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The implications of ecosystem dynamics for fisheries management: A case study of selected fisheries in the Gulf of Paria, Trinidad

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Abstract

It is accepted that if fisheries resources are to remain renewable and able to sustain livelihoods, appropriate management practices must be implemented. Even while fisheries management grapples to resolve single-species issues, the biological and economic interactions among species mandate that to be effective, management techniques must be based on more interactive and aggregate-level analyses. In order to implement these techniques, the actual links, and the potential impact of these links, among the fisheries must be established. Vector autoregression (VAR) analysis has the potential to play an increasingly important role in ecosystem modelling for fisheries management. This study uses VAR analysis to demonstrate the quantitative impact of certain ecosystem changes on the productivity of the carite, honey shrimp and croaker fisheries of the Gulf of Paria, Trinidad, in the particular context of the ecosystem dynamics of trophic linkages, bycatch and multispecies fisheries. Four VAR models are constructed to investigate the extent to which these factors affect the production of the selected fisheries, and to evaluate the management implications of these linkages. The empirical analysis is further evidence that, if sustainable management of fishery resources is to be achieved, management practices based on more multi-species, ecosystem approaches must replace the traditional, single-species management techniques.

Keywords: Fisheries management; Ecosystem dynamics; Bycatch; Trophic linkages; Multispecies fisheries vector autoregressive analysis (VAR); Gulf of Paria; Trinidad; Caribbean

1. Introduction

For many small islands the marine environment can be the most important economic resource (Bass, 1993). It is commonly accepted that the marine resources available to island states can, if properly utilised, significantly contribute to the sustainable development of the region (Dolman, 1990). The small-scale artisanal fishery sector in particular plays a critical socio-economic role (Dolman, 1990; Food and Agricultural Organization, 1999). To island states in particular, therefore, proper management of the marine fishery resources is essential.

Fisheries management objectives are multiple in nature and may be characterised by internal conflict (Mardle et al., 2002). There are many alternative management techniques designed to achieve the stated objectives (McAllister et al., 1999). Current trends of declining fishery resources and habitat degradation indicate, however, that current management techniques, either in conceptualisation or implementation, are failing to sustainably manage the resources. During the past 50 years, the dominant fisheries management paradigm has been to focus on a target species at a time (FAO, 2003). Failure has been linked to the fact that these management practices tend to reduce fisheries into their component parts, with stocks assessed on a species by species basis (Roberts, 1997; Tegner et al., 1999; FAO, 2003). It is now accepted that the complexity of fisheries requires sophisticated management processes (Cochrane, 1999; Gislason et al., 2000). Even as fisheries management struggles to resolve single-species

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issues, it is increasingly being called upon to take a multispecies and ecosystem perspective (Caddy and Cochrane, 2001; FAO, 2003).

The biological interactions among species require management techniques based on more aggregate-level analyses. Traditional fishery management models have, however, regarded exploited populations in isolation from their surrounding environment and have largely ignored species interactions (Goni, 1998). Because the ecosystem dynamics of species interactions are not accounted for, these models are not equipped to effectively manage the resources (Roberts, 1997; Bax, 1998; Arnason, 2000; Caddy and Cochrane, 2001; Manickchand-Heileman et al., 2004; Heymans et al., 2004).

Fisheries management objectives often assume that fishing mortality is the only factor that contributes to variation in species survival rates (Bax, 1998; Goni, 1998). Complex and numerous species interactions through the dynamics of predation and competition can cascade through entire ecosystems via direct and indirect ecosystem effects (Bax, 1998; Shannon et al., 2003). Losses to predation can sometimes exceed losses to fisheries (Bax, 1998). Yet the world's fisheries continue to remove large amounts of catch with little or no consideration of what may be the consequences of excessive removal of a predator or prey on the trophic structure (Parsons, 1992; Bax, 1998).

