Summary of blue marlin (*Makaira nigricans*) catch and size data from the Western and Central Pacific Fisheries Commission and the Inter-American Tropical Tuna Commission

Yi-Jay Chang[12], Annie Ji-Yih Yau[2], Jon Brodziak[2]

[1]Joint Institute for Marine and Atmospheric Research
University of Hawaii
Honolulu, Hawaii, USA, 96822

[2]NOAA NMFS Pacific Islands Fisheries Science Center
Honolulu, Hawaii, USA, 96816

Abstract

Data on blue marlin (*Makaira nigricans*) catch and length frequency data from member countries were provided by the Western and Central Pacific Fisheries Commission (WCPFC) and Inter-American Tropical Tuna Commission (IATTC) to the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) Billfish Working Group (BILLWG) for the purposes of conducting a 2016 stock assessment update. The results of Category I (1950-2014), II (1978-2015), and III data (1991-2014) from the WCPFC and Category I data (1954-2014) and III (1990-2013) from the IATTC were tabulated and visualized. We quantify the amount of catch and the size composition in the WCPFC and IATTC overlapping area. Time series of catches and size compositions of the fleets used in the stock assessment model were developed. Consistency between the two datasets was also evaluated in this working paper. The aim of this working paper is to provide the input assessment data to the BILLWG.

Working document submitted to the ISC Billfish Working Group Workshop, 13-20 January 2016, Honolulu, HI, USA. Document not to be cited without author's written permission.

Introduction

In 2013, the Billfish Working Group members of the ISC completed a benchmark stock assessment of blue marlin (*Makaira nigricans*) in the Western and Central North Pacific Ocean (ISC, 2013). In that assessment, data provided by member countries to the Western and Central Pacific Fisheries Commission (WCPFC) and the Inter-American Tropical Tuna Commission (IATTC) were included (1971-2011). There is an area where the jurisdictions of IATTC and WCPFC are overlapping (**Fig. 1**), bounded by 150 degrees longitude W, 130 degrees longitude W, 4 degrees latitude S, and 50 degrees of latitude S. Several countries have reported catch to both commissions. For the stock assessment of blue marlin unit Pacific Ocean stock, reported catch in the overlap area may cause an issue of duplication of total catch amount of blue marlin.

With the duplication of the catch data, there would be a decrease in the precision of biomass estimates and likely introduced error in the catch limit recommendations. For supporting the 2016 blue marlin stock assessment update, we analyzed the data provided by the WCPFC and IATTC. The objectives of this working paper were: (1) to tabulate the catch data; 2) to visualize the temporal and spatial variation of the catch and size data; 3) to quantify the amount of catch and the size composition in the overlap area; 4) to update the time series of catch and size (1971-2014) of the fleets for the input to the Stock Synthesis 3 model.

Materials and methods

This working paper summarizes various types of data provided by the WCPFC and the IATTC. For the WCPFC datasets, category I data is the annual total catch by country and gear type and was provided for 1950-2014. Category II data is the quarterly catch by 5º x 5º spatial squares by country and was provided for 1978-2015. Category III data is size frequency (Eye-to-fork length [EFL] measurement in cm) aggregated by quarter and 5º x 5º spatial degree squares by country and was provided for 1991-2014.

For the IATTC datasets, category I data is the annual total catch by fleet and the gear type and was provided for 1954-2014. Category III data is size frequency (EFL, cm) aggregated by month and 5º x 5º spatial degree squares by country and was provided for 1990-2013. Category II data for the IATTC was not provided. Category I data in the WCPFC and IATTC overlapping area from 2011 to 2014 was provided (Michael Hinton, personal communication, Jan 15, 2016) during the meeting.

Longitude of the category II and III data were converted to 0-360 º format. Furthermore, the designation of each 5º x 5º square was rearranged to the center point by adding 2.5º to latitude and longitude values such that when data are displayed spatially, they show up in the center of each square. GIS and spatial analysis techniques were used to analyze and display the entity and distribution of the catch and average size of the blue marlin in the Pacific Ocean. All statistical analyses were implemented in R language (R Development Core Team, 2006).

Time series of catches of the fleets OthLL, PYFLL, EPOPS, WCPFCPS, and EPOOth were developed (see **Table 1** for the fleet definition). For the OthLL fleet (i.e., other longline fisheries' catches excluding Japan, Taiwan and United States), 5 countries (Belize, China, Spain, Korea, and Vanuatu) have both reported to the WCPFC and IATTC. To minimize the duplication of the catch amount, the total catch of the OthLL fleet was estimated:

$$WCPFC + IATTC - Overlap \quad (1)$$

, where the WCPFC and IATTC are the catches in the two convention areas, Overlap is the catch in the WCPFC and IATTC overlapping area.

The previous benchmark stock assessment used size composition data of fleet EPOPS, OthLL and PYFLL based on the WCPFC and IATTC Cat III datasets. In this working paper, we followed the same fleet structure for compiling the size composition data. More specifically, the WCPFC Cat III data was used to develop the size composition of the OthLL fleet by removing countries of Japan, Taiwan, United States and French Polynesia, and then combining the rest of

the countries. Size composition of the PYFLL was derived by extracting French Polynesia from the WCPFC Cat III datasets. Since the IATTC Cat III data is countries combined, the whole dataset was used for the EPOPS. Length frequency data were compiled using 5-cm size bins from 80 to 320 cm for EPOPS and 10-cm bins from 80 to 320 cm for OthLL and PYFLL. The lower boundary of each bin was used to define each bin for all frequency data and each size frequency observation consisted of the actual number of blue marlin measured. Measurements smaller and larger than 80 and 320 cm were assigned to the 80 and 320 cm length bins, respectively. Comparisons between the observed size composition by season for the benchmark assessment and the observed size composition by season from the new dataset were made.

Results

WCPFC dataset

Category I

The blue marlin catch by the longline and purse seine fisheries is reported in **Fig. 2**. For the longline fisheries (**Fig. 2a**), a total of 31 countries reported blue marlin catches. The country codes used by the WCPFC and throughout this document are defined in **Table 2**. The main fishing countries are Japan, Taiwan, Korea, and China. Catches began in 1958 at 887 tons caught by Taiwan, Japan caught a substantial amount of blue marlin from 1962-1997, and thereafter Taiwan contributed most of the blue marlin catch. Indonesia also contributed many blue marlin catches since 1980s. Since 1960s the lowest amount of catch reported was 6,450 tons in 1971 and the catches peaked in 2003 at 24,193 tons.

23 countries have reported blue marlin catches in the purse seine fisheries (**Fig. 2b**). Catches began in 1970 at 6 tons caught by Philippines. Fishing countries of United States, Taiwan, Philippines, Papua New Guinea, and Indonesia reported most the of the purse seine catches from 1970-2014. Catches peaked in 2013 at 946 tons. Catch values of blue marlin by the longline and purse seine fisheries for the recent four years (2011-2014) are summarized in **Table 3**.

Category II

Spatial distribution of the total blue marlin catch during 2011-2015 by country was illustrated in **Fig. 3**. A total of 23 countries reported Cat II spatial information on blue marlin catches. China, Fiji, Japan, Korea, Taiwan, United States, and Vanuatu have reported blue marlin catch in most of the 5º x 5º spatial squares in the WCPFC area compared to other reported countries. Catch statistics in the WCPFC area for the recent four years (2011-2015) were summarized in **Table 4**. Taiwan and Indonesia have contributed most of the blue marlin catch (21,317 and 113,528 metric tons summed over the recent four years). 10 of 22 countries have reported blue marlin catch in the WCPFC and IATTC overlapping area. Catch statistics in the overlapping area for the recent four years (2011-2015) were summarized in **Table 5**. Among these 10 reporting countries, China, Japan, Korea, French Polynesia, and Taiwan have contributed most of the blue marlin catches. The total catch values in the overlapping area varied from 482 metric tons in 2011 to 873 metric tons in 2014. However, the total numbers of 5º x 5º spatial squares with blue marlin catch in the overlapping area were similar among years (ranged from 63 to 73 squares).

Category III

Bubble plots indicating size data in each quarter by countries (27 countries) for the previous dataset (1991-2011) and new dataset (1991-2014) are provided in **Fig. 4**. We found inconsistency of the size composition between two datasets for the same time period (1991-2011), but the change is minor. For the new dataset, changes of the size modes over time were found for China (decrease in 2010-2012 and increase in 2013-2014), Fiji (increase in 2010-2012 and decrease in 2013-2014), Taiwan (decrease in 2012), and Vietnam (high in the early records). This may imply changes of fishery selectivity. Similar to the previous dataset, the new dataset also suggests a sizeable shift of size mode in 2004 for French Polynesia. This supports separating the French Polynesia fishery from the rest of the dataset. Large variations in size compositions without clear modes were found for New Caledonia, Papua New Guinea, Solomon Islands, and Vanuatu.

Spatial distribution of the average blue marlin size (Eye-to-fork length, EFL, in cm) during 2011-2014 by country was illustrated in **Fig. 5**. A total of 16 countries have reported blue marlin size by area. Among the 16 countries, China, Korea, French Polynesia, and Taiwan have reported blue marlin size in the wider spatial coverage compared to other countries. Cook Islands, Fiji, New Caledonia, Papua New Guinea, Solomon Islands, Tonga, Vanuatu, Samoa reported blue marlin size between 0˚ and 15˚S latitude. The average size caught varied with each 5˚ by 5˚ grid and by country. China and Federated States of Micronesia both reported small blue marlin size in the area of 0˚-15˚N latitude and 155˚-180˚ longitude.

Size of blue marlin caught in the WCPFC area for the recent four years (2011-2014) was summarized by country and year, respectively, in **Table 6**. The mean size is relatively small for Taiwan and Vanuatu. Furthermore, Taiwan has reported the smallest size and New Caledonia has reported the largest size of blue marlin (**Table 6a**). The CV for blue marlin size by country was around 0.1 except for Taiwan (0.37). This suggests that blue marlin caught by Taiwan had a higher variability in size composition. China has reported the largest sample size (1,017 fish) for the size data. Size compositions were similar during 2011-2014 except the average size was relatively small in 2012 (**Table 6b**).

Only French Polynesia has reported the blue marlin size in the WCPFC and IATTC overlapping area. The average size caught by this fleet is 192.42 cm EFL during 2011-2014 (**Table 7a**). The average sizes and the CVs of sizes were similar among years (**Table 7b**).

For the recent 4 years, records from Australia, Spain, and Portugal were found in the Cat I dataset (**Table 3**) but were not found in the Cat II (**Table 4**) and Cat III datasets (**Table 6**). New Zealand has reported catch in the Cat II dataset but not in the Cat I dataset. All of the countries that reported size in the Cat III dataset also reported in the Cat I dataset.

IATTC dataset

Category I

The blue marlin catch by the longline and purse seine fisheries is reported in **Fig. 6**. The country codes used by the IATTC and throughout this document are defined in **Table 2**. For the longline fisheries (**Fig. 6a**), catches began in 1954 at 284 tons by Japan. The dominant fishing country was Japan before 2006 and switched to Ecuador thereafter. China (2008-2014), Costa Rica (1991-2014), Korea (1975-2014), and Taiwan (1964-2014) are the second largest group of blue marlin fishing countries in the Eastern Pacific Ocean. The total catches peaked in 1963 at 12,043 tons and then declined to the historical lowest amount of 2,200 tons in 1975. The catch increased to the second peak of 9,027 tons in 1994, then declined 2,498 tons in 2005, and then increased to the third peak of 7,038 tons in 2013.

Blue marlin catch reported in the purse seine fisheries was shown in **Fig. 6b**. Catches began in 1993 at total of 85 tons caught by Colombia, Ecuador, Mexico, United States, Venezuela, Vanuatu, and other countries. Ecuador has been the dominant fishing country since 1996. The total catches peaked in 1963 at 12,043 tons and then declined to the historical lowest amount of 2,200 tons in 1975. The catch increased to the second peak of 9,027 tons in 1994, then declined 2,498 tons in 2005, and then increased to the third peak of 7,038 tons in 2013.

Since 1990s the lowest amount of catch reported was 60 tons in 1996 and the catch peaked in 2005 at 209 tons. Catches of blue marlin by the longline and purse seine fisheries for the recent four years (2011-2014) are summarized in **Table 8**.

Category III

Bubble plots indicating size data in each quarter (countries combined) from 1990 to 2013 are shown in **Fig. 7**. The size composition is stable with a mode around 200 cm EFL over time except for two years (1992-1993) with higher variation. It should be noted that the largest size of

blue marlin reported from IATTC data is larger than 350 cm EFL compared to the WCPFC Cat III data.

Spatial distribution of the average blue marlin size during 2011-2013 is illustrated in **Fig. 8**. The average size caught varied with each 5˚x 5˚ grid. Blue marlin average sizes are relatively larger in the area of 0˚-25˚ S latitude and > 230˚ longitude.

Blue marlin size composition in the IATTC area for the recent four years (2011-2013) was summarized in **Table 9a**. It should be noted that 2014 data was missing. The mean sizes are similar from 2011 to 2013. The smallest blue marlin fish was reported in 2012. The CVs of the mean size are consistent over time. The reported sample size and spatial coverage are also consistent from 2011 to 2013.

Some blue marlin size data are reported in the WCPFC and IATTC overlapping area (**Table 9b**). The size composition (min, max and mean) and CVs of mean size are consistent from 2011 to 2013. However, 2013 reported data is of a relatively smaller sample size and spatial coverage compared to 2011 and 2012. In comparison the overlapping area to the whole IATTC area, the size compositions of recent data are comparable.

Input catch and size data for the Stock Synthesis model

Time series of catch

In the last stock assessment, the catch data from WCPFC and IATTC were grouped into 4 fleets (OthLL, PYFLL, EPOPS, WCPFCPS, and EPOth). In this working paper, the time series of catches of these fleets is provided. In the time series of OthLL catch, catch from 27 countries (Australia, Belize, Cook Islands, China, Costa Rica, Fiji, Federated States of Micronesia, Indonesia, Kiribati, Korea, Marshall Islands, Mexico, New Caledonia, Niue, New Zealand, Papua New Guinea, Philippines, Portugal, Samoa, Senegal, Solomon Islands, Spain, Tonga, Tuvalu, Vanuatu, and Vietnam) were included. Five countries (Belize, China, Spain, Korea, and

Vanuatu) have also reported to the IATTC longline catch. It was noted that new WCPFC Category I longline catch data was available for Ecuador and Portugal for the 2016 blue marlin assessment update, which were not available for the 2013 assessment. Ecuador's catch was not included because it represents other marlins and not blue marlin; only the Portugal longline catch data will be used. The updated time series of OthLL catch is shown in Fig. 9. The time series of catch generally matched with the previous catch data well. However, the new time series of catch has higher catch values.

Both WCPFC and IATTC have reported longline catch by French Polynesia (PYFLL). We simply used the WCPFC dataset and compare with the previous input data (**Fig. 10**). The 2016 WCPFC dataset generally matched with the previous data well except for 1999 and 2002. The 2016 WCPFC time series has much higher values in 1999 and 2002 compared to the 2013 SS input data.

Blue marlin catch (number of fish) of EPOPS from 2011-2014 was provided during the meeting (Michael Hinton, personal communication, Jan 15, 2016). We added the new catch data (2011-2014) to the previous SS catch data (1993-2010) to represent the EPOPS catch. The trend of the new time series was shown in **Fig. 11**.

We used the purse seine catch data from the WCPFC to represent the WCPFCPS catch. Nineteen countries were included in the dataset, 4 (Spain, Mexico, United States and Vanuatu) of which also reported purse seine catch to the IATTC. However, the purse seine catch by these 4 countries in the IATTC dataset were not included in the time series of EPOPS. The new time series is almost identical the previous catches (**Fig. 12**). However, the new time series has slightly lower catch values in 2009, 2010 and 2011.

The catch for French Polynesia unknown gear from the IATTC data was used to represent EPOOth (the French Polynesian miscellaneous fisheries in the EPO). The new time series is almost identical to the previous catches (**Fig. 13**). However, the new time series has higher catch

value in 2011. The difference of catch in 2011 may result from incomplete data for the last year in the last assessment.

The WG judged that the new catch data series were consistent with the 2013 data and also concluded that the 2016 catch series were the best available scientific information for conducting the 2016 stock assessment update.

Time series of size composition

For the size compositions of OthLL, 14 and 15 fishes are smaller and larger than 80 and 320 cm EFL, respectively. Size compositions were similar to the previous dataset for all quarters during 1991-2010 (**Fig. 14**). Only a few differences across years and quarters were present. However, size frequency distributions were different in 2011. More small fish (< 160 cm EFL) were measured in the new dataset. The difference of size composition in 2011 may result from incomplete data for the last year in the last assessment. Size compositions of the newly available years (2011-2014) were slightly different than the size compositions in 2010. The modes of size frequency distribution were around 170 cm EFL during 2011-2014 compared to the mode (around 150 cm EFL) in 2010.

Eight fishes are smaller than 80 cm EFL in the size compositions of PYFLL. New size frequency distributions were similar to the previous dataset for all quarters during 1991-2011 (**Fig. 15**). Size compositions of the newly available years (2011-2014) were consistent with the last few years' data of the previous dataset. This may imply that there was no significant change in fishery selectivity.

