Area-specific exploitation rates for Bering Sea/Aleutian Islands blackspotted/rougheye rockfish

Paul D. Spencer

NMFS-Alaska Fisheries Science Center, Seattle, WA

Executive summary

An evaluation of stock structure for BSAI blackspotted/rougheye rockfish was conducted in 2010, and resulted in the BSAI Groundfish Plan Team partitioning the ABC for this stock in into two areas. At the 2010 Plan Team meeting, an examination of spatial harvest patterns by INPFC subareas within the BSAI areas was also conducted. This analysis consisted of comparing the catch by subarea to a 'theoretical' subarea ABC value that would have been obtained by partitioning the BSAI ABC in accordance with the spatial distribution of survey biomass. Because this presentation of the data may have obscured the potential impact of harvest upon the population, the purpose of the document is to examine area-specific exploitation rates.

Exploitation rates in western Aleutian Islands (WAI) often exceed *M*, and sometimes approach or exceed twice the value of *M*. This reflects a large proportion of the catch occurring in the WAI, but only small portion of the survey biomass occurring in this area. For example, from 2004-2010, 40% of the harvest occurred in the WAI but only 9% of the survey abundance. Because the WAI exploitation rates exceed the assumed production of the stock, reductions in stock biomass would be expected to occur unless the local abundance was replenished by neighboring areas. However, the available information on stock structure for blackspotted/rougheye rockfish suggest that the spatial scale of the dispersal is relatively small. Underlying survey trends in the WAI are difficult to discern given the survey variability, but each of the biomass estimates from 2000 – 2010 (averaging 1,059 t) is below each of the biomass estimates from 1991-1997 (averaging 3,156 t).

Examination of spatial patterns within the WAI indicate that catches are broadly distributed in the WAI but the survey abundance occurs within a relatively small area, indicating that catches within the WAI are occurring in areas with relatively little survey abundance. Possible explanations include a different spatial association between POP and blackspotted/rougheye in the areas fished in the WAI relative to the areas surveyed, and/or spatial differences in catchability and availability between the survey tows and the fishery tows. Additional studies would be required to evaluate these hypotheses.

Using the available survey and catch data as the best available information, the distinct patterns observed between the WAI and CAI may be masked by the current use of a single ABC for combined WAI-CAI area. Monitoring of spatial harvest patterns in the WAI would be enhanced by separation of the WAI and CAI ABCs. Further, because BSAI blackspotted rockfish are taken as bycatch and not targeted, adoption of a WAI ABC (which would prevent targeting) would be expected to have little impact on current fishing practices. Under the ACL harvest regulations, there are implications of exceeding ABC levels at a frequency of > 25%. However, these regulations pertain to the stock-wide ABC (in this case, the BSAI ABC) and not to the subarea allocations of ABC.

This information is distributed solely for the purpose of pre-dissemination peer review under applicable information quality guidelines. It has not been formally disseminated by the National Marine Fisheries Service and should not be construed to represent any agency determination or policy.

Introduction

In 2010, a report on the stock structure for the BSAI blackspotted/rougheye rockfish was presented to the BSAI Plan Team, and included an evaluation of spatial harvest relative to abundance for the EBS and AI areas. Information on spatial harvest relative to abundance with AI subareas was also presented at the September, 2010, meeting of the BSAI Groundfish Plan team, and was motivated by genetic information suggesting that the spatial structure of blackspotted rockfish was smaller than the AI area. In both cases, this information consisted of comparisons between subarea catch and a "theoretical" ABC, which was defined as an ABC level which would result from allocating the stock-wide ABC in accordance to the proportions of survey biomass across the subareas. However, examination of the catch levels (in tons) relative to theoretical ABC, without explicit consideration of the underlying biomass, may have obscured the potential impact of catch upon the population. The purpose of this update is to reexamine spatial harvest patterns by considering area-specific exploitation rates relative to the estimated rates of stock productivity (i.e., natural mortality *M*). In addition, I also examine the spatial variation of bycatch rates of blackspotted/rougheye rockfish in their target fisheries, and the spatial scale of harvesting within subareas that have high exploitation rates.

This report pertains to the two-species blackspotted/rougheye complex, as fish historically referred to as "rougheye" rockfish are now recognized as consisting of two separate species (Orr and Hawkins 2008), with rougheye rockfish retaining the name *Sebastes aleutianus* and resurrection of a new species, blackspotted rockfish (*S. melanostictus*). However, several studies have used genetic (Hawkins et al. 2005, Gharrett et al. 2005, Gharrett et al. 2007) and morphometric (Orr and Hawkins 2008) analyses to document the scarcity of rougheye rockfish west of the eastern Aleutian Islands (AI) and the occurrence of blackspotted rockfish throughout the BSAI area, with the result that the two-species complex is composed predominately of blackspotted rockfish throughout most of the Aleutian Islands.

Methods

The spatial concentration of harvest relative to abundance was evaluated by calculating area-specific exploitation rates from 2004 to 2011. For years 2009-2011, an exploitation rate for a given year for each of the BSAI subareas was obtained by dividing the yearly catch by the estimate of biomass for the subarea. The subarea biomass for each year was obtained by partitioning the estimated biomass at the beginning of the year (obtained from the age-structured stock assessment and/or projection models applied in the fall prior to a given year) into the subareas. A weighted average of the three most recent surveys was applied to each subarea (weights of 4, 6, and 9, with recent surveys higher weights), and the proportions from these averages were used to partition the projected biomass. A non-age-structured model was used from 2004 – 2008, and produced lower biomass estimates than those obtained from 2009-2011 because a survey selectivity curve was not estimated. To produce exploitation rates comparable to the 2009-2011 period, the biomass values from 2004-2008 were obtained from the 2010 assessment model.

Because blackspotted/rougheye rockfish are taken as bycatch in other fisheries (predominately the POP trawl fishery), high estimates of area-specific exploitation rates could suggest that the association between blackspotted/rougheye rockfish and the target species of the fisheries that capture them differs between areas. The bycatch rate of blackspotted/rougheye

rockfish in tows targeting POP (i.e., the tons of blackspotted/rougheye caught per ton of POP caught) was calculated for BSAI subareas from hauls sampled by fishery observers from 2001 to 2011.

