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Catch and size data from Korean tuna longline fisheries in the Eastern Pacific Ocean

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INTRODUCTION

The data reporting and management of Korean distant water fisheries are legally based on the Distant Water Fisheries Development Act. Until November 2012, fishermen used paper logbooks to record their fishing information and submitted the logbooks either within 30 days (home-based) or 60 days (foreign-based) after completion of their operations, and it was difficult to achieve 100% data coverage. Hence, in December 2012, the government strengthened and revised the Act to require fishermen to report data every month using an electronic logbook format (e.g., excel format), and with this change it was possible to achieve 100% coverage thereafter. In addition, we begun to collect information on discard/release according to tuna Regional Fisheries Management Organizations (t-RFMOs) data requirements and added ecologically related species (sharks, seabirds, sea turtles, etc.) data reporting format. In September 2015, we developed and changed the Electronic Reporting System. Since then, fishermen have reported their fishing information every day, and the National Institute of Fisheries Science (NIFS) reviews the data in real time.

This paper describes catch and size data from Korean tuna longline fisheries in the Eastern Pacific Ocean (EPO).

DATA AND METHODS

All catch and effort data used in this paper were collected by the NIFS. The total annual catches of the Korean tuna longline fisheries in the EPO were taken from the IATTC database. The data used to analyze the temporal and spatial distributions of the fishing grounds and to compute nominal CPUE were based on the logbook data

[1] Postponed until a later date to be determined

(operational-level data) recorded by the captain and collected by NIFS, comprising: the vessel ID (call sign), fishing date and position, number of hooks and floats used, and catch in number by species. The species includes albacore (ALB), bigeye (BET), skipjack (SKJ), yellowfin (YFT), black marlin (BLM), blue marlin (BUM), striped marlin (MLS), sailfish (SFA), swordfish (SWO), other fish (OTH), and sharks (OSH). Under a special MOU, these operational-level logbook data also have been provided to IATTC by the NIFS for use in stock assessment modeling.

Operational-level data available are from 1971; however, the data prior to 1976 were excluded due to missing information in several data fields. A vessel's call sign can be one of three types of codes. The first type is a unique identifier of the vessel which comprises of numbers and letters. The second type consists of either a ZA or ZB with a 3-digit number. This is an arbitrarily assigned call sign where a vessel can be distinguished by its name, trip information, or any other information, but its call sign is unknown. The identical number indicates the same vessel. Thirdly, ZZ-NA is assigned when no information is available on the vessel.

The size data used in this study are what the captain has recorded on board and what has been collected by onboard observers from the Korean National Observer Program (NOP). Fishing vessels are recommended to measure one fish per one ton of catch, by species, in accordance with the general regulations of t-RFMOs. For those trips sampled by the NOP, a scientific observer collects data from about 70% (in number of hooks) of each haul from its start and measures the length and weight of the catch.

RESULTS AND DISCUSSION

Change in the number of fishing vessels

Figure 1 shows the number of active longline vessels that operated in the Pacific Ocean, 1987-2018. The number of vessels reached a record high of 220 vessels in 1991 and was at or above about 150 vessels until 2005. However, the number of vessels decreased to 130 in 2006 and further decreased to less than 100 in 2015. The cause of the decrease in 2006 may relate to Korea joining WCPFC and IATTC in 2004 and 2005, respectively, and the further decrease in 2015 could be due to a reduction of the bigeye quota by the WCPFC.

Nominal catch and its species composition

The annual catch of Korean tuna longline fisheries, analogous to the trend in the number of fishing vessels, was at a maximum of 27 thousand tons in 1991 and then decreased to a level of about 17 thousand tons by 2004. However, from 2006 to 2009, the annual catch was less than 10 thousand tons, the lowest level since 1990. The catch increased up to around 13 thousand tons in 2010 and has remained stable thereafter (Figure 2).

Species composition by year (Figure 3) shows that Korean tuna longline fisheries have been targeting bigeye and yellowfin tunas. Before the mid-1980s, the catch of albacore was greater than that of yellowfin. Since the mid-2000s, the proportion of bigeye in total catch increased by more than 60%, and yellowfin catch decreased while swordfish catch increased. The mean catch of bigeye and yellowfin for the 5 most recent years (2014-2018) was 7,991 and 1,030 tons, respectively.

In general, yellowfin inhabits depths around 100 m (Wikipedia 2020a), bigeye is found deeper, at about 100-600 m (Evans et al. 2008, Wikipedia 2020b), and swordfish is known to occur around 550 m deep during the day (Wikipedia 2020c). Given this information on species habitat preferences, the recent increase in swordfish catch in the Korean tuna longline fisheries may be related to a shift in fishing strategies to target bigeye instead of yellowfin.

Fishing effort

The Korean tuna longline fisheries mainly operated in the tropical area between 20°N and 20°S (Figure 4). Before the 1990s, fishing operations also took place in temperate areas north of 20°N and south of 20°S, but ever since, fishing effort has been concentrated in the tropical area, and the overall region occupied by the fleet has been reduced.

Changes in gear configuration (hooks, floats and HBF)

Figure 5 shows the changes in the number of hooks, floats and hooks between floats (HBF) used by the Korean tuna longline fisheries over time. The number of hooks was less than 2,000 in the early 1970s, but gradually increased thereafter. Since the mid-1970s, 2,000-3,000 hooks have been used, and there was no significant change from year to year. However, there has been an increase in the number of hooks used since 2014. For the number of floats, two major shifts have been found. Namely, there was a significant decrease in the median value to around 200 in the mid-1980s, and it was found that, since the mid-2000s, fishing vessels have rarely used over 400 floats. In contrast, the number of HBF had increased to more than 10 in the mid-1980s, and then shows an increasing trend overall, with a marked increase in 2014.

In short, the decrease in the number of floats and the increase of HBF, which have been observed since the mid-2000s, have likely increased the depth at which the longline gear is set, and this is a plausible cause of the increased bigeye and swordfish catch that has occurred since the mid-2000s.

Catch and CPUE

Figures 6-8 represent the spatial distributions of the catch and CPUE of bigeye, yellowfin and swordfish caught by the Korean tuna longline fisheries. High CPUE was observed for bigeye and yellowfin in the tropical area around the equator. Recently, bigeye CPUE has increased in the EPO, and the yellowfin CPUE has decreased or was at a low level, whereas the swordfish CPUE has increased.

Discards

Discard rates for bigeye and yellowfin tunas were analyzed using the 2015-2018 Annual Scientific Observer Reports submitted to the IATTC Secretariat (NIFS 2016-2019). Total catch and discards observed for bigeye and yellowfin are shown in Figures 9-10. The discard rate differs from year to year, but the changes are small. The mean discard rate was 3.4% for bigeye and 3.6% for yellowfin.

Sampling of size data

The size data used in this study were collected by fishermen and by the NOP from 2004 to 2018 (Figure 11). For the data collected by fishermen, the number of measurements was low prior to 2014 and in 2016. A database for the size data collected by fishermen is under development and will be updated with additional information in the future, which will increase samples sizes prior to 2014 and in 2016. The available observer data are for years 2004-2005, 2007, and 2013-2018, but there are a few length measurements available prior 2015.

