



FINAL REPORT BIO-PRÍNCIPE SCIENTIFIC EXPEDITION 2016



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INTRODUCTION

São Tomé and Príncipe islands are aligned in a volcanic island chain in the Gulf of Guinea (Equatorial Atlantic), surrounded by deep-sea trenches and host one of the world's biodiversity hotspots (Fig. 1), with several terrestrial endemisms (Gillespie and Clague, 2009), whereas its marine biota is not yet investigated. All the islands are within the wet tropical belt, with annual rainfall ranges from 1000 to over 4000 mm with a raining season running from October to May; average annual temperatures range from 18 - 21 °C minimums to 30 - 35 °C maximums. In general, the islands are very steep, covered with lush tropical forests and with lowlands along the coastlines as the only flat areas. Mangroves habitats are found only along the coasts of the islands of São Tomé and Príncipe in estuarine and scattered sheltered areas.

The Democratic Republic of São Tomé and Príncipe, one of the youngest and smallest countries in Africa, is made up of two main islands and several islets located about 440 km to the south and 225 km to the west, respectively, of the coasts of Nigeria and Gabon, very near to the equatorial line.

The island of Príncipe have a surface area of 142 km², the highest mountain is Pico do Príncipe (948 m altitude) and is populated by about 8000 people, making their living mainly from natural resources near or in the coasts, complemented by a small and responsible eco-tourism sector.

Since 2012, the island is part of the UNESCO World Reserve of Biosphere and its government is devoted to enhance sustainable development actions and promoting the well-being of its people under an ecosystem approach.

As result of diverse scientific relationships with other institutions, the Research Institute on Sustainable Aquaculture and Marine Ecosystems (IU-ECOQUA) of the University of Las Palmas de Gran Canaria (Spain) have been involved in diverse international projects to evaluate the biological assets of coastal and marine ecosystems in the Canary Islands and nearby coastal areas.



In August 2016, a Joint Agreement was defined and signed between the UNESCO Reserve of Biosphere of Príncipe (São Tomé and Príncipe) and the University Research Institute in Sustainable Aquaculture and Marine Ecosystems, IU-ECOQUA, belonging to the University of Las Palmas de Gran Canaria (Spain). Both institutions have interest in developing marine research and responsible use of marine resources under their respective responsibilities.



The UNESCO Reserve of Biosphere of Príncipe and the IU-ECOQUA agreed on the development of the following actions:

1. To facilitate the exchange of researchers and resources to enhance the scientific knowledge of marine species and key habitats.
2. To develop joint actions, such as marine research expeditions, secondments of scientific staff (including postgraduate students and technicians), fostering robust knowledge of marine life.

After the signature of that joint agreement, both parties started different contacts and activities with relevant administrations and authorities concerning with the potential definition of a Scientific Expedition to Príncipe Island. Those efforts turned out to define the first Marine Research Expedition to the coastal and marine ecosystems of the island of Príncipe, which was set for November 2016.



BIO-PRÍNCIPE 2016 SCOPE

Due to the fact that the UNESCO Reserva da Biosfera da Ilha do Príncipe was interested to start a comprehensive catalogue of marine life in the coastal and marine ecosystems of the Príncipe Island, the BIO-Príncipe 2016 Scientific Expedition have the following objectives:

The main objective of this scientific expedition was to initiate the assessment the diversity of marine life in the coasts as well as in selected subtidal areas of Príncipe Island.

The biodiversity assessment was mainly focused on specific botanical and faunistic taxonomic groups, such as macroalgae, fishes, cnidarians and mollusks, which are taxonomic groups highly represented in tropical waters and, in general, play a structural role in shallow water coastal ecosystems.

A second objective of this scientific expedition was to characterize the marine habitats of Príncipe, using the Side Scan Sonar and validating its identification by underwater surveys with scuba and remote camera analysis.

In this first marine expedition, the Side Scan Sonar surveys were concentrated on 4 areas distributed in the North, South, West and East part of the island. Inside these zones, a particular attention has been devoted to *gla-gla* (rhodolith) seabeds due to their potential role as a biodiversity hotspot and global carbon storage sites.

Another objective was to determine, for the first time in the equatorial West Africa, the marine litter present in the coastline of Príncipe Island. The evaluation of microplastics in the beaches and sheltered coastal areas was used as a proxy of direct and indirect human pressure in shallow water ecosystems.

The scientific data obtained by the marine biodiversity assessment, the Side scan sonar methodology, and the marine litter assessment will be employed later on in future conservation actions such as the definition of a Network of Marine Protected Areas in Príncipe Island.



MATERIAL AND METHODS

The BIO-Príncipe Scientific Expedition started in the last week of October and lasted until the end of November 2016, although most of the researchers involved in sampling activities stayed during a 2-week period in Príncipe Island.

Aside from the 8 researchers coming from the IU-ECOQUA, Prof. Dr. J.L. Cervera (University of Cádiz) and Mr. P. Gómez from Scopio Madeira Diving Center participated and contributed to the major outputs of BIO-Príncipe Scientific Expedition. Professor Cervera is a worldwide expert on taxonomic identification of diverse marine invertebrates, with a long expertise mainly working with sea slugs, whereas Mr. Gómez is an expert in sea security and acclaimed underwater photographer.

Marine biodiversity

The assessment of marine biota around the coastal ecosystems of the island of Príncipe was conducted in seven intertidal areas and, with the help of snorkel gear, the shallow water habitats encountered were also sampled in the same sites.

The subtidal habitats were prospected by more than 20 diving sites around Príncipe island, depending on the weather forecast and sea condition for each sampling day. In those diving sites, 44 benthic transects were done along a 25 m line and 4 m wide. All fishes, invertebrates and macroalgal species encountered were registered and, in some cases, samples were taken back for later analysis in the field laboratory.

Benthic invertebrates and macroalgae were sorted out and pre-identified in the field laboratory that was set up in the Bom Bom Resort area. Many samples were labelled and stored with alcohol / formalin for later studies in the marine laboratories of the Univ. of Las Palmas de Gran Canaria or at the Univ. of Cádiz.





Fig. 2 Different aspects of marine biodiversity sampling and identification works.

Fish Population methodology

Fish assemblages were evaluated during two weeks (October and November of 2015) using underwater visual counts. All samples were taken at a depth range between 3 and 25 m, during daylight hours, by two independent observers (Dr. Fernando Tuya at shallow water and Dr. Aketza Herrero at deep water). At each of 20 reef points, $n=2-4$, 25 m length x 4 m wide, transects were deployed by these two SCUBA divers using a metric tape. Overall, 44 transects were carried out, what supposed the inspection ca. 44 ha of reef bottom and ca. 20 hours of SCUBA diving. Along each transect, we annotated the abundance of each fish taxa, according to standard procedures (Tuya et al. 2004). Individual fish counts were done up to 20 individuals. The abundance of schooling species was estimated using abundance classes: 21-30, 31-40, 41-50, 51-100, 101-200 and >200 individuals. Seawater visibility ranged between 8 and 25 m. Non-cryptic species were counted along each transect, while cryptic species were counted on the way back. In this case, small caves, ledges, and overhangs were carefully inspected. Fishes that were not visually identified to species level were recorded as unidentified genera.

