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Honduras: Caribbean Coast

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The coast of Honduras, Central America, represents the southern end of the Mesoamerican Barrier Reef System, although its marine resources are less extensive and studied than nearby Belize and Mexico. However, the coastal zone contains mainland reef formations, mangroves, wetlands, seagrass beds and extensive fringing reefs around its offshore islands, and has a key role in the economy of the country. Like most tropical areas, this complex of benthic habitats experiences limited annual variation in climatic and oceanographic conditions but seasonal and occasional conditions, particularly coral bleaching and hurricanes, are important influences. The effects of stochastic factors on the country's coral reefs were clearly demonstrated during 1998 when Honduras experienced a major hurricane and bleaching event. Any natural or anthropogenic impacts on reef health will inevitably affect other countries in Latin America, and vice versa, since the marine resources are linked via currents and the functioning of the system transcends political boundaries. Much further work on, for example, movement of larvae and transfer of pollutants is required to delineate the full extent of these links.

Anthropogenic impacts, largely driven by the increasing population and proportion of people living in coastal areas, are numerous and include key factors such as agricultural run-off, over-fishing, urban and industrial pollution (particularly sewage) and infrastructure development. Many of these threats act synergistically and, for example, poor watershed management via shifting cultivation, increases sedimentation and pesticide run-off onto coral reefs, which increases stress to corals already affected by decreasing water quality and coral bleaching. Threats from agriculture and fishing are particularly significant because of the size of both industries. The desire to generate urgently required revenue within Honduras has also led to increased tourism which provides an overarching stress to marine resources since most tourists spend time in the coastal zone. Hence the last decade has seen a dramatic increase in coastal development, a greater requirement for sewage treatment and more demand for freshwater, particularly in the Bay Islands.

Although coastal zone management is relatively recent in Honduras, it is gaining momentum from both large-scale initiatives, such as the Ministry of Tourism's 'Bay Islands Environmental Management Project', and national and international NGO projects. For example, a series of marine protected areas and legislative regulations have been established, but management capacity, enforcement and monitoring are limited by funding, expertise and training. Existing and future initiatives, supported by increased political will and environmental awareness of stakeholders, are vital for the long-term economic development of the country. © 2001 Published by Elsevier Science Ltd.

The Defined Region

Honduras covers approximately 112 000 km^2 of land on the widest part of the isthmus of Central America (Fig. 1). Although Honduras has a limited Pacific coastline in the Gulf of Fonseca, this review focuses on the Caribbean coastline because the marine resources on the northern coast are more diverse and extensive and also biologically and economically more significant as they form the southern end of the Mesoamerican Barrier Reef System. The Caribbean coast of Honduras stretches from the border with Guatemala in the west to the border with Nicaragua in the east and also encompasses a number of offshore islands systems including the Islas de la Bahía (Bay Islands) archipelago. Hence this coastline encompasses more than 91% (735 km) of the country's 820 km coastline (Merrill, 1995) and includes coral reefs, mangrove forests, seagrass beds, estuaries, coastal lagoons, wetlands and tropical coastal fisheries.

Honduras lies within the wider Caribbean region which stretches from the Gulf of Mexico to the French Guiana – Brazil border. This region has well known interactions throughout its area, and the marine resources of Honduras are inextricably linked to a much larger area via water exchange. Such links lead to, for example, Sullivan Sealey and Bustamante (1999) defining the Tropical Northwestern Atlantic as the largest biogeographical province in the western hemisphere and places Honduras within the large, complex Central Caribbean 'ecoregion'. The close links between the coastal zones of Mesoamerican countries is exemplified in the Gulf of Honduras which is influenced by the watersheds of Honduras, Belize and Guatemala. Honduras plays a key role within this influx since, for example, the Rio Ulúa has a watershed of over 22 000 km^2 which is an order of magnitude greater than any river in southern Belize and hence has a significant impact on the Belize

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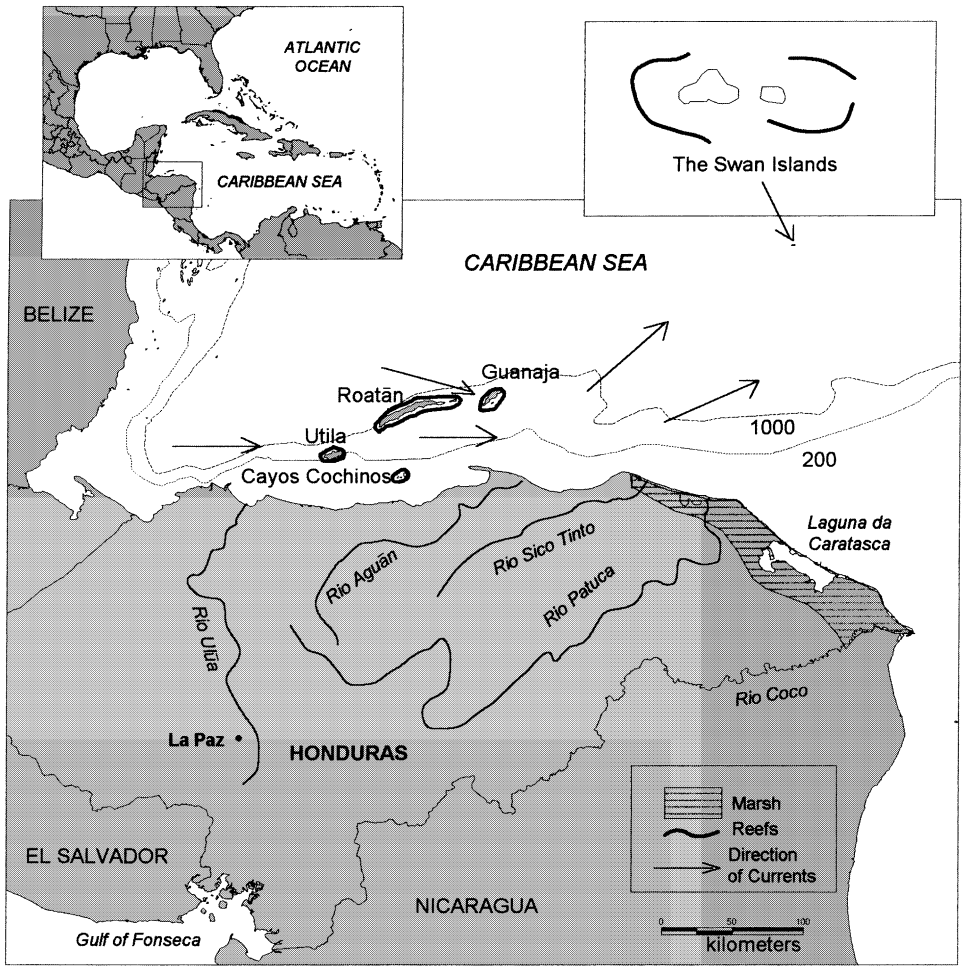

Fig. 1 Map of Honduras.

Barrier Reef (Heyman and Kjerfve, 1999). The oceanographic links within the wider Caribbean were highlighted by the spread of the waterborne pathogen which decimated populations of *Diadema* sea urchins throughout the region in the early 1980s (reviewed by Lessios, 1988). The artificiality of dividing the Mesoamerican Barrier Reef System via national borders has been recognised by recent management initiatives and indeed Heyman and Kjerfve (2001) highlight that the reserves in Honduras, Belize and Guatemala can be viewed as a system which contributes to the health of the entire ecosystem.

