Fisheries Research 145 (2013) 43–53

Contents lists available at SciVerse ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

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

Marta C.F. Leite*,[1], Maria A. Gasalla

Fisheries Ecosystems Laboratory, Instituto Oceanográfico, University of São Paulo, Praça do Oceanográfico 191, Cidade Universitária, 055080-900 São Paulo, SP, Brazil

ARTICLE INFO

Article history:
Received 4 July 2012
Received in revised form
15 December 2012
Accepted 17 February 2013

Keywords:
Fishers' ecological knowledge
Essential fish habitats
Fishing grounds
Marine resources temporal occurrence
Bycatch species

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).

* Corresponding author at: Fisheries Ecosystems Laboratory, Instituto Oceanográfico, University of São Paulo, Praça do Oceanográfico 191, Cidade Universitária, 055080-900 São Paulo, SP, Brazil. Tel.: +55 11 30916549; fax: +55 11 30916549.
E-mail addresses: martaleite20@gmail.com (M.C.F. Leite), mgasalla@usp.br (M.A. Gasalla).
[1] Current address: Natural Resources Institute, 303-70 Dysart Road, University of Manitoba, Winnipeg, MB, Canada R3T 2M6.

0165-7836/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.fishres.2013.02.013

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

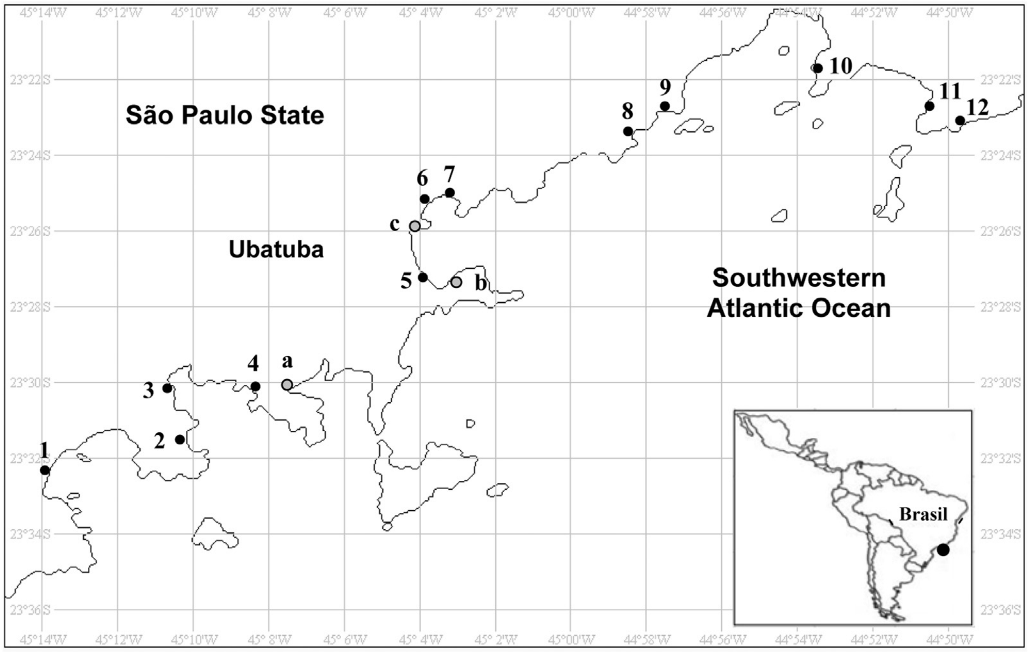

Fig. 1. Study area: Ubatuba region at São Paulo's northern coast, in southeastern Brazilian shelf. The numbers (1–12) correspond to the main fishing communities while the letters (a–c) to the main landing sites in the study area. Please see the names of fishing communities and landing sites as well as other details in Table 1.

dedication to fishing activity. Those with exclusive dedication or that had fishing as main occupations were given priority. Finally, the fourth and last criterion gave preference to fishers over 30 years old.

The interviews lasted an average of 45 min, totaling 82 h of interviews, distributed during 30 days (two field trips of 15 days each). In the three landing sites, it occurred in wharves or inside the anchored vessels, and in the 12 fishing communities, on ranches, beaches and fishers' houses. Sometimes more than one community or landing site was visited in the same day. The number of fishers interviewed per day varied from 6 to 12, according to the availability of the interviewees, the ability of respondents to transmit their knowledge and climatic and oceanographic conditions. For example, when there were cold fronts, fishers usually did not go to sea for fishing, making it easier to find them at the landing sites and in the fishing communities. Throughout this process, 41 small-scale key fishers (39 male and 2 female) were selected to participate in the next steps of the study, as described below.

2.3. First round of interviews with key fishers

The first round of interviews with the 41 key fishers selected occurred during the period of June–December 2009, during two field trips of 1 month each, at the landing sites and coastal communities (Table 2). The number of fishers interviewed per day varied from one to three. The interviews lasted an average of 2 h and a half, totalizing approximately 102 h of interviews.

The interviews were pre-scheduled with most key fishers, since most of them provided phone numbers to the researcher in the pilot stage. Only 4 of 41 fishers had no phones themselves, so they gave family members' phone numbers to facilitate contact. All key fishers were interviewed individually. However, there were cases in which the interviews of the pilot phase and the first round of interviews with key fishers occurred on the same day. This happened when a fisher interviewed met all of the required criteria and was available and willing to respond to the first round of interviews with key fishers at that time. Thus, in order to ensure that these opportunities

Table 1
Number of interviewed fishers at coastal communities and landing sites of Ubatuba coast, southeastern Brazilian shelf.

Corresponding number or letter in Fig. 1	Fishing communities and landing sites	No. of interviewed fishers	Site location in Ubatuba
1	*Maranduba*	7	South
2	*Brava da Fortaleza*	2	South
3	*Fortaleza*	1	South
4	*Lázaro*	11	South
5	*Itaguá*	6	Center
6	*Perequê-açu*	9	Center
7	*Barra Seca*	10	North
8	*Félix*	2	North
9	*Promirim*	8	North
10	*Almada*	8	North
11	*Picinguaba*	10	North
12	*Camburi*	8	North
a	*Saco da Ribeira*[a]	13	Center
b	*Cais do Alemão*[a]	5	Center
c	*Ilha dos Pescadores*[a]	9	Center
–	Total: 12 coastal communities and 3 landing sites	109	–

[a] Landing sites.

Table 2
Number of interviewed key fishers in coastal communities and landing sites of Ubatuba coast, southeastern Brazilian shelf and characteristics of those communities and landing sites.

Fishing communities and landing sites	No. of interviewed key fishers	Characteristic of the community or landing site
Camburi	2	Isolated and more traditional
Picinguaba	3	Isolated and more traditional
Almada	5	Touristic and traditional mix
Promirim	4	Touristic and traditional mix
Félix	2	Only a few fishers remain
Barra Seca	4	Touristic and traditional mix
Perequê-açu	4	Very touristic and traditional mix
Itaguá	2	Very touristic and traditional mix
Lázaro	5	Very touristic and traditional mix
Brava da Fortaleza	1	Touristic and traditional mix
Fortaleza	1	Touristic and traditional mix
Maranduba	1	Touristic and traditional mix
Saco da Ribeira[a]	2	Mainly for gillnets boats and pink-shrimp and pair-bottom trawlers
Cais do Porto e Alemão[a]	2	Mainly for gillnet boats
Ilha dos Pescadores[a]	3	Mainly for seabob-shrimp trawlers
Total: 12 coastal communities and 3 landing sites	41	–

[a] Landing sites.

were not lost, the two questionnaires (interviews of the pilot phase and of the first round) were applied sequentially.