Marine mapping & Side scan sonar

The use of sonar for marine mapping is on the rise. In particular, the side-scan sonar (SSS) can provides digital images of the composition and morphology, differences in materials and texture types of the seafloor. Its application is an effective tool for nautical (ex. finding pipelines, shipwrecks or even drowning), archaeology and ecological disciplines, particularly for the identification of habitats and mapping of their backgrounds (e.g. seagrass and seaweeds monitoring).

The side-scan sonar has the form of a military torpedo (usually called as "Tow-fish"), with hydrodynamic shape and fins (to facilitate its stability, movement, and dispersion of the acoustic signal), emitting pulses or acoustic beams (ping) perpendicular to the survey line that propagates through the water column throughout the surrounding area. The pulse frequencies can vary from low (e.g. 100 kHz) to high frequencies (e.g. 1600 kHz) depending on the study goals. The lower frequencies provide wide swath coverage instead increasing frequencies imply greater image resolutions, diminishing the data coverage. The ping of the sonar bounces against the objects, materials or morphologies transmitting energy sonar incidental and returning it to the sonar (backscattering). This final sound back is shown as an echo from the seafloor and recorded in a series of cross-track portions able to show an image of the sea bottom within the area covered by the device beam. The sonar may be towed from a surface boat or directly gripped to the ship's hull (Fig. 1).

The data obtained by the “Tow-fish” can be improved through software programs able to create mosaics in real time through acoustic maps (e.g. SonarWiz). These programs allow processing the visualization of the seafloor for a later characterization and geo-positioning involving Geographical Information System programs (e.g. ArcGIS).

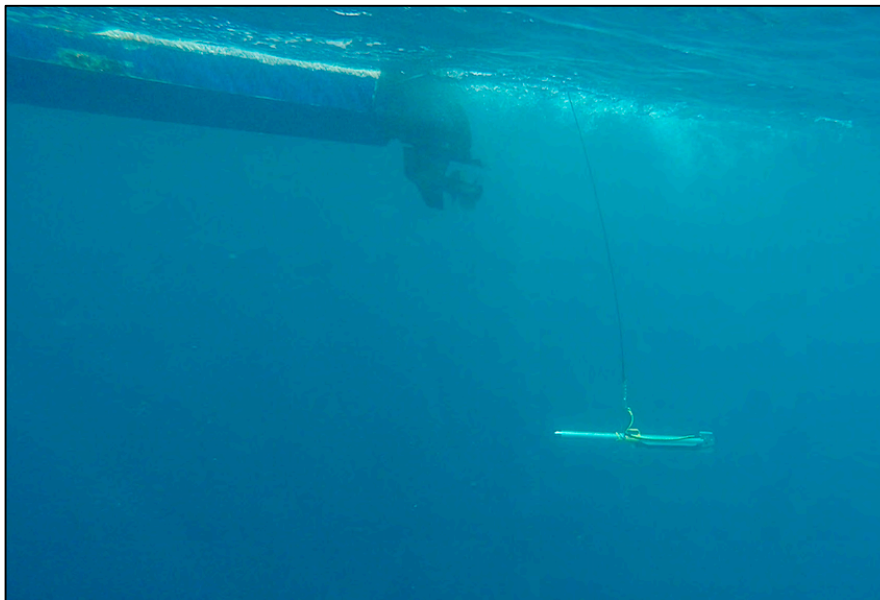


Figure 3. Side scan sonar towed by the boat

The fieldwork was performed from 10/20/16 till 11/13/16. The SSS employed was a digital CM2 Tow-fish (C-Max, UK), operating at a single frequency (780 kHz), not to exceed 50 m depth nor a band range width greater than 40m either side of the Tow-fish. The data acquisition were recorded through the CM2 Transceiver (STR) and processed by SonarWiz 6 software (Chesapeake Technology Inc, USA). All devices were installed in a 9 m recreational fishing boat (Fig. 3), including the towing davit with the count cable pulley able to calculate the amount of tow kevlar cable deployed and make estimates of the horizontal distances of towfish behind the boat. In addition, a differential GPS (Hemisphere GPS A325 GNSS Smart Antenna, USA) was used for navigation and side scan sonar positioning in the above-mentioned software.

The study areas were selected based on two criteria. First, they are currently inside the Principe Biosphere Reserve and second, they already have some biological indicators showing its marine richness Thus, the area around Bom Bom’s peninsula was selected in the North, the bay of Abades in the East; the bay of Agulhas in the Southwest and the bay of Praia Grande do Sur in the Southeast (Fig. 4). We had initially scheduled 50m depth as the limit for side scan sonar operations. However, logistic constraints obliged us to set 30m as the maximum depth to operate with this device. Therefore, the bathymetric range covered in the studied areas oscillated between 5 and 30m deep.

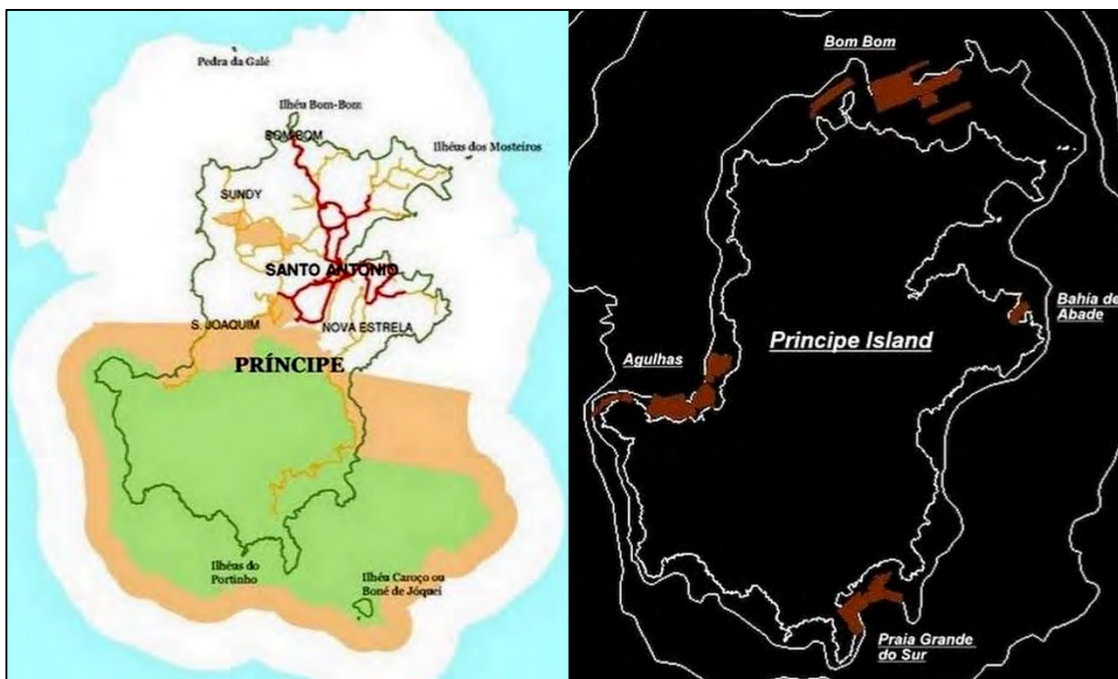


Figure 4. Map of Príncipe Island with the biosphere reserve zones (in green, core area; in brown, buffer zone) and the studied sites and areas covered by the side scan sonar transects (in red).