Two and 59 fishes are smaller and larger than 80 and 320 cm EFL, respectively, in size frequency distributions of EPOPS. New size frequency distributions were similar to the previous dataset for all quarters during 1991-2011 (**Fig. 16**). Size compositions were available in 1990. The 1990 data was not used in the previous assessment. Size compositions of the newly available

years (2011-2013) are consistent with the last few years' data of the previous dataset. This also may imply that there was no significant change in fishery selectivity.

The WG considered the new set of fishery statistics information to be the best available scientific information and finalized the set of input data for the base case assessment model.

Acknowledgments

We sincerely thank the member countries of the WCPFC and IATTC and the WCPFC and IATTC staffs for their help in preparing and providing this data for the 2016 blue marlin stock assessment update. We thank Brian J. Langseth for his comments on the draft working paper.

References

ISC (2013) Stock assessment of blue marlin in the Pacific Ocean in 2013, report of the Billfish Working Group, 13th Meeting of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean, Busan, Korea, 17-22 July 2013. 118 pp.

R Development Core Team (2008). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Table 1. Fisheries in the 2013 blue marlin assessment (ISC, 2013). Portugal are provided in the 2016 new dataset.

Alpha code	Fishing entities	Countries
OthLL	Various flags longline	Australia, Belize, China, Cook Islands, Costa Rica, Fiji, Indonesia, Kiribati, Korea, Marshall Islands, Mexico, Federated States of Micronesia, New Caledonia, Niue, New Zealand, Papua New Guinea, Philippines, Samoa, Senegal, Solomon Islands, Spain, Tonga, Tuvalu, Vanuatu, Vietnam
PYFLL	French Polynesia longline	French Polynesia
EPOPS	Various flags purse seine	Ecuador, Honduras, México, Nicaragua, Panamá, El Salvador, Spain, Venezuela, Vanuatu, USA
WCPFCPS	Various flags purse seine	Australia, China, Ecuador, Federated States of Micronesia, Indonesia, Kiribati, Marshall Islands, Mexico, New Zealand, Papua New Guinea, Philippines, Solomon Islands, El Salvador, Spain, Tuvalu, Vanuatu, Korea, Japan, USA
EPOOth	French Polynesia troll & handline, harpoon	French Polynesia

Table 2. Country codes used by the WCPFC and IATTC and throughout this document.

Country	**WCPFC country Code**	**Country**	**IATTC country Code**
Australia	AU	Belize	BLZ
Belize	BZ	China	CHN
Cook Islands	CK	Colombia	COL
China	CN	Costa Rica	CRI
Ecuador	EC	Ecuador	ECU
Spain	ES	Spain	ESP
Fiji	FJ	Honduras	HND
Federated States of Micronesia	FM	Japan	JPN
Indonesia	ID	Korea	KOR
Japan	JP	Mexico	MEX
Kiribati	KI	Nicaragua	NIC
Korea	KR	Others	OTR
Marshall Islands	MH	Panama	PAN
Mexico	MX	French Polynesia	PYF
New Caledonia	NC	El Salvador	SLV
Niue	NU	Taiwan	TWN
New Zealand	NZ	United States	USA
French Polynesia	PF	Venezuela	VEN
Papua New Guinea	PG	Vanuatu	VUT
Philippines	PH		
Portugal	PT		
Solomon Islands	SB		
Senegal	SN		
El Salvador	SV		
Tonga	TO		
Tuvalu	TV		
Taiwan	TW		
United States	US		
Vietnam	VN		
Vanuatu	VU		
Samoa	WS		

Table 3. Blue marlin (*Makaira nigricans*) catch (metric tons) in the WCPFC convention area during 2011-2014. Data source: WCPFC Cat I dataset. The country codes used by the WCPFC and throughout this document are defined in Table 2.

Country	Gear	Year				Total
		2011	2012	2013	2014	
AU	Longline	9	14	14	39	76
BZ		3	19	9	9	40
CK		39	93	35	33	200
CN		1226	1795	1926	1826	6773
ES		5	0	0	13	18
FJ		154	154	154	271	733
FM		175	111	147	166	599
ID		1163	1163	1163	1163	4652
JP		2670	2135	2145	1769	8719
KI		0	36	36	0	72
KR		1415	1486	1727	1887	6515
MH		37	25	9	0	71
NC		23	0	0	23	46
PF		201	241	243	240	925
PG		262	247	153	153	815
PH		39	6	2	2	49
PT		1	31	67	63	162
SB		35	0	0	0	35
TO		22	47	48	13	130
TV		39	102	4	14	159
TW		6197	5764	6459	6574	24994
US		375	313	352	506	1546
VN		489	130	384	384	1387
VU		195	437	545	493	1670
WS		7	11	7	8	33
Total		14781	14360	15629	15649	60419
CN	Purse seine	29	12	29	20	90
EC		14	4	6	8	32

ES	7	6	16	13	42
FM	6	9	9	7	31
ID	180	250	183	183	796
JP	54	75	45	66	240
KI	10	31	19	37	97
KR	51	89	54	95	289
MH	51	89	24	16	180
NZ	0	11	2	5	18
PG	39	74	61	61	235
PH	199	55	288	144	686
SB	6	2	14	13	35
SV	3	2	5	11	21
TV	1	3	4	5	13
TW	46	84	88	80	298
US	51	98	88	86	323
VU	5	24	11	9	49
Total	752	918	946	859	3475

Table 4. Blue marlin (*Makaira nigricans*) catch (metric tons) by (a) fishing country and (b) year in the WCPFC convention area during 2011-2015, where N_S is the number of 5˚x5˚ squares with reported catch. Data source: WCPFC Cat II dataset. The country codes used by the WCPFC and throughout this document are defined in Table 2.

(a)

Country	Min	Max	Sum	Mean	CV	Ns
BZ	0.33	5.10	8.96	2.24	0.91	4
CK	0.23	6.00	77.23	1.80	0.81	43
CN	0.00	121.78	6055.52	10.13	1.45	598
FJ	0.12	37.87	1541.41	5.17	1.01	298
FM	2.89	24.95	568.95	9.48	0.53	60
ID	3.96	5085.54	113527.55	1081.21	1.11	105
JP	0.00	100.43	7830.65	12.69	1.16	617
KI	3.37	22.24	105.20	9.56	0.60	11
KR	0.30	218.03	5795.15	19.00	1.02	305
MH	4.13	4.79	8.91	4.46	0.10	2
NC	0.20	7.06	65.63	1.77	0.82	37
NZ	0.00	1.10	3.82	0.22	1.48	17
PF	0.10	35.21	848.28	10.47	0.70	81
PG	0.39	34.36	329.26	7.48	0.94	44
PH	2.86	20.40	114.64	5.73	0.71	20
SB	0.00	67.87	655.64	10.09	1.27	65
TO	1.44	1.95	3.38	1.69	0.21	2
TV	1.21	22.44	127.72	7.51	0.89	17
TW	0.00	232.14	21317.25	18.90	1.40	1128
US	0.00	50.91	1479.31	7.63	1.05	194
VN	8.12	30.56	1003.01	20.90	0.46	48
VU	0.00	88.54	1551.10	9.34	1.58	166
WS	0.00	9.30	41.23	2.43	0.97	17

(b)

Year	Min	Max	Sum	Mean	CV	Ns
2011	0.00	832.55	23766.18	22.72	3.38	1046
2012	0.00	1386.24	30435.43	29.58	4.36	1029
2013	0.00	1204.94	28763.05	29.96	3.88	960
2014	0.00	5085.54	79897.44	94.44	5.51	846
2015	0.20	26.96	197.69	4.49	1.21	44

Table 5. Blue marlin (*Makaira nigricans*) catch (metric tons) by (a) fishing country and (b) year in the WCPFC and IATTC overlapping area during 2011-2015, where N_S is the number of 5˚x5˚ squares with reported catch. Data source: WCPFC Cat II dataset. The country codes used by the WCPFC and throughout this document are defined in Table 2.

(a)

Country	**Min**	**Max**	**Mean**	**Sum**	**CV**	**N_S**
BZ	0.33	2.17	1.25	2.50	1.04	2
CN	0.00	118.63	9.66	831.18	1.67	86
FJ	0.18	2.16	0.91	2.72	1.21	3
ID	5.40	5.40	5.40	5.40	NA	1
JP	0.61	32.36	8.42	210.58	0.80	25
KR	2.40	48.97	13.70	301.45	0.96	22
PF	0.10	35.21	10.92	655.25	0.74	60
PH	3.53	3.53	3.53	3.53	NA	1
TW	0.10	50.53	12.46	747.83	0.93	60
VU	0.00	3.11	0.53	5.81	1.80	11

(b)

Year	**Min**	**Max**	**Mean**	**Sum**	**CV**	**N_S**
2011	0.00	34.12	7.08	481.71	0.94	68
2012	0.00	48.97	8.30	523.06	1.10	63
2013	0.00	118.63	12.13	885.82	1.35	73
2014	0.00	54.52	13.23	873.49	1.00	66
2015	2.16	2.16	2.16	2.16	NA	1

Table 6. Summary statistics of blue marlin (*Makaira nigricans*) size (eye-to-fork length, cm) by (a) fishing country and (b) year in the WCPFC convention area during 2011-2014, where N_S is the number of 5˚x5˚ squares with reported catch and *n* is number of fish. Data source: WCPFC Cat III dataset. The country codes used by the WCPFC and throughout this document are defined in Table 2.

(a)

Country	**Min**	**Max**	**Mean**	**CV**	***n***	**Ns**
CK	94	236	184.16	0.11	98	78
CN	114	276	172.25	0.13	1017	638
FJ	112	310	174.38	0.15	435	297
FM	130	248	168.87	0.09	351	239
JP	154	186	168.00	0.06	9	6
KR	108	270	181.48	0.12	437	296
MH	114	234	169.46	0.10	108	76
NC	144	346	218.37	0.15	155	147
PF	80	294	188.11	0.12	874	663
PG	74	330	188.78	0.14	383	257
SB	114	260	183.30	0.15	63	53
TO	120	296	179.14	0.11	697	363
TW	60	332	146.17	0.37	682	408
VN	90	250	144.27	0.15	194	105
VU	90	300	180.56	0.17	198	159
WS	124	206	172.75	0.17	8	8

(b)

Year	**Min**	**Max**	**Mean**	**CV**	***n***	**Ns**
2011	100	346	177.85	0.16	1145	776
2012	60	296	160.43	0.28	1288	763
2013	74	332	179.51	0.14	2004	1373
2014	80	330	180.23	0.13	1272	881

Table 7. Summary statistics of blue marlin (*Makaira nigricans*) size (eye-to-fork length, cm) by (a) fishing country and (b) year in the WCPFC and IATTC overlapping area during 2011-2014, where N_S is the number of 5˚x5˚ squares with reported catch and *n* is number of fish. Data source: WCPFC Cat III dataset. The country codes used by the WCPFC and throughout this document are defined in Table 2.

(a)

Country	**Min**	**Max**	**Mean**	**CV**	***n***	**Ns**
PF	132	294	192.42	0.12	491	351

(b)

Year	**Min**	**Max**	**Mean**	**CV**	***n***	**Ns**
2011	154	294	194.10	0.13	60	50
2012	142	244	191.42	0.08	104	49
2013	140	270	194.40	0.11	115	89
2014	132	286	191.35	0.13	212	163

Table 8. Blue marlin (*Makaira nigricans*) catch (metric tons) in the IATTC convention area during 2011-2014. Data source: IATTC Cat I dataset. The country codes used by the IATTC and throughout this document are defined in Table 2.

Country	Gear	Year			
		2011	2012	2013	2014
BLZ	Longline	10	32	79	61
CHN		334	1054	1072	790
CRI		316	629	614	
ECU		2336	2090	2666	
ESP		96	81	29	70
JPN		457	740	866	773
KOR		303	384	854	713
PYF		149	171	162	177
TWN		288	577	429	682
USA		38	21	59	76
VUT		34	34	40	75
PYF	Unknown	144	177	168	186
Total		4505	5990	7038	3603
PYF	Purse seine	144	177	168	186
COL		9	4	6	14
ECU		86	124	118	141
ESP		7	5	1	2
MEX		15	19	17	20
NIC		4	2	5	11
OTR		11	4	5	1
PAN		12	14	9	13
VEN		6	5	11	6
Total		294	354	340	394

Table 9. Summary statistics of blue marlin (*Makaira nigricans*) size (eye-to-fork length, cm) in the (a) IATTC convention area and (b) WCPFC and IATTC overlapping area during 2011-2013, where N_S is the number of 5˚x5˚ squares with reported catch and *n* is number of fish. Data source: IATTC Cat III dataset.

(a)

Year	**Min**	**Max**	**Mean**	**CV**	***n***	**N_S**
2011	101	376	204.53	0.15	1078	1048
2012	58	385	206.90	0.15	1319	1253
2013	104	360	202.87	0.16	1278	1190

(b)

Year	**Min**	**Max**	**Mean**	**CV**	***n***	**N_S**
2011	104	281	205.77	0.15	61	59
2012	143	300	209.71	0.16	35	35
2013	115	310	201.32	0.23	19	19

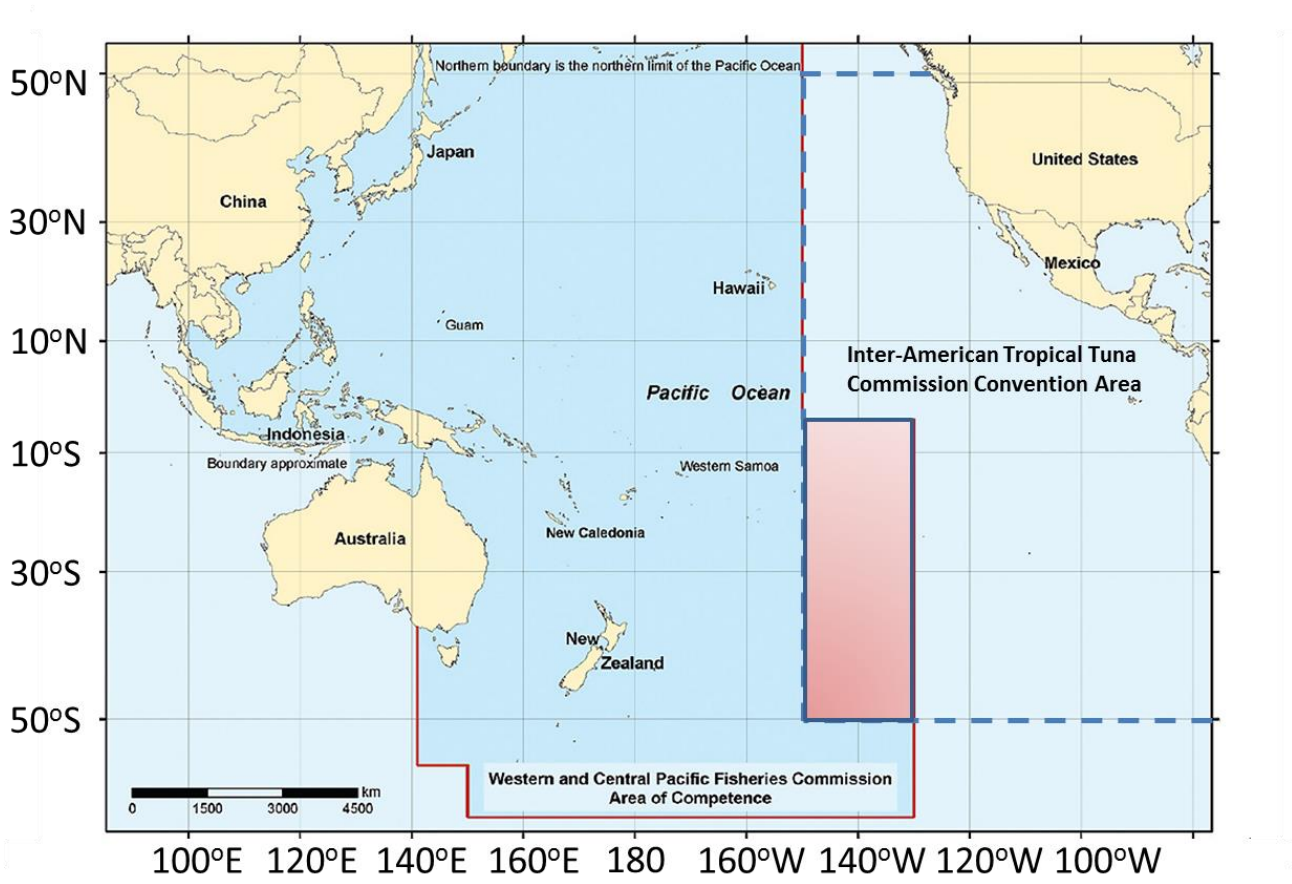

Figure 1. Map of the Western and Central Pacific Fisheries Commission (WCPFC) and Inter-American Tropical Tuna Commission (IATTC) convention areas. The red line denotes the WCPFC area and the blue dashed line denotes the IATTC area. The red rectangle denotes the overlapping area of the two commissions.

