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Oceanic whitetip and silky shark in longline fisheries between 20 N and 20 S and outside the area to evaluate CMM 2022-04 (Project 116)

WCPFC-SC20-2024/EB-WP-05

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Keith Bigelow[1], Aurélien Panizza[2], Tiffany Vidal[2] and Peter Williams[2]

Executive Summary

The purpose of the working paper is to evaluate CMM 2022-04 (Conservation and Management Measure for Sharks). Paragraph 28 in CMM 2022-04 states "In 2024, and commencing periodically thereafter, the SC shall review the impact of fishing gear on sharks that are not retained, including oceanic whitetip shark and silky shark, inside and outside of the area between 20 N and 20 S, and provide advice on potential mitigation measures that would benefit such shark species."

Longline fishing data were analyzed from the WCPFC Regional Observer Program (ROP) from 2010 to 2023 for three spatial areas: 1) to the north of 20°N, 2) between 20°S and 20°N and 3) south of 20°S. Nominal CPUE was estimated by flag, deep and shallow longline sectors and annually.

The area between 20°S to 20°N has higher nominal CPUE for both oceanic whitetip shark and silky shark which reflects the latitudinal habitat preferences of each species. In the deep-set sector, oceanic whitetip shark CPUE is 6.7 and 12.2 times higher in the spatial area 20°S to 20°N, than north of 20°N and south of 20°S; respectively. In the deep-set sector, silky shark CPUE is 68.8 and 37.1 times higher in the spatial area 20°N to 20°S, than north of 20°N and south of 20°S; respectively. The higher silky shark CPUE reflects a latitudinal preference for a tropical habitat compared to an oceanic whitetip shark which has additional habitat to the north of 20°N and south of 20°S.

1 Introduction

The updated stock assessment for oceanic whitetip shark (*Carcharhinus longimanus*, OCS) presented to the 15th WCPFC Science Committee (Tremblay-Boyer et al., 2019) showed that the stock was overfished (*SBcurrent/SBMSY* < 1) and undergoing overfishing (*Fcurrent/FMSY* > 1) in the Western and Central Pacific Ocean (WCPO). The stock assessment for silky shark (*Carcharhinus falciformis*, FAL) presented to the 14th WCPFC Science Committee (Clarke et al. 2018) showed the stock was undergoing overfishing (*Fcurrent/FMSY* > 1) in the WCPO and not in an overfished state (*SBcurrent/SBMSY* >1).

A review of potential mitigation measures to reduce fishing-related mortality on oceanic whitetip and silky explored reduction rates of both shark species under a variety of management scenarios (Harley et al. 2015, Bigelow and Carvalho 2021). The banning of both shark lines and wire branchlines was estimated to reduce fishing mortality by 30.8% and 40.5% for silky shark and oceanic whitetip shark, respectively (Bigelow and Carvalho 2021).

Two studies have investigated future population projections of oceanic whitetip shark in the WCPO. Rice et al. (2021) conducted projections to assess the impacts of recent conservation

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and management measures (CMM 2014-05), future fishing mortality on recovery timelines, using updated estimates of post-release mortality. Bigelow et al. (2022) updated the projections of Rice et al. (2021) for five scenarios to assess the impacts of various potential management measures with contemporary estimates of mortality at longline retrieval, post-release mortality, catch reductions and prohibitions of wire branchlines and shark lines. The projection with a prohibition on wire branchlines and shark lines resulted in an increase in spawning biomass in the latest time period (2031, mean $SB2031/SBF$=0, 0.118) relative to 2013-2015 ($SB2013$-$2015/SBF$=0, 0.039).

CMM 2022-04 prohibits wire branchlines and shark lines between 20°N and 20°S in the WCPO. The CMM instructs SC to "review the impact of fishing gear on sharks that are not retained, including oceanic whitetip shark and silky shark, inside and outside of the area between 20 N and 20 S, and provide advice on potential mitigation measures that would benefit such shark species."

This analysis estimated nominal longline CPUE for oceanic whitetip and silky sharks in the WCPO specifically for three spatial areas: 1) to the north of 20°N, 2) between 20°N and 20°S and 3) south of 20°S.

2 Methods

WCPFC ROP data were obtained from 2010 to 2023. There were a total of 116,345 sets from 16 fleets.

Data filtering

- Data were disaggregated into shallow longline sets (hooks between float (HBF) <15) and deep longline sets (HBF=>15).
- Data were assigned to north of 20°N, between 20°N and 20°S and south of 20°S based on the beginning of the set location.
- Data from fleets were removed if observer data indicated shark targeting which would be non-informative to assess potential mitigation effects on CMM 2022-04.
- Data for each flag were aggregated. To avoid potential confidentiality problems, data were deleted from any fleets that had less than 50 sets from 2010 to 2023.

After data filtering, the final dataset contained 116,153 sets (97,309 deep and 18,844 shallow). The final dataset contained 7,557 OCS (7,242 deep and 315 shallow) and 27,482 (26,118 deep and 1,364 shallow) FAL.

A summary of OCS and FAL bycatch in WCPFC longline fisheries has been estimated in Peatman and Nicol (2020) and Peatman and Nicol (2023). The overall approach in the two studies was to fit catch rate models to available observer data, and obtain catch estimates by applying the catch rates to aggregate longline effort. Models in the two studies consisted of a two-stage delta-lognormal approach with explanatory variables including sea-surface temperature (SST) , HBF, year and species composition cluster from L_BEST strata (SPC data product). Peatman and Nicol (2020) provided annual shark and ray estimates (2003-2018) for the WCPFC Convention Area (WCPFC-CA, Table 14) and disaggregated by area (north of 10°N, Table 22), 10°S to 10°N (Table 23) and south of 10°S (Table 24). Peatman and Nicol (2023) provided annual shark and ray estimates (2003-2021) for the WCPFC-CA (Table A.7).

The objective of CMM 2022-04 is for the WCPFC Scientific Committee to review the impact of fishing gear on sharks inside and outside of the area between 20°N and 20°S. Given that the

stratification of Peatman and Nicol (2020) is at 10°N and 10°S, the estimated catches from north of 20°N, 20°S-20°N and south 20°S are unknown. In this analysis the annual nominal CPUE of OCS and FAL for the predominant deep-set longline fisheries were applied to aggregated longline effort for all fleets in the L_BEST strata to estimate OCS and FAL catches from north of 20°N, 20°N-20°S and south 20°S. It should be noted that there is substantial variation in time, space, observer coverage, fleet and longline operational characteristics in the ROP data which results in uncertainty in catch estimation in using nominal or even a standardized CPUE analysis.

3 Results

The deep-set longline sector is more informative than the shallow-set sector given the higher number of observed sets. Three flags (China 12.1%, Taiwan 38.0% and the USA 30.8%) comprise 80.9% of the observed sets. Tables 1 and 2 illustrate estimates for the deep and shallow sets by flag. Estimates are provided for the number of sets, hooks, OCS, FAL and OCS CPUE, FAL CPUE and sets required to capture an OCS or FAL (defined as 1/(number of OCS or FAL)/longline sets). Tables 3 and 4 illustrate similar metrics by year and aggregated over all flags.

In the deep-set sector, OCS CPUE is 6.7 and 12.2 times higher in the spatial area 20°N to 20°S, than north of 20°N and south of 20°S; respectively. In the deep-set sector, FAL CPUE is 68.8 and 37.1 times higher in the spatial area 20°N to 20°S, than north of 20°N and south of 20°S; respectively. In the shallow-set sector, OCS CPUE is 2.4 times higher in the spatial area 20°N to 20°S, than north of 20°N. In the shallow-set sector, FAL CPUE is 71.9 times higher in the spatial area 20°N to 20°S than north of 20°N. The shallow-set sector is relatively non-informative for the area south of 20°S as there were only 2 OCS and 3 FAL observed from 2011 to 2023 (Tables 3 and 4).

Figures 1 to 3 illustrate the annual number of sets, hooks, OCS and FAL by spatial area for the deep-set sector. Figures 4 to 6 illustrate the annual number of sets, hooks, OCS and FAL by spatial area for the shallow-set sector. Figure 7 illustrates the OCS CPUE for deep-set by spatial area which has some inter-annual variability with no trend in any of the three areas. Figure 8 illustrates the OCS CPUE for shallow-set by spatial area which has some inter-annual variability for areas 20°N and 20°N-20°S and with no trend. Figure 9 illustrates the FAL CPUE for deep-set by spatial area which has declined since 2016 in the area 20°N-20°S. Figure 10 illustrates the FAL CPUE for shallow-set by spatial area which has no trend since 2014.

Table 5 and Figure 11 illustrate the longline effort by area and year aggregated over all flags. Longline effort in Table 5 and Figure 11 is both deep and shallow longline effort as the L_BEST database contains an aggregate effort. Longline effort is highest in the spatial area 20°N to 20°S (annual average 881 million hooks, 2010-2023) and has been in decline since 2012. Longline effort has been stable in the spatial area north of 20°N (annual average 127 million hooks, 2010-2023) and in the spatial area south of 20°S (annual average 80 million hooks, 2010-2023).

