People's seas: "ethno-oceanography" as an interdisciplinary means to approach marine ecosystem change

by

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I- Introduction

In times of climate change, global financial crisis, food demand, and unsustainable practices, fisheries are facing unique historic challenges worldwide which concern stakeholders, scientists and managers. They have been often viewed as a planetary-scale human exercise which requires regulation, control, and a continuous evaluation of performance and effects. In these circumstances, a demand for the so-called ecosystem-based fisheries management (or EAF) seems to be consistent with international scientific evidences of both: (1) changes and phenomena at the ecosystem level which impact fishery stocks and vice-versa (Cury 2005; Cury *et al.* 2008), and (2) genuine deficiencies in incorporating users and stakeholders' perspectives into fisheries science and management (McGoodwin *et al.* 2000; Berkes 2003). Methodological advances to deal, separately, with the two complex issues above have emerged, ranging from simple and complex statistical and ecosystem modeling (Plaganyi, 2007; Travers *et al*, 2008) to promising fisheries co-management schemes (Diegues, 2001; Kearney et al., 2007). However, examining the available models, there is still a clear disconnection between both those two areas of modern fisheries science, which can potentially polarize perspectives on priority settings for EAF in a changing environment. On the one hand, fisheries and ecosystem oceanographers face the challenge of integrating abiotic and biological responses in the ocean with the patterns of change, and on the other, social scientists often concentrate on the complexity of the human dimension itself. The boundaries between natural and social sciences seem to be generally imposed by scales, concepts and scopes across fields, and when facing with climate change challenges, also by epistemology. Hence, given the gaps regarding how to provide dialogue between fields and models, new strategies and analytical approaches that link available knowledge systems are required.

Considering data-poor marine ecosystems, difficulties in developing understanding of global change issues including knowledge of oceanic and ecological change, both regime and fish communities shifts and over-exploitation are particular accentuated (Gasalla, 2004; Gasalla and Rossi-Wongtschowski, 2004). In such cases, traditional ocean science knowledge seems to be often restricted to a very limited number of observational or *in-situ* values in time-series, while detected patterns of change carry high levels of uncertainty.
However, the view of the sea as a field for inter- or trans-disciplinarity (*sensu* Diegues, 1997, 1999) calls for both the organic cooperation between scientists and the incorporation of the relevant knowledge of people who have a long tradition of relationship with the ocean, such as fishers. Their social and cultural practices shape maritime communities by the fact that the open sea is the place where fishers spend most of their life. That marine environment is marked by danger, risk, mobility and physical change that together forge the production of a specialized expertise (Diegues, 2001). Fisher's environmental knowledge, at times considered as traditional (TEK), has been documented, detailed, and defended especially by anthropologists[i], while more interdisciplinary outlooks have exhorted it to be used together with scientific knowledge (see Neis, this volume). Nevertheless, comparatively less discussion has occurred about the ways that such goal can be reached, especially with respect to relevant global scientific questions.

We suggest that the perception of change of such users/stakeholders, particularly for specific features related to global and climate change implications for fisheries, can help scientists to track systemic changes (i.e. by guiding the shaping of hypotheses), taking a central part in the knowledge system. Here we therefore review and demonstrate how the research field termed here "ethno-oceanography" can strategically contribute to approaches to ecosystem and societal changes with respect to oceans, emphasising examples from the Brazilian literature. We also highlight the methodological approach of global change issues using an interdisciplinary feedback framework which combines bottom-up (people) and top-down (science) systems of knowledge.

II – Defining "ethno-oceanography" towards a broader scale.

Snapshot glossary:

ETHNO-OCEANOGRAPHY: (i) a field of research that relates environmental phenomena and their interactions with marine living populations as perceived by the humans that closely interact with the ocean by working at sea. (ii) a field of research that study the way mariners (particularly fishers) perceive and conceptualize (mentally represent) the physical and biological aspects of the ocean, such as currents, winds, water characteristics, wave patterns, lunar cycles as well as species, habitats, feeding, migration and spawning patterns, etc. (iii) as a branch of ethnoecology or maritime anthropology. (iv) as a branch of oceanography.

ETHNOECOLOGY APPROACH: involves sampling of people to be included in surveys with a proper methodology either quantitative or qualitative (see text below).

"Ethno-oceanography" is the scientific study of the way different groups of people understand the ocean around them in their relationship with the *physical/biological* environment in which they work and from which they make their living. Formerly, the terminology was based on the field of "ethnoecology" (such as in Posey, 1984) and on "maritime anthropology" (Diegues, 1995) which traditionally refers to the second definition in the glossary below (*ii*). In fact, the first use of the term "ethnoecological approach" seemed to come out in the 1950s from anthropological literature (Conklin, 1954; Nazarea, 2006).

At present, the study of *traditional fishing knowledge* is conducted within those disciplines, and seems to be mostly associated with societies or communities that: a) maintain strong economic and symbolic ties with the sea through continuous observation of natural cycles; b) are attached to continual use and occupancy of a specific territory or zone; c) show production and transmission of knowledge, symbols, myths and rituals associated with fishing through oral traditions, and, d) to a certain degree show social/cultural identity based on fishing and other maritime activities (Diegues, 2001). Fisher' traditional knowledge may be understood as a distinct cognitive realm consisting of a replicable, orally transmitted set of specialized skills and culturally shared practices and beliefs that have stood the test of time, enabling people to make a living from coastal and marine environments through the long observation of recurrent natural phenomena which allows a fishermen to make decisions about the timing of fishing activities, selection of favorable fishing spots and the use of appropriate techniques for specific species (Cunha, 1997; Diegues, 2001).