Results

Survey and catch data

The survey biomass estimates of blackspotted/rougheye rockfish is highest in the central and eastern AI survey areas, with an average biomass from 1991-2010 of 4,811 t and 4,441 t, respectively. The average rougheye biomass from 1991-2010 in the western AI and the southern Bering Sea portions of the AI survey were 1,837 t and 856 t, respectively. The average blackspotted/rougheye biomass in EBS slope surveys from 2002-2010 is 824 t. The average of the survey coefficient of variation (CV) from the western AI from 2000 – 2010 was 0.44, and ranged between 0.32 and 0.36 for the other subareas of the AI survey. Higher CV values for the eastern AI and SBS subareas were occasionally found in the 1991-1997 surveys (Figure 2). Using the weighted averages of the most recent three surveys produces relative stable estimates of area proportions, which ranged from 0.076 to 0.127 in the WAI and from 0.378 to 0.488 in the CAI (Figure 3).

Catches of blackspotted/rougheye rockfish from 2004-2011 are lowest in the eastern Bering Sea (averaging 21 t). The catches in WAI averages 73 t during this period, whereas the average catch for the CAI and EAI subareas averaged 51 t and 44 t respectively. The WAI catches in 2004, 2006, and 2010 were the largest subarea catches from 2004-2011, each exceeding 94 t; the next largest subarea catches were from the CAI in 2009 (84 t) and the EAI in 2010 (76 t) (Figure 4).

From 2004-2010, 40% of the catch was obtained the WAI only 9% of the survey biomass (using an unweighted average). In contrast, approximately 50% of the catch was obtained in the CAI and EAI, and these areas accounted for 78% of the survey biomass (see table below).

Area	Catch Proportion	Survey biomass Proportion
WAI	0.40	0.09
CAI	0.28	0.41
EAI	0.22	0.37
EBS	0.10	0.13

Exploitation rates

Exploitation rates for the WAI have been above *M* in 2004, 2006, and from 2008-2010, ranging between 1.13 to 2.16 times the *M* value of 0.03 (Figure 5). The exploitation rate for the WAI has exceed 0.75**M* (i.e., the level associated with F_{abc} for a Tier 5 stock) for each year from 2004-2010. The 2011 WAI catch of 46 t is the lowest since 2007, lowering the ratio of exploitation rate/*M* ratio to 0.67. The exploitation rates from 2004-2011 for the other subareas do not exceed 0.75**M* with the exception of the EBS in 2011, which was 0.88*M*.

Bycatch rates

Blackspotted/rougheye rockfish in the Aleutian Islands are captured predominately as bycatch in the POP trawl fishery, and high estimates of area-specific exploitation rates could suggest that the association between blackspotted/rougheye and POP differs between areas. The bycatch rate of blackspotted/rougheye rockfish in tows targeting POP (i.e., the tons of blackspotted/rougheye rockfish caught per ton on Atka mackerel caught) was calculated for AI subareas from hauls sampled by fishery observers from 2001 to 2011 (Figure 6). Bycatch rates were relatively high in the WAI, CAI, and EAI in 2001 and have since declined. The average bycatch rates from 2004-2011 for the WAI was 9.9×10^{-3} and 9.1×10^{-3} and 6.9×10^{-3} for the CAI and EAI, respectively. One would expect the bycatch of blackspotted/rougheye to be lower in areas with lower abundance of blackspotted/rougheye. For example, the SBS and EBS subareas have the lowest abundances and the lowest byctach rates. However, the average 2004-2011 bycatch rates in the WAI exceeds those in the CAI and EAI despite the WAI having about 1/4 the survey abundance of each of the other two areas (Figure 6).

Spatial pattern of catch within the WAI

The high exploitation rate within the WAI could potentially be less of a concern if the both catch and harvest occurred within a relatively small area within the WAI that was in close proximity to neighboring areas with high abundance. The AI survey tows of blackspotted/rougheye rockfish catch from 1991-2010 in the WAI and the western CAI are shown in Figure 7, with each degree of longitude marked to examine the distribution. The boundary between the WAI and CAI occurs at 177° E, and high survey catches are often observed in the western part of the CAI, near Amchitka and Kiska Islands. Similarly, when large survey tows occur in the WAI, they are most often found in the Tahoma Bank-Buldir Island area, close to the WAI-CAI boundary. Relatively few large survey catches have been observed in the central and western portion of the WAI, resulting in the majority of the survey abundance occurring within 2 degrees of longitude of the WAI-CAI boundary.

In contrast, the catches of blackspotted/rougheye rockfish are evenly spread throughout the WAI, with catches occurring in areas that have relatively low survey abundance. The observed catches from 2001-2012 in the WAI and western portion of CAI, grouped into two-year periods, are shown in Figure 8, and illustrate that a relatively large portion of the catch occurs near Agattu and Attu Islands, 3-4 degrees of longitude from the WAI-CAI border.

The correspondence between fishery catch and survey abundance can be considered by comparing the proportion of survey abundance to the proportion of catch for each longitude bin for recent years (Figure 9). Because the survey strata and abundance estimates are not defined for longitude bins, the relative abundance was obtained by summing the survey CPUE by longitude bin (from 177° E to 172° E) for each survey from 2002-2010 (this reflects that longitude bins with greater survey area typically have larger number of survey tows), and then averaging across the survey years. The catches of blackspotted/rougheye rockfish from hauls sampled by fishery observers from 2002-2010 were summed by year and longitude, and then averaged across years within each degree of longitude. Both the catch and survey data were then rescaled to produce relative proportions. Approximately 68% of the survey abundance occurs between 177° E and 176° E, but only 53% of the catch. In contrast, the two bins of longitude between 176° E and 174° E account for 16% of the survey biomass but 43% of the survey catch.

Based on the available data, it does not appear that both catch and survey abundance occurs within a relatively small area within the WAI. Additionally, there is a mismatch between the distributions of survey abundance and catch within the WAI such that relatively high levels of catch are being obtained from areas with relatively low survey abundance.

