XIV-47 Gulf of California: LME #4

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The Gulf of California LME (also known as the Sea of Cortez) is a long (1,130 km) and narrow (80-290 km), semi-enclosed LME bordered by the Baja California Peninsula and mainland Mexico. It has a surface area of about 221,600 km^2, of which 3.64% is protected, and includes 0.11% and 0.06% of the world's coral reefs and sea mounts, respectively (Sea Around Us 2007). The Gulf is one of the youngest ocean bodies and was formed by the separation of the North American Plate and the Pacific Plate by tectonic movement (Rusnak *et al*. 1964). Several deep basins (up to 3,600 m deep) occur in the southern part of the Gulf, including the Guaymas Basin. The northern part of the Gulf is shallower, due to the large amount of siltation produced over the years by the Colorado, the major river entering this LME. There are 898 islands of all sizes within the Gulf, included in the 'Area de Protección de Flora y Fauna Islas del Golfo de California' (Islands of the Gulf of California Flora and Fauna Protection Area) (SEMARNAP 1999). A report pertaining to this LME is UNEP (2004).

I. Productivity

Surface winds have an average direction that generally follows the axis of the Gulf (Marinone *et al*. 2004). Tropical storms and hurricanes can cause heavy rainfall and intensified water and sediment runoff. SST seasonality is very conspicuous. Highest annual SST is observed during August and September (30-31º C south of the islands). Between October and December, the SST of the northern Gulf falls by almost 20° C and of the central and southern by about 7º C. Intense tidal mixing and upwelling maintain minimum SSTs around the mid-gulf islands throughout the year (Marinone & Lavín 2003). The largest interannual variability signal in the Gulf SST is due to El Niño-La Niña. The largest SST positive anomaly in the satellite records is that of 1997-1998, 3º C over the seasonal climatology, while the largest negative anomaly is associated with the 1988-1989 La Niña (4ºC below the climatological mean). SST anomalies due to El Niño tend to be strongest in the region just south of the mid-gulf islands (Soto-Mardones *et al*. 1999, Lavín *et al*. 2003).

The Gulf has unique oceanographic characteristics because of its long axis and because the Baja California Peninsula limits moderating influences from the Pacific Ocean circulation. Water circulation varies in time from two main influences: diurnal, semidiurnal, and fortnightly tidal cycles, and annual and semiannual seasonal changes. The tides, which co-oscillate with those of the Pacific Ocean, are mixed semi-diurnal tides, with one of the greatest tidal ranges on Earth. For instance, maximum registered spring tidal range at San Felipe is 6.95 m (Gutierrez & González 1999), with even larger amplitudes at the entrance to the Colorado Delta. The best-documented features of Gulf of California circulation are large-scale seasonally reversing gyres in the northern Gulf. A cyclonic gyre lasts approximately from June to September, and an anticyclonic gyre from November to April. Estimates from ship drift and the distributions of temperature and salinity indicate surface outflow during winter and inflow during summer, with mass conservation requiring a compensating flow at depth (Lavín *et al*. 1997, Berón-Vera & Ripa 2002, Castro 2001, Palacios-Hernández *et al*. 2002, Marinone & Lavín 2003, Lluch-Cota *et al*. 2004).

The LME is a Class I, highly productive ecosystem (>300 gCm^{-2}yr^{-1}), and is one of the five marine ecosystems with high productivity (Enríquez-Andrade *et al*. 2005). The northern Gulf has two main natural fertilisation mechanisms: one is the year-round tidal mixing around the large islands leading to an area of strong vertical mixing and continuous flow of cool nutrient-rich water into the euphotic layer, providing a thermal refuge for temperate species during the warmer periods (Lluch-Belda *et al*. 2003); the second is wind-induced upwelling along the eastern central gulf, enriched waters from the islands and the east coast reaching the peninsular side and remaining trapped, contributing to higher primary production per unit area. Also, because this enrichment system operates only during winter, there is a strong annual gradient of pigment concentration in most of the Gulf (Lluch-Cota *et al*. 2004, 2007).

The Guaymas Trench has volcanic and hydrothermal vents, with biotic communities supported by chemosynthesis using hydrogen sulfide, rather than photosynthesis (Teske *et al*. 2002). One of the most diverse biological communities in the world is found in this LME, with 4,852 species of invertebrates, excluding copepods and ostracods, (767 endemic), 891 species of fish (88 endemic) and 222 species of non-fish vertebrates, (four endemic) (Enríquez-Andrade *et al*. 2005). An outstanding diversity of marine mammal species is also found in the LME: 36 species, including 4 pinnipeds, 31 cetaceans and one bat (Aurioles-Gamboa 1993, Brusca *et al*. 2004). This LME is also the habitat of one of the world's most endangered cetaceans, the Vaquita porpoise (*Phocoena sinus*), endemic to the upper Gulf and the world's smallest and rarest porpoise. The blue, fin and grey whales are also found in this LME. The high primary productivity supports sardine and anchovy, which are the main prey of large quantities of squid, fish, seabirds and marine mammals.

