Scoping Study on the Saya de Malha Bank Fisheries

Southern Indian Ocean Fisheries Agreement

SER2021-03

Final Report

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MRAG

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Acronyms

Acronym	Definition
AIS	Automatic Identification Systems
CMM	Conservation and Management Measure
CPUE	Catch Per Unit Effort
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
GFW	Global Fishing Watch
IOTC	Indian Ocean Tuna Commission
IUU	Illegal, Unreported and Unregulated
MSY	Maximum Sustainable Yield
SIOFA	Southern Indian Ocean Fisheries Agreement
SODA	Seychelles Digital Ocean Atlas
VME	Vulnerable Marine Ecosystem

Executive Summary

The Saya de Malha Bank (hereafter “Saya de Malha”) is the world’s largest submerged ocean bank, covering an area of approximately 41,000 km^2. Saya de Malha is a highly productive ecosystem and is thought to contain among the most extensive seagrass areas in the world, interspersed coral reefs. As such, Saya de Malha is likely an important biodiversity hotspot which may be highly sensitive to the impacts of fishing. Saya de Malha falls within the Southern Indian Ocean Fisheries Agreement’s (SIOFA’s) area of competence but has thus far received limited attention in terms of fisheries research and management. This report aims to collate available information on contemporary and historical fishing activities on Saya de Malha, and seeks to provide advice and recommendations on future work to fill priority information gaps.

Information on fisheries, species abundance, species biology, resources analyses, and management measures were collated from SIOFA’s Scientific Committee Meetings, Meetings of the Parties, and fisheries database, as well as peer-reviewed literature, grey literature, Automatic Identification Systems data from Global Fishing Watch, species biological data from FishBase, and R/V Dr Fridtof Nansen survey data. The study considered fishing activities of SIOFA’s Contracting Parties, cooperating non-Contracting Parties, participating fishing entities, signatories, and any third party for which information was available and relevant.

Thailand, operating primarily trawl fisheries, and Mauritius are likely the most important fishing nations on Saya de Malha, with the Comoros also actively fishing but at a much lower intensity. Through use of Global Fishing Watch and unpublished data held by MRAG, this report also demonstrates that Sri Lankan and, to a much lesser extent and more sporadically, Indian flagged vessels also operate on Saya de Malha. Neither Sri Lanka nor India are actively engaged with SIOFA. Other nations fishing within or directly adjacent to Saya de Malha include China, Chinese Taipei, Japan, Korea, Malaysia, and Seychelles. While these fisheries are likely targeting tuna and tuna-like species they have the potential to impact SIOFA-relevant species on Saya de Malha and should therefore be considered of potential relevance to management. At present, only Thailand and the Comoros report their catches on or over Saya de Malha to SIOFA, with catch per unit effort (CPUE) data only available for Thailand from 2020. Mauritius also collects CPUE data but this is only publicly available up until 2011. Biological information for species on Saya de Malha is similarly restricted, despite being critical for effective fisheries management. Of the 131 species having been reported from catches on Saya de Malha, only the sky emperor (*Lethrinus mahsena*) has received direct attention. As an interim measure, this scoping study has compiled available biological information for these same 131 species from other parts of their distributional range to provide a suitable foundation for species and fisheries management on Saya de Malha.

There are currently no SIOFA management measures that are specific to the fisheries on Saya de Malha, though a number of general measures are relevant. However, aspects of existing measures, currently not applied to shallow water species or areas, could provide a foundation for future development. Independently, Mauritius applies a quota-based system to its fisheries on Saya de Malha. This system appears to have been effective, facilitating a consistent CPUE for target species at least up until 2011, after which data are no longer publicly available.

This study demonstrates a clear need for SIOFA to foster engagement and improve cooperation between itself and the key contracting and non-contracting parties of Mauritius, the Comoros, Sri Lanka and India where possible. Further, efforts should be made to improve the understanding of gear use, target species, fishing effort, and CPUE in the ongoing fisheries operations on Saya de Malha. This understanding will be critical in underpinning effective management actions and informed decision-making for Saya de Malha. Research on biological information for Saya de Malha species is required but is of lower priority given the availability of biological parameters from other areas in their distributional ranges.

1 Introduction

The Southern Indian Ocean Fisheries Agreement (SIOFA) is a legally binding agreement that was signed in Rome the 7th July 2006 and entered into force in June 2012 to ensure the long-term sustainability of non-tuna fishery resources in the Southern Indian Ocean through cooperation among the Contracting Parties, and to promote the sustainable development of fisheries in the Area (Figure 1).

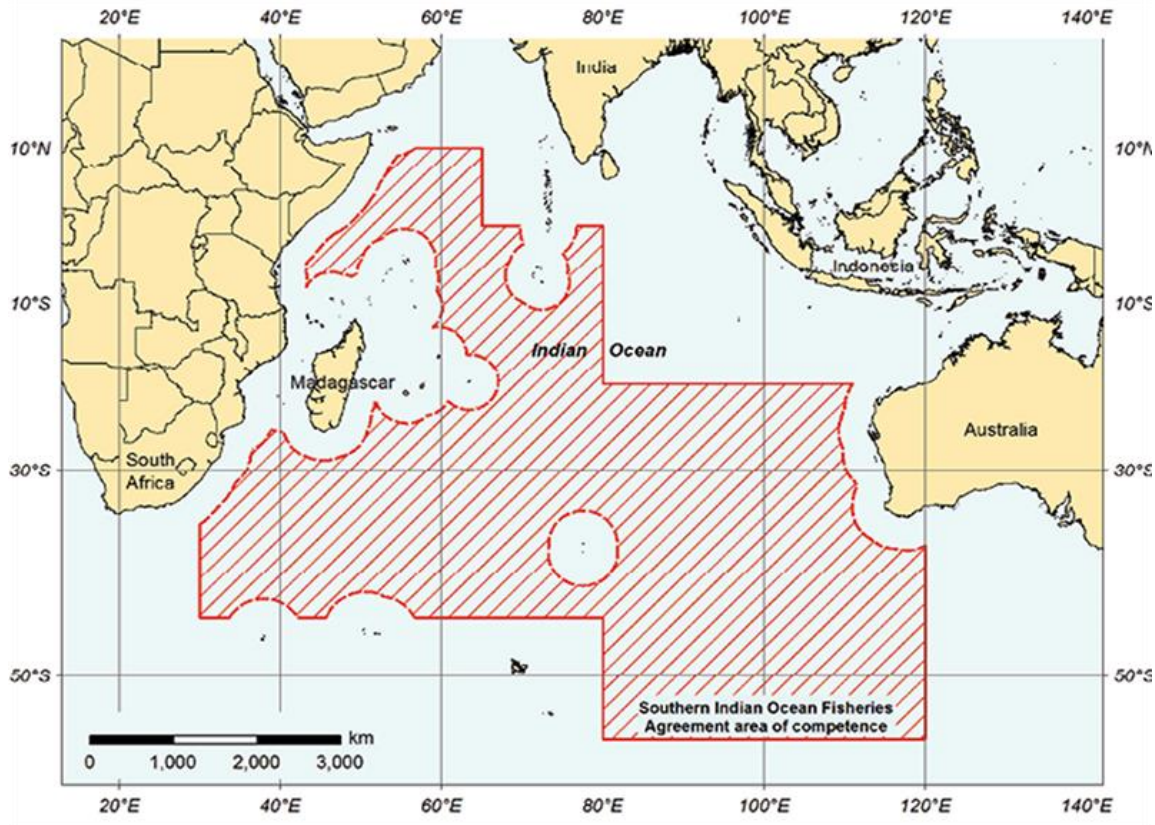


Figure 1. Southern Indian Ocean Fisheries Agreement Area (Source: Australian Government[1])

To date, SIOFA has ten Contracting Parties: Australia, China, the Cook Islands, the European Union (EU), France on behalf of its Indian Ocean Territories, Japan, the Republic of Korea, Mauritius, the Seychelles and Thailand, one Participating fishing entity: Chinese Taipei and one cooperating non-Contracting Party: the Comoros. Kenya, Madagascar, Mozambique and New Zealand are also signatories to this Agreement but have not ratified it.

SIOFA manages a variety of fishery resources, excluding highly migratory species and sedentary species subject to the jurisdiction of coastal States, through the implementation of conservation and management measures[2] (CMMs). CMMs make provision for control measures and area restrictions for species and ecosystem protection. Some of the main fish targeted in the SIOFA area include: sauries (*Scomberesocidae)*; scads (*Decapterus)*; Patagonian toothfish (*Dissostichus eleginoides)*; orange roughy *(Hoplostethus atlanticus)*; alfonsino *(Beryx splendens)* and oilfish (*Ruvettus pretiosus).*

[1] https://www.agriculture.gov.au/fisheries/international/siofa
[2] https://www.apsoi.org/cmm

The EU has agreed to a 2-year funding arrangement to enable SIOFA to commission a series of scientific studies to support the SIOFA/Scientific Committee's Work Plan (Report of the Scientific Committee, SC6). As part of this agreement, Specific Objective 4 (under General Objective 1) relates to the assessment of key target stocks of the Saya de Malha Bank (hereafter "Saya de Malha") fisheries.

Saya de Malha (Figure 2) is the largest submerged ocean bank in the world covering an area of approximately 41,000 km^2. Saya de Malha is comprised of two separate structures, the smaller North Bank and larger South Bank, which is recognised as a submerged atoll. Both banks are covered with seagrass interspersed with small coral reefs. The seagrass areas are thought to be among the most extensive in the world potentially extending beyond 4,000 km^2[,3].

The overall objective of this report is to collect and compile available information on contemporary and historical fishing activities on Saya de Malha, as well as any scientific survey activities, in order to meet the objectives of the EU Funding Agreement. So far as possible, the study also documents the impacts of fishing on Vulnerable Marine Ecosystems (VMEs). This scoping study is conducted with a view to providing advice and recommendations on future work to fill identified information gaps. The outputs on this report will also feed into and inform a subsequent impact assessment of bottom trawl fisheries on VME indicator species on Saya de Malha.

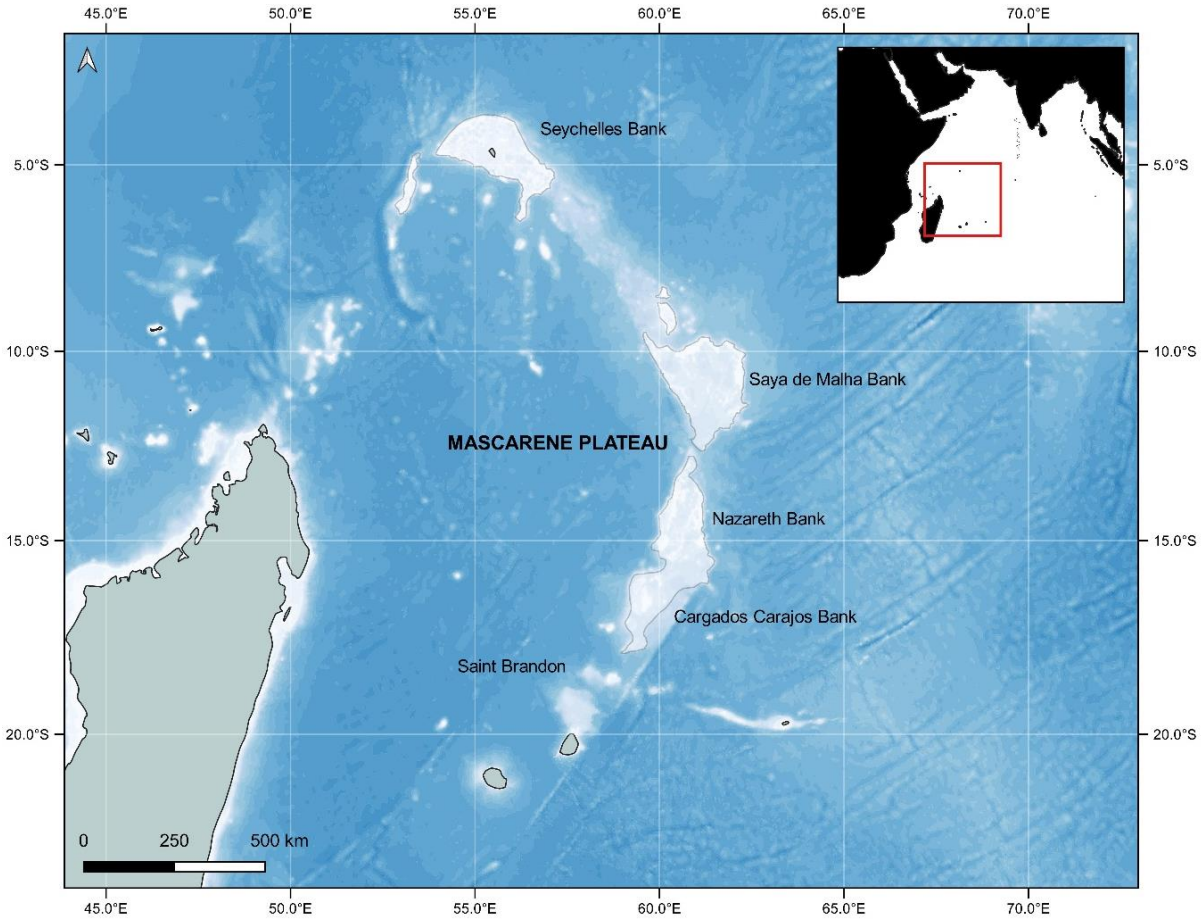


Figure 2. Mascarene Plateau; highlighting the Saya de Malha Bank

[3] http://www.wolfhilbertz.com/downloads/2002/saya_2002_rev1.pdf

2 Methodology

Information on Saya De Malha fisheries, species abundance, species biology, and resources analyses and management measures were collated from a variety of literature sources for each member state of SIOFA, including SIOFA reports from Scientific Committee Meetings[4], Meetings of the Parties[5], the SIOFA fisheries database, and peer-reviewed literature. Relevant peer-reviewed literature was identified using an online search engine (Google Scholar). Additional data sources were used to compliment and supplement this primary information and include Automatic Identification Systems (AIS) data from Global Fishing Watch (GFW)[6], grey literature pertaining to Saya De Malha, FishBase[7] and R/V *Dr Fridtof Nansen* survey data[8]. All information and data sources used in this study were collated and provided to SIOFA alongside this report.

The study considered fishing activities of Contracting Parties, cooperating non-Contracting Parties, participating fishing entities, signatories, and any third party for which information was available and relevant to the Saya de Malha area. Temporal coverage of the information collated included both before and after the establishment of SIOFA in 2012. An agreed list of VME species (Table 1) and fished species (Table 2) was created in consultation with the SIOFA Project Steering Group.

After relevant data was compiled, detailed summaries were created for fisheries information, abundance data, biological information, and resources analyses and management measures. Analyses and infographics were created using open-source software R[9] and RStudio[10], and maps were created using open-source software QGIS[11].

