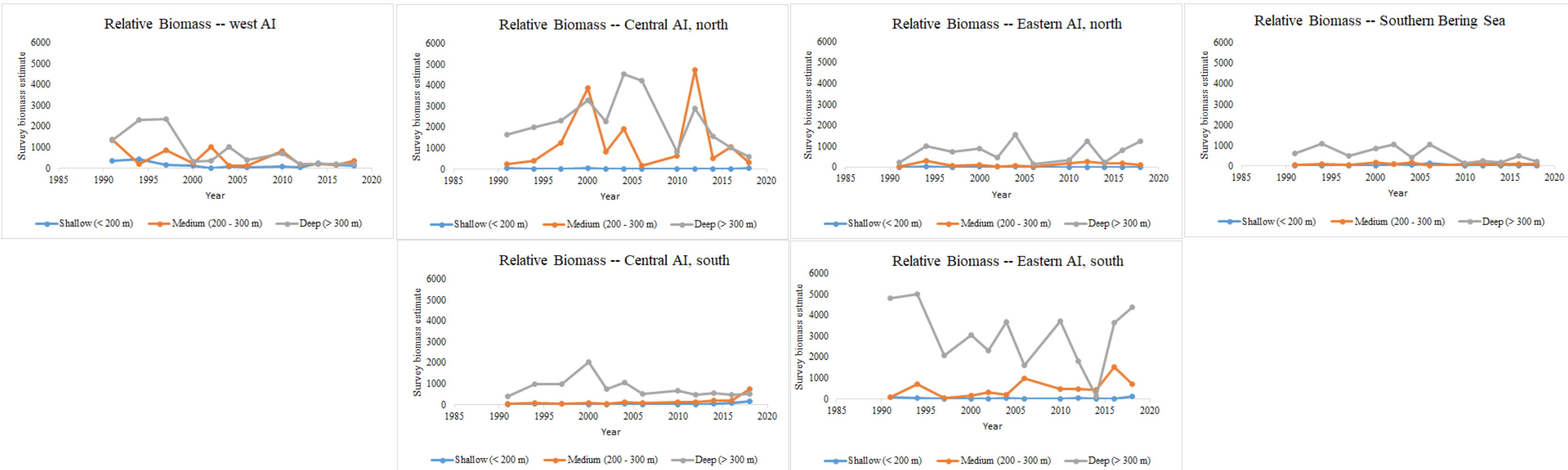


Figure 2. Aleutian Island trawl survey sampling cells in the WAI subarea. Green cells indicate sampling cells that have been successfully trawled, and red cells indicate untrawlable cells. The 3 ellipses indicate areas without survey sampling that commonly has fishing effort.

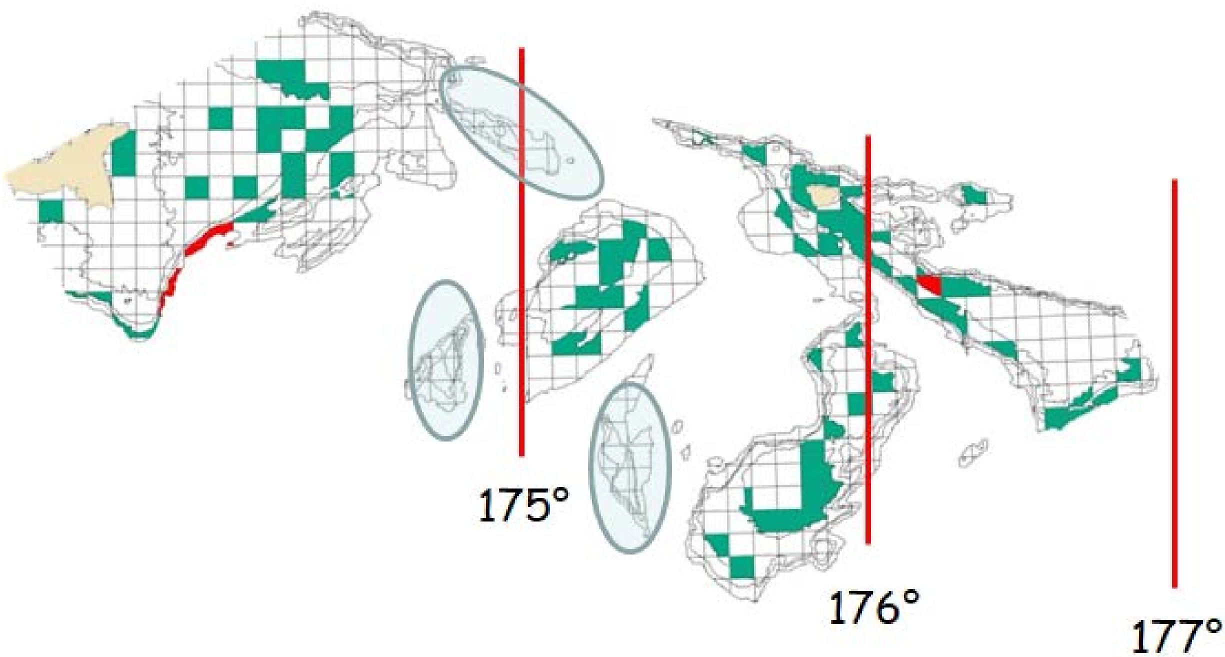


Figure 3. Proportion of Aleutian Islands fishery and survey hauls by 0.5° longitude bins. The red region spans 174.5° - 176° longitude, corresponding to the area shown in Figure 2.

