Descriptive analyses of the Japanese Indian Ocean longline fishery, focusing on tropical areas

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Abstract

We analysed Japanese operational longline catch and effort data in order to describe and characterize the fishery, and to increase understanding of both the fishery and the species caught. The primary interest is in the tropical tuna species bigeye and yellowfin tuna, but information on other species is included where their catches are important for the fishery, and provide valuable information on fishing methods and ecological patterns. Detailed data are only reported for bigeye, yellowfin, and albacore tunas. The full dataset included yellowfin tuna, bigeye tuna, albacore tuna, southern bluefin tuna, swordfish, striped marlin, black marlin, and blue marlin. We provide temporal and spatial plots of catch, effort, catch rate, fishing patterns, fleet composition, reporting patterns, gear usage, proportions of zero sets, and species composition.

Introduction

This report is an output of an Indian Ocean Tuna Commission project to explore factors affecting the catch rates of Japanese, Taiwanese, and Korean longline fleets fishing for bigeye and yellowfin tunas in the Indian Ocean. The work was funded by the International Seafood Sustainability Foundation (ISSF).

This report provides detailed information on the Japanese longline fleet. Complementary reports address the Taiwanese Hoyle Yeh (Hoyle *et al.* 2015) and Korean (Hoyle *et al.* 2015) fleets. A further report (Hoyle *et al.* 2015) addresses the main objectives of the study.

Methods

Full details of data preparation are included in Hoyle *et al.* (2015), some of which is repeated here. Data preparation and analyses were carried out using R version 3.1.2 (R Core Team 2014).

Japanese data were available from 1952-2013, with fields year, month and day of operation, location to 1 degree of latitude and longitude, vessel call sign, no. of hooks between floats, number of hooks per set, date of the start of the fishing cruise, and catch in number of southern bluefin tuna, albacore, bigeye, yellowfin, swordfish, striped marlin, blue marlin, and black marlin.

International call sign was available 1979 - present, and was selected as the vessel identifier. Call sign is unique to the vessel and held throughout the vessel's working life. The vessel id was rendered anonymous by changing it to an arbitrary integer. Sets without a vessel call sign were allocated a vessel id of '1'.

Latitude and longitude were reported at 1 degree resolution, with a code to indicate north or south, west or east. All data were adjusted to represent the south-western corner of the 1 x 1 degree square, and longitudes translated into 360 degree format. Each set was allocated to a yellowfin region (consistent with the definitions in the yellowfin stock assessment, Langley *et al.* 2012) and a bigeye region (consistent with the bigeye assessment, Langley *et al.* 2013), and data outside these

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areas ignored. Location information was used to calculate the 5 degree square (latitude and longitude).

The few sets without information on hooks were deleted. For the purposes of further analyses, we cleaned the data by removing data likely to be in error. The criteria were selected after discussion with experts in the data. Hooks per set above 5000 and less than 200 were removed.

The species reported were bigeye, yellowfin, albacore, southern bluefin tuna, swordfish, striped marlin, blue marlin, black marlin. Some very large catches were reported at times for individual species, but were not removed since there was anecdotal evidence that they may be genuine, and because they are unlikely to affect results substantially.

Hooks between floats (HBF) were available for almost all sets 1971-2010, and for a high proportion of sets 1958-1966. Sets after 1975 with HBF missing or > 25 were removed. Sets before 1975 with missing HBF were allocated HBF of 5, according to standard practice with Japanese longline data (e.g. Langley *et al.* 2005, Hoyle *et al.* 2013, Ochi *et al.* 2014).

Dates of sets were used to calculate the years and quarters (year-quarter) in which the sets occurred. They were also used to calculate the level of illumination from the moon, using the function lunar.illumination() from the lunar package in R (Lazaridis 2014).

Plotting

The plots provided are designed to provide an overview of the characteristics of the fishery through time. They address the temporal and spatial distribution of fishing effort (Figures 1 - 4), hooks per set (Figure 5), hooks between floats (Figures 6 - 8), vessel characteristics and longevity (Figures 9 - 12), catch (Figures 13 - 14), CPUE (Figures 15 - 16), proportions of sets with zero catch (Figures 17), species composition (Figures 18 - 27), catch by 5 degree square through time (Figures 28 - 33), catch per set (34 - 39), proportions of sets with > 1 fish per 100 hooks (40 - 45), and proportion of sets with zero catch by 5 degree square through time (Figures 46 - 51).

Acknowledgments

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Figures

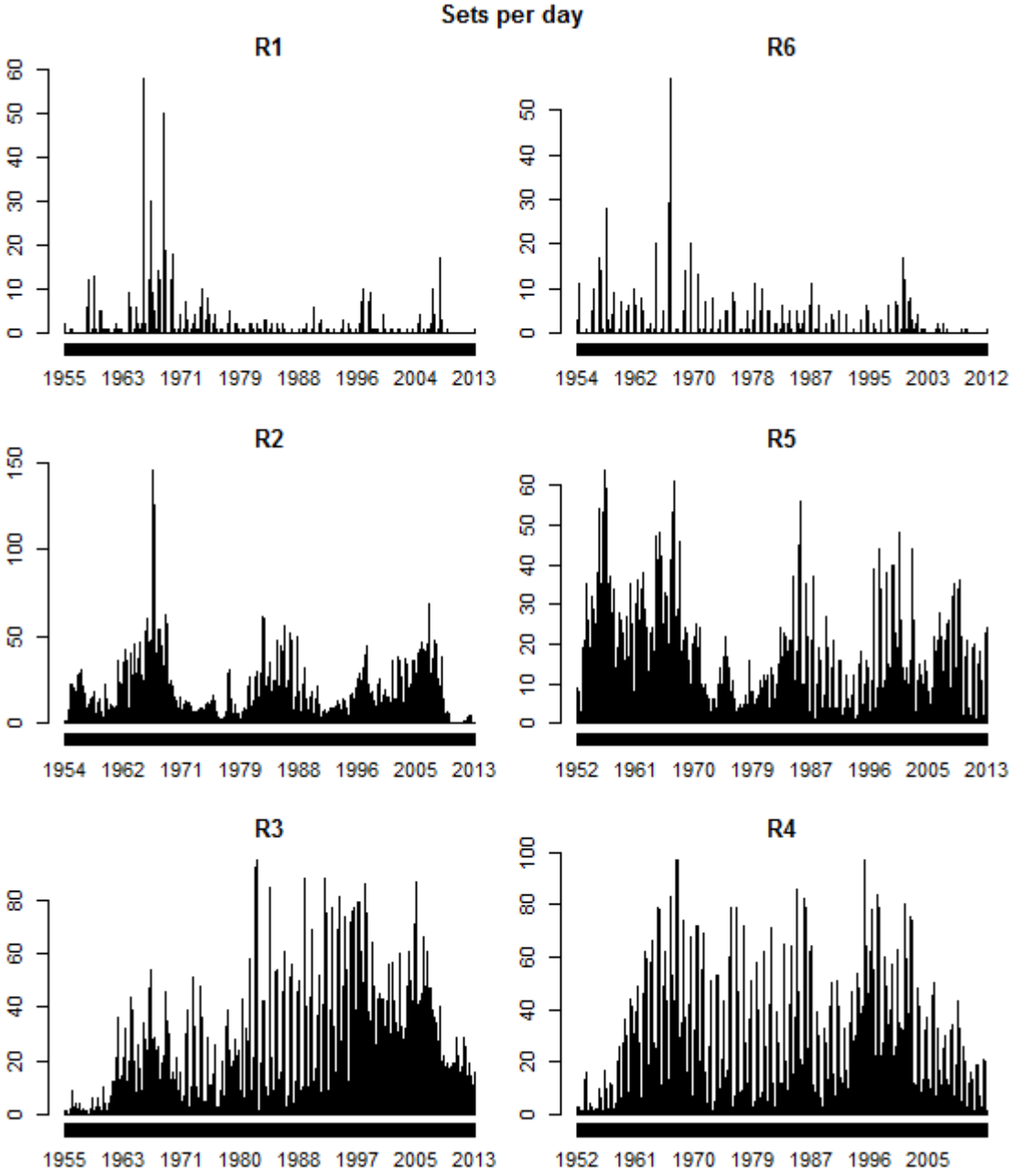

Figure 1: Sets per day by region

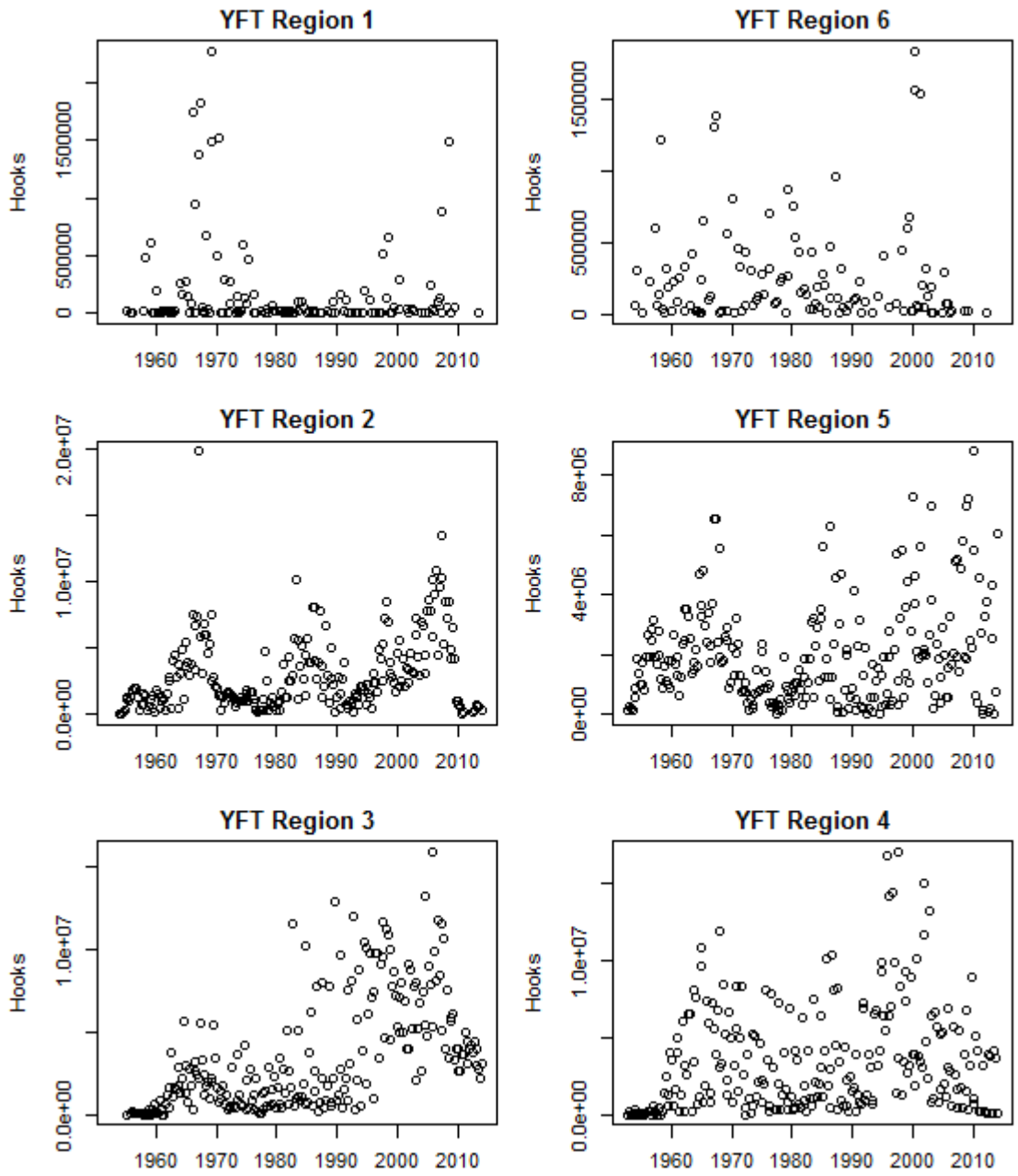

Figure 2: Hooks per year-qtr by region.

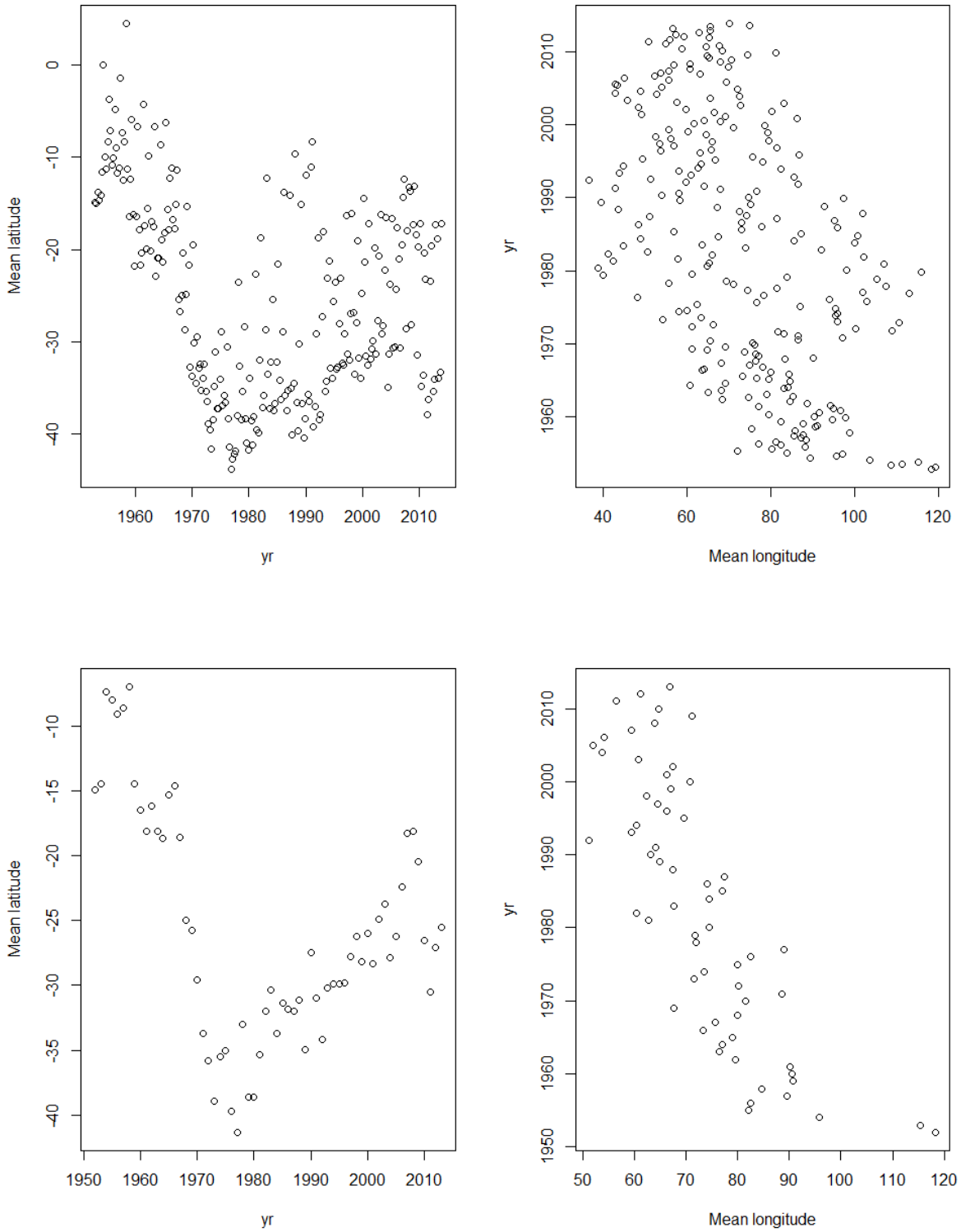

Figure 3: Median location of effort by year-qtr across the Indian Ocean, by year-qtr (top) and year (bottom) and either latitude (left) or longitude (right).

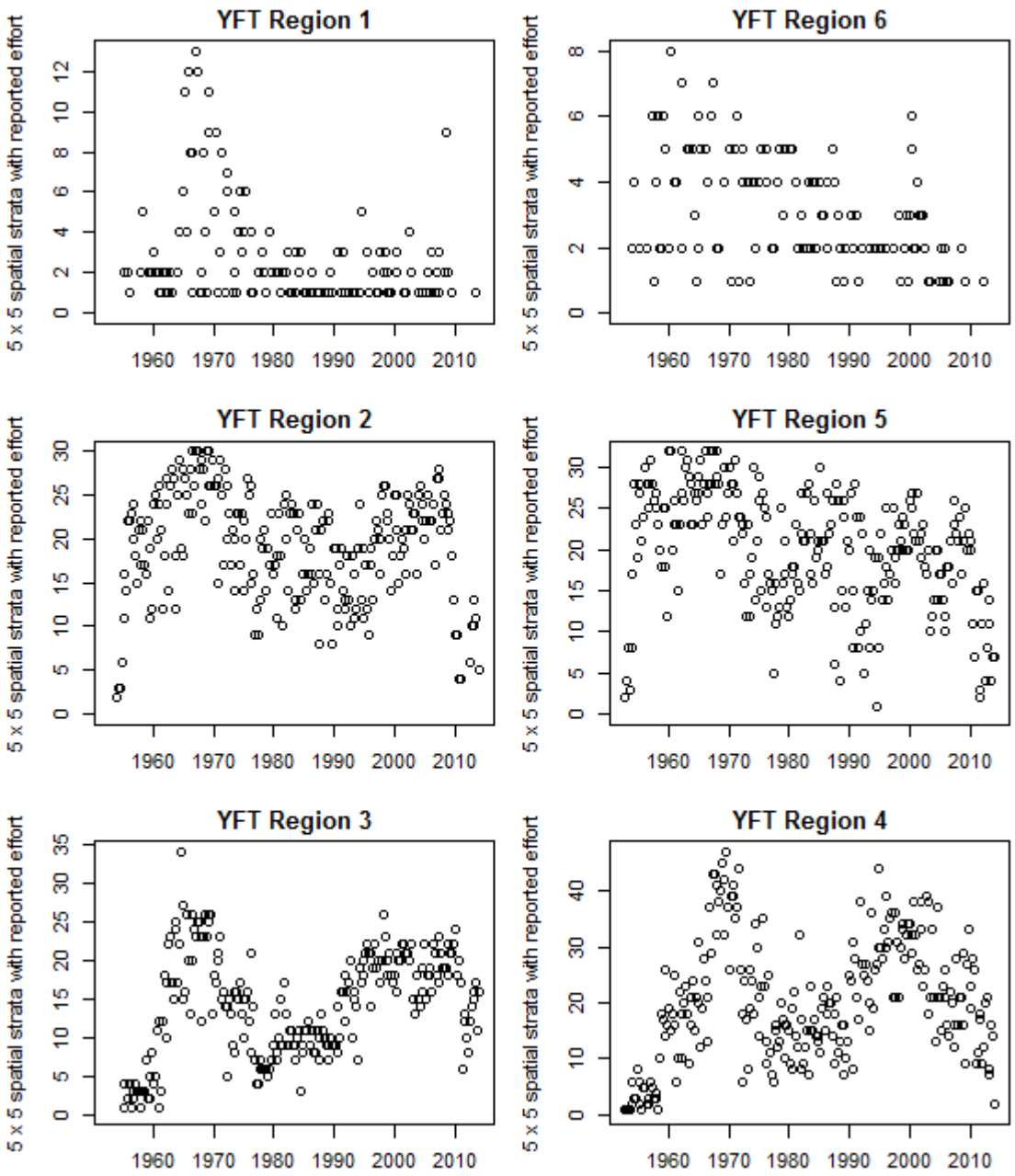

Figure 4: Spatial coverage through time, indicating the number of 5 degree cells with effort by year-qtr and region.

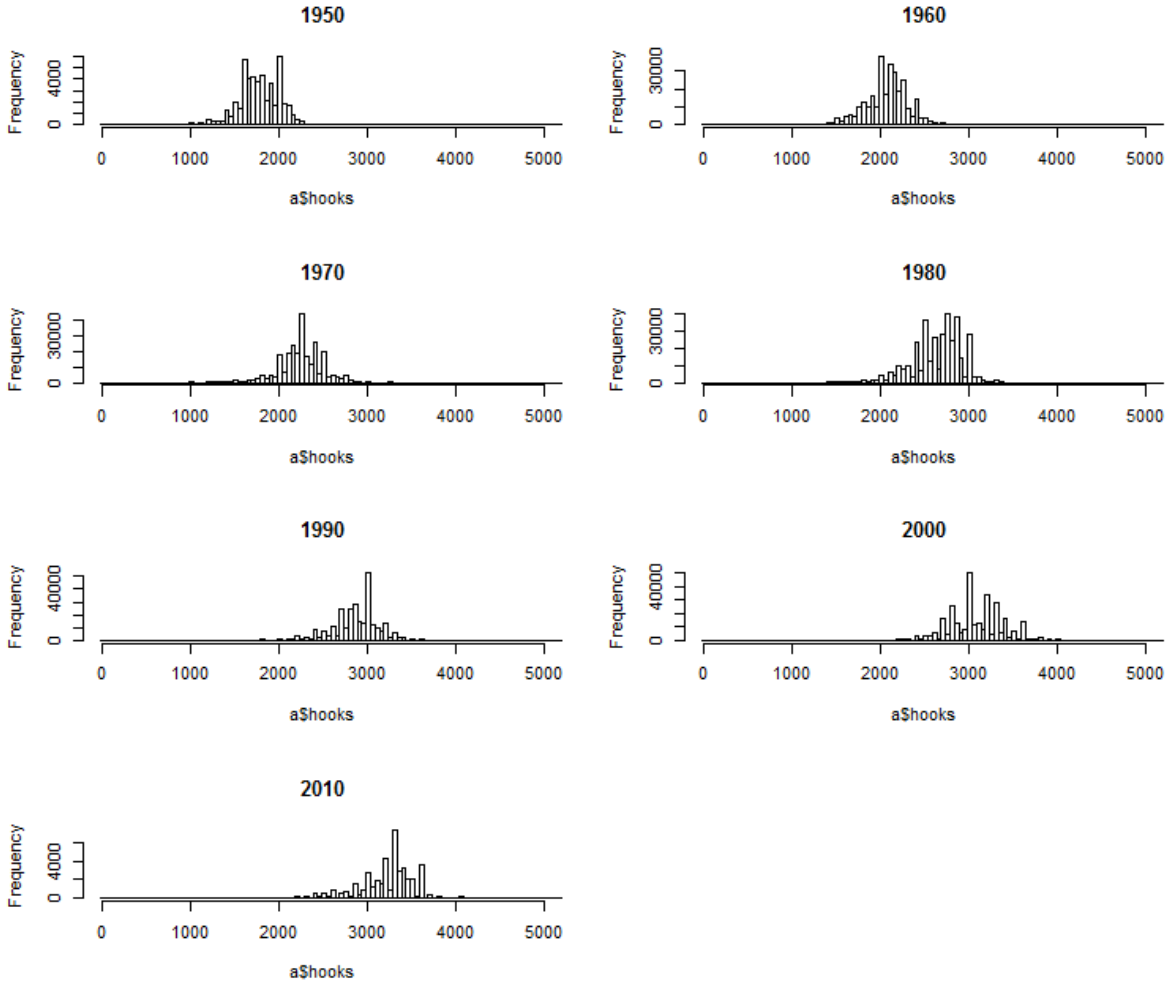

Figure 5: Frequency distribution of hooks per set by 10 year period.

