

Chapter 11

Loggerhead Turtles in the Mediterranean Sea:

Present Knowledge and Conservation Perspectives

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The Mediterranean Sea covers an area of about 2.5 million km², with a coastline of approximately 46,000 km, of which 19,000 km belong to islands. Natural communication with other seas is restricted to that with the Atlantic at the Straits of Gibraltar, where a narrow (approximately 12 km) passage is formed, across which lies a shallow sill. From an oceanographic point of view, the Mediterranean is an evaporation basin, and the resulting water deficit and salinity differences sustain a permanent strong incoming surface current and a weaker subsurface countercurrent across the Straits of Gibraltar. The Mediterranean Sea is roughly divided into two basins, the western and the eastern, connected by the shallow (approximately 400 m deep) Channel of Sicily and the narrow Straits of Messina. The two basins have different hydrological conditions, the eastern being more saline and warmer. Because of lack of nutrients, the Mediterranean is one of the less productive seas in the world (Miller 1983).

The loggerhead turtle is the most abundant

sea turtle species in the Mediterranean, having evolved local populations. It seems that the latest colonization occurred about 12,000 years ago from stocks in the western Atlantic (Bowen et al. 1993). Marine turtles in the Mediterranean have only relatively recently attracted the interest of researchers and conservationists (Argano 1979; De Metrio et al. 1983; Demetropoulos and Hadjichristophorou 1982; Geldiay et al. 1982; Margaritoulis 1982; Mayol and Castello Mas 1983).

This chapter presents a synthesis of the current knowledge, including the largely unpublished data gathered to date (1999), regarding the biology and conservation status of this regional population.

Nesting Habitats and Breeding Populations

Nesting Areas and Nesting Activity

Nesting in the Mediterranean is confined almost exclusively to the eastern basin. The main

Table 11.1.
Annual Nesting Effort in Cyprus

Nesting Area	Number of Seasons	Number of Nests/Season			Sources
		Average	Min.	Max.	
Akrotiri/Episkopi	6	22.7	10	32	6, 7
Chrysochou Bay	5	119.8	109	152	3
Northern beaches	7	372.0	245	519	1, 2, 4, 5
Western beaches	7	57.1	40	72	3
Total		571.6	404	775	

Source Key: 1. Broderick and Godley 1996. 2. Broderick et al. 1997, 1999. 3. A. Demetropoulos and M. Hadjichristophorou, pers. observ. 4. Godley and Kelly 1996. 5. Godley et al. 1998c. 6. MacLean et al. 1998. 7. I. Williamson, pers. comm.

Note: Data derived from monitoring projects.

nesting concentrations are found in Cyprus, Greece, and Turkey where long-term monitoring projects are in operation (Tables 11.1–11.3; Figure 11.1). Recently, nesting grounds were revealed in Libya, but their nesting potential needs quantification (Laurent et al. 1995). Current information on nesting areas and nesting effort is summarized by country below.

Algeria

No tracks were found during a 1989 survey of 16 beach samples, totaling 73.9 km, distributed throughout the main sandy zones, and surveyed one to seven times (Laurent 1990).

Croatia

A survey of the southern coasts showed no nesting (Lazar et al. 1997). Nonetheless, according to local people, eggs have been used in the past for domestic consumption (Lazar and Tvrtkovic in RAC/SPA 1998).

Cyprus

The first surveys of turtle nesting were conducted in 1976–77, and an annual conservation project was initiated in 1978, concentrating mainly on the beaches of the western coast and Chrysochou Bay (Demetropoulos and Hadjichristophorou 1989; Table 11.1). In 1988 a brief field study of marine turtle nesting was carried out on the northern beaches (Groombridge and Whitmore 1989), highlighting their regional importance, and an annual monitoring project was initiated in 1992 (see Table 11.1).

Egypt

Little nesting has been recorded along the Mediterranean shores of Egypt. In a single survey over 249 km of sandy coastline from Alexandria to the Libyan border, few signs of nesting were found (Kasperek 1993). Negligible nesting in this part of the Egyptian coastline was confirmed in 1998 by Clarke et al. (2000). A single survey along the Nile delta (166 km of sandy beach) found no nesting, but 200 km of sandy coastline, from the Suez Canal to the Israeli border, surveyed three times in one season, revealed 20 loggerhead turtle clutches (Clarke et al. 2000).

France

No nesting has been recorded on the Mediterranean coasts of France, including Corsica (De-laugerre 1987; Laurent 1991).

Greece

Nesting was first recorded in 1977 on the island of Zakynthos (Margaritoulis 1982). Nesting here was subsequently shown to constitute the single most important nesting concentration in the Mediterranean, reaching average nesting densities of more than 230 nests/km/season. The greater part of the 16,000 km Greek coastline has been investigated through aerial and ground surveys, and other nesting areas have been found, mainly along the western and southern coasts and on the island of Crete (Margaritoulis 1987, 1998; Margaritoulis et al. 1995a). Nesting areas have been classified as "major areas," "areas of moderate nesting," and

Table 11.2.
Annual Nesting Effort in Greece

Nesting Area	Number of Seasons	Number of Nests/Season			Sources
		Average	Min.	Max.	
“Major” Areas					
Bay of Chania, Crete	6	114.9	77	192	12, 17, 21, 23, 34
Kyparissia Bay, Peloponnesus ^a	15	580.7	286	927	7, 9, 11, 13, 22, 27, 29, 31, 35, 36
Lakonikos Bay, Peloponnesus	7	191.9	107	239	24, 27, 29, 31, 37
Rethymno, Crete	8	387.3	315	516	11, 12, 17, 21, 23, 34
Zakynthos (Bay of Laganas)	16	1,301.3	857	2,018	7, 8, 13–16, 20, 25, 26, 30, 32, 33
“Moderate” Areas					
Bay of Messara, Crete	8	53.5	15	80	12, 17, 21, 23, 34
Beaches adjacent to Kyparissia	2	64.0	60	68	10, 35
Ipirus coast ^b	1	40.0	40	40	28
Kefalonia (Mounda beach)	6	28.8	17	45	3–6
Kerkyra ^b	1	20.0	20	20	28
Koroni	5	55.0	35	66	19
Kos ^b	1	60.0	60	60	28
Kotychi	3	50.3	32	80	10, 31
Lefkas ^b	1	50.0	50	50	28
Rhodes	5	10.6	4	21	1, 2, 13
Romanos	3	22.3	17	30	10, 18
SE Peloponnesus (incl. Kythira) ^b	1	20.0	20	20	28
Total		3,050.6	2,012	4,472	

Source Key: 1. Gerosa et al. 1998. 2. G. Gerosa and M. Aureggi, pers. observ. 3. Houghton 1996. 4. Houghton et al. 1997.

5. Houghton et al. 1998. 6. J. Houghton, pers. observ. 7. Margaritoulis 1987. 8. Margaritoulis 1988a. 9. Margaritoulis 1988d. 10. Margaritoulis 1989. 11. Margaritoulis 1993. 12. Margaritoulis 1996. 13. Margaritoulis and Arapis 1990. 14. Margaritoulis and Dimopoulos 1993. 15. Margaritoulis and Dimopoulos 1994. 16. Margaritoulis and Dimopoulos 1995. 17. D. Margaritoulis and M. Dretakis, pers. observ. 18. D. Margaritoulis and G. Hiras, pers. observ. 19. D. Margaritoulis and C. Johnston, pers. observ. 20. D. Margaritoulis and K. Katselidis, pers. observ. 21. D. Margaritoulis and A. Panagopoulou, pers. observ. 22. D. Margaritoulis and A. F. Rees, pers. observ. 23. Margaritoulis and Sioris 1997. 24. D. Margaritoulis and K. Teneketzis, pers. observ. 25. Margaritoulis et al. 1991. 26. Margaritoulis et al. 1992. 27. Margaritoulis et al. 1994. 28. Margaritoulis et al. 1995a. 29. Margaritoulis et al. 1995b. 30. Margaritoulis et al. 1996a. 31. Margaritoulis et al. 1996b. 32. Margaritoulis et al. 1997. 33. Margaritoulis et al. 1998a. 34. Margaritoulis et al. 1998b. 35. Margaritoulis et al. 1999. 36. Margaritoulis et al. 2000. 37. Teneketzis 1997.

