Volume 50 Numbers 5–6 2007 ISSN 0964-5691

Ocean & Coastal Management

Available online at www.sciencedirect.com
ScienceDirect

Ocean & Coastal Management 50 (2007) 379–391

Ocean & Coastal Management

www.elsevier.com/locate/ocecoaman

A functional and integrated approach of methods for the management of protected marine areas in the Mexican Coastal Zone

L. Ortiz-Lozano[a,c], I. Espejel[b,*], A. Granados-Barba[c], P. Arceo[c]

[a]*Programa de Doctorado en Oceanografía Costera, Facultad de Ciencias Marionas-IIO, Universidad Autónoma de Baja California, Ensenada, B.C. CP. 22860, Mexico*

[b]*Facultad de Ciencias, Universidad Autónoma de Baja California, Ensenada, B.C. CP. 22860, Mexico*

[c]*Centro de Ecología y Pesquerías, Universidad Veracruzana. Av. Hidalgo # 617 Col. Río Jamapa, Boca del Río Veracruz, CP. 94290, Mexico*

Abstract

The management of the Marine Protected Areas in the Coastal Zone (MPACZ) is an endeavor that requires a comprehensive approach. Given the complexity of these areas, their management calls for the integration of methodologies directed to achieve their conservation. We examine several of the methodologies that have been proposed for the MPACZ management and propose a comprehensive and tactical methodology for the development of strategic management procedures. The resulting method encompasses several concepts; the presence of planning and regulation zones, the analysis of the MPACZ using different scales (macro, meso, and local), and the inclusion of the people involved in the uses and regulation.

1. Introduction

The designation of the Marine Protected Areas in the Coastal Zone (MPACZ) has become one of the important management strategies for natural resources in tropical countries like Mexico. These countries have important coastal environments subjected to different intensities of use and impact. Coral reefs, zones with intense terrestrial influence

*Corresponding author. Tel.: +52 646 174 5925; fax: +52 646 174 4560.
E-mail address: ileana@uabc.mx (I. Espejel).

0964-5691/$ - see front matter
doi:10.1016/j.ocecoaman.2006.12.001

because of their proximity to the coast, suffer direct repercussions from the condition and use of the reef [1–3].

From the perspective of a pure landscape, coral reefs are on the continental shelf in the transition zone between the continent and the ocean. These reefs are usually found close to land in the internal portion of the continental shelf, which gives them special features relevant for management and conservation because of the influence that landscape elements; highlands, coastal plains, and tidelands, have [4–7].

In this paper we present an eclectic framework for the analysis of the MPACZ based on gradual change. This grading integrates the traditional local framework and then enlarges to achieve a regional perspective. This way it is possible to consider the MPACZ as an environment immersed in a series of energy flows that on a larger scale have an effect over its current state and conditions [8].

The goal is to propose an integrated approach to evaluate the conservation and management actions taking place in the Mexican MPACZ by using functional relationships. The objective is to provide a basis to generate the key information that decision makers need to concentrate their management efforts. This methodology has been used in the project ''Determination of Critical Indicators for the Operability of the Management Plan for the Veracruz Reef System National Park''.

1.1. Regulation and planning zones

Usually an MPACZ includes a series of interrelated ecosystems joined by energy flows that are commonly intersected by administrative limits for the protection of the MAPCZ. If the administrative limit is selective for the activities allowed within the protected area, this nonphysical boundary is permeable to the energy interchange into and out of the area [9].

The establishment of an MPACZ generates a series of regulatory actions to protect the environment within the boundaries of the protected area, but usually ignores the energy flows affecting the area under protection, such as linked habitats, larval exchange, and others [5].

For Mexico, in many instances the declaration of a protected marine area incorporates the term ''Influence Zone'' to include those areas close to the protected zones that have certain ecological and socioeconomic interactions [10]. It is also common to find that MPACZ officials have no enforcement power over these areas.

To examine this situation we need to define two terms related to the management of coastal resources; planning zones and the regulation zones [11]. In broad terms, the management of natural resources can be placed under those schemes. The regulation zones are those areas (and the natural resources within) completely immersed under the power of one authority or those where the authority is in charge of issuing the regulations regulating the use of the resource.

