8. Coastal fisheries of the Dominican Republic

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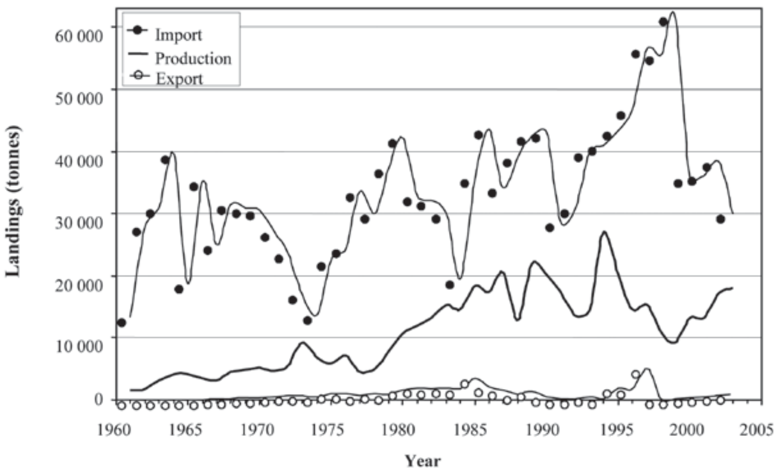
1. INTRODUCTION

In the Dominican Republic, fishing has traditionally been considered a marginal activity that complements other sources of income. This, and the low impact that fishing has on the gross domestic product (GDP) (approximately 0.5%), are likely causes for the limited economical and institutional support that the fishing sector has received compared with other sectors, such as agriculture or hydro resources. Despite this, Dominican Republic fishing activity has a long history, and has developed rapidly during the last two decades. The number of fishing boats, fishers and catches has grown since the beginning of the 1980s (FAO, 2001). The fleet, which is comprised of more than 3 361 boats (98% of them artisanal), 8 399 fishers and an average annual production of 11 000 tonnes, generates significant pressure on the traditional coastal and marine fishing resources (SERCM, 2004). Nevertheless, the national demand is still not fulfilled, leaving little opportunity for export (which is estimated at 900 tonnes), which results in an annual import of seafood products averaging 34 000 tonnes (Figure 1).

FIGURE 1
Fishing production, and import and export of seafood products, of the Dominican Republic from 1960 to 2005



Source: Subministry of Marine and Coastal Resources.

Fishing activities in the Dominican Republic include more than 300 species of fishes, crustaceans, molluscs and echinoderms. These species are captured along 1 575 km of coastline, 8 000 km² of platform (between 0 and 200 m of depth), and 4 500 km² of oceanic banks and the adjacent oceanic environment, though the exclusive economic zone (EEZ) encompasses 238 000 km² (Figure 2).

Fishing is carried out with more than 20 different fishing gear types and methods (Colom *et al.*, 1994), and catches are landed at more than 200 sites distributed among the 16 coastal provinces (SERCM, 2004; Table 1). Specialists are amazed by the growing dynamic nature of the fishing sector in the Dominican Republic, which has been developed solely through artisanal fishers' technologies and knowledge, with informal finances and resources and little external intervention (FAO, 2001).

FIGURE 2

The Hispaniola map shows the jurisdiction of the Dominican Republic, the 16 coastal provinces, the 200 m iso-bathymetric line, the oceanic banks and the EEZ

Note: The letters indicate: MO (Montecristi), PP (Puerto Plata), E (Espaillat), MT (María Trinidad Sánchez), S (Samaná), ES (El Seibo), HM (Hato Mayor), LA (La Altagracia), LR (La Romana), SP (San Pedro de Macorís), SD (Santo Domingo), SC (San Cristóbal), PV (Peravia), AZ (Azua), BH (Barahona), and PD (Pedernales).

2. DESCRIPTION OF FISHERIES AND FISHING ACTIVITIES

Although it is not yet acknowledged, it is difficult to provide an exact definition of the fishing types in the Dominican Republic due to two key aspects of the fishing activity. First, the partially controlled fishery and open access to the fishing grounds allows for any available resource to be caught at any moment and in any accessible area of the coast, insular platform or surrounding oceanic region. Second, the Dominican Republic artisanal fishery does not target exclusively one resource. Whatever is caught is considered potentially useful for consumption or commercialization.

For the purpose of this report we based the definition of fishing types on Colom *et al*. (1994) and CFRM (2004), and have included some types which have not been previously reported. We took a general approach, based on: (a) type of resources and their fishing productivity; (b) fishing areas; (c) fishing gear exclusivity; (d) depth intervals; and (e) relevance of the resource to the national fishing regulations (Table 1).

2.1 Description of fisheries

Spiny lobster fishery

The spiny lobster fishery is the most valued in the Dominican Republic (SERCM, 2004). The key species is the Caribbean spiny lobster (*Panulirus argus*). However, this fishery includes other species such as: the spotted spiny lobster (*Panulirus guttatus*; langosta pinta), the green lobster (*Panulirus laevicauda*; langosta verde), the copper lobster (*Palinurellus gundlachi*; langostín), the slipper lobster (*Parribacus antarticus*), and the Spanish lobster (*Scyllarides aequinoctialis*) (Silva, 1994).

Colom *et al*. (1994) indicates that spiny lobster is caught with traps in the Jaragua National Park, in the Pedernales Province. Historically, the spiny lobster coastal fishery has been associated with the Sud-Occidental platform (marine protected area of the Jaragua National Park), where lobsters are especially abundant. The frequent reports of puerulus stage larvae on the trap ropes and in the shallow larvae grounds in coastal protected areas could indicate important local post-larvae recruitment. In fact, we have observed juvenile lobsters in all the stages (algal, transitional and post-algal) in the area. A shallow marine grass and algae platform of 90 km^2 offers ideal conditions for a nursery area, while 25 km^2 of rocky bottom and coral reefs provide the appropriate environment for migrating juveniles and resident adults which require sites for reproduction (Herrera and Colom, 1995).

Despite Pedernales' importance as a lobster fishing area, it is questionable to place such a high value on an extractive practice where sublegal juveniles compose 90% of the catches from this area (Herrera and Betancourt, 2003b). Pedernales is not the only fishing site; spiny lobster is subject to strong fishing pressure along the whole Dominican Republic platform up to a depth of 30 m. This is documented with ecological and fishing data in Barahona (Schirm, 1995, 1995a), Azua (Melo and Herrera, 2002), La Altagracia (Chiappone, 2001) and Samaná (Herrera and Betancourt, 2003a). Lobster is also captured on the oceanic banks, where the fishery is associated with the reef environment; however, there are no studies on this matter.

TABLE 1

Main fishing types in the Dominican Republic. Fishing gears: At (Atarraya; casting net); Ba (Raft); Bu (Diving); Chah (Chinchorro de ahorque; gillnet); Char (Chinchorro de arrastre; trawl); Cd (Line); LC (Squid line); Ml (Manual); Nb (Nasa del bajo; shallow trap); Nc (Nasa chillera; depth trap); PA (Longline); Ja Jamos; bully nets); Main fishing zones Provinces of the Coasts (PC): AZ (Azua); BH (Barahona); BN (Banco de la Navidad – Christmas Bank); BP (Banco de la Plata – Silver Bank); LA (La Altagracia); MC (Montecristi); PE (Pedernales); PP (Puerto Plata); SA (Samaná); TP (Coastal provinces platform).

Name	Key species (local name/scientific/common)	Associated habitat	Depth (m)	Distance (nm)	Gear	Type of fishery	Main fishing zones	Key references
Lobster fishery	Caribbean spiny lobster *Panulirus argus* (langosta)	Coastal/coral reef/ocean banks	0–30	≤5.3	Nb, Bu	Small-scale artisanal/ Subsistence	PE, LA, MC, AZ, TP	Herrera and Betancourt, 2003b, 2003c
Shrimp fishery	White shrimp *Litopenaeus schmitti* (camarón blanco), pink shrimp *F. duorarum* (camarón rosado), Atlantic seabob *Xiphopenaeus kroyeri* (camarón siete barbas)	Demersal/bay	-	4-15	Char, At	Small-scale artisanal/ Subsistence	SA, MC	Núñez and García, 1983; Sang *et al.*, 1997
Queen conch fishery	Queen conch *Strombus gigas* (lambí)	Coastal/ocean banks	0–30	≤5.3	Bu	Small-scale artisanal/ Subsistence	PE, LA, MC, TP	Tejeda, 1995
Reef fishery	Many fish species (Lutjanidae, Haemulidae, Acanthuridae, Balistidae, Holocentridae, Serranidae, Pomacanthidae, Pomacentridae, Scaridae, Sparidae, Labridae), crustacean (Majidae y Xanthidae) and molluscs (Cassidae, Trochidae, Ranellidae, Fasciolaridae, Strombidae and Octopodidae)	Coastal/ocean banks	0–30	≤5.3	Nb, Bu Chah, Cd	Smal- scale artisanal	PE, MC, LA, SA, PP, AZ, TP	Schirm, 1995, 1995a; Sang *et al.*, 1997; Chiappone, 2001
Deep-sea fishery in the platform border	Silk snapper *Lutjanus vivanus* (chillo), blackfin snapper *L. bucanella* (chillo oreja negra), queen snapper *Etelis oculatus* (boral), cardinal snapper *Pristipomoides macrophtamus*, (roamo), vermilion snapper *Rhomboplites aurorubens* (besugo), misty yellowedge grouper *Epinephelus mystacinus*, misty grouper *E. flavolimbatus* (meros)	Coastal	100–500	≥5.3	Pa, Nc, Cd	Smal- scale artisanal	BH, SA, PE, TP	Sang *et al.*, 1997; Arima, 1997, 1998-1998b, 1999-1999b.
Ocean banks fishery*	Silk snapper *Lutjanus vivanus* (chillo), blackfin snapper *L. bucanella* (chillo oreja negra), queen snapper *Etelis oculatus* (boral), cardinal snapper *Pristipomoides macrophtalmus* (roamo), misty yellowedge grouper *Epinephelus mystacinus* (mero)	Ocean banks	300–600	90	Pa	Semi-industrial	BN, BP	Kawaguchi, 1974; Arima, 1997, 1998-1998b, 1999-1999b.