Risk and uncertainty handled by marine fishers (Hilborn, 1997) require such specific expertise, and shape their different kinds of technical, social, economic, and cultural practices used by fishers for coexisting with their maritime environment (Diegues, 1997). The construction of this body of complex and detailed concepts and symbols based on long-term empirical observation, guides their behavior and fishing strategies that are essential for predicting situations where fishing can be successful. In this sense, traditional knowledge helps local fishermen to produce their own mental maps that indicates to them where and how to fish (Diegues, 2001). As Ruddle (2000) points out, resource use patterns are not a product of the physical environment and its resources *per se*, but of their perceptions and culturally formed images of the environment and its resources.

Currently, there is a growing interest in the application of fisher's knowledge in non-anthropological studies as well, given that humanity cannot afford to dismiss useful sources of knowledge about marine ecosystems in the face of present sustainability concerns. It has been reported in several studies including fish taxonomy and ethno-ichthyology (Begossi and Figueiredo, 1995; Silva, 1997; Diegues, 2001), fish ecology and biology (Poizat and Baran, 1997; Berkes, 1999; Silvano and Begossi, 2005), spawning aggregations (Ruddle, 2001), marine mammals (Huntington, 2000a; Silvano *et al.*, 2008), marine population trends (Neis, 1999; Johannes, 2000; Pitcher, 2001; Gasalla, 2003, 2004), and conservation issues such as endangered species and location of biodiversity spots (Gadgil *et al*., 1993; Huntington, 2000b; Berkes *et al*., 2006; Haggan *et al*., 2007). Also, its potential use in management has been frequently emphasized by social scientists in recent decades (Dyer and McGoodwin, 1994; Diegues, 1997; Johannes, 1998; Berkes, 1999; Ruddle, 1994; 2000; Johannes *et al*., 2000; Haggan *et al*., 2003; Wilson *et al*., 2006; Haggan *et al*., 2007; Silvano and Valbo-Jorgensen, 2008). The discovery of folk-management methods (Johannes, 1981), such as sea-tenure regimes (Cordell, 1983) and the Brazilian experience with extractive reserve models (Diegues, 2001) are also important examples for local-level fishery management. In a recent book, Silvano *et al*. (2008) review current literature on the application of fishers' local ecological knowledge in order to better understand tropical fisheries, and indicate promising ways of using it in natural resources management. Therefore, if harvesters or "appropriators" (after Schlager and Ostrom 1992) face practical, legal and cultural obstacles to social inclusion, public trust, and empowerment (McCay, 2001; Diegues, 2001), conversely, a new trend to emphasize and recognize an endangered mythic wisdom from their fishing tradition and experience have emerged at least in some academic realms.

While the anthropological view focuses primarily on the study of a particular suite of ancestral or long-term traditional knowledge (TEK), the ethno-ecological approach complementarily, includes a search for scientific correspondence or correlation with "western" scientific knowledge. This attempt to integrate science and fisher's knowledge (FEK) have been generally applied on *a posteriori* basis rather than defined to examine *a priori* scientific questions. However, TEK/FEK (traditional fishers' knowledge/fishers' ecological knowledge) documentation on specific oceanological issues seems to be still scarce, even though descriptions of fishers' ocean-related knowledge required for decision-making on when begin to fish and where to find the fish are more common. For example, their observation of the presence/absence of sea birds, seawater color, current strength and direction, have been documented as important clues to line-fishing in the Caribbean Sea (Grant and Berkes, 2005). Fisher's general accurate perception of wind behaviors and their day-by-day direct visual observations are assumed to occur in most of the world's marine fishery systems. In some cases, such as in the whitemouth croaker (*Micropogonias furnieri)* fisheries in Pajas Blancas, Uruguay, for example, fishers taste the water collected from the bottom to assess the salinity in order to decide when begin to fish (Norbis, 1995).

In the context of ethno-oceanography, the suite of fishers'[ii] knowledge and observation on sea features, including their related explanations, theories, skills, practices, beliefs, symbols and cognitive maps or clues to fishing seems to be more properly designated as FOK (fisher's oceanological knowledge).

Despite its potential application in climate and global change science, it is practically absent in literature. Recently, Gasalla *et al* (2008) delineated and tested oceanographic hypothesis of change in the marine ecosystem off the South Brazil Bight based on issues raised by a FOK-based analyses on the perception of different categories of fishers, and found out an interesting sequence of methodological bottom-up (user-based) process that will be further illustrated in the next section. Accordingly, we consider that broadening the application and definition of ethno-oceanography and FOK, into the scale of climate change analyses can be of clear practical contribution to ocean science. Hence, in this sense, the inclusion and computation of human perceptions of change and trends can be of particular value in establishing scientific hypothesis and as a tracking mechanism for detecting and analysing signals of change in the context of global change science as well.

III- *"Qui langue à, a Rome va"* or *"With a tongue, one goes to Rome"* [iii]*:* ethno-oceanography and changes in marine social-ecological systems of Brazil.

Brazil has the largest coastline of South America, covering about 8.500 km, at the western border of the South Atlantic Ocean, where fishing communities and industries make a living and contain almost one million people. Even though characterized mainly by poor oligotrophic waters of the warm Brazil current (with high biodiversity, but medium or low levels of productivity and biomass/species on average), Brazilian fisheries are mostly multispecies, diverse and multigear, holding important social, cultural and economic importance for coastal communities. However, productive spots also occur along its long shelf and EEZ, with higher yields in the zones under the influence of rivers discharge (i.e the Amazon), seamounts and oceanic upwelling off the shelf, seasonal wind-driven coastal upwelling in the South Brazil Bight, and the Brazil-Malvinas frontal system which is on the southwestern corner of the subtropical gyre, where the northward cold water route interacts with continental shelf's promoting mixing and meso-scale eddies (Castro, 1998, Campos *et al*. 2008) (Figure 1). Fisheries in those related areas, respectively, target mainly penaied shrimps and catfish, tuna, sardines, and demersal fish and invertebrates (IBAMA, 2007).