Table 1. Vulnerable Marine Ecosystem (VME) species considered in the scoping study, VME taxon are defined in CMM-2020-01[12], seagrass was added under specific request

VME Species	
• Actiniaria	• Gorgonacea
• Alcyonacea	• Hexactinellida
• Anthoathecatae	• Pennatulacea
• Antipatharia	• Porifera
• Ascidiacea	• Pterobranchia
• Bathylasmatidae	• Scleractinia
• Brachiopoda	• ***Seagrass***
• Bryozoans	• Serpulidae
• Chemosynthetic organisms	• Stalked crinoids
• Cidaroida	• Stylasteridae
• Cnidaria	• Xenophyophora
• Demospongiae	• Zoantharia
• Euryalida	

[4] http://apsoi.org/meetings/groups/Scientific%20Committee%20Meeting
[5] http://apsoi.org/meetings/groups/Meeting%20of%20the%20Parties
[6] https://globalfishingwatch.org/; Global Fishing Watch use the automatic identification system (AIS) data collected from vessels that their research has identified as known or possible commercial fishing vessels, and apply a fishing detection algorithm to determine “apparent fishing activity” based on changes in vessel speed and direction. The algorithm classifies each AIS broadcast data point for these vessels as either “apparently fishing” or “not fishing”.
[7] https://www.fishbase.de/
[8] https://www.fao.org/in-action/eaf-nansen/en/
[9] https://www.r-project.org/
[10] https://www.rstudio.com/
[11] http://www.qgis.org/
[12] https://www.apsoi.org/node/638

Table 2. List of fish species known to be impacted by Saya de Malha fisheries

Species		
• African scad	• Hammerhead sharks nei	• Scalloped hammerhead
• Amberstripe scad	• Hawksbill turtle	• Scalybreast gurnard
• Angelfishes nei	• Hooktooth shark	• Scorpionfishes nei
• Anglerfishes nei	• Humpback red snapper	• Scorpionfishes, gurnards nei
• Arabian pandora	• Indian mackerel	• Scribbled leatherjac. filefish
• Banana fusilier	• Indian mackerels nei	• Sea cucumbers nei
• Bandfish	• Indian scad	• Seahorses nei
• Barracudas nei	• Indian squid	• Shortfin scad
• Batfish	• Inshore squids nei	• Short-tail stingray
• Batfishes	• Jacks, crevalles nei	• Sicklefin lemon shark
• Bengal snapper	• Japanese bigeye	• Siliceous sponges
• Bigeye barracuda	• Jobfishes nei	• Silver-cheeked toadfish
• Bigeye scad	• Kawakawa	• Slender ponyfish
• Bigeye snapper	• Largeeye breams	• Slender threadfin bream
• Bigeye trevally	• Largehead hairtail	• Sliteye shark
• Bigeyes nei	• Leatherjacket filefishes	• Smalltooth emperor
• Bigfisted swimcrab	• Lefteye flounders nei	• Smooth-hounds nei
• Bignose unicornfish	• Lizardfishes nei	• Snakefish
• Birdbeak burrfish	• Longface emperor	• Snappers nei
• Black jack	• Longfin batfish	• Softhead grenadier
• Blackbanded trevally	• Longhorned mobula	• Spangled emperor
• Blacksaddled coralgrouper	• Longspined porcupinefish	• Spanner crab
• Blacktip reef shark	• Lunartail puffer	• Speckled tonguesole
• Blacktip trevally	• Mackerel scad	• Spider-eye puffer
• Bludger	• Malabar trevally	• Spinefeet(=Rabbitfishes) nei
• Blue shark	• Marbled coralgrouper	• Spinner shark
• Blue-lined large-eye bream	• Marine fishes nei	• Squaretail coralgrouper
• Bowmouth guitarfish	• Masked triggerfish	• Squirrelfishes nei
• Boxfishes nei	• Mitre squid	• Starfishes nei
• Brown-marbled grouper	• Mobula nei	• Stargazers
• Brownspotted grouper	• Moontail bullseye	• Starry triggerfish
• Brushtooth lizardfish	• Mottled fusilier	• Stingrays nei
• Carcharhinus sharks nei	• Obtuse barracuda	• Stingrays, butterfly rays nei
• Cardinalfishes, etc. nei	• Ocellated angelshark	• Striped bonito
• Cephalopods nei	• Ocellated eagle ray	• Striped eel catfish
• Cinnabar goatfish	• Ornate eagle ray	• Sulphur goatfish
• Coralgroupers nei	• Paeony bulleye	• Surgeonfishes nei
• Cuttlefishes nei	• Painted sweetlips	• Sweetlips, rubberlips nei
• Damselfishes	• Pickhandle barracuda	• Tawny nurse shark
• Delagoa threadfin bream	• Pineconefish	• Thorny flathead
• Dogtooth tuna	• Pink ear emperor	• Threadfin breams nei
• Dusky spinefoot	• Plaintail turkeyfish	• Threespot swimming crab
• Duskytail grouper	• Ponyfishes (=Slipmouths) nei	• Tiger shark
• Elongate surgeonfish	• Portunus swimcrabs nei	• Titan cardinalfish
• Emperor red snapper	• Puffers nei	
• Flathead lobster	• Purple-spotted bigeye	
• Flutemouth	• Rainbow runner	

Species		
• Giant guitarfish • Giant trevally • Goatfishes • Goldband goatfish • Goldbanded jobfish • Golden trevally • Great hammerhead • Greater amberjack • Green jobfish • Grey reef shark • Groupers nei • Groupers, seabasses nei • Guitarfishes nei • Guitarfishes, etc. nei • Gulf damselfish • Gurnards, searobins nei	• Rays and skates nei • Rays, stingrays, mantas nei • Red bigeye • Red cornetfish • Redcoat • Redmouth grouper • Redtail scad • Reef squids nei • Requiem sharks nei • Ribbed tilefish • Round ribbontail ray • Roving coralgrouper • Sailfin velifer • Santer seabream • Sawtooth barracuda • Scads nei	• Titan triggerfish • Triggerfishes, durgons nei • Twobelt cardinal • Two-spot red snapper • Unicorn leatherjacket filefish • Variable torpedo ray • Variegated lizardfish • Yellow-edged lyretail • Yellowfin tuna • Yellowspotted trevally • Yellowstriped goatfish • Yellowtail barracuda • Yellowtail emperor

3 Results

This section compiles the available fisheries related information on Saya de Malha into four distinct categories, including:

- Historical fisheries and survey information;
- Abundance information of resources;
- Biological information; and
- Resources analyses and management measures.

3.1 Fisheries information

This section provides a spatial and temporal description of historical and contemporary fisheries as well as scientific surveys that have operated or currently operate on Saya de Malha. Specific data include: county, type of fisheries, number of vessels, operation period(s), gear type(s), species exploited, and catch and bycatch.

For the purpose of this study, historical fisheries are defined as fishing operations occurring between the commencement of fisheries in the eighteenth century to the turn of the current century (i.e., 2000). Contemporary fisheries are those which occur between 2000 and the present day (i.e., 2021), which includes the time in which SIOFA was established (i.e., 2012).

3.1.1 Historical fisheries

Descriptions of the historical fisheries operating on Saya de Malha (Wijkstrom and Kroepelein, 1979; Samboo, 1983; Samboo, 1987; Samboo, 1989; MRAG, 1996; Boistol et al., 2011) are primarily available through grey literature; including technical reports and seminar proceedings. The literature often refers to and presents data on the ‘Mauritian Banks Fishery’ or ‘Banks Fishery’ as a whole which, in addition to Saya de Malha, incorporates the Nazareth, St Brandon, and Soudan Banks too (Figure 2). It is therefore often difficult to disaggregate data in order to provide an exact delineation of the historical fisheries operating exclusively on Saya de Malha during this time period.

The majority of the of the literature describes the historical development of the Banks Fishery (in terms of the number of vessels and the gear types employed) and provides estimates of fishing effort (man-days), landings (wet weight tonnes) and or catch proportions (%) based on the available data at a given time. However, there are inconsistencies in the data reported between sources. Where inconsistencies have been identified, the most up to date source has been used.

Number of vessels

The Banks fishery is reported to have first commenced during the eighteenth century (Wijkstrom and Kroepelein, 1979; MRAG, 1996). Early exploitation was characterised by inter-island trade vessels fishing sporadically for demersal species (Boistol et al., 2011), predominantly for domestic consumption and salting (Wijkstrom and Kroepelein, 1979; Samboo, 1983; MRAG 1996). Systematic exploitation of the Banks commenced after the pioneering fisheries survey of the Mauritius-Seychelles ridge conducted by Wheeler and Ommannery (Wheeler and Ommannery, 1953; MRAG 1996; Boistol et al., 2011); after which the Mauritius Fishing Development Company and its sister company the Raphael Fishing Company Limited gained control of the St. Brandon group.

The development of on-board infrastructure (i.e., ice storage) during the 1960s enabled the commercialisation of frozen-fish distribution for the Mauritian market (Wijkstrom and Kroepelein, 1979; Ardill, 1986; MRAG 1996). However, this venture was commercially unsuccessful due to consumer resistance to a new product and lack of marketing infrastructure (Ardill, 1986). The year 1977 can be considered as a turning point in the history of the Banks Fishery. In 1977 eight refrigerated mother-ship vessels operated including two chartered from Korea and a further two Japanese trawlers targeting horse mackerel (*Trachurus trachurus*); lizardfish (*Synodus indicus*) and other demersal species (Figure 3). Commonly these mother-vessels were 20-60 m converted second hand tuna long-line vessels (Boistol et al., 2011). Each mother-vessel carried a number of smaller motorised vessels, each with three fishers using hand-lines rigged with eight to ten baited hooks targeting primarily sky emperors (*Lethrinus mahsena)*, with the remainder of the catch made up of serranids, lutjanids, siganids, and carangids (Boistol et al., 2011).

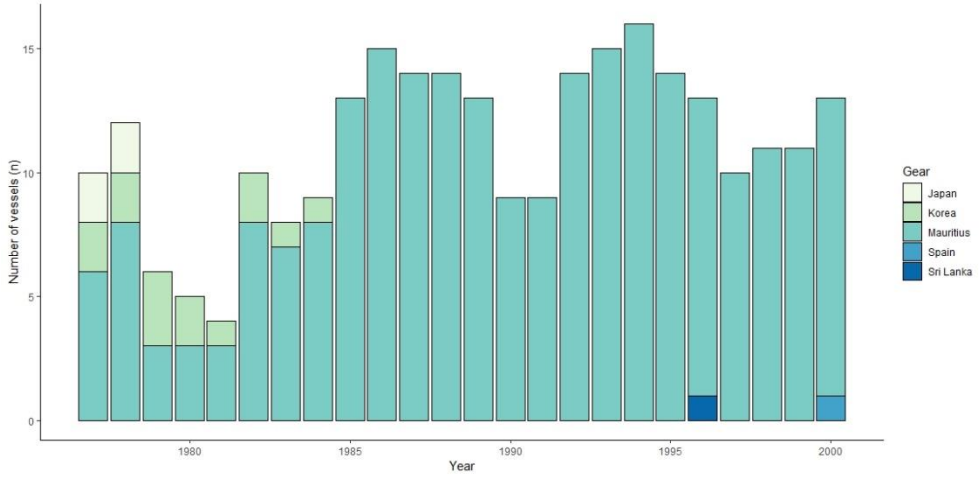


Figure 3. Number of vessels by flag State operating on the Saya de Malha Bank 1977-2000; constructed using the following data sources: Wijkstrom and Kroepelein, 1979; Ardill 1986; Samboo, 1983; MRAG 1996; Dharmendra and Sólmundsson 2005; Boistol et al., 2011; SIOFA Scientific Committee National Reports EU (FRA / ESP) 2021

Historically, the price of frozen fish was reported to have driven investment in the Banks fishery. For example, the price of frozen fish, formerly controlled by decree, was freed in 1981 resulting in a 50% increase in the number of operating vessels in the Banks fishery the next year (Figure 3) (Ardill, 1986). This situation led to the chartering of South Korean vessels by fishing companies for the purpose of fishing on Saya de Malha and supplying the local market from 1977 until 1984 (Figure 3) (Munbodh 2014). There was a strong increase of Mauritian participation in the Banks Fishery from 1984 following incentives provided by the Mauritian Government such as: reducing harbour dues, removing duty on fishing gears, equipment and spare parts, waiving import duty on vessels acquired by Mauritian companies, and providing adequate port facilities. The number of local Mauritian fishing vessels subsequently increased to a peak of 17 in 1993 (Figure 3).

Saya de Malha has historically been fished by vessels from Mauritius, Korea, Japan, Russia, La Réunion (as early as 1962 (Boistol et al., 2011)), and the Seychelles (MRAG, 1996) (Figure 3). However, early records do not always report the full number nor the flag State of vessels operating on Saya de Malha, therefore it difficult to provide an exact delineation of the composition of vessels operating in a given 12-month period. For example, in 1996, a Sri Lankan vessel is known to have fished unreported on Saya de Malha (British Indian Ocean Territory Fishery Patrol Vessel Report, unpublished) (see also 3.1.3 Other fisheries not reported to SIOFA).

Spatial footprint

Understanding of the spatial footprint of historical fisheries is limited due to the paucity of data available. Descriptions of fished areas are therefore reliant on those given in the literature. For example, Munbodh 2014 explains that historically the areas of the Banks that are fished are found on parts of the North Bank and the northern, north-eastern and eastern rim of the South Bank of Saya de Malha (Figure 4). This correlates with MRAG (1996), wherein it was estimated the fishable areas of Saya de Malha for demersal hook and line fisheries represented approximately 30% of the total area. Areas suitable for trawling, notwithstanding potential damage to VME species, have not been explicitly mapped but may represent a larger portion of the area.

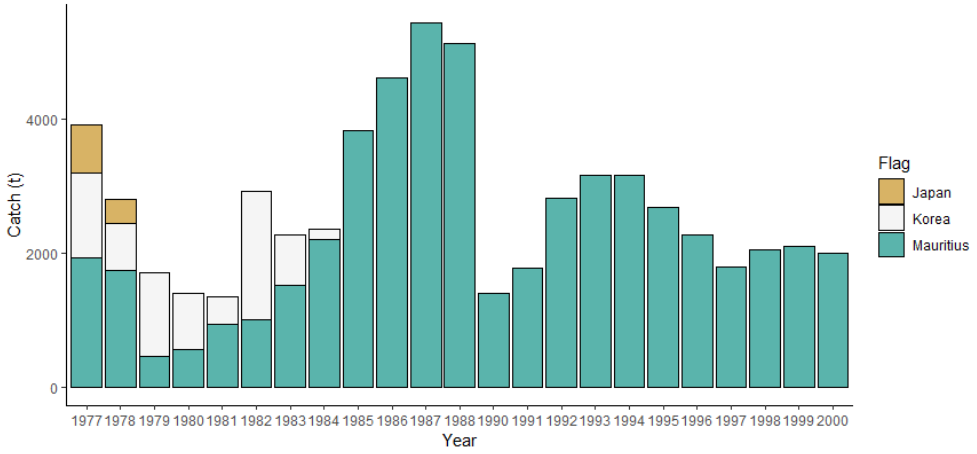


Figure 4. Catch (tonnes) from Mauritius, Korea chartered and Japan vessels, 1977-2000

Catch and bycatch

Historical catch records are available for Mauritius, Japan, and Korea through Albion Fisheries Research Centre data (Munbodh, 2014), National Reports submitted to SIOFA, and technical reports such as Samboo, 1989 (Figure 4). However, as highlighted in MRAG 1996, catch and effort statistics reported in the literature are inconsistent. Further, in many cases breakdown of catches by species is reported only in proportional composition without associated catch weights.

Across all flag States, *Lethrinus mahsena*, commonly known as the 'berri' fish, is the most important species in Saya de Malha and contributes some 80-90 % of the total catch (Soondron et al., 1999). Other notable contributions by species group include groupers (Serranidae spp.) 4 %, seabreams (*Lethrinidae spp*.) 2 %, jackfish (Carangidae spp.) 2 %, *Aprion virescens* 1 %, and *Lutjanus bohar*, *Pristipomoides spp*, and various tuna species, < 1 %. The two Japanese trawl vessels operating across Saya de Malha in 1977 and 1978 primarily targeted horse mackerels and lizardfish (snakefish) in the shallower waters, of which the species catch by species is reported in Table 3.

Table 3. Annual catch (tonnes) of Japanese trawl fisheries operating across the Saya de Malha Bank 1977-1978 (SC-03-03)

Year	Roudi escolar (*Promethichthys prometheus*)	Horse mackerels (*Caranginae*)	Lizardfish (*Synodontidae*)	Other	Total
1977	13	418	203	88	721
1978	2	229	53	69	352

Samboo 1989 reports Mauritian vessels used to spend 15-22 days fishing per trip and the Koreans 34-55 days. During each year, the vessels experience around 60 unproductive days (30 days in travel 30 days in bad weather). Despite the increase in the number of vessels operating on Saya de Malha in 1983, there was no drastic decrease in the catch per fisherman day, a potential indication of moderate exploitation of the stocks.

3.1.2 Contemporary fisheries

Literature describing the contemporary fisheries operating on Saya de Malha is primarily grey literature; including annual national reports and technical reports (e.g., Scientific Committee National Reports submitted by countries partied to SIOFA and Annual Reports from the Mauritian Ministry of Blue Economy, Marine Resources, Fisheries and Shipping).

