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- Demography of marine turtles nesting in the Mediterranean Sea: a gap analysis and research priorities –

Document prepared by
Demography Working Group of the Conference

DEMOGRAPHY OF MARINE TURTLES NESTING IN THE MEDITERRANEAN SEA: A GAP ANALYSIS AND RESEARCH PRIORITIES

Demography Working Group[1]

5[the] Mediterranean Conference on Sea Turtles

EXECUTIVE SUMMARY

The Mediterranean hosts two breeding populations of marine turtles, the loggerhead turtle (*Caretta caretta*) and the green turtle (*Chelonia mydas*), and both are of extreme conservation concern. Despite significant advances in recent years, there are still significant knowledge gaps that preclude effective evidence-based conservation at a regional scale. Here, 14 experts from 8 nations (see Appendix 1) outline the following recommendations:

1. **A regional genetics analysis** for both species including the major nesting beaches and foraging grounds should be established.
2. Ongoing **beach monitoring** projects in Greece, Cyprus, Northern Cyprus and Turkey should be maintained and a new project should be established in Libya.
3. **Aerial surveys** should be conducted at key foraging grounds and repeated every five years.
4. **Satellite tracking studies** are needed for the juveniles of both species (Aegean Sea, south of Turkey, Levantine Sea, and Libyan Sea) in addition to the south Adriatic for green turtles and Libyan Sea for loggerhead turtles. Rresearch on loggerhead females should focus at the top five rookeries in Turkey, Kyparissia (Greece) and Libya and that on female green turtles should focus at Akyatan (Turkey), Kazanli (Turkey), Latakia (Syria) and Ronnas Bay (Cyprus). Males of both species should be tracked from breeding sites, except Zakynthos.
5. **Stranding networks** should be created in every Mediterranean nation to collect data and samples.
6. A **regional stable isotope project** should be established for both species.
7. A **regional skeletochronology project** should be established for both species.
8. A **regional bycatch project should be established to** update bycatch figures and assess post-release mortality.
9. Support in the form of **funded post-doctoral researchers** is required to assist researchers in analysing and publishing their data.
10. A **regional network of experts** to advise managers and policy makers and **data sharing** and writing-up of research papers between multiple projects.

INTRODUCTION

Available information regarding the populations of the loggerhead turtle (*Caretta caretta*) and the green turtle (*Chelonia mydas*) nesting in the Mediterranean has improved greatly during the past two decades (Margaritoulis et al. 2003; Casale and Margaritoulis, 2010), but there are still major knowledge gaps that limit our capacity to accurately assess the conservation status of both species and predict the consequences of anthropogenic stressors, particularly fisheries bycatch and climate change. Only through the use of accurate demographic models, will researchers be able to advise policy makers and managers about the best management options to ensure the conservation of marine turtles in the region. The present document aims to identify those gaps and to establish an applied research

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[1] The Demography Working Group was created during the 5th Mediterranean Conference on Sea Turtles in 2015 (Dalaman, Turkey). The members of the Group are listed in Appendix 1, at the end of this document.

agenda for developing accurate demographic models for these species of such cultural and conservation importance in the region.

REVIEW OF CURRENT KNOWLEDGE AND GAP ANALYSIS

1. Nesting beaches

1.1 Genetic structuring

Current genetic information suggests six distinct populations of the loggerhead turtle nesting in the Mediterranean: Libya, Dalyan, Dalaman, Calabria, Western Greece and Crete and the Levant (central and eastern Turkey, Cyprus, Israel and Lebanon) (Saied et al. 2012; Yilmaz et al. 2012; Clusa et al. 2013). Turtles nesting in Egypt may be part of the latter, but this is not currently known. On the other hand, loggerhead turtles nesting in Tunisia are not genetically distinct from those belonging to other Mediterranean populations, as numbers are small and only one widespread haplotype has been reported there (Chaieb et al. 2010).

Available information is based on the use of mitochondrial haplotypes and nuclear microsatellites, which allow the individual assignment of loggerhead and green turtles to major nesting areas within the Atlantic (Carreras et al. 2011; Carreras et al. 2014). However, resolving the assignation to distinct populations within the Mediterranean remains problematic. The use of SNPs will likely improve individual assignation. Furthermore, this will improve estimates of remigration interval and clutch frequency through DNA fingerprinting of females (see 1.3 Nesting female parameters). Hence, a regional molecular study should be undertaken whereby a tissue voucher is collected from each female or nest and analyzed collectively.

Traditional mitochondrial markers have revealed no major genetic structuring of green turtles in the Mediterranean, but further research using new, more polymorphic markers may reveal some structure (Tikochinski et al. 2012). As for the loggerhead turtle, a regional molecular study should be undertaken whereby a tissue voucher is collected from each female or nest and analyzed collectively.

1.2 Major nesting sites

Loggerhead turtles: After much searching and due to variation among publications, it was decided to take this information from Casale and Margaritoulis (2010) as this was the most up to date and complete information. Mean nesting levels for each country known to support loggerhead turtle nesting can be found in Table 1. Greece and Turkey alone have more than 75% of the nesting in the Mediterranean; however, the smaller populations at other sites such as Libya and Cyprus are also of regional significance being at the edges of the species range. It should be noted that the data from Libya are from a relatively short monitoring period. Considering the available data, the project must give priority to monitoring of the nesting beaches of the loggerhead turtle in Libya, Dalyan, Dalaman, western Greece and Crete and central and eastern Turkey and Cyprus.

Green turtles: Kasparek et al (2001) lists the five major nesting beaches for green turtles in the Mediterranean as Akyatan (Turkey), Kazanli (Turkey), Ronnas (Cyprus), Samadağ (Turkey) and Alagadi (Cyprus). Stokes et al (2015) provides a more recent review with maximum nests/year resulting in the following list of top five beaches: Akyatan, Samadağ, Kazanli, Latakia (Syria) and Alagadi. Although no longer listed in the top five, based on recent monitoring data, by Stokes et al (2015), Ronnas Bay should still be considered a priority, as there has been a lack of data published from this site in recent years during which numbers have risen at other sites in the vicinity.

1.3 Nesting female parameters and clutch parameters

Female loggerhead turtles nesting in the Mediterranean are the smallest in the world, although variable among sites, with those nesting in Cyprus being the smallest within the region (Broderick and Godley 1996; Godley et al. 2003). With such wide variation within the Mediterranean we can expect variation in the demographics of the different populations. It is therefore important that a range of sites are studied in detail to ensure that data are representative of the Mediterranean population overall. Within the Mediterranean, mean curved carapace lengths range from 66.5-84.7 cm; curved carapace widths range from 50-88 cm and mean clutch sizes range from 65-130.4 (range = 6-211). For more detailed information see Table 2. Female morphometrics are well documented for the major nesting populations. Additionally the data from Libya are from a relatively small sample size considering the level of nesting documented for Libya. Clutch sizes (CS) are again well documented for all the major nesting sites across all countries; however, data from Libya, are not published or from a relatively small sample size (Table 2).