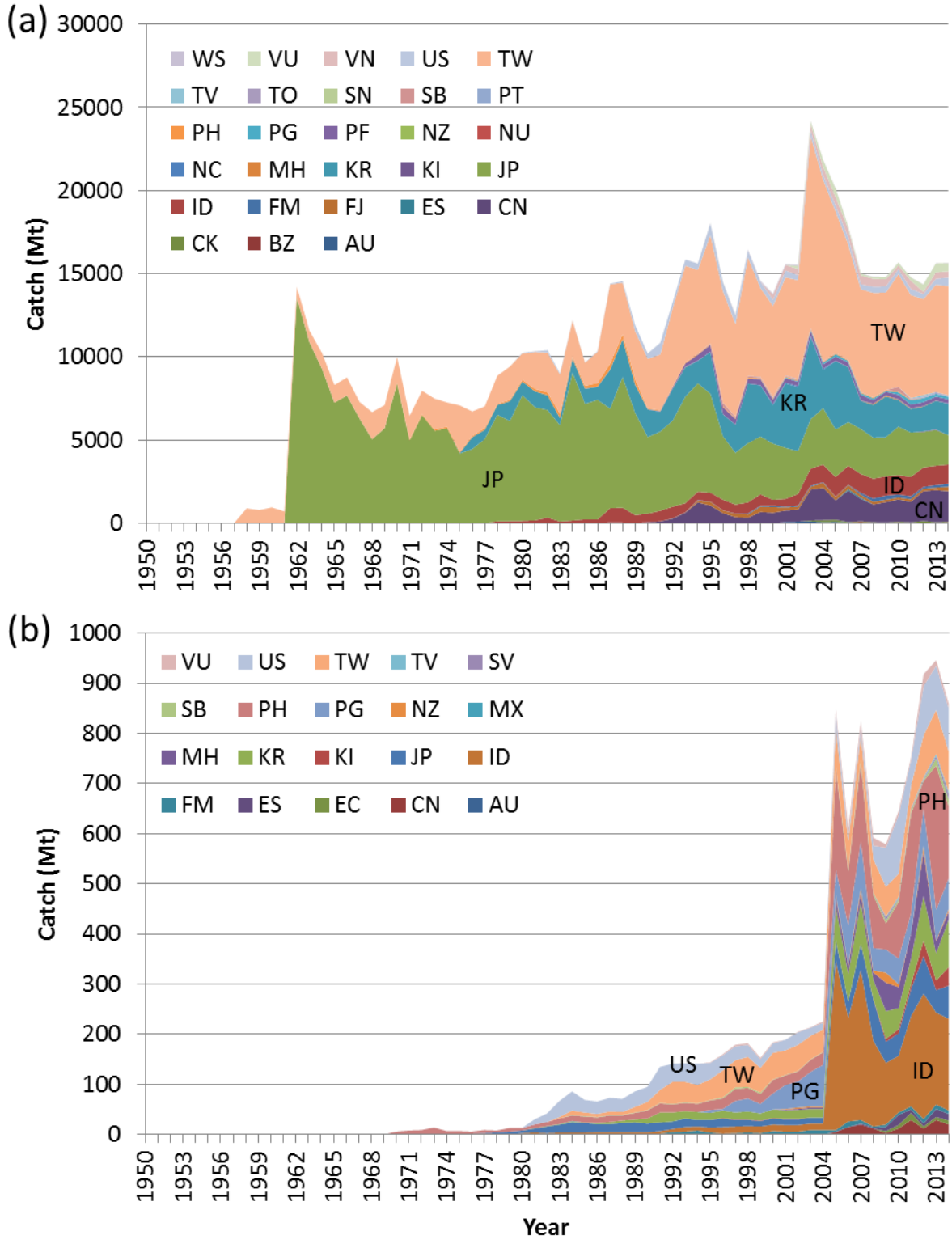

Figure 2. Blue marlin (*Makaira nigricans*) catch of the (a) longline fisheries and (b) purse seine fisheries in metric tons (Mt) in the WCPFC convention area. The country codes used by the WCPFC and throughout this document are defined in Table 2.

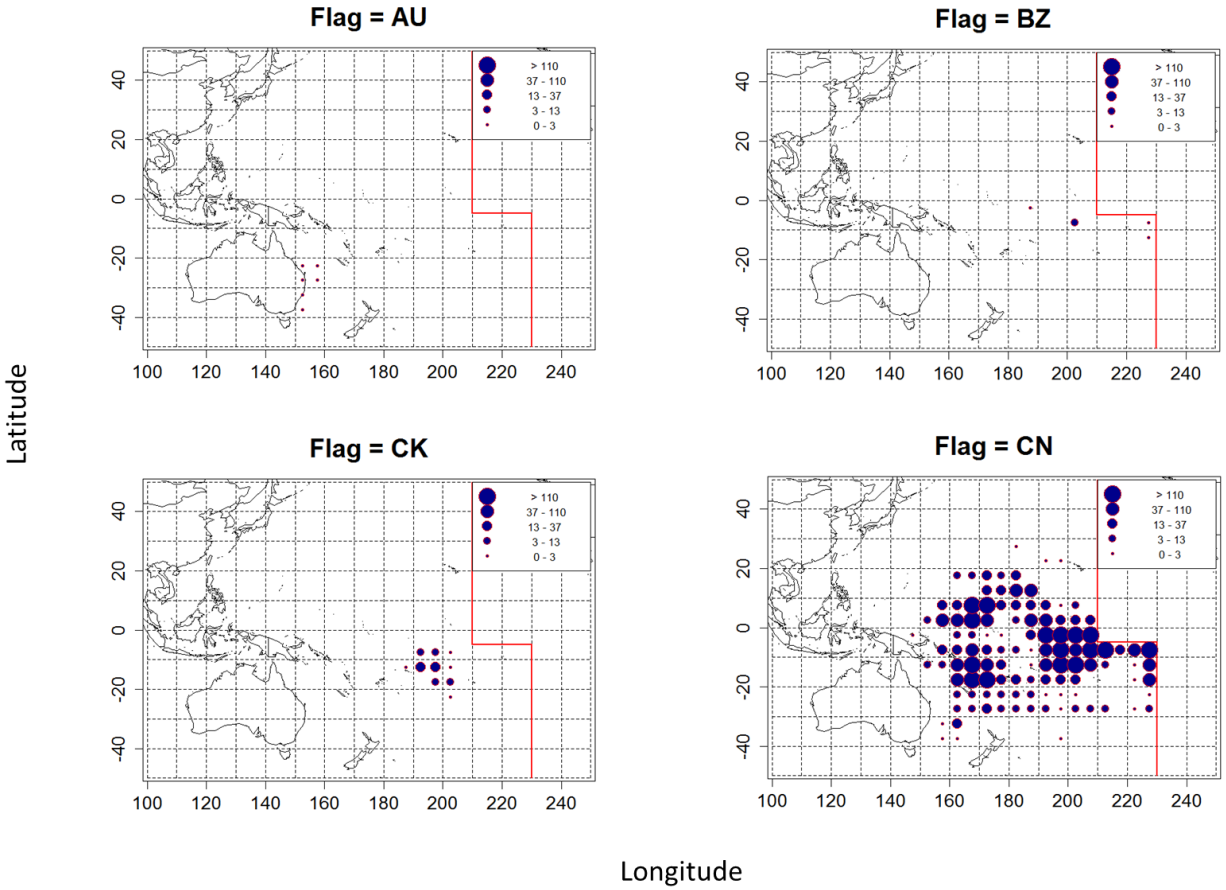

Figure 3. Spatial distribution of total catch (metric tons) of blue marlin (*Makaira nigricans*) by countries in WCPFC convention area during 2011-2015. Red boundary indicates the WCPFC convention area. The country codes used by the WCPFC and throughout this document are defined in Table 2.