Contracting Parties, cooperating non-Contracting Parties and participating fishing entities of SIOFA are required to submit National Reports to the Scientific Committee on an annual basis detailing descriptions of their fishing, research and management activities over the previous year. As minimum, reports should include a description of fisheries; catch, effort and catch per unit effort (CPUE) summaries; fisheries data collection and research activities; VME thresholds; biological sampling and length/age composition of catches; description of data verification mechanisms; summary of observer and port sampling programs and relevant social and economic information (optional). Data is often summarised by management unit of the SIOFA region (Areas 1-8); with Area 8 encompassing Saya de Malha.

Annual reports submitted by the Mauritian Ministry of Blue Economy, Marine Resources, Fisheries and Shipping highlight the main activities of the Fisheries Division; the performance of the fisheries sector within the overall economy; the various activities conducted to monitor fisheries activities and analysis of trends in the fisheries sector. Annual reports include a specific section on the Banks fishery which details production statistics for frozen fish; analysis of fishing activity on the Saya de Malha and Nazareth banks; length frequency data of *Lethrinus mahsena*; and fishing in Chagos waters.

The following sections summarise the available data on reported fishing operations by Thailand, France, Spain, Mauritius and the Comoros (Figure 5) using the above-mentioned reports.

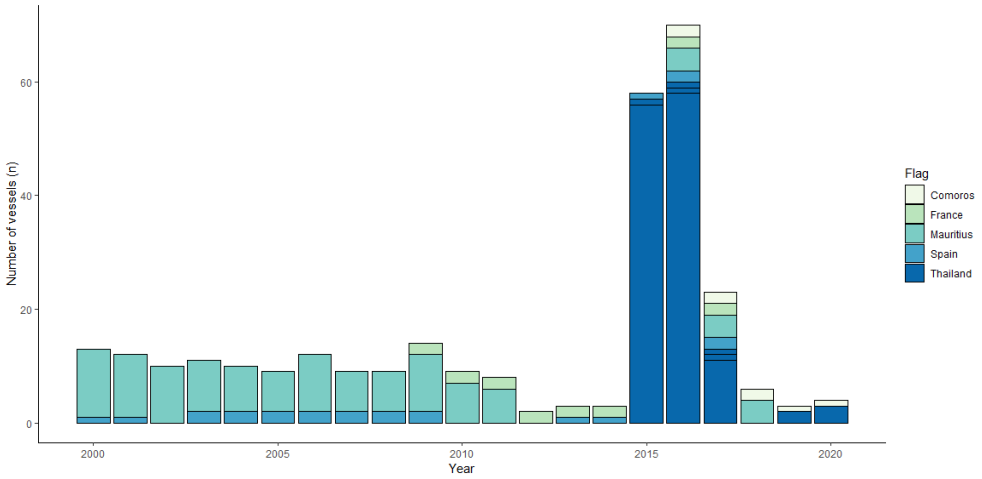


Figure 5. Number of vessels by flag State operating on the Saya de Malha Bank 2000-2020; constructed using the following data sources: Wijkstrom and Kroepelein, 1979; Ardill 1986; Samboo, 1983; MRAG 1996; Boistol et al., 2011; SIOFA Scientific Committee National Reports EU (FRA / ESP); Comoros and Thailand 2017-2021

3.1.2.1 **Comoros**

The Union of Comoros has been a cooperating and non-contracting party of SIOFA since 2018. National reports submitted by the Comoros are therefore available for the years 2019-2021, inclusive; representative of fishing activity data between years 2016-2020.

Number of vessels

Between the period 2016-2018, there were two mothership vessels authorised to fish outside the Comorian EEZ. Each vessel bearing 19 smaller motorised vessels, each with two or three fishers, using handlines. The main fishing area of the two Comorian vessels were Nazareth and Saya de Malha.

Spatial footprint

Figure 6 highlights the spatial footprint and apparent fishing effort (hours/1,000km^2) of the Comoros fishing fleet as indicated by AIS data collected from fishing vessels that GFW has identified as known or possible commercial fishing vessels. AIS data indicated fishing activity with drifting longlines to have occurred directly on, or within near proximity to, Saya de Malha in 2016-2018 inclusive, recording up to > 124 hours of fishing per 1,000 km^2 within a 12-month period. Dominant fishing areas include in the north and north west regions of the South Bank of Saya de Malha. No AIS data from Comoros-flagged vessels was detected by GFW in 2015, 2019, 2020 or 2021, reflective of the activity reported to SIOFA in National Reports.

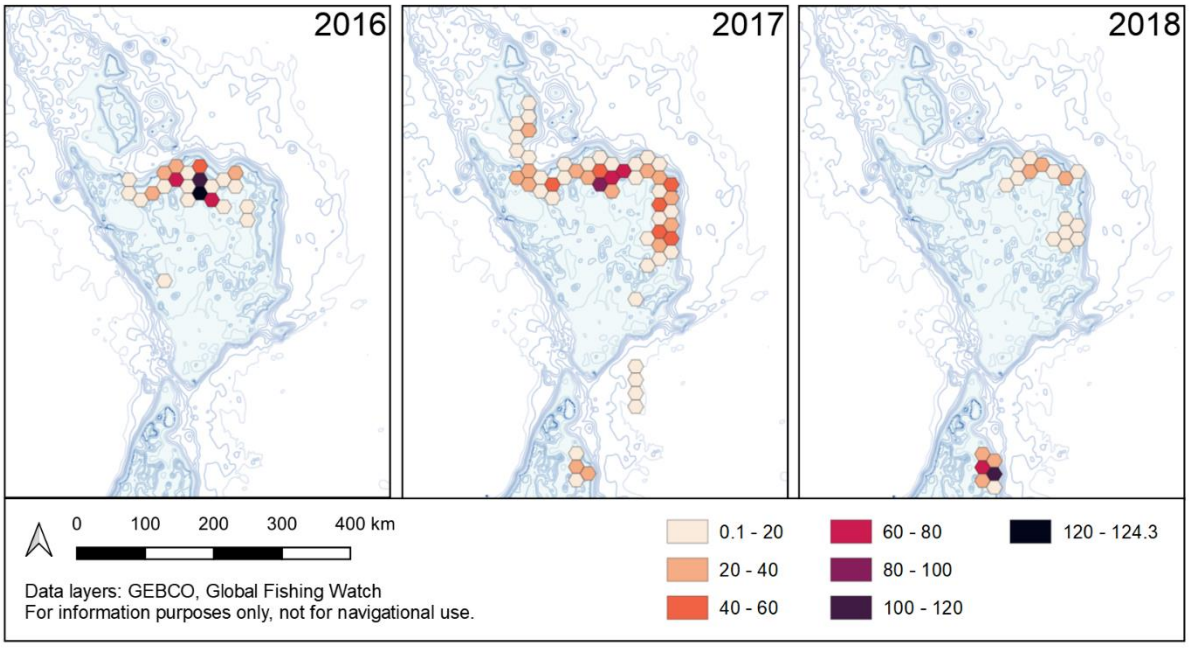


Figure 6. Spatial footprint and apparent fishing effort (hours/1,000 km^2) of Comoros fishing fleet (all gear types) 2016-2018; using AIS (Source: Global Fishing Watch)

Catch and bycatch

Catch data available for the Comoros is aggregated at species group level; with only catch proportions of the total catch per vessel available (Table 4). Between 2016- 2018, both vessels operating on Saya de Malha undertook 13 fishing operations each; resulting in a total of 4,100 fishing hours. Hence, a significantly greater catch than that yielded in 2019-2020, where only three fishing operations were undertaken over the two-year period, and a total of 64 fishing

days. Target species groups (as a proportion of total catch) include; Lethrinids (Emperors) (81 %), Serranids (Groupers) (17 %), Lutjanids (Snappers) (1 %) and other incidental catches (1 %).

Table 4. Vessels and catch by year between 2016-2020.

Year	Vessels	Catch (tonnes)
2016	2	257.3
2017	2	516.4
2018	2	453.5
2019 (Oct – Dec)	1	0.047
2020 (Jan – Jun)	1	0.039

3.1.2.2 **France (EU)**

National reports submitted by the European Union, on behalf of France, are available for 2017-2021, inclusive; representative of fishing activity data between years 2009-2020.

Number of vessels

There has been a directed fishery for demersal species since 2009 until 2017; whereby one or two longline vessels; less than 25 m, have operated on Saya de Malha. Whereas the vessels' main activity is in the tuna fishery, vessel regularly finish their fishing trip on Saya de Malha by catching demersal fishes for the fresh market of La Réunion. There have been no French-flagged vessels authorised to operate on Saya de Malha since 2017.

Spatial footprint

Figure 7 highlights the spatial footprint and apparent fishing effort (hours/1,000 km^2) of the French fishing fleet as indicated by AIS data collected from fishing vessels that GFW has identified as known or possible commercial fishing vessels. This includes vessels employing both tuna purse seine and drifting longlines.

AIS data indicated fishing activity to have occurred directly on, or within near proximity to, Saya de Malha Bank in 2015-2019 inclusive, recording up to > 450 hours of fishing per 1,000 km^2 within a 12-month period. Dominant fishing area include in the western region of the South Bank of Saya de Malha (2015-2017). No AIS data from French-flagged vessels was detected by GFW in 2021.

Catch and bycatch

French flagged vessels operating across Saya de Malha target a mixture of species, namely; crimson jobfish (*Pristipomoides filamentosus*); *Lutjanus spp*; green jobfish (*Aprion virescens*); deepwater longtail red snapper (*Etelis coruscans*); deep-water red snapper (*Etelis carbunculus*); porgies, seabreams nei (*Sparidae*); Groupers (nei) (*Epinephelus spp*); blacktip grouper (*Epinephelus fasciatus*); comet grouper (*Epinephelus morrhua*); white-blotched grouper (*Epinephelus multinotatus*); blacksaddled coralgrouper (*Plectropomus laevis*); sky emperor (*Lethrinus mahsena*).

Due to confidentiality restrictions that prevent the disclosure of fishing activity of fewer than five vessels; catch data is not published for EU-France operations. Only catch composition data is available at a species and species group level, and is presented in Figure 8.

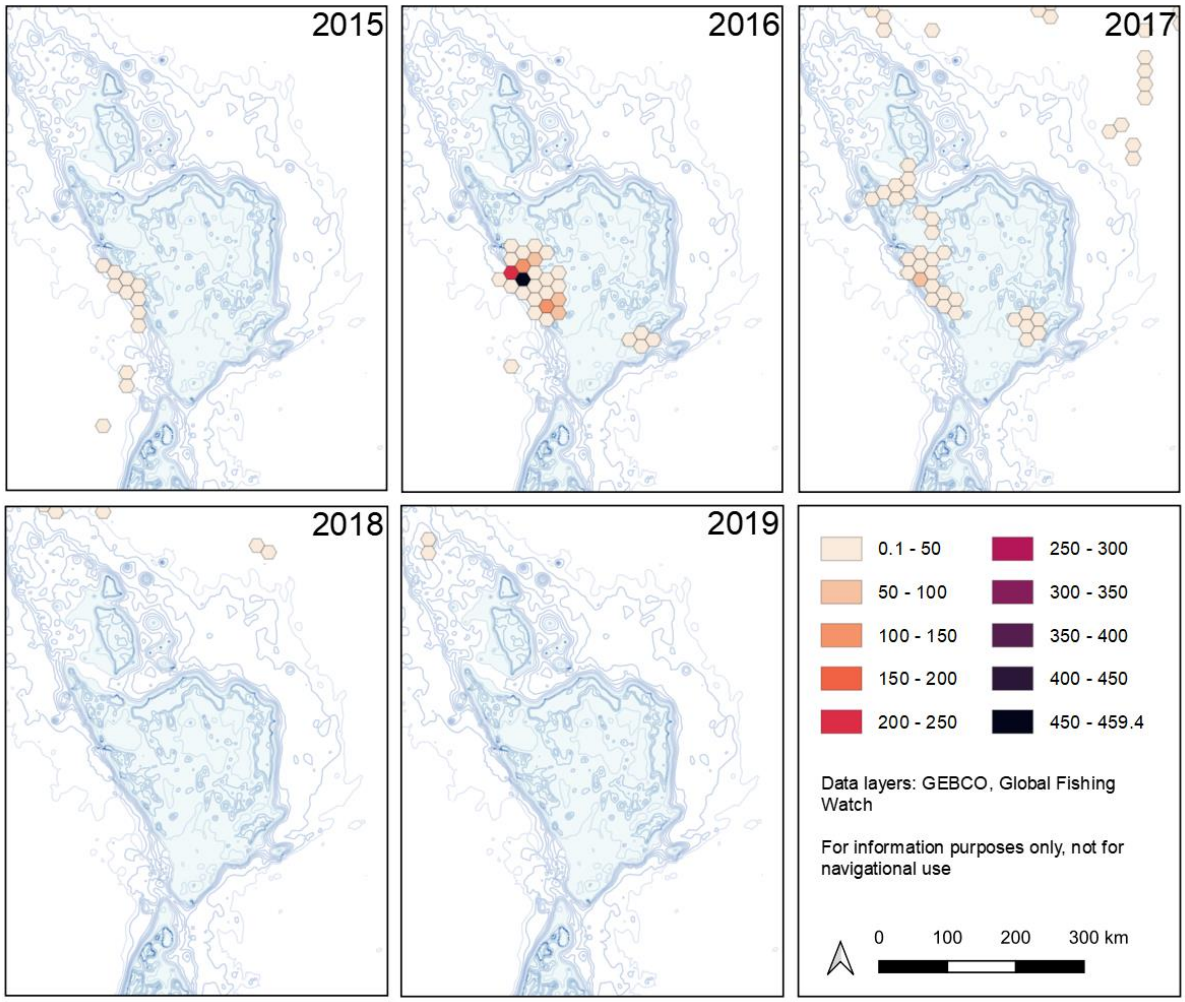


Figure 7 Spatial footprint and apparent fishing effort (hours/1,000 km^2) of French fishing fleet (all gear types) 2015-2019; using AIS (Source: Global Fishing Watch)

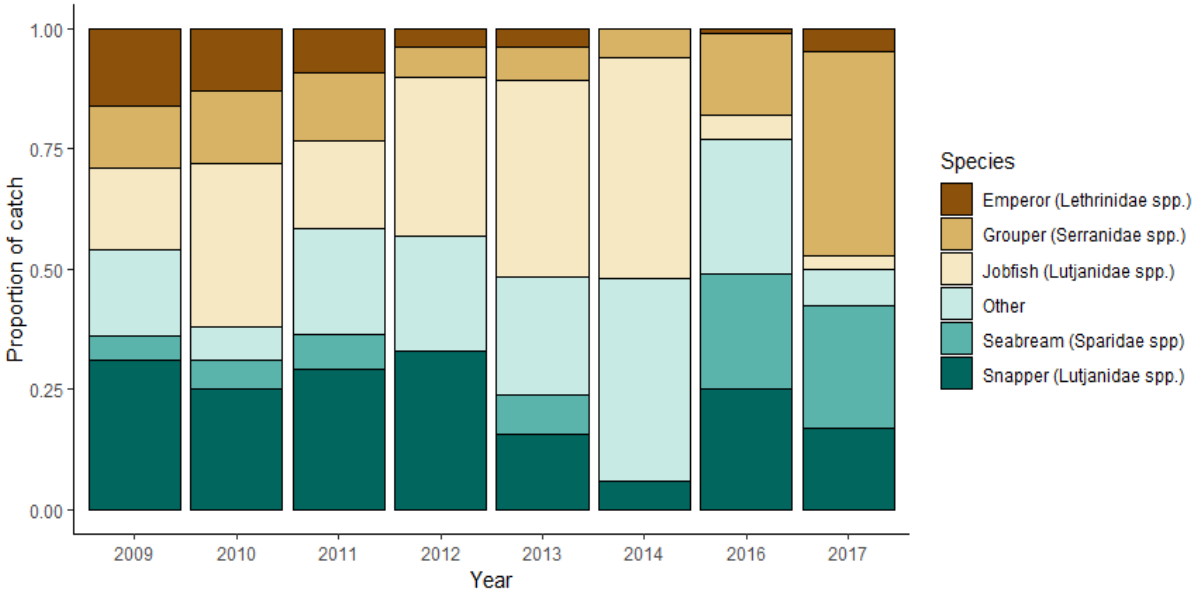


Figure 8. Catch composition (%) of catches made by French flagged vessels operating across Saya de Malha

3.1.2.3 **Thailand**

National Reports submitted to SIOFA by Thailand are available for the years 2019, 2020 and 2021 encompassing fishing activity from 2015-2020.