Table 1. Mean loggerhead turtle nests per year for each country (Casale and Margaritoulis 2010).

Country Totals	Mean	Years monitored
Greece	3472	1984-2007
Turkey	2145	1979-2006
S. Cyprus	458	2005-2008
Libya	726	2006-2007
N. Cyprus	236	1993-2007
Egypt	67	1998
Lebanon	60	1997-2006
Israel	57	1993-2008
Tunisia	<15	1993-2008
Italy	10	2000-2004
Spain	1	1992-2007
France	1	2002-2006
Total	**7233**	

Inter-nesting (or re-nesting) intervals (RNI) are well reported for the main nesting beaches of Turkey, Greece and N. Cyprus. Mean inter-nesting intervals range from 12.7-19.9 days (Table 2). Inter-nesting periods are affected by the sea temperature, with warmer sea conditions producing shorter inter-nesting periods. The inter-nesting intervals of the rookeries in Libya and S. Cyprus are not reported in the scientific literature. Again to accurately determine RNI's intensive beach patrols are required at the nesting beach and adjacent nesting beaches. Alternatively, the use of satellite transmitters can provide information in this regard and offers insights as to the in-water behavior during this time. It can also give valuable insights into nest site fidelity and exchange between sites. This technique is expensive, however, and is prohibitive to many conservation projects and is often constrained in sample size is possible. Such data could be augmented by planned molecular studies.

Remigration intervals (RMI) are poorly covered in the published literature with only information available for Greece, Turkey and North Cyprus. Both Greece and Cyprus report mean remigration intervals of approximately 2 years and Turkey slightly longer at 3.35 years (Table 2). To accurately determine RMI's intensive night time beach patrols are required. For many conservation projects this may be particularly challenging either through lack of personnel or nesting beach logistics. Such data however could again be effectively captured through molecular studies.

Clutch frequency (CF), the number of clutches deposited by a female in a single season, is well documented for some nesting beaches in Turkey, Greece and N. Cyprus, but either doesn't exist or is not reported for all the other countries which have significant loggerhead turtle nesting rookeries. For those countries mentioned above the mean clutch frequency ranges from 1.2-2.2 clutches per season (Table 2). The accurate determination of CF also requires intensive night patrols so as to intercept all nesting females and assign each clutch to an individual female. Again, molecular studies and satellite telemetry could be used to help accurately determine these demographic parameters.

In general, incubation period, hatchling sex ratio, hatching success and emergence success are well covered Greece, Turkey and Cyprus. **Incubation periods** (IP) are well covered with large sample sizes across numerous nesting beaches in most countries which have loggerhead turtle nesting, although probably further more work is required in Libya. Mean incubation periods range 47.3-59.6 days, with North Cyprus experiencing the shortest incubation periods (Table 3). Published accounts of estimated **hatchling sex ratios** can only be found for some rookeries in Greece, Turkey and North Cyprus. For all the other nations there are no published accounts of estimated sex ratios (Table 3). For the three aforementioned countries all rookeries produce female biased hatchling sex ratio. Again published accounts of **hatching success** (HS%) is well covered by the major nesting countries (Greece, Turkey and Cyprus), but missing or with small sample sizes from all the other nations. Hatching success is largely similar in all countries ranging from 60-80% (Table 3). Similar to the previous two parameters, **hatchling emergence success** (ES%) has been published for the three major countries, with data missing for the remaining countries. For the most part mean hatchlings ES ranges from 60-70%, (Table 3).

Table 2. Details of female morphometrics and clutch sizes for the major loggerhead turtle nesting populations within the Mediterranean Sea.

Country	Beach	CCL (mean or range of means)	CCL (range/sd)	n	CS (mean/range of means)	CS (range)	n	RMI (range;yrs)	n	RNI (Range of means, days; range)	CF (range; n)
N. Cyprus	Alagadi	71.1 - 77.9	64.5 - 90.0		74.8 - 82.7	9 – 159				12.7 - 13.7 (7-34)	
N. Cyprus	Alagadi	73.6	4.6	159	73	28-144	229	2 (1-6)	44		1.8-2.2 (1-5; 170)
N. Cyprus		73.4	65-86.5	78	70		323			13.4 (11-17; n=32)	
S. Cyprus	West Beaches	66.5 - 79.8	60.0 - 90.0		74.2 - 97.2	25 – 164					
Greece	Kefalonia	81.6 - 84.7	71.9 - 93.0		99.8 - 120.4	39 – 176				15.8 - 17.0 (9-20)	
Greece	Kefalonia	82.5	3.78	16	115	55-151	38	2.56		17 (11-24)	
Greece	Kyparissia Bay	83.1 - 83.8	70.0 - 99.0	72	105.2 - 126.8	6 – 211				15.2 - 19.3 (12-24)	
Greece	Kyparissia Bay				117.7		52				
Greece	Lakonkos Bay	84.1 - 84.6	78.0 - 92.0		107.1 - 126.1	7 – 197					
Greece	Zakynthos	82.7 - 83.8	70.0 - 96.5		111.4 - 130.4	11 – 199				14.6 - 19.9 (11-28)	1.18 (1-3; 148)
Greece	Zakynthos	80.4	6.2	27	115.4		102	2.3			
Libya		78.0	71.0 - 86.3	11	95.2	72 – 128	14				
Tunisia		79.7	73.0 - 85.0		81.5 - 105.5	59 – 145					
Turkey	Fethiye	77.3	68.0 - 91.0		82.9 - 86.0	29 – 203		3.35 (1-7)		16.2 (12-34)	
Turkey	Patara				80.1	30-119	47				
Turkey	Dalyan	76.3	68.5-90	54	73.4	15-108	61			16 (10-27)	1.3 (1-3; 46)
Turkey	Dalyan	76.4	67-93	49	82.1	17-147	57			12.7 (10-19)	1.4 (1-3; 42)
Turkey	Goksu				90.3	42-151	43				
Turkey		76.0	63.0 - 91.0		65.0 - 101.0						
Greece	Zakynthos				116.5	110-130.4	5972				
Turkey	Dalyan	73.1	60.2-83.9	49	73.4	24-148	235				

Table 3. Mediterranean loggerhead clutch parameters (IP = incubation period, SR = sex ratio, HS = hatching success,ES = hatchling emergence)

