Report Code: AR_SNAPPER_COMPARISON_050525

Recent trends in catch characteristics indicating changes in the stocks of snappers and groupers in the Indonesian deep demersal fisheries

YKAN Technical Paper

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MAY 5, 2025



PEOPLE & NATURE CONSULTING INTERNATIONAL

KEMENTERIAN KELAUTAN DAN PERIKANAN

10 2014 - 2024

Konservasi Alam Nusantara
Untuk Indonesia Lestari

Abstract

Length-based stock assessments showed high risk of overfishing and further declining trends in the Indonesian deep demersal fisheries for snappers and groupers in 2020 (Pet et al., 2023). Almost all of the larger target species, especially the larger snappers, were harvested well below the optimum size, and bigger specimens (mega spawners) of these species had become extremely rare by 2020. In the present study we seek to find out if any major changes have occurred in recent years after 2020. For this purpose, we implemented follow-up surveys in 2023 focussing on the same species of snappers and groupers, as well as on the main Indonesian fisheries management areas where these are caught, and on the main fleet segments catching them.

The current follow-up study shows that risk levels have remained high, and have even further increased since 2020, across multiple length-based indicators for most target species in most segments of the Indonesian deep demersal fisheries. Direct comparisons of median lengths between 2020 and 2023 show that these have further declined for many species and in many fisheries segments, except for a few cases in WPP 711 and the western part of WPP 712. In these latter cases though, the median lengths have come from very low levels in 2020 and were mostly still well below the size of maturity for target species by 2023, leaving these fisheries also at very high risk. Especially risk levels related to the relative abundance of large mature fish and mega spawners in the catch were extremely high across the Indonesian deep demersal fisheries in 2023, and have not improved or have even further declined since 2020, in a continuation of previously recorded trends.

Suggested citation

Pet, J.S., W.B. IGede, and S. Agustina, 2025. Recent trends in catch characteristics indicating changes in the stocks of snappers and groupers in the Indonesian deep demersal fisheries. Yayasan Konservasi Alam Nusantara and People & Nature Consulting International, Bali Indonesia. Report AR_SNAPPER_COMPARISON_050525

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1 Introduction

Deep demersal fisheries targeting snappers (Lutjanidae) and groupers (Epinephelidae) in Indonesia yielded close to 119,000 Metric Tons over a range of 100 species of fish, landed by a fleet of more than 11,500 fishing boats in 2020 (Pet et al., 2023). With a contribution of 81% to the catch of the Top 100 species in 2020, snappers and groupers were the dominant families in these fisheries. Groupers made up a smaller part of total landings than snappers, but are of considerable economic importance due to the high price per kg for these species (Khasanah et al., 2019). The substantial bycatch in these fisheries includes trevallies (Carangidae), emperors (Lethrinidae), grunts (Haemulidae), croakers (Sciaenidae) as well as species from many other co-occurring families (Dimarchopoulou et al., 2021).

Indonesian production of snappers alone had previously been estimated to contribute some 119,000 Metric Tons (MT) or 45% of the average global supply of just over 264,000 MT annually in the period 2006 to 2013 (Cawthorn and Mariani, 2017). Therewith Indonesia was by far the single largest Lutjanid-producing country in the World during that time. In a separate study on supply lines and official statistics, total snapper landings in Indonesia were estimated to reach 117,000 MT in 2007 (Anggraeni, 2012). Snapper landings in Indonesia therewith may have plateaued somewhere close to 120.000 MT well before 2020.

Concerns about the health of the target stocks started to grow between 2010 and 2015, as catches were not increasing while fishing fleets expanded and became more efficient. At the same time interest grew in potential certification of fisheries that supply western markets. It became clear though that these "data poor" fisheries needed to be better defined, monitored and assessed, before effective management would become possible. Before 2015, information on these dispersed small- to medium-scale fisheries was scarce, while reliable species-specific data on catch and effort were non-existent. This data-deficiency made stock assessments impossible and harvest strategies could not be specified.

A Crew-Operated Data Recording System (CODRS) was therefore developed to collect species- and length-composition data from catches across all segments of the fleet and to enable a length-based stock assessment (Pet et al., 2023). The CODRS approach involves fishers taking photographs of all fish in the catch, displayed on measuring boards, while a GPS tracking system provides data on fishing grounds, effort, and fleet dynamics. Our target fisheries operate mostly at depths between 30 and 350 meters and to differentiate from shallow water and coral reef fisheries which target species from the same families of fish, we refer to the "*deep demersal fisheries for snappers and groupers*". In our recent study (Pet et al., 2023) we focused stock assessments on the Top 16 species (Figures 1.1 and 1.2) from these 2 families, which together represented 71% of the catch in 2020. We used Spawning Potential Ratio (SPR), percentage immature fish in the catch, exploitation level, and relative amount of "mega-spawners" (Froese, 2004), as indicators for sustainability.

Our length-based stock assessments showed high risk of overfishing in the Indonesian deep demersal fisheries for snappers and groupers in 2020 (Pet et al., 2023). Most of the target species of snappers and groupers show a rapid decline in numbers above the size where the species becomes vulnerable to the fisheries, indicating high fishing mortality. Time series up to 2020 also showed a deteriorating trend in the stocks of most

species, across all major Fisheries Management Areas (FMAs). Over 90% of the most relevant combinations of species, FMA, and sustainability indicator led to conclusions of unsustainable levels of exploitation in 2020, while close to 70% of combinations showed a deteriorating trend. In the present study we seek to find out if any major changes have occurred in recent years after 2020. For this purpose we implemented follow-up surveys in 2023 focussing again on the same Top 16 species of snappers and groupers, as well as on the main Indonesian fisheries management areas where these are caught, and on the main fleet segments catching them.



Figure 1.1: Top 8 out of Top 16 species of snappers and groupers, based on volumes caught in 2020, with maximum lengths recorded, in the Indonesian deep demersal fisheries.

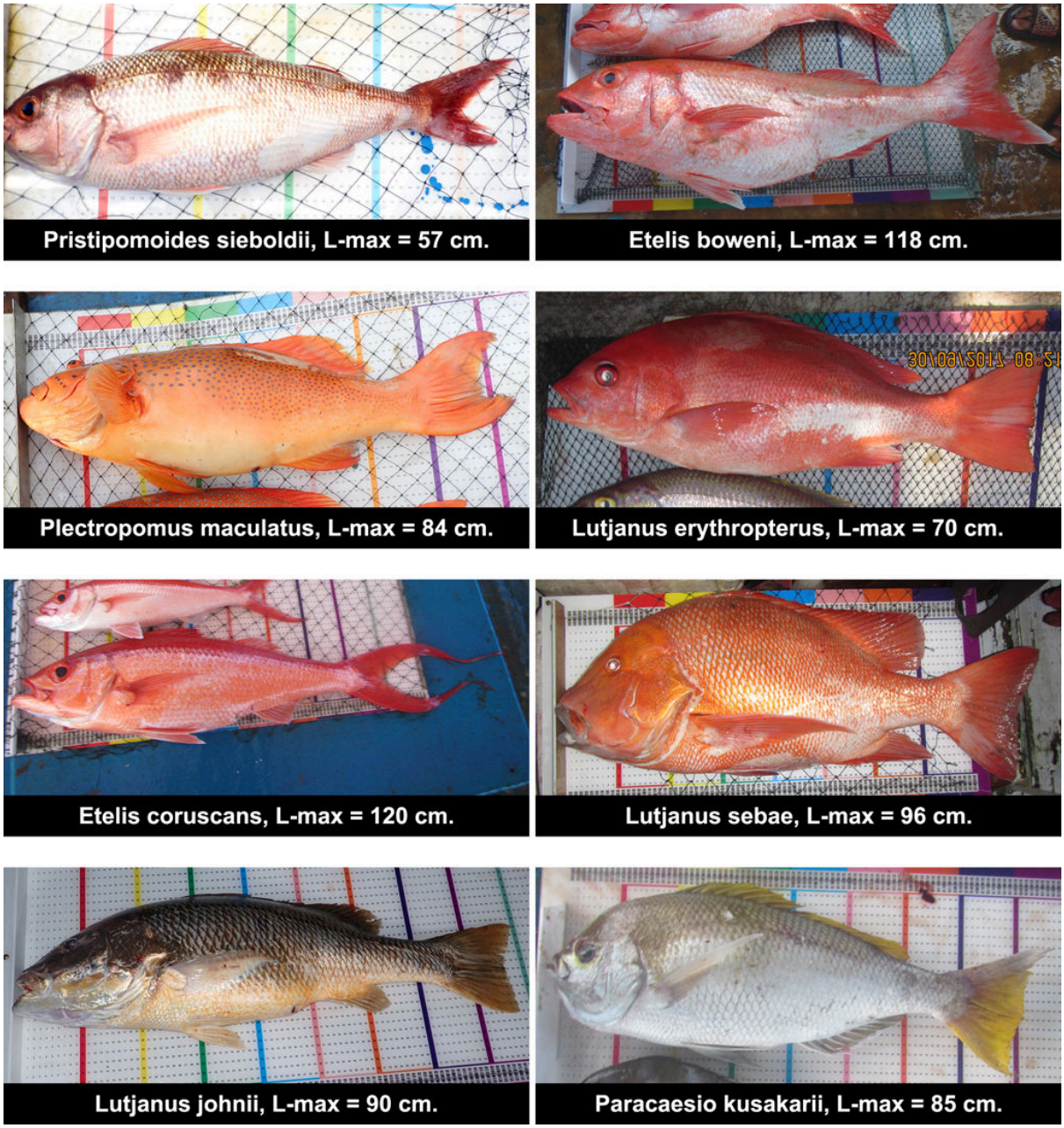


Figure 1.2: Bottom 8 out of Top 16 species of snappers and groupers, based on volumes caught in 2020, with maximum lengths recorded, in the Indonesian deep demersal fisheries.

Management of Indonesia's fisheries is organized across 11 Fisheries Management Areas or Wilayah Pengelolaan Perikanan (WPP). These FMAs include multiple water bodies, joining the Indian Ocean in the southwest and mingling with the Pacific Ocean in the northeast (Figure 1.3). Habitats and fisheries characteristics differ considerably between FMAs. The bathymetry of FMAs 573, 713, 714, 715, 716 and 717 is characterized by narrow coastal shelves, seamounts, and deep trenches. The bathymetry of FMA 711, 712 and 718 is mostly comprised of shallow waters over continental shelves (30 to 100 m depth). FMAs 571 and 572 have a mix of shallow continental shelf habitat and deeper slopes and drop offs in the Indian Ocean and Malacca Strait, around Sumatra. Due to differences in bathymetry, snapper and grouper production can greatly differ even between neighbouring FMAs.

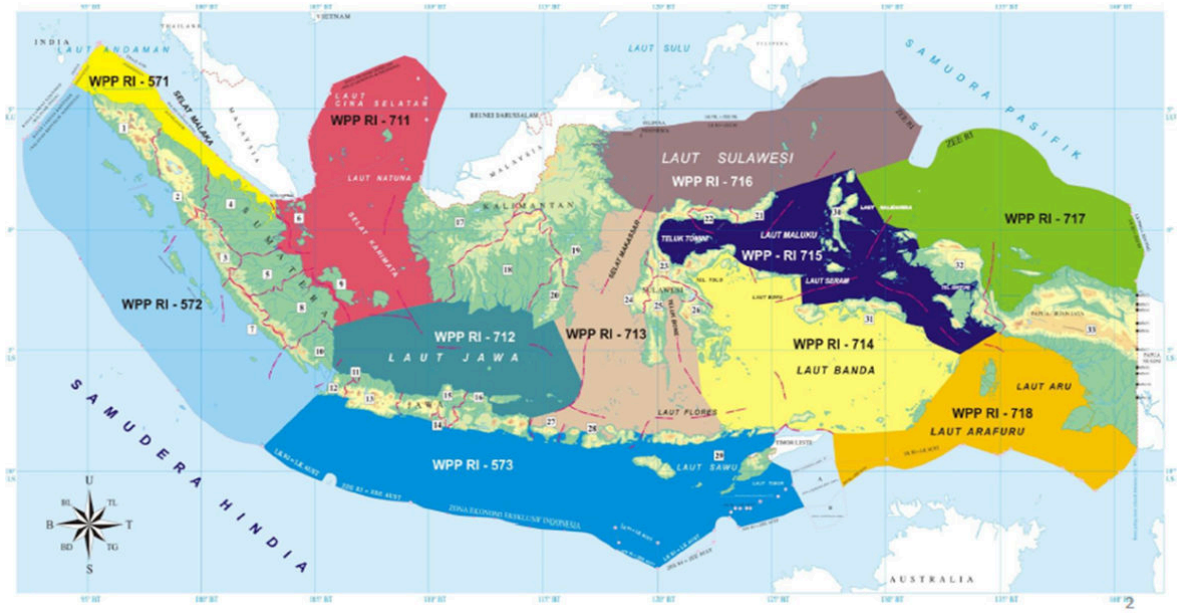


Figure 1.3: Fisheries Management Areas (*Wilayah Pengelolaan Perikanan* or WPP) in Indonesian marine waters.

Between 2015 and 2020 we developed the CODRS, starting in FMA 573, including the Timor and Savu Seas, as well as the Sumbawa, Lombok, Bali and Java southern coastlines, facing the Indian Ocean. By 2018 the program had expanded to all Indonesian fishing grounds including the Malacca Strait on the North East side of Sumatra (FMA 571), the Indian Ocean on the South West side of Sumatra (FMA 572), the Natuna Sea and the Karimata Strait (FMA 711), The Java Sea (FMA 712), the Makassar Strait (FMA 713), the Banda Sea (FMA 714), the Molucca and Seram Seas (FMA 715), the Sulu Sea (FMA 716), the Western Pacific Ocean (FMA 717), and the Arafura Sea (FMA 718).

Based on total landings in the deep demersal fisheries, with a focus on snappers and groupers, as well as on government policy priorities, we selected only the most important FMAs (Pet et al., 2023) for our follow up survey in 2023 (this study). Following practices by fisheries managers in Indonesia and in line with our previous approach (Pet et al., 2023) we distinguished 4 boat size categories including "nano" (<5 GT), "small" (5-<10 GT), "medium" (10-30 GT), and "large" (>30 GT). We also distinguish again the same 4 major gear types used in these fisheries, including vertical drop lines, bottom long lines, deep water gillnets, and traps. For our follow up survey in 2023 we focussed on the 3 most important gear types for our target species, which are drop lines, long lines and traps. To maximize sample sizes with a minimal number of CODRS contracts, we focussed on the fleet segments with the largest vessels, producing the largest catches, and thus the largest sample sizes for our follow up survey. With this approach we could make a comparison of catch characteristics like median lengths and catch per unit of effort (CPUE), within selected FMAs and fleet segments, between 2020 and 2023, and quantify any changes for these (important) cases.

2 Materials and Methods

In the present study we seek to find out if by 2023 any changes had occurred in length-based catch characteristics and Catch per Unit of Effort (CpUE) from the Indonesian deep demersal fisheries for snappers and groupers, since the 2020 Holistic Assessment (Pet et al., 2023). That assessment was for the Top 16 snappers and groupers, representing the main spectrum of target species in these fisheries, and resulting in conclusions on status of stocks as well as trends therein, from length-based indicators. In the 2020 assessment, we focused for each of the Top 16 species on the main 2 Fisheries Management Areas (FMA), or Wilayah Pengelolaan Perikanan (WPP), where the largest catches for that species were realized, and we noted which gear types produced the bulk of the catches for each species and WPP (Table 2.1). In Tables 2.2 and 2.3 the assessment results from 2020 are presented for those species and WPPs. This combination of the most important species and most productive WPPs, with their 2020 assessments, forms the basis for our comparison of 2023 catch characteristics with the situation back in 2020 and before.

Table 2.1: Total catch volume in Metric Tons (MT) for Top 16 snapper and grouper species in the Indonesian deep demersal fisheries in 2020, for main and secondary FMA by species, with main gear types by FMA for each species, and percentage of total catch Top 100 species.

Species	Category	FMA1				FMA2				FMA1+2	
		WPP	Main Gear	MT	%	WPP	Main Gear	MT	%	MT	%
Lutjanus malabaricus	Snapper	712	Dropline	7857	7	718	Longline	6602	6	14459	12
Pristipomoides multidens	Snapper	718	Gillnet*	5289	4	712	Dropline	4434	4	9723	8
Aphareus rutilans	Snapper	715	Dropline	3929	3	713	Dropline	2091	2	6020	5
Epinephelus coioides	Grouper	711	Trap	2154	2	712	Trap	1427	1	3582	3
Etelis radiosus	Snapper	716	Dropline	1188	1	717	Dropline	1036	1	2224	2
Pristipomoides typus	Snapper	573	Dropline	1333	1	712	Longline	624	1	1958	2
Epinephelus areolatus	Grouper	711	Trap	1098	1	712	Dropline	799	1	1897	2
Pristipomoides filamentosus	Snapper	572	Dropline	993	1	715	Dropline	627	1	1619	1
Pristipomoides sieboldii	Snapper	572	Dropline	1478	1	573	Dropline	884	1	2362	2
Etelis boweni	Snapper	715	Dropline	787	1	717	Dropline	578	0	1365	1
Plectropomus maculatus	Grouper	711	Trap	1478	1	712	Trap	656	1	2134	2
Lutjanus erythropterus	Snapper	712	Dropline	1091	1	715	Dropline	410	0	1501	1
Etelis coruscans	Snapper	715	Dropline	560	0	717	Dropline	455	0	1014	1
Lutjanus sebae	Snapper	718	Longline	535	0	711	Trap	509	0	1044	1
Lutjanus johnii	Snapper	711	Trap	846	1	712	Trap	288	0	1133	1
Paracaesio kusakarii	Snapper	715	Dropline	643	1	717	Dropline	326	0	969	1
Total 16 Species				31257	26			21747	18	53004	45
Total Top 100 Species				48543	41			27331	23	72913	61

* Recorded average CpUE of *P. multidens* from a limited number of gillnet catch observations was high in WPP 718 in 2020, but it is unclear if this was representative of performance in the fleet segment that year. The fleet of gillnet boats was substantial, but due to field circumstances only few were contracted in the CODRS program here in 2020, resulting in a limited sample size of gillnet CpUE observations. Therefore potential bias may have affected our estimate of the relative contribution of gillnets to the catch of *P. multidens* in WPP 718.

Three years after the 2020 holistic assessment, in 2023, we implemented a follow-up study that aimed to compare catch characteristics between the 2 years, identify any major changes, and draw conclusions on where stock status might be heading for important snapper and grouper species in the most important WPPs in terms of production. With a limited budget and therefore limited number of CODRS contracts available for this study, we aimed to maximise the efficiency of the CODRS allocation over the fleet. First of all, we concentrated the sampling effort in one single but complete calendar year, to obtain the most meaningful result. We then organized the CODRS allocation in our follow-up study in such a way that we could focus our sampling effort in the WPPs

where the largest catches were realized for the Top 16 species. Within those WPPs we then concentrated on the major gear types producing those catches, and prioritized fleet segments with the largest vessels for CODRS contracts, in order to maximize sample sizes in terms of numbers of fish.

Table 2.2: Risk levels in the Indonesian deep demersal fisheries for snappers and groupers in 2020 based on estimated SPR and other length-based indicators, for the Top 16 target species, in the main FMA (FMA1) and secondary FMA (FMA2) for each species, ranked by volume in the catch.

Species	Immatures		Exploitation		Mega Spawners		SPR	
	FMA1	FMA2	FMA1	FMA2	FMA1	FMA2	FMA1	FMA2
Lutjanus malabaricus	high	medium	high	high	high	high	high	high
Pristipomoides multidens	high	high	high	high	high	high	high	high
Aphareus rutilans	high	high	high	high	high	high	high	high
Epinephelus coioides	medium	medium	high	high	high	high	high	high
Etelis radiosus	high	high	high	high	high	high	high	high
Pristipomoides typus	high	high	high	high	high	high	high	high
Epinephelus areolatus	low	low	high	high	high	high	high	high
Pristipomoides filamentosus	high	high	high	high	high	high	high	high
Pristipomoides sieboldii	low	low	high	high	high	high	high	high
Etelis boweni	high	high	high	high	high	high	high	high
Plectropomus maculatus	medium	low	high	high	high	high	medium	low
Lutjanus erythropterus	high	medium	high	high	high	high	high	high
Etelis coruscans	high	high	high	high	high	high	high	high
Lutjanus sebae	high	high	high	high	high	high	high	high
Lutjanus johnii	high	high	high	high	high	high	high	high
Paracaesio kusakarii	high	high	high	high	high	high	high	high

Table 2.3: Trends in relative abundance by size group and Spawning Potential Ratio (SPR) in the Indonesian deep demersal fisheries for snappers and groupers between 2015 and 2020, in the 2 main FMAs for each of the Top 16 species, ranked by volume in the catch.

Species	% Matures		% Large Matures		% Mega Spawners		SPR	
	FMA1	FMA2	FMA1	FMA2	FMA1	FMA2	FMA1	FMA2
L. malabaricus	declining	declining	declining	declining	declining	declining	declining	declining
P. multidens	declining	declining	declining	improving	declining	improving	improving	improving
A. rutilans	declining	improving	declining	improving	declining	improving	declining	improving
E. coioides	unknown	declining	unknown	declining	unknown	declining	unknown	declining
E. radiosus	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
P. typus	declining	declining	declining	declining	declining	declining	declining	declining
E. areolatus	unknown	declining	unknown	improving	unknown	improving	unknown	improving
P. filamentosus	unknown	declining	unknown	declining	unknown	declining	unknown	declining
P. sieboldii	unknown	declining	unknown	improving	unknown	improving	unknown	improving
E. boweni	improving	unknown	declining	unknown	declining	unknown	declining	unknown
P. maculatus	unknown	declining	unknown	declining	unknown	declining	unknown	declining
L. erythropterus	improving	declining	improving	declining	improving	declining	improving	declining
E. coruscans	declining	unknown	declining	unknown	declining	unknown	declining	unknown
L. sebae	improving	unknown	improving	unknown	stable	unknown	stable	unknown
L. johnii	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
P. kusakarii	declining	unknown	declining	unknown	declining	unknown	declining	unknown

NB: Trends are "unknown" when there are no time series available of at least 3 years or more.

2.1 Selecting WPPs and Gear Types for the 2023 Follow-up Study

Table 2.1 lists the Top 16 species of Snappers and Groupers with production in the main 2 WPP for each of those Top 16 species in 2020 (Pet et al., 2023). When selecting WPPs for our comparison between 2020 and 2023, we keep in mind also that the top 3 WPPs for snapper production in 2020 were WPPs 712, 718, and 573, whereas the Top 3 WPPs for

grouper production in 2020 were WPPs 711, 712, and 571 (Pet et al., 2023). The main WPPs to concentrate on for a follow-up survey, according to the 2020 Holistic assessment results, would be 572, 573, 711, 712, 713, 715, 716, 717, and 718. That would be no less than 9 out of 11 WPPs, however, excluding only WPP 571 and WPP 714 from the 2023 follow-up survey. These 2 WPPs are not of major importance for any of the Top 16 species of Snappers and Groupers.

Re-assessment in 9 WPP was not achievable with limited resources available. We therefore minimized the number of WPPs to reduce sampling effort and costs, while maximizing the efficiency in terms of expected outputs. Three WWP were dropped from the original list of 9. While WPP 572 is the #1 WPP for *P. filamentosus* and *P. sieboldi* production, logistics are challenging here and we could look at these same species in WPPs 573 and 715. We have therefore **not** included WPP 572 in the 2023 survey. WPP 716 is the #1 WPP for *E. radiosus*, but not of major importance for any other species. We therefore also dropped WPP 716, even though this meant that we will not cover either #1 or #2 WPP for this species. WPP 717 is the #2 WPP for 4 out of 16 species, but logistics are difficult here, landing sites are remote and the fleet consists mainly of large numbers of nano-sized boats. This WPP was therefore also dropped, noting that most relevant species from WPP 717 will still be covered in their #1 WPP. WPP 713 is only the #2 WPP for one single species, and thus not one of the most important WPPs for our comparative study. However, WPP 713 is important in terms of production for all species combined and also in terms of policy development, while logistics are relatively easy. WPP 713 was thus included in the 2023 follow-up survey.

The above selection process left us with 6 WPPs (573, 711, 712, 713, 715 and 718) for our comparative study of catch characteristics in 2020 and 2023. As a result of this selection of 6 WPPs, we "lost" just one species (*E. radiosus*) out of the Top 16 in terms of its major two WPPs, while we still obtained useful data from a tertiary WPP, also for this species. Within each selected WPP, we focussed on the most productive gear types and vessel categories, to obtain the largest samples per CODRS contract. Some fleet segments represent major fishing power (large boats in large numbers) but, due to gear type and targeting practices (habitats and species), have only small percentage of deepwater snapper and grouper target species in the catch. For example, the gillnet fleet in WPP 718. This fleet segment was therefore not selected for the 2023 follow-up study. In a few other cases, fleet segments were also not included due to logistical issues, sometimes due to remoteness of locations.

In all of the 6 selected WPPs we worked with the largest vessels available for CODRS contracts in 2023, to maximize sample sizes for this study. Furthermore, we focussed on the most relevant gear types for the top 16 species in each WPP (Tables 2.4 to 2.9). In WPP 573, following above principles, we focussed on medium sized dropline boats, of which 15 were contracted as CODRS vessels in the port of Kupang. In WPP 711 we focussed on medium sized trap boats, with 5 contracted as CODRS vessels in Belitung and another 10 in Bintan. In WPP 712 we decided to work with 10 medium sized trap boats fom Jepara and another 10 medium sized dropline boats from Lamongan. In WPP 713 we worked with 19 dropline boats from Takalar, mostly medium sized and a few of them small. In WPP 715 we contracted 7 dropline boats from Minahasa Utara, mostly large vessels but including one smaller boat. In the same WPP we also worked with 8 dropline boats from Sorong, ranging in size from nano to small. Finally, in WPP 718 we contracted 10 medium sized drop line boats from Kepulauan Aru, as well as 9 large long line boats from Aru and Probolinggo.

