

# Pelagic and demersal fish diversity of the Saya de Malha and Nazareth Banks, Mascarene Plateau

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## Abstract

The Saya de Malha (SMB) and Nazareth Banks (NB) are the main offshore locations where fishing activities are carried out by the Republic of Mauritius, targeting mainly shallow water Lethrinids, deep-water snappers and groupers. A multi-disciplinary survey was carried out on the two banks in May 2018 on-board the R/V Dr. Fridtjof Nansen with the objective of studying the diversity of fish on both banks using pelagic trawls, bottom trawls, basket traps and video using a Remotely Operated Vehicle (ROV). Analysis of data showed that the main fish family recorded in the pelagic waters of SMB, using pelagic trawl, was Myctophidae while the bottom trawls on NB showed the presence of fishes from the families Gobiidae, Triglidae and Synodontidae, mainly at depths between 200 and 300 m. The ROV video analysis highlighted principally the presence of demersal fishes of the family Lethrinidae and other reef-associated and commercial families recorded between 20 and 50 m. The main catch from the basket traps set at the SMB was *Lethrinus mahsena*, caught at a depth of 21 m. While previous studies focussed mainly on commercial fishes, this study brings forth new information on other fish families, contributing to the knowledge of the fish community that exists at these two banks.

**Keywords:** fish diversity, Saya de Malha Bank, Nazareth Bank, trawls, VAMS, basket traps

## Introduction

The Republic of Mauritius, being a coastal state, has an Exclusive Economic Zone (EEZ) that extends from the islands of Mauritius, Rodrigues, Cargados Carajos Shoals, Agalega, Tromelin and Chagos Archipelago (United Nations, 1993), covering a total surface area of 2.3 million km<sup>2</sup>. In March 2011, the United Nations Commission on the limits of the Continental Shelf conferred upon the Republic of Mauritius and the Republic of Seychelles an extended continental shelf, of area 396,000 km<sup>2</sup>, also known as the Mauritius-Seychelles Joint Management Area (United Nations, 2018a, 2018b). The Saya de Malha Bank (SMB) and the

Nazareth Bank (NB) are situated some 650 km and 1050 km from Mauritius island, respectively (Samboo and Mauree, 1987). NB is characterised by a shallow central part of about 50-60m deep with a sandy bottom, and surrounded by a sloping rim to around 150 m followed by an abrupt outer slope (Mees, 1996), while SMB consists of narrow shoals (depths range between 17 to 29 m on the rim) and slopes on all side of the bank (New *et al.*, 2013).

Fishery resource exploitation in the shallow waters of the SMB and NB occurs mainly from industrial refrigerated vessels (length range of vessel: 35-50 m) and

semi-industrial boats (length range of boats: 13-24 m) at depths of around 20-50 m (Ministry of Fisheries and Rodrigues, 2011). In 2018, there were four active industrial fishing vessels and 23 active semi-industrial fishing boats operating on both banks (AFRC, 2018; unpublished data). About 90% of the fish catch from the shallow waters of the banks comprises of the sky emperor *Lethrinus mahsena* (Forsskal, 1775), while the rest consists mainly of other shallow water demersal fishes such as Serranids and other Lethrinids (Sambou, 1983; Sambou and Mauree, 1987; Mees, 1996, Degambur and Sólmundsson, 2005; Munbodh, 2012). Fishing activities are also carried out on the slopes of the banks, targeting mainly deep-water snappers and groupers, at a depth of 150 to 300 m (Degambur and Korsbrekke, 2011).

Marine survey expeditions have been carried out in the past mainly by the Russians to investigate the fishery resources and the oceanography aspects of the SMB during the 1960s and 1970s (Vortsepneva, 2008), while limited attention has been given to the NB. One such survey was carried out between 1975 and 1977 on-board the Research Vessel Professor Mesyatsev by the Food and Agriculture Organization (FAO) and the Ministry of Fisheries of the Soviet Union to investigate the pelagic and demersal fish resources on SMB and NB, (Birkett, 1979). The main pelagic species encountered on SMB during the survey were species of Carangidae including *Decapterus kiliche* (Cuvier, 1833), *Decapterus macarellus* (Cuvier, 1833) and *Trachurus indicus* Nekrasov, 1966. The main demersal species included *Etelis carbunculus* Cuvier, 1828 (Lutjanidae) from NB, and *Polysteganus* spp (Sparidae), *Saurida undosquamis* (Richardson, 1848), and *Nemipterus* spp.

In Vortsepneva's (2008) review of the Russian expeditions on SMB, the presence of ten families of fish were recorded from 10 to 1300 m depth; namely Carangidae, Trachichthyidae, Lethrinidae, Stromateoidei, Synodontidae, Nemipteridae, Sparidae, Chlorophthalmidae, Macrouridae and Chimaeridae. A British survey, the Percy Sladen Trust Expedition, was carried out in the Indian Ocean in 1905, and according to the report by Regan (1908), resulted in the description of 10 new fish species from the SMB, from families Macrouridae (described as Macruridae in the report), Oreosomatidae (described as Cyttidae in the report), Bothidae and Cynoglossidae (described as Pleuronectidae in the report), Synanceiidae (described as Scorpaenidae in the report), Hoplichthyidae, Triglidae, Ogcocephalidae (described as Malthidae in the report) and Tetraodontidae (described as Tetrodontidae in the report).

In 2006, through the Technical Cooperation Programme between the Government of Mauritius and the FAO, an acoustic survey was carried out on the slopes of St Brandon and Nazareth Bank. The aims of the survey programme were to determine the presence of deep-water demersal fishery resources, and the abundance and productivity of the resources (Boyer *et al.*, 2006). The survey highlighted the presence of snappers and groupers, namely *Polysteganus baissaci* Smith 1978, *Etelis coruscans* Valenciennes, 1862, *Pristipomoides argyrogrammicus* (Valenciennes, 1832), *Pristipomoides auricilla* (Jordan, Evermann and Tanaka, 1927) and *Epinephelus morrhua* (Valenciennes, 1833). The results of the above surveys led to the regular exploitation of the deep-water resources at St Brandon and on the NB.

Most of the research carried out on fish diversity is dated and mainly limited to commercial fishery resources, while little is known about diversity of other fishes and their occurrence within these two banks. An expedition was carried out on-board the R/V Dr Fridtjof Nansen in May 2018, focusing on the regional resources and ecosystems of the Indian Ocean, with the main objective of characterizing the ecosystems and morphology of the SMB and NB (Bergstad *et al.*, 2018). This study is focussed on the pelagic and demersal fish diversity of the SMB and NB. While previous studies on fishery resources used bottom trawls as the main sampling method, this study brings forth additional data using four different sampling methods to determine diversity and occurrence at both banks.