From data acquired by sonar, a habitat pre-characterization list was performed in each studied area using software post-processing tools (e.g. histogram equalizers) and then corroborated through underwater visual transects using SCUBA and trawled cameras (Sony HDR-AS50) (Figs. 5 & 6). All data were also correlated with images obtained by satellite through GoogleEarth® program.

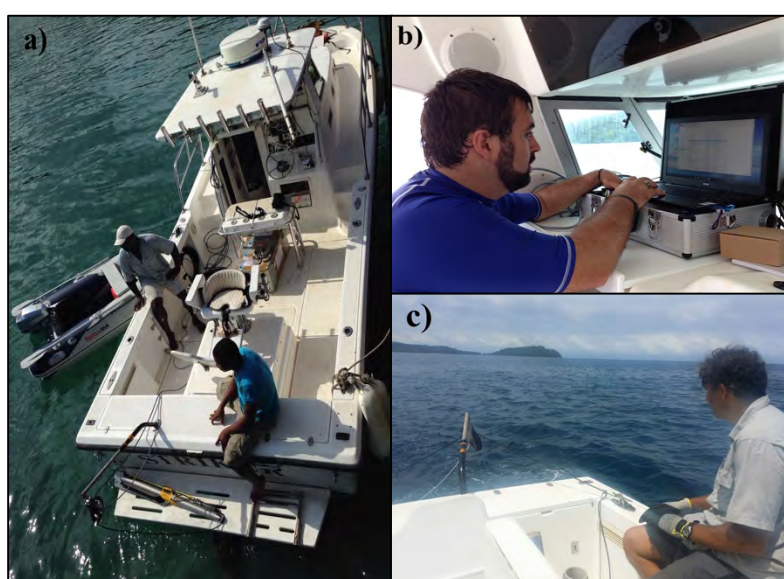


Figure 5. a) Recreational fishing boat used for the SSS campaign; researchers manipulating b) data acquisition software and c) tow-fish cable.

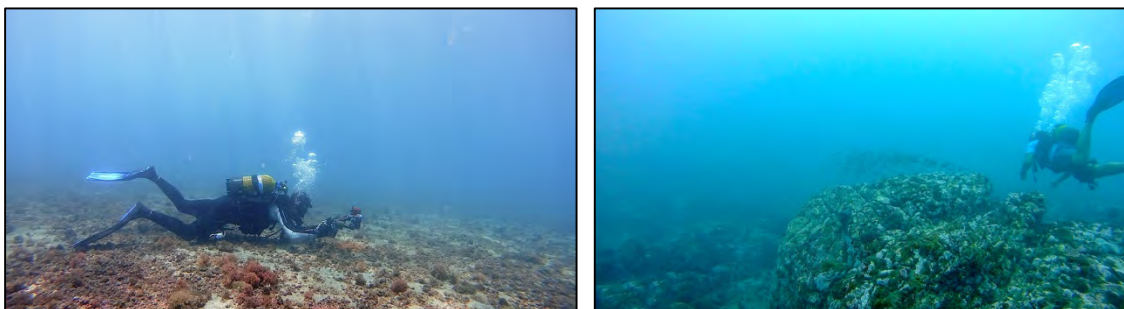


Figure 6. Scuba divers during underwater visual transects, surveying data obtained from sonar.

Rhodoliths sea beds sampling

In addition to habitat characterization, rhodolith samples were collected in two sites (1 & 2) and three depths (5/15/20m) inside the bay of Agulhas (Fig. 7). SCUBA divers collected five replicas by each depth of rhodolith and associated epibenthic communities using plastic containers. Samples were then transported to the humid laboratory at Bom Bom resort, frozen and stored at -20°C during 24h. Measurements of size and sphericity of rhodoliths were then performed using calipers (Graham & Midgley, 2000), and epibenthic communities (algae and fauna) were also separated, preserved in 4% formalin and 100% ethanol respectively, until further analysis.

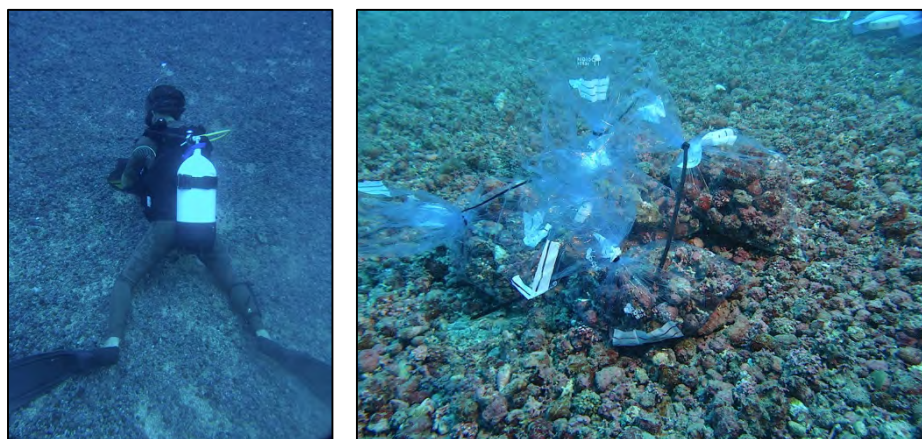


Figure 7. Scuba diver collecting *gla-gla* (rhodolith) in Agulhas Bay and close-up of rhodoliths sampling bags.

Marine litter: microplastics

The methodological approach done with the assessment of marine litter in the coastal area is the standardized sampling process used by our and other international teams for the same purpose.

The sampling sites were distributed along the coastline of Príncipe, namely: Praia Bom Bom, Praia Boi, Praia Ioia, Praia María Correia, Praia Grande do Sur, Praia Abelha and Praia de Santo Antonio. In each beach, sampling was conducted in the high tide line, with a quadrant of 50 x 50 cm and collecting 1 l

of superficial sand. Then, the sampled sand was introduced in a bucket with seawater, removed and after few minutes of sedimentation, all microplastic particles floated and were collected (Fig. 8). Finally, the water is filtered with a 2 microns mesh and the smaller particles were also collected and stored.