Country	Beach	IP (mean or range of means, indiv ranges)	n	Hatchling SR (% female, range)	HS% Mean (n)	HS% Range	ES% Mean (n)
N. Cyprus	Alagadi	47.3 - 48.7 (42-60)	386	89.2			70.2-73.8 (38)
N. Cyprus	All beaches	49 (40-66)	628	89 (0-100)	79.1 (321)		
N. Cyprus	Karpaz beaches	48 (41-58)	43		60.9		
N. Cyprus	All except Karpaz	50 (40-66_	585				
N. Cyprus		48 (42-60)	115				
Greece	Kefalonia	54.9 (47-64)					
Greece	Kefalonia				71.6 (8)		71.6 (8)
Greece	Kyparissia Bay	48.1 - 53.9 (43-67)		70			54.9
Greece	Kyparissia Bay	55.5	598		72.7 (243)		62.4 (243)
Greece	Lakonkos Bay	52.1 - 59.3 (43-84)					
Greece	Zakynthos	57.6 - 62.3 (42-97)	2460	70			60.1 (572)
Greece	Peloponesus						54.9 (39)
Greece	Zakynthos	55.2 (42-89)	666	68-75	71.5 (19)	61.7-80.2	66.6 (19)
Greece	Crete	49.4	345				
Libya		55.0 (48-62)					
Turkey	Fethiye	55.0 - 56.9	276	61-69.3 (31-96)		58.1-67.8	
Turkey	Patara	52.1-60	52	72			
Turkey	Dalyan	52.9 (46-66)	222	90	61.7	56.8-66.1	
Turkey	Dalyan	59.3 (51-71)	235				
Turkey	Dalyan	52.3 (45-79)					93
Turkey	Goksu Delta	50.4 (46-58)	85	73-81			61.2 (34)
Turkey	Goksu Delta	57.0	89				
Turkey	Goksu Delta	54.8	117		77 (33)	2-99	63 (37)
Turkey	Kizilot	59.6	143				
Israel	North Med					0-90	
Egypt	North Sinai				71.3 (2)	66.4-76.2	

Table 4. Overview of the data available for each nesting parameter from each country (**+** = Good levels of published data; **-/+** = some data available but small sample size; **-** = no published data).

Country	CCL	CS	IP	RMI	RNI	SR	CF	HS	ES
Greece	+	+	+	+	+	+	+	+	+
Turkey	+	+	+	+	+	+	+	+	+
N. Cyprus	+	+	+	+	+	+	+	+	+
S. Cyprus	+	+	-	-	-	-	-	-	-
Egypt	-	+	-	-	-	-	-	-/+	-
France	-	-	-	-	-	-	-	-	-
Israel	-	+	-	-	-	-	-	-	-
Italy	-	+	-	-	-	-	-	-	-
Lebanon	-	-	-	-	-	-	-	-	-
Libya	-/+	+	+	-	-	-	-	-	-
Spain	-	-	-	-	-	-	-	-	-
Tunisia	-/+	+	-	-	-	-	-	-	-

A detailed review of green turtle nesting demographics was not undertaken here as nesting is much more limited in its distribution and we do not anticipate such marked differences within the region. Stokes et al (2014) and Broderick et al (2002) provide demographic parameters for green turtles nesting in Cyprus. Such published data are lacking for most other sites in the Mediterranean and should be collected as a priority.

2. Foraging grounds

Most of the research effort on marine turtles has traditionally been conducted at nesting beaches, although they spend most of the time in the ocean. The Mediterranean Sea comprises a number of sub-basins differing in primary productivity, continental shelf width and other attributes relevant for sea turtles. Available information indicates that turtles do not distribute homogenously within those sub-basins (Clusa et al. 2014) and that some key parameters such adult body size and fecundity vary among females foraging at different sub-basins, even if they nest in the same beach (Zbinden et al. 2011; Cardona et al. 2014). Thus, detailed information about adult habitat use is critical, but for some major nesting beaches this is still missing (see 2.2 Habitat Use: Satellite Telemetry and 2.3 Habitat Use: Stable Isotopes).

On the other hand, juvenile and immature turtles represent the bulk of the population and hence information about size structure and abundance of turtles at foraging grounds is essential to contextualize changes in nest counts. For instance, stable nest counts, declining numbers of turtles at sea and increasing average size of stranded turtles may anticipate a serious demographic decline. On the contrary, declining nest counts, stable numbers of turtles at sea and a stable class size composition of strandings may indicate temporary reduction in nesting frequency due to climatic or other environmental reasons but not a long term population decline. Thus, data about at-sea abundance are critical.

Mixed stock analysis and direct assignation using microsatellites has revealed the origin of turtles occurring at several Mediterranean foraging grounds (Maffucci et al. 2006; Giovannotti et al. 2010; Carreras et al. 2011; Yilmaz et al. 2012; Garofalo et al. 2013; Clusa et al. 2014). However, current genetic markers have limited capacity to assign individuals of unknown origin to the distinct populations nesting within the Mediterranean. The use of SNPs will likely improve individual assignation. Accordingly, collecting samples at the major foraging grounds for genetic analysis is recommended.

2.1 At-sea abundance

Aerial surveys are the best method to assess abundance of turtles at sea and detect changes in population before they translate into changes in nest counts. There is published information about aerial surveys conducted in the western Mediterranean sub-basins during the 2000s (Gómez de Segura et al. 2003 and 2006; Cardona et al. 2005; Lauriano et al. 2011) and there are several recent unpublished surveys covering the Balearic Sea (Tomás, personal communication), the Gulf of Lions (Poisson, personal communication), the Tyrrhenian Sea and the Ionian Sea (Lauriano, personal communication) and the Adriatic Sea (Lazar, personal communication). Nothing is known about the Alboran Sea, the Libyan Sea, the Aegean Sea, the southern coast of Turkey and the Levantine Sea. Furthermore, there are no recent surveys covering the Algerian Basin. Accordingly, priority should be given to aerial surveys covering the Alboran Sea, the Algerian Basin, the Libyan Sea, the Aegean Sea, the southern coast of Turkey and the Levantine Sea.

Aerial surveys require information about the proportion of time spent at surface to produce absolute estimates of turtle abundance. Reliable estimates of **surface time** exist for the Balearic Sea, the Algerian Basin, the Tyrrhenina Sea (Table 5) and the Adriatic Sea (Lazar, personal communication). However, there is no published information or any ongoing project covering the Libyan Sea, the Aegean Sea, the southern coast of Turkey and the Levantine Sea and hence satellite tracking of juvenile loggerhead turtles in these areas is a high priority (see 2.2 Habitat use: Satellite telemetry).

2.2 Habitat use: satellite telemetry

Satellite telemetry of adult turtles is critical to identify the foraging grounds used by the adults of each population. Furthermore, satellite telemetry is critical to assess the surface time of turtles at foraging grounds, a parameter necessary to derive absolute population estimates for aerial surveys.

The recent 2014 paper of Luschi and Casale provides an excellent overview of peer-reviewed satellite tracking studies of marine turtles in the Mediterranean (up to and including 2013) and provides summary figures of the locations of individuals tracked. Luschi and Casale (2014) include only published studies of adults and juveniles, male and female green and loggerhead turtles. Here we report data from the above paper and include additional studies, both published in the peer-reviewed and grey literature and those unpublished (after consultation with the researchers involved). Some of these studies build upon and include those in Luschi and Casale (2014), for example recently published green turtle tracks from Cyprus (Stokes et al 2015) include those published in Broderick et al (2007) and others are novel pieces of work. For those not yet published, only data on the number of turtles tracked, year and location of deployment are reported. In gathering these data, the authors have consulted with colleagues researching marine turtles in Cyprus (Snape; Stokes), Israel (Levy), Italy (Casale, Hochsheid, Luschi) Greece (Panagopoulou; Patel; Rees), Libya (Hochscheid) Syria (Rees), Turkey (Canbolat; Candan; Kaska; Sezgin; Turkecan; Turkozan).

