

Ecological, cultural, and economic approaches to managing artisanal fisheries

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Abstract Approaches towards the management of artisanal fisheries have been enlightening the scientific literature for approximately the last 20 years. Coming from diverse disciplines such as anthropology, biology, economy, and ecology (especially human ecology), these approaches have dealt with common theory, strategies for cooperation, decision-making models, cultural contexts, and local knowledge. Fishery management depends on an understanding of the interactions between humans and aquatic resources, and in case of indigenous or of native populations, forestry resources are also considered for livelihoods. Acquiring an understanding of the local knowledge about fish and other resources, of collective local arrangements and institutions, of market interactions, and of the decision-making processes of fishers is fundamental for the management of artisanal fisheries. This review includes historical and current approaches associated with the management of artisanal fisheries. These approaches include the following: (a) cultural and human ecological approaches, including ecological models such as optimal foraging theory; (b) institutional approaches, including processes of cooperation associated with local knowledge and institutions; and (c) current ecological-economic propositions towards fishery management, such as payments for environmental services. This revision is illustrated through examples, in particular, of data collected among coastal artisanal fisheries of the SE Atlantic Forest in Brazil.

Keywords Cooperation · Cultural ecology · Fisheries · Kinship · Management

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1 Introduction

Ecology examines the relationships between human populations and the environment. Fisheries encompass the relationships of fishers, fish, and other communities (biotic) within the abiotic environment. Viewing fisheries from this ecological perspective represents a 'human ecological', 'cultural ecological', or 'ecological-economical' (among others) context (Begossi 1993). Here, how to deal with artisanal or small-scale fisheries, including their ecological, social, cultural, and economic contexts, is analysed without losing focus on the interaction between predators and prey (fishers–fish or other aquatic resources). This goal may sound ambitious, but different disciplines have found ways to address artisanal fisheries and have been successful at analysing them in a broader context.

This revision illustrates, by navigating within the concepts offered by particular disciplines, how some models could help in understanding the dynamics of fisheries and the decision-making process of fishers who operate in an ecological environment that requires management. Illustrative cases will be drawn from particularly marine tropical artisanal fisheries, with an illustrative case of Paraty, Rio de Janeiro State, SE Brazilian coast.

Currently, studies have been trying to revise and bring new light and suggestions to overcome old paradigms and management problems in the face of urgent biodiversity conservation demands. Examples are Jones (2013) and Reid et al. (2010), among others. Social-ecological systems include approaches that enrich our understandings on how to deal with small-scale communities, poverty, and conservation demands. Socio-ecological approaches permit interplays between local and regional tiers, such as local and regional institutions, as well as formal and informal institutions (Ostrom 2007). A study on Paraty (Rio de Janeiro Coast) has detailed such aspects in a local artisanal fishery in Brazil (Begossi et al. 2012a) (Fig. 1), linking sustainability and social-ecological issues. This review intends to approach historical and current approaches associated with the management of artisanal fisheries. These approaches include the following: (a) cultural and human ecological approaches, including ecological models such as optimal foraging theory; (b) institutional approaches, including processes of cooperation associated with local knowledge and institutions; and (c) current ecological-economic propositions towards fishery management, such as payments for environmental services.

2 Cultural and human ecological approaches, including ecological models such as optimal foraging theory

Cultural ecology was born in the 1950s in the United States. Its proponents included White (1943) and Steward (1955). In particular, Steward proposed a method based on the 'culture core'. This method analysed the relationship between culture and the environment. The culture core was seen as the intersection of environment and culture, and subsistence was viewed as an output of that interaction. The concept of adaptation by human populations to the environment acted as one of the links of culture and the environment. Other methods pursued research themes of cultural ecology (Harris 1979; Orlove 1980), including studies on fisheries dealing with themes of subsistence, management, common-pool resources, and political ecology (Acheson 1981; McCay and Acheson 1987; Orlove 2002). Orlove (1980) is an inspiring revision on cultural ecology that I should recommend for readers, especially graduate students.

One enlightening concept taken from the discipline of cultural ecology is the idea of *emic* and *etic* (Harris 1976; Pike 1954 *apud* Headland et al. 1990). These concepts are

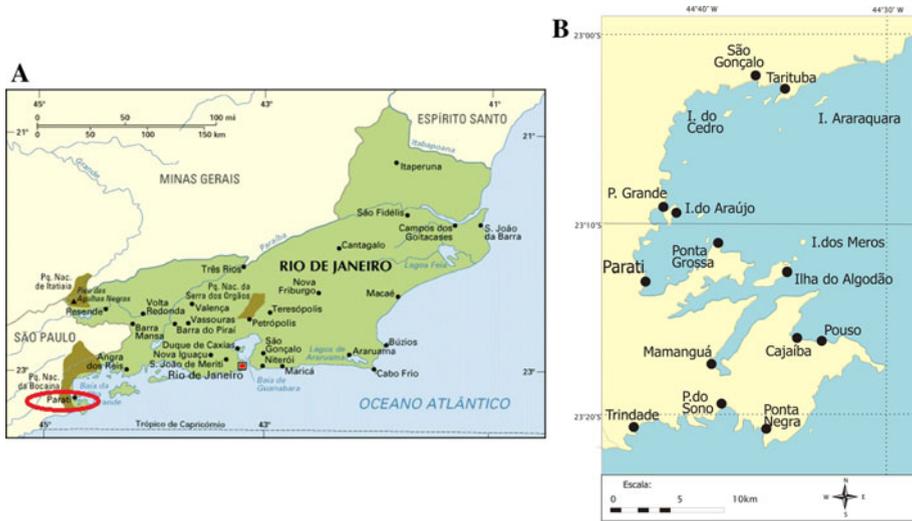


Fig. 1 a Location of Paraty in SE Brazil. b Paraty municipality, Rio de Janeiro State, Brazil, where the 13 small-scale fishing communities studied are shown

derived from the words *phonemic* and *phonetic*. They embody the contrasts and differences between the etic (outsider, researcher) and the emic (insider, community). Emic and etic concepts are significant because they facilitate the relationship between two bodies of knowledge (folk or local, and scientific) whose interaction is important for fishery management. These concepts are also crucial for understanding decision-making processes for managing natural resources. They furnish a mode of thought that allows us to enter a culture and to try to see things from the perspective of the artisanal fisher population. An illustrative example is presented in Box 1.

The following list illustrates the relevance of the etic/emic understanding to management:

- a. It helps us understand the cognitive and decision-making processes of fishers; for example, it is a form to understand the emic reasons given by fishers to target some

Box 1 Source: Begossi (1992), Begossi et al. (2004)

Food taboos among artisanal fishers: These include fish avoided as food during the periods of illness.

Food taboos on fish from the Atlantic Forest coast and from the Amazon include species that are dangerous to eat, such as pufferfish, and morays, or other species that are carnivorous, occupy high trophic levels and thus are able to accumulate natural toxins or pollutants. This second category of food taboos involves fish such as bonito (a species of Scombridae) on the Atlantic Forest coast and surubim (*Pseudoplatystoma* spp.) in the Amazon. However, perceptions by fishers of the non-palatability of fish are often based on the fishers' own histories and accounts (emic). An etic approach would be represented by research findings. For example, a food taboo on pufferfish can be explained by the fish's toxicity (caused by tetrodotoxin) (etic). A food taboo on morays can be explained by awareness of the possibility of ciguatera poisoning (etic perception) or by a mythological story (emic perception). For toxicity in some fish, including morays, see Rosenberg (1987). In a study conducted on Búzios Island, in SE Brazil, the diet and preferences of the islanders were explained by the role of fish in the diet, the smell of fish, and the aggressiveness of the fish (emic). Etic explanations of food taboos are based on toxic aspects of fish, on their place in the food chain, and on the functional value of the medicinal uses of fish (see food taboos of 'use' and 'disuse', Harris 1977, 1985). See for details Begossi (1992); Begossi et al. (2004)

- species and to fish in certain periods or areas. Such reasons or knowledge can be compared to biological and ecological knowledge on species, as well as on their distribution and abundance.
- b. It helps us analyse the interaction between fishers and the fish resource. When paying attention on what fishers think about resources, managers can analyse how to approach them (including specific items to be analysed and discussed with them) in order to evaluate necessities of conservation and management in the fishery.
 - c. It helps us develop proposals for management because they can be based both on the emic understanding embedded in a culture and on etic explanations that can clarify public policies. In that case, management procedures can take shapes more understandable and accepted within a culture.
 - d. It helps us develop arguments that are embedded in local culture and that can serve as drivers to stimulate the interest of artisanal fishers in biodiversity conservation. Fish consumed or commercialized can be approached by taking into consideration the interests of fishers; alternative pathways can be evaluated, interactively, with fishers since their arguments and interests can be taken into account. Fishers will probably feel more interested in participating in management procedures if they perceive a relationship between their economic needs/arguments and the positive outcomes for their livelihoods. Those interactive processes and foreseen outcomes act as drivers based on emic considerations. This consideration is especially important for fisheries that include populations that depend on aquatic resources for their livelihood. Most tropical artisanal fisheries fall into this category.

The idea of emic/etic understanding introduces a second concept: local ecological knowledge (LEK). LEK is emic because it stems from within a culture; however, it can be analysed through 'etic' eyes or lens. Local ecological knowledge is defined here as the body of knowledge that a native population possesses. This body of knowledge is often applied to the environment, and it can be related to traditional ecological knowledge or indigenous knowledge (Berkes 2008). Ruddle and Hickey (2008: 578) describe it in the following terms:

Empirically-based and practically-oriented local knowledge of the environment and resources used is fundamental to sustainable resource management. Among near-shore fishers in coastal-marine societies, for example, most such knowledge combines empirical information on fish behavior, marine physical environments and fish habitats, and the interactions among the components of ecosystems, into generally complex fish taxonomies to ensure regular catches and, often, long-term resource sustainment.

A classic example of an application of LEK to management was made by Johannes (1981) in the book *Words of the Lagoon*, one of the precursors of the use of local knowledge towards the management of fisheries. The book emphasizes, for example, the richness of unrecorded ecological knowledge that fishers have on fish. Studies on artisanal fisheries in Brazil have identified and analysed local knowledge and its applications to management by looking at four aspects of the issue (Begossi 2008: 591):

- (1) an understanding of the natural environment of the fishery and on the use of natural resources by locals;
- (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 and their LEK, based on studies of the ethno-biology, ethnoecology, and ethnotaxonomy of fish.

Local knowledge and emic and etic approaches help us understand the decision-making processes of fishers. These are complementary approaches to classical modelling, as is optimal foraging theory.

Optimal foraging theory stems from ecological theory (but was originally borrowed from microeconomics (Rapport and Turner 1977) and was based on the classic studies by MacArthur and Pianka (1966) and by Emlen (1966)) (see also a review by Pyke 1984). In general, these models assume that the decision process involves trade-offs that can be explained in terms of the costs and benefits of obtaining food. These costs include, for example, the time required to search for and to manipulate the food. The benefits of obtaining food involve returns that may be expressed in different currencies. The frequent currency of calories is used in research on animal behaviour (in human ecological studies, food value represented by prices can be used as well). Instead of food, the choice of patches in which to feed can also be used in the model ('food choice' models and 'patch choice' models).