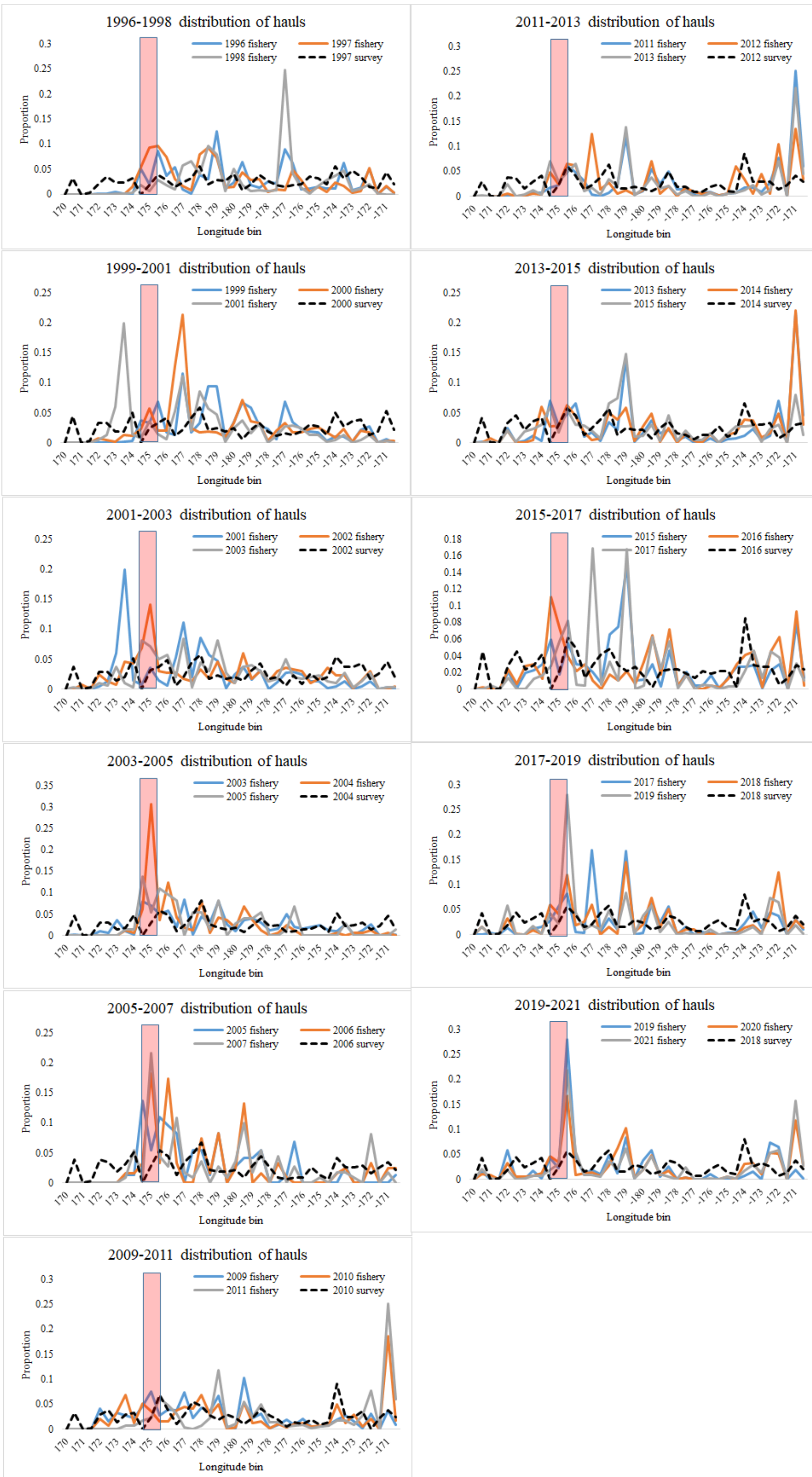


Figure 4. Proportion of Aleutian Islands fishery catch and survey CPUE by 0.5° longitude bins. The red region spans 174.5° - 176° longitude, corresponding to the area shown in Figure 2.