Adult turtles tagged at nesting beaches

Loggerhead turtles: Females have been tracked in recent years in reasonable numbers from Cyprus (n=27; Snape et al. in review), and from some of the Greek rookeries: Zakynthos (n=36; Schofield et al. 2013; Zbinden et al. 2011), Crete (n=21 Margaritoulis & Rees 2011; Patel 2013; Patel et al. in press) and Cephalonia (n=1; Hays et al. 1991). For the other significant nesting populations however, there is a lack of data, in particular for Turkey, where only six females have been tracked from Dalyan and one from Fetiyhe Beach (A. Canbolat personal communication; Y.Kaska upublished data). Using maximum nests recorded from Turkozan and Kaska (2010) the following are the top five loggerhead nesting beaches in Turkey (Belek, Anamur, Dalyan, Fenike, Kizilot). Only five turtles have been tracked from nesting beaches in Libya (Hochscheid et al. 2012) and of the largest nesting population in the Mediterranean at Kyparissia (Greece), only three females have been previously tracked from the nesting beach (Backoff 2013). Satellite tracking of nesting loggerhead turtles has also been conducted in Israel and Italy where small but significant populations occur (Y. Levy unpublished data; T. Mingozzi and P. Luschi personal communication; see Table 5). Priorities for future satellite tracking of nesting loggerhead turtles should be Kyparissia, Greece; Libya and the top five nesting beaches in Turkey.

A significant number (n=33; Schofield et al. 2013) of adult male loggerhead turtles have been tracked offshore from Zakynthos Beach; the only other breeding loggerhead male tracked in the Mediterranean was from Crete (Patel et al. in press). Future studies of male loggerhead turtles should be prioritized at all major rookeries other than Zakynthos.

Green turtles: Of the six major nesting sites for green turtles in the Mediterranean, only two have been the subject of satellite tracking studies of >5 turtles. In Turkey, although eight females have been tracked from their nesting beach at Samadağ (Stokes et al 2015), only two turtles have been tracked from the largest rookery at Akyatan (Turkecan & Yerli 2011) and none have been tracked from Kazanli. These latter two sites should be a priority. With only one turtle previously tracked from Syria (Rees et al 2008) further study of this population should also be a priority. Although a reasonable number have been tracked from Cyprus (n=22; Stokes et al 2015), nearly all were from Alagadi Beach and there have been no turtles tracked at this site since 2010. Females nesting at other major beaches in Cyprus have not been tracked. Although not included in the top five nesting beaches for green turtles by Stokes et al (2015), Ronnas Bay should be prioritized for future studies. Thus, priorities for future satellite tracking of nesting green turtles should be Akyatan and Kazanli (Turkey), Latakia (Syria) and Ronnas (Cyprus).

Only one male green turtle has been tracked from a breeding location in the Mediterranean. This was an opportunistic capture of a green turtle on a nesting beach in Cyprus (Wright et al 2012). Future studies of male green turtles should be prioritized at all major rookeries.

Table 5. Number and location of adult *C.caretta* males and females tracked from breeding sites in the Mediterranean. * eight PTTs deployed but only two post-nesting migrations.

Country		Female	Male	Year	Reference
Turkey	Dalyan	1		2007	A.Canbolat pers.comm
	Dalyan	1		2010	Y. Kaska pers comm
	Dalyan	2		2011	Y Kaska pers comm
	Fetihye	1		2011	Y. Kaska pers comm
	Dalyan	2		2013	Y. Kaska pers comm
Israel	Haifa/Betzet	5		2008-2010	Y. Levy pers. comm.
Greece	Cephalonia	1		1990	Hays et al 1991
	Rethymno, Crete	1		2005	Margaritoulis & Rees 2011
	Rethymno, Crete	20		2010-2011	Patel 2013
	Rethymno, Crete		1	2011	Patel et al in press
	Zakynthos	18		2004-2007	Zbinden et al 2011
	Zakynthos	18	33	2007-2011	Schofield et al 2013
	Kyparissia	2*		2012	Backof 2013
	Kyparissia	1		2005	ARCEHLON
Cyprus	Alagadi/Tatlisu	20		2001-2011	Snape et al in review
	West Coast	2		2011	Snape et al in review
	East Coast	5		2012	Snape et al in review
Italy	Calabria	7		2009-2013	T. Mingozzi & P. Luschi pers. comm
Libya	Sirte/Misurata	5		2009/2010	Hochscheid et al; 2012

Table 6. Number and location of *C.mydas* adult males and females tracked from breeding sites in the Mediterranean.

Country	Beach	Female	Male	Year	Reference
Turkey	Akyatan	2		2007-2008	Turkecan & Yerli 2011
	Samandağ	8		2004-2005	Stokes et al 2015
	Samandağ	1		2012	B. Sönmez pers comm
Israel	Haifa	3		2008-2009	Stokes et al 2015
Syria	Latakia	1		2006	Rees et al 2008
Cyprus	Alagadi		1	2009	Wright et al 2012
	Alagadi/Esentepe	22		1998-2010	Stokes et al 2015

Juvenile turtles

Since marine turtles in their immature life stages are more difficult to access, the satellite tracking studies included principally individuals that were either by-caught in fisheries, deliberately hand-caught or rehabilitated for various amounts of time. Although it may be questionable whether rehabilitated animals behave naturally after their re-introduction into the sea (Cardona et al. 2012), a substantial part of the tracking was conducted by or in association with rescue and rehabilitation centers, to ascertaining that the turtles have been successfully re-introduced and take up their natural activities. However, with so few studies on healthy turtles taken directly from the sea there are no sufficient base data to measure “natural” behavior. Although these data cannot be ignored for the purpose of this review, we recommend that future studies using satellite telemetry should make an effort of capturing healthy individuals directly from the marine habitats which are the focus of the study.

Some studies also included specimens of adult size or nearly adult size (e.g. ≥66 cm) yet sexual maturity has never been confirmed for these turtles which were usually caught outside their breeding grounds and not subjected to reliable sexing techniques other than biometrics of the tail length. This review will mainly focus on the behavior of juvenile turtles, but since the larger individuals were not included in the section on adult turtles, some general information is provided here.

In compiling the data we concentrated on information regarding the size of the turtle, differentiating between juveniles and sub-adults/adults with a curved carapace length of 66 cm and more; on the sex for those larger individuals, if such information was available; on the release country and the main marine area of residence (which could be multiple for one turtle if it had spent equal amounts of time in more than one area); on the behavior according to the general life history pattern (oceanic, neritic, intermediate). Individuals which were monitored for less than 30 days were excluded from the data set for two reasons: 1) short periods of tracking are not sufficient to establish preferred residence areas and life-stage related behaviour, and 2) 30 days was considered a long enough time for rehabilitated turtles to re-acclimate to their natural environment and commence “normal” activities.

