COASTAL ZONE MANAGEMENT IN SOUTH AMERICA WITH A LOOK AT THREE DISTINCT ESTUARINE SYSTEMS

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1 INTRODUCTION

Estuaries and adjacent coastal areas can be characterized by several variables such as: size, shape and bathymetry, tidal influence, fresh water inflow, turbidity, residence times, sediment properties, and water-column turbidity. Also of great importance are the geographical location (mainly the latitude) and human pressures. In combination, all these characteristics shape the ecology of an estuary, conferring singularity to each system. The ECOMANAGE project focused on three estuarine systems in South America: Santos Estuary (24º S) and Bahía Blanca (39º S) in the Atlantic coast, and Aysén Fjord (45° S) in the Pacific coast. These estuaries, in terms of their ecology, differ in features like the role of the benthic system, anthropogenic nutrient inputs, presence/absence of tidal flats. The main purpose of this chapter is to describe in general terms the backdrop of the South American coastal zone management reality, highlighting the major features of these three system. Together, they represent key coastal zones regarding their integrated management. All show conflicting interests between urban, industrial and agricultural development and environmental conservation. Thus, beyond their differences, they share some of the major regional environmental concerns in South America, namely, the transformation of the landscape and seascape with the loss of natural patrimony, increased human waste and industrial disposal (UNEP 1999).

2 THE SOUTH AMERICAN REALITY

The South American region is characterized by a remarkable heterogeneity in climate, ecosystems, human population distribution and economic development. The combination of the prevailing atmospheric and oceanic circulation defines the climate and the land and sea productivity of the region. This partly explains the distribution of human settlements and the availability of basic services (e.g., water supply). According to the medium prospect of the United Nations (Nawata 1999), an increase in population to 838 million is expected for South America by the year 2050. The growth rate of coastal populations in almost every Latin American country is greater than its national growth rate. Nearly 75% of the region's inhabitants live in cities, and 60% of the largest 77 cities are in the coastal zone. As a result, over the last decades South America has become more urban and also much more coastal (Hinrichsen 1997). This concentration along the coast is accompanied by a similarly disproportionate share of the region's infrastructure and economic activity, some of which requires proximity to the waterfront. Land-use changes have become a major force driving ecosystem changes. Up to 19% of the total area of Latin America is used as agricultural lands (excluding pastures). The waters of Peru and Chile support one of the top five commercial fisheries and, until recently, the world's fastest growing fishery thrived off the coasts of Argentina and Uruguay (IDB 1995).

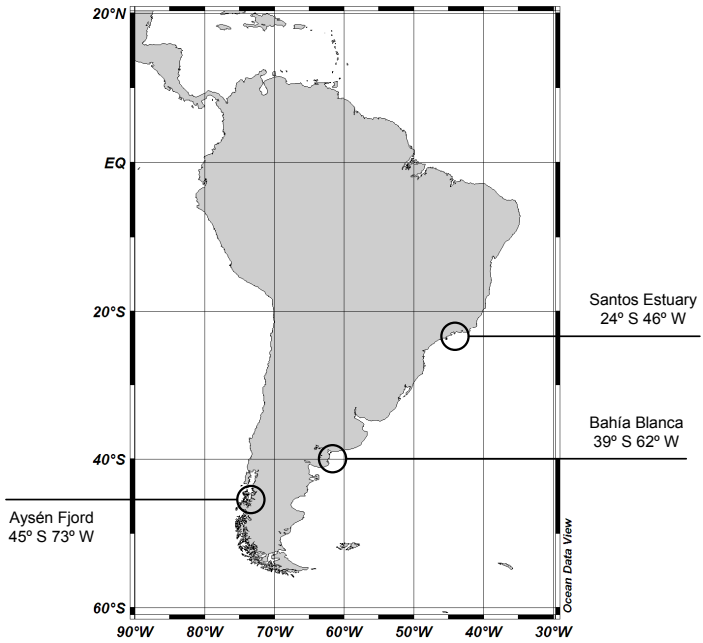

FIGURE 1: *The three ECOMANAGE study sites in South America: Santos Estuary in Brazil, Bahía Blanca in Argentina and Aysén Fjord in Chile.*

2.1 Biodiversity of the Region

South America hosts a significant percentage of the world's biodiversity in terrestrial and marine habitats (Heywood and Watson 1995). For example, there is a large variety of coastal wetlands. The unique location of the region, its extreme climatic variations, tidal patterns, and geological features, make these coastal wetlands rank among the most productive of the world. However, a significant part of them endure the impact of population growth, expansion of the agricultural activity, and land-use changes. However, considering that seven of the world's most diverse and threatened areas are in Latin America and the Caribbean (Myers et al. 2000), the continent faces today serious challenges in natural resources management.