Note: Data derived from monitoring projects, unless otherwise specified.

^aExtrapolated, in some seasons, to the whole bay length from the monitored core area.

^bEstimate after a number of surveys in one season.

"areas of occasional or diffuse nesting" (Margaritoulis 2000). All major areas and several areas of moderate nesting are monitored annually (see Table 11.2).

Israel

Little nesting is recorded along the 190 km coastline of Israel. It seems that nesting is greatly reduced, probably due to heavy past ex-

Table 11.3.
Annual Nesting Effort in Turkey

Nesting Area	Number of Seasons	Number of Nests/Season			Sources
		Average	Min.	Max.	
Akyatan	4	15.3	1	29	4, 5, 10
Anamur	2	191.0	187	195	10, 11
Belek	3	129.7	68	168	2, 8, 10
Cirali (Olympos)	1	34.0	34	34	10
Dalaman	1	73.0	73	73	10
Dalyan	9	165.0	52	269	2, 3, 9, 10
Demirtas	1	98.0	98	98	2
Fethiye	7	124.1	88	158	1, 2, 7, 9, 10
Gazipasa	1	110.0	110	110	2
Göksu Delta	5	64.6	36	117	2, 6, 10
Kale	1	39.0	39	39	10
Kizilot	4	107.2	50	146	10
Kumluca	2	162.5	75	250	2, 10
Patara	6	52.5	33	85	2, 9, 10
Total		1,365.9	944	1,771	

Source Key: 1. Baran and Türkozan 1996. 2. I. Baran, pers. observ. 3. Erk'akan 1993. 4. Gerosa et al. 1995. 5. G. Gerosa and M. Aureggi, pers. observ. 6. Glen et al. 1997. 7. Türkozan and Baran 1996. 8. Türkozan et al. 1998. 9. Other references in Türkozan et al. 1998. 10. Yerli and Demirayak 1996. 11. Yerli and Dolezel 1998.

Note: Data derived from monitoring projects.

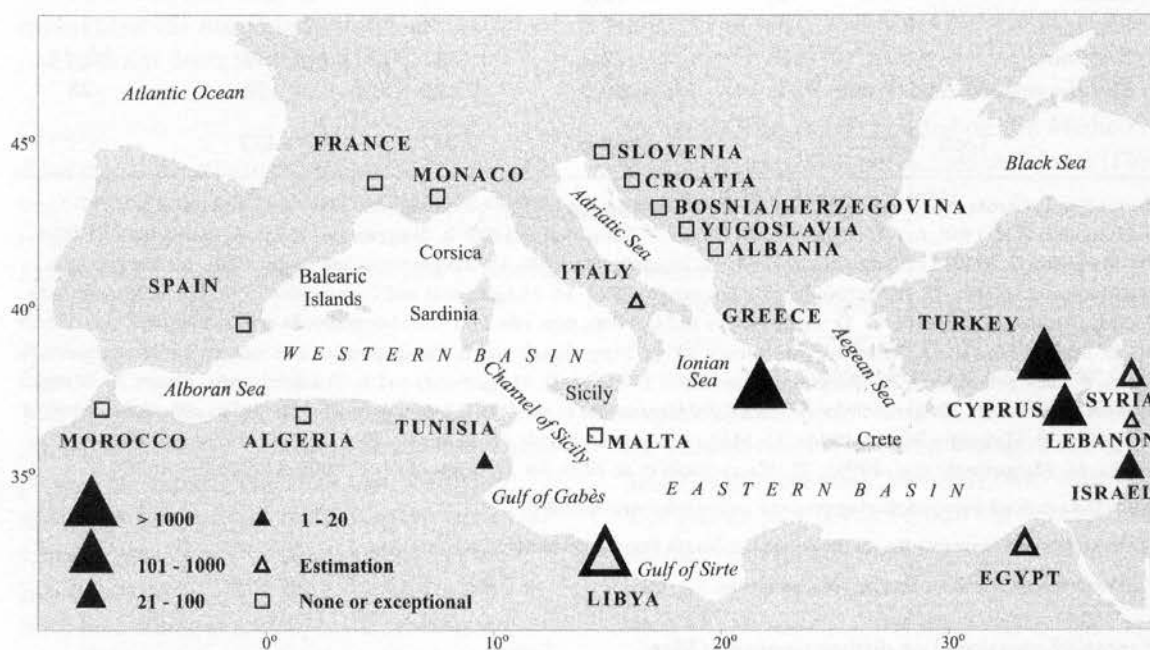


Figure 11.1. Map showing the annual nesting effort per country. Numbers represent average values of nests per season. Solid triangles feature values derived from monitoring projects; open triangles are estimates.

Table 11.4.
Overall Nesting Effort in the Mediterranean

Country	Number of Nests/Season			Sources
	Average	Min.	Max.	
Cyprus	571.6	404	775	Table 11.1
Greece	3,050.6	2,012	4,472	Table 11.2
Israel ^a	32.7	10	52	2, 3
Tunisia (Kuriat Islands) ^b	10.2	5	15	1
Turkey	1,365.9	944	1,771	Table 11.3
Total	5,031.0	3,375	7,085	

Source Key: 1. Bradai 1996. 2. Kuller 1999. 3. Z. Kuller, pers. comm.

Note: Data derived from monitoring projects.

^aData over seven seasons.

^bData over four seasons.

exploitation and the degradation of beaches (Sella 1982; Kuller 1999). Since 1993 almost the entire coast is surveyed annually, and all nests are relocated to beach hatcheries (Kuller 1999; Table 11.4).

Italy

Nesting is only recorded in southern Italy and is mostly confined to the islands of Lampedusa and Linosa, with occasional nests in Sicily and on the Ionian coasts and the Adriatic-Apulian coasts (Basso 1996; Cocco and Gerosa 1990; Di Palma 1978; Freggi 1997; Gerosa et al. 2000; Gramentz 1989; Ragonese and Jereb 1992). The maximum annual number of nests is estimated at 15.

Lebanon

Although no specific survey has been conducted, some nesting is reported (Ramadan-Jaradi in RAC/SPA 1998).

Libya

Nesting was first reported from the area of the Kouf National Park (Schleich 1987) and from the Gulf of Sirte and the eastern coasts (Hadoud and Assigier, in press; Meininger et al. 1994). In 1995, a single survey of 50 beach segments, totaling 142 km spread between the

Egyptian border and Sirte (744 km of sandy coastline), revealed 176 nests, suggesting a nesting population of regional importance (Laurent et al. 1995). Further surveys (Hadoud and El Gomati, in press; Laurent et al. 1999) from Sirte to the Tunisian border demonstrated that nesting activity, although spread over the entire coast, may be less dense in western areas.

Morocco

No nesting was recorded during a 1989 survey of four beach samples, totaling 24 km, distributed throughout the main sandy zone and surveyed one to four times (Laurent 1990).

Spain

No nesting is known along the Mediterranean coast, except a fully developed loggerhead embryo found in Ebro Delta (Llorente et al. 1992/93).

Syria

Eighteen nests (presumably of loggerheads) were found during a single survey over 79.5 km of sandy coastline (Kasperek 1995).