## Materials and methods

### Study sites

The SMB and NB are both part of the Mascarene Plateau with the SMB being the larger bank with an area of approximately 40,000 km<sup>2</sup>. The SMB is composed of two structures; the main Saya the Malha Bank in the south and the smaller bank in the north, also known as the Ritchie Bank. Data on fish was collected using the four methods of pelagic trawls, bottom trawls, basket traps and underwater video footage using a Video-Assisted Multi Sampler (VAMS) attached to a Remotely Operated Vehicle (ROV). Pelagic trawls were carried out at 10 stations at the SMB; namely PTS 1, PTS 2, PTS 3, PTS 4, PTS 5, PTS 6, PTS 7, PTS 8, PTS 9 and PTS 10, and two stations at NB; namely PTS 11 and PTS 12. Four bottom trawls were carried out at the NB only (BTS 1, BTS 2, BTS 3 and BTS 4). Basket traps were deployed at two stations at SMB; BT 1 and BT 2. Video seafloor exploration by the ROV in depths from

23-50 m was carried out at 10 predetermined stations on SMB; SS 4, SS 9, SS 13, SS 34, SS 36, SS 37, SS 38, SS 39, SS 40 and SS 42. (Table 1 and Fig. 1). Being large stations, SS 36, SS 37 and SS 39 were subdivided into SS 36-1, SS 36-2, SS 37-1, SS 37-2, SS 39-1, SS 39-2, SS 39-3 and SS 39-4, respectively.

mounted in a drop keel. The raw data from the EK80 was primarily obtained from the 38 kHz transducer and was treated with the KORONA software to reduce noise influence. Trawls were deployed to collect fish samples to identify scattering layers observed on echograms from the EK80 multi-frequency echo-

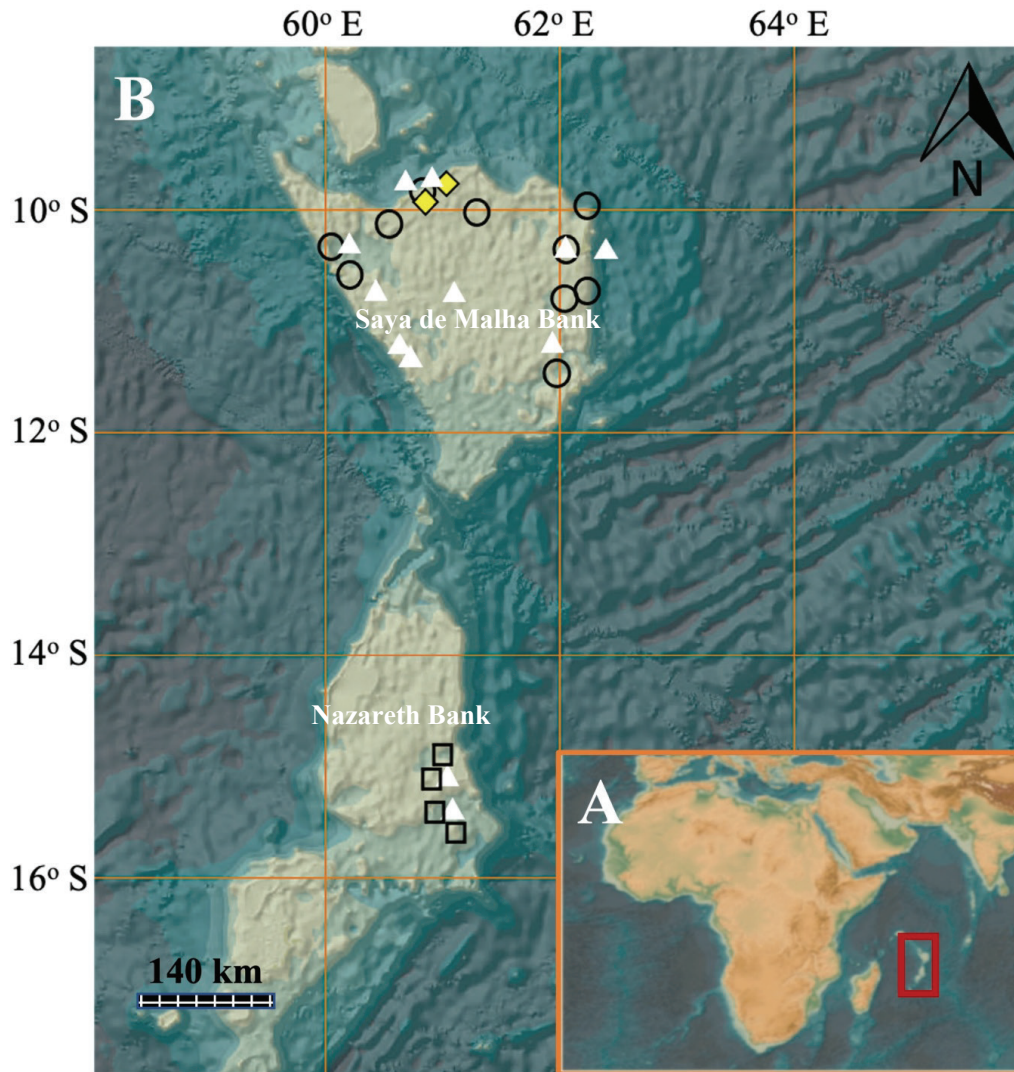


Figure 1. Map showing locations of stations for fish data collection from pelagic trawls (defined by  $\Delta$ ), bottom trawls (defined by  $\square$ ), basket traps (defined by  $\diamond$ ) and video ROV (defined by  $\circ$ ) from the Saya de Malha (SMB) and Nazareth Banks (NB). A: Western Indian Ocean map showing locations of Saya de Malha and Nazareth Banks within the red outlined rectangle. B: Map showing the 12 stations for pelagic trawls, four stations for bottom trawls, two stations for basket traps and the ROV stations. The map was generated using GEBCO Bathymetry Grid layer data 2020.