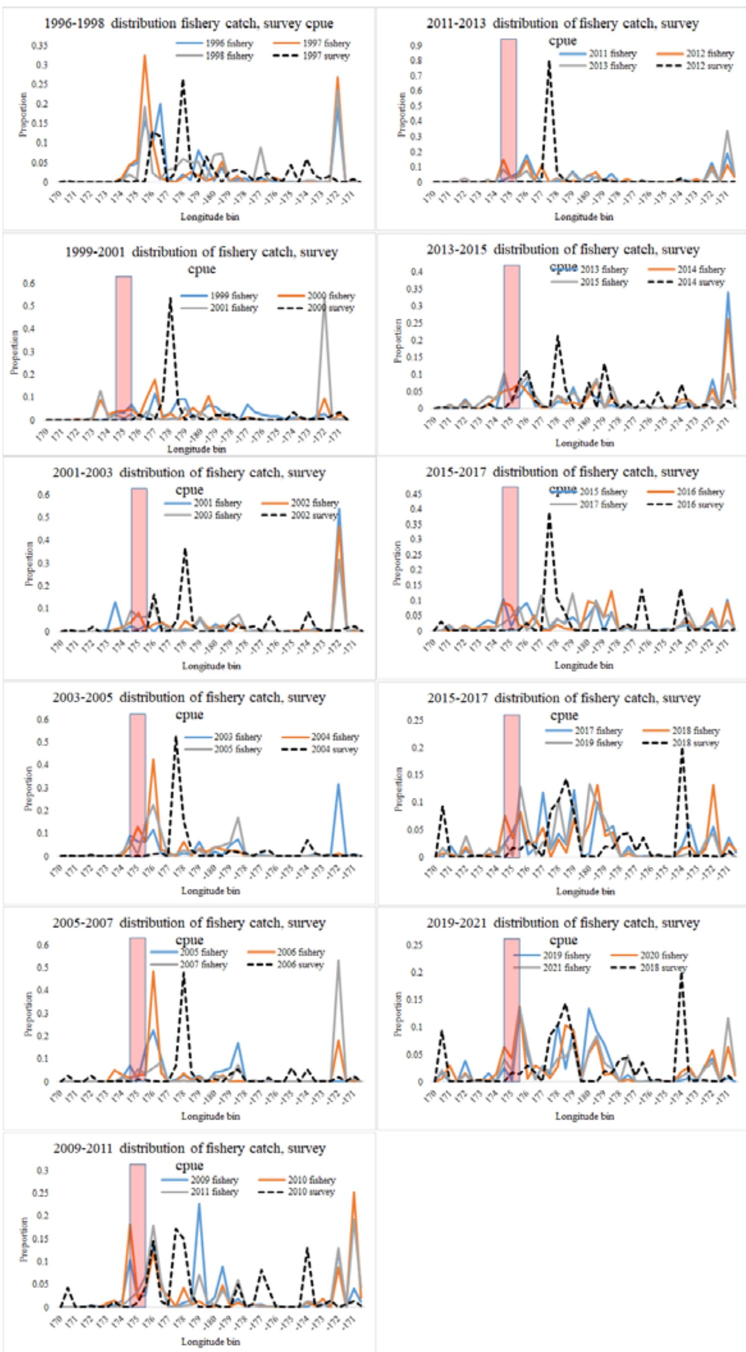


Figure 5. Sampling locations of the AFSC Longline Survey (from Echave et al. 2013).