In human ecology, optimal foraging analyses of hunting originated with studies by Winterhalder and Smith (1981), and analyses of fisheries started with the work of McCay (1981), among others (Box 2). An analysis of the behaviour of fishers in the aquatic environment of Sepetiba Bay, Rio de Janeiro, Brazil, addresses the fishers' travel time between patches to obtain fish and shrimp. This analysis reveals different behavioural strategies that may have implications for management, and such behaviours can influence attitudes towards management. Whether fishers will be pro-management depends on the context in which fishing occurs (Box 2).

3 Institutional approaches, including processes of cooperation associated with local knowledge and institutions

The literature on cooperation has been an important source of useful information for dealing with management processes. One basic concept linking this domain with management is that resources that are taken by an individual or group are not available to other users ('subtractability', Berkes 2008). The extraction of natural resources and the associated conflicts represent a social dilemma. This dilemma is exacerbated because it involves

Box 2 Optimal foraging on the coast of the Atlantic Forest (Begossi 1992)

Shrimp fishers in Sepetiba Bay in Brazil behave differently when using fishing spots for fish or for shrimp. Fish are caught in several different spots, whereas shrimp are caught by making many attempts in one spot. An analysis of the optimal time for leaving a patch (a fishing spot) was performed by comparing a theoretical prediction of the optimal time for leaving a spot with observations of the time at which the fishers actually left the spot. Fishers tended to leave a spot at a later time than that predicted by the model. In other words, they remained in the spot longer than predicted. Thus, according to the optimal foraging model, they were fishing suboptimally. The following hypotheses were proposed to explain the observed behaviour: (a) fishers have difficulty evaluating the available amount of a hidden, non-visible prey or (b) in Sepetiba Bay, conflict between artisanal and industrial fishers makes the artisanal fishers vulnerable and forces them to stay in a single spot until they see that the amount of shrimp they are catching in their nets is beginning to decrease. This behaviour leaves fewer shrimp for trawlers that enter the bay.

a conflict between private and public benefits (Grafton et al. 2008) and other forms of conflict.

For example, when a conservation unit is established where there are indigenous people living within its limits, it involves conflicts between the public (biodiversity conservation) and private (individual or communal rights). Special cases where such conflict is observed were studied by Begossi et al. (2011a, b) among small-scale fishers from Paraty, in Brazil, where socio-ecological-economical suggestions were given providing possible solutions, through the use of payments for environmental services (PES). Especially in tropical countries, where rural populations depend upon the extraction of natural resources for sustaining their livelihoods, such dilemmas are conspicuous. In that regard, cooperation (and reciprocal relationships) can be important in order to overcome such dilemmas, including conflicts between conserving nature and sustaining livelihoods.

The literature on reciprocity and on collective action has shown that the relative value of an item depends on the delay on its use or on its benefit; long delays also decrease the possibility of reciprocating (Hawkes 1992). Brosnan et al. (2010) observed that time delay affects cooperation in organisms with cognition: when time delay between investment and compensation exists, a tendency to discount the future preferring then smaller immediate rewards is observed. Biodiversity conservation tends to proportionate distant or future rewards, which increases difficulties for immediate cooperation. Biodiversity conservation is a future benefit in the sense that it is difficult to perceive in a short time. Long delays make reciprocity difficult to observe and measure; therefore, long delays make future favours less likely as compensation for current costs (Hawkes 1992: 286). The literature on reciprocity has dealt with delayed reciprocity and group size (a larger group size indicates a lower possibility of encounters and/or reciprocal returns), with the prisoner's dilemma, with strategies and rules of reciprocity (such as tit for tat), and with opportunists and free riders, as forms to understand social dilemmas (Axelrod 1984; Ostrom 1990; Trivers 1986). Such reciprocity dilemmas complicate co-management and nature conservation. Of special interest for analysing reciprocity is, from game theory, tit for tat; it is a strategy in which the player cooperates on the first move of a game and then does what the other player did on the previous move (Axelrod 1984). These complications are especially tricky in developing countries, where rural and poor populations are not convinced that they should avoid consuming resources now in favour of saving them for the future or for non-use values from which neither they nor their descendants can envision any likely benefit. This dilemma is critical especially because those populations observe a differential in the application of legislation, where political influence actors are, on many occasions, not reached by fiscal monitoring. Therefore, propositions that bring current and measurable returns to the local populations of extractors have a greater probability of success than those that do not. Studies dealing with fishers' perceptions of the benefits of conservation are necessary to shed light on specific proposals for co-management on the coast. One example of nepotistic reciprocity is the frequent occurrence of kinship crews among artisanal fishers, including crews composed of brothers (Nemec 1972).

Management, co-management, and nature conservation are in the core of the mentioned dilemmas.

Jentoft (2003: 3) shows a clear definition of co-management as a participatory action: 'co-management is a collaborative and participatory process of regulatory decision-making between representatives of user groups, government agencies, research institutions, and other stakeholders'. Such definition showed to be helpful when analysing Latin American fisheries associated protected areas (Begossi 2010). Currently, Solomon et al. (2012) have used the term 'collaborative resource management' (CRM) including various governance

processes, such as community-based management and integrated environmental management, among others; co-management seems a process integrated in CRM.

Participatory dilemmas are especially critical if populations receive a differential in the application of legislation: often, whereas local poor inhabitants are visible and easy targets in the supervision process, rich and/or political influent individuals are, on many occasions, not easily taxed or punished by fiscal monitoring (see Begossi et al. 2012a for specific cases, as well as Zanetell and Knuth (2002) for other situations in Latin America).

Therefore, propositions that bring current and measurable returns to the local populations of extractors have a greater probability of success than those that do not. Studies dealing with fishers' perceptions of the benefits of conservation are necessary to shed light on specific proposals for co-management on the coast.

Some studies have shown that, in some circumstances, fishers are able to perceive the benefits of conservation. Gelcich et al. (2009) were able to detect fisher's perceptions in fisheries of Chile, Argentina, Peru, and Uruguay by analysing variables, such as of management success and stakeholder satisfaction, among others; Defeo and Castilla (2012) have shown the importance of 'well-defined boundaries' in Latin American and Caribbean fisheries, where small-scale shellfisheries were successful at a local scale, such as the lobsters in Punta Allen (Mexico) and Juan Fernandez Archipelago (Chile), among others. Obura (2012) exemplified the cases on reef restoration associated with local benefits, such as ecotourism and economic credit, acting as drivers for encouraging local populations to participate in conservation programs. Another important point was shown by Acheson (2003), studying lobster fishers of Maine, USA: when fishers had the opportunity to experience resource depletion, they tended to be prone to conservation measures. In another study, Gelcich et al. (2008) observed how the perception of fishers on conservation was fundamental for management success: fishers' perception was related to individual variables or to fishers' union features. Such studies are very important in trying to find the drivers behind fishers' behaviours concerning biodiversity management. In that regard, recent studies have detailed fisher's perception. Solomon et al. (2012), at Kibale National Park (Uganda), observed that permission to residents to fish inside the park helped alleviating poverty and encouraged participants in conservation programmes. Other examples are the studies by Pita et al. (2013) showing that Scottish inshore fishers' perception is heterogeneous and associated with the gear type used; Trimble and Johnson (2013) analysed fishers from Uruguay (Piriápolis) and Brazil (Paraty) using an analytical tool ('well-being perspective') in order to understand social heterogeneity, and fishers' interest and involvement in governance, among others aspects. Still on the region of Paraty, Lopes et al. (2013), using local knowledge, mapping of fishing areas, and information on gear and species, concluded that management measures should not be equivalent across the whole region of Paraty, since there are clear differences in target species and gear use.

3.1 The role of kinship and cooperation

Historical authors and paradigms from economics, political economics, cultural ecology, common theory, and evolutionary ecology were chosen based on their reference to ties of economy and environment to understand the relationship between kinship, market, culture, and management ('Appendix').

According to Polanyi (1957), market interactions are embedded in local cultures and are therefore the outcomes of social organization and culture. When considering petty commodities or small mercantile communities (such as of small-scale or artisanal fishers), market interactions are associated with the extraction of natural resources and with

decisions regarding subsistence (the dilemma of which fish to eat and which fish to sell, for example—Begossi and Richerson 1992). Petty commodities include a production with a household basis, where products are commercialized and some even bartered. It can be associated with a precapitalist economy, in which use and symbolic values are more important for commodities rather than their exchange value (see Cook 2006 for analysis of commodity cultures in Mesoamerica). Lindblom (2001: 5) observed that in premarket households, paternal or other authorities coordinate activities; market began when these households start producing for sales.

Other authors have understood subsistence interactions and market processes in these small-scale communities by taking into consideration other reasoning and other methods ('Appendix'). Beginning with Marx, and followed by Sahlins in cultural anthropology (1976: 5), the economic structure is considered as the sum of the relations of production, which are the foundations of the superstructure (social organization and consciousness). Terray (1972: 97), another follower from anthropology, is inspired in Marx's Capital in defining a mode of production as a three-part system: an economic base, a juridical-political structure, and an ideological structure ('Appendix').

Other anthropologists, following different arguments, have drawn similar paradigms, such as Harris's cultural materialism (1979: 53), in which *infrastructure* includes modes of production and reproduction together, *structure* includes the domestic and political economy, and *superstructure* includes the mental and behavioural components.

Even the *culture core* concept and method suggested by J. Steward follows a similar pattern, by considering as the *culture core* the subsistence-related processes, including social, political, and religious, connected with economic arrangements (Steward 1979: 57) ('Appendix').

Nevertheless, in a parallel point of view, Polanyi (1957) takes economic and market relations as the product of social organization.

In this review, and drawing from illustrative cases from the Atlantic Forest small-scale communities in Brazil, we will compare such paradigms and discuss their applicability for the management of natural resources within those communities.

3.1.1 Cooperation, markets, and management

Embedded in small-scale communities are the strategies of cooperation: these forms of relationships are often nepotistic in small communities because most individuals are related through kinship.

If market processes are the result of social organization, following Polanyi (1957), then cooperative processes should be in existence in the market of small-scale communities, known by their petty commodity relationships. Such an understanding is important for constructing scenarios of strategies of management and conservation that depend on cooperative local behaviour (and local rules). The existence and forms of cooperative behaviour in small-scale communities can be a trigger to develop behaviours that could contribute to the management of natural resources, thus enhancing the resilience of the systems. Cooperative local behaviours of market and exchange in small-scale communities are thus dependent on, or are the outcome of, or can be a basis for managing resources by considering the following:

- a. local knowledge of the resources being exchanged or commercialized;
- b. local norms and rules concerning cooperative interactions that can be based on nepotism or reciprocal altruism and based on kinship ties;

- c. local rules and norms in the extraction, use, and commercialization of resources; and
- d. market devices and culture, specifically how they are related to the development of management tools and incentives.

This study will develop an analysis of the processes interacting in the subsistence-market-culture of small-scale fishing communities, focusing on the management of natural resources. Concepts of cooperative, embedded local culture markets will be recalled, as illustrated by small fisheries from SE Brazil. Some frameworks will be developed (and others recalled from historical backgrounds) to proceed with the analysis, as illustrated by small-scale (artisanal) fisheries of the Atlantic Forest coast (Box 3).