## Sampling and identification

### Pelagic and bottom trawling

The instrument used for observing sound-scatters within the water column was a single-beam multi-frequency sounder, namely the SIMRAD EK80 Scientific Split Beam Echo Sounders with 6 different transducers (18, 38, 70, 120, 200 and 333 kHz)

sounder and were carried out on an ad-hoc basis due to scarcity of indications from echograms. Each trawl catch was first sorted to the lowest possible taxonomic level, and numbers and bulk weight of each taxon recorded. When the sorted catches were large, a sample of the catch was weighed and the number of specimens in the taxon recorded. This was then

**Table 1.** Station details for the pelagic trawls (PTS), bottom trawls (BTS), basket traps (BT) and Video (VAMS: Video-Assisted Multi Sampler) at Saya de Malha Bank (SMB) and Nazareth Bank (NB).

| Bank                | Fish Data Collection Method | Station    | Latitude   | Longitude |
|---------------------|-----------------------------|------------|------------|-----------|
| Saya de Malha (SMB) | Pelagic trawl               | PTS 1      | -10.7645   | 60.439667 |
|                     | Pelagic trawl               | PTS 2      | -10.766333 | 61.086667 |
|                     | Pelagic trawl               | PTS 3      | -11.216167 | 60.583667 |
|                     | Pelagic trawl               | PTS 4      | -11.202667 | 60.507833 |
|                     | Pelagic trawl               | PTS 5      | -10.422333 | 60.3475   |
|                     | Pelagic trawl               | PTS 6      | -9.7503333 | 60.659333 |
|                     | Pelagic trawl               | PTS 7      | -9.7955    | 60.825667 |
|                     | Pelagic trawl               | PTS 8      | -10.383833 | 62.4235   |
|                     | Pelagic trawl               | PTS 9      | -10.384167 | 62.0065   |
|                     | Pelagic trawl               | PTS 10     | -11.091    | 61.677167 |
|                     | Basket Trap                 | BT 1       | -9.8771667 | 60.797333 |
|                     | Basket Trap                 | BT 2       | -9.8245    | 60.918167 |
|                     | VAMS                        | SS 4       | -10.113192 | 60.575226 |
|                     | VAMS                        | SS 9       | -10.427421 | 60.140288 |
|                     | VAMS                        | SS 13      | -10.732368 | 62.130394 |
|                     | VAMS                        | SS 34      | -10.625219 | 60.199550 |
|                     | VAMS                        | SS 36-1    | -9.831724  | 60.762377 |
|                     | VAMS                        | SS 36-2    | -9.859240  | 60.791336 |
|                     | VAMS                        | SS 37-1    | -10.094556 | 61.221217 |
|                     | VAMS                        | SS 37-2    | -10.092485 | 61.242757 |
|                     | VAMS                        | SS 38      | -10.062541 | 62.183355 |
|                     | VAMS                        | SS 39-1    | -10.382314 | 62.078151 |
|                     | VAMS                        | SS 39-2    | -10.381302 | 62.093671 |
|                     | VAMS                        | SS 39-3    | -10.379792 | 62.123875 |
|                     | VAMS                        | SS 39-4    | -10.377526 | 62.204940 |
|                     | VAMS                        | SS 40      | -10.736205 | 61.945050 |
| VAMS                | SS 42                       | -11.676877 | 61.948717  |           |
| Nazareth (NB)       | Pelagic Trawl               | PTS 11     | -15.243833 | 61.0465   |
|                     | Pelagic Trawl               | PTS 12     | -15.491833 | 61.0215   |
|                     | Bottom Trawl                | BTS 1      | -15.1835   | 61.146    |
|                     | Bottom Trawl                | BTS 2      | -15.348    | 61.023833 |
|                     | Bottom Trawl                | BTS 3      | -15.508167 | 61.030667 |
|                     | Bottom Trawl                | BTS 4      | -15.665333 | 61.018    |

extrapolated to obtain the estimated number (N) of individuals caught using the formula below:

$$N_i = \frac{W_i}{w_i} (n_i),$$

Where  $W_i$  is the total weight of the sorted species  $i$  obtained from the catch,  $w_i$  is the weight of the sample taken from species  $i$ , and  $n_i$  is the number of individuals obtained in the sample.

Preliminary identification of fish species was carried out through examination of morphometric and meristic characteristics using identification guides (e.g., FAO Identification sheets for fishery purposes:

Western Indian Ocean Fishing Area 51, Food and Agriculture Organization, 1984). Species were identified to the lowest taxon possible and data from each trawl were inputted in the NANSIS Survey Information System, with corresponding catches. The catch rate per hour was expressed as weight/hour (W/hr) and as number of individuals caught per hour (N/hr):

$$W/hr = \frac{W_i}{t_i} (60)$$

$$N/hr = \frac{N_i}{t_i} (60),$$

Where  $t$  is the duration of the trawling activity in minutes.



**Table 2.** Gear depths, catch rate (kg/hr) and number of families obtained from each pelagic trawl station (PTS) on the Saya de Malha Bank (SMB) and Nazareth Bank (NB).

| Bank                | Trawl Station No. | Gear Depth (m) | Weight (kg)/hour | No. of families identified |
|---------------------|-------------------|----------------|------------------|----------------------------|
| Saya de Malha (SMB) | PTS 1             | 10 - 60        | 2.1              | 10                         |
|                     | PTS 2             | 0 - 30         | 520.6            | 7                          |
|                     | PTS 3             | 0 - 5          | 38.9             | 10                         |
|                     | PTS 4             | 0              | 41.5             | 14                         |
|                     | PTS 5             | 0              | 74.4             | 8                          |
|                     | PTS 6             | 150 - 420      | 11.3             | 10                         |
|                     | PTS 7             | 0 - 6          | 89.9             | 8                          |
|                     | PTS 8             | 0              | 91.3             | 12                         |
|                     | PTS 9             | 0              | 5.2              | 8                          |
|                     | PTS 10            | 0              | 37.1             | 8                          |
| Nazareth (NB)       | PTS 11            | 0 - 10         | 0.5              | 2                          |
|                     | PTS 12            | 20 - 50        | 0.0              | 0                          |

### Basket traps

Bottom trawls were not allowed on the SMB. Attempts were therefore made to obtain data on demersal fish using different methods. A set of three collapsible traps were deployed at two stations in the shallow waters of SMB at 20 and 21 m deep within a seagrass and sandy bottom substrate. The set of traps were left for approximately six hours. The traps were then hauled and the catch was sorted and identified.

### Remotely Operated Vehicle (ROV) videos

Video data was collected with the ROV which was attached to a video-assisted multi sampler (VAMS). Two exploration modes were used to record videos of the bottom environments. In the first method, the ROV was deployed in four directions (North, South, East and West), each covering a distance of 15 m from the VAMS. In the second method, the VAMS was towed by the vessel along pre-determined paths, while the ROV recorded the bottom habitats along the transect. The video footages recorded at depths from 23 to 50 m on SMB were analysed and the fish specimens observed along the transects were identified to Family level and the maximum number of individuals encountered in a frame was calculated. Fish individuals that could not be identified was categorised as 'Unidentified'. The percentage composition of a given family (% F<sub>i</sub>) was calculated for each station as follows:

$$\% F_i = \frac{Nf_i}{N_{max}} \times 100$$

Where Nf<sub>i</sub> is the total number of individuals calculated for Family i; N<sub>max</sub> is the total number of fish encountered per Station.

