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EXPERT CONSULTATION ON INTERACTIONS BETWEEN SEA TURTLES AND FISHERIES WITHIN AN ECOSYSTEM CONTEXT

Rome, 9–12 March 2004

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PREPARATION OF THE DOCUMENT

This volume includes the final version of the papers presented at the Expert Consultation on Interactions between Sea Turtles and Fisheries within an Ecosystem Context, held in Rome, Italy, from 9 to 12 March 2004.

The views expressed in this publication are those of the authors and do not necessarily reflect the views of the Food and Agriculture Organization of the United Nations.

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ABSTRACT

An Expert Consultation on Interactions between Sea Turtles and Fisheries within an Ecosystem Context was convened by FAO and held in Rome, Italy, from 9 to 12 March 2004. The meeting was attended by 11 experts from seven countries, covering expertise related to sea turtle biology and conservation, fishing gear technology, fisheries management and socio-economics. The Expert Consultation was organized to provide technical input to the Technical Consultation to take place in Bangkok, Thailand, later in 2004, as agreed at the twenty-fifth session of the Committee on Fisheries (COFI), held in Rome, Italy, from 24 to 28 February 2003. This document includes all the contributions prepared by the participating experts as background information to the Expert Consultation.

The first four papers provide an overview of available information on biology, distribution and main sources of natural and man-induced sea turtle mortality for the Atlantic, Pacific and Indian Oceans and the Mediterranean Sea, respectively.

Gear technology developments to reduce impacts on sea turtles are reviewed in papers 5 to 7. Special emphasis is given to the Turtle Excluder Devices (TEDs) and mitigation measures in pelagic longline fishing. Management experiences in reducing sea turtle bycatch in coastal fisheries, including implementation of technology standards and area/time closures, are covered by paper 8.

Examples of conservation efforts aimed at preserving nesting beach habitats and at preventing direct take of sea turtles and their eggs are presented for two locations in Indonesia (paper 9). The examples show the importance of community empowerment in the implementation of conservation measures.

Finally, paper 10 describes an important case study from the State of Orissa (India). Here olive ridley turtles congregate in large numbers in the shallow coastal waters that also happen to be the richest fishing grounds and the source of livelihoods for traditional fishing communities in that region. Experiences made in implementing various management measures to reduce sea turtle mortality due to fishing are presented, with particular emphasis on the consequences that these have had on traditional fishing communities.

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Sea turtles population dynamics, with special emphasis on sources of mortality and relative importance of fisheries impacts – Atlantic Ocean

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Abstract

This document reviews available information on biology, distribution and main sources of natural and man-induced mortality of the six sea turtle species that occur in the Atlantic Ocean. Direct take of sea turtles has been a major source of stock collapses in this area, but several other threats, including incidental capture in fisheries, are also causing concern as important sources of further declines in already strongly reduced populations. In some cases, however, conservation activities and appropriate management measures have resulted in sea turtle populations becoming stable or even increasing.

INTRODUCTION

The amplitude of the Atlantic Ocean allows a great diversity of ecosystems that favour the development of abundant fauna, including marine turtles, which are distributed throughout the tropical and temperate waters. The habitats preferred by these species range from wide prairies, with abundant sea grass and marine algae, to the rocky–sandy bottoms and coralline areas rich in bottom-dwelling organisms. The pelagic environment with abundant nekton fauna is also important, providing developmental areas and an adult habitat. Different species of turtles have different requirements during reproduction periods, during their migrations to feeding grounds, in the areas of growth and migratory corridors. Consequently, they are not distributed in a homogeneous way – there are areas of great abundance and areas of low density or total absence. As far as the distribution of turtles is concerned, the western part of the Atlantic Ocean has more areas of major importance than the eastern part, but perhaps this also reflects the fact that more studies have been conducted in the western Atlantic than elsewhere and research is more advanced in this region. Accordingly, information on fisheries, biology and related aspects is more abundant for the western part of the Atlantic and difficult to obtain for the eastern part. As a consequence, this report is not exhaustive and hopefully more information will be available in the near future.

IDENTIFICATION OF SEA TURTLE POPULATIONS (MANAGEMENT UNITS)

Species and subspecies of marine turtles are distributed throughout the tropical and subtropical seas. The different species and subspecies can be differentiated by their morphology, behaviour and geographical distribution. The populations can be characterized by their reproductive and feeding behaviour and by their distribution and migratory patterns. Another particularity of the populations is the tendency to come together periodically in the feeding and breeding grounds. They also display great fidelity, returning to the same beach season after season to reproduce. According to the characteristics mentioned, in the Atlantic each species or subspecies can be separated into populations, although for the great majority there are not enough studies to allow a conclusive definition. Recent genetic studies have shown that populations can mix in the feeding grounds, which makes it even more difficult to study them.

Genus *Chelonia*
Common names: green sea turtle (English), tortue verte (French), tortuga blanca (Spanish)

The genus includes one subspecies (*Chelonia mydas mydas*), distributed throughout the tropical and subtropical parts of the Atlantic Ocean, particularly in areas with abundant sea grass and marine algae. It is known that some populations make long migrations from feeding to breeding grounds, sometimes several thousand kilometres apart. The periods of higher abundance on the beaches are the months of summer and autumn. The reproductive cycle generally repeats itself every two or three years.

Populations inside a limited geographical range can be distinguished when they are present on the nesting beaches, although a certain amount of overlapping between contiguous populations is possible, mainly in the feeding grounds and migratory corridors. Besides, it is not an infrequent occurrence that the same nesting beach is visited by two or more species, although what normally happens is that their nesting periods are synchronized in a successive way, producing minimum overlap in terms of time and space. According to the distribution of the reproduction areas, for *Ch. mydas mydas*, important populations can be distinguished inhabiting the following areas.

Western Atlantic – east of Florida, western Gulf of Mexico, the whole peninsula of Yucatan, Nicaragua and Costa Rica, islands to the north of Venezuela (including Aves Island), Suriname, Brazil (from Pará to Sergipe), the Bahamas, southwest Cuba, Grenada, Saint Vincent, etc. (Sternberg, 1981; Márquez, 1990). The feeding areas are not well defined but apparently occur in shallow waters, from the north of Florida, inside the Gulf of Mexico, across the Caribbean and continue scattered until the mouth of the Rio de la Plata, Uruguay.

Eastern Atlantic – turtles are less abundant in this region, which stretches from the northern Iberian Peninsula and continues all the way down the African coast to Angola. Investigations carried out by Fretey (2001) indicate evidence of nesting and feeding in: Guinea-Bissau, Equatorial Guinea, Ghana and the Islands of Sao Tome and Principe. Areas of growth also exist off the coast of Mauritania, Gambia, Senegal, Ghana, Gabon and southern Angola and, in addition, the Canary Islands, Cape Verde and Ascension Island.

Genus *Caretta*
Common names: loggerhead turtle (English), tortue caouanne (French), caguama (Spanish)

The genus includes one subspecies (*Caretta caretta caretta*) that can be found throughout tropical and subtropical Atlantic waters. It often enters bays and has been observed swimming along marine currents, far from the coast. Juveniles have been recorded navigating in flotillas near the Bahamas, the Azores (juveniles of 10–55 cm carapace length, Bolten *et al*., 1993), Bermuda, Madeira (juveniles of 20–60 cm carapace length, Bolten *et al*., 1993), west of Gibraltar and off the Canary Islands and Cape Verde. Because this species feeds mainly on crustaceans and molluscs, it can be observed at greater depths than those at which *Chelonia* are typically found. Using the nesting areas as an index (the most reliable one), some of the most important populations are found in the following localities:

Western Atlantic – the species has been recorded from Virginia to Florida, the highest concentrations of nests are found in South Carolina, Georgia and eastern Florida; in the Caribbean there is some nesting in the Bahamas and Isla de la Juventud (Cuba); in the Gulf of Mexico nesting is rare, except in the east of Yucatan, where there are breeding colonies of some importance, such as that on Cozumel Island. There is also scattered nesting in the rest of the Caribbean, in Central America and on the coast of Brazil.

Eastern Atlantic – it is less abundant than in the western Atlantic, although there is information on its presence in important numbers in the Canary Islands, Madeira, the most important islands of Cape Verde, in Senegal and Namibia. There are records of feeding grounds from Morocco to Namibia, although there is little information on the abundance of populations in feeding and breeding grounds (Sternberg, 1981; Márquez, 1990; Fretey, 2001).

