Sea turtles of the Mediterranean Sea: population dynamics, sources of mortality and relative importance of fisheries impacts

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Abstract

Two sea turtle species nest in the Mediterranean, the green turtle and the loggerhead turtle. Leatherbacks are widely distributed in the Mediterranean, although they do not have any permanent nesting area. Two other species, the hawksbill and the Kemp's ridley turtle only occur occasionally. Available information on sea turtle populations in the Mediterranean Sea, including distribution, population abundance estimates and population dynamics is presented. Main sources of sea turtle mortality are reviewed, with special emphasis on threats due to fishing activities, with the aim at assessing, where possible, the relative importance of these on overall sea turtle mortality.

INTRODUCTION

The Mediterranean region is an important breeding area for two marine turtle species: the loggerhead (*Caretta caretta*), with nesting beaches in ten countries (Cyprus, Egypt, Greece, Israel, Italy, Lebanon, the Libyan Arab Jamahiriya, the Syrian Arab Republic, Turkey and Tunisia), and the green turtle (*Chelonia mydas*), which nests predominantly in Cyprus and Turkey (where 99 percent of recorded nesting occurs), but also on beaches in Lebanon, Israel and Egypt. Another species distributed across the whole region is the leatherback (*Dermochelys coriacea*), although regular reproduction has not been observed. Some other turtle species, such as the hawksbill (*Eretmochelys imbricata*) and Kemp's ridley (*Lepidochelys kempii*) have also been observed occasionally.

The distribution range of the loggerhead populations extends from the eastern to the western Mediterranean limits, including the Black Sea. Green turtles, on the other hand, are restricted to the eastern basin and are regarded as critically endangered. Leatherbacks are distributed throughout the Mediterranean Sea.

Most of the relevant international agreements, such as the Convention on International Trade in Endangered Species (CITES) and the Bonn and Bern Conventions, include marine turtles in lists of endangered species or in annexes listing species to be protected. All Mediterranean marine turtle species are listed as threatened or endangered in the IUCN (World Conservation Union) Red List of Threatened Species.

OBJECTIVES

The general objectives of this document are expressed in the terms of reference of Theme 1 of the Expert Consultation on Interactions between Sea Turtles and Fisheries within an Ecosystem Context and, in particular, are to "identify sea turtle populations, report on population abundance estimates, on various sources of sea turtle mortality, including habitat degradation, pollution, natural causes, fishing etc., define sustainable population levels, model the effect of various sources of mortality and finally determine the contribution of fishing to overall sea turtle mortality".

BACKGROUND

The impact of fisheries on marine turtle populations is an important issue in the Mediterranean. In 1989 the Barcelona Convention adopted the Action Plan for the Conservation of Mediterranean Marine Turtles. This plan defines some priorities for their protection, namely the banning of exploitation and minimization of accidental catches. Gerosa and Casale (1998) reviewed available information on interactions between sea turtles and fisheries.

A Council of Europe document provides a baseline for future assessment (Groombridge, 1990). A report (Laurent, 1996a) includes a chapter on fisheries impacts on turtle. Another document regarding the eastern Mediterranean focuses on green turtles, summarizing the main fisheries affecting this endangered population (Oruç, Demirayak and Sat, 1997). The journal *Zoology in the Middle East* published a volume dedicated to the marine turtles in the eastern Mediterranean including a review of the green turtle population (Kasparek, 2001a). Other documents concerning different aspects have recently appeared (Miranda, 2001; Tudela, 2000; WWF, 2003; Margaritoulis *et al*., 2003).

GEOGRAPHICAL CONSIDERATIONS

The Mediterranean Sea occupies an area of around 2.5 million km^2, is about 3 800 km from east to west, and its maximum north–south extent is around 900 km, between France and Algeria. The eastern basin is connected to the Black Sea. The Mediterranean waters include Atlantic surface water masses in the western Mediterranean and slightly hypersaline warm–temperate surface water masses in the Levant basin. The Mediterranean Sea and the Black Sea make up FAO Fishing Area 37.

The Mediterranean region is vast and includes countries where fisheries represent an important form of revenue and countries where only artisanal fisheries exist. The bathymetry of the Mediterranean Sea determines the distribution of marine turtles and their abundance. The continental shelf and slope, which constitute the main adult turtle feeding areas, are relatively narrow in most areas. In some places, such as the Gulf of Gabes (Tunisia/Libyan Arab Jamahiriya) and the northern part of the Adriatic, the continental shelf is larger and turtles use these areas as resting or wintering areas.

SEA TURTLE SPECIES FOUND IN THE MEDITERRANEAN

Currently, two marine turtle species nest in the Mediterranean – the loggerhead, *Caretta caretta* (Linnaeus, 1758) and the green turtle, *Chelonia mydas* (Linnaeus, 1758). The main nesting concentrations of the loggerhead are found in Greece and Turkey, Cyprus and the Libyan Arab Jamahiriya, while those of the green turtle are restricted to Turkey and Cyprus, with minor activity in Israel and Lebanon (Figure 2, Annex 1). A third species, the leatherback (*Dermochelys coriacea*), is observed throughout the region all year round (Camiñas, 1998). Two other species, *Eretmochelys imbricata* and *Lepidochelys kempii*, are occasionally present (Camiñas, 2003).

These Mediterranean species were established recently by the migration of a very small number of females from the Atlantic. This may have occurred after the last glacial period (Bowen *et al*., 1994). The isolation of different populations within the Mediterranean must have produced genetic differentiation (Kaska, 2000).

Loggerhead

Caretta caretta is the most abundant species breeding in Mediterranean waters. The Ionian Sea constitutes its major breeding ground. Results obtained by Broderick *et al*. (2002) showed 1.8–2.2 clutches per female per season. They estimate that there are 2 280–2 787 loggerheads nesting annually in the Mediterranean. Based on the recorded annual numbers in Cyprus, Greece, Israel, Tunisia ad Turkey, the total nesting effort for the loggerhead ranges from 3 375 to 7 085 nests per season (Margaritoulis *et al*., 2003). The numbers produced by Groombridge (1990) are similar (2 000 loggerhead), assuming on average three clutches per season. An additional contingent from the Atlantic Ocean is known to migrate into the Mediterranean Sea during the first half of the year (Camiñas, 1995b).

Loggerheads from the Mediterranean and North Atlantic populations congregate annually for feeding in a broad area around the Balearic Islands (Figure 3, Annex 1). The aggregations occur from spring to late summer (Camiñas and de la Serna, 1995) with a period of migration from the Atlantic to the western Mediterranean and vice versa (Figures 4, 5 and 6, Annex 1).

Green turtle

Chelonia mydas is represented in the Mediterranean by a reduced population nesting on only a handful of beaches in Cyprus and Turkey. It is estimated that only 350 to 1 750 clutches are laid per year (Kasparek, Godley and Broderick, 2001). Broderick *et al*. (2002) results showed a frequency of 2.9–3.1 clutches per female green turtle and 339–369 green turtles nesting annually. The numbers given by Groombridge (1990) are similar (300–400 green turtles), assuming on average three clutches per season. The regional stock seems to be the remnant of a former larger population. For the green turtle both pelagic developmental and demersal habitats are restricted to the easternmost part of the Levantine basin.

Leatherback

Dermochelys coriacea is present in the whole area all year round but most of the observations concern isolated individuals (Camiñas, 1998). Leatherbacks observed in the Mediterranean Sea came from nesting areas situated almost entirely in the tropics, usually in an area from Costa Rica to Colombia and in eastern French Guiana. The observed and captured leatherback turtles in the Mediterranean are mainly adults. Only a small number of leatherbacks are thought to nest occasionally in Israel and on the south coast of Sicily (Groombridge, 1990). Leatherbacks are frequently stranded on the Mediterranean coast (Camiñas, 1998).

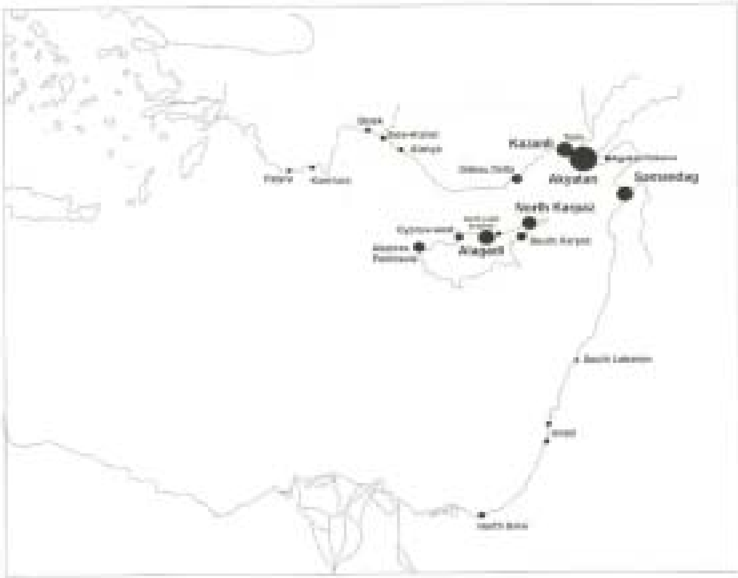

Figure 1. Nesting distribution of green turtle (*Chelonia mydas*) in the Mediterranean. The size of the dots represents the approximate number of nests laid. Source: Kasparek, Godley and Broderick, 2001

Other species

Other species present in the eastern Atlantic and occasionally in the Mediterranean are the hawksbill (*Eretmochelys imbricata*) and Kemp's ridley (*Lepidochelys kempii*), recorded from time to time along the Spanish coast (Camiñas, 2003).

Another species, the Nile soft-shelled turtle (*Tryonix triunguis*), is an endangered species and is confined to a few countries. The largest populations are in Turkey, with additional occurrences in Egypt, Israel, Lebanon and the Syrian Arab Republic; there is a single record in Greece. Kasparek (2001b) observes that the subpopulation does not contain more than 1 000 mature individuals. Fishermen catch and kill them because of the damage they cause to their nets (Kasparek, 2001b).

POPULATION ABUNDANCE ESTIMATES

Loggerhead

Apart from apparent morphological and biological differences, identification of breeding stocks within the Mediterranean has been possible through the use of genetic markers. Indeed, mitochondrial DNA analyses have identified demographically independent nesting colonies. These studies have shown that although loggerheads nesting in Greece and Cyprus share common haplotypes with those nesting in the western Atlantic, they seem to have diverged genetically as a result of reduced gene flow (Bowen *et al*., 1993; Laurent *et al*., 1993). This genetic isolation is more prominent in the case of colonies nesting in Turkey, defined as a demographic unit (Laurent *et al*., 1998). Indeed, from analysis of *cytochrome b* and control region haplotype frequencies, it was estimated that 53–55 percent of the oceanic loggerheads in both the western and eastern basins were derived from Mediterranean nesting populations, and the rest were derived from the western Atlantic stocks (Laurent *et al*., 1998). Genetic analyses among loggerheads from different nesting areas in Turkey showed further differentiation (Schroth, Streit and Schierwater, 1996), providing evidence of subpopulations (Margaritoulis *et al*., 2003). On the other hand, genetic identification of large juvenile and adult loggerheads caught by bottom trawlers (and therefore, presumably, in a neritic stage) revealed that they originated exclusively from Mediterranean stocks (Laurent *et al*., 1998). Biological parameters (carapace measurements, egg mass and diameter, and renesting intervals) are presented in Tables 5, 6 and 7, Annex 1.

The Gulf of Laganas, off the island of Zakynthos (Greece) has one of the highest densities of nests in the world. The beaches of the island of Kefallonia, other Ionian islands and the west coast of the Peloponnisos are also important (Margaritoulis and Dimopoulos, 1995; Margaritoulis, Dretakis and Kotitsas, 1995). Other nesting areas are found in Cyprus, Egypt, the Libyan Arab Jamahiriya, Tunisia and Turkey (Demetropoulos and Hadjichristophorou, 1989; Laurent *et al*., 1995). Sporadic cases have been reported in Croatia and on the Italian Adriatic coast and recently in southern Spain (in the summer of 2001 a total of 30 hatchlings emerged from a controlled nest). Overall nesting effort in the Mediterranean is presented in Table 4, Annex 1. The loggerhead is very common at sea in the two basins.

Cyprus. Although there are fluctuations in the number of turtles nesting from year to year, on average, over 7 000 loggerhead and green turtle hatchlings are released every year from the Lara reserve and another 7 000 loggerheads from the protected nests on the Polin Limni in Chrysochou Bay (Hadjichristophorou and Demetropoulos, 1998). The first surveys of turtle nesting were conducted in 1976–1977, and an annual conservation project was initiated in 1978 (Demetropoulos and Hadjichristophorou, 1989). In 1988 a study was carried out on the beaches of northern Cyprus (Groombridge and Whitmore, 1989), highlighting their regional importance, and an annual monitoring project was initiated in 1992 (Margaritoulis *et al*., 2003). Annual nesting effort is presented in Table 1, Annex 2.

Egypt. *Caretta caretta* are nesting on the Mediterranean and Red Sea coasts. In a single survey of over 249 km of sandy coastline from Alexandria to the Libyan border, few signs of nesting were found (Kasparek, 1993). In 1998, Clarke *et al.* (2000) confirmed that the amount of nesting on this part of the Egyptian coastline was negligible.

Greece. The first record was in Zakynthos in 1977 (Margaritoulis, 1983). Subsequently it was shown that Zakynthos hosted the most important single nesting concentration in the Mediterranean, reaching an average of more than 200 nests/km/season. Other nesting areas have been found along the western and southern coasts and on the island of Crete (Margaritoulis, 1987; Margaritoulis, Dretakis and Kotitsas, 1995). Nesting areas have been classified as “major areas”, “areas of moderate nesting”, and “areas of occasional or diffuse nesting” (Margaritoulis *et al*., 2003). Annual nesting effort is presented in Table 2, Annex 1.

Israel. Although the number of nests per kilometre fell from 15 during the 1950s to two in the 1970s before turtles completely disappeared from Israeli beaches, the Israel Nature and National Parks Protection Authority (Kuller, 1998) reports that 40–50 loggerheads per nesting season are nesting on the Israeli coast.

Italy. Nesting has been recorded only in southern Italy, confined to the islands of Lampedusa and Linosa, with occasional nests in Sicily, and on the Ionian and Adriatic coasts (Di Palma, 1978; Gramentz, 1989; Cocco and Gerosa, 1990; Ragonese and Jereb, 1992; Basso, 1996; Freggi, 1997).

Lebanon. Nesting success was observed during June and July in Lebanon in 2002 (Newbury, Khalil and Venizelos, 2002). A total of 37 nests was recorded. Approximately 12 loggerheads nested at El Mansouri beach during the year of the study.