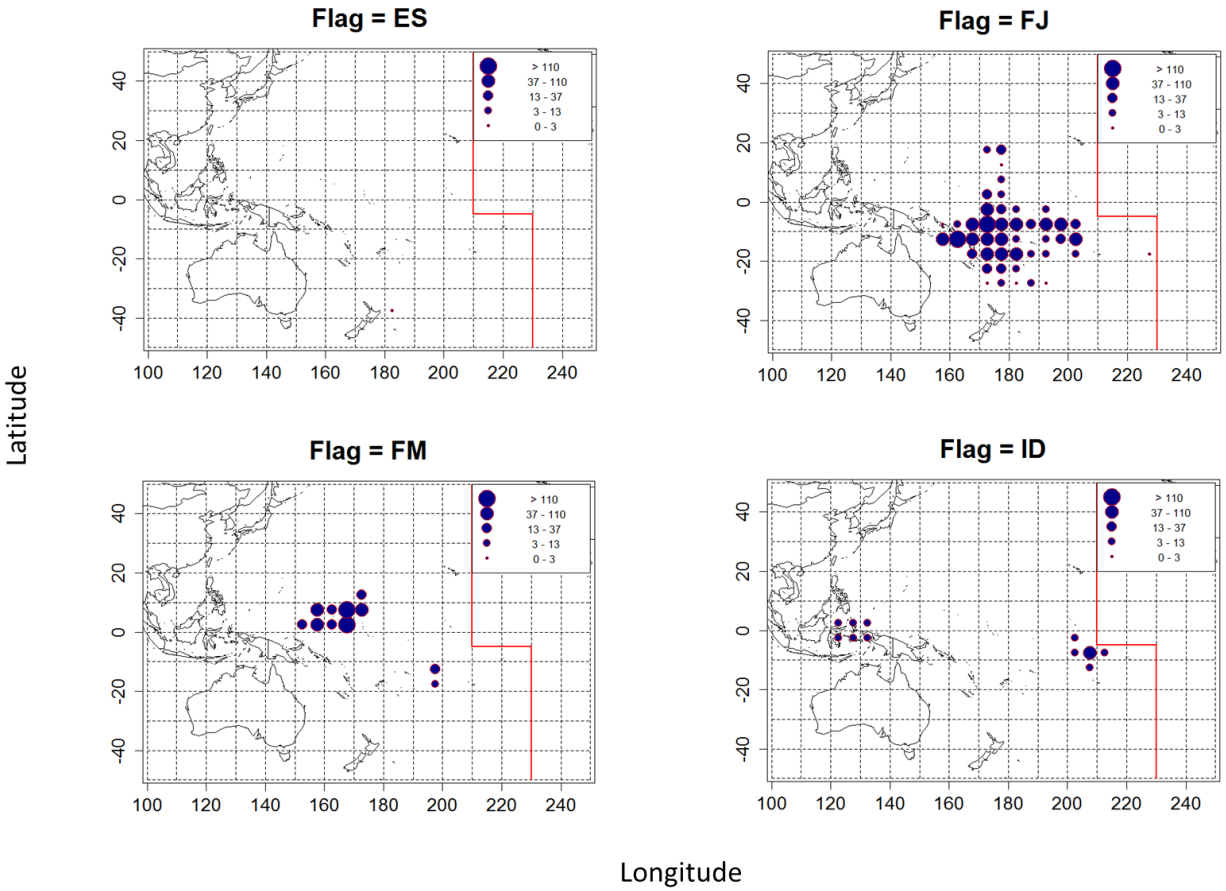

Figure 3. Continued

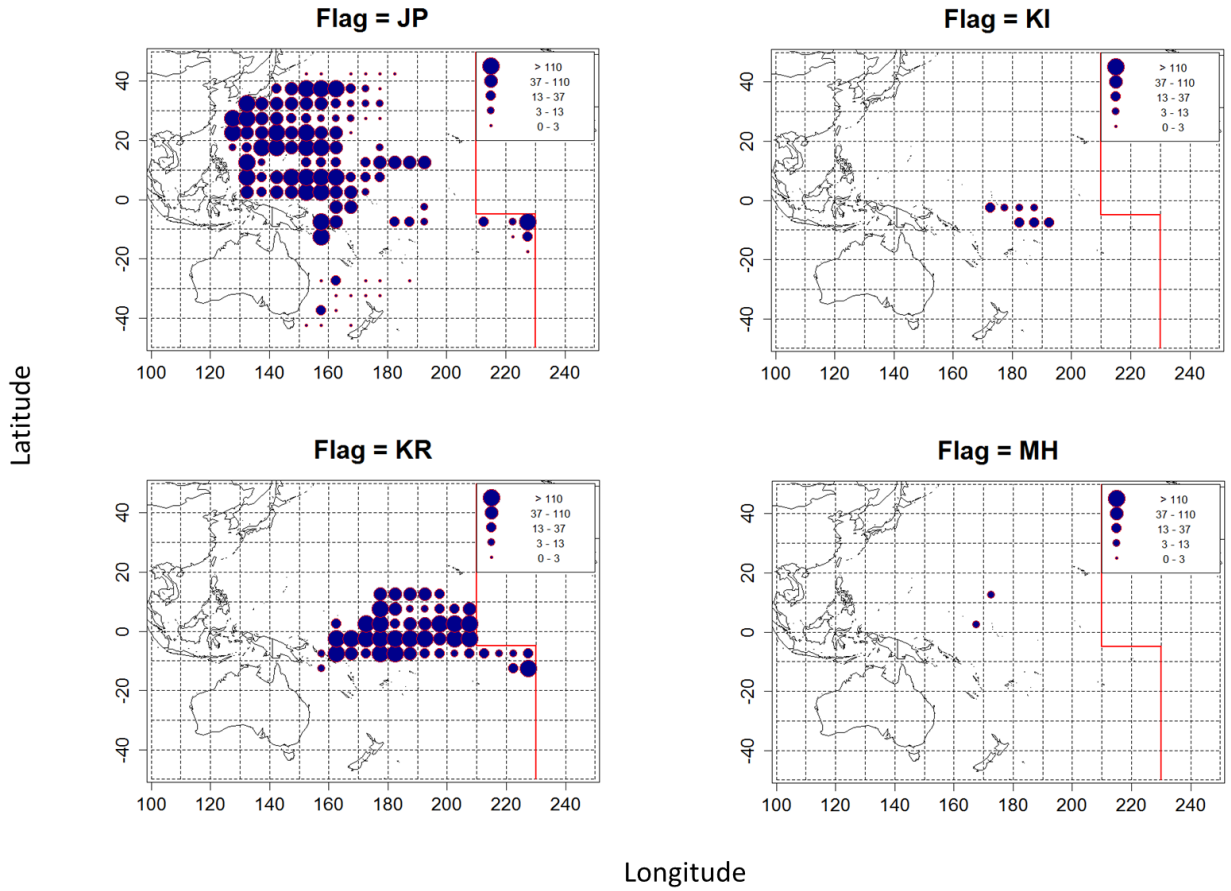

Figure 3. Continued

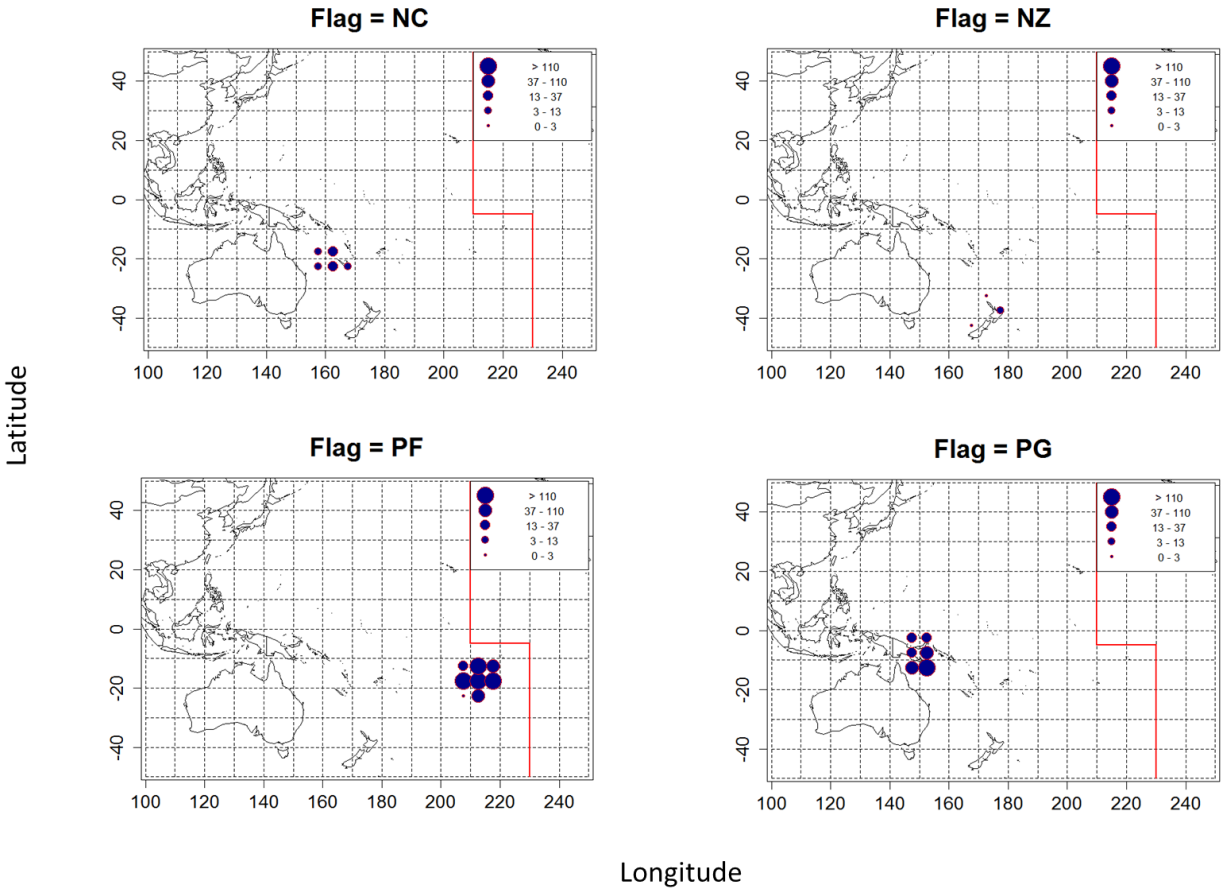

Figure 3. Continued

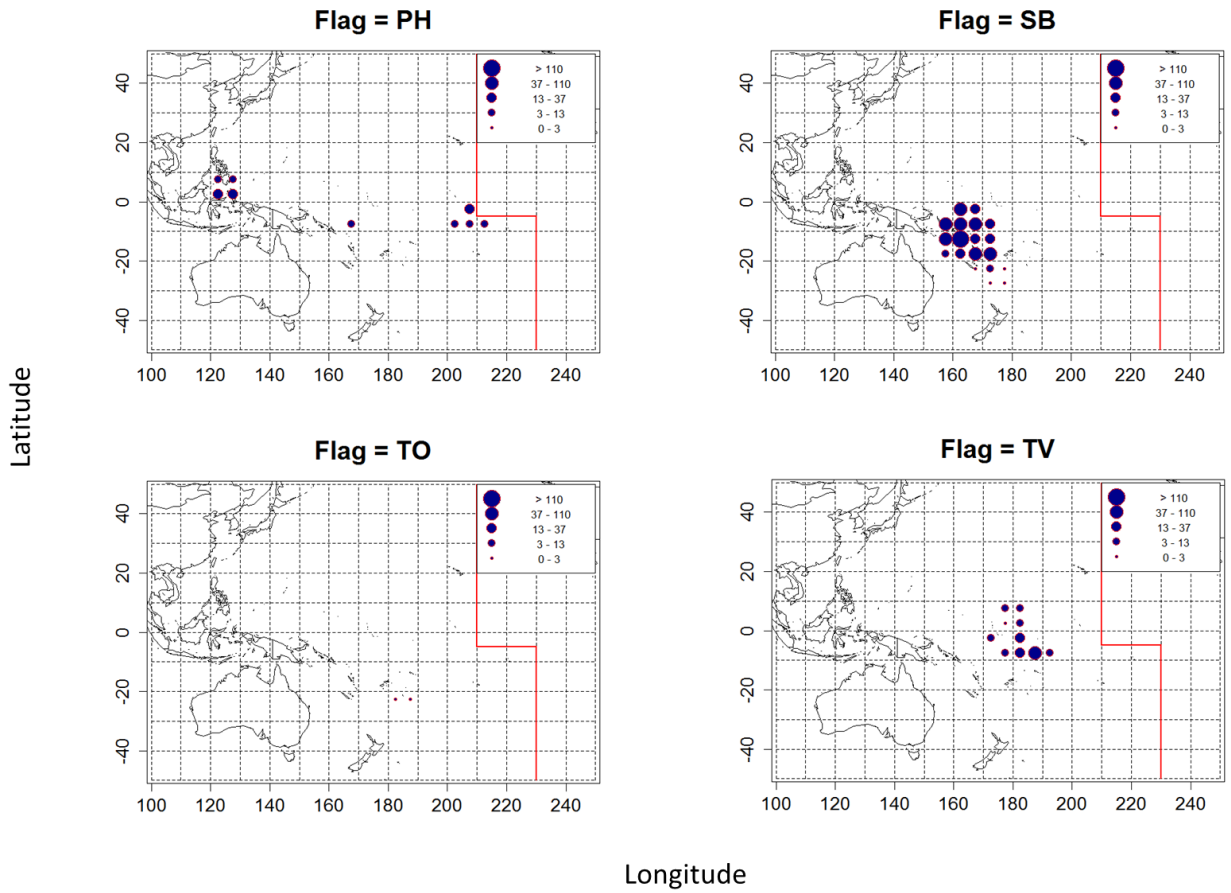

Figure 3. Continued

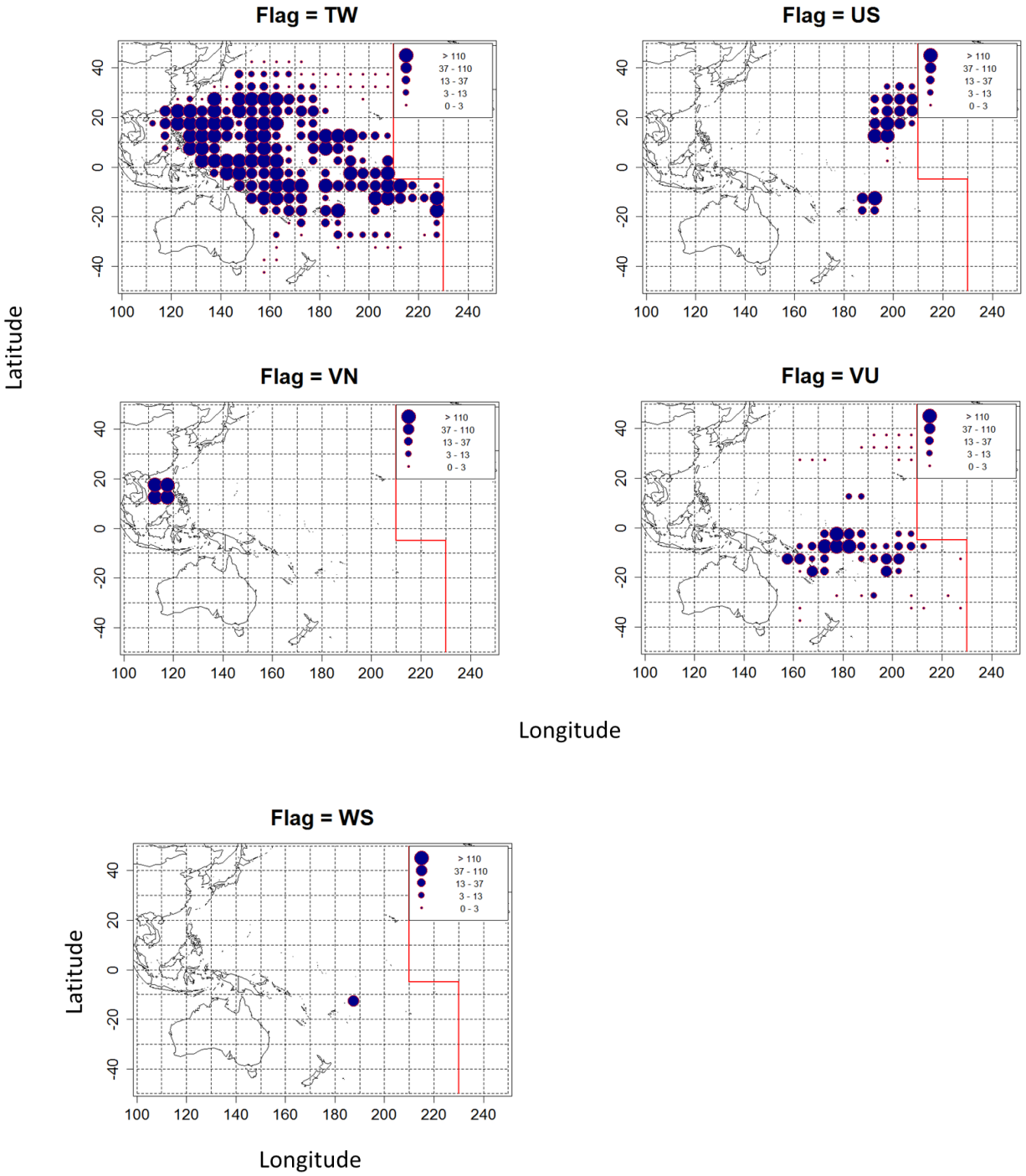

Figure 3. Continued

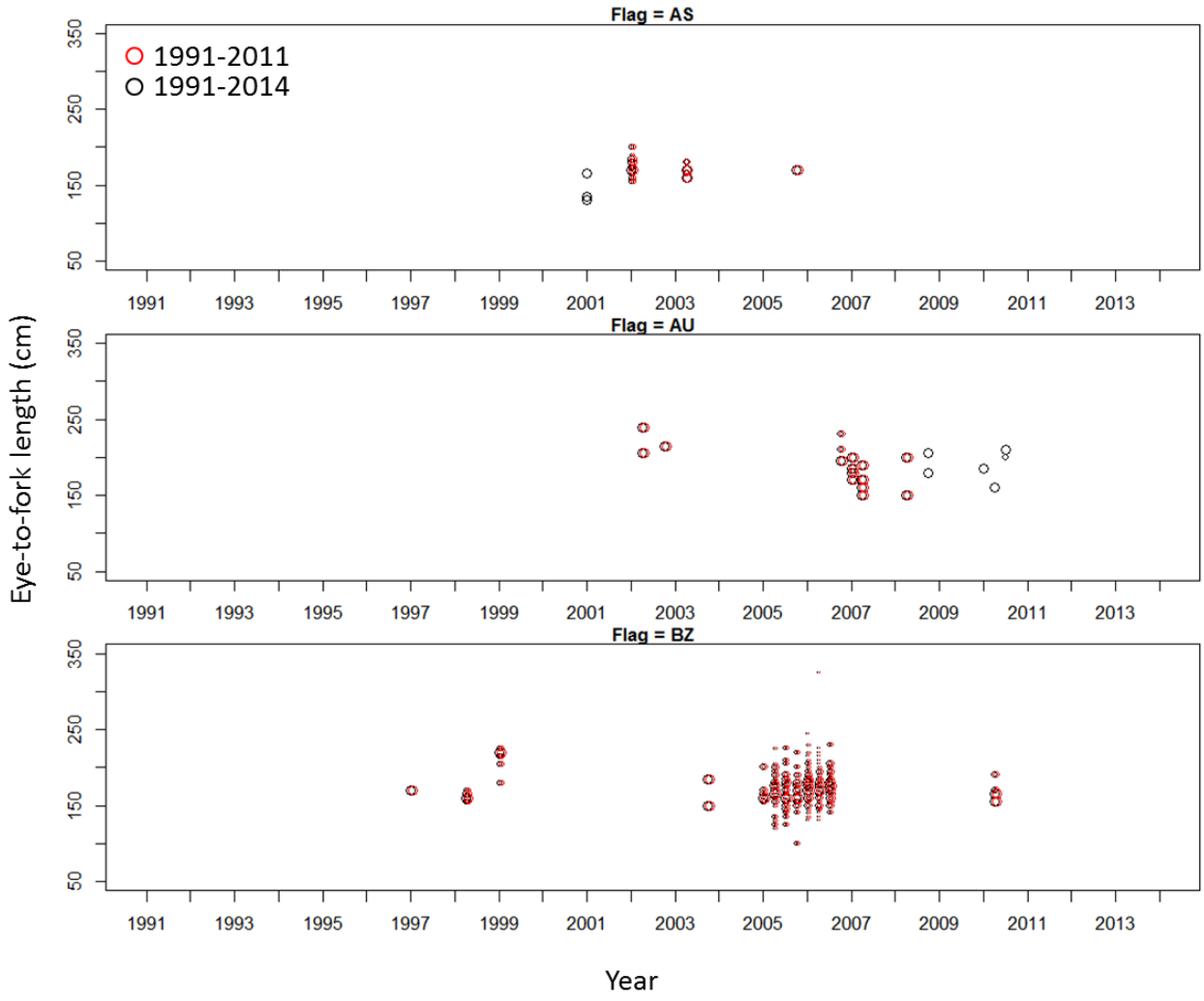

Figure 4. Bubble plot indicating size frequency (eye-to-fork length, cm) of blue marlin (*Makaira nigricans*) over time by countries fishing in the WCPFC convention area. Bubble size corresponds to proportional frequency, and data is plotted by quarter. Data source: WCPFC Cat III dataset. The country codes used by the WCPFC and throughout this document are defined in Table 2.

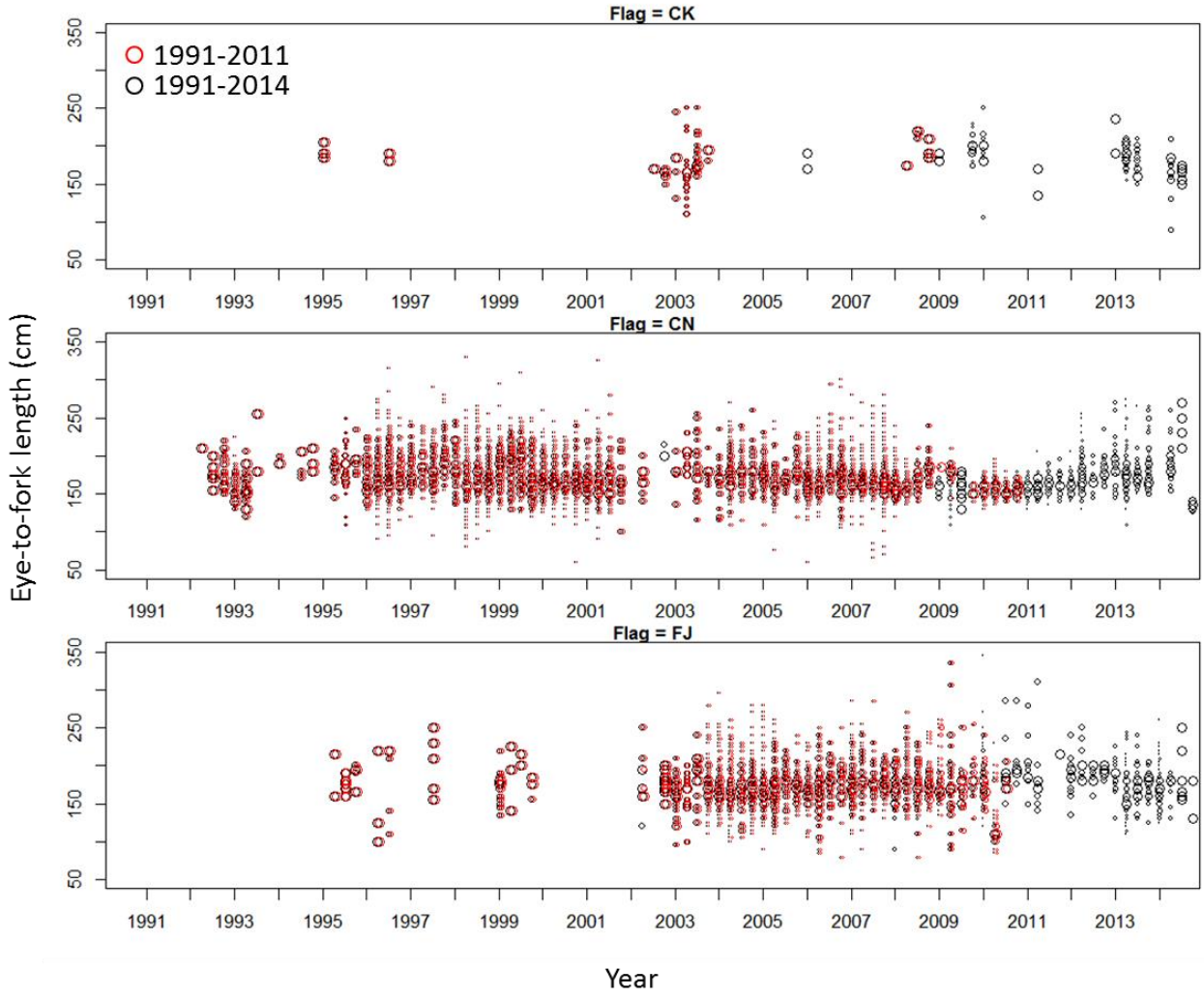

Figure 4. Continued.

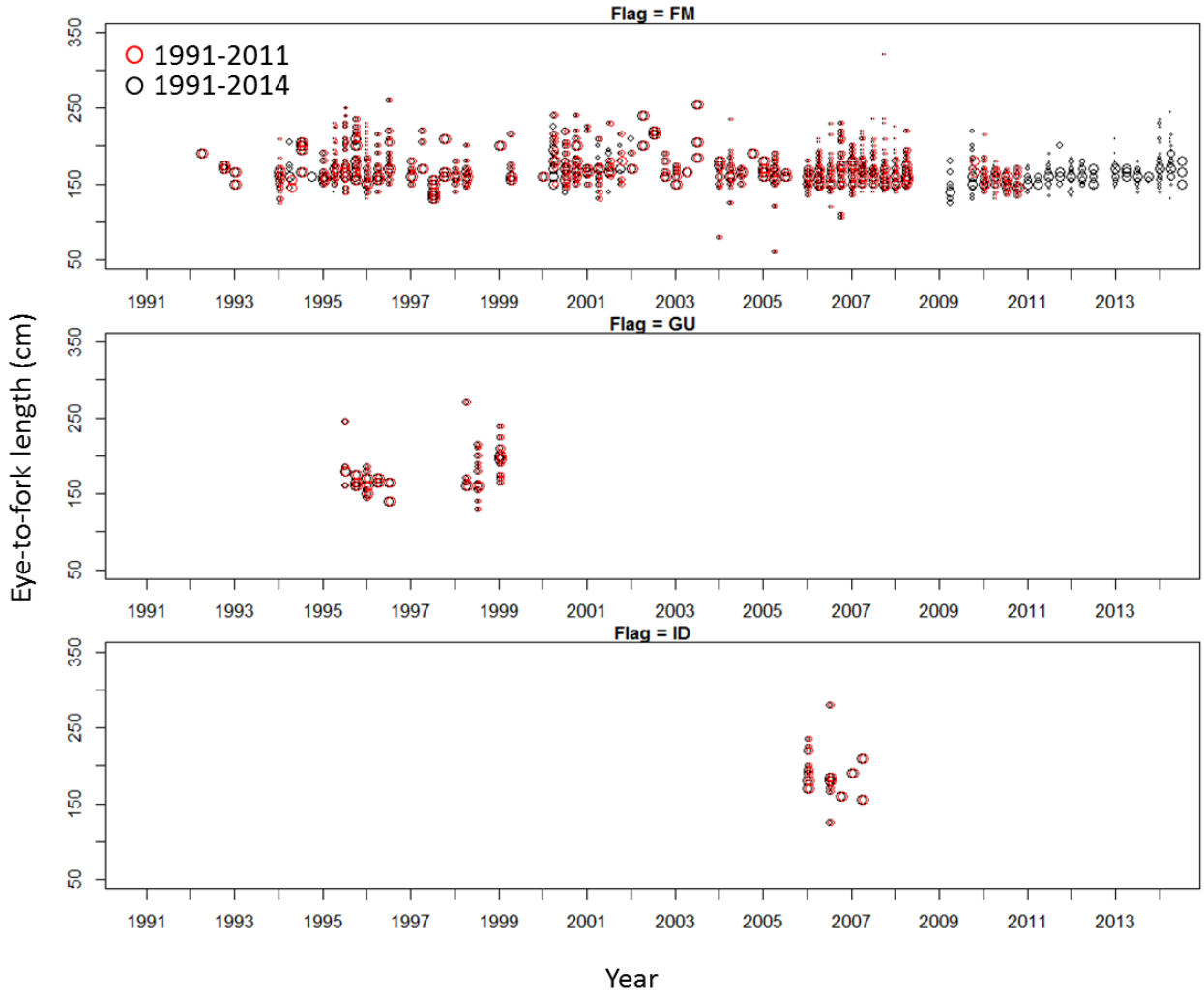

Figure 4. Continued.

