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Ocean & Coastal Management 89 (2014) 117–126

Contents lists available at ScienceDirect

Ocean & Coastal Management

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

Commentary

Marine ethnobiology a rather neglected area, which can provide an important contribution to ocean and coastal management

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ARTICLE INFO

Article history:
Available online 26 October 2013

ABSTRACT

This report describes marine ethnobiology as it has been presented and discussed under the conference session "Ethnothalassic interactions" organized for the 13th International Congress of Ethnobiology. We define marine ethnobiology as a field within ethnobiology that specifically comprises the study of the relationships of present and past human societies to marine biota and ecosystems. The session stimulated discussion on this emerging field and its contribution to coastal and ocean management, by exchanging experiences on a diverse array of studies within this field that include: co-management of marine protected areas, seascape management, demise, re-discovery and re-implementation of traditional knowledge-based management schemes, history of artisanal shellfish-farming and of the management of artisanal fisheries, medicinal knowledge of algae, as well as the outreach of ethnobiological studies for the conservation of the cultural-ecological heritage in the coastal zone. We here offer the conclusions of the conference session in the form of a *longue duree* perspective on coastal management that highlights a broad array of human adaptations to coastal environments. We suggest that these adaptations have to be researched and understood in detail in order to incorporate them into broader coastal management strategies in the presence of the severe environmental and political-economical pressures that currently threaten fishing stocks, marine habitats, and the livelihoods of the 2.6 billion people that depend on the oceans as their main source of protein.

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http://dx.doi.org/10.1016/j.ocecoaman.2013.09.014

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1. Introduction

1.1. "Ethnothalassic interactions" a session dedicated to marine ethnobiology during the 13th congress of the international society of ethnobiology (May 2012, Montpellier)

In order to raise the interest for marine and coastal issues in ethnobiology, we organized a special session during the 13th congress of the international society of ethnobiology (May 2012, Montpellier, France) with the title "ethnothalassic interactions". The discipline of ethnobiology has no general accepted definition, but it is widely understood that it comprises the study of the complex set of relationships of present and past human societies to living nature (see Berlin, 1992). Ethnobiological studies are of important intellectual transcendence as human use of living nature is not limited to obtaining food, garments, and tools (Castetter, 1935; Schultes, 1992), as they are also extremely important for theory building in the fields of human health (Erickson, 2008; Heinrich et al., 2006), biodiversity conservation (Alves and Rosa, 2005; Rosa et al., 2005), evolutionary medicine (De Britto and Mahesh, 2007; Huffman, 2001; Huffman and Seifus, 1989), and human cognition (Etkin, 1988; Forth, 2012). Ethnobiological knowledge is also fundamental in understanding human relationship with plants and animals comprising culinary traditions (Pieroni et al., 2009) and economic aspects (Godoy et al., 2006; Vestal and Schultes, 1981), as well as for (i) habitational (Rijal, 2008; Speck and Dexter, 1952), (ii) religious (Reis and Hibbeld, 2006), (iii) ornamental (Motte-Florac et al., 2012; Ryerson, 1976), (iv) ludic (Ruan-Soto et al., 2006), (v) sexual (Andrade and Costa-Neto, 2005), and (vi) medicinal (Balick et al., 1996; Berlin and Berlin, 1996; Schultes, 1988) uses. All these relationships also include the organisms living in the marine environment, and while acknowledging the importance of the ethnothalassic interactions, we define marine ethnobiology as a field within ethnobiology that specifically comprises the study of the relationships of present and past human societies to marine biota and ecosystems.

With nearly 40% of the human population living within 100 km from the sea (Millennium Ecosystem Assessment, 2005) and considering recent estimates that the oceans may shelter ~50% of the life-forms of the planet (Appeltans et al., 2012), and ~80% of all animal life-forms (May, 1988), one would expect marine ethnobiology to be a thriving area of research with a vast and diverse literature, and for some part it is. Several studies in the marine domain have focused on community-based management (CBM), which have yielded valuable ethnobiological knowledge. As a result, marine ethnobiological knowledge has had a tremendous impact in terms of resource management, more specifically in the practical aspects of fisheries (e.g. Blount, 2005; King and Faasili, 1999; Sáenz Arroyo et al., 2005) and conservation of fisheries resources (Basurto, 2002, 2006). However, so far, the contributions marine ethnobiology has made to marine sciences have been mostly focused on fisheries and fisheries management, including a deepening in common-pool resources theory (Basurto et al., 2000; Beitl, 2011, 2012). Other realms of marine ethnobiology have not been as extensively explored as traditional fisheries, although, marine ethnobiology has mobilized the indigenous knowledge that has contributed to the discovery of new species (e.g., Lucas et al., 1991), alternative strategies for mangrove management (e.g., Walters et al., 2008), previously unknown behavior of ecological relevance (e.g., Felger et al., 1976; Johannes, 1981), and ultimately, to the discovery of novel metabolites like palytoxin (Moore and Scheuer, 1971). Nonetheless, we believe that there are currently too few examples in the literature referring to realms of marine ethnobiology outside of the topics in fishing and traditional fisheries management and that this is largely due to the fact that mainstream ethnobiology has paid little attention to marine issues so far. Therefore, the acknowledgment of the myriad of interactions that humans populations living in coastal environments and sailors at sea, have established with the marine and coastal biota is still shallow. Nevertheless, marine ethnobiology, while still in its infancy, emerges nowadays as a promising field within ethnobiology.