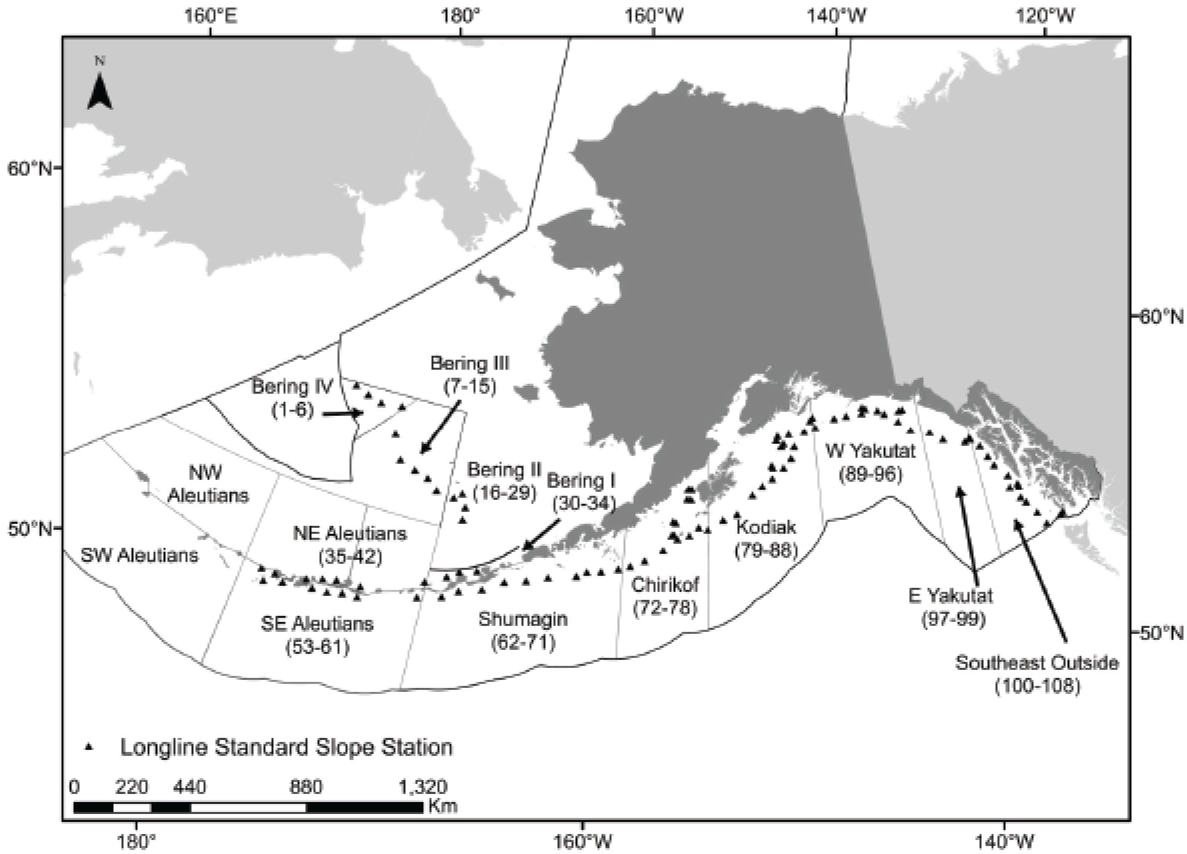


Figure 6. Correlation between AFSC longline survey RPN estimates from the NE and SE regions.

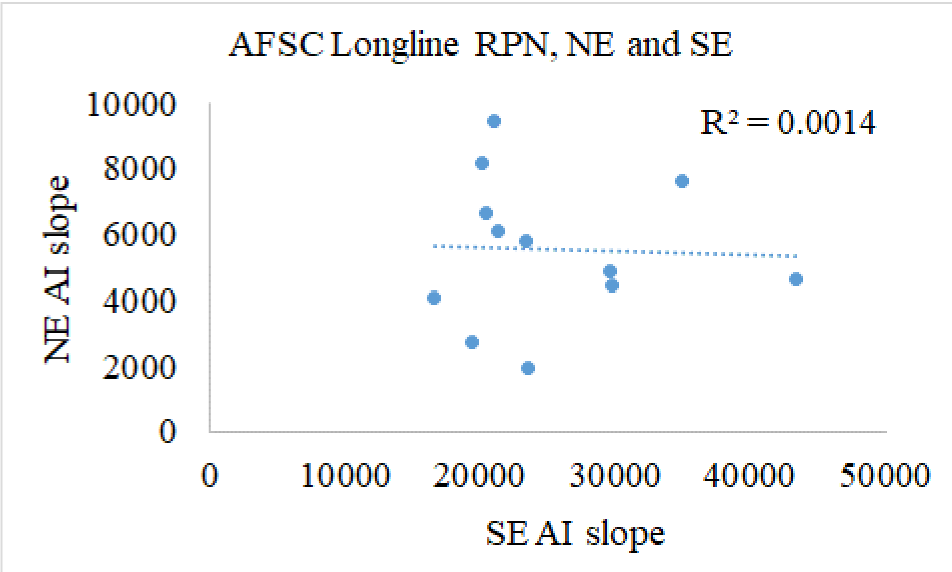
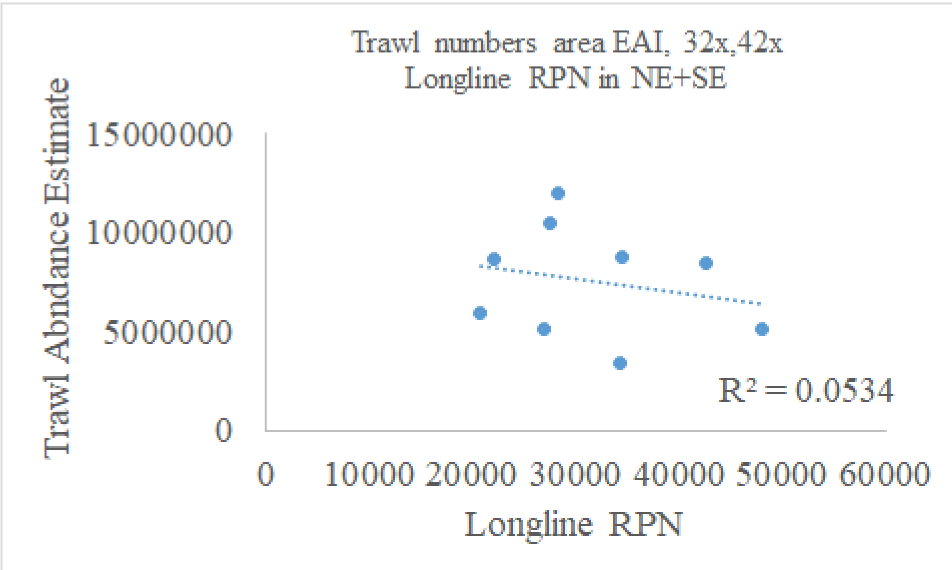


