

## Size composition of yellowfin and bigeye tuna in IOTC fisheries

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### Introduction

The Indian Ocean Tuna Commission (IOTC) is responsible for managing tuna and tuna-like species in the Indian Ocean, including yellowfin tuna (*Thunnus albacares*) and bigeye tuna (*Thunnus obesus*) throughout the IOTC area of competence. The report of the IOTC performance review panel highlighted that it is necessary for IOTC to adopt the FAO Precautionary Principle which requires that management advice is based on the best scientific evidence, taking account of uncertainty.

A clear understanding of the size distributions of yellowfin and bigeye tuna caught by the different fleets in the Indian Ocean, including impacts of different gear types and spatial differences will be vital in understanding the potential impact of any proposed spatio-temporal closures on fishing activities.

The purpose of this paper is to present data that already exist in IOTC datasets through a summary of the size frequency data, catch and catch distribution data for yellowfin tuna available for all Members to support any decision-making process at this Working Group. This paper does not recommend any particular option or direction for management of FADs it is here purely for information.

### Methods

In this paper, we focus on yellowfin and bigeye tuna size frequency data held by the IOTC (available within <https://iotc.org/oqs>). The complete set of size frequency data available was downloaded but data were filtered only to use the most recent data available (2000 to 2020) to reflect recent fishing patterns, with both artisanal and industrial fishing practices included where data have been collected. It is noted that some of the time period selected would have fishing patterns that may be affected due to piracy issues in the northwest Indian Ocean.

The size frequency data were analysed for each available gear type and for purse seine data these have been subdivided by “log school” (LS), i.e. FAD or free school (FS). Data are then presented as simple size frequency distributions aggregated by month (1-12, equivalent to January - December). Data were also split into two geospatial groups. Data were aggregated by FAO SubArea and by the classification used by IRD (see Figure x).

Gears where sufficient data were available to be examined were gillnet, longline, baitboat (Maldivian-based pole and line), purse seine (focusing on free swimming schools and those setting on FADs). We have excluded all other gear types due to their smaller contribution to the catch or small size frequency sample numbers e.g. those from recreational fisheries.

NB: All plots are presented as relative frequency distributions without numbered y axes, i.e. they are not scaled by equivalent numbers and the total catch by gear, month or area is not reported here.

Catches from Maldives / Chagos, NW Seychelles and SE Seychelles (FAO Subareas 51.4 and 51.5) are observed to have more mature fish in the catch composition than other areas

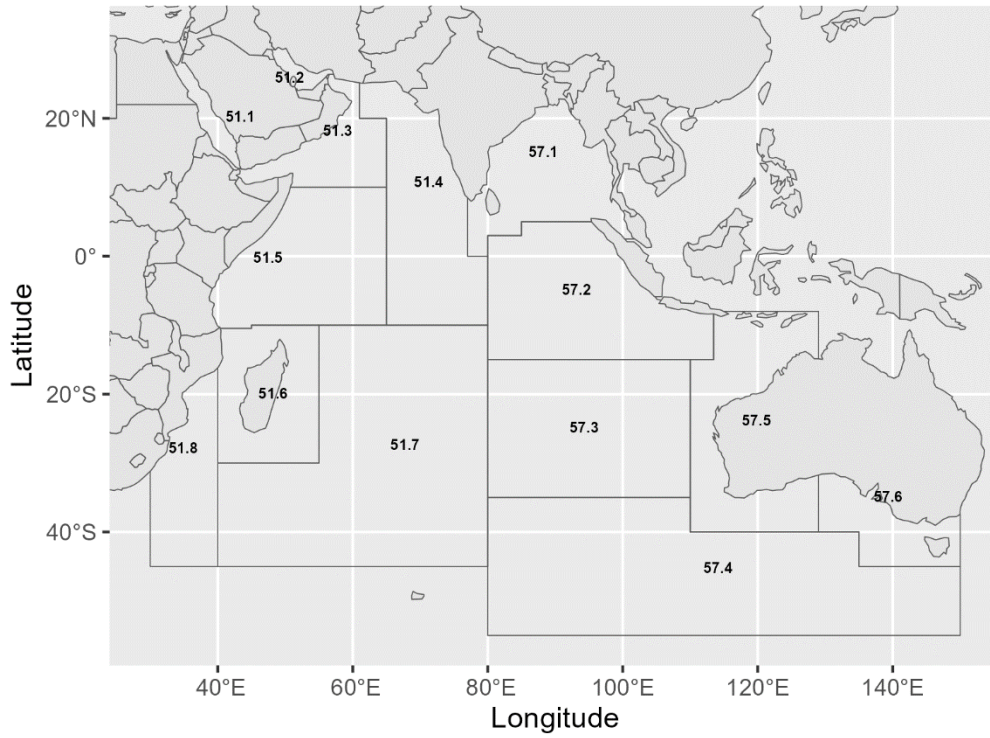


Figure 1 FAO Subareas in the Indian Ocean.

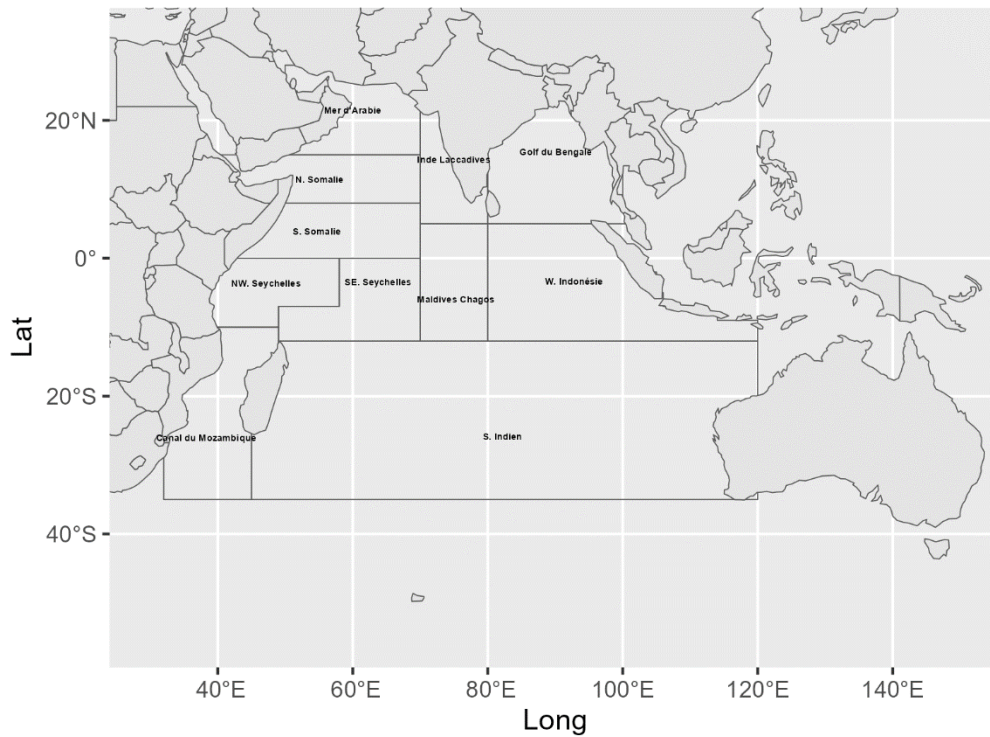


Figure 2 Locations of IRD areas in the Indian Ocean.

## Results

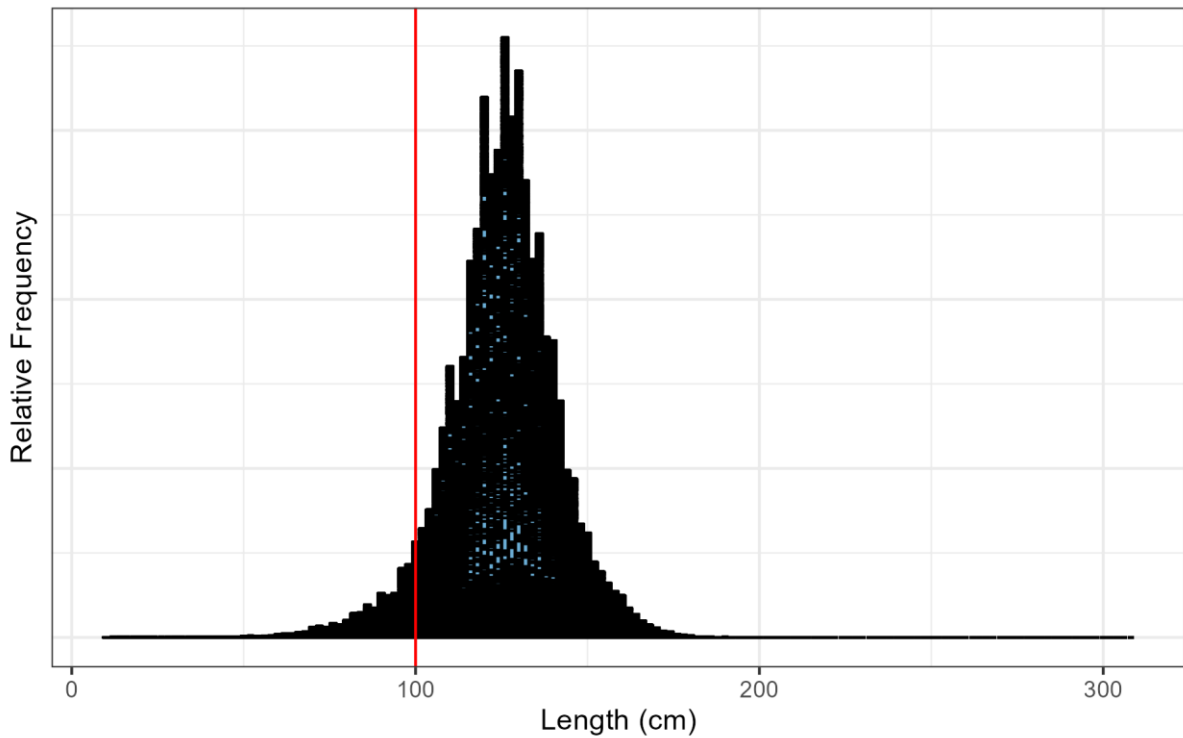
The longline fishery size frequency data show that the fishery catches mature fish, nearly all over the estimated length at first maturity (100cm in length for yellowfin tuna and 110cm for bigeye tuna) (see Figure 3 and Figure 8). There is little difference between months (see Figure 4 and Figure 9). Longline size frequency data is available across the IOTC Area of Competence where longline fisheries occur (see Figure 5 and Figure 10). There appears to be little difference in size frequency based on the location fished (Figure 6 and Figure 7 for yellowfin tuna and Figure 11 and Figure 12 for bigeye tuna).

Purse seine data are available for a wide geographical range (see Figure 15 and Figure 20). FAD free catches by purse seiners with FADs show almost all fish caught are under length at first maturity for both yellowfin (Figure 23 and Figure 27) and bigeye tuna (Figure 18). Very little difference can be observed by month (Figure 24 and Figure 28) or by area (Figure 25, Figure 26, Figure 29 and Figure 30) for either species. Free school catches by purse seiners show catches of both immature and mature fish of both species (Figure 13 and Figure 18). Free school caught fish are observed to be of a slightly larger size with a higher proportion of mature fish during December to February and possibly during June and July for yellowfin (Figure 14), though this pattern is not clear for bigeye tuna (Figure 19). Catches from Maldives / Chagos, NW Seychelles and SE Seychelles (IRD areas) and in FAO Subareas 51.4 and 51.5 (see Figure 25 and Figure 26) are observed to have more mature fish in the catch composition than other areas. Bigeye show little geospatial variation (see Figure 29 and Figure 30).

Pole and line size frequency data is only available for the Maldives pole and line fishery (see Figure 33 and Figure 38). Reported size frequencies for this fishery show that the small numbers of yellowfin and bigeye tuna caught as bycatch with the target skipjack tuna are all under the length at first maturity. There is no clear difference in size frequencies for either species when analysed by month (see Figure 32 for yellowfin tuna and Figure 37 for bigeye tuna). Data by location are limited due to the focussed area where pole and line fishing takes place close to the Maldives (see Figure 34, Figure 35, Figure 39 and Figure 40).

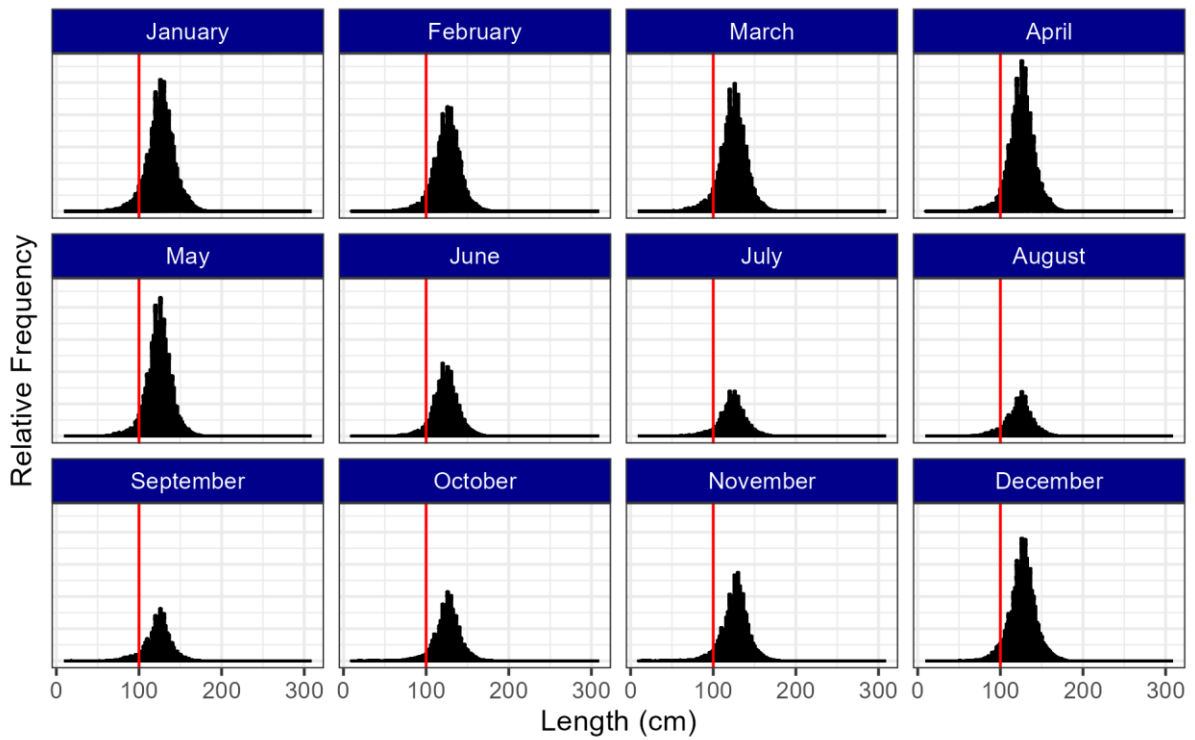
Reported gillnet size frequencies indicate that a high proportion of both yellowfin and bigeye tunas caught are below the length at first maturity (see Figure 41 for yellowfin tuna and Figure 46 for bigeye tuna). There is no clear difference in size frequencies for either species when analysed by month (see Figure 42 for yellowfin tuna and Figure 47 for bigeye tuna). Reported gillnet size frequencies for both yellowfin and bigeye tunas are dominated by catch in subarea 51.2 / the Arabian Sea (see Figure 43, Figure 44, Figure 45, Figure 48, Figure 49 and Figure 50).

### Yellowfin tuna - Longline



**Figure 3** Size frequency of yellowfin tuna catch by longline (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.



**Figure 4** Size frequency of yellowfin tuna catch by longline by month (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.

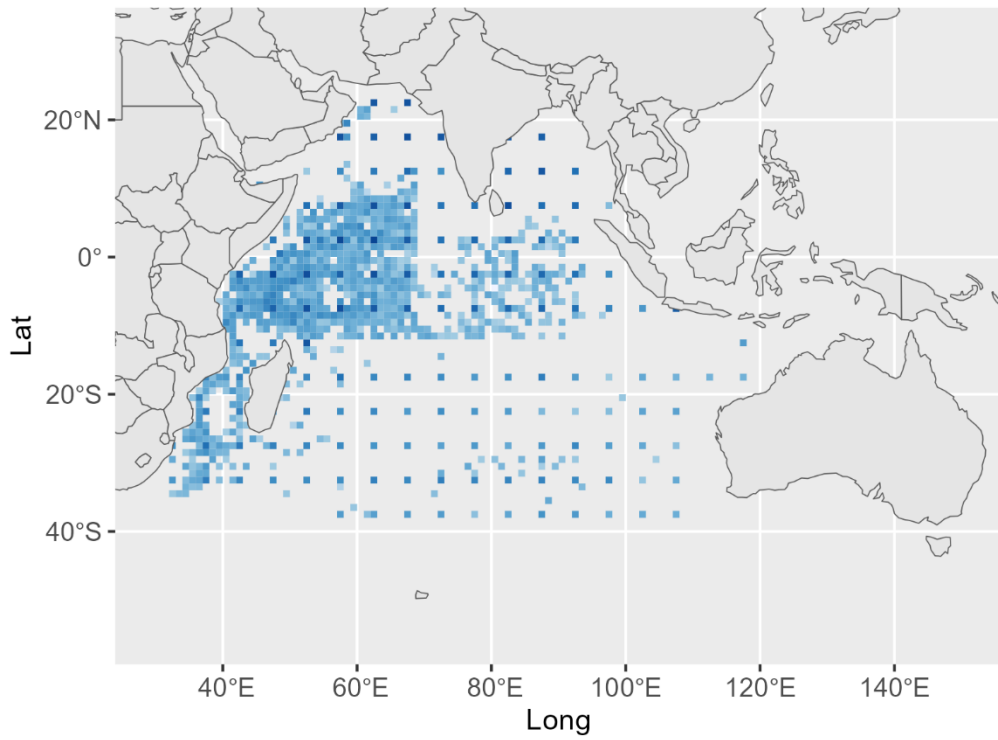


Figure 5 Locations of yellowfin tuna sampled from longliners (2000 to present).

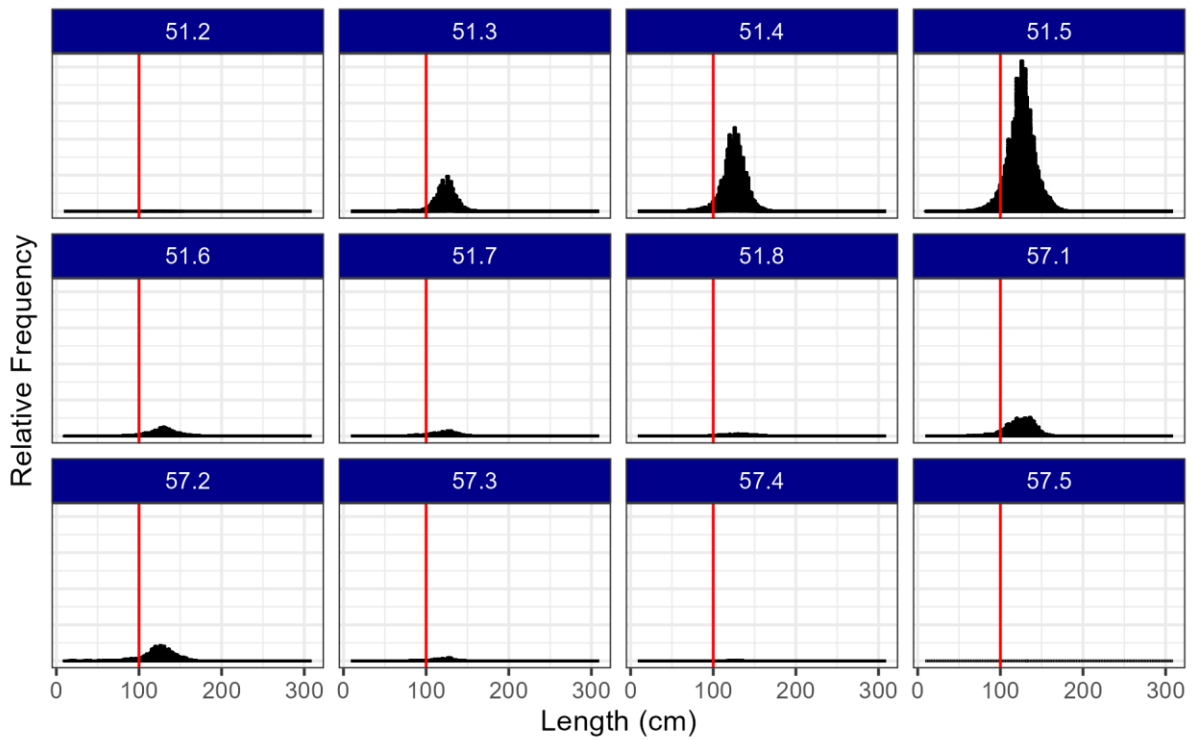
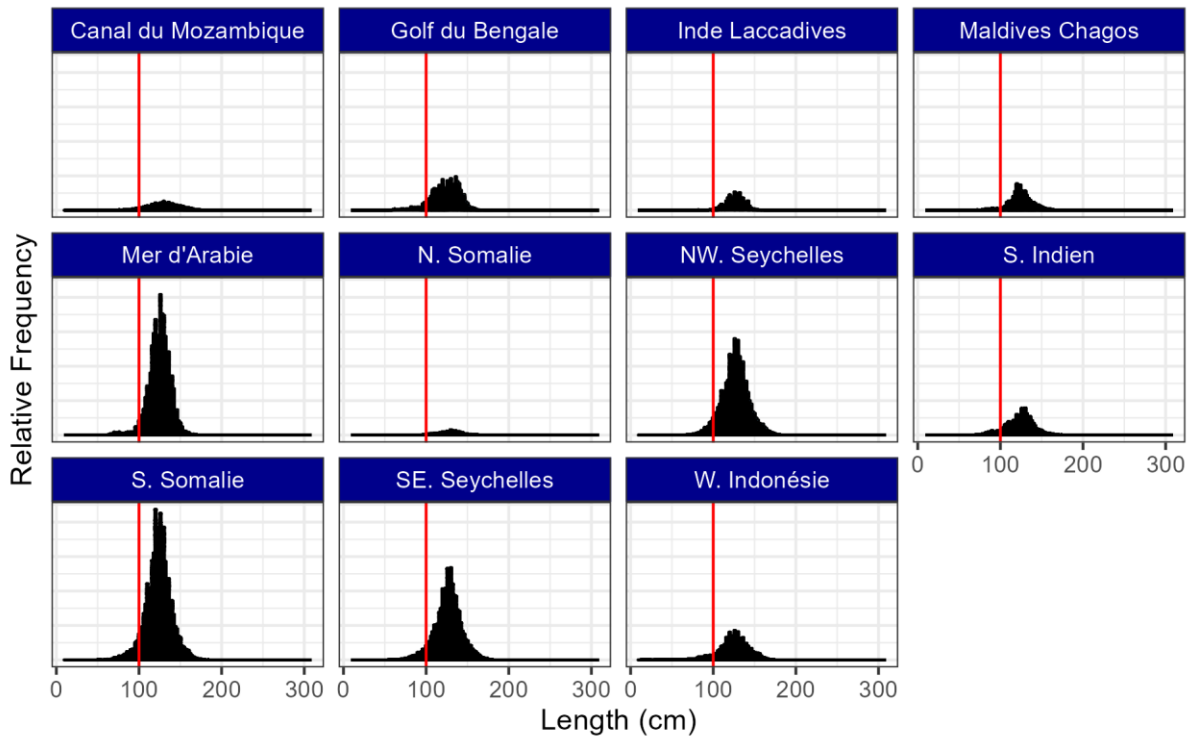


Figure 6 Size frequency of yellowfin tuna catch by longline by FAO Subarea (2000 to present).