## Results and discussion

### Pelagic fish

The catch rates from the pelagic trawls varied from 2 kg from PTS 1 to 520 kg from PTS 2. All trawls were carried out within depths of 0 to 60 m, except for PTS 6, where the trawl was done at a depth of 150 to 420 m. A total of 38 families were identified from the pelagic trawl catches. The station with the highest number of different families recorded was PTS 4, with 14 families; while the lowest was PTS 2, with seven families (Table 2). The main fish family encountered during the pelagic trawl surveys was Myctophidae which were recorded at five (PTS 3, PTS 4, PTS 6, PTS 8 and PTS 9) out of 10 stations. This family was obtained from 0 to 420 m deep and the species are characterised by the presence of photophores along the body. Samples from stations PTS 1 and PTS 5 consisted mainly of unidentified fish larvae, collected between the sea surface to 60 m. Diodontidae was found mainly at PTS 2 (10-30 m) with the main species identified as *Diodon holocanthus* Linnaeus, 1758. Juvenile fish were the main catch at PTS 9 and PTS 11 from 0 - 10 m. The PTS 10 catch consisted mainly of Carangids *Selar crumenophthalmus* (Bloch, 1793) and *Decapterus* sp., and Scombrid *Euthynnus affinis* (Cantor, 1849). No catch was obtained from station PTS 12 (20-50m) at the NB (Table 3). Most of the families identified during this study have also been recorded in the waters of Reunion Island (Durville *et al.*, 2009b; Durville *et al.*, 2021). The resource survey carried out by the R/V 'Professor Mesyatsev' from 1975 to 1977 on the SMB showed concentrations of *Decapterus kiliche*, *Trachurus indicus* (both Carangidae) and *Saurida undosquamis* (Synodontidae) which were detected by acoustic surveys and sampled using bottom trawls (Birkett, 1979). Both families

**Table 3.** Percentage composition of families of fish obtained from pelagic trawls (PT) on the Saya de Malha (SMB) and Nazareth Banks (NB). The main family identified from each station is highlighted in gray.

| Location                            | Saya de Malha Bank |               |              |            |            |                  |              |            |            |             | Nazareth Bank  |                 |
|-------------------------------------|--------------------|---------------|--------------|------------|------------|------------------|--------------|------------|------------|-------------|----------------|-----------------|
|                                     | PTS 1 (10-60m)     | PTS 2 (0-30m) | PTS 3 (0-5m) | PTS 4 (0m) | PTS 5 (0m) | PTS 6 (150-420m) | PTS 7 (0-6m) | PTS 8 (0m) | PTS 9 (0m) | PTS 10 (0m) | PTS 11 (0-10m) | PTS 12 (20-50m) |
| <b>Family</b>                       |                    |               |              |            |            |                  |              |            |            |             |                |                 |
| Acanthuridae                        | -                  | -             | -            | -          | -          | -                | -            | 0.3        | 65.2       | 9.5         | -              | -               |
| Alepocephalidae                     | -                  | -             | -            | -          | -          | 1.1              | -            | -          | -          | -           | -              | -               |
| Balistidae                          | -                  | -             | -            | <0.1       | -          | -                | 0.5          | -          | -          | -           | -              | -               |
| Barbourisiidae                      | -                  | -             | -            | <0.1       | -          | 0.2              | -            | -          | -          | -           | -              | -               |
| Belonidae                           | -                  | <0.1          | -            | -          | -          | -                | -            | -          | -          | -           | -              | -               |
| Bothidae                            | -                  | -             | -            | -          | -          | -                | -            | 0.5        | -          | -           | -              | -               |
| Bramidae                            | -                  | -             | -            | -          | -          | -                | -            | 0.1        | -          | -           | -              | -               |
| Bregmacerotidae                     | -                  | -             | 0.1          | -          | -          | -                | -            | -          | 0.8        | -           | -              | -               |
| Caesionidae                         | -                  | -             | 0.2          | -          | 4.2        | -                | -            | -          | -          | -           | -              | -               |
| Carangidae                          | 30.2               | 15.6          | 0.1          | <0.1       | 10.2       | -                | 0.6          | -          | 3.8        | 23.8        | -              | -               |
| Carcharhinidae                      | -                  | -             | -            | -          | -          | -                | -            | -          | -          | -           | 4.8            | -               |
| Champsodontidae                     | -                  | 0.1           | 10.5         | 0.1        | -          | -                | -            | -          | -          | -           | -              | -               |
| Cynoglossidae                       | 0.4                | -             | -            | -          | -          | -                | -            | -          | -          | -           | -              | -               |
| Dactylopteridae                     | 0.1                | -             | -            | -          | -          | -                | -            | -          | -          | -           | -              | -               |
| Diodontidae                         | <0.1               | 82.9          | 14.2         | 0.9        | 0.6        | -                | -            | -          | -          | -           | 9.5            | -               |
| Diretmidae                          | -                  | -             | -            | -          | -          | 2.0              | -            | -          | -          | -           | -              | -               |
| Echeneidae                          | -                  | -             | -            | -          | 0.1        | -                | -            | -          | 2.3        | 19.1        | -              | -               |
| Exocoetidae                         | -                  | -             | -            | -          | -          | -                | -            | -          | -          | 4.8         | -              | -               |
| Gempylidae                          | -                  | -             | -            | -          | -          | -                | 0.1          | 0.3        | -          | -           | -              | -               |
| Gonostomatidae                      | -                  | -             | -            | -          | -          | 5.7              | -            | -          | -          | -           | -              | -               |
| Hemiramphidae                       | -                  | -             | 0.1          | <0.1       | -          | -                | -            | 0.3        | 0.8        | -           | -              | -               |
| Holocentridae                       | -                  | -             | <0.1         | 0.1        | -          | -                | -            | -          | -          | -           | -              | -               |
| Melamphaidae                        | -                  | -             | -            | -          | -          | 2.7              | -            | -          | -          | -           | -              | -               |
| Mobulidae                           | -                  | -             | -            | -          | -          | -                | -            | -          | -          | 4.8         | -              | -               |
| Myctophidae                         | -                  | -             | 73.9         | 98.0       | -          | 63.0             | 82.6         | 84.7       | -          | -           | -              | -               |
| Nemichthyidae                       | -                  | -             | -            | -          | -          | 14.3             | -            | -          | -          | -           | -              | -               |
| Nomeidae                            | 0.6                | -             | -            | 0.6        | -          | 1.6              | -            | 4.2        | -          | -           | -              | -               |
| Ogcocephalidae                      | 0.1                | -             | -            | -          | -          | -                | -            | -          | -          | -           | -              | -               |
| Ophichthidae                        | 0.2                | -             | 0.1          | <0.1       | -          | -                | 4.9          | 8.2        | -          | -           | 5.4            | -               |
| Ostraciidae                         | -                  | -             | -            | -          | -          | -                | -            | 0.1        | 0.8        | -           | -              | -               |
| Paralepididae                       | -                  | -             | -            | 0.1        | -          | -                | 2.7          | -          | -          | -           | -              | -               |
| Scombridae                          | 0.2                | <0.1          | -            | <0.1       | 13.0       | -                | -            | 0.2        | -          | 23.8        | -              | -               |
| Sphyrnidae                          | -                  | -             | -            | <0.1       | 2.3        | -                | <0.1         | -          | 3.0        | -           | -              | -               |
| Sternoptychidae                     | -                  | -             | -            | -          | -          | 1.1              | -            | -          | -          | -           | -              | -               |
| Stomiidae                           | -                  | -             | -            | -          | -          | 8.4              | -            | -          | -          | -           | -              | -               |
| Synodontidae                        | 5.2                | 1.4           | 0.7          | <0.1       | 1.0        | -                | 8.3          | 0.8        | 12.9       | -           | -              | -               |
| Tetraodontidae                      | <0.1               | <0.1          | -            | -          | 0.1        | -                | -            | -          | -          | -           | 1.4            | -               |
| Zanclidae                           | -                  | -             | -            | -          | -          | -                | -            | 0.4        | -          | -           | -              | -               |
| Unidentified Fish Larvae            | 61.7               | -             | 0.2          | -          | 68.5       | -                | -            | -          | 9.9        | -           | -              | -               |
| Unidentified fish juvenile          | 1.1                | -             | -            | <0.1       | -          | -                | 0.30         | -          | 0.8        | -           | 93.2           | -               |
| Total No. of families identified    | 10                 | 7             | 10           | 14         | 8          | 10               | 8            | 12         | 8          | 8           | 2              | -               |
| Total No. of individuals caught /hr | 4684               | 13229         | 6664         | 24864      | 1435       | 559              | 2957         | 8554       | 132        | 21          | 74             | -               |