Number of vessels

Overall, during the period 2015-2020, there were a total 62 authorised Thai vessels with active fishing operations in the western Indian Ocean (SC-04-22), employing a mixture of gear types namely; otter board trawls (OTB); pair trawl (PTB); traps (PTO) and handline (LHP) (Table 5).

Table 5. Number of Thai flagged vessels operating on the Saya de Malha Bank 2015-2020, by gear type

Year	Number of vessels (n)				
	Otter Board Trawls	Pair Trawls	Traps	Handlines	Total
2015	56	-	1	-	57
2016	58	1	1	-	60
2017	11	1	1	-	13
2018	-	-	-	-	-
2019	2	-	-	1	3
2020	3	-	-	3	3

Spatial footprint

Thai vessels predominately operate on Saya de Malha Bank, between latitude 9-12 °S and longitude 60-62 °E at depths of approximately 20-80 m. The fishing area of Thai fleet is around 33,336.00 km^2, mostly on continental shelf area which covers 7.15 % of trawlable area or 0.12 % of total SIOFA area. Fishing trips are reported to last up to three months. Figure 9 highlights the spatial footprint and apparent fishing effort (hours/1,000 km^2) of the Thai fishing fleet as indicated by AIS data collected from fishing vessels that GFW has identified as known or possible commercial fishing vessels. AIS data indicated fishing activity to have occurred directly on, or within near proximity to, Saya de Malha Bank in 2016 and 2020 recording up to 439 hours of fishing per 1,000 km^2 within a 12-month period.

Catch and bycatch

Reported catch and species composition data is based off logbook data from authorised vessels. The total catch (tonnes) per gear type and total annual catch amongst the Thai high-seas vessels is given in Table 6. As Thai vessels did not operate in SIOFA area in 2018, there is no effort and catch data to report. In most cases, catch data is reported at species group level with limited species level identification.

Table 6 and Figure 10 detail the catch, by species or species group, retained by both otter board trawls and handline vessels for the years 2019 and 2020. Before 2019, only catch composition by percentage weight is available. The dominant catch species by Otter Board Trawl vessels comprised of round scad (*Decapterus spp.*), lizard fish (S*aurida spp.*), threadfin bream (*Nemipterus spp.*), goat fish (*Parupeneus spp*.), bigeye scad (*Selar spp.*) and Indian mackerel (*Rastrelliger spp*.). Most of the discarded *Decapterus spp.* are kept as bait for handline vessels*;* which primarily target Carangoides *spp*., Golden trevally (*Gnathanodon speciosus), Epinephelus spp*., Green jobfish (*Aprion virescens)* and *Lutjanus spp.*

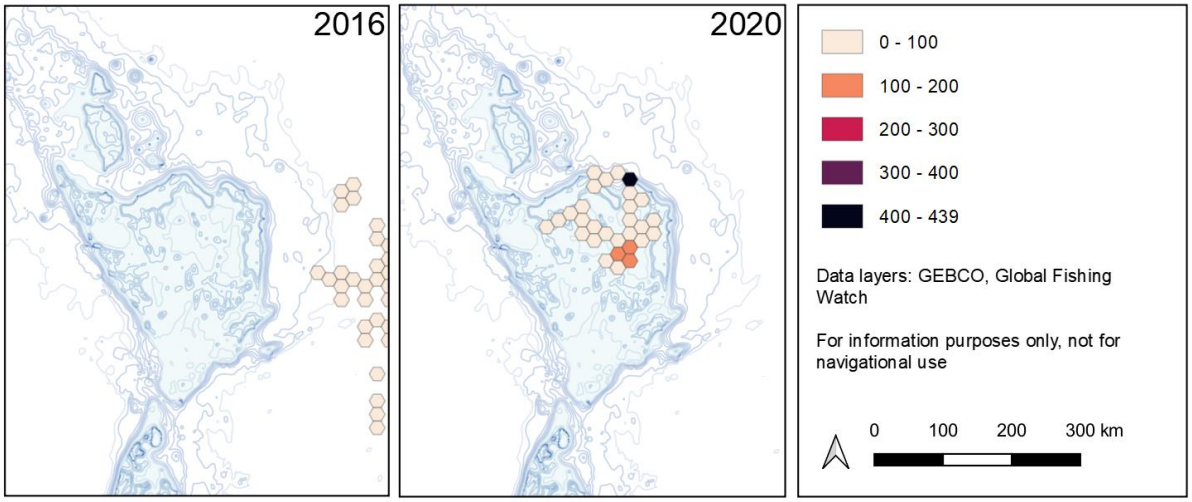


Figure 9. Spatial footprint and apparent fishing effort (hours/1,000 km^2) of Thai fishing fleet (all gear types) in 2016 and 2020; using AIS (Source: Global Fishing Watch)

Table 6. Summary of catch (tonnes) per gear type; operating in Area 8 (encompassing the Saya de Maya Bank) of SIOFA (SC-06-11).

Year	Total catch (tonnes) per gear type				
	Otter Board Trawls	Pair Trawls	Traps	Handlines	Total
2015	22,729.05	-	389.00	-	23,118.05
2016	8,435.24	2,318.39	2.53	-	10,756.16
2017	1,617.84	416.18	8.32	-	2,042.34
2018	-	-	-	-	-
2019	358.12	-	-	304.80	662.92
2020	924.51	-	-	379.39	1,303.91

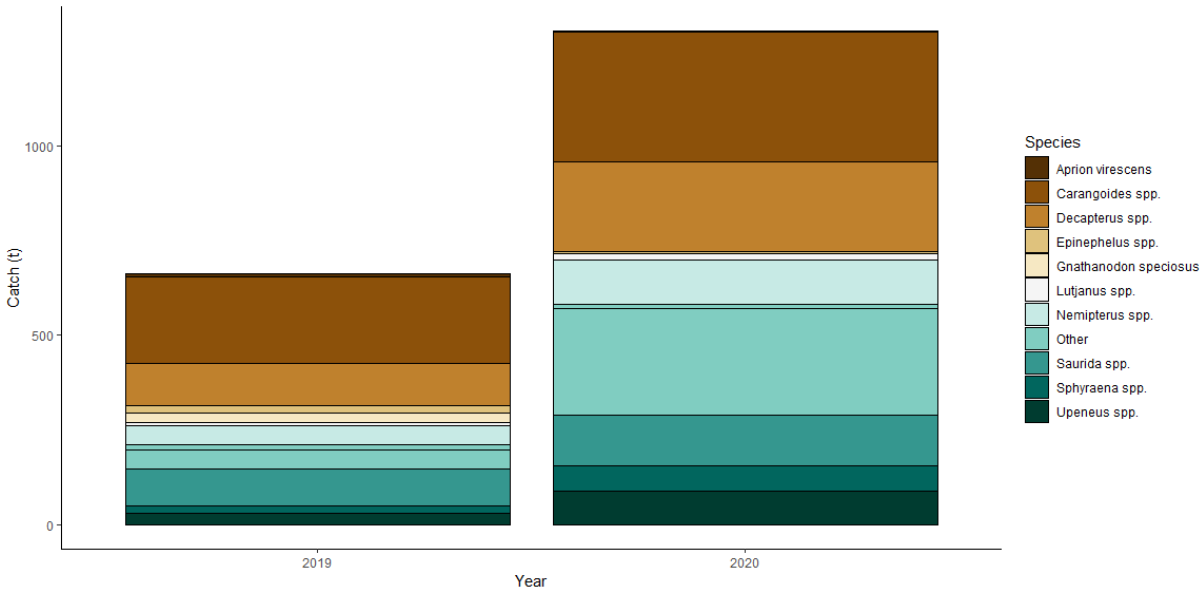


Figure 10. Catch (tonnes) retained by both otter board trawls and handline Thai vessels for 2019 and 2020 (SC-06-11)

Discard data (tonnes) by species is available for the years 2019 and 2020, presented by gear type; otter board trawls and handlines in Table 7 and Table 8 respectively. Most of the discarded *Decapterus spp.* caught by otter board vessels are kept as bait for handline vessels*;* which primarily target Carangoides *spp*., Golden trevally (*Gnathanodon speciosus), Epinephelus spp*., Green jobfish (*Aprion virescens)* and *Lutjanus spp.* There is no record from observer reports that Thai fishing operations encountered endangered, threatened or protected species neither marine mammal, corals or sponges.

Table 7. Discards (tonnes) by Thai otter board trawl vessels 2019-2020

Year	*Decapterus spp.*	*Saurida spp.*	*Nemipterus spp.*	*Upeneus spp.*	*Sphyraena spp.*	Other	Total
2019	0.40	-	-	-	-	19.75	20.15
2020	6.35	-	-	-	-	24.19	30.54

Table 8. Discards (tonnes) by Thai handline vessels 2019-2020

Year	*Carangoides spp.*	*Gnathanodon speciosus*	*Epinephelus spp.*	*Aprion virescens*	*Lutjanus spp.*	Other	Total
2019	-	-	-	-	-	0.16	0.16
2020	-	-	-	-	-	0.01	0.01

3.1.2.4 **Mauritius**

Annual reports submitted by the Mauritian Ministry of Blue Economy, Marine Resources, Fisheries and Shipping describing activities conducted to monitor fisheries activities and analysis of trends in the fisheries sector were available for years 2003-2011 and 2016-2018.

Number of vessels

Since 2001, there have been between four to ten mother vessels operating on Saya de Malha (Table 9). Handlines remain the only effective method of fishing since fishing operations began on Saya de Malha; carried out by 6-7 m dories transported to fishing grounds aboard the mother fishing vessels. The length of the mother vessels ranges from 35-55 m Length and can carry from 15-22 dories.

Table 9. Number of vessels; catch (tonnes) between 2001-2011; 2016-2018 (Albion Fisheries Research Centre 2003-2012; Dharmednra and Sólmundsson, 2005 and Munbodh, 2014).

Year	Vessels	Catch (tonnes)
2001	11	1,283
2002	10	2,090
2003	9	2,354
2004	8	1,686
2005	7	1,028
2006	10	1,654
2007	7	1,481
2008	7	966
2009	10	1,835
2010	7	737
2011	6	757
2016	4	Not available

Year	Vessels	Catch (tonnes)
2017	4	Not available
2018	4	Not available

Spatial footprint

Figure 11 highlights the spatial footprint and apparent fishing effort (hours/1,000 km^2) of the Mauritius fishing fleet as indicated by AIS data collected from fishing vessels that GFW has identified as known or possible commercial fishing vessels. AIS data indicated fishing activity to have occurred directly on, or within near proximity to, Saya de Malha Bank in 2015-2021 inclusive, recording up to > 800 hours of fishing per 1,000 km^2 within a 12-month period. Over the years more fishing operations have been carried out during the summer months from September to the end of May (Munbodh, 2014).

Catch and bycatch

Catch data is available from the Ministry of Fisheries on behalf of the Albion Fisheries Research Centre. However, published catch data is only available on contemporary fisheries from 2001-2011. After the total catch had peaked in 1994 at 4,758 tonnes, catch gradually decreased to 1,283 tonnes in 2001 and fluctuated thereafter to 757 tonnes in 2011 (Table 9).

The main targeted species is Dame Berri (*Lethrinus mahsena*) which contributes about 80-90 % of the total catch (Munbodh, 2014). The other part of the catch is composed mostly of groupers (*Serranidae spp*.), snappers (*Lutjanids spp*.) and other sea breams (*Lethrinidae spp.)* (mainly *Plectropomus maculatus* and *Aprion virescens*) with smaller quantities of tuna. The catch is mostly gilled, gutted and frozen on board.

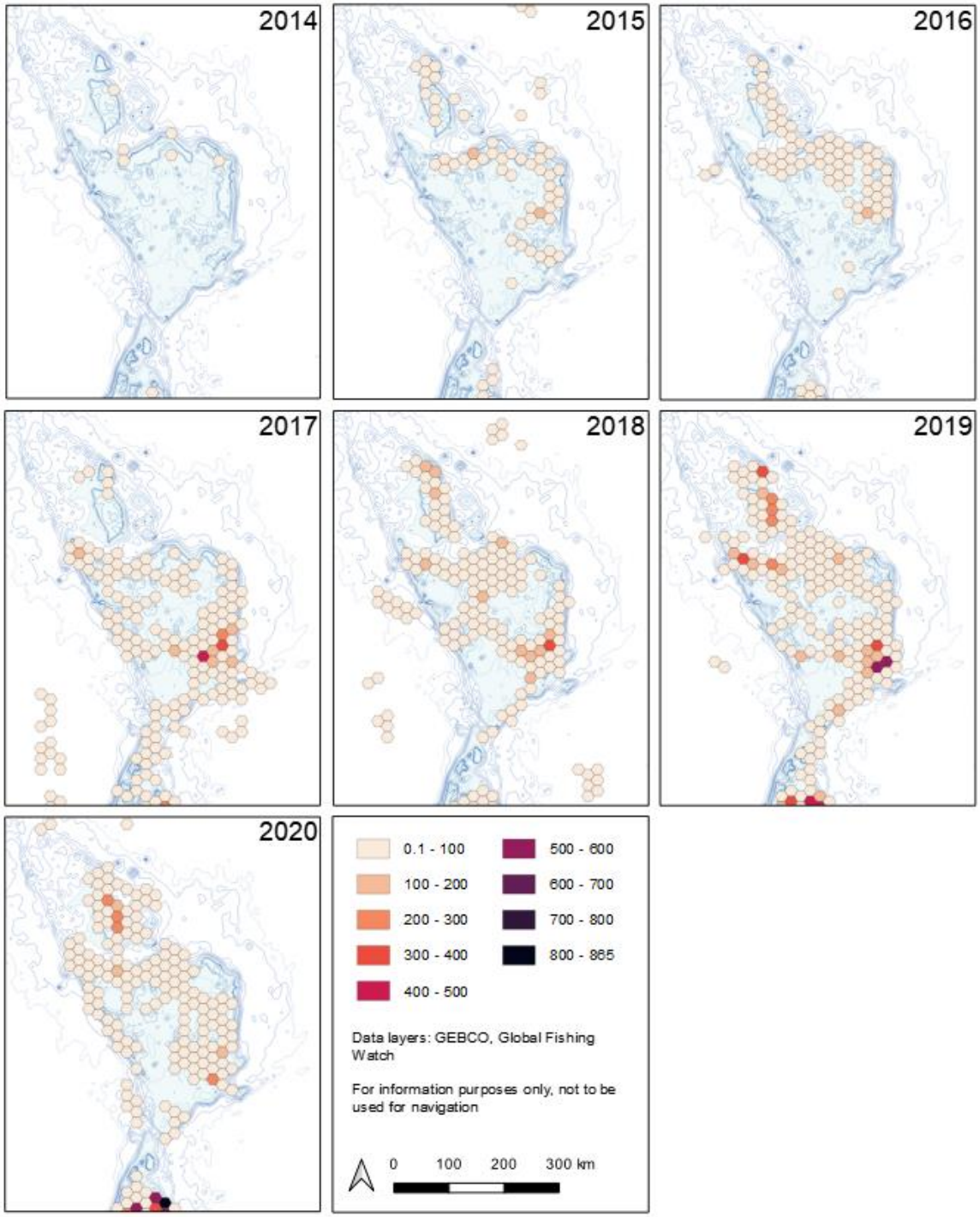


Figure 11. Spatial footprint and apparent fishing effort (hours/1,000 km^2) of Mauritius fishing fleet (all gear types) 2014-2020; using AIS (Source: Global Fishing Watch)

3.1.2.5 **Spain (EU)**

National reports submitted by the European Union, on behalf of Spain, are available for 2017-2021, inclusive; representative of fishing activity data between years 2000- 2020.

Number of vessels

Since 2000, there has been between one and two Spanish flagged vessels operating in the SIOFA region per year; using a combination of trawl, bottom longline and bottom gillnet gear. Since, 2015 only one bottom longline vessel has been present in the SIOFA region.

