Abundance and distribution of deepwater fishes in MesoAmerica

La Abundancia y distribución de peces de aguas profundas en Mesoamérica

L'abondance et répartition des poissons d'eau profonde en Méso-Amérique

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EXTENDED ABSTRACT

The MesoAmerican Reef (MAR) countries of Mexico, Belize, Guatemala and Honduras support several artisanal coastal fisheries, which are overall overfished and under-managed (Heyman and Graham 2000; Graham et al. 2008, 2009; Paddack et al. 2009; Dunn et al. 2010). As a result, deepwater fisheries (100-500 m) in the MAR's Caribbean Sea have been expanding in recent years, especially in Belize, where exploitation rates have historically been lower than in surrounding MAR countries (Grant 2019; Baremore et al. 2021). Though deepwater fisheries of the MAR are largely artisanal, there is some evidence of overexploitation at nearshore deepwater fishing grounds in Honduras, which also hosts the only semi-industrial fleet of deepwater vessels and is the only country with a strong export market for deepwater finfish (Baremore et al. 2021).

Deepwater snappers and groupers are the main targets of the fisheries in the MAR, but sharks are targeted and landed, mainly in Guatemala and to a lesser extent in Mexico (Gobert et al. 2005a; Hacohen-Domené et al. 2020; Polanco-Vásquez et al. 2017; Baremore et al. 2021). Currently there are no management measures in any MAR countries that directly address deepwater fisheries or species, though the government of Belize is actively seeking to develop the fishery (Grant 2019). Although many deepwater fishes are especially vulnerable to exploitation due to conservative life histories, there is virtually no information available on the abundance, distribution, ecology, or life history of the deepwater species in the western Caribbean. The aims of this study are to: 1) examine the vertical and horizontal distribution and abundance of fish species that make up the deepwater fisheries of the MesoAmerican region; and 2) determine to what extent differences in exploitation rates in Belize and Honduras have affected the abundance and size distributions of these species.

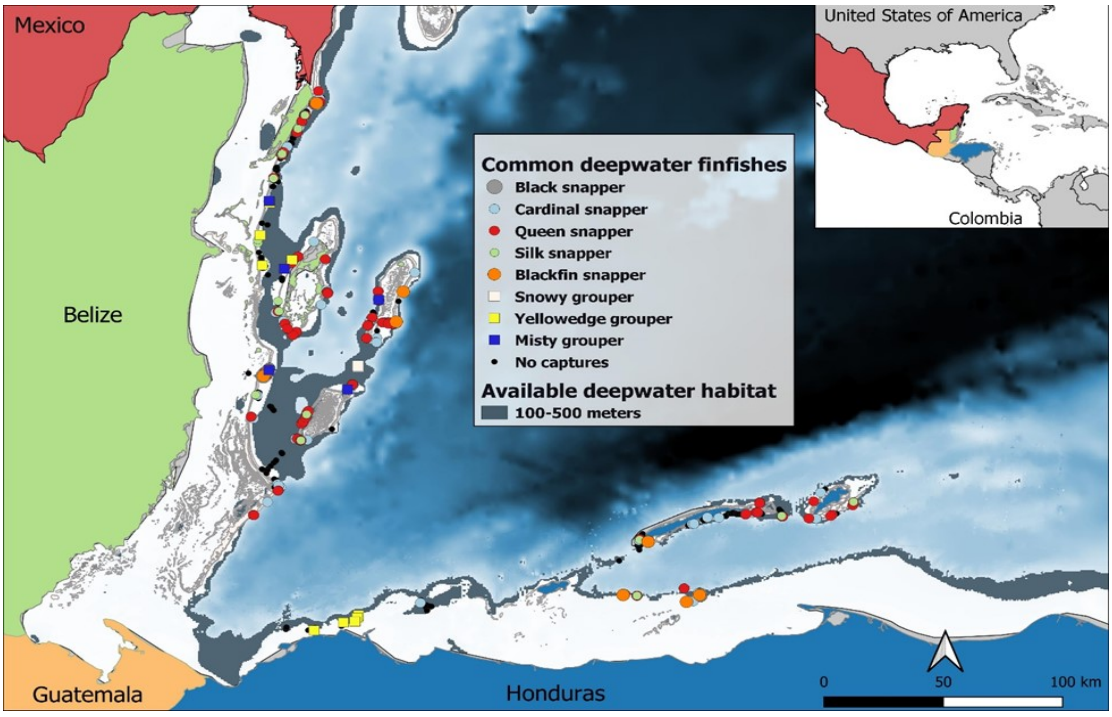

Figure 1. Map of the Mesoamerican Reef (MAR) countries of Mexico, Belize, Guatemala, and Honduras showing locations of capture for commercially important deep water finfish species, with an overlay of the approximate area where deep water fishing can occur (100-500 m).

Vertical longline surveys were used to capture deepwater finfishes and elasmobranchs. Vertical longlines consisted of monofilament line terminating in 5, 9/0, 10/0 or 13/0 circle hooks, and set between 150 and 500 m. Soak time was a minimum of 30 minutes, and lines were deployed and retrieved by hand. Temperature depth recorders (TDRs) were attached to lines to record accurate depth and temperature data for each set when possible.

