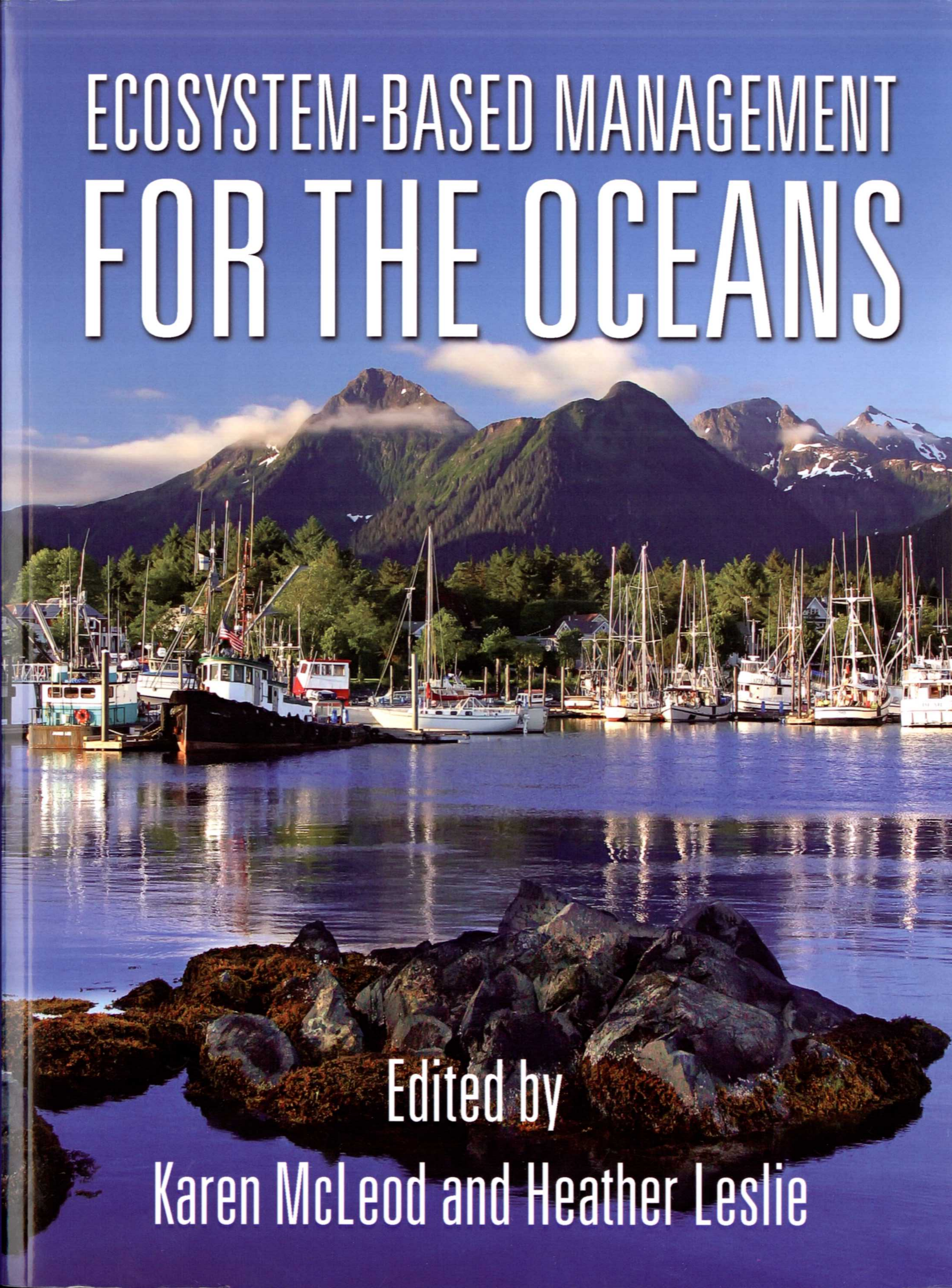
ECOSYSTEM-BASED MANAGEMENT FOR THE OCEANS



Edited by

Karen McLeod and Heather Leslie

Ecosystem-Based Management for the Oceans

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CHAPTER 13
Gulf of California, Mexico

Exequiel Ezcurra, Octavio Aburto-Oropeza, María de los Ángeles Carvajal, Richard Cudney-Bueno, and Jorge Torre

The Gulf of California in northwest Mexico, also known as the Sea of Cortés, together with its area of direct influence in the Pacific Ocean, covers an area of 375,000 km^2 (fig. 13.1). The region includes not only one of the most important large marine ecosystems on the planet, but also the Sonoran and Baja Californian deserts and significant portions of two terrestrial hotspots: the southern part of the California Biotic Region and the northern portion of the Mesoamerican dry tropical forest. In the gulf itself, over one hundred islands surrounded by powerful upwellings of cold, nutrient-rich waters house a unique biodiversity that faces increasing pressures.

The gulf's subtidal habitats, together with 6,000 km^2 of coastal lagoons and 2,560 km^2 of mangrove forests, serve as reproductive, nesting, and nursing sites for hundreds of resident and migratory species. A large proportion of the world's marine phyla are represented in the gulf. The gulf is home to 891 fish species, 181 marine birds, 34 marine mammals, and 4,853 known marine macroinvertebrates (some authors estimate that more than 4,000 invertebrate species remain undescribed). Of these species, 831 are endemic to the region, including the *totoaba* (a giant sea bass) and the *vaquita* (the Gulf of California's harbor porpoise).

Not only is the gulf biologically important, it also provides the socioeconomic sustenance of the inhabitants of the region who have developed systems of natural resource use, access, and appropriation, often threatening the long-term sustainability of the resources. The most important threats to biodiversity are driven by the growth of economic activities that cause the deterioration of coastal areas due to decreasing freshwater flows, pollution by agrochemicals and urban waste, sedimentation, and the use of inappropriate fishing technologies such as bottom-trawling nets (Lavín et al. 1998; Carriquiry and Sánchez 1999; Lavín and Sánchez 1999; Steller et al. 2003; Beman et al. 2005). This rate of biodiversity loss is substantially higher in many coastal lagoons around the gulf, where shrimp farms have been developed during the last decade (Glenn et al. 2006). Critical mangrove forest habitat is being lost in Mexico at an annual rate of 1.0%–2.5% because of sedimentation, eutrophication, and changes in water flows caused by the construction of shrimp ponds, marinas, inland channels, and deforestation (INE 2005).

Significance of Marine Resources in the Gulf's Regional History

For thousands of years, the population of the Gulf of California has benefited from the marine resources of the region, using the bays, coastal lagoons, river mouths, salt marshes, and estuaries to find food. In isolation from the rest of Mesoamerica, the early inhabitants of Baja California were fishers and coastal hunters and developed one of the most incredible assemblages of cave paintings in the American continent that bear witness of their close association to the sea and its resources. Other coastal indigenous groups from Sonora and Sinaloa, such as the Cucapá, the Seri, and the Yaqui, also developed unique lifestyles as fishermen and sailors, with cultures finely adapted to the sea and its coastal resources.

