Reducing the susceptibility of Parrotfish to fish traps;
A meta-analysis identifying feasible management strategies.

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Introduction:

Herbivores play a crucial ecological role on coral reefs as mediators in the spatial competition between corals and algae. Following the mass die off of the long-spined sea urchin, parrotfish have become the most functionally important grazers on Caribbean coral reefs[1,2]. Yet, despite their importance in maintaining the resilience of coral reefs to external perturbations[3] few countries have enacted specific management to conserve their populations and across the Caribbean parrotfish continue to be caught as part of near shore mixed fisheries. It is widely assumed that trapping has lead to the observed declines in local parrotfish populations. Here we specifically examine the vulnerability of parrotfish to fish trapping and produce feasible management recommendations to protect these ecologically important species in areas where simply prohibiting fish traps is unfeasible.

Materials and methods:

Two fish trap designs, Antillean Z-trap (1.25" hexagonal mesh, horseneck funnel) and rectangular trap (1" square mesh, straight funnel) were tested in the waters of Utila, Honduras. Traps were deployed in two strings of 6 traps, soaked for 24hours (±2hrs) at a depth of 6m (±2m), for five days. Trap catches were identified to species level, counted and fork length measured (FL) to nearest 0.5cm. Fish surveys were conducted on 30x4m transects using SCUBA. Fish were identified to species, and FL estimated to nearest 1cm. Fish FL's were converted to biomass using species specific data from fishbase.org. Estimates for area specific biomass depletion rates (defined as the proportion of biomass per unit area removed by a trap in 24 hours) were calculated for all species that occurred both in transects and in traps using the formula:

$$\text{Depletion rate}_{(species)} = \frac{\text{Mean biomass (g).trap}^{-1}\ 24\text{hr}^{-1}}{\text{Mean biomass (g).100m}^{-2}}$$

To assess region wide parrotfish vulnerability to fish traps we conducted a meta-analysis using published and unpublished data from 10 studies incorporating 967 trap hauls. We built a general linear model (GLM) using binary logistic regression (BLR) and the logit link function to evaluate the importance of different factors affecting the likelihood of parrotfish being captured.

Results:

The Honduran field study revealed that herbivorous fish, parrotfish (Scaridae) and surgeonfish (Acanthuridae) are not as susceptible to fish traps as other fish species, with many parrotfish species present on surveys, not being caught by the traps. However the Red band parrotfish (*Sparisoma aurofrenatum*), Blue tangs (*Acanthurus coeruleus*) and Ocean surgeon (*A. bahianus*) were vulnerable, particularly to rectangular

