Updated Operational Information and Descriptive Catch Statistics for Striped Marlin *Kajikia audax* in the Hawaii-based Pelagic Longline Fishery

Yi-Jay Chang
Joint Institute for Marine and Atmospheric Research, University of Hawaii—NOAA Fisheries, Honolulu, HI 96818, USA

William A. Walsh
Joint Institute for Marine and Atmospheric Research, University of Hawaii—NOAA Fisheries, Honolulu, HI 96818, USA

Jon Brodziak
NOAA Fisheries, National Marine Fisheries Service, Pacific Islands Fisheries Science Center, Honolulu, HI, 96818, USA

INTRODUCTION

A stock assessment update for North Pacific striped marlin *Kajikia audax* will be conducted in 2015 under the aegis of the ISC Billfish Working Group (ISC BILLWG) with standardized catch-per-unit-effort (CPUE) time series from the various member nations used as inputs. This working paper (WP) presents background information pertaining to the standardized CPUE time series computed for the Hawaii-based pelagic longline fishery for 1995–2013.

This WP presents operational information and nominal catch statistics reported by the NOAA Fisheries Pacific Islands Regional Observer Program (PIROP). It provides supplementary information regarding the covariates used in the CPUE standardizations for striped marlin in this longline fishery (Langseth 2015; Walsh and Chang, 2015).

METHODS

Catch and operational data were collected by the NOAA Fisheries Pacific Islands Regional Observer Program (PIROP). This WP uses data from 1995–2013 because 1995 was the first full year of PIROP activities, following its establishment early in 1994. All observer data were collected aboard Hawaiʻi-based pelagic longline vessels during commercial fishing operations.

The Hawaii-based pelagic longline fishery is managed in two sectors, defined as deep-set (≥15 hooks per float) and shallow-set fishing sectors (<15 hooks per float). For each sector, catch and effort trends were investigated by fishing year, fishing season (i.e., calendar quarter), fishing region, sea surface temperature (SST), the number of hooks per float, and the number of hooks per longline set, which corresponded to the variables used in the previously fitted CPUE standardization models (Walsh and Lee, 2011). Exploratory analyses of possible effects of various types of baits and hooks on striped marlin catch rates and of the species composition of the catch in both fishery sectors are also presented.

RESULTS

The CPUE spatial patterns for the two fishery sectors are presented in Figure 1. In the deep-set sector, high nominal CPUEs were observed in Regions 4, 5 and 6. High CPUEs in the shallow-set sector were mainly observed in Regions 6 and 8.

Spatiotemporal variation in striped marlin CPUE for the deep- and shallow-set sector is illustrated in Figures 2 and 3, respectively. In the deep-set sector, high CPUEs were observed in Regions 3 and 4 during the first quarter and at higher latitudes in Region 6 during the second. High CPUEs were again observed in Region 6 during the fourth quarter. For the shallow set sector, high CPUE were observed in regions 5 in quarter 1, then high CPUE were observed in the higher latitude areas (regions 5 and 6) in quarter 2, CPUE is high in region 8 in quarter 3, high CPUE were observed in region 5 in quarter 4.

The yearly nominal striped marlin CPUE (number of striped marlin/1000 hooks) decreased between 1995 and 1998, followed by fluctuations around 0.5 thereafter in both fishery sectors (Fig. 4). It should be noted that striped marlin CPUE of both sectors showed a slightly increasing trend after 2010.

Nominal CPUE is illustrated by fishing seasons and set types in Figure 5. In general, striped marlin catch rates in both sectors are greater in autumn, winter, and spring than in the summer months.

Fishing effort by regions and set type was shown in Figure 6. Most deep sets were deployed in Regions 3, 4, 5 and 6; shallow-set effort was more concentrated in Regions 6, 7, and 8.

Regional yearly nominal CPUE by set types is shown in Figure 7. The nominal CPUE showed variation occurred across regions and among quarters. In the deep-set sector (Fig. 7a), CPUE showed a declining trend between 1995 and 2000, fluctuated without a clear trend during 2001–2010, and then increased slightly after 2010. CPUE in Region 6 was relatively higher than in the other regions in both sectors. In the shallow-set sector (Fig. 7b), there was no apparent CPUE trend.

The patterns of use of several hook types have changed over time (Fig. 8). In the deep-set sector (Fig. 8a), tuna hooks (type 1) were the most commonly type used during 2000–2005, but offset circle hooks have been in wide use during 2007–2013. J-hooks were widely used in the shallow-set sector (Fig. 8b) during 1995–2000, but were largely replaced by offset circle hooks during 2005-2013. Annual mean nominal CPUEs by hook type were shown in Figure 9. For the deep set sector (Fig. 9a), although there were temporal changes of hook types, the nominal CPUEs across hook types were generally consistent over time. High variability in yearly nominal CPUEs across bait types were observed in the shallow set sector (Fig. 9b).

The total numbers of sets that used different bait types have also changed over time (Fig. 10). For the deep set sector (Fig. 10a), bait types 3 (saury), 5 (mixed) and 7 (sardine) were the most dominant bait at various times between 2000 and 2010. There was an increasing trend of use of sauries as bait. For shallow set sector, bait type 4 (mackerel) was the most dominant bait between 2004 and 2013. Yearly nominal CPUE by bait type were shown in Figure 11. For the deep set sector (Fig. 11a), the nominal CPUEs were generally consistent over time no matter what bait type was. The annual mean nominal CPUEs varied considerably among bait types in the shallow-set sector (Fig. 11b).

The nominal CPUE time series was examined in relation to sea surface temperature (SST), with SST set at several levels (level 1: 14 – 22.8 ^{o}C; level 2: 22.8 – 24.6 ^{o}C; level 3: 24.6 – 25.5 ^{o}C; level 4: 25.5 – 26.4 ^{o}C; level 5: 26.4 – 30.6 ^{o}C) (Fig. 12). In the deep-set sector (Fig. 12a), nominal CPUEs showed a consistent pattern across all SST levels. CPUEs showed a declining trend between 1995 and 2000, no significant trend between 2001 and 2010, and a slightly increasing trend after 2010. In the shallow-set sector (Fig. 12b), the CPUEs varied across SST levels by year. There is no consistent pattern of nominal CPUE across all SST levels between 1995 and 2002. The CPUEs became more consistent between 2003 and 2013. In general, there are no clear trends in the nominal CPUEs.

Species composition was examined to explore the potential changes in targeting within Hawaii-based pelagic longline fishery (Fig. 13). For the deep set sector (Fig. 13a), there were more albacore tuna caught per set between 1995 and 2002 compared to 2003 – 2013. The proportion of bigeye tuna caught per set was higher in the latter period (2003 – 2013). Striped marlin usually constituted less than 10% of the catch of the six species examined. In the shallow-set sector (Fig. 13b), there were also more albacore tuna caught per set in the early time period (1995 - 2000). In general, the proportion of striped marlin caught per set was generally less than 5% of the catch of these species.