Libyan Arab Jamahiriya. Nesting was first reported from the area of Kouf National Park, the Gulf of Sirte and the eastern coasts. Extensive loggerhead nesting was recorded during a single survey of 142 km, suggesting that this country holds a nesting population of regional importance (Laurent *et al.*, 1995). Further surveys (Hadoud and El Gomati, 1997; Laurent *et al.*, 1999) demonstrated that nesting activity is spread along the entire length of the Libyan Arab Jamahiriya coast.

Spain. A single loggerhead nesting was observed at Vera beach (Almeria province) in 2001. A total of 30 hatchlings were counted alive.

Syrian Arab Republic. Nesting is concentrated between Latakia and Jablah (15 km), where 25 old tracks (18 nests), most of which are thought to belong to loggerheads, were recorded (Kasparek, 1995).

Tunisia. Little nesting has been recorded (Laurent *et al.*, 1990; Bradai, 1995, 1996). The loggerhead is an abundant species in Tunisian waters.

Turkey. Loggerhead nesting was recorded in the region of Marmaris in the 1970s (Geldiay, Koray and Balik, 1982). In 1988, 17 important nesting areas, for both loggerhead and green turtles, were identified in the Dalyan region (Baran and Kasparek, 1989; Margaritoulis *et al.*, 2003). Aureggi (2003a, 2003b) reviewed and updated the status of the populations in Patara and Belek. Annual nesting effort is presented in Table 3, Annex 2.

Green turtle

This species is a long-lived animal requiring up to 30 years for maturity and hence population recruitment. An estimated 78 percent of all nests are concentrated at only five key nesting beaches (Kasparek, 2003). Nesting in the Mediterranean appears always to have been confined to the Levantine basin – there are records of nesting in Turkey and Cyprus (which account for 99 percent of all nesting records), Egypt, Israel and Lebanon. For many of the nesting beaches data are limited, and the high inter-annual fluctuation in nesting numbers makes comparison among the various nesting areas difficult. The current recruitment rates are probably much lower than the number of deaths related to fishing, and this could lead to the virtual collapse of the population in the near future (Demetropoulos and Hadjichristophorou, 1989). The Turkish localities of Kazanli, Akyatan and Samandag, with about 1 000 nests laid annually and scattered along more than 40 km of beaches, are the most important nesting areas (Groombridge, 1990). Remaining nesting populations in Turkey and Cyprus and total number of nests per season are presented in Tables 1 and 2, Annex 4.

Kasparek, Godley and Broderick (2001) and Kasparek (2003) reviewed the extent of the nesting. The former based their assessment on literature and unpublished data. Main nesting areas are summarized in Table 1.

Table 1. Nesting areas for the green turtle in the Mediterranean

1. Most important nesting areas for the Green Turtle in the Mediterranean

Beach name	Beach length (km)	max. no. of nests	max. nest density (nests/km)	notes on protective status
Akyatan	21.7	735	33.8	Permanent Wildlife Reserve, Ramsar Site (lagoon), Natural SIT (areas adjacent to the nesting beach)
Kazanlı	5.4	216	40.0	No protective status
North Karpaz (beach nos. 51-56)	3.1	179	57.7	No protective status
Samandağ	10.3	113	10.9	No protective status; partly restricted access (border with Syria)
Alagadi (beach nos. 76-77)	2.0	111	55.5	Specially Protected Area

2. Nesting areas of moderate importance

Beach name	Beach length (km)	max. no. of nests	max. nest density (nest/km)	Notes on protective status
Akamas Peninsula (5 beaches)	5.5	approx. 75	13.6	Protected area (turtle reserve) since 1989
Göksu Delta	36.1	20	0.6	Specially Protected Area, Wildlife Protection Area, Ramsar Site (lagoons)
West Coast: beach no. 82	0.3	43	143.3	No protective status
West Coast: beach nos. 83-84	2.1	52	24.7	No protective status
North Coast: beach nos. 73-75	1.3	27	20.7	No protective status
South Karpaz: beach nos. 45-46	4.0	57	14.2	No protective status
South Karpaz: beach nos. 38-39	1.2	31	25.8	No protective status
South Karpaz: (beach nos. 34-35	0.8	25	31.3	No protective status
South Karpaz: beach nos. 32-33	0.5	14	28.0	No protective status

3. Discrete nesting areas of minor importance

beach name	beach length (km)	max. no. of nests	max. nest density (nests/km)	Notes on protective status
Israel (3 areas)	n.a.	13	n.a.	No protective status
Tuzla	20.0	8	0.4	Permanent Wildlife Reserve
Kumluca	20.5	7	0.3	No protective status
Belek	21.8	4	0.2	A sand spit of the Acısu River has been designated Specially Protected Area
Ağyatan and Yelkoma beaches	31.5	4	0.1	Yumurtalık Nature Reserve and Natural SIT.
Northern Sinai	n.a	3	n.a.	Partly within Zaranik Protected Area (Biosphere Reserve)
Patara	11.8	2	0.2	Specially Protected Area, SIT Area
Side-Kızılot area	16.2	2	0.1	No protective status.
Lebanon	n.a.	1	n.a.	No protective status.

Source: Kasparek, Godley and Broderick, 2001; Kasparek, 2003

Cyprus. Nesting beaches in Cyprus are concentrated in four main areas: the Akamas Peninsula, where a small number of turtles nest, notably in Lara Bay and Toxefra Bay; the southwestern coast, with small numbers of nests (one or two a year); Ayia Napa, where small numbers were found nesting in 1977 but nesting ceased because of the intensive use of the beach for tourism (Demetropoulos, 2000); and northern Cyprus, where nesting is centred in four main areas of the Karpaz Peninsula. Numbers at all sites fluctuate greatly from year to year with the lowest annual total being 135 and the highest 461 nests. Migration from northern Cyprus is shown in Figure 2, Annex 3.

Egypt. Nesting in Egypt is occasional (Campbell *et al*., 2001). One nest was found in 1998 and two in 2000 between Rafah and Port Said (Kasparek, Godley and Broderick, 2001).

Israel. Nesting in Israel occurs in low numbers in most years, at different localities. Kasparek, Godley and Broderick (2001), with data from Kuller (1998, 1999), report a data series from 1993 to 2000 for green turtle nesting in Israel with a maximum of 13 nests in 1998.

Lebanon. Nesting success of *Chelonia mydas* was recorded during the peak nesting period (June–July) in Lebanon in 2002 (Newbury, Khalil and Venezelos, 2002). Five green turtle nests were recorded. Assuming that each turtle nests on average three times in a season, it is likely that two green turtles nested in El-Masouri beach during the study period.

Libyan Arab Jamahiriya. Green turtle nesting activity has not been observed. Immature turtles have been recorded (Laurent *et al*., 1999). The observations suggest that the country may host feeding grounds for green turtle juveniles.

Syrian Arab Republic. Observed green turtles tracks were old, obliterated by wind, or covered by litter (Kasparek, Godley and Broderick, 2001).

Turkey. Green turtles have been reported nesting at 12 sites along the Turkish Mediterranean coastline: Dalyan, a well-known loggerhead nesting site, which has also provided us with anecdotal reports of green turtle; Patara, which represents the westernmost site for green turtle nesting in the Mediterranean; Kumluca, also a loggerhead nesting site; Belek, where low numbers of nests have been mentioned in different nesting seasons; the Side-Kiziolot area; the Alanya area; the Göksu Delta, with surveys recording from 3 to 20 nests; Kazanh, where a total of 152 nests was recorded in 1988; Tuzla beach; Akyatan, the most important single nesting site for green turtles in the Mediterranean, with a total of 108 nests recorded in 1988 and up to 735 in 1998, which means that 43 percent of the entire Mediterranean population nests there (Kasparek, Godley and Broderick, 2001); Agyatan and Yelkoma beaches, with occasional nesting recorded; and Samandag, which is the fifth most important green turtle nesting beach in the Mediterranean. The highest nesting density occurred on Seyhhidir beach, where 126 nests were recorded. The major nesting areas in Turkey are shown in Figure 1, Annex 3; statistics of movements to foraging areas are shown in Table 1, Annex 3.

Nesting in the central and western Mediterranean

Despite surveying throughout the Mediterranean, green turtle nesting has not been confirmed.

SOURCES OF SEA TURTLE MORTALITY

In the Mediterranean, general degradation caused by humans has been noted at some significant nesting sites and some areas that hosted nesting activity in the past have been lost to turtles (e.g. Malta) or severely degraded (e.g. Israel). The main anthropogenic threats affecting marine turtle nesting areas include tourism and recreational activities, an increasing human presence, vehicular and pedestrian traffic, beachfront lighting and noise, uncontrolled development and construction, beach pollution, marine pollution, planting of vegetation, being struck by a boat, near-shore fishing and the use of underwater explosives (Margaritoulis *et al*., 2003). Beach erosion is a further threat. In addition, there are a number of perceived general threats to the Mediterranean green turtle population for which quantitative data are generally lacking (Kasparek, Godley and Broderick, 2001; Kasparek, 2003).

Habitat Degradation

Tourism

The Mediterranean Sea is the destination of millions of tourists during summer, coinciding with the nesting season. The extensive urbanization of the coastline, especially in areas with sandy beaches, is probably the most serious threat.

Human activities and their consequences affect many nesting beaches, such as Patara (Aureggi, 2003a). The list includes tourism, increased human presence, artificial lights, animal grazing, vehicles driving along the beach, garbage, recreational equipment, sand and shingle extraction, fisheries (including the use of dynamite), collision with boats and other kinds of pollution. Several large nesting concentrations in the Mediterranean are more or less severely threatened by intensive tourist development (Margaritoulis *et al*., 2003). Large numbers of tourists use the beaches during the day. The deck chairs and umbrellas are rented out to tourists and remain scattered overnight on Patara beach (Taskin and Baran, 2001). Sometimes tourists and local people visit the beaches leaving rubbish – mainly plastic bottles and plastic food wrappings – and beach towels. Few of the beaches are regularly cleaned. Moreover, tour operators organize horse tours on the beaches during the day.

A document entitled "The impact of tourism development on marine turtles nesting: strategies and actions to minimize impact" (Demetropoulos, 2000) summarizes the problem.

> *Many causes can make beaches unsuitable for turtle nesting, for the incubation of eggs or for the successful emergence and descent of hatchlings down to the sea. Most of them originate in tourism and urban development in the coastal zone, in areas adjacent to or near nesting beaches. Tourism with its related spin-offs, in the Mediterranean, is directly or indirectly based on the utilisation of beaches. Hotels, apartment blocks, restaurants, taverns and cafes, overlooking beaches are characteristic of much of the region. The problems caused by such development include: stationary lights (street lights, hotels, apartments, houses etc.), moving lights (cars, etc.), movement of holiday-makers on beaches at night (and day) and barriers of sun beds and umbrellas, physical alteration of nesting beaches and environs. Increased traffic on land (including 4-wheel drive cars on beaches) and in the adjacent sea, add to the problems; speed boats, water sports, such as water skiing, surf-sailing, paragliding, etc. are only a few.*

The main threats posed by tourism to turtles are:

- Moving lights and movement on the nesting beaches at night will scare female turtles away when they come up to nest.
- Lights in the hinterland will disorientate hatchlings away from the sea and towards the land where the lights are.
- Barriers of sun beds and umbrellas may stop nesting females reaching a suitable nesting location on the beach.
- Umbrellas may damage nests or interfere with incubation temperatures.
- Physical alteration of nesting beaches comes about as a result of structures built both on land (hotels, apartments etc.) and at sea.
- Mechanical cleaning of beaches will hide tracks and nests and may destroy nests.
- Driving on beaches “for fun” has taken new dimensions with the spread of four-wheel drive cars, beach buggies, etc.
- Holidaymakers in large numbers on the beach during daylight hours will inevitably damage nests by treading on them (causing chambers to collapse, etc.). Such treading may also result in the compaction of sand, making the beach unsuitable for nesting or hatchling emergence.
- Interest by holidaymakers in watching turtles nesting at night disturbs the animals and stops them from nesting. Holidaymakers may also disturb nests by digging up the eggs out of curiosity and turning them, which results in embryo death or changes to the structure of the egg chamber. Mortality at the late embryonic and hatching stages is almost invariably associated with a bad or disturbed egg chamber.

Marina and dock development

Many areas near nesting beaches are affected by marinas and other kinds of infrastructure. The western part of the Egyptian Mediterranean coast is heavily developed for tourism and the sea defence activity on the Nile Delta beaches seems to deter nesting. Beachfront developments are likely to impact and degrade important nesting beaches in Egypt (Campbell *et al*., 2001). The construction of a jetty at Mersin harbour (Turkey) and water-works at streams around Kazanli contribute significantly to the continuous loss of land. Marinas, and onshore and offshore (parallel) breakwaters also cause alteration, sometimes radical, of beaches and of the dynamics of coastal systems. Ensuing erosion is mitigated by further land defence structures.

Collisions with boats

The effect of speedboats is of great concern in turtle-frequented waters that offer an array of tourist activities, such as those of Greece and Turkey. Losses of nesting females have been documented in Zakynthos and more recently in Crete. From samples recovered in the Gulf of Naples, 28.1 percent had injuries attributed to being struck by a boat (Margaritoulis *et al*., 2003). Boats at sea (and especially speedboats) near nesting beaches during the reproduction season will, at best, scare prospecting females away from the beach and may also cause injury and death. This is also important in mating areas for both sexes during the season (Demetropoulos, 2000). In most of the recovery centres on the Mediterranean coast the numbers of turtles hospitalized annually as a result of injuries caused by collisions with boats are increasing.

Construction

Many new buildings have been constructed in new villages near the nesting beaches and on the beaches in countries such as Greece and Turkey. According to Yerli and Demirayak (1996), over 90 buildings were constructed illegally on Patara beach (Turkey) and demolition orders were issued. In areas such as the Gösku Delta in Turkey, large parts of the sand dunes were lost some years ago because of sand extraction for construction proposes. Although now prohibited, extraction still occurs (Kasparek, Godley and Broderick, 2001) as it does on other Turkish beaches. At El-Mansouri beach, Lebanon, where loggerhead and green turtles reproduce, there is a ruined house next to the beach with inhabited buildings behind it and an abandoned army watch-post that is crumbling, with tyres, sandbags and concrete blocks spilling from it on to the beach. In this country there is severe development pressure along the coastline.