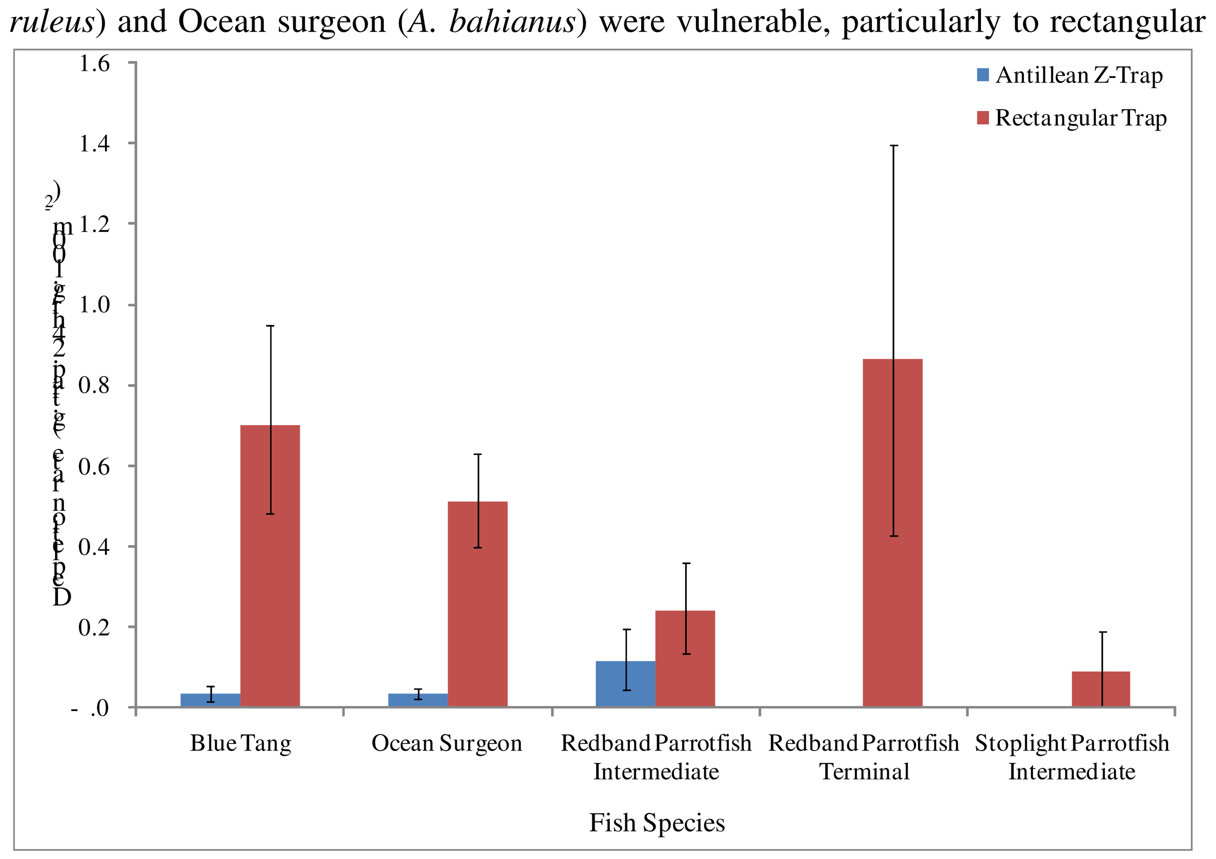
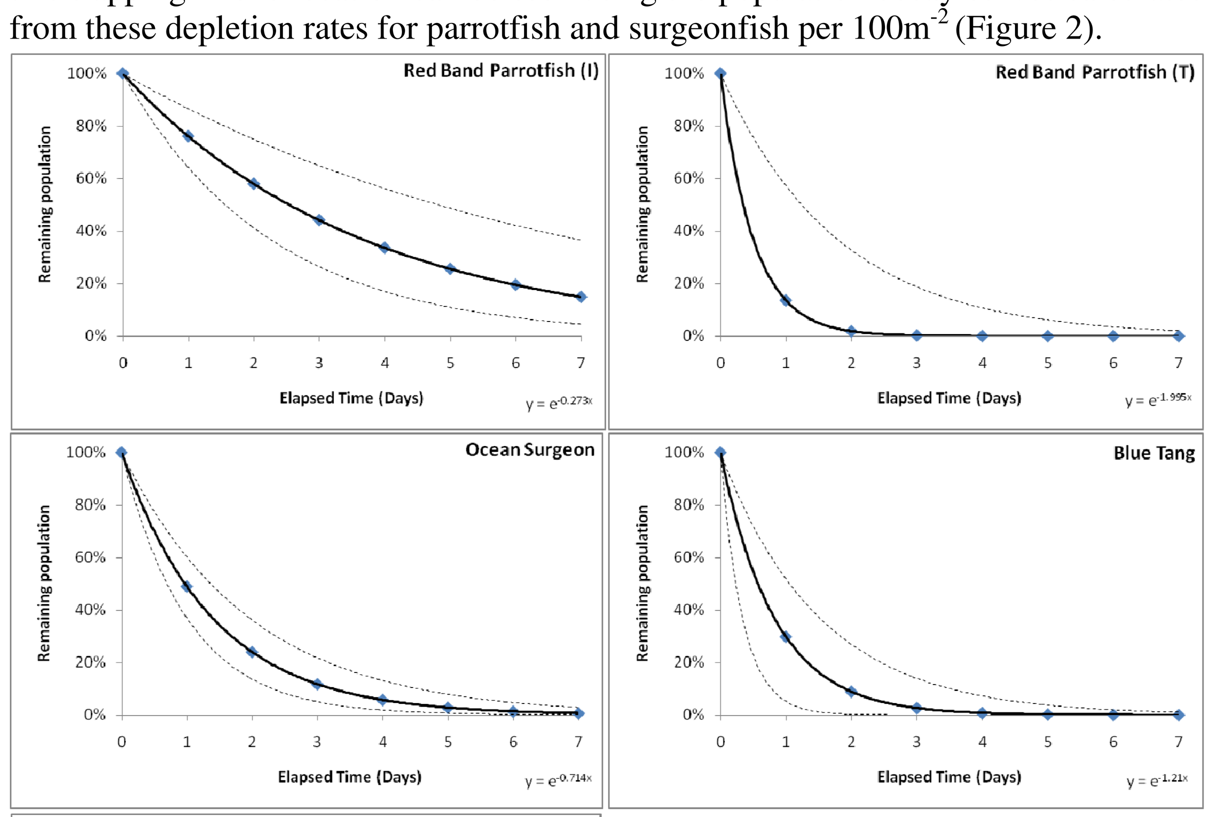