Spatial footprint

Spanish vessels operate across several SIOFA areas: 1, 2, 3, 3b and 8. However, upon review of submitted National Reports, fishing operations within Area 8, across Saya de Malha, appear to have ceased in 2018. Moreover, GFW AIS data shows evidence of minimal fishing activity over Saya de Malha by Spanish-flagged vessels in 2014 only (Figure 12).

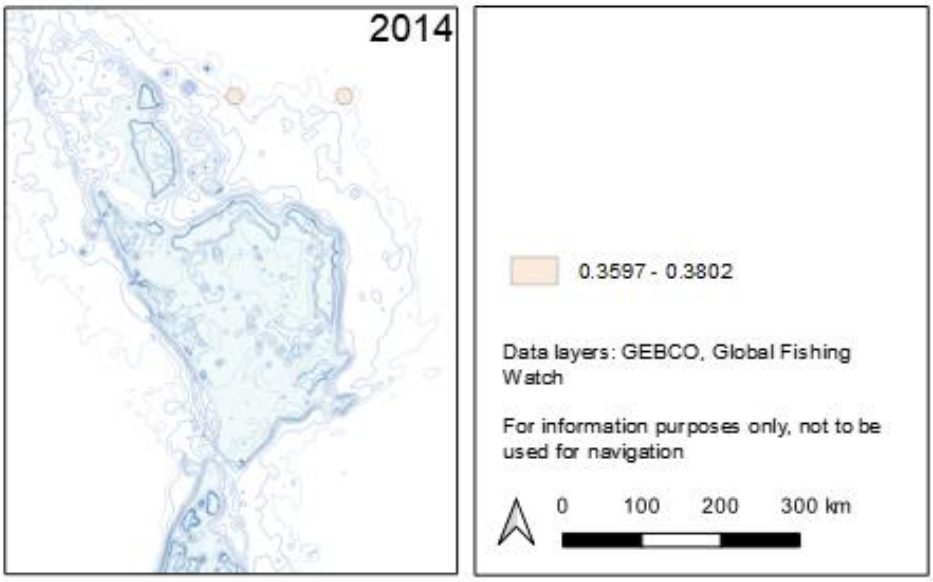


Figure 12.Spatial footprint and apparent fishing effort (hours/1,000 km^2) of Spanish fishing fleet in 2014; using AIS (Source: Global Fishing Watch)

Catch and bycatch

Within the National Reports submitted by the European Union, on behalf of Spain; despite the reporting of fishing activity up to 2018, catch data is only reported for Areas 1, 2, 3b and 7. Specific catches representative of the fishing footprint on Saya de Malha can therefore not be presented at this time.

3.1.3 Other fisheries not reported to SIOFA

For several of the Contracting Parties (China, Japan and the Seychelles) and participating fishing entities (Chinese Taipei), fisheries information and data relevant to Saya de Malha was unavailable or not reported to SIOFA. Through spatial resources made available by GFW, apparent fishing activity over Saya de Malha by these countries was visualised using AIS data from vessels that GFW has identified as known or possible commercial fishing vessels. GFW data also highlighted countries with substantial fishing on Saya de Malha but currently not engaged with SIOFA (e.g., India and Sri Lanka). Other countries with apparent historical fishing effort on Saya de Malha, albeit minimal effort include; Belize, Italy, Oman, Philippines and Tanzania.

It is important to note that not all fishing effort on Saya de Malha is reported to SIOFA. The majority of this fishing activity is likely reflective of vessels targeting tuna (and other pelagic tuna-like species), which is reported to the regional tuna fisheries management organisation the Indian Ocean Tuna Commission (IOTC). In order to delineate fishing effort likely targeting tuna, spatial data has been disaggregated by gear type, where possible. Activity of tuna vessels over Saya de Malha may have implications for SIOFA relevant species as bycatch for example. Figure 13-Figure 20 depict the total apparent fishing hours per 1,000 km^2 per gear type by the above-mentioned nations since SIOFA was established in 2012-2020, inclusive. The years in which vessels were active are indicated in Table 10. Clear spatial patterns of apparent fishing activity are depicted, for example; fished areas by Chinese Taipei; China; Seychelles and Japan-flagged vessels are predominantly focused on the edge of Saya de Malha, perhaps reflective of longline activity targeting large pelagics. Whereas, Indian and Sri Lankan-flagged vessels apparent fishing effort is focussed on Saya de Malha itself.

3.1.3.1 **China**

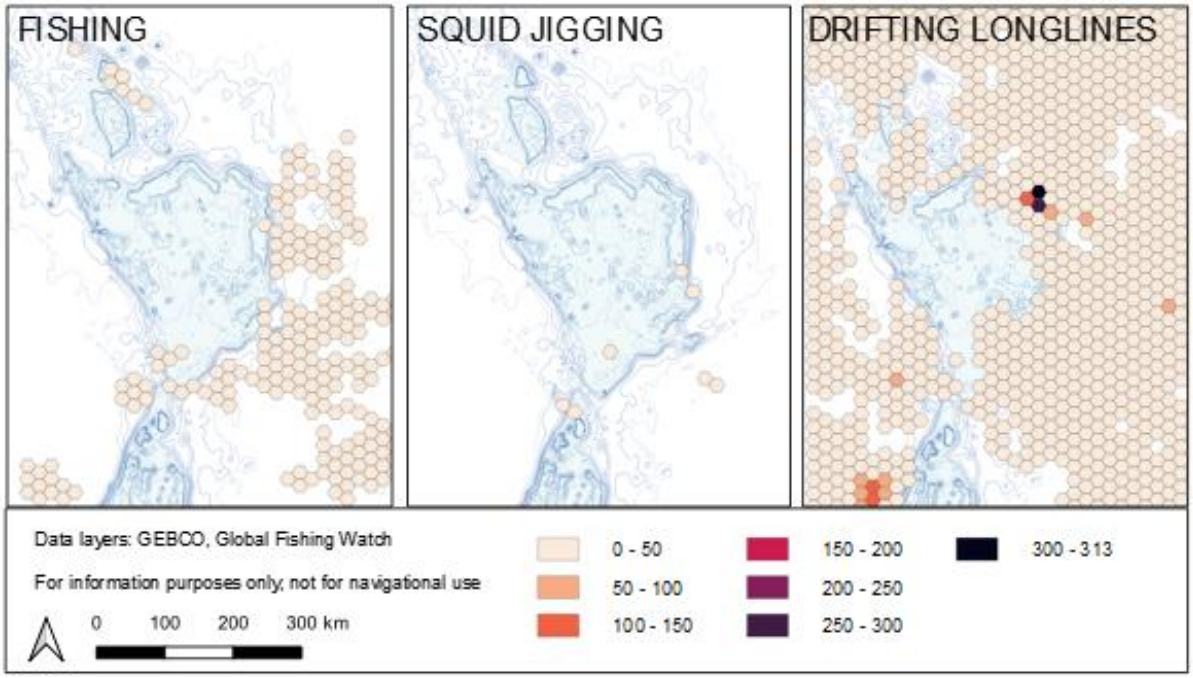


Figure 13. Spatial footprint and apparent fishing effort (hours/1,000 km^2) of Chinese fishing fleet, by gear type, 2012-2020; using AIS (Source: Global Fishing Watch)

3.1.3.2 **Chinese Taipei**

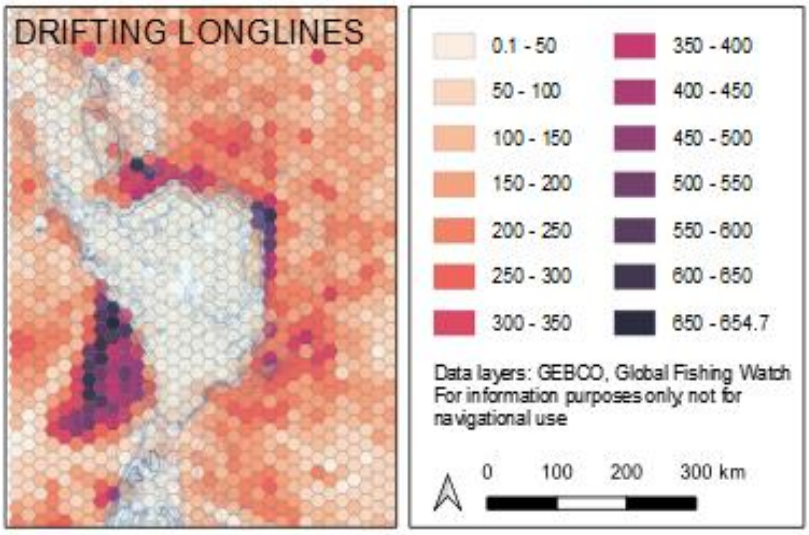


Figure 14. Spatial footprint and apparent fishing effort (hours/1,000 km^2) of Chinese Taipei fishing fleet (drifting longlines) 2012-2020; using AIS (Source: Global Fishing Watch)

3.1.3.3 **India**

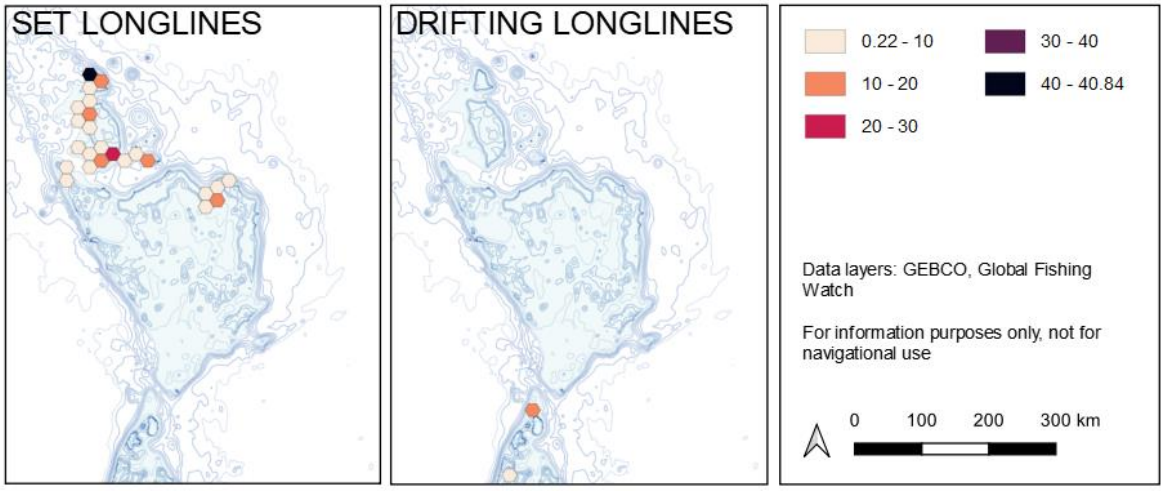


Figure 15. Spatial footprint and apparent fishing effort (hours/1,000 km^2) of Indian fishing fleet (set and drifting longlines) 2012-2020; using AIS (Source: Global Fishing Watch)

3.1.3.4 **Japan**

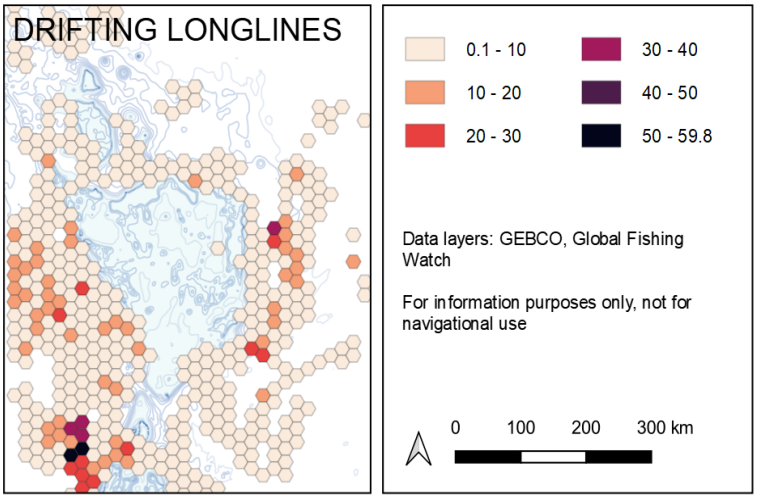


Figure 16. Spatial footprint and apparent fishing effort (hours/1,000 km^2) of Japanese fishing fleet (drifting longlines) 2012-2020; using AIS (Source: Global Fishing Watch)

3.1.3.5 **Korea**

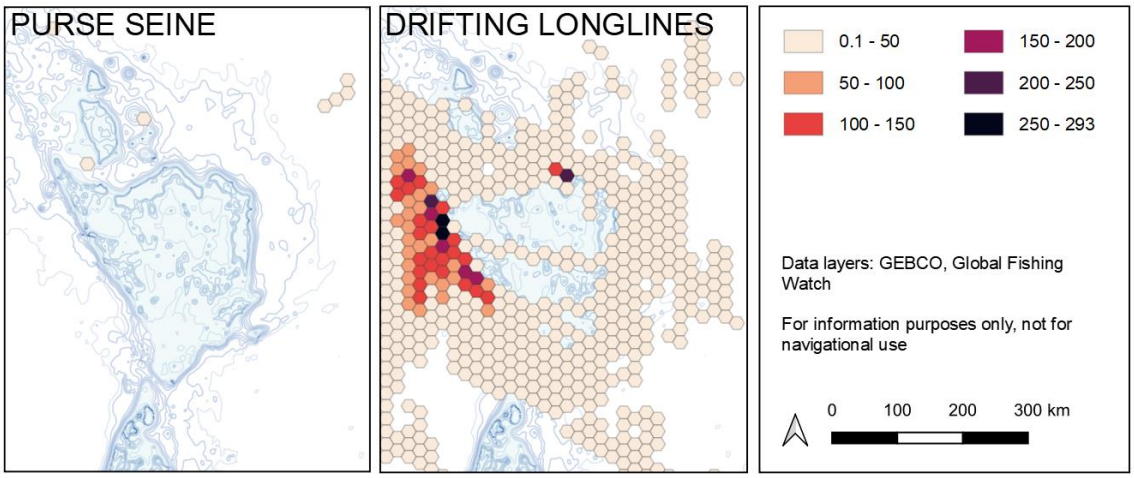


Figure 17. Spatial footprint and apparent fishing effort (hours/1,000 km^2) of Korean fishing fleet (purse seine and drifting longlines) 2012-2020; using AIS (Source: Global Fishing Watch)

3.1.3.6 **Malaysia**

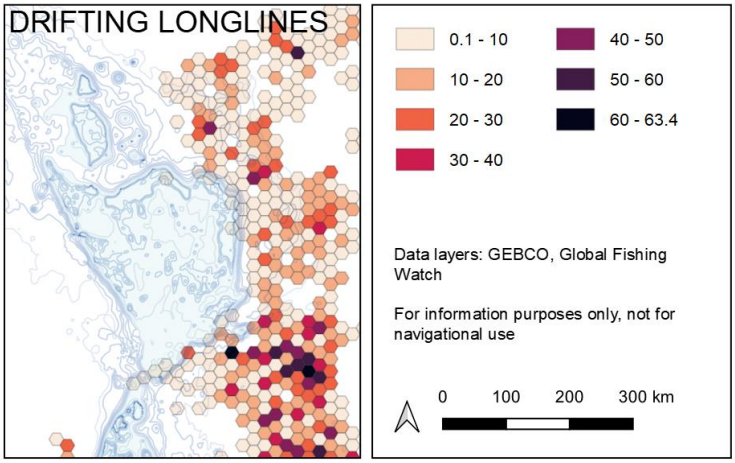


Figure 18. Spatial footprint and apparent fishing effort (hours/1,000 km^2) of Malaysian fishing fleet (drifting longlines) 2012-2020; using AIS (Source: Global Fishing Watch)