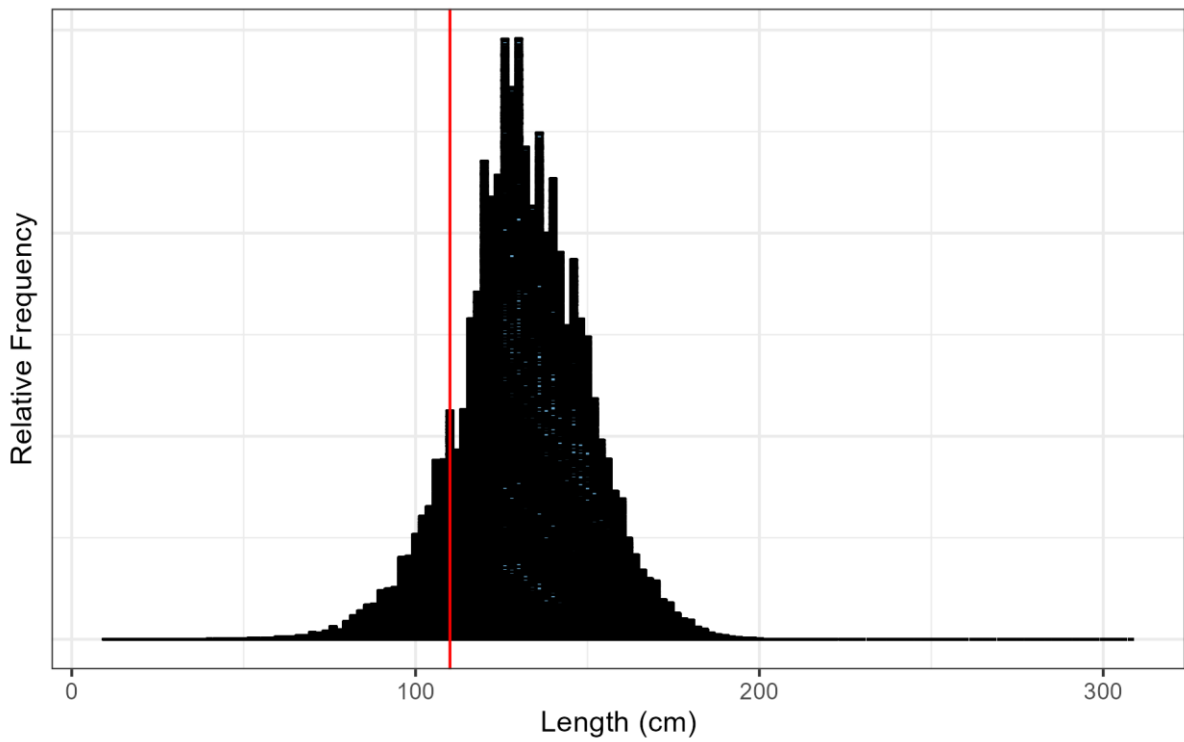
NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.



**Figure 7 Size frequency of yellowfin tuna catch by longline by IRD Area (2000 to present).**

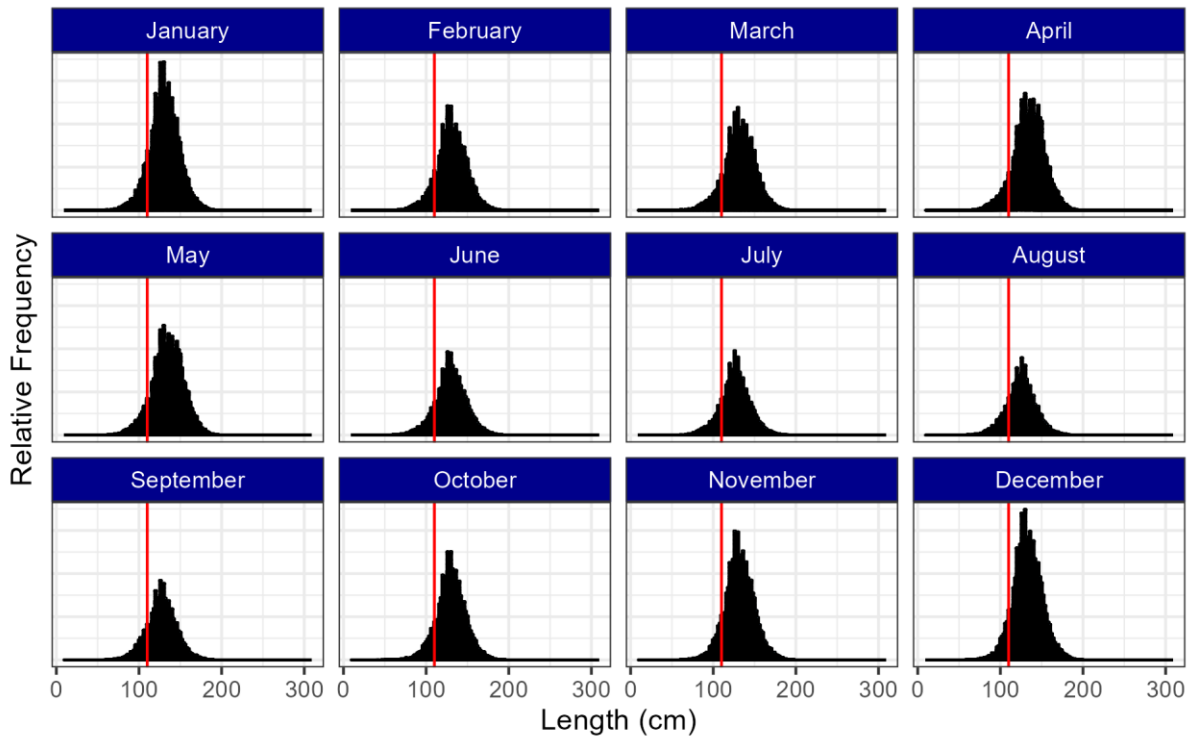
NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.

**Bigeye tuna - Longline**



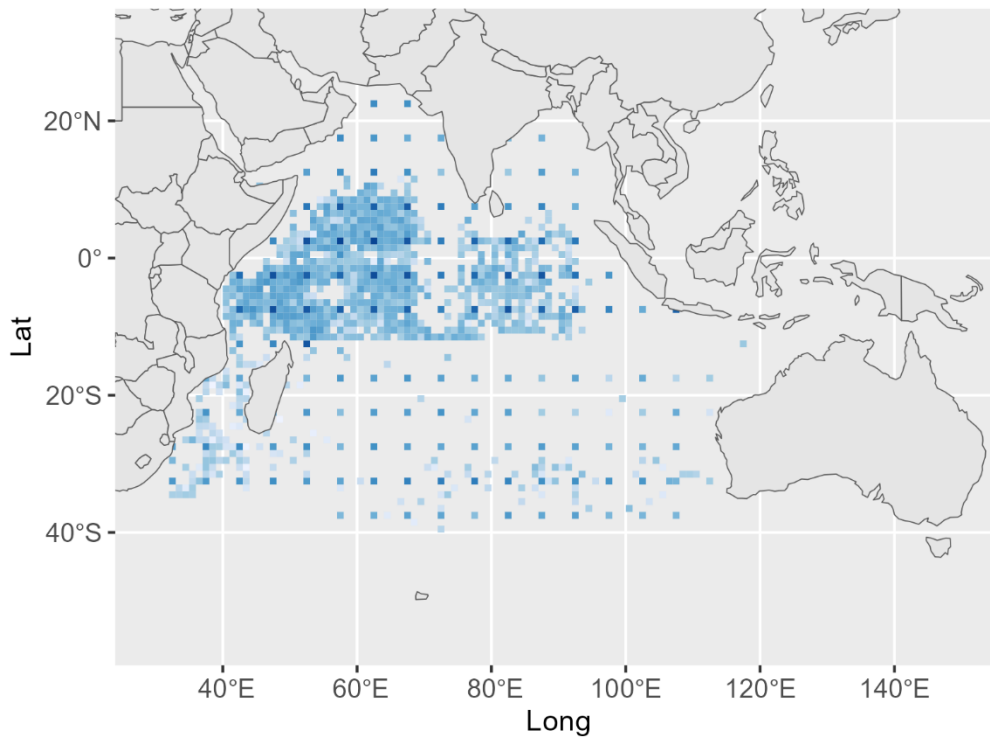
**Figure 8 Size frequency of bigeye tuna catch by longline (2000 to present).**

NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.

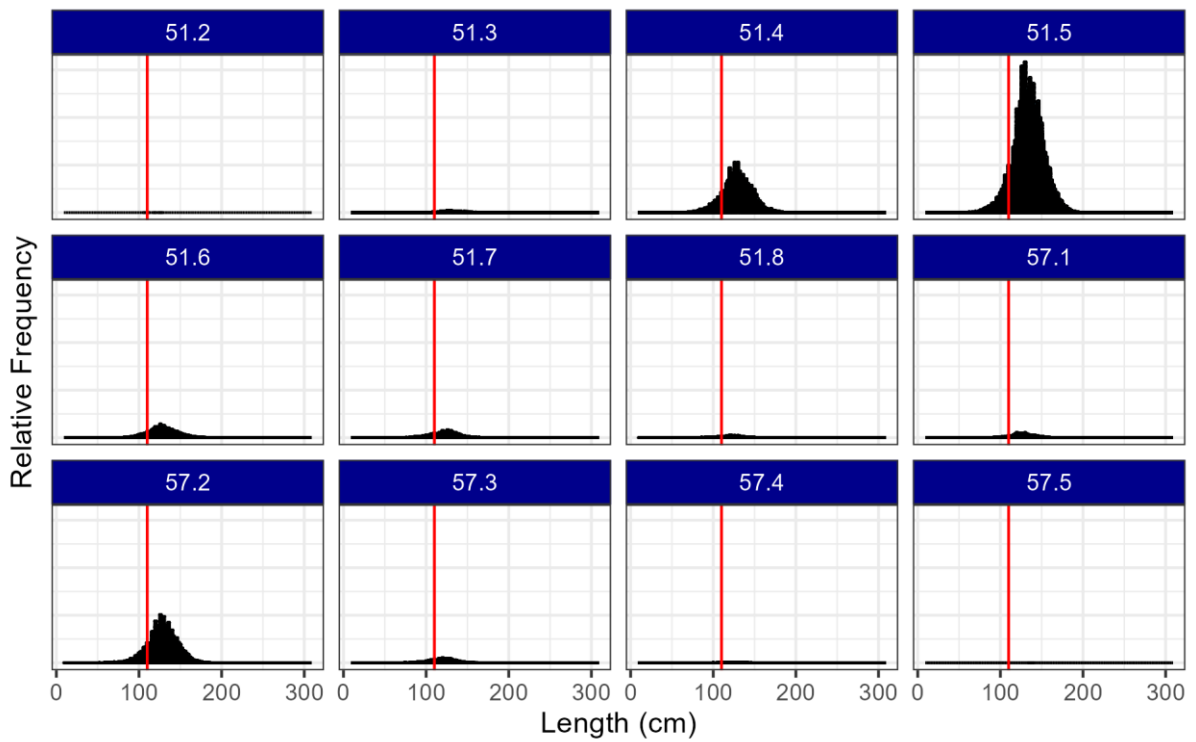


**Figure 9** Size frequency of bigeye tuna catch by longline by month (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.

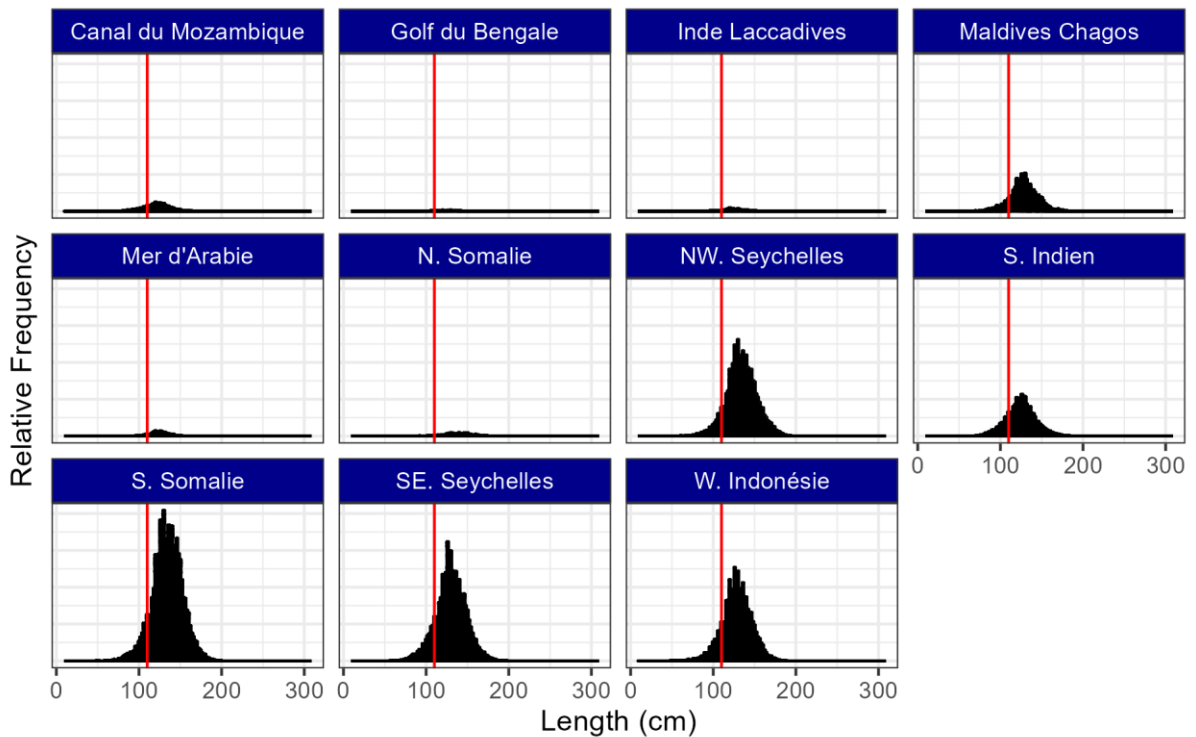


**Figure 10** Locations of bigeye tuna sampled from longliners (2000 to present).



**Figure 11** Size frequency of bigeye tuna catch by longline by FAO Subarea (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.



**Figure 12** Size frequency of bigeye tuna catch by longline by IRD Area (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.



Purse Seine

Yellowfin tuna – Purse Seine (Free school)

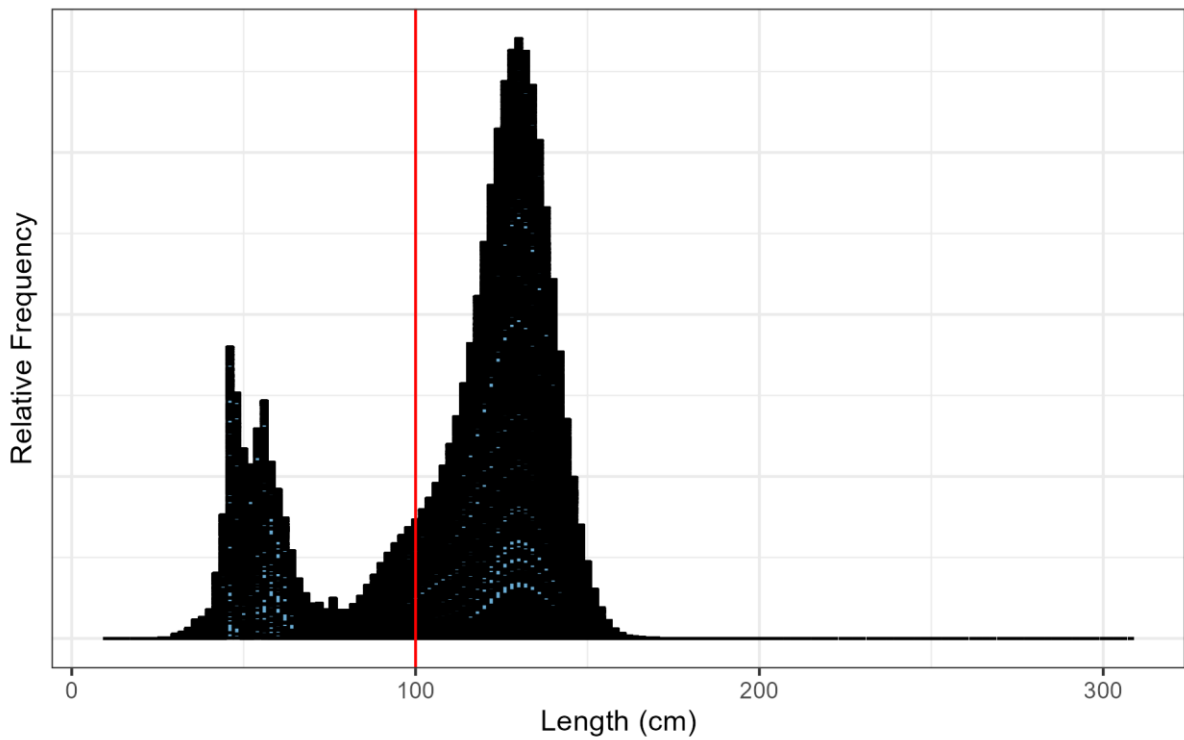


Figure 13 Size frequency of yellowfin tuna catch by purse seines (free school) (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.

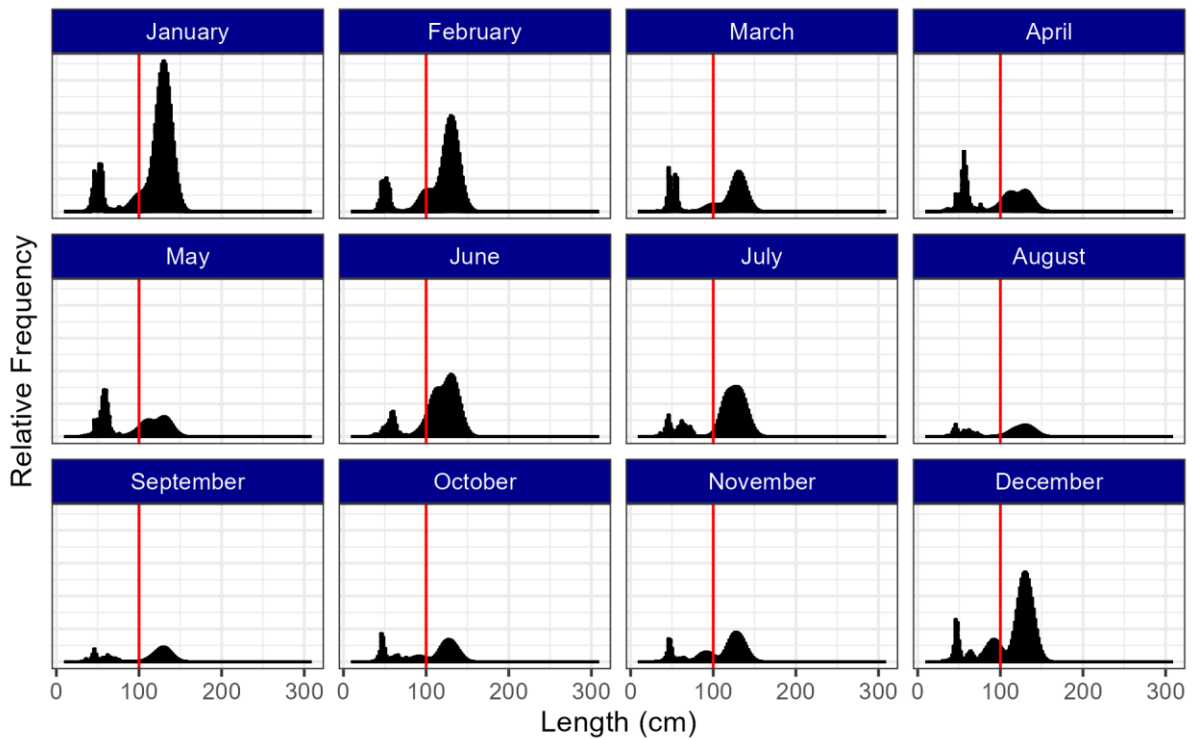


Figure 14 Size frequency of yellowfin tuna catch by purse seines (free school) by month (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.