Figure 7. Correlation between AFSC longline survey RPN estimates from the combined NE and SE regions, and AFSC trawl survey estimates from the EAI and strata 32x and 42x (i.e., the eastern portion the CAI area).



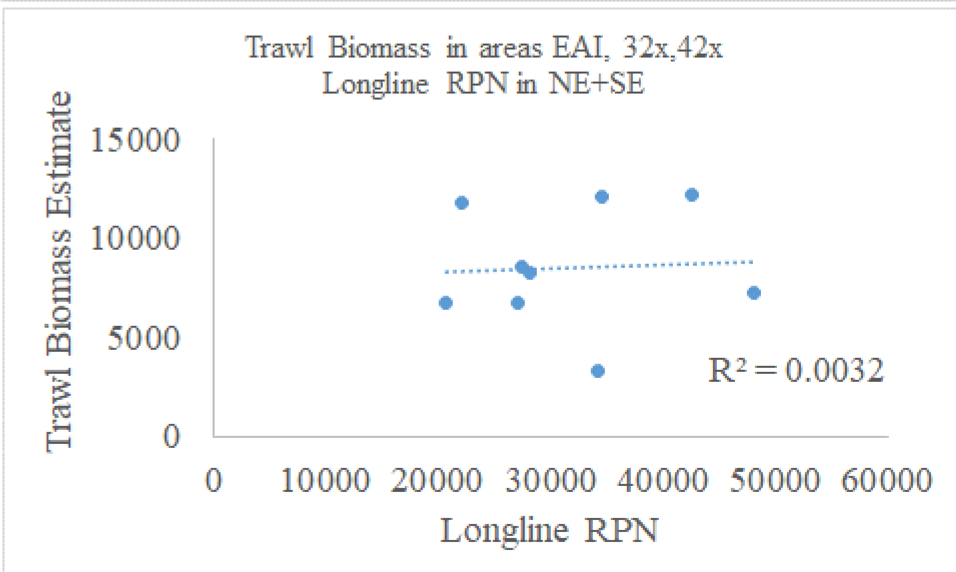


Figure 8) CVs of biomass and abundance estimates from the AFSC longline and trawl surveys (for the EAI and eastern portion of the CAI).

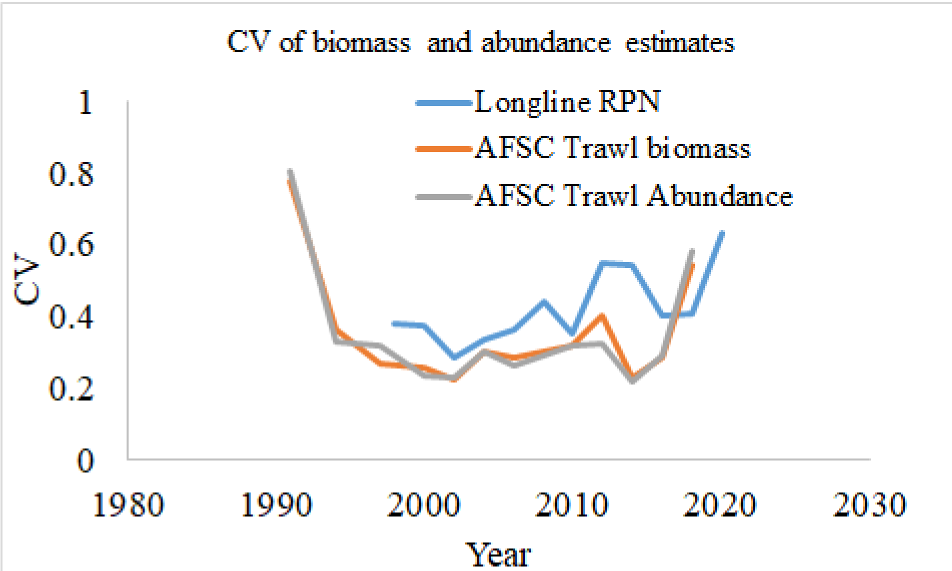


Figure 9). Correlation between IPHC longline survey RPN estimates and AFSC trawl survey estimates from the Aleutian Islands (areas WAI, CAI, and EAI).