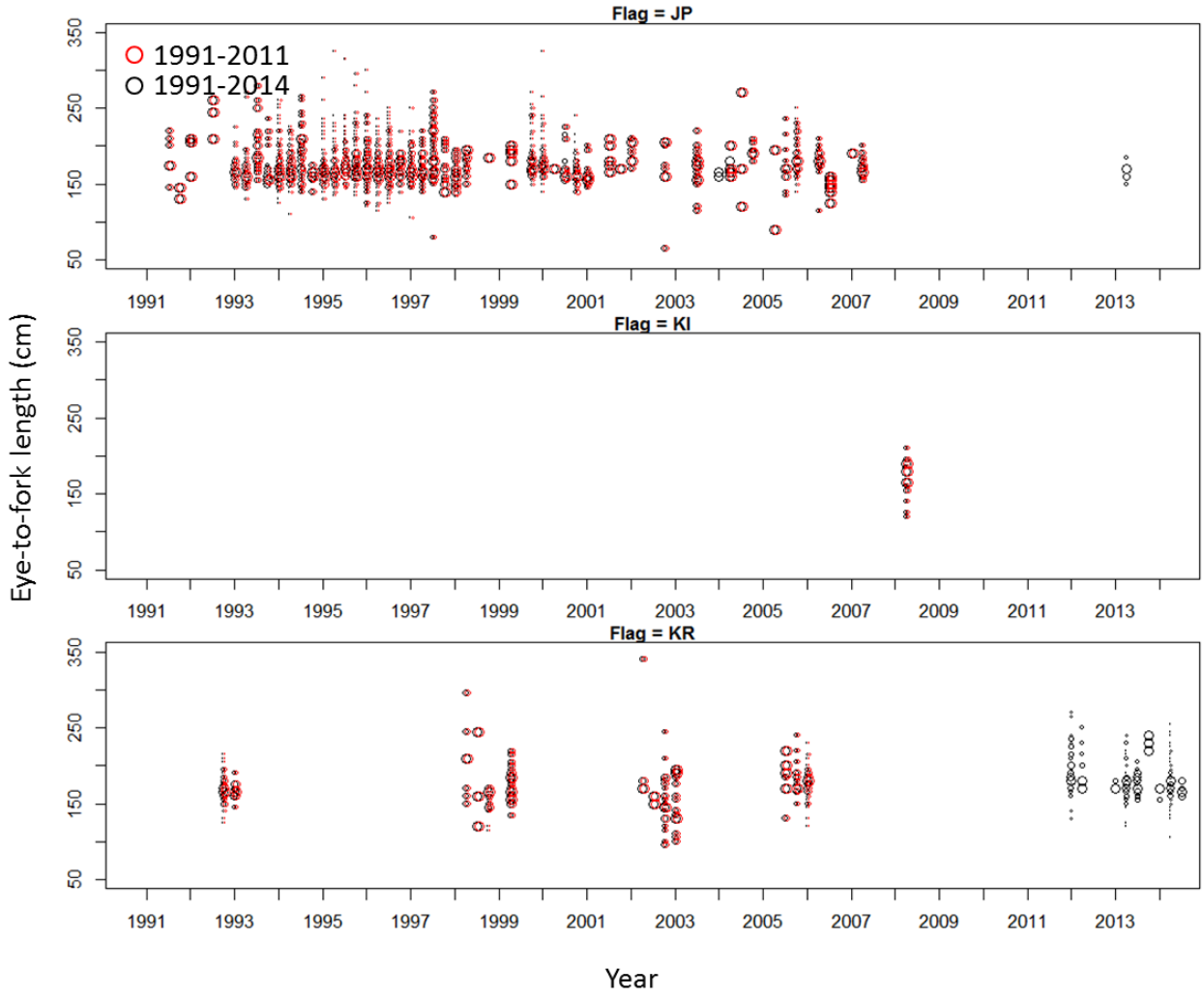

Figure 4. Continued.

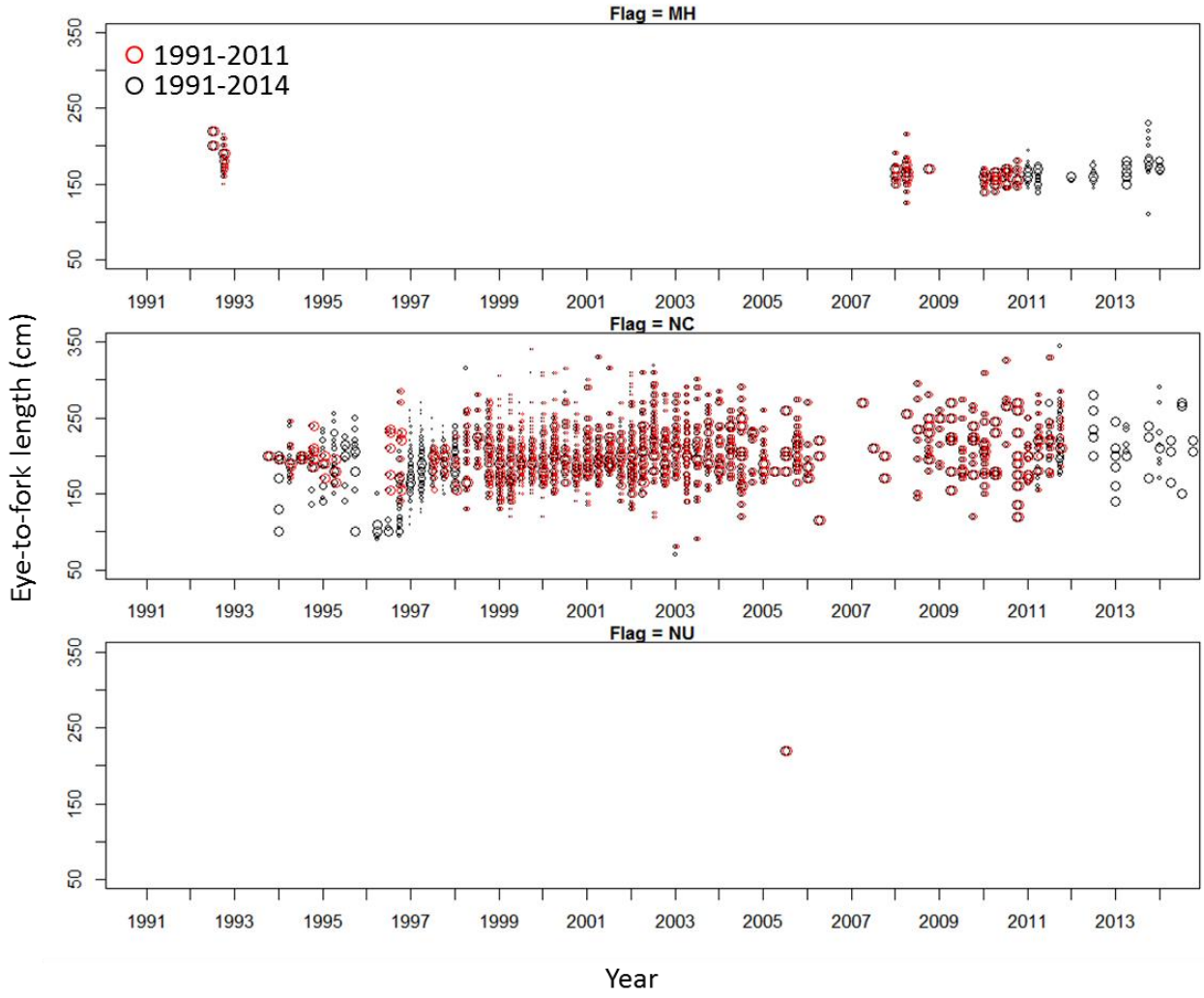

Figure 4. Continued.

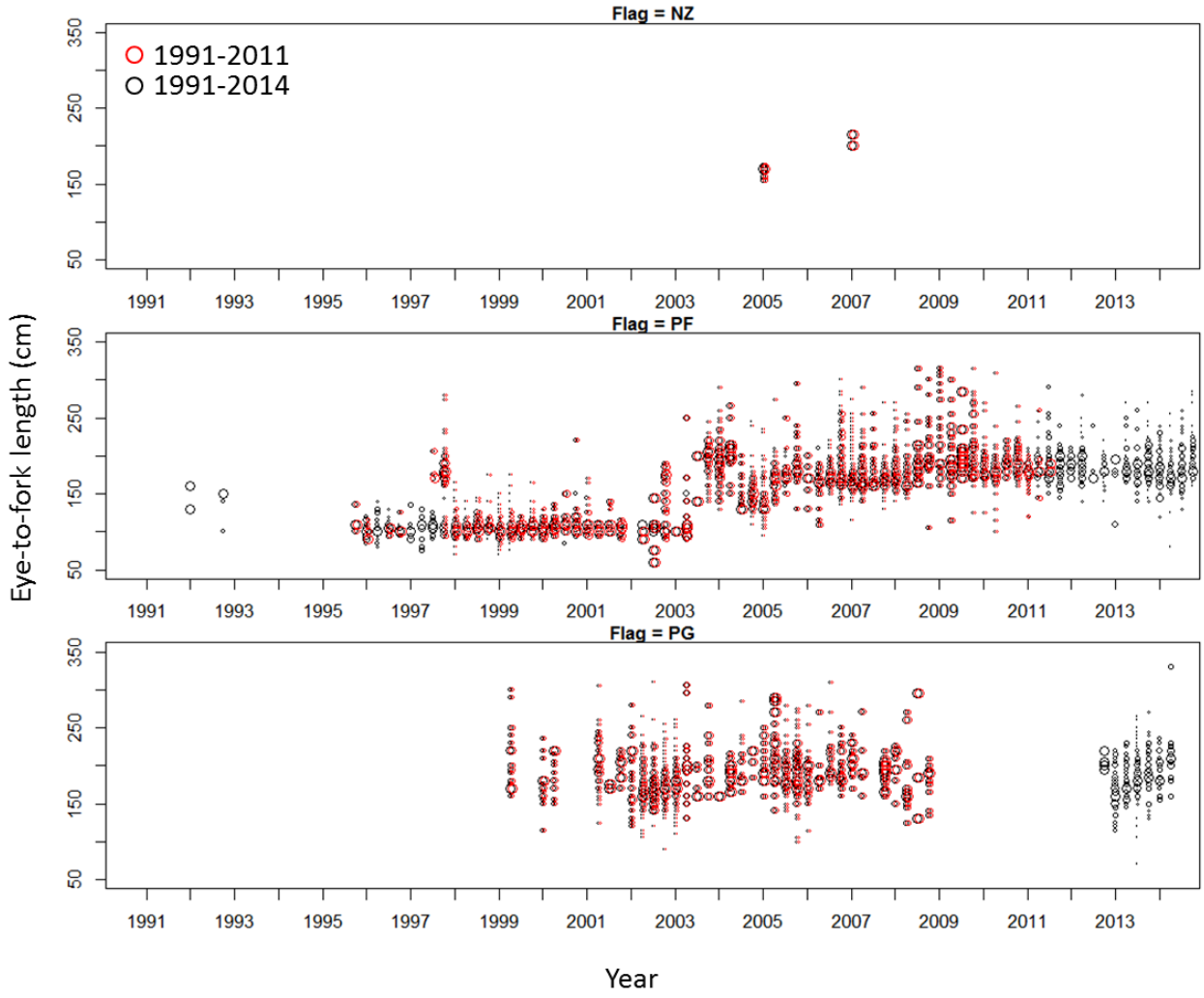

Figure 4. Continued.

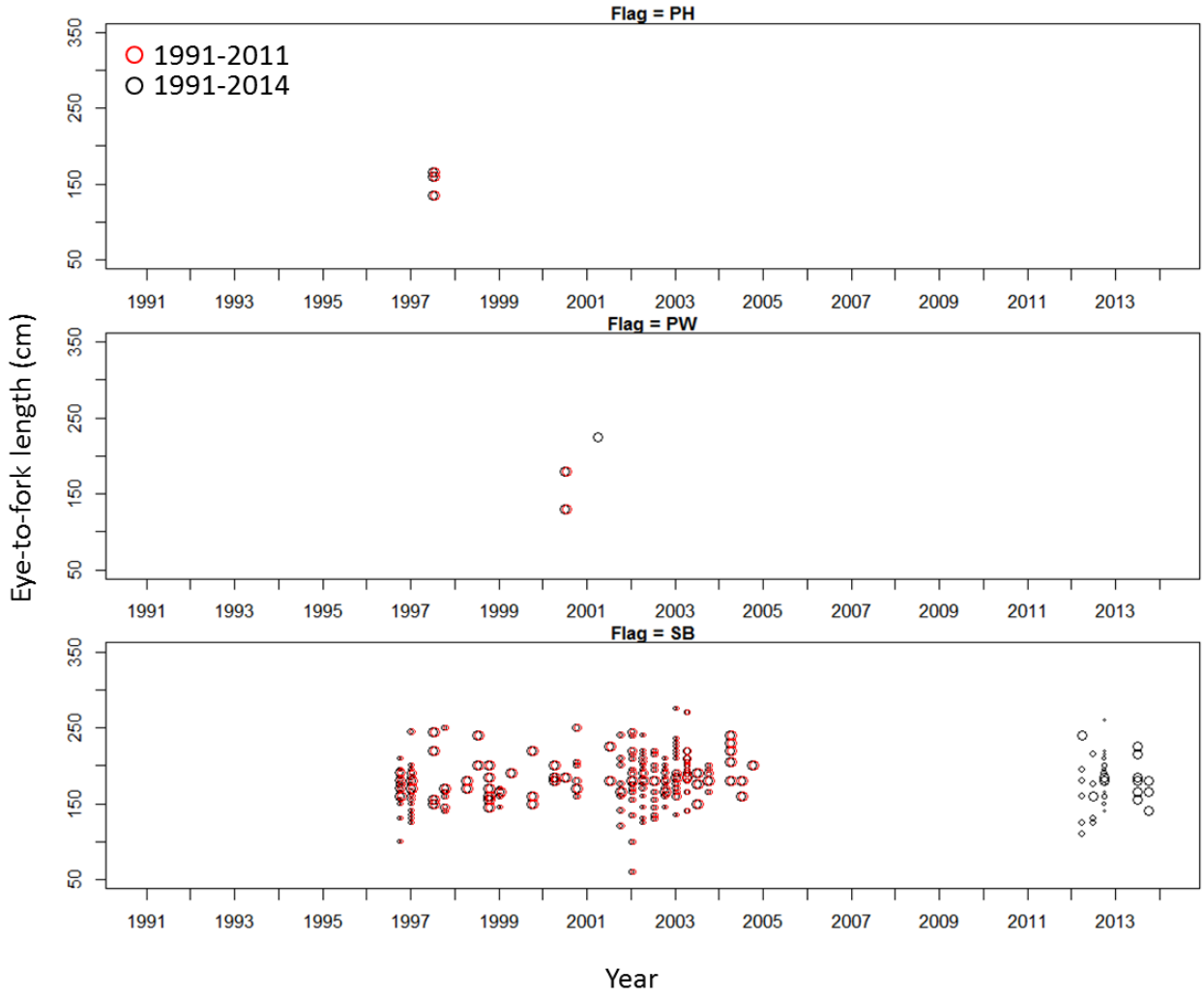

Figure 4. Continued.