Captured teleost fishes were retained and identified to species. The position on the line (hook number) for each fish was recorded, and a uniquely numbered tag was used for identification upon landing. After landing, fish were measured for straight-line standard (SL), fork (FL), and total lengths (TL, ±0.1 cm), and weighed (±0.1 kg). When possible, otoliths were removed, cleaned, and stored dry, and a 1-5 g piece of muscle tissue was stored frozen. Fish were sexed and staged for reproductive analysis by macroscopic examination of the gonads (1=juvenile, no development, 2=developing/transitioning juvenile, 3=pre-spawning adult, 4=spawning adult, 5= spent/recently spawned) (Gobert et al. 2005b), and a photo was taken of the gonads of each fish and catalogued. When possible gonads were weighed (g).

Catch per unit effort (CPUE) was calculated for each species by set and averaged by set:

$$CPUE = \frac{\#\ individuals\ captured}{\#\ hooks * \ soak\ time\ (hrs)}$$

Fishery-dependent sampling was used to refine species distributions. Contracted fishers recorded the locations of capture, number of hooks used, depths fished, and number of sets deployed, and fish were retained whole and processed as described previously.

A specially constructed baited remote underwater video (BRUV) installation was used to record species and habitat type. BRUVs recorded for a minimum of 60 and a maximum of 240 minutes. The number of individuals sighted by species were reported as MaxN (maximum number of individuals in the frame at a given time) and sequential MaxN (total number of individuals per video) per BRUV deployment.

A total of 1,135 fishery-independent vertical longline sets and 37 BRUVs have been deployed in Belize and Honduras at depths between 130 and 700 m (Fig. 1), and eight fishery-dependent trips have been sampled from 2015-2021. Eight commercially important finfish species have been identified and captured, with the most common being silk (Lutjanus vivanus), cardinal/wenchman (Pristipomoides spp.), queen (Etelis oculatus), blackfin (L. buccanella) and black (Apsilus dentatus) snappers (Fig. 1). Vermillion snapper (Rhomboplites aurorubens) are locally important, but appear to be somewhat shallower than other species and are therefore under-sampled by this survey. Snapper species are depth-stratified, with black, silk, and blackfin snappers occupying the shallowest depths, followed by cardinal and queen snappers, which are the

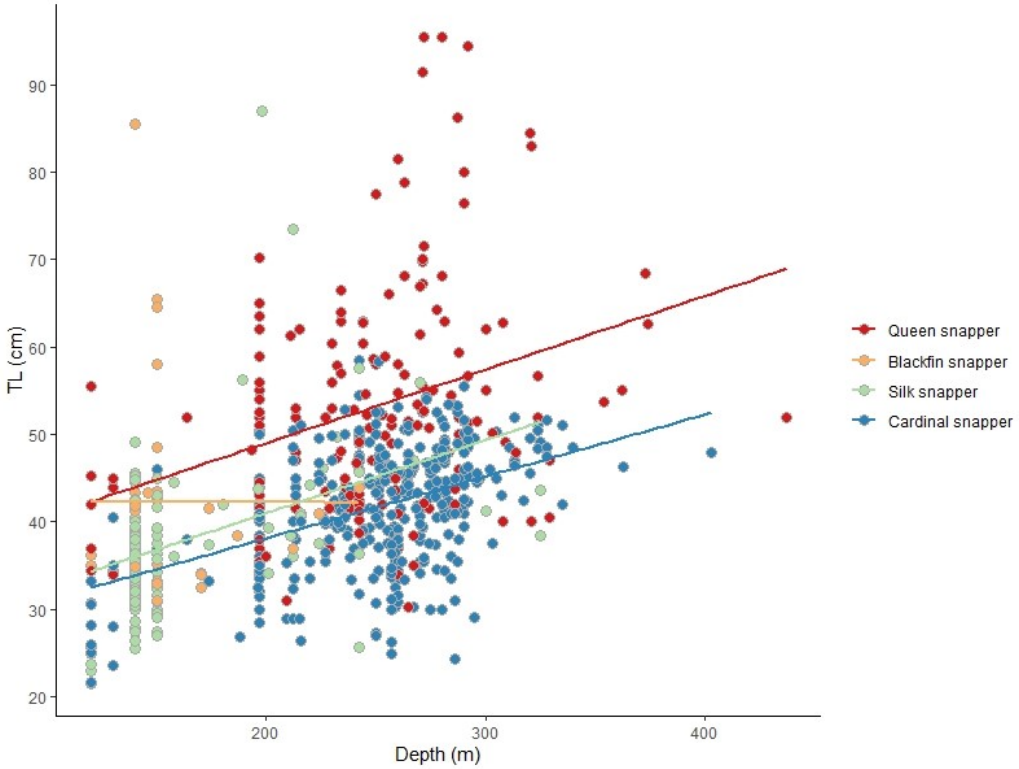

Figure 2. Plot of the relationship between fish total length (TL) and depth of capture for the four most commonly captured deepwater snappers, showing that in general size increases with increasing depth.