Pollution

The Mediterranean is an enclosed sea and organic and inorganic wastes, toxic effluents and other pollutants rapidly affect the ecosystems. Pollution includes marine debris, oil pollution and a variety of chemicals. Plastic debris, including discarded fishing netting, packing bands and plastic bags has been associated with turtle mortality and there is evidence that this is an increasingly important problem. The incidence of turtles stranded after becoming entangled in such materials or found to have ingested marine debris has almost certainly increased (Hutchinson and Simmonds, 1991). Small garbage (any solid material in its present state or that degrades into another state), mostly associated with human activities, results in a deleterious effect on the marine environment. Of the garbage produced by the fishing industry, monofilament netting made of artificial fibres is the most dangerous. The list of domestic waste is seemingly endless. Metals, glass, fibres and plastic are all now part of the marine environment. A Mediterranean average of 1–3 tonnes per mile of coastline was estimated after a clean up on the French coast (Venizelos and Smith, 1997).

The effects of oil pollution are not known in detail, although small size turtles can clearly be immobilized and exhausted by heavy contamination. Although parts of the Mediterranean are profoundly polluted, little is known of the effects of contaminants on marine turtles (Margaritoulis *et al*., 2003).

Lead concentrations in Mediterranean loggerhead hatchlings are at levels known to cause subclinical toxic effects in other vertebrates (Godley, Thompson and Furness, 1999). Marine debris has been found to affect Mediterranean loggerheads (Gramentz, 1989; Basso, 1992). Special attention should be given to floating pieces of plastic, tar balls and other garbage, which are frequently mistaken by turtles for food items (Camiñas and Valeiras, 2000). An examination of 54 loggerheads stranded in the western Mediterranean showed that 79.6 percent had inedible garbage in their gastric contents. Plastic items (75.9 percent) were the most frequent (Tomas *et al*., 2002) but tar, paper, wood fragments and terrestrial insects were also found. In the Gulf of Naples about 3 percent of the juvenile loggerheads recovered had swallowed marine litter (Bentivegna and Paglialonga, 1998). Pollution on beaches used for reproduction has been reported as a serious problem (Campbell *et al*., 2001).

The eastern Mediterranean is subject to high levels of pollution and much litter is washed up on nesting beaches. This is particularly true of the nesting beaches of Cyprus, Samandag (Turkey) and Egypt. Although the eastern Mediterranean is highly contaminated with litter, this does not necessarily mean that turtles are exposed to high levels of all environmental contaminants. In studies of green turtle tissues and eggs it was found that levels of heavy metals and concentrations of chlorobiphenyls and organochlorine pesticides were very low. A soda-chromium factory close to the nesting beach at Kazanli regularly discharges chemical substances into the sea, including highly toxic chromium compounds (Kasparek, Godley and Broderick, 2001). A recent document recalls that in 2001 the Standing Committee of the Bern Convention focused its attention on Kazanli beach (Kasparek, 2003). The author underlined that "still no serious attempts have been made to find a solution for the 1.5 million tonnes of hazardous waste which has been produced by the chrome factory in the past and which are deposited on the beach in front of the factory". It is clear that a solution to this problem is of prime importance for the conservation of the Mediterranean green turtle population.

Another environmental problem that results from tourism and industry is light pollution. The construction of tourism facilities and factories near the sea produces important light pollution in some Mediterranean areas with nesting beaches. Demetropoulos (2000) emphasizes light pollution as a problem on some nesting beaches. Newbury, Khalil and Venezelos (2002) indicate that the only nesting beach in Lebanon where loggerheads and green turtles reproduce is illuminated with bright security lights at night. The same problem is commented on by Aureggi (2003b) with regard to beaches in Turkey (Belek) that are important for nesting loggerheads.

Natural causes

Predators

The decline in turtle populations and reduction of nesting habitats has triggered management programmes to address the natural loss resulting from predators feeding on nests. Loggerhead nests in the Mediterranean are preyed on by wild canids, feral/domestic dogs and ghost crabs. Wild canids are absent from Zakynthos, Crete and Kefallonia. The loss of turtle clutches to predators has reached 48.8 percent at Kyparissia Bay, Greece (Margaritoulis, 1988b), 65–70 percent in Dalyan, Turkey (Erk'akan, 1993), 36.0 percent in Cyprus (Broderick and Godley, 1996) and 44.8 percent in the Libyan Arab Jamahiriya (Laurent *et al*., 1995). On Patara beach (Turkey), 35 percent of the nests were preyed on by foxes (*Vulpes vulpes*) and subsequently ghost crabs. Plundering of nests by the red fox, golden jackal and domestic/feral dogs is widespread at green turtle nesting sites in Cyprus, Turkey and Israel. Nest loss rates have been described as up to 70 percent in Cyprus and 68 percent at Akyatan (Kasparek, Godley and Broderick, 2001; Kasparek, 2003).

Ghost crabs preying on hatchlings was reported on nesting beaches in northern Cyprus and Egypt, suggesting that up to 66 percent of emerging hatchlings could be lost in this way (Simms, Clarke and Campbell, 1997).

Other damage caused by invertebrates to loggerhead eggs and hatchlings in Turkey was investigated on Fethiye and other beaches (Türkozan and Baran, 1996; Türkozan, 2000; Baran *et al*., 2001). Nematoda, Acarina, Myrmeleonidae, Elateridae, Scarabeidae, Muscidae and Tenebrionidae were recorded infesting loggerhead nests.

Natural habitat changes

Changes in the shape and slope of beaches can modify the turtles' behaviour. Beach erosion caused by natural changes and subsequent inundation by high waves, together with the covering of nests by shifting sand dunes are the major reason for the loss of nests, and are responsible for about half of all loggerhead nest losses on Patara (Turkey). This beach varies in width from 40 to 100 m and is generally flat, but the slope increases in some places. In some parts sand has been carried about 500–600 m inland through wind erosion, and flat and wet sand extends well inside the beach (20–30 m) because of the tidal inundation. In order to prevent erosion, fences were erected and trees (mainly *Eucalyptus* spp.) were planted in the sand dunes (Taskin and Baran, 2001). New recommendations to stabilize the dynamic beach/sand dune ecosystem by initiating a dune restoration programme have been reported by the Mediterranean Association To Save the Sea Turtles (MEDASSET) to the Council of Europe (Aureggi, 2003a).

Because of temperature-dependent sex determination and likely skews in natural sex ratios of hatchling production towards female, an emerging threat is that of rapid global environmental change and resultant warming, which could alter the thermal characteristics of sand on turtle nesting beaches resulting in the reduction or cessation of female hatchling production. This could threaten the survival of Mediterranean turtle populations in the long term but needs to be monitored.

Fishing (direct exploitation)

At sea, marine turtles in the eastern Mediterranean suffered severe exploitation until about the mid-1960s (Margaritoulis *et al*., 2003). Recent decades have seen the exploitation of turtles in Egypt, where loggerhead and green turtles are sold in some fish markets, despite legislation prohibiting this. It is estimated that several thousand individuals are killed each year in Egypt, with loggerheads accounting for 68 percent of the total. The proportion of large-sized individuals (37.5 percent) is high (Laurent *et al*., 1996).

Although relatively few loggerheads appear to be taken by directed fisheries at present, this has not always been the case. Di Palma (1978) notes that before 1980 a specialized fishery operated in the Isole Eolie, north of Sicily, catching an estimated 500–600 turtles (presumably *Caretta caretta*) annually. Fishing for marine turtles has been prohibited in Italy since 1980, but the exploitation of turtles caught accidentally allows some local traditions connected with the consumption of turtle meat to continue (Basso and Cocco, 1986; Argano *et al*., 1990), and the illegal sale of turtle shells (Argano *et al*., 1990). Sella (1982) estimates that from the end of the first world war until the mid-1930s at least 30 000 turtles, both green turtles and loggerheads, were caught offshore of what is now the coast of Israel. A similar situation developed in the 1950s at Iskenderun Bay, Turkey, where a slaughterhouse operated. The fishery closed after depletion of the local stocks. Although *Chelonia mydas* was the primary target, it is thought that *Caretta caretta* stocks were also affected.

Turtles were also sold in Malta (Gramentz, 1989), Spain (Mayol and Castelló Mas, 1983), Algeria and Morocco (Laurent, 1990). In all these countries bans prohibiting capture and marketing have been enforced and turtle shell can only be produced illegally. In Tunisia, despite a ban on the sale of turtles in fish markets since 1990, there was a clandestine trade for local consumption owing to tradition (Laurent *et al*., 1996).

The consumption of turtles in the Libyan Arab Jamahiriya by local fishermen is probably low, but they are eaten by Egyptian fishermen. Human consumption of eggs appears to be a local tradition along the coast of Ras Ajdir-Sabratah where Laurent *et al*. (1999) recorded nests opened by fishermen. Venizelos (2000) reported the consumption of eggs by fishermen in the Syrian Arab Republic.

Fishing (indirect, bycatch)

The Mediterranean fisheries are characterized by: (i) multispecificity; (ii) a high level of interaction between trawls and set gears (they use the same fishing areas and resources); (iii) the major importance of artisanal fisheries, and (iv) the increasing size of the tuna fleets.

The demersal species of most commercial interest are: hake (*Merluccius merluccius*), blue whiting (*Micromesistius poutassou*), red shrimps (*Aristeus antennatus*), Norway lobster (*Nephrops norvegicus*), red mullet (*Mullus surmuletus* and *Mullus barbatus*), octopuses (*Octopus vulgaris* and *Eledone cirrhosa*) and sole (*Solea vulgaris*). Among the small pelagic species, sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) are the most significant. Bluefin tuna (*Thunnus thynnus*) and swordfish (*Xyphias gladius*) are the most important large pelagic species and albacore (*Thunnus alalunga*) ranks third in importance.

The Barcelona Convention adopted an Action Plan for the Conservation of Mediterranean Marine Turtles in 1989, acknowledging that catches by fishermen are the most serious threat to the turtles at sea, and that the conservation of the green turtle deserved special priority (Tudela, 2000).

Mediterranean fisheries have an enormous impact on the local turtle stock: more than 60 000 turtles are caught annually as a result of fishing practices, mortality rates ranging from 10 percent to 50 percent of individuals caught. The problems related to the interaction between fisheries and turtles in the Mediterranean are common to all fisheries. However, local features can affect reproduction, feeding or wintering populations of turtles differently in different areas (Tudela, 2000).

Bottom trawl, surface longline and driftnet, along with coastal gillnet and entangling net fisheries have a large bycatch causing fishery-related mortality (Argano and Baldari, 1983; De Metrio *et al*., 1983; Delaugerre, 1987; Camiñas, 1988; Laurent, 1991; Margaritoulis *et al*., 1992; Argano *et al*., 1992; Laurent and Lescure, 1994; Aguilar, Mas and Pastor, 1995; Laurent *et al*., 1996; Godley *et al*., 1998). Many other fisheries affect marine turtles in the Mediterranean, but for most of them information is very scarce or does not exist.

Green turtles are caught as bycatch in the eastern Mediterranean. The overall mortality rate of captured turtles is still unknown. Trawling close to some of the most important nesting beaches may have significant impact in terms of mortality, disturbance and destruction of habitats. This is true in particular for Kazanli, Akyatan and the Göksu Delta. Green turtles are also subject to direct exploitation in Egypt by fishermen who, although they may capture turtles incidentally, sell them for human consumption (Kasparek, Godley and Broderick, 2001).

The fishing gears that have the potential to capture marine turtles incidentally are summarized by country in Table 2. For some fisheries, data on incidental captures exist although the numbers per year are incomplete. For other gears recent studies (Laurent *et al*.,

2001) have evaluated the captures by country, gear and quarter. There are important differences in the quality and quantity of information from one country to another.

The main gear types and fisheries affecting marine turtles in the Mediterranean are shown by country, season and target species in Table 2.

Table 2. Gear types and fisheries that affect marine turtles in the Mediterranean

Gear type	Country	Season	Target species	Bycatch species
Driftnets (*spadara* and other types) (mesh size 18 to 42 cm)	Morocco, Turkey, France, Italy, a few vessels are also present in Albania, Algeria, Greece	April–August	*Xyphias gladius, Thunnus alalunga*	*Caretta caretta, Chelonia mydas Dermochelys coriacea*
Driftnets (*thonaille*) (mesh size 18 to 24 cm)	France, Monaco	May–September	*Thunnus thynnus*	*Caretta caretta*
Driftnets (mesh size 8 to 16 cm)	Italy	Spring–autumn	*Sarda sarda, Auxis rochei*, other small tuna species	*Caretta caretta*
Driftnets (mesh size 4 to 7 cm)	Many coastal areas	Spring	*Scomber* spp., *Boops boops,* and other small pelagic species	*Caretta caretta Chelonia mydas*
Bottom-set gillnets (including coastal trammels)	Many coastal areas	All	*Mullus* spp., *Sepia* spp. Sparidae, *Scorpaena* spp., other demersal species	Unknown
Bottom-set gillnets	Many deep coastal areas	All	*Palinurus elephas, Merluccius merluccius*	*Caretta caretta*
Middle-water set gillnets	Many coastal areas	All	*Boops boops, Oblada melanura, Trachurus* sp.*, Spicara* spp.	Unknown
Purse seine	All	All	*Sardina pilchardus, Engraulis encrasicolus*, other small pelagic species	*Caretta caretta Chelonia mydas*
Tuna purse seine	Spain, France, Italy, Greece, Tunisia, Turkey, Croatia, Algeria, Morocco	March–October	*Thunnus thynnus*	Unknown

Gear type	Country	Season	Target species	Bycatch species
Tuna traps	Spain, Italy, Tunisia, Libyan Arab Jamahiriya, Morocco, Croatia	April–July	*Thunnus thynnus*	*Caretta caretta*
Bottom trawl	All areas	All	A large range of demersal species	*Caretta caretta Chelonia mydas*
Drifting longlines	Spain, Italy, Greece, Albania, Turkey, Cyprus, Lebanon, Egypt, Libyan Arab Jamahiriya, Tunisia, Algeria, Morocco, Malta	March–December	*Xyphias gladius, Thunnus thynnus*	*Caretta caretta Chelonia mydas*
Drifting longlines	Spain, Italy, Greece, Albania	Spring–autumn	*Thunnus alalunga* and other small tunas	*Caretta caretta Dermochelys coriacea*
Drifting longlines	Spain, Italy, Greece	Spring–summer	*Thunnus thynnus*	*Caretta caretta*
Pelagic pair trawl	Italy, Croatia	All	Pelagic schooling species	*Caretta caretta*
Pelagic trawl	France, Italy	All	Demersal species	*Caretta caretta*
Encircling gillnets	Spain, Italy, Greece	Spring–summer	*Boops boops, Oblada melanura, Belone belone, Spicara* spp., other small and medium size pelagic species	Unknown
Bottom longlines	Spain, Italy, Greece, Albania,	All	*Merluccius merluccius,* Sparidae spp., *Lepidopus caudatus*	Unknown
Rod and reel	Spain, France, Italy, Morocco	Spring–summer	*Thunnus thynnus*	Unknown
Hand-line	Spain, Italy, Greece, Morocco	Spring–autumn	*Thunnus thynnus*	Unknown
Jigging line	Spain, Italy, Greece	May–September	*Todarodes sagittatus, Illex* sp.	Unknown

Table 3 shows a compilation of the annual numbers of captures and the direct mortality of the loggerhead.