Changes in the fishery in 2011 and 2012

The catches (Figure 4) and exploitation rates (Figure 5) in the WAI have declined in 2011 and 2012. Because the bycatch rates have remained fairly similar to recent years (Figure 6), this decline can be attributed to reduced fishing effort in these years. Directed fishing for Atka mackerel in the WAI has been prohibited beginning in 2011, and some of the vessels targeting Atka mackerel also target POP. From 2004-2010, catches of both POP and blackspotted/rougheye rockfish occurred largely throughout the year. However, in 2011-2012 POP fishing in the WAI has only occurred in the late-spring and summer (July of 2011 and May-July in 2012). The 2012 catch of blackspotted/rougheye rockfish through the end of July was 66 t, which results in a 2012 WAI exploitation rate slightly larger than 0.75**M* (Figure 5; based on the 2002-2010 surveys). If fishing for POP in the WAI were to continue in the fall of 2012, the exploitation rates would increase from this level.

Conclusions and implications for conservation

The purpose of spatially allocating harvest specifications in accordance with the distributions of survey abundance is to help ensure that harvest is not disproportionate to abundance. However, for BSAI blackspotted/rougheye rockfish a high proportion of the catch occurs in the WAI, but only a small percentage of the biomass occurs in this area. This has led to subarea exploitation rates that often substantially exceed *M*, which is used as measure of F_{ofl} for many north Pacific groundfish stocks.

The exploitation rates are based upon the available survey biomass data, and examination of survey tows and fishery catches in the WAI reveal a pattern where catches are being obtained from areas with low survey abundance. Given that the catch of blackspotted/rougheye rockfish is obtained as bycatch in the POP fishery rather than directed fishing, one would expect that the survey data and the bycatch data would be similar. One potential explanation is that the association between blackspotted/rougheye and POP is different in the WAI than in other subareas (i.e., blackspotted/rougheye are more likely to occur in the areas fished for POP in the WAI than in other subareas), as this would explain the high bycatch rates in the WAI.

Comparison between the survey and fishery tows is complicated in that there are likely differences in the coverage of tows, the habitats towed, the seasonal patterns of tows, and the catchability of the nets. Clearly, the relatively broad distribution of catches in the WAI indicates that there must have been some blackspotted/rougheye in order for these catches to occur – the question regards the numbers of blackspotted/rougheye that remain in the water and are *not* caught by the fishery. It is possible that the survey abundance is an underestimate of the true abundance. However, unless this underestimation occurred only in some spatial areas, there would still be a pattern of the distribution of catches being disproportionate to relative survey abundance. It is not possible to evaluate these hypotheses without additional detailed spatial data, and future studies should be pursued.

Using the current survey data as the best available information, the pattern of high exploitation rates in the WAI pose a potential conservation concern because the available information on stock structure suggests that reductions in abundance on the scale of the WAI would not be expected to be replenished quickly from neighboring areas. A temporal reduction in abundance in the WAI could be evaluated from the survey data, although the subarea CVs on the biomass estimates would hinder the recognition of any underlying trends. However, it is notable that while the proportion of the survey abundance in the WAI has remained relatively stable over time (Figures 1 and 3), each of the biomass estimates from 2000 – 2010 (averaging 1,059 t) is below each of the biomass estimates from 1991-1997 (averaging 3,156 t).

In 2010, the BSAI Plan Team adopted an ABC for the combined WAI-CAI, and a separate ABC that combined the remaining EAI and EBS areas. While this partitioning of ABC is at a finer spatial scale than a BSAI ABC, the distinct patterns observed between the WAI and CAI may be masked by examination of the combined WAI-CAI data. Monitoring of spatial harvest patterns in the WAI would be enhanced by separation of the WAI and CAI ABCs. Currently, this monitoring is contained within the biennual stock assessments and/or in evaluations of stock structure, and is thus not prominently communicated to many people. Adoption of sub-area ABCs would enhance the visibility of spatial harvest patterns and thus allow more effective communication of this information. Further, because BSAI blackspotted rockfish are taken as bycatch and not targeted, adoption of sub-area ABCs (which would prevent targeting) would be expected to have little impact on current fishing practices. Under the new ACL harvest regulations, there are implications of exceeding ABC levels at a frequency of > 25%. However, these regulations appear to pertain to the stock-wide ABC (in this case, the BSAI ABC) and not to the subarea allocation of ABC.

References

Gharrett, A.J., A.P. Matala, E.L. Peterson, A.K. Gray, Z. Li, and J. Heifetz. 2005. Two genetically distinct forms of rougheye rockfish are different species. Trans. Am. Fish. Soc. 134:242-260.

Gharrett, A.J., A.P. Matala, E.L. Peterson, A.K. Gray, Z. Li, and J. Heifetz. 2007. Distribution and population genetic structure of sibling rougheye rockfish species. Pages 121-140 *In* J. Heifetz, J. DiCosimo, A.J. Gharrett, M.S. Love, V.M. O'Connell, and R.D. Stanley (eds.) 2007. Biology, assessment, and management of North Pacific rockfishes. Alaska Sea Grant College Publication AK-SG-07-01, University of Alaska Fairbanks.

Hawkins, S.L., J. Heifetz, C.M. Kondzela, J.E. Pohl, R. L. Wilmot, O. N. Katugin, and V.N. Tuponogov. 2005. Genetic variation of rougheye rockfish (Sebates aleutianus) and shortraker rockfish inferred from allozymes. Fish. Bull. 103:524-535.

Orr, J.W. and S. Hawkins 2008. Species of the rougheye rockfish complex:resurrection of *Sebastes melanostictus* (Matsubara, 1934) and a redescription of *Sebastes aleutianus* (Jordan and Evermann, 1898) (Teleostei: Scorpaeniformes). Fish Bull. 106:111-134.

