

Summaries



Summary

Populations of sharks and rays (*i.e.*, elasmobranchs) are under pressure from human activities. Combined with their slow population growth, this has resulted in declining shark and ray populations. The decline of sharks and rays threatens the functioning of marine ecosystems and local communities that depend on fisheries. The impact of human disturbances on the ecological role of sharks and rays in intertidal ecosystems - *i.e.*, habitats (often soft-bottom flats) exposed during low tide - is poorly understood, especially in the West African region. In this thesis, I address this important knowledge gap by focusing on the two largest intertidal ecosystems in the West African region: the Banc d'Arguin in Mauritania and the Bijagós Archipelago in Guinea-Bissau, placing results into a regional and global (intertidal) context. This thesis addresses the central question: "How do fisheries impact the role of sharks and rays as intertidal predators, and how does this potentially impact other predators (*e.g.*, migratory shorebirds) and ecosystem functioning?". I focus on four themes to address this question, which I summarized consecutively.

Fisheries

We studied the extent of industrial and small-scale fisheries to determine their impact on shark and ray populations in the Banc d'Arguin and the Bijagós Archipelago (**Section I**). For this, we used data from industrial fishing vessels' onboard 'Automatic Identification System' (AIS) to determine the distribution of their fishing activity near both study areas (**Chapter 2**). We then combined this with information on shark and ray catches by fishers in the waters of Mauritania and Guinea-Bissau. We found that industrial fishing effort is concentrated around the borders of the marine protected areas, with 72% and 78% of the area around the borders of the Banc d'Arguin and Bijagós Archipelago impacted by fishing activity, respectively. We further show that the bycatch of sharks and rays can be high in these waters.

We reconstructed the population changes over the past decades in both study areas to determine a historical baseline for sharks and rays. In the Banc d'Arguin, we based population trends on landing site surveys (**Chapter 3**) and fishers' ecological knowledge in the Bijagós Archipelago (**Chapter 4**). We concluded that shark and ray populations declined severely, with some species (groups), such as blackchin guitarfish (*Glaucostegus cemiculus*) and hammerhead sharks (*Sphyrna spp.*), declining by over 90% between 1960 and 2020.

These results show that sharks and rays are at risk from small-scale fisheries locally, whereas individuals moving outside these areas are at risk from industrial fisheries. In addition, the available marine habitat in intertidal areas shrinks dramatically with the receding tide, making these species even more susceptible to capture and decreasing survivability in intertidal fishing gear. Therefore, future research should quantify the relative risk of both fisheries to shark and ray populations in intertidal areas and examine how fisheries intervene with these species' movements across ecosystem boundaries.

Diversity & Life History

The lack of information on the occurrence of sharks and rays or their life cycle hampers the effective management of these species. This is especially relevant in the poorly studied West African waters. We used environmental DNA (eDNA) to determine the species richness of the elasmobranch community in the Bijagós Archipelago (**Chapter 5**). We show that this technique can successfully be used in remote and data-deficient intertidal areas to detect the presence of threatened sharks and rays. We concluded that the presence of some species differs across the dry and rainy seasons and that critically endangered scalloped hammerhead (*Sphyrna lewini*) and blackchin guitarfish are still widely distributed throughout the archipelago. In total, we detected 13 species (2 shark and 11 ray species), of which 54% are threatened with extinction. The pearl whipray (*Fontitrygon margaritella*) was found to be the most commonly occurring elasmobranch species. In **Chapter 6**, we specifically studied this species (pearl whipray) and showed that it is a fast-growing species that matures between 2.2 and 3.9 years of age and completes its entire lifecycle in the Bijagós Archipelago.

Species Interactions

Intertidal habitats are traditionally studied from a low-tide and shorebird perspective. However, we show that intertidal habitats are also used by various shark and ray species (**Chapter 7**). Globally, we identified 43 shark and 45 ray species that use intertidal habitats. These habitats are mainly used as feeding refugia by early life stages or small-bodied species. We conceptualize the shared intertidal habitat and resource use by sharks, rays, and shorebirds, and how the decline of elasmobranch populations can affect intertidal ecosystem functioning. In **Chapter 8**, we studied this potential overlap between sharks and shorebirds further and determined that elasmobranchs and migratory waders are likely to use similar intertidal habitats and food sources. The

trophic niche overlap between shorebirds and rays is especially profound, as these species groups share 28 to 42% of their trophic niche and feed on similar foodweb positions (trophic positions 2.3 to 4.3). As such, although separated by the tide, rays and shorebirds exploit similar intertidal prey during high and low tide, respectively.

Next to playing a significant role in the ecosystem's food web, we also show that benthic rays in the Bijagós Archipelago can change the biogeomorphology and macrozoobenthic communities of intertidal habitats (**Chapter 9**). Benthic rays such as the common pearl whipray can turn over the entire top-sediment layer every 27 days. This is evidence of a landscape-wide impact of small benthic rays and suggests that removing their predators or fisheries directly targeting this species may impact the broader functioning of intertidal ecosystems.

Conservation

To enable the inclusion of ecologically important areas for sharks and rays into area-based conservation measures, we have described criteria for Important Shark and Ray Areas (ISRAs; **Box F**). These Important Shark and Ray Areas represent areas of importance to sharks and rays, such as migratory corridors, areas with many threatened species, or known nursery areas. ISRAs inform decision-makers about which areas to include in area-based strategies if the objective is to conserve shark and ray populations. However, sharks and rays are not only ecologically important but are also part of the complex socio-economic systems of many coastal communities, including in both study areas. We highlight important lessons learned from field researchers who conducted shark value chain assessments and emphasize the necessity to include local researchers and fishers in the process is essential for accurate data collection, communicating outcomes, and for adaptive management strategies to be effective (**Chapter 10**).

Management Implications

This thesis concludes that sharks and rays have an important role as predators and in socio-economic systems in (intertidal) coastal communities. However, as shown throughout the thesis, intertidal sharks and rays are threatened by fisheries in and outside these coastal areas. Therefore, **Chapter 11** outlines numerous recommendations to turn the tide for these species in West Africa. These include:

1. Improve data collection regarding industrial and small-scale fisheries catches by strengthening local research capacity.

Summary

2. Identify ecological areas for sharks and rays within large intertidal areas to prevent interactions between elasmobranchs and fisheries or other human activities.
3. Restrict the use of specific intertidal fishing methods to reduce fishing mortality of sharks and rays.
4. Enforce protected area boundaries and limit fisheries to registered vessels.
5. Involve local communities in enforcing fishing regulations and ensure equality across fisheries value chains.

Without appropriate interventions, the loss of sharks and rays from the Banc d'Arguin and the Bijagós Archipelago is imminent. Although future research is necessary to determine the consequences of this loss, it is clear that these species provide links across ecosystem boundaries. The role of sharks and rays in the functioning of intertidal ecosystems and their importance to coastal livelihoods should be integrated into future conservation strategies.