Tables 6 and 7 illustrate OCS and FAL catches from north of 20°N, 20°N-20°S and south 20°S estimated from annual nominal CPUE and the aggregated longline effort for all fleets. The total WCPFC-CA catches from this analysis are compared with the total OCS and FAL from Peatman and Nicol (2023) Table A.7. There is good correspondence in total catches in some years; however, there are substantial differences in other years. The average annual difference between methodologies was 4,319 higher OCS in this study and 6,097 higher FAL in Peatman and Nicol (2023).

4 Discussion

The area between 20°S to 20°N has higher nominal CPUE for both oceanic whitetip shark and silky shark which reflects the tropical habitat preference of each species. In the deep-set sector, oceanic whitetip shark CPUE is 6.7 and 12.2 times higher in the spatial area 20°N to 20°S, than north of 20°N and south of 20°S; respectively. In the deep-set sector, silky shark CPUE is 68.8 and 37.1 times higher in the spatial area 20°N to 20°S, than north of 20°N and south of 20°S; respectively. The higher silky shark CPUE reflects a latitudinal preference for a tropical habitat compared to an oceanic whitetip shark which has additional habitat to the north of 20°N and south of 20°S. If CMM 2022-04 were revised to extend to the north of 20°N and/or south of 20°S, the OCS population would benefit more than the FAL population.

The banning of both shark lines and wire branchlines was estimated to reduce fishing mortality by 30.8% and 40.5% for FAL and OCS, respectively (Bigelow and Carvalho 2021). The reduction was modeled from 20°N to 20°S. The reduction in fishing mortality in the spatial area to the north of 20°N and south of 20°S depends on operational characteristics in longline fleets, especially the use of wire branchlines which were more prevalent than shark lines from 2010 to 2018 (Bigelow and Carvalho 2021, Table 1).

Longline catch estimates for OCS and FAL are available in Peatman and Nicol (2020, 2023) and this study. Nominal CPUE was used in this study; however, a preferred approach would be to estimate a standardized CPUE as a function of time, spatial area, fleet, and operational characteristics such HBF and the use of wire branchlines and shark lines. The current observer data are probably not amenable to calculate a standardized CPUE for the three spatial areas for considering the effect of banning wire branchlines and shark lines in evaluating CMM 2022-04. There is a general imbalance in ROP coverage with three flags dominating the number of observed sets (80.9%) from 2010 to 2023 (China 12.1%, Taiwan 38.0% and the USA 30.8%). In contrast, these three flags represent 38.8% of longline effort (hooks) from 2010 to 2023 (China 13.8%, Taiwan 20.4 and the USA 4.6%).

Recommendations

- There are several fleets that are not represented in the ROP data. The EU (Spanish) fleet should be informative for the south of 20°S stratum as the fleet has a shallow-set longline fishery that targets swordfish and blue shark. Currently the longline data format from the Spanish fleet requires additional work in order to be incorporated into the WCPFC database.
- Catches of OCS and FAL to the north of 20°N, 20°N-20°S and south 20°S were estimated from nominal CPUE. It would be advantageous to use the estimation procedures of Peatman and Nicol (2020, 2023) to stratify to the north of 20°N, 20°N-20°S and south 20°S for comparison with estimates in the current study. An alternative estimation procedure would provide catches in areas in order to assess impacts of additional spatial management.

5 Acknowledgements

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Table 1. Longline oceanic whitetip shark (OCS) and silky shark (FAL) estimates by flag for three spatial areas (north of 20°N, 20°N to 20°S and south of 20°S) in the WCPFC Convention Area. Estimates were for the deep-set longline fishery (=>15 hooks between floats) and based on Regional Observer Program data from 2010 to 2023.

Flag	Sets >20N	Hooks >20N	OCS >20N	FAL >20N	OCS >20N CPUE	FAL >20N CPUE	Sets to capture one OCS	Sets to capture one FAL
CN	286	874,544	1	2	0.0011435	0.0022869	286.0	143.0
JP	1,733	3,396,680	6	13	0.0017664	0.0038273	288.8	133.3
TW	401	693,460	1	8	0.0014420	0.0115364	401.0	50.1
US	14,301	38,173,842	266	77	0.0069681	0.0020171	53.8	185.7
Total	16,721	43,138,526	274	100	0.0063516	0.0023181	61.0	167.2

Flag	Sets >20N-20S	Hooks 20N-20S	OCS 20N-20S	FAL 20N-20S	OCS 20N-20S CPUE	FAL 20N-20S CPUE	Sets to capture one OCS	Sets to capture one FAL
AS	83	228,561	17	23	0.0743784	0.1006296	4.9	3.6
CK	547	1,622,391	36	129	0.0221895	0.0795123	15.2	4.2
CN	12,367	32,180,550	1,362	2,995	0.0423237	0.0930686	9.1	4.1
FJ	1,431	4,312,119	134	1,035	0.0310752	0.2400212	10.7	1.4
FM	950	2,088,620	15	576	0.0071818	0.2757802	63.3	1.6
JP	1,694	3,428,602	69	1,279	0.0201248	0.3730383	24.6	1.3
KI	1,425	3,937,049	132	164	0.0335276	0.0416556	10.8	8.7
KR	8,261	16,590,481	947	6,059	0.0570809	0.3652094	8.7	1.4
MH	148	296,681	0	6	0	0.0202237	-	-
SB	723	1,737,122	19	248	0.0109376	0.1427649	38.1	2.9
TV	153	458,087	31	51	0.0676727	0.1113326	4.9	3.0
TW	31,112	53,174,779	1,291	9,517	0.0242784	0.1789758	24.1	3.3
US	15,004	38,963,037	2,745	2,619	0.0704514	0.0672176	5.5	5.7
VU	1,748	3,420,028	107	1,139	0.0312863	0.3330382	16.3	1.5
WF	72	122,043	2	31	0.0163877	0.2540088	36.0	2.3
WS	102	235,899	22	99	0.0932603	0.4196711	4.6	1.0
Total	75,820	162,796,049	6,929	25,970	0.0425625	0.1595248	10.9	2.9

Flag	Sets >20S	Hooks >20S	OCS >20S	FAL >20S	OCS >20S CPUE	FAL >20S CPUE	Sets to capture one OCS	Sets to capture one FAL
CK	109	327,762	1	1	0.0030510	0.0030510	109.0	109.0
CN	1,198	3,475,772	9	1	0.0025894	0.0002877	133.1	1,198.0
FJ	809	2,208,240	17	22	0.0076984	0.0099627	47.6	36.8
SB	105	290,908	0	2	0	0.0068750	-	52.5
TW	2,547	4,849,180	12	22	0.0024746	0.0045368	212.3	115.8
Total	4,768	11,151,862	39	48	0.0034972	0.0043042	122.3	99.3

Table 2. Longline oceanic whitetip shark (OCS) and silky shark (FAL) estimates estimates by flag for three spatial areas (north of 20°N, 20°N to 20°S and south of 20°S) in the WCPFC Convention Area. Estimates were for the shallow-set longline fishery (<15 hooks between floats) and based on Regional Observer Program data from 2010 to 2023.

Flag	Sets >20N	Hooks >20N	OCS >20N	FAL >20N	OCS >20N CPUE	FAL >20N CPUE	Sets to capture	Sets to capture
CN	68	190,120	0	0	0.0000000	0.0000000	-	-
JP	306	878,972	0	0	0.0000000	0.0000000	-	-
TW	3,043	4,841,644	56	35	0.0115663	0.0072289	54.3	86.9
US	6,495	7,281,132	90	4	0.0123607	0.0005494	72.2	1,623.8
VU	44	109,019	0	1	0.0000000	0.0091727	-	44.0
Total	9,956	13,300,887	146	40	0.0109767	0.0030073	68.2	248.9

Flag	Sets >20N-20S	Hooks 20N-20S	OCS 20N-20S	FAL 20N-20S	OCS 20N-20S CPUE	FAL 20N-20S CPUE	Sets to capture one OCS	Sets to capture one FAL
CN	88	154,288	1	0	0.0064814	0.0000000	88.0	-
TW	3,877	5,887,209	166	1,321	0.0281967	0.2243848	23.4	2.9
VN	111	68,600	0	0	0.0000000	0.0000000	-	-
Total	4,076	6,110,097	167	1,321	0.0273318	0.2161995	24.4	3.1

Flag	Sets >20S	Hooks >20S	OCS >20S	FAL >20S	OCS >20S CPUE	FAL >20S CPUE	Sets to capture	Sets to capture
JP	1,350	3,567,138	0	0	0.0000000	0.0000000	-	-
TW	3,185	5,651,147	0	2	0.0000000	0.0003539	-	1,592.5
VU	277	489,062	2	1	0.0040895	0.0020447	138.5	277.0
Total	4,812	9,707,347	2	3	0.0002060	0.0003090	2,406.0	1,604.0

Table 3. Longline oceanic whitetip shark (OCS) and silky shark (FAL) estimates by year for three spatial areas (north of 20°N, 20°N to 20°S and south of 20°S) in the WCPFC Convention Area. Estimates were for the deep-set longline fishery (=>15 Hooks between Floats) and based on Regional Observer Program data from 2010 to 2023.