Table 2.4: CODRS vessels supplying data in 2023 on their operations and catches in WPP-573

	Boat Name	Landing Site	Fishing WPP	GT Estimate	Boat Size	Fishing Gear
1	KM. Anggoli Jaya 02	Kupang	573	17.80	Medium	Dropline
2	KM. Anggur Merah	Kupang	573	11.60	Medium	Dropline
3	KM. Kalsel Bergerak	Kupang	573	13.00	Medium	Dropline
4	KM. Nelayan 2016 175	Kupang	573	11.10	Medium	Dropline
5	KM. Nelayan 2016 176	Kupang	573	11.00	Medium	Dropline
6	KM. Nelayan 2016 177	Kupang	573	11.00	Medium	Dropline
7	KM. Nelayan 2016 188	Kupang	573	15.70	Medium	Dropline
8	KMN. Nirra	Kupang	573	12.80	Medium	Dropline
9	KMN. Sumber Barakah	Kupang	573	19.40	Medium	Dropline
10	KMN. Taufiqurrahman 01	Kupang	573	10.70	Medium	Dropline
11	KM. Pantai Kelapa	Kupang	573	26.00	Medium	Dropline
12	KM. Pante Nyiur 03	Kupang	573	11.00	Medium	Dropline
13	KM. Raudatul Djana	Kupang	573	22.10	Medium	Dropline
14	KM. Senang Hati 18	Kupang	573	27.60	Medium	Dropline
15	KM. Senang Hati 31	Kupang	573	18.00	Medium	Dropline

Nano less than 5 GT. **Small** 5 - <10 GT. **Medium** 10 - 30 GT. **Large** >30 GT.

Table 2.5: CODRS vessels supplying data in 2023 on their operations and catches in WPP-711

	Boat Name	Landing Site	Fishing WPP	GT Estimate	Boat Size	Fishing Gear
1	KM. Armada Jaya	Belitung	711	12.60	Medium	Trap
2	KM. Cita Prisma	Belitung	711	25.90	Medium	Trap
3	KM. Kerapu Sawar 1	Belitung	711	23.40	Medium	Trap
4	KM. Syahira	Belitung	711	10.70	Medium	Trap
5	KM. Syera Anugrah 1	Belitung	711	21.20	Medium	Trap
6	KM. Alhamdulillah 7	Bintan	711	10.70	Medium	Trap
7	KM. Aneka Jaya	Bintan	711	10.60	Medium	Trap
8	KM. Apandi	Bintan	711	10.00	Medium	Trap
9	KM. Gemilang 22	Bintan	711	10.20	Medium	Trap
10	KM. Jaya Raya 8	Bintan	711	10.50	Medium	Trap
11	KM. Laut Indah	Bintan	711	23.90	Medium	Trap
12	KM. Metrix II	Bintan	711	14.30	Medium	Trap
13	KM. Naga Emas XIII	Bintan	711	17.40	Medium	Trap
14	KM. Risma A	Bintan	711	12.90	Medium	Trap
15	KM. Jaya Raya 7	Bintan	711	9.20	Small	Trap

Nano less than 5 GT. **Small** 5 - <10 GT. **Medium** 10 - 30 GT. **Large** >30 GT.

Table 2.6: CODRS vessels supplying data in 2023 on their operations and catches in WPP-712

	Boat Name	Landing Site	Fishing WPP	GT Estimate	Boat Size	Fishing Gear
1	KM. Barokah Mama	Jepara	712	14.40	Medium	Trap
2	KM. Bintang Laut	Jepara	712	17.50	Medium	Trap
3	KM. Dewi Mustika	Jepara	712	17.10	Medium	Trap
4	KM. Lancar Abadi	Jepara	712	11.80	Medium	Trap
5	KM. Legenda	Jepara	712	19.90	Medium	Trap
6	KM. Pitaloka	Jepara	712	14.40	Medium	Trap
7	KM. Restu Ibu	Jepara	712	11.80	Medium	Trap
8	KM. Sekar Wangi	Jepara	712	20.10	Medium	Trap
9	KM. Sinar Buana	Jepara	712	12.00	Medium	Trap
10	KM. Warga Baru 02	Jepara	712	13.40	Medium	Trap
11	KMN. Al Mubarok	Lamongan	712	19.10	Medium	Dropline
12	KMN. Baru Jaya III	Lamongan	712	17.00	Medium	Dropline
13	KMN. Candra Karya Abadi	Lamongan	712	15.10	Medium	Dropline
14	KMN. Elang Samudra	Lamongan	712	22.20	Medium	Dropline
15	KMN. Ika Jaya II	Lamongan	712	20.00	Medium	Dropline
16	KMN. Jagorawi	Lamongan	712	17.00	Medium	Dropline
17	KMN. Legowo	Lamongan	712	17.00	Medium	Dropline
18	KMN. Putri Sejati	Lamongan	712	21.10	Medium	Dropline
19	KMN. Vanamie 1	Lamongan	712	19.90	Medium	Dropline
20	KMN. Vannamei I	Lamongan	712	19.90	Medium	Dropline

Nano less than 5 GT. **Small** 5 - <10 GT. **Medium** 10 - 30 GT. **Large** >30 GT.

Table 2.7: CODRS vessels supplying data in 2023 on their operations and catches in WPP-713

	Boat Name	Landing Site	Fishing WPP	GT Estimate	Boat Size	Fishing Gear
1	KMN. Aditya Utama	Takalar	713	10.90	Medium	Dropline
2	KMN. Anugrah Ilahi 01	Takalar	713	21.20	Medium	Dropline
3	KMN. Anugrah Ilahi 11	Takalar	713	25.50	Medium	Dropline
4	KMN. Anugrah Laut 07	Takalar	713	11.60	Medium	Dropline
5	KMN. Anugrah Laut 08	Takalar	713	14.10	Medium	Dropline
6	KMN. Anugrah Laut 09	Takalar	713	18.90	Medium	Dropline
7	KMN. Indi Utama	Takalar	713	23.30	Medium	Dropline
8	KMN. Irsan Eristya Jaya 01	Takalar	713	11.80	Medium	Dropline
9	KMN. Remaja Indah	Takalar	713	24.90	Medium	Dropline
10	KMN. Sumber Alam Laut	Takalar	713	19.60	Medium	Dropline
11	KMN. Sumber Cahaya 15	Takalar	713	10.50	Medium	Dropline
12	KMN. Sumber Cahaya 889	Takalar	713	15.90	Medium	Dropline
13	KMN. Usri anugrah	Takalar	713	12.80	Medium	Dropline
14	KMN. Minasa Indah 01	Takalar	713	6.20	Small	Dropline
15	KMN. Muhammad Radit 02	Takalar	713	9.10	Small	Dropline
16	KMN. Nur Fadillah 01	Takalar	713	8.00	Small	Dropline
17	KMN. Sumber Cahaya 79	Takalar	713	8.40	Small	Dropline

Nano less than 5 GT. **Small** 5 - <10 GT. **Medium** 10 - 30 GT. **Large** >30 GT.

Table 2.8: CODRS vessels supplying data in 2023 on their operations and catches in WPP-715

	Boat Name	Landing Site	Fishing WPP	GT Estimate	Boat Size	Fishing Gear
1	KM. Karya Anugerah	Minahasa Utara	715	30.10	Large	Dropline
2	KM. Natanael	Minahasa Utara	715	30.10	Large	Dropline
3	KM. Noelfel	Minahasa Utara	715	32.90	Large	Dropline
4	KM. Tetap Setia 02	Minahasa Utara	715	45.00	Large	Dropline
5	KM. Tetap Setia 03	Minahasa Utara	715	30.10	Large	Dropline
6	KM. Milenium 04	Minahasa Utara	715	27.00	Medium	Dropline
7	KMN. Rifandi Jaya	Sorong	715	25.80	Medium	Dropline
8	PM. Cinta	Sorong	715	3.20	Nano	Dropline
9	PM. Garuda	Sorong	715	3.00	Nano	Dropline
10	KM. Camara	Sorong	715	7.30	Small	Dropline
11	KM. Iza Jaya 01	Sorong	715	8.40	Small	Dropline
12	KM. Jaya Laksana	Sorong	715	7.10	Small	Dropline
13	KMN. Cahaya Rizky 99	Sorong	715	5.30	Small	Dropline

Nano less than 5 GT. **Small** 5 - <10 GT. **Medium** 10 - 30 GT. **Large** >30 GT.

Table 2.9: CODRS vessels supplying data in 2023 on their operations and catches in WPP-718

	Boat Name	Landing Site	Fishing WPP	GT Estimate	Boat Size	Fishing Gear
1	KM. Almultakbir	Kepulauan Aru	718	14.00	Medium	Dropline
2	KM. Bahari 02	Kepulauan Aru	718	25.60	Medium	Dropline
3	KM. Basmalah	Kepulauan Aru	718	15.40	Medium	Dropline
4	KM. Bulan Purnama	Kepulauan Aru	718	16.80	Medium	Dropline
5	KM. Cinta Makkah	Kepulauan Aru	718	13.30	Medium	Dropline
6	KM. Karya Abadi	Kepulauan Aru	718	10.00	Medium	Dropline
7	KM. Kasmi	Kepulauan Aru	718	15.00	Medium	Dropline
8	KM. Putry 02 Naila	Kepulauan Aru	718	14.00	Medium	Dropline
9	KM. Resky Jaya	Kepulauan Aru	718	13.30	Medium	Dropline
10	KM. Sumber Sinar 01	Kepulauan Aru	718	14.00	Medium	Dropline
11	KM. Indah Jaya	Kepulauan Aru	718	63.00	Large	Longline
12	KM Lautan Berlian 3	Kepulauan Aru	718	54.60	Large	Longline
13	KM. Pesona Mandiri 6	Kepulauan Aru	718	40.40	Large	Longline
14	KM. Sabang maju	Kepulauan Aru	718	42.00	Large	Longline
15	KM. Semangat Jaya 8	Kepulauan Aru	718	42.00	Large	Longline
16	KM. Setia Budi	Kepulauan Aru	718	42.00	Large	Longline
17	KM. Teratai Mas	Kepulauan Aru	718	87.00	Large	Longline
18	KM. Edo Icha Jaya	Probolinggo	718	51.20	Large	Longline
19	KM. Nasib Jaya Baru	Probolinggo	718	67.10	Large	Longline
20	KM. Pulau Sentosa	Probolinggo	718	87.50	Large	Longline

Nano less than 5 GT. **Small** 5 - <10 GT. **Medium** 10 - 30 GT. **Large** >30 GT.

2.2 Zooming in on Landing Ports and Fishing Grounds for 2020 and 2023

As we decided to work with selected fleet segments, we set up the study to compare 2020 and 2023 characteristics within those fleet segments only. We could not compare the results from the 2023 study by fleet segment with the full holistic assessment of 2020, as the latter included all fleet segments, weighted by effort. For a meaningful direct comparison between years, we filtered out the same fleet segments from the 2020 assessments, as we had selected for the 2023 follow-up study. We also zoomed in further to landing ports because CODRS contracts for our 2023 survey were clustered in major ports or major landing areas, rather than being spread out across each WPP. This was done for practical and efficiency reasons, but consequently produced conclusions for specific species by fleet segments based in specific landing ports and operating on specific fishing grounds. We compared 2023 results only with 2020 results from the same or very similar fleet segments, operating on overlapping fishing grounds.

To ensure justifiable comparisons between 2020 and 2023 catch characteristics, we plotted fishing activity on the fishing grounds for our selected CODRS vessels in both years and included data from 2020 only when fishing grounds indeed overlapped. In some cases, this resulted in sample sizes for 2020 that were too small to compare with 2023, when criteria of inclusion were strictly implemented. This could be dealt with however, by including some fleet segments from other home ports to the 2020 selection, using identical gear types and similar boat sizes, but only when these operated on the same fishing grounds that were used by the CODRS vessels in 2023. Plots of activity on fishing grounds were prepared to show overlap between 2020 and 2023 operations.

2.3 Testing for Shifts in Species Composition from 2020 to 2024

The Kendall Tau Rank Correlation test was applied to assess the correlation between sample sizes collected in 2020 and 2023 across different vessel segment and landing sites. This analysis was conducted to determine whether there were any significant changes in the relative species composition as reflected by the sample sizes collected in 2020 and 2023. By correlating sample sizes between these two years, we aimed to understand if shifts in species prevalence could be detected across different vessel segments and landing sites. Understanding these shifts is crucial for assessing the impact of fishing pressure and environmental changes on species composition.

The non-parametric Kendall Tau Rank Correlation test is suitable for ordinal data and robust for datasets that do not meet normal distribution assumption (Kendall, 1983). The Kendall Tau rank correlation coefficient T, ranging from -1 to +1, was calculated for each location to measure the strength and direction of the relationship between the two years. A p-value (a=0.05) was used to determine the statistical significance of each correlation. Based on Hinkle et al., (2003), the criteria for the Kendall's Tau coefficients were weak correlation (T = 0.0-0.3), moderate (T = 0.3-0.5), and strong correlation (T = 0.5-1.0), with positive and negative values.

2.4 Testing for Differences in Median Lengths and CpUE

Significant, substantial and consistent changes in median length in the catch of any species in a specific fishery could be an indicator of changes in stock health if there is no change in selectivity of the fishing gear and no change in fishing behaviour (Östman et al, 2023). Changes in CpUE are more traditional indicators of stock health, although estimates of CpUE are subject to continuous changes in the fisheries operations, which are often hard to quantify and can result in uncertainties in effort estimates, (Hoyle et al., 2024). In the present study we have looked at changes in median lengths as well as changes in CpUE using data from catches of the Top 16 species of snappers and groupers in the Indonesian deep demersal fisheries. We have compared median lengths and CpUE for these species in 2020 and 2023 in catches of some of the most important fleet segments.

We used the Permutation and Wilcoxon sum-rank tests to evaluate differences in median lengths from 2020 and 2023 catch length frequency distributions across different fleet segments and landing sites. The same tests were used to assess changes in CpUE by species and fleet segment from 2020 to 2023. The permutation test is a non-parametric method that does not rely on assumptions of normal distributions and is particularly useful for small sample sizes or when data do not meet parametric test assumptions

(Good, 2013). In this approach, the observed data were permuted multiple times (e.g., 10,000 permutations) to generate a distribution of test statistics with the hypothesis:

$H_0 = MedianDifference, 0x - 0y = 0$

$H_1 = MedianDifference, 0x - 0y \neq 0$

The Wilcoxon Sum Rank Test (Kvam & Vidakovic 2007) was used as a non-parametric alternative to the two-sample t-test, to compare independent samples which are not necessarily normally distributed. This test ranks all observations across both groups, sums the ranks for one group, and calculates a test statistic, with statistical significance determined by a p-value ($a = 0.05$). By using the Wilcoxon Sum Rank Test, we assumed that:

1. The two samples are independent.
2. The observations are randomly drawn from the populations of interest.
3. The distributions of the two populations have similar shapes.
4. The variable being measured is continuous.

We addressed occasional differences in conclusions between the two tests by adopting a conservative approach: a difference is considered "significant" only when both tests show significant differences. If either test, or both, yield non-significant differences, we classify the outcome as "not conclusively significant according to both tests".

2.5 Substantial Changes and Trends in Length-based Indicators and CpUE

Significant changes from 2020 to 2023 of 10% or more in median length were considered by us as "substantial" changes that deserve attention from fisheries managers. For those combinations of species, WPP and fleet segment where substantial changes occurred in median length, we have also looked at changes in CpUE and again highlighted substantial changes in CpUE when these reached 10% or more. We have assessed time trends in 3 other length-based indicators for cases that showed substantial changes in median lengths from 2020 to 2023. These indicators are percentages immatures, large matures and mega-spawners in the catch of highlighted combinations of species, WPP and fleet segment.

Length-based life history parameter values for the Top 16 species of snappers and groupers in the Indonesian deep demersal fisheries (Table 2.10) were previously estimated (Pet et al., 2023) and used here again to set indicator limits for sustainable harvesting. Lmat is the length at which this species reaches maturity and Lopt is the optimum harvest size. Lmax is the maximum attainable length for each species and Linf is the asymptotic length, or the mean size in the cohort when it stops growing.

While 0% immature fish in the catch may be an ideal target (Froese, 2004), 10% or less is considered a reasonable indicator for sustainable harvesting (Fujita et al., 2012; Vasilakopoulos et al., 2011). Zhang et al. (2009) consider 20% immature fish in the catch as an indicator for high risk, in their approach to an ecosystem-based assessment. Results from meta-analysis over multiple fisheries showed stock status over a range of stocks to fall below precautionary limits at 30% or more immature fish in the catch (Vasilakopoulos et al., 2011). The fishery is considered at very great risk when more than 50% of the fish in the catch are immature and effort is high (Froese et al, 2016).

Table 2.10: Sample sizes (2020 and 2023) and life history parameter values for the 16 most important species of snappers and groupers in the Indonesian Deep Demersal Fisheries. Lengths in cm Total Length (TL) and weights in grams

Rank	Species Name	Family	N2020	N2023	Lmax	Linf	Lopt	Lmat	Wmax	Wmat
1	Lutjanus malabaricus	Lutjanidae	144602	48948	94	85	67	50	13202	1822
2	Pristipomoides multidens	Lutjanidae	108153	73334	92	83	66	49	8664	1356
3	Aphareus rutilans	Lutjanidae	9066	988	120	108	85	64	13693	2129
4	Epinephelus coioides	Epinephelidae	3871	2463	119	107	86	49	26435	1713
5	Etelis radiosus	Lutjanidae	2595	895	115	104	82	61	13967	2539
6	Pristipomoides typus	Lutjanidae	38516	33296	85	76	60	45	6047	946
7	Epinephelus areolatus	Epinephelidae	53941	48814	53	48	38	22	1931	132
8	Pristipomoides filamentosus	Lutjanidae	10271	3359	90	81	64	48	8078	1393
9	Pristipomoides sieboldii	Lutjanidae	2164	2662	57	51	40	30	2144	324
10	Etelis boweni	Lutjanidae	7766	4874	118	106	84	63	21722	3411
11	Plectropomus maculatus	Epinephelidae	4945	3218	84	76	61	35	9246	669
12	Lutjanus erythropterus	Lutjanidae	37894	22097	70	63	50	37	4817	773
13	Etelis coruscans	Lutjanidae	5399	3322	120	108	85	64	12049	2128
14	Lutjanus sebae	Lutjanidae	14355	9287	96	86	68	51	18291	2404
15	Lutjanus johnii	Lutjanidae	2724	571	90	81	64	48	8486	1365
16	Paracaesio kusakarii	Lutjanidae	4427	2328	85	76	60	45	8220	1119

Immature fish are smaller than Lmat, Large Matures are fish larger than Lopt, and Mega Spawners are fish larger than 1.1 times the optimum harvest size (Froese, 2004).

We also consider a majority (or more than 50%) in the catch around or above the optimum harvest size (Pet et al. 2023) as an indicator for minimizing the impact of fishing (Froese et al., 2016). "Mega spawners" are fish larger than 1.1 times the optimum harvest size (Froese, 2004), and a proportion of 30% or more "mega spawners" in the total catch is considered to be a sign of a healthy population (when other fisheries do not catch much smaller fish), whereas lower proportions are increasingly leading to concerns. Risk levels related to recruitment overfishing are thus considered to be low when 30% or more of the catch consists of "mega spawners".

The size structure in the total catch is assumed to represent the size structure in the population here, with a fishery characterized by a very broad selection range. As our selected fleet segments in theory would only represent a part of the selection curve of the total fisheries, we will put less emphasis on the absolute values of indicators in specific years, but focus mainly on any changes in indicator values over time. Representativeness of the selected fleet segments for the total fisheries, in terms of the median size in the catch, will be discussed separately below.

For all cases (pairs of species * fleet segment) showing substantial differences of 10% or more in median lengths between 2020 and 2023 we have taken a closer look at changes in positions and shapes of the length frequency distributions in relation to various length-based indicator values for those years. Furthermore, we have also investigated longer term time trends in indicator values for the same cases, using all available data from the SNAPPER project, which started in 2015 in WPP 573 and in later years elsewhere throughout Indonesia.

3 Results

3.1 Fleet Segments, Landing Ports, Fishing Grounds and Sample Sizes

For our 2023 follow up study in WPP 573, we selected and contracted a CODRS fleet of 15 medium sized drop line vessels which were all based in the port of Kupang in West Timor (Table 2.4), the main landing port for snappers and groupers in this WPP. The main fishing ground for this fleet segment was located along the Sahul Banks, on the edge of the Australian continental shelf, at the south eastern border of WPP 573, and extending in the Joint Petroleum Development Area (JPDA) in East Timorese waters (Figure 3.1). In 2023, a small part of the total fishing effort by this fleet segment also concentrated around the island of Rote, in the southern part of the Savu Sea. Fishing grounds used by Kupang-based medium drop line vessels were roughly the same in 2020 and in 2023, with the exception of some fishing in 2020 in the south western corner of WPP 718, further east along the Sahul Banks.

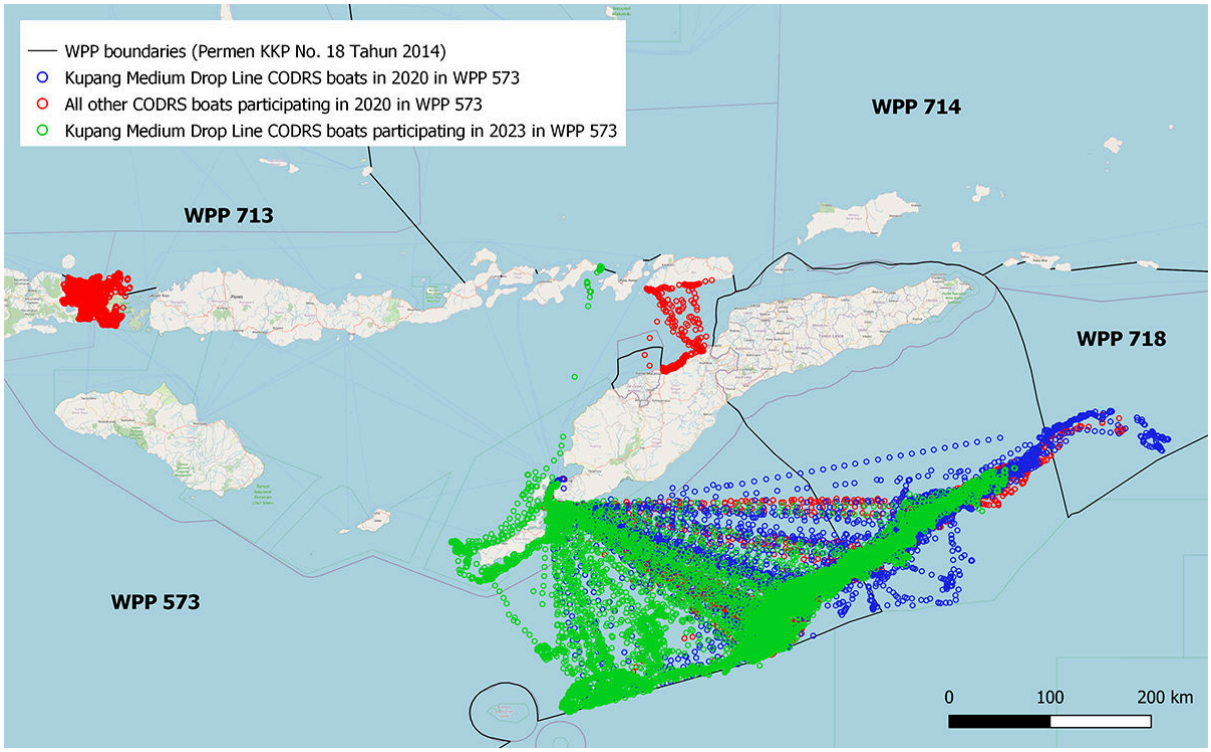


Figure 3.1: Positions of Kupang Medium Drop Line vessels in WPP 573 in 2020 and in 2023, and other fleet segments participating here in 2020.

Other CODRS fleet segments in WPP 573 used distinctly different fishing grounds in 2020 (Figure 3.1), so it was clear that we could not compare 2023 data from the Kupang medium drop liners with the complete set of data from WPP 573 as collected in 2020 and before. We thus decided to compare 2023 data from Kupang medium drop line vessels only with data from the same fleet segment in other years. Sample sizes for both 2020 and 2023 (Table 3.1) were more than sufficient for a number of target species caught by Kupang medium drop line vessels, on mostly overlapping fishing grounds, to enable a clean comparison of catch characteristics between years, for this fleet segment. We compare catch characteristics between 2020 and 2023 only when sample sizes of at least 200 specimen per species were available for both years.

In WPP 711, the 2023 follow up study worked with 14 medium and one small trap boat based in the islands of Belitung and Bintan (Table 2.5), and operating mostly in the Natuna Sea and the Karimata Strait. The fishing grounds used by these medium sized trap vessels in 2023 overlapped sufficiently with fishing grounds used by most of the same fleet segment in 2020 (Figure 3.2), and sample sizes were sufficiently large (Table 3.1) for both years from overlapping fishing grounds, to allow comparison of catch characteristics for a number of target species. Other fleet segments in 2020 fished also further north into the South China Sea and to the south into the Java Sea, included in WPP 712.

In a similar way, we could make direct comparisons of catch characteristics between 2020 and 2023 for Lamongan medium drop line vessels (Table 2.6; Figure 3.4 and Table 3.1), for Minahasa Utara large drop line vessels (Table 2.8; Figure 3.6 and Table 3.2), for Sorong nano, small and medium (Sorong NSM) drop line vessels (Table 2.8; Figure 3.7 and Table 3.2), Kepulauan Aru medium drop line (Table 2.9; Figure 3.8 and Table 3.2) and Kepulauan Aru & Proboblinggo large longline vessels (Table 2.9; Figure 3.9 and Table 3.2). With the note that, even though Kepulauan Aru & Probolinggo large longliners operated on the Arafura Sea fishing grounds both in 2020 and 2023, at a finer scale they used different sub-areas each year and also operated in an area on the Sahul Banks in the Timor Sea in 2023, where they may not have been active in 2020 (Fig. 3.9).

In some cases, sample sizes were not sufficient (i.e. less than 200 specimen for all or most species) in both years for direct comparison of catch characteristics from fleet segments participating in the 2023 survey with data from exactly the same fleet segments and landing ports in 2020. In those case combinations of fleet segments were used with identical gear types, comparable boat sizes and overlapping fishing grounds, but using different landing ports. This approach was taken for the Jepara and Belitung medium and small vessels using traps (Table 2.6; Figure 3.3 and Table 3.1) in the Java Sea, and for the Takalar, Balikpapan and East Java medium drop line vessels (Table 2.7; Figure 3.5 and Table 3.2) operating in the Makassar Strait.

Due to ecological characteristics and habitat availability (water depth, bottom structure, etc.), combined with specific habitat requirements for each species, we cannot expect all species to be abundant at all fishing grounds in all fisheries management areas. Furthermore, due to our approach with selected important fleet segments in terms of total production, and focus on larger units to maximize sample sizes, we have covered a somewhat limited range of species in each WPP, missing some important species in the comparisons between 2020 and 2023 in some WPP (Tables 3.1 and 3.2). For example, *Aphareus rutilans* has been an important species in the landings in WPP 713 in 2020 (Pet et al., 2023), but not in the fleet segments selected for the current study.