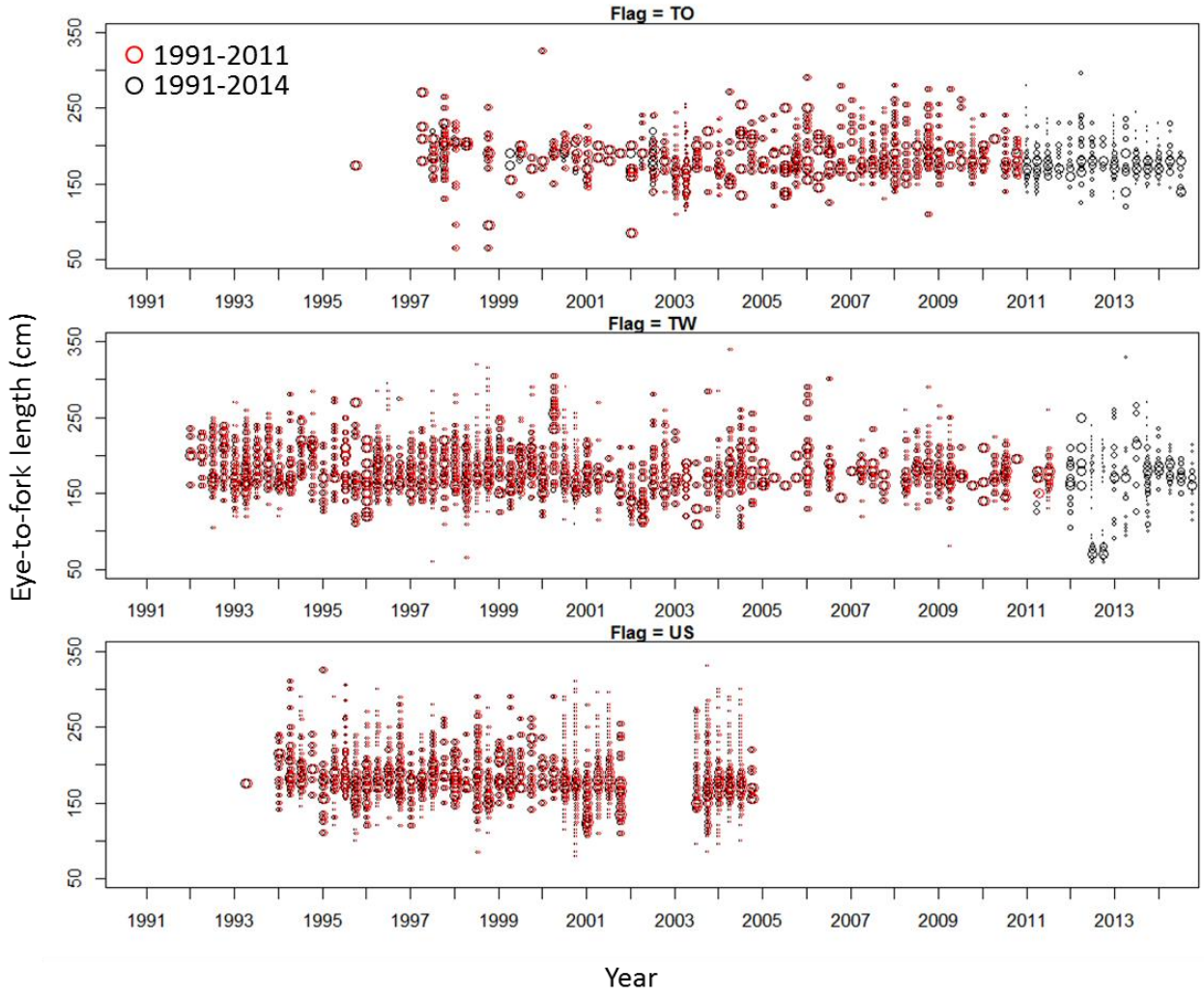

Figure 4. Continued.

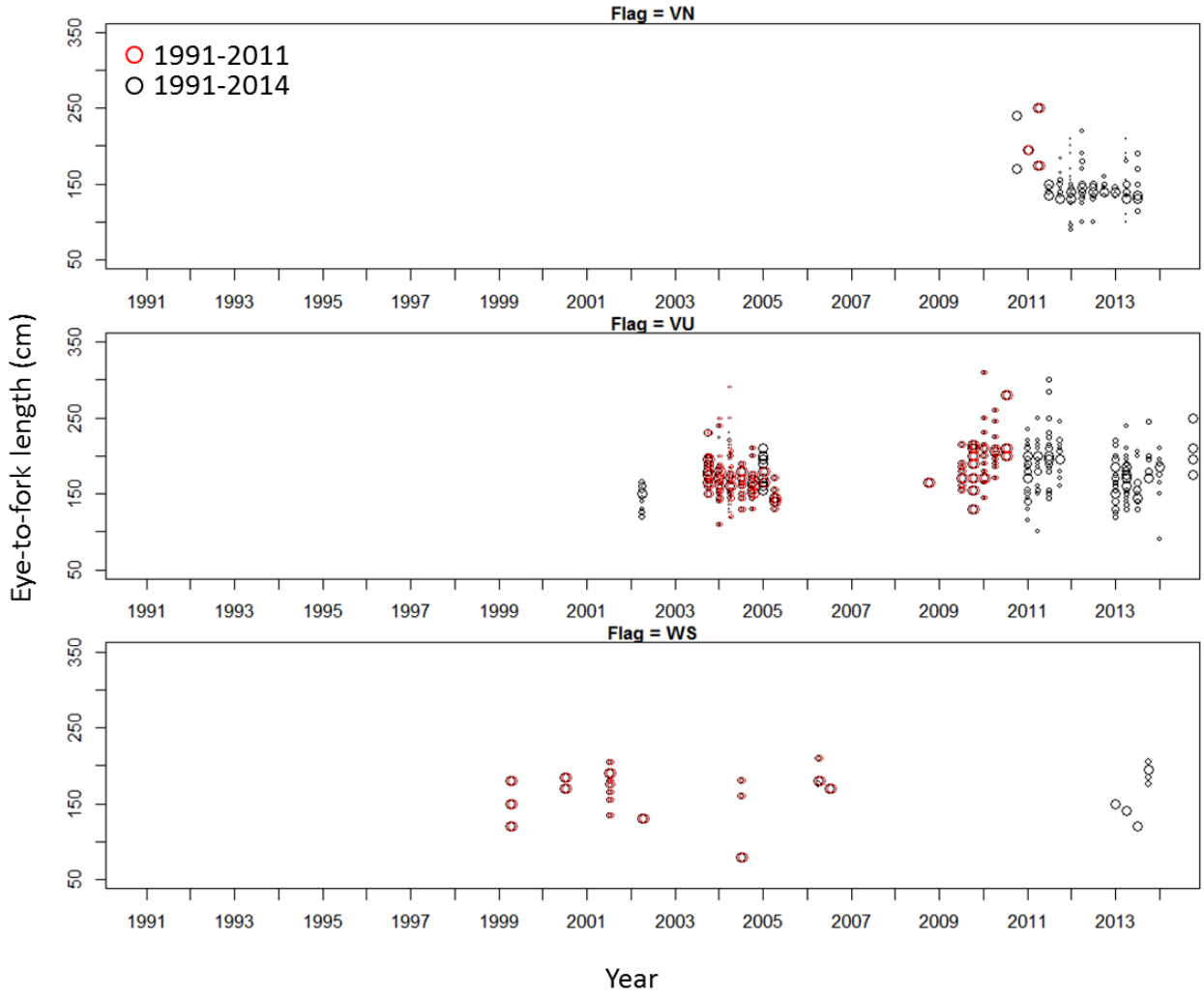

Figure 4. Continued.

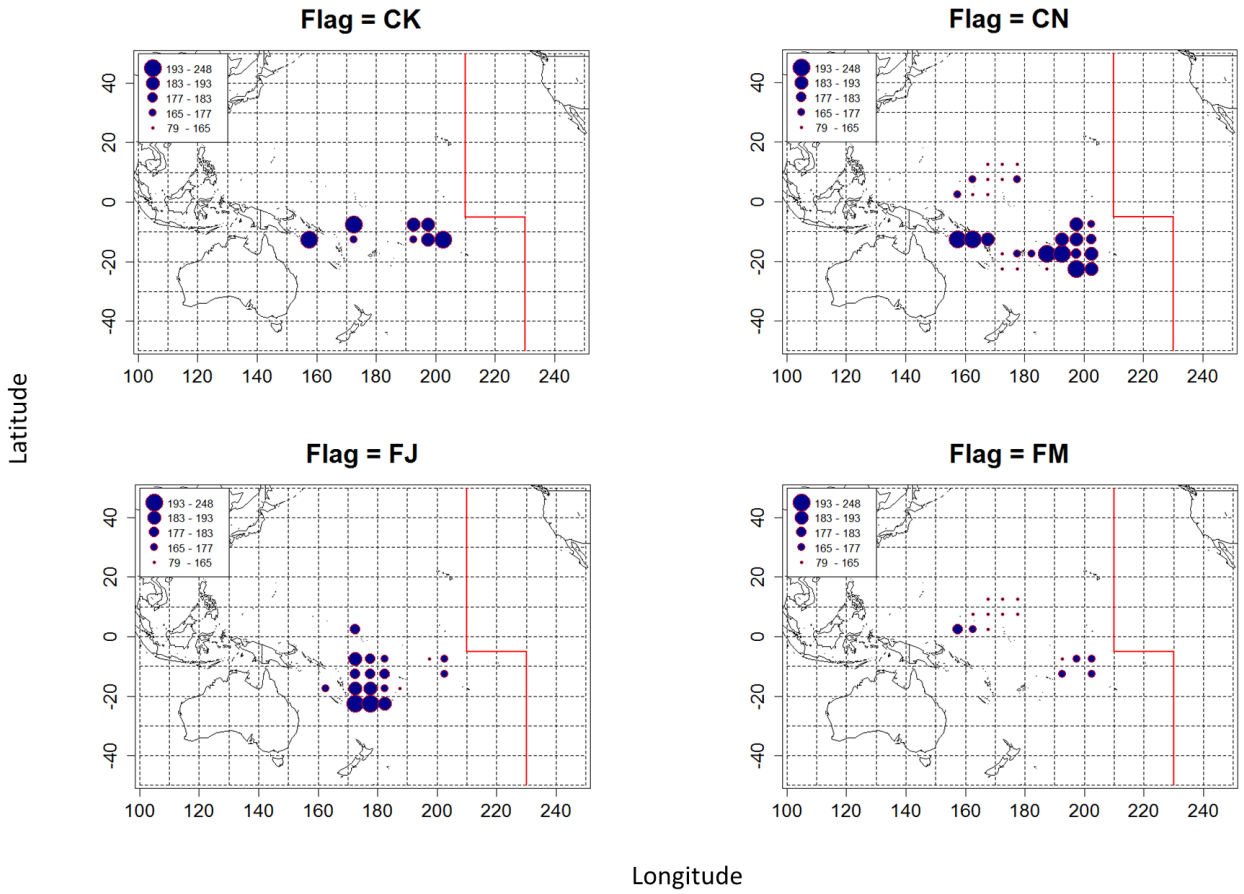

Figure 5. Spatial distribution of average size (eye-to-fork length, cm) of blue marlin (*Makaira nigricans*) by fishing countries in the WCPFC convention area during 2011-2014. Blue bubble size corresponds to average length in a given 5˚ by 5˚ grid. The red boundary indicates the WCPFC convention area. Data source: WCPFC Cat III dataset. The country codes used by the WCPFC and throughout this document are defined in Table 2.

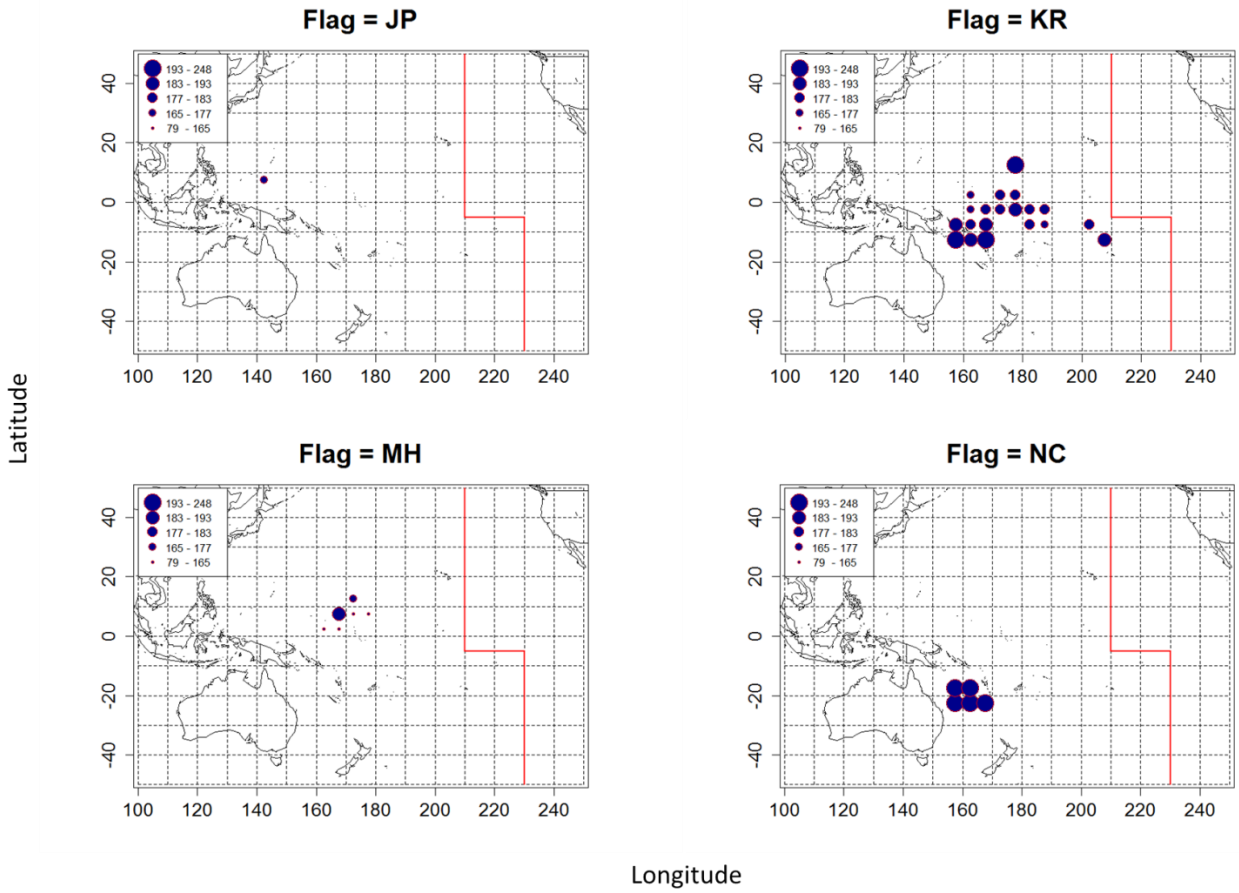

Figure 5. Continued.

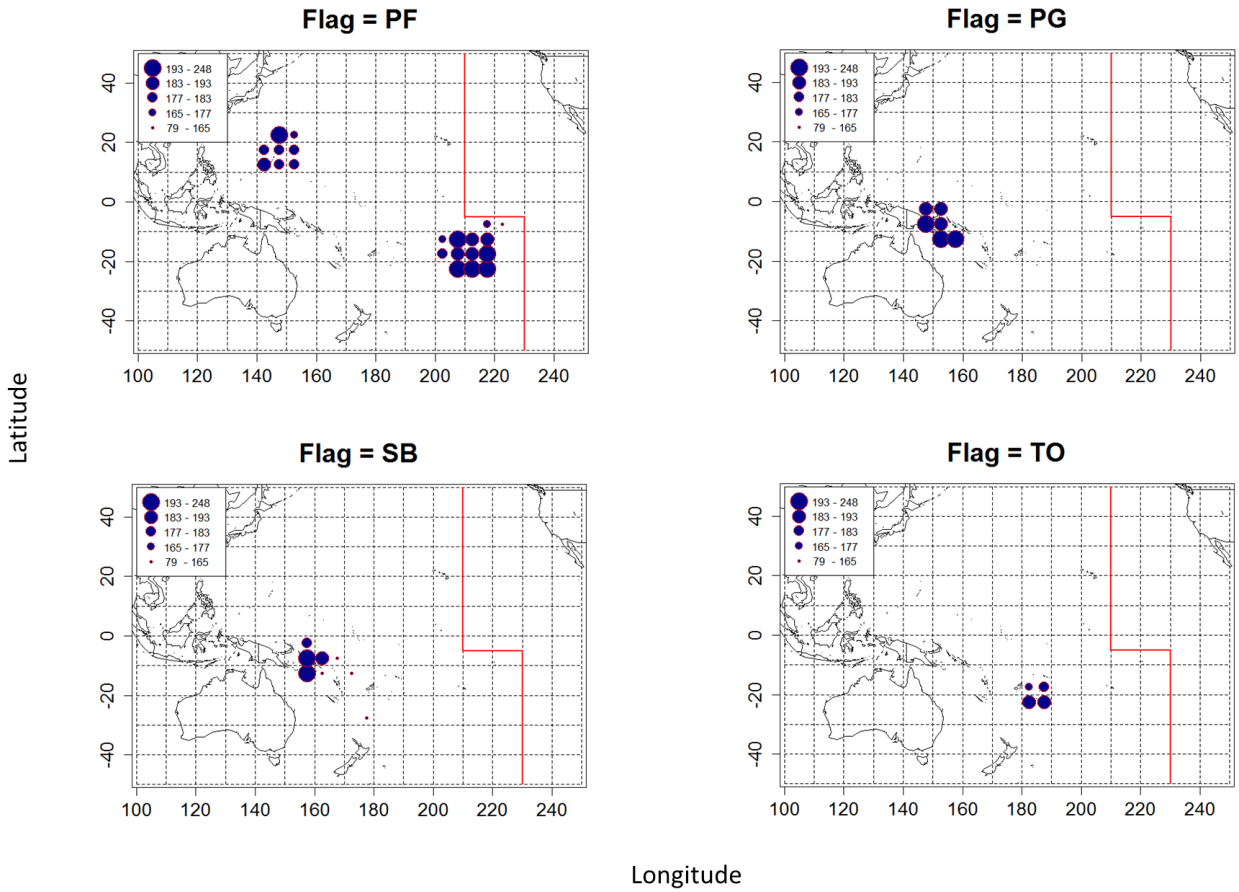

Figure 5. Continued.