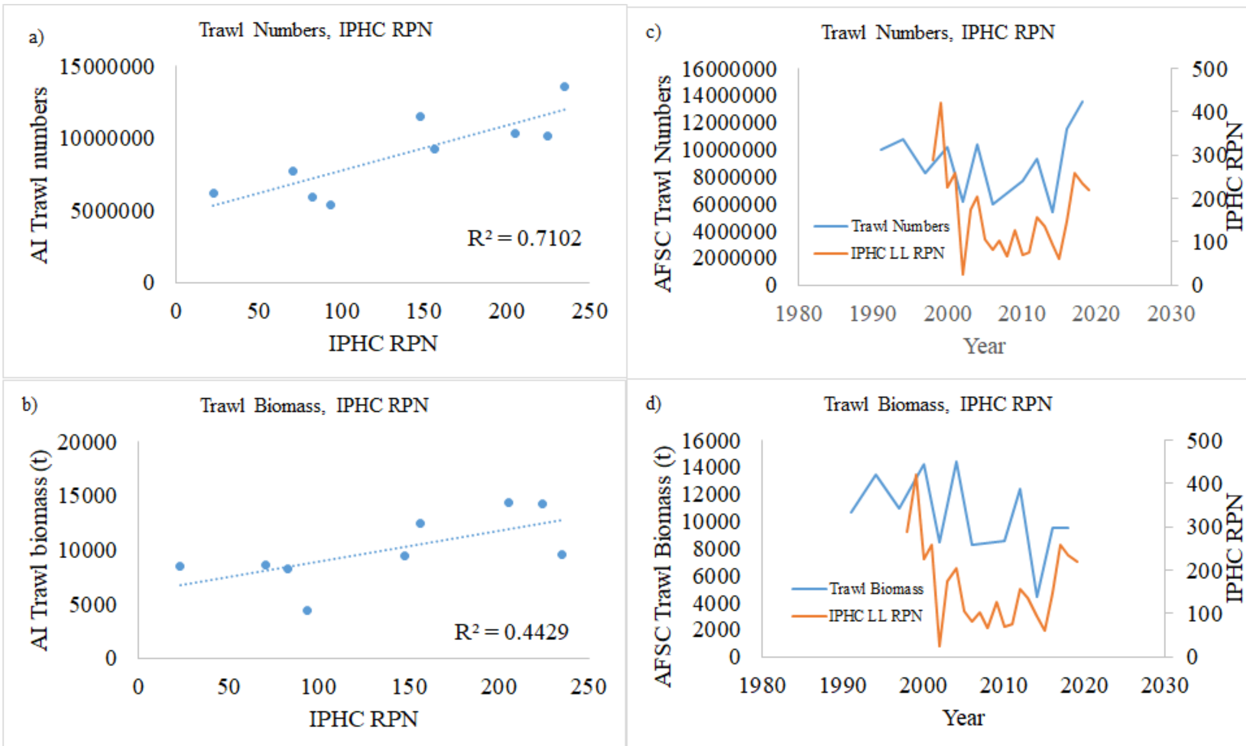


Figure 10) CVs of biomass and abundance estimates from the IPHC longline and AFSC trawl surveys (areas WAI, CAI, and EAI).

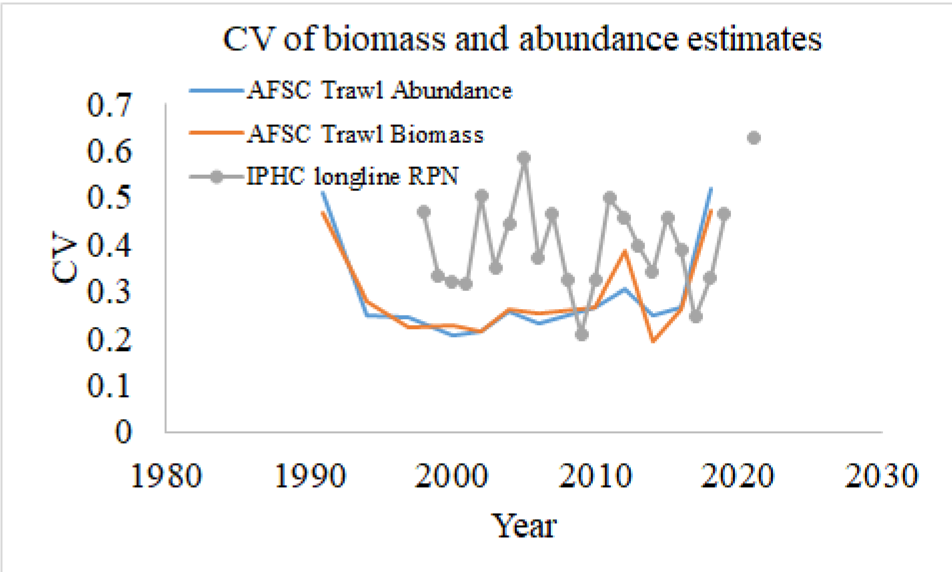


Figure 11. Correlations (upper diagonal) and scatterplots (lower diagonal) of subarea biomass estimates from the AFSC trawl survey (1991 – 2018)