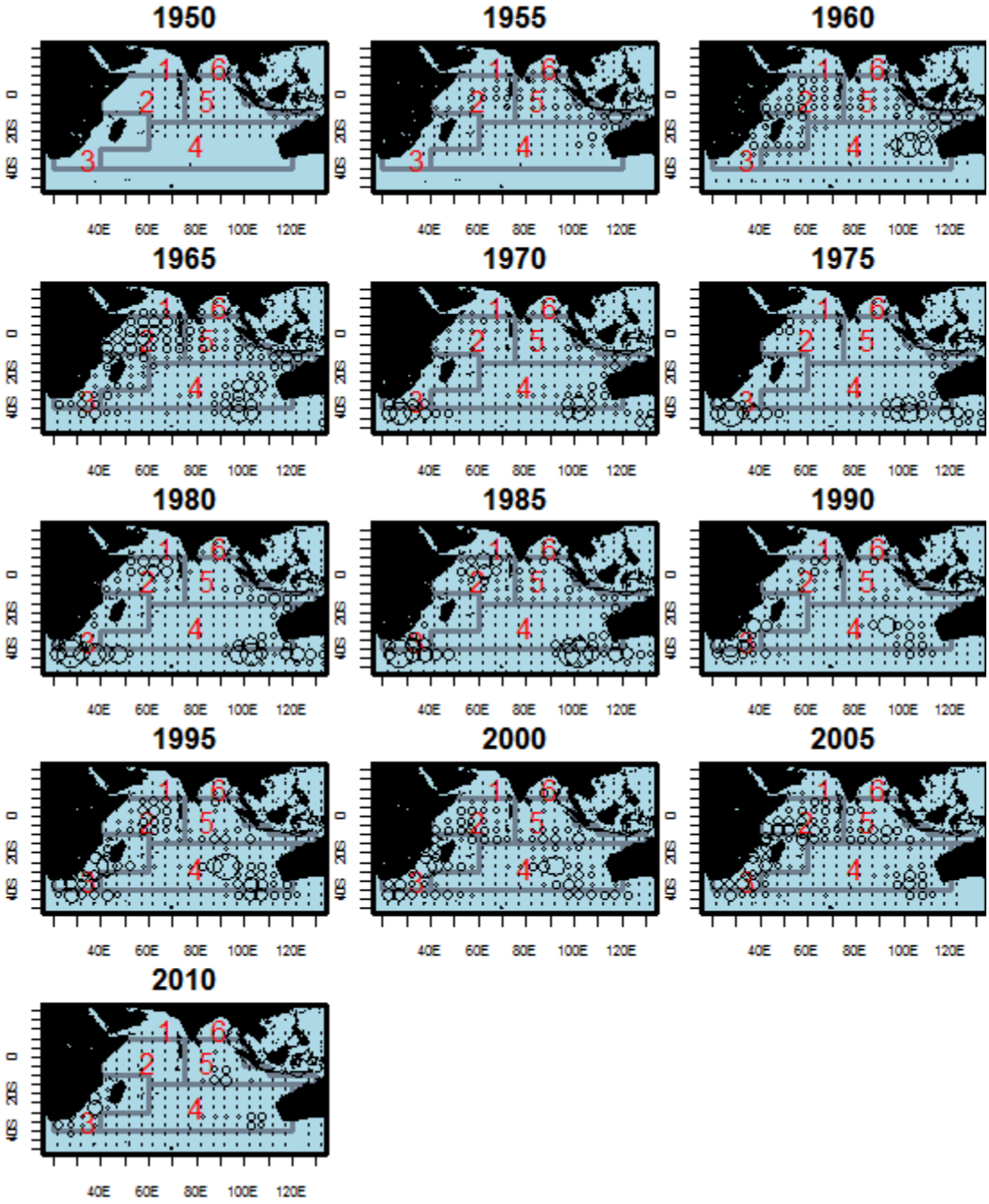

Figure 6: Spatial distribution of sets per 5 degree square by 5 year period.

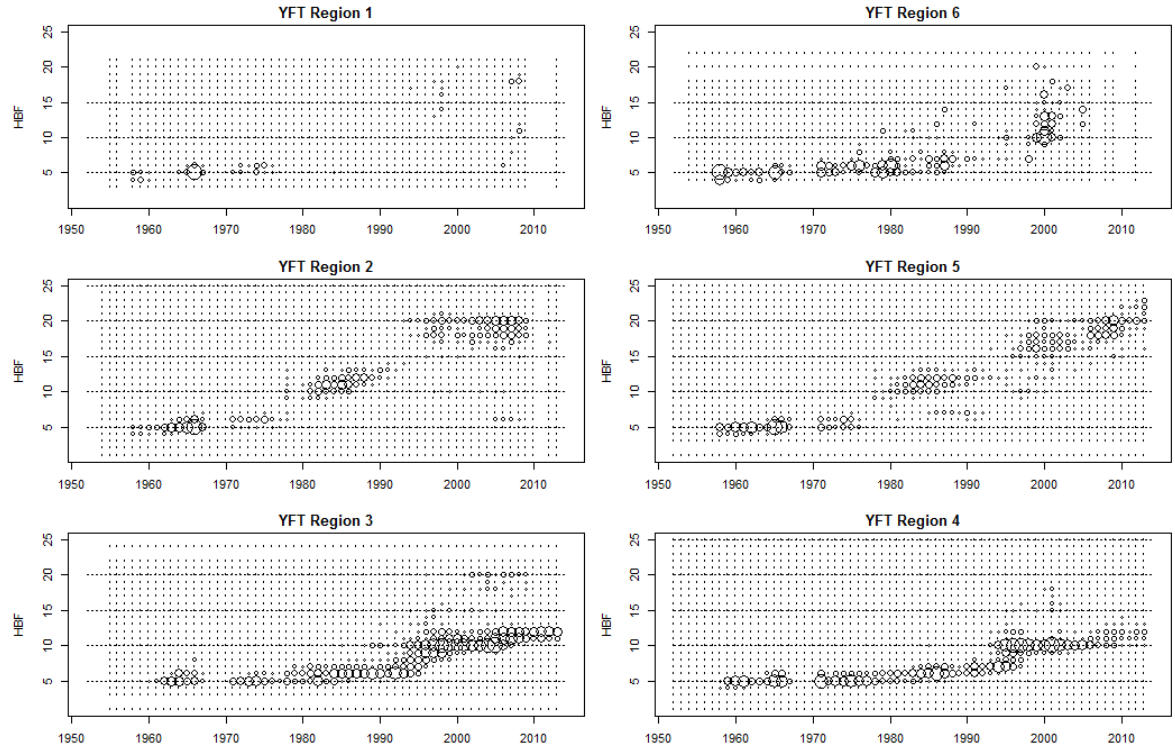

Figure 7: HBF by year and region. Circle area is proportional to effort in hooks.

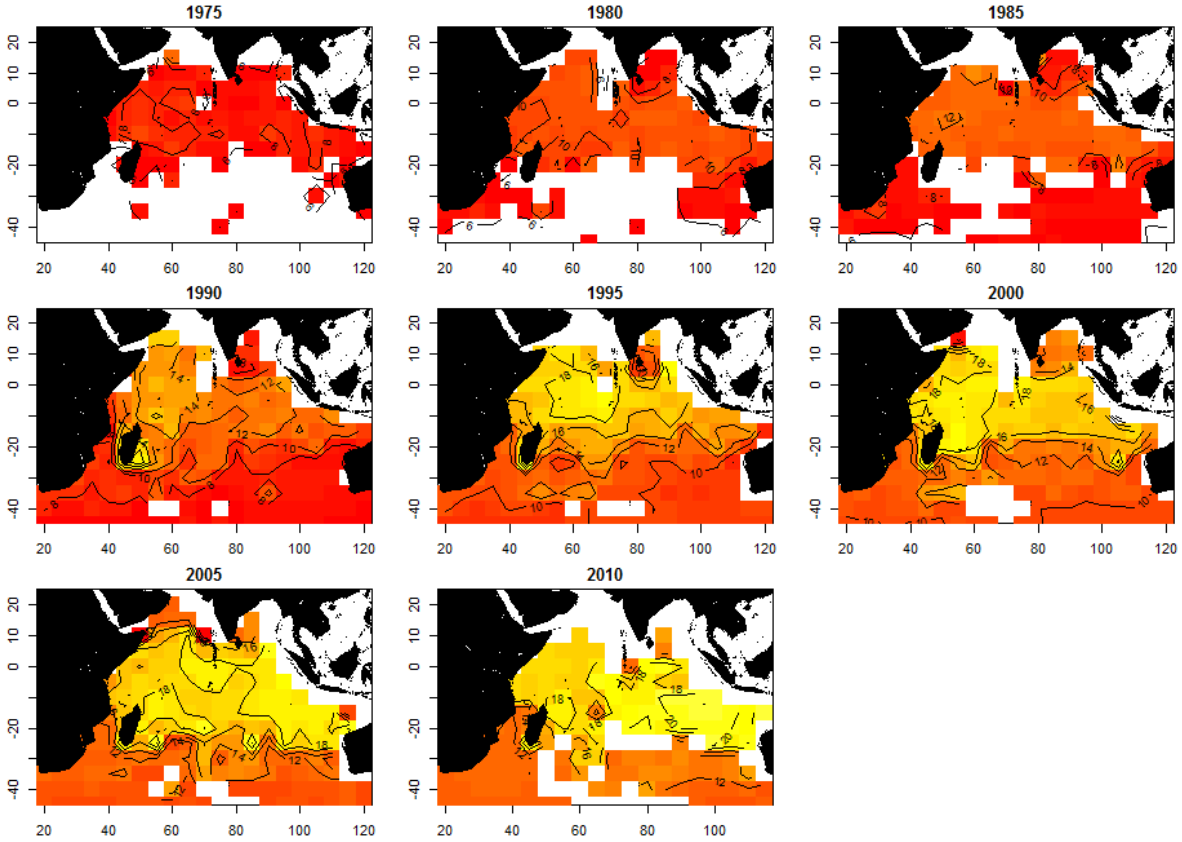

Figure 8: Mean HBF per 5 degree square, by 5 year period.

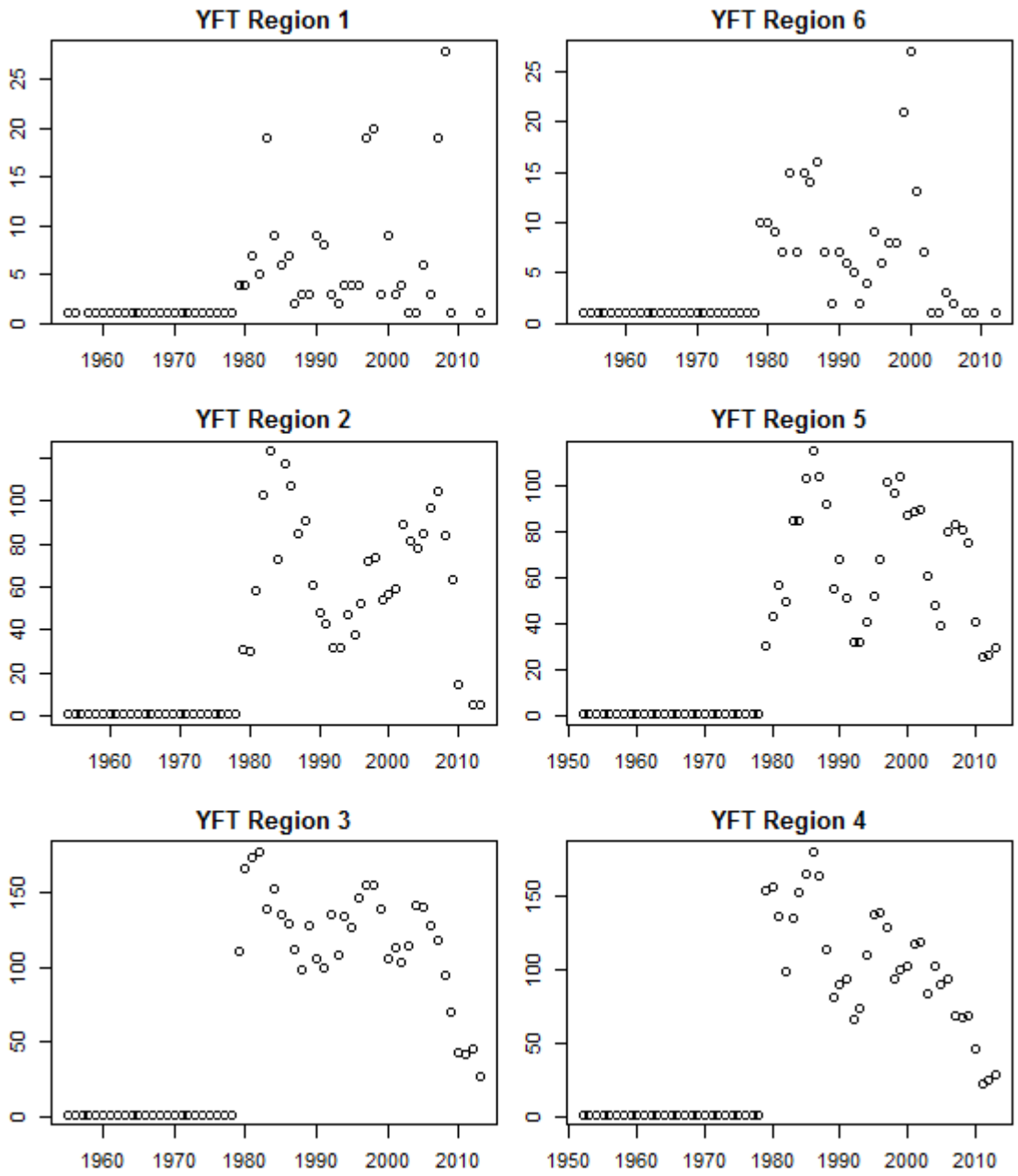

Figure 9: Unique vessels per year by region.

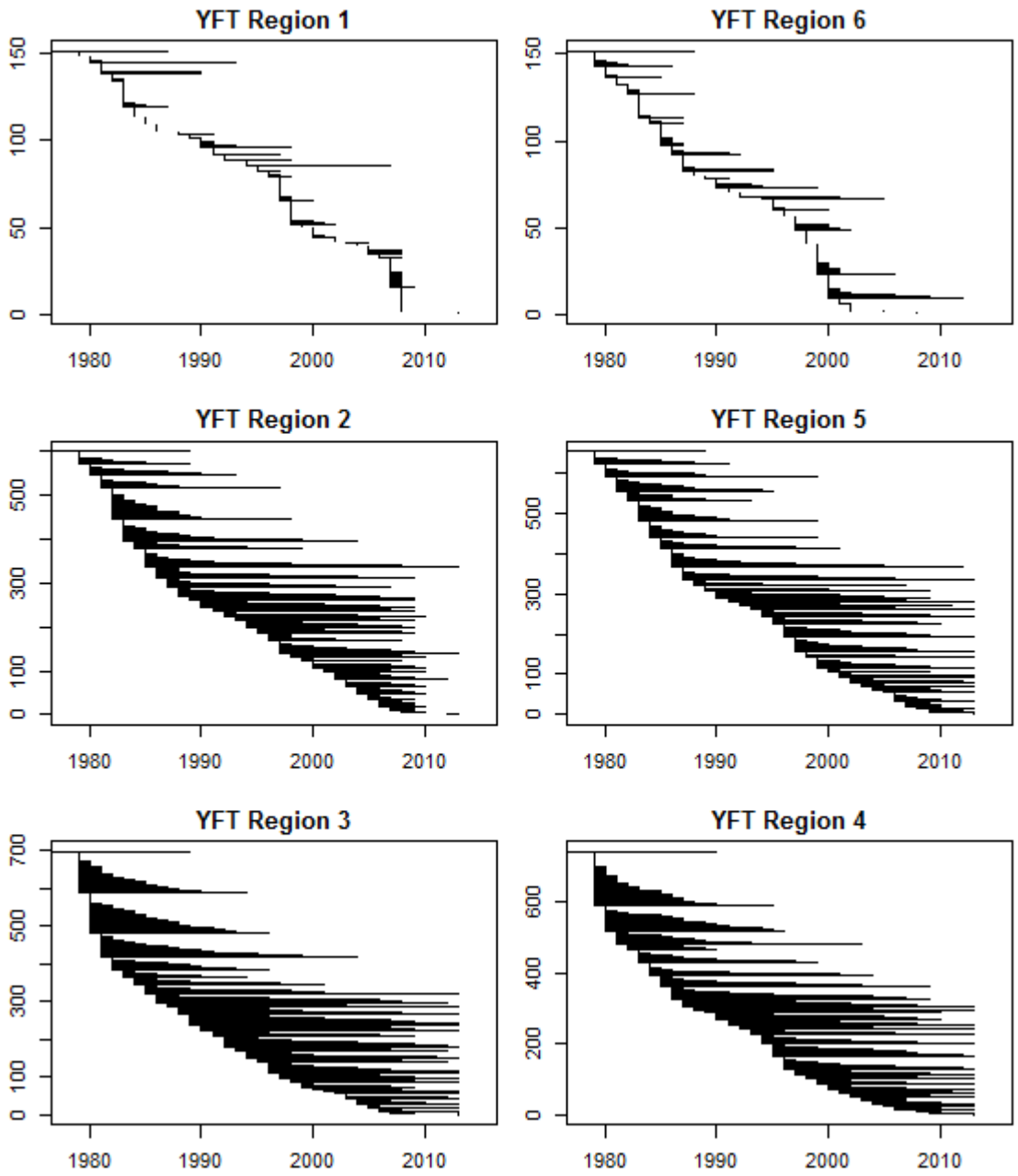

Figure 10: Vessel sorted by year of first set, with a line between the years of first and last set by each vessel.

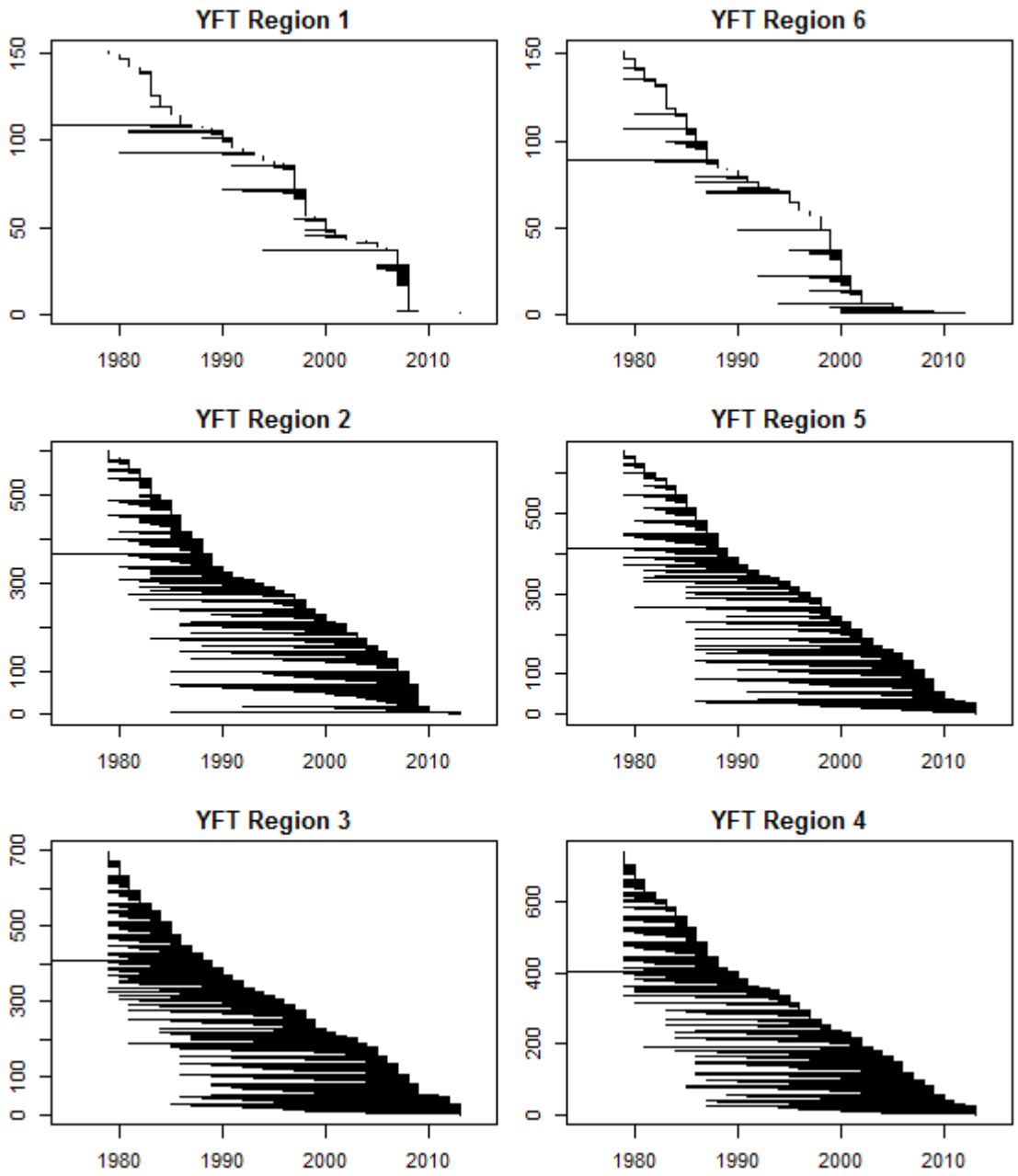

Figure 11: Vessel sorted by year of last set, with a line between the years of first and last set by each vessel. Vessels are coloured by tonnage.

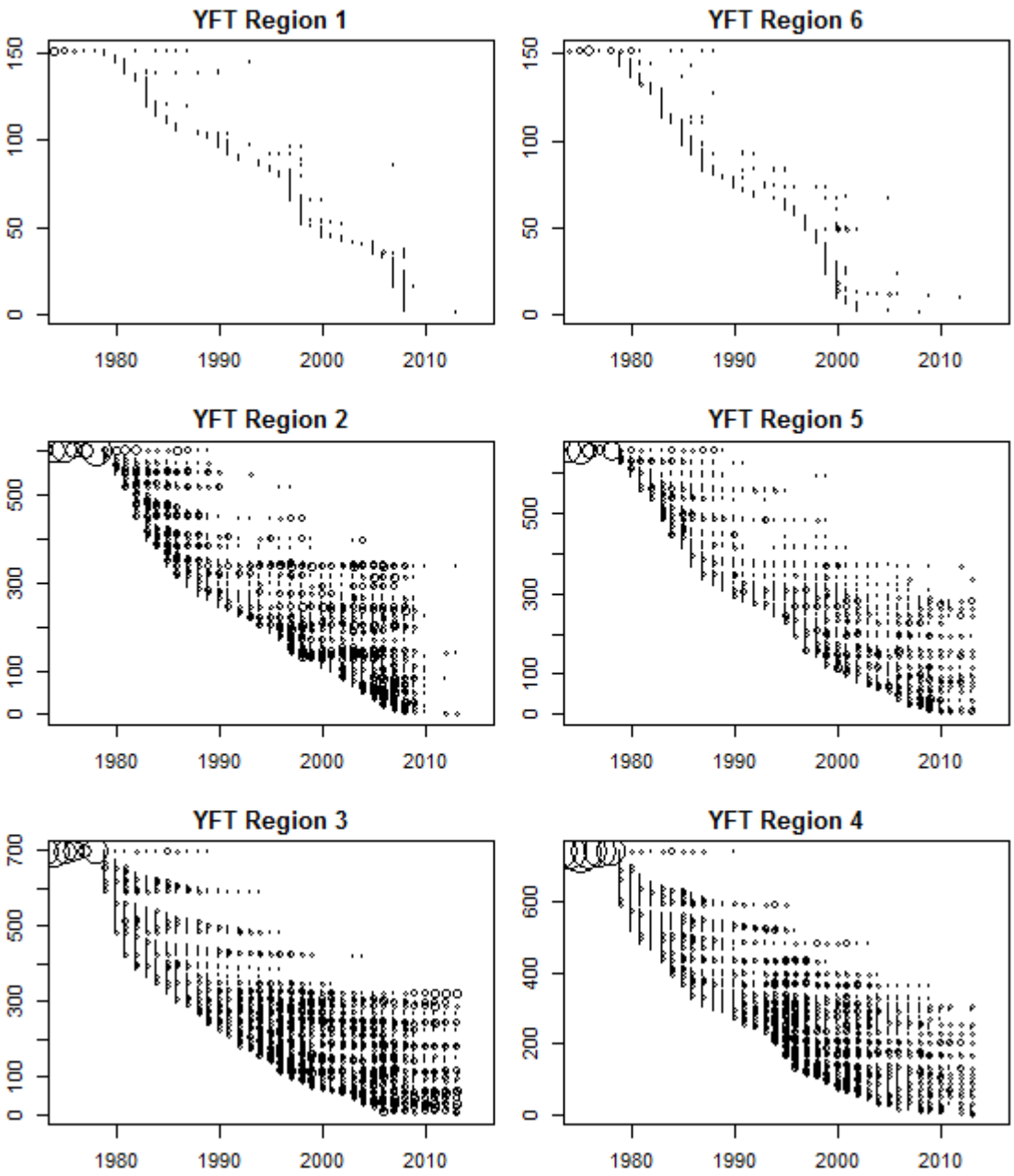

Figure 12: Vessel sorted by year of first set, with circles proportional to number of sets by each vessel.