The questionnaire of the first round of interviews addressed issues related to spatial and temporal patterns of local fisheries and 12 commercially important species landed in the region (Instituto de Pesca, 2008). Regarding spatial issues, the key fishers pointed to their fishing areas and the main places of occurrence of juveniles and mature females of the target species. The species were identified by their common names and images of the species were presented to fishers to confirm their recognition (Silvano et al., 2006; Silvano and Valbo-Joergensen, 2008). With respect to temporal matters, seasonal calendars (Berkes et al., 2006) in table form were used and completed with FEK information about seasonality of occurrence of the species in different stages of life (young and mature females). Key fishers identified bycatch species associated with different fishing gear, also identified by their common names. And finally, questions were raised regarding solutions, envisioned by the key fishers, for fisheries management in the study area. All the data found in the questionnaires of the first round of interviews with key fishers were scanned, tabulated and systematized.

2.4. Second round of interviews with key fishers

The second round of interviews took place between February and March 2010, during one fieldtrip of 45 days. The interviews lasted an average of 2 h each, totaling 74 h of interviews. The number of key fishers interviewed per day varied from two to four. Among the 41 key fishers interviewed in the first round, it was possible to locate only 37 to contribute to the second round. This was due to several factors, such as fishers' fishing trips during the field period devoted to the second round, fishers' health problems, or difficulty in locating the fishers in the landing sites.

During the second round of interviews, the information found and tabulated in the first round was presented to the 37 fishers involved in the study and they could review their responses according to the new general data. In this round of interviews we used maps of the region of Ubatuba (Nautical Chart number 1635) where the respondents pointed out their fishing areas and location of major fishing grounds, as well as where concentrations of young and mature females of the target species were located. We chose to introduce the maps during the second round of interviews assuming the fishers would be more comfortable with the researcher in that stage. In the case of fishers who were illiterate, or had difficulties reading, reference points were used, such as islands, beaches, cliffs and deep isobaths, to help interviewees to interpret the maps. Hence, fishers personally marked or pointed out to the researcher the location of these areas, in a process of participatory mapping (Berkes et al., 2001). Subsequently, all maps were digitized and overlaid to identify consensus with regard to the most frequented areas according to fishing gear, or areas of higher occurrence of resources in different stages of life. For the temporal issues, the months of occurrence of young and mature females cited during both rounds of interviews were compared with respect to their percentage of citations, and the months of major significance were highlighted. The information considered consensual were those confirmed by more than 50% of key fishers. Finally, all respondents' suggestions for fisheries management made during the first round of interviews were presented to key fishers, individually, in the second round and again those suggestions that were confirmed by more than 50% of key fishers were considered consensual. The same researcher applied all the interviews and there was no field assistant or additional researches participating during the interviews. Fig. 2 shows a schematic illustration of the proposed method, and its sequence.

3. Results

The selection of "experts" allowed us to access the oldest knowledgeable fishers in the fishing communities and landing sites. Consequently 76% of the interviewees selected were over 45 years old, had at least 30 years experience in the study area, and dedicated the majority of their time to fishing activities.

Moreover, the data provided by key fishers allowed the identification of consensual information regarding: (1) spatial and seasonal occurrence of mature females and juveniles of commercial species; (2) fishing areas, bycatch species and most important fishing grounds per fishing gear; (3) suggestions for local fisheries management (e.g. mesh and size of gillnets, closure seasons, gears restriction by fishing area).

3.1. Commercial species ecological data

Specific output on spatial and temporal issues are illustrated for five different fishery stocks: the croaker *Micropogonias furnieri*, the seabob-shrimp *Xiphopenaeus kroyeri*, the inshore squid *Loligo* spp., the white shrimp *Litopenaeus schimitti* and the blue runner *Caranx crysos*. The first two are species with the major landing biomasses, in kilograms, in Ubatuba, and represent fish resources of greatest commercial value in the municipality (Instituto de Pesca, 2008). The squid and the white shrimp were chosen because of their

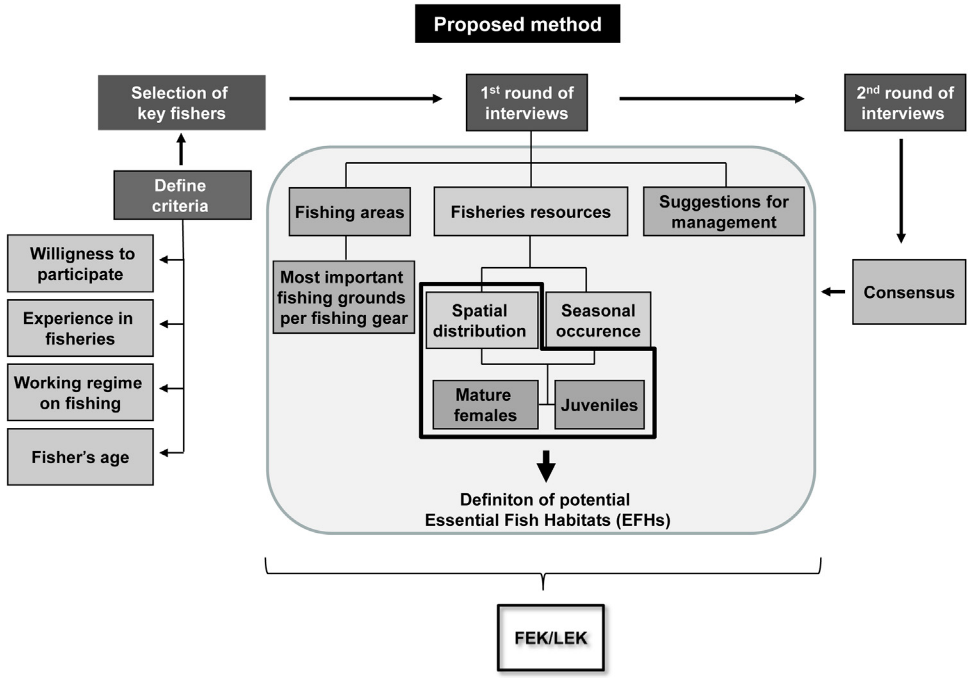

Fig. 2. Summary of the stages addressed during the process of accessing FEK/LEK to identify important issues for ecosystem-based fisheries management in Ubatuba, southeastern Brazil.

importance (in catch and income) for local communities, the squid during summer, especially from November to April (Rodrigues and Gasalla, 2008; Postuma and Gasalla, 2010), and the white shrimp during winter, especially from June to September (Costa et al., 2007). Finally, the blue runner *Caranx crysos* was also selected because of its commercial importance and the lack of local data and knowledge regarding its ecology in the study area (and in Brazil, in general).

After the whole process, maps with spatial data (Fig. 3) and tables with seasonal data (Tables 3 and 4) were developed, based on consensual FEK relating to the occurrence of mature females and juveniles. With regards to the spatial data, the maps allowed the identification of the areas, cited by more than 50% of the key fishers, which were considered as potential EFHs.

Finally, after key fishers were confronted with the responses of the first round of interviews, the majority of them did not change their contributions, but rather, they added more information at the second round of interviews (especially by agreeing with other key fishers' contributions). For example, at the first round of interviews 60% of key fishers considered only the summer months as the spawning season of the whitemouth croaker (*Micropogonias furnieri*), however, after the general results of the first round were presented to them, 90% added the information that whitemouth's croaker females are also caught with eggs during the winter months, although less frequently than in summer.

3.2. Fishing gear features

Questions aimed at the fishing gear, directed for the catches of the addresses species in this study, were: (1) fishing grounds and (2) bycatch species (Table 5). The information collected regarding fishing grounds allowed the construction of general maps (Fig. 4) representing the fishing grounds per type of fishing gear. Maps refer only to the information presented by the fishers that were concurrently fishing with a specific fishing gear (differently from the data regarding different species ecological data, that could be transmitted by key fishers that target that species in the past). Therefore, fishers did not change their contributions in the second round, although, it allowed fishers to identify them on in situ maps. Moreover, the overlapping of the digitalized cognitive maps of each fishing gear allowed the identification of the most important (or most frequent) fishing grounds per fishing gear.