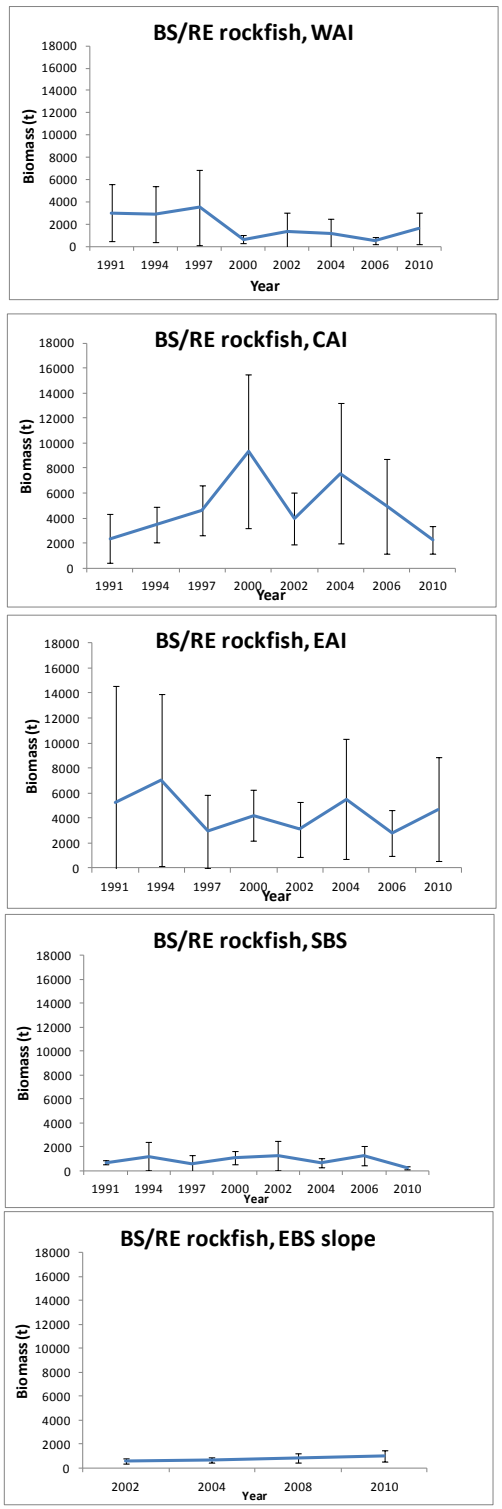

Figure 1 Blackspotted/rougheye rockfish biomass estimates from the Aleutian Islands survey.

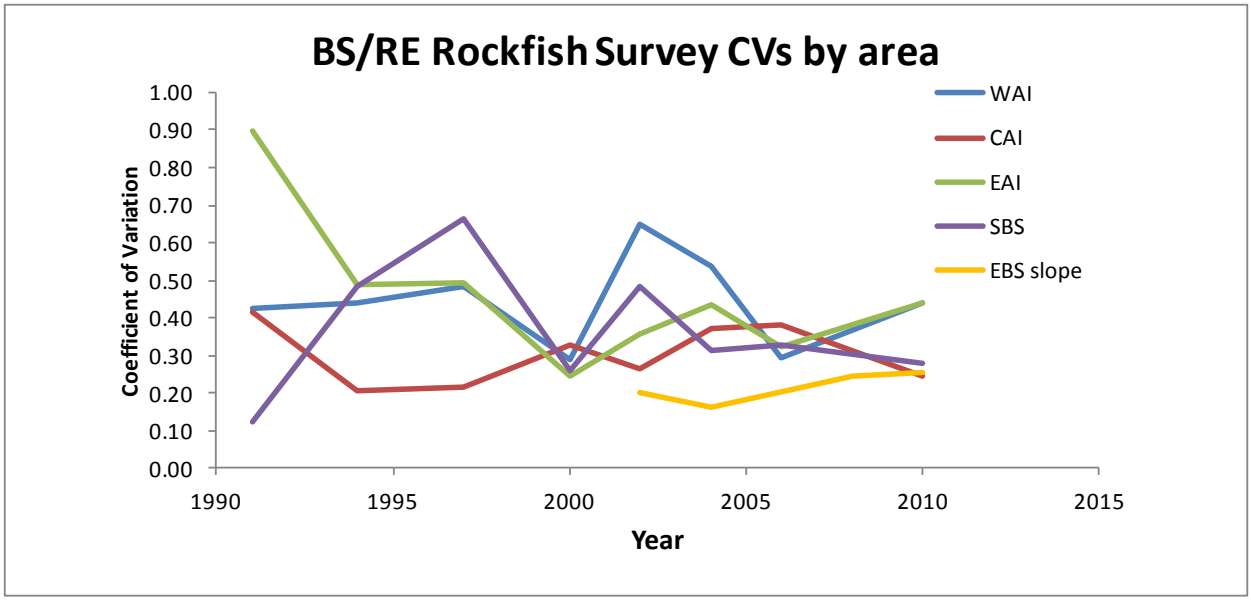

Figure 2. Coefficients of variation (CV) for blackspotted/rougheye rockfish biomass estimates from the Aleutian Islands survey.

