

COMMENT

Apparent rapid fisheries escalation at a remote Caribbean island

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Navassa Island is a small uninhabited island, approximately 60 km west of the south-west tip of Haiti (18°24'N, 75°00'W). Haiti laid claim to the island in 1804, however the USA claimed it under the Guano Act of 1856 and recently placed it under jurisdiction of the US Fish and Wildlife Service (USFWS). Remoteness from USFWS administration in Puerto Rico and disputed sovereignty by Haiti make enforcement of management impractical. Artisanal fishers from Haiti have frequented Navassa over the past several decades. Given the lack of current land-based development and limited transient land-based activity (for example salting fish and gear construction), Navassa provides a case study where fishing is largely isolated as the dominant human impact on coastal resources.

Although no quantitative catch or effort data for the Navassa fishery are available, fishing effort and impacts may be growing (Miller & Gerstner 2002; Miller *et al.* 2003) and socioeconomic pressures in Haiti are unlikely to abate. Severe overexploitation of nearshore reef fisheries in south-west Haiti was reported from the mid-1980s (Ferry & Kohler 1987). A host of factors (such as recruitment variability and human impacts on reef habitat) can affect reef fish assemblages, and fisheries other than the Haitian artisanal sector may also be active at Navassa. We sought to explore the social context of fishing impacts on Navassa reefs and characterize the reef fish assemblage there via direct observation, ethnographic documentation (primarily interviews with Haitian fishers) and in-water visual survey, in order to assess the hypothesis that the Navassa fishery is experiencing rapid escalation (for methodology see Supplementary material at http://www.ncl.ac.uk/icef/EC_Supplement.htm, Appendix 1).

All fishers interviewed agreed that the fisheries at Navassa were critically important to the local economy in south-west Haiti. Those who were able to go to Navassa said that they found more fish there than in the waters surrounding the Haitian mainland and were therefore able to make more money to provide for their families. Navassa was described as the fishers' *kane bank* (bank account). Many interviewees reported that if Navassa was 'like any other land', they would go and live there. However, harsh conditions including heat, lack of food and water, difficulty accessing the island (i.e. no beach or other landing site) and remoteness have prevented its habitation by fishers.

Various types of fishing gear with a range of target and non-target catch (see Supplementary material at http://www.ncl.ac.uk/icef/EC_Supplement.htm, Appendix 2) were observed: Caribbean 'Z' traps; nets including *twa-nap* (triple mesh, 40 cm/13 cm/40 cm, made of natural/synthetic

fibre, c. 1-m tall by 100-m long); *filet simp* (single mesh net made of natural/synthetic fibre); and mono-filament line and hooks for trolling and bottom fishing. Traps were made of bamboo and wood, had c. 3.5 cm maximum hexagonal hole size and were generally baited with undesirable catch. Traps are generally checked every day, but may be left in the water for extended periods if a boat returns to Haiti unexpectedly. Fishers confirmed the suggestion (Miller *et al.* 2003) that the adoption of net fishing is a recent phenomenon enabling catch of turtles and conch as well as finfish. They reported that the use of nets both in Navassa and south-west Haiti is a direct result of declining effectiveness of traditional methods (traps and hook-and-line) and acknowledged that nets are a more destructive gear; many fishers are adamantly opposed to their use. No snorkelling or SCUBA gear, spear guns, harpoons or other gear types were observed.

A daily average of 2.0 (± 1.7 SD) Haitian fishing-vessel sightings at Navassa in 2002 (Miller *et al.* 2003), had increased to 4.4 (± 1.6) sightings during our 2004 expedition conducted during a similar observation period (10–11 days in early November) (2-sample t-test, $p = 0.001$).

Fisher interviews in 2005 indicated approximately 250 fishers were involved in the Navassa fishery and each made approximately three trips per year (the estimate with poorest confidence) averaging eight days per trip and five fishers per boat. These numbers yield an estimate of 150 boat trips per year. Using an estimate of six work days per week for full time (Hawkins & Roberts 2004), the Navassa fishery supports approximately 20 full-time equivalents (FTEs) along approximately 14 km of reef (generously calculated as the circumference of the Navassa shelf break) or about 1.4 FTE fishers km⁻¹ reef.

There were 175 gear buoys (or 0.2 ha⁻¹) deployed around the Navassa shelf in 2004 (see Supplementary material at http://www.ncl.ac.uk/icef/EC_Supplement.htm, Appendix 2). Similar quantitative information is unavailable from 2002, but a dramatic increase in gear density was clear from our ability to navigate around the island. In 2004, careful manoeuvring of our research vessel was required to avoid fouling buoys, whereas in 2002, the same vessel could be navigated with minimal care.