3.3. Local fishers' management suggestions

The key fishers, at the first round of interviews, provide with many suggestions for local fisheries management. Table 6 presents the recommendations supported by more than 50% of the fishers at the second round of interviews (and thereby considered consensual) together with their explanations given in respect of each issue, per fishing gear. When comparing the results of the two rounds of interviews, we observed that the majority of fishers (90%) maintained their suggestions at the second round. However, 100% of the key fishers agreed with at least three suggestions of other respondents at the second round of interviews. This allowed the identification of key fishers' consensual management suggestions for local fisheries at the study area. Recommendations focused especially on the need for a reconsideration of present closing seasons' duration, new regulations and spatial zoning concerning the fishing areas of larger vessels and nets' mesh size to avoid the catch of juveniles.

4. Discussion

In this paper, we present a method to access FEK as a practical tool for ecosystem-based fisheries management. Here we agree with Berkes (2011) that ecosystem-based management (EBM) is not a simple exercise, as it implies uncertainties and complexity, and presupposes an interdisciplinary approach to management objectives. According to Berkes (2011), implementing EBM is more like a revolutionary, than an evolutionary process, as it requires going beyond conventional management practices. Nevertheless, we argue that the participation of fishers, and the incorporation of their ecological knowledge, is an essential part of a process

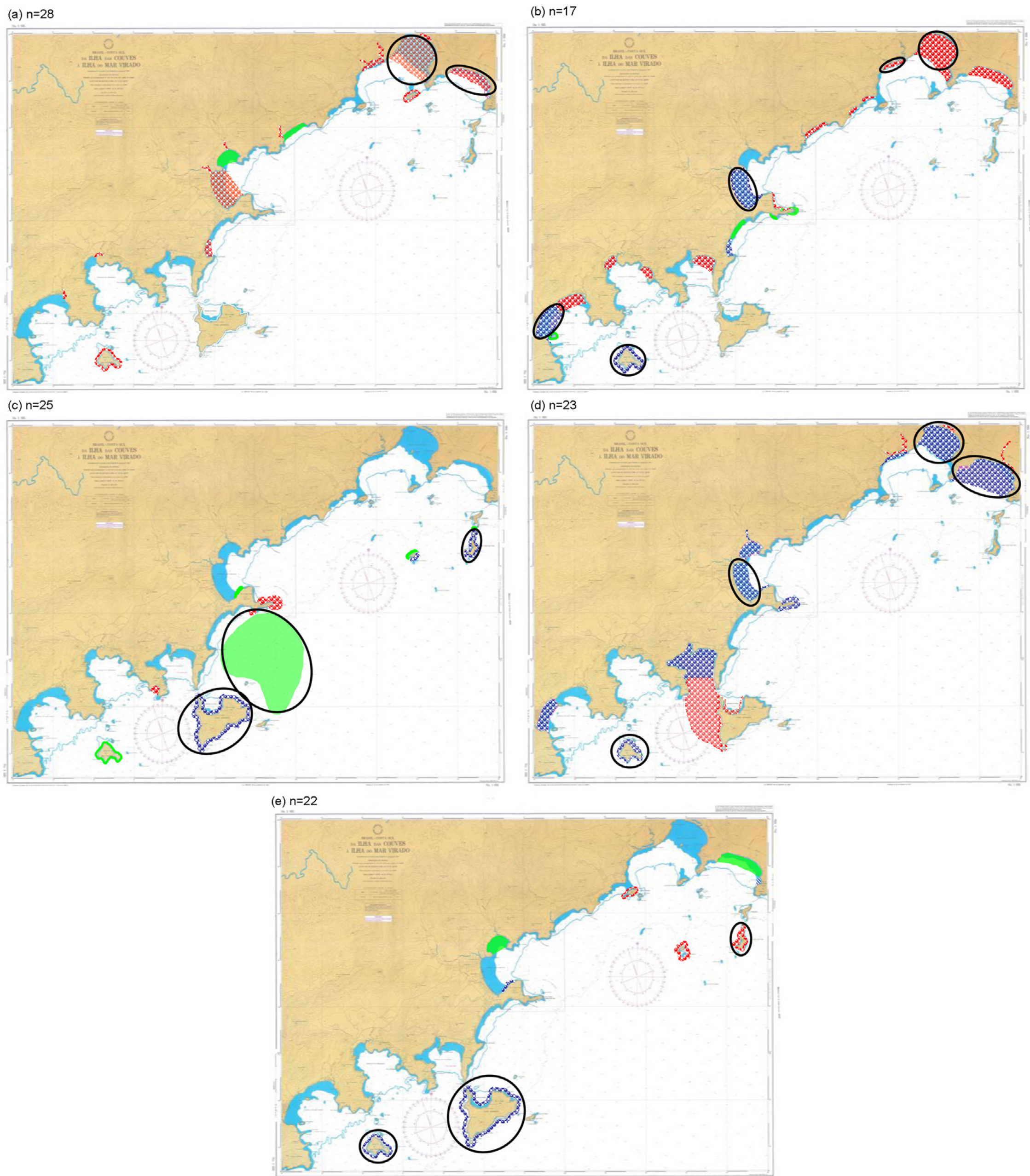

Fig. 3. Area of occurrence of mature females (in red), juveniles (in green), and both (in blue) of: (a) *Micropogonias furnieri*, (b) *Xiphopenaeus kroyeri*, (c) *Loligo* spp., (d) *Litopenaeus schimitti* and (e) *Caranx crysos*, as indicated by the fishers; (n) corresponds to the number of fishers that provided information upon the fishing gear. The circled areas are those cited by more than 50% of interviewees. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

Table 3
Number of citations for the months of occurrence of mature females of the resources addressed in the study, during the first (1st) and second (2nd) round of interviews with key fishers in Ubatuba. The months cited by more than 50% of interviewees are boldfaced.

Fishery resource	Rounds	J	F	M	A	M	J	J	A	S	O	N	D	Total number of citations
Micropogonias furnieri	1st	**22**	**21**	10	10	12	14	14	14	12	10	**26**	**28**	33
	2nd	**22**	**19**	9	7	8	12	13	12	8	9	**20**	**22**	31
Xiphopenaeus kroyeri	1st	7	6	8	7	7	4	4	4	6	6	7	7	18
	2nd	**6**	5	**10**	**10**	**10**	**6**	**6**	4	**6**	**7**	**7**	**7**	11
Loligo spp.	1st	6	8	8	4	2	1	1	0	0	0	6	9	20
	2nd	**14**	**17**	**17**	6	3	0	0	0	1	1	4	**12**	22
Litopenaeus schimitti	1st	4	4	4	3	4	3	3	2	2	3	4	3	14
	2nd	**7**	2	4	1	1	1	0	1	2	3	**4**	**7**	11
Caranx crysos	1st	**7**	**8**	**6**	0	0	0	0	0	0	1	5	**8**	11
	2nd	**7**	**9**	**6**	1	0	0	0	1	1	1	4	**6**	9

Table 4
Number of citations for the months of occurrence of juveniles of the resources addressed in the study, during the first (1st) and second (2nd) round of interviews with key fishers in Ubatuba. The months cited by more than 50% of interviewees are boldfaced.

Fishery resource	Rounds	J	F	M	A	M	J	J	A	S	O	N	D	Total number of citations
Micropogonias furnieri	1st	6	6	5	5	6	6	4	5	7	7	7	7	17
	2nd	**22**	**24**	13	12	**14**	**17**	**17**	**17**	13	13	**22**	**21**	27
Xiphopenaeus kroyeri	1st	5	4	4	2	3	**9**	4	3	2	4	4	6	16
	2nd	**9**	7	1	1	1	**13**	2	1	2	5	5	4	17
Loligo spp.	1st	6	6	5	5	6	6	4	5	7	7	7	7	17
	2nd	**22**	**24**	13	12	**14**	**17**	**17**	**17**	13	13	**22**	**21**	27
Litopenaeus schimitti	1st	3	1	2	2	3	**8**	2	1	0	0	0	2	13
	2nd	**12**	**12**	**12**	**12**	**11**	**13**	4	1	0	0	0	2	20
Caranx crysos	1st	3	3	**5**	3	3	3	1	0	1	0	0	3	7
	2nd	5	6	**10**	6	5	5	4	1	1	1	4	5	16

Table 5
Summary of information on the addressed fisheries: (a) target species; (b) number of bycatch species and number of those that showed more than 50% of citations, boldfaced; (c) number of fishing grounds pointed out on maps by the key fishers, and those cited by more than 50% of the interviewees, boldfaced; (d) number of management suggestions for each fishing gear and number of suggestions cited by more then 50% of interviewees, boldfaced in the table.