Loggerhead turtles are widely distributed in the Mediterranean and occur in almost all marine areas (Casale and Margaritoulis 2010). According to current knowledge, the two most important neritic loggerhead foraging grounds in the Mediterranean, which host both juvenile and adult turtles, are in the Adriatic Sea and on the Tunisian Continental Shelf (including Gulf of Gabés) (Casale et al. 2012 and references cited therein; Margaritoulis et al. 2003). Important oceanic areas were identified in the Alboran Sea, the Balearic Sea and along different parts of the North African coasts as well as the Sicily Channel. Nursery and early developmental areas are less well known, although Casale et al. (2010) reported high incidences of juvenile turtles found in the south Adriatic Sea. More recently, hatchling drift simulations indicated that hatchlings from more easterly rookeries are retained within the area of origin, whereas hatchlings from the Ionian area disperse into the Ionian, Adriatic, and

South-central Mediterranean areas (Casale and Mariani 2014). Satellite tracking of early juveniles (15-20 cm CCL) would be needed to assess the reliability of such simulations.

A total of 92 loggerhead turtles were tracked for more than 30 days, of which 55 were juveniles and 37 were adult sized. Tracks or part of the tracks were recorded in the following marine areas (decreasing order of sample size): Algerian Sea (n = 27); Tyrrhenian Sea (n = 17); Ionian Sea (n = 17); Adriatic Sea (n = 8); Balearic Sea (n = 7); Tunisian Continental Shelf Area (n = 7); Sicily Channel (n = 5); Alboran Sea (n = 5), Libyan Sea (n = 2), Ligurian Sea (n = 2), and Levantine Sea (n = 1). Seven rehabilitated turtles have been satellite tracked in southern France and remained within the western Mediterranean, but nothing has been published about them yet (Darmon, personal communication). In any case, the majority of movement trajectories are available for the Western Mediterranean, whereas only 30% of the tracked juveniles prevailed in the Eastern Basin, mainly in the Ionian Sea. More juvenile turtles should be tracked in the Eastern Mediterranean basin where many developmental areas are expected to be. The association of juvenile loggerhead movements and oceanographic features (such as sea surface height and eddies) have been explored in the most western part of the Mediterranean and it would be useful to extend this kind of study to the Tyrrhenian and Ionian Sea, where few oceanic tracks have been recorded as well as to the Sicily channel, the main passage between the western and eastern basin.

Turtles in neritic areas have been tracked mostly around the Italian peninsula, and a few in Spain, Greece, Tunisia and Libya. It may be regionally important to identify the small scale movements and home ranges of turtles with high precision, especially there where high mortalities are of concern, so that the threats can be mitigated by developing knowledge-based conservation plans. Priorities for future satellite tracking of juvenile loggerhead turtles should be oceanic areas in the marine areas off the main eastern rookeries as well as the Gulf of Lion, Tyrrhenian Sea, Ionian Sea and Sicily Channel. Studies on neritic stage turtles should be intensified in areas where few data are already available and which are priority concerns for turtle mortality.

Most of the current knowledge on the distribution and habitats of green turtles in the Mediterranean relates to the nesting beaches, much less is known about their foraging, overwintering and developmental habitats. Satellite tracking of females leaving their nesting grounds in Cyprus revealed fidelity of these turtles to foraging and overwintering sites along the north African coast, especially in the Gulf of Bomba and western Sirte in Libya (Broderick et al. 2007). Margaritoulis and Teneketzis (2003) identified a neritic developmental habitat in Lakonikos bay of the Western Peloponnesus (Greece) and Lazar et al. (2004) reviewed historical presence of green turtles in the Adriatic Sea, suggesting the southern Adriatic as a suitable pelagic habitat for this species. In the Western Mediterranean instead green turtles are extremely rare and nesting has never been observed (Carreras et al., 2014). A review on green turtle sightings around the Italian peninsula was made by Bentivegna et al. (2011). Up to date no published data on the tracking of juvenile green turtles in the Mediterranean are available and it is recommended that studies be conducted into the behavior of juvenile neritic stage green turtles cover the South Adriatic Sea, the Aegean Sea and the Levantine Sea.

Adult sized turtles tagged at foraging grounds

Some studies regarding turtles captured at foraging grounds included specimen of adult size or nearly adult size (e.g. ≥66 cm) yet sexual maturity has never been confirmed for these turtles which were usually caught outside their breeding grounds and not subjected to reliable sexing techniques other than biometrics of the tail length. There were too few identified male and female turtles to make any conclusions on sex-dependent movements and habitat use. Interestingly, there is great variability in the tracks of these turtles, some showing residential areas, some migrated along the Italian coasts to move between summer and winter areas or for less known reasons. Tracking of adult turtles, particularly males, outside the breeding season and in less well known neritic areas should be prioritized to better understand site fidelity, migration and connectivity patterns of adult turtles. Future studies should focus on long-term monitoring of adult sized turtles in the Western Mediterranean to establish their connection to known breeding and adult foraging sites.

Table 7. Studies on satellite tracking of juvenile loggerhead turtles in the Mediterranean. CCL = curved carapace length; m = male; f = female, u = unknown; oc = oceanic; ner = neritic; im = intermediate