Length distribution

Figures 12-13 show annual length distributions for bigeye and yellowfin tunas by data source. In general, the median lengths of fish measured by fishermen were larger than those of fish measured by the NOP for both species, and the interquartile ranges (*IQR*) were smaller. Such differences could be related to the differences between their measurement methods. That is, because observers measured all fish associated with about 70% (in number of hooks) of each haul from its start, their data include measurements from small to large sizes, while fishermen measure only a few fishes per set, and it is likely that their data were biased toward a certain size, for example, which they preferred.

Sex ratio

Spatial pattern in the sex ratio was analyzed using data for cells (5°×5° areas) for which more than 30 fish were sampled for sex. It was found that there was no marked spatial difference in the sex ratio (Figure 14).

Relationship between length and weight

The relationship between processed weight (PW) and round weight (RW), and the relationship between fork length (FL) and round weight (RW), for bigeye and yellowfin tunas were analyzed using the scientific observer data. Results are shown in Figures 15-16, which include a comparison to equations used for stock assessments of those species (Langley et al. 2006, Aires-da-Silva and Maunder 2010; 2012). There is little difference in the relationship between PW and RW for both species, and the relationship between FL and RW differed at size classes of 100 kg and more.

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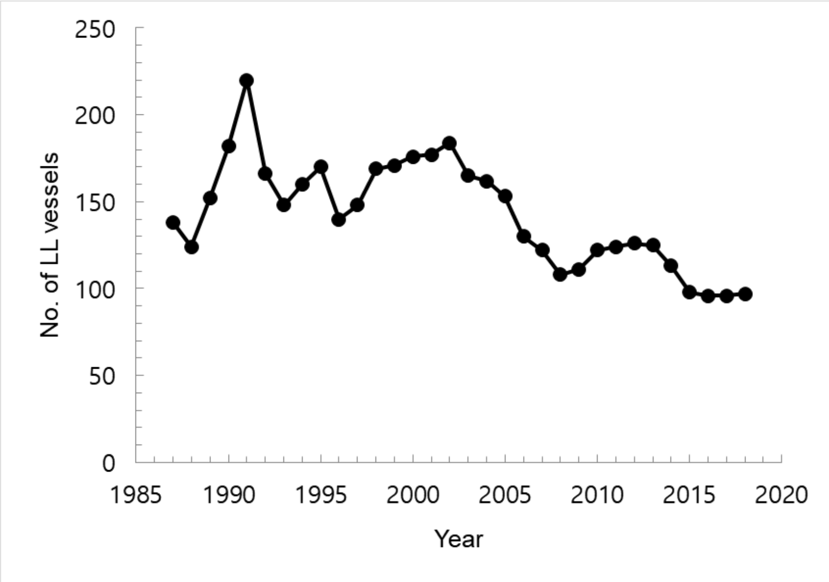

Figure 1. Annual number of Korean tuna longline vessels in the Pacific Ocean.

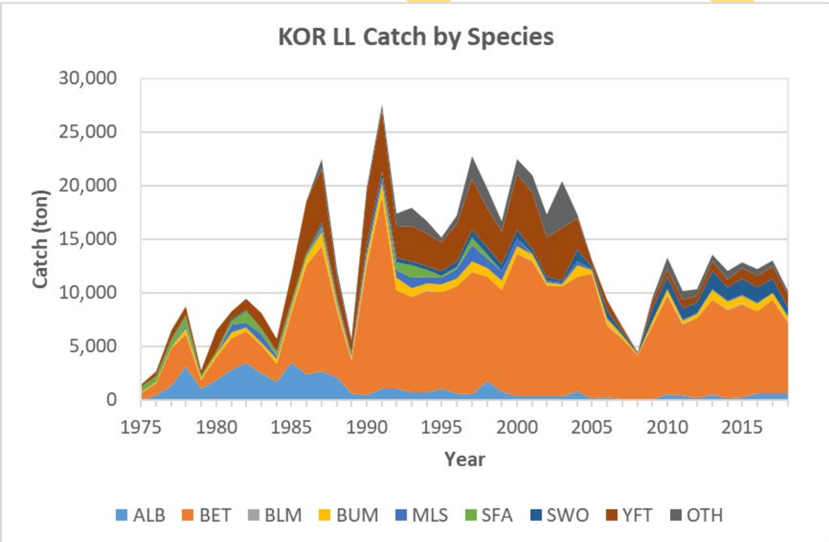

Figure 2. Annual catches, by species, of the Korean tuna longline fishery operating in the EPO.

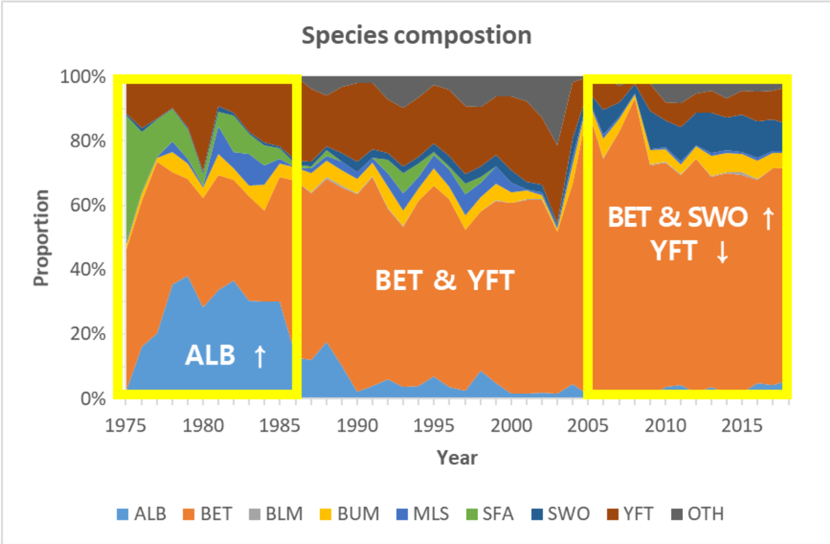

Figure 3. Species composition of the Korean tuna longline fishery catch in the EPO.

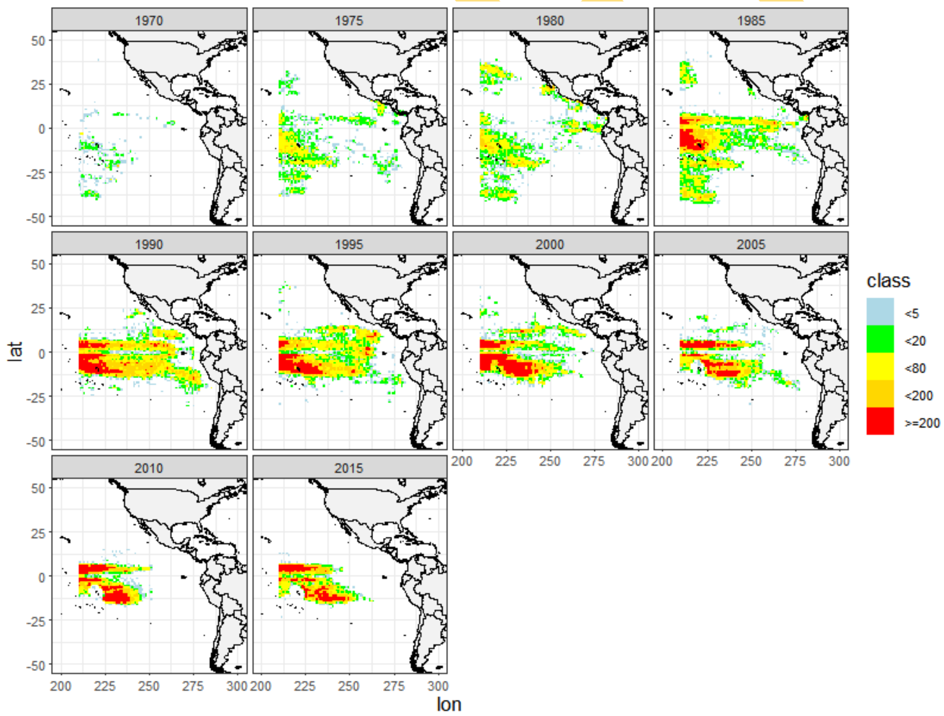

Figure 4. Spatial distribution of fishing effort of Korean tuna longline vessels operating in the EPO, aggregated by 5 years.

