Collectomics in Mauritania - An integrated biodiversity assessment in underexplored lagoons and the implementation of a scientific reference collection

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„*Ex Africa semper aliquid novi*“

Gaius Plinius Secundus (77ad)

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Zusammenfassung

Die Gewässer des westafrikanischen Landes Mauretanien zeichnen sich durch eine besonders hohe Artenvielfalt aus. Aufgrund der geographischen Lage überschneiden sich die Verbreitungsgebiete tropischer, sub-tropischer und borealer Arten genau vor dessen Küste. Der dadurch entstehende Artenreichtum wird zudem auch durch ein enormes Vorhandensein an Nährstoffen begünstigt, dass infolge saisonaler Auftriebsereignisse vor Nordwest Afrika entsteht. Somit findet man entlang der mauretanischen Küste neben der bemerkenswert hohen biologischen Artenvielfalt, auch einige der ertragreichsten Fischbestände des atlantischen Ozeans. Trotz der enormen Biodiversität sind die Küstengebiete Mauretaniens bisher nur unzureichend untersucht, da sich frühere Forschungsprojekte hauptsächlich auf die Fischerei, Seegraswiesen und das Verhalten der Zugvögel und deren Überwinterung in Mauretanien konzentriert haben. Um diese Lücke zu schließen und um eine wichtige Grundlage für den zukünftigen Meeresschutz in Mauretanien zu schaffen, untersucht diese Dissertation die marine Artenvielfalt Mauretaniens und erstellt eine wissenschaftliche Referenzsammlung der untersuchten Meeresfauna, welche durch moderne Methodiken wie DNA-Barcoding und Digitalisierung integrativ nach dem Prinzip der Collectomics erweitert wird. Hierfür wurden mehrere Ökosysteme entlang der Küste untersucht sowie artisanale Fischmärkte besucht. Im Rahmen der hierfür durchgeführten Feldkampagnen konnten neue, bislang unbekannte Fischarten aus Mauretanien entdeckt und wissenschaftlich beschrieben werden. Die gesammelten Gewebeproben der dokumentierten Fauna wurden genutzt, um die Arten nicht nur morphologisch, sondern auch genetisch zu identifizieren und für zukünftige Arbeiten auch in einer genetischen Datenbank hinterlegt. Zusätzlich wurde die marine Artenvielflat zweier unterschiedlicher Buchten mittels Umwelt-DNA auf die saisonalen Dynamiken sowie den Einfluss von Anthropogenen Stressoren auf die Biodiversität hin untersucht.

Die gesammelten Informationen dienen dazu eine dringend benötigte und solide Grundlage für die mauretanische Biodiversitätsforschung zu etablieren, durch welche zukünftige Biodiversitätsassesments referenziert und potentiell gefährdete Meeresgebiete erkannt und unter Schutz gestellt werden können.

Abstract

The waters of the West African country Mauritania are characterised by a particularly high biodiversity. Due to its geographical location, the distribution of tropical, subtropical, and boreal species overlap off its coast. This resulting species richness is further enhanced by surplus of nutrients, which arises from seasonal upwelling events off Northwest Africa. Consequently, the Mauritanian coastline is home to not only a remarkably high marine biodiversity but also houses some of the most productive fish stocks in the Atlantic Ocean. Despite the significant biodiversity, the coastal areas of Mauritania have been insufficiently studied, as previous research has primarily focused on fisheries, seagrass beds, and the behaviour of migratory birds and their overwintering in Mauritania. To address this gap and to establish an essential foundation for future marine conservation in Mauritania, this dissertation investigates the marine biodiversity of the country and compiles a scientific reference collection of the studied marine fauna, expanded integratively through modern methodologies such as DNA barcoding and digitalisation following the principles of Collectomics. To achieve this, multiple ecosystems along the coast were examined, and artisanal fish markets were surveyed. During the field campaigns conducted for this purpose, new, previously undocumented fish species from Mauritania were discovered and scientifically described. The collected tissue samples of the documented fauna were utilised for species identification and were deposited in a genetic database for future research. Additionally, the marine biodiversity of two different bays was assessed using environmental DNA to examine seasonal dynamics and the impact of anthropogenic stressors on the marine biodiversity.

The gathered data aims to establish a much-needed and solid foundation for biodiversity research in Mauritania, enabling future biodiversity assessments to be referenced and potentially vulnerable marine areas to be identified and designated for protection

Outline and author contributions

This cumulative doctoral thesis includes 12 chapters and starts with a general introduction to Mauritania and the prevailing conditions as well as the previously conducted research projects (Chapter 1). The following two chapters (Chapters 2 and 3) highlight the importance of scientific collections and the development of genetic methods in combination with taxonomy for biodiversity research. Chapter 4 comprises a detailed description of fieldwork methods and laboratory protocols used within this dissertation. The scientific objectives are set out in six peer-reviewed scientific articles that have been published (Chapters 9 and 10), submitted (chapter 5) and are currently in preparation for submission (Chapters 5, 6, and 7). Chapter 11 further explains the detailed connections between the different scientific publications and their purpose in the context of this dissertation. Chapter 12 emphasises the importance of this work for future research projects along the Mauritanian coast.

Chapter 5: **“**Annotated checklist of the marine ichthyofauna of Mauritania from shallow-water habitats and artisanal fish markets” submitted to *CheckList* in June 2024.

Content: Morphological identification of 104 fish species collected along shallow-water habitats and artisanal fish markets in Mauritania. The collected individuals and tissue samples are part of the scientific reference collections of the IMROP and Senckenberg research institutes.

Contribution: The study was initiated by A. Knorrn and A. Freiwald. The samples were collected by A. Knorrn, S. Moctar, M. Sonnewald, N. Aliougne, M. Dia and A. Freiwald during five field trips to Mauritania during the period 2021-2024. A. Niang and M. Dia performed additional surveys at the artisanal fish markets in Nouadhibou. A. Knorrn identified the majority of the collected fish species and assessed the current IUCN red list status for the identified species. A. Knorrn, M. Sonnewald and A. Freiwald analysed the generated data discussed the observations in comparison with already published observations from online repositories such as OBIS (Ocean Biodiversity Information System). All co-authors contributed to both the original manuscript and its improved version.

Chapter 6: **“**Annotated checklist of the marine macrozoobenthos from Mauritanian marine shallow-water habitats” in preparation for *CheckList*.

Content: Morphological identification of 118 marine invertebrate species collected along shallow-water habitats and artisanal fish markets in Mauritania. The collected individuals and tissue samples are part of the scientific collections of the IMROP and Senckenberg research institutes.

Contribution: The study was initiated by A. Knorrn and A. Freiwald. The involved samples were collected by A. Knorrn, S. Moctar, M. Sonnewald and A. Freiwald during five field trips to Mauritania. A. Knorrn, M. Sonnewald, L. Hoffman, E. Tilic, M. Putgignano and A. Freiwald identified the majority of the collected marine invertebrate species. A. Knorrn, M. Sonnewald and A. Freiwald analysed the generated data. All co-authors contributed to both the original manuscript and its improved version.

Chapter 7: **“**Unlocking Mauritania's Marine Secrets: A DNA barcode library for Mauritanian coastal marine biota” In preparation for *Molecular Ecology Resources*

Content: Creation of a CO1 DNA barcode library of the collected fauna (Chapter 5 & 6) with previously morphological species identification. Referencing of the previous identification with a BIN discordance analysis. The 419 new DNA barcodes will serve as baseline for future references for eDNA metabarcoding and are linked to the vouchers of the IMROP and Senckenberg research institutes.

Contribution: The study was initiated by A. Knorrn and A. Freiwald. A. Knorrn, M. Sonnewald and A. Freiwald performed the tissue sampling across five field trips to Mauritania. M. Dia additionally sampled at different artisanal fish markets in Mauritania. The majority of the DNA barcoding was performed by A. Knorrn at the laboratories of biome-id in close cooperation with A. Barco and T. Knebelsberger. The BIN discordance analysis and the preparation of the manuscript was performed by A. Knorrn. All authors edited the corrected proof of the manuscript.

Chapter 8: **“**Seasonal Shifts in Coastal Biodiversity: eDNA Insights from two Mauritanian lagoons” in preparation for *Conservation Biology*

Content: Marine Biodiversity assessment of two distinct lagoons in Mauritania via an eDNA metabarcoding approach from seawater. A comparison between the marine biodiversity during the summer and winter months within a young, facies poor but undisturbed and a geologically older, facies diverse but heavily anthropogenically influenced lagoon.

Contribution: The study was initiated by A. Knorrn and A. Freiwald. A. Knorrn sampled and filtered the water and performed the metabarcoding in cooperation with A. Barco and T. Knebelsberger. The statistical analysis was performed by K. Panksep and V. Kisand in close communication with A. Knorrn. The discussion of the metabarcoding results was performed by A. Knorrn and A. Freiwald. The manuscript was prepared by all co-authors.

Chapter 9: “*Didogobius lanceolatus* spec. nov., a new goby species from Mauritania (Teleostei: Gobiidae: Gobiinae), with diagnoses for two new gobiine genera” published 2023 in *Spixiana*, ISSN 0341-8391.

Content: Description of a new Mauritanian goby species from Mauritania with two additional diagnoses of two new goby genera.

Contribution: A. Knorrn identified the animal as a potential new species of goby and carried out the morphological measurements, previous species identification and the DNA barcoding. U. Schliewen systematically classified the animal and described the head lateral line system, osteology, colouration of the animal and described the two new genera. L. Beuck and A. Freiwald collected the holotype during fieldwork in 2010.The manuscript was written by all mentioned co-authors.

Chapter 10: “*Gaidropsarus mauritanicus* (Gadiformes, Gaidropsaridae) a new three-bearded rockling species from a deep-water coral ecosystem with a genetically verified biogeographical distribution of the genus” published 2024 in Journal of Fish Biology, https://doi.org/ 10.1111/jfb.15859.

Content: Description of a new three-bearded rockling species from a Mauritanian deep-water coral habitat. Additional ROV footage shows a territorial behaviour of the species. In addition, a genetically validated distribution map with depth profiles of the genus was created.

Contribution: A. Knorrn described the holotype morphologically in detail and compared it with of other species. L. Beuck and A. Freiwald collected the holotype during fieldwork in 2010. A detailed species delimitation analysis was carried out by D. Barros-García. The behaviour and sightings of other species associated with deep-water coral ecosystems and the genetically validated distribution map were compiled in collaboration between L. Beuck and A. Knorrn. All co-authors took part in writing the manuscript and performed adjustments during the review process

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Chapter 1
Scientific Background and Objectives

1.1 Objectives

The primary objective of this dissertation is to establish a comprehensive scientific reference collection of the Mauritanian coastal marine fauna. This scientific collection will serve as the baseline for future biodiversity research in Mauritania and adopts a Collectomics approach, which integrates traditional specimen collection with modern techniques, including DNA barcoding and the digitisation of associated metadata. The collected specimens, which are morphologically identified, will form the foundation of a scientific reference collection, while simultaneously generating a linked DNA barcode database. This dataset will not only aid future marine biodiversity research, but will also play a critical role in supporting conservation efforts by pinpointing areas of ecological significance and identifying species at risk. In addition, by performing environmental DNA (eDNA) metabarcoding from collected seawater, this dissertation investigates the seasonal biodiversity dynamics within two structurally different lagoons in Mauritania, offering critical insights into how different environmental factors shape marine ecosystems and their biodiversity. The combination of Collectomics with these modern techniques will provide a valuable resource for both marine biodiversity research and marine conservation, which plays a particularly crucial role in the context of the ongoing Anthropocene-driven biodiversity loss.

To achieve this, the following objectives will be addressed within this dissertation:

I Assessment of the current marine fauna of coastal habitats in Mauritania (Chapters 5 and 6).

II Development of a genetic DNA barcode database of the collected Mauritanian biota from coastal habitats (Chapter 7).

III Seasonal eDNA-based biodiversity assessments of two distinct lagoons in Mauritania (Chapter 8).

IV Description of two new fish species from Mauritanian waters (Chapters 9 and 10).

1.2 Mauritania

Located in northwest Africa, the Islamic Republic of Mauritania covers an area of 1.030.000 square kilometres. The country shares its borders with Senegal, Western Sahara, Mali, Algeria and the Atlantic Ocean. It forms a geographical and cultural bridge between the Arab Maghreb and western Sub–Saharan Africa (Ramos et al. 2017). The Mauritanian waters are part of the Canary Current Large Marine Ecosystem (CCLME), which spreads from the Strait of Gibraltar to the Sierra Leone border (Heileman & Tandstad 2009). Aside from that, the CCLM facilitates upwelling conditions around the Mauritanian coastline, which brings nutrient-rich cold water from the deep to the surface. The coastline of Mauritania extends 755 kilometres along the Saharan desert with a continental shelf area that reaches 110-120 kilometres into the Atlantic Ocean. These shelf areas harbour more than 100 square kilometres of seagrass beds along the coastline (Ly 2009). The extensive seagrass habitat in the Gulf d'Arguin represents the third largest in the world and is a major hotspot for blue carbon sequestration (Chefaoui et al. 2021). A large part of the seagrass-covered area is integrated into the UNESCO World Heritage National Park Banc d’Arguin and is among West Africa’s, as well as of the world’s, most important migratory bird nesting and breeding sites (Ly 2010; Mahfoud et al. 2013). The marine fauna of the Mauritanian continental shelf region is characterised by species from tropical, subtropical, and temperate regions, which overlap in their distributions off the Mauritanian coast (Jaeger 1993; Le Loeuff & von Cosel 1998). Unfortunately, the majority of the marine flora and fauna of Mauritania remains inadequately studied. Previous studies have predominantly focused on commercially significant species and on migratory birds (Wolff et al. 1993, Ramos et al. 2017). This lack of knowledge about Mauritanias marine fauna poses a serious problem, particularly in the context of current biodiversity loss due to human-made climate change and the constant overexploitation of the marine resources. Therefore, a thorough understanding and knowledge of the local ecosystems and their inhabitants is paramount, especially in the light of complex food webs and ecosystem structures. This knowledge is additionally essential to detect large-scale ecosystem changes and their potential effects. This dissertation thus focuses on the assessment and identification of marine fauna along the Mauritanian coast. The generated data provides crucial information on the current biodiversity and helps to pinpoint areas with exceptionally high biodiversity and fragility, making them prime candidates for future marine protected areas. This work additionally creates a scientific reference collection that documents key aspects of Mauritania's coastal marine fauna and provides a solid baseline for future comparative studies. The collection contains morphologically and genetically identified vouchers, following the Collectomics principle by extending the scientific collection with modern techniques like DNA barcoding or the digitisation of the vouchers. The generated DNA barcodes, can be used as references for future genetic species identification and environmental DNA-based biodiversity surveys in Mauritanian waters.

1.3 Geological background of the sampling areas

The two main investigation areas, namely the Baie de l'Étoile and the Bellaat lagoon, are situated in northern Mauritania. More precisely, they are located at the Cap Blanc peninsula (Baie de l'Étoile) and the Cap Sainte Anne coastal plain area (Bellaat lagoon). Throughout its geomorphological development, the Mauritanian coastline has undergone significant changes due to multiple episodes of rising and falling sea-levels throughout its history (Elouard et al. 1969; Ly 2009). The most recent of these events, the Nouakchottian marine transgression, which occurred between 8.000 and 5.000 years BP, played a crucial role in shaping the region's current geomorphological features. However, the Cap Blanc peninsula bears the marks of an even older marine transgression, known as the Aioujian, which took place between 100.000 and 70.000 years BP (Ly, 2009). During the Aioujian period, sea-levels are estimated to have risen by 6 to 10 metres, resulting in the deposition of cross-stratified sandstones, limestone with dissolved shells, and conglomerate formations characterised by marine facies (Diagana 2005). This marine transgression most likely contributed to shape the eastern shore of the Cap Blanc peninsula, including the formation of the Baie de l'Étoile (Figure 1).

At the northern rim of the Tintan peninsula, about 45.28 km southeast of Cap Blanc, is the Cape Saint Anne coastal plain area located. During the Nouakchottian transgression, the progradation of wind-driven sedimentary input formed this coastal plain. The inputs resulted from two different events: sandy littoral ridges of low height, formed by the rearrangement of sands by the action of the sea (littoral drift), and sand flats formed by the joint action of waves and tides. This resulted in a succession of prograding paleo-shores and intertidal zones (Ly & Barusseau 2021). Today, the Mauritanian coastline is primarily shaped by aeolian inputs of Saharan sand resulting from hinterland erosion (Trégarot et al. 2020). Parts of these wind-shaped coastlines are newly formed lagoons, such as the Bellaat lagoon, which was created by the collapse of a coastal dune during heavy rainfall and now forms new marine habitats.

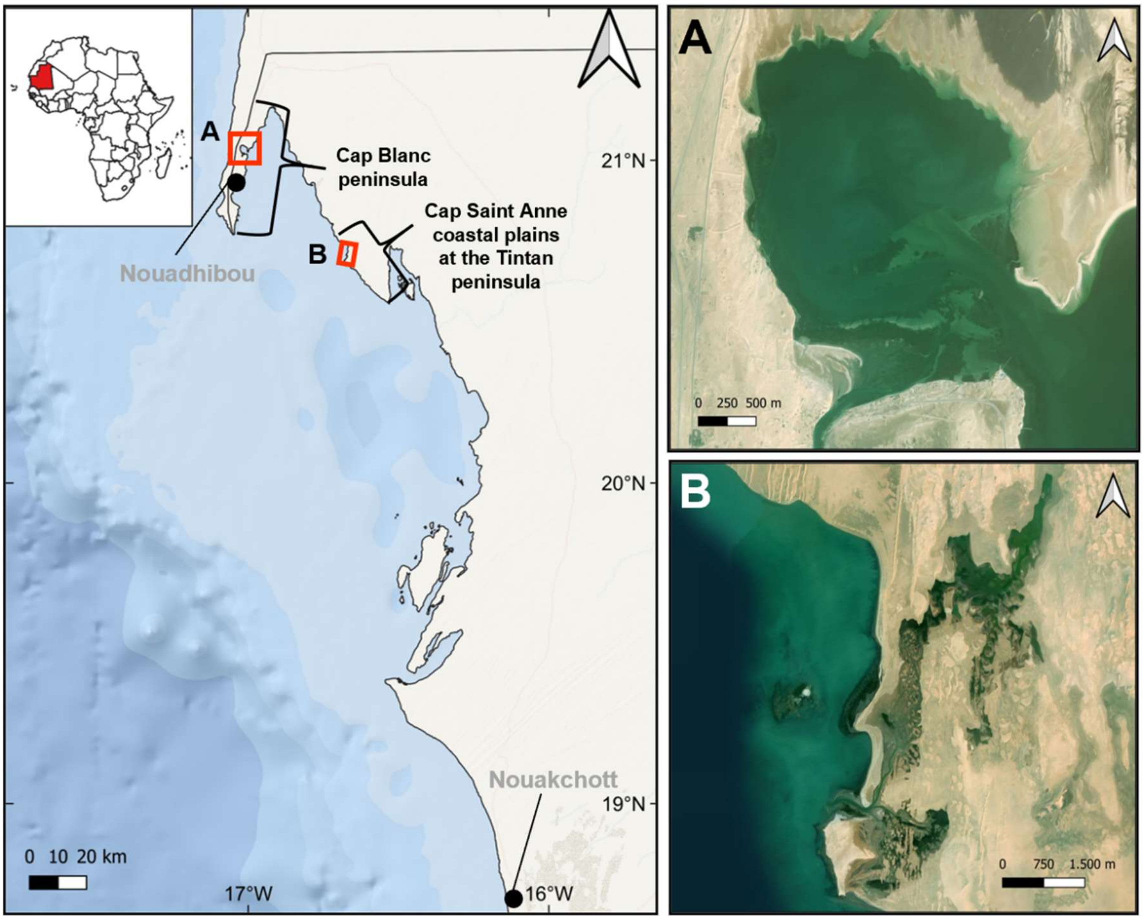

Figure 1: Overview map of the coastal area of Mauritania. Red boxes indicate the two main sampling areas: Baie de l'Étoile and Bellaat lagoon. Basemap from ESRI (2019) (www.esri.com). **A**: Satellite image of the Baie de l'Étoile. Basemap from Bing Aerial Maps (https://www.bing.com). **B**: Satellite image of the lagoon. Basemap from Bing Aerial Maps (https://www.bing.com).

Chains of coastal dunes are the major barrier protecting these flat and almost even coastal plains from storm surges. Therefore, coastal plains are particularly subject to significant mechanical stress from waves and wind. Notably, dunes vegetated with plants like the halophyte *Sesuvium portulacastrum* (L.) L. (Figure

2) demonstrate increased resilience to these mechanical stressors, as the plants prevent erosion of the dunes (Sheela & Uthayakumari 2013). However, with a rising sea level the coastal dunes become prone to erosion up to the point, where breaches may occur, thus flooding the hinterland (Thompson et al. 2017). This already has devastating consequences for populated areas such as Mauritania's capital, Nouakchott, or smaller coastal villages. Without adequate protection, these regions are at high risk of flooding (Senhoury et al. 2016). On the other hand, such events can also lead to the formation of newly ingressed lagoonal environments, such as the Bellaat lagoon (see section 1.3.2).

Figure 2: *Sesuvium portulacastrum* plants at the top of a coastal dune in Mauritania. *Sesuvium* vegetation helps stabilise the dune structure and prevent erosion. © Kristina Hopf.

1.3.1 The Baie de l’Étoile

The Baie de l’Étoile is a relatively old lagoon and was flooded during the Nouakchottian (8.000 to 5.000 years BP). It is located in the northern part of Mauritania (Figure 1A & 3), within the eastern part of the Cap Blanc peninsula facing the Baie du Lévrier in close proximity to the harbour city Nouadhibou. The lagoon extends 2.99 km from north to south, and 2.37 km from east to west. The western area and parts of the northern edges of the lagoon are characterised by sandstone cliffs. Below these cliffs and further to the northwest lies a sebkha (tidal salt/mud flat), which extends along a great sand dune towards the east. The southern part of this sebkha is interrupted towards the southwestern part of the lagoon by a freshwater inlet known as "La Riviere." The remaining southern edge of the lagoon features multiple sandstone layers along the coast. To the east, the lagoon opens directly into the Baie du Lévrier. Approximately 750 metres behind this opening, there is a rocky island surrounded by seagrass, maerl beds and sandy areas. The lagoon is notably influenced by semi-diurnal tidal forces, which seem to have stronger amplitudes between high and low tide during the winter months compared to the summer months (own observation). The tidal range was indicated to be approximately 2 metres by Ly (2009). Similar to the Baie du Lévrier, the Baie de l'Étoile is also a rather shallow area. The edges of the lagoon are, in general, relatively shallow and no deeper than 1.5 metres. A maximum depth of around 5 metres is reached in the middle of the lagoon. The lagoon becomes steadily deeper towards the centre. However, the tidal range of approximately 2 metres must be considered (Ly 2009).

Within the Baie de l’Étoile, different ecosystems have been established during its formation. One of the dominant habitats within the Baie de l’Étoile are the seagrass beds and tidal mudflats. These habitats merge into each other smoothly and typically following a specific sequence. The subtidal zones are predominantly characterised by the little Neptune seagrass (*Cymodocea nodosa* (Ucria) Ascherson, 1870), while in the intertidal areas, *C. nodosa* is replaced by the dwarf eelgrass (*Zostera noltei* Hornemann, 1832). The seagrass beds generally end immediately in front of the tidal mudflats, which are often colonised by the small cordgrass (*Spartina maritima* (Curtis) Fernald). This sequence of habitats is particularly evident along the sebkha areas, the freshwater inlet, and the sand spit within the Baie de l’Étoile. The southern part of the lagoon is characterised by sandstone areas, which form several tidal pools during low tide. Additionally, a pier called Centre de Pêche approximately 130 metres long, provides further artificial hard substrate, where sponges, barnacles, and ascidians have settled. This southern coastal area hosts a diverse array of algae and sponges, with occasional fragments of coralline red algae present. The rocky island (Figure 3C) at the opening of the Baie de l’Étoile offers additional hard substrate for various organisms. Sessile sponges and ascidians grow around the island, and the submerged parts are covered with a variety of algae. Notably, a previously undocumented habitat has been discovered in the hydrodynamic shadow of the island and its vicinity (Figure 3C). This unknown habitat, formed by coralline red algae known as maerl, appears to have developed over the past 30–63 years according to Eyrich (2024) and hosts an expansive diversity of marine organisms.

These different and complex habitats display an astonishing diversity of species in the Baie de l’Étoile and provide important shelter and nursery grounds for the local fauna. The lagoon is also an important refuge for endangered species such as the black chin guitarfish (*Glaucostegus cemiculus* (Geoffroy Saint-Hilaire, 1817)) and milk shark (*Rhizoprionodon acutus* (Rüppell, 1837)), or juveniles of commercially important species such as the brown meagre (*Sciaena umbra* Linnaeus, 1758) and eagle fish (*Argyrosomus regius* (Asso, 1801)) (see Chapter 5). However, the local fauna and flora is under great pressure from man-made plastic and sewage pollution combined with high levels of fishing pressure. In April 2023, for example, a mass mortality event of mugilid fish along the Baie de l’Étoile and the Baie de l'Archiméde occurred, most likely triggered by pathogenic bacteria (*Photobacterium damselae* Love, Teebken-Fisher, Hose, Farmer III, Hickman & Fanning, 1981) (Knorrn & Freiwald 2023). The first detailed biodiversity and geological assessment of the Baie de l’Étoile was conducted by Amadou Ly in 2009 as part of his dissertation, which set a baseline for this dissertation and noted the importance of Baie de l’Étoile area for local marine biodiversity. This work also included the first demand to protect the Baie de l’Étoile as a marine protected area. Since then, an increasing number of projects have been launched over the years by local NGOs and research institutes, confirming the value of the Baie de l’Étoile for local biodiversity and fisheries. As part of these concerted actions, the Baie de l’Étoile officially became a marine protected area and part of the Abidiján Convention by the Mauritanian Ministry of environment and sustainable development at the July 30 2024.

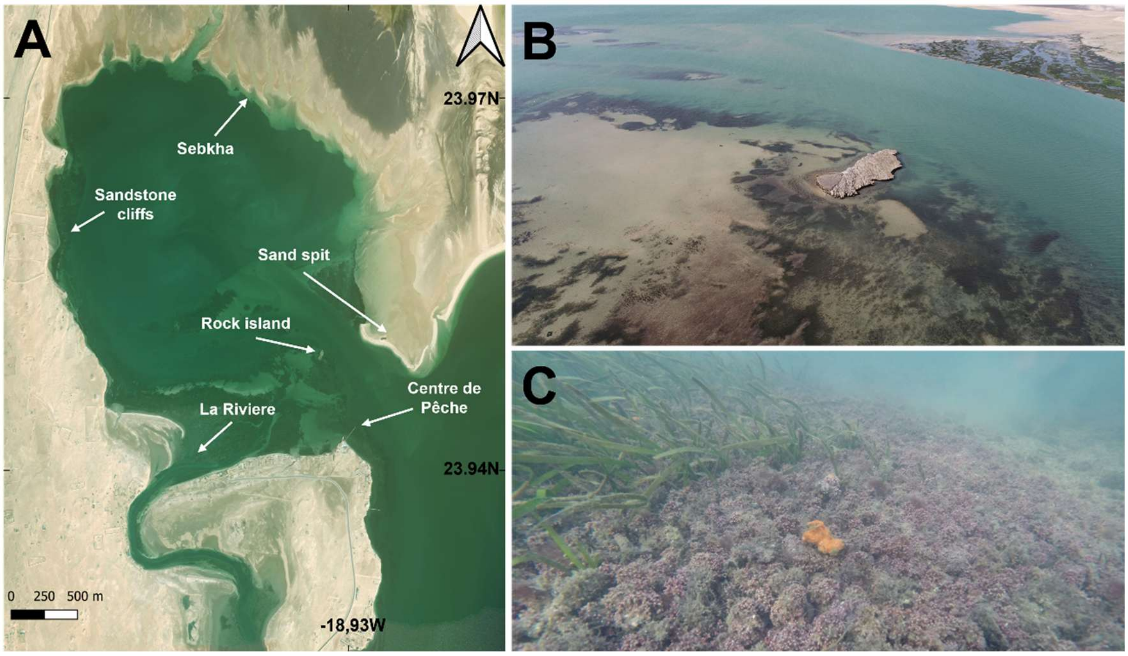

Figure 3: The Baie de l'Étoile in northern Mauritania near the harbour city Nouadhibou: **A**: Satellite Image of the entire Baie de l'Étoile from Bing Aerial Maps. Basemap from Bing Aerial Maps (https://www.bing.com). **B**: Drone image of the rocky island in the centre of the Baie de l'Étoile. Purple maerl ripples are visible in the lower left area of the picture. **C**: Close-up image of the newly discovered coralline algal habitat in the Baie de l'Étoile.

1.3.2 The Bellaat lagoon

A breach of a coastal dune occurred during a heavy rain event at Cap Sainte Anne in August 2013, causing a partial flooding of the desert area (Trégarot et al. 2020). In the following years, an embayment formed in this area, which is now permanently flooded and known as the "Bellaat lagoon" (Figure 1B, 4 & 5).

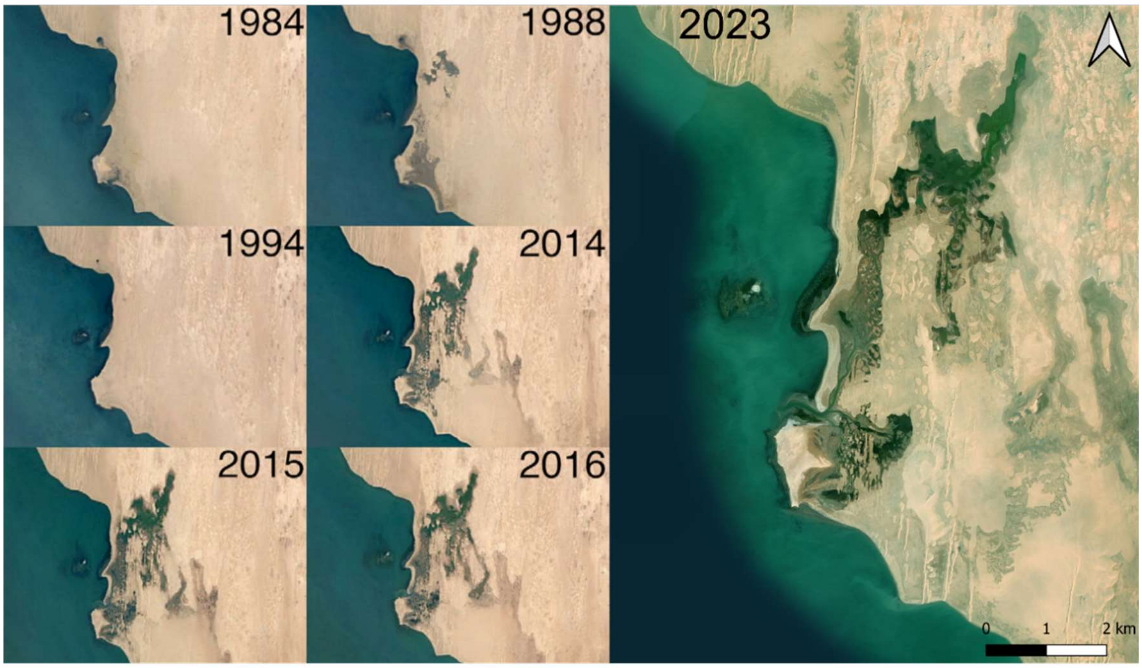

Figure 4: Development of the Bellaat lagoon from satellite imagery. Left images from Trégarot et al. (2020). Left picture from Bing Aerial maps 2023 (https://www.bing.com).

The lagoon comprises an opening approximately 500 metres wide and extends 7.59 km from north to south and 2.10 km from east to west. During high tide, the opening reaches a maximum depth of about 3.4 metres (own observation). The appearance of the lagoon changes significantly with each tidal cycle. During low tide, large areas of the lagoon are exposed, and many small channels within the lagoon have depths of less than one metre, at some parts, even during high tide. The Cap Saint Anne area has historically been subject to flooding events and dune breaches. It has even been used by local fishermen and seafarers. Neolithic shell middens also indicate previous fishing activities around Cape Saint Anne during the late Green Sahara period (See Chapter 1.3).

At the entrance of the lagoon, there is a sand spit which is mainly inhabited by numerous birds. Approximately 2.14 km northeast of the entrance, there is an island formed from sandstone and sand, known as Pelican island. This island is predominantly inhabited by pelicans and forms several tidal pools during low tide. Although the Bellaat lagoon is a relatively young ecosystem, approximately 11 years old, large seagrass beds built by the dwarf eelgrass (*Zostera noltei*) have been established within the Bellaat lagoon, similar to those in the Baie de l’Étoile (Figure 5 C). However, due to the shallow depth of the lagoon, another common seagrass species occurring in Mauritania, the little Neptune seagrass (*Cymodocea nodosa*), has not established itself in the Bellaat lagoon. Seagrass beds in the lagoon are not followed by tidal mudflats vegetated with *Spartina maritima* but are instead bordered inland by further sand dunes covered with *Sesuvium portulacastrum*. The large barrier dune, which is in direct contact with the sea, also shows vegetation with *S. portulacastrum* on its crest. Apart from the seagrass beds, the rest of the Bellaat lagoon is characterised by sand mudflats.

The Bellaat lagoon provides an optimal environment not only for *Zostera noltei* beds (Figure 5 C), but also a habitat for marine organisms like cone snails (*Conus byssinus* (Röding, 1798)), blue crabs (*Callinectes* Stimpson, 1860 sp.), young mugilid fish (*Mugil capurrii* (Perugia, 1892) & *Mugil cephalus* Linnaeus, 1758) to endangered guitarfishes (*Glaucostegus cemiculus*) and cownose rays (*Rhinoptera marginata* (Geoffroy Saint-Hilaire, 1817)). This remarkably young ecosystem seems to act not only as a nursery area for the local fish community but also as a refuge for critically endangered elasmobranch species. Since the area is located within the borders of the National Park of Banc d'Arguin (PNBA), nearly no anthropogenic influence from fishing or human made pollution affects this ecosystem.

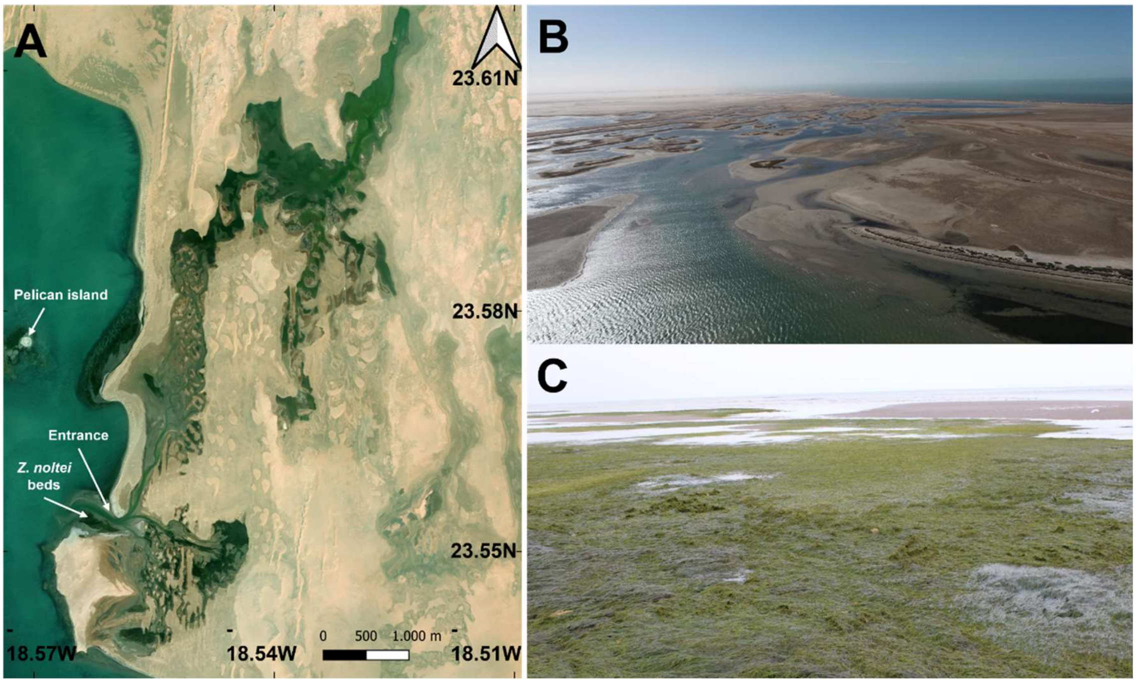

Figure 5: The Bellaat lagoon at Cap Saint Anne. **A**: Satellite image of the Bellaat lagoon. **B**: Drone image of the lagoon entrance during high tide in spring 2023. **C**: A newly established *Zostera noltei* bed in the Bellaat lagoon.

1.3.3 Differences and similarities

Fundamentally, the two lagoons differ significantly in terms of their age. While the Baie de l’Étoile has existed since the Nouakchottian (8.000 to 5.000 years BP) (Ly 2009), the Bellaat lagoon is an extremely young ecosystem, only 11 years old (Trégarot et al. 2020). Over time, the coastal plain of Cape Saint Anne, and the Bellaat lagoon, have been repeatedly flooded and drained, making its ecosystems highly fluctuating. In contrast, the Baie de l’Étoile has remained permanently flooded over the years, allowing for the establishment of much more complex and older habitats. Both lagoons are similar in the dominant presence of subtidal *Zostera noltei* beds. Consequently, both areas play an important role in CO_2 fixation and serve as crucial nursery areas for various marine organisms. Even critically endangered species occur in both lagoons. However, the Bellaat lagoon lacks greater assemblages of hard substrate on which sessile organisms can establish themselves. In contrast, the Baie de l’Étoile features sandstone cliffs, the Centre de Pêche, and a rock island, providing significant amounts of hard substrate that support a variety of marine organisms. This difference should naturally be reflected in the species composition unique to each lagoon. Additionally, the Baie de l’Étoile is subject to significant anthropogenic stressors, such as plastic pollution, wastewater discharge, and intense fishing pressure. Conversely, the Bellaat lagoon, located within the protected area of the National Park d'Arguin, is largely uninfluenced by human-induced stressors like pollution and high fishing pressure. Only local Imraguen fishers are allowed to fish in the area, using traditional methods such as non-motorised boats and handlines (Ly & David 2021). Thus, the anthropogenic stressors impacting the Bellaat lagoon are considerably less severe than those affecting the Baie de l’Étoile. Consequently, in the comparisons throughout this dissertation, it is important to recognize that a young, constantly fluctuating ecosystem with soft bottom habitats such as seagrass beds and mudflats, but nearly no hard substrate therefore facies poor, and relatively minimal human disturbance, is compared to an geologically older, more stable ecosystem that contains soft bottom habitats such as seagrass beds and tidal mudflats as well as hard substrates, therefore facies diverse, and is significantly impacted by human activities.

1.4 The marine resources of Mauritania

Mauritania's economy heavily depends on two key sectors: its rich iron ore deposits and the highly productive fish stocks along its coast, sustained by a coastal upwelling system. The fishing industry plays a crucial role in the national economy, contributing 20% of the country's revenue and 18% of its total exports. Additionally, it provides employment for 40.000 Mauritanians. (IMROP 2014; Ramos et al. 2017). Over the past two decades, the fishing industry in Mauritania has undergone substantial development, as evidenced by the increase in landed catches. The annual catch weight doubled from 200.000 tonnes in 2008 to more than 400.000 tonnes in 2012 (IMROP 2014; FAO 2016). However, this significant increase in fishing pressure, ranging from large commercial trawlers to small-scale fishermen, has led to overfishing, threatening the sustainability of fish stocks vital to Mauritania´s economy. The combined effects of overfishing and anthropogenic climate change pose a serious threat to local marine biodiversity. To establish a sustainable fisheries management in Mauritania, it is essential to investigate the underlying food webs and to develop an ecosystem-based fisheries management approach. This approach requires comprehensive studies to identify which habitats and species are critical and essential for the local food webs, ensuring their protection against collapse. These studies focus not only on target fish species but also on the broader components of the local food web, helping to preserve ecological balance and prevent fish stocks from decline.

The utilisation of marine resources in Mauritania is not a new practice. Evidence of early fishing activities can frequently be found along the Mauritanian coast in the form of shell middens (Figure 6A). These middens date back to between 6.730 and 2.520 years BP (Vernet 2014), providing insights into the species composition of the Mauritanian coast during the late Green Sahara period. These shell middens mainly consist pottery fragments and shells of *Senilia senilis* (Linnaeus, 1758) as well as shells of gastropod species such as *Pugilina morio* (Linnaeus, 1758) and *Bulla striata* Bruguière, 1792 (own observation). The presence of these species, which are still found along the Mauritanian coast today, suggests that seagrass beds have long been an established habitat in the region. *Senilia senilis, Bulla striata*, and *Pugilina morio* are all commonly found near seagrass beds until nowadays, indicating the long-term stability and ecological significance of these habitats.

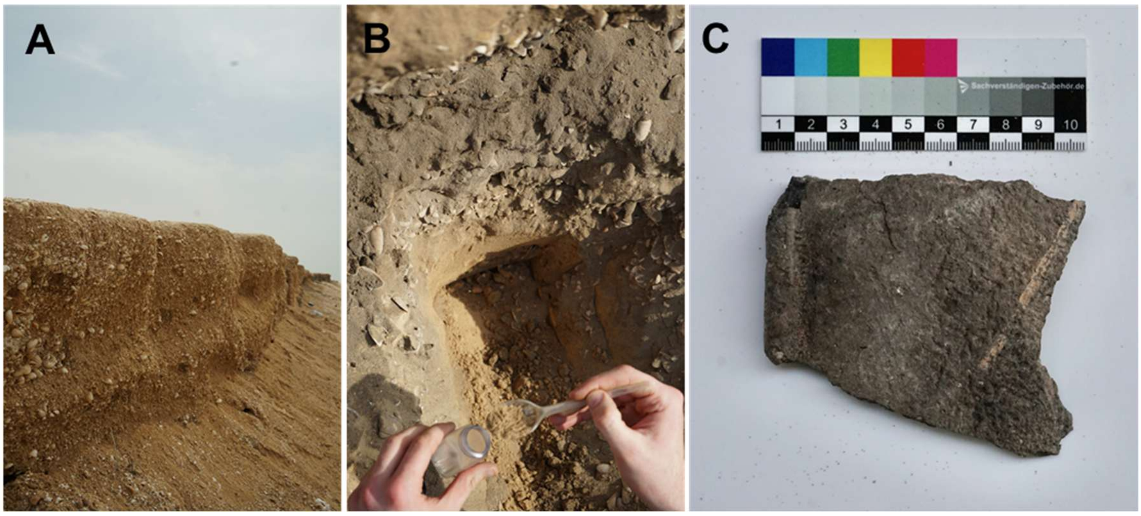

Figure 6: Mauritanian shell middens. **A**: Shell midden on the beach of El Mirador near the Mauritanian capital Nouakchott. **B**: Sampling along various outcrops of the shell midden. **C**: Fragment of a shell clay jug of the Tin Mahham culture from the shell midden near El Mirador (Nouakchott). © K. Hopf: A, B, C.

1.5 Upwelling dynamics

Mauritanian as well as north-western African waters are located within the Canary Current Large Marine Ecosystem (CCLME), which spreads from the Gibraltar Strait to the Sierra Leone border. This region is hydrologically influenced by the Canary Current, which flows southwards along the African coast between 30°N and 10°N and reaches 20°W offshore (Heileman & Tandstad 2009). The waters around Mauritania harbour one of the four largest and productive upwelling areas in the world’s oceans. This phenomenon is driven by wind-induced Ekman transport, which brings nutrient-rich deep waters to the surface. The prevailing north-easterly trade winds along the northwest African coast led to the Ekman transport of surface waters offshore. This offshore movement allows the upwelling of nutrient-rich, cold, and oxygenated waters from the subsurface layers (Stewart 2008), a process known to be particularly intense off the Mauritanian shelf. These upwelled waters carry an abundance of essential nutrients, such as nitrate and phosphate, fuelling primary productivity and supporting a complex food web and ecosystems in Mauritanian waters. The upwelling phenomenon occurs permanently north of Cap Blanc (21°-26°N) and seasonally between Cap Timiris (Mauritania) and Cap Roxo (Guinea-Bissau) (10°-12°N), coupled with the displacement of a thermal front named the Cap Verde Frontal Zone (Pelegrí and Peña-Izquierdo 2015). The Cap Verde Frontal

Zone acts as a boundary between tropical southern and temperate northern waters, which strongly influences the climate and the species distribution along the Mauritanian coast (Bambayé et al. 2010; Mahfoud et al. 2013). Consequently, the upwelling zones off Mauritania are recognised as some of the most productive marine ecosystems globally, playing a crucial role in sustaining the abundance and diversity of west African marine life.

1.6 Marine biodiversity

The influence of upwelling on the marine biodiversity of Mauritanian waters is profound. The enhanced nutrient availability fosters the growth of phytoplankton, forming the basis for highly productive ecosystems. This productivity cascades through all trophic levels, supporting a diverse array of marine life, from microscopic organisms to megafauna. This surplus of nutrients is especially evident in the fishing industry. Some of the most productive fish stocks in the Atlantic are located off the Mauritanian coast. These fish stocks are targeted by large international fishing fleets, whose fishing pressure has increased significantly in recent years (IMROP 2014; FAO 2016; Chapter 1.1.1), leading to the overfishing of some stocks and the associated shifts within the food webs (Gascuel et al. 2007; Braham et al. 2024; Fall & Asiedu 2024). However, not only commercially relevant species benefit from the rich nutrient supply. The permanent high nutrient availability in Mauritanian waters also supports the local ecosystems such as seagrass beds, maerl beds, and coral gardens. The abundance of nutrients ensures that the various trophic levels can become established and that sufficient food is also passed on to higher trophic levels. Additionally, Mauritania's geographical location plays an important role in local biodiversity, as species from tropical, subtropical and temperate regions (Jaeger 1993; Le Loeuff & von Cosel 1998) overlap in their distributions off Mauritania's coasts. Some of the tropical species have their northernmost distribution off Mauritania, while some temperate species, have their southernmost distribution off Mauritania.

The complex interaction between the physical oceanography and the resulting biological responses in the understudied Mauritanian coastal waters highlights the significance of understanding and monitoring these processes. This study aims to examine the intricate relationships between the prevailing oceanographic conditions, particularly upwelling, and the region's marine biodiversity, with a focus on the identification and characterisation of species thriving in these unique ecological niches. Through comprehensive analysis and documentation, we aim to contribute to a more profound understanding of the interconnected dynamics that shape the coastal marine ecosystems off Mauritania.

1.7 Previous research

The Mauritanian marine fauna has repeatedly been the subject of scientific investigations throughout history. This includes the French colonial era, starting with the *Gruvel* Mission (1905) along the Mauritanian coast, and in the immediate aftermath of independence from France in 1960, by the *Thalassa* expeditions (1962, 1968, & 1971), and spanning from the Canary island s to the Banc d'Arguin and extending to the Senegal River. These voyages primarily yielded insights into marine resources such as fishes, crustaceans, and molluscs, and pioneered the mapping of Mauritanian soft bottom communities (Maurin 1968; Maurin & Bonnet 1970; Bonnet et al. 1971; Wolf et al. 1993; Ramos et al. 2017).

Furthermore, the benthic fauna of northern Mauritania was meticulously sampled and studied during the Dutch *CANCAP III* expeditions (1974–1989), elucidating the biogeography and distribution of benthic organisms from the coastline to depths of 400 metres. The Mauritanian shelf and its edge were comprehensively investigated during the *Tyro* Mauritania expeditions (1988), shedding light on the function and interaction of the Banc d'Arguin with the open ocean. During the last few decades, different studies have focused on specific areas or subjects related to marine research in the Mauritanian shelf and continental slope. Since the 1980s, IMROP (Institut Mauritanien de Recherche Océanographique et des Pêches) has carried out biological and ecological research on different aspects of particular commercial species from coastal areas and littoral habitats at the Cap Blanc region, Baie de l’Étoile and Banc d’Arguin (Maigret 1980; Mint 1987; Diop 1988; Ly 2009; Ould Baba 2010). The Major recent biologically-driven offshore expeditions in Mauritanian waters were conducted by German and Spanish multidisciplinary surveys developed on-board the R/V Maria S. Merian (2010) and Vizconde de Eza (2007-2010) (Hernández et al. 2008; Ramos et al. 2010; Westphal et al. 2007; 2012) focused on the research of deep ecosystems on the Mauritanian slope.

Samples of these cruises were additionally used within this dissertation as described in Chapter 4.2. Recently, the cooperation between the Senckenberg Research Institute and the IMROP resulted in the establishment of the WASP project (West African Biodiversity under Pressure). The project initiated the establishment of a scientific reference collection at the IMROP institute in Cansado near Nouadhibou. Building on this foundation, this dissertation, as part of the RESTORESEAS project, investigates the marine fauna and the environmental influences on marine coastal ecosystems, such as seagrass beds and rocky shores and further develops the previously integrated scientific collection. Additional research resulted from samples collected during this dissertation and has led to investigations relating to the growth, taxonomy and hydrodynamics of the maerl beds within the Baie de l’Étoile (Eyrich 2024).

The collected samples serve as additional vouchers for the scientific collections of the IMROP and Senckenberg research institutes. This work will play a crucial role in a new construction project funded by the KfW Bank, which aims to build a new IMROP research institute near Nouadhibou. As part of the collection efforts, a scientific collection with an additional implemented DNA barcode library and the necessary laboratories for DNA barcoding will be established within the planned institute, in close collaboration with the Senckenberg Institute. This current work lays the foundation by providing an initial inventory of samples and DNA barcodes for IMROP.

Thus, most investigations have primarily focused on commercially relevant fish species and migratory birds. Additional missions have focused on deep-sea environments, deep-water reefs, and the Mauritanian shelf region. While these areas were thoroughly examined, coastal zones, such as seagrass beds or tidal mud flats exhibit such a wide range of research opportunities, that even more research, besides the actually conducted research, is needed in order to fully cover and understand the actual marine biodiversity in these ecosystems. This results in a knowledge gap regarding the local coastal and intertidal fauna. This knowledge gap becomes evident when comparing the sample coverage of intertidal areas around the world, highlighting a significant lack of sample coverage for West African and especially Mauritanian coastal areas (Thyrring et al. 2024; see Fig. 7). Additionally, there are almost no studies that address a depth range of approximately 5 to 20 metres, due the difficult conditions in operating in such s shallow area. This area is not easily accessible from land but also to shallow to conduct research with bigger ships due to the relatively high drafts of bigger research vessels. Parts of this region are investigated within this dissertation (Chapters 5, 6, and 8). During a pilot study to cover this depth interval, we discovered previously unknown but vulnerable octocoral forests (see Chapters 5, 6, and 8).

This general lack of knowledge is evident not only evident in the scarcity of museum specimens from this region but also in the absence of a comprehensive collection dedicated to this area. Some samples from older missions are housed in the collections of the Natural History Museums in Paris (France), Leiden (Netherlands) and Malaga (Spain). Furthermore, there is no unified scientific collection adequately representing the Mauritanian coastal fauna that could serve as a basis for future comparative studies.

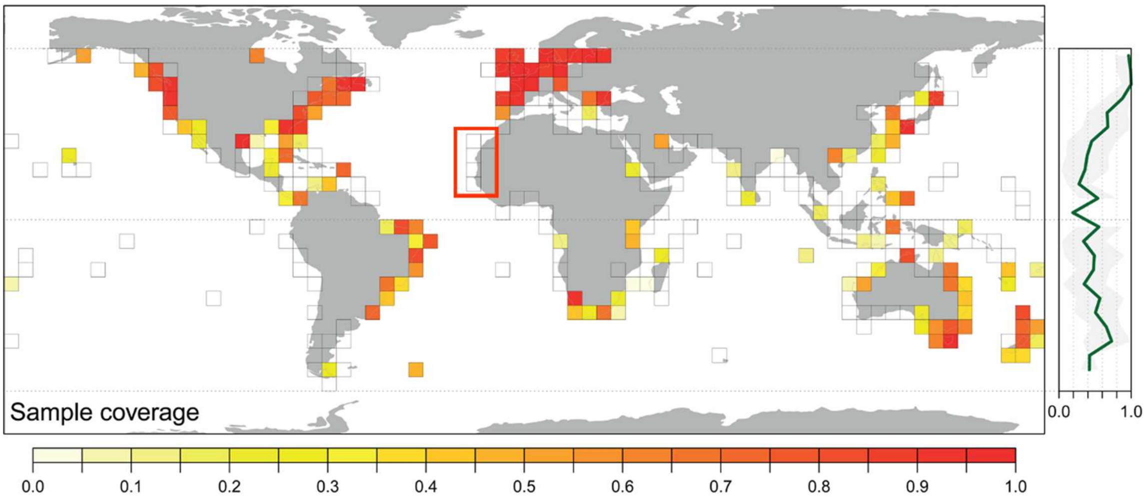

Figure 7: Global distribution map of the intertidal records retrieved from the OBIS biodiversity database. The map shows the sample coverage within 5° resolution grid cells. The subplot on the right side represents the average values per latitudinal band, standardised by the maximum observed range between 0 and 1. Note the paucity of sample coverage along the West African coast. Red frame indicates the West African and Mauritanian coast. Modified from Thyrring et al. (2024).

Another significant gap is the lack of genetic reference sequences for species identification. While commercially relevant species such as fish and lobsters are well represented in online databases like GenBank (https://www.ncbi.nlm.nih.gov/genbank/) and BOLD-Systems (https://www.boldsystems.org/), commercially irrelevant species such as smaller species like bivalves, gastropods, and polychaetes are virtually nearly absent.

This makes species identification, especially for morphologically similar taxa extremely difficult. Additionally, there is a notable absence of reference sequences for environmental DNA (eDNA) assessments, resulting in limited informative value for eDNA samples as there are no reference sequences available (see Chapter 3), thus restricting identifications to a relatively low resolution. Therefore, the establishment of a genetic reference database for the marine fauna of Mauritania is urgently needed for future non-invasive biodiversity analyses, as well as a scientific collection with meticulously identified specimens at the species level, serving as reference.

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Chapter 2
Natural History Collections and their importance for biodiversity research

2.1 Natural History Collections

Natural history collections serve as the primary repositories for diverse natural specimens, including minerals, plants, animals, fossils, and cultural artifacts. These collections are meticulously catalogued, preserved, and curated, holding immense value for scientific research and public education across multiple disciplines (Patterson 2002; Beck & Joger 2018). What began as a cabinet of curiosities for the nobles and the wealthy during the early 16th century (Deblbourgo 2018) (Figure 1A) has nowadays evolved into a fundamental pillar of taxonomic and evolutionary research (Figure 1B). These collections comprise carefully gathered objects resulting from natural exploration, providing insights across temporal, evolutionary and spatial dimensions, allowing comparisons with the current state of knowledge (Schindel & Cook 2018; Lendemer et al. 2020).

Such comparisons enable the tracing of fundamental mechanisms in ecology, biodiversity and climate change, such as shifts in distribution due to climate change, regional extinctions of specific species and the development of new species over time. This knowledge greatly supports conservation efforts (Carter et al. 2001; Sanders et al. 2023) and provides as a baseline for ongoing conservation work. As such, it remains crucial in today's context to maintain and expand natural history collections for the sake of future research. This is especially true, for poorly known groups such as animals with a fragmented habitat and distribution patterns (Patterson 2002; Johnson & Owens 2023).

Scientific collections not only serve as a baseline for conservation efforts, but also provide an important foundation for taxonomic research. By providing previously identified material or facilitating detailed comparisons between species, they enable precise descriptions of the morphological characteristics of various species. In the context of describing new species, such scientific collections represent an indispensable resource for housing the type material. When describing a new species, a so-called holotype is designated, which represents the morphological characteristics of a described species. Additional paratypes may be provided, which belong to the same species and represent the intraspecific variability of the described species. This type material must be deposited in a scientific collection and thereby made available to other scientists for comparative studies (Dubois 2007, Code 1999). Consequently, these collections play an essential role in the description of new species and taxonomic research. Overall, the preservation and continuation of natural history collections is crucial for future biodiversity assessments, taxonomic research and the protection of biological diversity.

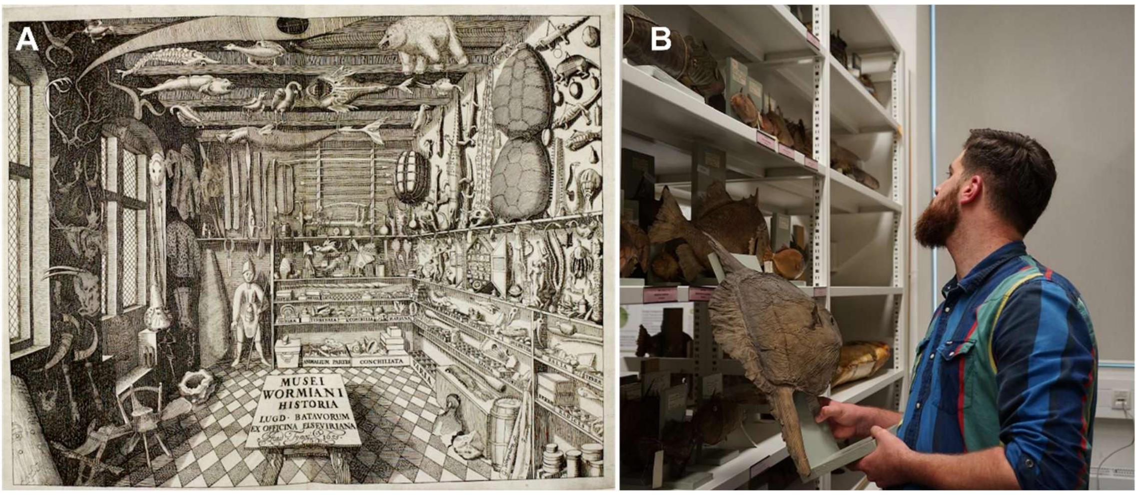

Figure 1: The evolution of natural history collections. **A**: Ole Worm’s Cabinet of Wonder: Natural Specimens and Wondrous Monsters (1655) is one of the first examples of a natural history collection. **B**: A modern example of the dry collection of the ichthyology department at the Senckenberg Natural History Museum in Frankfurt am Main.

2.2 Natural History Collections as a baseline for nature conservation

“One cannot protect something of whose existence one is unaware of”. Designating an area as a protected natural reserve requires a thorough assessment of its species diversity and unique ecological characteristics. This task becomes particularly challenging in poorly explored regions, where the local fauna may be scientifically undocumented (see Thyrring et al. 2024 in terms of sampling coverage in Mauritania). This dissertation focuses on the Mauritanian coastal areas, where the marine fauna exhibits a remarkable high diversity, ranging from gastropods and echinoderms to large fish such as sharks and rays. The local fauna is carefully documented and, whenever possible, preserved for the scientific collections. Thus, a scientific collection of Mauritanian marine fauna is being established at the IMROP (Institut Mauritanien de Recherche Océanographique et des Pêches) institute in Nouadhibou and the Senckenberg Research Institute (Figure 2B). However, the collected specimens are not simply gathered and deposited in a collection. Before that, they are meticulously examined by taxonomists and, if possible, identified at the species level, with the specimen's location precisely documented using GPS data. This ensures the creation of a scientific collection in Mauritania that encompasses a significant portion of the local fauna and illustrates the distribution of the observed species. These collection vouchers can then be used for further scientific investigations. Through comparative studies, threatened species can be identified, and their presence in potentially protected areas confirmed. This allows referenced local biodiversity assessments along the Mauritanian coastline and helps to facilitate the establishment of marine protected areas in Mauritania, by documenting the presence of endangered or important species in the investigated areas.

These assessments become particularly effective, when scientific collections are connected within an integrative approach that includes genetic species identification trough environmental DNA metabarcoding of environmental DNA, which will be described in detail in the following chapters (see Chapter 3).

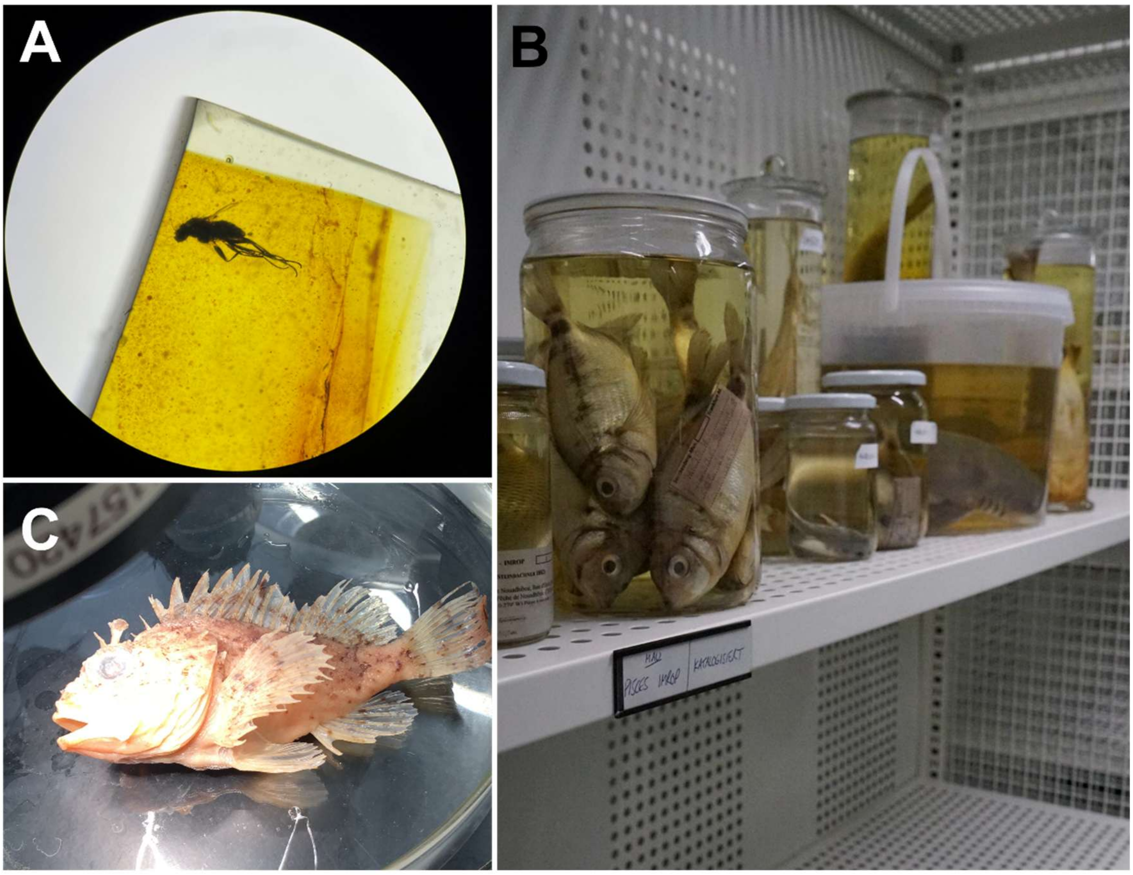

Figure 2: Impressions of vouchers from scientific collections. **A**: An insect embedded in ember, from the National Natural History Museum of China. **B**: Ichthyological samples collected during fieldwork for this dissertation in Mauritania, housed at the ichthyological collection of the Senckenberg Research Institute in Frankfurt am Main. **C**: A spiny sea scorpion from an artificial reef in southern France, preserved in ethanol at the ichthyological collection of the Senckenberg Research Institute in Frankfurt am Main. © A. Knorrn: A, B. © K. Hopf: C

2.3 Digital Collections

With the advancement of digitisation, several new areas for the use of scientific collections have opened in recent years (Lendemer et al. 2020; Johnson and Owens 2023). Typically, museum specimens such as amber (Figure 2A) or fish of a particular genus (Figure 2C) are sent to the corresponding scientists for comparative studies, or the scientists must visit the museum possessing the respective specimen. Such investigations, especially those involving holotypes (specimens serving as a reference for a particular species), are particularly important. Since these specimens hold a significant scientific value, they are usually not available for loan. However, with recent advances in digitisation, there is an increasing trend towards digitising type material for scientific purposes using 3D scans or micro-CT scans (Figure 3A). These digital representations of the type specimens or other scientific vouchers are made available to scientists around the world through online repositories. Consequently, access to museum material is greatly facilitated by digitisation without exposing the material to major risks such as damage or loss during postal delivery. Another new aspect is DNA barcoding, which greatly facilitates phylogenetic studies on preserved specimens and holds great value as reference material for genetic species identifications and the analysis of environmental DNA samples (see Chapter 3). The DNA barcodes are usually uploaded on referenced online data repositories and can be accessed by scientists around the globe. Additional information, such as the locality, depth/height of the locality, and other descriptive information, is usually consolidated under the term metadata. This information is of great value for every scientific voucher. For instance, this information is listed in the Senckenberg institutes collection database (SeSam) for each voucher and is utilised by organisations such as the Global Biodiversity Information Facility (https://www.gbif.org) or the Ocean Biodiversity Information System (OBIS, https://obis.org/) to depict the global distributions of animal and plant species from scientific collections (Figure 3 B) around the world.

A scientific collection, therefore, consists not only of physical objects but also of additional generated information, such as digital resources like DNA barcodes or 3D-models, along with the associated metadata collected during fieldwork. The principle of connecting physical specimens with their digital information and linking them to the world-wide databases is commonly known as the extended specimen network (Lendemer et al. 2020). To utilise such a large amount of data as effectively as possible, the Senckenberg Research Institute has developed a new approach under the term "Collectomics" (Siegward et al. 2021). This approach aims to use a scientific collection comprehensively and interdisciplinarily and to make it available for the widest possible range of uses. Usually, this is done by enhance classical biological sampling methods with modern research techniques such DNA barcoding and the digitisation of the metadata of the vouchers. This approach grants wide access to the vouchers of a scientific collection including new methods for generating additional data (genomics, imaging, and artificial intelligence) and data networking on national and international levels through databases. Such utilisation of a scientific collection enables the full potential of a collection to be realised and additionally allows for the worldwide distribution and use of valuable scientific collection data.

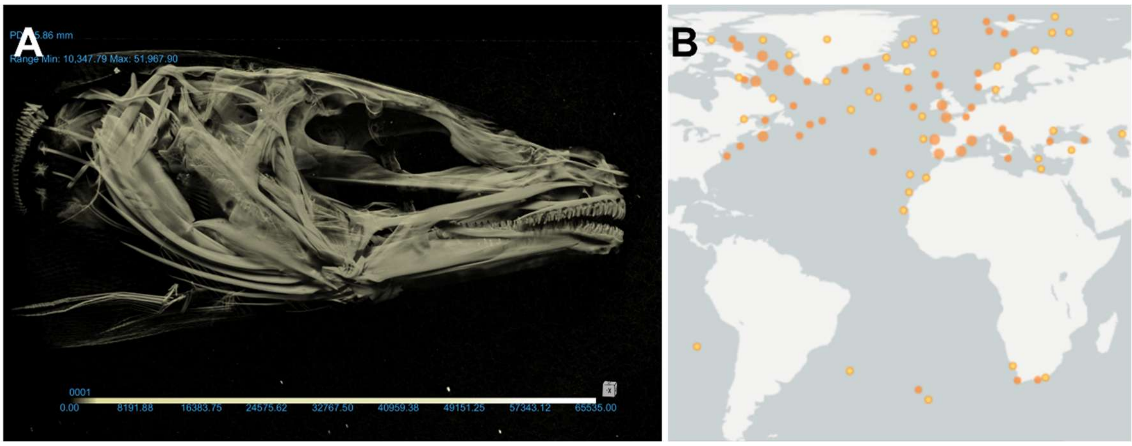

Figure 3: Examples of digitisation of scientific collections. **A**: MicroCT scan of the cephalic region of *Gaidropsarus mauritanicus* Knorrn, Beuck & Freiwald 2024. **B**: Image of the distribution of the three-bearded rocklings (*Gaidropsarus* sp.) based on metadata from scientific collections, gathered by the Global Biodiversity Information Facility (https://www.gbif.org/). © R. Britz: A, © A. Knorrn: B.

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Chapter 3
Genetics and Biodiversity

3.1 DNA Barcoding

Species identification and classification have traditionally been the specialised domain of taxonomists, providing a nomenclatural backbone and foundation for numerous biological studies. However, molecular species identification and classification are nowadays another domain not only used by taxonomists. Molecular species identification is more frequently referred to by the term DNA barcoding. DNA barcoding is a genetic system that provides rapid, accurate, and automatable species identifications by using short, standardised DNA sequences as species tags (Hebert & Gregory 2005; Mitchell 2008; Riehl et al. 2024). DNA barcoding accelerates species discovery and identification by allowing taxonomists to rapidly sort specimens and highlight divergent taxa that may represent already known or new species. By augmenting their capabilities, DNA barcoding offers taxonomists the opportunity to greatly expand, and eventually complete, a global inventory of living organisms. DNA barcodes are stored in online repositories or databases such as GenBank (https://www.ncbi.nlm.nih.gov/genbank/, Ratnasingham & Hebert 2007) or the Barcode Of Life Data System (https://www.boldsystems.org/). Additionally, DNA barcoding as a technique is also useful for scientists from other fields like forensic science, biotechnology, and the food industry (Valentini et al. 2008).

3.2 Environmental DNA

Environmental DNA (eDNA) is a key component in various research fields such as ecology and biodiversity research (Taberlet et al. 2018; Lejzerowicz et al. 2021; Cordier et al. 2022). It has proven to be a useful method for biodiversity assessments, monitoring purposes and even for single-species-detection (Tréguier et al. 2014; Nathan et al. 2015; Lejzerowicz et al. 2021; Cordier et al. 2022). However, the question arises — what exactly is eDNA? Environmental DNA is defined as a complex mixture of genomic DNA from many different organisms found in an environmental sample (Taberlet et al. 2012). An environmental sample is therefore considered to be a sample of soil, sediment, water, and even faeces, but it can also include material obtained from filtering air or water. These samples contain genetic information about the majority of species occurring in the area surrounding the sample. Depending on the purpose of one's research, different methods can be applied to generate specific information out of those environmental samples. One can either identify the different taxa present in an environmental sample by conducting a polymerase chain reaction (PCR) targeting a specific group, a process known as metabarcoding (Mullis & Faloona 1987; Saiki et al. 1988) or to determine the presence/absence of a specific species by using a quantitative PCR approach (Logan et al. 2009, Taberlet et al. 2018). The present dissertation, however, focusses exclusively on the metabarcoding approach to determine marine biodiversity. During the metabarcoding process, DNA from an environmental sample is amplified by a specific primer that only binds to the DNA of a particular taxon (for example, fish or invertebrates). This DNA is replicated multiple times during several PCR cycles. The PCR product is then sequenced and the genetic barcodes of each different species within the environmental samples are generated. These sequences can now be used to compare them with already identified DNA barcodes from a reference database in order to determine the species occurring in the investigated area. However, working with eDNA is not entirely straightforward, as there are several methodological constrains that need to be considered. The major constraints are described below.

3.2.1 Contamination and preservation of samples

Working with a highly sensitive method such as metabarcoding harbours several challenges. One of the primary priorities in sampling is to avoid contamination of the sample with your own or other unwanted DNA. This necessitates strict sampling procedures; for example, the seawater sampling container must be decontaminated using hypochlorite before each use. If the sampled water or sediment cannot be filtered immediately, the samples must be kept cool they are processed, in order to prevent DNA degradation. The filtering of seawater has to be conducted under the most sterile conditions possible. For each filtration, a new sterile single-use filter must be employed, and the working environment should be decontaminated between every sampling procedure. Filters containing the environmental DNA were preserved in a 99.8% ethanol solution. Further laboratory work was carried out under working benches that were decontaminated using UV light. Negative control samples with distilled water were used to check that the filtering process did not result in contamination of the samples.

As described, working with such a sensitive method requires a lot of prior planning, both in terms of organisation and especially in situations where reliable laboratory infrastructure is unavailable.

3.2.2 Reference databases

A primary objective of DNA metabarcoding is to assess the taxonomic composition of an environmental sample. To create such an assessment, the generated DNA sequences need to be taxonomically identified. Taxonomic identification is based on comparing the unidentified sequences against a reference database containing pre-identified sequences (Taberlet et al. 2018). This suggests that the quality of results obtained from metabarcoding heavily depends on the quality and completeness of the reference database used. For the evaluation of eDNA, this implies that certain taxa are more suitable for eDNA investigations than others. This can partly be attributed to commercial interest in these animal groups. In the case of fishes, there is generally a good availability of genetic reference sequences due to their commercial relevance and for food inspection purposes. However, this situation is different for marine invertebrates such as molluscs or polychaetes, where only a few reference sequences are available in online databases. Additionally, the availability of data varies by region. For instance, there is a relatively good data availability for non-commercial relevant species in the North Sea based on numerous previously conducted scientific projects in this area. However, fin other regions with less sample coverage, there is a lack of usable data for relatively poorly studied areas, such as the West African coast. Here, the data foundation is relatively weak, with only a few commercially utilised species having been sequenced. This naturally complicates the evaluation of environmental DNA and only allows the recognition of trends at a very broad resolution.

3.2.3 Significance of the results

Another significant consideration is the validity of the generated results. In this regard, it is advisable to maintain consistent laboratory and storage conditions across all samples to ensure comparability. Furthermore, careful attention should be paid to the conditions of sample collection, as they can directly influence the validity of the findings. For instance, in the case of filtered water samples, it may not be impossible to accurately assess the biodiversity of a specific area (e.g. a seagrass bed) due to the continuous movement of the water body. This ensures that filtered water may have passed through multiple ecosystems during tidal cycles, transporting DNA from the fauna inhabiting those ecosystems. As outlined in the concept of an environmental sample (3.2), this mixture of DNA may contain traces of various life forms present in the vicinity. Therefore, this possibility must always be considered when interpreting such data. Consequently, these results can be analysed within a broader context, and statistical correlations may still reveal potential relationships and similarities among certain ecosystems.

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Chapter 4
Material and Methods

4.1 Sample collection

The marine biodiversity of the Mauritanian coast was investigated during five field trips (see Table 1). These field trips aimed to investigate species diversity of Mauritanian marine forests and other coastal habitats along the coast and to implement a scientific collection with genetic reference barcodes at the IMROP (Institut Mauritanien de Recherche Océanographique et des Pêches) and Senckenberg Research Institute.

The primarily sample collection sites were in conducted in the Baie de l'Étoile in northern Mauritania, close to the harbour city Nouadhibou and the Bellaat lagoon within the borders of the UNESCO World Heritage National Park Banc d'Arguin. Additional sampling was conducted around the littoral area of Cap Blanc, a sandstone beach south of Port Tanit, and the seagrass beds around Kijji island and around the Agadir island. Further sampling was conducted at the fish markets in Nouadhibou and Nouakchott (Figure 1). A complete list of the sampling stations can be seen in Chapter 13 (Appendix) at the Table 13.1.

To cover a wide range of habitats, samples were collected using various methods, including hand collections, fish traps, gill nets, beam trawls, ganchorra (a Portuguese version of a dredge, Figure 2E) hauls, sterilised tissue sampling, and sediment coring. Additionally, water samples were collected at 21 stations during summer in 2022 and winter in 2023. These water samples were used to determine the biodiversity of Mauritania's marine forests using an environmental DNA metabarcoding approach.

Table 1: List of field trips to Mauritania and the specific areas investigated during the different campaigns.

Fieldwork	Study areas						
	Baie d'Etoile	**Bellaat lagoon**	**Cap Blanc**	**Kijji island**	**Fish Market Nouadhibou**	**Fish Market Nouakchott**	**Port Tanit**
30.11.2021 – 04.12.2021	●						
23.07.2022 – 31.07.2022	●	●			●		
15.02.2023 – 10.03.2023	●	●	●		●		
19.06.2023 – 20.06.2023		●		●		●	
20.01.2024 – 08.02.2024	●	●	●			●	●

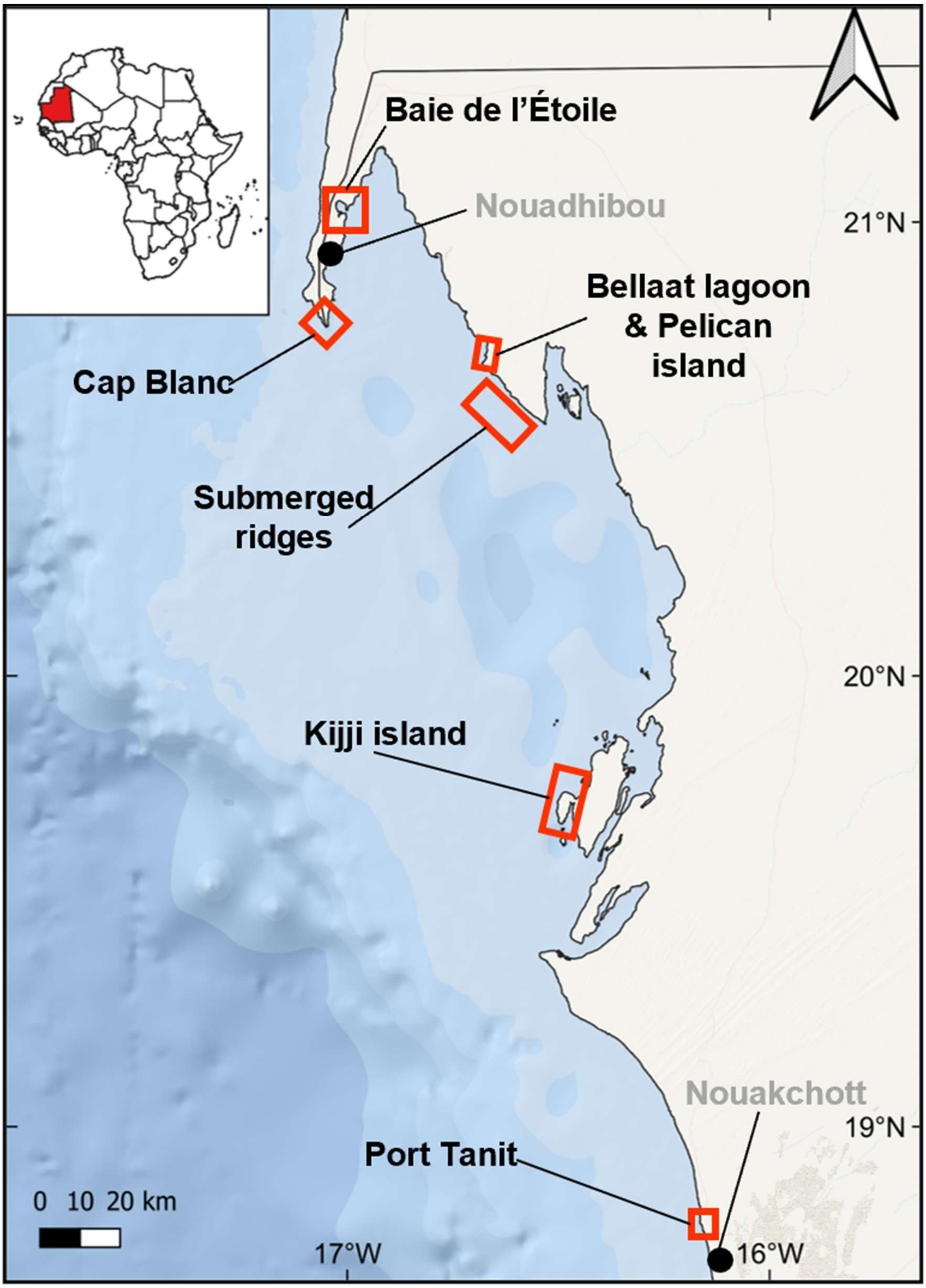

Figure 1: Geographical map of sampling areas along the Mauritanian coastline. The green area indicates the UNESCO World Heritage, National Park Banc d'Arguin. Basemap from ESRI (2019) (www.esri.com).

4.2 Sample treatment

All collected samples were briefly identified in the field and photographed to capture the living colouration. Small individuals, less than 10 cm in length, were preserved in 70% ethanol, while larger specimens were preserved in a 4% freshwater formaldehyde solution, with a tissue sample additionally preserved in a 96% ethanol solution for DNA barcoding. Vertebrate and cephalopod specimens were euthanised with an overdose of clove oil as an anaesthetic prior to the preservation. Tissue samples from the artisanal fish markets were sampled from the dorsal or pectoral fin in fish and from the fifth pereopods in crustaceans and immediately preserved in 96% ethanol.

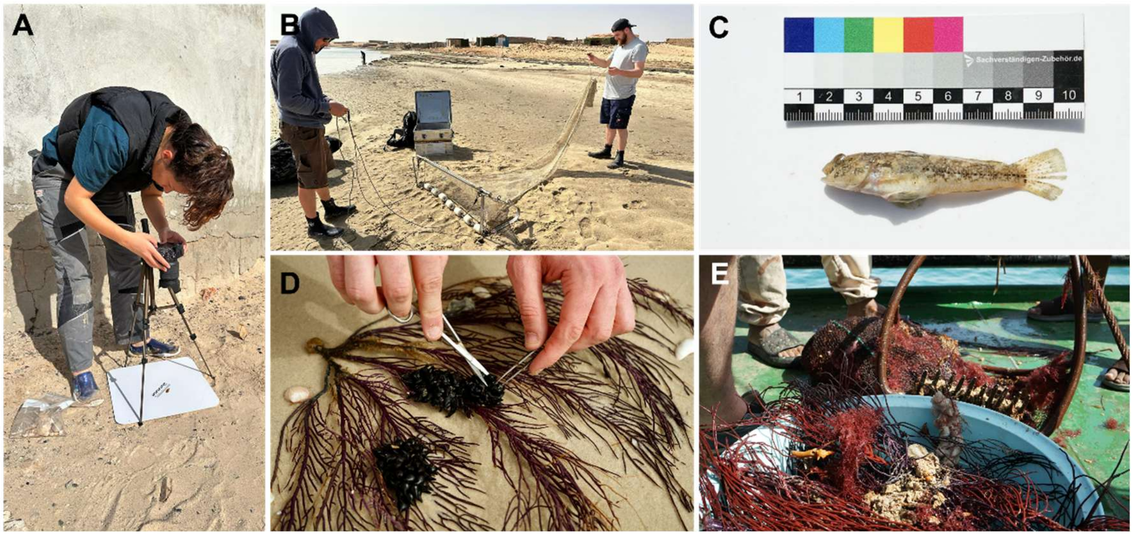

Figure 2: Fieldwork impressions. **A**: Photo documentation in the Baie de l'Étoile during fieldwork. **B**: Preparation of a beam trawl for benthic sampling. **C**: Photography of *Gobius niger* for capturing the live colouration of the specimen. **D**: Sampling of cephalopod eggs (*Sepia* sp.) from a washed up *Leptogorgia* sp. **E**: Ganchorra sample from a submerged ridge field on board the research vessel *Amrigue.* © A. Freiwald: A, © K. Hopf: B, C, D, E.

All samples were sent to Germany via air freight. Upon arrival in Germany, tissue and eDNA samples were stored at -20° Celsius until further laboratory treatment at Senckenberg am Meer (Wilhelmshaven). Once in Wilhelmshaven, the specimens were identified to species level using specialised literature, with additional involvement from taxonomists specialised in the corresponding animal group (Table 2). The samples were then photographed in high resolution. All samples were integrated into the scientific collections of the Senckenberg Research Institute in Frankfurt am Main and the IMROP Institute in Nouadhibou. Each sample was treated as a voucher with its own Museum Identification

Number (SMF, SAM & IMROP), and the collection data was implemented into the SESAM catalogue system as open-access information. The SESAM data is mirrored into the database from the Global Biodiversity Information Facility (GBIF, https://www.gbif.org/), and the generated DNA Barcodes are available to the public via the Barcode Of Life Data System (BOLD-Systems, https://www.boldsystems.org).

Table 2: List of involved taxonomists, their specialised taxon, and institutes, contributed to the species identifications conducted during this dissertation.

Name	Institute	Phyla
Dr. Ulrich K. Schliewen	Bavarian State Collection for Zoology	Pisces (Gobiidae)
Enrico Schwabe	SNSB	Mollusca (Polyplacophora)
Prof. Dr. Carsten Lüter	Museum für Naturkunde Berlin MUSEUM FÜR NATURKUNDE BERLIN	Brachiopoda
PD. Dr. Ekin Tilic	Senckenberg Research Institute	Polychaeta
Leon Hoffmann	SENCKENBERG world of biodiversity	Mollusca (Bivalvia & Gastropoda)
Dr. Moritz Sonnewald		Crustacea
Dr. Sabine Stöhr	Swedish Museum of Natural History Naturhistoriska riksmuseet	Echinodermata

Additional fish and mollusc samples were gathered during the RV Maria S. Merian cruise MSM 16/3 “PHAETON” – Paleoceanographic and paleoclimatic record on the Mauritanian Shelf (Westphal et al. 2012). The studied samples were collected using a Van Veen grab. The specimens were morphologically identified and genetically barcoded. A detailed morphological description of the species was conducted in the case of a new species (*Didogobius lanceolatus* Schliewen, Knorrn & Boehmer 2023) (Chapter 9) and *Gaidropsarus mauritanicus* (Knorrn, Beuck & Freiwald 2024) (Chapter 10). Additional X-ray photography (Figure 2B) and detailed photo documentation of the cephalic lateral line system (Figure 2A) were conducted for both species. An additional high-resolution X-ray micro-computed tomography of the cephalic region of *G. mauritanicus* was performed with a Zeiss X-Radia Context at the Senckenberg Natural History Collection in Dresden, Germany (Figure 2C). The two new species were compared with other closely related species from the same genus to distinguish them from all other congeners.

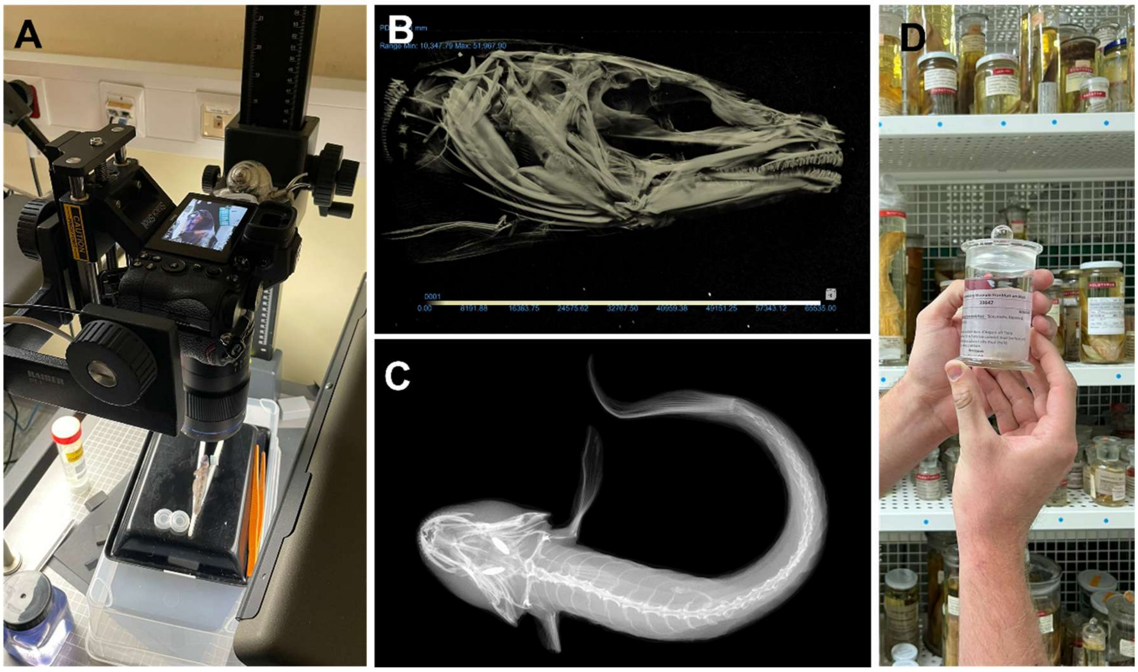

Figure 3: Ichthyological work impression: **A**: High resolution imaging of the cephalic lateral line system of *Gobius senegambiensis*. **B**: High resolution micro-CT scan from the cephalic region of *Gaidropsarus mauritanicus*. **C**: X-ray imageof *Didogobius lanceolatus*. **D**: Final storage of the holotype of *Didogobius lanceolatus* at the ichthyological type collection at the Senckenberg Research Institute in Frankfurt am Main. ©: A. Knorrn: A, © R. Britz: B, © U. Schliewen: C, © K. Hopf: D.

4.3 Laboratory work

The laboratory work was performed at biome-id laboratories in Wilhelmshaven, Germany.

4.3.1 DNA-Barcoding operations

The genomic DNA of 327 samples was extracted using the Macherey-Nagel Genomic DNA from a tissue kit. All samples were amplified at the CO1 (mitochondrial cytochrome c oxidase subunit 1) barcode locus. Fish samples had a target length of 660 base pairs excluding primer binding sites, and were amplified by using a cocktail of two forward (pUC-VF2-t1 & FishF2-t1) and two reverse (pUC-FishR2-t1 & FR1d-t1) primers. Decapod samples had a target length of 675 base pairs, excluding primer binding sites, and were amplified using CrustCOI-F and DecapCOI-F primer pairs (Teske et al. 2009). Molluscs and other invertebrates had a target length of 570 base pairs, excluding primer binding sites and were amplified by jgLCO1490 and jgHCO2198 (Geller et al. 2013). Additional M13 forward and reverse tails were added to the used primer pairs for al taxa to provide defined nucleotide sequences for sequencing (Ivanova et al. 2007). All PCR products were amplified using One Taq 2x Master Mix (New England Biolabs, Frankfurt am Main). The PCR thermal conditions included an initial denaturation at 94°C for 3 min, followed by 35 cycles at 94°C (denaturation, 20 s), 48°C (annealing, 30 s), 68°C (extension, 45 s), and a final extension at 68°C for 5 min. All PCR reactions were conducted using an Eppendorf Mastercycler Pro system (Eppendorf, Hamburg, Germany). In the case of PCR, failure amplification was repeated using AccuStart II PCR Though Mix (Quanta Bio, Baverly, USA) with 40 instead of 35 cycles during the PCR. PCR products were checked using a 1.6-1.7% agarose gel and were purified by incubating them with a mix of FastAP and Exonuclease I. Bidirectional barcoding was conducted for every sample at the Macrogen Laboratories in the Netherlands. The resulting sequences, corresponding metadata, and voucher information were uploaded to the Barcode Of Life Database (BOLD). The data is accessible on BOLD in the dataset (MAU - Mauritanian marine life barcode library).