Year	Sets >20N	Hooks >20N	OCS >20N	FAL >20N	OCS >20N CPUE	FAL >20N CPUE
2010	835	1,915,882	8	0	0.0041756	0
2011	754	1,788,563	12	1	0.0067093	0.0005591
2012	979	2,458,822	3	1	0.0012201	0.0004067
2013	1,246	3,061,880	8	0	0.0026128	0
2014	1,124	2,778,950	21	1	0.0075568	0.0003598
2015	1,233	2,807,991	18	4	0.0064103	0.0014245
2016	1,645	3,867,474	17	5	0.0043956	0.0012928
2017	1,581	3,918,119	12	10	0.0030627	0.0025522
2018	1,794	4,781,962	26	10	0.0054371	0.0020912
2019	1,248	3,414,392	57	31	0.0166940	0.0090792
2020	1,322	3,671,301	39	11	0.0106229	0.0029962
2021	1,115	3,200,469	17	11	0.0053117	0.0034370
2022	907	2,701,176	21	4	0.0077744	0.0014808
2023	938	2,771,545	15	11	0.0054121	0.0039689
Total	16,721					

Year	Sets >20N-20S	Hooks 20N-20S	OCS 20N-20S	FAL 20N-20S	OCS 20N-20S CPUE	FAL 20N-20S CPUE
2010	1076	2251644	200	180	0.0888240	0.0799416
2011	2258	4942789	267	1593	0.0540181	0.3222877
2012	3362	7603534	256	1235	0.0336686	0.1624245
2013	5469	9112390	407	1629	0.0446645	0.1787676
2014	4417	7540075	344	1164	0.0456229	0.1543751
2015	4742	8891285	468	2658	0.0526358	0.2989444
2016	4948	9621763	604	3396	0.0627744	0.3529499
2017	7005	15674410	677	3917	0.0431914	0.2498978
2018	7863	16866958	416	2950	0.0246636	0.1748982
2019	7757	17644537	575	2194	0.0325880	0.1243444
2020	5635	13191683	497	1041	0.0376753	0.0789134
2021	6372	14354436	743	1624	0.0517610	0.1131358
2022	7374	16638135	863	1467	0.0518688	0.0881709
2023	7542	18462410	612	922	0.0331484	0.0499393
Total	75,820					

Year	Sets >20S	Hooks >20S	OCS >20S	FAL >20S	OCS >20S CPUE	FAL >20S CPUE
2011	17	40,245	0	0	0	0
2012	38	111,902	0	0	0	0
2013	340	629,989	0	3	0	0.0047620
2014	317	434,536	2	4	0.0046026	0.0092052
2015	89	221,313	5	0	0.0225924	0
2016	235	516,496	0	0	0	0
2017	428	1,097,684	1	11	0.0009110	0.0100211
2018	773	1,892,573	4	14	0.0021135	0.0073973
2019	928	2,409,079	10	9	0.0041510	0.0037359
2020	923	2,082,261	13	4	0.0062432	0.0019210
2021	251	565,935	0	1	0	0.0017670
2022	137	344,184	3	0	0.0087163	0
2023	292	805,665	1	2	0.0012412	0.0024824
Total	4,768					

Table 4. Longline oceanic whitetip shark (OCS) and silky shark (FAL) estimates estimates by year for three spatial areas (north of 20°N, 20°N to 20°S and south of 20°S) in the WCPFC Convention Area. Estimates were for the shallow-set longline fishery (<15 hooks between floats) and based on Regional Observer Program data from 2010 to 2023.

Year	Sets >20N	Hooks >20N	OCS >20N	FAL >20N	OCS >20N CPUE	FAL >20N CPUE
2010	781	763,172	10	0	0.0131032	0
2011	606	621,012	10	0	0.0161027	0
2012	632	780,899	3	0	0.0038417	0
2013	588	823,976	7	0	0.0084954	0
2014	851	948,238	13	2	0.0137096	0.0021092
2015	622	920,305	11	0	0.0119526	0
2016	530	672,925	10	0	0.0148605	0
2017	908	1,302,972	16	18	0.0122796	0.0138146
2018	666	1,073,803	27	9	0.0251443	0.0083814
2019	656	861,489	1	1	0.0011608	0.0011608
2020	280	409,744	2	2	0.0048811	0.0048811
2021	852	1,244,980	16	7	0.0128516	0.0056226
2022	1,123	1,750,299	9	0	0.0051420	0
2023	861	1,127,073	11	1	0.0097598	0.0008873
Total	9,956					
Year	Sets >20N-20S	Hooks 20N-20S	OCS 20N-20S	FAL 20N-20S	OCS 20N-20S CPUE	FAL 20N-20S CPUE
2011	134	129,955	0	12	0	0.0923397
2012	24	37,231	0	40	0	1.0743735
2013	488	371,339	0	460	0	1.2387603
2014	29	40,644	1	3	0.0246039	0.0738116
2015	119	89,138	15	47	0.1682784	0.5272723
2016	164	159,450	8	29	0.0501725	0.1818752
2017	964	1,745,816	65	347	0.0372319	0.1987609
2018	780	1,444,980	29	75	0.0200695	0.0519038
2019	791	1,078,892	36	222	0.0333676	0.2057667
2020	258	492,737	5	29	0.0101474	0.0588549
2021	294	468,553	6	32	0.0128054	0.0682954
2022	31	51,362	2	25	0.0389393	0.4867412
Total	4,076					
Year	Sets >20S	Hooks >20S	OCS >20S	FAL >20S	OCS >20S CPUE	FAL >20S CPUE
2011	33	100,139	0	0	0	0
2012	322	998,719	0	2	0	0.0020026
2013	489	515,576	0	0	0	0
2014	539	571,740	0	0	0	0
2015	580	1,142,163	0	0	0	0
2016	579	1,194,434	0	0	0	0
2017	305	748,699	0	0	0	0
2018	346	728,775	0	0	0	0
2019	786	1,799,550	2	1	0.0011114	0.0005557
2020	225	526,163	0	0	0	0
2021	165	340,554	0	0	0	0
2022	281	676,578	0	0	0	0
2023	162	364,257	0	0	0	0
Total	4,812					

Table 5. Annual longline effort (million hooks) by year for three spatial areas (north of 20°N, 20°N to 20°S and south of 20°S) in the WCPFC Convention Area. Estimates were for the deep and shallow-set longline fisheries and based on L_BEST (SPC data product).

Year	Hooks_20N	Hooks_20N_20S	Hooks_20S
2010	142.98	934.70	92.20
2011	164.44	1040.98	69.59
2012	155.81	1099.39	78.46
2013	126.44	909.89	75.46
2014	133.35	950.33	79.02
2015	125.29	1002.05	84.43
2016	131.56	931.75	68.52
2017	121.09	830.11	92.27
2018	113.62	897.13	88.30
2019	124.40	875.51	81.49
2020	125.67	776.88	101.16
2021	114.56	699.64	75.60
2022	99.77	706.53	60.58
2023	109.10	679.07	67.70

Table 6. Longline oceanic whitetip shark (OCS) estimates by year for three spatial areas (north of 20°N, 20°N to 20°S and south of 20°S) in the WCPFC Convention Area. Estimates were calculated by nominal CPUE and compared to estimates from Peatman and Nicol (2023).

Year	OCS_nominal >20N	OCS_nominal_20N_20S	OCS_nominal >20S	Total	OCS_Peatman and Nicol 2023
2010	597	83,024		83,621	59,500
2011	1,103	56,232	0	57,335	61,500
2012	190	37,015	0	37,205	63,200
2013	330	40,640	0	40,970	41,300
2014	1,008	43,357	364	44,728	35,700
2015	803	52,744	1,908	55,454	42,800
2016	578	58,490	0	59,069	33,800
2017	371	35,854	84	36,309	28,200
2018	618	22,127	187	22,931	26,200
2019	2,077	28,531	338	30,946	32,300
2020	1,335	29,269	632	31,236	33,600
2021	609	36,214	0	36,823	26,700
2022	776	36,647	528	37,950	
2023	590	22,510	84	23,185	

Table 7. Longline silky shark (FAL) estimates by year for three spatial areas (north of 20°N, 20°N to 20°S and south of 20°S) in the WCPFC Convention Area. Estimates were calculated by nominal CPUE and compared to estimates from Peatman and Nicol (2023).