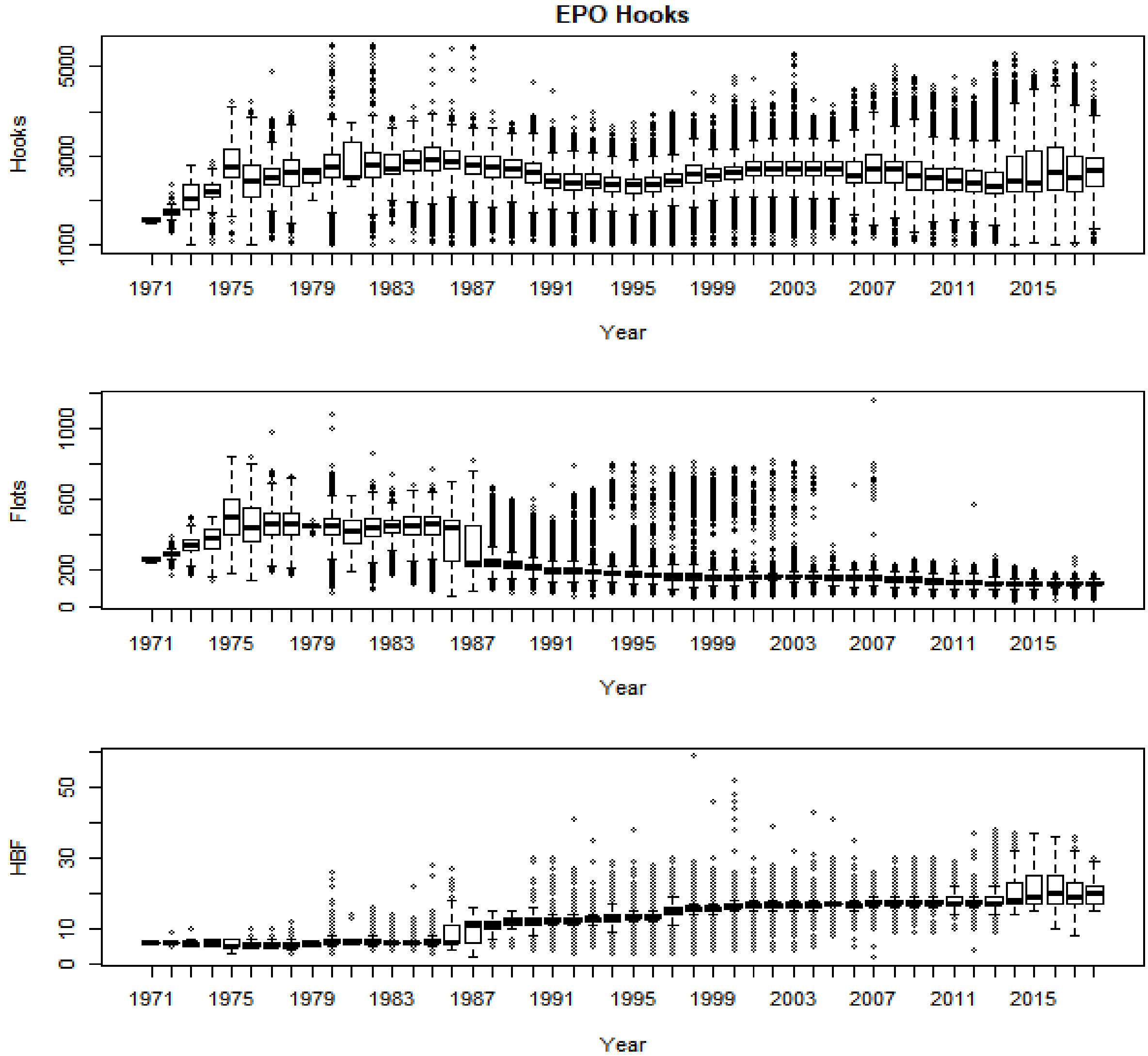

Figure 5. Changes in gear configuration of Korean tuna longline vessels operating in the EPO.