The session was introduced by Rutger de Wit and five papers were orally presented. In addition, one poster and an oral presentation presented in other sessions were recognized as highly pertinent for this emerging field in ethnobiology and have been included for this report. Several of the marine ethnobiological presentations integrated approaches from other disciplines (e.g., political ecology, economy, history, sociology, law) as well as participatory approaches and outreach. Many of these presentations comprised an important aspect of applying ethnobiological knowledge for ocean and coastal management. The objectives of this report are (i) to summarize and review the marine ethnobiological contributions at the 13th congress of the international society of ethnobiology, (ii) to improve exchanges of experiences and results of studies and *in fine* to stimulate the emergence of the field of marine ethnobiology, (iii) to discuss how ethnobiological knowledge can contribute to improving ocean and coastal management.

1.2. Preambule, why has ethnobiology employed so little interests in coastal and marine issues?

Perhaps the lack of interest of mainstream ethnobiology for marine issues follows the established paradigm that fishing is a modern human behavior, which developed during the Pleistocene–Holocene transition some 12 000 years ago (y.a.), (Clark, 1948; McGoodwin, 1990; Lubell et al., 1994; Sandweiss, 2008; Erlandson et al., 2009). Therefore, it is often considered of lesser innovational importance than agriculture, despite the fact that several anthropological studies have highlighted that the histories of agriculture and fisheries show specific analogies (Breton, 1981).

The evidence for an early coastal life of our species is relatively recent and scarce when compared to that of inland sites. Few coastal sites predate the late upper Paleolithic in the Old World. Those that predate the upper Paleolithic show either scanty evidence of use of coastal resources or less use of those resources than upper Paleolithic or later times at the same locations (Singer and Wymer, 1982; Yesner, 1987). Secondly, the Pleistocene megafauna associated with archaeological sites has lead researchers to conceptualize the image of early humans as romanticized big game hunter-gatherers roaming terrestrial ecosystems (Braniff, 2001).

Therefore, until recently, it was considered that human coastal livelihoods developed throughout the Pleistocene–Holocene transition, in a point in time where several factors negatively impacted terrestrial megafauna. These factors included the sharp rise in temperature and the migration of ocean currents, which resulted in local shifts of precipitation patterns and coastlines as well as changes in patterns of seasonality and vegetation between 12 000 and 8 000 y.a. The decrease of megafaunal densities directly affected the ability of hunter-gatherers to procure food and survive (Straus, 1996). As a result, humans were then driven to the coast and forced to start exploiting the sea for the first time. In these past times of famine, coastal livelihoods offered the only chance for the survival of our species.

In spite of these arguments, there is some evidence suggesting that Neanderthals cooked marine shellfish in caves in Italy as early as 110 000 y.a. (Stiner, 1994). Our species has held a taste for seafood for a long time as well. Richter et al. (2008) have provided sound evidence that anatomically modern humans depleted the Red Sea stocks of *Tridacna costata* some 125 000 y.a. Finally, novel

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evidence from Pinnacle Point South Africa, offers a new glimpse into early human adoption of coastal livelihoods (Bar-Matthews et al., 2010). The findings described by Marean et al. (2007) at Pinnacle Point show a systematic large-scale exploitation of marine shellfish beds by humans 165 000 y.a.

Even considering the fact that coastal livelihoods are relatively new to our species we have to acknowledge that the diversity of strategies involved in fishing, collecting and farming marine organisms is extremely important for the history of our species and probably comparable in impact to that of agricultural practices. Marine and coastal resources are economically important for many traditional and indigenous populations. Coastal land and seascapes have shaped the cultural identities of populations and actually represent an important cultural heritage (Cordell, 1978; Johannes, 1977, 1981). Our species' long-lasting relationship with the biology of the ocean is not limited to fishing and gathering food resources. Written records show that our species has obtained marine medicines for some 5 000 years (Jia et al., 2004). Humans have been using aquaculture techniques since *circa* 5 000 y.a. (Hickling, 1962, 1968). Not surprisingly, humans have also incorporated seashells as currency. Cowries, still in use as currency in some parts of West Africa, came into Africa with Arab traders, who brought them from the Indian Ocean, where one species, *Cypraea moneta* has had monetary value for at least 1 000 years (Marion, 1970).

Presently, some 2.6 billion people depend on the oceans as their main protein source. The data of the USA Federal National Oceanic and Atmospheric Administration (NOAA) suggests that 5% of the world intake of protein is marine derived. Nonetheless, islander societies and coastal communities living in arid environments derive as much of 90% of their protein intake from marine sources (Bell et al., 2009). These figures become much more dramatic and underscore the alimentary vulnerability of these communities when considering that the world oceans are heavily affected by human activities, including pollution, depleted fisheries, and loss of coastal habitats.