Fishing gear	Target species	Bycatch species		Fishing grounds		Management suggestions	
		No.	>50%	No.	>50%	No.	>50%
Shrimp-trawlers	*Xiphopenaeus kroyeri*	46	**11**	9	**3**	4	**2**
Gillnets	*Micropogonias furnieri*	17	**6**	18	**2**	7	**5**
Hand jigs	*Loligo* spp.	0	0	17	**6**	0	0
Gillnets for white shrimp	*Litopenaeus schimitti*	30	**4**	10	**1**	2	**2**
Line and hook	*Caranx crysos*	0	0	9	**4**	0	0

that aims to implement ecosystem-based fisheries management (EBFM), especially in data-poor contexts, where FEK can be the only source of data on the resources and fleets distribution. In this sense, methods to access local and traditional ecological knowledge are of great value.

There are many studies that focus on traditional knowledge, and specifically, on fishers' ecological knowledge (FEK). Many use open or semi-structured interviews. The interviews can be applied to the maximum number of respondents as possible (Begossi and Figueiredo, 1995; Paz and Begossi, 1996; Silvano and Begossi, 2005; Silvano et al., 2006, 2008), to a few select ones or to a group of interviewees (Huntington, 1998, 2000). According to Silvano et al. (2008), the choice of the approach will depend on the research objectives, which seems critical since it will influence directly the quality of the results.

Table 6
Summary of fishers' consensual suggestions (cited by more than 50% of key fishers) for management initiatives in the study area.

Fishing gear	Target species	Suggestions to management	Fishers' given reasons
Shrimp-trawlers	*Xiphopenaeus kroyeri (seabob-shrimp)*	Increase the fishing closure season from 3 to 4 months long.	After the closure season (March–May) they still catch small (juvenile) shrimps (especially during June).
		Allow only seabob-shrimp trawlers to operate up to 30 m (restrict large trawlers).	Other type of trawlers (pair-bottom trawlers and pink-shrimp trawlers) occur in deeper waters, where target species are also present, while the shrimp-seabob trawlers cannot operate at depths greater than 30 m.
Gillnets	*Micropogonias furnieri (whitemouth croaker)*	Prohibit mesh size smaller than 12 cm in gillnets.	The smaller the mesh more juveniles are caught. A 12 cm mesh size catches good size fish and not juvenile.
		Prohibit purse-seiners of catching the white-mouth croaker.	The purse-seiners catch enormous quantities of the stock at once, reducing the stock size available to artisanal fishers.
		Define a closed season for the whitemouth croaker.	There is no closed season defined for the stock.
		Prohibit boats over 11 m length of fishing at depths less than 30 m.	Industrial vessels catch also in shallow and coastal areas, reducing stock available for artisanal fishers.
		Define a spatial zoning for fishing with gillnets according to the size of boats.	Smaller boats do not have autonomy to operate in deeper waters; shallower depths should be guarantee and reserved for smaller boats (less than 12 m length).
Gillnets for white-shrimp	*Litopenaeus schimitti* (white shrimp)	Prohibit boats greater than 11 m in length from fishing white-shrimp in shallow coastal areas (in depths less than 30 m). Rather, restrict the fishery to small boats and canoes in these areas.	The white shrimp occurs in the study area only seasonally when artisanal fishers have the opportunity to catch it.

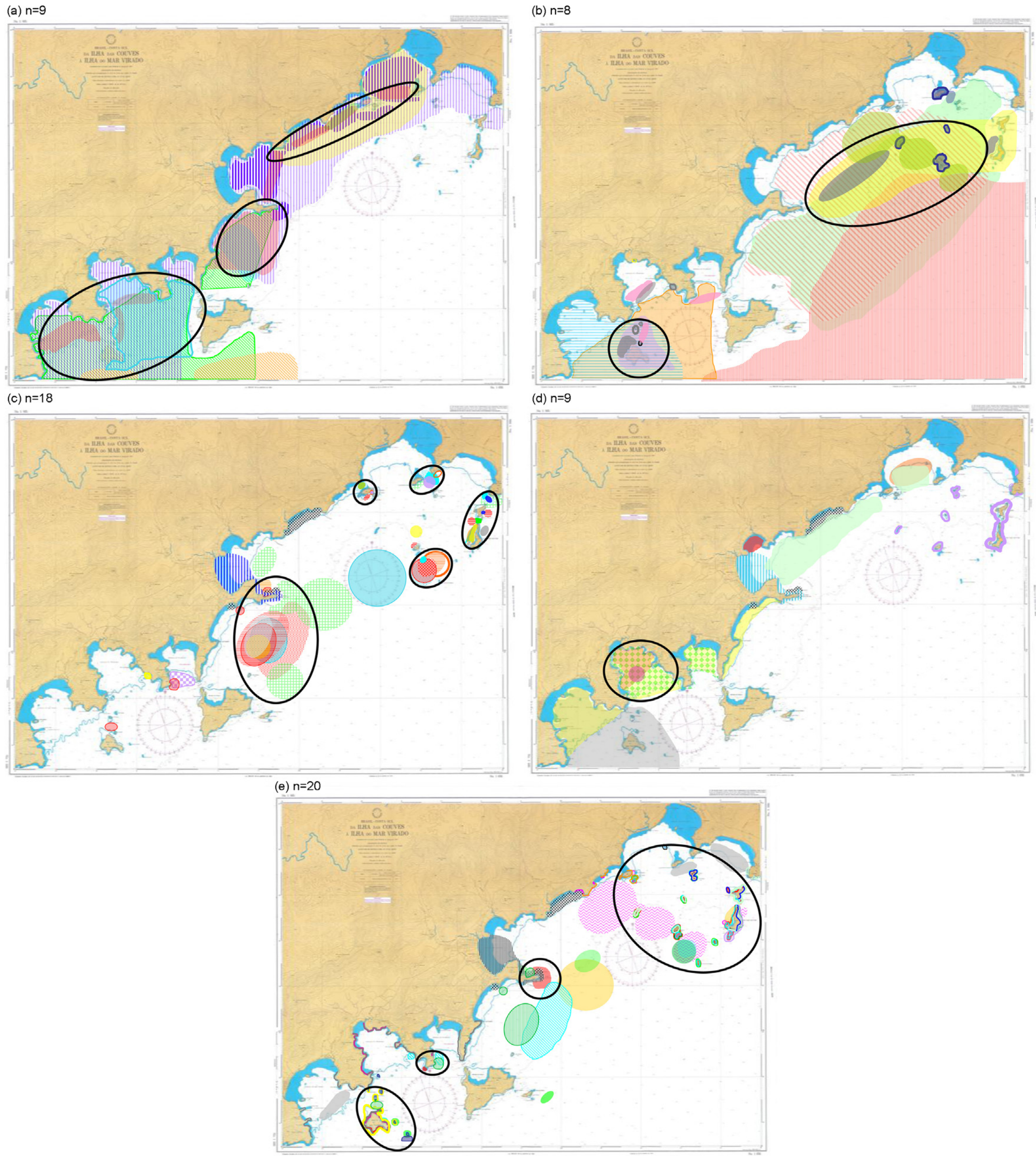

Fig. 4. Maps of the total area of fishing operations of: (a) shrimp-trawlers, (b) gillnets, and (c) hand jigs (d) Gillnets for white-shrimp and (e) Line and hook. Each deferent color refers to the fishing area of a diferent fisher; (n) corresponds to the number of fishers that provided information upon the fishing gear. The most significantly cited areas (by more than 50% of fishers) are circled. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

