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Habitat structure determines coral reef fish assemblages at the northern tip of the Red Sea

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Abstract

Coral reefs and reef fish communities at the northern tip of the Gulf of Aqaba (Red Sea) are at the extreme of their distribution range. We investigated the effect of habitat structure on fish community structure in five different habitats and over four seasons (during 1 year) at Eilat.

Reef fish assemblages varied between habitats and sites, but not between seasons. The combination of habitat parameters that best explained community structure were average depth, distance from shore, vertical relief, percentage cover by rock and the cover complexity index. Our research indicates a high correlation between fish community structure and habitat and demonstrates the ability of multivariate methods to predict community structure in a particular region, based only on habitat parameters. This may offer an effective tool for monitoring programs to detect changes in community composition. We found that the complex relationship between habitat and community structure cannot be described by single community indices nor by their combination. Therefore, a multivariate approach is needed. It is shown to be sufficient to record only 50 of the most common species in order to obtain a community structure similar to that obtained from all the species. Our findings validate the use of multivariate methods when trying to interpret spatial and temporal patterns in fish communities.

Keywords: Multivariate; Monitoring; Eilat; Gulf of Aqaba

1. Introduction

Roberts et al. (2002) and Mora et al. (2003) consider the Red Sea as a multitaxa center of endemism and fish center of endemism, respectively. The Gulf of Aqaba is considered as a separate bio-geographical region in the Red Sea (Shepherd et al., 1992). Corals, fishes and other organisms of this area create distinct assemblages (Ormond and Edwards, 1987; Shepherd et al., 1992). At the northern tip of the Gulf of Aqaba coral and fish communities are at the extreme northern end of their west Indo-Pacific distribution. Several studies have been conducted in this unique area dealing with the effect of the habitat structure on selected fishes or fish groups (Gundermann and Popper, 1975; Edwards and Rosewell, 1981)

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and specific trophic guilds such as herbivores (Harmelin-Vivien and Bouchon-Navaro, 1981). Although a few studies dealt with fish communities in specific artificial and natural habitats (Clark et al., 1968; Ben-Tuvia et al., 1983; Rilov and Benayahu, 1998, 2000; Golani and Diamant, 1999; Khalaf and Kochzius, 2002), no comprehensive study has been performed on the effect of habitat structure on reef fish assemblages in the Gulf of Aqaba's unique environment.

Habitat structure and its related abiotic parameters are considered important to processes affecting fish species, families and trophic groups (Sheppard et al., 1992; Meekan et al., 1995; Friedlander and Parrish, 1998; Nanami and Nishihira, 2002) and are known to be the main factors in structuring fish communities (McGehee, 1994; Lara and Gonzalez, 1998; Wantiez and Chauvet, 2003). Many scientists have tried to explain the factors affecting the community structure of fishes by investigating the relation between the physical parameters of the habitat (such as depth, complexity and biotic cover indices) and different indices of the fish community (Carpenter et al., 1981; Mcmanus et al., 1981; Grigg, 1994; Chabanet et al., 1997; Lewis, 1997; Adjeroud et al., 1998; Ohman and Rajasuriya, 1998). These indices have been considered important in evaluating coral reef health, general status and environmental quality (Bortone et al., 1989). However, different fish species respond differently to changes in the environment (Jones and Syms, 1998), thus diversity indices will not necessarily reflect the true changes for all considered species. Recent studies use multivariate methods in an attempt to understand the effect of the habitat parameters on the fish community as a whole (Friedlander and Parrish, 1998; Wantiez and Chauvet, 2003). Clarke (1993) suggested a multivariate approach to reveal community patterns and to link these patterns to the physical and chemical environment of the habitat. Ohman and Rajasuriya (1998) demonstrated a new method of analyzing fish-habitat interaction by using different multivariate methods (e.g. MDS and the RELATE procedure).

In the present study we explored the response of the fish community to the habitat structure and to several abiotic parameters at the extreme end of both coral reefs and coral reef fish communities. This unique area where corals and fishes are accustomed to surface temperature dropping below 20 °C in winter is currently under stress from anthropogenic perturbations, mainly high levels of tourism and eutrophication from various sources (Hawkins and Roberts, 1994; Diamant et al., 2000; Zakai and Chadwick-Furman, 2002). Due to this situation, with monitoring in mind, we explored the possibility of representing the entire fish community with a smaller set of species for simplification of future monitoring programs as well as describing the typical fishes in each habitat. Seasonal changes in water temperature may influence fish abundances due to recruitment in warmer months. Although the effect of recruitment on community structure as expressed in multivariate statistics is minor we nonetheless explored seasonal variations.

2. Methods

2.1. Study sites

The study was carried out in the Coral Reserve of Eilat (Israel) on the west shoreline of the northern tip of the Gulf of Aqaba (Red Sea) (Fig. 1). This narrow and deep gulf is characterized by narrow and deep fringing reefs extending from very shallow waters to a depth of tens and even hundreds of meters. The reefs in the area of Eilat are the northernmost extension of the Indian Ocean and represent some of the world's northernmost coral reefs. The Israeli coastline is about 12 km long, of which about 4 km is a marine nature reserve. This reserve includes the northernmost continuous fringing reef of the area.

Three sites were chosen for this research: (1) 'North Coral Beach Reserve (''NCBR'')', (2) 'The Japanese Gardens (''JG'')' and (3) 'The Caves area (''Caves'')', which is the southernmost reef in the Israeli shoreline, located about 1 km south of the Japanese Gardens (Fig. 1).

We studied five habitats in each site, which were previously defined for Eilat's reefs and thoroughly described by Loya and Slobodkin (1971) and also by Mergner (1971). These habitats are narrow and in close proximity to each other, measuring from only meters to tens of meters in width. The habitats were as follows (from inshore to offshore): (I) the lagoon (found only in the two northern sites), (II) the reef flat ('table'), (III) the fore reef, (IV) the upper moderate