TABLE 1 (CONTINUED)

Name	Key species (local name/scientific/common)	Associated habitat	Depth (m)	Distance (nm)	Gear	Type of fishery	Main fishing zones	Key references
Pelagic fishery or FAD fishery**	Tunas, bonitos and albacores: *Thunnus albacares* (yellowfin tuna), *Euthynnus alleteratus* (little tunny), *Auxis thazard* (frigate tuna), *Katsuwomis pelamis* (skipjack tuna), mackerels *Scomberomorus* sp. (macarelas), wahoo *Acanthocybium solandri* (guatapaná), dolphinfish *Coryphaena hippurus* (dorado) and Atlantic sailfish *Istiphorus albicans* (aguja)	Pelagic	–	≥5.3	Co, Ba, Cu	Small scale artisanal	S and NE coasts	Schirm, 1995b
Marlin fishery	Blue marlin *Makaira nigricans* (marlin azul), white marlin *Tetrapturus albidus* (marlin blanco)	Pelagic	40–100	8–32	Co	Sport	LA	Just Us, 2006
Squid fishery	Diamond squid *Thysanoteuthis rhombus* (calamar diamante)	Pelagic	300–750	3–4	LC	Small scale commercial	SA	SERCM, 2000
Pelagic coastal fishery	Carangidae (jacks), Clupeidae (herrings), Atherinidae (silversides), Hemiramphidae (ballyhoo), Gerridae, Sciaenidae (drums), Centropomidae (snooks), Engraulidae (anchovies), Sphyraenidae (juvenile barracuda), some juvenile sharks (bull, blackfin, hammerhead, nurse, reef and lemon sharks)	Pelagic/coastal	–	–	At, Co	Small scale commercial	Whole coastline	SERCM, 2004
Crab fishery	Blue land crab *Cardisoma guanhumi* (paloma de cueva), swamp ghost crab *Ucides cordatus* (zumbá), black crab mountain *Gecarcinus ruricola* (cangejo moro)	Mangrove, coastal	0	–	Ml	Small scale commercial	SA, PE, LA, MC	Ramírez and Silva, 1994
Ornamental species fishery	Many fish species: (Apogonidae, Balistidae, Chaetodontidae, Diodontidae, Grammidae, Haemulidae, Labridae, Ostracidae, Pomacanthidae, Pomacentridae, Sciaenidae, Syngnatidae, Tetrodontidae) and invertebrates	Coastal, coral reef	0–30	≤5.3	Ja	Medium scale commercial	MC	CIBIMA, 1994; SERCM, 2004

* Does not include the lobster, queen conch and reef fish fishery in the shallow ocean banks region.
** FAD: fish aggregating device.

The traps used for the lobster fishery in Pedernales catch many bycatch fish species, particularly white grunt (*Haemulon plumieri*; bocayate blanco) and spotted goatfish (*Pseudopeneus maculates*; salmonete). There are also invertebrate bycatch species caught in this fishery. These species are also considered part of the catches (Schirm, 1995, 1995a); however, the small ones and those with no commercial value are discharged. Some invertebrates, such as the starfish (*Oreaster reticulates*), are used as bait. There is no estimation of the proportion of discarded species. This fishery can be considered as a small-scale artisanal fishery and as a subsistence fishery. The fishery takes place year-round, except during the closure from April to July (Decree 316-86).

According to the Subsecretaría de Estado de Recursos Costeros y Marinos (SERCM – Environment and Natural Resources State Subsecretariat, 2004), lobster markets can be classified into three types: (a) internal consumption in restaurants, supermarkets, fish shops; (b) tourism; and (c) export. The highest consumption occurs in the tourism market, in which all the capture is commercialized and consumed fresh in the domestic market. The lobster production of the last 12 years (1992–2003) has fluctuated from minimum values of 500 tonnes in 1996 up to a maximum of 2 651 tonnes in 2002, with a drastic drop in 2003. This drop is attributed to loss of information in the fishing areas, or to a decrease in the capture due to extreme meteorological events that occurred along the Dominican coastline in 2003.

Shrimp fishery

Colom *et al.* (1994) recognize the shrimp fishery carried out with gillnets and casting nets in Sánchez, Samaná Province, as a national fishing unit, which was described by Núñez and García (1983) and complemented by Silva and Aquino (1993) and Zorrilla *et al.* (1995). This fishery started in the early 1960s, when the closure of train operations forced the local people to seek out other income sources. Three shrimp species are landed in Sánchez town (Núñez and García, 1983): the Atlantic seabob (*Xiphopenaeus kroyeri*), the pink shrimp (*Farfantepenaeus duorarum*) and the white shrimp (*Litopenaeus schmitti*). The white shrimp can be considered the key species, since it comprises between 86% (Sang *et al.*, 1997) and 95% (Then *et al.*, 1995) of the total shrimp catch.

The west region of Samaná Bay is the most important due to the fishing area extension, the resource abundance and the number of fishers involved in the fishery. The flow of the Yuna and Barracote Rivers define an estuary region of 400 km^2 in the west of Samaná Bay. Due to its high productivity, Samaná is considered the most important fishing area of the country, though SERCM (2004) indicates Manzanillo, Montecristi as another important fishing area.

The fishing gear used in the shrimp fishery catches great quantities of non-target (or incidental) species, both invertebrate and fish species, which can comprise 54% of the total catch. Sang *et al.* (1997) showed that this bycatch could include up to 24 fish families and two crustacean families. Atlantic anchoveta (*Cetengraulis edentulous*), Jamaica weakfish (*Cynoscion jamaicensis*; gogó), stardrum (*Stellifer colonensis*; mandarín chino), whitemouth croaker (*Micropogonias furnier*; corvina), hospe mullet (*Mugil hospes*; lisa), swordspine snook (*Centropomus ensiferus*; robalo) and the blue crabs (*Callinectes sapidus* and *C. danae*; portúnidos) were among the main species of bycatch. This is a small-scale fishery, which is carried out year-round except during closure, in February and March (Decree 3546-73).

The landings ranged between 125 and 200 tonnes between 1963 and 1980 (Fisheries Development Limited, 1980), and according to recent data the average catch between 1992 and 2003 has been 184 tonnes with important fluctuations (SERCM, 2004). This amount is smaller than the production figures (400 tonnes) resulting from aquaculture in other regions of the country (FAO, 2001).

Queen conch fishery

The queen conch (*Strombus gigas*) fishery occurs all along the Dominican Republic platform. This is a highly valued resource that represents between 6% and 16% of the national fisheries value. The queen conch fishery is linked to the platform areas with sea grass and algae, where juveniles and adults are especially abundant. These areas are located in the southeast of La Altagracia (Delgado *et al*., 1998; Chiappone, 2001), Montecristi (Geraldes *et al*., 1998) and particularly Pedernales, where most of the landings of the Dominican Republic take place (Appeldoorn, 1993; Tejeda, 1995, 1995b; Posada *et al*., 1999, 2000). Nevertheless, the queen conch is under strong fishing pressure along the whole Dominican Republic platform up to a depth of 30 m, as well as on the oceanic banks.

This is a small-scale fishery that takes place year-round. The fishery's main commercial target is the domestic market (fresh or frozen), with a high tourism demand. Queen conch production in the last 12 years (1992–2003) has fluctuated between a minimum of 1 200 tonnes in 1999 and a maximum of 3 000 tonnes in 1992, with an average of approximately 2 000 tonnes. The export figures in 2000 were around 300 tonnes (SERCM, 2004). Because diving is the method of harvesting, there is no bycatch in this fishery.

Coral reef fishery

The coastal reef fishery takes place on the coral reefs along the entire Dominican Republic platform, up to 30 m of depth. The main fishing locations are the wide platform areas with relevant coastal reef ecosystems, including barrier reefs (with the typical ecological zoning from the reef lagoons to the deepest frontal reef), fringe and patch reefs. Reef fishery studies have been conducted on the platforms of Montecristi (Luczkovich, 1991; Geraldes *et al*., 1998), Puerto Plata (Betancourt and Herrera, 2004), María Trinidad Sánchez (Decena and Díaz, 1982), Samaná (Sang *et al*., 1997), La Altagracia (León *et al*., 1995; Schmitt, 1998; Chiappone *et al*., 2000; Chiappone, 2001), Santo Domingo (Geraldes *et al*., 1997), Azua (Bouchon *et al*., 1995), Barahona (Aquino and Infante, 1994; Beck and Colom, 1994; Beck *et al*., 1994; Schirm, 1995, 1995a; Tejeda *et al*., 1995) and Pedernales (Schirm, 1995, 1995a; Reveles *et al*., 1997). Reef fish and invertebrates are under strong fishing pressure on the whole Dominican Republic platform, as well as in the shallow areas of the oceanic banks.

More than 100 species are caught, and they belong to typical reef species, mainly Lutjanidae and Serranidae; however, the list also includes Haemulidae, Acanthuridae, Balistidae, Holocentridae, Pomacanthidae, Pomacentridae, Sparidae, Scaridae and Labridae. These species are distributed in mangroves and sea grass (juvenile stages), as well as on coral reefs (adult stages).

An exploratory trap fishery on the Barahona reef (Aquino and Infante, 1994) indicates that there are more than 30 families of fish, with half of the catch composed by Haemulidae (27%), Scaridae (16%) and Acanthuridae (12%). In Samaná, Sang *et al*. (1997) report 29 families in the reef fishery caught with various gear in Sabana de la Mar. The study indicates that half of the catch is composed of Lutjanidae (33%), Haemulidae (15%) and Scaridae (8%). Among the most frequently reported species caught in the reef fishery are: mutton snapper (*Lutjanus analis*; sama), grey snapper (*L. griseus*; pargo prieto), lane snapper (*L. ynagris*; bermejuelo), yellowtail snapper (*Ocyurus chrysurus*; colirrubia), graysby (*Cephalopholis cruentata*; arigua), Nassau grouper (*Epinephelus striatus*), many species of parrotfish (*Sparisoma aurofrenatum* and *Scarus taeniopterus*), *Haemulon aerolineatum, H. flavolineatum* and *H. plumieri* (grunts) and *Acanthurus bahianus*.

This fishery also catches crabs (Majidae and Xanthidae), such as the coral crab (*Carpilius corallinus*; dormilona), *Mitrax spinosissimus* (centolla) and the spider crab (*Stenocionops* furcata; cangrejo araña), as well as molluscs (Cassidae, Trochidae, Ranellidae, Fasciolaridae, Strombidae and Octopodidade), cameo helmet (*Cassis madagascariensis*; lambí), West Indian Top Shell (*Cittarium pica*; burgao), Atlantic trumpet triton (*Charonia variegate*; tritón), common tulip snail (*Fasciolaria tulipa*; tulipán), *Strombus costatus* and *Stromus pugilis* (lambíes), and the Caribbean reef octopus (*Octopus briareus*; pulpos) and common octopus (*Octopus vulgaris*; pulpos).

This is a coastal artisanal, small-scale fishery mainly directed to the local market, with a high tourism demand. The fishery is characterized by the various fishing gear utilized, which relates to the species diversity: traps, gillnet, diving (including diving with compressor), and a variety of fishing lines. Traps can catch non-targeted species, and only the small species or those invertebrates which have no commercial or fishing value are discarded. There are no reports on the amount of discarded fish. The gillnet causes accidental death of many non-targeted species, including some pelagic species, which do not belong to the reef fishery. There is no estimation of bycatch numbers. This fishery takes place year-round.