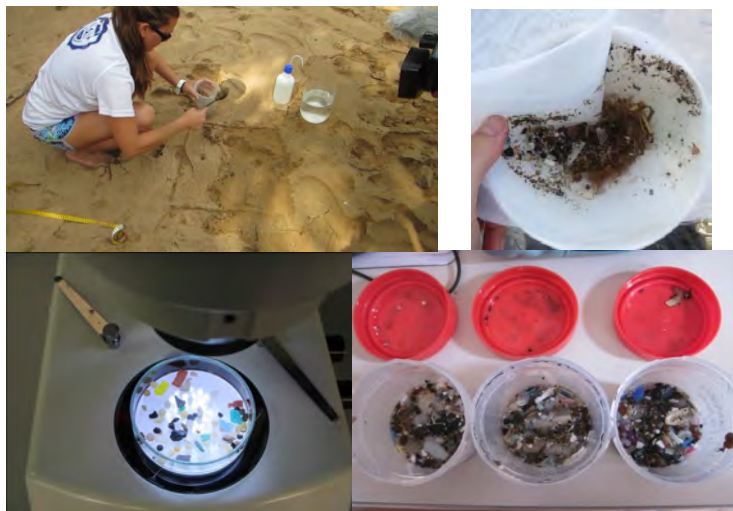


Fig. 8. Diverse stages of the microplastic sampling protocol.

In the field laboratory, the samples were digested to eliminate the organic matter and microplastics units were sorted out by color and size before putting them to dry out and, finally each type was weighted.

The results obtained are later analyzed comparing the different beach sources, its orientation as well as its prevailing oceanographic conditions.



Fig. 9. Group picture of participants of the BIO-Príncipe 2016 Scientific Expedition at Praia Banana



MAIN RESULTS

MARINE BIODIVERSITY

Fish populations at Principe Island

A total of 12,753 fishes were censused during the 2-week period sampling campaign (n=44 transects), including 73 fish taxa; 8 taxa were identified to genera, while 65 taxa were identified to species level. The mean total fish abundance per transect was 335.29 ± 387.2 ind 100 m^2 (mean \pm SD, n=44), which oscillated between a minimum of 39 and a maximum of 1,544 ind 100 m^2 . The mean number of fish taxa was 10.7 ± 4.8 taxa 100 m^2 (mean \pm SD, n=44), which oscillated between a minimum of 3 and 21 taxa 100 m^2 .

Out of the 12,753 fishes censused, exclusively 180 were top-predators, i.e. carnivorous fish species, mainly preying on fish, and large-sized mollusks and crustaceans, including the following 15 fish taxa: *Balistes carolinensis*, *Balistes punctatus*, *Canthidermes sufflamen*, *Caranx crysos*, *Caranx hippos*, *Cephalopholis nigri*, *Cephalopholis taeniops*, *Decapterus punctatus*, *Ephinephelus adscensionis*, *Katsuwonus pelamis*, *Lutjanus agennes*, *Lutjanus goreensis*, *Muraena melanotis*, *Muraena spp.* and *Sphyrna barracuda*. The mean abundance of top predators was $4.1 \text{ ind} \pm 6.06 \text{ ind } 100 \text{ m}^2$ (mean \pm SD, n=44). In summary, this supposes that only 1.22% of the total fish abundance was accounted by top-predators.

When compared with other oceanic Atlantic archipelagos, the abundance of top predators is similar, in order of magnitude, to areas subjected to high fishing pressure; for example, in the Canary Islands, abundances of top predators range between ca. 1-5 ind 100 m^2 (Tuya et al. 2004).

Since fish taxonomic richness of Principe is larger than at other oceanic archipelagos (ca. 11 species per 100 m^2 versus ca. 7 species per 100 m^2 at the Canary Islands, Tuya et al. 2004, and ca. 9 species 100 m^2 at Madeira Island, Ribeiro et al. 2005), the low presence of top predators at Principe reflect that the inshore waters of the island are subjected to a relevant fishing intensity.

On the other hand, omnivorous fishes, what included a total of 29 fish taxa preying on algae and small-sized invertebrates, represented the 47.2 % of the total fish abundance. Such omnivorous taxa included: *Abudefduf hoefleri*, *Abudefduf saxatilis*, *Abudefduf Taurus*, *Acanthurus monroviae*, *Cantherines pullus*, *Chromis cadenati*, *Chromis limbata*, *Chromis multilineata*, *Chromis limbata*, *Chromis multilineata*, *Cirrhitus atlanticus*, *Clepticus africanus*, *Coris atlantica*, *Elagatis bipinnulata*, *Gobius spp.*, *Gorogobius nigricinctus*, *Heteroconger longissimus*, *Kipphosus spp.*, *Melichthys niger*, *Microspathodon frontatus*, *Ophioblennius atlanticus atlanticus*, *Prionurus biafrensis*, *Scarus hoefleri*, *Sparisoma choati*, *Sparisoma rubripinne*, *Sphoereoides marmoratus*, *Stegastes imbricatus*, *Stegastes sp.*, *Stepanolephis hispidus*, *Stepanolephis*



hispidus, *Thalassoma newtoni*. The mean abundance of omnivorous fishes was 158.22 ind \pm 245.24 ind 100 m⁻² (mean \pm SD, n=44).

As a general remark about the fish populations around Príncipe island, it is possible to say that there were high number of herbivorous species as well as high presence of oceanic species (such as Carangids, Tunas, etc.). Another interesting feature encountered were the high presence of morey eels in the rocky outcrops.

Benthic invertebrates at Principe Island

As result of the intense sampling activities of marine life done in the coastal and subtidal habitats located around Príncipe Island, a catalogue of the marine gasteropods is being produced organized in phylogenetic order. Besides, few specimens of a Flatworm was collected and it is also included in this report. The identification process is not yet finalized for some species and some taxonomic units still needs some research effort taking into consideration not only a classical taxonomical approach but also new molecular techniques.

Systematic catalogue

Phylum MOLLUSCA

Class GASTROPODA Cuvier, 1795

Subclass HETEROBRANCHIA Burmeiester, 1837

Order CEPHALASPIDEA P. Fischer, 1883

- Family Haminoeidae Pilsbry, 1895

Genus *Haminoea* Turton and Kingston, 1830

• *Haminoea orbignyana* (Férussac, 1822)

Order ANASPIDEA P. Fischer, 1883

- Family Aplysiidae Lamarck, 1809

Genus *Aplysia* Linnaeus, 1767

• *Aplysia dactylomela* Rang, 1828

Genus *Dolabrifera* Gray, 1847

• *Dolabrifera dolabrifera* (Rang, 1828)

Order SACOGLOSSA Ihering, 1876

- Family Oxynoidae Stolitzka, 1868

Genus *Oxynoe* Rafinesque, 1814

• *Oxynoe olivacea* Rafinesque, 1814

- Family Plakobranchidae Gray, 1840

Genus *Elysia* Risso, 1818

• *Elysia timida* Risso, 1818

- Family Caliphyllidae Tiberi, 1881

Genus *Caliphylla* A. Costa, 1867

• *Caliphylla cf mediterranea* A. Costa, 1867

- Family Limapontiidae Gray, 1847

Genus *Placida* Trinchese, 1876

• *Placida cf. dakariensis* (Pruvot-Fol, 1953)