Large amounts of *A. rutilans* were landed by nano units in WPP 713 in 2020, but with the limited number of CODRS contracts for 2023, that fleet segment would not have produced sufficiently large sample sizes. There are a few more examples like this, but in most situations of small sample sizes (in Tables 3.1 and 3.2) this was due to prevalent habitats. And as we decided to compare catch characteristics only for cases where we had sample sizes of 200 specimen or more for both years (2020 and 2023) the number of comparisons was also reduced by omitting cases with small sample sizes. Nevertheless, with the above restrictions, we were able to compare catch characteristics based on large samples sizes of multiple species in all WPPs covered in this study.

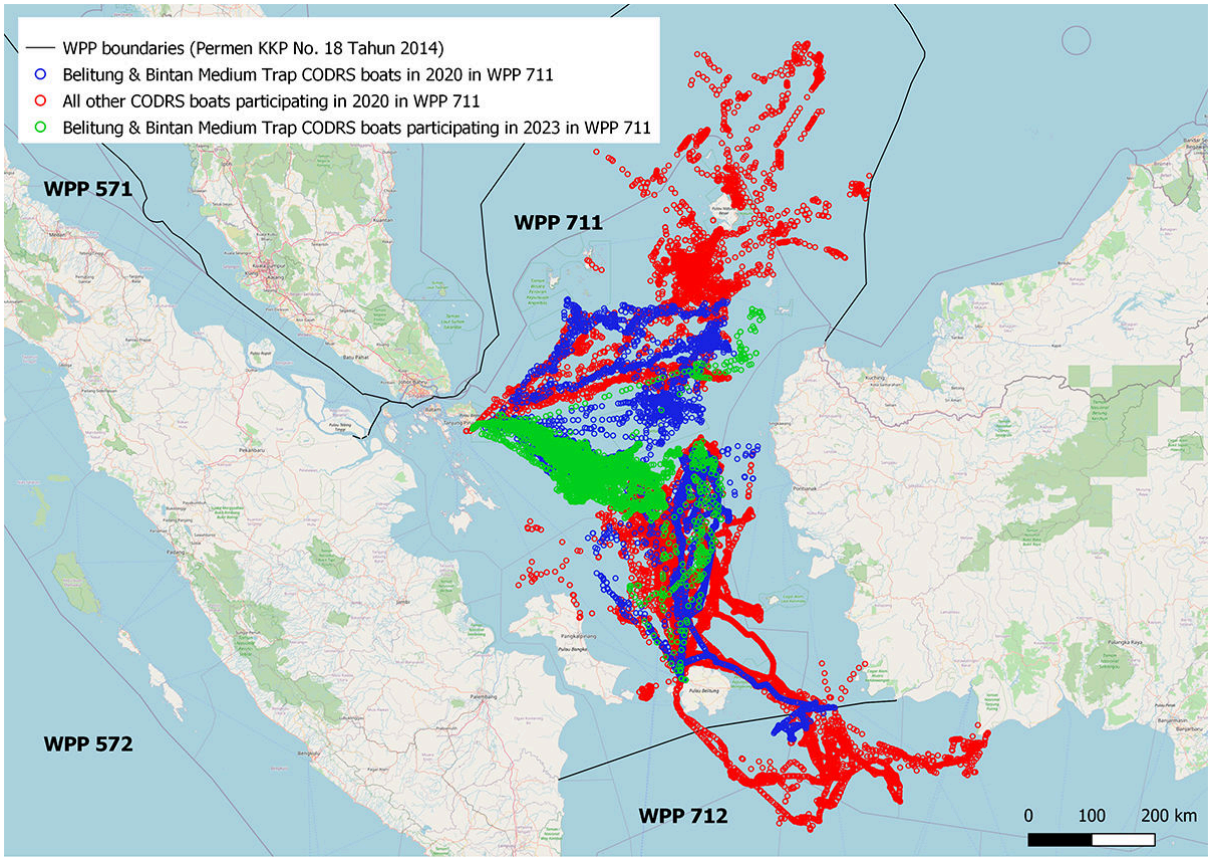


Figure 3.2: Positions of Belitung and Bintan Medium Trap vessels in WPP 711 in 2020 and in 2023, and other fleet segments participating here in 2020.

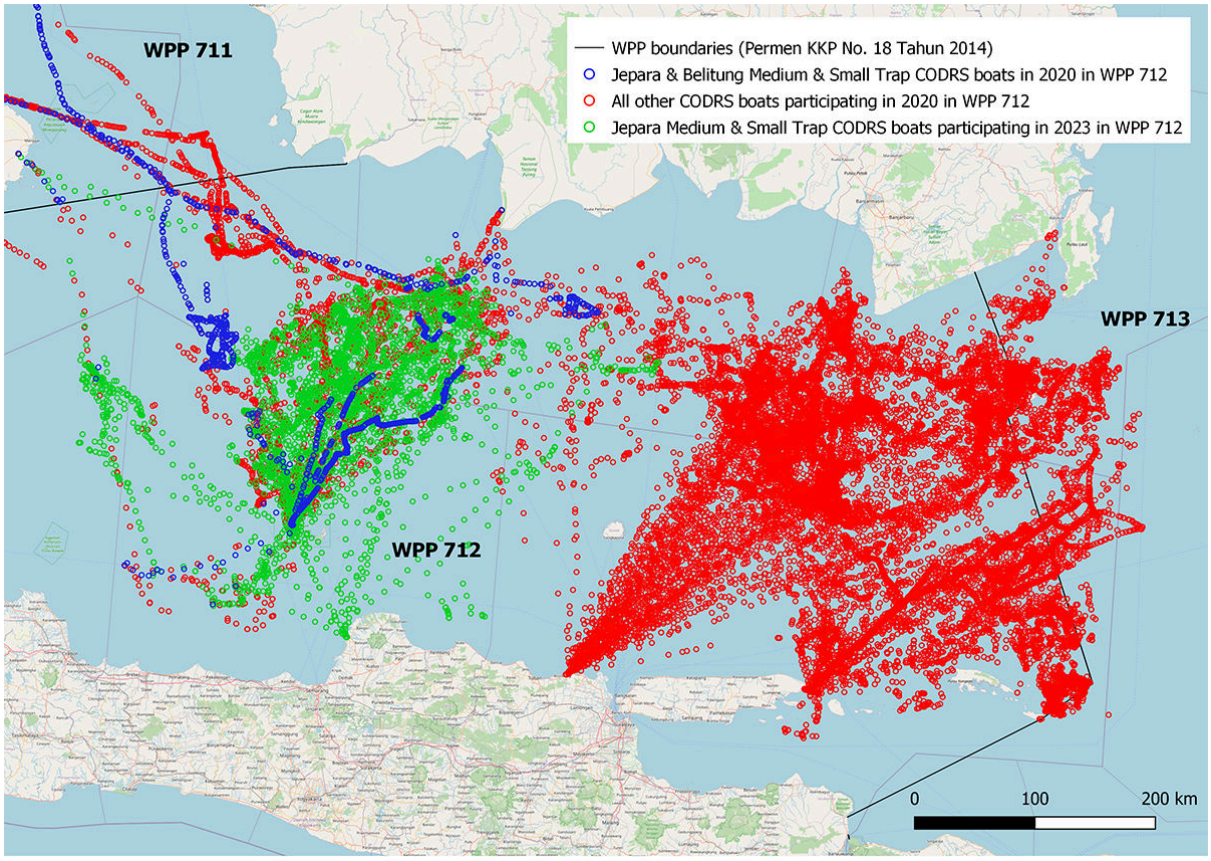


Figure 3.3: Positions of Jepara and Belitung Medium and Small Trap vessels in WPP 712 in 2020 and in 2023, and other fleet segments participating here in 2020.

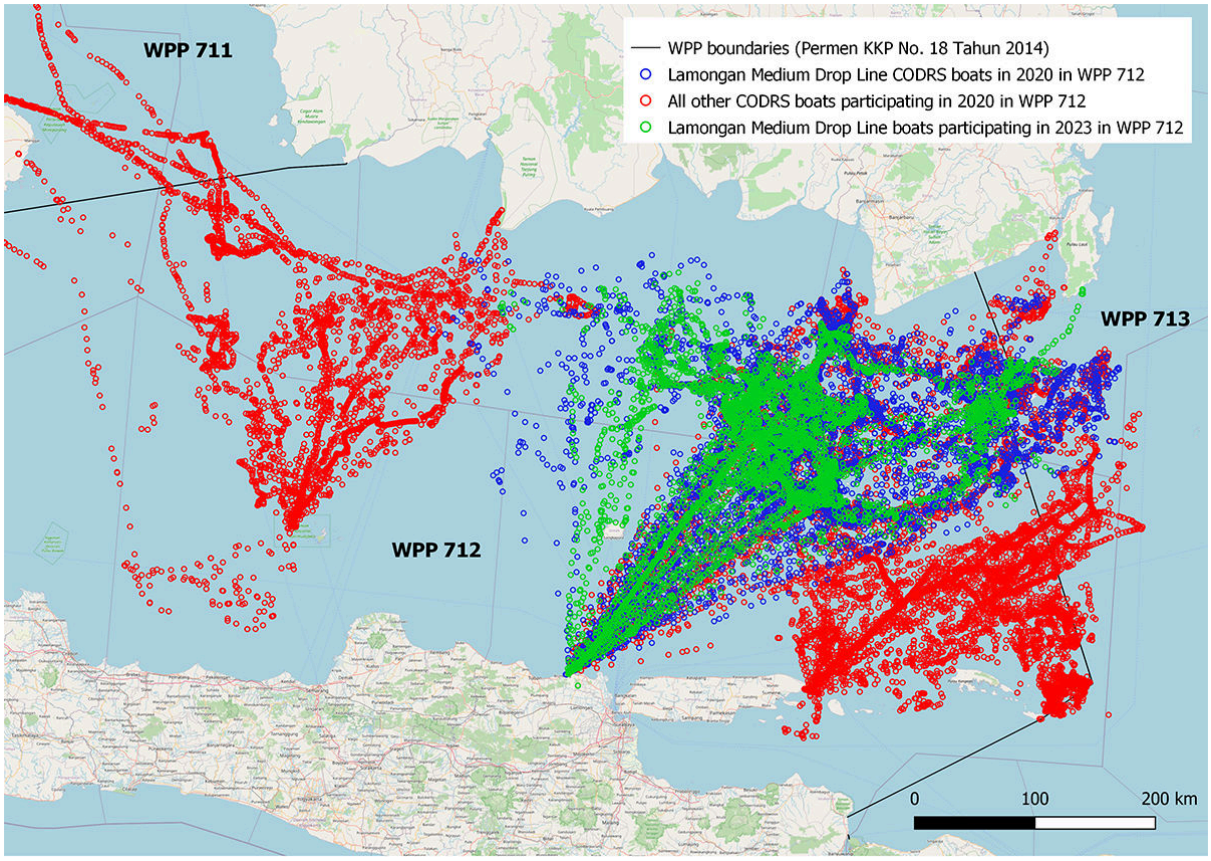


Figure 3.4: Positions of Lamongan Medium Drop Line vessels in WPP 712 in 2020 and in 2023, and other fleet segments participating here in 2020.

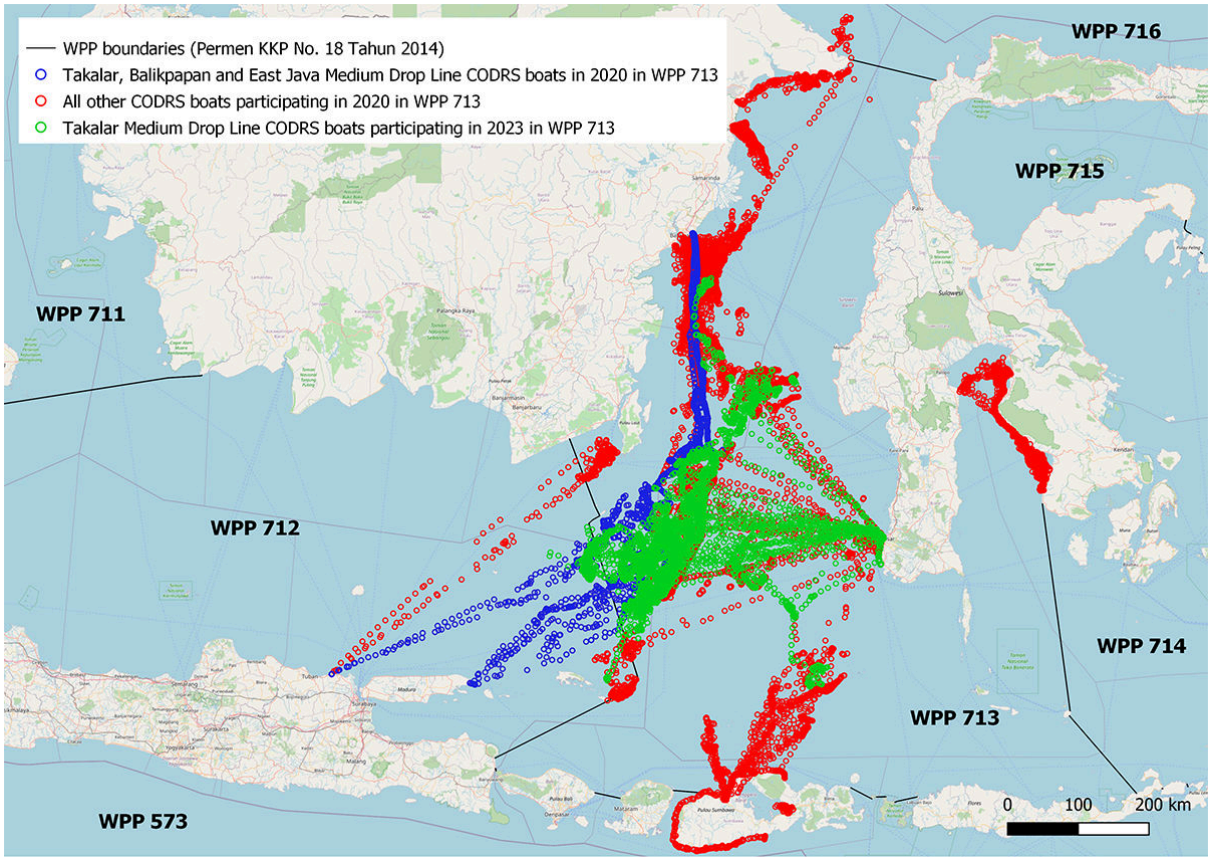


Figure 3.5: Positions of Takalar, Balikpapan and East Java Medium Drop Line vessels in WPP 713 in 2020 and in 2023, and other fleet segments participating here in 2020.

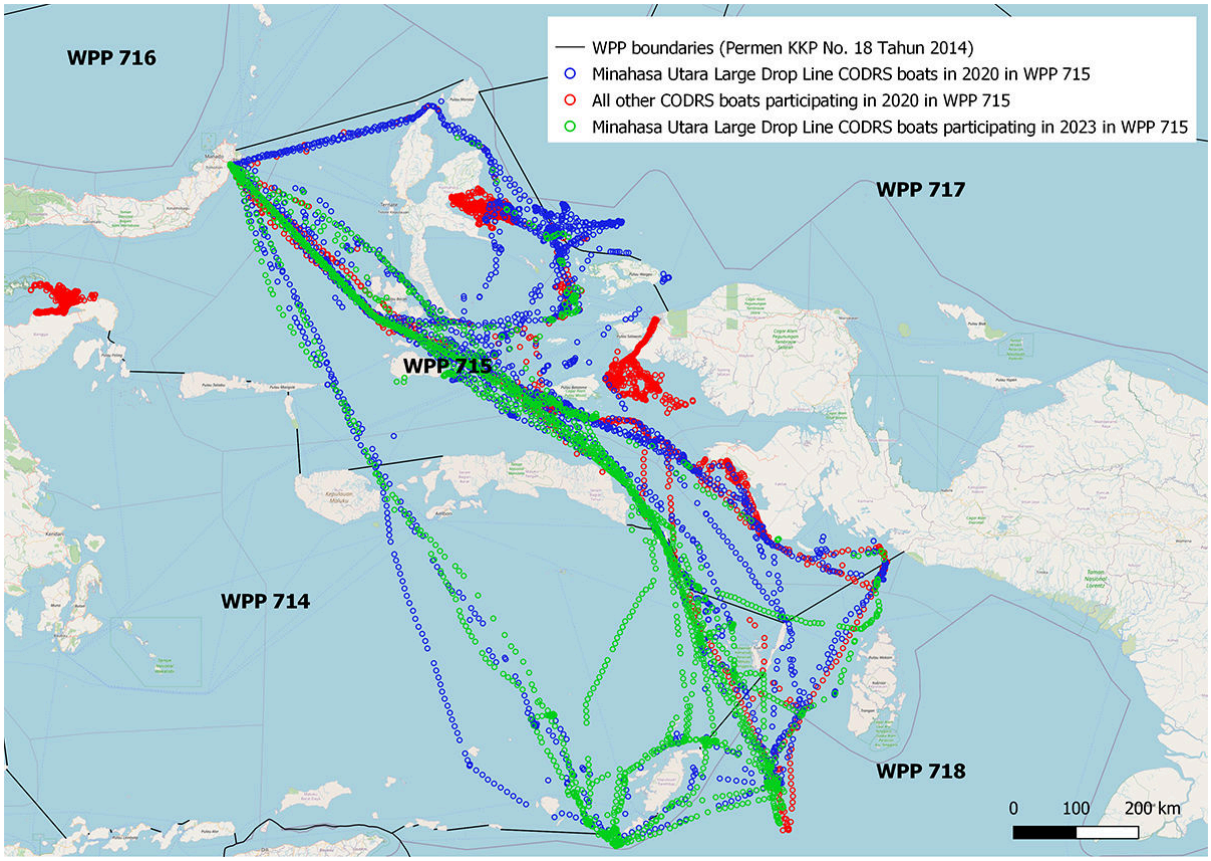


Figure 3.6: Positions of Minahasa Utara Large Drop Line vessels in WPP 715 in 2020 and in 2023, and other fleet segments participating here in 2020.

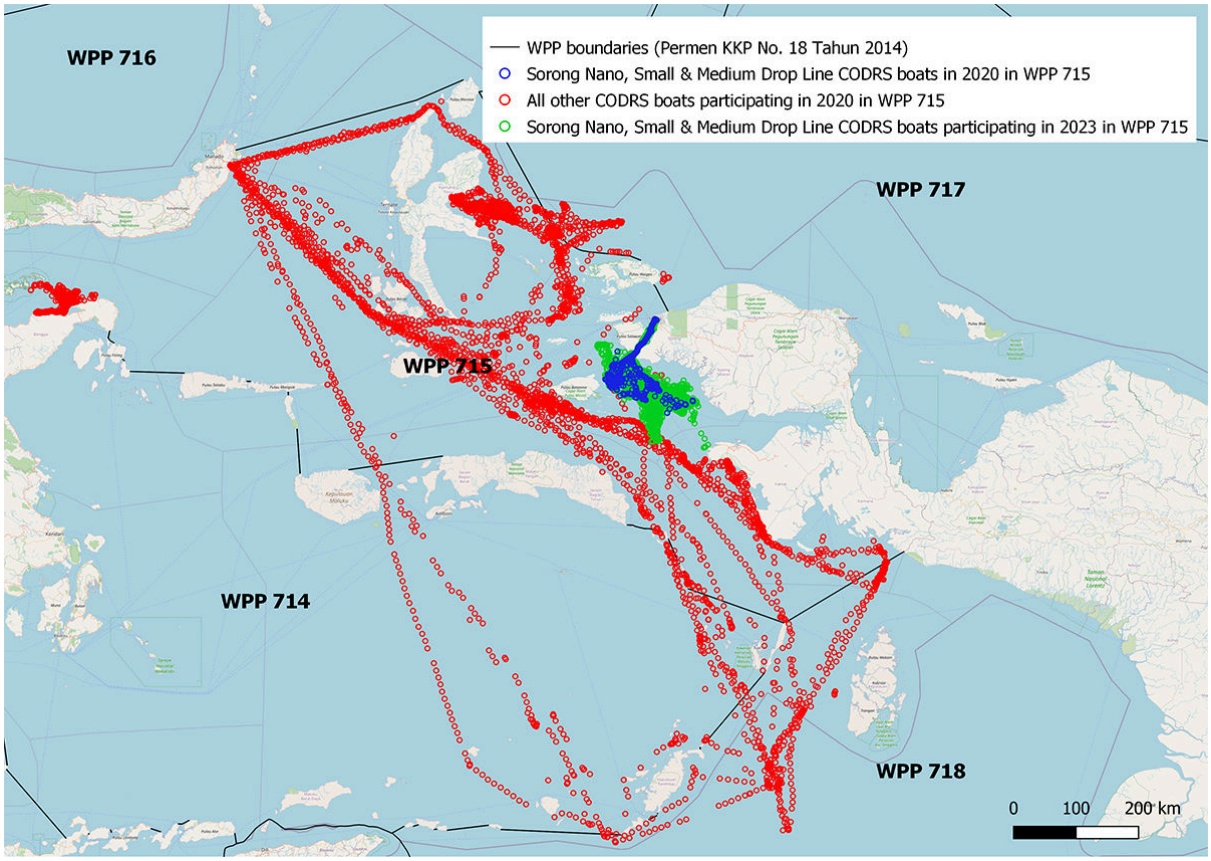


Figure 3.7: Positions of Sorong Nano, Small and Medium Drop Line vessels in WPP 715 in 2020 and in 2023, and other fleet segments participating here in 2020.

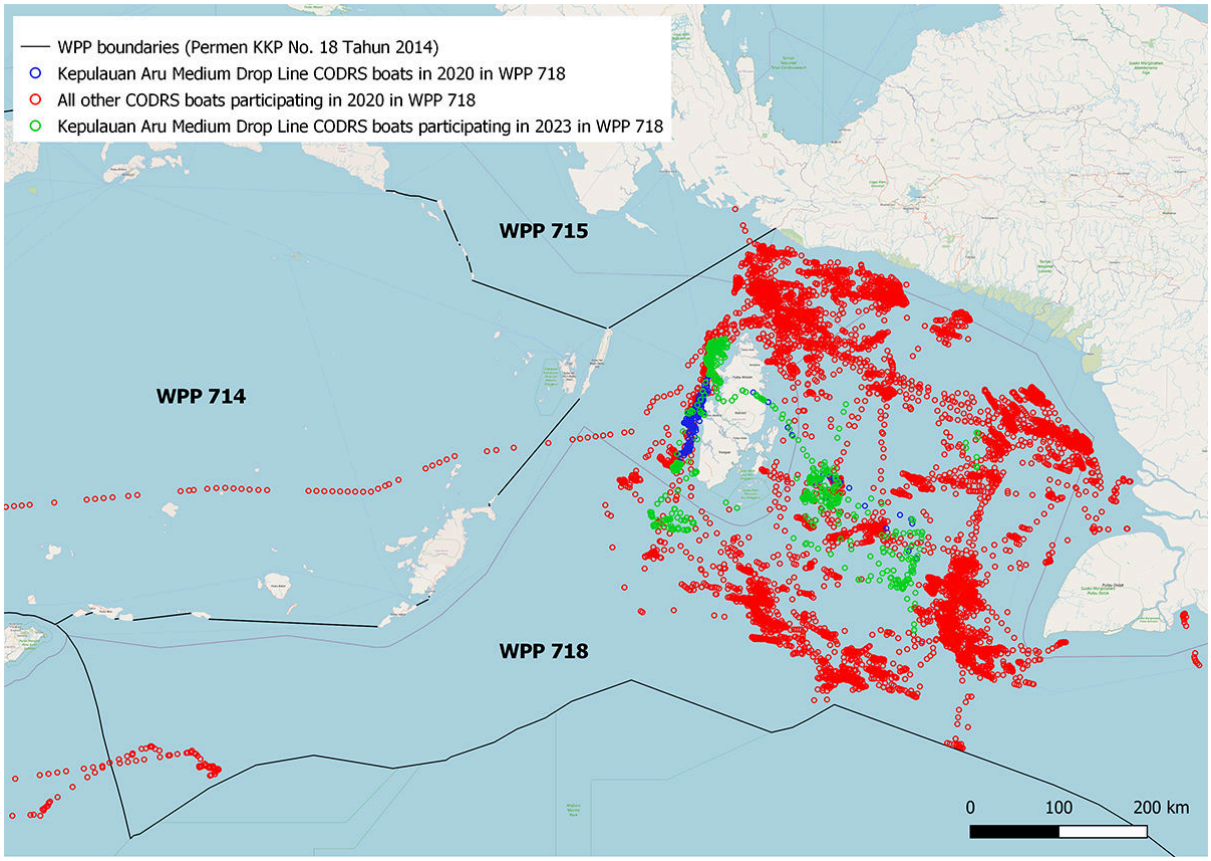


Figure 3.8: Positions of Kepulauan Aru Medium Drop Line vessels in WPP 718 in 2020 and in 2023, and other fleet segments participating here in 2020.

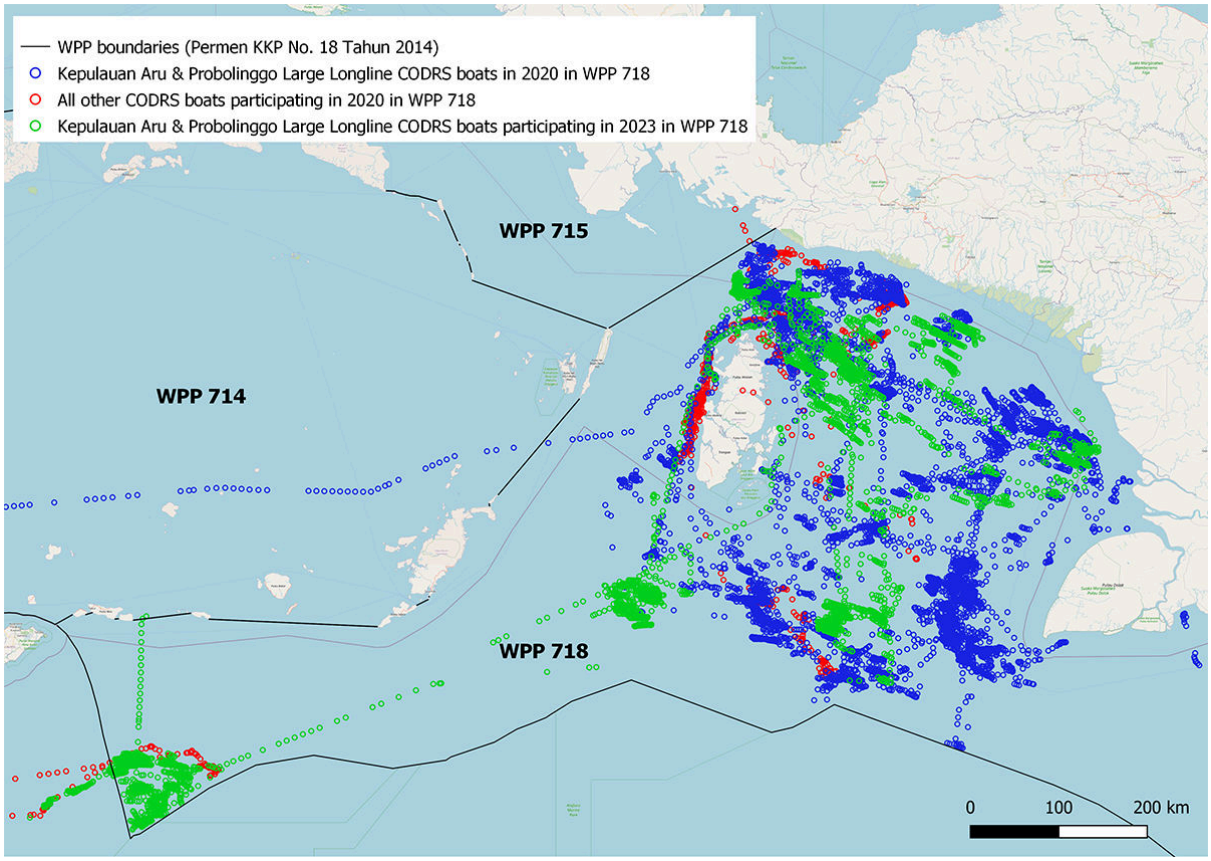


Figure 3.9: Positions of Kepulauan Aru and Probolinggo Large Longline vessels in WPP 718 in 2020 and in 2023, and other fleet segments participating here in 2020.