2. Traditional Ecological Knowledge and Local Ecological Knowledge are key concepts in ethnobiology

Traditional Ecological Knowledge (TEK) and Local Ecological Knowledge (LEK) are closely related key concepts in ethnobiology, which are presently also used in anthropology and ecology (Berkes et al., 2000). Applied to the coastal zone and marine environments, these concepts describe the knowledge that coastal populations have acquired about the ecological properties (structure and functioning) of the coastal and marine ecosystems from which they benefit by obtaining resources and by deriving esthetic, cultural, and spiritual benefits. TEK puts the emphasis on the knowledge transferred from generation to generation and implies that these populations have a long historical relationship with the marine environment. TEK is largely dependent on social and cultural practices, often shaped by traditional customs and institutions and incorporated in a worldview (Berkes et al., 2000).

While TEK and LEK have often been used interchangeably in the ethnobiological and ecological literature, for marine ethnobiological research we think that it makes sense to make a clear difference between them and found that the Local Fisheries Knowledge Project of the NOAA has provided an operational definition for LEK to clearly distinguish it from TEK. Accordingly, LEK is similar to TEK in that it is tied to place and is knowledge acquired through experience and observation. It can be acquired over a single lifetime or over many generations. LEK differs from TEK in that it does not require an ancient or even a multi-generational accumulation of knowledge, it does not require that the population be indigenous, and it does not require embedding in a broader shared culture (Local Fisheries Knowledge Project, NOAA). In other words, individuals can accumulate LEK over the course of one lifetime interacting with a local environment and such empirical knowledge can be shared within the local community. Hence, LEK relates to the ecological knowledge of local communities at a given point in time and can thus also apply to coastal populations that have a shorter history of living with the marine environment or that have changed their maritime behavior more recently in historic times in order to cope with changed conditions. With world populations ever increasing combined with a migration of inland populations towards coastal areas, increasing amounts of people have started interacting with coastal systems. It will take some time for these newcomers to gain LEK by empiric approaches and even much longer before the well-established LEK accumulates over generations and may become TEK. The key role of ethnobiological studies for ocean and coastal management is thus based on the fact that it provides a scientific basis and methodology for incorporating LEK and TEK in the management practice in addition to other approaches.

3. Main issues for marine ethnobiology

3.1. Marine ethnobiology in the global change context

In his introduction to the session, Rutger de Wit highlighted that indigenous populations in the coastal zone cannot be studied in isolation, because the human coastal populations are connected through the coastal seas and oceans. Presently, the vast majority of the marine ecosystems have been significantly impacted by humans (Halpern et al., 2008), and many coastal biotas have been impoverished in terms of species richness (local extinctions) and species abundances, particularly since the industrial revolution and increasingly so since the introduction of a global market economy (Lotze et al., 2006). Therefore, indigenous coastal populations suffer from anthropogenic factors including pollution, overfishing, ocean acidification, sea-level rise and climate change that will be exacerbated in the near future. The study of their adaptive capacities in face of these changes should be an important area of research for marine ethnobiology.

Hence, ethnobiology cannot neglect the issue of global change. This issue is particularly compulsory for the field of marine ethnobiology because it is likely that changes will have a more rapid impact than in most terrestrial ecosystems. Predictions about sea level rise are still uncertain and range from 30 cm to 190 cm for the next hundred years. The increase of the global air temperature will also induce an increase of ocean temperatures, which will be modulated by the local currents. As ocean temperatures change, there will be a large-scale redistribution of species, especially in the southward margins of semi-enclosed seas (Cheung et al., 2010). Moreover, as the amount of CO_2 increases in the atmosphere, the equilibrium CO_2 concentration in the ocean will increase as well. The uptake of CO_2 by the oceans alters their pH, inducing a decrease of the saturation index of calcium carbonate (Doney et al., 2009). The shift in calcium carbonate equilibrium conditions will make the shells, testes and skeletons shellfish, echinoids, corals, and phytoplankton, brittle and non-viable (Caldeira and Wickett, 2003; Hoegh-Guldberg et al., 2007). Redistribution of marine stocks and ocean acidification will make an immediate impact on coastal populations in terms of their alimentary vulnerability (Bell et al., 2011). Something else to consider is that coastal communities do not limit their ethnobiological interactions with the sea to the extraction of animal protein. A good number of coastal communities use the sea to obtain medicines and adornments, which they exchange for cash income, as well as building materials, and

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firewood in the forms of mangrove and driftwood. Peoples in coastal communities do not only derive material goods from the oceans, their coastal livelihoods also provides them their identity, cosmogony and sense of belonging; the ocean has a profound cultural value. Unfortunately, the current state of health of the world's oceans is, without any doubt, a direct and immediate risk to the livelihoods of 40% of the human population (Millennium Ecosystem Assessment, 2005).