Genus *Lepidochelys*

Species *Lepidochelys kempii*
Common names: Kemp's ridley turtle (English), tortue de Kemp (French), tortuga lora (Spanish)

This species has a restricted geographical distribution – the adults are observed only in the Gulf of Mexico, although there is also a record in Santa Marta, Colombia. However, part of the population of juveniles and pre-adults seems to wander among tropical and temperate coastal waters of the northwest Atlantic (Márquez, 1990). Their migration routes generally follow the continental shelf and the juveniles and immature turtles can reach the northwestern temperate waters of the Atlantic. They may even cross the Atlantic in an accidental way, sometimes reaching the English Channel. There are also records from the islands of Madeira and the coast of Morocco, but going south the records are more uncertain (Sternberg, 1981; Márquez, 1990). Occasionally, some individuals are surprised by the coolness of winter outside the warm areas of the Gulf of Mexico and they survive the low temperatures in a kind of winter lethargy. Turtles in this condition can be found in places such as Chesapeake Bay, Virginia and Cape Canaveral, Florida. The most important nesting ground in Mexico can be found on the coast of Tamaulipas, Veracruz. It is a small breeding colony. There are some recent reports of isolated nesting in Texas and Florida (Shaver, 2000; Johnson, Yeung and Brown, 1999).

Species *Lepidochelys olivacea*
Common names: olive ridley turtle (English), tortue olivatre (French), tortuga golfina (Spanish)

The olive ridley inhabits mainly the Pacific Ocean, with some populations of a certain importance in the western Atlantic, where it is restricted to South America. It nests chiefly in Suriname and French Guiana. There are sporadic records in the Caribbean (Cuba and Puerto Rico) (Márquez, 1990; Moncada *et al.*, 2000), but without nesting records. This is a highly gregarious species – the presence of large flotillas in the open sea is well documented. There are some small colonies in the eastern Atlantic. The northern limit is not clear, but may be found in Mauritania or Senegal. The species has nesting points between Guinea Bissau and Angola, in particular in Cameroon, Equatorial Guinea, Sao Tome and Angola (Fretey, 2001).

Genus *Eretmochelys*
Common names: hawksbill sea turtle (English), tortue caret (French), tortuga de carey (Spanish)

The genus includes one subspecies (*Eretmochelys imbricata imbricata*) that congregates in small, loosely knit groups, occupying wide areas around almost all the tropical rocky and coralline coastal habitats. The hawksbill turtle lives in environments with abundant benthic fauna (sponges) and meadows of marine vegetation, where they find shelter and food. Hawksbills often migrate regularly between feeding and breeding grounds, which are usually close to one another. These turtles nest during the night, without forming large *arribazones* (the arrival of large groups), and solitary nesting is most common. To nest, they look for isolated areas with vegetation near the beach, surrounded by shallow water with a coralline or rocky bottom. The reproduction period occurs in spring and summer, although it varies between localities.

Western Atlantic – it is not abundant in the north of the Gulf of Mexico. In Mexico it nests mainly in the southeast, in the states of Campeche and Yucatan. In the Caribbean, nesting takes place in Cuba, Saint Vincent, Puerto Rico, Virgins Islands, Saint Croix, Panama, Guyana, Suriname, French Guiana and Colombia. In Brazil there is scattered nesting between Pará and Espirito Santo (Sternberg, 1981; Márquez, 1990). The feeding and growth areas extend from the Straits of Florida, the Gulf of Mexico and the Caribbean Sea to the central-south region of Brazil.

Eastern Atlantic – hawksbills are less abundant here than on the western Atlantic coast. They can occasionally be observed in the Macaronesian Islands (the Canaries, Madeira and the Azores) and even in the Cape Verde Islands. They are present from Mauritania to Angola. Nesting grounds are more frequent between Guinea-Bissau and the Congo, but hawksbills also nest on the region's islands. Their presence is generally associated with rocky and coralline coasts. The coralline habitat is not frequently found along the coast of this part of Africa (Fretey, 2001).

Genus *Dermochelys*
Common names: leatherback turtle (English), tortue lute (French), tortuga laud (Spanish)

The genus includes one subspecies (*Dermochelys coriacea coriacea*). The leatherback turtle can support lower temperatures than other sea turtles and can thus also be observed in temperate waters. The species displays pelagic behaviour and cannot easily be observed near the coast, except during the reproduction season. Leatherbacks are not abundant in the Atlantic Ocean, but there are some beaches where nesting is significant. On the high seas the turtles form small flotillas and can generally be observed in areas of loops, fronts and sea upwelling, where the organisms they feed on congregate (Márquez, 1990 and 2000). This species migrates over long distances.

Western Atlantic – there is sporadic nesting in the Gulf of Mexico (Márquez, 1990), but this species reproduces with more frequency on the southern Caribbean coast and islands, especially between Nicaragua and Panama, in Saint Lucia and Trinidad, and there are important nesting beaches in Suriname and French Guiana (Sternberg, 1981). Low-density feeding groups are observed from the eastern coast of the United States to Uruguay.

Eastern Atlantic – as for the American coast, the distribution is very wide, but leatherbacks nest only on a few beaches between Mauritania and Angola. The most important breeding grounds are in Gabon, the Congo and Angola. There are some recaptures of turtles coming from French Guiana, Guyana, Suriname and Trinidad (Fretey, 2001). Knowledge on the extent of the feeding and developmental areas in this region is scarce.

POPULATION ABUNDANCE ESTIMATES

It is often difficult to estimate the size of a sea turtle population, principally because the distribution range is wide and discontinuous, and we generally have access only to the part formed by the adults. Usually it is not easy to observe juveniles and subadults, which rarely appear in the sampling surveys, with the result that the estimates are only partial. In general, abundance estimates are carried out by counting the number of females on nesting beaches, but because the females can nest several times in the course of a breeding season and nesting generally takes place at night, this method is far from perfect. A direct count of the nests deposited on the beach is easier and can be an appropriate index to quantify the number of females breeding in each season, especially if the reproductive parameters are known, such as the number of times that each female nests per season and if the reproduction cycle is annual, or every two, or more, years (Table 1). If these conditions are known, it is possible to follow the evolution of a certain population of females over time. To estimate the total population, it is necessary to include the males, which is more difficult, since they behave in a different way as compared to the females. It is easier to observe them in the feeding areas than in reproduction areas, although with some species it is possible to watch the males swimming around the females during the breeding season, although generally the number of males is lower.

Thus the simplest way to follow the trend of the population is to count the number of nests produced each season while assuming a) that the number of nests laid per female will be constant over time and b) the nesting cycle remains the same.

The information available in the literature is often qualitative and anecdotal, indicating just the nesting level, e.g. “low”, “medium”, “large”, “uncertain” or “none”. Reports may be compiled for one or two years, which makes it difficult to make comparisons and follow changes in the abundance of populations over time. Only in a few cases has the research been more constant, conducted over a period of ten years or more. Examples are *L. kempii* in Tamaulipas, Mexico, *C. caretta* on the southeast coast of the United States, *Ch. mydas* in Costa Rica and Brazil, *D. coriacea* in French Guiana, *E. imbricata* on the Yucatan Peninsula, Cuba and Puerto Rico. Such information regarding the eastern side of the Atlantic is nearly impossible to obtain, which makes it more difficult to reach conclusions and any degree of certainty about quantitative changes concerning the sea turtle populations in the region.

Table 1 includes general and averaged data about the reproductive characteristics of the different species (Márquez, 2000). To estimate abundance in more detail these values should be included, but determined for each nesting population, since we know that these parameters may have slight variations among different populations of the same species. In general, marine turtles are able to spawn successfully in one season more often than indicated in Table 1. However, for various reasons, such as physiological status, environmental changes and behavioural patterns, it is better to use the average values.

Table 1. Average nesting frequency in Mexico, by season and reproductive cycle

Species	**Spawns (times)**	**Cycle (years)**
C. caretta	4.0	2.3
Ch. mydas	4.0	2.3
E. imbricata	3.5	2.3
L. kempii	2.4	1.5
L. olivacea	2.3	1.5
D. coriacea	5.5	2.3

Tables 2 and 3 show some of the available nesting data on marine turtles in the Atlantic, including the number of nests per season. An approximate number of female turtles can be obtained using the information in Table 1. The total size of the population is not usually available for any of the species. Information regarding the African coast is meagre, or was not available to the author. Fretey (2001) put together a detailed compilation of the information on sea turtles on the Atlantic coast of Africa, which should be reviewed with more thoroughness to arrive at better conclusions than those reached in this paper.

Table 2. Nesting abundance of sea turtles on Atlantic Ocean beaches.
Approximate average number of nests in 2000 [(a, b,i)]

Species	**Gulf of Mexico** [a]	**Caribbean Sea** [b]	**Western Atlantic**	**Eastern Atlantic**	**Total** [i] **nesting**
Green turtle	7 450	1 400	10 000 [c]	>1 500	>20 350
Loggerhead	1 640	1 900	90 000 [d]	unknown	>93 540
Hawksbill	5 600	4 500	>1 200 [e]	>500 [h]	>11 800
Olive ridley	00	00	>1 000 [f]	unknown	>1 000
Kemp's ridley [i]	8 200	00	00	00	8 200
Leatherback	~10	3 800	12 000 [g]	>29 500	>45 310

NOTES: [a] Mexico, [b] Cuba, Antigua, Dominica, Dominican Republic, Grenada, Saint Kitts and Nevis, Saint Lucia, Saint Vincent, Trinidad, Nicaragua, Venezuela, [c] Rough data from Florida, Suriname, Costa Rica (1980–1990), [d] East United States (Carolina to Florida, 1998), [e] Guyana, French Guiana, Suriname, Brazil (1993), [f.]Suriname, French Guiana, Brazil, [g.]French Guiana, Suriname (1998), [h] Guinea-Bissau and islands of West Africa, [i] Data for 2003.