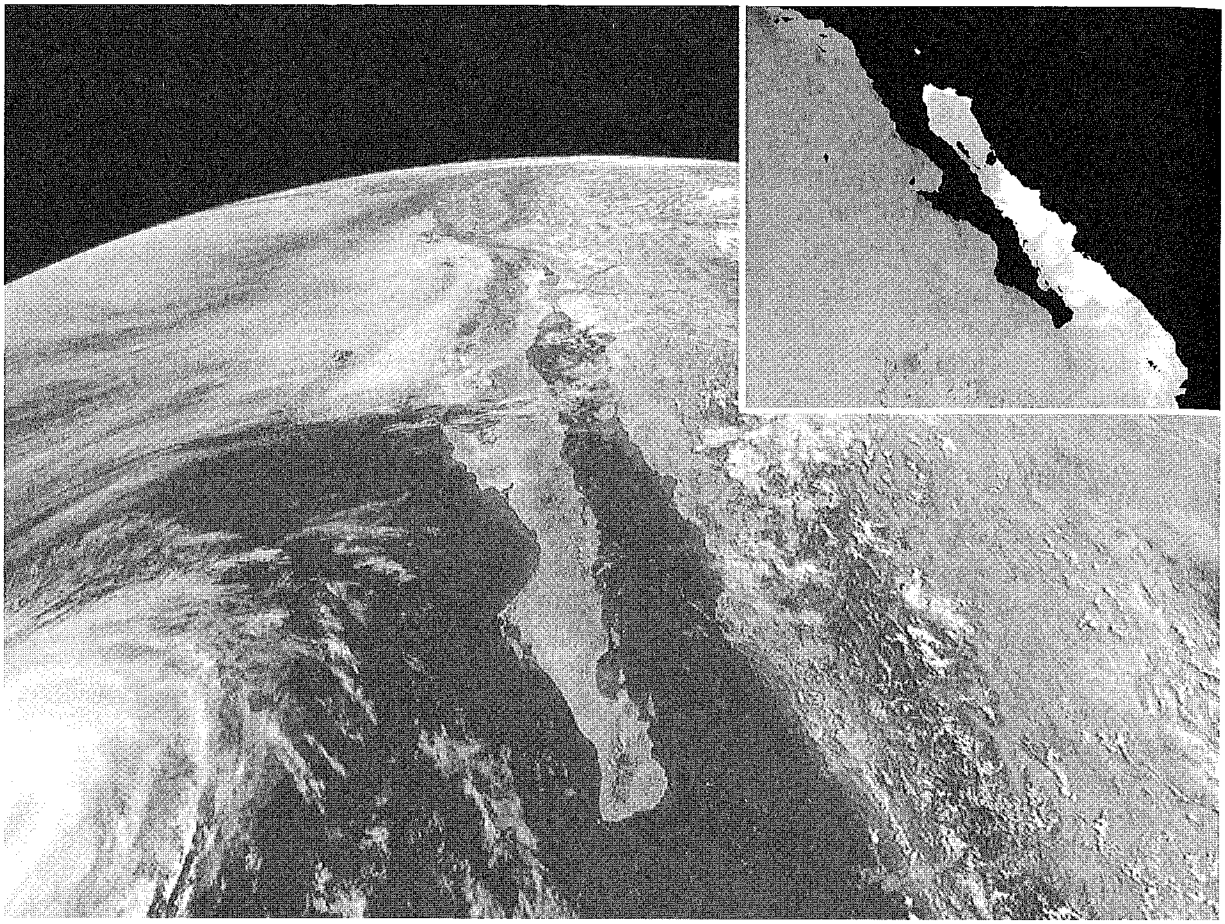

Figure 13.1 Satellite view of the Gulf of California. Coastal fog can be seen in the northern-Pacific side of the peninsula, as the prevailing northwesterly winds cross over the cold California Current. In the southern-Pacific side, a typical fall hurricane storm is seen forming. These storms often enter through the mouth of the gulf and bring torrential autumnal storms to the region. In the insert, a sea surface temperature scan is shown for the same month; lighter colors indicate warmer temperatures. The thermal difference between the gulf and the Pacific coastal upwelling is clearly visible, as well as the tide-induced upwelling in the gulf's Midriff Islands region. Derived from NASA satellite images 2007.

After the disappearance of the missions, the discovery of pearls led to the exploitation of one of the most valuable resources and export items the gulf had to offer. The largest pearl beds in the world were located on the east coast of Baja California Sur, and in the nineteenth century the city of La Paz was recognized worldwide for its pearls (Cariño 1996). Nevertheless, by 1892 pearl diving had declined significantly, possibly as a result of overharvesting (Cariño and Monteforte 1999).

Until the early twentieth century, fishing was only practiced in inshore areas, with small vessels powered by oars and sail and using lines and hooks as the main fishing gear (Robles and Carvajal 2001). A new era in the history of fishing came in the 1930s when outboard motors and gill nets came into use. Inshore fisheries in estuaries and lagoons started to increase steadily. Valuable species began to decrease, like the *totoaba*—an endemic fish to the Sea of Cortés and highly appreciated for export—that suffered significant population declines in the region (Bahre et al. 2000). In 1933, the shrimp fishery began to operate trawler boats over soft seabeds. Since then, sandy seabeds in the Gulf of California are being swept by shrimp trawls every year, with a significant impact to the ecosystem through the bycatch of other species—fish, octopus, conchs, sponges, and sea stars. As the twentieth century progressed, the shrimp fishery became one of the most important activities within the fishing sector. In 1997, the five states surrounding the Gulf of California produced 57,000 tons of shrimp, representing approximately 70% of the national shrimp production and 90% of the Pacific landings (Robles et al. 1999).

Parallel to changes seen in marine and coastal habitats, river ecosystems were also being subjected to changes caused by human activities. The Colorado River was until the 1930s the largest river flowing into the Gulf of California, with its vast delta covering 300 km^2 of wetlands (Sykes 1937; Fradkin 1984; Ezcurra et al. 1988). The dense cottonwood and mesquite forests on the riverbanks were a major source of charcoal and lumber, allowing the development of steamboat traffic on the Colorado River from the Sea of Cortés into the Yuma trail during the nineteenth and early twentieth centuries. In 1935, however, the Colorado River was dammed after an international water treaty was signed between the United States and Mexico, triggering the development of the Imperial and the Mexicali agricultural valleys but bringing the demise of the great delta, which dried up in less than a decade (Bergman 2002; Arias et al. 2004 and references therein). Similarly, in the 1940s dams and channel works were initiated in the Fuerte, Mayo, and Yaqui rivers, and farming was encouraged through government subsidies, such as cheap electrical tariffs for water pumping, and low-interest credit. These irrigation projects resulted in reduction of the freshwater supply to river estuaries and coastal lagoons, causing degradation and loss of native riparian ecosystems (Robles et al. 1999).

By the 1950s, fishing had become a major driving force of regional development (Hernández and Kempton 2003; Sala et al. 2004). The success of this industry attracted financial resources and led to the establishment of freezing and packing companies, as well as shipyards. This period was characterized by an apparent inexhaustible abundance of marine resources. In reality, however, the decline of the fishing sector was already under way, driven by unsustainable harvests, overcapitalization of the fishing fleet, and wasteful fishing technologies (Robles and Carvajal 2001). In the 1960s, a purse seine fishery for sardines developed in the region. This technology, a particularly selective fishing gear, is still in use today. The Monterey sardine fishery is the most productive one with a mean of approximately 200,000 metric tons per year (DOF 2004a). The yellowfin tuna fishery also developed during this time, focusing its efforts in the mouth of the gulf (Torres-Orozco et al. 2006). In the 1980s, the Humboldt squid fishery began and is currently the second most important fishery in the region in terms of biomass, with annual catches of 50,000–120,000 metric tons between 1996 and 2001 (de la Cruz-González et al. 2007).

Socioeconomic Dynamics

The gulf region is a large, sparsely populated area with human densities of only one-third of Mexico's national average. Indicators of economic development (education, housing, and human fertility) suggest a relatively high level of economic development compared with the rest of Mexico (Ezcurra 2003). It is also a relatively wealthy region, with the per capita contribution to the country's GDP being 5% above the national average. This productive advantage is even higher in the Baja California peninsula and the State of Sonora, where the per capita income is about 22% higher than the national average. In particular, the region is a major contributor to the national fisheries, producing approximately 50% of the landings and 70% of the value of all fisheries in Mexico (Robadue 2002; Enríquez-Andrade et al. 2005).

In spite of low fertility rates, the success of the regional economy has brought a large demographic increase, chiefly derived from immigration. While the demographic growth rate in Mexico has declined considerably in the last decades, from a national average of more than 3% to less than 2%, growth rates around the gulf—and especially in the Baja California peninsula—still remain high. The cities with the most dynamic and active economies grew especially rapidly: Tijuana, fueled by the immigration magnet of the maquiladora industry, grew at a rate of 6.5%, while the population of Los Cabos, under the impulse of a tourism boom, grew at the extraordinary rate of 9.7% (López-López et al. 2006). There is, however, considerable differentiation among the five states, and only some specific zones seem to be driving the region's economic growth. Furthermore, most of the regional population is concentrated in the coastal zone, where growth is fastest and where pressure on natural resources is greatest.

Until a few decades ago, the economy of the gulf region was mainly based on agriculture, fisheries, and mining. In fisheries, overcapitalization of the shrimp-trawling fleet and other fishing fleets that share limited marine resources has caused profits to plummet (Cisneros-Mata 2004). Apart from a series of studies that have shown marked signs of overfishing in the gulf, it is interesting to note that, according to Mexico's own *Carta Nacional Pesquera* published by the National Fisheries Commission, all of the important fisheries in the gulf have been showing a downward trend in catches and profits during the last three to four decades. This has resulted in the classification of all large fisheries, with the exception of the Humboldt squid, as overfished (DOF 2004a).

Recently, there has been a major shift in the economic structure. Macroeconomic policy changes, trade agreements, and globalization have created new opportunities in export-oriented manufacturing and in services such as tourism. This economic environment results in increasing demands for natural resources derived from population growth. In recent years, the agriculture, livestock, and fisheries sector has been by far the one showing the lowest growth rates. While the annual growth rate of this sector between 1980 and 2000 was 0.7%, the rest of the regional economy grew at an average combined rate of 4.7%. Furthermore, official statistics published in the last 5 years clearly show that most of the aquifers in Mexico's northwest are "overdrafted," and in some cases rapidly dwindling (DOF 2003), while fisheries have reached a "maximum sustainable threshold" (DOF 2004a). In essence, resource management government agencies have publicly accepted the collapse of the resources they administer, making it clear that further economic growth has reached a limit. This overexploitation of resources may also explain why the areas within the region showing a high dependence on natural resource use are lagging behind in economic development.

