Two hundred years after a commercial marine turtle fishery: the current status of marine turtles nesting in the Cayman Islands

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Abstract Large populations of marine turtles breeding in the Cayman Islands were drastically reduced in the early 1800s. However, marine turtle nesting still occurs in the islands. The present-day status of this nesting population provides insight into the conservation of marine turtles, a long-lived species. In 1998 and 1999, the first systematic survey of marine turtle nesting in the Cayman Islands found 38 nests on 22 beaches scattered through the three islands. Three species were found: the green *Chelonia mydas*, hawksbill *Eretmochelys imbricata* and loggerhead *Caretta caretta* turtles. Comparison with other rookeries suggests that the small number of sexually mature adults surviving Cayman's huge perturbations may be impeding population recovery. This shows the need to implement conservation measures prior to massive reductions in population size.

Keywords commercial fishery, conservation, marine turtles, monitoring, recolonization.

Introduction

Historically, nesting marine turtles were abundant in the Cayman Islands (Williams, 1995), with a large migrant population reproducing between May and October (Lewis, 1940; Parsons, 1984). The population was so large that a few authors have suggested that the Cayman Islands may have been the largest rookery for the green turtle *Chelonia mydas* in the Caribbean (Groombridge, 1982; King, 1982). This easily attainable resource attracted people to the islands, which were first colonized in the mid 1600s. Jackson (1997), based on fishery records between 1688 and 1730, estimated a population size of 6.5 million adults in the Caribbean. By the early 1800s, however, Caymanian turtle fishermen had exhausted the local nesting populations and were sailing to Cuba, then to the Miskito Cays, Nicaragua to catch turtles (Lewis, 1940).

Although Stoddart (1980a) found no evidence of marine turtle nesting activity in the Cayman Islands and concluded that they were locally extinct, with Groombridge (1982) and King (1982) reiterating this, recent observations and reports suggest that marine turtles were not extirpated. Between 1971 and 1991, Wood & Wood (1994) verified 78 marine turtle nests (76 being on Grand Cayman, with one on each of Little Cayman and Cayman Brac). They found four different species of marine turtles nesting in the Cayman Islands (green *Chelonia mydas*, loggerhead *Caretta caretta*, hawksbill *Eretmochelys imbricata* and leatherback *Dermochelys coriacea* turtles).

The present-day status of turtles nesting on the Cayman Islands has important general implications for the conservation of marine turtle populations. Populations in this nesting area have been subjected to a huge perturbation, i.e. massive exploitation, from which their long-term recovery (i.e. over several centuries) can be assessed by present-day monitoring. The study of recolonization following dramatic population declines is a key area in conservation biology (Letnic & Fox, 1997; Driscoll, 1998; Peck *et al*., 1999; Armstrong & Nichols, 2000), but has received surprisingly little attention in sea turtles, despite the fact that all species are endangered or threatened (Groombridge & Luxmoore, 1989). In general, how species are able to recover following dramatic declines is intimately related to their life history (Meffe & Carroll, 1977). As sea turtles take many years to reach sexual maturity (i.e. generation times are long), it might be expected that population recovery would be protracted. Surprisingly, however, for some rookeries, which have been protected in recent decades, population increases have been fast. For example, for green turtles nesting in Costa Rica, Bjorndal *et al*. (1999) report an increase in nesting emergences from approximately 16,000 in 1970 to 57,000 in 1996. As the ability of turtle populations in the Cayman Islands to recover following historical exploitation will have far-reaching implications for the management of marine turtles, here we describe the first systematic survey of marine turtle nesting on these islands.

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Methods

Area of study

The Cayman Islands (Fig. 1) are composed of three low-lying carbonate islands that are emergent sections of the Cayman Ridge, which runs along the northern margin of the Cayman trench between the Sierra Maestra of Cuba and the coast of Belize (Stoddart, 1980b). Grand Cayman is located at 19°21N, 81°17W, Little Cayman at 19°43N, 80°03W, and Cayman Brac at 19°43N, 79°51W.

Preliminary investigation of the 37-km coastline of Little Cayman identified 18 sandy beaches (21 km of coastline) suitable for marine turtle nesting (Fig. 2a). Of the 129-km coastline of Grand Cayman, 23 beaches (32 km of coastline) suitable for marine turtle nesting were described (Fig. 2b). The third of the Cayman Islands, Cayman Brac (Fig. 2c) had little suitable nesting habitat with less than 2 km of sandy beach on the 41 km of shoreline. The remaining coastline of all three islands was composed of exposed rock and mangroves.