Although there are obvious oceanographic connections between Honduras and neighbouring reefs in Central America, and also the wider Caribbean, little is known about migration of adult populations or larval interchange. One exception is the current research on the movement of whale sharks (*Rhincodon typus*) (see Box 1). However, there are many other species with large home ranges or migration patterns that remain effectively unstudied. Similarly, even a basic understanding of larval sources and sinks within Honduras is currently lacking, although Ehrhardt (2000) provides a brief discussion on how counter-clockwise currents correspond with peak lobster spawning times and must have a key role in both local larval retention and supplying downstream areas. While knowledge of larval interchange is a function of limited direct research, Guzmán (1998) also highlights the lack of systematic studies of the population structure of coral species, the geographical range of these species and the distribution and diversity of habitats throughout Central America. Such data would provide insights into the physical and biological factors governing regional larval dispersal.

Seasonality, Currents and Natural Environmental Variables

Currents

Similarly to the rest of the Caribbean Sea, the surface waters of Honduras originate in the Equatorial Atlantic and enter the region via the Lesser Antilles as the Caribbean Current (Stalcup and Metcalf, 1972). Off the coast of Nicaragua a counter-clockwise gyre develops from the Caribbean Current which flows to the south-western Caribbean (Gordon, 1967). D'Croz *et al.* (1998) highlight a second, smaller, cyclonic counter clockwise current that affects the Bay Islands, particularly from January to March. These counter-clockwise currents

Box 1. The whale sharks of Honduras

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Whale sharks (*Rhincodon typus*) are the largest of the three planktivorous sharks and range broadly across tropical geopolitical boundaries, including the territorial waters of Honduras. The global population and structure is yet unknown but thought to be low because of the rarity of sightings worldwide. Researchers are also unsure of whether whale sharks belong to a single global population or several subpopulations but DNA studies currently underway may soon elucidate this issue.

An opportunistic feeder, the whale shark is known to gulp water and filter a variety of tiny animals but appears to target high-density food sources such as thick 'soups' of plankton, often migrating large distances to locate them. Ordinarily solitary, the whale shark will congregate seasonally while targeting dense patches of food. Whale sharks have been documented feeding on copepods close to Baja, Mexico and the freshly released spawn of snappers in Belize. In Honduras, whale sharks are found off the Bay Islands in variable numbers throughout the year where they are known to follow schools of tuna and feed on pelagic baitfish.

Recent research on whale shark migration patterns undertaken in the Pacific proved that whale sharks undertake large-scale transoceanic migrations possibly in search of, or targeting, patches of food. Several tools such as conventional marker tags, geolocating archival pop-off satellite tags and acoustic tags are currently being used to elucidate site fidelity and movement patterns in the Caribbean. Sharks tagged in Belize are now known to move north and south along the Belize Barrier Reef and also into Honduran waters. Furthermore, sharks tagged in Honduras have been sighted in Belize, confirming the movement of the Mesoamerican population between the two countries and beyond and the need for regional accords for the management of this transboundary migratory species.

early in the year cause a decrease in sea surface temperatures which are associated with coastal upwelling (Brenes *et al.*, 1998) and high productivity along the southern Belize Barrier Reef and Gulf of Honduras (Heyman and Kjerfve, 1999). Density-driven easterly surface currents also exit the inner Gulf of Honduras because of the flux of freshwater from the extensive fluvial inputs (Heyman and Kjerfve, 2001). Productivity is further increased by the occasional deep, clear, nutrient rich oceanic waters that enter the Gulf of Honduras, in the opposite direction to surface currents, from the Caribbean Sea (Heyman and Kjerfve, 1999).

Tidal range in Honduras is small with, for example, changes of only 30–35 cm around Roatán (MacKenzie and Stehlik, 1996). However, although astronomical tides are weak and are dominated by meteorological tides, tidal currents are important for dispersion of sediments and larvae in reef passages and near river mouths (Heyman and Kjerfve, 2001). Surface temperatures in deeper water typically range from 27°C to 31°C and salinities are approximately 37‰ but decrease significantly at the end of the wet season and within enclosed coastal bays (Heyman and Kjerfve, 2001).

Seasonality

The climate along the Caribbean coast of Honduras is dictated by seasonal easterly tradewinds which cause a rainy season for approximately eight months and a dry season from November to February. Rainfall is greater than 2000 mm per year and air temperatures range from 25°C to 29°C (D'Croz *et al.*, 1998). Temperatures in Honduras vary primarily with elevation rather than season (Merrill, 1995) but during December and January an occasional strong cold front from the north brings cooler northwest winds. Rainfall is particularly copious in the Mosquitia region of eastern Honduras where average rainfall is 2400 mm (Merrill, 1995). Such high levels of rainfall means that reefs are periodically subjected to siltation and Ogden and Ogden (1998) state that the Cayos Cochinos archipelago is affected by plumes of sediment originating from coastal rivers. Although the effects of this sediment on the reefs of both Cayos Cochinos and the Bay Islands are poorly understood it seems likely that it is a significant stressor and will be increased by further agricultural development of the coastal plain. Similarly, although seasonal changes are known to, for example, cause variations in macroalgal and seagrass productivity, there has been little research on more specific effects of annual climate variation on other components of the marine flora and fauna of Honduras. However, sporadic large storms may cause localised mortalities of the echinoid *Lytechinus variegates* (Lessios, 1998).

Hurricanes and coral bleaching

Hurricanes and major coral bleaching events are a more significant factor on marine communities than seasonal variations. Although Honduras lies within the hurricane belt, hurricanes are relatively infrequent but damage has been reported from, for example, Hurricane Fifi in 1974 which killed 8000 people (Merrill, 1995; Ogden and Ogden, 1998). Hurricane Mitch in 1998 (category 5 with occasional wind speeds greater than 250 km^{-1} is regarded as the most deadly hurricane to strike

the western hemisphere for the last two centuries and killed 10 000 people, mainly in Honduras and Nicaragua, and caused an estimated $5 billion of damage in Honduras (Fielding, 2000b). Hurricane Mitch also had significant effects on the marine resources of Honduras, particularly as it occurred shortly after a mass coral bleaching event. Kramer *et al.* (2000) report losses in coral cover of 15–20% across the Central American region and damage to 50–70% of corals in parts of Honduras, although recent mortality was only moderately high (<25%). Physical damage (broken, knocked over and abraded colonies) from the hurricane's direct action was approximately 11% of corals on shallow reefs and 2% on deep reefs in Honduras (Kramer and Kramer, 2000). Damage was particularly severe in the Bay Islands as the hurricane slowed and stalled close to Guanaja for two days. Secondary effects, such as the extensive run-off of low salinity, sediment-laden water into the Gulf of Honduras are more difficult to quantify in the short term (Kramer and Kramer, 2000).

Coral bleaching events occur during occasional periods when climate conditions raise seawater temperatures and solar irradiance (summarised in Westmacott *et al.*, 2000). Coral bleaching, the paling of coral tissue from the loss of symbiotic zooxanthellae, has presumably occurred previously in Honduras but evidence of severe events prior to the mid-1990s is sparse. However, a mass bleaching event was recorded in 1995 by Guzmán and Guevara (1998) which affected 73% of scleractinians along with over 90% of all hydrocorals, zoanthids and octocorals. More detailed information is available for the more severe mass bleaching event in 1998 when high sea-surface temperatures affected Honduras in September and October. Interestingly there is some evidence that the water movements caused by Hurricane Mitch may have reduced sea-surface temperatures and allowed some corals to recover. However, the effects of bleaching were severe, leading to an average regional coral mortality of 18% on shallow reefs and 14% on forereefs along with subsequent increases in the prevalence of diseases and will have long-term ecological and socio-economic consequences (Kramer *et al.*, 2000; Kramer and Kramer, 2000).