Table 3 shows the sources of sea turtle mortality by specific level, but it is necessary to develop this information (at least the most important values) for each population or country.

Table 3. General diagnosis of the situation of the species/populations of marine turtles in the Atlantic Ocean. Sources of sea turtle mortality:
A - habitat degradation, B - tourism, C - pollution, D - natural predators, E - natural habitat changes,
F1 - direct fishing, F2 - indirect fishing.

Species/pop.	**Fraction**		**Present level (no. of nests)**	**Best estimation of mortality level**							**Population trend**	**Observations**
	Terrestrial	**Oceanic**		**A**	**B**	**C**	**D**	**E**	**F1**	**F2**		
Ch. mydas	Gulf of Mexico		7 450	M	M	M	L	L	L	M	Positive	
	Caribbean Sea		1 400	M	H	L	L	M	L	M	Positive	
	Western Atlantic		10 000	M	M	M	L	L	L	M	Positive	
	Eastern Atlantic		>1 500	L	L	L	L	L	L	M	Unknown	
C. caretta	Gulf of Mexico		1 640	M	M	M	L	L	L	M	Steady	
	Caribbean Sea		1 900	L	H	L	L	M	L	M	Unknown	
	Western Atlantic		90 000	M	M	M	L	L	L	M	Unknown	
	Eastern Atlantic		U	L	M	L	L	L	L	M	Unknown	
E. imbricata	Gulf of Mexico		5 600	M	M	M	L	L	L	L	Positive	Breeding ground
	Caribbean Sea		4 500	L	H	L	L	M	M	M	Decreasing	
	Western Atlantic		>1 200	M	M	L	L	L	L	L	Unknown	
	Eastern Atlantic		>500	L	M	L	L	L	L	L	Unknown	
L. kempii	Gulf of Mexico		8 200	L	N	M	M	L	L	M	Positive	Breeding ground
		Gulf Mexico	U	L	L	L	L	L	L	M	Positive	Feeding grounds
		NW Atlantic	U	L	L	L	L	L	L	M	Positive	Juveniles/subadults
L. olivacea	Gulf of Mexico		0	-	-	-	-	-	-	-	Absent	
	Caribbean Sea		0	-	-	-	-	-	-	-	Absent	
	Western Atlantic		>1 000	L	L	L	L	L	M	H	Decreasing	
	Eastern Atlantic		U	-	?	?	L	?	?	?	Absent	
D. coriacea	Gulf of Mexico		10	L	L	M	L	L	N	L	Unknown	
	Caribbean Sea		3 800	M	H	L	L	M	L	L	Positive	
	Western Atlantic		12 000	L	L	L	L	L	L	M	Unknown	
	Eastern Atlantic		29 500	L	L	L	L	L	L	L	Steady	

NOTE: Mortality level or trend: N - none, L - low, M - medium, H - high, U - unknown

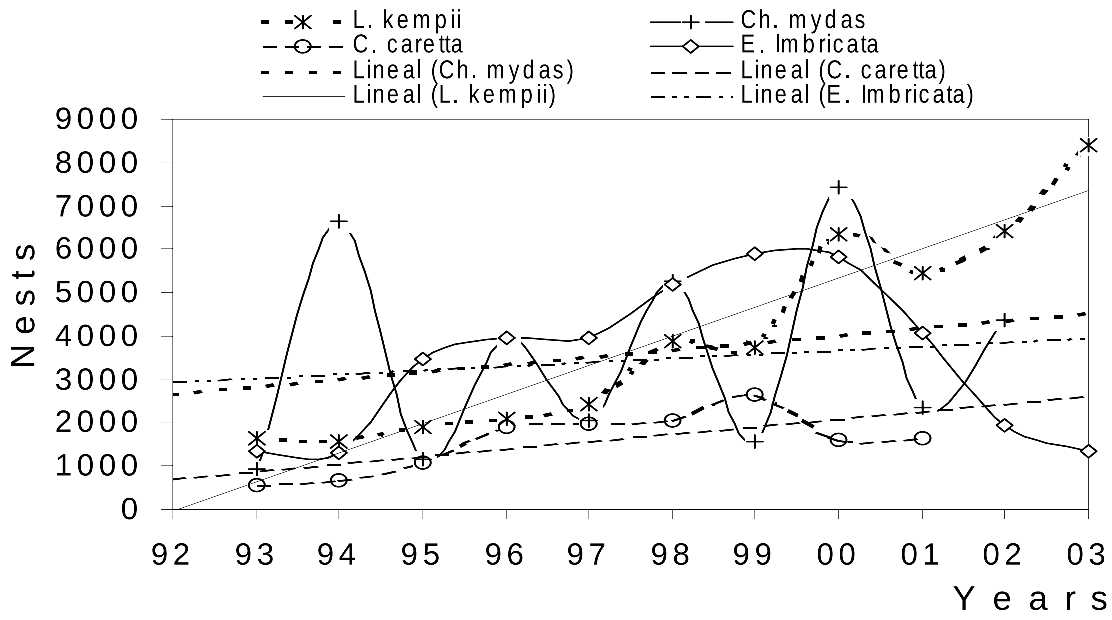

Figure 1. Nesting abundance trends of sea turtles on the eastern coast of Mexico. Data for the last two years shown are not complete for *Ch. mydas, C. caretta* and *E. imbricata*

The information in Table 4 and Figure 1 summarizes 10 years of data from the most important nesting beaches on the eastern coast of Mexico (Márquez, in press). The relative importance of reproductive behaviour was shown in Table 2, and all four of these species give us the impression that the trend in annual nesting abundance is positive, but with different values: the highest is that for *L. kempii* and the least positive trend is observed in *C. caretta.* Although the trend is positive, all populations remain at very low levels with respect to their historical levels. Moreover, in 2001 the work dedicated to the protection of the nesting of the species *Ch. mydas* and *E. imbricata* on beaches of the Yucatan Peninsula lost the level of priority that it had previously enjoyed and is now suffering from a budget shortfall. The work on the beaches has consequently been affected and the data on nesting abundance are incomplete (or, at least, the reduction that they show is not very clear).

Table 4. Equations of the nesting trend of sea turtles in eastern Mexico

Species	Equation	R
E. imbricata	y = 483.4x + 916.1	0.680
L. kempii	y = 598.59x + 345.12	0.882
Ch. mydas	y = 116.18x + 2721.6	0.023
C. caretta	y = 175.07x + 523.16	0.488

The information presented in Table 5 was used by the working group of the Regional Cooperation Programme on Marine Turtles of the Atlantic Coast of Africa to construct a rough estimate of the total number of nests recorded on the west coast of Africa. This work should be continued and more information obtained to improve these data.

Table 5. Approximate nesting and feeding abundance of sea turtles in the eastern Atlantic

Country/island	*C. c.*	*Ch. m.*	*E. i.*	*L. o.*	*L. k.*	*D. c.*	Comments
Madeira	F	F	f	f	r	f	
Cape Verde	N	?	?	?	r	?	
Senegal	?	?	?	?	r	?	? N, F
Guinea-Bissau	?	+1000	n	n	A	n	
Guinea	A	A	A	A	A	f	bycatch
Liberia	F	n, f	n, f	n	A	n	
Côte d´Ivoire	?	?	?	?	A	n	smuggling
Ghana	A	?n	A	?n	A	?n	?
Togo	A	f	f	n	A	n	smuggling
Benin	A	f	f	n	A	n	
Nigeria	A	f	f	?n	A	?n	
Cameroon	A	?f	?f	n	A	n	?
Gabon	A	?f	?f	n	A	29 700	935 tags
Congo	A	A	A	n	A	N	72 dead
Sao Tome and Principe	A	+500, f	A	A	A	A	460 tags

Source: Fretey, Billes and Dontaine, 2000

NOTES: Feeding: F = High, f = low; Nest number: N = high, n = low; ? = possible; + = more than…; r = rare, A = absent

A report concerning *L. kempii* and *C. caretta* in the western Atlantic has been produced by the Sea Turtle Experts Working Group, and published by the National Oceanic and Atmospheric Administration (NOAA) (TEWG, 2000). This report is a useful example of how to carry out detailed studies on the populations of marine turtles linked to the different regions of the Atlantic. At the present time we can say that several populations of the Atlantic region are increasing slowly, such as *L. kempii*, *E. imbricata* and *Ch. mydas* in Mexico, and *C. caretta* in the United States. The number of recorded nests of *D. coriacea* in Gabon was surprisingly large, but the population trend is unknown.