Table 3. Estimates of number of loggerheads caught annually and direct mortality rate for different fisheries

Fishing gear/ Fishery	Fishing zone	Annual number of captures	Direct mortality (%)	No.	References
Trammel nets					
Lobster nets	France (continental)	Low	100	8	Laurent, 1991
	Corsica	Low	93.3	15	Delaugerre, 1987; Laurent, 1996b
Fish nets	France (continental)	Low	28.5	9	Laurent, 1996b
Fish nets Sole nets	Corsica France (continental)	Low Low	75.0 53.1	4 128	Laurent, 1996b Laurent, 1991
Gillnets	France	Low	50.0	6	Laurent, 1991
	Italy	?	50.0	?	Argano *et al.*, 1992
Drifting Longlines					
	Spain 1990 Spain 1991 Italy (Ionian Sea)	35 637 22 000– 23 637 100–1 000	0.4 0.4 24.4 [a] ?	673* 425* 45	Aguilar, Mas & Pastor, 1995 Aguilar, Mas & Pastor, 1995 Aguilar, Mas & Pastor, 1995; Mas, 1996 De Metrio & Megalofonou, 1988
	Malta	1 500– 2 500	?		Gramentz, 1989
	Greece (Kefallonia)	50	?		Panou *et al.*, 1992
	Morocco	3 000	?		Laurent, 1990
	Algeria	300	?		Laurent, 1990
Drifting nets					
	Italy (Ionian Sea)	16 000	29.0	31*	De Metrio & Megalofonou, 1988
	Italy (Ligurian and Tyrrhenian Seas)	Low	0.0	5*	Di Natale, 1995
	Spain (1994)	117–354 [b]	3.3	30*	Aguilar, Mas & Pastor, 1995
Bottom trawl					
	Greece (Peloponnisos)	?	2.6	38	Margaritoulis *et al.*, 1992
	Italy	1 000– 1 500	?		Argano, 1979

Fishing gear/ Fishery	Fishing zone	Annual number of captures	Direct mortality (%)	No.	References
	Former Yugoslavia	2 500	?		Lazar & Tvrtrovic, 1995
	Tunisia	3 500–4 000	0.0	15*	Laurent & Lescure, 1994
	Tunisia	2 000–2 500	0.0	1*	Bradai, 1992
	Turkey	High	0.5	138	Oruç, Demirayak & Sat, 1997
	Turkey	High	0.0	1*	Laurent *et al.*, 1995
	Egypt	High	?		Laurent *et al.*, 1995
	France (continental)	Low	3.0	97	Laurent 1991, 1996b
	Corsica	Low	3.8	26	Delaugerre, 1987
	Spain	Low	?		Aguilar, Mas & Pastor, 1995

Source: Laurent, unpublished data

NOTE: No. – number of individuals sampled to estimate mortality; [a] delayed mortality; [b] 95 percent confidence limits; * onboard observations.

Table 4. Revised country-by-country literature list

Country	Gears	Captures/ mortality	Species	References
Albania	Dynamite Fishing gears	Unknown	*C. caretta*	Haxhiu & Uruci, 1998
Algeria	Surface longline	?	*C. caretta*	Laurent, 1990*
Croatia	Bottom trawls	2 500	*C. caretta*	Lazar & Tvrtrovic, 1995
	Gillnets	?	*C. caretta*	Margaritoulis *et al.*, 2003 Argano *et al.*, 1992
Cyprus	Gillnets	500	*C. caretta* *Ch. mydas*	Godley *et al.*, 1998
	Surface longline	2 000		Godley *et al.*, 1998
Egypt	Nets	Several thousand	*C. caretta* *Ch. mydas*	Laurent *et al.*, 1996*
	Several gears	135		Nada, 2001
France	Different gears		*C. caretta*	See Table 3*
Greece	Surface longline	280/year	*C. caretta* *D. coriacea*	Laurent *et al.*, 2001 Margaritoulis, 1986
	Bottom trawls	No mortality		Margaritoulis *et al.*, 2003
	Gillnets	?		Margaritoulis & Arapis, 1990 Margaritoulis *et al.*, 1992 Suggett & Houghton, 1998
	Trawlers	80	*C. caretta*	Panou *et al.*, 1999

Country	Gears	Captures/ mortality	Species	References
Israel	?	20	*Ch. mydas*	Laurent, 1996a
		17	*C. caretta*	Kuller, 1998
	Nets and others	14	*D. coriacea*	Camiñas, 1998
Italy	Surface longline	199	*C. caretta*	Laurent *et al.*, 2001
		4	*Ch. mydas*	
	Bottom trawls	62	*C. caretta*	
	Driftnets Gillnets	?	*C. caretta* *D. coriacea*	Di Natale, 1995
			D. coriacea	Groombridge, 1990
Libyan Arab Jamahiriya	Bottom trawls Driftnets Gillnets	Low	*C. caretta*	Laurent *et al.*, 1995
Malta	Longlines	1 500–2 500	*C. caretta*	Laurent, 1996a*
Morocco	Bottom trawls	?	*C. caretta*	Laurent, 1996a* WWF, 2003
	Surface longline	3 000		
	Drifnets	?		
Slovenia	Coastal gears	Low	*C. caretta*	Turk, 1998
Spain	Drifnets from Morocco	?	*C. caretta* *D. coriacea*	Ocaña & de los Rios, 2002
	Surface longline	6.5–9.8 /day/boat		Aguilar, Mas & Pastor, 1995
		1 953–23 889		Camiñas, 1997, 1998
	Trawls + purse seines	?		Aguilar, Mas & Pastor, 1995
Tunisia	Bottom trawls	5 000	*C. caretta*	Laurent * Bradai, 1995
	Small gears	2 000–2 500		Bradai & El Abed, 1998
	Trawlers	5.2 % mortality	*C. caretta*	Bradai, 1992
Turkey	Bottom trawls	809	*Ch. mydas* *C. caretta*	Oruç, 2001 Kasparek, Godley & Broderick, 2001 Godley *et al.*, 1998
	Fishing activities	Significant		
	Artisanal	200/year		
	Gillnets	1	*D. coriacea*	Taskavak & Farkas, 1998

* For more detailed information, see Table 3.

In bottom trawls

Bottom trawlers fish on the continental shelf and the slope, and in the deep sea. In all countries the trawl fleet is the most important in terms of number of boats and effort. Other gears such as purse seines or longlines are employed during the periods of the year corresponding to the presence of the target species in the area. Loggerheads move through corridors from nesting beaches to courtship areas, foraging areas or resting areas. These areas are in many cases situated above the continental shelf and the bottom trawlers incidentally capture the turtles. Wintering areas such as the north Adriatic and the Gulf of Gabes are well known because adult loggerheads are caught there in winter.

There are no reliable estimates of the global extent of trawl fishing in areas where sea turtles occur, but according to the results of a European Union (EU) project (Laurent *et al*., 2001) the mortality caused by trawlers is not as important as that associated with surface longlines because the trawl hauls are shorter in the Mediterranean than in other regions.

Croatia. A yearly incidental catch of 2 500 specimens has been estimated, the majority captured by bottom trawlers. The peak of incidental catches occurs during the winter months (Lazar and Tvrtrovic, 1998). The mortality rate for the trawl gear seems to be higher than 60 percent (Argano *et al*., 1992).

Greece. In 2000, turtle catch rates (number of turtles caught per standard trawl net) ranged from 0.00336 ± 0.00062 (95 percent confidence intervals [CI]) in the northern Aegean Sea to 0.00092 ± 0.00182 in the Ionian Sea. Direct mortality was estimated at 0 percent (Laurent *et al*., 2001), but there are documented reports of Greek trawl fisheries impacting turtles around Rhodes and the Lakonikos Bay area (Margaritoulis and Arapis, 1990; Margaritoulis *et al*., 1992). Margaritoulis and Arapis (1990) refer to trawl fishery captures of immature green turtles around Rhodes in unquantified numbers.

Italy. The main fisheries affecting marine turtles in Italy are bottom trawlers in the northern and central Adriatic and surface longlines and driftnets in the rest of the fishing areas. Midwater trawlers are more likely to capture sea turtles close to the sea bottom when fishing in very shallow waters; ideally, this gear should not be used in areas where sea depth is less than 50 m. Midwater trawlers operate in pairs, the trawl net being towed by two boats working together.

Laurent *et al*. (2001) observed a total of 62 turtles caught. Catch rates (number of turtles caught per 30.5 m headrope trawl net per hour) were highly variable, depending on the fleets and the season. They were higher during the fourth and first calendar quarter, indicating differences in spatial and depth distribution of turtles throughout the year. Capture depths ranged from 14.9 to 74.5 m in the north Adriatic.

Total turtle catch per year in the bottom trawl fishery working in the north Adriatic (1999 and 2000) was estimated at 3 588 ± 2 975. Direct mortality was estimated at 14.3 percent and 0 percent for two different fleets (one based at Fano, one not). Total turtle direct mortality per year was estimated at 513 ± 425, while the total number of turtles in a comatose state was estimated at 2 050 ± 1 700.

Morocco. Laurent (1996a) reports loggerhead captures by bottom trawling in unknown numbers.

Spain. Loggerhead captures by trawlers have also been reported (Camiñas, 1995b) although numbers are few.

Tunisia. Before the protection regulations came into force, captures reported were important in bottom trawling (Laurent *et al*., 1996). Turtles are also victims of fishing bycatches in several fisheries (Panou *et al*., 1999; Bentivegna, 2002). The trawler fleet, composed of more than 300 units, caught 2 000–2 500 turtles a year (Bradai, 1996).

Turkey. The region between Mersin and Ïskenderun in the Mediterranean is considered the most important nesting ground for green turtles. According to official information 350 boats are registered with Iskenderun Harbour Management, and 145 of these are active trawlers.

Fishing activities cause significant mortality (Demirayak, 1999). A fleet of trawlers, longliners and small-scale boats using nets operates intensively, even within the fishing-restricted coastal strip, off Kazanli. Trawlers also violate the three-mile coastal limit and seriously impact the green turtle population. Trawl fisheries – bottom and midwater trawling nets – were analysed (Oruç, 2001) during the 1995–1996 fishing seasons. Five trawl boats took part in the project. *Caretta caretta*, *Chelonia mydas* and *Trionyx triunguis* were captured. The following are the results:

Bottom trawls		
Species	**Number**	**Percentage**
Chelonia mydas	30	27.78
Caretta caretta	43	39.81
Trionyx triunguis	35	32.41
Total captures	108	100

Midwater trawls		
Species	**Number**	**Percentage**
Chelonia mydas	249	35.12
Caretta caretta	71	10.01
Trionyx triunguis	389	54.87
Total captures	709	100

Gear	**Number**	**Percentage**
Midwater trawls	709	86.78
Bottom trawls	108	13.22
Total captures	817	100

Midwater trawlers accounted for 87 percent of total turtle captures, mostly at depths of 11–30 m. Most of the turtles (95 percent) were captured alive and healthy and released back into the sea.

In surface longlines

Pelagic longlines used for the capture of swordfish and tuna capture incidentally more than 25 000 loggerheads annually (Camiñas, 1995b), although the fishing mortality is dependent on the gear type and structure (size and shape of hook, number of hooks, length of branch lines, etc). Italian, Spanish and Greek fishermen in the Mediterranean use different types of surface longlines to target swordfish, bluefin tuna and albacore. Differences in longline structure are very important with respect to the number of incidental captures and direct mortality. Branch lines in longlines targeting bluefin tuna fish deeper (about 50 to more than 100 m depth) than those targeting swordfish (from the surface to about 50-60 m depth) .

As a result of these differences in structure and fishing depth, direct mortality is higher for bluefin tuna longlines than those used for swordfish (Camiñas and Valeiras, 2000).

Experimental studies on mortality rates of individuals injured by fishing gears show that 20–30 percent of the turtles caught by Spanish longlines may die (Aguilar, Mas and Pastor, 1993). Around 80 percent of specimens are released with the hook still fixed in the mouth, pharynx or oesophagus (Camiñas and Valeiras, 2000). Furthermore, the probability of drowning at the gear was higher for turtles caught by the albacore longline fleet than for those captured in the swordfish fishery. Some observations seem to point to a rapid degradation of non-stainless hooks in the mouths of the turtles released (Panou *et al.*, 1999).

Algeria. The incidental captures are 250–300 marine turtles/year.

Egypt. A total of 54 turtle corpses (38 loggerhead, eight green turtles and one leatherback) were found along the Mediterranean coast in 1998. In most cases the cause of the turtle's death was difficult to ascertain. However, in several cases it was obvious that death had resulted from entanglement in fishing lines (Ghoneim *et al*., 2000).

Greece. The Greek large pelagic fleets exploit mainly the Aegean and Ionian Seas and the waters around Crete but occasionally extend their activities to the eastern Levantine basin. The fishing season for swordfish lasts from February to the end of September. Swordfish fishing is carried out using surface drifting longlines.

The fleet consists of 495 vessels. Since June 1999, vessels wishing to operate drifting longlines have had to be longer than 12 m. Two groups of vessels can be identified: the smaller group, below 15 m in length, fish around the home port while the larger vessels fish everywhere. Two types of longline are used. The first is the one with the well-known line basket while the second type, the more modern, is the so-called *karoula*. This gear is used on larger vessels. Most of the fishermen use the classic longline. In Kalymnos, however, most fishermen use the *karoula*.

The Greek drifting longline targeting swordfish is structurally similar to other Mediterranean surface longlines but has a reduced number of hooks per unit. During the European Marine Turtle Project (EMTP) (Laurent *et al*., 2001) 23 captured turtles were observed by the Greek on-board monitoring programme (22 loggerhead and one leatherback). In 2000, in the swordfish fishery, turtle catch rates (number of turtles caught per 1 000 hooks) were estimated at 0.63±0.38 (95 percent CI). Direct mortality was estimated at 4.3 percent. A previous study on the bycatch of turtles conducted from 1989 to 1995 showed that each vessel caught an average of 7.7 loggerheads per year (Panou *et al*., 1999). Loggerheads are also taken on longlines in the Ionian Sea (Panou *et al*., 1992). Although the nesting season in that area coincides with the peak of the swordfish fishery, 77 percent of individuals caught were immature, highlighting the special vulnerability of this group to fishing. Extrapolating from these data, an estimate of 280 turtles caught per year is obtained for the whole of the professional Greek longline fleet in the Ionian Sea (which accounts for more than 50 percent of total Greek fishing effort in western Greece). Panou *et al*. (1992) estimate that 80 loggerheads are captured annually by the Kefallonian fleet.