For a long time, Brazilian maritime anthropological literature has described several examples of the traditional knowledge about environmental issues that affect small-scale fishing strategies and navigation. One outstanding example is the work of John Cordell (1974; 1983) describing complex particularities of traditional canoe fishing in Valença, Bahia (see location in Fig. 1), demonstrating that the influence of estuarine/sea currents and lunar cycles on seining strategies appeared to be tied to the intricate tidal changes along Bahia's estuaries and creeks that wind back into the mangrove swamps. He recorded in detail the establishment of a fishing territorial foundation and sea-tenure system in which skippers (*mestres*) consolidate control over premium water space, by distinctive spatial limitations within the lunar/tidal cycle. They exercise "informal" exclusive rights over these tiny tidal traditional casting spots (called *pesqueiros*), giving names to those micro environmental areas for fishing that are subdivided for a particular fishing technique into *lanços* (casting sites) or minimal water space, as determined by fortnightly current and daily tide-level changes, light conditions during different phases of the moon, bottom conditions, etc. Another example is given by Maranhão (1975) who described the traditional fisher's knowledge in Ceará (Fig. 1) with respect to the interaction between coastal currents and the sea bottom topography according to the formation and movements of the waves. He classified three types of "seas" that influence the strategies for fishing navigation, according to local TEK, even though in the context of traditional knowledge, those data showed that fishers had detailed FOK of the near-shore habitat.

Recently, Moura (2008) described the TEK of estuarine-lagoon artisanal fishers of Rio Grande do Sul, in South Brazil, specifically the very detailed and complex hydrodynamics of their fishing territories related to wind, river discharge and lunar-tidal waves. Nishidai *et al.* (2006) focused on the lunar-tide cycle as perceived by crustacean and mollusk gatherers in Paraiba, around 3.500 km long northward, in Northeastern Brazil

(Fig.1). This draws attention to the fact that marine fishers are permanent observers of ocean behavior.

Somewhat differently, by applying the ethno-oceanographic approach in a larger scale situation, Gasalla (2003a; 2003b, 2004a) correlated FEK/FOK of industrial fishers from the South Brazil Bight, focusing fundamentally on the shelf's fishery stocks abundance and catch trends, food webs, and indicator species, with scientific ecosystem models of change (Gasalla, 2004b) that gained robustness after the input of FEK corroborations (Gasalla, 2007; 2008).

Lately, with the intent of contextualizing global change, Gasalla *et al.* (2008) outlined a hypothesis of change in the ocean off the Southeast Brazil shelf (Figure 1) based on a FOK-based analysis, which took into consideration different categories of fishers. We began with the join analysis of questionnaires responses from different interviews surveys (and projects), carried out in recent last years, that dealt with fisher's perceptions of change in the marine ecosystem they explored. We created a fisher's observations report chart of different fishers' perception of ocean change characteristics, depending on three different fisher's categories: small-scale, industrial and canoe-fishers (Figure 2). Small-scale fishers were considered those members of artisanal communities from the coast of the states of São Paulo and Rio de Janeiro, whose follow the "*caiçaras*" (local population) fishing traditions using gillnets, lines, trawling and seining in coastal areas. The industrial category included surface long-liners for tuna like-fish that operate in most oceanic areas off South Brazil. Canoe-fishers were fishers that specialize on the use of traditional wooden one-log canoes operated with paddles in bays, creeks and near-shore.

The analysis showed that, bearing in mind their last decade of fishing, fishers from all categories recalled their own perceptions of temporal "average" trends of ocean change on the following topics: sea-level rise, rain intensification, what they called "more sea agitation", winds intensification, seawater cooling and seawater warming. However, the pattern of observations' sense of what was important varied between categories especially with respect to water temperature trends: industrial fishers perceived the water to be warming, while almost 100% of the interviewed canoe-fishers recorded a perceived marked decrease in the water temperature (Fig. 2). The FOK analysis provided a new hypothesis on ocean shifts' trends. The following step was to put physical oceanographers round the table to try to find scientific explanations that corresponded to the FOK-based picture, but the area of study was considered data-less in terms of observational temporal datasets. However, after the attempt to correlate fishers' perceptions with scientific hypothesis, and based on an observational data search procedure, the authors were able to find important *in-situ* evidences of change, as well as further explanations derived from available knowledge on the South Atlantic oceanography. Looking at global-scale research, we found that an evidence of a warming trend in the South Brazil Large Marine Ecosystem was actually identified by Belkin (2008), coinciding with the perception of most of the industrial fishers and some of the small-scale fishers, such it is shown in Figure 2 and 3. The team have encountered an analysis using telemetry-based data (such as altimeter-derived SSH trends and surface seawater temperature anomalies) and have corroborated some of the hypothesis raised by analyzing FOK, such as the winds intensity, "sea agitation" and sea-level increasing trends with time (Figures 2 and 4). Considering the differences in water temperature trends from near-shore (canoes) and offshore (industrial) fisher's perception, satellite oceanography revealed a different trend of sea-surface temperature anomalies for the area of study, and between the South Brazil Bight and the offshore oceanic area (Figure 5). By explaining why fishers based in different ocean zones have perceived opposite trends in relation to the temporal variation tendency in seawater temperature, we have been able to go further in the scientific examination of the ocean shifts, identifying new hypothesis in the process.