4 An illustrative example: human ecological background of fishers and the study case of Paraty, Rio de Janeiro State

The study case described here and orienting this analysis is related to the use of resources among communities from Paraty and is based on information from other studies of small-scale (artisanal) fisheries of the Atlantic Forest coast, locally named ‘caïçarás’.

4.1 Background of regional history

The Atlantic Forest in the coast of Brazil is known by its huge diversity of organisms. As an example of such diversity, Dean (1995) observed that 270 tree species were found in one hectare in a site in Bahia State; he also observed that endemism is a feature of the forest, where more than a half of the trees are endemic (sharing about 8 % of tree species with the Amazon forest). Atlantic Forest remnants include about 13 % of the original forest (SOS Mata Atlântica 2012).

Box 3 An illustrative case: historical data on economic cycles of the Caiçarás on the Atlantic Forest coast

Period (century)	Economic activities ^a
Before 1870	Gold mining products. Paraty was a centre of major importance for commerce and export Sugar cane plantations and production of Brazilian rum
1870–1880	Construction of railroad between São Paulo and Santos (São Paulo State) Coffee plantations Manioc cultivation, manioc flour commerce
1890 and after	Agricultural decline after railroad and after the end of slavery, but still coffee export in Paraty Small-scale agriculture; manioc
1950 and after	Decline of price of agricultural products Small-scale agriculture; manioc Artisanal fishing for commerce Increasing tourism ^b Loss of properties
2000 and after	Tourism important Artisanal fisheries: conflicts with protected areas Small-scale agriculture; manioc: forbidden in many sites that are now protected areas

^a Source: Begossi (2006) updated, França (1954), Diegues (2005), Mussolini (1980)

^b Highway Rio-Santos increased tourism

Small-scale fishers of the Atlantic Forest coast are the result of mixed influences and ethnic descent, such as Native Indians, Portuguese colonists, and Africans who arrived through the 1800s with the slave traffic (Marcílio 1986). Even the Japanese have influenced fishing in the SE Brazilian coast, being responsible, for example, for the use of *kaku-ami*, a floating net locally called *cerco* (Mussolini 1980) and still in use in areas of the SE coast (Begossi 2011). For a description of historical accounts on fishing on the coast of Rio de Janeiro, including the classic Hans Staden's accounts, see Bernardes and Bernardes (1950), where a description of fishing techniques, such as nets (set gillnets, beach seines), traps, and hooks, is found.

Currently, the inhabitants of the Atlantic Forest coast are primarily fishers, but they are also active in the regional market associated with fishing and tourism. They still extract plants from the rainforest for medicine. Cultivation and hunting have been forbidden by agents that are connected with the protected areas of the region.

Beginning in the 1800s, with the land dedicated to sugar cane plantations for the manufacture of rum (and gold mining commerce in Paraty) and then to agricultural products, the *caiçaras* finally concentrated on fishing and, more recently, tourism, as shown by their integration into the regional economic cycles (Box 3). The *caiçara* cycles described in Box 3 are part of their historical local development. In the Paraty case, as described by Diegues (2004: 30), the combined way of life of the *caiçaras* consisted of agriculture and fishing, having participated in the nineteenth century in sugar cane cultivation and slavery and in banana plantations in the twentieth century during the 1930s and 1940s.

Studies on the municipality of Paraty, particularly that of Plante and Breton (2005), provide a history that includes its economy (Box 3), but they also give us information on the importance of Paraty, as in the following information (pp. 25–29): when the first Portuguese migrants arrived in the area of Angra dos Reis and Paraty in 1559, Native Indians occupied the coast. Paraty, in particular, became an important centre of agricultural and commercial products, especially in the gold mining period. Its location is a centre where different routes with ports and railroads (1877) made possible the commercialization of and route for salt, sugar, rum, and the mining products coming from the State of Minas Gerais. With the ending of slavery in 1888, sugar cane plantations were substituted by banana and cattle, having then, at the beginning of the twentieth century, entered into a process of deterioration. The large boats that came from Santos in the Paraty area (such as in the community of Trindade) after 1910 became an alternative for the locals to sell their produce, including manioc flour, fish, banana, and tobacco. Conflicts due to the creation of protected areas and to the settlement of companies in the area resulted in local economical-political movements by the *caiçaras* (Plante and Breton 2005).

The decline in the price of agricultural products represented a trigger pushing the local inhabitants to increase their efforts towards fishing. Thus, after the 1950s, fish became one of the main products sold by the local inhabitants (Diegues 1983, 2004); *caiçaras* then became small-scale fishers, some of them full-time. In a fieldwork conducted in 1986–1987, Begossi et al. (1993) calculated the trade-off of producing manioc flour compared with fishing. On average, one-person-hour of labour yielded 1 kg of manioc flour (valued at US\$ 0.23 in June 1987). Fishing produced a higher return, being at least 1.5 times more productive. The average catches yielded 1.5 kg of fish per hour, and a cheap fish would sell for US\$ 0.23/kg and a high-price fish, such as grouper, for US \$0.58/kg.

Paraty, after the sixties, and with the building of the Rio-Santos Highway (1973–1975), was an arena of changes: migrants and urbanization followed economic and social impacts (Box 3). According to Diegues (2004: 39), the Cobras slum in Paraty started in the sixties

and reached four thousand inhabitants in 1994. The local production by caiçaras is seen by Diegues as petty commodity production ('pequena produção mercantil', p. 41). Such production includes the extraction of products from the forest, minor cultivation of manioc (because of the control of protected area legislation), and the commercialization of fish. Hunting has been forbidden since the advent of the protected areas around Paraty after the sixties, and cultivation has been an activity prohibited by authorities from the protected areas. It is important to stress that the lifestyle of the caiçaras is analogous to the riverine caboclos of the Amazon (rural people), being widespread among the rural people in Brazil that live in high biodiversity areas, such as the coast (Atlantic Forest) or rivers (Amazon) (Begossi et al. 2004a).

Regarding the fisheries in the coast of Brazil, Diegues (1983) observed the linkage of the petty commodity production with the internal market and characterized it as a 'household production of agriculture–fishing' and as the 'artisanal fishing production', as follows (p. 150): in 'household production', products are more directed to subsistence than to barter or commerce, and there is the kin ownership of the means of production, the use of paddled or sail canoes in part-time fishing, 'compadrio' relationships, and the use of estuarine areas, among others; in 'artisanal fishing production', products are more directed to commerce rather than to subsistence, there is an individual ownership of the means of production, small sail or motorized canoes are used in full-time fishing, there are 'compadrio' and class relationships (such as in the Colônias de Pescadores, the local associations of fishers), and there is the use of coastal areas.

4.2 The role of kinship

Kinship is a basic feature of caiçara life and of the current small-scale fisheries that occur along the coast. Such communities of caiçaras are linked through a kinship network of intermarriages that are analogous to the metapopulation concept in ecology (Begossi 2006).

There are many examples of kinship interactions among the caiçaras, and detailed accounts are developed in Camargo and Begossi (2006) for Búzios Island, an isolated community approximately 20 miles from Paraty, showing kinship as an important feature within its social relationships. Due to its details, the Búzios Island case is illustrative and comparable to Paraty.

Kinship and cooperation, especially in small groups, take the form of nepotism. Authors, in 'Appendix', have taken kinship as a basis for human social relations. Cooperation has been studied in much detail by Axelrod (1997) and in an evolutionary context by Richerson and Boyd (2005). The understanding of cooperation in larger groups among humans, in contrast to the classical kin ties and kin selection approaches, has also been analysed by recent evolutionary theories of human behaviour (Boyd et al. 2011).

At Búzios Island, reciprocity associated with kinship enhanced the benefits obtained from fishing (Box 4). For example, kinship plays a special role in the economy of Búzios Island, as do social relationships:

- a) The extended families that have their houses around the casa de farinha (flour house, the place where manioc flour is processed): Frequently, after a man marries, he builds or locates his house adjacent to his father's house, where a 'casa de farinha' exists and supplies the manioc flour for the group of houses, constituted by sons and spouses (the extended family). The processing of manioc flour is an activity of the family. Examples of these processes have been illustrated for Búzios Island (Begossi 1996a;

Box 4 Fishing alone versus fishing with a brother at Búzios Island (Begossi 1996b: 135–137): strategies of cooperation

Data from the eighties (1986–1987) from Búzios Island, Brazil, on the coast of São Paulo, portraying fishers using paddled and motorized canoes to fish around the island. Nets, hooks, and jigs were still used to fish for bluefish, squid, and other species. A total of 906 fishing trips involving 56 fishermen were sampled in 1986–1987. Fishermen were alone on 668 fishing trips, with brothers on 142 trips, and with another family member (often a son) on 46 fishing trips. Interviews were conducted with 28 fishermen. In all, 57 % of the fishermen reported that they fished alone and 43 % with a brother or father. Crews were often fixed based on reciprocity between brothers and were limited by canoe size. A comparison of the yields resulting from these strategies (one-way ANOVA of the average yield per fisherman per hour obtained from fishing alone versus fishing with a brother) showed that the yield when fishing with a brother was higher. An additional benefit was obtained because the catch was shared if the brother had to be absent (due to illness, for example). Fishing occurs in a risky and uncertain environment. Relationships of this kind can work only if brothers reciprocate. This situation is similar to that represented by the tit for tat strategy (Axelrod 1984).

The long-term alliances of fixed pairs of brothers at Búzios Island were based on kinship ties and nepotistic behaviour. These factors assist a long-term alliance of the tit for tat form that can bring benefits to both brothers. Fishing alone makes the fisher more vulnerable to the uncertainties of the fishery environment.

Begossi et al. 1993; Willems 1952). Willems (1952) and Diegues (2004) refer to the relations around manioc cultivation and processing as the ‘manioc flour complex’. Peroni et al. (2008) report on the current extractive and agricultural activities on caíçaras, especially on the importance of exchanging varieties and maintaining biodiversity among manioc small farmers along the São Paulo Atlantic coast.

- b) Fishing is often performed in pairs, in paddled or motor canoes, or small boats, often in crews composed of brothers that share the catch (Begossi 1996b) (Box 4). In the specific case of Búzios Island, we observed that cooperation between brothers yielded a higher catch rather than fishing alone (man per hour fishing). In other areas, Diegues (2004) observed that until 1950, fishing with beach nets (seines) was developed within a process of cooperation within families. Fishing through cooperative behaviour based on kin ties still exists, such as the fishing of snook that occurs periodically, at night, at Puruba Beach using beach seines, a method observed in the Puruba community by Begossi (1998) and, 10 years later, by Lopes and Begossi (2008).
- c) The importance of kinship in managing territorial rights to fishing activities. Such fishing rights can be based on kin ties, as shown in several communities, such as Búzios Island (São Paulo coast), Sepetiba Bay, and Ilha Grande Bay. The importance of kin ties for maintaining informal ownership of a fishing spot, as a local rule, is based on an informal division of the marine space that occurs among local families (Begossi 1995, 2006).

4.3 Artisanal fisheries in Paraty in the twenty-first century

Paraty, having being part of the local regional economic history of the southeast Brazilian coast, has had its development through participation in the regional economy of the SE coast of Brazil, and by maintaining several features of the caíçara lifestyle (Box 3).

From 2009 until now, we have been collecting data on the fisheries in Paraty, and some information is provided here, especially regarding the use and knowledge of natural resources, fishing, local institutions, and market interactions regarding fishing (Begossi et al. 2010).