3.2. Marine ethnobiology and conservation policies for marine ecosystems and biodiversity

Nature protection measures, such as the creation of national parks, have been implemented since the late 19th century for terrestrial ecosystems on continents as well as some islands. Bio-cultural heritage sites, which underscore the link between humans and their environment, have been implemented later opening the way to the community-based management and conservation (Agrawal and Gibson, 2001; Roe, 2000). Similar measures have also been implemented for a part of the terrestrial and aquatic environments along the coastlines and their watersheds. However, the current dire state of the marine fisheries and poor overall health of the oceans called for new conservation schemes and mechanisms specifically targeting the protection of marine biota and resources. Hence, the creation of marine protected areas (MPA) is a relatively recent development.

The process of implementing MPAs started in the 1970's and has been accentuated worldwide more recently. Nevertheless, indigenous populations in the Pacific have preceded this movement by traditional measures aimed at maintaining fish and shellfish stocks including closed areas for fishing and crabbing, and reserves for turtles and seabirds on uninhabited islands (Johannes, 1978). Nowadays, the process of implanting MPA shows an increasing interest in traditional marine tenure often identified as customary marine tenure due to the wide literature dedicated to the subject in the Pacific islands (e.g., Cordell, 1978; Johannes, 1977; Johannes, 1981; Ruddle and Akimichi, 1984; Ruddle and Johannes, 1985, 1989). The international Convention on Biological Diversity (CBD) represents a founder treaty, which recognizes the importance of MPAs, while it engages member States to create a complete and consistent network that should cover 20%–30% of the global marine surfaces (Dahou et al., 2004). According the International Union for Nature Conservation (IUCN), a MPA is a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values (Day et al., 2012).

These new conservation efforts fall short of fulfilling their goal because they are conceived to respond rapidly to a perceived state of emergency. As such their planning and implementation occurs *ipso facto* despite meager sociodemographic and biophysical information (Fiske, 1992; Kelleher and Recchia, 1998), limiting the definition of stakeholder to those that participate actively in the market economy in the area (e.g., Cudney and Turk, 1998; Fuentes and Vázquez, 2003) or those empowered by concessions made by the state (e.g., Walker et al., 2007; Cinti et al., 2010). Too often, the poor and marginalized, but often very active actors are neglected during the participatory approaches.

During the recent past, MPAs and their continental counterparts were mostly based on ecological considerations with the aim to preserve a specific natural marine heritage and particularly to protect emblematic species. Hence, their management was mainly based on restrictive and all exclusive prohibitions. But this way of acting has been called into question due to some counter-productive effects. Several studies have emphasized the necessity to integrate the diversity of stakeholders affected by MPA projects and, therefore, a specific multidisciplinary methodology needs to be adopted during the implementation and the management processes (e.g., Claudet, 2011). This recent approach is based on the ecosystemic theory, which aims to combine and optimally reconcile the stakes of biological conservation with cultural, socio-economic, and political considerations (e.g., Browman and Stergiou, 2004; Christensen et al., 1996). Indeed, the coastal areas targeted by such projects have been occupied and exploited by autochthonous populations. Hence, these populations should be allowed to continue to benefit from the ecosystem goods and services that they have been used to obtain from the area before its declaration as an MPA, provided that their exploitation will not jeopardize the biodiversity of the sites. According to the terminology of the IUCN, such MPA would correspond to type VI, i.e., protected areas with sustainable use of natural resources (Day et al., 2012).

Hence, customary management (CM) falls into the IUCN type VI management scheme. CM generally refers to indigenous systems encountered in coastal communities aimed to control and regulate the uses and access to marine resources and territories (Aswani, 2002). The main design principles of CM are the spatial and social boundaries determining the authority, the rights and rules within fishing communities (Ruddle, 1996). However, these studies have also underlined the great diversity of traditional marine tenure systems (TMTSs), the importance of particular social conditions for TMTSs maintenance, as well as their dynamic and continuous adaptation to diverse endogenous or exogenous changes (see Dahl, 1988). This makes generalizations extremely difficult and underscores the importance to pay particular attention to each case study context and to avoid a simplistic conceptualization of the community (Waylen et al., 2013). Nevertheless, new schemes have progressively been developed to try and integrate TMTSs into modern management regimes and marine conservation policies (e.g., Cinner and Aswani, 2007; Evans et al., 1997).

Samuel Cornier described a project initiated and supported by the World Wide Fund For Nature (WWF) in order to create a so-called multi-zoning MPA in New Caledonia working with the indigenous Kanak populations belonging to the tribe of Yambé on the north east coast of the main island. In his presentation, he introduced the local socio-economic and historical context and the customary land-law supporting terrestrial and marine tenure in Yambé to understand how the local ethnological context combined with natural science considerations have lead to such conservation schemes.