The generated sequences were assembled and edited using Geneious, version 5.4.5., created by Biomatters (available from http://www.geneious.com/). The edited sequences were aligned using MUSCLE (Edgar 2004) implemented in MEGA11. Intra- and interspecific nucleotide variability was analysed using the Kimura 2-parameter model through the "Barcode Gap Analysis" tool on BOLD (Puillandre et al. 2012). Highly similar sequences were assigned to a globally unique identification number, the Barcode Index Number (BIN). BINs were calculated for the whole data set, and discrepancies between species clusters were revealed using BOLD's "Bin Discordance Report" function (Ratnasingham & Hebert 2013). A neighbour-joining tree was constructed using MEGA11 to graphically represent nucleotide divergences based on the Kimura 2-parameter distance clustering for fish, crustaceans, molluscs, other invertebrate groups, and algae. A non-parametric bootstrap support was built upon 1000 replicates. The previous made alignments and the K2P NJ tree was uploaded to TreeParser, producing an output FASTA file that followed the terminals in the tree.

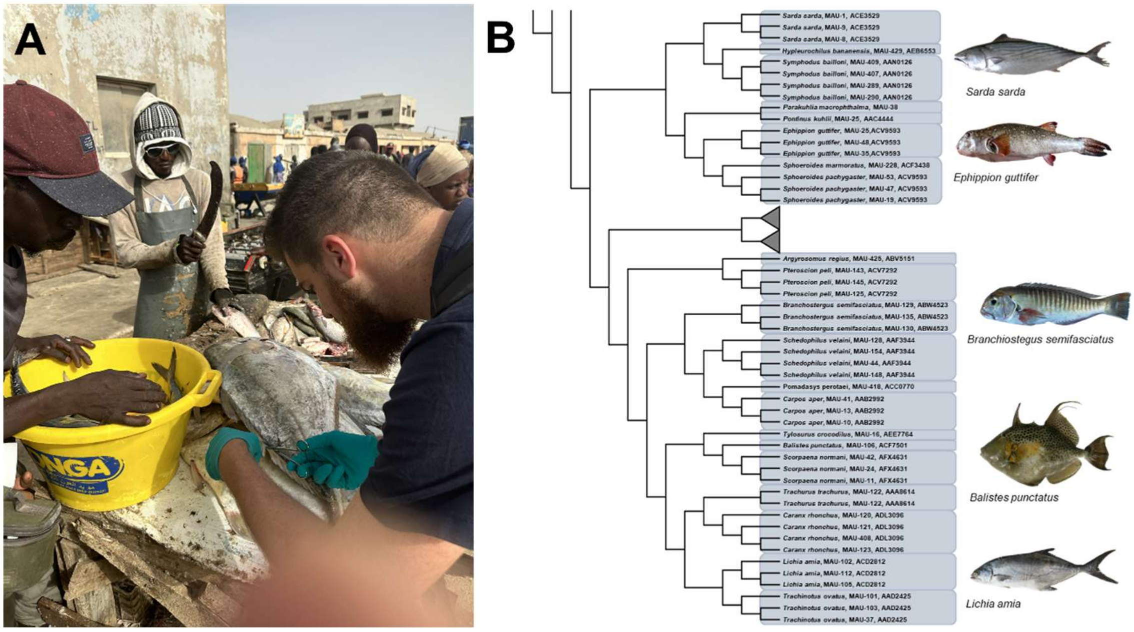

Figure 4: DNA Barcoding impressions. **A**: Tissue sampling at the Nouakchott fish market. The samples were taken as sterile as possible. **B**: Phylogenetic Neighbour-Joining tree created from tissue samples from Mauritania. © André Freiwald: A, © Alexander Knorrn: B.

4.3.2 Environmental DNA-metabarcoding operations

Water samples were collected using a Niskin bottle positioned in close proximity to the seabed. Prior to use, the Niskin bottle was rinsed with 8% chlorine bleach to neutralise any DNA residue. Additionally, the Niskin bottle was rinsed at each station with seawater from that station before being used. The collected seawater was then transferred into a clean, previously sealed bottle and cooled with ice until processing. The collected seawater was filtered in the most sterile environment possible, at IMROP in Cansado and on board the research vessel Amrigue. This process involved filtering 0.5 L of the collected water through sterile disposable filters with a mesh size of 0.45 µm, after which the filters were stored in 99.8% undenatured ethanol until it was processed in biome-id's laboratories. The filters were air-dried, cut into pieces, and suspended in lysis buffer and proteinase K (Macherey-Nagel, Düren, Germany). The lysate was then used for eDNA extraction, following the NucleoSpin Tissue Kit (Macherey-Nagel, Düren, Germany) protocol.

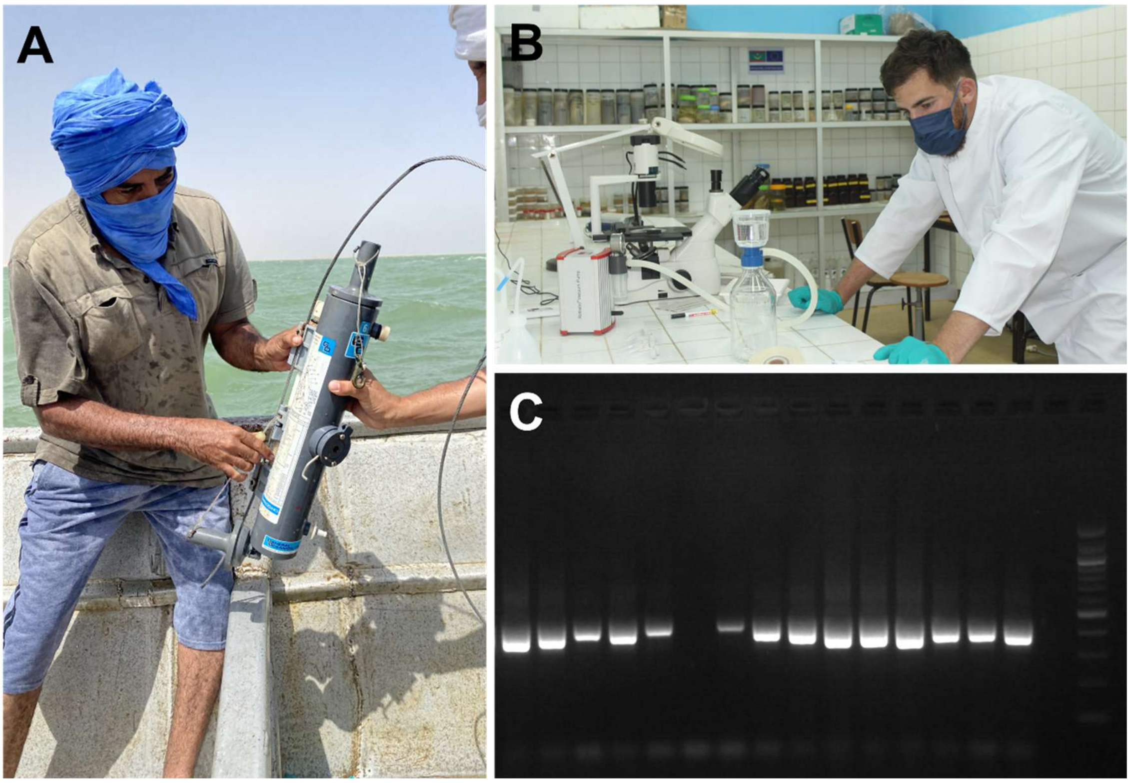

Figure 5: Environmental DNA sampling and analysis impressions. **A**: Water sampling with a Niskin bottle. **B**: Seawater filtration under most sterile conditions possible at the IMROP laboratories. **C**: PCR product verification using a 1.5% Agarose gel. © André Freiwald: A, © Alexander Knorrn: B, C.

The eDNA extracts were used as templates to amplify a 313 bp fragment of the cytochrome c oxidase I (*COI*) gene using the primers mlCOIintF (Leray et al. 2013) and jgHCO2198 (Geller et al. 2013). A fragment of the mitochondrially encoded 12S gene was also amplified using the MiFish universal primer pair (https://royalsocietypublishing.org/doi/full/10.1098/rsos.150088). Each primer was modified to include 5‘ Illumina overhang adapters. Correct amplicon amplification was verified via electrophoresis on a 1.5% agarose gel, and the PCR products were then purified using the NucleoMag NGS Clean-up kit (Macherey Nagel, Düren, Germany). Dual indexes and Illumina sequencing adapters were attached to the amplicons using the Nextera XT Index Kit (Illumina Inc., San Diego, CA, USA), following the manufacturer‘s protocol. The amplicons were then purified again using the NucleoMag NGS Clean-up Kit. The libraries were quantified using the Promega Quantifluor ONE dsDNA system (Promega, Mannheim, Germany) and pooled equimolarily. The pooled libraries were sequenced on an Illumina MiSeq system using the 2 x 300 bp paired-end read module.

Paired-end reads were assembled using VSEARCH (v. 2.18.0, Rognes et al. 2016), with a minimum overlap of 100 bases between paired-end reads. Assembled reads were then demultiplexed according to the sample-specific dual indexes using cutadapt (Martin 2011). All contigs were then filtered for uncalled bases ("N") and dereplicated with VSEARCH. Dereplicated *COI* sequences were clustered in to Operational Taxonomic Units (OTUs) with a 97% similarity threshold. Dereplicated *12S* sequences were not clustered but analysed further as Amplicon Sequence Variants (ASV). Chimera sequences were detected using the UCHIME algorithm (Edgar et al. 2011) as implemented in VSEARCH, and subsequently removed. All non-chimeric OTUs and ASVs were taxonomically assigned using the BOLD reference database (COI sequences) and a local version of the BLAST algorithm (Camacho et al. 2008) with a local version of the MitoFish Mitochondrial Genome Database of Fish (http://157.82.243.220/).

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Chapter 5

Annotated checklist of the marine ichthyofauna of Mauritania from shallow-water habitats and artisanal fish markets

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5.1 Abstract

Due to their location in a strong upwelling area, Mauritanian waters are one of the most nutrient-rich and productive areas in the East Atlantic Ocean. At the Mauritanian coast, a remarkably high biodiversity consisting of tropical, subtropical and temperate species with overlapping distributions can be found. This study reports 105 fish species from 53 different families. Overall, the findings indicate Mauritanian waters as a coastal area with a high biodiversity and occurrences of several critically endangered elasmobranch species such as *Sphyrna lewini* (Griffith & Smith, 1834) and *Glaucostegus cemiculus* (Geoffroy Saint-Hilaire, 1817). Moreover, this survey indicated an urgent need for updates concerning the IUCN red list classification of several Mauritanian species, which serve as an essential income source for artisanal fishermen in Mauritania.

Key words. Biodiversity, Upwelling, West Africa, Fisheries

5.2 Introduction

One of the most nutrient-rich and productive ecoregions in the Atlantic Ocean stretches along the northwestern African coast (Demarcq and Soumou 2015). This region is part of the Canary Current Large Marine Ecosystem (CCLME) and is strongly influenced by permanent upwelling in the north and seasonal upwelling in the south of the Mauritanian coast (Heileman and Tandstad 2009; Pelegrí and Peña-Izquierdo 2015). The upwelling, caused by a wind-induced Ekman transport brings nutrient-rich deep water to the surface. The prevailing northeasterly trade winds along the northwest African coast lead to an offshore movement of surface water. This process enables the upwelling of nutrient-rich, cold, and oxygen-rich water from the subsurface layers, a phenomenon that is particularly intense off the Mauritanian shelf. Additional nutrients enter the waters through the steady input of Saharan aeolian dust to the sea by the prevailing northeastern trade wind system. These environmental conditions not only foster a remarkably diverse array of species but also sustain some of the largest and most productive fish stocks in the Atlantic Ocean. However, Mauritania's fish stocks are highly endangered and declining due to increasing fishing pressure (Gascuel et al. 2007; IMROP 2014; Lemrabott et al. 2023).

Mauritania's geographical location favours a remarkably high species diversity, not least due to marine upwelling. Species from tropical, subtropical and temperate regions overlap in their distribution along the Mauritanian coast (Jager 1993; Le Loeuff and von Cosel 1998). Mauritania thus represents one of the northernmost distribution areas for several tropical species, while at the same time, it is one of the southernmost distribution areas for temperate species. The seagrass beds in the Baie de l’Étoile and in the Banc d'Arguin are of particular ecological importance and play a crucial role in carbon sequestration and in the promotion of biodiversity (Ly 2009; Chefaoui et al. 2021; Pottier et al. 2021). These two sensitive sites provide crucial habitats, feeding grounds, foraging and resting places for a plethora of bird species (Jarry et al. 2010; Cornet et al. 2023). The third largest seagrass population in the World and the universal value as bird sanctuary led to the implementation of the Banc d’Arguin into UNESCO’s Marine World Heritage Sites in 1989 (UNESCO 1989). However, efforts to grant the species-rich Baie de l'Étoile a prominent protected status have not yet come to a satisfactory conclusion.

The shallow-water marine biodiversity of Mauritania is still understudied. We highlight not only frequently targeted fish species but also small and sometimes very rare species that are considered to represent an essential part of nodes in the marine food web. In order to use the Mauritanian fisheries resources more sustainable, it is worth considering smaller and non-commercially used species as these play an important part in marine food webs, especially in population and multispecies models to predict future fish stocks. Our comprehensive checklist can provide a basis for future conservation and management measures in Mauritanian coastal waters.

5.3 Study area

We focused our studies on two Mauritanian sites, the Baie de l’Étoile (BdE) and the Bellaat lagoon, which is located further south in the Baie du Lévrier (BdL) (Fig. 1). Seagrass beds are present at both sites, the Baie de l’Étoile and the Belaat Lagoon. However, the Baie de l’Étoile contains a hitherto undescribed macrophyte habitat for Mauritania, the ecologically important maerl bed formed by calcareous coralline algae. Additional hard substrate can be found at the wooden pier of the Centre de Pêche, the rocky island and several sandstone tidepools around the southern and western Baie de l’Étoile. As the Baie de l’Étoile is located in close proximity to the port city of Nouadhibou, it is subject to significant anthropogenic impact through pollution (plastic and wastewater), increased urbanization and fishing activities. In contrast, the Bellaat lagoon is situated within the boundaries of the UNESCO World Heritage Site Banc d’Arguin National Park (UNESCO 1989). Here, artisanal fishery is allowed with unmotorised launches only. A set of submerged ridges located close to Cap Saint Anne within the PNBA's borders were also investigated as well as around the tide pools of Pelican island in front of the Bellaat lagoon entrance (Fig. 1). On several occasions, we conducted surveys of fish sold at the artisanal fish landing places in Nouadhibou (February 2023 and February 2024) and the fish market in Nouakchott (August 2022, June 2023, and January 2024). The latter fish market is by far the largest in Mauritania. Additional samples from the fishing area of the artisanal fisheries in Nouadhibou were collected during independent sampling campaigns (IMROP, Scientific campaign). Coordinates of the specific sampling areas are listed in Table 1.

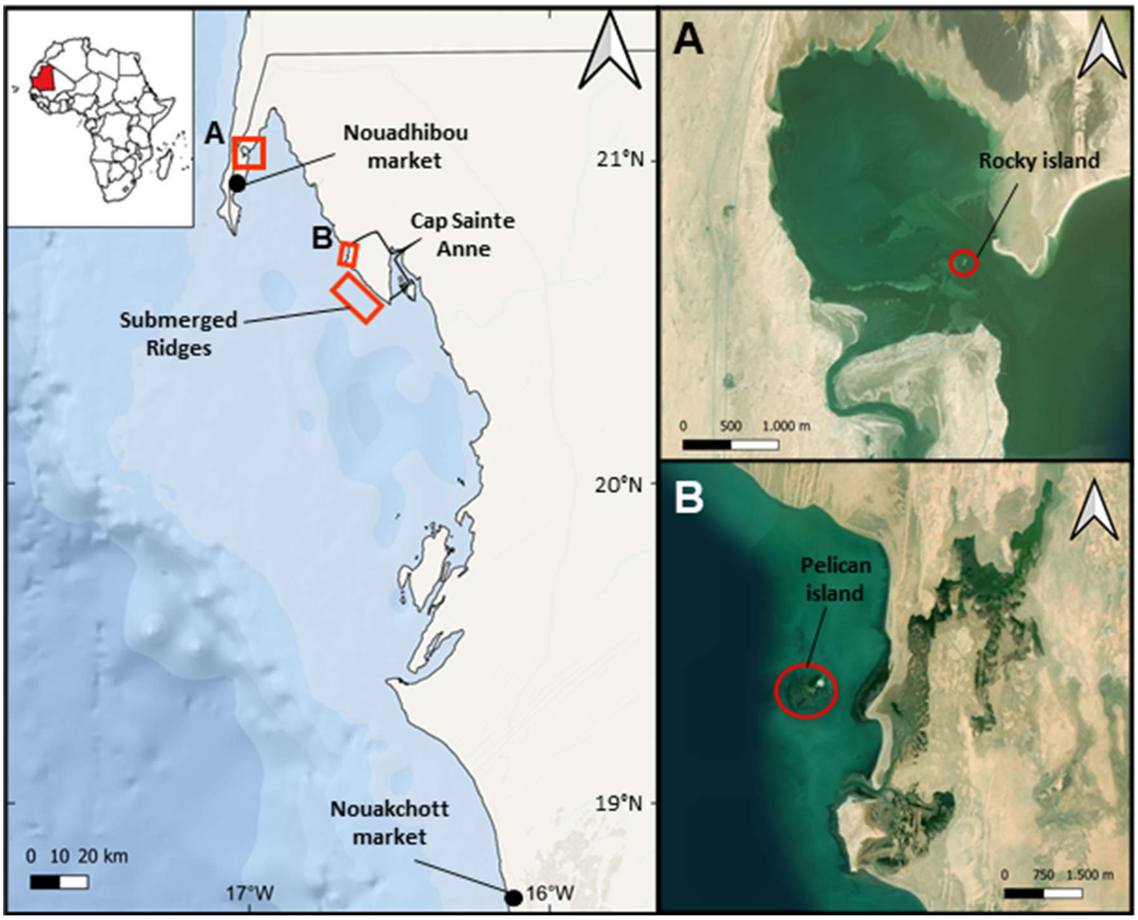

Figure 1: Geographical map of study areas along the Mauritanian coastline. Basemap from ESRI (2019) (www.esri.com). A: Baie de l'Étoile. B: Bellaat lagoon and Pelican island. Basemap from ESRI (2019), contours from GEBCO Compilation Group (2023). Satellite Images of A and B from Bing Aerial Maps (https://www.bing.com).

Table 1: Approximate sampling locations in shallow-water habitats and at artisanal fish markets. Coordinates only represent the centre of each location and do not indicate the exact sampling site of each species.

Habitat	Location	Latitude (N)	Longitude (W)
Maerl bed	Baie de l'Étoile (M-BdE)	21.0209	-17.0058
Seagrass beds	Baie de l'Étoile (S-BdE)	21.0383	-17.0234
	Bellaat lagoon (S-BdL)	20.6936	-16.6749
Submerged ridge field	Baie de Lévrier (SRF)	20.6531	-16.7267
Hard substratum	Old Pier, Baie de l'Étoile (OP)	21.0207	-17.0046
	Sandstone, Baie de l'Étoile (S)	21.0198	-17.0056
	Rocky island, Baie de l'Étoile (RI)	21.0256	-17.0071
	Pelican island (PI)	20.7111	-16.6880

Artisanal fish landing sites	Nouakchott market (NKM)	18.1033	-16.0263
	Fisherman from Baie de l'Étoile (F-BdE)	21.0198	-17.0028
	Nouadhibou Market (NDBM)	20.9121	-17.0425
	IMROP scientific campaign (SC)	20.9121	-17.0425

5.4 Methods

The ichthyofaunal diversity of the Mauritanian coastline has been documented through five expeditions conducted between 2020 and 2024. Various methods were deployed for fish capturing, including hand collection, beam trawling, fish traps, beach seine, ganchorra sampling (a Portuguese kind of beam trawl) and artisanal fish market surveys around the cities of Nouadhibou and Nouakchott. The collected specimens were euthanised with clove oil and subsequently preserved for the scientific collections at the Mauritanian institute of Oceanographic Research and Fisheries (IMROP) and the Senckenberg research institute in Frankfurt am Main. All collected vouchers got a museum specific identification number (SMF followed by the respective number). Specimens smaller than 10 cm were directly preserved in 70% ethanol, while larger specimens were initially preserved in formalin and gradually transferred to 70% ethanol after several weeks (Freyhof et al. 2020). Tissue samples from the pectoral and dorsal fins of the investigated individuals were taken and directly preserved in 96% ethanol for future DNA barcoding. The tissue samples were labelled with a specific tissue sample identification number (Mau followed by the tissue sample number) and are stored at the Senckenberg research institute in Frankfurt am Main. Subsequently, the collected specimens were morphologically identified on species level using ichthyological literature (Whitehead et al. 1986; Carpenter and De Angelis 2016A, 2016B, 2016C).

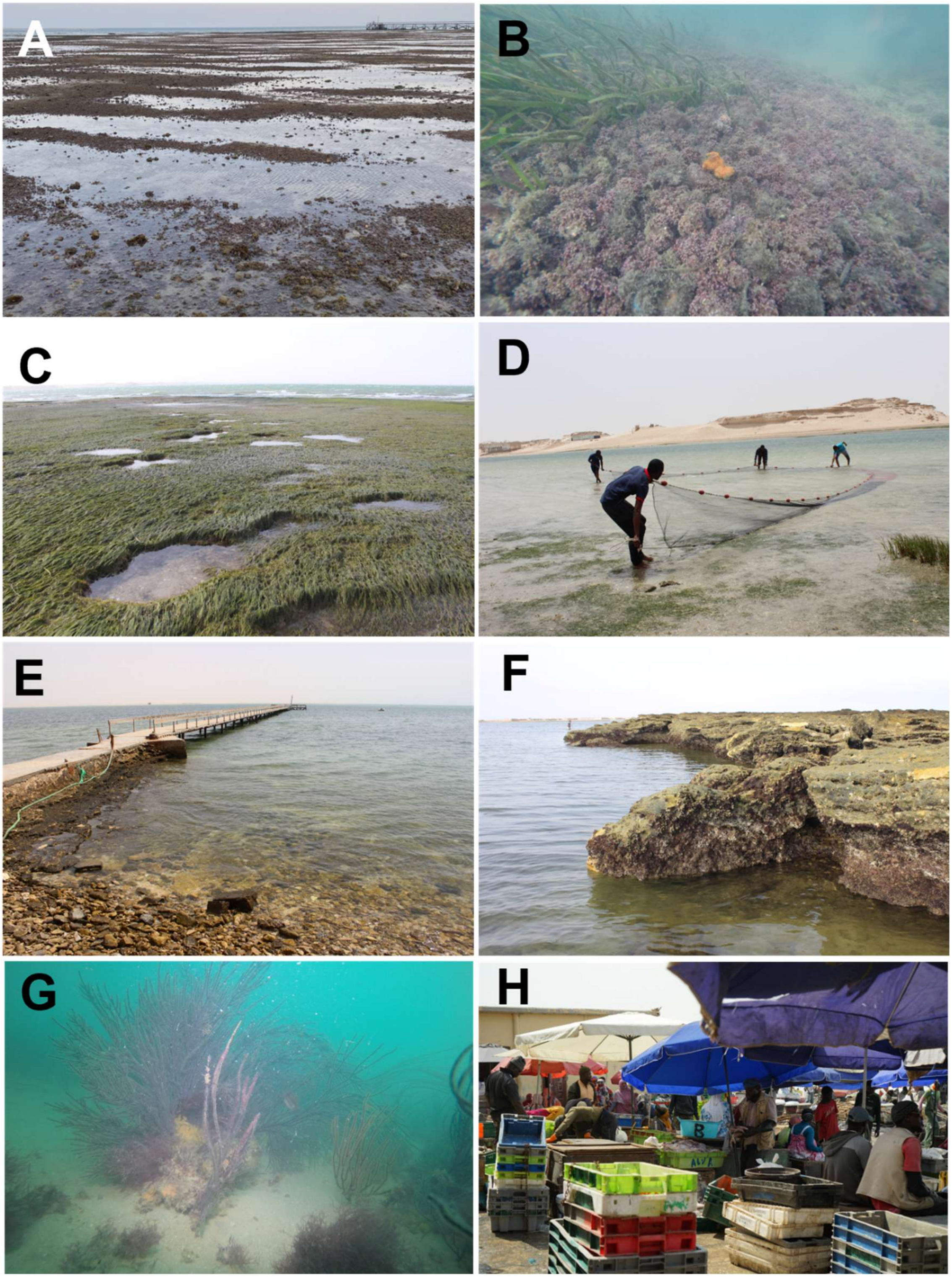

Figure 2: Overview of the investigated areas and impressions of the fieldwork. **A**: Maerl ripples at the Baie de l'Étoile during low tide. **B**: Close-up photography of the submerged maerl ecosystem. **C**: *Zostera noltei* bed in the Baie de l'Étoile. **D**: Deployment of a beach seine in the Baie de l'Étoile. **E**: The old pier at the Centre de Pêche. **F**: Hard substratum of the rocky island in the Baie de l'Étoile. **G***: Leptogorgia* forest at the submerged ridge field. **H**: Artisanal fishermen selling their catch of the day at the landing place in Nouakchott. © Kristina Hopf: H © Friedhelm Krupp: C, D, © André Freiwald: A, E, F, © Alexander Knorrn: B, G.

5.5 Results

We identified 104 species from 53 families within 27 orders to species level at the various study areas. The majority of species were gathered from the artisanal fish markets. The fish were caught in the surrounding waters of the cities Nouadhibou and Nouakchott, and thus, can be considered part of Mauritania's local shallow-water zones. The following checklist (Table 2) represents all encountered species and lists the localities where each species was individually observed. Information about the IUCN red list status (https://www.iucnredlist.org/) is also provided for each species.

Table 2: Checklist and IUCN status of the marine ichthyofauna from shallow-water habitats and artisanal fish markets in Mauritania. Coordinates of the approximate locations are given in table 1, exact coordinates are given in the specific recording of the species. Station abbreviations are M-BDE: Maerl bed in the Baie de l'Étoile, S-BDE: Seagrass bed in the Baie de l'Étoile, S-BDL: Seagrass bed in the Bellaat lagoon, OP: Old Pier, S: Sandstone, RI: Rocky Island, PI: Pelican island, NKM: Nouakchott market, F-BDE: Fishermen from the Baie de l'Étoile, NDBM: Nouadhibou Market, SC: Scientific campaign of the IMROP institute. IUCN red list abbreviations are: DD: Data Deficient, LC: Least Concern, NT: Near Threatened, VU: Vulnerable, EN: Endangered, CR: Critically Endangered.

Species	**Location**	**IUCN status**
Pisces (N = 104)		
Scyliorhinidae		
Scyliorhinus canicula (Linnaeus, 1758)	SC	LC
Carcharhinidae		
Prionace glauca (Linnaeus, 1758)	NDBM	NT
Rhizoprionodon acutus (Rüppell, 1837)	OP, SRF, NDBM	VU
Sphyrnidae		
Sphyrna lewini (Griffith & Smith, 1834)	NDBM	CR
Rajidae		
Raja undulata Lacepède, 1802	SRF	EN
Glaucostegidae		
Glaucostegus cemiculus (Geoffroy Saint-Hilaire, 1817)	F-BDE	CE
Polynemidae		
Galeoides decadactylus (Bloch, 1795)	RI, NDBM	NT
Pristigasteridae		
Ilisha africana (Bloch, 1795)	NKM	LC
Dorosomatidae		
Sardinella aurita Valenciennes, 1847	NKM	LC
Ethmalosa fimbriata (Bowdich, 1825)	NKM, NDBM	LC
Ariidae		
Carlarius parkii (Günther, 1864)	SRF	LC
Zeidae		
Zeus faber Linnaeus, 1758	NKM, NDBM	DD
Ophidiidae		
Brotula barbata (Bloch & Schneider, 1801)	NKM, NDBM	LC
Batrachoididae		
Halobatrachus didactylus (Bloch & Schneider, 1801)	OP, NDBM	LC
Gobiidae		
Periophthalmus barbarus (Linnaeus, 1766)	S-BDE	LC
Gobius niger Linnaeus, 1758	S-BDE, OP	LC
Gobius paganellus Linnaeus, 1758	M-BDE, PI	LC
Gobius senegambiensis Metzelaar, 1919	M-BDE, RI	LC
Pomatoschistus microps (Krøyer, 1838	S-BDE	LC

Pomatoschistus pictus (Malm, 1865)	S-BDE	LC
Mugilidae		
Chelon auratus (Risso, 1810)	S-BDE, SRF, NKM	LC
Chelon dumerili (Steindachner, 1870)	S-BDE	DD
Chelon ramada (Risso, 1827)	S-BDL	LC
Mugil capurrii (Perugia, 1892)	S-BDE, SRF, NDBM	LC
Cichlidae		
Sarotherodon melanotheron Rüppell, 1852	NKM	DD
Blenniidae		
Hypleurochilus bananensis (Poll, 1959)	OP, RI	LC
Microlipophrys velifer (Norman, 1935)	RI, S	LC
Labrisomidae		
Malacoctenus africanus Cadenat, 1951	OP	DD
Atherinidae		
Atherina presbyter Cuvier, 1829	S-BDE	LC
Hemiramphidae		
Hyporhamphus picarti (Valenciennes, 1847)	S-BDE	LC
Belonidae		
Tylosurus crocodilus (Péron & Lesueur, 1821)	NKM	LC
Coryphaenidae		
Coryphaena hippurus Linnaeus, 1758	NKM	LC
Carangidae		
Lichia amia (Linnaeus, 1758)	NKM	LC
Campogramma glaycos (Lacepède, 1801)	NKM	LC
Alectis alexandrina (Geoffroy Saint-Hilaire, 1817)	NKM	LC
Chloroscombrus chrysurus (Linnaeus, 1766)	NKM	LC
Trachurus trachurus (Linnaeus, 1758)	NDBM	VU
Seriola rivoliana Valenciennes, 1833	NKM	LC
Caranx rhonchus Geoffroy Saint-Hilaire, 1817	SRF, NDBM	LC
Sphyraenidae		
Sphyraena sphyraena (Linnaeus, 1758)	NKM	LC
Psettodidae		
Psettodes bennettii Steindachner, 1870	NKM, NDBM	DD
Citharidae		
Citharus linguatula (Linnaeus, 1758)	SC	LC
Soleidae		
Dagetichthys lusitanicus (de Brito Capello, 1868)	NDBM	DD
Microchirus wittei Chabanaud, 1950	SC	LC
Pegusa lascaris (Risso, 1810)	NKM	LC
Solea senegalensis Kaup, 1858	S-BDE, NKM	LC
Cynoglossidae		
Cynoglossus monodi Chabanaud, 1949	NKM	NT
Syngnathidae		
Syngnathus acus Linnaeus, 1758	S-BDE	LC
Fistulariidae		
Fistularia tabacaria Linnaeus, 1758	NKM	LC
Gempylidae		
Ruvettus pretiosus Cocco, 1833	NKM	LC
Trichiuridae		
Trichiurus lepturus Linnaeus, 1758	NKM	LC
Scombridae		
Scomberomorus tritor (Cuvier, 1832)	NKM	LC
Sarda sarda (Bloch, 1793)	NKM, NDBM	LC
Centrolophidae		
Schedophilus velaini (Sauvage, 1879)	NKM, SC	LC
Stromateidae		
Stromateus fiatola Linnaeus, 1758	NKM	LC
Uranoscopidae		
Uranoscopus scaber Linnaeus, 1758	NKM	LC
Labridae		
Symphodus bailloni (Valenciennes, 1839)	S-BDE, OP, SRF	LC
Nicholsina collettei Schultz, 1968	NDBM	LC
Mullidae		
Pseudupeneus prayensis (Cuvier, 1829)	NKM	VU
Serranidae		
Cephalopholis taeniops (Valenciennes, 1828)	NKM	LC
Epinephelus aeneus (Geoffroy Saint-Hilaire, 1817)	NKM, F-BDE, NDBM	NT
Epinephelus caninus (Valenciennes, 1843)	NKM	DD
Epinephelus costae (Steindachner, 1878)	NKM	DD
Epinephelus marginatus (Lowe, 1834)	NKM	VU
Mycteroperca rubra (Bloch, 1793)	NKM	LC
Pomatomidae		
Pomatomus saltatrix (Linnaeus, 1766)	NKM	VU

Bramidae		
Brama brama (Bonnaterre, 1788)	NKM	LC
Priacanthidae		
Priacanthus arenatus Cuvier, 1829	NKM	LC
Chaetodontidae		
Chaetodon hoefleri Steindachner, 1881	SRF, NKM	LC
Malacanthidae		
Branchiostegus semifasciatus (Norman, 1931)	NKM	LC
Haemulidae		
Brachydeuterus auritus (Valenciennes, 1832)	NKM	NT
Parakuhlia macrophthalma (Osório, 1893)	NKM	DD
Pomadasys incisus (Bowdich, 1825)	SRF	LC
Pomadasys perotaei (Cuvier, 1830)	NKM	LC
Parapristipoma octolineatum (Valenciennes, 1833)	NDBM	LC
Plectorhinchus mediterraneus (Guichenot, 1850)	SRF, F-BDE	DD
Lutjanidae		
Lutjanus goreensis (Valenciennes, 1830)	NKM	DD
Scorpaenidae		
Pontinus kuhlii (Bowdich, 1825)	NDBM	DD
Scorpaena normani Cadenat, 1943	SC	LC
Moronidae		
Dicentrarchus punctatus (Bloch, 1792)	S-BDE, SRF	LC
Drepaneidae		
Drepane africana Osório, 1892	NKM	LC
Sciaenidae		
Argyrosomus regius (Asso, 1801)	F-BDE	LC
Pseudotolithus senegalensis (Valenciennes, 1833)	NKM, F-BDE	EN
Pteroscion peli (Bleeker, 1863)	NKM	LC
Sciaena umbra Linnaeus, 1758	OP, F-BDE, NDBM	NT
Sparidae		
Dentex angolensis Poll & Maul, 1953	NDBM	NT
Dentex canariensis Steindachner, 1881	NDBM	LC
Dentex gibbosus (Rafinesque, 1810)	NKM	LC
Diplodus bellottii (Steindachner, 1882)	OP	LC
Diplodus cervinus (Lowe, 1838)	NDBM	LC
Diplodus puntazzo (Walbaum, 1792)	NDBM	LC
Diplodus sargus (Linnaeus, 1758)	S-BDE, F-BDE, NDBM	LC
Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817)	NDBM	LC
Lithognathus mormyrus (Linnaeus, 1758)	NKM, NDBM	LC
Pagrus caeruleostictus (Valenciennes, 1830)	NKM, F-BDE	LC
Sparus aurata Linnaeus, 1758	S-BDE, NDBM	LC
Spondyliosoma cantharus (Linnaeus, 1758)	SRF, NDBM	LC
Caproidae		
Capros aper (Linnaeus, 1758)	SC	LC
Balistidae		
Balistes punctatus Gmelin, 1789	NKM	VU
Stephanolepis hispida (Linnaeus, 1766)	S-BDE, NKM, F-BDE	LC
Tetraodontidae		
Ephippion guttifer (Bennett, 1831)	NKM, NDBM	LC
Lagocephalus guentheri Miranda Ribeiro, 1915	NKM	LC
Lagocephalus laevigatus (Linnaeus, 1766)	NKM	LC
Sphoeroides marmoratus (Lowe, 1838)	OP	LC
Sphoeroides pachygaster (Müller & Troschel, 1848)	NKM, NDBM	LC

Observed species Identification

All identified species characteristics were obtained from ichthyological literature indicating the most pronounced morphological characteristics for each observed species following ichthyological literature (Carpenter and De Angelis 2016 A, B, C; Whitehead et al. 1986).

Scyliorhinus canicula (Linnaeus, 1758)

New record. MAURITANIA - Dakhlet Nouadhibou • Scientific campaign**;** 20.9121, -17.0425 ; 03.VIII.2022; M. Dia and A. Niang leg.; trawl haul (tissue sample); MAU-55.

Identification. Slender shark with a cream-coloured ventral side and light brownish colouration dorsally with numerous small to large dark brown spots, often accompanied by white spots. Anterior nasal flaps are greatly enlarged. The oronasal grooves are broad and shallow.

***Prionace glauca* (Linnaeus, 1758)**

New record. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 23. VI.2022; M. Dia and A. Niang leg.; Fish market survey (tissue sample); MAU-3.

Identification. Slender and fusiform body. A relatively long snout and large eyes. Body colouration usually dark blue on dorsal side and a brighter bluish colouration on the lateral sides of the body with a brighter ventral side. Dusky fin tips. Very long and elongated pectoral fin and no interdorsal ridge between dorsal fins. A weak keel is present on each side of caudal peduncle.

***Rhizoprionodon acutus* (Rüppell, 1837)**

Figure 3A

New records. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0207, -17.0046; 03.XII.2021; Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection during low tide; SMF 39807. • Nouadhibou Market; 20.9121, -17.0425; VI.2021; M. Dia and A. Niang leg.; Fish market survey (tissue sample); MAU-536. • Submerged ridges; 20.6531, -16.7267; 02.III.2023; A. Knorrn, A. S. M. Moctar, M. Sonnewald and A. Freiwald leg.; fishing rod; SMF 39676.

New records. Body slender and fusiform. Dorsally greyish to greyish-brown in coloration, white ventrally. The dorsal and anal fins have dusky or blackish edges and are slightly darker coloured than the dorsal side. Anal fin base expanded anteriorly by a very long pair of preanal ridges. Snout long and depressed. Its length is usually greater than the width of the mouth. The upper labial folds are long and prominent and horizontal on the upper lip.

***Sphyrna lewini* (Griffith & Smith, 1834)**

New record. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; VII. 2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-61.

Identification. Elongated and laterally compressed body with a “hammer” shaped head. Body uniformly greyish to brownish coloured with black to dark greyish tips at the end of the pectoral fin. A median indentation on the anterior margin of the head. The free rear tip of the second dorsal fin nearly reaches the upper caudal-fin origin. The anal-fin base is noticeably larger than that of the second dorsal fin.

***Raja undulata* Lacepède, 1802**

Figure 3B

New record. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6531, -16.7267; 03.III.2023; A. Knorrn, A. S. M. Moctar, M. Sonnewald and A. Freiwald leg.; hand collection at a beach close to the submerged ridge field; SMF 39681.

Identification. Batoid fish. Its dorsal surface is ochre to greyish brown coloured, with undulating dark bands outlined by series of white spots. The ventral surface of the tail is greyish brown coloured. No denticles on the ventral surface except the snout, the anterior margin of the disc and the tail.

Glaucostegus cemiculus **(Geoffroy Saint-Hilaire, 1817)**

New record. MAURITANIA - Dakhlet Nouadhibou • Fishermen from the Baie de l'Étoile; 21.0198, -17.0028; 09.III.2023; A. Knorrn, S. M. Moctar and A. Freiwald leg.; in front of the BdE opening, gill net of local fishermen (tissue sample); MAU-426.

Identification. Guitarfish with a typical wedge-shaped disc and an elongated snout. The dorsal side coloured uniformly beige to light brown, except for the semi-transparent snout area. The ventral side white, usually with a blackish blotch on tip of snout, that is fading in adults. The anterior nasal flaps are not extending onto internasal space. The interspace between rostral ridges is narrow. The ridges are joining toward tip of snout.

Galeoides decadactylus **(Bloch, 1795)**

Figure 3C

New records. MAURITANIA - Dakhlet Nouadhibou • Rocky island; 21.0256, -17.0071; 27.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; Hand collection at the submerged part of the rocky island; SMF 39806. • Nouadhibou Market; 20.9121, -17.0425; 23.VI.2022; M. Dia and A. Niang leg.; Fish market survey (tissue sample); MAU-161.

Identification. A fish with large eyes (eye diameter greater than head length). The dorsal sides of the head and trunk have a brown tinge, becoming silver on lower sides. A black spot is present below anterior part of lateral line. The pectoral fin has 9 to 11 prominent and elongated filaments. Its colouration is mostly black and at the base of pectoral filaments white, which is becoming blackish on posterior tips.

Ilisha africana **(Bloch, 1795)**

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 08. VII.2022; M. Dia and A. Niang leg.; Fish market survey (tissue sample); MAU-40.

Identification. Deep and compressed body with series of sharp and serrate scutes along abdomen from gill opening to anus. The dorsum is coloured grey, the flanks pale grey or silver, with faint dark spot on body posterior to gill cover. Dorsal fin yellow, with a dusky tip. Mouth directed obliquely upward, with lower jaw projecting beyond upper with 2 supramaxillae, and small or minute jaw teeth, a gap at centre of upper jaw.

Sardinella aurita **Valenciennes, 1847**

Figure 3D

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 24.I.2024; A. Knorrn; K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-509.

Identification. Body elongate, subcylindrical in cross-section, and sometimes slightly compressed. A distinct black spot on the posterior margin of gill cover is present. No black spot is present at the dorsal fin origin. The pelvic fin has nine fin rays. Two fleshy outgrowths along outer margin of gill opening.

Ethmalosa fimbriata **(Bowdich, 1825)**

New records. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 24.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-656. - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 14.III.2022; M. Dia and A. Niang leg.; Fish market survey (tissue sample); MAU-134.

Identification. Body fairly deep and compressed with a great head. Caudal fin deep chrome yellow, but the upper and posterior margins are grey. A smooth gill cover. The posterior borders of scales fringed.

Carlarius parkii **(Günther, 1864)**

Figure 3E

New record: MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6531, -16.7267; 04.III.2023; M. Sonnewald and A. Freiwald leg.; plankton net above submerged ridge field; SMF 39673.

Identification: Fish with a dark brown to greenish colouration dorsally and light brownish to silvery colouration on the ventral side. Head shield clearly visible. Palatal teeth arranged in two large patches separated by their own diameter or less.

Zeus faber **Linnaeus, 1758**

Figure 3F

New records. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; VII.2021; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-657. - Dakhlet Nouadhibou • Nouadhibou Market**;** 20.9121, -17.0425; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-658.

Identification. Body very deep, depth contained 1.6 to 2.1 times in standard length. The body is golden to greenish grey coloured with a conspicuous ocellus (black spot encircled by a narrow greyish or yellowish border) on middle of side. The caudal peduncle is about as long as deep. Dorsal fin with nine to 11 spines and 21 to 25 soft rays. The spinous portion with interspinous membrane filaments about as long as spines.

Brotula barbata **(Bloch & Schneider, 1801)**

Figure 3G

New records: MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 24.I.2024; A. Knorrn, K. Hopf and K. Pfennings; fish market survey (tissue sample); MAU-659. - Dakhlet Nouadhibou • Nouadhibou Market; 20.9122, -17.0425; 21.II.2021; M. Dia and A. Niang leg.; fish market survey (tissue sample), MAU-544.

Identification: Brownish to reddish fish with one enlarged dorsal and anal fin. Six barbels present on snout and chin. Two rayed pelvic fins which are inserted well behind the eye about the level of the operculum.

Halobatrachus didactylus **(Bloch & Schneider, 1801)**

New records. MAURITANIA - Dakhlet Nouadhibou • Old Pier 21.0207, -17.0046; 18.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; SMF 39662 • Nouadhibou Market**;** 20.9121, -17.0425; 14.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-17.

Identification. Head large and massive, body dorso-ventral flattened. The head and body are covered with small dark spots superimposed on a lighter network. A small axillary pore high up in pectoral axilla just below edge of opercular membrane. The second dorsal fin has brown oblique lines. The operculum and dorsal fin spines are often surrounded by light areas at bases.

***Periophthalmus barbarus* (Linnaeus, 1766)**
Figure 3H
New record. MAURITANIA - Dakhlet Nouadhibou • *Spatina marina* meadow in close proximity to the seagrass bed in the Baie de l'Étoile; 21.01813289, -17.01888817; 29.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection, SMF 39658
Identification. Eye large and erectile. Pelvic fins divided. Head and body tannish to dark brown to blue-grey with blue-white spots on sides, cheeks, snout, and operculum. Both dorsal fins with a wide, bright blue distal band edged by narrow white bands. Pectoral-fin base long and muscular. The Pelvic fins are divided.

***Gobius niger* Linnaeus, 1758**
Figure 3I
New records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0383, -17.0234; 02.II.2024; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand beam trawl; SMF 39793. • Old Pier 21.0207, -17.0046; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; SMF 39661.
Identification. Fish with united pelvic fins (one spine and five soft rays) that form a simple disc with an anterior membrane**.** Nape scaled; first dorsal fin with spot in upper anterior corner, and middle rays more or less elongate; scales in lateral series 32 to 42.

***Gobius paganellus* Linnaeus, 1758**
Figure 3J
New records. MAURITANIA - Dakhlet Nouadhibou • Maerl bed in the Baie de l'Étoile; 21.0199; -17.0048; 10.III.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; SMF 39809. • Pelican island; 20.7111, -16.6880; 03.III.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; from tidepools around pelican island; hand collection; SMF 39808.
Identification. Fish with united pelvic fins (one spine and five soft rays) that form a simple disc with an anterior membrane. First dorsal fin with a pale edge and 50 – 55 scales in lateral series.

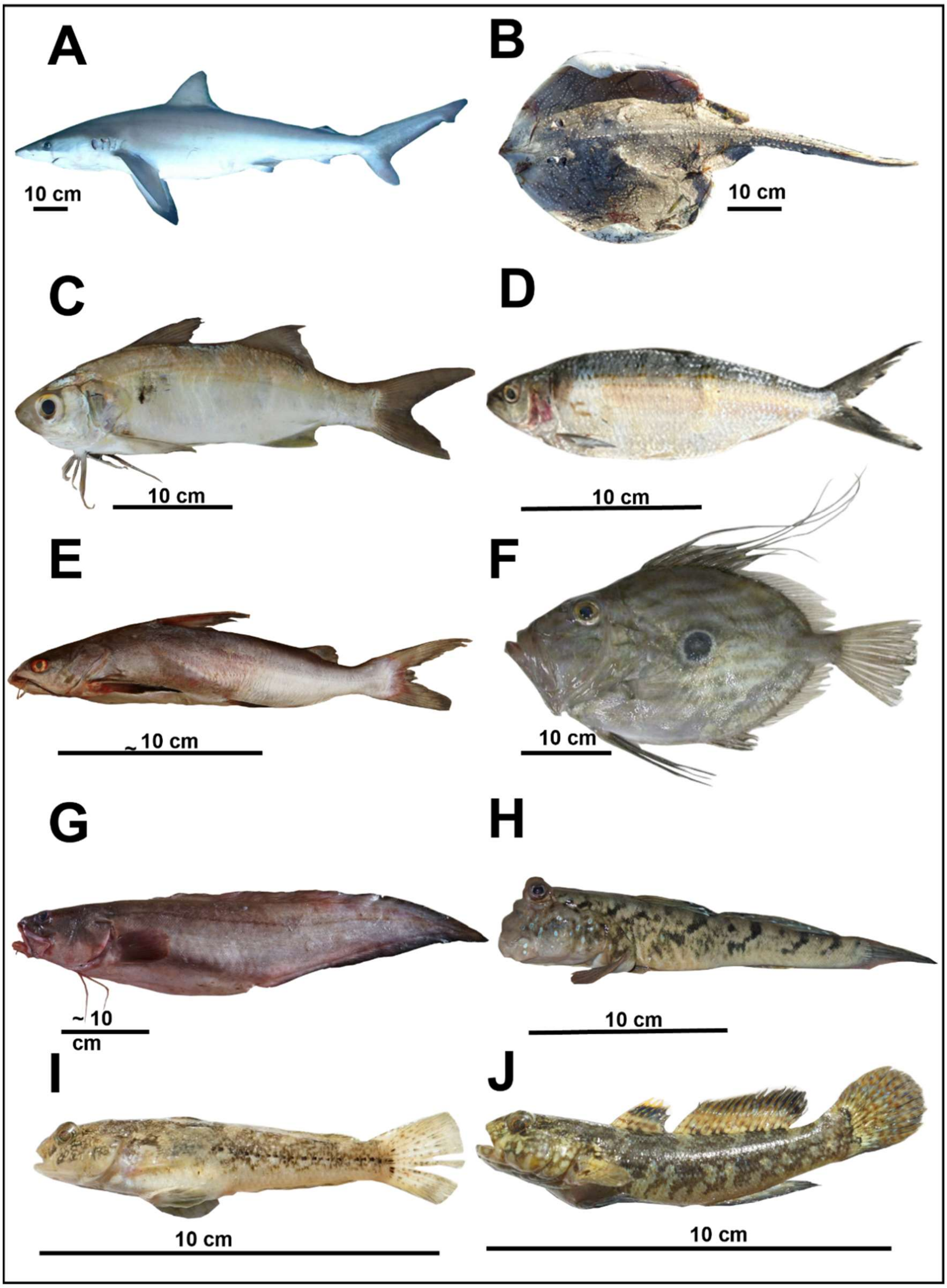

Figure 3: **A**: Milk shark (*Rhizoprionodon acutus*) **B**: Undulate ray (*Raja undulata*) **C**: Lesser African threadfin (*Galeoides decadactylus*) **D**: Round sardinella (*Sardinella aurita*) **E**: Guinean sea catfish (*Calarius parkii*) **F**: John Dory (*Zeus faber*) **G**: Bearded brotula (*Brotula barbata*) **H**: Atlantic mudskipper (*Periopthtalmus barbarus*) **I**: Black Goby (*Gobius niger*) **J**: Rock goby (*Gobius paganellus*). © Niang Alioune: A, F, © Kristina Hopf: E, G, I, J, © Friedhelm Krupp: H, © Moritz Sonnewald: B, © Alexander Knorrn: C, D

***Gobius senegambiensis* Metzelaar, 1919**

New records. MAURITANIA - Dakhlet Nouadhibou • Maerl bed in the Baie de l'Étoile; 21.0209, -17.0058; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; SMF 39811. • Rocky island; 21.0256, -17.0071; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; SMF 39810.

Identification. Fish with united pelvic fins (one spine and five soft rays) that form a simple disc with an anterior membrane. Pelvic disc without enlarged lateral lobes. Nape scaled, first dorsal fin without upper spot, scales in lateral series 41 to 55.

***Pomatoschistus microps* (Krøyer, 1838)**

New record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21,0273, -17,0042; 27.VII.2022; A. Knorrn, S. M. Moctar and A. Freiwald leg.; Beach seine; SMF 39797.

Identification. Fish with united pelvic fins (one spine and five soft rays) that form a simple disc with an anterior membrane. Cylindrical shaped body. Cheek with longitudinal lateral line row along lower margin of eye. Dorsal fins lacking series of conspicuous dark spots, except in rear of first dorsal fin, conspicuous in male.

***Pomatoschistus pictus* (Malm, 1865)**

New record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21,0273, -17,0042; 27.VII.2022; A. Knorrn, S. M. Moctar and A. Freiwald leg.; Beach seine (tissue sample); MAU-660.

Identification. Fish with united pelvic fins (one spine and five soft rays) that form a simple disc with an anterior membrane. Cylindrical shaped body. Cheek with longitudinal lateral line row along lower margin of eye. Dorsal fins with series of prominent dark spots in both sexes.

***Chelon auratus* (Risso, 1810)**

Figure 4A

New records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0383, -17.0234; 26.VII.2022; A. Knorrn, S. M. Moctar and A. Freiwald leg.; Beach seine; SMF 39790. • Nouadhibou Market; 20.9121, -17.0425; 21.II.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-64. • Submerged ridges 20.6890, -16.6851; 04.III.2023; M. Sonnewald and A. Freiwald leg.; plankton net above submerged ridge field; SMF 39812. - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 24.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey; Mau-661.

Identification. The translucent adipose eye fold is weakly developed in adults, forming a narrow ring around the eye and extending anteriorly a short way onto the lateral part of the snout. Conspicuous goldish spot on the operculum and another just behind the eye. Upper lip with outer row of small to moderate-size unicuspid teeth slightly spaced from each. Lower lip without teeth.

***Chelon dumerili* (Steindachner, 1870)**

New record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21,0168, -17,01844; 25.VII.2022; A. Knorrn, S. M. Moctar and A. Freiwald leg.; Beach seine, SMF 39813.

Identification. The translucent adipose eye fold is weakly developed in adults, forming a narrow ring around the eye and extending anteriorly a short way onto the lateral part of the snout. Yellowish gold spot on dorsal part of operculum. Upper lip of juvenile and adult fish (under microscope) with outer row of close-set teeth, which have slightly flattened, blunt unicuspid tips. Teeth usually absent on the lower lip; rarely, the outer margin of the lip may bear sparse, minute ciliiform teeth.

***Chelon ramada* (Risso, 1827)**
Figure 4B
New record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Bellaat lagoon; 20.6938, -16.6723; 04.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; hand collection during low tide; SMF 39814.
Identification. Translucent adipose eye fold weakly developed in adults, forming a narrow ring around the eye and extending anteriorly a short way onto the lateral part of the snout. Diffuse gold spot on the operculum and another just behind the eye. Upper lip of juvenile and adult fish (under microscope) with outer row of very small unicuspid teeth, close-set in a fine ‘comb. Lower lip usually without teeth, but a single row may be present.

***Mugil capurrii* (Perugia, 1892)**
Figure 4C
New records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l’Étoile; 21.0383, -17.0234; 26.VII.2022; A. Knorrn, S. M. Moctar and A. Freiwald leg.; Beach seine; SMF 39683. • Nouadhibou Market; 20.9121, -17.0425; 21.II.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-505. • Submerged ridges; 20.6531, -16.7267; 04.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; fishing line; SMF 39664.
Identification. Translucent adipose eyefold extensive over iris. Greyish brown dorsally, flanks silvery and abdomen off-white. Fins greyish except for pelvic and anal fins which are whitish. Pectoral fins have a dark spot at origin. Upper lip with single row of moderately well-spaced, long unicuspid teeth. Lower lip with single row of sparse unicuspid teeth.

***Sarotherodon melanotheron* Rüppell, 1852**
Figure 4D
New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 24.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MaAU-662.
Identification. Cichlid fish with a beige colouration with several intense black patches along the ventral side. The caudal fin is lacking those black patches. The scales on the belly are only slightly smaller than the flank scales.

***Hypleurochilus bananensis* (Poll, 1959)**
New records. MAURITANIA - Dakhlet Nouadhibou • Rocky island; 21.0254; -17.0067; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection, SMF 39815. • Old Pier; 21.0207; -17.0046; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; SMF 39816.
Identification. Slender fish without scales. Segmented anal (15-16) and dorsal fins (13-14). Entire lateral line composed of short separate tubes, each with a pore at either end, and without transverse branches. A marbled head and a brownish body with five vertical dark bars.

***Microlipophrys velifer* (Norman, 1935)**

New records. MAURITANIA - Dakhlet Nouadhibou • Rocky island; 21.0254, -17.0067; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; SMF 39817 • Sandstone; 21.0196, -17.0056; 15.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; out of sandstone tubes at intertidal areas; SMF 39818.
Identification. Slender fishes with no scales. 12 pectoral fin rays. Anterior part of lateral line with regularly spaced side branches. Large, dark eye-sized spot on the side of the head posterior to eye.

***Malacoctenus africanus* Cadenat, 1951**
Figure 4E
New record. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0207, -17.0046; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg. ; fish trap; SMF 39819.
Identification. Elongated fish with cirri or fleshy flaps on anterior nostrils, eyes, and laterally sides of the head. Maxillary bone almost completely hidden when mouth closed. Brownish hue with irregular vertical bands.

***Atherina presbyter* Cuvier, 1829**
Figure 4F
New record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0383, -17.0234; 26.VII.2022; A. Knorrn, S. M. Moctar and A. Freiwald leg.; Beach seine; SMF 39794.
Identification. Elongated fish with a bright stripe running the whole length of its side from head to tail. Anal fin always originating slightly in advance of second dorsal fin. Lateral line absent.

***Hyporhamphus picarti* (Valenciennes, 1847)**
Figure 4G
New record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0383, -17.0234; 19.II.2024; A. Niang and A. Freiwald leg.; Beach seine; SMF 39820.
Identification. An elongate fish with a greatly prolonged beak-like lower jaw. The upper jaw is short, triangular and scaly. Preorbital ridge (bony ridge under nostril) is present. Greenish colouration dorsally and silvery white below. There are three distinct narrow black lines along middle of back from head to the dorsal fin. The fleshy tip of beak is red. Caudal fin emarginate to slightly forked.

***Tylosurus crocodilus* (Péron & Lesueur, 1821)**
New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 06.VII.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-16.
Identification. Body elongate, rounded in cross section. A dark bluish green colouration dorsally and a silvery colouration ventrally. A dark blue stripe along the lateral side. A small black lateral keel on caudal peduncle. Caudal fin deeply forked and the lower lobe is much longer than upper lobe.

***Coryphaena hippurus* Linnaeus, 1758**
Figure 4H

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 22.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-663.

Identification. Body elongate and compressed, the greatest body depth in adults less than 25% of standard length. The colouration is brilliant metallic blue/green in life, after death fading to grey with a green tinge. The lateral sides are silvery with a golden sheen, and 1 row of dark spots or golden blotches running below dorsal fin and one, two or more rows on and below lateral line. Tooth patch on tongue small and oval. A single dorsal fin extending from above eye almost to caudal fin.

***Lichia amia* (Linnaeus, 1758)**

Figure 4I

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-507.

Identification. Body elongate, moderately deep and compressed, with upper and lower profiles similar. Lateral line very irregular and sinuous, describing a convex curve above and a concave curve behind the pectoral fin. Adults silvery grey dorsally, silvery white below the lateral line and with grey fins. The teeth in both jaws are arranged in a broad band anteriorly and becoming narrower posteriorly. The upper jaw extending beyond posterior margin of eye.

***Campogramma glaycos* (Lacepède, 1801)**

Figure 4J

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-518.

Identification. Body elongate, moderately deep and slightly compressed, with upper profile slightly more convex than lower. Single row of large, widely spaced canines in each jaw. Upper jaw broad and rounded at end, extending to below posterior margin of eye or beyond. Greenish grey coloration dorsally, extending on sides to lateral line in a series of prominent zigzag lobes.

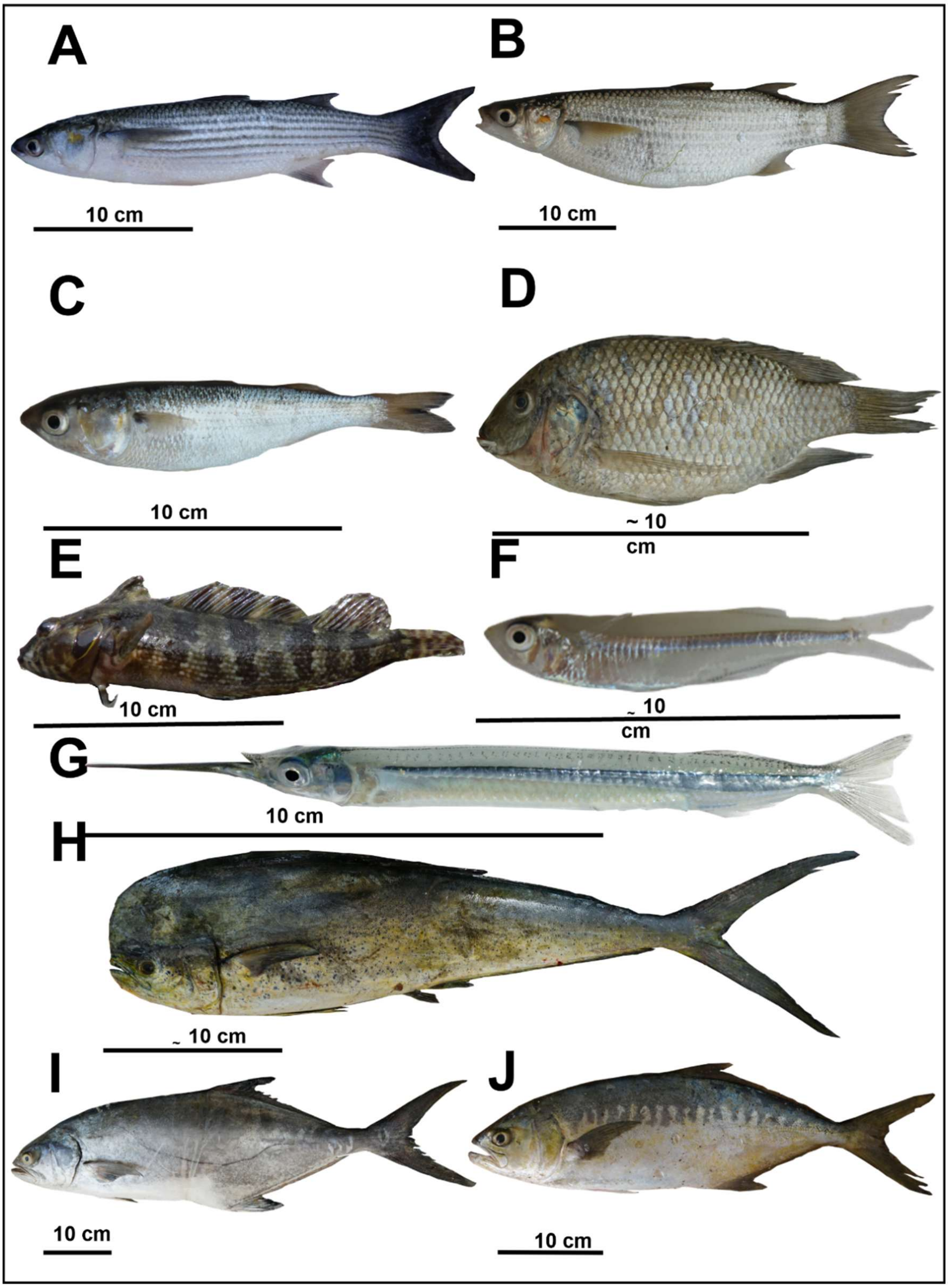

Figure 4: **A**: Golden grey mullet (*Chelon auratus*) **B**: Thinlip grey mullet (*Chelon ramada*) **C**: Leaping African mullet (*Mugil capurrii*) **D**: Blackchin tilapia (*Sarotherodon melanotheron*) **E**: Orange-saddled blenny (*Malacoctenus africanus*) **F**: Sand smelt (*Atherina presbyter*) **G**: African halfbeak (*Hyporhamphus picarti*) **H**: Common dolphinfish (*Coryphaena hippurus*) **I**: Leerfish (*Lichia amia*) **J**: Vadigo (*Campogramma glaycos*). © Kristina Hopf: D, G, H, I, J, © Friedhelm Krupp: A, B, © Moritz Sonnewald: E, © Alexander Knorrn: F, © André Freiwald: C.

***Alectis alexandrina* (Geoffroy Saint-Hilaire, 1817)**
Figure 5A
New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-506.
Identification. Very deep and compressed body. Body with a silvery colouration with a light metallic bluish tinge on upper third of the body and head. Lateral line with a strong and moderately long anterior arch, its posterior (straight) part with four to 20 scutes. The body is superficially naked. The scales are minute and embedded. The pelvic fin relatively long and longer than upper jaw length. There are 20 to 22 dorsal fin rays and 18 to 20 pelvic fin rays.

***Chloroscombrus chrysurus* (Linnaeus, 1766)**
Figure 5B
New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 24.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-664.
Identification. Body ovate with ventral profile more convex than dorsal, deep, and very compressed. Lateral line with a strong short anterior arch, posterior (straight) part with about six to 12 weak scutes, mainly over caudal peduncle. Body and head dark above (metallic blue to irridescent green) and silvery on sides and belly; a black saddle spot on upper part of caudal peduncle.

***Trachurus trachurus* (Linnaeus, 1758)**
New record. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 01.V.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-122.
Identification. Body elongate and slightly compressed, with upper and lower profiles about equal. Dorsal accessory lateral line normally extends posteriorly at least to below first dorsal-fin spine, usually much farther posteriorly. Dorsal accessory lateral line terminates below. Dorsal-fin soft rays 19 to 31; scales in curved part of lateral line 33 to 45, total scales and scutes in lateral line 66 to 78.

Seriola rivoliana Valenciennes, 1833
New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-517.
Identification. Body elongate, moderately shallow, and slightly compressed, with upper profile slightly more convex than lower. The body is bluish grey or olivaceous coloured on the dorsal side and the sides and belly are silvery white, sometimes brownish or with a pinkish tinge. Usually, a dark nuchal bar often persistent in adults and extending from eye to first dorsal-fin origin. Upper jaw broad posteriorly and extending to below about anterior margin of pupil.

***Caranx rhonchus* Geoffroy Saint-Hilaire, 1817**
Figure 5C
New records. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; III.2021; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-

123. • Submerged ridges; 20.6531, -16.7267; 04.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; fishing line; SMF 39670.
Identification. Body elongate and slightly compressed with upper and lower profiles about equal and well-developed adipose eyelid. Black spot on the margin of the operculum near the upper edge. Lobe of the second dorsal fin with black blotch and narrow pale border distally.

Sphyraena sphyraena **(Linnaeus, 1758)**
New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 06.VII.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-39.
Identification. Body elongate and cylindrical. Lower jaw with fleshy knob. pectoral fins not reaching to level of origin of ventral fins. Lateral line scales smaller, sides of body without irregular black blotches. Preopercle entirely scaled and a single spine on operculum. Second and third spines of first dorsal fin about equal to longest ray of second dorsal fin.

Psettodes bennettii **Steindachner, 1870**
Figure 5D
New records. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 03.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-81. - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-665.
Identification. Body oval and flat, but thicker than in most other flatfishes. The ocular side is uniformly brownish with irregular spots and blotches. Jaws large, with strong canine teeth. Preopercular margin easily seen, not hidden by skin and scales. Dorsal-fin origin well posterior to upper eye. Caudal fin without large spots. Caudal peduncle with 34 to 43 scales.

Citharus linguatula **(Linnaeus, 1758)**
New record. MAURITANIA - Dakhlet Nouadhibou • Scientific campaign; 20.9121, -17.0425; 03.VIII,2022; M. Dia and A. Niang leg.; trawl haul (tissue sample); MAU-12.
Identification. Body elliptical, moderately compressed. Conspicuous pair of black spots on the dorsal and ventral body margins at and slightly posterior to posterior ends of dorsal and anal fins. Mouth large, terminal, with lower jaw protruding and large jaws. Dorsal and anal fins without spines. Dorsal-fin origin on blind side of head anterior to vertical through anterior margin of upper eye.

Dagetichthys lusitanicus **(de Brito Capello, 1868)**
New record. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 01.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-95.
Identifications. Body elongate, laterally compressed. Anterior snout with bony process. Eyes separated by narrow, scaly, interorbital space. Blind-side anterior nostril not enlarged. The middle of excrescence is limited by a non-scaly groove. Eye side greyish to brownish coloured with blackish blotches tending to form longitudinal series with the largest blotches along the lateral line. Blind side nostril tubular.

***Microchirus wittei* Chabanaud, 1950**

New record. MAURITANIA - Dakhlet Nouadhibou • Scientific campaign; 20.9121, -17.0425; 03.VIII.2022; M. Dia and A. Niang leg.; trawl haul (tissue sample); MAU-49.

Identification. Body oval, elongate and laterally compressed. The ocular side is dark brown with five dark brown cross-bands on body and vertical fins. The pectoral fin dark brown coloured. The blind side is whitish with dorsal and anal fins coloured as on the ocular side.

***Pegusa lascaris* (Risso, 1810)**

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-666.

Identification. Body oval, elongate, laterally compressed. The blind-side anterior nostril is enlarged and rosette-shaped. No dark spots on eye side. The eye side is uniformly yellowish to brownish coloured with several small dark spots. Pectoral fin on eye side has a distinct black patch towards the end of the middle fin rays surrounded by yellow and white areas.

***Solea senegalensis* Kaup, 1858**

Figure 5E

New records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0383, -17.0234; 19.II.2024; A. Niang and A. Freiwald leg.; Beach seine; SAM 39686. - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VII.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-279.

Identification. Body oval, elongate, laterally compressed. Pectoral fins equally well developed. Membrane between rays of ocular-side pectoral fin darker than body colour. Ocular side greyish to reddish brown in life with small blue spots tending to disappear after death. Pectoral fin of eyed side with black membrane and greyish rays; caudal fin uniformly coloured.

***Cynoglossus monodi* Chabanaud, 1949**

Figure 5F

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-515.

Identification: Body compressed and elongate with two lateral lines on ocular side. Angle of mouth extending just posterior to vertical through posterior margin of lower eye, nearer to branchial opening than to tip of snout.

***Syngnathus acus* Linnaeus, 1758**

Figure 5G

New record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0383, -17.0234; 19.II.2024; A. Niang and A. Freiwald leg.; Beach seine; SMF 39788.

Identification. Extremely elongated body encased in bony armour arranged into series of rings. Mouth small, toothless, placed at end of tubular snout. The median post-orbital part of the head is clearly elevated. Dorsum and side are brownish to greenish coloured, usually with dark bars on trunk and tail.

Fistularia tabacaria **Linnaeus, 1758**

Figure 5H

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 22.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-667.

Identifications. Body elongated and depressed. Mouth at end of a long, tubular snout, hexagonal in cross section. No elongate bony plates along midline of back. Posterior lateral- line ossifications without a spine (may be rough to the touch). Several rows of blue spots on back, sides and snout.

Ruvettus pretiosus **Cocco, 1833**

Figure 5I

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 22.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-668.

Identification. Body semi fusiform and slightly compressed. Body uniformly brown to dark brown, tips of pectoral and pelvic fins black. Skin very rough with medium-sized scale interspersed with spinous bony tubercles. Belly keeled by bony scales between pelvic fins and anus.

Trichiurus lepturus **Linnaeus, 1758**

Figure 5J

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-513.

Identification. Body elongate and strongly compressed, ribbon-like, tapering to a point. Body steel blue with silvery reflection, pectoral fin semi-transparent, other fins sometimes tinged with pale yellow. Pelvic fins absent.

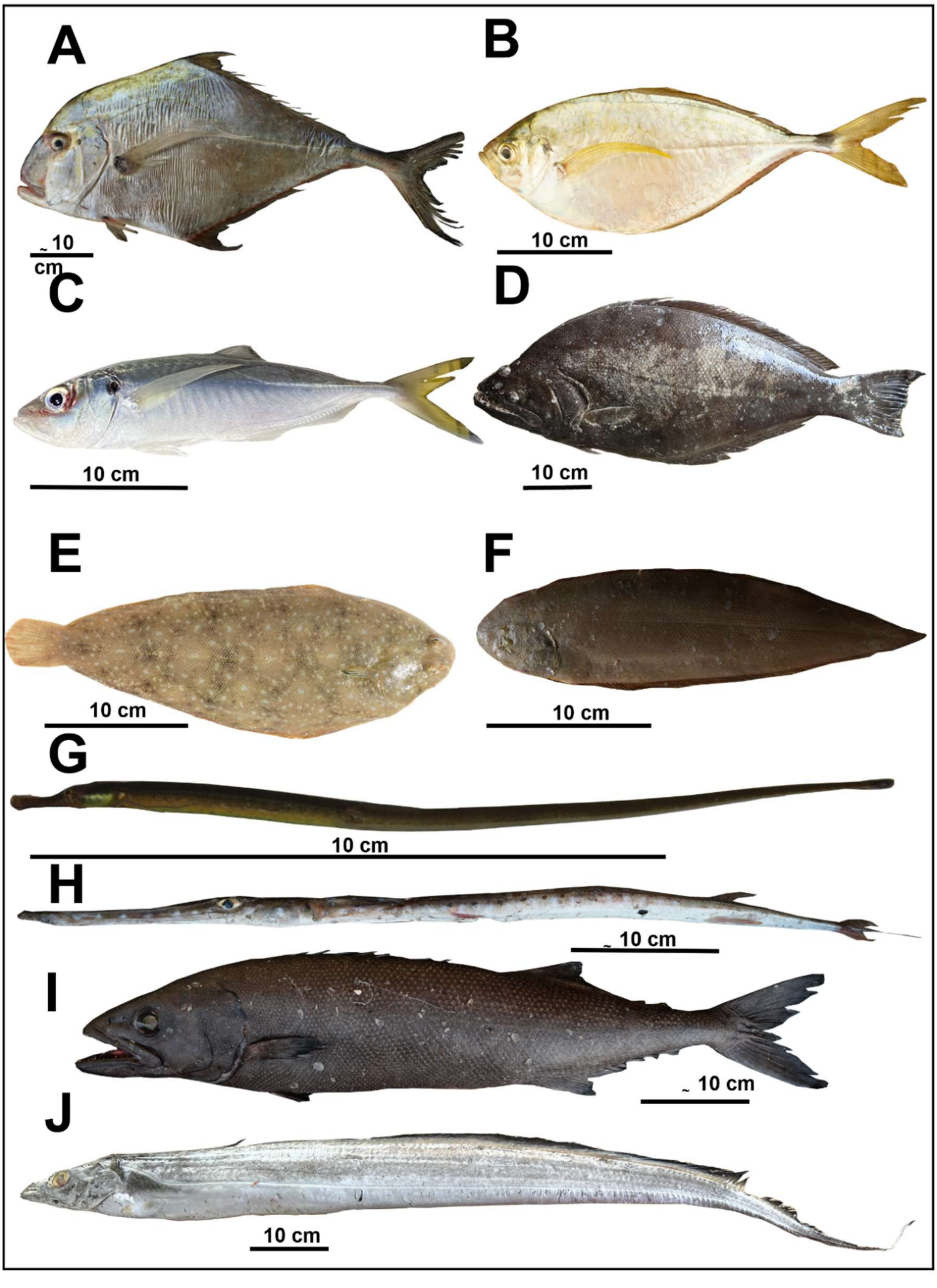

Figure 5: **A**: African threadfish (*Alectis alexandrina*), **B**: Atlantic bumper (*Chloroscombrus chrysurus*), **C**: False scad (*Caranx rhonchus*), **D**: Spiny turbot (*Psettodes bennettii*), **E**: Senegalese sole (*Solea senegalensis*), **F**: Guinean tonguesole (*Cynoglossus monodi*), **G**: Greater pipefish (*Syngnathus acus*), **H**: Cornetfish (*Fistularia tabacaria*), **I**: Oilfish (*Ruvettus pretiosus*), **J**: Largehead hairtail (*Trichiurus lepturus*). © Kristina Hopf: A, B, C, E, H, I, © Moritz Sonnewald: D, F, © André Freiwald: J, © Alexander Knorrn: G.

***Scomberomorus tritor* (Cuvier, 1832)**

Figure 6A

New record. MAURITANIA - Nouakchott Nord • Nouakchott market ;18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-668.

Identification. Body elongate, strongly compressed. Lateral line straight or gradually curving down toward caudal peduncle. Body colouration back bluish green, sides silvery with about three rows of vertically elongate spots.

***Sarda sarda* (Bloch, 1793)**

Figure 6B

New records. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 23.VI.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-1. - **Nouakchott Nord** • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); Mau-669.

Identification. A relatively narrow-bodied fish. The dorsal fins are close together. The first spiny dorsal fin is very long, with 20 to 23 spines and straight or only slightly concave in outline. The dorsal and upper lateral side is steel-blue, with five to 11 dark slightly oblique stripes running forward and downward. The lower ventral sides and belly is coloured silvery.

***Schedophilus velaini* (Sauvage, 1879)**

Figure 6C

New records. MAURITANIA - Dakhlet Nouadhibou • Scientific campaign; 20.9121, -17.0425; 03.VIII.2022; M. Dia and A. Niang leg.; trawl haul (tissue sample); AU-148. - **Nouakchott Nord** • Nouakchott market; 18.1033, -16.0263; 22.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-670.

Identification. Body generally uniformly dark green to grey, or brownish, with an indistinct vertical, or more usually horizontal, pattern of darker irregular stripes; eyes often golden. A single continuous dorsal fin with 23 to 25 soft rays.

***Stromateus fiatola* Linnaeus, 1758**

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 22.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-671.

Identification. Silvery fish with a deep and compressed head. Snout short and blunt with a small mouth. Dorsal and anal fins long and a deeply forked caudal fin. Blue to brownish coloured with a silvery cast and numerous dark spots on the dorsal side.

***Uranoscopus scaber* Linnaeus, 1758**

Figure 6D

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 24.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-672.

Identification. Body robust anteriorly and compressed posteriorly. Origin of first dorsal fin not surrounded by a large, distinct white patch. Venomous cleithral spine short, less than 25% of head length. Mouth tentacle long, slender, and grey in colour.

Symphodus bailloni **(Valenciennes, 1839)**

Figure 6E

New records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0383, -17.0234; 27.VII.2022; F. Krupp and S. M. Moctar, leg.; Beach seine; SMF 39660. • Old Pier; 21.0207, -17.0046; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; SMF 39663. • Submerged ridges; 20.6531, -16.7267; 04.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; beam trawl; SMF 39822.

Identification. Body moderately deep, snout short and large lips. Head length equal to or shorter than body depth and preopercular edge serrated. Dorsal fin continuous with 14 or 15 spines and nine to 11 soft rays. Both sexes with a dark spot on the caudal peduncle and another brown-black or dark blue spot on beginning of soft part of dorsal fin; a blue arc on base of pectoral fin. Three longitudinal dark brown stripes on middle and upper sides.

Nicholsina collettei **Schultz, 1968**

New record. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 23.VI.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-63.

Identification. Elongated body. A small dermal cirrus at edge of anterior nostril. The teeth fused only basally, thus not fully coalesced to form dental plates. Mottled olive green on dorsal side. Scales of sides with bluish white centres and reddish edges and head below level of mouth yellowish. Two diagonal narrow red-orange bands on cheek.

Pseudupeneus prayensis **(Cuvier, 1829)**

Figure 6F

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 24.II.2023; A. Knorrn H. Taleb and M. Sonnewald leg.; fish market survey (tissue sample); MAU-514.

Identification. Body moderately elongate and slightly compressed. Snout somewhat pointed. Head profile gently convex. One spine on the posterior opercular margin. Pinkish red with three or four longitudinal darker red to brownish yellow lines.

Cephalopholis taeniops **(Valenciennes, 1828)**

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 6.VI.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-109.

Identification. Body oblong, compressed and depth less than head length. Body colouration reddish orange. The head, body and median fins are covered with distinct small blue spots with dark edges.

Epinephelus aeneus **(Geoffroy Saint-Hilaire, 1817)**

Figure 6G

New records. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 21.II.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-422. • Fishermen from the Baie de l'Étoile; 21.0198, -17.0028; 09.III.2023; A. Knorrn, S. M. Moctar and A. Freiwald leg.; infront of the BdE opening; gill net of local fishermen (tissue sample); MAU-673. - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 24.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-511.

Identification. Body moderately elongate and slightly compressed. Snout somewhat pointed and the head profile is gently convex. One spine on the posterior opercle margin. Dorsal fin with 11 spines and 14 to 16 rays. The third and fourth spines longest, the interspinous membranes slightly incised. Anal fin with three spines and eight rays. Caudal fin rounded. Pinkish red colouration with two or three prominent oblique white stripes on head behind eye.

***Epinephelus caninus* (Valenciennes, 1843)**

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-674.

Identification. Body depth less than head length. Dorsal fin with 11 spines and 13 to 15 rays, the third and fourth spines longest. The interspinous membranes are deeply incised. The anal fin with three spines and eight rays. The caudal fin is truncate or emarginate. Body uniform dark reddish brown to greyish violet, without prominent markings, belly slightly paler, head with two oblique dark stripes running downward.

***Epinephelus costae* (Steindachner, 1878)**

Figure 6H

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-675.

Identification. Body depth less than head length, contained 2.8 to 3.4 times in standard length. The preopercle angle forms a rounded lobe, with an indentation immediately above the lobe; middle and lower opercular spines are flat but distinct. Yellowish brown to sepia brown. Large specimens often have a diffuse golden blotch on sides which disappears quickly after death.

***Epinephelus marginatus* (Lowe, 1834)**

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-676.

Identification. Body depth less than head length. Dorsal fin with 11 spines and 14 to 16 rays, the third or fourth spines longest, and about equal to longest dorsal-fin ray. Interspinous dorsal-fin membranes distinctly incised. The anal fin has three spines and eight rays and the caudal fin is rounded. Head and body dark reddish brown or greyish dorsally, usually yellowish gold ventrally, irregular white, pale greenish yellow or silvery grey spots and blotches usually visible on body and head, and mostly arranged in vertical series.

***Mycteroperca rubra* (Bloch, 1793)**

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 28.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-149.

Identification. Body depth less than head length**.** Body generally uniform reddish brown coloured. Sometimes mottled with irregular, blackish or pale grey spots and a black streak above maxilla.

Pomatomus saltatrix **(Linnaeus, 1766)**
Figure 6I

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 24.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-510.

Identification. A compressed body and large head. Two dorsal fins, the first short and low, with seven or eight feeble spines connected by membranes. The second long with one spine and 23 to 28 soft rays. The scales are small and cover the head, body, and bases of vertical fins. The lateral line is almost straight. The back presents a greenish blue, sides and belly are silvery. Dorsal and anal fins are pale green tinged with yellow.

Brama brama **(Bonnaterre, 1788)**

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 24.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-677.

Identification. Oval shaped Fish. Dorsal profile of head between eyes strongly arched and rounded Dorsal fin originating over the pectoral fin base. No keel on caudal peduncle and a prominent axillary scale at base of the pelvic fin. Silvery blackish colouration with lighter paired fins and trailing edge of caudal fin.

Priacanthus arenatus **Cuvier, 1829**

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 24.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-678.

Identifications. Reddish fish with a deep, ovate, and laterally compressed body. Anterior profile of head more asymmetrical, extremity of lower jaw usually above level of midline of body. Posterior portion of preopercle with scales. Pelvic fins usually with well-developed with a black area at base.

Chaetodon hoefleri **Steindachner, 1881**
Figure 6J

New records. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6531, -16.7267; 04.II.2024; A. Knorrn, S. M. Moctar, M. Sonnewald, K. Hopf, K. Pfennings and A. Freiwald obs.; video lander. - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 24.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey; SMF 39821.

Identification. Deep and compressed body with a short snout. Four dark vertical bars. The first and fourth black, the second and third brownish. The fourth on the caudal peduncle. A black spot at the top of the third bar at the junction of the dorsal fin. First bar extending downward from nape to eye, continuing downward to lower border of operculum. Pelvic fin yellow.

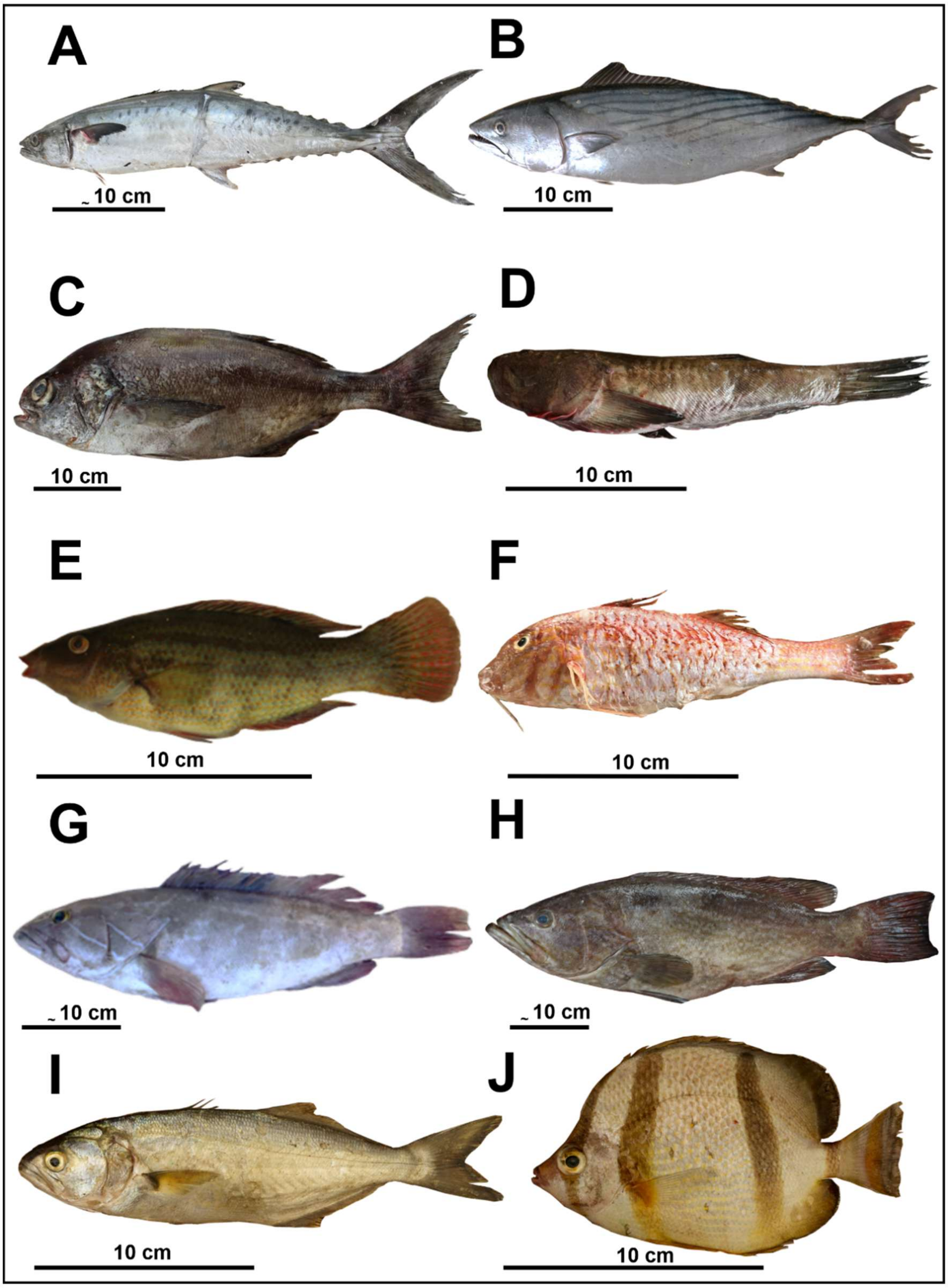

Figure 6: **A**: West African Spanish mackerel (*Scomberomorus tritor*), **B**: Atlantic bonito (*Sarda sarda*), **C**: Violet warehou (*Schedophilus velaini*), **D**: Stargazer (*Uranoscopus scaber*), **E**: Baillon's wrasse (*Symphodus baillioni*), **F**: West African goatfish (*Pseudupenaeus prayensis*), **G**: White grouper (*Epinephelus aenus*), **H**: Goldblotch grouper (*Epinephelus costae*), **I**: Bluefish (*Pomatomus saltatrix*), **J**: Four-banded butterflyfish (*Chaetodon hoefleri*). © Kristina Hopf: A, D, I, J, © Moritz Sonnewald: G, F, © André Freiwald: B, C, H, © Friedhelm Krupp: E.

***Branchiostegus semifasciatus* (Norman, 1931)**

Figure 7A

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 28.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); Mau-135.

Identification. Body quadriform, body. Snout blunt with jaws extending to well under eye anterior margin. Head with elevated predorsal ridge (raised seam in front of dorsal fin). Relatively large eye and a preoperculum with fine serrae on upper limb. One single blunt opercular spine or tab. Golden yellow colouration on sides. A large dark area between axil of pectoral fin and dorsal margin of operculum. Body with a series of 16 to 20 grey-violet (dark) tapering vertical bars to below midbody alongside of body from anterior of dorsal fin base to posterior dorsal-fin base.

***Brachydeuterus auritus* (Valenciennes, 1832)**

Figure 7B

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 24.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-679.

Identification. Body oblong and compressed. Snout shorter than eye diameter. Chin with a pair of small pores near lips and another pair of pores, very close to each other, at symphysis of lower jaw. Back bluish coloured, sometimes small dark spots present on dorsal fin near base.

***Parakuhlia macrophthalma* (Osório, 1893)**

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 08.VII.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); Mau-38.

Identification. Body ovate, moderately deep and laterally compressed. Dorsal profile of head relatively steep, slightly concave over eye. Body mostly silvery, slightly darker on dorsal surface. All fins, base of dorsal and anal fins, and caudal peduncle are dark yellow. A single dorsal fin, deeply notched between spinous and soft-rayed portions, with 11 spines in anterior section and one spine and 15 or 16 soft rays posteriorly.

***Pomadasys incisus* (Bowdich, 1825)**

New record. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6531, -16.7267; 04.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; fishing line; SMF 39679.

Identification. Body oblong and compressed, more convex dorsally. One pair of small chin pores at symphysis of low lip and a single pit opening to a pair of pores at symphysis of lower jaw. Background silvery grey, with a dark blotch on posterior edge of operculum with no spots or stripes. Pectoral, pelvic and anal fins yellowish, dorsal and caudal fin yellowish to blackish.

***Pomadasys perotaei* (Cuvier, 1830)**

Figure 7C

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-519.

Identifications. Body oblong and compressed. One pair of small chin pores at symphysis of low lip and a single pit opening to a pair of pores at symphysis of lower jaw Back silvery grey with a bluish cast, belly silvery; light brown spots irregularly spread on back and sides. Upper back anterior to line from origin of dorsal fin to origin of lateral line typically with distinct spots; spots present in scale rows above, below and on anterior scales of lateral line.