Year	FAL_nominal_20N	FAL_nominal_20N_20S	FAL_nominal_20S	Total	_Peatman and Nicol 2023
2010	0	74,721	0	74,721	346,000
2011	92	335,496	0	335,588	369,000
2012	63	178,568	0	178,632	381,000
2013	0	162,658	359	163,018	162,000
2014	48	146,707	727	147,482	113,000
2015	178	299,556	0	299,735	152,000
2016	170	328,863	0	329,033	149,000
2017	309	207,444	925	208,677	134,000
2018	238	156,907	653	157,798	116,000
2019	1,129	108,865	304	110,299	123,000
2020	377	61,306	194	61,877	105,000
2021	394	79,154	134	79,682	69,700
2022	148	62,295	0	62,443	
2023	433	33,912	168	34,513	
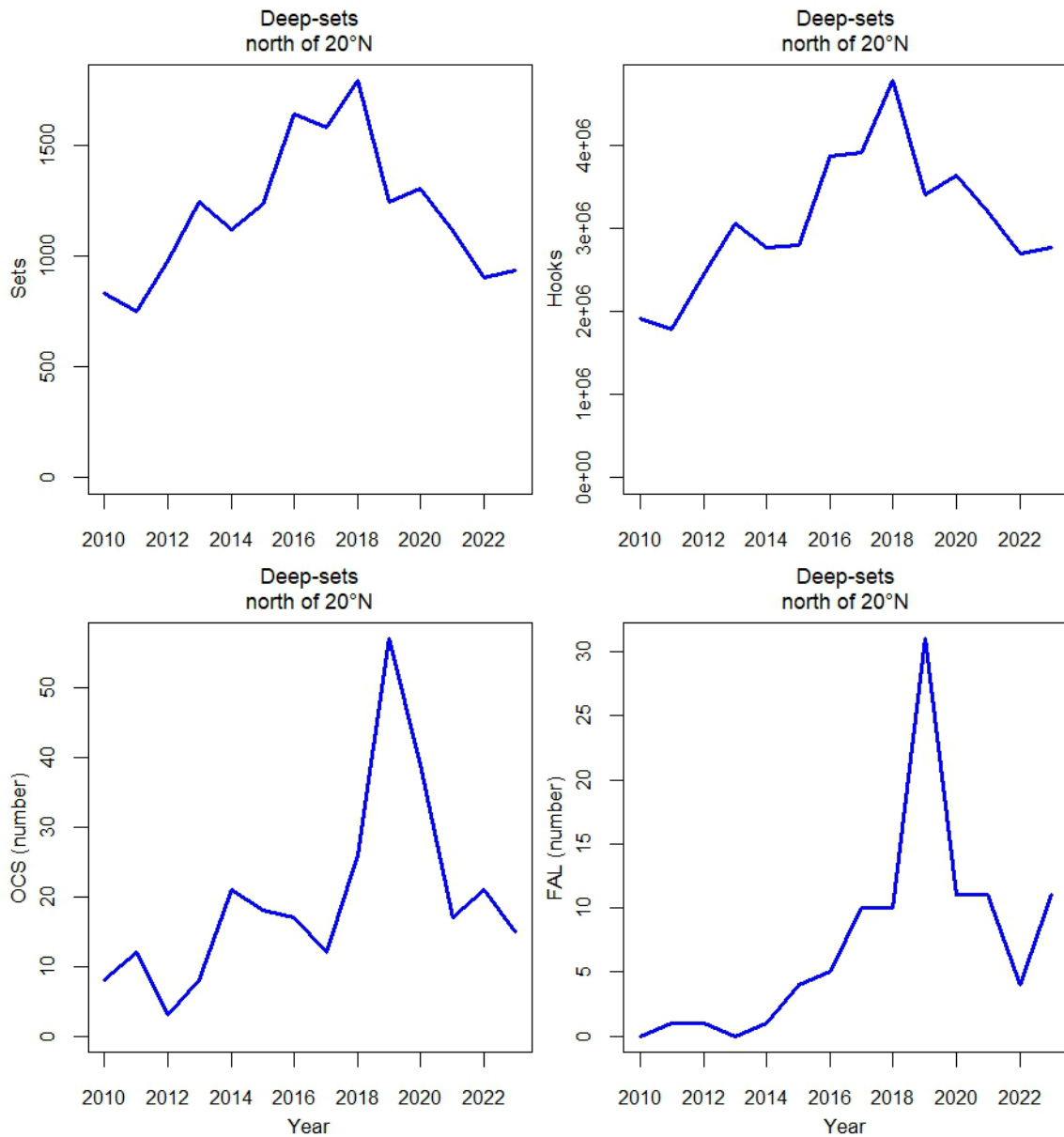
Figure 1. Longline estimates for sets, hooks, oceanic whitetip shark (OCS) and silky shark (FAL) by year for the spatial