Order PLEUROBRANCHMORPHA Pelseneer, 1906



- Family Pleurobranchidae Gray, 1827
- Genus *Pleurobranchus* Cuvier, 1804
- *Pleurobranchus reticulatus* Rang, 1832
- Genus *Berthella* Blainville, 1824
- *Berthella ocellata* (Delle Chiaje, 1830)
- *Berthella* cf. *africana* (Pruvot-Fol, 1953)
- Order NUDIBRANCHIA Cuvier, 1817
- Family Discodorididae Bergh, 1891
- Discodorididae sp.
- Genus *Discodoris* Bergh, 1877
- *Discodoris* cf. *ghanensis* Edmunds, 2011
- Genus *Jorunna* Bergh, 1876
- *Jorunna* sp.
- Genus *Geitodoris* Bergh, 1891
- *Geitodoris* cf. *reticulata* Eliot, 1906
- *Geitodoris* cf. *tema* (Edmunds, 1968)
- Genus *Tayuva* Er. Marcus and Ev. Marcus, 1967
- *Tayuva lilacina* (Gould, 1852)
- Genus *Platydoris* Bergh, 1877
- *Platydoris argo* (Linnaeus, 1767)
- *Platydoris rolani* Dorgan, Valdés and Gosliner, 2002
- Family Dendrodorididae O'Donoghue, 1924
- Genus *Dendrodoris* Ehrenberg, 1831
- *Dendrodoris* cf. *senegalensis* Bouchet, 1975
- Family Chromodorididae Bergh, 1891
- Genus *Felimida* Ev. Marcus, 1971
- *Felimida edmundsi* (Cervera, García-Gómez and Ortea, 1989)
- *Felimida* cf. *rolani* (Ortea, 1988)
- Genus *Felimare* Ev. Marcus and Er. Marcus, 1963
- *Felimare senegalensis* (Bouchet, 1975)
- *Felimare tema* (Edmunds, 1981)
- *Felimare xicoi* (Ortea and Valdés in Ortea, Valdés and García-Gómez, 1996)
- Family Flabellinidae Gray in Griffiths and Pidgeon, 1833
- *Flabellina arveloi* Ortea and Espinosa, 1998
- Family Facelinidae Bergh in Carus, 1889
- Genus *Phidiana* Gray, 1850
- *Phidiana* cf. *lynceus* Bergh, 1867
- *Phidiana* sp.
- Genus *Cratena* Bergh, 1864
- *Cratena scintilla* Ortea and Moro, 1998
- Family Fionidae Gray, 1857
- Fionidae sp.
- Genus *Tenellia* A. Costa, 1866
- *Tenellia tema* (Edmunds, 1968)
- *Tenellia* sp.
- Family Glaucidae Gray, 1827
- Genus *Glaucus* Foster, 1777
- *Glaucus atlanticus* Foster, 1777



- Family Tritoniidae Lamarck, 1809
- Genus *Tritonia* Cuvier, 1798
- *Tritonia* sp.

Phylum PLATHYELMINTES
 Order Polycladida Lang, 1884
 Family Pseudocerotidae Lang, 1884
 Genus *Pseudobiceros* Faubel, 1984
 • *Pseudobiceros* sp.

MOLLUSCA, GASTROPODA HETEROBRANCHIA	NUMBER OF SPECIES IDENTIFIED
Order CEPHALASPIDEA	1 new species
Order ANASPIDEA	2
Order SACOGLOSSA	4
Order PLEUROBRANCHMORPHA	3
Order NUDIBRANCHIA	23 (5)
PLATHYELMINTES	
Order Polycladida	1 new species for Science

Table I. Number of invertebrates, mollusks, sorted out by different taxonomic groups.

In summary, the benthic invertebrates samples showed a large number of gastropods, nudibranchs, cnidarians and echinoderm species. Some species are already identified, but most of them still are in the un-named stage, with lengthly and costly efforts to be able to give them a proper scientific name.



Macroalgal surveys at Principe Island

The macroalgal assemblages are dominated by *gla-gla* (=rhodoliths) communities, with diverse species and numerous epiphytic species. Another interesting feature is the large presence of tropical species, similar to those found in the Caribbean Sea, as well as the low richness of brown macroalgal species. Nevertheless, the genus *Dictyota* is highly present and may develop thick biomass stands upon the rhodoliths.

TAXONOMIC GROUP	NUMBER OF IDENTIFIED SPECIES
RHODOPHYTA	22
CHLOROPHYTA	11
PHAEOPHYTA	8

Table II. Number of macroalgal species by major taxonomic groups.

MAIN RESULTS

MARINE HABITATS

The few data obtained during previous campaigns showed the presence of rhodolith seabeds, locally called as “gla gla”, at several points of the island (Steentoft, 1967). This habitat is distributed worldwide and composed by unattached crustose red algae, provides heterogeneous and three-dimensional biogenic structures (microhabitats) of CaCO₃ for diverse benthic communities (Peña & Barbara, 2007; Amado-Filho et al., 2012; Nelson et al., 2012; Neill et al., 2014). Linked to its function as “ecosystem engineer”, rhodoliths have also been described as nursery areas or biodiversity hotspots for several species, being one of the most productive marine habitats in the world (Barberá et al., 2009). In addition, these environments contribute to control the seawater pH and the decrease of the CO₂ concentration (carbon sequestration). At the same time, the slow growth rate of rhodoliths specimens forming this habitat makes them a non-renewable resource affected by local human impacts, such as eutrophication and towed demersal fishing activities (Díaz-Pulido, 2012) but also by global changes such as acidification and global warming (Grall & Chauvaud, 2002; Bordehore et al., 2003). These ecological and anthropogenic benefits but also their threats, make them unique and relevant, and essential to the establishment of conservation priorities for each country. Nowadays, few or no data about extension, species or physical characteristics of rhodolith seabeds have been yet described in these western Africa latitudes.

Throughout the habitat mapping campaign, we cartographed a total of 97 km (equivalent to 10km²), split by transects varying between 600 to 900m length (depending on the coastline and depth) in the four designated areas. Several marine habitats were identified and grouped into three broad categories: sandy, rocky and biogenic bottoms.

Generally, sandy bottoms covered most of the surveyed areas. These habitats usually appeared as flat surfaces; also designed with sandy ripples of various dimensions (Fig. 8a). Sometimes in the valleys of these dunes, we found accumulations of mostly-dead unattached calcareous red algae (rhodoliths) (Fig. 8b). Close to rocky coastlines, sonar detected isolated rocky outcrops in the middle of bare sandy fields (Fig. 7).

These outcrops placed near coastal areas, constitute the potential substrate for the colonization of numerous species of invertebrates (e.g. gorgonians, sponges, corals, etc) but also another associated macrofauna, such as demersal and benthic fish. Finally, the biogenic habitats were detected as significant extensions of rhodoliths, partially covered with frondose and filamentous algae or patched with colonies of Scleractinian corals (Fig. 7).