Because of the connection of energy flows, the planning zones would be represented by those areas in which the authority in charge of the regulation zones does not have the authority to generate regulations for use, although they are functionally related to the zones under its jurisdiction. As a consequence, the authority that administers the regulation zone is forced to consider the planning zones within the plans and regulation initiatives because of the ecological interactions between these two zones.

From these concepts emerge the need to analyze the relationships between both zones, generate pertinent conservation and management policies, and optimize the conservation efforts on the protected areas. This can be accomplished only with an understanding of the inherent relationships between the MPACZ and its influence zones.

1.2. Functional relationships among landscape elements

Identifying and describing planning and regulation zones is complex, but it is possible to generate methodological tools to examine the relationships among the various landscapes and recognize critical points at which it is possible to intervene, thus warranting the permanence of the MPACZ.

The principal sources describing a systematic approach to this complexity are Proctor et al. [6] and Ray and Hayden [4]. They use a graphic representation of the coastal landscapes based on the presence of different landscape units connected by the energy flows (mainly water and sediments).

Proctor et al. [6] show the repercussions of the gradient of the land and its water flow on the highland landscapes, the coastal plains, and the continental shelves. The dynamics of these flows have a direct influence on the trophic networks and mark the transition between the land and marine environments. Ray and Hayden [4] generated a scheme (Fig. 1) to help perceive the different ecotones involved in the coastal zones and locate the MPACZs (such as the reef systems) within the framework of marine currents running parallel to the coast.

The approaches of Proctor and Hayden and Ray together make it possible to understand the fragility of the reef systems located on the continental shelf because they show the location in the strip where the runoff from the land remains temporarily trapped and affects the condition of systems like coral reefs.

2. Methodological tools

Once the relationships among the different environments and the energy flows relevant to the MPACZ are understood, a question emerges: How do we approach these complexities to reflect them in the management actions applied to these areas?

In what follows, the methodologies, which traditionally have been used separately in several environments, are presented. Putting together these methodologies allows systematizing the approaches towards a better management of the MPACZs. If we classify these methodologies by the scale to which they apply, they can be divided as (a) macroscale, (b) mesoscale, and (c) local-scale approaches. The macroscale is 1:250,000 or larger, the mesoscale < 1:250,000–1:50,000, and the local scale is from 1:50,000 to 1:1. We will also present concepts and methodologies for the integration of the approaches of the different scales.

2.1. Macroscale approach

It is clear that the creation of an MPACZ is to protect the processes taking place within the boundaries at the local scale. However, those processes act in accordance with events and factors at a larger scale that regulate them over space and time [12,13]. Thinking of the protected environments as nested into larger scale processes [14] helps in the understanding of the factors determining the presence and importance of habitats relevant to the protection of the MPACZ.