Green turtles are also sporadically caught as a bycatch by the Greek longline fleet operating in the Ionian Sea (Panou *et al*., 1999).

Italy. The main drifting longline fisheries target the swordfish (*Xyphias gladius*) and albacore (*Thunnus alalunga*). The fleet use two different longlines to target swordfish (LLSWO) and albacore (LLALB) depending on the period of year, geographical area and species abundance (Laurent *et al*., 2001).

During the whole period of on-board observations for the EMTP, a total of 233 marine turtles (81 in 1999, 151 in 2000 and 1 in 2001) were captured: 94 loggerheads were caught in the northern Ionian Sea; 134 marine turtles (132 loggerheads and 2 green turtles) were caught in the southern Ionian Sea; and 5 loggerheads were caught in the southern Tyrrhenian Sea in 2000.

Slightly over 60 percent of the animals were captured in the southern Ionian Sea, while 39.6 percent were taken in the northern Ionian Sea. The highest number of captures was registered between May and October. The size (SCCL – standard curve carapace length) of the loggerheads ranged between 19.7 cm and 72.8 cm. The turtles captured by LLSWO were the largest and the mean sizes (SCCL) observed in 1999 and 2000 were 62.2 ± 8.6 cm and 48.1 ± 7.8 cm, respectively. The smallest specimens were those caught by LLALB.

In 2000, for the swordfish fishery, turtle catch rates (number of turtles per thousand hooks) were estimated at 0.22 ± 0.12 and 0.71 ± 0.14 in the Italian northern and southern Ionian Sea, respectively. In albacore fisheries turtle catch rates varied from 0.50 ± 0.19 and 0.20 ± 0.06. Direct mortality was estimated at 0 percent (N = 214).

Leatherback is also taken as bycatch in Italian longline albacore fisheries (De Metrio, Petrosino and Tursi, 1982; De Metrio *et al.*, 1983; Laurent *et al*., 2001).

Malta. Gramentz (1989) reported 1 500–2 000 loggerheads captured annually by longlines, mostly immature. Groombridge (1990) reports 1 000–3 000 turtles captured annually by longlines, nets and other gears, both as target and accidentally, and estimates 500–600 turtle deaths yearly. Since the 1930s turtles have been captured for food in Maltese waters, a practice that continued until the turtle was legally protected. Unknown numbers of loggerheads and probably also green turtles are captured incidentally every year. The length of the longline and number of hooks used depends on the vessel and the crew (de la Serna, Srour and Rioja Garay, 1999).

Morocco. Most of the longliner fleet is based at the ports of Tangier and Nador. Today, these ports have 275 and 45 active longliners respectively (de la Serna, Srour and Rioja Garay, 1999). Laurent (1996a) estimates that swordfish longliners based at Moroccan ports capture more than 300 loggerheads annually.

Spain. Swordfish is targeted by surface longline all year round with maximum activity during the summer and autumn. The fishing area comprises the Spanish coastal area to 42° N and extends to 7° E. The fleet comprises 145 boats whose mean characteristics are: 24.95 GRT (gross registered tonnage), 144.9 HP and 11.27 m in length. The boats are based in ports in Andalucía, Murcia, Valencia and the Balearic Islands. The standard gear is made up of a nylon and plastic multifilament main line of 2.5–3 mm section. Branch lines are connected to the main line with a distance between branches of about 2 m. Near the surface buoys that have bright signals and reflectors for easy location support the main line. Mean gear length is about 30 km (up to 60 km is allowed). Between 1 000 and 2 000 hooks are used per fishing operation. Hooks are baited with *Sardinella aurita* and *Scomber* spp. The main gear targeting swordfish (LLHB) is the *marrajera*. The other three types of gear have the same structure but with modifications to some parts and materials for temporary fishing of albacore (LLALB) or bluefin tuna (LLJAP). A semi-pelagic gear called *piedrabola* (LLPB) is also used for swordfish.

From the early 1980s different studies and research projects on the Spanish fisheries have demonstrated the important effects that the swordfish longline has on marine turtles in the western Mediterranean. A study on the Spanish swordfish longline fleet suggested that turtle bycatches in the region were very high (Aguilar, Mas and Pastor, 1993). Catch rates as high as 6.5–9.8 turtles per day per boat were recorded in 1990 and 1991, allowing for an estimated total catch ranging from 22 000 to 35 000 individuals each year, with 66 percent of captures concentrated in only two months (July and August). Estimates of total captures by the Mediterranean fleet for the period 1988–1996 range from 1 953 individuals in 1993 to 23 888 in 1990 (Camiñas, 1995b).

The main findings from the EMTP (Camiñas and Valeiras, 2001) are: a total of 2 127 turtles caught was recorded over the whole project. During 1999, 498 loggerheads and one leatherback were captured in 291 monitored fishing sets. In 2000, a total of 1 627 loggerheads and one leatherback were captured in 507 sets.

The fleet is divided into two parts: an artisanal fleet with vessels under 12 m in length, fishing near the coast for a maximum of one or two days at a time; and a fleet of vessels over 12 m in length, fishing in an extensive area towards the eastern waters off the Balearic Islands for five to ten days at a time or more. The LLHB is used all year round, but a small group of vessels change to the albacore longline (LLALB) from June to October and others to bluefin gear (LLJAP) from May to June. Some vessels use the *piedrabola* gear (LLPB) in August.

Geographic distribution of the fleet operations in 1999 and 2000 shows gear segregation. LLALB was deployed mainly north and east of Mallorca; LLJAP was found south of Ibiza; LLPB was employed near the Iberian Peninsula coast; and LLHB was distributed throughout the western Mediterranean, but mainly from south of the Balearic Islands to Cape Gata and north of Cape San Antonio.

The main areas where turtles are concentrated, with monthly variations, are the waters surrounding the Balearic Islands; the north Balearic Sea; and the eastern region off Cape Palos (an extensive area from 1º W to 1º E). Monthly distribution of the captures has followed the same pattern in recent years (Camiñas, 1986; 1988; 1995a; Camiñas, de la Serna and Alot, 1992; Camiñas and de la Serna, 1995). Loggerheads are captured all year round, with the highest numbers caught from May to September.

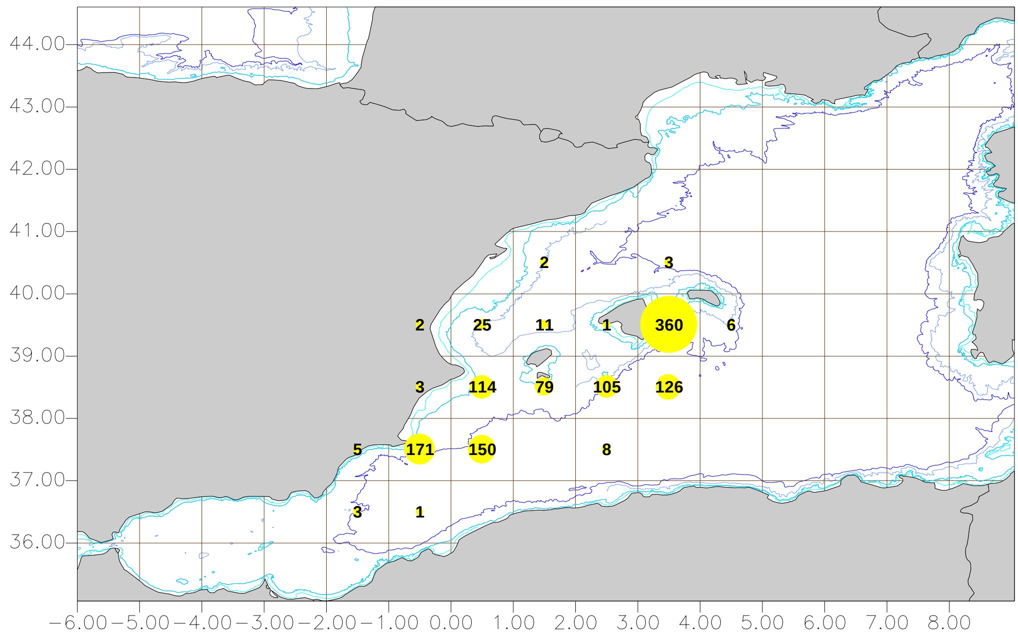

Figure 2. Geographical distribution of marine turtle catches (number of turtles) for Spanish swordfish longliners in 2000. Source: Camiñas and Valeiras, 2001

The selectivity of the gears allows loggerhead captures to be separated into three groups: the largest turtles are captured with the LLJAP (mean = 548 mm MSCL [minimum straight carapace length]); LLHB capture medium-size loggerheads (mean = 495 mm MSCL) and LLALB capture the smallest sizes (mean = 331 mm MSCL).

Catch rates are different according to gear type and period of year. No turtles were captured with the recently introduced *piedrabola* gear (LLPB) during the observation period (23 sets distributed in 1999 and 2000). The highest capture rates are found with LLALB and LLJAP, with values over 3.27 turtles per 1 000 hooks (CI ± 4.03) for LLALB and 1.74 turtles per 1 000 hooks for LLJAP (CI ± 0.99). The direct mortality rate is also related to the gear type and the hook position. LLALB and LLJAP generate higher direct mortality than LLHB. Direct mortality for LLJAP is related not only to the gear structure and hook size but also to the fishing depth – when turtles are captured with this gear it is difficult for them to reach the surface to breathe. Another factor affecting direct mortality is the total catch by set. Higher catches sink the gear and increase turtle mortality.

Leatherback. Swordfish longlines appeared to be responsible for most of the incidental catches and entanglements recorded in the western Mediterranean (Crespo, Camiñas and Rey, 1988; Camiñas, 1998), although until the mid-1990s some additional captures resulted from the activity of the former Spanish swordfish driftnet fishery in the Alboran Sea (Camiñas, 1995a). Two individuals were entangled in longlines in the course of 217 fishing operations in 1999 (Camiñas and Valeiras, 2000).

Tunisia. Longline fleets catch an estimated 4 000 individuals annually (Demetropoulos and Hadjichristophorou, 1989).

In pelagic driftnets

Information on pelagic driftnets in the Mediterranean is incomplete. Pelagic driftnets have been banned in EU countries since January 2002, but in recent years the use of such gears by non-European countries has increased. The Turkish fleet, Italian boats using *espadara* or *ferratella*, French fishermen using *thonaille* and Moroccan boats with driftnets in the Alboran and Gibraltar area are the main users of this gear. A recent World Wildlife Fund for Nature (WWF) research project focused on the activity of the Moroccan Mediterranean driftnet fleet, monitoring fishing operations and the effect on non-target species with on-board observers. There were 177 active boats. Most boats are able to use driftnets all year round, which results in high annual bycatch figures (Tudela *et al*., 2003).

An estimated 30 percent of turtles caught in nets used by the Italian driftnet fishery are drowned (De Metrio and Megalofonou, 1988). Entanglement in ghost gears (such as discarded netting), although frequent, has not yet been evaluated.

France. The *thonaille* is a surface driftnet targeting bluefin tuna (*Thunnus thynnus*). The fleet fishing with *thonaille* in the Provence–Côte d'Azur region comprised 46 boats. The *thonaille* is usually used from late spring to the end of the summer (May–September). The bycatch species account for 4.4 percent of the total commercial catch. The loggerhead is one of five species that have shown different rates of incidental capture. During the 2000 fishing season three loggerheads were captured and rejected alive at sea in 67 observed hauls.

Italy. Tuna driftnets, although banned by an EU resolution, continue to be used in unknown numbers in different Italian waters. Some studies have shown an uncertain number of marine turtles captured in Italian fisheries, both loggerheads and leatherbacks. Di Natale (1995) reported loggerheads entangled in the Ligurian and Tyrrhenian Seas (catch rates were 0.057 and 0.046 loggerheads per day per vessel, respectively). De Metrio and Megalofonou (1988) estimated that an Italian driftnet fleet operating in the Ionian Sea in the 1980s captured about 16 000 turtles annually. Gillnets fishing for tuna are also responsible for some incidental capture of leatherbacks (Camiñas, 1998).

Morocco. Swordfish fishing is a seasonal activity, since it coincides with the passage of the swordfish through the Straits of Gibraltar. It starts around the end of March and continues until November. Artisanal drift gillnets are used specifically for swordfish during their migration through the Straits of Gibraltar. Nevertheless, the incidental capture of turtles by the driftnets in the Gibraltar Straits area should be similar to that seen with the driftnets formerly used by Spanish fishermen (Camiñas, 1995a; 1995b). A case study on the impact of the Moroccan driftnet fleet on protected and vulnerable species in the Alborán Sea (Tudela *et al*., 2003) found that moderate numbers of loggerheads were captured from December to April, but the numbers were much smaller during the summer. Thus there is a marked seasonality. A total of 46 loggerheads was recorded – they were taken in 8.4 percent of the monitored sets (369 fishing operations from December 2002 to September 2003). Loggerheads are released alive whenever possible, which points to a low fishing-induced mortality for this gear and area, contrasting with the high number of dead turtles in Ceuta (a Spanish city in north Africa) referred to by Ocaña and García de los Ríos (2002) and Silvani, Gazo and Aguilar (1999).

Turkey. In the Bay of Edremit, 100–150 boats fish for swordfish using driftnets. In the southern Aegean Sea mainly driftnets are used. The fishing period begins in September and goes on until the end of October. In 2000 the ban on fishing in all Turkish waters was from 15 June to 1 August. Turkish law has protected marine turtles since 1973, although before the law was introduced the capture of turtles for export to central Europe was a common activity – a total of 270 tonnes was supplied in 1968 (Oruç, Demirayak and Sat, 1997).

In small-scale fisheries

Bycatch of marine turtles has been reported from the Mediterranean region artisanal fisheries. According to the most recent information, a total of 24 Mediterranean countries, five Black Sea countries and five non-Mediterranean countries, included under the statistics category of nei (not elsewhere included), are currently fishing with different gears in FAO Area no. 37.

The total number of fishing boats that may be operating across the Mediterranean Sea has been estimated at approximately 100 000. The Mediterranean has an extensive continental shelf with important fishing areas. These areas are important for bottom trawlers and artisanal gears. Some areas (including all those in Table 5 except the Gulf of Lion) are visited annually by marine turtle juveniles and adults, which spend periods resting or foraging there. The continental shelf areas where turtles can be observed, some of which are situated outside the national exclusive economic zone (EEZ), are shown in Table 5.