The Major Shallow Water Marine and Coastal Habitats

Geological setting

The geology underlying the marine resources of Honduras is relatively well studied and reviews are provided by Ivey *et al.* (1980); Donnelly (1992); Bermingham *et al.* (1998). The Bay Islands and mainland coast lie to the south of the east-west Transform Fault which separate the northern Maya Terrane from the southern Chortis Terrane. The Bay Islands and Cayos Cochinos are relative recent (less than few thousand years) and represent topographic high points of the ancient basement. They are situated on the Bonacca Ridge which is orientated east-west, south of the deep ocean Cayman Trench.

Mainland coast

The marine resources of the mainland are very poorly studied and there is virtually no published literature on the presence or absence of coral reefs (UNEP/IUCN, 1988). Kramer *et al.* (2000) and Cortés (1997) state that because of high levels of runoff there are only scattered, poorly developed coral communities around Puerto Cortés, La Ceiba and Trujillo. It seems reasonable to assume that reefs along the coastline are similar to those found in better studied, neighbouring countries such as Belize. In Belize, the mainland reefs are restricted to areas where sediment is removed most efficiently and the fauna is species poor with only resistant genera such as *Siderastrea* and *Porites* (Perkins, 1983).

There are extensive continental mangrove forest and wetland systems along the central section of coastline and bordering the Gulf of Honduras but severe degradation from overfishing, mangrove clearance and pollution has been reported (Sullivan Sealey and Bustamante, 1999). The extensive mangrove system contains a number of lagoons, riverine estuaries as well as offshore mangrove cays (MacKenzie and Stehlik, 1996). The eastern Mosquitia region of mainland Honduras also has a complex environment of reefs, lagoons, wetlands and barrier beaches in an expansive savanna which plays a key role in fisheries health (Sullivan Sealey and Bustamante, 1999) and is an important breeding ground for waterbirds. The inaccessibility of the Mosquitia region has limited deforestation and agriculture and part of it is further protected by the Rio Plátano Biosphere Reserve (Richards, 1996).

Reefal islands

The Caribbean coastline of Honduras includes a highly developed small island reef system which can be divided into three groups, the Bay Islands and Cayos Cochinos archipelago, the Mosquitia cays and banks and the small Swan Islands with a coastline length of only 6 km (Cortés, 1997; Sullivan Sealey and Bustamante, 1999). The Bay Islands group, on the edge of the 75 km wide continental shelf, has a number of smaller cays but is dominated by three major islands; Utila, Roatán and Guanaja (Fig. 2). These islands are the centre of both reef related tourism and the fishing industry in Honduras and in addition to the coral reefs they also contain significant mangrove wetlands.

There is only limited published information describing the reefs of Honduras (UNEP/IUCN, 1988), although the Cayos Cochinos archipelago has been relatively well studied by scientists working at the Cayos Cochinos Research Station. However, wind generated wave energies are generally higher on more exposed northern coasts and subsequently, for example, the north coasts of the larger islands of the Cayos Cochinos are dominated by massive colonies such as *Montastraea*

Fig. 2 The Bay Islands support a significant proportion of the coral reef habitats in Honduras and are a popular tourist destination.

annularis (Ogden and Ogden, 1998). In contrast, lee areas support a more diverse coral assemblage. Currently unpublished reef mapping work in the Bay Islands by the Ministry of Tourism's 'Bay Islands Environmental Management Project' and Coral Cay Conservation has extended knowledge of the extent and complexity of the reef systems in this area significantly.

The Bay Islands are generally surrounded by fringing reefs, but the north coast of Roatán, the largest and best known island, is dominated by a nearly continuous barrier and fringing reef (UNEP/IUCN, 1988). In contrast, the south coast of Roatán supports a discontinuous fringing reef broken up by channels and bights that were formed by erosion during glacial events. Reefs on both coasts have a relatively narrow landward lagoon dominated by seagrass and additional information on zonation is provided in UNEP/IUCN (1988), Fenner (1993) and Kramer *et al.* (2000). Similarly, on the reefs of Utila, zonation is much more pronounced to the north of the island and the reefs of the leeward side typically comprise of a narrow shelf characterised by a poorly developed reef crest and with little reef development beyond a depth of 25 m. Since Hurricane Mitch and the bleaching events of 1995 and 1998, coral cover is generally low, for example rarely being higher than 30% on Utila (Coral Cay Conservation, unpub. data) and only reaching 50% at the west end of Roatán (Kramer *et al.*, 2000). In addition to the fringing reefs, throughout the Bay Islands and Cayos Cochinos there are numerous seamounts which are poorly studied but some are known to have relatively high coral cover and fish populations. These seamounts are also important locations for local fisherfolk and at least some are important as fish spawning areas (Fine, 1992).

The reefs of the Swan Islands and the Mosquitia cays and banks are poorly known because of their inaccessibility and the results of research visits are mainly restricted to unpublished grey literature. Cortés (1997) reports that the Mosquitia cays are surrounded by fringing reefs and patch reefs in lagoonal areas. An expedition in 1960 to the Swan Islands indicated that coral growth may be less abundant than on the reefs of Panama (UNEP/IUCN, 1988) and there is some evidence that the biota of some taxa are less diverse than the Bay Islands because they have a lower habitat diversity and less protection from severe storms (Keith, 1992). More recent anecdotal reports indicate that, because of their isolation and use for only small-scale artisanal fishing, the coral health and fish populations of the Swan Islands may be higher than those of the Bay Islands and Cayos Cochinos. However, the reefs are likely to have suffered significantly from wave damage in 1998 because of the proximity of the Swan Islands to the path of Hurricane Mitch.

Continental shelf

There is limited information on the shallow continental shelf north of the Honduran mainland but Ogden and Ogden (1998) indicate that shallow areas support scattered patch reefs dominated by *Agaricia tenuifolia*, sand lenses and seagrass beds. These authors also describe extensive beds of seagrasses, dominated by *Thalassia testudinum* and *Syringodium filiforme* to the south of the major islands of the Cayos Cochinos archipelago. Furthermore, aerial observations by the authors indicate that there are numerous shallow, hard substratum banks between Cayos Cochinos and the Bay Islands, but the benthic communities which they support are poorly known.

Biodiversity

The marine biodiversity of Honduras is relatively poorly known and most of the taxonomic research has been focused at Cayos Cochinos. For example, Guzmán (1998) documents a diverse fauna of 66 species and forms of hermatypic corals (including *Millepora*) and Clifton and Clifton (1998) report 'diverse and abundant populations' of reef fish including 226 species. Guzmán (1998) also lists 44 species of octocorals and five species of antipatharians and this study extends earlier coral inventories by Fenner (1993) and Keith (1992) on Roatán and Tortora and Keith (1980a,b) in the Swan Islands. Additional taxonomic studies for Cayos Cochinos include marine benthic algae (Ogden, 1998), decapods (Jácome, 1998) and echinoids (Lessios, 1998). Honduras also supports low to moderate numbers of nesting turtles (*Dermochelys coriacea*, *Chelonia mydas*, *Caretta caretta* and *Eretmochelys imbricata*; Groombridge, 1982). Overall, diversity appears to be similar to other reefs in Central America but further research will certainly extend the species lists for Honduras significantly.

Offshore Systems

Beyond fringing reef development, the deep slopes of Honduras are very poorly studied but evidence from Belize (e.g. Colin, 1974) indicates that there is likely to

be a true deep-reef fish fauna. Caribbean offshore fisheries are limited despite 80% of the water being deeper than 1800 m (UNEP/ECLAC, 1984) and in Honduras most of the fishing activity is restricted to relatively shallow water habitats. Hence, there is only limited commercial and recreational fishing for commercially important species such as blue marlin (*Makaira nigricans*), tuna (*Thunnus* spp) and mackerel (*Scomboromerous* spp) which are known to inhabit the pelagic zone, particularly in the deep water of the Cayman Trench (Heyman and Kjerfve, 2001).