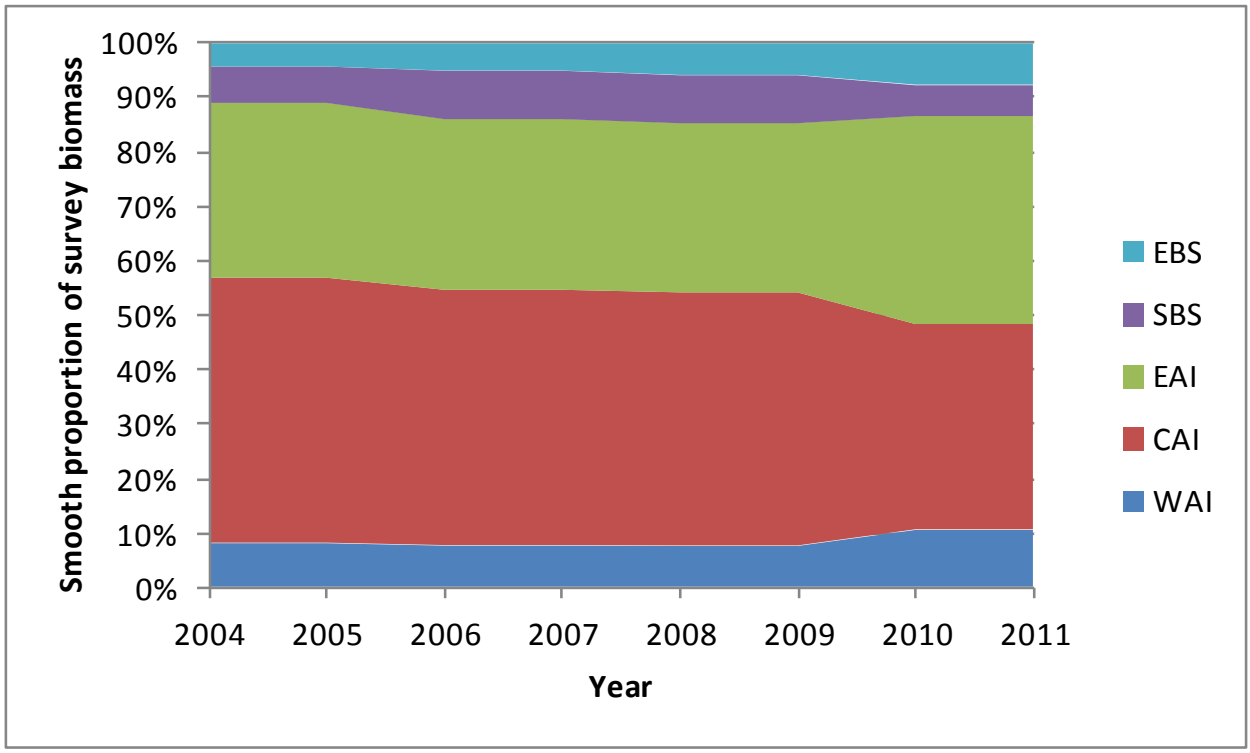

Figure 3. Estimated proportions of blackspotted/rougheye rockfish biomass for Aleutian Islands survey subareas, 2004-2011. For each year, the proportions were computed from weighted averages of the three most recent surveys.

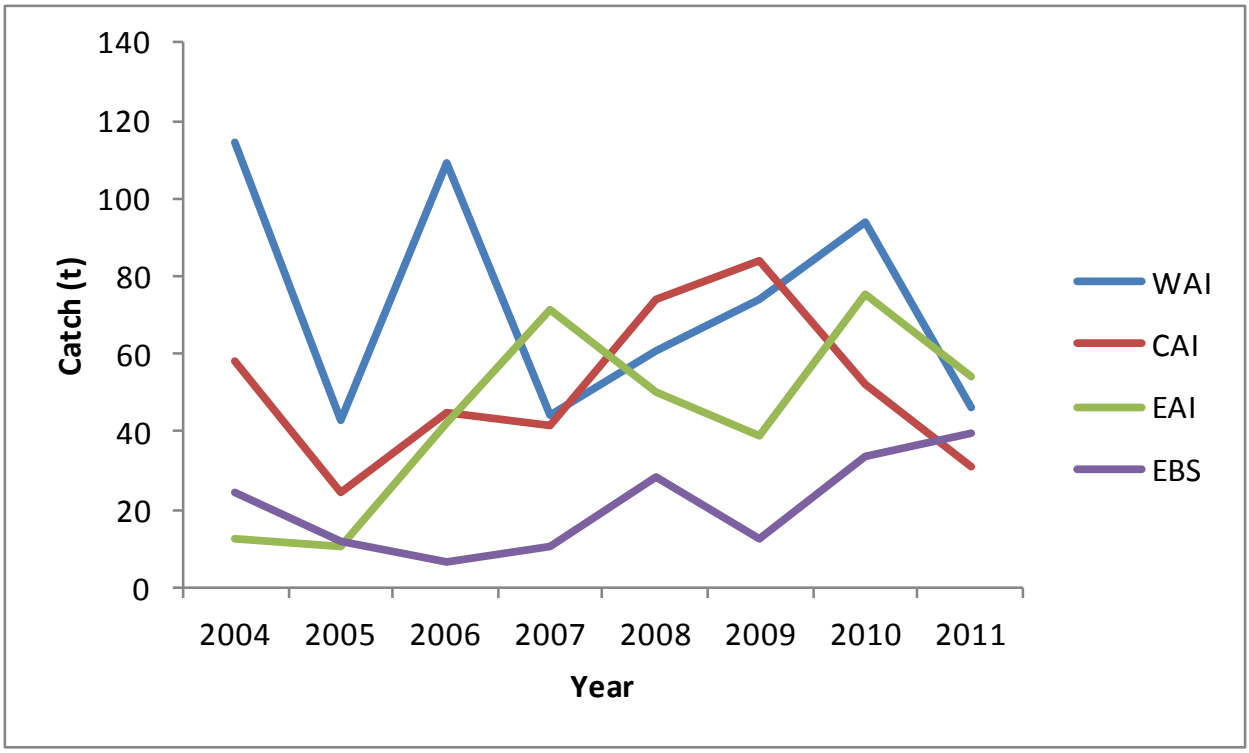

Figure 4. Catch (t) of blackspotted/rougheye rockfish by BSAI subarea, 2004-2011.