Oceanic Fronts (Belkin et al. 2009)***:*** This is one of the smallest LMEs, located between Baja California and Mexico's mainland. The temperature contrast between the northern and southern Gulf is 2ºC to 3ºC, depending on the season. This gradient is enhanced along a bathymetric step in the middle of the Gulf, where a thermal front is observed (Inner Gulf Front, IGF) (Figure XIV-47.1).

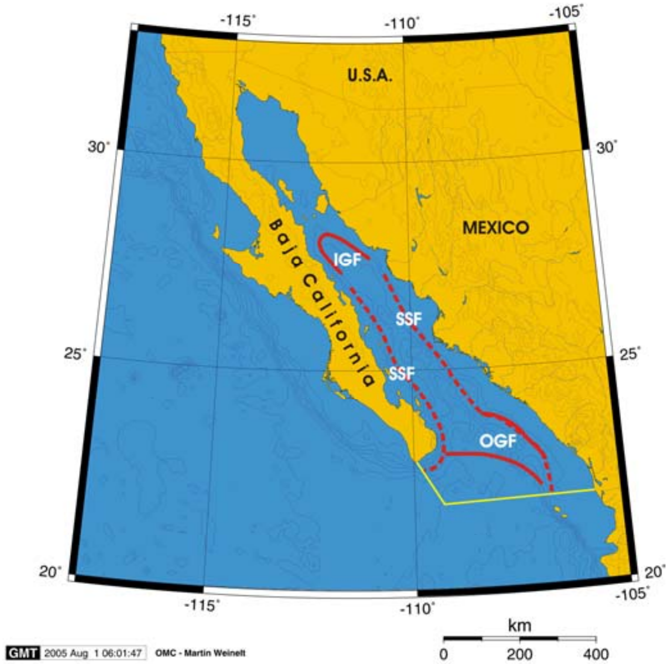

Figure XIV-47.1. Fronts of the Gulf of California LME. IGF, Inner Gulf Front; OGF, Outer Gulf fronts; SSF, Shelf-Slope Front (most probable location). Yellow line, LME boundary.(Belkin et al. 2009)

Other fronts form between Mexico's mainland and Baja California where Pacific inflow waters meet resident waters of the Gulf of California (Outer Gulf fronts (OGF) (Belkin *et al*. 2005). The Pacific and resident waters have different salinities and different temperatures; the salinity differential is the main factor responsible for the maintenance of this front.

Gulf of California SST (Belkin 2009)
Linear SST trend since 1957: 1.24°C.
Linear SST trend since 1982: 0.31°C.

The semi-landlocked Gulf of California shares some similarities with the California Current. The global cooling of the 1960s-1970s manifested here as a 2.2°C drop from 1958 to 1975. After a 2.8°C rebound in 1979-1983, the Gulf of California remained warm until the present. The sharp SST peak of 1983 attributed to a major El Niño 1982-1983 was synchronous with similar peaks in the California Current LME, the Central American Pacific LME and the Humboldt Current LME. Since 1983, the Gulf of California thermal history is strongly correlated with the California Current LME, including major events (peaks) of 1992 and 1997, associated with major El Niño events.

The relatively small warming of 0.31°C over the last 25 years is misleading since the transition from the cold epoch to the warm occurred in the late 1970s. Regardless of the exact timing of the breakpoint between the cold and warm epochs (1975 or 1979), the overall warming since then exceeded 1.5°C, which would put the Gulf of California into the league of fast-warming LMEs. The absolute minimum in 1975 was synchronous with absolute minima in both adjacent LMEs, the California Current LME and Central-American Pacific LME.

The Gulf of California is considered to be a primary source of moisture for the North American or Mexican monsoon, "the most regular and predictable weather pattern in North America" (Mitchell et al., 2002, p.2261), therefore warmer surface temperatures are expected to increase evaporation from the Gulf, which in turn would fuel stronger Mexican monsoons.

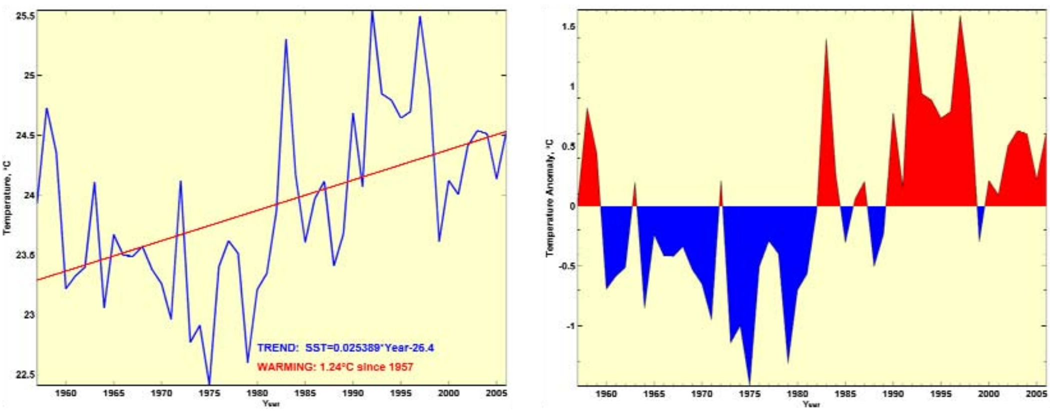

Figure XIV-47.2. Gulf of California annual mean SST and annual SST anomalies, 1957-2006. After Belkin 2009.