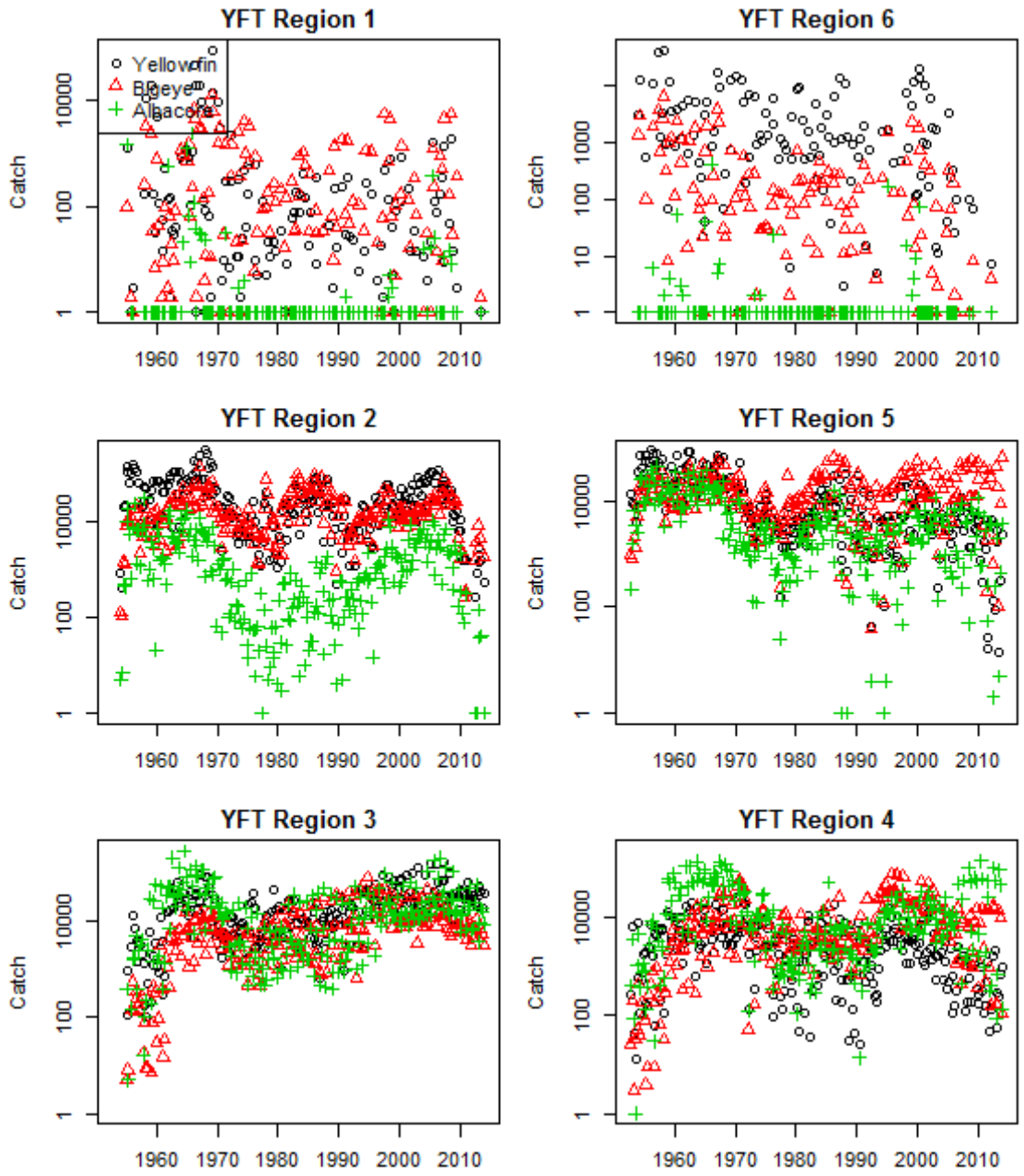

Figure 13: Log(catch) by year-qtr and region for bigeye, yellowfin, and albacore.

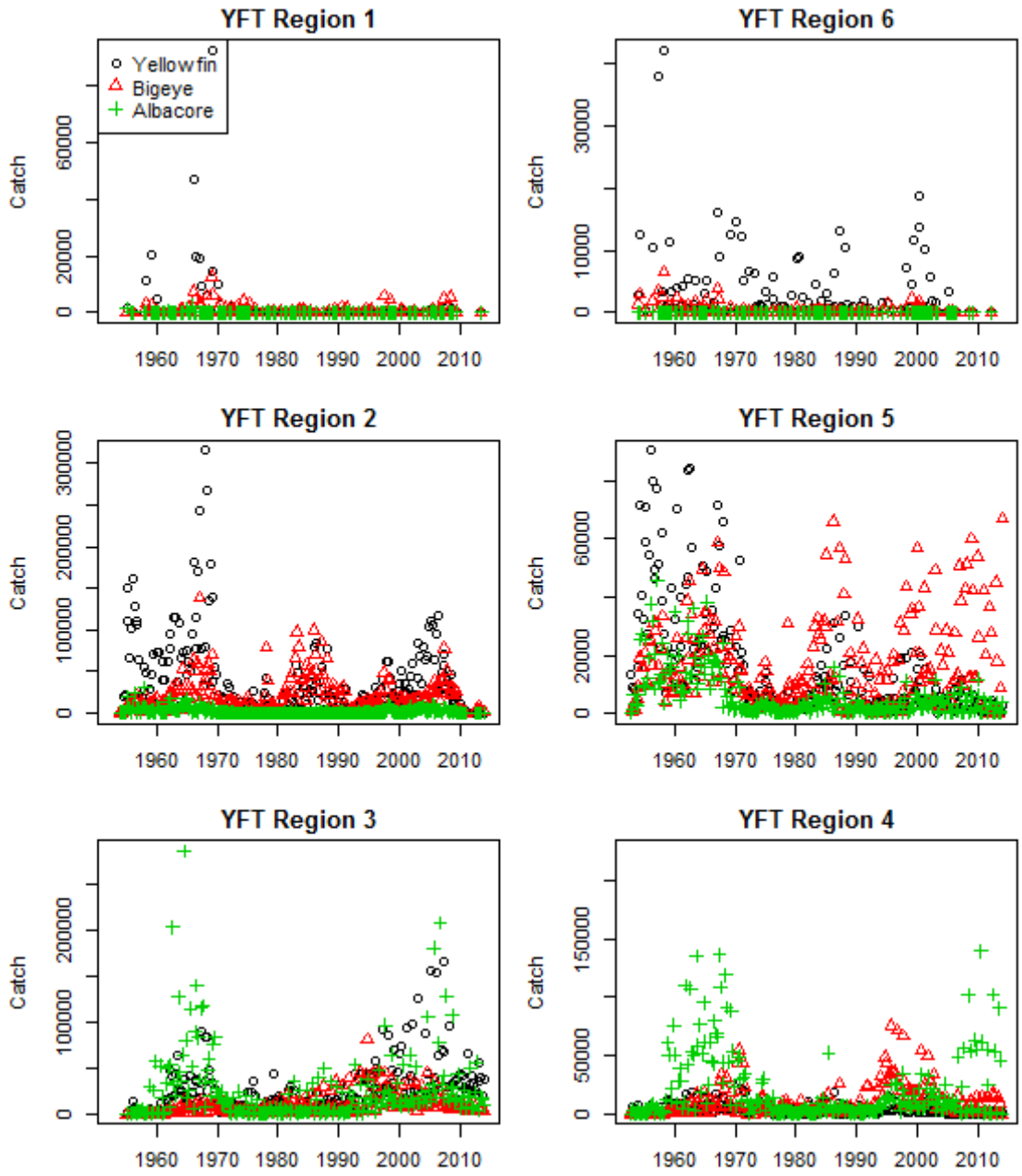

Figure 14: Catch by year-qtr and region for bigeye, yellowfin, and albacore

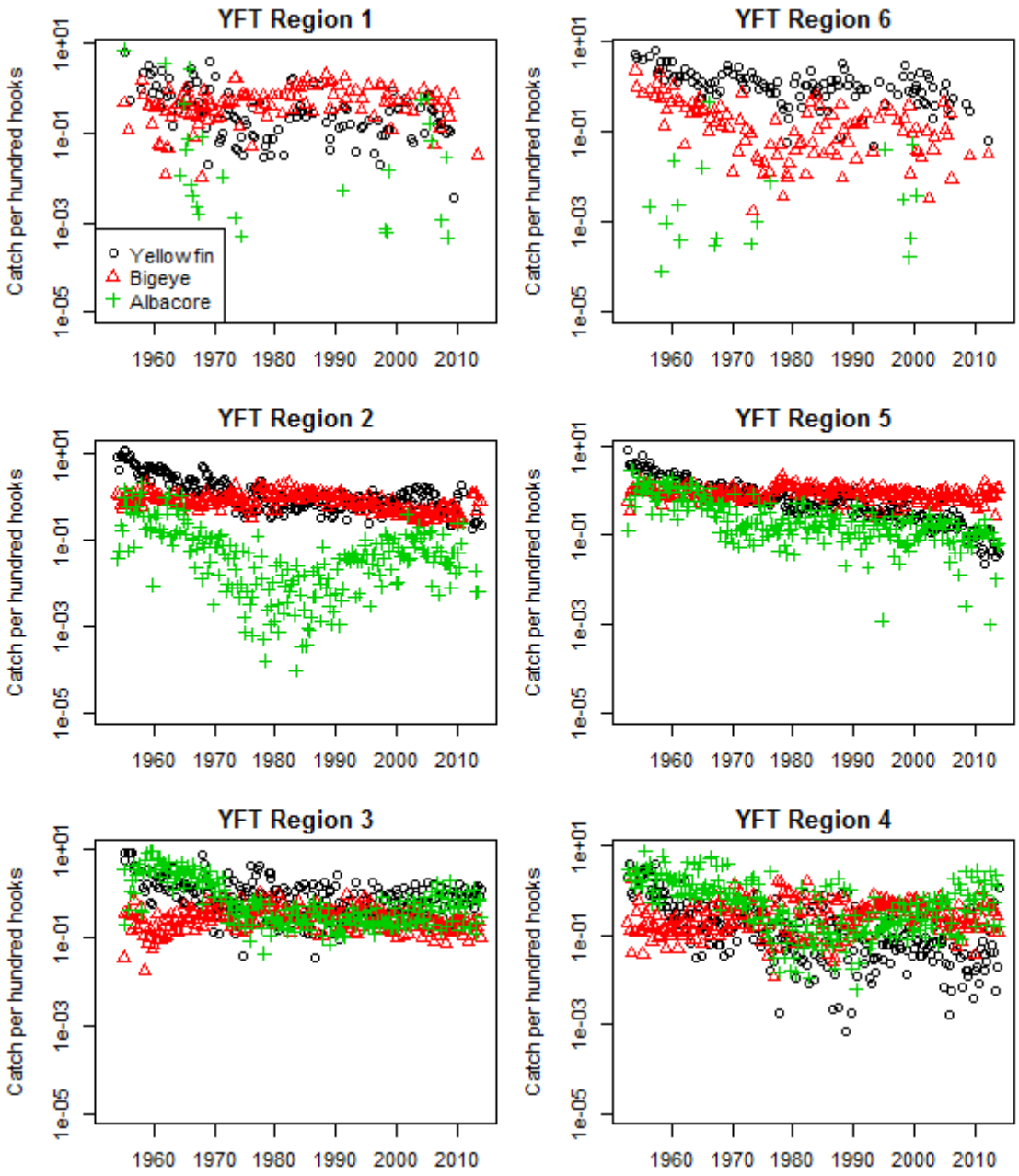

Figure 15: Log(CPUE) by year-qtr and region for yellowfin, bigeye, and albacore.

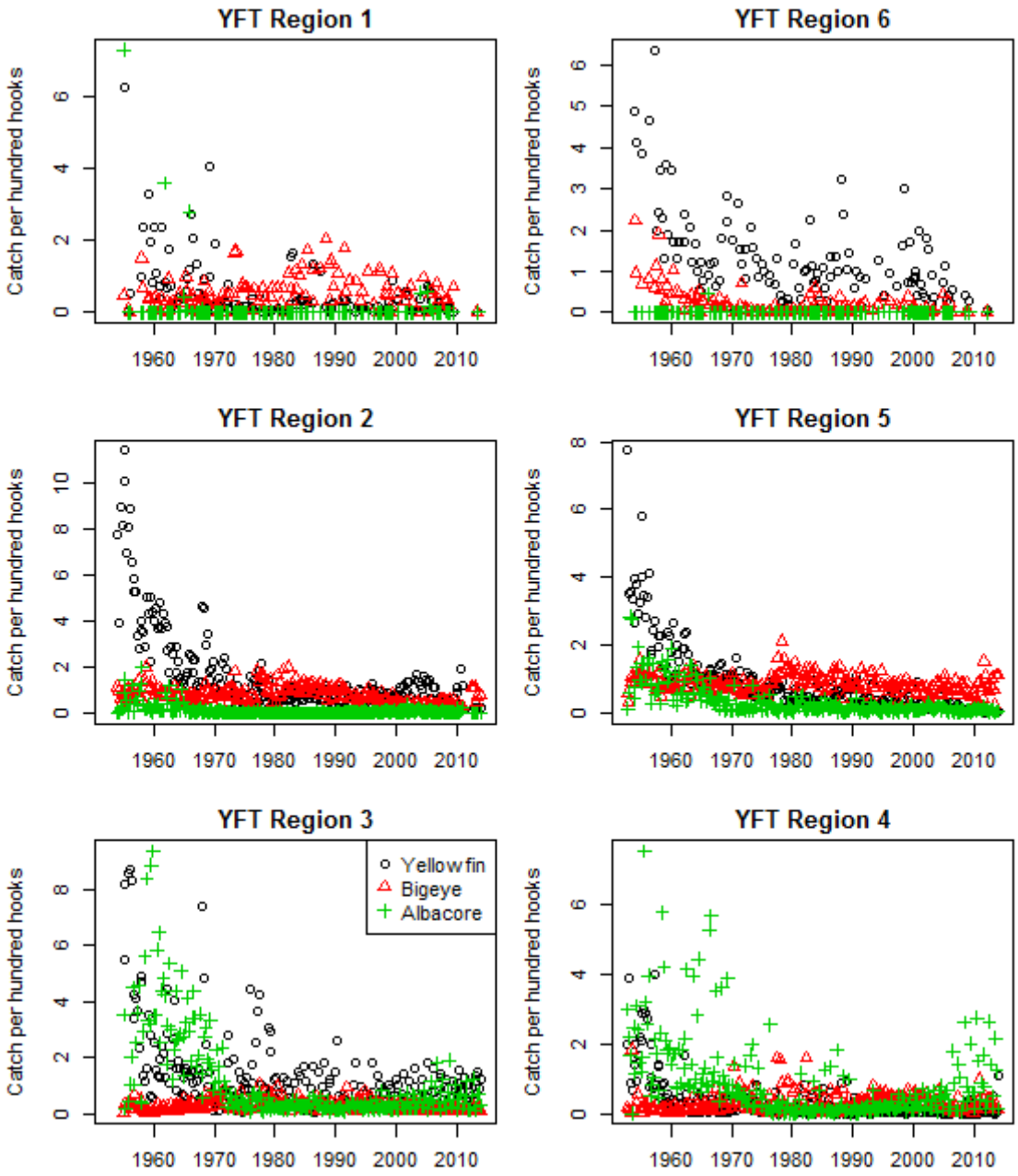

Figure 16: CPUE by year-qtr and region for yellowfin, bigeye, and albacore

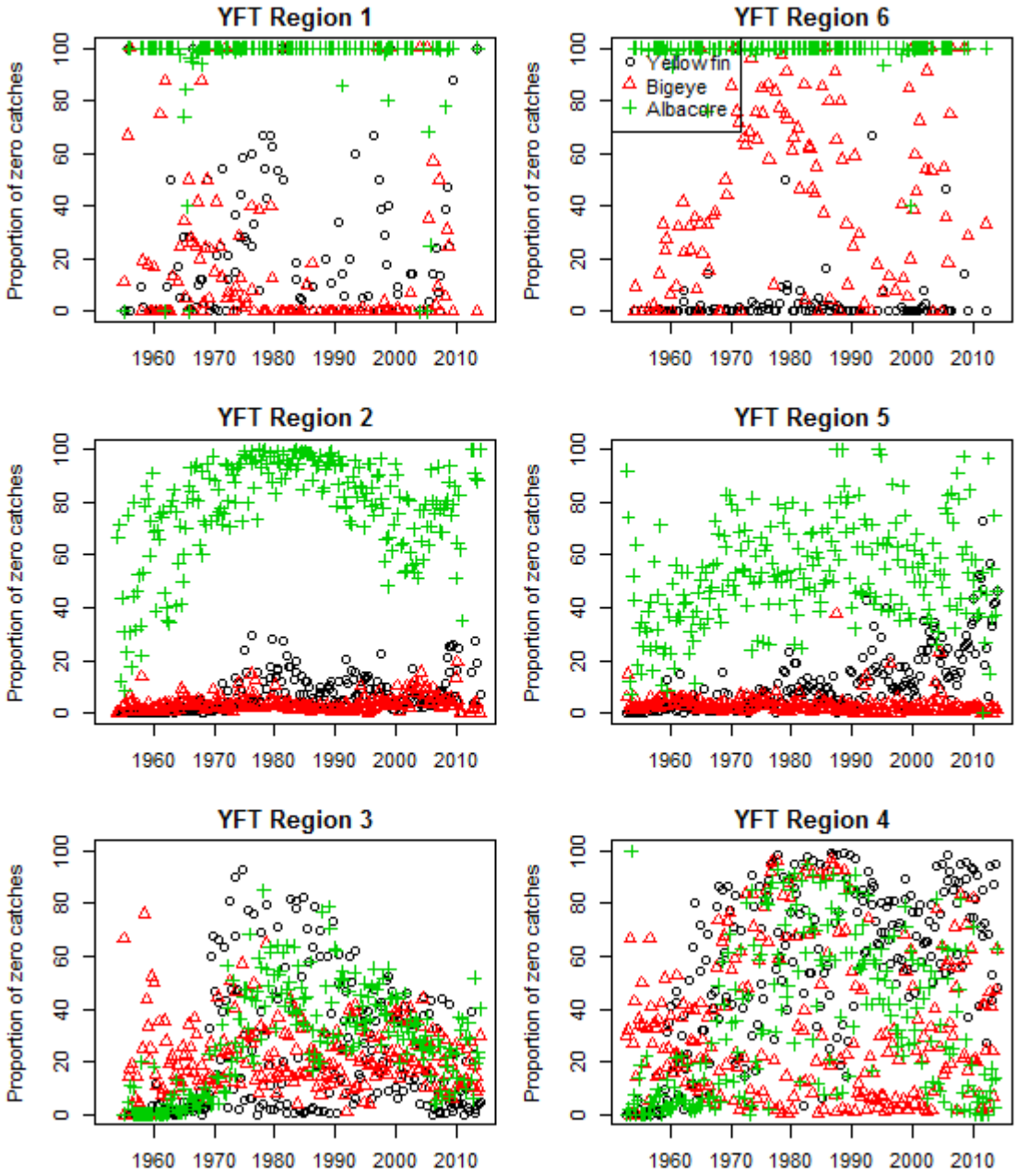

Figure 17: Proportion of zero catches by year-qtr and region for bigeye, yellowfin, and albacore.

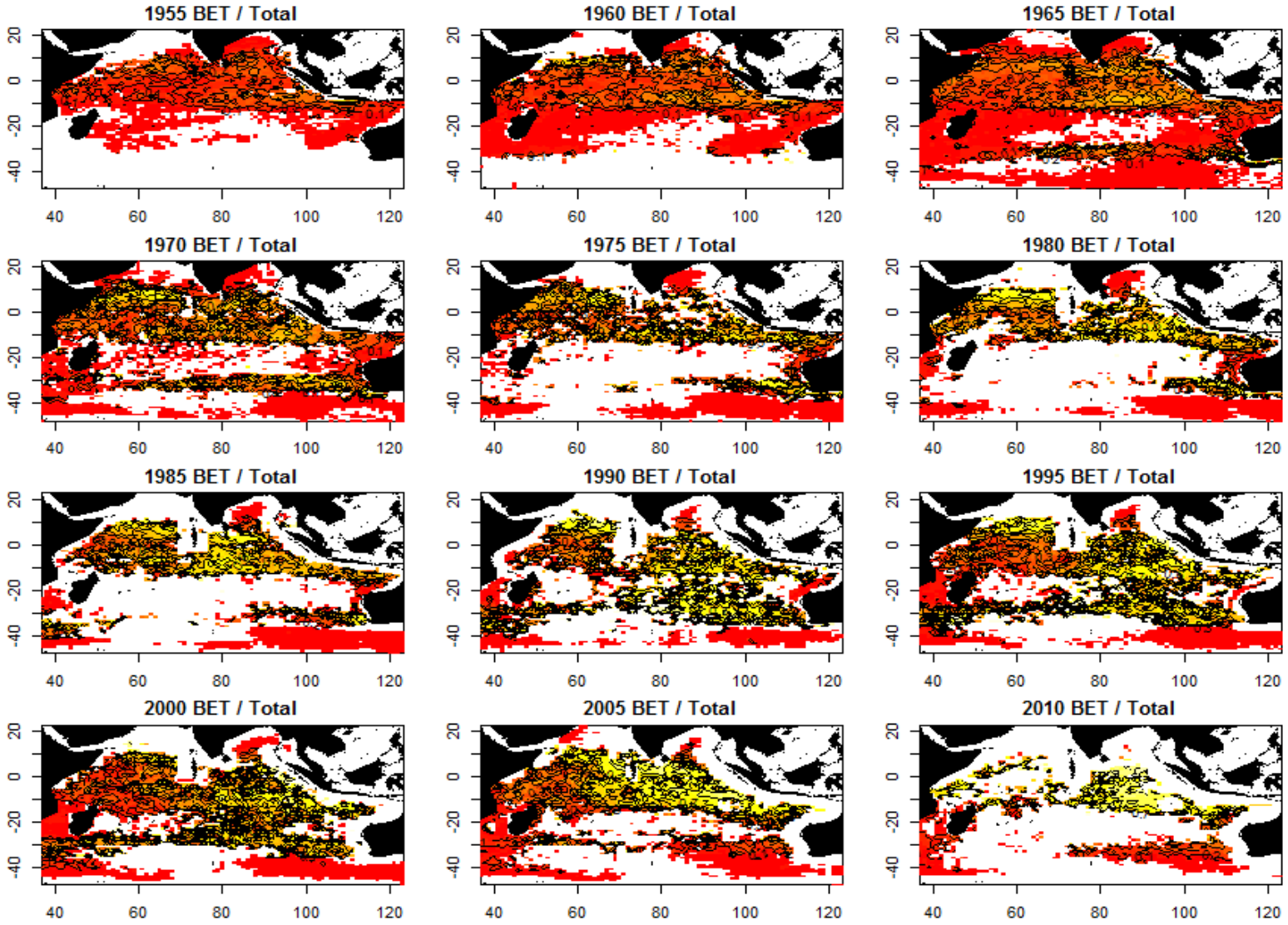

Figure 18: Proportion bigeye in total catch by 5 year period and 1 degree square. Yellow indicates higher proportion. Contour lines are at 0.1 intervals.

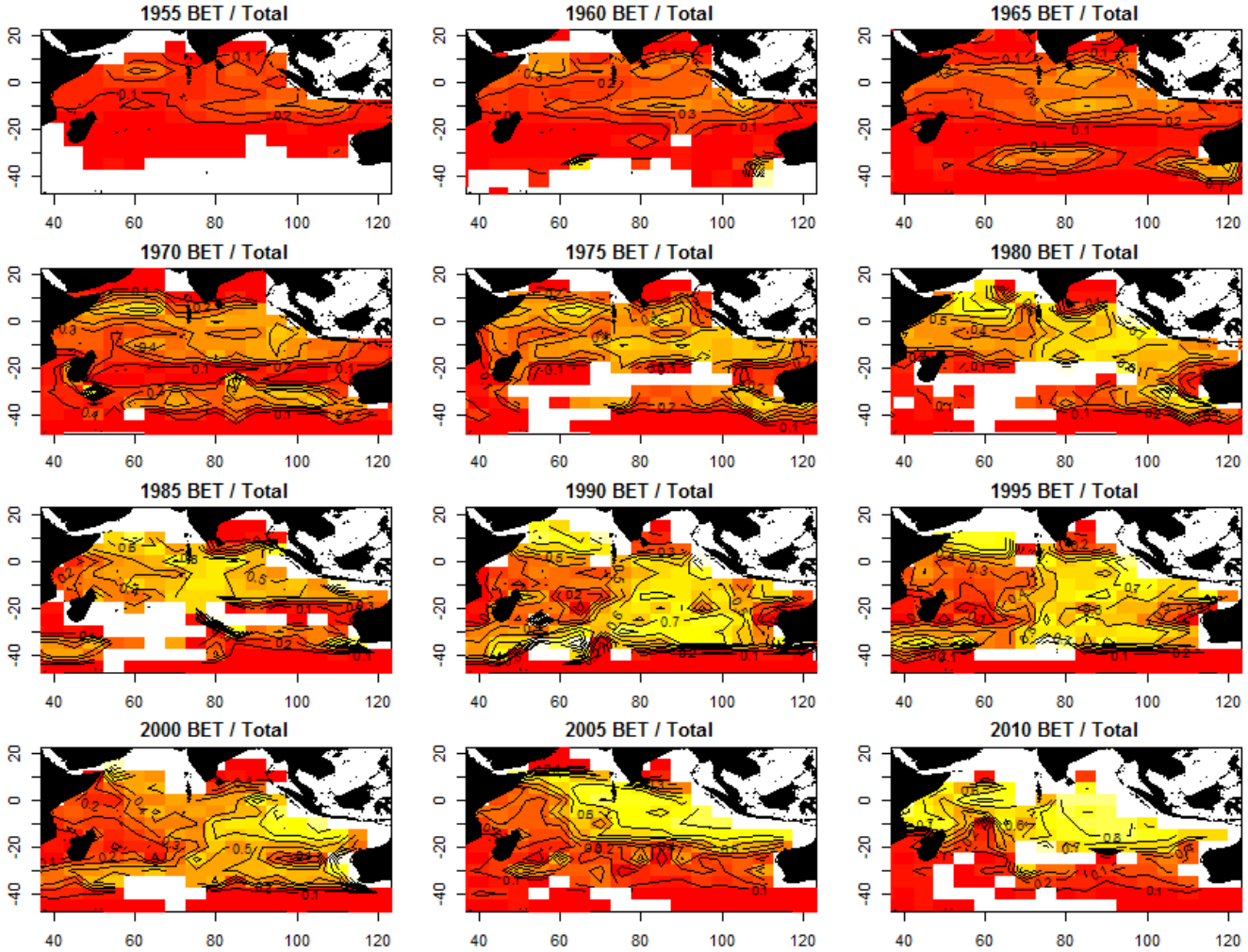

Figure 19: Proportion bigeye in total catch by decade and 5 degree square. Yellow indicates higher proportion. Contour lines are at 0.1 intervals.