Parapristipoma octolineatum **(Valenciennes, 1833)**

New record. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 14.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-117.

Identification. Body elongate and compressed. Snout rounded, shorter than eye diameter. Chin with three pairs of pores, where the anterior pair is smaller than the others. Body colouration brownish with four longitudinal whitish to bluish stripes along back and sides beginning on head fins yellowish to brownish.

Plectorhinchus mediterraneus **(Guichenot, 1850)**

Figure 7D

New records. MAURITANIA - Dakhlet Nouadhibou • Fishermen from the Baie de l'Étoile; 21.0198, -17.0028; 09.III.2023; A. Knorrn, S. M. Moctar and A. Freiwald leg.; infront of the BdE opening; gill net of local fishermen (tissue sample); MAU-416. • Submerged ridges; 20.6531, -16.7267; 04.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; fishing line (tissue sample); MAU-680.

Identification. Body oblong and compressed. Lips thick. Right and left elements of lower jaw posterior to symphysis separated at ventral midline by a fleshy isthmus. Chin with three pairs of pores, where the anterior pair smaller than the others. Body greyish to brownish. Fins greyish to brownish, the tips generally darker, especially the pectoral fins.

Lutjanus goreensis **(Valenciennes, 1830)**

Figure 7E

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-681.

Identifcation. Relatively deep body and a pointed head. Enlarged preorbital bone and vomerine teeth that are arranged in a triangular patch with a pronounced posterior extension medially. Vivid pink grading to whitish on ventral portion with a narrow blue subocular band, or row of broken spots. Blue stripe on head, sometimes extending from near tip of snout to angle of operculum.

Pontinus kuhlii **(Bowdich, 1825)**

New record. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 01.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-25.

Identification. Relatively large head that is covered with spines and a slightly compressed body. Second and/or third dorsal spines relatively elongate. Lacrimal with two spines both pointing posteroventrally over the maxilla. Suborbital ridge with three or four spines. Second preopercular spine small or absent. Red or reddish pink coloured body, with small, scattered irregular, reddish brown and yellow spots, sometimes most pronounced at base of dorsal fin.

***Scorpaena normani* Cadenat, 1943**

New record. MAURITANIA - Dakhlet Nouadhibou • Scientific campaign; 20.9121, -17.0425; 03.VIII.2022; M. Dia and A. Niang leg.; trawl haul (tissue sample); MAU-42.
Identification. Fish with large heads covered with spines and a slightly compressed but robust body. Bright red body colouration with dark spots around the body. The pectoral fin has dark red spots, Membranes between anterior dorsal-fin spines are deeply incised for more than half length of the spine. Chest and base of pectoral fin without scales. No occipital pit, but with slight depressions anterior to parietal bones.

***Dicentrarchus punctatus* (Bloch, 1792)**

Figure 7F
New records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0383, -17.0234; 19.II.2024; A. Niang and A. Freiwald leg.; Beach seine; SMF39659. • Submerged ridges; 20.6531, -16.7267; 04.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; fishing line; SMF39665.
Identification. Body elongate and eye diameter about half snout length. Silvery grey body colouration. Bluish dorsally, adults with small black spots scattered over back and sides. A conspicuous black spot between spines on upper rear edge of operculum.

***Drepane africana* Osório, 1892**

Figure 7G
New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 28.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-137.
Identification. Body deep, rhomboid, strongly compressed with fleshy lips. Dorsal fin notched between spinous and soft portions, with eight or nine spines and 20 or 21 soft rays. Primarily silvery white colouration, darker dorsally; a series of about 8 vertical dark bars frequently present but often faint on sides.

***Argyrosomus regius* (Asso, 1801)**

Figure 7H
New record. MAURITANIA - Dakhlet Nouadhibou • Fishermen from the Baie de l'Étoile; 21.0198, -17.0028; 09.III.2023; A. Knorrn, S. M. Moctar and A. Freiwald leg.; infront of the BdE opening; gill net of local fishermen (tissue sample); MAU-425.
Identification. A elongated and moderately compressed fish. Eye moderately small, its diameter less than interorbital width. silvery grey with a bronze reflection on back, inside of mouth yellowish to orange; distal portions of caudal, anal, pelvic fins darker.

***Pseudotolithus senegalensis* (Valenciennes, 1833)**

New records. MAURITANIA - Dakhlet Nouadhibou • Fishermen from the Baie de l'Étoile; 21.0198, -17.0028; 09.III.2023; A. Knorrn, S. M. Moctar and A. Freiwald leg.; infront of the BdE opening; gill net of local fishermen (tissue sample); MAU-682. - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 24.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-683.
Identification. A elongated and moderately compressed fish with medium eyes. Long pectoral fins that reach beyond the pelvic fin tips. silvery grey to yellowish, back with distinct dark oblique wavy lines along scale rows, extending to head and becoming horizontal posteriorly. Axils of pectoral-fin base dark, distal portions of caudal, anal and pelvic fin darkish.

***Pteroscion peli* (Bleeker, 1863)**

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 28.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-143.

Identification. Body short and robust, its depth less than 3.5 times of total length. The top of head cavernous, spongy to touch. The mouth is strongly oblique, pointed upward exceeding 45° angle. Gill rakes longer than gill filaments at the angle. 23 or more on first gill arch; gas bladder with a pair of short arborescent appendages anterolaterally. Silvery greyish olive colouration dorsally, lighter below. Pale to yellowish fins and a dark blotch at the axils of pectoral fins.

***Sciaena umbra* Linnaeus, 1758**

Figure 7I

New records. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0207, -17.0046; 30.I.2024; A. Knorrn, M. Sonnewald, K. Pfennings, K. Hopf and A. Freiwald leg.; fish trap (tissue sample); MAU-684. • Fishermen from the Baie de l'Étoile; 21.0198, -17.0028; 09.III.2023; A. Knorrn, S. M. Moctar and A. Freiwald leg.; infront of the BdE opening; gill net of local fishermen (tissue sample); MAU-685.

Identification. A deep-bodied and compressed fish with a strongly arched dorsal profile. Chin without barbel, but with 5 conspicuous mental pores. Body greyish to silvery coloured with a golden or metallic hue. Dusky lining on the dorsal corner of the operculum. Pelvic and anal fins black, soft dorsal fin and lower edge of caudal fins dark.

Dentex angolensis Poll & Maul, 1953

New record. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 03.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-86.

Identification. Body oval, moderately deep and compressed. Straight head profile and a narrow interorbital space (21 to 25% of head length). Suborbital space wide (17 to 21% of head length). Body colouration red with silvery reflections. Head darker and belly lighter. A small dark area above the insertions of pectoral fins visible. The dorsal and anal are fins red except on their bases.

***Dentex canariensis* Steindachner, 1881**

Figure 7J

New record. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; III.2021; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-139.

Identification. Body oval, moderately deep and compressed. Head profile regularly convex except for a slight hump on the front. Colouration reddish with silvery reflections. The belly is lighter and head darker coloured. A dark red spot posteriorly on base of dorsal fin extending well beyond the scaly sheath. A dark area at axil of pectoral fin. Several more or less aligned dark spots on soft portion of dorsal fin.

***Dentex gibbosus* (Rafinesque, 1810)**

New record*.* MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 28.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-138.

Identification. Body oval, more or less elongate and compressed. Head profile with a conspicuous hump on front. Colouration reddish with bluish silvery reflections. Belly lighter and head darker. A small black spot behind posterior end of dorsal fin and a brownish black spot at axil of pectoral fin. Dark area at upper angle of operculum. One or two dark lines on soft part of dorsal fin.

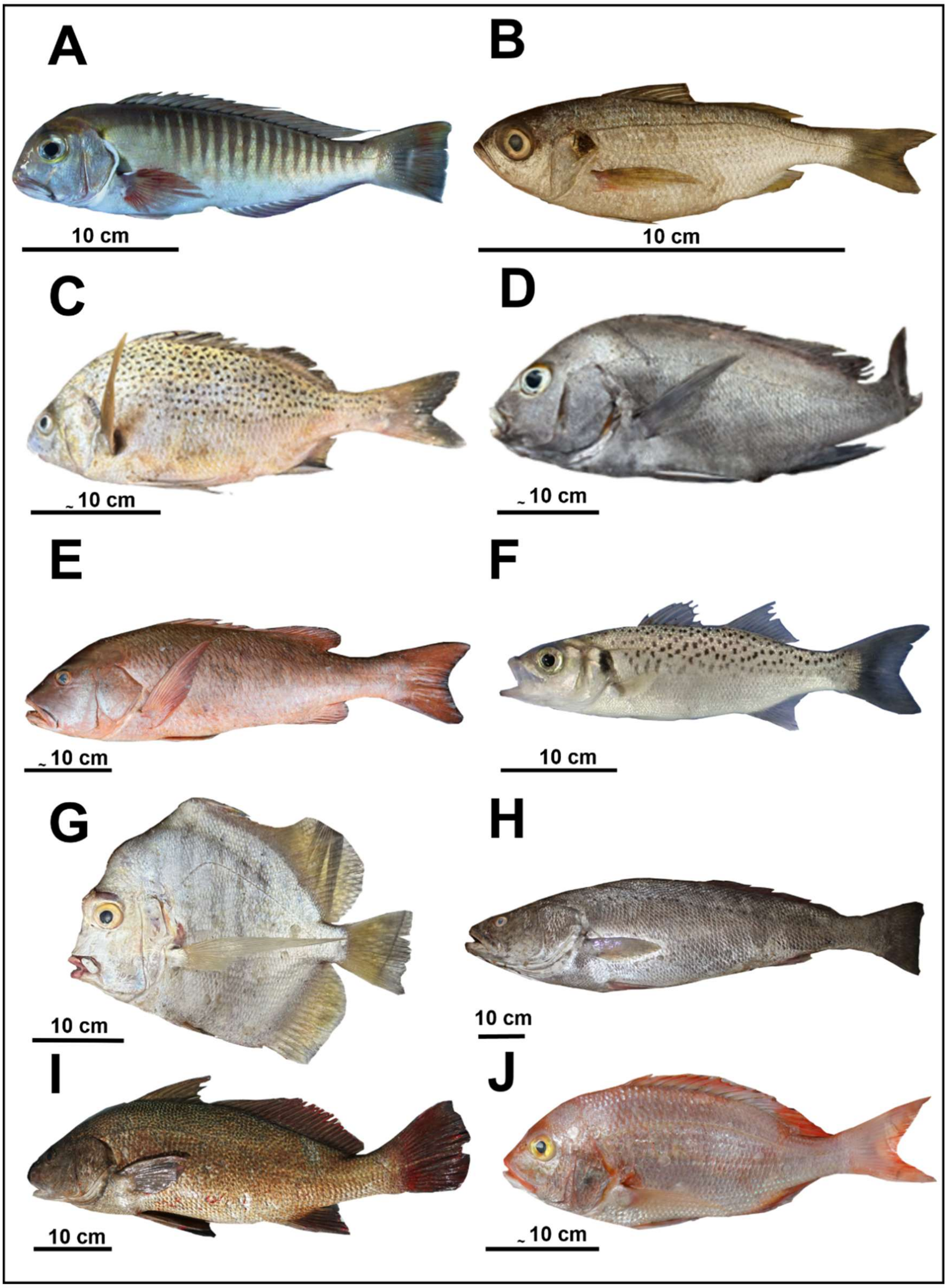

Figure 7: **A**: Zebra tilefish (*Branchiostegus semifasciatus*), **B**: Bigeye grunt (*Brachydeuterus auritus*), **C**: Parrot grunt (*Pomadasys perotaei*), **D**: Rubberlip grunt (*Plectorhinchus mediterraneus*), **E**: Gorean snapper (*Lutjanus goreensis*), **F**: Spotted seabass (*Dicentrarchus punctatus*), **G**: African sicklefish (*Drepane africana*), **H**: Meagre (*Argyrosomus regius*), **I**: Brown meagre (*Sciaena umbra*), **J**: Canary dentex (*Dentex canariensis*). © Niang Alioune: A, F, © Kristina Hopf: B, C, E, I, J, © André Freiwald: D, G, H.

Diplodus bellottii **(Steindachner, 1882)**

New record. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0207, -17.0046; 02.XII.2021; M. Sonnewald, S. M. Moctar and A. Freiwald ; hand collection; SMF 39609.

Identification. Body oval, moderately deep and compressed. Mouth slightly protrusible. eight chestnut-coloured, incisor-like teeth in each jaw, followed by two to three (usually two) rows of molars; a single row of molars behind the incisors. Background colour silvery grey, head darker; a dark, saddle-shaped bar on caudal peduncle and a dark blotch at origin of lateral line extending onto upper angle of operculum.

Diplodus cervinus **(Lowe, 1838)**

New record. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 23.VI.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-58.

Identification. Body oval, deep and compressed. 10 to 12 incisor-like teeth in upper jaw, eight in lower jaw, followed by one to three (usually two) rows of small molars. Background colour silvery grey with golden reflections, five broad, dark cross-bars on sides, the first before dorsal fin, the last on caudal peduncle; a dark band on interorbital space extending onto eyes and cheeks.

Diplodus puntazzo **(Walbaum, 1792)**

Figure 8A

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish makret survey (tissue sample); MAU-686.

Identification: Body oval and compressed. Snout pointed, jaws protrusible, lips thin. Eight conspicuously forward-pointing, chestnut-coloured, incisor-like teeth in each jaw, followed by one or two rows of small, very rudimentary molars. Six or seven alternatingly very dark and lighter cross-bars on sides and a large, dark, nearly annular bar on caudal peduncle.

Diplodus sargus **(Linnaeus, 1758)**

Figure 8B

New records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0383, -17.0234; 19.II.2024; A. Niang and A. Freiwald leg.; Beach seine; SMF 39791. • Fishermen from the Baie de l'Étoile; 21.0198, -17.0028; 09.III.2023; A. Knorrn, S. M. Moctar and A. Freiwald leg.; infront of the BdE opening; gill net of local fishermen (tissue sample); MAU-419. • Nouadhibou Market; 20.9121, -17.0425; 09.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-45.

Identification. Body oval, moderately deep. Mouth slightly protrusible, lips thin. Eight incisor-like teeth (exceptionally 10) in upper, and eight in lower jaw, followed by molars arranged in three or four (rarely five) rows in upper and two or three (rarely four) rows in lower jaw. Nine alternating dark and attenuated vertical bars on body covering about two-thirds of body depth from the dorsal profile downward, a saddle-like dark blotch on caudal peduncle, just behind end of dorsal fin.

Diplodus vulgaris **(Geoffroy Saint-Hilaire, 1817)**

Figure 8C

New record. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 14.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-34.

Identification. Body oval, deep and compressed. narrow, chestnut-coloured, incisor-like teeth in each jaw, three to five rows of molars in upper and two to four rows in lower jaw, set behind the incisors and on sides of jaws. A large, very dark nuchal band extending from origin of dorsal fin to pectoral-fin insertions and to the posterior margin of operculum. A dark annular band on caudal peduncle extending onto the bases of posterior dorsal- and anal-fin rays.

Lithognathus mormyrus **(Linnaeus, 1758)**

Figure 8D

New records. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 09.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-75. - **Nouakchott Nord** • Nouakchott market; 18.1033, -16.0263; 22.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-687.

Identifications. Body oblong and compressed. Head profile straight and the posterior nostril are slit-like. Body greyish with silvery reflections and darker colouration dorsally. 14 or 15 narrow dark brown to grey vertical bars on sides.

Pagrus caeruleostictus **(Valenciennes, 1830)**

Figure 8E

New records. MAURITANIA - Dakhlet Nouadhibou • Fishermen from the Baie de l'Étoile; 21.0198 -17.0028; 09.III.2023; A. Knorrn, S. M. Moctar and A. Freiwald leg.; infront of the BdE opening; gill net of local fishermen (tissue sample); MAU-420. - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-512.

Identification. Body oval, moderately deep and compressed. Dorsal fin with 11 or 12 spines and nine to 11 soft rays. First two spines always very short, the third to fifth longest. Body pink with silvery reflections and large bluish black spots on back and sides.

Sparus aurata **Linnaeus, 1758**

Figure 8F

New records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0383, -17.0234; 19.II.2024; A. Niang and A. Freiwald leg.; Beach seine; SMF 39798. • Nouadhibou Market; 20.9121, -17.0425; 03.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-78.

Identification. Body oval, moderately deep and compressed. Body colouration silvery grey. A large black blotch at origin of lateral line extending on upper margin of operculum where it is edged below by a reddish area. Dark longitudinal lines often present on sides of body. Dark band on dorsal fin; fork and tips of caudal fin edged with black.

Spondyliosoma cantharus **(Linnaeus, 1758)**

New records. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 21.II.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-

73. • Submerged ridges; 20.6531, -16.7267; 04.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; fishing line; SMF 39668.
Identification. Body oval and compressed. Dorsal profile of head depressed above eyes. Four to six rows of pointy teeth in each jaw. Silvery grey with bluish, greenish or pinkish reflections. Head darker, especially between the eyes and on snout. More or less discontinuous, yellow golden longitudinal lines on sides. Vertical fins darker than body.

Capros aper **(Linnaeus, 1758)**
New record. MAURITANIA - Dakhlet Nouadhibou • Scientific campaign; 20.9121, -17.0425; 03.VIII.2022; M. Dia and A. Niang leg.; trawl haul (tissue sample); MAU-13.
Identification. Body deep, compressed with a body depth distinctly more than the head length. Body covered with spinoid scales and each scale is hidden by a cluster of long slender spinelets. Head and body silver-gold coloured. Eye pale yellow and the spinous dorsal fin is black with a broad red margin. Dorsal fin deeply notched between spinous and soft parts, with nine or 10 strong, grooved spines and 23 to 25 branched rays.

Balistes punctatus **Gmelin, 1789**
Figure 8G
New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 06.VII.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample), MAU-106.
Identification. Deep and moderately compressed body. Dorsal fin with three spines and 27 to 30 soft rays. Scales enlarged above pectoral-fin base and just behind gill slit to form a flexible tympanum. Body colouration generally greyish with a regular pattern of large round blue or green spots covering most of the body.

Stephanolepis hispida **(Linnaeus, 1766)**
New records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0383, -17.0234; 31.I.2024; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; from local fisherman; gill net; photo documentation. • Fishermen from the Baie de l'Étoile; 21.0198, -17.0028; 09.III.2023; A. Knorrn, S. M. Moctar and A. Freiwald leg.; infront of the BdE opening; gill net of local fishermen (tissue sample); MAU-688. - Nouakchott Nord • Nouadhibou Market; 20.9121, -17.0425; 14.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-31.
Identifications. Body deep and highly compressed. Region of back just behind dorsal spines without a deep groove to receive first dorsal-fin spine when it is not erected. Enlarged encasing scales at end of pelvis flexible dorsoventrally. First dorsal spine over posterior part of eye. Greenish, olive or brownish colouration. Sometimes with dark blotches.

Ephippion guttifer **(Bennett, 1831)**
Figure 8H
New records. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 14.III.2022; M. Dia and A. Niang leg.; fish market surve (tissue sample); MAU-22. - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263, 24.I.2024; A. Knorrn, K. Hopf and K. Pfennings leg.; fish market survey (tissue sample); MAU-689.
Identification. Blunt body capable of rapid inflation by intake of water (or air). Nasal papilla not a simple tube, but expanded to two lateral and one posterior flap. Basal pigmentation of upper flanks and back a rich brown with a slight maroon tinge, the basal

colour fading laterally to the unpigmented belly. Pigmented surfaces covered with discrete white spots, about a third to a fourth of the eye diameter.

***Lagocephalus guentheri* Miranda Ribeiro, 1915**

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 28.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-133.

Identification. Blunt-headed fish with heavy jaws forming a beak of two teeth in both upper and lower jaws. Caudal fin moderately emarginate lunulated. Dorsal side dark grey (adults) to olive-green with dark blotches (young). Side of head and flank-silvery, often with golden sheen.

***Lagocephalus laevigatus* (Linnaeus, 1766)**

Figure 8I

New record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 28.III.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-144.

Identification. Blunt-headed fish with heavy jaws forming a beak of two teeth in both upper and lower jaws. Caudal fin distinctly concave, in adults its upper lobe longer than lower lobe. Upper side a uniform grey or greenish grey, sides mostly silver, belly white.

***Sphoeroides marmoratus* (Lowe, 1838)**

Figure 8J

New record. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0207, -17.0046; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; SMF 39612.

Identification. Body with a single pair of black lappets on the back about half the distance from the posterior margin of the orbits to the dorsal-fin origin. Ventral sides bordered with an even row of 11 to 14 sharply defined round dark spots. Caudal fin with a black or very dark bar at its base and another at its posterior margin.

***Sphoeroides pachygaster* (Müller & Troschel, 1848)**

New records. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 03.VIII.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-47. - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; 25.VI.2023; A. Knorrn, H. Taleb and A. Freiwald leg.; fish market survey (tissue sample); MAU-53.

Identification. A blunt-headed pufferfish with heavy jaws forming a beak of two teeth in both upper and lower jaws. Lower caudal lobe longer than upper lobe. dark green or blue dorsally, white ventrally, with distinct dark spots around pectoral-fin base, extending to ventral surface. Pectoral fin dark above, with lower third distinctly lighter.

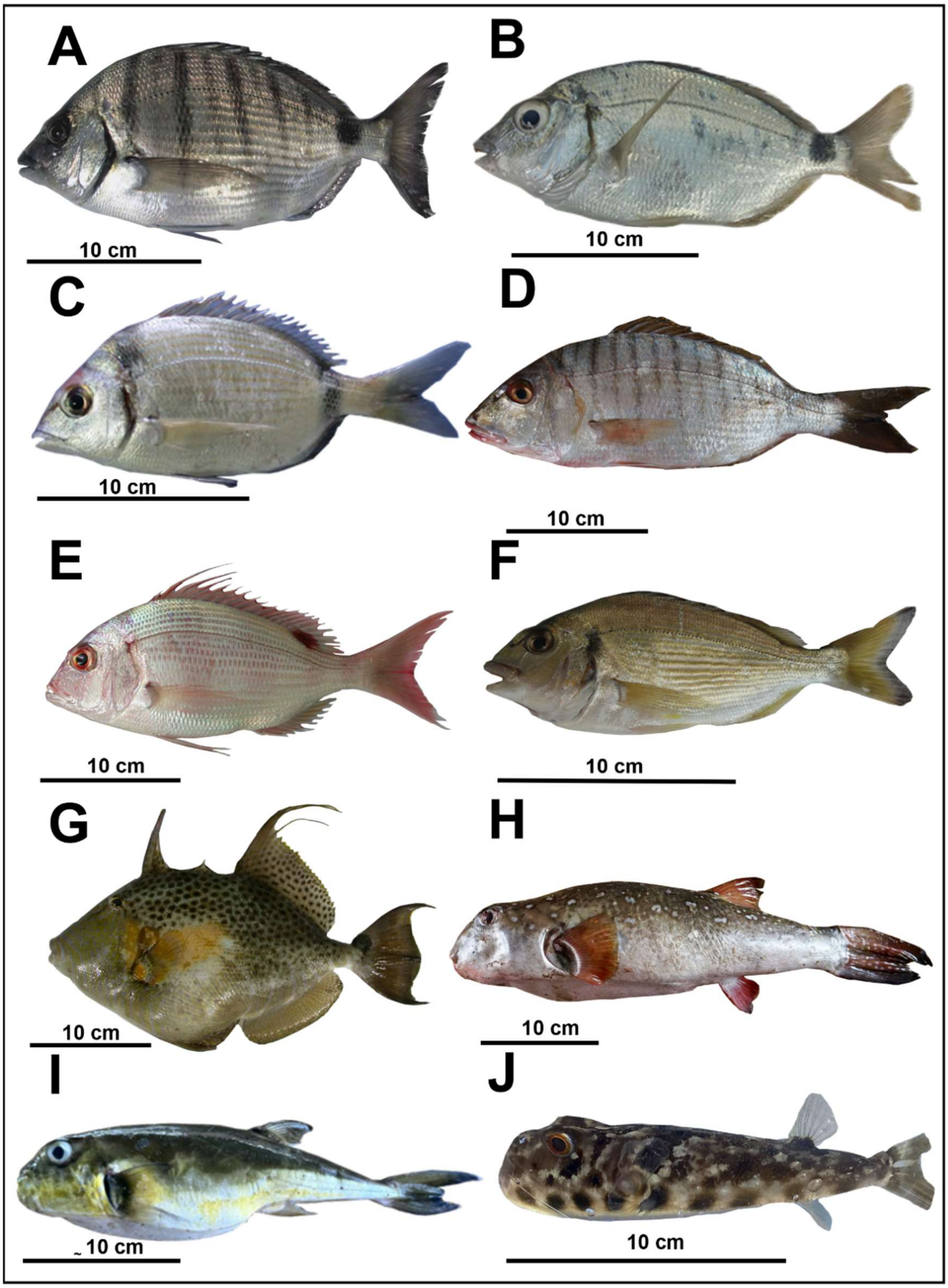

Figure 8: **A**: Sharpsnout seabream (*Diplodus puntazzo*), **B**: White seabream (*Diplodus sargus*), **C**: Common two-banded seabream (*Diplodus vulgaris*), **D**: Sand steenbras (*Lithognathus mormyrus*), **E**: Bluespotted seabream (*Pagrus caeruleostictus*), **F**: Gilthead seabream (*Sparus aurata*), **G**: Bluespotted triggerfish (*Balistes punctuatus*), **H**: Prickly puffer (*Ephippion guttifer*), **I**: Smooth puffer (*Lagocephalus laevigatus*), **J**: Guinean puffer (*Sphoeroides marmoratus*). © Niang Alioune: B, C, E, G, © Kristina Hopf: A, D, H, © André Freiwald: F, I, © Alexander Knorrn: J.

5.6 Discussion

In this study, we detected and identified 105 different fish species, which represent about 25% of all currently known Elasmobranch and Actinopterygian species from the coastal zone of Mauritania which currently are accessible via The Ocean Biodiversity Information System (https://www.obis.org). Moreover, this study contributes to a gain of ~5% of fish species (Table 3) which are not yet reported from that marine region (Fig. 9).

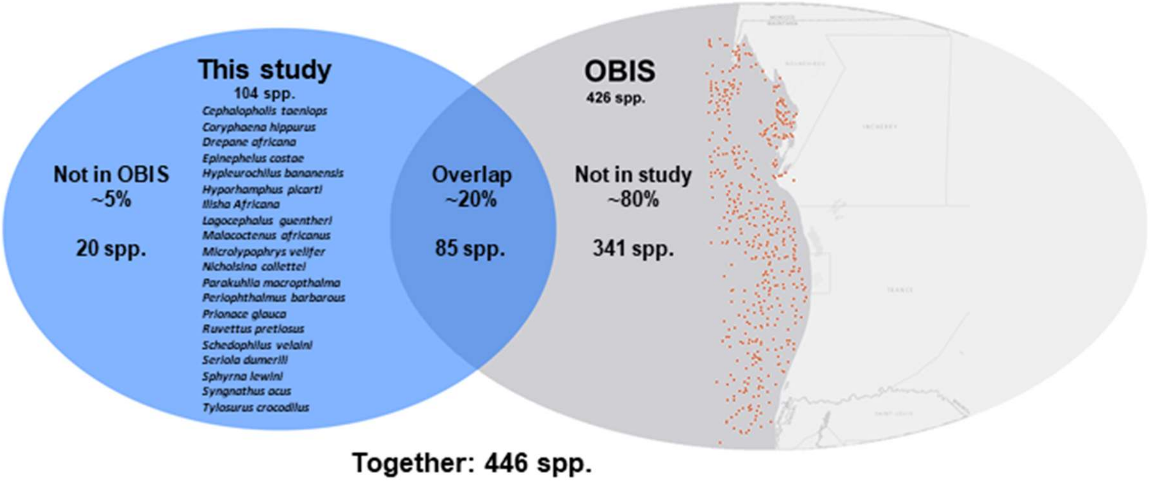

Figure 9: Comparison between all Actinopterygian and Elasmobranch species of this study and from the repository of the Ocean Biodiversity Information System (OBIS). OBIS site selection and point density to be seen on the map in the right circle.

Table 3: Species from this study that were not included within the OBIS databank.

Species
Cephalopholis taeniops (Valenciennes, 1828)
Coryphaena hippurus Linnaeus, 1758
Drepane africana Osório, 1892
Epinephelus costae (Steindachner, 1878)
Hypleurochilus bananensis (Poll, 1959)
Hyporhamphus picarti (Valenciennes, 1847)
Ilisha africana (Bloch, 1795)
Lagocephalus guentheri Miranda Ribeiro, 1915
Malacoctenus africanus Cadenat, 1951
Microlipophrys velifer (Norman, 1935)
Nicholsina collettei Schultz, 1968
Parakuhlia macrophthalma (Osório, 1893)
Periophthalmus barbarus (Linnaeus, 1766)
Prionace glauca (Linnaeus, 1758)
Ruvettus pretiosus Cocco, 1833
Schedophilus velaini (Sauvage, 1879)
Seriola dumerili (Risso, 1810)

Sphyrna lewini (Griffith & Smith, 1834)
Syngnathus acus Linnaeus, 1758
Tylosurus crocodilus (Péron & Lesueur, 1821)

The comparison shows that there still is much more to discover and emphasizes the need for additional investigations. In order to fulfil at least parts of this need, our both institutes engage in building up a local, natural history reference collection in Nouadhibou, forming a baseline for present voucher specimen and for to monitor future changes in biodiversity. All the fish specimens and tissue samples we collected during this study will be shared between the collections of both Senckenberg and IMROP. The metadata will be entered into our collection databases and thus be automatically mirrored to OBIS and GBIF in order to close potential gaps of knowledge not only for science.

Among the 105 fish species observed within this study, a mix of various species from tropical, subtropical, and temperate regions was observed. Similar observations were made by Jager (1993) and Le Loeuff and von Cosel in 1998. For example, *Chaetodon hoefleri* exhibits a typical tropical distribution for butterflyfishes and has one of the most northern distributions in the East Atlantic in front of Nouakchott. Similarly, there are widely distributed species, such as the *Diplodus sargus*, found from temperate to tropical regions off the coast of Mauritania. However, it is important to note that there is a thermal front in the north of Mauritania – the Cape Verde Frontal Zone. This oceanic frontal system separates the warmer southern waters from the cooler northern waters (Bambaye et al. 2010; Mahfoud et al. 2013), limiting the migration of some species. As a result, more species from temperate regions should be observed in the northern part of Mauritania than in the southern part. Overall, the results indicate that along the Mauritanian coast, a mixed fish community can be found that is benefiting from the abundant nutrient resources.

The observed fish species and their habitats in which they were sampled reveal that, apart from the findings at the artisanal fish landing sites, areas with hard substrate have attracted high numbers of fish. This may largely be due to the fact that such hard substrates, whether natural (Sandstone and Rocky islands) or man-made (Old Pier) structures, provide surfaces for biofouling communities such as algae, sponges, cnidarians and ascidians to colonize. Consequently, these reef-like ecosystems offering a wide range of food sources and hiding places that attract the surrounding marine life. This effect is generally known as the "reef effect". Another important shallow-water habitat are the seagrass beds. These habitats are not only known to host great numbers of marine life (Unsworth and Cullen 2010), they are also important ecosystems, since they provide valuable nursery areas for a diverse range of fish species, which are targeted by commercially and small-scale fisheries (Lilley and Unsworth 2014). Similarly, to those hard substrate habitats, do seagrass beds generate additional hiding places and food resources, which attract the surrounding fauna.

Due to the great availability of nutrients caused by oceanic upwelling and wind driven input of Saharan dust, some of the commercially most profitable fish stocks in the Atlantic Ocean are found off the coast of Mauritania. This is also reflected economically, as a significant portion of the Mauritanian gross domestic product is generated by the fisheries sector (Hausmann et al. 2014). However, Mauritanian marine fisheries have undergone massive development in the last 20 years (Gascuel et al. 2007; IMROP 2014; FAO 2016), leading to the overfishing of several fish stocks. The continuation of these intensive fishing activities poses a severe threat to marine ecosystems and to the local biodiversity (Colman et al. 2005). Consequently, some of the target species of artisanal fisheries shown in this study, such as *Trachurus trachurus* and *Pseudopeneus prayensis*, have already been classified as vulnerable by the IUCN Red-List. Cartilaginous fish species are particularly affected by fishing activities. For example, *Sphyrna lewini* (Critically Endangered, CR), *Glaucostegus cemiculus* (Critically Endangered, CR), *Rhizoprionodon acutus*) (Vulnerable, VU), and *Raja undulata* (Endangered, ED) are highly vulnerable and threatened species and were also observed repeatedly at the artisanal fish markets. Due to their low fecundity, the recovery of populations of these species is very slow, making them highly vulnerable to overfishing and potential extinction. However, there are also some species, such as *Zeus faber*, *Chelon dumerili*, *Lutjanus goreensis*, and *Psettodes bennetti* found frequently in artisanal fish landing places that are not assessed by the Red List assessments. Therefore, these species have been classified as Data Deficient (DD). Generally, some of the Red List assessments were conducted several years ago and are likely to require a revision, especially considering the high fishing pressure and climate change. It is possible that the classifications of most commercially exploited species off the coast of Mauritania may have changed by now.

This work presents our current knowledge of the ichthyofauna from Mauritanian shallow-water habitats and artisanal fish markets. This list supports future ecosystem-based management by providing a baseline of frequently traded and sighted fish from shallow-water habitats and artisanal landing places. Further investigations are needed to provide a more detailed and comprehensive list of the ichthyofauna occurring in Mauritanian waters. This information is very valuable in future, especially in the context of global environmental change enhanced by increased exploitation of fish resources in the oceans. The information generated in this study highlights the urgent need of further biodiversity and IUCN Red List assessments along the Mauritanian coastline.

5.7 Acknowledgements

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Chapter 6

Annotated checklist of the marine macrozoobenthos from Mauritanian marine shallow-water habitats

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6.1 Abstract

From 2020 to 2024, The IMROP (Institut Mauritanien de Recherches Océanographiques et de Pêches) and the Senckenberg Research Institute conducted five joint expeditions to the Mauritanian coastal habitats, primarily focusing on the “Baie de l’Étoile” north of Nouadhibou and to the Banc d’Arguin National Park. In order to establish a scientific reference collection of the Mauritanian fauna and to build a DNA barcode library, macrozoobenthic animals from all major groups and fish (addressed in a separate checklist) were collected using various methods and gear. A total of 118 living marine macrozoobenthic species were found and their key morphological features described. This checklist gives an overview on the most common species of the Mauritanian coastal macrozoobenthos and provides a foundation for future biodiversity assessments along the Mauritanian coast.

Key words: Biodiversity, Upwelling, West Africa, macrozoobenthos

6.2 Introduction

The Mauritanian coast is situated within the Canary Current Large Marine Ecosystem (CCLME), which is subject to strong seasonal upwelling (Heileman and Tandstad 2009). This upwelling occurs when cold, nutrient-rich deep water is brought to the surface by offshore winds, resulting in high nutrient concentrations in the upper water layers. This nutrient surplus leads to large phytoplankton blooms, which form the basis for extensive food webs and support some of the most productive fish stocks in the Atlantic Ocean.

The abundance of nutrients and the geographic location of Mauritania contribute to a remarkably high biodiversity along its coast, encompassing species from temperate, tropical, and subtropical regions (Jager 1993; Le Loeuff and von Cosel 1998). The northernmost distribution of some tropical species and the southernmost distribution of certain temperate species overlap in this region, resulting in a unique species composition. The coastal habitats, such as seagrass beds or tidal mud flats, are of particular importance for this rich marine biodiversity (Coll et al. 2010; Unsworth & Cullen-Unsworth 2014). These habitats in the shallow, euphotic zone provide essential hiding places and food sources for many marine organisms and additionally serve as nurseries for numerous endangered and commercially exploited species (Dewsbury et al. 2016; Jackson et al. 2015). Understanding the interspecific relationships within these ecosystems is crucial to initiate necessary conservation measures in response to threats from climate change and urbanisation. Such understanding relies on knowledge of the locally occurring species. Previous research in Mauritania has predominantly focused on specific animal groups like migratory birds, commercially important fish species (Wolff et al. 1993; Ramos et al. 2017) or sea turtles (Catry et al. 2023), and only investigated small areas. The overall low sampling coverage along the Mauritanian and West African coast (Thyrring et al. 2024) has led to significant knowledge gaps concerning invertebrate species such as crustaceans, molluscs, and polychaetes.

This study aims to provide an overview of the coastal shallow-water habitats of Mauritania, including seagrass beds, maerl beds, and tidal mudflats, and to catalogue the macrozoobenthic species present in these environments. Additionally, this study aims to create a checklist of the most abundant macrozoobenthic species of this area and to highlight their most outstanding characteristics, including a literature overview for species identification of this region.

6.3 Study area

The study area comprises nine different locations along the Mauritanian coast. Four areas (Bellaat lagoon, Kijji island, Pelican island and Submerged Ridge field) are situated within the UNESCO World Heritage Site Banc d'Arguin National Park (PNBA), where artisanal fishing is permitted only with non-motorised boats (Ly and David 2016). Additionally, the Baie de l'Étoile was designated as a marine protected area since August 30, 2024 the Ministère de l'Environnement et du Développement Durable. The seagrass beds of the Baie de l'Étoile consist of *Zostera noltei* and *Cymodocea nodosa*, and are heavily impacted by artisanal fisheries, and pollution through waste water discharge and plastic pollution. A hitherto undescribed maerl bed is located near a rocky island in the Baie de l'Étoile. Additional hard substrates, including a rocky island in the centre of the lagoon and artificial structures such as an old fishing pier (Centre de Pêche) support the local sessile fauna assemblages. Despite its newly acquired protection status, the Baie de l'Étoile is still subjected to significant anthropogenic stressors as a consequence of expanding urbanisation of Nouadhibou city. These impacts include fishing, plastic pollution, and wastewater discharge. A similar situation applies to the following three areas (Cap Blanc, Baie du Lévrier, Blaouakh beach), which lack an official protection status but face similar anthropogenic threats. However, it must be noted that a small part of Cap Blanc functions as a marine protected area, as it is home to the southernmost population of the Mediterranean monk seal (*Monachus monachus*), which inhabits two caves that are under protection (Badosa et al. 2006). The artisanal Fish Market in Nouakchott was additionally visited during several surveys and potentially interesting specimens and tissue samples were collected.

The Bellaat lagoon is a very young ecosystem formed by a dune breach during a heavy rain event in 2013 (Trégarot et al. 2020). This shallow water ecosystem resembles an undisturbed lagoon, with extensive *Zostera noltei* assemblages and a sandy seafloor facing only a marginal human impact, except from the local Imragen fishermen using non-motorised boats (Grebenart 2001; Ly & David 2021). Nearly no hard substrate is available within the Bellaat lagoon.

The seagrass beds around Kijji island are located along a sandy area and rooted above old oyster shells. Hard substrate habitats were investigated along the rocky shores of Cape Blanc, the sandstone tide pools of Pelican island in front of the Bellaat lagoon entrance, and the rocky island in the Baie de l’Étoile. The submerged ridge fields with their gorgonian forest habitats along several submerged ridges were additionally investigated. These gorgonian forests, formed by *Leptogorgia* sp. corals and great ascidian assemblages (cf. *Stolonia socialis*), are previously undescribed.

On various occasions, surveys were conducted at the artisanal fish landing places in Nouadhibou (February 2023 and February 2024), the Baie de l’Étoile (August 2023) and Nouakchott (August 2022, June 2023, and January 2024). Additionally, the sandy beaches around the small village Blaouakh were sampled.

Table 1: Sampling locations in shallow-water habitats and at artisanal landing places of northern Mauritania. Coordinates expressed in decimal degrees, only represent the centre of each location and do not indicate the exact sampling site of each species.

Habitat	Location	Latitude (N)	Longitude (W)
Maerl bed	Baie de l’Étoile (M-BdE)	21.0209	-17.0058
	Pelican island (M-PI)	20.7111	-16.6880
Seagrass beds	Baie de l’Étoile (S-BdE)	21.0383	-17.0234
	Bellaat lagoon (S-BdL)	20.6919	-16.6703
	Kijji island (Kijji)	19.8227	-16.5940
Submerged ridge field	Submerged ridge field (SRF)	20.6531	-16.7267
Sandy seafloor	Blaouakh beach (BB)	18.5187	-16.0750
	Agadir Sandy Beach (ASB)	20.6106	-16.4468
	Baie du Lévrier (BdL)	20.9623	-16.8805
Hard substratum	Old Pier, Baie de l’Étoile (OP)	21.0207	-17.0046
	Rocky island, Baie de l’Étoile (RI)	21.0256	-17.0071
	Cap Blanc (CB)	20.7711	-17.0468
	Rocky shore Cansado (RSC)	20,8536	-17,0287
	Old Stone Pier at Agadir (OSP)	20.6125	-16.4472
Artisanal Fishermen	Nouakchott fish market (NKM)	18.1033	-16.0263
	Fish landing place in the Baie de l’Étoile (F-BdE)	21.0198	-17.0028

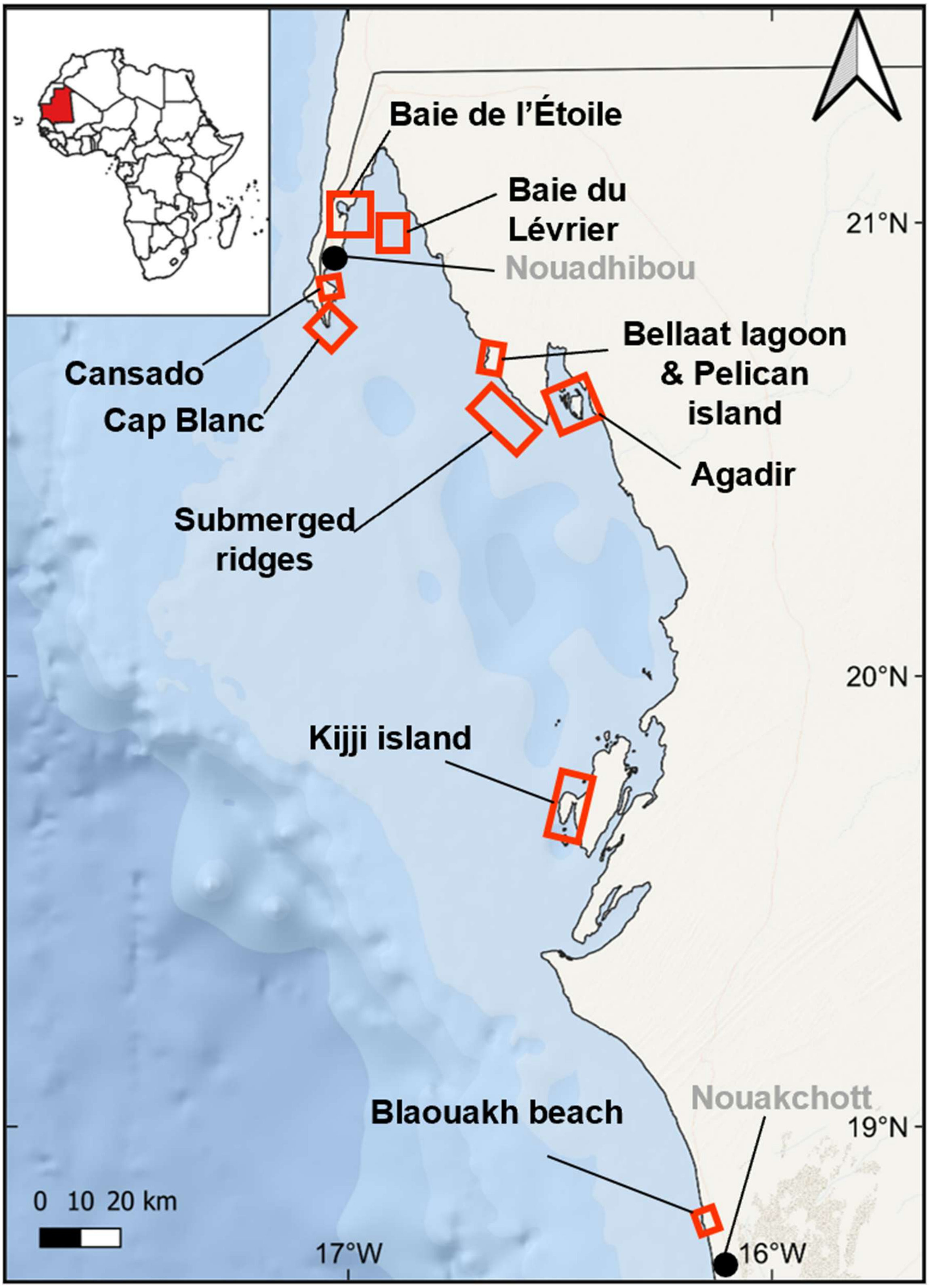

Figure 1: Geographical map of study areas along the Mauritanian coastline. Basemap from ESRI (2019, www.esri.com). Red boxes indicate the sampling locations.

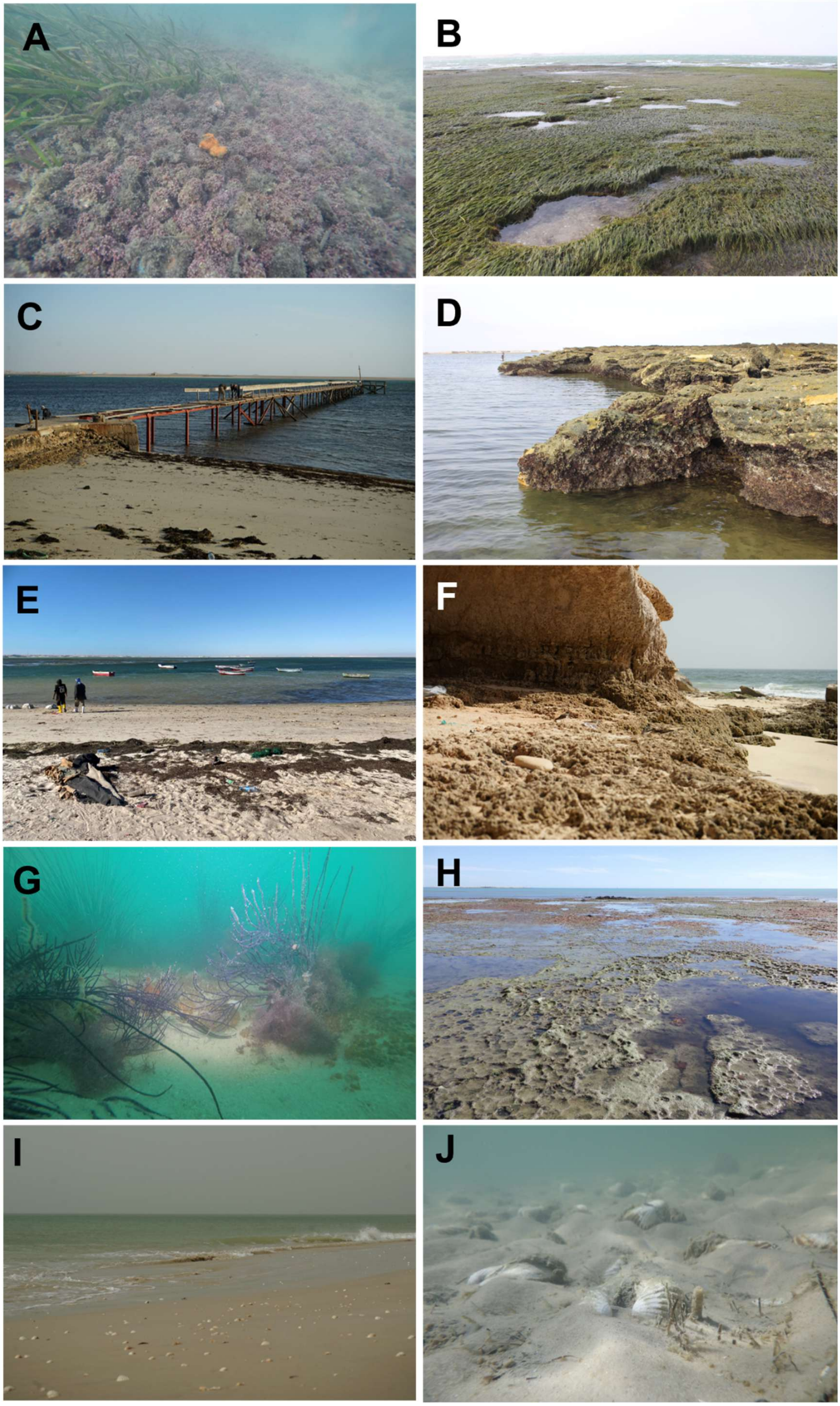
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Figure 2: Overview of the investigated areas in Mauritania. **A**: Underwater image of the maerl ecosystem at the Baie de l'Étoile. **B**: *Zostera noltei* bed in the Baie de l'Étoile. **C**: The old pier at the Centre de Pêche. **D**: Hard substrate of the rocky island in the Baie de l'Étoile. **E**: Artisanal fisheries landing place at the Baie de l'Étoile. **F**: Rocky shoreline at Cap Blanc. **G**: *Leptogorgia*-forest at the submerged ridge field. **H**: Sandstone tidepools at Pelican island in front of the Belaat lagoon entrance. **I**: Sandy beach at the Blaouakh village. **J**: Sandy beach area at Agadir with great abundances of alive *Senilia senilis*. © Alexander Knorrn: A, G, © Kristina Hopf: C, F, I, © André Freiwald: D, E, H, © Friedhelm Krupp: B, © Moritz Sonnewald: J.

6.4 Methods

The marine biodiversity of the Mauritanian coastline has been documented through five expeditions conducted between 2020 and 2024 by the "Institut Mauritanien de Recherche Océanographique et des Pêches" (IMROP) and the "Senckenberg Research Institute" (SRI). Various sampling methods were applied, including hand collection, beam trawling, fish traps, beach seine sampling, ganchorra (a Portuguese beam trawl) sampling and artisanal fish market surveys. The live collected specimens were euthanised on crushed ice or with an overdose of clove oil (for cephalopods) and subsequently preserved. Specimens smaller than 10 cm were, in most cases, directly preserved in 70% ethanol, while larger specimens were initially preserved in formalin and gradually transferred to 70% ethanol after several weeks, according to Freyhof et al. (2020). Tissue samples were taken directly in the field and preserved in 96% ethanol for later DNA barcoding. Several photographs of the studied specimens were taken in the field and laboratories. Subsequently, the collected specimens were morphologically identified (in most of the cases to species level) using specific identification literature. If a clear morphological identification was not possible, genetic sequence data was used to additionally validate the identification. In our labs, all finally identified lots of species were separated into even parts and were catalogued for the scientific collections of IMROP and SRI. While the collections of SRI are already well established, the collections of IMROP were newly founded and currently are still hosted at SRI until the appropriate infrastructure at IMROP is built. The SRI collection metadata can be accessed via "https://search.senckenberg.de/aquila-public-search/search" or via "http://sesam.senckenberg.de/", while the IMROP metadata portal will soon be available via "http://imrop.sesam.senckenberg.de". For this checklist, the ID numbers (following the codes “SMF” for SRI and “IMROP” for IMROP) for a representative lot of each species are given. These, along all the other lots are accessible via the above-mentioned meta-databases. While the data from the SRI collections are already mirrored to “https://www.gbif.org/” and https://www.obis.org/, this procedure still has to be established for IMROP.

6.5 Results

Species Identification

Morphological characteristics for all identified species were obtained from specific identification literature which is given in the checklist below, together with the respective species.

Abbreviations

SMF [accession number] = reference collections of the Senckenberg Research Institute; IMROP [accession number] = reference collections of the Institut Mauritanien de Recherche Océanographique et des Pêches; MAU-[accession number] = reference to according genetic sequence data stored in BOLD-Systems project “MAU Mauritanian marine life barcode library”.

Table 2: Checklist of the marine Cnidaria from coastal habitats in Mauritania. Abbreviations can be seen in Table 1.

Species	Locations
Cnidaria (N = 2)	
Actiniidae	
Actinia equina (Linnaeus, 1758)	OP
Anemonia viridis (Forsskål, 1775)	M-BdE, RI

***Actinia equina* (Linnaeus, 1758)**
Hayward and Ryland 2017
New Records. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0199, -17.0055; 24.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; collected from stones in close proximity to an old pier; BdE-2; MAU-256.
Identification. Solitary specimens with distinct adhering disc, body uniformly reddish, greenish or brownish coloured. A smooth column with a relatively equal height and diameter. Up to 196 tentacles without distinct pattern and terminal knobs, arranged in six cycles around the mouth opening. Verrucae absent.

Anemonia viridis **(Forsskål, 1775)**

Hayward and Ryland 2017

New Records. MAURITANIA - Dakhlet Nouadhibou • Maerl bed in the Baie de l'Étoile; 21.0254, -17.0073; 26.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-20-Maerl • Rocky island; 21.0252, -17.0069; 18.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-102.

Identification. Column usually brownish to bright brownish in colouration with brownish, greyish or even bright-green tentacles with purple tips. The body is typically wider than high. The species bears around 200 long and sinuous tentacles, which are rarely retracted. Inconspicuous acrorhagi on the parapet.

Table 3: Checklist and of the marine Crustacea from coastal habitats and artisanal markets in Mauritania. Abbreviations can be seen in Table 1.

Species	**Locations**
Crustacea (N = 33)	
Sphaeromatidae	
Sphaeroma serratum (J. C. Fabricius, 1787)	OP
Chthamalidae	
Chthamalus montagui Southward, 1976	OP
Balanidae	
Amphibalanus amphitrite (Darwin, 1854)	OP
Perforatus perforatus (Bruguière, 1789)	RI
Pollicipedidae	
Pollicipes pollicipes (Gmelin, 1791)	CP
Alpheidae	
Athanas nouvelae Holthuis, 1951	OP
Palaemonidae	
Palaemon elegans Rathke, 1836	S-BdE
Periclimenes sagittifer (Norman, 1861)	KI
Palinuridae	
Palinurus mauritanicus Gruvel, 1911	NDM
Panulirus regius de Brito Capello, 1864	NDM
Penaeidae	
Penaeus kerathurus (Forskål, 1775)	NDM, S-BdE
Penaeus notialis Pérez Farfante, 1967	NDM, S-BdE, F-BDE
Porcellanidae	
Pisidia bluteli (Risso, 1816)	OP
Pisidia longicornis (Linnaeus, 1767)	OP, M-BdE, RI, KI
Porcellana platycheles (Pennant, 1777)	RI, PI, SRF, OP
Diogenidae	
Diogenes pugilator (Roux, 1829)	BdL
Paguridae	
Pseudopagurus granulimanus (Miers, 1881)	S-BdE, M-BdE, RI, PI, SRF
Epialtidae	
Pisa tetraodon (Pennant, 1777)	OP, SRF
Leucosiidae	
Atlantophila cristata (Miers, 1881)	SRF
Inachidae	
Macropodia linaresi Forest & Zariquiey Álvarez, 1964	KI

Majidae	
Maja brachydactyla Balss, 1922	OP, SRF, M-BdE
Oziidae	
Eupilumnus stridulans (Monod, 1956)	S-BdE, RI, KI
Pilumnidae	
Serenepilumnus pisifer (MacLeay, 1838)	SRF
Portunidae	
Callinectes amnicola (de Rochebrune, 1883)	S-BdL
Callinectes marginatus (A. Milne-Edwards, 1861)	S-BdE
Thalamita poissonii (Audouin, 1826)	S-BdE, OP
Carcinidae	
Carcinus maenas (Linnaeus, 1758)	S-BdL, S-BdE
Panopeidae	
Panopeus africanus A. Milne-Edwards, 1867	S-BdE, S-BdL, RI, PI
Xanthidae	
Xantho poressa (Olivi, 1792)	OP
Grapsidae	
Pachygrapsus transversus (Gibbes, 1850)	OP
Varunidae	
Asthenognathus atlanticus Monod, 1933	BdL
Ocypodidae	
Afruca tangeri (Eydoux, 1835)	S-BdE, S-BdL, IdA
Pinnotheridae	
Pinnotheres pisum (Linnaeus, 1767)	OP

***Sphaeroma serratum* (J. C. Fabricius, 1787)**

Naylor 1972

New Record. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0197, -17.0054; 02.XII.2021; M. Sonnewald, S. M. Moctar and A. Freiwald leg.; collected underneath an old pier; CDP21-02-2; IMROP 1, SMF 58179.

Identification. Various in colouration, ranging between a reddish to brownish to dark greyish colouration. A slightly acute pleotelson and an antenulae with 9 to 15 aesthetascs. The ischium of pereopod1 is covered with up to 60 pulmose setae, which are arranged in two rows. The uropods have four to seven well defined serrations on the outer edge of the exopod.

***Chthamalus montagui* Southward, 1976**

Figure 3A

Hayward and Ryland 2017

New Record. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0256, -17.0071; 26.II.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; scratched from an old fish trap; BdE-20; IMROP 35; SMF 61106, MAU-245.

Identification. Brownish or greyish colouration. Surface often corroded with obliterated sutures. Kite shaped operculum and the junction between tegum and scutum is close to the carinal edge. The scutum is longer than broad.

Remarks. This species is currently only known from the Mediterranean coasts of Italy, France and Spain, from the North-East Atlantic coast of Portugal, Spain, France and all coasts of the UK and Ireland.

***Amphibalanus amphitrite* (Darwin, 1854)**
Figure 3B
Darwin 1854
New Record. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0254, -17.0067; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; scratched from an old fish trap; BdE-64; IMROP 44, SMF 61116, MAU-460.
Identification. Shell longitudinally striped with purple or pink, sometimes with confluent stripes or wholly white in colour. Scutum internally with a prominent broad adductor ridge.

Perforatus perforatus (Bruguière, 1789)
Hayward and Ryland 2017
New Record. MAURITANIA - Dakhlet Nouadhibou • Rocky island; 21.0256, -17.0071; 26.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; from littoral rocks; BdE-20; MAU-244.
Identification. A dark purple ground colour with additional patches of blue and white and sometimes even pink. Body in a regular conical shape and a relatively small opercular opening. The scutum shows moderate growth ridges but without longitudinal striations.

***Pollicipes pollicipes* (Gmelin, 1791)**
Figure 3C
Hayward and Ryland 2017
New Record. MAURITANIA - Dakhlet Nouadhibou • Cap Blanc; 20.7710, -17.0467; 23.II.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; hand collection from rocky shoreline; BdL-22; IMROP 51, SMF 61123.
Identification. The peduncle is usually dark brown to reddish in colour with ivory to brownish white plates. Capitulum laterally compressed with five prominent plates and a variable number of smaller spine like plates, all with terminal umbones. The surface of the peduncle is armoured with uniformly small plates.

***Athanas nouvelae* Holthuis, 1951**
Holthuis 1951
New Record. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.02061; -17.00457; 16.II.2023; A. Knorrn and A. Freiwald leg.; from sunken wood plank; BdE-56; MAU-406.
Identification. Rostrum slender, distinctly curved upwards, its upper margin distinctly concave, lower margin convex. Apex pointed, reaching slightly to distinctly beyond base of third segment of antennular peduncle. Overreaching stylocerite, which is more slender than that of A*. nitescens*, lateral wings narrower. Corneal teeth arrangement rather variable, extra-corneal tooth less slender than in *A. nitescens*. Abdomen and telson as in *A. nitescens*, pleurae of the fifth segment generally more pointed. Stylocerite slender, not reaching the 2nd segment of antennular peduncle, scaphocerite reaching the end of antennular peduncle. Male 1st pereopods with chela reach beyond scaphocerite. Female first legs carpus very long and slender, being only slightly shorter than palm and four times as long as high.

***Palaemon elegans* Rathke, 1836**
Hayward and Ryland 2017
New Record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0273, -17.0042; 27.VII.2022; A. Knorrn, S. M. Moctar and A. Freiwald leg.; Beach seine; BdE-16; IMROP 28, SMF 61097, MAU-234.

Identification. Body uniformly greyish with a dark yellow to brownish band around the thorax and pleon. Rostrum straight with seven to nine dorsal teeth, three ventral teeth and three of the dorsal teeth are located behind the posterior edge of the orbit. Second pereopod of carpus region not subdivided. The first pereopod with a well-developed chela.

***Periclimenes sagittifer* (Norman, 1861)**

Grippa and d'Acoz, 1996

New Record. MAURITANIA - Dakhlet Nouadhibou • Kijji island; 19.8227, -16.5940; 20.VI.2023; A. Knorrn and A. Freiwald leg.; ganchorra haul; K1; IMROP 57, SMF 61129, MAU-469.

Identification. Body and walking legs quite robust. Rostrum very high: 2.8-3.4 times longer than high. Second pereopods distinctly unequal with a short carpus, less than 2 times longer than broad. Fingers of the large second pereiopod shorter than palm

Remarks. Currently, only known from the North-East Atlantic coasts of Portugal, Spain, France and from the English Channel, from the Azores and from Lanzarote as the southernmost tip of its distribution.

***Palinurus mauritanicus* Gruvel, 1911**

Figure 3D

Carpenter and De Angelis 2016

New Record. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121,-17.0425; 21.II.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); Mau-71.

Identification. Reddish or pinkish body colouration with whitish marbling and spots over the entire dorsal surface. Legs have several irregular pinkish or white spots. Carpus of the first pereopod without an anterodorsal spine. Anterior border of carapace bearing two strong, rather wide, externally convex, frontal horns. Their tips separated by slightly concave margin armed with several denticles. The anterior margin of the carapace not deeply concave between the frontal horns.

***Panulirus regius* de Brito Capello, 1864**

Figure 3E

Carpenter and De Angelis 2016

New Record. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market ; 20.9121, -17.0425; 21.II.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); Mau-68.

Identification. Body generally coloured in various shades of green. Each tail segment with a white transverse band, separated from the posterior margin by a greenish to brownish band. Several small whitish spots on the pleura bases of each abdominal segment. Abdominal segments with shallow transverse grooves filled with short hairs and broadly interrupted in midline.

***Penaeus kerathurus* (Forskål, 1775)**

Figure 3F

Carpenter and De Angelis 2016

New Records. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 21.0168, 17.0184; 01.II.2024; M. Dia and A. Niang leg.; fish market survey (tissue sample); Mau-

392 • Seagrass bed in the Baie de l'Étoile; 21.0383, -17.0234; 01.II.2024; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; Beach seine; BdE 227; SMF 61117.

Identification. Males with pink bars on the abdomen. Females are greyish or yellowish coloured with copper-green or brownish bars. Tail fan sometimes blueish towards the tip and edged with red. Rostrum slightly curved upwards at the tip. Usually eleven (eight to 13) teeth on the dorsal side and one single and strongly pronounced tooth on the ventral margin.

Remarks. Easy to be distinguished from *P. notailis* by the presence of only one single tooth on the ventral margin of the rostrum.

Penaeus notialis **Pérez Farfante, 1967**

Figure 3G

Carpenter and De Angelis 2016

New Records. MAURITANIA - Dakhlet Nouadhibou • Nouadhibou Market; 20.9121, -17.0425; 21.II.2022; M. Dia and A. Niang leg.; fish market survey (tissue sample); SMF 58348, Mau-393 • Seagrass bed in the Baie de l'Étoile; 21.0383, -17.0234; 01.II.2024; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; Beach seine; BdE-227; IMROP 45, SMF 61118 • Fishermen from the Baie de l'Étoile; 21.0198, -17.0028; 09.III.2023; A. Knorrn, S. M. Moctar and A. Freiwald leg.; infront of the BdE opening; gill net of local fishermen (tissue sample); Mau-464.

Identification. Body uniformly blond to orange coloured. Mostly with a dark blotch at the junction of the third and fourth abdominal segments. Rostrum usually with nine (8-11) teeth on the dorsal side and two strong teeth on the ventral side. Three cicatrices are present laterally. The dorsolateral grooves on the sixth abdominal segment are well-defined and broad.

Remarks. Easy to be distinguished from *P. kerathurus* by the presence of two strong teeth on the ventral margin of the rostrum.

Pisidia bluteli **(Risso, 1816)**

Ferreira and Tavares 2020

New Record. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0206, -17.0046; 02.XII.2021; M. Sonnewald, S. M. Moctar and A. Freiwald leg.; collected underneath an old pier; CDP21-01-3; SMF 58347.

Identification. Body colouration dark brownish to olive. Almost circular carapace but with several distinct spines along the dorsal part of the carapace. A trilobed front with a median and with longitudinal furrows that are serrated terminally. A very long and slender antenna and unequal chelipeds.

Remarks. Easy to be distinguished from *P. longicornis* by its thorned meri.

Pisidia longicornis **(Linnaeus, 1767)**

Figure 3H

Hayward and Ryland 2017

New Records. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0259, -17.0069; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; from underneath an old pier; BdE-66 • Maerl bed in the Baie de l'Étoile; 21.0207, -17.0056; 16.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-44 • Rocky island; 21.0248, -17.0071; 17.II.2023; A. Knorrn and A. Freiwald leg.; fish trap; BdE-63; SMF 61121 • Kijji island; 19.8227, -16.5940, 20.06.2023, ganchorra sample; K1.

Identification. Body colouration dark brownish to olive. Almost circular carapace, slightly convex with no hair. A trilobed front with a median and with longitudinal furrows that are serrated terminally. A very long and slender antenna and unequal chelipeds.
Remarks. Easy to be distinguished from *P. bluteli* by its unthorned meri.

Porcellana platycheles **(Pennant, 1777)**
Figure 3I
Hayward and Ryland 2017
New Records. MAURITANIA - Dakhlet Nouadhibou • Rocky island; 21.0259, -17.0069; 17.II.2023; A. Knorrn and A. Freiwald leg.; hand collection; BdE-65; SMF 61124 • Pelican island; 20.7111, -16.6880; 03.III.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection from a maerl and rock habitat; BdL-74; IMROP 53, SMF 61125 • Submerged ridges; 20.6531, -16.7267; 04.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-51 • Old Pier; 21.0197, -17.0054; 30.XI.2021; M. Sonnewald, S. M. Moctar and A. Freiwald leg.; collected underneath an old pier; CDP21-00; IMROP 5, SMF 58341, MAU-220.
Identification. Greyish to brownish coloured dorsally and yellowish white ventrally. A nearly circular carapace that is slightly longer than broad with a setose posterior margin. The Front of the carapace with advanced median tooth flanked by smaller submarginals. The chelipeds are strongly pronounced, unequal and compressed. The pereopods and distal edges of the abdominal segments are setose.

Diogenes pugilator **(Roux, 1829)**
Hayward and Ryland 2017, Ingle and Christiansen 2004
New Record. MAURITANIA - Dakhlet Nouadhibou • Baie du Lévrier; 21,0135, -16.9611; 04.XII.2021; S. M. Moctar and A. Freiwald leg.; grab sample; BdL-21-3-2; Mau-225.
Identification. The body is pale brown with darker mottling. The carapace is semi-circular with a smooth surface. The chelae are unequal, with the larger one on the left side. The bigger chela is smooth and robust, while the smaller one is elongated and more delicate. The eyestalks are long and slender, with an intercalary process. Antennal flagellum with numerous setae.

Pseudopagurus granulimanus **(Miers, 1881)**
Figure 3J
Forest 1952
New Records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0191, -17.0063; 24.VII.2022; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-5; IMROP 32, SMF 61103, MAU-235. • Maerl bed in the Baie de l'Étoile; 21.0254, -17.0067; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-64; MAU-461. • Rocky island; 21.0256, -17.0068; 19.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; BdE-106. • Pelican island; 20.7085, -16.6839, 03.III.2023, A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection from a maerl and rock habitat; BdL-73; IMROP 47 • Submerged ridges; 20.6547, -16.7260; 02.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-53; SMF 61119.
Identification. The left cheliped is much larger than the right. From a certain size onward, the external surface of the forceps has the appearance of a mosaic of smooth, polygonal or rounded plates, which does not allow any specific confusion.

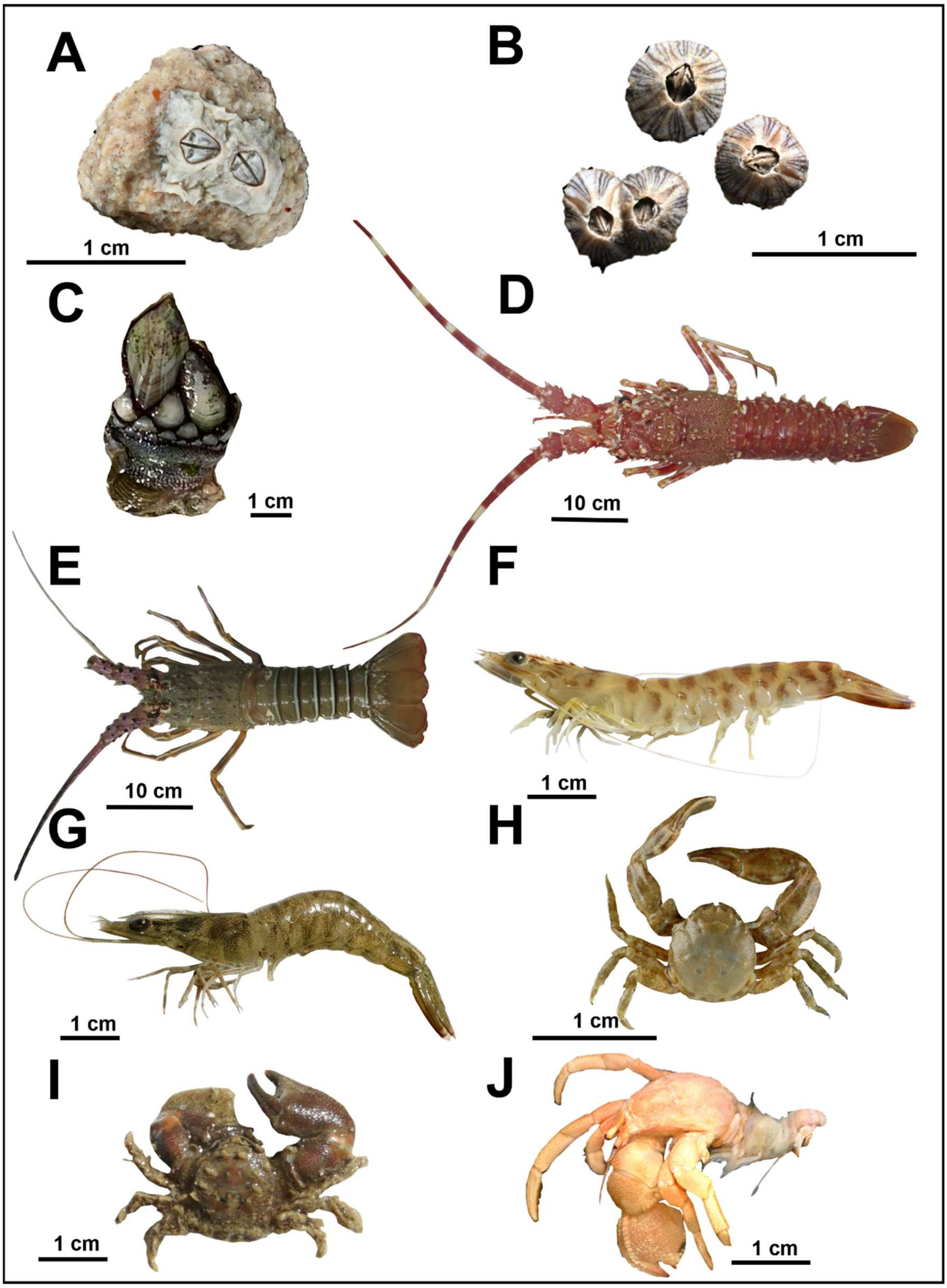

Figure 3: Marine crustaceans from coastal habitats in northern Mauritania **A**: *Chthamalus montagui* **B**: *Amphibalanus amphitrite* **C**: *Pollicipes pollicipes* **D**: *Palinurus mauritanicus* **E**: *Palinurus regius* **F**: *Penaeus kerathurus* **G**: *Penaeus notialis* **H**: *Pisidia longicornis* **I**: *Porcellana platycheles* **J**: *Pseudopagurus granulimanus*. © Alexander Knorrn: A, G, © Nicol Mahnken: A, B, © Kristina Hopf: F, G, I, © Moritz Sonnewald: C, J, © Mamadou Dia: D, E, © Sven Tränckner: H.

***Pisa tetraodon* (Pennant, 1777)**

Figure 4A

Hayward and Ryland 2017

New Records. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0207, -17.0046; 19.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; BdE-103-2; IMROP 30, SMF 61100, MAU-396. • Submerged ridges; 20.6562, -16.7199; 04.II.2024; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-124; IMROP 55, SMF 61127.

Identification. Body colouration brownish red. Three large spines on each lateral side between post-orbitalis and post-lateralis. Posterior-median spine is reduced and the pre-orbital spine is larger than the other spines.

Remarks. New record for Mauritanian waters. Currently only known from Teneriffe as the southernmost tip of its distributional range.

***Atlantophila cristata* (Miers, 1881)**

Muñoz et al. 2023

New Record. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6531, -16.7267; 02.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-51; MAU 463.

Identification. The shell is reddish-brown with darker striations. It is elongated and subcylindrical with a pointed apex. The aperture is oval and small, located near the anterior end. The surface is smooth with fine longitudinal lines, and there is no distinct umbilicus.

***Macropodia linaresi* Forest & Zariquiey Álvarez, 1964**

Figure 4B

Van Noort and Adema 1985

New Record. MAURITANIA - Dakhlet Nouadhibou • Kijji island; 19.8227, -16.5940; 20.06.2023; ganchorra haul; K1; MAU-466.

Identification. The body is reddish-brown with numerous fine white spots. It has a slender and elongated carapace, with long, spindly legs. The carapace is covered with fine granules and lacks distinct ridges. The chelae are slender and slightly unequal. Rostrum very short and curved upwards. It does not extend beyond the proximal quarter of fifth segment of the antennal peduncle. Dactylus of the fifth pereopod is sickle-shaped, with long spines over the whole inner margin.

***Maja brachydactyla* Balss, 1922**

Carpenter and De Angelis 2016

New Records. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0206, -17.0046; 02.XII.2021; M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; CDP21-1-3; SMF 58350, MAU-218 • Submerged ridges; 20.6531, -16.7267; 02.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-51 • Maerl bed in the Baie de l'Étoile; 21.0202, -17.0046; 20.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-117; IMROP 24.

Identification. Body rather uniformly reddish brown or yellowish-brown coloured. The carapace is strongly vaulted with its greatest width behind the middle of the body. Anterior part of the carapace ends with two strong and divergent teeth. Walking legs without any spines.

***Eupilumnus stridulans* (Monod, 1956)**

Carpenter and De Angelis 2016

New Records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Bellaat lagoon; 21.0248, -17.0071; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; hand collection during low tide; BdL-70 • Rocky island; 21.0254, -17.0067; 17.II.2023; A. Knorrn and A. Freiwald leg.; hand collection; BdE-64 • Kijji island; 19.8227, -16.5940; 20.VI.2023; A. Knorrn and A. Freiwald leg.; ganchorra haul; K1; SMF 61128.

Identification. Body with a sparse cover of hairs. Meian notch very shallow and no spines present. The black part of the chela of males is not extending on the palm. Male abdomen with seven movable segments. The second gonopod in males is longer than the first one. The distal part of the second gonopod developed into filiform flagellum.

***Serenepilumnus pisifer* (MacLeay, 1838)**

Figure 3C

Smith 1838

New Record. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.8795, -17.0286; 02.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; KU3; MAU-571.

Identification. Body bright brownish coloured. Carapace convex in the middle part. The anterolateral margin with four blunt tubercles. The front is sub-acuminate with a crenated apex. Chelae are slightly unequal in size, but both are large.

***Callinectes amnicola* (de Rochebrune, 1883)**

Carpenter and De Angelis 2016

New Record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Bellaat lagoon; 20.6803, -16.675285; 03.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; hand collection during low tide; BdL-62; IMROP 19; SMF 61088, MAU-388.

Identification. Olive brown body colouration with bluish colour at the anterior parts of the first pereopod. Carapace broad, ending laterally in a strong spine. Eight distinct teeth at the lateral margin. The length of the lateral spine is twice or more than that of the preceding teeth. epibranchial ridge almost straight. Several granules along the carapace with anterior to epibranchial ridges larger and placed wider apart than those posterior to ridges.

***Callinectes marginatus* (A. Milne-Edwards, 1861)**

Figure 4D

Carpenter and De Angelis 2016

New Record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0168, -17.0184; 26.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; Beach seine; BdE-7; SMF 61075, MAU-271.

Identification. Carapace brownish with a marbled pattern. Carapace broad and coarsely granulated, ending laterally in a strong spine. Eight distinct teeth at the lateral margin. The length of the lateral spine is twice or more than that of the preceding teeth. The epibranchial ridges have a distinct inflection in the middle. First abdominal somit ends laterally in a triangular point, which is neither sharply drawn our not curved up.

Thalamita poissonii **(Audouin, 1826)**

Carpenter and De Angelis 2016

New Records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0386, -17.0236; 24.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-130; SMF 61113 • Old Pier; 21.0207, -17.0046; 19.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; BdE-103-2; SMF 61111, MAU-395.

Identification. Frontal margin of carapace with two very broad teeth that give the impression of continuous margin with a media incision. The last anterolateral tooth of the carapace is larger than the preceding tooth. The merus of the fifth pereopod has one or several ventro-distal teeth.

Carcinus maenas **(Linnaeus, 1758)**

Carpenter and De Angelis 2016

New Records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Bellaat lagoon; 20.6929, -16.6757; 03.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; hand collection during low tide; BdL-70 • Seagrass bed in the Baie de l'Étoile; 21.0191, -17.0063; 24.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; Beach seine; BdE-5; IMROP 15.

Identification. Body colouration deep-green mottled with brown and blackish. A semicircle of whitish spots on each half of the carapace. Body rather flat, finely granular and hardly pubescent. The frontal part of the carapace with three blunt teeth. The anterolateral margin is cut into five rather blunt teeth.

Panopeus africanus **A. Milne-Edwards, 1867**

Figure 4E

Carpenter and De Angelis 2016

New Records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0213, -17.0057; 16.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; Hand collection; BdE-51; SMF 61115 • Seagrass bed in the Bellaat lagoon; 21.0371, -17.0261; 24.II.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; hand collection during low tide; BdE-132; IMROP 14, SMF 61084 • Rocky island; 21.0254, -17.0067; 17.II.2023; A. Knorrn and A. Freiwald leg.; hand collection; BdE-64; SMF 61108, MAU-574 • Pelican island; 20.7111, -16.6880; 03.III.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection from a maerl and rock habitat; BdL-74; IMROP 37, SMF 61107.

Identification. Body reddish brown with a brownish shine. Dark brown coloured chela with brighter tips. Carapace hexagonal and rather flat, with some transverse rows of small granules on the anterior half. Male abdomen elongate and narrow, with segments 3 to 5 fused, covering most of sternite 4.

Xantho poressa **(Olivi, 1792)**

Carpenter and De Angelis 2016

New Record. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21,0206, -17,0046; 02.XII.2021; M. Sonnewald, S. M. Moctar and A. Freiwald leg.; collected underneath an old pier; CDP21-01-3; IMROP 3, MAU-221.

Identification. The body coloration is dark green with mottled yellow spots. The carapace is broadly oval and smooth. It bears five blunt teeth on the anterolateral margins, with the frontal margin displaying three rounded teeth. The chelae are robust and equal, with finely granular surfaces.

***Pachygrapsus transversus* (Gibbes, 1850)**
Figure 4F
Carpenter and De Angelis 2016
New Records. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0196, -17.0056; 15.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; in close proximity to the old pier; BdE-42.
Identification. Body brownish coloured with a green to yellowish variegated pattern. Carapace slightly convex with several transverse ridges dorsally. Front with a sinuous anterior margin with a distinctly greater width than half the carapace. The lateral margin has one single tooth behind the exorbital tooth. The chela is smooth without tubercles or spines. The merus of all walking legs has teeth at the posterodistal angle.

***Asthenognathus atlanticus* Monod, 1933**
Bocquet 1963
New record. MAURITANIA - Dakhlet Nouadhibou • Baie du Lévrier; 21,0135, -16.9611; 04.XII.2021; S. M. Moctar and A. Freiwald leg.; grab sample; BdL21-3-2; IMROP 22, SMF 58346, MAU-217.
Identification. Body overall ochre coloured with a reddish-brown in the hepatic and branchial parts of the body. Pereopod 3 and 4 have a distinct vine red at the distal part. Irregular hexagonal carapace, which is wider than long with relatively small chelipeds. The second and fifth pereopods are strongly reduced in size. The merus, carpus and propodus of the third and fourth pereopods are enlarged.

***Afruca tangeri* (Eydoux, 1835)**
Figure 4G
Carpenter and De Angelis 2016
New Records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0191, -17.0063; 24.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-5; IMROP 23, MAU-242 • Seagrass bed in the Bellaat lagoon; 20.6929, -16.6757; 03.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; hand collection during low tide; BdL-69; IMROP 33, SMF 61105 • Agadir Sandy beach; 20.6106, -16.4468; 05.III.2023; M. Sonnewald and A. Knorrn, collected along the sandy beach of Agadir; IdA-09; IMROP 34.
Identification. Carapace greyish to purplish-reddish. Cheliped are purplish at the base and pincers are white to partly yellowish. The eyes are slender and the orbits occupying the entire anterior margin of the front. The chelipeds in females are small and equal in size. The cheliped in males are unequal in size. Only 1 cheliped is small like that of females, the other one is very large with a chela being more than twice as long as carapace.

***Pinnotheres pisum* (Linnaeus, 1767)**
Figure 4H
Hayward and Ryland 2017
New Record. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0197, -17.0053; 23.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; from a living

Ruditapes decussatus bivalve from close proximity of an old pier; BdE-1; SMF 61099, MAU-241.

Identification. Body yellowish to greyish coloured with symmetrical darker markings. Females with carapace translucent, revealing orange-coloured internal organs. Chelas equal in length and antennas minute. Dactyl of 2-5 pereopod strongly curved.

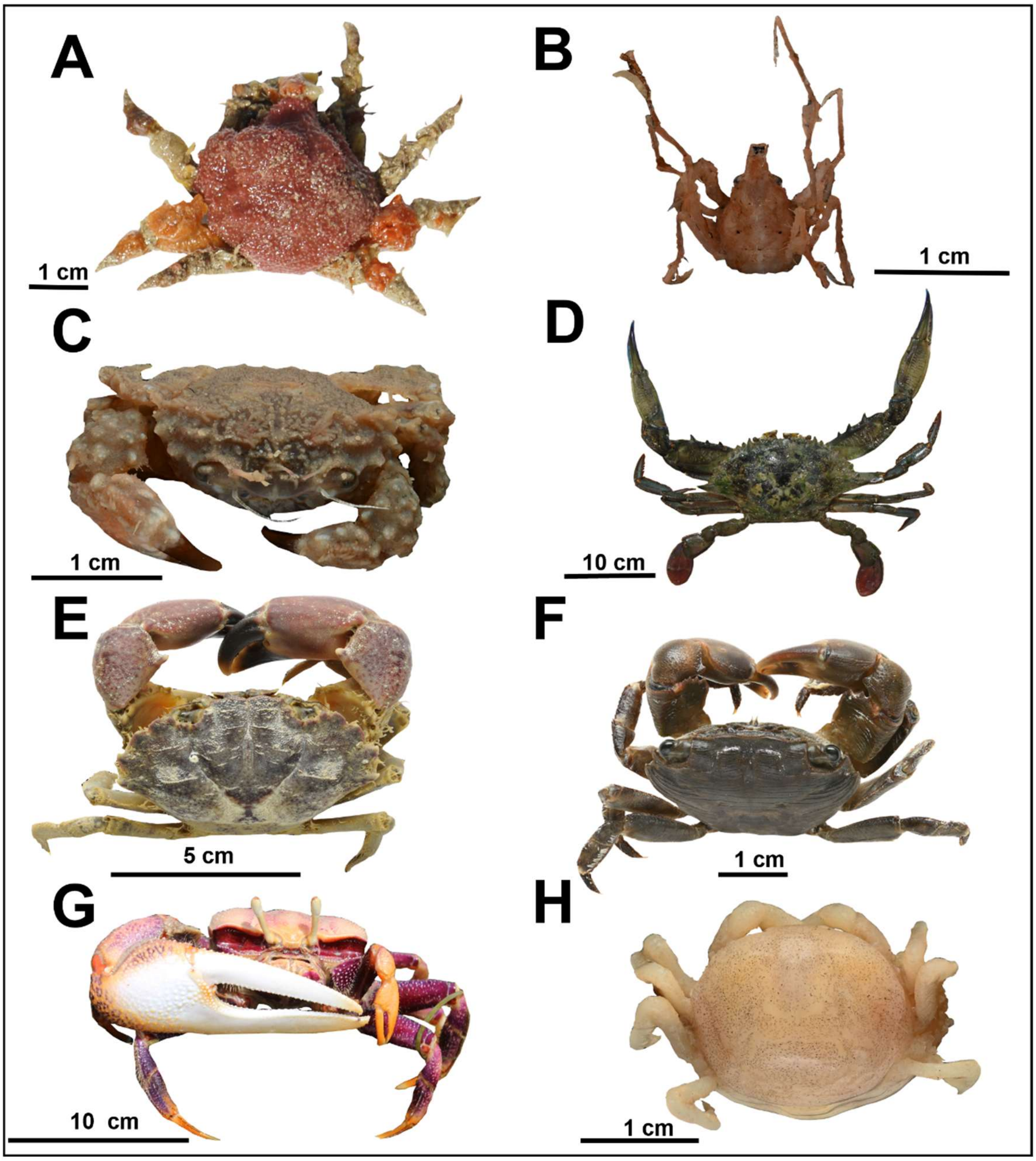

Figure 4: Marine crustaceans from coastal habitats in northern Mauritania. **A**: *Pisa tetraodon* **B**: *Macropodia linaresi* **C**: *Serenepilumnus pisifer* **D**: *Callinectes marginatus* **E**: *Panopeus africanus* **F**: *Pachygrapsus transversus* **G**: *Afruca tangeri* **H**: *Pinnotheres pisum*. © Nicol Mahnken: B, C, E, F, H, © Kristina Hopf: A, © Friedhelm Krupp: D, G.

Table 4: Checklist of the marine Polyplacophora from shallow-water habitats in Mauritania. Abbreviations can be seen in Table 1.

Species	Location
Polyplacophora (N = 2)	
Acanthochitonidae	
Acanthochitona fascicularis (Linnaeus, 1767)	KI
Ischnochitonidae	
Ischnochiton cessaci (Rochebrune, 1881)	KI

***Acanthochitona fascicularis* (Linnaeus, 1767)**
Hayward and Ryland 2017
Figure 5A
New Record. MAURITANIA - Dakhlet Nouadhibou • Kijji island ; 19.8227, -16.5940; 20.VI.2023; A. Knorrn and A. Freiwald leg.; ganchorra haul; K1; IMROP 147, SMF 367253, MAU-564.
Identification. Very variable in colour, ranging between grey, yellowish, chestnut, olive-green, brown to some shades of blue and sometimes with streaks or a marbled pattern. The eight shell valves are strongly arched with a rounded keel and prominent beaks. The longitudinal ridges are laterally packed with rounded granules. The girdle is packed with 18 dense tufts of bristles.

***Ischnochiton cessaci* (Rochebrune, 1881)**
Rochebrune 1881
Figure 5B
New Record. MAURITANIA - Dakhlet Nouadhibou • Kijji island; 19.8249, -16.5954; 20.VI.2023; A. Knorrn and A. Freiwald leg.; ganchorra haul; K3; MAU-565.
Identification. Variable in colour, mostly pinkish to creamy white in Mauritanian waters. The anterior valve as well as the posterior area of the posterior valve is concentrically lineated in a brighter colouration than the rest of the valve. The central area of the intermediate valves is striatulated with sometimes interrupted striae. The lateral areas finely undulated. No tufts of bristles present.

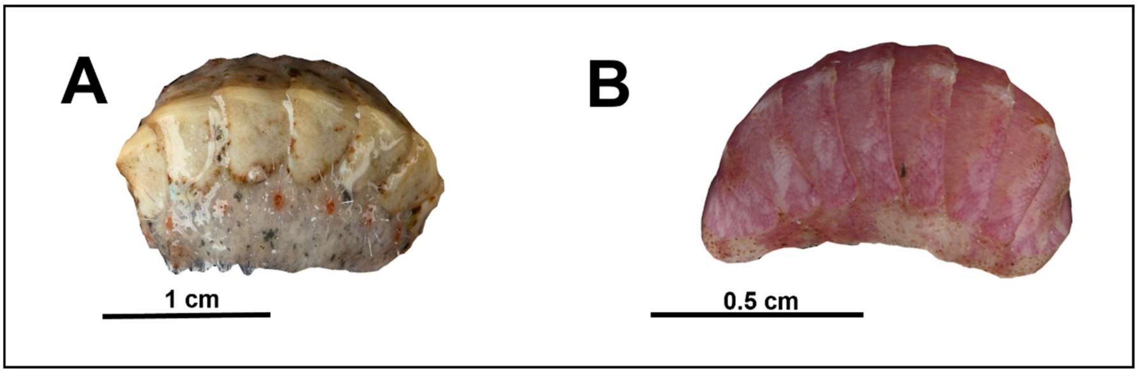

Figure 5: Marine polyplacophorans collected near Kijji island, northern Mauritania. **A**: *Acanthochitona fascicularis* **B**: *Ischnochiton cessaci*. © Nicol Mahnken: A, B.

Table 5: Checklist and of the marine Gastropoda from shallow-water habitats in Mauritania. Abbreviations can be seen in Table 1.