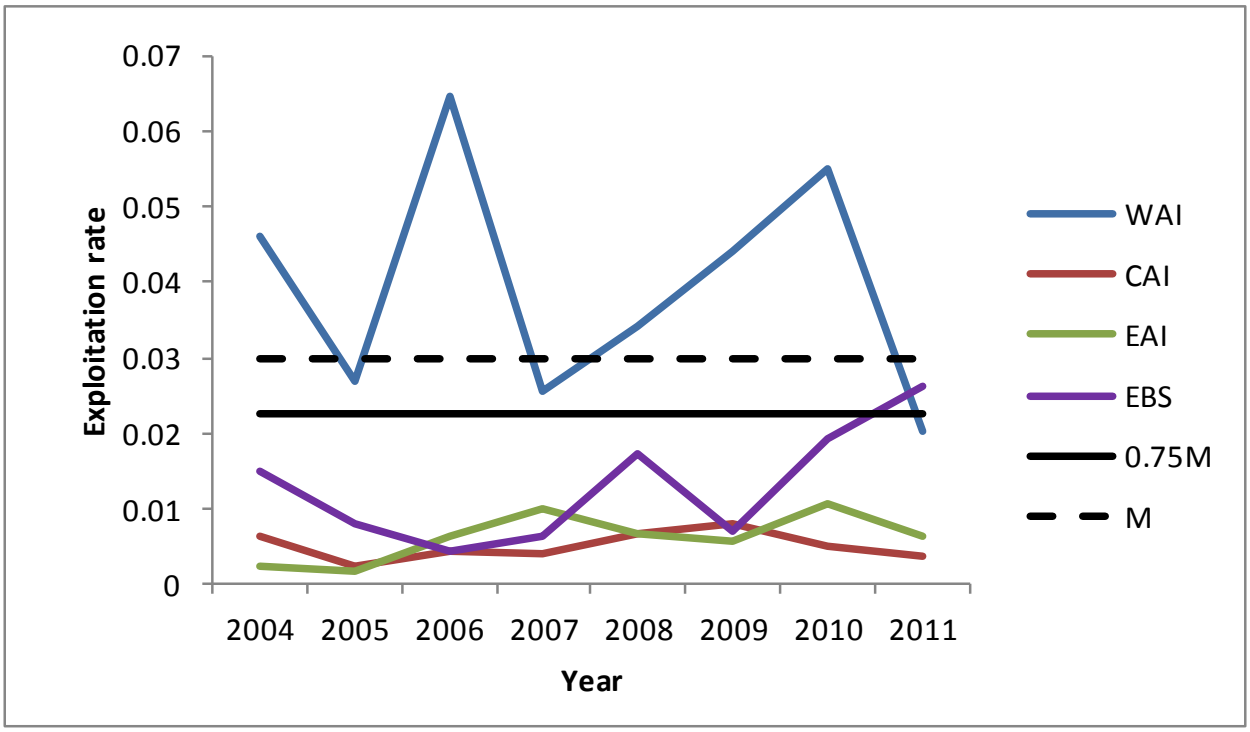

Figure 5. Estimated blackspotted/rougheye rockfish exploitation rates by area from 2004-2011.

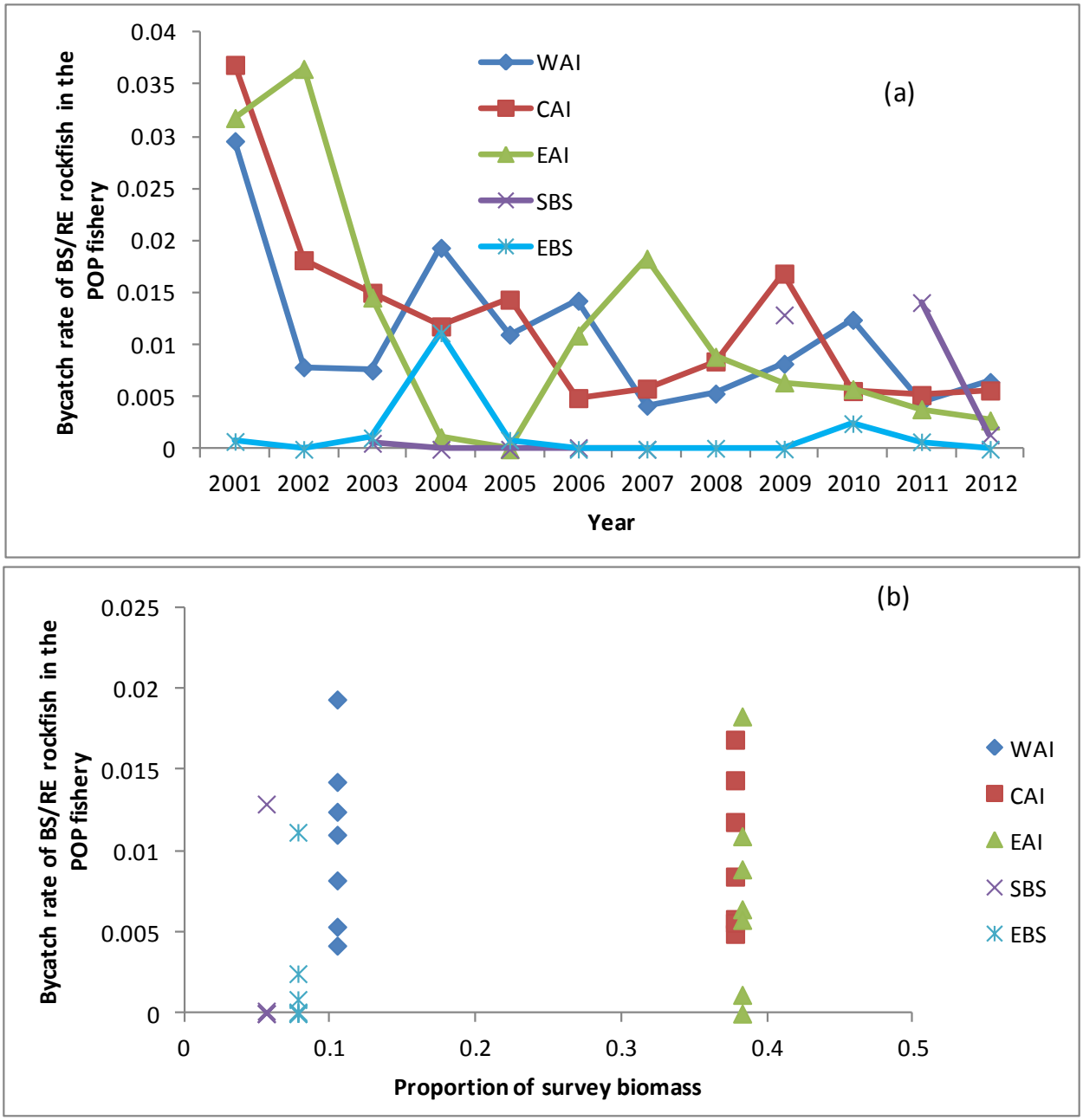

Figure 6. Blackspotted/rougheye rockfish bycatch rates from 2001-2012 (a), and from 2004-2010 as function of average proportion of Aleutian Islands survey biomass. Bycatch rates were computed as the tons of blackspotted/rougheye rockfish caught per ton of POP caught in hauls sampled by fishery observers.