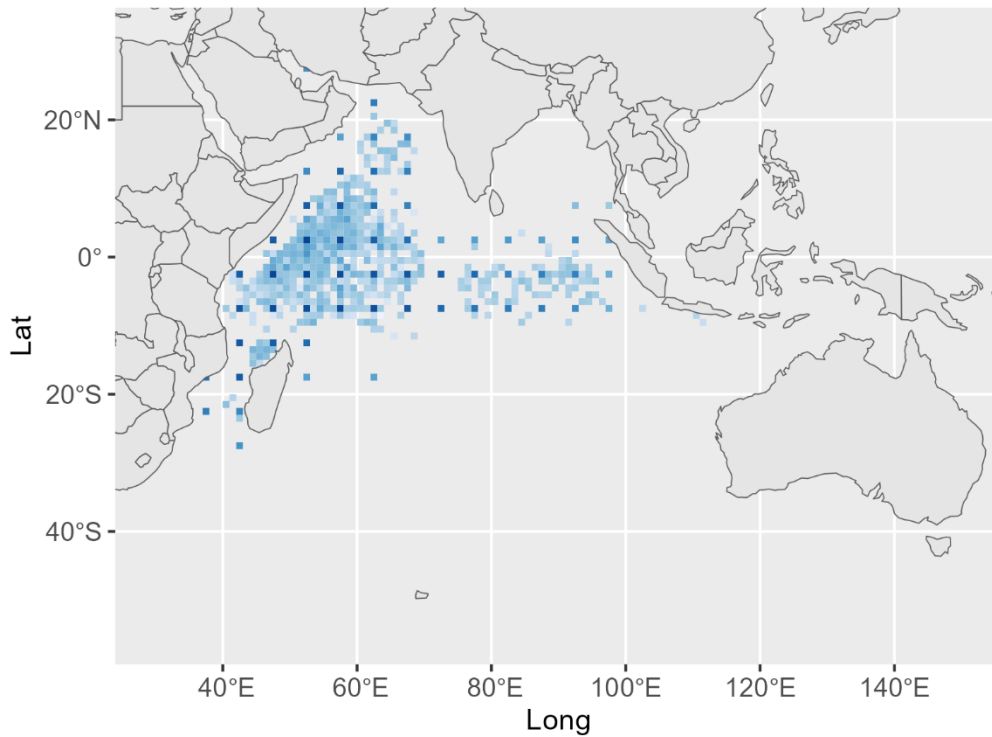


Figure 15 Locations of yellowfin tuna sampled from purse seine vessels (2000 to present).

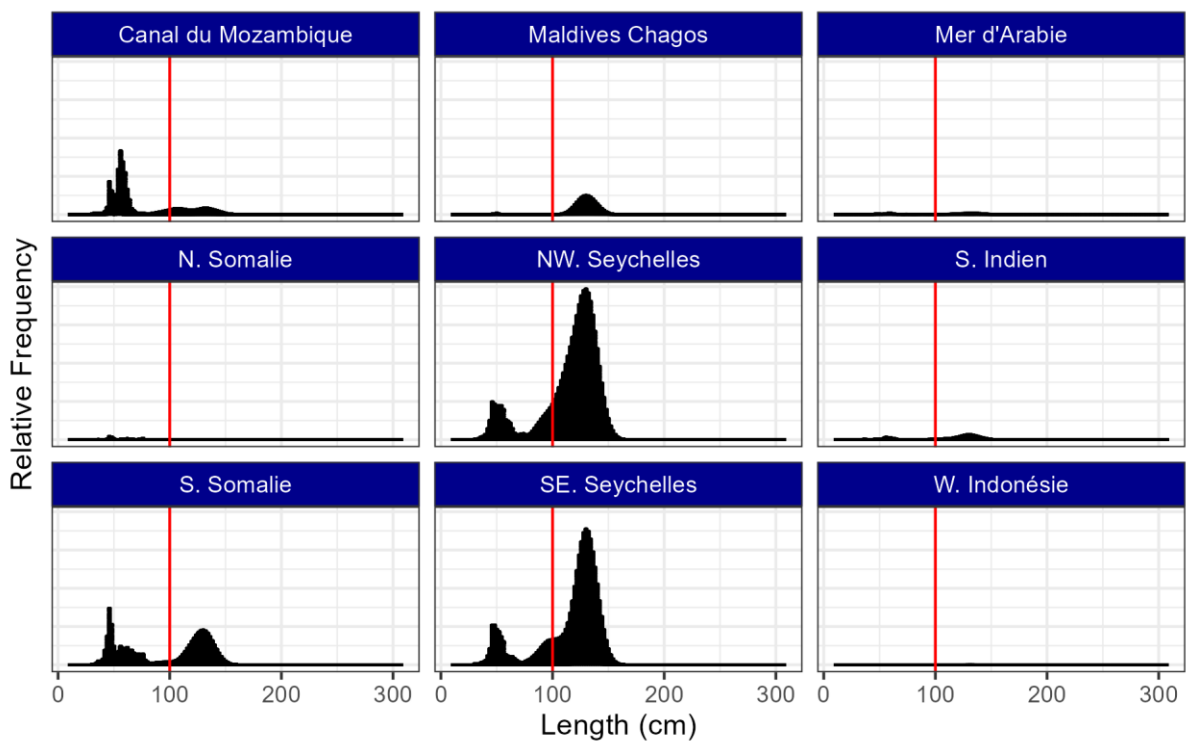
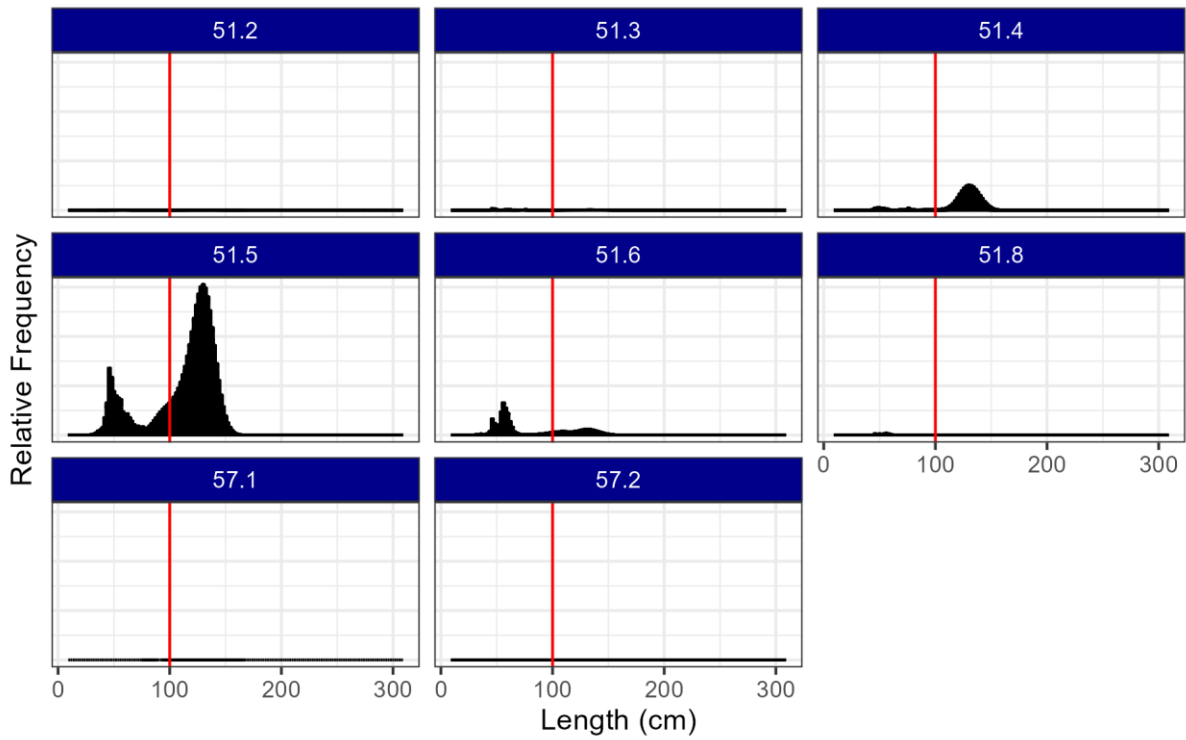


Figure 16 Size frequency of yellowfin tuna catch by purse seines (free school) by IRD Subarea (2000 to present).

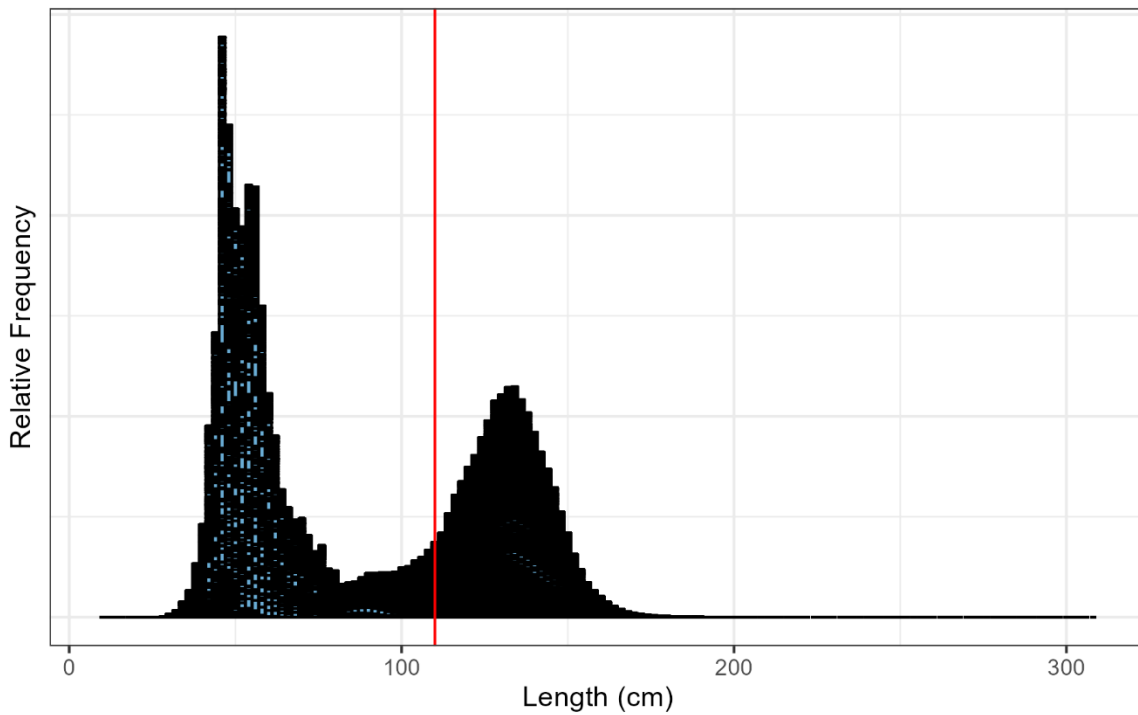
NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.



**Figure 17** Size frequency of yellowfin tuna catch by purse seines (free school) by FAO Area (2000 to present).

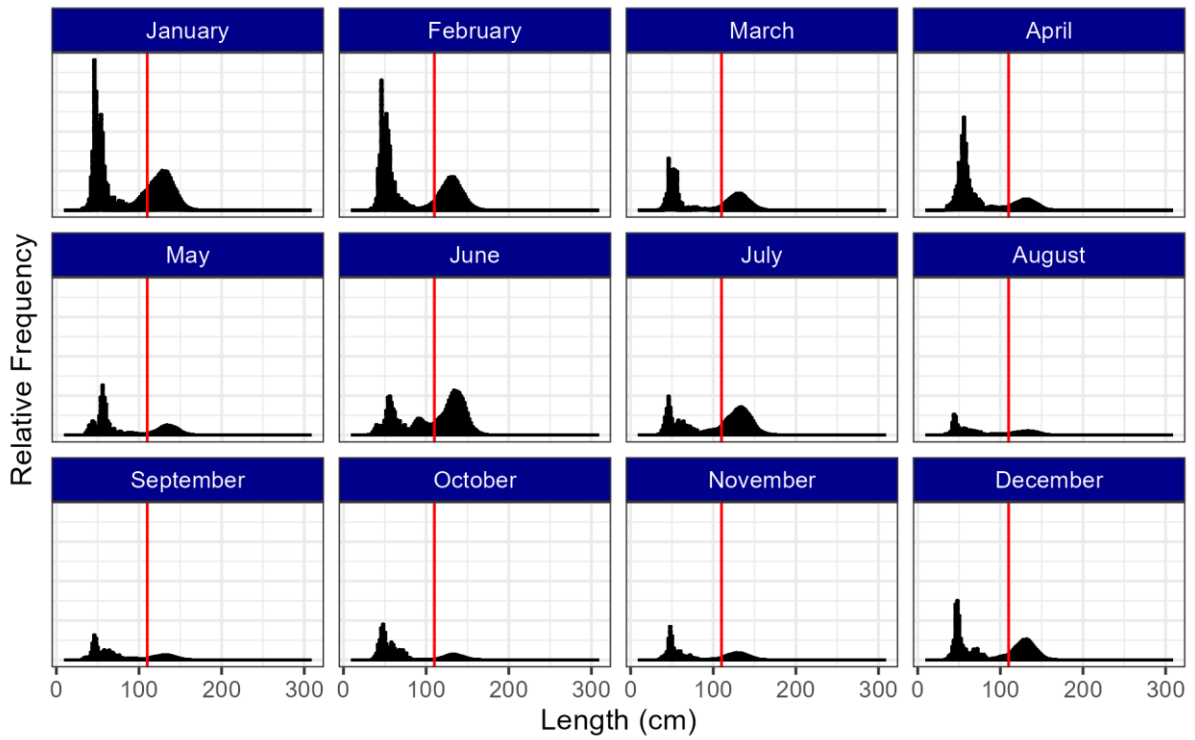
NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.

**Bigeye tuna - Purse Seine (Free School)**



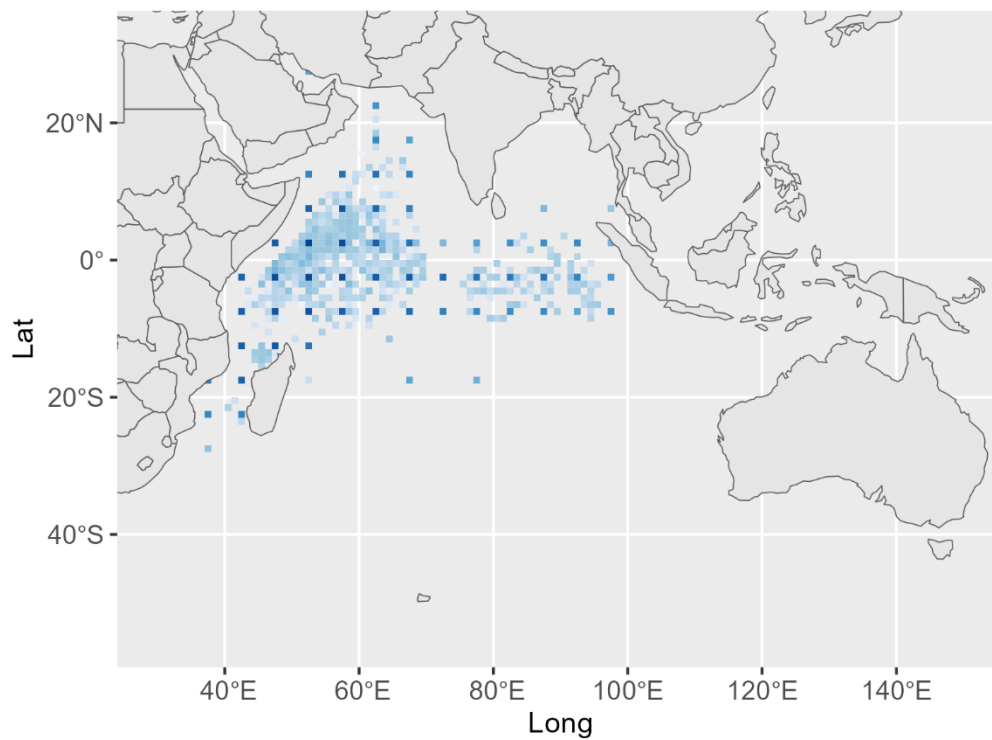
**Figure 18** Size frequency of bigeye tuna catch by purse seines (free school) (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.

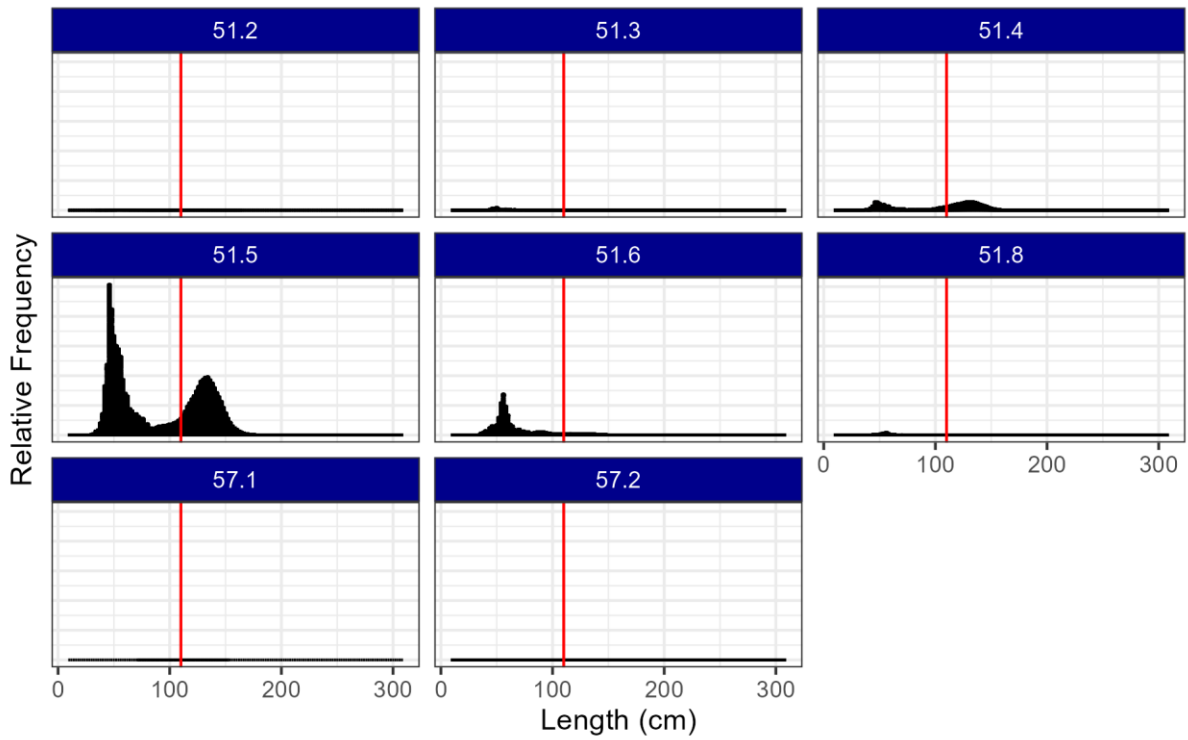


**Figure 19** Size frequency of bigeye tuna catch by purse seines (free school) by month (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.