Beach monitoring schedule

Areas deemed suitable for marine turtle nesting were patrolled during the day in search of tracks which signalled previous nesting activity. Beaches on Little Cayman were surveyed every 1–15 days (mean = 4.0, SD = 2.1) between 23 May and 20 October 1998 and those on Grand Cayman were surveyed every 1–14 days (mean = 3.7, SD = 2.5) between 26 April and 14 October 1999. The beaches of Cayman Brac were surveyed throughout the 1998 season on a weekly basis.

Interpretation of turtle tracks

Marine turtle nesting activities could be recorded as a result of the tracks left by the turtles in the sand. Not every nesting activity results in the deposition of a clutch, but it is possible to determine if laying has occurred from observation of track morphology (Schroeder & Murphy, 1999). Activities were classified as a 'nest', i.e. when a clutch had been deposited, or a 'non-nesting emergence'. Species identification was based on track symmetry and depth of body pit, and verification with live or dead hatchlings (Pritchard & Mortimer, 1999).

The location of each nest was fixed by triangulation using 100 m survey tape and pre-established markers at the back of the beach (50–100 m apart). In addition, a numbered plastic tag was buried in the sand 1 m to the side of each nest. Nests were monitored daily for signs of hatchling emergence, continuing for 55 days after egg deposition in 1998 and 50 days after egg deposition in 1999. Nests were excavated the morning after the first hatchling emergence. If there were no signs of hatchling emergence 70 days after egg deposition, nests were excavated. Excavated eggs and eggshells were counted.

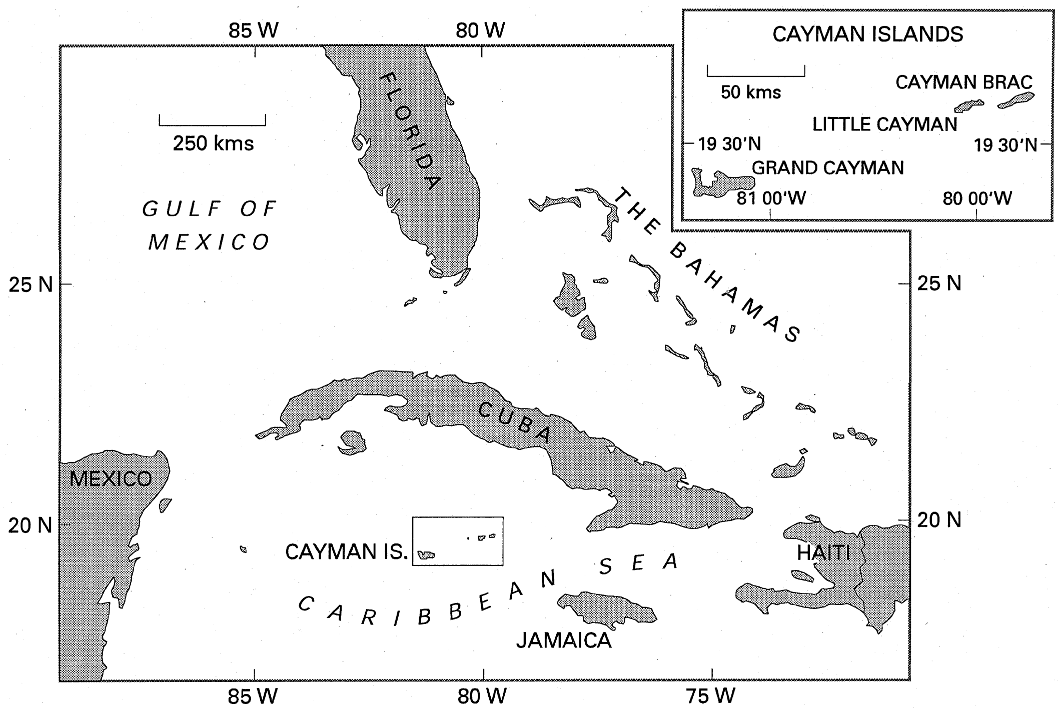

Fig. 1 Location of the Cayman Islands in the Caribbean.