Trinidad has seen an increase in the numbers of leatherback nests on its northeastern coast, particularly at Grande Riviere. During the peak season of 2001, at least 300–400 females per night came ashore to lay their eggs. In 2002 the numbers declined considerably. The reason for this phenomenon is yet to be determined (D. Salvary, pers. comm.).

SOURCES OF SEA TURTLE MORTALITY

Mortality in sea turtles can have a variety of causes. Natural ones are, for instance, aging, predation, sickness, starvation and meteorological phenomena. The effects of these maintain the population's growth in balance. Anthropogenic causes can have effects that produce instability in the populations and can even bring them to extinction. These regulatory factors, both natural and anthropogenic, are common to all sea turtle species, affecting all their developmental stages, from eggs to adults, and because of this a solution that is found for the difficulties faced by some populations can be useful to others or used as an example to follow.

For the purposes of this paper we will try to describe briefly some anthropogenic causes that produce changes in the abundance of marine turtles. A good number of these causes that increase the mortality of the turtles have been identified, but the majority has not been quantified.

Inappropriate manipulation

It frequently occurs that, during conservation activities, mainly when eggs and hatchlings are managed on nesting beaches, there may be excessive manipulation and this, combined with a lack of knowledge, may cause much mortality among eggs and hatchlings. Excessive manipulation of eggs and hatchlings must be avoided, and hatchlings should be released as soon as they emerge from the sand to avoid encouraging inappropriate behaviour and introducing them to illnesses (Márquez, 2000).

When the small turtles are confined to small cultivation tanks for weeks or months, the crowded conditions favour the transmission of some illnesses. Moreover, in these circumstances the turtles frequently develop aggressive behaviour that causes heavy mortality. Turtles that survive to reach maturity can have lesions, such as the loss of the tips of the flippers, which reduces their capacity to swim and may create problems during mating. When the injured turtle is a female that has lost portions of the rear flippers, this can make nest construction difficult, increasing the mortality of the eggs during incubation because they are too close to the surface of the sand. Turtles with such lesions or any kind of illness must not be released (Márquez, 2000). There has not been any evaluation of these problems and their effects on wild populations.

Habitat degradation

The problem in these cases is that the degradation of the habitat reduces the ability of the populations to recover because, for example, when beaches are lost as a result of the development of tourism or industrial complexes, it becomes impossible or extremely difficult for the turtles to find suitable places to lay their eggs so that the embryos develop properly and hatch. There is no information on how much populations have been reduced as a result of these factors, nor are there data on the total amount of suitable habitat for turtles that has been lost.

There are many factors that cause habitat degradation and they can be very diverse, but because information on the size of the populations before the damage is done is so scarce, it is not possible to do an evaluation once the habitat has been degraded. Because such an evaluation is done in a rough way, it becomes just a piece of anecdotal information. The following are some examples:

- The area where the tourist facilities in Cancun Island, Quintana Roo, Mexico were built was an important nesting beach for green turtle (*Ch. mydas*) and loggerhead (*C. caretta*), but no evaluation was undertaken before or after the construction of the tourist complex. There are many similar cases along the coasts of the Caribbean and the Atlantic. This problem is increasing continually and the islands are more vulnerable to the deterioration of their ecosystems.

- The nuclear complexes are a serious threat to the sea turtles. A total of 45 turtles have been caught in the refrigeration systems of the nuclear power station of Crystal River, Florida. This type of data, which concerns a threat to nature, has recently been given much more attention by the American authorities. The National Marine Fisheries Service (NMFS) has now established a control programme concerning the nuclear power stations and how they affect biodiversity.
- Black rats introduced by man have infested sea turtle and sea bird nesting islands off the western Australian coast in the past. Generally, these islands have been uninhabited. The rats have been successfully eradicated from a number of these locations within the past 20 years (Dr R. Prince, pers. comm.). This problem is common all around the world.

Tourism, marinas and dock development

This has been commented on above. The problem is increasing everywhere. There is much more information, mainly anecdotal, which it is necessary to search for. Large marinas and dock development bring great habitat modification that excludes the sea turtles. Extensive developments can be found particularly in the western Atlantic, the Caribbean Sea and many parts of the northeastern Atlantic.

Collisions with boats

This is a frequent problem in localities such as river mouths and bays, and close to jetties. Not all species are affected at the same rates – accidents are more common with juveniles and subadults of *Chelonia, Lepidochelys* and *Caretta.* There were no quantitative data available in the information sources consulted. Some information is provided in the tables of Appendix 2, found in the paper NMFS-SEFSC (2001).

Construction blasting

Not much information is available, but one example is the study made by the National Marine Fisheries Service to evaluate the effect of the longline fishery on sea turtles of the western Atlantic (NMFS-SEFSC, 2001). Tables 1 and 2 (Appendix 2) include some data on the mortality of sea turtles caused by dredging and blasting in channels and marinas in the Atlantic and the Gulf of Mexico. The mortality occurs with adult and immature turtles of all the species. The annual number of deaths reported is as follows: first loggerheads (about 100), next Kemp's ridley and green turtles (20 each) and finally the hawksbill and leatherback (fewer than 10).

Pollution

Debris

Plastic trash such as bags and bottles floating in the sea can affect sea turtles, particularly leatherbacks, which can mistake these materials for food. The World Wildlife Fund for Nature (WWF) reported that free-floating monofilament nets have resulted in a number of turtle deaths and are of concern to the turtle researchers. Dumping trash in the sea is a common practice that has a deleterious effect on marine organisms, including sea turtles. Unfortunately, in many countries governments have taken little action and show little interest in reducing the extent of the problem.

Agricultural and industrial pollution and domestic sewage

This is an extensive problem. All countries contribute to a greater or lesser degree in the contamination of the oceans. Many of them have laws and regulations that are not enforced This happens in a large part of the world, increasing day by day the negative effect on the survival chances of the different marine species, including sea turtles. The degree of contamination in the oceans must be evaluated and the necessary measures to correct these problems enforced. Large cities can contribute to the contamination and the problem may be linked to the increase of "fibropapilomatosis" in sea turtles and other marine vertebrate animals.

Oil/gas exploration and exploitation

Events with negative effects occur frequently in continental shelf areas around the world. Oil spills are common – some are caused by oil tankers, some occur in the oil fields by accident and some take place when oil rigs of submarine wells are retired, particularly when explosives are used (Márquez, 2000). The Ixtoc well in Campeche Sound provides an example of such an oil spill. The accident happened in July 1979, at the end of the Kemp's ridley nesting season (Márquez, 1994), affecting the migration of several thousands of newborn hatchlings. Hall, Belisle and Sileo (1983) have reported the effects of the Ixtoc spill in sea turtles: "There is evidence of oil in all the tissues examined and indications that the exposure had been chronic. Comparisons with results of studies done on birds indicate consumption of 50 000 ppm or more of oil in the diet of the turtles."

A study carried out by NMFS-SEFSC (2001) gives information (Tables 1 and 2, Appendix 2) on mortality related to this problem, which occurs in the Gulf of Mexico. Apparently the level of mortality is low, particularly of adult and immature loggerhead turtles (*C. caretta*). It is also reported that the problem can impact benthic immature turtles of this species and that it may affect the Kemp's ridley (*L. kempii*) too.

Other related activities include the gas drilling campaigns approved for Padre Island National Seashore in Texas. Each drilling operation involves ploughing an access road through the dunes, allowing hundreds of trips by tractor-trailer trucks up and down the beach, bulldozing a square-mile site or more for each well pad, and installing a 100-foot-tall rig. The drilling puts in jeopardy 25 years of work by the Park Service to bring the Kemp's ridley sea turtle back to the United States. This is the smallest and most critically endangered sea turtle in the world, with only about 3 000 to 5 000 adult females remaining. Padre Island is also the only location in United States where all five protected species of sea turtle in the Gulf of Mexico have nested. The main risk to turtles is the heavy trucks on the beach. The trucks could crush nests or pack down the sand so that hatchlings are unable to emerge from nests. Even the vibrations from rumbling trucks can increase the probability of embryonic damage or mortality, according to the official Sea Turtle Recovery Plan (F. Richardson and S. Narayan, pers. comm.).

Natural causes

Marine turtles are aquatic organisms that temporarily depend on the terrestrial habitat for reproduction. They nest on sandy beaches and when they do so the females, eggs and hatchlings can be decimated by predation. During this short period on land, hurricanes, high tides, extreme temperatures and humidity can all cause serious damage. In the sea the level of predation is high in all the initial phases of development and it continues during the long migrations between the feeding grounds and nesting areas. Such journeys usually last more than one year. The growth of the individual and the population depends on many factors, such as food quality/availability, genetic factors, temperature and illnesses. Because of this, some populations of the same species can grow and mature more rapidly than others. In general, almost all the sea turtle species that reach maturity in the tropical areas do so between the ages of 10 and 20. Rapid growth means less predation, so the carnivore species may mature more rapidly. All sea turtles, at least up to juvenile status, are carnivores.