Table 5. Areas of the continental shelf where turtles are found

Zone	Fisheries involved
Gulf of Valencia	Spain
Gulf of Lion	France, Spain
Adriatic Sea	Albania, Bosnia and Herzegovina, Croatia, Italy, Slovenia, Serbia and Montenegro
Gulf of Gabes	Italy, Libyan Arab Jamahiriya, Tunisia
Deeper water of Sicilian Channel	Italy, Tunisia
Gulf of Iskenderun	Turkey
Northern Aegean	Greece, Turkey

Source: Adapted from Oliver (1998)

Albania. Fishermen catch loggerheads along the coast relatively frequently. The use of dynamite in fishing activities has a devastating effect on marine turtles.

Croatia. *Caretta caretta* is the most frequent species (Lazar and Tvrtrovic, 1995). *Dermochelys coriacea* and *Chelonia mydas* are occasional. Juveniles are common (Lazar and Tvrtrovic, 1998). Turtles are incidentally captured in gillnets, which are artisanal gears (Margaritoulis *et al*., 2003). This is recognized as the most deadly fishing method for turtles (Argano *et al*., 1992; Lazar, Margaritoulis and Tvrtrovic, 1998), with a mortality rate of about 75 percent.

Cyprus. Fishermen have traditionally killed turtles caught incidentally in their nets. Over 500 turtles a year are caught, mostly with gillnets and longlines (Godley *et al*., 1998). A survey based on interviews with artisanal fishermen (using both nets and longlines) in northern Cyprus and on the Turkish coast yielded estimated bycatches of 4 and 2.5 turtles per boat per year respectively, giving a total minimum estimate of about 2 000 turtles for the whole region (Godley, Thompson and Broderick, 1998). Although 90 percent of the specimens were reported to have been caught alive, an unknown proportion of them could have been killed on board.

Egypt. According to Laurent *et al.* (1995) and Margaritoulis *et al.* (2003) exploitation of turtles is done openly in Egypt. Both loggerheads and green turtles are sold in fish markets (Kasparek, 1993; Laurent *et al*., 1996; Venizelos and Nada, 2000; Camiñas, personal observations). It is estimated that several thousand individuals are killed each year in Egypt, with loggerheads accounting for 68 percent of the total. A high proportion (37.5 percent) of them are large-sized individuals (Laurent *et al*., 1996). Nada (2001) reports 135 turtles offered for sale over a six-month period of observations at the Alexandria fish market in 1998/99.

France. Information on captures in artisanal gears is available in Laurent (1991) and Laurent *et al.* (1996). Delaugerre (1987) reported a mortality rate of 94.4 percent for *Caretta caretta* caught in Corsica by trammel nets placed at depths of over 60 m. A mortality rate of 53.7 percent out of 149 turtles caught at depths of less than 50 m is reported by Laurent (1991). About ten loggerhead juveniles and some leatherbacks are annually observed alive or dead on the coast.

Greece. Suggett and Houghton (1998) report the entanglement of loggerhead turtles in gillnets off Kefallonia.

Israel. Twenty-six small purse seiners conduct coastal pelagic fishing. As this fishery is seasonal, most purse seiners also operate bottom-set gillnets and trammel nets, setting up to 3 000 m of gear at a time (Laurent, 1996a). Kuller (1998) presents information on incidental catches for fishing gears but numbers are not high (20 green turtles and 17 loggerheads from 1993 to 1998). The author does not provide information regarding the gears that affect marine turtles in Israel.

Italy. An EU fleet register (July 2002) includes 16 384 Italian boats (17.9 percent of the total EU fleet) fishing in the Mediterranean. Turtles are very common in Italian waters, migrating from the eastern to the western Mediterranean basin and vice versa through the Straits of Messina and the Sicilian Channel (Argano and Baldari, 1983; Margaritoulis, 1988a; Argano *et al*., 1992; Bentivegna, 2002). The two corridors are characterized by intense fishing and heavy marine traffic that peaks when loggerheads migrate, i.e. autumn and spring, the area being highly exploited by the tourism industry (Bentivegna, 2002). Gerosa and Casale (1998) refer to “Italy… where bottom longlines are used, capturing numerous marine turtles”. This gear apparently penalizes juveniles in particular because large specimens are able to drag the main line to the surface to breath.

Lebanon. No information on fisheries and number of turtles caught is available for Lebanon. Some artisanal fishermen were observed on the reproduction beach and carcases of turtles were seen on other beaches near the reproduction area (Newbury, Khalil and Venezelos, 2002).

Libyan Arab Jamahiriya. Laurent *et al*. (1995) highlight incidental captures of sea turtles by bottom and drifting longlines, trammel nets and gillnets, but the numbers seem to be low.

Malta. Most of the vessels could be considered as multipurpose on a small scale. Small pelagic driftnets are used mostly from November to February when addled bream (*Oblada melanura*) and small tunas (*Scombridae*) are known to congregate. Approximately 50 small vessels are licensed to use this gear.

Morocco. Artisanal fisheries include a total of 1 402 gears including longlines (not specified), handlines and pole-lines (hand operated), trammel nets, driftnets, set gillnets (anchored), beach seines, trolling lines, traps, purse lines (Lampara), surrounding nets, pots, dredges and others.

Artisanal driftnets are used in the entire Moroccan Mediterranean region, except in the province of Tangier. Their overall length ranges from 300 to 800 m. This fishery began with two target species, bonito (*Sarda sarda*) and bullet tuna (*Auxis* spp.) The fishing period for these two species is from September to February. There is very little information available on the effects of artisanal gear on marine turtles in Morocco.

Spain. Artisanal gears used in Spain are trammel nets, set longlines, gillnets, boat dredges, pots, barriers, handlines and pole-lines (hand operated), trolling lines, boat seines, driftnets, gillnets and trammel nets combined and other gear. An EU fleet register (July 2002, EU fleet) includes 4 155 Spanish boats (4.5 percent of the total EU fleet) fishing in the Mediterranean, 2 251 of them (54.2 percent of the Mediterranean Spanish fleet) under 12 m in length. There is a dearth of information regarding the effects of these gears on turtles.

Tunisia. The artisanal fleet is the most important in terms of number of boats and is located along the whole length of the Tunisian coast. A total of 2 525 *metier* are included in the FAO-COPEMED database of artisanal fisheries (711 trammel nets; 356 setting longlines; 231 drifting longlines). An important fleet fishes for lobsters using gillnets and entangling nets. Groombridge (1990) reported that marine turtles were captured for domestic consumption and for tourist souvenirs. The species have been protected since 1992. In 1995 the harvesting of eggs was also banned (Bradai and El Abed, 1998). The highest catch rates in the region are returned by bottom longliners (an average of nearly 23 turtles per boat per year). Some incidental captures of leatherbacks were also reported during the 1990s, mostly by trammel nets, bottom trawls and driftnets (Bradai and El Abed, 1998). Bradai (1992) found a mortality rate of 5.2 percent for turtles caught with trammel nets. The total annual bycatch of the Tunisian small-scale fleet operating in the Gulf of Gabès was estimated at 5 000 individuals (Bradai, 1995).

Turkey. The number of artisanal boats fishing in the Ïskenderun Gulf is 1 200. Most of them use longline, locally named *baragat*. The exact numbers of small boats are unknown (Oruç, Demirayak and Sat, 1997). Godley, Thompson and Broderick (1998) surveyed the levels of marine turtle bycatch in the artisanal fishery based in northern Cyprus and the Turkish region from Alanya to Mersin in the Mediterranean (see section on Cyprus). The first leatherback recorded on the Aegean coast of Turkey was caught in a gillnet.

Black Sea countries

Total catches of fish for all the nations bordering the sea, which includes Bulgaria, Georgia, Romania, the Russian Federation, Turkey and the Ukraine, fell from 814 000 tonnes in 1988 to 213 000 tonnes in 1991. Since then they have risen to 523 000 tonnes.

Only *Caretta caretta* is distributed in the western part of the Black Sea in deeper waters and also near river mouths. There are no marine turtle nesting beaches. Observations of the species are infrequent (Marquez and Bauchot, 1987). Nankinov (1999) collected a total of five loggerhead field observations and one for green turtle reported in Bulgaria and Romania from 1585 to 1987, when three loggerheads were observed near the southern coast of Bulgaria. Because of the scarcity of marine turtles in the Black Sea there is little information on interactions with fisheries.

POPULATION TRENDS

Loggerheads and green turtles nesting in the Mediterranean are listed in Appendix 1 of CITES. The loggerhead is globally categorized as endangered on the 2000 IUCN Red List. The green turtle is globally categorized as endangered but the Mediterranean subpopulation is categorized as critically endangered. Nevertheless, there are few estimates of the population's trend. A recent document (Broderick *et al*., 2002) estimated the Mediterranean populations of loggerheads and green turtles based on intensive monitoring and results analysis at Alagadi Beach (northern Cyprus) over a six-year period. Alagadi Beach is one of the few sites in the Mediterranean where both green turtles and loggerheads nest. The population trends presented here are based mainly on this document.

Loggerheads

Trends in nesting data for loggerheads were examined (Broderick *et al*., 2002) at the following sites: Alagadi, Zakynthos (Greece) and Israel. Figure 3 illustrates the data sets and associated regression analysis for Zakynthos during the period 1984–1994 using data taken from the literature. As there did not appear to be any positive or negative trend in the nesting number, the authors used the mean annual number of nests to give an estimate of 2 280–2 787 loggerhead females nesting annually in the Mediterranean.

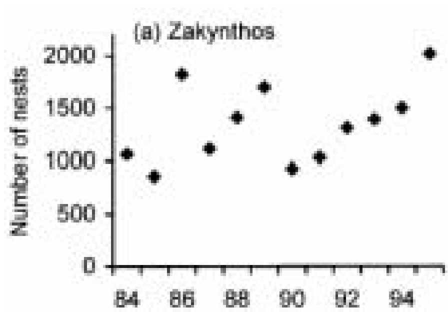

Figure 3. Number of loggerhead turtle nests recorded at Zakynthos, Greece, 1984–1995 (y= - 84726 – 43.3 x, $R^2 = 0.18$, $F_{1,12} = 2.2$, $P>0.05$). Source: Broderick *et al*., 2002

Green turtles

Nesting data from three sites for green turtles were examined (Broderick *et al*., 2002): Israel, Akyatan (Turkey) and Alagadi. Figure 4 illustrates the data sets and associated regression analysis in Akyatan. As there did not appear to be any positive or negative trend in the nesting number, the authors used the mean annual number of nests to give an estimate of 339–360 green turtle females nesting annually in the Mediterranean.

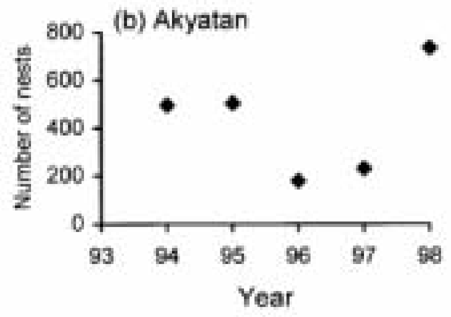

Figure 4. Number of green turtle nests recorded at Akyatan (Turkey), 1994–1998 (y= -40489 + 20.5 x, R^2 = 0.2, $F_{1,5}$ = 0.06, P>0.05). Source: Broderick *et al*., 2002

Kasparek, Godley and Broderick (2001), when plotting the annual number of nests from 1993 to 1999 in northern Cyprus and other nesting areas, observed that fluctuations in the number of green turtles nesting apparently follow a general pattern in the whole of the eastern Mediterranean (Figure 5).

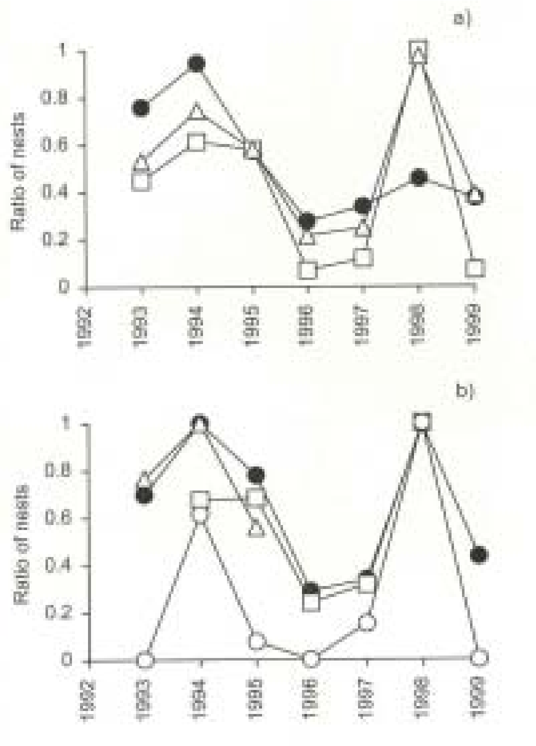

Figure 5. Relative annual nesting activity by green turtles: a) at different sites in northern Cyprus, and b) at different sites in the eastern Mediterranean: northern Cyprus (filled circles), Akyatan (squares), Goksu Delta (triangles) and Israel (open circles). Source: Kasparek, Godley and Broderick, 2001

DEFINITION OF SUSTAINABLE POPULATION LEVELS

No reference point has yet been proposed for the Mediterranean populations of loggerhead and green turtles. The numbers of marine turtles nesting annually at sites in the Mediterranean and reproducing are: 2 280 to 2 787 loggerheads and 339–369 green turtles.

For the marine turtle populations, some limit reference point should be developed and introduced as a guide for population management. This should be done population by population, because there is no information regarding the total population. Limits should be based on numbers of observed females nesting during a season, for both loggerheads and green turtles. This means intensive monitoring programmes are necessary for most of the nesting beaches where there is no such programme. A possible limit reference point to be considered would be one developed from the mean number of nesting females by beach/year.

Another reference point that could be employed is one based on the mean annual number of nests per nesting beach. Every single nesting beach could be considered an independent breeding system. The fluctuations in the number of nests per beach could be used as an easily measurable population index.

MODELLING THE EFFECT OF VARIOUS SOURCES OF MORTALITY

Eggs are consumed by foxes, ghost crabs and other predators. They can become infected by nematodes, muscidae and other invertebrates. Juveniles and adults are affected by marine pollution from land activities and waste from vessels, nesting beach loss, tourism and artisanal fishing. In some countries direct exploitation for local consumption based on religious practices continues to affect marine turtles; predators at sea are an important source of mortality affecting hatchlings, juveniles and adults of both species. Habitat degradation reduces the number of natural nesting habitats. The degradation of sea grass meadows, which are green turtle feeding grounds, has had an enormous effect on the population. Indirect capture by fishing gear operating offshore is the main source of mortality.

The total turtle stock mortality in the Mediterranean has not been evaluated. Table 6 summarizes the main causes of mortality and the level of uncertainty associated with each. The uncertainty level *high* means that insufficient information exists; level *above average* of uncertainty means that some information on the problem exists; when periodic information exists, at least for a year period, the level of uncertainty is considered *moderate*; when the cause of mortality has been evaluated the uncertainty level is considered *low*.

