Coral reef elasmobranchs in Puerto Rico's fishery and MPA effects

Los elasmobranquios de los arrecifes de coral de Puerto Rico en la pesquería y efectos de AMP

Les élasmobranches des récifs coralliens dans les effets de la pêche et des AMP de Porto Rico

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EXTENDED ABSTRACT

Elasmobranchs are a key component of tropical marine ecosystems due to their biodiversity, key roles in trophic webs and fisheries potential, yet they are long-lived, late maturing and have low fecundities, which increases their risk to fishing mortality (Stevens et al. 2000). Elasmobranchs of Caribbean coral reefs have very low abundances, especially near highly populated islands (Ward-Paige et al. 2010; Stallings 2009), and Puerto Rico's elasmobranchs are considered data poor, hindering the ability to assess their condition. Fisheries regulations banned the capture and sale of nurse sharks, *Ginglymostoma cirratum* (DNER 2010), however the population status is unknown. We assessed the relative abundance of elasmobranchs on coral reefs and list the species that could be affected by interactions with local small-scale commercial fisheries. Information was extracted from the scientific literature (published and unpublished), commercial fishery landings reports and local fisheries biostatistical data, for species that are subject to capture in the local fishery. In collaboration with the Global FinPrint (Florida International University) a standardized baited remote underwater video (BRUV) survey was conducted to document the diversity and relative abundance of elasmobranchs in areas with different fishery restrictions.

Fifty-two species (47 sharks and 5 rays) are reported for the US Caribbean, of which at least 12 (23 %) are caught locally (Matos-Caraballo 2012 and 2019, and pers. comm.). Most pounds of shark are classified as 'tiburon' (shark) and almost all the rays are classified as 'manta-raya' (manta ray). However, some data are classified further into Caribbean reef shark (*Carcharhinus perezi*), Great hammerhead (*Sphyrna mokarran*), Scalloped hammerhead *(S. lewini*), Lemon shark (*Negaprion brevirostris*), seven-gilled shark (*Heptranchias perlo*), tiger shark (*Galeocerdo cuvier*), requiem sharks (*Carcharhinus spp*.), manta ray (*Mobula spp*.), southern stingray (*Hypanus americanus*) and unspecified stingrays. These fish categories are provided to fishers on pre-printed sheets without any validation procedures. Highest annual landings for sharks occurred in 1995 with over 83,000 lbs., and the highest ray landings just under 10,000 lbs. in the year 2000 (Fig. 1) yet elasmobranchs compose a small proportion of total fisheries landings (0.5 to 2.5% yearly). A decreasing trend of capture over time is evident to less than half of what was reported during the 1990's. Fishery development projects led by CODREMAR for 'underutilized resources' in the 1980's promoted shark fisheries and documented lemon and tiger sharks as the most abundant species at the time (Rivera and Gonzalez, 1985). One shark meat processor was established locally in Vieques, but abandoned in 1990, reportedly due to a lack of quality shark meat, since lemon, blue, mako and dusky sharks were preferred, while hammerhead, tiger and nurse sharks were not accepted (The Vieques Times, 1988).

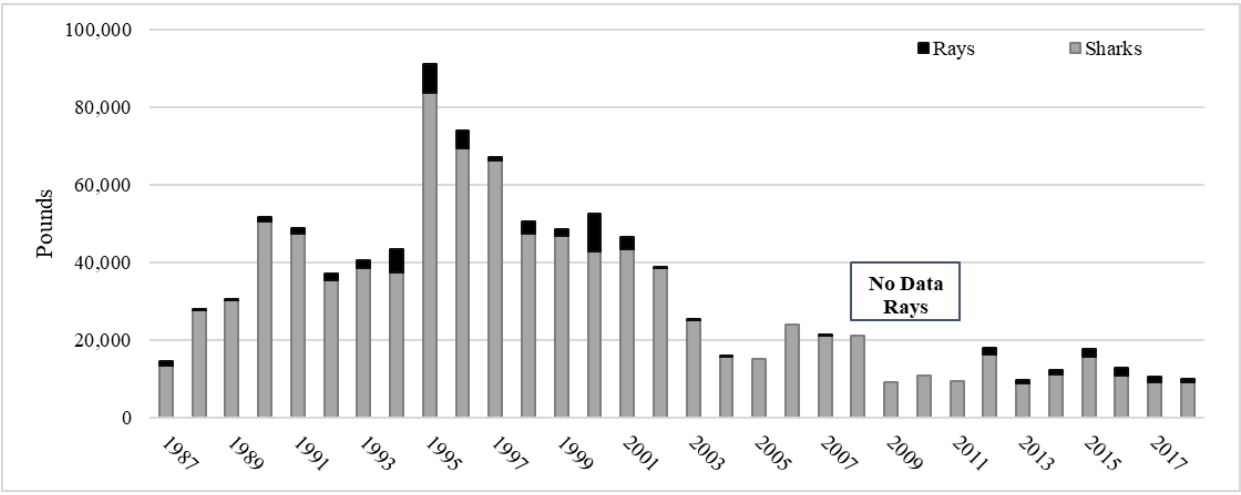

Figure 1. Puerto Rico commercial fishery landings of sharks and rays per year.

Elasmobranch diversity reported for Puerto Rico is high, yet landings information is limited, mainly due to lack of species identifications. Nonetheless the catch composition suggests threatened and endangered species are landed locally.