Reef resources are under high fishing pressure; however, there are no production estimations of the reef fishery as a whole. For example, as we indicate later in this chapter, SERCM (2004) reports all Lutjanidae species together, without specifying whether the species had been caught in the reef fishery with trap or in the deep sea fishery at 500 m with longline. Linton *et al*. (2002) recognize that the artisanal fishery represents one of the most important challenges for the recovery of the Dominican Republic reefs, which are now lacking most of the relevant commercial species. Our numerous diving experiences in the reefs indicate almost complete absence of the fish in the Puerto Plata, Santo Domingo and Punta Cana reefs. This impact is increased by the overexploitation of fish and invertebrate species for the artisanal market that is induced by tourism.

Deep-sea fishery in the platform border

In some areas of the Dominican Republic platform, a deep-sea fishery is undertaken beneath the slope, at 100 to 500 m of depth. The most important areas are documented by exploratory fisheries, and they coincide with the areas where the platform narrows and 100-m depth can be reached a short distance from the coast by an artisanal boat. Examples of these areas are the Bahía de Neiba in Barahona (Aquino, 1994; Colom, 1994; Colom and Aquino, 1994; Colom and Infante, 1995; Tejeda and Feliz, 1995), around Isla Beata and Alto Velo, in Pedernales (Schirm, 1995b), and the north and east coast of the Península de Samaná (Sang *et al*., 1997; Arima, 1997, 1998a, 1998b, 1998c, 1999a, 1999b, 1999c).

The fishery is directed for Lutjanidae and Serranidae, in particular to seven species that could account for 80% of the catch. Such species are (listed according to their importance): cardinal snapper (*Pristipomoides macrophtalmus*; roamo), silk snapper (*Lutjanus vivanus*; chillo), blackfin snapper (*L. bucanella*; chillo oreja negra), vermillion snapper (*Rhomboplites aurorubens*; besugo), queen snapper (*Etelis oculatus*; boral), and the misty yellowedge grouper (*Epinephelus mystacinus*; meros) and yellowedge grouper (*E. flavolimbatus*; meros). Every exploratory deep-sea fishery and catch analysis shows that these are the dominant species by weight in the catch; however, the percentages of the species may vary according to the location, depth and fishing gear.

CFRM (2004) indicates another set of species as representative to the deep-sea fishery. They are: snappers (*Apsilus dentatus, Lutjanus apodus, L. mahagoni,* and *L. analis*); and groupers (*Epinephelus adscensionis, E. guttatus, E. striatus* and *E. morio*). These species are typical of more shallow waters; however, their distribution pattern does allow for them to be caught in the deep-sea fishery, though they are not dominant. Similarly, *L. synagris, L. campechanus, Verilus sordidus, Mycteroperca venenosa* and *Cephalopholis cruentata* have been reported in exploratory deep-sea fisheries. Traps, handlines and bottom longlines are the fishing gear used in this fishery.

There are more than 20 species reported as bycatch in the deep-sea fishery. The species belong to the families: Branchiostegidae, Brotulidae, Carangidae, Congridae, Holocentridae, Labridae, Mullidae, Muraenidae, Ophycthidae, Polimyxidae, Sciaenidae, Sparidae and Synodontidae. The deep-sea fishery also reports catches of shark: *Carcharinus limbatus* and *Mustelus canis* (Colom, 1994). Traps capture most of the accidental fish species (belonging to 12 families), as well as crabs (*Carpilius coralinus*) and lobsters. In deep waters, most of the catch is composed by large species. This is a small-scale fishery that applies fishing effort year-round, and it seems to be spatially allocated in seasonal spawning areas that are well known by fishers.

Deep-sea fishery on the ocean banks

There are two ocean banks in the Dominican Republic marine territory: La Navidad and La Plata, as well as other small banks in the north. The ocean bank fishery shares many species with the deep-sea fishery on the inshore platform. Nevertheless, this work separates the ocean bank fishery from the deep-sea fishery since it is undertaken more than 90 miles from land, which makes it inaccessible to most artisanal fishers. In fact, FAO (2001) considers the ocean bank fishery as a semi-industrial fishery, in which boats with decks, diesel engines, freezing equipment and ice storage, and 5 to 25 crew members, make 7- to 10-day trips to the ocean banks. Kawaguchi (1974) carried out the first exploratory fishery in the La Navidad Bank, and indicated the relevance of species such as Etelis oculatus and Pristipomoides macrophtalmus. Later papers by Arima (1997, 1998–1998b, 1999–1999b) reported 16 species and defined Lutjanus vivanus, Lutjanus bucanella, and Epinephelus mystacinus as key species other than those reported by Kawaguchi (1974). Puerto Plata and Samaná are departure ports, and bottom longline and handline are the fishing gear used in this year-round fishery, which can be limited by the hurricane season.

Pelagic fishery or fish aggregating device (FAD) fishery

The pelagic fishery occurs along the south coast, particularly in the provinces of Barahona (Lee and Aquino, 1994; Colom and Tejeda, 1995; Reyes and Melo, 2004), San Pedro de Macorís (Schirm, 1995b), Samaná (León, 1996; Sang *et al*., 1997) and the north region. The main species are yellowfin tuna (*Thunnus albacares*), little tunny (*Euthynnus alleteratus*), frigate tuna (*Auxis thazard*), skipjack tuna (*Katsuwomis pelamis*), mackerels (*Scomberomorus* sp.), wahoo (*Acanthocybium solandri*), dolphinfish (*Coryphaena hippurus*) and Atlantic sailfish (*Istiphorus albicans*). Sharks are also accidentally caught in this fishery.

This is a seasonal small-scale artisanal fishery. Nevertheless, since it targets many species (most of them are migratory species), the fishery occurs year-round, depending on resource availability. SERCM (2004) considered the pelagic fishery as a developing fishery that produced 227 tonnes in 2003. Rainbow runner (*Elegatis bipinnulatus*; macarela), jack (*Seriola* sp.; blanquilla) and barracuda (*Sphyraena barracuda*; picúa) are non-target species; nonetheless, they are caught and consumed.

Sport fishery

Since 1998, the sport fishery is undertaken in the coastal regions of Bávaro, Cabeza de Toro, Punta Cana, Boca de Yuma, Santo Domingo, La Romana and Montecristi. This activity is run by nautical clubs and it can be part of the tourist activities offered by hotels and resorts. Among the main nautical clubs which organize annual fishing contests in the Dominican Republic are the Club Náutico de Santo Domingo, located in Boca Chica, which has branches in Cabeza de Toro and Boca de Yuma, the Club Náutico de Haina, Club Caza y Pesca de La Romana and Club Náutico de Montecristi, as well as Marina de Chavón (SERCM, 2004).

This is a seasonal sport activity. The main species are the blue marlin (*Makaira nigricans*; marlin azul) and the white marlin (*Tetrapturus albidus*; marlin blanco), though other species can be included in this fishery. The white marlin is usually caught about 8 to 10 nautical miles from the coast, at 40 to 100 m depth. The fishing season for this species runs from the end of April until the end of July. The best fishing area for blue marlin is located 32 nautical miles from Punta Cana, on the Pichincho Bank, Canal de la Mona. This species is generally distributed in deeper waters, generally at 70 m of depth. The fishing season starts in June and continues until the end of August. There are no official catch statistics for these species. Tourism promotional Web sites offer some sporadic data. For example, in 2003 during 28 fishing days, 46 white marlins and 10 blue marlins were reported to be caught and released (Just Us, 2006).

Pelagic coastal fishery

CFRM (2004) refers to the pelagic coastal fishery that occurs particularly on the sea grass bottom in reef lagoons. Target species are numerous, and they belong to a wide range of families: Carangidae (jacks), Atherinidae (silversides), Hemiramphidae (balyhoo), Sciaenidae (drums), Sphyraenidae (juvenile barracuda), Gerridae (mojarra), Clupeidae (herrings), Centropomidae (snooks) and Engraulidae (anchovies). The last four families are related to outflows of fresh water to the coast, where Mugilidae (mullet) is also caught. The pelagic coastal fishery catches some juvenile sharks as well, such as bull, blackfin, hammerhead, nurse, reef and lemon sharks.

The fishery occurs year-round, catching both target and incidental species with gillnets, casting nets, hook-and-line, and occasionally traps. CFRM (2004) indicates that the most abundant species in terms of volume of catch are *Caranx bartholomaei*, with a mean annual catch of 176.20 tonnes, and *Caranx hippox* with a mean annual catch of 143.68 tonnes. However, in the case of the species used for baits, such as sardines and machuelos (*Opisthonema oglinum*), the exact volume of catch is unknown, though they can reach high values. The pelagic coastal fishery is considered a moderately exploited fishery; nonetheless, there are no data to conduct a complete assessment. The fish stocks could also be affected by coastal pollution. The fishery is unregulated.

Diamond squid fishery

The diamond squid fishery started in 2001 in the Dominican Republic under the direction of the Japanese expert Tsinchichi Arima. The fishery was undertaken on-board of the Guarionex ship, donated by the Japanese government to the Centro de Desarrollo Pesquero (CEDEP/Fishing Development Center), in Samaná (SERCM, 2004). The target species is the diamond squid (*Thysanoteuthis rhombus*), which is an oceanic epipelagic species whose mantle can reach a length of 1 m and weight of 20 kg. The species distribution area covers the tropical and subtropical waters in the world. Fishing depth ranges between 300 and 750 m, and the main fishing site is three miles off the coast, to the east of El Francés, on the east coast of the Samaná Peninsula. The diamond squid is fished with a special line for squids (squid dropline fishing). This is an artisanal seasonal small-scale fishery in the early stages of development. The fishing seasons are not clearly defined since the diamond squid's oceanic migration patterns are practically unknown. The Subsecretaría de Estado de Recursos Costeros y Marinos (State Subsecretariat of Coastal and Marine Resources) indicates that the diamond squid fishery could develop into the most important fishery in the near future (SERCM, 2004).

Mangrove crab fishery

Many species of crab are caught in the mangrove areas of the Dominican Republic, which occupy 260 km^2. The mangrove crab fishery is more relevant in the provinces that have the largest mangrove ecosystems, particularly in Samaná, Montecristi, Pedernales and La Altagracia, which total almost 70% of the mangroves in the Dominican Republic. The target species are blue land crab (*Cardisoma guanhumi*; paloma de cueva), swamp ghost crab (*Ucides cordatus*; zumbá) and black mountain crab (*Gecarcinus ruricola*; cangrejo moro), with 2003 catches of 77.83, 28.49, and 33.01 tonnes, respectively.

Though these crab species are highly commercialized and consumed throughout the country, the mangrove crab fishery has never been reported among the Dominican Republic fisheries. Nevertheless, its relevance is acknowledged since this is the most regulated fishery in the country, with seven Presidential Decrees in 37 years (Ramírez and Silva, 1994). The regulations address key fishing-biological issues, such as the prohibition to catch females (Decrees 1345-67 and 2515-72); restriction to the legal minimum length; closures (Decrees 2945-72, 976-79 and 317-86); fishing prohibitions (Decree 1867-76); and the national closure of five years from 1996 to 2000 (Decree 68-96).