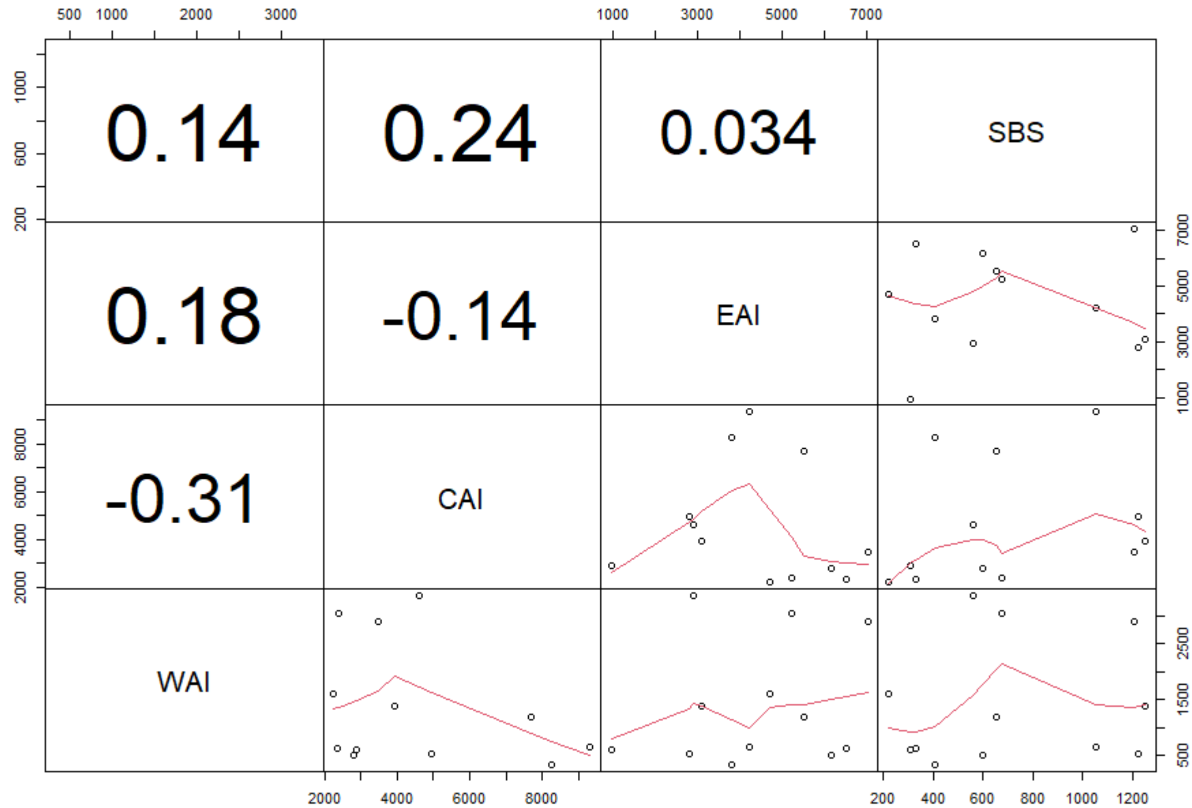


Figure 12. Mean depth for fishery and survey tows by year and subarea in the Aleutian Islands. The fishery unweighted time series corresponds to all trawls capturing blackspotted rockfish or rougheye rockfish, whereas fishery weighted time series weights tows by the extrapolated number in the haul. The survey unweighted time series uses all survey hauls, whereas the survey weighted time series weight tows by the numerical CPUE.