No catch

**Table 4.** Gear depths, catch rate (kg/hr) and number of families recorded from bottom trawls (BT) from the Nazareth Bank (NB).

| Bank          | Trawl Station No. | Gear Depth (m) | Weight (kg)/hour | No. of families recorded |
|---------------|-------------------|----------------|------------------|--------------------------|
| Nazareth (NB) | BTS 1             | 213-214        | 26.6             | 9                        |
|               | BTS 2             | 240-242        | 9.2              | 10                       |
|               | BTS 3             | 276-288        | 50.4             | 24                       |
|               | BTS 4             | 288-290        | 45.8             | 18                       |

**Table 5.** Percentage composition of families of fish obtained from bottom trawls on the Nazareth Bank (NB). The main family identified from each station is highlighted in gray.

| Location                            | Nazareth Bank (NB)   |                  |                  |                  |
|-------------------------------------|----------------------|------------------|------------------|------------------|
|                                     | Bottom Trawl Station |                  |                  |                  |
| Family                              | BTS 1 (213-214m)     | BTS 2 (240-242m) | BTS 3 (276-288m) | BTS 4 (288-290m) |
| Ariommatidae                        | -                    | -                | -                | 0.3              |
| Bothidae                            | 4.8                  | -                | 0.6              | 0.3              |
| Caproidae                           | 2.4                  | -                | 12.046           | 1.5              |
| Carangidae                          | 2.4                  | 4.3              | 5.6              | 0.2              |
| Cepolidae                           | -                    | -                | 0.2              | -                |
| Champsodontidae                     | 2.4                  | 3.8              | 0.4              | 35.2             |
| Chaunacidae                         | -                    | -                | 0.6              | 0.1              |
| Chlorophthalmidae                   | -                    | -                | 1.9              | 0.3              |
| Cynoglossidae                       | -                    | -                | 0.7              | 0.1              |
| Diodontidae                         | -                    | 8.7              | 0.5              | -                |
| Emmelichthyidae                     | -                    | -                | 0.1              | 0.1              |
| Exocoetidae                         | -                    | -                | -                | 0.1              |
| Gempylidae                          | -                    | -                | 0.1              | -                |
| Gobiidae                            | 4.8                  | 61.4             | 39.3             | 57.9             |
| Malacanthidae                       | -                    | 0.5              | 0.1              | -                |
| Mullidae                            | -                    | 0.9              | -                | -                |
| Ogcocephalidae                      | 2.4                  | -                | 1.0              | 0.1              |
| Ophichthidae                        | -                    | 0.9              | 0.9              | -                |
| Peristediidae                       | -                    | -                | 0.1              | 0.1              |
| Pristiophoridae                     | -                    | -                | -                | 0.1              |
| Rhinobatidae                        | -                    | -                | 0.1              | -                |
| Serranidae                          | -                    | -                | -                | 0.1              |
| Sparidae                            | -                    | 4.3              | 0.1              | -                |
| Squatinae                           | 7.2                  | -                | -                | -                |
| Synodontidae                        | 55.4                 | 2.2              | 39               | 1.2              |
| Tetraodontidae                      | 18.1                 | -                | 0.4              | -                |
| Triacanthidae                       | -                    | -                | 0.4              | -                |
| Trichiuridae                        | -                    | -                | 0.1              | -                |
| Triglidae                           | -                    | 13.0             | 29.6             | 2.2              |
| Uranoscopidae                       | -                    | -                | 0.9              | 0.1              |
| Unidentified                        | -                    | -                | 0.18             | -                |
| Total No. of families identified    | 9                    | 10               | 25               | 18               |
| Total No. of individuals caught /hr | 83                   | 446              | 2201             | 4701             |