Figure 1. Antillean Z-trap and rectangular trap depletion rates of parrotfish and surgeonfish.

traps with smaller mesh size (Figure 1). For example, based on the mean depletion rate of terminal phase *S. aurofrenatum* 86% of the biomass in a 100m^2 area could be removed by one trap in one 24 hour period.

The potential impact on the total biomass of resident fish populations from consecutive trapping in one location can be seen using the population decay curves calculated from these depletion rates for parrotfish and surgeonfish per 100m^{-2} (Figure 2).



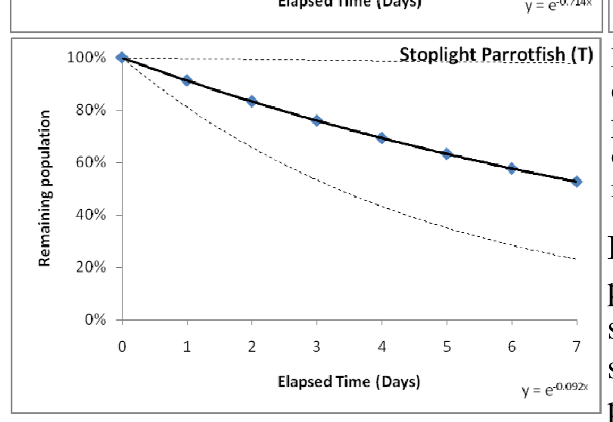


Figure 2. Decay rates of parrotfish and surgeonfish on Honduran reefs. Error bars are maximum catch per trap divided by minimum parrotfish densities on reef, and minimum catch per trap divided by maximum parrotfish densities on the reef.

It is clear from the decay curves that repetitive fishing in one location can have serious consequences for resident Sparisoma and Acanthurid biomass. Thus parrotfish are more vulnerable to longer soak times of traps. However it also highlights that *S. viride* is less susceptible to trap fishing.

Larger parrotfish such as *S. viride* are not particularly vulnerable to trapping, but this seems inconsistent with reported population declines. In small scale fisheries, however trapping often occurs concurrently with spearfishing. To evaluate if spearfishing is more of a threat than trapping we assessed catch proportions from seizures of illegal spearfishing activities within the Roatán Marine Park (where trapping rarely occurs). Results show that parrotfish make up 8% of individuals landed, (Figure 3).