During migration, sea turtles can be preyed upon or become weakened by the effort, which can increase mortality. Chesapeake Bay, Virginia (United States) provides an example: "The loggerhead (*C. caretta*) and the Atlantic ridley (*L. kempii*) are the two species that visit Chesapeake Bay. The sea turtle research at the Virginia Institute of Marine Sciences began in 1979 to determine the magnitude of sea turtles deaths in this bay. A large number (200–300 on average) of loggerheads die every year in the bay and are stranded on our beaches. Nearly all the turtles encountered are immature, and it is nearly impossible to determine the cause of death by autopsy. A contributing factor to the mortalities in the bay, both explained and unexplained, is the poor condition of many of our turtles when they first migrate in the spring" (Byles, 1985).

Density dependence

On occasion turtles, during the *arribazones* (large-scale arrivals), owing to the high density, can dig out the nests of their predecessor. The situation is compounded when the following arrival occurs in the same place, where there are incubating nests of the previous arrival, destroying the embryos of the old clutch and the eggs of the new nests.

Predators

Sea turtles, like any living organism, are vulnerable to predation; this vulnerability varies according to the developmental phase and the kind of predator. Obviously one of the most vulnerable stages is the egg phase. The eggs incubate at ambient temperature for nearly two months, exposed to climatic changes, atmospheric phenomena, predator attack and parasites. The most important loss, without including those for which human beings are responsible, takes place during or immediately after spawning, because the beaches are constantly searched by dogs and pigs, and in solitary places, by coyotes, skunks, badgers and raccoons, which rapidly attack the nests. If there are some remains of eggs and hatchlings in nests that have been opened, they are devoured by vultures, gulls, crabs and ants. During the final days before the hatchlings emerge to the beach surface, maggots of flies of the Sarcophagidae family, which can destroy the nest entirely, commonly infest nests.

Hatchlings are vulnerable to predation, especially when they emerge during the day, since they can be decimated in the run from the nest to the sea, which can be a journey of several dozen metres; they usually emerge between the evening and dawn. In this brief journey the hatchlings are attacked by crabs or devoured by mammals, such as feral dogs and pigs, coyotes, skunks, badgers and raccoons, or birds such as the night heron (*Nicticorax*), gulls, eaglets, auras (*Catartes*), vultures (*Coragyps*), ravens and crows.

During the migration at sea the hatchlings face other predators, particularly pelicans, frigates, gulls and cormorants, and a great variety of pelagic fishes and sharks. After the hatchlings move away from the coast any information on them becomes uncertain, until they have reached juvenile size, over 15 cm of total straight carapace length. However, it is logical to suppose that as the turtles increase in size, the variety of possible predators narrows.

Natural habitat changes

Meteorological phenomena can occasionally destroy all the nesting area on a beach, either through rivers flooding, erosion or excess rain. The death toll is greater if such an event happens during the peak of the nesting season or when hatching occurs. Hurricanes can generate high tides that cover the beaches for several days, causing the death of the eggs and the hatchlings. The erosion barriers that remain for a long time afterwards affect the turtles, which are not able to overcome them, and nesting and survival are negatively affected. Published evaluations of the damage caused by meteorological phenomena in the Atlantic were not available.

Fishing (direct)

Sea turtles and their eggs have in general been exploited over many centuries in a sustainable way. They were part of the daily diet in the villages of these coasts, especially the green turtle (*Ch. mydas*), which was even exported in the last century from, for instance, Mexico, Costa Rica and Nicaragua to the United States. The leather and the oil of this species and of the loggerhead (*C. caretta*) were marketed thoroughly in the region and handcrafts decorated with the tortoiseshell of the hawksbill turtle (*E. imbricata*) were sought after. In Mexico, as in many other countries, commercial exploitation was carried out using special nets and harpoons. Some turtles were caught illegally during the nesting process (Márquez, 1976). The level of commercial capture in Mexico between 1964 and 1981 is shown in Figs. 2 and 3. According to the number of years that were registered, the green turtle accounted for 67.9 percent in 17 years, the loggerhead 24.8 percent in 13 years, the hawksbill 1.13 percent in 9 years, leather 5.56 percent in 8 years and oil 0.6 percent in 7 years. In the missing years for these data, either there were no captures or data were not registered (Márquez, in press). In 1972 a total ban was declared and permits for commercial capture started to be issued again in mid-1973. After 1981 the government did not grant any more catch permits for the east coast and the statistical information was no longer recorded (Figs. 2 and 3). Finally, in 1990 (Márquez, in press) a new ordinance prohibited the capture and use of sea turtles throughout the country.

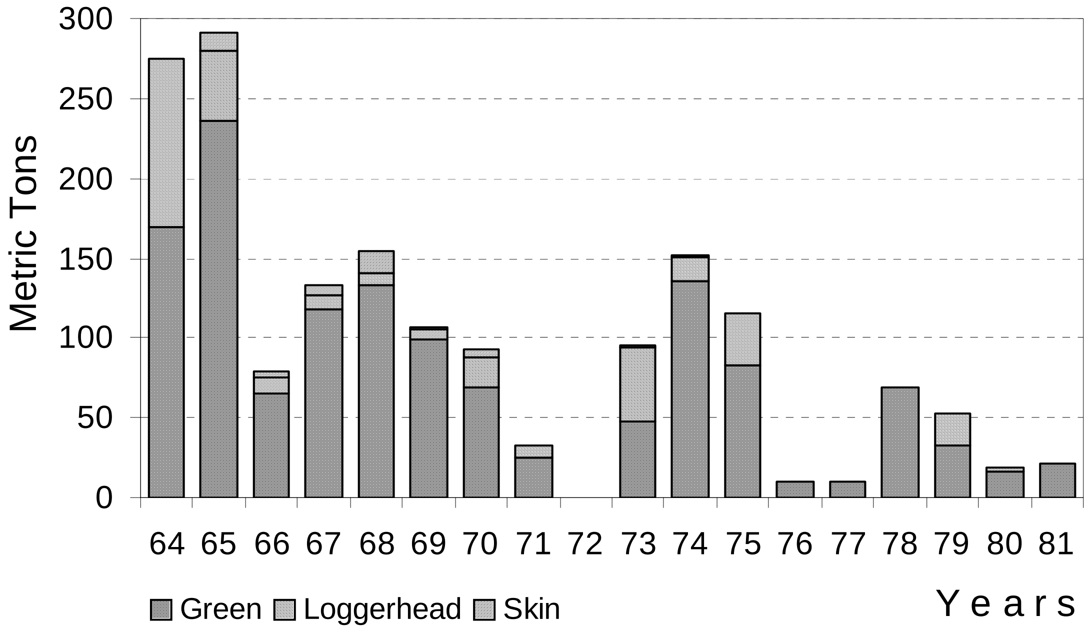

Figure 2. Reported commercial capture of the green (*Ch. mydas*) and loggerhead (*C. caretta*) turtles and leather in Mexico, 1964–1981

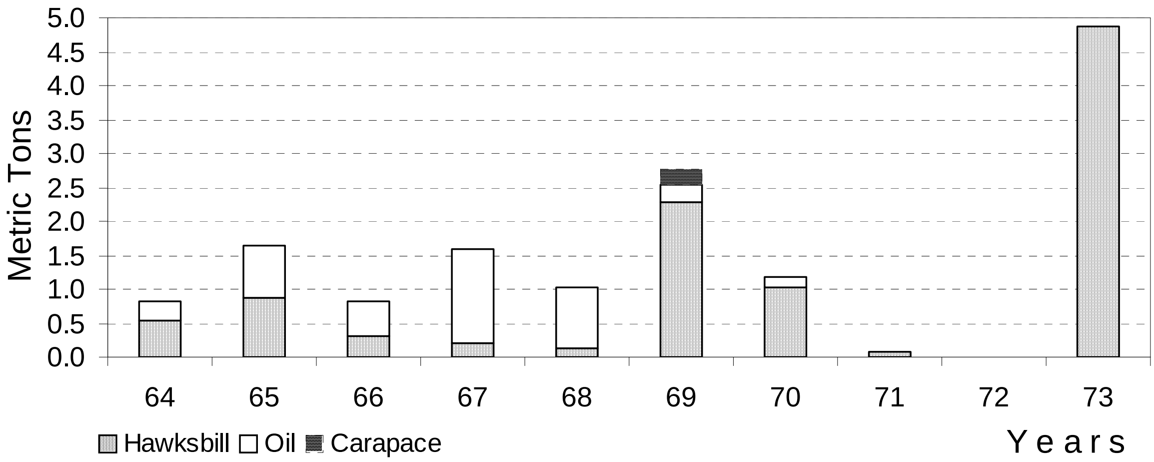

Figure 3. Reported commercial capture of hawksbill turtle (*E. imbricata*) oil and carapace in Mexico, 1964–1973.