REFERENCES

Langseth, B., 2015. Standardization of Striped marlin (*Kajikia audax*) CPUE in the Hawaiian longline fishery II: Additional covariates, distribution, and use of data from the deep-set fishery sector only. Working paper presented to the ISC Billfish Working Group Meeting.

Walsh, W, and H.-H., Lee. 2011. Standardization of striped marlin, *Kajikia audax,* CPUE with generalized linear models fitted to pelagic longline observed data from the Hawaii-based fishery: 1995-2009. ISC working paper number 8.

Walsh, W, and Y.-J., Chang, 2015. Standardization of Striped Marlin *Kajikia audax* CPUE for the Hawaii-based Longline Fishery during 1995–2013 using Generalized Linear Models: An Update from 2011. Working paper presented to the ISC Billfish Working Group Meeting.

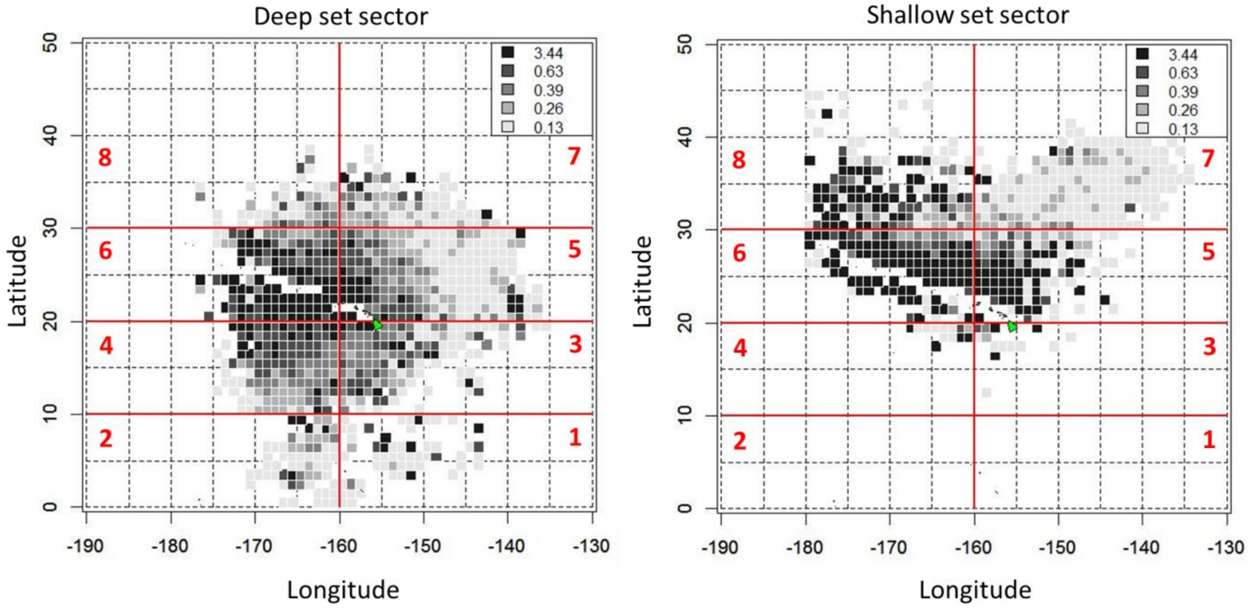


Figure 1. Striped marlin nominal CPUE in the deep-set (left) and the shallow-set (right) sectors of Hawaii-based pelagic longline fishery in 1995–2013. The colors of the squares (1 x 1^{o}) are proportional to the CPUE. Numbers denote the fishing regions.

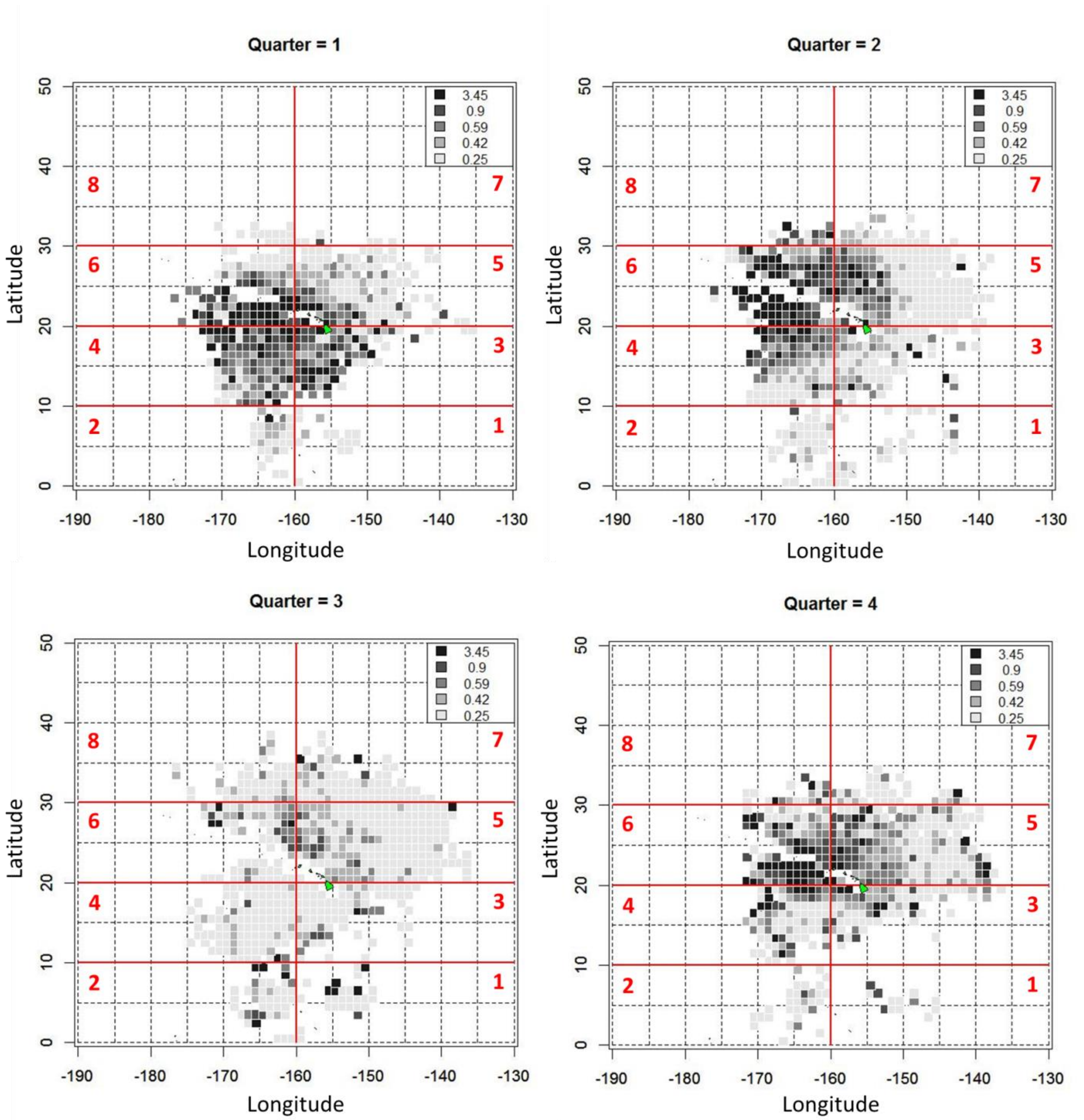


Figure 2. Quarterly mean striped marlin nominal CPUE the deep-set sector of the Hawaii-based pelagic longline fishery during 1995–2013. The colors of the squares (1 x 1°) are proportional to the CPUE. Numbers denote the fishing regions.