This sequence illustrates the steps that can be followed in order to incorporate an oriented ethno-oceanographic approach into formal oceanography and global change science (Gasalla *et al.*, 2008). A user-based process can contribute especially in data-poor ecosystems, such as in under-supported developing countries, as a collaborative complementary approach to establish interdisciplinary dialogue. The experiences illustrated above, rooted in ethno-oceanography aspects and users' environmental perceptions, served as the main basis for the formulation of a broader framework for this research field, detailed in the next section. However, some considerations on the future research on fisher's perception of change on marine social-ecological systems in Brazil should be mentioned first.

As Diegues (1991) pointed out, when considering the vulnerability of Brazilian coastal zones to climate change and human impacts, several factors affecting fisheries have been anthropogenic. Harbours and highways construction, oil and chemical industries, fertilisers, coal mining, iron production, paper pulp production, alcohol distilleries, urbanization, oil drilling, tourism, river-runoff, aquaculture and overfishing, are activities that drive degradation and pollution in Brazilian coastal and marine ecosystems (Diegues, 2006). Whether or not FOK analysis will be able to contribute to the understanding of anthropogenic factors remains unknown, but the approach certainly warrants further exploration. As a collaborative and diversified interdisciplinary methodology, it appears that the ethno-oceanography investigation can be adapted to the needs of a variety of ocean research contexts. For example, other global change issues impacting socio-economic and cultural characteristics of fishers, the increasing loss of traditional values and "savoir-faires" as well as the migration patterns from and to the coast, are transformations that have occurred in Brazilian fisheries (Diegues, 1995). The role of new markets, sale points, fisher's organizational responses, and middlemen interactions are usually associated with such changes. Globalized markets, as well as environmental alterations, will certainly influence the future of fishery social-ecological systems of Brazil. It would be also expected that environmental concerns might drive pressure prioritization in both Brazilian fishery management and research contexts, and that resilience, new institutions and governance strategies should be created to cope with adaptation and anticipation needs. Ethno-oceanography should contribute in all these directions.

III- "Ethno-oceanography" as a framework to approach climate and marine ecosystem change.

An innovative framework for ethno-oceanography within the scope of climate and global change studies is presented in this section. Firstly, we provide a diagram summarizing the potential factors responsible for shifts and trends originating from climate variation affecting marine social-ecological fishery systems, in order to propose an *a priori* science-based schema for the investigation of FOK within the ethno-oceanographic approach. Subsequently, the conceptual approach will be detailed and discussed.

Looking beyond uncertainty: implications of climate change to fisheries.

The unique character of maritime communities is linked to the oceanic physical environment which suffers marked temporal changes and is affected by atmospheric phenomena and climate change leading to rapid transformations in the marine conditions (thunderstorms, hurricanes, seaquakes), which in turn offer constant danger to those working there (Diegues, 2001). Human-induced changes as a result of increasing green-house gas concentration (Miles *et al* 2006) and natural cyclic changes on seasonal to decadal variations (Klyashtorin and Lyubushin, 2007) are both elements of climate change. Thus, climate-related dynamics have had serious consequences on the evolution of species, society and fisheries variability (Sharp, 2003).

Focusing on its potential implications for fishery systems, Figure 6 highlights factors that are affected by climate change and have effects on others, as well as their interactions, including direct and indirect causal relationships and systems relevant biological and societal responses. Complex air-sea interactions may alter ocean characteristics, i.e. temperature, salinity, ph (i.e. acidification), ice cover, etc., which affect oceanographic processes such as turbulence and mixing, ocean currents and circulation patterns. Several trends of variation in those parameters produce shifts in winds speed and direction as well as in essential habitats.

Global changes such as warming (see also Figure 4) may alter pressure, winds intensity and thermohaline circulation, which may alter important habitats for fishery resources, fish *recruitment factors* (and success), such as the *optimum environmental window* (i.e. winds speed) for small pelagic (Cury *et al.*, 2008), *larval dispersal, timing of spawning, etc.,* causing important implications to fisheries. Also, new strategies responsive to fluctuations in *productivity* due to environmental influences can arise, influencing the whole fishery system. Ocean warming can increase the frequency of extreme events such as storms or cyclones, which will have repercussion to maritime safety. Sea-level rise can cause a potential loss of coastal fish nursery or breeding areas and reduce the fisheries production. In terms of other implications for fisheries-relevant biological process, bottom-up trophic alterations can produce species dominance shifts, with repercussions to secondary production, fish yields and pelagic fisheries distribution. Societal responses to those changes may possibly be the related fishery management adaptation needs, the modification of exploitation and industrial strategies, market and consumption demands, new conservation concerns, and food security issues (Figure 6).

In summary, the picture represents simplified pathways of changes, variables, impacts and outcomes to fisheries, including the natural, human and management subsystems (*sensu* Charles, 2001). In order to address long-term trends or potential large-scale shifts in marine resources and ecosystems, the ethno-oceanographic approach considering the factors above can provide important input to interdisciplinary focused research, as is described as follows.

Redefining the reach of ethno-oceanography: a conceptual approach

Ethno-oceanography can be also seen as an innovative approach for combining subjective human perceptions and formal analytical approaches to global change in fisheries. The development of a research structure aimed at providing data incorporating the multiple use of FEK/FOK in climate change and marine ecosystem change studies as well as interdisciplinary scientific context supportive to EAF concerns seem to be relevant. Thus, the consideration and inclusion of human perceptions of change and trends, is here of particular value to test scientific hypothesis and to track signals or evidences of change from an interdisciplinary perspective.