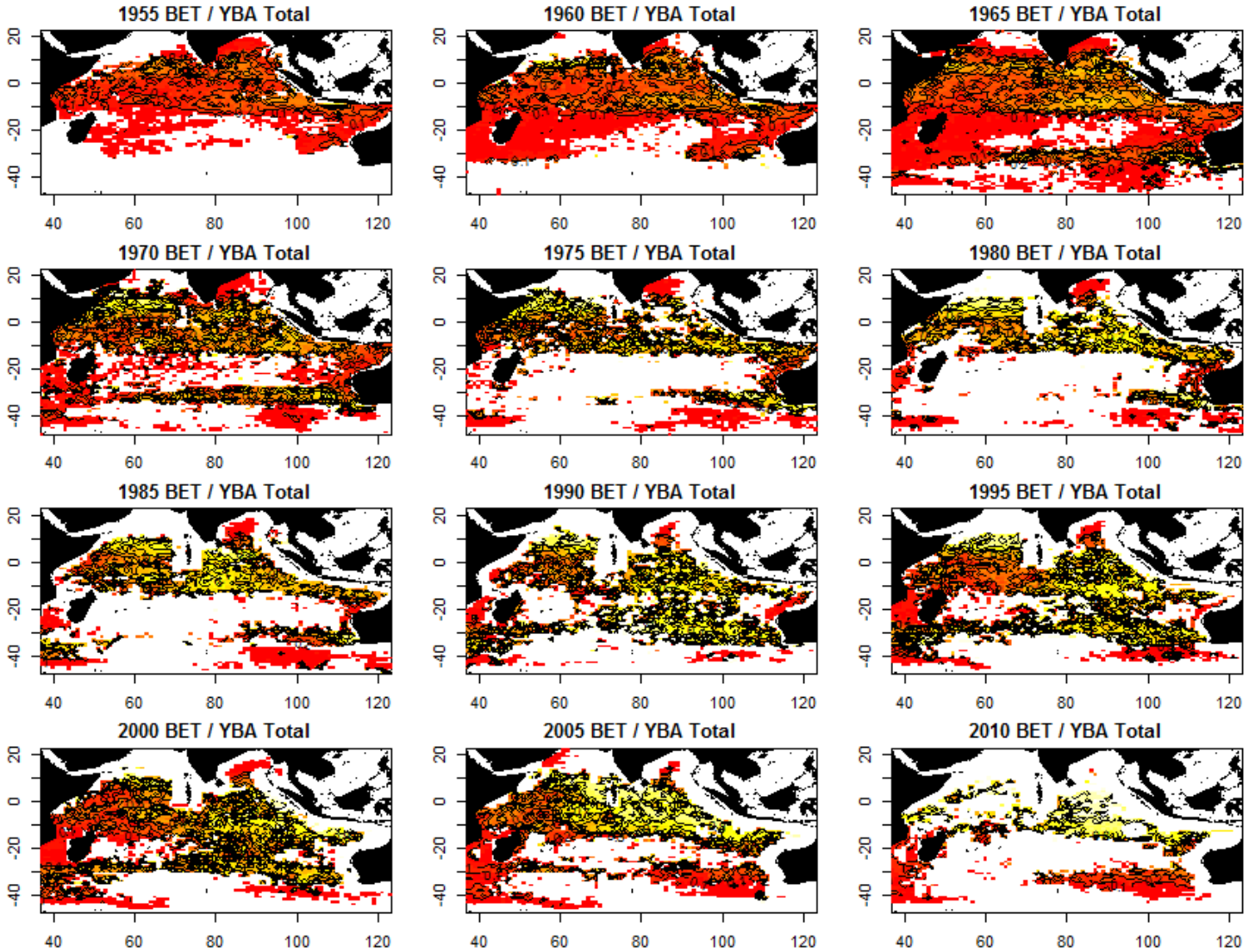

Figure 20: Proportion bigeye in catch of yellowfin, bigeye, and albacore (YBA) by 5 year period and 1 degree square. Yellow indicates higher proportion. Contour lines are at 0.1 intervals.

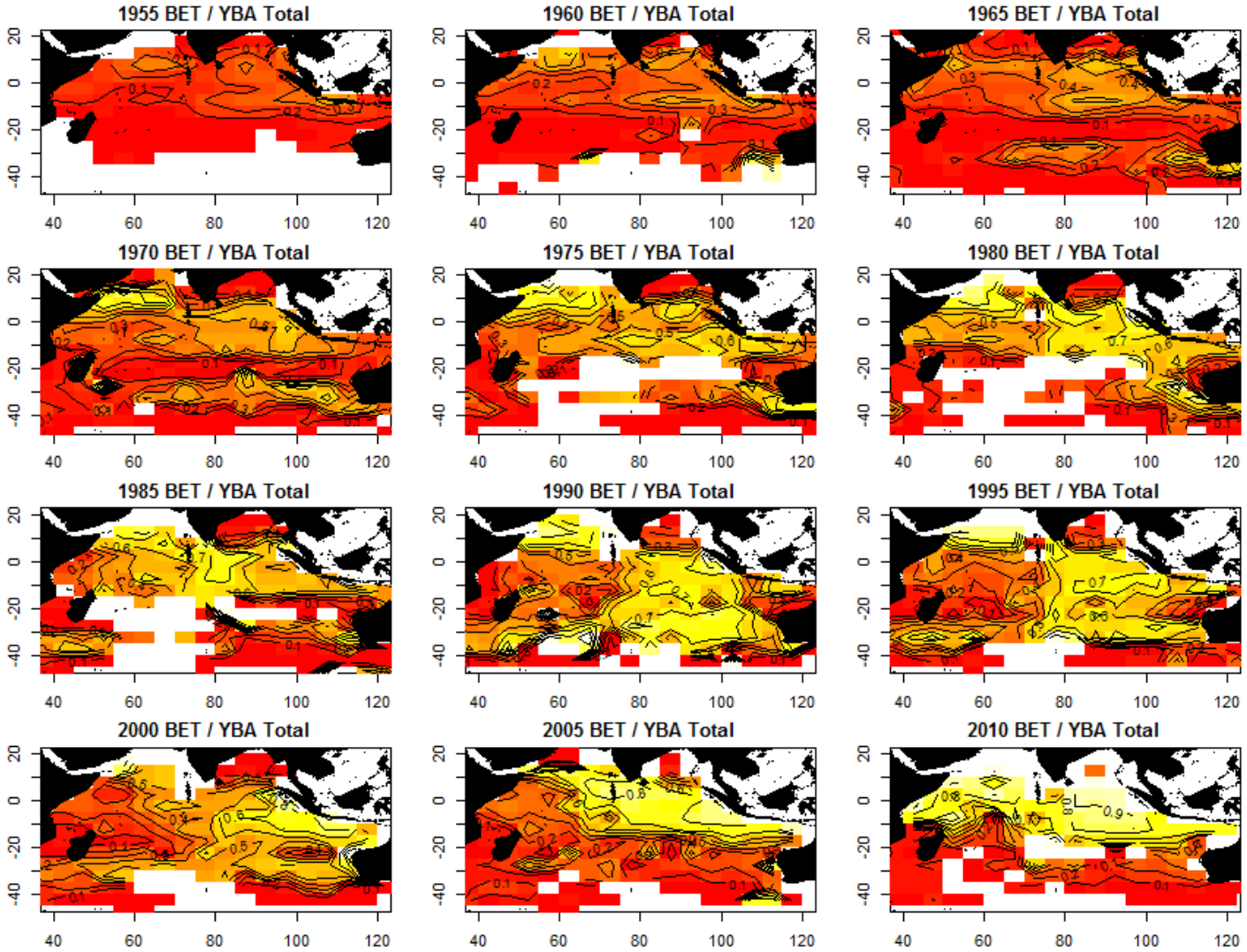

Figure 21: Proportion bigeye in catch of yellowfin, bigeye, and albacore (YBA) by 5 year period and 5 degree square. Yellow indicates higher proportion. Contour lines are at 0.1 intervals.

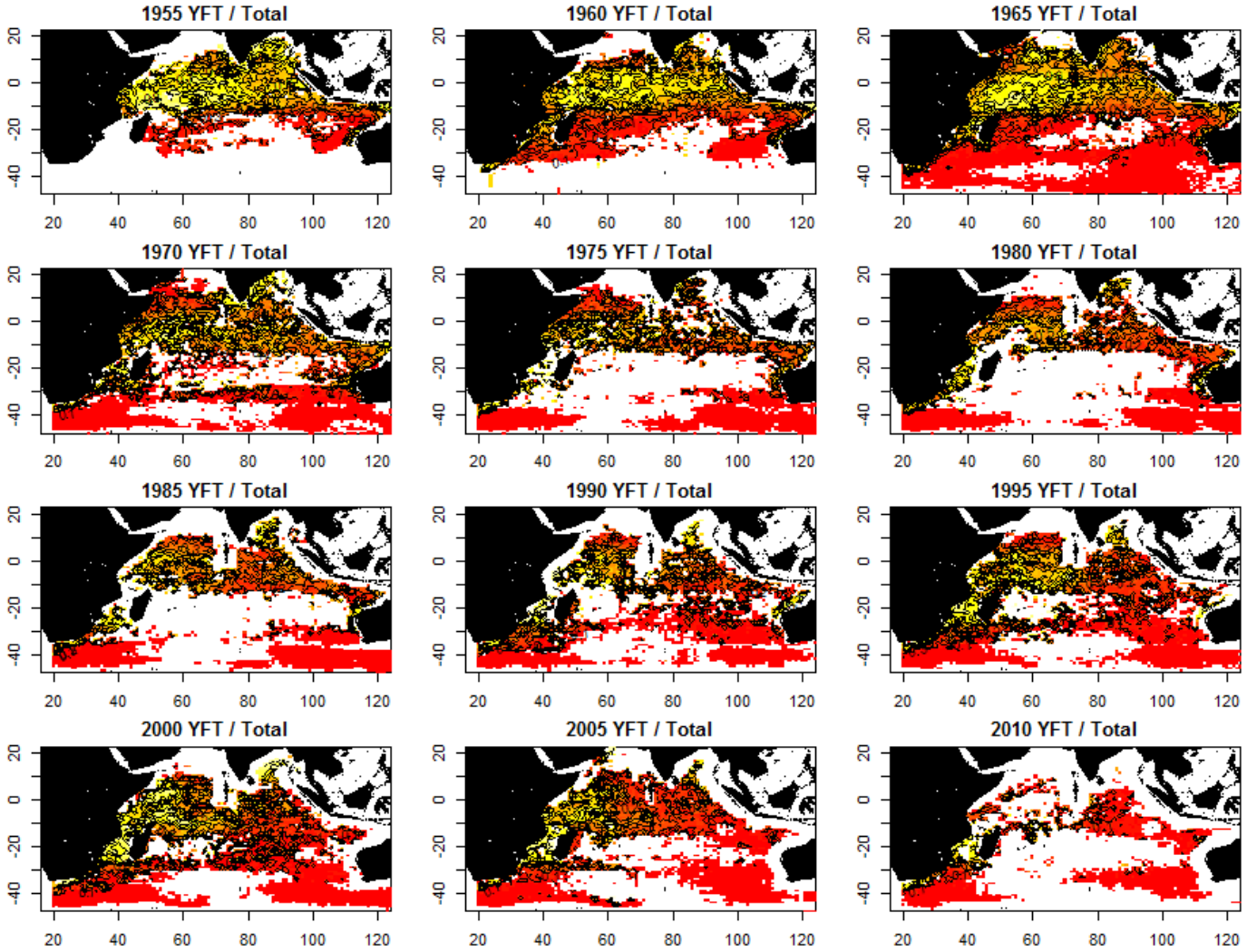

Figure 22: Proportion yellowfin in total catch by 5 year period and 1 degree square. Yellow indicates higher proportion. Contour lines are at 0.1 intervals.

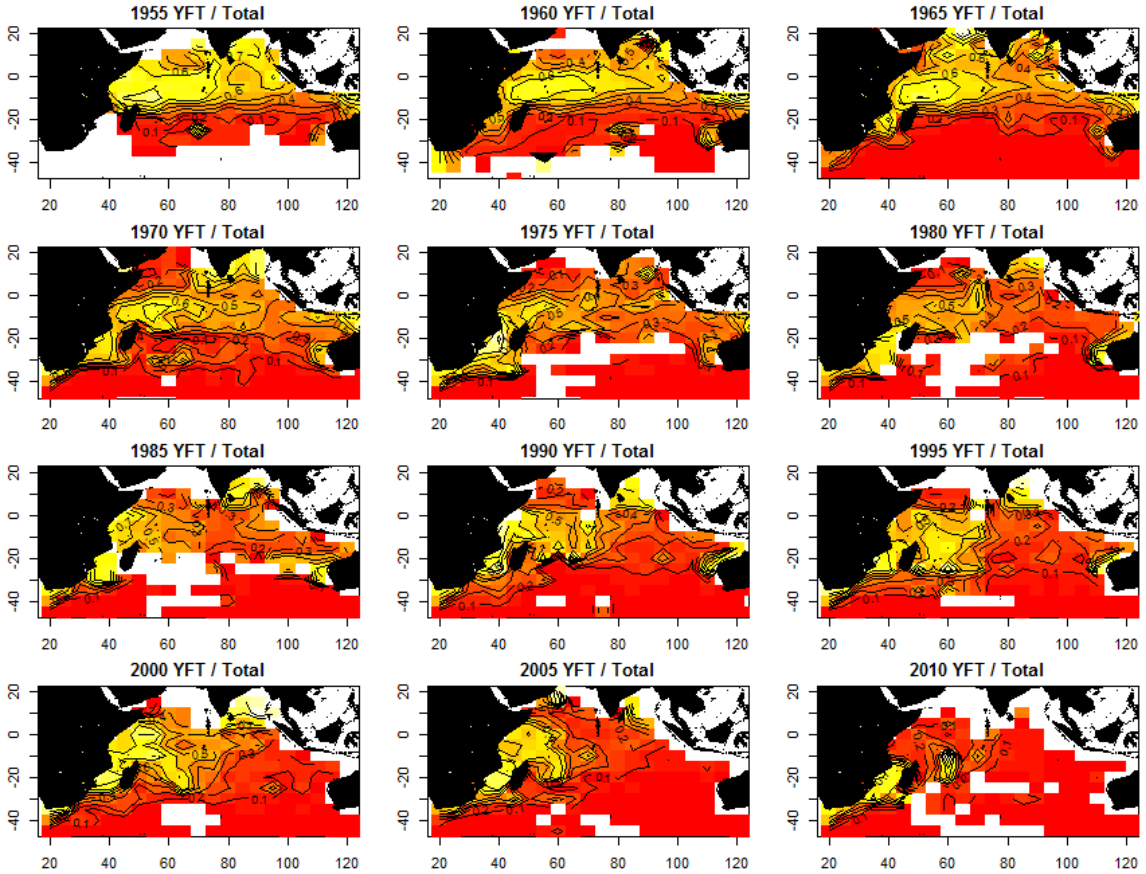

Figure 23: Proportion yellowfin in total catch by 5 year period and 5 degree square. Yellow indicates higher proportion. Contour lines are at 0.1 intervals.

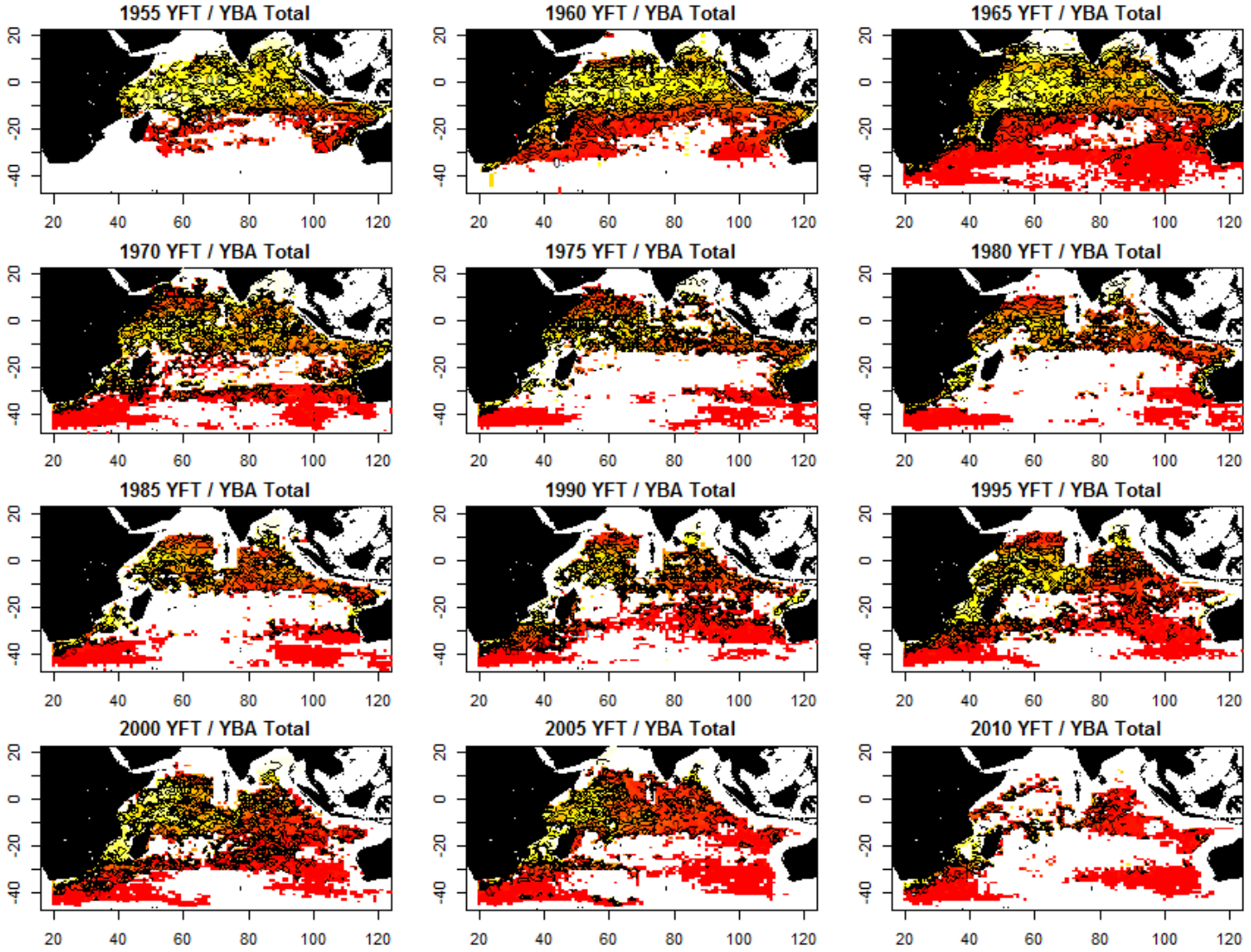

Figure 24: Proportion yellowfin in catch of yellowfin, bigeye, and albacore (YBA) by 5 year period and 1 degree square. Yellow indicates higher proportion. Contour lines are at 0.1 intervals.

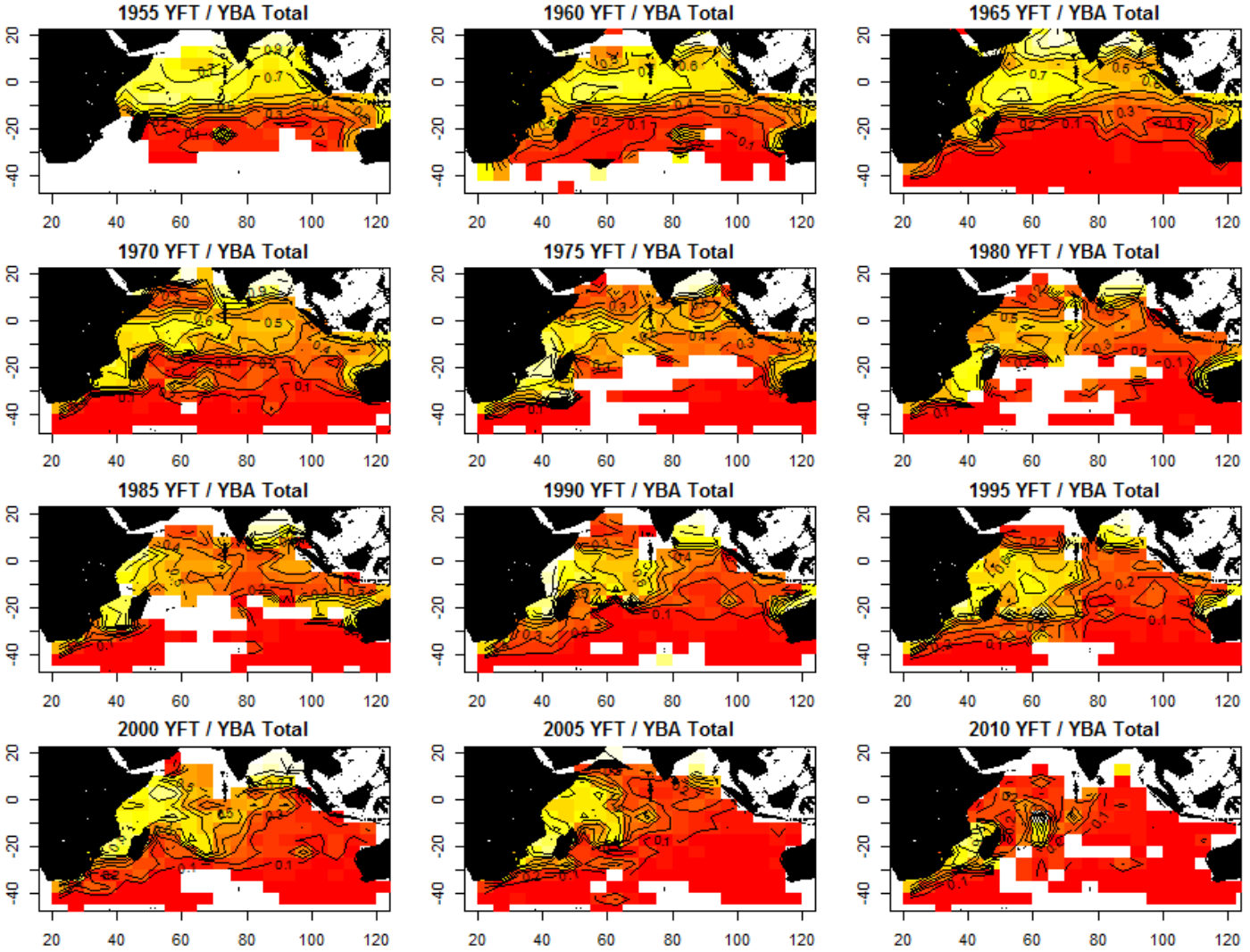

Figure 25: Proportion yellowfin in catch of yellowfin, bigeye, and albacore (YBA) by 5 year period and 5 degree square. Yellow indicates higher proportion. Contour lines are at 0.1 intervals.