2.2 Socioeconomic factors

From an historical perspective, the use of ocean and maritime access has been at the heart of the southern hemisphere's economic and political development. The ports of South America are important nodes in the flow of goods brought into and exported from the Region. For example, the Region's industrial ports are the second leading destination for containerized U.S. exports. Expanding ports and maritime trade are often accompanied by intensified

transportation corridors in coastal ocean areas, as is happening off Argentina, Brazil, Ecuador and Uruguay. The ports of South America are also a significant factor in land use changes in the coastal zone. Most commodity ports serve as development poles for manufacturing and processing activities, often contributing to both the urbanization and increasing industrial character of coastal areas. South American economies are increasingly dependent on trade agreements like the Mercosur that has Argentina, Brazil, Paraguay, and Uruguay as participating countries, and Bolivia and Chile as associate members. These have developed with the main purpose of speeding up socioeconomic development, and have important effects on the economy and, indirectly, on the environment of the region. Even with a strong economic perspective at its core, much of these agreements are gradually considering environmental issues. Indeed, a growing environmental awareness is evident in local legislations in the region. Furthermore, a large percent of coastal populations, especially those with low income, still depends on natural resources exploitation (e.g. artisan fisheries, small-scale aquaculture and farming). As a result, sustainable development strategies and integrated management are rather timely in order to decrease conflicts.

2.3 Environmental awareness

Over the last decades, and especially after Río 1992, South American countries have been developing a strong environmental awareness. This is evident in the ratification of international and regional conventions and agreements, and in the adaptation into the national legislation of many countries to reflect the need of a sustainable development. Two major steps of South American government have initiated a path for preventive actions regarding the use of natural resources: the ratification of the recommendations of the United Nations Conference on Environment and Development (UNCED 1992), and the incorporation of recommendations from the Agenda 21 into national legislation.

As environmental concerns become more pressing, they are receiving more attention on the international political agenda. South America is no exception to this. In line with United Nations Resolution A/52/629 calling for cooperation to incorporate sustainable development programs at national, regional and global levels, countries in South America have been engaged in accomplishing the objectives of such development programs. The large majority of countries follow the recommendations made by the United Nations Commission for Sustainable Development (UNCSD), and the Economic Commission for Latin America and the Caribbean (ECLAC) is assisting them in the integration process of relevant disciplines and sectors. There are also a significant number of regional agreements and a vast body of laws, rules, and regulations to ensure systematic and coordinated actions for protecting the environment and promoting sustainable development (Bertucci et al. 1996, Solano 1997). Most South American governments have developed and implemented comprehensive environmental legal frameworks with relevant laws and procedures for specific resources and activities like marine resources, coastal areas, tourism, etc. However, local empowered stakeholder participation is still in an early stage (Bachmann et al. 2007).

2.4 Challenges in integrated coastal zone management

Habitat transformation (for infrastructure expansion, aquaculture, agriculture, etc.), and sewage and garbage disposal are among the most recurrent problems in South American coastal zones. Water resource management has been identified as a guiding objective by South American countries, with the following subdivisions: (1) Water Supply; (2) Watershed Management; Management of marine coast and related resources; and (3) improved quality of groundwater (UNEP 2003). The legal frameworks for coastal management are being revised in many countries and in some cases modified to change the sectorial focus to a more integrated management approach. This is being pursued having in mind the multiple uses of resources by different sectors like agriculture, fishing, aquaculture, industry, domestic consumption, energy and recreational use. From this perspective, the challenge of coastal ecosystem management in South America can be address with common and shared methods.

3 DRIVERS OF CHANGE IN COASTAL AREAS

Coastal and marine areas of South America undergo fast and frequently drastic transformation. Many of these changes, typical of coastal areas, are experienced as environmental, economic and social problems. For the region, these can be summarized in the following topics, with their relative importance varying from one location to another (Lemay 1998).