As natural resources reach an exploitation limit and new economic opportunities stimulate demand for alternative uses of these resources and the ecosystem services they provide, new conflicts have arisen. This is especially true in the case of common resources, which lack clear property rights and enforceable regulations for access. For example, sportfishing operators argue with industrial fishing boats over the impact of longlines on billfish; artisanal fishers quarrel with shrimp trawlers over access to fishing grounds (Meltzer and Chang 2006), and open-sea shrimp fishers have criticized the impact of coastal shrimp farms on postlarval recruitment. The current clash between sectors contrasts with the regulated access and collaborative atmosphere that sound ecosystem-based management demands at a regional level.

In short, extractive use of natural resources seems to have reached its limit, while the rapid growth of the manufacturing and service sectors is placing additional strain on regional resources. Rapid demographic growth results in increasing pressures on resources such as water, which is preciously scarce in the arid coasts of the gulf, and in increasing amounts of pollutants generated by unbridled growth. Thus, this population growth comes at the expense of depleting underground aquifers and damaging the natural ecosystems and watersheds that surround large urban conglomerates. It is extremely difficult to meet the demand for services such as running water and sewage in cities that double in size every 6 to 10 years.

Ecosystem Resilience and Natural Resource Management

A number of efforts within the last 15 years have underscored the need to understand the gulf as a single large marine ecosystem (LME). The gulf is one of the world's sixty-four LMEs, relatively large regions characterized by distinct bathymetry, hydrography (tides, currents, and physical conditions of the water), biological productivity, and trophically linked populations (Sherman 1994). A global effort by the United Nations' Intergovernmental Oceanographic Commission, the US National Oceanic and Atmospheric Administration, and the International Union for Conservation of Nature (IUCN) is currently under way to improve the long-term sustainability of resources within LMEs and their associated watersheds, with a particular focus on ecosystem-based approaches for fisheries. Several efforts by regional NGOs and scientists (including the Coalition for the Sustainability of the Gulf of California) have articulated conservation priorities for the region as a whole (Enríquez-Andrade et al. 2005). More recently, following intensive public consultation, the Mexican federal government developed a territorial use plan (*Ordenamiento Ecológico*) for the gulf using the LME approach (DOF 2006a, b).

Resilience, State Shifts, and Thresholds

Resilience science may provide a useful context in which to understand this marine ecosystem from a regional perspective and offer the conceptual framework needed to understand current ecological and social changes and implications for the future of the region. The concept of resilience highlights the nonlinear dynamics observed in many ecosystems, as well as their capacity to shift between multiple possible states (Leslie and Kinzig, chap. 4 of this volume). Under a relatively low degree of perturbation, a system will tend to regress to its original state, but when the perturbation is strong, many ecosystems will shift to new stability domains instead of reverting to their original states (Walker and Salt 2006). Transitions among stable states have been described for many ecosystem components in the Gulf of California, and understanding the causes of these shifts may help inform future management actions.

Perhaps the clearest example of a transition toward a new steady state is the shrimp fishery. It is well known that shrimp trawling severely damages the seafloor (Young and Romero 1979; Dayton et al. 2002). The report presented by Steinbeck and Ricketts (1941) predicted that "a very short time will see the end of the shrimp industry in Mexico," due to bottom trawling. Although the fishery has declined, as described in Mexico's own *Carta Nacional Pesquera*, the predicted collapse has not occurred as once imagined. Rather, it seems that the repeated combing of the seafloor by the trawlers has shifted the original ecosystem to a new steady state, similar in some ways to the dynamics of a tropical forest when converted to pasture. Unfortunately, there are no good descriptions of the original system, and understanding of the state shifts has been derived primarily from indirect evidence, such as interviews with fishermen and local residents, and a systematic description of the shift in baselines in fisheries descriptions from old and young fishermen in the gulf (Sáenz-Arroyo et al. 2005a, b, 2006).

In other fisheries, transitions between ecosystem states and the subsequent failure to return to the original system also have been documented. Velarde and colleagues (2004), for example, found two readily distinguishable states in the gulf's sardine fishery. Prior to 1989, there was a clear linear relationship between fishing effort and sardine landings, with fishing effort growing exponentially. In 1989, the sardine fishery collapsed, forcing the reorganization of the fleet to decrease their effort in order to allow the stocks to recover. However, the system did not regress to its previous domain, but rather persisted in a new state in which stocks are lower, and catch is mostly regulated by oceanographic conditions (fig. 13.2). The sardine fishery shifted from a mature phase (pre-1989, where landings were basically predicted by fishing effort), to a disturbance phase (1989–1990, when the fishery collapsed), and then into a reorganization phase in which the system adjusted to the new high-extraction conditions and likely stabilized in a new domain (mirroring the adaptive cycle, as explained by Walker and Salt 2006). The disappearance of top predators, such as that documented in the gulf by Sala and colleagues (2004) due to unsustainable fishing practices, may be destabilizing the entire system and making it more vulnerable to these types of irreversible changes.

Together with fisheries, quite possibly the most rapidly changing components of the gulf ecosystems are the coastal lagoons, especially the mangrove forests. These habitats are rapidly disappearing under the growing pressures of coastal development, mostly for tourism infrastructure and shrimp farms (fig. 13.3; Páez-Osuna 2001; Páez-Osuna et al. 2003; Whitmore et al. 2005). Mexican regulations state that mangrove clear-cutting can be authorized, provided that the proponent establishes "compensation measures" (DOF 2004b; recent additions to the Wildlife Law have made mangrove clear-cutting illegal, and the issue is now under debate in the Mexican Congress). In practice, compensation measures are ineffective because mangrove destruction also happens when developers fill lagoon swamps in order to gain ground for developments or to construct aquaculture ponds, resulting in a true and irreversible loss of wetland habitat (Wolanski et al. 2000).

Even when mangrove clearing is done without destroying the mudflat, the cutting of woody plants may move the mudflat ecosystem to a new steady state, from which it may not recover. Although no direct experiments have been done in the Gulf of California, experiments with black mangrove (*Avicennia germinans*) in similar mudflats in the Gulf of Mexico (López-Portillo and Ezcurra 1989 and fig. 13.4) have clearly shown that reducing mangrove cover in the mudflat results in a "catastrophic" (sensu Scheffer et al. 2001 and Scheffer and Carpenter 2003) and often irreversible shift in ecosystem states. As with the sardine fishery described above, the clearing of mangrove forests moves the lagoon ecosystem from a mature phase (the dense mangrove forest) to a disturbance phase (the aquaculture pond, or simply the barren mudflat). When the disturbed system is finally left alone, it progresses toward a new reorganization phase (the mudflat dominated by *Batis maritima* and other low-cover, salt marsh plants).

In conclusion, a number of ecosystem components within the Sea of Cortés seem to have reached an irreversible transition boundary, or a "tipping point," in the last decade.