Tunisia

Little nesting has been recorded on the main-

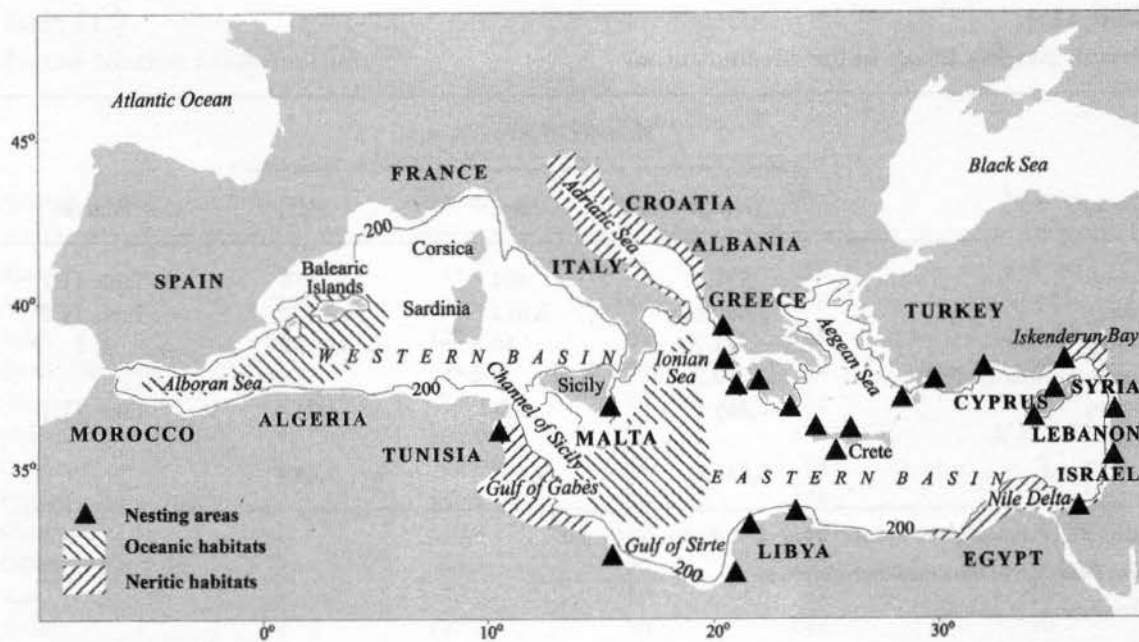


Figure 11.2. Map of the Mediterranean region showing approximate locations of nesting areas and of known oceanic and neritic habitats. The 200 m isobath delimits the continental shelf. Schematic presentation of nesting areas does not imply similar nesting levels.

land (Bradai 1995, 1996; Laurent et al. 1990). Nesting on Kuriat Islands, the most important Tunisian nesting site, is monitored annually (see Table 11.4).

Turkey

Preliminary work in the late 1970s revealed loggerhead nesting from the region of Marmaris east to Mersin (Geldiay et al. 1982). In a systematic 1988 survey, 17 important nesting areas, for both loggerhead and green turtles, were identified (Baran and Kasperek 1989a). Thereafter, specific monitoring projects have been conducted at some of these areas (see Table 11.3).

Other Countries

Although no systematic beach surveys have yet been undertaken, loggerheads may nest in Albania where tracks have been reported (Haxhiu and Uruci in RAC/SPA 1998), and along the sandy coast of Montenegro, in Yugoslavia. No nesting has been documented in Bosnia-Herzegovina, Slovenia, or Monaco. Although, there are historical records on egg laying in the Maltese islands (Despott 1915), no nesting has been recorded there since 1930 (Gramentz 1989).

Summary for the Region

Based on the recorded annual numbers in Cyprus, Greece, Israel, Tunisia, and Turkey, the total nesting effort in the Mediterranean ranges from 3,375 to 7,085 nests per season (see Table 11.4). These are minimum numbers, as a proportion of clutches (in Greece 15%, after Margaritoulis 2000) are laid at sites other than monitored beaches. In addition, these numbers do not include nests in countries where monitoring has not yet been completely instigated. Future monitoring, particularly in Libya, is expected to substantially increase these figures. The distribution of nesting sites in the Mediterranean is illustrated in Figure 11.2.

Reproductive Parameters

The vast majority of loggerhead nesting in the Mediterranean occurs between beginning of June and early August, with sparse nesting from mid-May to early September. Tables 11.5–11.10 summarize baseline data on several reproductive parameters. It is known that nesting loggerheads in the Mediterranean are significantly smaller than those in other parts of the world (Broderick and Godley 1996; Margari-

Table 11.5.

Carapace Measurements of Nesting Females

Country, Area	Number of Seasons	Mean (cm)	Range of Individual Values (cm)	Sample Size	Sources
Straight Length					
Greece, Kefalonia	5	76.8–80.1	63.5–87.0	11–15	10, 11, 17, 19
Greece, Kyparissia Bay	3	78.6–79.1	66.0–95.0	13–97	13, 14
Greece, Zakynthos	3	78.3–79.2	68.5–90.0	195–343	14, 15
Libya	1	78.7	62.3–83.2	9	9
Turkey, Dalyan	1	73.1	60.2–83.9	49	6
Turkey, Fethiye	1	73.2	66.0–87.5	22	1
Turkey ^a	1	72.0	58.0–87.0	58	20
Straight Width					
Greece, Kefalonia	5	57.1–59.2	45.0–77.0	11–15	10, 11, 17, 19
Greece, Kyparissia Bay	3	59.1–59.4	46.0–72.0	12–99	13, 14
Greece, Zakynthos	3	58.6–59.3	49.0–68.5	194–343	14, 15
Turkey, Dalyan	1	53.5	46.8–62.3	49	6
Turkey, Fethiye	1	54.4	47.5–65.5	22	1
Turkey ^a	1	52.0	43.0–67.0	58	20
Curved Length					
Cyprus, Alagadi	8	71.1–77.9	64.5–90.0	6–39	3, 4, 7, 8
Cyprus, western beaches	20	66.5–79.8	60.0–90.0	2–11	5
Greece, Kefalonia	5	81.6–84.7	71.9–93.0	11–15	10, 11, 17, 19
Greece, Kyparissia Bay	3	83.1–83.8	70.0–99.0	28–101	13, 14
Greece, Lakonikos Bay	2	84.1–84.6	78.0–92.0	11–12	16, 18
Greece, Zakynthos	4	82.7–83.8	70.0–96.5	146–345	14, 15
Libya	1	78.0	71.0–86.3	11	12
Tunisia	1	79.7	73.0–85.0	3	2
Turkey, Fethiye	1	77.3	68.0–91.0	27	1
Turkey ^a	1	76.0	63.0–91.0	58	20
Curved Width					
Cyprus, Alagadi	8	63.8–68.2	54.5–82.0	6–39	3, 4, 7, 8
Cyprus, western beaches	20	50.0–69.8	50.0–77.0	2–11	5
Greece, Kefalonia	5	71.3–76.2	52.0–79.0	11–15	10, 11, 17, 19
Greece, Kyparissia Bay	3	73.9–75.2	57.0–88.0	27–102	13, 14
Greece, Zakynthos	4	73.5–74.6	60.0–87.0	35–345	14, 15
Turkey, Fethiye	1	69.2	61.0–79.0	27	1
Turkey ^a	1	68.0	50.0–79.0	58	20

Source Key: 1. Baran and Türkozan 1996. 2. M. N. Bradai and I. Jribi, pers. observ. 3. Broderick and Godley 1996. 4. Broderick et al. 1997, 1999. 5. A. Demetropoulos and M. Hadjichristophorou, pers. observ. 6. Erk'akan 1993. 7. Godley and Kelly 1996. 8. Godley et al. 1998c. 9. Haddoud and El Gomati, in press. 10. Houghton 1996. 11. Houghton et al. 1997, 1998. 12. Laurent et al. 1995. 13. Margaritoulis 1988b. 14. D. Margaritoulis, pers. observ. 15. D. Margaritoulis and K. Katselidis, pers. observ. 16. D. Margaritoulis and K. Teneketzis, pers. observ. 17. Stringell et al. 1996. 18. Teneketzis 1997. 19. White 1998. 20. Yarli and Demirayak 1996.