Species	**Location**
Gastropoda (N = 30)	
Patellidae	
Patella rustica Linnaeus, 1758	CB
Patella depressa	RSC
Fissurellidae	
Diodora graeca (Linnaeus, 1758)	SRF
Trochidae	
Phorcus lineatus (da Costa, 1778)	RI, OP, S, PI, CB, IdA
Steromphala umbilicalis (da Costa, 1778)	M-BdE, OP, IdA
Turritellidae	
Mesalia mesal (Deshayes, 1843)	SRF, S-BdE
Mesalia opalina (A. Adams & Reeve, 1849)	SRF
Hydobiidae	
Peringia ulvae (Linnaeus, 1767)	S-BdE
Truncatellidae	
Truncatella subcylindrica (Linnaeus, 1767)	SBA
Calyptraeidae	
Crepidula porcellana Lamarck, 1801	M-BdE, S-BdE, OP, SRF, PI, IdA
Cypraeidae	
Zonaria zonaria (Gmelin, 1791)	SRF
Naticidae	
Natica fulminea (Gmelin, 1791)	KI, SRF, S-BdE
Muricidae	
Bolinus cornutus (Linnaeus, 1758)	S-BdE
Hexaplex rosarium (Röding, 1798)	M-BdE, OP
Stramonita haemastoma (Linnaeus, 1767)	RSC
Melongenidae	
Pugilina morio (Linnaeus, 1758)	S-BdE, M-BdE, PI, OP
Nassariidae	
Tritia pfeifferi (R. A. Philippi, 1844)	PI, OP, S-BdE, SRF
Columbellidae	
Columbella adansoni Menke, 1853	S-BdE
Mitrella broderipii (G. B. Sowerby I, 1844)	OP, M-BdE, S-BdE
Pisaniidae	
Aplus assimilis (Reeve, 1846)	OP, RI
Volutidae	
Cymbium marmoratum Link, 1807	F-BdE
Marginellidae	
Marginella cleryi Petit de la Saussaye, 1836	SRF, S-BdE
Marginella glabella (Linnaeus, 1758)	S-BdE
Volvarina ampelusica Monterosato, 1906	SRF, S-BdE
Cystiscidae	
Persicula cingulata (Dillwyn, 1817)	KI, SRF, S-BdE
Conidae	
Conus byssinus (Röding, 1798)	M-BdE, S-BdE
Bullidae	
Bulla striata Bruguière, 1792	S-BdE, PI

Aplysiidae	
Bursatella leachii Blainville, 1817	SRF, S-BdE
Onchidiidae	
Onchidella celtica (Audouin & Milne-Edwards, 1832)	RI
Siphonariidae	
Siphonaria pectinata (Linnaeus, 1758)	RI, OP, IdA

***Patella rustica* Linnaeus, 1758**

Carpenter and De Angelis 2016

New Record. MAURITANIA - Dakhlet Nouadhibou • Cap Blanc; 20.7709, -17.0468; 23.II.2023; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdL-20; IMROP 138, SMF 367240.

Identification. Typical grey to greenish-brown in colour with radiating dark stripes. The shell is conical and robust, with well-defined ridges running from the apex to the margin. The apex is often slightly off-centre and curved. The interior of the shell is usually white with a central muscle scar.

***Patella depressa* Pennant, 1777**

Figure 6A

Hayward and Ryland 2017

New Record. MAURITANIA - Dakhlet Nouadhibou • Rocky shore of Cansado; 20,8536, -17,028761; 26.II.2023; A. Knorrn & M. Sonnewald leg.; hand collection; BdL-34; SMF 367241, MAU-334.

Identification. Greyish to brown shell with distinctive orange-brown rays on the inner surface. Foot dark olive to black in colouration with chalky white palial tentacles Shell resembles a flattened cone with various fine radiating ribs

***Diodora graeca* (Linnaeus, 1758)**

Figure 6B

Alastair Graham 1988

New Record. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; ganchorra haul; BdL-6-1; SMF 372467, MAU-499.

Identification. Shell brownish to a dirty grey. Body coloured in a creamy white to a deep orange or red. Shell conical with a key-hole shaped apical hole, placed about one third of shell length behind the anterior end. The surface has numerous radiating ridges crossed by other radial ribs, which often have an upturned edge.

***Phorcus lineatus* (da Costa, 1778)**

Figure 6C

Carpenter and De Angelis 2016

New Records. MAURITANIA - Dakhlet Nouadhibou • Rocky island; 21.0256, -17.0071; 26.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-20; IMROP 27, SMF 372438 • Old Pier; 21.0199, -17.0055; 24.VII.2022; A. Knorrn, S. M. Moctar and A. Freiwald leg.; along stones underneath and around the old pier; BdE-2-1; IMROP 35, SMF 372453 • Sandstone; 21.0426, -17.0259; 24.II.2023; A. Freiwald leg.; out of sandstone around the champion formation; BdE-129; IMROP 100 •

Pelican island 20.7085, -16.6839, 03.III.2023, A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection from a maerl and rock habitat; BdL-73; SMF 367202 • Cap Blanc; 20.7710, -17.0467; 23.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdL-22; IMROP 102, SMF 367197 • Old Stone Pier at Agadir; 20.6125, -16.4472; 05.III.2024 ; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; IdA-06; IMROP 95, SMF 367198.

Identification. Solid, blunt shell, conical spire with about five convex whorls, apical angle 80 degrees. Sculpture about ten spiral cords, some of which protruding, numerous strongly prosocline growth lines, umbilical area smooth with umbilical impression. Suture shallow. Aperture rounded. Internally smooth with spiral imprint. Diameter up to 20 mm. Numerous and very fine oblique dark purplish brown to green lines interrupted by other zigzag patterns or fine spiral streaks on a pale buff ground. Operculum corneous, multi-spiral.

Steromphala umbilicalis **(da Costa, 1778)**
Figure 6D
Carpenter and De Angelis 2016
New Records. MAURITANIA - Dakhlet Nouadhibou • Maerl bed in the Baie de l'Étoile; 21.0248, -17.0071; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-63; IMROP 133. • Old Pier; 21.0206, -17.0046; 27.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; BdE-142. • Old Stone Pier at Agadir; 20.6106, -16.4468; 05.III.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; IdA-09; IMROP 132, SMF 367235, MAU-495.

Identification. Shell cream or greenish in colour with broad reddish or purple bands. Shell conical and cytroconoid in shape with five to six whorls. An angular last whorl and eight to 11 spiral ridges along the base of the last whorl. The umbilicus is relatively large and circular.

Mesalia mesal **(Deshayes, 1843)**
Figure 6E
Carpenter and De Angelis 2016
New Records. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6547, -16.7260; 02.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-53 • Seagrass bed in the Baie de l'Étoile; 21.0455, -17.01960; 25.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-129.

Identification. Shell whitish with chestnut to fawn coloured axial streaks. The spiral sculpture of the whorls is reduced to a strong groove under the suture. The base of the columella without a spiral ridge above the recurved inner lip.

Mesalia opalina **(A. Adams & Reeve, 1849)**
Carpenter and De Angelis 2016
New Record. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; ganchorra haul; BdL-6-1.

Identification. Shell whitish to brownish coloured without distinct axial streaks. Spiral structure with a few distant ridges on the apical part of the whorls. Base of the columella with a small spiral ridge, just above the recurved inner lip.

***Peringia ulvae* (Pennant, 1777)**

Graham 1988

New Records. MAURITANIA – Baie de l'Étoile, Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0189, -17.0071; 01.II.2024; K. Pfennings leg.; hand collection, BdE230.

Identification. Solid, elevated shell, conical spire with 6-7 convex whorls, apical angle 40 degrees. Smooth with numerous slightly prosocline growth lines, umbilical area covered by callus. Suture shallow, impressed. Aperture rounded, almond shaped. Internally smooth. Diameter up to 9 mm. Colour grey or light brown. Operculum corneous, paucispiral.

***Truncatella subcylindrica* (Linnaeus, 1767)**

Graham 1988

New Records. MAURITANIA – Ile d'Arguin • Sandy beach at Agadir; 20.6127, -16.4475; 05.III.2024; A. Knorrn and A. Freiwald leg.; hand collection; IdA-7.

Identification. Solid, highly elevated shell, highly conical spire with 4-7 weakly convex whorls, apical angle 20 degrees in juveniles, decapitated in adults. Smooth with numerous orthocline growth lines, umbilical area covered by callus. Suture shallow, impressed. Aperture rounded, oval. Internally smooth. Diameter up to 1.5 mm. Colour grey or cream white. Operculum corneous, paucispiral.

***Crepidula porcellana* Lamarck, 1801**

Figure 6F

Carpenter and De Angelis 2016

New Records. MAURITANIA - Dakhlet Nouadhibou • Maerl bed in the Baie de l'Étoile; 21.0254, -17.0073; 26.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-20; SMF 372432, MAU-261 • Seagrass bed in the Baie de l'Étoile; 21.0383, -17.0260; 24.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-131; IMROP 131, SMF 367224 • Old Pier; 21.0207, -17.0046; 19.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; BdE-103-2; IMROP 115, SMF 367219 • Submerged ridges; 20.6531, -16.7267; 02.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-51; SMF 367230 • Pelican island; 20.7111, -16.6880, 03.III.2023, A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection from a maerl and rock habitat; BdL-71 • Old Stone Pier at Agadir; 20.6106, -16.4468; 05.III.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; IdA-9; IMROP 127.

Identification. The shell is white to pale brown, often with darker blotches. It is oval and flattened, resembling a slipper. The interior is smooth and white, with a prominent septum forming a shelf-like structure. The exterior surface is smooth with fine growth lines.

***Zonaria zonaria* (Gmelin, 1791)**

Figure 6G

Carpenter and De Angelis 2016

New Record. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6826, -16.7168; 04.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-86; SMF 367205, MAU-482.

Identification. Surface highly polished, smooth and lateral shell margins with several dark spots. Ventral side of shell cream to pale greyish coloured. Shell ovate and spire short and concealed under the body whorl. Both lips with raised transverse ridges or teeth, the outer one thickened and incurved. Inner lip with a shallow longitudinal furrow situated towards the frontal end.

***Natica fulminea* (Gmelin, 1791)**
Figure 6H
Carpenter and De Angelis 2016
New Records. MAURITANIA - Dakhlet Nouadhibou • Kijji island; 19.8227, -16.5940; 20.VI.2023; A. Knorrn and A. Freiwald leg.; ganchorra haul; K1; SMF 367193 • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; ganchorra haul; BdL-6-1; SMF 372433, MAU-261 • Seagrass bed in the Baie de l'Étoile 21.0217, -17.0065; 16.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-54; IMROP 92, SMF 367194.
Identification. Outside of shell creamy white with a variable reddish to brownish colour pattern typically composed of angular zigzag lines. Interior and the inner lip callus are coloured white. Shell globose and about as long as wide with a short spire. Moderately convex whorls and a very large body whorl that is lightly flattened at the suture. The umbilicus is widely open without a funicle.

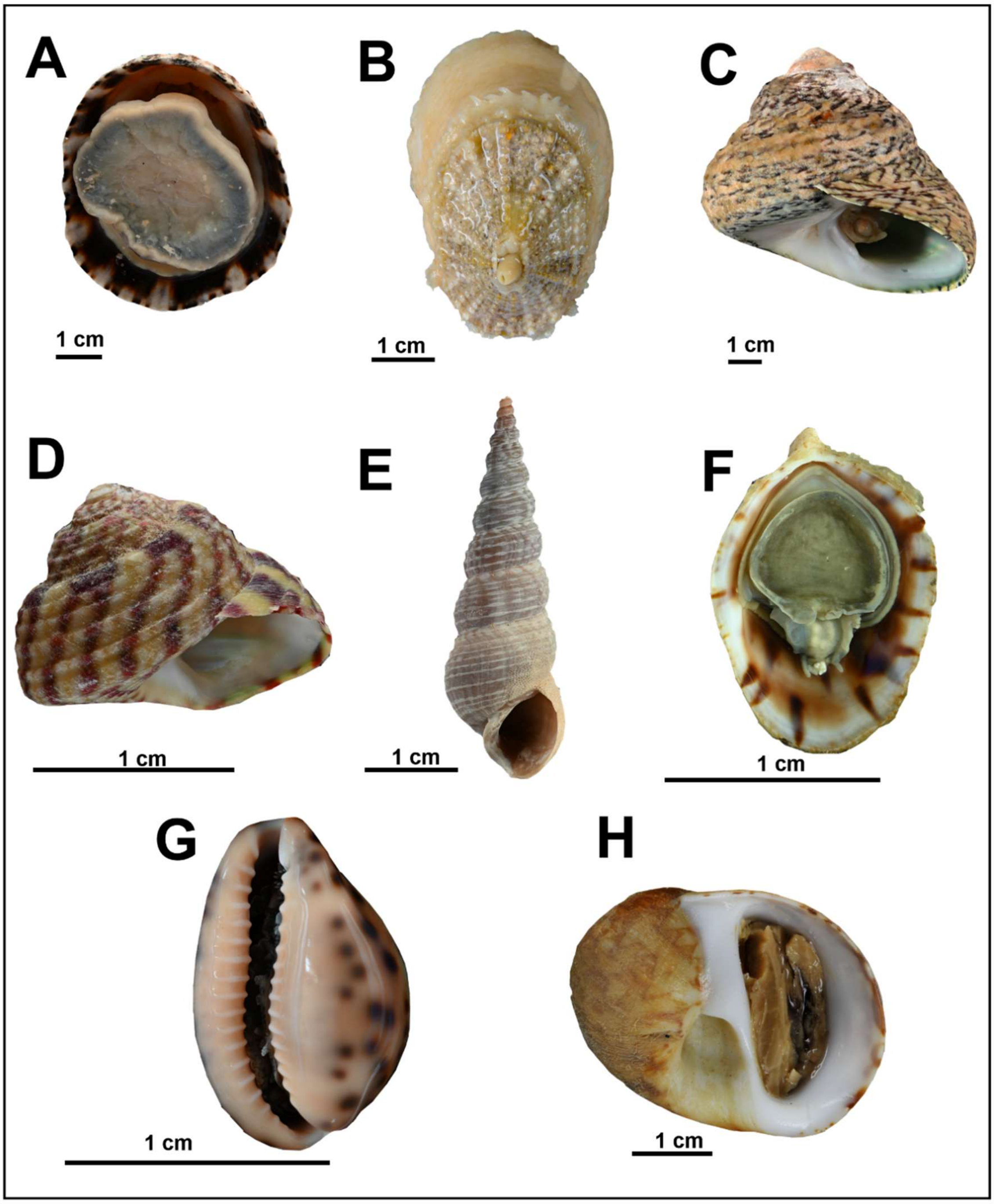

Figure 6: Marine gastropods from coastal habitats in northern Mauritania **A**: *Patella depressa* **B**: *Diodora graeca* **C**: *Phorcus lineatus* **D**: *Steromphala umbilicalis* **E**: *Mesalia mesal* **F**: *Siphonaria pectinata* **G**: *Zonaria zonaria* **H**: *Natica fulminea*. © Nicol Mahnken: A, B, C, D, E, F, G, H.

Bolinus cornutus **(Linnaeus, 1758)**
Figure 7A
Carpenter and De Angelis 2016
New Record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0449, -17.0224; 31.I.2024; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-191.
Identification. Outer part of the shell yellowish to beige to tan coloured. Often with three darker spiral bands. The aperture is glossy and whitish, often with a lighter orange part

around the outer lip edge and the columellar callus. The shell is large and club shaped, with a very narrow and long siphonal canal. The outer surface of the shell with several varices.

Hexaplex rosarium **(Röding, 1798)**
Figure 7B
Carpenter and De Angelis 2016
New Records. MAURITANIA - Dakhlet Nouadhibou • Maerl bed in the Baie de l'Étoile; 21.0256, -17.0071; 26.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-20; IMROP 20 • Old Pier; 21.0207, -17.0046; 19.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; BdE-103-2; IMROP 110, SMF 367215.
Identification. Outer part of the shell whitish creamy to fawn coloured with up to three brown spiral bands. Aperture glossy white within and the inner lip is bright reddish to pink in colouration. Shell globose to ovate in shape with a relatively low and pointed spire. The body whorl is large and globose with six to eight knobby axial varices.

Stramonita haemastoma **(Linnaeus, 1767)**
Carpenter and De Angelis 2016
New Record. MAURITANIA - Dakhlet Nouadhibou • Rocky shore of Cansado; 20,8536, -17,0287; 26.II.2023; A. Knorrn & M. Sonnewald leg.; hand collection; BdL-34; IMROP 32, SMF 372446, MAU-336.
Identification. Outside of shell creamy white to dirty grey coloured with areas of brighter and darker colouration. The aperture is coloured in a bright orange to salmon-like colour and often tinged with a darker brown on the grooves around the outer lip margins. The shell is relatively thick and almost biconical in shape. The surface of the shell with a variable arrangement of fine incised spiral lines. The outer lip is crenulated with numerous spiral grooves.

Pugilina morio **(Linnaeus, 1758)**
Figure 7C
Carpenter and De Angelis 2016
New Records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0191, -17.0063; 24.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-5; IMROP 29, SMF 372464, MAU-263 • Maerl bed in the Baie de l'Étoile; 21.0202, -17.0046; 20.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-117; SMF 367156 • Pelican island; 20.7111, -16.6880; 03.III.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdL-74. • Old Pier; 21.0207, -17.0046; 19.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; BdE-103-2.
Identification. Shell coloured in a dark brown to black with one or several contrasting spiral band in a brighter brown. The periostracum is relatively thick and dark brownish, strong enough to hide the colouration of the shell. Shell more or less fusiform with a rather high spire and expanded body whorl. Surface of the shell with a single row of blunt spines along the angular shoulder and many low spiral threads all along the shell. Aperture large and subquadrate narrowing into the siphonal canal.

***Tritia pfeifferi* (R. A. Philippi, 1844)**

Adam and Knudsen 1984

New Records. MAURITANIA - Dakhlet Nouadhibou • Pelican island; 20.7111, -16.6880; 03.III.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdL-74 • Old Pier; 21.0206, -17.0046; 27.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; BdE-142 • Seagrass bed in the Baie de l'Étoile; 21.0191, -17.0063; 24.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-5 • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; ganchorra haul; BdL-6-1.

Identification. Solid, elevated shell, conical spire with about five weakly convex whorls with weak shoulder area, apex finely rounded, apical angle 45 degrees. External surface smooth with numerous prosocline growth lines, umbilical area covered by callus. Suture shallow impressed. Aperture piriform, lip thickened, denticles on inside external lip, twisted wide siphonal channel. Internally smooth. Diameter up to 5 mm. Background colour white, most of extarnal covered by dark brown blotches, axial bands leaving, most of the callus and internal area white.

***Columbella adansoni* Menke, 1853**

Figure 7D

Hernández et al. 2011

New Record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0217, -17.0065; 16.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-53.

Identification. Solid, elevated shell, conical spire with about five flattened whorls with corrugated shoulder area, apex rounded, apical angle 50 degrees. External surface largely smooth with numerous prosocline growth lines. Suture shallow. Aperture flexuous, strongly protruding lip, denticles on inside external lip, twisted wide siphonal channel. Internally smooth. Diameter up to 10 mm. Background colour white, most of extarnal covered by light to dark brown blotches, axial bands leaving only internal area white.

***Mitrella broderipii* (G. B. Sowerby I, 1844)**

Hernández et al. 2011

New Records. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0207, -17.0046; 19.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; BdE-103-2; MAU-503. • Maerl bed in the Baie de l'Étoile; 21.0184, -17.0030; 20.II.2023; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-119 • Seagrass bed in the Baie de l'Étoile; 21.0369, -17.0258; 27.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-140.

Identification. Solid, highly elevated shell, conical spire with about six convex whorls, apex rounded, apical angle 40 degrees. External surface largely smooth with numerous slightly prosocline growth lines, columellar area with spiral grooves. Suture shallow, impressed. Aperture elongated piriform, very weak fine denticles on inside external lip, twisted wide siphonal channel, columella straightened, slightly s-shaped. Internally smooth. Diameter up to 4 mm. Background cream white, most of external covered by regular axial brown bands that may be crossed by broad spiral white, light- or dark brown bands.

***Aplus assimilis* (Reeve, 1846)**

Aissaoui et al. 2016

New Records. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0207, -17.0046; 19.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; fish trap; BdE-103-2 • Rocky island; 21.0254, -17.0067; 03.III.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-64.

Identification. Solid, elevated shell, conical spire with about six flattened whorls, apex finely rounded, apical angle 45 degrees. Sculpture with coarse spiral cords and flexuous ribs of equal strength. Suture shallow, impressed. Aperture elongated piriform, spiral notches on inside external lip, twisted wide siphonal channel, columella straightened, slightly s-shaped. Internally with imprint of external spiral sculpture. Diameter up to 5 mm. Background cream white to dark brown, light band at suture and near base.

***Cymbium marmoratum* Link, 1807**

Carpenter and De Angelis 2016

New Record. MAURITANIA - Dakhlet Nouadhibou • Fishermen from the Baie de l'Étoile; 21.0198, -17.0028; 09.III.2023; A. Knorrn, S. M. Moctar and A. Freiwald leg.; infront of the BdE opening; gill net of local fishermen (tissue sample); Mau-335.

Identification. The shell is marbled reddish brown and white on a pale brown base. The shell is moderately large (up to 20 cm) and solid with an elongated to ovate but somewhat inflated shape. A large and V-shaped channel developed between shoulder ridge and spire whorls.

***Marginella cleryi* Petit de la Saussaye, 1836**

Figure 7E

New Records. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6547, -16.7260; 02.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-53; IMROP 83, SMF 367185 • Seagrass bed in the Baie de l'Étoile; 21.0247, -17.0065; 19.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-109; SMF 367184, MAU-481.

Identification. Solid, elevated shell, conical spire with about four slightly convex whorls, apex rounded, apical angle 65 degrees. Surface smooth, polished. Suture smeared. Aperture elongate, smooth thickened external lip, twisted wide siphonal channel, columella straightened, slightly concave, 4 spiral folds of which the lower three are strongly oblique. Internally smooth. Diameter up to 15 mm. Background bluish white, fine dark brown to black axial lines in complex zic-zac pattern, frequently bifurcating or merging.

***Marginella glabella* (Linnaeus, 1758)**

Figure 7F

Carpenter and De Angelis 2016

New Record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0367, -17.0258; 24.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-133; IMROP 85, SMF 367187.

Identification. Shell creamy brown coloured with several weakly defined white spots that are irregularly distributed about the shell. The animal is purplish to reddish coloured with fine pale coloured streaks. Shell elongated, oval in shape with a smooth and highly polished surface. Aperture elongated with a relatively short anterior siphonal canal. The outer lip is thickened and reflected interiorly.

***Volvarina ampelusica* Monterosato, 1906**

Figure 7G

New Records. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; ganchorra haul; BdL-6-1; IMROP 31, SMF 372443 • Seagrass bed in the Baie de l'Étoile; 21.0224, -17.0062; 16.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection from a sandy area in close proxymity to a *Cymodocea nodosa* bed; BdE-108; IMROP 51.

Identification. Solid, convolved shell, small blunt spire with about four whorls, apex rounded, apical angle 90 degrees. Surface smooth, polished. Suture smeared. Aperture elongate and curved, inside external lip with denticles, twisted wide siphonal channel, columella straightened, slightly concave, 3-4 strongly oblique folds. Internally smooth. Diameter up to 6 mm. Background white to light brown, spiral brown colour bands.

***Persicula cingulata* (Dillwyn, 1817)**

New Records. MAURITANIA - Dakhlet Nouadhibou • Kijji island; 19.8227, -16.5940; 20.VI.2023; A. Knorrn and A. Freiwald leg.; ganchorra haul; K1; SMF 367213 • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; ganchorra haul; BdL-6-1 • Seagrass bed in the Baie de l'Étoile; 21.0367, -17.0258; 22.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-133.

Identification. Solid, convolved shell, tiny blunt spire with sutural groove, apical angle of 120 degrees. Surface smooth, polished. Aperture elongate and strongly curved, lip externally embossed, also at siphonal channel, denticles on inside external lip and on columella, large calloused notch on apical end of parietal margin, wide siphonal channel, columella and parietal area convex. Internally smooth. Diameter up to 10 mm. Background white, external spiral brown colour bands, occasionally merging towards the lip.

***Conus byssinus* (Röding, 1798)**

Figure 7H

New Records. MAURITANIA - Dakhlet Nouadhibou • Maerl bed in the Baie de l'Étoile; 21.0211, -17.0057; 24.II.2023; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-20; IMROP 19 • Seagrass bed in the Baie de l'Étoile; 21.0256, -17.0071; 26.VII.2022; A. Knorrn, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-131; SMF 372476.

Identification. Solid, convolved shell, broad blunt spire, conical, 5-6 whorls, apical angle 120 degrees. Suture deeply impressed. Ultimate whorl conical, slightly convex with blunt keeled shoulder. Surface smooth, with fine nearly orthocline growth lines. Aperture elongate, very weakly curved, lip thin, straight wide siphonal end, Internally smooth. Diameter up to 40 mm. Background cream white, externally with light-brown broad spiral bands and a dark brown or black interrupted patterns of notches variable in size, but both spirally and axially aligned.

***Bulla striata* Bruguière, 1792**

New Records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0390, -17,0235; 24.VII.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; Beach seine; BdE-128; IMROP 145 • Pelican island; 20.7111, -16.6880;

03.III.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdL-74; IMROP 144, SMF 367249.
Identification. Thin, convolved shell, oblong, oval, spire sunken, Surface smooth, with fine nearly orthocline growth lines. Aperture elongate piriform, narrow adapically, wide abapically, lip thin, straightened upper half. Demarcated white callus on columella and parietal area. Diameter up to 10 mm. Background cream white, externally light brown with dark brown axially aligned blotches.

***Bursatella leachii* Blainville, 1817**
Figure 7I
Hayward and Ryland 2017
New Records. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6547, -16.7260; 02.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-53; IMROP 34, SMF 367243 • Seagrass bed in the Baie de l'Étoile; 21.0151, -17.0203; 02.II.2024; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-240.
Identification. A mottled coloration of green, brown, and blue, often with a distinctive blue-green sheen. The body is oval and flattened, covered with numerous fleshy papillae and small, branched cerata. Anteriorly, two short rhinophores and large, lobed oral tentacles are prominent. This species also features a broad foot, which is often fringed.

***Onchidella celtica* (Audouin & Milne-Edwards, 1832)**
Figure 7J
Hayward and Ryland 2017
New Record. MAURITANIA - Dakhlet Nouadhibou • Rocky island; 21.0256, -17.0071; 26.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-20; IMROP 25, SMF 372436, MAU-258.
Identification. Body dark olive green to black in colour and fleshy oval in shape. The mantle is covered with large and well-spaced tubercles. Two short tentacles and thick tentacles are visible anteriorly.

***Siphonaria pectinata* (Linnaeus, 1758)**
Hayward and Ryland 2017
New Records. MAURITANIA - Dakhlet Nouadhibou • Rocky island; 21.0256, -17.0071; 26.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-20; IMROP 30, SMF 372442, MAU-262 • Old Pier 21.0197, -17.0053; 23.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-1 • Old Stone Pier at Agadir; 20.6106, -16.4468; 05.III.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; IdA-09; IMROP 103, SMF 367206.
Identification. The shell is grey with darker radial lines. It is cap-shaped and low, with a broad base. The surface is covered with fine radial ribs, and the apex is slightly off-center. The interior is smooth and white, with a distinct muscle scar.

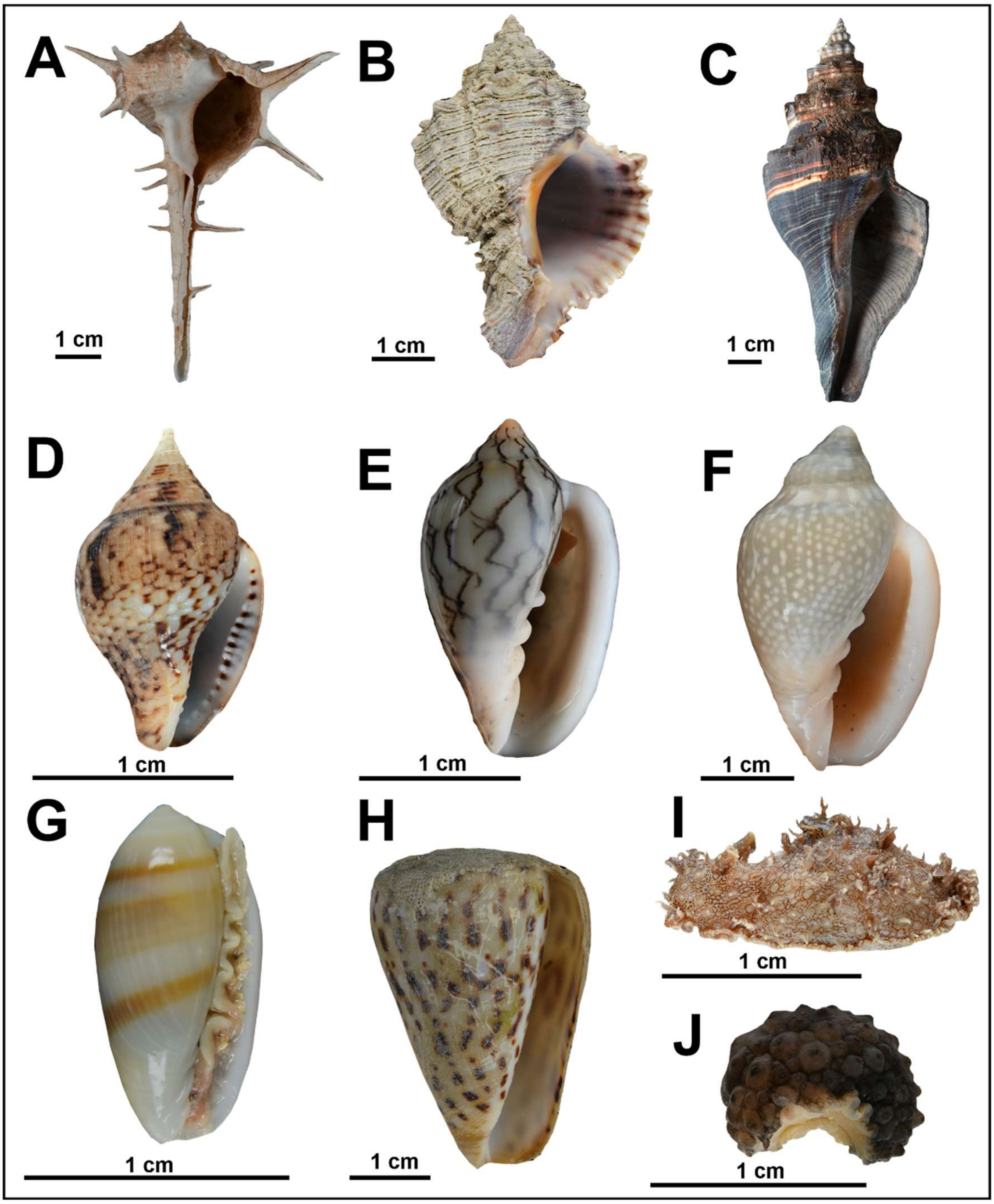

Figure 7: Marine gastropods from coastal habitats in northern Mauritania **A**: *Bolinus cornutus* **B**: *Hexaplex rosarium* **C**: *Pugilina morio* **D**: *Columbella adansoni* **E**: *Marginella cleryi* **F**: *Marginella glabella* **G**: *Volvarina ampelusica* **H**: *Conus byssinus* **I**: *Bursatella leachii* **J**: *Onchidella celtica*. © Nicol Mahnken: B, C, D, E, F, G, H, I, J, © Kristina Hopf: A.

Table 6: Checklist of the marine Bivalvia from shallow-water habitats and artisanal fish markets in Mauritania. Abbreviations can be seen in Table 1.

Species	**Location**
Bivalvia (N = 29)	
Nuculanidae	
Lembulus bicuspidatus (A. Gould, 1845)	BdL
Arcidae	
Acar olivercoseli M. Huber, 2010	KI
Senilia senilis (Linnaeus, 1758)	KI, IdA
Mytilidae	
Leiosolenus aristatus (Dillwyn, 1817)	RI
Perna perna (Linnaeus, 1758)	RI, CB
Pinnidae	
Atrina chautardi (Nicklès, 1953)	S-BdE
Pectinidae	
Aequipecten flabellum (Gmelin, 1791)	BB
Ostreidae	
Magallana gigas (Thunberg, 1793)	S-BdE
Ostrea stentina Payraudeau, 1826	RI
Crassatellidae	
Crassatina alba Cosel, 1995	SRF
Crassatina guineensis Cosel & Gofas, 2018	SRF
Lucinidae	
Lucinoma borealis (Linnaeus, 1767)	BdL
Cardiidae	
Cerastoderma edule (Linnaeus, 1758)	S-BdE, SRF
Papillicardium papillosum (Poli, 1791)	KI, SRF
Tellinidae	
Gastrana matadoa (Gmelin, 1791)	S-BdE
Huberimactra inconstans (Cosel, 1995)	SRF
Psammobiidae	
Gari depressa (Pennant, 1777)	S-BdE, SRF
Gari fervensis (Gmelin, 1791)	SF
Gari jousseaumeana Bertin, 1880	BdL
Solenidae	
Solen capensis P. Fischer, 1881	S-BdE
Veneridae	
Callista chione (Linnaeus, 1758)	SRF
Callista floridella (Gray, 1838)	KI, SRF
Petricola lithophaga (Retzius, 1788)	RI, SRF
Pitar tumens (Gmelin, 1791)	SRF
Polititapes durus (Gmelin, 1791)	SRF, KI
Ruditapes decussatus (Linnaeus, 1758)	S-BdE
Venerupis corrugata (Gmelin, 1791)	SRF, IdA
Venus casina Linnaeus, 1758	SRF, BdL
Venus verrucosa Linnaeus, 1758	S-BdE, M-BdE, SRF

***Lembulus bicuspidatus* (A. Gould, 1845)**
von Cosel and Gofas 2019
New Record. MAURITANIA - Dakhlet Nouadhibou • Baie du Lévrier; 21.0135, -16.9611; 04.XII.2021; S. M. Moctar and A. Freiwald leg.; grab sample; BdL21-3-2; IMROP 7.
Identification. Valve interiorly and exteriorly white coloured. Shell bicuspidate and inflated. Anterior margin rounded and posterior end bicuspidate. Surface with numerous slightly irregular striae. Escutcheon very long and broad. Ligament restricted well behind the beaks. The chevrons are very narrow and up to 8 in regular specimens up to 20 in very old ones.

***Acar olivercoseli* M. Huber, 2010**
Figure 8A
von Cosel and Gofas 2019
Figure 5A
New Record. MAURITANIA - Dakhlet Nouadhibou • Kijji island; 19.8227, -16.5940; 20.06.2023; ganchorra sample; K1; SMF 367180.
Identification. Shell dirty creamy coloured on the outside and inside coloured whitish. Shell subrectangular or subtrapezoidal in shape and slightly inflated. Surface with up to 30 broad commarginal ridged crossed by 25-35 radial ribs.

***Senilia senilis* (Linnaeus, 1758)**
Figure 8B
von Cosel and Gofas 2019
Figure 5B
New Records. MAURITANIA - Dakhlet Nouadhibou • Kijji island; 19.8249, -16.5954; 20.VI.2023; A. Knorrn., E. Serrao and A. Freiwald; collected during snorkeling along seagrass beds; K3; MAU-447 • Agadir Sandy beach; 20.6106, -16.4468; 05.III.2023; M. Sonnewald & A. Knorrn, collected during snorkeling; IdA-09; IMROP 63, SMF 372450.
Identification. Outside of shell whitish coloured and covered by an olive green to dark brown or black periostracum. Shell about as high as long and subrhomboidal to triangular with strongly projecting submedian umbones. Outer sculpture with 12 (10-15) ribs with narrow interspaces. Hinge plate very broad with up to 15 anterior and 16 posterior teeth.

***Leiosolenus aristatus* (Dillwyn, 1817)**
Figure 8C
von Cosel and Gofas 2019
Figure 5D
New Record. MAURITANIA - Dakhlet Nouadhibou • Rocky island; 21.0254, -17.0067; 17.II.2023; A. Knorrn and A. Freiwald leg.; hand collection; BdE-64; IMROP 76, SMF 367175.
Identification. Shell coloured ochre to whitish. The periostracum is brownish coloured and encrusted with a greyish calcareous layer which project beyond the posterior margin and ends at the pointy tips. The shell is elongated, subcylindrical and posteriorly narrowed. Each shell ends in a pointy tip. A smooth hinge line without teeth or crenulations.

***Perna perna* (Linnaeus, 1758)**
Figure 8D
von Cosel and Gofas 2019

Figure 5C

New Records. MAURITANIA - Dakhlet Nouadhibou • Rocky island; 21.0259, -17.0070; 26.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; from litoral rocks; BdE-20-3; IMROP 40, SMF 372458 • Cap Blanc; 20.7709, -17.0468; 23.II.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; hand collection from rocky shoreline; BdL-20; IMROP 69, SMF 367168.

Identification. Shell lightly purplish to brownish coloured underneath the yellowish, greenish or brownish coloured periostracum. The shell is very variable in shape, but roughly trigonal-ovate and elongated. Posterior retractor scars are widely separated in two different groups. No anterior adductor scar. The ligamental ridge is finely pitted.

***Atrina chautardi* (Nicklès, 1953)**

Figure 8E

von Cosel and Gofas 2019

Figure 5E

New Record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0383, -17.0234; 01.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection.

Identification. Outside of shell horn to dark brownish coloured, somewhat greenish brown. Shell quite variable in outline and structure, but generally elongated and ham shaped. The shell is very thin and fragile. The outer surface with 12-20 or more irregular ribs with several scaly spine. The eight to ten ribs close to the dorsal margin are well defined.

***Aequipecten flabellum* (Gmelin, 1791)**

Figure 8F

von Cosel and Gofas 2019

Figure 5F

New Record. MAURITANIA - Dakhlet Nouadhibou • Sandy beach at Blaouakh; 18.5187, -16.0751; 23.I.2024; A. Knorrn, K. Pfennings & K. Hopf leg.; hand collection; B2.

Identification. Colouration very variable but mostly bright vermilion to pink, brownish-red to purple. Interior shiny white with brownish with exterior colour shining through near the margin. Both valves convex with the right valve slightly more inflated than the left. The ears are well developed and about the same size.

***Magallana gigas* (Thunberg, 1793)**

von Cosel and Gofas 2019

New Record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0376, -17.0257; 24.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-134; IMROP 56; SMF 372479.

Identification. Outside of shell dirty white to creamy yellowish coloured. Interior whitish and shiny sometimes with chalky white patches. Posterior conductor scar pale coloured. Shell elongated and ovate in outline.

***Ostrea stentina* Payraudeau, 1826**

von Cosel and Gofas 2019

Figure 8G

New Record. MAURITANIA - Dakhlet Nouadhibou • Rocky island; 21.0256, -17.0071; 26.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-20-1; IMROP 26, SMF 372437, MAU-252.

Identification. Outside of shell greyish to brownish in colouration. Interior of shell tinged greenish, bluish grey to purplish brown. Shell very variable in shape but mostly higher than long, rounded and irregularly oval. Outer surface of left valve with about a dozen radial ribs or folds disappearing towards the dorsal half of the shell.

***Crassatina alba* Cosel, 1995**

von Cosel and Gofas 2019

New Record. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; ganchorra haul; BdL-6-1; MAU-249.

Identification. Shell whitish coloured and covered by a light greenish brown to darker brown coloured periostracum. The umbonal region is often eroded and the inner margin finely crenulated. Interior whitish coloured. Shell rounded to trigonal in shape and slightly longer than high. Outer surface with numerous regular ridges which become obsolete in posterior parts of the shell.

***Crassatina guineensis* Cosel & Gofas, 2018**

Figure 8H

von Cosel and Gofas 2019

New Record. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; ganchorra haul; BdL-6-1; SMF 367204, MAU-453.

Identification. Shell whitish to pinkish white coloured with pinkish to red blotches and zigzag markings. Periostracum light yellowish brown to dark brown and usually persistent around the whole shell. Interior white, to pinkish white and or lightly brownish. Shell in somewhat triangular shape with a strong hinge plate. Surface with several slightly irregular ridges which become obsolete at the posterior parts of the shell.

***Lucinoma borealis* (Linnaeus, 1767)**

Figure 8I

von Cosel and Gofas 2019

New Record. MAURITANIA - Dakhlet Nouadhibou • Baie du Lévrier; 21.0135, -16.9611; 04.XII.2021; S. M. Moctar and A. Freiwald leg.; grab sample; BdL21-3-2; MAU-213.

Identification. Exterior and interior part of the shell white. Very thin periostracum and greyish yellow to light-brown coloured and often partly eroded. Shell subcircular and rather inflated. Surface with numerous fine and irregular commarginal ridges or lamellae. The posterior area is delimited by a very faint radial depression.

***Cerastoderma edule* (Linnaeus, 1758)**

Figure 8J

von Cosel and Gofas 2019

New Records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0426, -17.0259; 24.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-129; SMF 367189 • Submerged ridges; 20.6531, -16.7267; 02.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-51; IMROP 88.

Identification. Outer part of the shell dirty whitish to brownish yellowish coloured. Interior whitish and gets chestnut coloured posterior direction. The shell is strongly inflated and a bit longer than high. The outer surface consists of 22 to 28 radial ribs that are rounded and flattened at the median part of both valves.

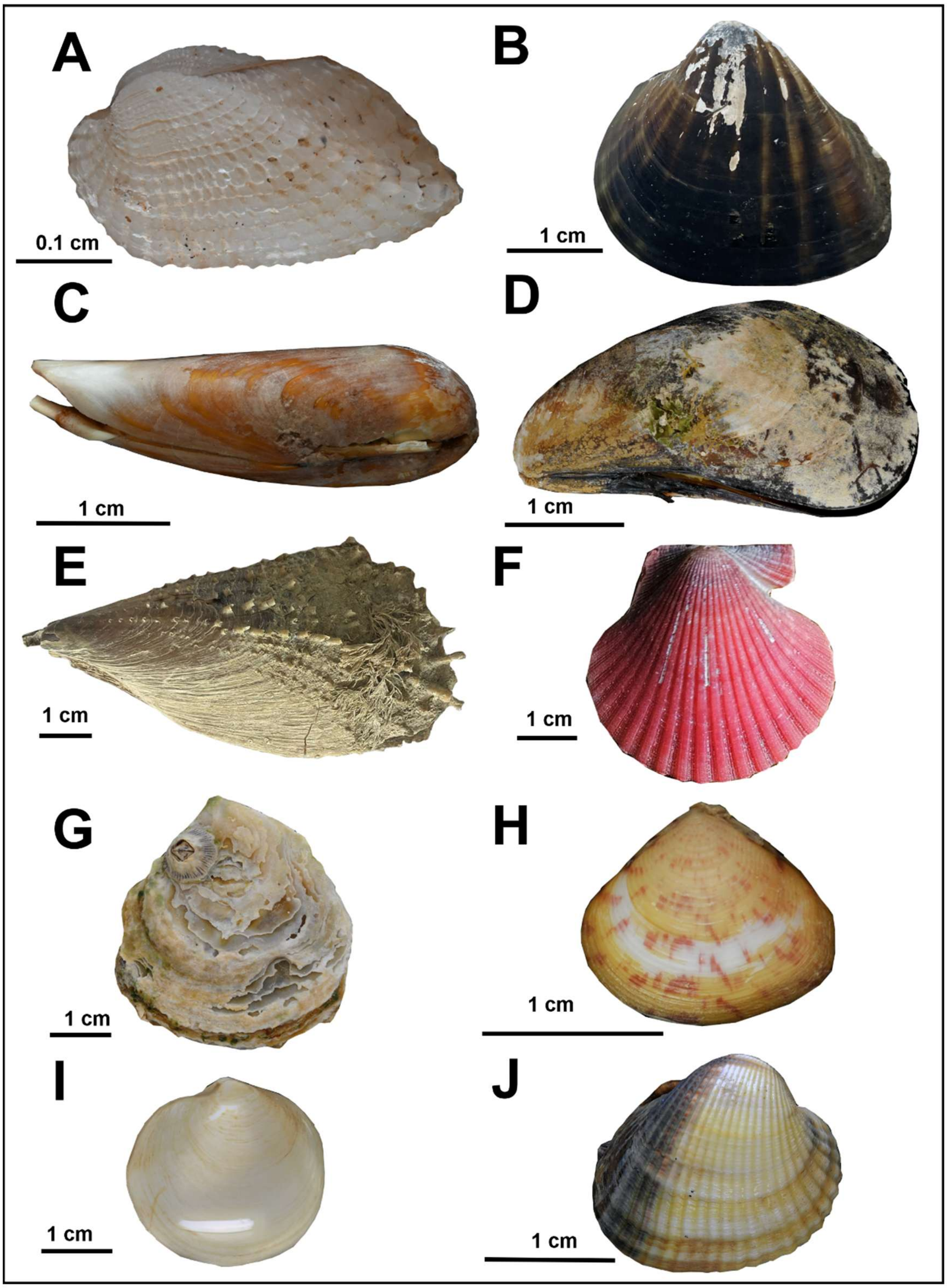

Figure 8: Marine bivalves from coastal habitats in northern Mauritania **A**: *Acar olivercoseli* **B**: *Senilia senilis* **C**: *Leiosolenus aristatus* **D**: *Perna perna* **E**: *Atrina chautardi* **F**: *Aequipecten flabellum* **G**: *Ostrea stentina* **H**: *Crassatina guineensis* **I**: *Lucinoma borealis* **J**: *Cerastoderma edule*. © Nicol Mahnken: A, B, C, D, G, H, I, J, © Kai Pfennings: F; © Alexander Knorrn: E.

Papillicardium papillosum **(Poli, 1791)**
von Cosel and Gofas 2019
Figure 9A
New Records. MAURITANIA - Dakhlet Nouadhibou • Kijji island; 19.8227, -16.5940; 20.06.2023; ganchorra sample; K1; Mau-457 • Submerged ridges; 20.6547, -16.7260; 02.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-53; IMROP 89, SMF 367190, MAU-450.
Identification. Outside of shell whitish to pale pinkish with irregular commarginal reddish-brown streaks or markings. Interior white to reddish brown coloured with and pinkish to purple coloured near the posterior margin. Shel subcircular to oval and longer than high. Surface with 24 to 26 strong and rather flat radial ribs bearing bead-like nodules. Interspace narrow with dense transverse grooves.

Gastrana matadoa **(Gmelin, 1791)**
von Cosel and Gofas 2019
New Record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0224, -17.0062; 16.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; push core sample from a sandy area between two seagrass beds; BdE-55; SMF 367183.
Identification. Shell whitish to pale yellowish coloured on the outside whitish to pale orange posteriorly and yellowish around the umbonal part on the interior. Periostracum brownish coloured and only present at marginal parts of the shell. Shell irregular in shape but generally suboval and rather inflated. The anterior margin is well rounded. The shell surface with coarse and irregular commarginal lamellae and very fine radial depressions that ends in a slight sinuosity at the postero-ventral margin.

Huberimactra inconstans **(Cosel, 1995)**
von Cosel and Gofas 2019
New Record. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6547, -16.7260; 02.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-53; MAU-446.
Identification. Shel is interiorly and exteriorly coloured whitish with a pale yellowish coloured periostracum, which is bristly on the posterior keel. Shell more or less subtriangular and can be very inflated. The anterior margin in broadly rounded. The shell surface is smooth with fine and irregular growth lines.

Gari depressa **(Pennant, 1777)**
Figure 9B
von Cosel and Gofas 2019
New Records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0224, -17.0062; 16.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-55; IMROP 82 • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; ganchorra haul; BdL-6-1; SMF 372465.
Identification. Outside of shell whitish to cream-yellowish coloured with darker commarginal zones and purple, violet or light brownish radial rays. Periostracum strong brownish to olive coloured and persistent on marginal parts of the shell. Interior cream

white to orange and violet with the exterior pattern shining through. Shell oblong to oval in shape and compressed. Shell surface without conspicuous tent shaped or zigzag markings.

***Gari fervensis* (Gmelin, 1791)**
von Cosel and Gofas 2019
New Record. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; ganchorra haul; BdL-6-1; IMROP 41, SMF 372459, MAU-248.
Identification. Outside of shell whitish to pale violet coloured with several darker rays that often show lighter mottlings on them. Interior light to dark violet to bright yellow in colour. Shell more or less elongate and compressed. Posterior slope with about eight radial riblets that cross the concentric ridges and produce a cancellated pattern.

***Gari jousseaumeana* Bertin, 1880**
Figure 9C
von Cosel and Gofas 2019
Figure 6B
New Record. MAURITANIA - Dakhlet Nouadhibou • Baie du Lévrier; 21.0398, -16.9066; 04.XII.2021; S. M. Moctar and A. Freiwald leg.; grab sample; BdL21-4-2; IMROP 8.
Identification. Outside of shell whitish to light yellowish or violet coloured, with irregular brownish rays or zigzag pattern. Interior pinkish to violet in colour with intensely coloured parts of the exterior shining through. Shell more or less elongate and compressed. Posterior slope with only one conspicuous radial rib crossing the concentric ridges.

***Solen capensis* P. Fischer, 1881**
von Cosel and Gofas 2019
New Record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0455, -17.0196; 25.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-12.
Identification. Shell whitish to yellowish and pale brown and sometimes with darker growth zones. Interior whitish with exterior colouration shining through. Shell very elongated, nearly rectangular. Anterior margin obliquely and posterior margin vertically truncated. Surface with irregular growth lines.

***Callista chione* (Linnaeus, 1758)**
von Cosel and Gofas 2019
New Record. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; ganchorra haul; BdL-6-1.
Identification. Outside of shell glossy tawny brown to pinkish brown, often with concentric and radial ribs. These ribs tend to form quadrangular spots around the umbonal area. Interior whitish. Hinge with three irregular cardinal teeth. Palial sinus deep and not ascending anteriorly, pointed at the anterior end. Elliptical ovate in outline. Outer surface nearly smooth.

***Callista floridella* (Gray, 1838)**
Figure 9D
von Cosel and Gofas 2019

New Records. MAURITANIA - Dakhlet Nouadhibou • Kijji island; 19.8227, -16.5940; 20.06.2023, ganchorra haul; K1; IMROP 130 • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; ganchorra haul; BdL-6-1; SMF 367233.
Identification. Outer surface of shell with very irregular or geometric patterns of brown. Interior orange to vermilion with paler to whitish coloured towards the margin. Shell trigonal ovate in outline. Outer surface with narrow and regular concentric grooves posteriorly. Hinge with three irregular diverging cardinal teeth. Palial sinus deep and not ascending anterior wards, pointed at anterior end.

Petricola lithophaga **(Retzius, 1788)**
von Cosel and Gofas 2019
New Records. MAURITANIA - Dakhlet Nouadhibou • Rocky island; 21,0252, -17,0070; 19.II.2023; A. Knorrn, S. M.Moctar, M. Sonnewald and A. Freiwald leg.; hand collection; BdE-107; SMF 367207, MAU-452 • Submerged ridges; 20,6878, -16,7131; 04.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-86; SMF 367208.
Identification. Shell dirty white and sometimes with a brownish-red colouration on the postero-dorsal slope or the posterior end. Interior white, with the exterior colouration shining through. The shell is quite irregular, oval-shaped and very inflated. Surface with fine irregular ribs, which are most prominent on the posterior half of the shell and seem to disappear gradually around the middle part of the shell and are missing completely on the anterior half.

Pitar tumens **(Gmelin, 1791)**
von Cosel and Gofas 2019
New Record. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6547, -16.7260; 02.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-53.
Identification. Outside of shell creamy white, yellowish or ochre coloured. Interior white to light orange. Shell rounded ovate and not pointed posteriorly. Shell usually broadly suboval with anterior umbones. Shell rather compressed to moderately inflated. Ventral margin evenly curved, and the lunule is poorly distinct. Shell surface with very irregular and sometimes prominent growth lines and ridges.

Polititapes durus **(Gmelin, 1791)**
von Cosel and Gofas 2019
New Records. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; ganchorra haul; BdL-6-1; SMF 372466 • Kijji island; 19.8227, -16.5940; 20.VI.2023; A. Knorrn and A. Freiwald leg.; ganchorra haul; K1; IMROP 106.
Identification. Outside of shell glossy creamy to light fawn, often with light coloured zigzag markings and four interrupted radial bands of dark brown. Interior white to creamy in colour and sometimes pinkish under the beaks. Outer surface glossy with many concentric ridges and narrow groves.

***Ruditapes decussatus* (Linnaeus, 1758)**
von Cosel and Gofas 2019
New Record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0426, -17.0259; 24.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-129; SMF 367167.
Identification. Outside of shell white to light brownish coloured with various pattern of deep brown. Interior white to yellowish coloured with a purple hue along the ligamental margin. Shel solid and inflated, elongate to subquadrate in its outline. Outer surface with fine radial riblets and concentric grove, strongly impressed towards anterior and lateral sides. Palial sinus deep and reaches the midline of shell or slightly exceeding it.

***Venerupis corrugata* (Gmelin, 1791)**
Figure 9E
von Cosel and Gofas 2019
New Records. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; ganchorra haul; BdL-6-1; SMF 367171 • Agadir Sandy beach; 20.6106, -16.4468; 05.III.2023; M. Sonnewald and A. Knorrn, collected during snorkelling; IdA-09; IMROP 71.
Identification. Outside of shell cream or light buff to brownish coloured with various brownish pattern. Interior white and often stained with a deep purplish to blue colour on the posterior side. Shell very variable in form but generally rather inflated, oblong and subovate in outline. Surface dull with a very irregular sculpture consisting of irregular and fine commarginal ridges become coarser on the postero-dorsal part.

Venus casina Linnaeus, 1758
New records. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6531, -16.7267; 02.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-51; SMF 367161 • Baie du Lévrier; 20.8705, -17.0377; 02.III.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; grab sample; BdL-42-2; IMROP 62.
Identification. Outside of shell of shell pale yellowish to fawn coloured with brownish to purplish rays, dots and zigzag markings. Interior white, sometimes with a light pinkish hue. Shell variable in shape but mosty suboval to circular and more of less inflated. Surface of shell with thin irregular commarginal lamellae. The prominent lamellae are often slightly bent towards the dorsal side.
Remarks. Similar to *Venus verrucosa,* but without diverging rows of warty tubercles on the anterior and posterior parts of the shell.

***Venus verrucosa* Linnaeus, 1758**
Figure 9F
von Cosel and Gofas 2019
New Records. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0248, -17.0071; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-63; IMROP 58, SMF 367157 • Maerl bed in the Baie de l'Étoile; 21.0207, -17.0056; 16.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-45; IMROP 59 • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, S. M. Moctar, F. Krupp and A. Freiwald leg.; ganchorra haul; BdL-6-1; IMROP 44, SMF 372462.

Identification. Outside of shell dirty white to brownish coloured with pinkish to brown markings. Escutcheon with transverse brown markings at the left valve. Interior white and sometimes maculated with brown posteriorly. Shell rounded ovate with a pronounced escutcheon on the left valve. Outer surface with lamellose and prominent concentric ridges forming diverging rows of warty tubercles.

Remarks. Similar to *Venus casina*, but with prominent diverging rows of warty tubercles on the anterior and posterior parts of the shell.

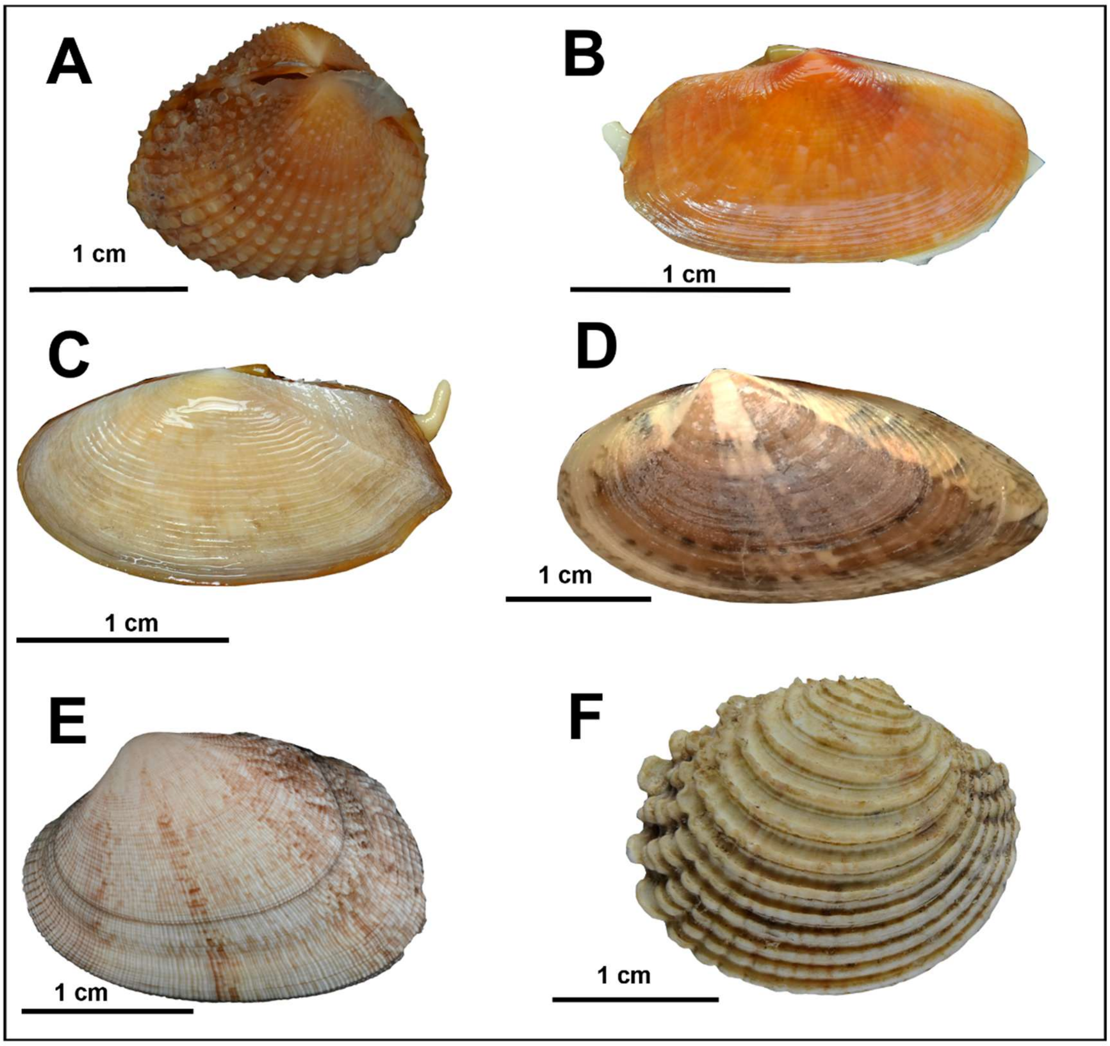

Figure 9: Marine bivalves from coastal habitats in northern Mauritania **A**: *Papillicardium papillosum* **B**: *Gari jousseaumeana* **C**: *Gari depressa* **D**: *Callista floridella* **E**: *Venerupis corrugata* **F**: *Venus verrucosa*. © Nicol Mahnken: A, B, C, D, E, F.

Table 7: Checklist of the Cephalopoda from shallow-water habitats and artisanal fish markets in Mauritania. Abbreviations can be seen in Table 1.

Species	Location
Cephalopoda (N = 2)	
Sepiidae	
Sepia officinalis Linnaeus, 1758	S-BdE
Ommastrephidae	

Todarodes sagittatus (Lamarck, 1798)	NKM

***Sepia officinalis* Linnaeus, 1758**

Figure 10A

Hayward and Ryland 2017

New Record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0168, -17.01844; 25.VII.2022; F. Krupp, A. Freiwald leg.; Beach seine; BdE-8; IMROP 47, MAU-459.

Identification. Body colour changeable but mostly light brown. Head with several white spots. The dorsal side of the mantel has a zebra stripe pattern during the breeding season. Body broadly oval and rather flattened. Dorsal and anterior part of the mantel formed a blunt and rounded lobe. The arms have four rows of suckers. The fins extend along the entire length of the body.

***Todarodes sagittatus* (Lamarck, 1798)**

Figure 10B

Carpenter and De Angelis 2016

New Record. MAURITANIA - Nouakchott Nord • Nouakchott market; 18.1033, -16.0263; VII.2021; M. Dia and A. Niang leg.; fish market survey (tissue sample); MAU-5.

Identification. Cartilaginous appearing funnel with an inverted T-shaped grooves, a distinct groove and without side pockets. Arms with two rows of suckers. Arm suckers with one enlarged central tooth and eight to ten regular teeth and no small alternating teeth. The tentacular club has four rows of suckers with the median ones being bigger. The tentacular club extends along the stalk and occupies around 75 to 83% of the arm length.

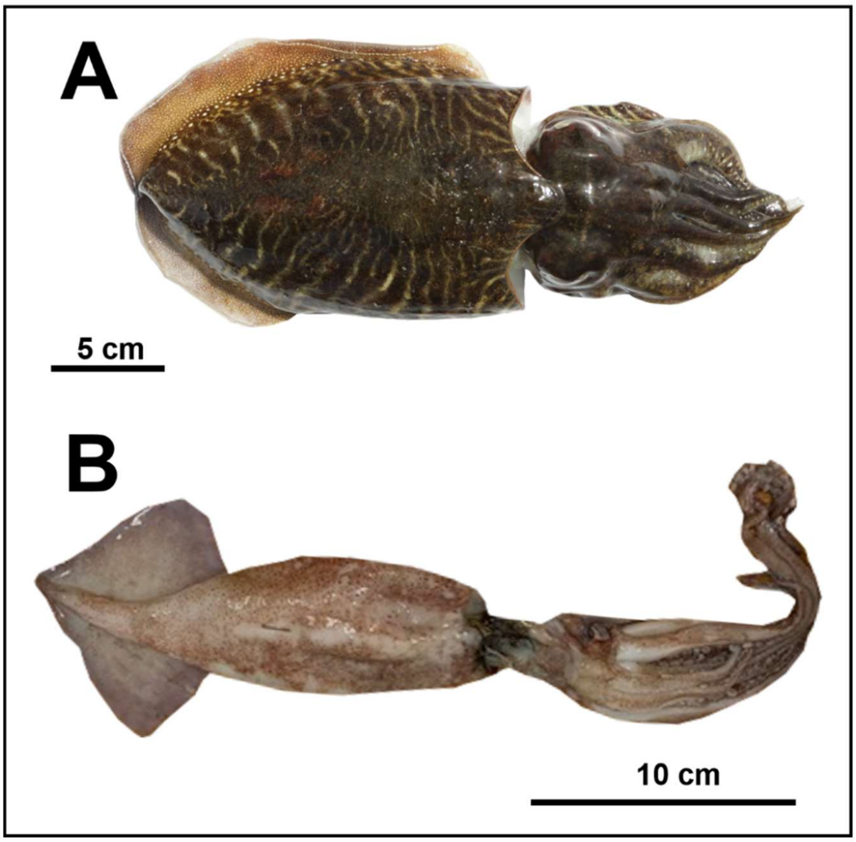

Figure 10: Cephalopods from coastal habitats and artisanal fish markets in Mauritania **A**: *Sepia officinalis* **B**: *Todarodes sagittatus*. © Kristina Hopf: A, © Mamadou Dia: B.

Table 8: Checklist of the Brachiopoda species from shallow-water habitats in Mauritania. Abbreviations can be seen in Table 1.

Species	**Location**
Brachiopoda (N = 1)	
Lingulidae	
Lingula parva Smith, 1872	BdL

***Lingula parva* Smith, 1872**
Emig and Le Loeuff 1978
New Records. MAURITANIA - Dakhlet Nouadhibou • Baie de Archimede; 21.0398, -16.9066; 04.XII.2021; M. Sonnewald and A. Freiwald leg.; Grab sample; BDL21-4-2 • Kijji island; 19.8227, -16.5940; 20.VI.2023; A. Knorrn and A. Freiwald leg.; ganchorra haul; K1.
Identification. Shell and body light brownish to greyish brown to copper in colour. The shell is elongated and oval in shape, weakly transparent and calcified with several certain muscular insertions. The ventral valve extends beyond the dorsal valve.

Figure 12: A living marine brachiopod (*Lingula parva)* collected twice at coastal habitats in Mauritania © Nicol Mahnken: A.

Table 9: Checklist of the marine Echinodermata from shallow-water habitats and artisanal fish markets in Mauritania. Abbreviations can be seen in Table 1.

Species	**Location**
Echinodermata (N = 7)	
Asterinidae	
Asterina gibbosa (Pennant, 1777)	M-BdE
Asterina stellifera (Möbius, 1859)	PI
Amphiuridae	
Amphipholis squamata (Delle Chiaje, 1828)	M-BdE
Ophiactidae	

Ophiactis lymani Ljungman, 1872	RI, M-BdE
Ophiotrichidae	
Ophiothrix cotteaui (de Loriol, 1900)	SRF
Arbaciidae	
Arbacia lixula (Linnaeus, 1758)	BB
Holothuriidae	
Holothuria arguinensis Koehler & Vaney, 1906	BB

***Asterina gibbosa* (Pennant, 1777)**

Figure 12A

Southward & Campell 1996

New Record. MAURITANIA - Dakhlet Nouadhibou • Maerl bed in the Baie de l'Étoile; 21.0184, -17.0030; 20.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-119.

Identification. Uniformly to mottled pale brown to grey and olive green in colour. Body roughly pentagonal in shape with very short arms. The upper side is slightly swollen with sharp edges. The lower side is flat. Spines on the upper side are arranged in groups of four to eight. The spines of the lower side are arranged in groups of two or three.

Remarks: Smaller individuals can have a similar resemblance to *A. stellifera* but differ in less pointed arms and an irregular arrangement of abactinal plates.

***Asterina stellifera* (Möbius, 1859)**

Figure 12B

Clark and Downey 1992

New Record. MAURITANIA - Dakhlet Nouadhibou • Pelican island; 20.7111, -16.6880; 03.III.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdL-74; MAU-359.

Identification. Greyish to olive in colouration with occasional orange or reddish spots. Body thick and laterally slopping. Short rayed with evenly tapering, almost pointed rays. Abactinal skeleton with a reinforced pentagon on the disc formed by plates linking the five primary radials. The other primary plates are mostly elongated and crescentig.

Remarks: Smaller individuals have a resemblance to *A. gibbosa* but differ externally in more pointed arms and a more regular arrangement of abactinal plates.

***Amphipholis squamata* (Delle Chiaje, 1828)**

Figure 12C

Hayward and Ryland 2017

New Record. MAURITANIA - Dakhlet Nouadhibou • Maerl bed in the Baie de l'Étoile; 20.7111, -16.6880; 20.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-56.

Identification. Arms and disk greyish to light brown in colour. The dorsal disc is covered by small scales. The radial shields are equal to one third of the dorsal disc radius and joined for almost the entire length. The dorsal arm plates are rounded, triangular and broader than long in the proximal apex. Three to four proximal arm spines are present.

***Ophiactis lymani* Ljungman, 1872**

Figure 12D

Borges et al. 2002

New Records. M AURITANIA - Dakhlet Nouadhibou • Rocky island; 21.0252, -17.0070; 19.II.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-107 • Maerl bed in the Baie de l'Étoile; 21.0248, -17.0071; 17.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-63.

Identification. The five arms and the discs are coloured in a creamy white to dark grey with a dark brownish marble pattern. The disc is covered in large irregular scales. The radial shields are twice as long as wide. The spines area sparsely distributed along the marginal region of the disc. Behind the radial shield there are two blunt spines. It has two oral papillae on each side of the mandible and a pair of irregular infradentals at the apex. The dorsal brachial plate is flabelliform and ventraly rounded on the posterior margin.

***Ophiothrix cotteaui* (de Loriol, 1900)**

Figure 12E

De Loriol 1900

New Record. MAURITANIA - Dakhlet Nouadhibou • Submerged ridges; 20.6562, -16.7199; 04.II.2024; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-122.

Identification. Body and arms are coloured in a dark red to dark violet with a whitish marble pattern on the dorsal side of the disc. The central disc is covered in fine grains instead of spines. Radial plates very large, absolutely naked and shaped like an unequilateral triangle with the short side more or less parallel to the rim. Five arm spines at the proximal end and four arm spines at the distal end of the arms.

***Arbacia lixula* (Linnaeus, 1758)**

Figure 12F

Riedl 1983

New record. MAURITANIA - Dakhlet Nouadhibou • Sandy beach at Blaouakh; 18.5187, -16.0750; 23.I.2024; A. Knorrn, K. Pfennings & K. Hopf leg.; hand collection; B2.

Identification. Black coloured body with black spines. Spines about as long as the body diameter. Aboral ambulacral plate with 3 pairs of pores and deep gill incisions. Aboral suction feet without suction disc.

***Holothuria arguinensis* Koehler & Vaney, 1906**

Figure 12G

González-Wangüemert and Borrero-Pérez 2012

New Record. MAURITANIA - Dakhlet Nouadhibou • Sandy beach at Blaouakh; 18.5187, -16.0750; 24.II.2023; A. Knorrn, K. Pfennings & K. Hopf leg.; hand collection; B2.

Identification: Body cylindrical shaped with a uniformly yellowish colouration with a browner dorsal side. Whitish dots are distributed along the body with punctuations that match the retracted pedicels, which are light brown. Large papillae or warts on the dorsal surface, they are blackish brown to whitish, and they are arranged in six longitudinal rows.

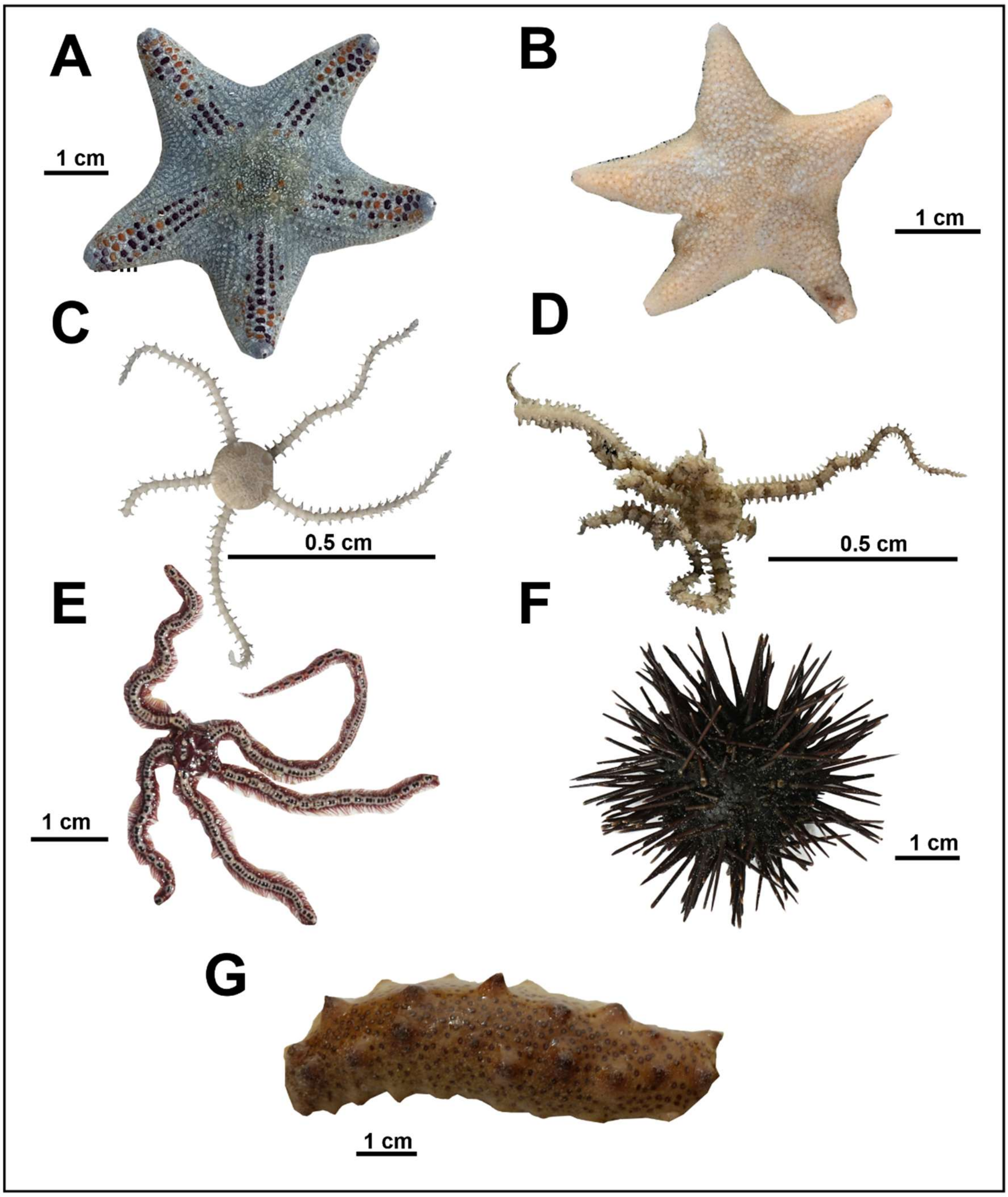

Figure 12: Echinoderms from coastal habitats in northern Mauritania **A**: *Asterina gibbosa* **B**: *Asterina stellifera* **C**: *Amphipholis squamata* **D**: *Ophiactis lymani* **E**: *Ophiothrix cotteaui* **F**: *Arbacia lixula*, **G**: *Holothuria arguinensis*. © Nicol Mahnken: A, B, C, D, © Kristina Hopf: E, F, G.

Table 10: Checklist of the Polychaeta from shallow-water habitats in Mauritania. Abbreviations can be seen in Table 1.

Species	Location
Polychaeta (N = 12)	
Syllidae	
Amblyosyllis madeirensis Langerhans, 1879	OP

Sabellidae	
Branchiomma luctuosum (Grube, 1870)	OP, RI
Onuphidae	
Diopatra marocensis Paxton, Fadlaoui & Lechapt, 1995	BdL, SRF
Syllidae	
Exogone naidina Örsted, 1845	OP
Glyceridae	
Glycera alba (O.F. Müller, 1776)	BdL
Sigalionidae	
Sthenelais boa (Johnston, 1833)	M-BdE, SRF
Nereididae	
Perinereis oliveirae (Horst, 1889)	RI
Capitellidae	
Notomastus latericeus Sars, 1851	S-BdE
Orbiniidae	
Naineris setosa (Verrill, 1900)	S-BdE
Terebellidae	
Terebella lapidaria Linnaeus, 1767	OP
Maldanidae	
Nicomache lumbricalis (Fabricius, 1780)	BdL
Sabellariidae	
Sabellaria alveolata (Linnaeus, 1767)	CB

***Amblyosyllis madeirensis* Langerhans, 1879**
Aguado et al. 2019
New Record. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0206, -17.0045; 16.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection from a sunken wood; BdE-56; SMF 33008.
Identification: Small Syllidae Grube, 1850 with long and coiled dorsal cirri, in some specimens clearly distally articulated. Colour pattern variable and not well-defined, with a varying number of transverse lines. Nuchal lappets ciliated, extending to the end of the first chaetiger. Long to medium bidentate chaetae, 14–16 on midbody parapodia. Trepan with six pentacuspid teeth; lateral cusps on each tooth difficult to discern.

***Branchiomma luctuosum* (Grube, 1870)**
Figure 13A
Licciano, Margherita, and Adriana Giangrande 2008
New Records. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0206, -17.0045; 16.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection from a sunken wood and old fish traps; BdE-56; BdE-103-2; IMROP 1 • Rocky island; 21.0252, -17,007072; 19.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-107; SMF 33006.
Identification: Medium to large-sized sabellid, often occurring in aggregates. Crown purple to red-orange, with white and red stripes in juveniles. Body ranges from dark green to reddish, occasionally with dark dots. Macro-stylodes absent; stylodes foliaceus. Radioles articulated in appearance; collar not fused dorsally. Thoracic tori extending to the ventral shield. Companion chaetae absent.

***Diopatra marocensis* Paxton, Fadlaoui & Lechapt, 1995**

Figure 13B

Paxton and Arias 2017

New Records. MAURITANIA - Dakhlet Nouadhibou • Baie du Lévrier; 20.9623, -16.8805; 04.XII.2021; S. M. Moctar and A. Freiwald leg.; grab sample; BdL21-1-02; SMF 33005 • Submerged ridges; 20.6528, -16.7316; 30.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-6-1; SMF 33004.

Identification: Branchiae spiralled. Prostomium anteriorly rounded; palps extending to chaetiger 3, antennae reaching chaetiger 10–12, with ceratophores bearing six to nine rings. Peristomial cirri present. Pectinate chaetae with 11–20 teeth, from chaetiger 4–5 to 30–40. Brown pigmentation with irregular white dots. Tube composed of an inner secreted layer and an outer layer of foreign particles, primarily algae and vegetal material.

***Exogone naidina* Örsted, 1845**

San Martin 2003

New Record. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0206, -17.0045; 16.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection from a sunken wood; BdE-56; SMF 33008.

Identification: Very small Syllidae Grube, 1850, whitish to transparent in color. Prostomium with four large, rounded eyes and three antennae; central antenna longer. Dorsal cirri rounded, absent on chaetiger 2. Proventricle small and barrel-shaped. First chaetigers bear short composite chaetae with unidentate blades, each featuring a long basal spine. Subsequent chaetigers have composite falciger chaetae, with the blade's sub-apical tooth markedly larger than the distal tooth.

***Glycera alba* (O.F. Müller, 1776)**

Böggemann 2002

New Record. MAURITANIA - Dakhlet Nouadhibou • Baie du Lévrier; 21.0150, -16.9168; 04.XII.2021; S. M. Moctar and A. Freiwald leg.; grab sample; BdL21-2-22; IMROP 4.

Identification: Medium-sized Glyceridae Grube, 1850, elongated with clearly visible parapodia. Prostomium consists of 9-11 rings. Proboscis long, covered with three types of papillae: numerous elongated papillae with a terminal fingernail-like structure, a few elongated and smooth papillae, and a sparse, wider smooth papillae. Post-chaetal lobes shorter than the digitiform pre-chaetal lobes. From mid-body chaetigers, notopodial post-chaetal lobes are shorter than neuropodial ones. Color whitish to straw-white.

***Sthenelais boa* (Johnston, 1833)**

Parapar Vegas 2018

New Records. MAURITANIA - Dakhlet Nouadhibou • Maerl bed in the Baie de l'Étoile; 21.0209, -17.0058; 16.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; hand collection; BdE-46; SMF 33009 • Submerged ridges; 20.6531, -16.7267; 02.III.2023; A. Knorrn, S. M. Moctar, M. Sonnewald and A. Freiwald leg.; ganchorra haul; BdL-51; SMF33010, IMROP 9.

Identification: Medium-sized Sigalionidae Kinberg, 1856, elongated and covered with elytrae. Elytrae sub-rectangular to reniform, covered in tubercles, with digitiform papillae along the external border. Spiny simple notochaetae with thin, barely visible bifid tip. Composite falciger neurochaetae, bidentate, with two types: a thinner form with multi-articulated, elongated blade, and a wider form with a short blade.

Perinereis oliveirae **(Horst, 1889)**
Figure 13C
Prajapat et al. 2024
New Record. MAURITANIA - Dakhlet Nouadhibou • Rocky island; 21.0259, -17.0070; 26.VII.2022; A. Knorrn, F. Krupp, S. M. Moctar and A. Freiwald leg.; from littoral rocks; BdE-20; SMF 32997.
Identification: Small to medium-sized Nereididae Blainville, 1818. Tentacular cirri short; ligulae with a markedly enlarged base in posterior chaetigers; dorsal cirri short. Oral ring with a single long, thin, plank-like paragnath in each area VI, occasionally divided into two smaller pieces; area V with one paragnath aligned with those in area VI. Notochaetae homogomph spinigers; supra-acicular neurochaetae as homogomph spinigers and heterogomph falcigers; sub-acicular neurochaetae heterogomph spinigers and falcigers. Body color ranges from green to bronze.

Notomastus latericeus **Sars, 1851**
Parapar Vegas 2018
New Record. MAURITANIA - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0247, -17.0065; 19.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; push core sample from a sandy area between two seagrass beds; BdE-109; SMF 32999.
Identification: Medium-sized Capitellidae Grube, 1862, elongated. Prostomium conic, with a group of eyespots on each side. First chaetiger with both noto- and neurochaetae; 11 thoracic chaetigers with only limbate chaetae. Abdomen with hooded hooks on both notopodia and neuropodia. Branchiae reduced.

Naineris setosa **(Verrill, 1900)**
Álvarez and Budaeva 2023
New Record. - Dakhlet Nouadhibou • Seagrass bed in the Baie de l'Étoile; 21.0224, -17.0062; 16.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.; push core sample from a sandy area between two seagrass beds; BdE-54; SMF 33001.
Identification: Medium-sized Orbiniidae Hartman, 1942, yellow with reddish branchiae and flattened in appearance. Prostomium rounded; peristomium with two annular rings, only weakly marked. Branchiae from chaetiger 5–6, cirriform, tapering to sharp a tip. Thorax comprises 20 chaetigers; notopodial lobes lanceolate, neuropodial lobes as wide flanges. Abdominal notopodial and neuropodial lobes cirriform. Uncini and subuluncini absent in thoracic neuropodia.

Terebella lapidaria **Linnaeus, 1767**
Lavesque et al. 2021
New Record. MAURITANIA - Dakhlet Nouadhibou • Old Pier; 21.0199, -17.0055; 15.II.2023; A. Knorrn, M. Sonnewald, S. M. Moctar and A. Freiwald leg.;underside of sandstone rocks in close proximity to the Old Pier; SMF 33011.
Identification: Large size Terebellidae Johnston, 1846. Buccal tentacles numerous, filiform; peristomium forming lips, upper lip convoluted, lower lip swollen. Three pairs of dichotomous branchiae arising from long stems. Ventral shields on SG II–XIII, rectangular, well defined. Notopodia short, rectangular, from SG IV, extending posteriorly until last few chaetigers; neuropodia present from SG V, as low, almost sessile ridges throughout. Notochaetae narrowly-winged with curled serrated tip; neurochaetae as

short-handled avicular uncini, arranged in double rows from SG XI to posterior body, in face-to-face arrangement.

Nicomache lumbricalis **(Fabricius, 1780)**
Parapar Vegas 2018
New Record. MAURITANIA - Dakhlet Nouadhibou • Baie du Lévrier; 20.9623, -16.8805; 04.XII.2021; S. M. Moctar and A. Freiwald leg.; grab sample; BdL21-1-02; IMROP 6.
Identification: Medium size Maldanidae Malmgren, 1867, elongated, with 22-23 chaetigers and 2 short pre-anal achaetous segments. Cephalic plate absent, cephalic kneel short. First 3 chaetigers with acicular neurochate. Following chaetigers with neuropodial hooks. Pygidial funnel cup-shaped, symmetrical, with 15-25 triangular cirri of similar size. Anus terminal.

Sabellaria alveolata **(Linnaeus, 1767)**
Hayward and Ryland 2017
New Record. MAURITANIA - Dakhlet Nouadhibou • Cap Blanc; 20.7701, -17.048979; 5.II.2024; A. Knorrn, M. Sonnewald, K. Hopf, K. Pfennings, S. M. Moctar and A. Freiwald leg.; hand collection from rocky shoreline; SMF 33012.
Identification: Tube composed of cemented sand grains, often forming dense aggregations with apertures arranged in a honeycomb pattern. Body length 30-40 mm. Three parathoracic chaetigers. Opercular chaetae: inner and middle rows with asymmetrical spines—inner spines point distally; middle spines point transversely. Outer rows feature flattened, flexible chaetae with about five serrations across a blunt distal margin.

Figure 13: Polychaetes from coastal habitats in Mauritania **A**: *Branchiomma luctuosum* **B**: Typical tube build by *Diopatra marocensis* **C**: *Perinereis oliveirae*. © Kristina Hopf: A © Nicol Mahnken: B, C.

Additional species that could not be identified at the species level or for which no exact location could be determined are listed in Table 11. Further research of specialised taxonomists is urgently needed to identify these species.

Table 11: List of observed species with no exact location (NEL) and/or no identification to species level (NSI). Location abbreviations can be seen in Table 1.

Species	Location	Status	Remarks
Cnidaria			
Leptogorgia sp.	SRF, BB	NSI	Different morphotypes of this genus were found along the sandy beaches of Mauritania and within the submerged ridge fields. Due to an unclear taxonomy, no species identification could be made.
Crustacea			
Tanaidacea indet.	S-BdE	NSI	Due to the lack of time no species identification has yet been made
Isopoda indet.	RI, OP, PI	NSI	Only one species (*Sphaeroma serratum*) was morphologically identified. Additional species could be found.
Amphipoda indet.	RI, OP, PI, SRF, CP	NSI	Due to the lack of time no species identification has yet been made
Calappa rubroguttata Herklots, 1851	BB	NEL	Two dead individuals were found within abandoned fishing gear
Mollusca			
Pteria atlantica (Lamarck, 1819)	CP, BB	NEL	Found within abandoned fishing nets
Cardium costatum Linnaeus, 1758	BB	NEL	Only the shells were found washed up to the beach
Tunicata			
Microcosmus Heller, 1877 sp.	BB, RI, SRF	NSI, NEL	Several observations were made but no specific species identification could be made. Additional individuals were found washed up on the beach at BB.
CF. Stolonica socialis Hartmeyer, 1903	SRF	NSI	Great abundances along the SRF, but no clear taxonomic identification for approval.
Porifera			
Cinachyrella Wilson, 1925	OP, RI, SRF	NSI	Great abundances of this sponge species occurred along the Mauritanian coast. No exact species identification could be made.
Porifera indet.	SRF	NSI	Various morphologically different sponge species were observed along the SRF, but no exact species identification could be made.
Polychaeta			
Serpulidae indet.	S-BdE	NSI	Several sightings of serpulid tubes growing around the rhizomes of *C. nodosa* and build star like structures. *No clear*

			species identification could be made
Polychaeta indet.	S-BdE, BdL, SRF, OP, RI,	NSI	Several polychaetes smaller than 1cm were found. No precise species identification could be made, additional DNA barcoding and phylogenetic analyses are required.

6.6 Discussion

Within this study, 118 different living macrozoobenthic species from Mauritanian coastal habitats were observed (Cnidaria: 2, Crustacea: 33, Polyplacophora: 2, Gastropoda: 30, Bivalvia: 29, Cephalopoda: 2, Brachiopoda: 1, Echinodermata: 7, Polychaeta: 12). Some animal groups showed a conspicuously high diversity of species in correlation with certain habitats. For example, most of the observed bivalve species were found at the submerged ridge field habitats. Like the habitat-forming gorgonians of the submerged ridge fields, the bivalves also exhibit a filter-feeding lifestyle. The current conditions along this habitat, potentially influenced by strong tidal currents and a rich supply of nutrients, may favour animal groups that primarily filter-feed. Gastropods and crustaceans were evenly distributed between seagrass beds and hard substrate habitats. Both habitats are intertidal and offer shelter and hiding places. In particular, seagrass beds may become especially important and more frequent habitats along the Mauritanian coast in the future. With rising sea levels, the erosion of coastal sand will increase, which could lead to the formation of new shallow-water lagoons and sebkhas due to dune breaches, similar to those observed in the Bellaat lagoon during August 2013 (Trégarot et al. 2020). However, with ongoing sea-level rise, many coastal areas around Mauritania, including coastal cities and villages like the capital city Nouakchott, are at great risk of flooding in the upcoming years (Senhoury et al. 2016).

Due to the unavailability of exact sampling locations for specimens (or body parts) ashore, entangled in abandoned fishing gear or not yet fully identified to species level, some observations were excluded from the checklist and are mentioned in Table 11. These unidentified specimens highlight the actual lack of appropriate identification literature and taxonomic work in the area. Further investigations and newly built taxonomic expertise are required to report checklists of these specific phyla to expand our knowledge of the Mauritanian marine fauna. Considering this, the list highlights that much remains to be discovered in Mauritanian waters, and there are still many significant knowledge gaps, especially for non-commercial and smaller parts macrozoobenthic species. Studies like these are of particular importance as a basis for studies on local foodwebs, where many more than just commercially used species have to be considered. Scientific collections play a particularly important role in overcoming this knowledge gap in Mauritania, as they serve as the basis for further scientific work. By making specimens identified to species level available to other scientists, these vouchers can be used for comparative work. Additionally, scientific collections serve as valuable reference points for future research, offering information on past biodiversity that can be compared with present or future states (Carter et al. 2001; Sander et al. 2023). To address this need, IMROP and SRI are working together to establish and continuously expand the scientific reference collections of the Mauritanian marine fauna in both Frankfurt am Main (Germany) and Cansado (Mauritania). These scientific collections currently consist of specimens mentioned herein, as well as additional fish vouchers mentioned in a previous study (Knorrn et al. 2024). The connection between metadata and voucher specimens follows the extended specimen approach (Lendemer et al. 2020) and allows a broader use (and reference) of the collected data.

This checklist presents our current knowledge of the invertebrate macrofauna from Mauritanian coastal habitats. It supports future ecosystem-based management planning by providing a baseline of frequently traded but also lesser-known invertebrates from these habitats and artisanal landing sites. Additionally, the most outstanding morphological characteristics of each species are described in detail and to aid in identification. Further investigations are needed to provide a more detailed and comprehensive list of the marine fauna occurring in Mauritanian waters, especially focusing on smaller invertebrates as well as cnidarians, tunicates, and sponges. Checklists like these in combination with a reference collection are very valuable sources for future biodiversity assessments, especially in the context of environmental and anthropogenically induced change enhanced by increased exploitation of fish resources in our oceans.

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Chapter 7

Unlocking Mauritania's Marine Secrets: A DNA barcode library for Mauritanian coastal marine biota

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7.1 Abstract

In recent years, DNA barcoding and biomonitoring techniques, including environmental DNA (eDNA) have emerged as important tools for species identification and biodiversity monitoring. However, in underexplored regions such as the Mauritanian coast, reference DNA barcodes are generally limited to commercially relevant species. This study lays the baseline for future investigations of the Mauritanian marine biodiversity by generating a genetic reference database based on DNA barcodes. The DNA barcodes are identified through morphological species identification and are further validated through a BIN (Barcode Index Number) discordance analysis. A total of 419 DNA barcodes from 209 different marine species, ranging from algae to marine molluscs and fish were generated. These DNA barcodes not only serve as essential reference points for future genetic species identification but also facilitate the detailed analysis of environmental DNA samples from the coastal habitats in Mauritania and West African waters.