3.1 Degradation of coastal ecosystems

Degradation of coastal systems occurs mainly by the combination of land conversion and the expansion of coastal infrastructures. The loss of mangrove areas is a clear example. It has been estimated that 55% of the entire mangrove coast of Latin America and Caribbean was classified as either critical or endangered, 30% vulnerable and only 15% as stable (Olson et al. 1995). In the tropical Americas, the loss of coastal forests, mainly mangroves, occurs at a rate of approximately 1% year (Ellison and Farnsworth 1996). In some parts of the region this poses a threat to local subsistence because most commercial shellfish and finfish use mangrove forests for nurseries and refuge, and so the fisheries in mangrove regions are declining at a similar rate as mangrove communities (Ewell and Twilley 1998). Many areas are experiencing a rapid and often drastic transformation and degradation to coastal and marine areas. Land conversion is causing degradation of coastal habitats, including mangroves, estuaries and coral reefs. Mangroves, for example, have been disappearing at an alarming rate over the past 20 years. Coastal water quality has been declining throughout the region, due to increasing discharges of untreated municipal waste.

3.2 Depletion of commercial fisheries stock

Depletion of stocks, overcapitalization and plant closures, habitat degradation, non-compliance with management regulations and illegal practices, are among the main problems that the fish-

eries sector faces in the Region. The expansion of aquaculture, which often depends on wild fisheries stocks for seeding and food, also contributes to enhance pressure on natural stocks.

3.3 Land use and resource allocation conflicts

Land reclamation for residential, industrial, agricultural and tourism purposes has caused the degradation of coastal and marine ecosystems of the sub-region. The massive and largely unplanned investments in sectors like aquaculture, port and industrial facilities expansion, and tourism is coastal and estuarine areas has been pointed out as the reasons of accelerated land use changes and associated conflicts. Frequently new activities compete for the same resource upon which traditional communities depend. When compared to other tropical regions such as Southeast Asia, the importance of aquaculture in South America is relatively small. Nonetheless its importance is growing in countries such as Ecuador, where a significant shrimp mariculture industry has developed mostly in mangrove converted areas and salt ponds. More recently important breakthroughs have taken place in aquaculture in Chile (mostly salmon), induced by attractive export markets and made possible by favorable environmental conditions for their growth (Lemay 1998). This activity has been steadily growing at an impressive rate of 30% a year, when compared with 9.5% worldwide. Indeed salmon farming, induced by favorable export markets, is generating around US$450 million a year in export earnings. The environmental impact of this activity has been generating growing concerns, especially because of the habitat losses; eutrophication associated with effluent discharges, other changes is estuarine water quality and the introduction of exotic species.

Tourism investments represent an important catalyst of land use change in coastal areas, and the South American continent is no exception. Tourism has increased in the last decades and this may lead to important environmental impact when it takes place in estuaries and mangroves (Garreta-Harkot 2003). In addition to generating employment, tourism investments lead to important land use changes in coastal areas. Many rural coastal areas are experiencing a gradual shift from dependence on local fisheries and agriculture towards the provision of tourism services and related activities (WTTC 1993). The development of the tourism sector implies a demand for improved access along the coast in places that until recently had no basic services. Improvements in access, energy distribution and communications needed for resort development or other infrastructures, as well as prospects for employment, attract new residents to the coast. A frequent outcome is the transformation of natural (ecosystems composition) and human landscape (e.g., traditional fishing villages). These changes trigger rising prices for land, competition for resources, conflicts with sectors such as fisheries and agriculture, and may hinder the development of proper management policies.

3.4 Degradation of coastal water quality induced by land-based sources

Estuarine and coastal habitats are receiving waters for significant volumes of municipal and industrial wastewater discharges, combined with urban and agricultural runoff, and other point

and non-point sources. In many estuaries there are signs that the natural dilution capacity is being exceeded by the volumes and concentration levels of effluents. Also in the estuaries, the raising levels of pollution represent an increasing public health hazard. For instance, The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities from UNEP has summarized the environmental priorities for the Region as: (1) Inadequate discharge of liquid urban effluents; (2) Industrial effluents pollution; (3) Pollution related to inadequate use of agrochemical products; (4) Degradation of aquatic environments due to expansion of urban limits; (5) Inadequate disposal of urban solid residues; and (6) Activities related to extraction, transport and storage of oil or derivates (Marcovecchio 2000).