Note: Lengths measured from notch to tip and widths at the widest point.

^aAnamur, Fethiye, Göksu Delta, Kale, Kizilot, Kumluca.

Table 11.6.
Clutch Size

Country, Area	Number of Seasons	Mean	Range of Individual Values or (SD)	Sample Size	Sources
Cyprus, Alagadi	8	74.8–82.7	9–159	27–194	3, 4, 10, 11
Cyprus, western beaches and Chrysochou Bay	19	74.2–97.2	25–164	20–94	6
Greece, Bay of Chania	3	110.3–117.1	2–177	92–103	24, 25, 30
Greece, Bay of Messara	1	108.1	62–150	49	24
Greece, Kefalonia	6	99.8–120.4	39–176	23–32	13–15, 33, 36
Greece, Kyparissia Bay	9	105.2–126.8	6–211	33–506	18, 21, 28, 29, 31
Greece, Lakonikos Bay	5	107.1–126.1	7–197	24–208	22, 26, 28, 34
Greece, Rethymno	5	102.0–124.6	1–190	160–378	19, 20, 24, 25, 30
Greece, Rhodes	3	78.0–108.3	45–152	2–6	8
Greece, Zakynthos	16	111.4–130.4	11–199	49–598	17, 21, 22, 23, 27
Israel ^a	—	76.3	(15.2)	31	1
Israel ^a	—	82.0	55–149	—	32
Libya	1	95.2	72–128	14	12, 16
Tunisia, Kuriat Islands	3	81.5–105.5	59–145	5–11	5
Turkey, Akyatan	2	68.0–87.5	35–108	4–7	8, 9
Turkey, Anamur	1	89.0	(20.9)	20	38
Turkey, Dalyan	1	73.4	24–148	235	7
Turkey, Fethiye	2	82.9–86.0	29–203	156–156	2, 35
Turkey ^b	1	65–101	40–139	5–156	37

Source Key: 1. Ashkenazi and Sofer 1988. 2. Baran and Türkozan 1996. 3. Broderick and Godley 1996. 4. Broderick et al. 1997, 1999. 5. M. N. Bradai and I. Jribi, pers. observ. 6. A. Demetropoulos and M. Hadjichristophorou, pers. observ. 7. Erk'akan 1993. 8. G. Gerosa and M. Aureggi, pers. observ. 9. G. Gerosa and P. Casale, pers. observ. 10. Godley and Kelly 1996. 11. Godley et al. 1998c. 12. Haddoud and El Gomati, in press. 13. Hays and Speakman 1991, 1992. 14. Houghton 1996. 15. Houghton et al. 1997, 1998. 16. Laurent et al. 1995. 17. Margaritoulis 1987, 1988a. 18. Margaritoulis 1988b. 19. Margaritoulis 1993. 20. Margaritoulis 1996. 21. D. Margaritoulis, pers. observ. 22. Margaritoulis and Arapis 1990. 23. D. Margaritoulis and K. Katselidis, pers. observ. 24. D. Margaritoulis and A. Panagopoulou, pers. observ. 25. Margaritoulis and Sioris 1997. 26. D. Margaritoulis and K. Teneketzis, pers. observ. 27. Margaritoulis et al. 1991, 1992. 28. Margaritoulis et al. 1994, 1995b. 29. Margaritoulis et al. 1996b. 30. Margaritoulis et al. 1998b. 31. Margaritoulis et al. 1999, 2000. 32. Silberstein and Dmi'el 1991. 33. Stringell et al. 1996. 34. Teneketzis 1997. 35. Türkozan and Baran 1996. 36. White 1998. 37. Yerli and Demirayak 1996. 38. Yerli and Dolezel 1998.

Notes: Clutch size measured during clutch relocations or posthatch excavations of nondepredated nests. SD = standard deviation.

^aData from several seasons.

^bAnamur, Belek, Cirali, Dalaman, Dalyan, Fethiye, Gazipasa, Göksu Delta, Kale, Kizilot, Kumluca, Patara.

toulis 1982, 1988b; Table 11.5). Furthermore, there seem to be substantial differences, particularly in nesting female size and clutch size, among the Mediterranean colonies (Tables 11.5 and 11.6). Other differences among sites may appear in the duration of re-nesting intervals (Table 11.9); however, insufficient data have as yet been gathered to undertake robust statistical analysis. Incubation durations (Table 11.8) are generally short in the Mediterranean. When comparison is made with studies of other conspecific populations, this is highly suggestive of

female-biased sex ratios in hatchling production (Godley et al. 2001). First attempts to estimate the sex ratio of hatchlings, in relation to nest temperatures, were undertaken in Cyprus and Turkey; the results suggest a pivotal temperature of approximately 29°C (Kaska et al. 1998).

Population Structure

In addition to the apparent morphological and biological differences, substructuring of breeding stocks within Mediterranean has been con-

Table 11.7.
Mass and Diameter of Eggs

Country, Area	Number of Seasons	Mean	Range of Individual Values	Sample Size	Sources
Mass (g)					
Cyprus, Alagadi	1	32.4	26.4–38.6	12	1
Cyprus, western beaches	2	26.9–31.9	22.8–36.5	13–30	2
Greece, Zakynthos	1	29.8	23.0–35.4	45	8
Turkey, Dalyan	1	27.5	15.9–36.5	173	3
Diameter (mm)					
Cyprus, Alagadi	1	37.4	32.9–39.6	12	1
Cyprus, western beaches	2	38.0–38.6	34.9–40.2	13–26	2
Greece, Kefalonia	5	36.1–38.7	27.0–42.6	12–30	5–7, 9, 10
Greece, Zakynthos	1	36.7	33.0–41.9	45	8
Turkey, Akyatan	1	34.5	31–37	15	4
Turkey, Dalyan	1	37.0	33.0–41.0	65	3
Turkey ^a	1	40.4–42.1	37.0–45.0	5–8	11

Source Key: 1. A. Broderick and B. Godley, pers. observ. 2. A. Demetropoulos and M. Hadjichristophorou, pers. observ. 3. Erk'akan 1993. 4. G. Gerosa and M. Aureggi, pers. observ. 5. Houghton 1996. 6. J. Houghton, pers. observ. 7. Houghton et al. 1997, 1998. 8. D. Margaritoulis, pers. observ. 9. Stringell et al. 1996. 10. White 1998. 11. Yerli and Demirayak 1996.

^aCirali, Gazipasa, Kumluca.