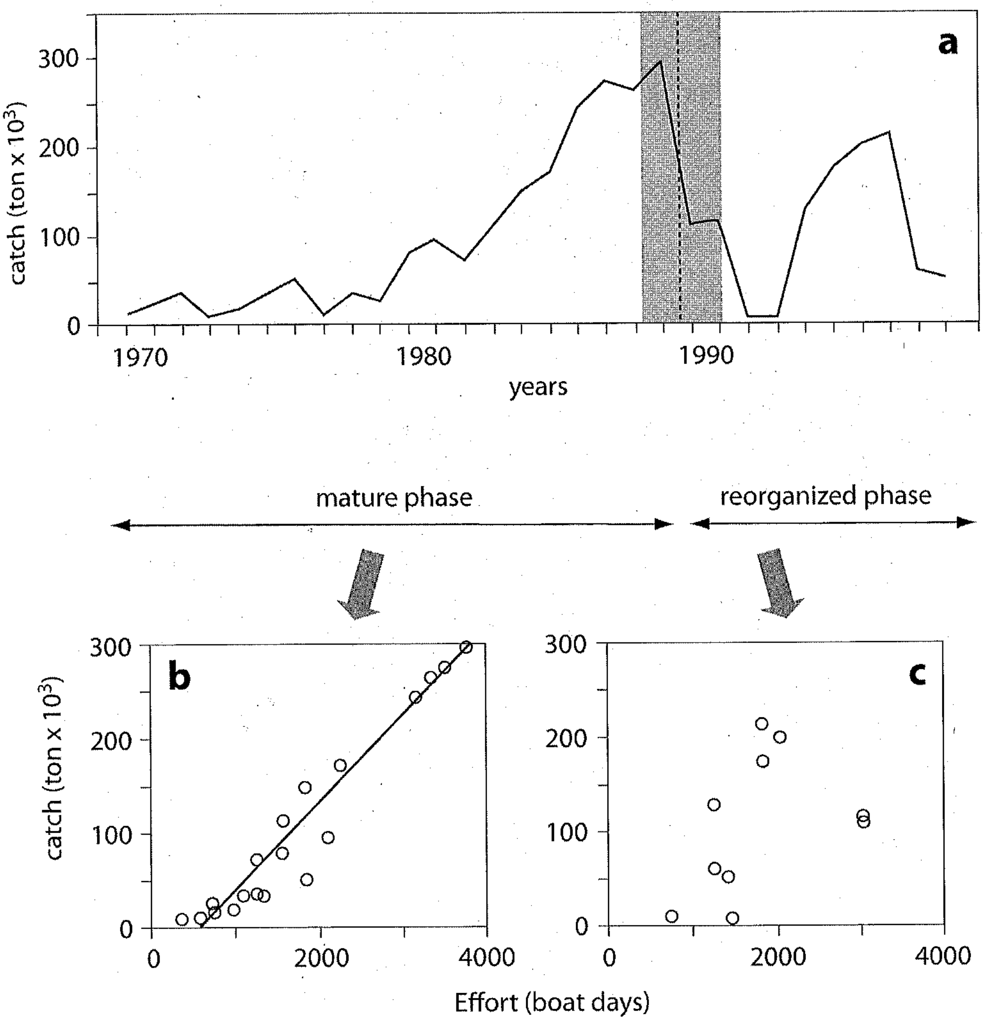

Figure 13.2 Transition between ecosystem states in the Gulf of California. (A) Total sardine catch in the Gulf of California between 1970 and 1999. (B) Linear relationship between fishing effort and catch from 1970 to 1989. (C) Nonsignificant relationship between effort and catch from 1990 to 1999. The gray area indicates the transition period. Modified with permission from Velarde et al. 2004.

Understanding which of these ecological changes are reversible and which are not, and what needs to be done to return critical ecosystem components to a functional state, is among the biggest challenges for sustainability science in the region. With these challenges in mind, we will analyze some of the most conspicuous obstacles that face environmental sustainability in the region.

The Challenges for Environmental Sustainability

While the extractive use of natural resources in the gulf seems to have reached a limit, the rapid growth of the manufacturing and services sectors is putting additional strains on the limited supply of natural resources. However, the economic shift could also open new doors for

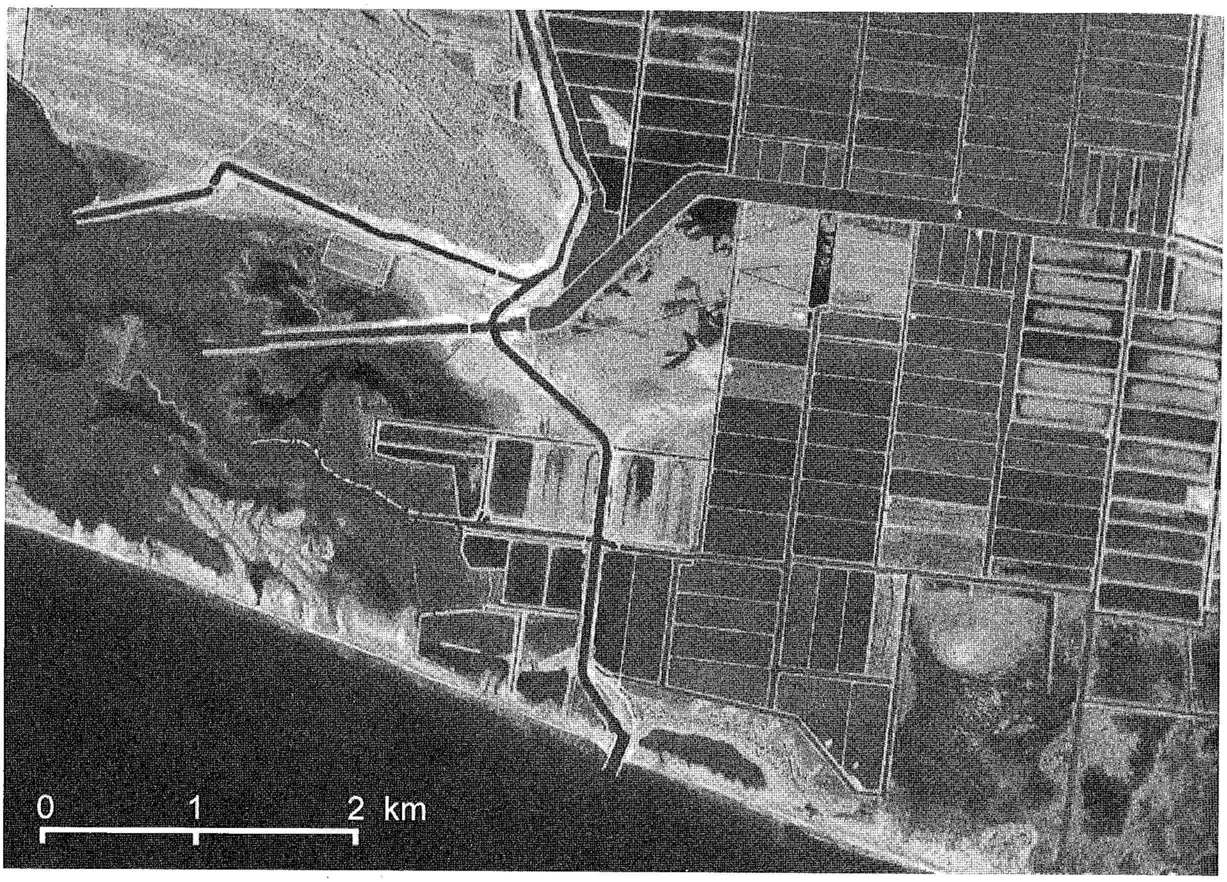

Figure 13.3 Shrimp farms advancing on the coastal wetlands of the Yaqui River, near Ciudad Obregón, in Sonora. The occupation of mangrove swamps by new developments is noticeable, together with lines showing the dredging of the swamp's natural channels and the opening of canals that drain agricultural effluents directly into the gulf's waters. Used with permission from Google Earth 2007.

a drastic change toward sustainable resource use. The growth of these newer sectors creates an important opportunity to reduce pressure on natural resources. As a result of growing concerns regarding sustainable use of natural resources and the impacts of tourism, a few environmentally concerned business leaders have formed a group called *Noroeste Sustentable* (NOS). In short, although the gulf is undergoing extreme pressures from overexploitation in many parts, with the consequent collapse of some of its resources, it also harbors a number of successful and encouraging examples of communities that are trying to maintain their resources in a healthy and productive state, with an eye to the future.

Fisheries

With thirty-nine species listed on IUCN's Red List, it is clear that ecological degradation has already hit the gulf's biodiversity hard. Populations of five species of sea turtles have declined dramatically in the gulf (Nichols 2003; Seminoff et al. 2003). The endemic vaquita porpoise (*Phocoena sinus*) is near extinction. The

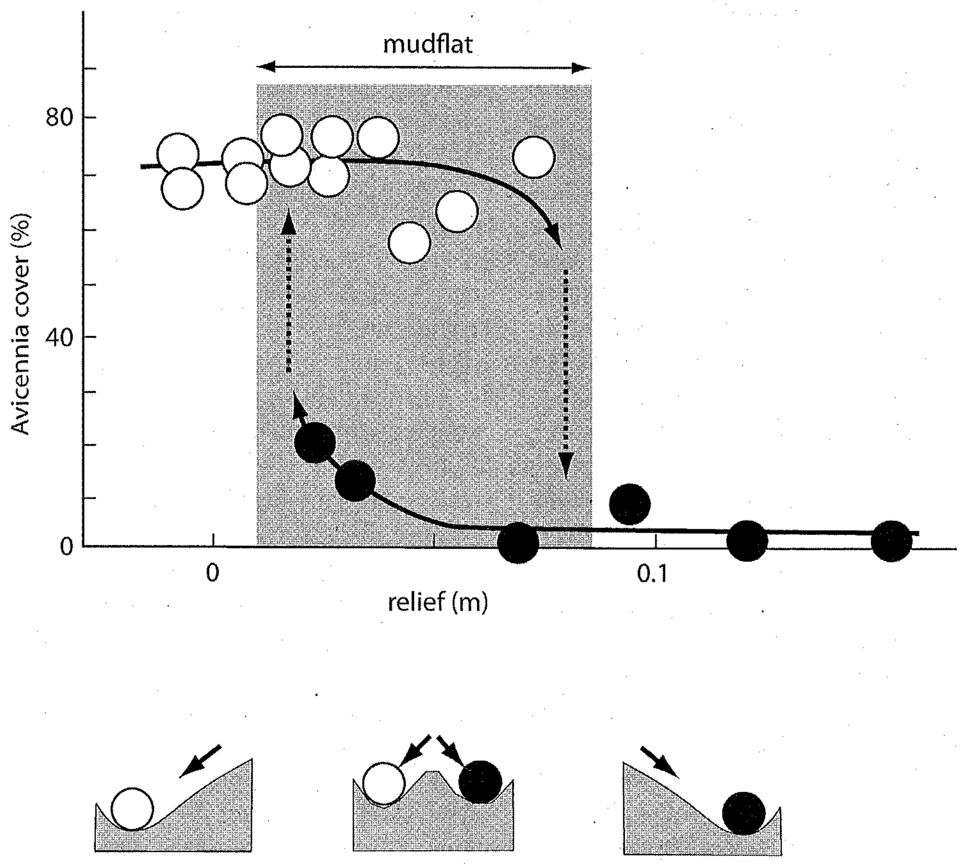

Figure 13.4 Catastrophic regime shift in mangrove ecosystems: In the lower parts of the relief gradient, frequent flooding maintains the growth of mangrove forests (open circles). In the upper hinterland, the lack of floodwater and the salinity of the soil maintain a halophyte scrub with no mangroves (black circles). In the mudflat, the system can maintain either a mangrove forest (in its mature phase) or, if cleared, a halophyte scrub (in its reorganized phase). Intermediate states are rarely seen, because once the system is transformed into a halophyte scrub, mangrove seedlings have difficulty establishing in the sun-scorched, salt-encrusted soil. Modified from López-Portillo and Ezcurra 1989.