FAO compiles information on the commercial fisheries of the world and produces the annual publication, *Yearbook of fisheries statistics, catches and landings*. Data from this source were used to prepare Figs. 4 to 8. The data allow us to make some comparisons between the catch volumes reported by the different states of the region. The change in volume of sea turtle captures could in part be a response to the population status of the different species. The reduction in recent years may well be the result of national and international regulations concerning commerce in sea turtles, or it could be a result of overexploitation. The statistics produced by the eastern Atlantic countries do not specify the species.

Chelonia mydas was captured by nearly all the tropical Atlantic countries, but on the western coast it was registered only by Cuba, Dominican Republic, Grenada and Mexico (Figure 4). If we compare the data of Figure 4 with those of Figure 2, there are some differences between these data and those concerning Mexico. Such differences can be explained by a possible confusion with *Chelonia agassizii*, which is captured in the Pacific and is registered in the official statistics as *tortuga blanca de mar*, or white sea turtle, the equivalent name in Spanish of the green turtle.

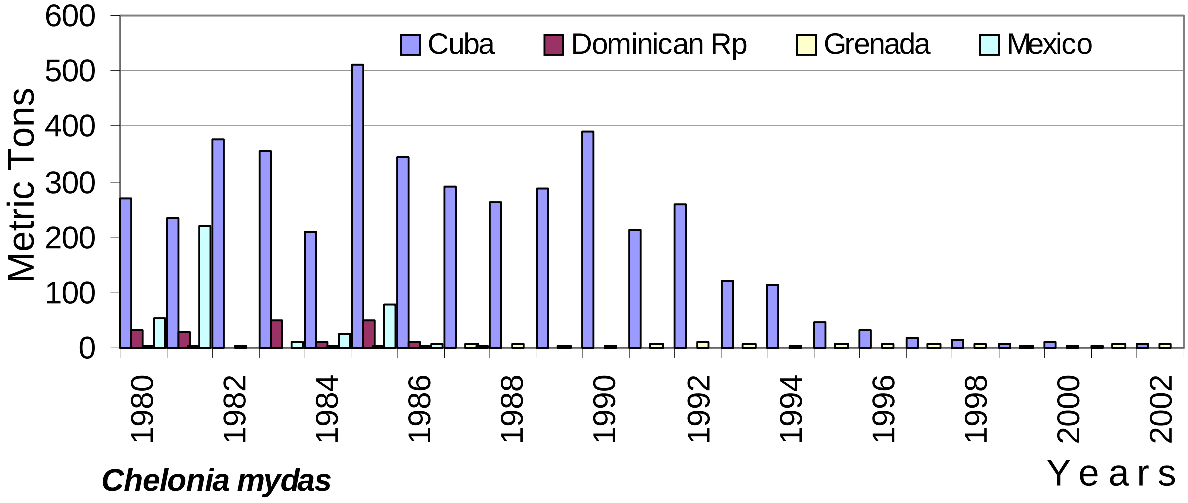

Figure 4. Reported commercial capture of *Chelonia mydas* in western Atlantic countries

Figure 5 shows the exploitation of *Caretta caretta* in the western Atlantic. The most significant captures occur in the Caribbean, in Cuba, but it is likely that this species is captured more widely in the region, without being officially registered. Consequently, FAO has no information on this, but it is possible that a portion of the captures is included in the range of “species not identified” (Figures 7 and 8). Apparently their population has been decreasing throughout the Atlantic except in countries such as Brazil, Mexico and the United States. In the case of Cuba, the catches of all species were intentionally reduced after 1990 (Moncada, 2000), but the decrease between 1987 and 1990 could be a result of overexploitation.

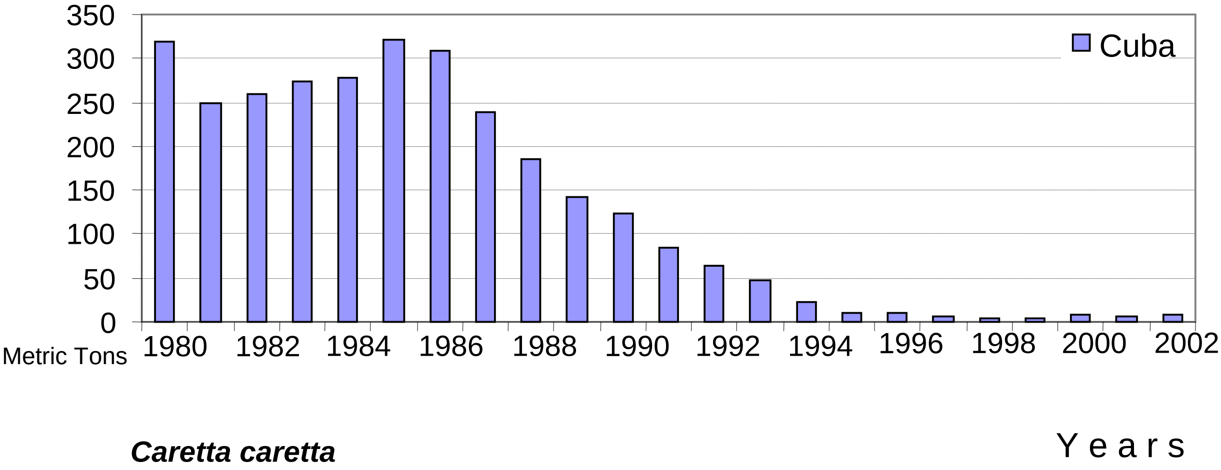

Figure 5. Reported commercial capture of *Caretta caretta* in western Atlantic countries

As all the other species, *Eretmochelys imbricata* is widely captured but not registered. In the western Atlantic only two countries have reports, Cuba and Dominican Republic (Figure 6). The catch in Cuba was reduced after 1990 by regulation, but in the case of the Dominican Republic the catch of and commerce in hawksbills continued without being registered. Other countries have regular commerce in hawksbills but its volume is unknown. In some countries, the commercial catch has been greatly reduced or banned altogether (e.g. Brazil, Costa Rica and Mexico).

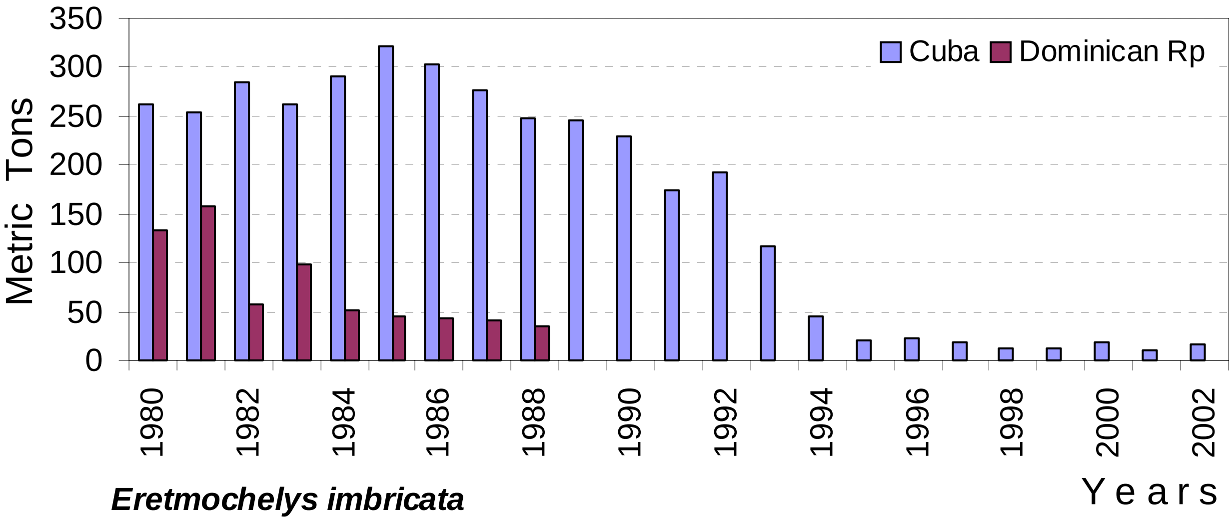

Figure 6. Reported commercial capture of *Eretmochelys imbricata* in western Atlantic countries

Marine turtles are still broadly marketed in many countries of the region, but unfortunately such captures are either not recorded or they are registered using the general term “sea turtle”. This makes it difficult to determine which species are referred to. In Figures 7 and 8 the information registered by FAO under the term “non-identified species” is included.

The figures show that in most countries the capture developed in a more or less stable manner until the mid-1980s, but at the beginning of the 1990s catches started to decrease and continued to do so until they almost disappeared, with the exception of Gabon (Figure 8). It needs to be clarified whether the change in this country is the result of an actual increment in captures, or of improved record-keeping. It should be highlighted that Cuba also appears in this category, although the recording of statistics in the country is well organized. Other countries in the region capture marine turtles, but they do not appear in the official registrations. For the western Atlantic there are six countries that register this information (Figure 7) and there are six for the eastern Atlantic (Figure 8).