Reference	Sub-Adult/Adult (CCL >/= 66 cm)			Juvenile	Release Country	Main Area of Residence	Life Stage		
	M	F	u				oc	ner	Im
Cardona et al. 2005				5	Spain	Algerian Sea (n=4); Balearic Sea (n=1)	4		1
Revelles et al. 2007a;b				10	Spain	Algerian Sea	10		
Eckert et al. 2008			8	6	Spain	Alboran Sea (n=5); Balearic Sea (n=4); Algerian Sea (n=2); Tyrrhenian Sea (n=1); Ionian Sea (n=1)	14		
Cardona et al. 2009				7	Spain	Algerian Sea (n=6); Sicily Channel (n=1)	1	6	
Cardona et al. 2012				6	Spain	Algerian Sea (n=3); Balearic Sea (n=2); Ligurian Sea (n=1)	3	2	1
Bentivegna 2002; Bentivegna et al. 2007		3	1		Italy	Tyrrhenian Sea (n=2); Ionian Sea (n=2); Libyan Sea (n=1); Sicily Channel (n=1)	1	1	2
Hochscheid et al. 2007			3	4	Italy	Tyrrhenian Sea (n=5); Ligurian Sea (n=1); E Ionian Sea (n=2); S Adriatic Sea (n=1);		6	1
Hochscheid et al. 2010				1	Italy	Tyrrhenian Sea	1		
Casale et al. 2012a		1		4	Italy	N Adriatic Sea (n=3); Gulf of Otranto, Ionian Sea (n=2); Algerian Sea (n=1)		5	
Casale et al. 2012b			2	4	Italy	Tunisian Continental Shelf; Sicily Channel	1	2	3
Luschi et al. 2013		2	1		Italy	Ionian Sea (n=2); Aegean Sea (n=1); Tyrrhenian Sea (n=1)		2	1
Luschi et al., unpubl. data			1	4	Italy	Tyrrhenian Sea (n=4); Sardinian Sea (n=1)		4	1
Hochscheid et al., unpubl. data	5	3	1	2	Italy	Ligurian Sea (n=1); Tyrrhenian Sea (n=8); Adriatic Sea (n=2); Ionian Sea (3)	1	6	4
Hochscheid et al., unpubl. data			1	1	Malta	Sicily Channel (n=1); Algerian Sea (n=1)	1		1
Hochscheid et al. 2007			1	1	Tunisia	Tunisian Continental Shelf		2	
Casale et al. 2012a				1	Croatia	N Adriatic Sea		1	
Lazar & Casale, unpubl. data				14	Croatia	North-Central Adriatic Sea		14	
Casale et al. 2012a				1	Slovenia	N Adriatic Sea		1	
Lazar & Casale, unpub. data				6	Slovenia	North-Central Adriatic Sea		6	
Rees et al. 2013	2	2	2		Greece	Amvrakikos Gulf, Greece		6	
Kaska et al., unpubl. data	1	3	1	4	Turkey	Turkish Sea (n=8), Libyan Sea (n=1)		9	
Hochscheid et al. 2010	1		1		Libya	Libyan Sea (n=1); Tunisian Shelf (n=1)		2	

Reference	Sub-Adult/Adult (CCL >/= 66 cm)			Juvenile	Release Country	Main Area of Residence	Life Stage		
	M	**F**	**u**				**oc**	**ner**	**Im**
Hochscheid et al., unpubl. data				1	Libya	Ionian Sea	1		
Hochscheid et al., unpubl. data				1	Lebanon	Levantine Sea		1	
Darmon et al., unpubl. data			3	4	France	Western Mediterranean			
Total per group	**9**	**14**	**26**	**87**			**38**	**76**	**15**
Overall				**136**					

2.3 Habitat use: stable isotope analysis

Although, satellite telemetry of adult turtles is critical to identify key foraging grounds used by the adults of each population, it is a relatively expensive method per animal and probably no more than a few tens of adult turtles can be tracked at each nesting beach. Stable isotope analysis offers an inexpensive method for mass monitoring in conjunction with telemetry. The Mediterranean Sea is subdivided into a number of isotopical distinct sub-basins (Cardona et al. 2014), which offers a good opportunity to use stable isotopes as habitat markers both for loggerhead and green turtles (Zbinden et al. 2011; Cardona et al. 2014; Bradshaw et al. unpublished data). The regular collection of tissue samples from nesting females will allow identify the foraging grounds used by the females nesting at each major site.

To do so, we need to generate a robust isoscape of the Mediterranean Sea. There are three alternative approaches. The first one is collecting tissue samples from adult satellite tagged turtles, tagged at their nesting beaches, and use the stable isotope ratios in those samples to characterize the foraging grounds of the turtles (Zbinden et al. 2011; Bradshaw et al. unpublished data). This is the best approach, but the number of individuals tagged from every nesting beach is necessarily low because of the high cost of satellite tracking. The second approach is collecting tissue samples of adults and juveniles captured at their foraging grounds and use those stable isotope ratios to characterize them. This approach assures a large sample size from most areas, but there is no way to discriminate between transient and resident individuals, which will reduce the spatial accuracy of the data. Avoiding sampling during the pre-nesting and post-nesting migration seasons is a possible way to reduce uncertainly for adults. The stable isotope ratios of satellite tracked turtles are also useful to identify potential transient individuals. The third one is using stable isotope ratios in potential prey from different foraging grounds to characterize them. This is necessary to understand the sources of variability among foraging grounds and to make sure that differences in the stable isotope ratios of turtles are because differences in isotopic baseline and not because of differences in diet. However, to derive stable isotope ratios in turtle tissues from those in potential prey is not straightforward even if prey-to-predator discrimination factors are known.

Tissue selection is critical for stable isotope analysis, as diet-to-predator discrimination factors are tissue dependent (Seminoff et al. 2006; Reich et al. 2008; Vander Zanden et al. 2012). Skin is probably the best option, as can be sampled easily from both dead and live individuals and integrates diet over several months. However, collecting skin samples from most females is unlikely at most nesting beaches due to logistical constraints. Sampling dead hatchlings is easier and less intrusive, but the probability of finding a dead hatchling increases with clutch size and hence this approach may bias the sample in favor of the females using the most productive foraging grounds, as they lay more eggs (Cardona et al. 2014). Egg sampling offers an alternative to avoid such a bias, but this means that each nest has to be excavated once discovered. Furthermore, we need to improve the methods to infer stable isotope ratios in female skin from those in egg.

3. Growth and age at maturity

3.1 Size structure

Information about the size structure at the foraging grounds is essential to contextualize changes in the numbers of nests and to develop an early warning system, in combination with aerial surveys. Direct sampling of wild sea turtles for morphometrics is possible, but time consuming and difficult due to logistical constrains. Conversely, hundreds of turtles strand annually in Mediterranean beaches as a result of bycatch, boat strikes and other causes. Although stranded turtles are certainly a biased sample, they offer the most cost-effective method to gain information about the size distribution at foraging grounds. Carapace length is a parameter commonly recorded from most stranded and rehabilitated turtles, but stranded animals are also extremely useful for molecular studies, stable isotope analysis and skeletochronology and should be monitored regularly.

Currently, stranding networks operate in some Mediterranean countries, usually in coordination with rescue centers, but not everywhere. Acording to Ulmann and Stachowitsch (2015), there are 34 confirmed sea turtle rescue centres, 8 first aid station and 7 informal rescue institutions currently in operation around the Mediterranean, with as many as 20 of them in Italy (Hochscheid personal communication) but none in 8 out of 22 coastal Mediterranean countries. The gaps are principally in the Middle East and North Africa. Following the last Mediterranean Marine Turtle Meeting, an online email exchange for personnel involved in such rehabilitation centres was created and it is proving quite effective as a means of communication among such centres and as a portal for notifying recaptures, and methods to be followed in particular situations which are more familiar with some practioners than others.

Steps towards the coordination of rescue centres are valuable, but valuable information from dead stranded individuals is sometimes overlooked if rescuing injured animals is perceived as the only role of stranding networks. Hence, there is a need not only to develop stranding networks all around the Mediterranean but to emphasize the need to collect data and samples from every stranded turtle, dead or alive, using common protocols. There is also a need to develop information for sharing information.

3.2 Growth curves

Sea turtles are characterized by slow growth and late sexual maturity (Scott et al. 2013). Accordingly, demographic models are highly sensitive to errors in the estimate of the age at first maturity. The relationship between age and carapace length can be addressed through capture-tagging-recapture studies or through skeletochronology.