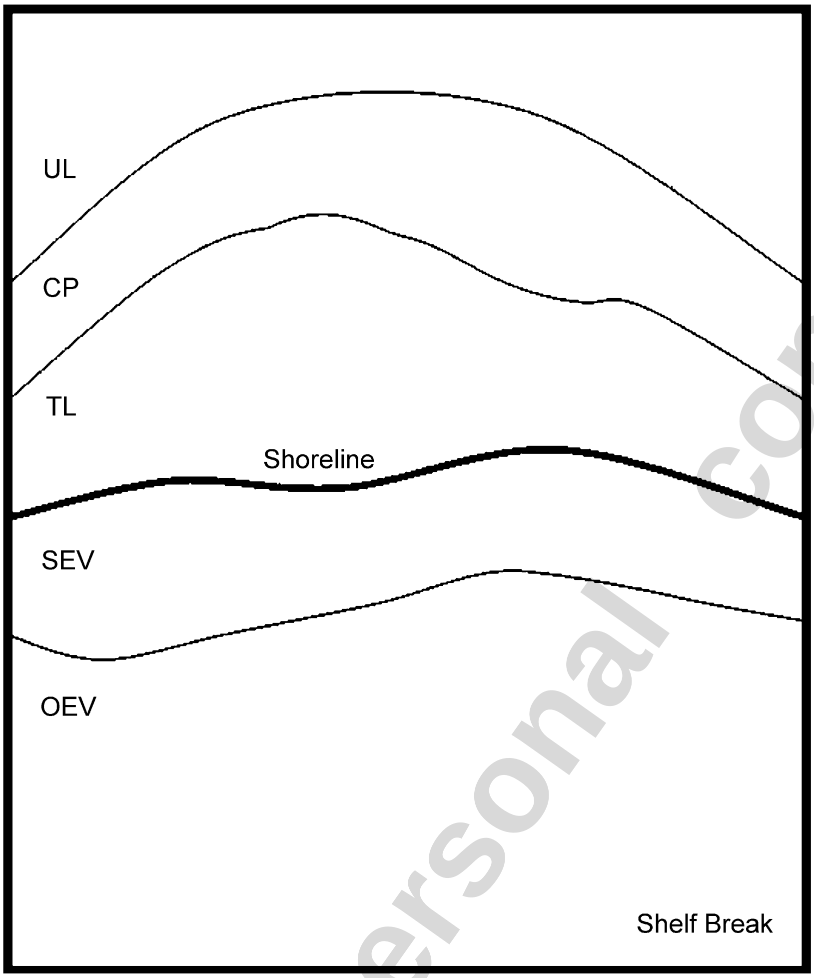

Fig. 1. Coastal Zone Ecotones. UL, uplands; CP, coastal plains; TL, tide lands; SEV, shoreface entrainment volume (at inner shelf); OEV, offshore entrainment volume (at outer shelf). Modified from Ray and Hayden [4].

The understanding of those large-scale processes requires a multidisciplinary approach using chemical, physical, and biological processes, together with the social and economic phenomena in the analysis. To understand these processes, we need to understand the international initiatives developed to facilitate the use and conservation of marine resources, such as the Large Marine Ecosystems (LMEs) initiative [15]. This method classifies the marine environments based on their environmental characteristics; water masses, bathymetry, biology, and human resources. This regionalization has been accepted by the scientific community [16,17] and in principle allows one to differentiate the processes that generate LMEs and makes them different from the adjacent ecosystems.

Based upon this classification, we need to refine the analysis with specific information to understand the processes taking place within the system and characterize the LME where the MPACZ is located [16,17]. The large-scale processes provide information about the spatial and time variability of important events; marine currents, weather, salinity and temperature changes, primary productivity, biogeographical patterns, fishery exploitation, and pollution.

The analysis should answer the question: Which large-scale processes ensure the permanence of the MPACZ in the spatial and time dimensions?

As noted below, the information generated by using this scale is useful for the analysis at the regional and local scales because it permits us to consider the factors affecting the macroscale and modulate the processes in the other scales.

2.2. Mesoscale approach

The MPACZs have the environmental characteristics of the transition zone between the continent and the ocean, widely defined as the *coastal zone space* or *coastal zone*. Independent of the many uni- or multidisciplinary definitions of this zone, its most relevant factor is the conjunction of terrestrial and marine components. This compels us to consider both components for the analysis of the processes in the protected areas. For this, we propose the analysis of the coastal zone using strips parallel to the coastline [4,6,7,18,19]. This approach discriminates the energy flow of the different landscapes that delineate the coastal zone. This eases the process of arranging the MPACZ in one or more characteristic strips or ecotones and contributes to the understanding of the regional dynamics of the MPACZ.

The classification of coastal ecotones given by Ray and Hayden [4] is a useful basis for this analysis (Fig. 1). Using the traditional approaches to coastal resource management, the energy transfer among the different landscape components is shaped by water flow [6], therefore we recommend limiting the land component area by the geographic limits of the hydrological basins directly influencing the MPACZ.

The marine component should be delineated based on the bathymetry (generally the continental shelf limit or the 200-m depth) and also by the characteristics of currents and water masses; the waters running parallel to the coast or littoral currents, the regional or shelf currents, and/or the free shelf waters.

Once the MPACZ has been characterized within this framework, we need to answer the following questions: What are the dynamics of the strip in which the MPACZ is located? How do the rest of the strips and coastal ecotones influence the MPACZ strip? What is the heterogeneity caused by the physical, biological, and human factors in every strip? How are these characteristics modulated through the strips?

Answering these questions gives a clear idea of the connectivity of the MPACZ with other environments, which is fundamental to the understanding of the natural and anthropogenic phenomena in the planning zones and their consequences on the regulation zones. For this reason, we need to cartographically depict the components of the ecotones or parallel coastal strips and the features of the energy exchanges in the MPACZ.