Industries dealing with horticulture and aquaculture, oil, lumber, chemicals, textiles, vehicle repairs and ship building have all added large quantities of hazardous materials to rivers, estuaries, wetlands and coastal areas, and have had major impacts on the aquatic and marine environments (Davidson 1990). The disposal of more than 87% of Municipal Wastewater in rivers, lakes, and seas create serious damage to aquatic ecosystems and implies a significant impact to public health; the enormous lack of minimum facilities for the disposal of wastewater contributes significantly to the deterioration of underground water systems, rivers and coastal environments (UNEP 2003).

3.5 Increasing coastal erosion

Deforestation, dredging and filling, poorly designed coastal structures and illegal sand mining has contributed to the increase of coastal erosion and often intensify the risk associated with coastal hazards.

4 A LOOK AT THREE CONTRASTING SITES IN SOUTH AMERICA

A significant number of estuarine areas in South America have been affected by human influence to some degree. Many of these systems show conflicting interests between urban, industrial and agricultural pressures and environmental maintenance. From heavily populated area of Santos Estuary to the near-pristine water conditions of Aysén Fjord, the sites addressed here cover a wide range of ecological and socio-economical conditions, and their inevitable conflicts and challenges in management, which can be found in South America. These systems share some similarities and also some conspicuous differences, but together they face many of the main challenges discussed above. Tables 1 and 2 contain a brief summary of the major features of each system and Figures 2 to 4 bring additional information by adding visual insights.

4.1 Santos estuary

Located at the Southern Brazilian Coast, the estuarine system of Santos comprises three major estuarine channels, namely São Vicente, Santos and Bertioga, interconnected in its

inner area. Santos and São Vicente channels comprise an approximate area of 44,100 m^2, with an average depth of 15 m in the central dredged channel of Santos and 8 m in São Vicente channel. Six main rivers discharge in Santos estuary: Piaçaguera, Boturoca, Cubatão, Mogi, Quilombo e Jurubatuba. There are also many tributaries and artificial channels that collect rain drainage water and clandestine domestic waste. The tropical and subtropical climate causes high rainfall in the summer period. The Santos Estuary can be classified as a typical sub-tropical mangrove system under significant anthropogenic pressure. After hundreds of years of urban, industrial and port development, the estuary is a highly changed ecosystem. Its extensive areas of mangrove, with associated fauna and flora have been destroyed over time and are now partially degraded. The estuarine water column can be stratified, mainly due to vertical gradients of temperature. The estuarine system has a considerable ecological importance because it has a natural high productivity and is a natural habitat for many animals like birds, mammals, fish and numerous kinds of invertebrates.

The phytoplankton is dominated by diatom communities from the Genus *Skeletonema* spp. and *Thalassiosira* spp. Nanoplanktonic phytoflagellates share the dominance (alternate) with diatoms because of the adaptation to the changing light and nutrients conditions induced by the spring-neap tide cycles. Red tides caused by *Mesodinium rubrum* in the inner shelf of Santos have been reported (Moser et al. 2005), a species that is not toxic but can cause oxygen depletion problems at the end of the bloom. Other primary producer groups found in the region are the seaweeds, conspicuous in many areas in the soft substratum of mangrove forests, and *Spartina* spp, which occupy many mangrove fringe areas.

The Santos estuarine system holds the larger Brazilian harbor as well as the most important industrial complex of the Brazilian coast. The Santos estuarine complex, regarded as a polluted area (de Sousa et al. 1998), is an area heavily occupied by urban, industrial and port activities. The construction of an underground generating plant by the Light Company in the late fifties lead to the amplification of the capacity of generating energy in this area, turning possible the installation of a petroleum refinery, a petrochemical complex and, later, a metallurgical complex. These development have modified significantly the environmental and hydrodynamic conditions of the estuary. This period of fast growth during the 1950s-1960s, required amplification of the port area, and the need for continuous dredging of the main channels to allow the circulation of heavy ships in the harbor and access to areas of the upper estuary where major industries are located.