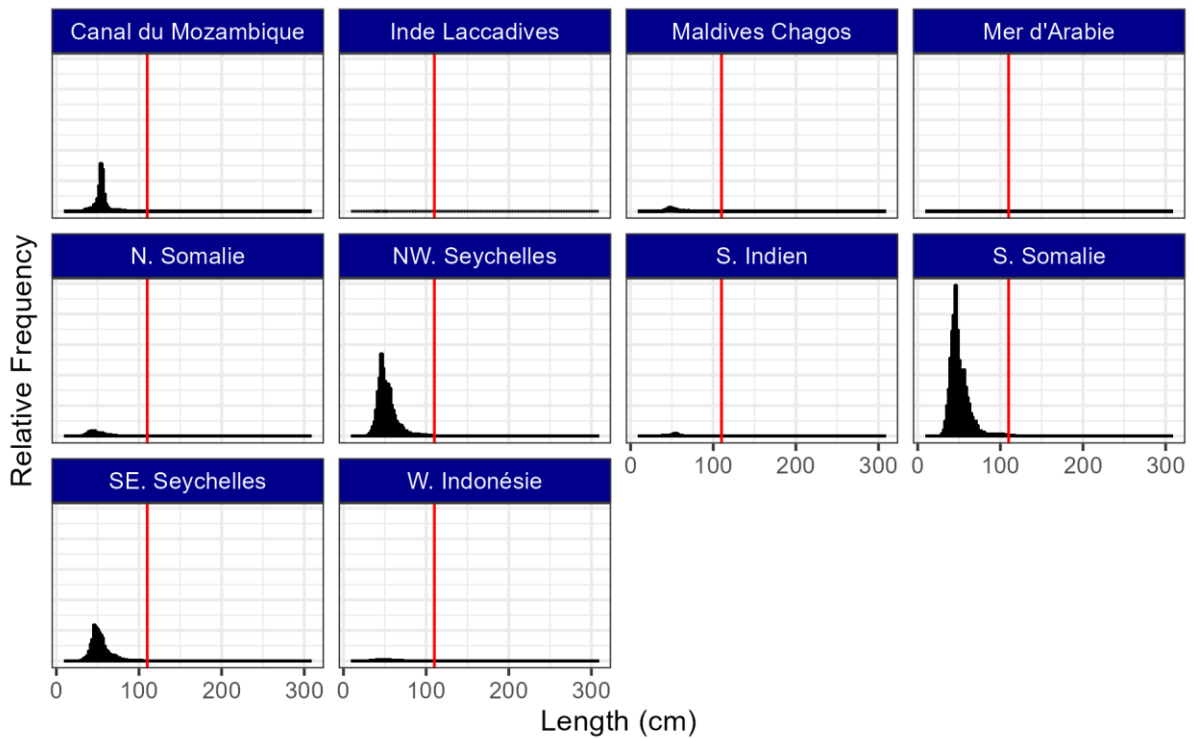


**Figure 20** Locations of bigeye tuna sampled from purse seine (free schools) (2000 to present).



**Figure 21** Size frequency of bigeye tuna catch by purse seines (free school) by FAO Subarea (2000 to present).

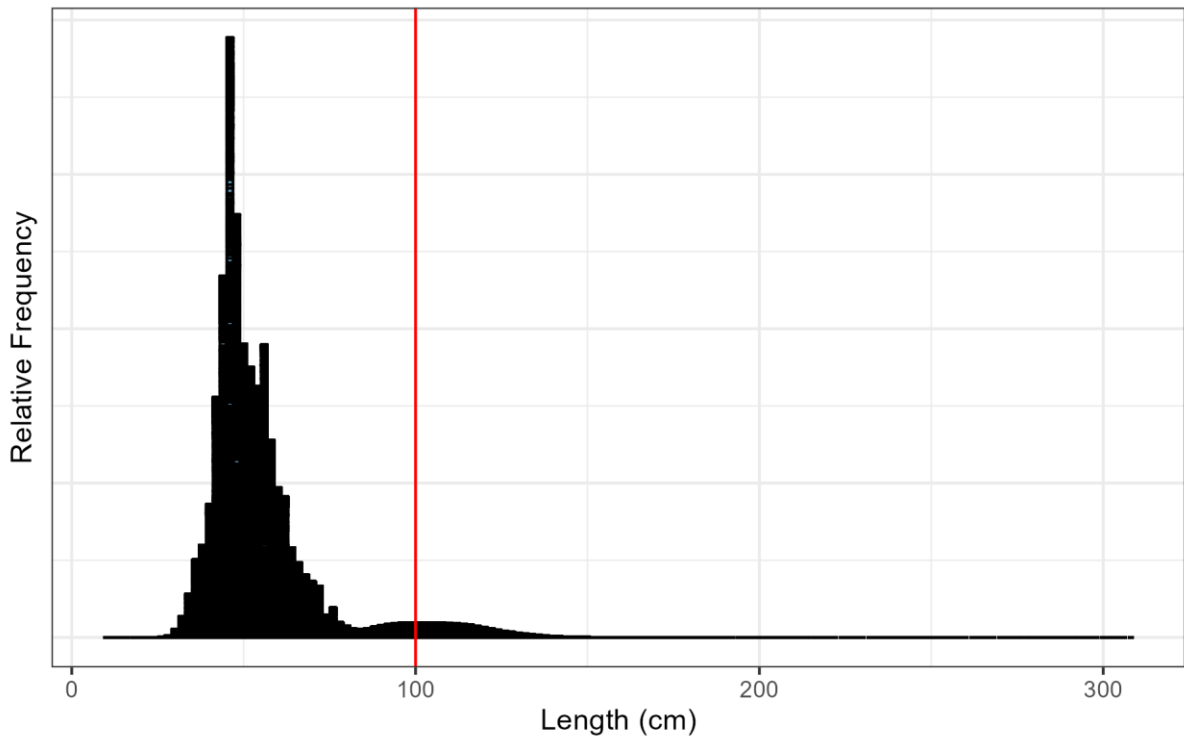
NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.



**Figure 22** Size frequency of bigeye tuna catch by purse seines (free school) by IRD Area (2000 to present).

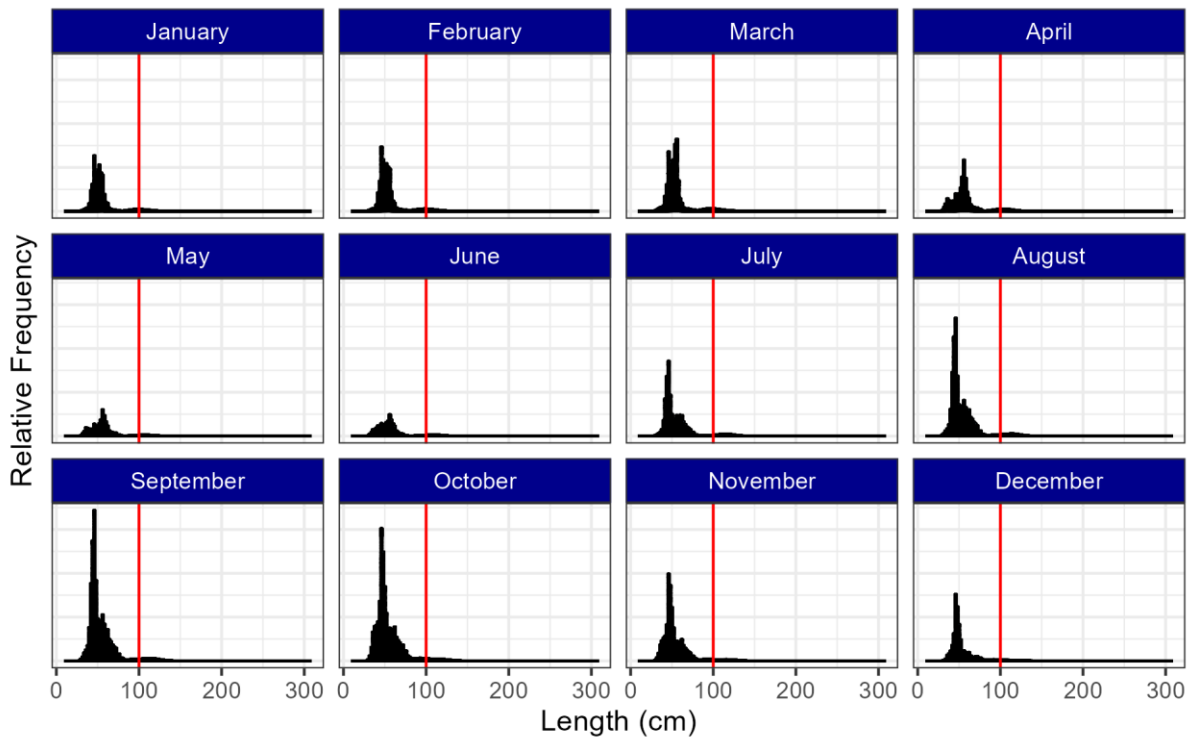
NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.

**Yellowfin tuna – Purse Seine (FAD school)**



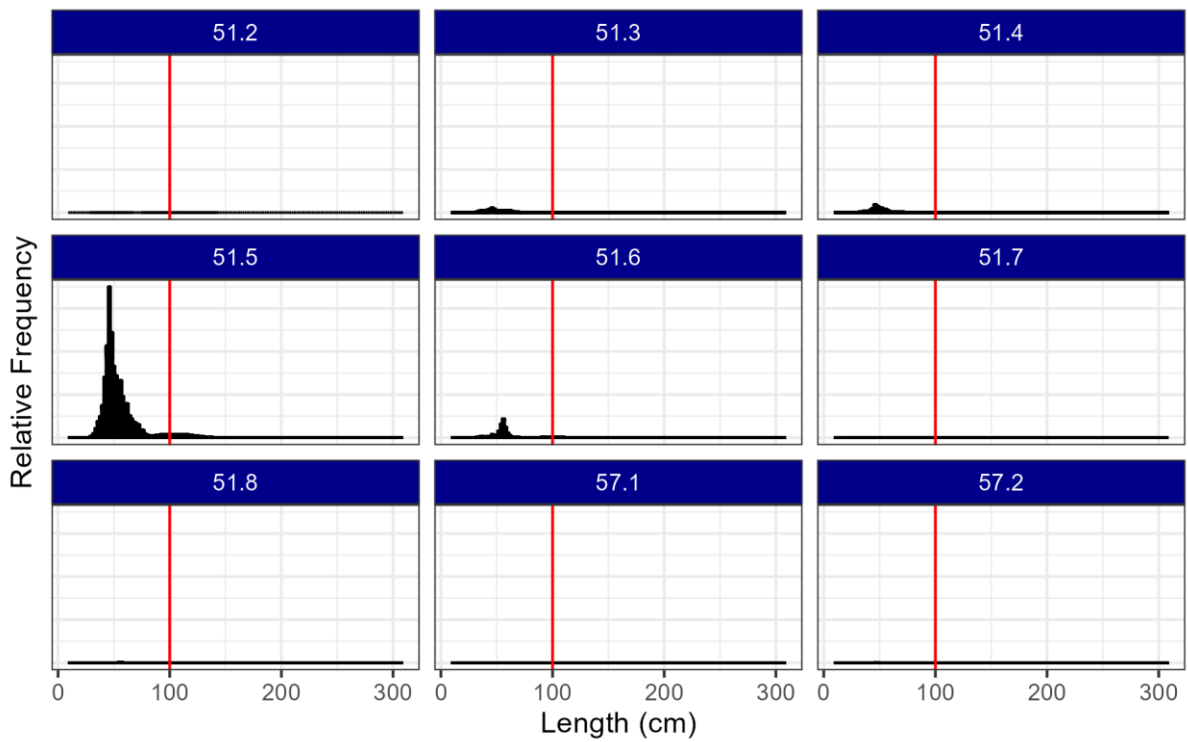
**Figure 23** Size frequency of yellowfin tuna catch by purse seines (FAD school) (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.



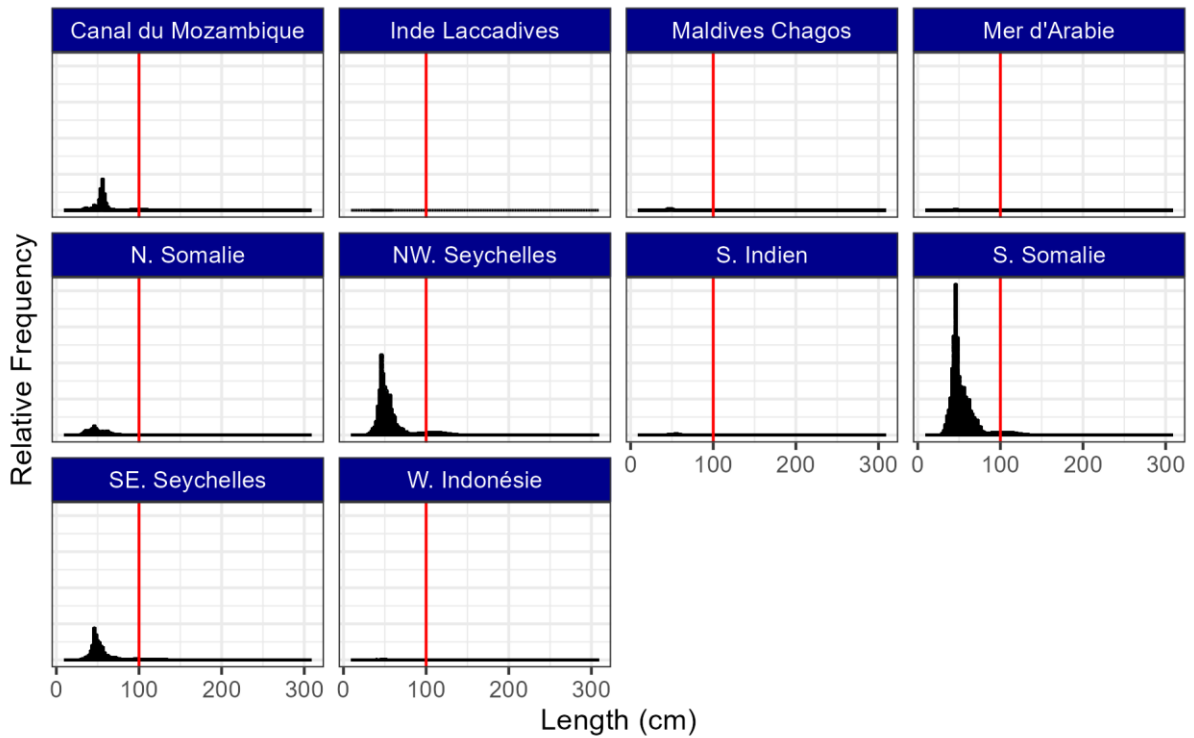
**Figure 24** Size frequency of yellowfin tuna catch by purse seines (FAD school) by month (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.



**Figure 25** Size frequency of yellowfin tuna catch by purse seines (FAD school) by FAO Subarea (2000 to present).

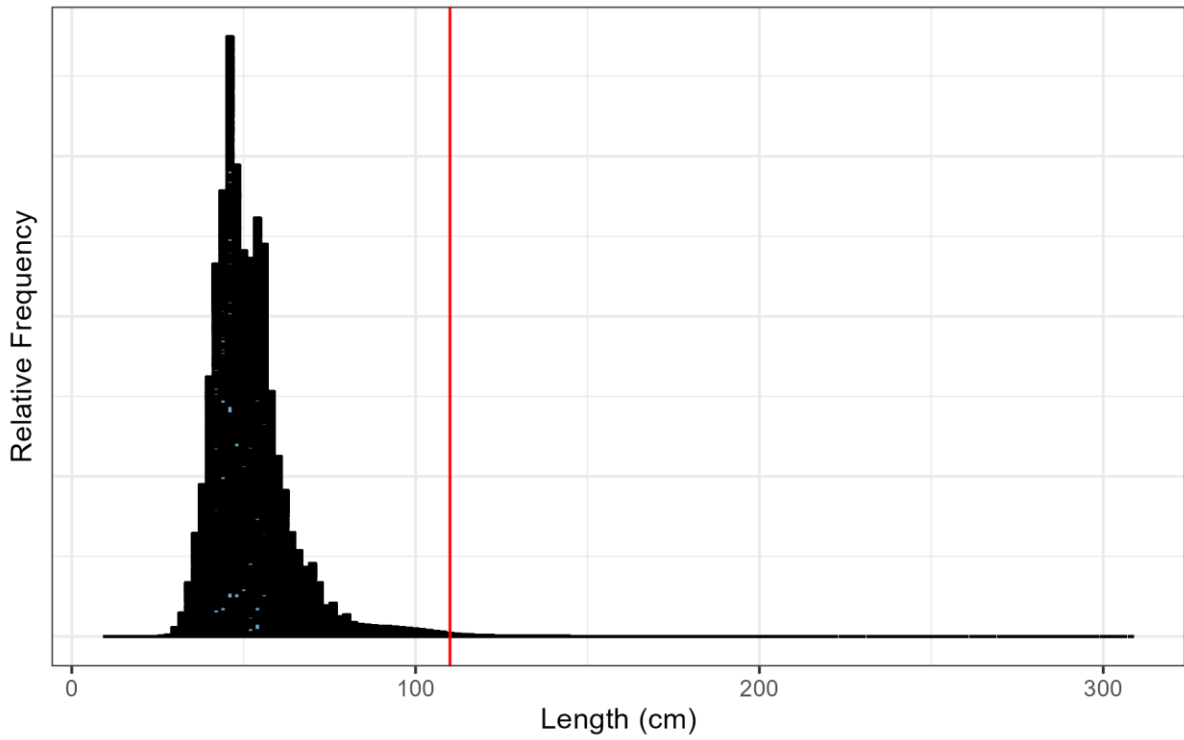
NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.



**Figure 26** Size frequency of yellowfin tuna catch by purse seines (FAD school) by IRD Area (2000 to present).

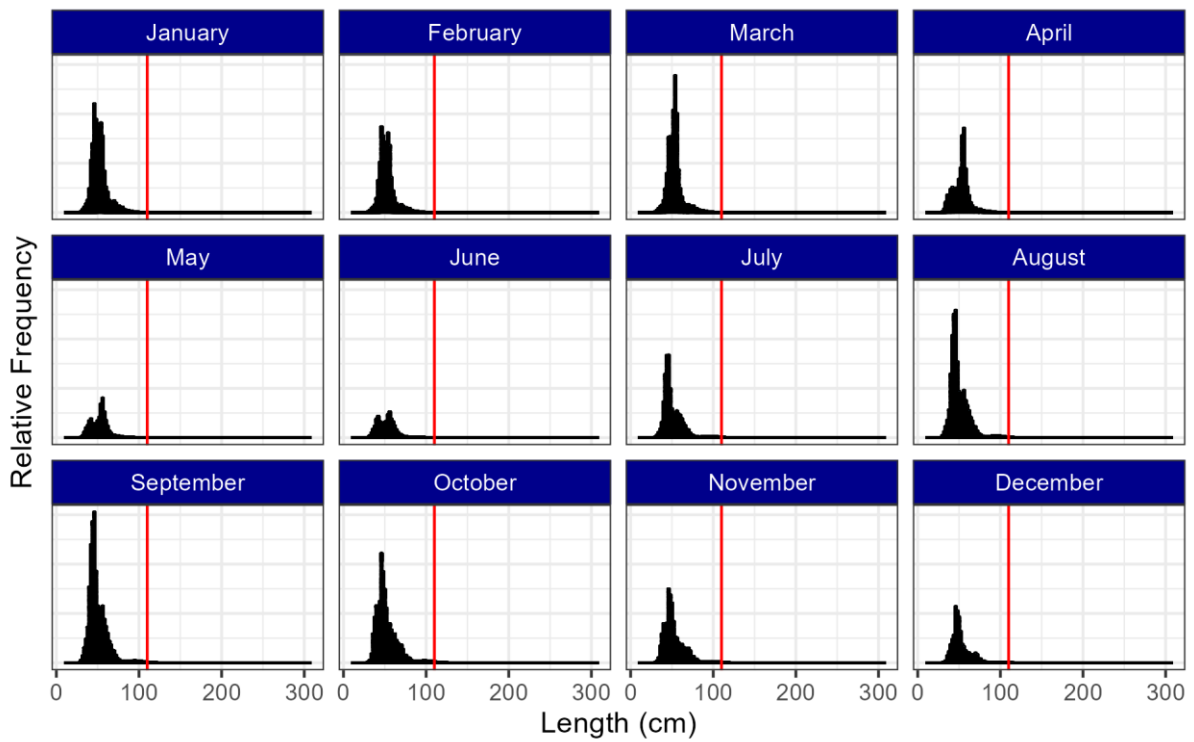
NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.

**Bigeye tuna - Purse Seine (FAD School)**



**Figure 27** Size frequency of bigeye tuna catch by purse seines (FAD school) (2000 to present).

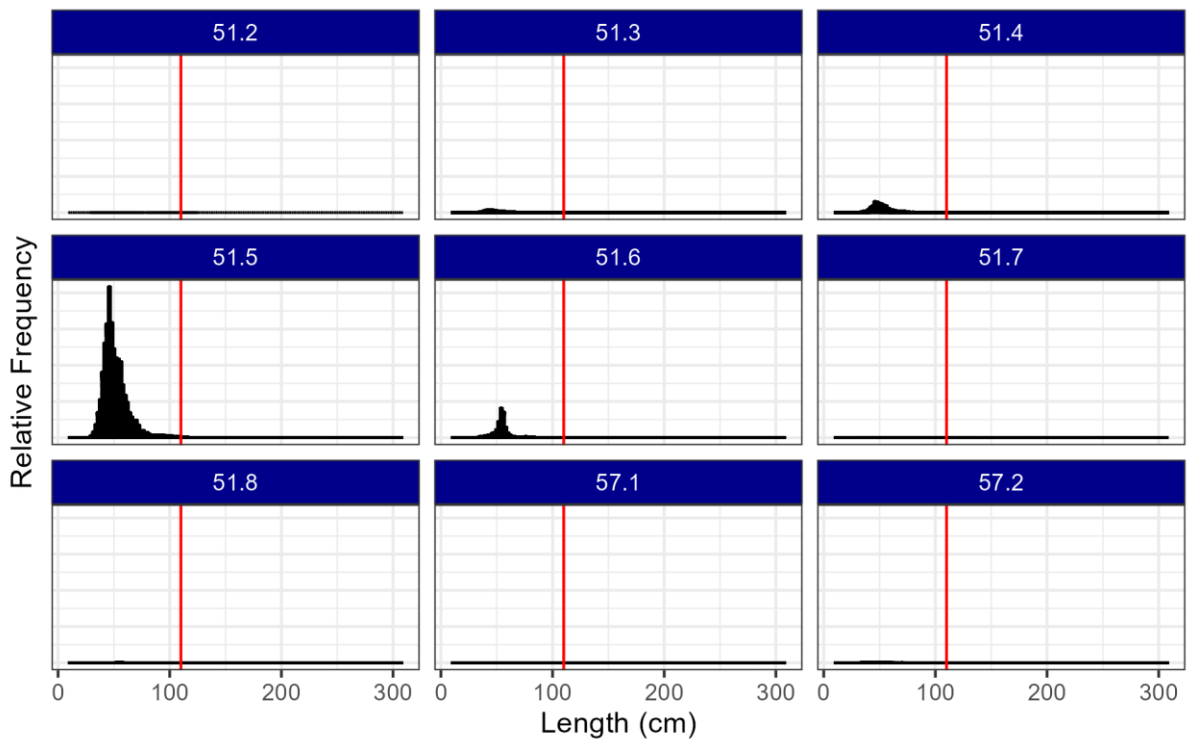
NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.