Considering important contributions that were useful in our adaptation of the Delphi technique to approach FEK to EBFM issues, Davis and Wagner (2003) and Huntington (1998) may be highlighted. Davis and Wagner (2003) selected experts throughout solicited recommendation of local knowledgeable fishers in Nova Scotia (Canada), while Huntington (1998) applied semi directive interviews, individually or to groups, to document TEK in a species specific research on beluga whales in Alaska (US). The method we propose somehow incorporates some considerations of both studies, among others. However, our study seems to be the first application of the Delphi method to this field, and therefore, to use rounds of interviews to find concensus. Moreover, despite extensive literature on FEK studies, and few studies on methods to access it for several purposes, there is a lack of detailed methodologies that explain how this valuable knowledge can be properly and effectively considered and incorporated into EBFM schemes. Additionally, the skills needed, the approaches, challenges, and difficulties faced by researchers who are dedicated to this field are rarely described.

Firstly, the method we describe allowed the identification of the most experienced fishers in the study area and for consensus to be reached with regards to the range of information and knowledge that these fishers hold. Overall, the second round of interviews provided an opportunity for key fishers to consider new information, and to confirm, or not, the information provided by other respondents. These data allowed important outputs such as the construction of maps with EFHs and identification of the major seasons of spawning and recruitment of important species of commercial value, which seems to be still very unclear for local science. In this sense, a consistent compatibility was found between the data transmitted by key fishers and some previous scientific studies in other regions for the: (1) white-mouth croaker

Micropogonias furnieri (Menezes and Figueiredo, 1980; Robert and Chaves, 2001; Costa and Araújo, 2003; Bernardes et al., 2005; Carneiro et al., 2005; Carneiro, 2007; Vazzoler, 1971; Vazzoler et al., 1989); (2) seabob-shrimp *Xiphopenaeus kroyeri* (Nakagaki and Negreiros-Fransozo, 1998; Fransozo et al., 2000; Castro et al., 2005; Freire, 2005); (3) inshore squid *Loligo* spp. (Perez et al., 2002, 2005; Martins and Perez, 2006; Rodrigues and Gasalla, 2008; Gasalla et al., 2010; Postuma and Gasalla, 2010); (4) white shrimp *Litopenaeus schimitti* (Chagas-Soares et al., 1995; Costa, 2002; Castilho et al., 2007; Costa et al., 2007; Gonçalves et al., 2009) and (5) blue runner *Caranx crysos* (Leak, 1981). However, these studies were conducted in other areas of the Brazilian coast, and there is no information for our study site. Nevertheless, we do believe that FEK does not necessarily need to be validated by scientific data, but rather, they can be complementary one to another. In this sense, FEK validation through scientific literature was not included as part of the proposed method.

The FEK identified may help to fill the data gap in the study area, and thus increase the potential to support ecosystem-based management of fishery resources and activities. In this sense, we found the presented method as a transparent, consensual and useful tool to assess FEK and for its inclusion in EBFM, since it revealed multispecies ecological data, fishing grounds, as well as eventually pertinent local fishers' suggestion for management. The identification of the temporal and spatial distribution of resources, including EFHs, is of great value for EBFM and for planning MPA (Marine Protected Area) management (Bergmann et al., 2004, 2005). The information regarding EFHs is new, since these habitats had not been previously identified or defined at the study area for any species. Besides, mapping the most important fishing grounds and bycatch species will allow effective measures for the conservation of resources, and may simultaneously ensure specific rights for fishers themselves. The most frequented fishing ground per fishing gear were not identified and mapped in previous studies for the study area. Another important point relies on fishers' suggestions for local fisheries management, since identifying measures that are both accepted by fishers and scientifically valid is of utmost relevance for the planning and long-term success of ecosystem-based fisheries management (Himes, 2003; Bundy et al., 2008; Lawson et al., 2008). The data obtained were not implemented in practice so far. However, the study area is part of a recent implemented type of MPA, which the management plan is still under development. There is not any provision in the MPA management criteria for fishers knowledge to be recognized and used. Nevertheless, we expect the findings of the study may contribute, in this sense, by: (1) providing EFHs for important fisheries resources, (2) pointing the important fishing grounds that should be considered when restricting small-scale fishers' rights to access specific areas, and (3) indicating areas relevant for the protection of particular fisheries/fishers and for co-management schemes.

The incorporation of LEK/FEK and fishers' participation in management plans are also important in order to decentralize government and institutional power, reduce conflicts between fishers and governmental institutions, promote community development and empowerment, and support enforcement, helping to ensure representativeness of local actors in the public policy arena (Begossi, 2008; Garcia and Charles, 2008; Gasalla, 2011; Lam and Pauly, 2010). Furthermore, in traditional fisheries management, purely biological objectives may be imposed in a top-down manner, without considering fishers' livelihoods. In this case, it is unlikely that management and enforcement will be successful, since fishers will not agree and cooperate with a non-participatory approach. In general, this form of conduct leads to more conflicts between fishers and governments (Bundy et al., 2008; Lawson et al., 2008). On the other hand, the objectives of fisheries management, whether social, economic or cultural, cannot be achieved in the long term if there is no ecological balance and biological yields maintenance (Degnbol et al., 2006).

Nevertheless, some considerations regarding the method should be made. According to Brook and McLachlan (2005), the personality of the interviewer, the level of familiarity with the interviewees, the approach and the method used, fundamentally influence the study results and the nature of the responses in LEK studies. In this study, we found that as the different steps were followed, fisher bonds/relationships were strengthened, allowing for greater reliability in the data provided, since this empirical knowledge was not disseminated quickly and accessed at once (Drew, 2005).

Such a research approach contrasted with the ongoing experiences of fisher participants with the top-down implementation of a new São Paulo's marine protected area, which at least at its foundation, threatened fishing activities as it was not based on consultations (Agardy, 2005; Mascia, 2003) with local fishing communities. Obviously, when the process started fishers found themselves apprehensive and insecure about the possible impacts on their livelihoods and incomes. However, the degree of contact and respect developed during the research described here led to fishers showing greater confidence in transmitting their knowledge. One factor in generating this level of confidence was the fact that the same researcher went to all the field trips alone and always interviewed the fishers on their own. It was important that no new actors/researchers appeared during the process, which would likely have weakened the bonds that had developed between researcher and fishers. Hence, if the researcher is not going to field alone, we suggest that it is important that the team remains the same during the whole process of interviews. Moreover, the way of approaching fishers proved to be successful in this case, but one can suggest that a gender/age reason could have contributed to the success of this interaction, since the interviewer was a young woman and the key fishers were mainly older males. However, several issues should be carefully considered significantly more relevant.

Firstly, the Adapted Delphi Methodology seems a simple exercise to be employed, but some points need to be carefully considered in order to avoid failures in the reliability of results. It seems critical that an appropriate and representative group of respondents are selected, prioritizing those with proven experience (the experts) to contribute to the research (Davis and Wagner, 2003). Secondly, during the interviews the researcher must demonstrate impartiality to the issues addressed, to exclude the possibility of imposing one's own views and preconceptions upon a subject, which could bias the results. In present study the researcher introduced herself to respondents as a student, from a oceanographic institute, with limited fishing knowledge, and as a sincere apprentice. Third, once a round of interviews was completed, these had to be summarized and presented back to the group of fishers in the most effective manner as possible. At this stage, it is essential not to ignore disagreements, which can lead to artificial consensus regarding the information provided by fishers. According to the findings of this study, when these steps are taken, the chances of success greatly increase.