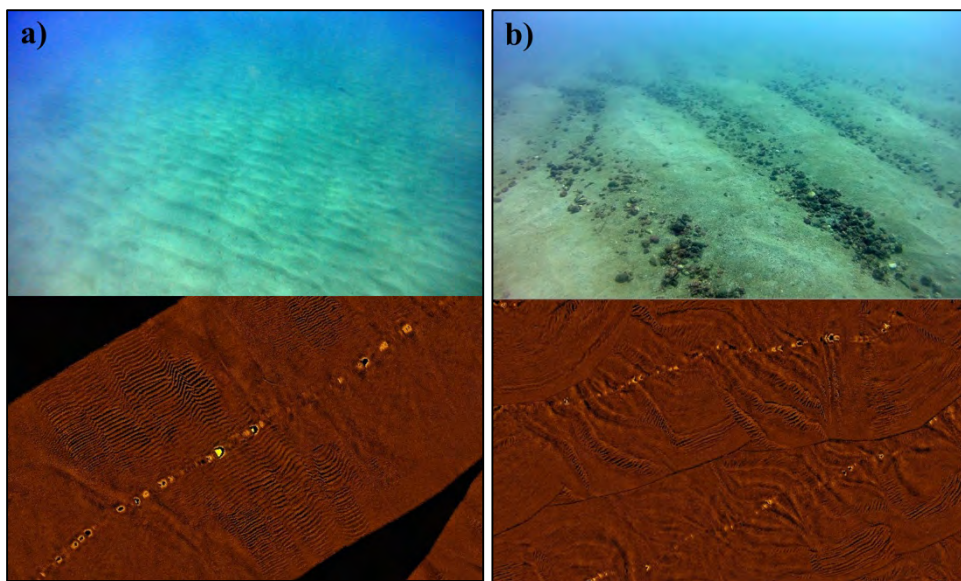


Figure 8. Side scan sonar records and underwater pictures showing sandy seabeds with a) small and b) large ripples with accumulations of rhodoliths.

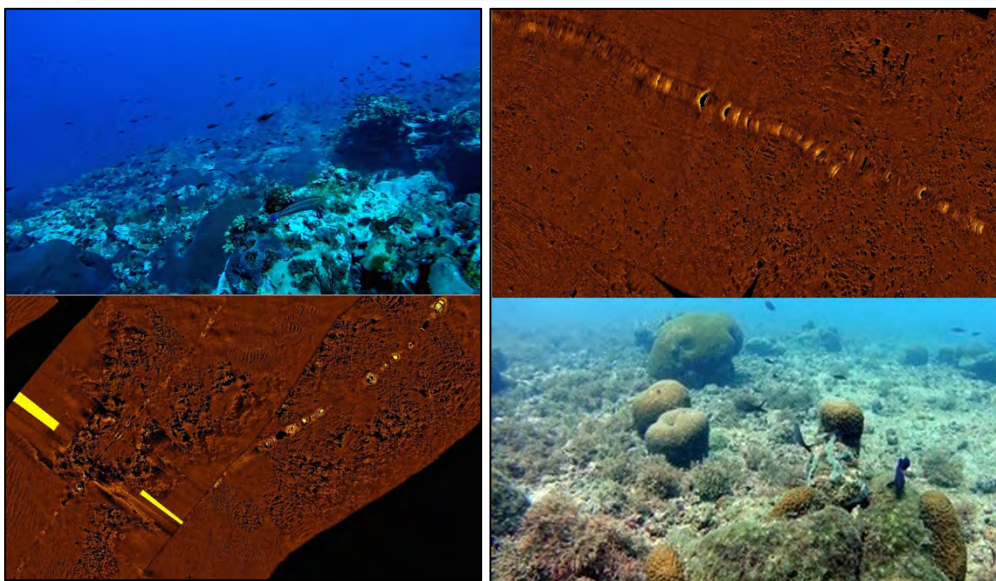


Figure 9. Side scan sonar records and underwater pictures showing a) rocky outcrops and b) biogenic sea bottoms combining rhodoliths sandy seabeds with colonies of Scleractinian corals.

Thus, the North area of the island was divided by the Bom Bom peninsula into two zones, east and west (Fig. 8a). The eastern zone is larger than western, and the main substrate mapped was sandy bottoms. These habitats varied in morphology, with areas of small ripples interleaving with large ripples (Fig. 10), and areas of smooth sand. The presence of isolated dead rhodoliths in the valleys of the large ripples was confirmed through underwater surveys, as also concentrations of sea snails (*Persististrombus latus*) over the sand (Fig. 8b). In the middle of the eastern bay (25m depth), we observed a large rock outcrop, known as "Pedra Adalio" (Fig. 9), where underwater surveys showed uniform fields of live rhodoliths surrounding the rocky reef with also large banks of demersal fish and sessile invertebrates. On the western face of the bay, the marine seabeds morphology was similar to the one described on the eastern zone, with sandy bottoms covered with large and small ripple morphologies, and a high number of rocky outcrops. In addition, two airplane fuselages, sunk to create an artificial reef for fishing purposes, lay over the sand (Fig. 11).

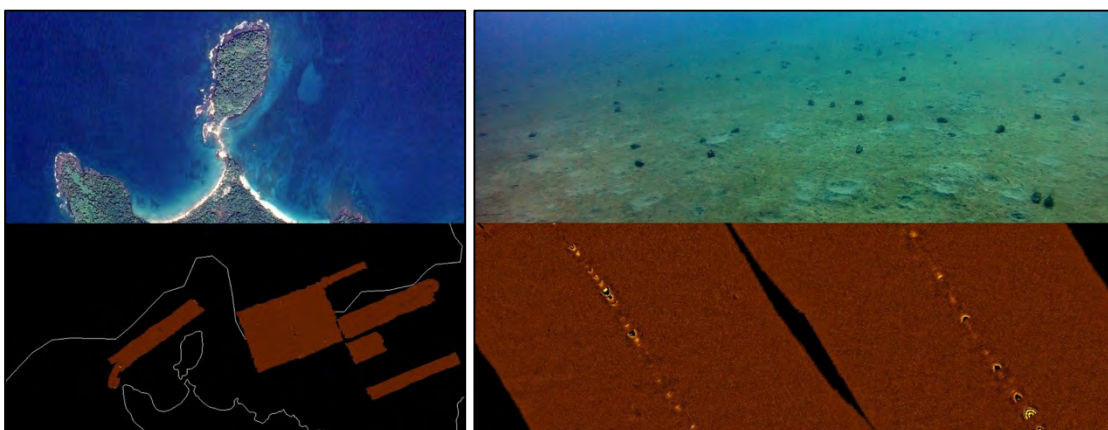




Figure 10. Map of Bom Bom peninsula (source: Google Earth) with side scan sonar transects and b) sandy areas with sea snail concentrations (Side scan sonar record and underwater pictures).