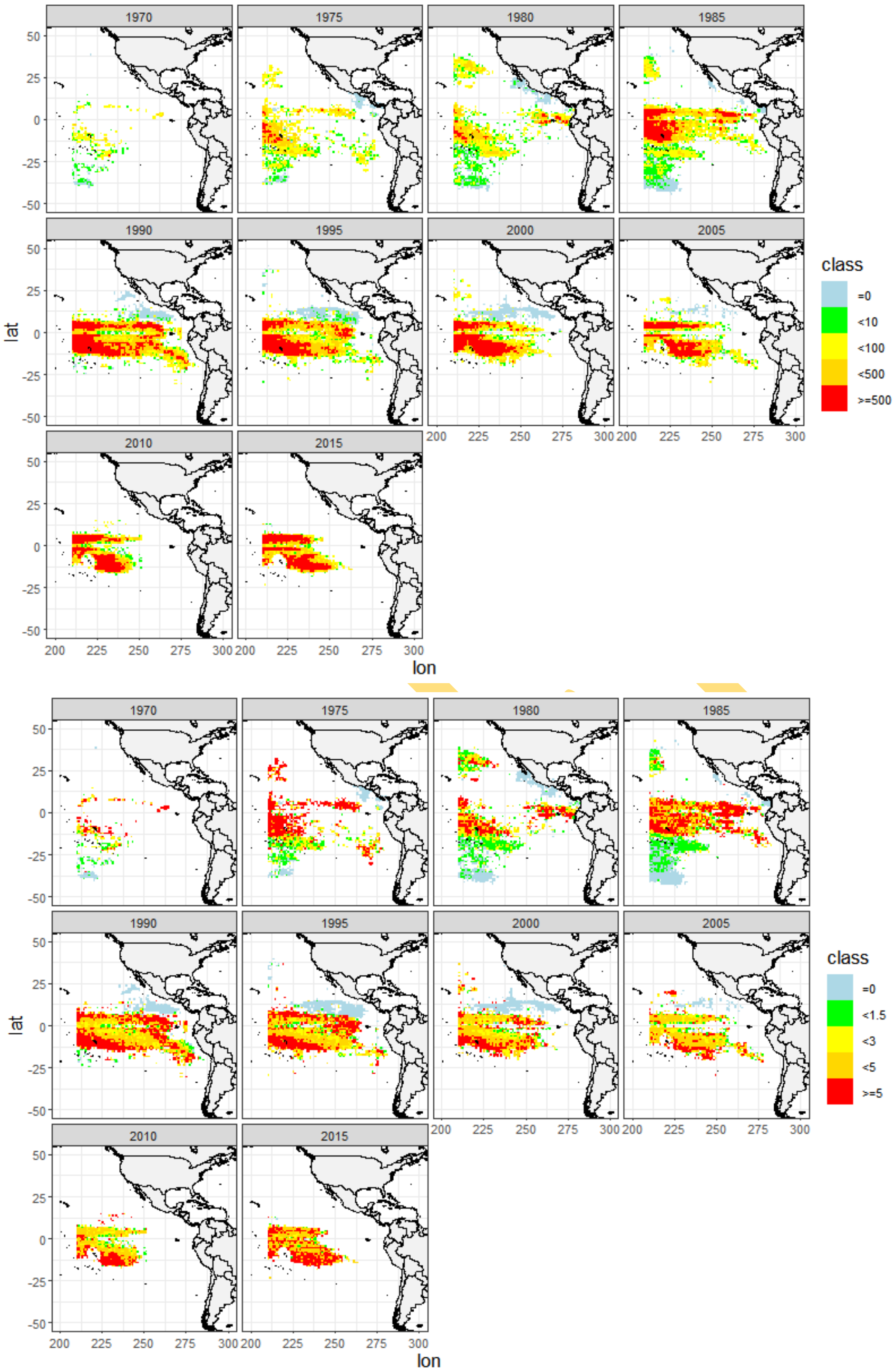

Figure 6. Spatial distribution of bigeye catch (in numbers; upper) and CPUE (in number per 1000 hooks; lower) of the Korean tuna longline fishery in the EPO. Catch is aggregated by 5 years and CPUE is the median for 5 years.

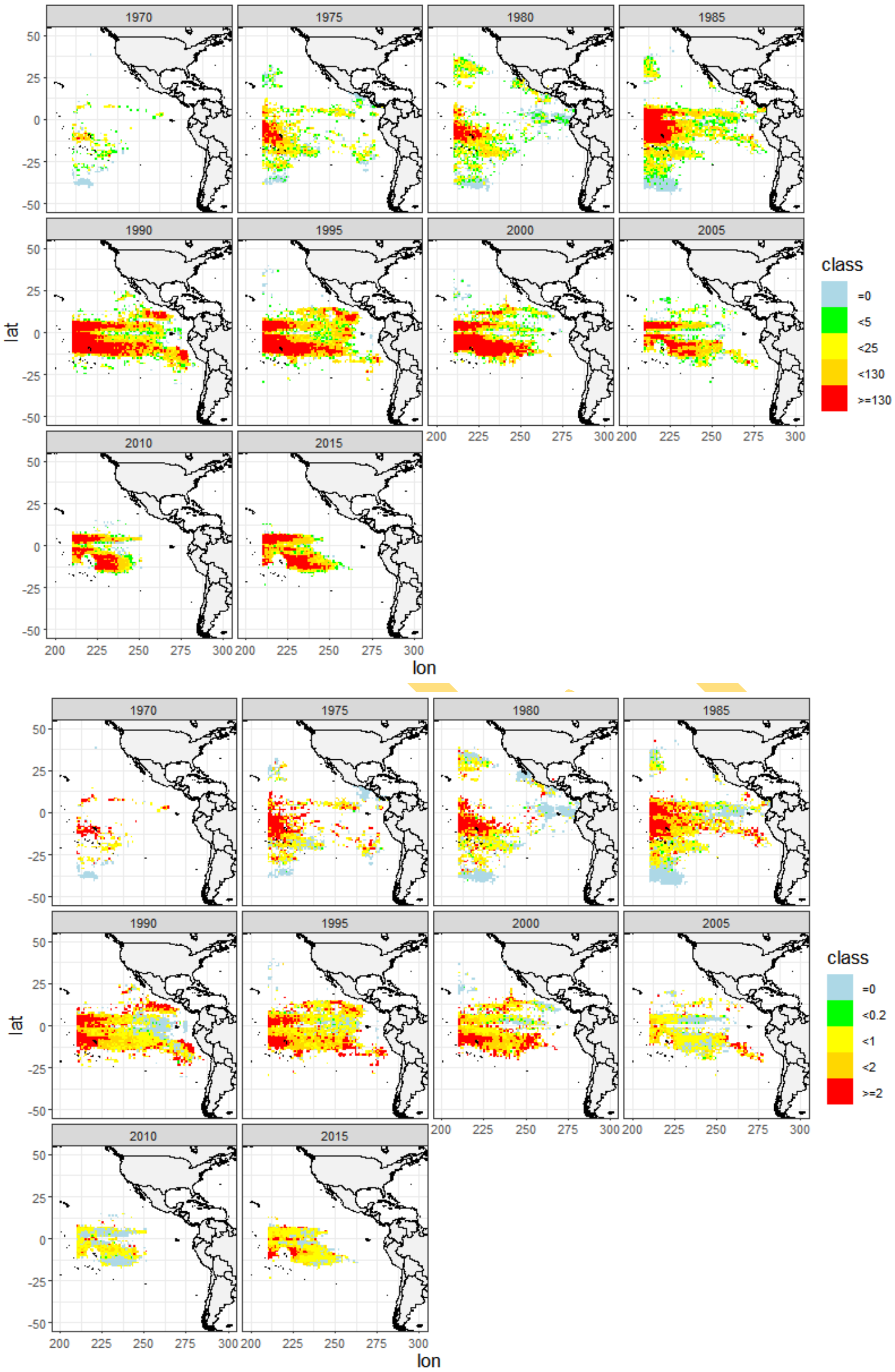

Figure 7. Spatial distribution of yellowfin catch (in numbers; upper) and CPUE (in number per 1000 hooks; lower) of the Korean tuna longline fishery in the EPO. Catch is aggregated by 5 years and CPUE is the median for 5 years.