2.3. Local-scale approach

On the local scale the analysis rests on the study of the administrative boundaries of the MPACZ. It is then useful to use the Boundary Model proposed by Schonewald-Cox and Bayless [9]. As we mentioned above, the imaginary boundaries of the MPACZ are permeable to the resource uses within the area. The uses are in turn selectively regulated by restraining actions from the responsible authorities and connected to the protection of the area. This is accomplished by the implementation of management programs and official regulations, rules, or permits to limit the way the resources within the MPACZ are to be used. Nevertheless, and particularly for a marine environment, the administrative boundaries are totally permeable to the energy flows in the water column (Fig. 2). It is by recognizing the energy entering the MPACZ in the form of contributing water masses, genetic flows (such as larvae), migratory species, or environmental impacts influencing the protected area that we will be able to identify the attributes relevant to the management of the area and the potential causes of environmental problems.

Under this perspective, we need to differentiate the attributes affecting the internal and the external part of the MPACZ and evaluate the boundary heterogeneity by identifying any segmentation (Fig. 3). For this we recommended analyzing the individual MPACZ boundaries based on the portion of the boundary parallel and adjacent to the coast line, the portion of the boundary parallel to and seaward of the coast line in the MPACZ, and the boundaries perpendicular to the coast.

This analysis differentiates the importance of every component of the boundaries and the energy flows entering the MPACZ used for the maintenance of the protected area.

The second approach that we may use at this scale rests on the spatial heterogeneity. This will identify the different environmental components of the MPACZ. In many

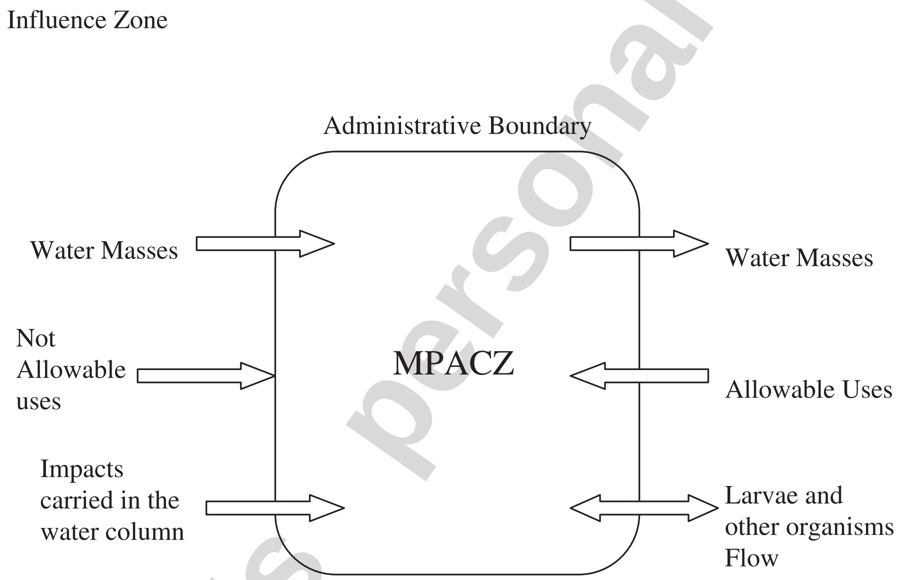

Fig. 2. Boundary Model. The administrative boundary of the CMPA is permeable to the different uses of the area according to the regulations and the enforcement of the authority in charge (dark arrows). The boundary is totally permeable to the water mass flows and to the energy carried with them whether in the form of live organisms or as environmental impacts. Modified from Schonewald-Cox and Bayless [9].

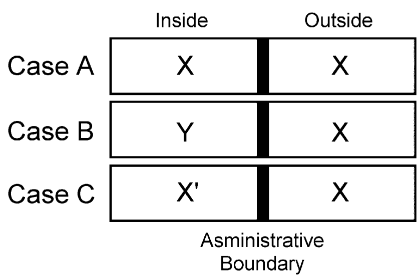

Fig. 3. Possible administrative boundary associated heterogeneity. Case A: the attributes inside and outside the MPACZ are equal. Case B: the attributes inside and outside the MPACZ boundary are different. Case C: at the time of the administrative boundary implementation the attributes inside and outside are equal, but at a time "*z*" the condition of the specific attribute changes because of the effectiveness of the regulation inside the MPACZ. Modified from Schoewald-Cox and Bayles [9].

instances, the declaration of the MPACZ specifies a precise zoning of the area into relevant environments, but we recommend analyzing the areas based on attributes such as currents, physical and chemical variables, bathymetry, biological components, and uses. To accomplish this, we recommend considering the presence of nested environments, the existence of systems formed by several subsystems, which are formed by landscapes, and so on. We believe it is necessary that the first approximation for the zoning of the MPACZ is based on geomorphology.