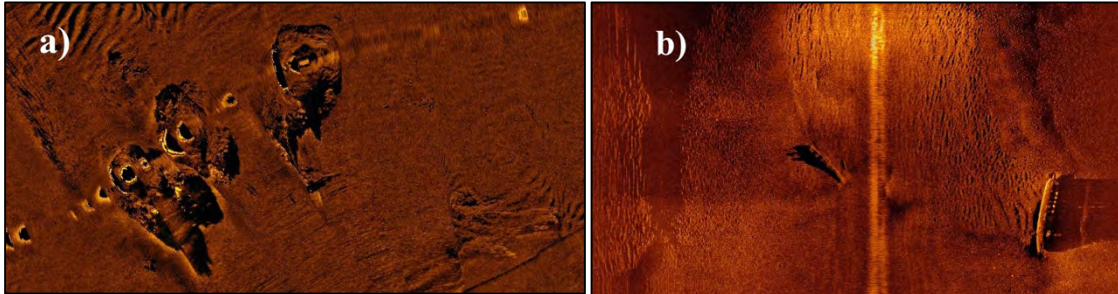


Figure 11. Side scan sonar records showing a) “Pedra Adalio” outcrop and b) airplane fuselages sunk to create an artificial reef in western part of Bom Bom bay.

The eastern area, the small and shallow bay of Abades (maximum surveyed depth 15m), receives the water flow from the stream, going through the mangrove “Praia Salgada”, that condition the nearest seabeds (Fig. 12). In these areas near the small river mouth, sandy flats were filled with mud, silt and organic sediments (coconuts, branches, and large leaves) forming anoxic zones and turbid waters. Sandy flats with small-medium ripples constituted the main habitat in the bay with rocky coastlines flanking its entrance.

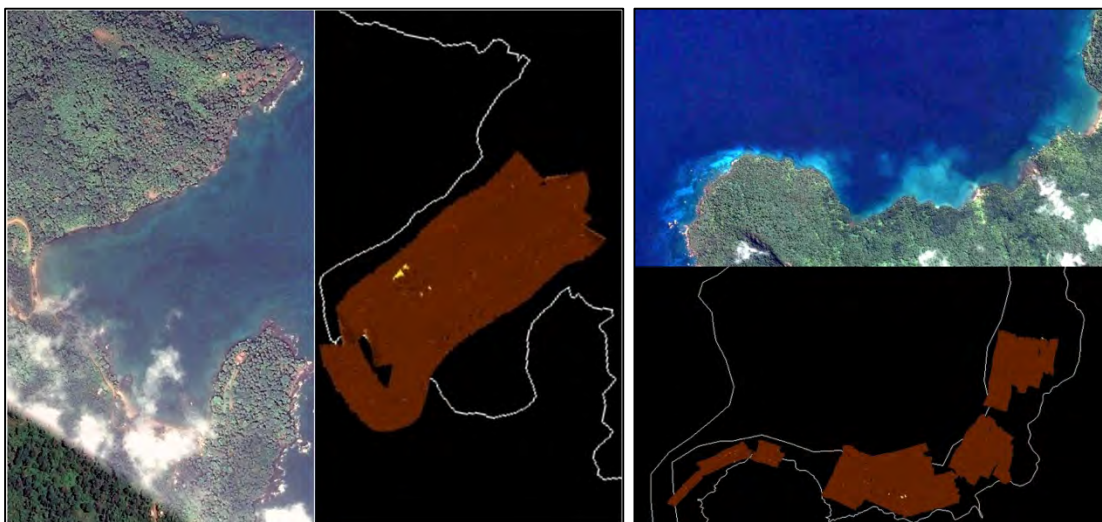


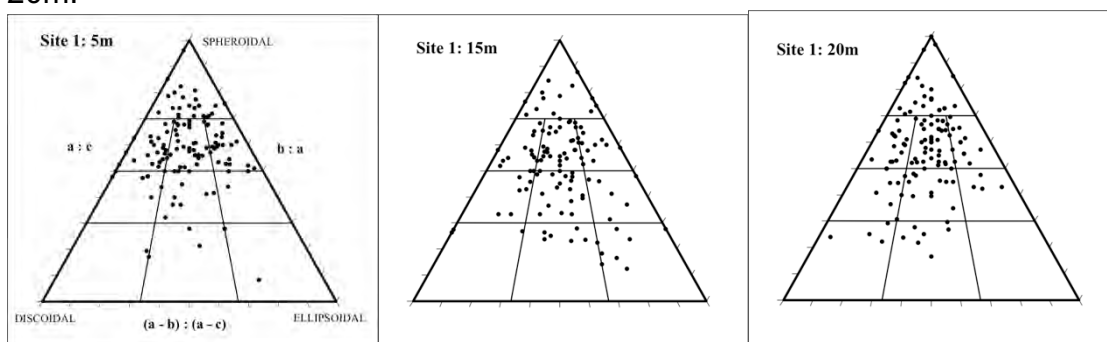
Figure 12. a) Map of “Baia de Abades” and b) “Baia das Agulhas” (source: Google Earth) with side scan sonar transects.

In the Bay of Agulhas, located in the western part of the island, we found the most varied and rich marine landscape from all surveyed areas of Principe island (Fig. 10). As other zones, the habitat morphology was highly conditioned by river contributions. Therefore, from the river including the mangrove of “Praia Caixao” in the northern part of the bay, continuing towards southwest to the small community of “Praia das Lapas” and “Praia Lemba-Lemba”, the seabeds

mixed sandy bottoms partially filled with mud, silt, and organic sediments. At the beginning of the core area of the marine reserve, the biogenic habitats began to emerge mixed with sand flats. This area beginning close to Fortaleza site and extending towards the western part of the bay appeared as uniform living rhodolith fields in the first meters (5-10m). Rhodolith sea bottoms were total or partially colonized by brown and red algae (e.g. *Dictyota sp.*), which they disappeared progressively since 10m. Then, they leave the place to a non-uniform layer of dead-rhodoliths fragments, mixed with living algae forms interleaved with isolated colonies of Scleractinian corals (e.g. *Montastrea sp.*) and some small patches of red algae (e.g. *Galaxaura sp.*). These observations made by underwater surveys were also correlated with side scan sonar records. In deeper areas (15-20m), the uniform living rhodolith sea beds were recorded again with patches of extensive meadows of *Galaxaura sp.* sometimes covering the rhodolith nodules. Deeper surveys (30m), showed again the presence of large sand ripples with rhodoliths concentrated between them. In the outer zone of the bay, in the western side, in front of a coastal rocky shore, a vast amount of rocky outcrops were intercalated in a big field of living rhodoliths almost uniform from the 5 up to the 30m. As other parts of the bay, the shallow zone (5-10m) of rhodolith seabeds was covered with brown algae.

Finally, the southern studied area called “Praia Grande do Sur”, showed mainly sand bed habitats interspersed by a great quantity of rocky outcrops of various sizes that began on the eastern side of the bay, Ponta Café at 15-20m depth. Underwater surveys denoted that these rocky reefs could occupy hundreds up to thousands of square meters, occasionally reaching more than three meters from the top to the bottom. These microhabitats appeared colonized by different species of gorgonians, also concentrating fish and other invertebrates in the middle of sandy bare areas. In the western part of the bay and close to the area called Praia Sêca, shallow sandy bottoms built small-size ripples mixed with isolated dead-rhodoliths. This pattern is probably extended towards eastern areas, but seawater conditions prevented boat accessibility for scanning. Rhodolith sea bed characterization

Regarding sphericity, the pattern measured in the different studied sites and depths was similar. In general, the shape of rhodoliths can be mainly considered as spheroidal, overall in the shallower habitats. However, ellipsoidal and discoidal slightly trends were observed in the samples collected at 15m and 20m.