The main socio-economic drivers for the Santos estuary are the industrial and port activities, and the resident population. Currently, there are nearly 400,000 people living in this area, but the Santos, Cubatão and S. Vicente cities and adjoining region account for $\sim$1,000,000 inhabitants (almost doubled in the vacation period). The Baixada Santista region is, at the same time, a tourism, industrial and port center. Cubatão city has a remarkable industrial pole with different kinds of industries but mainly associated with the petroleum products, fertilizer production and a very remarkable steel production. The main sources of pollution at this region are: the Santos port and ships which are involved in the spillage and loss of shipped products,

the industrial pole of Cubatão, the domestic waste of São Vicente and Santos cities (which are mainly discharged through an emissary), the garbage dump of the Baixada Santista region, besides the discharge of waters from the Billings water reservoir which receives used water from some parts of São Paulo City. The population accounts for the high levels of pollutants discharged in the system through sewage water. The discharges of domestic waste waters are scattered, due to the existence of only 3 WWTPs. Clandestine domestic sewage disposal arises from slum quarters at the channel margins and make up a significant contribution to the eutrophication of the system. Several industrial effluents are discharged in the inner areas of the estuary and port activities act as another anthropogenic impact in the system.

Some kinds of hazardous compounds are dispensed into the estuary such as nutrient salts, heavy metals, organic compounds and petroleum hydrocarbons. These pressures in the estuary have impacts not only in the estuary, by inducing changes in the ecologic dynamics, but also in Santos Bay and adjacent beaches. Water quality is a public health problem in this coastal zone. The main stakeholders in Santos include local government, university and educational system, industrial and harbour consortiums and NGOs (environmental protection). All the uses of the estuary make this a place of conflictive interests and uses, adding serious difficulties to its management and governance.

4.2 Bahía Blanca estuary

Bahía Blanca is a mesotidal coastal plain estuary in the southwest of the Buenos Aires Province. The main channel of this estuary has a total length of 60 km, varying in width from about 3-4 km at the mouth (22 m depth) to 200 m at the head (3 m depth). This channel is partly closed by a modified ebb delta. Three freshwater tributaries enter the estuary: the sauce Chico River (with a drainage area of about 1,620 km^2), discharging into the principal channel about 3km downstream from the head of the estuary, Saladillo (with a drainage area of 830 km^2) and the Napostá Grande Creek (with a drainage area of about 1,260 km^2) that reaches the estuary about 1km downstream of Ingeniero White Port. Both Sauce Chico and Napostá Grande rivers are originated in "Serra de la Ventana" in the top part of the watershed.

The Bahía Blanca estuarine system shows some striking similarities with Santos estuary. The similarities are related to the intensive anthropogenic pressure and some ecological features such as the dominance of diatoms. However, there are some major differences, especially in the vertical physical structure and in the tidal range. Unlike Santos, the Bahía Blanca estuary is not stratified and has a larger tidal range. Unlike most southern hemisphere temperate systems, phytoplankton bloom takes place in winter months reaching 70 mg Chla m^{-3}. The bloom is dominated by diatoms (especially *Thalassiosira curviseriata*) with flagellates appearing only near the end of the bloom episodes. The typical phytoplankton succession starts with large diatoms, followed by dinoflagellates and ends with small diatoms. This succession suggests a complex nutrient control on primary production. Nutrient concentrations are always high inside the estuary all year round, yet there are no signs of eutrophication in the system.

The inner estuarine area receives high loads of organic matter from WWTPs, limiting light penetration in the vicinity of the discharge points and they can have a significant contribution to nutrient budgets in the upper estuary. The estuary has extensive intertidal areas with high halophytes coverage.

The main identified socio-economic drivers for the Bahía Blanca are the agricultural activity and population growth. This population growth generates a pressure over land use, impacting the water quality of the estuary, and also affecting the coastal zone. To augment production, soil fertility has been increased over the last year by fertilization. Consequently, agriculture practices have contributed to the eutrophication of the estuary through soil leaching and runoff. The city of Bahía Blanca has rapidly expanded to a total of 350,000 inhabitants over the last two decades and still has a large potential for growth.

The demographic growth has been fuelled by a large petrochemical park, fertilizer and thermoelectric plants, as well as expanding port activities since much of Argentina's export moves through Ingeniero White Port (Perillo et al. 2001). As a consequence, the discharge of industrial wastes and untreated or partially treated domestic sewage has generated increasing problems of contamination. Dredging of the Principal Channel from 9.5- to 13.5 m depths has generated over 35×10^6 m^3 of sediments, dumped on tidal flats and in off-shore locations. Dredging and deposition has introduced major changes of circulation patterns in the estuary.