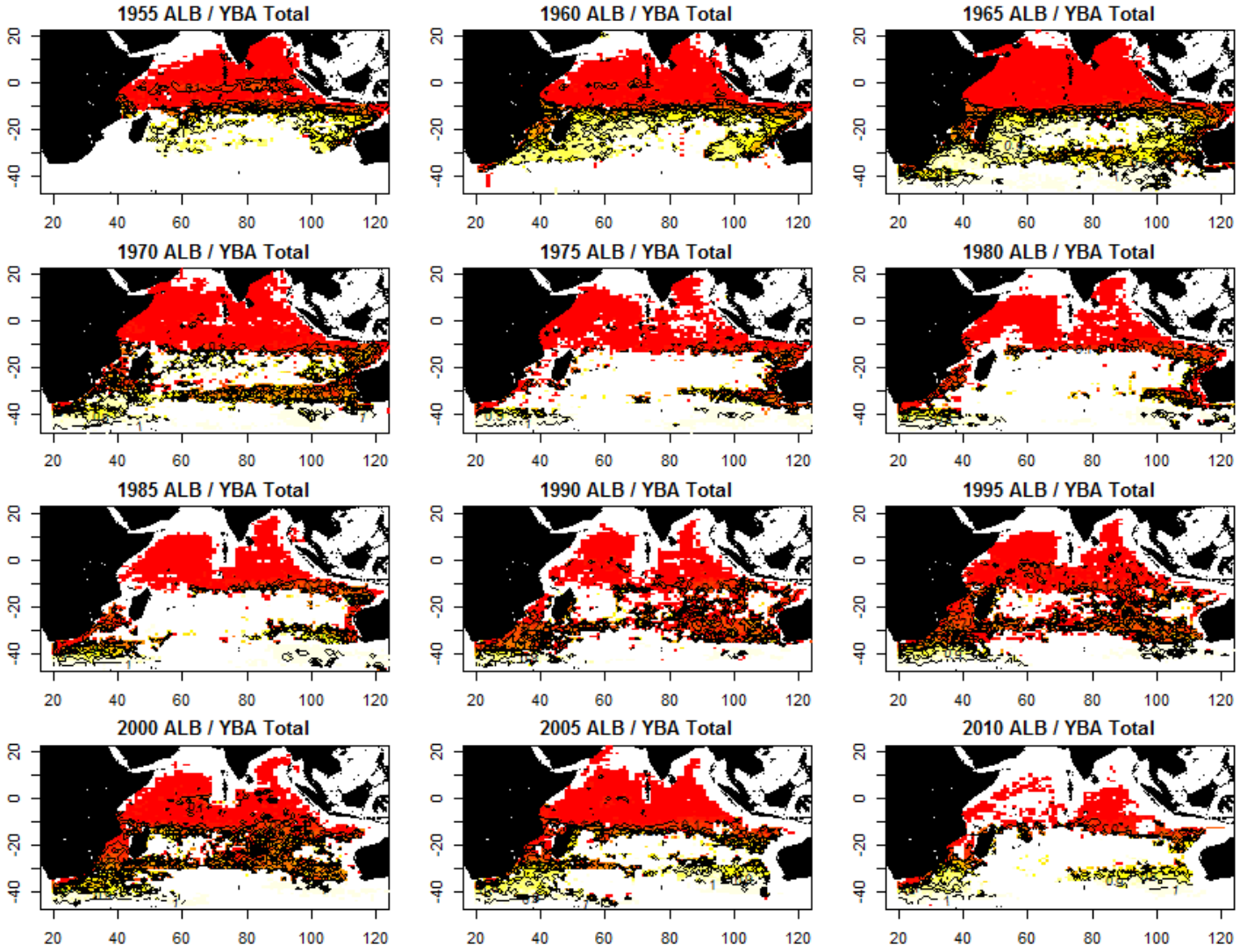

Figure 26: Proportion albacore in catch of yellowfin, bigeye, and albacore by 5 year period and 1 degree square. Yellow indicates higher proportion. Contour lines are at 0.1 intervals.

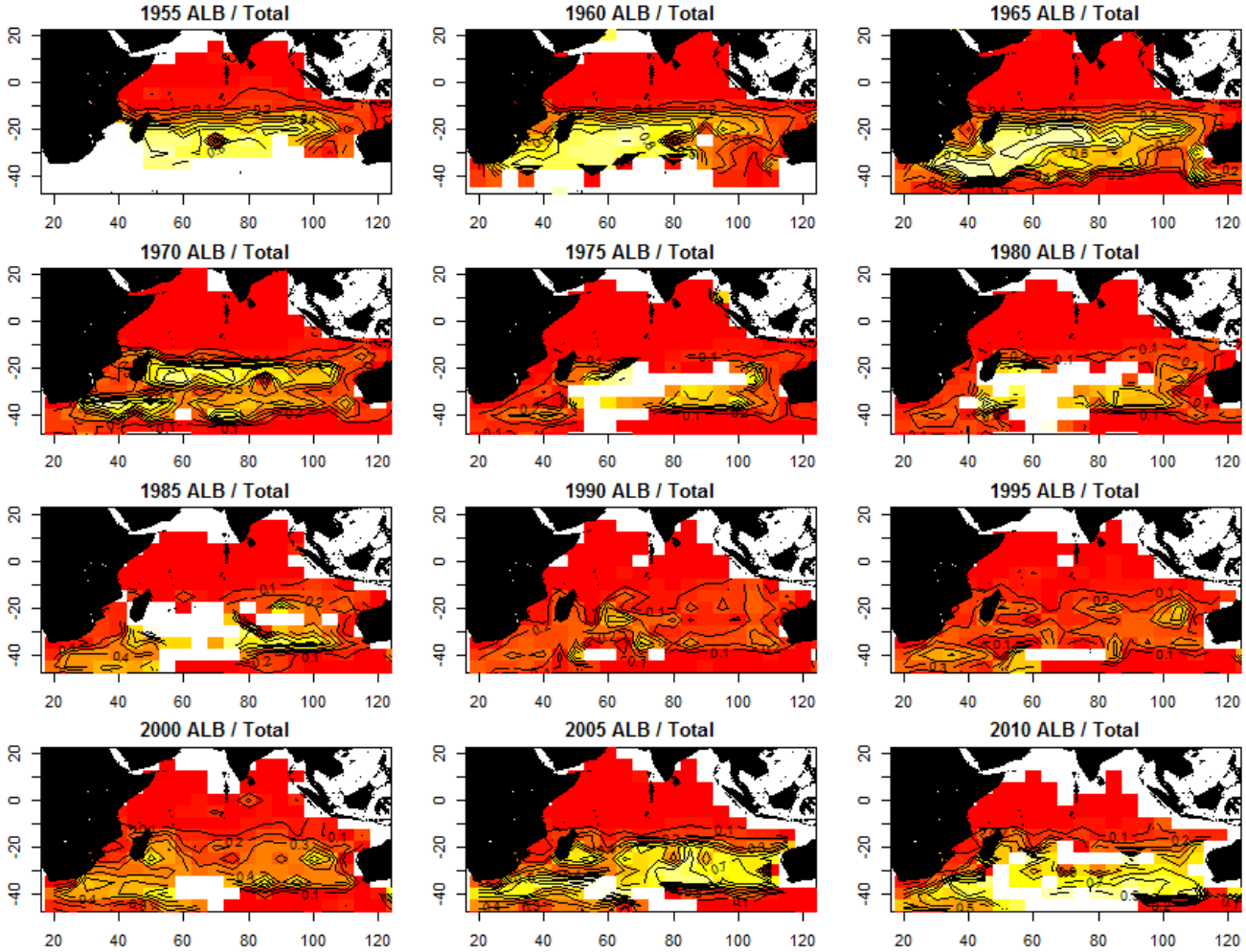

Figure 27: Proportion albacore in total catch by 5 year period and 5 degree square. Yellow indicates higher proportion. Contour lines are at 0.1 intervals.

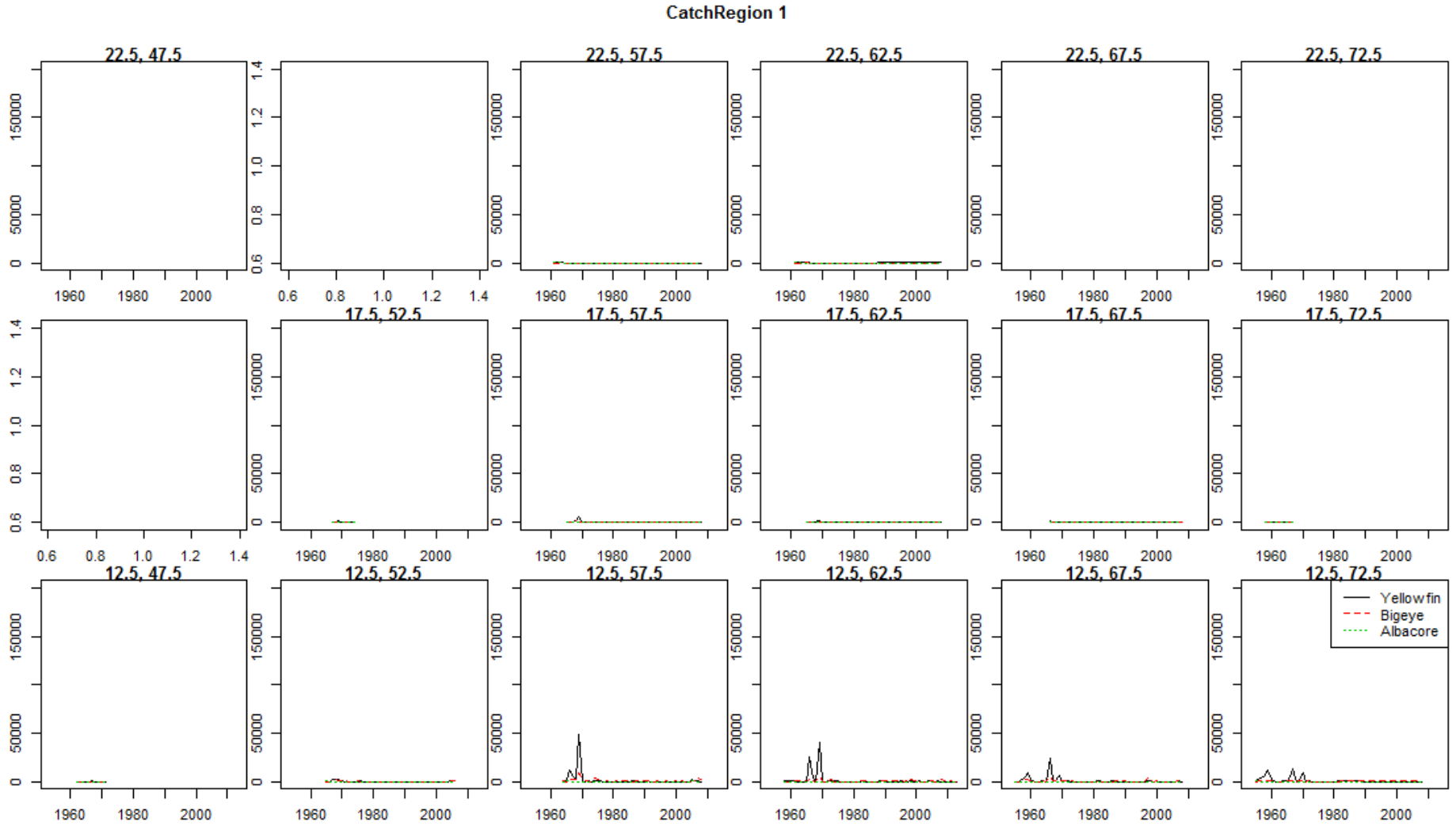

Figure 28: Catch by year-qtr and 5 degree square in region 1 for bigeye, yellowfin, and albacore.

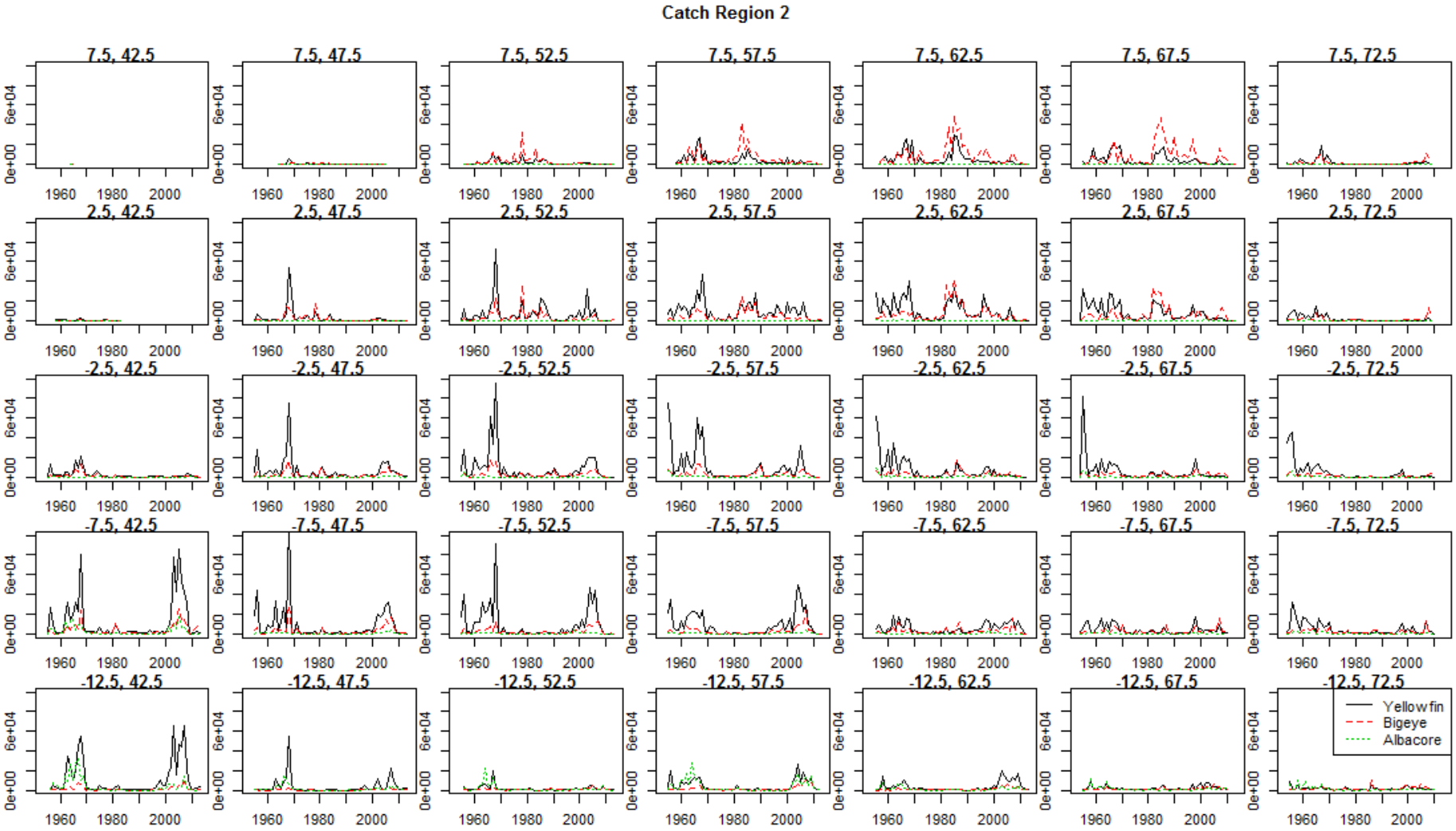

Figure 29: Catch by year-qtr and 5 degree square in region 2 for bigeye, yellowfin, and albacore.

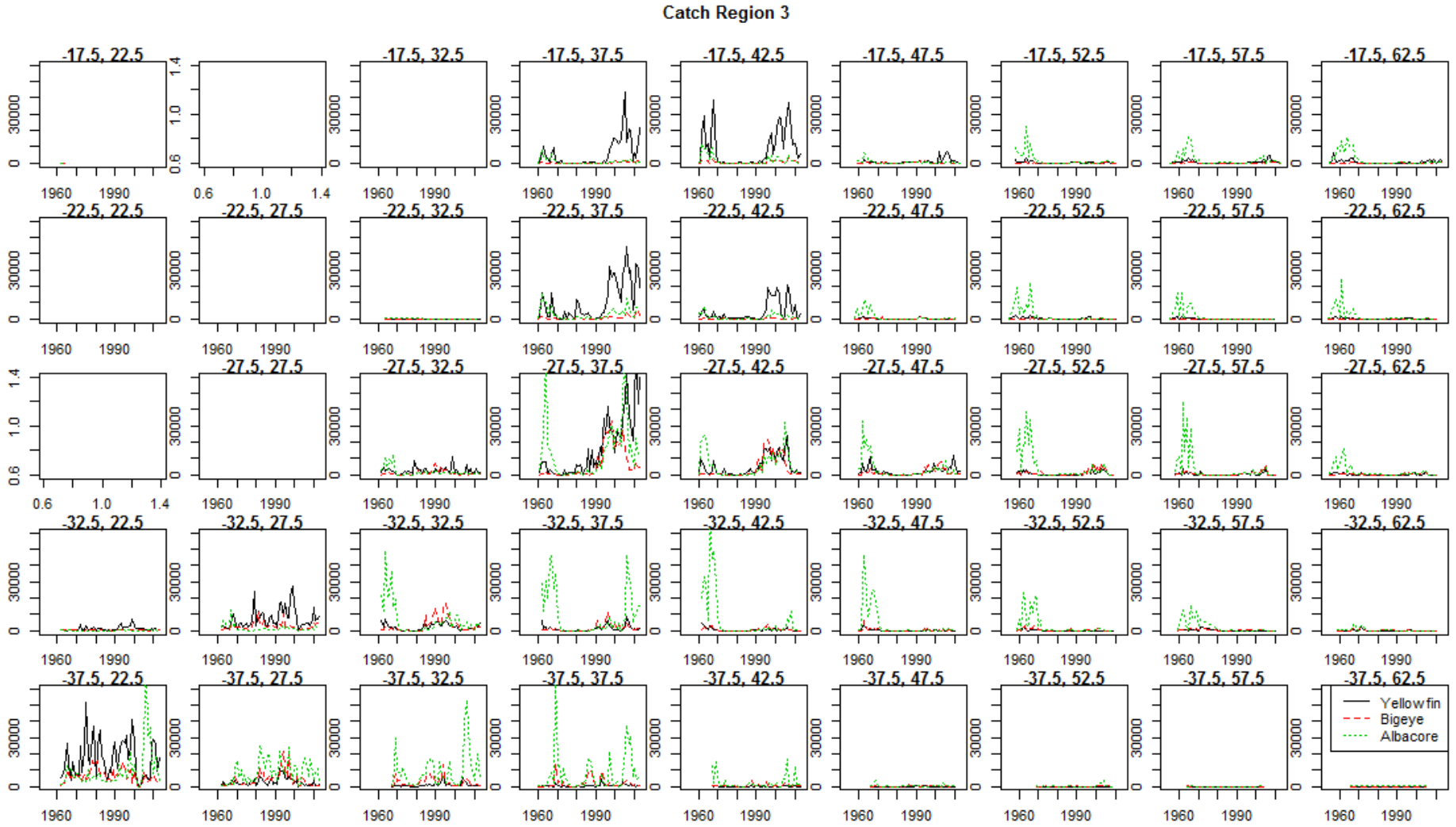

Figure 30: Catch by year-qtr and 5 degree square in region 3 for bigeye, yellowfin, and albacore.

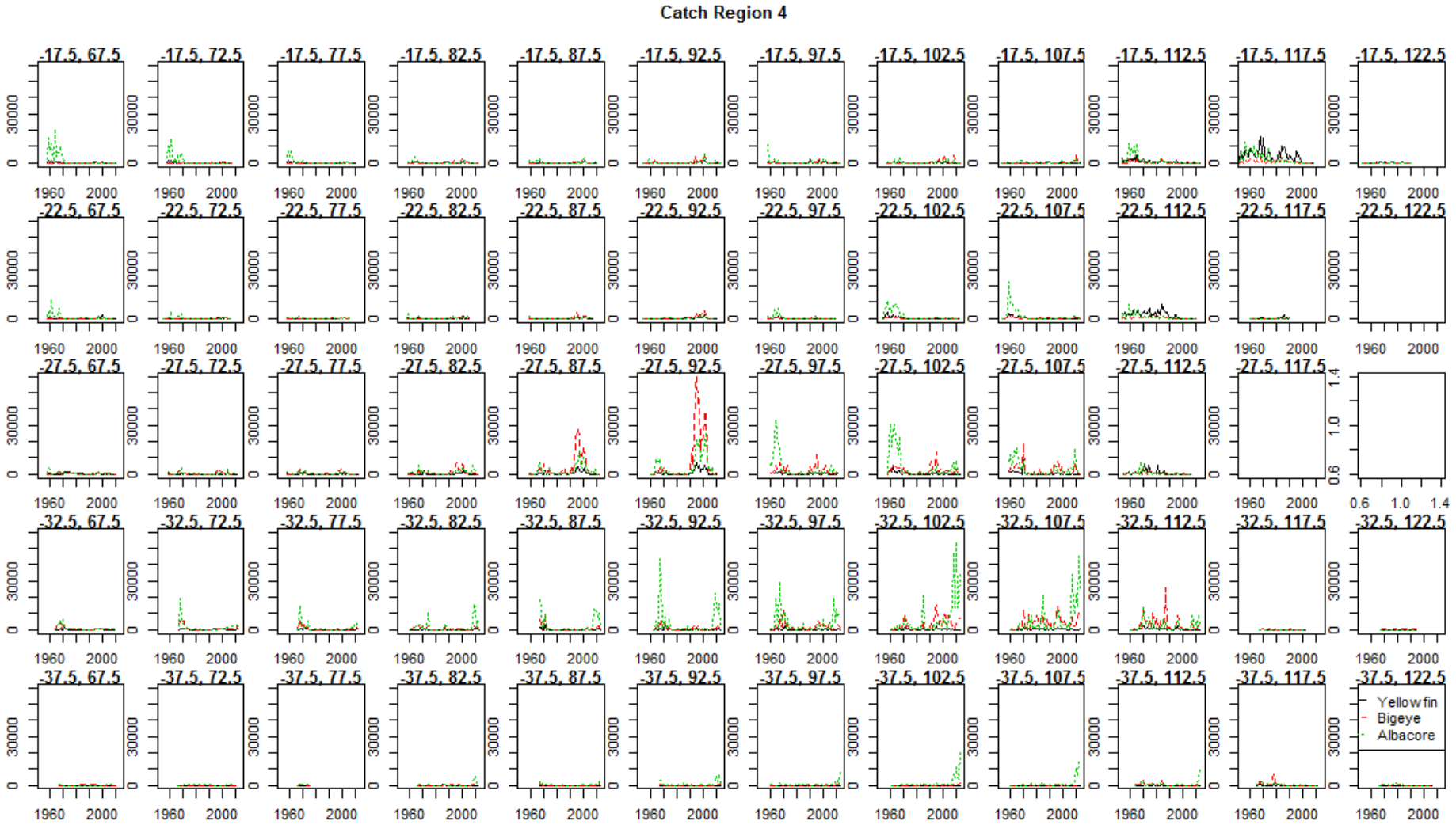

Figure 31: Catch by year-qtr and 5 degree square in region 4 for bigeye, yellowfin, and albacore.

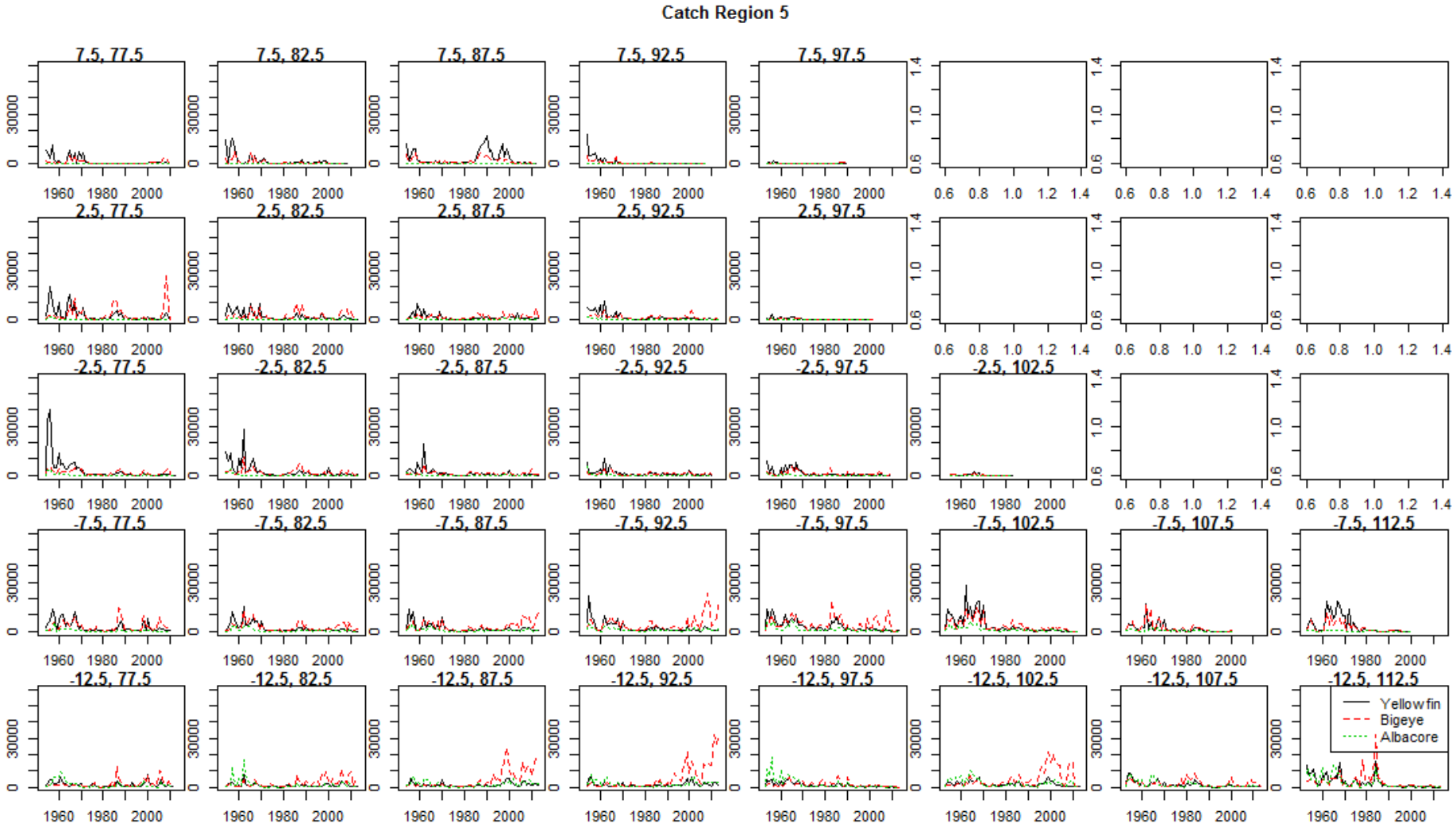

Figure 32: Catch by year-qtr and 5 degree square in region 5 for bigeye, yellowfin, and albacore.