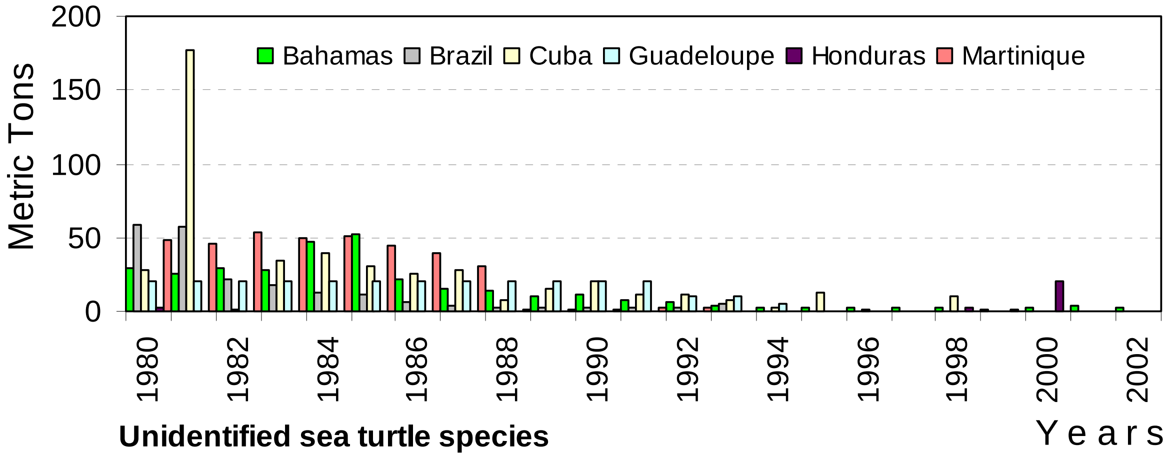

Figure 7. Reported commercial capture of unidentified species in western Atlantic countries

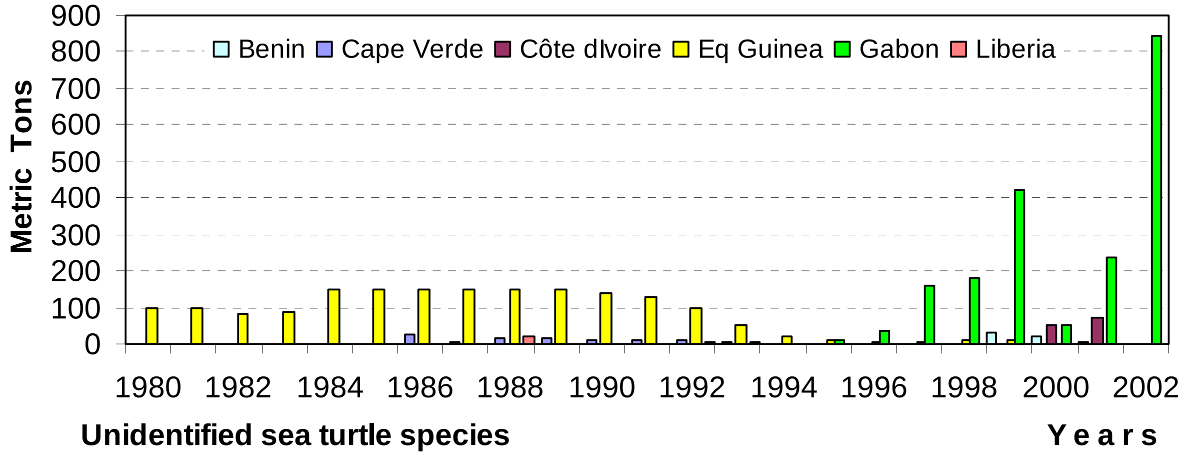

Figure 8. Reported commercial capture of unidentified species in eastern Atlantic countries

Exploitation of eggs

The exploitation of eggs has generally been carried out in nearly all the countries of the region since ancient times. However, there are no statistics on the volume of this exploitation. In Mexico the unlawful exploitation of eggs took place largely on the Pacific coast. Their harvest volume was never regulated and there are no official records because most of the harvest was clandestine. In many countries of the area it is recognized that there is high consumption of eggs, but again no quantitative data are available.

Mrosovsky (2003) makes the following comment: "Figures on the take of eggs are mentioned for various places but these may not tell the whole story. In some cases, it is possible that people are collecting eggs that would otherwise have been eaten by other predators. Also lists of places where eggs have been collected should be balanced by lists of places where eggs have been protected, often in hatcheries, and often with records of the numbers of hatchlings released."

Fishing (indirect, bycatch)

The concept of indirect fishing or bycatch comprises all captures that do not correspond to any of the target species of the commercial fishery. The capture of sea turtles occurs in several important fisheries.

Table 6. Types of gear related to incidental captures of female and juvenile Kemp's ridley turtles (L. kempii), from recovery of turtles tagged between 1966 and 1988

Method	**Females [a]**		**Juveniles [b]**	
	%	**No.**	**%**	**No.**
Gillnet	7.91	14	3.6	17
Shrimp vessel	71.19	126	27.6	132
Fish trawl	1.69	3	-	-
Swimming	-	-	0.8	4
Hook line	1.13	2	5.7	27
Beach seine	1.13	2	0.2	1
Sport fishing	2.26	4	-	-
Purse seine	0.56	1	-	-
Bag seine	-	-	1.1	5
Cast net	-	-	0.4	2
Butterfly net	-	-	0.4	2
Crab trap	-	-	0.2	1
Stranded alive	-	-	10.0	48
Stranded dead	8.47	15	24.3	116
Nesting [c]	0.56	1	-	-
Unknown	5.08	9	25.7	123
Total	**100**	**177**	**100**	**478**

[a] Márquez, 1994; [b] Manzella, Caillouet and Fontaine, 1988; [c] It is said that the turtle was observed nesting on a beach of Santa Marta, Colombia

In general, the bycatch has not been fully evaluated – with the exception of some fleets of shrimp vessels and longliners – even when information exists. In other kinds of fisheries the information is not available and it is impossible to assess the degree to which populations of marine turtles are affected. Some programmes with onboard observers have been developed for some vessels of the fleets that capture shrimp, tuna and shark. However, with the exception of the United States and some European countries, information is scarce.

In some coastal localities of the United States, Mexico and other countries, investigations on beaches are carried out. Stranded sea turtles, dead or alive, are sought in order to determine the causes of such strandings. Some preliminary results are presented in Tables 6 and 7.

Some information is now available on the drowning of turtles in trawlnets and recently evaluations have been undertaken on the effect of the longline fisheries, the gillnet fisheries and other kinds of fishing gears (TEWG, 2000; NMFS-SEFSC, 2001).

Table 7. Types of gear related to incidental captures of female and juvenile sea turtles – the possibilities of being captured, according to their behaviour. L - low, M - medium, H - high, U - unknown, N - none

Method	***Chelonia***	***Caretta***	***Lepidochelys***	***Eretmochelys***	***Dermochelys***
Gillnet	M	M	M	M	L
Shrimp trawl	M	H	H	L	L
Fish trawl	L	M	M	L	L
Longline	L	L	L	N	M
Purse seine	L	L	L	N	M
Beach seine	L	L	L	L	N
Crab trap	L	L	L	L	N
Cast net	L	L	L	L	N
Butterfly net	L	L	L	L	N
Hook line	L	L	L	L	L
Sport fishing	L	L	L	L	L
Swimming	U	U	L	L	N
Stranded alive	L	L	L	L	L
Stranded dead	L	L	L	L	L

For the turtles of the northwest Atlantic (*C. caretta, L. kempii* and *D. coriacea*) it is known that certain fisheries affect specific parts of some populations. Migratory adults are affected by pelagic longline fisheries and purse seines; the juvenile and mature turtle benthic phases in feeding areas are affected by bottom nets used to catch skate in Cuba, flounder in the United States, lobster in Mexico, Cuba and the United States, and by the trawl fisheries for shrimp and other benthic species elsewhere.

In bottom trawls

Shrimp trawlnets. This is the fishing gear that most affects species that feed mainly on crustaceans and molluscs. In 1983 the shrimp fleet of the eastern United States gave the following information on the proportion of various species of sea turtle in the bycatch: 89 percent *C. caretta*, 6 percent *L. kempii*, 2 percent *Ch. mydas*, 1.3 percent *D. coriacea* and 1 percent *E. imbricata*. There are certain controls on this incidental capture, and it is supposed that with the use of Turtle Excluder Devices (TEDs) it has decreased significantly. However, the extent of the reduction has not yet been determined. Some information has recently been published on this kind of bycatch in United States Atlantic waters, as has some data for other countries in the Atlantic region (NMFS-SEFSC, 2001, Appendix 2, Tables 1 and 2).