Populations Affecting the Area

The population of Honduras currently totals approximately 6 250 000 and is compromised of a variety of ethnic groups, although mestizo (mixed Amerindian and European) are by far the most numerous. The diversity of people in Honduras has been further increased by European influences, especially in the Bay Islands which have a particularly colourful history. Columbus discovered the Bay Islands in 1502 and the islands were used by the Spanish to supply their fleets but the Dutch, English and French pirated the islands between 1536 and 1700. The Bay Islands were originally populated by a tribe of Amerindians but these were removed in the mid-seventeenth century so that the islands could not be used by British pirates (Fielding, 2000b), the descendants of whom still live on the islands. Subsequently the islands were populated by Black Carib slaves (now represented by the Garifuna) and then black freedmen and white farmers from the Cayman Islands. Sovereignty was returned by the British to Honduras in 1859 after holding them as a crown colony but Bay Islanders still have a better standard of living than their countrymen on the mainland (Fielding, 2000b).

During the second half of the twentieth century, Honduras has experienced a population explosion and significant immigration and the population doubles approximately every 25 years. Most of the population is based in the interior highlands (Merrill, 1995) but despite the relatively low population density there is overpopulation in certain areas. Traditionally, the population has been approximately 50% rural but internal migration, particularly from the southwest, is increasing urban populations in the coastal lowlands (Merrill, 1995). Honduras is now unusual in Central America by having two large urban centres (Tegucigalpa and San Pedro Sula). Internal migration was started in the early part of the century by employment opportunities in the new banana plantations. Furthermore, the economic hardships caused by Hurricane Mitch in 1998 has increased the number of poor, uneducated mainlanders moving to the Bay Islands, largely in order to seek employment within the tourist industry (Fielding, 2000b). The movement to the Bay Islands encapsulates the significant social concerns throughout Honduras where wealth distribution is uneven and frustrated expectations for a better standard of living may lead to civil unrest (Merrill, 1995). Currently, most of the population consists of subsistence farmers and agricultural labourers, although there is an emerging middle class.

Even though there has traditionally been a dependence on farming, the marine resources of Honduras have a long history of exploitation and, for example, mollusc shells of several species have been found in many Mayan ruins (MacKenzie and Stehlik, 1996). Most indigenous groups hunt and fish extensively and, for example, in the Mosquitia area the Garifuna, Pech, Ladinos and Miskitos all utilise the coastal zone for food, often with traditional checks on overexploitation (Richards, 1996). However, increasing coastal populations require more marine protein, drinking water and infrastructure for sewage treatment and, combined with coastal development for revenue from tourism, threaten the integrity of the systems on which they depend (Fig. 3). Such demands seem likely to keep increasing and sustainable management of the coastal zone is urgently required. Honduras currently faces a suite of threats to its marine resources but Cortés (1997) lists the main human impacts to coral reefs as being over-fishing (including habitat damage), sedimentation, development of the tourist industry, agrochemicals, sewage, coral extraction and solid wastes. The recent effects of the 1995 and 1998 coral bleaching events and Hurricane Mitch have exacerbated all these factors.

Assessment of the changes to the marine environment in Honduras is limited by the lack of comparative data and information from studies more than 15 years ago are sparse even by the standards of Caribbean marine science. There is no national monitoring programme and the only data available are from individual research efforts, although a Caribbean Coastal Marine Productivity (CARICOMP) site is being established in the Cayos Cochinos (UNESCO, 1998) and this protocol has also been used as part of the assessment work by the Ministry of Tourism's 'Bay Islands Environmental Management Project'. Additional monitoring data of

Fig. 3 The development of Utila Town to support an increasing coastal population demonstrates the pressures being placed on the marine resources of the Bay Islands.

both benthic communities and fisheries are urgently needed to assist coastal zone management planning and raise awareness of decreasing ecosystem health by local stakeholders. Such programmes may be facilitated by the growing number of national, international and NGO initiatives in Honduras. However, new and existing programmes can only document very recent changes to the health of marine resources and, as Jackson (1997) highlights, baseline data for a truly natural Caribbean reef are not available.

Rural Factors

Agriculture

Honduras has three distinct topographical regions; an extensive interior highland area (80% of the country's area) and two narrow coastal lowlands (Merrill, 1995). Historically, Kammerbauer and Ardon (1999) describe two periods of land use development in Honduras. The first (1955–1975) was agricultural expansion via occupation of steep peripheral areas, driven by an increasing population, migratory movement and a lack of regulation. The second phase, from 1975 to 1995, was a period of agricultural intensification and diversification caused by a suite of factors including technology transfer, improved access to local markets and subsidised agricultural input prices. This second phase of land use decreased the complexity of the landscape and increased erosion and landslide rates. As in many other countries, such erosion threatens the health of marine resources by increasing sediment loads but such links are poorly understood in Honduras. Since Honduras is a water-rich country with numerous rivers draining the highlands, this threat is significant. For example, the large river Ulúa drains into the Caribbean west of the Bay Islands after flowing 400 km through the economically important Valle de Sula (Merrill, 1995).

Although Honduras has a land area of 11.2 million hectares, the extensive highlands mean that only 15% is well suited for agriculture (Merrill, 1995). Hillsides are generally used by small-scale farmers for basic grains and coffee via shifting cultivation which is a non-sustainable agricultural management practice because of slow soil rehabilitation (Paniagua *et al*., 1999). Despite these limitations, Honduras relies heavily on agriculture and in 1992 it was the largest sector of the economy (28% of the GDP; Merrill, 1995). By the early 1990s, 60% of Honduras' cultivable land was owned by the government and two banana companies but much of it is unused, or used for pastures, because only 14% is irrigated. Most of the land under cultivation is planted with bananas, coffee and specialised export crops such as melons. In 1992, banana sales were US$287 million and coffee US$148 million (approximately 50% of exports) (Merrill, 1995). In the late 1980s approximately 7 50 000 hectares had been eroded following poor practices used by cattle ranchers and slash-and-burn squatters. The approach of expanding the hectarage of cultivated land, as opposed to using improved techniques, has led to continual deforestation and hence erosion.

Since chemical pesticides have been shown to increase crop yields, their use has accelerated and imports of insecticides, fungicides and herbicides are all increasing annually with only limited training of farmers and enforcement of regulations (reviewed by Castillo *et al*., 1997). However, information is lacking on the residue of these chemicals within the environment and their effect on marine resources, along with public health. Some research on pesticide residues has been conducted in a Gulf of Fonseca watershed by Kammerbauer and Moncada (1998), who also looked at variations between farming practices (e.g. traditional and intensive). This study showed that the situation in 1998 did not appear to show great cause for concern and that the food and feed supply was not seriously contaminated, but a monitoring programme was recommended, especially of drinking water in intensively farmed areas. Kammerbauer and Moncada (1998) found evidence of biological accumulation in fish tissue but subsequent effects on the marine food web are not clear. Equivalent data on pesticide residue and effects on the marine resources of the Caribbean coast of Honduras appear to be almost completely lacking and inferences must be drawn from research in the temperate zones of the northern hemisphere and limited work elsewhere in Central America (Castillo *et al*., 1997).

Artisanal fishing

Artisanal fishermen are defined by the Honduran government as those who concentrate solely on fishing, are independent and land less that three metric tons per year (MacKenzie and Stehlik, 1996). Nearly 6000 artisanal fishermen were registered in 1995 (MacKenzie and Stehlik, 1996) and in the Gulf of Honduras alone there are approximately 650 fisherfolk, compared to approximately 200 in Belize (Heyman and Graham, 2000). Much of the fishing activity for molluscs and crustaceans occurs on the continental shelf along the north coast since the fringing reefs of the Bay Islands have been virtually extirpated. However, organized industrial fishing and the increase in artisanal fishermen has dramatically decreased stocks in all shallow water areas (MacKenzie and Stehlik, 1996). Following extensive interviews, Heyman and Graham (2000) provide an excellent case study on the attitudes of artisanal fisherfolk on the northern coast of mainland Honduras towards decreasing catches.