Table 3.1: 2020 and 2023 sample sizes of Top 16 snapper and grouper species from major fleet segments in the Indonesian Deep Demersal Fisheries in WPPs 573, 711 and 712.

	WPP-573		WPP-711		WPP-712A		WPP-712B	
	Kupang		Belitung Bintan		Jepara Belitung		Lamongan	
	Medium Dropline		Medium Trap		Medium Trap		Medium Dropline	
Species Name	2020	2023	2020	2023	2020	2023	2020	2023
Lutjanus malabaricus	19381	10259	3577	1977	3835	9084	35954	8484
Pristipomoides multidens	59137	36963	3973	768	27	108	485	537
Aphareus rutilans	38	337	0	0	0	0	0	0
Epinephelus coioides	31	46	251	227	612	1066	482	400
Etelis radiosus	21	105	0	0	0	0	0	0
Pristipomoides typus	31936	17465	1693	428	0	17	110	197
Epinephelus areolatus	14214	12937	7110	9411	616	2521	13270	6749
Pristipomoides filamentosus	1580	2074	0	6	0	0	0	0
Pristipomoides sieboldii	355	1203	0	0	0	0	0	0
Etelis boweni	177	1881	0	0	0	0	0	0
Plectropomus maculatus	0	6	2448	2032	237	259	1563	763
Lutjanus erythropterus	3656	1860	198	129	225	573	23208	6791
Etelis coruscans	2	795	0	0	0	0	0	0
Lutjanus sebae	2194	1096	2051	2492	83	228	2175	463
Lutjanus johnii	0	0	115	79	387	167	432	86
Paracaesio kusakarii	182	981	0	0	0	0	0	0

Nano less than 5 GT. **Small** 5 - <10 GT. **Medium** 10 - 30 GT. **Large** >30 GT.

Table 3.2: 2020 and 2023 sample sizes of Top 16 snapper and grouper species from major fleet segments in the Indonesian Deep Demersal Fisheries in WPPs 713, 715 and 718.

	WPP-713		WPP-715A		WPP-715B		WPP-718A		WPP-718B	
	Takalar++		Minahasa Utara		Sorong		Kepulauan Aru		Aru Probolinggo	
	Medium Dropline		Large Dropline		NSM Dropline		Medium Dropline		Large Longline	
Species Name	2020	2023	2020	2023	2020	2023	2020	2023	2020	2023
Lutjanus malabaricus	2521	1481	36	5	3445	2735	2551	802	71038	14121
Pristipomoides multidens	1407	6003	2760	415	46	99	137	424	40060	28017
Aphareus rutilans	0	164	8844	473	0	0	3	0	7	14
Epinephelus coioides	10	8	2	6	73	48	65	39	2282	623
Etelis radiosus	0	3	2552	781	0	0	0	0	2	6
Pristipomoides typus	395	1445	278	158	22	13	8	143	3696	13430
Epinephelus areolatus	1173	4624	160	123	134	33	86	182	7640	12234
Pristipomoides filamentosus	0	8	8416	901	0	0	0	24	194	346
Pristipomoides sieboldii	0	0	1802	1311	0	0	0	0	4	148
Etelis boweni	0	0	7554	2808	0	0	0	12	35	173
Plectropomus maculatus	27	2	0	0	172	63	56	17	152	76
Lutjanus erythropterus	1482	815	782	1	6115	11676	420	61	1143	191
Etelis coruscans	0	0	5395	2527	0	0	0	0	0	0
Lutjanus sebae	212	552	18	1	143	36	58	65	5797	4354
Lutjanus johnii	5	0	0	0	176	41	71	34	1525	164
Paracaesio kusakarii	0	0	4242	1334	0	0	0	0	3	13

Nano (N) less than 5 GT. **Small (S)** 5 - <10 GT. **Medium (M)** 10 - 30 GT. **Large (L)** >30 GT.

The Kendall Tau Rank Correlation Test results showed a strong and statistically significant correlation between the rankings of sample sizes by species in 2020 and 2023 for most locations. This indicates a consistent pattern in sample size ranking by species across these two years. From this sample size rank correlation analysis, we can thus conclude that the species composition, based on the overall ranking of the most important species in terms of numbers in the samples, has not changed significantly from 2020 to 2023. The Kendall Tau test is particularly suitable for evaluating this kind of relationship (sample size rank consistency).

3.2 Median Lengths and CPUE in Catches by Selected Fleet Segments

The Kupang-based medium-sized drop line vessels, operating in the south-eastern corner of WPP 573 on the Sahul Banks in the Timor Sea (Figure 3.1), landed snappers and groupers in 2023 with a smaller medium size than what was recorded in 2020, for the majority of target species for which sufficiently large sample sizes could be compared (Table 3.3). A comparison between 2020 and 2023 could be made in WPP 573 for 8 out of the Top 16 species in the Indonesian deep demersal fisheries. For 6 out of these 8 species a significant reduction in medium size was recorded from 2020 to 2023, while just one species showed a significant but very small increase in median size and one more species showed no difference at all in median sizes between 2020 and 2023.

Three major target species in the Kupang-based medium-sized drop line fishery, including Malabar Snapper (*Lutjanus malabaricus*), Goldband Snapper (*Pristipomoides multidens*) and Sharptooth Jobfish (*Pristipomoides typus*), showed a substantial decrease in median length in the catch of 10% or more. CPUE values in this drop line fishery (Table 3.5) also declined significantly for the same species that showed a decline in median length. Declines in CPUE were considerably more than 10% for all 6 of these species, and even close to 50% for 4 of them. Overall, the pattern in CPUE changes from 2020 to 2023 was identical to the pattern observed for median lengths in the Kupang-baed medium-sized drop line fishery.

In the Belitung and Bintan trap fishery, operating with medium-sized boats in the Natuna Sea and the Karimata Strait in WPP 711, in the northwest of Indonesia (Figure 3.2), the pattern from 2020 to 2023 was the reverse from what we observed in the Timor Sea. Four out of the 7 species for which the comparison could be made, showed a signif icant and substantial increase of 10% or more in median length in the catch (Table 3.3). This group included the 3 major species of snappers, *L. malabaricus*, *P. multidens* and *P. typus*, as well as one valuable species of grouper, *P. maculatus*. One species of grouper (*E. areolatus*) showed a significant but minor drop in median length, while another (*E. coioides*) showed a significant but minor increase. One more species of snapper (*L. sebae*) did not show any significant change in median length. Just like in WPP 573, the trends from 2020 to 2023 in median length in WPP 711 were mostly confirmed by trends in CPUE. Four out of 7 species showed a significant and substantial increase in CPUE, while just one species showed a significant and substantial decrease, and changes in CPUE for the 2 remaining species were not statistically significant (Table 3.5).

In WPP 712 we have looked at two distinct fisheries operating on different fishing grounds. At the western end of the Java Sea, we analysed catches of the Jepara- and Belitung-based trap fishery with medium and small boats (Figure 3.3), while at the eastern end of the Java Sea, near the boundary with the Makassar Strait, we looked at the Lamongan-based drop line fishery with medium-sized boats (Figure 3.4). For the trap fishery on the western fishing grounds, we had obtained large samples sizes in 2023 from medium-sized boats operating out of Jepara. To enable comparison with catch characteristics from 2020 however, we needed to add catches from Belitung based vessels, operating on the same fishing grounds, and we had to combine data from medium-sized vessels with catches from smaller boats as well. For the fishery at the eastern end, we had obtained sufficiently large samples from Lamongan-based medium-sized drop line boats for both years to enable direct comparisons.

Table 3.3: 2020 & 2023 median lengths in CODRS samples of Top 16 snapper & grouper species from major fleet segments in the Indonesian Deep Demersal Fisheries in WPPs 573, 711 & 712. Median lengths are displayed only when sample sizes of at least 200 specimen were available for both years.

	WPP-573		WPP-711		WPP-712A		WPP-712B	
	Kupang		Belitung Bintan		Jepara Belitung		Lamongan	
	Medium Dropline		Medium Trap		Medium Trap		Medium Dropline	
Species Name	2020	2023	2020	2023	2020	2023	2020	2023
Lutjanus malabaricus	**54**	**49**	**36**	**47**	**34**	**40**	38	38
Pristipomoides multidens	**50**	**41**	**40**	**44**			**45**	**41**
Aphareus rutilans								
Epinephelus coioides			**59**	**63**	**64**	**67**	**65**	**70**
Etelis radiosus								
Pristipomoides typus	**45**	**41**	**35**	**41**				
Epinephelus areolatus	**33**	**32**	**29**	**28**	30	31	29	30
Pristipomoides filamentosus	44	44						
Pristipomoides sieboldii	**38**	**40**						
Etelis boweni								
Plectropomus maculatus			**47**	**55**	**54**	**65**	**47**	**54**
Lutjanus erythropterus	**54**	**51**			32	32	31	32
Etelis coruscans								
Lutjanus sebae	**51**	**48**	29	28			27	27
Lutjanus johnii								
Paracaesio kusakarii								

Nano less than 5 GT. **Small** 5 - <10 GT. **Medium** 10 - 30 GT. **Large** >30 GT.
Sets displayed in **green** show a substantial increase of 10% or more in length from 2020 to 2023.
Sets displayed in **red** show a substantial decrease of 10% or more in length from 2020 to 2023.
Sets of lengths (2020-2023) are significantly different only when displayed in **bold**.

Table 3.4: 2020 & 2023 median lengths in CODRS samples of Top 16 snapper & grouper species from major fleet segments in the Indonesian Deep Demersal Fisheries in WPPs 713, 715 & 718. Median lengths are displayed only when sample sizes of at least 200 specimen were available for both years.

	WPP-713		WPP-715A		WPP-715B		WPP-718A		WPP-718B	
	Takalar++		Minahasa Utara		Sorong		Kepulauan Aru		Aru Probolinggo	
	Medium Dropline		Large Dropline		NSM Dropline		Medium Dropline		Large Longline	
Species Name	2020	2023	2020	2023	2020	2023	2020	2023	2020	2023
Lutjanus malabaricus	46	45			**44**	**38**	**54**	**51**	**55**	**57**
Pristipomoides multidens	**53**	**39**	59	57					50	49
Aphareus rutilans			66	70						
Epinephelus coioides									**63**	**70**
Etelis radiosus			58	56						
Pristipomoides typus	**45**	**38**							**51**	**47**
Epinephelus areolatus	**31**	**29**							32	33
Pristipomoides filamentosus			**46**	**41**						
Pristipomoides sieboldii			38	37						
Etelis boweni			**68**	**61**						
Plectropomus maculatus										
Lutjanus erythropterus	37	38			**44**	**40**				
Etelis coruscans			**58**	**54**						
Lutjanus sebae	33	34							55	54
Lutjanus johnii										
Paracaesio kusakarii			**53**	**48**						

Nano (N) less than 5 GT. **Small (S)** 5 - <10 GT. **Medium (M)** 10 - 30 GT. **Large (L)** >30 GT.
Sets displayed in **green** show a substantial increase of 10% or more in length from 2020 to 2023.
Sets displayed in **red** show a substantial decrease of 10% or more in length from 2020 to 2023.
Sets of lengths (2020-2023) are significantly different only when displayed in **bold**.

Table 3.5: 2020 and 2023 median CpUE (kg/GT/day) of Top 16 snapper and grouper species from major fleet segments in the Indonesian Deep Demersal Fisheries in WPPs 573, 711 and 712.

	WPP-573 Kupang Medium Dropline		WPP-711 Belitung Bintan Medium Trap		WPP-712A Jepara Belitung Medium Trap		WPP-712B Lamongan Medium Dropline	
Species Name	2020	2023	2020	2023	2020	2023	2020	2023
Lutjanus malabaricus	**2.63**	**1.42**	0.36	0.43	**2.60**	**1.59**	**1.77**	**0.95**
Pristipomoides multidens	**5.08**	**2.65**	**0.50**	**0.32**			0.11	0.14
Aphareus rutilans								
Epinephelus coioides			**0.24**	**0.37**	**3.02**	**1.02**	**0.35**	**0.85**
Etelis radiosus								
Pristipomoides typus	**2.07**	**1.02**	0.17	0.21				
Epinephelus areolatus	**0.59**	**0.42**	**0.13**	**0.27**	0.22	0.16	0.22	0.28
Pristipomoides filamentosus	0.42	0.36						
Pristipomoides sieboldii	0.11	0.13						
Etelis boweni								
Plectropomus maculatus			**0.36**	**0.59**	**1.48**	**0.53**	**0.21**	**0.38**
Lutjanus erythropterus	**0.53**	**0.35**			**0.67**	**0.12**	**0.38**	**0.29**
Etelis coruscans								
Lutjanus sebae	**0.42**	**0.21**	**0.10**	**0.20**			**0.06**	**0.04**
Lutjanus johnii								
Paracaesio kusakarii								

Nano less than 5 GT. **Small** 5 - <10 GT. **Medium** 10 - 30 GT. **Large** >30 GT.
Sets displayed in **green** show a substantial increase of 10% or more in CpUE from 2020 to 2023.
Sets displayed in **red** show a substantial decrease of 10% or more in CpUE from 2020 to 2023.
Sets of CpUEs (2020-2023) are significantly different only when displayed in **bold**.

Table 3.6: 2020 and 2023 median CpUE (kg/GT/day) of Top 16 snapper and grouper species from major fleet segments in the Indonesian Deep Demersal Fisheries in WPPs 713, 715 and 718.

	WPP-713 Takalar++ Medium Dropline		WPP-715A Minahasa Utara Large Dropline		WPP-715B Sorong NSM Dropline		WPP-718A Kepulauan Aru Medium Dropline		WPP-718B Aru Probolinggo Large Longline	
Species Name	2020	2023	2020	2023	2020	2023	2020	2023	2020	2023
Lutjanus malabaricus	**3.08**	**0.55**			1.34	1.45	**1.56**	**0.57**	**1.05**	**0.84**
Pristipomoides multidens	**2.76**	**1.19**	0.44	0.27					**0.46**	**0.70**
Aphareus rutilans			**1.43**	**0.32**						
Epinephelus coioides									**0.14**	**0.23**
Etelis radiosus			0.46	0.38						
Pristipomoides typus	**0.59**	**0.20**							**0.12**	**0.38**
Epinephelus areolatus	0.30	0.23							**0.03**	**0.11**
Pristipomoides filamentosus			**0.85**	**0.35**						
Pristipomoides sieboldii			**0.09**	**0.25**						
Etelis boweni			1.46	3.26						
Plectropomus maculatus										
Lutjanus erythropterus	**0.44**	**0.27**			**1.50**	**5.84**				
Etelis coruscans			0.62	0.73						
Lutjanus sebae	0.15	0.14							**0.17**	**0.32**
Lutjanus johnii										
Paracaesio kusakarii			0.51	0.42						

Nano (N) less than 5 GT. **Small (S)** 5 - <10 GT. **Medium (M)** 10 - 30 GT. **Large (L)** >30 GT.
Sets displayed in **green** show a substantial increase of 10% or more in CpUE from 2020 to 2023.
Sets displayed in **red** show a substantial decrease of 10% or more in CpUE from 2020 to 2023.
Sets of CpUEs (2020-2023) are significantly different only when displayed in **bold**.

In the Jepara- and Belitung-based trap fishery with medium and small boats, operating in the western Java Sea in WPP 712, we recorded a significant increase in median length in the catch for 3 out of 5 species (Table 3.3), with 2 species showing substantial increases of more than 10% in median length. The remaining 2 out of 5 species showed no significant changes at all. For 4 of these 5 species however, a substantial decrease in median CPUE was recorded in this fishery with traps in the western Java Sea (Table 3.5). This may be partly due to uncertainties introduced in the effort estimates by combining various fleet segments to enable the comparison. The median length in the catch would be much less sensitive to this effect of combining fleet elements with different size vessels.

At the eastern end of WPP 712, in the Lamongan-based median drop line fishery, one important species of snapper (*L. multidens*) showed a substantial decrease in the median length in the catch. One valuable species of grouper (*P. maculatus*), showed a substantial increase in median length while another grouper (*E. coiodes*) also showed a significant but small increase in median length. Four other species of snappers and groupers showed no significant change in median size in this fishery (Table 3.3). Trends in CPUE from 2020 to 2023 in this fishery (Table 3.5), showed a substantial decrease for various species of snappers, while the same indicator increased substantially for 2 species of groupers.

Patterns were consistent between median length and CPUE in the drop line fisheries with medium sized boats out of Takalar (South Sulawesi), Balikpapan (East Kalimantan) and ports in East Java, operating in the southern Makassar Strait in WPP 713 (Figure 3.5). Two major target species of snapper, *P. multidens* and *P. typus*, showed a significant and substantial decrease in both median length and CPUE, from 2020 to 2023 (Tables 3.4 and 3.6). One species of grouper (*E. areolatus*) also showed a significant decrease in median length over those years, and two more important species of snappers (*L. malabaricus* and *L. erythropterus*) showed a significant and substantial decrease in CPUE during that time. A decline in indicator values from 2020 to 2023 was thus evident in the WPP 713 medium drop line fishery with medium sized boats, across the range of target species in the southern Makassar Strait.

In WPP 715 we have looked at two distinct fisheries operating on different fishing grounds. Focussing mostly on true deepwater snappers (*Etelis spp.* and *Pristipomoides spp.*), the Minahasa Utara drop line fleet engages in long-range operations, across WPP 715 and beyond (Figure 3.6). This fleet specifically targets the true deepwater snappers (Eteline snappers) along deep drop offs and around remote seamounts, with large-sized vessels, equipped with sophisticated GPS tracking and depth sounding equipment. In a smaller area west of the Papua Bird's Head, the Sorong-based drop line fishery operates with nano-, small-, and medium sized boats on shallower fishing grounds (Figure 3.7), targeting mainly Malabar and Crimson Snapper (*L. malabaricus* and *L. erythropterus*).

The species-diverse catch of the Minahasa Utara drop line fishery in WPP 715 showed a substantial (more than 10%) decrease in median size from 2020 to 2023 for 3 out of 8 species, with only small or insignificant changes recorded for the remaining 5 (Table 3.4). The picture was mixed for CPUE in this fishery, with 1 out of 8 species showing a significant and substantial increase in CPUE from 2020 to 2023, while 2 species showing a significant and substantial decrease during that same time (Table 3.6). In the Minahasa Utara drop line fishery, multiple species showed no significant or just minor changes in median length and CPUE, but the pattern was not consistent across the two indicators. We note here that this is a wide-ranging fishery, which often changes fishing locations in WPP 715.

In the more localized Sorong-based drop line fishery in WPP 715, a significant and substantial decrease in median size in the catch was recorded from 2020 to 2023, for both target species (*L. malabaricus* and *L. erythropterus*). Median CPUE values, however, showed no significant change for Malabar and a substantial increase for Crimson Snapper during this time. The latter may very well be due to uncertainties in effort estimates in this fleet segment, covering nano, small, and medium sized vessels, in ratios that changed between 2020 and 2023.

In WPP 718 we also looked at 2 different fisheries, including the drop line fisheries operating around the Aru Islands (Kepulauan Aru) with medium sized boats (Figure 3.8) and the Aru- and Probolinggo-based long line fishery operating throughout the Arafura Sea with large-sized vessels (Figure 3.9). The Kepulauan Aru medium drop line fishery showed a significant decrease from 2020 to 2023 in both median length and CPUE for Malabar Snapper (Tables 3.4 and 3.6), one of their main target species.

In the Aru- and Probolinggo-based long line fishery in WPP 718, there were no substantial (10% or more) changes in the median lengths of 4 target species of snappers from 2020 to 2023, although for 2 out of these 4 species the changes were significant, with 1 up and 1 down during this period. One species of grouper (*E. coioides*) showed a significant and substantial increase in median size in the catch, while another (smaller) species (*E. areolatus*) did not show any significant change at all. The vast majority of target species in this long line fishery (including both snappers and groupers), however, showed a substantial increase in CPUE, except for Malabar Snapper, the main target species, which showed a decline in CPUE. Changes in CPUE in this fishery may be related to changes in positioning to less fished locations within WPP 718 from 2020 to 2023 (Figure 3.9).

3.3 Length Frequency Distributions and Trends in Indicator Values

For the 19 combinations of species and fleet segment that exhibited substantial changes in median length from 2020 to 2023, we took a closer look at relative length frequency distributions in the catch of CODRS vessels in those years. Starting with *L. malabaricus* caught by Kupang Medium Dropline boats in WPP 573 (Figure 3.11), we noted that the median length dropped from just above the length at 50% maturity in 2020 to just below in 2023. This means that more than 50% of the catch in 2023 consisted of immature fish, and risk levels had thus further increased from where they were already in 2020. The relative frequency of medium sized fish with lengths between 50 and 60 cm decreased dramatically between 2020 and 2023, while for the same period the relative frequency of immature fish increased substantially. Interestingly, the relative frequency of sizes around and above Lopt remained stable during the same period.

The large increase in relative frequency of immature *L. malabaricus* from 2020 to 2023 could have been a temporary situation, caused for example by a large recruitment impulse after 2020. Other length-based indicators could potentially exhibit similar changes for these years, while these would not necessarily have to be part of long-term trends. We therefore filtered out the length-based indicator values including median length (as percentage of Lmax), and percentages of immatures, large matures and mega-spawners, for the fleet segment "Kupang Medium Dropline" (operating in WPP 573), from the CODRS data base for all years with available data, and plotted the 2020 and 2023 values together with the longer-term data points (Figure 3.12).

Longer-term trends of decreasing median lengths, increasing percentages of immature fish and stable but very low percentages of large matures and mega-spawners in the catch are indeed evident for *L. malabaricus* in the Kupang medium drop line fishery (Figure 3.12). Percentages immatures in the catch seemed to fluctuate a bit more than other length-based indicators (Figure 3.12), possibly due to variation in recruitment from year to year. The same trends in length-based indicator values, showing increasing levels of risk to sustainability, were also evident in this fishery for *P. multidens* and *P. typus* (Figures 3.13 to 3.16). Conclusions on declining trends in WPP 573 from our 2020 holistic assessment (Pet et al., 2023) were thus clearly reconfirmed by results from 2023 and 2024.

In WPP 711 we looked at relative catch length frequencies and time trends in length-based indicators from the Belitung and Bintan medium trap fishery for *L. malabaricus*, *P. multidens*, *P. typus*, and *P. maculatus* (Figures 3.17 to 3.24). For all these 4 species the relative length frequencies clearly showed a shift to larger fish in the catches here, although for all 3 snappers the median length still remained below the length at maturity, indicating that risk levels still remain high for this indicator. The grouper *P. maculatus*, on the other hand, the length frequencies from the 2023 catches showed a broad peak around the optimum harvest size, indicating low risk for this species. For all 4 species that we investigated here from the Belitung and Bintan medium trap fishery in WPP 711, trends in length-based indicator showed either improvement or stable levels, with the note that levels for the 3 species of snapper had come from very high risk and remained at risk until 2024.

In the Jepara and Belitung medium trap fishery at the western end of WPP712, the patterns for *L. malabaricus* and *P. maculatus* (Figures 3.25 to 3.28) were roughly the same as observed for these 2 species in the adjacent WPP 711. Very small immature Malabar snappers and in fact very large P. maculatus caught by the medium trap fishery here. Some improvement for *L. malabaricus* in terms of median length and percentage of immatures, but not in terms of large matures or mega-spawners. Continuous improvement in all the length-based indicators for *P. maculatus*, but only few data points (years) available, indicating that this species is not abundant in the catch every year.

At the eastern end of WPP 712 we looked at the Lamongan-based medium drop line fisheries and we investigated catch length frequencies and trends in length-based indicators for *P. multidens* and *P. maculatus* (Figures 3.29 to 3.32). For the Goldband Snapper (*P. multidens*) we observed mainly very small immature fish in the catch, both in 2020 and in 2023. The median length further decreased during these years, and dropped well below the length at maturity, indicating high levels of risk. Trends in length-based indicators over multiple years showed continuous decline or stable situations at dangerously low levels. For *P. maculatus* in the same fishery, however, we observed an increase in median length and a shift to more large mature fish in the catch from 2020 to 2023, while most length-based indicators remained stable at lower risk levels over the longer term.

The drop line fisheries with medium sized boats out of Takalar (South Sulawesi), Balikpapan (East Kalimantan) and ports in East Java, operates in the southern Makassar Strait in WPP 713, as well as on other fishing grounds. We looked at relative length catch length frequencies and time trends in length-based indicator values from catches of *P. multidens* and *P. typus*, originating from WPP 713 (Figures 3.33 to 3.36). For both species we observed shifts of peak catches to length classes below the length at maturity, indicating increased risk levels from 2020 to 2023. Long-term time trends for both species showed deterioration in stock health for all indicators.

For WPP 715 we have looked at two distinct fisheries operating on different fishing grounds. The Minahasa Utara drop line fleet engages in long-range operations, targeting deep water snappers with large sized boats all across this WPP, while the Sorong-based drop line fishery operates with nano-, small-, and medium sized boats on shallower fishing grounds near the Papua Bird's Head. Catches of *P. filamentosus*, *E. boweni*, and *P. kusakarii* by the Minahasa Utara drop line fleet showed substantial drops in median length and shifts of catch length frequency peaks to the left, towards or below the size of maturity for these deep-water snappers between 2020 and 2023. Longer-term time trends in length-based indicator values however did not show very clear deterioration or improvements, while risk levels remained high throughout the period for which data were available (Figures 3.37 to 3.42).