A conceptual approach for ethno-oceanography as a feedback framework within a circular knowledge integration process is illustrated by Figure 5. It includes linkages between bottom-up (FOK-based) and top-down (science-based) knowledge. It summarizes important aspects of the dialogue between disciplines to find a resulted common epistemology. It deviates considerably from the established methods of traditional model building and analysis in oceanography as well as in maritime anthropology.

The process may start with the identification of issues, drivers or scenarios of change – e.g. ocean temperature. It is assumed that these issues can be related to their potential effects, and with a pattern-oriented search of systems response. The next step is the detection of FOK or fishers' perception of change, and subsequently, the analysis and identification of trends of alteration or change. Defining new hypothesis can now be compared with ocean science observations with respect to its ability in pursuing a predefined set of hypothesis. The validation step initiates with new scenarios or drivers that can be examined beginning the sequence once again. The process can start at any step and represent the descriptions derived from the analyst, and the trends from data of various types, a distinct feature of the approach being the incorporation of FOK and the subjective perception of users into the model building.

Examination of Figure 6 provides a starting point map for the definition of drivers (see step A in Figure 7). We propose that each one of the listed factors (or diagram's boxes) related to indirect, direct, biological and societal responses in Figure 6 can be investigated in the context of ethno-oceanography. Fishers' perception of trends related to those factors can be approached by using the picture as a guide for FOK/FEK surveys delineation.

The proposed methodology appears to have to begin with scientific *a priori* considerations such as in Figure 6, but, actually, it can start or be modified from cognitive relations perceived in the FOK analysis step. Identifying additional driving forces that are associated with the practical observation of the sea by its people should be of valuable input. However, we suggest that the knowledge in global and climate change science may be used to delineate focused issues for the investigation of trends. Hence, one concrete mode of knowledge integration would be the identification of general patterns of science-interest interaction through the ethno-oceanographic model.

The methodological framework showed in Figure 7 has as its the goal the provision of a learning process about climate and global change and the importance of people's perception and assumptions to be able to come up with new hypothesis. Also, the process can correct models that are factually wrong. Cross-steps information flow and time-series could shed light on linear relationship or provide counterfactuals to prove that non-linearities exist. Of course, change in large-scale complex systems can be often difficult to perceive or plan for, particularly in the realm of global change and governance, but it appear that the methodological approach proposed here provides a foundation for multi-disciplinary research that has proven to be particularly difficult and not very well focused up to this time.

The complexity of a common dialog between traditional and scientific knowledge and the experience on this arena so far show that when both experienced people and skillful scientist take part on the debate the outcomes may be more fruitful. In addition, focused and well-defined issues seem to be essential to reach the approach's objective tracking into the detection of change patterns.

IV- Concluding remarks

The application of FEK/FOK to examine *a priori* scientific questions, and practical ways to use it as a complementary source of observations of ocean and climate change are helpful. The approach can also give added value to scientific findings: ethno-oceanography broadens the knowledge base crucial for raising and testing comprehensive hypotheses of change, particularly when applied to objective, focused and well defined issues. We conclude it might be considered as a relevant piece of the scientific puzzle by providing notable observations as well as explanations triggered by empirical trends. If we agree that interdisciplinary enriches the research results on global change issues, then we must conclude that so far non-effective discussion and deficient input have been the result of the lack of a broader perspective. Moreover, considering major conceptual gaps that exist regarding how to include the human dimension of users perceptions into marine global change and EAF models, the ethno-oceanographic approach can be a strategic contribution to support collaborative and well-focused interdisciplinarity.

A better combination of 'top-down' and 'bottom-up' understanding of the sources of stability and change in the international fisheries sector can provide insights into broader problems of global change governance. Hence, as a framework to deal with climate and marine ecosystem change, our conceptual approach appear to be in consonance with earlier recommended heuristics (Nicholson et al., 2002) by (a) embracing stakeholders, (b) helping codify knowledge from different disciplines in to a unified and coherent framework, (c) encouraging integrated and clear thinking about causal relationships, (d) allowing researchers managers and stakeholders to explore plausible scenarios, and (e) identifying crucial information gaps to climate change detection. EAF can benefit from the ethno-oceanography approach as an integrated field to assess new problems that fisheries are going to face. Our approach seems also to indicate room for a fruitful collaboration model between oceanographers, social scientists, fishers and knowledge users and has been applied to cross-validate regional models and explanations of a system's behaviour.

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Notes

[i] See section II

[ii] Both subsistence, native/indigenous/aboriginal, recreational or commercial, after Charles (2001) typology, including traditional practices or not.

[iii] The proverb in the section's title, respectively in French and English, forewarns to the fact that communication is the keyword for the ethno-oceanographic approach on marine social-ecological systems.

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Figure Captions

Figure 1. Brazil's location with different regions in the context of an schematic representation of the large-scale, upper level currents and fronts in the South Atlantic Ocean (Adapted from Peterson and Stramma (1991).

Figure 2 – Percentage of citation of ocean trends issues by distinct type of fishermen interviewed in the South Brazil Bight area during 2005-2008. Fishers categories are described in the text.
See differences in perception of an increasing trend in sea-water warming and sea-water cooling respectively by near-shore coastal and off-shore fishers.

Figure 3 – Global map of altimeter-derived SSH trends from the difference of two means between periods 1993-99 and 1999-2006 divided by the time difference (from Polito and Sato, 2007).
See the increasing trend for the South Atlantic circled area as a possible scientific correspondence to fisher's perception on sea-level rise in Figure 2.