He also showed how this project is part of a MPA network linked to the classification of the lagoons of New Caledonia in the list of the World heritage (UNESCO). This main political process aims at the conservation and valuation of six particular zones considered as representative of the marine and coastal bio-cultural diversity of the archipelago (UNESCO, 2008). He then discussed the political and legal implications to reconcile customary and state laws for implementing this conservation scheme and the efforts to combine scientific ecological knowledge (SEK) with the TEK of the indigenous populations.

Thus, he paid critical attention to the interrelated theoretical concepts used during the implementation process comprising (i) integrated coastal zone management (Cicin-Sain, 1993; Post et al., 1996), (ii) participatory co-management (Beaumont, 1997; McCay and Jentoft, 1996), (iii) community-based approach (Pollnac et al., 2001; Pomeroy and Carlos, 1997), (iv) decentralization (Lowry, 2002; Pomeroy and Berkes, 1997), (v) MPA network (Cicin-Sain and Belfiore, 2005) and (vi) ecotourism (Agardy, 1993; Orams, 1995; Scheyvens, 1999), to see how the stakeholders use these and operate on the fieldwork. In the meantime, he analyzed the perception of local populations with respect to these concepts and

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to the MPA, which enabled him to highlight several induced effects due to specific divergences between both views of the project. From the point of view of the local populations, i.e., the endogenous point of view, the MPA is seen as a way to protect a singular identity and to perpetuate the TEK and CM systems to build a sustainable future around alternative livelihoods options. Meanwhile, from an institutional or exogenous point of view, the MPA is mainly strategic for the management and the development of the coastal areas in an isolated part of New Caledonia, contributes to legitimize and to reinforce the authority of the state over the customary-law while offering potential economic benefits based on environmental issues and conservation policies. Finally, he emphasized some weakness of this project and the necessity to systematically adopt from the beginning a transdisciplinary and participative methodology in order to improve the process of implementing MPAs.

In conclusion, the marine resources and coastal land and seascapes provide the goods that are vital for these populations as well as many symbolic components. Hence, these resources, land and seascapes have contributed to shape the identities of local communities, their social and their political organization, but also to their economic activities. Thereby, conservation schemes and MPA projects in particular must deal with local particularities that reflect the cultural and biological diversity of traditional marine management systems developed by coastal groups over the world. While various factors can be invoked for poor success for MPA implementation, one essential point is the weak empowerment of indigenous and local fishing and coastal communities in MPAs global management process. Therefore, several reports call for more independent studies from the community perspective and for a real transdisciplinary and participative methodology, in which marine ethnobiology has a relevant role to play.

A main focus on economic issues is perhaps the basis for the idea that privatizing natural resources may represent a mean to preserve them and there is a growing tendency to use such a privatization among new conservation schemes (Vogel, 1994; McAfee, 1999; Büscher, 2008). While indicating that privatization can in some cases, when accompanied by very effective governance, yield good results for biodiversity conservation, it has been shown that in most cases in the coastal zone, particularly where governance is weak, privatization has a very negative impact both for biodiversity conservation as well for local populations (Cabral and Aliño, 2011). Indeed it appears that the 'neoliberal' solution to environmental conservation has been conceived without noticing that there are a great number of marine elements in coastal ethnopharmacies. Thus, the privatization of marine areas will, as it does in terrestrial environments, restrict the access of coastal communities (FAO, 2005), usually the poor and marginalized, to relatively inexpensive resources that have always been part of their food and health systems. As no-fishing zones and private ownership of marine areas continue to develop we will be confronted with a discrepancy between dominant discourses of biodiversity conservation and the discourses and attitudes of social movements. In the end, poor information equals poor policy (David and Brian, 2004). We conclude that it is perhaps within conservation schemes that marine ethnobiology can potentially have its greatest impact. Therefore it is important not only to try to incorporate the local and TEK and to accommodate social organization into conservation strategies and/or fisheries management, but rather to consider TEK and the local social organization as the starting point for developing conservation and management. In the recent past, unsuccessful projects have often been based on biodiversity conservation strategies and their related concepts, which were based on an exogenous vision on 'nature' and 'culture' that doesn't fit with local social and managerial schemes. As a major highlight, the presentation invited to reconsider the ways in which MPAs are planned and implemented in order to switch the focus towards collective production of knowledge or 'co-learning'.

3.3. Marine ethnobiology for artisanal fisheries management

Three presentations were directly related to fisheries management in coastal lagoons and coastal seas. Donata Melaku Canu showed how urban populations in the emblematic city of Venice (Italy) and the fisherman populations in its surroundings have coevolved with their lagoon environment. The natural history of many coastal lagoons is deeply interconnected with the human history and the lagoon hydrology and morphology have been shaped by the interplay between natural processes and human interventions. For strategic reasons, such as political and military security as well as local wellbeing, the Republic of Venice adopted, for centuries, appropriate policies to preserve a hydrological equilibrium between the opposing aquatic and terrestrial elements (Caniato, 2005). For example, during the 16th century major rivers were diverted in order to prevent the infilling of the lagoon by alluvial sediments. In addition, the governance acted particularly to preserve the local fish stocks. In the past, fisherman used to live in geographically-rooted closed communities with oral transmission of traditional knowledge, including TEK, from fathers to sons and were targeting a variety of fishes in an open-access mode according to seasonal cycles. The individual needs were subordinated to the general interest, and the fishermen were organized in corporations called Fraglie. Fishermen representatives were also involved in local government.