All indicators however showed clear and continuous deterioration of health indicators in the stocks of *L. malabaricus* and *L. erythropterus* targeted by the Sorong-based drop line fishery (Figures 3.43 to 3.46). The peak of *L. malabaricus* catch length frequencies in this fishery had dropped well below the length at maturity by 2023, while the peak in the distribution for *L. erythropterus* rapidly reached that critical size by that time.

In WPP 718 the only species showing a substantial change in median length from 2020 to 2023 was the grouper *E. coioides* (Figure 3.10) in the catches of the Aru- and Probolingo-based long line fishery with large sized vessels (Figures 3.47 and 3.48). All other species, including all snappers, for which sufficiently large samples were obtained, showed only small or insignificant changes in median lengths from 2020 to 2023. And even though a substantial increase in median size in the catch of large long line vessels was observed in WPP 718 for *E. coioides*, to well above its size at maturity, longer term time trends did not show any clear trends in either direction in the period from 2017 to 2024 for this species. Risk levels may not be very high for this grouper in WPP 718, but risk levels remained high, based on size-based indicators, for all snapper species during this same period (Pet et al., 2020; this study).



Figure 3.10: *Epinephelus coioides* (Orange-spotted Grouper, Estuary Cod)

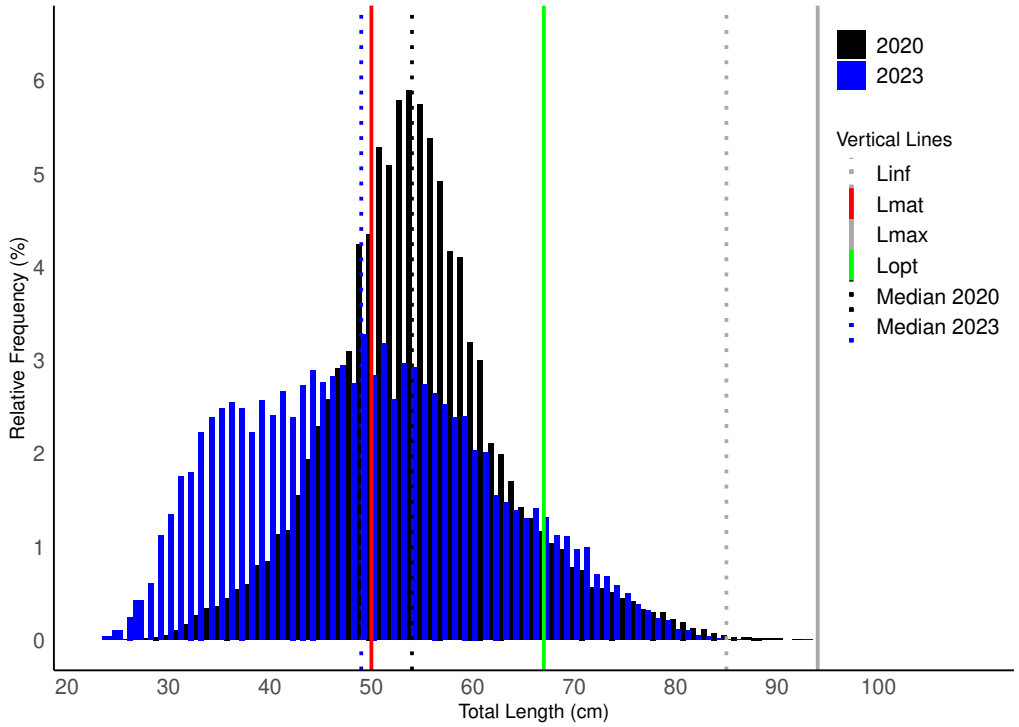


Figure 3.11: 2020 and 2023 relative length frequency distributions of *Lutjanus malabaricus* caught by Kupang Medium Dropline boats participating in the CODRS program in WPP 573.

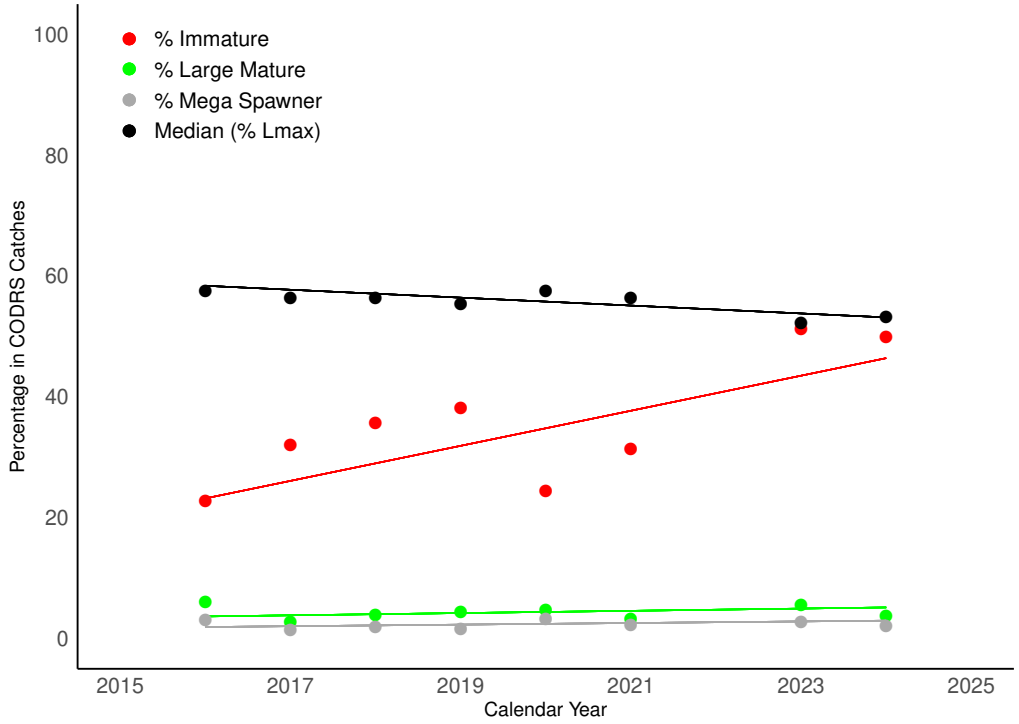


Figure 3.12: Trends in relative abundance by size group of *Lutjanus malabaricus* caught by Kupang Medium Dropline boats participating in the CODRS program in WPP 573.

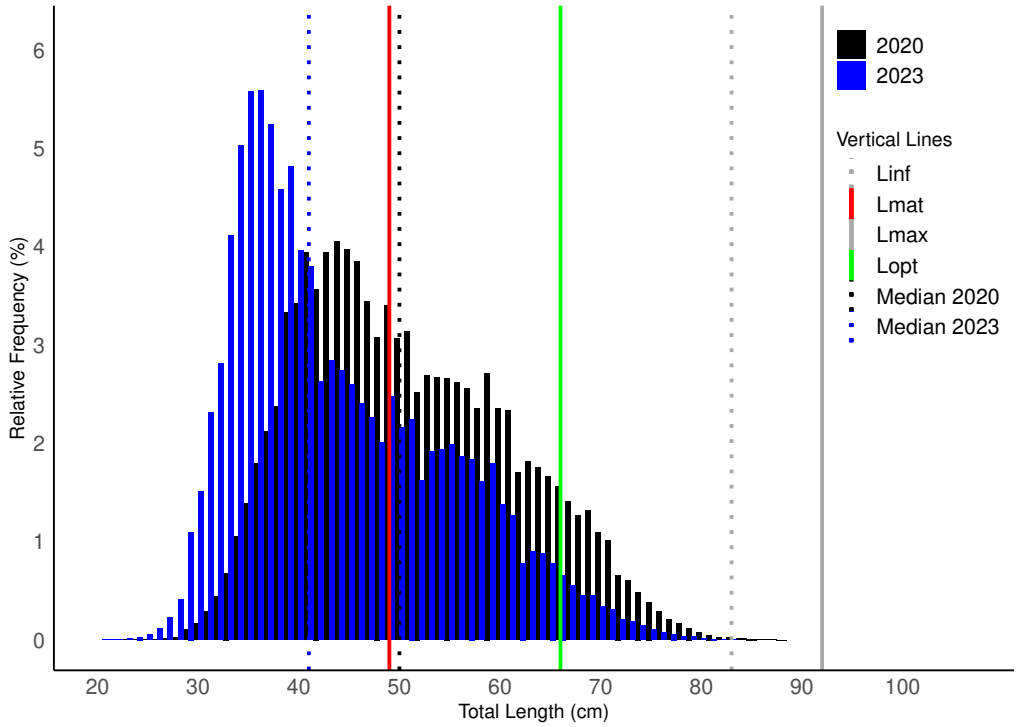


Figure 3.13: 2020 and 2023 relative length frequency distributions of *Pristipomoides multidens* caught by Kupang Medium Dropline boats participating in the CODRS program in WPP 573.

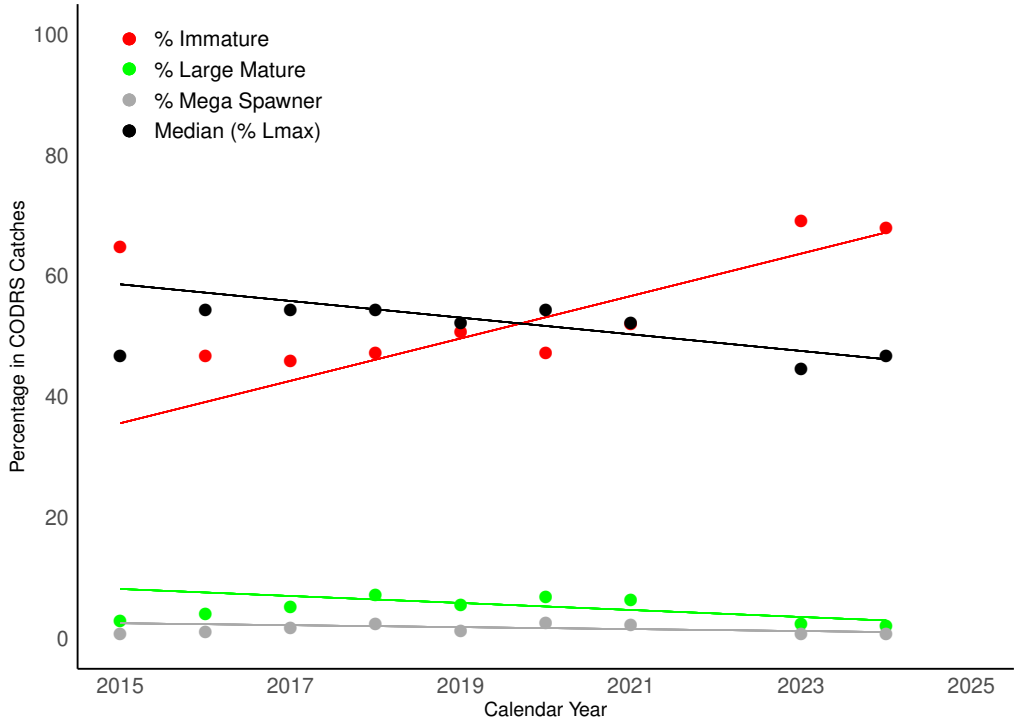


Figure 3.14: Trends in relative abundance by size group of *Pristipomoides multidens* caught by Kupang Medium Dropline boats participating in the CODRS program in WPP 573.

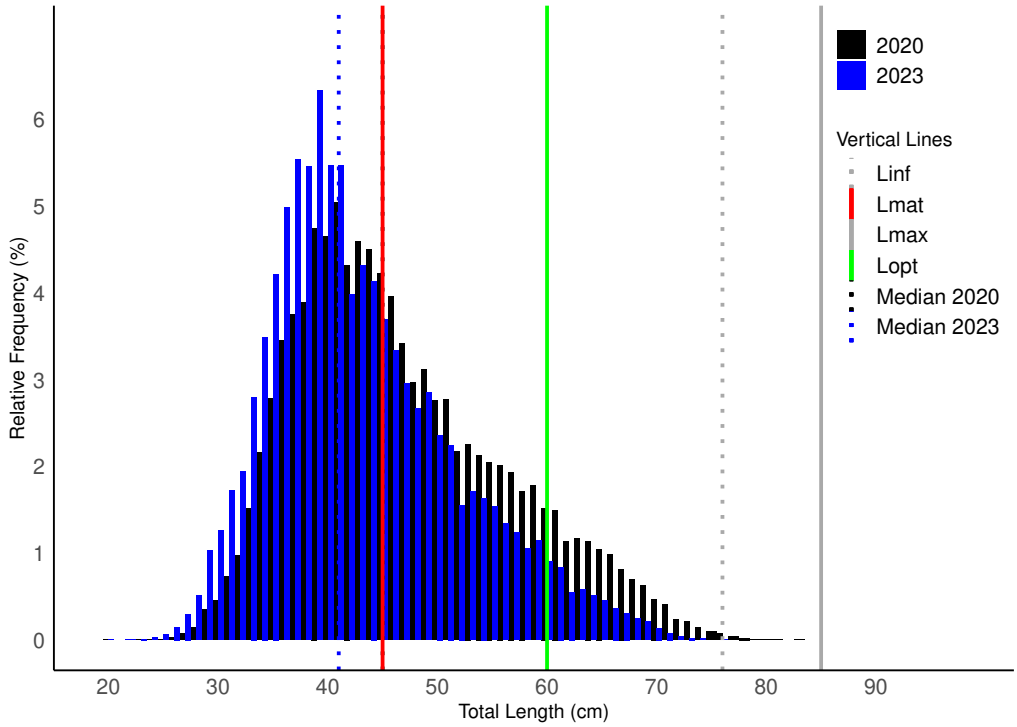


Figure 3.15: 2020 and 2023 relative length frequency distributions of *Pristipomoides typus* caught by Kupang Medium Dropline boats participating in the CODRS program in WPP 573.

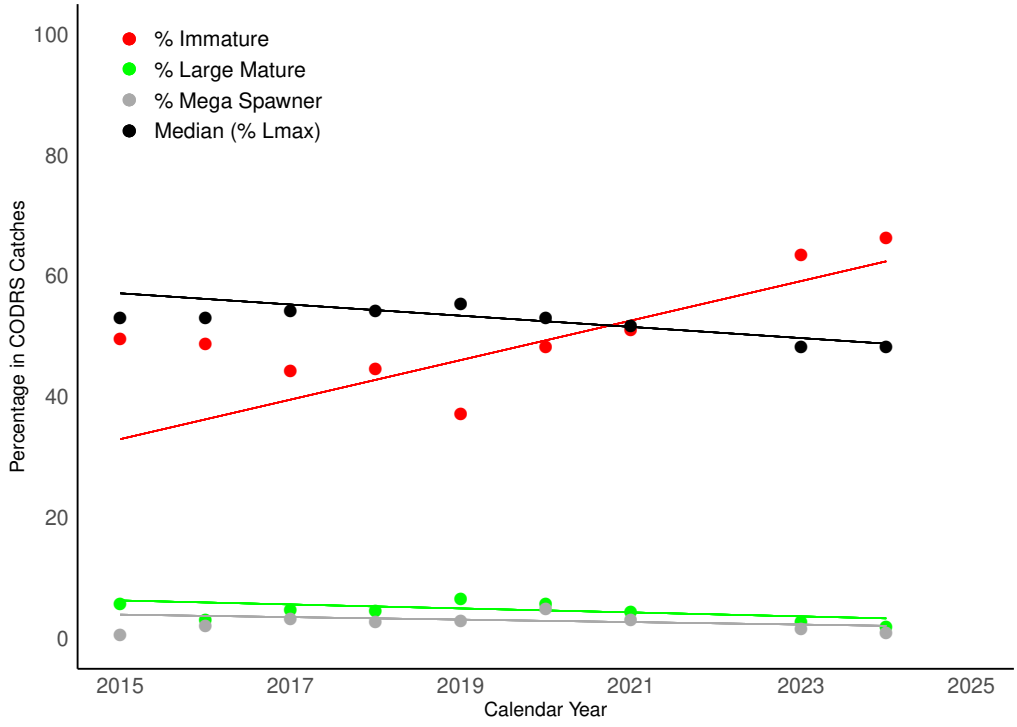


Figure 3.16: Trends in relative abundance by size group of *Pristipomoides typus* caught by Kupang Medium Dropline boats participating in the CODRS program in WPP 573.

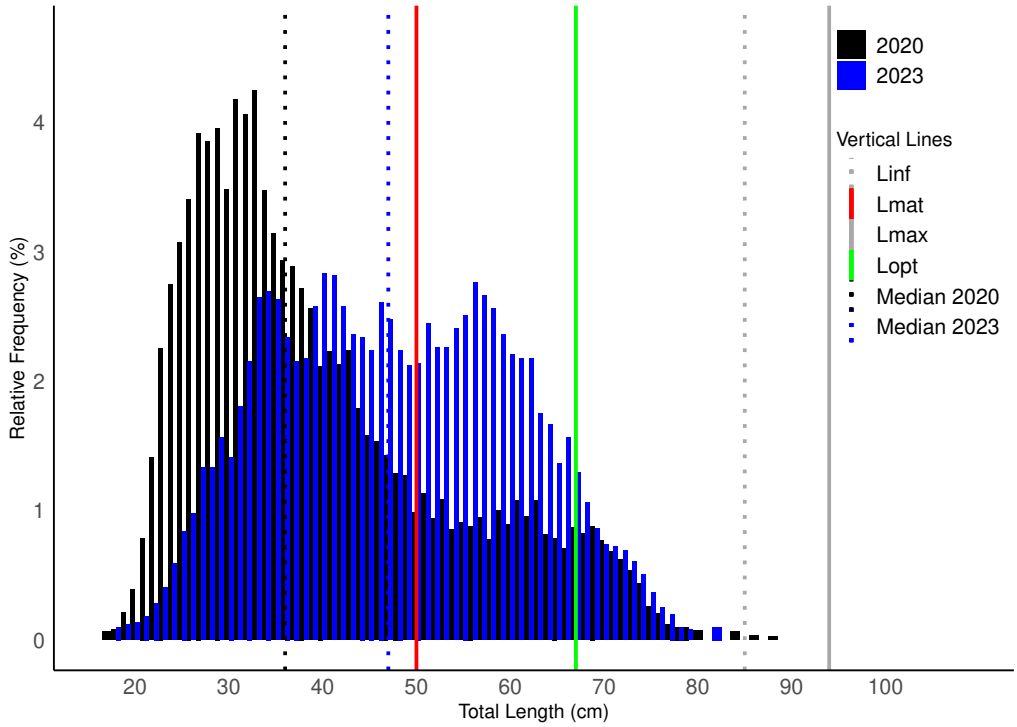


Figure 3.17: 2020 and 2023 relative length frequency distributions of *Lutjanus malabaricus* caught by Belitung Bintan Medium Trap boats participating in the CODRS program in WPP 711.

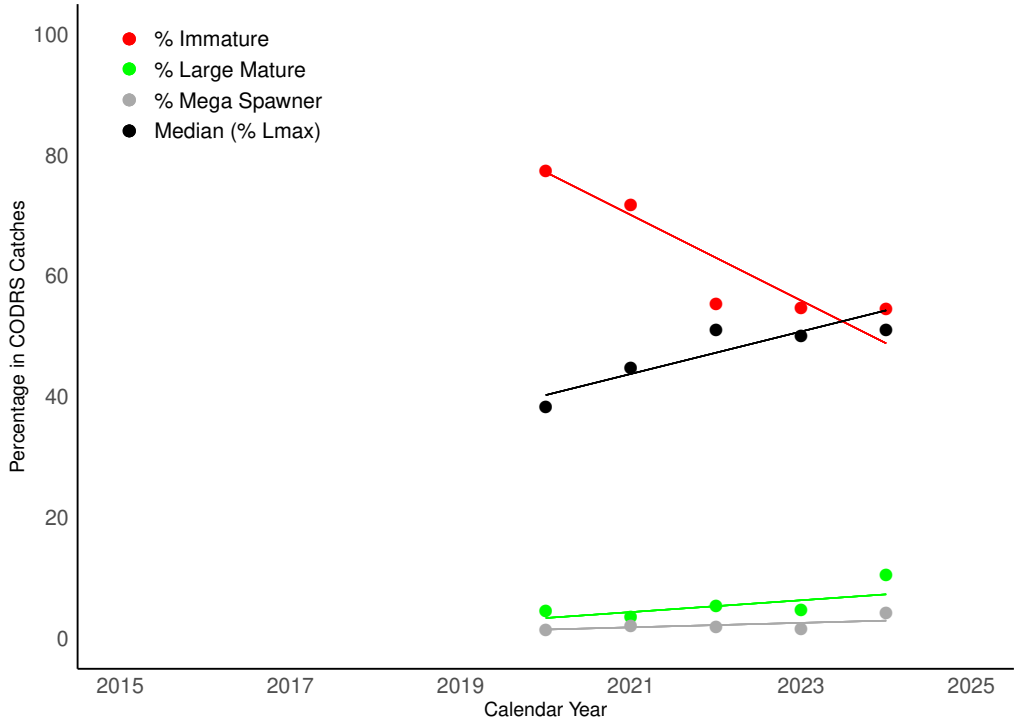


Figure 3.18: Trends in relative abundance by size group of *Lutjanus malabaricus* caught by Belitung Bintan Medium Trap boats participating in the CODRS program in WPP 711.

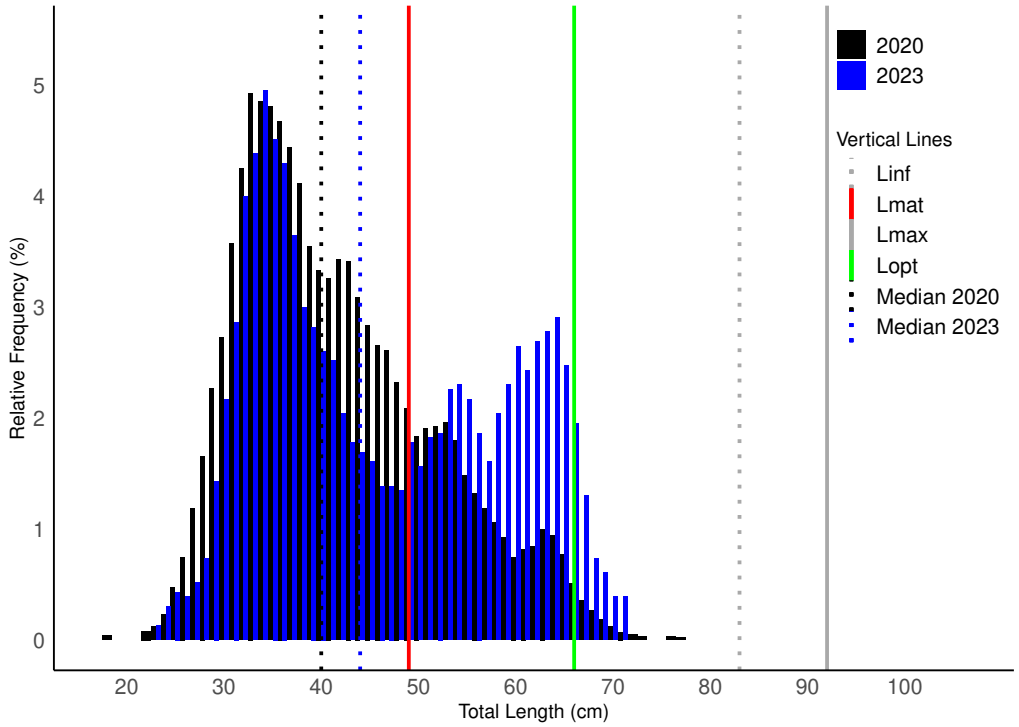


Figure 3.19: 2020 and 2023 relative length frequency distributions of *Pristipomoides multidens* caught by Belitung Bintan Medium Trap boats participating in the CODRS program in WPP 711.

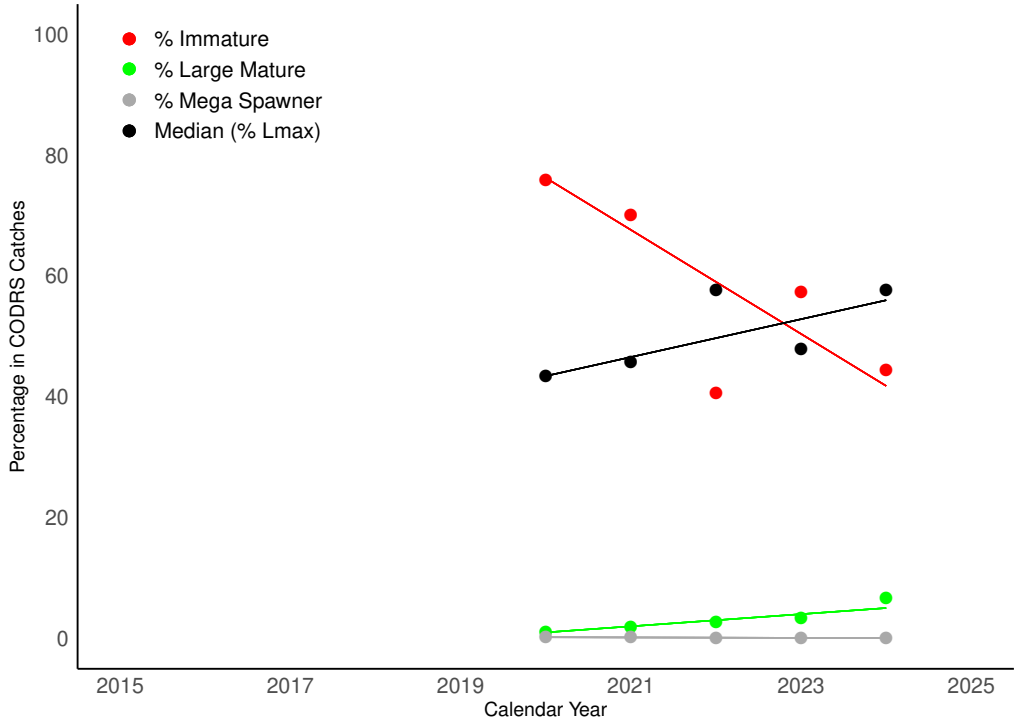


Figure 3.20: Trends in relative abundance by size group of *Pristipomoides multidens* caught by Belitung Bintan Medium Trap boats participating in the CODRS program in WPP 711.