Finfish. Finfish, particularly groupers (Serranidae), snappers (Lutjanidae), grunts (Haemulidae) and jacks (Carangidae), constitute an important fishery throughout the Caribbean and are targeted by artisanal fisherfolk in Honduras. A variety of traditional techniques are used, all of which are generally of limited impact to the benthic communities, but the use of spear-guns by

fishermen and tourists has now been banned in the Bay Islands (Fielding, 2000b). Although quantitative data are sparse, intensive fishing effort has clearly impacted populations and now, for example, fishermen in the Bay Islands favour more remote offshore banks compared to the heavily exploited fringing reefs. Detailed documentation of fishing patterns in the Bay Islands has been provided by the Ministry of Tourism's 'Bay Islands Environmental Management Project' but final published reports are currently unavailable. Significant damage to the integrity of the grouper fishery has also been caused by uncontrolled near-extirpation of spawning aggregations (Fine, 1992). Fisheries may have been further compromised by mass bleaching events (Guzmán and Guevara, 1998) and in addition all three fish packing plants on Guanaja were damaged by Hurricane Mitch and few fishermen are currently solvent (Fielding, 2000b).

Some documentation on the effects of fishing pressure has been conducted in Cayos Cochinos. Although little quantitative data were presented, Ogden and Ogden (1998) and Clifton and Clifton (1998) reported that there were no large predatory or herbivorus fish at sites close to human populations in the Cayos Cochinos. A more detailed assessment of fishing at Cayos Cochinos (where only artisanal fishing with hook-and-line is allowed within a marine reserve) was carried out by Guzmán and Jácome (1998). This study showed that 80% of the fishery was comprised of eight species (mainly Lutjanidae, Serranidae and Haemulidae). CPUE was equivalent to over-fished areas elsewhere and Guzmán and Jácome (1998) concluded that exploitation was jeopardising the integrity of the fisheries.

Lobsters and other crustaceans. The western central Atlantic region is a major producer of lobster and, like most other Central American countries, it is a significant fishery resource on reef formations bordering the islands and mainland (Tewfik *et al*., 1998a). The primary target species are *Panulirus argus* and *P. guttatus* and most are caught by commercial vessels with wooden traps and divers. Hence less than 4% of lobster are caught by artisanal fishermen (Ehrhardt, 2000). However, on the north coast of Honduras, artisanal fishermen land a range of crustaceans including Caribbean spiny lobsters (*Panulirus argus*), white shrimp (*Penaeus schmitt*) and blue crabs (*Callinectes* spp), often using wooden dugout canoes (MacKenzie and Stehlik, 1996). Lobster are caught via free diving and, particularly close to the mainland coast, using traps which are often baited with cowhide (MacKenzie and Stehlik, 1996). Crabs and shrimp are caught via baited traps and cast nets respectively. Although detailed data are lacking, the lobster fishery is generally considered to be over-exploited.

Conch and other molluscs. Conch (mainly *Strombus gigas*) is an important fishery in Honduras and it is generally accepted that over-fishing has reduced populations significantly. Such over-fishing is exacerbated by the use of SCUBA and 'hookah' gear as opposed to more traditional conch hooks and free-diving techniques. However, few data are available on the ecology of conch in Honduras. An exception is the study by Tewfik *et al*. (1998b) which assessed the densities of *S. gigas* around Cayos Cochinos. This study indicated a density of 14.6 conch per hectare, which is similar to many other countries in the region, and a total population of approximately 2 23 000 in the area. Tewfik *et al*. (1998b) conclude that harvesting should be limited to free-diving, the minimum shell length restriction should be increased and important nursery and breeding areas should be closed either permanently or seasonally. Similarly to fisherfolk in the Bay Islands, artisanal fishermen on the northern coast of Honduras catch a range of molluscs, particularly queen conch (*Strombus gigas*) but also coquina clams (*Donax denticulata*) and marsh clams (*Polymesoda placans*) using wooden dugout canoes (MacKenzie and Stehlik, 1996).

Coastal Erosion and Landfill

Numerous development projects are known to have affected the coastal resources of Honduras but the lack of monitoring data limits their quantification. For example, the building of an international airport on Roatán, which included infilling, is known to have caused chronic turbidity and reduced both coral density via sediment smothering and fish populations (UNEP/IUCN, 1988). Indeed, anecdotal reports by local researchers indicate that sedimentation caused by erosion from road building and hotel construction is one of the most important impacts to reefs of the Bay Islands (Fielding, 2000a). More recent construction of an international airport on Utila has also had the added impact of infilling a significant area of critical swamp habitat.

Many of these coastal developments are difficult to regulate because of the selling of small plots of land, particularly in the Bay Islands and Cayos Cochinos, which leads to development without environmental impact reports. Private ownership also leads to problems with implementing over-arching coastal zone management initiatives. Furthermore, when there are local community concerns, including environmental considerations, their inclusion in coastal development projects has been limited because the municipal governments received instructions from national government in Tegucigalpa. Rijsberman (2000) gives examples of such actions, including extraction of construction material for airport maintenance, without permission, from private property and construction of a wharf on Roatán without permission of the local authority. The Bay Islands Environmental Management Project, since it is managed via the Ministry of Tourism, has recently provided a conduit for public consultation on such projects but awareness of this work is limited.

Effects from Urban and Industrial Activities

Forestry and watershed management

Honduras lost 1.8 million hectares of forest from 1964 to 1988 and forest has continued to decline, partly from agriculture but also from the focus on logging rather than management (Merrill, 1995). This policy, and its subsequent effects on marine resources, was encouraged by the Honduran Corporation for Forestry Development (COHDEFOR) who granted numerous licenses to private lumber companies with few conservation considerations. Recent decentralization of COHDEFOR has improved the situation, with responsibility transferred to local municipalities and legislation has encouraged reforestation. Additional changes to major watersheds of the country will also be caused by hydropower, which is an increasingly important solution to meeting the country's power demands, but the impacts of dam schemes are poorly studied (Vargas and Vaux, 1988).

Shrimp farming

The shrimp industry in Honduras, particularly in the south of the country, developed significantly in the 1980s and quickly became a major Latin American exporter (the industry was worth US$72 million from 11 500 ha in 1995; Teichert-Coddington *et al*., 2000). Natural shrimp stocks, raised by both large corporations and independent businesses, are supplemented by imported and laboratory larvae. However, there has been significant debate over the impacts to the environment of corporate methods, particularly through the destruction of breeding areas in mangrove swamps. This has led to corporate shrimp farmers moving inland and local shrimpers are now suffering from decreased natural supplies (Merrill, 1995). In addition, the chemical budgets of the shrimp ponds are poorly known but nitrogen and phosphorous are both added as feed and promote a net discharge, via effluent, to estuaries (Teichert-Coddington *et al*., 2000). Although this study concluded that shrimp farms should minimize the use of fertilizers, the effects of shrimp ponds, which often act synergistically with other factors that decrease water quality, on the marine resources of Honduras are not clearly understood.