Key words. Biodiversity, West Africa, DNA barcoding

7.2 Introduction

The coastlines of Mauritania stand out as some of the most nutrient-rich regions in the Atlantic Ocean. Seasonal upwelling and sporadic inputs of Saharan sand contribute to a substantial nutrient availability, fostering high productivity in the area (Valdés and Déniz-González 2015). This nutrient enrichment sustains some of the Atlantic's most productive fish stocks off the Mauritanian coast (Nagel & Gray 2012). The favourable ecological conditions support thriving marine life and give rise to a diverse array of species from tropical, subtropical, and temperate zones (Jager 1993, Le Loeuff & von Cosel 1998).

However, precise identification is crucial for biodiversity assessments, particularly in the context of mass extinctions and biodiversity loss resulting from human activities (González-Oreja 2008; Dubois 2010). Achieving sustainable conservation of Mauritanian marine biodiversity demands a foundational understanding of the community structure in natural ecosystems (Fierro et al. 2019). This necessitates the effective monitoring of biodiversity changes, identification of vulnerable areas, and the establishment of priority conservation targets for susceptible taxa. Species identification, discovery, and monitoring have emerged as critical field of research for biodiversity conservation and management (Tsoupas et al. 2022). Accurate identification is pivotal across various biological research fields (Knebelsberger et al. 2014), especially in regions where morphological species identification poses challenges due to a lack of detailed identification keys. Genetic species identification, particularly through DNA barcoding, plays a crucial role in overcoming the limitations associated with morphological identification. DNA barcoding is most effective when based on well-curated and identified reference data (Hausmannet al. 2015; Miller et al. 2016). One commonly used method involves routine species identification using partial cytochrome c oxidase subunit 1 (*CO1*) sequences (Hebert et al. 2003). However, the scarcity of specialised taxonomists often makes this method unfeasible, emphasizing the urgent need for taxonomic research in the present days (Stribling, et al. 2003; Wheeler, 2014).

An alternative method to verify the accuracy of a genetic reference sequence involves using the Barcode of Life Database (BOLD, Ratnasingham & Herbert 2007) as a reference library. Assigning a taxonomic reliability grade to barcodes using the Barcode Index Number (BIN) from BOLD can enhance the accuracy of morphological identification. Nonetheless, verification by a specialised taxonomist remains crucial to ensure the robustness of the genetic sequence and the linked species identification.

The ongoing expansion of open-access DNA barcode data is essential for the taxonomic reliability of future records (Knebelsberger et al. 2014), particularly in regions like West Africa, which lack specialised genetic reference libraries. These DNA barcode libraries not only facilitate efficient and accurate species identifications for scientific purposes but also find applications in broader areas such as food monitoring by allowing for more detailed species identification.

Metabarcoding, utilising high-throughput sequencing technology, extends the capabilities of DNA barcoding by enabling rapid species inventories from complex bulk samples (Singh et al. 2021). Environmental DNA (eDNA) extracted from various sources like water, sediment or air samples, allows for non-invasive sampling and monitoring, with applications spanning from soil to aquatic systems (Taberlet et al. 2012; Belle et al. 2019). However, the effectiveness of eDNA analysis relies heavily on a detailed and well-curated reference database. Incorrect reference data may lead to erroneous results, highlighting the importance of using morphologically identified and reliable reference sequences in the barcode library.

This study presents a comprehensive DNA barcode library for Mauritanian coastal marine life. It relies on meticulously identified species by specialised taxonomists and additional verification through a BIN discordance analysis (Ratnasingham & Hebert 2013), providing ranked reference sequences for future species identifications and eDNA biodiversity assessments.

7.3 Material & Methods

Fieldwork sample collection & preservation

Sampling expeditions were carried out during five field trips to Mauritania spanning from December 2021 to January/February 2024. The marine fauna was systematically sampled across different shallow water habitats such as seagrass beds in the Baie de l’Étoile, Kijji island, and the Bellaat lagoon. Additionally, the rocky shorelines around Cap Blanc, Pelican island and the submerged ridge fields along Cap Saint Anne were also sampled (Figure 1). Additional sampling surveys at the artisanal fish markets and landing places in Nouadhibou and Nouakchott were conducted. For further information regarding the morphologic species identification and sample deposition, see Knorrn et al. 2024a,b.

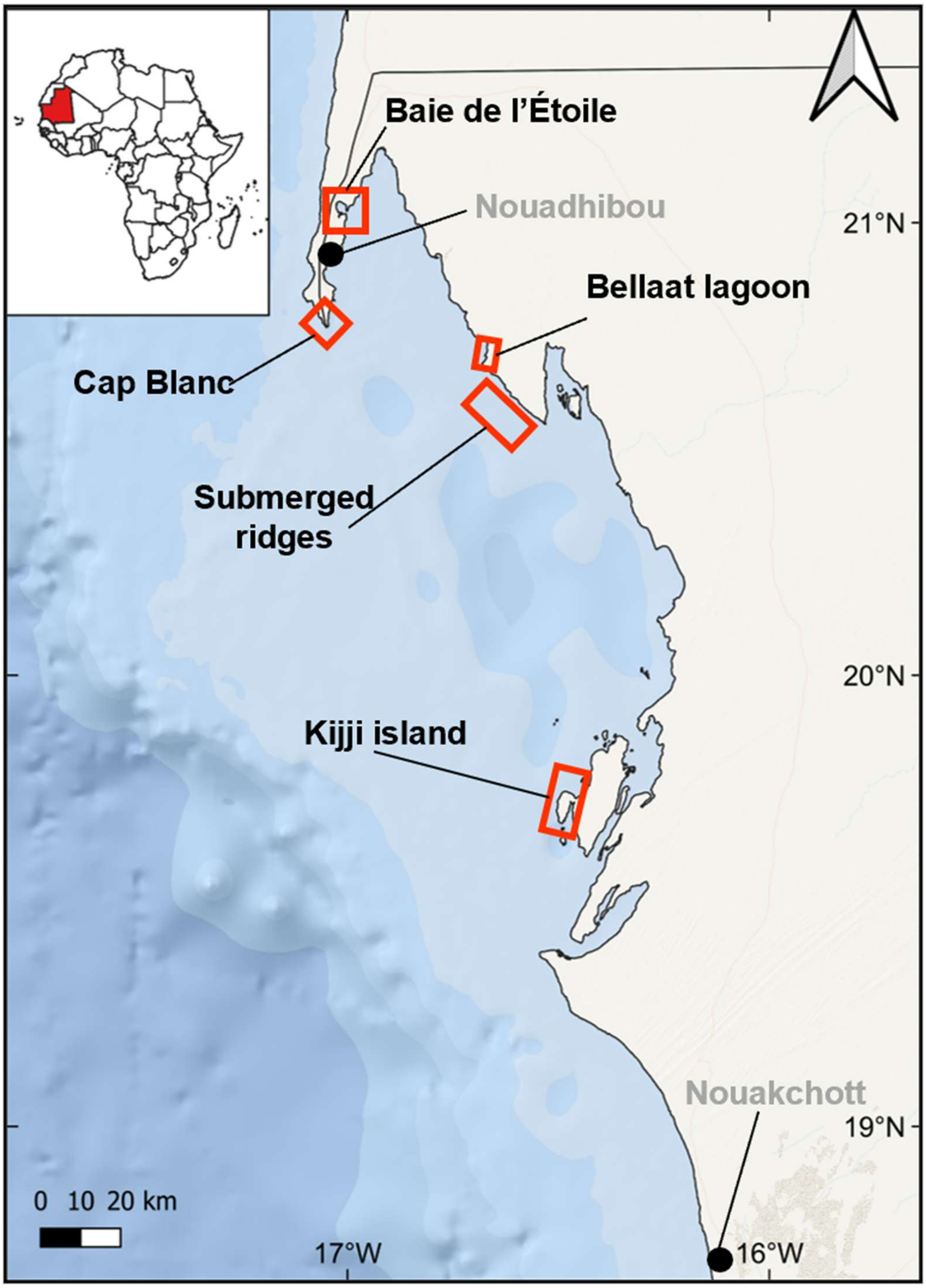

Figure 1: Geographical map of sampling areas along the Mauritanian. Red frames indicate sampling areas. Cities and their artisanal fish markets are indicated by a black dot. Basemap from ESRI (2019) (www.esri.com).

Various collection methods were applied to cover a wide range of microhabitats, including beach seines, beam trawling, throwing nets, hand collections, and fish traps. The collected vertebrates and cephalopods were kept on crushed ice and were euthanised using an anaesthetic overdose (Clove Oil). Marine invertebrates were directly preserved in 70% ethanol. Animals larger than 10 cm were initially preserved in a 4% formalin/seawater solution and later transferred in 70% ethanol, following the ethanol concentration protocol outlined by Freyhof et al. (2020). Whenever feasible, seaweed samples were pressed into herbaria sheets for future reference. Genetic samples were obtained under the most sterile conditions feasible in the field. Before each sampling event, forceps and tweezers were disinfected using ethanol and flame. Subsequently, the genetic samples from animals were preserved in 96% denatured ethanol. Seaweed samples were individually dehydrated and preserved in silica gel.

All collected and identified specimens now serve as vouchers stored in the scientific collections of the IMROP institute in Nouadhibou (Mauritania), CCMAR in Faro (Portugal) and the Senckenberg research institute in Frankfurt am Main (Germany). Detailed information about each specimen is accessible through the information systems of the institutes. Species-level identifications were verified by taxonomic specialists for each taxon.

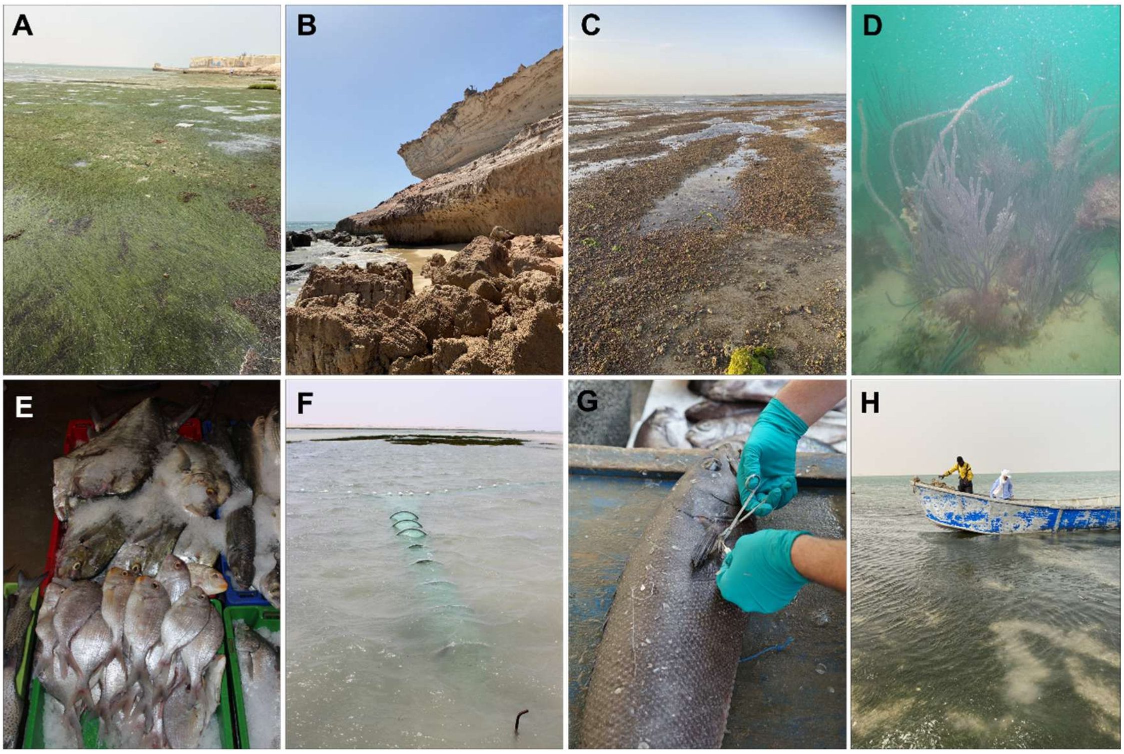

Figure 2: Habitat and sampling impressions. **A**: Seagrass (*Zostera noltei*) beds in the Baie de l'Étoile. **B**: Rocky shoreline of Cap Blanc. **C**: Maerl bed during low tide in the Baie de l'Étoile. **D**: *Leptogorgia* forest at the submerged dune field. **E**: Freshly caught fish from the artisanal fish market in Nouakchott. **F**: Fish trap in the Baie de l'Étoile. **G**: Genetic tissue sampling at the artisanal fish market in Nouakchott. **H**: Sample collection from a boat in the Baie de l'Étoile. © André Freiwald: A, C, E, F, H, © Alexander Knorrn: D. © Kristina Hopf: B, G,

DNA Isolation, PCR Amplification, Sequencing, and Assembly:

Laboratory procedures were conducted at biome-id laboratories (Wilhelmshaven, Germany) and CCMAR (Faro, Portugal). Genomic DNA extraction from animal samples was accomplished using the Macherey-Nagel Genomic DNA from a Tissue kit. Additional DNA from seaweed samples was extracted using the Genomic DNA the Nucleospin® Plant II kit (Macherey-Nagel Duren, Germany). Amplification targeted the CO1 (mitochondrial cytochrome c oxidase subunit 1) barcode locus for all samples.

Fish samples aimed for a target length of 660 base pairs, excluding primer binding sites. Amplification involved a cocktail of two forward (VF2 & FishF2) and two reverse (FishR2 & FR1d) primers following Ivanova et al. (2007). Decapod samples targeted a length of 675 base pairs, excluding primer binding sites. Amplification utilised CrustCOI-F and DecapCOI-F primer pairs (Teske et al. 2009). Molluscs and other invertebrates aimed for a length of 658 base pairs, excluding primer binding sites. Amplification was carried out using jgLCO1490 and jgHCO2198 primers (Geller et al. 2013). Amplification targeted standard seaweed barcode markers known for their resolution, including mtDNA cox1 for brown and red macroalgae and cpDNA tufA for green algae (Saunders & McDevit 2012; Lane et al. 2007; Saunders 2005; Nielsen et al. 2013). For some Dictyotales, the mtDNA psbA gene was also amplified. Universal M13 tails were added to all primers for Sanger sequencing. PCR amplification was performed using One Taq 2x Master Mix (New England Biolabs, Frankfurt am Main).

PCR thermal conditions included an initial denaturation at 94°C (3 min), followed by 35 cycles at 94°C (denaturation, 20 s), temperatures between 46°C and 52°C depending on the used primer (annealing, 30 s), 68°C (extension, 45 s), and a final extension at 68°C (5 min). Eppendorf Mastercycler Pro system (Eppendorf, Hamburg, Germany) was used for all PCR reactions. In cases of failed amplification, a repeat using AccuStart II PCR Tough Mix (Quanta Bio, Beverly, USA) with 40 cycles was conducted.

PCR products were assessed with a 1.6-1.7% agarose gel and purified by incubating with a mix of FastAP and Exonuclease I before sequencing. Bidirectional sequencing was conducted for every sample at the Macrogen Laboratories in the Netherlands, and in an ABI PRISM 3130xl automated capillary sequencer (Applied Biosystems) at CCMAR, Portugal.

Sequence Alignment and Data Analyses

The sequences were assembled and edited using Geneious, version 5.4.5 (http://www.geneious.com/). The edited sequences were aligned using MUSCLE (Edgar 2004) implemented in MEGA11. The generated sequences were trimmed, proofread, and verified against the NCBI nucleotide database using the BLAST algorithm (https://blast.ncbi.nlm.nih.gov/Blast.cgi). Taxonomic assignments were based on E-value and % similarity. Each sequence was aligned with the first 10-50 hits to assess consistency (number of sequences) and ambiguity (number of taxa) underlying each taxonomic assignment.

Sequence differences of the barcodes (mean and maximum pairwise distances for intraspecific variation, and minimum genetic distance to the nearest neighbour species) were computed using the "Barcode Gap Analysis" tool provided by BOLD (Ratnasingham & Hebert 2007). Closely similar sequences were assigned to a globally unique identification number, Barcode Index Number (BIN). Bins were calculated for the whole data set, and bins shared between species clusters were revealed using BOLD's “Bin Discordance Report” function (Ratnasingham & Hebert 2013). A neighbour-joining tree was constructed using MEGA11 to graphically represent the nucleotide divergences based on the Kimura-2-Parameter distances clustering for fish, crustaceans, molluscs, other invertebrate groups and algae. A non-parametric bootstrap support was built upon 1000 replicates. In case of a discrepancy between the morphological and genetic species identification, a reidentification of the specimens was conducted. We follow the concept of integrative taxonomy (Padial et al. 2010; Schlick-Steiner et al. 2010; 2014; Fujita et al. 2012; Riedel et al. 2013) to infer whether there are previously overlooked species in the sample, or if a barcode divergence between species is too low or absent to allow the species to be delineated using only CO1.

7.5 Results

This study includes a total of 419 barcode sequences with a length over 500 bp. 78.3% of the 535 collected tissue samples were successfully barcoded. (210 Chordata, 70 Mollusca, 51 Arthropoda, 9 Polychaeta, 3 Cnidaria, 6 Echinodermata, 32 Rhodophyta, 30 Ochrophyta, 8 Chlorophyta). The genetical species identification resulted in 209 different species. A detailed list of the generated DNA barcoded with their assigned species can be seen in Chapter 13 (Appendix) at the table 13.2.

DNA barcoding – species delimitation

The CO1 regions were amplified from all 419 sequences. No insertions, deletions, and stop codons were observed within the analysed sequences. A total of 94.08% of the sequences ranged between 600 and 680 base pairs. The average base composition was 18.99% of guanine (G), 23.20% cytosine (C), 24.30% adenine (A) and 23.86% thymine (T).

The generated NJ-tree of the CO1 genetic distances (K2P) with additional 1000 Bootstraps, grouped the different haplotypes of the same species within several nonoverlapping clusters. The bootstrap value between different species clusters were between 99% and 100%. No single haplotype was shared between different species. Detailed K2P distances can be seen in Table 1.

Table 1: Summary of K2P pairwise genetic distances (%) at different taxonomic levels.

Comparisons within	Taxa	Number of comparisons	Min. distance (%)	Mean distance (%)	Max. distance (%)
Species	89	265	0.00	0.94	75.00
Genus	20	137	0.00	11.21	34.00
Family	30	771	0.17	19.50	75.00

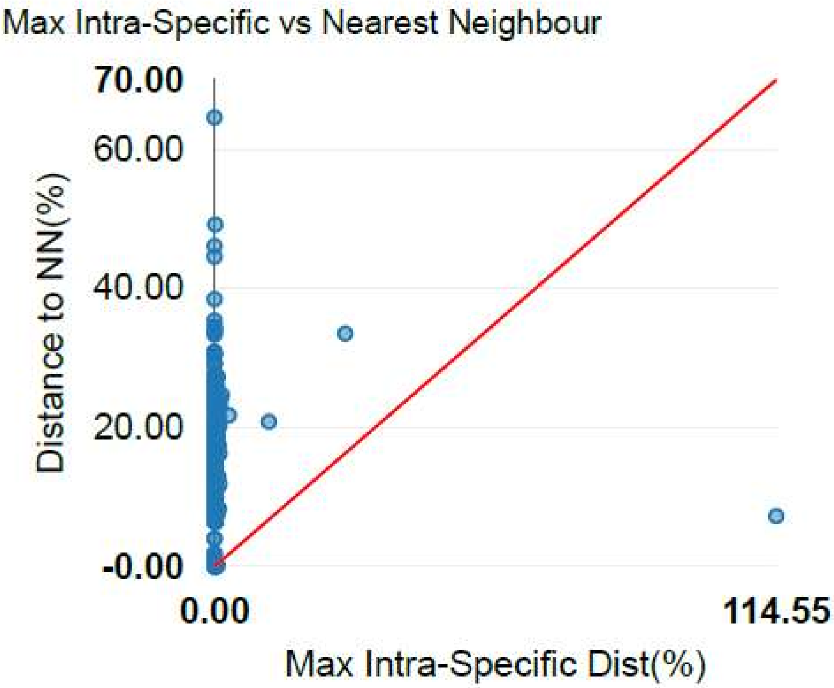

Figure 3: Maximum intraspecific K2P distance vs. minimum distance to the nearest neighbour for sequences longer than 500 base pairs.

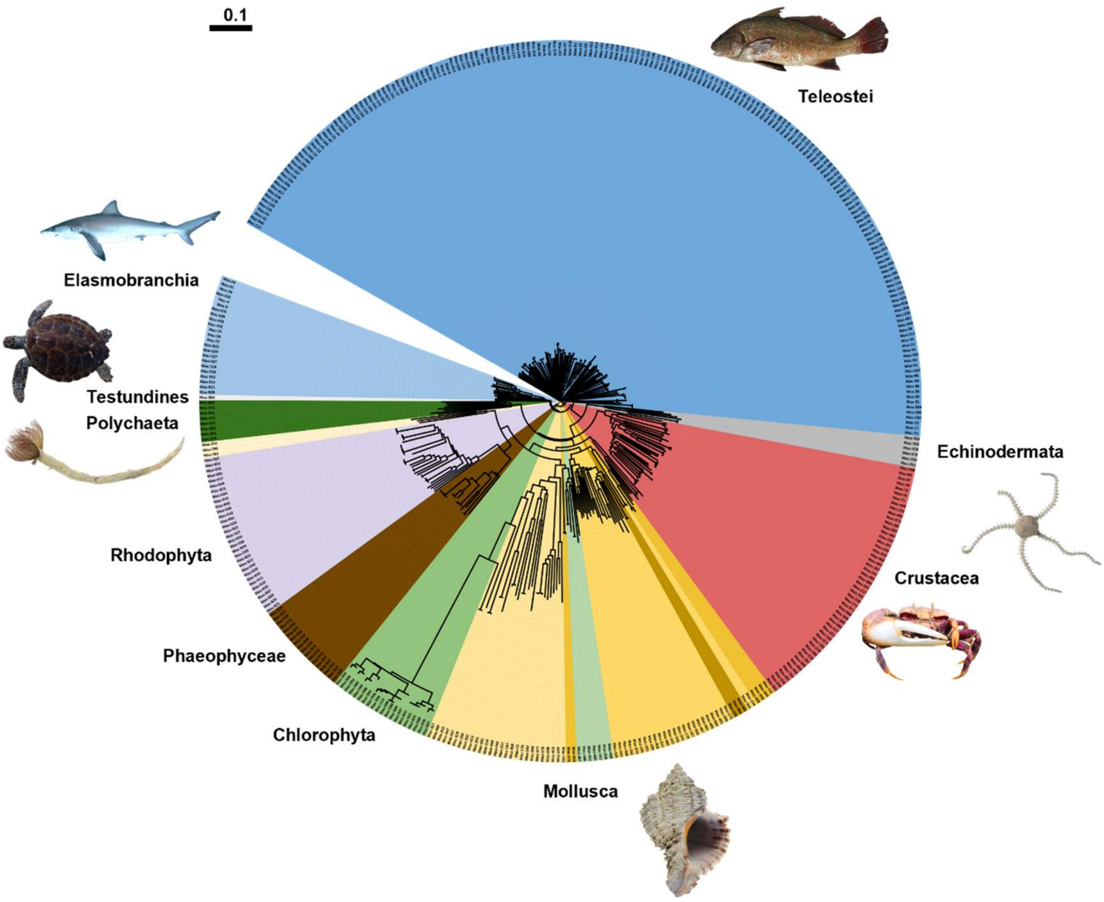

Figure 4: Circular Neighbour Joining (NJ) tree of all 471 generated CO1 sequences, based on Kimura-2-Parameter with an additional bootstrap of 1000 replicates. The

phylogenetic tree was generated using Mega XI and represents 209 different species from found in Mauritania. The different phyla are marked as: teleostei = dark blue, Echinodermata = grey, crustacea = red, mollusca = yellow, chlorophyta = green, phaeophycaeae = brown, rhodophyta = purple, polychaeta = ivory, testundines = bright grey, chondryichties = bright blue. © Alexander Knorrn.

BIN Discordance Analysis

All generated sequences were further analysed by the BIN Discordance Analysis for sequences with a length over 500bp. An inspection of the sequence clustering in a neighbour-joining (NJ) tree revealed a high congruence between the morphological and genetic species identification. A total of 95.7% (346 individuals) of the generated BIN were assigned to a single bin representing a species. However, nine species (25 individuals) were assigned to two different BINs. These species with discordant BINs show conflicts on genetical and morphological species identification. The nine discordant BINs contain species from the same genus up to taxa belonging to different families (Table 2). After review, five of nine discordant BINs could be established as concordant bins. They represented no “true” discordance. These BINs could be assigned to other species, genera or families derived from other research projects on different online repositories. In most of these cases, were those discordant BINs results of morphological misidentification. Most of these BINs unequivocally correlate with unambiguous species identification, but occasionally also enabled the delineation of geographical subclades.

Table 2: Species with discordant BINs detected by the BIN discordant analysis performed within Bold-Systems.

Species	Discordant BIN	Highest rank of conflict	After review
Eupilumnus stridulans	BOLD:ADK5484	Family	discordant
Huberimactra inconstatus	BOLD:AFX6228	Family	concordant
Callista sp.	BOLD:AAW8731	genus	discordant
Collumbella adansoni	BOLD:AFX7557	genus	concodrant
Gari sp.	BOLD:AFY7154	species	discordant
Chelon sp.	BOLD:AAD7360	species	discordant

Sepia officinalis	BOLD:AAA1559	species	concordant
Lagocephalus laevigatus	BOLD:ADF4470	species	concordant
Dentex canariensis	BOLD:ACJ1858	species	concordant

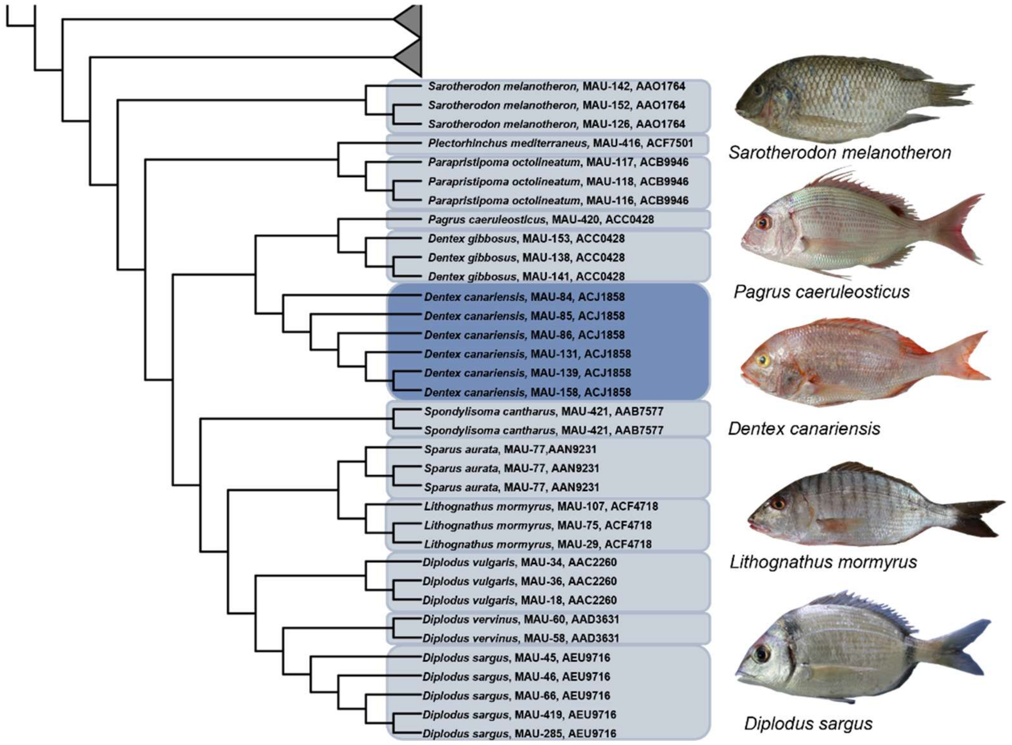

Figure 5: Neighbour joining tree based on Kimura-2-Parameter with an additional bootstrap of 1000 replicates of parts from the generated teleost and chondryichtian sequences. Dark blue chest indicates phyla with a discordant BIN. © Alexander Knorrn.

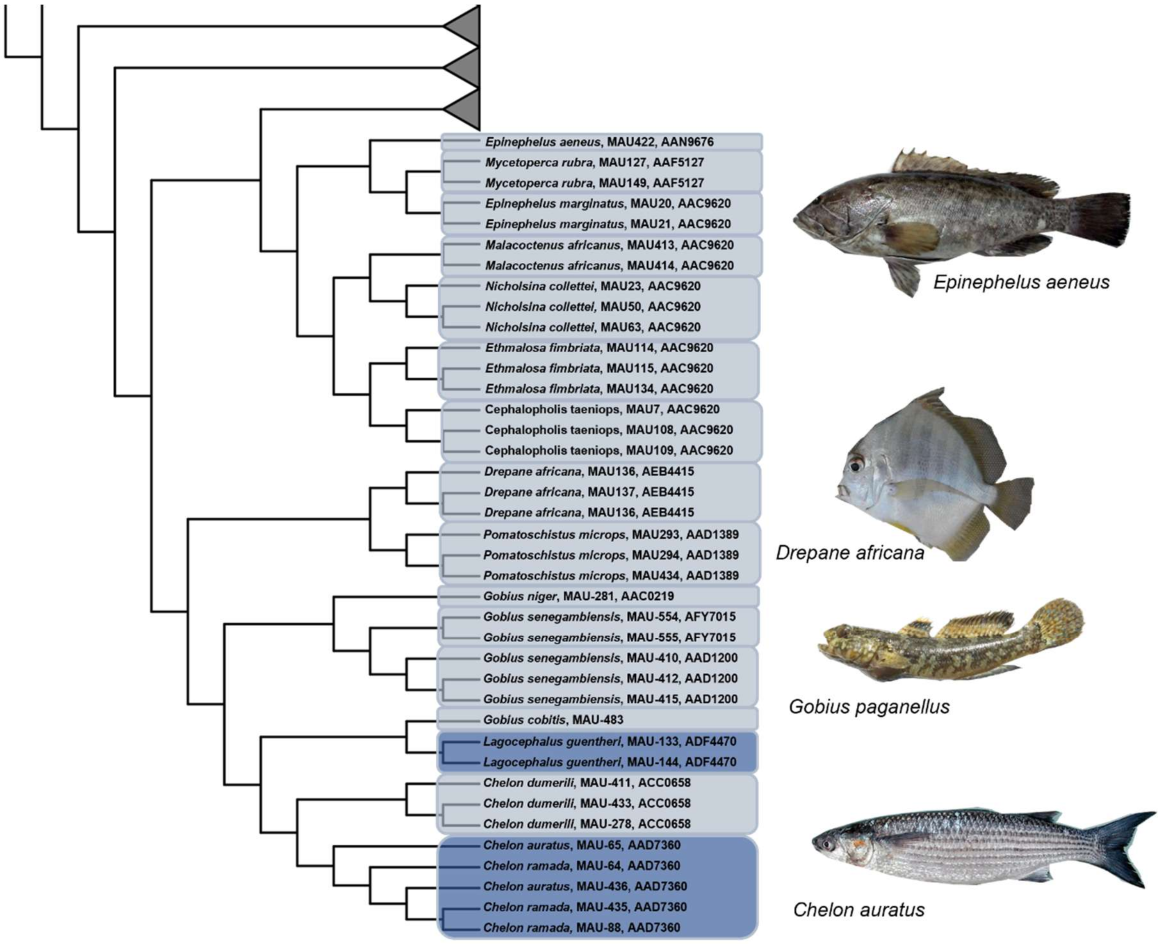

Figure 6: Neighbour joining tree based on Kimura-2-Parameter with an additional bootstrap of 1000 replicates of parts from the generated teleost and chondryichtian sequences. Dark blue chest indicates phyla with a discordant BIN. © Alexander Knorrn.

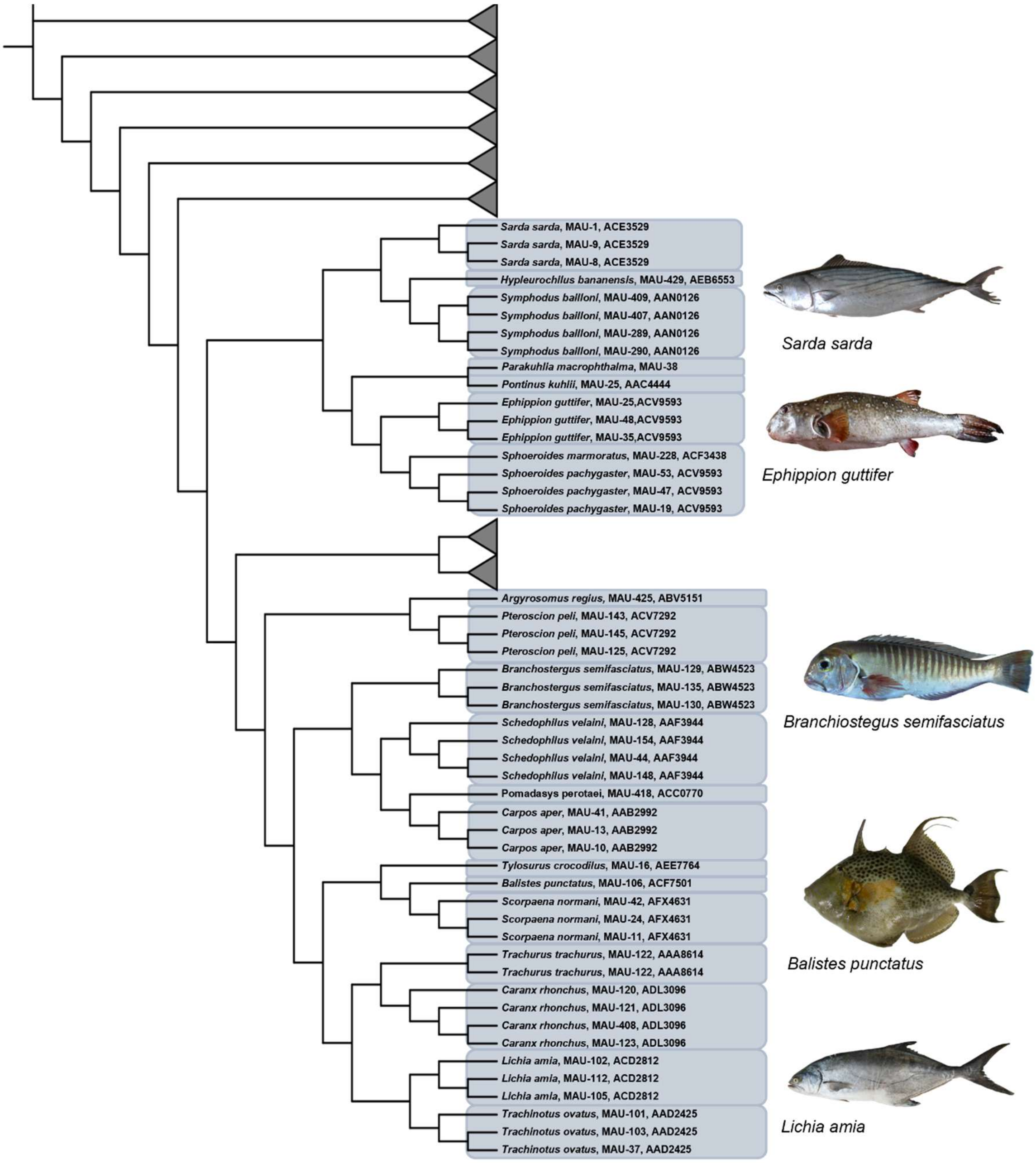

Figure 7: Neighbour joining tree based on Kimura-2-Parameter with an additional bootstrap of 1000 replicates of parts from the generated teleost and chondryichtian sequences. Dark blue chest indicates phyla with a discordant BIN. © Alexander Knorrn.

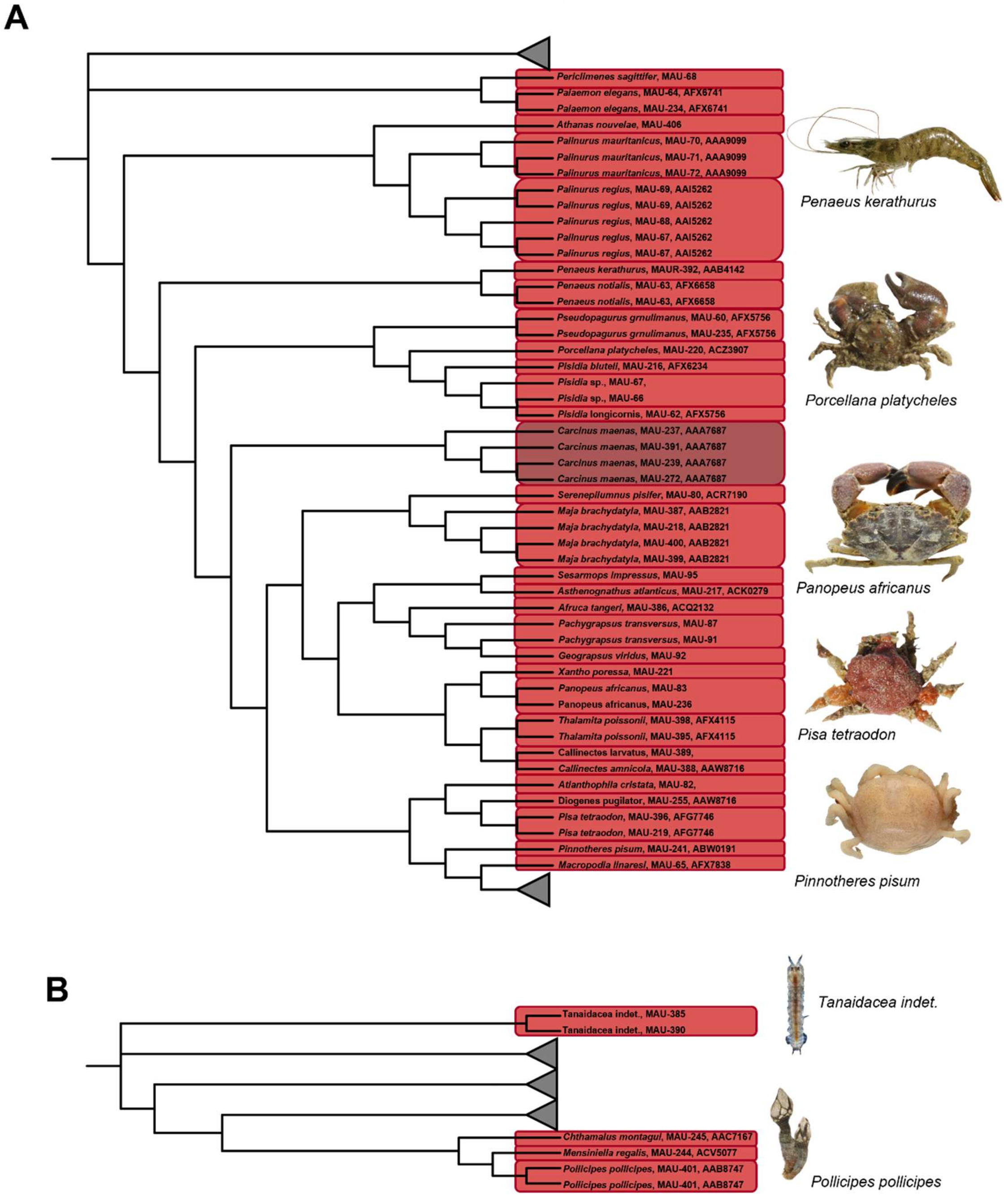

Figure 8: Neighbour joining tree based on Kimura-2-Parameter with an additional bootstrap of 1000 replicates of parts from the generated crustacean sequences. Dark red chest indicates phyla with a discordant BIN. © Alexander Knorrn.

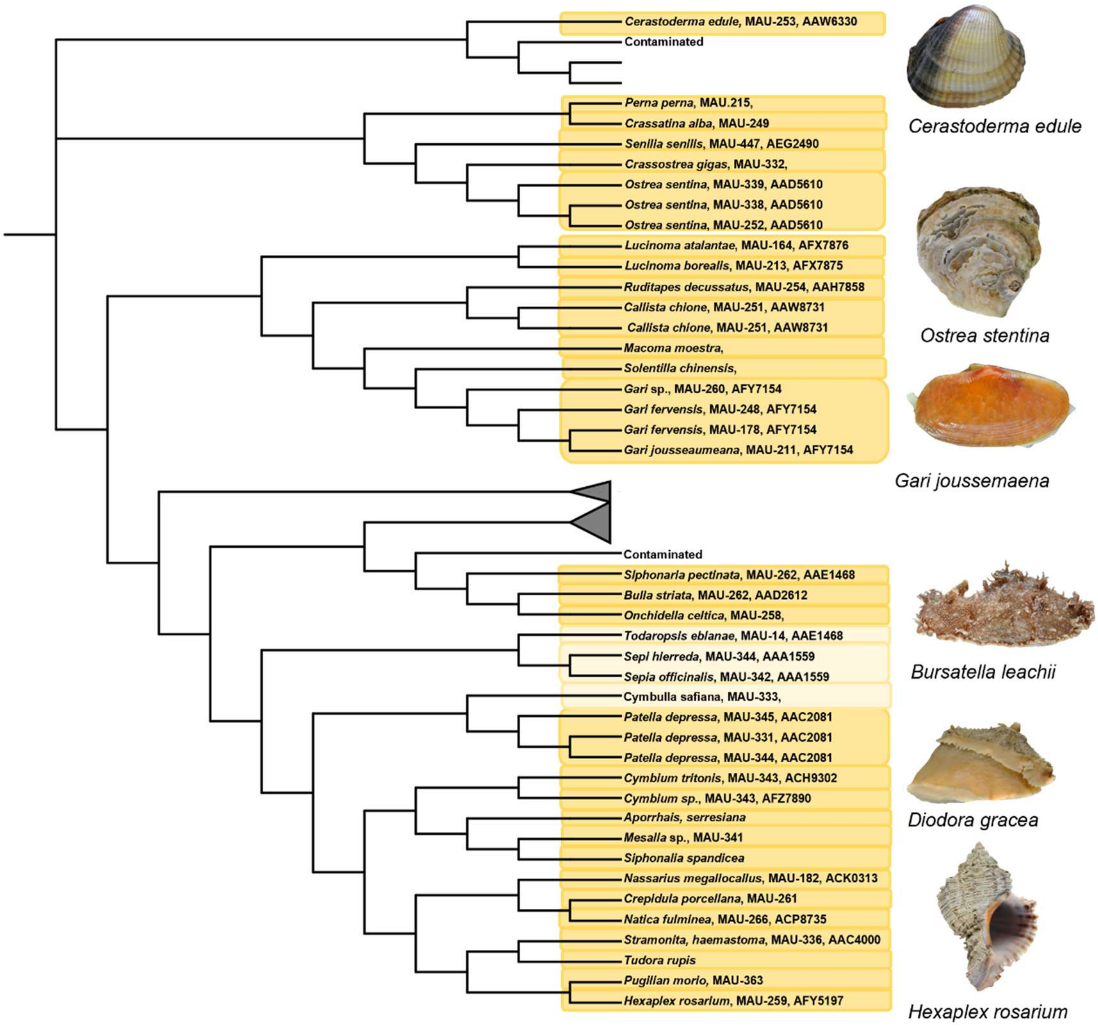

Figure 9: Neighbour joining tree based on Kimura-2-Parameter with an additional bootstrap of 1000 replicates of parts from the generated mollusc sequences. Bright yellow chest indicates phyla with a discordant BIN. © Alexander Knorrn.

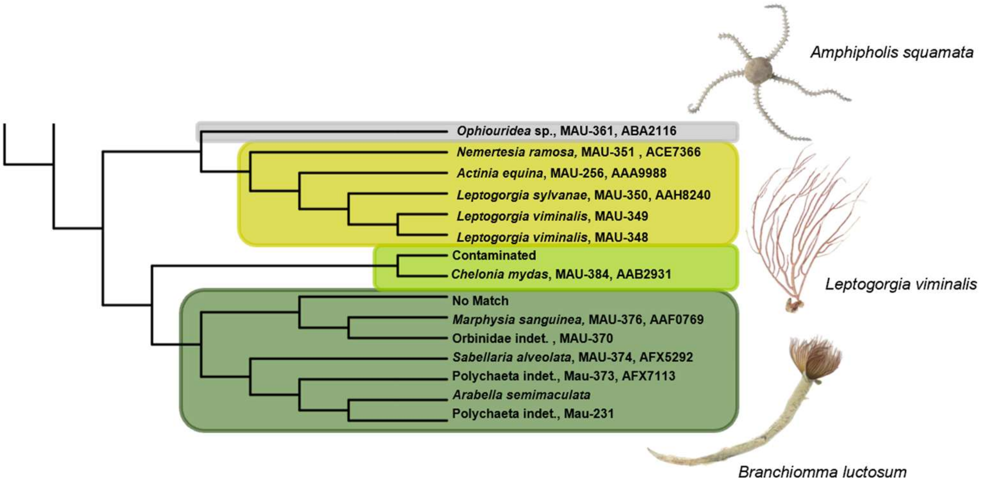

Figure 10: Neighbour joining tree based on Kimura-2-Parameter with an additional bootstrap of 1000 replicates of parts from the generated mollusc sequences. © Alexander Knorrn. Bright green chest indicates cnidarian sequences, green chest

indicates testundine sequences, dark green polychaete sequences and grey chest indicates ophiuroid sequences.

7.6 Discussion

This work comprises the first DNA barcode library for the Mauritanian coastal marine life. The results represent important progress in the taxonomic work and biodiversity conservation of Mauritania. This study comprises 419 DNA barcodes from Mauritanian marine life ranging from various algae species to polychaetes and molluscs to marine fishes and represents 209 different marine species. All represented animal species were carefully identified using a morphological identification approach referenced through taxonomists for each specific taxon (Knorrn et al. 2024a, b).

Methodological constraints

The relatively low amplification success rate (76,4%) relies on several aspects: The genetic sampling was performed under the most sterile conditions possible. Depending on the situation, sampling tools were sterilised using ethanol and fire or used as single-use sterile tools. However, under the given conditions, completely sterile sampling was not always feasible, especially in places like the Mauritanian fish markets, where numerous people and a variety of other organisms (flies, bacteria, and birds) were present and could potentially contaminate the samples. Additionally, tissue samples were preserved only in 96% ethanol and stored in shaded areas. Cooling of the samples was not possible, which may have led to further DNA degradation and consequently contributed to the relatively low success rate of DNA amplification.

The usage of universal primers during the PCR is probably affected by nucleotide variations within the different classes, which could additionally explain the lower success rate, especially within marine invertebrates (Barco et al. 2016). The amplification rate was especially low for marine molluscs, which are known to cause problems during the PCR due to the high amount of mucopolysaccharides in their tissues and their alcohol co-precipitation with the DNA (Winnepenninckx et al. 1993; Van Moorsel et al. 2000). The presence of these polysaccharides is known to inhibit the activity of polymerases (Aoki & Koshihara 1972; Furukawa & Bhyavanandan 1983), which further alters the DNA amplification success.

The West African coast is relatively unexplored as a research area compared to other marine regions (Ramos et al. 2017). Consequently, the data available for modern research techniques such as DNA barcoding or environmental DNA (eDNA) studies is still limited (Takahasi et al. 2023). Only commercially relevant taxa such as lobsters and fish have been genetically sequenced and are available in online repositories like BOLD-Systems or GenBank. There exists a large gap of identification possibilities for marine invertebrates along the West African coast. The situation is further complicated by the limited availability of identification literature, which typically covers only specific groups or commercially utilised species (e.g., van Cosel & Gofas 2019, Carpenter & DeAngelis 2016a, b, c, d). However, precise species identification is of great importance for conservation efforts, as it allows for the implementation of appropriate protective measures and to assess the current health status of an ecosystem (Andreasen et al. 2001; Vivien et al. 2015). Consequently, a robust scientific identification of the Mauritanian fauna forms an essential foundation for future marine conservation initiatives.

Lately, eDNA-metabarcoding has emerged as a particularly non-invasive and precise tool for marine biodiversity monitoring. This technique involves the isolation of DNA from an environmental sample like water and subsequent High-Throughput-Sequencing of PCR amplified DNA barcodes (Blackman et al. 2021). The generated DNA sequences are thereafter being compared with reference sequences from online repositories like GenBank or BOLD-Systems to identify the fauna of the sampled area. However, the accuracy of the results strongly depends on the used reference sequences and database. Regular metabarcoding of the Mauritanian fauna will play a crucial role in future biodiversity assessments (Jerde 2019). This study provides an initial set of reference sequences, which must be expanded through further research to enable detailed biodiversity assessments along the Mauritanian coast using eDNA analysis.

7.7 Conclusion

In this study we generated a total of 419 new DNA barcodes from the marine life of the Mauritanian coastal waters. The DNA barcodes represent 209 different species (210 Chordata, 70 Mollusca, 51 Arthropoda, 9 Polychaeta, 3 Cnidaria, 6 Echinodermata, 32 Rhodophyta, 30 Ochrophyta, 8 Chlorophyta). The data generated in this study represents an important step towards the establishment of a comprehensive and detailed DNA barcode library of the Mauritanian marine fauna. Nevertheless, some species are still unrepresented, highlighting the importance of a DNA barcode library for accurately identifying the majority of Mauritania's marine wildlife.

7.8 Acknowledgments

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Chapter 8
Seasonal Shifts in Coastal Biodiversity: eDNA insights from two Mauritanian lagoons

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8.1 Abstract

The Mauritanian coast is a remarkably species-rich marine environment where species from tropical, subtropical and boreal regions overlap. This high marine biodiversity is enhanced by seasonal upwelling, which supports the local biodiversity and sustains some of the Atlantic Ocean's most productive fish stocks. However, most previous research in Mauritania has focused mainly on migratory birds and fisheries biology, leaving marine biodiversity largely unexplored. This study estimates the marine fish and invertebrate biodiversity by using an eDNA metabarcoding approach. It examines seasonal variations in biodiversity between a geologically young, facies poor lagoon with minimal anthropogenic influence, and an older facies diverse lagoon significantly impacted by fishing pressure, wastewater discharge, and plastic pollution. The findings indicate that the marine biodiversity is strongly linked to seasonal upwelling, with a significantly higher species diversity in winter compared to summer. Furthermore, this article shows, that marine protected areas significantly contribute to the promotion of marine biodiversity in the coastal habitats of Mauritania.

Keywords: DNA metabarcoding, West Africa, upwelling, DNA barcoding

8.2 Introduction

The marine biodiversity of the West African coast is an understudied research field in marine science. In particular, countries like Mauritania, influenced significantly by the Canary Current Large Marine Ecosystem (CCLME) (Heileman & Tandstad 2009; Pelegrí & Peña-Izquierdo 2015), have limited studies on their local marine biodiversity and its dynamics. The seasonal upwelling within the CCLME, brings cold, nutrient-rich deeper water to the surface of Mauritania’s coast, providing the necessary nutrients to sustain large commercially exploited fish stocks and supports a high level of biodiversity. Mauritania’s geographical location contributes to an overlap of tropical, subtropical, and temperate species along its coast (Jager 1993; Le Loeuff & von Cosel 1998), futher enhancing local marine biodiversity. Coastal habitats such as seagrass beds, tidal mudflats, and mangroves are particularly important for the local fauna and flora. These habitats provide shelter and food for a wide variety of species, serve as crucial nursery grounds, and play a significant role in recruiting several threatened or commercially important species. Despite the relatively high biodiversity, coastal and shallow water habitats are constantly threatened by various anthropogenic stressors worldwide (Clark et al. 2024). Direct stressors (Wernberg et al. 2011; Andersen et al. 2020) like overfishing or strong fishing pressure (Coll et al. 2008; Link & Watson 2019), marine pollution (Steneck et al. 2002; Lu et al. 2022) and human-induced climate change (Smale et al. 2013; Brodie et al. 2014; He & Silliman 2019), are constantly threatening these ecosystems. These stressors negatively impact the local species diversity, causing population declines and potentially leading to local extinctions (Yan et al. 2021; O’Hara, Frazier & Halpern 2021).

Given the constant threat to marine biodiversity, assessing local species diversity is crucial for enabling comparisons with future studies. This assessment, known as biomonitoring, is a key component of environmental conservation. By accurately documenting local fauna, it is possible to quantify biodiversity (van der Heyde et al. 2015), to assess the ecological status of habitats (Andreasen et al. 2001; Vivien et al. 2015), to identify potential invasive species (Guareschi et al. 2021; Pirtle et al. 2021), and to document various other indicators representing the health condition of the investigated area (Takahashi et al. 2023). In recent years, the study of environmental DNA (eDNA) has emerged as a revolutionary method for biomonitoring and biodiversity research. This technique is based on the isolation of DNA from an environmental sample, like water or sediments, and subsequent High-Throughput-Sequencing (HTS) of PCR amplified DNA barcodes (Blackman et al. 2021). With the selection of suitable PCR primers, specific taxonomic groups can be detected within the ecosystem of the eDNA sampled (Pawlowski et al. 2020). This approach provides crucial information about the local biodiversity for the baseline for conservation management (Jerde 2019). Additionally, this biomonitoring method significantly reduces the costs and resources associated with traditional sampling methods that require large equipment, divers, or invasive sampling gear (Zinger et al. 2019). It offers a less invasive approach to investigating biodiversity, allowing for the detection of both common and rarely encountered species, thereby providing a more detailed picture of the ecosystem (Deiner et al. 2017).

In this study, we aim to assess marine biodiversity and its dynamics during summer and winter periods using metabarcoding of environmental samples. The two lagoons under investigation are located in the northern part of Mauritania. Unlike Baie de l’Étoile, which is estimated to be between 70,000 and 100,000 years old (Ly 2009), the Bellaat lagoon is a relatively young ecosystem that was formed in August 2013 following a dune breach during heavy rainfall (Trégarot et al. 2020). This study therefore compares marine biodiversity within an ancient, established lagoon and a relatively young ecosystem, examining their seasonal dynamics. The scientific outcome of this study will contribute valuable information for future ecological studies and for the implementation of future marine protected areas in Mauritania, by highlighting the seasonal dynamics of the marine biodiversity in coastal habitats in Mauritania.

8.3 Material and Methods

Study area

The study area encompasses two distinct lagoons along the Mauritanian coast: the Baie de l'Étoile and the Bellaat lagoon. The Baie de l'Étoile is located in northern Mauritania, adjacent to the port city of Nouadhibou. This lagoon, formed during the Nouakchottian transgression 8.000 and 5.000 years BP (Ly 2009), is notable for its soft bottom facies built by extensive subtidal (*Cymodocea nodosa*) and intertidal (*Zostera noltei*) seagrass beds. Within the lagoon, additional hard substrate facies like a rocky island or maerl beds provide habitat for various sessile organisms. However, the Baie de l'Étoile faces significant anthropogenic pressures, including wastewater discharge, intensive fishing, and plastic pollution. The Baie de l'Étoile was recently assigned as a marine protected area and part of the Abidiján Convention (30 July 2024) by the Mauritanian Ministry of Environment and Sustainable Development. In contrast, the Bellaat lagoon is situated slightly further south, within the boundaries of the UNESCO world heritage National Park Banc d'Arguin and therefore considered a marine protected area. This young ecosystem resulted from a dune breach during heavy rainfall in August 2013 (Trégarot et al. 2020). The lagoon is primarily characterised by the presence of soft bottom facies mainly built by the intertidal seagrass *Zostera noltei* and sandy mudflats. During low tide, these seagrass beds are exposed and not covered by seawater. Unlike the Baie de l'Étoile, the Bellaat lagoon is a very young and constantly fluctuating ecosystem that experiences minimal anthropogenic influence. Fishing in this area is restricted, only local Imraguen fishermen, who use non-motorised boats, are allowed to fish with hand lines and gill nets (Grebenart 2001).

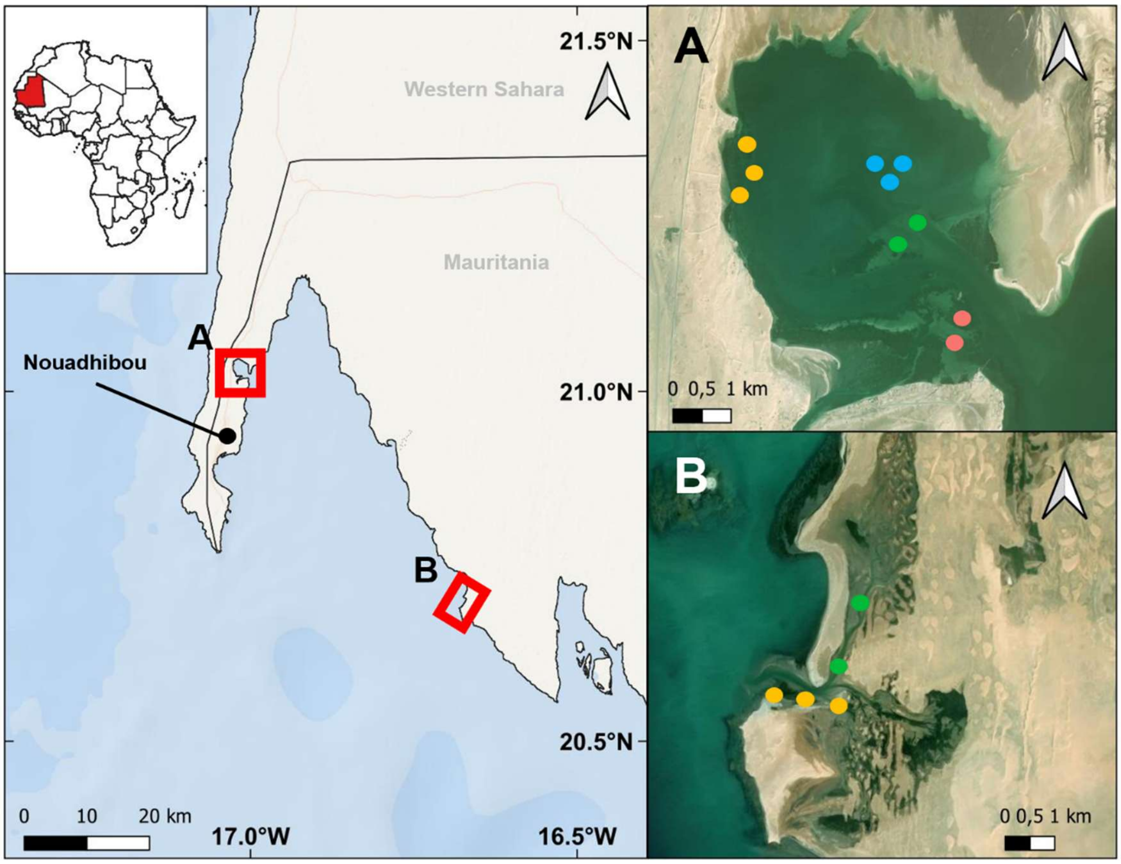

Figure 1: Geographical map of northern Mauritania. Red areas indicate the appropriate lagoon investigated. Basemap from ESRI (2019, www.esri.com). **A**: Satellite image of the Baie de l'Étoile showing the eDNA sampling areas. Orange spots indicate sampling locations above *Zostera noltei* beds, bright blue spots indicate sampling areas above *Cymodocea nodosa* beds, green spots indicate sampling areas above sandy substrate, and pink dots indicate sampling above maerl beds. Basemap from Bing Aerial Maps (https://www.bing.com). **B**: Satellite image of the Bellaat lagoon showing the eDNA sampling areas. Orange spots indicate sampling locations above *Zostera noltei* beds, and green spots indicate sampling areas above sandy substrate. Basemap from Bing Aerial Maps (https://www.bing.com).

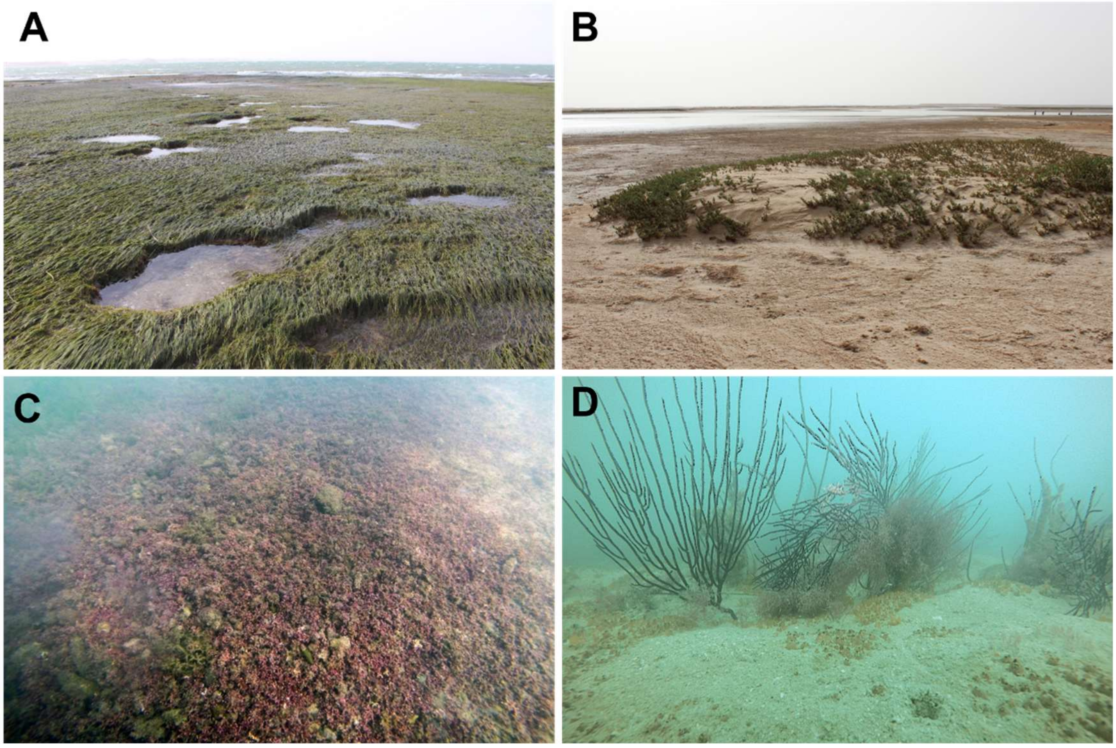

Figure 2: Impressions from the different habitats involved in this study. **A**: Seagrass beds formed by *Zostera noltei* in the Baie de l'Étoile. **B**: Sandy mudflat of the Bellaat lagoon photographed from the top of a sand dune covered by *Sesuvium* plants. **C**: Maerl ripple from the maerl bed in the Baie de l'Étoile. **D**: Submerged ridge field infront of the Bellaat lagoon entrance covered with *Leptogorgia* octocorals and ascidians (*Stolonia socialis*). © Friedhelm Krupp: A, © Kristina Hopf: B, © Alexander Knorrn: C, D.

Seawater collection

The samples were collected from each habitat during summer and winter. Seawater samples were collected using a 1.7L Niskin bottle, which was sterilised with a 3.7% sodium hypochloride solution between samplings and rinsed with seawater from the specific sampling site. The Niskin bottle was deployed from a small boat, and seawater was sampled near the seafloor. A total of 0.5L seawater was filled into a sterile bottle and stored in a refrigerated cooling box until filtration, which occurred up to four hours after collection. The collected water samples were filtered using a peristaltic pump through 0.45µm cellulose acetate (CA) filters in summer and polyethersulfone (PES) filters in winter. Different filter materials were used during the seasons due to the delivery challenges. Filters were air-dried, cut into pieces, and stored in 99.8% ethanol at room temperature until further processing in the laboratories of biome-id (Wilhelmshaven, Germany).

Table 1: Sampling stations for the metabarcoding samples during summer and winter seasons in Mauritania.

Station	Habitat	Season	Lat	Long	Date
BdL-14-1	*Zostera noltei*	Summer	20.6932	-16.6736	31.07.2022
BdL-14-2	*Zostera noltei*	Summer	20.6932	-16.6736	31.07.2022
BdL-14-3	*Zostera noltei*	Summer	20.6925	-16.6719	31.07.2022
BdL-12-1	Sand area	Summer	20.7009	-16.6674	31.07.2022
BdL-13-1	Sand area	Summer	20.6948	-16.6705	31.07.2022
BdL-6-2	Submerged ridge field	Summer	20.6528	-16.7316	30.07.2022
BdL-6-2	Submerged ridge field	Summer	20.6528	-16.7316	30.07.2022
BdL-17-1	Submerged ridge field	Summer	20.6526	-16.7297	31.07.2022
BdE-21-1	Sand area	Summer	21.0321	-17.0077	26.07.2022
BdE-21-2	Sand area	Summer	21.0317	-17.0081	26.07.2022
BdE-20-5-1	Maerl bed	Summer	21.0251	-17.0074	26.07.2022
BdE-19-1	*Zostera noltei*	Summer	21.0271	-17.0241	26.07.2022
BdE-19-2	*Zostera noltei*	Summer	21.0271	-17.0239	26.07.2022
BdE-19-3	*Zostera noltei*	Summer	21.0272	-17.0239	26.07.2022
BdE-17.1	*Cymodocea nodosa*	Summer	21.0389	-17.0247	26.07.2022
BdE-17.2	*Cymodocea nodosa*	Summer	21.0390	-17.0246	26.07.2022
BdE-17.3	*Cymodocea nodosa*	Summer	21.0390	-17.0246	26.07.2022
BdE-20-5-2	Maerl bed	Summer	21.0251	-17.007	26.07.2022
BdE-20-5-3	Maerl bed	Summer	21.0251	-17.0074	26.07.2022
BdE-148-1	Sand area	Winter	21.0321	-17.0055	08.03.2023
BdE-148-2	Sand area	Winter	21.0321	-17.0055	08.03.2023
BdE-150-1	*Cymodocea nodosa*	Winter	21.0383	-17.0234	08.03.2023
BdE-150-2	*Cymodocea nodosa*	Winter	21.0383	-17.0234	08.03.2023
BdE-150-3	*Cymodocea nodosa*	Winter	21.0383	-17.0234	08.03.2023
BdE-151-1	*Zostera noltei*	Winter	21.0264	-17.0235	08.03.2023
BdE-151-2	*Zostera noltei*	Winter	21.0264	-17.0235	08.03.2023
BdE-151-3	*Zostera noltei*	Winter	21.0264	-17.0235	08.03.2023
BdE-152-2	Maerl bed	Winter	21.0212	-17.0057	08.03.2023
BdE-152-3	Maerl bed	Winter	21.0212	-17.0057	08.03.2023
BdE-152-4	Maerl bed	Winter	21.0212	-17.0057	08.03.2023

BdL-79-2	Sand area	Winter	20.6984	-16.6688	04.03.2023
BdL-83-2	Sand area	Winter	20.6939	-16.6731	04.03.2023
BdL-80-2	*Zostera noltei*	Winter	20.6919	-16.6703	04.03.2023
BdL-81-2	*Zostera noltei*	Winter	20.6926	-16.6725	04.03.2023
BdL-82-2	*Zostera noltei*	Winter	20.6935	-16.6750	04.03.2023
BdL-96-1	Submerged ridge field	Winter	20.6518	-16.7296	06.03.2023
BdL-96-2	Submerged ridge field	Winter	20.6494	-16.7294	06.03.2023

DNA extraction, PCR and Illumina library preparation

DNA extraction of the filter membranes was conducted using the NucleoSpin Tissue Kit (Macherey-Nagel, Düren, Germany) according to the manufacturer’s instructions. The eDNA extracts were used as templates for the amplification of a 313 bp fragment of the cytochrome c oxidase I gene (*CO1*) using the primers mlCOIintF from Leray et al. (2013) (forward primer sequence 5'-GGWACWGGWTGAACWGTWTAYCCYCC-3' and reverse primer sequence 5'-GGRGGRTASACSGTTCASCCSGTSCC-3') and jgHCO2198 from Geller et al. (2013) (primer sequence 5'- GGRGGRTASACSGTTCASCCSGTSCC-3'). A fragment of the mitochondrially encoded 12S rRNA gene fragment was amplified using the MiFish universal primer pair from Myia et al. (2015) (forward primer sequence: 5′-GTC GGT AAA ACT CGT GCC AGC-3′ and reverse primer sequence: 5′-CAT AGTGGG GTATCT AATCCCAGTTTG-3′). Each primer was modified to include 5‘ Illumina overhang adapters. The amplification of a correct amplicon was verified via electrophoresis on a 1.5% agarose gel, and the PCR products were then purified using the NucleoMag NGS Clean-up kit (Macherey Nagel, Düren, Germany). Dual indexes and Illumina sequencing adapters were attached to the amplicons using the Nextera XT Index Kit (Illumina Inc., San Diego, CA, USA) following the manufacturer's protocol and then purified using the NucleoMag NGS Clean-up. Libraries were quantified using the Promega QuantiFluor ONE dsDNA system (Promega, Mannheim, Germany) and pooled equimolarily. Pooled libraries were sequenced on an Illumina MiSeq system with the 2 x 300 bp paired-end read module.

Bioinformatics and analysis

Paired-end reads were assembled using VSEARCH (v. 2.18.0, Rognes et al. 2016) setting a minimum overlap of 100 bases between paired-end reads. Assembled reads were then demultiplexed according to the sample-specific dual indexes using cutadapt (Martin 2011). All contigs were then filtered for uncalled cases (“N”) and dereplicated with VSEARCH. Dereplicated CO1 sequences were clustered in Operational Taxonomic Units (OTUs) using a 97% similarity threshold. Dereplicated 12S sequences were not clustered but further analysed as Amplicon Sequence Variants (ASV). Chimera sequences were detected using the UCHIME algorithm (Edgar et al. 2011) as implemented in VSEARCH and removed. All non-chimeric OTUs and ASVs were then taxonomically assigned using the BOLD reference database (Ratnasingham & Hebert 2007) (CO1 sequences) and a local version of the BLAST algorithm (Camacho et al. 2008) with a local version of the MitoFish Mitochondrial Genome Database of Fish (http://157.82.243.220/).

Statistical analysis

Statistical analyses and visualizations were generated with R version 4.1.2 (R Core Team 2014). Subsequently, the ASV table, metadata, and taxonomic assignment files were imported into *phyloseq* package fortified with *microbiome* and *microViz* packages for further downstream analysis. Datasets based on the 12S rRNA and CO1 gene were analysed separately. Samples with <1000 reads per sample were removed, Also, non-target taxa such as bacteria, insects, spiders, algae, and plants were removed from the downstream analyses.

Chao1 was calculated to estimate the species richness using the function estimate:richness from the *phyloseq* package. Analysis of variance (ANOVA) (function aov) was used to compare the species richness between different seasons (X.Season), protection level (X) and biome types (X.Biome) (Table 2 and 3). The Beta diversity of the samples was assessed using the function ordinate in phyloseq. Differences between the beta diversities of sample types were assessed using the PERMANOVA test with adonis2 from the *vegan* package. Data visualization was carried out using the ggplot2 package (Wickham 2016).

8.4 Results

Library quality, raw data and controls.

We generated 5.784.480 reads from the 12S library and 3.547.093 reads from the CO1 library. After paired-end reads assembly, quality filtering and removal of potential chimeric sequences, the average read count per sample (excluding control samples) was 113.406 for 12S rRNA gene and 78.029 for CO1. After dereplication, an average of 3.298 sequences per sample were processed as ASV for the 12S amplicon. The CO1 sequences were clustered in 3.355 Molecular Operational Taxonomic Units (MOTUs) with a 3% similarity threshold, with an average of 9.008 sequences per MOTU.

Species richness and diversity

A total of 94 different fish species were detected using the 12S rRNA gene primers and 131 different marine invertebrate species were detected using the CO1 primers. The 10 most abundant taxa for both primers are shown in Figures 3 and 4. The most abundant fish species are members of the Mugilidae family, which are exceptionally abundant during the summer and winter. The majority of generated 12S rRNA gene reads were not assigned to the species level. The most abundant invertebrate taxa were arthropods, but several CO1 gene fragment reads were only identified at class or even phylum level. Some of the most abundant taxa were the Calanoidea (Crustacea) class and the Verongida (Porifera) order.

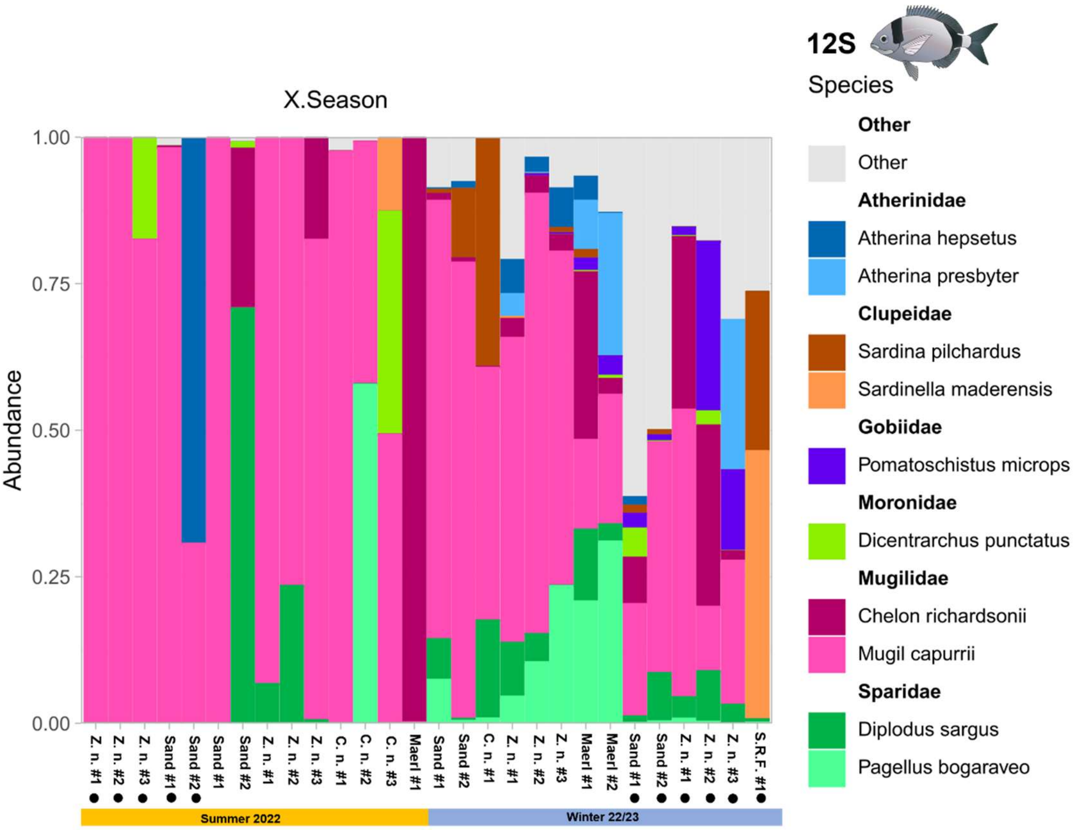

Figure 3: The ten most abundant fish taxa detected during summer and winter season using the 12S MiFish primers. Black dots indicate samples from the Bellaat lagoon.

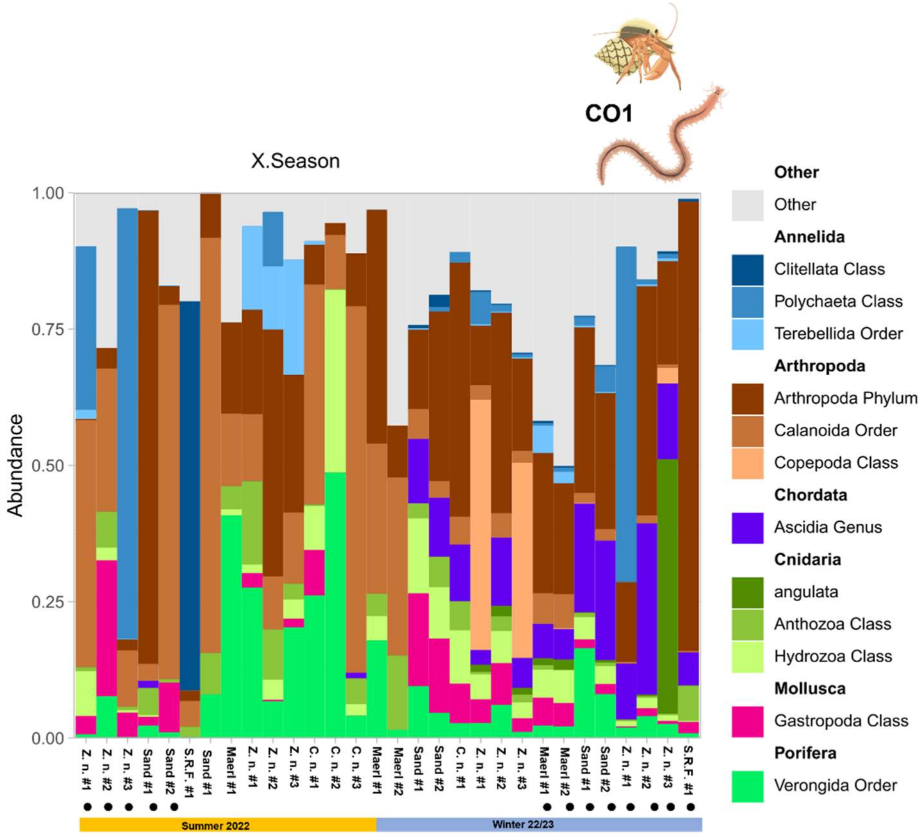

Figure 4: The ten most abundant fish taxa detected during summer and winter season using the CO1 gene fragment primers. Black dots indicate samples from the Bellaat lagoon.

The Chao1 index was calculated as a proxy for the alpha diversity (Figure 5 & 6). The alpha diversity ranged between 5 and 39 for 12S and between 14±2.9 and 269.8±6.0 for CO1. The winter samples overall showed a significantly higher alpha diversity/species richness compared to the summer samples in both primers (Table 2, ANOVA, p < .001, (for 12S); Table 3, ANOVA, p < .001, (for CO1). Additionally, the alpha diversity/species richness during the winter season in protected areas was significantly higher than in unprotected areas (Table 2, ANOVA, p < .01, for 12S; Table 3, ANOVA, p < .001, for CO1). This difference is no longer present during the summer months, Baie de l'Étoile and Bellaat lagoon habitats do not significantly differ from each other (Table 2, ANOVA, p < .001, for 12S; Table 3, ANOVA, p < .001, for CO1) during this period. The highest species richness was observed around the sandy area within the Bellaat lagoon with both primer sets.

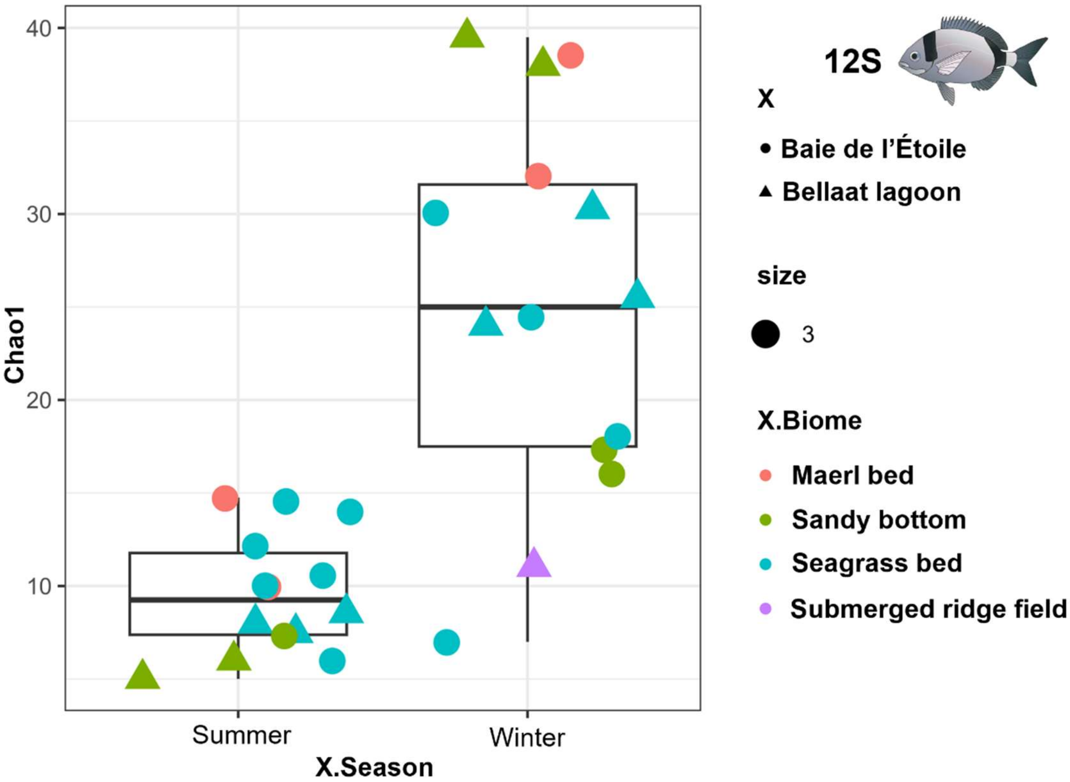

Figure 5: Species richness/alpha diversity represented through Chao1 Index of the pooled species from the 12S locus during summer and winter seasons in both investigated lagoons.

Table 2: Statistical results of the conducted ANOVA of the 12S locus reads from both seasons in both investigated lagoons. The term represents the comparative value as follows: X.season: winter or summer; X. Biome: the described habitats such as maerl bed, seagrass bed, sand bottom and submerged ridge field; X: anthropogenically disturbed or not.

Term	df	sumsq	meansq	Statistic	p.value
X. season	1	1687.69691	1687.69691	71.868152	1.643033e-07
X. biome	3	380.61451	126.87150	5.402641	8.519987e-03
X	1	97.69541	97.69541	4.160219	5.723819e-02
X. season: X. biome	2	172.21045	86.10523	3.666668	4.743533e-02
X. season: X	1	312.77345	312.77345	13.319009	1.983765e-03
X. biome: X	1	95.14840	95.14840	4.051758	6.024118e-02
X. season: X. biome: X	1	54.54584	54.54584	2.322756	1.458804e-01
Residuals	17	399.21505	23.48324	NA	NA

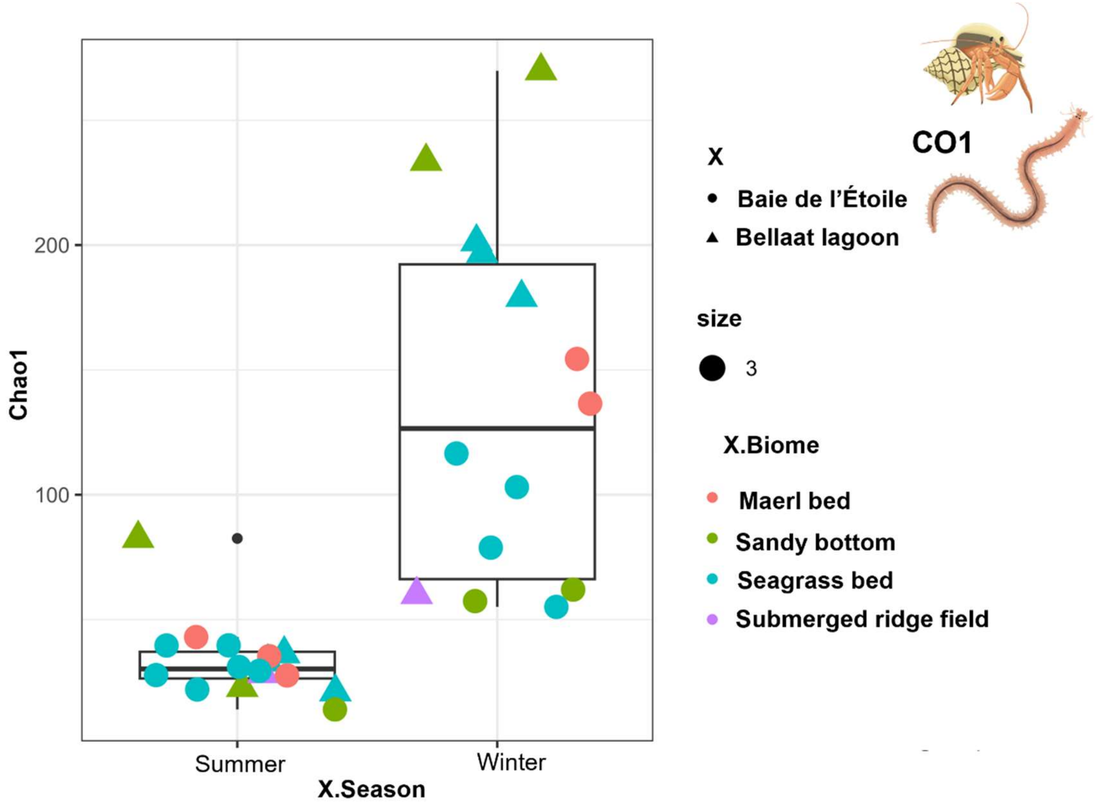

Figure 6: Species richness/alpha diversity represented through Chao1 Index of the pooled species from the CO1 locus during summer and winter seasons in both investigated lagoons.

Table 3: Statistical results of the conducted ANOVA of the CO1 locus reads from both seasons in both investigated lagoons. The term represents the comparative value as follows: X.season: winter or summer; X. biome: the described habitats such as maerl bed, seagrass bed, sand bottom and submerged ridge field; X: anthropogenically disturbed or not.

Term	df	sumsq	meansq	Statistic	p.value
X. season	1	78732.3469	78732.3469	252.609442	4.716130e-12
X. biome	3	4892.3137	1630.7712	5.252972	8.842977e-03
X	1	27695.4090	27695.4090	89.211293	2.133961e-08
X. season: X. biome	3	3892.3486	1297.4495	4.179290	2.070623e-02
X. season: X	1	21990.8172	21990.8172	70.835900	1.180944e-07
X. biome: X	1	5059.9415	5059.9415	16.298872	7.730867e04
X. season: X. biome: X	1	641.2151	641.2151	2.065455	1.678262e-01
Residuals	18	5588.0522	310.4473	NA	NA

The redundancy analysis (RDA) was conducted to visualise the β-diversity between the different sampling locations and during the different seasons (Figure 7 & 8). Both primer sets showed a clear separation between the summer and winter regarding their Beta diversity (Table 4, PERMANOVA, p < .001, for 12S; Table 5, PERMANOVA, p < .001, for CO1). Additionally, a clear and significant separation between protected and unprotected areas was applicable in both primer sets (Table 4, PERMANOVA, p < .01, for 12S; Table 5, PERMANOVA, p < .001, for CO1), with a more pronounced separation within the CO1 data set. Both graphics show a general trend of a greater species richness during winter, with higher species richness in protected areas than unprotected ones. Since the RDA values of both graphics are below 50% (30.5% for 12S and 25.7% for CO1), the validity of these results needs to be interpreted with caution.

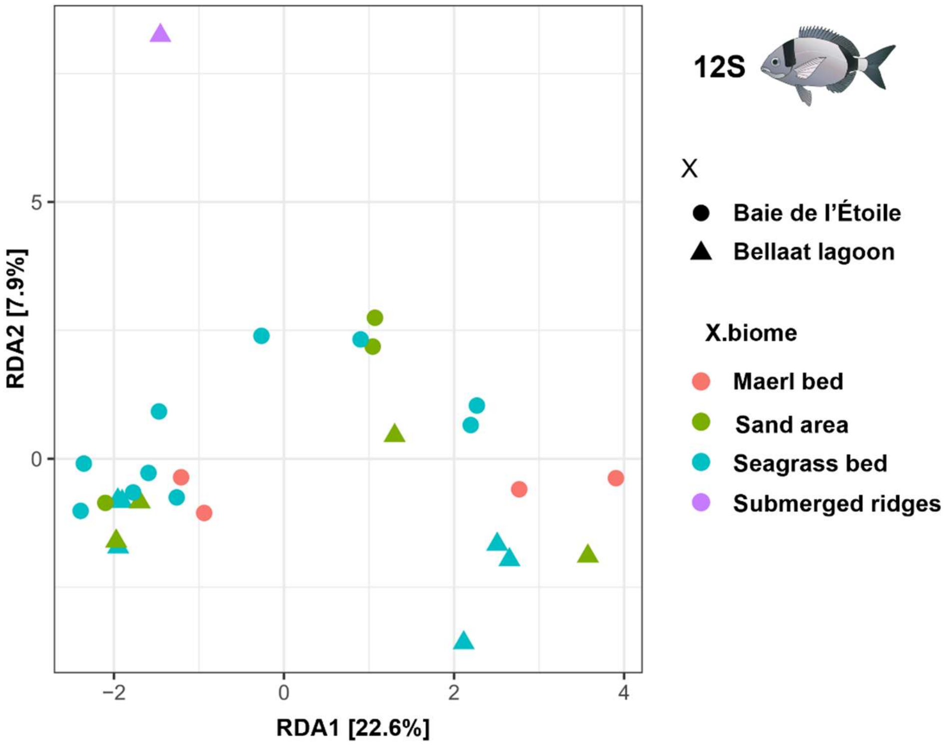

Figure 7: Redundancy analysis of the generated 12S data to estimate the β-diversity between the different sampling locations and during the different seasons.

Table 4: Statistical results of the redundancy analysis (Figure 7) performed with the generated 12S data, comparing the β-diversity between the different sampling locations and the different seasons.