International Committee for Vaquita Recovery estimated the current vaquita population is 150 individuals (Rojas-Bracho et al. 2006), contrasting with a previous estimate of 567 vaquitas for 1997. This new estimate takes into consideration an annual growth rate of 4% and the loss of 39 to 78 individuals per year (D'Agrosa et al. 2000). These values make the vaquita the most endangered marine cetacean in the world.

Overharvesting of fish stocks is rapidly becoming a strongly limiting factor for the success of the regional fisheries. Twenty years ago, there was a correlation between catch and effort in many of the regional fisheries: The more days the fleets operated, the more catch they brought in. Now, that correlation is largely gone, the total landings in most fisheries are chiefly independent of fishing effort, and catch per unit effort has decreased severely for many species (Sala et al. 2004; Velarde et al. 2004). Additionally, there is clear evidence that coastal food webs in the Gulf of California have been "fished down" during the last 30 years (i.e., fisheries shifted from large, long-lived species at high trophic levels to smaller, short-lived species from lower trophic levels), and the maximum length of individuals has significantly decreased in only 30 years (Sala et al. 2004).

Unfortunately, the industrial shrimp fleet is an apt example of the tragic decline of common-pool resources. Thirty years ago, the fleet was made up of approximately 700 boats, each capturing about 50 tons of shrimp per season. Today, the fleet is nearing 1,500 boats, with annual catches barely surpassing 10 tons per boat (Meltzer and Chang 2006; de la Cruz-González 2007). Despite governmental subsidies of nearly US$ 30 million each year—provided in the form of cheap fuel—many boats are facing economic collapse.

The environmental impact of this fishery is also a matter of concern. Bottom trawlers destroy some 200,000 tons of bycatch every year for a meager annual catch of 30,000 tons of shrimp (Madrid-Vera et al. 2007). While working, dragnets also impact approximately 30,000–60,000 km^2 of the seafloor (García-Caudillo et al. 2000; Brusca and Bryner 2004); some of this area is within the Upper Gulf Biosphere Reserve. The boats also collectively emit about 30,000–40,000 tons of greenhouse gases derived from the cheap subsidized fuel that keeps the already inefficient business running. Benthic habitats have been so depleted in some places that local artisanal fishermen in places such as Loreto Bay and Bahía de los Ángeles demanded the establishment of no-take zones and other marine protected areas. In often open conflict, local communities and large industrial fleets debate over the establishment of protected areas and the demand for permits that allow trawling inside some of these areas. In the gulf, conflict among sectors and the battle over particular interests have been increasingly the rule at sea (Meltzer and Chang 2006).

Fortunately, there are success stories to be told from the gulf's fisheries, and learning from them is fundamental for future conservation efforts. For example, artisanal fishermen have started to work with local researchers to understand the phenomenon of spawning aggregations (Sala et al. 2003; Erisman et al 2007), in order to identify and protect areas that are important for reproduction. As a result of pressure from local resource users, the Bay of Loreto marine park now includes two small no-take areas, and the fishermen of Bahía de Los Ángeles supported the movement to declare the area a biosphere reserve. In the San Ignacio Lagoon, fishermen have organized to preserve the environment, train community members in basic natural history knowledge, and organize whale-watching tours (Cariño et al. 2006).

The abalone and lobster cooperatives of the Pacific coast of Baja provide yet another example of long-term sustainable use (Hilborn et al. 2005). With no support from the federal government, fishermen have established strict rules for resource extraction and have developed their own enforcement program. Many generate their own electricity, run their own canneries, and finance their own schools. More than 40 years after the establishment of these communities, their productivity is still high, and their resources seem to be in fairly good shape (Chaffee et al. 2004).

But small communities and conservationists are not the only ones critical of some of the region's unsustainable modes of development. A growing number of entrepreneurs and businesspeople are also becoming committed supporters of environmental causes. Even large fishing fleets can be sustainable when their operators work in cooperation: In contrast with the decline of captures of the shrimp bottom-trawling fleet, the sardine fishery has controlled its fishing effort, and—after a past collapse—the fishery has partially recovered and is now managed sustainably (Lluch-Belda et al. 1986; Cisneros-Mata et al.1995b, 1996).

Coastal Tourism and Recreational Activities

The magnificent landscapes and the amazing density of charismatic wildlife make the Gulf of California a superb place for visitors (Tershy et al. 1999; López-Espinosa de los Monteros 2002). The first tourists in the gulf were attracted by the extraordinary catches sportfishing had to offer. Nautical tourism developed afterward, and soon the idea of connecting the region with the states of California, Oregon, and Washington in the Unites States through a series of marinas attracted developers. During President Vicente Fox's administration, this idea materialized in the form of a regional project, the *Escalera Náutica* or Nautical Stairway, with the goal of jump-starting nautical tourism in the gulf.

Over the past few years, *Escalera Náutica* has become one of the most debated projects in the region (Bowen 2004; Álvarez-Castañeda et al. 2006). Because the economy seems to be shifting from fisheries and agriculture toward the service sector (including tourism), this project seemed, in principle, a desirable path. However, experiences with unsustainable tourism in Mexico (and its sequel of failed and abandoned projects like dredged mangrove swamps and exhausted aquifers) have left a deep scar in the perception of local communities. The big challenge in the Gulf of California is to promote sustainable tourism while ensuring the preservation of the region's natural beauty and biodiversity, the very attributes that initially triggered tourism in the gulf.

ALCOSTA (*Alianza para la Sustentabilidad del Noroeste Costero Mexicano*, an alliance of several environmental organizations), among other players, has been instrumental in raising awareness regarding the *Escalera Náutica* development plan. They have spearheaded efforts to reduce the environmental impacts of the project and to make it more open to environmental conservation issues. Through public consultation, ALCOSTA developed a critical analysis of the regional environmental impact assessment for the *Escalera* project and presented it in a public hearing to federal authorities. All the general conditions proposed by ALCOSTA for the environmental authorization of the project were taken into account by the federal government in the final resolution and led President Fox to announce that the Gulf of California is a joint priority for both tourism and conservation. Hence, the *Ordenamiento Ecológico Marino* program was initiated, and a promise to enlarge the protected areas surrounding the gulf's islands to include surrounding waters was made. This occurred on World Environment Day 2004, with the signature of a coordination agreement between six ministerial secretaries and five state governments (Baja California, Baja California Sur, Nayarit, Sinaloa, and Sonora).

Recently, the state governments have adopted aggressive plans to promote tourism development by creating infrastructure. They see tourism as an opportunity to create much-needed jobs, foster economic development, and compensate for the job losses in other sectors while moving away from the growing subsidies demanded by farmers and fishermen. The question, however, remains how to promote sustainable tourism while ensuring the preservation of the region.

Case Studies of Ecosystem-Based Conservation Measures

If effective conservation in the region is to be achieved, a strategy that addresses the most critical environmental challenges needs to be developed. Such a strategy should allow for the protection of seriously endangered species, spawning aggregation areas, and endangered ecosystems such as seamounts, coastal lagoons, coral reefs, estuaries, and marine mammal habitats (Sala et al. 2002, 2003). Expansion or establishment of new protected areas is one of several approaches needed to ensure long-lasting conservation efforts (Hyun 2005); but most importantly, they require the support of the local communities and stakeholders (Aburto-Oropeza and López Sagástegui 2006).

For other areas such as coastal wetlands, the development of comprehensive plans is needed to manage and protect them effectively. The degradation of coastal wetlands is one of the gulf's most serious threats (Brusca et al. 2006), and there is little consideration for the fundamental ecosystem services they provide. Mangrove forests are being destroyed to give way to aquaculture (mostly shrimp farms) and tourism projects. Furthermore, coastal wetlands are also threatened by consumptive water use upstream and by pollution of rivers and waterways. The ecosystem services provided by estuaries and lagoons are critical for the survival of the Sea of Cortés fisheries (Aburto-Oropeza et al. 2007) and for the health of the large marine ecosystem as a whole.

