



Influence of habitat structure and population density on the distribution and survival of four species of harvested coral reef fishes

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Why this study? 1) Effective management of harvested coral reef fishes depends on sound knowledge of their ecology.
2) Little is known about key aspects of the ecology of most harvested coral reef fishes, despite extensive studies of small non-harvested species, which might be poor models for larger, valuable species.

Study System

Study species 4 species of snappers and grunts that are harvested throughout the wider Caribbean. All are medium sized, generalist carnivores that are abundant on shallow reefs. The four species are morphologically and ecologically similar (e.g., body size, diet, schooling behavior). Although harvested throughout their range, there is very low fishing pressure in the study area.

Study sites 8 large (1000's of m²) natural reefs in the central Bahamas.



Schoolmaster snapper
Lutjanus apodus



Lane snapper
Lutjanus synagris



French grunt
Haemulon flavolineatum



White grunt
Haemulon plumieri

Are demographic rates density dependent?

Density dependence

- occurs when demographic rates change with population density
- assumed by many fisheries models – fishing will “thin” populations and survivors will grow, reproduce, or survive at higher rates
- often found in small, abundant, non-harvested reef fishes, but hasn't been studied in harvested coral reef fishes

Methods: Mark-recapture used to calculate survival probabilities for each species. 1863 schoolmasters, 1327 lane snappers, 833 French grunts, 593 white grunts were tagged between June 2002 and August 2005. Density and habitat structure surveyed along transects.

Findings:

- No density dependence in survival evident in any of the four study species.
- Habitat also had no apparent effects on survival of any of the four species.

Implications: These harvested species may lack the natural mechanisms (density dependence) that would allow them to rebound from overfishing or compensate for fishing mortality.

Limitation of approach: Because for most species, density covaried with habitat, the tests for effects of density and habitat are confounded (allows the possibility of “cryptic density dependence”).

- We therefore experimentally manipulated density of one species, the schoolmaster snapper, to provide a rigorous test for density dependence...

For methods and validation studies see:

Wormald, C.L. & Steele, M.A. 2008. Testing assumptions of mark-recapture theory in the coral reef fish *Lutjanus apodus*. *Journal of Fish Biology* 73: 1-12.

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How is the abundance of commercially valuable coral reef fishes influenced by habitat structure?

Methods: Fish density and habitat structure surveyed along several 10 x 50 m transects at each reef between June 2002 and June 2004.

Findings:

Relationship to habitat varied among the four species, despite other similarities among the species.

- 2 species closely tied to corals, 1 species not associated with corals, 1 species negatively related to coral density.
- Differences among species probably related to predator avoidance behavior.

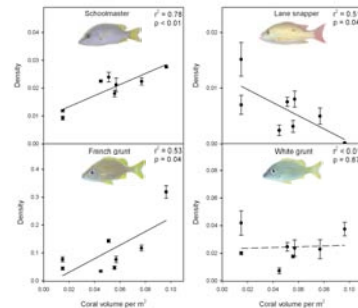


Fig. 1.

Relationships between fish density and coral boulder volume per m². Mean densities (number of individuals per m² ± SE) and coral boulder volume per m² are shown for the premanipulation period of the study, between June 2002 and June 2004.

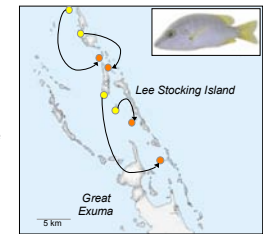
Implications: Managing snappers and grunts as a single complex is risky, given the very different associations of species in this group with coral reef habitat.

An experimental test for density dependence in schoolmaster snapper survival

Methods: Schoolmaster densities were manipulated and their survival rates measured by mark-recapture.

Fig. 2.

The density of schoolmaster snappers was experimentally manipulated at 8 sites in the central Bahamas in June 2004 by transplanting fish from paired low-density treatment (○) to high-density treatment (●) sites.



Findings:

- Density had a strong POSITIVE effect on survival of schoolmasters.

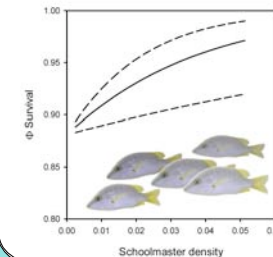


Fig. 3.

Relationship between survival (Φ) and density in the schoolmaster snapper. Survival values were reconstituted from parameters estimated by model $\Phi(\text{density})$, $p(\text{site} + m + t)$. Survival is the probability of survival over a time period of one month. The range of densities shown spans the range encountered during the study. Broken lines represent the 95% confidence interval of the survival estimate.

Implications for management of harvested reef fishes

- This study highlights the need for experimental studies of exploited reef fishes at large scales relevant to management.
- The positive effect of density on survival of the schoolmaster snapper and apparent lack of effects of density on the other study species contrast with the results of most studies on small, non-exploited coral reef fishes and suggests these small abundant species may be poor models for harvested species.
- Positive or no effects of density found in this study imply that regulatory mechanisms that would help populations recover from overfishing may be absent in the species studied, but marine protected areas may be particularly effective for management and conservation of these and similar species.