Term	df	Variance	Statistic	p. value
X. season	1	82.25861	7.905928	0.001
X. biome	3	66.99469	2.120522	0.001
X	1	24.30983	2.308371	0.017
Residual	22	231.68555	NA	NA

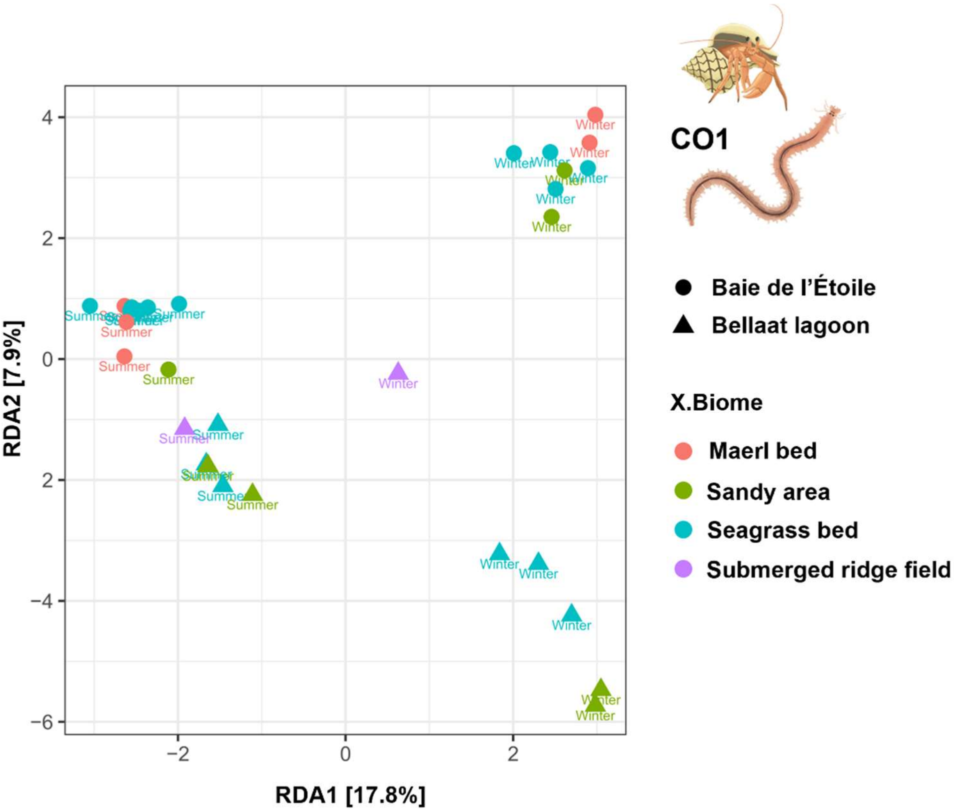

Figure 8: Redundancy analysis of the generated CO1 data to estimate the β-diversity between the different sampling locations and during the different seasons.

Table 5: Statistical results of the redundancy analysis (Figure 8) performed with the generated CO1 data, comparing the β-diversity between the different sampling locations and the different seasons.

Term	df	Variance	Statistic	p. value
X. season	1	152.24923	6.281660	0.001
X. biome	3	88.50409	1.209256	0.150
X	1	63.12034	2.587292	0.003
Residual	24	585.51108	NA	NA

Seasonal variation and comparative analysis

The study analysed the impact of different seasons and sampling areas (biomes) on biodiversity in Mauritania using eDNA data. The performed ANOVA indicates significant effects from different factors on the species richness in the investigated areas (see Table 1 & 2). The seasonality and its characteristic environmental differences in temperature, salinity and upwelling intensity has a highly significant effect on the local biodiversity (Table 1, ANOVA, *p < .001,* for 12S; Table 2, ANOVA, p < .001, for CO1;) and seems to have the biggest impact from all other factors such as habitat type and the protection status (sumsq: 1687.69691 for 12S; sumsq: 1270050.243 for CO1). The habitat type also has a significant effect on the detected species richness (Table 1, ANOVA, p < .001, for 12S; Table 2, ANOVA, p < .001, for CO1). However, the influence of the habitat type on the general species richness is a magnitude below the seasons influence with a sumsq of 380.61451 for 12S and 60286.510 for CO1. There is also a highly significant influence from the ecosystem status (protected vs. unprotected) on the prevailing species richness (Table 1, ANOVA, p < .001, for 12S; Table 2, ANOVA, p < .001, for CO1). Even with a significant difference in species richness between protected and unprotected areas in both primers, seems the species richness to be stronger pronounced in the CO1 samples. In summary, the factors Season, Habitat, and protection level seem to have a highly significant effect on the detected species richness, with significant interactions between season and habitat.

Additional calculations of Venn-diagrams supported the observation of a higher species richness during winter months (November to March) compared to summer months (Figure 9 & 10). During summer, 11 fish and 98 different invertebrate species were observed, compared to 62 fish and 576 invertebrate species during the winter months. During both seasons, 14 fish and 62 invertebrate species seemed to occur in the investigated habitats. However, these 14 and 62 different species constitute the majority of the detected DNA from the environmental samples (Fig. 9B 84.7% for 12S; Fig. 10B, 48.3% for CO1).

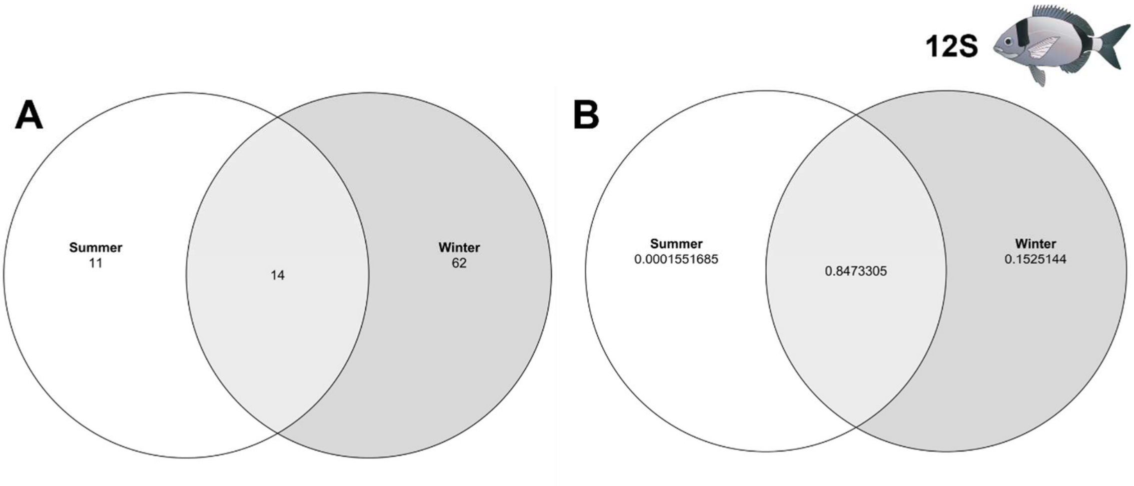

Figure 9: Venn diagram of the pooled results of the 12S metabarcoding of water samples. **A**: Number of species observed during the summer season (white) and winter season (dark grey) with observations made during both the summer and winter seasons (light grey). **B**: Percentage abundance of species observed during the summer season (white) and winter season (dark grey) and species observed during both seasons (light grey).

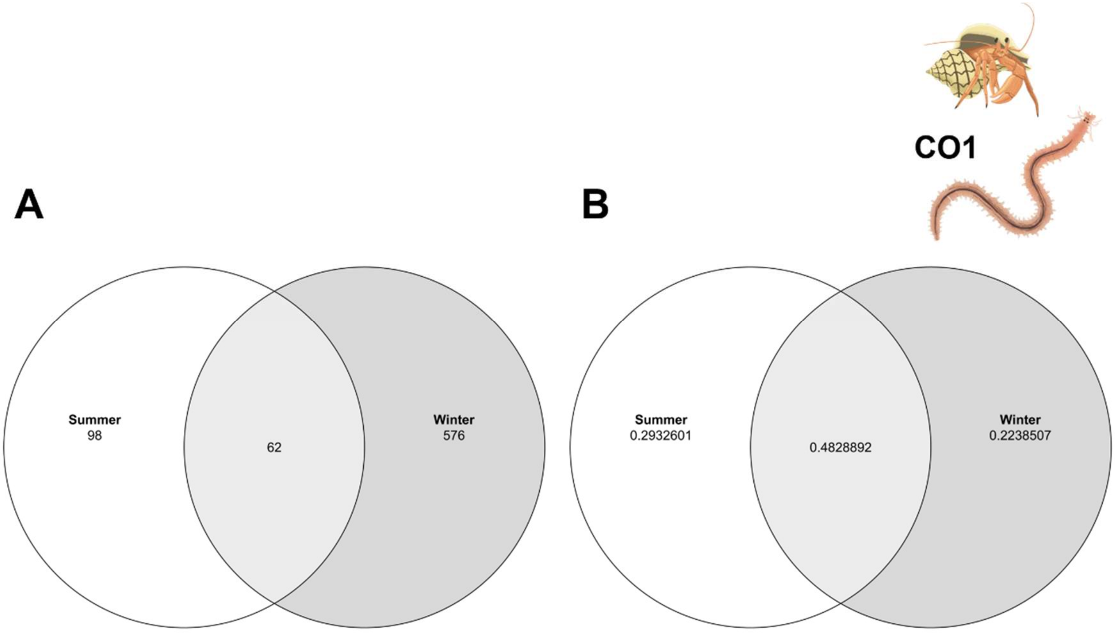

Figure 10: Venn diagram of the pooled results of the CO1 metabarcoding of water samples. **A**: Number of species observed during the summer season (white) and winter season (dark grey) with observations made during both the summer and winter seasons (light grey). **B**: Percentage abundance of species observed during the summer season (white) and winter season (dark grey) and species observed during both seasons (light grey).

8.5 Discussion

The marine biodiversity along the Mauritanian coast exhibits pronounced seasonal variations between summer and winter months (Pelegrí & Peña-Izquierdo 2015). These variations seem to be closely linked to the seasonal upwelling activities along the West African coast, with stronger upwelling activity during the winter months compared to reduced upwelling activities during the summer months (Wolff et al. 1993, Heileman & Tandstad 2009). During the winter months, the observed species richness for both fish and marine invertebrates is notably higher, as seen in Figure 4 & 5. It is already known that wind-driven upwelling occurs nearly permanently in the coastal area north of Cap Blanc, but a also seasonal upwelling, which is caused by north-easterly winds, occurs between November and May in the coastal parts south of the Cap Blanc peninsula (Benazzouz et al. 2014a, b; Pelegrí and Benazzouz 2015). The enhanced nutrient availability supports the growth of phytoplankton, which serves as base for various marine food webs in Mauritania's coastal habitats, promoting overall marine biodiversity. This nutrient enrichment sustains large populations of pelagic and benthic fish species, thereby enhancing both ecological diversity and fisheries productivity (Arístegui et al. 2009). In contrast, during the summer months (June to September), the upwelling is less intense, leading to lower primary production, and consequently results in a lower phytoplankton biomass, adversely affecting higher trophic levels. Interestingly, the observed biodiversity during winter months in protected areas is higher compared to unprotected areas. Several factors contribute to this observation, as the protected areas offer refuge from anthropogenic threats like fishing pressure, shipping noise, and pollution, resulting in a more stable and less disturbed environment. These stable conditions, along with the structural complexity provided by habitats like seagrass beds or hard substrate support a higher diversity of species. Less disturbed habitats not only offer shelter and food resources for a multitude of species but also serve as a critical nursery area for the local fauna, as predators cannot reach those and the seagrass beds offer valuable protection. This makes them particularly important for the recruitment of both endangered and commercially relevant species (Gell & Roberts 2003). Moreover, the seasonal migration of certain species to these protected areas during the winter months, seeking refuge from less favourable conditions in the open sea or northern areas or for spawning, further enhances the observed local biodiversity (Halpern et al. 2010). It is well-known that certain fish species, such as *Diplodus sargus*, and some mugilid species like *Liza dumerili* or *Chelon auratus*, preferentially migrate to coastal areas during the spawning season in the winter and spring months (Van der Horst and Erasmus 1981; Mehanna 2006; Mouine et al. 2007; Ghaninejad et al. 2010). This behaviour can also be observed in a large number of shrimp species along the Mauritanian coast. Schaffmeister et al. (2006) reported that several shrimp species also using the seagrass beds of the Banc d’Arguin as nursery areas during the winter months, once more highlighting the importance of these habitats for fisheries. These seasonal migrations are naturally increasing the marine biodiversity during the spawning season, temporarily boosting the observed biodiversity. This effect can be seen through the Venn diagrams (Figures 9 and 10). Both figures show that the majority of the observed fauna is present during both seasons. However, certain species were observed exclusively during either the summer or winter months in the studied areas. These species seem to migrate into the regions seasonally, and these migrations may be closely linked to the reproductive cycles of the respective species. The Venn diagrams further indicate that this migration is considerably stronger during the winter months compared to the summer.

The two studied lagoons, namely the Baie de l’Étoile and the Bellaat lagoon, differ in several aspects. While the Baie de l’Étoile formed approximately 8.000 to 5.000 BP during the Nouakchottian transgression (Ly 2009), the Bellaat lagoon was only created recently, following the breach of a coastal dune during a heavy rainfall event in August 2013 (Trégarot et al. 2020). Over time, the Baie de l’Étoile has been a permanently choked lagoon, containing a range of facies, including hard substrates in the form of sandstone, a rocky island and maerl beds, as well as soft sediments, such as tidal mudflats and seagrass beds. In contrast, the Bellaat lagoon has experienced periodic flooding and drying out. The facies diversity in this lagoon is limited to soft sediments, similar to those in the Baie de l’Étoile, but with no notable presence of hard substrate.

Given the age of the Baie de l’Étoile and its higher facies diversity, one might expect the marine biodiversity within this lagoon to be significantly higher than in the geologically younger, facies poor Bellaat lagoon. Contrary to this assumption, the eDNA analysis reveals a considerably higher marine biodiversity within the Bellaat lagoon during the winter months. This effect is even more pronounced for marine invertebrates compared to the fish species studied (see Figures 5 and 6). These differences in biodiversity could be attributed to anthropogenic stressors such as intense fishing and pollution in the Baie de l'Étoile. Additionally, the seasonal migration of species for reproductive purposes or as a response to climate change may also lead to a significant increase in species richness, particularly during the winter months. The anthropogenic stressors in the Baie de l'Étoile could drive migrating species to settle in less disturbed marine areas like the Bellaat lagoon, explaining the higher species diversity in the significantly younger and facies poor Bellaat lagoon.

Considering the pronounced influence of seasonal upwelling on marine biodiversity and the vital role of less anthropogenically disturbed habitats, continuous monitoring of these ecosystems is essential, especially in the context of climate change and the rising sea level. The ongoing climate change is expected to alter oceanographic processes, including upwelling intensity and patterns, which could have profound impacts on nutrient availability and marine biodiversity. Long-term monitoring data and continuous research are crucial for understanding changes and for developing adaptive management strategies. These efforts can help preserve marine biodiversity along the Mauritanian and West African coast by establishing marine protected areas, reducing or even banning wastewater discharge, and ensuring the sustainability of fisheries and other marine resources.

Since the effectiveness of eDNA assessment depends heavily on the quality of its underlying reference library (Elbrecht et al. 2017; Thomsen & Sigsgaard 2019; Wee et al. 2023), this work emphasizes the urgent need for comprehensive DNA barcode libraries. Such libraries are essential for the successful implementation of DNA metabarcoding as a reliable biomonitoring tool, as advocated by Milan et al. (2020). The comparison of the metabarcoding results with the publicly available reference barcode database BOLD-Systems (Ratnasingham & Hebert 2007) clearly demonstrated that commercially valuable species are significantly more represented compared to other, less relevant species, such as marine invertebrates (e.g., polychaetes, smaller crustaceans, or gastropods). Additionally, the identification of fish sequences at the species level using the MiFish primers was not always reliable, whereas identification at the genus level was consistently more accurate. Therefore, the results of metabarcoding should be interpreted with a degree of caution. Nonetheless, they generally provide a reasonable representation of the actual fauna present in the investigated environments. In contrast, marine invertebrates were represented with much lower resolution, where the sequences found could only be identified to the genus or sometimes even class level. This disparity implies that the eDNA studies from this region can only capture the actual biodiversity in broad terms. As a result, dietary studies based on these data cannot be depicted in detail. Therefore, it would be highly valuable for future research to identify the local fauna at first and provide genetic reference sequences of the respective species in online repositories later to ensure a higher resolution and more accurate results in future eDNA studies, in order to overcome the currently existing incompleteness and underrepresentation of specific taxa (Porter and Hajibabaei, 2018; Wee et al. 2023). The lack of reference barcodes in publicly available online repositories like BOLD-Systems or GenBank, clearly demonstrates one of the biggest bottlenecks regarding DNA metabarcoding in understudied regions (Stat et al. 2017; McGee et al. 2019). This issue arises from various challenges related to sampling coverage across the globe. Firstly, there is insufficient sampling along the West African coast and other less-studied marine regions, such as the South American Pacific and Indo-Pacific coasts (Thyrring et al. 2024), resulting in a general lack of reference data for these areas. Secondly, the available reference databases are often region-specific, limiting their applicability to other ecosystems or ecoregions (Wee et al. 2023).

8.6 Conclusion

This study demonstrates clear seasonal differences in marine biodiversity, with significantly higher species diversity observed during the winter compared to summer, particularly in less anthropogenically disturbed habitats like Bellaat lagoon. This increase in biodiversity during winter is largely attributed to seasonal upwelling activities and the influx of migrating species, which reproduce or move from colder regions. A key finding of the study is the significant lack of published DNA barcodes, which hinders accurate species identification. As a result, the study emphasizes the urgent need for a comprehensive DNA barcode reference library for the marine fauna of Mauritania and West Africa.

8.7 Acknowledgment

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Chapter 9
Didogobius lanceolatus sp. nov., a new goby species from Mauritania (Teleostei: Gobiidae: Gobiinae), with diagnoses for two new gobiine genera

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The format has been adapted to match the thesis

9.1 Abstract

Didogobius lanceolatus sp. nov. is described from a single specimen collected from the southern Banc d'Arguin, Mauritania. The species differs from all currently described congeners, as well as from all species of the closely related species of the genera *Chromogobius* and *Gammogobius,* by the combination of the following characters: (1) lanceolate caudal fin; (2) small (reduced) vs. large eyes; (3) 27 vertebrae; (4) D2 I, 13, A I, 11; (5) predorsal region in front of first dorsal fin D1 naked; (6) body squamation reduced, with only few areas on flank covered by externally visible cycloid scales behind pectoral origin and on caudal peduncle; (7) anterior oculoscapular canal present, with only pores σ, κ, α, ρ; (8) posterior oculoscapular and preopercular head canal absent; (9) suborbital row 7 close to pore α with more than five papillae; (10) suborbital rows 2 and 4 close to orbit; (11) interorbital papillae absent. The new species appears most closely related to the type species of *Didogobius* Miller 1966, *D. bentuvii* Miller, 1966, as it shares a set of apparently derived morphological characters, such as the lanceolate caudal fin, minute eyes and the anterior oculoscapular canal with only pores σ, κ, α, ρ present. Phylogenetic analysis of COI-barcoding data further suggests a close relationship with two other species of the genus *Didogobius* exclusively sharing with the new species and *D. bentuvii* elevated unpaired fin ray counts, i. e., D2 branched rays ≥ 12 (vs. ≤ 11 in all other species) and A branched rays ≥ 11 (vs. ≤ 10 in all other species); these two species are D. kochi Van Tassell, 1988 and D. schlieweni Miller, 1992. Based on the description of new Didogobius species obviously closely related to the type species of *Didogobius*, on re-examination of the single type specimen of *D. bentuvii* and on the new DNA barcoding data we restrict and re-diagnose the genus *Didogobius* to include only the aforementioned four species. The other former *Didogobius* species are placed in two new genera, each unambiguously diagnosable on previously established morphological data: *Marcelogobius* gen. nov. with *M. splechtnai*, *M. helenae* and *M. janetarum*, and *Peter* gen. nov. with the two shrimp-associated species *P. amicuscaridis* and *P. wirtzi*.

Keywords

Didogobius, Chromogobius, Marcelogobius, Peter, Eastern central Atlantic, Banc d'Arguin, NW Africa

9.2 Introduction

With slightly more than 2000 valid species gobies (Teleostei: Gobiiformes: Gobiidae, incl. Kraemeriidae and Microdesmidae) belong to the most-species-rich vertebrate groups (Fricke et al. 2023). Most species are small or even miniature, rarely exceeding 10 cm total length. As with many predominantly marine and brackish-water taxa, the highest species richness is found in the Indo-Pacific region (Fricke et al. 2023). Nevertheless, a substantial part belonging to only two phylogenetic lineages, the *Pomatoschistus*-lineage and the *Gobius*-lineage (sensu Agoretta et al. 2013) is endemic to the eastern Atlantic (including the South African Cape), the Mediterranean and the Ponto-Caspian regions (Kovačić & Patzner 2011, Schliewen 2011). In addition, the Western Indian Ocean genus Coryogalops Smith, 1958 belongs to the *Gobius*-lineage (Agorreta et al. 2013) The diversity of the *Gobius*-lineage currently falls into approx. 30

genera, with approximately 150 described and undescribed species (Kovačić & Patzner 2011, Schliewen 2011, Schliewen, pers. obs.). Based on the phylogenetic analysis of Agorreta et al. (2013), the *Gobius*-lineage comprises several well-defined major clades, whose interrelationships remain poorly resolved. One of these clades is represented by members of the genera *Didogobius* Miller, 1966 and *Chromogobius* de Buen, 1930 with eleven valid and at least five undescribed species (including the one described below) distributed from the islands in the tropical eastern Atlantic, Portugal, the Mediterranean and, with one species, in the Black Sea. As far as their life history is known, all species are truly cryptobenthic (sensu Kovačić et al. 2012), i.e. they always live underneath the bottom surface, in rock crevices or within biocover surface (Kovačić et al. 2012). It is thus unsurprising that before targeted sampling of cryptobenthic habitats using SCUBA diving and anaesthetics started at around the 1970´s the knowledge about the diversity of cryptobenthic gobies had remained limited mainly too few species occurring in the intertidal or which had been collected sporadically in deeper habitats.

One species of the *Gobius*-lineages collected accidentally is *Didogobius bentuvii* Miller, 1966, the type species of the genus *Didogobius*. It was apparently collected only because a small-meshed beam-trawl, designed to collect epibenthic fishes, had unintentionally been driven deep into the clay-and-silt bottom off the River Rubin estuary (Israel) at a depth of about 36 m. The single specimen was similar to the genus *Chromogobius* and to the Caspian genus Asra Iljin, 1941 (now included in *Benthophiloides* Beling & Iljin 1927), but differed from all described members of these genera known at that time by a combination of characters of the head lateral line system, the vertebrae count, caudal fin shape, and eye size (Miller 1966). Mainly these multiple differences provided the original diagnosis of the new monotypic genus Miller (1966). Subsequently, more species were described, which shared the head lateral line character states, but which differed in several other characters. The first species, *D. kochi* van Tassel, ,1988 (distributed in the Canary islands, Madeira and Senegal) differed, e.g., substantially from the type species, but nevertheless was placed in *Didogobius* because of similarities of the head lateral line system; thus, its inclusion in *Didogobius* necessitated a revised diagnosis of the genus *Didogobius*. This was necessary for virtually all subsequent descriptions of new *Didogobius* species, i.e. *D. splechtnai* Ahnelt & Patzner 1995 (Mediterranean), *D. schlieweni* Miller, 1993 (Mediterranean), *D. amicuscaridis* Schliewen & Kovačić, 2008 (São Tomé und Príncipe), *D. wirtzi* Schliewen & Kovačić, 2008 (Cape Verde), *D. helenae* van Tassell & Kramer, 2014 (Canary islands) and D. janetarum Schliewen et al. 2018 (Cape Verde). To assign all *Didogobius* species in a single genus despite substantial morphologically heterogeneity the latest re-diagnosis of the genus differentiates it from *Chromogobius* on the basis of only two disputed head lateral line characters despite the study reiterates previous findings, that multiple other character states would allow for the delineation of new genera within the *Didogobius* species complex (Schliewen et al. 2018). It was cautioned that a formal generic reassessment necessitates the critical examination of new data of the highly divergent type species *D. bentuvii*, known to date only from the holotype.

In 2010 an unknown goby was accidentially collected at 30 m water depth in the southern Banc d'Arguin off the island Tidra, Mauritania, via grab sampling mud and silty mud. This specimen revealed to be phenotypically similar to *D. bentuvii* and it was collected from a similar muddy habitat and depth. Nevertheless, a comparison showed that it is clearly a different species, despite sharing multiple character states previously believed to be unique to the type species of *Didogobius*. The description of the new species, re-examination of the single type specimen of *D. bentuvii*, new DNA-barcoding data including the new species closely related to the type species and the re-assessment of previously established morphological data allowed for the re-diagnosis of *Didogobius* and to establish diagnoses for two new genera, formerly placed in *Didogobius*.

The Banc d'Arguin is located along the coast of northern Mauritania and is characterised as a coastal wetland with shallow water, tidal flats and large sea grass beds (Schaffmeister et al. 2006), along with mudflats, channels, sand banks, and islands of variable sizes (Araujo & Campredon, 2016). The Banc d'Arguin covers an area of around 10.000 km² (Wolff et al. 1993). Generally, the species composition of the Banc d'Arguin varies along with the different habitat features (Compain, 2021). Its fish fauna is characterised by temperate, sub-tropical as well as tropical elements (Jager 1993). Additionally, the shallow areas of the Banc D'Arguin are known as a nursery for many fish species, providing a rich source of food for many seabirds (Camphuysen & van der Meer 2005). A study by Gushchin and Fall (2012) identified 91 fish species in the littoral area of the Golfe d’Arguin, while van Etten (2002) already identified 23 fish species with most of them belonging to the family Gobiidae, despite only a very small area near Zira island (19.86°, -16.29°) was sampled.

9.3 Material and Methods

The specimen was collected during the RV Maria S. Merian cruise MSM 16/3 “PHAETON” – Paleoceanographic and paleoclimatic record on the Mauritania Shelf (Westphal et al. 2012) in the southern Banc d’Arguin 19.682450° and -16.922700° in 30 m water depth via grab sampling (station GeoB: 14820-1, see Fig. 1). The holotype was documented with a Nikon D700 camera and a digital light microscope (Keyence VHX – 1000D) for detailed observation and further description. It was preserved in ethanol, denatured ≥96% plus 1% MEK, for morphological and genetic analyses. A fin-clip of the left pectoral was taken thereafter. Distance measurement methods followed definitions provided in Schliewen & Kovačić (2008) and were taken with a Mitutoyo 505-732 dial calliper (accuracy 0.01 mm) or, in order to avoid specimen damage, in some cases from variously enlarged digital x-rays or specimen photos with a 10.0 mm size standard. Meristic counts were taken following definitions provided in Schliewen et al. (2018). Terminology of lateral line system follows Miller (1986), a modification for suborbital row terminology in Schliewen et al. (2018), and they are based on Sanzo (1911). The specimen was reversibly stained in 2% solution of Cyanine Blue in distilled water (Saruwatari et al. 1997) for studying scales and sensory papillae rows. X-rays were prepared using the default autoexposure settings of the UltraFocus Digital Radiography System (Faxitron Bioptics, Arizona, USA).

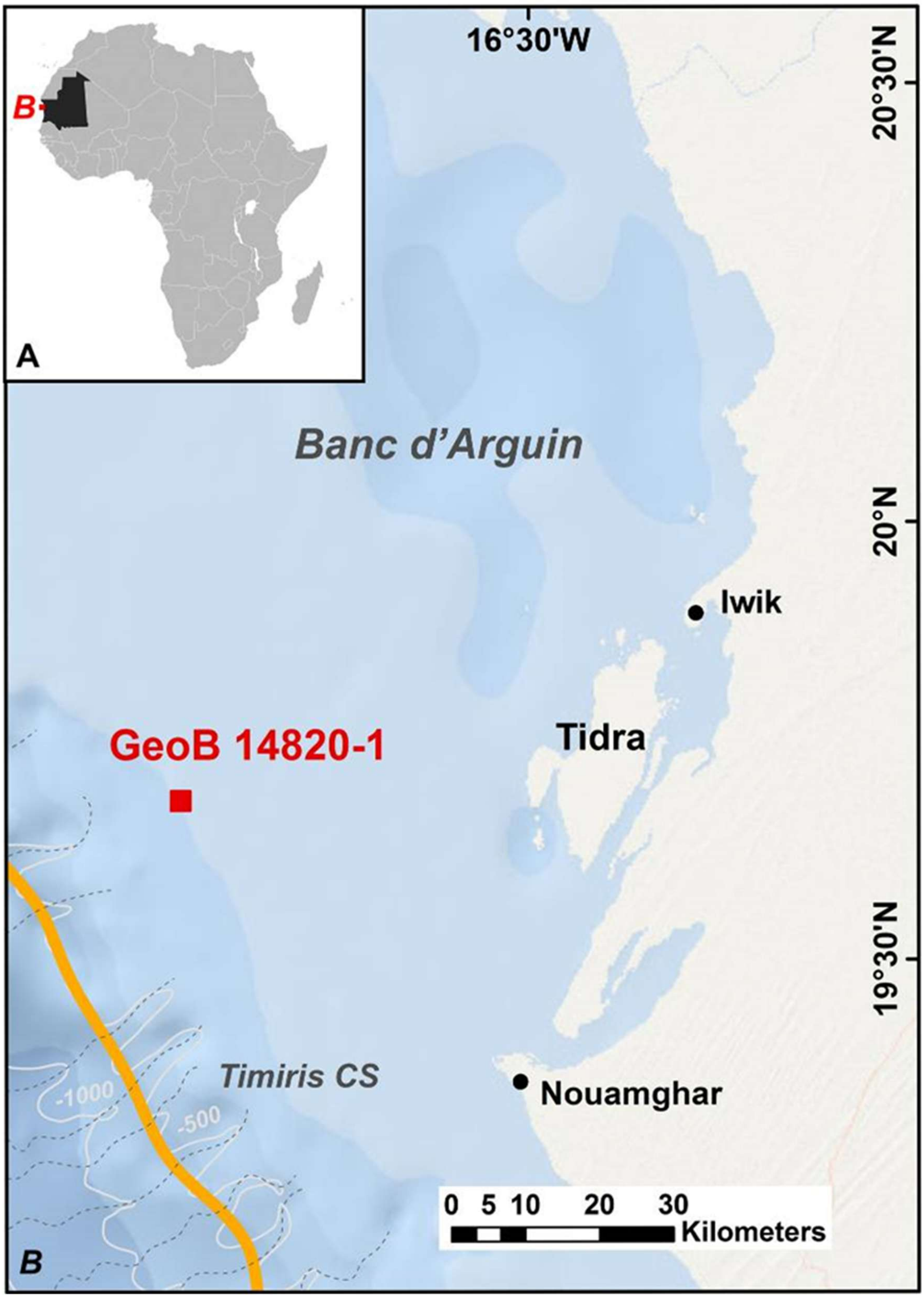

Figure 1: **A**: Overview map of Africa indicating Mauritania (black) and the study area (B, red square). **B**: Study area with MSM 16/3 " sample location (red) and the deep-water coral ecosystem (orange) along the slope of Mauritania and inside the Canyon Systems (CS). Basemap from ESRI (2019) (www.esri.com) and contours from GEBCO (2019) (www.gebco.net), deep-water scleractinian framework distribution, canyon positions and names from Sanz et al. (2017).

For assessing the phylogenetic position of the new species described herein, DNA extraction was performed at the biome-id laboratories (Wilhelmshaven, Germany). The genomic DNA of D. lanceolatus sp. nov. was extracted using the NucleoSpin® Tissue Kit (Macherey Nagel, Düren, Germany). A fragment of the mitochondrial Cytochrome-c-Oxidase (COI) was amplified with a fish-specific primer cocktail (Ivanova et al., 2007). Additional M13 forward and reverse tails were added to the primers for Sanger sequencing. The PCR product was amplified using One Taq 2x Master Mix (New England Biolabs, Frankfurt am Main). The PCR thermal conditions included an initial denaturation at 94°C (3 min), followed by 35 cycles at 94°C (denaturation, 20 s), 48°C (annealing, 30 s), 68°C (extension, 45 s), and a final extension at 68°C (5 min). The PCR product was visualised via electrophoresis on a 1,5% agarose gel stained with GelRed (Biotium Inc., Fremont, CA, USA) and 10 µL of the amplicon was purified using 2,5 µL of ExoSap Mix (10 Unit Exonuclease I und 2 Unit FastAP Thermosensitive Alkaline Phosphatase). All PCR reactions were conducted using an Eppendorf Mastercycler Pro system (Eppendorf, Hamburg, Germany). Forward and reverse sequencing was conducted on an AB3730XL (Thermo Fisher Scientific, Waltham, MA, USA) Macrogen Europe (Amsterdam, The Netherlands). Additional COI sequences were generated using the lab protocol described in Kovačić et al. (2017). Sequences were first manually edited using Sequencer v5.4. (Gene Codes, Ann Arbor, MI, USA) and imported as fasta files into BioEdit v. 7.2.5 (Hall 1999), then aligned with default settings and adjusted by eye; finally, the alignment was trimmed to equal fragment length of 572 base pairs. To infer mtDNA-based phylogenetic relationships the new data were combined with published (Genbank) or newly sequenced COI-data from related species. BOLD or Genbank accession numbers are based on species names in the phylogenetic analyses results presented below, except for the 15 newly generated COI-haplotypes deposited under the following GenBank accession-numbers and BOLD-ID numbers: *Didogobius lanceolatus* sp. nov. (BOLD-ID: DNGLB01; SMF 39647; ZSM tissue voucher PIS-GO-2348); OQ672514: *Marcelogobius janetarum* nov. comb. (ZSM tissue voucher PIS-GO-1801); OQ672516: *Marcelogobius splechtnai* nov. comb. (ZSM tissue voucher PIS-GO-1878); OQ672509, OQ672512, OQ672513: *Didogobius kochi* “Cape Verde Islands” (ZSM tissue vouchers PIS-GO-1016, PIS-GO-1216, PIS-GO-1217); OQ672518:

Didogobius schlieweni (PMR VP4629; ZSM tissue voucher ZSM-PIS-GO-2123); OQ672510, OQ672515: *Chromogobius quadrivittatus* (ZSM tissue vouchers PIS-GO-1070, PIS-GO-1085); OQ672506—OQ672508, OQ672511 and OQ672517: *Chromogobius* cf. *zebratus* (ZSM tissue vouchers PIS-GO-561, PIS-GO-918, PIS-GO-1091, PIS-GO-1175, PIS-GO-891, PIS-GO-1091). A Maximum Likelihood tree hypothesis (ML) were calculated with the software package MEGA7.02.6 (Kumar et al. 2016), using the HKY+Gamma+I model (Gamma with five discrete categories). HKY+Gamma+I was chosen from 24 nucleotide substitution models based on the lowest Bayesian Information Criterion (BIS) values after running the “Model Selection” tool in MEGA7. *Gorogobius nigricinctus* was selected as outgroup taxon based on Agorreta et al. (2013). Statistical node support was assessed using nonparametric bootstrap analysis with 1000 pseudoreplicates. All specimens used in the present study are deposited in the Senckenberg Museum, Frankfurt (SMF), the SNSB-Bavarian State Collection of Zoology, Munich, Germany (ZSM) or in the Natural History Museum Rijeka, Croatia (PMR).

Generic identification and phylogenetic position

Generic identification would be consistent with the most recently modified diagnosis of the genus *Didogobius* Miller, 1966 in Schliewen et al. (2018): “*Didogobius* are Gobiinae sensu Pezold (1993) with the following characters shared by all currently valid members of the genus: (1) suborbital papillae without row a; (2) six suborbital transverse rows, row 3 missing, last row 7 represented by a single papilla or several papillae near pore α, or, if the head canal is absent it is near replacement large papilla; (3) suborbital row 5 long, from near eye to near row d; (4) paired rows of interorbital transversal papillae absent, if head canal absent, individual large replacement papillae are present but not a pair of transversal rows. (5) Head naked, predorsal area naked or scaled posteriorly (scaled up to six rows of cycloid scales in middorsal and up to approx. 1/4 of predorsal area length); (6) no mental barbels; (7) pelvic disc complete with fully developed anterior membrane (frenum); (8) head canals variably reduced from anterior oculoscapular and preopercular canals present and posterior oculoscapular canal absent to complete absence of head canals.” However, as discussed already in Schliewen et al. (2018), and as now supported with new

DNA-barcoding data conflicting molecular phylogenetic and morphological evidence implies that *Didogobius*, as defined in Schliewen et al. (2018), is paraphyletic with respect to *Chromogobius*. We therefore restrict *Didogobius* to the type species and those three species sharing with the type species elevated second dorsal fin (D2) and anal fin ray counts and whose mitochondrial DNA-barcoding (COI) haplotypes from a well-supported clade within all investigated members of the *Chromogobius-Didogobius* species complex. Based on morphological data compiled in Schliewen & Kovačić (2008), van Tassell & Kramer (2014) Schliewen et al. (2018) including the confirmation of osteological data previously published by Miller (1966) for the holotype of *D. bentuvii* (BMNH 1965.2.1.1) the revised diagnosis of *Didogobius* is presented here:

Revised diagnosis of *Didogobius*: Gobiinae sensu Pezold (1993) with the following characters shared by all currently valid members of the genus: (1) suborbital papillae without row a; (2) six suborbital transverse rows, row 3 missing, last row 7 represented by a single papilla or several papillae near pore α; (3) suborbital row 5 long, from near eye to near row d; (4) paired rows of interorbital transversal papillae absent; (5) Head naked, predorsal area naked; (6) no mental barbels; (7) pelvic disc complete with fully developed anterior membrane (frenum); (8) anterior oculoscapular canal present but variably reduced with either only pores σ, κ, α, ρ present or pores σ, λ, κ, ω, α, β, ρ present; preopercular canals present or absent, and posterior oculoscapular canal absent; (9) D2 branched rays ≥12 and A branched rays ≥11; (10) first D1 ray not the longest; (11) posterior nostril tubular.

Support for the generic identification comes from the phylogenetic analysis of mitochondrial COI-barcoding data. A hypothesis for phylogenetic relationships of DNA-haplotypes places the new species in a statistically strongly supported clade (BS 95.1) with *Didogobius kochi* and *D. schlieweni*, two species matching the revised diagnosis of *Didogobius* as given above (Fig. 2). Since the type species of *Didogobius*, *D. bentuvii*, shares multiple unique character states with the new Mauritanian species described herein, we infer that those two are closely related, although COI-barcoding data are not available for D. bentuvii, known only from the holotype. Thus, under the revised diagnosis given above, *Didogobius* now is restricted to the type species *D. bentuvii*, the highly similar *D. lanceolatus* sp. nov., *D. schlieweni* and *D. kochi*.

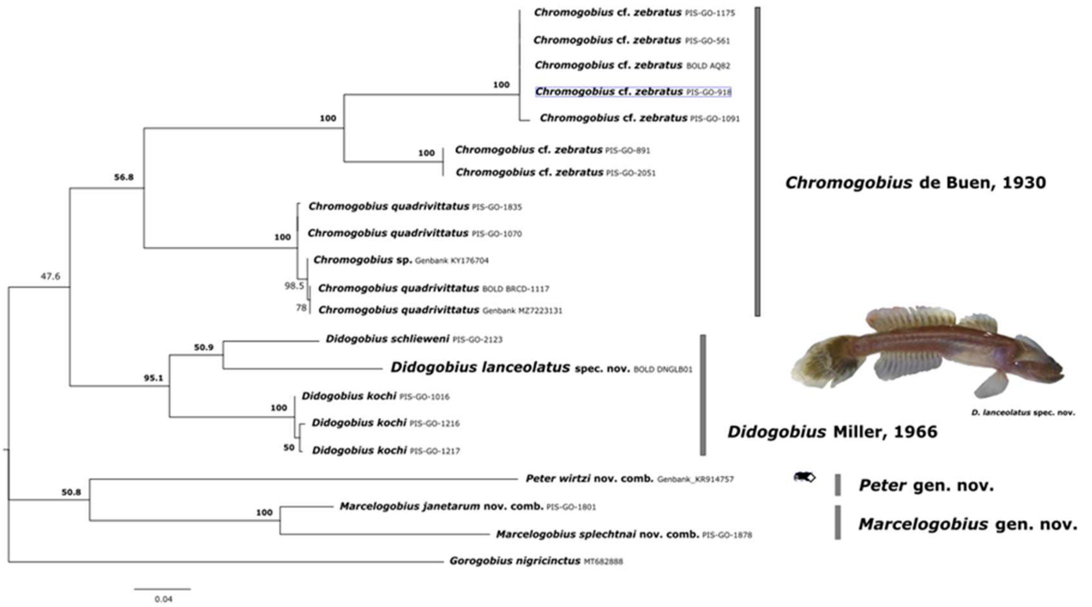

Figure 2. Maximum likelihood phylogeny of COI-barcode haplotypes (572 bp) of all available sequences of *Didogobius* species and members of the related genera *Chromogobius*, *Marcelogobius* gen. nov. and *Peter* gen. nov.. The tree was rooted with Gorogobius nigricinctus based on Agorreta et al. (2013). Numbers on branches are bootstrap support values (%) for the Maximum Likelihood analysis. Tip labels include the ZSM-PIS-GO goby tissue collection number (if newly sequenced in this study), GenBank accession or Barcode of Life Data System (BOLD) numbers. Inserted: Photo of the live holotype of D. lanceolatus sp. nov.. (Photo: André Freiwald and Lydia Beuck).

With the restriction of *Didogobius* to this diagnosis, several species are now excluded from *Didogobius* and thus in need of generic reassignment, i.e. (i) the two shrimp-associated species *D. amicuscaridis* and D. wirtzi, and (ii) the banded species *D. splechtnai*, *D. helenae* and *D. janetarum*. Since both are unambiguously diagnosable on the basis of multiple previously established characters we provide diagnoses for these two species groups below and formally assign them to two new genera (see below). Together with the three described *Chromogobius* species, the *Chromogobius-Didogobus* complex thus comprises four genera.

9.4 Species identification

Apart from the type species of the genus *Didogobius, D. bentuvii* Miller, 1966, the new species differs from all remaining species of the *Chromogobius-Didogobius* species complex by the following characters: a lanceolate vs. rounded caudal fin, the anterior oculoscapular canal with only pores σ, κ, α, ρ present, and small (reduced) vs. large eyes; from *Didogobius bentuvii, D. kochi*

Van Tassell, 1988 *D. schlieweni* Miller 1992, *Marcelogobius helenae*, *M. splechtnai, M. janetarum*, and *Chromogobius britoi* it differs by having more than one papilla (six or seven) in suborbital row 7; from *D. kochi, D. schlieweni* Miller, 1993, *Peter amicuscaridis* Schliewen & Kovačić, 2008 and *P. wirtzi* Schliewen & Kovačić, 2008 by having only 10 vs. 11–14 D2 soft rays; from *M. helenae* by having anterior oculoscapular head canal present vs. absent; from *M. janetarum* Schliewen, Wirtz & Kovačić, 2018 and *D. kochi* specimens from the Canary islands by a naked predorsal region vs. posterior quarter of predorsal region in front of first dorsal fin origin with several rows of cycloid scales; from *C. zebratus, C. britoi, C. quadrivittatus, D. kochi, D. schlieweni, M. splechtnai, P. amicuscaridis* and *P. wirtzi* by preopercular canal absent vs. present. For a comprehensive comparison see character compilations in Schliewen & Kovačić (2008: Table 2), Van Tassell & Kramer (2014: Table 2), and Schliewen et al. (2018), Kovačić et al.(2019).

Class Osteichthyes Huxley, 1880

Order Gobiiformes Günther, 1880

Family Gobiidae Cuvier, 1816

Genus Didogobius Miller, 1966

Didogobius lanceolatus Schliewen, Knorrn & Boehmer, 2023 sp. nov.

(Figs. 3—7)

Types. Holotype: SMF 39647, male, 65.1+20.6 mm, Mauritania, southern Banc d'Arguin off Tidra (19.682450°, -16.922700°), in 30 m depth collected with olive-colored mud (surface) and dark greenish grey-colored silty mud (bulk), 4th of November 2010 at 15:28 UTC, MSM 16/3 grab sample, sta. no. GeoB 14820-1.

Diagnosis. *Didogobius lanceolatus* sp. nov. differs from all currently described members of the genera *Didogobius, Chromogobius, Marcelogobius* gen. nov. and Peter gen. nov. by the combination of the following characters: (1) lanceolate caudal fin; (2) small (reduced) vs. large eyes; (3) 27 vertebrae; (4) D2 I + 13, A I + 11; (5) predorsal region in front of D1 naked; (6) body squamation reduced, with only a few cycloid scales anteriorly and in tail region; (7) anterior oculoscapular canal present, with only pores σ, κ, α, ρ; (8) posterior oculascapular and preopercular head canal absent; (9) suborbital row 7 with more than five papillae; (10) suborbital rows 2 and 4 close to orbit.

9.5 Description

General morphology. Body proportions and meristics of the holotype are given in Table I. For a general view see Figs. 3, 4). Body elongate and laterally compressed, head moderately depressed; interorbital space broad (more than three times of eye diameter), dorso-laterally positioned eyes. Mouth oblique (~35° from horizontal), lower jaw slightly projecting, posterior angle of jaws slightly behind rear margin of pupil. Snout longer than eye and rounded in dorsal view. Anterior nostril tubular (longer than diameter), without process from rim, reaching but not overlapping the upper lip; posterior nostril with slightly erected rim, but not tubular. Upper lips about as thin anteriorly as laterally. Branchiostegal membrane attached along entire lateral margin; posterior margin of operculum almost reaching frontal edge of pectoral fin base. Cranial roof covered by dorsal axial musculature. Pectoral girdle without dermal flaps on anterior edge.

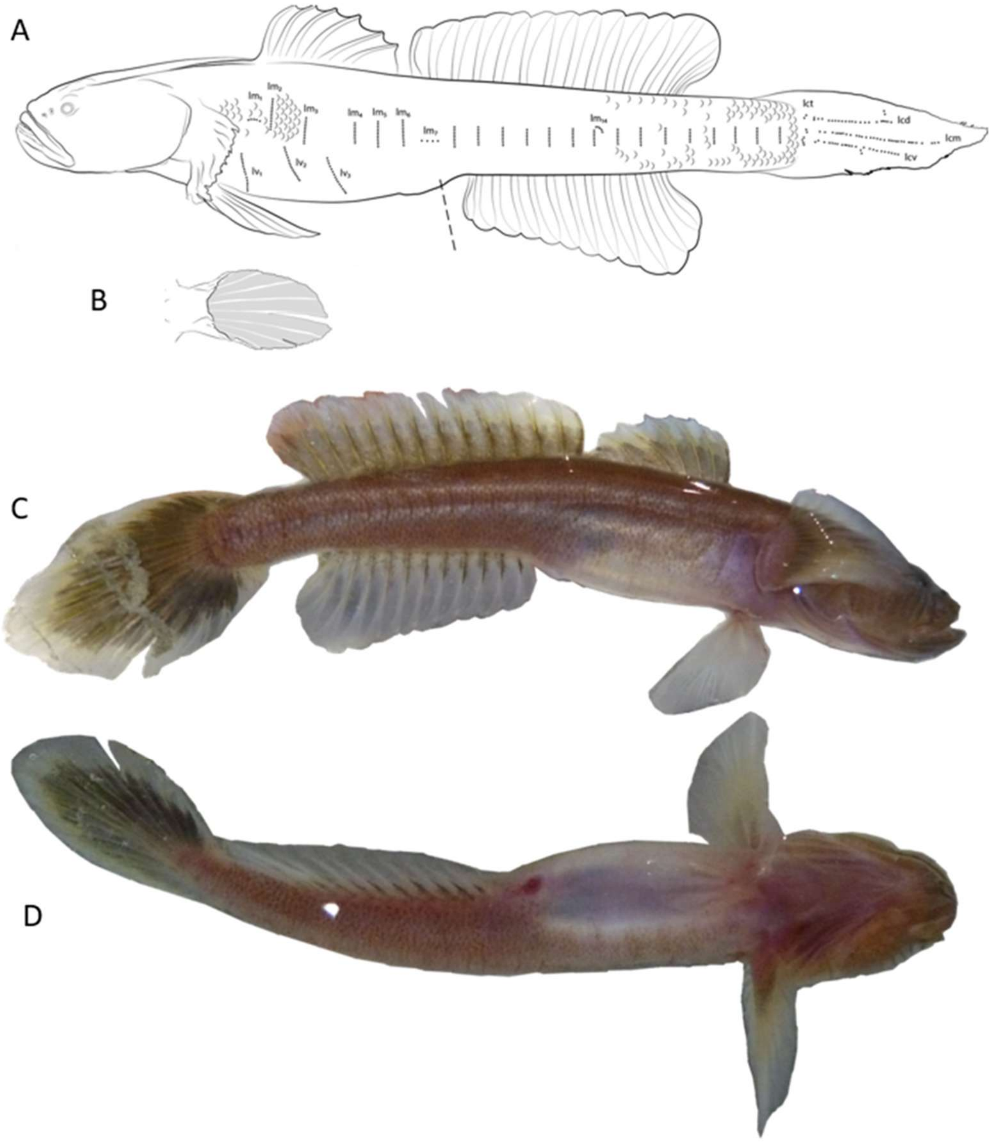

Figure 3: *Didogobius lanceolatus* sp. nov. (SMF 39647, male, 65.1 + 20.6 mm, Mauritania, southern Banc d´Arguin, holotype, **A**: Schematic drawing of fins, trunk squamation, trunk lateral line system sensory papillae, left lateral view (abbreviations and nomenclature of lateral line system based on Sanzo (1911) and Miller (1986)) **B**: pelvic fin disc, ventral view (Drawing by R. Böhmer) **C**: right lateral view, **D**: ventro-lateral view; images of live specimen in seawater (Photos: André Freiwald and Lydia Beuck).

Fins. D1 VI; D2 I/13 (last bifid); A (left/right) I/11; P (21,21); V (left/right) I/5 + 5/I; C (branched/segmented rays) 17/17; upper and lower procurrent rays: 7/8; total caudal rays: 32. Fin lengths and proportions are given in Table I. First D1 slightly shorter than second spine, third to sixth spines becoming progressively shorter; interdorsal space not distinct (fin folded without fin membrane, thus membrane connection between D1 and D2 not discernible without damaging specimen); longest D2 rays not reaching base of uppermost caudal fin rays. A originates posterior of vertical through D2 origin; C lanceolate, longer than head length; uppermost rays of P not free of membrane, P not reaching D2; V complete and elliptical with ray 1 to ray 5 becoming progressively shorter, and a well-developed anterior pelvic membrane (frenum), its height in midline approx. half of V spine length and at its lateral margins approx. 3/4 of V spine length (ventral fin membrane slit along midline).

Table 1: Morphometric measurements and meristic counts of *Didogobius lanceolatus* sp. nov. following Schliewen & Kovačić (2008)

	Holotype		
	mm	% of SL	% of HL
Total length (TL)	86.55	-	-
Standard length (SL)	67.78	-	-
Head length (HL)	16.56	24.4	-
Snout length	4.71	6.9	28.4
Eye (horizontal diameter)	1.58	2.3	9.5
Eye (vertical diameter)	1.26	1.9	7.6
Interorbital distance	4.62	6.8	27.9
Pre-anal length	32.94	48.6	-
Pectoral fin length	11.50	17.0	-
Pectoral fin height	7.44	11.0	-
Pelvic fin length	11.71	17.3	-
1st dorsal fin length	10.50	15.5	-
2nd dorsal fin length	26.62	38.3	-
Pre-1st-dorsal fin length	22.85	33.7	-
Pre-2nd-dorsal fin length	34.23	50.5	-
Anal fin length	17.99	26.5	-
Caudal fin length	18.77	27.7	-
Body height at anus	10.27	15.2	62.0
Body height at pectoral-fin base level	10.19	15.0	-
Caudal peduncle length	9.16	13.5	-
Caudal peduncle height	6.38	9.4	-
Meristics			
First dorsal fin (D1) spines	VI		
Second dorsal fin spine and rays	I,13		
Anal fin rays	I,11		
Pectoral fin rays	21,21		
Pelvic fin rays	I,5		
Branched/Segmented caudal fin rays	17/17		
Upper/Lower procurrent rays	8/7		
Vertebrae	10+17=27		

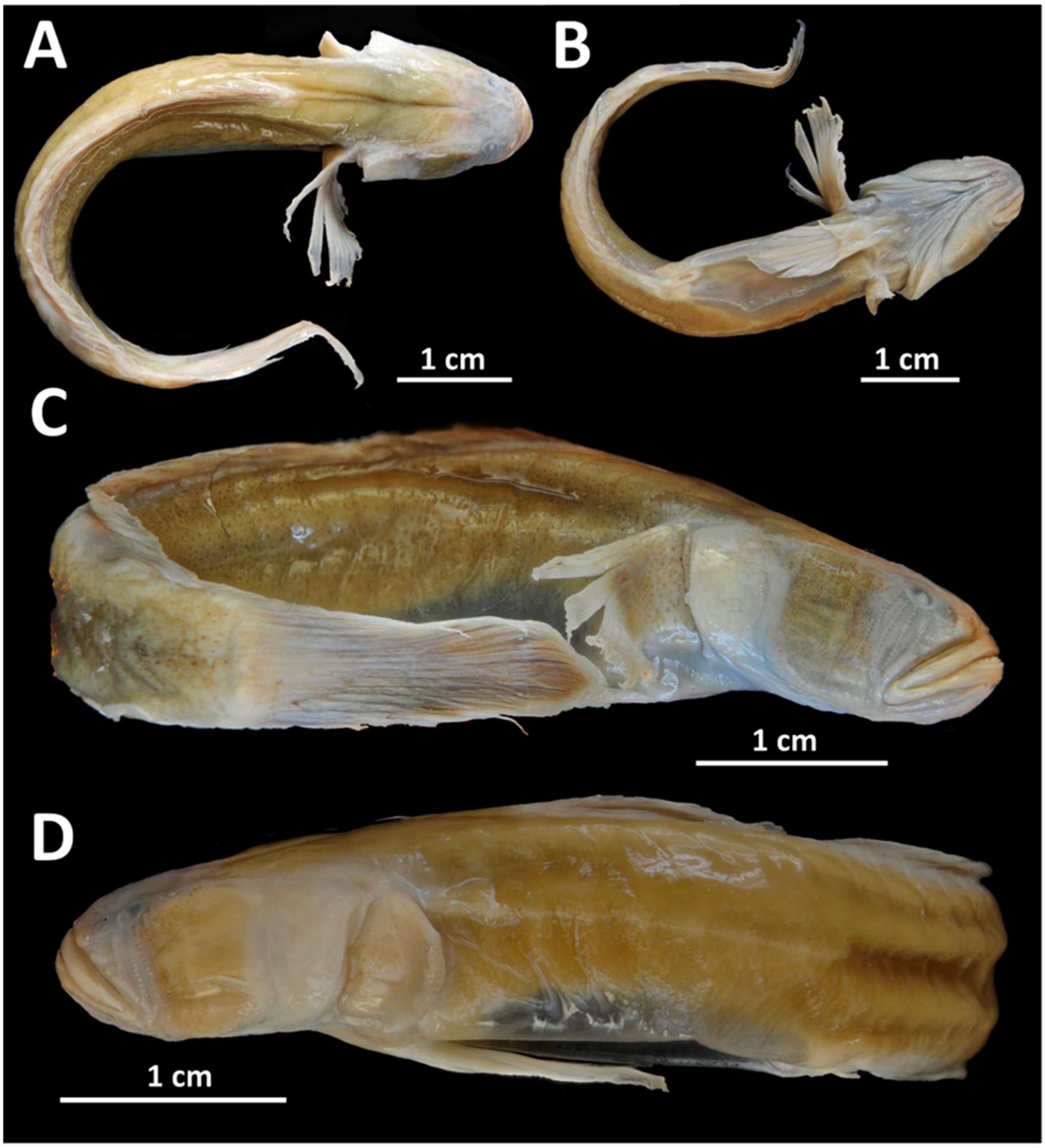

Figure 4: *Didogobius lanceolatus* sp. nov. (SMF 39647, male, 65.1 + 20.6 mm, Mauritania, southern Banc d´Arguin, preserved holotype), **A**: dorsal view, **B**: ventral view, **C**: right lateral view, D: lef lateral view, blueish hue on breast and head are an artefact after cyan-blue staining © Nicol Mahnken and Alexander Knorrn.

Scales. Body squamation apparently strongly reduced. Head, predorsal, prepectoral, breast and abdominal area without externally visible scales. Flanks without externally visible scales except for a patch of thin cycloid scales behind P origin and on dorsal, caudal and ventral areas of caudal peduncle. On the photograph of the freshly collected specimen, however, darkly pigmented areas are visible on the flanks, which most likely correspond to scales deeply embedded into the flank skin, remnant “empty” scale pouches after scale loss due to sampling, or just relict pigments patches after regressive evolution of scale cover.

In the preserved holotype no clearly discernible scale pouches were visible despite clearly discernible flank neuromast rows.

Teeth. Teeth in lower jaw in two rows. Outer row with five (left side) or six (right side) comparatively large-sized anterior teeth frontally on each side, caniniform, pointing slightly backwards. Inner anterior teeth smaller and conical, numerous, more or less in one row in anterior position; the three or four innermost of inner row large, caniniform. Teeth in upper jaw in three rows. Outer row with approximately ten teeth of about equal size on each side, the anterior three ones on each side large and caniniform, the posterior-lateral ones medium to small, decreasing in size posteriorly; second row a rather broad band of small conical teeth; innermost third row consisting of only three large strongly recurved canine teeth across dorsal midline (one visible on left, two on right side).

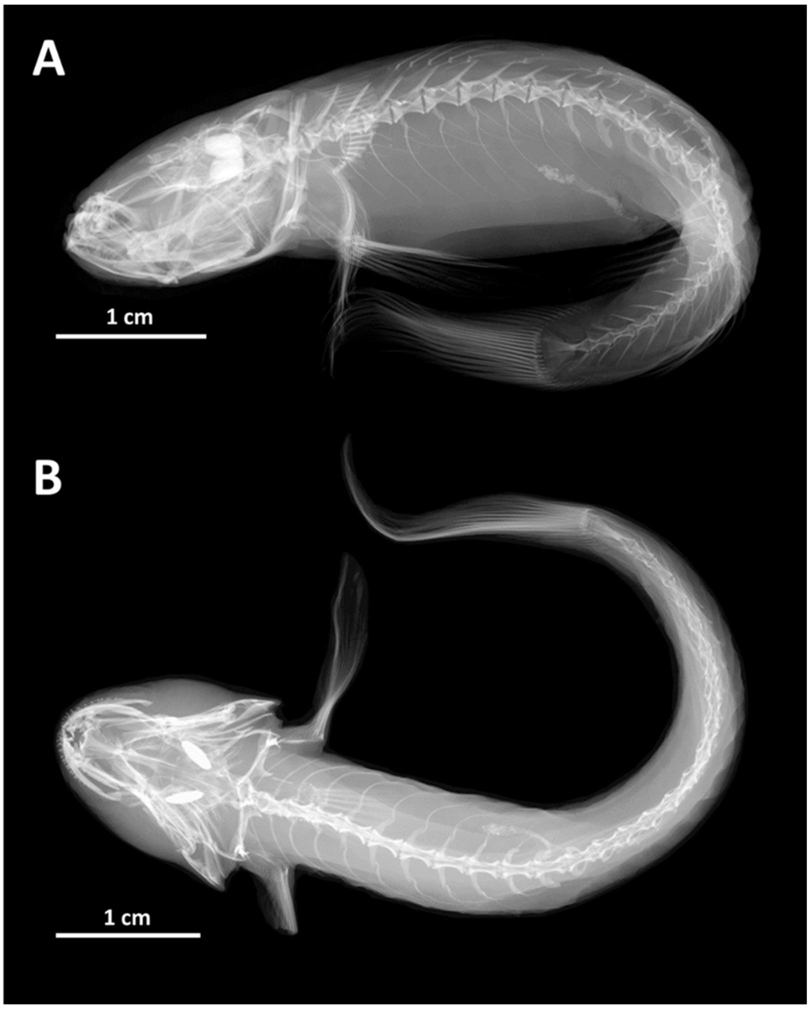

Figure 5: *Didogobius lanceolatus* sp. nov. (SMF 39647, male, 65.1 + 20.6 mm, Mauritania, southern Banc d´Arguin, radiograph of the holotype). **A**: left lateral view, **B**: ventral view (X-rays: U. Schliewen).

Osteology. Vertebral column and pteryghiophore insertion pattern (pty) (Fig. 5). 10 precaudal and 17 caudal vertebrae (including urostyle), total count: 27. Pty 3-22110; two pterygiophores anterior to the first haemal spine. Two epurals. Number of C rays total branched rays: 17, Upper procurrent rays: 8, lower procurrent rays: 7.

Lateral line system (Figs. 3, 5, 6). Head with anterior oculoscapular canal with pores σ, κ (merely visible), α, ρ. Posterior oculoscapular canal and preopercular canal absent. Rows and number of sensory papillae, counted on left and right side of holotype are: (I) preorbital: snout with four rows in median preorbital series. Row r (9,9) median to pore σ. Upper row s1 (11, 6) transversal near posterior nostril, lower s2 (6,4) near anterior nostril, and s3 longitudinal above upper lip (8,8). Lateral series c in four parts: superior c2 as two rows, internal row between posterior and anterior nostrils (4,4), external row (8,7); middle transversal c1 (6,5) below anterior nostril; inferior upper c2 (7,8) and lower c1 (4, 4) as two rows between lips and row 1. (II) suborbital: six transverse and two longitudinal rows of sensory papillae on cheek. Rows 1,2,4 and 5 before longitudinal row b; row 6 divided by row b in superior (6s) and inferior sections (6i); row 7 near pore α. Row 1 (12,13) slightly in front of eye orbit. Rows 2 (15,17) below center of orbit, row 4 (16,15) slightly anterior to rear margin orbit, row 5 (21,21) starting slightly posterior to rear margin of orbit, row 6 starting with row 6s (15,12) well behind rear margin of orbit and ending ventrally below level of row d with lower extension of row 6i (12+7,13+6), row 7 with more than one single papilla (6,5). Longitudinal row b (14, 15). Longitudinal row d subdivided into anterior section d1 (11,10), starting parallel to upper lip starting anterior to row 1 and ending at end of row 2; d; middle section d2 (9,6) between end of row 2 and end of row 5; and posterior section d3 (4,4) between end of row 5 and mid of row 6i, (III) preoperculo-mandibular: external row e slightly separated into an anterior section e1 (32,30) and a posterior section e2 (25,27); internal row i continuous (18 (21 incl. paired papillae), 19(24 incl. paired or tripled papillae); papillae 1, 9, 15 being paired on left side and papillae 1, 9, 18 and papilla 19 tripled on right side, row f longitudinal long (17,16) with anterior 10 papillae arranged in oblique paired order and posterior papillae linear. (IV) oculoscapular: anterior longitudinal row x1 (19,17), located between rows n and tr; posterior longitudinal row x2 (5,5) above transversal row y (5,4) which is directly below center of row x2 and not separated from it; transversal row z (13,13) originating dorsally before pore ρ and descending to level of row b but separated from posterior end of latter; transversal row q (6, 5) behind pore ρ; row u as one large papilla behind row q; transversal row tr (7,6) slightly distant from posterior end of row x1; a single large papilla below anterior part of row x2. Axillary papillae transversal axillary rows as1 (7, 9), as2 (7,-6), as3 (9, 9) present, and longitudinal rows la1 (4,4) between as1 and as1 and la2 (3,3) between as2 and as3. (V) opercular: transverse row ot (28,-27); superior longitudinal row os (11,-11); and inferior longitudinal row oi (7, 6); two large papillae present on the place of absent preopercular canal pores ε and δ. (VI) anterior dorsal: transversal row n (11, 10) long, posterior to interspace between pores α and κ; transversal rows o (5, 5) divided from each other; longitudinal row g (8, 7) ends posteriorly to center of row o, longitudinal row m behind row g (/, 4, i.e. counted on right side only), longitudinal row h not continuous (5+4, 5+4 extending anteriorly from origin of D1. (VII) Interorbital papillae absent. (VIII) Trunk. lm series in 22 (left) or 21 (right) predominantly transverse rows along midline from behind pectoral fin origin to before caudal fin origin; only lm1 and lm7 longitudinal; lm neuromast counts (starting anteriorly): lm1 (5, 6), lm2 (13, 13), lm3 (11,8), lm4 (9,9), lm5 (11,10), lm6 (11,11), lm7 (4 or 5,4), lm8 (9,9), lm9 (8,8), lm10 (8,8), lm11 (7,8), lm12 (8,8), lm13 (8,8), lm14 (7+8), lm15 (8,7+5), lm16 (7,8), lm17 (7,8), lm18 (6 7), lm19 (7,6), lm20 (7,7), lm21 (7,7), lm22 (7, n/a); rows lm14 (left side) and lm15 (right side dorso-caudally prolonged into a curved series of 5 papillae and dorsally extended after a gap with additional two neuromasts; lv series in three transverse rows: lv1 (15,14), lv2 (15,12) and lv3 (15,15). (IX) Caudal fin. Three longitudinal rows lc on caudal fin: lcd (22, the first two neuromasts arranged transversally; two additional neuromasts dorsally of terminal part of lcd); lcm (33); lcv (23) two additional neuromasts ventrally of middle section of lcv at about half caudal fin length); one transverse row lct (8).

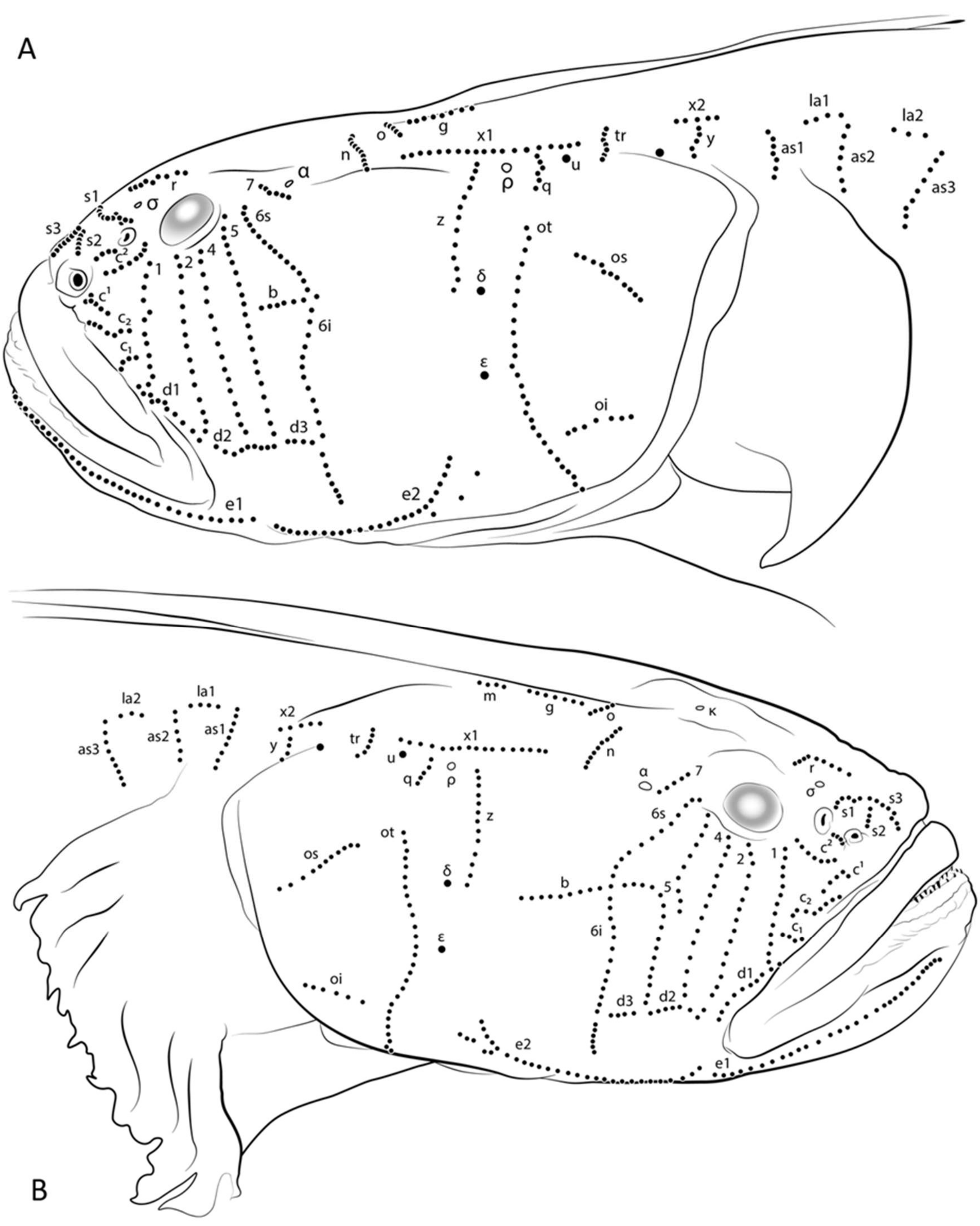

Figure 6: *Didogobius lanceolatus* sp. nov. (SMF 39647, male, 65.1 + 20.6 mm, Mauritania, southern Banc d´Arguin, Head lateral line neuromasts and canal pores, holotype, **A**: left lateral view, **B**: right lateral view (abbreviations and nomenclature of lateral line system based on Sanzo (1911), Miller (1986) and Schliewen et al. 2018; Drawings by R. Böhmer).

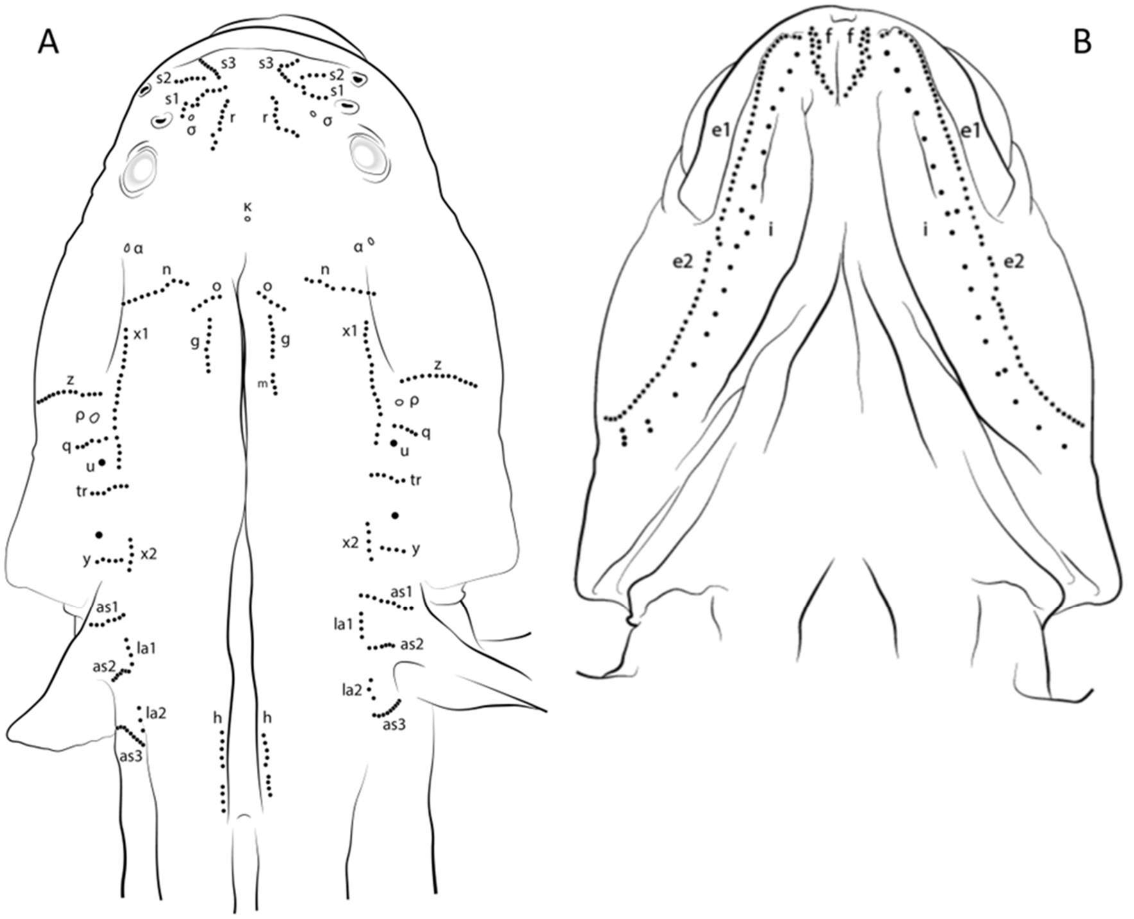

Figure 7: *Didogobius lanceolatus* sp. nov. (SMF 39647, male, 65.1 + 20.6 mm, Mauritania, southern Banc d´Arguin, Head lateral line neuromasts and canal pores, holotype, **A**: dorsal view; **B**: ventral view (abbreviations and nomenclature of lateral line system based on Sanzo (1911) and Miller (1986)); drawings by R. Böhmer).

Coloration. In life (based on photographs of holotype exposed to seawater (Fig. 2) shortly after capture). Flank ground coloration pale rosy with a dusky-grey hue, with superficial neuromast (rows lm and lv) clearly distinguishable as tiny black papillae rows, and each presumable scale (or scale pocket) with as a grey little spot. Basal two thirds of D1 and D2 greyish-beige opaque with spines and rays and their immediate surroundings distinguishable as greyish-black vertical lines; outer third of D1 and D2 white. Basal third of A beige-opaque with rays distinguishable as narrow greyish-black vertical lines; outer two thirds whitish-opaque with areas of rays dusky-grey. Base of C pale rosy as flank, central area blackish-grey becoming beige-grey more caudally, outer quarter of C as a broad white caudal fin margin. Abdomen whitish-translucent with the silvery shining peritoneum visible through skin in lateral view; ventral abdomen, breast and isthmus translucent, rendering the abdomen light grey, the breast reddish and the isthmus whitish-grey. Pelvic disc and pectorals opaque whitish-grey, central area of pectoral with a yellowish-beige tinge closing basally with a dark grey area around pectoral fin base. Head coloration light beige with snout, jaws and branchiostegal rays dark grey; head neuromasts visible as black dots and dot rows. Preserved in ethanol (based on photographs of holotype (Figs. 3)). Body and head beige with scattered melanophores visible on flanks, predorsal head region and pectoral fin base. Fins, operculum, suborbital and ventral head region opaque whitish. Belly translucent. Iris dark. First dorsal fin with oblique dark band in middle. Second dorsal fin with widely scattered dots and narrow dark upper margin. Anal fin lightly pigmented. Caudal fin transparent. Pectoral fins transparent, few melanophores visible. Pelvic fins transparent with a few melanophores on spines.

Etymology. Latin for “with a little lance”, derived from Latin lanceola, a diminutive term of lancea, meaning “lancet”, i.e. a small lancet. An adjective referring to the lancet-shaped caudal fin of the new species, a character shared in the *Chromogobius-Didogobius* species complex only shared with the type species of the genus *Didogobius, D. bentuvii*.

Distribution. The location where the only individual of the new species of *Didogobius* described herein was detected is situated at a shallow, muddy area adjacent to the continental slope of Mauritania. There, the waters are characterised by the large Canary Upwelling System (12-43°N), causing a massive production of phytoplankton, which fuels species richness and abundance, especially the one of fish (Carlier et al. 2015).

Ecology. As known for other members of the subfamily Gobiinae, such as, e.g. *Lesueurigobius* species (Malm, 1874) (Rice & Johnstone 1971) and also presumed for the congener *Didogobius bentuvii* based on morphological similarities with unrelated burrowing goby genera (see Miller 1966), we suppose for *Didogobius lanceolatus* sp. nov. a cryptobenthic lifestyle, living at least temporarily sheltered in soft sediment burrows. This species had remained undescribed and just was an accidental finding collected with (silty) mud where the individual could not be documented on the grab sample surface but was found during post-processing/sieving process. Indeed, its inconspicuous body and fin coloration resembling the habitat substrate, its relatively small eye diameter, elongate body, lanceolate caudal fin and squamation with numerous minute cycloid scales and the large sensory papillae on head further support this burrowing ecology hypothesis. The sediment sample contained agglutinated worm tubes and shells of *Atrina chautardi*. Live associated fauna comprised a second unidentified fish species and beyond abundant polychaetes, gastropods, bivalves, amphipods and shrimps. A potential burrow-dwelling lifestyle might provide shelter against predators on this relatively flat seafloor lacking any hard substrates. In addition, it should be mentioned that the presumed crypto-benthic lifestyle of *D. lanceolatus* sp. nov. is supported by the fact that no other individual of this species has been found so far. This may also be the case with *D. bentuvii*, who seems to display a similar burrowing lifestyle (Miller 1966) of which only the holotype is currently accessible to scientists.

Generic reassignment taxa excluded from *Didogobius*

As mentioned above, with the restriction *of Didogobius* to the new species, *D. bentuvii, D. schlieweni* and *D. kochi*, several species are now excluded from *Didogobius* and thus in need generic reassignment, i.e. (i) the two shrimp-associated species *D. amicuscaridis* and *D. wirtzi*, and (ii) the banded species *D. splechtnai, D. helenae* and *D. janetarum*. Since both these species-groups are unambiguously diagnosable on the basis of multiple previously established characters (see character compilations in Schliewen & Kovačić 2008, van Tassell & Kramer 2004, Schliewen et al. 2018) the following diagnoses are provided for these two species groups and they are formally assigned to two new genera, *Marcelogobius* gen. nov. and *Peter* gen. nov., respectively:

Marcelogobius Schliewen gen. nov.

Type species: *Didogobius splechtnai* Ahnelt & Patzner 1995 based on the holotype (NMW 92804, 22.7 mm SL) and six paratypes (19.4 to 27.8 mm SL), collected by R. A. Patzner near Portinatx, Ibiza island, Balearic islands, Spain, in submarine caves between 7 to 11 m in September 1991 and 1992.

Diagnosis of *Marcelogobius* gen. nov.: Gobiinae sensu Pezold (1993) with the following characters shared by all currently valid members of the genus: (1) suborbital papillae without row a; (2) six suborbital transverse rows, row 3 missing, last row 7 represented by a single papilla near pore α; (3) suborbital row 5 long, from near eye to near row d; (4) paired rows of interorbital transversal papillae absent; (5) head naked, predorsal area naked or scaled in front of D1 origin; (6) no mental barbels; (7) pelvic disc complete with fully developed anterior membrane (frenum); (8) anterior oculoscapular canal present with pores σ, λ, κ, ω, α, β, ρ, or absent; preopercular canals present or absent, posterior oculoscapular canal absent; (9) D2 branched rays ≤ 11 and A branched rays ≤ 10; (10) first D1 ray longest; (11) posterior nostril tubular.

Etymology. The generic name Marcelogobius gen. nov. honours the Croatian biologist, Marcelo Kovačić, who is the leading active goby expert for the Eastern Atlantic, Mediterranean and Ponto-Caspian region.

Included species: the type species, *M. splechtnai* (Ahnelt & Patzner, 1995) nov. comb., *M. helenae* (van Tassell & Kramer, 2014) nov. comb., and *M. janetarum* Schliewen, Wirtz & Kovačić 2018 nov. comb.

Peter Schliewen gen. nov.

Type species: *Didogobius wirtzi* Schliewen & Kovačić 2008 based on the holotype (ZSM 36566, 30.5 mm SL) and the paratype (SMNS 26370, 26.6 mm SL), collected by P. Wirtz at Bay of Tarrafal, Santiago Island, Cape Verde islands over mixed sand and coral rubble bottom in 16 m depth in August 2007.

Diagnosis of *Peter* gen. gen. nov.: Gobiinae sensu Pezold (1993) with the following characters shared by all currently valid members of the genus: (1) suborbital papillae without row a; (2) six suborbital transverse rows, row 3 missing, last row 7 represented by more than three papillae near pore α; (3) suborbital row 5 long, from near eye to near row d; (4) paired rows of interorbital transversal papillae absent; (5) head naked, predorsal area naked or scaled in front of D1 origin; (6) no mental barbels; (7) pelvic disc complete with fully developed anterior membrane (frenum); (8) anterior oculoscapular canal present with pores σ, λ, κ, ω, α, β, ρ; preopercular canals present, posterior oculoscapular canal absent; (9) D2 branched rays ≤ 11 and A branched rays ≤ 10; (10) second D1 ray longest or as long as first D1 ray; (11) posterior nostril flat; (12) flank coloration of with brown bands and broad white interspaces.

Etymology. The generic name Peter gen. nov. refers to the same first name of two outstanding goby enthusiasts at the same time, i.e. first Peter J. Miller, the British goby systematicist, who has contributed particularly to the knowledge of European and African gobies more than any other goby scientist; and second, Peter Wirtz, the tirelessly diving German naturalist and biologist, who discovered dozens of new animal species in the marine waters of the eastern tropical Atlantic, including the two shrimp-associated goby species *Peter amicuscaridis* nov. comb. and *Peter wirtzi*. nov. comb.. Gender masculine.

Included species: the type species, *P. wirtzi* (Schliewen & Kovačić, 2008) nov. comb. and *P. amicuscaridis* (Schliewen & Kovačić, 2008) nov. comb..

9.6 Discussion

The type species of *Didogobius, D. bentuvii*, is known from a single specimen collected in the southeastern Mediterranean Sea close to the entry of the Suez Canal, and its phylogenetic relationships were difficult to determine at the time of description of *Didogobius* (Miller 1966). Albeit deemed unlikely, a relationship with Indo-Pacific goby genera rather than with other Eastern Atlantic, Mediterranean or Ponto-Caspian ones could not be excluded with certainty (Miller 1966). Later, more newly described goby species shared character states with the *D. bentuvii*, but several character states remained unique for *D. bentuvii* (Ahnelt & Patzner 1995, Miller 1992, van Tassell 1988, van Tassel & Kramer 2014, Schliewen & Kovačić 2008, Schliewen et al. 2018). The discovery of a first *Didogobius* species sharing most of these unique characters with the *Didogobius* type species, e.g., the minute eyes, lanceolate fin and pale coloration in combination with its eastern Atlantic distribution and with its molecularly relationships with eastern Atlantic and Mediterranean *Didogobius and Chromogobius* species supports Miller´s preferred hypothesis that the type species is rather not a Lessespian immigrant but a specialised goby with Eastern Atlantic-Mediterranean relationships. However, the clade combining *Didogobius, Marcelogobius* gen. nov., *Peter* gen. nov. and *Chromogobius* species does not appear to form the sistergroup to the Ponto-Caspian benthophiline gobies but rather represents an ancient Atlanto-Mediterranean lineage within the *Gobius*-lineage (Agorreta et al. 2013, COI-data presented herein), living in subtropical shallow-water and with a presumed cryptobenthic lifestyle Thus, Miller´s alternatively proposed relationship of the type species of *Didogobius* with benthophiline gobies of the Ponto-Caspian, particularly with *Benthophiloides turcomanus* (Iljin, 1941), appears rather based on eco-phentoypic convergence than on phylogenetic relationships. Nevertheless, more data with more goby taxa are needed to consolidate the phylogenetic placement of the *Didogobius-Chromogobius* species complex.

9.7 Acknowledgments

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Chapter 10
Gaidropsarus mauritanicus (Gadiformes, Gaidropsaridae) a new three-bearded rockling from a deep-water coral ecosystem with a genetically verified biogeographical distribution of the genus and notes to its ecology and behaviour

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The format has been adapted to match the thesis

10.1 Abstract

Gaidropsarus mauritanicus sp. nov. is described from one specimen collected via a grab sample from the Tanoûdêrt Canyon (ca. 20° N) off Mauritania at a depth of 595 m. The new species was further observed during eight remotely operated vehicle (ROV) dives along the Mauritanian slope southwards down to the Tiguent Coral Mound Complex (~ 17° N) in a bathymetric range between 613-416 m. It can be distinguished from congeners by a combination of characteristics, including large eyes (38.1% HL), large head (25.8% SL), elongated pelvic fins (35.7% SL), low number of vertebrae (44) and colouration (pinkish with a dorsal darker brownish hue and bright blotches along the dorsal-fin base). A species-delimitation analysis performed with available COI sequences of valid Gaidropsarus species additionally supported the validity of the new species. Video analyses showed a deep-water coral associated and protection-seeking behaviour, which may explain why the species has remained undescribed until now. Additional ROV footage from separate deep-water coral sites in the North Atlantic and Mediterranean Sea further highlights the ecological behaviour and the hidden diversity of bathyal three-bearded rocklings. Here we additionally discuss the biogeographical distribution of all genetically verified *Gaidropsarus* sp., in combination with genetic data and morphological characters. *Gaidropsarus mauritanicus* sp. nov. is closely related to a species from Tasmania (43° S), a geographical point furthest among the studied samples, which may hint to an important influence of (paleo-) oceanography on the distributions of *Gaidropsarus* species.

Keywords: NW Africa, NE Atlantic, species delimitation, micro-CT, x-ray, Tanoûdêrt Canyon, deep-water coral habitat, phylogenetics

10.2 Introduction

The order Gadiformes encompasses some of the most important species for today's commercial fisheries. There are also smaller species, such as the three-bearded rocklings of the genus *Gaidropsarus* Rafinesque, 1810 with nearly no commercial value but a remarkable distribution range. The phylogenetic position of three-bearded rocklings has been subject to much scientific debate, resulting in various classifications, including placement within different family groups such as Gaidropsaridae (Howes 1991; Roa-Varón et al. 2021), Gadidae (Endo 2002; Teletchea et al. 2006; Roa-Varón & Ortí 2009; Nelson et al. 2016), or Lotidae (Van der Laan et al. 2014). The systematics and diversity of *Gaidropsarus* remain unclear, although its placement within the family Gaidropsaridae, along with *Ciliata* and *Enchelyopus*, is well supported by Rao-Varón et al. (2021). Some members of the genus have since been synonymised, such as *Gaidropsarus biscayensis*, which is now considered a synonym of *G. macrophthalmus*, or *G. guttatus*, considered a synonym of *G. mediterraneus* (Barros-Garcia et al. 2018, Orsi Relini & Relini 2014). The genus currently comprises 13 recognised species, including *G. argentatus* (Reinhardt, 1837), *G. capensis* (Kaup, 1858), *G. ensis* (Reinhardt, 1837), *G. gallaeciae* Bañón, Baldó, Serrano, Barros-García & de

Carlos 2022, *G. granti* (Regan, 1903) 2022, *G. insularum* Sivertsen, 1945, *G. macrophthalmus* (Günther, 1867), *G. mauli* Biscoito & Saldanha 2018, *G. mediterraneus* (Linnaeus, 1758), *G. novaezealandiae* (Hector, 1874) *G. pakhorukovi* Shcherbachev, 1995, *G. parini* Svetovidov, 1986 and *G. vulgaris* (Cloquet, 1824).

Rocklings display a wide range of ecological adaptations, inhabiting environments from the intertidal zone to deep-sea habitats and from arctic to temperate and subtropical waters (Bañón et al. 2022). Members of the genus are characterised by a slender, elongated body, a chin barbel, nostril barbels, three barely separated dorsal fins, a long anal fin and a lateral line that is uninterrupted along the entire length of their bodies (Cohen et al. 1990, Svetovidov 1986a). However, Svetovidov (1986b) notes that distinguishing between different species of *Gaidropsarus* can often be challenging.

Due to a lack of comprehensive rockling collections (Balushkin 2009) and no comprehensive barcode library for the genus, the taxonomy of this group is incomplete and inadequately understood. Recent molecular studies (Barros-Garcia et al. 2022) have revealed inconsistencies with the morphology-based taxonomic concept, identified potential new species, and indicated possible synonyms for some shallow-water species. In this study, we confirm the presence of a new species, previously referred to as *Gaidropsarus* sp. 3 in Barros-García et al. (2022), and incorporate it into the existing knowledge regarding the genus, contributing to the advancement of our understanding of rockling taxonomy. The additional analysis of video material from a remotely operated vehicle (ROV) has further allowed the characterisation of its habitat and behaviour. In addition, we have conducted species delimitation analyses for all genetically validated *Gaidropsarus* sp. records available to test this new species hypothesis and compare it with morphological characters. We also mapped all genetically verified records with exact coordinates and extracted from GEBCO (2023) the depth for each record. This has allowed us to characterise biogeographical and bathymetrical patterns on species level and discuss the role of deep-water coral ecosystems in relation to deep-water *Gaidropsarus* species.

10.3 Material & Methods

Study and sampling area.

From October to November 2010, the R/V Maria S. Merian (MSM) Cruise 16/3 PHAETON carried out targeted ROV surveys and sampling off Mauritania (Westphal et al. 2012). Twelve ROV dives were made along an N-S stretch of approximately 353 km (following the 500 m depth contour). They were conducted on submarine canyon flanks and open-slope mound complexes. The spatial coverage stretched from off Cape Blanc (20°14.840' N) southwards to latitude 17°08.203’ N. The holotype was collected in the Tanoûdêrt Canyon via grab with a diverse assemblage of live deep-water fauna on dead coral framework (Station Geo-B: 14802-1; 20°14.791' N 17°40.188' W) at a depth of 595 m (Westphal et al. 2012, Gil et al. 2020; Matsuyama et al. 2015, Sampaio et al. 2022).

The collected specimen was promptly photographed while alive and subsequently preserved in 96% EtOH plus 1% MEK. The preserved holotype underwent further documentation and imaging using a Nikon D700 camera and a digital light microscope (Keyence VHX - 1000D). A tissue sample was obtained from the right flank for subsequent DNA sequencing of the Cytochrome c oxidase subunit one mitochondrial gene (*COI*) (Bold-ID GSRUS149-16), as outlined in Barros-García et al. (2018), where the specimen was initially referred to as *Gaidropsarus* sp. 3.