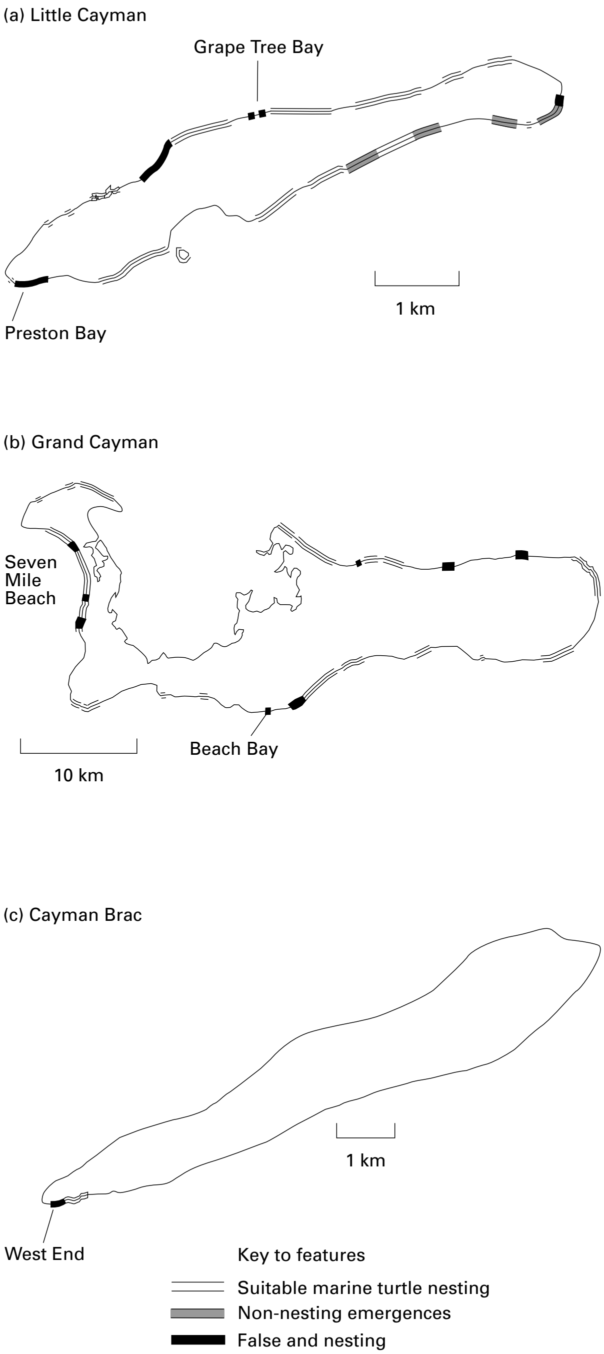

Fig. 2 (a) Little Cayman (b) Grand Cayman and (c) Cayman Brac, showing habitat suitable for marine turtle nesting. Delineated are those areas which supported non-nesting emergences and nesting in the season of survey.

Egg shells with no remnants of yolk and greater than half of the shell intact were counted as one hatched egg. All others were considered unhatched.

Results

Number of nests for each species

On Little Cayman 38 marine turtle nesting activities were recorded. Of these, 15 were nests (Table 1): two were identified as hawksbill turtle nests, nine were identified as green turtle nests and four nests were not identified to species. Given the temporal distribution of nesting and the published information on the duration of the internesting intervals in these species (hawksbill turtle: 13–15 days; loggerhead turtle: 12–16 days; green turtle: 10–14 days; Miller, 1997) we estimate that the nests on Little Cayman in 1998 were the result of the efforts of between four and nine green turtles and one to two hawksbill turtles.

Fifty-two marine turtle nesting activities were recorded on Grand Cayman. Of these, 23 were nests (Table 1): 18 were identified as loggerhead turtle nests, two were identified as hawksbill turtle nests, one was identified as a green turtle nest and two were not identified to species. Given the temporal distribution of nesting and the published information on the duration of the internesting intervals in these species, we estimate that the nests on Grand Cayman in 1999 were the result of the efforts of between 8 and 18 loggerhead turtles and 1–2 hawksbill turtles.

Only one marine turtle nesting activity, of unknown species, was recorded on Cayman Brac in 1998; this occurred on the West End on 8 July.