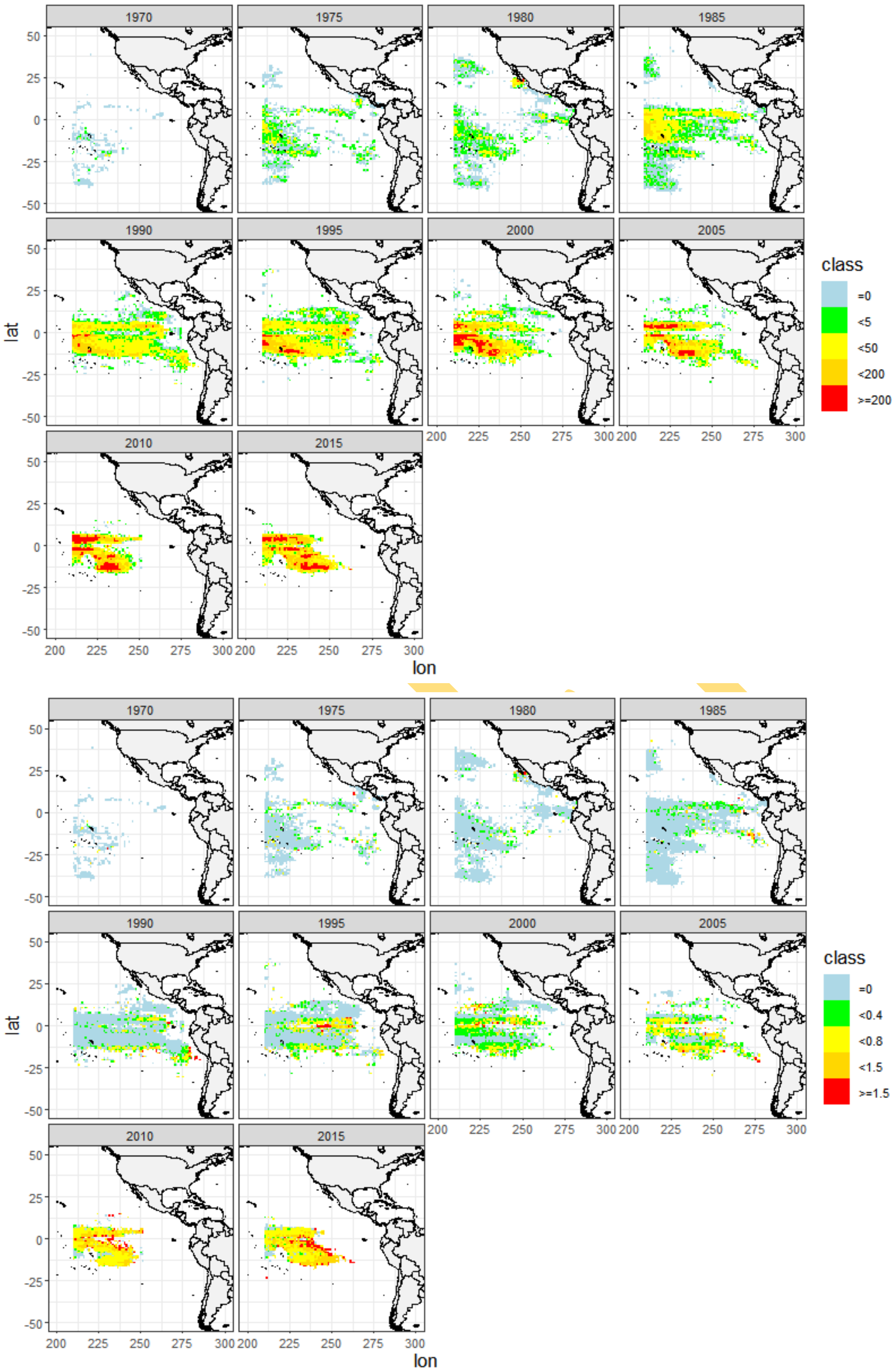

Figure 8. Spatial distribution of swordfish catch (in numbers; upper) and CPUE (in number per 1000 hooks; lower) of the Korean tuna longline fishery in the EPO. Catch is aggregated by 5 years and CPUE is the median for 5 years.

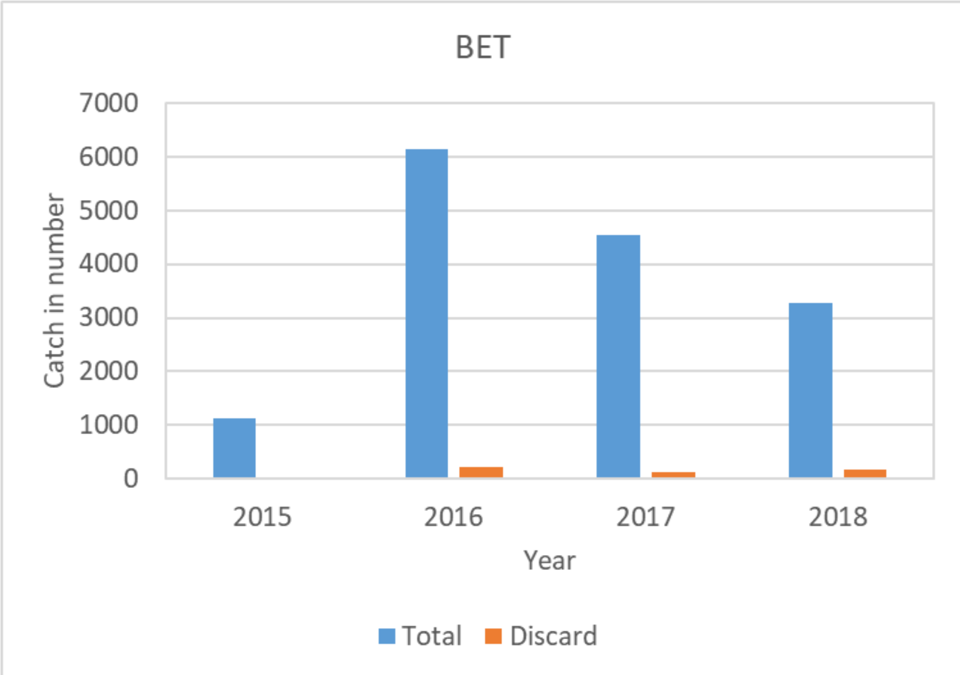

Figure 9. Total catch and discards of bigeye observed by the NOP.

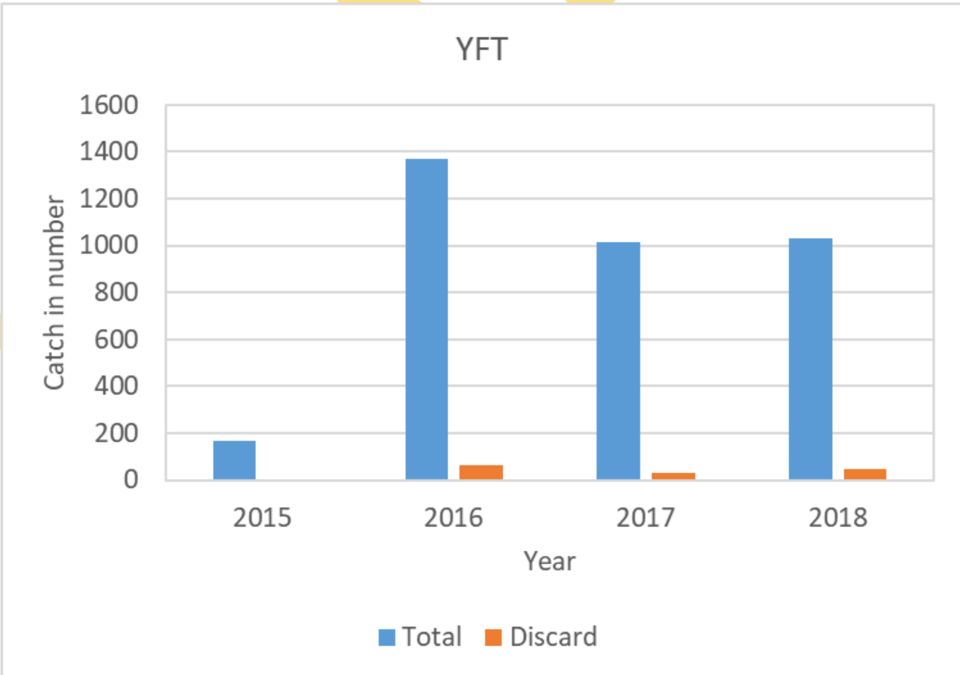

Figure 10. Total catch and discards of yellowfin observed by the NOP.