**Figure 28** Size frequency of bigeye tuna catch by purse seines (FAD school) by month (2000 to present).

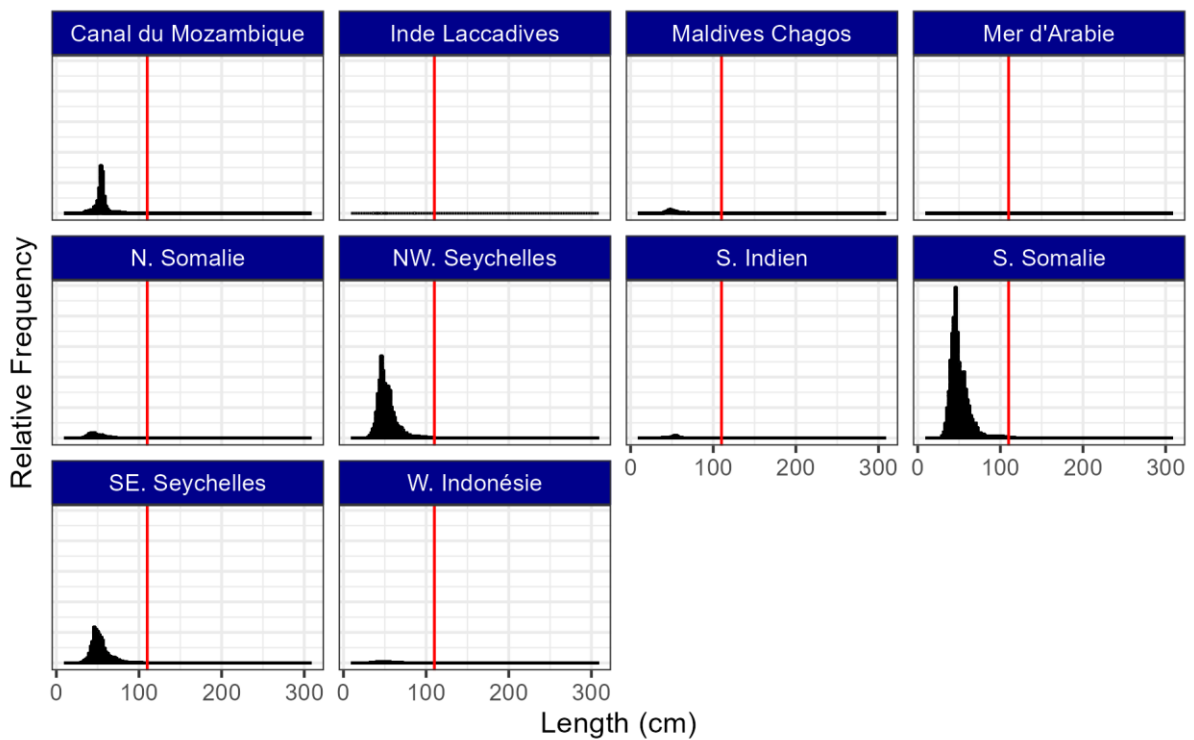
NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.





**Figure 29** Size frequency of bigeye tuna catch by purse seines (FAD school) by FAO Subarea (2000 to present).

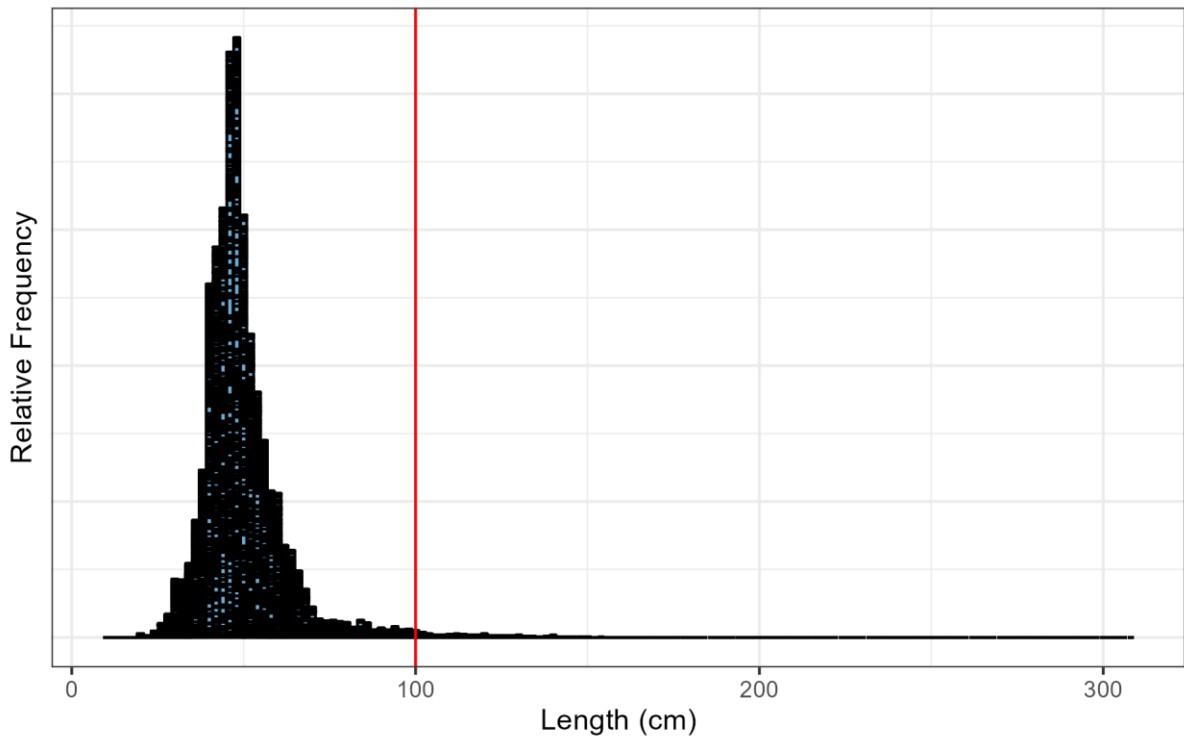
NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.



**Figure 30** Size frequency of bigeye tuna catch by purse seines (FAD school) by IRD Area (2000 to present).

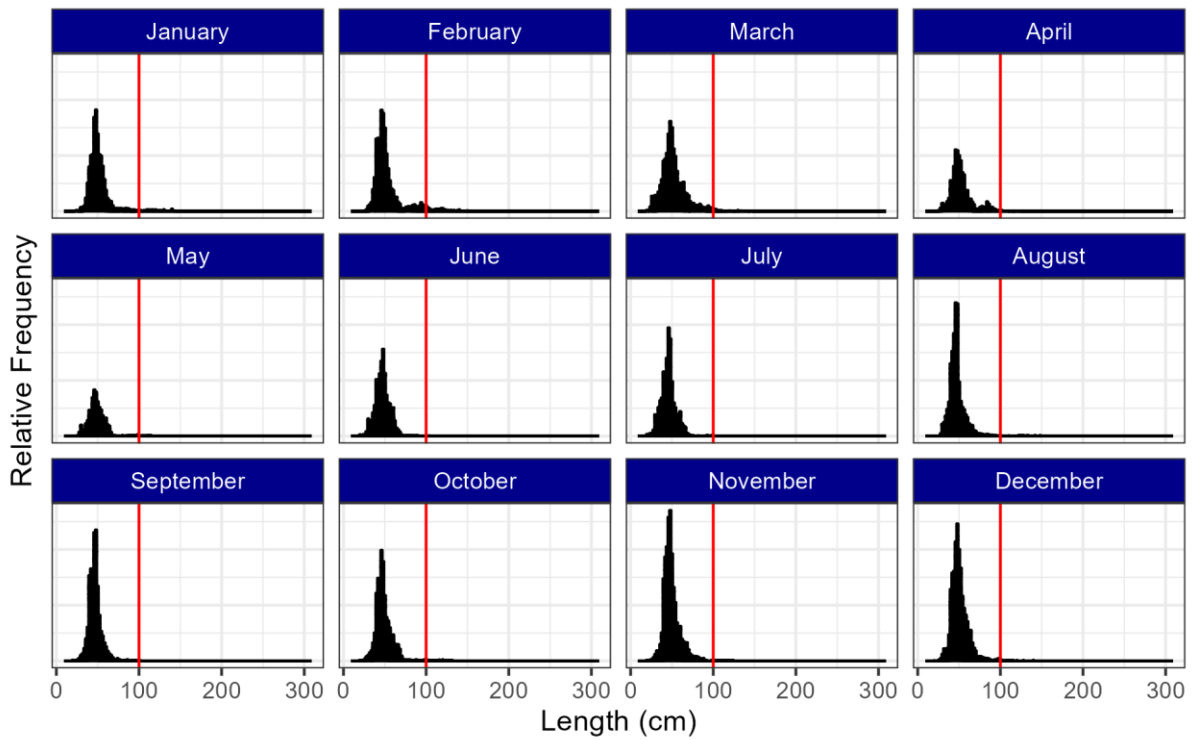
NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.

**Yellowfin tuna – Pole and Line (Baitboat)**



**Figure 31 Size frequency of yellowfin tuna catch by pole and line gear (2000 to present).**

NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.



**Figure 32 Size frequency of yellowfin tuna catch by pole and line gear by month (2000 to present).**

NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.

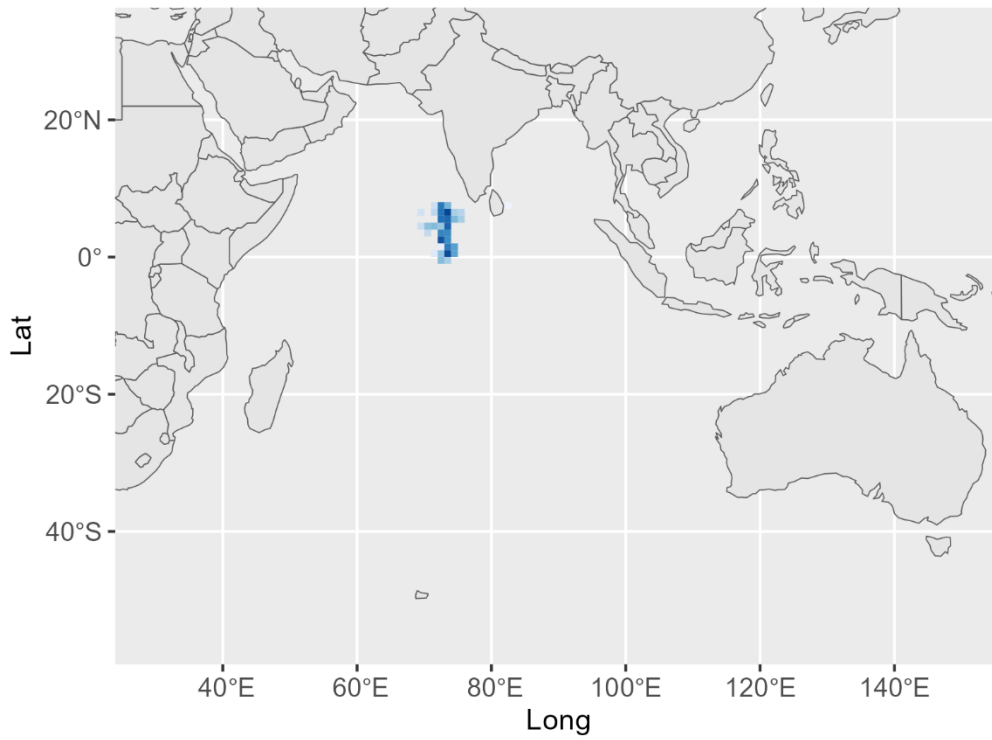


Figure 33 Locations of yellowfin tuna sampled from pole and line vessels (2000 to present).

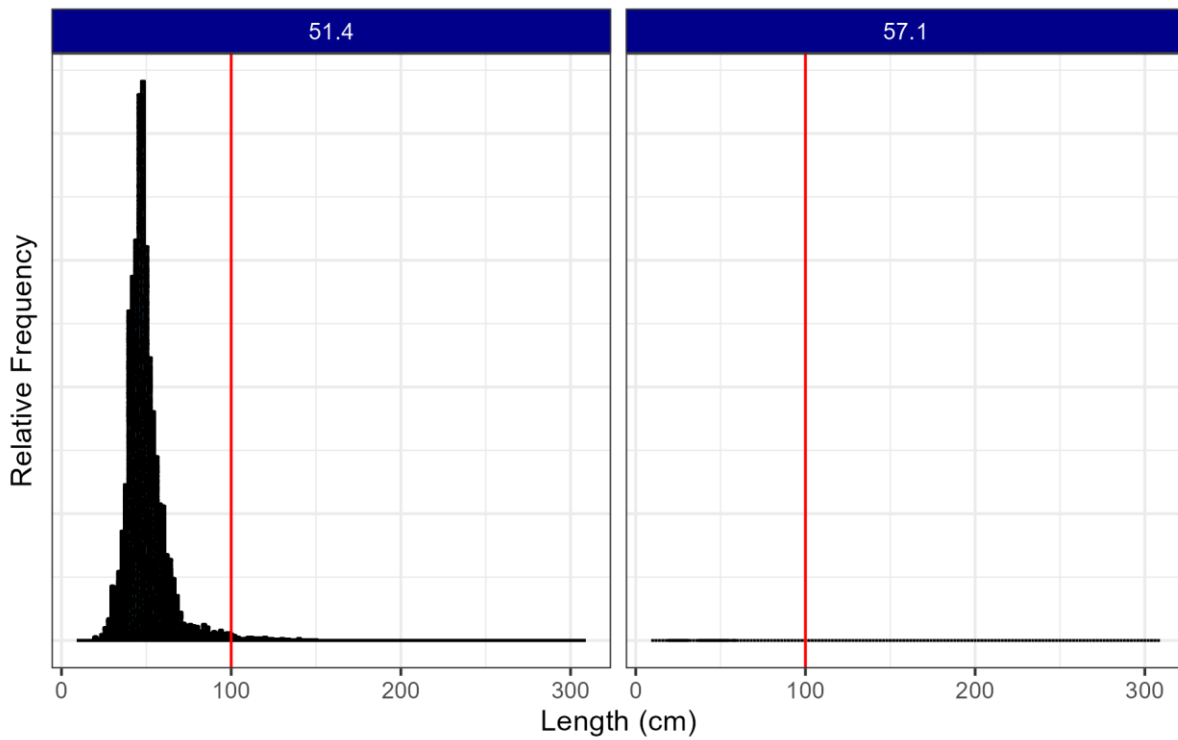
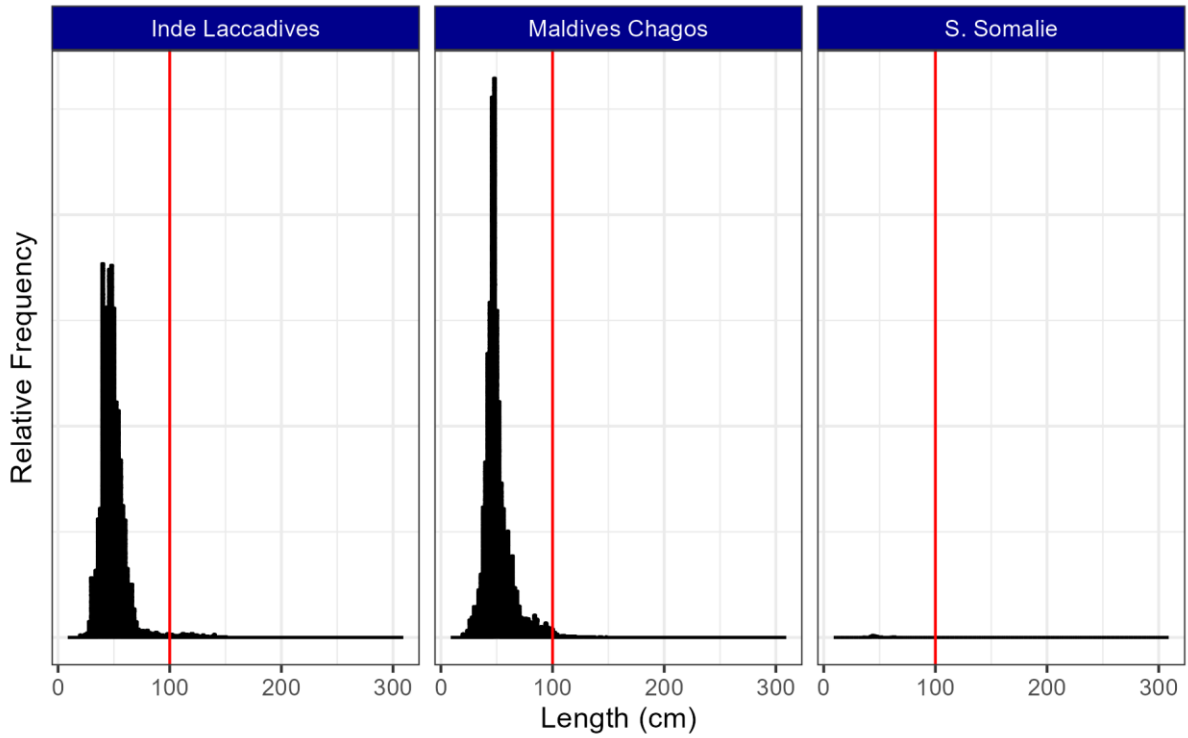


Figure 34 Size frequency of yellowfin tuna catch by pole and line gear by FAO Subarea (2000 to present).

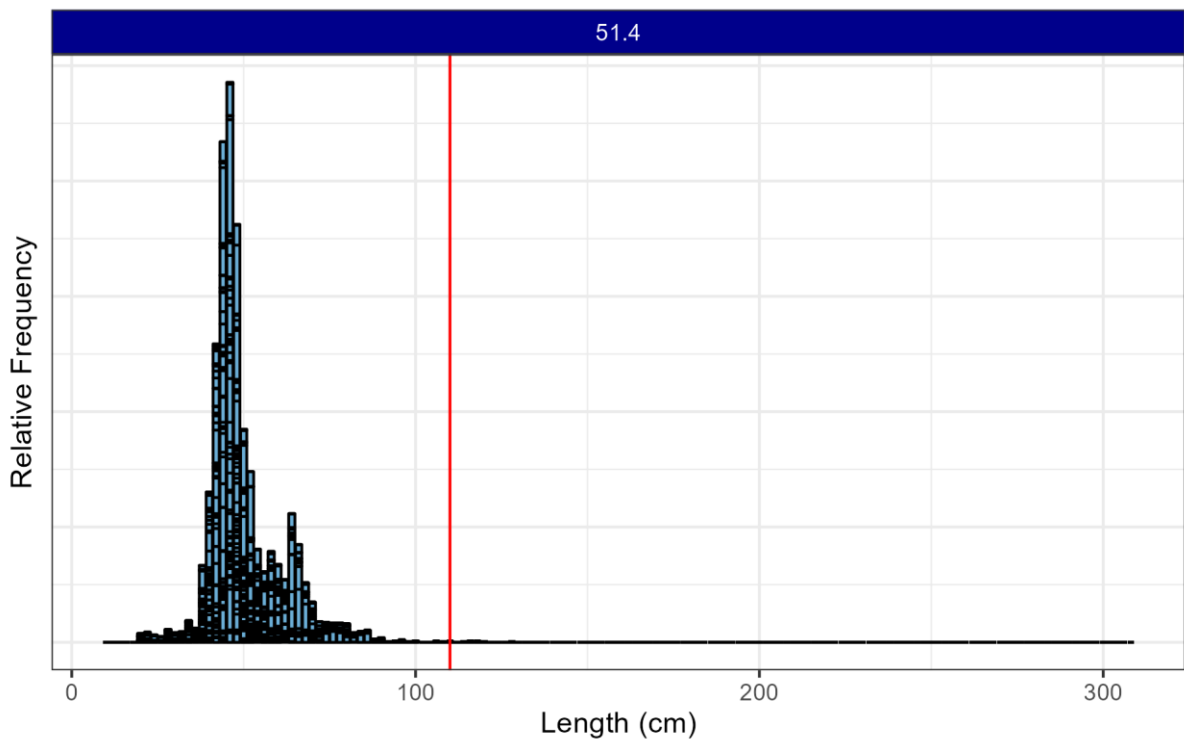
NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.



**Figure 35** Size frequency of yellowfin tuna catch by pole and line gear by IRD Area (2000 to present).

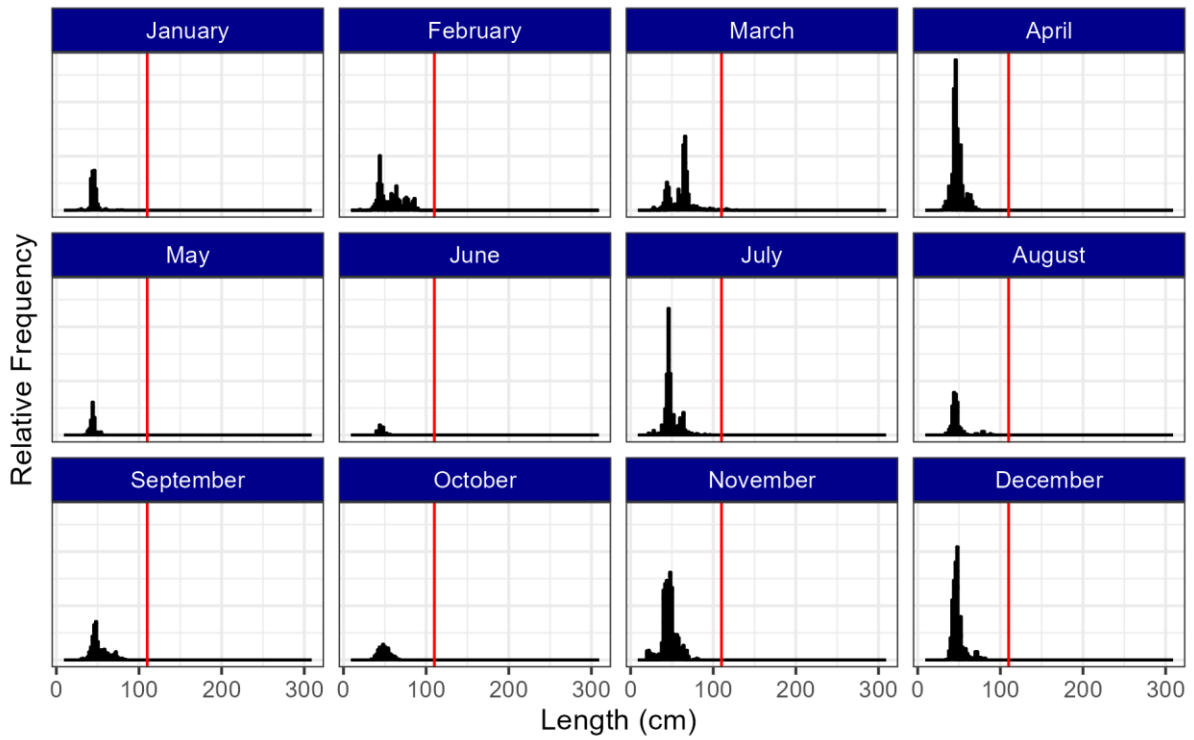
NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.