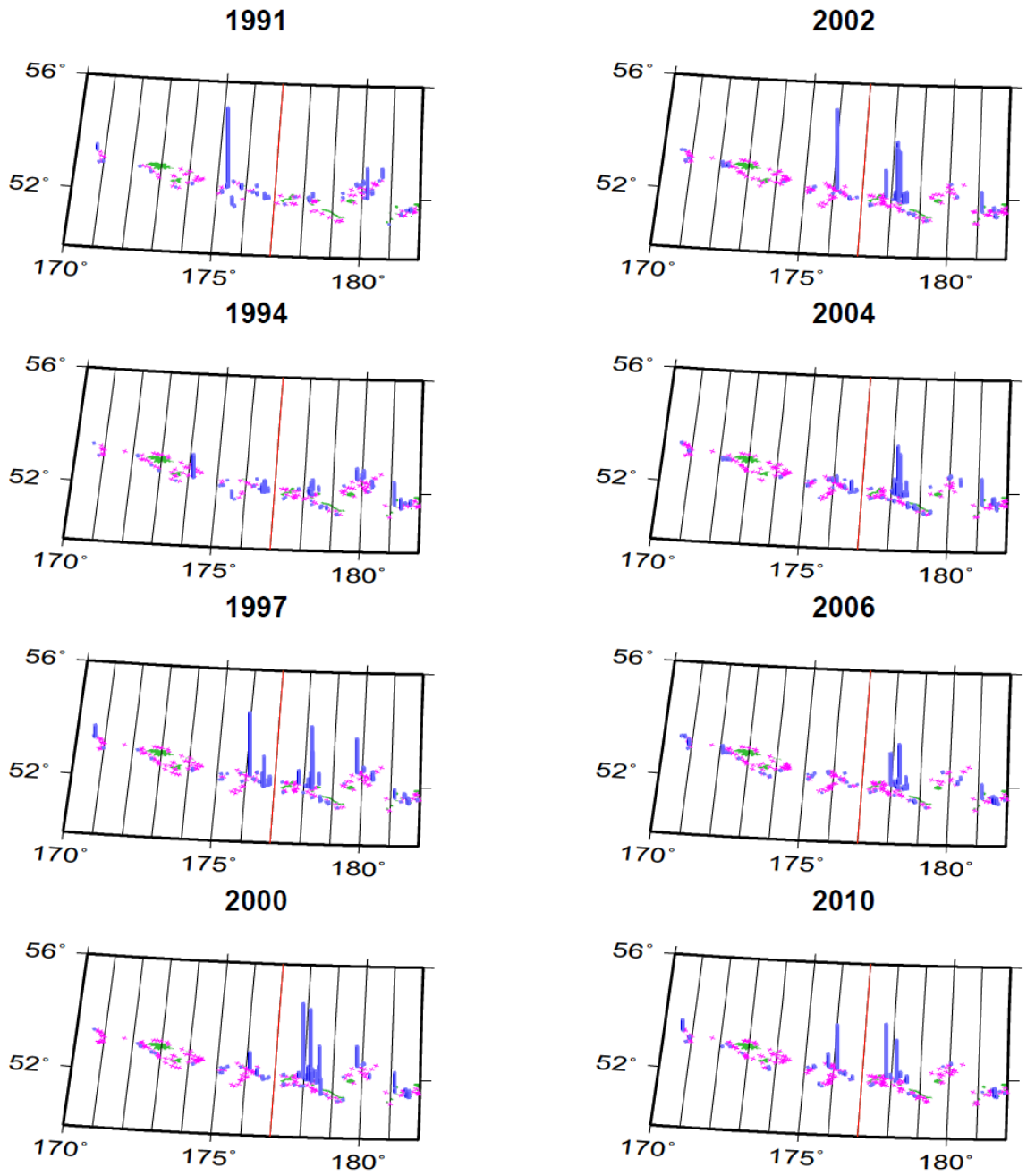

Figure 7. Spatial pattern of the survey catch per unit effort of blackspotted/rougheye rockfish in the WAI and western portion of the CAI (the red line is the boundary between the WAI and CAI).