2.4. Analysis integration

In practical terms, the information analyzed in the scales of (a), (b), and (c) could also be done in reverse (starting from the local scale) to systematize the causal networks linked to the environmental problems inherent to the MPACZ.

As causal networks we refer to the relation between a specific environmental problem and the factors causing the problem [20]. These factors may have natural or anthropogenic origins. The latter can be linked to a social activity or a productive activity, inside or outside the limits of the MPACZ. We exemplify this with a situation diagram such as Fig. 4, where we draw the presence of the boundaries of the regulation zone and the spatial concept of the planning zone.

In this analysis each subsystem is a component of the system under protection. For every subsystem there is one or more environmental problems caused by one or more sources, which in turn are caused by one or more activities or natural phenomena.

Starting with the subsystems and landscapes already identified inside the MPACZ (see Section 2.3), we need to consider the environmental problems specific to each. This is accomplished by the analysis of previous studies, cartographic information, questionnaires, field work, and/or indirect information from interviews with key informants to include all possible sources of information.

From the information gathered we need to properly identify the types of problems in each subsystem. General terms such as "water pollution" should be avoided because these may be of different types (i.e. it is not the same to talk about water pollution as talking about solid waste pollution, chemical pollution, or oil pollution). Once we have identified the specific problems we can classify those affecting all the MPACZ and understand their role.

It is also useful to depict the results in a table (Table 1) and specify in columns the subsystems composing the MPACZ with the rows showing the identified problems. This helps to understand, synoptically, the subsystems having greater pressures, the types of pressures, the problems affecting a larger number of subsystems, and their relevance for the whole protected area.

The next step is to investigate the sources of the particular problems. Each subsystem is to be considered separately because it may be possible for a problem to affect various subsystems, but not necessarily have come from the same source. First we should consider whether the problem is caused by a natural or an anthropogenic factor and then whether it is generated inside or outside the MPACZ. The information to be able to recognize the source of the problem may come from direct observation in the area, literature analysis, cartographic analysis, and/or the indirect sources noted before.

The results of the analysis rest also on the approximations made at the local, meso- and macroscales, which allow reinforcing the functional ties between the protected area and the

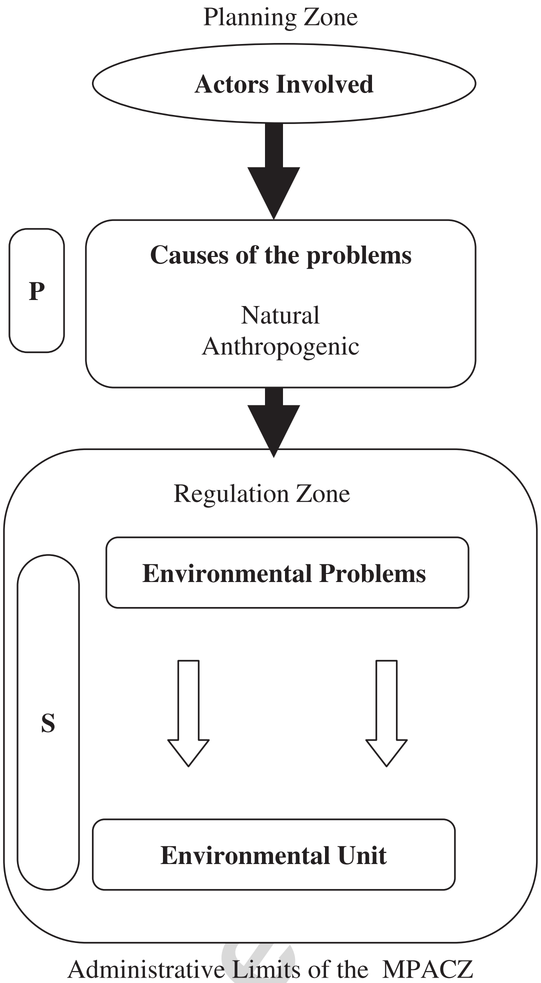

Fig. 4. Situation diagram. For an environmental unit within the MPACZ there is a specific problem caused by one or more natural and/or human causes. For the latter, behind the causes are one or more actors generating them. Joining this diagram with the Status–Pressure–Response-indicators concept by OCDE [22], the Status indicators (S) are derived from the information of environmental units and environmental impacts. The Pressure (P) indicators may arise from the causes of the identified problem.