4.3 Aysén fjord

The Aysén Fjord stands in striking contrast with the previous estuarine systems. Aysén is the eleventh administrative Chilean region; located between 45° and 46° S. The region is characterized by a significant oceanic climate range and vast diversity of ecosystems. There are an insular part and a continental part, with a total territory of 108,000 km^2. It is the least populated of the fourteen political regions of Chile (around 90,000 habitants) with a density of 0.8 habitants km^{-2}. Commercial activities have been primarily based on the exploitation of the region's natural resources and include: fishing and aquaculture, mining, livestock production and ranching, sawmills, agriculture and forestry.

As any fjord system, Aysén fjord has an extremely high residence time ($>$200 days) and is permanently stratified. There is a strong seasonal signal in the freshwater inputs, resulting mostly from the ice melting in the watershed and seasonal rain pattern. Aysén River is the main freshwater water input into Aysén Fjord, having a total watershed area of about 12000 km^2. Fresh water only affects the upper layer (less than 10 m deep) of the system. Primary production in the water column is dominated by diatoms and dinoflagelates. The strong oxygen production of the upper layer contrasts with the low oxygen conditions of the bottom (around 2.5 $ml\ l^{-1}$) resulting from the bacterial degradation of organic matter in the sediment. Aysén is a 300 m deep fjord and consequently the sediment is exclusively a mineralization compartment.

Given the late colonization of this area (mainly during the first half of the XX century), Aysén is still a low population region with a large governmental organization, given its geopolitical importance. Consequently, many key stakeholders correspond to governmental organizations. Salmon farmers are also key stakeholders and have been identified as the main actors of the future economic development of the area. Other primary stakeholders correspond to artisan fishermen, tourism companies, agricultures and mining companies. Although the Aysén region is often seen as a pristine and undisturbed zone in southern Chile, it has a past record of devastating human impact. Colonization during last century was accomplished using fire as a management tool; the fires were started intentionally by settlers (and supported by government policies of the time) to clear areas for cattle and sheep. Wildfires that burned throughout the 1940s have left a long-lasting mark on the watershed by changing the physical and chemical characteristics of the soils.

Nowadays, the region still holds its almost pristine state, but the estuarine system is slowing being enriched with organic matter originated in the numerous mariculture units scattered in the Fjord. Salmon farming industry is the main socio-economic driver in the Aysén Fjord. This activity, strongly supported by foreign capital investment, is characterized by having some of its industries ranking on the top ten industries nationwide and two of them worldwide. Recent investment initiatives indicate that aquaculture production in the area is in a process of expansion: by 2010 it is projected that the XI region (and Aysén county in particular) will produce 42% of the national salmonid production (up from 20% today). Besides salmon farming, the system has been used for other purposes such as mollusk harvesting and, more recently, industrial development. About 80% of the population in Aysén watershed is concentrated in the urban areas (Coyhaique, Puerto Aysén, Puerto Chacabuco). In the region of Aysén, 70% of the total habitants are connected to sewer system. This fjord receives the liquid residues of Puerto Aisén (a town of 37,000 people, located close to its head). Its also home of the only seaport for the region (Puerto Chacabuco).

5 FUTURE TRENDS

The environmental costs of regional economic expansion have been extremely high, and seem to be growing. The major issues are the accelerating over-exploitation of land and marine resources, increasing conflict over access to and use of water, loss of biodiversity and habitat degradation, urban waste disposal problems. South America interest in a solid economical development in pace with sustainable natural resource usage is expected to increase over the next few decades, stimulated mostly by new trade opportunities, changing markets, heightened awareness of coastal hazards and natural resources conflicts, and the participation in international agreements (Lemay 1998). Undoubtedly, a key challenge for the Region over the next decades will be to cope with rates of change in coastal areas, especially in estuarine systems, recognizing shortcomings of traditional approaches and building on the lessons of emerging policy reforms for integrated coastal zone management.