Gulf of California Chlorophyll and Primary Productivity: The LME is a Class I, highly productive ecosystem (>300 $gCm^{-2}yr^{-1}$),

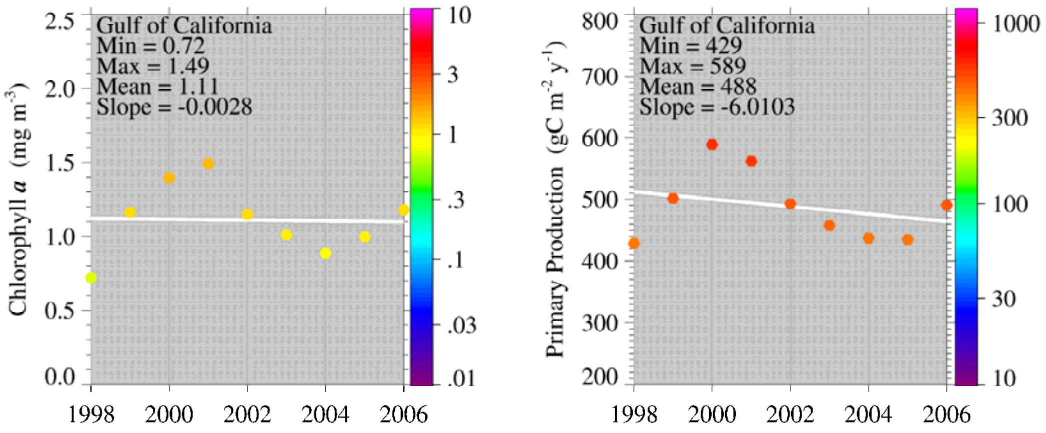

Figure XIV-47.3. Gulf of California trends in chlorophyll a and primary productivity, 1998-2006. Values are colour coded to the right hand ordinate. Figure courtesy of J. O'Reilly and K. Hyde. Sources discussed p. 15 this volume.

II. Fish and Fisheries

Historically, the LME has supported numerous fisheries of commercially valuable species. Fisheries resources in the Gulf are targeted by the commercial, artisanal, and recreational fishing sectors. In terms of weight caught, the major fisheries are dominated by small pelagic fish, primarily Californian anchovy (*Engraulis* mordax) and South American pilchard (*Sardinops sagax* [formerly known as Pacific sardine, *Sardinops caeruleus*]), as well as penaeid shrimps (blue, white and brown shrimp, *Litopenaeus stylirostris*, *Litopenaeus vannamei*, *Farfantepenaeus californiensis*, respectively, together with other less important species). Californian anchovy (*Engraulis mordax*) undergoes major scale abundance fluctuations related to environmental variation (Nevárez-Martínez *et al*. 2001). Jumbo squid (*Dosidicus gigas*), also a highly variable resource, is a major constituent in recent years (Nevárez-Martínez *et al*. 2000; Lluch-Cota 2007)). At a lower level of abundance, but much more consistent, are larger pelagic tuna-like fishes (mostly yellowfin and skipjack tuna) representing important commercial fisheries. The total annual catch of tuna-like resources increased rapidly from the late 1970s to peak in the mid 1980s. This increase was followed by a general downward trend until 1995, when catches began to increase again. The trend in catch of tuna-like species is mirrored by that of small pelagic fish.

Due to difficulties in separating landing from the Mexican State of Baja California Sur into components from the Gulf of California and those from the Pacific coast (and belonging mainly to the California Current LME), the values presented in Figure XIV-47.4 are only indicative of the magnitude of the catches in this small, yet highly productive LME, In particular, they differ from catch series (1980-2002) for 'sardines', jumbo squids', and 'shrimps' (though they match for tuna) presented in the review by Lluch-Cota *et al.* (2007, Fig. 5), which was not available when Figure XIV-47.4 and derived graphs (Figures XIV-47.5-10) were obtained. However, these graphs can still be expected to give a general impression of the fisheries and their status in the Gulf of California LME. [See www.seaaroundus.org for updated version on these graphs]