Ornamental fish and invertebrate fishery

SERCM (2004) groups this fishery together with the coral reef fishery because the fishing occurs basically in the same environment. However, we considered addressing the ornamental fishery independently since: (a) the objective of the fishery is not consumption, but commercialization in aquariums; (b) the target species are small and colourful fish and invertebrate species, which do not have commercial value for consumption; (c) fishing is undertaken manually, with small bully nets and traps; and (d) currently the fishery is located only in the country's northwestern region, in the Montecristi Province. The ornamental fishery is a commercial medium-scale fishery undertaken by a small number of fishers and for which there is no precise statistical control in place.

The export of ornamental fish started in the 1980s, and currently is distributed exclusively among three companies (Tropical Seas, Petrosa S.A., Montecristi Export y Puerto Libertador S.A.), which direct the fishery to 30 species of ornamental fish and a similar number of marine invertebrates. The companies export to international markets, mainly the United States. The amount of reef species caught is not accurately known, though it has been estimated at 205 901 animals between 1996 and 2001, averaging 34 316 animals per year and 56 317 animals in 2003 (SERCM, 2004), indicating a substantial increasing trend.

The families represented in the catch are predominantly Apogonidae, Balistidae, Chaetodontidae, Diodontidae, Grammidae, Haemulidae, Labridae, Ostracidae, Pomacanthidae, Pomacentridae, Sciaenidae, Syngnatidae and Tetrodontidae. SECRM (2004) indicates that the species with highest catch volume are: blue chromis (*Chromis cyanea*; cromis azul) and Royal gramma (*Gramma loreto*; gramma real), but the Centro de Investigaciones de Biología Marina (CIBIMA) had reported other species that even today are still caught, such as Sergeant Major (*Abudefduf saxatilis*; sargento mayor), cardinal fish (*Apogon binotatus*; cardenal), banded butterflyfish (*Chaetodon striatus*; banderita), porcupine fish (*Diodon hystrix*; guanábana), spotted drum (*Equetus punctatus*; obispos) and jacknife fish (*E. lanceolatus*; obispos), small mouth grunt (*Haemulon chrysargyreum*; bocayate), slippery dick (*Halichoeres bivitattus*; doncella), rock beauty (*Holacanthus tricolor*; guinea), spotted boxfish (*Lactophrys bicaudalis*; pez cofre), blue head wrasse (*Thalassoma bifasciatum*; cabeza azul) and slender seahorse (*Hyppocampus reidi*; caballito de mar) (CIBIMA, 1994). All these species are protected by the Ley Sectorial de Biodiversidad (Biodiversity Sectorial Law) (USAID, 2002), in particular the slender seahorse which is on the Lista Roja (Red List) of the International Union for Conservation of Nature (IUCN).

CFRM (2004) indicates that statistical data also report the export of black coral, anemones, crabs, bivalves, gastropods, polychaetes, starfish, sea cucumbers and other invertebrates. The extraction of these resources can affect the equilibrium of coral reefs; however, there are no studies on this subject. Moreover, the country is losing a valuable source of organisms with bioactive substances, which are highly valued in the international market. The extraction and commercialization of these resources is regulated by Decree 318-86.

2.2. Fishing activity

Spiny lobster (Panulirus argus)

Lobster is caught along the Dominican Republic platform by artisanal fishery methods. The main fishing gear is trap. The trap could be made of chicken wire or plant fiber (Haitian traps). Most of the lobster fishing traps have a mesh size of 24 mm (if they are made of wire), and 41 mm (if they are Haitian traps). None of these traps have escape vents or biodegradable panels. The mesh used in the current traps catch lobsters of 35 to 45 mm carapace length, although 80 mm carapace length is the minimum legal size. This explains the high percentage of sublegal lobsters in shallow fishing areas on sea grass (in or close to nursery areas), which can reach 90% in Pedernales and Samaná.

Average crew size is two men fishing in small wooden boats called *cayucos* (2.9 to 6.4 m in length), wooden or fibreglass boats called *yolas* (3 to 7 m in length), or small boats called *botes* (5.5 to 8.4 m in length). Fishers set 10 to 100 traps, mainly on the sea grass bottom, between 1 and 30 m of depth, for 3 to 13 days. Some lobsters are caught by free diving (between 1 and 10 m), or with a compressor (up to 30 m) using hooks or harpoons. Occasionally, lobsters are caught with gillnets.

About 40% of the fishers at national level target lobster exclusively (SERCM, 2004). Therefore, it is estimated that 3 360 fishers and more than 1 500 boats are concentrated in this fishery. Thus, the remaining 60% of fishers may catch lobster incidentally; however, they still land and consume or commercialize their catch. It is a fact that the growing and uncontrolled fishing effort on the lobster resource and unsustainable fishing practices have caused a significant decrease in the catch, a disappearance of commercial-sized lobster, and an extinction of lobster in some regions (Herrera and Betancourt, 2003, 2003e).

White shrimp (Litopenaeus schmitti)

The white shrimp is caught in the Samaná Bay using 250 casting nets and 350 trawls, which operate from 387 *cayucos* (small boats) and an average crew of two men. About 933 fishers participate in this fishery (SERCM, 2004). Even though the resource is overexploited, the high prices and the tourism demand have resulted in increased fishing effort despite decreasing catches.

There are no biological fishery studies on the white shrimp, and the stock (already overexploited) has never been assessed. Sang *et al.* (1997) measured 492 shrimps and indicated an average of 35 mm for the cephalotorax length of white shrimp (113 mm of total length). There is a clear lack of biological information on this resource, whose life cycle in the bay has never been studied, as well as a lack of information on gear selectivity and exploitation levels.

Queen conch (Strombus gigas)

Queen conch is the most important resource in the Dominican Republic. The queen conch fishery is completely artisanal; catches are obtained manually, by free diving or diving with an air compressor on the sea grass marine bottom. It occurs in up to 33 m of depth. Crew members are two free divers, or three divers, if the diving is done with compressor. The fishery is undertaken with *cayucos*, or boats (*yolas*), whose exact number is unknown. The number of divers is also unknown. The fishery is regulated by Decree 312-86, which establishes the minimum legal fishing size at 25 cm of siphon length; and Decree 833-03, which establishes the annual closure of the fishery from 1 July to 31 October. However, there is no effective control of the fishery. In fact, the resource is overexploited in the whole country, and the reports of sublegal juveniles in catches can reach 90% (Tejeda, 1995). The species is listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (UNEP-WCMC, 2006), and export permits have been temporarily suspended to protect the species.

Grouper (Serranidae)

There are about 30 species of the Serranidae family in the Dominican Republic reef and deep-sea fishery (Silva, 1994; Sang *et al.*, 1997). *Cepalopholis fulva, C. ruentatus* (graysby), *Epinephelus guttatus* and *E. striatus* (Nassau grouper) are reported in practically all reef fishery areas, while *Epinephelus mystacinus* and

E. flavolimbatus (yellowedge grouper) are reported in the deep-sea fishery on the platform border and the oceanic banks. In the case of the reef fishery, Serranidae are caught by handline, traps (made of wire of fibre, similar to the lobster fishery), or diving. In the deep-sea fishery, the fishing gear are longlines, handlines and type-Z traps that are 2.30 m long, 1.80 m wide and 0.55 m high, made with chicken wire with a maximum mesh size of 0.37 cm, and using sardines as bait.

The Serranidae catch reached 6 605 tonnes between 1992 and 2001, with an annual average of 657 tonnes. In terms of catch volume, the main species was *E. adcensionis* with an annual average of 521 tonnes, equivalent to 79% of the total catch of Serranidae (SERCM, 2004). Non-discriminatory fishing, paired with the lack of effective regulations, has caused many Serranidae species to be in a critical state in some regions of the country. Studies in Samaná (Sang *et al.*, 1997) reveal that all reef species are being caught before reaching maturity. Data from La Altagracia indicate that the intensive exploitation on the reef manifests itself through population decreases, as well as decreases in species composition and size. Currently, the dominant species in terms of number and biomass are small-sized species such as *C. cruentatus* (graysby) and *C. fulva* (coney) (Chiappone *et al.*, 2000), which are no larger than 35 cm (Schmitt, 1998).

There are no studies addressing the state of the Serranidae family species that are targeted in the deep-sea fishery. Thus, high exploitation on the reproductive stocks could be occurring, especially in the spawning areas where they aggregate. The Serranidae family is protected only by Decree 2099-84, which prohibits fishing during the spawning season, but the Decree does not clarify dates or species that are to be protected.

Snapper (Lutjanidae)

There are about 16 Lutjanidae species caught in the reef and deep-sea fishery (Silva, 1994; Sang *et al.*, 1997). *Lutjanus analis*, *L. griseus*, *L. synagris* and *Ocyurus chrysurus* are reported in practically every reef fishery, while *L. vivanus*, *L. bucanella, Etelis oculatus*, *Pristipomoides macrophtalmus* and *Rhomboplites aurorubens* are reported in the deep-sea fishery on the platform border and the oceanic banks. The Lutjanidae family is caught with the same fishing gear as the Serranidae family: handlines, traps or diving in the reef fishery, and longline, handline and traps in the deep-sea fishery.

Lutjanidae catches from 1992 to 2003 fluctuated from a minimum of 800 tonnes in 1997 to a maximum of 3 000 tonnes in 2003 (SERCM, 2004), with an annual average of 1 600 tonnes. Like Serranidae, biological fishery studies reveal that most of the Lutjanidae species caught in the reef fishery are smaller than their size at maturity. This group is not protected by any specific regulation.

Other demersal fish

The reef fishery catches over 70 species of fish that belong to the families Acanthuridae, Balistidae, Haemulidae, Holocentridae, Labridae, Pomacanthidae, Pomacentridae, Scaridae and Sparidae, from which there is almost no information on the catches. However, Chiappone *et al.* (2000) data from ecological studies on La Altagracia reef indicate that the intensive fishery has changed the abundance ranges, density and size of the parrotfish in the region, as the most abundant species (*Scarus taeniopterus, Sparisoma aurofrenatum* and *Scarus croicensis*) have sizes that do not exceed 30 cm in length. Schmitt (1998) shows the same low density and small-size situation in the Haemulidae commercial species. Sang *et al.* (1997) data in Samaná are consistent with these examples.

Pelagic resources

Pelagic resources are comprised of a large group of tuna, bonito and albacore, mackerel (*Scomberomorus* sp.), wahoo, dolphinfish and sailfish. These species are caught in the sport fishery and in the pelagic fishery or by using FADs. The fishery can be undertaken with longline, gillnet, trolling and live baiting fishing (viveo), with or without rafts. There are no regulations to control the pelagic fishery. Pelagic fish catches increased from 2001 to 2003, reaching 217 tonnes (SERCM, 2004). This is attributed to the improvement of fishing technology and the use of rafts, as well as the fishers' sailing capacities, which allow them to work in areas further from the coast.