TABLE 1: *Major biotic and abiotic features of the three estuarine systems (see text for details).*

Feature	Santos Estuary	Bahía Blanca	Aysén Fjord
Zone	Sub-tropical	Warm temperate	Cold temperate
Mixing characteristics	Partly mixed	Well mixed	Permanently stratified
Dilution potential	Moderate	High	Low
Vegetation	Mangrove swamps High emergent vegetation Tidal flats	Spartina fringes Tidal flats Relatively low emergent vegetation	No marine vegetation
Nutrients	Nutrient exporter	Nutrient exporter	Nutrient importing from the sea
Production	Strongly heterotrophic system (mineralizing system)	Neutral (varying from auto to heterotrophic)	Strongly autotrophic system

TABLE 2: *Major socio-economical features of the three estuarine systems (see text for details).*

Feature	Santos Estuary	Bahía Blanca	Aysén Fjord
Drivers	Industrial and port activities Population growth	Agricultural activity Industrial and port activities Population growth	Salmon Farming
Population (in the area)	1,000,000	350,000	90,000
Economic activities	Petrochemical park Refineries and terminals Fertilizer plants Thermoelectric plant Metal industries Port activities	Petrochemical park Refineries and terminals Fertilizer plants Thermoelectric plant Several industries (meat and fish factories, leather and textile plants, etc.) Port activities	Salmon fish farming Artisan fishing Forestry
Pressures	Urban and industrial pollution (wastewater effluents discharges with and without treatment) Dredging	Urban and industrial pollution (wastewater effluents discharges with and without treatment) Dredging	Organic inputs (associated with fish feed and faecal pallets), sediments from terrestrial systems
Major impacts	Eutrophication Habitat degradation (loss)	Eutrophication	Local bottom modification
Human utilization of the system	Occupation (housing) Recreation (bathing in the bay area) Food source	Food source	Habitat Food source Tourism
Overall State	Highly modified Heavily Polluted	Modified Polluted	Near pristine, unpolluted
Key stakeholders	Regional government Industrial consortiums Port authorities NGOs	Regional government Industrial consortiums Port authorities	Regional and national government Salmon farmers

FIGURE 2: *The Santos Estuary is a highly changed system after decades of occupation and development. These snapshots show different areas of the estuary depicting some of the main drivers: urban pressure with an example of occupation in the frontline of the bay area (top), an industrial plant in Cubatão area (middle), located in the inner part of the estuary, and port activities (bottom). (Photos by M. Mateus)*

FIGURE 3: *The large industrial pole of Bahía Blanca (top, partial view) is a major driver in this system. Water pollution is among its most significant impacts, as seen in the middle plate, where a sign warns against toxic residues. Fishing is also a main economic activity in Bahía Blanca and the industrial port is also an harbor for both the fishing fleet (bottom) and cereal and oil/gas exportations. (Photos by M. Mateus)*

FIGURE 4: *The Aysén Fjord is in almost pristine state, maintaining much of its landscape (top) and system functioning unchanged over the recent decades of human settlement and growth in the area. The main drives in the system are the tourism, justified by the search for its esthetic value (top), fishing (middle) and salmon farming (bottom). (Photos by M. Mateus)*

A commitment towards sustainable development of the Region's estuarine resources is gradually emerging. Unreasonable demands from society in the past led to a general decline of the resources and irreversible changes in the nature of many ecosystems. Many of the natural assets of the Region have been undervalued but this trend is now being reversed. The contribution of coastal and marine areas to sustainable development is increasingly gaining recognition among public, private and political sectors in coastal states. Combined with this increasing recognition of importance is an emerging awareness of the need to manage coastal and marine resources hand-in-hand with the optimization of allocation of its uses. The region's central challenge is now to build a political consensus that will maintain stability and economic growth while addressing the growing social and environmental problems (UNEP 1999). Clearly, careful planning and management of all sectoral activities simultaneously will result in greater overall benefits than pursuing sectoral development plans independently of one another. Integrated coastal management approaches are required, combining all aspects of the human, physical and biological aspects of the coastal zone within a single management framework.

The main challenges in estuarine and coastal zone management faced by South American nations have been identified in the three study sites presented here. The remaining of this volume will deal with the work done for each site during the ECOMANAGE project and the results obtained. The research effort undertaken will be used to assist local stakeholders and decision making entities to implement adequate management strategies. This will lead, eventually, to achieve satisfactory results for the improvement of the ecological status of each site, and at the same time helping their steady and sustainable socio-economic development.