Industrial fishing

Industrial fishermen in Honduras concentrate on pink and white shrimp (*Penaeus notialis* and *P. schmitti*), lobster and conch (MacKenzie and Stehlik, 1996). The shrimp fishery is large, particularly along the mainland coast, where shrimp and a finfish bycatch are caught using trawl nets at night (MacKenzie and Stehlik, 1996). There is also a long history of industrial fishing for finfish. Although total recorded catches for Honduras are presented in Fig. 4, there is very limited enforcement of fishery regulations and data on catches are partial and segmented so that regulations are difficult to formulate (Rijsberman, 2000). Furthermore, there is some illegal fishing by Honduran fisherfolk in Belize because the latter has a lower population density and resources are less exploited (Heyman and Kjerfve, 2001).

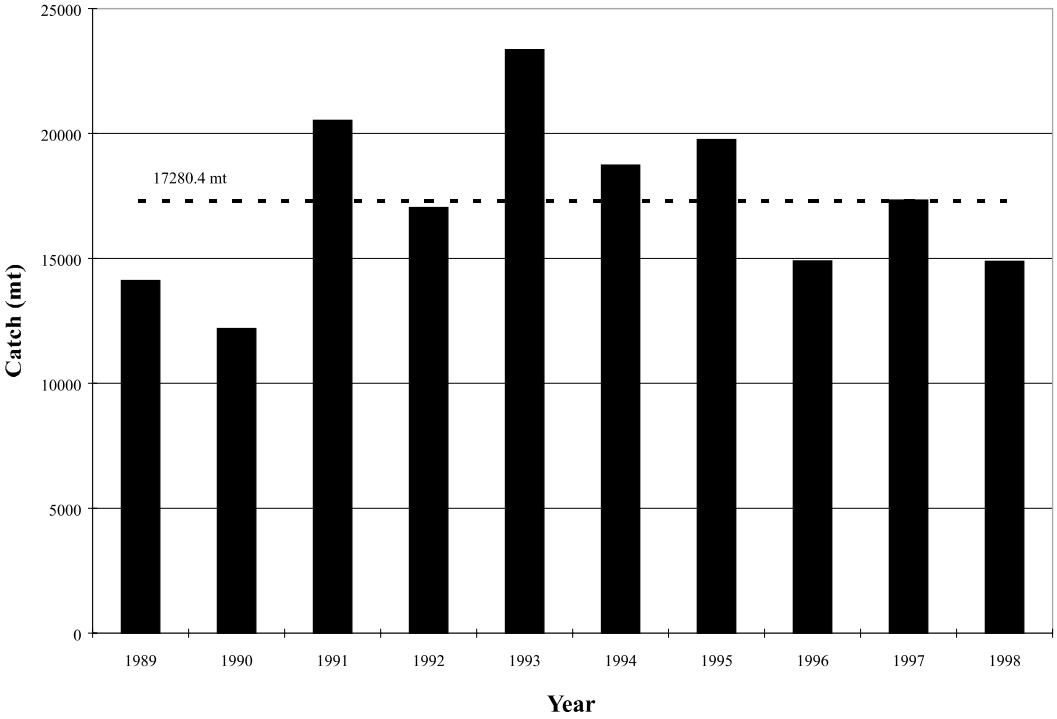

Fig. 4 Nominal catches from all fisheries in Honduras. Dashed line represents mean catch. Data source: FAO 1998. Fishery statistics capture production. FAO Yearbook Volume 86/1.

Commercial fishing for conch and lobster, largely for export to the USA, has been conducted industrially in Honduras since at least 1970. Indeed, the majority of lobster catches in Honduras are by commercial vessels and it maintains the largest fleet of all Central American countries with 190 vessels by the early 1990s (Ehrhardt, 2000). Originally boats carried between five and ten free divers but increasing demand and decreasing catches have led to the use of SCUBA by 12–24 divers per boat, with each boat making approximately 12 trips of 12 days per year (MacKenzie and Stehlik, 1996). Although most harvesting occurs at depths equivalent to those attained by sport diving, repeated dives for extended periods and limited training has led to a large number of decompression illness incidents amongst the fishermen but recent formal organisations of divers are attempting to improve practices. In addition to the boats of divers, Honduras has a large fleet of boats deploying lobster traps on an industrial scale.

Almost all of the divers are employed from villages in the Mosquitia region and the economy of this region is heavily dependent on income from lobster diving. Following fears of overexploitation the government placed a ban on lobster diving for a three and six month period in 1993 and 1994, respectively. These bans forced Miskito families to find alternative sources of income, resulting in the clearance of large areas of riverine forest for rice cultivation. This significantly increased pressure on upriver natural resources and had implications for the management of the Rio Plátano Biosphere Reserve (Richards, 1996).

While it is accepted that lobster and conch populations are over-fished throughout Honduras, few quantitative data are available. An exception for lobster is the study by Tewfik *et al.* (1998a) in Cayos Cochinos. This research reported densities of 19.9 lobster per hectare (*Panulirus argus*) and 9.4 per hectare (*P. guttatus*) but found evidence of over-fishing from the ratio of *P. argus* to *P. guttatus* and their low mean size. Based on these data, Tewfik *et al.* (1998a) make a series of recommendations including a ban on catching berried or spermatophore carrying females, a distinction between *P. argus* and *P. guttatus* for minimum size regulations and the elimination of hooks to allow lobsters to be released if they are undersized or berried.

Urban and industrial pollution

Increasing coastal populations, development for the tourist industry and diversification of the economy is placing escalating threats on the marine resources of Honduras via pollution. Like most of the Caribbean, Honduras has limited industrialization and pollution of the coastal zone has not reached levels seen in other regions. However, localised coastal areas of relatively heavy industry, such as around French Harbour on the south coast of Roatán, are now almost certainly having a detrimental effect on marine resources but published water quality studies are scarce. Similarly, the limited human waste treatment facilities were not regarded as a problem in the 1980s but sewage was considered a threat as the population and tourist industry increased (UNEP/IUCN, 1988). Increased nutrient levels, especially close to large towns and cities, is now regarded as a significant reef stressor throughout the Mesoamenican Barrier Reef System.

Nutrification via sewage input acts concomitantly with additional factors that have led to decreases in coral cover and increases in macro-algae on Caribbean reefs over the last two decades. The most important of these is the mortality of key herbivorous species via both the waterborne pathogen that killed *Diadema* urchins in the 1980s and also fishing. Such an ecological shift, however, is the result of a complex set of synergistic factors and spatial variations can be caused by the physico-chemical environment via, for example, increased flushing in certain localities and reef zones.

The need for better public access to water supplies and sewerage has been a major element of development programmes in Honduras and throughout Central America. Oakley *et al.* (2000) highlight 12 waste stabilization pond systems that have been built in the last 15 years because of their efficacy in pathogen removal (equivalent to tropical ponds systems elsewhere in the world) and their low operation and maintenance costs. These ponds have been designed for municipalities of up to 80 000 persons but larger facilities are being constructed for large cities such as San Pedro Sula, although such plans and existing facilities were affected by damage from Hurricane Mitch. However, in order for these ponds to maintain their sustainability and acceptance, Honduras, along with the rest of Central America, needs to develop better design guidelines, realistic levels of effluent release, monitoring programmes, long-term financing for operation and maintenance and training programmes for staff (Oakley *et al.*, 2000). For example, funding sources for new and improved sewage and sanitation facilities on the Bay Islands are not clear and there is resistance to levying charges and user fees to local communities.

Mining

In the late 1800s, mining was a vital part of the Honduran economy but its importance has subsequently declined. However, Honduras still mines lead and zinc with associated copper, gold, silver and cadmium, along with cement, gypsum, limestone, marble and salt with approximately 40% exported (Doan, 1997). The El Mochito Mine near Lake Yojoa is the largest lead-zinc mine in Central America and is known to have impacted the lake via runoff but the impacts of the mining industry on the coastal zone via riverine transport are unclear.