Ethical statement.

All research was conducted under appropriate research permits granted by the Government of the Islamic Republic of Mauritania. Animal handling was conducted following guidelines of accepted best practice for the focal species.

Morphological measurements.

All measurements and fin ray counts were conducted on the left side of the specimen, following the methodology outlined by Svetovidov (1986a, b). The terminology for the lateral line system employed in this study was adopted from Böhlke (1989). To ensure accuracy, measurements and fin ray counts were obtained by observing the left side of the fish under a stereomicroscope at a magnification of 20x and by using x-ray photography. Morphological features were carefully compared with the comprehensive review of the genus

Gaidropsarus provided by Bañón et al. (2022) and Biscoito & Saldanha (2018), which included data on morphological characters, distribution, and colouration reported in ichthyological literature as well as measurements obtained by Bañón et al. (2022).

X-ray photography and micro-CT scanning.

High-resolution X-ray micro-computer tomography of the holotype was performed with a Zeiss X-Radia Context at the Senckenberg Natural History Collections in Dresden, Germany. The scanning parameters were as follows: duration 3.56 h, 2401 projections, eight frames and an exposure time of 0.6 sec., voxel size 9.1 µm, source voltage and power 70 kV and 6W with a filter LE1. Subsequently, the volumetric data obtained from the scan was post-processed using the Thermo Scientific™ Amira 3D Pro ™ and XFiber software. Additional radiographs were obtained using a Fxitron LX-60 unit.

Phylogenetic analyses.

All publicly available *COI* sequences belonging to Gaidropsarus were mined from the repositories BOLD-Systems and Genbank (August 2023) (Ratnasingham & Hebert 2007, Sayers et al. 2022). After cross-referencing and validation, the dataset comprised 204 Gaidropsarus sequences (see supplemental material). From these, unique haplotypes were retrieved for further analyses (n=47). In addition, a sequence of Atlantic cod (BNSF005-11 *Gadus morhua*) was used as an outgroup for phylogenetic inference. The final alignment was comprised of 48 sequences with a length of 651 nucleotides.

The optimal partition strategy for the data and substitution model was estimated with PartitionFinder v1.1.1 (Lanfear et al. 2012) and jModelTest2 (Darriba et al. 2012, Guindon & Gascuel 2003), respectively. Therefore, the Hasegawa model (HKY) with a Gamma distribution (+G) and a single partition were used as priors for phylogenetic analyses.

Bayesian inference was carried out using BEAST V2.5.2 with two runs of 10 million generations sampling each 1,000 and four independent chains. The convergence of the analyses (EES values > 200) was confirmed with TRACER.1.7.0 (Rambaut et al. 2018). The final consensus tree was obtained after discarding the first 25% of the trees and a posterior probability limit of 0.9 in

TreeAnnotator v.2.4.5 and visualised with FigTree v.1.4.3 (http://tree.bio.ed.ac.uk/software/ figtree/).

A Maximum Likelihood (ML) analysis was carried out using the IQ-tree tool present in XSEDE (3.2.6) in the CIPRES portal with 1.000 rapid bootstrap replicates (Miller et al. 2010). The tree with the highest maximum likelihood was selected as input for the Poisson Tree Processes (PTP) analyses.

Species delimitation analyses.

Six different species DNA delimitation analyses were carried out in the *Gaidropsarus* dataset to test the validity of *Gaidropsarus mauritanicus* sp. nov. Two of them were distance-based; the Barcode Index Number (BIN) available at BOLD systems (https://www.boldsystems.org/) (Ratnasingham & Hebert 2013) and the Assemble Species by Automatic Partitioning (ASAP) available at https://bioinfo.mnhn.fr/abi/public/asap/ (Puillandre et al. 2021). The BIN data regarding *Gaidropsarus* sequences was obtained from BOLD systems (supplemental material). A web server was used to estimate the best data partition with ASAP. To this end, p-distance was applied to the COI alignment without outgroup. The best partition was selected considering the ASAP score and the threshold distance.

Four different approaches were used for delimitation analyses based on phylogenetic trees: bPTP; a variation of PTP that adds Bayesian support values to delimited species (Zhang et al. 2013), mPTP; a multi-rate PTP which includes different levels of intraspecific diversity (Kapli et al., 2017), GMYC; identifies the time threshold that defines coalescent or speciation processes on ultrametric trees (Pons et al. 2006; Fujisawa & Barraclough 2013), and mGMYC; identical to the former, but assuming several coalescence processes across the tree (Monaghan et al., 2009). The webserver (https://species.h-its.org/ptp/) was used for bPTP and (https://mptp.h-its.org/#/tree) for the mPTP, using in both the ML tree as input after removing the outgroup to optimise the results (Zhang et al. 2013). Both GMYC and mGMYC analyses were executed using the R Package “splits” with the function “gmyc” and the functions “method = single" and "method = multiple” for both analyses (Fujisawa & Barraclough, 2013).

Data analysis of ROV dives.

All dives were conducted with the ROV Sperre AS SUB-fighter 7500 DC, operated by Sven Lovén (Centre for Marine Infrastructure at the University of Gothenburg, Sweden). The ROV was equipped with one video camera (720x576 pixels), a high-definition video camera, still camera, halogen lights, sonar, CTD, oxygen metre (optode), two laser points (scaling: 5 cm), five function manipulator and sampler box. A ROV-based positioning system was used and the video footage was linked to the navigation track via time code. During the dive, the video signal was stored in digital Quick Time MPEG-4 format (*.mov) with a resolution of 1280x720 pixels, a bit rate of 100 MB/s and in sequences of each about five minutes. Minifilms with an interval of one second were created for all dives. The ROV navigation track was cleaned with the ArcGIS extension Adelie of IFREMER via manual cleaning and Gaussian smoothing. Observation records of Gaidropsarus individuals were each annotated with habitat type, depth and behaviour. Video clips showing its behaviour were produced with Pinnacle Studio 21.

Mapping of validated records.

To map the geographic distribution of Gaidropsarus species, the specimens with both a validated species assignation and with metadata containing exact coordinates were selected. Thus, the final sub-dataset contained in total 186 *Gaidropsarus* sequences (see supplemental table). After a manual correction of the coordinates due to technical issues (compare row I with K and J with L in Appendix table), all records were plotted in ArcMap (see also Table 3 and Fig. 9).

10.4 Results

Class: Osteichthyes Huxley, 1880
Order: Gadiformes Goodrich, 1909
Family: Gaidropsaridae Jordan & Evermann, 1898
Genus: *Gaidropsarus* Rafinesque, 1810
Species: *Gaidropsarus mauritanicus* sp. nov. Knorrn, Beuck & Freiwald, 2023

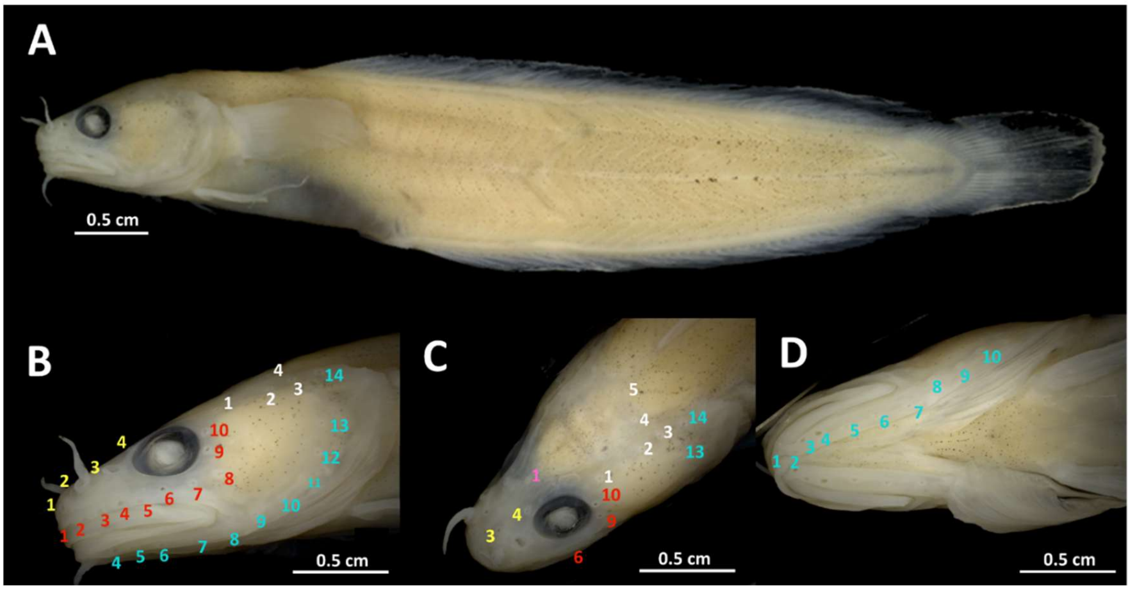

Figure 1: Photography of preserved holotype of *Gaidropsarus mauritanicus* sp. nov. **A**: Overview, lateral view (left side). (**B-D**) Detailed view of head with head lateral line system of *G. mauritanicus* sp. nov.: supraorbital canal (yellow), infraorbital canal (red), supraorbital commissure (pink), temporal canal (white), and preoperculo-mandibular canal (blue). © Alexander Knorrn.

Species identification.

The specimen can be affiliated with the genus *Gaidropsarus* Rafinesque 1810 as it displays the morphological characters previously described by Cohen et al. (1990). These characteristics include the presence of three barely separated dorsal fins, with the first possessing only one single thickened and unsegmented ray, the second having several small and unsegmented rays in a fleshy elongated groove, and the third with segmented rays in an elongated fin. Additionally, the species has three prominent barbels: one located on the chin and one at each anterior nostril on the snout, in addition to a prominent anal fin is a lateral line that is uninterrupted along the entire length of the body.

Gaidropsarus mauritanicus sp. nov. can morphologically be differentiated from all other valid *Gaidropsarus* species: by having 44 vertebrae, which sets it apart from *G. argentatus, G. ensis, G. mediterraneus, G. vulgaris, G. mauli, G. insularum, G. novaezealandiae, G. pakhorukovi,* and *G. parini*. Additionally, *G. mauritanicus* sp. nov. has a longer pelvic fin (35.7% SL) than species with fewer vertebrae, (*G. gallaeciae, G. granti, G. macrophthalmus, G. capensis*); a shorter pectoral fin (13.8% SL) than *G. argentatus, G. gallaeciae, G. ensis, G. macropththalmus* and *G. mauli*. Notably, in having fewer than 45 vertebrae, *G. mauritanicus* sp. nov. forms a clade with *G. gallaeciae, G. macrophthalmus, G.*

capensis and *G. granti*. An overview of the most outstanding morphological characteristics between *G. mauritanicus* sp. nov. and every other valid species is given in Table 3.

Holotype: SMF: 39643 (72.61 mm TL, 62.49 mm SL); Mauritania; Tanoûdêrt Canyon; 20°14.791' N; 17°40.188' W; 595 m water depth associated with deep-water coral fauna; 3rd of November 2010 at 22:33 UTC; André Freiwald & Lydia Beuck leg.; RV Maria S. Merian (MSM) 16/3 grab sample; sta. no. Geo-B: 14802-1; GenBank-ID: KY370534.

Diagnosis.

Gaidropsarus mauritanicus sp. nov. differs from all other 13 valid *Gaidropsarus* species by the combination of the following characteristics: large eyes (38.1% HL) vs. small eyes, relatively large head (25.8% SL), elongated pelvic fin (35.7% SL) vs. medium-sized pelvic fin, small pectoral fin (13.8% SL) vs. enlarged pectoral fin, 44 vertebrae, colouration (pinkish with a darker brownish hue around the dorsal side and brighter dots around the dorsal fin bases) and habitat preference (deep-water coral ecosystems). For detailed comparisons between the species see Tables 2-3.

Description

Body morphology. Morphometric and meristic characteristics of *G. mauritanicus* sp. nov. are given in Table 1. For a general view of the specimen, see Figures 2-4. Body elongated and laterally compressed, head large and moderately compressed (25.8% SL) with dorso-laterally positioned large eyes (38.1% HL). Mouth Inferior with slightly longer upper jaw. Lower jaw extends to posterior end of eye. Snout shorter than eye diameter. Anterior nostrils tubular, with one barbel directly behind each nostril. A third barbel positioned at the tip of the lower jaw. Total vertebrae 44,13 precaudal and 31 caudal (including the urostyle).

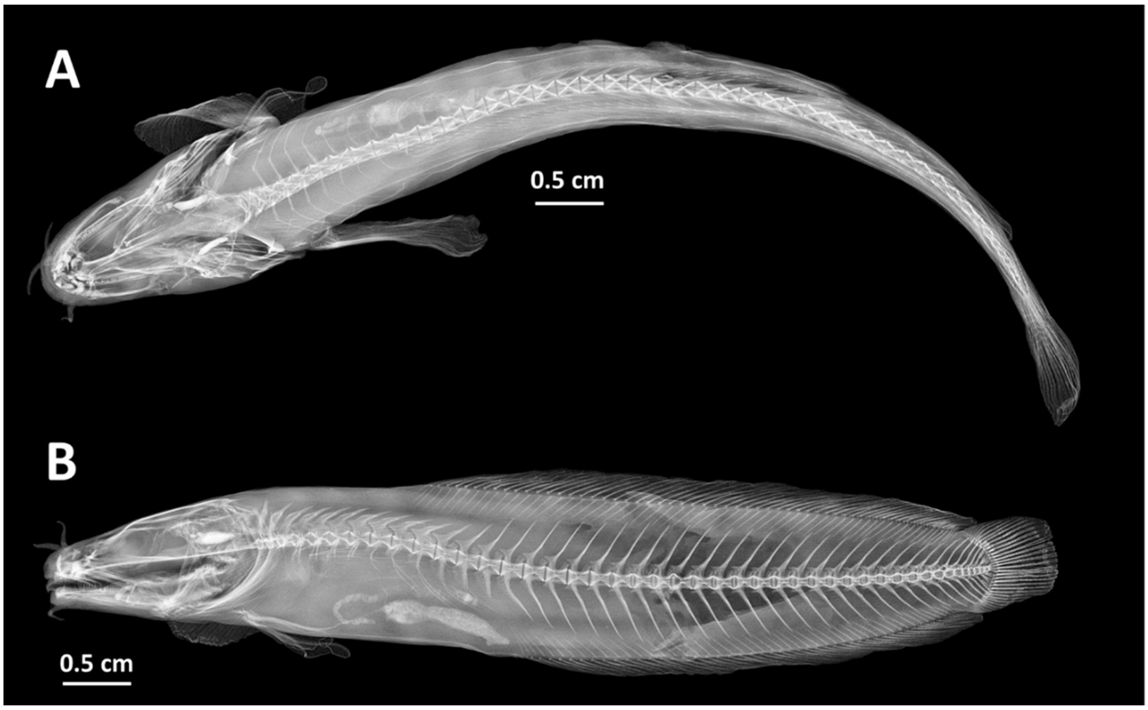

Figure 2: X-ray footage of the holotype of *Gaidropsarus mauritanicus* sp. nov. **A**: Dorsal view; **B**: Lateral view. © Ralf Britz.

Table 1: Morphometric measurements and meristic counts from the holotype of *Gaidropsarus mauritanicus* sp. nov.

	Holotype		
Morphometrics	mm	% SL	% HL
Total length (TL)	72,61	-	-
Standard length (SL)	62.49	-	-
Head length (HL)	16.121	25.8	-
Snout length	4.099	6.5	25.4
Upper Jaw length	6.013	9.6	37.3
Lower Jaw length	5.739	9.2	35.6
Eye (horizontal diameter)	6.142	9.8	38.1
Eye (vertical diameter)	4.174	6.7	25.9
Interorbital distance	3.068	4.9	19
Postorbital length	8.189	13.1	50.8
Pectoral fin length	8.602	13.8	-
Pectoral fin height	4.616	7.4	-
Pelvic fin length	22.283	35.7	-
Prepelvic fin length	13.310	21.3	-
1st Predorsal length	14.248	22.8	-
2nd Dorsal base fin length	10.561	16.9	-
3rd Dorsal base fin length	35.244	56.4	-

3rd Predorsal length	24.871	39.8	-
Anal fin length	30.495	48.8	-
1st ray of 1st dorsal fin length	4.017	6.4	24.9
Body height at anus	0.998	1.6	6.2
Body height at pectoral-fin base level	0.910	1.5	-
Right nasal barbel length	2.208	3.5	-
Left nasal barbel length	2.646	4.2	-
Chin barbel length	3.238	5.2	-
Caudal peduncle length	3.344	5.4	-
Caudal peduncle height	3.844	6.2	-
Body depth	6.124	9.8	-
Meristics			
First dorsal fin rays	1		
Second dorsal fin rays	46		
Third dorsal fin rays	57		
Anal fin rays	53		
Pectoral fin rays	24		
Pelvic fin rays	7		
Caudal fin rays	35		
Gill rakers (outer row)	7-8		
Vertebrae	13+31= 44		

Fin morphology. D1 1, D2 46, D3 57, P 24, V 7, A 53, C 35. Fin length, proportions, and meristics are given in Table 1. Fin ray of D1 fleshy and longer than the following fin rays of D2. Broad pectoral fin and a strongly elongated V. P reaches D3. There is no connecting membrane between D2 and C. A originates posterior of origin of D3. Rounded C which is longer than tall.

Lateral line system. Lateral line is weakly pronounced and consists of five small segments with a pore at the end. The head lateral line system is strongly pronounced and can be seen in Figure 1. Supraorbital canal commissure consists of four pores: the first one close to the tip of the snout, the second slightly behind the first and on the same level as the anterior nostril, the third one higher on the level between the anterior and posterior nostrils, and the fourth at the anterior base of the eye. One single pore is present between the eyes at the supraorbital commissure. Temporal canal possesses five pores: the first post orbital behind the eye, with the second through fifth in a row reaching the end of the operculum and the start of the lateral line. Supratemporal canal possesses one pore on each side of the face in dorsal direction, slightly behind the fourth temporal canal pore. Infraorbital canal has ten pores: the first six pores are located along the anterior margin of the upper labial fold and numbers seven to nine underneath the eye. Number ten is located in a post-orbital position. Preoperculo-mandibular canal has fourteen pores: first in front of the barbel, second to six underneath the lower jaw in a single row, seventh and eighth closely together at the end of the lower jaw, and tenth to fourteenth in a preopercular position.

Dentition. Lanceolate and pointy teeth, pointing slightly backwards. Teeth are present on the premaxilla, mandible, and vomer, as well as on the cerato- and pharyngobranchial tooth plates. Premaxillary teeth are smaller than dentary teeth. The dentition in the upper and lower jaws consists of densely arranged tooth bands. Premaxillary teeth are arranged in four rows. Mandibular teeth are arranged in three rows, where the teeth of the second row are slightly larger than the other. V-shaped vomer possesses two rows of teeth. The most distal tooth is strongly pronounced and canine-like. Pharyngeal teeth are arranged in several rows. The pharyngeal teeth become larger moving from the outside inwards. Gill rakers are present as dentated tubercles along the first branchial arch. There are 7 to 8 gill rakers on the outer row of the branchial arch.

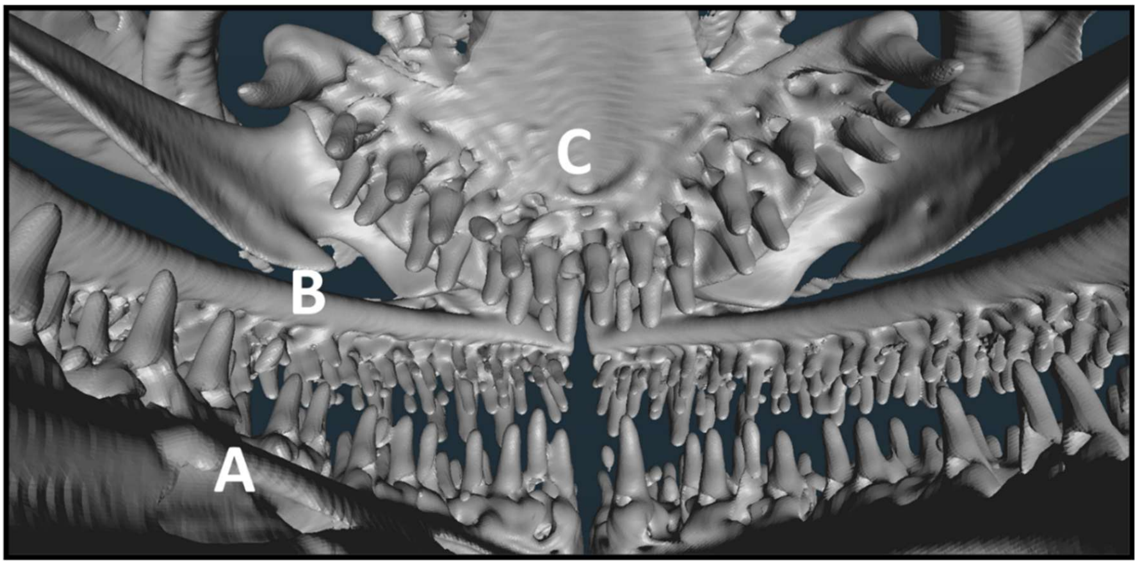

Figure 3. 3D visualisation of head based on micro-CT scan showing the anterior dentition of *Gaidropsarus mauritanicus* sp. nov. **A**: Mandibular teeth arranged in three rows, **B**: Premaxillary teeth arranged in four rows, **C**: V-shaped vomer and its dentition.

Colouration. The characterisation of the in vivo colouration of *G. mauritanicus* sp. nov. is based on the living holotype and additional ROV footage documenting various individuals from deep-water coral ecosystems off Mauritania. Living individuals exhibit a predominantly pinkish hue, with the dorsal side displaying a darker brownish shade than the ventral side, which appears brighter and more pinkish than the lateral side. Older individuals have several pale blotches along the base of the dorsal fins (Fig. 7 E & H). Younger individuals do not possess these blotches (Fig. 4 & 7 A). Notably, the pores of the head lateral-line system exhibit a brighter colouration in contrast to the rest of the head. Conversely, the holotype's colouration, preserved in ethanol (see also Fig. 1), appears opaque, with scattered melanophores sparsely distributed throughout the body. The iris is dark, and the pupil appears turbid and whitish. The fins exhibit opacity at the base and gradually transition to translucency towards the distal ends. No discernible patterns are evident.

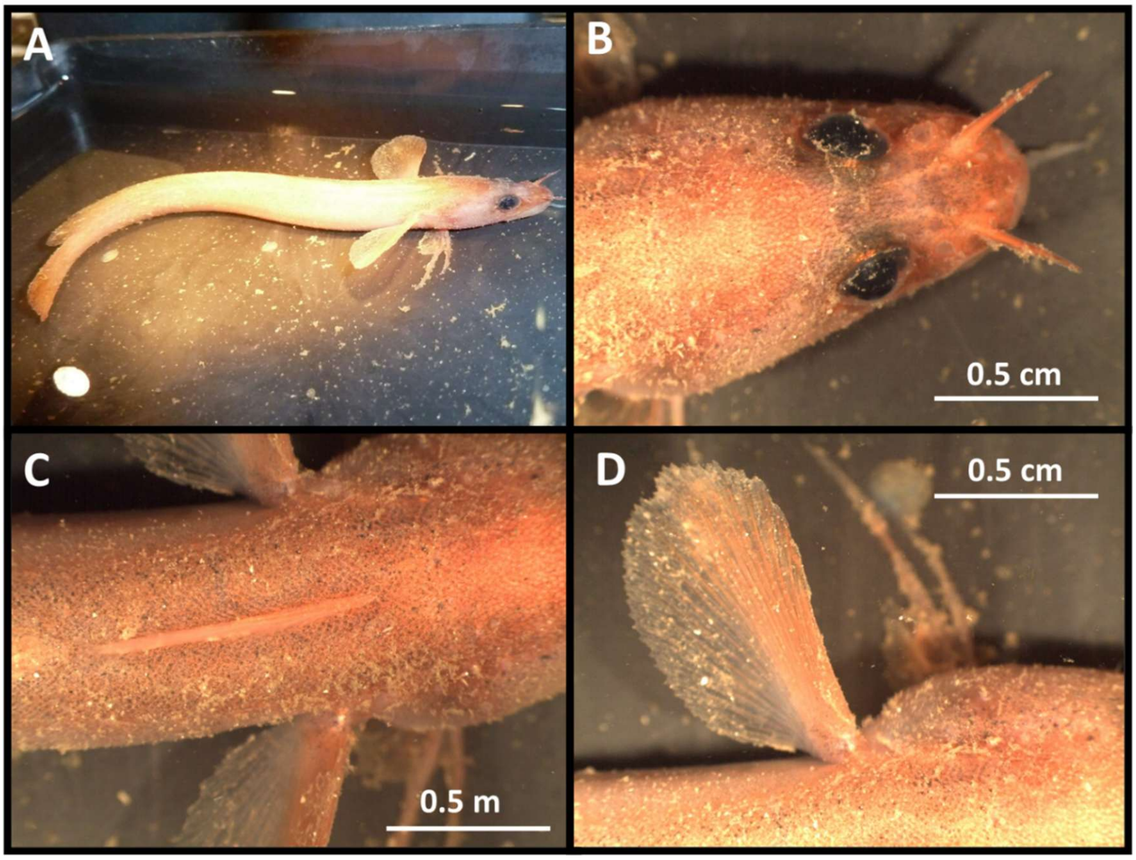

Figure 4: Photograph showing in vivo colouration of the holotype of *G. mauritanicus* sp. nov. in seawater after sampling. **A**: Overview, dorso-lateral side. **B-D**: Details, dorsal view. **B**: Cephalic region. **C**: 1st and 2nd dorsal fin. **D**: Left pectoral fin. © Lydia Beuck and André Freiwald.

Etymology. The species name "*mauritanicus*" is derived from the Latin name of the Islamic Republic of Mauritania, known for its species-rich marine ecosystems, amongst them the most extensive known “chain”-shaped, habitat-forming deep-water coral ecosystem, where this species is associated to.

Comparison with other species. Table 2 presents a comprehensive overview of the morphometric characteristics of *G. mauritanicus* sp. nov., highlighting the key distinctions observed compared to all other species within the genus *Gaidropsarus*, as documented by Bañón et al. (2022). Table 3 additionally incorporates supplementary observations gathered from the study conducted by Biscoito & Saldanha (2018) and Bañón et al. (2022).

Table 2: Comparison of the morphometric and meristic characteristics of *G. mauritanicus* sp. nov. with all 13 valid *Gaidropsarus* species from Bañón et al. (2022) and Biscoito & Saldanha (2018).

As % SL	***G. mauritanicus* sp. nov.**	***G. argentatus***	***G. capensis***	***G. ensis***	***G. gallaeciae***
Head length	25.8	19.7–25.1	19.4–22.5	19–22	21.1–25.2
1st Predorsal length	22.8	20.7–22.6	-	18.7–20.2	21.8–27.7
3rd Predorsal length	39.8	31.7–36.8	-	29.1–32.3	33.7–40.4
2nd Dorsal base fin length	16.9	8.6–11.4	12.2–13.2	8–11.3	9.8–11.7
3rd Dorsal base fin length	56.4	57.1–62.4	-	59.3–64.4	55.9–64.4
Anal base fin length	48.8	38.7–39.8	48.4–49	39.9–46.3	39.6–48
Pectoral fin length	13.8	16.1–18.9	-	17–20	15.3–17.5
Pelvic fin length	35.7	18.1–21.5	-	17–26.3	16.2–19
Preanal length	47.6	51.4–53.4	-	48–50	43.4–49.1
Body depth	9.8	15.6–23.5	16.5–17.3	16.7–25.2	15.7–21.6
Prepectoral length	29.2	20.7–28	-	17.8–21.3	22–27.5
Prepelvic length	21.3	16.9–19.9	-	12.7–16	16.8–21.3
Caudal peduncle height	6.2	5.5–7.4	7–8.1	5.1–7.2	6.2–7.7
As % HL					
Snout length	25.4	25.2–27	28.2–33.2	23.6–27.9	20.9–25
Eye diameter	38.1	14.8–21.8	16.1–20.9	17.3–24.5	15.8–20.5
Postorbital length	50.8	57.3–58.4	-	54.1–59.1	54.7–64.3
Interorbital space	19.0	13.1–23.1	13.5–19.5	14.4–25.1	21.7–28
Upper jaw length	37.3	44.7–47.7	48.8–52.1	45.3–64.8	37.9–47.2
Lower jaw length	35.6	36.6–41.1	-	36.1–60.3	32–40.1
Chin barbel length	20.0	19.8–23.8	-	15.1–20.8	16.7–22.6
1st Dorsal fin ray length	24.9	24.1–43	19.5–32.5	82.1–145.5	15.8–27
Meristics					
Third dorsal fin rays	57	52–65	43–52	52–64	54–60
Anal fin rays	53	43–51	37–43	40–48	44–52
Pectoral fin rays	24	22–25	18–21	20–27	21–23
Pelvic fin rays	7	7–8	6–7	6–7	7
Gill rakers outer row	7-8	8-11	4–9	11–13	7–9
Gill rakers inner row	-	10-11	8–9	12–14	6–9
Vertebrae	44	49–53	41–43	50–54	43–44
Head lateral line system					
SO canals	4	4	4	4	-
IO canals	11	12-13	11	11-12	-
STC canals	1	2	3	2	-
POM canals	14	11-13	13	13-14	-

As % SL	***G. granti***	***G. insularum***	***G. macrophthalmus***	***G. mauli***	***G. mediterraneus***
Head length	20.9–25.5	18.7–21.5	19.3–23.2	23.4–25.4	18.8–24
1st Predorsal length	-	-	20.5–22.9	22.8–23.9	18.6–18.9
3rd Predorsal length	21.1–37.9	-	33.3–38.3	36–36.3	20.1–38.5
2nd Dorsal base fin length	10.7	8.5–9.8	8.6–11.7	-	13.2–18.4
3rd Dorsal base fin length	54.4–59.7	65.1–67.5	55.6–66.3	-	54.1–60.9
Anal base fin length	43.6–45.6	46.4–49.6	48.5–50	-	45–52.2
Pectoral fin length	13.8–15.4	-	14.7–15.5	17.8–19.4	12.3–14.6
Pelvic fin length	15.5–23.1	-	9.6–16.1	27.5–33.3	13–15.5
Preanal length	48.7–54.8	-	44–47.6	50.8–53.1	44.1–51.1
Body depth	13.1–14	-	14.2–19.5	15.2–21.9	14–19.3
Prepectoral length	-	-	19.3–25	-	20.5–22.7
Prepelvic length	-	-	16.3–20.2	-	15–17.2
Caudal peduncle height	5.6–6.9	6.8–8.5	4.8–7.1	5.6–6.8	4.5–6.3
As % HL					
Snout length	19.3–29.2	27.6	21–26	25.4–26.7	18.8–30.4
Eye diameter	13.7–18.8	-	16–23.7	10.4–12	13.3–22.5
Postorbital length	59.6	-	54.3–59.1	-	60.63.5
Interorbital space	10.5–17.6	16.7–19.4	12.5–26.5	20.9–21.3	9.1–25.7

Upper jaw length	42.9	59.2–61.3	46.2–52.9	-	42.9–45.6
Lower jaw length	41.7	48.4–55.1	36.6–44	-	38.9–40.2
Chin barbel length	-	-	14–22.2	26.9	15.3–18.5
1st Dorsal fin ray length	12.7–14.9	11.2–25	10.1–25.1	21.3–25.4	14.9–42
Meristics					
Third dorsal fin rays	55–60	66–70	48–59	57–58	48–63
Anal fin rays	45–52	50–57	40–50	46–47	41–53
Pectoral fin rays	20–22	19–22	17–22	25–26	15–19
Pelvic fin rays	7–8	-	6–7	9	5–8
Gill rakers outer row	10	7	6–9	1+7	7–10
Gill rakers inner row	-	9	8–11	1+8	9-11
Vertebrae	44–47	47–49	43–47	47–48	46–50
Head lateral line system					
SO canals	-	-	4	4	4
IO canals	-	-	12-13	12	12-13
STC canals	-	-	3	2	3 on each side
POM canals	-	-	13	11-13	13

	G. novaezealandiae	*G. pakhorukovi*	*G. parini*	*G. vulgaris*
As % SL				
Head length	17.9–20.7	23.7–24.7	22.1–22.8	23.6–25.9
1st Predorsal length	-	24.4–25.3	17.8–18.5	22.1–24
3rd Predorsal length	-	-	-	36.4–38.1
2nd Dorsal base fin length	-	12.8–15.5	10.4–11.6	11.3–13.9
3rd Dorsal base fin length	58.5–65.3	55.3	56–58.1	54.9–61.1
Anal base fin length	48.2–51.5	41.7	43.8–48.6	40.5–45.3
Pectoral fin length	-	17.7–19.2	17.3–17.8	14.1–15.4
Pelvic fin length	-	-	19.9–20.7	17.4–20.3
Preanal length	-	-	45.2–48.5	48.9–54.8
Body depth	-	-	-	14.8–20.4
Prepectoral length	-	-	-	23.5–25.4
Prepelvic length	-	22.4	-	18.6–20.7
Caudal peduncle height	6.3–8.1	6.5	6.7–7.1	7–8.5
As % HL				
Snout length	-	-	-	21.2–26.6
Eye diameter	15.2–19	17.2–19.8	13.9–16.4	10.5–16.7
Postorbital length	-	-	-	55.3–65.2
Interorbital space	15.2–18.7	16	-	14.4–19.5
Upper jaw length	-	-	-	42.3–49.3
Lower jaw length	-	-	-	36.8–40
Chin barbel length	-	-	-	19.6–24.2
1st Dorsal fin ray length	20–27.9	12–15.1	26.7–28	9.5–16.9
Meristics				
Third dorsal fin rays	56–69	60–62	60–64	56–64
Anal fin rays	50–59	50–51	52–53	46–54
Pectoral fin rays	20–21	22–26	23–25	20–24
Pelvic fin rays	7–8 (5)	7–8	7–8	6–7
Gill rakers outer row	6–8	9	7	7–9
Gill rakers inner row	9–10	9	10	10–11
Vertebrae	46–49	46–47	47–48	46–49
Head lateral line system				
SO canals	4	4	4	4
IO canals	11-13	12	12-13	12-13
STC canals	3	-	3	3
POM canals	13-14	13	13	13

Table 3: Notable morphological characteristics and known geographical and bathymetrical distribution of *G. mauritanicus* sp. nov. compared to the valid species

records of the genus *Gaidropsarus* following Bañón et al. (2022) and Biscoito & Saldanha (2018) indicated by *; depth range information was gathered from Fish Base (Froese & Pauly 2023) indicated by **. Biogeographical distribution of genetically validated *Gaidropsarus* species with World seas names from Flanders Marine Institute (2018), depth infos from GEBCO (2023) with records >0 listed as 0, exact depth mentioned in metadata from samples in brackets; Province (Ecoregion(s)) after Spalding et al. (2007).

Species	***Differentiating characteristics from *G. mauritanicus* sp. nov.**	***Geographical distribution and **depth [m]**	**World seas and GEBCO depth [m]**	**Province (Ecoregion(s))**
***G. mauritanicus* sp. nov.**	Large eyes (38.1.% HL), long pelvic fin (35.7% SL), low number of vertebrae (44)	Eastern central Atlantic 595	Eastern North Atlantic Ocean 622 (595)	West African Transition (Sahelian Upwelling)
It differs from other valid *Gaidropsarus* species by having:				
G. argentatus	Longer 2nd dorsal fin (16.9% SL vs. 8.6-11.4% SL), longer anal fin (48.8% SL vs. 38.7-39.8% SL), longer pelvic fin (35.7% SL vs. 18.1-21.5% SL), fewer vertebrae (44 vs. 49-53), smaller upper jaw (37.3% HL vs. 44.7-47.7% HL)	North Atlantic, Off Newfoundland and Labrador and west of British Isles 150-2260	Arctic Ocean; Greenland Sea; Northern Norwegian Sea; Western North Atlantic Ocean; Labrador Sea; North-western Davis Strait 233-2158	Arctic (Western part of North and East Barents Sea; Eastern part of North Greenland; southern part of East Greenland Shelf; Baffin Bay – Davis Strait; Northern Grand Banks – Southern Labrador); Cold Temperate North-West Atlantic (Southern Grand Banks – South Newfoundland; Gulf of Maine/Bay of Fundy)
G. capensis	Larger head (25.8% SL vs. 21.5% SL), more 3rd dorsal fin rays (57 vs. 43-52), more anal fin rays (53 vs. 37-43) and fewer pectoral fin rays (24 vs. 18-21)	South-eastern Atlantic and South-western Indian Ocean From tide pools to 50	-	-
G. ensis	Greater head length (25.8% of vs. 19.7-22.5% HL), shorter pectoral fin (13.8% SL vs. 17-20% SL), longer pelvic fin (35.7% SL vs. 17-26.3% SL), more anal fin rays (53 vs. 40-48), fewer vertebrae (44 vs. 50-54)	North Atlantic, off Newfoundland and Labrador 0-2000	Western North Atlantic Ocean; Labrador Sea; Mid Davis Strait 83-2875	Cold temperate North-West Atlantic (Southern Grand Banks – South Newfoundland; Gulf of St.

				Lawrence – Eastern Scotian Shelf; Scotian Shelf; Gulf of Maine/Bay of Fundy); Arctic (Northern Grand Banks – Southern Labrador)
G. gallaeciae	Longer pelvic fin (35.7% SL vs. 16.2-19% SL), smaller interorbital distance (19.0% HL vs. 21.7-28% HL), different geographical distribution [Although both species are closely related within the genus *Gaidropsarus*, their Cytochrome Oxidase 1 units differ by 4.6% (following Barros-Garcia et al. 2018), providing support for *G. mauritanicus* sp. nov. as a distinct species.]	North-eastern Atlantic, Galicia Bank and Porcupine Bank 751–788	Eastern North Atlantic Ocean 767-1592	Northern European Seas (Celtic Seas); Lusitanian (South European Atlantic Shelf)
G. granti	Longer 2nd dorsal fin (16.9% SL vs. 10.7% SL), longer pelvic fin (35.7% SL–15.5-23.1% SL), more pectoral fin rays (24 vs. 20-22)	South-western Atlantic, in Porcupine Bank (southwest of Ireland), Galicia Bank, Azores, Madeira and Canary Islands and Mediterranean 20-823	Alboran Sea 316-930	Alboran Sea
G. insularum	Longer head (25.8% SL vs. 18.7-21.5% SL), longer 2nd dorsal fin (16.9% SL vs. 8.5-9.8% SL), shorter 3rd dorsal fin (56.4% SL vs. 65.1-67.5% SL	South-eastern Atlantic and South-western Indian Ocean Littoral (tide pools)	-	-
G. macrophthalmus	Longer 2nd dorsal fin (16.9% SL vs. 8.6-11.7% SL), longer pelvic fin (35.7% SL vs. 9.6-16.1% SL), smaller upper jaw (37.3% HL vs. 46.2-52.9% HL), more pectoral fin rays (24 vs. 22), fewer vertebrae (44 vs. 45-47)	North-eastern Atlantic from Faroe Islands and British Isles to south of the Azores and Mediterranean 150-600	Bay of Biscay; Eastern North Atlantic Ocean; Alboran Sea; Mediterranean Sea – Western Basin; Balearic Sea; Tyrrhenian Sea; Mediterranean Sea – Eastern Basin; Black Sea 40-2401	Northern European Seas (Celtic Seas); Lusitanian (Azores Canaries Madeira; South European Atlantic Shelf); Mediterranean Sea (Ionian Sea: Western Mediterranean; Alboran Sea); Black Sea

G. mauli	Smaller pectoral length (13.8% SL vs. 17.8-19.4% SL), greater eye diameter (38.1% HL vs. 10.4-12% HL), higher number of anal fin rays (53 vs. 46-47), fewer pelvic fin rays (7 vs. 9), lower number of vertebrae (44 vs. 47-48)	Atlantic, Azores and Bay of Biscay 870-1500	Bay of Biscay 1229	Lusitanian (South European Atlantic Shelf)
G. mediterraneus	Longer pelvic fin (35.7% of SL vs. 13-15.5% of SL), shallower body depth (9.8% SL vs. 14–19.3% SL), more pectoral fin rays (24 vs. 15–19) and fewer vertebrae (44 vs. 46-50)	North-eastern Atlantic, from Norway and British Isles south to Morocco, including Canaries, Azores and Madeira, Mediterranean Sea and Black Sea 1-450	Eastern North Atlantic Ocean; Bay of Biscay 0-24	Lusitanian (Azores Canaries Madeira; South European Atlantic Shelf)
G. novaezealandiae	Greater head length (25.8% SL vs. 17.9-20.7% SL), lower number of vertebrae (44 vs. 46-49)	South-western Pacific, New Zealand and south of Tasmania 0–50, but two specimens collected at 300–500	-	-
G. pakhorukovi	Shorter pectoral fin (13.8% SL vs. 17.7–19.2% SL), fewer third dorsal fin rays (57 vs. 60 – 62)	South-western Atlantic, Rio Grande Seamount ?-690	-	-
G. parini	Shorter pectoral fin (13.8% SL vs. 17.3 - 17.8% SL), less 3rd dorsal fin rays (57 vs. 60-64) and fewer vertebrae (44 vs. 47-48)	South-eastern Pacific, Nazca Ridge ?-310	-	-
G. vulgaris	Longer pelvic fin (35.7% SL vs. 17.4-20.3% SL), shorter upper jaw (37.3% HL vs. 42.3-49.3% HL), fewer vertebrae (44 vs. 46-49)	North-eastern Atlantic, from Norway and Iceland south to Gibraltar, including Madeira and Mediterranean 10-120	Eastern North Atlantic Ocean; Bay of Biscay; Kattegat 0-100	Lusitanian (South European Atlantic Shelf); Northern European Seas (North Sea)

Genetic species delimitation analysis.

The validity of *Gaidropsarus mauritanicus* sp. nov. has been tested through several DNA-based species delimitation analyses (Fig. 5). Both distance-based methods (BIN and ASAP) agreed into considering the sequence GSRUS149-16

Gaidropsarus mauritanicus sp. nov. as an independent MOTU. Among the tree-based methods, only bPTP showed similar results, while mPTP, GMYC and mGMYC clustered GSRUS149-16 together with *Gaidropsarus gallaeciae* (GSRUS015-16) and an unknown sequence (FOAO845-15) from Tasmania (Figs. 5 and 8).

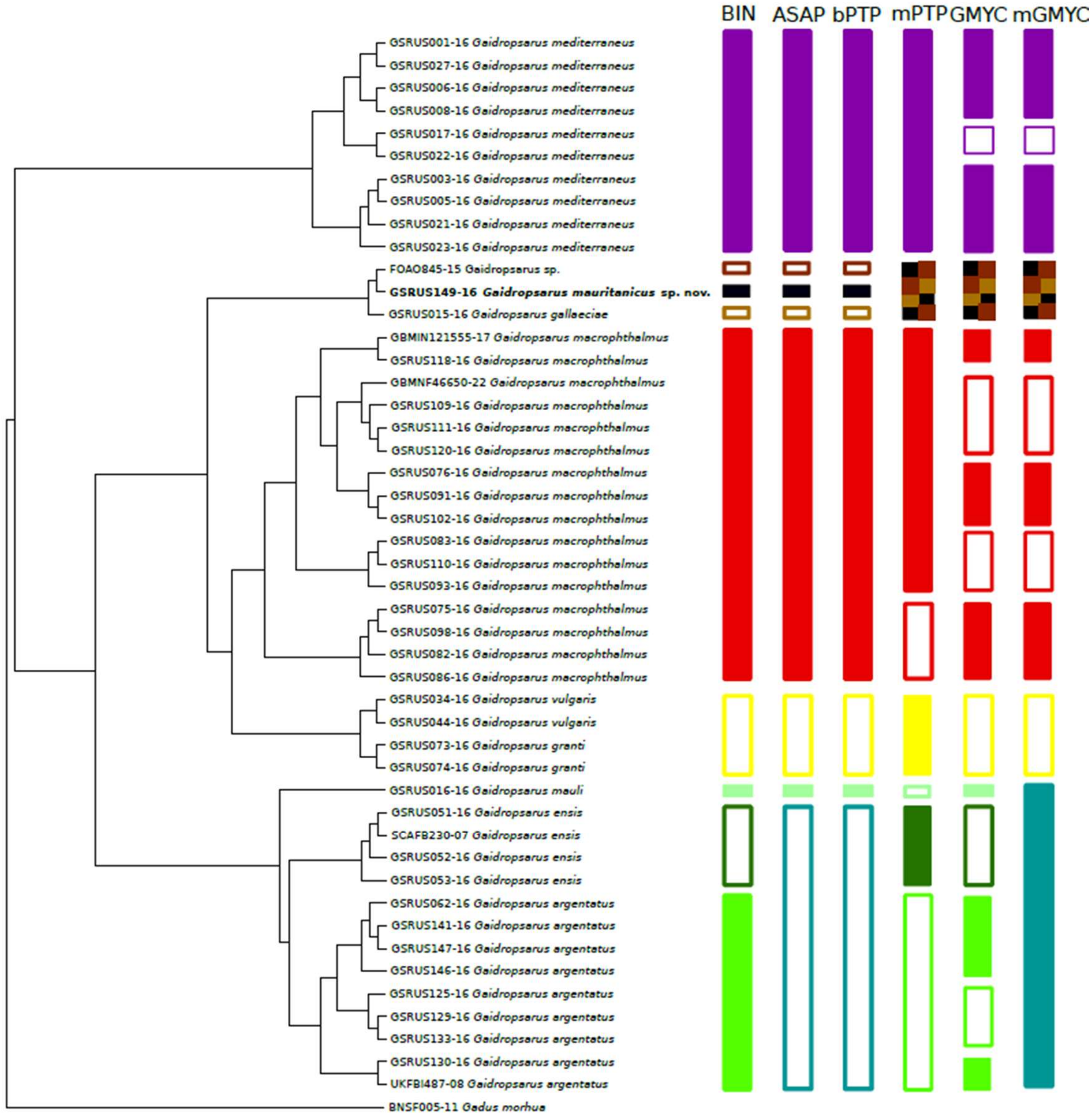

Figure 5: Species delimitation analysis of *G. mauritanicus* sp. nov., including distance-based (BIN and ASAP) and tree-based (bPTP, mPTP, GMYC and mGMYC) methods.

Biogeographical distribution, habitat and accompanying fauna.

The holotype derives from the Tanoûdêrt Canyon, Mauritania, collected in 595 m water depth via grab sampling. The species was additionally observed three times during the ROV dive carried out in this canyon (GeoB 14796-1). The Tanoûdêrt Canyon was the northernmost canyon studied during the MSM 16/3 cruise. The species was further observed during dives in the Timiris Canyon

System – particularly in the Nouamghar (one individual) and Inchiri Canyon (two ind.). Further south, individuals were documented during ROV dives investigating different coral mounds along the “coral mound chain”, namely Timiris (six ind.), Banda (one ind.), Tamxat (five ind.) and Tiguent Coral Mounds (four ind.; see Fig. 6). The deepest record was observed at 613 m in the Tanoûdêrt Canyon, the shallowest at 416 m on the Tiguent Coral Mounds. The temperature range of the 22 presumably *G. mauritanicus* sp. nov. individuals observed was between 9.67 °C (Nouamghar Canyon) and 11.58°C (Tiguent Coral Mounds) and oxygen values were between 1.64 ml/l (Tanoûdêrt Canyon) and 1.12 ml/l (Tiguent Coral Mounds).

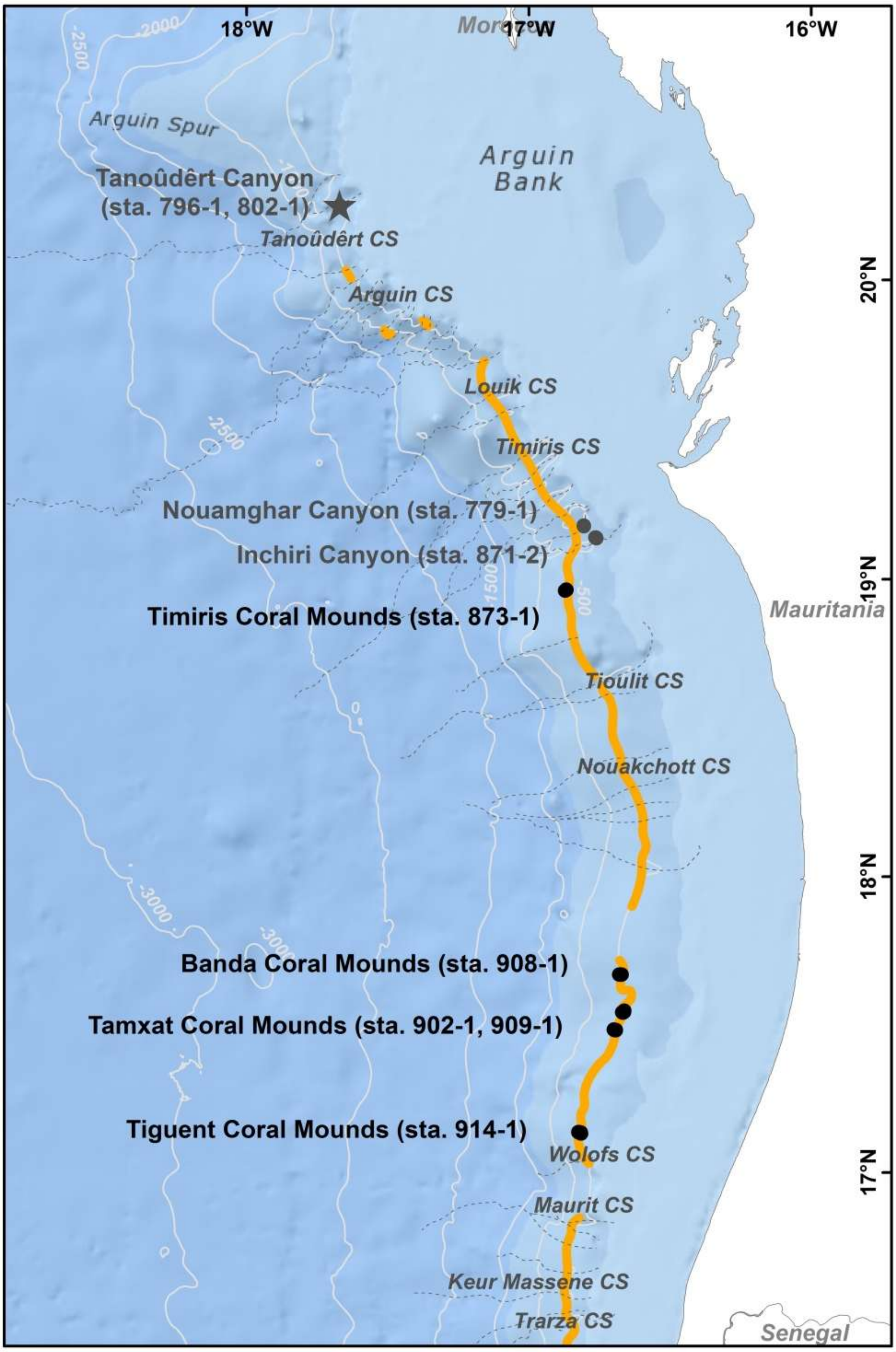

Figure 6: Biogeographical distribution of *Gaidropsarus mauritanicus* sp. nov. along the Mauritanian slope based on MSM 16/3 cruise material with main canyon systems (CS) and habitat-forming deep-water coral distribution (orange). Sampling station of the holotype (asterisk) and observations (dots) during ROV dives with site name and GeoB 14***-* station (=sta). Grey = canyons; black = coral mounds. Basemap from ESRI (2019), contours from GEBCO Compilation Group (2019), scleractinian distribution, canyon position and names from Sanz et al. (2017).

The holotype was collected together with a diverse assemblage of live deep-water fauna, including corals, such as *Desmophyllum pertusum*, *D. dianthus*, *Caryophyllia* sp., and *Swiftia phaeton* as well as larger sponge colonies, bryozoans, ophiuroids, polychaetes, decapods, hydrozoans, gastropods, bivalves and chitons with dead *D. pertusum* framework, coral rubble and olive-coloured silt as substrate (Gil et al. 2020, Matsuyama et al. 201, Sampaio et al. 2022). These findings indicate *G. mauritanicus* sp. nov. as a demersal species associated with deep-water coral ecosystems. This is further supported by ROV footage deriving from the submarine canyons and coral mounds off Mauritania. Individuals exclusively occurred either on dense coral rubble or were associated with dispersed, patchy or dense live and/or dead scleractinian framework.

The distribution of framework-forming deep-water coral ecosystems extends northwards off Western Sahara southwards off Senegal (Wienberg et al. 2023). It can be assumed that future studies will find this species along the slope north and south of Mauritanian waters.

Behaviour.

Individuals observed during ROV dives were mainly resting on the bottom (video MSM16-3_9_14-13_Gaidropsarus_mauritanicus_resting_and_hiding), preferentially associated with live or dead coral framework or framework portions (inside, below or next to), or, in the absence of framework, next to larger protective structures like hard-ground ledges (see Fig. 7). When individuals felt threatened (e.g., by the approaching ROV), they attempted to hide in or below protective structures (see also video MSM16-3_9_14-13_Gaidropsarus_mauritanicus_resting_and_hiding). Observed swimming was fast-paced in minimal altitude over ground and along protective structures (video

MSM16-3_5_12-43_Gaidropsarus_mauritanicus_swimming).

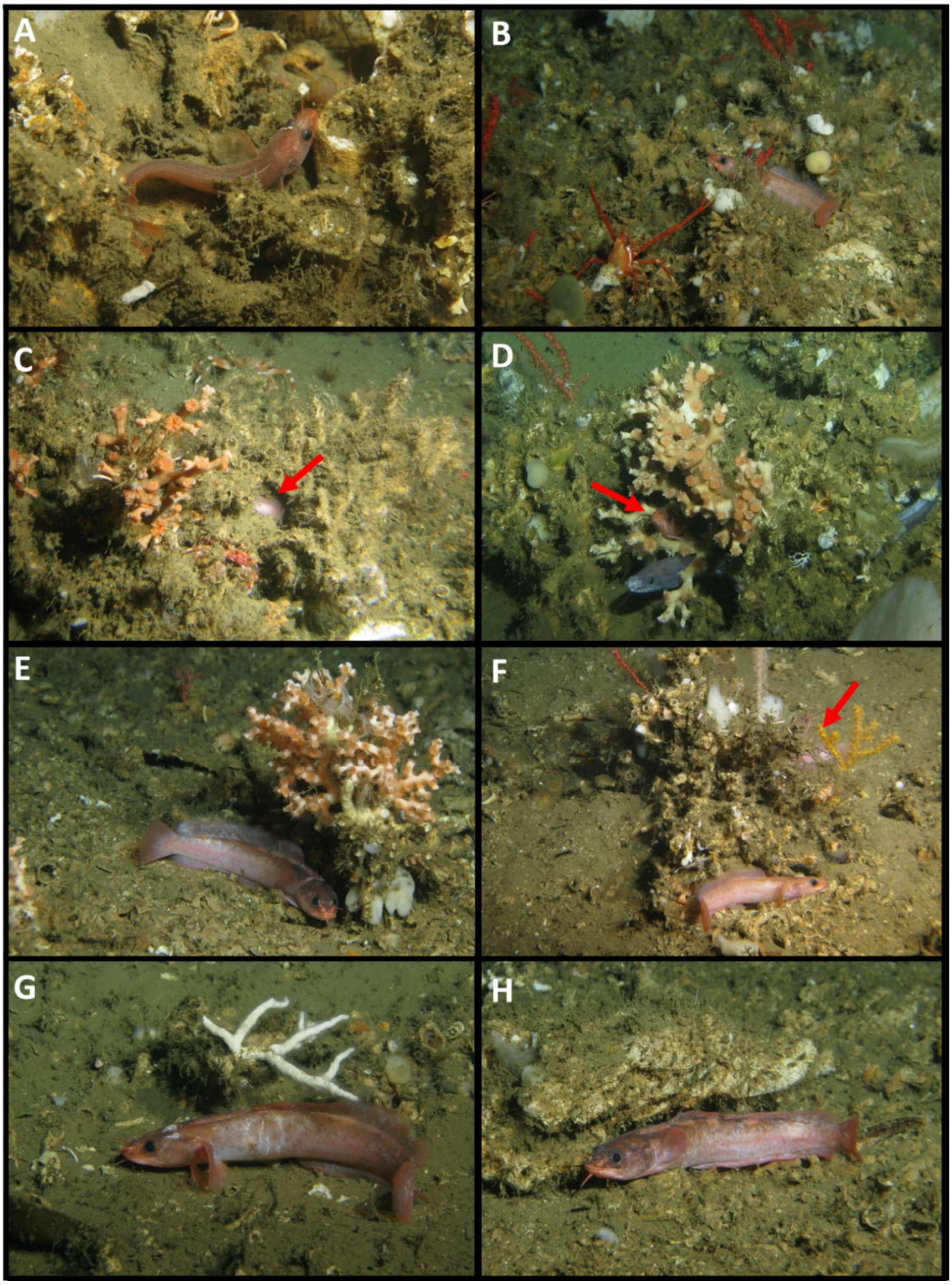

Figure 7: Representative ROV images of *Gaidropsarus mauritanicus* sp. nov. in its habitat (copyright Tomas Lundälv from the Sven Lovén Centre for Marine Infrastructure of the University of Gothenburg, Sweden). **A**: A small individual - similar in size to holotype - between coral rubble (Banda Coral Mounds, 523 m water depth); **B:** Inside a coral garden (*Swiftia phaeton*), sheltered between dead coral framework fragments and rubble (Timiris Coral Mounds, 492 m water depth); **C**: Hiding inside a dead coral framework, see red arrow (Tanoûdêrt Canyon, 610 m water depth); **D**: Co-existence with

cf. *Japonoconger africanus* inside live *Desmophyllum pertusum* framework (red arrow) (Tamxat Coral Mounds, 501 m water depth); **E**: Below protective "canopy" of live *Madrepora oculata* (Tiguent Coral Mounds, 418 m). **F**: Two individuals next to a dead scleractinian framework, which is colonised by sponges and various octocorals, amongst *Swiftia phaeton* (Tamxat Coral Mounds, 535 m water depth; see also video MSM16-3_9_14-13_*Gaidropsarus_mauritanicus*_resting_and_hiding). **G**: Next to a framework fragment, which is colonised by a branched bryozoan (*Celleporina* cf. *lucida*); note the whitish marks on the skin (Tamxat Coral Mounds, 479 m water depth). **H**: Adult individual finds shelter next to hardground ledge; note the slightly varying colouration with respect to young individuals (Tiguent Coral Mounds, 434 m water depth).

10.5 Discussion

Morphological and genetic identification of *Gaidropsarus mauritanicus* sp. nov.

The number of vertebrae divides the genus *Gaidropsarus* into two clades (Bañón et al. 2022), with one clade possessing species with fewer than 45 vertebrae (*G. mauritanicus, G. gallaeciae, G. macrophthalmus, G. capensis*, and *G. granti*) and the other clade with species having 45 or more vertebrae. The new species is further distinguished from all other species by its long pelvic fin, large eyes, and short pectoral fin. The pinkish colouration of *G. mauritanicus* is shared with *G. ensis*, *G. argentatus*, *G. mauli*, and *G. gallaeciae*, but adults of this new species differ from these others by having a brownish hue on the dorsum and several pale blotches along the base of the dorsal fins.

The DNA-based delimitation analyses with a multi-locus approach have already been discussed in Barros-García et al. (2022). Discrepancies have been found, for instance, *COI* had failed to differentiate between the closely related *G. granti* and *G. vulgaris* which are grouped together in all analyses. Similarly, three of the analyses clustered together *G. argentatus* and *G. ensis* which are two valid independent species. These discrepancies highlight that single locus results must always be interpreted cautiously and integrated with other available data (e. g. morphology, ecology), testing multiple methods to assess congruence among them, a widely used approach in species delimitation analysis (Rannala, 2015).

Both distance-based methods (BIN and ASAP) agree with the morphospecies *Gaidropsarus mauritanicus* sp. nov.; whereas three out of four tree-based methods (mPTP, GMYC and mGMYC) combined *G. mauritanicus* sp. nov. with *G. gallaeciae* and a third unknown individual (FOAO845-15). Distance-based approaches rely on a threshold value to determine whether a pair of specimens belong to the same species; values higher than optimal merge different species, while a lower value will split species into two or more (Ratnasingham & Hebert 2013). A study comparing *COI* sequences representing more than 2000 animal species found that 98% of pair-species comparisons showed divergence values over 2%, except cnidarians, and therefore proposed the 2% value as a threshold for delimitation for animal species (Hebert et al. 2003). The genetic distance between *G. mauritanicus* sp. nov. and the two most close sequences range from 4.76 to 4.92% (data not shown). It is not surprising therefore, that BIN analysis clustered them independently since the threshold applied in BIN analyses is 2.2% (Ratnasingham & Hebert 2013). Similarly, the threshold used in the selected partition of ASAP is 3.3%, which explains the similarity in the results. Even when the genetic distance between *G. mauritanicus* sp. nov. and *G. gallaeciae* is lower (4.92%) compared with the average genetic distance among *Gaidropsarus* species (around 10-15%) (Barros-García et al., 2018), it is adequate to be considered a separate species from a DNA-barcoding standard (Hebert et al. 2003). Several hypotheses can explain the disparity observed in genetic distances among *Gaidropsarus* species; from recent speciation, to a past introgressive event, but more evidence should be obtained to test these theories.

Instead of a threshold, tree-based approaches rely on the evolutionary history of the selected marker. However, this is a potentially problematic assumption if the gene does not reflect the species´ evolutionary history and speciation, especially when using a single locus-approach (Sagorny et al. 2019). PTP uses the expected number of substitutions to estimate branch processes, but is limited to two independent distributions (one for speciation and one for coalescence) which ignore variation among species due to different population sizes and demographic histories, in contrast to the mPTP (Kapli et al. 2017). mPTP works under the same principles, but allows more than two independent distributions through the tree. Nevertheless, mPTP can be less suitable for datasets with incomplete sampling, i.e., cluster together taxa on long branches with no close relatives in the dataset (Servis et al. 2020).

In the present study four putative species are represented for a single individual, including *G. mauritanicus* sp. nov., *G. gallaeciae* and FOAO845-15 which are clustered together by GMYC and mGMYC. GMYC analyses use maximum likelihood and an ultrametric tree to find branch patterns to model the difference between speciation events and neutral coalescence within species (Blair & Bryson 2017). Traditionally, GMYC has been considered a tool with a tendency to over-split, and therefore, it is useful to find cryptic species when morphospecies are divided into several units (Ceccarelli et al. 2012). This over-splitting phenomenon has been previously observed in *Gaidropsarus* (Barros-García et al. 2022). Collapsing sequences to haplotypes is a common approach for GMYC analyses for less demanding computational methods, and there is no evidence of different results when non-collapsed and collapsed datasets are compared (Talavera et al. 2013). However, a high presence of singletons in the data (a single representative for species) will lower the portion of the tree that provides information to the GMYC mode (Lim et al. 2011). Nevertheless, some studies concluded that singletons are not a problem as long as other better represented taxa can allow for the calibration of the divergence (Reid & Carstens 2012). This might not be the case, since the dataset presented here could show more recent speciation events among some species (i.e. *G. mauritanicus* sp. nov. and *G. gallaeciae*) than others. Moreover, since recent studies have highlighted the presence of unknown diversity in *Gaidropsarus*, we can consider the phylogenetic inference incomplete due to undersampled taxa (Barros-García et al. 2022, 2018, Biscoito & Saldanha 2018). Therefore, the results obtained with GMYC and mGMYC should be interpreted cautiously and compared with separate analyses.

Of particular note is that from all genetically studied samples, *G. mauritanicus* sp. nov. is genetically most closely related to a species from the Huon Marine Park, Tasmania (43°58’ S, 147°32’ E) from 180-237 m depth (Process ID FOAO845-15) (Figs. 5 & 8), which is from biogeographical point the most distant among the studied species. So far, two species could potentially be considered for this haplotype, especially – with regard to depth – *G. novaezealandiae* (300-500 m) and *G. parini* (310-610 m) could be potential species of the undetermined sample. Looking more closely at the colouration of the animal after it was frozen for 8 years (pers. communication J. Pogonoski 31.08.2023) (Figure 8 A), one can see a golden body colouration with many dark pigments on the dorsal side of the animal and comparatively smaller ones towards the lateral and the ventral side. This colouration is very similar to the colouration of an individual identified and photographed as *G. novaezealandiae* in Fishes of Australia (*Gaidropsarus novaezealandiae* in Fishes of Australia, accessed 11 Sep 2023, https://fishesofaustralia.net.au/home/species/2856). However, no reliable identification can be made based on colouration alone. The individual also has 46 vertebrae, suggesting *G. novaezealandiae* instead of *G. parini*. Further, an individual with chocolate-brown skin colouration identified as *G. novaezealandiae* is listed in the Natural History Museum collection with the collection number 2019.8.15.4 (see https://data.nhm.ac.uk/object/15c6390c-230e-4b8f-b575-111e7084fd4c/1694563200000; Retrieved: 13 Sep 2023 11:26:45 (UTC). It was collected in a rock pool near the harbour of Tristan da Cunha Island (37°03’51’’ S 12°18°45’’ W). However, a chocolate brown colouration from *G. novaezealandiae* was additionally reported from Svetovidov (1986b) from an individual preserved in ethanol. Therefore, a detailed morphometric analysis will clarify its species affiliation in the future.

Figure 8: *Gaidropsarus* sp. from the Huon Marine Park, Tasmania (sampling location: 43° 58’ S, 147° 32’ E; Process ID: FOAO845-15, Collection ID: CISRO H 7737-01). **A**: Photography of the collected individual after it was frozen. Taken by Carlie Devine (CSIRO Australian National Fish Collection). **B**: X-ray photography taken by John Pogonoski (CSIRO Australian National Fish Collection).

However, apart from the Tasmanian sample, there is no publicly available genetic data on *Gaidropsarus* species from the southern hemisphere. Future studies might clarify a potential influence by southern oceanographic features, such the Antarctic Circumpolar Current, as “highways” for larvae to the northern hemisphere. The second genetically closely related species is *G. gallaeciae*, which morphologically resembles *G. mauritanicus* sp. nov. very closely. Its close relation could be explained by the distribution of the Poleward Undercurrent Flow (PUC) (see e.g., Versteegh et al. 2022).

Biogeographical distribution, habitat and behaviour of *Gaidropsarus mauritanicus* sp. nov.

In addition to the holotype sampled in the Tanoûdêrt Canyon, 22 individuals were documented during ROV dive analyses off Mauritania, amongst also upward the southern flank of the Tanoûdêrt Canyon (station GeoB 14796-1). The upper slope and outer rim of the canyon shoulder, features the largest and most flourishing coral reef constructions seen on the entire MSM 16/3 expedition. The Tanoûdêrt Canyon System (TanCS), is the northernmost Mauritanian canyon system – situated off Banc d’Arguin, about 70 km southwest of Cape Blanc. The TanCS is included in an exceptionally productive area, belonging to the along-slope upwelling region (Hernández-León et al. 2007; Peña-Izquierdo et al., 2012). These canyons constitute the northern limit of the most productive area from the Mauritanian slope, called the ‘tongue of the Banc d’Arguin’, where very high values of density and biomass of fishes and cephalopods are located in a continuous band that extends from the shelf to the deep slope (Ramos et al. 2017), thus making this a site the most promising region to encounter *G. mauritanicus* sp. nov.. However, just three individuals could be documented during the ROV dive in the Tanoûdêrt Canyon, supporting our presumption that this methodology does not reveal the existing amount due to the high habitat complexity in combination with the sheltering behaviour of the species. Therefore, we have not conducted any statistical analysis on the observation data and have chosen to remain on a descriptive level to characterise its distribution, habitat and behaviour.

One of the individuals was observed with whitish coloured marks on its skin and was the only individual associated with a branched, live bryozoan of whitish colour (*Celleporina* cf. *lucida*), grown on a dead coral framework fragment. The distinctive marks, in addition to the preferred resting behaviour of the species in protective places might also indicate territoriality for this species. The protective habitat of *Gaidropsarus mauritanicus* sp. nov., combined with its “guarded” behaviour, could be why this species has remained undescribed until now and why we are unable to add paratypes to the species description.

Deep-water coral ecosystems are known as biodiversity hotspots in the deep, although only a few fish species are known to be exclusively associated with these ecosystems. Despite this, high numbers of gravid female redfish (*Sebastes norvegicus* (Ascanius, 1772)) on Norwegian *Desmophyllum pertusum* reefs imply that deep-water coral ecosystems may provide an essential habitat as spawning sites or nursery areas for juveniles (Husebø et al., 2002, Costello et al. 2005). It is possible that the three-dimensional structure of a deep-water coral habitat allows a variety of animals to use these structures to find hiding places from predators or to raise their offspring protected and close to food. As these habitats can usually only be studied at great expense due to the need for specialised research vessels and specific sampling gear (Caiger et al. 2021), little is known about deep-water coral habitats and their inhabitants compared to shallow-water coral habitats. There are still huge gaps in our knowledge, especially in the behaviour and ecology of such deep-water coral-associated species.

Biscoito and Saldanha (2018) report from *G. mauli* an opportunistic feeding behaviour, which is supported by the analysis of gut contents collected from several individuals. The guts contained crustacean and fish, which were known to live in close association with hydrothermal vents but also deep-water coral reef associated fauna. We presume a similar feeding habit for *G. mauritanicus* sp. nov. living in deep-water coral ecosystems. An opportunistic feeding habit and protection-seeking behaviour might also be supported by its elongated body. Additionally, there is also a potential sensitivity gain in having an elongated body, and this may be an important factor in the evolution of elongated bodies (Priede, 2021), including those seen in the genus *Gaidropsarus*. However, the genus is also characterised by an interrupted lateral line. Whether or not these interruptions of the lateral line are useful for perception cannot be answered with the current level of knowledge and requires further investigation.

Distribution and genetic relationship of *Gaidropsarus*.

Members of *Gaidropsarus* inhabit a remarkable variety of ecosystems in both the northern and southern hemisphere. They range from shallow-water areas to deep-sea hydrothermal vent fields and coral ecosystems, and from the Arctic to subtropical marine ecosystems. In Figure 9 all genetically validated *Gaidropsarus* records with published sampling coordinates are mapped (see Appendix, Table 1). So far, two boreal species (*G. argentatus* and *G. ensis*) have been identified genetically in the western North Atlantic, partly co-occurring and both with broad bathymetric distributions (Table 3) *G. argentatus* dominates in Arctic waters and *G. ensis* in Labrador waters (see Fig. 9B). Genetically, the closest relative of the boreal species is a Gaidropsarus specimen sampled from the deep northern Bay of Biscay (from approximately 1229 m depth), recently identified as *G. mauli* (Bold-ID: GSRUS016-16, Collection-ID: MNHN-IC 2004-1517). So far, this record represents the only COI sequence of *G. mauli*, but the species was further reported from the Lucky Strike vent site on the Mid-Atlantic Ridge and the Blackmud Canyon at the slope of the Bay of Biscay, however, to date without any further genetic data (Biscoito & Saldanha 2018). A comparison of the genetic data indicates that ancestors of *G. mauli* might have migrated to the Northwest Atlantic, resulting in the two boreal species over time. This would imply a palaeoceanographic situation that has enabled an E-W biogeographic spread, opposite to the present situation in the Bay of Biscay (e.g., Pingree 1973, van Aken 2000, Mulder et al. 2011).

Genetically verified records of the eurybathic species *G. macrophthalmus* depict a wide biogeographical distribution in the north-eastern Atlantic, mainly occurring in the Mediterranean Outflow Water. *G. macrophthalmus* is further present in the Mediterranean Sea and in the Black Sea. It is worth noting that its Black Sea records are still listed in BOLD systems as *G. mediterraneus*. In contrast, the genetically verified distribution of *G. mediterraneus* is so far just reported from to the coastal waters off the Azores (Portugal), off Concarneau (France) and off Galicia (Spain), at the latter two sites co-occurring with *G. vulgaris*. Due to species delimitation analyses, we transferred all records for *G. mediterraneus* from the Mediterranean Sea to the species *G. macrophthalmus* (see Figure 5 and Appendix table). The current identifications of *G. mediterraneus* and *G. macrophthalmus* might have used the first available sequences as a reference, and if these were incorrectly identified, this could have a negative impact on further genetic identifications. Genetic data would therefore be biased and could explain the differences in the representation of the distribution of the two species. The lack of *G. mediterraneus* individuals plotting in the Mediterranean and Black Sea can also be a sampling bias; however, both species appear similar in colouration at first glance, based on the literature (Cohen et al. 1990, Bañón et al. 2022). Therefore, it is important to refer to other morphological characteristics when differentiating between *Gaidropsarus* species, e.g., the eyes in *G. macrophthalmus* are much larger ("eye large, more than half the snout length" (Cohen et al. 1990, Svetovidov 1986a)) than those of *G. mediterraneus*. In addition, *G. macrophthalmus* has "enlarged" canine teeth compared to *G. mediterraneus*. To address this question in future research and validate the publicly available sequences, type material of both species should be used for additional sequencing. This would ensure that the sequences indeed correspond to the respective species. The second verified species from the Mediterranean Sea is *G. granti*. Unfortunately, only few records of this species exist and they all plot in the bathyal Alboran Sea near deep-water coral occurrences (see also Freiwald et al. 2021).

Our depth extraction from GEBCO (2023) for all records shows that *G. mediterraneus* and *G. vulgaris* have been so far just verified from coastal shallower zones down to 120 m (see Table 3). For *G. vulgaris* the northernmost, genetically verified record is Kattegat.

Furthermore, the colouration of *Gaidropsarus* individuals, which have previously been studied, shows a clear visual separation between dark skin with bright mottled markings for *G. mediterraneus* (including the synonym *G. guttatus*) in contrast to bright skin with or without darker (mainly brownish) mottled markings for the rest. This visual separation is also mirrored in the genetic relationship of the species analysed (see Figure 5). In addition, *G. macrophthalmus* is most closely related to *G. vulgaris* and *G. granti* and all are characterised by a bright skin with strong or light darker mottled markings. The boreal species all share a strong pinkish skin colouration, and *G. gallaeciae* and *G. mauritanicus* sp. nov. possess pinkish skin. For some *Gaidropsarus* species, juvenile individuals can be coloured differently than adults, which holds also for *G. mauritanicus* sp. nov.

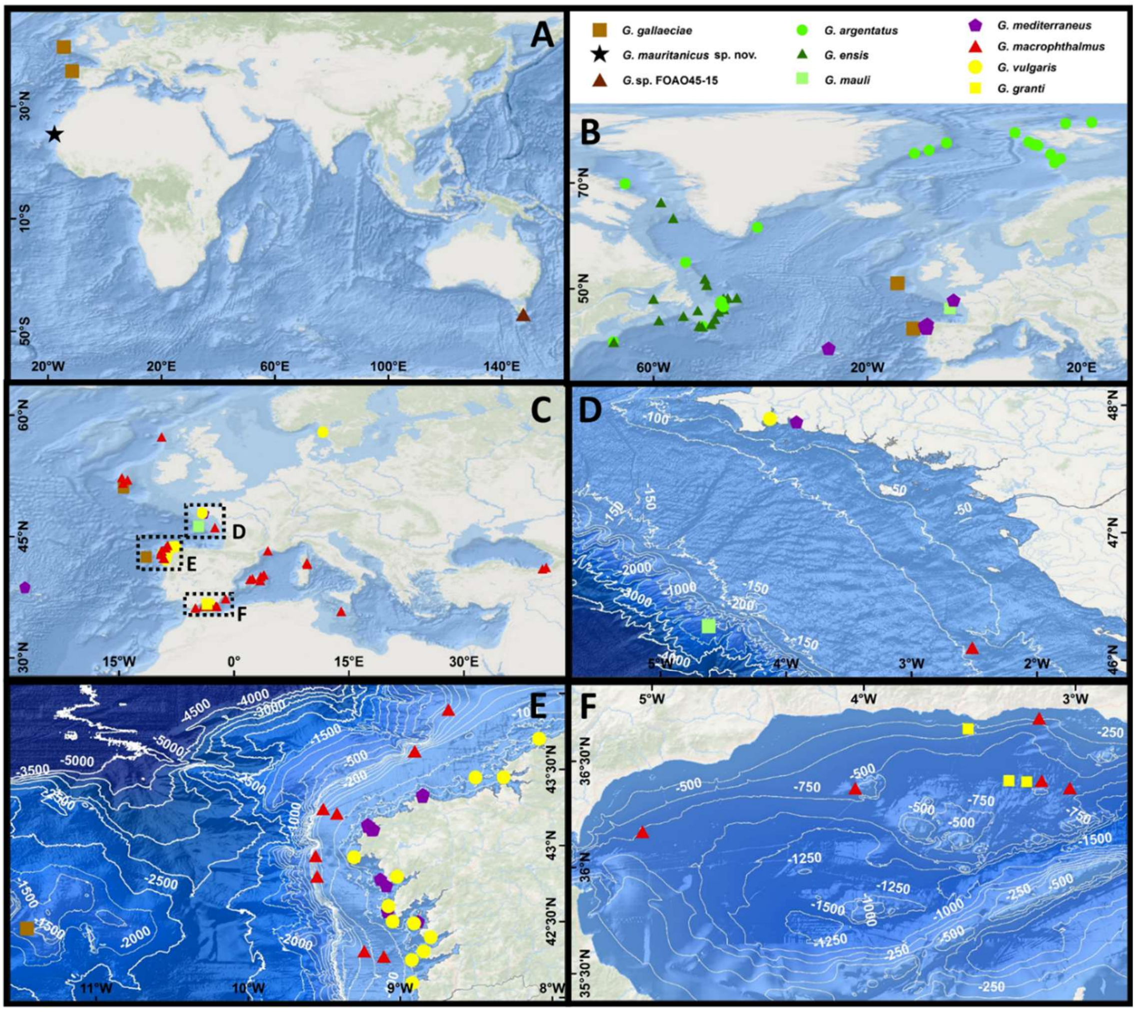

Figure 9: Geographical distributions of the genetically verified *Gaidropsarus* species records mined from BOLD-System and GenBank. **A**: Map with *G. mauritanicus* sp. nov. and its two closest related species (compare with Fig. 5). **B**: Distribution of boreal species. **C**: Overview of records from the NE Atlantic, Mediterranean Sea and Black Sea; dashed boxes indicate close-ups shown in D-F. *Gaidropsarus* sp. distribution **D**: in the northern Bay of Biscay. **E**: Off Galicia. **F**: in the Alboran Sea. A-C Basemap from ESRI (2019). D-F Bathymetry and conducted contours based on EMODnet Digital Bathymetry (DTM 2022).

Ecology of deep-water *Gaidropsarus* species

The deep-water ecology of the genus *Gaidropsarus* presents a complex picture, consisting of reports from various regions. Associations with framework-forming deep-water coral ecosystems are reported from several species, including *G*. cf. *vulgaris* in the Celtic Seas (Duineveld et al. 2007, Beuck 2008, van Oevelen et al. 2018) and *G. gallaeciae*, *G. vulgaris, G. granti*, and *Gaidropsarus* sp. in the South European Atlantic Shelf (Altuna 2012, 2017, Bañón et al. 2022, Bañón et al. 2020, Rios et al. 2018, González-Irusta et al. 2021). Further records are published from the Mediterranean Sea, in particular *G. granti* and *G. macrophthalmus* from the western Mediterranean, *G. granti* from the

Adriatic Sea and *G. macrophthalmus* from the Ionian Sea (Arena & Li Greci 1973, Angeletti et al. 2014, Bo et al. 2012, 2020, D'Onghia et al. 2010, Mastrototaro et al. 2010, Panetta et al. 2012, Massuti et al. 2022). Additionally, *G. ensis* has been reported from the north-western Atlantic subarctic (Durán Muñoz et al. 2012), and from the Gulf of Maine/Bay of Fundy, *G. argentatus* and *G. ensis* have been documented (Quattrini et al. 2015).

Beyond this, *Gaidropsarus* individuals have been observed via ROV in deep-water ecosystems, such as seamounts and deep-water coral ecosystems near hydrothermal vent fields. However, sampling has often been challenging due to the sheltering behaviour of these species. Predictions by Bañón et al. (2022) and Barros-Garcia (2018 & 2022) suggest the existence of several undescribed *Gaidropsarus* species in deep-water habitats and a decline in shallow-water species due to synonymy. The first theory is also supported by our ROV observations from deep-water coral ecosystems (see Figure 10), where a species affiliation based on ROV footage in some cases failed. Furthermore, an identification of juvenile individuals posed a particular challenge, such as for juveniles sampled in association with the interstices of *Madrepora oculata* colonies in the Bari Canyon of the Mediterranean Sea (Le Guilloux 2011, see also Fig. 10 G+H). Although only *G. macrophthalmus* is traditionally considered a deep-sea species in that area (e.g. Cohen et al. 1990), morphological differences from known pelagic juveniles of *G. mediterraneus* and *G. macrophthalmus* (former *G. biscayensis*) raised questions (see Le Guilloux 2011). Nevertheless, the presence of juveniles in deep-water coral frameworks highlights the importance of these ecosystems as potential spawning and nursery grounds for fish. Interestingly, Beuck (2008) also noted *Gaidropsarus* from a benthic lander study on the Galway Mound (see also Hebbeln et al. 2004), where an individual was observed remaining for an entire tide cycle in a depression below protective scleractinian coral framework canopies (see also Figure 10 A and B). Linley et al. (2017) also observed a *Gaidropsarus* individual in close association with deep-water coral ecosystems in the Porcupine Seabight. These observations support the hypothesis that many deep-water *Gaidropsarus* are closely associated with deep-water coral ecosystems during their entire ontogeny (see also Fig. 10 D-F). Furthermore, the presence of individuals with mottled markings dorsally (Figure 10 A and B) or laterally (see Fig. 10C) suggests a form of camouflage when hiding below or next to coral frameworks, potentially providing protective advantages, especially for species with territorial tendencies.

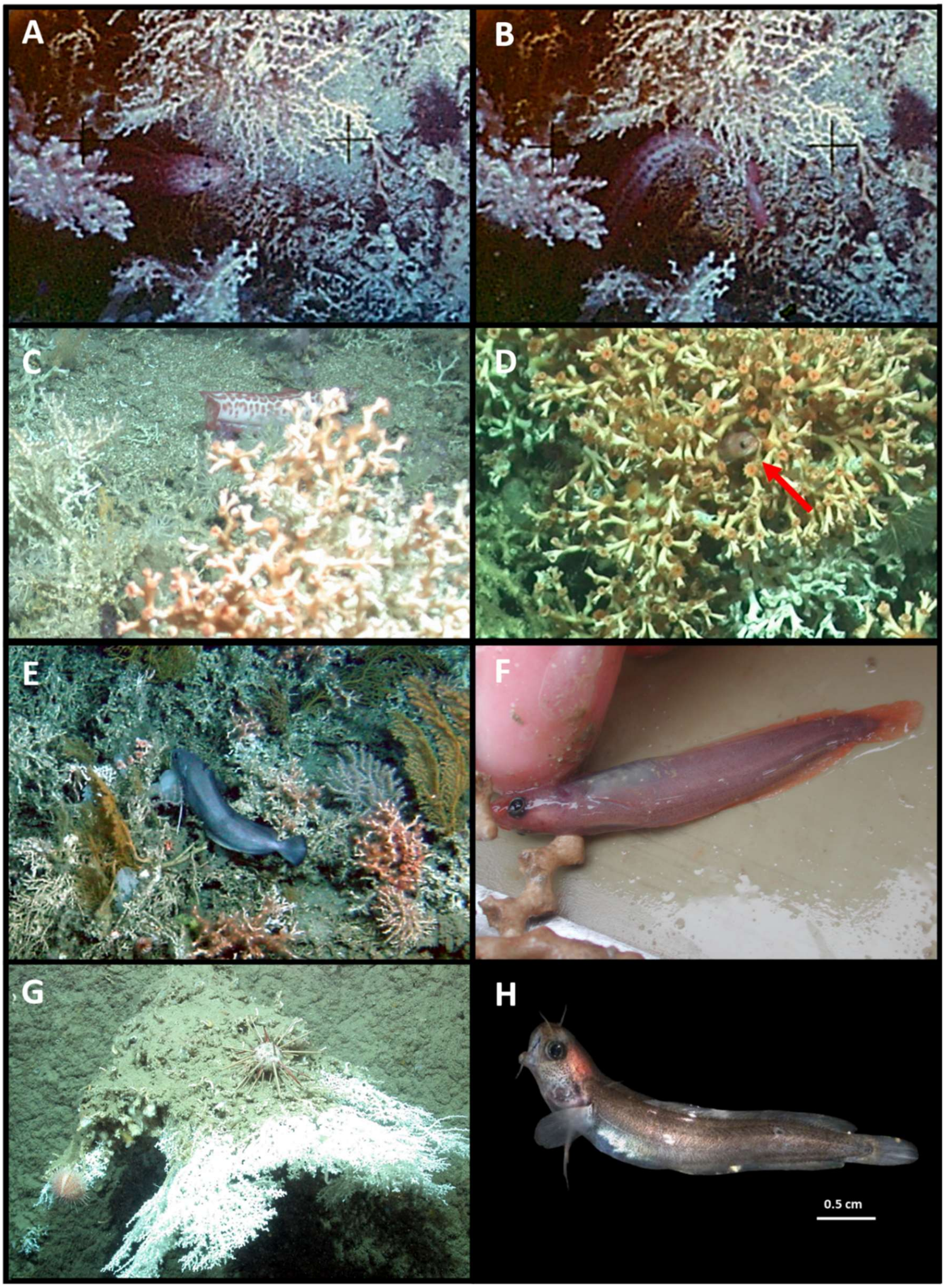

Figure 10: Members of the Genus *Gaidropsarus* associated with framework-forming deep-water coral ecosystems. **A** and **B:** *Gaidropsarus* sp. in 864 m water depth on Galway Mound (copyright O. Pfannkuche and P. Linke 2004; see also Hebbeln et al. 2004 and Beuck 2008); **C**: *G.* cf. *granti* between live deep-water coral framework on Galway Mound (copyright MARUM – Center for Marine Environmental Sciences, University of Bremen 2004); **D**: *Gaidropsarus* sp. in a live *Desmophyllum pertusum*

colony at Connacht Mound (copyright MARUM – Center for Marine Environmental Sciences, University of Bremen 2004); **E**: Live deep-water coral ecosystem at Thérèse Mound; image showing dense framework coverage and another gadiform fish (*Phycis blennoides*) (Copyright: Ifremer, Caracole cruise (2001) - https://doi.org/10.17600/1010080); **F**: Juvenile *Gaidropsarus* cf. *gallaeciae* collected via giant box corer from 860 m water depth at Thérèse Mound together with *Madrepora oculata* (Poseidon cruise 292, station 633-1, 51°27.10' N 11°44.98' W); **G**: Downward-growing *Madrepora oculata* colony collected during the M70/1 cruise from a steep cliff in the Bari Canyon, Mediterranean Sea (copyright MARUM – Center for Marine Environmental Sciences, University of Bremen2006); **H**: *Gaidropsarus* sp. individual found in the interstice of the coral framework, shown in G (see also Le Guilloux (2011)).

10.6 Conclusion

The existence of *Gaidropsarus mauritanicus* as a new species is morphologically confirmed by the presence of only 44 vertebrae, a conspicuously long pelvic fin (35.7% SL), the large eyes (38.1% HL), medium-sized pectoral fin (13.8% SL) and the pinkish colouration with several brighter dots along the base of the dorsal fin, as well as genetically confirmed by several independent species delimitation analyses. Furthermore, ROV and lander surveys reveal insights into the ecology and behaviour of deep-water coral-associated *Gaidropsarus* species, suggesting that these species are territorial and protective. Genetically supported distribution data show clear patterns in the biogeographical and bathymetrical distribution of the different *Gaidropsarus* species. Recent and ancient oceanography seems to be an important factor in terms of larval distribution and phylogenetic relationships, such as the first evidence of *G. mauli* as a basal member of the boreal *Gaidropsarus* species. Further, the genetic and distribution data also indicate possible misidentifications between *G. macrophthalmus* and *G. mediterraneus*. This highlights the urgent need for a comprehensive taxonomic identification key and a complete scientific collection. There still remains a great knowledge gap concerning the *Gaidropsarus* species of the southern hemisphere, which should be the focus of future investigations.

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Chapter 11
Synthesis

11.1 Summary of individual work and common context

This chapter aims to synthesise the scientific contributions of the six research articles included in this dissertation, highlighting their significance for advancing future marine and biodiversity research in Mauritania. The geographical location and strong upwelling activities off the Mauritanian coast result in the region exhibiting exceptionally high marine biodiversity and supporting highly productive fish stocks. These resources are under constant threat from overfishing and human-induced climate change. This dissertation provides fundamental knowledge of species' distribution and local marine biodiversity in Mauritanian coastal habitats (Chapters 5, 6, and 9). This dissertation offers an urgently needed baseline for future research by establishing a scientific collection of the Mauritanian marine fauna following a Collectomics approach (Chapter 2) and conducting one of the first comprehensive biodiversity assessments in this region. Additionally, it investigates seasonal dynamics and the influence of undisturbed areas on the local biodiversity using an environmental DNA metabarcoding approach (Chapter 9).