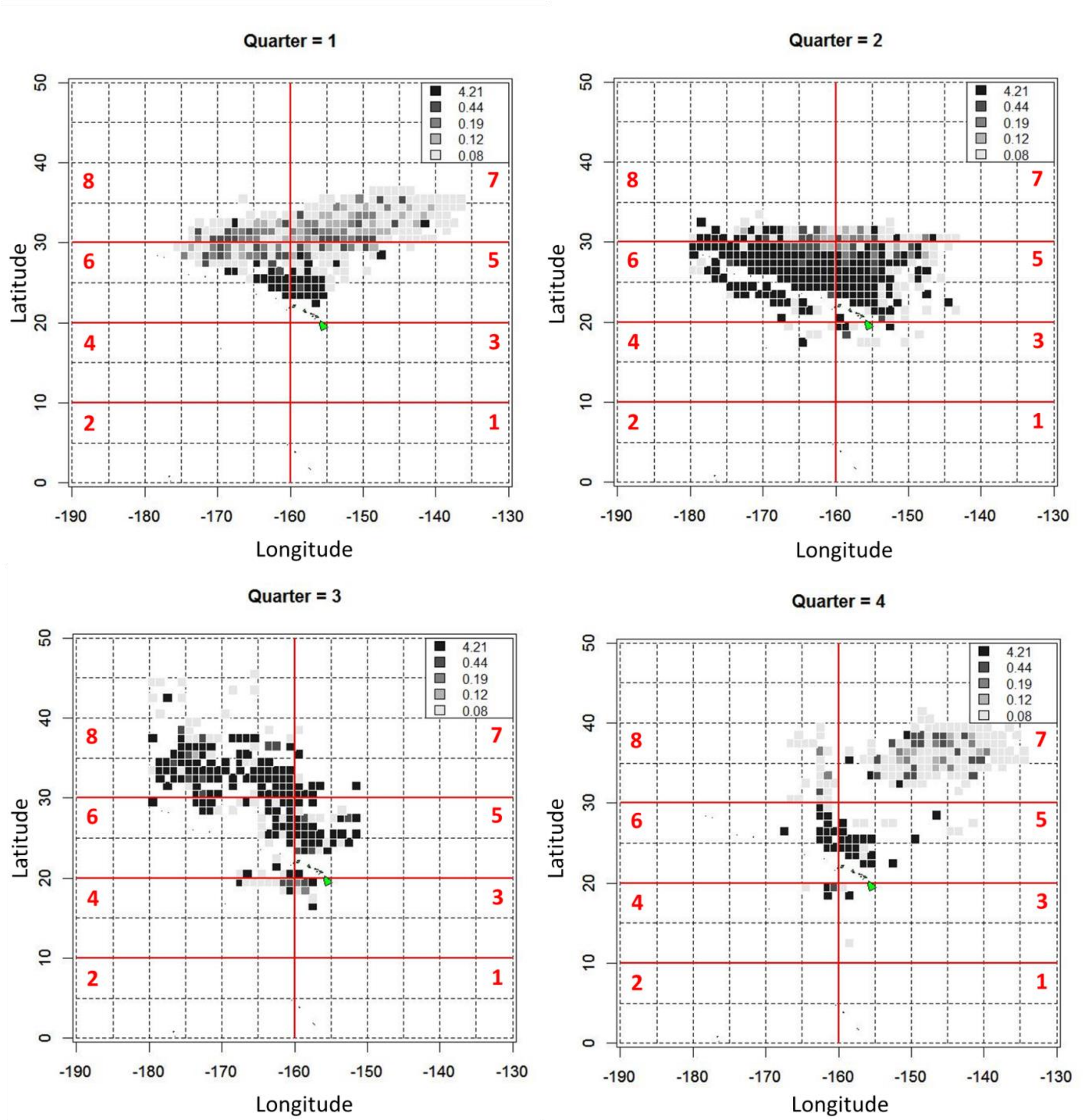


Figure 3. Striped marlin nominal CPUE by fishing (i.e. calendar) quarters in the shallow-set sector of Hawaii-based pelagic longline fishery in 1995–2013. The colors of the squares (1 x 1^o) are proportional to the CPUE. Numbers denote the fishing regions.

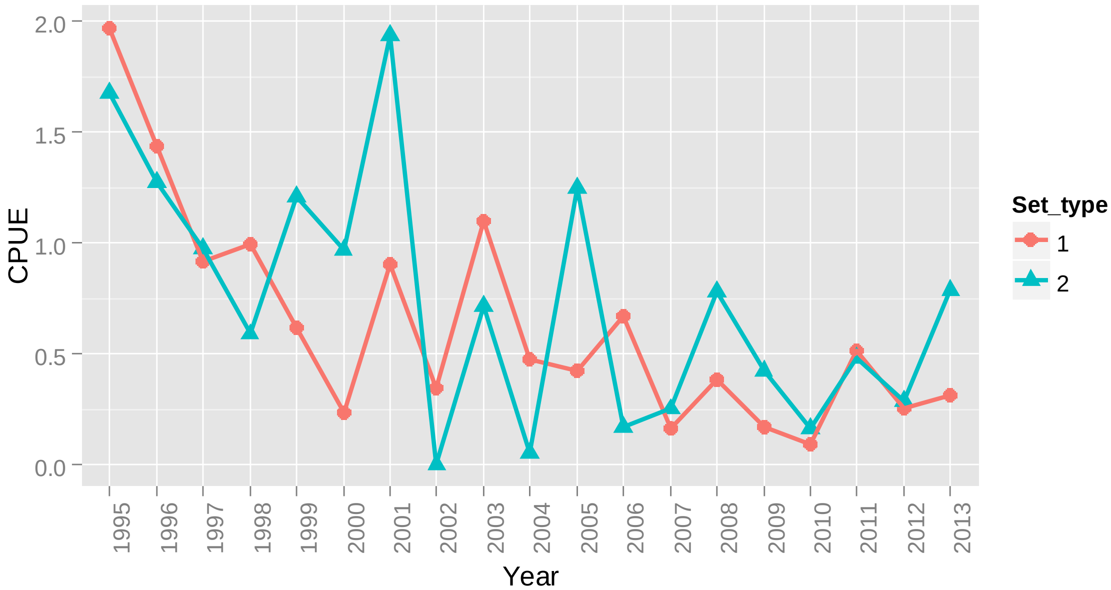


Figure 4. Annual mean striped marlin nominal CPUE by sectors in the Hawaii longline fishery during 1995–2013. Blue line with triangles = deep-set sector; Red line with circles = shallow-set sector.