area to the north of north of 20°N in the WCPFC Convention Area. Estimates were for the deep-set longline fishery (=>15 hooks between floats) and based on Regional Observer Program data from 2010 to 2023.
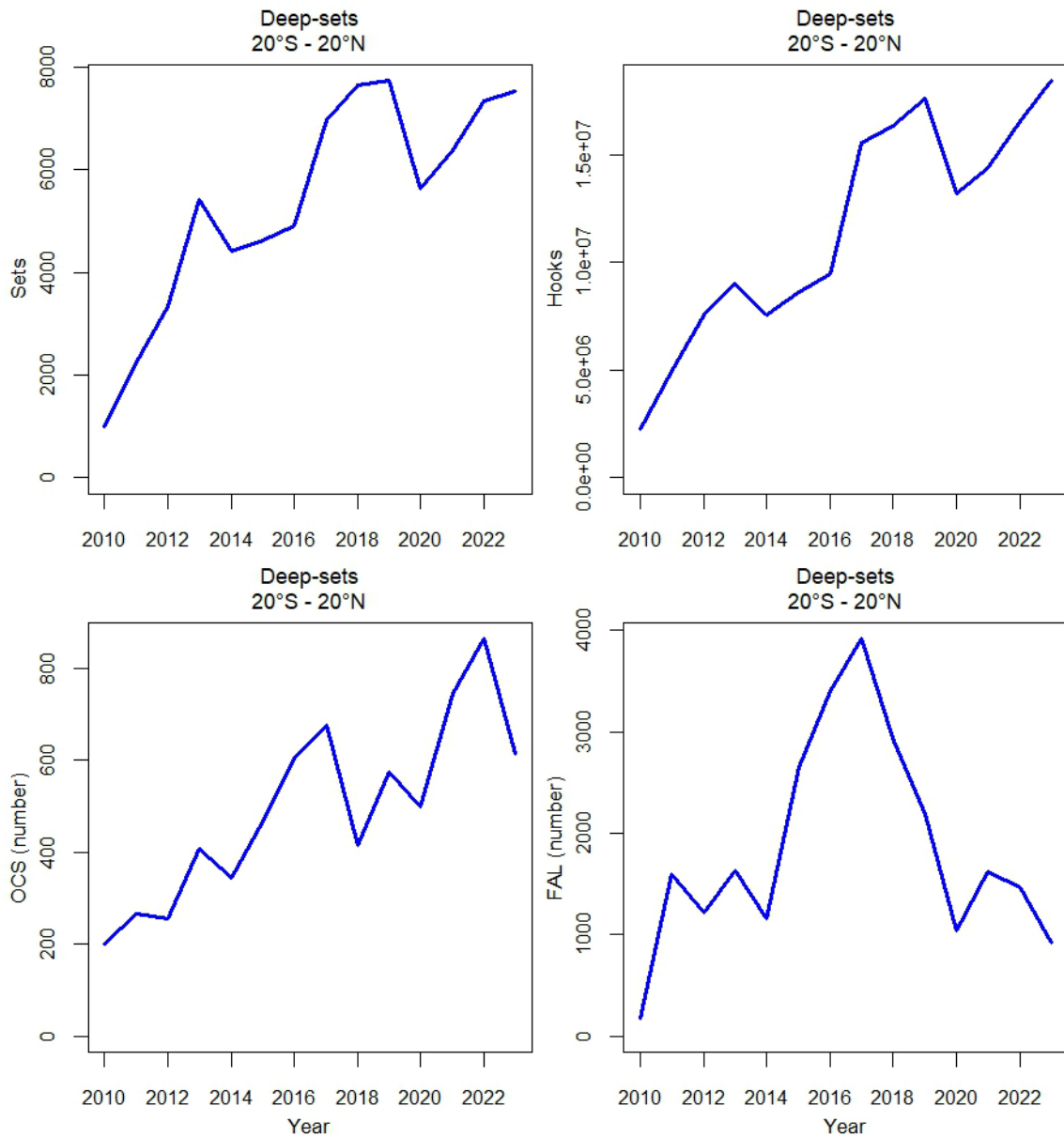
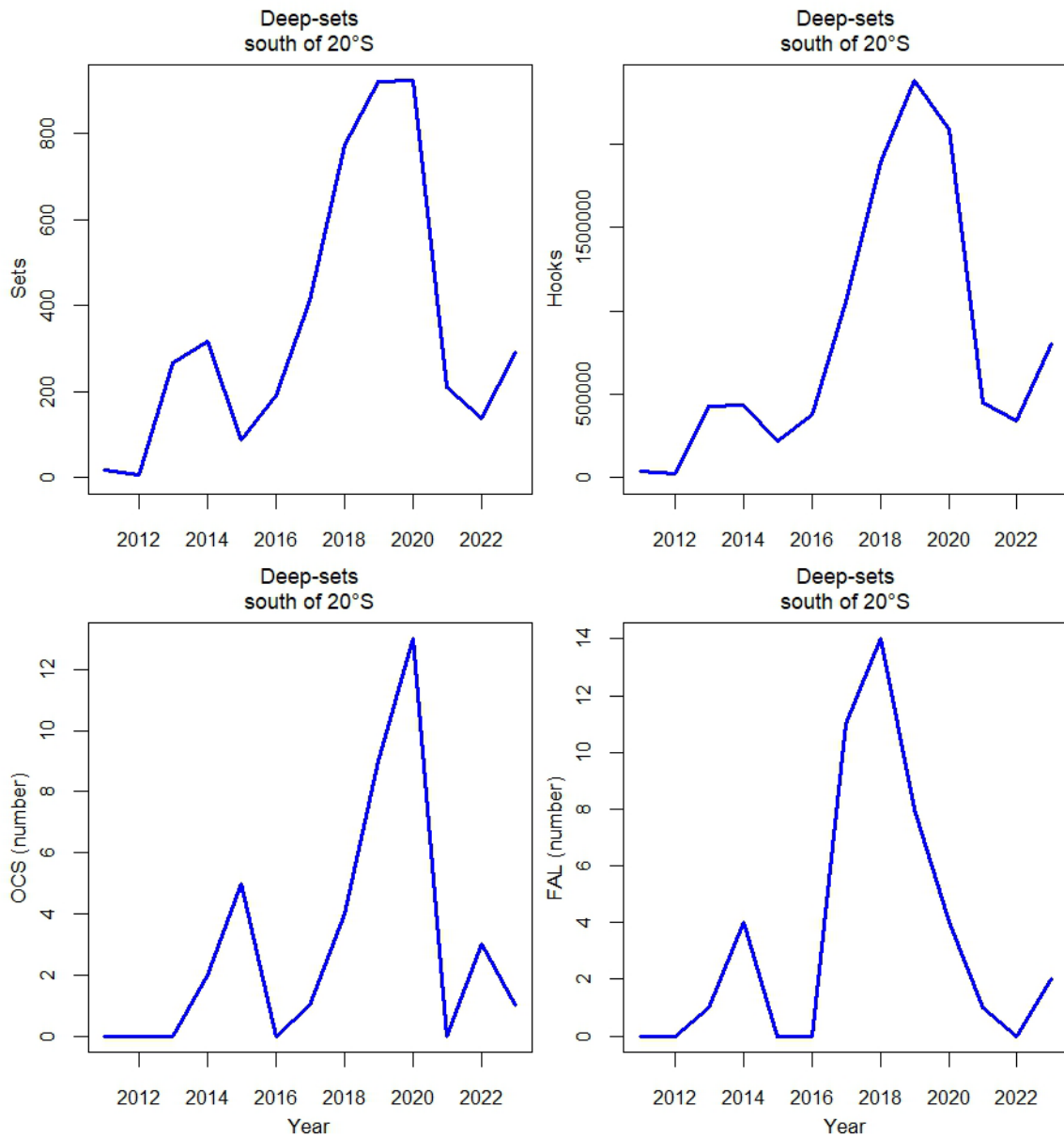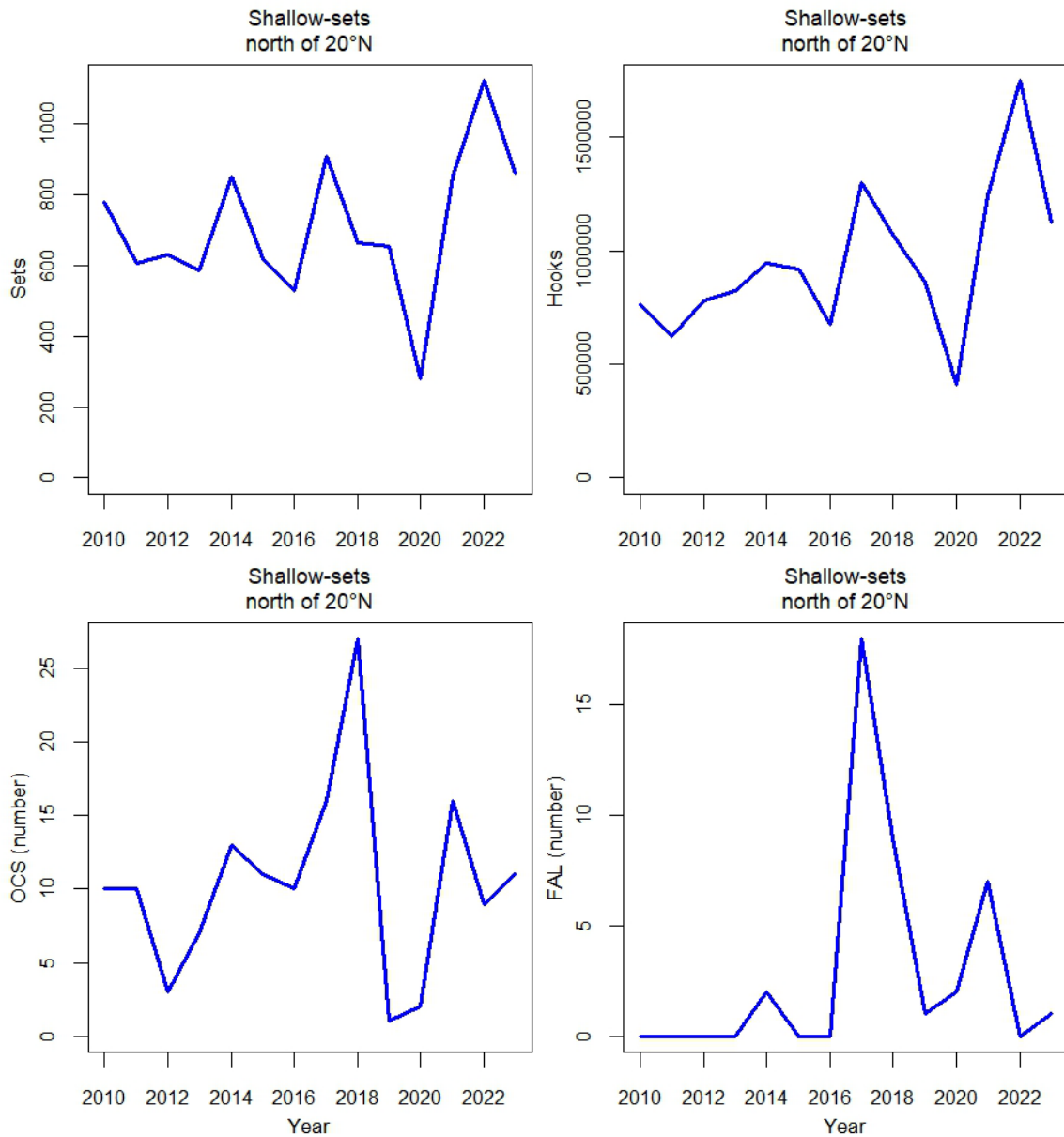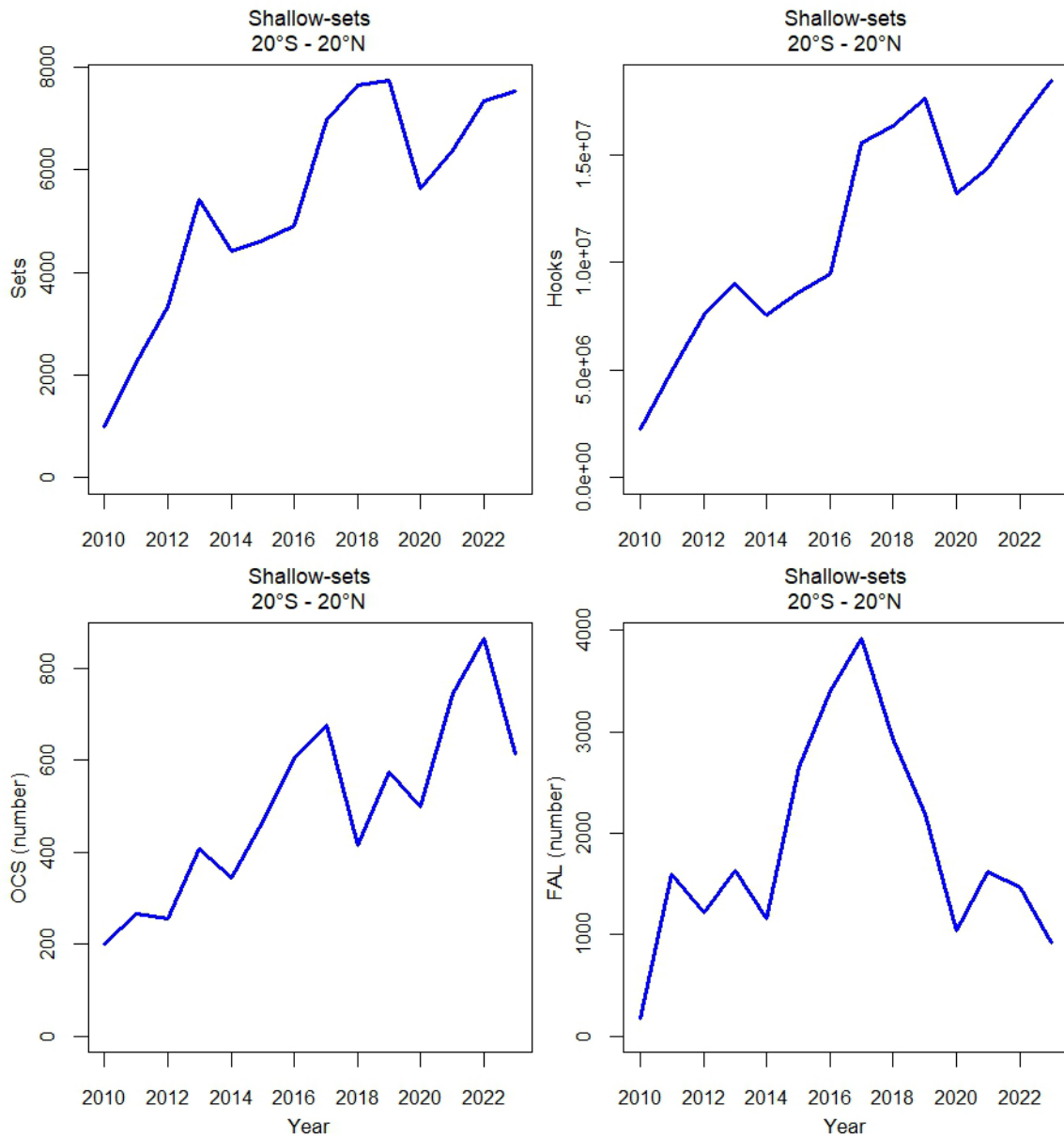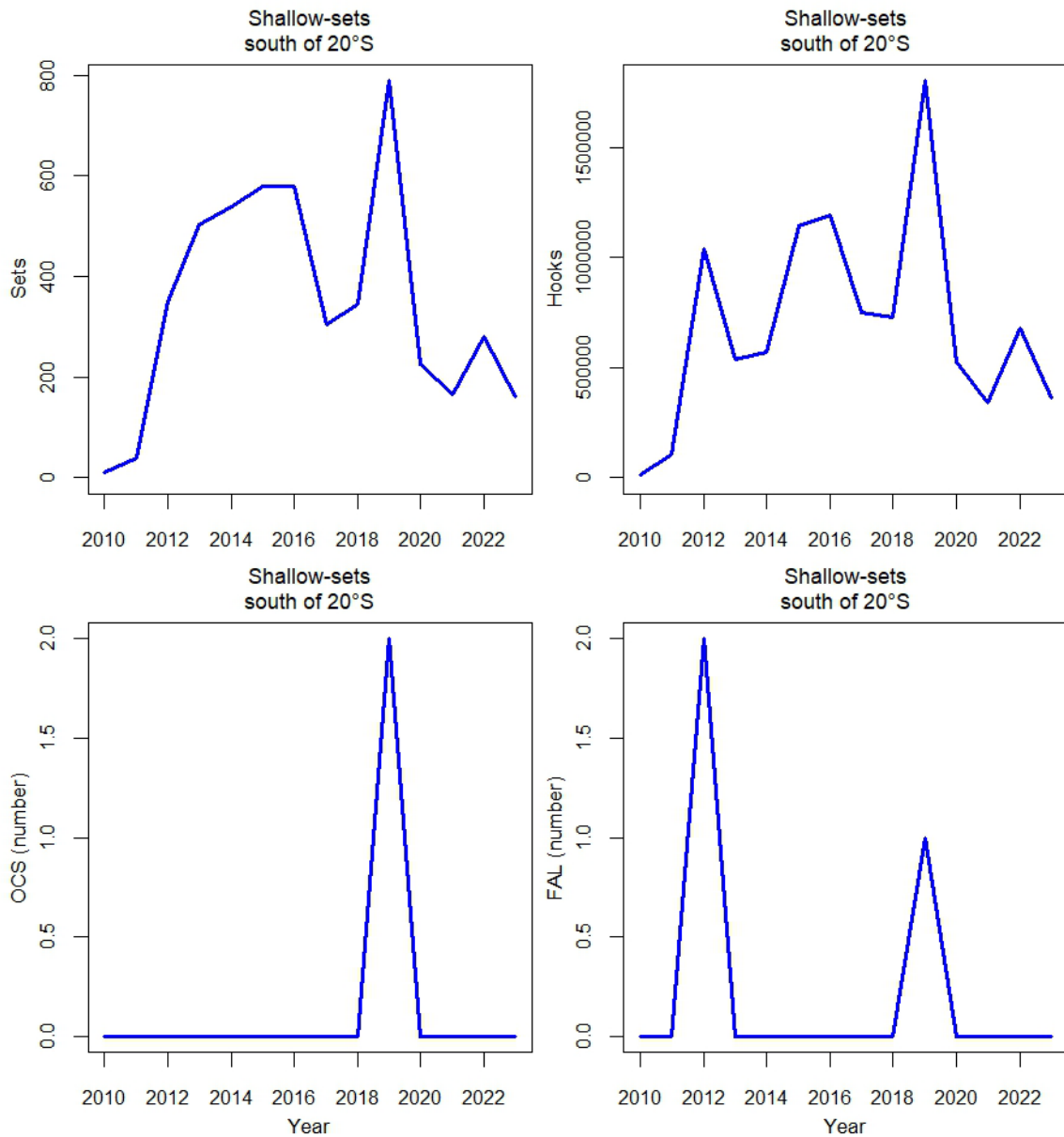*Figure 2.* Longline estimates for sets, hooks, oceanic whitetip shark (OCS) and silky shark (FAL) by year for the spatial area 20°N to 20°S in the WCPFC Convention Area. Estimates were for the deep-set longline fishery (=>15 hooks between floats) and based on Regional Observer Program data from 2010 to 2023.