The degree of incertitude regarding the causes of mortality is generally high for most of the sources. There are no models of survival rates of loggerhead and green turtle in the Mediterranean that take into consideration all the causes of mortality affecting them, but for fishing mortality some tentative efforts have been made although direct quantification of the level of mortality is rare.

Table 6. Marine turtles – main causes of mortality and associated level of uncertainty

Source of mortality	**Causes**	**Level of uncertainty**	**Area**	**References**
Habitat degradation	Tourism	High	Eastern and central Mediterranean	
	Marinas	High	Eastern Mediterranean	
	Collisions with boats	Above average (av.)	Crete, Zakynthos	Margaritoulis *et al*., 2003
	Construction	High	Turkish beaches	
	Traffic	High	Gibraltar, Sicilian Channel, Eastern passages	Camiñas, 1995b
Pollution	Oil	High	Mediterranean	Valeiras *et al*., 2000
	Heavy metals	High	Mediterranean	
	Floating plastic	Above av.	Western Mediterranean	Tomás *et al*., 2002 Valeiras *et al*., 2000
	Tar balls	High		Tomás *et al*., 2002
	Other litter	Above av.	Central Mediterranean	Bentivegna & Paglialonga 1998
	Light pollution	Above av.	Western Mediterranean	Demetropoulos, 2000
	On beaches	Above av.	Eastern and Central Med.	Campbell *et al*., 2001
Natural causes	Vertebrate predators	Low	48.8% loss of clutches in Kiparissia (Greece)	Margaritoulis, 1988b
			65.7% loss in Dalyan	Erk'akan, 1993
			36.6% loss in Cyprus	Broderick & Godley, 1996
			44.8% loss in Libyan Arab Jamahiriya	Laurent *et al*., 1995
			35% loss, Patara (Turkey)	
	Ghost crabs	Moderate	66% of hatchlings lost in Egypt and Cyprus	Simms, Clarke & Campbell, 1997
	Invertebrates on eggs	High	On green and loggerhead turtle (Turkey, Cyprus)	Broderick & Hancock, 1997

NOTE: See text for a detailed explanation of levels of uncertainty.

CONTRIBUTION OF FISHING TO OVERALL SEA TURTLE MORTALITY

A demographic model for the loggerhead Mediterranean population (Laurent *et al.*, 1996) showed that adult survival was the main factor affecting population growth rates, fecundity being less significant. According to the model results, an individual of stage 70 (individuals with a size equal or superior to 70 cm SCCL) is 75 to 654 times as important as an egg, 7.6 to 26.3 times as important as an individual of stage Y2 (32–51 cm SCCL) and 3.2 to 4.3 times as important as an individual of stage Y3 (51–70 cm SCCL). Conservation measures regarding eggs are not sufficient to ensure the survival of the species. A better strategy would be to orient conservation measures towards protection of the adults as a first priority.

A global estimate of turtle mortality in the Mediterranean was provided by Lee and Poland (1998). Table 7 summarizes the main direct and indirect fishing captures of marine turtles.

Table 7. Main causes of direct and indirect fishing captures of marine turtles

Source of mortality	Causes[a]	Level of uncertainty	Number of turtles	Area	References
Direct exploitation	Sold	Low	Several thousand/year	Egypt markets	Laurent, 1996a Venizelos & Nada, 2000
	Consumed	High	Some	Italy	Argano *et al.*, 1990
	Exploitation[b]	Low	None	Mediterranean	Margaritoulis *et al.*, 2000
	Clandestine trade	High	Some	Tunisia	Laurent, 1996a
	Eggs consumed	High	Some nests	Lebanon	Newbury, Khalil and Venezelos, 2002
		Moderate	Some nests (banned in 1995)	Tunisia	Bradai & El Abed, 1998
Incidental fishing captures	All fisheries	High	60 000	Mediterranean	Lee & Poland, 1998
	Surface longline	Moderate	>25 000/year Mortality 10–50%	European countries	Laurent *et al.*, 2001
	Bottom trawl	Above average	Several thousand	Mediterranean	Bradai, 1992 Bradai & El Abed, 1998 Laurent, 1996a Laurent *et al.*, 1990 Laurent *et al.*, 2001

Source of mortality	Causes[a]	Level of uncertainty	Number of turtles	Area	References
	Pelagic driftnet	High	Unknown	Italy, France, Morocco	SEC, 2002 WWF, 2003
	Other gears	High	Unknown	Mediterranean	Bradai & El Abed, 1998 Laurent, 1996a

[a] Causes affect both loggerheads and green turtles.
[b] Severe exploitation until about 1960s. All Mediterranean countries now penalize the capture of turtles and commerce in them, and most are CITES members.

Source of loggerhead and green turtle mortality

The sources of mortality for loggerheads and green turtles in the Mediterranean are different and depend on the species and the population. Mortality at nesting beaches can be quantified on beaches where continuous monitoring and tagging programmes exist, but for most populations an intensive monitoring programme needs to be implemented at regional level. Nesting females are a crucial part of the population but we do not have sufficient information about other stages of the life cycle of this species (particularly juveniles and males) during its life at sea. We should remember that the loggerhead Mediterranean population is considered endangered and the green turtle subpopulation critically endangered (2000 IUCN Red List of Threatened Species).

Tables 8 and 9 summarize in a qualitative form the sources of mortality for loggerhead and green turtle populations in the Mediterranean. The evaluation levels given in the tables were obtained from various publications and grey literature; most of the sources are referenced in this document.

Table 8. Mediterranean loggerhead (*Caretta caretta*) – source of mortality by population

Mediterranean loggerhead, main population/stocks	Current status (in relation to pristine)	Population trends	[a] Sources of mortality (*levels*)							Are fisheries interactions important?
			A	B	C	D	E	F1	F2	
Cyprus	Stable?	No trends	2	2	2	3	2	0	3	Yes
Greece	Stable?	No trends	2	3	2	3	2	0	4	Yes
Turkey	Stable?	No trends	3	3	2	3	3	0	3	Yes
Libyan Arab Jamahiriya	Unknown	Unknown	1	0	2	1	1	1	1	Yes
Atlantic population in Mediterranean	Unknown	Unknown	2	1	2	1	1	1	4	Yes

[a] Sources of mortality: **A -** Habitat degradation, **B -** tourism, **C -** pollution, **D -** natural predators, **E -** natural habitat changes, **F1 -** direct fishing, and **F2 -** indirect fishing.

Explanation of levels:
0 – a specific source of mortality has no effects on the population
1 – insufficient information exists, although some mortality impact is suspected
2 – some information on the source of mortality exists
3 – periodic information exists on the source of mortality
4 – the mortality cause has been evaluated

Table 9. Source of mortality for the green turtle (*Chelonia mydas*) populations

Green turtle, main populations	**Current status**	**Population trends**	**[a] Sources of mortality (*levels*)**							**Are fisheries interactions important?**
			A	**B**	**C**	**D**	**E**	**F1**	**F2**	
Turkey	Stable?	?	3	3	2	3	3	0	3	Yes
Cyprus	Stable?	No trends	2	2	2	3	2	0	3	Yes

[a] Sources of mortality: **A -** Habitat degradation, **B -** tourism, **C -** pollution, **D -** natural predators, **E -** natural habitat changes, **F1 -** direct fishing, and **F2 -** indirect fishing.
Explanation of levels:
0 – a specific source of mortality has no effects on the population
1 – insufficient information exists, although some mortality impact is suspected
2 – some information on the source of mortality exists
3 – periodic information exists on the source of mortality
4 – the mortality cause has been evaluated

In Tables 8 and 9, the question is asked: Is the importance of fisheries interactions with the turtle populations important? The answer is "yes" in both cases because, independently of the population origin, both species are affected by several Mediterranean fisheries, as has already been seen.

CONCLUSIONS

Two species of marine turtles, the loggerhead and the green turtle, reproduce in the eastern Mediterranean basin. Another species, the leatherback, is common throughout the area although it has no permanent nesting areas. The presence of other species is rare.

There is no information on trends regarding the Mediterranean populations and their status. However, according to recent estimates, only 2 280–2 787 loggerheads and 339–369 green turtle females nest annually in the Mediterranean. The total population for each species is unknown.

An analysis of the fisheries and their effects on marine turtles in the Mediterranean and Black Sea shows different situations, depending on species, country and gear. The main fisheries affecting marine turtles are: Spanish and Italian surface longline; North Adriatic Italian trawl, Tunisian trawl, Turkish trawl; Moroccan driftnet, Italian driftnet. The same gears from other countries also affect turtles, but the numbers are low. The fishing effects of most of the artisanal gears on marine turtles have not been estimated.

Recalling some important threats affecting local populations in some countries (e.g. the chrome factory in Turkey and the development of tourism in Greece and Turkey), the assessment of status on a population-by-population basis should be considered.

The Black Sea differs notably from the Mediterranean. There are no marine turtle nesting areas and the presence of these reptiles is only occasional.

National action plans and local (nesting beach) plans, as foreseen by the Barcelona Convention action plan on marine turtles, are needed instead of continuing to focus on the turtle conservation problem from the perspective of the threat posed by fisheries. The analysis of the effects of fishing should be considered together with other threats. At the same time, the implementation of fishing bans, restricted and protected areas, the monitoring of fleets and gears and the use of other fisheries management tools can reduce the incidental capture and mortality of turtles associated with some Mediterranean fisheries.

Limit reference points and mortality threshold should be defined for the Mediterranean populations, based on female nesting frequency and number – yearly nesting numbers must be carefully monitored.

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ANNEX 1

Loggerhead distribution maps, nesting areas, habitats and migration

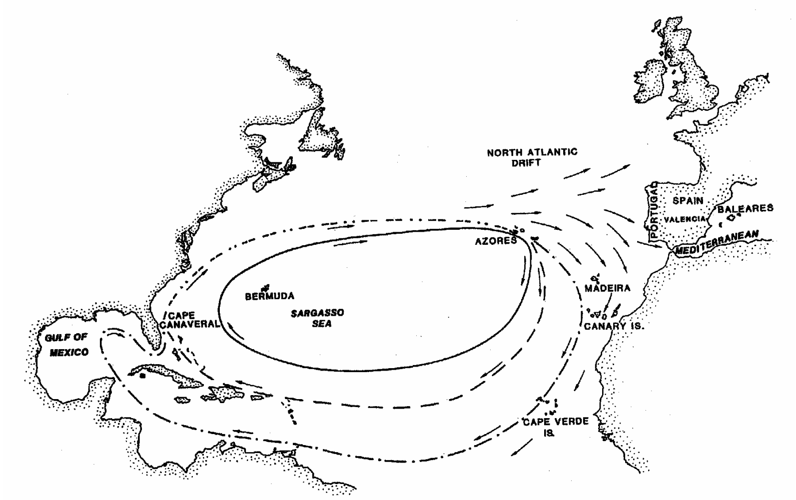

Figure 1. General migratory paths for marine turtles in the Atlantic Ocean

Figure 2. Main loggerhead nesting areas (Source: Margaritoulis *et al.*, 2003)

Figure 3. Loggerhead pelagic and demersal habitats in the Mediterranean
(Source: Margaritoulis *et al*., 2003)

Figure 4. Recoveries of immature loggerheads tagged in Italy
(Source: Margaritoulis *et al*., 2003)

Figure 5. Recoveries of loggerhead inside and outside the Mediterranean (Source: Margaritoulis *et al*., 2003)

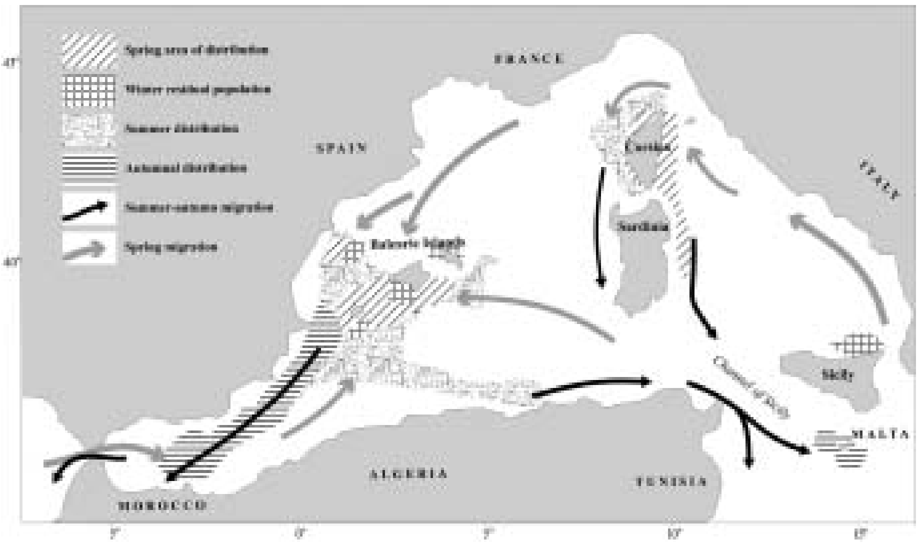

Figure 6. Loggerhead migratory model in the western Mediterranean and contiguous Atlantic waters (Source: Camiñas and De la Serna, 1995)

ANNEX 2

Loggerhead biological parameters in the Mediterranean population (from Margaritoulis *et al*., 2003)

Table 1. Annual nesting effort in Cyprus (derived from monitoring projects)

Nesting area	Number of seasons	Number of nests/season		
		Average	Min	Max
Akrotiri/Episkopi	6	22.7	10	32
Chrysochou Bay	5	119.8	109	152
Northern beaches	7	372.0	245	519
Western beaches	7	57.1	40	72
TOTAL		571.6	404	775

Table 2. Annual nesting effort in Greece (mostly derived from monitoring projects)

Nesting area	Number of seasons	Number of nests/season		
		Average	Min	Max
"Major" areas				
Kyparissia Bay, Peloponnisos	16	580.7	286	927
Bay of Chania, Crete	6	114.9	77	192
Lakonikos Bay, Peloponnisos	7	191.9	107	239
Rethymno, Crete	8	387.3	315	516
Zakynthos (Bay of Laganas)	16	1286.0	857	2018
"Moderate nesting" areas				
Beaches adjacent to Kyparissia	2	64.0	60	68
Bay of Messara, Crete	8	53.5	15	80
Ipirus coast [a]	1	40.0	40	40
Kefallonia (Mounda beach)	6	28.8	17	45
Kerkyra [a]	1	20.0	20	20
Koroni	5	55.0	35	66
Kos [a]	1	60.0	60	60
Kotychi	3	50.3	32	80

Nesting area	Number of seasons	Number of nests/season		
		Average	Min	Max
Lefkas [a]	1	50.0	50	50
Rhodes	5	10.6	4	21
Romanos	3	22.3	17	30
Southeast Peloponnisos (including Kythira) [a]	1	20.0	20	20
TOTAL		3035.3	2012	4472

[a] Estimation after a number of surveys in one season.