Skeletochronology is the best method to determine the length-to-age relationship and relies on the analysis of the lines of arrested growth (LAGs) in bones. It is a rapid and reliable chronological tool already successfully used in many reptile species. It is used for the comparison of several populations and species, and it is the only method for fossils. This method can provided individual age of the studied specimen and important demographic information such as age at maturity or other life stages and longevity. Age structure can also provide - under some assumptions - demographic rate such as age specific survival.

Skeletochronology can also infer individual growth. Thanks to the allometry between growth of the bone used for age estimation and longitudinal growth of the carapace, back-calculations can be applied to obtain individual growth curves. Skeletochronology needs validation. It is based on the counting of the lines of arrested growth. It has to be shown that the LAGs correspond to ecological constraints (eg growth decrease in winter) of known periodicity. Estimation of growth has to consider the underlying growth model used.

Anomalous LAGs that are a common problem in reptile skeletochronology because of double, splitting and supplemental lines, compression of LAGs at the periphery of the bone and resorption of the innermost LAGs. Furthermore, endosteal resorption can be intense, leading to the loss of early LAGs. Nevertheless, several studies have validated this method for sea turtles. Validation methods have included the use of known age of turtles (Snover & Hohn (2004), the use of LAGs labelling (e.g. injection of fluorescent tetracycline intrabone marker; Klinger and Musick, 1992; Coles et al., 2001) and the comparison of results of skeletochronology and mark-recapture records (Van Houtan et al., 2014).

The humerus is the most common tissue analyzed in sea turtles, although phalanges have also been used. As a consequence, age can be assessed only on dead turtles. The bone is cut into 2−3 mm thick sections using a low speed saw. Sections are fixed in 10% formalin, decalcified and sectioned using a freezing microtome (25µ), stained and mounted on slides. This method has been used to determine the growth rate and age at first maturity of loggerheads in the Mediterranean (Casale et al. 2011a; Casale et al. 2011b; Piovano et al. 2011), but published data present two major shortcomings. Firstly, all the published data have been collected around Italy and growth rates and age at first maturity are expected to be basin-dependent. Secondly, loggerheads of Atlantic and Mediterranean origin occurring in the Mediterranean Sea are known to grow at different rates (Piovano et al. 2011) and hence these two groups of turtles have to be analyzed independently, even when inhabiting the same foraging grounds.

It is recommended that studies of growth rate and age at first maturity of loggerhead sea turtles of Mediterranean origin are conducted at least in the Adriatic Sea, the Aegean Sea, the Libyan Sea, the Levantine Sea, the Tyrrhenian Sea and the Balearic Sea.

4. Bycatch

Although many definitions of bycatch are available we use here the one proposed by the General Fisheries Commission for the Mediterranean (GFCM): "*Bycatch is the part of the catch unintentionally captured with a gear in addition to target species during fishing operation (e.g. undersized and damaged specimens etc.) and/or non-commercial species that are kept on board, as well as to incidental catch of endangered, vulnerable or rare species (e.g. turtles, shark, mammals, birds, etc.). Part of the bycatch can also be discarded at sea*".Bycatch is gear-type dependent, cumulative across fisheries and trans-national.

Existing information on sea turtles bycatch is incomplete and information gaps include both industrial and small scale fisheries (SSF) fleets all over the world (Lewison et al., 2014). According to the published information, three species of sea turtles are incidentally captured in the Mediterranean Sea: the loggerhead turtle, the green turtle and the eatherback turtle, although the latter is very scarc in the region. Given the spatial overlap of both oceanic and neritic foraging patterns of loggerhead and green turtles with the fishing grounds of the longline and trawl fleets within the Mediterranean Sea, both oceanic and neritic stages of marine turtles are at risk of bycatch from industrial and artisanal fisheries. Trawl fisheries are responsible for significant bycatch of loggerhead and green turtle in the Mediterranean (Casale et al. 2007, Álvarez de Quevedo et al. 2010). Loggerhead and green turtles are also at risk from small scale artisanal fisheries using a variety of gears types, as reported elsewhere (Carreras et al. 2004, Echwikhi et al. 2010, Coelho et al., 2013). Nevertheless, accurate risk assessment from artisanal fisheries is difficult due to a lack of data.

Demetrio and Megalofonou (1988) for the southern Italy, Panou et al. (1992) for the Ionina Sea and Aguilar et al. (1995,) Camiñas (1988) and Mayol et al., (1988) for Spain, provided the first information on sea turtles bycatch by longlines in the Mediterranean Sea and Camiñas (1997a and 1997b) estimated sea turtles bycatch by the Spanish surface longline in the western Mediterranean (Camiñas and de la Serna, 1995). Wallace et al., (2010) pointed out that the bycatch rate and the fishing intensity in the Mediterranean Sea were among the highest in the world, although the catch was dominated by small turtles with a low reproductive value. Accordingly, they recommend urgent actions to reduce bycatch levels.

Nevertheless, estimation of turtles bycatch is based on data from a few fleets (surface longline, bottom trawlers and some artisanal gears) from selected countries, although the GFCM fleet data include 9,942 vessels with more than 15 m LOA (www.gfcm.org) and recent estimations of the GFCM (Farrugio, personal communication) indicate that the Mediterranean Sea supports more than 81,000 fishing vessels, with 83% classified as Small Scale Fisheries (SSF) and seldom considered when estimating the total capture of turtles in the region. At least,50% of the SSF fleet is concentrated in the Aegean Sea, Gulf of Gabès, Adriatic and Eastern Ionian Sea, four major foraging grounds for loggerhead and green turtles in the region. Moreover 27,767 vessels of the SSF fleet use gillnet and entangling nets and 12.181 vessels use hooks and lines, all of them known to capture sea turtles.

Casale (2011) estimated that there are more than 132,000 incidental captures per year in the Mediterranean, of which more than 44,000 are predicted to be fatal, although very little is known about post-release mortality (Álvarez de Quevedo et al. 2013). Of the projected 132,000 annual captures, more than 39,000 turtles are captured by bottom trawlers, and more than 13,000 turtles expected to be captured by demersal longlines. With set gillnets, although data are lacking, it is likely that over 23,000 turtles are caught each year in the Mediterranean (Casale, 2011). Although strandings give insights here, numbers of stranded turtles actually represents a minimum estimate of mortality because carcasses decompose rapidly while drifting in currents and eddies and eventually sink (Epperly et al., 1996; Hart et al. 2006), and thus many dead turtles probably never get to the shore.