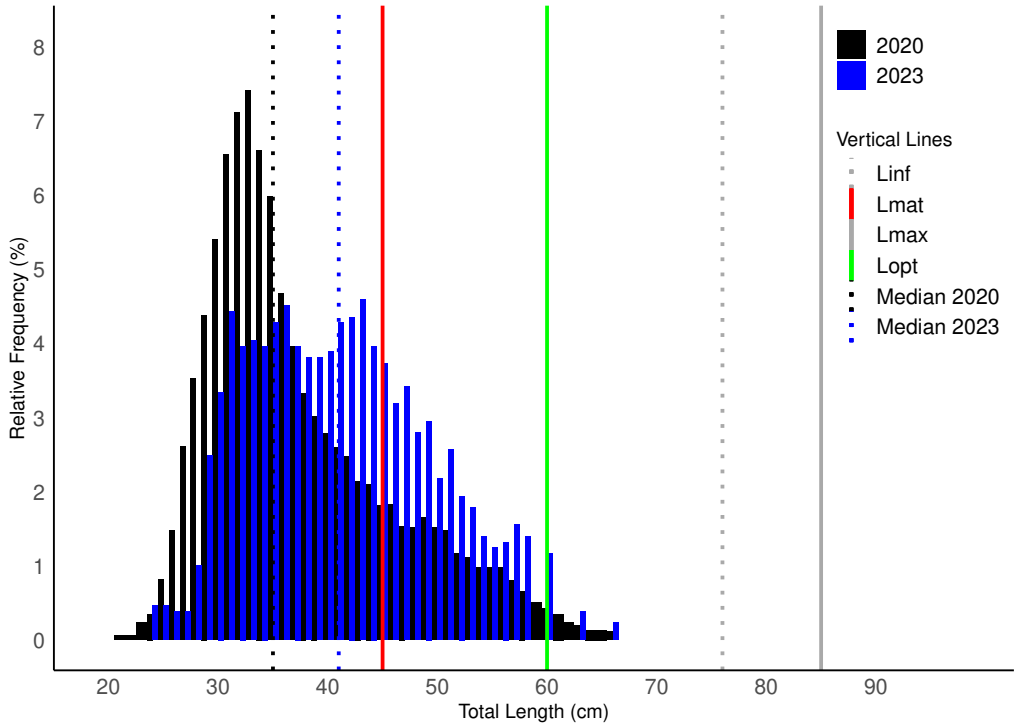


Figure 3.21: 2020 and 2023 relative length frequency distributions of *Pristipomoides typus* caught by Belitung Bintan Medium Trap boats participating in the CODRS program in WPP 711.

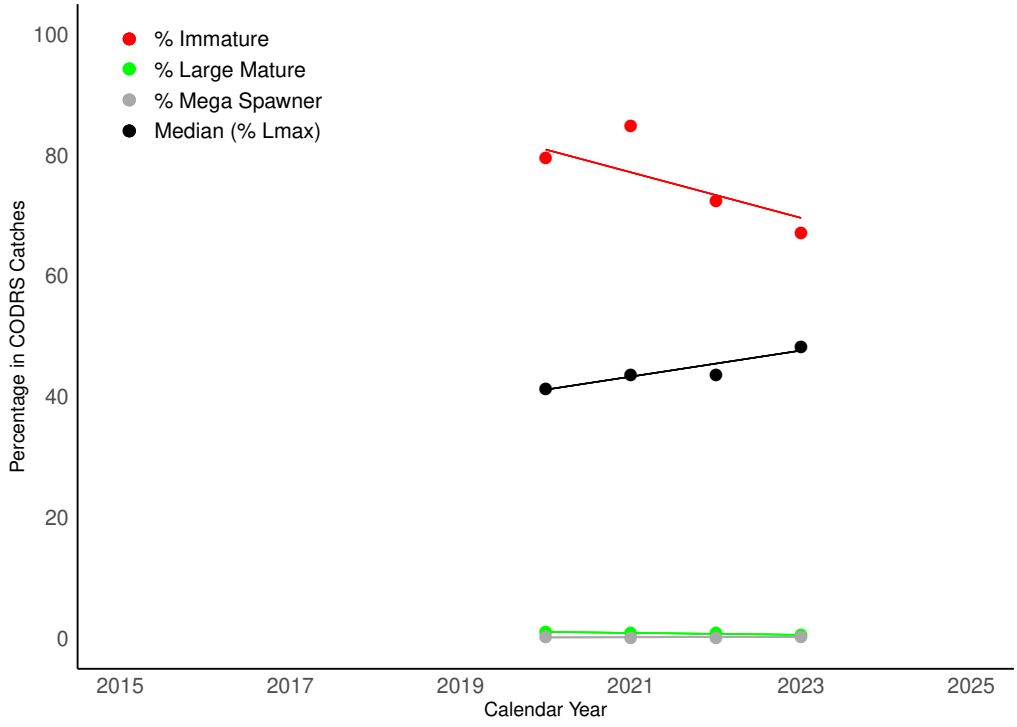


Figure 3.22: Trends in relative abundance by size group of *Pristipomoides typus* caught by Belitung Bintan Medium Trap boats participating in the CODRS program in WPP 711.

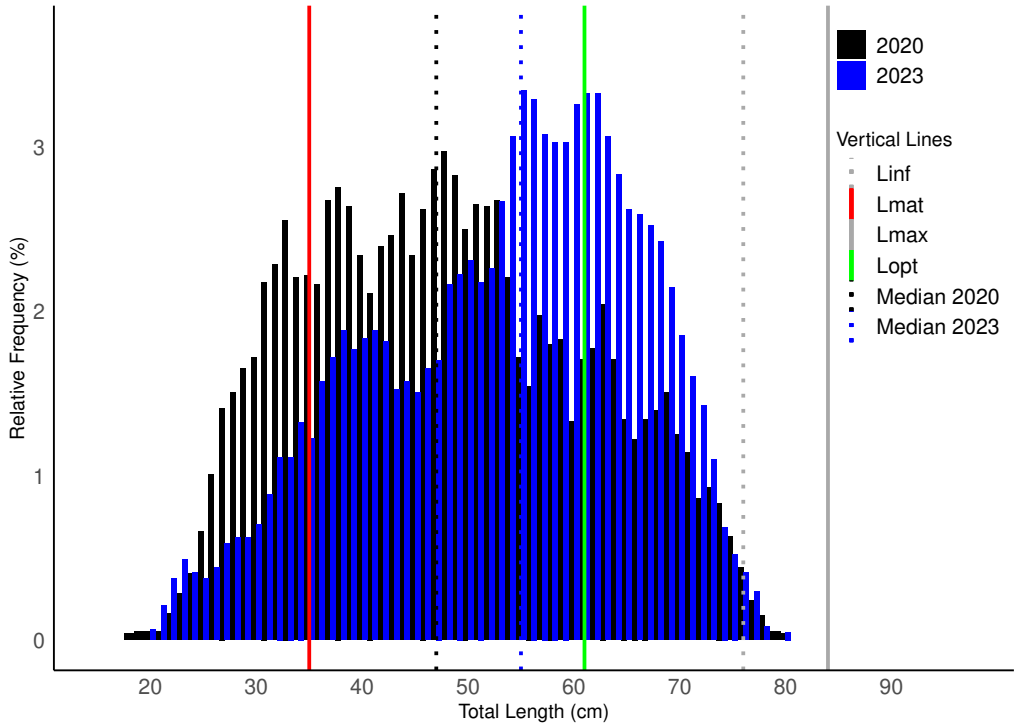


Figure 3.23: 2020 and 2023 relative length frequency distributions of *Plectropomus maculatus* caught by Belitung Bintan Medium Trap boats participating in the CODRS program in WPP 711.

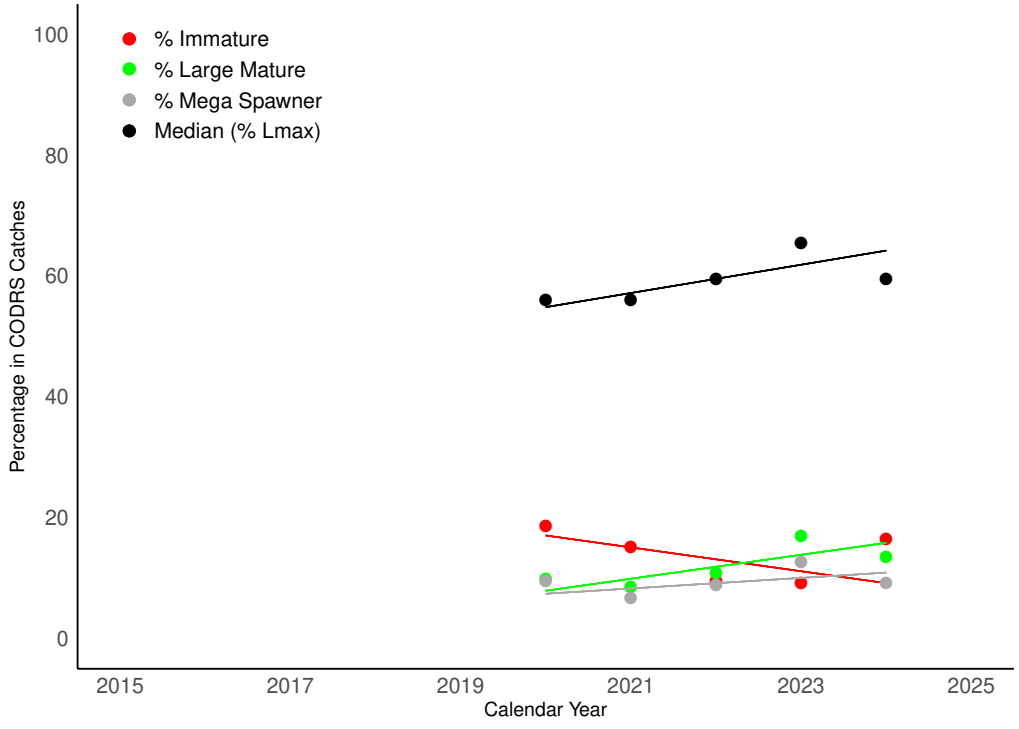


Figure 3.24: Trends in relative abundance by size group of *Plectropomus maculatus* caught by Belitung Bintan Medium Trap boats participating in the CODRS program in WPP 711.

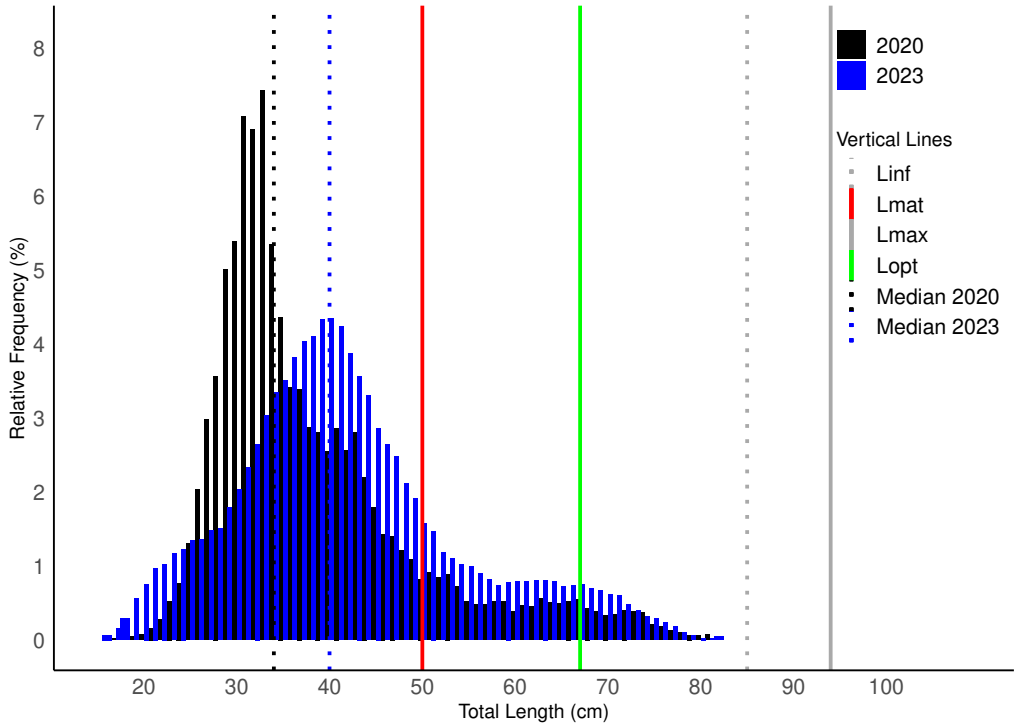


Figure 3.25: 2020 and 2023 relative length frequency distributions of *Lutjanus malabaricus* caught by Jepara Belitung Medium Trap boats participating in the CODRS program in WPP 712.

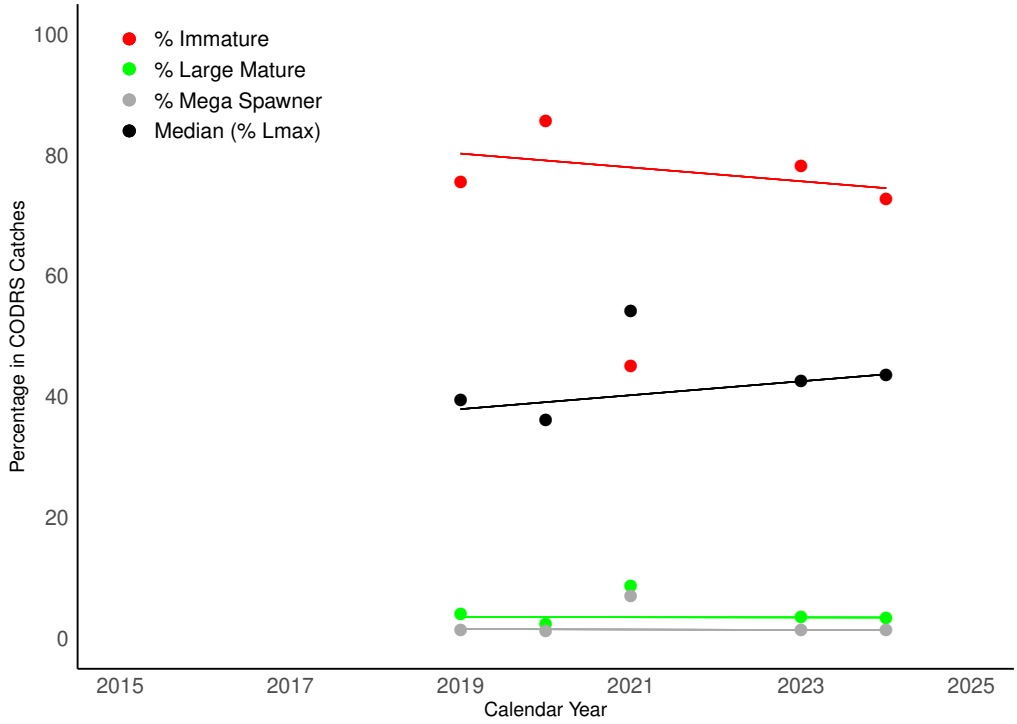


Figure 3.26: Trends in relative abundance by size group of *Lutjanus malabaricus* caught by Jepara Belitung Medium Trap boats participating in the CODRS program in WPP 712.

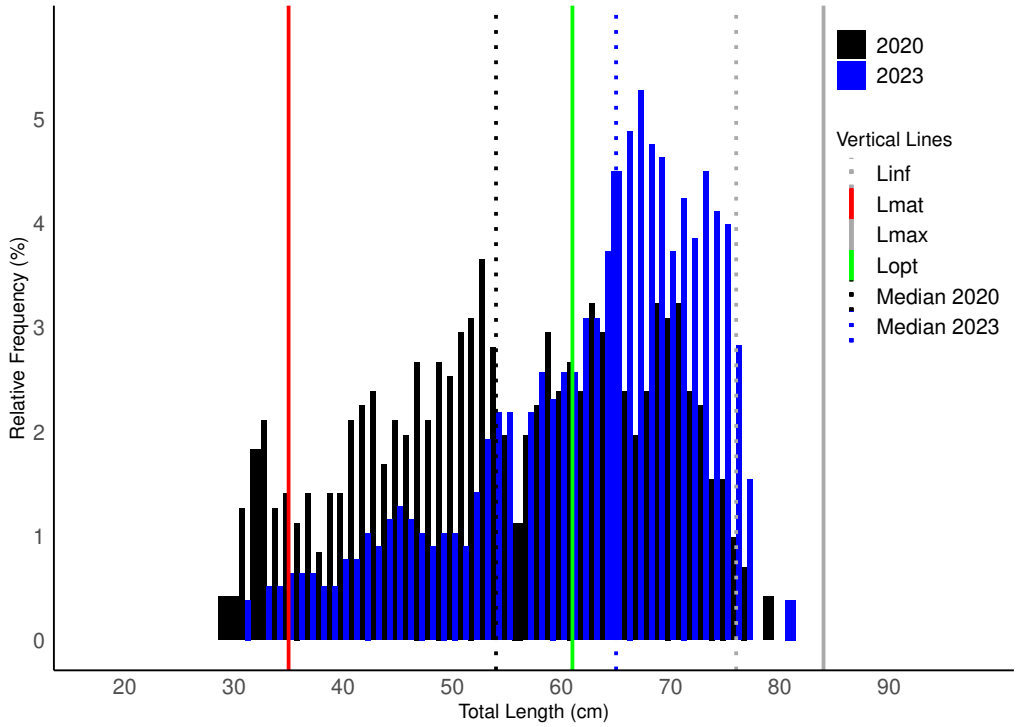


Figure 3.27: 2020 and 2023 relative length frequency distributions of *Plectropomus maculatus* caught by Jepara Belitung Medium Trap boats participating in the CODRS program in WPP 712.

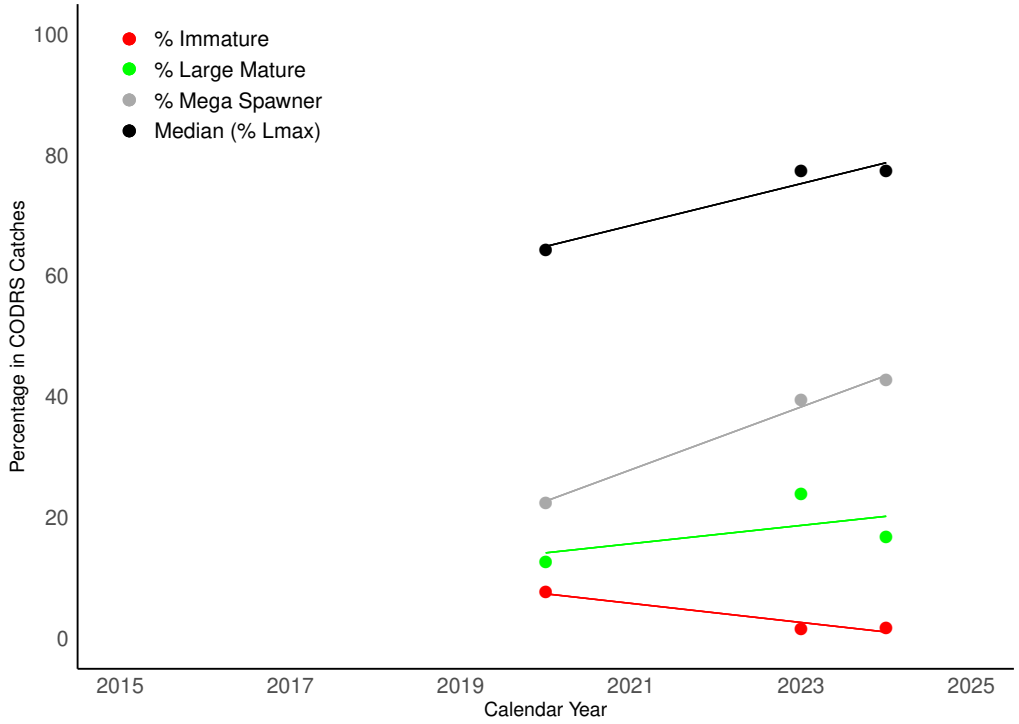


Figure 3.28: Trends in relative abundance by size group of *Plectropomus maculatus* caught by Jepara Belitung Medium Trap boats participating in the CODRS program in WPP 712.

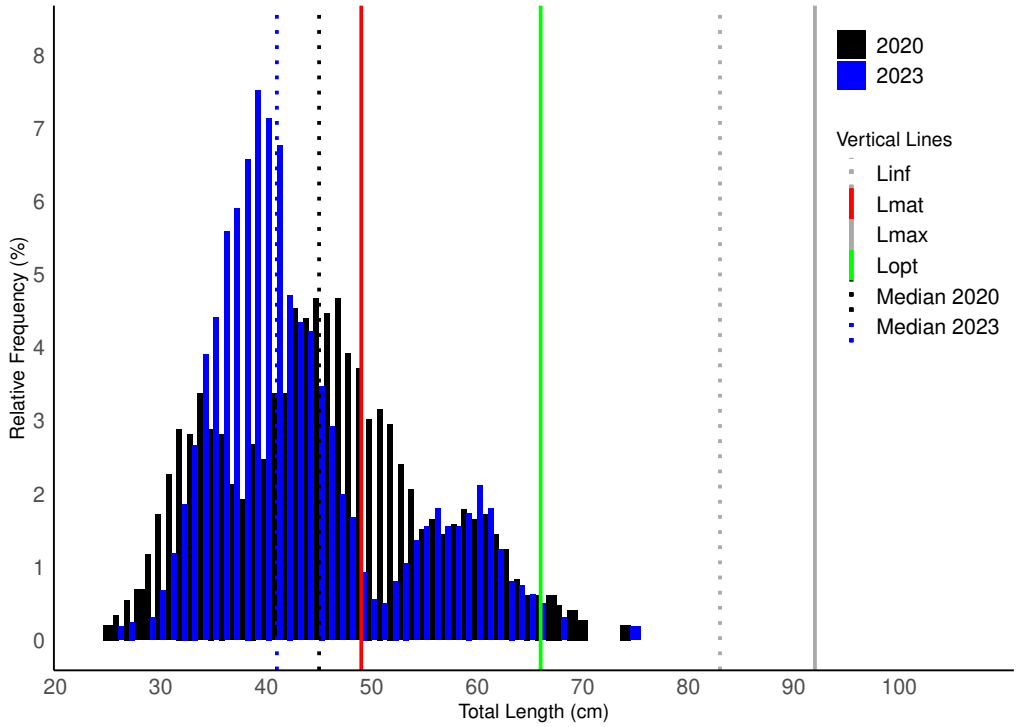


Figure 3.29: 2020 and 2023 relative length frequency distributions of *Pristipomoides multidens* caught by Lamongan Medium Dropline boats participating in the CODRS program in WPP 712.

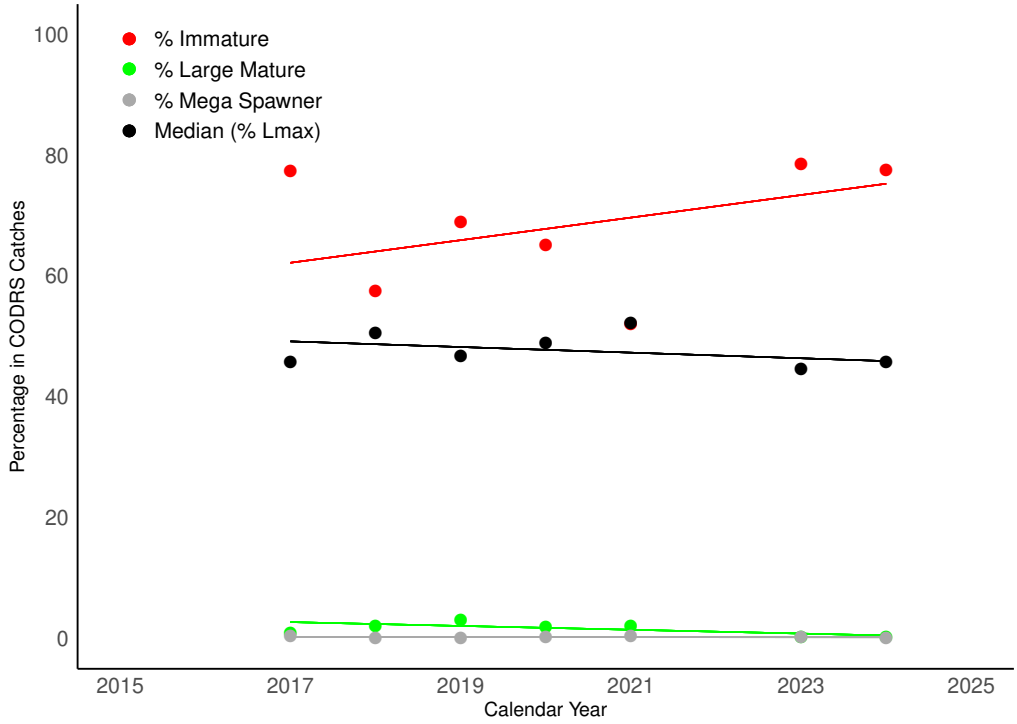


Figure 3.30: Trends in relative abundance by size group of *Pristipomoides multidens* caught by Lamongan Medium Dropline boats participating in the CODRS program in WPP 712.

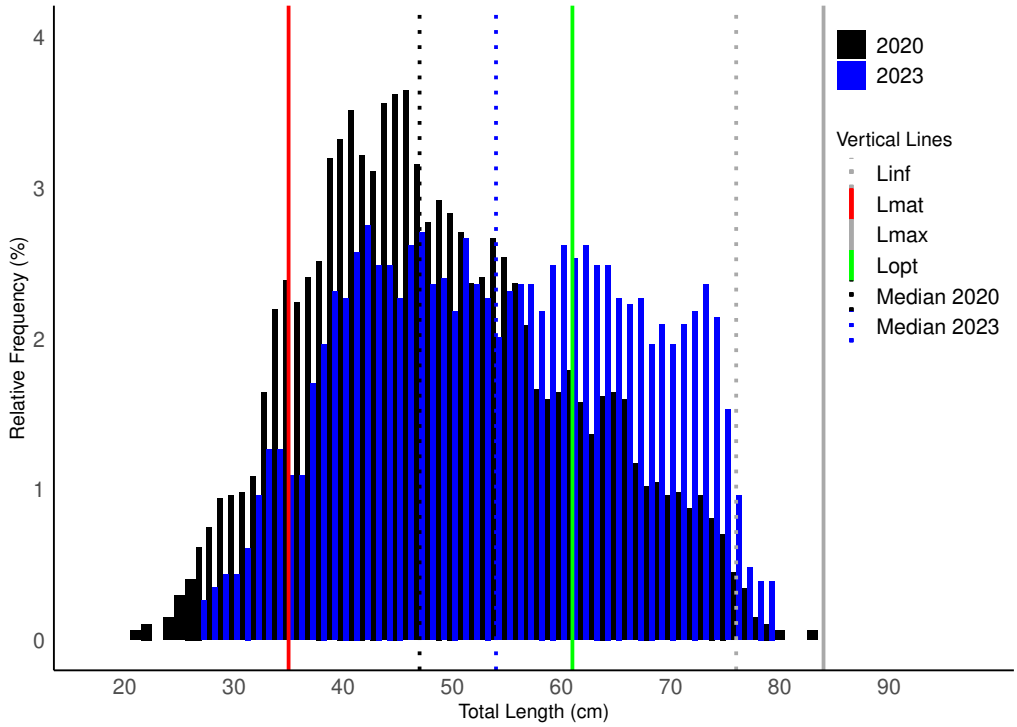


Figure 3.31: 2020 and 2023 relative length frequency distributions of *Plectropomus maculatus* caught by Lamongan Medium Dropline boats participating in the CODRS program in WPP 712.