In 2009, we performed interviews in 13 fishing communities of Paraty (Begossi et al. 2010). Livelihood here subsists on aquatic resources, plant extraction, and tourism. Figure 2 shows an example of the main fishing resources consumed and sold by the families of Paraty. It can be observed that there are fishing resources that are more targeted for commerce, such as shrimp, snook (*Centropomus* spp.), and snapper (species of Lutjanidae), whereas weakfish (*Cynoscion* spp., among others), sand drum (*Micropogonias furnieri*), and mullets (*Mugil* spp.) are especially consumed. Others are both consumed and sold and are part of the classic dilemma of consuming or selling the food extracted (Begossi and Richerson 1992). This dilemma is well illustrated in Fig. 3: we conducted 206 interviews in Paraty (Begossi et al. 2010). The data from these interviews indicated that fishing resources that had a high price in the market, such as snooks and shrimp, tended to be sold in preference to low-priced fishing resources, such as weakfish and croaker (details are published in Begossi et al. 2012a).

Medicinal fish, in Paraty, was cited by a very few fishers, such as filefish (*Aluterus monocerus*, *Stephanolepis hispidus*, 26 fishers) and sea horses (*Hippocampus reidi*, 12 fishers), among others. Medicinal plants, however, are still extracted and used, especially plants to treat liver problems, pain, inflammation, and for use as sedatives (Fig. 3) (Begossi et al. 2010).

Nets and hooks and lines are the main technologies used by fishers, and the results of fishing trips taken from samples at landing points at Praia Grande and Tarituba in Paraty (261 trips sampled, November 2009 through August 2010) show that through these fishing

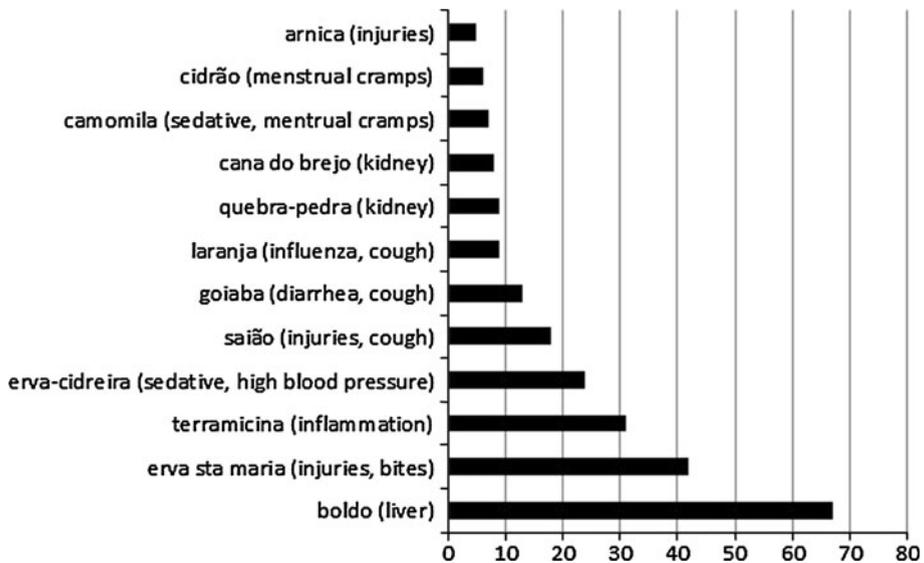


Fig. 2 Number of respondents in interviews in Paraty ($n = 206$) on local plants used in local medicine. Among 30 species mentioned by local fishers, we show here the most mentioned ($>$ or $=$ to 5). Scientific names are based on other studies (Begossi et al. 1993; Hanazaki et al. 2007; Rossato et al.), which are as follows: arnica (*Porophyllum ruderale*, *Indigofera suffruticosa*), cidrão (lemon grass) (*Melissa officinalis*, *Cymbopogon citratus*), camomila (*Matricaria chamomilla*), cana do brejo (*Costus spicatus*), quebra pedra (fly-root leafhopper) (*Phyllanthus niruri*, *P. corcovadensis*), laranja (orange) (*Citrus sinensis*), goiaba (guava) (*Psidium guajava*), saião (*Kalanchoe* sp.), erva-cidreira (lemon verbena) (*Melissa officinalis*, *Lippia citriodora*), terramicina (?), erva de santa maria (wormseed) (*Chenopodium ambrosioides*), boldo (*Plectranthus barbatus*, *Vernonia condensata*)

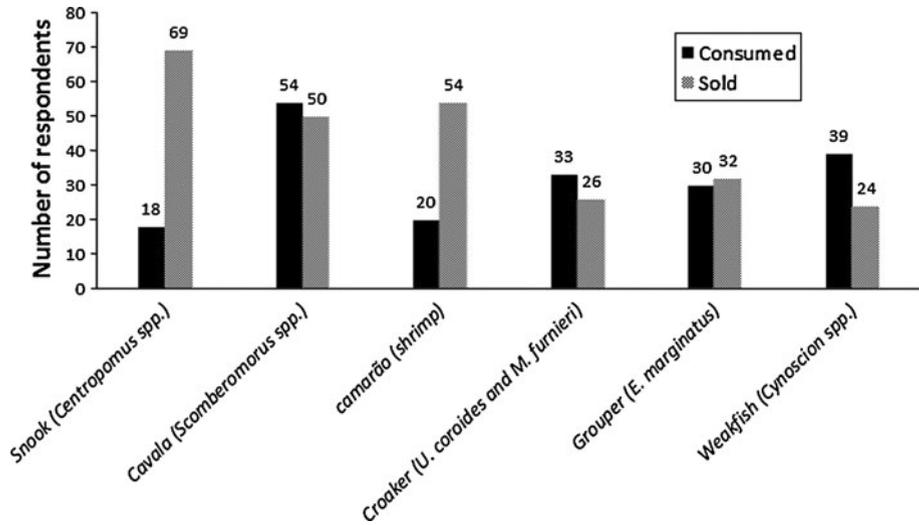


Fig. 3 The most important aquatic resources mentioned by fishers in Paraty as important for consumption or commerce. Selection is based on the number of respondents in interviews. Included are resources mentioned by more than 15 respondents

methods, among others, 80 % ($n = 11,471.89$ kg) of the catch was represented mainly by, in the following order, shrimp (various species), sand drum (*M. furnieri*), bluerunner (*Caranx* spp.), weakfish (*Cynoscion* spp., among others), mullets (*Mugil* spp.), snook (*Centropomus* spp.), and catfish (*Aspistor luniscutis*, *Sciades passany*) (Begossi et al. 2012a, b, additional file).

Local knowledge in Paraty is observed based on other earlier studies, such as on snappers (Begossi et al. 2011a), and on natural resources (such as plants used for medicine, fish used as food and as medicine) and on the perceptions of the need for the conservation of marine resources (Begossi et al. 2010).

Local institutions in Paraty can be referred to as formal, such as the Colônias de Pescadores, and informal, such as related to fishing rules and processes, especially including the use of fishing spots. The general rules found among artisanal fishers from the coast is a kind of division, or exclusivity, in the use of fishing spots that are maintained through kinship ties and cooperation (Begossi 1995). Local conflicts with controllers of adjacent protected areas and an analysis of the possible institutions that can serve to manage the artisanal fisheries in Paraty have shown the importance of fishing agreements as a form of negotiation of a set of rules between fishers and the government. Those negotiations can be associated with ecological-economic mechanisms, such as payments of environmental services, that could act as drivers, or stimuli, for fishers (Begossi et al. 2011b).

5 Discussion

5.1 Local populations and pro-conservation attitudes

To be embedded in local culture, how should the management of artisanal fisheries be conducted? The idea that people would be prone to manage natural resources should not be

considered a behaviour taken for granted. To be able to discriminate the variables, or the cultural features, that could drive or stimulate and push people to be part of the processes of co-management is tricky, but key for management success. Uncovering the variables from each ecological-cultural-social-economical context will allow embedding co-management locally. Variables are, for example, the natural resources used and needed by a local community, the forest or marine space used, their source of income, and the income dependency from nature, among others.

One interesting example (Nogara 2000) is the local movement in the Mamanguá community, Paraty, that was developed to avoid the entrance of shrimp trawlers. Mamanguá is along bay (like a channel) of 8 km length in Paraty bay adjacent to Algodão Island that is important as a locale for fish reproduction and growth, as stated by the fishers (Begossi et al. 2010). In our study (Begossi et al. 2010), we collected data in 2009 in Mamanguá, interviewing fishermen from the community of Baixios and Cruzeiro, and the movement studied by Nogara (2000) was mentioned by fishers in the interviews as a successful attempt to exclude the trawlers of that bay. Nogara (2000) stated that the movement was initiated with a project of placing tyres as artificial reefs to avoid the entrance of shrimp trawlers in the channel. The local population concluded that tyres would not be enough, and they decided that the artificial reefs should be made of concrete with rebar (iron rods). These reefs were installed in points in the channel that fishers considered as frequented by trawlers. The key point here is that, according to Nogara (2000), the artificial reef movement was a real representation of local demands that were answered through action by the demanders, the local fishers. This process is a legitimate process embedded within the context of the local fishers of Mamanguá channel, Paraty.

Legitimacy within a fishery can be one parameter that could serve to evaluate embeddedness. Legitimacy can be understood by considering that fishers perceive as effective and fair the regulations and the outcome of the regulations (a regulatory legitimacy) (Pinkerton and John 2008). However, for each case, local variables should be important to have a legitimate and embedded management process.

A method of analysis of social-ecological systems (Ostrom 2007) that evaluates tiers through decomposable systems (or subsystems) could be of help by picking up the second-tier variables of a community (a subsystem) where important variables within the culture could be found. Nevertheless, without finding these key variables for each subsystem, it is difficult to have a type of management absorbed and identified by the community. Ecological systems are local, a nest inserted within suprascale systems, as the systems of tiers shown by Ostrom (2007). Thus, local variables that might drive fishers to manage resources, inserted within their cultural contexts, should produce participatory processes of management.

Participatory approaches are widely discussed as necessary for co-management, but the drivers that could promote such participation are often neglected. What we propose here is that such drivers must be found within the historical-cultural-ecological and economic contexts of a community. Perhaps, the 'special incentives' mentioned by Olson (1965) and cited in the works of Ostrom (1990, 2005) and Acheson and Knight (2000) are those variables we are seeking.

Axelrod (1984, 1997) has developed models to understand the evolution and mechanisms of cooperation through 'tit for tat' strategies and by studying the interactions and understandings of players within cooperative games (Axelrod and Cohen 2000, 'Appendix'). They used adaptive models in which the limitation of information by participants is assumed, among other aspects ('Appendix'). The understanding of norms by Axelrod (1997) is illustrative for cases where kinship plays a role (1997: 47): 'A norm exists in a

given social setting to the extent that individuals usually act in a certain way and are often punished when seen not to be acting in this way'. The social mechanisms to support norms are metanorms (Axelrod 1997). When, for example, a fisher is socially punished because he used the fishing spot of an uncle without permission, the social punishment is the metanorm being practiced. Those definitions are important especially where kinship plays a role and where cooperation is based on extended family networks.