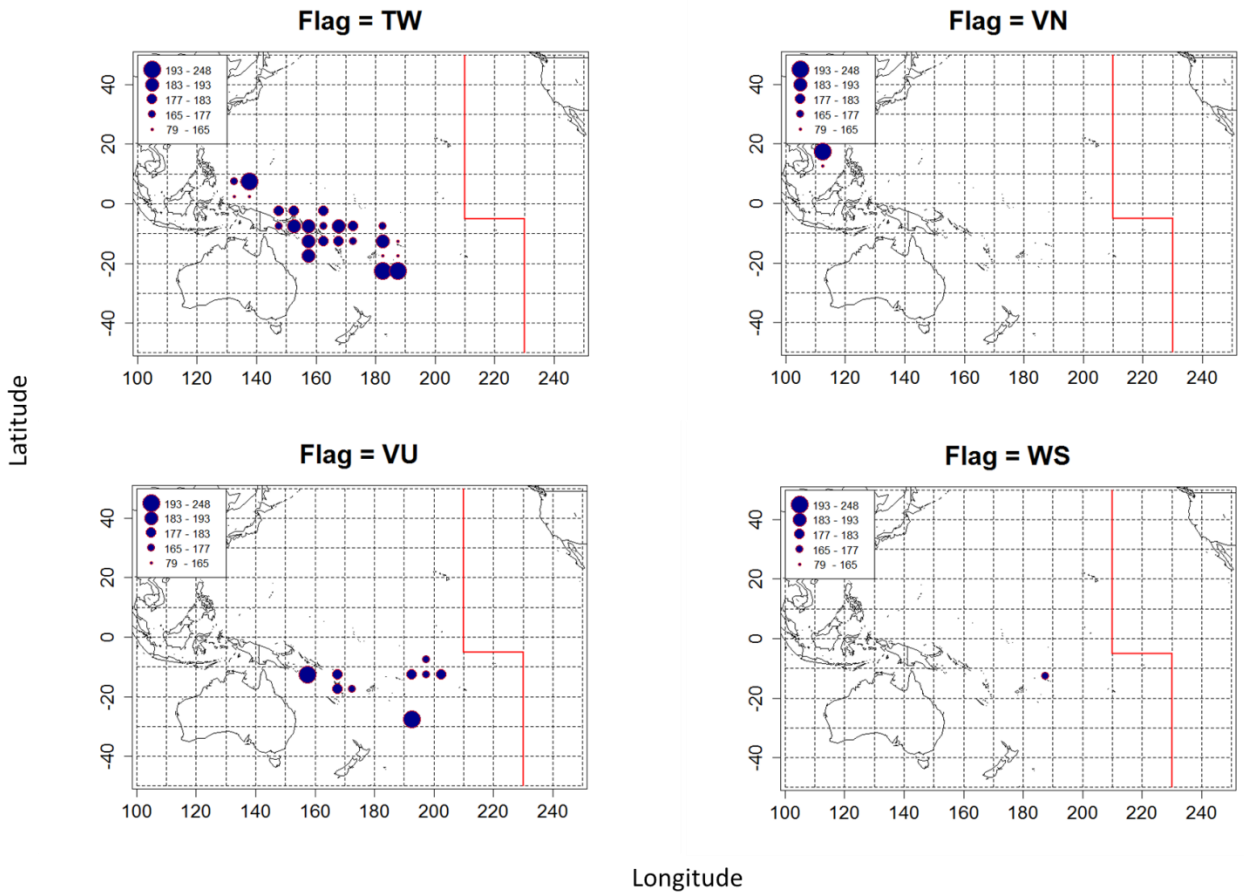

Figure 5. Continued.

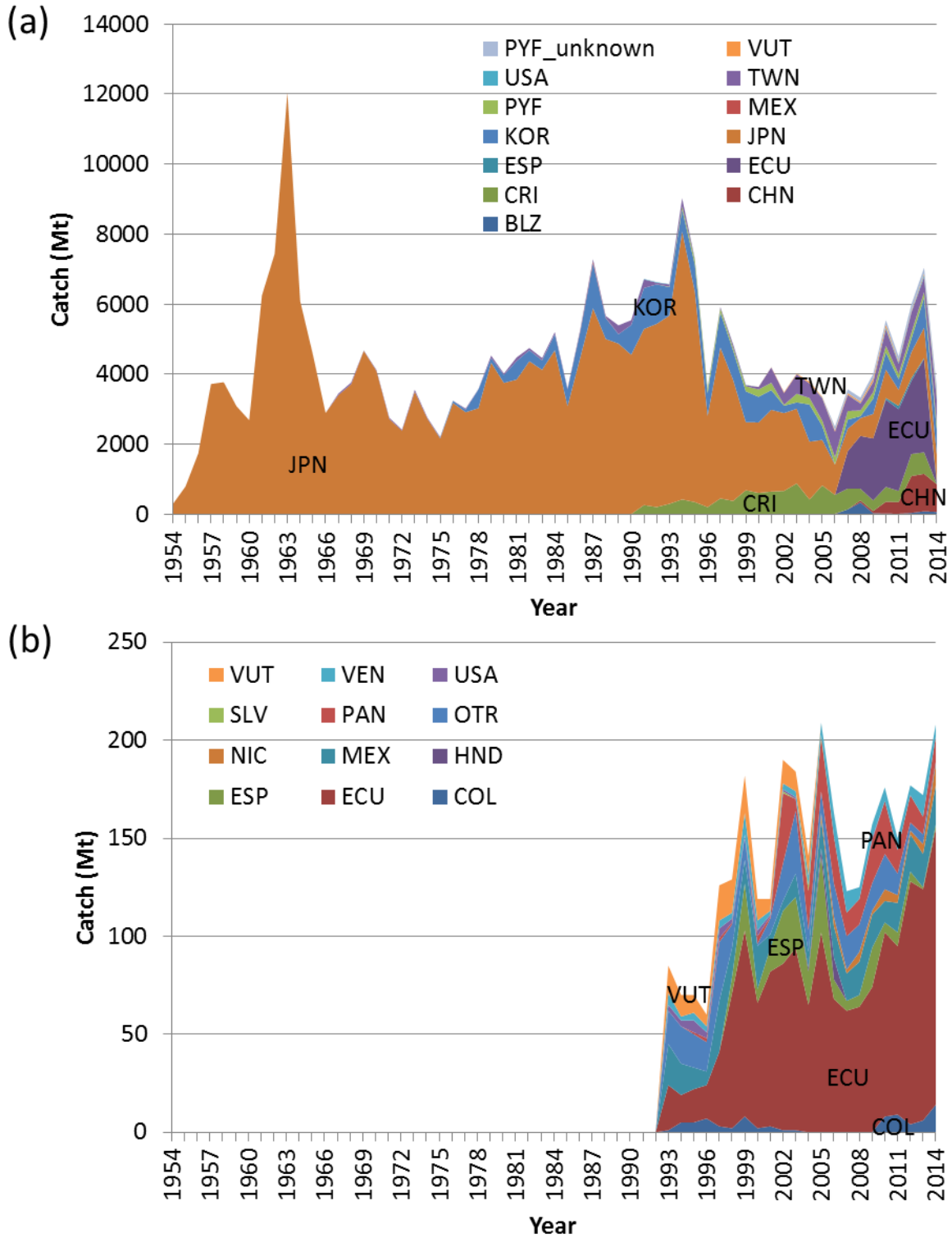

Figure 6. Blue marlin (*Makaira nigricans*) catch of the (a) longline fisheries and (b) purse seine fisheries in metric tons (Mt) in the IATTC convention area. The country codes used by the IATTC and throughout this document are defined in Table 2.

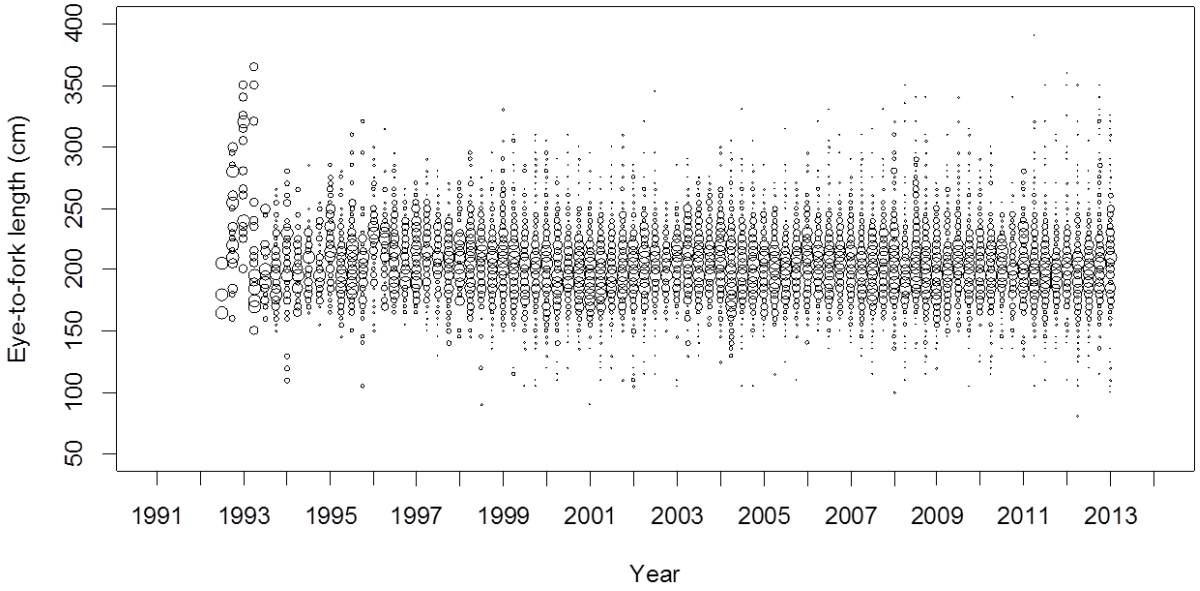

Figure 7. Bubble plot indicating size frequency (eye-to-fork length, cm) of blue marlin (*Makaira nigricans*) over time in the IATTC convention area. Bubble size corresponds to proportional frequency, and data is plotted by quarter. Data source: IATTC Cat III dataset. It should be noted the range of the y-axis is different from Figure 4.

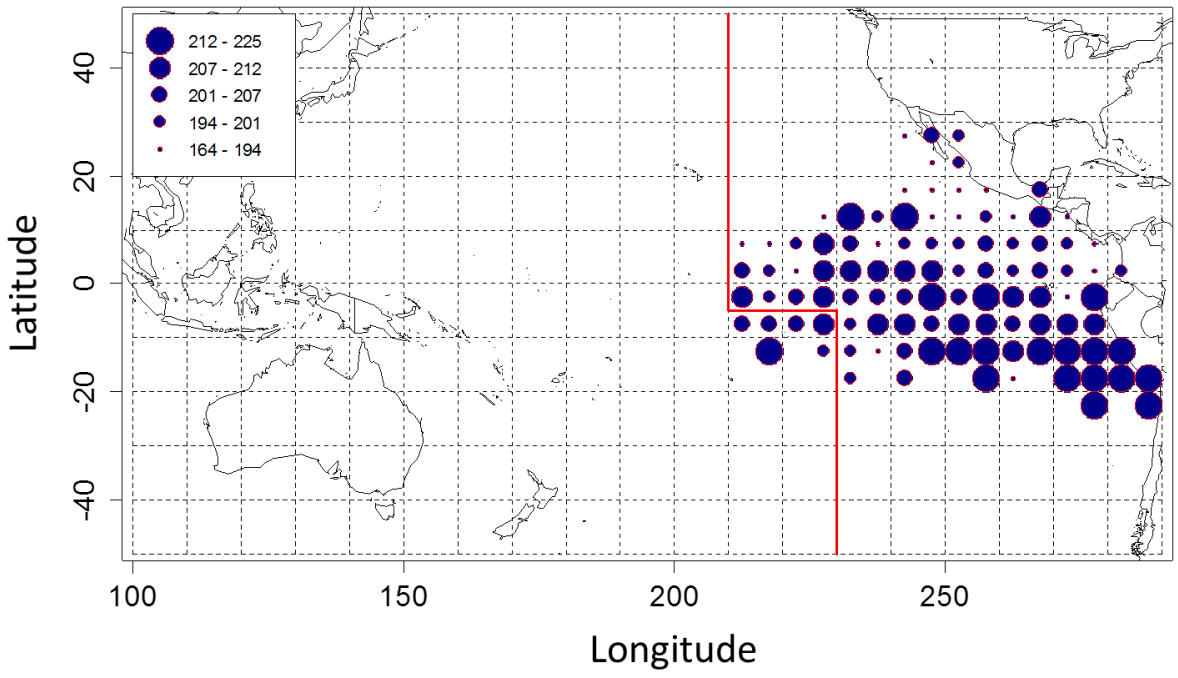

Figure 8. Spatial distribution of average size (eye-to-fork length, cm) of blue marlin (*Makaira nigricans*) by fishing countries in the IATTC convention area during 2011-2013. Blue bubble size corresponds to average length in a given 5˚ by 5˚ grid. The red boundary indicates the WCPFC convention area. Data source: IATTC Cat III dataset.

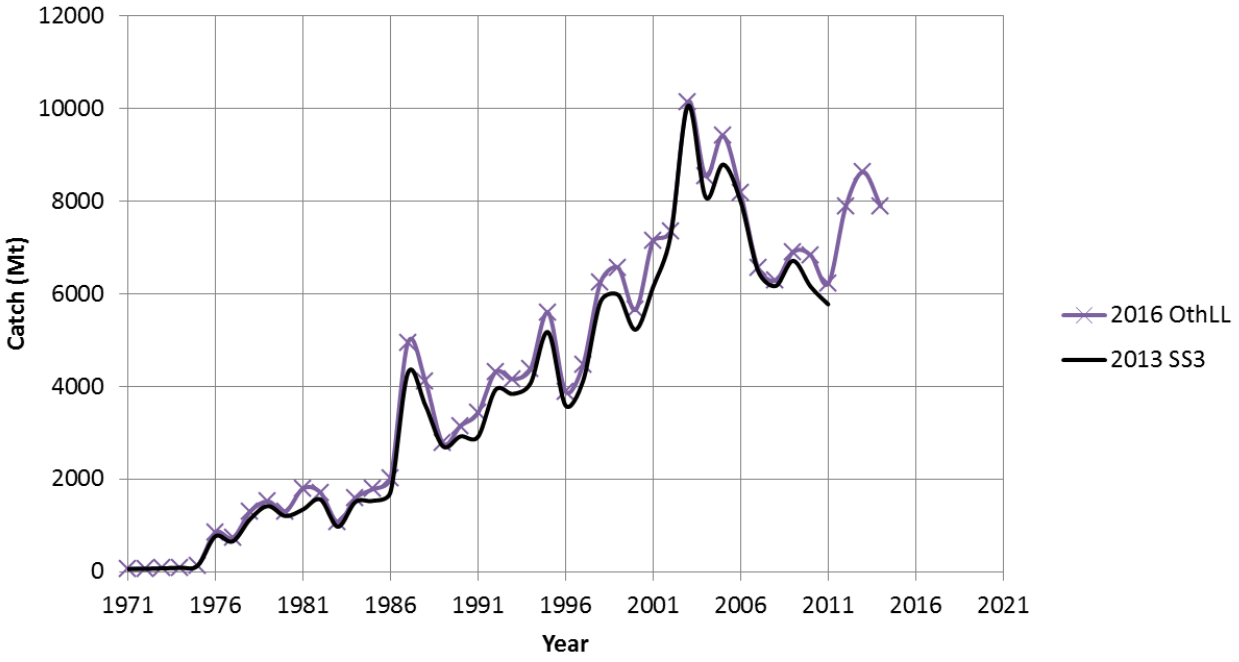

Figure 9. Time series of the blue marlin (*Makaira nigricans*) catch (metric tons, Mt) of the fleet OthLL in the Pacific Ocean. The black line is the time series of catch used in the previous assessment (ISC, 2013).