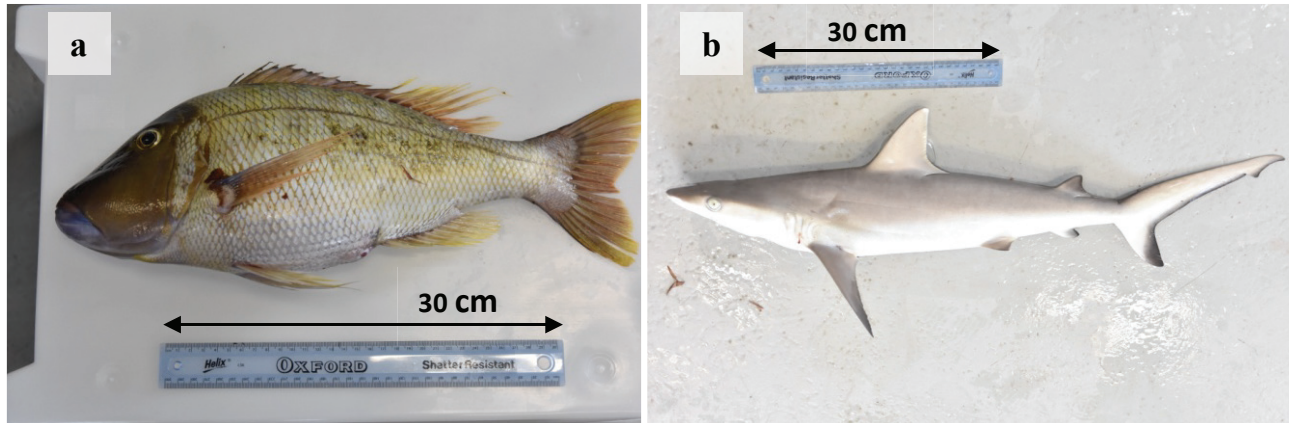


Figure 2. Catch from basket traps set at the Saya de Malha Bank (SMB) at 21 m depth. a) *Lethrinus mahsena*; and b) *Carcharhinus amblyrhynchos*.

were encountered during this study and were present at most of the stations. However, unlike the survey carried out in 1975-1979 which made use of bottom trawls on the SMB, records of this study were obtained from pelagic trawls.

#### Demersal fish

##### Bottom trawl

The bottom trawls carried out in the deep-water of the eastern slopes of NB at the four stations between 200 and 300 m (BTS 1, BTS 2, BTS 3 and BTS 4) resulted in catch rates of 26.6 kg/hr, 9.2 kg/hr, 50.4 kg/hr and 45.8 kg/hr, respectively. The total number of families obtained from BTS 1, BTS 2, BTS 3 and BTS 4 were 9, 10, 24 and 18, respectively (Table 4). A total of 30 families were identified from the bottom trawls. The fish family with highest percentage composition was

Gobiidae and was obtained from BTS 2, BTS 3 and BTS 4. The main fish family recorded was Synodontidae (*Synodus* spp.) at BTS 1 while other families such as the Champsodontidae (*Champsodon* spp.) and Triglidae (*Lepidotrigla* sp. and *Trigla* sp.) were also prevalent (Table 5). *Polysteganus* sp. (Sparidae) were also collected from the trawls and this coincides with the results of Boyer *et al.* (2006) and Iwatsuki and Heemstra (2011; 2015) where this species was collected at the same depths on the NB. *Polysteganus* sp. is an important commercial deepwater demersal fish from the slopes of the NB (Degambur and Korsbrekke, 2011). An exploration of the deep waters of Reunion Island showed similarities with families encountered in this study such as Caproidae, Carangidae, Gobiidae, Mullidae, Serranidae, Synodontidae, Tetraodontidae, and Trichiuridae (Durville *et al.*, 2009a)

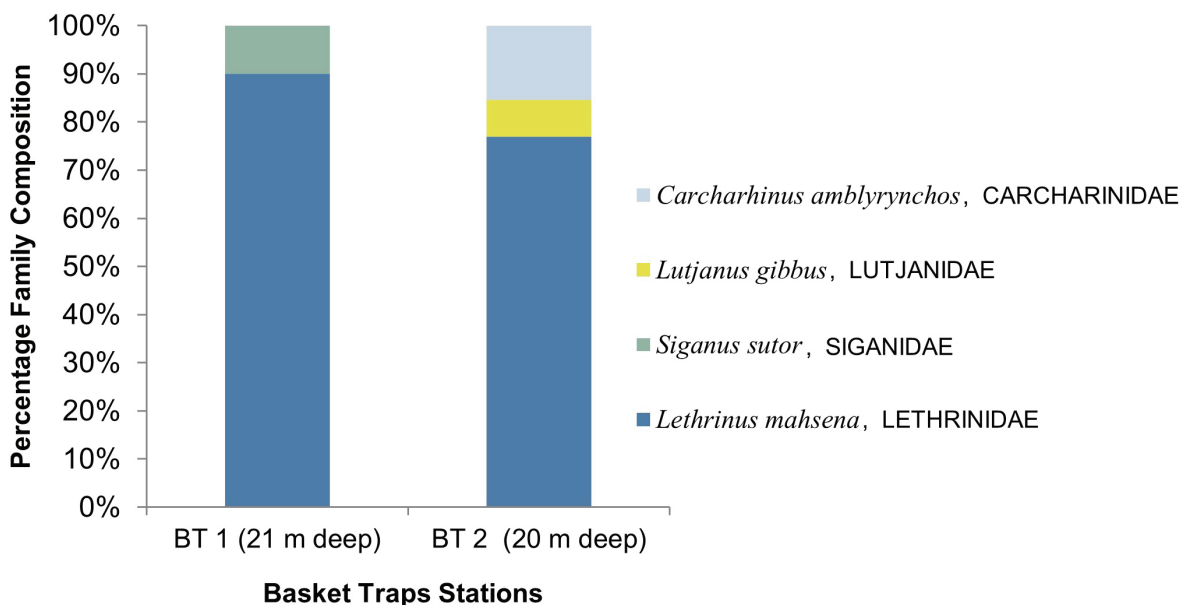


Figure 3. Percentage composition of families of fish obtained from basket traps (BT) on the Saya de Malha Bank (SMB). The main species identified from each station is indicated.