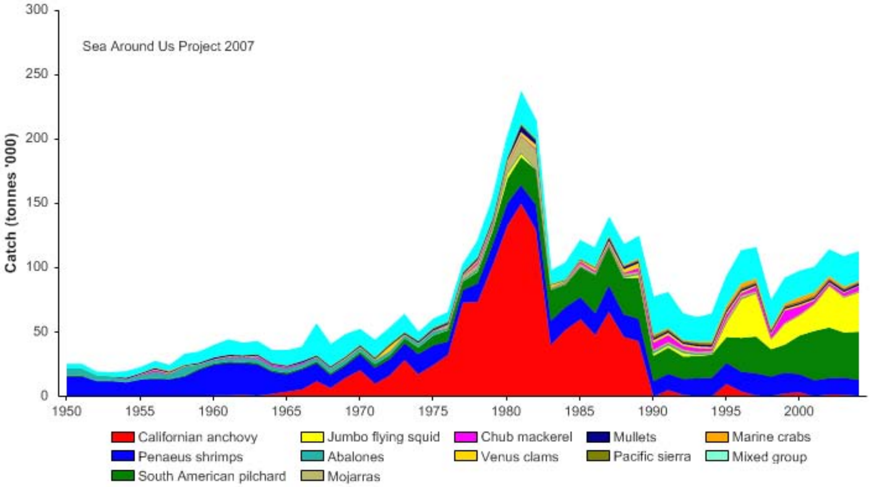

Figure XIV-47.6. Total reported landings in the Gulf of California LME by species (Sea Around Us 2007); see www.seaaroundus.org for a corrected update.

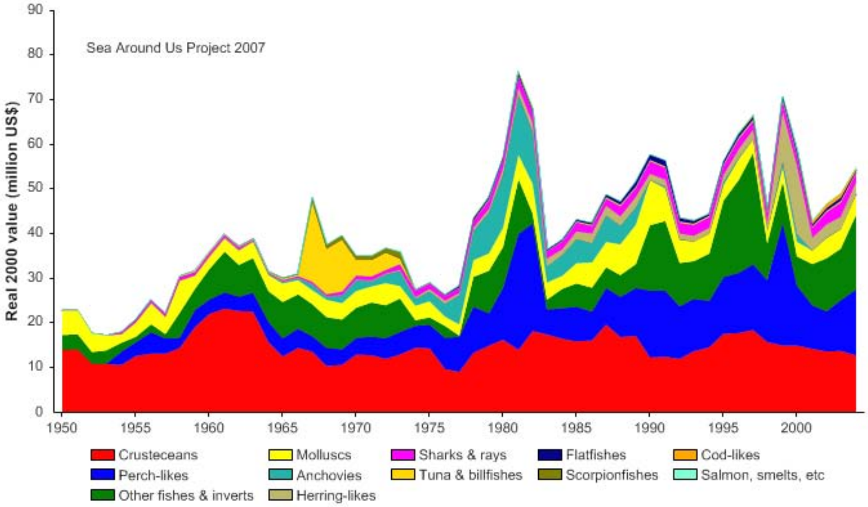

Figure XIV-47.7. Value of reported landings in the Gulf of California LME by commercial groups (Sea Around Us 2007); see www.seaaroundus.org for a corrected update.

The primary production required (PPR; Pauly & Christensen 1995) to sustain the reported landings reached 10% of the observed primary production in 1996 and has fluctuated between 5 to 9% in recent years (Figure XIV-47.6). Accounting for the catches in Fig. 5 of Lluch-Cota *et al.* (2007) would increase this figure to 15% at most. Since the mid 1970s, Mexico has been the only country fishing in this LME and hence accounts for all of the ecological footprint.

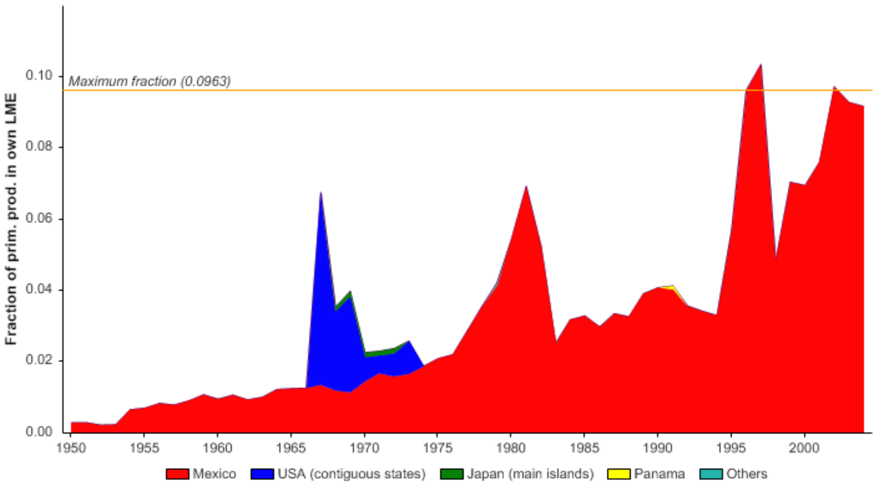

Figure XIV-47.8. Primary production required to support reported landings (i.e., ecological footprint) as fraction of the observed primary production in the Gulf of California LME (Sea Around Us 2007). The 'Maximum fraction' denotes the mean of the 5 highest values; see www.seaaroundus.org for a corrected update.