Table 3. Annual nesting effort in Turkey (derived from monitoring projects)

Nesting area	Number of seasons	Number of nests/season		
		Average	Min	Max
Akyatan	4	15.3		1
Anamur	2	191.0		187
Belek	3	129.7		68
Cirali (Olympos)	1	34.0		34
Dalaman	1	73.0		73
Dalyan	9	165.0		52
Demirtas	1	98.0		98
Fethiye	7	124.1		88
Gazipasa	1	110.0		110
Göksu delta	5	64.6		36
Kale	1	39.0		39
Kizilot	4	107.2		50
Kumluca	2	162.5		75
Patara	6	52.5		33
TOTAL		1365.9		944

Table 4. Overall nesting effort in the Mediterranean (derived from monitoring projects)

Country	Number of nests/season			Source
	Average	Min	Max	
Cyprus	571.6	404	775	Table 1
Greece	3035.3	2012	4472	Table 2
Israel [a]	32.7	10	52	[c]
Tunisia (Kuriat islands) [b]	10.2	5	15	[d]
Turkey	1365.9	944	1771	Table 3
TOTAL	5015.7	3375	7085	

[a] Data over seven seasons.
[b] Data over four seasons.
[c] Kuller 1999; Z. Kuller, personal communication.
[d] Bradai 1996.

Table 5. Carapace measurements of nesting females (in cm) [a]

Country, area	Number of seasons	Range of means	Range of individual values	Range of sample size
Straight length				
Greece, Kefallonia	5	76.8–80.1	63.5–87.0	11–15
Greece, Kyparissia Bay	3	78.6–79.1	66.0–95.0	13–97
Greece, Zakynthos	3	78.3–79.2	68.5–90.0	195–343
Libya	1	78.7	62.3–83.2	9
Turkey, Dalyan	1	73.1	60.2–83.9	49
Turkey, Fethiye	1	73.2	66.0–87.5	22
Turkey, [b]	1	72.0	58.0–87.0	58
Straight width				
Greece, Kefallonia	5	57.1–59.2	45.0–77.0	11–15
Greece, Kyparissia Bay	3	59.1–59.4	46.0–72.0	12–99
Greece, Zakynthos	3	58.6–59.3	49.0–68.5	194–343
Turkey, Dalyan	1	53.5	46.8–62.3	49
Turkey, Fethiye	1	54.4	47.5–65.5	22
Turkey, [b]	1	52.0	43.0–67.0	58
Curved length				
Cyprus, Alagadi	8	71.1–77.9	64.5–90.0	6–39
Cyprus, western beaches	20	66.5–79.8	60.0–90.0	2–11

Country, area	Number of seasons	Range of means	Range of individual values	Range of sample size
Greece, Kefallonia	5	81.6–84.7	71.9–93.0	11–15
Greece, Kyparissia Bay	3	83.1–83.8	70.0–99.0	28–101
Greece, Lakonikos Bay	2	84.1–84.6	78.0–92.0	11–12
Greece, Zakynthos	4	82.7–83.8	70.0–96.5	146–345
Libya	1	78.0	71.0–86.3	11
Tunisia	1	79.7	73.0–85.0	3
Turkey, Fethiye	1	77.3	68.0–91.0	27
Turkey, [b]	1	76.0	63.0–91.0	58
Curved width				
Cyprus, Alagadi	8	63.8–68.2	54.5–82.0	6–39
Cyprus, western beaches	20	50.0–69.8	50.0–77.0	2–11
Greece, Kefallonia	5	71.3–76.2	52.0–79.0	11–15
Greece, Kyparissia Bay	3	73.9–75.2	57.0–88.0	27–102
Greece, Zakynthos	4	73.5–74.6	60.0–87.0	35–345
Turkey, Fethiye	1	69.2	61.0–79.0	27
Turkey [b]	1	68.0	50.0–79.0	58

[a] Lengths measured from notch to tip and widths at the widest point.
[b] Anamur, Fethiye, Göksu, Kale, Kizilot, Kumluca.

Table 6. Mass and diameter of eggs

Country, area	Number of seasons	Range of means	Range of individual values	Range of sample size
Mass (g)				
Cyprus, western beaches	2	26.9–31.9	22.8–36.5	13–30
Cyprus, Alagadi	1	32.4	26.4–38.6	12
Greece, Zakynthos	1	29.8	23.0–35.4	45
Turkey, Dalyan	1	27.5	15.9–36.5	173
Diameter (mm)				
Cyprus, western beaches	2	38.0–38.6	34.9–40.2	13–26
Cyprus, Alagadi	1	37.4	32.9–39.6	12
Greece, Kefallonia	5	36.1–38.9	27.0–42.6	12–30
Greece, Zakynthos	1	36.7	33.0–41.9	45
Turkey, Akyatan	1	34.5	31–37	15
Turkey, Dalyan	1	37.0	33.0–41.0	65
Turkey, [a]	1	40.4–42.1 [b]	37.0–45.0	20

[a] Cirali, Gazipasa, Kumluca.
[b] Range of means per beach.

Table 7. Renesting interval (in days) calculated from subsequently observed nestings of same individuals

Country, area	Number of seasons	Range of means	Range of individual values	Range of sample size
Cyprus, Alagadi	7	12.7–13.7	10–18	7–34
Greece, Kefallonia	4	15.8–17.0	13–20	9–20
Greece, Kyparissia Bay	2	15.2–19.3	12–24	6–14
Greece, Rethymno	1	13.6	12–18	17
Greece, Zakynthos	9	14.6–19.9	11–28	14–181
Turkey, Fethiye	1	16.2	12–34	6

ANNEX 3

Green turtle distribution maps, nesting areas, habitats and migration

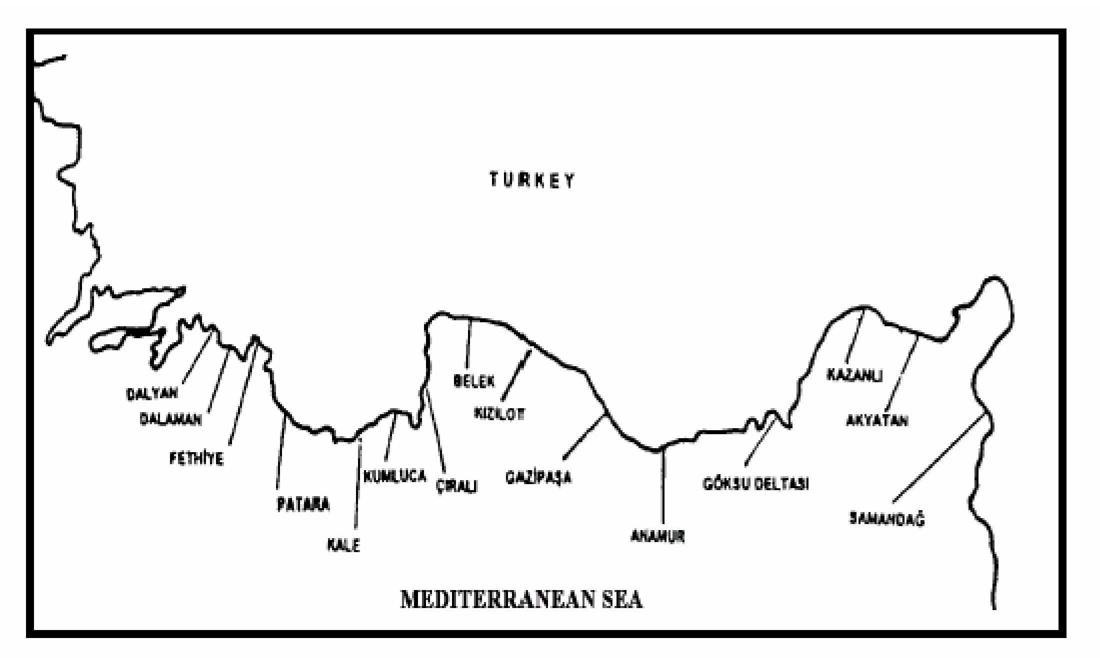

Figure 1. Major green turtle nesting areas in Turkey (Source: Kasparek, 2003)

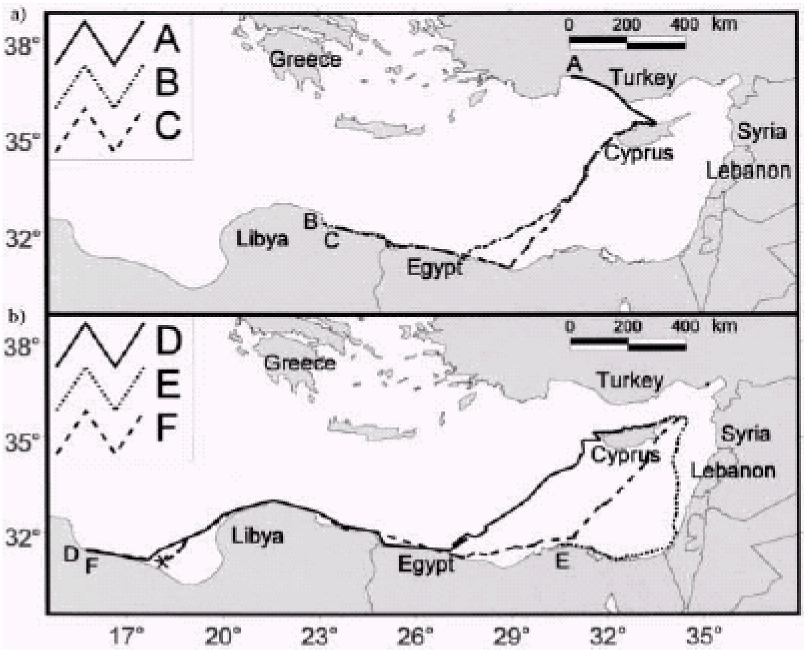

Figure 2. The tracks of green turtles migrating away from Cyprus at the end of the nesting season in a) 1998 (n = 3; turtles A–C) and b) 1999 (n = 3; turtles D–F). For the tracks of individual F, the end of the initial route is denoted by x with the subsequent part of the line being that necessary to complete the route based upon fixes obtained after 21 days with no fixes (Source: Godley *et al.*, 2002)

Table 1. Mediterranean green turtle movements to foraging areas

Location		Individual A	B	C	D	E	F
Cyprus	Duration (h)	37.0 (18.8)	95.0 (16.1)	82.9 (14.0)	59.1 (5.9)	91.0 (16.8)	95.7 (9.1)]
	Distance (km)	21.8 (6.8)	141.1 (11.2)	154.0 (12.2)	149.5 (6.8)	120.8 (11.9)	181.9 (8.6)
	Speed (km h^{-1})	0.6	1.5	1.8	2.5	1.3	1.9
Open sea	Duration (h)	60.1 (30.6)	203.5 (34.4)	173.0 (29.3)	244.8 (24.5)	212.1 (39.1)	179.7 (17.1)
	Distance (km)	162.9 (50.5)	651.3 (51.5)	530.6 (42.2)	802.5 (36.5)	464.1 (45.8)	448.9 (21.1)
	Speed (km h^{-1})	2.7	3.2	3.1	3.3	2.2	2.5
	Straightness index	0.99	0.94	0.977384	0.75	0.89	0.97
Coastal	Duration (h)	99.5 (50.6)	292.6 (49.5)	334.3 (56.6)	694.0 (69.5)	239.7 (44.2)	776.2 (73.8)
	Distance (km)	137.9 (42.7)	471.5 (37.3)	572.9 (45.6)	1247.6 (56.7)	428.1 (42.3)	1494.7 (70.3)
	Speed (km h^{-1})	1.4	1.6	1.7	1.8	1.8	1.9
Overall	Duration (h)	196.6	591.1	590.2	997.9	542.8	1051.6
	Distance (km)	322.6	1263.9	1257.5	2199.6	1013.0	2125.5
	Speed (km h^{-1})	1.6	2.1	2.1	2.2	1.9	2.0
Minimum distance km		274.0	1035.6	1019.7	1704.0	692.0	1730.9
Distance (% increase)		17.7	22.0	23.3	29.1	46.4	22.8

Source**:** Godley *et al*., 2002

NOTE: Summary statistics of movements to foraging areas. For each individual (A–F) summary statistics – duration (h), minimum distance (km) and resultant average speed (km/h^{-1}) – are given for each of the three stages of movement: through Cyprus coastal waters, across the open sea and during subsequent coastal travelling. Numbers in parentheses are the proportion of time and distance constituted by each stage. In addition, the total duration, distance and overall speed for travel is given, as well as the minimum distance that the journey would have been should the open-ocean crossing have been direct from Cyprus to the endpoint. The resultant increase in distance (percent) over the minimum feasible bee-line route as a result of the coastal phase is given.

ANNEX 4

Nesting parameters of the Mediterranean green turtle population

Table 1. Mean number of green turtle nests per season

Nesting site	Mean no. of nests/season (range)	No. of years surveyed	Mean no. of nesting females/year (range)
Cyprus			
North	297 (135–461)	8	96–102 (44–159)
South	75* (73–78)		25 (25–25)
Israel	5 (0–13)	8	1–2 (0–5)
Turkey			
Akyatan	429 (179–735)	5	138–148 (58–253)
Göksu	12 (3–20)	4	3–4 (0–7)
Kazanli	265 (128–216)	3	53–57 (41–74)
Samandag	64 (21–126)	3	20–22 (7–43)
Total	1047 (539–1622)		339–360 (175–567)

*Nesting data is not available for southern Cyprus; this figure is based on an estimate of 25 nesting females (Demetropoulos and Hadjichristophorou, 1989)

Source**:** Broderick *et al*., 2002

Table 2. Mediterranean green turtle nesting population in Turkey and Cyprus

Country	Beach region	Mean nests p.a.	Nesting females p.a	Recent hatchings success	Protective status
Turkey	Kazanli	109	30	Low	None
	Akyatan	297	85	Very low	Good but…
	Samandag	64	18	Low	None
Cyprus	S. Karpas	64	18	High	None
	N. Karpas	104	30	High	None
	Alagadi	68	15	High	(SPA)
	W. Coast	55	16	High	None
	Akamas	75	21	(High)	Threatened

All other remaining "populations"are extremely small, i.e., Turkey: Belek, Göksu Delta; Lebanon: Palm Island, Tyre, Mansouri (further quantitative field survey is required); Israel: Hadera/Netanya, Ashgelon

Source**:** Corbett and Kasparek, 2003