Figure 4- South Brazil Shelf LME annual mean STT 1957-2006, as shown by Belkin (2007).
See the increasing trend as a scientific correspondence to industrial fisher's perception on a sea water warming trend in Figure 2.

Figure 5- Correlation between the AVHRR sea surface temp. anomalies from the Pathfinder project v5 and interannual indices of El Nino and the NAO for the period 1985-2006. The anomalies are estimated by removing the annual and semi-annual signals from the timeseries (From Sato and Constantino- Courtesy of Olga Sato.
See the differences inside the bight and offshore as a possible eventual corresponcance to the different perceptions of small-scale and canoe fishers from the industrial fishers in terms of cooling or warming between fishing zones.

Figure 7. Proposed "ethno-oceanography" framework within a circular knowledge integration process for the approach of marine ecosystem change. See Figure 4 on the issues to be included as the step "A" in the diagram above.

Figures

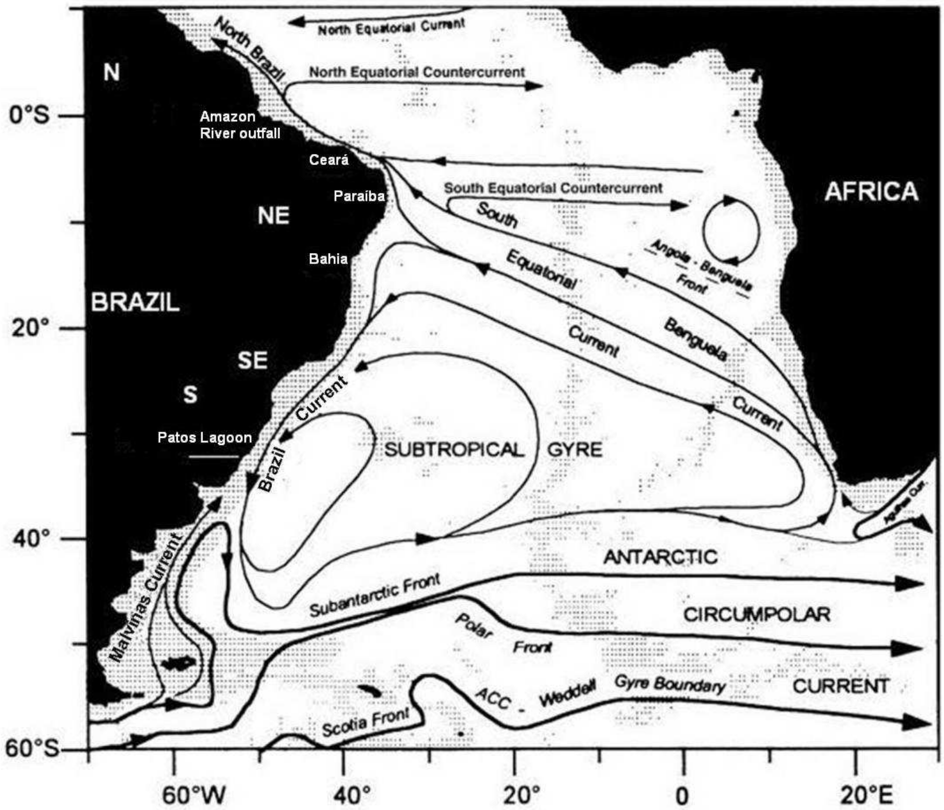


Figure 1

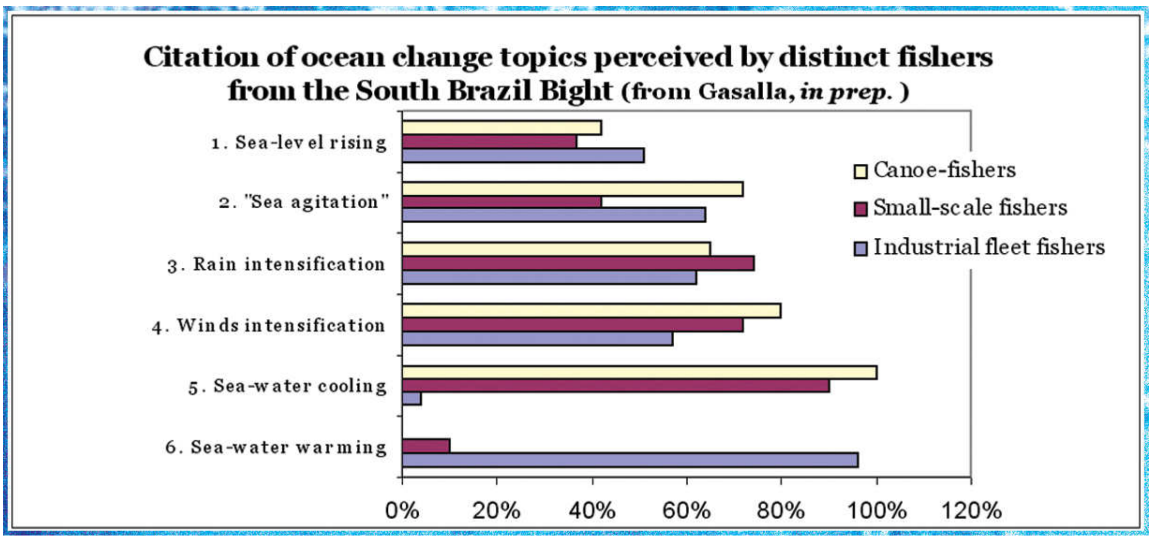
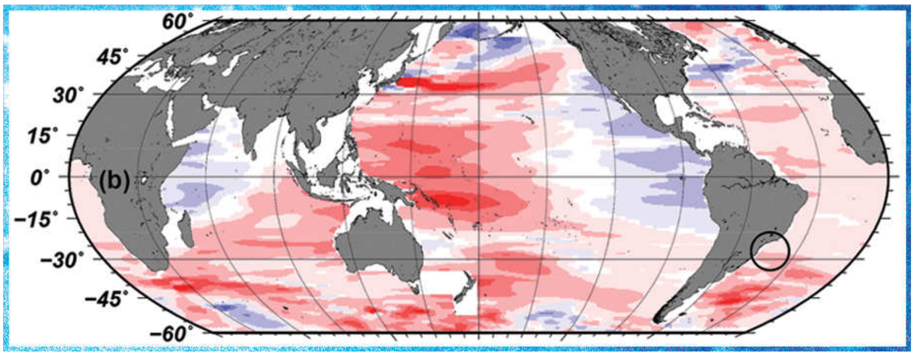


