III Seminário de Gestão Socioambiental para o Desenvolvimento Sustentável da Aqüicultura e da Pesca no Brasil – III SEGAP 2009 –Proceedings em CD ROM

FISHERS' DECISION MAKING, OPTIMAL FORAGING AND MANAGEMENT

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Abstract. This study analyses the foraging behavior of coastal fishers of the Brazilian southern Atlantic Forest coast (States of São Paulo and Rio de Janeiro), and of riverine fishers of Amanã and Mamirauá Sustainable Development Reserves, State of Amazonas, Amazon. Optimal foraging theory has been helpful in clarifying the variables involved in decision processes concerning where to fish, what prey should be searched, and how long to stay fishing in a patch (fishing ground or fishing spot). In this study, data were collected at landing points in various trips from 2000 to 2004 at the Coraci River (Amanã), Japurá River (Mamirauá), São Paulo Bagre (Cananéia Island), and Itaipu Beach (Niterói). Data were obtained on fish species caught and fish weight, as well as time involved in fishing activities, among other variables. We used the model of central place foraging, in which travel time influences the catch obtained, in order to analyze how fishers behave, considering a currency to be maximized (in this case, catch). Our results indicate that, most of the time, fishers are not acting as 'catch maximizers'. We compared the results obtained in this study with results obtained in previous studies in other coastal and riverine areas. The high unpredictability of catches and of time used to fish, along with an understanding of the context where fishing occurs, the prey species searched, and gear used help in understanding the foraging behavior observed among Brazilian riverine and coastal fishers. Part of this paper was presented at the *XIV INTERNATIONAL CONFERENCE OF THE SOCIETY FOR HUMAN ECOLOGY October 18-21, 2006, BAR HARBOR, MAINE, USA.*

Key Words: Ethnoecology, Human Ecology, Fisheries, Optimal Foraging, Fishers' Behavior

I. Introduction

The urgency in managing tropical fisheries has been pushing for new methods and approaches in current studies In this regard, four elements should be considered in the process of linking human and ecological systems towards management (Begossi, 2008): 1) an understanding of the natural environment of the fishery and on the use of natural resources by fishers; 2) the knowledge of the marine area used by fishers, i.e., location of fishing spots for each species; 3) the understanding of fisher behavior, e.g., using tools from optimal foraging theory; and 4) the knowledge fishers have of the biology and ecology of species (local ecological knowledge (LEK)), based on studies of the ethnobiology, ethnoecology, and ethnotaxonomy of fish. **This study exemplifies the third aspect, the understanding of fisher's behavior through optimal foraging theory** (Begossi, 2008)**.**

Optimal foraging theory includes classical models in ecology that aim to understand the behavior of organisms when searching and handling natural resources to be eaten. Even through the initial ecological models were borrowed from microeconomic theory (Rapport and Turner, 1977), they were firstly applied to animals. Classical reviews of this theory and its applications are found in Pyke (1984) and in Stephens and Krebs (1986). Applications of optimal foraging theory on human behavior and on decision-making processes are found especially in archaeology, ecological anthropology, and evolutionary ecology (Bird and Bliege 1997; Bettinger, 1980, 1991; Setz, 1989; Smith, 1983, Winterhalder and Smith, 1981).

A special category of foraging models, the 'Central place foraging theory' (Orians and Pearson, 1979), is applied to small scale fisheries, since fishers returns to a 'central place' (their residences or landing points) with their catch. Examples of those applications are found in Aswani (1998 a, b), Alvard (1993), Begossi (1992, 1995), Begossi and Richerson (1992), and Begossi et al. (2005), Nehrer and Begossi (2000), Nordi (1994, 1997), Seixas and Begossi (2000), Thomas (2007).

In this study we address the foraging behavior and decision-making process of fishers from marine and riverine environments concerning a central place foraging hypothesis: *the larger the distance from the central place, the larger the fisher's catch intake.* We included data from a coastal marine fishing community, Itaipu beach, Rio de Janeiro; an estuarine fishing community, São Paulo Bagre, Cananéia Island and two riverine communities, Jarauá, Japurá River, and Ebenezer, Amanã River, in the Amazon.

1. METHODS

Data from fishing trips were collected at landing points, directly from fishers, using standard questionnaires. Information about the fish species caught, including weight, was obtained in monthly samples, and distance in minutes to the fishing spot was given by fishers, for each trip recorded (with the exception of Itaipu beach, where information on total time spent fishing was available). These communities have been studied in earlier research projects (Barbosa and Begossi, 2004; Begossi, 1996; 2006; Hanazaki 2001; MacCord & Begossi, 2006; Silvano et al., 2006). At Itaipu, we complemented information on fishing trips by approaching the fishers while they were fishing, by boat, a method referred as 'fishing approach'(Begossi, 2006). Regression analyses were performed, and data were transformed into natural logarithm, when needed, in order to normalize variables (Table 1).