The mean trophic level of the reported landings (MTI; Pauly & Watson 2005), has increased from 1950 to the early 1970s, and remained relatively steady thereafter, except for a more recent increase (Figure XIV-47.7 top). The FiB index suggests a spatial expansion of the fisheries until the early 1980s, and has remained relatively level since, suggesting that natural limits may have been reached (Figure XIV-47.7 bottom).

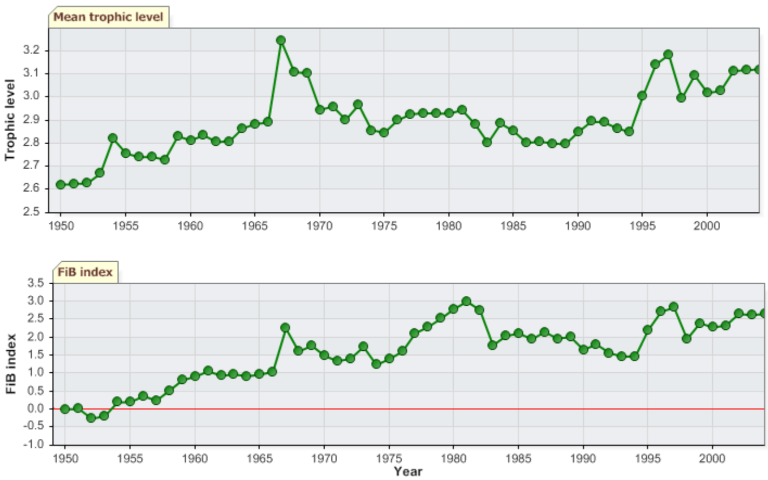

Figure XIV-47.9. Mean trophic level (i.e., Marine Trophic Index) (top) and Fishing-in-Balance Index (bottom) in the Gulf of California LME (Sea Around Us 2007); see www.seaaroundus.org for a corrected update.

A decline in trophic levels in the coastal food webs of this LME was reported by Sala *et al*. (2004), based on interviews with fishers, fisheries statistics and field surveys. According to Sala and colleagues, the decline in fish stocks has been accompanied by a marked shift in the species composition of the coastal fisheries and a decrease in the maximum individual length of fish catches by approximately 45 cm in 20 years. Large predatory fishes were among the most important catches in the 1970s, but became rare by 2000. Moreover, species that were not targeted in the 1970s have now become common in the catches. These findings contradict the conclusion of Pérez-España (2004) who, strangely, failed to find evidence of 'fishing down the food web' in this LME. The work of Saenz-Arroyo *et al.* (2005a, 2005b, 2006), and of Lozano-Montes *et al.* 2008) should, in any case, lay this controversy to rest as these authors not only demonstrated massive changes in the catch composition of the Gulf of California fisheries, but also that the bulk of these changes occurred before the period covered here, which, put them before the cognitive reach of researchers using based only on official catch statistics (Pauly 1995).

The Stock-Catch Status Plots indicate that the number of collapsed and overexploited stocks have been increasing in the LME, to about 70% of the commercially exploited stocks (Figure XIV-47.10 top). These stocks supply half of the reported landings (Figure XIV-47.10, bottom).

Several authors have suggested that the LME's fish resources are overexploited and regard the impacts of overfishing as severe, at least in the upper Gulf (Brusca *et al*. 2001). Distinct areas of concern include: impacts of fishing on shrimp populations, impacts of shrimp fishing on non-targeted populations (mostly the bycatch issue) and on the physical habitat, and catch of fish for bait and in sport fisheries.