However, the method also presents some constraints. It does not allow fishers to undertake real-time discussions of different points of views and possible exchange of knowledge, since the interviews are applied individually and the respondents are kept anonymous. Another constraint is that when a fisher lacks specific knowledge, he or she may speculate, as some experienced fishers may not admit to not knowing a particular answer and thus "lose face". And finally, the fisher's own interest may influence the answers, biasing the obtained results (e.g. by not pointing out the "real" spawning season of a species if it occurs during holidays, to avoid future fishing closures during an important period of income). For the reasons outlined above, a degree of subjectivity always remains and has to be considered.

In summary, our critical considerations on the proposed method seems to be in accordance with what was previously found by other authors on the Delphi technique (Linstone and Turoff, 1975; Zuboy, 1980; Drew, 2005; MacMillan and Marshall, 2006).

5. Conclusions

The adapted Delphi methodology proved to be useful for the identification of EFHs and EBFM issues, by providing innovative input and guidelines for decision makers. However, it has to be emphasized that as natural systems vary temporally and spatially, FEK studies need to be frequently updated.

Fishers' ecological knowledge is indeed a necessary and irreplaceable data source for fisheries management under community-based schemes in Brazil and elsewhere, but especially in data-poor environments. However, its approach and assessment is not simple or trivial, requiring effective and locally elaborated methods and communication skills (Gasalla and Diegues, 2010).

Finally, we concluded that this methodology may be of great value for assessing the traditional, many-sided and valuable knowledge of fishers, and its inclusion in EBFM and can be adapted to other fields of ethnoecology and natural resource management as well as in other locations.

Acknowledgements

We thank all the fishers from Ubatuba for their kind contributions; the logistics and staff of the Research Station of the University of São Paulo Instituto Oceanográfico in Ubatuba, and the University of São Paulo Graduate Program on Oceanography. M.C.L. Leite and M.A. Gasalla received financial support from the Brazilian National Research Council (CNPq), as a Master's and Productivity Grant, respectively. A previous version of this paper was awarded as a best student's work during the World Small-Scale Fisheries Congress, held in Bangkok in 2010. We thank Drs. Ratana Chuenpagdee, Fikret Berkes, M. Rafiqul Islam and Silvia Salas for their considerations and encouragement. Renato Silvano and Paula M.G. Castro provided useful comments as local academic reviewers. Finally we thank Dr. Jim Robson for the English review and two anonymous reviewers for fruitful comments.

References

Agardy, T., 2005. Global marine conservation policy versus site-level implementation: the mismatch of scale and its implications. Mar. Ecol. Prog. Ser. 300, 242–248.

Allison, E.H., 2011. Should states and international organizations adopt a human rights approach to fisheries policy. MAST 10 (2), 95–116.

Allison, E.H., Ratner, B.D., Asgard, B., Willmann, R., Pomeroy, R., Kurien, J., 2012. Rights-based fisheries governance: from fishing rights to human rights. Fish Fish. 13 (1), 14–29.

Allison, E.H., Badjeck, M.C., 2004. Livelihoods, local knowledge and the integration of economic development and conservation concerns in the Lower Tana River Basin. Hydrobiology 527 (1), 19–23.

Begossi, A., 2008. Local knowledge and training towards management. Environ. Dev. Sustain. 10 (5), 591–603.

Begossi, A., Figueiredo, J.L., 1995. Ethnoichthyology of southern coastal fisherm cases from Búzios Island Sepetiba Bay (Brazil). Bull. Mar. Sci. 56, 710–717.

Bergmann, Hinz, M., Blyth, H., Kaiser, R.E.M.J., 2004. Using knowledge from fishers and fisheries scientists to identify possible groundfish 'essential fish habitats'. Fish. Res. 66, 373–379.

Bergmann, M., Hinz, H., Blyth, R.E., Kaiser, M.J., 2005. Combining scientific and fisher's knowledge to identify possible roundfish essential fish habitats. Am. Fish. Soc. Symp. 41, 265–276.

Berkes, F., Mahon, R., Mcconney, P., Pollnac, R., Pomeroy, R., 2001. Managing Small-Scale Fisheries: Alternative Directions and Methods. International Research Development Centre, Ottawa, Ontario, Canada.

Berkes, F., 2010. Shifting perspectives on resource management: resilience and the reconceptualization of 'natural resources' and 'management'. MAST 9 (1), 11–38.

Berkes, F., 2011. Implementing ecosystem-based management: evolution or revolution? Fish Fish., doi:10.1111/j.1467-2979.2011.00452.x.

Bernardes, R.A., Figueiredo, J.L., Rodrigues, A.R., Ficher, L.G., Vooren, C.M., Haimovoci, M., Rossi-Wongtschowski, C.L.D.B., 2005. Peixes da Zona Econômica Exclusiva da região sul-sudeste do Brasil: levantamentos com armadilhas pargueiras e rede de arrasto de fundo. EDUSP, São Paulo, p. 295.

Barrett, P.J., 2009. Estimating devils hole pupfish lifestage rations using the Delphi Method. Fish. Am. Fish. Soc. 34 (2), 73–79.

Brook, R.K., McLachlan, 2005. On using expert-based science to "test" local ecological knowledge. Ecol. Soc. 10 (2), r3 http://www.ecologyandsociety.org/vol110/iss2/resp3/ (online).

Bundy, A., Chuenpagdee, R., Jentoff, S., Mahon, R., 2008. If science is not the answer, what is? An alternative governance model for the world's fisheries. Front. Ecol. Environ. 6 (3), 152–155.

Conover, D.O., Coleman, F.C., 2000. Essential fish habitat and marine reserves: an introduction to the second mote symposium in fisheries ecology. Bull. Mar. Sci. 66 (3), 527–534.

Campos, E.J.D., Gonçalves, J.E., Ikeda, Y., 2005. Water mass characteristics and geotrophic circulation in the South Brazil Bight: summer of 1991. J. Geophys. Res. 100 (c9), 18537–18550.

Carneiro, M.H., Castro, P.M.G., Tutui, S.L.S., Bastos, G.C.C., 2005. *Microponias furnieri* (Desmarest, 1823). In: Cergole, M.A., Ávila-da-Silva, A.O., Rossi-Wongtschowski, C.L. (Eds.), Análise das principais pescarias comerciais da região Sudeste do Brasil: dinâmica populacional das espécies em exploração. IOUSP, São Paulo, pp. 94–100.

Carneiro, M.H., 2007. Diagnóstico dos recursos pesqueiros marinhos, Cynoscion *jamaicensis, Macrodon ancylodon* e *Micropogonias furnieri* (Perciformes, Sciaenidae) da região sudeste-sul do Brasil, entre as latitudes 23° e 28°40′ S. Ph.D. Thesis, Universidade Federal de São Carlos, p. 110.

Castilho, A.L., Teixeira, G.M., Costa, R.C., Fransozo, A., 2007. Distribuição batimétrica dos camarões marinhos (Decapoda: Penaeoidea) no Litoral Norte do Estado de São Paulo. In: Congresso de Ecologia do Brasil, Caxambu. Proceedings, Sociedade de Ecologiado Brasil, Caxambu.

Castro, B.M., Miranda, L.B., 1998. Physical oceanography of the western Atlantic continental shelf located between 48N and 348S. In: Robinson, A.R., Brink, K.H. (Eds.), The Sea. John Wiley, New York, pp. 209–251.

Castro, R.H., Costa, R.C., Fransozo, A., Mantellato, F.L.M., 2005. Population structure of the seabob shrimp *Xiphopenaeus kroyeri* (Heller 1862) (Crustacea: Penaeoidea) in the litoral of São Paulo, Brazil. Sci. Mar. 69 (1), 105–112.

Chagas-Soares, F., Pereira, O.M., Santos, E.P., 1995. Contribuição ao ciclo biológico de Penaeus schmitti Burkenroad, 1936, Penaeus brasiliensis Latreille, 1817 e Penaeus paulensis Pérez-Farfante, 1967, na região Lagunar-Estuarina de Cananéia, São Paulo, Brasil. Bol. Inst. Pesca 22, 49–59.