5.2 Embedding in Paraty, important variables towards co-management

Paraty has several features that could be understood by analysing the context and the paradigms in 'Appendix'. Those paradigms are closely associated in meaning, and when observed in chronological order by authorship, they give us a sense of the complementarity and evolution of thought. Beginning with Proudhon in 'Appendix', we see the importance of reciprocity and cooperation within a social structure and the importance of the difference in possession (*just in rem*, the right to a thing). This understanding is crucial within the general caçara context, including Paraty, where possession of land is a reality (and of the sea through possession of fishing spots), instead of property, and where social structure depends on the kin networks. Marx and Engels (see 'Appendix' for refs.) add several concepts and methods, even disagreeing with Proudhon on the centrality and importance of labour for understanding property, among other disagreements.

Such Marxist definitions and concepts are especially important, being the core and source for methods in cultural ecology, even if not properly assumed. These concepts are in particular the understanding of the mode of production as a tripartite system that involves an economic infrastructure, a juridical-political structure, and an ideological superstructure, even though Marx and Engels assumed as central the economic structure, and the superstructure flowing from it ('Appendix'). The understanding of production associated with reproduction is also an applicable idea, especially considering societies where cooperative ties are linked to kinship. One of the most striking features of the paradigms in 'Appendix' is that cultural ecologists in the 1950–1990s followed the earlier path of ideas by understanding subsistence (and economy), behaviour, and social organization at infra- and suprascales as a link to environment–economy–social relationships. Examples run through the culture core by Steward (1955) or through the cultural materialism of Harris (1979), or even by Sahlins (1976), who emphasized symbolic meanings associated with kinship structures in small-scale societies, but having an entirely economic meaning in Western societies ('Appendix'). Another major point of all paradigms and authors shown in 'Appendix' is the importance of kinship as a driver of social relationships and cooperation. Terray (1972) analysed economic exchange and cooperation in those terms by studying the mercantile production of the Guro society of the Ivory coast; Polanyi (1957) is quite direct in that regard, by associating behaviour and economics as reciprocity, redistribution, and householding ('Appendix').

These paradigms, roughly shown in 'Appendix', are consilient according to Wilson's (1998) analysis: they 'jump together', linking facts and theory, which in this case is economy and social relations based on kinship, reciprocity, exchange, and cooperation. From Morgan's theories, from which some of the authors in 'Appendix' base their analysis (see also Bloch 1983, for more) to the current adaptive complexity of Axelrod and Cohen (2000), we find attempts to understand the evolution of economic systems and of social relationships having cooperation and kinship as a focal basis.

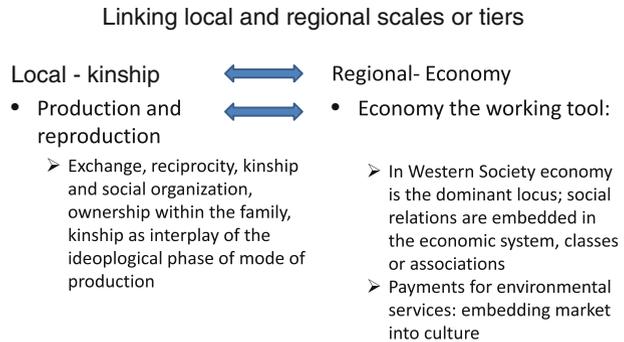
The theories shown in 'Appendix' are important for understanding how to manage natural resources in a way in which the local population can be driven to such an enterprise

and in a way in which local processes are aligned with the cooperative processes that are the basis of the communities on which we are focusing.

In the case of the *caíçaras*, we would suggest the following:

1. Management should be included in their livelihoods, that is, in their household activities. *Caíçaras*, as the current artisanal fishers of the Atlantic Forest coast, have economic and social ties that are linked to family ties, and they are connected among communities on the coast through intermarriage (Begossi 2006). We can estimate that within their major activities, from their poly-varietal agricultural system of manioc (Peroni et al. 2008) to the fishing spots used, kinship ties support exchanges and local rules.
2. Exchange and distribution are important factors to consider for local management. In this regard, kin groups could be the main loci of negotiations. The current locus of negotiation between individuals and formal organizations, such as ‘*Colônias de Pescadores*’, probably does not represent the most efficient form of negotiation. Negotiations should be decentralized into interest and kin groups.
3. There is a need to study, in more detail, the market processes of the fishery outputs to analyse it through kin ties. The data we have, based on Begossi et al. (2010), are not sufficient to address the distribution process from the fish market. How fish are distributed after being caught and how the fish market is related to family groups is important information to be addressed when managing fish resources, as we can deal better with demands and with the choice of prey for consumption and for commerce.
4. Fishing agreements and payments for environmental services should be negotiated and addressed through family groups that are involved in specific activities. Often associated with kin groups, gear uses and preferences (as well as associated target species) should be taken into account for different management procedures. A fishing agreement in Brazil is an ‘*instrução normativa*’ that can turn into a decree, and it has been a form of co-managing aquatic resources in the Amazon (Begossi 2010). Payments for environmental services are payments for avoiding extracting resources so as to maintain biodiversity. Earlier studies by Vinha et al. (2010) and Begossi et al. (2011a, b) have addressed this marketable mechanism, which could take the form of a ‘*defeso*’, or a payment given to fishers in Brazil when they are off-duty to maintain certain fish stocks. (for details of fishing agreements in the Amazon and on payments for environmental services, see, respectively: McGrath et al. (1993) and Engel et al. (2008)). These suggested human-ecological-economic mechanisms can be applied at the local scale, thus resulting in decentralization of negotiation processes. Negotiation processes should go beyond the municipality or community scale (Fig. 4). Examples are as follows:
 - a) Example 1: A group of related families involved in manioc flour processing could negotiate their practice of these activities through an agent of a protected area that inhibits their activities. I participated in a meeting in Trindade, Paraty, in 2010, where one concern, among others, was the pressure of agents from the National Park of Bocaina regarding activities of cultivation and fishing. Negotiations should then be through groups of interest and some kin-based groups associated with the activity.
 - b) Example 2: A group of families that fish with a certain fishing technique should negotiate fishing management concerning the technique used for fishing. There are in Paraty many different groups identified as ‘users of a fishing technique’, and some are associated through kin ties or just living near each other. Examples are the group from Tarituba who fish using the technique called ‘*cercos do robalo*’ (snook), the group of

Fig. 4 Linking scales of kinship and reciprocity (local) to regional economy and ecological-economic conservation tools



small-shrimp trawlers from Cajaíba, and families who employ the cerco (floating chambers of net, kaku-ami) in Trindade. Lopes (2010: 105) identified at least 14 different techniques of fishing that are performed by specific groups in Paraty, as the example given.

- c) Example 3: A group who deals with the fish market also has their own peculiarities concerning the local exchange of fish, local distribution, and other fish market interactions. These aspects deal with prey selection and targeting in the management process. These are also specific aspects that are supported by economic and kin ties, as families deal together with fish stores and markets.

The suggestion of PES as a form of engaging local artisanal fishers in management makes a link between scales: the local and the regional. This is a mechanism of rewarding who participates in helping conserving biodiversity, which could act as drivers or stimuli for fishers, as already studied in detail by Begossi et al. (2011b). Thus, those groups or individuals could receive a payment for some activity on biodiversity conservation. The local scale is based on kin groups and groups of interest regarding the use of natural resources in Paraty. The regional scale is the scale caíçaras have been part of through their participation in the economic cycles (Box 3). These suggestions follow the idea that the regional economy is the representation of economy and classes ('Appendix', Marx, Sahlins), but the small-scale society is primarily based on small groups and kinship (authors in 'Appendix') (Fig. 4).

5.3 Current ecological-economic propositions regarding fishery management: the question of payments for environmental services (PES)

Payments for environmental services (PES) are a form of compensation offered to fishers in exchange for a service, such as biodiversity conservation or management of natural resources. This mechanism is especially important in the tropics, where fishers depend upon fishing for their livelihoods. This dependence can make it difficult to interest the fishers in conserving aquatic resources. Even in Brazil, where a variety of co-management processes, such as fishing agreements and sustainable reserves (Begossi 2010), are underway in the public policy sector, fishers are not always convinced that they should avoid fishing for a species of a certain size or that they should avoid fishing at certain spots, such as islands and reefs. Offering PES is an approach that has been applied in forests, watersheds, and agricultural areas in several areas of the world, and it may be effective for fisheries as well. The mechanism of PES includes a provider, an environmental service, and a buyer (Wunder et al. 2008).

Box 5 Local knowledge and payments for environmental services (PES)

Payments for environmental services have been a form to drive stakeholders to participate in co-management processes. There are many examples of this mechanism, and the 2010 volume of *Ecological Economics* brings many examples and insights. In Brazil, in particular, there are examples in water programmes (Rodrigues et al. 2012) as well as in the Amazon, analysing REDD + (Scriven 2012), among others.

a) Vinha et al. (2010: 10) have explained how payments for environmental services could work in the Arraial do Cabo fishery, Rio de Janeiro State:

'Artisanal fishing communities or individuals will receive a payment for both attitudes: no fishing in specific areas at certain periods (the meaning of "defeso" policy), and monitoring and restricting access to the fishing areas (pesqueiros) against industrial fishers, recreational fishers, and divers, among others. Payment can be made in the form of the 'defeso', a PES already occurring in Brazil'.

b) Begossi et al. (2012b) have observed the critical environmental situation of some reef species, such as groupers and snappers. Some of these species are already considered to be endangered or vulnerable. These species exhibit late maturation and slow growth. The authors have suggested that fishers need to be stimulated to preserve reef species. Indeed, some species, such as the grouper, *Epinephelus marginatus*, are targets of fishing and are urgently in need of management. The study suggests that fishers should be given the motivation to conserve reef fish, to apply local knowledge to these dataless fisheries, and to use co-management processes to associate protected areas with the help and participation of artisanal fishers. Monitoring of reef resources in collaborative processes with fishers as well as funding through PES (by payments to fishers for help with monitoring areas and species) is proposed. The use of local knowledge in this case is crucial. Fishers tend to be more likely to help when they feel that what they know about fish is of interest to researchers and managers. Knowledge of fish biology and ecology is important. This knowledge includes information on fish diet, habitat, migratory behaviour, and more (Silvano and Begossi 2005; Begossi and Silvano 2008). Methods for accessing this knowledge among small-scale fishers in Brazil have been published elsewhere (Begossi 2008; Leite and Gasalla 2013; Silvano and Valbo-Jorgensen 2008)

c) Suggestions for applying PES into the Paraty fishery have also paralleled the studies mentioned above (Begossi et al. 2011b)

Box 5 presents representative suggestions for the application of PES to artisanal fisheries. These suggestions recognize the necessity of developing mechanisms to enlist the engagement and the interest of the affected communities in conserving biodiversity.

An integrated example of a management system is the co-management in riverine Amazonian communities through 'sustainable extractive reserves'. Such management combines the management of natural resources, food security, health, sanitation, and other social and economic aspects of local populations. The first sustainable extractive reserve in Brazil is Mamirauá in Amazonas State (<http://www.mamiraua.org.br/>).

6 Conclusions

We conclude that all the paradigms cited in 'Appendix' form the basis of important theories and methods that supported the development of cultural ecology. These theories are complementary and useful for understanding the dynamics of the current systems of the caíças and of the artisanal fisheries of the SE coast of Brazil.