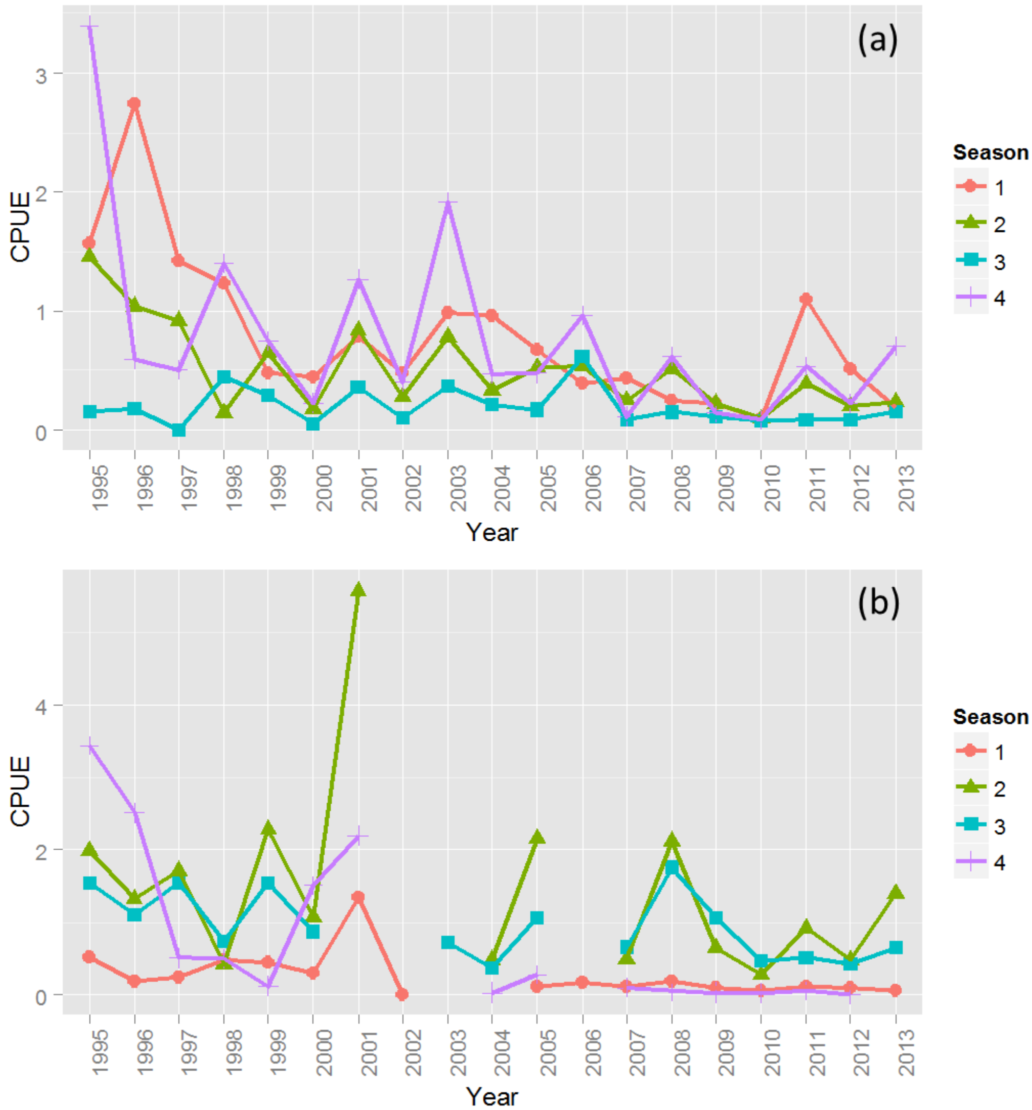


Figure 5. Quarterly mean striped marlin nominal CPUE in the (a) deep-set sector and (b) shallow-set sector of the Hawaii longline fishery during 1995 – 2013.

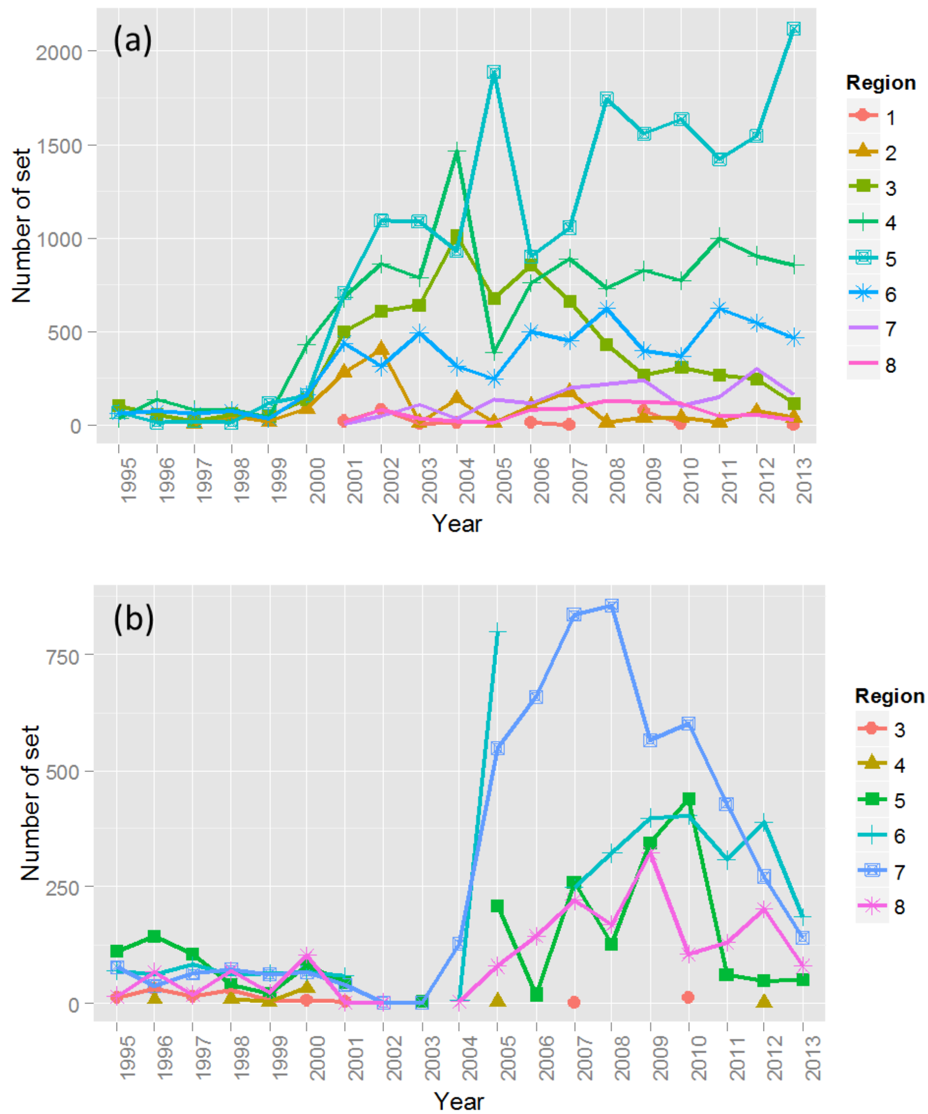


Figure 6. Annual longline set totals by regions in the (a) deep-set sector and (b) shallow-set sector of the Hawaii longline fishery during 1995 – 2013.