Table 11.8.
Duration of Incubation Measured in Nondepredated, Noninundated and/or Nonrelocated Nests

Country, Area	Number of Seasons	Mean (days)	Range of Individual Values or (SD)	Sample Size	Sources
Cyprus, Alagadi	7	47.3–48.7	42–60	17–58	3, 4, 7
Greece, Bay of Chania	2	53.3–54.3	43–74	73–76	14
Greece, Kefalonia	1	54.9	47–64	26	9, 10
Greece, Kyparissia Bay	3	48.1–53.9	43–67	35–302	11, 16
Greece, Lakonikos Bay	4	52.1–59.3	43–84	35–150	12, 15
Greece, Rethymno	3	51.7–55.2	40–77	105–156	14
Greece, Rhodes	2	49.0–55.0	44–55	1–3	6
Greece, Zakynthos	4	57.6–62.3	42–97	14–185	11, 13
Israel	—	—	50–55	—	1
Libya	1	55.0	48–62	5	8
Turkey, Akyatan	1	52.0	48–55	5	6
Turkey, Anamur	1	51.3	(5.6)	26	18
Turkey, Dalyan	1	59.3	51–71	47	5
Turkey, Fethiye	2	55.0–56.9	—	—	2, 17

Source Key: 1. Ashkenazi and Sofer 1988. 2. Baran and Türkozan 1996. 3. Broderick and Godley 1996. 4. Broderick et al. 1997, 1999. 5. Erk'akan 1993. 6. G. Gerosa and M. Aureggi, pers. observ. 7. Godley and Kelly 1996. 8. Haddoud and El Gomati, in press. 9. J. Houghton, pers. observ. 10. Houghton and Hays 2002. 11. D. Margaritoulis, pers. observ. 12. Margaritoulis and Arapis 1990. 13. D. Margaritoulis and K. Katselidis, pers. observ. 14. D. Margaritoulis and A. Panagopoulou, pers. observ. 15. D. Margaritoulis and K. Teneketzis, pers. observ. 16. Margaritoulis et al. 1999, 2000. 17. Türkozan and Baran 1996. 18. Yerli and Dolezel 1998.

Table 11.9.
Renesting Interval Calculated from Subsequently Observed Nestings of the Same Individuals

Country, Area	Number of Seasons	Mean (days)	Range of Individual Values	Sample Size	Sources
Cyprus, Alagadi	7	12.7–13.7	10–18	7–34	2–5
Greece, Kefalonia	4	15.8–17.0	13–20	9–20	6–9
Greece, Kyparissia Bay	2	15.2–19.3	12–24	6–14	11, 13
Greece, Rethymno	1	13.6	12–18	17	14
Greece, Zakynthos	9	14.6–19.9	11–28	14–181	10–12, 14–16
Turkey, Fethiye	1	16.2	12–34	6	1

Source Key: 1. Baran and Türkozan 1996. 2. Broderick and Godley 1996. 3. Broderick et al. 1997, 1999. 4. Godley and Kelly 1996. 5. Godley et al. 1998c. 6. Hays and Speakman 1991, 1992. 7. Houghton 1996. 8. J. Houghton, pers. observ. 9. Houghton et al. 1997, 1998. 10. Margaritoulis 1983. 11. Margaritoulis 1987. 12. Margaritoulis 1988a. 13. Margaritoulis 1988b. 14. D. Margaritoulis, pers. observ. 15. Margaritoulis and Arapis 1990. 16. Margaritoulis et al. 1991.

firmed by genetic studies. Indeed, although loggerheads nesting in the Mediterranean share common haplotypes with those nesting in the western Atlantic, they have diverged genetically (Bowen et al. 1993; Laurent et al. 1993, 1998). Genetic divergence appears more prominent in

nesting colonies in Turkey (Laurent et al. 1998). Other genetic analyses from different nesting areas in Turkey showed differentiation among rookeries (Schroth et al. 1996), providing evidence of subpopulations.

Table 11.10.
Size and Mass of Hatchlings

Country, Area	Number of Seasons	Mean	Range of Individual Values or (SD)	Sample Size	Sources
Straight Carapace Length (mm)					
Cyprus, Alagadi	1	40.0	24.9–49.3	2064	2
Cyprus, western beaches	2	40.3–41.5	36–45	180–325	1
Greece, Zakynthos	1	40.4	(0.7)	20	3
Turkey, Fethiye	1	39.8	28–45	302	5
Turkey, Göksu Delta	1	39.1	36–42	37	4
Straight Carapace Width (mm)					
Cyprus, Alagadi	1	30.4	20.0–39.7	2064	2
Greece, Zakynthos	1	33.9	(0.7)	20	3
Turkey, Fethiye	1	30.1	24–35	302	5
Mass (g)					
Cyprus, Alagadi	1	15.3	9.4–21.4	1482	2
Cyprus, western beaches	2	15.9–16.7	12.0–21.5	180–325	1

Source Key: 1. A. Demetropoulos and M. Hadjichristophorou, pers. observ. 2. Loughran et al. 2000. 3. Margaritoulis 1982. 4. Peters et al. 1994. 5. Türkozan and Baran 1996.

Note: Data taken from hatchlings that emerged naturally from nests in situ.

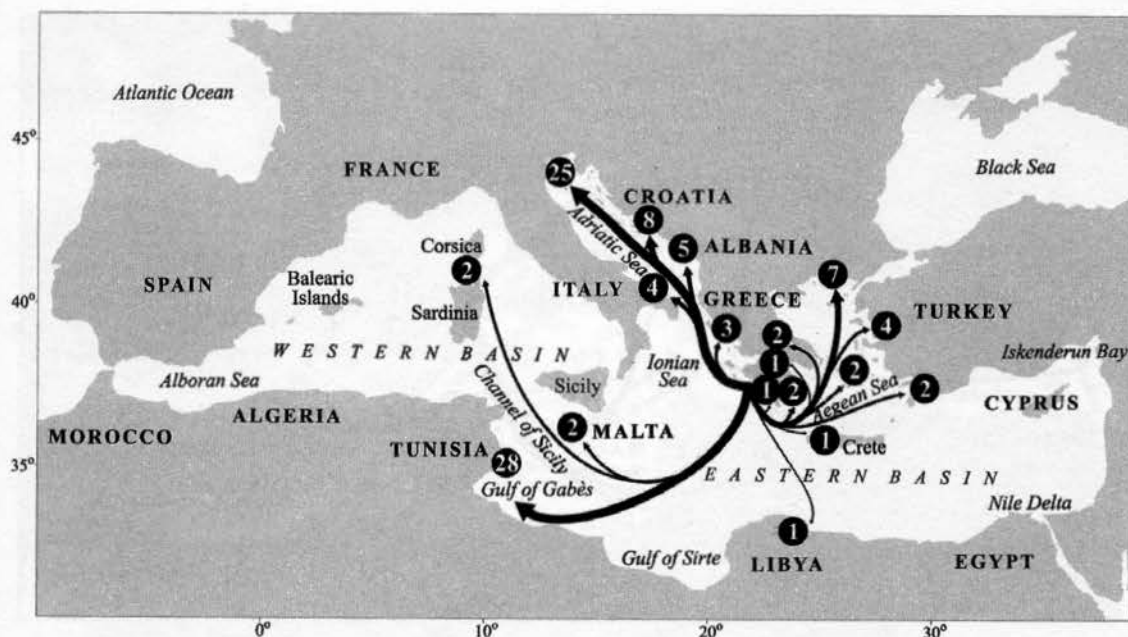


Figure 11.3. Postnesting movements of loggerheads, tagged in Greece from 1982 to 1999, adapted from Margaritoulis (1988c) with the inclusion of unpublished data. From a total of 2,868 females, tagged from 1982 until 1999 at the nesting beaches of Zakynthos and Kyparissia Bay, 100 individuals (3.5%) were recovered at distances longer than 150 km from the respective nesting areas. Of the recovered animals, 28% were found in the Gulf of Gabès, 42% in the Adriatic Sea. Arrows are indicative and do not suggest migratory paths.

Migrations and Marine Habitats

Migrations within the Mediterranean

Postnesting movements of turtles tagged in Greece show a wide dispersion in the eastern basin, with marked clusters of recaptures at the Gulf of Gabès and the Adriatic Sea; only two females were recovered in the western basin (Margaritoulis 1988c; Figure 11.3). An Italian project (Argano et al. 1992) was operated in collaboration with fishermen from 1981 until 1990. During this period, 1,047 loggerheads, mostly juveniles, were tagged after their capture (mostly in longlines). Of these, 51 (4.9%) have been recovered at both the eastern and western basins, showing active passage in both directions through the Channel of Sicily and the Straits of Messina. Some individuals were recaptured in the same area after one, two, or four years, suggesting a possibility of site fidelity. As in the postnesting females from Greece, a proportion of juveniles, tagged after their capture in a particular longline fishery in the north Ionian Sea, showed similar clusters of recaptures in the re-

gion of the Gulf of Gabès and in the Adriatic Sea (Figure 11.4). One individual from this group was recovered outside the Mediterranean (Portugal).