In-water stationary visual census of the reef fish assemblage in 2002 and 2004 revealed substantial differences. All trophic groups displayed lower average biomass in 2004 than in 2002, the trend being significant for piscivores ($p < 0.05$, Fig. 1a). For fish >10 cm, grouper, parrotfish, surgeonfish, jack, squirrelfish, snapper and triggerfish families all showed small,

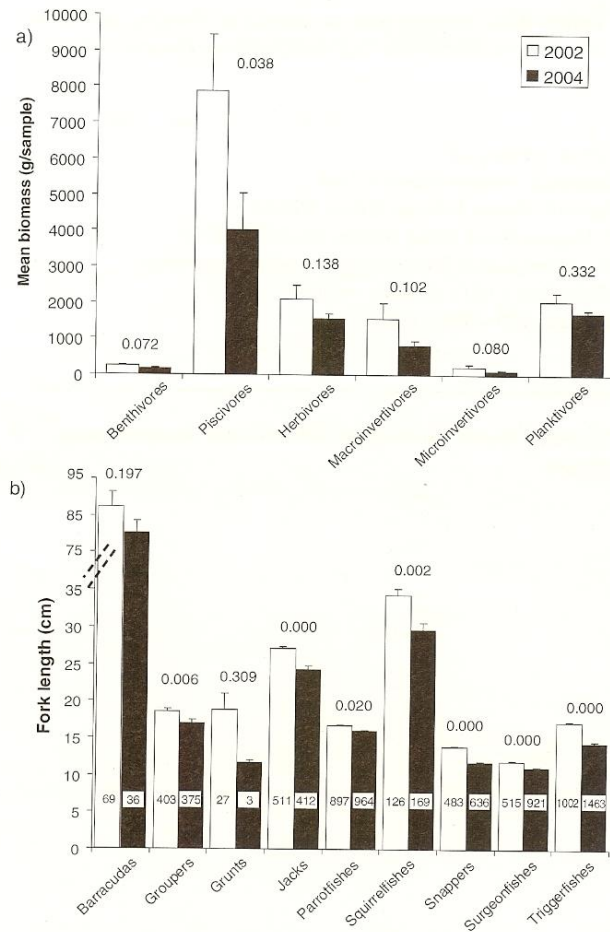


Figure 1 Reef fish assemblage sampled in 2002 ($n = 110$) and 2004 ($n = 114$). Mean \pm ISE of (a) reef fish trophic guild biomass (p -values for one-way ANOVAs for each group given above the pairs of bars) and (b) fork length of exploitable fish (>10 cm) by family (n given in each bar, p -value for one-way ANOVA given above each pair of bars).

but statistically significant declines in average fork length between surveys (ANOVA, $p < 0.05$; Fig. 1b).

Several lines of evidence indicate that the Navassa fishery underwent rapid escalation during 2002–2004; declines in the reef fish biomass and average size (Fig. 1) of most fish types, shifts to more intensive, less-sustainable gear types and increased effort both in terms of number of boats per day and a qualitative increase in density of gear buoys. The Navassa artisanal fishery is unselective in that everything caught is used, for bait if not human consumption. We commonly observed small-bodied damselfish and butterflyfish being caught.

Two data points cannot constitute a trend, but limited prior observations support the hypothesis of rapid intensification of fishing effort and declines in fish abundance and size. Sampling in 2000 revealed a reef fish assemblage which compared favourably in terms of density and size structure

with published values for a range of other Caribbean reefs (Miller & Gerstner 2002, Table 1). By 2002 and 2004, density of large (>30 cm) grouper was much lower (mostly zero) around the same five high-relief sites sampled in 2000 (Miller & Gerstner 2002).

Our estimate of fishing effort (1.4 FTE fishers km^{-1} shelf edge) is in the medium range for Caribbean artisanal fisheries (Hawkins & Roberts 2004). Navassa had higher fishing intensities than Puerto Rico, Saba and Bonaire, and clearly falls within the ‘tail’ of the distribution of fish biomass shared by sites with high fishing intensity (Hawkins & Roberts 2004). The average number of boats observed fishing at Navassa doubled between 2002 and 2004, and, in 2004, buoys marking stationary gear suggested a density of fishing gear on the Navassa shelf of $c. 0.2 \text{ ha}^{-2}$, similar to overall trap densities in Puerto Rico and the US Virgin Islands (R. Hill, personal communication 2006). The US Virgin Islands and Puerto Rican trap fisheries have declined consistent with overexploitation over decadal and shorter timescales (increases in soak time and number of traps per fisher over historical levels; Garrison *et al.* 1998; Sharer *et al.* 2004).

Changes to reef habitat as well as direct harvest can affect fish assemblages. Multiple hurricane impacts occurred at Navassa in 2004 prior to our 2004 survey. Mean coral cover averaged among three sites sampled in 2000 (22.9%; Miller & Gerstner 2002), 2002 (16.3%; Miller 2003) and 2004 (17.4%; unpublished data 2004) declined from 2000 to 2002, possibly owing to seasonal effects (spring versus fall) but remained stable from November 2002 to November 2004. Thus, drastic habitat changes were not evident over the period of observation.

Social factors (such as education, peer pressure and fuel cost), as well as ecological conditions, vary over time and may influence future fishery changes. However, if the observed trend in fishing pressure continues, impacts on the fishery resource will occur and may cascade through the Navassa reef ecosystem. Monitoring of the Navassa fishery and reef may be able to better discern these potential trajectories.

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