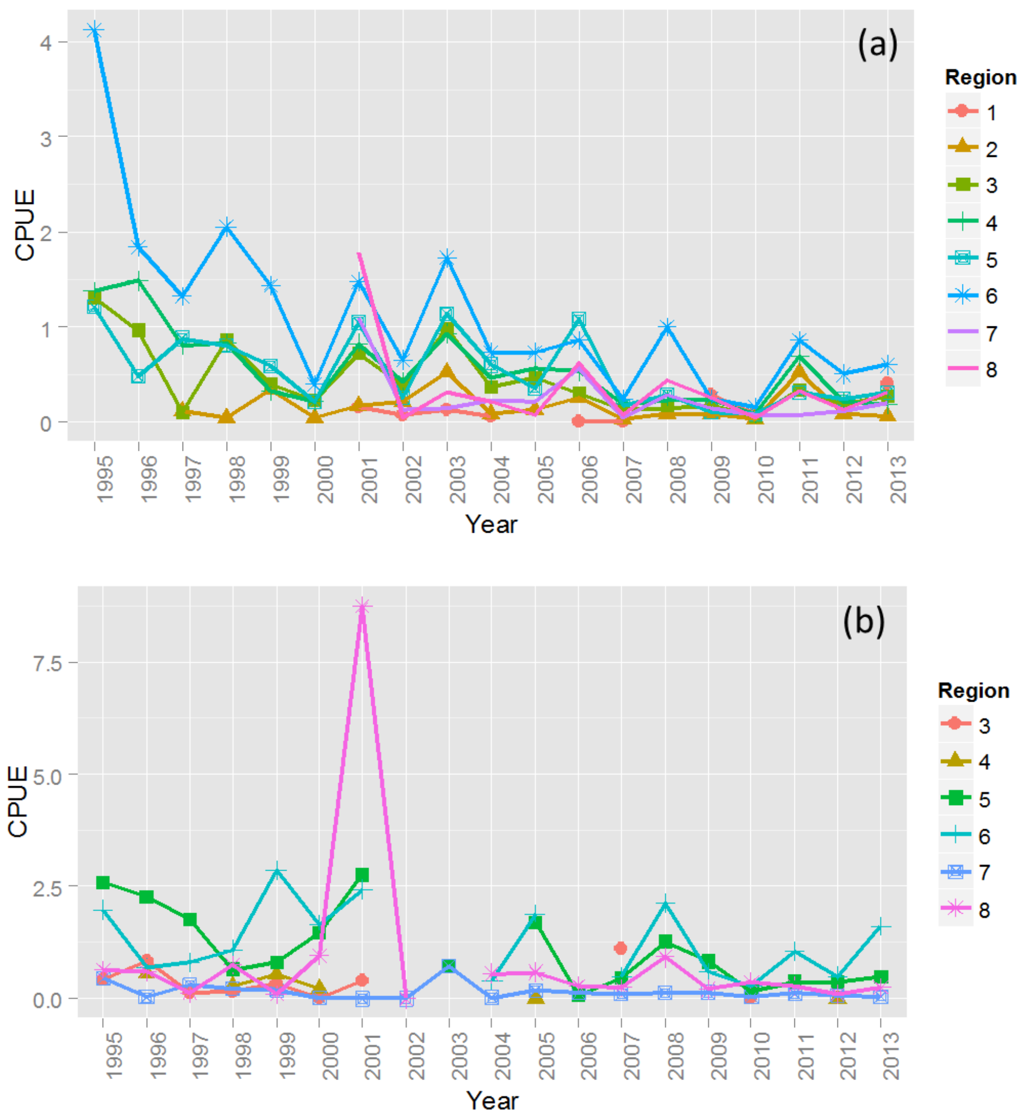


Figure 7. Annual mean striped marlin nominal CPUE by regions in the (a) deep-set sector and (b) shallow-set sector of the Hawaii longline fishery during 1995 – 2013.