large landscapes in which it is immersed. For example, the limit analysis of the MPACZ based on the proposal of Schonewald-Cox and Bayless [9] (see Section 2.3) allows us to cartographically identify the subsystems closer to energetic flows located at the edge of the MPACZ boundaries, which may have different problems than those located farther from the edge boundary.

For environmental problems generated by human activities, we recommend identifying those in the influence zones and then refine the analysis to detect the activities, and also the specific activities of each activity causing the environmental problem. For example, the impacts that cattle breeding in the coastal zone may have on the MPACZ are well-known, but specifically it may be the use of tick baths that causes the pollution. The result of this analysis helps to find a way to modify the specific activity and reduce its effects.

To ease the analysis, this information may be systematized in a matrix such as Table 2. In this matrix, we can condense the information about the sectors perceiving or resenting the problems and their location and generating factors.

Table 1
Detachment of the environmental problem by environmental unit in the Priority Conservation Zone of Barra del Tordo, Tamaulipas, México [23]

Type of environmental problem	Environmental problems	Unit where it is perceived						Total
		Carrizal river	Vidal lagoon	Chilillo lagoon	Low forest	Salt flat	Beaches	
Cartography depicted	Loss of mangrove coverage	●		●				2
	Loss of low forest coverage				●			1
	Loss of halophytes			●		●		2
Cartography depicted and 1:1 scale perceivable	Changes in the configuration of the estuary mouth of Barra del Tordo	●						1
	Beach and dune erosion						●	1
1:1 scale perceivable	Pollution by fecal coliforms	●		●				2
	Pollution by organic material	●		●				2
	Pollution by tick baths	●	●	●				3
	Pollution by herbicides	●	●	●				3
	Pollution by hazardous residues	●		●				2
	Pollution by trash	●		●		●	●	4
	Red tide invasion	●	●	●			●	4
Short term social repercussions	Decrease of the estuary sport fishing	●						1
	Oyster population decline	●	●	●				3
	Loss of natural oyster banks	●						1
	Death of fish	●	●	●				3
	Changes in the commercial channels for oysters	●	●	●				3
	Human settlement presence in tidal zones					●		1
	Problems by unit	14	6	12	1	3	3	
	Exclusive problems by unit	3	0	0	1	1	1	
	Cartography depicted environmental problems	1	0	2	1	1	0	
	Cartography depicted environmental and 1:1 scale perceivable problems	1	0	0	0	0	1	
	Environmental 1:1 scale perceivable problems	7	3	7	0	1	2	
	Environmental problems with short term social repercussions	5	3	3	0	1	0	

The arrangement of this information allows the identification of those problems that are more relevant for the system as a whole and those environmental units with higher impact. Environmental problems by homogeneous unit (● presence of the problem).

Linked to the sources of impact are the social activities responsible for them. We need to identify and learn the different aspects of the organizations, their range of action, and their interests. One classification of these activities is the following (modified from Sorensen et al. [11]):

1. Public administrators.
2. Governmental agencies.
3. Private sector.
4. Loan and assistance institutions.
5. Scientific Community.
6. Conservationist organizations.
7. Coastal owners.
8. Artisanal and subsistence users.

As more information is obtained, we can then distinguish conflicts of present and potential uses among the productive and protection activities by using the technique proposed by SEMARNAP and FAO [21]. This technique consists in building a matrix to depict the interactions between the priority activity (the protection of the MPACZ, in this case) and the other activities causing the environmental problems (Table 3).