**Bigeye tuna – Pole and Line (Baitboat)**



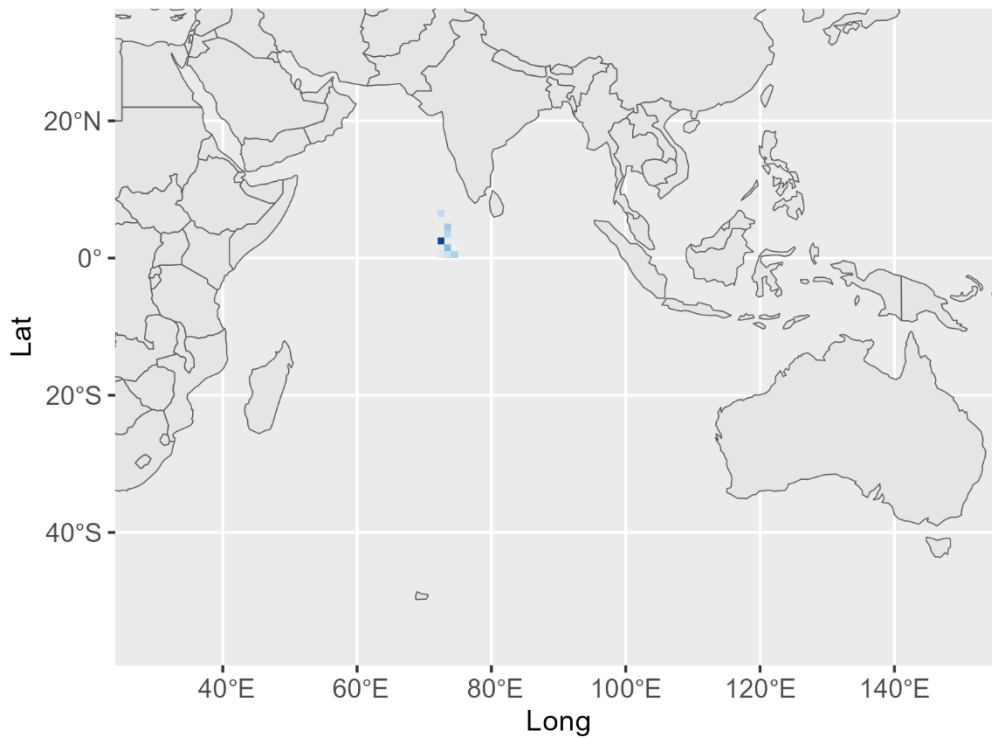
**Figure 36** Size frequency of bigeye tuna catch by pole and line gear (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.

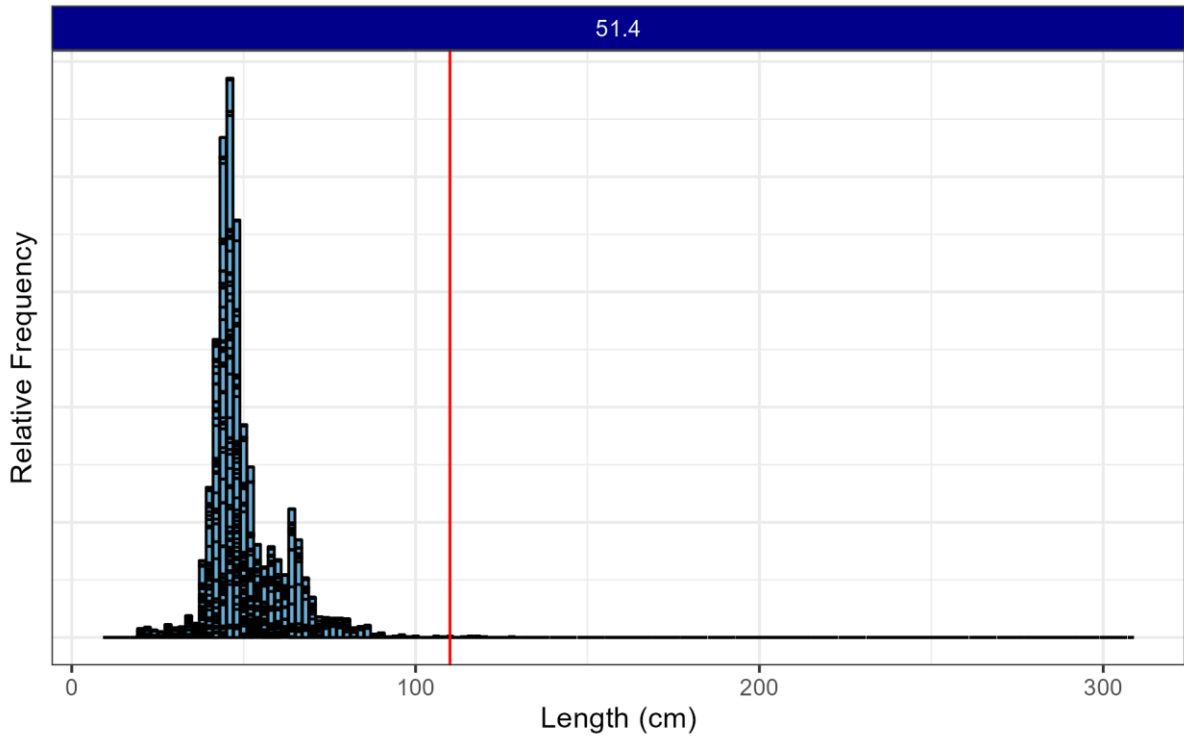


**Figure 37** Size frequency of bigeye tuna catch by pole and line gear by month (2000 to present)

NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.

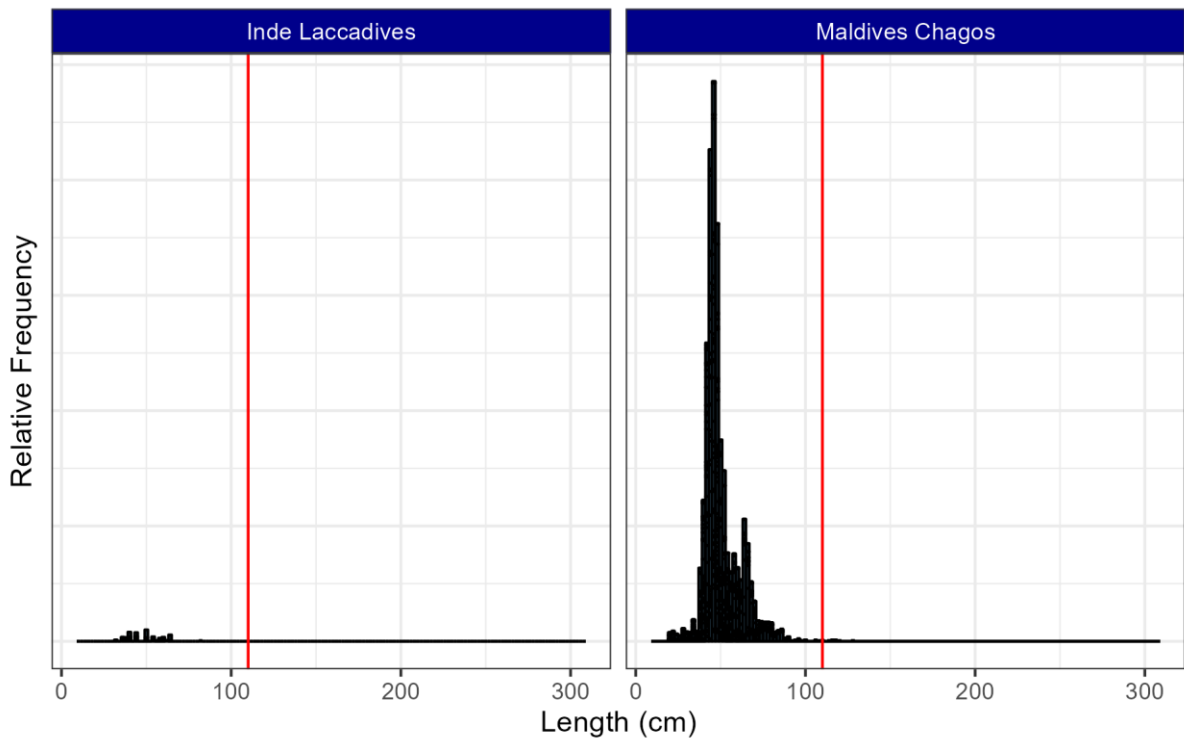


**Figure 38** Locations of bigeye tuna sampled from pole and line vessels (2000 to present).



**Figure 39** Size frequency of bigeye tuna catch by pole and line gear by FAO Subarea (2000 to present).

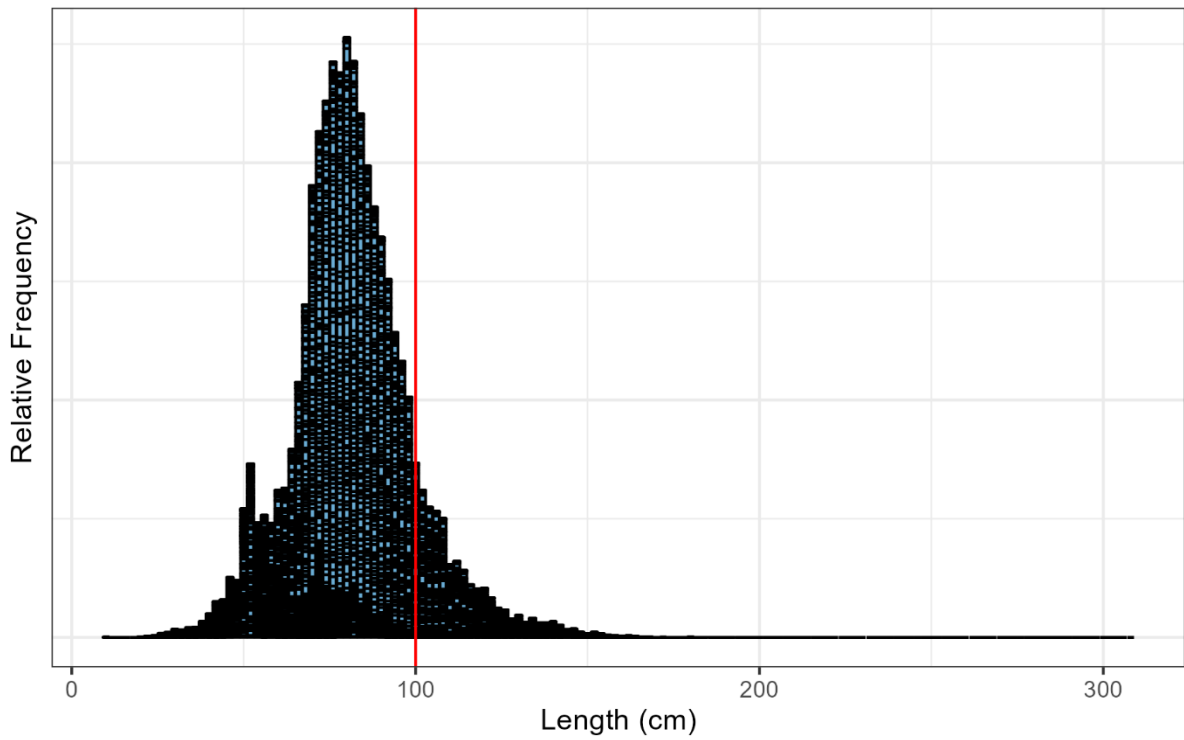
NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.



**Figure 40** Size frequency of bigeye tuna catch by pole and line gear by IRD Area (2000 to present).

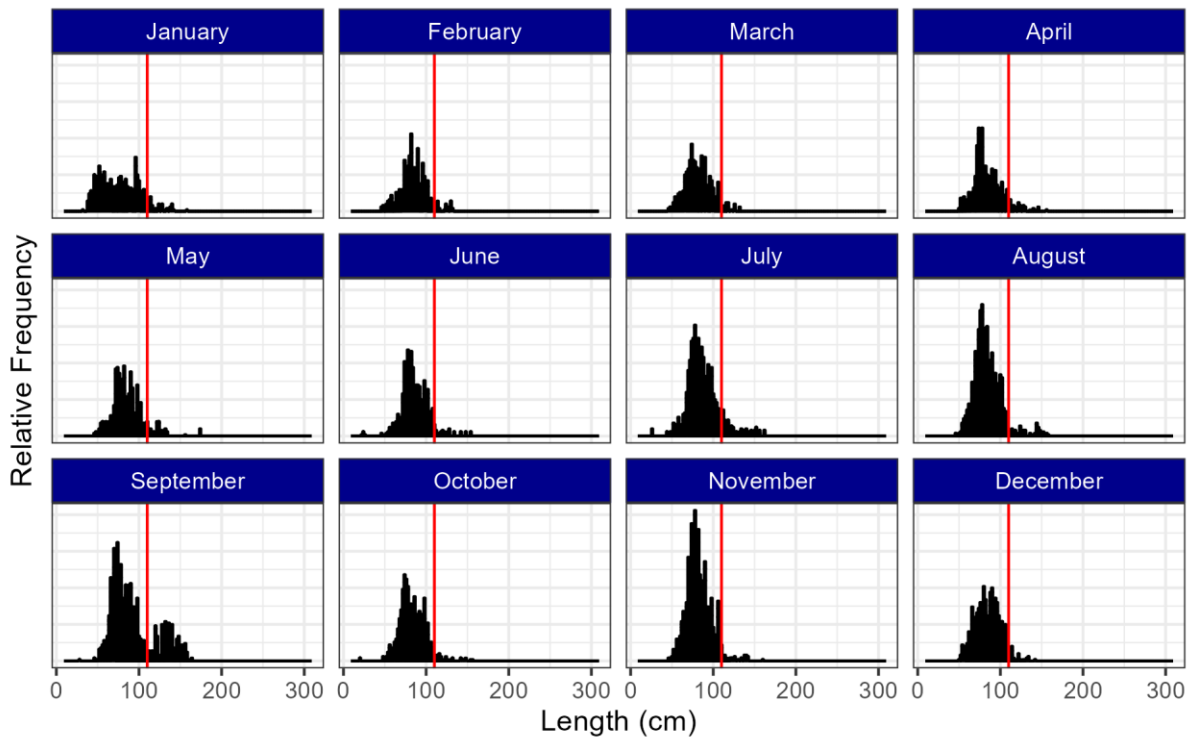
NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.

**Yellowfin tuna – Gillnet**



**Figure 41 Size frequency of yellowfin tuna catch by gillnet (2000 to present).**

NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.



**Figure 42 Size frequency of yellowfin tuna catch by gillnet by month (2000 to present).**

NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.

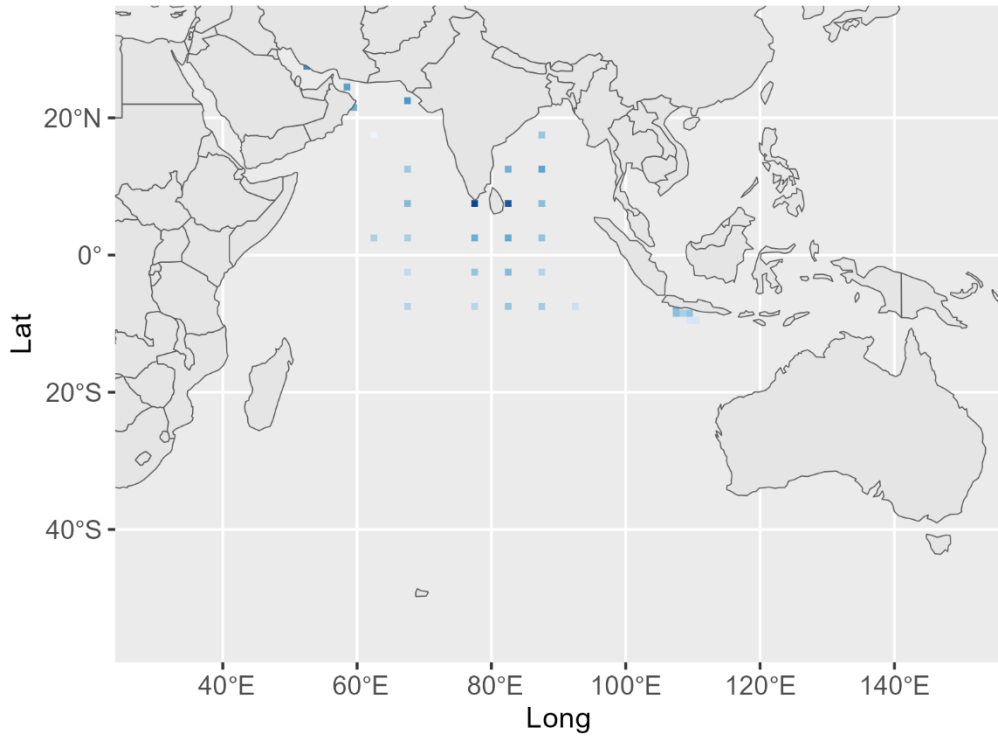


Figure 43 Locations of yellowfin tuna sampled from gillnetters (2000 to present).

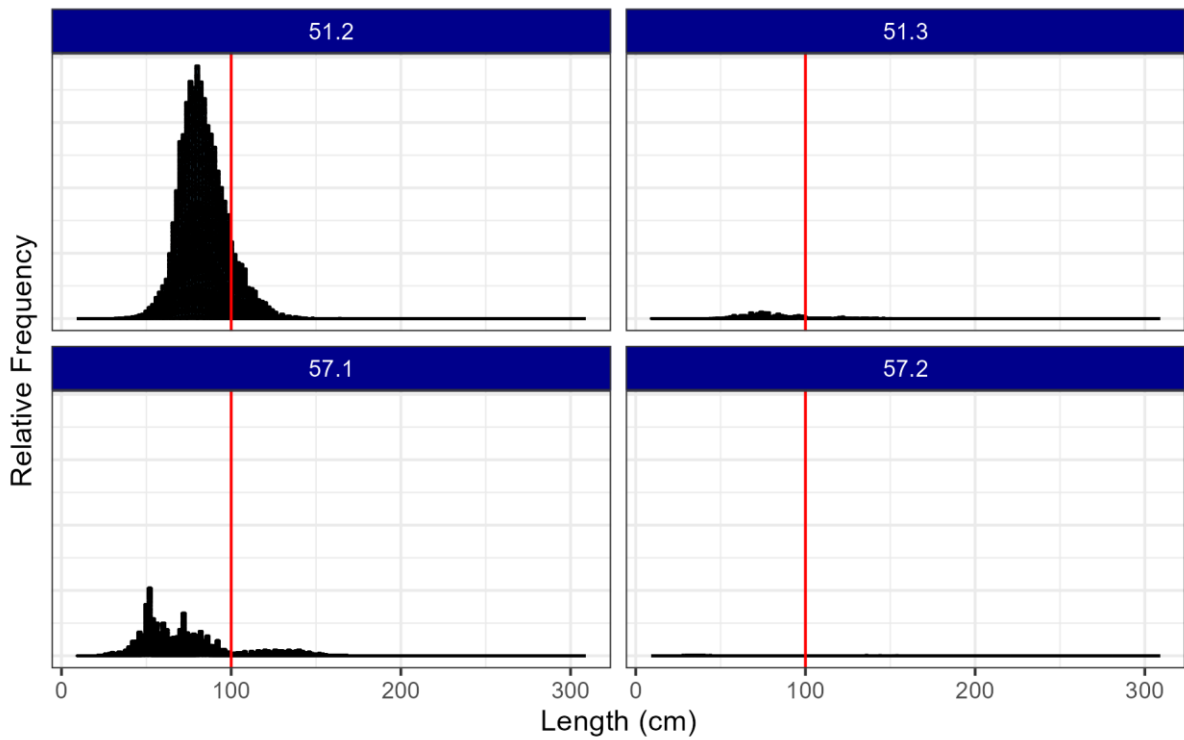
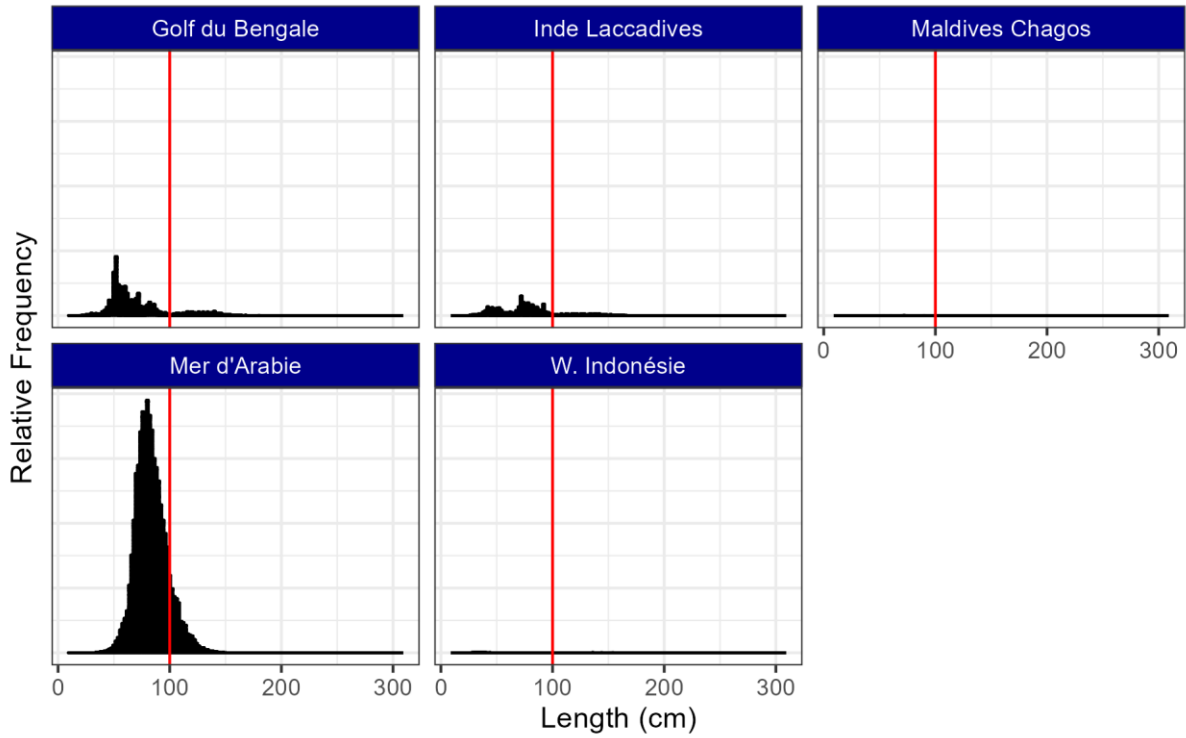


Figure 44 Size frequency of yellowfin tuna catch by gillnet by FAO Subarea (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.