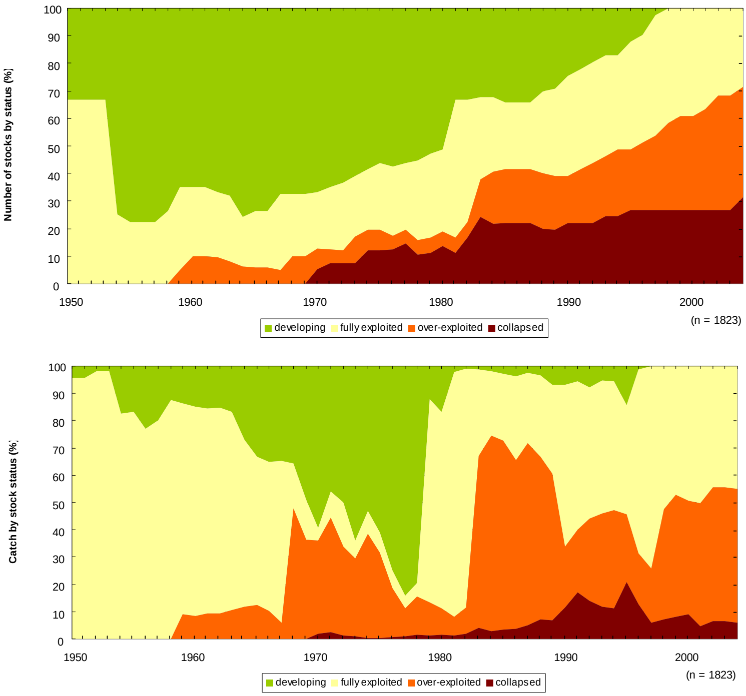

Figure XIV-47.10. Stock-Catch Status Plots for the Gulf of California LME, showing the proportion of developing (green), fully exploited (yellow), overexploited (orange) and collapsed (purple) fisheries by number of stocks (top) and by catch biomass (bottom) from 1950 to 2004. Note that (n), the number of 'stocks', i.e., individual landings time series, only include taxonomic entities at species, genus or family level, i.e., higher and pooled groups have been excluded (see Pauly *et al*, this vol. for definitions).

The abundance and availability of small pelagic fish fluctuate mostly because of natural environmental variations at various interannual scales, as shown by several studies including paleosedimentary evidence for the last 250 years (Holmgren-Urba & Baumgartner 1993, Cisneros-Mata *et al*. 1995a, Lluch-Cota *et al*.1999, Nevárez *et al*. 2001). The sudden collapse of the sardine population during the 1991-1993 fishing seasons was related to overfishing and natural variation (Cisneros-Mata *et al*. 1995a, Nevárez *et al*. 1999), and resulted in the closure of more than 50% of the fish plants. However, the industry and governmental and research agencies together agreed on time and area closures, a reduction of the fishing fleet by 50% and a programme of research cruises to monitor recruitment. The fishery fully recovered after three years. No major concerns seem to be related to the fisheries for jumbo squid and tuna-like fishes.

The shrimp fishery, which has been assessed since the 1970s, was found to be overfished as a result of excessive fishing effort and small mesh size in the trawl nets. Since then, fishing effort has increased further with the increase in the number of large boats and their fishing power, but most of all, with the number of outboard powered *pangas* now fishing for offshore shrimp. According to data in Páez *et al*. (2003), total shrimp catch has been declining by an average of 600 tonnes per year in the period 1980-2001, while shrimp aquaculture has increased by 30% per year since 1990 and now exceeds the catch. Natural variation may further impact shrimp abundance, as suggested several decades ago (Castro-Aguirre 1976). Galindo-Bect *et al*. (2000) found a significant correlation between total shrimp catch in the upper Gulf and the rate of freshwater discharge by the Colorado River. Although the damming of the Colorado River may have been the principle cause of the decline in the shrimp fishery, the escalation in the number of fishing vessels and fishing gear types could have also contributed to this decline (UNEP 2004). Catches of offshore shrimp could improve substantially both in volume and individual sizes if fishing effort were to be reduced to adequate levels and mesh sizes regulated for optimum selectivity. While it would appear that the trend has been to allow more fishers to participate as a means of further distributing the benefits, it is becoming increasingly clear that such a process has involved extra financing through tax exemptions and subsidies and is no longer viable.

Conservation International Mexico (2003) has estimated that each kilogramme of shrimp caught in the commercial fishery is accompanied by at least 10 kg of bycatch. (Tis bycatch is not included in catch statistics, but should be). Estimates for the Gulf of California LME have ranged from 1:2 up to 1:10 (Rosales 1976) and larger at times. This proportion is similar to those reported for shrimp fisheries in tropical areas around the world, i.e., 1:10 (Cascorbi 2004). The magnitude of bycatch is highly variable, depending on area and season. At the beginning of the shrimp season the proportion may be lower; bycatch tends to increase towards the end of the season, when shrimps have been fished out. The National Fisheries Institute of Mexico (INP) began developing fish excluders together with Conservation International in 1992, particularly directed to the protection of totoaba *Cynoscion macdonaldi* (Balmori *et al*. 2003). Such efforts have continued with the FAO on an international project to develop suitable excluders.

Some species, such as juveniles of totoaba, a large endemic species that was heavily fished during the 1930s-1940s, and marine turtles, both vulnerable to trawl nets, are of particular concern. Cisneros-Mata *et al*. (1995b) estimated that an average of 120,300 juvenile totoaba was killed by shrimp vessels each year from 1979 to 1987. Other icon species, such as dolphins, are rarely killed by these gears. Vaquitas and sea turtles are incidentally captured in gill nets. The total estimated incidental mortality caused by the fleet of El Golfo de Santa Clara was 39 Vaquitas per year, over 17% of the most recent estimate of population size (D'Agrosa *et al*. 2000). The vaquita population is estimated to be less than 600 (Jaramillo-Legorreta *et al*. 1999). Therefore, considering normal replacement rates (maximum rate of population growth for cetaceans is of 10% per year), this incidental loss is unsustainable. Although turtle-excluder devices are mandatory for industrial fishing vessels, poaching of sea turtles is still a problem throughout western Mexico.