Costa, M.R., Araújo, F.G., 2003. Use of a tropical bay in Southeastern Brazil by juvenile and subadult *Micropogonias furnieri* (Perciformes, Sciaenidae). ICES J. Mar. Sci. 60, 268–277.

Costa, R.C., 2002. Biologia e distribuição ecológica das espécies de camarões Dendrobranchiata (Crustácea: Decapoda) na região de Ubatuba (SP). Ph.D. Thesis, Instituto de Biociências, Universidade Estadual Paulista, Botucatu, p. 178.

Costa, R.C., Fransozo, A., Castilho, A.L., 2007. Período de recrutamento juvenil do camarão-branco Litopenaeus schmitti (Burkenroad, 1936) (Dendrobranchiata, Penaeidae), em áreas de berçários do Litoral Norte Paulista. In: Congresso de Ecologia do Brasil, Caxambu. Proceedings, Sociedade de Ecologiado Brazil, Caxambu.

Degnbol, P., Gislason, H., Hanna, S., Jentoft, S., Raakjaer, N., Sverdrup-Jensen, S., Wilson, D.C., 2006. Painting the floor with a hammer: technical fixes in fisheries management. Mar. Policy 30, 534–543.

Davis, A., Wagner, J.R., 2003. Who knows? On the importance of identifying "experts" when researching local ecological knowledge. Hum. Ecol. 31 (3), 463–489.

Diegues, A.C., 1974. A Pesca em Ubatuba: Estudo Socioeconômico. Sudelpa, São Paulo.

Drew, J.A., 2005. Use of traditional ecological knowledge in marine conservation. Conserv. Biol. 19 (4), 1286–1293.

FAO Fisheries Department, 2003. The ecosystem approach to fisheries: issues, terminology, principles, institutional foundations, implementation and outlook. FAO Fish. Tech. Paper 443, 1–71.

Francis, R.C., Hixon, M.A., Clarke, M.E., Murawski, S.A., Ralston, S., 2007. Ten commandments for ecosystem-based fisheries scientists. Fish 32 (5), 217–233.

Fransozo, A., Pinheiro, R.C., Santos, M.A.A., Mantelatto, F.L.M., 2000. Juvenile recruitment of seabob *Xiphopenaeus kroyeri* (Heller, 1862) (Decapoda, Penaeidae) in the Fortaleza Bay, Ubatuba, SP, Brazil. Naupl. 8 (2), 179–184.

Freire, F.A.M., 2005. Distribuição ecológica e biologia populacional de *Xiphopenaeus Kroyeri* (Heller, 1862) (Crustacea, Decapoda, Penaeidae) no litoral do estado de São Paulo. Ph.D. Thesis, Instituto de Biociências, Universidade Estadual Paulista, Botucatu, p. 309.

Friesinger, S., Bernatchez, P., 2010. Perceptions of Gulf of St. Lawrence coastal communities confronting environmental change: hazards and adaptation, Québec, Canada. Ocean Coast. Manage. 53, 669–678.

Garcia, S.M., Charles, A.T., 2008. Fishery systems and linkages: implications for science and governance. Ocean Coast. Manage. 51, 505–527.

Gasalla, M.A., 2004. Impactos da pesca industrial no ecossistema da plataforma continental interna do Sudeste do Brasil: a abordagem ecossistêmica e a integração do conhecimento. Ph.D. Thesis, Instituto Oceanográfico, Universidade de São Paulo, São Paulo, SP, Brazil, p. 276.

Gasalla, M.A., 2009. Mares de alimento: desafios globais do manejo da pesca. Scientific. American. Brasil, v. special 2, 28–35.