Spatial distribution of nesting

Marine turtle nesting activity was recorded on ten beaches scattered around Little Cayman (Fig. 2a), with nests being observed on six of these beaches. A beach on the south-west end of Little Cayman in an area known as Preston Bay had the greatest number of emergences ($n = 16$), including all hawksbill nesting crawls. Nesting activity was recorded on 11 beaches scattered around Grand Cayman (Fig. 2b) with nests being recorded at eight of these sites. The greatest number of nests ($n = 8$) was recorded on a small beach (*c.* 60 m in length) on the southern point of Grand Cayman, called Beach Bay.

Temporal distribution of nesting

Marine turtle nests were found between the months of May and September (Table 1). Loggerhead turtles nested May–August with a peak in June, hawksbill turtle nests were recorded in July and August, and green turtle nesting was recorded July–September, with a peak in August.

Date	Number of nests											
	C. caretta			*E. imbricata*			*C. mydas*			Unidentified		
	LC	GC	CI	LC	GC	CI	LC	GC	CI	LC	GC	CI
May	0	4	4	0	0	0	0	0	0	0	0	0
June	0	8	8	0	0	0	0	0	0	2	0	2
July	0	5	5	2	0	2	2	0	2	1	0	1
August	0	1	1	0	2	2	5	1	6	1	1	2
September	0	0	0	0	0	0	2	0	2	0	0	0
Unknown	0	0	0	0	0	0	0	0	0	0	1	1
Total	0	18	18	2	2	4	9	1	10	4	2	6

Table 1 The number of nests of loggerhead *Caretta caretta*, hawksbill *Eretmochelys imbricata*, green *Chelonia mydas*, and unidentified marine turtle species in Little Cayman 1998 (LC), Grand Cayman 1999 (GC), and the Cayman Islands total (CI).

Incubation periods and reproductive output

Incubation periods could only be calculated accurately for nests of one green turtle on Little Cayman, one hawksbill and 16 loggerhead turtles on Grand Cayman. The green and hawksbill turtle had incubation periods of 61 and 57 days, respectively. The loggerhead turtles had an average incubation period of 57 days (range = 54–60, SD = 2.4).

The mean clutch size and hatch success for each species are presented as indices of reproductive output (Table 2). The mean clutch sizes for loggerhead, hawksbill, and green turtles were 119 (SD = 18, $n = 18$), 154 (SD = 9, $n = 2$), and 113 (SD = 26, $n = 10$), respectively. The mean hatch success for loggerhead, hawksbill, and green turtles are 86% (SD = 10, $n = 4$), 54% (SD = 30, $n = 4$), and 28% (SD = 35, $n = 10$), respectively. An overall lower mean hatch success was observed in Little Cayman (31%, SD = 32, $n = 11$) than in Grand Cayman (81%, SD = 21, $n = 21$).

Discussion

Although a small number of marine turtle nests were found in 1998 and 1999, the results of this study support a status designation of 'Endangered' and refute the findings of Stoddart (1980a) and Groombridge (1982) i.e. that they are extinct/extirpated. It appears that the number of marine turtle nests is a vestige of the large number of nests that were once laid on the beaches of the Cayman Islands.

Coastal areas of marine turtle nesting activity have been mapped for both Little Cayman and Grand Cayman (Fig. 2a & b). Marine turtle nesting on both islands is sparse, but widespread. Intensive marine turtle nesting activity was never observed. However, on certain beaches relatively more marine turtle nesting activity was observed than on others; these higher use beaches could be targeted for future monitoring.

The season through which marine turtle nesting activity was observed is similar to that found in historical accounts of both the Cayman Islands (Lewis, 1940) and other locations around the Caribbean (Hirth, 1980; Moncada *et al*., 1999). The nesting season for green turtle populations in the Caribbean region extends from as early as March in St Kitts-Nevis to as late as December in the Dominican Republic (Hirth, 1997). Typically, green turtle nesting seasons are between May and September; a similar pattern was observed for the Cayman Islands. Nesting seasons for Caribbean hawksbill populations are more varied, with some populations nesting year round (Richardson

Table 2 The mean clutch size and hatching success for loggerhead *Caretta caretta*, hawksbill *Eretmochelys imbricata*, and green *Chelonia mydas* on Little Cayman 1998 (LC), Grand Cayman 1999 (GC), and the Cayman Islands total (CI).