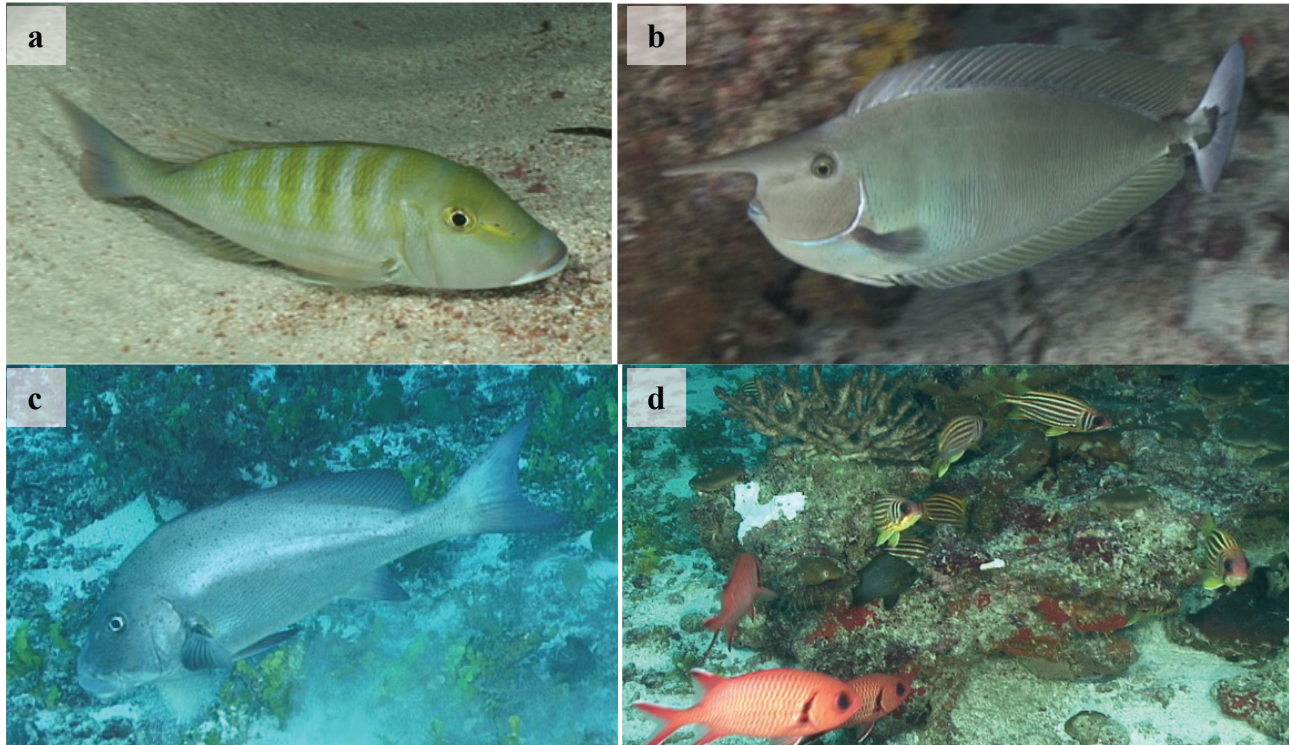
**Table 6.** Percentage composition of fish families encountered at the VAMS (Video-Assisted Multi Sampler) stations from video footage. The main family encountered from each station is highlighted in gray.

| Family                                      | SS 4      | SS 9      | SS 13     | SS 34     | SS 36-1    | SS 36-2    | SS 37-1    | SS 37-2   | SS 38     | SS 39-1    | SS 39-2    | SS 39-3   | SS 39-4    | SS 40     | SS 42    |
|---|-----------|-----------|-----------|-----------|------------|------------|------------|-----------|-----------|------------|------------|-----------|------------|-----------|----------|
| Acanthuridae                                | -         | -         | -         | -         | 3.8        | 48.6       | 20.7       | 5.1       | -         | 19.2       | 22.5       | -         | 20.1       | -         | -        |
| Apogonidae                                  | -         | -         | -         | 5.0       | 10.2       | -          | -          | 3.4       | -         | 14.4       | 0.7        | -         | -          | -         | -        |
| Balistidae                                  | -         | -         | -         | 2.5       | -          | 0.9        | 3.0        | -         | -         | 1.0        | -          | 3.3       | 1.0        | 2.3       | -        |
| Callionymidae                               | -         | 5.9       | -         | -         | -          | -          | -          | -         | -         | -          | -          | -         | -          | -         | -        |
| Carangidae                                  | -         | -         | -         | 37.5      | -          | -          | 14.8       | 20.3      | 94.3      | 2.9        | -          | -         | -          | 36.4      | -        |
| Chaetodontidae                              | -         | -         | -         | -         | 2.7        | 3.7        | -          | -         | -         | -          | 2.8        | 1.6       | 1.9        | -         | -        |
| Dasyatidae                                  | -         | -         | -         | -         | 0.5        | -          | -          | -         | -         | -          | -          | -         | -          | 2.3       | -        |
| Diodontidae                                 | -         | -         | -         | -         | -          | -          | -          | -         | -         | 1.0        | -          | -         | -          | 4.6       | -        |
| Echeneidae                                  | -         | -         | -         | 2.5       | -          | -          | -          | -         | -         | -          | -          | -         | -          | -         | -        |
| Fistulariidae                               | -         | -         | -         | -         | -          | -          | -          | -         | -         | -          | -          | -         | -          | 2.3       | 25.0     |
| Gobiidae                                    | -         | 29.4      | -         | -         | 1.1        | -          | 0.6        | -         | -         | -          | -          | -         | 0.5        | -         | -        |
| Haemulidae                                  | -         | -         | -         | -         | -          | -          | 15.4       | -         | -         | -          | -          | 1.6       | -          | -         | -        |
| Holocentridae                               | -         | -         | -         | 2.5       | -          | -          | 6.5        | 17.0      | -         | 28.9       | 10.6       | -         | 7.2        | -         | -        |
| Labridae                                    | 12.9      | -         | 2.9       | -         | 15.6       | 3.7        | 16.0       | -         | -         | 12.5       | 9.9        | 18.0      | 17.2       | -         | -        |
| Lethrinidae                                 | 80.7      | -         | 71.4      | 2.5       | 1.6        | 14.0       | -          | 28.8      | 1.9       | -          | -          | 42.6      | 21.5       | 34.1      | -        |
| Lutjanidae                                  | -         | -         | 2.9       | -         | -          | -          | 1.2        | -         | -         | -          | 21.8       | -         | 0.5        | -         | -        |
| Monacanthidae                               | -         | -         | 2.9       | -         | -          | -          | -          | -         | -         | -          | -          | -         | -          | -         | -        |
| Mullidae                                    | -         | -         | -         | 5.0       | 3.2        | -          | 1.2        | -         | -         | -          | -          | -         | -          | -         | -        |
| Muraenidae                                  | -         | -         | -         | -         | 0.5        | -          | 0.0        | -         | -         | -          | -          | -         | -          | -         | 25.0     |
| Nemipteridae                                | -         | -         | 11.4      | 5.0       | -          | 4.7        | -          | 10.2      | 1.9       | -          | 2.8        | -         | 4.3        | -         | -        |
| Ophichthidae                                | -         | -         | -         | -         | -          | -          | -          | -         | -         | -          | -          | -         | 0.5        | -         | -        |
| Ostraciidae                                 | -         | -         | -         | 2.5       | -          | -          | -          | -         | -         | -          | -          | -         | 0.5        | 4.6       | -        |
| Pegasidae                                   | -         | 5.9       | -         | -         | -          | -          | -          | -         | -         | -          | -          | -         | -          | -         | -        |
| Plotosidae                                  | -         | -         | -         | 12.5      | -          | -          | -          | -         | -         | -          | -          | -         | -          | -         | -        |
| Pomacanthidae                               | -         | -         | -         | -         | 0.5        | -          | 0.6        | -         | -         | 1.9        | -          | -         | 1.0        | -         | -        |
| Pomacentridae                               | 1.6       | -         | -         | 2.5       | 7.0        | 2.8        | 11.8       | 6.8       | -         | 12.5       | 2.1        | 26.2      | 20.1       | -         | -        |
| Priacanthidae                               | -         | -         | -         | -         | -          | -          | -          | 1.7       | -         | -          | 0.7        | -         | -          | -         | -        |
| Pseudochromidae                             | -         | -         | -         | 5.0       | -          | -          | -          | -         | -         | -          | -          | -         | -          | -         | -        |
| Rhinidae                                    | -         | -         | -         | 2.5       | -          | -          | -          | -         | -         | -          | -          | -         | -          | -         | -        |
| Scaridae                                    | -         | -         | -         | -         | -          | 7.5        | 1.8        | -         | -         | -          | 20.4       | 1.6       | -          | -         | -        |
| Scorpaenidae                                | -         | -         | -         | 2.5       | -          | -          | 1.2        | -         | -         | -          | -          | -         | -          | 4.6       | -        |
| Serranidae                                  | -         | -         | -         | -         | 2.7        | -          | 2.4        | -         | -         | -          | 0.7        | -         | 0.5        | -         | -        |
| Siganidae                                   | -         | -         | -         | -         | -          | -          | -          | -         | 1.9       | -          | -          | -         | -          | -         | -        |
| Syngnathidae                                | -         | 5.9       | -         | 2.5       | -          | -          | -          | -         | -         | -          | -          | -         | -          | -         | -        |
| Synodontidae                                | -         | 23.5      | -         | -         | -          | -          | -          | 1.7       | -         | -          | -          | -         | -          | -         | -        |
| Tetraodontidae                              | -         | 11.8      | -         | 2.5       | -          | -          | -          | 3.4       | -         | -          | -          | -         | -          | 2.3       | -        |
| Trichonotidae                               | -         | 17.7      | -         | -         | -          | -          | -          | -         | -         | -          | -          | -         | -          | -         | -        |
| Zanclidae                                   | -         | -         | -         | -         | -          | -          | 1.2        | -         | -         | 4.8        | 0.7        | -         | -          | -         | -        |
| Unidentified                                | 4.8       | -         | 8.6       | 5.0       | 50.5       | 14.0       | 1.8        | 1.7       | -         | 1.0        | 4.2        | 4.9       | 3.4        | 6.8       | 50.0     |
| <b>Total no. of families identified</b>     | <b>3</b>  | <b>7</b>  | <b>5</b>  | <b>16</b> | <b>12</b>  | <b>5</b>   | <b>15</b>  | <b>10</b> | <b>4</b>  | <b>10</b>  | <b>12</b>  | <b>7</b>  | <b>14</b>  | <b>9</b>  | <b>2</b> |
| <b>Total no. of individuals encountered</b> | <b>62</b> | <b>17</b> | <b>35</b> | <b>40</b> | <b>186</b> | <b>107</b> | <b>169</b> | <b>59</b> | <b>53</b> | <b>104</b> | <b>142</b> | <b>61</b> | <b>209</b> | <b>44</b> | <b>4</b> |