Gasalla, M.A., 2011. Do all answers lie within (the community)? Fishing rights and marine conservation. In: Chuengpagdee, R. (Ed.), World Small-Scale Fisheries Contemporary Visions. Eburon Academic Publishers, Delft, Netherlands.
Gasalla, M.A., Tutui, S.L.S., 2006. "Fishing for responses": a local experts consultation approach on the Brazilian sardine fishery sustainability. J. Coast. Res. 39, 1294–1298.
Gasalla, M.A., Rodrigues, A.R., Postuma, F.A., 2010. The trophic role os the squid *Loligo plei* as a keystone species in the South Brazil Bigth ecosystem. ICES J. Mar. Sci. 67 (7), 1413–1424.
Gasalla, M.A., Diegues, A.C., 2011. People's seas: "ethno-oceanography" as a means to approach marine ecosystem change. In: Ommer, R.E., Perry, R.I., Cochrane, K., Cury, P. (Eds.), World Fisheries: A Social-Ecological Analysis. Wiley-Blackwell, Oxford, UK.
Gonçalves, S.M., Santos, J.L., Rodrigues, E.S., 2009. Estágios de desenvolvimento gonadal de fêmeas do camarão-branco *Litopenaeus Schmitti* (Burkenroad 1936), capturadas na região marinha da Baixada Santista, São Paulo. Rev. Ceciliana. 1 (2), 96–100.
Hill, N.A.O., Michael, K.P., Frazer, A., Leslie, S., 2010. The utility and risk of local ecological knowledge in developing stakeholder driven fisheries management: the Foveaux Strait dredge oyster fishery, New Zealand. Ocean Coast. Manage. 53, 659–668.
Himes, A.H., 2003. Small-scale Sicilian fisheries: opinions of artisanal fishers and sociocultural effects in two MPA case studies. Coast. Manage. 31 (4), 389–408.
Huntington, H.P., 1998. Observations on the utility of the semi-directive interview for documenting traditional ecological knowledge. Arctic 51 (3), 237–242.
Huntington, H.P., 2000. Using traditional ecological knowledge in science: methods and applications. Ecol. Appl. 10 (5), 1270–1274.
Instituto de Pesca, 2008. available at: http://www.pesca.sp.gov.br – Inst. Pesca: 20_serreltec – 2004 (accessed June 2008).
Johannes, R., 1998. The case for data-less marine resource management: examples from tropical near shore fin fisheries. Trends Ecol. Evol. 13 (6), 243–246.
Johannes, R.E., Freeman, M.M.R., Hamilton, R.J., 2000. Ignore fishers' knowledge and miss the boat. Fish Fish. 1, 257–271.
Kooiman, J., Bavinck, M., Jentoft, S., Pullin, R. (Eds.), 2005. Fish for Life: Interactive Governance for Fisheries. MARE Publication Series No. 3. Amsterdam University Press, Amsterdam, Netherlands.
Lam, M.E., Borch, T., 2011. Cultural valuing of fishery resources by the Norwegian Saami. In: Westra, L., Bosselmann, K., Soskolne, C. (Eds.), Globalisation and Ecological Integrity in Science and International Law. Cambridge Scholars Publishing, Cambridge, UK, pp. 361–376.
Lam, M.E., Pauly, D., 2010. Who is right to fish? Evolving a social contract for ethical fisheries. Ecol. Soc. 15 (3), 16 http://www.ecologyandsociety.org/vol15/iss3/art16/ (online).
Lawson, P.W., Ciannelli, L., Ireland, B., 2008. Spatial patterns in fisheries: new techniques new opportunities for ecosystem-based management. In: Ocean Sciences Meeting: From the Watershed of the Global Ocean, Orlando, FL, pp. 2–7.
Leak, J.C., 1981. Distribution and abundance of carangid fish larvae in the eastern Gulf of Mexico 1971–1974. Biol. Oceanogr. 1 (1), 1–28.
Link, J.S., 2002. What does ecosystem-based fisheries management mean? Fish. Manage. 27, 18–21.
Linstone, H.A., Turoff, M., 1975. The Delphi Method. Techniques and Applications. Addison-Wesley, Boston, USA, p. 620.
MacMillan, D.C., Marshall, K., 2006. The Delphi process: an expert-based approach to ecological modeling in data-poor environments. Anim. Conserv. 9, 11–19.
Menezes, N.A., Figueiredo, J.L., 1980. Manual de Peixes Marinhos do Sudeste do Brasil: v. 4 Teleostei 3. Museu de Zoologia, USP, São Paulo.
Martins, R.S., Perez, J.A.A., 2006. Cephalopods and fish attracted by night light in coastal shallow-waters, off southern Brazil, with the description of squid and fish behavior. Rev. Etol. 8 (1), 27–34.
Mascia, M.B., 2003. The human dimension of coral reef marine protected areas: recent social science research and its policy implications. Conserv. Biol. 17 (2), 630–632.
Miller, K., Charles, A., Barange, M., Brander, K., Gallucci, V.F., Gasalla, M.A., Khan, A., Munro, G., Mutugudde, R., Ommen, R.E., Perry, R., 2010. Climate change, uncertainty, and resillient fisheries: institutional responses through integrative science. Prog. Oceanogr. 87, 338–346.
Moreno, G., Dagorn, L., Sancho, G., Itano, D., 2007. Fish behavior from fisher's knowledge: the case study of tropical tuna around drifting fish aggregating devices (DFADs). Can. J. Fish. Aquat. Sci. 64 (11), 1517–1528.
Murawski, S.A., 2000. Definitions of overfishing from an ecosystem perspective. ICES J. Mar. Sci. 57, 649–658.
Nakagaki, J.M., Negreiros-Fransozo, M.L., 1998. Population biology of *Xiphopenaeus kroyeri* (Heller, 1862) (Decapoda: Penaeidae) from Ubatuba Bay, São Paulo, Brazil. J. Shellfish Res. 17 (4), 931–935.
Neis, B., Felt, L., Haedrich, R.L., Schneider, D.C., 1999. An interdisciplinary method for collecting and integrating fishers' local knowledge into resource management. In: Newell, D., Ommer, R.E. (Eds.), Fishing Places, Fishing People. University of Toronto Press, Toronto.
Paz, V.A., Begossi, A., 1996. Ethnoichthyology of Gamboa fisheries (Sepetiba Bay Brazil). J. Ethnobiol. 16 (2), 157–168.
Perez, J.A.A., Aguiar, D.C., Oliveira, U.C., 2002. Biology and population dynamics of the long-finned squid *Loligo plei* (Cephalopoda: Loliginidae) in southern Brazilian waters. Fish. Res. 58 (3), 267–279.
Perez, J.A.A., Gasalla, M.A., Aguiar, D.C., Oliveira, U.C., Marques, C.A., Tomás, A.R.G., 2005. *Loligo plei*. In: Cergole, M.C., Ávila-da-Silva, A.O., Rossi-Wongtschowski, C.L.B. (Eds.), Análise das principais pescarias comerciais da região Sudeste-Sul do Brasil: dinâmica populacional das espécies em explotação. Instituto Oceanográfico da USP, São Paulo, pp. 62–68.
Pikitch, E.K., Santora, C., Babcock, E.A., Bakun, A., Bonfil, R., Conover, D.O., Dayton, P., Doukakis, P., Fluharty, D., Heneman, B., Houde, E.D., Link, J., Livingston, P.A., Mangel, M., Macallister, M.K., Pope, J., Sainsbury, K.J., 2004. Ecosystem-based fishery management. Science 305, 346–347.
Pitcher, T.J., Lam, M.E., 2010. Fishful thinking: rhetoric, reality and the sea before us. Ecol. Soc. 15 (2), 12.
Pincinato, R.B.M., Corá, M.J., Oliveira, G.Q.D., Salaroli, A.B., Kuniyoshi, L.S., Gasalla, M.A., 2006. Contribuição à caracterização da atividade pesqueira em Ubatuba (SP), a partir de abordagem com pescadores locais. In: Simpósio Brasileiro de Oceanografia, 3. São Paulo. Proceedings, Instituto Oceanográfico, São Paulo.
Postuma, F.A., Gasalla, M.A., 2010. On the relationship between squid and the environment: artisanal jigging for *Loligo plei* at São Sebastião Island (24°S) southeastern Brazil. ICES J. Mar. Sci. 67 (7), 1353–1362.
Robert, M.C., Chaves, P.T.C., 2001. Observações sobre o ciclo de vida da corvina, *Micropogonias furnieri* (Demarest) (Teleostei, Sciaenidae), no Litoral do Paraná, Brasil. Ver. Bras. Zool. 8 (2), 421–428.
Rodrigues, A.R., Gasalla, M.A., 2008. Spatial and temporal patterns in size and maturation of *Loligo plei* and *Loligo sanpaulensis* (Cephalopoda: Loliginidae) in southeastern Brazilian waters, between 23°S and 27°S. Sci. Mar. 72 (4), 631–643.
Rosenberg, A., Bigford, T.E., Leathery, S., Hill, R.H., Bickers, K., 2000. Ecosystem approaches to fishery management through essential fish habitat. Bull. Mar. Sci. 66 (3), 535–542.
Scholz, A., Bonson, K., Fujita, R., Bemjamin, N., Woodling, N., Black, P., Steinback, C., 2004. Participatory socioeconomic analysis: drawing on fishermen's knowledge for marine protected areas planning in California. Mar. Policy 28 (4), 335–349.
Silvano, R.A.M., Begossi, A., 2005. Local knowledge on a cosmopolitan fish Ethnoecology of *Pomatomus saltatrix* (Pomatomidae) in Brazil and Australia. Fish. Res. 71, 43–59.
Silvano, R.A.M., Begossi, A., 2010. What can be learned from fishers? An integrated survey of fishers' ecological knowledge and bluefish (*Pomatomus saltatrix*) biology on the Brazilian coast. Hydrobiology 637, 3–18.
Silvano, R.A.M., Gasalla, M.A., Pacheco, S., 2008. Applications of fisher's ecological knowledge to better understand and manage tropical fisheries. In: Begossi, A., MacCord, P. (Eds.), Curr. Trends Hum. Ecol. Cambridge Press, New Castle upon Tyne, UK.
Silvano, R.A.M., MacCord, P.F.L., Lima, R.V., Begossi, A., 2006. When does this fish spawn? Fishermen's local knowledge of migration and reproduction of Brazilian coastal fishes. Environ. Biol. Fish. 76, 371–386.
Silvano, R.A.M., Valbo-Joergensen, J., 2008. Beyond fishermen's tales: contributions of fishers' local ecological knowledge to fish ecology and fisheries management. Environ. Dev. Sustain. 10 (5), 657–675.
SMA, 2012. Secretaria do Meio Ambiente do Estado de São Paulo, Fundação Florestal. Internal Document.
Vazzoler, A.E.A.M., 1971. Diversidade fisiológica e morfológica de *Micropogonias furnieri* (Desmarest 1822) ao sul de Cabo Frio, Brasil. Bol. Inst. Oceanogr. (São Paulo) 20 (2), 1–70.
Vazzoler, A.E.A.M., Rocha, M.L.C.F., Soares, L.S.H., 1989. Aspectos reprodutivos dos Sciaenidae da costa sudeste do Brasil. Simpósio sobre Oceanografia. Proceedings, São Paulo, p. 70.
Vianna, M., Valentini, H., 2004. Observações sobre a frota pesqueira em Ubatuba, Litoral Norte do Estado de São Paulo, entre 1995 e 1996. Bol. Inst. Pesca (São Paulo) 30 (2), 171–176.
Wilson, D.C., Raakjaer, J., Degnbol, P., 2006. Local ecological knowledge and practical fisheries management in the tropics: a policy brief. Mar. Policy 30 (6), 794–801.
Zuboy, J.R., 1980. The Delphi technique: a potential methodology for evaluating recreational fisheries. In: Technical Consultation on Allocation of Fishery Resources, 1980, Vichy, Proceedings, Rome, FAO, pp. 519–529.