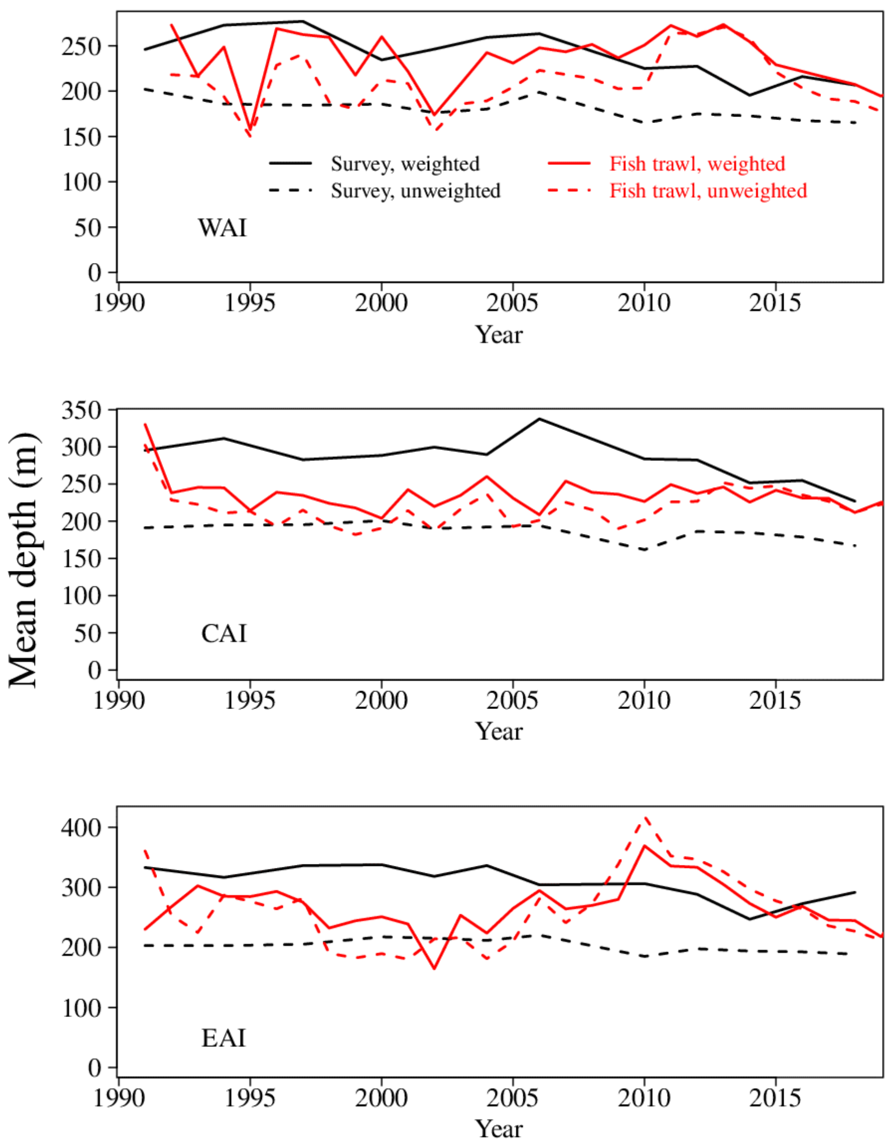


Figure 13) Length compositions (shown as cumulative distributions) from the fishery and AFSC trawl survey, by area and time periods.

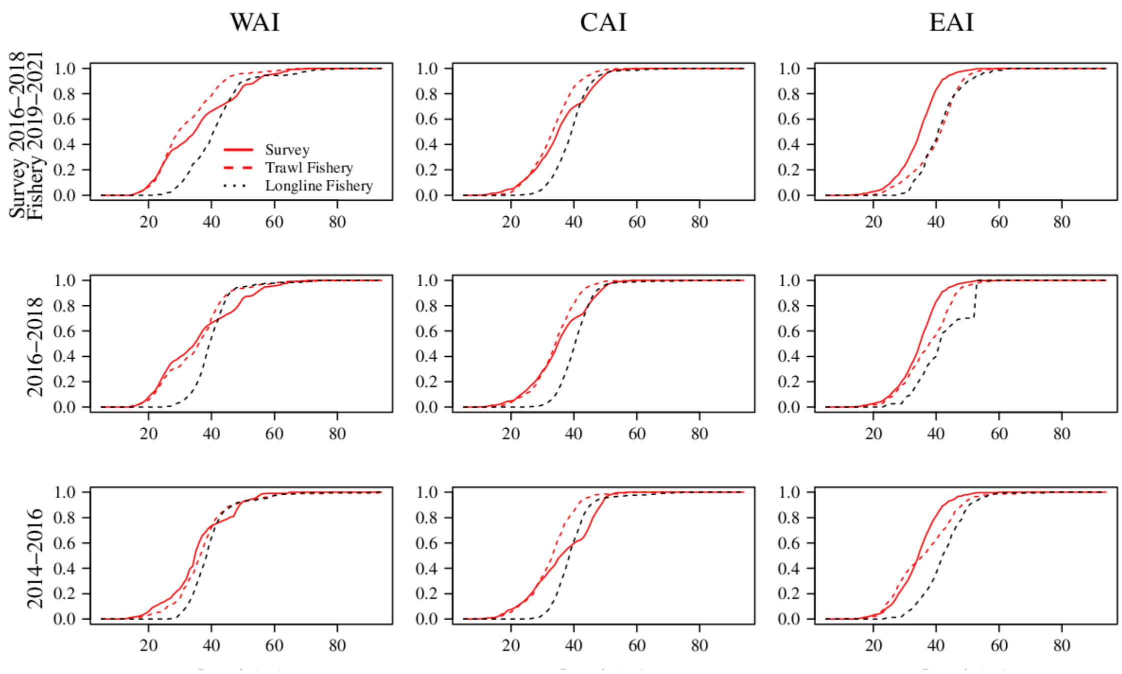


Figure 13, continued).