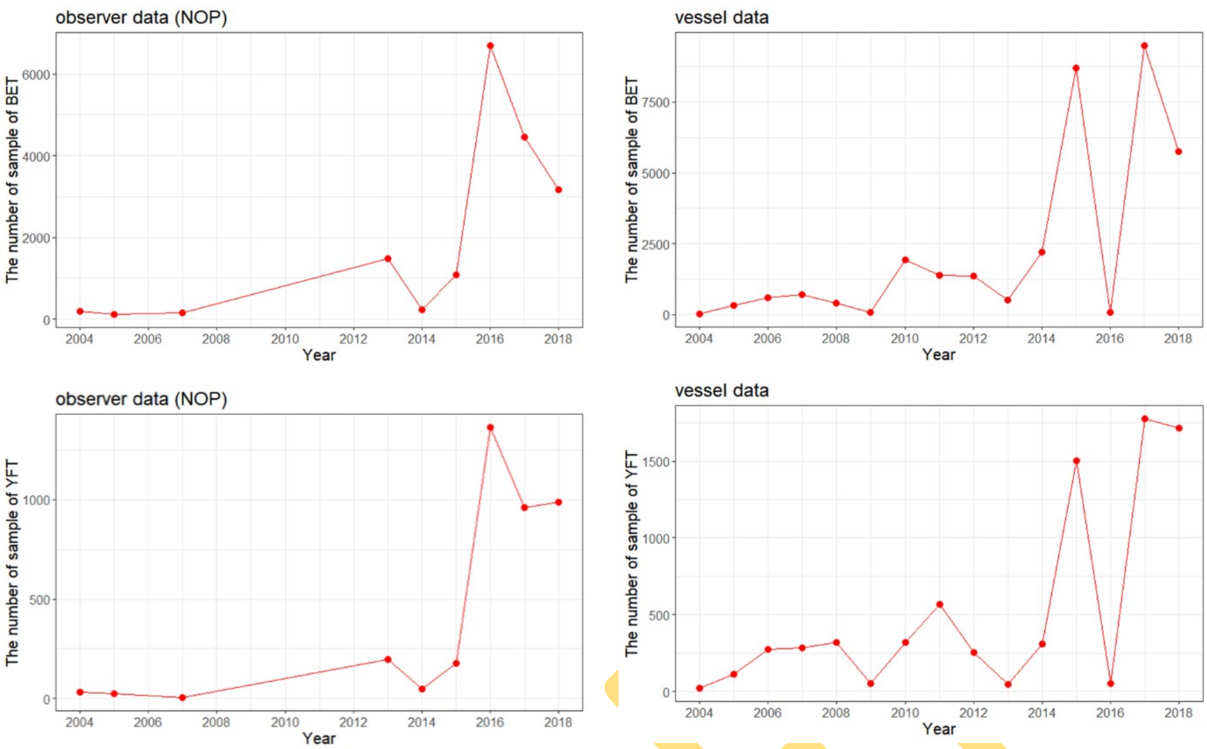

Figure 11. The number of length measurements of bigeye (upper row) and yellowfin (lower row), by year for the NOP (left) and fishermen (right).

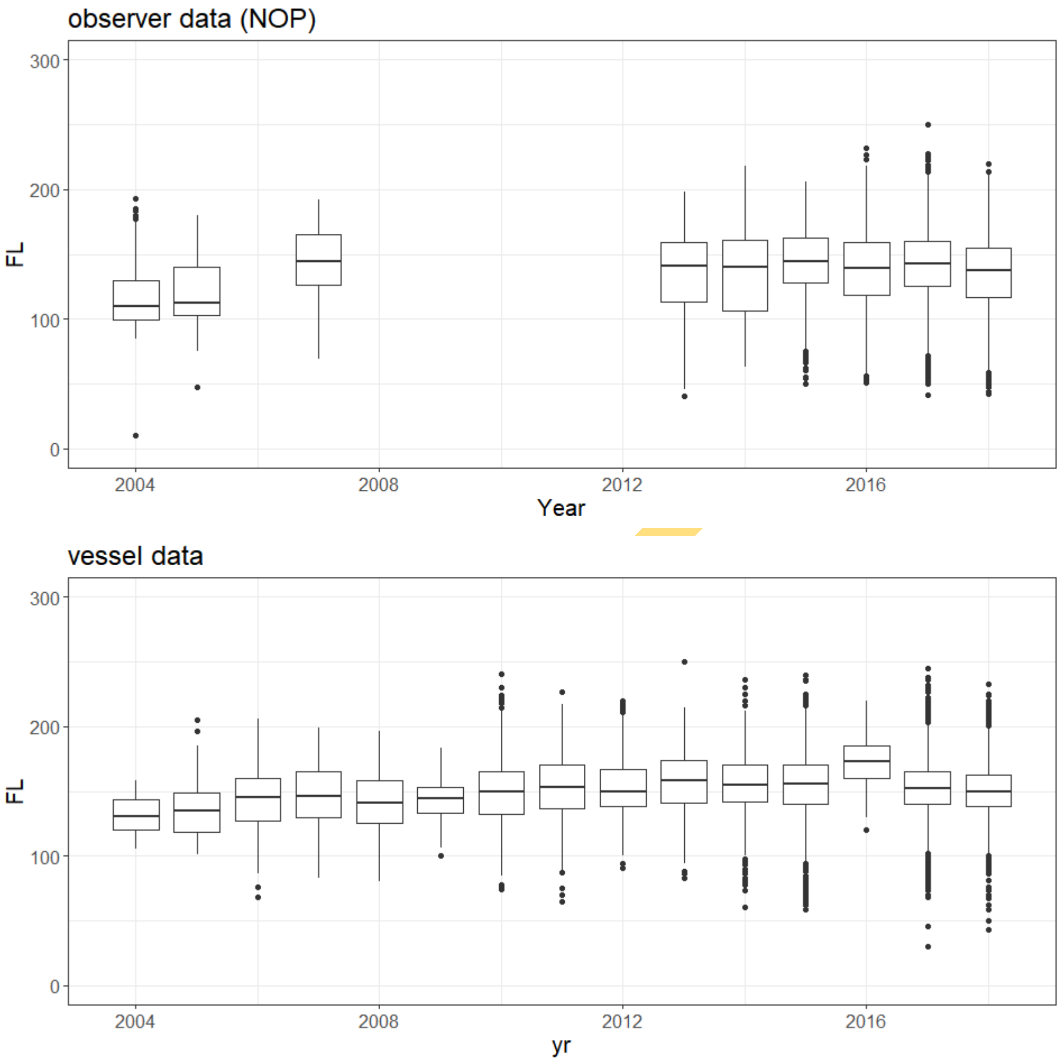

Figure 12. Box-and-whisker plots of fork length (cm) of bigeye caught by Korean tuna longline vessels in the EPO, from the NOP (top) and from fishermen (bottom).