In this section we offer three case studies of how ecosystem-based management (EBM) is developing in the gulf region. Each captures an ongoing initiative and thus, like the other case studies in this section of the book, provides a glimpse of both the present and possible future of marine EBM in a particular ecological and social context.

Case Study 1: The Alto Golfo Biosphere Reserve

There are myriad stories of dedicated work and heated debates around each one of the protected areas in the Gulf of California, the conflicts behind their creation, and ongoing discussions about their future resource use (Ezcurra et al. 2002). Perhaps the most emblematic of these cases is the *Alto Golfo de California y Delta del Río Colorado* in the northernmost portion of the gulf, over which discussions and debate have been, and continue to be, especially heated. Understanding the past and ongoing conflicts in the upper gulf is essential to understanding the conservation movement, including efforts to implement marine EBM, in Mexico.

The Upper Gulf of California and Colorado River Delta Biosphere Reserve is formed by part of the surrounding Sonoran Desert, the northern marine waters of the Gulf of California, and the lowermost part of the Colorado River. Its high marine biological productivity is a result of the churning of nutrients in Colorado River sediment deposits by one of the strongest tidal fluxes on the planet (Santamaría del Ángel et al. 1994; Thomson et al. 2000). This productivity makes the area very important for reproduction, nursery, and growth of many resident and migratory species (Glenn et al. 2001; Calderón-Aguilera et al. 2003; Rowell et al. 2005). Currently, the total number of marine species recorded for the reserve is 1,438, of which 11 are in danger of extinction, notably the vaquita and totoaba, both endemic to the northern part of the gulf (as discussed previously in this chapter).

The upper gulf's marine richness is reflected in its highly valuable fisheries, especially shrimp, which make this region one of the most important fishing grounds in Mexico (Brusca and Bryner 2004). Historically, the most significant economic activity for the reserve's inhabitants has been gill net and trawl fishing (McGuire and Greenberg 1993). In 1955, the Mexican fishery authority declared the region to be protected as a breeding site and nursery for birds and fish. As years passed, the region was still being subjected to an ever-growing fishing pressure. By the early 1970s, the totoaba was facing extinction due to overfishing (Lercari and Chávez 2007), forcing the federal government to decree a moratorium for totoaba harvest in the Sea of Cortés. The area was re-decreed in 1974 as a reserve zone for fisheries resource restocking. However, the depletion of the totoaba population continued catastrophically, and in 1975 the Ministry of Fisheries established a permanent ban for totoaba captures, which remains in effect today. Incidental capture of the vaquita in gill nets resulted in strong concern over its population status in the upper gulf in the 1980s, and by the early 1990s, its population was estimated to be less than five hundred (D'Agrosa et al. 2000) and it was declared endangered. At this point, Mexican federal government created the Technical Committee for the Protection of the Totoaba and the Vaquita to recommend strategies for conserving both endangered species (Rojas-Bracho et al. 2006). While some members of the committee favored immediate action to protect the upper Gulf of California from the effects of overfishing, others were of the opinion that regulating fisheries would harm the local economy. This conflict resulted in a request that research centers in Sonora develop a feasibility study for a biosphere reserve.

That study recommended establishing a marine protected area in the upper gulf (CTPTV 1993). Discussions with the local communities (Golfo de Santa Clara, Puerto Peñasco, and San Felipe, as well as the *ejidos* in the delta of the Colorado River) about the costs and benefits of the protected area took place during the first months of 1993. With the support of local businesspeople, scientists, conservationists, social leaders from the small-scale fisheries, and traditional authorities from the indigenous peoples around the Sea of Cortés, the project was presented to the Mexican government. A key element in this process was the participation of Luis Donaldo Colosio, an important politician and native of Northern Sonora, who enthusiastically supported the project.

On June 10th, 1993, the President of Mexico, Carlos Salinas de Gortari, decreed the establishment of the Biosphere Reserve of the Upper Gulf of California and Delta of the Colorado River. Many important decision makers attended the ceremony, including many cabinet members from the Mexican federal government; the governors of Sonora, Baja California, and Arizona; US Secretary of the Interior Bruce Babbitt; and the traditional governor of the Tohono O'Odham (Papago) people, whose lands extend to both sides of the Mexico–United States border. This reserve was the first marine protected area established in Mexico and included the territories of Baja California and Sonora as well as federal marine waters (INE 1995). Thus, coordination among these entities became a critically important factor to fulfill the protected area's objectives.

In 1993, the upper gulf was undergoing a socioeconomic crisis, which led to the acceptance of the protected area as a temporary solution (McGuire and Greenberg 1993). After a few years, the initial enthusiasm waned. The administration of protected areas in Mexico was at that time very small, and most of the reserves existed only on paper. There was little governmental field experience and few resources for conservation and management of protected areas, and PROFEPA, the federal authority in charge of environmental enforcement, had just been created and did not have the capacity to operate in remote areas. It would seem now that neither the federal government nor the local communities were prepared for the long-term commitment that the establishment of this reserve required. However, the creation of the National Commission for Natural Protected Areas (CONANP) in 1993 gave the reserve core funding for field operations, a director, active field staff, and a management plan.

Critical obstacles to achieving the reserve's objectives have been poor intergovernmental coordination and conflict among sectors (particularly fisheries and agriculture), poor institutional capacity, and a lack of political will to enforce the law. Thus, illegal fishing inside the reserve has grown, resulting in increased vaquita mortality. Recognizing the desperate need to protect the species, in September 2005 the Mexican government added an additional 155,500 ha protected marine polygon to the upper gulf biosphere reserve as a refuge area for the vaquita. This additional protected area covers 70% of the mammal's core habitat, a geographic range that was not well identified at the time of the establishment of the upper gulf biosphere reserve. Unfortunately, and despite the added protection, the vaquita population seems to be still in critical decline (Rojas-Bracho et al. 2006), among other species that reproduce and live in this unique and fragile area. Movement toward a more ecosystem-based approach would benefit this imperiled mammal as well as the many other species—including humans—who call this region home. But the current outlook for such a shift in perspective is uncertain.

Case Study 2: Community-Managed No-Take Marine Reserves

Community-managed no-take marine reserves have been playing a growing role in the Gulf of California. Although their establishment has been organized locally, their cumulative effect is becoming regionally significant. Two types of no-take marine reserves are present in the gulf: those inside federal marine protected areas (MPAs) and those defined by restrictions in fishing permits. Currently there are eleven MPAs established in the gulf, of which only eight include no-take zones ("core-zones" in Mexican legislation) that cover 93,125 ha, or 1.9% and 4.8% of the total area of the gulf and of the gulf's MPAs, respectively (table 13.1). The levels of full protection vary from 35% in Cabo Pulmo to a negligibly low proportion (0.08%) in Loreto Bay.

Moreover, two fishing cooperatives are in the process of obtaining permits that would facilitate sustainable fisheries and ecosystem-based management in the gulf. These two cooperatives are unique in their characteristics: The Peñasco cooperative (*Union de Buzos de Puerto Peñasco*) won the National Conservation Award in 2003 (Cudney-Bueno 2004), while the Loreto Bay cooperative (*Mujeres del Golfo*) is constituted by eight fisherwomen. The Peñasco cooperative would fish rock scallop (*Spondylus calcifer*) around Puerto Peñasco, outside the southern limit of the upper gulf biosphere reserve, while the Loreto Bay cooperative would collect four aquarium fish species of rocky reefs (*Chromis limbaughi, Holocanthus passer, Pomacanthus zonipectus,* and *Opistognathus rosenblatti*) in the southern area of the Loreto Bay national park. These cooperatives propose, in addition to the use of the traditional fishing quotas, the implementation of no-take zones as an experimental management instrument. In Peñasco, fishers are closing 800 ha, which represents 20% of the unique coquina rocky reefs of the upper Gulf of California (Cudney-Bueno 2004, 2007). Similarly, the Loreto fisherwomen have closed 30% (24 ha) of the area in five (79 ha) of the thirteen traditional fishing sites (483 ha) for aquarium species.

There is a third type of closure that can be considered as a no-take zone: where transit is prohibited for security reasons. The thermoelectric power plant in Puerto Libertad and the penal complex of the Islas Marías Archipelago are closed to all boat traffic. The latter was decreed a biosphere reserve in 2005. Although the sites have not been monitored, fishers describe high catch in areas close to the islands. For example, sport divers near the power plant describe large aggregations of the gulf grouper (*Mycteroperca jordani*), a formerly abundant species (Sáenz-Arroyo et al. 2005a, b), in the power plant area. And in the case of the Islas Marías Archipelago, many fishers operate illegally in the vicinity of the islands since the high catch warrant taking the risk of being detained.