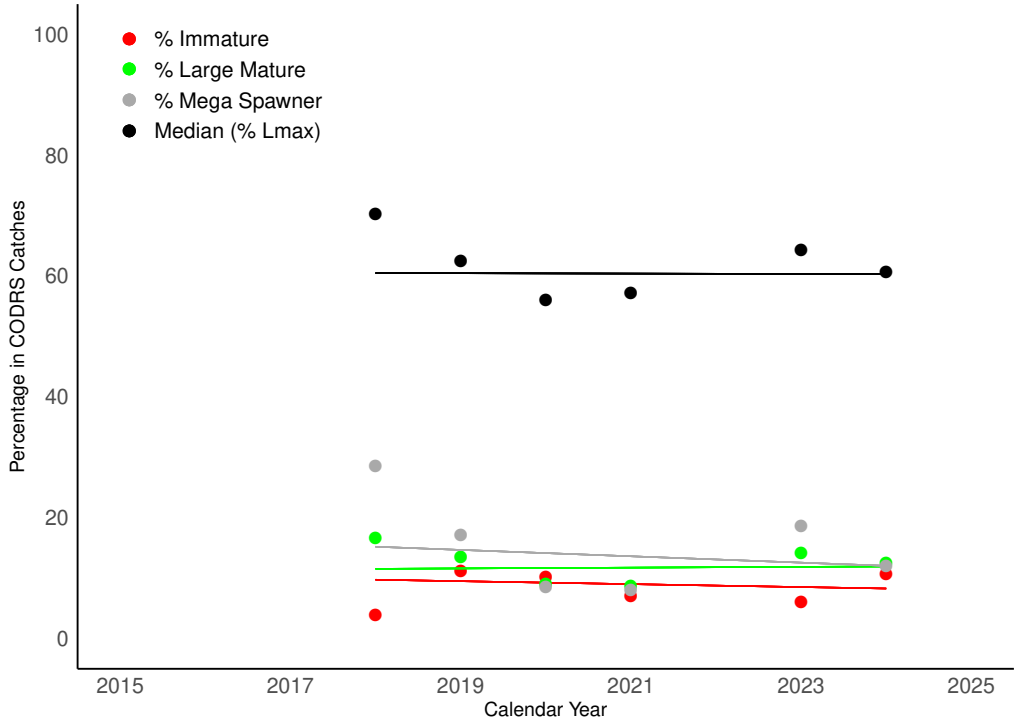


Figure 3.32: Trends in relative abundance by size group of *Plectropomus maculatus* caught by Lamongan Medium Dropline boats participating in the CODRS program in WPP 712.

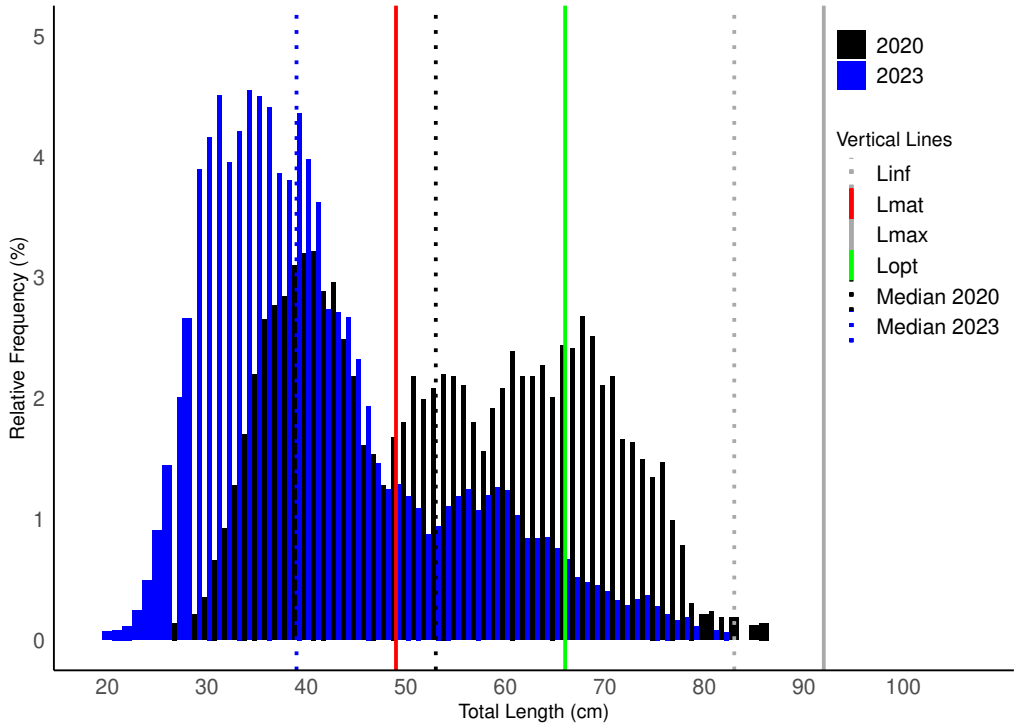


Figure 3.33: 2020 and 2023 relative length frequency distributions of *Pristipomoides multidens* caught by Takalar++ Medium Dropline boats participating in the CODRS program in WPP 713.

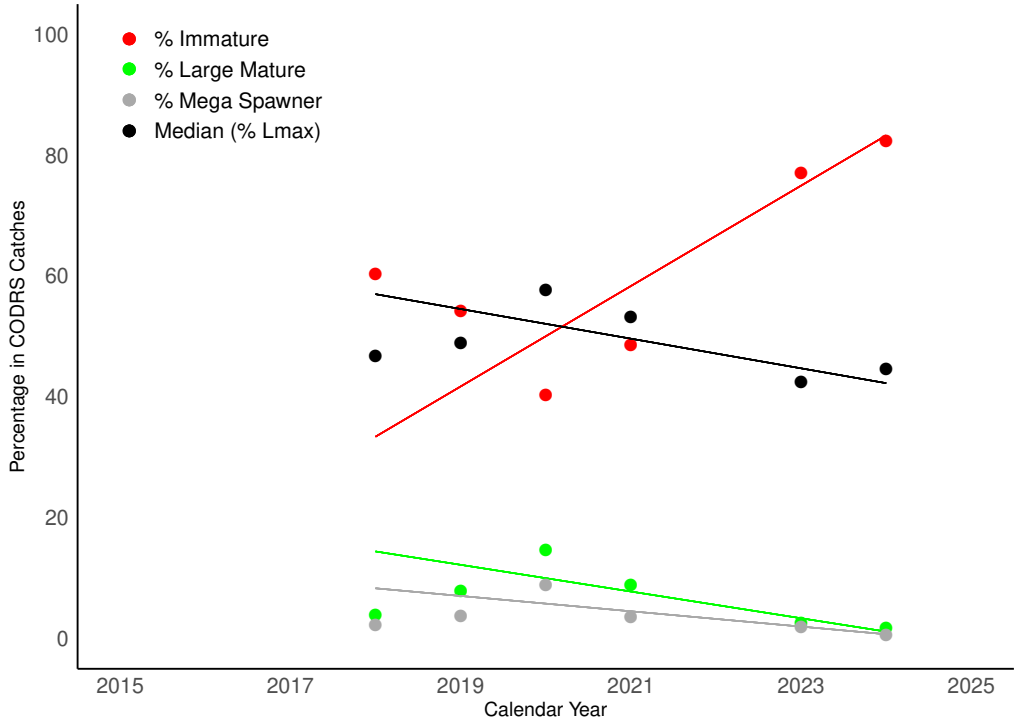


Figure 3.34: Trends in relative abundance by size group of *Pristipomoides multidens* caught by Takalar++ Medium Dropline boats participating in the CODRS program in WPP 713.

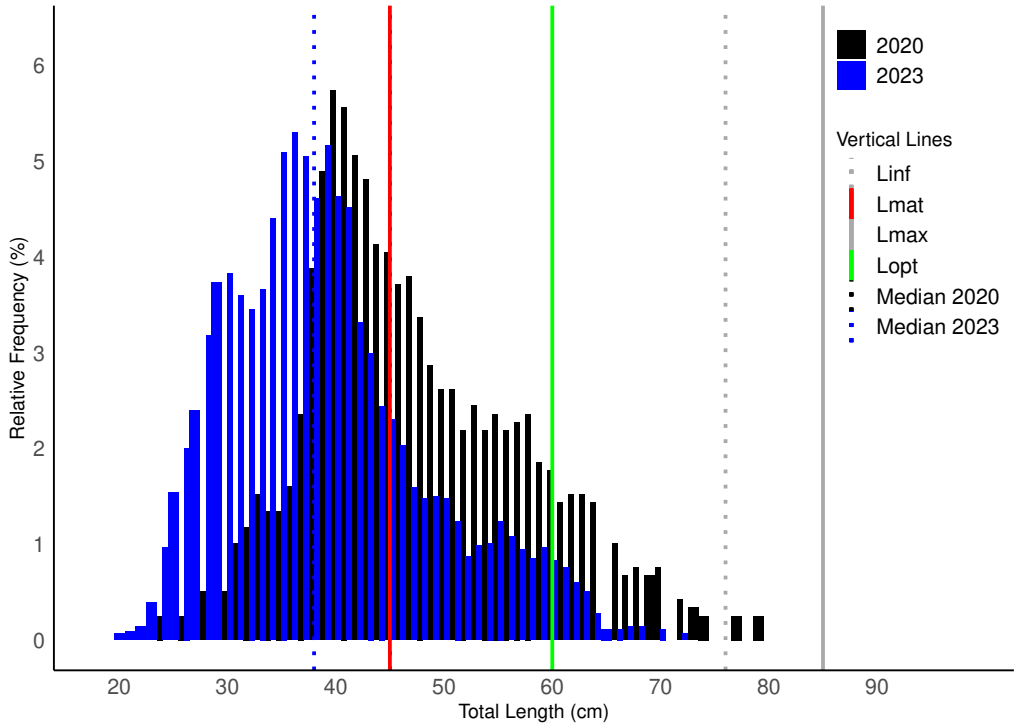


Figure 3.35: 2020 and 2023 relative length frequency distributions of *Pristipomoides typus* caught by Takalar++ Medium Dropline boats participating in the CODRS program in WPP 713.

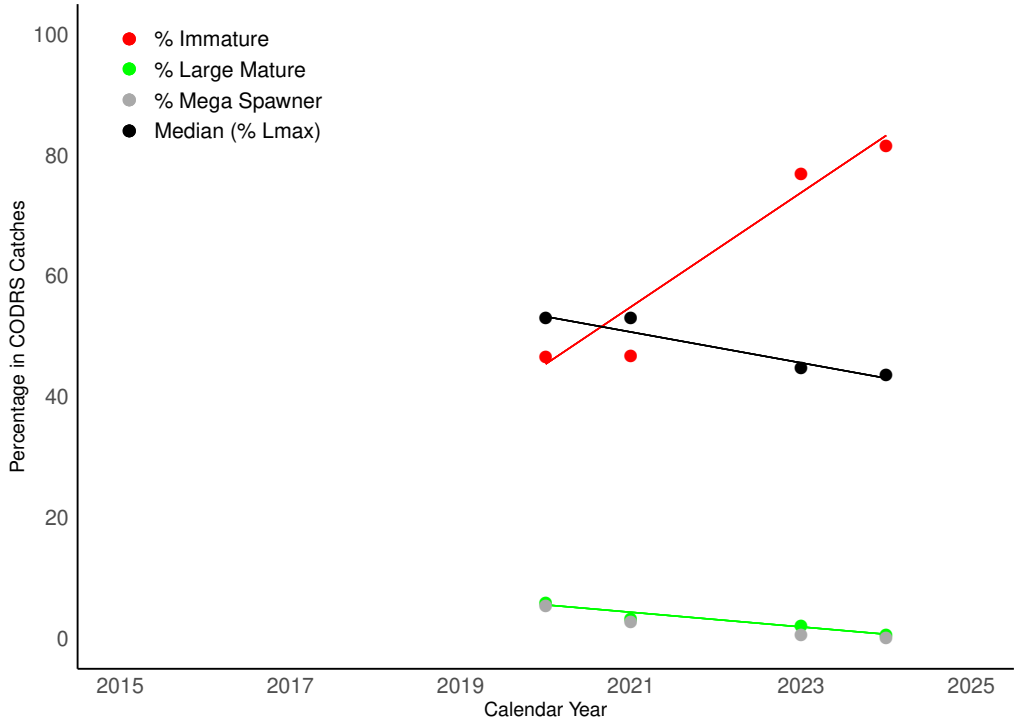


Figure 3.36: Trends in relative abundance by size group of *Pristipomoides typus* caught by Takalar++ Medium Dropline boats participating in the CODRS program in WPP 713.

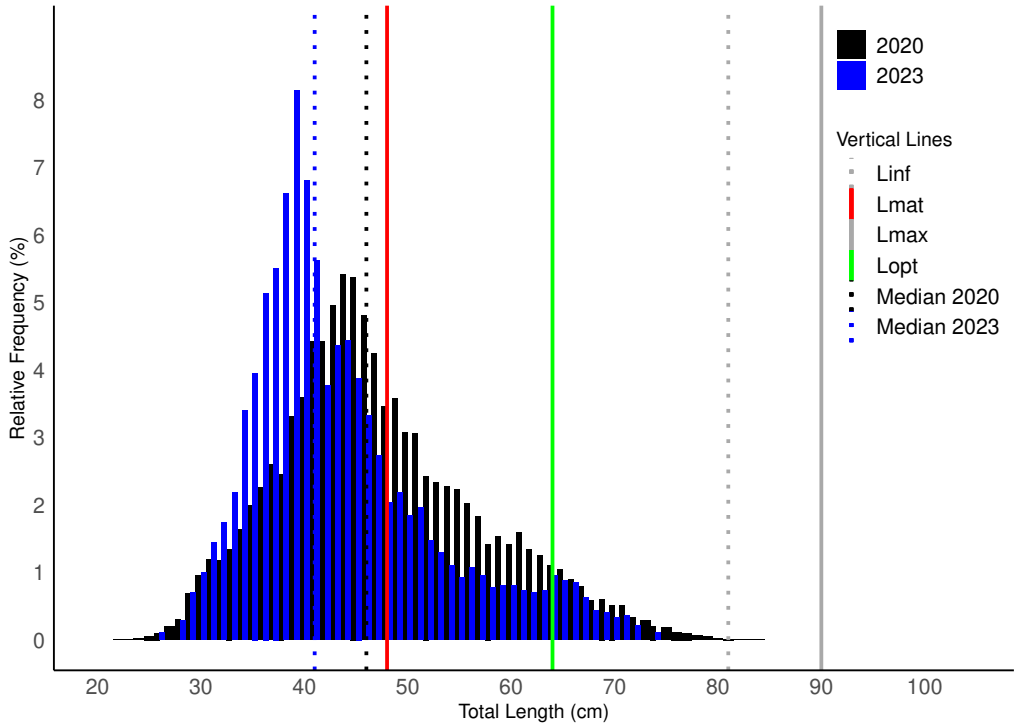


Figure 3.37: 2020 and 2023 relative length frequency distributions of *Pristipomoides filamentosus* caught by Minahasa Utara Large Dropline boats participating in the CODRS program in WPP 715.

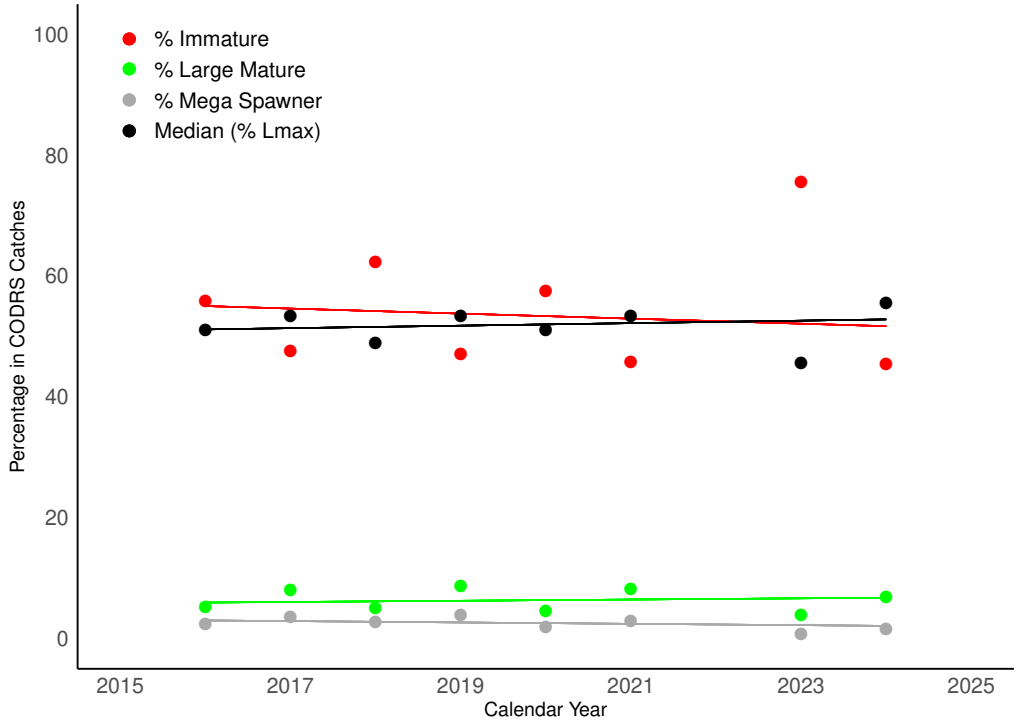


Figure 3.38: Trends in relative abundance by size group of *Pristipomoides filamentosus* caught by Minahasa Utara Large Dropline boats participating in the CODRS program in WPP 715.

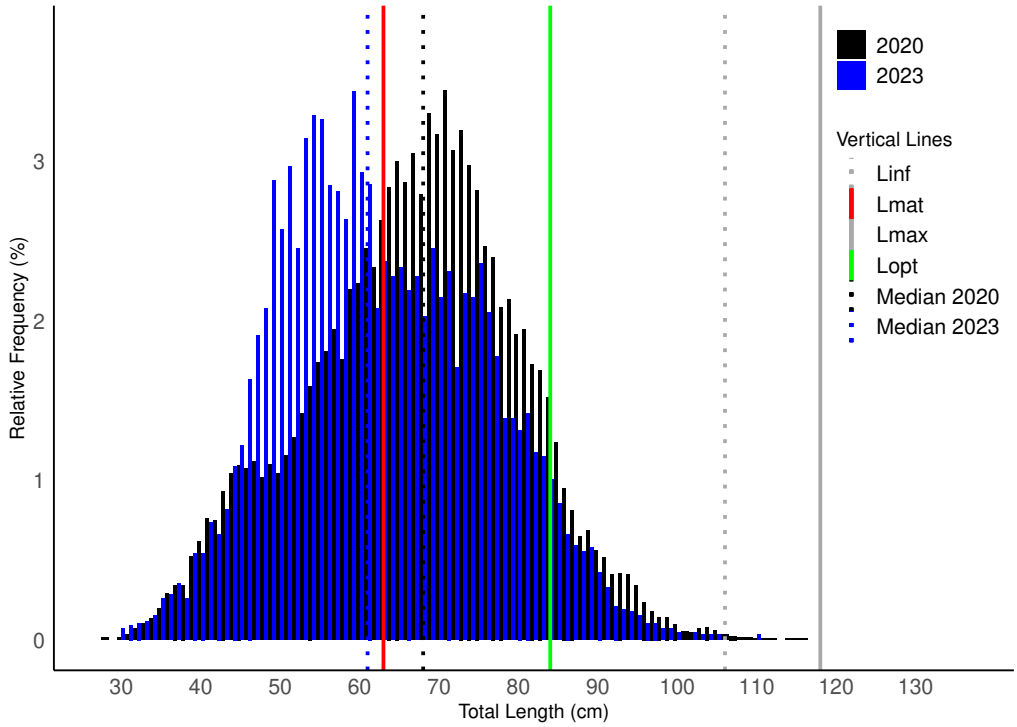


Figure 3.39: 2020 and 2023 relative length frequency distributions of *Etelis boweni* caught by Minahasa Utara Large Dropline boats participating in the CODRS program in WPP 715.

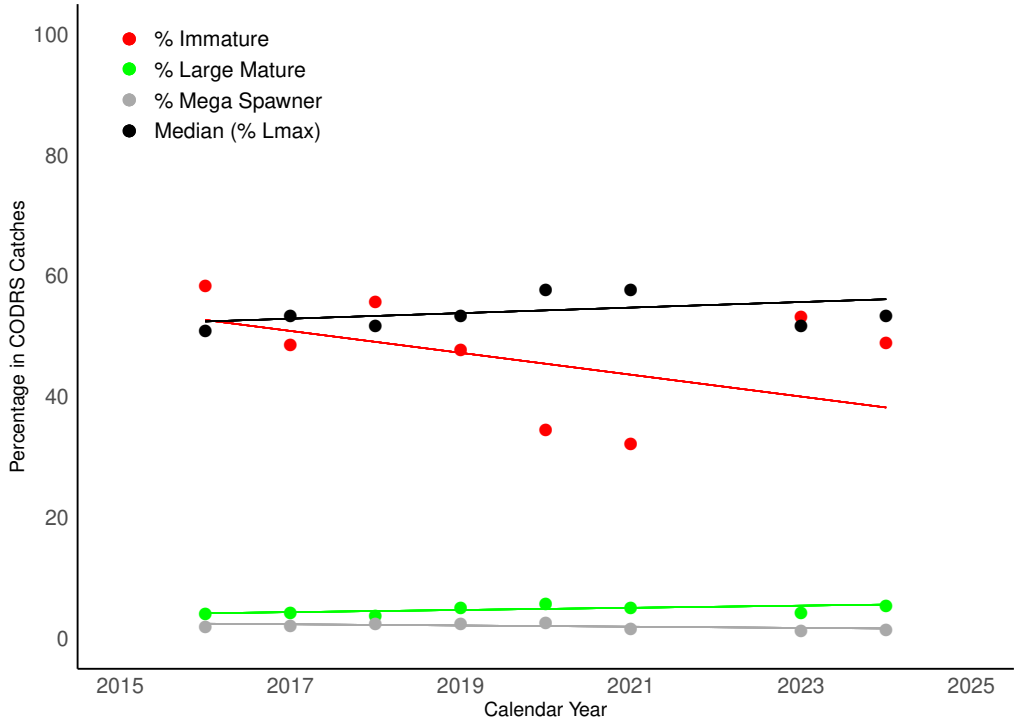


Figure 3.40: Trends in relative abundance by size group of *Etelis boweni* caught by Minahasa Utara Large Dropline boats participating in the CODRS program in WPP 715.

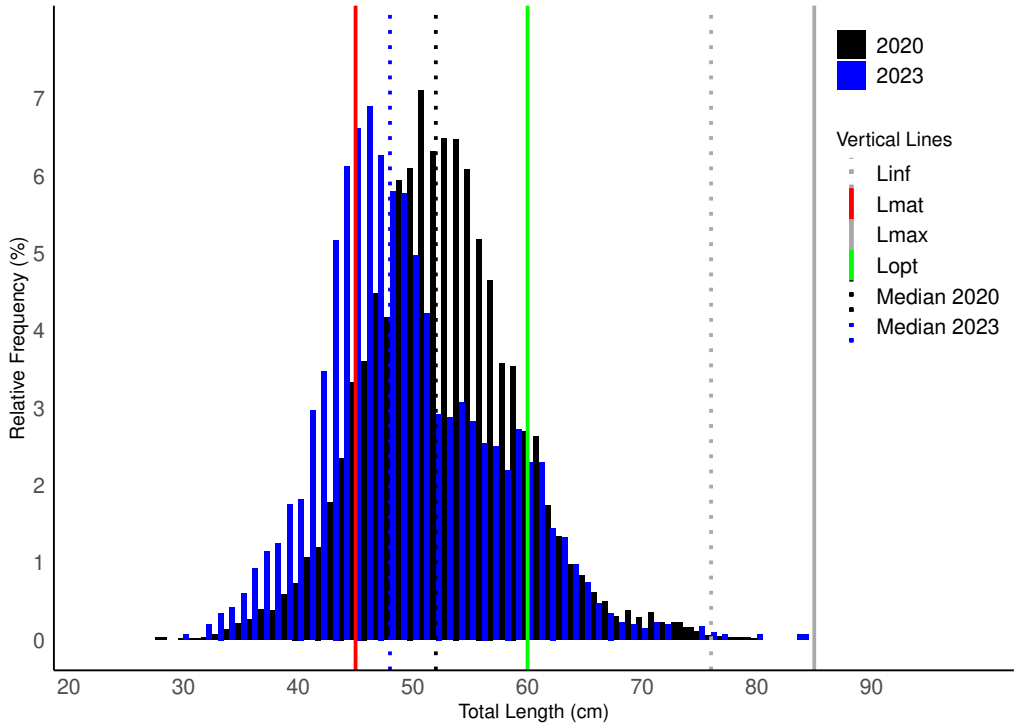


Figure 3.41: 2020 and 2023 relative length frequency distributions of *Paracaesio kusakarii* caught by Minahasa Utara Large Dropline boats participating in the CODRS program in WPP 715.

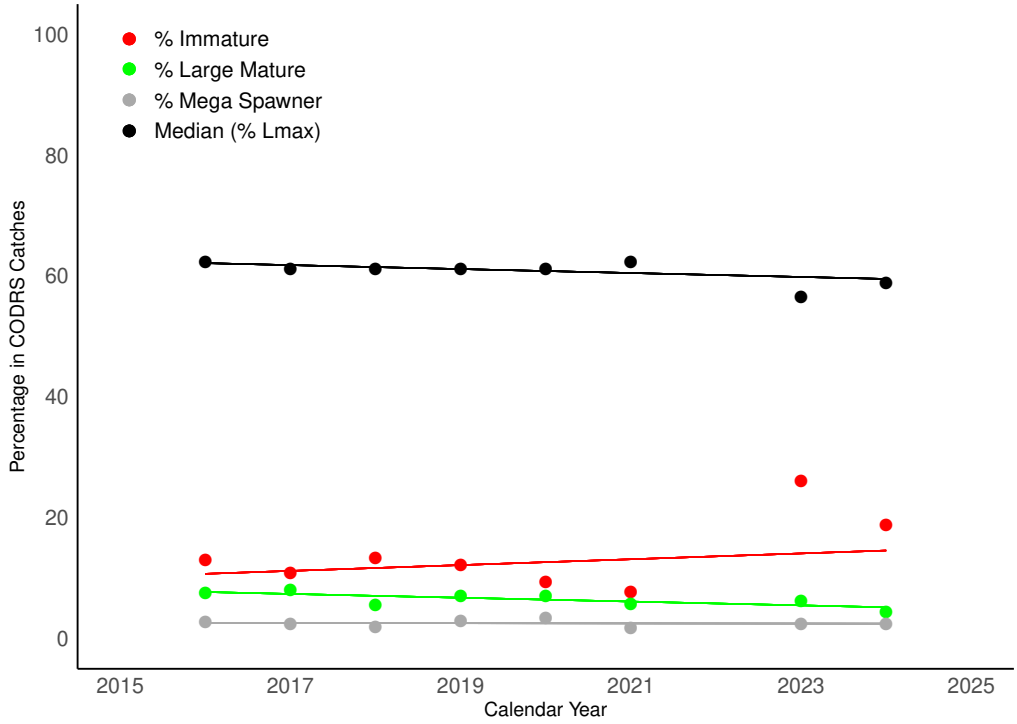


Figure 3.42: Trends in relative abundance by size group of *Paracaesio kusakarii* caught by Minahasa Utara Large Dropline boats participating in the CODRS program in WPP 715.