Fish trawlnets. This capture is generally carried out to obtain fishing bait, or fish to be processed in the manufacture of fish powder concentrate (menhaden, thread herring, shad, sardines, jacks, etc.). This fishery affects several species of sea turtle in their feeding grounds, e.g. *L. kempii* and *Ch. mydas* from the mouth of the Mississippi River up to west Florida (United States) and in Campeche Sound, Mexico. The rate of incidental capture has not been completely evaluated. The turtles are generally recovered dead and they are discharged on the high seas. Some arrive on nearby beaches in a state of decomposition.

Beach seines. This gear mainly affects juveniles of several species. The turtles are generally released alive, when they are not retained for immediate consumption by the fishermen. There has been no evaluation of the incidence of turtles captured using this fishing method.

In surface longlining

This gear is used to catch shark, tuna, billfish, snapper, etc. The incidence of sea turtle captures can be high in these fisheries. Some assessment of this bycatch has been undertaken. All species are generally affected, but those most affected are those of pelagic habits, such as *L. kempii*, *D. coriacea*, *Ch. mydas* and *C. caretta.*

The most complete report available is the *Stock assessment of loggerhead and leatherback sea turtles and stock assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the western North Atlantic*, produced by the National Marine Fisheries Service - Southeast Fisheries Science Center (NMFS-SEFSC, 2001). The report describes the loggerhead sea turtle population structure and trends regarding some of these populations. The authorized takes of turtles estimated for the longline fishery are between 293 and 2 439 loggerhead turtles taken annually, based on observer data from 1992–1999. It is estimated that 50 percent of these animals are killed annually. The United States and 26 other nations participate in longline fishing in the western North Atlantic Ocean. The number of hooks used by the United States fleet is small compared with the numbers used by foreign fleets. However, the United States fleet is more efficient than the others.

A conclusion to the modelling of the population growth rate is that the large juvenile turtles are yet to be excluded from current Turtle Excluder Devices.

The largest nesting aggregation of leatherback turtles in the region occurs in French Guiana and "has been declining 15 percent per year since 1987." Based on observer data from 1992 to 1999, the takes of leatherback turtles from the United States longline fishery range from 308 to 1 054 annually, and probably 50 percent of these die.

The report recommends research to begin immediately to identify and evaluate the rate of mortality from the longline fishery, for the United States fishery and those of other countries, together with mortality rates from other fisheries.

The NOAA reports that leatherbacks are mostly caught by their flippers by longline hooks, which means that this turtle does not bite the hook like the other sea turtles. This has implications for the regulations necessary to avoid the bycatch. Apparently this species is currently the most vulnerable.

In pelagic nets

Purse seines. These affect mainly pelagic species. The turtles are generally caught alive and are often released during the task of recovering the net. There is some information for the Atlantic (NMFS-SEFSC, 2001) but the incidence of captures and the impact on the sea turtle populations has not been sufficiently evaluated.

Trammel nets and driftnets. They affect all species and phases, but have a greater effect on species with pelagic habits, in some cases, and coastal-dwelling species in others, according to the net characteristics and the way the nets are set. No evaluation of incidental captures has been undertaken. Nets that are abandoned or lost continue to trap fish and turtles and when they remain drifting in the currents, they are sometimes used as lures for the capture of tuna, since they attract schools of fish – large fish – and birds, dolphins and turtles.

In North Carolina, sea turtle interactions with the southern flounder gillnet fishery in Pamlico Sound are a concern. Two approaches have been implemented to try to reduce sea turtle bycatch while still allowing the gillnet fishery to operate. North Carolina has tried to reduce sea turtle bycatch by testing experimental gear configurations, with an area/seasonal closure of the area in which the greatest number of interactions occur, starting up a permitting system to monitor sea turtle bycatch by sending out observers on permitted boats, and implementing gear attendance and length restrictions (A. Bianchi, pers. comm.).

In small-scale fisheries

Sport fishing and fishhooks. These affect mainly small and large juvenile phases of nearly all species, but captures are not frequent. No evaluation of the incidence of turtle captures has been carried out.

Other methods. These include bag nets, cast nets and traps. In all these fishing gears there are incidental captures, but the numbers are small. Mainly juveniles and even hatchlings are caught when they are attracted by the lights. No evaluation of the incidence of turtle captures has been undertaken.

DEFINITION OF SUSTAINABLE POPULATION LEVELS

These vary with the different populations and with the developmental phase that is affected by the catch. It has been observed that the exploitation of eggs is the kind of exploitation that can be most easily regulated and the kind that, if carried out at appropriate levels, can be undertaken in a sustainable manner. There are some examples of this way of using the resource without affecting the population's future.

On the other hand, Mrosovsky's argument (2003) is important: "Sea turtles are extremely resilient. They have been intensively exploited in the Caribbean for centuries, but there are still turtles there. Sea turtles are 'proven survivors against incredible odds'. It is not right therefore to imply that no turtle population could be used because it would be likely to disappear rapidly. But of course there are limits…"

MODELLING THE EFFECT OF VARIOUS SOURCES OF MORTALITY

Besides natural mortality, the most important causes of mortality that affect the turtles are of anthropogenic origin, e.g. the exploitation of eggs, the capture of females on the beaches, and capture in the sea by different fishing gears. Mortality results from diverse factors, such as destruction of habitat, contamination, the garbage thrown away by ships, sewage from cities, industrial activities such as the retirement or installation of oil platforms, dredging and port activities. Together they all affect certain phases of the turtle populations. There are several stock assessment studies, particularly in relation to fishing mortality, such as those already mentioned for Kemp's ridley and loggerhead turtles (TEWG, 2000) and for loggerhead and leatherback turtles (NMFS-SEFSC, 2001), both studies cover the western North Atlantic.

CONTRIBUTION OF FISHING TO OVERALL SEA TURTLE MORTALITY

Sea turtle mortality varies with regard to the kind of commercial fishery, the species, the locality, the capture time and the phase of development of the captured turtle. Each of these factors should be evaluated in an integrated way, together with other relevant factors. Some studies have been undertaken, including those already mentioned (TEWG, 2000; NMFS-SEFSC, 2001) on incidental capture during shrimp trawling and in longline fisheries. The kind of fishing that has had the greatest effect on sea turtle populations has been catches targeting the resource as food, either on the beach or in the sea. The amount of exploitation has been so high that it has taken some populations to the point of extinction and others remain at levels from which they are unlikely to recover. The following paragraph is an example of what is happening in the region:

- Several types of endangered sea turtles live in the waters off the Angolan coast. For a few months every year, the females try to crawl on to the beaches and lay their eggs, but many get caught in fishermen's nets and die. The ones that are still alive are not released but killed by the fishermen for meat. Praia da Onca, 55 km south of Luanda, is one of the few places where the turtles are reasonably safe because a landowner has fenced a 7 km area in front of the beach, which keeps poachers out. He aims to turn it into an ecotourism site, but it is also a good spot for research (M. Verissimo de Morais, pers. comm.).

The problem is that when turtles are captured off beaches or on nesting beaches, the damage is great, because the population's future recruitment is affected – a large majority of captured turtles are female and mature.

The biological characteristics of each of the six varieties of sea turtle in the Atlantic greatly influence the incidence of commercial capture. Each of them is affected in different ways and the main factors are directly related to their abundance, distribution, feeding behaviour, reproduction and migration. In this region (the Atlantic, the Gulf of Mexico and the Caribbean Sea), the abundance of the sea turtles varies temporarily and geographically. The most abundant is *C. caretta*, followed by *Ch. mydas, E. imbricata, D. coriacea, L. olivacea*. The least abundant is *L. kempii.* Most countries of the region operate a total or partial prohibition on commercial catches. However, clandestine capture is frequent and harmful to these populations.

On the other hand, at the present time the need to reduce the death rate resulting from incidental capture with longline and nets of any type is now a high priority if some populations of marine turtles are to survive. As a first step, it is necessary to develop dedicated studies on this issue.

A detailed study has been carried out by Johnson, Yeung and Brown (1999) on incidental capture in the pelagic fishery with longlines, operated by the by the United States in the Atlantic. The author indicates that the incidence of sea turtle capture is greater than that of mammals. Between 1992 and 1997, 516 sea turtles were captured in 318 sets, as follows:

C. caretta, 271; *D. coriacea*, 215; *Ch. mydas*, 15; *E. imbricata*, 2; and *L. kempii*, 2 and 11 unidentified.

The incidental capture, although relatively small, can accelerate the collapse of some populations of marine turtle, particularly if they are already decimated.

New tools that can facilitate the conservation and study of marine turtles have recently been developed. For example, the use of satellites allows us to follow the turtles along their migration routes, between the breeding and the feeding grounds, over one or two years. This enables us to see if these animals, during their journey, pass through areas where important and intensive fisheries can affect their survival. Such tools can also determine with much more precision how the turtles are distributed in the sea and can help us to define the critical areas and the season of the year where (and when) measures must be applied to reduce levels of mortality.

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