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Comparative spatial ecology of fished spiny lobsters *Panulirus argus* and an unfished congener *P. guttatus* in an isolated marine reserve at Glover's Reef atoll, Belize

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Abstract Palinurid lobsters are being exploited with increasing intensity in coral reef ecosystems, but marine protected areas may play a key role in preventing overfishing and local extinctions. In order to define the spatial requirements for protection, we compared the spatial and temporal patterns in distribution, density, biomass, size structure, and reproductive seasonality of Caribbean spiny lobsters *Panulirus argus* and the congeneric spotted lobsters *P. guttatus* on coral patch reef, forereef, and deep reef habitat at Glover's Reef, Belize. The relative impact of fishing on *P. argus* was also examined in an isolated marine reserve and adjacent fished habitats, in comparison with the relatively unfished distribution of *P. guttatus*. Over a 5-year period, both species co-occurred in all major reef habitats, but aspects of their population dynamics differed markedly due to both habitat and fishing effects. All size classes of spiny lobsters *P. argus* occupied shallow patch reefs, but large adults were predominant on the deep wall reef. *Panulirus guttatus* also occupied patch reefs in the lagoon, but spur-and-groove forereef appeared to be the primary habitat of this species. Density and exploitable (adult) biomass of *P. argus* increased significantly over time in the protected patch reef habitat of the lagoon but remained stable on deep reef habitat. The biomass of spotted lobsters *P. guttatus* in all habitats was at least an order of magnitude less than that of exploitable *P. argus*. Reproductive activity by both species was evident most of the year in all habitats, but breeding *P. argus* females were concentrated on the deep reef. Commercial fisheries

for spotted lobsters *P. guttatus* are currently being considered for development, but data from this and other studies suggest that such a fishery may be relatively unproductive and may lead to rapid localized extinctions. Spiny lobsters *P. argus* used a variety of coral reef habitats, but spotted lobsters *P. guttatus* were habitat specialists restricted to shallow reef habitat. The protection needs of both species are similar in one aspect: large protected areas. However, *P. argus* required large areas with heterogeneous habitats including coral reefs and seagrass beds, whereas *P. guttatus* required large areas of coral reef habitat.

Keywords Spiny lobster · *Panulirus argus* · *Panulirus guttatus* · Marine reserves · Reef fisheries

Introduction

Overfishing has resulted in precipitous declines in many exploited populations in coastal habitats (Dayton et al. 1995). Because current fishery regulations appear to be inadequate to protect many exploited populations and maintain sustainable fisheries, researchers and managers have suggested that marine reserves in which fishing is prohibited may be necessary to prevent local extinctions (Ballantine 1991; Bohnsack 1993; Lauck et al. 1998). A marine reserve that functions as an effective harvest refuge has the potential for increasing local population size, mean individual size, and, consequently, reproductive output, compared to fully exploited populations (Dugan and Davis 1993). These effects may result in increased regional larval supply, as well as net movement of adults from the reserve to adjacent fishing grounds as densities build up in the reserve (Polacheck 1990; Carr and Reed 1993; DeMartini 1993). However, a number of factors may impact the efficacy of marine reserves as functional harvest refuges, and the comparative effects on species with different life histories are largely unknown.

The fishery for the spiny lobster *Panulirus argus* is the largest and most economically valuable in many

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