Comunidad y Biodiversidad (COBI), a nongovernmental organization (NGO) that seeks the conservation of marine and coastal biodiversity through participatory approaches, has promoted community-based no-take zones

Table 13.1. Marine protected areas in the Gulf of California

	Total area (ha)	*Marine zone (ha)*	*No-take zone (ha)*	*Percentage no-take*	*Fully protected ecosystem*
Wildlife protection areas					
Cabo San Lucas	3,996	3,875	3,875	100	Rocky reefs
Biosphere Reserve					
Alto Golfo de California y Delta del Río Colorado	934,756	560,853	80,000	14.2	Sandy bottoms and mudflats
Bahía de los Ángeles, Canales de Ballenas y Salsipuedes	387,957	387,957	207	0.05	Wetlands and mangroves
El Vízcaino	2,546,790	40,451	—	—	—
Islas Marías	641,284	617,257	—	—	—
Isla San Pedro Mártir	30,165	29,876	821	2.6	Rocky reefs
National Parks					
Archipiélago de San Lorenzo	58,442	58,442	8,805	15.0	Rocky reefs
Bahía de Loreto	206,580	181,997	150	0.08	Rocky reefs
Cabo Pulmo	7,111	7,111	2,476	35.5	Coral reefs
Islas Marietas	1,383	1,311	—	—	—
Marine Zone of Isla Espíritu Santo	48,655	48,655	666	1.4	Rocky reefs
Total	4,863,123	1,933,910	93,125	4.8	

Sources: Vargas-Márquez and Escobar 2003; Mexico's *Comisión Nacional de Áreas Naturales Protegidas* online database available at www.conanp.gob.mx/anp/.

since 2000. Based on the experience gathered at a number of sites throughout the gulf, COBI has developed a framework to guide implementation of these zones, involving the fishing community at each step. This approach includes (1) communicating what a no-take marine reserve is, what its benefits are, and the commitments involved; (2) evaluating the acceptance/rejection of the community of use of marine reserves as a management tool; (3) designing a reserve network and developing a work plan to monitor the marine reserves; and (4) disseminating the monitoring results. In order to implement this framework, COBI initiated the Fishers Fund to support the technical, financial, and legal elements of community-based marine reserves (Torre et al. 2005).

Case Study 3: Project Pangas

One way to overcome the daunting task of researching and managing marine ecosystems in a more integrated fashion is to rely on the understanding of proxies indicating wider ecosystem processes and health. In the northern gulf, small-scale fisheries are being used as an operational proxy by PANGAS. Project PANGAS was born to address the complexity of this challenge and the growing need for local ecosystem-based management. In essence, the formula is relatively simple. Healthy and resilient local fisheries imply the existence of healthy coastal marine ecosystems. The project was developed with the dual purpose of (1) building a framework for research and management of small-scale fisheries as a means to address coastal marine ecosystem conservation and (2) initially applying and testing this framework in the northern Gulf of California. Hence its name, PANGAS, which stands for *Pesca Artesanal del Norte del Golfo de California: Ambiente y Sociedad* (Small-Scale Fisheries of the Northern Gulf of California: Society and the Environment). A *panga* is also the name given by many fishers in Latin America to the small boat used in this activity. A *panga*, then, represents a link between fishers and the marine ecosystem they depend on.

In the gulf, over a hundred species are harvested on a regular basis by the small-scale fishery fleet, which is distributed in twenty communities and at least twenty seasonal fishing camps. These species cover all trophic guilds, from top predators such as sharks and groupers, to bottom filter feeders. They are also representative of all environments (i.e., pelagic waters, benthic rocky and sandy areas, rhodolith beds). Small-scale fisheries provide approximately 50% of the world's total fish catch (Berkes et al. 2001), and this figure is likely an underestimate, as much of the worldwide catches are never officially registered. These fisheries also have an intrinsic holistic research value, providing a means to address wider ecosystem functions and health. Although it is small scale, relative to capital investment and production per boat, once added up, the cumulative outcome of this activity is anything but small. Perhaps small-scale fisheries' most important characteristic, and certainly the most relevant for the purpose of this book, is their comprehensiveness. They are not directly or technologically coupled to the extraction of a particular species. Rather, in any given coastal ecosystem where they operate, small-scale fisheries tend to target a slew of species representative of entire ecosystems.

Despite the various conservation efforts, the northern gulf is in a state of conflict between fisheries management and marine conservation, fueled by the growth of coastal human populations and marine resource use. In response to national fisheries policies and conflicts within Mexico's land-based economies, small-scale fisheries have grown considerably in the past two decades and are predicted to continue growing. Today, over three thousand *pangas* operate in the northern gulf (Cudney-Bueno 2000); this represents more than double the size of the small-scale fishing fleet 20 years ago. Considering that each *panga* is capable of carrying 1–2 metric tons, collectively the impact on the marine environment is substantial. Additionally, the *panga* fishery can easily shift as targeted species are depleted or market demands change. With this increase in effort and the flexibility of fleets, the northern gulf has also seen a rapid evolution of institutional change, the development of numerous territorial conflicts over access to fishery resources, and a downtrend in the production of most targeted species.

BUILDING LONG-TERM INSTITUTIONAL RESILIENCE THROUGH PARTICIPATORY RESEARCH AND TRAINING

The basic premise of the project is that the performance of fisheries is the result of interacting biophysical and social processes. PANGAS's research questions aim at obtaining a better understanding of these interactions. Because the northern gulf's small-scale fisheries not only cover a wide range of fishing gear, methods, and species, but also take place in a variety of environments under various social/

institutional settings, a detailed ecosystem-based analysis of all of the region's fisheries would be impossible. PANGAS's research operates at two levels. The first involves a general characterization of small-scale fisheries, primarily in terms of (1) identification and characterization of key habitats, (2) reproductive sites/times of targeted species, (3) spatial–temporal distribution of fishing activities (including gear/methods used and species targeted), and (4) existent governance structure. The second level encompasses in-depth and integrative research of small-scale fishery management units that are representative of the wider spectrum of the region's coastal marine ecosystem. PANGAS uses key commercial species as representative proxies of the region's four main types of fisheries: (1) rocky habitat fishing/commercial diving and line fisheries, (2) sand bottom fishing/longline, (3) sand bottom fishing/traps, and (4) open water fishing/gill nets.

PANGAS also emphasizes the importance of strengthening human capital for long-term research and monitoring. This is carried out via training and participation of fishers in underwater surveying, graduate degrees in interdisciplinary programs, and short training courses.

TRANSLATING RESEARCH INTO MANAGEMENT OUTCOMES

Ecosystem-based research would be futile if not translated to management outcomes. This translation demands an understanding of the main management issues and a vision for improvement that is representative of various interested parties. Interviews are conducted at various levels of governance (from fishers to local, state, and federal government officials) in order to obtain a broad understanding of the decision-making process affecting the region. These interviews also provide an understanding of the prevalent management concerns and recommendations for improvement. Parallel to this research, PANGAS is developing partnerships with key stakeholders from the fishing industry as well as with governing bodies affecting the Gulf of California. Thus, by the time management recommendations are made, they will address, as much as possible, the various concerns and recommendations of various groups.

Given Mexico's current administration and legal structure affecting marine resource use, PANGAS's management guidelines will likely fall into two main categories: (1) a combination of regional management plans for key targeted species (under the jurisdiction of the National Fisheries Commission) and/or (2) establishment of marine protected areas (endorsed by the Secretariat of the Environment). Regardless of the specific recommendation, PANGAS will first present their results through appropriate local governance structures. Depending on the regional scope of the recommendations, these institutions may be local community-based fishing groups or associations, cooperatives, federations of cooperatives, and regional councils. These initiatives will then be conveyed to the government via existing governing bodies, such as councils, the advisory group of the National Fisheries Commission, and the House of Representatives, and/or through direct meetings with leading government officials. Finally, assuming implementation of the recommendations, they will be followed by long-term monitoring that in turn contributes to an adaptive management framework that is used to assess progress and revise recommendations accordingly.

Toward a Regional Ecosystem-Based Conservation Agenda

The case studies above lead to the question, How are these local efforts contributing to ecosystem-based management of the gulf ecosystem as a whole? We see one of the primary means to be through inspiration of a regional vision, which in turn encourages more local-level action. Regional cooperation among nongovernmental institutions striving to develop an ecosystem-based vision of the gulf has been attempted in the past. In December 1997, a group of scientists and conservationists convened the Coalition for the Sustainability of the Gulf of California and, after 3 years, produced a comprehensive map defining conservation priorities in the region. The conservation-priority maps produced by the coalition were critically important inputs in the governmental land use and ocean use plans for the Sea of Cortés and the surrounding coasts, and they also became the basis for other regional planning exercises (Enríquez-Andrade et al. 2005; Aburto-Oropeza and López Sagástegui 2006, and references therein).