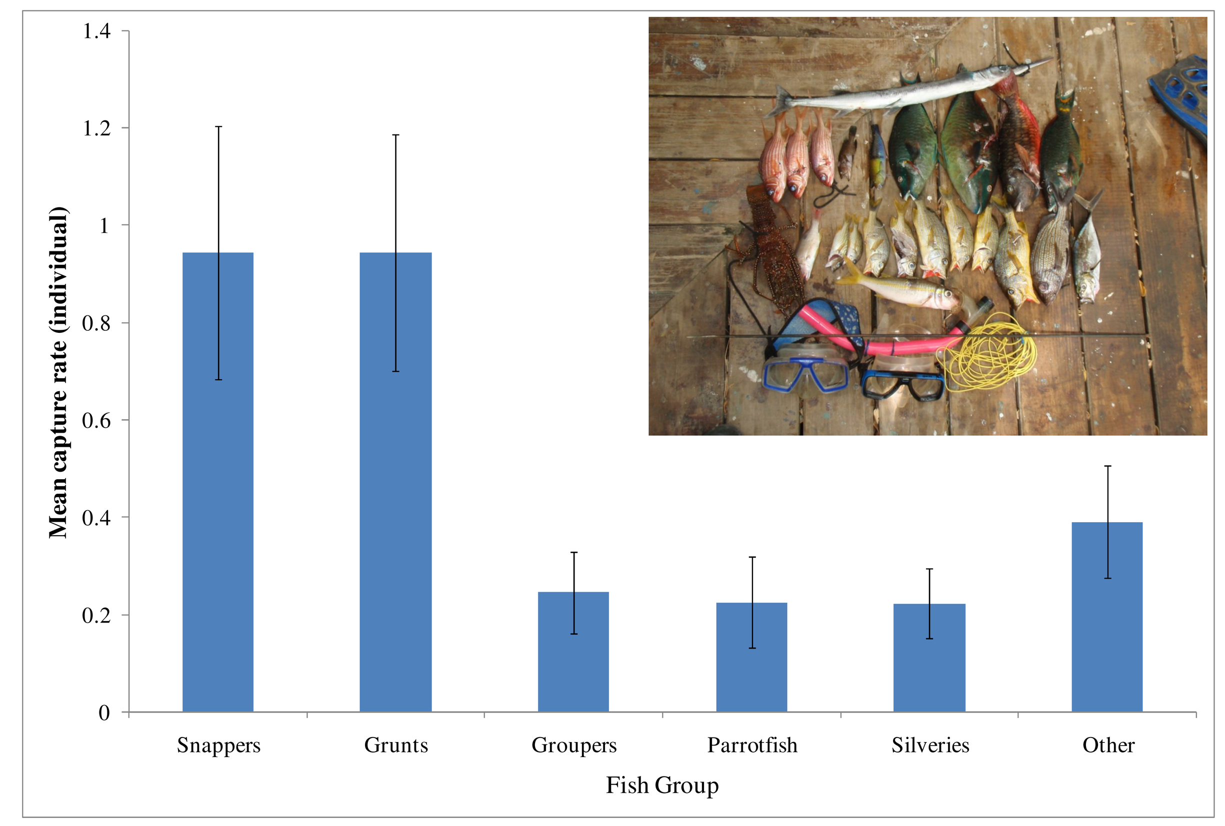


Figure 3. Mean capture rates of fish groups by illegal spearfishing in Roatan Marine Park, inlaid by a photograph of a typical haul.

Spearers only caught larger species of parrotfish (*S.viride* and *S.chrysopterum*). The relative capture rate was also comparatively greater than that of fish traps, with an estimated daily removal rate of 67.4g (± 26.9g) per spear fisher. Therefore one spearfishing trip is equivalent to seven 24 hour trap soaks in terms of their removal of larger parrotfish from reefs.