Analyses of tag recoveries in the Adriatic provide evidence of a possible postnesting pathway along the eastern coast (Lazar et al. 2000). The use of satellite telemetry, which has already been undertaken on a small scale in the Mediterranean (Bentivegna and Paglialonga 1998; Hays et al. 1991), will play an important role in future determination of migratory routes.

Analyzing information on incidental catch, solicited through inquiries in the longline fishery of Alicante (Spain), Camiñas and de la Serna (1995) developed a seasonal migration model for the western basin (Figure 11.5). According to the model, juvenile stocks, originating from both the Mediterranean and the Atlantic, increase in spring and reach their highest number in July (spring migration). After that, part of the stock gradually moves towards the Alboran Sea, where it stays until December, then disappears. Another part follows the Algerian current to the warmer waters of the eastern Mediter-

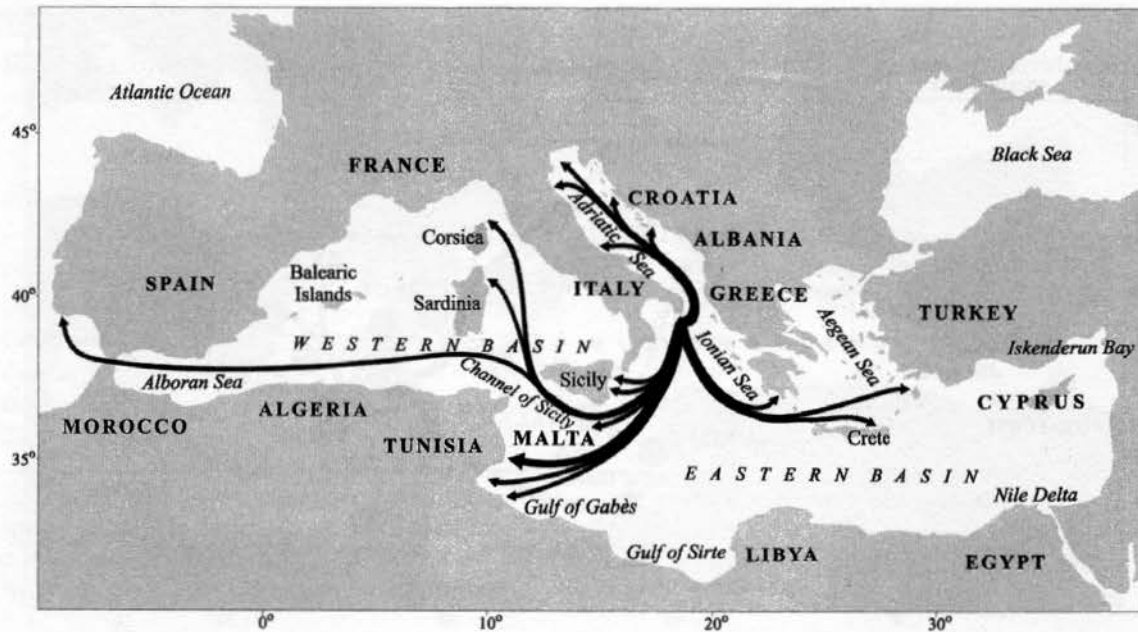


Figure 11.4. Tag returns of mostly juvenile loggerheads, tagged (and released) after capture in northern Ionian Sea, adapted from Argano et al. (1992). Arrows are indicative and do not suggest migratory routes.

ranean (autumn migration). During winter few turtles remain around the Balearic Islands. Furthermore, data analysis in the Gibraltar area shows the entry of Atlantic specimens during the spring and an exit at the end of the summer (Camiñas 1997a).

The wider dispersal of juvenile loggerheads, in comparison with green turtles, has been noted in the eastern Mediterranean through analysis of size distribution in stranding data (Baran and Kasperek 1989b; Godley et al. 1998a).

Oceanic Zone

High incidental captures in pelagic fisheries, that is, drifting longlines and drift nets, and analysis of size class distribution (see Laurent 1998a and references therein), as well as recaptures of tagged juvenile specimens (Argano et al. 1992) provide evidence that both Mediterranean basins are exploited by oceanic stage juveniles (see Figure 11.2).

Neritic Zone

The benthic habitats in the neritic zone are used as foraging grounds by both juveniles and

adults (Musick and Limpus 1997). Analyses of size distribution in Mediterranean turtle by-catch, notably in shallow waters, as through bottom trawling (Laurent 1998a and references therein), have revealed that benthic foraging habitats are found mainly in the eastern basin (Laurent and Lescure 1994; Laurent et al. 1996). This is consistent with studies of tag recoveries (Argano et al. 1992; Lazar et al. 2000; Margaritoulis 1988c).

Following the high percentage of tag returns (see Figure 11.3), the Gulf of Gabès, an intensively fished shallow area of about 77,000 km², was originally thought to be a wintering area for the adult loggerhead population nesting in Greece (Margaritoulis 1988c). However, analysis of recaptures by the Italian tagging project (Argano et al. 1992), as well as research results in Tunisia (Bradai 1992; Laurent and Lescure 1994), revealed that juveniles also frequent this area. Dietary analyses of 31 digestive tract samples showed that loggerheads were actively feeding on benthic invertebrates, mostly gastropods, hermit crabs, holothurians, and lamellibranchs, at sea water temperatures between 16.3°C and 17.1°C (Laurent and Lescure 1994).

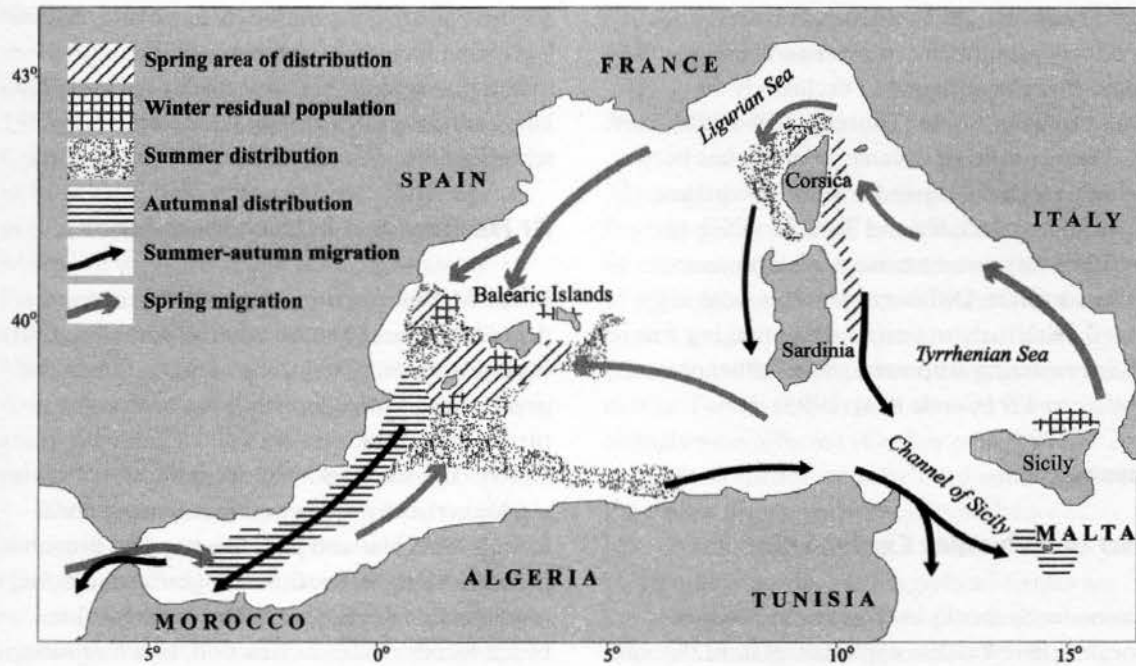


Figure 11.5. Model of loggerhead migrations in the western Mediterranean Sea, adapted from Camiñas and de la Serna (1995).