deepest-dwelling. There is a positive relationship between depth of capture and total length, as larger silk, cardinal, and queen snappers tend to be captured at greater depths (Fig. 2) Groupers (mostly yellowedge (Hyporthodus flavolimabuts) and misty (H. mystacinus)) are important to the fishery, but are patchily distributed over mud bottom habitats and in several areas populations have declined (Baremore et al. 2021) (Fig. 1). Vertical longline surveys indicate finfish populations in Belize are higher in abundance and overall larger than those in Honduras; however, more sampling in Honduras at key fishing sites is needed to confirm this supposition. BRUV deployments mostly confirmed the presence and abundance of species that were captured by vertical longline, but in at least 6 (16%) deployments target species were identified on cameras that were not captured by concurrent fishing effort. The camera instalment is a nonlethal sampling method that appears to be useful for observing individuals that are not susceptible to capture, whether due to size-selection or other unknown factors that may influence catchability, and is especially valuable for characterizing bottom habitat.

As coastal fisheries resources decline due to high demand from domestic and international sources, fishing in deeper waters is expected to increase. Data on the vertical distribution and abundance of the species captured in deepwater fisheries are needed to inform species distribution models and to identify important areas for conservation, such as spawning sites or other critical habitats. Results from this study will inform management and conservation initiatives, and will be shared with local fishers to ensure information exchange among stakeholders. Combined with ongoing ecological studies, these data will be used to develop a socio-ecological risk assessment for deepwater species and their dependent communities.

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LITERATURE CITED

Baremore, I. E., R. T. Graham, and M. J. Witt. 2021. Fishing down the reef slope: Characteristics of the nearshore deepwater fisheries of MesoAmerica. Ocean and Coastal Management 211:105773.

Dunn, D. C., K. Stewart, R. H. Bjorkland, M. Haughton, S. Singh-Renton, R. Lewison, L. Thorne, and P. N. Halpin. 2010. A regional analysis of coastal and domestic fishing effort in the wider Caribbean. Fisheries Research 102(1–2):60–68.

Gobert, B., P. Berthou, E. Lopez, P. Lespagnol, M. D. Oqueli Turcios, C. Macabiau, and P. Portillo. 2005a. Early stages of snapper–grouper exploitation in the Caribbean (BayIslands, Honduras). Fisheries Research 73(1–2):159–169.

Gobert, B., A. Guillou, P. Murray, P. Berthou, M. D. Oqueli Turcios, E. Lopez, P. Lorance, J. Huet, N. Diaz, and P. Gervain. 2005b. Biology of queen snapper (*Etelis oculatus*: Lutjanidae) in the Caribbean. Fishery Bulletin 103(2):417–425.

Graham, R. T., R. Carcamo, K. L. Rhodes, C. M. Roberts, and N. Requena. 2008. Historical and contemporary evidence of a mutton snapper (*Lutjanus analis* Cuvier, 1828) spawning aggregation fishery in decline. Coral Reefs 27(2):311–319.

Graham, R. T., K. L. Rhodes, and D. Castellanos. 2009. Characterization of the goliath grouper *Epinephelus itajara* fishery of southern Belize for conservation planning. Endangered Species Research 7(3):195–204.

Grant, S. 2019. A review of the Deepslope Demersal Fishery in Belize. Pgs 1-23. MCCAP.

Hacohen-Domené, A., F. Polanco-Vásquez, C. Estupiñan-Montaño, and R. T. Graham. 2020. Description and characterization of the artisanal elasmobranch fishery on Guatemala's Caribbean coast. PloS one 15 (1):e0227797.

Heyman, W., and R. Graham. 2000. The Voice of the Fishermen of Southern Belize. Page Toledo Institute for Development and Environment.

Paddack, M. J., J. D. Reynolds, C. Aguilar, R. S. Appeldoorn, J. Beets, E. W. Burkett, P. M. Chittaro, K. Clarke, R. Esteves, A. C. Fonseca, G. E. Forrester, A. M. Friedlander, J. García-Sais, G. González-Sansón, L. K. B. Jordan, D. B. McClellan, M. W. Miller, P. P. Molloy, P. J. Mumby, I. Nagelkerken, M. Nemeth, R. Navas-Camacho, J. Pitt, N. V. C. Polunin, M. C. Reyes-Nivia, D. R. Robertson, A. Rodríguez-Ramírez, E. Salas, S. R. Smith, R. E. Spieler, M. A. Steele, I. D. Williams, C. L. Wormald, A. R. Watkinson, and I. M. Côté. 2009. Recent Region-wide Declines in Caribbean Reef Fish Abundance. Current Biology 19(7):590–595.

Polanco-Vásquez, F., A. Hacohen-Domené, T. Méndez, A. Pacay, and R. T. Graham. 2017. First record of the chimaera *Neoharriota carri* (Bullis and Carpenter 1966) in the Caribbean of Guatemala. Marine Biodiversity Records 10(1):1. Marine Biodiversity Records.