2.5. Generation of indices to evaluate the effectiveness of the management actions

The methodological approaches under the Pressure–State–Response-indicators scheme [22] for the analysis of the relationships between the MPACZ and its influence zones allow the evaluation of the actions that decision makers take for the management of the area. This scheme has a close resemblance to the causal networks approach by considering that the ecosystem (State) responds to a series of factors that modify it (Pressure). The indicators, "response indicators", are those reflecting the responses society makes to modify both the pressure and the state of the ecosystem.

Comparing the OCDE scheme [22] with that proposed in the Analysis Integration Section (Fig. 4), we can locate the different attributes characterizing the identified systems among the state indicators. The sources of the problems (specific directions of the human activities) can be matched up to the pressure indicators.

In this way it is possible to specifically detect aspects where it is necessary to focus the management efforts of the MPACZ. The characterization of the impact sources shows information about the processes that should be modified to decrease the problems within a specific subsystem. The way decision makers negotiate with the social actors to modify the Status and Pressure within the MPACZ allows the generation of the Response indicators.

3. Conclusion

The methodology approach presented here is composed mainly of two elements. The combination of the two elements results in the integrated analysis of the MPACZ and we believe are fundamental to accomplishing the management objectives. The first element is the space analysis. In this element we recommend the use of three spatial scales. This permits us to identify the processes within the MPACZ and those large-scale elements causing the permanence of the system. This helps define those actions over which the park

Table 2
Matrix to condense the information from the Priority Conservation Zone Barra del Tordo, Tamaulipas, México [23]

Problems and causes	Units where it is perceived						Sector where the problem is felt	Other sectors which perceive the problem	Spatial allocation and origin of the source	Factors generating the problem
	Rio Carrizal	Laguna Vidal	Laguna Chilillo	Low forest	Salt flat	Becaches				
Loss of mangrove coverage	●		●				Oyster culture	Academic NGOs		
Village of Barra del Tordo expansion	◇		◇						Internal, anthropogenic	Lack of development plans for the village
Construction of harbors	◇		◇						Internal, anthropogenic	Infrastructure required for oyster culture and fishery sectors
Construction of ponds for shrimp farms			◇						Internal, anthropogenic	Infrastructure required for shrimp culture
Construction of infrastructure for the tourist center Paraíso	◇								Internal, anthropogenic	Activities of the internal tourist sector
Changes in the configuration of the mouth of Barra del Tordo	●						Oyster Fisheries	Academic		
Sediment contributed from the dam of the Rio Carrizal	◇								Anthropogenic external	Construction of the dam República Española in 1970–74 to create an irrigation system
Seasonal changes in the wave trends	◇								Natural external	Natural factors
Storms and hurricanes	◇								Natural external	Natural factors
Droughts	◇								Natural external	Natural factors

This arrangement eases the interpretation of the data generated and is useful as a guide to learn about the lack of information in the course of the research. Environmental problems, causes, sectors factors, sources, and origins (● problem presence, ◇ source presence).

Table 3
Matrix activities interactions

Interactions among human activities in the MPACZ	
Human activities	**Priority activities**
Specific maneuvers	**Conservation of the MPACZ**
Activity	
Specific maneuver	Interaction type **(D/I)** **(a/p)**

In this matrix, the information related to the different activities related to the MPACZ can be summarized and also the way they interact for the conservation of the area. The interactions might be of two types (modified from SEMARNAT and FAO [21]); the direct type (D) interactions are those in which two or more human activities take place simultaneously in time, space, or demand for some resource. The interactions of the indirect type (I) are those for which the demand for resources is not simultaneous, differing in time or space. These latter interactions can be classified as present (a) when they are already occurring, or potential (p) if there are enough reasons to consider its future presence.

authority has direct control, and those actions calling for the participation of other authorities outside the park. This takes us to the other element of the proposed analysis, the definition of Status, Pressure, and Response indicators related to the natural and the social phenomena occurring within and outside the park limits. The two approaches intersect and complement one another.

Acknowledgments

We thank Dr. Anamaría Escofet and Dr. Francisco Correa and Dr. Gabriela Montaño for the revision of this paper and to Dr. Ellis Glazier for editing the English-language text. Also to Consejo Nacional de Ciencia y Tecnolgía (CONACyT) and the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), Mexico, for the funds provided to the project FOSEMARNAT-2004-01-181.