Gustavo G.M. Moura and Emmanuel D. Almada studied the fisheries management of resources in the Patos Lagoon estuary (S. Brazil). They discussed the conflict that may arise when dealing simultaneously with TEK and SEK and invoked that it would be impossible to give equal weight to both approaches. They conducted an extensive literature review of the scientific knowledge, particularly SEK, which has inspired the official guidelines for pink shrimp management based on restricting the fishing season in the Patos Lagoon estuary. In addition they studied the ethno-scientific literature, which describes traditional calendars as a basic element for the management by artisanal fishers in the Patos Lagoon estuary. They compared how both approaches fitted to 'reality' at two different levels comprising (i) the ecological knowledge and (ii) the management practice, according to the approach of Lertzman (2009). They argued that the key to understand the compatibility of management systems is to understand both calendars, i.e., the traditional calendar and the official calendar ('seasonal closures'). In this approach, time is knowledge (Gardet, 1975) and the calendar is one way to the resource management. Notwithstanding the congruencies between science and fisherman in the description of the estuarine biological processes (knowledge level), the incongruence's emerge in the recommendations for use of resources according to different calendars based on time perceptions (management level) similar to the fishing conflicts between fisherman and government in northern of Brazil discussed by Da Silva-Huguenin (2005). Based on their knowledge, the fishermen have developed three flexible calendars and have migrated through different ethno zones of their territory. Their behavior has been based on an ethic code with two main criteria, i.e. (i) the size and (ii) the quantity of harvested fish valued as 'good' by the group. Conflicts arose when the scientific community and government institutions recommended and applied a fixed calendar to all fishery resources in all parts of the estuary. They concluded that in this specific case, the traditional fishers' behavior is more flexible and adaptive to the spatial and temporal heterogeneity of this ecosystem then the governmental institutions. Therefore, TEK might give guidelines to the management resources in the Patos

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Lagoon estuary and the scientific and governmental institutions should make efforts in order to change ways of learning and acting.

Mariana Bender showed that, at the population level, the LEK of fishermen is vulnerable to the shifting baseline syndrome (SBS). This is a phenomenon affecting peoples' abilities to recognize long-term environmental trends. I.e., as one generation replaces another, there is a risk of failing to perceive long-term environmental changes. Along the Brazilian coast they have found not only that older, more experienced fishermen landed larger fish catches and fish individuals, but they also identified more species as over-exploited, when compared to younger, less experienced fishers (Bender et al., 2013). Hence, paraphrasing Pauly (1995), we can state that each generation of fishers in Eastern Brazil accepts as a baseline the stock size and fish species composition that occurred at the beginning of their career. As a result, the older fishermen are more aware of how things have changed since previous decades than the younger.

In conclusion, the historic case of the Venice lagoon and the current situation in the Patos lagoon estuary showed that use of TEK is very valuable as it often complies with scientific ecological criteria, while at the same time providing the social support of the local populations for a specific governance of fisheries which is embedded in the local socio-cultural context. Nevertheless, Mariana Bender highlights the differences in resource users' perceptions across generations, and that fisher's age and experience must be taken into account when incorporating LEK with scientific knowledge. Despite the fact that older fishermen could also have shifted perceptions themselves, their generation was able to provide more detailed information on fisheries – valuable information to help us build a more accurate baseline on the status of marine biodiversity. Mariana showed that you have to be careful when relying on LEK and TEK for fisheries management, because this type of knowledge gathering and transmission may not be capable to evaluate the long-term trends in ecosystems in a scientifically sound way.

3.4. Role of ethnobiology for marine aquaculture

Rutger de Wit discussed the introduction of oyster-farming in South France during the 19th century as a response to the depletion of natural stocks of *Ostrea edulis*. Jacques-Marie Cyprien Victor Coste (1807–1873) was an enlightened scientist (embryologist, nowadays developmental biology) who combined a strong concern about the negative impact of humans on ecosystem structure and functioning with a typical 19th century belief in the possibilities of science and technology to solve the societal problems. Commissioned by the Emperor Napoleon III he undertook a long journey along the coasts of France and Italy to study aquaculture techniques and gather TEK (Coste, 1861). In Fusaro lake (Gulf of Naples) he studied oyster-farming techniques that had been in use since Roman times. Based on these observations he contributed (i) to the creation of artificial reef structures for oysters to repopulate the impoverished populations, and (ii) to the introduction of oyster-farming techniques in the French coastal zone. The latter became established in the coastal lagoon of Arcachon in 1865 after several years of experimentation and failures. After more than a century of practicing oyster farming, it is nowadays considered as a traditional activity and as a result several generations have accumulated a large amount of LEK, which may now be considered TEK. Nevertheless, the oyster farmers have been confronted to emergent crises like viral diseases and eutrophication, which has required the help from scientists to adapt this activity.