The incidental harvesting of unwanted, untargeted species or age classes is an issue that poses sustained challenges to fishery management and remains firmly on the fisheries and conservation agendas (Boyce, 1996; Bache, 2003). While bycatch may be of other fish species, it can sometimes include taxa very different from targeted harvests such as birds and mammals (Norman, 2000). Bycatch can also often change the trophic structure of entire ecosystems with the encouragement of scavengers (Gislason et al., 2000; FAO, 2003). Shrimp trawl fisheries in particular warrant particular attention, where the shrimp-catch is, in most cases, outweighed by the weight of the fish-dominated bycatch (Stratoudakis et al., 2001; Stobutzki et al., 2003).

The nature of the marine environment and the inherent non-selectivity of fishing gear imply that it is hardly practical or profitable to target a single species at any one time. Multispecies fisheries and their ecosystem effects are one of the most prevalent problems in fisheries, with the incorporation of multispecies dynamics into resource management being increasingly investigated and implemented (Squires et al., 1995; Walters et al., 1997; Cochrane, 1999; Arnason, 2000; Le Pape and Vigneau, 2001). A path of conservative management can often be the prescription for fisheries that consciously and simultaneously harvest, by the same gear, different species that are characterized by different points on the over-exploitation scale (Dedah et al., 1999).

In order to implement ecosystem management approaches that can effectively deal with the challenges posed by more holistic analysis, the interlinkages between the various ecosystem components and the potential impacts of these linkages must be established. This paper seeks to empirically demonstrate the ecosystem interactions of trophic linkages, bycatch and multispecies fisheries among the carite, croaker and honey-shrimp fisheries of the Gulf of Paria, Trinidad, and to evaluate the implications of these interactions for their future effective management.

2. The Gulf of Paria, Trinidad

The island of Trinidad is the most southerly of the Caribbean island chain. It lies just off the coast of Venezuela and is part of a twin island state known as Trinidad and Tobago. The west coast of Trinidad borders the waters of the Gulf of Paria, a shared body of water on the northeastern continental shelf of South America, between eastern Venezuela and the west coast of Trinidad, covering an area of 7600 km^2 (Manickchand-Heileman et al., 2004). The Gulf of Paria coastline is the most utilised coastal zone of the island of Trinidad and one of the most industralised areas in the region. More than 90% of the country's 1.2 million population resides and works along the west coast and in the watershed areas draining into the Gulf of Paria (FAO, 1998) Fig. 1.

The Gulf of Paria is an enclosed basin with a flat bottom and gentle slopes, and with an average depth of ~20 m. Because of the island's proximity to the South American continent, the Gulf has often been defined as part of the greater Orinoco region of Venezuela (Boodoosingh, 1992). The Orinoco is among the world's largest rivers and drains an area of approximately 9×10^5 km^2 in Colombia and Venezuela. Prevailing winds and currents result in the movement of outflow of the Orinoco directly into the Gulf of Paria. These nutrient rich and sediment laden waters contribute considerably to the high productivity to be found within the Gulf. The Gulf of Paria is presently the most active fishing area around the island of Trinidad (Boodoosingh, 1992).

Biologically, the marine fisheries of Trinidad and Tobago can be broadly categorised into pelagic and demersal. The most important pelagic fishes are the carite, kingfish, cavalli and sharks, while the more important demersal stocks are the penaeid shrimp, croaker, sharks, snapper and salmon (Boodoosingh, 1992). The industry has traditionally been an inshore and artisanal one, and remains largely unmanaged (Manickchand-Heileman et al., 2004).

"Carite" is the local name for the Spanish mackerel *Scomberomorous brasiliensis*. In terms of weight it is the most commercially important species in Trinidad (Fisheries Division, 1993a). The carite can live up to 9 years (Fishbase, 2004) and are coastal inhabitants. The carite has been found to spawn throughout the year with periods of peak spawning activity from October to April in the Gulf of Paria, from May to September on the Guyana shelf and from July to September off northeastern Brazil.