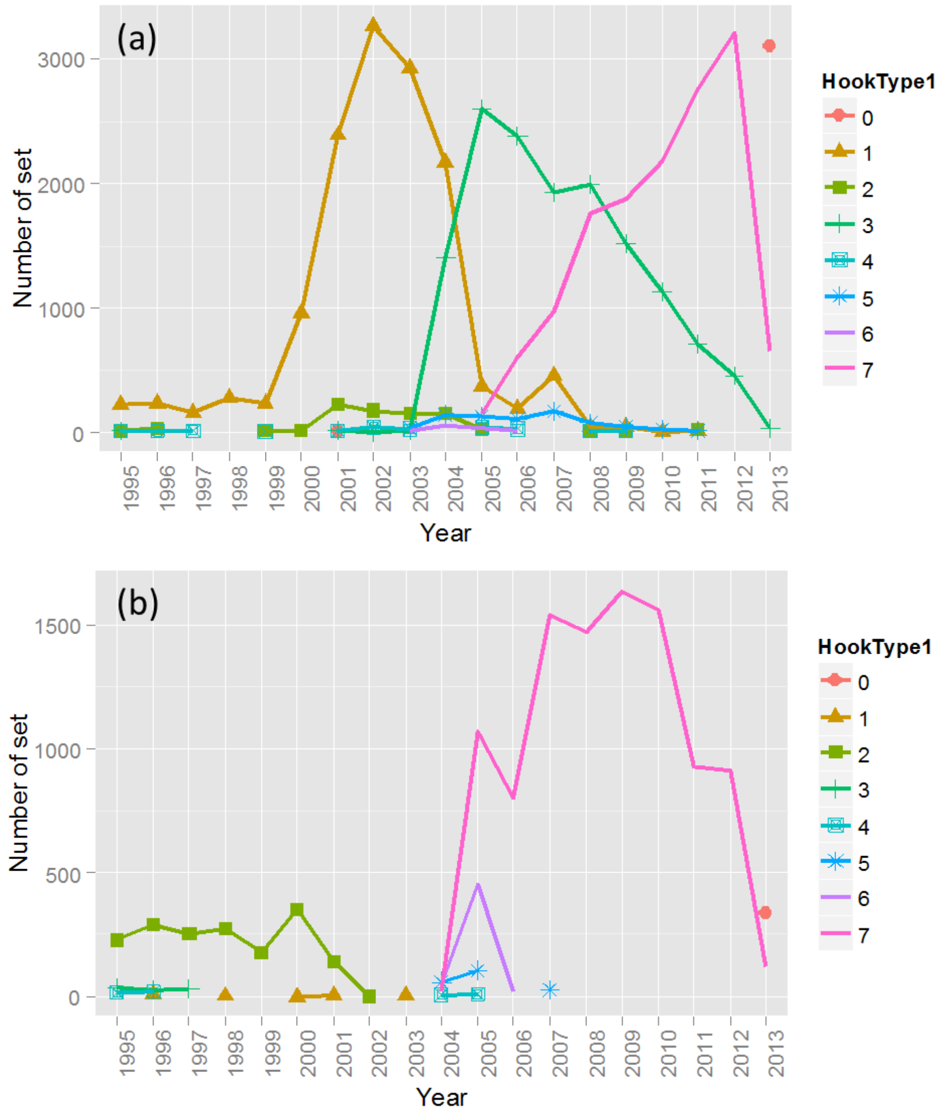
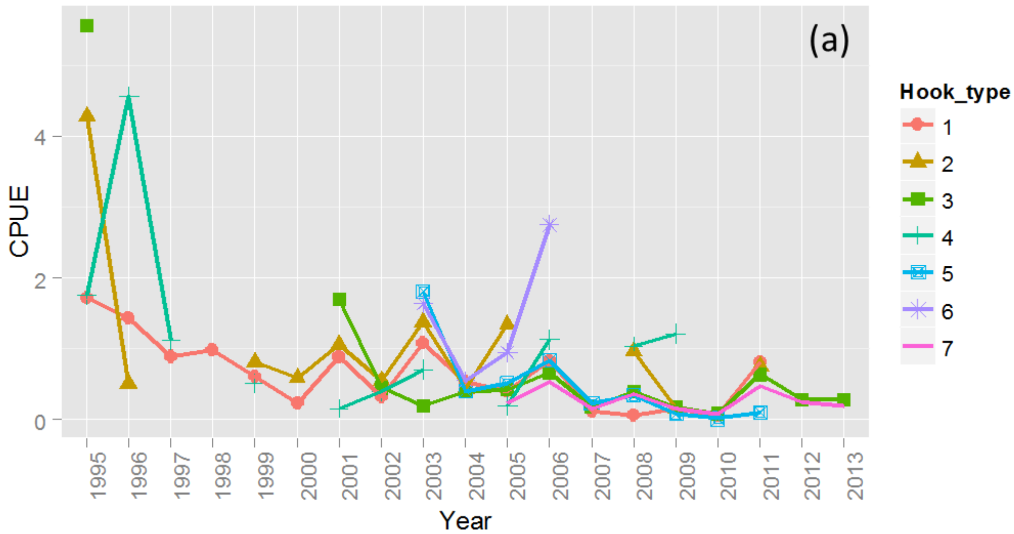


Figure 8. Annual longline set totals by hook types in the (a) deep-set sector and (b) shallow-set sector of Hawaii longline fishery during 1995 – 2013. The hook types are: 1 = tuna; 2 = J-Hook; 3 = offset tuna; 4 = offset J-Hook; 5 = circle; 6 = other; 7 = offset circle.



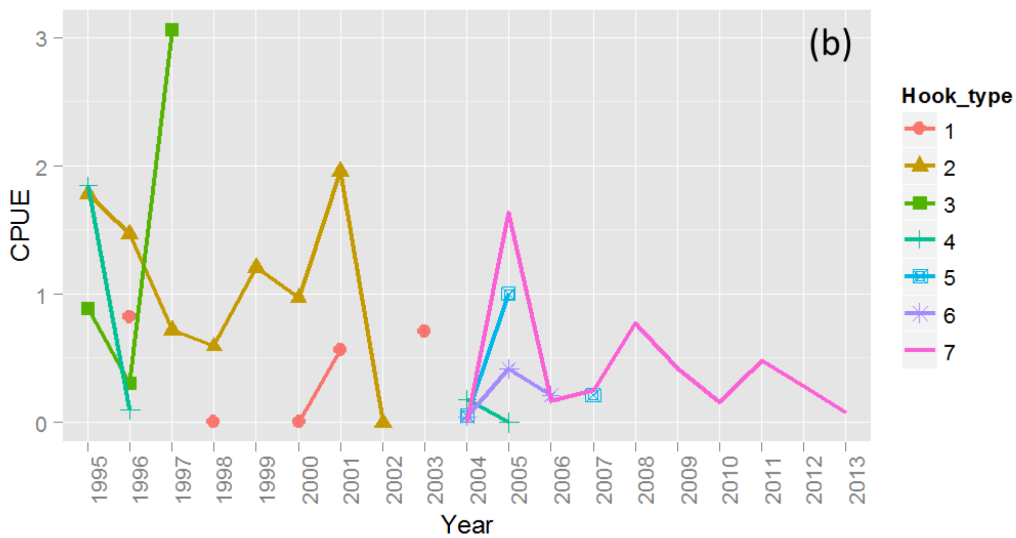


Figure 9. Annual mean striped marlin nominal CPUE by hook types in the (a) deep-set sector and (b) shallow-set sector of the Hawaii longline fishery during 1995 – 2013. 1 = tuna; 2 = J-Hook; 3 = offset tuna; 4 = offset J-Hook; 5 = circle; 6 = other; 7 = offset circle.