In terms of the exploitation of the pelagic species by the sport fishery, and by national or international tourist fishers, there are no official statistics. However, it is estimated that there are between 1 000 and 1 500 sport fishers, and about 250 boats of every size, and that more than 3 000 tourists request sport fishery services in Bávaro, El Cortecito, Macao, Punta Cana and Cabeza de Toro (SERCM, 2004).

Diamond squid (Thysanoteuthis rhombus)

Diamond squid is caught from boats with a three-man crew by dropline fishing. Currently, only 20 fishers, 6 boats and 12 types of fishing gear are involved in the diamond squid fishery. Catches per boat can reach up to four or five squids a day (E. Fermín, personal communication). SERCM (2004) indicates that in 2003 the diamond squid experimental catch was estimated at 2 tonnes. The average weight per squid was about 13 kg. There have not been any biological fishery studies for this species, whose reproduction, feeding and migratory patterns are unknown (Kazunari *et al.*, 2001).

3. FISHERS AND SOCIO-ECONOMIC ASPECTS

3.1 Fishers' characteristics

The last SERCM (2004) census showed that the total number of fishers in the Dominican Republic was 8 399 (Table 2). Also, there are about 46 500 people indirectly employed in activities related to the fishery (SERCM, 2004).

TABLE 2
Number of fishers, landing sites and boats per coastal province

Coastal province	Landing sites	Number of fishers	Number of boats
Montecristi	8	612	225
Puerto Plata	19	1 232	342
Espaillat	4	105	48
María Trinidad Sánchez	13	435	170
Samaná	37	2 514	1 082
Hato Mayor	6	402	259
El Seibo	5	309	138
La Altagracia	10	185	143
La Romana	7	255	148
San Pedro de Macorís	8	318	185
Santo Domingo	4	228	128
San Cristóbal	4	160	57
Peravia	8	376	135
Azua	7	387	180
Barahona	13	432	192
Pedernales	12	449	229
Total	165	8 399	3 661

Source: Based on SERCM fishing census data (2004).

Most of the fishers are not dedicated full time to fishing. The Centro para la Conservación y Ecodesarrollo de la Bahía de Samaná y su Entorno, Inc. (CEBSE, 1994) reports that in Samaná only 27% of fishers are exclusively dedicated to fishing. Other income activities are carpentry (6%), street/beach vending (2%), and agriculture (46%). Agriculture can be undertaken simultaneously with fishing activities. In Montecristi, 80% of coastal fishers are full-time fishers (Luperón, 1998). The percentage of fishers who are dedicated full time to fishing is related to the economic benefits of the activity. Overexploitation of resources has resulted in more and more fishers looking into alternative economical activities, making tourism (direct or indirect) related activities one of the most relevant options.

Fishing in the Dominican Republic is primarily artisanal, and it is undertaken almost exclusively by men. Very few women participate directly in this activity on-board, since working conditions are very hard and work can last the whole day. Women participate in cleaning of fish and its commercialization, either fresh or processed (fried). Also, many women's associations are oriented to the aquaculture of fish in tanks (Nolasco, 2000).

At the national level, artisanal fishers show loyalty to their fishing grounds, and are generally very territorial. For example, the CEBSE (1994) reports that 93% of Samaná fishers were born in the province. Historically, fishing has been recognized as an important traditional family economic activity. Moreover, there are family names that have been linked to the exploitation of certain fishery resources for many years.

In Montecristi, 22% of fishers have been fishing in the area for more than 25 years. However, there is also a migratory population that lives between different communities, fishing during specific times of the year and linking their fishing activity to seasonal species such as wahoo (*Acanthocybium solandri*) (Luperón, 1998). In Samaná, 40% of fishers have been fishing for more than 20 years (Silva and Aquino, 1993). This indicates the existence of a permanent fishing population that carries out a significative historical traditional fishery.

3.2 Social and economic aspects

The socio-economic studies of the fishery sector are fragmented, rare, and more descriptive than quantitative. The most recent national artisanal fishery censuses (Colom *et al*., 1994; SERCM, 2004) include only the number of fishers, fishing sites, fishing gear and boats, but do not address education or any other social and economic aspects of the sector. In general, it is understood that fishers have a low education level; however, the actual data are provided by local studies. Luperón (1998) indicates that 72% of the Montecristi fishers have completed primary studies, 18% secondary studies and 7.2% are illiterate. The workforce in the fishery has a very low educational level and a high illiteracy rate, and no fishers with any university level of education. CEBSE (1994) reports that 64% of fishers have primary educational level, 11.2% secondary level and 0.2% has reached some kind of technical or university level; 24.4% of fishers are illiterate. Only approximately 50% of fishers have some elementary educational level (SERCM, 2004).

In terms of the fishers' family structure, CEBSE (1994) is the only source of information available in Samaná, which reports between 3 and 6 people in the household, with an average of 5 people. There are households with a significantly higher number of members, reaching 12 or 13; however, these cases represent less than 1% of the total households. We have not been able to find information on family planning or family members' roles. It is known, however, that fishing activity has a family tradition in the Dominican Republic.

Unfortunately, national artisanal fisher censuses (Colom *et al*., 1994; SERCM, 2004) do not include economic income data. Therefore, the available information is scattered, dated and narrowly focused. In Montecristi, in the northwest area of the country, 58% of coastal fishers received a monthly income that fluctuated between RD$500 and RD$1 000, which was below the national minimum salary established by the government; 22% received income between RD$1 000 and RD$1 500; and 20% between RD$1 500 and RD$4 000 (Luperón, 1998). In Barahona, González *et al*. (1995) estimated fishers' average monthly income as less than RD$500. SERCM (2002) recently indicated that the average monthly income in this area was RD$3 000, and RD$4 000 in Azua. One United States dollar is equivalent to 37 RD pesos.

CEBSE (1994) shows age structural data of the Samaná fishers grouped by less than 20 years (8%), from 20 to 30 years (32%), from 30 to 40 years (28%), from 40 to 50 years (16%), from 50 to 60 years (11%), and more than 60 years (5%). These numbers are similar to the Montecristi data, where 71.2% of the workforce in the fishery is between 20 and 50 years old, with values of 29.6% and 23.2% for the age groups of 20 to 30 years and 40 to 50 years, respectively (Luperón, 1998).

With regard to the quality of life of fishers, the information available for the south region (González *et al.*, 1994, 1995a, 1995b) and north region (CEBSE, 1994; Luperón, 1998), as well as the authors' experiences with fishing communities in the whole country, show that the majority of the fishing sector lacks the appropriate basic living infrastructure, medical care and education. The low educational level, low income (that must be distributed among large families), and the total dependence on fish buyers and processors are the main causes of poverty in the fishery, which has never been eradicated by any official programme.

4. COMMUNITY ORGANIZATION AND INTERACTIONS WITH OTHER SECTORS

4.1 Community organization

Nationally, it is recognized that fishers' organizational levels are low, and generally occur circumstantially under the influence of a local leader who typically then becomes an entrepreneur. In Samaná, CEBSE (1994) reports that 81% of fishers are not organized, 16% participate in some kind of association, 2% in cooperatives, and 1% are unionized. In Montecristi, Luperón (1998) comments on the current absence of organizations, and explains that the heterogeneity of occupations and interests make it difficult to create an organizational structure that responds to the collective interests of the sector. There have been many attempts to create cooperatives, which have received fishing gear, boats, refrigerating systems, vehicles and technical assistance; however, the absence of fiscal policies and resource mismanagement have damaged the institutionalization and sustainability of these endeavors, whose goods ended up in private entrepreneurs' hands.

Nevertheless, in other regions of the country there are fishing organizations that are strong locally. They define themselves as associations or cooperative groups, though they do not differ much from each other in their organizational structure and functioning. Some organizations are simply collaborative groups with a few members united by working relationships and common problems. On the other hand, there are some organized associations with Memorandums of Understanding, administrative and accounting registry, and associated economic and social achievements. We have not found a national registry of these organizations; thus, Table 3 has been constructed on the basis of our field experience.

The engagement of fishers and community in co-management at the national level seems limited. Mateo *et al.* (2000) offers an example of a co-management experience by Jaragua Group, an NGO that works in Pedernales region, with the design of a joint programme for fishing in Oviedo Lagoon. However, the pioneer for fishing resources co-management strategies with fishers is Centro para la Conservación y Ecodesarrollo de la Bahía de Samaná y su Entorno (CEBSE), an

NGO that works in Samaná region (Lamelas, 1997). NGOs have been the only successful initiators for co-management of fishing resources with fishers in the Dominican Republic. This has not been the case with governmental institutions, even though they are responsible for promoting co-management work.

TABLE 3
Some of the fishing organizations in the Dominican Republic

Coastal province	Site	Fishing organization
Azua	Puerto Viejo	Asociaciones El Progreso y Centolla (association)
	Puerto Viejo	Grupo Cooperativo Pedro Tejeda (group)
	Puerto Viejo	Asociación San Rafael (association)
Barahona	Barahona	Grupo Manatí (group)
La Altagracia	Boca del Yuna	Cooperativa de Pescadores de Boca de Yuma (coop.)
Puerto Plata	Luperón	Asociación de Pescadores de Luperón (association)
Samaná	Sánchez	Asociación de Pescadores de la Fe (association)
	Samaná	Cooperativa del Golfo de la Flecha (coop.)
	Las Terrenas	Asociación de Pescadores Unidos de Las Terrenas (association)
	Las Pascualas	Asociación de Pescadores de Las Pascualas, El Valle y La Majagua (association)
San Cristóbal	Nigua	Asociación de Pescadores de Nigua (association)
San Pedro de Macorís	San Pedro	Asociación de Pescadores del Parque (association)

As part of the strategy to integrate all social sectors in the co-management process, CEBSE created programmes for organizing the fishing sector that includes a diagnostic study for the sector. By a participative process that included hundreds of persons, CEBSE managed to identify the main problems, recommend policies, and suggest the people or groups of people who should be involved in the problem-solving process. CEBSE (1996) offers an integrated management plan for Samaná region that includes concrete actions to address the fishing sector problems with the participation of state stakeholders (Samaná Municipality), control stakeholders (Navy), financial stakeholders (Fishing Commerce and Agricultural Bank), educational stakeholders (CEDEP) and fishing stakeholders (independent fishers and associations).

4.2 Fishers’ interactions with other sectors

The Dominican Republic coastal zone has tourism, ports and industry as priority uses, with tourism being the most influential activity on the fishing sector. From a socio-economic and cultural point of view, this new industry has established itself in the middle of villages that have traditionally lived on coastal resources, resulting in use conflicts, changing demographic patterns, and increasing the impact of human activities on coastal ecosystems. Tourism increased the range of impacts in coastal areas by developing new uses (to satisfy tourism demand) or by introducing non-sustainable practices.