Tourism

Foreign tourists are attracted to Honduras by, for example, the opportunities for SCUBA diving in the

Bay Islands and impressive Mayan ruins. The importance of the income from this industry is well recognised and the Bay Islands were designated as an important tourism zone by the Honduran congress as early as 1982 and laws to promote this industry were passed in the 1990s (Rijsberman, 2000). Between 1987 and 1991, tourist arrivals in Honduras grew at average annual rates of approximately 15%, which exceeded global trends (Fielding, 2000a). By 1993, the annual number of international tourists to the Bay Islands (approximately 30 000, with a high season from September to December) exceeded the local population (Fielding, 2000b). However, current tourist numbers are still short of the country's full potential because of expensive airline prices, limited promotion and relatively unfriendly laws for foreign investment (Fielding, 2000a). Even with these limitations, tourism in the Bay Islands, particularly from SCUBA divers, generates an estimated US$11 million annually in gross operating revenues (Forest, 1998). All three Bay Islands now have SCUBA diving establishments, restaurants, hotels and resorts but the main focuses are the west end of Roatán and Utila Town. This has led to some conflict between the tourism industry and local communities because, for example, they have been displaced by large resorts and there is limited distribution and explanation of economic benefits (Rijsberman, 2000).

The growth of tourism to the Bay Islands places additional stresses on marine resources, particularly coral reefs, beyond damage caused by coastal development, increased sewage and the need for higher fish catches. For example, tourism development has not taken into account the limited beach area and potable water is scarce, with wells susceptible to salt intrusion (Rijsberman, 2000). There are no formal laws regarding proper reef use and damage has been caused by anchoring dive boats and impacts from divers. However, mechanical damage to the reefs of Utila by boat anchors has been reduced significantly since the introduction of mooring buoys, particularly the impressive programme established by the Bay Islands Conservation Association in Utila (Fig. 5). There is now a need for data on the numbers of divers visiting each dive site to assist management of popular reefs and provide carrying capacities.

Tourism is also expanding elsewhere in Honduras and there are some efforts to ensure it is sustainable. For example, there is a World Bank project planned to increase existing tourism to the north coast of the mainland since this area has excellent natural resources and the additional income would greatly benefit the many impoverished local communities. Background documentation, including interviews with local stakeholders have already been completed by the Institute of Tourism of Honduras and the World Bank Resident Mission in Honduras.

Finally, cruise shipping is currently an expanding sector of the Honduran tourism market in order to profit from the growing popularity of the Caribbean as a destination. Hence Honduras has promoted cruising to the Bay Islands and five ships visited Roatán during a six month period in 2000 and the first cruise ship arrived in Utila during this time (Fielding, 2000a). However, this represents a significant environmental threat and case studies from elsewhere in the region show negative effects from dredging, coastal development, mechanical damage to marine resources and sewage, along with socio-economic issues of labour migration and alienation of local communities (Fielding, 2000a). Cruise ship capacity is currently limited by the available docking but economic pressures may lead to additional facilities.

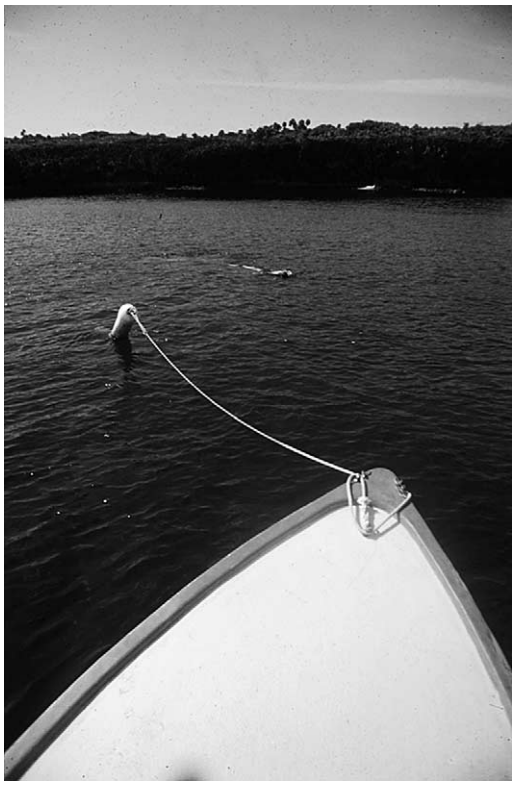

Fig. 5 Anchor damage to the reefs of Utila has been dramatically reduced following the establishment of over 50 mooring buoys by the Bay Islands Conservation Association.

Shipping and offshore effects

Heyman and Kjerfve (2001) state that industrial shipping is one of the largest and potentially most environmentally damaging industries in the Gulf of Honduras. Puerto Cortés, on the western coast of mainland Honduras, is one of the largest ports in the region and a spill from one of the many petroleum or chemical vessels could be catastrophic.

Protective Measures

The need for coastal zone management and sustainable development in Honduras is well documented and recognised both nationally and internationally. For example, Sullivan Sealey and Bustamante (1999) list the

Bay Islands as a high priority for conservation action within their review of Latin America and the Caribbean. However, as Guzmán (1998) states 'Honduras, in particular, serves to illustrate the paradigm of hasty development associated with casual protection'.

Marine protection in Honduras dates back to the 'Ley de Pescar' decree of May 1959 which declared coral reefs as 'protected areas'. More recently, a particularly significant step for marine conservation in Central America was the signing of the Tulum Declaration in 1997, when Mexico, Belize, Guatemala and Mexico agreed to work towards regional conservation of the Mesoamerican Barrier Reef System. Instigating such initiatives inevitably relies on the support of local stakeholders and despite the continued problems, Honduran ecologists are encouraged by the increasing environmental consciousness among many sectors of the community (Merrill, 1995). For example, following interviews with fishermen, Heyman and Graham (2000) provide a series of conclusions and recommendations relating to the artisanal fisheries of Honduras. They highlight the awareness of fishing communities of the causes of declining catches and list a series of suggestions from the fisherfolk, including better enforcement of existing regulations, gear restrictions and use of marine protected areas. Furthermore, although environmental education is currently limited in Honduras, there is some evidence that local communities appreciate the benefit of marine protected areas. A study by Barahona and Guzmán (1998) showed that 77% of survey respondents believed it was important to protect the marine and terrestrial habitats of Cayos Cochinos and 66% thought that commercially important species were more abundant since fisheries restrictions were enforced.

Existing coastal zone management initiatives

The national government recognises the ecological and economic needs to conserve marine resources but is severely limited by capacity, funding and expertise. However, in order to co-ordinate and expand local and national initiatives, the Ministry of Tourism has established the 'Bay Islands Environmental Management Project' (Programa Manejo Ambiental de las Islas de la Bahía; PMAIB). This multi-faceted project is funded by a US$19.1 million loan from the Inter-American Development Bank, along with further funding from national government to a total of US$27 million, and has four sub-programmes covering natural resources, sanitation, real estate census and institutional strengthening. For example, one aim of the natural resources subprogramme is to fully establish the marine parks either designated or proposed for the Bay Islands but which are currently 'paper parks'. PMAIB is due to finish at the end of 2001 and at the time of writing this paper is disseminating information from the sub-programmes and entering an implementation phase. However, time limitations will affect the efficacy of implementing many of the coastal management initiatives developed by the project and further funding is required to continue the work.

Conservation in the Bay Islands will be further strengthened by the World Bank/Global Environment Facility project 'Conservation and sustainable use of the Mesoamerican Barrier Reef System'. This project's objective is to assist the countries of Belize, Guatemala, Honduras and Mexico manage the Mesoamerican Barrier Reef System as a shared, regional ecosystem, safeguard its biodiversity values and functional integrity and create a framework for its sustainable use (Kramer *et al.*, 2000). Final approval for the funding of this project was given in early 2001 to facilitate implementation of the project components.