Coral Reef		Soak time (days) 1-2	3-4	5-6	7-8	9+
Depth (m)	1 -6	*3.4%*	52.7%	37.3%	51.3%	22.7%
	7 -12	*2.4%*	43.2%	28.9%	41.9%	16.8%
	13-20	*1.0%*	24.3%	14.6%	23.3%	7.8%
	>20	*3.4%*	52.8%	37.5%	51.5%	22.8%

Gorgonian Plain		Soak time (days) 1-2	3-4	5-6	7-8	9+
Depth (m)	1 -6	*5.4%*	64.2%	49.0%	63.0%	32.2%
	7 -12	*3.8%*	55.1%	39.6%	53.8%	24.5%
	13-20	*1.6%*	34.1%	21.7%	32.9%	12.0%
	>20	*5.4%*	64.4%	49.1%	63.1%	32.3%

Seagrass		Soak time (days) 1-2	3-4	5-6	7-8	9+
Depth (m)	1 -6	*0.1%*	*4.3%*	*2.4%*	*4.1%*	*1.2%*
	7 -12	*0.1%*	*3.0%*	*1.6%*	*2.9%*	*0.8%*
	13-20	*<0.1%*	*1.3%*	*0.7%*	*1.2%*	*0.3%*
	>20	*0.1%*	*4.4%*	*2.4%*	*4.1%*	*1.2%*

Rock		Soak time (days) 1-2	3-4	5-6	7-8	9+
Depth (m)	1 -6	*5.0%*	62.2%	46.8%	60.9%	30.3%
	7 -12	*3.5%*	53.0%	37.6%	51.6%	22.9%
	13-20	*1.5%*	32.2%	20.2%	31.0%	11.1%
	>20	*5.0%*	62.4%	47.0%	61.1%	30.4%

Other		Soak time (days) 1-2	3-4	5-6	7-8	9+
Depth (m)	1 -6	*5.4%*	64.3%	49.1%	63.1%	32.3%
	7 -12	*3.8%*	55.2%	39.7%	53.9%	24.6%
	13-20	*1.6%*	34.2%	21.7%	33.0%	12.1%
	>20	*5.5%*	64.5%	49.2%	63.2%	32.4%

Figure 4. Binary logistic regression probabilities of parrotfish catches for soak time, substrate type and depth.

We used the meta-analysis to look for explanations of variability in parrotfish capture. Whilst overall about one quarter (28.4%) of all hauls had at least one parrotfish in, the GLM(BLR) found significant differences in which hauls were likely to catch parrotfish. Interestingly, whilst neither trap type (Z-trap, chevron or rectangular) or mesh size (1.25", 1.5", 2") significantly affected the probability of parrotfish capture, the soak time, substrate and depth, each had a highly significant influence. The most important influence was soak time. Traps soaked for 1 or 2 days, irrespective of depth or substrate, had very low probabilities of catching parrotfish (<0.1% - 5.5%) As soak time increased to 3 days and more, catch probabilities increased dramatically (up to a maximum of 64.5% probability, when set for 3- 4 days, at >20m) (Figure 4, highlighted red).

The substrate the trap was set on significantly affected catch probabilities. Traps on seagrass were considerably less likely to catch parrotfish than on any other bottom type (Figure 4, highlighted green). Capture probabilities also varied with depth. In shallow water, <6m, catch probabilities were significantly higher. This is logical since shallow waters are where parrotfish abundance is normally highest. Probabilities dropped as the depth traps were set increased to 7-12m and decreased further at 13-20m. Catch probabilities however significantly increased again at >20m. This apparent anomaly may be explained by the diurnal vertical migrations made by parrotfish, where they graze during the day in shallower areas and rest at night on deeper reefs[4]. Thus they may be vulnerable to capture at each end of their depth range, but less vulnerable in the intervening depths (Figure 4).