The fishing sector's interaction with other sectors that use the coastal zone is not documented in any published work. The information provided in this work derives from the authors' experiences, as well as some isolated data from environmental impact studies and public consultation, which analyse the fishing sector as part of the socio-economic realm. For example, interaction with the tourism sector has been negative in the east and northeast, where tourism development has impacted the fishing sector. The negative impact of tourism manifests itself through the physical exclusion of the coastal zone (fishing villages and landing sites) and the marine zone (traditional fishing areas). Also, in many cases, tourism development is responsible for the relocation of fishers to sites far away from the fishing areas, causing fishers to look for other economic alternatives that are foreign to their traditions. In other cases, fishers have incorporated the possibilities that tourism offers, increasing the exploitation of highly demanded species such as lobster and queen conch. One of the worst consequences of these new practices is the extraction of reef species for handicrafts, which are sold to tourists in hotels or at shops on the beach. More than 50 invertebrate and fish species are involved in these practices, most of them protected by national and international laws. Many of these species are key species of the ecosystem and, furthermore, relevant for the maintenance of its biological equilibrium. It is also clear that overfishing of marine organisms results from the high demand of these species in tourist centres.

Another antagonistic factor between the fishing and tourism sectors is the destruction and contamination of fishing sites due to nautical and subaquatic activities, which are carried out without any educational environmental approach. This is common in diving enterprises, which are concessionaries of tourist hotels in Puerto Plata, Bávaro or San Pedro de Macorís. Most of these problems have arisen due to the lack of national policies in territorial planning and integrated coastal management, even though there are many proposals with regard to the latter that have not been pursued, such as the most recent CFRM (2004) proposal. Impacts from diving also occur during non-regulated excursions, which are undertaken with no environmental educational purposes.

Resorts established mainly in coastal areas have now been globalized, with change as well in the fishing village culture that was so attractive to tourists when tourism began its development in the Dominican Republic. Currently, we find a mix of behaviours and lifestyles that have forgotten, and in many cases neglect, the cultural values that have taken hundreds of years to develop (ABT, 2002).

There are some examples where the fishing and tourism sectors have been able to share the use of the coastal zone. In Bayahibe, La Romana, some fishers managed to integrate into the local tourism sector via an economically beneficial maritime transportation system for tourists. In the Bahía de Luperón (Luperón Bay) in Puerto Plata, the Marina Tropical Luperón (Luperón Tropical Marine) prioritized jobs for local fishers (Betancourt and Herrera, 2004).

5. ASSESSMENT OF FISHERIES

As a starting point, we should make clear that biological fisheries studies have basically taken a descriptive approach in the Dominican Republic; and traditional stock assessment methods that are based on size frequency analysis, estimation of mortality and growing parameters, cohort analysis, fishing gear selectivity, predictive modelling and others have been absent. In fact, most of the references in this report relate to works that have addressed population dynamics in a general manner, or simply have addressed general biological or ecological aspects of valued fishing species.

This is understandable when considering that most of the development of this activity has occurred outside the academic realm, without official support, and with a major autodidactic component. In fact, 75% of the national researchers' works that are cited in the Reference section belong to biologists working independently in NGOs. State subsidized academic institutions have had a smaller influence in the development of fishery biology, due mainly to the fact that their work has been directed to basic research; while independent organizations, which require financial support from international organizations for their projects, need to present applied research proposals with participation and benefits to the communities.

Only a few works have attempted to obtain production estimates in Barahona and Pedernales (Infante and Silva, 1994; Schirm, 1995; Silva, 1995) and Bahía de Samaná (Samaná Bay) (Silva and Aquino, 1994; Herrera, 2000), but they are isolated efforts. One of the main problems for fishery research in the Dominican Republic is the lack of stock assessments. As part of the Proyecto Propescar Sur (Propescar Sur Project), Schirm (1995) estimated some population parameters for four relevant fishing resources in Pedernales (Table 4), though we have not found more information on this matter.

TABLE 4
Basic population parameters for some resources in the Dominican Republic

Species	Males		Females		Combined		Measure
	L∞	k	L∞	k	L∞	k	
Panulirus argus	21	0.24	19.5	0.28	–	–	CL (cm)
Haemulon plumieri	–	–	–	–	42	0.34	FL (cm)
Pseudopeneus maculatus	27	0.70	25	0.35	–	–	FL (cm)
Lutjanus synagris	–	–	–	–	45	0.23	FL (cm)

Source: Estimated by Schirm (1995) using FISAT Programme.
Note: L∞ = maximum length; k + parameter of curvature (from von Bertalanffy growth model).

Fisheries Development Limited (1980) was responsible for one of the most comprehensive fishery plans in the Dominican Republic. Based on acoustic and exploratory research on the platform over one year, Fisheries Development Limited estimated the annual maximum fishing production. According to its results, the fishing resources on the platform (up to 200 m) and on the oceanic banks Navidad and La Plata had the annual sustainable production capacity shown in Table 5, with 1.8 tonnes/km² of yield per year.

TABLE 5
Annual sustainable production capacity tonnes of the fishing resources on the platform and oceanic banks

	Extension (km²)	Demersal	Pelagic	Total
Platform (200 to 500 m)	3 400	1 500	–	1 500
Platform (up to 200 m)	8 000	10 738	3 439	14 177
Oceanic banks	4 500	6 325	1 810	8 135
Total	12 500	18 563	5 249	238 012

Source: Based on Fisheries Development Limited (1980) and Giudicelli (1996).

These figures, which seem to be the only realistic estimation available, are also supported by later assessments, which offer similar numbers for the annual productivity of pelagic and demersal resources on the southwestern platform (1.7 tonnes/km²) (Infante and Silva, 1994) and demersal resources (0.9 tonnes/km²) (Schirm, 1995). For Bahía de Samaná (Samaná Bay), Silva and Aquino (1994) estimated a total annual production of 163.3 tonnes for demersal and pelagics which, considering catch data from Sang *et al.* (1997), they were theoretically divided in 17.6 tonnes for the estuarine littoral complex and 143.8 tonnes for the coral reef-sea grass complex, with 1.2 tonnes/km² and 0.3 tonnes/km² of yield per year, respectively (Herrera, 2000).

Giudicelli (1996) calls attention to the fact that former assessments have only taken into account coastal pelagic and demersal resources up to 180 to 200 m of depth, without considering the demersal resources of the slope at 200 to 500 m of depth and the oceanic pelagic resources. Therefore, he adds to the assessment an estimated figure for the slope demersal resources, concluding that the sustainable annual production potential for the platform, slope and oceanic banks could be around 18 500 tonnes for demersal and 5 000 tonnes for pelagic, with a total of 23 500 tonnes. This limit has already been reached; thus, we can think that all potential demersal (and some pelagic) species of the country are exploited to the limit of their maximum level. Therefore, increasing production in a rational manner would require directing the effort to oceanic pelagic resources.

As far as we know, ecosystem modelling, cost-benefit analysis, financial analysis, or risk analysis applied to fisheries have not been undertaken. The only economic fisheries assessment was done by Walter (1994), which has not been updated. León (1997) analysed the distribution, commercialization and end-point of fishing products in Samaná.

Artisanal fishery endeavors are not large enough to require undergoing an environmental impact assessment process. Artisanal fishery proposals are managed by the State. Social impact assessments directed to artisanal fisheries have not been done. However, many environmental impact studies consider this sector as a socio-economic component of the projects, and thus they are treated as secondary. Even though some works have analysed social and economic aspects of the artisanal fishery sector as we mentioned before, we cannot state that actual demographic studies of the sector have been systematically undertaken.

6. FISHERY MANAGEMENT AND PLANNING

Currently, the Dirección de Recursos Pesqueros (DRP) is responsible for fisheries management in the Dominican Republic. DRP responds to the Environment and Natural Resources Subministry, which in turn responds to the Environment and Natural Resources State Secretariat (SEMARN). The Environment and Natural Resources State Subsecratariat (SERCM) replaced the former Ministry of Agriculture (SEA), and at the moment is the only national authority for the fishing sector.

Theoretically, there is a traditional management system in place that covers the basic control, enforcement and monitoring aspects of the national fishing activities. Part of this system involves developing and maintaining a Registro Nacional de Pescadores (Fishers National Record), which considers licence applications to ensure that whoever undertakes any fishing activity is properly registered. To control the authorized fishing activity, fulfillment of the licence system and regulations are enforced, particularly fisheries closures, minimum catch size and gear. This is carried out by inspectors trained by SERCM. On the other hand, SERCM periodically collects statistics data from the freshwater and marine fisheries to assess catch trends and the degree of exploitation for the fishing resources. This provides key information for new temporary or permanent regulations at the national or local level. SERCM indicates that data are collected in eleven Fishing and Coastal and Marine Administrative Service Stations that are distributed state-wide and which receive instructions to collect field data.

Other institutions related to the fishing sector are the Banco Agrícola de la República Dominicana (BAGRICOLA), which offers loans for acquiring equipment and gear to fishing groups, or associations, and the Development and Cooperative Credit Institute (IDECOOP), which advises and certifies fishing cooperatives according to the legislation on national cooperatives. IDECOOP has implemented financing projects for equipment to cooperatives on a few occasions.

Fisheries management in the Dominican Republic has been the objective for several national plans, which coincided with the beginning of the 1980s (Fisheries Development Limited, 1980; ONAPLAN, 1983), 1990s (JICA/SEA, 1992) and

2000s (ICRAFD, 2001). The first of these plans was developed by Fisheries Development Limited (1980), in coordination with the Instituto Dominicano de Tecnología Industrial (INDOTEC), which presented a report for fishing development in the Dominican Republic that included a comprehensive compilation of former studies. This first plan also provided the first census for the fishing sector, with socio-economic, technological, commercial and biological fishing data, as well as results from exploratory fisheries and the first estimates of fishing productivity. The Planning National Office (ONAPLAN) adds some recommendations for scientific and technological policies for the fishing sector (ONAPLAN, 1983). The second plan was developed by the Japan International Cooperative Agency (JICA) that, together with SEA, elaborated the basic design of the Dominican Republic coastal fishery development project (JICA/SEA, 1992). This work analyses in detail the fishing antecedents in many regions of the Dominican Republic and provides criteria for implementing fishing projects. More recently, ICRAFD (2001) and CFRM (2004) offer a third plan that analyses the current situation, which provides practical guidance for future actions to improve the organization of fisheries in the Dominican Republic. Besides some isolated achievements, none of these plans have actually contributed to improving the socio-economic situation of the fishing sector at the national scale. Moreover, none of them have developed into a long-term plan to address and solve the multiple problems of the system.

Even though there is an institutional framework, and despite the above-mentioned plans indicating the major problems and needs, fisheries management in the Dominican Republic has not been fully successful. One of the first challenges is open access. While there is a legal requirement for fishers to obtain a fishing licence issued by SERCM, in practice, there is no adequate control; thus any resource is fished at any time of the year, on any coastal area, platform or oceanic region. Even then, the official licence does not indicate precise catch quotas, fishing areas, species to be caught or fishing gear. Therefore, fishing is an uncontrolled activity directed by economic interests. Moreover, none of the Dominican Republic's artisanal fisheries target exclusively one species. Regardless of gear type, catches are utilized for consumption or commercialization, regardless of size or quality.