A similar phenomenon seems to occur in the Adriatic Sea (Argano et al. 1992; Lazar 1995; Lazar and Tvrtkovic 1995; Lazar et al. 2000; Margaritoulis 1988c), where a high incidence of turtle bycatch in the winter, through bottom trawling, has been recorded (Lazar and Tvrtkovic 1995). Preliminary data on stomach contents of turtles in a shallow (< 50 m) continental shelf of the northern Adriatic revealed echinoids and crustaceans as major prey groups (Lazar et al. 2002).

Other large continental shelf areas where large-sized loggerheads interact with bottom trawling activities, namely the bays of Mersin and Iskenderun in Turkey (Laurent et al. 1996; Oruç et al. 1997) and the Nile Delta in Egypt (Laurent et al. 1996, 1998) might also contain important neritic habitats (see Figure 11.2).

Stock Composition at Marine Habitats

Since the western Mediterranean holds no nesting grounds, the relatively large number of juvenile loggerheads caught incidentally in pelagic fisheries raised the question as to their origin. It was initially suggested that the juveniles were

derived mostly from populations nesting in the eastern Mediterranean and, in part, from the Atlantic (Argano and Baldari 1983). On the other hand, while comparing loggerhead sizes in the western Atlantic, the Azores, and the Balearic islands, Carr (1987) hypothesized that loggerheads originating from beaches in the western Atlantic follow a transatlantic migration and that some of them enter the Mediterranean. This has been corroborated by recoveries in the Mediterranean of loggerheads tagged in the western Atlantic (Basso and Cocco 1986; Bolten et al. 1992; Manzella et al. 1988).

Genetic markers, identified recently for nesting populations in the Mediterranean, confirmed the suspected demographic link between nesting colonies in the eastern basin and oceanic juvenile feeding aggregates in the western Mediterranean. Indeed, from analysis of cytochrome b and control region haplotype frequencies, it was estimated that 53–55% 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 (Laurent et al. 1998). 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).

The sex ratio of oceanic juveniles has been preliminarily investigated around Lampedusa Island, between Sicily and Tunisia, which is considered a representative Mediterranean oceanic habitat. Different scenarios were suggested, with male to female ratios ranging from 0.8 (considering suspected stress influence on results) to 4.9 (Casale et al. 1998).

Threats

Past and Present Exploitation

Marine turtle stocks in the eastern Mediterranean suffered severe exploitation until the mid 1960s. According to Sella (1982), it is estimated 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 Israel. A similar situation developed in the 1950s at Iskenderun Bay, where a slaughterhouse operated. Although that turtle harvest was primarily aimed at green turtles, it is thought that loggerhead stocks were also affected. In Italy, Di Palma (1978) noted that before 1980 a specialized fishery operated in the Isole Eolie, north of Sicily, catching an estimated 500–600 turtles annually. Even though fishing of turtles has been prohibited in Italy since 1980, the exploitation of accidentally caught turtles allows the existence of some local traditions connected with the consumption of turtle meat (Argano et al. 1990; Basso and Cocco 1986) and the illegal selling of turtle shells (Argano et al. 1990; Vallini, in press). Turtles were also sold until recently in Malta (Gramentz 1989), Spain (Mayol and Castello Mas 1983), and Algeria and Morocco (Laurent 1990). In Tunisia, although selling of turtles in fish markets was stopped in 1990, there is still a clandestine trade for local consumption (Laurent et al. 1996) as well as occasional consumption by fishermen onboard their vessels (M. N. Bradai, pers. observ.).

Today, exploitation of turtles is still undertaken openly in Egypt, where both loggerheads

and green turtles are sold in fish markets, despite legislation forbidding the practice. It is estimated that several thousand turtles are probably killed annually in Egypt, with loggerheads constituting 68% of the total (Laurent et al. 1996).

At Nesting and Internesting Areas

In the Mediterranean, a general anthropogenic degradation has been noted at almost all significant nesting sites, and some areas known in the past to host nesting activity have been lost to turtles (e.g., Malta) or severely degraded (e.g., Israel). The main anthropogenic threats affecting loggerhead nesting and internesting areas include vehicular and pedestrian traffic, human presence at night, beachfront lighting and noise, uncontrolled development and construction, beach furniture, sand extraction, beach erosion, beach pollution, marine pollution (see separate section below), planting of vegetation, boat strikes (see separate section below), near-shore fishing, and use of underwater explosives. The Mediterranean is the destination of millions of tourists during summer months, coinciding with the nesting season. The extensive urbanization of the coastline, especially in areas with sandy beaches, largely aimed at tourism and recreation, is probably the most serious threat.

The assumed decline in turtle populations and reduction of nesting habitats has triggered management programs to address the seemingly natural loss due to nest predation. Loggerhead nests in the Mediterranean are subject to predation by wild canids, feral/domestic dogs and, to a lesser extent, ghost crabs. Wild canids are absent from the islands of Zakynthos, Crete, and Kefalonia. The loss of loggerhead clutches to predators has been recorded as 48.4% at Kyparissia Bay, Greece (Margaritoulis 1988b), 70–80% in Dalyan, Turkey (Erk'akan 1993), 36.0% (including green turtle clutches) in Cyprus (Broderick and Godley 1996), and 44.8% in Libya (Laurent et al. 1995).

Incidental Catch and Mortality

There is a significant bycatch of sea turtles in various Mediterranean fisheries. The most severe catch occurs around the Balearic Islands

where it is estimated that between 1,950 and more than 35,000 juveniles are caught annually in the drifting longline fishery (Aguilar et al. 1995; Camiñas 1988, 1997b; Mayol and Castello Mas 1983). Total bycatch also seems to be high in "less industrialized" fisheries such as those using gill nets and bottom longlines, which are widespread and difficult to assess. Furthermore, data on the turtle bycatch of several non-Mediterranean fleets fishing in the Mediterranean (Aguilar et al. 1995) are lacking. A description of fisheries in the Mediterranean and a review of incidental captures of marine turtles are found in Gerosa and Casale (1999).

Direct mortality is generally low in trawlers and highest in gill nets and trammel nets (Gerosa and Casale 1999; Laurent 1998a; and references therein). Although captures in drifting longlines seem to be low in direct mortality, their subsequent effect has not been adequately documented. Aguilar et al. (1995) have reported a delayed mortality of 24.4%, which is alarming, considering the thousands of juvenile loggerheads caught annually in this fishery. Although some turtles caught incidentally are used for local consumption, a number of turtles are killed by fishermen for various and rather obscure reasons such as antagonism, prejudice, and ignorance (Gerosa and Casale 1999; Godley et al. 1998b). A stranding data analysis in Cyprus revealed that over 40% of the sample had skull injuries (Godley et al. 1998c), whereas from a sample of 524 strandings (90% loggerheads) along the coasts of Greece, over 23% had injuries presumably inflicted intentionally after capture (Kopsida et al. 2002).

