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A method for assessing fishers' ecological knowledge as a practical tool for ecosystem-based fisheries management: Seeking consensus in Southeastern Brazil

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ABSTRACT

Studies on fishers' ecological knowledge (FEK) and local ecological knowledge (LEK) have rarely been undertaken for practical application in a management context. Here, we describe a methodology to access FEK that was designed under an ecosystem-based fisheries management framework. The procedure was adapted from the Delphi technique, which seeks experts' consensus, and focused on several spatial and temporal issues related to the small-scale fisheries of the northern coast of São Paulo, Brazil (particularly, in Ubatuba, between 23°20′ S and 23°35′ S). Experienced fishers, considered as experts, were selected during a pilot phase to participate in two sequential rounds of semi-structured interviews at 3 main landing sites and 12 coastal fishing communities. The issues addressed were: (1) spatial and seasonal occurrence of mature females and juveniles of the main commercial species, (2) fishing grounds and bycatch species for each type of fishing gear, and (3) fishers' suggestions for local fisheries management (e.g. mesh and size of gillnets, closure seasons, gear restrictions by fishing area). It was possible to identify consensus rates on the spatial and temporal issues, as well as on fishers' management suggestions. The former allowed the construction of maps representing fishing grounds and the local spatial distribution of different fishery stocks *strata*. We illustrate the output by focusing on five fishery stocks: the seabob-shrimp *Xiphopenaeus kroyeri*, the whitemouth croaker *Micropogonias furnieri*, the inshore squid *Loligo* spp, the white shrimp *Litopenaeus schimitti* and the blue runner *Caranx crysos*. Overall, the results provided new guidelines for future local fisheries management and conservation initiatives. The methodology proved to be useful for the definition of essential fish habitats (EFHs), suggesting their potential application in other locations.

1. Introduction

The rapid change in fisheries systems as a consequence of continuous population growth, globalization, improved technology, increasing fleet operations, as well as climatic and environmental changes, interfere with and threaten the dynamic interaction between humans and the natural environment. Therefore, natural resource management must be adaptive and respond quickly and efficiently to new realities (Berkes, 2010; Gasalla, 2009; Miller et al., 2010).

Communities dependent on fisheries resources are often the first to perceive changes in aquatic ecosystems and in the fishery stocks with which they interact, as these affect directly their livelihoods and income (Friesinger and Bernatchez, 2010). In this sense, fishers' experience-based knowledge about marine ecosystems and resources are of great value for fisheries management (Hill et al., 2010). However, while recognition of the value and significance of studies on local ecological knowledge (LEK) or fishers' ecological knowledge (FEK) has increased in recent decades (Allison and Badjeck, 2004; Begossi, 2008; Berkes et al., 2001; Drew, 2005; Gasalla, 2004; Johannes, 1998; Johannes et al., 2000; Neis et al., 1999; Silvano et al., 2008; Wilson et al., 2006), resource-dependent communities have often remained politically, culturally and socioeconomically marginalized (Brook and McLachlan., 2005; Lam and Borch, 2011) such that these studies findings have rarely been used for practical application in management, especially in ecosystem-based fisheries management (EBFM) (Gasalla and Diegues, 2011; Gasalla and Tutui, 2006).

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In this type of management, the focus is on an integrated vision of the ecosystem within which the fishery is placed, rather than on single target fishery stocks and fishing fleets (Murawski, 2000). Thus, it should include ecological, social and economic factors (FAO, 2003) and simultaneously consider fish, fishers, the maintenance of fishery resources and the environment (Berkes, 2010; Degnbol et al., 2006; Francis et al., 2007; Link, 2002; Pikitch et al., 2004; Pitcher and Lam, 2010). As an integral part of EBFM, the concept of "essential fish habitats"(EFHs) has been applied, and is based on the "health" of fish habitats and their productivity (Rosenberg et al., 2000). The identification of EFHs is important to protect areas that are critical to marine resources, including spawning and nursery grounds of commercially important species (Bergmann et al., 2004; Conover and Coleman, 2000; Francis et al., 2007).

In many developing countries, including Brazil, governments face many structural obstacles to gathering data, implementing regulations and making appropriate marine resource management decisions (Allison, 2011; Allison et al., 2012; Kooiman et al., 2005). In this sense, FEK can be useful to identify EFHs and other important data for EBFM (Bergmann et al., 2005), particularly where detailed scientific datasets are unavailable and fishers can be the only source of information of environmental and stock conditions (Johannes et al., 2000; Silvano and Begossi, 2010). Moreover, despite wide recognition of the importance of FEK studies, there are only a few studies that address methods to access this knowledge (Davis and Wagner, 2003; Huntington, 1998, 2000).