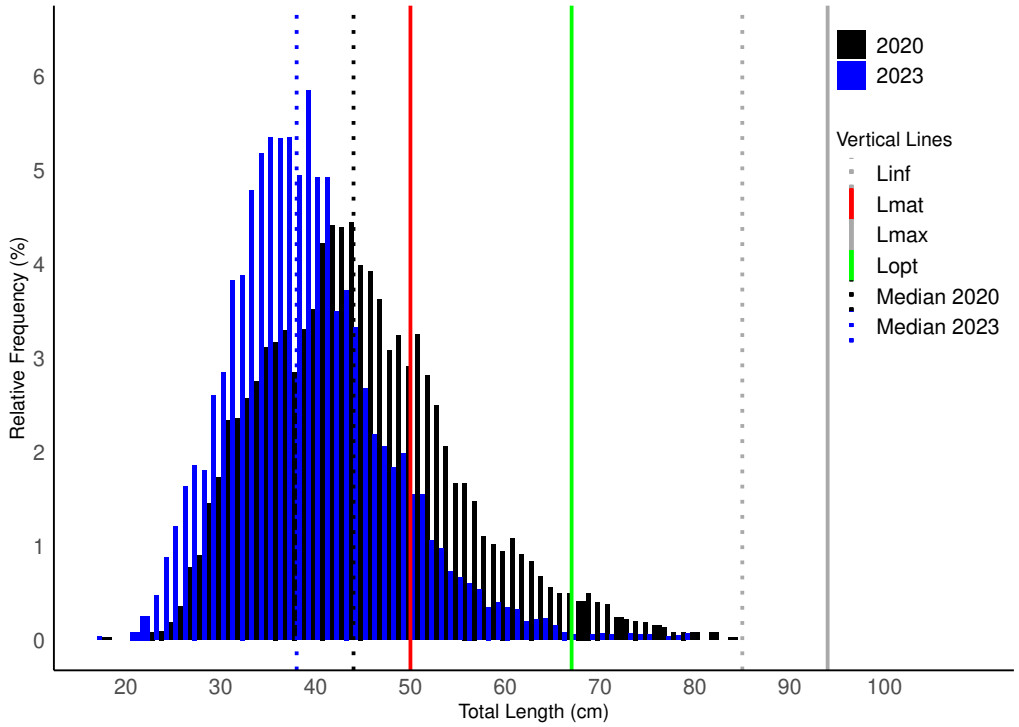


Figure 3.43: 2020 and 2023 relative length frequency distributions of *Lutjanus malabaricus* caught by Sorong Small Dropline boats participating in the CODRS program in WPP 715.

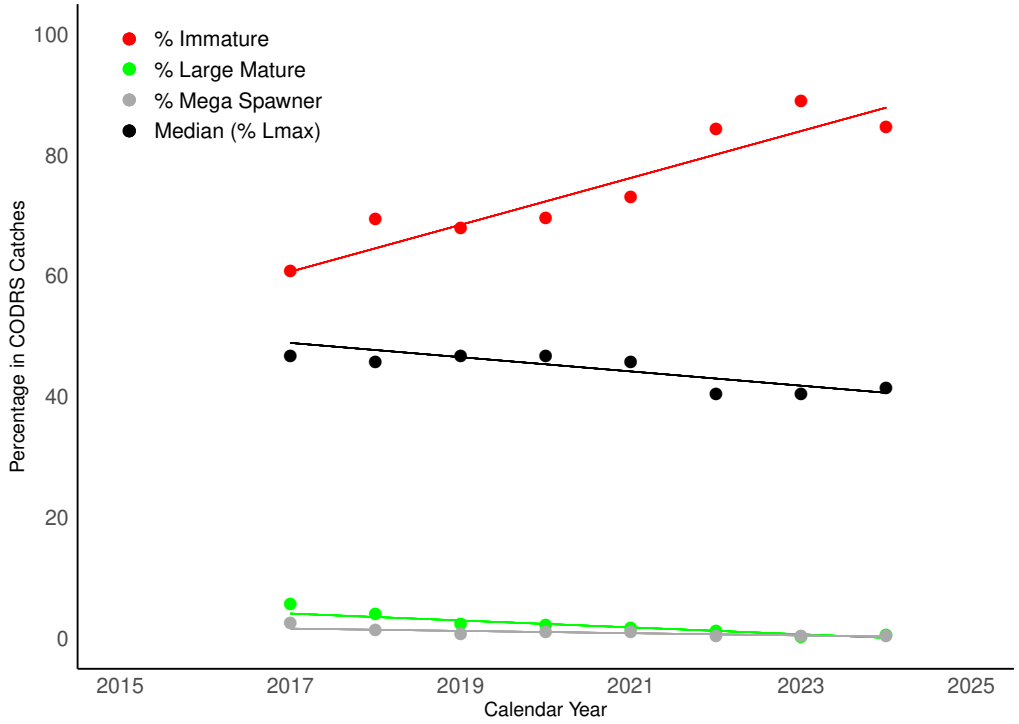


Figure 3.44: Trends in relative abundance by size group of *Lutjanus malabaricus* caught by Sorong Small Dropline boats participating in the CODRS program in WPP 715.

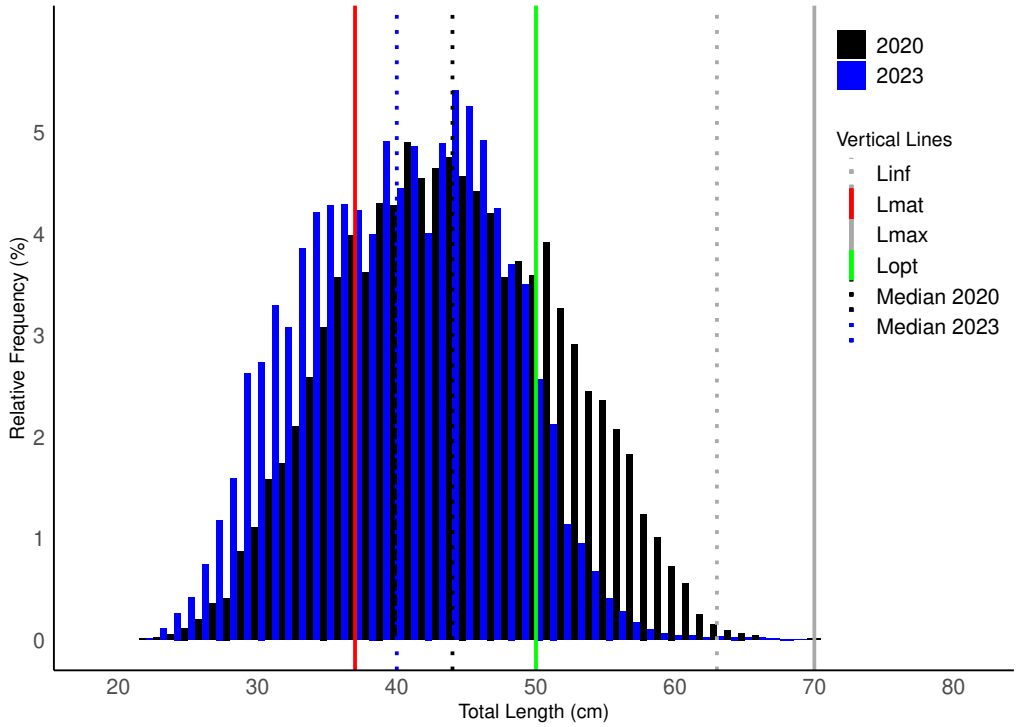


Figure 3.45: 2020 and 2023 relative length frequency distributions of *Lutjanus erythropterus* caught by Sorong Small Dropline boats participating in the CODRS program in WPP 715.

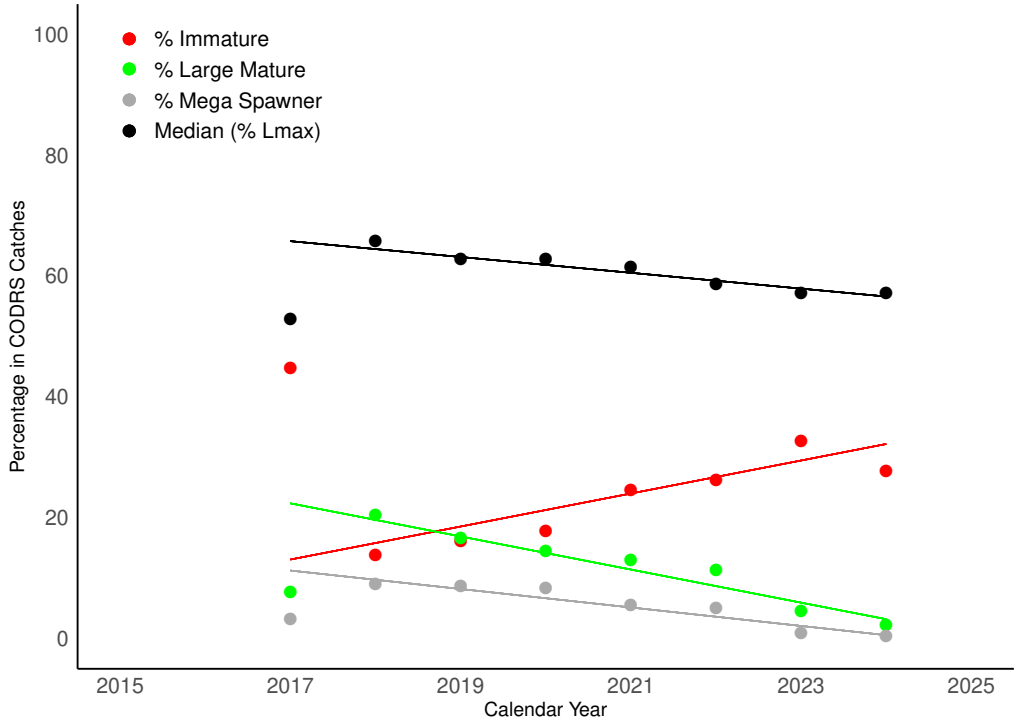


Figure 3.46: Trends in relative abundance by size group of *Lutjanus erythropterus* caught by Sorong Small Dropline boats participating in the CODRS program in WPP 715.

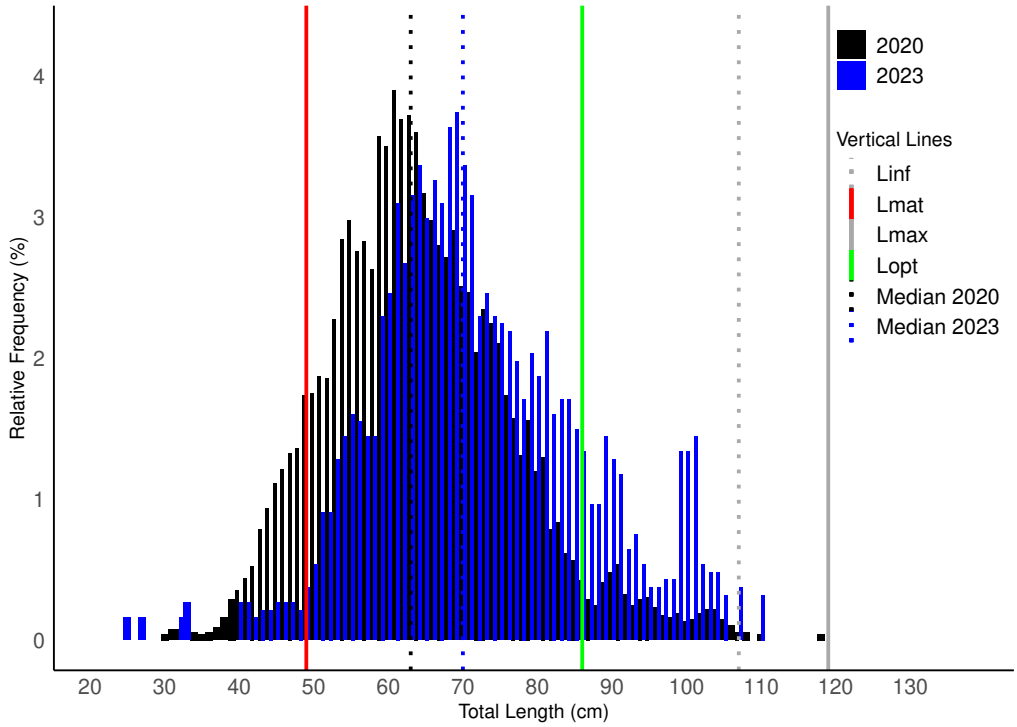


Figure 3.47: 2020 and 2023 relative length frequency distributions of *Epinephelus coioides* caught by AruProbo Large Longline boats participating in the CODRS program in WPP 718.

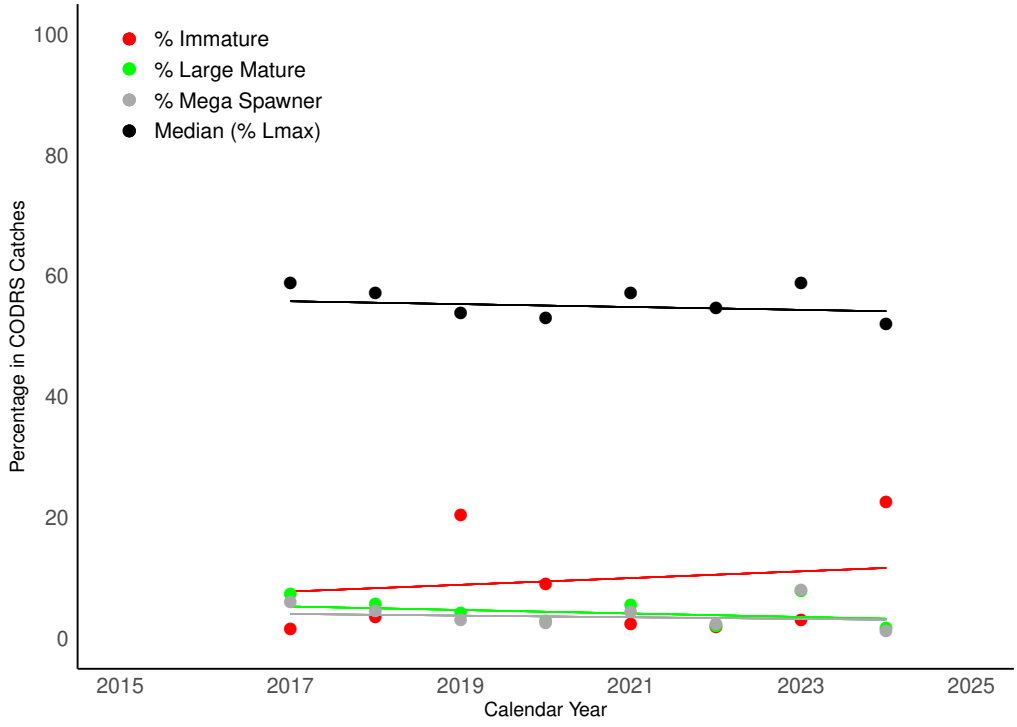


Figure 3.48: Trends in relative abundance by size group of *Epinephelus coioides* caught by AruProbo Large Longline boats participating in the CODRS program in WPP 718.

4 Conclusions and Discussion

Length based stock assessments for 2020 showed very high risk against a range of length-based sustainability indicators for the Top 16 snapper and grouper species in the deep demersal fisheries in Indonesia (Pet et al., 2023). Time series up to 2020 also showed a deteriorating trend in the stocks of most species, across many important fishing grounds in Indonesia. There were major differences between FMAs, but fishing mortality among the main target species seemed unacceptably high, while the catches of the main target species included large percentages of relatively small and even immature specimen. Almost all of the larger target species, especially the larger snappers, were harvested well below the optimum size, and bigger specimens (mega spawners) of these species had become extremely rare by 2020. Only the smallest snapper in the Top 16 (*P. sieboldii*) at that time seemed less vulnerable to overfishing of juveniles.

The three species of groupers also seemed less vulnerable to targeting of the juveniles in the deep demersal fisheries up to 2020. Groupers mature as females at a size relative to their maximum size which is lower than for snappers. This strategy enables them to reproduce before they are being caught, although fecundity is still relatively low at sizes below the optimum length. Fecundity for the population peaks at the optimum size for each species, and this is also the size around which sex change from females to males happens in most groupers. Some grouper species have reached their optimum harvest size by the time they are caught by the deep demersal fisheries. For groupers which spend most of their life cycle on the deep demersal fishing grounds, a relatively low vulnerability to overfishing of juveniles is good news. For other grouper species which spend major parts of their life cycle in shallower habitats, like coral reefs or mangroves or estuaries, populations in general are in bad shape due to excessive fishing pressure by small scale fisheries in shallow habitats.

The current follow-up study shows that risk levels had remained high across multiple length-based indicators for most target species in most fisheries that contributed data to the CODRS program in 2023 (Table 4.1). Direct comparisons of median lengths between 2020 and 2023 showed that these had even further declined for many species and in many fisheries, except for a few cases in WPP 711 and the western part of WPP 712. In these latter cases though, the median lengths had come from very low levels in 2020 and were mostly still well below the size of maturity for target species by 2023, leaving these fisheries also at very high risk. Especially risk levels relating to the relative abundance of large mature fish and mega spawners in the catch were extremely high across the Indonesian deep demersal fisheries in 2023 and had not improved in recent years, except for those few cases in WPP 711 and 712, where median sizes in the catch however are still extremely small, and even smaller than in other areas where sizes are on the decline.

Risk levels related to the relative abundance of immatures were low in 2023 only for some of the smaller snapper species and for the groupers in several places and fisheries, as was noted also for 2020. For this indicator as well though, only few cases of improvement were recorded up to 2023, with the majority of the fisheries still exhibiting continuous decline or stable levels of high risk. At the other side of the size-spectrum, we could only conclude that relative abundance of mega-spawners in catches of the Indonesian deep demersal fisheries remained stable at dangerously low level, indicating very high risk to sustainability. The relative number of large mature fish in the catch also continued to decline or remained stable at dangerously low levels for the vast majority of the cases that we investigated, further strengthening a conclusion of grave risk in these fisheries.

Table 4.1: 2023 Risk levels and time trends in length-based indicators for sustainability in stocks of major target species of snappers and groupers in the Indonesian Deep Demersal Fisheries

		Risk Level			Trend		
WPP	Species Name	Immatures	Exploitation	Mega Spawners	% Matures	% Large Matures	% Mega Spawners
573*	L. malabaricus	high	high	high	declining	stable	stable
573*	P. multidens	high	high	high	declining	declining	stable
573*	P. typus	high	high	high	declining	declining	stable
573*	E. areolatus	low	high	high	stable	declining	stable
573*	P. filamentosus	high	high	high	improving	stable	stable
573*	P. sieboldii	low	medium	high	declining	improving	improving
573*	L. erythropterus	low	low	high	stable	stable	declining
573*	L. sebae	high	high	high	declining	stable	stable
711*	L. malabaricus	high	high	high	improving	improving	improving
711*	P. multidens	high	high	high	improving	improving	stable
711*	E. coioides	low	high	high	improving	improving	declining
711*	P. typus	high	high	high	improving	stable	stable
711*	E. areolatus	low	high	high	stable	declining	stable
711*	P. maculatus	low	high	high	improving	improving	improving
711*	L. sebae	high	high	high	declining	stable	stable
712A*	L. malabaricus	high	high	high	improving	stable	stable
712A*	E. coioides	low	high	high	improving	improving	stable
712A*	E. areolatus	low	high	high	stable	declining	stable
712A*	P. maculatus	low	low	low	improving	improving	improving
712A*	L. erythropterus	high	high	high	improving	stable	stable
712B*	L. malabaricus	high	high	high	stable	stable	stable
712B*	P. multidens	high	high	high	declining	declining	stable
712B*	E. coioides	low	high	high	improving	stable	declining
712B*	E. areolatus	low	high	high	improving	stable	stable
712B*	P. maculatus	low	high	high	stable	stable	declining
712B*	L. erythropterus	high	high	high	declining	stable	stable
712B*	L. sebae	high	high	high	declining	stable	stable
713*	L. malabaricus	high	high	high	declining	declining	declining
713*	P. multidens	high	high	high	declining	declining	declining
713*	P. typus	high	high	high	declining	declining	declining
713*	E. areolatus	low	high	high	declining	declining	declining
713*	L. erythropterus	high	high	high	improving	stable	stable
713*	L. sebae	high	high	high	declining	stable	stable
715A*	P. multidens	medium	high	high	declining	stable	declining
715A*	A. rutilans	high	high	high	declining	stable	stable
715A*	E. radiosus	high	high	high	declining	stable	stable
715A*	P. filamentosus	high	high	high	improving	stable	stable
715A*	P. sieboldii	low	high	high	stable	declining	declining
715A*	E. boweni	high	high	high	improving	stable	stable
715A*	E. coruscans	high	high	high	declining	declining	declining
715A*	P. kusakarii	medium	high	high	declining	declining	stable
715B*	L. malabaricus	high	high	high	declining	declining	stable
715B*	L. erythropterus	high	high	high	declining	declining	declining
718A*	L. malabaricus	high	high	high	declining	declining	stable
718B*	L. malabaricus	medium	high	high	declining	stable	declining
718B*	P. multidens	high	high	high	declining	declining	declining
718B*	E. coioides	low	high	high	declining	declining	stable
718B*	P. typus	high	high	high	declining	declining	declining
718B*	E. areolatus	low	high	high	stable	declining	declining
718B*	L. sebae	high	high	high	improving	improving	stable

* Referring to the combination of fleet segments and landing ports in Tables 3.1 and 3.2

As we looked only at selected major fleet segments in important fisheries management areas in Indonesia for the current follow-up study, we should consider potential issues with representativeness of the conclusions from these fleet segments for the total Indonesian deep demersal fisheries. It is important to note here that the selected fisheries did represent an important part of the effort and catch in the fisheries. Questions of size-selectivity could remain, however, when the total fleet is not being included in the survey, and certain fleet segments remain absent from the samples.

We therefore compared for each WPP in this study the 2020 results from the full holistic approach (with all fleet segments included) with the 2020 results from the selected fleet segments (Tables 4.2 and 4.3). The result of this comparison showed that in the majority of cases there was no significant difference between 2020 median lengths from full assessments with median lengths from the selected fleet segments. Only in a few WPPs there were multiple cases of significant differences, with some of those substantial. In situations with substantial differences in median length, the conclusions on absolute levels of risk could be affected by the choice of fleet segment that we investigated. Event in those cases with substantial differences though, these differences were not overly dramatic towards much larger fish, and few if any would lead to conclusions of low risk levels in those fisheries. And importantly, in all cases, the trends observed in these major fleet segments are indicative of the situation in the fisheries in each WPP.

Table 4.2: 2020 median lengths comparison between full-assessment (Full) (Pet et al., 2023) and selected-samples (Select) of Top 16 snapper and grouper species from major fleet segments in the Indonesian Deep Demersal Fisheries in WPPs 573, 711 and 712.

	WPP-573		WPP-711		WPP-712A		WPP-712B	
	2020	2020	2020	2020	2020	2020	2020	2020
Species Name	Full	Select	Full	Select	Full	Select	Full	Select
Lutjanus malabaricus	54	54	37	36	39	34	39	38
Pristipomoides multidens	**48**	**50**	42	40			48	45
Aphareus rutilans								
Epinephelus coioides			61	59	61	64	61	65
Etelis radiosus								
Pristipomoides typus	**44**	**45**	39	35				
Epinephelus areolatus	33	33	29	29	31	30	31	29
Pristipomoides filamentosus	**39**	**44**						
Pristipomoides sieboldii	**36**	**38**						
Etelis boweni								
Plectropomus maculatus			45	47	53	54	53	47
Lutjanus erythropterus	**53**	**54**			34	32	34	31
Etelis coruscans								
Lutjanus sebae	50	51	27	29			31	27
Lutjanus johnii								
Paracaesio kusakarii								

The "2020-Full" column shows lengths from the 2020 full assessment, whereas "2020-Select" only includes data from selected major fleet segments (Table 3.1).
Sets in **green** show substantially (>=10%) larger lengths in Select compared to Full.
Sets in **red** show substantially (>=10%) smaller lengths in Select compared to Full.
Sets of lengths are significantly different only when displayed in **bold**.

Table 4.3: 2020 median lengths comparison between full-assessment (Full) (Pet et al., 2023) and selected-samples (Select) of Top 16 snapper and grouper species from major fleet segments in the Indonesian Deep Demersal Fisheries in WPPs 713, 715 & 718.

	WPP-713		WPP-715A		WPP-715B		WPP-718A		WPP-718B	
Species Name	2020 Full	2020 Select	2020 Full	2020 Select	2020 Full	2020 Select	2020 Full	2020 Select	2020 Full	2020 Select
Lutjanus malabaricus	47	46			42	44	54	54	54	55
Pristipomoides multidens	53	53	**46**	**59**					51	50
Aphareus rutilans			66	66						
Epinephelus coioides									64	63
Etelis radiosus			57	58						
Pristipomoides typus	46	45							51	51
Epinephelus areolatus	**29**	**31**							32	32
Pristipomoides filamentosus			**41**	**46**						
Pristipomoides sieboldii			**35**	**38**						
Etelis boweni			**61**	**68**						
Plectropomus maculatus										
Lutjanus erythropterus	**35**	**37**			44	44				
Etelis coruscans			**55**	**58**						
Lutjanus sebae	33	33							55	55
Lutjanus johnii										
Paracaesio kusakarii			**47**	**53**						

The "2020-Full" column shows lengths from the 2020 full assessment, whereas "2020-Select" only includes data from selected major fleet segments (Table 3.2).
Sets in **green** show substantially (>=10%) larger lengths in Select compared to Full.
Sets in **red** show substantially (>=10%) smaller lengths in Select compared to Full.
Sets of lengths are significantly different only when displayed in **bold**.

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