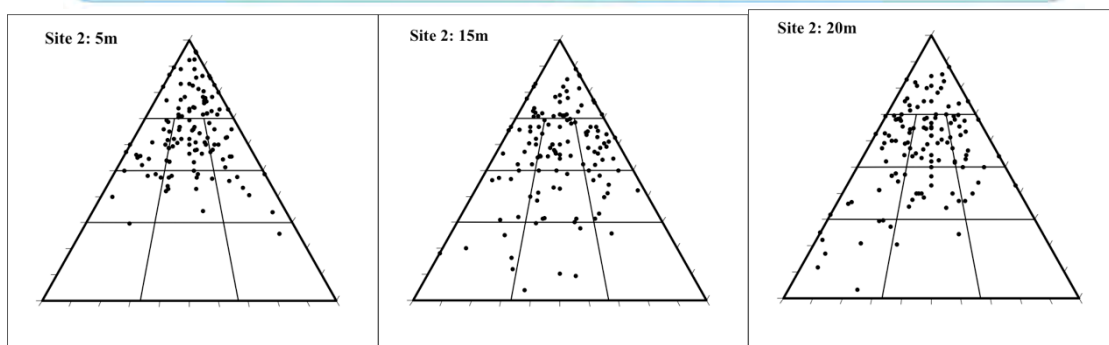


Fig 13. Sphericity diagrams of rhodoliths from sampling depths (5/15/20m) and sites (1/2). a, b and c correspond to long, intermediate and short rhodolith axes, respectively.

MAIN RESULTS

MARINE LITTER: MICROPLASTICS

The main results obtained from the marine litter sampling effort are represented in the Figure 14, which shows the accumulation of microplastics mainly at two different sites: Praia Grande do Sul and Praia Bom Bom, without almost not particles observed in the rest of the sampled areas.

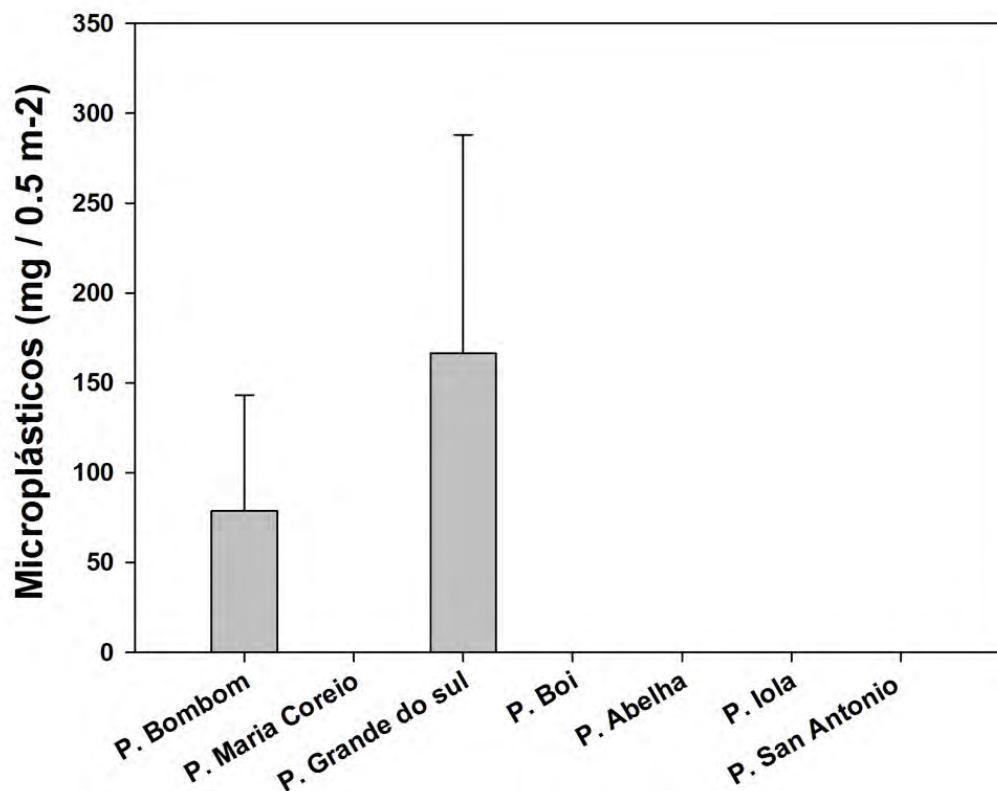


Fig. 14. Distributional pattern of microplastics around Príncipe coastline.



CONCLUSIONS

From the results obtained during the fish population evaluation we can conclude that the low presence of top predators at Príncipe reflect that the inshore waters of the island are subjected to a relevant fishing intensity.

The macroalgal assemblages are dominated by *gla-gla* (=rhodoliths) communities, with diverse species and numerous epiphytic species. Red fleshy macroalgal are dominant species whereas some members of the brown algal genus *Dictyota* may develop thick biomass stands upon the rhodoliths.

The results obtained after the marine habitat mapping of Príncipe, denoted combinations of three different main habitats, with 1) Sandy bottoms, 2) Isolated rocky outcrops and 3) Biogenic bottoms; the last one is more abundant and widespread in the south-west part of Príncipe island (“Baia das Agulhas”).

In Baia das Agulhas area, the presence of these biogenic habitats: *gla-gla* (= rhodoliths) and coral outcrops, seemed to be conditioned by decreases in watercourse inputs from the western part of the bay. Due to its habitat variability and richness, the entire Baia das Agulhas should be considered for future conservation purposes.

Side scan sonar campaign also showed new isolated rocky reefs, potential small-scale biodiversity spots in the North and the South of the island, which will require further and detailed studies to evaluate its sustainable use potentials.

At the same time, it was identified that diverse coastal management actions needs to be implemented in the Baia de Abades, east of Príncipe island. This embayment hosts an important local community closely living from traditional fisheries activities in the surrounding marine and mangrove habitats (e.g. Praia Salgada mangrove).

The coastline of Praia Salgada is been affected by some erosion process threatening the conservation status of the mangrove forest. It seems that this recent coastal erosion it is related to climate change and oceanographic modifications. Future actions are needed to determine the main causes, secure the persistence of the mangrove habitat and, at the same time, increase the living standards of local people.

From a more specialized point of view, the researchers involved in BIO-Príncipe 206 Scientific Expedition are already analysing and extracting more detailed results in the different topics covered along the marine expedition. Those results will be used to produce some scientific papers to be published in specific journals dealing with marine biota, marine mapping, marine litter or ecosystem assessment.



Finally, the diverse interactions between Men and Nature already observed and measured in the coasts and sea of Príncipe Island make necessary the development of innovative Ecosystem Approach Policies in order to promote the well-being of local population and, at the same time, protect its natural heritage.



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ANNEX: MARINE HABITATS MAPPING





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