In particular, the commonality of kinship associated with the use, processing, and marketing of local natural resources extracted from the Atlantic Forest coast and from the adjacent marine and estuarine areas is still important when management processes of the natural resources are considered. The main point is to tie a tier or scale of kin-based group to a society where the market and the economy play the main roles. PES could provide such a link.

The historical processes of the *caíças* (Box 3) show that families and communities have been tied to market regional exchanges, as they continue to be through fishing and tourism.

Adaptive processes, through complex adaptive systems, suggest analysis specifying economic actors and their behaviours (Axelrod and Cohen 2000). Ostrom (2005) suggested a local level of analysis, the action arena, but inserted in tiers of different scales; Berkes (2010) recommended policies that consider uncertainty and change ('Appendix'). These are complementary processes that can be considered when we break the traditional idea of 'community', 'class association', and 'local organization' and start dealing with groups of interests. In the case of the *caíças* of the Atlantic Forest coast, where kinship ties and groups of extractors can have their own interests, addressing management through families or groups may be a driver to stimulate interest in participating in negotiations concerning the extraction and use of natural resources.

We finally conclude by suggesting the decentralization of negotiation processes, of the action arenas, and of the specific purposes of management. This decentralization is suggested through the illustrative case of the *caíças* of the Atlantic Forest coast, particularly in Paraty, Rio de Janeiro.

The following suggestions take inspiration from human ecology and related areas.

1. The local culture and the local economy of the population of fishers should be considered. This interaction of the culture and the economy could support conservation in most tropical artisanal fisheries that depend upon fish for their living. Such fisheries are often run by poor rural people whose economic dependence on fish can turn conservation into a conflict between food and resources.
2. In this regard, it is wise to stimulate fishers to work in association with researchers using their local knowledge. Such cooperation is especially critical when there are no systematic data available, as is the case for tropical artisanal fisheries.
3. Co-management processes are especially crucial because they are the processes through which a dialogue between public policies and artisanal fisheries can occur. It is important to include local institutions, such as local rules, as well as local knowledge.
4. Finally, ecological-economic stimuli can support co-management initiatives. Here, I suggest that payments for environmental services could represent an appropriate mechanism. Through a payment for helping conserving biodiversity, the *caíças* could be then prone to participate in local management and green economic demands.¹

Acknowledgments I am grateful to the University of Greenwich in London, UK, for the keynote invitation to the conference 'It's not just about the fish', social and cultural perspectives of sustainable marine fisheries (<http://www.gre.ac.uk/sci/conf/fisheries>) and for support, and to Julie Urquhart for suggestions on this manuscript. I wish to thank Katja Neves-Graça for stimulating a very fruitful debate before on the meeting *Nature™ Inc.* (held at The Hague, ISS, in July 2011), which stimulated the production of some sessions of this paper; anonymous referees from ENVI deserve to be acknowledged since they read carefully the manuscript and enriched it through valuable suggestions; finally, I thank FAPESP (grants # 07/58700-7 and 09/11154-3), IDRC/UNICAMP (grant # 104519-004.y), and CNPq (productivity scholarship).

Appendix

See Table 1.

¹ For information and overall debate on such demands as well analysis on green economy, I suggest to consult the ISEE Conference Proceedings on <http://www.isee2012.org/anais/> (*Ecological Economics and Rio +20: challenges and contributions for a green economy*, Rio de Janeiro, Brazil, June 16–19, 2012).

Table 1 Some related concepts of subsistence, kinship, market, and culture: production, reproduction, and social structures

References in chronological order	Main structure	Research tools	Position of exchange and market within culture	Named paradigm or hypothesis	Level of analysis
Proudhon (1840, 1847)	Property ^a : domain and possession: <i>jus in re</i> , 'the right in a thing', and <i>jus ad rem</i> , 'the right to a thing'. In the first, possession and property are united; the second refers to naked property Primitive societies, the original communism, no property (Classical affirmations: 'property is robbery', 'misery is an effect of labour')	Sociability and cooperation—three degrees of sociability: the first, the similarity among ourselves, is reciprocity; the second, justice, is the recognition of equality between the others and our own; and the third, equitability, is determined by associations—communication (<i>Equité</i>)	Labour originates private possession, or property, the 'right in a thing'; it is the principle of proportionality of values; to eliminate scarcity, labour should be organized. Complex and modern society having as its basis property. Depends on sociability, justice, and equitability.	Cooperatives and working associations; peasant ownerships, instead of private property or nationalization for transforming society. Concepts of justice and social revolution through reforms.	Societies, economic subsystems
Marx and Engels (1845–1846, 1977), Engels (1884)	History, or the action of man upon nature; how and what is produced The history of nature and the history of man: these are not separable because they have reciprocal conditions. Ownership is firstly tribal; second, it is ancient communal and state; third, it is feudal or estate property, and then modern private property. Satisfaction of first needs, and production of new needs, the first historical act; consciousness, the beginning of a social product	Means of subsistence, production, and reproduction; in tribal societies, social structure is an extension of the family. Production of life: the natural and the social relationship (cooperation—a productive force—mode of production)	The first ownership is tribal and based on the natural division of labour within the family; organization is restricted by conditions of production; trade and manufacture: accumulation of capital. Social institutions are not unchanging or eternal but come in periods of history as a result of socio-economic conditions Money entering natural economy ('a corroding acid', p. 111)	Historical materialism: the materialist concept of history as a science of society. It embodies concepts such as of mode of production, of relations of production, of the economic structure of the society from which emerges the legal and political superstructure, among other concepts and processes.	Societies

Table 1 continued

References in chronological order	Main structure	Research tools	Position of exchange and market within culture	Named paradigm or hypothesis	Level of analysis
Marx (1867)	Technology's transforming nature for sustaining life, giving rise to social relations and to mental conceptions that flow from them	A mode of production comprises an economic structure which forms the basis from which the superstructure is raised (juridical and political, social forms, and thought). Economy: productive forces (material aspects) and relations of production (producers and work). Use of commodities is dependent upon social conditions (and class conflicts)	Means of production and subsistence seen as capital as well as money and commodities; money is converted to capital, and capital to a source of surplus value	Historical materialism	Societies
Polanyi (1944) (reprinted in 1957)	Economy is submerged in social relationships (p. 48). Behaviours associated with economics (three principles): reciprocity, redistribution, and householding. The economic system of the market is a consequence of the organization of the society (the economic order is a function of the social order)	Historical analysis of socio-economic systems.	Tribal society: Patterns of reciprocity, fulfilled by rewards of generosity, bringing social prestige. Examples: reciprocity and kinship, the Kula in Melanesia; the potlatch of the Kwakiutl The market: a meeting place for the purpose of barter, buying or selling (p. 59)	Social relations are embedded within the economic; the economic society (by the market) as a consequence of the organization of society.	Macro-level in two dimensions: a) Temporal: historical analysis b) Socio-economic: Societies

Table 1 continued

References in chronological order	Main structure	Research tools	Position of exchange and market within culture	Named paradigm or hypothesis	Level of analysis
Steward (1955, 1979)	<p><i>Culture core</i>—the constellation of features that are most closely related to subsistence activities and economic arrangements (p. 37)</p> <p>Economy and subsistence</p> <p>The core: social, political, and religious, associated with subsistence and economy</p> <p>Cultural regularities (cultural subsystems), cultural types^b</p>	<p>Three procedures: 1) <i>material culture</i>: technology and environment; 2) behavioural patterns, cooperation; 3) secondary or other aspects of culture, such as demography, kinship (social organization)</p>	<p>Classes as sociocultural groups; the culture core as economic, social, political, religious, and military, parts of cultural types.</p> <p>The market is then within the culture core, as the features of the culture core contain structural relationships (p. 94)</p>	<p>Adaptation to environment; cultural ecology (cultural-environment situations)</p>	<p>Cultural subsystems (patrilineal bands, irrigation economies)</p>
Terray (1972)	<p>Example of Guro Society, Ivory Coast (two systems of relation of production, extraction, and cultivation)</p> <p>The lineage system influences the distribution of the catch; the tribal-village system operates inside the village.</p>	<p>Cooperation: Simple (limited to number and duration) and complex (collective work with division of labour)</p> <p>Analysis of exchange and cooperative systems: importance of kinship as an interplay of the economic, juridical-political, and ideological phases of the mode of production (p. 145)</p>	<p>Mercantile production becomes capitalist when labour itself becomes merchandize.</p> <p>In self-subsistence systems, the production and consumption units are not divorced units within a household; these are organized by kinship relations.</p>	<p>Historical materialism applied to economic anthropology</p>	<p>Societies</p>

Table 1 continued

References in chronological order	Main structure	Research tools	Position of exchange and market within culture	Named paradigm or hypothesis	Level of analysis
Sahlins (1976)	Material aspects depend upon culture: 'in bourgeois society, material production is the dominant locus of symbolic production; in primitive society, it is the set of social (kinship) relations' (p. 212)	Symbolic meanings; symbolic structures in material utility	Economy, sociopolitical and ideological: in primitive societies, these are organized within a kinship structure. Economy is the dominant institutional locus in Western society: in that regard, the relations of production occur in the entire cultural scheme; 'rational production for gain is in one and the same motion the production of symbols' (p. 215)	Symbolism; symbolic structures of culture; modes of symbolic production	Culture, culture subsystems
Harris (1979)	<i>Infrastructure</i> : mode of production and reproduction, the interface between culture and nature <i>Structure</i> : domestic and political economy <i>Superstructure</i> : behavioural, arts, rituals, science, etc	<i>Etics</i> (native informant) and <i>emics</i> (observers) concepts and tools ^c	Patterns of exchange (p. 64: reciprocity, trade, market, and relationships of production, among others) as part of the structure and superstructure ^d . Feedbacks between political economy and infrastructure	Cultural Materialism: a non-Hegelian strategy rooted on David Hume and British empiricists, approaching interactions between thought and behaviour, among others (preface, Harris 1979)	Individuals and populations: Behavioural choices made by individuals and aggregates in response to sociocultural system

Table 1 continued

References in chronological order	Main structure	Research tools	Position of exchange and market within culture	Named paradigm or hypothesis	Level of analysis
Axelrod and Cohen (2000) Here also literature on altruism, reciprocal altruism, and cooperation is related, especially the one based on evolutionary theory, through authors:	Complexity can be harnessed Change processes create variation; populations have structure, interaction patterns and market clearing ^e , as emergent properties of a system taken from Adam Smith, 1776. Evolutionary adaptation as a result of mutation and differential reproduction, from Darwin, 1859 Thus, theories are from decentralized market and biological evolution	Variation, interaction, and selection compose the key processes of complex adaptive systems Complexity differs from chaos; chaos indicates situations that are highly disordered and unmanageable; complexity deals with many interactions, but that permit intervention. Change, how strategies change over time	When analysing economic markets, there is a need to specify economic actors, how they generate variety in behaviour, how they interact, and how actors and their strategies are selected for retention, amplification, or extinction Concepts Agent, strategy, population of agents	Complex adaptive systems: based upon evolutionary biology, computer science, and social design (organization theory and game theory)	Individuals and populations
Axelrod (1984, 1997), Hawkes (1992), Trivers (1986); see special volume of <i>Philosophical Transactions of the Royal Society B</i> (2010)	Understanding institutions: prescriptions that human use to organize all forms of repetitive and structured actions. Action arenas: they are based on action situation and participant, where a particular action occurs What affects structure of an action arena: rules, biophysical world, communities.	Are there universal building blocks used in crafting structured situations? Components and layers Multilayer conceptual maps	Exclusion: difficulty excluding those who benefit from a good or service. Subtractability: the extent to which one individual uses subtracts for the consumption of others. Definition of public, private goods and common-pool resources	Institutional analysis and development framework IAD Game theory Agent-based models <i>Holons</i> (nested subassemblies of complex adaptive systems)	Institutions The focal level of analysis: action arena. Rules: strategies adopted by participants within ongoing situations
Ostrom (1990, 2005)					