Figure 3. Longline estimates for sets, hooks, oceanic whitetip shark (OCS) and silky shark (FAL) by year for the spatial area south of 20°S in the WCPFC Convention Area. Estimates were for the deep-set longline fishery (=>15 hooks between floats) and based on Regional Observer Program data from 2010 to 2023.

Figure 4. Longline estimates for sets, hooks, oceanic whitetip shark (OCS) and silky shark (FAL) by year for the spatial area to the north of north of 20°N in the WCPFC Convention Area. Estimates were for the shallow-set longline fishery (<15 hooks between floats) and based on Regional Observer Program data from 2010 to 2023.
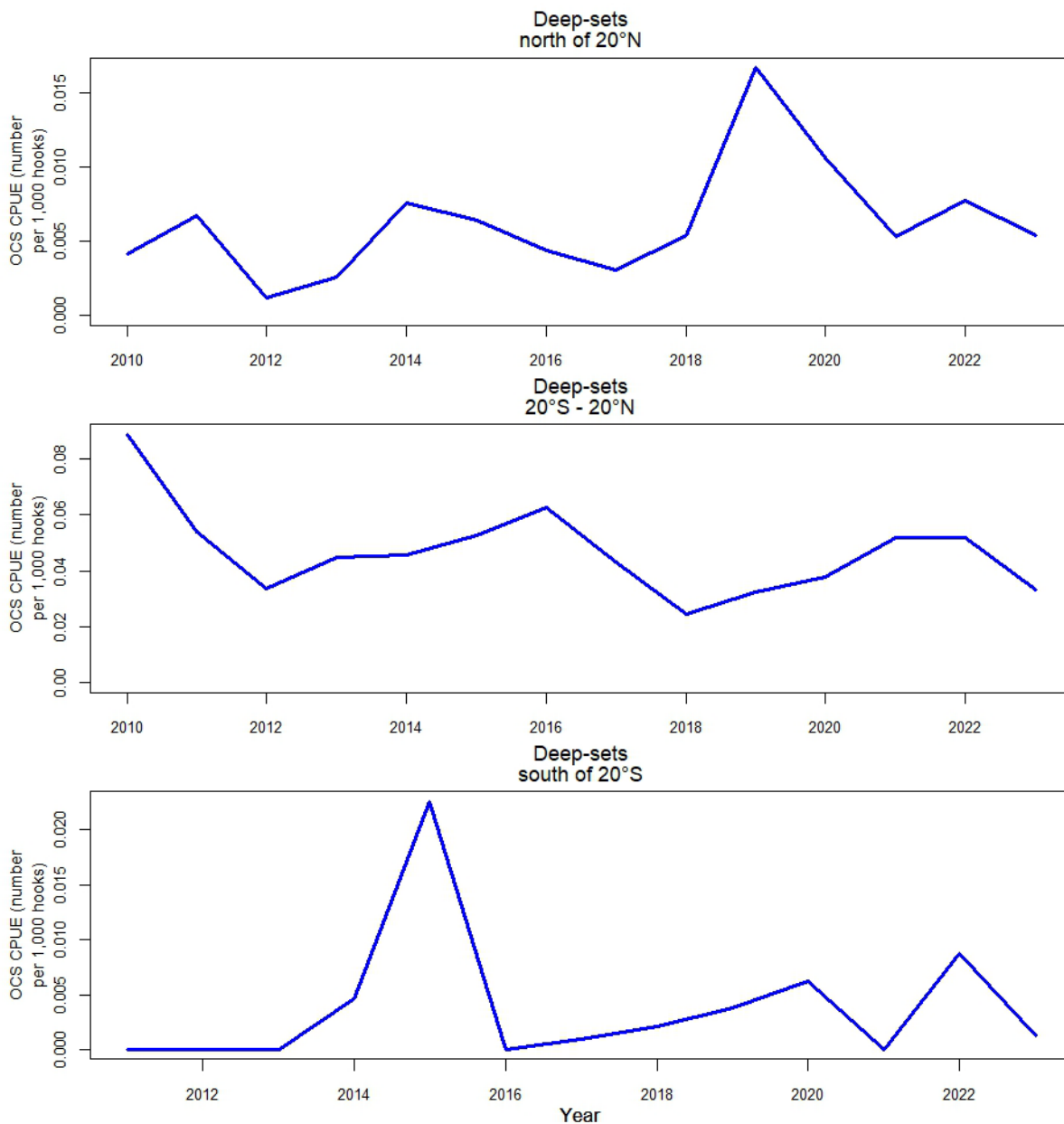
Figure 5. Longline estimates for sets, hooks, oceanic whitetip shark (OCS) and silky shark (FAL) by year for the spatial area 20°N to 20°S in the WCPFC Convention Area. Estimates were for the shallow-set longline fishery (<15 hooks between floats) and based on Regional Observer Program data from 2010 to 2023.