3.1.3.7 **Seychelles**

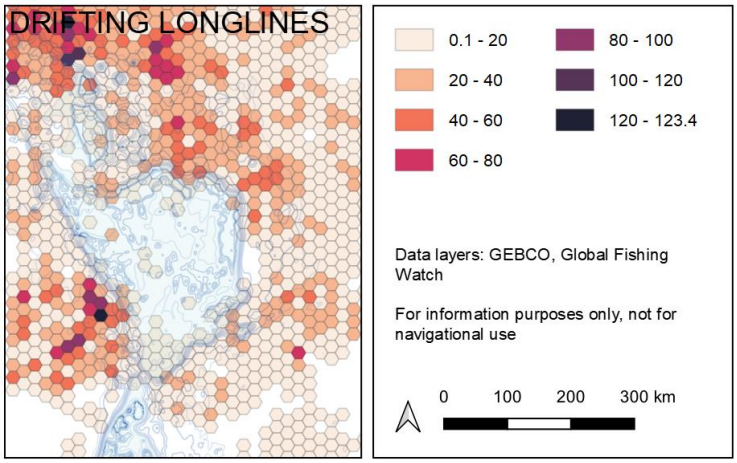


Figure 19. Spatial footprint and apparent fishing effort (hours/1,000 km^2) of Seychelles fishing fleet (drifting longlines) 2012-2020; using AIS (Source: Global Fishing Watch)

3.1.3.8 **Sri Lanka**

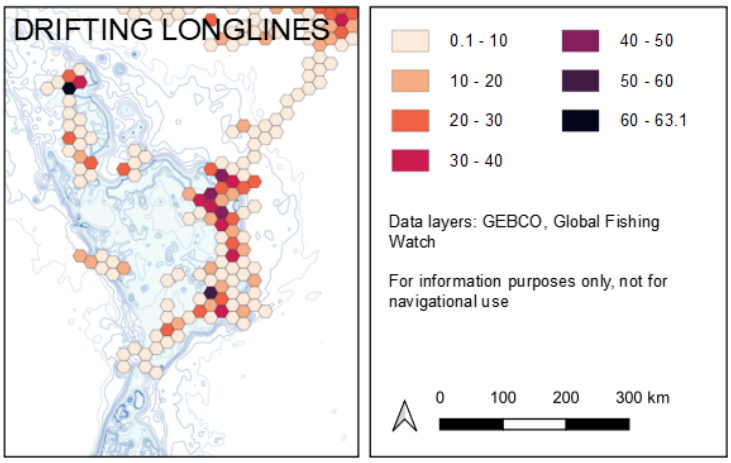


Figure 20. Spatial footprint and apparent fishing effort (hours/1,000 km^2) of Sri Lankan fishing fleet (drifting longlines) 2012-2020; using AIS (Source: Global Fishing Watch)

Table 10. Years in which identified countries fishing on the Saya de Malha Bank were active, by gear type, using Global Fishing Watch's apparent fishing effort model, based on AIS data

Country	Gear	Years active
China	Fishing	2014; 2015; 2017; 2018; 2019
	Squid jigging	2015
	Drifting longlines	2013; 2015 - 2020
Chinese Taipei	Drifting longlines	2012 – 2021, inclusive
India	Set longlines	2020
	Drifting longlines	2018
Japan	Drifting longlines	2013 – 2021, inclusive
Korea	Purse seine	2013; 2016; 2018
	Drifting longlines	2013; 2016; 2018; 2019; 2020
Malaysia	Drifting longlines	2014; 2015; 2017; 2020
Seychelles	Drifting longlines	2012 – 2021, inclusive
Sri Lanka	Drifting longlines	2017 – 2021, inclusive

3.1.4 Scientific surveys

Recognised as an area of great ecological and biological significance with the potential to yield commercially exploitable fisheries, a series of historical surveys with mixed objectives have been undertaken on Saya De Malha. Objectives include; understanding the productivity, biodiversity and biomass of the pelagic ecosystem and mapping the hydrographic characteristics of the Mascarene Plateau (Table 11). Literature describing historical surveys on Saya de Malha are primarily survey reports, peer-reviewed literature, technical reports; supported by data sets available through data repositories such as EAF-Nansen Programme.

Table 11. Summary of documented surveys undertaken on the Saya de Malha Bank

Year(s)	Survey	Data collected	Area	Reference
1952	Wheeler and Ommaney fisheries survey		Mauritius – Seychelles ridge	Wheeler and Ommaney 1953

Year(s)	Survey	Data collected	Area	Reference
1976 - 1977	Exploratory trawl surveys carried out by FAO/UNDP chartered vessel "Professor Mesyatsev"	Weight by species (kg); catch rates (kg/h)	Kenya; Tanzania; Sophala Bay; Mozambique; Delago Bay; Seychelles; Saya de Malha and Mauritius to Nazareth	Birkett, 1979
1993	Biomass, stock density and the maximum sustainable yield available to a line fishery for *Pristipomoides filamentosus* of the north western submarine promontory of Saya de Malha Bank	Total weight by species; date; location; fishing time; fishing method; bait types; fishing depth; number of men; and number of lines.	North western submarine promontory of Saya de Malha Bank	Grandcourt, 1994
2002	Bathymetric survey (RV Orphee / SY Vaka-Lele / MSY Ceres)	Bathymetric depth	North Bank	Hilbertz et al., 2002
2008	(RV) Dr Fridtjof Nansen (Survey 2008407)	Hydrographic characteristics of the Mascarene Plateau, and the productivity, biodiversity and biomass of the pelagic and demersal ecosystem	Around Mauritius, Nazareth Bank, Saya de Malha, Seychelles Bank, channels and shoals between banks	Groeneveld and Koranteng, 2017 Strømme et al., 2009
2018	**(**RV) Dr Fridtjof Nansen Leg 2.1. Mascarene Plateau and Nazareth Bank	Geomorphology, benthic habitats; fish and crustacean populations; oceanographic conditions and micro plastics and marine debris.	Mascarene Plateau and Nazareth Bank	EAF Nansen Programme

Saya de Malha is first thought to have been surveyed by Captain Robert Moresby of the Royal Navy in 1883, who successfully completed charting Southern Bank of Saya de Malha. Between the years 1975-1977, exploratory trawling of Saya de Malha was carried out by the FAO/UNDP chartered vessel R/V Professor Mesyatsev investigating the potential for the development of a trawl fisheries for small pelagic species (*Decapterus* spp.) and deep-water lobster. Birkett 1979 estimated the potential yield of the fish stock to be 26,000 tonnes. However, the feasibility of commercial fishing was unknown due to the lack of pilot studies.

In 1993, a survey investigating the biomass, stock density and the maximum sustainable yield available to a line fishery for the blue spotted jobfish (*Pristipomoides filamentosus*) on the North western submarine promontory of Saya de Malha was carried out using the Seychelles-flagged mothership 'Pecheur Breton' (Grandcourt, 1994). The 13-day survey was conducted within a depth range of 55-130 m over an area of 30.7 km^2. Specific data recorded included; total weight by species, date, location, fishing time, fishing method, bait type, fishing depth, number of fishers and number of lines. A total catch of 74,284 kg was recorded from 173 fishing trips over the 13-day period; 80.1 % (59,522 kg) of which was *P. filamentosus*, with an average CPUE of 21.86 kg/man/hour (Grandcourt, 1994) Other species caught of note included *Epinephelus multinotatus.* Overall, snappers (*Lutjanidae spp.*) contributed 79.6 % to total species composition.

The research vessel (R/V) Dr Fridtjof Nansen (Nansen), built in 1970 by Norad for use by the FAO Fisheries Department, first surveyed Saya De Malha Bank in 2008 (Survey ID: 2008407, Figure 21), as part of two ecosystem surveys focussing on process studies on the offshore banks between Mauritius and Seychelles (Strømme et al., 2009). Survey outputs are documented in Groeneveld and Koranteng, 2017 comprising of mainly biomass estimates, distribution maps of pelagic fish and species composition from trawl sampling. However, it lacks detailed data and information useful for further investigation into seasonal distribution patterns, feeding and spawning behaviour for example.

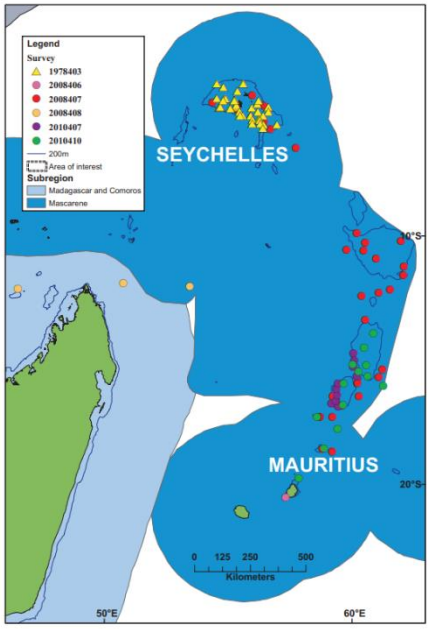


Figure 21. Sampling locations in the Mascarene sub-region, including survey 2008407 over the Saya de Malha Bank

Considered to be few, only 25 trawls were undertaken as part of the 2008 Nansen survey; mainly due to the undulating topography of the seafloor and presence of corals. Therefore, some surveys used demersal fish traps, and acoustic assessment of demersal resources occurring in waters between 100-350 m (Strømme et al., 2009). Six of the 25 trawls occurred directly on the Saya de Malha shelf. Snappers (*Lutjanidae spp*.) were most common in shelf trawl catches. Percentage contribution of (nominal) species to the total weight (kg) and number of organisms caught in trawls during two survey periods is provided in Groeneveld and Koranteng, 2017. However, catch data is aggregated to encompass all catches made across the Mascarene sub-region. It is therefore difficult to delineate the catches that relate to Saya de Malha. Other species groups caught in shelf trawls included groupers (*Serranidae spp*.), seabream (*Lethrinidae spp*.) and grunts (*Haemulidae spp.*).

Acoustic estimates of small mesopelagic fishes found a higher density in the north of the Mascarene sub-region, around Saya de Malha, when compared to the south (north coast of Mauritius and around Nazareth Bank). Species recorded in immediate proximity to Saya de Malha included jacks (*Carangidae spp*.) and lantern fish (*Myctophidae spp*.) with the highest recordings associated with the margins of the banks. No commercially viable densities of pelagic fish were observed.

Oceanographic data collected by R/V Nansen in 2008 (Figure 22) encompassed the following variables; nutrients, nitrates, fluorescence profiles, chlorophyll-a, phytoplankton composition, particulate organic matter, primary production, microzooplankton and zooplankton. A survey along the axis of the Mascarene Plateau showed the northern sector (N of 12 °S) to be most productive, with fluorescence maxima at 30-100 m depth and elevated phytoplankton biomass over Saya de Malha. A typical salinity minimum below 34.6 and temperature range of 5-7 °C, was found between Saya de Maya and Nazareth Banks.

In May-June of 2018, the R/V Nansen was again deployed to the Mascarene Plateau and Nazareth Bank. The first leg of the survey was focused on studying the Mascarene Plateau, specifically; the geomorphology, benthic habitats and benthos, map the occurrence of fish and crustacean resources. The research team also looked into the oceanographic conditions, and recorded the occurrence of micro plastics and marine debris.

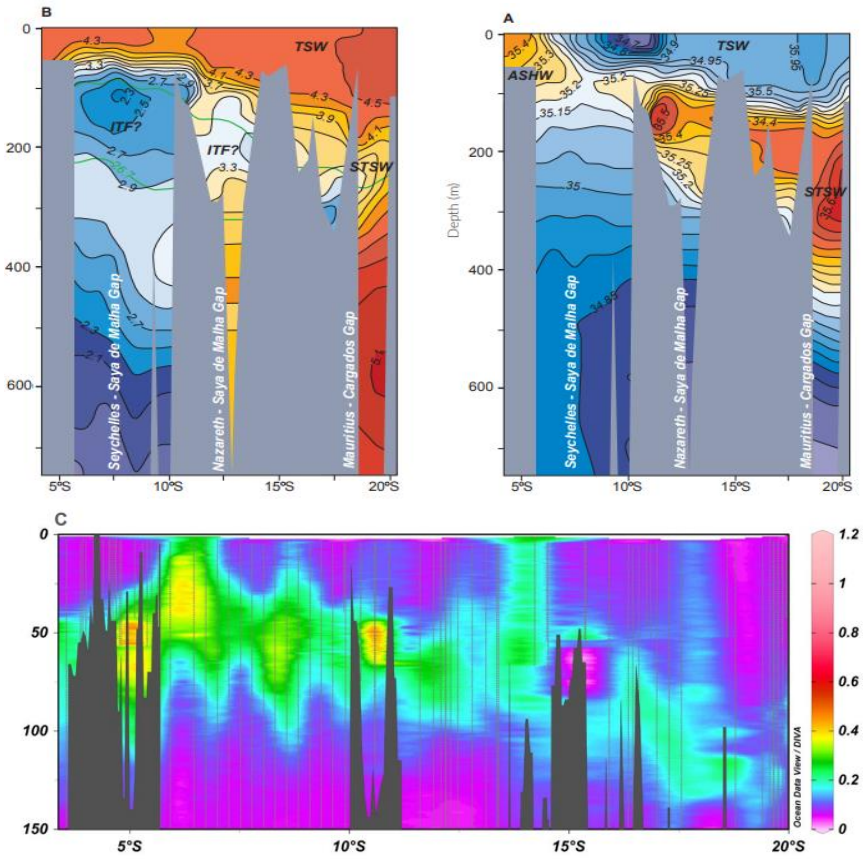


Figure 22. Section across the Mascarene Plateau, from 5-20 °S, showing (A) salinity, (B) oxygen and (C) chl-a (mg m^3) during Oct-Nov 2008 (Survey 2008407)

3.2 Oceanographic Data

As in any other marine regions, the biophysical conditions of Saya de Malha and the surrounding region play an important role in intra-annual and inter-annual patterns in the distribution of marine life and marine fisheries. Oceanographic data is there likely to be a key resource in the future management of Saya de Malha. The Seychelles Digital Ocean Atlas (SDOA) project (Marsac1 and Noel 2021) seeks to develop a database of oceanographic products (including may relevant products from the European Copernicus Database[13]) covering the EEZ of Seychelles and the neighbouring ocean regions (of which Saya de Malha is part), and make these products easily and freely accessible to users (including managers). The pilot phase of the SDOA project is due to be completed in the first quarter of 2022. Further development is dependent on securing additional funding. The outputs of this project will be highly valuable to the future management of Saya de Malha.

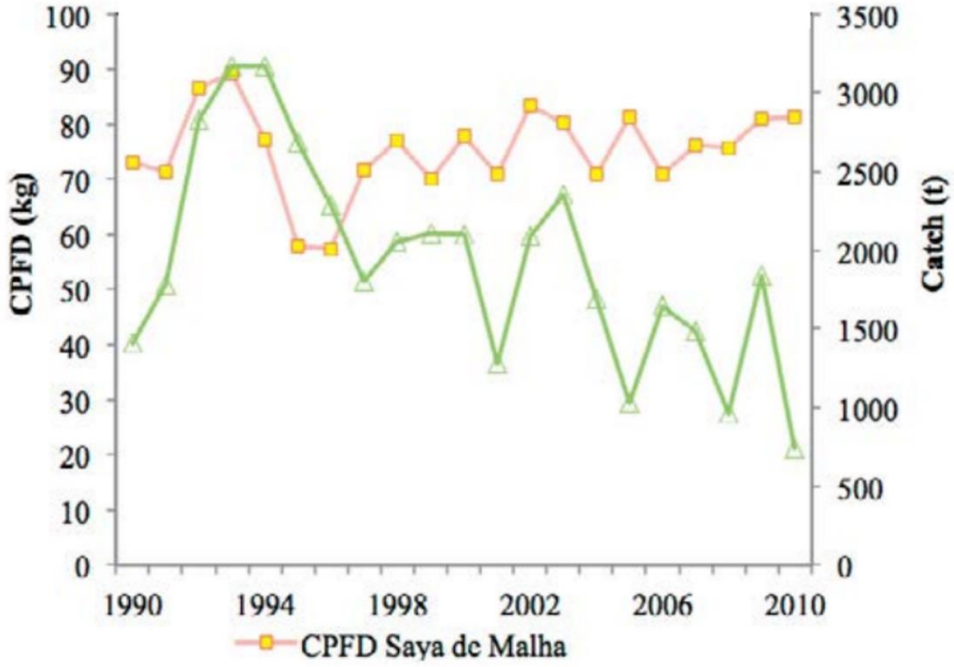
[13] https://www.copernicus.eu/en

3.3 Abundance information

Abundance related data, such as CPUE is only available for Thailand and Mauritius' fisheries; with the former available for 2020 only and the latter only available publicly up until 2011.