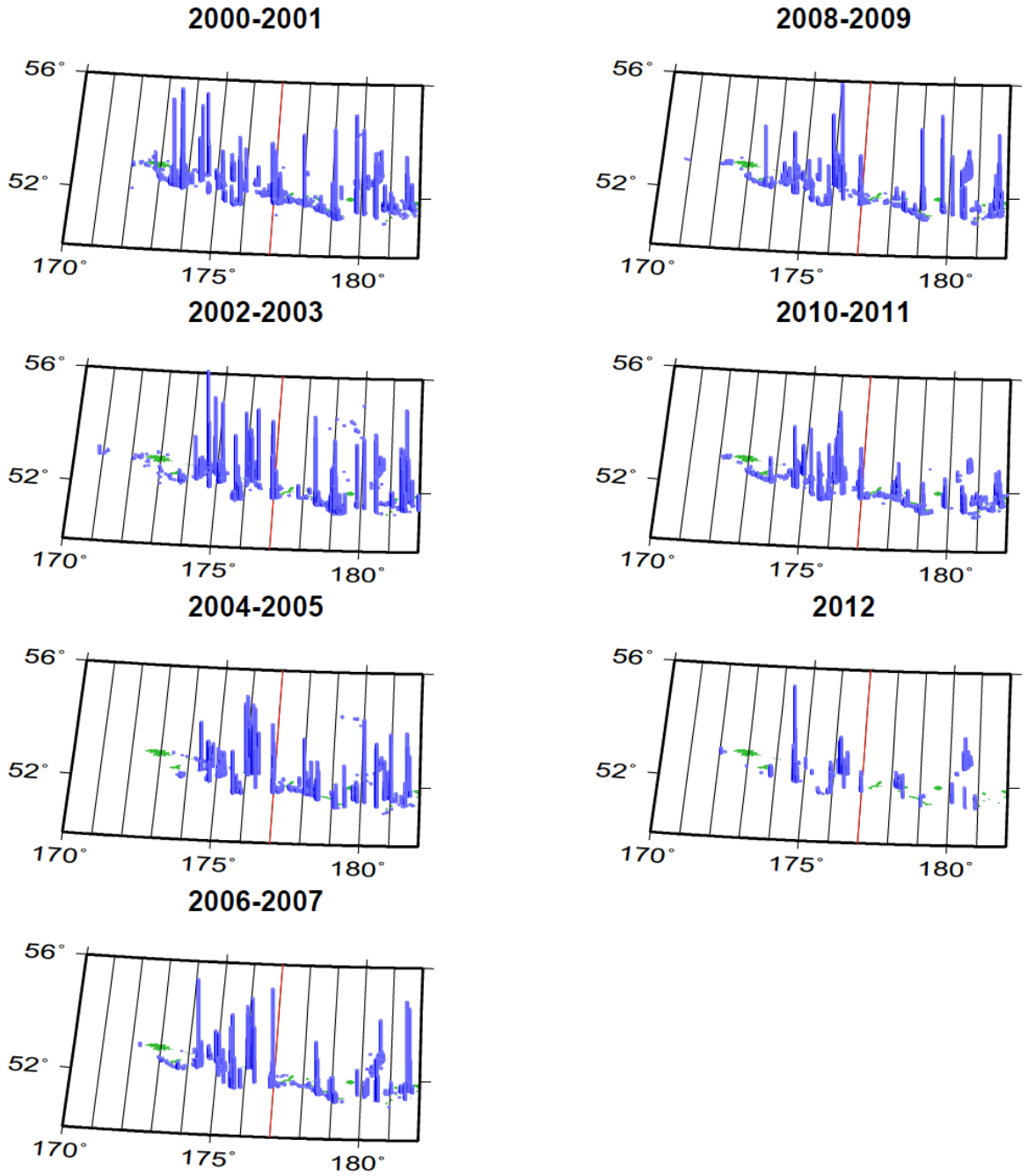

Figure 8. Spatial pattern of the blackspotted/rougheye rockfish catch in fishery hauls sampled by fishery observers in the WAI and western portion of the CAI (the red line is the boundary between the WAI and CAI).

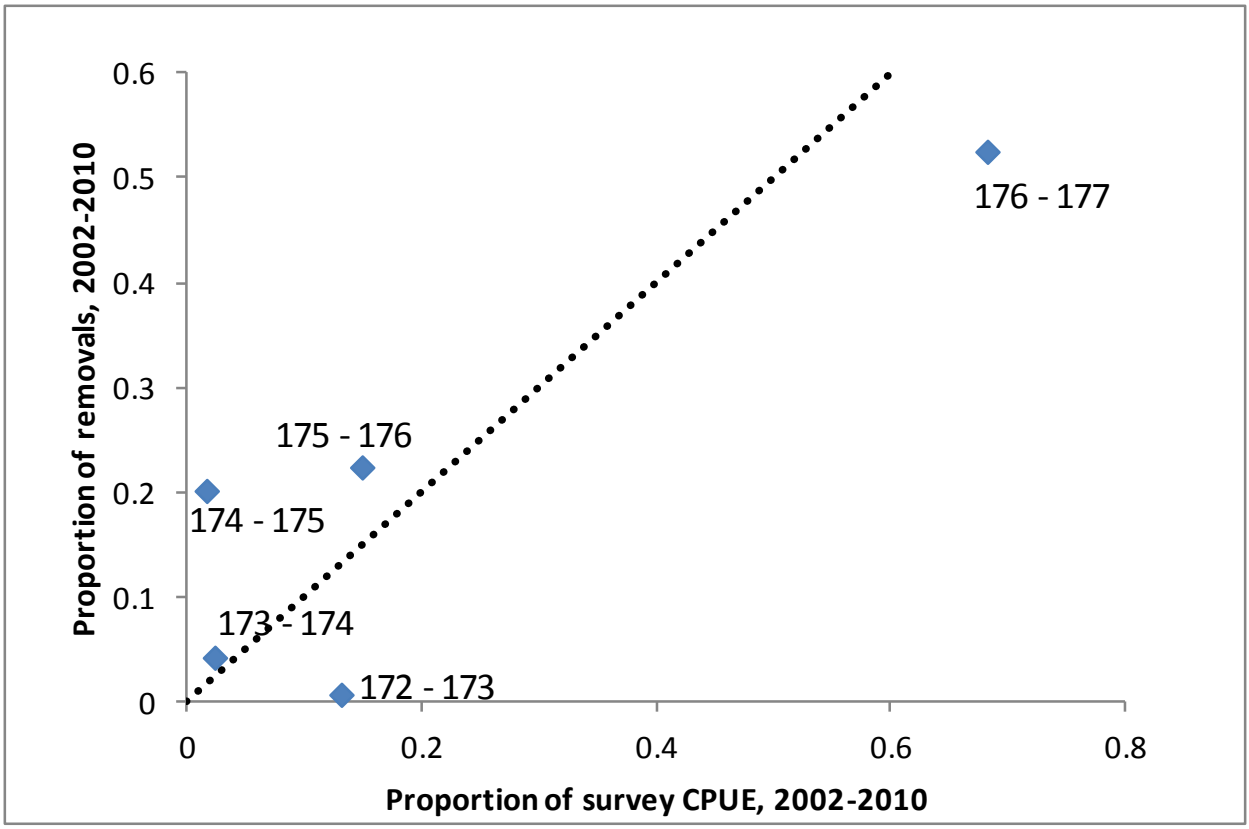

Figure 9. Relative survey abundance and catch within the WAI by longitude bin from 2002-2010; labels indicate the longitude boundaries of each bin.