REFERENCES

Bachmann P, Delgado L E, Marin V H (2007) Aanalysis of the citizen's participation concept used by local decision makers: the case of the Aysén watershed in southern Chile. Int. J. Sustainable Development 10: 251-266

Bertucci R, Cunha E, Devia L, Figueria M, Ruiz R, Diaz Labrano F, Vidal Perera R (1996) Mercosur y Medio Ambienta. Edición Ciudad, Argentina.

Davidson L (1990). Environmental Assessment of the Wider Caribbean Region. UNEP Regional Seas Reports and Studies No. 121. Nairobi, Kenya.

Ellison A M, Farnsworth E J (1996) Anthropogenic disturbance of Caribbean mangrove ecosystems: Past impacts, present trends, and future predictions. Biotropica 28: 549-565

Ewell K C, Twilley R R (1998) Different kinds of mangrove forests provide different goods and services. Global Ecology and Biogeography Letters 7: 83-94

Garreta-Harkot P F (2003) The Brazilian National Plan of Coastal Management, the health and the environment. MD Thesis. Faculdade de Saúde Pública da Universidade de São Paulo, São Paulo.

Heywood V H, Watson R T (1995) Global Biodiversity Assessment. Cambridge University Press, Cambridge, United Kingdom and New York, USA. 1140p

Hinrichsen D (1997) Living on the Edge: Managing Coasts in Crisis. Island Press.

IDB (1995) Coastal and Marine Resources Management: Strategy Profile. Inter-American Development Bank, Washington DC, United States.

Lemay M H (1998) Coastal and Marine Resources Management in Latin America and the Caribbean - Technical Study. Inter-American Development Bank, Washington, D. C. 57p.

Marcovecchio J E (2000). UNEP: Overview of Land-Based Sources and Activities Affecting the Marine, Coastal and Associated Freshwater Environment in the Upper Southwest Atlantic Ocean. UNEP/GPA Coordination Office, Regional Seas Report and Studies Series No170, 57pp.

Moser G A O, Belém A L, Soares J A, Carbeiro M A. 2005. Descrição de uma maré vermelha, causada por Mesodinium rubrum (Lohmann, 1908), na plataforma interna de Santos (SP, Brasil). In: XXV Congreso de Ciencias del Mar / XI Congreso Latino Americano de Ciencias del Mar. COLACMAR XXI.

Myers N, Mittermeler R, Mittermeler C, da Fonseca G, Kent J (2000) Biodiversity hotspots for conservation priorities. Nature 403: 21-26

Nawata K (1999) "Society" in 2050: Choice for Global Sustainability. In: Nawata K. Global Industrial and Social Progress Research Institute. Asahi Glass Foundation, Japan, pp 15-49

Olson D, Dinerstein E, Cintrón G, Iolster P (1995) A Conservation Assessment of Mangrove Ecosystems of Latin America and the Caribbean. World Wildlife Fund, Washington, D.C.

Perillo G M E, Piccolo M C, Parodi E, Freije R H (2001) The Bahía Blanca Estuary, Argentina. In: Seeliger U, Kjerve B (eds) Coastal Marine Ecosystems of Latin America. Springer-Verlag Berlin Heidelberg, pp 205-217

Solano P (1997) Legislación Ambiental Suramericana Aplicable a los Humedales. UICN, Wetlands International SPDA. 204p.

Sousa E C P M, Tommasi L R, David C J (1998) Microphytobenthic primary production, biomass, nutrients and pollutants of Santos Estuary (24 degrees S,46 degrees 20 ' W). Sao Paulo, Brazil. Brazilian Archives of Biology and Technology 41: 27-36

UNCED (1992) Earth Summit, Rio de Janeiro. United Nations Conference on Environment and Development. London Regency Press, London, United Kingdom.

UNEP (1999) Global Environmental Outlook 2000. United Nations Environment Programme, Nairobi, Kenya.

UNEP (2003). Water Resources Management in Latin America and the Caribbean. Fourteenth Meeting of the Forum of Ministers of the Environment of Latin America and the Caribbean. Panama City, Panama.

WTTC (1993) Travel and Tourism: A New Economic Perspective. The 1993 WTTC Report, Research Edition. World Travel and Tourism Council, London, United Kingdom.