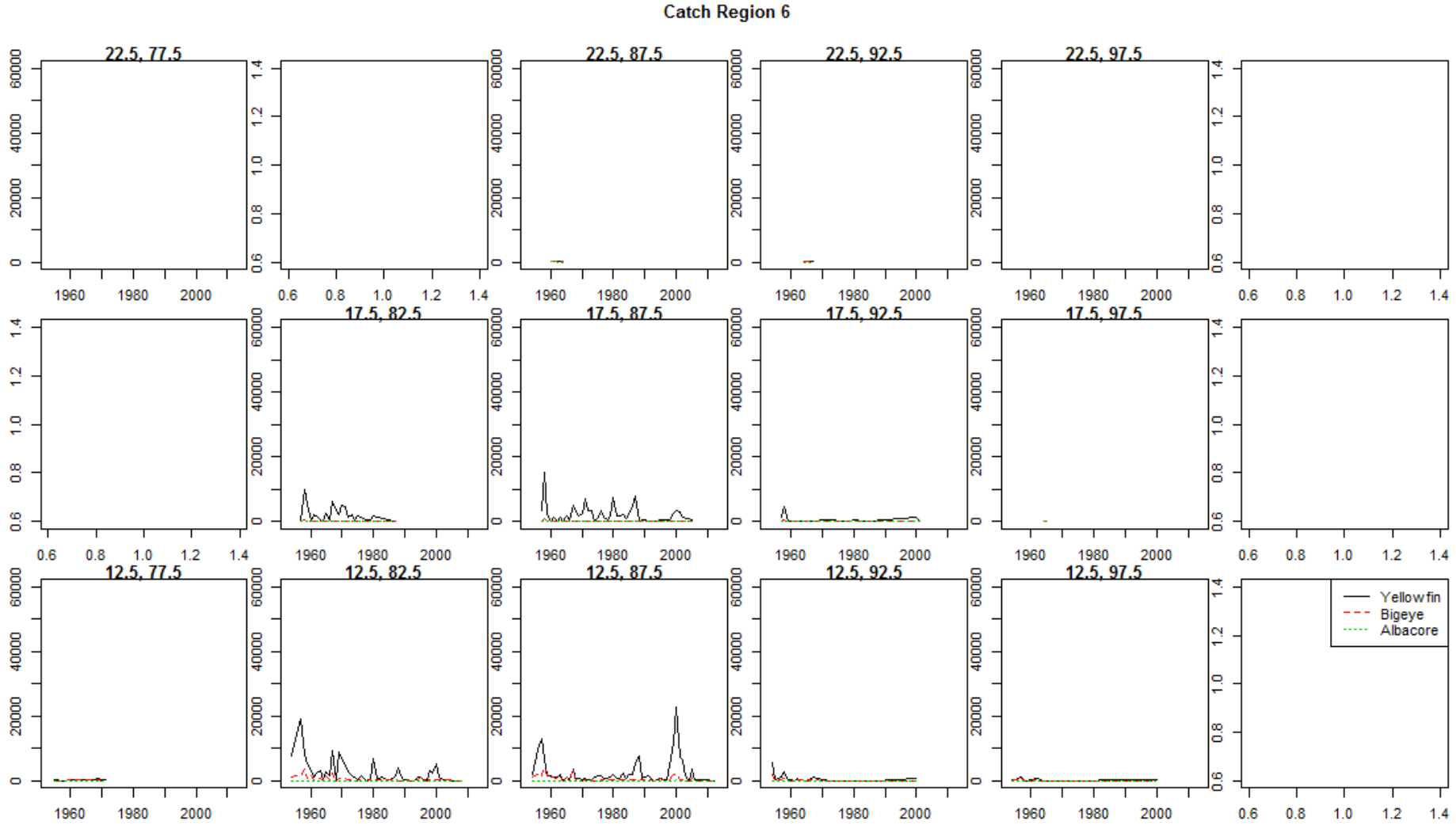

Figure 33: Catch by year-qtr and 5 degree square in region 6 for bigeye, yellowfin, and albacore.

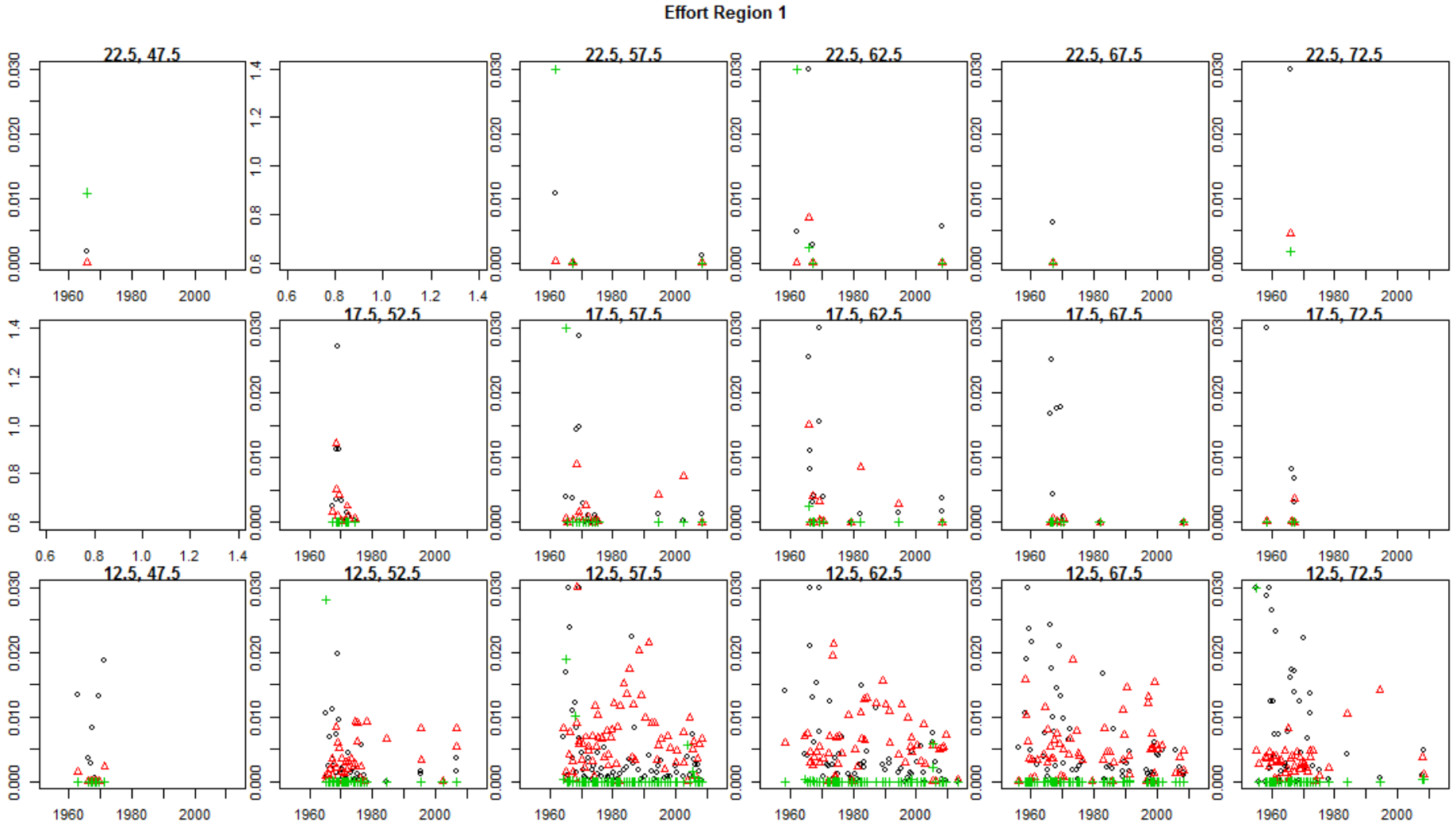

Figure 34: Mean catch per set by year-qtr and 5 degree square in region 1 for bigeye, yellowfin, and albacore.

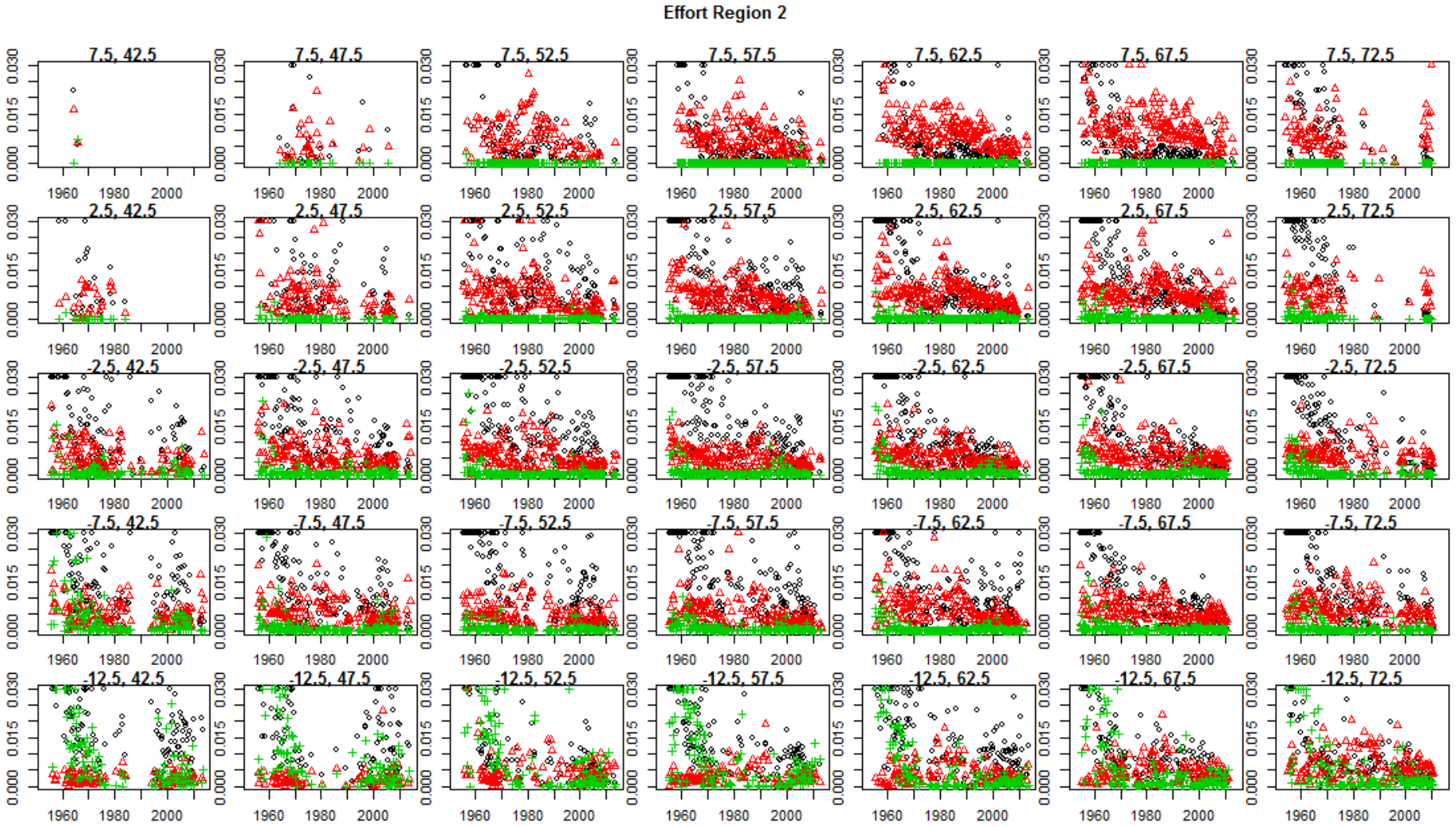

Figure 35: Mean catch per set by year-qtr and 5 degree square in region 2 for bigeye, yellowfin, and albacore.

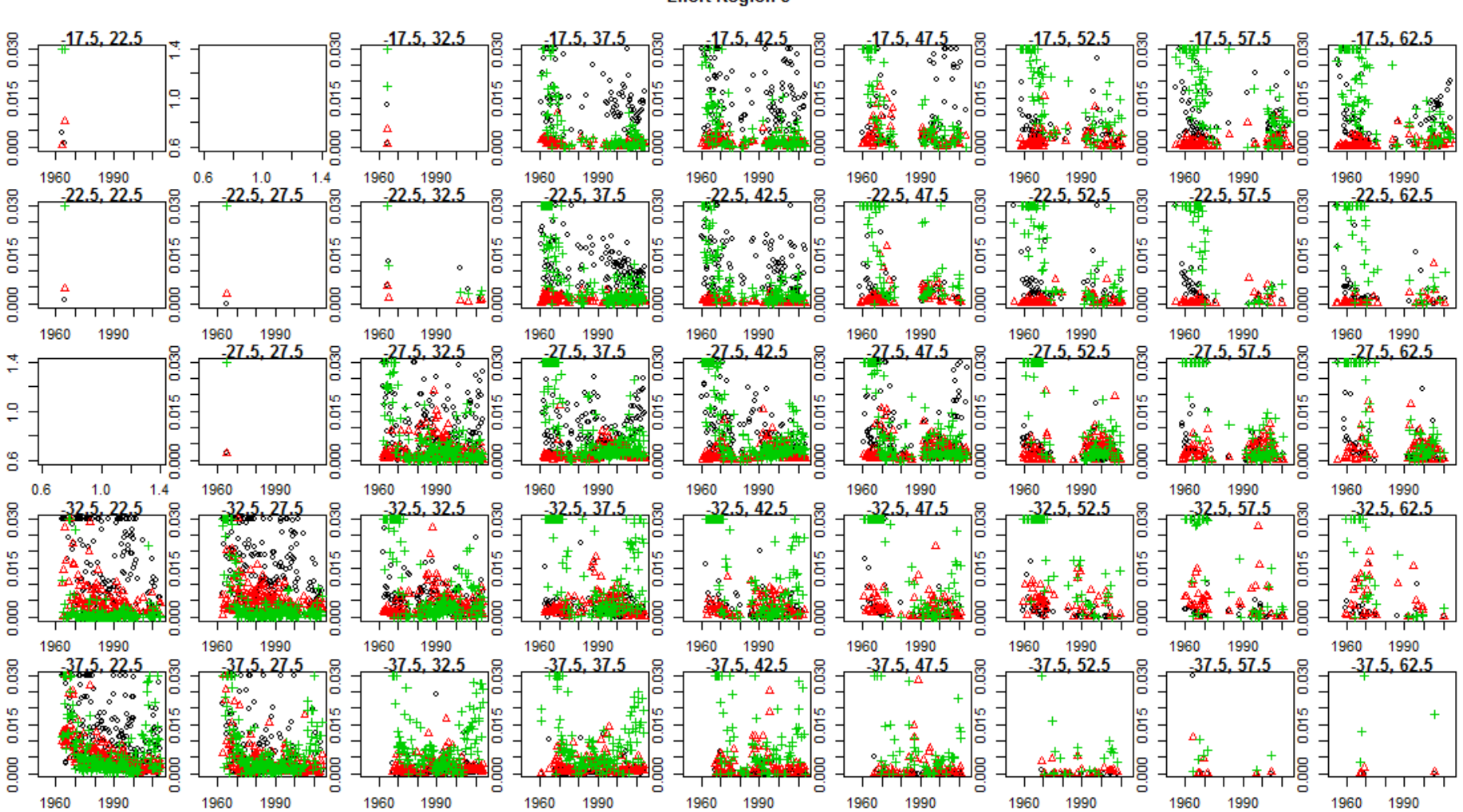

Figure 36: Mean catch per set by year-qtr and 5 degree square in region 3 for bigeye, yellowfin, and albacore.

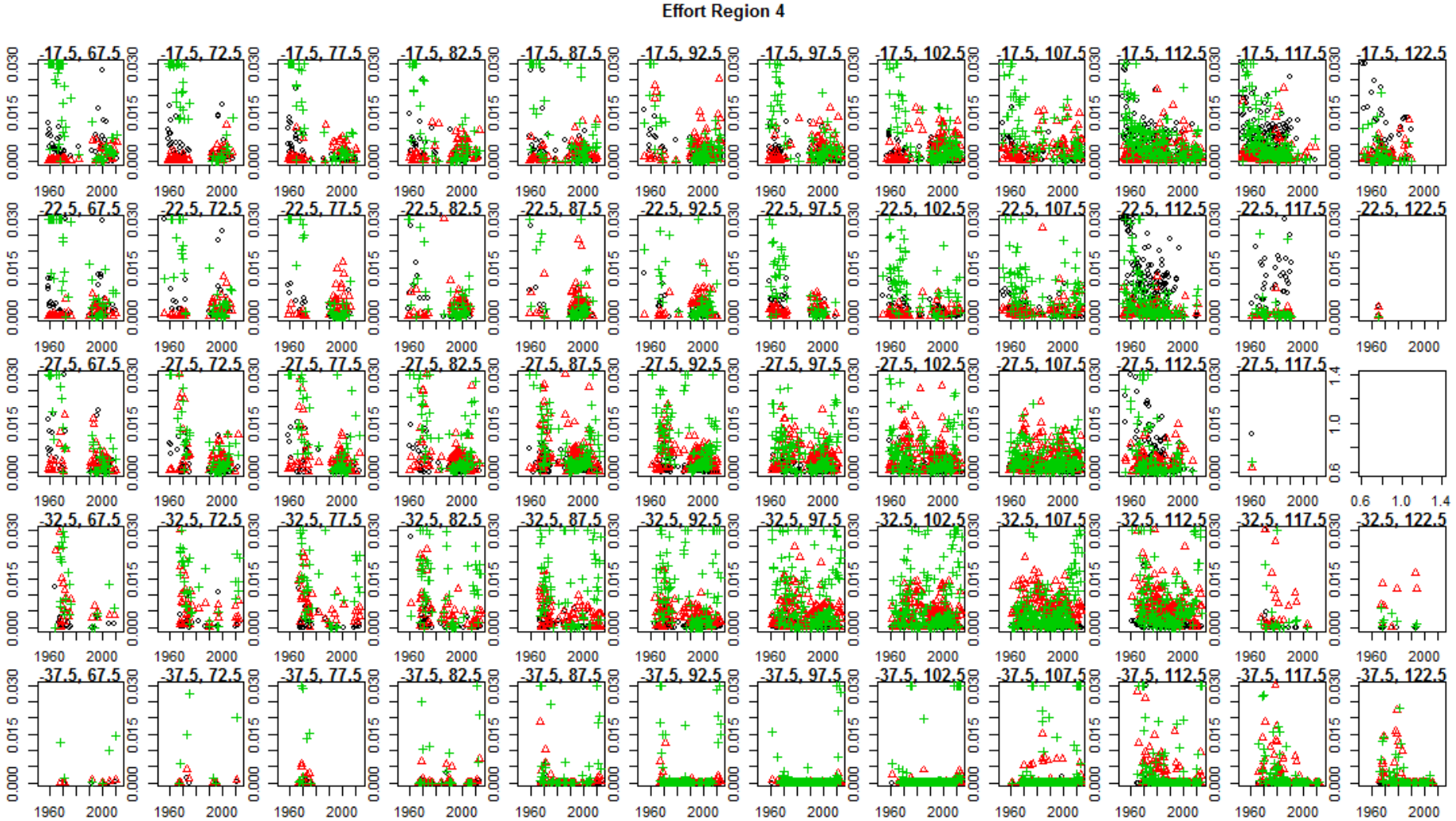

Figure 37: Mean catch per set by year-qtr and 5 degree square in region 4 for bigeye, yellowfin, and albacore.

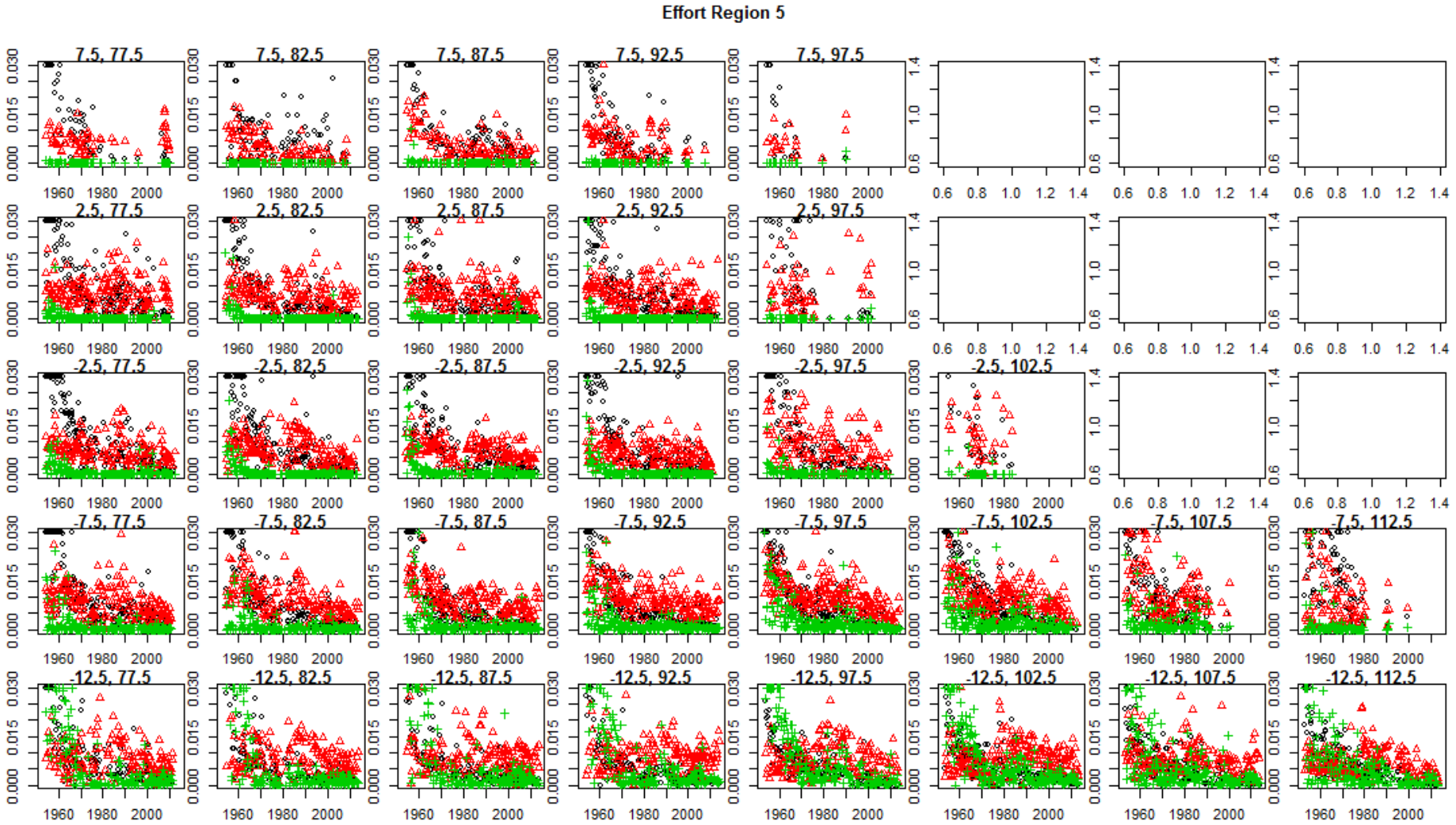

Figure 38: Mean catch per set by year-qtr and 5 degree square in region 5 for bigeye, yellowfin, and albacore.