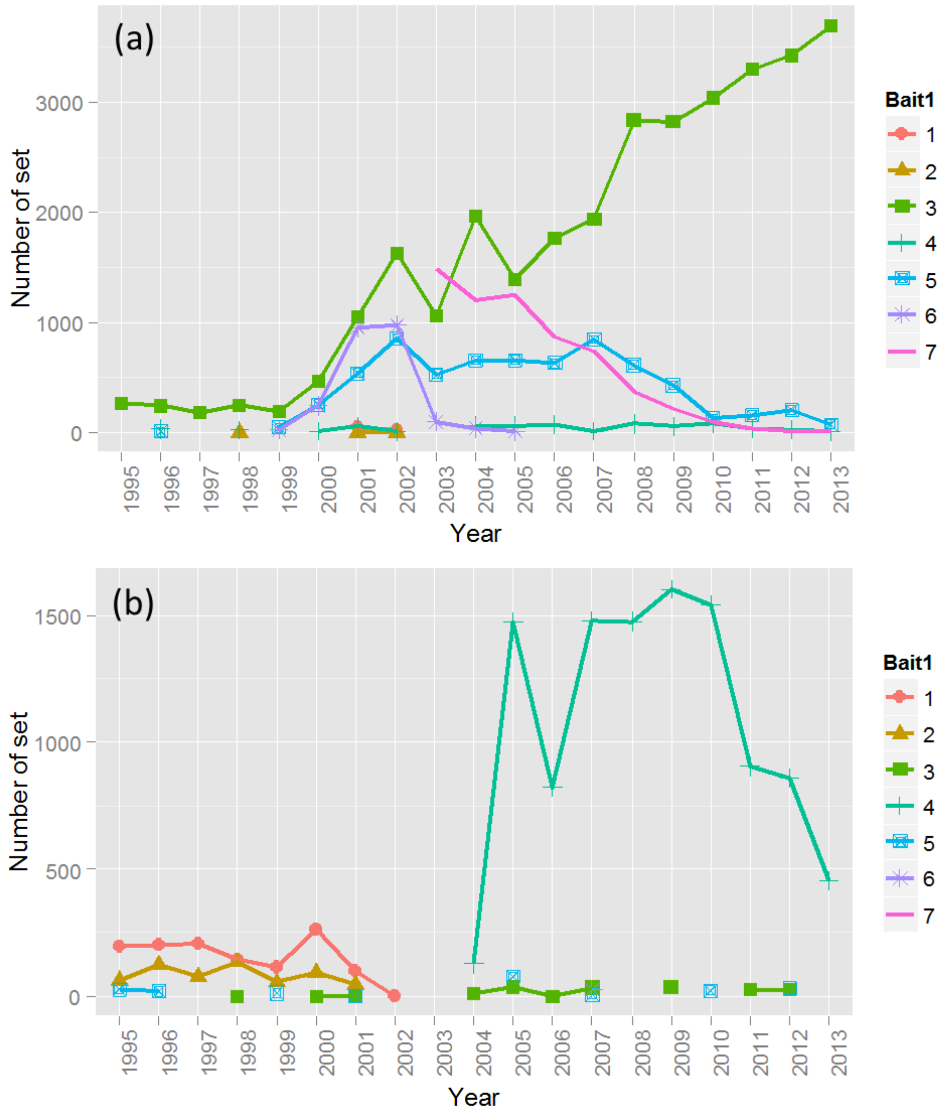


Figure 10. Annual longline set totals by bait types in the (a) deep-set sector and (b) shallow-set sector of Hawaii longline fishery during 1995 – 2013. The bait types are: 1 = large squid; 2 = small squid; 3 = saury; 4 = mackerel; 5 = mixed; 6 = other; 7 = sardine.

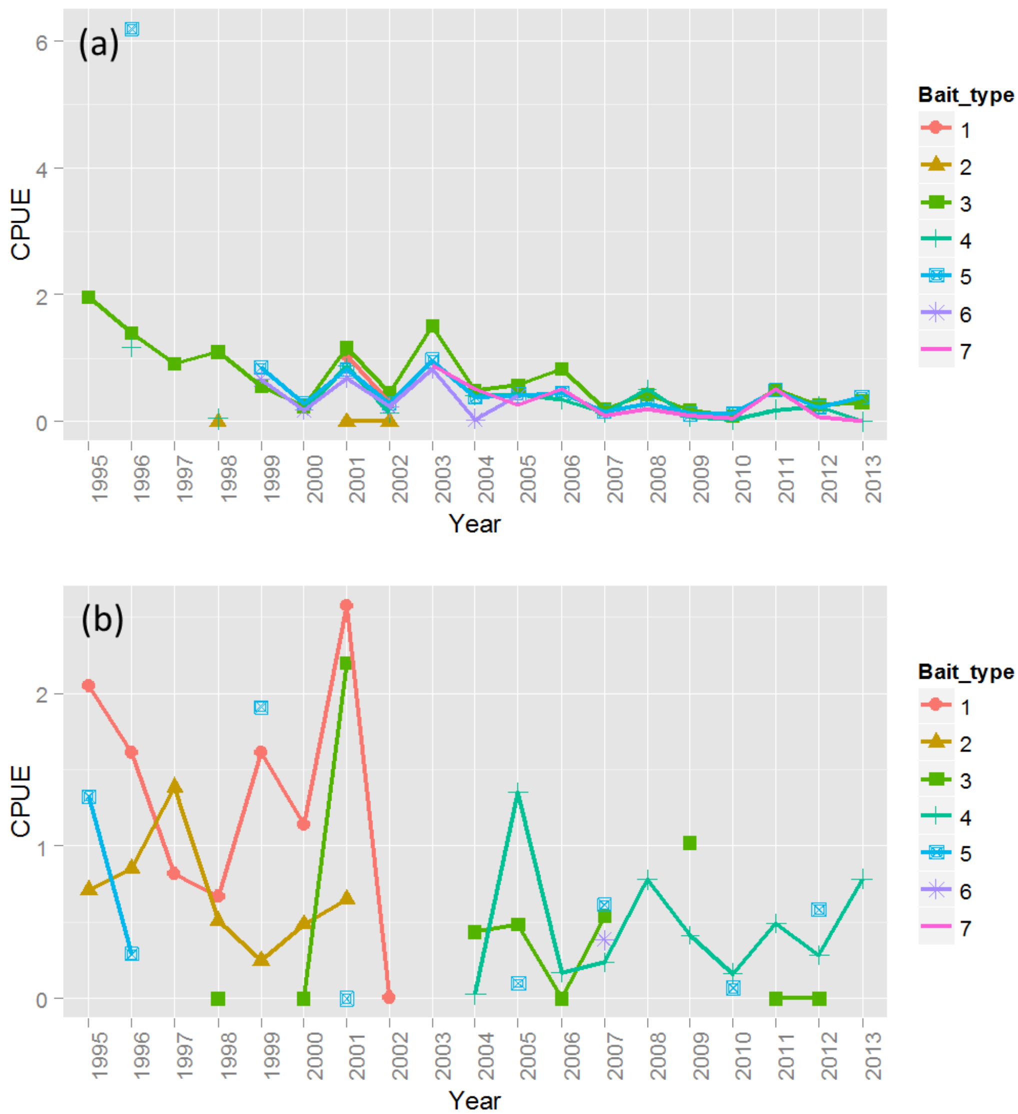


Figure 11. Annual mean striped marlin nominal CPUE by bait types in the (a) deep-set sector and (b) shallow-set sector of Hawaii longline fishery during 1995 – 2013. The bait types are: 1 = large squid; 2 = small squid; 3 = saury; 4 = mackerel; 5 = mixed; 6 = other; 7 = sardine.