The impacts of the trawl fishery on the ecosystem are of major concern. Anecdotal information suggests that sweeping changes in benthic community structure have taken place over the past 30 years of these disturbances. Commercial shrimp trawling exacts a harsh toll on the Gulf's marine environment, as more than a thousand shrimp trawlers annually rake an area of sea floor equivalent to four times the total size of the Gulf. This constant bottom trawling is considered to damage fragile benthic habitats and non-commercial, small invertebrate species (Brusca *et al*. 2001). However, this area of research is in need of attention since data are not sufficient to evaluate the extent of this damage in the LME.

UNEP (2004) recalls that the American Fisheries Society's official list of marine fish at risk of extinction includes six species of large groupers and snappers, four of which are endemic to the Gulf of California and adjacent areas. Of these, two are regarded as endangered, while the remaining four are considered as vulnerable, given the fact that these species are sensitive to overfishing because of late maturity and the formation of localised spawning aggregations (Musick *et al*. 2001). The effect of fishing is particularly evident in large, slow-growing fish, and includes a decrease in abundance and in the average individual size, where both are unavoidable consequences when aiming at maximizing yield. What occurs in the Gulf of California LME is similar to what occurs in Puget Sound, Florida and the southern Gulf of Mexico, the other 'hot spots' described by Musick *et al*. (2001). Of particular concern has been the totoaba. Although overfishing has been blamed for the early decline of the fishery, the reduction in the flow of the Colorado River may have been a major cause of depletion through the alteration of the estuarine habitat of the river delta, its normal spawning and nursery area (UNEP 2004). The totoaba fishery declined since 1970 due to declining populations and to restrictions imposed (in 1975) when catch levels threatened the population. Despite closures, the totoaba gill net fishery continues on a small-scale.

The tremendous diversity and complexity of the fisheries within the Gulf of California LME and the large size of the basin make it a difficult area to manage. This is aggravated by the lack of sufficient resources for implementing and enforcing management decisions and federal laws, inadequate knowledge about the ecology of exploited species, and insufficient past efforts to actively involve fishing communities in management decision-making. However, current efforts are succeeding in conserving the natural resources upon which a large number of people depend, and an improvement in terms of overexploitation is expected in the future (UNEP 2004).

III. Pollution and Ecosystem Health

Pollution: A sizeable portion of the eastern coast of the Gulf of California LME is subject to pollution from industrial and human wastes, agricultural run-off and aquaculture residues. Other pollution threats include sedimentation from deforestation, bilge water from ships, the construction of tourist marinas in sensitive coastal areas, and the risk of oil spills from a steady traffic of oil tankers. While pollution was found to be generally slight, it is more serious in some localised coastal areas (UNEP 2004). Beman *et al*. (2005) have reported eutrophication episodes caused by agricultural irrigation in the coastal area off the Yaqui Valley. A long time series of data related to eutrophication and HABs available from Mazatlán showed an increase in the number of toxic species as well as in the length and frequency of HABs events. Mortalities of marine mammals, birds, and fish in 1995, 1997 and 1999 were related to HABs (Sierra-Beltrán *et al*. 1998, 1999). Except for La Paz Bay and Los Cabos areas, the west coast of the Gulf is nearly pristine.

In the few places where towns or villages do exist, some pollution occurs. Agricultural pesticides used in the Mexicali Valley and in Sonora and Sinaloa States have led to concerns since the early 1970s about the possibility of pesticide transport into the Upper Gulf of California. Pesticides have been found in organisms of the Mexicali Valley irrigation canals as well as the Upper Gulf of California (García-Hernández *et al*. 2001). For instance, DDE, DDT and DDD were detected in fish and invertebrate sampled from the delta wetlands even though such pesticides have been banned (Mora & Anderson 1995). Preliminary findings indicate high concentrations of zinc and lead in Navachiste Bay, Sinaloa (Orduña-Rojas *et al*. 2004).

Habitat and community modification: The delta wetlands and marine areas provide unique and valuable habitats for a large number of invertebrates, marine mammals, birds and commercial species of fish (Alvarez-Borrego 1983). These habitats are, however, being altered by various human activities, the impacts of which are magnified by the semi-enclosed nature of the Gulf. The most notable human activity to impact the upper Gulf has been the damming of the Colorado River, which has significantly modified the environment in this area. The river supplied freshwater, silt and nutrients to the delta, and helped to create a complex system of wetlands that provided feeding and nesting grounds for birds, and spawning and nursery habitat for fishes and crustaceans (Glenn *et al*. 1996). The reduced freshwater input has drastically changed what used to be an estuarine system into one of high salinity. It has also reduced the influx of nutrients to the sea and critical nursery grounds for many commercially important species such as the totoaba, Gulf curvina, and brown shrimp (Aragón-Noriega & Calderon-Aguilera 2000).