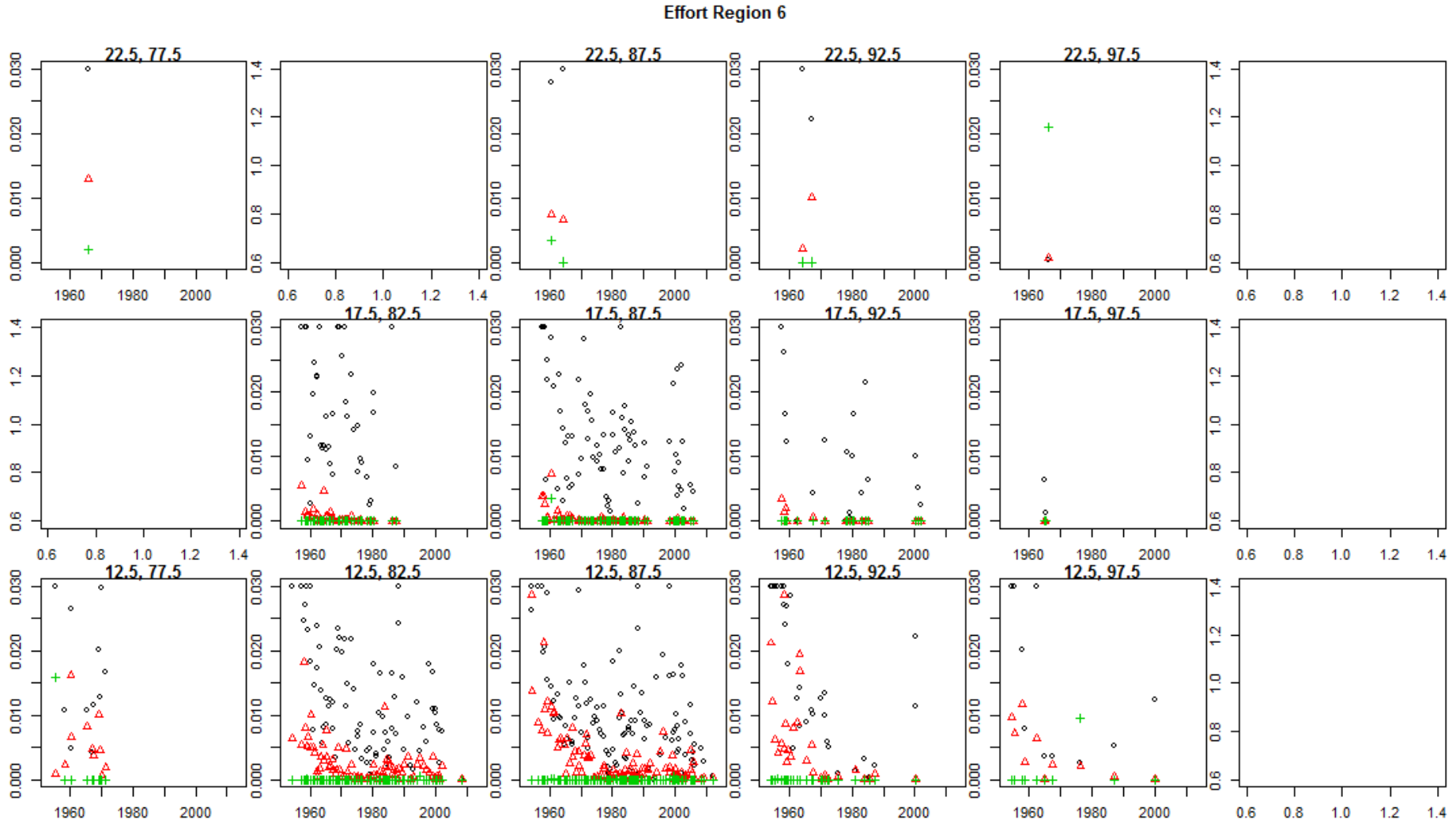

Figure 39: Mean catch per set by year-qtr and 5 degree square in region 6 for bigeye, yellowfin, and albacore.

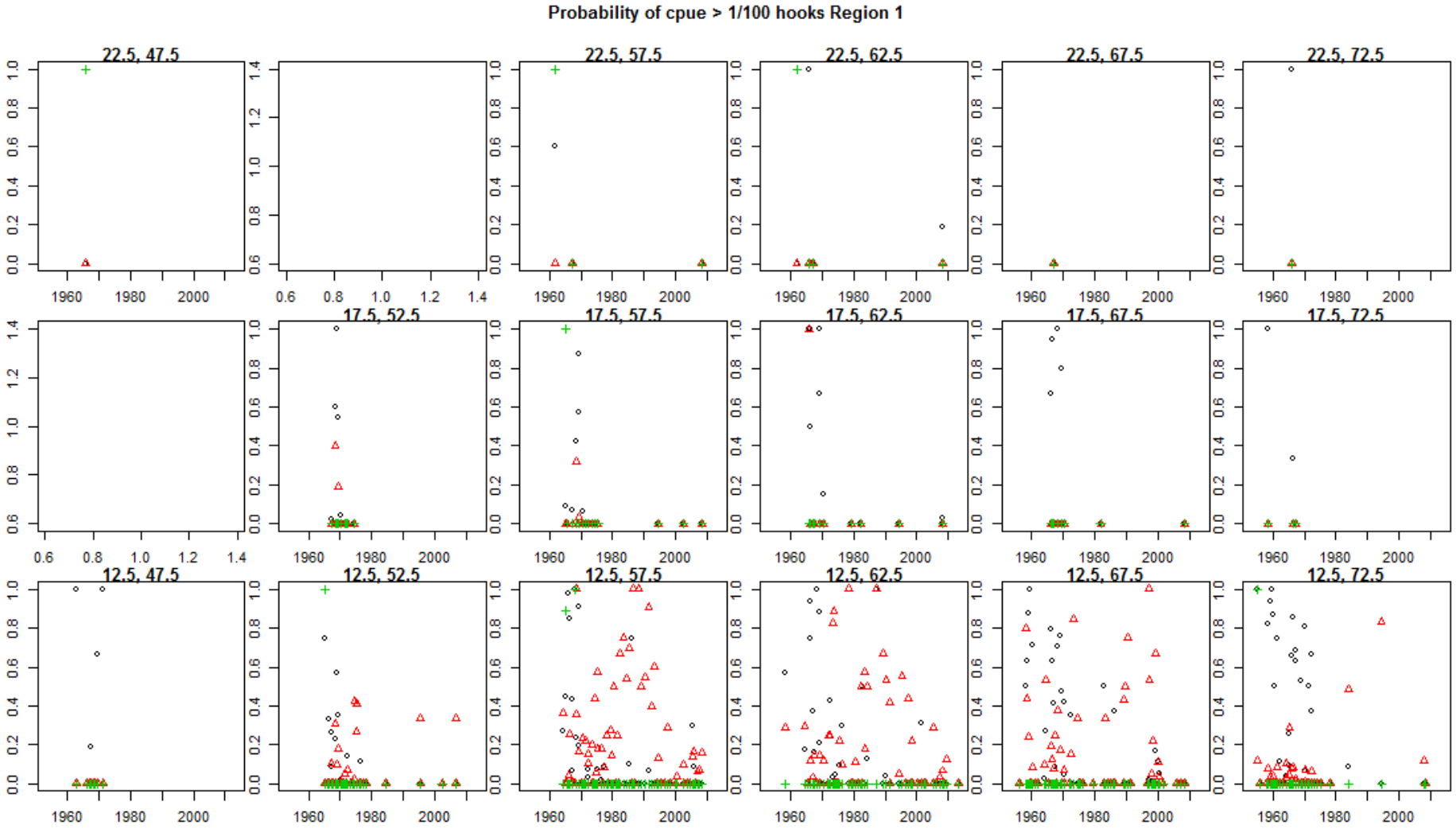

Figure 40: Probability that cpue > 1 fish per 100 hooks by year-qtr and 5 degree square in region 1 for bigeye, yellowfin, and albacore.

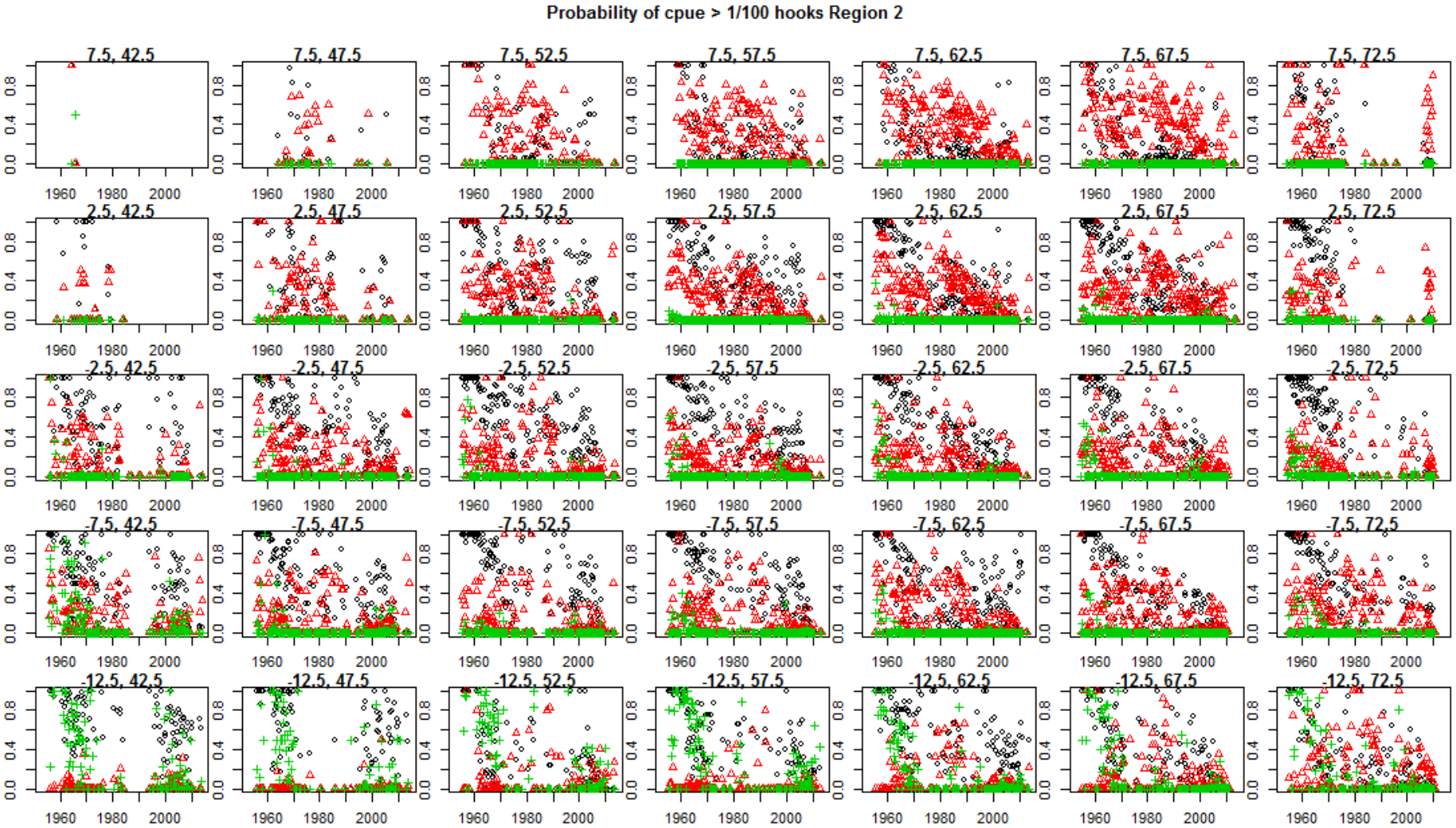

Figure 41: Probability that cpue > 1 fish per 100 hooks by year-qtr and 5 degree square in region 2 for bigeye, yellowfin, and albacore.

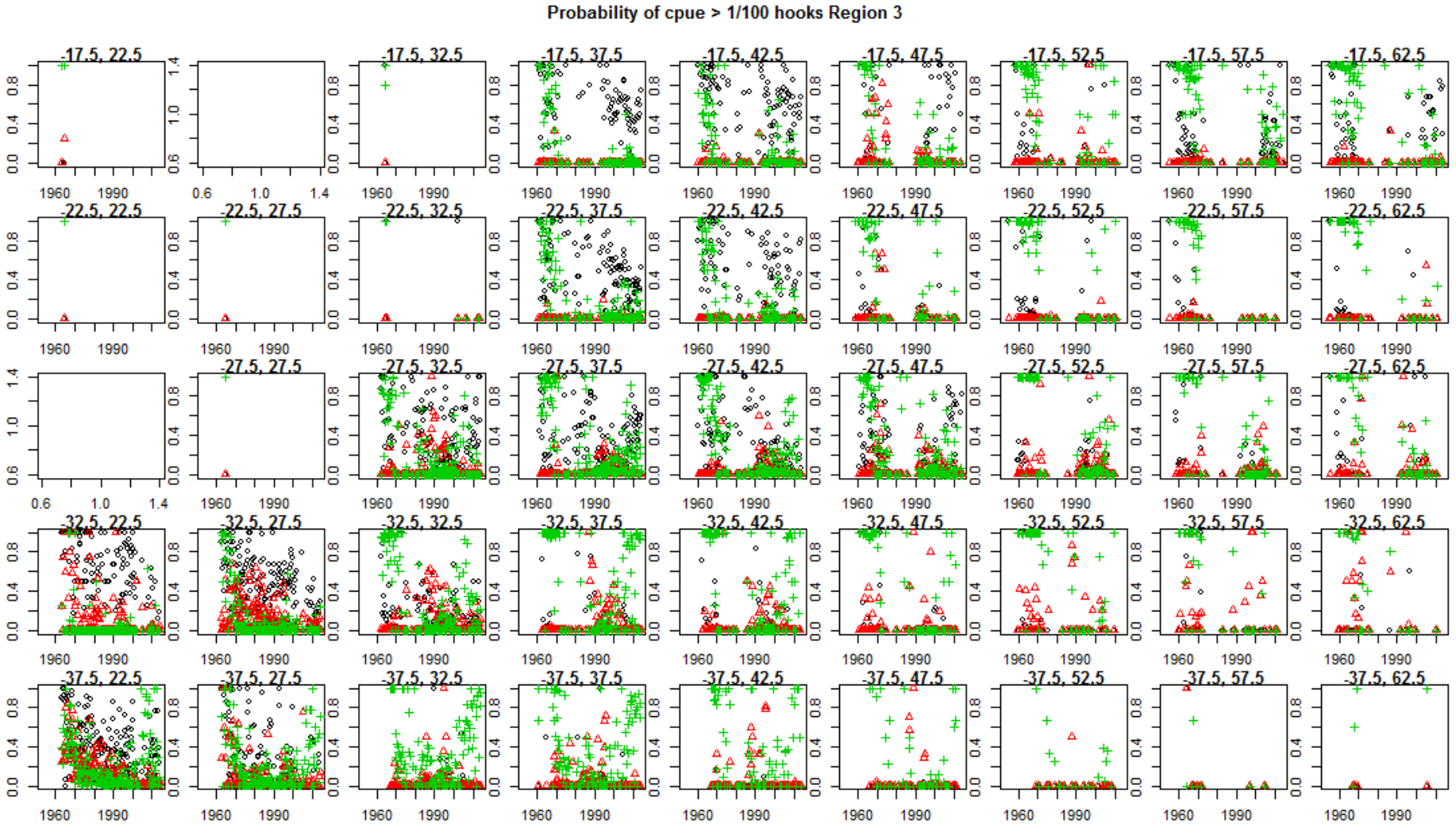

Figure 42: Probability that cpue > 1 fish per 100 hooks by year-qtr and 5 degree square in region 3 for bigeye, yellowfin, and albacore.

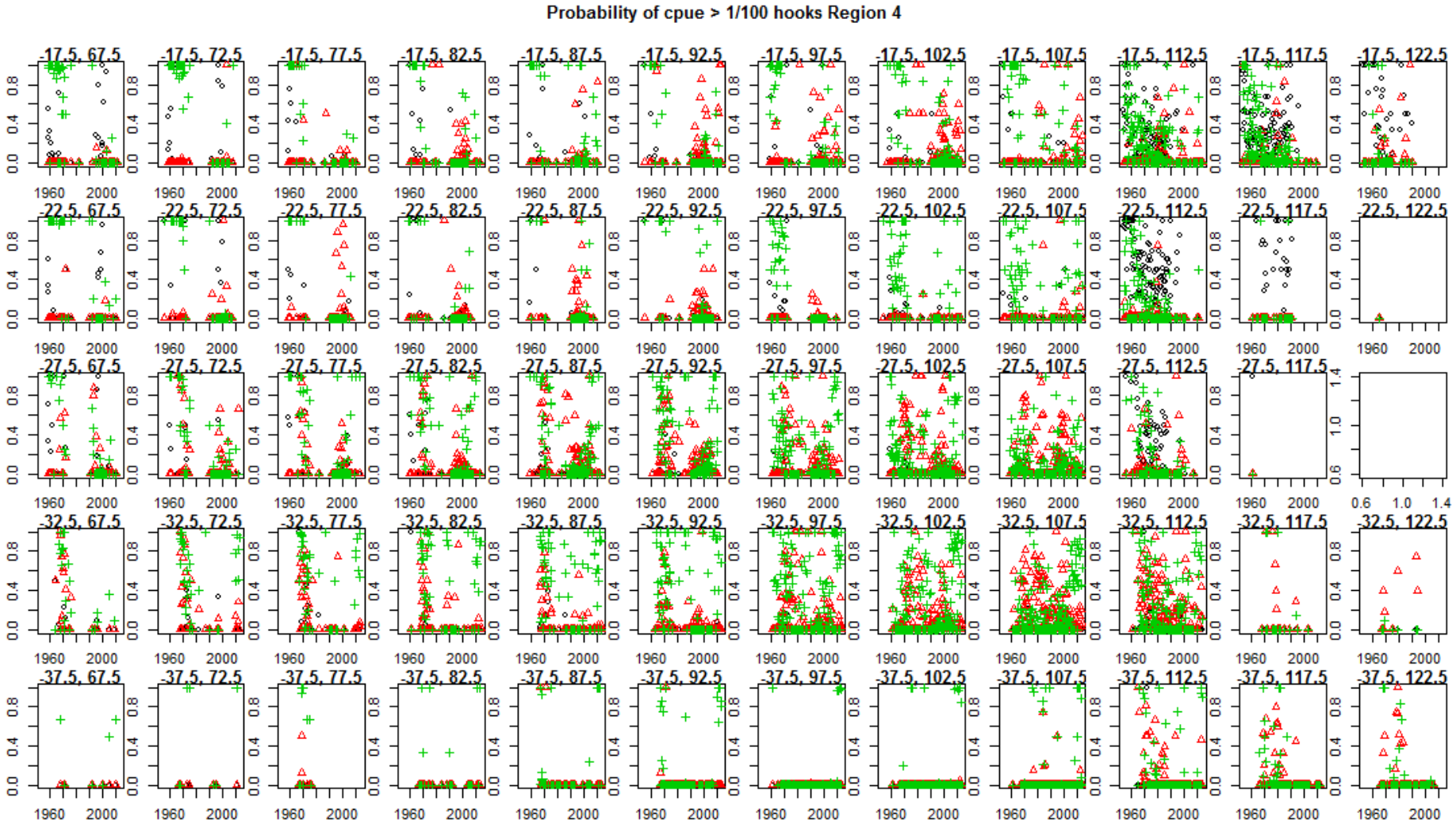

Figure 43: Probability that cpue > 1 fish per 100 hooks by year-qtr and 5 degree square in region 4 for bigeye, yellowfin, and albacore.

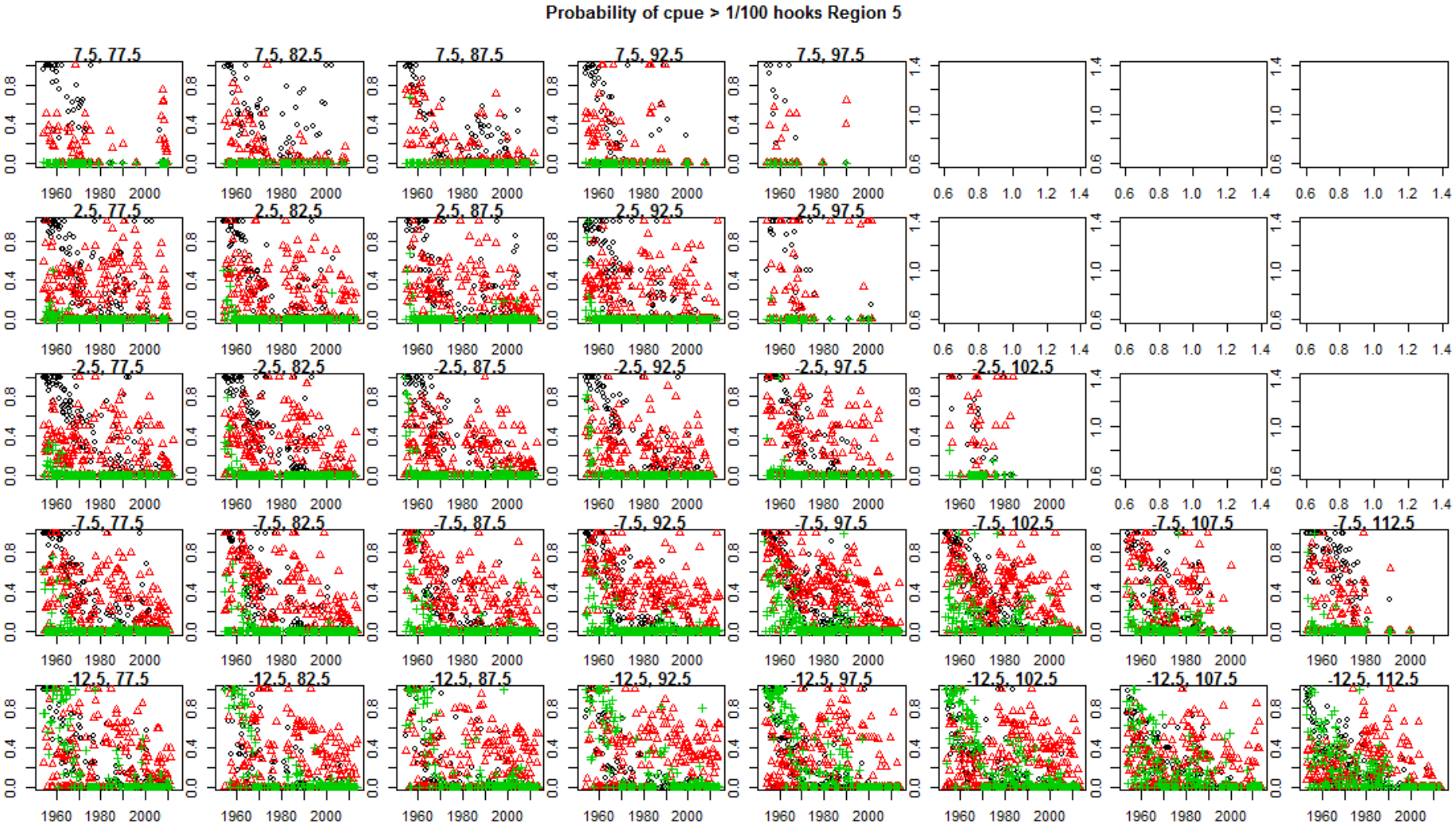

Figure 44: Probability that cpue > 1 fish per 100 hooks by year-qtr and 5 degree square in region 5 for bigeye, yellowfin, and albacore.

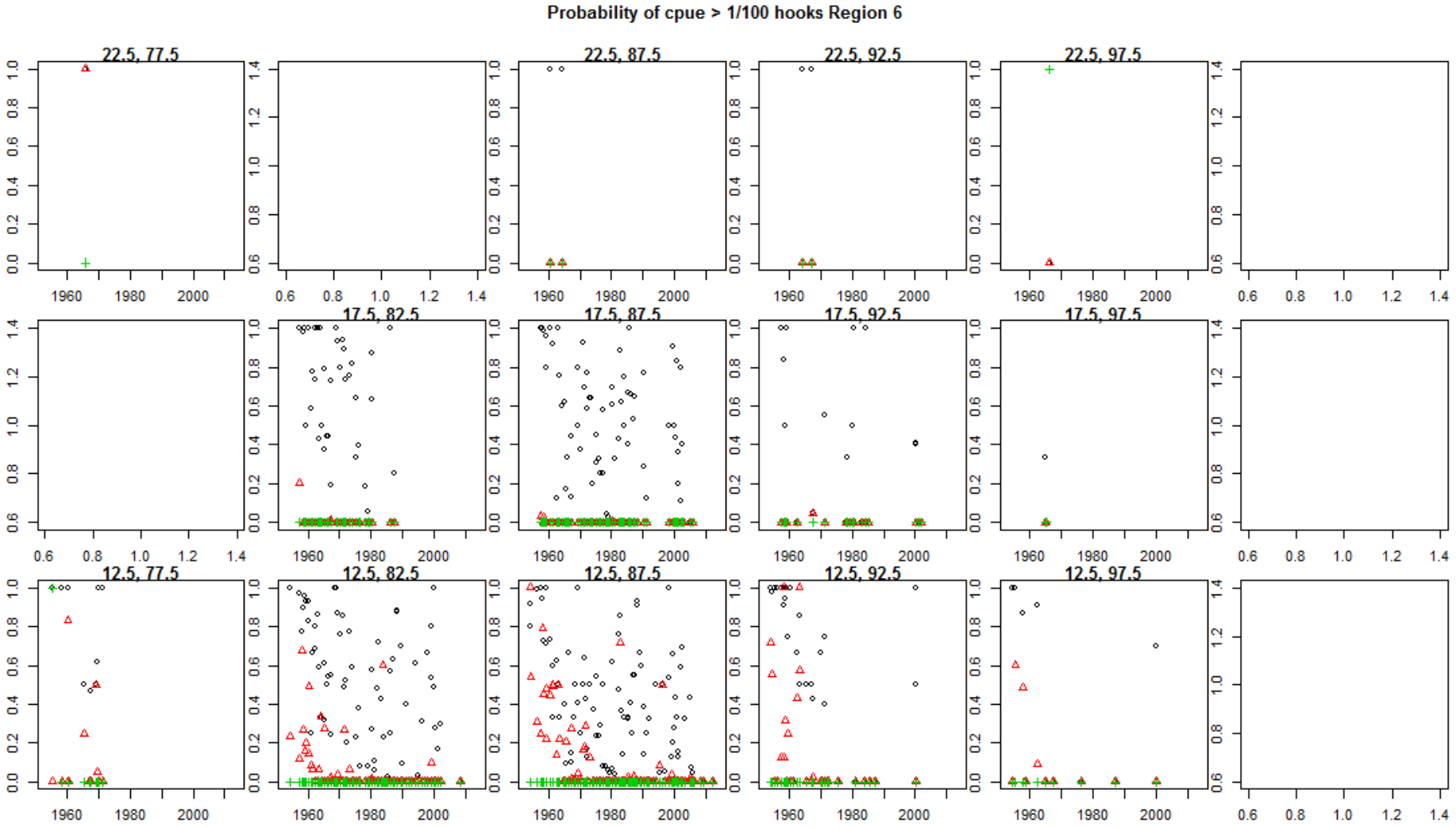

Figure 45: Probability that cpue > 1 fish per 100 hooks by year-qtr and 5 degree square in region 6 for bigeye, yellowfin, and albacore.