References

[1] Cesar H. Economic analysis of Indonesian coral reefs. World Bank, Environment Department; 1996. 103pp.
[2] Cicin-Sain B, Knecht RW. Integrated coastal zone management. Concepts and practices. Washington, DC: Island Press; 1998. 517pp.
[3] Nugues MM, Roberts CM. Coral mortality and interaction with algae in relation to sedimentation. Coral Reefs 2003;22:507–16.
[4] Ray GC, Hayden BP. Coastal zone ecotones. In: Hansen AJ, di Castri F, editors. Landscape boundaries, consequences for biotic diversity and ecological flows. New York: Springer; 1992. p. 403–20.
[5] Salm RV. Ecological boundaries for coral-reef reserves: principles and guidelines. Environ Conserv 1984;11(3):209–15.
[6] Proctor ChM, García JC, Galvin DV, Joyner T, Lewis GB, Loehr LC, et al. An ecological characterization of the Pacific Northwest Coastal Region. Conceptual models, vol. 1, US Fish and Wildlife Service, Biological Services Program, FWS/OBS-79/11; 1980. 389pp.
[7] Beer T. Environmental oceanography. Boca Ratón: CRC Press; 1996 367pp.
[8] Buddemeier RW, Fautin DG. Large-scale dynamics: the state of the science, the state of the reef, and the research issues. Coral Reefs 2002;21:1–8.

[9] Schonewald-Cox CM, Bayless JW. The boundary model: a geographical analysis of design and conservation of nature reserves. Biol Conserv 1986;38:305–22.
[10] Diario Oficial de la Federación. Ley General del Equilibrio Ecológico y Protección al Ambiente, Diario Oficial de la Federación, México; 2000.
[11] Sorensen JC, McCreary ST, Brandani A. Coasts: institutional arrangements for managing coastal resources and environments. Coastal Resources Center, Rhode Island University; 1992. 185pp.
[12] Brown JH. Grand challenges in scaling up environmental research. In: Peuquet DJ, Marble DF, editors. Environmental information management and analysis: ecosystem to global scales. UK: Taylor and Francis Ltd, Burguess Press; 1994. p. 21–6.
[13] Nixon SW. Regional Coastal Research—What is it? Why do it? What role should NAML play? Biol Bull 1996;190:252–9.
[14] Kolasa J, Rollo CD. 1. Introduction: the heterogeneity of heterogeneity: a glossary. In: Kolasa J, Pickett STA, editors. Ecological heterogeneity. New York: Springer; 1991. p. 1–23.
[15] Sherman K, Alexander LM, Gold BD. Large marine ecosystems: stress, mitigation and sustainability. Washington, DC: AAAS Press; 1993 376pp.
[16] Yáñez-Arancibia A, Day JW. The Gulf of Mexico: towards an integration of coastal management with large marine ecosystem management. Ocean Coastal Manage 2004;47:537–63.
[17] Escofet A, Espejel I. Geographic indicators of coastal orientation and large marine ecosystems: alternative basis for management-oriented cross-national comparisons. Coastal manage 2004;32(2):117–28.
[18] Escofet A. Los puertos en el marco del desarrollo costero sustentable. IV Congreso Internacional Puertos y Costas, realidades y Perspectivas. Acapulco, Guerrero, México; Noviembre 2003.
[19] Escofet A. Aproximación conceptual y operativa para el análisis de la zona costera de México: un enfoque sistémico-paisajístico de multiescala. Tesis de Doctorado en Oceanografía Costera, Universidad Autónoma de Baja California, México; 2004.
[20] Andrade HM, Morales G, Hernández Yáñez A. Guía de análisis de impactos y sus fuentes en áreas naturales. The Nature Conservancy, México; 1999. 43pp.
[21] Secretaría del Medio Ambiente, Recursos Naturales y Pesca and Food and Agriculture Organization. Methodological guide for the formulation and implementation of aquaculture development local plans at coastal lagoons in México. Proyecto UTF/MEX/035/MEX "Modernización del sector pesquero" Estudios para el mejoramiento productivo de áreas lagunares costeras. México; 1995. 76pp.
[22] Organization for Economic Cooperation and Development. Environmental Indicators: OCDE core set. OCDE, France; 1994. 160pp.
[23] Ortiz-Lozano LD. Environmental impacts, actors and use conflict at Barra del Tordo, Tamaulipas, México. Master Thesis, El Colegio de la Frontera Norte, México; 2000. 83pp.