Unfortunately, available bycatch estimates combine many different sources of disparate quality and accuracy, adopt a national approach vs. a foraging ground approach and quickly become out of date because of the dynamic nature of fishing fleets. There is an urgent need for updated estimates adopting a sub-basin approach derived from common survey methods combining onboard observers with questionnaire-based surveys (Carreras et al 2004; Álvarez de Quevedo et al. 2010; Domènech et al. in press). The survey should incorporate information about the spatial and temporal distribution of fishing effort of each fishery, gear specifications and target species. Particularly, longline fisheries should be stratified by gear (métiers), each with its own characteristics and therefore individual management needs. Furthermore, there is an urgent need to estimate the post-release mortality caused by bottom trawling and artisanal fisheries as those using set nets. PSAT tags offer the best approach to tackle this problem (Álvarez de Quevedo et al. 2013).

RESEARCH PRIORITIES

Recommendation 1: A **regional molecular project** should be established for both species. These projects should include the major nesting beaches and foraging grounds. A sample should be collected from every nest laid. Samples should be collected from 50 turtles of every species from each major foraging ground. New generation sequencing markers should be used to 1) refine genetic structuring at nesting beaches and foraging grounds, 2) estimate remigration interval, 3) estimate clutch frequency through female fingerprinting and 4) resolve the contribution of nesting beaches to foraging grounds.

Recommendation 2: Ongoing **beach monitoring projects** in Greece for loggerheads and for both species in Cyprus, Northern Cyprus and Turkey should be maintained. A new project for loggerheads should be established in Libya.

Recommendation 3: **Aerial surveys** should be conducted in the Alboran Sea, the Algerian Basin, the Libyan Sea, the Aegean Sea, the southern coast of Turkey and the Levantine Sea as soon as possible to fill major gaps. Aerial surveys should be conducted at every major foraging grounds (Alboran Sea, Balearic Sea, Algerian Basin, Tyrrhenian Sea, Libyan Sea, Adriatic Sea, Aegean Sea, the southern coast of Turkey and Levantine Sea) every five years. The use of UAVs in coastal areas should be tested as an alternative to airplane surveys.

Recommendation 4: **Satellite tracking studies** of juvenile turtles should be a priority. For loggerhead turtles this should focus on the Levantine Sea, the Aegean Sea, the south of Turkey and Libyan Sea. We further suggest intensifying studies in areas which are already confirmed oceanic habitats: the Ionian Sea, the Tyrrhenian Sea and the Strait of Sicily. For adult female loggerhead turtles studies should be conducted at the top five rookeries in Turkey (Belek, Anamur, Dalyan, Fenike, Kizilot), Kyparissia (Greece) and Libya with efforts to track male loggerheads focusing on all major breeding sites other than Zakynthos (Greece). For juvenile green turtles studies should focus on the South Adriatic Sea, the Aegean Sea and the Levantine Sea. For adult female green turtles studies should be conducted at Akyatan (Turkey), Kazanli (Turkey), Latakia (Syria) and Ronnas Bay (Cyprus) and for males studies should be conducted at all major breeding sites. Wild caught animals should be prioritized over rehabilitated ones. All telemetry work should be integrated with stable isotope project sampling study animals and a large sample of others.

Recommendation 5**: Stranding networks** should be created in every Mediterranean country to collect data about turtle size and sample at least skin for stable isotopes and bone for skeletochronology. Stranding networks should be coordinated with rescue centres. A protocol for data and sample sharing should be developed, in addition to sampling protocols.

Recommendation 6: A **regional stable isotope project** should be established for both species. A sample should be collected from every adult turtle satellite tracked and from every nest laid. Furthermore, samples should be collected from stranded and bycaught turtles at foraging grounds (Alboran Sea, Balearic Sea, Algerian Basin, Tyrrhenian Sea, Libyan Sea, Adriatic Sea, Aegean Sea, the southern coast of Turkey and Levantine Sea) and also from potential prey.

Recommendation 7: A **regional skeletochronology project** should be established for both species, with the aim to assess growth rate and age at first maturity. Analysis should be conducted independently for each forging ground (Alboran Sea, Balearic Sea, Algerian Basin, Tyrrhenian Sea, Libyan Sea, Adriatic Sea, Aegean Sea, the southern coast of Turkey and Levantine Sea).

Recommendation 8: A **regional bycatch project should be established to** update bycatch figures and the associated mortality. Such project should cover at least surface longline, bottom trawl and selected artisanal gears in the Alboran Sea, Balearic Sea, Gulf of Lyons, Algerian Basin, Tyrrhenian Sea, Libyan Sea, Adriatic Sea, Aegean Sea, the southern coast of Turkey and Levantine Sea. Questionnaire based surveys have to be combined with onboard observers. Research on the post-release mortality of turtles bycaught in bottom trawls and set nets should be included.

Recommendation 9: Support in the form of **funded post-doctoral researchers** working across multiple institutions with expertise in analysis of marine turtle data is required to assist individual researchers in publishing their data. At least four positions should be available: demography, genetics, bycatch and habitat use.

Recommendation 10: A stable **regional network** of experts and a regional repository of scientific and grey literature should be created. **Data sharing** and writing-up of research papers between multiple projects that have no stand-alone impact.

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APPENDIX 1. MEMBERS OF THE DEMOGRAPHY WORKING GROUP[2]

Broderick, Annette. Centre for Ecology and Conservation, College of Life and Environmental Sciences, University of Exeter, UK.

Camiñas, Juan Antonio, Insituto Español de Oceanografía, Centro Oceanográfico de Málaga, Fuengirola, Spain.

Cardona, Luis, IRBio and Department of Animal Biology, Faculty of Biology, University of Barcelona, Barcelona, Spain.

Casale, Paolo. Department of Biology and Biotechnology, University of Rome “La Sapienza”. Rome, Italy.

Fuller, W.J. Faculty of Veterinary Medicine, Near East University, Nicosia, North Cyprus, Mersin 10, Turkey.

Godley, Brendan. Centre for Ecology and Conservation, College of Life and Environmental Sciences, University of Exeter, UK.

Hochscheid, Sandra, Coordinator of Aquarium Unit, Department Research Infrastructures for Marine Biological Resources, Stazione Zoologica Anton Dohrn, Napoli, Italy

Kaska, Yakup, Pamukkale University, Denizli, Turkey.

Lazar, Bojan, Department of Biodiversity, Faculty of Mathematics, Natural Sciences and Information Technologies, University of Primorska, Koper, Slovenia.

Levy, Yaniv. Israel's Sea Turtle Rescue Center, National Nature and Parks Authority, Michmoret 4029700, Israel.

Mafucci, Fulvio. Aquarium Unit, Department Research Infrastructures for Marine Biological Resources, Stazione Zoologica Anton Dohrn, Napoli, Italy

Miaud, Claude, CEFE/CNR, Campus du CNRS 1919, route de Mende 34293 Montpellier cedex 5, France.

Mifsud, Carmen, ‘Ave Maria’ Our Lady of Sorrows Str., Zejtun, ZTN 02, Malta.

Tomás, Jesús, Cavanilles Insititute of Biodiversity and Evolutionary Biology, University of Valencia, Burjassot, Spain.

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[2] Contact Luis Cardona (luis.cardona@ub.edu) for any question about this document and the Demography Woring Group.