The first two research articles (Chapters 5 and 6; Figure 1) are dedicated to fundamental investigations of the animal species found in the coastal habitats of Mauritania. These checklists present the species compositions observed and collected from various habitats, including seagrass beds, submerged ridge fields, as well as artisanal fishery landing sites. A total of 104 fish and 118 marine invertebrate species were identified, including 2 Cnidaria 33 Crustacea, 63 Mollusc, 12 Polychaete, seven Echinoderm, and one Brachiopod species. For several species, first distribution records from Mauritania were documented (Chapters 5 and 6). These findings document a clear faunal shift from colder to warmer regions for boreal species and from warmer to colder areas for tropical species. The resulting data documents the current macrofaunal diversity within these areas and provides initial insights for further research questions. The observed organisms were collected and identified to the species level by the author and collaborating taxonomists (Chapter 4, Table 1), and are now accessible to other researcher as vouchers in the natural history collections of the IMROP (Nouadhibou, Mauritania) and the Senckenberg Research Institute (Frankfurt am Main, Germany). This refers to the objective I from Chapter 1.1. These precisely identified vouchers now serve as the foundation for additional studies, which aim to establish a baseline for future biodiversity monitoring along the Mauritanian coast. In line with the Collectomics approach (Chapter 2), these collected samples are integratively supplemented using modern techniques such as DNA barcoding and the digitisation of metadata. The previously collected material (Chapter 5 & 6; Figure 1) is hereby used for DNA barcoding to verify the morphological species identifications and to create new DNA barcode references for previously unsequenced and thus genetically unidentified species from the Mauritania waters (Chapter 7). A total of 419 DNA barcodes were generated, covering phyla ranging from algae (32 Rhodophyta, 30 Ochrophyta, 8 Chlorophyta) to marine invertebrates (70 Mollusca, 51 Arthropoda, 9 Polychaeta, 3 Cnidaria, 6 Echinodermata) over to marine vertebrates (210 Chordata). All generated sequences are freely accessible via the online database Bold-Systems (Project MAU: Mauritanian marine life barcode library, https://boldsystems.org/index.php/MAS_Management_DataConsole?codes=MAU) referring to objective II (Chapter 1.1). These DNA sequences were derived from reference material in the newly established research collections of the IMROP and Senckenberg institutes. The genetic sequences will be published in a separate research article (Chapter 7, Figure 1) and are being analysed using a BIN-Discordance Analysis, which suggests the presence of cryptic species or potential misidentifications. As demonstrated in Chapter 7, a significant knowledge gap regarding genetic reference sequences of marine invertebrates and their taxonomic expertise exists. This database provides an initial step towards closing this gap. In the context of future ecosystem monitoring, it is crucial not only to document commercially relevant species, but also to represent the underlying trophic levels. The interspecific relationships within a food web cannot be reduced to just one or two species. A detailed depiction of the local fauna allows a more accurate reconstruction of such a food web, enabling the detection of potential disturbances and the implementation of countermeasures if necessary. For this purpose, a precise understanding of the local fauna is essential.

Lately, the use of environmental DNA (eDNA) has emerged as a highly useful method for assessing the local biodiversity. By comparing eDNA extracted from an environmental sample, for instance, a water sample, with the genetic references of already identified species, such as the Mauritanian database created in Chapter 7, the locally occurring fauna can be detected. This allows the detection of the occurring fauna and the visualisation of the different components of the food webs. However, it is important to note that the outcome of such biodiversity assessments is only as good as the available reference data (more on this in Section 11.2).

After assessing and identifying the local fauna and setting up a DNA barcode library of the observed species, potentially essential habitats such as seagrass beds and maerl beds as well as potentially new species (Chapter 9 and 10, Figure 1) were identified. The newly established reference collection with physical samples and genetic barcodes of the local fauna (Chapters 5, 6, and 7) serves as a solid baseline for a biodiversity assessment of these areas using an eDNA analysis approach, which detects seasonal changes of biodiversity in two distinct lagoons in Mauritania (Chapter 8, Figure 1). Due to a delay in the publication of the generated DNA barcodes from Mauritania, only sequences available online could be used, resulting in a lower accuracy of the species identifications and delimitations.

However, the analysis clearly highlights fluctuations of the marine biodiversity between the summer and winter season in two distinct lagoons. The biodiversity assessment reveals that the general marine biodiversity of both coastal lagoons is higher during the winter season compared to the summer season. This effect is even more pronounced in a very young and facies poor, but only marginally disturbed environment (Bellaat lagoon) compared to a geologically older, but facies diverse and heavily anthropogenically disturbed lagoon (Baie de l’Étoile). These fluctuations might likely be attributed to stronger seasonal upwelling intensities during the winter months off the Mauritanian coast, which increases nutrient availability in the water, leading some migratory species to inhabit the coastal areas during these months. Additionally, several marine fish and shrimp species are known to spawn during the winter months in the Mauritanian coastal waters. In summary, anthropogenic impacts such as increased fishing pressure and pollution appear to cause seasonally occurring species to prefer undisturbed areas like the Bellaat lagoon, despite its lower facies diversity compared to the heavily impacted but facies richer Baie de l'Étoile. Therefore, the eDNA study clearly demonstrates that marine protected areas play a crucial role in preserving and promoting Mauritania's coastal marine biodiversity. This result refers to objective III as described in Chapter 1.1.

Species emerged during the studies on the Mauritanian marine fauna, that could not be precisely identified at species level, even by specialised taxonomists. Some of these species are still under investigation, such as two potentially new coralline red algal species from the genera *Lithophyllum* and *Roseolithon*, as well as a potentially undescribed *Ophiothrix* species. Additionally, a potentially new amphipod species from the family Talitridae is currently the focus of taxonomic research. Other organisms, like the two Mauritanian fish species *Didogobius lanceolatus* (Chapter 9) and *Gaidropsarus mauritanicus* (Chapter 10), have been described in detail with an integrative approach as new species within this dissertation also visible in Figure 1 and described as objective IV in Chapter 1.1. The fact that so many potentially new species were discovered during the fieldwork underscores Mauritania's remarkable biodiversity and highlights the urgent need of taxonomic research and the establishment of a comprehensive scientific reference collection of the Mauritanian marine fauna. Such a scientific reference collection plays a particularly important role in times of Anthropocene-driven biodiversity loss, as it allows the assessment of the current state of marine biodiversity, and serves as a valuable reference for future comparisons and potential conservation measures.

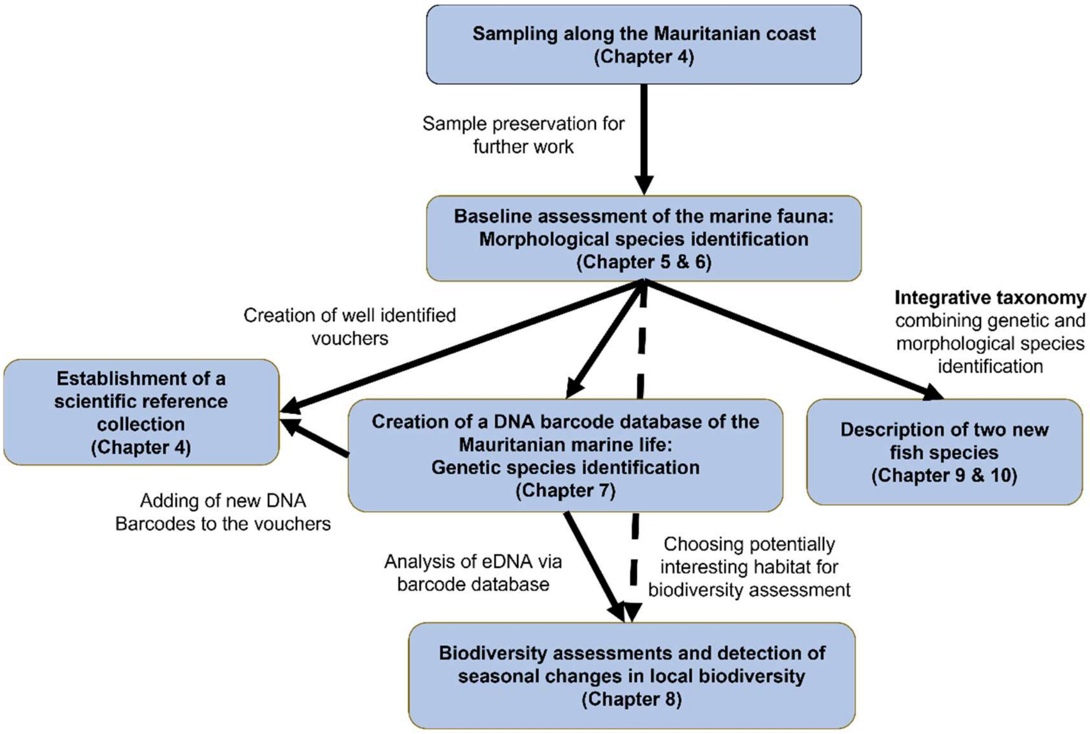

Figure 1: Schematic representation of the scientific components of this dissertation and their relations to each other.

11.2 Methodological Constraints

During the fieldwork in Mauritania, several mechanical and methodological complications arose, particularly regarding the preservation of important genetic tissue samples and their proper handling. These challenges were addressed and resolved through close collaboration between IMROP and the Senckenberg institute. A general challenge during the fieldwork was obtaining sufficient preservation agents, such as ethanol and formaldehyde. Proper preservation of genetic material is as indispensable as contamination-free tissue sampling. Typically, this requires sterile laboratories and disposable tools, which was not feasible due to the large volume of samples and the lack of suitable laboratory facilities. Ensuring the sterilisation of sampling tools, especially during tissue sampling at the artisanal fish markets, was crucial but challenging. The tools were sterilised using a lighter and flammable ethanol after each use, or alternatively sterile single-use scalpels were used instead.

Another major challenge was the handling of environmental eDNA samples during the fieldwork in Mauritania. The collected water needed to be stored properly until filtration and to prevent the eDNA from degrading. This was managed by temporarily storing the samples on crushed ice in a dark box to reduce the biological processes that could degrade the DNA and to prevent additional damage to the DNA through UV sunlight. Since working with eDNA and DNA metabarcoding involves highly sensitive DNA detection, the samples had to be as free from foreign DNA as possible. For that reason, sterile disposable filter units were used, and the laboratory rooms were locked and thoroughly disinfected during the work. The filtered eDNA was preserved in 99.8% non-denatured ethanol for transport from Mauritania to Germany, due to the unavailability of cooling materials. Ideally, such eDNA samples would be shipped using dry ice or specific buffer solutions that prevent the DNA from further degradation.

Analysing the eDNA metabarcoding results proved to be another challenge. The generated DNA sequences from the filtered water samples are compared with reference sequences from online repositories to identify them. Unfortunately, the marine fauna of Mauritania is understudied, which is reflected in the limited number of available DNA references for that region, particularly for marine invertebrates. As a result, the metabarcoding results can only broadly depict the biodiversity dynamics within the study areas. Nevertheless, changes and dynamics can still be observed. The lack of reference sequences for the Mauritanian and West African fauna once again highlights the urgent need for a comprehensive scientific reference collection, incorporating DNA barcodes and taxonomic work, in order to address more in-depth biodiversity questions.

Despite some limitations in sample preservation and laboratory hygiene standards, the work with eDNA was highly successful in answering the initial research questions. This demonstrates that scientific work, even with sensitive detection methods such as eDNA metabarcoding is feasible in Mauritania. However, several logistical steps must be considered in advance to prevent potential contamination or DNA degradation.

In close collaboration with the Mauritanian Ministry of Environment and Sustainable Development, IMROP, and the Senckenberg institute, an infrastructure has been developed to adhere to the Nagoya-Protocol. In the coming months, once all sequences are available on the BOLD-Systems online database, further eDNA analyses will be conducted using our own referenced data.

11.3 Implementation of a scientific reference collection

As previously mentioned in Chapter 2, a generous grant from the KfW Bank is facilitating the construction of a new and modern research centre for the IMROP institute, located north of the harbour city of Nouadhibou in Cansado. This infrastructure project includes provisions for a scientific collection room of the Mauritanian fauna, as well as suitable laboratories for genetic work. The Senckenberg institute serves as an advisory partner for IMROP in both of these areas. Among other things, all specimens collected during this dissertation project will be divided evenly between the two scientific collections. Consequently, the project work will also establish the initial foundation of voucher specimens of the Mauritanian coastal fauna (Chapters 5, 6, and 7) for IMROP's newly established scientific collection. These voucher specimens are not only morphologically identified to the species level by different taxonomists (Chapters 5 and 6), but additional DNA barcodes have also been sequenced for most of the species (Chapter 7) and are available to future colleagues at the IMROP institute. This foundational collection of voucher specimens, along with a new collection building and associated genetic laboratories, provides optimal conditions for ideal observations and documentation of the marine biodiversity of Mauritania in the future. This paves the way for tracking and comparing biodiversity shifts over time, especially against the backdrop of accelerating climate change.

Chapter 12

Outlook

This dissertation establishes an essential foundation for future biodiversity monitoring along the Mauritanian and West African coast. Through this work, a scientific reference collection of the Mauritanian marine fauna has been developed. This collection follows the Collectomics approach and interactively combines classical research collections with mother technical approaches such as DNA barcoding and digitisation of the metadata of the specific vouchers. This newly established reference collection therefore not only consists of specimens identified at the species level by various taxonomists but also includes additional information such as DNA barcodes of the corresponding species. This collection not only creates ideal conditions for future biodiversity research in Mauritania but also highlights fragile and potentially endangered ecosystems in the region. Specifically, this dissertation supports future research through:

- a broad foundation of collected material (Chapters 5 and 6), which will fill the collection rooms of the newly build IMROP research institute, funded by the KfW Bank. This collection will be continuously expanded through future research collaborations between the Senckenberg and IMROP institutes, providing reference material for the Mauritanian marine fauna. By re-sampling the already studied sites in upcoming years, changes in species composition can be detected, allowing an early identification of potential negative impacts on ecosystems. Such comparative studies will be particularly important in the context of anthropogenic climate change and overfishing during the upcoming years.
- the establishment of a genetic reference database of the Mauritanian marine fauna. The DNA barcodes generated in this work (Chapter 7) represent only a small portion of the actual marine fauna existing in Mauritania. Compared to well-studied marine regions such as the North Sea, there are relatively few reference sequences available in online databases like the BOLD System or GenBank, making genetic species identification challenging. However, with the newly established IMROP research institute, the capability for DNA barcoding will be created, allowing for the expansion of the already existing DNA barcoding database

- in future years the resulting reference sequences will enable more detailed results from the metabarcoding of environmental DNA samples,
  thereby facilitating in-depth studies of Mauritanian ecosystems and their food webs.
- the designation of potentially protected marine areas, such as the Baie de l'Étoile. The sightings of endangered species documented in this work, such as the blackchin guitarfish (*Glaucostegus cemiculus*) and the milk shark (*Rhizoprionodon acutus*), clearly demonstrate the importance of seagrass beds for threatened species and their juveniles. Future collection efforts can continue this documentation of endangered and valuable species, potentially leading to the protection of additional marine areas. For Mauritanian conservation efforts, such documentation of endangered species is crucial, as it provides concrete evidence of the relevance of certain marine areas. Additionally, with future DNA barcoding and eDNA studies, especially threatened species can be detected and confirmed using metabarcoding of environmental DNA samples.
- The description of previously unknown animals (Chapters 9 and 10) and algal species (11.1), which will be described in detail by taxonomists and confirmed in future publications. This further highlights the great species richness of the Mauritanian waters and how little we currently know about this scarcely explored marine region.

In summary, this dissertation provides a much-needed baseline for future biodiversity assessments in the form of a scientific reference collection, that interactively combines modern approaches such as DNA barcoding and digitisation of the collected vouchers with classical biological sampling. Furthermore, this dissertation provides one of the first biodiversity assessments of Mauritania's marine biodiversity using eDNA metabarcoding. The results highlight the significant fluctuations of the marine biodiversity between the summer and winter months, clearly demonstrating the positive impact of protected areas on the marine biodiversity. By continuing the collection and DNA barcoding efforts, this collection can be expanded, facilitating future conservation efforts for the Mauritanian marine fauna by identifying potentially protected areas. Additionally, this dissertation highlights the urgent need of further taxonomical and biodiversity research in this area, especially in the face of the Anthropocene biodiversity loss.

Chapter 13 Appendix

13.1 Station list

This station list comprises every sampling activity conducted during the five field trips to Mauritania mentioned in Chapter 4. This table consists of the station number for every sampling event, the performed sampling activity, the latitudinal and longitudinal coordinates as well as the sampling date.

Station	Sampling	Latitude	Longitude	Date
CDP21-00	Waddensea	21.019716	-17.005418	30.11.2021
CDP21-01-1	Subtidal	21.02063026	-17.00465622	02.12.2021
CDP21-01-2	Waddensea	21.02063026	-17.00465622	02.12.2021
CDP21-01-3	Waddensea	21.02063026	-17.00465622	02.12.2021
CDP21-02-1	Algae and stones	21.01976566	-17.00541286	02.12.2021
CDP21-02-2	Waddensea	21.01976566	-17.00541286	02.12.2021
CDP21-03	From sandsone	21.01989328	-17.00558167	02.12.2021
CDP21-04	Waddensea, *Spatina*	21.01918689	-17.00647954	02.12.2021
BdL 1-1	Water sample	20.962333	-16.880583	04.12.2021
BdL 1-2	Sediment sample, shelly sand	20.962333	-16.880583	04.12.2021
BdL 2-1	Water sample	21.015050	-16.916833	04.12.2021
BdL 2-2	Sediment sample, dark green mud	21.015050	-16.916833	04.12.2021
BdL 3-1	Water sample	21.0135	-16.961117	04.12.2021
BdL 3-2	Sediment sample, dark green mud	21.0135	-16.961117	04.12.2021
BdL 4-1	Water sample	21.039883	-16.906667	04.12.2021
BdL 4-2	Sediment sample, silty sand	21.039883	-16.906667	04.12.2021
BdL 5-1	Water sample	21.022	-16.992767	04.12.2021
BdL 5-2	Sediment sample, silty mud	21.022	-16.992767	04.12.2021
BdE-0001-1	Collection	21.0197272	-17.00533316	23.07.2022
BdE-0001-2	Collection	21.0192641	-17.004485668	23.07.2022
BdE-0001-3	Collection	21.0192641	-17.004485668	23.07.2022
BdE-0002-1	Collection	21.01990538	-17.00559643	24.07.2022
BdE-0002-Becken	Collection	21.019855	-17.005593	24.07.2022
BdE-0003	Sieve	21.01990538	-17.00559643	24.07.2022
BdE-0004	Collection	21.01990538	-17.00559643	24.07.2022
BdE-0005	Collection	21.01914669	-17.00636302	24.07.2022
BdE-0006	Collection	21.02007184	-17.00501579	24.07.2022
BdE-0007	Beach Seine	21.0168	-17.01844	25.07.2022
BdE-0008	Beach Seine	21.01201	-17.01334	25.07.2022
BdE-0009	Beach Seine	HRIV 3	HRIV 3	25.07.2022
BdE-0010	Grab	21.02391524	-17.0034892	25.07.2022
BdE-0011-1	Collection	21.02637663	-17.00351459	25.07.2022
BdE-0011-2	Collection	21.02771827	-17.0035024	25.07.2022

BdE-0012	Collection	21.04555385	-17.01960122	25.07.2022
BdE-0013	Collection	21.03404742	-17.02615285	25.07.2022
BdE-0014	Collection	21.02298179	-17.01917434	25.07.2022
BdE-0015	Beach Seine	21.0419	-17.01424	26.07.2022
BdE-0016	Beach Seine	21.02734	-17.00422	26.07.2022
BdE-0017-1	Niskin	21.03896028	-17.02475927	26.07.2022
BdE-0017-2	Niskin	21.03901735	-17.02460635	26.07.2022
BdE-0017-3	Niskin	21.03903133	-17.02462308	26.07.2022
BdE-0017-4	Grab	21.03899987	-17.02463601	26.07.2022
BdE-0017-5	Anchor	21.03899987	-17.02463601	26.07.2022
BdE-0018-1	Niskin	21.02699047	-17.02379361	26.07.2022
BdE-0018-2	Niskin	21.02724995	-17.02362711	26.07.2022
BdE-0018-3	Niskin	21.02718929	-17.02366502	26.07.2022
BdE-0018-4	Grab	21.02723507	-17.023363627	26.07.2022
BdE-0019-1	Niskin	21.02714134	-17.02411876	26.07.2022
BdE-0019-2	Niskin	21.0271857	-17.02396602	26.07.2022
BdE-0019-3	Niskin	21.02720982	-17.02391185	26.07.2022
BdE-0019-4	Grab	21.027201	-17.023912	26.07.2022
BdE-0020-1	Collection	21.02569892	-17.00713508	26.07.2022
BdE-0020-2	Drone	21.02569	-17.007135	26.07.2022
BdE-0020-3	Snorkeling	21.0259527	-17.00700697	26.07.2022
BdE-0020-4	Snorkeling	21.02540722	-17.00732777	26.07.2022
BdE-0020-5-1	Niskin	21.02519216	-17.00740337	26.07.2022
BdE-0020-5-2	Niskin	21.02519245	-17.00740321	26.07.2022
BdE-0020-5-3	Niskin	21.02519278	-17.00741318	26.07.2022
BdE-0021-1	Niskin	21.03211201	-17.00772272	27.07.2022
BdE-0021-2	Niskin	21.03176655	-17.0081447	27.07.2022
BdE-0022	Bongo Net	21.03142107	-17.00858528	27.07.2022
BdE-0023	Bongo Net	21.0275889	-17.00906907	27.07.2022
BdE-0024	CTD	21.02759	-17.00907	27.07.2022
BdE-0025-A	Core	21.02794067	-17.00427755	27.07.2022
BdE-0025-B	Core	21.02794067	-17.00427755	27.07.2022
BdE-0025	Collection	21.02794067	-17.00427755	27.07.2022
BdE-0026-A	Core	21.02589303	-17.02353838	27.07.2022
BdE-0026-B	Core	21.02589307	-17.02353841	27.07.2022
BdE-0026	Collection	21.02589307	-17.02353841	27.07.2022
BdE-0027	Beach Seine	HRIV3	HRIV3	27.07.2022
BdE-0028	Collection	21.02278424	-17.019174	29.07.2022
BdE-29A	Core	21.02278424	-17.019174	29.07.2022
BdE-29B	Core	21.02278424	-17.019174	29.07.2022
BdE-30A	Core	21.02344552	-17.01892719	29.07.2022
BdE-30B	Core	21.02344552	-17.01892719	29.07.2022
BdE-31A	Core	21.01813289	-17.01888817	29.07.2022
BdE-31B	Core	21.01813289	-17.01888817	29.07.2022
BdE-31-2	Collection	21.01813289	-17.01888817	29.07.2022
BdL-0006-1	Dredge	20.65288134	-16.73166469	30.07.2022
BdL-0006-2	Niskin	20.65288134	-16.73166469	30.07.2022
BdL-0006-3	CTD	20.65288134	-16.73166469	30.07.2022
BdL-0007	Core	20.69404206	-16.67571425	31.07.2022

BdL-0007-1	Collection	20.69404206	-16.67571425	31.07.2022
BdL-0008-1	Drone	20.69403699	-16.67187232	31.07.2022
BdL-0008-2	Collection	20.69403699	-16.67187232	31.07.2022
BdL-0009	Core	20.6939552	-16.67196551	31.07.2022
BdL-0010	Collection	20.69444996	-16.6727092	31.07.2022
BdL-0011	Drone	20.7004362	-16.66723727	31.07.2022
BdL-0012-1	Niskin	20.70094822	-16.667445	31.07.2022
BdL-0012-2	CTD	20.70094822	-16.667445	31.07.2022
BdL-0013-1	Niskin	20.69483878	-16.67058364	31.07.2022
BdL-0013-2	CTD	20.69483878	-16.67058364	31.07.2022
BdL-0014-1	Niskin	20.69325546	-16.67366178	31.07.2022
BdL-0014-2	Niskin	20.69325546	-16.67366178	31.07.2022
BdL-0014-3	Niskin	20.6925383	-16.67198138	31.07.2022
BdL-0014-4	CTD	20.6925383	-16.67198138	31.07.2022
BdL-0015	Collection	20.69355224	-16.67386187	31.07.2022
BdL-0016	Drone	20.69406693	-16.67210719	31.07.2022
BdL-0017-1	Niskin	20.652683	-16.729717	31.07.2022
BdL-0017-2	CTD	20.65128221	-16.72815223	31.07.2022
BdE-34	Collection	21.02027	-17.0054	15.02.2023
BdE-35	Collection	21.0199	-17.0055	15.02.2023
BdE-36-1	Collection	21.0198	-17.0054	15.02.2023
BdE-36-2	Collection	21.0198	-17.0054	15.02.2023
BdE-37	Collection	21.0195	-17.0059	15.02.2023
BdE-38	Collection	21.0198	-17.0056	15.02.2023
BdE-39	Collection	21.0194	-17.0072	15.02.2023
BdE-40	Collection	21.0198	-17.0056	15.02.2023
BdE-41	Collection	21.0195	-17.006	15.02.2023
BdE-42	Collection	21.0196	-17.0056	15.02.2023
BdE-43	Collection	21.0198	-17.0056	15.02.2023
BdE-44	Push Core	21.02075	-17.00567	16.02.2023
BdE-45	Hand collection	21.020784	-17.005646	16.02.2023
BdE-46	Push Core	21.0209	-17.0058	16.02.2023
BdE-47	Hand collection	21.021114	-17.00576	16.02.2023
BdE-48	Collection	21.0209	-17.0058	16.02.2023
BdE-49	Push Core	21.0209	-17.0058	16.02.2023
BdE-50	Hand collection	21.021614	-17.005976	16.02.2023
BdE-51	Hand collection	21.02137	-17.005732	16.02.2023
BdE-52	Hand collection	21.021557	-17.005945	16.02.2023
BdE-53	Collection	21.0217	-17.0065	16.02.2023
BdE-54	Push Core	21.0217	-17.0065	16.02.2023
BdE-55	Push Core	21.0224	-17.0062	16.02.2023
BdE-56	Collection	21.02061	-17.00457	16.02.2023
BdE-57	Cast net	21.022440	-17.006069	16.02.2023
BdE-58 (=BdE-51 Majidae crab)	Hand collection	21.021683	-17.005795	16.02.2023
BdE-59-1	Fishtrap #1	21.020716	-17.00465	17.02.2023
BdE-59-2	Fishtrap #2	21.0207	-17.00471	17.02.2023
BdE-60	Hand collection	21.019822	-17.005131	17.02.2023
BdE-61	Hand collection	21.024233	-17.005495	17.02.2023

BdE-62	Hand collection	21.024359	-17.006784	17.02.2023
BdE-63	Hand collection	21.024875	-17.00718	17.02.2023
BdE-64	Fishtrap #3 + Hand collection	21.025471	-17.006742	17.02.2023
BdE-65	Hand collection	21.025471	-17.006742	17.02.2023
BdE-66	Fishtrap #4	21.025976	-17.006901	17.02.2023
BdE-67	Hand collection	21.022703	-17.006115	17.02.2023
BdE-68	old Fishtrap	21.020716	-17.00465	17.02.2023
BdE-69-1	old Fishtrap	21.020716	-17.00465	18.02.2023
BdE-69-2	Fishtrap #5	21.0207	-17.00471	18.02.2023
BdE-70	Hand collection	21.02	-17.005	18.02.2023
BdE-71	Drone	21.019734	-17.005408	18.02.2023
BdE-72	Hand collection	21.023322	-17.00678	18.02.2023
BdE-73	Light Fish Trap	21.025846	-17.007118	18.02.2023
BdE-74	Counting Frame	21.02463	-17.00682	18.02.2023
BdE-75	Counting Frame	21.02452	-17.00681	18.02.2023
BdE-76	Counting Frame	21.02451	-17.006815	18.02.2023
BdE-77	Counting Frame	21.02436	-17.00678	18.02.2023
BdE-78	Counting Frame	21.02425	-17.00672	18.02.2023
BdE-79	Counting Frame	21.02405	-17.00668	18.02.2023
BdE-80	Counting Frame	21.02386	-17.00664	18.02.2023
BdE-81	Counting Frame	21.02363	-17.00653	18.02.2023
BdE-82	Counting Frame	21.02342	-17.00648	18.02.2023
BdE-83	Counting Frame	21.02323	-17.00643	18.02.2023
BdE-84	Counting Frame	21.02305	-17.00641	18.02.2023
BdE-85	Counting Frame	21.02278	-17.00633	18.02.2023
BdE-86	Counting Frame	21.02268	-17.00631	18.02.2023
BdE-87	Counting Frame	21.02253	-17.00626	18.02.2023
BdE-88	Counting Frame	21.02229	-17.00618	18.02.2023
BdE-89	Counting Frame	21.02217	-17.00615	18.02.2023
BdE-90	Counting Frame	21.022	-17.00611	18.02.2023
BdE-91	Counting Frame	21.02171	-17.00604	18.02.2023
BdE-92	Counting Frame	21.02153	-17.00596	18.02.2023
BdE-93	Counting Frame	21.02141	-17.00592	18.02.2023
BdE-94	Counting Frame	21.02125	-17.00584	18.02.2023
BdE-95	Counting Frame	21.02114	-17.00577	18.02.2023
BdE-96	Counting Frame	21.02098	-17.00569	18.02.2023
BdE-97	Counting Frame	21.02078	-17.00563	18.02.2023
BdE-98	Counting Frame	21.02063	-17.00558	18.02.2023
BdE-99	Counting Frame	21.02047	-17.00551	18.02.2023
BdE-100	Counting Frame	21.02027	-17.00543	18.02.2023
BdE-101	Hand collection	21,023655	-17,00658	18.02.2023
BdE-102	Hand collection	21,025244	-17,006996	18.02.2023
BdE-103	Hand collection	21,020567	-17,006851	18.02.2023
BdE-103-1	Fish traps	21.020716	-17.00465	19.02.2023
BdE-103-2	Fish traps	21.020717	-17.00466	19.02.2023
BdE-104	Fish traps	21.020716	-17.00465	19.02.2023
BdE-105	Hand collection	21,023438	-17,006474	19.02.2023
BdE-106	Fish traps	21,025618	-17,006861	19.02.2023
BdE-107	Hand collection	21,025276	-17,007072	19.02.2023

BdE-108	Push Core	21,025248	-17,006733	19.02.2023
BdE-109	Push Core	21,024752	-17,006571	19.02.2023
BdE-110	Push Core	21,023773	-17,006281	19.02.2023
BdE-111	Push Core	21,022438	-17,006281	19.02.2023
BdE-112	Push Core	21,021194	-17,00662	19.02.2023
BdE-113	Hand Collection	21.020308	-17.005442	19.02.2023
BdE-114	Counting Frame	2.102.058	-1700567	19.02.2023
BdE-115	Hand collection	21.02133	-17.00748	20.02.2023
BdE-116	Hand collection	21.02078	-17.00715	20.02.2023
BdE-117	Hand collection	21.020267	-17.004692	20.02.2023
BdE-118	Hand collection	21.0195539	-17.0047666	20.02.2023
BdE-119	Hand collection	21.0184331	-17.0030314	20.02.2023
BdE-120	Hand collection	21.0185071	-17.0036438	20.02.2023
BdE-121	Hand collection	21.0188208	-17.0038719	20.02.2023
BdL-18	Hand collection	20.86047	-17.03537	21.02.2023
BdL-19	Hand collection	20.77107	-17.04687	23.02.2023
BdL-20	Hand collection	20.77096	-17.04687	23.02.2023
BdL-21	Hand collection	20.7714	-17.04645	23.02.2023
BdL-22	Hand collection	20,771076	-17,046701	23.02.2023
BdL-23	Hand collection	20,76993	-17,048422	23.02.2023
BdL-24	Hand collection	20,770136	-17,048901	23.02.2023
BdL-25	Hand collection	20,770075	-17,048746	23.02.2023
BdL-26	Hand collection	20.7714	-17.04645	23.02.2023
BdL-27	Drone	20.771691	-17.046274	23.02.2023
BdL-28	Net collection	20.7714	-17.04645	23.02.2023
BdL-29	Drone	20.86089	-17.036287	23.02.2023
BdL-30	Counting Frames	20.860603	-17.035648	23.02.2023
BdL-31	Hand collection	20,86047	-17,03537	23.02.2023
BdL-32	Hand collection	20.86047	-17.03537	23.02.2023
BdL-33	Drone	20.860570	-17.035222	23.02.2023
BdE-122	Hand collection	21.03884	-17.02508	24.02.2023
BdE-123	Hand collection	21.03869	-17.02564	24.02.2023
BdE-124	Hand collection	21.03777	-17.02568	24.02.2023
BdE-125	Hand collection	21.03731	-17.025911	24.02.2023
BdE-126	Hand collection	21.03765	-17.02649	24.02.2023
BdE-127	Hand collection	21.03922	-17.02559	24.02.2023
BdE-128	Hand collection	21.03907	-17.02548	24.02.2023
BdE-129	Hand collection	21.042624	-17.025938	24.02.2023
BdE-130	Hand collection	21.038604	-17.02363	24.02.2023
BdE-131	Hand collection	21.038315	-17.026018	24.02.2023
BdE-132	Hand collection	21.037121	-17.026133	24.02.2023
BdE-133	Hand collection	21.036764	-17.025812	24.02.2023
BdE-134	Hand collection	21.037622	-17.025734	24.02.2023
BdE-135	Hand collection	21.038315	-17.025347	24.02.2023
BdE-136	Hand collection	21,037655	-17,026241	24.02.2023
BdE-137	Hand collection	21,036541	-17026159	24.02.2023
Cymbium sample	From fishermen	21.04246	-17.02296	24.02.2023
Sand Sample 1-3	Hand collection	21,038528	-17,025671	24.02.2023

BdE-138	Tissue sample	n.a.	n.a.	25.02.2023
BdL-34	Hand Collection	20,853611	-17,028761	26.02.2023
BdL-35	Drone	20.853923	-17.017933	26.02.2023
BdL-36	Hand Collection	20,837955	-17,034428	26.02.2023
BdL-37	Drone	20.838073	-17.033193	26.02.2023
BdE-139	Drone	21.038474	-17.025887	27.02.2023
BdE-140	Hand Collection	21.036936	-17,025822	27.02.2023
BdE-141	Hand Collection	21,037622	-17,025822	27.02.2023
BdL-38	Drone	20984731	-17009004	27.02.2023
BdL-39	Hand Collection	20,977392	-17,009781	27.02.2023
BdL-40	Hand Collection	20,970034	-17,006086	27.02.2023
BdL-41	Hand Collection	20,960144	-17,009933	27.02.2023
BdE-142-1	Old Trap right	21,020646	-17,004645	27.02.2023
BdE-142-2	Old Trap left	21,020677	-17,004689	27.02.2023
LG-1	Hand collection	20.8284	-17.08721	28.02.2023
LG-2	Hand collection	20.827679	-17.08867	28.02.2023
LG-3	Hand collection	20.82698	-17.08926	28.02.2023
BdL-42-1	CTD	20.870567	-17.03775	02.03.2023
BdL-42-2	Van Veen Grab	20.870567	-17.03775	02.03.2023
BdL-42-3	Underway CTD Start	20,8839976	-17,03951765	02.03.2023
BdL-43	PAR Sensor	20.86327	-17.0373	02.03.2023
BdL-44	Van Veen Grab	20.8614	-17.034294	02.03.2023
BdL-45	Van Veen Grab	20.86086	-17.033382	02.03.2023
BdL-46	Van Veen Grab	20.86088	-17.032707	02.03.2023
BdL-47	lost Octopus traps	20.86371	-17.037526	02.03.2023
BdL-48	Van Veen Grab	20.86645	-17.042455	02.03.2023
BdL-49	Beam Trawl-Start	20.879529	-17.028663	02.03.2023
	Beam Trawl-End	20.870114	-17.031566	02.03.2023
BdL-50	CTD-Logger-Start	20.871489	-17.0306408	02.03.2023
	CTD-Logger-End	20.656074	-16.726579	02.03.2023
BdL-51	Ganchorra-Start	20.653121	-16.726702	02.03.2023
	Ganchorra-End	20.653904	-16.726389	02.03.2023
BdL-52	CTD (SGN + IMROP probes)	20.654949	-16.724934	02.03.2023
BdL-53	Ganchorra-Start	20.654792	-16.726024	02.03.2023
	Ganchorra-End	20.65434	-16.726648	02.03.2023
BdL-54	PAR Sensor	20.65430	-16.727063	02.03.2023
BdL-55	Drone	20.670416	-16.673222	02.03.2023
BdL-56	Fishing rod	20.670416	-16.673222	02.03.2023
BdL-57	Drone	20.679547	-16.673439	03.03.2023
BdL-58	Hand collection	20.679246	-16.674007	03.03.2023
BdL-59	Hand collection	20.679547	-16.673439	03.03.2023
		20.674928	-16.664022	03.03.2023
BdL-60	Hand collection	20.679839	-16.675381	03.03.2023
BdL-61	Hand collection	20.679591	-16.675573	03.03.2023
BdL-62	Hand collection	20.68031	-16.675285	03.03.2023
BdL-63	Van Veen Grab	20.691337	-16.681108	03.03.2023
BdL-64	Van Veen Grab	20.692044	-16.680385	03.03.2023
BdL-65	Van Veen Grab	20.691883	-16.679703	03.03.2023
BdL-66	Van Veen Grab	20.695792	-16.683634	03.03.2023

BdL-67	Drone	20.69403	-16.672031	03.03.2023
BdL-68	Hand collection	20.695485	-16.674485	03.03.2023
BdL-69	Hand collection	20.692919	-16.675753	03.03.2023
BdL-70	Hand collection			03.03.2023
BdL-71	Gill net set up	20.693887	-16.6723688	03.03.2023
BdL-72	Van Veen Grab	20.708165	-16.683025	03.03.2023
BdL-73	Hand collection	20.708519	-16.683964	03.03.2023
BdL-74	Hand collection	20.711115	-16.688095	03.03.2023
BdL-75	Trade with Imraguen	20.711596	-16.696502	03.03.2023
BdL-76	Drone	20.708519	-16.683964	03.03.2023
BdL-77	Drone	20.694047	-16.672039	04.03.2023
BdL-78-1	Sediment Core	20.694867	-16.671463	04.03.2023
BdL-78-2	Sediment Core	20.694867	-16.671463	04.03.2023
BdL-78-3	Sediment Core	20.694867	-16.671463	04.03.2023
BdL-79-1	CTD probe (IMROP)	20.698496	-16.668837	04.03.2023
BdL-79-2	eDNA Niskin	20.698496	-16.668837	04.03.2023
BdL-80-1	CTD probe (IMROP)	20.691934	-16.670316	04.03.2023
BdL-80-2	eDNA Niskin	20.691934	-16.670316	04.03.2023
BdL-81-1	CTD probe (IMROP)	20.692639	-16.672579	04.03.2023
BdL-81-2	eDNA Niskin	20.692639	-16.672579	04.03.2023
BdL-82-1	CTD probe (IMROP)	20.693578	-16.675064	04.03.2023
BdL-82-2	eDNA Niskin	20.693578	-16.675064	04.03.2023
BdL-83-1	CTD probe (IMROP)	20.693994	-16.673175	04.03.2023
BdL-83-2	eDNA Niskin	20.693994	-16.673175	04.03.2023
BdL-84	Beam Trawl start	20,6945148	-16,69889663	04.03.2023
BdL-84	Beam Trawl end	20,6945148	-16,69889663	04.03.2023
BdL-85	Beam Trawl 2 start	20,6826398	-16,70073839	04.03.2023
BdL-85	Beam Trawl 2 end	20,6908313	-16,70506513	04.03.2023
BdL-86	Beam Trawl 3 start	20,6826135	-16,71687322	04.03.2023
BdL-86	Beam Trawl 3 end	20,6878209	-16,7131478	04.03.2023
BdL-87	CTD (SGN)	20,6875888	-16,71270758	04.03.2023
BdL-88	Ganchorra-Start	20,6752043	-16,69706628	04.03.2023
BdL-88	Ganchorra-End	20,6747409	-16,69651131	04.03.2023
BdL-89	Hand catch	20.693887	-16.6723688	04.03.2023
BdL-90	PAR Sensor	20.689011	-16.6851519	04.03.2023
BdL-91	Drone	20.689011	-16.6851519	04.03.2023
BdL-92	Plankton Net	20.689011	-16.6851519	04.03.2023
BdL-93	Drone	20.689011	-16.6851519	04.03.2023
BdL-94	Drone	20.689011	-16.6851519	04.03.2023
BdL-95	Hook fishing, throw net, fish trap	20.689011	-16.6851519	04.03.2023
IdA-1-1	PAR Sensor	20.565596	-16.408353	05.03.2023
IdA-1-2	CTD (SGN)	20.565596	-16.408353	05.03.2023
IdA-2	Drone	20.610106	-16.448391	05.03.2023
IdA-3	Hand collection	20.611759	-16.44789	05.03.2023
IdA-4	Hand collection	20.61088	-16.44781	05.03.2023
IdA-5	Hand collection	20.608869	-16.448872	05.03.2023
IdA-6	Hand collection	20.61254	-16.44724	05.03.2023
IdA-7	Hand collection	20.612729	-16.447534	05.03.2023

IdA-8	Hand collection	20.612262	-16.447233	05.03.2023
IdA-9	Snorkeling	20,610664	-16,44685	05.03.2023
IdA-10	Drone	20.612236	-16.447424	05.03.2023
IdA-11	Underway CTD Start	20.588275	-16.432216	05.03.2023
IdA-11	Underway CTD End	20.565596	-16.408353	05.03.2023
IdA-12	Hook fishing by crew	20.565596	-16.408353	05.03.2023
IdA-13	Underway CTD Start	20.712014	-16.804628	05.03.2023
IdA-13	Underway CTD End	20.630606	-16.710897	05.03.2023
IdA-14	Hand collection	20.608964	-16.448002	05.03.2023
BdL-96-1	eDNA Niskin	20.651892	-16.729679	06.03.2023
BdL-96-2	eDNA Niskin	20.649426	-16.729406	06.03.2023
BdL-96-3	CTD (SGN)	20.649426	-16.729406	06.03.2023
BdL-97	PAR Sensor	20.721562	-16.800064	06.03.2023
BdL-98	Underway CTD Start	20.722499	-16.8013612	06.03.2023
BdL-98	Underway CTD End	20.895753	-17.0509628	06.03.2023
BdE-143	PAR Sensor + CTD	21.018091	-17.001711	08.03.2023
BdE-144	PAR Sensor + CTD	21.022853	-17.001126	08.03.2023
BdE-145-1	PAR Sensor + CTD	21.025753	-17.004264	08.03.2023
BdE-145-2	PAR Sensor + CTD	21.025753	-17.004264	08.03.2023
BdE-146	Drone	21.026565	-17.003468	08.03.2023
BdE-147	Drone	21.026565	-17.003468	08.03.2023
BdE-148-1	eDNA Niskin	21.0321137	-17.005594	08.03.2023
BdE-148-2	eDNA Niskin	21.0321137	-17.005594	08.03.2023
BdE-148-3	CTD (IMROP)	21.0321137	-17.005594	08.03.2023
BdE-149	PAR Sensor + CTD	21.033592	-17.0082118	08.03.2023
BdE-150-1	eDNA Niskin	21.038361	-17.0234044	08.03.2023
BdE-150-2	eDNA Niskin	21.038361	-17.0234044	08.03.2023
BdE-150-3	eDNA Niskin	21.038361	-17.0234044	08.03.2023
BdE-150-4	CTD (IMROP)	21.038361	-17.0234044	08.03.2023
BdE-151-1	eDNA Niskin	21.026455	-17.023592	08.03.2023
BdE-151-2	eDNA Niskin	21.026455	-17.023592	08.03.2023
BdE-151-3	eDNA Niskin	21.026455	-17.023592	08.03.2023
BdE-151-4	CTD (IMROP)	21.026455	-17.023592	08.03.2023
BdE-152-1	PAR Sensor + CTD	21.0212331	-17.005766	08.03.2023
BdE-152-2	eDNA Niskin	21.0212331	-17.005766	08.03.2023
BdE-152-3	eDNA Niskin	21.0212331	-17.005766	08.03.2023
BdE-152-4	eDNA Niskin	21.0212331	-17.005766	08.03.2023
BdE-152-5	CTD (IMROP)	21.0212331	-17.005766	08.03.2023
BdE-153	Tissue samples from fishermen catch	21.019885	-17.00283	08.03.2023
BdE-154 (HRIV-1)	Beach Seine	21.0168	-17.01844	08.03.2023
BdE-155 (HRIV-2)	Beach Seine	21.01201	-17.01334	08.03.2023
BdE-156 (HFAL)	Beach Seine	21.02682	-17.02355	09.03.2023
BdE-157 (NBS)	Beach Seine	21.02734	-17.00422	09.03.2023
BdE-158 (NBE	Beach Seine	21.0419	-17.02414	09.03.2023
BdE-159	Tissue sample from fishermen catch	21.019885	-17.00283	09.03.2023
BdE-160	Drone	21.01444	-17.019615	09.03.2023
BdE-161	Drone	21.01444	-17.019615	09.03.2023
BdE-162	Hand collection	21.0201997	-17.005522	10.03.2023
BdE-163	Hand collection	21.0201997	-17.005522	10.03.2023

BdE-164	Counting Frame	21.0204774	-17.005821	10.03.2023
BdE-165	Counting Frame	21.0204353	-17.006015	10.03.2023
BdE-166	Counting Frame	21.0207599	-17.006255	10.03.2023
BdE-167	Counting Frame	21.0209507	-17.006458	10.03.2023
BdE-168	Counting Frame	21.0211796	-17.006874	10.03.2023
BdE-169	Counting Frame	21.0212458	-17.007143	10.03.2023
BdE-170	Counting Frame	21.0202057	-17.0049014	10.03.2023
BdE-171	Hand collection	21.019986	-17.004851	10.03.2023
BdE-172	Drone	21.018484	-17.011922	10.03.2023
BdL-99	Hand collection	20.70098	-16.671244	19.06.2023
BdL-100	Hand collection	20.69791	-16.672342	19.06.2023
BdL-101	Hand collection	20.69778	-16.67239	19.06.2023
BdL-102	Hand collection	20.69751	-16.67254	19.06.2023
BdL-103	Hand collection	20.69726	-16.67263	19.06.2023
BdL-104	Hand collection	20.69671	-16.67292	19.06.2023
BdL-105	Hand collection	20.69571	-16.67279	19.06.2023
BdL-106	Hand collection	20.69571	-16.67279	19.06.2023
BdL-107	Hand collection	20.69401	-16.672077	19.06.2023
BdL-108	Chirp Sonar	20.69401	-16.672077	19.06.2023
K-001 Start	Ganchorra	19.82276576	-16.59401102	20.06.2023
K-001 End	Ganchorra	19.82224154	-16.59427281	20.06.2023
K-002	Drone	19.824933	-16.59540711	20.06.2023
K-003	Diving with CTD and GoPro	19.824933	-16.59540711	20.06.2023
K-004	Snorkeling	19.824933	-16.59540711	20.06.2023
SB1	Hand collection	18.110457	-16.026938	21.01.2024
M5	Drone	18.1609984	-16.02857	21.01.2024
M6	Excavation sample	18.1609984	-16.02857	21.01.2024
M7	Excavation sample	18.1609984	-16.02857	21.01.2024
M8	Drone	18.1609984	-16.02857	21.01.2024
M9	Excavation sample	18.1609984	-16.02857	21.01.2024
M10	Excavation sample	18.1609984	-16.02857	21.01.2024
NFM1-1	Tissue sample	18.1030325	-16.0262254	22.01.2024
NFM1-2	Tissue sample	18.1030325	-16.0262254	22.01.2024
NFM1-3	Tissue sample	18.1030325	-16.0262254	22.01.2024
NFM1-4	Tissue sample	18.1030325	-16.0262254	22.01.2024
NFM1-5	Tissue sample	18.1030325	-16.0262254	22.01.2024
NFM1-6	Tissue sample	18.1030325	-16.0262254	22.01.2024
NFM1-7	Tissue sample	18.1030325	-16.0262254	22.01.2024
NFM1-8	Tissue sample	18.1030325	-16.0262254	22.01.2024
NFM1-9	Tissue sample	18.1030325	-16.0262254	22.01.2024
NFM1-10	Tissue sample	18.1030325	-16.0262254	22.01.2024
NFM1-11	Tissue sample	18.1030325	-16.0262254	22.01.2024
NFM1-12	Tissue sample	18.1030325	-16.0262254	22.01.2024
NFM1-13	Tissue sample	18.1030325	-16.0262254	22.01.2024
NFM1-14	Tissue sample	18.1030325	-16.0262254	22.01.2024
NFM1-15	Tissue sample	18.1030325	-16.0262254	22.01.2024
NFM1-16	Tissue sample	18.1030325	-16.0262254	22.01.2024
B1	Hand collection	18.518789	-16.0750255	23.01.2024

B2	Hand collection	18.518789	-16.0750255	23.01.2024
B2	Hand collection	18.518789	-16.0750255	23.01.2024
B2	Hand collection	18.518789	-16.0750255	23.01.2024
S	Hand collection	18.253716	-16.017252	23.01.2024
NFM2-17	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM2-18	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM2-19	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM2-20	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM2-21	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM2-22	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM2-23	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM2-24	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM2-25	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM2-26	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM2-27	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM2-28	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM2-29	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM2-30	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM2-31	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM2-32	Tissue sample	18.1030325	-16.0262254	24.01.2024
NFM3	Hand collection	10.103031	-16.026963	24.01.2024
NFM4	Hand collection	10.103031	-16.026963	24.01.2024
NFM33	Tissue sample	18.57401	-16.090987	24.01.2024
ST01	Rock sample	18.574961	-16.091131	25.01.2024
ST02	Hand collection	18.575195	-16.091307	25.01.2024
ST03	Hand collection	18.578264	-16.091844	25.01.2024
ST04	Hand collection	18.580194	-16.092293	25.01.2024
ST05	Tissue sample	18.580194	-16.092293	25.01.2024
ST06A-B	Hand collection	18.5832	-16.09345	25.01.2024
ST07	Hand collection	18.58437	-16.09429	25.01.2024
ST08	Hand collection	18.58437	-16.09429	25.01.2024
ST09	Hand collection	18.58437	-16.09429	25.01.2024
ST10	Hand collection	18.5878	-16.09778	25.01.2024
ST11	Hand collection	18.58864	-16.09913	25.01.2024
ST12	Hand collection	18.58841	-16.0989	25.01.2024
ST13	Hand collection	beachwalk	beachwalk	25.01.2024
RN01	Hand collection	18.999623	-16.187158	28.01.2024
RN02	Hand collection	18.999962	-16.18731	28.01.2024
RN03	Hand collection	19.5918	-15.9892	28.01.2024
RN03	Hand collection	19.59164	-15.9891	28.01.2024
RN05	Hand collection	19.59152	-15.9891	28.01.2024
RN06	Hand collection	19.87954	-15.9312	28.01.2024
RN07	Hand collection	20.05189	-15.92083	28.01.2024
RN08	Hand collection	20.17555	-15.973655	28.01.2024
RN09	Hand collection	21.04845	-16.3297	28.01.2024
RN10	Hand collection	21.2853	-16.8565	28.01.2024
RN11	Hand collection	21.2853	-16.8565	28.01.2024
RN12	Hand collection	21.2853	-16.8565	28.01.2024
BdE-173	Drone	21021284	-17006841	30.01.2024

BdE-174	Drone	21.020319	-17.009755	30.01.2024
BdE-175	Hand collection	21,019792	-17,005124	30.01.2024
BdE-176	Hand collection	21,019727	-17,004562	30.01.2024
BdE-177	Hand collection	21,01908	-17,003484	30.01.2024
BdE-178	Hand collection	21,019033	-17,003257	30.01.2024
BdE-179	Hand collection	21,018773	-17,003244	30.01.2024
BdE-180	Hand collection	21,018446	-17,003052	30.01.2024
BdE-181	Hand collection	21,018193	-17,003103	30.01.2024
BdE-182	Hand collection	21,0179	-17,003146	30.01.2024
BdE-183	Hand collection	21,018319	-17,003625	30.01.2024
BdE-184	Hand collection	21,020711	-17,004669	30.01.2024
BdE-185	Hand collection	21,01989	-17,005615	30.01.2024
BdE-186	Deeper / CTD			30.01.2024
BdE-187	Drone	21.0390189	-17.026186	31.01.2024
BdE-188	Hand collection	21.039509	-17.025499	31.01.2024
BdE-189	Hand collection	21.042523	-17.025853	31.01.2024
BdE-190	Hand collection	21.043239	-17.025716	31.01.2024
BdE-191	Hand collection	21.044902	-17.022474	31.01.2024
BdE-192	Hand collection	21.045016	-17.020756	31.01.2024
BdE-193	Hand collection	21.044129	-17.024185	31.01.2024
BdE-194	Hand collection	21.037214	-17.026002	31.01.2024
BdE-195	Hand collection	21.03626024	-17.026572	31.01.2024
BdE-196	Hand collection	21.0373961	-17.025951	31.01.2024
BdE-197	Hand collection	21.03886244	-17.0251606	31.01.2024
BdE-198	Hand collection	21.0383354	-17.0254025	31.01.2024
BdE-199	Hand collection	21.0380119	-17.0253597	31.01.2024
BdE-200	Hand collection	21.0379786	-17.0254682	31.01.2024
BdE-201	Hand collection	21.038941	-17.02507	31.01.2024
BdE-202	Hand collection	21.039344	-17.025678	31.01.2024
BdE-203	Hand collection	21.03863223	-17.026055	31.01.2024
BdE-204	CTD			31.01.2024
BdE-205	Hand collection	21.038931	-17.025509	31.01.2024
BdE-206	Hand collection	21.038033	-17.025545	31.01.2024
BdE-207	Hand collection	21.037809	-17.026173	31.01.2024
BdE-208	Hand collection	21.039953	-17.026440	31.01.2024
BdE-209	Drone	21.039163	-17.025554	31.01.2024
BdE-210	Drone	21.043446	-17.026028	31.01.2024
BdL-109	Drone			31.01.2024
BdL-110	Drone	20.860445	-17.0355172	31.01.2024
BdE-211	Drone			01.02.2024
BdE-212	Hand collection	21.020574	-17.005523	01.02.2024
BdE-213	Hand collection	21.020572	-17.005527	01.02.2024
BdE-214	Hand collection	21.020744	-17.005353	01.02.2024
BdE-215	Hand collection	21.020831	-17.005193	01.02.2024
BdE-216	Hand collection	21.212284	-17.005453	01.02.2024
BdE-217	Hand collection	21.021419	-17.005686	01.02.2024
BdE-218	CTD			01.02.2024
BdE-219	Hand collection	21.02530153	-17.00723207	01.02.2024

BdE-220	Hand collection	21.02558032	-17.00717624	01.02.2024
BdE-221	Hand collection	21.02585164	-17.00711246	01.02.2024
BdE-222	Hand collection	21.02589041	-17.00698036	01.02.2024
BdE-223	Hand collection	21.0253784	-17.00706904	01.02.2024
BdE-224	Hand collection	21.02519894	-17.00732829	01.02.2024
BdE-225	CTD	21.02355269	-17.0069299	01.02.2024
BdE-226	BLANK			
BdE-227 (HRIV1)	Beach Seine	21.0168	17.01844	01.02.2024
BdE-228	Hand collection	21.020650	-17.006277	01.02.2024
BdE-229	Hand collection	21.020385	-17.007969	01.02.2024
BdE-230	Hand collection	21.018957	-17.007135	01.02.2024
BdE-231	Hand collection	21.018804	-17.007862	01.02.2024
BdE-232-1	Drone	21.012666	-17.020361	02.02.2024
BdE-233-1	CTD	21.0161299	-17.0192577	02.02.2024
BdE-233-2	CTD	21.0162	-17.019351	02.02.2024
BdE-234	Hand collection	21.0142637	-17.020363	02.02.2024
BdE-235	Hand collection	21.0174461	-17.0157	02.02.2024
BdE-236	Hand collection	21.0186114	-17.0121698	02.02.2024
BdE-237	Deeper	21.015154	-17.020495	02.02.2024
BdE-238	Hand collection	21.0141428	-17.0210399	02.02.2024
BdE-239 Start	Beam Trawl	21.0149234	-17.0210117	02.02.2024
BdE-239 End	Beam Trawl	21.0152774	-17.020939	02.02.2024
BdE-240 Start	Beam Trawl	21.015146	-17.020396	02.02.2024
BdE-240 End	Beam Trawl	21.0152774	-17.020939	02.02.2024
BdE-241 Start	Beam Trawl	21.0152774	-17.020939	02.02.2024
BdE-241 End	Beam Trawl	21.015277	-17.020939	02.02.2024
BdE-242	Beam Trawl	XXX	XXX	02.02.2024
BdE-243	Beam Trawl	XXX	XXX	02.02.2024
BdE-244	Deeper	21.016292	-17.0193702	02.02.2024
BdE-245 Start	Beam Trawl	21.0155547	-17.0208608	02.02.2024
BdE-245 End	Beam Trawl	21.0159587	-17.0205336	02.02.2024
BdE-246 Start	Beam Trawl	21.015569	-17.020269	02.02.2024
BdE-246 End	Beam Trawl	21.0159518	-17.0205633	02.02.2024
BdE-247	Beam Trawl	21.0153782	-17.020951	02.02.2024
BdE-248 Start	Beam Trawl	21.0154051	-17.020946	02.02.2024
BdE-248 End	Beam Trawl	21.014771	-17.0211391	02.02.2024
BdE-249 Start	Beam Trawl	21.014727	-17.0211843	02.02.2024
BdE-249 End	Beam Trawl	21.0145918	-17.0211698	02.02.2024
BdE-250	Snorkeling	21.510120	-17.020618	02.02.2024
BdE-251	Beam Trawl			02.02.2024
BdE-252	Hand collection	21.0146735	-17.021177	02.02.2024
BdE-253	Drone	20.999226	-17.016332	02.02.2024
BdE-254	Hand collection under stones	20.97718476	-17.01009574	03.02.2024
BdE-255	Hand collection under stones	20.97792781	-17.01015752	03.02.2024
BdE-256	Hand collection in water	21.02117487	-17.00631819	03.02.2024
BdE-257	Hand collection in water	21.02488583	-17.00711405	03.02.2024
BdE-258	Hand collection in water	21.02515774	-17.00704414	03.02.2024
BdE-259	Hand collection in water	21.02227768	-17.00473971	03.02.2024
BdE-260	Beam Trawl	21.03072505	-17.02618724	04.02.2024

BdE-261	Beam Trawl	21.03036781	-17.02602983	04.02.2024
BdE-262	Hand collection	21.03110001	-17.02604399	04.02.2024
BdE-263	Beam Trawl	21.03038223	-17.02589689	04.02.2024
BdL-111 Start	CTD	20.8944386	-17.046259	03.02.2024
BdL-111 End	CTD	20.6525238	-16.732441	03.02.2024
BdL-112 Start	Deeper	20.6536783	-16.727013	03.02.2024
BdL-112 End	Deeper	20.6566823	-16.724045	03.02.2024
BdL-113	Deeper	20.662633	-16.724667	03.02.2024
BdL-114	Camera Lander	20.662633	-16.724667	03.02.2024
BdL-115 Start	Camera Lander	20.649662	-16.728216	03.02.2024
BdL-115 End	Camera Lander	20.650964	-16.731106	03.02.2024
BdL-116-1 Start	Side-Scan Sonar	20.649938	-16.732339	03.02.2024
BdL-116-1 End	Side-Scan Sonar	20.653909	-16.727307	03.02.2024
BdL-116-2 Start	Side-Scan Sonar	20.652891	-16.726844	03.02.2024
BdL-116-2 End	Side-Scan Sonar	20.649499	-16.731017	03.02.2024
BdL-116-3 Start	Side-Scan Sonar	20.649833	-16.731379	03.02.2024
BdL-116-3 End	Side-Scan Sonar	20.653846	-16.726438	03.02.2024
BdL-117	Hook fishing	20.670345	-16.674227	03.02.2024
BdL-118 Start	Side-Scan Sonar	20.668391	-16.681692	04.02.2024
BdL-118 End	Side-Scan Sonar	20.667289	-16.697091	04.02.2024
BdL-119 Start	Camera Lander	20.656484	-16.721255	04.02.2024
BdL-119 End	Camera Lander	20.656941	-16.722788	04.02.2024
BdL-120 Start	Camera Lander	20.656719	-16.720807	04.02.2024
BdL-120 End	Camera Lander	20.657529	-16.722842	04.02.2024
BdL-121 Start	Camera Lander	20.656197	-16.72112	04.02.2024
BdL-121 End	Camera Lander	20.656368	-16.721509	04.02.2024
BdL-122 Start	Ganchorra	20.656206	-16.719999	04.02.2024
BdL-122 End	Ganchorra	20.656498	-16.721518	04.02.2024
BdL-123 Start	Camera Lander	20.661834	-16.704181	04.02.2024
BdL-123 End	Camera Lander	20.663225	-16.704744	04.02.2024
BdL-124 Start	Ganchorra	20.664804	-16.705049	04.02.2024
BdL-124 End	Ganchorra	20.662202	-16.705437	04.02.2024
BdL-125	Van Veen Grab	20.663033	-16.699814	04.02.2024
BdL-126	Van Veen Grab	20.662977	-16.699513	04.02.2024
BdL-127 Start	Ganchorra	20.665229	-16.704943	04.02.2024
BdL-127 End	Ganchorra	20.665042	-16.704035	04.02.2024
BdL-128 Start	CTD	20.67	-16.710173	04.02.2024
BdL-128 End	CTD	20.883299	-17.041012	04.02.2024
BdL-129	BLANK			
BdL-130	Hand collection	20.770151	-17.048979	05.02.2024
BdL-131	Molofilamentous Seine	20.771341	-17.04587	05.02.2024
BdL-132	Beam Trawl	20.771549	-17.046	05.02.2024
BdL-133	Hook and line fishing	20.771301	-17.046579	05.02.2024
BdL-134	Drone			05.02.2024
BdL-135	Hand collection			05.02.2024
BdL-136	Hand collection			05.02.2024

13.2 List of barcoded species from Mauritanian coastal habitats

This table comprises every successfully barcoded sample from the Mauritanian marine life barcode library BOLD project. The ID-number represents the BOLD-ID found for every DNA barcode in the project. For further information see Chapter 7.

ID	Species	Station	Latitude	Longitude
Mau-1	*Sarda sarda*	Fishmarket Nouackchott	18.103375	-16.026176
Mau-3	*Prionace glauca*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-4	*Prionace glauca*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-6	*Microchirus wittei*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-7	*Cephalopholis taeniops*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-8	*Sarda sarda*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-9	*Sarda sarda*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-10	*Capros aper*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-11	*Scorpaena normani*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-12	*Citharus linguatula*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-13	*Capros aper*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-14	*Todaropsis eblanae*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-15	*Lesueurigobius* sp.	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-16	*Tylosurus crocodilus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-17	*Halobatrachus didactylus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-18	*Diplodus vulgaris*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-19	*Sphoeroides pachygaster*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-20	*Epinephelus marginatus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-21	*Epinephelus marginatus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-22	*Ephippion guttifer*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-23	*Nicholsina collettei*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-24	*Scorpaena normani*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-25	*Pontinus kuhlii*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-28	*Sphyrna lewini*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-29	*Lithognathus mormyrus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-30	*Stephanolepis hispida*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-31	*Stephanolepis hispida*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-32	*Stephanolepis hispida*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-33	*Halobatrachus didactylus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-34	*Diplodus vulgaris*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-35	*Ephippion guttifer*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-36	*Diplodus vulgaris*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-37	*Trachinotus ovatus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-38	*Parakuhlia macrophthalma*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-39	*Sphyraena sphyraena*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-40	*Ilisha africana*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-41	*Capros aper*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-42	*Scorpaena normani*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-43	*Citharus linguatula*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-44	*Schedophilus velaini*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-45	*Diplodus sargus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-46	*Diplodus sargus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-47	*Sphoeroides pachygaster*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-48	*Ephippion guttifer*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-49	*Microchirus wittei*	Fishmarket Nouackchott	18.1033757	-16.026176

Mau-50	*Nicholsina collettei*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-52	*Microchirus wittei*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-53	*Sphoeroides pachygaster*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-54	*Lesueurigobius* sp.	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-55	*Scyliorhinus canicula*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-56	*Citharus linguatula*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-57	*Scyliorhinus canicula*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-58	*Diplodus cervinus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-59	*Spondyliosoma cantharus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-60	*Diplodus cervinus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-61	*Sphyrna lewini*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-62	*Sphyrna lewini*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-63	*Nicholsina collettei*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-64	*Chelon ramada*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-65	*Chelon auratus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-66	*Diplodus sargus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-67	*Panulirus regius*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-68	*Panulirus regius*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-69	*Panulirus regius*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-70	*Palinurus mauritanicus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-71	*Palinurus mauritanicus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-72	*Palinurus marutanicus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-74	*Halobatrachus didactylus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-75	*Lithognathus mormyrus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-76	*Scyliorhinus canicula*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-77	*Sparus auratus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-78	*Sparus auratus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-79	*Psettodes bennettii*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-80	*Psettodes bennettii*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-81	*Psettodes bennettii*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-83	*Solea senegalensis*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-84	*Dentex canariensis*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-85	*Dentex canariensis*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-86	*Dentex angolensis*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-87	*Solea senegalensis*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-88	*Chelon ramada*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-89	*Dagetichthys lusitanicus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-91	*Dagetichthys lusitanicus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-93	*Dagetichthys lusitanicus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-95	*Dagetichthys lusitanicus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-96	*Dagetichthys lusitanicus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-97	*Psettodes bennettii*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-98	*Psettodes bennettii*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-99	*Psettodes bennettii*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-100	*Sparus auratus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-101	*Trachinotus ovatus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-102	*Lichia amia*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-103	*Trachinotus ovatus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-105	*Lichia amia*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-106	*Balistes punctatus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-107	*Lithognathus mormyrus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-108	*Cephalopholis taeniops*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-109	*Cephalopholis taeniops*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-112	*Lichia amia*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-113	*Sphyraena sphyraena*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-114	*Ethmalosa fimbriata*	Fishmarket Nouackchott	18.1033757	-16.026176

Mau-115	*Ethmalosa fimbriata*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-116	*Parapristipoma octolineatum*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-117	*Parapristipoma octolineatum*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-118	*Parapristipoma octolineatum*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-119	*Trachurus trachurus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-120	*Caranx rhonchus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-121	*Caranx rhonchus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-122	*Trachurus trachurus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-123	*Caranx rhonchus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-125	*Pteroscion peli*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-126	*Sarotherodon melanotheron*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-127	*Mycteroperca rubra*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-128	*Schedophilus velaini*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-129	*Branchiostegus semifasciatus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-130	*Branchiostegus semifasciatus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-131	*Dentex canariensis*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-133	*Lagocephalus guentheri*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-134	*Ethmalosa fimbriata*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-135	*Branchiostegus semifasciatus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-136	*Drepane africana*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-137	*Drepane africana*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-138	*Dentex gibbosus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-139	*Dentex canariensis*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-141	*Dentex gibbosus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-142	*Sarotherodon melanotheron*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-143	*Pteroscion peli*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-144	*Lagocephalus laevigatus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-145	*Pteroscion peli*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-148	*Schedophilus velaini*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-149	*Mycteroperca rubra*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-152	*Sarotherodon melanotheron*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-153	*Dentex gibbosus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-154	*Schedophilus velaini*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-156	*Priacanthus arenatus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-158	*Dentex canariensis*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-159	*Drepane africana*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-163	*Galeoides decadactylus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-164	*Lucinoma atalantae*	14848-01 (MSM16-3)	19.8218	-17.261683
Mau-167	*Mesalia opalina*	14729-1 (MSM 16-3)	19.7149167	-16.9453
Mau-175	*Cerastoderma* sp.	14788-1 (MSM 16-3)	20.28315	-17.333483
Mau-176	*Mesalia mesal*			
Mau-178	*Gari fervensis*	14780-2 (MSM 16-3)	20.8169167	-17.01855
Mau-179	*Moerella boucheti*	14780-2 (MSM 16-3)	20.8169167	-17.01855
Mau-182	*Nassarius megalocallus*	14703-1 (MSM 16-3)	20.2353333	-17.602883
Mau-209	*Ophiotrix* sp.	CDP21-1-3	21.0206303	-17.004656
Mau-211	*Gari jousseaumeana*	BdL21-4-2	21.039883	-16.906667
Mau-213	*Lucinoma borealis*	BdL21-5-2	21.022	-16.992767
Mau-215	*Perna perna*	CdP21-3	21.0197657	-17.005413
Mau-216	*Pisidia bluteli*	CdP21-1-3	21.0206303	-17.004656
Mau-217	*Asthenognathus atlanticus*	BDL21-3-2	21.0135	-16.961117
Mau-218	*Maja brachydactyla*	CDP21-1-3	21.0206303	-17.004656
Mau-219	*Pisa tetraodon*	CDP21-1-3	21.0206303	-17.004656
Mau-220	*Porcellana platycheles*	CdP21-00	21.019716	-17.005418
Mau-221	*Xantho poressa*	CDP21-1-3	21.0206303	-17.004656
Mau-225	*Diogenes pugilator*	BdL21-3-2	21.0135	-16.961117
Mau-227	*Microlipophrys velifer*	CdP21-00	21.019716	-17.005418

Mau-228	*Sphoeroides marmoratus*	CdP21-01	21.0206303	-17.004656
Mau-234	*Palaemon elegans*	BdE-16	21.02734	-17.00422
Mau-235	*Pseudopagurus granulimanus*	BdE-5	21.01914669	-17.00636302
Mau-236	*Panopeus africanus*	BdE-13	21.03404742	-17.02615285
Mau-237	*Carcinus maenas*	BdE-13	21.03404742	-17.02615285
Mau-239	*Carcinus maenas*	BdE-5	21.01914669	-17.00636302
Mau-241	*Pinnotheres pisum*	BdE-1	21.0192641	-17.004485668
Mau-244	*Menesiniella regalis*	BdE-20-N-W	21.02569892	-17.00713508
Mau-245	*Chthamalus montagui*	BdE-20-Island-Top	21.02569892	-17.00713508
Mau-248	*Gari fervensis*	BdL-6-1	20.65288134	-16.73166469
Mau-249	*Crassatina alba*	BdL-6-1	20.65288134	-16.73166469
Mau-250	*Tellenidae* sp.	CdP21-00	21.0206303	-17.004656
Mau-251	*Callista chione*	BdL-6-1	20.65288134	-16.73166469
Mau-252	*Ostrea stentina*	BdE-20-Island-Top	21.02569892	-17.00713508
Mau-253	*Cerastoderma edule*	BdE-12	21.04555385	-17.01960122
Mau-254	*Ruditapes descussatus*	BdE-1	21.0192641	-17.004485668
Mau-256	*Actinia equina*	BdE-2	21.01990538	-17.00559643
Mau-258	*Onchidella celtica*	BdE-20-W	21.02569892	-17.00713508
Mau-259	*Hexaplex rosarium*	BdE-6	21.02007184	-17.00501579
Mau-260	*Gari* sp.	BdL-6-1	20.65288134	-16.73166469
Mau-261	*Crepidula porcellana*	BdE-20-Maerl	21.02569892	-17.00713508
Mau-262	*Siphonaria pectinata*	BdE-20-Island-Top	21.02569892	-17.00713508
Mau-263	*Pugilina morio*	BdE-5	21.01914669	-17.00636302
Mau-266	*Natica fulminea*	BdL-6-1	20.65288134	-16.73166469
Mau-272	*Carcinus maenas*	BdE-5	21.01914669	-17.00636302
Mau-278	*Chelon dumerili*	BdE-7	21.0168	-17.01844
Mau-279	*Solea senegalensis*	BdE-7	21.0168	-17.01844
Mau-281	*Gobius niger*	BdE-8	21.01201	-17.01334
Mau-284	*Atherina presbyter*	BdE-8	21.01201	-17.01334
Mau-285	*Diplodus sargus*	BdE-8	21.01201	-17.01334
Mau-286	*Syngnathus acus*	BdE-9	21.01201	-17.01334
Mau-287	*Gobius paganellus*	BdE-9	21.01201	-17.01334
Mau-288	*Gobius paganellus*	BdE-9	21.01201	-17.01334
Mau-289	*Symphodus bailloni*	BdE-9	21.01201	-17.01334
Mau-290	*Symphodus bailloni*	BdE-9	21.01201	-17.01334
Mau-293	*Pomatoschistus microps*	BdE-16	21.02734	-17.00422
Mau-294	*Pomatoschistus microps*	BdE-16	21.02734	-17.00422
Mau-332	*Magallana gigas*	BdE-134	21.037622	-17.025734
Mau-334	*Patella depressa*	BdL-34	20.853611	-17.028761
Mau-335	*Cymbium marmoratum*	BdE-153	21.019885	-17.00283
Mau-336	*Stramonita haemastoma*	BdL-34	20.853611	-17.028761
Mau-337	*Senilia senilis*	IdA-09	20.610664	-16.44685
Mau-338	*Ostrea stentina*	BdE-103-1	21.020716	-17.00465
Mau-340	*Bulla striata*	BdE-109	21.024752	-17.006571
Mau-341	*Mesalia* sp.	BdE-129	21.042624	-17.025938
Mau-342	*Sepia officinalis*	BdE-130	21.038604	-17.02363
Mau-343	*Cymbium marmoratus*	Cymbium sample	21.019885	-17.020796
Mau-344	*Sepia hierredda*	BdE-130	21.038604	-17.02363
Mau-345	*Patella depressa*	BdL-19	20.77107	-17.04687
Mau-350	*Leptogorgia sylvanae*	BdE-67	21.022703	-17.006115
Mau-351	*Nemertesia ramosa*	BdL-51	20.653121	-16.726702
Mau-359	*Asterina gibbosa*	BdL-74	20.711115	-16.688095
Mau-360	*Holothuroidea* indet.	BdL-74	20.711115	-16.688095
Mau-361	*Ophiotrix* sp.	BdE-119	21.0184331	-17.0030314
Mau-363	*Amblyosyllis* cf. *spectabilis*	BdE-56	21.02061	-17.00457
Mau-364	*Streblosoma* sp.	BdE-112	21.021194	-17.00662

Mau-370	*Orbinidae* indet.	BdE-111	21.022438	-17.006281
Mau-372	*Branchiomma luctuosum*	BdE-56	21.02061	-17.00457
Mau-373	*Nicomachinae* indet.	BdE-112-2	21.021194	-17.00662
Mau-375	*Oenonidae* indet.	BdE-109	21.024752	-17.006571
Mau-376	*Marphysa sanguinea*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-384	*Chelonia mydas*	IdA-9	20.610664	-16.44685
Mau-386	*Afruca tangeri*	BdE-126	21.03765	-17.02649
Mau-387	*Maja brachydactyla*	BdE-64	21.025471	-17.006742
Mau-388	*Callinectes amnicola*	BdL-62	20.68031	-16.675285
Mau-389	*Callinectes marginatus*	BdL-62	20.68031	-16.675285
Mau-391	*Carcinus maenas*	BdE-132	21.038604	-17.02363
Mau-392	*Penaeus kerathurus*	Fish Market	18.1033757	-16.026176
Mau-393	*Penaeus notialis*	Fish Market	18.1033757	-16.026176
Mau-394	*Pollicipes pollicipes*	BdL-25	20.770075	-17.048746
Mau-395	*Thalamita poissonii*	BdE-103-2	21.020716	-17.00465
Mau-396	*Pisa tetraodon*	BdE-103-2	21.020716	-17.00465
Mau-397	*Metopograpsus* sp.	BdL-74	20.711115	-16.688095
Mau-398	*Thalamita poissonii*	BdL-61	20.679591	-16.675573
Mau-399	*Maja brachydactyla*	BdE-62	21.024359	-17.006784
Mau-400	*Maja brachydactyla*	BdE-62	21.024359	-17.006784
Mau-401	*Pollicipes pollicipes*	BdL-40	20.970034	-17.006086
Mau-405	*Ceratothoa* sp.	BdE-66	21.025976	-17.006901
Mau-406	*Athanas nouvelae*	BdE-56	21.02061	-17.00457
Mau-407	*Symphodus bailloni*	BdE-59-2	21.020716	-17.00465
Mau-408	*Caranx rhonchus*	BdL-35	20.853611	-17.028761
Mau-409	*Symphodus bailloni*	KU2	20.879529	-17.028663
Mau-410	*Gobius paganellus*	BdE-59-2	21.020716	-17.00465
Mau-411	*Chelon dumerili*	BdE-60	21.019822	-17.005131
Mau-412	*Gobius paganellus*	BdL-74	20.711115	-16.688095
Mau-413	*Malacoctenus africanus*	BdE59-1	21.020716	-17.00465
Mau-414	*Malacoctenus africanus*	BdE-103-1	21.020716	-17.00465
Mau-415	*Gobius paganellus*	BdE-116	21.02078	-17.00715
Mau-416	*Plectorhinchus mediterraneus*	BdE-153	21.019885	-17.00283
Mau-417	*Mugil capurii*	BdE-141	21.037622	-17.025822
Mau-418	*Pomadasys perotaei*	BdE-153	21.019885	-17.00283
Mau-419	*Diplodus sargus*	BdE-153	21.019885	-17.00283
Mau-420	*Pagrus coeroleosticus*	BdE-153	21.019885	-17.00283
Mau-422	*Epinephelus aeneus*	BdE-153	21.019885	-17.00283
Mau-424	*Synaptura lusitanica*	BdE-153	21.019885	-17.00283
Mau-425	*Argyrosomus regius*	BdE-153	21.019885	-17.00283
Mau-428	*Rhizoprionodon acutus*	BdL-56	20.670416	-16.673222
Mau-429	*Hypleurochilus bananensis*	BdE-64	21.025471	-17.006742
Mau-430	*Halobatrachus didactylus*	BdE-69-2	21.0207	-17.00471
Mau-431	*Spondylisoma cantharus*	IdA-12	20.565596	-16.408353
Mau-432	*Mustelus punctulatus*	BdL-56	20.670416	-16.673222
Mau-433	*Chelon dumerili*	NBE	21.0419	-17.01424
Mau-434	*Pomatoschistus microps*	NBE	21.0419	-17.01424
Mau-435	*Chelon ramada*	BdL-89	20.693887	-16.6723688
Mau-436	*Chelon auratus*	BdL-92	20.689011	-16.6851519
Mau-437	*Raja undulata*	BdL-58	20.679246	-16.674007
Mau-438	*Gobius cobitis*	BdL-74	20.711115	-16.688095
Mau-439	*Carlarius parkii*	IdA-12	20.565596	-16.408353
Mau-440	*Carlarius parkii*	IdA-12	20.565596	-16.408353
Mau-442	*Mugil capurii capurii*	BdL-95	20.689011	-16.6851519
Mau-446	*Huberimactra inconstans*	BdL-53	20.654792	-16.726024
Mau-447	*Senilia senilis*	K3	19.824934	-16.59540712

Mau-448	*Pitar* sp.	Belaat KU1	20.879529	-17.028663
Mau-450	*Papillicardium papillosum*	BdL-53	20.654792	-16.726024
Mau-451	*Crassatina* sp.	50982	20.6528813	-16.731665
Mau-452	*Petricola lithophaga*	BdE-107	21.025276	-17.007072
Mau-453	*Crassatina goerensis*	50984	20.6528813	-16.731665
Mau-454	*Pitar tumens*	BdL-53	20.654792	-16.726024
Mau-455	*Leiosolenus aristatus*	BdE-65	21.025471	-17.006742
Mau-457	*Papillicardium papillosum*	K1	19.82276576	-16.59401102
Mau-459	*Sepia officinali*	BdE-8	21.01201	-17.01334
Mau-460	*Amphibalanus amphitrite*	BdE-64	21.025471	-17.006742
Mau-461	*Pseudopagurus granulimanus*	BdE-64	21.025471	-17.006742
Mau-463	*Pisidia longicornis*	BdL-51	20.653121	-16.726702
Mau-464	*Penaeus notialis*	50976	21.01201	-17.01334
Mau-465	*Palaemon elegans*	51020	21.02734	-17.00422
Mau-466	*Macropodia linaresi*	K1	19.82276576	-16.59401102
Mau-467	*Pisidia* sp.	K3	19.824934	-16.59540712
Mau-468	*Pisidia* sp.	K1	19.82276576	-16.59401102
Mau-469	*Periclimenes sagittifer*	K1	19.82276576	-16.59401102
Mau-476	*Ophiactis lymanii*	BdE-107	21.025276	-17.007072
Mau-478	*Ophiactis lymanii*	BdE-63	21.024875	-17.00718
Mau-481	*Marginella cleryi*	BdE-109	21.024752	-17.006571
Mau-482	*Zonaria zonaria*	Belaat KU1	20.879529	-17.028663
Mau-483	*Bulla striata*	MFAL	21.02682	-17.02365
Mau-485	*Mitrella ocellina*	BdE-107	21.025276	-17.007072
Mau-487	*Columbella adansoni*	BdE-53	21.0217	-17.0065
Mau-488	*Doriopsilla pelseneeri*	BdL-51	20.653121	-16.726702
Mau-491	*Cancilla* sp.	BdL-51	20.653121	-16.726702
Mau-495	*Steromphala umbilicalis*	IDA-9	20.610664	-16.44685
Mau-496	*Bursatella leachii*	BdL-53	20.654792	-16.726024
Mau-497	*Bursatella leachii*	BdL-54	20.654793	-16.726025
Mau-498	*Nassarius contrarum*	BdL-53	20.654792	-16.726024
Mau-499	*Diodora graeca*	50987	20.65288134	-16.73166469
Mau-500	*Volvarina ambigua*	51015	20.65288134	-16.73166469
Mau-501	*Anachis* sp.	BdE-103-2	21.020716	-17.00465
Mau-503	*Mitrella ocellata*	BdE-103-2	21.020716	-17.00465
Mau-505	*Mugil capurrii*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-506	*Alectis alexandrina*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-507	*Lichia amia*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-509	*Sardinella aurita*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-510	*Pomatomus saltatrix*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-511	*Epinephelus aeneus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-512	*Pagrus caeruleostictus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-513	*Trichiurus lepturus*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-514	*Pseudupeneus prayensis*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-517	*Seriola rivoliana*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-518	*Campogramma glaycos*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-519	*Pomadasys perotaei*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-520	*Glaucostegus cemiculus*	Fatimetou		
Mau-521	*Glaucostegus cemiculus*	Fatimetou		
Mau-522	*Alopias vulpinus*	Fatimetou		
Mau-524	*Gymnura* sp.	Fatimetou		
Mau-527	*Raja miraletus*	Fatimetou		
Mau-528	*Gymnura margarita*	Fatimetou		
Mau-529	*Gymnura margarita*	Fatimetou		
Mau-532	*Sphyrna zygaena*	Fatimetou		

Mau-536	*Rhizonprionodon acutus*	Fatimetou		
Mau-539	*Raja miraletus*	Fatimetou		
Mau-542	*Antigonia capros*	Fishmarket Nouackchott	18.1033757	-16.026176
Mau-545	*Phycis phycis*	Fishmarket Nouackchott	18	-16.026176
Mau-546	*Chelidoperca africana*	Fishmarket Nouackchott	18	-16.026176
Mau-548	*Blennuis normani*	Fishmarket Nouackchott	18	-16.026176
Mau-549	*Fistularia petimba*	Fishmarket Nouackchott	18	-16.026176
Mau-554	*Gobius senegambiensis*	BdE-65	21.025471	-17.006742
Mau-555	*Gobius senegambiensis*	BdE-62	21.024359	-17.006784
Mau-556	*Hypleurochilus bananensis*	BdE-121	21.0188208	-17.0038719
Mau-561	*Euphrosine* sp.	K1	19.82276576	-16.59401102
Mau-562	*Platynereis dumerilii*	K1	19.82276576	-16.59401102
Mau-564	*Acanthochitona fascicularis*	K1	19.82276576	-16.59401102
Mau-565	*Echinochiton cessaci*	K1	19.82276576	-16.59401102
Mau-566	*Acanthochitona fascicularis*	K3	19.824934	-16.59540712
Mau-569	*Antalis dentalis*	BdL-51	20.653121	-16.726702
Mau-570	*Antalis dentalis*	BdL-51	20.653121	-16.726702
Mau-571	*Serenepilumnus pisifer*	KU3	20.6826135	-16.716873
Mau-573	*Atlantophila cristata*	GA1	20.653121	-16.726702
Mau-574	*Eupilumnus stridulans*	BdE-64	21.025471	-17.006742
Mau-576	*Periophthalmus barbarus*	Fishmarket Nouackchott	18	-16.026176
Mau-577	*Gastrana* cf. *matadoa*	Fishmarket Nouackchott	18	-16.026176
Mau-578	*Tritia pfeifferi*	Fishmarket Nouackchott	18	-16.026176
Mau-579	*Prionace glauca*	Fishmarket Nouackchott	18	-16.026176
Mau-582	*Fontitrygon* sp.	Fishmarket Nouackchott	18	-16.026176
Mau-583	*Bryopsis*	BryTAG01	20.158171	-16.22556
Mau-584	*Caulerpa taxifolia*	CT-TE-01		
Mau-585	*Caulerpa cupressoides*	CC-AR	20.158171	-16.22556
Mau-586	*Enteromorpha*	EntTAG01	20.158171	-16.22556
Mau-587	*Codium*	CodTag01	20.158171	-16.22556
Mau-588	*Acetabularia*	AceTAG01	20.158171	-16.22556
Mau-589	*Ulva*	UL-CB-01	20.771270	-17.046221
Mau-590	*Ulva*	UlvTAG01	20.158171	-16.22556
Mau-591	*Dictyota*	DI-BE-01		
Mau-592	*Dictyota*	DI-IW-01		
Mau-593	*Dictyota* sp.	DicTAG02	20.158171	-16.22556
Mau-594	*Dictyota* sp.	DicTAG03	20.158171	-16.22556
Mau-595	*Dictyopteris*	DpolTAG01	20.158171	-16.22556
Mau-596	*Dictyota spiralis*	DS-AR-01	20.158171	-16.22556
Mau-597	*Dictyota* sp.	DiSerTAG01	20.158171	-16.22556
Mau-598	*Dictyota ciliolata*	DD-IW-01		
Mau-599	*Dictyota ciliolata*	DiRCHE01		
Mau-600	*Lobophora*	LobTAG01		
Mau-601	*Padina* sp.	PA-CB-01	20.771270	-17.046221
Mau-602	*Padina antillarum*	PA-BE-01		
Mau-603	*Padina*	PadTAG01	20.158171	-16.22556
Mau-604	*Taonia atomaria*	TA-CB-01	20.771270	-17.046221
Mau-605	*Filamentous brown floating*	FilBKIL01		
Mau-606	*Pylaiella?*	PylTID01		
Mau-607	*Taonia slim?*	TaSTAG01	20.158171	-16.22556
Mau-608	*original ID as C. compressa*	CcomTAG01	20.158171	-16.22556
Mau-609	*"Cystoseira tamariscifolia"*	CysNOV		
Mau-610	*"Cystoseira tamariscifolia"*	CT-NO-01		
Mau-611	*Cystoseira*	CysET02		
Mau-612	*Cystoseira*	CnodTEC01		
Mau-613	*Cystoseira*	CnodTEC02		

Mau-614	*Cystoseira*	CY-NO-01		
Mau-615	*Cystoseira*	CysET01		
Mau-616	*Sargassum*	SA-BE-01		
Mau-617	*Sargassum*	SA_IW01		
Mau-618	*Sargassum*	SA-AR-01	20.158171	-16.22556
Mau-619	*Sargassum*	SA-TE-01		
Mau-620	*Sargassum*	SA_3f		
Mau-621	*Acanthophora*	Ac_3b		
Mau-622	*Acanthophora*	Ac_2c		
Mau-623	*Hypoglossum hypoglossoides*	HH-CB-01	20.771270	-17.046221
Mau-624	*Chondria*	ChoCHE01		
Mau-625	*Osmundea*	OS-BE-01		
Mau-626	*Laurencia-like #1*	LauTAG01	20.158171	-16.22556
Mau-627	*Laurencia-like #2*	LauTAG02	20.158171	-16.22556
Mau-628	*Laurencia*	LA-CB-01	20.771270	-17.046221
Mau-629	*Osmundea pinnatifida*	OP-CB-01	20.771270	-17.046221
Mau-630	*Laurencia?*	RL_1-5A		
Mau-631	*Red Algae*	RVP_2a		
Mau-632	*Jania*	JA_1-5		
Mau-633	*Jania*	JanCHE02		
Mau-634	*Jania*	JanCHE03		
Mau-635	*Corallina elongata*	CE-CB-01	20.771270	-17.046221
Mau-636	*Hypnea*	HypCHE01		
Mau-637	*Jania*	JanCHE01		
Mau-638	*Hypnea-like #1*	HypTAG01		
Mau-639	*Gelidium corneum*	GC-CB-01/Gelco-CB01		
Mau-640	*Gelidium corneum*	GC-CB-02/Gelco-CB02		
Mau-641	*Gigartina pistillata*	GP-CB-01	20.158171	-16.22556
Mau-642	*Hypnea musciformis*	HM-CB-01	20.771270	-17.046221
Mau-643	*Hypnea musciformis*	HM-TE-02	20.771270	-17.046221
Mau-644	*Hypnea 2*	HypMAU02	20.771270	-17.046221
Mau-645	*Hypnea*	HY_3d	20.771270	-17.046221
Mau-646	*Hypnea-like #2*	HypTAG02		
Mau-647	*Hypnea-like #3*	HypTAG03		
Mau-649	*Gracillariacea*	GraTAG01	20.158171	-16.22556
Mau-650	*Gracillariacea*	GraCHE01	20.158171	-16.22556
Mau-652	*Plocamium-like #1*	PloTAG01	20.158171	-16.22556
Mau-654	*Plocamium*	PloTAG01		
Mau-655	*Plocamium*	PloCHE01	20.158171	-16.22556

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Publication list

Schliewen U, Knorrn AH, Boehmer R, Beuck L, Sonnewald M, Freiwald A (2023) *Didogobius lanceolatus* spec. nov., a new goby species from Mauritania (Teleostei: Gobiidae: Gobiinae), with diagnoses for two new gobiine genera. *Spixiana* 46 (1): 119-133. ISSN 0341-8391

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