Figure 2



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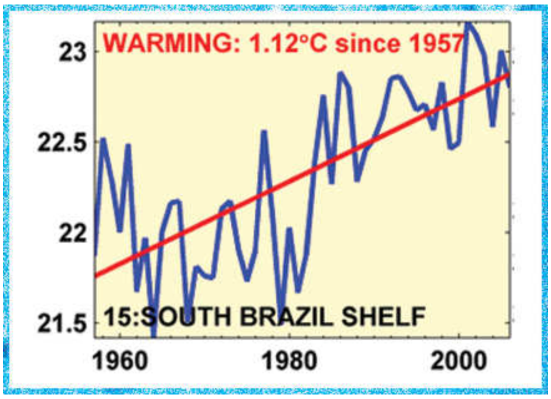

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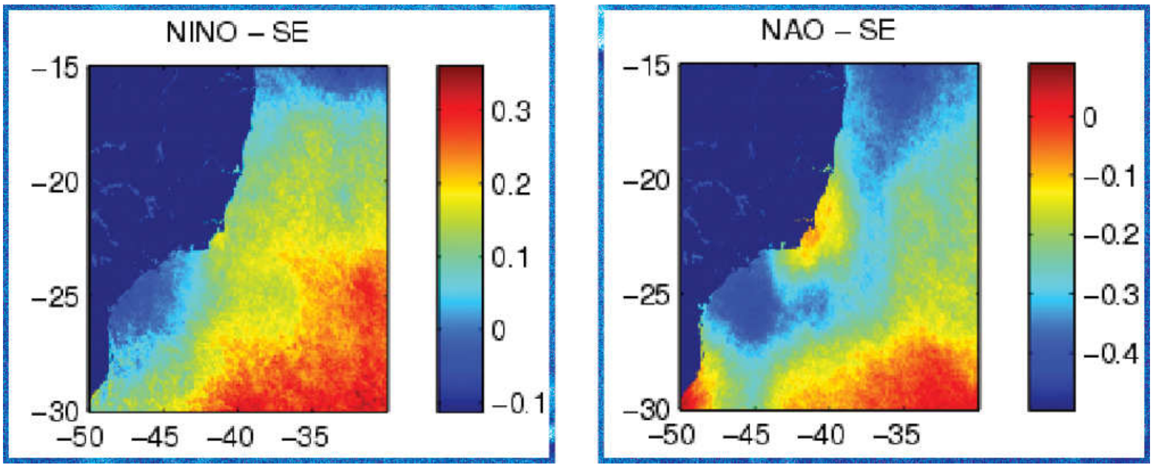