One of the most noticeable results of this collaborative effort between regional NGOs and research groups was the presentation of a regional agenda at the Defying Ocean's End meeting in Los Cabos in 2003, where seven specific objectives were articulated in order to advance sustainability efforts in the gulf on the basis of a large-scale, ecosystem-based approach (Carvajal et al. 2004):

1. *Improve the management of regional marine and coastal protected areas.* Although impressive progress was attained in the 1990s by the Mexican government in the funding and management of its protected natural areas, many of them still subsist as "paper parks," with inadequate funding and little effective management. If the regional protected areas are to be effective in their conservation goals, they must improve in their level of funding, equipment, and staffing. In part as a result of this initiative, the Mexican Commission for Protected Natural Areas has increased its budget substantially since then for marine and coastal protected areas in the gulf.
2. *Enlarge the system of marine and coastal protected areas.* Although some marine protected areas have been created in the gulf, these cover less than 4% of the gulf's marine area. If effective conservation in the region is to be achieved, a significant increase in the marine protected areas must be obtained, reaching at least 15% of the gulf's surface. This would allow the protection of spawning aggregation areas and critically endangered ecosystems such as seamounts, coastal lagoons, coral and rocky reefs, estuaries, and marine mammal habitats (Sala et al. 2002). The regional agenda led to the creation, in 2007, of the Bahía de los Ángeles Biosphere Reserve and of the Espíritu Santo Marine Park.
3. *Develop a comprehensive plan to manage and protect priority coastal wetlands.* The degradation of coastal wetlands is one of the gulf's most serious threats. With little consideration to the ecosystem services they provide, mangrove forests are being cut for the development of aquaculture (mostly shrimp farms) and tourism projects. Furthermore, coastal wetlands in general are threatened by consumptive water use upstream and by pollution of rivers and waterways. The ecosystem services provided by estuaries and lagoons are critical for the survival of the Sea of Cortés fisheries and for the health of the large marine ecosystem as a whole. Thanks to this demand, modifications were introduced into the Mexican Wildlife Law to prevent mangrove clear-cutting, and discussions are currently ongoing in the Mexican Congress on this very important issue.
4. *Reduce the shrimp-trawling fleet and improve its fishing technology.* Many of the

strongest issues of unsustainabilty in the gulf stem from the destructive effect and the economic inefficiency of the current shrimp bottom-trawling fleet. The only alternative that will solve this growing problem is to reduce the fleet by at least 50% through a legal buyout. If effective legal means are put in place to ensure that no new fishing permits will be issued in the future—and hence that the fleet will not grow again to unsustainable levels—this will allow the negotiation of effective enforcement of the existing no-take zones, and of the introduction of better fishing gear with more-efficient excluder devices.

5. *Develop a regional plan regulating the use of land, coasts, and waters.*The main instrument in the Mexican legislation to regulate the use of space within environmental guidelines is the *Ordenamiento Ecológico,* or Ecological Planning of the Territory, which demands full and comprehensive hearings and negotiations with local governments, local businesses, and nongovernmental organizations. Because of its complexity, effective territorial planning has been difficult to achieve in the Sea of Cortés, and it is now one of the most urgent objectives to reach, with the full participation of civil society and local conservation alliances. In 2005, the Secretariat of the Environment started the process of the *Ordenamiento Ecológico* for the gulf, which was published in its general guidelines in late 2006.
6. *Reorient regional tourism toward low-impact, environmentally sustainable resource uses.* The *Escalera Náutica,* now renamed *Proyecto Mar de Cortés,* has become one of the most debated projects in the region. Most environmentalists agree that a shift in the economy from unsustainable fisheries and water-intensive agriculture into the services sector (including tourism) seems a desirable move, but the question remains of how to make the new players in the regional economy sustainable and compatible with resource conservation. Regional cooperation among nongovernmental agencies has proved critically important for this purpose. ALCOSTA, a regional alliance of NGOs, was capable of bringing a voice of alarm and concern into the *Escalera Náutica* development project, thereby transforming the initiative forever by making it much more open to environmental conservation issues.
7. *Articulate a common regional development vision.* The last point of the agenda, the development of a regional vision, is possibly the most crucial aspect in the gulf's conservation agenda. As a group, conservationists desperately need to transcend the image of negative activists and move toward a joint way of seeing the region that will enable proposals of new and sustainable modes of development, rather than attacking unsustainable alternatives. Regional conservation will be successful if, in collaboration with local business and political leaders, a regional development vision based on the long-term protection of the gulf and its resources can be pieced together collectively, and agreed upon.

This seven-point agenda parallels many of the ecosystem-based management elements highlighted in other chapters of this book. Together with the rich technical information generated by the Coalition for the Sustainability of the Gulf of California, the agenda is now being used by a group of the gulf's key stakeholders who call themselves *Noroeste Sustentable,* or NOS. Its members believe that in order to facilitate well-planned sustainable development with a regional vision, it is important to build a common, ecosystem-based regional development vision and establish a highly motivated and committed group of leaders from business, environmental organizations, civil society, and government, working together on common regional goals for sustainable development. The aim of NOS is to assess the environmental issues that the region is facing and to determine the best way in which to address them through a regionwide agreement. This agreement needs to include clear, ambitious, and measurable long-term goals for key elements of the gulf's coupled social and ecological systems, including key species and habitats, and vital industries like fisheries and tourism, as well as a comprehensive implementation plan.

NOS's efforts have already yielded a better understanding of the context necessary to develop a successful regional agreement that integrates biodiversity conservation and economic opportunity in the region. The final regional vision must work in conjunction with several other regional plans under development and promote collaborative efforts, rather than duplicating them. The next step will be to attract business leaders and government agencies to support the agreement, and build broad-based support. If successful, this important initiative will encourage the governments of the five states surrounding the Gulf of California and the federal government to agree on a viable vision for sustainable development and to commit to its implementation.

In short, the ecosystem-based vision that was developed by the Coalition for the Sustainability of the Gulf of California has contributed to myriad other regional efforts, all the way from the governmental *Ordenamiento Ecológico Marino* to the work of many nongovernmental organizations that are trying to visualize and plan their efforts within an ecosystem-based regional perspective. But the task is not easy; it involves a complex maze of administrative agencies at the federal, state, and municipal levels, and it demands an understanding of ecological and development processes at a scale that has never been attempted in Mexico before. The ultimate success of this approach is yet to be seen, but a large-scale, ecosystem-based perspective has certainly changed the way regional problems are debated, as well as the economic discourse of many local authorities.

Conclusions

Hopefully, the increasing pace of conservation efforts in the Gulf of California will be able to reverse the environmental degradation that the region has suffered and will diminish threats to its long-term sustainability in the future. There seems to be growing awareness in the region, as never seen before, of the need to take urgent action to protect the environment. Conservation groups, research institutions, federal and state governments, conscientious businesspersons, and ecotourism operators have all been contributing to the growing appreciation of the environment and to the attendant conservation actions. The involvement of local groups and their commitment as allies in conservation efforts has possibly been the single most important element in successful conservation programs.

It is now the time to develop a vision, a social pact between sectors that may drive regional development for years to come, with ever-increasing consideration for the environment, for the gulf's natural resources, and for their sustainability. The gulf receives what remains of the discharges of the Colorado River Basin, and the survival of the upper gulf is a challenge for both Mexico and the United States. Clearly, the gulf's larger basin is part of a binational wilderness, where both Mexico and the Unitd States share the responsibility of protecting their joint natural heritage. To achieve this, both countries need to develop further and continuing efforts, to promote true collaborative work. The region is but one large continuum, with shared watersheds and estuaries, species, and natural resources. The protection of these unique environments is of the uttermost importance for our survival and well-being, today and for generations to come.

There are plenty of opportunities and creative solutions to the problems the gulf is facing today, though in the end, the solution lies in the hands of all the local actors in all sectors. We need a better understanding of the gulf's resilience to the range of perturbations it faces. We need a better understanding of the gulf as a single large marine ecosystem. But perhaps more importantly, we need a shared vision, and goals, and a common commitment to regional sustainability. If we are to conserve the amazing beauty, the remarkable biological productivity, and the magnificent biological richness of this unique place, we must find new ways to cooperate, coordinating and collaborating among ourselves. We need to change the way we work, change our behaviors, and use our extraordinary collective knowledge, creativity, abilities, and capacities to achieve common goals.

Key Messages

1. A number of the Gulf of California's ecosystem components appear to have reached a tipping point in the last decade. Understanding which of these ecological changes are reversible and which are not and what needs to be done to return critical ecosystem components to a functional state are among the biggest challenges for sustainability in the region.
2. Critical obstacles to success have included poor intergovernmental coordination, conflict among sectors, poor institutional capacity, and a lack of enforcement.
3. Conservation success depends on the involvement of local groups and their commitment as allies in conservation efforts, strengthening diverse human capital, and long-term commitments by all parties.
4. Place-based efforts are contributing to larger-scale EBM in the gulf through inspiration of a regional shared vision for long-term sustainability, which in turn encourages more local action. Large-scale perspectives can also change the context within which regional problems are tackled.

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