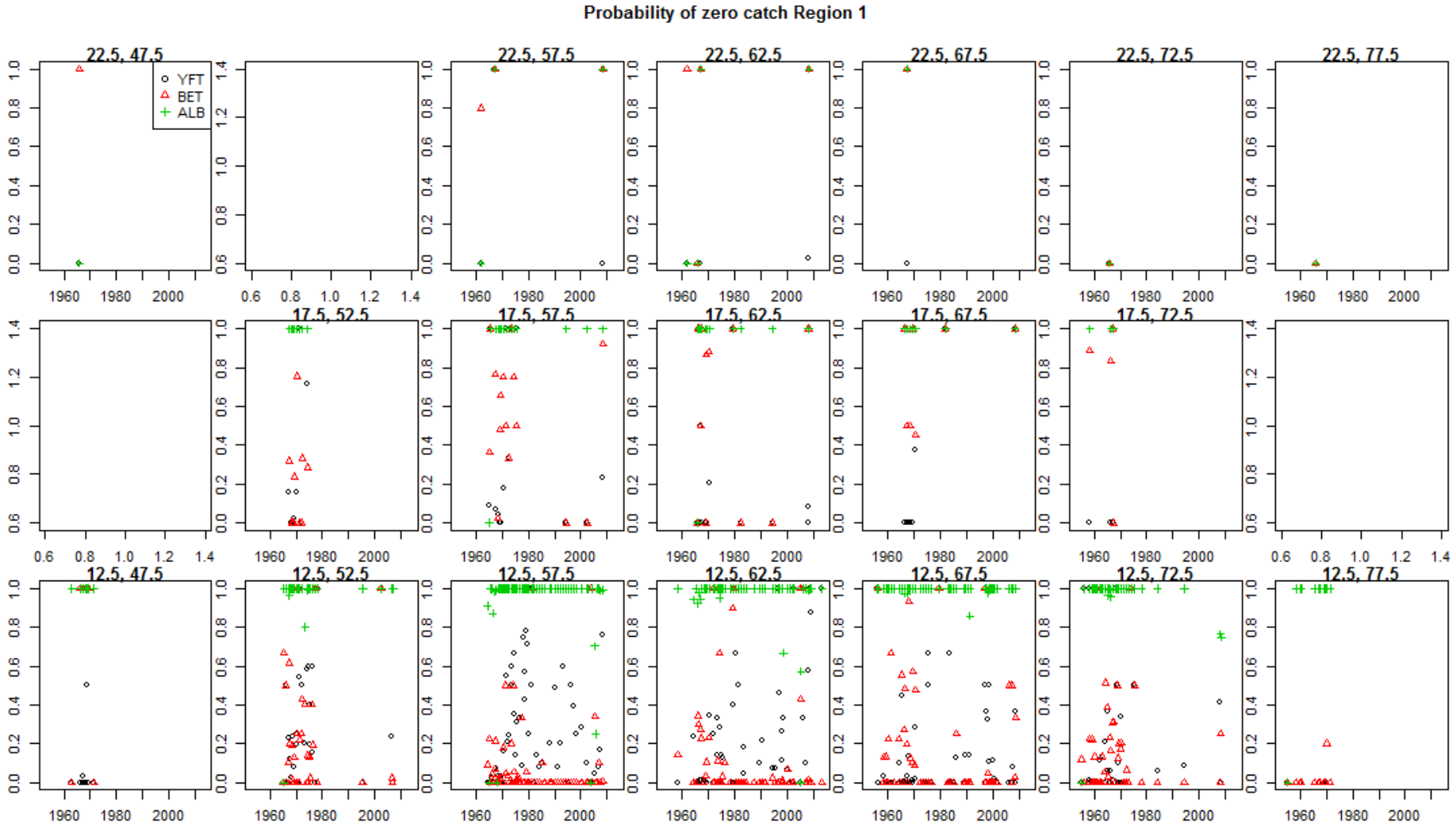

Figure 46: Probability of zero catch by year-qtr and 5 degree square in region 1 for bigeye, yellowfin, and albacore.

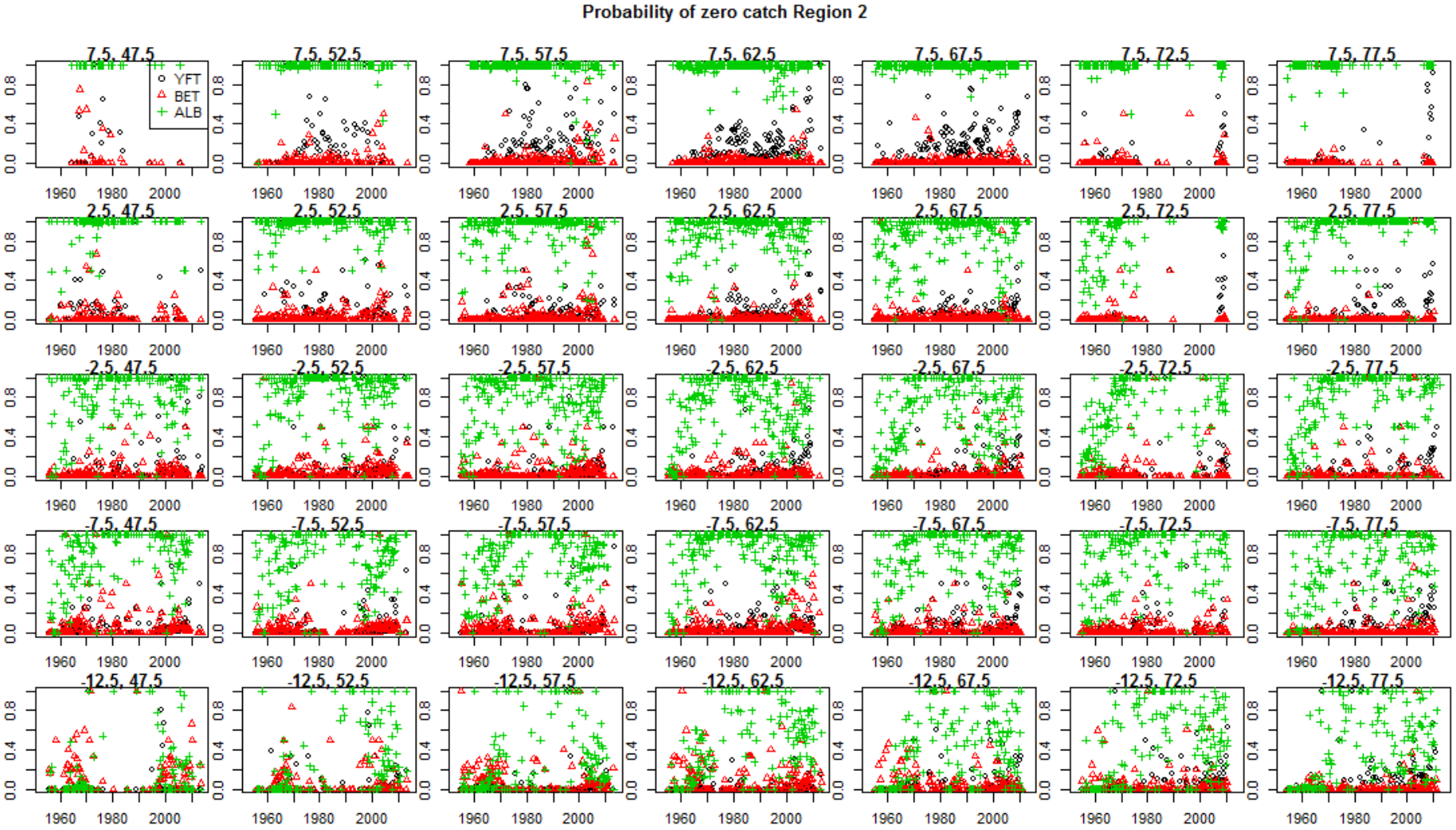

Figure 47: Probability of zero catch by year-qtr and 5 degree square in region 2 for bigeye, yellowfin, and albacore.

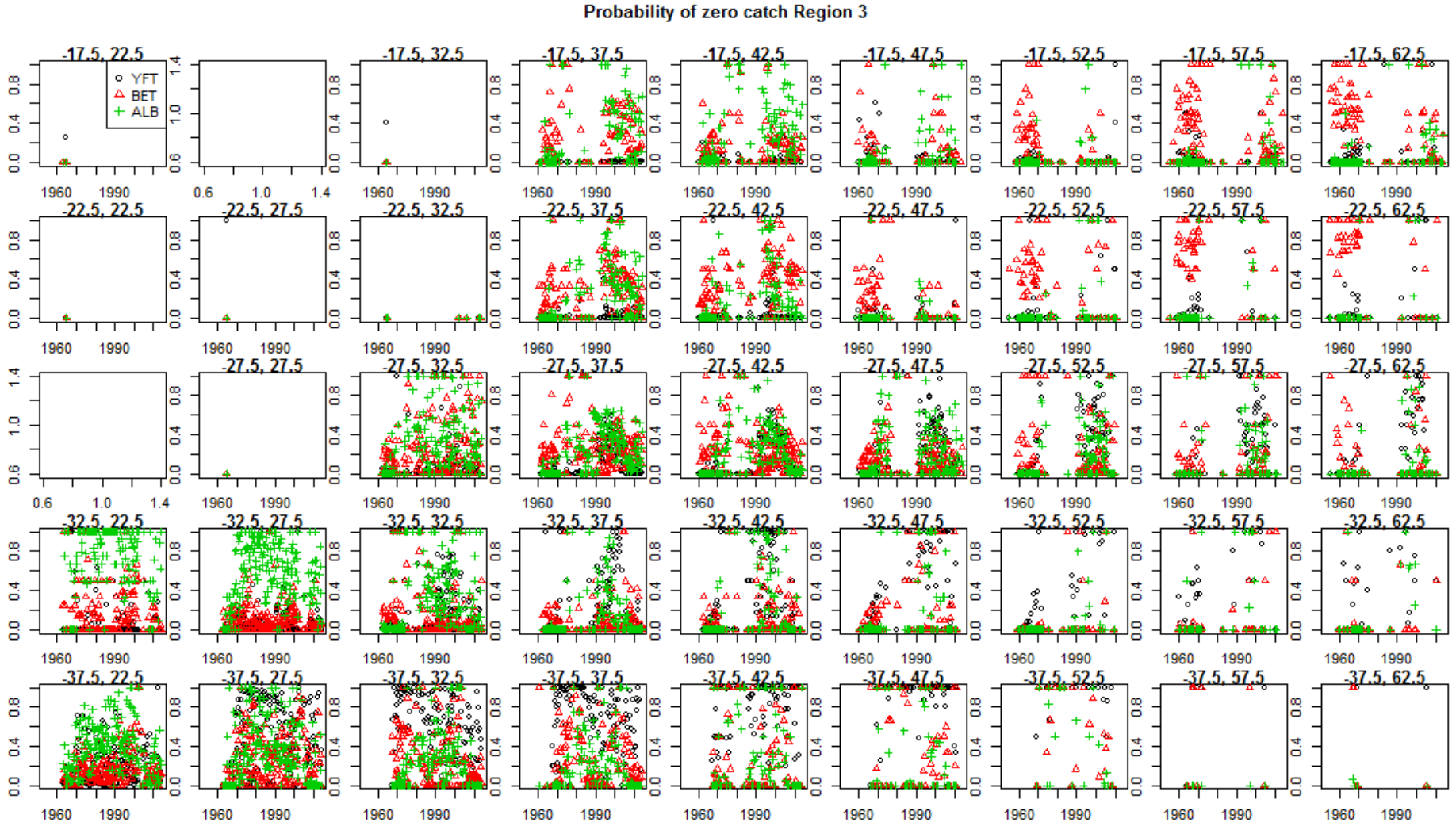

Figure 48: Probability of zero catch by year-qtr and 5 degree square in region 3 for bigeye, yellowfin, and albacore.

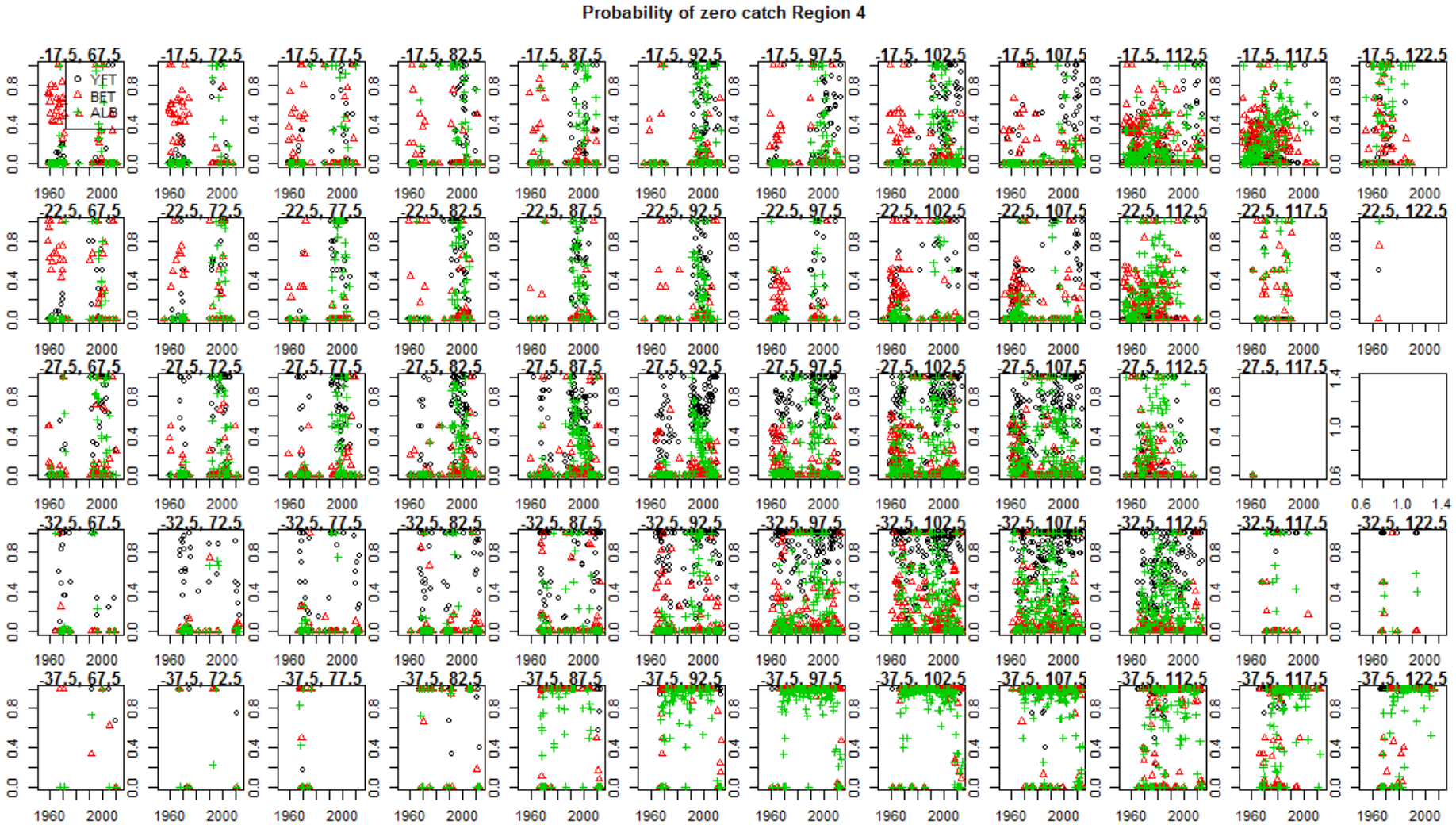

Figure 49: Probability of zero catch by year-qtr and 5 degree square in region 4 for bigeye, yellowfin, and albacore.

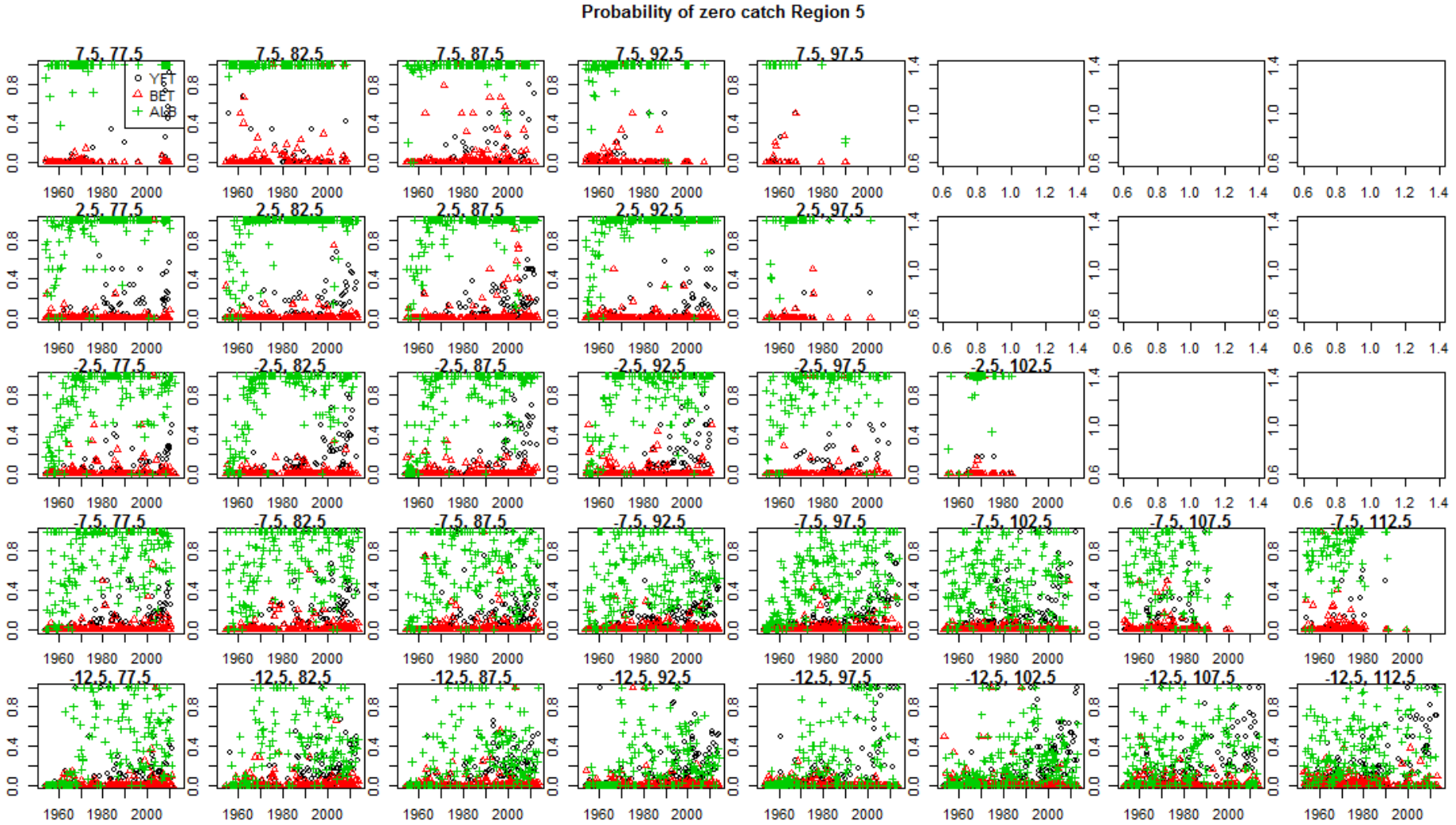

Figure 50: Probability of zero catch by year-qtr and 5 degree square in region 5 for bigeye, yellowfin, and albacore.

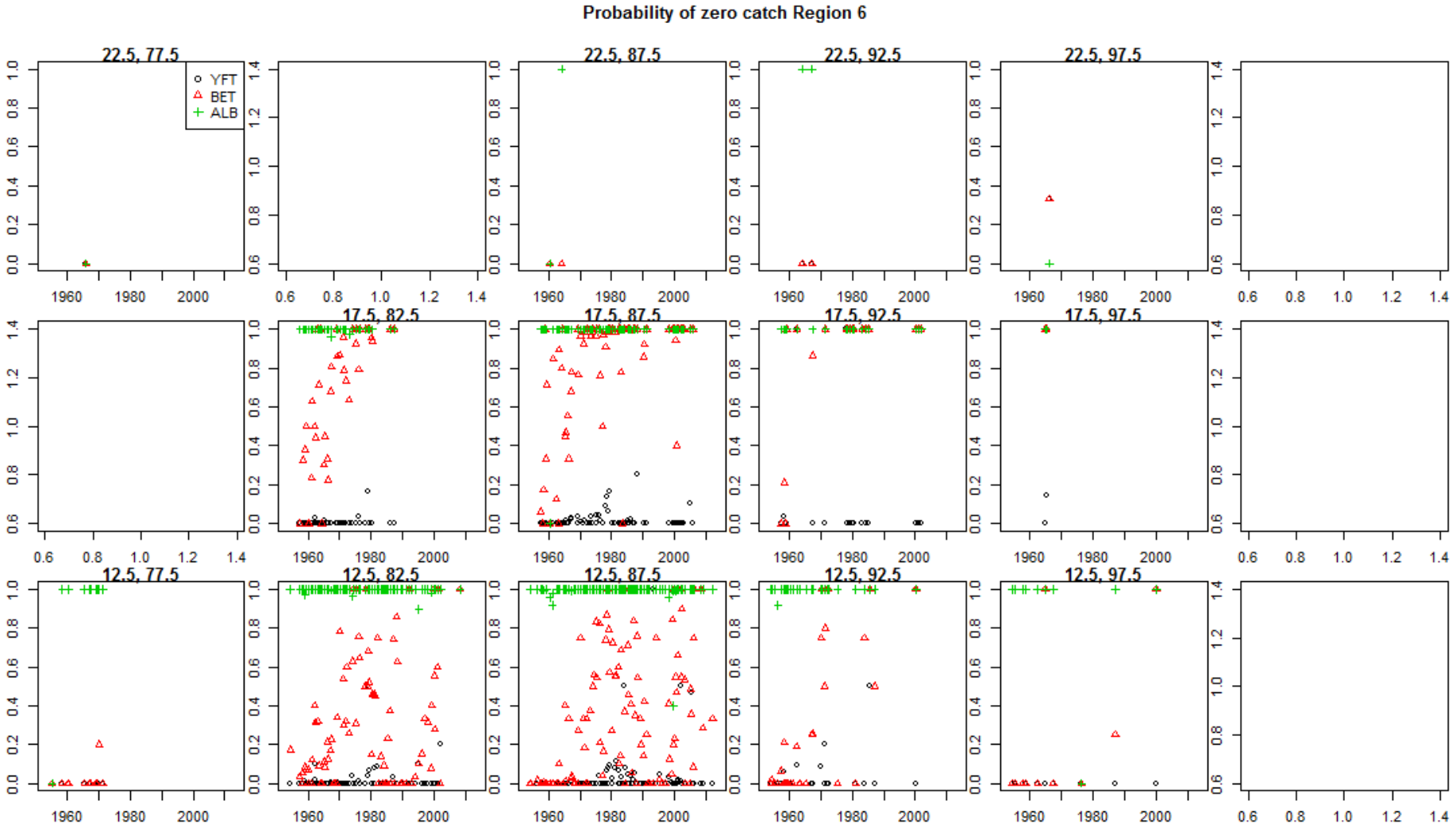

Figure 51: Probability of zero catch by year-qtr and 5 degree square in region 6 for bigeye, yellowfin, and albacore.