In addition to international programmes, there is an NGO movement in Honduras but it is relatively nascent. However, there are, for example, three groups present in the Bay Islands (the Association for the Development of the Bay Islands, the Bay Islands Conservation Association and the Foundation for the Integrated Development of the Bay Islands) and their activities are reviewed by Forest (1998). Further assistance for coastal zone conservation initiatives in Honduras is increasingly being provided by international NGOs and for example, the Wildlife Conservation Society has assisted management planning in the Bay Island's existing reserves and the Municipalities of Utila and Roatán, along with PMAIB, have been assisted with data collection, technical advice, training and environmental education programmes by Coral Cay Conservation (Harborne *et al.*, in press).

Current regulations

Environmental legislation in Honduras is relatively extensive and laws and regulations relating to marine resources include the Biodiversity Convention, Central American Component for the Protection of the Environment Convention and Climate Change Convention (Kramer *et al.*, 2000). Forest (1998) reviews a series of coastal regulations relating to the Bay Islands which have attempted to encourage sustainable development. The Honduran government has also set several regulations on its fisheries and there is a license requirement for both artisanal and industrial fisherfolk, a minimum tail size for lobster and closed seasons for lobster, shrimp and conch (MacKenzie and Stehlik, 1996). Further restrictions are proposed by Heyman and Graham (2000) following a synthesis of fishermens' recommendations from all three countries bordering the Gulf of Honduras (Honduras plus Belize and Guatemala). The authors suggest, for example, closure of certain fisheries (e.g. manatee), protection of spawning sites, harmonisation of fishing laws, improved monitoring of all fisheries and greater involvement of fishermen in fisheries management and planning.

Despite the range of regulations, enforcement capacity is extremely limited and many stakeholders are able to ignore germane legislation with impunity (Fielding,

2000b). For example, since 1991 more emphasis has been placed on environmental assessments prior to obtaining a permit for coastal development but the process is still being implemented inconsistently and without coordination (Forest, 1998). Subsequently, public perception of the implementing agencies is poor and there is selective pursuit of violators, largely arising from limited funds. Forest (1998) provides a series of recommendations to both international assistance organisations and local authorities to improve the permitting process and environmental assessment for development of the Bay Islands. Furthermore, even high levels of compliance can mask significant threats to marine resources. Analysis by Forest (1998) of the effect of 'Acuerdo Dos', a key piece of legislation establishing a series of land use regulations and conservation activities, showed that compliance had reached 74% in 1994. However, this did not necessarily lead to improved environmental outcomes because, for example, projects were changed after the permit had been issued or developers denied permits simply proceeded with construction.

Marine protected areas

Despite apparent threats to the marine resources, the establishment of a marine park in Roatán was not considered essential in the 1980s (UNEP/IUCN, 1988). However, the recent recognition of the importance of reserves for conservation means that a total of 15% of Honduras (1.7 million hectares) is now protected via 106 'natural areas' including national parks, wildlife refuges, biological reserves, national forests, anthropological reserves, protected watersheds, natural monuments, cultural monuments and multiple-use areas (Hodges, 1997). Within this system, there are 25 marine protected areas covering 4300 km^2 (Kramer *et al.*, 2000) but levels of enforcement of reserve regulations are unknown. Examples of marine protected areas include relatively innovative solutions to environmental issues, such as the Punta Ratón Wildlife Reserve in the Gulf of Fonseca which is a 4 km beach and is protected to conserve turtle nesting areas (Hodges, 1997). A further example is the Rio Plátano Biosphere Reserve which is Honduras' largest protected area and encompasses some marine resources, including feeding grounds for the manatee (*Trichechus manatus*) (Richards, 1996).

Enforcement of reserve regulations is difficult with limited funds, capacity and expertise in many of the reserves (see Box 2 for a case study). However, it is known to be more effective in the Cayos Cochinos Biological Reserve which was established in 1993 and banned all commercial harvests (non-artisanal) of marine life within a 460 km^2 area (Clifton and Clifton, 1998). In contrast to many 'paper parks' in Central America, this reserve is enforced via patrols by the Honduran Navy. However, the reserve does allow artisanal fishing and there is some evidence that its impact has been underestimated and that regulations need to be altered to avoid the collapse of populations of certain species (Guzmán and Jácome, 1998).

The apotheosis of the policy to establish protected areas was arguably in 1997 when legislation was passed declaring most of the Bay Islands as a marine park with varying levels of restrictions on resource use. Among other objectives, this park aimed to strengthen the municipal reserves of Turtle Harbour in Utila and Sandy Bay in Roatán which were designated in 1982. However, although the whole perimeter of Roatán and Guanaja and parts of Utila were included, enforcement is limited and the forestry department (Coorporación Hondureasimna de Desarrollo Forestal; COHDEFOR), which is

Box 2. The Sandy Bay – West End Marine Reserve: a case study of the problems associated with establishing marine protected areas in Honduras

A series of marine reserves have been planned in the Bay Islands, but perhaps the most successful has been the Sandy Bay – West End Marine Reserve on Roatán. The reserve, the current extent of which was designated in 1993 following environmental concern in the local community, has been the subject of two management plans in 1997 and 1999 and is managed by the Bay Islands Conservation Association (BICA). However, although the reserve has been relatively successful compared to many other examples in the region, it has encountered many problems, particularly those associated with the socio-economic concerns of Bay Islanders (Forest, 2000). For example, there is suspicion of the motives of the hoteliers who finance the park and that regulations are either enforced ineffectually or inconsistently between poor fisherfolk and wealthy land owners (Forest, 2000). Much of this suspicion is caused by the reserve's reliance on private funding rather than governmental support and perceived inequalities of membership fees for local businesses (Luttinger, 1997) and lack of integration of various community groups and stakeholders (Forest, 1998).

Forest (2000) lists a series of solutions for improving the reputation of the reserve, including a transparent decision-making process, equitable representation of all resource users on the Board of Directors and provision for independent management decisions. In addition to changes to decision-making structure, more data are required to improve management of the reserve. Hence the authors are planning to work with the Wildlife Conservation Society to resurvey monitoring transects from 1997 to assess changes caused by mass bleaching events, Hurricane Mitch, coastal development and diver damage.

responsible for protected areas, has virtually no capacity on the islands. Furthermore, many stakeholders are unaware of the reserve's status or its consequences. Unilateral decisions by central government with little local consultation has also affected support for the PMAIB project which included amongst its aims a desire to strengthen the effectiveness of existing legislation (Rijsberman, 2000). Rijsberman (2000) provides an extensive discussion of possible techniques for resolving conflicts relating to integrated coastal zone management via stakeholder participation.

The future of marine resource management

Like almost all countries with a significant coastline, Honduras is struggling with the paradox of exploiting marine resources with the simultaneous conservation of their ecological and economic values. Hence there are significant and complex socio-economic issues to resolve including loss of fishing grounds with increasing marine protected areas, expanding coastal populations and exclusion of local communities from profits generated by foreign developers. However, while Honduras lags behind nearby Belize, there are encouraging signs that integrated coastal zone management is gaining momentum. A key catalyst has been the willingness of government to establish PMAIB in the Bay Islands and future work will be significantly influenced by lessons learnt during this project and imminent World Bank initiatives. Such high-profile interventions, however, must be in conjunction with increased environmental awareness of stakeholders, school programmes of conservation education and strengthening of national capacity for marine protected area management and enforcement of existing legislation. The marine resources of the Caribbean are being detrimentally affected by a complex suite of interrelated local, regional and global factors and Honduras represents a microcosm of these threats. Whether it can resolve the current problems will directly influence the long-term development and prosperity of the country.

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