Table 1. Frequency of occurrence of sharks and rays per site, N is the number of videos analyzed per site.

Site	Sharks	Rays	N
Islands	88%	47%	49
Ponce	66%	24%	50
Cabo Rojo	66%	21%	47
Rincón	54%	18%	50
Guayanilla	31%	10%	48
Lajas	23%	13%	52

At least two species are at risk, the scalloped hammerhead (*S. lewini*), for which Central & SW Atlantic distinct population segment (DPS) is designated as threatened under the US Endangered Species Act (NOAA, 2014) and the giant manta ray (*Manta birostris*) designated as threatened throughout its range (NOAA, 2018) and both were included on Appendix II (CITES). Efforts to improve the identification and validation to species, would be a first step to accurately assess the risks of incidental or targeted fisheries interactions to populations that need to be recovered.

The BRUV field survey was conducted with 296 BRUV deployments in six areas with coral reefs off the south and west of the main island and two offshore islands in 2018 following the Global FinPrint protocol (Bond et al. 2012). Randomly selected sites in 3 to 30 m (mean 13.8 m) in depth were grouped by area (Lajas, Guayanilla, Ponce, Cabo Rojo, Rincón/Aguadilla and the islands Mona and Desecheo. Each of the islands' coral reefs are contained within a no-take marine reserve (MR). Results indicated spatial differences in the frequency of occurrence of sharks and rays that was highest at the two offshore islands (Table 1). The most common species identified were the Caribbean reef shark (C. perezi) and the nurse shark (G. cirratum), followed by the southern stingray (H. americanus) and the spotted eagle ray (Aetobatus narinari). The yellow stingray (Urobatis jamaicensis) was only seen at Mona Island, and a single juvenile tiger shark (G. cuvier) was only detected off Ponce.

The mean maximum number of elasmobranchs observed per video deployment (MaxN) ranged from 0.27 (0.04 SE) sharks in Lajas and 0.10 (0.02 SE) rays in Guayanilla, to 2.6 (0.37 SE) sharks and 0.6 (0.09 SE) rays at the offshore islands. The relative abundance of the two most abundant shark species (MaxN/hr) was standardized and compared between sites classified as MR, MPA or open access areas under island-wide fisheries regulations. The relative abundance of Caribbean reef and nurse sharks was analyzed with a one-way ANOVA. The Caribbean reef shark had significant differences between the three categories ($p < 0.001$) but for nurse shark differences were not significant (Fig. 2). The magnitude between MR and the other classifications was higher for Caribbean reef than for nurse sharks, suggesting the relative abundance of *G. cirratum* was similar throughout the areas sampled.

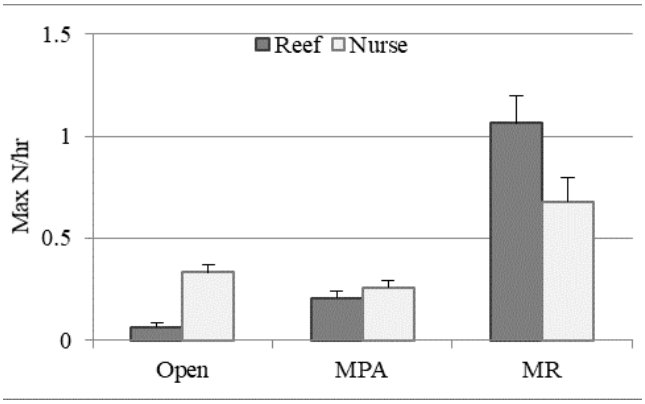

Figure 2. Maximum number of individuals per hour (MaxN/hr) mean (SE) for Caribbean reef shark (gray) and nurse shark (light gray) per spatial management category; open access area (Open), multiple-use marine protected area (MPA) and no-take marine reserve (MR).

Offshore islands had a higher mean MaxN/hr for C. perezi, with the highest MaxN per deployment at Desecheo for both *C. perezi* and *G. cirratum*, while most *C. perezi* at offshore islands were small sized juveniles, suggesting shallow reefs nearshore may provide a nursery function, since high residency of *C. perezi* was attributed to habitat preferences at an offshore island in Brazil (Garla et al. 2006).

Coral reefs in Puerto Rico, including areas designated as MR had a very low diversity of elasmobranchs, a trend that has been documented at the global scale, especially in the Caribbean (MacNeil et al. 2020). Multi-use MPAs and open access areas had similar relative abundances of Caribbean reef or nurse sharks, which could be expected for the latter due to the island wide species ban. These results may be due to different fishing rates between the main island and the offshore islands or MR status, however, there is no previous measure of the elasmobranch abundances prior to the MR designations to attribute a reserve effect and secondly habitat differences between offshore MRs and sites sampled on the much larger main island may confound these results. Coral reef habitats offshore may have oceanographic regimes, habitat combinations, prey base, predators and population dynamics that differ from the main island, masking the reserve effect. It has been proposed that large area MRs are necessary to include all the habitats of the elasmobranch's ontogeny, i.e. 50 km of contiguous habitat (MacKeracher et al. 2019), and the main island of Puerto Rico has no large MR that could be used as a reference site for elasmobranchs. Given the low abundances of elasmobranchs in coral reefs and the potential risk of fishery interactions for some species threatened with extinction, conservation plans should incorporate this information to sustain productive and resilient ecosystem .

KEYWORDS: Elasmobranchs, coral reefs, MPA, Puerto Rico, fisheries

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