3.3.1 Mauritius

Fisheries CPUE data for Mauritius' fisheries (Figure 23) is reported as catch per fishermen days; made available by the Albion Fisheries Research Centre published in annual reports published by the Ministry of Fisheries. Data is available for years 1990-2011, inclusive; whereby values fluctuate between a maximum of 89.1 kg/fisher days recorded in 1993 and a minimum of 57.4 kg/fisher days in 1996.



Year	CPFD
1990	73.0
1991	71.4
1992	86.6
1993	89.1
1994	77.2
1995	57.8
1996	57.4
1997	71.8
1998	76.9
1999	70.1
2000	77.8
2001	71.0
2002	83.3
2003	80.1
2004	71.0
2005	81.2
2006	70.8
2007	76.1
2008	75.7
2009	81.1
2010	86.2
2011	77.3

Figure 23.Trends in catch (tonnes) and CPUE (kg/fishermen days) for the Saya de Malha Bank. Figure from Munbodh, 2014, x-axis represents year.

3.3.2 Thailand

Fisheries independent data for Thailand's fisheries is reported as CPUE (kg/hr) per gear type employed; made available through the submission of National reports to SIOFA. Data is available for 2020 only; where the average CPUE of otter board trawl was 476.92 kg/hr. The major species consisted of *Decapterus spp*., *Saurida spp*., *Nemipterus spp*., *Selar crumenophthalmus*, and *Sphyraena spp*. The CPUE of the referred species was 122.02, 68.47, 60.64, 52.75, and 34.71 kg/hr respectively. The average CPUE of handline was 2,852.59 kg/day. The major species consisted of *Carangoides spp*., *Lutjanus spp*., Serranidae, *Aprion virescens*, and *Lethrinus spp*. The CPUE was 2,570.76, 130.03, 83.13, 21.95, and 15.61 kg/day respectively.

3.4 Biological information

Direct assessments of the biology of species populations found on Saya de Malha are severely limited due, at least in part, to a lack of research focus on these fisheries. The only species with a direct assessment is the sky emperor *Lethrinus mahsena* (locally known as “dame berri”). *Lethrinus mahsena* is the primary target of the Mauritian Bank fisheries which operate on Saya de Malha, accounting for around 90 % of the catch (Munbodh 2014).

Lethrinus mahsena is a protogynic hermaphrodite displaying a relatively conservative life-history. The species begins as a female, maturing at around 3 years of age (Bertrand et al. 1986) with a 50 % fork length at first maturity of 19.8 cm on the Saya de Malha Bank (Soondron et al. 1999). Females undergo sex reversal at around 5-6 years, and so females with a fork length of > 35 cm and males with a fork length of < 20 cm are rare (Bertrand et al. 1986). Maximum age is estimated to be up to 27 years and maximum length thought to be around 65 cm (Grandcourt 2002). Female fecundity is between 26,700-166,200 eggs, with spawning thought to occur annually between October and February (Bertrand et al. 1986), peaking in December (Soondron et al. 1999). *Lethrinus mahsena* are found at depths of up to 100 m (Lieske & Myers 1994). It is a carnivorous fish, feeding primarily on crustaceans, echinoderms and fish. Molluscs, polychetes, and sponges are also consumed but in much lower volumes (Carpenter and Allen, 1989). *Lethrinus mahsena* is currently listed as Endangered on the IUCN Red List of Species (Al Abdali et al. 2019).

In order to make up for the lack of direct biological data collected for fishes on Saya de Malha we extracted biological data for the fisheries impacted species from global datasets (FishBase and IUCN Red List). Data were extracted for 131 of those species listed in Table 2 which were identifiable to species level (Table 12).

Table 12 List of species for which biological information was compiled

Common Name	Scientific Name	Common Name	Scientific Name
Starry triggerfish	*Abalistes stellaris*	Bigeye snapper	*Lutjanus lutjanus*
Bandfish	*Acanthocepola abbreviata*	Emperor red snapper	*Lutjanus sebae*
Elongate surgeonfish	*Acanthurus mata*	Softhead grenadier	*Malacocephalus laevis*
Redmouth grouper	*Aethaloperca rogaa*	Longhorned mobula	*Mobula eregoodootenkee*
Ocellated eagle ray	*Aetobatus ocellatus*	Pineconefish	*Monocentris japonica*
Ornate eagle ray	*Aetomylaeus vespertilio*	Bignose unicornfish	*Naso vlamingii*
Unicorn leatherjacket filefish	*Aluterus monoceros*	Tawny nurse shark	*Nebrius ferrugineus*
Scribbled leatherjac. filefish	*Aluterus scriptus*	Sicklefin lemon shark	*Negaprion acutidens*
Twobelt cardinal	*Apogonichthyoides taeniatus*	Delagoa threadfin bream	*Nemipterus bipunctatus*
Green jobfish	*Aprion virescens*	Slender threadfin bream	*Nemipterus zysron*
Titan triggerfish	*Balistoides viridescens*	Arabian pandora	*Pagellus affinis*
Ribbed tilefish	*Branchiostegus doliatus*	Cinnabar goatfish	*Parupeneus heptacanthus*
Bigfisted swimcrab	*Callinectes amnicola*	Longfin batfish	*Platax teira*
Spider-eye puffer	*Canthigaster amboinensis*	Squaretail coralgrouper	*Plectropomus areolatus*
Yellowspotted trevally	*Carangoides fulvoguttatus*	Blacksaddled coralgrouper	*Plectropomus laevis*

Common Name	Scientific Name	Common Name	Scientific Name
Bludger	*Carangoides gymnostethus*	Roving coralgrouper	*Plectropomus pessuliferus*
Malabar trevally	*Carangoides malabaricus*	Marbled coralgrouper	*Plectropomus punctatus*
Blacktip trevally	*Caranx heberi*	Striped eel catfish	*Plotosus lineatus*
Giant trevally	*Caranx ignobilis*	Threespot swimming crab	*Portunus sanguinolentus*
Black jack	*Caranx lugubris*	Paeony bulleye	*Priacanthus blochii*
Bigeye trevally	*Caranx sexfasciatus*	Moontail bullseye	*Priacanthus hamrur*
Grey reef shark	*Carcharhinus amblyrhynchos*	Red bigeye	*Priacanthus macracanthus*
Spinner shark	*Carcharhinus brevipinna*	Purple-spotted bigeye	*Priacanthus tayenus*
Blacktip reef shark	*Carcharhinus melanopterus*	Blue shark	*Prionace glauca*
Hooktooth shark	*Chaenogaleus macrostoma*	Japanese bigeye	*Pristigenys niphonia*
Santer seabream	*Cheimerius nufar*	Goldbanded jobfish	*Pristipomoides multidens*
Birdbeak burrfish	*Cyclichthys orbicularis*	Gulf damselfish	*Pristotis jerdoni*
Speckled tonguesole	*Cynoglossus puncticeps*	Banana fusilier	*Pterocaesio pisang*
Flying gurnard	*Dactyloptena gilberti*	Plaintail turkeyfish	*Pterois russelii*
Short-tail stingray	*Dasyatis brevicaudata*	Spanner crab	*Ranina ranina*
Redtail scad	*Decapterus kurroides*	Indian mackerel	*Rastrelliger kanagurta*
Mackerel scad	*Decapterus macarellus*	Bowmouth guitarfish	*Rhina ancylostoma*
Shortfin scad	*Decapterus macrosoma*	Smoothback guitarfish	*Rhinobatos lionotus*
Amberstripe scad	*Decapterus muroadsi*	Giant guitarfish	*Rhynchobatus djiddensis*
Indian scad	*Decapterus russelli*	Thorny flathead	*Rogadius pristiger*
Painted sweetlips	*Diagramma pictum*	Striped bonito	*Sarda orientalis*
Longspined porcupinefish	*Diodon holocanthus*	Redcoat	*Sargocentron rubrum*
Mottled fusilier	*Dipterygonotus balteatus*	Brushtooth lizardfish	*Saurida undosquamis*
Rainbow runner	*Elagatis bipinnulata*	Bigeye scad	*Selar crumenophthalmus*
Duskytail grouper	*Epinephelus bleekeri*	Greater amberjack	*Seriola dumerili*
Brownspotted grouper	*Epinephelus chlorostigma*	Blackbanded trevally	*Seriolina nigrofasciata*
Brown-marbled grouper	*Epinephelus fuscoguttatus*	Dusky spinefoot	*Siganus luridus*
Slender ponyfish	*Equulites elongatus*	Yellowtail barracuda	*Sphyraena flavicauda*
Hawksbill turtle	*Eretmochelys imbricata*	Bigeye barracuda	*Sphyraena forsteri*
Kawakawa	*Euthynnus affinis*	Pickhandle barracuda	*Sphyraena jello*
Red cornetfish	*Fistularia petimba*	Obtuse barracuda	*Sphyraena obtusata*
Tiger shark	*Galeocerdo cuvier*	Sawtooth barracuda	*Sphyraena putnamae*
Golden trevally	*Gnathanodon speciosus*	Scalloped hammerhead	*Sphyrna lewini*
Blue-lined large-eye bream	*Gymnocranius grandoculis*	Great hammerhead	*Sphyrna mokarran*

Common Name	Scientific Name	Common Name	Scientific Name
Dogtooth tuna	*Gymnosarda unicolor*	Ocellated angelshark	*Squatina tergocellatoides*
Batfish	*Halieutaea stellata*	Masked triggerfish	*Sufflamen fraenatum*
Titan cardinalfish	*Holapogon maximus*	Snakefish	*Synodus myops*
Lunartail puffer	*Lagocephalus lunaris*	Variegated lizardfish	*Synodus variegatus*
Silver-cheeked toadfish	*Lagocephalus sceleratus*	Round ribbontail ray	*Taeniura meyeni*
Scalybreast gurnard	*Lepidotrigla faurei*	Slipper lobster	*Thenus indicus*
Yellowtail emperor	*Lethrinus crocineus*	Flathead lobster	*Thenus orientalis*
Pink ear emperor	*Lethrinus lentjan*	Yellowfin tuna	*Thunnus albacares*
Smalltooth emperor	*Lethrinus microdon*	Variable torpedo ray	*Torpedo sinuspersici*
Spangled emperor	*Lethrinus nebulosus*	African scad	*Trachurus delagoa*
Longface emperor	*Lethrinus olivaceus*	Largehead hairtail	*Trichiurus lepturus*
Mitre squid	*Loligo chinensis*	Goldband goatfish	*Upeneus moluccensis*
Indian squid	*Loligo duvauceli*	Sulphur goatfish	*Upeneus sulphureus*
Sliteye shark	*Loxodon macrorhinus*	Yellowstriped goatfish	*Upeneus vittatus*
Bengal snapper	*Lutjanus bengalensis*	Yellow-edged lyretail	*Variola louti*
Two-spot red snapper	*Lutjanus bohar*	Sailfin velifer	*Velifer hypselopterus*
Humpback red snapper	*Lutjanus gibbus*		

The following characteristics were extracted, compiled and can be found in the database provided alongside this report (Supplemental Data 1):

General Information

- FAO species code (FAO_Code)
- Species' common name (SpeciesEnglishName)
- Species' subfamily (Subfamily)
- Species' scientific name (SpeciesScientificName)
- Stock geographic definition (StockDefsGeneral)

Commercial Information

- CITES appendix listing (CITES)
- CMS appendix listing (CMS)
- Commercial importance – nominal (Importance)
- Price/value category – nominal (PriceCategory)
- Reliability of price/value category – nominal (PriceReliability)

Distribution and Ecology

- Geographic zonation - nominal (EnvironmentalTemp)
- Found in freshwater? (Freshwater)
- Found in brackish water? (Brackish)
- Found in marine water? (Marine)
- Minimum distribution depth in meters (DepthMin_m)
- Maximum distribution depth in meters (DepthMax_m)
- Habitat categorisation (DemersalPelagic)
- Migratory categorisation (Migration)
- Estimated trophic level (Troph)

Life-history – size

- Body shape (BodyShape)
- Maximum length in centimetres (LengthMax_cm)
- Maximum length type i.e. fork length, total length etc. (LTypeMax)
- Maximum weight in grams (WeightMax_g)
- Length-weight equation values given the form $Weight = a \times Length^b$
    - Minimum estimated a value (aMin)
    - Maximum estimated a value (aMax)
    - Minimum estimated b value (bMin)
    - Maximum estimated b value (bMax)

Life-history - time

- Longevity in years (Longevity_Yrs)
- Estimated growth co-efficient K (K)

Life-history - reproduction

- Minimum estimated age at reproductive maturity (tmMin)
- Maximum estimated age at reproductive maturity (tmMax)
- Minimum estimated length at reproductive maturity (LmMin)
- Maximum estimated length at reproductive maturity (LmMax)
- Minimum estimated annual fecundity (FecMin)
- Maximum estimated annual fecundity (FecMax)

Status

- FishBase resilience category – nominal (ResilienceCategory)
- FishBase vulnerability index (Vulnerability)
- IUCN Red List code (IUCN_Code)
- IUCN Red List assessment date (IUCN_DateAssessed)

3.5 Resource analyses and management measures

3.5.1 Management

3.5.1.1 **SIOFA**

There is currently relatively little in the way of management implemented through SIOFA that is of specific relevance for fisheries on Saya de Malha. A series of general provisions exist which address:

- Standards for collection and reporting of fisheries data to SIOFA (CMM 2021/02[14])
- Combatting Illegal, Unreported and Unregulated (IUU) fishing via:
    - Identification of and cooperation on enforcement against vessels not operating under the flag of any state and thus engaging IUU fishing ((CMM 2016/04)[15]
    - Establishment and maintenance of an agreed IUU vessel list among the Contracting and non-Contracting Parties and participating fisheries entities (CMM 2018/06[16])
    - Establishment and maintenance of an authorised vessel list among the Contracting and non-Contracting Parties and participating fisheries entities (CMM 2019/07[17])
    - Port-based inspection of vessels conducting fisheries activities in the SIOFA area of remit (CMM 2020/08[18])
    - High-seas boarding and inspection of vessels conducting fisheries activities in the SIOFA area of remit (CMM 2021/14[19])
- Cooperation on the management and monitoring, control, compliance and surveillance of fisheries activities undertaken by vessels flagged under the Contracting and non-Contracting Parties and participating fisheries entities (CMM 2018/09[20], CMM 2019/10[21], and CMM 2020/11[22])
- Conservation of deep-sea sharks (CMM 2019/12[23])
- Conservation of seabirds in relation to demersal gears, including longlines, below 25°S (CMM 2019/13[24])
- Conservation and management measures for deep-sea demersal stocks including both target and bycatch (CMM 2021/15[25])

Of specific relevance to fishing operations on Saya de Malha are the management of bottom trawling activities (CMM 2021/01[26]). The agreed measure required that by 2020 and upon any

[14] https://www.apsoi.org/sites/default/files/documents/cmm/CMM%202021_02%20Data%20Standards_0.pdf
[15] https://www.apsoi.org/sites/default/files/documents/cmm/CMM%202016_04%20Vessels%20without%20Nationality%20%282016.10.18%29%20edited%202017.pdf
[16] https://www.apsoi.org/sites/default/files/documents/cmm/CMM%202018_06%20IUU%20Vessel%20List%20%282018.10.08%29.pdf
[17] https://www.apsoi.org/sites/default/files/documents/cmm/CMM%202019_07%20Vessel%20Authorisation.pdf
[18] https://www.apsoi.org/sites/default/files/documents/cmm/CMM%202020_08%20Port%20Inspection.pdf
[19] https://www.apsoi.org/sites/default/files/documents/cmm/CMM%202021_14%20High%20Sea%20Boarding%20and%20Inspection%20Procedures_0.pdf
[20] https://www.apsoi.org/sites/default/files/documents/cmm/CMM%202018_09%20Control.pdf
[21] https://www.apsoi.org/sites/default/files/documents/cmm/CMM%202019_10%20Monitoring.pdf
[22] https://www.apsoi.org/sites/default/files/documents/cmm/CMM%202020_11%20Compliance%20Monitoring%20Scheme_0.pdf
[23] https://www.apsoi.org/sites/default/files/documents/cmm/CMM%202019_12%20Sharks_0.pdf
[24] https://www.apsoi.org/sites/default/files/documents/cmm/CMM%202019_13%20Mitigation%20of%20seabirds%20bycatch_0.pdf
[25] https://www.apsoi.org/sites/default/files/documents/cmm/CMM%202021_15%20Management%20of%20Demersal%20Stocks_1.pdf
[26] https://www.apsoi.org/sites/default/files/documents/cmm/CMM%202020_01%20Interim%20Bottom%20Fishing%20Measures_0.pdf

major changes in the fisheries thereafter the Scientific Committee develop and provide advice on 1) a SIOFA Bottom Fishing Impact Assessment; 2) maps of VME in the SIOFA area; 3) a protocol for provision of protected areas; and 4) definitions for encounters and associated threshold levels for VMEs – all of which could be considered relevant to the bottom fisheries (Thailand) operating on Saya de Malha. Additionally, CMM 2021/01 requires that Contracting and non-Contracting Parties and participating fisheries entities 1) limit bottom trawl fisheries effort to levels in line with the average across previous years; 2) constrain the spatial extents of their bottom trawl fisheries; and 3) minimise their impact on VMEs until such time as agreements or alterations are set by the Meetings of the Parties. The measure sets out a threshold of 60 kg of coral or 300 kg of sponges in a given tow above which remedial action must be taken through the relocation of fishing activity away from the area. Encounters with VMEs must be reported to the SIOFA Secretariat.