Boat Strike

The effect of speedboats is of great concern in turtle-frequented waters with dense tourist activities. Losses of nesting females were documented at Zakynthos in 1993 (Margaritoulis and Dimopoulos 1994) and, more recently, in Rethymno, Crete (D. Margaritoulis and T. Belalidis, pers. observ.). From a sample of 42 loggerheads recovered in the Gulf of Naples, 28.1% had injuries attributed to boat strikes (Bentivegna and Paglialonga 1998), and from a total of 524 strandings (90% loggerheads) along

the coasts of Greece, 9% had injuries caused by boat strikes (Kopsida et al. 2002).

Marine Pollution

Although parts of the Mediterranean are profoundly polluted, little is known of the effects of contaminants on marine turtles. Twenty out of 99 loggerheads examined in the Maltese islands were contaminated, mostly with crude oil (Gramentz 1988). However, a similar examination in Turkey and Cyprus showed that very few animals were affected (Godley et al. 1998a). As loggerhead turtles are long-lived animals, they have been shown to be bioaccumulators of heavy metals (Storelli et al. 1998a, 1998b). Heavy metal burdens in loggerhead turtles are similar to or lower than corresponding concentrations in turtles from Japan (Godley et al. 1999), and a study to determine chlorobiphenyls and organochlorine pesticide residues in tissues collected from green and loggerhead turtles in the Mediterranean found burdens to be low but higher in the omnivorous loggerheads (McKenzie et al. 1999). Marine debris has been found to affect Mediterranean loggerheads (Basso 1992; Gramentz 1988). In the Gulf of Naples, over a period of four years (1993–1996), about 3% of the juvenile loggerheads recovered had swallowed various marine litter (Bentivegna and Paglialonga 1998). In a digestive tract analysis in the Adriatic, a juvenile loggerhead was found with plastic, nylon ropes, and Styrofoam pieces in its gut (Lazar et al. 2002).

Conservation

Legal and Regulatory Aspects

There are several international conventions containing provisions applicable to marine turtles in the Mediterranean region. The one with the highest regional importance is the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention), to which all Mediterranean countries (except the former Yugoslavia) are parties. In the context of the convention, the parties adopted in 1989 and revised in 1999 the Action Plan for the Conservation of

Mediterranean Marine Turtles (see RAC/SPA 1998). Coordination of activities for the implementation of the Action Plan is undertaken by the RAC/SPA, based in Tunis. Furthermore, priority actions for implementing the Action Plan have been adopted by the parties at both regional and national levels (RAC/SPA 1999). Another important supranational instrument is the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), which has taken a leading role (with an effective administrative structure) in establishing specific recommendations for countries hosting nesting habitats. More recently, the Convention on the Conservation of Migratory Species of Wild Animals (CMS, the Bonn Convention) became active in the region.

Other instruments originate from the European Union, whose member states must comply with various regulations and directives, decided by the European Parliament. The Habitats Directive (no. 92/43), featuring the loggerhead turtle among "priority" species, aims at the establishment of a coherent network of protected sites, known as Natura 2000.

Most Mediterranean countries have developed national legislation to protect sea turtles. Species-specific protective legislation generally prohibits intentional killing, harassment, possession, trade, or attempts at these. Furthermore, some countries have taken steps towards introducing site-specific legislation for turtle habitats. The nesting areas at Zakynthos have been protected since 1984 under a presidential decree that restricts building and development behind the nesting beaches. These regulations have been recently (December 1999) incorporated into new legislation establishing a National Marine Park in the area, including maritime restrictions. In Turkey, the nesting beaches of Belek, Dalyan, Fethiye, Göksu Delta, and Patara were designated a Specially Protected Area (SPA), in the context of the Barcelona Convention. In Cyprus, the nesting beaches of Lara and Toxeftra (about 10 km of coastline), including a maritime zone extending to the 20 m isobath, have been protected since 1989 under the Fisheries Regulation. In Italy, a reserve for the protection of the nesting beach on Lampedusa was established in 1984.

Protection of Populations and Habitats

In the case of nesting areas, usual management practices involve mitigating abiotic, biotic, and anthropogenic factors that may adversely affect incubation and hatching. These have been in effect for several years in most Mediterranean nesting areas. In some countries (e.g., Cyprus, Israel) competent state agencies undertake this responsibility, while in other countries (e.g., Greece, Italy) this is mostly done by nongovernmental organizations with varying support from the state. Universities and research institutes, in the course of their research programs, have also taken up management responsibilities.

Protection of marine habitats, both oceanic and neritic, is at an early stage. This is apparently a combined result of the relative paucity of data on these habitats, the difficulty in their delineation, and above all, the high-value economic activities involved (e.g., fisheries). The revised Action Plan for the Conservation of Mediterranean Marine Turtles contains several provisions regarding the identification of, the assessment of threats to, and the protection of marine habitats (RAC/SPA 1998). A priority for Mediterranean populations should be the reduction of human impacts (especially fishing-induced mortality) affecting the large-sized classes, which are more important for the population's viability (Laurent et al. 1992), in the neritic habitats of the eastern Mediterranean (Laurent 1998b).

The relatively high degree of public sensitization, noted the last few years in the Mediterranean, has required the development of an appropriate infrastructure to rehabilitate injured or sick turtles. This need is currently covered either in existing aquaria or in specially established rescue centers (Bentivegna et al. 1993; Corsini 1996; Gerosa and Cocco 1990; Pont and Alegre 2000; Schofield and Kopsida 2000). However, hospitalizing sea turtles should not be considered as a solution to the serious problem of intentional and incidental mortality at sea.

Public Awareness, Education, and Capacity Building

At a regional level, the RAC/SPA promotes capacity building on sea turtle conservation tech-

niques by organizing or supporting practical courses and training seminars. Furthermore, it supports field surveys, production of informative material, and elaboration of specific reports and manuals (Demetropoulos and Hadjichristophorou 1995; Gerosa 1996; Gerosa and Casale 1999). Public awareness projects on behalf of sea turtles, either aiming at specific target groups or at the general public, are conducted in several Mediterranean countries (Dimopoulos 1995; Kuller 1999; Lazar and Tvrtkovic in RAC/SPA 1998; Margaritoulis 1998). Present trends, in line with the IUCN Global Strategy for the Conservation of Marine Turtles (Donnelly 1995), advocate that local stakeholders be incorporated in any conservation plan. Inhabitants and visitors of nesting areas are sensitized on site and, in several cases, through involvement of the tourist industry (Gerosa 1992; Margaritoulis 1998). Children comprise an important target group. Using the sea turtle as a "flagship" species, presentations by talented animators, specially designed traveling kits to be deployed by teachers, and guided visits to nesting areas and rescue centers sensitize children and prepare the ground for participation in future conservation practices (Bentivegna 1998; Kremezi-Margaritoulis 1992; Kuller 1999).

Conclusions

The Mediterranean holds a remarkable loggerhead breeding population, with morphological and genetic differentiation. The noted population substructuring makes the Mediterranean population as a whole more vulnerable, and breeding colonies must be considered as separate management units.

Although progress has been made in the protection of some nesting areas, providing adequate protection to additional significant nesting beaches is a priority action. The implementation and enforcement of legal measures specified for nesting beaches and the improvement of the effectiveness of beach management are also priority issues.

At the same time there is a need to identify the different management units and assess the anthropogenic impacts affecting them, across all habitats. Fisheries interaction should be of spe-

cial concern, taking into account that early juveniles use oceanic habitats in both Mediterranean basins, while large juveniles and adults exploit neritic habitats confined to the eastern basin.

Conservation of marine turtles in the Mediterranean is a complicated endeavor involving many nations and a diversity of human activities on land and at sea, requiring both a regional approach and considerable effort at the national level. The provisions of the Action Plan, in the context of the Barcelona Convention, and the ensuing priorities for its implementation are a great step towards this goal.

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