2. THE FISHERIES

Research in Itaipu beach, Niterói, Rio de Janeiro State was conducted from 2001 to 2003. Hook and lines, gillnets, beach seines and diving were used for fishing by fishers that have their residence in Itaipu and neighborhoods (Begossi, 2006). About 44 fishers were interviewed in this community and data on 210 fishing trips were collected. For the optimal foraging model, we had complete data for 129 fishing trips, since data collected in the fishing approach bring information on fishing spots and catches, but not on total time fishing.

São Paulo Bagre is a fishing community located in the estuary of Iguape-Ilha Comprida. Local fishers use gerival (a kind of small net operated from a boat), a gear that is exclusively used in the shrimp fishery. Monthly samples of fishing trips and catches were taken in 1999-2000, with a total of 232 fishing trips recorded. For the optimal foraging model, 204 trips were available.

The fishing communities studied in the Amazon River are named Jarauá and Ebenezer. Jarauá is located at the Japurá river, in the Mamirauá Sustainable Development Reserve (Begossi and Brown, 2003) and is under management for 12 years, especially for fish targets such as tambaqui (*Colossoma macropomum*) and pirarucu (*Arapaima gigas*). Ebenezer is located in the Coraci River, in the Amanã Sustainable Development Reserve (Viana et al., 2002; Queiroz, 1999; MacCord *et al*., 2007). Fish landings were recorded in Jarauá and Ebenezer in 2003. A total of 485 fish landings were recorded in these two communities at low and high water seasons, 270 in Jarauá and 215 in Ebenezer. In the high water season, hook and lines were used in Jarauá and gillnets by Ebenezer fishers, while in low water seasons gillnets were used in both places (MacCord *et al*., 2007).

3. RESULTS

We suggested a hypothesis to be tested that ‘as far as fishers go the returns are higher’, or, in other words: as fishers look for catches in distant fishing spots, they tend to bring higher returns than when fishing in closer spots. Linear regression models were used to test that hypothesis, being travel time used as independent variable and catch as the dependent variable. Just for the Itaipu case, total time fishing (which includes travel time) is used as dependent variable (Table 1). Table 1 shows that, in spite of the significant results shown in most regressions for the fisheries studied, it is worth to pay attention especially on two cases: São Paulo Bagre, the estuarine community and Ebenezer in the low water season (dry season), due to their relative higher regression coefficients. In São Paulo Bagre, travel time influenced the number of shrimp obtained by 19% other things being equal. At Ebenezer, during low water season, travel time influenced in 22% the catch obtained, other things being equal.

4. DISCUSSION AND APPLICATIONS

The first question that we may think by observing results in Table 1 refers to which variables influenced such results. In other words, what are fishers optimizing (total catch, selective catch) and in which conditions (gear used, the fish target, the water season)? Which variables can be considered as relevant while fishing? The fisher’s evaluation of catches might depend on the mobility of the prey, as observed for Sepetiba bay shrimp fishers (Begossi, 1992, Table 2). Thus, after evaluating the prey and its density, fishers could be capable of estimating the proximate catch in the fishing spots. Such evaluation depends on a variety of factors, such as prey mobility, results of the previous catches in that spot, among others. Travel time influencing fishing returns are observed at the coastal communities of Sepetiba bay, Ubatuba (Puruba), and Cananéia (Tables 1 and 2), and at the riverine community of Amanã, Ebenezer (Table 1). Ebenezer, just in the low water season, shows results in which travel time influenced the total fish catch. In this community, a variety of techniques are used in the low water season for many species, whereas tambaqui (*C. macropomum*) is a target in the wet season (Table 1). The reasons to explain the fisher´s better perception of the trade-off in the dry season can be due to a better evaluation of the density of preys by the fishers, in a situation where the water is low and the relative density of preys is larger. Maybe, a higher water visibility in the dry season could also play a better rule in finding fish. In Table 2, we observe for coastal communities that sedentary prey as shrimp, compared to fish, can also be better estimated in order to evaluate costs and benefits of fishing (Table 2). The unpredictability of fish resources, along with their non-visibility, turns the extractive systems of artisanal fishing an activity based on ‘rules-of-thumb’, probably based on previous experiences (see Boyd and Richerson, 1985, for analysis of decision-making processes). The application of optimal foraging theory to understand fisher decision-making processes can be helpful in linking two systems of thought the local and the scientific (Begossi, 2008). For example: a) the local: how fishers manage to obtain what they need, or want as targets, and b) the scientific - variables that are part of the fisher´s decision-making processes, approached by the ecological models. These two systems are in ethnobiology named by the words *emic* (native/local thinking, vision from inside) and *etic* (scientific parameters, outsider view) (Harris, 1976) (see Begossi, 2008). Such applications are important, especially in areas where fishers have demands for management. By knowing the variables that are influencing fishers’ choices, management can reflect more accurately the reality, being thus more effective. The example given here is just a small example of what can be performed using optimal foraging theory. Certainly, this theory can be useful in deciding about specific management procedures in fisheries, such as quotas, rotation of fishing spots, target species, and fishing agreements among fishers and other users.

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