CMM 2019/12 (sharks), CMM 2019/13 (seabirds), and CMM 2021/15 ([demersal] stock management) are not currently relevant to fisheries on or around Saya de Malha. However, these existing management measures could be used as a foundation for management of fisheries operating on bank areas like Saya de Malha if desired, or their existing remit expanded to encapsulate shallow water species and/or shallow water areas within SIOFAs remit. Further, where CMM 2021/01 (bottom trawl management) does not currently address shallow water species/areas (e.g., stock status assessment for target and where possible bycatch species) similar requirements could be considered.

3.5.1.2 **Mauritius**

Mauritius has enacted a series of management measures for its fisheries on te Saya de Malha, in addition to those management measures mandated through its contracting party status in SIOFA. No formal management plan appears to be in place, or at least does not appear to be publicly available, though developing one has been discussed on several occasions. Regardless Mauritius does undertake a number of management measures for these fisheries.

The management of the Mauritian Bank fishery covers both Saya de Malha and the Nazareth Bank simultaneously and does not discriminate between them. Since 1992 Mauritian Banks fisheries have required vessel licences (Munbodh 2014), with licences used in part as an indirect restriction on fishing effort. Despite restrictions, extraction of *Lethrinus mahsena* from the banks was beyond sustainable levels and so a catch quota (not species specific) was brought in to force in 1994. The total allowable catch was gradually reduced and is believed to have been brought into line with MSY from 1999 onwards (Munbodh 2014). Since 1995 quotas have been assigned on a company-by-company basis and are transferrable. Additionally, Mauritius regulates gear specifications, hooks must have gap sizes of > 5 mm, traps must have mesh sizes > 4 cm and trawl usage is restricted (Munbodh 2014). A minimum landing size of 30 cm is also in place for *Lethrinus mahsena* (Munbodh 2014), meaning that landings of immature animals (maturity is reached at 19.8 cm (Soondron et al. 1999)) is completely prohibited.

3.5.2 Resource

Ongoing assessments for *Lethrinus mahsena* across both Saya de Malha and the Nazareth Bank have been carried out by Mauritius since 1989 (Sanders 1989). Over the period the Maximum Sustainable Yield (MSY) has remained relatively consistent. MSY was estimated at 4,167 tonnes in 1989 using the Thompson and Bell model (Sanders 1989); at 3,780 tonnes based on a yield estimate of 168 kg/km^2 annually using catch per unit area data (Mees, 1992); and at 3,974 and 4,150 tonnes in 2005 using the Shaeffer's model and using surplus production dynamic biomass models and length frequency data, respectively (Dharmendra and Solmundsson 2005). On the basis of these MSY estimates *Lethrinus mahsena* were

overexploited in the early 1990's (93-95) but, at least up until 2010, have been exploited at or under MSY and thus are likely in a good state (Munbodh 2014). This is consistent with the stability of the CPUE reported for the handline fishery between 1990-2007 (Figure 23, Munbodh 2014). However, these CPUE's could be misleading and qualification is required. The patchy nature of the habitat for demersal species taken by the Mauritian Banks fisheries means that sequential fishing can occur, maintaining CPUE but with local depletions (MRAG 1996). Consequently, good spatial data is required in addition to CPUE data in order to monitor the status of these fisheries with greater certainty.

Historical assessments have also been carried out for crimson jobfish *Pristipomoides filamentosus* on the northwestern promontory of Saya de Malha. Undertaken by the Seychelles in 1993, the assessments indicate that localised stocks are susceptible to overfishing from intensive mothership/dory line fisheries, historically practiced by both the Seychelles and Mauritius (Grandcourt 1994, Munbodh 2014). Over the source of a 13-day fishing operation in 1993 mothership/dory line fishing on the north western promontory of Saya de Malha is estimated to have harvested more than three times the maximum sustainable yield of *Pristipomoides filamentosus* in the area (Grandcourt 1994). This is a clear demonstration of the potential impacts the ongoing line fisheries could have on unmanaged stocks on Saya de Malha if improperly managed and therefore the importance of engagement of SIOFA with Mauritius in particular because of its ongoing fisheries on Saya de Malha.

4 Conclusions

Saya de Malha is the largest submerged ocean bank in the world covering an area of approximately 41,000 km^2. Saya de Malha is a highly productive ecosystem thought to contain among the most extensive seagrass areas in the world, interspersed with small coral reefs. As such, Saya de Malha is likely an important biodiversity hotspot which may be highly sensitive to the impacts of fishing. Conversely, if fished in a sustainable manner the area could be a valuable source of seafood and resultant food, nutritional, and economic security for fishers and consumers.

Saya de Malha sits within the remit of the SIOFA. At present the fisheries exploiting Saya de Malha are poorly understood. Thailand and Mauritius, both of which are Contracting Parties to SIOFA, are likely the most important fishing nations. The Comoros also actively fishes on Saya del Malha but at a much lower intensity. At present only Thailand and the Comoros reports their catches and associated data to SIOFA. Through use of GFW and unpublished data held MRAG this report also demonstrates that Sri Lanka, and to a much lesser extent and more sporadically, India have flagged vessels which operate on Saya de Malha. SIOFA are not presently engaged with Sri Lanka nor India. Other nations with recent fishing operations on or near Saya de Malha include: China, Chinese Taipei, Japan, Korea, Malaysia, and the Seychelles. Most of these fisheries are likely for tuna and tuna-like species but their presence over or directly parallel to the bank may impact SIOFA-relevant species and therefore should be taken into consideration. To build a more complete understanding the fisheries of Saya de Malha, upon which appropriate management decisions can be based, SIOFA should prioritise actions which facilitate data exchange and fishing management cooperation with Mauritius and Sri Lanka. Cooperation with India should also be sought pre-emptively on the basis that their fishing on the Saya de Malha may increase in the coming years.

Given the limited understanding of fisheries on Saya de Malha it is unsurprising that there is also limited data and information on the status of target catch, by-product, bycatch (including VME species) in these fisheries. Abundance related data, such as CPUE is only available for Thailand and Mauritius' fisheries, with the former available for 2020 only and the latter only available publicly up until 2011. CPUE data is a vital first step in understanding the health of Saya de Malha's fisheries and continued reporting from Thailand will be key to management in the short term. However, a reliance on CPUE from Thailand's fisheries data in isolation will severely restrict the ability of SIOFA to sustainably manage these fisheries. Gaining access to contemporary CPUE information from other Contracting Parties (Mauritius), cooperating Non-Contracting Parties (the Comoros), and parties which are currently not cooperating with SIOFA (Sri Lanka, India) is also critical. Failing this, SIOFA may need to consider fisheries independent approaches to monitoring stock and ecosystem health for the purposes of fisheries management.

Biological information for species on Saya de Malha is similarly restricted. As the main target species of the Mauritian Banks fishery, sky emperors (*Lethrinus mahsena*) have received some attention, with studies addressing various aspects the species' growth and reproduction. However, some 131 species have been reported to SIOFA from the catches thus far. Whilst research which specifically addresses the biological characteristics of species populations on Saya de Malha would be beneficial this is likely to be both time intensive and costly. A careful risk-based prioritisation of species for such assessments will be important and should take into consideration 1) species' resilience to fisheries, 2) their commercial importance and the associated economic incentive to overfish, and 3) the current level of exploitation whether that be as target, by-product, or bycatch. In the meantime, the biological data provided in this scoping study, compiled for these same species from other parts of their distributional range, should provide a suitable foundation for species and fisheries management on Saya de Malha.

There are currently no SIOFA management measures that are specific to the fisheries on Saya de Malha, though a number of general measures are of relevance. Aspects of existing measures such as CMM 2019/12 (sharks), CMM 2019/13 (seabirds), CMM 2021/15 ([demersal] stock management), and elements of CMM 2021/01 (bottom trawl management) which are currently not applied to shallow water species or areas could provide a foundation for development of management measures specific to shallow water banks within SIOFAs remit if wishes by the Parties. Beyond the SIOFA management measures Mauritius is known to apply a quota-based systems with a Total Allowable Catch based on estimated Maximum Sustainable Yield. The Mauritian Bank fisheries are highly selective (80-90 % of catch is made up of a single target species) and historically this approach seems to have been effective, facilitating a seemingly consistent CPUE for target species at least until 2011.

This scoping study has outlined the current state of knowledge with regards to fisheries on Saya de Malha and the species impacted by them. The study demonstrates a clear need for SIOFA to foster engagement and improve cooperation between itself and the key contracting and non-contracting parties of Mauritius, Comoros, Sri Lanka and India where possible. Specific efforts should be made to improve the understanding of key elements (gear use, target species, fishing effort, and CPUE) of the ongoing fisheries operations on Saya de Malha. This improved understanding will be critical in underpinning informed decision making around the of management of Saya de Malha and the formulation of effective management actions. Additionally, research on biological information for Saya de Malha species populations should also be considered but is of lower priority given the availability of biological parameters from other areas in their distributional ranges.

5 References

Al Abdali, F.S.H., *et al.* 2019. *Lethrinus mahsena*. The IUCN Red List of Threatened Species 2019.

Albion Fisheries Research Centre (AFRC). 2003-2012. Annual Reports. Ministry of Fisheries, Mauritius.

Ardilll, J.D. 1986. Current status of fisheries in Mauritius. FAO/SWIOP Document, OISO RAF/79/065/WP/37/87/E, 30p.

Bertrand, J. *et al.* 1986. Pour une évaluation des ressources en capitaine/dame berri (Lethrinus mahsena) des bancs de Saya de Malha. Rapport du Groupe de Travail. IFREMER/Albion Fisheries Research Centre (Mauritius), 23−25 juillet, 1985. 39 pp.

Birkett, L. 1979. Technical Report Indian Ocean Programme, (26):97 P• Western Indian Ocean fishery resources survey. Report on the cruises of R/V Professor Mesyatsev, December 1975 - June 1976/July 1977 - December 1977

Boistol, L. *et al*. 2011. Reconstruction of marine fisheries catches for Mauritius and its outer islands, 1950-2008. pp. 39-61. In: Harper, S. and Zeller, D. (eds.) Fisheries catch reconstructions: Islands, Part II. Fisheries Centre Research Reports 19(4).

Carpenter, K.E. and Allen, G.R. 1989. FAO species catalogue. Emperor fishes and large-eye breams of the world (family Lethrinidae). An annotated and illustrated catalogue of lethrinid species known to date. FAO, Rome.

Dharmendra and Solmundsson. 2005. Stock assessment of the offshore Mauritian Banks using dynamic biomass models and analysis of length frequency of the sky emperor (*Lethrinus mahsena*)

Grandcourt, E.M, 1994. Biomass, stock density and the maximum sustainable yield available to a line fishery for *Pristipomoides filamentosus* (Valenciennes, 1830) on the Northwestern submarine promontory of Saya de Malha Bank

Grandcourt, E.M. 2002. Demographic characteristics of a selection of exploited reef fish from the Seychelles: preliminary study.

Groeneveld, J.C. & Koranteng, K.A. (Eds). 2017. The RV Dr Fridtjof Nansen in the Western Indian Ocean: Voyages of marine research and capacity development. FAO. Rome, Italy

Hilbertz, W. 2002. Saya del Malha Expedition. 107pp

Lieske, E. and Myers, R. 1994. Collins Pocket Guide. Coral reef fishes. Indo-Pacific and Caribbean including the Red Sea.

Marsac, F. and Noel, E. (2021) Development of an online ocean digital atlas for the Seychelles EEZ and neighbouring ocean regions. IOTC-2021-WPDCS17-22.

Mees, C.C. 1992. Seychelles demersal fishery-an analysis of data relating to four key demersal species: *Pristipomoides filamentosus*, *Lutjanus sebae*, *Aprion virescens*, *Epinephelus chlorostigma*. SFA/R&D/019. Seychelles Fishing Authority, Victoria: p. 43.

MRAG (1996) The Mauritian banks fishery - a review, and spatial analysis. Technical report. Albion Fisheries Research Centre (Mauritius) and Marine Resources Assessment Group (MRAG, UK). *https://mrag.co.uk/sites/default/files/fmspdocs/R5484/R5484_Rep2.pdf*

Munbodh M. 2014. An EAF baseline report for the fisheries of shallow water demersal fish species of the Saya de Malha and Nazareth banks of Mauritius. In: Koranteng L.A., Vasconcellos M.C., Satia B.P. (Eds.). Baseline Reports – Preparation of Management Plans for Selected Fisheries in Africa: Ghana, Kenya, Liberia, Mauritius, Mozambique, Nigeria, Seychelles, Sierra Leone and Tanzania. FAO EAF-Nansen Project Report No. 23 (EAF-N/PR/23), Food and Agriculture Organization of the United Nations, Rome, pp. 118-154

Samboo, C. R. 1983. An appraisal of the banks fishery in Mauritius. Report No 1, p. 17.

Samboo, C.R. 1987. A preliminary review of the artisanal and banks fisheries of Mauritius. Albion Fisheries Research Centre. RD (F)/SU/87/2

Samboo, C.R. 1989. A reappraisal of the banks fishery in Mauritius. In SWIOP/MAFNR Proceedings of the seminar on the management of the banks handline fishery. FAO/UNDP: RAF/87/008/52/89/E: 13-30.

Sanders, M.J. 1989. An assessment of exploitation levels in the Banks handline fishery and a management plan to improve the fishery performance. In SWIOP/MAFNR. Proceedings of the seminar on the management of the banks handline fishery. FAO/UNDP: RAF/87/008/WP/52/89/E: 42-53 https://www.fao.org/fishery/docs/CDrom/aquaculture/a0845t/volume2/docrep/field/313229.htm#TopOfPage

Soondron, S.; Venkatasamy, A. & Mamode, S.A. 1999. Some results on the sexual maturity of *Lethrinus mahsena* from the Saya de Malha Bank, AFRC. In: Proceedings of the Annual Meeting of Agricultural Scientists, Mauritius. 150 pp.

Strømme, T., Ansorge, I., Bornman, T., Kaehler, S., Ostrowski, M., Tweddle, D. & Alvheim, O. 2009. 2008 ASCLME Survey No. 3. Cruise report No 7/2008. 8 October–27 November 2008. Report No. EAF-N2008/7. Bergen, Norway, Institute of Marine Research

Wheeler, J. F. G. & Ommanney, F. D. P. (1953). Report on the Mauritius - Seychelles Fisheries Survey 1948 - 49. Colonial Office Fishery Publication. His Majesty's Stationery Offices, 145 p.

Wijkstrom, U. N. and Kroepelien N, T. (1979). Revitalization of the Mauritian Bank Fishery: An Appraisal. FAO, Rome. IOP/Tech/79/35,56 p.