In terms of vegetation cover, the degree of mangrove deterioration in Mexico is not as evident as in other countries (Páez-Osuna *et al*. 2003). However, on a regional scale, there is evidence of mangrove destruction mainly in Sinaloa (Ceuta and Huizache-Caimanero coastal lagoons) and Nayarit (Marismas Nacionales). The drying out of lagoons in the Huizache-Caimanero system caused a 20% reduction in water surface area from 1973 to 1997 and an increase in adjacent seasonal salt pans (Ruiz-Luna & Berlanga-Robles 1999). The Huizache-Caimanero coastal lagoon supports an important shrimp fishery. Until the 1980s, this system had yields up to 1,500 tonnes (de la Lanza & García-Calderón 1991) and provided the highest yields per unit area for shrimp fisheries in coastal lagoons in Mexico. During the last decade, yields notably decreased (Zetina-Rejón *et al*. 2003). Rogerío-Poli & Calderón-Pérez (1987) considered that the changes in postlarvae density were mainly due to changes in water temperature. On the other hand, Ruiz-Luna & Berlanga-Robles (1999) suggested that the loss of freshwater, which changed the salinity in this lagoon, was a consequence of the removal of deciduous tropical forest for agricultural purposes and a 50% decrease of mangrove forests between 1973 and 1997. In addition to the elevated rate of mangrove deforestation (1.9% per year), mangrove coverage for this zone is scarce and with patchy distribution that aggravates an unstable condition (Páez-Osuna *et al*. 2003). Carrera & de la Fuente 2001 reported that in Marismas Nacionales about 1,500 hectares of wetlands have been replaced by shrimp farming. Nonetheless, DeWalt (2000) considered that shrimp aquaculture in Mexico has thus far developed largely without the major detrimental environmental effects seen in other countries and has found little evidence of mangrove destruction.

IV. Socioeconomic Conditions

The Gulf of California LME is a very economically active zone. Overall, the region accounts for approximately 10% of Mexico's GDP, with a human population of about 8.6 million. Approximately 40% of Mexico's agricultural production comes from the region, mainly from the States of Sonora, Sinaloa and Nayarit. Because of the richness of the marine basin and a very particular social-geographic situation (border with the

U.S.), key productive activities have been increasing along the littoral areas, driving an uncontrolled coastal population growth (WWF Mexico 2005). Port activities and marine traffic represent a fundamental support for agriculture, industry, mining and fishing. The region is considered a natural port for international traffic routes and tourism development. The Mexican government and the Fondo Nacional de Fomento al Turismo (FONATUR) have announced plans to proceed with a project called Escalera Nautica, or Nautical Ladder, consisting of at least 22 yachting marina resorts placed strategically along the coast. The project also contemplates new and improved highways, airports, airstrips, and the development of hotels, golf courses, etc. (Enríquez-Andrade *et al*. 2005).

An increase in the demand for oil, gas and mineral resources has stimulated the exploration of the non-living resources of the EEZ. The LME's fisheries are an important source of food and income for Mexicans (Enríquez-Andrade *et al*. 2005). Major resources are small pelagic fishes, jumbo squid, tuna-like fishes and shrimp. Shrimp production continues to be of important value, despite the decline in offshore shrimp catches in the upper Gulf in the late 1980s-early 1990s.

V. Governance

The LME is governed by Mexico. Fisheries regulations are numerous and complex, responding to the diverse array of natural resources. All fisheries resources in the country are managed by the Federal Government through the Ministry of Agriculture, Livestock, Fisheries and Food, by the National Commission of Aquaculture and Fisheries (CONAPESCA), while the environment is under the responsibility of the Ministry of Environment and Natural Resources. CONAPESCA has a technical branch, the National Fisheries Institute (INP), which conducts regular assessments and evaluations of the status of fisheries resources.

Several natural protected areas have been established in the region, including five biosphere reserves (among them the Upper Gulf of California and the Colorado River Delta, the coast of the Reserva de la Biosfera del Vizcaíno and the San Pedro Mártir Island), five marine parks (including the Bay of Loreto and Cabo Pulmo), three wildlife reserves (including Cabo San Lucas and all of the Islands of the Gulf of California) and three areas with other protection status. In addition, two new marine parks are being considered for decree (Enríquez-Andrade *et al*. 2005). There are 16 areas designated as 'priority' by the National Commission of Biodiversity. Protected areas are managed by the National Commission of Protected Areas (CONANP), reporting to Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT). After several years of relatively uncoordinated efforts by several NGOs, a Coalition for the Sustainability of the Gulf of California was created in December 1997 in an attempt to integrate available information and generate broad consensus on conservation priorities for the region (Enríquez-Andrade *et al*. 2005). At present there is an ongoing process to develop an Ecological Ordering of the Gulf of California, started June, 2004. This is a coordinated effort of the Federal Government through SEMARNAT, SAGARPA, the Ministry of Communications and Transportation (SCT), Ministry of Tourism (SECTUR), Ministry of the Interior (SEGOB) and the Ministry of the Navy (SEMAR). At the same time, SEMARNAT, Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA) and Secretaría de Turismo de México (SECTUR) signed an agreement with the governments of the states of Baja California, Baja California Sur, Sonora, Sinaloa and Nayarit to develop the ecological ordering of the terrestrial components of the coastal areas.

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