Table 1 continued

References in chronological order	Main structure	Research tools	Position of exchange and market within culture	Named paradigm or hypothesis	Level of analysis
Berkes (2010)	A focus on fisheries Social and ecological aspects of the management of fisheries are associated; integrated social-ecological systems Uncertainty admitted and holistic approaches	Resilience concepts dealing with uncertainty. Ecosystems are changing and show multiple stable states Ability to renew and reorganize in the face of disturbances	Living with uncertainty and adapting to change; ability to deal with change; policy options for dealing with uncertainty and change Drivers and change processes	Complex adaptive system: based on resilience concepts and on the assumption that uncertainty is part of the system; learning by doing	Ecosystems
Boyd and Richerson (1985), Boyd et al. (2011) Also: Cavalli-Sforza and Feldman (1981), Cloak (1975), among others.	Forces of cultural evolution (biased transmission, for example) and imitation as drivers for cultural evolution	Coevolutionary processes of culture and genes, culture is transmitted through a system of inheritance	Reciprocity and cooperation: conformist transmission (common type favoured)—mechanisms of reciprocity and punishment can stabilize behaviours, including social cooperation	Based on evolutionary theory, models of cultural evolution linking macroscopic patterns of behaviours and microscopic details of individuals.	Individuals/ Population

^a The understanding of property here is of overwhelming importance, as conservation and management have been based on the delimitation of property rights or property limits, among others

^b A cultural type consists of core features determined by cross-cultural regularities of cultural ecological adaptation, representing a level of sociocultural integration (Steward 1955, 1979: 89)

^c For an understanding of etics and emics, see also Harris (1976), Headland et al. (1990), and Pike (1954)

^d Clearly, some aspects of ownership and exchange will never be predicted simply from knowledge of the demographic, technological, economic, and environmental components (Harris 1979: 65)

^e Hidden hand is that sense of mystery about how market works, since Adam Smith wrote that Market activities are coordinated by a 'hidden hand' (Lindblom 2001: 3)

^f Market clearing is the market price based on the law of supply and demand

References

- Acheson, J. M. (1981). Anthropology of fishing. *Annual Review of Anthropology*, 10, 275–316.
- Acheson, J. M. (2003). *Capturing the commons*. Lebanon, USA: University Press of New England.
- Acheson, J. M., & Knight, J. (2000). Distribution of fights, coordination games, and lobster management. *Comparative Studies on Society and History*, 42, 209–238.
- Axelrod, R. (1984). *The evolution of cooperation*. New York: Basic Books.
- Axelrod, R. (1997). *The complexity of cooperation*. Princeton: Princeton University Press.
- Axelrod, R., & Cohen, M. D. (2000). *Harnessing complexity*. New York: Basic Books (kindle edition, Amazon.com).
- Begossi, A. (1992). Food taboos at Búzios Island (Brazil): Their significance and relation to folk medicine. *Journal of Ethnobiology*, 12, 117–139.
- Begossi, A. (1993). Ecologia humana: um enfoque das relações homem-ambiente. *Interciência*, 18(3), 121–132.
- Begossi, A. (1995). Fishing spots and sea tenure in Atlantic Forest coastal communities: Incipient forms of local management. *Human Ecology*, 23(3), 387–406.
- Begossi, A. (1996a). The fishers and buyers from Búzios Island (Brazil): Kin ties and production. *Ciência e Cultura*, 48(3), 142–147.
- Begossi, A. (1996b). Fishing activities and strategies at Búzios Island (Brazil). In R. M. Meyer, C. Zhang, M. L. Windsor, B. J. McCay, L. J. Hushak, & R. M. Muth (Eds.), *Proceedings of the world fisheries congress, Theme 2*, (pp. 125–141), Athens, May 1992. Calcutta, India: Oxford & IBH Publishing CO. PVT. LTD.
- Begossi, A. (1998). Property rights for fisheries at different scales: Applications for conservation in Brazil. *Fisheries Research*, 34, 269–278.
- Begossi, A. (2006). The ethnoecology of Caiçara metapopulations (Atlantic Forest, Brazil): Ecological concepts and questions. *Journal of Ethnobiology and Ethnomedicine*, 2, 40. www.ethnobiomed.com/content/2/1/40 (Online).
- Begossi, A. (2008). Local knowledge and training towards management. *Environment, Development and Sustainability*, 10, 591–603.
- Begossi, A. (2010). Small-scale fisheries in Latin America: Management models and challenges. *MAST*, 9(2), 7–31.
- Begossi, A. (2011). O cerco flutuante e os caiçaras do litoral norte de SP, com ênfase a pesca de Trindade. *RJ. Interciência*, 36(11), 803–807.
- Begossi, A., & Richerson, P. J. (1992). The animal diet of families from Buzios island: An optimal foraging approach. *Journal of Human Ecology*, 3(2), 433–458.
- Begossi, A., & Silvano, R. A. M. (2008). Ecology and ethnoecology of dusky grouper (*Epinephelus marginatus* (Lowe, 1834)) along the coast of Brazil. *Journal of Ethnobiology and Ethnomedicine*, 4. www.ethnobiomed.com/content/4/1/20 (Online).
- Begossi, A., Leitão-Filho, H. F., & Richerson, P. J. (1993). Plant uses at Búzios Island (SE Brazil). *Journal of Ethnobiology*, 13(2), 233–256.
- Begossi, A., Hanazaki, N., & Ramos, R. (2004). Food chain and the reasons for food taboos in the Amazon and in the Atlantic Forest coast. *Ecological Applications*, 14(5), 1334–1343.
- Begossi, A., Lopes, P. F., Oliveira, L. E. C., & Nakano, H. (2010). *Ecologia de Pescadores da Baía da Ilha Grande*. São Carlos: Ed. RIMA.
- Begossi, A., May, P. H., Lopes, P. F., Oliveira, L. E. C., Vinha, V., & Silvano, R. A. M. (2011a). Compensation of environmental services from artisanal fisheries in SE Brazil. *Ecological Economics*, 71, 25–32.
- Begossi, A., Salivonchik, S. V., Araujo, L., Andreoli, T. B., Clauzet, M., Martinelli, C. M., et al. (2011b). Ethnobiology of snappers (Lutjanidae): Target species and suggestions for management. *Journal of Ethnobiology and Ethnomedicine*, 7, 11. <http://www.ethnobiomed.com/content/7/1/11> (Online).
- Begossi, A., Lopes, P., & Silvano, R. (2012a). Co-management of reef fisheries of the snapper-grouper complex in a human ecological context in Brazil. In G. H. Kruse, H. I. Browman, K. L. Cochrane, D. Evans, G. S. Jamieson, P. A. Livingston, et al. (Eds.), *Global progress in ecosystem-based fisheries management* (pp. 353–373). Fairbanks: Alaska Sea Grant, University of Alaska. doi:10.4027/gpebfm.2012.018 (Online).
- Begossi, A., Salivonchik, S. V., Lopes, P., Nora, V., Silvano, R. A. M. (2012b). The Paraty artisanal fishery (southeastern Brazilian coast): Ethnoecology and management of a social-ecological system (SES). *Journal of Ethnobiology and Ethnomedicine*, 8, 22. <http://www.ethnobiomed.com/content/8/1/22>.
- Berkes, F. (2008). *Sacred ecology*. New York: Routledge.

- Berkes, F. (2010). Shifting perspectives on resource management: Resilience and the reconceptualization of 'Natural Resources' and 'Management'. *MAST*, 9(1), 13–40.
- Bernardes, L. M. C., & Bernardes, N. (1950). A pesca no litoral do Rio de Janeiro. *Revista Brasileira de Geografia*, 2–53.
- Bloch, M. (1983). *Marxism and anthropology*. Oxford: Oxford University Press.
- Boyd, R., & Richerson, P. J. (1985). *Culture as an evolutionary process*. Chicago: University of Chicago Press.
- Boyd, R., Richerson, P. J., & Henrich, J. (2011). Rapid cultural adaptation can facilitate the evolution of large-scale cooperation. *Behavioral Ecology and Sociobiology*, 65, 431–444.
- Brosnan, S. F., Salwiczek, L., & Bshary, R. (2010). The interplay of cognition and cooperation. *Philosophical Transactions of the Royal Society B*, 365, 2699–2710.
- Camargo, E., & Begossi, A. (2006). *Os diários de campo da Ilha dos Búzios*. São Paulo: Ed. HUCITEC.
- Cavalli-Sforza, L. L., & Feldman, M. W. (1981). *Cultural transmission and evolution*. Princeton: Princeton University Press.
- Cloak, F. T. (1975). Is cultural ethology possible? *Human Ecology*, 3, 161–182.
- Cook, S. (2006). Commodity cultures, Mesoamerica and Mexico's changing indigenous economy. *Critique of Anthropology*, 26, 181–208.
- Dean, W. (1995). *With broadax and firebrand*. Berkeley: University of California Press (kindle Ed., Amazon Pub.).
- Defeo, O., & Castilla, J. C. (2012). Governance and governability of coastal shellfisheries in Latin America and the Caribbean: Multi-scale emerging models and effects of globalization and climate change. *Environmental Sustainability*, 4, 344–350.
- Diegues, A. C. (1983). *Pescadores, camponeses e trabalhadores do mar*. São Paulo: Editora Ática.
- Diegues, A. C. (2004). A mudança como modelo cultural: o caso da cultura caiçara e a urbanização. In *Enciclopédia Caiçara*, (Vol. 3, pp. 21–48), A. C. Diegues (Org.). São Paulo: Ed. HUCITEC, São Paulo.
- Diegues, A. C. (2005). Esboço de história ecológica e social caiçara. In *Enciclopédia Caiçara*, (Vol. 4, pp. 273–319), A. C. Diegues (Org.). São Paulo: Ed. HUCITEC São Paulo.
- Emlen, J. T. (1966). The role of time and energy in food preference. *American Naturalist*, 100, 611–617.
- Engel, S., Pagiola, S., & Wunder, S. (2008). Designing payments for environmental services in theory and practice: An overview of the issues. *Ecological Economics*, 65, 663–674.
- Engels, F., 1884 (1972). *On the origin of the family, private property, and the state*. New York: Pathfinder Press.
- França, A. (1954). A ilha de São Sebastião: estudo de geografia humana. *Boletim 178, Geografia no. 10*. São Paulo: Universidade de São Paulo.
- Gelcich, S., Kaiser, M. J., Castilla, J. C., & Edward-Jones, G. (2008). Engagement in co-management of marine benthic resources influences environmental perceptions of artisanal fishers. *Environmental Conservation*, 35(1), 36–45.
- Gelcich, S., Defeo, O., Iribarne, O., Del Carpio, G., DuBois, R., Horta, S., et al. (2009). Marine ecosystem-based management in the Southern Cone of South America: Stakeholder perceptions and lessons for implementation. *Marine Policy*, 33, 801–806.
- Grafton, R. Q., Hilborn, R., Ridgeway, L., Squires, D., Williams, M., Garcia, S., et al. (2008). Positioning fisheries in a changing world. *Marine Policy*, 32, 630–634.
- Harris, M. (1976). History and significance of the emic/etic distinction. *Annual Review of Anthropology*, 5, 329–350.
- Harris, M. (1977). *Cannibals and kings, the origin of cultures*. New York: Vintage Books.
- Harris, M. (1979). *Cultural materialism*. New York: Vintage books.
- Harris, M. (1985). *Sacred cow and the abominable pig*. New York: A Touchstone book.
- Hawkes, K. (1992). Sharing and collective action. In *Evolutionary ecology and human behavior* (pp. 269–300). New York: Aldine de Gruyter.
- Headland, T. N., Pike, K. L., & Harris, M. (1990). *Emics and etics/The insider/outsider debate. Frontiers in Anthropology* (Vol. 7). Newbury Park: Sage Publications.
- Johannes, R. E. (1981). *Words of the lagoon*. Berkeley: University of California Press.
- Jones, P. J. S. (2013). Governing protected areas to fulfill biodiversity conservation obligations: From Habermasian ideals to a more instrumental reality. *Environment, Development and Sustainability*, 15, 39–50.
- Leite, M. C. F., & Gasalla, M. A. (2013). A method for assessing fishers' ecological knowledge as a practical tool for ecosystem-based fisheries management: Seeking consensus in Southeastern Brazil. *Fisheries Research*, 145, 45–53.
- Lindblom, C. E. (2001). *The market system*. New Haven: Yale University Press.