Figure 6. Longline estimates for sets, hooks, oceanic whitetip shark (OCS) and silky shark (FAL) by year for the spatial area south of 20°S in the WCPFC Convention Area. Estimates were for the shallow-set longline fishery (<15 hooks between floats) and based on Regional Observer Program data from 2010 to 2023.
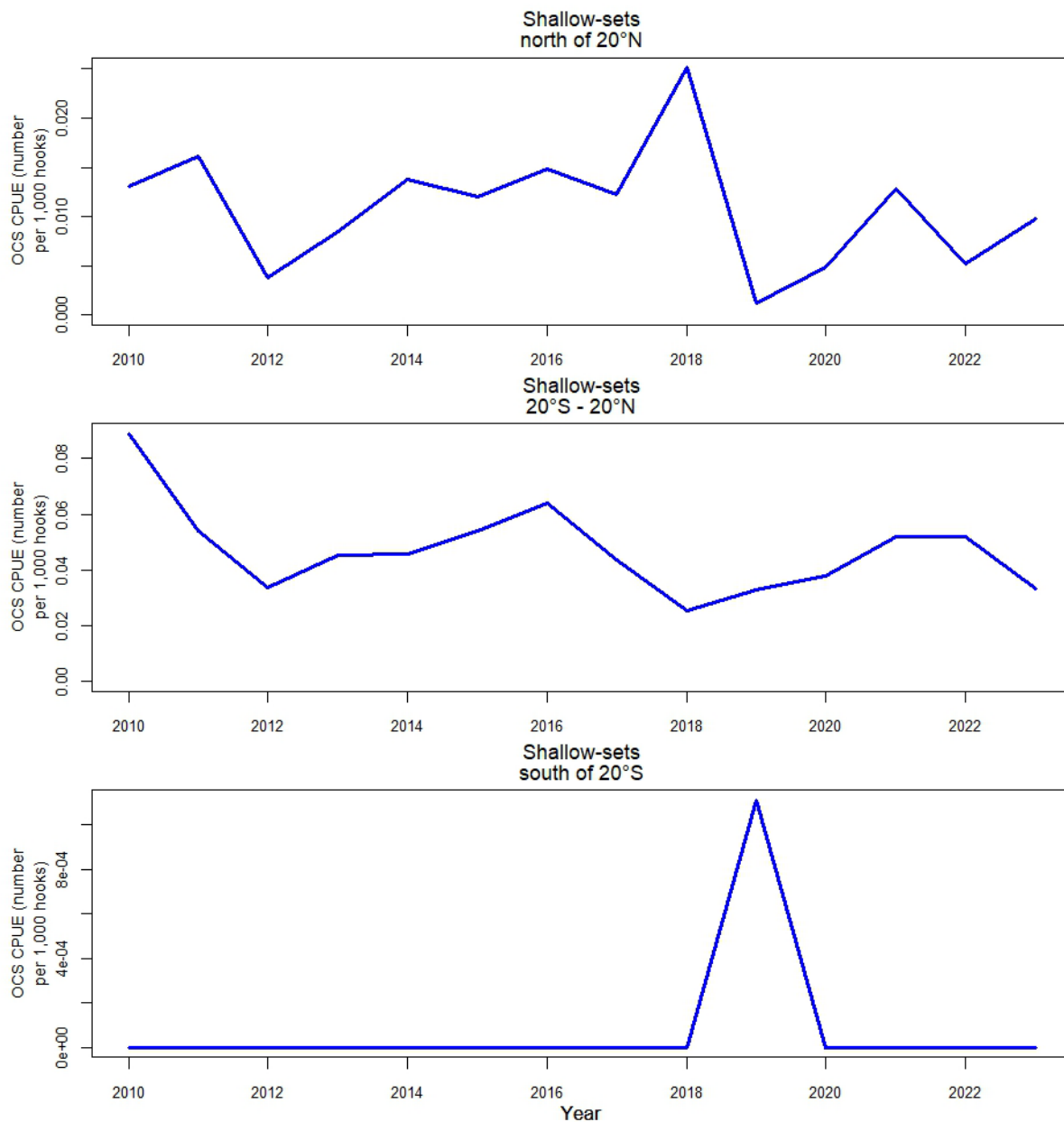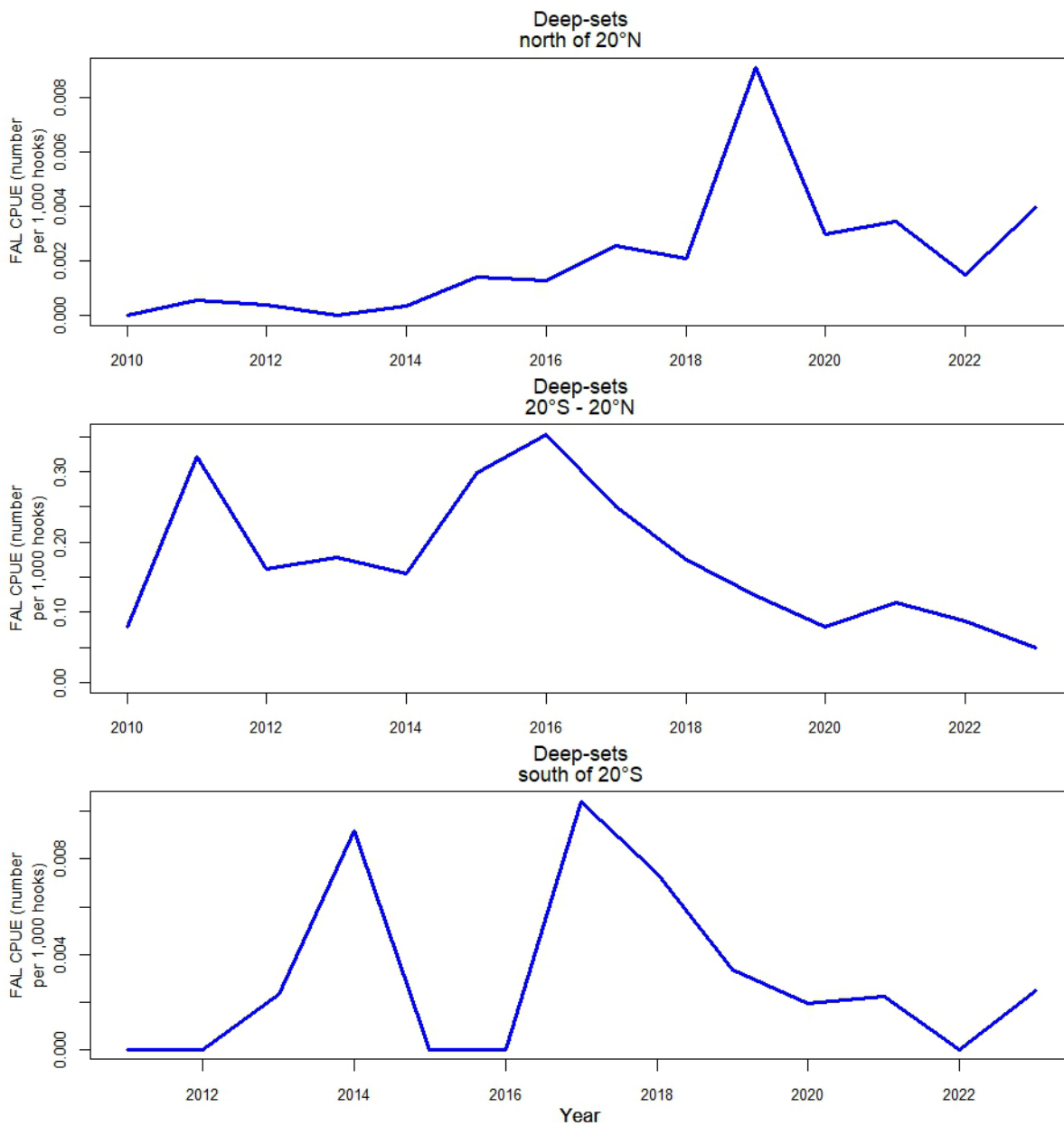
Figure 7. Longline oceanic whitetip shark (OCS) CPUE estimates by year for three spatial areas (north of 20°N, 20°N to 20°S and south of 20°S) in the WCPFC Convention Area. Estimates were for the deep-set longline fishery (=>15 hooks between floats) and based on Regional Observer Program data from 2010 to 2023.