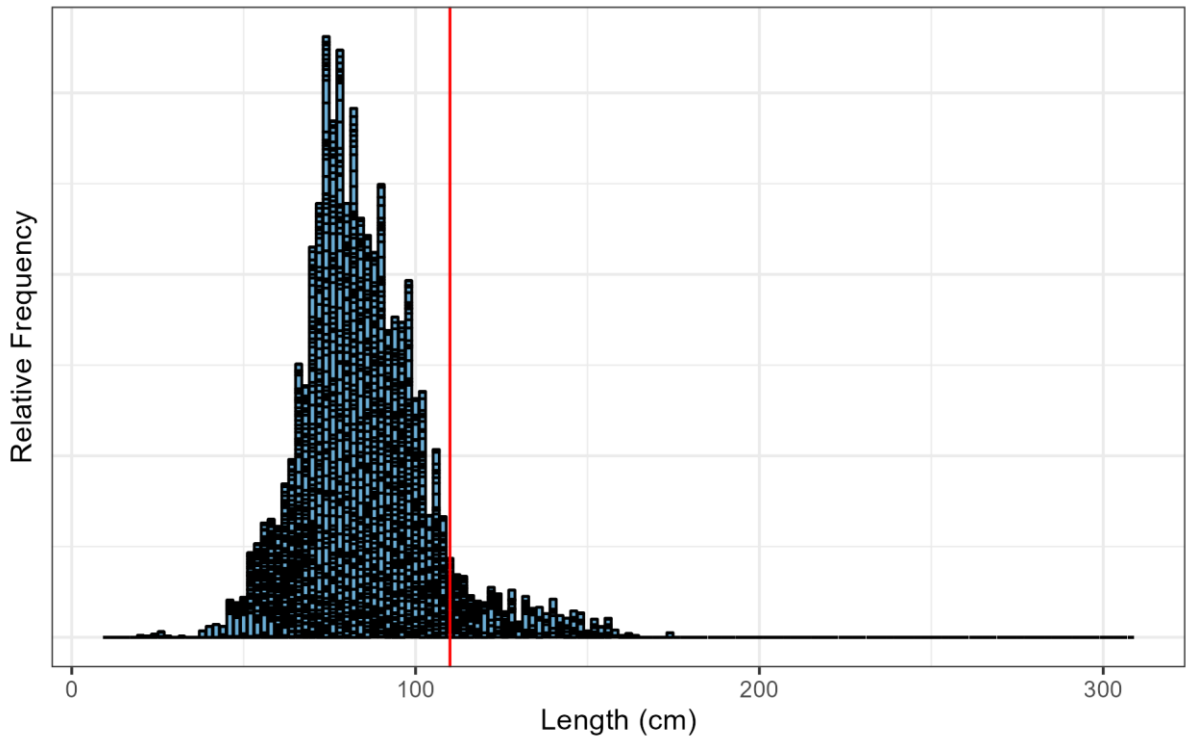




**Figure 45** Size frequency of yellowfin tuna catch by gillnet by IRD Area (2000 to present).

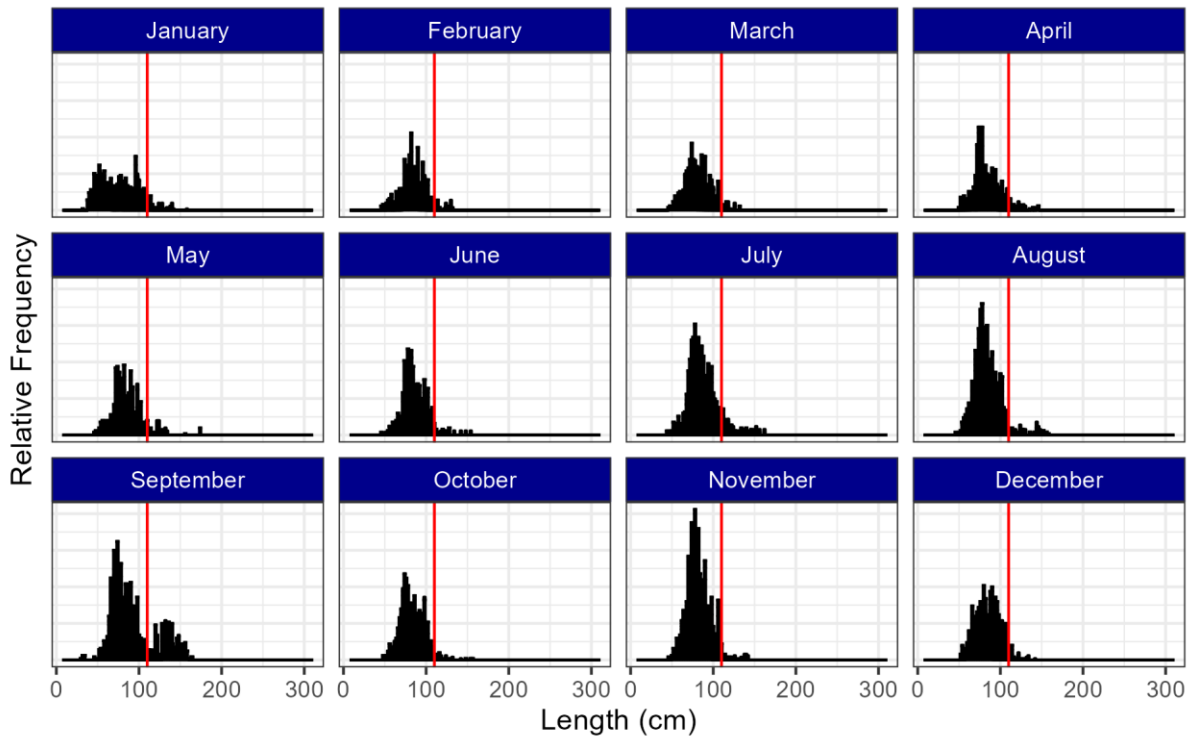
NB: Red line indicates assumed  $L_{MAT}$  for yellowfin tuna.

**Bigeye tuna – Gillnet**



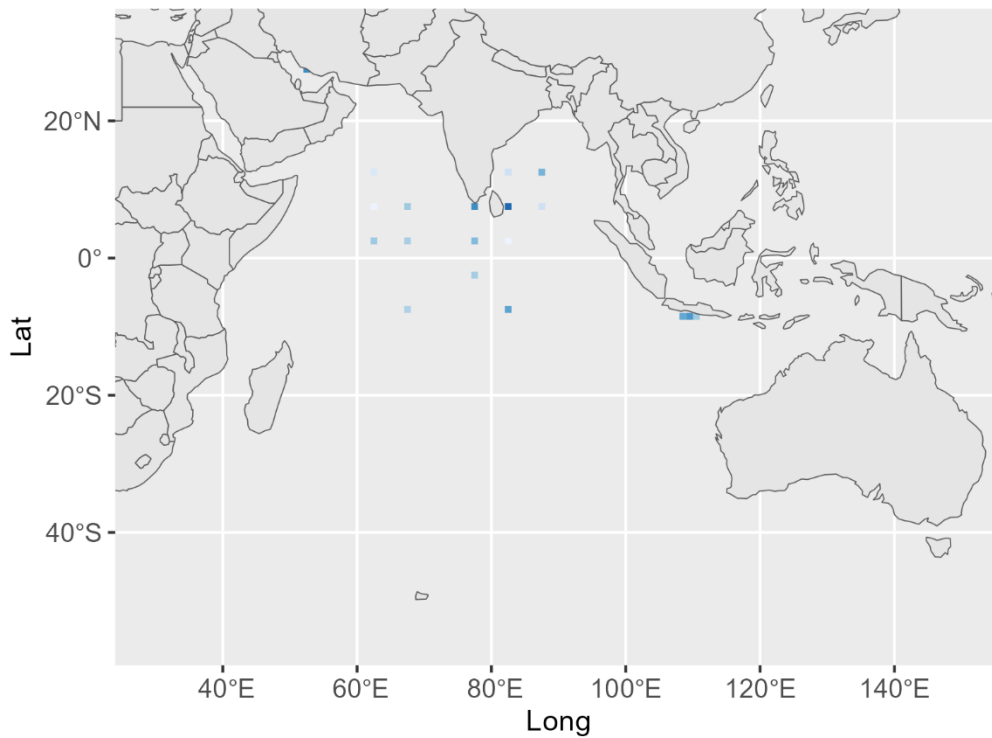
**Figure 46** Size frequency of bigeye tuna catch by gillnet (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.

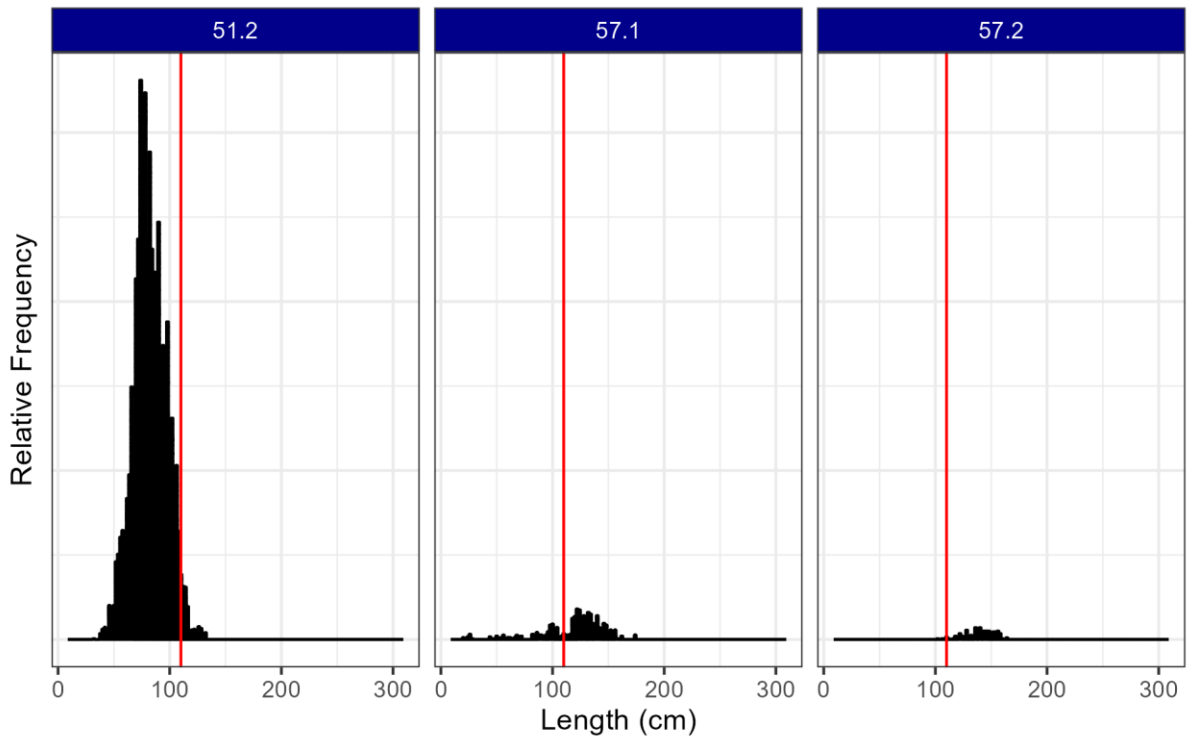


**Figure 47** Size frequency of bigeye tuna catch by gillnet by month (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.

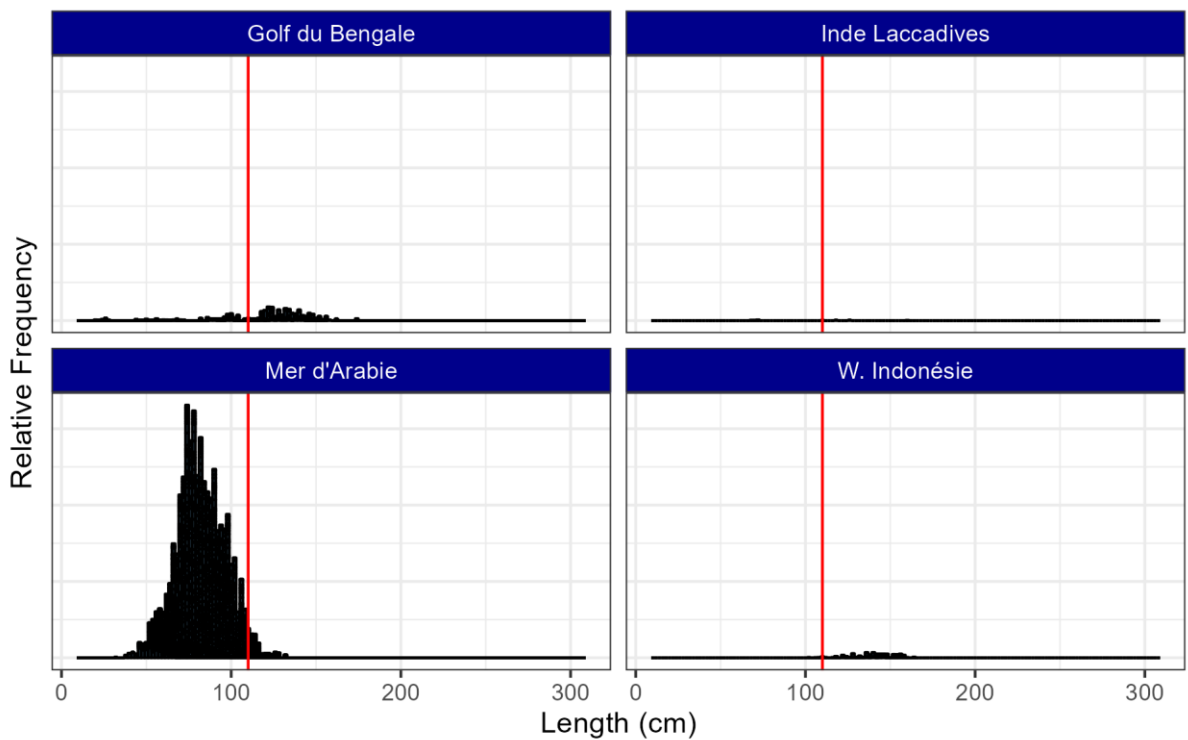


**Figure 48** Locations of bigeye tuna sampled from gillnetters (2000 to present).



**Figure 49** Size frequency of bigeye tuna catch by gillnet by FAO Subarea (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.



**Figure 50** Size frequency of bigeye tuna catch by gillnet by IRD Area (2000 to present).

NB: Red line indicates assumed  $L_{MAT}$  for bigeye tuna.

## ANNEX

```

library(tidyverse)
library(ggplot2)
library(readxl)
library(RColorBrewer)
library(sfheaders)
library(sf)

# Server
month.labels <-
c("January", "February", "March", "April", "May", "June", "July", "August", "September", "October", "November", "December")
names(month.labels) <- c(1,2,3,4,5,6,7,8,9,10,11,12)

## Read yellowfin size frequency data in and de-pivot
## dYFT <- read_excel("IOTC_YFT_SF.xlsx") Original
dYFT <- read_excel("IOTC_YFT_SF_WGFAD04UpdateZones.xlsx")
dBET <- read_excel("IOTC_BET_SF_WGFAD04UpdateZones.xlsx") # Updated - note the extension difference

## IOTC_YFT_SF_WGFAD04UpdateZones / IOTC_YFT_SF_WGFAD04Update
## IOTC_BET_SF_WGFAD04UpdateZones / IOTC_BET_SF_WGFAD04Update

# First convert the dataframes to shapefile so we can spatially manipulate them.
dYFT <- dYFT %>%
  st_as_sf(coords=c("Longitude_Centroid", "Latitude_Centroid"), crs= 4326)

dBET <- dBET %>%
  st_as_sf(coords=c("Longitude_Centroid", "Latitude_Centroid"), crs= 4326)

### FAO Sub Areas ###

# First we'll do the FAO Sub Areas

# Read in the FAO Areas shapefile and filter out only the relevant Areas (51 and 57)
FAO_Areas <- read_sf("fa_subareas.shp") %>%
  filter(F_AREA %in% c(51, 57))

IRD_Areas <- read_sf("ZET.shp")

# Run the intersection.
# Remove unnecessary columns.
# This provides the FAO Sub area column, as well as omitting data outside of the boundaries
# Note here is that some data is removed with this intersection - largely those with unknown lat/lons (-
999) as well as those that fall outside the boundaries
# of the shapefile.
ggplot()+
  geom_sf(data = FAO_Areas)+
  geom_sf(data = dYFT)

dYFT <- st_intersection(dYFT, FAO_Areas) %>%
  select(-c(SUBOCEAN, OCEAN, F_AREA))

ggplot()+
  geom_sf(data = FAO_Areas)+
  geom_sf(data = dBET)

ggplot()+
  geom_sf(data = dBET)

dBET <- st_intersection(dBET, FAO_Areas) %>%
  select(-c(SUBOCEAN, OCEAN, F_AREA))

ggplot()+
  geom_sf(data = FAO_Areas)+
  geom_sf(data = dYFT)

ggplot()+
  geom_sf(data = FAO_Areas)+
  geom_sf(data = dBET)

dYFT <- st_intersection(dYFT, IRD_Areas)

dBET <- st_intersection(dBET, IRD_Areas)

ggplot()+
  geom_sf(data = IRD_Areas)+
  geom_sf(data = dYFT)

ggplot()+
  geom_sf(data = IRD_Areas)+
  geom_sf(data = dBET)

write.csv(dYFT, "YFT_FAO_SUBAREA.csv")
write.csv(dBET, "BET_FAO_SUBAREA.csv")

```

```

### Manual fix to files to enforce LF bin lengths

dYFT <- read_excel("YFT_FAO_SUBAREA_IRD_AREA.xlsx")
dBET <- read_excel("BET_FAO_SUBAREA_IRD_AREA.xlsx")

dYFT$L_ZET[dYFT$L_ZET == "W. IndonÃfÃ©sie"] <- "W. IndonÃ©sie"
dBET$L_ZET[dBET$L_ZET == "W. IndonÃfÃ©sie"] <- "W. IndonÃ©sie"

dYFTbyLength <- pivot_longer(dYFT, c(29:178), names_to = "Length_CM", values_to = "CountFish")
dYFTAggregated <- aggregate(CountFish ~ Year + Fleet + MonthStart + Gear + Species + SchoolType + F_SUBAREA
+ L_ZET + Length_CM, data = dYFTbyLength, FUN = sum, na.rm = TRUE)
dYFTAll <- dYFTAggregated
dYFTAggregated <- filter(dYFTAggregated, Year >= 2000)

dBETbyLength <- pivot_longer(dBET, c(29:178), names_to = "Length_CM", values_to = "CountFish")
dBETAggregated <- aggregate(CountFish ~ Year + Fleet + MonthStart + Gear + Species + SchoolType + F_SUBAREA
+ L_ZET + Length_CM, data = dBETbyLength, FUN = sum, na.rm = TRUE)
dBETAll <- dBETAggregated
dBETAggregated <- filter(dBETAggregated, Year >= 2000)

##All Longline SF plot
dYFT_LL <- filter(dYFTAggregated, Species == "YFT" & Gear == "LL" )
dYFT_LL$Length_CM <- as.numeric(as.vector(dYFT_LL$Length_CM))

YFT_LL <- ggplot(dYFT_LL, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 100) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

YFT_LL_ByMonth <- ggplot(dYFT_LL, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 100) +
  facet_wrap(~ MonthStart,labeller=labeler(MonthStart = month.labels))+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

ggsave("YFT_Longline.png", plot = YFT_LL, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("YFT_Longline_ALL_ByMonth.png", plot = YFT_LL_ByMonth, width = 15.92, height = 10, units = "cm", dpi
= 300)

YFT_LL_ByFAOSUBAREA <- ggplot(dYFT_LL, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 100) +
  facet_wrap(~ F_SUBAREA)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

ggsave("YFT_Longline_ALL_ByFAOSUBAREA.png", plot = YFT_LL_ByFAOSUBAREA, width = 15.92, height = 10, units =
"cm", dpi = 300)

YFT_LL_ByIRDAREA <- ggplot(dYFT_LL, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 100) +
  facet_wrap(~ L_ZET)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

ggsave("YFT_Longline_ALL_ByIRDAREA.png", plot = YFT_LL_ByIRDAREA, width = 15.92, height = 10, units = "cm",
dpi = 300)

```

```

##All Purse Seine plot

dYFT_PS_LS <- filter(dYFTAggregated, Species == "YFT" & Gear == "PS" )
dYFT_PS_LS <- filter(dYFT_PS_LS, SchoolType == "LS")
dYFT_PS_FS <- filter(dYFTAggregated, Species == "YFT" & Gear == "PS" & SchoolType == "FS" )
dYFT_PS_FS$Length_CM <- as.numeric(as.vector(dYFT_PS_FS$Length_CM))
dYFT_PS_LS$Length_CM <- as.numeric(as.vector(dYFT_PS_LS$Length_CM))

YFT_PS_LS <- ggplot(dYFT_PS_LS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 100) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

YFT_PS_FS <- ggplot(dYFT_PS_FS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 100) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

YFT_PS_LS_ByMonth <- ggplot(dYFT_PS_LS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  facet_wrap(~ MonthStart,labeller=labeller(MonthStart = month.labels))+
  geom_vline(colour="red",xintercept = 100) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

YFT_PS_FS_ByMonth <- ggplot(dYFT_PS_FS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  facet_wrap(~ MonthStart,labeller=labeller(MonthStart = month.labels))+
  geom_vline(colour="red",xintercept = 100) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

YFT_PS_LS_ByFAOSUBAREA <- ggplot(dYFT_PS_LS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 100) +
  facet_wrap(~ F_SUBAREA)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

YFT_PS_LS_ByIRDAREA <- ggplot(dYFT_PS_LS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 100) +
  facet_wrap(~ L_ZET)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

YFT_PS_FS_ByFAOSUBAREA <- ggplot(dYFT_PS_FS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +

```

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geom_vline(colour="red",xintercept = 100) +
facet_wrap(~ F_SUBAREA)+
theme(legend.position = "none") +
theme(axis.title.x=element_text(size=20)) +
theme_bw() +
theme(strip.background =element_rect(fill="blue4"))+
theme(strip.text = element_text(colour = 'white')) +
theme(axis.text.y=element_blank(),
      axis.ticks.y=element_blank() )

YFT_PS_FS_ByIRDAREA <- ggplot(dYFT_PS_FS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 100) +
  facet_wrap(~ L_ZET)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

ggsave("YFT_PS_Free.png", plot = YFT_PS_FS, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("YFT_PS_FAD.png", plot = YFT_PS_LS, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("YFT_PS_Free_ByMonth.png", plot = YFT_PS_FS_ByMonth, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("YFT_PS_FAD_ByMonth.png", plot = YFT_PS_LS_ByMonth, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("YFT_PS_Free_ByFAOSubArea.png", plot = YFT_PS_FS_ByFAOSUBAREA, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("YFT_PS_FAD_ByFAOSubArea.png", plot = YFT_PS_LS_ByFAOSUBAREA, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("YFT_PS_Free_ByIRDAREA.png", plot = YFT_PS_FS_ByIRDAREA, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("YFT_PS_FAD_ByIRDAREA.png", plot = YFT_PS_LS_ByIRDAREA, width = 15.92, height = 10, units = "cm", dpi = 300)

##Maldviesia BB SF plot
dMDV_YFT_BB_All <- filter(dYFTAggregated, Fleet == "MDV" & Species == "YFT" & Gear == "BB")
dMDV_YFT_BB_All$Length_CM <- as.numeric(as.vector(dMDV_YFT_BB_All$Length_CM))

YFT_BB <- ggplot(dMDV_YFT_BB_All, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 100) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

YFT_BB_ByMonth <- ggplot(dMDV_YFT_BB_All, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  facet_wrap(~ MonthStart,labeller=labeller(MonthStart = month.labels))+
  geom_vline(colour="red",xintercept = 100) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

YFT_BB_ByFAOSUBAREA <- ggplot(dMDV_YFT_BB_All, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 100) +
  facet_wrap(~ F_SUBAREA)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

YFT_BB_ByIRDAREA <- ggplot(dMDV_YFT_BB_All, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 100) +
  facet_wrap(~ L_ZET)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +

```

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theme_bw() +
theme(strip.background =element_rect(fill="blue4"))+
theme(strip.text = element_text(colour = 'white')) +
theme(axis.text.y=element_blank(),
      axis.ticks.y=element_blank() )

ggsave("YFT_BB.png", plot = YFT_BB, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("YFT_BB_ByMonth.png", plot = YFT_BB_ByMonth, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("YFT_BB_ByFAOSubarea.png", plot = YFT_BB_ByFAOSUBAREA, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("YFT_BB_ByIRDArea.png", plot = YFT_BB_ByIRDAREA, width = 15.92, height = 10, units = "cm", dpi = 300)

##Gillnet SF plot
dGillnet_YFT <- filter(dYFTAggregated, Species == "YFT" & Gear == "GILL")
dGillnet_YFT$Length_CM <- as.numeric(as.vector(dGillnet_YFT$Length_CM))

YFT_GILLNET <- ggplot(dGillnet_YFT, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 100) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

YFT_GILLNET_ByMonth <- ggplot(dGillnet_YFT, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  facet_wrap(~ MonthStart,labeller=labeller(MonthStart = month.labels))+
  geom_vline(colour="red",xintercept = 100) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

YFT_GILLNET_ByMonth <- ggplot(dGillnet_YFT, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  facet_wrap(~ MonthStart,labeller=labeller(MonthStart = month.labels))+
  geom_vline(colour="red",xintercept = 100) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

YFT_GILLNET_ByFAOSUBAREA <- ggplot(dGillnet_YFT, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 100) +
  facet_wrap(~ F_SUBAREA)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

YFT_GILLNET_ByIRDAREA <- ggplot(dGillnet_YFT, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 100) +
  facet_wrap(~ L_ZET)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

ggsave("YFT_Gillnet.png", plot = YFT_GILLNET, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("YFT_Gillnet_ByMonth.png", plot = YFT_GILLNET_ByMonth, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("YFT_Gillnet_ByFAOSubarea.png", plot = YFT_GILLNET_ByFAOSUBAREA, width = 15.92, height = 10, units = "cm", dpi = 300)

```



```

ggsave("YFT_Gillnet_ByIRDAREA.png", plot = YFT_GILLNET_ByIRDAREA, width = 15.92, height = 10, units = "cm",
dpi = 300)

##All Longline SF plot
dBET_LL <- filter(dBETAggregated, Species == "BET" & Gear == "LL" )
dBET_LL$Length_CM <- as.numeric(as.vector(dBET_LL$Length_CM))

BET_LL <- ggplot(dBET_LL, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 110) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

BET_LL_ByMonth <- ggplot(dBET_LL, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 110) +
  facet_wrap(~ MonthStart,labeller=labeler(MonthStart = month.labels))+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

BET_LL_ByFAOSUBAREA <- ggplot(dBET_LL, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 110) +
  facet_wrap(~ F_SUBAREA)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

BET_LL_ByIRDAREA <- ggplot(dBET_LL, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 110) +
  facet_wrap(~ L_ZET)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

ggsave("BET_Longline_All.png", plot = BET_LL, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("BET_Longline_ALL_ByMonth.png", plot = BET_LL_ByMonth, width = 15.92, height = 10, units = "cm", dpi
= 300)
ggsave("BET_Longline_ALL_ByFAOSUBAREA.png", plot = BET_LL_ByFAOSUBAREA, width = 15.92, height = 10, units =
"cm", dpi = 300)
ggsave("BET_Longline_ALL_ByIRDAREA.png", plot = BET_LL_ByIRDAREA, width = 15.92, height = 10, units = "cm",
dpi = 300)

##All Purse Seine plot

dBET_PS_LS <- filter(dBETAggregated, Species == "BET" & Gear == "PS" )
dBET_PS_LS <- filter(dBET_PS_LS, SchoolType == "LS")
dBET_PS_FS <- filter(dBETAggregated, Species == "BET" & Gear == "PS" & SchoolType == "FS" )
dBET_PS_FS$Length_CM <- as.numeric(as.vector(dBET_PS_FS$Length_CM))
dBET_PS_LS$Length_CM <- as.numeric(as.vector(dBET_PS_LS$Length_CM))

BET_PS_LS <- ggplot(dBET_PS_LS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 110) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

BET_PS_FS <- ggplot(dBET_PS_FS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +

```

```

labs(x = "Length (cm)", y = "Relative Frequency") +
geom_vline(colour="red",xintercept = 110) +
theme(legend.position = "none") +
theme(axis.title.x=element_text(size=20)) +
theme_bw() +
theme(strip.background =element_rect(fill="blue4"))+
theme(strip.text = element_text(colour = 'white')) +
theme(axis.text.y=element_blank(),
      axis.ticks.y=element_blank() )

BET_PS_LS_ByMonth <- ggplot(dBET_PS_LS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  facet_wrap(~ MonthStart,labeller=labeller(MonthStart = month.labels))+
  geom_vline(colour="red",xintercept = 110) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

BET_PS_FS_ByMonth <- ggplot(dBET_PS_FS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  facet_wrap(~ MonthStart,labeller=labeller(MonthStart = month.labels))+
  geom_vline(colour="red",xintercept = 110) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

BET_PS_LS_ByFAOSUBAREA <- ggplot(dBET_PS_LS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 110) +
  facet_wrap(~ F_SUBAREA)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

BET_PS_LS_ByIRDAREA <- ggplot(dBET_PS_LS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 110) +
  facet_wrap(~ L_ZET)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

BET_PS_FS_ByFAOSUBAREA <- ggplot(dBET_PS_FS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 110) +
  facet_wrap(~ F_SUBAREA)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

BET_PS_FS_ByIRDAREA <- ggplot(dBET_PS_FS, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 110) +
  facet_wrap(~ L_ZET)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

```

```

ggsave("BET_PS_Free.png", plot = BET_PS_FS, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("BET_PS_FAD.png", plot = BET_PS_LS, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("BET_PS_Free_ByMonth.png", plot = BET_PS_FS_ByMonth, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("BET_PS_FAD_ByMonth.png", plot = BET_PS_LS_ByMonth, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("BET_PS_Free_ByFAOSubArea.png", plot = BET_PS_FS_ByFAOSUBAREA, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("BET_PS_FAD_ByFAOSubArea.png", plot = BET_PS_LS_ByFAOSUBAREA, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("BET_PS_Free_ByIRDAREA.png", plot = BET_PS_FS_ByIRDAREA, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("BET_PS_FAD_ByIRDAREA.png", plot = BET_PS_LS_ByIRDAREA, width = 15.92, height = 10, units = "cm", dpi = 300)

##Maldviesia BB SF plot
dMDV_BET_BB_All <- filter(dBETAggregated, Fleet == "MDV" & Species == "BET" & Gear == "BB")
dMDV_BET_BB_All$Length_CM <- as.numeric(as.vector(dMDV_BET_BB_All$Length_CM))

BET_BB <- ggplot(dMDV_BET_BB_All, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 110) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

BET_BB_ByMonth <- ggplot(dMDV_BET_BB_All, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  facet_wrap(~ MonthStart,labeller=labeller(MonthStart = month.labels))+
  geom_vline(colour="red",xintercept = 110) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

BET_BB_ByFAOSUBAREA <- ggplot(dMDV_BET_BB_All, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 110) +
  facet_wrap(~ F_SUBAREA)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

BET_BB_ByIRDAREA <- ggplot(dMDV_BET_BB_All, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 110) +
  facet_wrap(~ L_ZET)+
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +
  theme_bw() +
  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white')) +
  theme(axis.text.y=element_blank(),
        axis.ticks.y=element_blank() )

ggsave("BET_BB.png", plot = BET_BB, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("BET_BB_ByMonth.png", plot = BET_BB_ByMonth, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("BET_BB_ByFAOSubarea.png", plot = BET_BB_ByFAOSUBAREA, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("BET_BB_ByIRDArea.png", plot = BET_BB_ByIRDAREA, width = 15.92, height = 10, units = "cm", dpi = 300)

##Gillnet SF plot
dGillnet_BET <- filter(dBETAggregated, Species == "BET" & Gear == "GILL")
dGillnet_BET$Length_CM <- as.numeric(as.vector(dGillnet_BET$Length_CM))

BET_GILLNET <- ggplot(dGillnet_BET, aes(x=Length_CM,y=CountFish)) +
  geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
  labs(x = "Length (cm)", y = "Relative Frequency") +
  geom_vline(colour="red",xintercept = 110) +
  theme(legend.position = "none") +
  theme(axis.title.x=element_text(size=20)) +

```

```

theme_bw() +
theme(strip.background =element_rect(fill="blue4"))+
theme(strip.text = element_text(colour = 'white')) +
theme(axis.text.y=element_blank(),
      axis.ticks.y=element_blank() )

BET_GILLNET_ByMonth <- ggplot(dGillnet_BET, aes(x=Length_CM,y=CountFish)) +
geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
labs(x = "Length (cm)", y = "Relative Frequency") +
facet_wrap(~ MonthStart,labeller=labeller(MonthStart = month.labels))+
geom_vline(colour="red",xintercept = 110) +
theme(legend.position = "none") +
theme(axis.title.x=element_text(size=20)) +
theme_bw() +
theme(strip.background =element_rect(fill="blue4"))+
theme(strip.text = element_text(colour = 'white')) +
theme(axis.text.y=element_blank(),
      axis.ticks.y=element_blank() )

BET_GILLNET_ByMonth <- ggplot(dGillnet_BET, aes(x=Length_CM,y=CountFish)) +
geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
labs(x = "Length (cm)", y = "Relative Frequency") +
facet_wrap(~ MonthStart,labeller=labeller(MonthStart = month.labels))+
geom_vline(colour="red",xintercept = 110) +
theme(legend.position = "none") +
theme(axis.title.x=element_text(size=20)) +
theme_bw() +
theme(strip.background =element_rect(fill="blue4"))+
theme(strip.text = element_text(colour = 'white')) +
theme(axis.text.y=element_blank(),
      axis.ticks.y=element_blank() )

BET_GILLNET_ByFAOSUBAREA <- ggplot(dGillnet_BET, aes(x=Length_CM,y=CountFish)) +
geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
labs(x = "Length (cm)", y = "Relative Frequency") +
geom_vline(colour="red",xintercept = 110) +
facet_wrap(~ F_SUBAREA)+
theme(legend.position = "none") +
theme(axis.title.x=element_text(size=20)) +
theme_bw() +
theme(strip.background =element_rect(fill="blue4"))+
theme(strip.text = element_text(colour = 'white')) +
theme(axis.text.y=element_blank(),
      axis.ticks.y=element_blank() )

BET_GILLNET_ByIRDAREA <- ggplot(dGillnet_BET, aes(x=Length_CM,y=CountFish)) +
geom_bar(stat="identity", fill = "#6BAED6", colour = "black") +
labs(x = "Length (cm)", y = "Relative Frequency") +
geom_vline(colour="red",xintercept = 110) +
facet_wrap(~ L_ZET)+
theme(legend.position = "none") +
theme(axis.title.x=element_text(size=20)) +
theme_bw() +
theme(strip.background =element_rect(fill="blue4"))+
theme(strip.text = element_text(colour = 'white')) +
theme(axis.text.y=element_blank(),
      axis.ticks.y=element_blank() )

ggsave("BET Gillnet.png", plot = BET_GILLNET, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("YTT_Gillnet_ByMonth.png", plot = BET_GILLNET_ByMonth, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("BET Gillnet_ByFAOSubarea.png", plot = BET_GILLNET_ByFAOSUBAREA, width = 15.92, height = 10, units = "cm", dpi = 300)
ggsave("BET Gillnet_ByIRDArea.png", plot = BET_GILLNET_ByIRDAREA, width = 15.92, height = 10, units = "cm", dpi = 300)

### Plot_01 Showing IOTC Areas labeled
library(tidyverse)
library(rnaturalearth)
library(sf)
library(sfheaders)
options(scipen = 999)
countries <- ne_countries(returnclass = "sf")
st_bbox(FAO_Areas)

# IOTC sub areas - I assume you meant FAO sub areas.
IOTC_FAO_Areas_Map<- ggplot()+
  geom_sf(data = FAO_Areas, fill = NA)+
  geom_sf(data = countries)+
  coord_sf(xlim = c(30, 150), ylim = c(-55, 32))+
  geom_sf_text(data = FAO_Areas, aes(label = F_SUBAREA), size = 2, fontface = "bold", position = "jitter")+
  xlab(label = "Longitude")+
  ylab(label = "Latitude")

ggsave("IOTC_FAO_Areas.png", plot = IOTC_FAO_Areas_Map, width = 15.92, height = 10, units = "cm", dpi = 300)

```

```

# IRD Sub Areas
IOTC_IRD_Areas_Map <- ggplot()+
  geom_sf(data = IRD_Areas, fill = NA)+
  geom_sf(data = countries)+
  coord_sf(xlim = c(30, 150), ylim = c(-55, 32))+
  geom_sf_text(data = IRD_Areas, aes(label = L_ZET), size = 1.25, fontface = "bold", position = "jitter")+
  xlab(label = "Long")+
  ylab(label = "Lat")

ggsave("IOTC_IRD_Areas.png", plot = IOTC_IRD_Areas_Map, width = 15.92, height = 10, units = "cm", dpi =
300)

### Plots 3 to 7 - Heat /density map of gear effort by TgFish (weight in KG)

# bind YFT and BET together to get an aggregated data set
Aggregated_spp <- rbind(dBET, dYFT)%>%
  rename(lon = geometry1) %>% # rename x and y lon and lat
  rename(lat = geometry2)

# Remove unwanted string chars from lon lat value column
Aggregated_spp$lon <- str_replace(Aggregated_spp$lon, "\\(", "")
Aggregated_spp$lon <- str_replace(Aggregated_spp$lon, "c", "")
Aggregated_spp$lat <- str_replace(Aggregated_spp$lat, "\\)", "")
# assign lon lat cols numeric type values
Aggregated_spp$lat <- as.numeric(Aggregated_spp$lat)
Aggregated_spp$lon <- as.numeric(Aggregated_spp$lon)

# Plot 3 - LL - This is facetable due to groupings
LL <- Aggregated_spp %>%
  filter(Gear == c("LL", "LLOB", "LLCO", "LLFR", "LLSW", "LLTU"))%>%
  group_by(lat, lon, Year, Fleet) %>%
  summarise(Metric = sum(TkgFish))

#This is LL - but not facet able due to grouping - filter for species can be changed
LL <- Aggregated_spp %>%
  filter(Gear == c("LL", "LLOB", "LLCO", "LLFR", "LLSW", "LLTU"))%>%
  filter(Species == "BET")%>%
  group_by(lat, lon) %>%
  summarise(Metric = sum(TkgFish))

LL_Map <- ggplot() +
  geom_tile(data = LL, aes(x=lon, y=lat, fill=log10(Metric)), width = 1, height = 1)+
  scale_fill_distiller(palette = "Blues", direction = 1)+
  geom_sf(data = countries)+
  coord_sf(xlim = c(30, 150), ylim = c(-55, 32))+
  xlab(label = "Long")+
  ylab(label = "Lat")+
  theme(axis.text = element_text(size = 10))+
  guides(fill="none")

#faceting lines for above mapping if faceting
theme(strip.background =element_rect(fill="blue4"))+
theme(strip.text = element_text(colour = 'white', size = 10))+
theme(axis.title = element_text(size = 20))
#facet_wrap(~Species)

ggsave("LL_MAP_BET.png", plot = LL_Map, width = 15.92, height = 10, units = "cm", dpi = 300)

# Plot 4 - PS firstly -facetable
PS <- Aggregated_spp %>%
  filter(Gear == c("PS", "PSS", "PSOB"))%>% # PS or PSS or PSOB
  group_by(lat, lon, Year, Fleet) %>%
  summarise(Metric = sum(TkgFish))

# Not facetable
PS <- Aggregated_spp %>%
  filter(Gear == c("PS", "PSS", "PSOB"))%>% # PS or PSS or PSOB
  filter(Species == "YFT")%>%
  group_by(lat, lon) %>%
  summarise(Metric = sum(TkgFish))

PS_Map <- ggplot(data = PS) +
  geom_tile(aes(x=lon, y=lat, fill=log10(Metric)), width = 1, height = 1)+
  scale_fill_distiller(palette = "Blues", direction = 1)+
  geom_sf(data = countries)+
  coord_sf(xlim = c(30, 150), ylim = c(-55, 32))+
  xlab(label = "Long")+
  ylab(label = "Lat")+
  theme(axis.text = element_text(size = 10))+
  guides(fill="none")

#faceting lines for above mapping if faceting
theme(strip.background =element_rect(fill="blue4"))+
theme(strip.text = element_text(colour = 'white', size = 6))+
theme(axis.title = element_text(size = 5))

```

```

#facet_wrap(~Fleet)

ggsave("PS_MAP_YFT.png", plot = PS_Map, width = 15.92, height = 10, units = "cm", dpi = 300)

# Plot 5 - BB
BB <- Aggregated_spp %>%
  filter(Gear == c("BB", "BBOF"))%>%
  group_by(lat, lon, Year, Fleet) %>%
  summarise(Metric = sum(TkgFish))

#Non facetable
BB <- Aggregated_spp %>%
  filter(Gear == c("BB", "BBOF"))%>%
  filter(Species == "BET") %>%
  group_by(lat, lon) %>%
  summarise(Metric = sum(TkgFish))

BB_Map <- ggplot(data = BB) +
  geom_tile(aes(x=lon, y=lat, fill=log10(Metric)), width = 1, height = 1)+
  scale_fill_distiller(palette = "Blues", direction = 1)+
  geom_sf(data = countries)+
  coord_sf(xlim = c(30, 150), ylim = c(-55, 32))+
  xlab(label = "Long")+
  ylab(label = "Lat")+
  theme(axis.text = element_text(size = 10))+
  guides(fill="none")

  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white', size = 6))+
  theme(axis.title = element_text(size = 5))
#facet_wrap(~Fleet)

ggsave("BB_MAP_BET.png", plot = BB_Map, width = 15.92, height = 10, units = "cm", dpi = 300)

# Plot 6 - GILL
GILL <- Aggregated_spp %>%
  filter(Gear == c("GILL", "GIOF"))%>%
  group_by(lat, lon, Year, Fleet) %>%
  summarise(Metric = sum(TkgFish))

#Not facetable
GILL <- Aggregated_spp %>%
  filter(Gear == c("GILL", "GIOF"))%>%
  filter(Species == "YFT") %>%
  group_by(lat, lon) %>%
  summarise(Metric = sum(TkgFish))

GILL_Map <- ggplot(data = GILL) +
  geom_tile(aes(x=lon, y=lat, fill=log10(Metric)), width = 1, height = 1)+
  scale_fill_distiller(palette = "Blues", direction = 1)+
  geom_sf(data = countries)+
  coord_sf(xlim = c(30, 150), ylim = c(-55, 32))+
  xlab(label = "Long")+
  ylab(label = "Lat")+
  theme(axis.text = element_text(size = 10))+
  guides(fill="none")

  theme(strip.background =element_rect(fill="blue4"))+
  theme(strip.text = element_text(colour = 'white', size = 6))+
  theme(axis.title = element_text(size = 5))
#facet_wrap(~Fleet)+

ggsave("GILL_MAP_YFT.png", plot = GILL_Map, width = 15.92, height = 10, units = "cm", dpi = 300)

```