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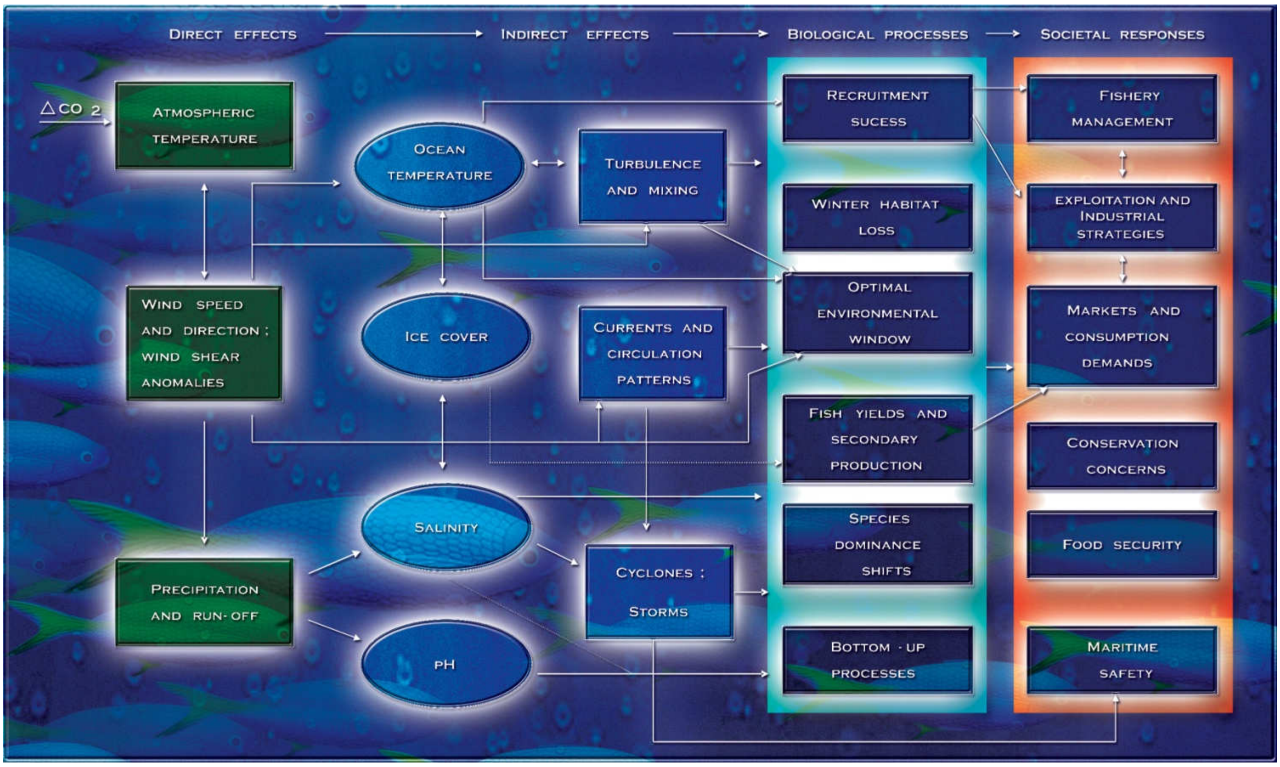
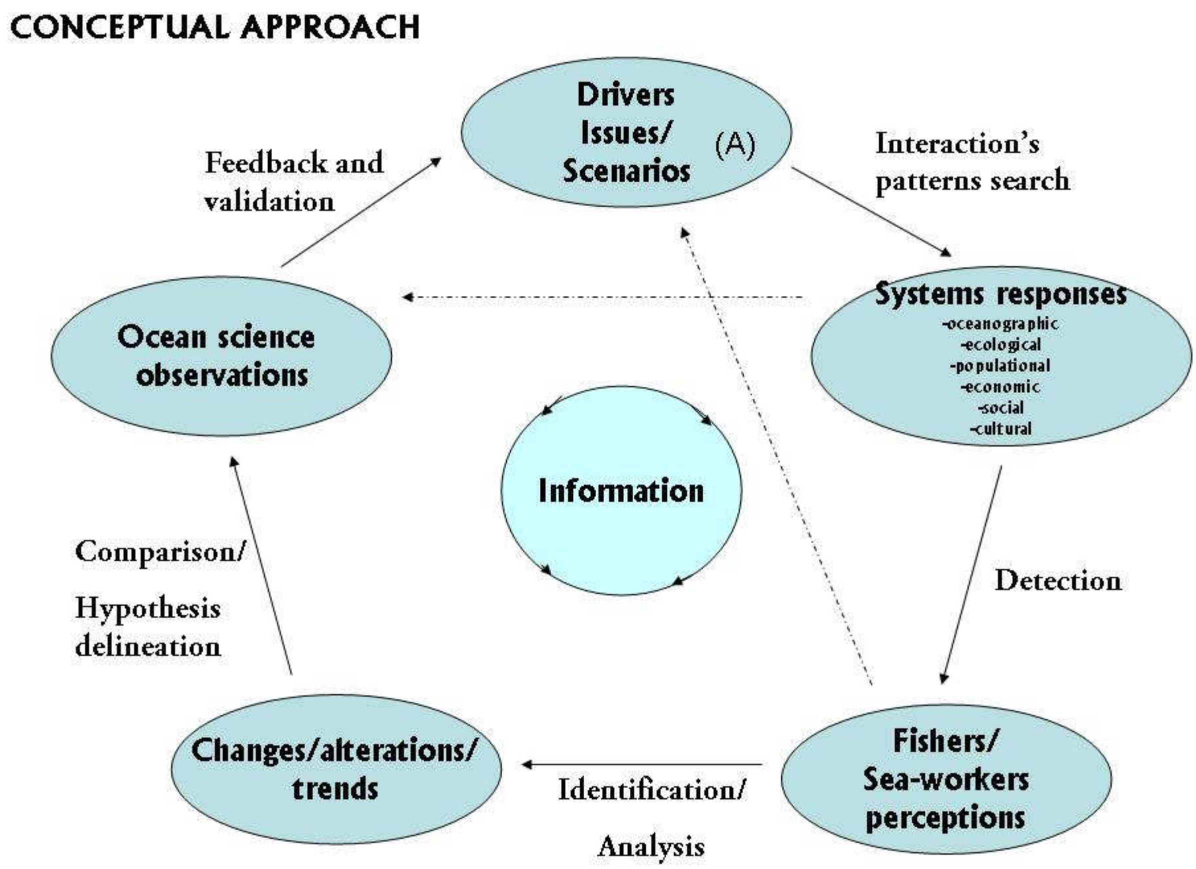

Direct effects
Indirect effects
Biological processes
Societal responses
△CO 2
Atmospheric temperature
Wind speed and direction ; wind shear anomalies
Precipitation and run-off
Ocean temperature
Ice cover
Salinity
pH
Turbulence and mixing
Currents and circulation patterns
Cyclones ; Storms
Recruitment sucess
Winter habitat loss
Optimal environmental window
Fish yields and secondary production
Species dominance shifts
Bottom-up processes
Fishery management
Exploitation and industrial strategies
Markets and consumption demands
Conservation concerns
Food security
Maritime safety

(Figure 6).



(Figure 7)

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[i] See section II

[ii] Both subsistence, native/indigenous/aboriginal, recreational or commercial, after Charles (2001) typology, including traditional practices or not.

[iii] The proverb in the section's title, respectively in French and English, forewarns to the fact that communication is the keyword for the ethno-oceanographic approach on marine social-ecological systems.