This situation also reaches protected areas, such as the National Park Jaragua in Pedernales or the National Park Montecristi, where fisheries resources are under the same fishing pressure as in non-protected areas. The management plans of these protected areas include measures to protect fisheries resources, but they are simply not followed. There are several basic regulations for the protection of fishing resources at the national level; however, they cannot be enforced since there are no personnel or resources for this purpose.

The major problem relates to the institutional instability because SERCM employees are removed every four years in accordance to the electoral term. This causes loss of time, knowledge and valued personnel. Since there are no biological research institutions (either private or governmental), there is no periodical scientific assessment independent from the fishery management sector, and official reports generally focus more on achievements than on difficulties.

7. RESEARCH AND EDUCATION

7.1 Fishing statistics

One of the main challenges to organizing the Dominican Republic fisheries is the lack of standardized and continued series of timely data, which would allow for a regional and national analysis of the catch trends. At the national level, the Subministry of National Resources, under the SEA and currently SERCM, has been reporting official global data of the catch (SERCM, 2004). It is stated that the information comes from statistics obtained in various landing sites in the country. These are the only available statistics, and their reliability is questioned (Giudicelli, 1996).

Nevertheless, there have been some relevant local attempts to address this matter. CEBSE maintained the fishing statistics in Samaná for some years (Silva and Aquino, 1994; Silva *et al*., 1995; Aquino and Silva, 1995). Silva and Colom (1996) elaborated guidelines for collecting fishing statistics in the Dominican Republic. In Pedernales, Schirm (1995) offered the only known work for the estimation of fisheries productivity on the south platform, and showed the increasing trend in catches. However, these efforts were discontinued when the projects that supported them finished and are no longer up-to-date.

The catch classification system applied in the Dominican Republic is one of the problems that make statistics difficult to be obtained (Silva and Colom, 1996). Independent from where it is caught, catches are divided into special categories that follow a commercial criterion, rather than an ecological or biological criterion, and fish are grouped according to the quality and acceptability by consumers (Table 6). This also applies to many of the research catches.

TABLE 6
Dominican Republic catch classification

Categories	Groups of species
Class 1	Lutjanidae, Serranidae and Scomberidae
Class 2	Lutjanidae, Carangidae, Mugilidae, Serranidae and small Scomberidae
Class 3	Pomadasidae, Pomacantidae and Scaridae
Class 4	Acanturidae, Balistidae and others
Lobster	Lobsters from the Family Palinuridae and Scyllaridae
Shrimp	Family Penaeidae
Crab	Genus *Cardisoma, Callinectes, Mithrax*
Queen conch	Genus *Strombus*
Octopus	Genus *Octopus*
Others	Rays and sharks

Source: Silva and Colom, 1996.

This system can be useful commercially; however, it is not useful for fishing statistics. For example, Class 1 is a heterogeneous mix of snappers, yellowtail snappers, silk snappers, mutton snappers, groupers, jewfish, graysbies, and king and Spanish mackerels. This includes demersal fish such as Lutjanidae (about 20 species) and Serranidae (about 50 species), which are distributed in the mangroves and at 600 m, as well as pelagic species such as Scomberidae (about 14 species). Some of these species have clear seasonality, some represent a reef fishery, while other species represent the deep-sea fishery on the border of the platform or pelagic fishery, and they are caught with different fishing gears, making difficult any attempt of fishing effort standardization.

To analyse the catch, it is necessary to identify individual species or groups of species; thus, the current commercial classification must be complemented with biological criteria. On this subject, it has been demonstrated that the concept of 'complex ecological fishing' (Baisre, 1985) could be an approximation of high methodological and practical value (Silva and Colom, 1996; Herrera, 2000). One of the key concepts to achieving clear statistics is categorizing resources harvested, so that catch, effort, and size and sex composition registries can be carried out in a relatively easy manner to obtain reliable statistics.

7.2 Biological and ecological fishing research

The Dominican Republic does not have a fishing research centre, nor does it have a national research plan to respond to scientific needs for fisheries management. Some governmental institutions, such as the Centro de Investigaciones de Biología Marina (the Center for Marine Biology Research) and the Acuario Nacional (National Aquarium), have temporarily adopted these functions through specific projects. Even more relevant than these endeavors are the results obtained by non-governmental organizations, such as the CEBSE, Grupo Jaragua, Centro para el Desarrollo del Noroeste, and Programa EcoMar (CEBSE, Jaragua Group, Center for the Development of the northeast and EcoMar Programme). Despite their limitations in time and geography, these efforts have created the basis for the Dominican Republic fish biology studies over the long term (e.g. Table 4). Coastal provinces have been the pilot areas for these endeavors, and thus the available information is concentrated in those areas (Montecristi, Samaná, La Altagracia and Pedernales). There is practically no information in the remaining provinces. There is some isolated information on pelagic resources from regional institutions that have included Dominican waters in their study areas. All these results, which are presented in Table 7, belong to isolated efforts.

Shrimp fishery data: There are only general descriptive works on the shrimp fishery: key species, fishing gear and number of fishers (Núñez and García, 1983; Silva and Aquino, 1993; Then *et al*., 1995). Sang *et al*. (1997) offer some data on size and catches of accidental species.

TABLE 7
Projects that have contributed to the Dominican Republic fishing research. Coastal provinces: Barahona (BH), Pedernales (PD), Samaná (SA) and La Altagracia (LA)

Year	Name of the project	Area	Sponsors/ participants
1980	Fishing development in the Dominican Republic	General	FDL/INDOTEC
1987–1995	Promotion of artisanal coastal fishery at the south littoral	BH, PD, AZ	GTZ/SEA
1992–1996	Fishing communities involvement in the co-management of fishing resources in Samaná Bay	SA	FF/CEBSE
1993	Parks in peril: National park of the east	LA	TNC/MAMMA/ PRONATURA
1993–1996	Biodiversity inventory and characterization of the communities around Samaná Bay and Peninsula	SA	HELVETAS/CEBSE
1995–1998	Conservation and management of the marine coastal biodiversity in the Dominican Republic	MC, SA, PD	PNUD/ONAPLAN/ CEBSE/GJI/CIBIMA/ CIDEN
2002–2003	Fishing and ecological research of the lobster *Panulirus argus*	PD, SA, AZ	Programa EcoMar, Inc.

Acronyms: CIDEN: Centro para el Desarrollo del Noroeste; CEBSE: Centro para la Conservación y Ecodesarrollo de la Bahía de Samaná y su Entorno; CIBIMA: Centro de Investigaciones de Biología Marina; FDL: Fisheries Development Limited; FF: Ford Foundation; GJI: Grupo Jaragua, Inc.; GTZ: German International Cooperation Agency; HELVETAS: Switzerland Association for Development and Cooperation; INDOTEC: Instituto Dominicano de Tecnología Industrial; JICA: Japan International Cooperation Agency; MAMMA: Fundación Dominicana Pro-Investigación y Conservación de los Recursos Marinos; ONAPLAN: Oficina Nacional de Planificación; SEA: Ministry of Agriculture; TNC: The Nature Conservancy; UNDP: United Nations Development Programme.

Lobster fishery data: All the information on the lobster fishery has been recently summarized by Herrera and Betancourt (2003b–2003d), who offer the first diagnosis of the resource. Information comes from catches on 60 landing sites in the coastal provinces of Pedernales, Samaná, El Seibo, Hato Mayor and Azua, where 3 594 lobsters were measured, sexed, and had their reproductive condition assessed. Lobsters were caught between 2 and 37 m of depth, in 3 325 traps (as well as by diving or using gillnet). Sites, gear and fishing methods are described for this fishery; selectivity of wire traps and Haitian traps are compared; structure of size (by sex, fishing areas and depth) are analysed; and catch and effort data are assessed. This analysis enabled the identification of the primary problems in the management of this fishery, as well as offered specific recommendations for organization of the fishery and the implementation of future regulations. The lobster (*Panulirus argus*) also underwent a Postlarvae Recruitment Monitoring Programme, which was developed but not completed (Herrera, 1996).

Queen conch data: There are some general fishing evaluations on queen conch (Appeldoorn, 1993, 1997), but the most complete fishing-biological works are by Tejeda (1995a–1995c), which offer a complete description of the fishery in Pedernales, including size structure, habitat, distribution, morphometry of the shell, areas and fishing gear, catch data by effort unit by area and depth, and production estimations. More recent ecological work has been focused on larvae studies (Vargas and Billini, 2000) and abundance estimation, distribution, and juveniles and adults size structure in the marine protected areas in Parque Nacional Jaragua (Jaragua National Park) in Pedernales (Delgado *et al*., 1998; Posada *et al*., 1999, 2000) and Parque Nacional del Este (east National Park) (Torres *et al*., 2000; Torres and Sealey, 2002a, 2002b).

Oceanic banks fishing data: Arima's studies (1997, 1998a–1998c, 1999a–1999c) are the only data on fishing operations with bottom longline on the oceanic banks Navidad and Plata between 90 and 600 m of depth. The information relates to seasons, depth, species, catch weight and fishing effort for about 16 species, among which there are key species (*Lutjanus vivanus, Lutjanus bucanella, Etelis oculatus* and *Pristipomoides macrophtalmus*). These biological data can be the basis for future assessments of fishing stocks on the oceanic banks, and have special relevance when comparing key species on the coastal platform and the oceanic banks fisheries (Table 8).

TABLE 8
Comparison of weight data (in grams) of the species and frequency (in percentage) in the catch of four key species caught on the oceanic banks and Samaná Bay

Local name	Scientific name	Weight range (g)		Catch frequency (%)	
		Samaná platform	Oceanic banks	Samaná platform	Oceanic banks
Ruama	*Pristipomoides macrophthalmus*	92–432	227–953	0.3	93.0
Queen snapper	*Etelis oculatus*	386–964	227–2 903	0.1	90.6
Ojo amarillo	*Lutjanus vivanus*	92–1 132	454–3 629	0.3	11.6
Ala negra	*Luthanus bucanella*	154–1 364	544–1 724	0.2	10.5

Source: Based on Arima, 1999c and Sang *et al*., 1997.

Pelagic fishery: Lee and Aquino (1994) and Colom and Tejeda (1995a) offer the first data on catch-per-unit effort for the pelagic fishery with rafts in Barahona. Schirm (1995c) offers a more complete analysis in this type of fishery, including sites, fishing methods, species composition, abundance, resource seasonality, catch-per-unit effort, fishing yield, and management measures. Valdivia (2003) provides data on an experimental tuna fishery with longline. There is relevant research on pelagic species undertaken by Virginia University in oceanic waters, around Punta Cana, which includes marking and recapture of species and their habitat preferences (Graves, 2002; Graves *et al*., 2003; NOAA Fisheries, 2004). In particular, sport fishery data on marlin belong to Web pages that promote this type of fishery as a tourism option. Data include species, catch weight and seasonality (Just Us, 2006).