- Lopes, P. F. M. (2010). A pesca na Baía da Ilha Grande. In A. Begossi, P. F. Lopes, & O. L. E. C. Nakano (Eds.), *Ecologia de Pescadores da Baía da Ilha Grande* (pp. 103–178). São Carlos: Ed. RIMA.
- Lopes, P. F. M., & Begossi, A. (2008). Temporal changes in caíçara artisanal fishing and alternatives for management: A case study on the southeastern Brazilian coast. *Biota Neotropica*, 8(2), 100–110.
- Lopes, P. F. M., Rosa, E. M., Salyvonchik, S., Nora, V., & Begossi, A. (2013). Suggestions for fixing top-down coastal fisheries management through participatory approaches. *Marine Policy*, 40, 100–110.
- MacArthur, R. A., & Pianka, E. R. (1966). On optimal use of a patchy environment. *The American Naturalist*, 100, 603–609.
- Marcílio, M. L. (1986). *Caíçara, terra e população*. São Paulo: Edições Paulinas.
- Marx K.(1867). *Das Kapital*. Kindle Ed. (Amazon.com).
- Marx, K., & Engels, F. (1845–6, 1977). *A ideologia alemã*. São Paulo: Editorial Grijalbo, São Paulo.
- McCay, B. J. (1981). Optimal foragers or political actors? Ecological analysis of a New Jersey fishery. *American Ethnologist*, 8, 356–381.
- McCay, B. J., & Acheson, J. (1987). *The question of the commons: The culture and ecology of communal resources*. Tucson: University of Arizona Press.
- McGrath, D., de Castro, F., Futemma, C., & do Amaral, B. D. (1993). Fisheries and the evolution of resource management on the lower Amazon floodplain. *Human Ecology*, 21, 167–195.
- Mussolini, G. (1980). *Ensaio de antropologia indígena e caíçara*. Rio de Janeiro: Editora Paz e Terra.
- Nemec, T. F. (1972). I fish with my brother: The structure and behavior of agnatic-based fishing crews in a Newfoundland Irish outpost. In R. Andersen & C. Wadel (Eds.), *North Atlantic fishermen* (pp. 9–34). Newfoundland: Memorial University of Newfoundland, University of Toronto Press.
- Nogara, P. J. N.(2000). Proteção e gestão participativa dos recursos pesqueiros do Saco do Mamanguá, Paraty, Rio de Janeiro. In A. C. Diegues, V. Viana, M. (orgs.). (Eds.), *Comunidades tradicionais e manejo dos recursos naturais da Mata Atlântica* (pp.131–142). São Paulo: NUPAUB, ESALQ.
- Obura, D. (2012). Coral reefs and society—finding a balance? *Oryx*, 46(4), 467–468.
- Olson, M. (1965). *The logic of collective action: Public goods and the theory groups*. Cambridge: Harvard University Press.
- Orlove, B. J. (1980). Ecological anthropology. *Annual Review of Anthropology*, 9, 235–273.
- Orlove, B. (2002). *Lines in the water, nature and culture on Lake Titicaca*. Berkeley: University of California Press.
- Ostrom, E. (1990). *Governing the commons*. Cambridge: Cambridge University Press.
- Ostrom, E. (2005). *Understanding institutional diversity*. Princeton: Princeton University Press.
- Ostrom, E. (2007). A diagnostic approach for going beyond panaceas. *PNAS*, 104(39), 15181–15187.
- Peroni, N., Begossi, A., & Hanazaki, N. (2008). Artisanal fisher's ethnobotany: From plant diversity use to agrobiodiversity management. *Environment, Development and Sustainability*, 10, 623–637.
- Pike, K. L. (1954). *Language in relation to a unified theory of the structure of human behavior* (Vol. 3). Glendale, CA: Summer Institute of Linguistics.
- Pinkerton, E., & John, L. (2008). Creating local management legitimacy. *Marine Policy*, 32, 680–691.
- Pita, C., Theodossiou, I., & Pierce, G. J. (2013). The perceptions of Scottish inshore fishers about marine protected areas. *Marine Policy*, 37, 254–263.
- Plante, S., & Breton, Y. (2005). Espaço, Pesca e turismo em Trindade. In Y. Breton, S. Plante, C. Benazera, & J. Cavanagh (Eds.), *Enciclopédia caíçara, o olhar estrangeiro* (pp. 21–74), Diegues A. C. (org.). São Paulo: Editora Hucitec.
- Polanyi, K. (1944, 1957). *The great transformation*. Boston: Beacon Press.
- Proudhon, P. J. (1840). *What is property? An inquiry into the principle of right and government*. Brad K. Berner Pub. (kindle version, Amazon Books).
- Proudhon, P. J (1847, 2007). *The philosophy of misery*. New York: Cosimo, Inc. (kindle version, Amazon Books).
- Pyke, G. H. (1984). Optimal foraging theory: A critical review. *Annual Review of Ecology*, 15, 523–575.
- Rapport, D. J., & Turner, J. E. (1977). Economic models in ecology. *Science*, 195, 367–373.
- Reid, W. V., Chen, D., Goldfarb, L., Hackmann, H., Lee, Y. T., Mokhele, K., et al. (2010). Earth system science for global sustainability: Grand challenges. *Science*, 330, 916–917.
- Richerson, P. J., & Boyd, R. (2005). *Not by genes alone*. Chicago: Chicago University Press.
- Rodrigues, D. B. B., Oliveira, P. T. S., Sobrinho, T.A., & Mendiondo, E. S. (2012). Hydrological benefits in the context of Brazilian environmental services programs. doi. [10.1007/s10668-012/9424-y](https://doi.org/10.1007/s10668-012/9424-y).
- Rosenberg, P (Ed.). (1987). Common name index: Poisonous animals, plants and bacteria. *Toxicon*, 25, 799–890.
- Ruddle, K., & Hickey, F. R. (2008). Accounting for the mismanagement of tropical nearshore fisheries. *Environment, Development, and Sustainability*, 10(5), 565–589.
- Sahlins, M. (1976). *Culture and practical reason*. Chicago: The University of Chicago Press.

- Scriven, J. (2012). Developing REDD + policies and measures from the bottom-up to the buffer zones of Amazonian protected areas. *Environment, Development, and Sustainability*, 14. doi:10.1007/s10668-012/9350-z.
- Silvano, R. A. M., & Begossi, A. (2005). Local knowledge on a cosmopolitan fish. Ethnoecology of *Pomatomus saltatrix* (Pomatomidae) in Brazil and Australia. *Fisheries Research*, 71, 43–59.
- Silvano, R. A. M., & Valbo-Jorgensen, J. (2008). Beyond fishermen's tales: Contributions of fishers' local ecological knowledge to fish ecology and fisheries management. *Environment, Development and Sustainability*, 10, 657–675.
- Solomon, J., Jacobson, S. K., & Liu, I. (2012). Fishing for a solution: Can collaborative resource management reduce poverty and support conservation? *Environmental Conservation*, 39, 51–61.
- Jentoft, S. (2003). Co-management the way forward. In D. C. Wilson, J. R. Nielsen & D. Degnbol (Eds.), *Fisheries co-management experiences* (pp. 1–14). Dordrecht: Kluwer Academic Publisher.
- SOS Mata Atlântica. (2012). <http://www.sosma.org.br/5697/sos-mata-atlantica-e-inpe-divulgam-dados-do-atlas-dos-remanescentes-florestais-da-mata-atlantica-no-periodo-de-2010-a-2011/>.
- Vinha V., May P., & Begossi, A. (2010). Payments to avoid overfishing: PES potential for the Arraial Cabo Resex in Brazil. Paper present at the XI conference of the international society for ecological economics, August 28, 2010, Oldenburg/Bremen, Germany. www.isee2010.org (Online).
- Steward, J. (1955, 1979). *Theory of culture change*. Urbana: University of Illinois Press.
- Terray, E. (1972). *Marxism and primitive societies*. New York: Monthly Review Press.
- Trimble, M., & Johnson, D. (2013). Artisanal fishing as an undesirable way of life? The implications for governance of fishers' wellbeing aspirations in coastal Uruguay and southeastern Brazil. *Marine Policy*, 37, 37–44.
- Trivers, R. (1986). *Social evolution*. Menlo Park: The Benjamin/Cummings Pub. Co.
- Vinha, V., May, P., & Begossi, A. (2010). *Payments to avoid overfishing: PES potential for the Arraial Cabo Resex in Brazil*. Paper present at the XI Conference of the International Society for Ecological Economics, August 28, 2010, Oldenburg/Bremen, Germany. www.isee2010.org (online).
- White, L. (1943). Energy and the evolution culture. *American Anthropologist*, 45, 335–356.
- Willems, E. (1952). *Búzios island*. Seattle: Seattle University Press.
- Wilson, E. O. (1998). *Consilience*. New York: Alfred A. Knopf.
- Winterhalter, B., & Smith, E. (1981). *Hunter-gatherer foraging strategies*. Chicago: University of Chicago Press.
- Wunder, S., Engel, S., & Pagiola, S. (2008). Taking stock: A comparative analysis of payments for environmental services programs in developed and developing countries. *Ecological Economics*, 65, 834–852.
- Zanetell, B. A., & Knuth, B. A. (2002). Bribing biodiversity: Corruption, participation, and community-based management in Venezuela. *Southern Rural Sociology*, 18(2), 130–161.