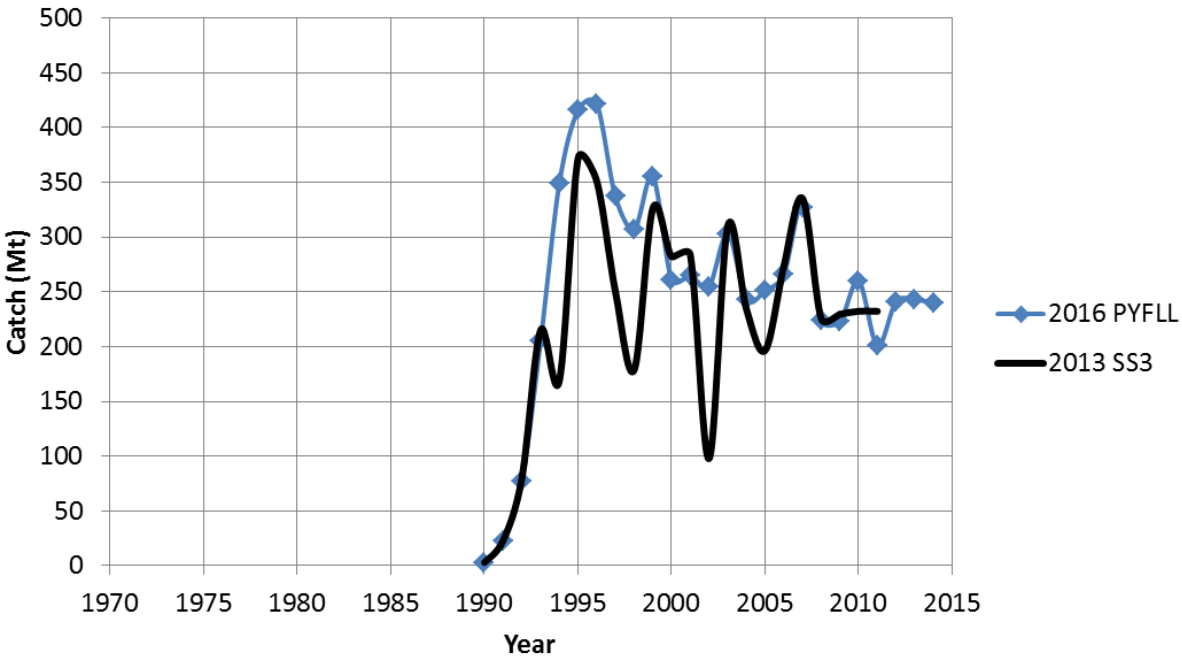

Figure 10. Time series of the blue marlin (*Makaira nigricans*) catch (metric tons, Mt) for the fleet PYFLL in the Pacific Ocean. The black line is the time series of catch used in the previous assessment (ISC, 2013).

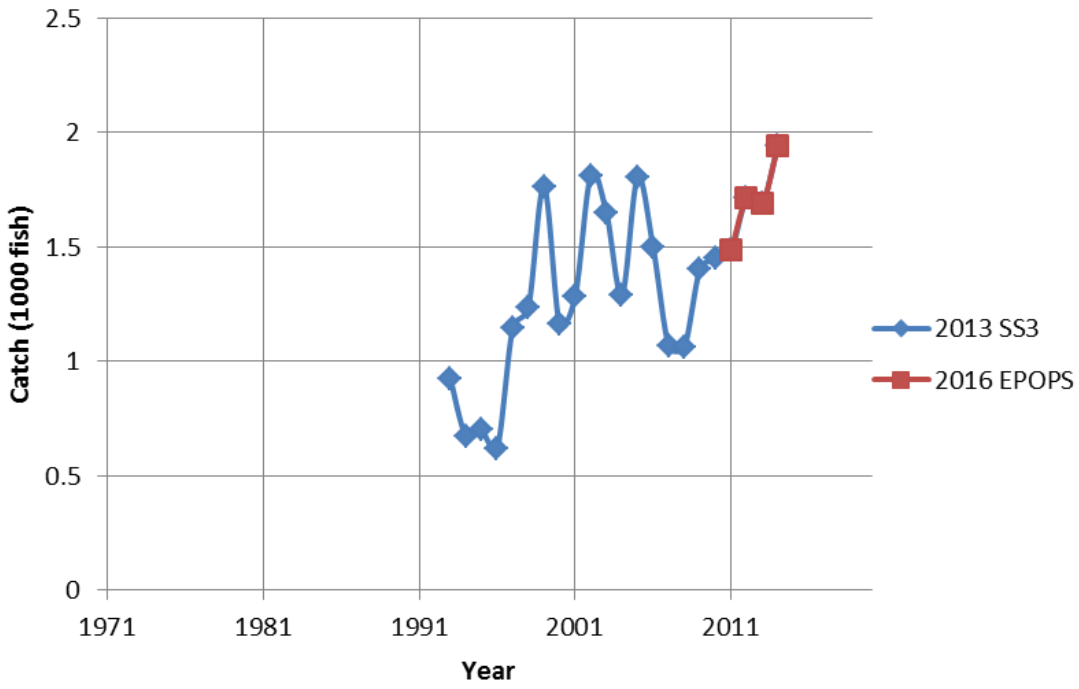

Figure 11. Time series of the blue marlin (*Makaira nigricans*) catch biomass (metric tons, Mt) (left axis) of the fleet EPOPS in the Pacific Ocean. The black line (right axis) is the time series of catch number (in thousands of fish) used in the previous assessment (ISC, 2013).

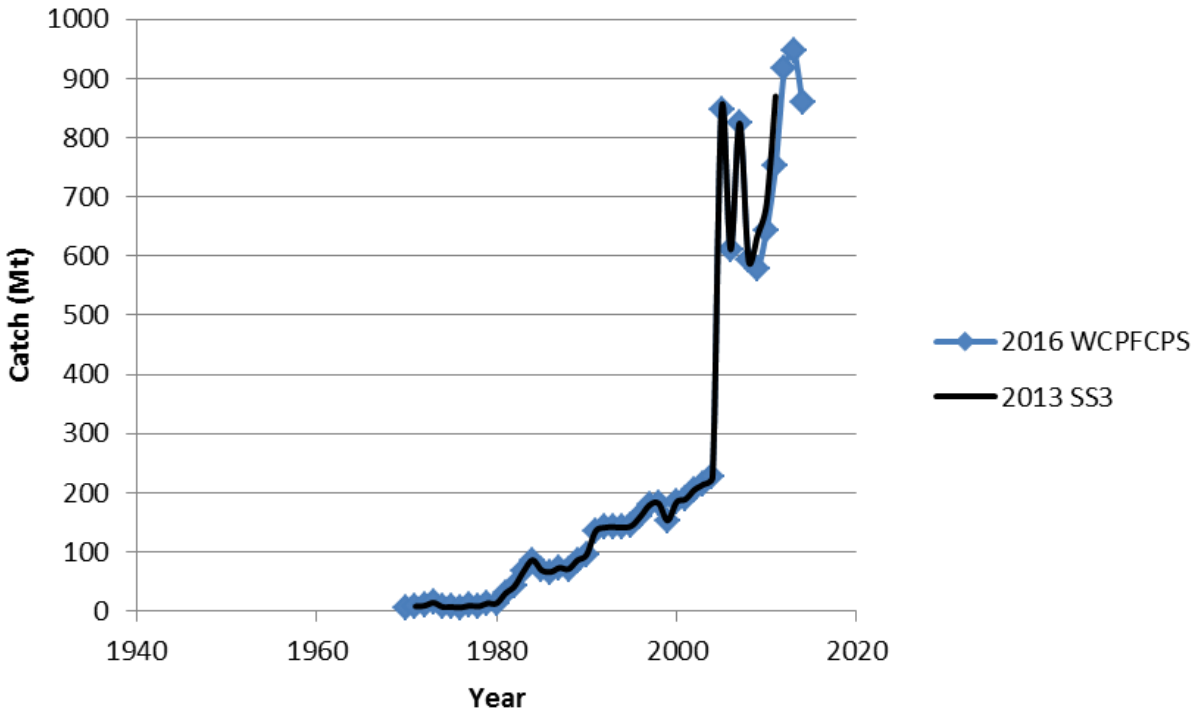

Figure 12. Time series of the blue marlin (*Makaira nigricans*) catch (metric tons, Mt) of the fleet WCPFCPS in the Pacific Ocean. The black line is the time series of catch used in the previous assessment (ISC, 2013).

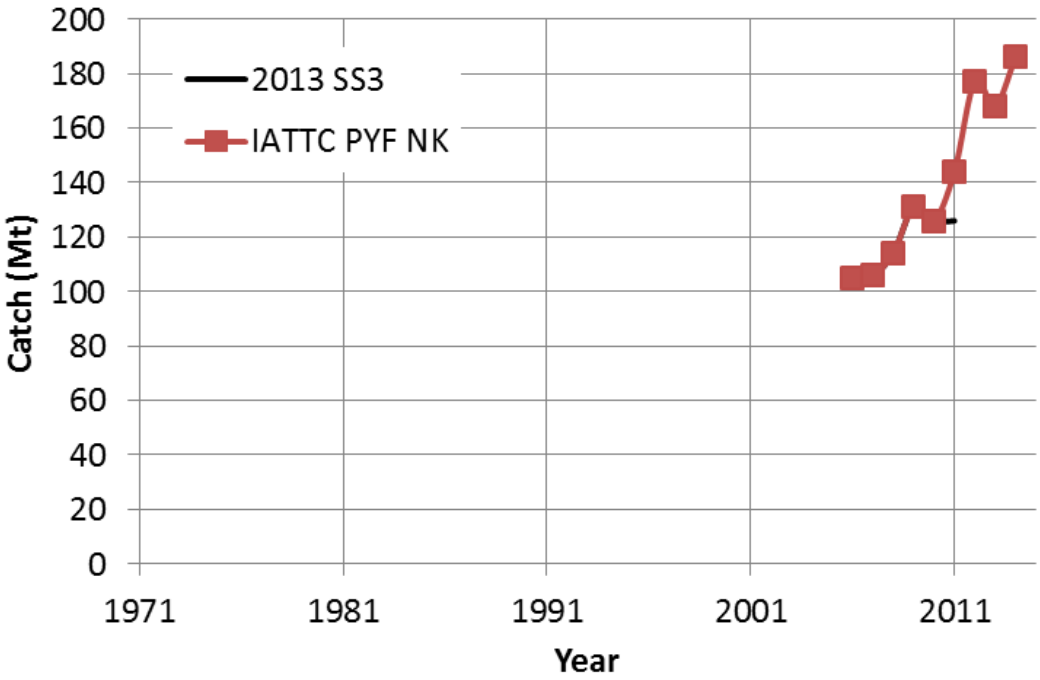

Figure 13. Time series of the blue marlin (*Makaira nigricans*) catch (metric tons, Mt) of the fleet EPOOtr in the Pacific Ocean. The black line is the time series of catch used in the previous assessment (ISC, 2013).

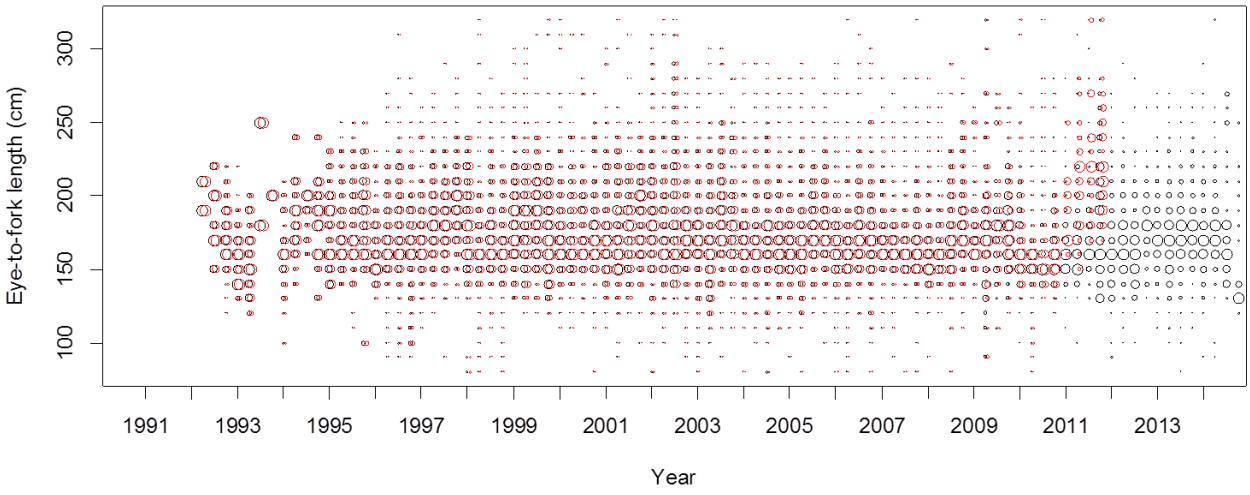

Figure 14. Bubble plot indicating size frequency (eye-to-fork length, cm) of blue marlin (*Makaira nigricans*) by the fleet OthLL in the Pacific Ocean. Bubble size corresponds to proportional frequency, and data is plotted by quarter. Size frequency was compiled using 10-cm bins from 80 to 320 cm. The red circles denote the 2013 assessment data. The black circles denote the new input data.

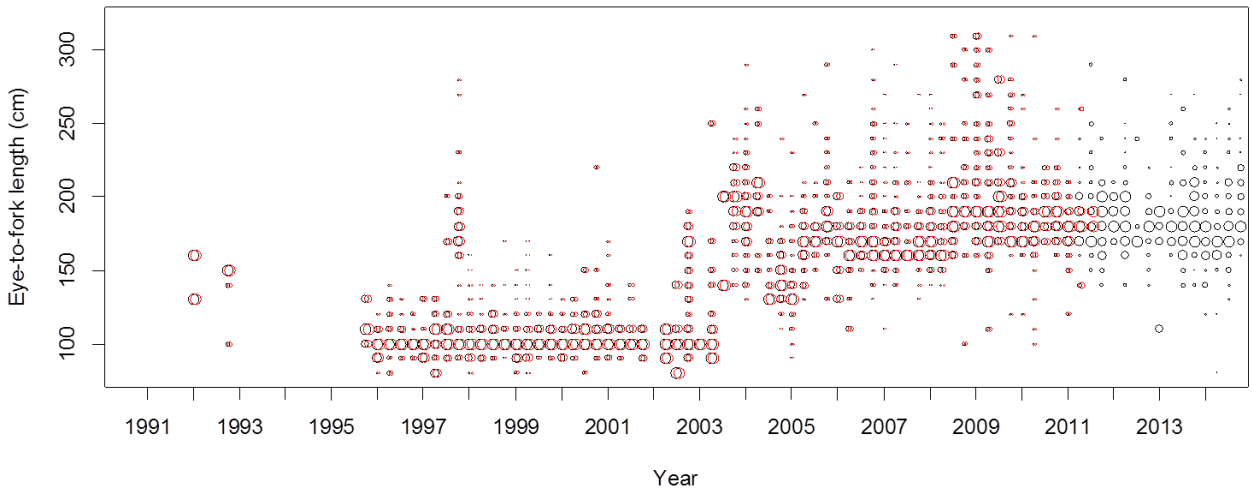

Figure 15. Bubble plot indicating size frequency (eye-to-fork length, cm) of blue marlin (*Makaira nigricans*) by the fleet PYFLL in the Pacific Ocean. Bubble size corresponds to proportional frequency, and data is plotted by quarter. Size frequency was compiled using 10-cm bins from 80 to 320 cm. The red circles denote the 2013 assessment data. The black circles denote the new input data.

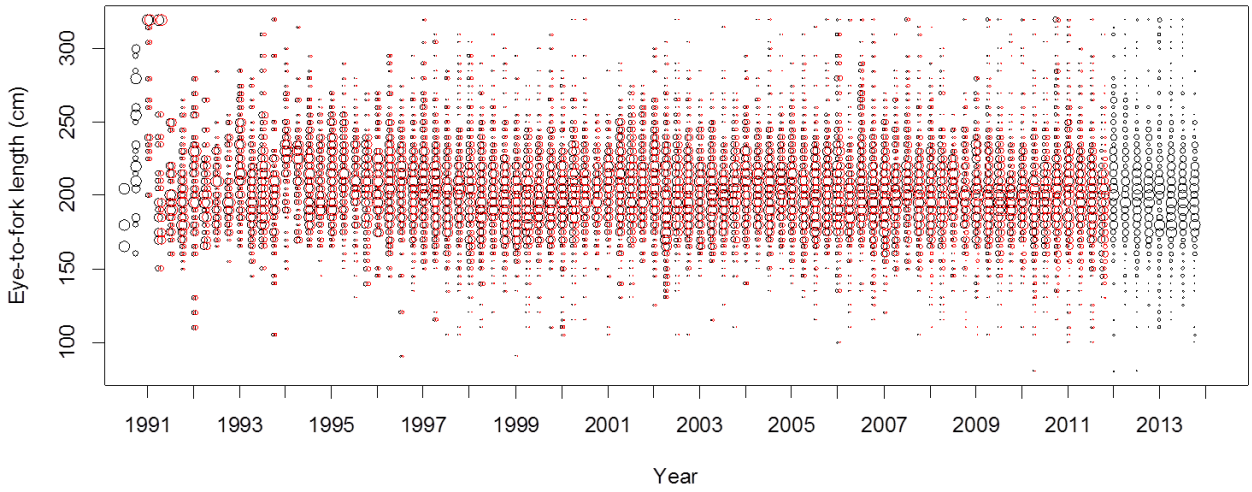

Figure 16. Bubble plot indicating size frequency (eye-to-fork length, cm) of blue marlin (*Makaira nigricans*) by the fleet EPOPS in the Pacific Ocean. Bubble size corresponds to proportional frequency, and data is plotted by quarter. Size frequency was compiled using 5-cm bins from 80 to 320 cm. The red circles denote the 2013 assessment data. The black circles denote the new input data.