Fishing gear assessment in exploratory fisheries: Fishing gears have been assessed in certain fisheries, including: variation in species composition and catch for three types of traps (Aquino and Infante, 1994), the effect of trap mesh size on the size structure (Herrera and Betancourt, 2003a), and the comparison between bottom longline types in the catch of deep-sea fisheries (Arima, 1999c). Many fishing gears and methods have been tested, such as the trawl (Beck and Colom, 1994; Beck *et al*., 1994), bottom longline (Colom, 1994; Valdivia, 2003), depth line fishing (Aquino, 1994; Colom and Aquino, 1994; Colom and Infante, 1995), FADs (Lee and Aquino, 1994; Colom and Tejeda, 1995; León, 1996), handline (Tejeda *et al*., 1995) and traps (Lee, 1995; Tejeda and Feliz, 1995). All these studies provide specific data on species caught, catch volume and catch-per-unit effort.

There are inventories of fishing biodiversity in the provinces of Montecristi (Luczkovich, 1991; Geraldes *et al*., 1998), Samaná (Sang *et al*., 1997), María Trinidad Sánchez (Decena and Díaz, 1982), La Altagracia Sur (León *et al*., 1995; Schmitt, 1998), Santo Domingo (Geraldes *et al*., 1997), San Cristóbal (Terrero, 1989), Azua (Bouchon *et al*., 1995) and Pedernales (Silva, 1994; Reveles *et al*., 1997).

In general, fisheries biology studies have had a descriptive approach, whether economical, commercial, technological, social, taxonomical, or focused on gear assessment. Research on fishery biology with a long-term approach and with stock assessment of key species is practically non-existent. Despite the relevance in fishery biology of studying the size and sex composition of exploited populations with a spatial-temporal approach, there are no studies on this matter and much of the population data is inconsistent.

Due to the limited research efforts as mentioned above, according to Giudicelli (1996) it is difficult to undertake reliable assessments for maximum sustainable catch in Dominican waters. The only fisheries where population structure has been studied are queen conch (Posada *et al*., 1999, 2000) and lobster (Herrera and Betancourt, 2003b–2003d) in Samaná, Pedernales and Azua, where spatial distribution criteria has been derived for many life stages (nursery and reproductive areas), as well as direct proof of overexploitation in growing and recruitment stages. However, these fisheries have not been studied over a long enough duration to assess population parameters and thus there have been no attempts at some kind of fisheries modelling.

7.3 Fishery socio-economic research

Social and economic research on the fishery sector has not been a priority in the scarce studies undertaken, which have basically followed a descriptive approach. There are general data on the socio-economic characteristics of the fishing communities in Samaná (CEBSE, 1994), Barahona, Pedernales (Beck *et al*., 1994a; González *et al*., 1994, 1995a, 1995b) and Montecristi (Stoffle *et al*., 1994; Luperón, 1998). It should also be mentioned that Nolasco (2000) addresses gender issues.

7.4 Fishery environmental education

There are no national plans or programmes for fishers' environmental education. The NGOs have taken the responsibility of developing informative materials, as well as carrying out workshops and educational activities with fishers and coastal communities. There are important examples of environmental educational activities undertaken by PRONATURA in the Parque Nacional Submarino La Caleta (Submarine National Park La Caleta) in Santo Domingo (Vega, 1998), the Grupo Jaragua, Inc. (Jaragua Group, Inc.) in Pedernales (Reveles *et al*., 1997; Mateo *et al*., 2000), the didactic manual from Fundación Dominicana ProInvestigación y Conservación de los Recursos Marinos (MAMMA – Dominican Foundation for Research and Conservation of Marine Resources) (Geraldes *et al*., 2001), and the workshops in ecology and conservation of the lobster, carried out at the national level by Programa EcoMar, Inc. (EcoMar Programme, Inc.).

The only centre devoted to fishers capacity building is the Centro para el Desarrollo y Entrenamiento Pesquero (CEDEP – Center for Fishery Development and Training) in Samaná (SEA, 2000). This centre was donated by the Japanese government through the Japan International Cooperation Agency (JICA) and it is managed by SERCM. According to SERCM (2004), 150 professional fishers have been trained in the country, especially in Samaná and surrounding areas. This is a very low number considering that the centre has sufficient resources to train at least 50 fishers per month in its facilities.

JICA has provided important support to the development of artisanal fishers in Samaná. Japanese specialists have developed educational materials on every issue that could be relevant for artisanal fishers, such as freezing equipment, fish preparation and conservation, gear, fishing methods, use of GPS and ultrasound, repairing and maintenance of boats and engines, and basic knowledge on fishing cooperatives (Saito, 1999). All of these materials are in Hara's (1999) Manual of Fishery Techniques and Knowledge introduced in the Dominican Republic.

According to SERCM (2004), approximately 1 660 fishers in the south region received assistance from PROPESCAR-Sur, either in administration matters or in social organization and business management.

8. ISSUES AND CHALLENGES

Currently, there is much strength that we can rely on to improve the fishery system in the Dominican Republic. First, despite the above-mentioned deficiencies, there is a history and institutional organizational basis for the management and ordering of fisheries. Second, key issues are clearly identified for the main resources, as well as the necessary measures to start solving the problems. Third, there is a group of technicians who can face the challenge of taking fishery biology to a new level of development. Fourth, the development of the Environmental Management System (Sistema de Gestión Ambiental), promulgated by the Natural Resources and Environment General Law (Ley General de Medio Ambiente y los Recursos Naturales), provides the setting for addressing fisheries resources and coastal community impacts.

However, there are many gaps that have to be addressed in order to take advantage of the above-mentioned strengths, such as the lack of institutional assessment, management and fisheries control, as well as the absence of national plans for short-, mid- and long-term development, existing fragmented fishery legislation without efficient enforcement mechanisms, lack of reliable and precise fishery statistics, and the absence of fishery research institutions with scientific sustainability criteria to undertake socio-economic studies directed to the fishery sector.

The establishment of management institutions that are independent from the dynamics of the national political sector is one of the major challenges that the fishing sector faces. There is need for stable, experienced, responsible and knowledgeable institutions to develop and implement a long-term National Plan for Fishery Development in the Dominican Republic (Plan Nacional para el Desarrollo Pesquero de la República Dominicana). This plan must have an open scientific vision, promote modern and efficient legislation, include reliable statistical fishery systems, represent the reality of the national fishery in every aspect, position the country as a leader in fishery resource management, and firmly support international fishing commitments. One of the national challenges would be to create a scientific institution responsible for undertaking fishery biological studies of the national resources. This would concentrate the national experience and would assure (through research and projects) a move from the current descriptive research to the assessment and modelling of fisheries.

8.1 Institutionalism

If we really want to start assessing and managing our fisheries resources in a rational manner, the Dirección de Recursos Pesqueros (DRP – Fishing Resources Directorate) of SERCM must become a scientific institution for national fisheries management (stable and long-lasting), independent from political changes, rather than the current situation where office personnel are removed every four years. It would be necessary to implement policies for hiring technical personnel, as well as developing specific programmes to educate the authorities in the sustainability of coastal zone management concepts. The fishing sector requires clear administrative direction by implementing strategies based on technical, ecological, economic and social criteria to achieve rational management.

8.2 Fishery sector plans and policies

It is necessary to review the fishery plans developed since 1980 to the present, to identify the positive aspects related to fisheries development and elaborate a unified and definitive National Plan for Fishery Development in the Dominican Republic, which would identify solutions for all the sector's issues and gaps. Based on the changes in the world economy, this plan should consider a subject that has never been addressed before: the relationships between the fishing sector stages (commercialization, distribution, export and import) to establish the sector trends in relation to current global economy processes. It is necessary to develop clear policies for each of the sector components, especially for the most vulnerable element: the fishers.

8.3 Diffusion and fishery legislation

It is necessary to develop pieces of legislation unified in a General Law of Coastal and Marine Fishery Resources in the Dominican Republic to incorporate the country's international commitments. Legislation should be explicit in terms of the resources being regulated and the specifications of the minimum legal size, closure periods and protected areas; and the legislation must be based on the ecological and biological scientific knowledge of fishing resources. Regulations for those resources that are not yet regulated should be developed, and stricter legislation should be assessed for protected resources. Regulation should clarify that fisheries' resources cannot be exploited prior to the undertaking of experimental fishing and population assessments. The updating and complementation of fisheries legislation should be accompanied by efficient administrative and enforcement mechanisms, as well as by effective diffusion mechanisms that reach every level of the fishery sector. Environmental education programmes should be developed by governmental and non-governmental institutions to teach the biological, ecological and conservational aspects supporting the regulations. This would allow for understanding the regulations as a means of preserving the resources that support the fishery, and not just as restrictive rules. In this sense, diffusion of the FAO Code of Conduct for Responsible Fisheries is essential.

8.4 Fishery statistics

It is necessary to implement a national fishery resources organizational system that includes economic (commercial categories) and ecological (resources, fishing type, fishery ecological complex) criteria to define general categories, which would provide the basis for the systematic compilation of the fishery biological information. It is necessary to develop and maintain a fisheries statistics system for the Dominican Republic, which would include a permanent inventory of species composition, length, weight, catch, effort, as well as other fishery biology data to assess the evolution of the fisheries and develop predictive models. To contribute to controlling fishing activities it is necessary to start planning the establishment of catch assessment and monitoring centres in at least some key areas in every coastal province, in particular those with major potential such as Montecristi, Puerto Plata, Samaná and Pedernales.

8.5 Establishment of INDOPESCA

An important aspect for the assessment and management of the Dominican Republic fishery would be the creation of the Instituto Dominicano de Investigaciones Pesqueras (INDOPESCA – Dominican Fishery Research Institute). INDOPESCA would be responsible for designing and implementing the fishery biology research plan, which should include comprehensive studies of distribution processes and life cycles of the fishery resources, as well as address, for the first time, relevant aspects such as stock assessment and population dynamic studies of our main resources. It should also include fishery productivity estimates, with an emphasis on important areas such as the slope edge and La Navidad and La Plata oceanic banks which encompass highly valued reproductive stocks. INDOPESCA would also be responsible for baseline social and economic studies of the fishery sector, as well as advising official institutions for the protection of fishery resources through cutting-edge assessment and management criteria. Moreover, INDOPESCA would play the main role in fisheries environmental education and technical assistance to the national fishery sector.

8.6 Conventions/agreements and organizations/institutions

It is essential to review and update the national and international agreements on fishing and fisheries resources, which have been subscribed to by the Dominican Republic. Therefore, it is crucial to create an office to address these issues while working closely with the Ministry of International Affairs. It is crucial to analyse our participation in and commitment to current agreements, and identify inaction on agreements that could be relevant for national development. The same applies to our involvement in regional organizations or institutions related to fishery cooperation. This would allow for improving the fishery sector with international financial and technical support.

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