In modern time in the Venice lagoon, the traditional lagoon fishery system (see above) has a marginal role compared to marine fisheries and lagoon clam harvesting. Lagoon clam harvesting started after the introduction of the allochthonous species, *Tapes philippinarum*, in 1983. Due to the high economic return, this activity attracted around 2000 people, mainly newcomers having no previous fishery knowledge. Hence, these people lacked LEK and TEK and at the same time were resistant to accept the SEK developed by local institutions and by the scientific community specifically for managing the harvesting of the clam. Therefore this activity induced noxious environmental impacts, resulting in social and governance conflicts. LEK is difficult to obtain and consolidate, while it is also difficult to recover previously existing TEK in a complex system like the Venice lagoon, whose economy is driven by several sectors. Moreover, the fact that the noxious impact of clam fisheries in the Venice Lagoon is not on the clam stock itself, but rather its indirect effects on ecosystem functioning further exacerbate this difficulty. Hence, impacts are, therefore, externalized to other ecosystem processes and are less evident to the clam harvesters themselves. Thus, this recent episode marked a sign of discontinuity with the historical relationship between fisheries and environment in the Venice lagoon (Melaku-Canu et al., 2011), where there was a tradition to incorporate ethnobiological information into the actual governance in order to support the sustainable management of the lagoon within the urban and cultural environment.

In conclusion, this shows that a highly dedicated scientist in the 19th century quite naturally adopted ethnobiological approaches to introduce specific aquaculture techniques, which were further developed using scientific approaches. If this aquaculture is performed at an intensity that is compatible with the maintenance of biodiversity and ecosystem functioning, the shellfish farmers will tend to acquire knowledge about the ecology of the system and thus develop LEK that progressively becomes TEK. However, the Venice case shows that the culturing of alien species by newcomers may have dramatic consequences.

3.5. Indigenous knowledge of medicinal properties of marine algae

Nemer E. Narchi and Luis Aguilar described ethnophycological knowledge of Seri populations in Sonora, Mexico. Seri ethnomedicinal knowledge is vast and comprises a myriad of organisms that include terrestrial plants and animals, marine creatures, marsh halophytes, and algae (Felger and Moser, 1970, 1971, 1974, 1976; Felger et al., 1980; Nabhan, 2000, 2003; Narchi et al., 2002). Seri ethnomedicine is not a consolidated and immovable body of knowledge, but rather this knowledge is dynamic as more remedies are constantly being added (Felger and Moser, 1985). Using cultural consensus techniques and ethnographic data, they suggested that the algal medicines are a fairly new addition to the Seri pharmacopoeia in comparison to other marine organisms that have been used as medicine for longer. Lastly, it was highlighted that in spite of an evident worldwide distribution of marine medicines and a history of use expanding nearly 5 000 years (Halstead, 1992: Jia et al., 2004), research on marine ethnomedicine has largely been ignored. This neglect is worrying given the importance of understanding the history and ecology of human adaptations to the coast. It is also important in understanding the role that marine medicines have in the procurement of health in rural coastal populations which are constantly dispossessed of their coastal territories (e.g., Ávila-García and Luna-Sánchez, 2013; Baños-Francia, 2012; Coomansingh, 2004; Valdivieso and Coll-Hurtado, 2010), and thus, are denied access to strategic food and medicinal resources.

3.6. Marine ethnobiology outreach as a mean to create social support for the conservation of coastal seascapes

Christian Jacquelin and Marion Thiba showed how ethnobiological studies have been developed following a demand from

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the regional natural park the Narbonnaise located on Mediterranean coast in South France. The public organization of the park dedicates a lot of efforts to publish nicely illustrated books and audiovisuals and organize cultural events in order to raise public awareness and appreciation of the ethnobiological issues as an important cultural heritage. The ensemble of these activities named "Les archives du sensible" (http://www.parc-naturel-narbonnaise.fr/archives_du_sensible/index.html) is based on a collaboration between local populations, archivists, researchers, photographers, film producers, artists and writers. However, in addition to creating a historical archive, the aim is to develop a body of contemporary products that allow a sensitive approach to the living world and thinking about the links between past and present. For example, the presence of islands in the coastal lagoons of this region has shaped the local cultural identity characterized by a shared feeling of insularity, which can even be considered a founding myth for the indigenous population.

4. Conclusions and future role of marine ethnobiology for ocean and coastal management

The diversity of themes related to human–ocean interactions is enormous and marine ethnobiology is no exception, as the relationships emerging from the encounter of humans with marine biota is far from being limited to food production systems. The presentations in the area of marine ethnobiology during the 13th congress of the international society of ethnobiology are a good example of this, as the presentations were very diverse and reflected a pluralistic vision of the field. The session comprised classical ethnobiological approaches as e.g., linking taxonomy of marine algae to the ethnotaxonomy used by indigenous populations and the study of their ethnomedical applications. However, many presentations also used approaches from very different disciplines including history, geography, ecology, political ecology, anthropology, sociology, and law. We think that the dire state of the marine ecosystems and the burning issues in the coastal and marine zones indeed calls for comprehensive transdisciplinary studies. This is particularly the case for global change, which will have great impact in coastal zones. In this interdisciplinary or preferably transdisciplinary context there is also an important place for a contribution by marine ethnobiology in order to mobilize the pertinent TEK and LEK and contribute to participatory approaches involving the indigenous populations.