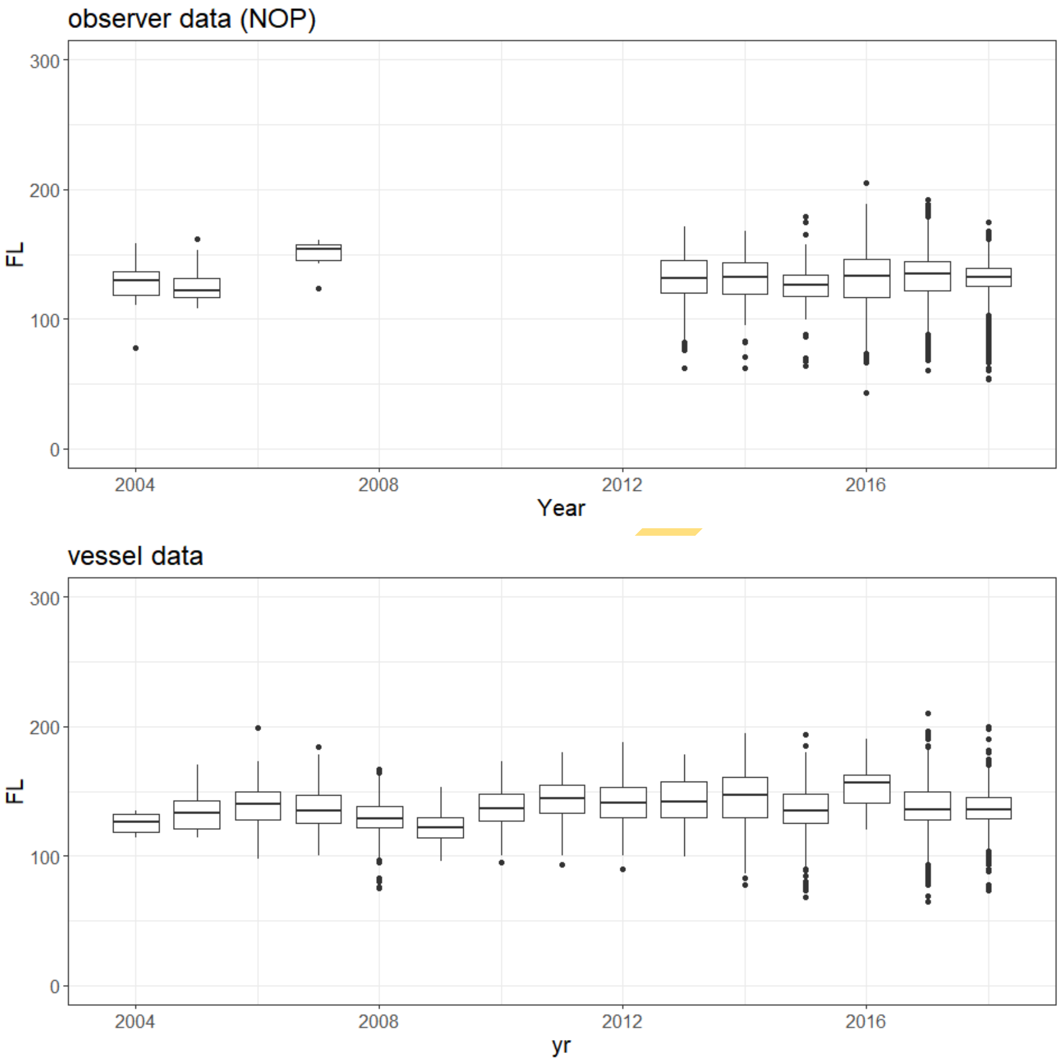

Figure 13. Box-and-whisker plots of fork length (cm) of yellowfin caught by Korean tuna longline vessels in the EPO, from the NOP (top) and from fishermen (bottom).

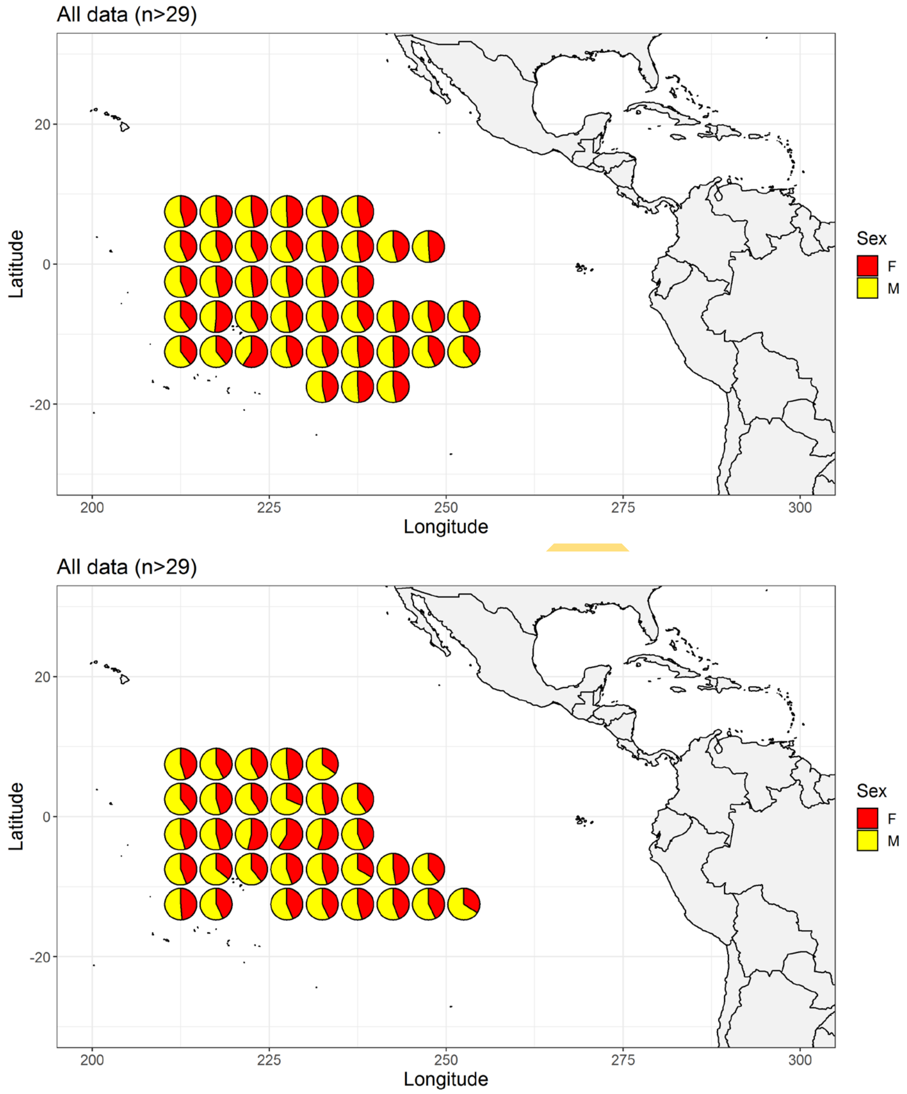

Figure 14. Spatial distributions of the sex ratio of bigeye (upper) and yellowfin (lower). Shown in each 5° area for which there were at least 30 fish sampled is the proportion of males (M; yellow) and females (F; red).