This paper aims to present a tested method, adapted from the Delphi technique, and evaluate its efficiency to assess strategic FEK with potential to provide more accurate responses to issues of importance to EBFM initiatives, including the identification of potential EFHs, fishing grounds, bycatch species per fishing gear as well as local fishers' suggestions for management in the study area.

1.1. Study area

Ubatuba is located on the north coast of São Paulo (between 23°20′ S and 23°35′ S), which lies in the southeastern Brazilian shelf (Fig. 1). The last shelf receives seasonal upwelling and cool intrusions, resulting in moderately high productivity (Campos et al., 2005; Castro and Miranda, 1998).

Hence, Ubatuba is characterized by intense fishing activity, mostly small-scale. Local commercial fishing records date from 1910, and over decades, fishing became a major source of income of the municipality, which presents many fishing communities and three main landing sites (Fig. 1). Signs of overfishing and declining yields were being noted as far back as the 1970s (Diegues, 1974). Moreover, the area has been the scene of many conflicts, past and present, with regard to the use of natural resources. Nowadays, the study area is part of a recently created type of marine protected area (Área de Proteção Ambiental do Litoral Norte de São Paulo) whose management plan is still under development and future fishing restrictions are still unclear (SMA, 2012). So far, some fisheries are still allowed in the area, mostly small-scale, but there is a movement to promote a more restrictive protection level under the definition of that management plan.

2. Materials and methods

2.1. The adapted Delphi methodology

The methodology addressed in this study was adapted from the Delphi method. This method involves applying several rounds of consultations to a set of experts on a particular subject. After each round of consultation the results of all responses are summarized and presented individually to each participant. Participants can change their opinions and contributions, according to new general data, in the next round of consultations, which have their results represented to all involved, and so on, in the sequential rounds. The purpose of the method is to find consensus, while a key premise is the ability to maintain respondent anonymity throughout the process (Barrett, 2009; Linstone and Turoff, 1975; Zuboy, 1980).

We adapted the Delphi method in this study in the following ways. First, a pilot phase addressed the identification of key fishers (here considered as experts) through interviews, pre-structured questionnaires, and pre-established criteria. The second and third phases consisted of two rounds of interviews with the key fishers selected. All the information provided by key fishers at the first round of interviews were tabulated and presented to key fishers, individually, at the second round. We considered as consensual information/data those confirmed by more than 50% of key fishers at the second round of interviews. The methodology was previously explained to interviewees and they were kept anonymous so that individual opinions were not influenced by the opinions of specific individuals and so that the chance of conflict between stakeholders was reduced (Zuboy, 1980). Finally, we requested permission to publicize the collection of information found (Scholz et al., 2004).

2.2. Pilot phase: selection of key fishers

In order to access reliable and valid data from FEK, it is essential to identify the most qualified and experienced fishers to be responding to the questionnaires (Moreno et al., 2007). Thus, between April and September 2009 two fieldtrips were made, and a pilot phase was conducted in order to select key fishers. For this purpose, the researcher visited the major landing sites of Ubatuba: *Saco da Ribeira*, *Cais do Alemão* and *Ilha dos Pescadores* (Pincinato et al., 2006; Vianna and Valentini, 2004) and 12 coastal fishing communities, including: *Pinciguaba*, *Barra Seca*, *Itaguá* and *Maranduba*, which are the communities that presented the largest number of vessels in the municipality (Vianna and Valentini, 2004). During the visits, local small-scale fishers were approached and interviewed with the use of semi-structured questionnaires.

The "snowball" methodology, also called "chain of informants", was used in this pilot phase of the project. Each interviewed fisher was thus asked to indicate the next respondent to contribute in the study, in succession (Scholz et al., 2004; Silvano and Begossi, 2010). In this way, a total of 109 fishers were interviewed (Table 1).

The questionnaires addressed questions related to fishers' personal data (age, place of birth, community were they lived, phone number) and fishing experience (number of years fishing and working regime on fishing) and responses were tabulated and analyzed to provide a selection of key fishers.

The pre-established criteria adopted for the selection of key fishers, following advice offered in Bergmann et al. (2005) and Silvano et al. (2006), were:

(a) Willingness to participate in the research,
(b) Experience in fishing,
(c) Working regime on fishing (or dedication to fishing activity),
(d) Fisher's age.

The first criterion considered for selection was the willingness and availability of the respondent to participate in the research, since a fisher who did not present interest in sharing knowledge, even if experienced, would be of no value to the FEK investigation. However, after the study procedures were explained, including the method used and the goal of seeking consensus, many fishers were willing and enthusiastic to contribute. The second criterion adopted was the experience of the respondent in fishing, focusing on the fishers who had more time fishing, especially in the study area. The third criterion was the respondent's current regime on fishing, or

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