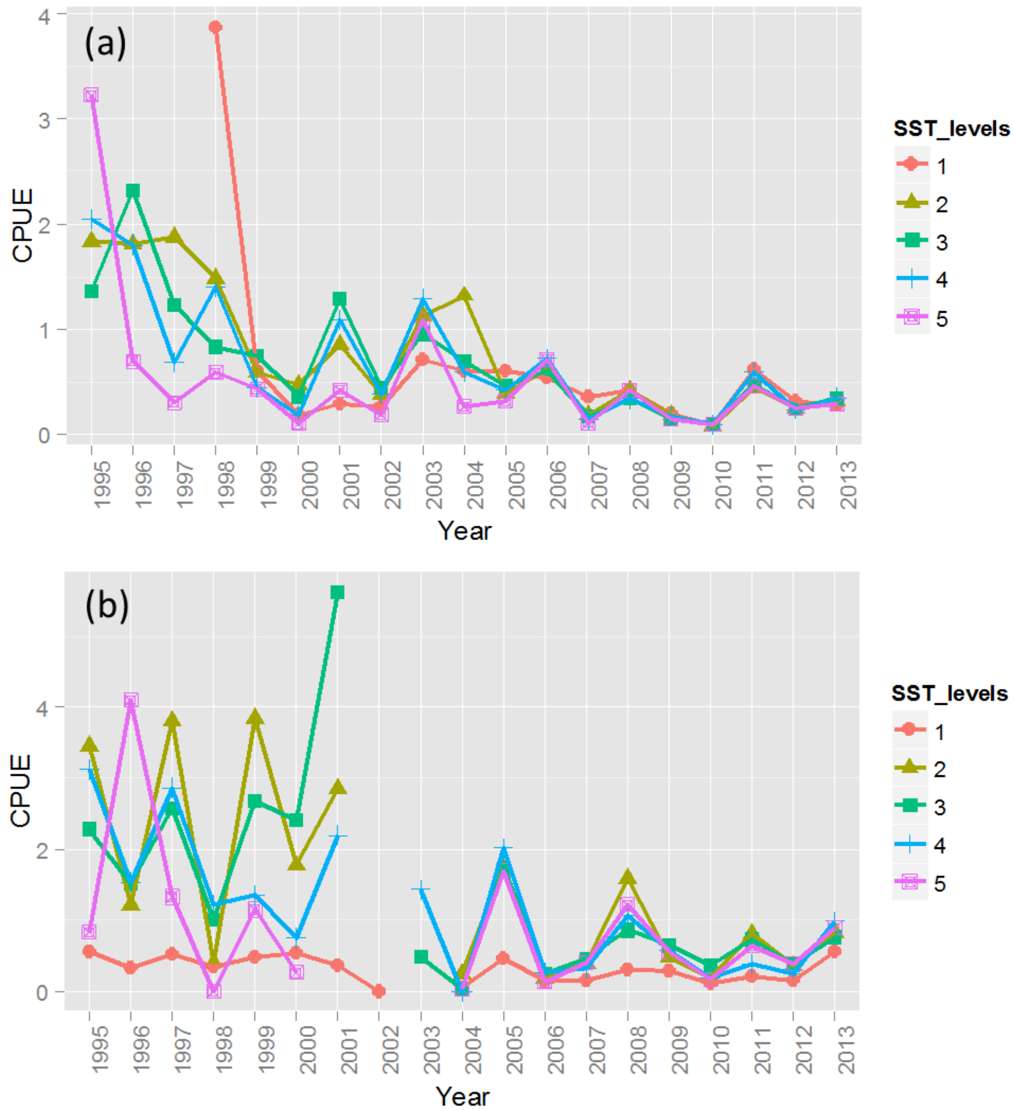


Figure 12. Annual mean striped marlin nominal CPUE by sea surface water temperature (SST) levels in the (a) deep set sector and (b) shallow set sector of Hawaii longline fishery, 1995 – 2013. 1 = 14-22.8 (^{o}C); 2 = 22.8-24.6 (^{o}C); 3 = 24.6-25.5 (^{o}C); 4 = 25.5-26.4 (^{o}C); 5 = 26.4-30.6 (^{o}C)

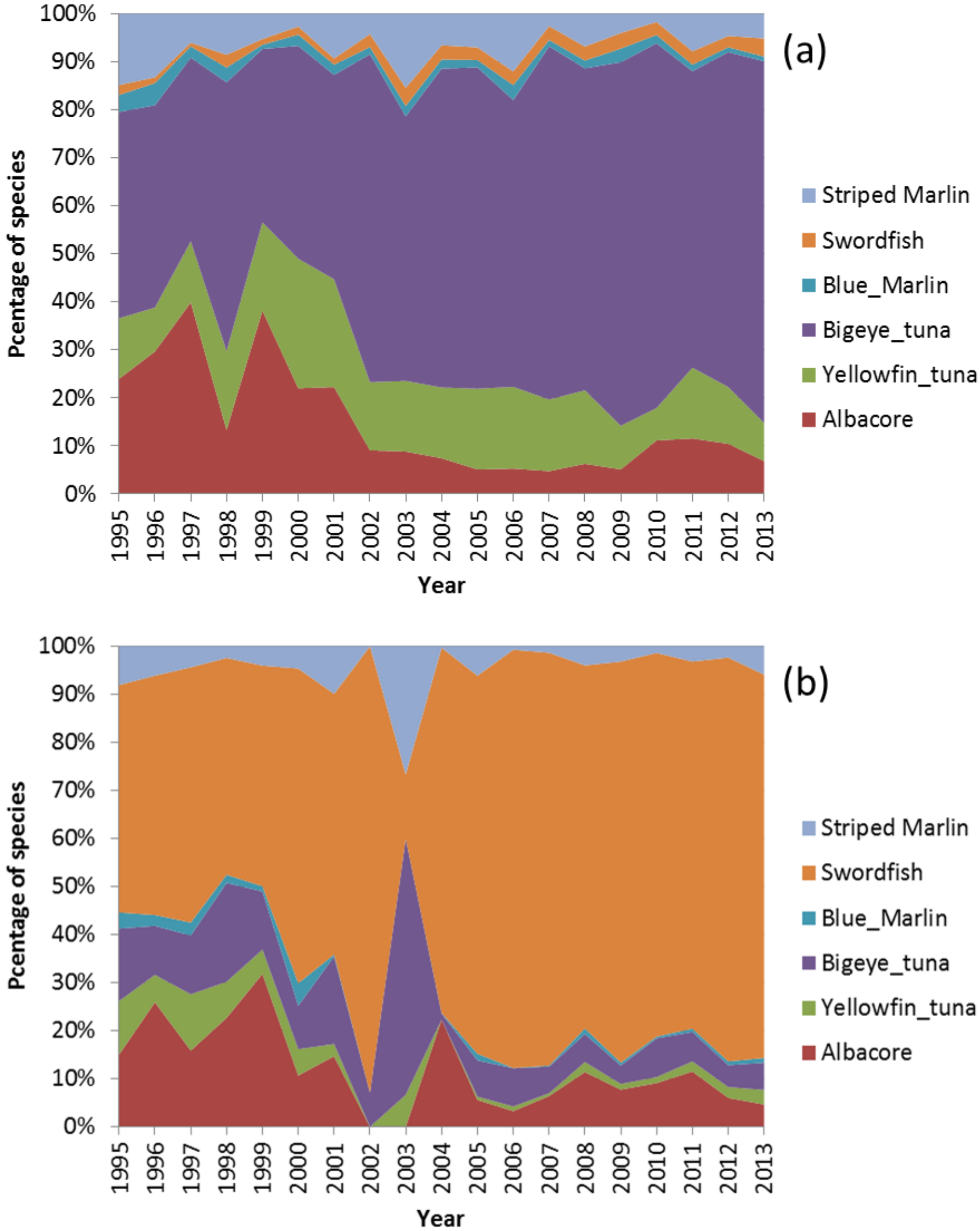


Figure 13. Temporal variation of species composition in the (a) deep-set sector and (b) shallow-set sectors of the Hawaii longline fishery during 1995 – 2013.