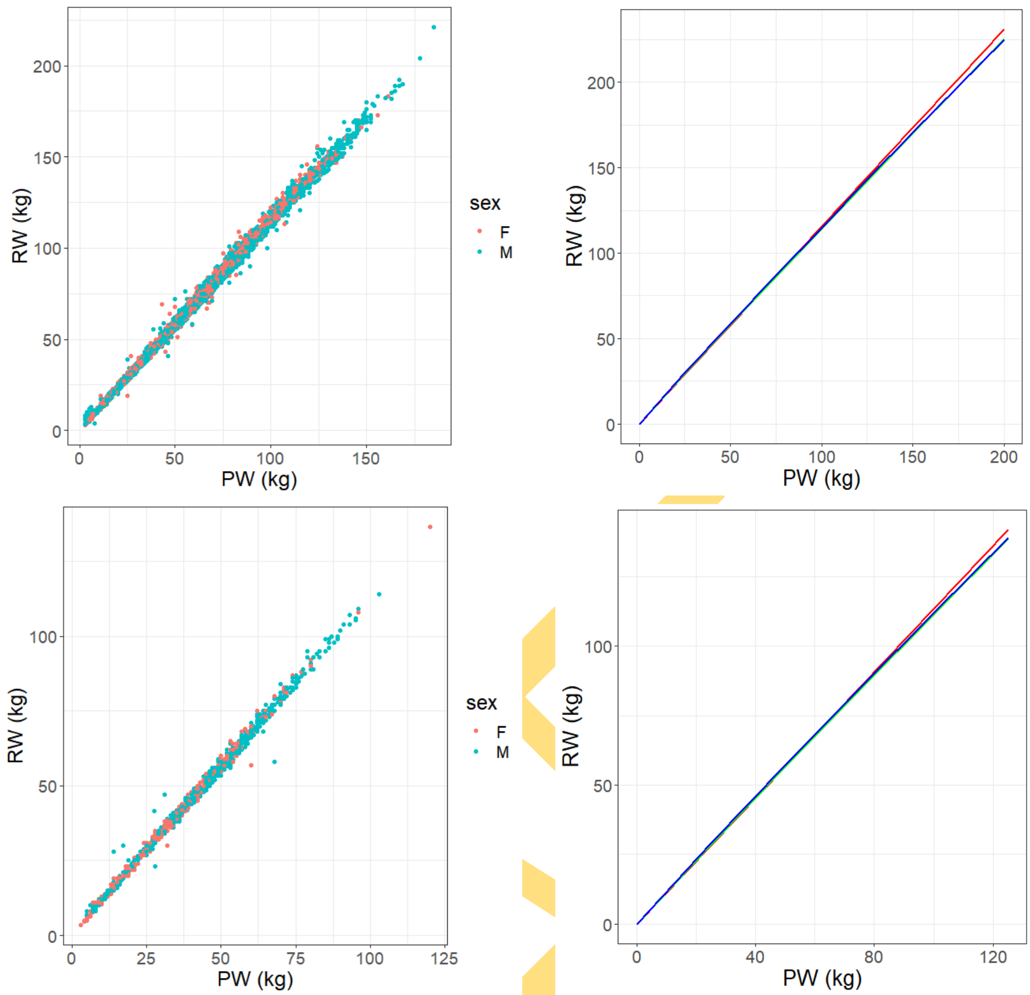

Figure 15. The relationships between processed weight (PW) and round weight (RW) for bigeye (left) and yellow (right) in the EPO. Red and green lines are the results from this study and the blue line from Langley et al. (2006) (red: RW = 1.1553*PW, green: RW = $1.2637*PW^{0.978}$, blue: RW = $1.3264*PW^{0.969}$ for bigeye; red: RW = 1.1361*PW, green: RW = $1.2318*PW^{0.978}$, blue: RW = $1.2988*PW^{0.968}$ for yellowfin).

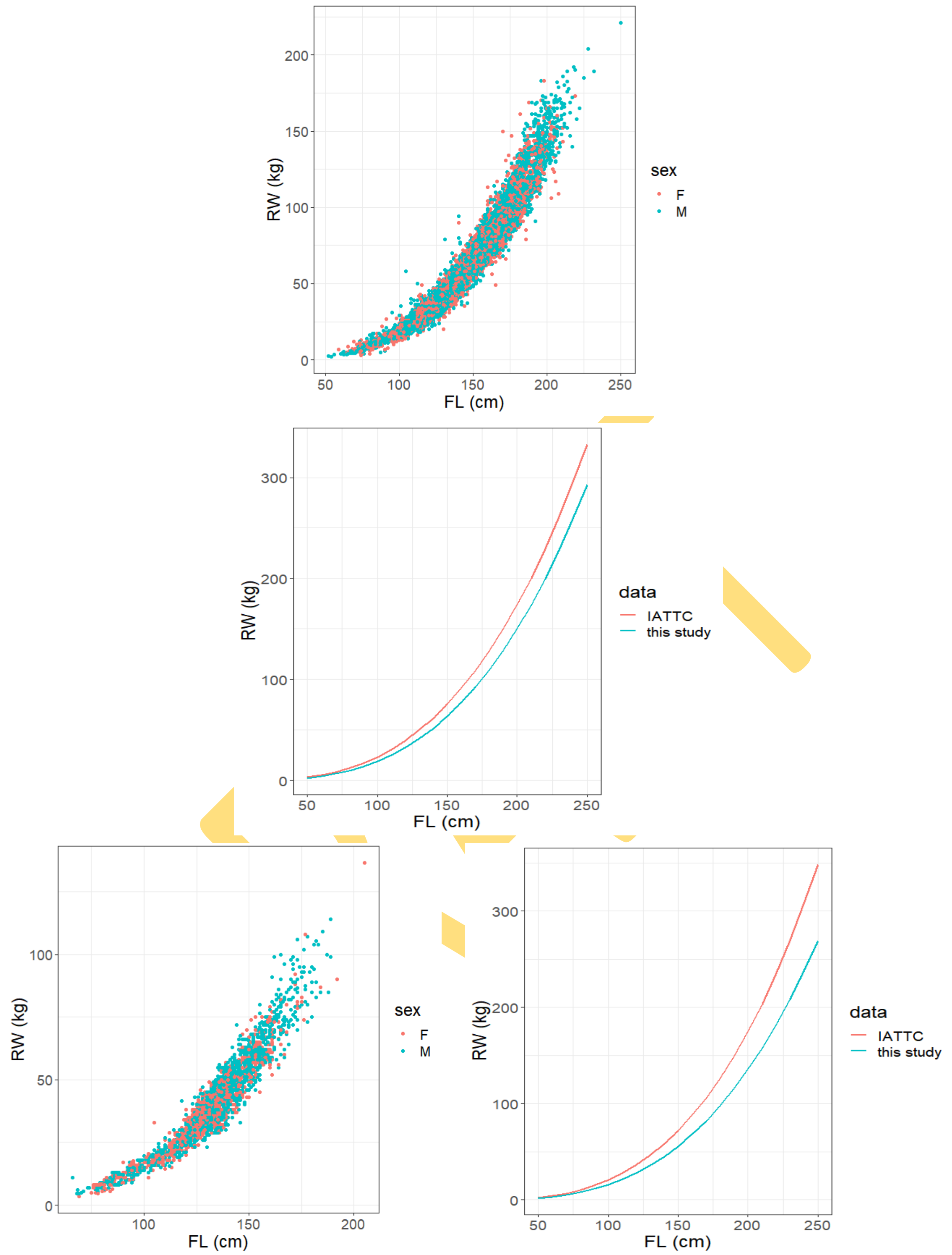

Figure 16. The relationships between fork length (FL) and round weight (RW) for bigeye (upper) and yellow (lower) in the EPO. The blue line is the result from this study and the red line from Aires-da-Silva and Maunder (2010, 2012) (blue: RW = 1.999e-05*FL$^{2.988}$, red: RW = 3.661e-0.5*FL$^{2.902}$ for bigeye; blue: RW = 1.085e-05*FL$^{3.084}$, red: RW = 1.387e-0.5*FL$^{3.086}$ for yellowfin).