Conclusions:

- There are species specific variations in the vulnerability of parrotfish to fish trapping with *S.aurofrenatum* the most susceptible.
- Repetitive, localized trapping can rapidly deplete local populations of herbivorous fish in short time periods (days).
- Spearfishing is likely to be a greater threat to medium sized parrotfish that are uncommon in traps and depletes *S. viride* at a greater rate than trapping
- Areas where both trapping and spearing occur are likely to suffer synergistic impacts on total grazing potential as the two fishing types remove different herbivore guilds[5] (stratified by size).

Considerations for management :

- Limiting soak times to 24 to 48 hrs would significantly reduce parrotfish capture, whilst unlikely to impact overall catch of target fish.
- Setting traps on seagrass, whilst beneficial in reducing parrotfish capture, significantly reduces the catch of other fish and so would not be economically viable for fishers.
- Changes to mesh size of traps tends to shift the species of parrotfish that are caught rather than reducing overall capture.
- Managers must focus on building awareness of conserving parrotfish populations among local fishers.

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Reducing the Susceptibility of Parrotfish to Fish Traps: A Meta-Analysis Identifying Feasible Management Strategies

KEY WORDS: Scaridae, vulnerability, fish traps, management strategies

Reduciendo la Susceptibilidad de los Peces Loro a las Trampas: Un Meta-Análisis que Identifica Estrategias Viables de Manejo

PALABRAS CLAVE: Scaridae, susceptibilidad, trampas, estrategias viables de manejo

En Réduisant la Susceptibilité des Poissons Perroquet aux Pièges: Une Méta-Analyse Identifiant des Stratégies Faisables de Maniement

MOTS CLÉS: Scaridae, susceptibilité, pièges, stratégies faisables de maniement

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ABSTRACT

Parrotfish are essential to the health and resilience of coral reefs. As the Caribbean's main herbivores, they reduce the extent and canopy height of macroalgae, create space for coral settlement, and mediate spatial competition between corals and algae. Due to their crucial ecological function, protecting parrotfish populations is an increasing management priority across the region. Identifying and implementing realistic yet effective management strategies for areas that are subject to fishing pressure is essential, considering that 98% of Caribbean coastal waters are not under marine protection. Parrotfish may be particularly vulnerable in locations where fish traps are widely used. Their simple construction and ease of deployment, combined with their ability to capture fish not susceptible to hook-and-line, make this non-selective fishing gear advantageous to fishers. However, their sustained use has been widely blamed for the overexploitation of near shore reef fish populations including parrotfish in many areas of the Caribbean. In the current study, we collated data from the literature and combined this with results from original trap experiments conducted in Honduras to build a regression model to calculate the importance of different factors affecting the susceptibility of parrotfish species to trapping, including design, dimensions, mesh size, deployment substrate, depth, and soak times. The results suggest easily interpretable management guidelines for fish trap use to be applied in areas where banning fish traps is currently unachievable due to limited enforcement capacity, strong cultural connections to fish traps, or a large economic dependence with few available alternatives.

High Profit Pelagic Fisheries Lure Artisanal Fishers into Cycles of Debt, Risk, and Climate Vulnerability

KEY WORDS: Pelagic, artisanal, economics, fisheries

La Pesca Pelágica de Alta Rentabilidad Lleva a Pescadores Artesanales a Ciclos de Deuda, Riesgo y Variabilidad Climática

PALABRAS CLAVE: Pelágic, artesanales, económico, pesquerias

La Pêche Pélagique à Bénéfices Élevés Appâte les Pêcheurs Artisanaux dans la Faillite, Les Risques et l'Impact de la Vulnérabilité Climatique

MOTS CLÉS: Pélagique, artisanaux, pêcheurs

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ABSTRACT

Fishing is an important source of income to many who have limited employment opportunities in tropical rural areas. Typically, most descriptions of fishing practices in these areas have been restricted to reef fish fisheries, and studies that document pelagic fisheries are rare. This paper provides a socio-economic description of the artisanal pelagic fishery in San