Figure 8. Longline oceanic whitetip shark (OCS) CPUE estimates by year for three spatial areas (north of 20°N, 20°N to 20°S and south of 20°S) in the WCPFC Convention Area. Estimates were for the shallow-set longline fishery (<15 hooks between floats) and based on Regional Observer Program data from 2010 to 2023.
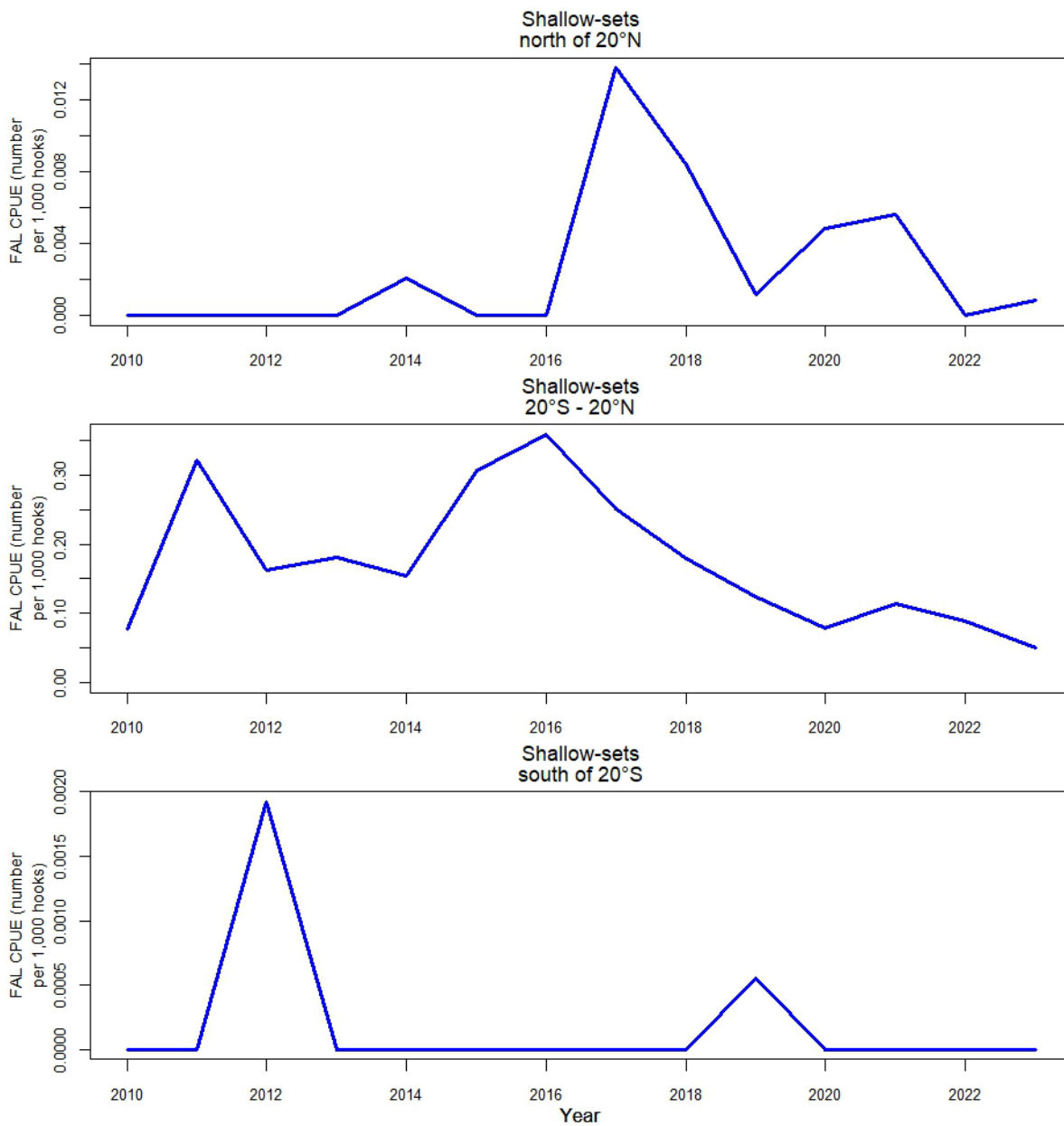
Figure 9. Longline silky shark (FAL) CPUE estimates by year for three spatial areas (north of 20°N, 20°N to 20°S and south of 20°S) in the WCPFC Convention Area. Estimates were for the deep-set longline fishery (=>15 hooks between floats) and based on Regional Observer Program data from 2010 to 2023.

Figure 10. Longline silky shark (FAL) CPUE estimates by year for three spatial areas (north of 20°N, 20°N to 20°S and south of 20°S) in the WCPFC Convention Area. Estimates were for the shallow-set longline fishery (<15 hooks between floats) and based on Regional Observer Program data from 2010 to 2023.
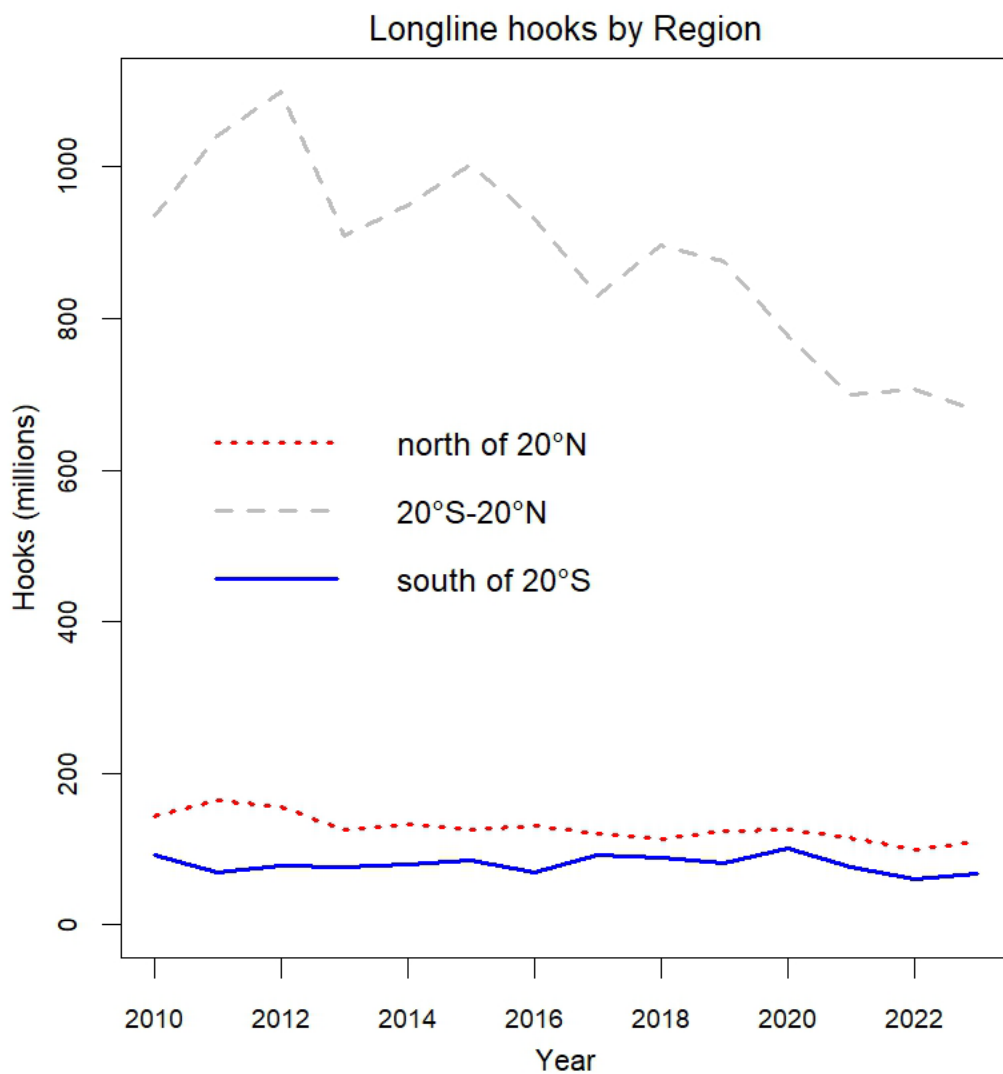
Figure 11. Annual longline effort (million hooks) by year for three spatial areas (north of 20°N, 20°N to 20°S and south of 20°S) in the WCPFC Convention Area. Estimates were for the deep and shallow-set longline fisheries and based on L_BEST (SPC data product).