### Basket traps

The main species caught in the traps was the sky emperor *Lethrinus mahsena* (Fig. 2a) with nine individuals caught at BT 1, and ten individuals at BT 2. Other species caught in the traps were one *Siganus sutor* (Valenciennes,

1835) at BT 1 and two specimens of *Carcharhinus amblyrhynchos* (Bleeker, 1856) (Fig. 2b) and one *Lutjanus gibbus* (Forsskål, 1775) at BT 2. Station BT 1 yielded 2 families while BT 2 yielded three families (Fig. 3). All specimens were caught at around 20 m depth.



**Figure 4.** Species captured on videos from the shallow waters of the Saya de Malha Bank: a) *Lethrinus mahsena*, Lethrinidae at 35 m deep; b) *Naso brevirostris* (Cuvier, 1829), Acanthuridae at 33 m deep; c) *Diagramma labiosum* Macleay, 1883, Haemulidae at 39 m deep; d) *Myripristis* and *Sargocentron* spp, Holocentridae and *Dascyllus trimaculatus* (Rüppell, 1829), Pomacentridae at 38 m deep.

#### Remotely Operated Vehicle (ROV) videos

A total of 37 families of bony fish and one family of cartilaginous fish (Rhinidae) were encountered from the 10 stations. The number of families identified per station ranged from two (SS 42) to 16 for SS 34 which showed the highest family diversity recorded. In terms of fish abundance, the highest number of fish encountered was 209, from SS 39-4. The least diverse and least abundant station was SS 42, with a total of four fish individuals encountered, of which two were unable to be identified due to blurred video footage. The main families that occurred were Lethrinidae, Acanthuridae and Carangidae. Other families identified included several commercial families such as Serranidae, Scaridae, Holocentridae (Table 6 and Fig. 4). Some of the commercial fish encountered during the video transects are the same species recorded during fishing activities within the shallow waters of SMB (Ministry of Fisheries and Rodrigues, 2011; Munbodh, 2012). As described by Munbodh (2012), the main catch from the shallow water fishery is *Lethrinus mahsena*, along with some other species from the Lethrinidae and Serranidae. Though other commercial fish were encountered during this survey, such as from the families Acanthuridae, Scaridae and Siganidae, those species are not targeted by the banks fishery industry. This is attributed to the

fact that fishermen make use of handlines for fishing at the SMB (Degambur and Korsbrekker, 2011). Handlines are highly selective fishing gears for carnivorous fish, and target mainly Lethrinids and some Serranids. Other herbivorous species like rabbit fish (Siganidae), parrot fish (Scaridae) or unicorn fish (Acanthuridae) are not caught by this fishing method (Mees, 1996). Carangidae, though a family of commercial importance, do not appear in commercial catches. This is because the carangids from the fishing banks have been categorised as toxic by the 'Fisheries and Marine Resources (Toxic Fish) Regulations' of Mauritius since 2004 and the regulations prohibit the fishing and landing of these fishes.

#### Conclusions

This study highlighted the presence of several fish families that occur in the pelagic and demersal waters of the Saya de Malha and Nazareth Banks. Since the information on the composition of the fish fauna of these two banks was previously based only on catch data, this study provides new data that expands the current knowledge of fish diversity in this region using four different fishing gears. Further in-depth studies are however warranted to obtain a better understanding of fish diversity and occurrence on these two banks and the Mascarene Plateau in general.

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