Many marine ethnobiological studies have been initiated by applied and fundamental natural marine sciences, while mainstream ethnobiology has shown less interest in marine issues so far. Therefore, the field of marine ethnobiology is currently facing two major challenges. In the first place, we think that while adopting a pluralistic vision for marine ethnobiology, the field should be repositioned at the core of the ethnobiology discipline. This is important for developing more comprehensive studies on the interactions between humans and marine biota. These should include all the different aspects listed in this paper, although we recognize that our list is not comprehensive. This way it can also benefit more effectively from the knowledge and concepts developed by ethnobiology for terrestrial environments. Secondly, the emerging field of marine ethnobiology has to engage immediately in multidisciplinary studies and contribute to transdisciplinary approaches. Presently, this is also the case for mainstream ethnobiology, although this discipline has historically evolved through different stages, to be carried out nowadays in a highly transdisciplinary context Wolverton (2013).

Marine ethnobiology has already been applied in combination with socio-economics and ecology to improve the management of mangrove forests and contribute to their restoration (Walters et al., 2008). In this context, the contribution of environmental economics and its particular concepts such as ecosystem goods and services (e.g., Barbier et al., 2011) are particularly important in a transdisciplinary approach. However, we strongly warn against a neo-classical vision in economics that aims at calculating market values for ecosystem services and which *in fine* contributes to the neoliberal idea that it is useful to privatizing nature as the only way of preserving it. The privatization of marine areas will inevitably restrict the access of coastal communities (FAO, 2005), usually the poor and marginalized, to relatively inexpensive resources that have always been part of their food and health systems. In developed countries this could induce the loss of traditional marginal fisheries activities. This would imply the erosion of cultural heritage and potentially the negative alteration of human–environmental interactions. In the meantime, it would also dispossess coastal peoples from economical and readily available resources. Human populations in the coastal zone are increasing faster than inland, which is mainly due to migration of human populations to the coast. As a result, newcomers are an important category in many coastal populations. In many cases these newcomers adopt maritime activities and will thus interact with marine biota and can obtain LEK. Particularly in the coastal zone, therefore, it makes sense to make a clear distinction between LEK and TEK. Following the elaborate definition of LEK by the Local Fisheries Knowledge Project of the NOAA (see Section 2) we consider that LEK relates to the ecological knowledge that is locally shared by communities at a given point in time and can thus also apply to coastal populations that have a shorter history of living with the marine environment or that have changed their maritime behavior more recently in historic times in order to cope with changed conditions.

By adopting a pluralistic vision for marine ethnobiology and by using inter- and transdisciplinary approaches, we envision that marine ethnobiology can contribute to (i) make better use of the coastal and marine resources, while contributing to their conservation, (ii) contribute to novel management schemes that incorporate TEK and LEK effectively, (iii) facilitate participatory approaches involving indigenous and other coastal populations in learning and decision making for ocean and coastal management, (iv) help people to think about the link between present and past and (v) adapt and prepare indigenous and other local coastal populations for adaptations to future changes. This way, LEK and TEK and results from ethnobiological studies can contribute to the conservation of marine biodiversity and maritime cultural heritage. This will help coastal populations to improve the perception of their specific environment and life styles and provide support to implement uses and management aimed at reducing their vulnerability to global change and help them to develop their adaptive capacities. During the session we have seen how local communities evolve along with their seascapes and constantly adapt to changing conditions. However, and in spite of this marked resilience, these communities are vulnerable to large-scale quick change regardless of whether this change is a product of policy implementation or climate change. The former highlights the importance to further explore marine ethnobiology as there is a need to understand and preserve coastal habitats and livelihoods and to inquire into the different realms that assemble the life sustaining systems of coastal communities.

In this regard, we are convinced that ethnobiology can offer deep insight into our species' environmental adaptation capabilities, foster theoretical thinking beyond the field of ethnobiology, and, in conjunction with conservation biology, marine and fisheries sciences, provide us with sound guidelines for applied research.

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Acknowledgments

We thank Edmond Dounias for his encouragements and support for presenting this session at the 13th congress of the International Society of Ethnobiology, which he and his colleagues organized superbly. Special thanks are due to Luc Énoka Camoui, poet and writer of the Tribe in Yambé from the indigenous Kanak people, who collaborated with us on studies on the multi-zoning MPA in New Caledonia, and who gave us enthusiastic support for organizing this session. We also take the opportunity to acknowledge the anonymous reviewers who helped improve this manuscript with detailed comments and thoughtful recommendations.

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