Species	Mean clutch size (No. of eggs per nest)			Mean hatch success (percentage of eggs that hatch)		
	LC	GC	CI	LC	GC	CI
C. caretta	–	119 (SD = 18, $n = 18$) (Range: 93–155)	119 (SD = 18, $n = 18$) (Range: 93–155)	–	86 (SD = 10, $n = 18$) (Range: 61–98)	86 (SD = 10, $n = 18$) (Range: 61–98)
E. imbricata	157 (SD = 15, $n = 2$) (Range: 146–167)	151 (SD = 1, $n = 2$) (Range: 150–152)	154 (SD = 9, $n = 4$) (Range: 146–152)	31 (SD = 14, $n = 3$) (Range: 1–41)	77 (SD = 22, $n = 2$) (Range: 61,92)	54 (SD = 30, $n = 4$) (Range: 21–92)
C. mydas	120 (SD = 15, $n = 9$) (Range: 101–146)	53 ($n = 1$)	113 (SD = 26, $n = 10$) (Range: 53–146)	31 (SD = 36, $n = 9$) (Range: 0–85)	2 ($n = 1$)	28 (SD = 35, $n = 10$) (Range: 0–24)

et al., 1999; Starbird *et al.*, 1999). However, most populations have nesting peaks between May and November (Hirth, 1980; Garduno-Andrade, 1999; Moncada *et al.*, 1999; Richardson *et al.*, 1999; Starbird *et al.*, 1999), and similar timing was found for hawksbill nesting activity in this study. On Grand Cayman we observed loggerhead nesting emergences between May and August similar to the loggerhead nesting season on beaches in Florida (Hirth, 1980).

The incubation periods observed in the Cayman Islands for green, hawksbill and loggerhead turtles are similar to those observed in other populations around the world (Witzell, 1983; Buskirk & Crowder, 1994; Hirth, 1997). The incubation period for the green turtle nest on Little Cayman falls within the ranges reported for the El Cuyo (Mexico) and Tortuguero (Costa Rica) populations (Hirth, 1997). On Grand Cayman, the incubation periods for the hawksbill nests fall within the range of incubation periods reported for Tortuguero (Costa Rica) but falls below the range reported for Grenada (Witzell, 1983). The average incubation period for loggerhead turtle nests in the Cayman Islands are similar to nests on Sanibel Island, Florida (56 days), but shorter than nests on Hutchinson Island, Florida (65.5 days) (Buskirk & Crowder, 1994).

The average clutch sizes for the green, loggerhead, and hawksbill turtle nests found in both Little Cayman and Grand Cayman are similar to other marine turtle populations in the Caribbean region and world-wide (Hirth, 1980; Buskirk & Crowder, 1994). The average hatch success per nest for marine turtle nests on Grand Cayman are found within the 60–85 per cent range suggested by Hirth (1980). However the average hatch success per nest on Little Cayman is lower (31–42 per cent). This is partially the result of one-third of the Little Cayman nests having a hatch success of 5 per cent or lower. Eggs from low hatch success nests were broken open to investigate the developmental status approximately 70 days after deposition. Most eggs showed no gross signs of development. Miller (1997) reports that after 55 days of incubation it is very difficult to determine whether an egg is fertilized, because of the difficulty of detecting intraovidual or early embryonic death (the first few days of incubation). Reasons for intraovidual death are unknown. Gas exchange, moisture and temperature must be within certain limits for embryonic development to occur (Ackerman, 1997). However, whether or not values exceeding the limits of these conditions can cause embryonic death in the first few days of incubation is uncertain. Furthermore, low hatch success nests were deposited on the same beaches as successfully hatched nests. Therefore, the low hatch success may be the result of infertility or intraovidual death. It is possible that the population size is so small that there is an insufficient number of males to insure fertilization of all the eggs.

The Cayman Turtle Farm released 26,995 green turtle hatchlings and yearlings between 1980 and 1991 (Wood & Wood, 1993) and continues to release more annually. Of 5959 yearlings, which were tagged with titanium tags engraved with a return address, 141 were subsequently recaptured in the North Sound of Grand Cayman (Wood & Wood, 1993). Two turtles, previously released as juveniles by the farm between 1980 and 1991, have been accidentally recaptured in local waters as adults (Joe Parsons, pers. comm.). It is possible, therefore, that the green turtles nesting on Little Cayman originated, at least in part, from the Cayman Turtle Farm. However, the stock in the Cayman Turtle Farm includes turtles originating from Ascension Island, Costa Rica, Guyana, Nicaragua, Mexico and Suriname and their progeny. Depending on the mechanisms driving natal philopatry, it is possible that surviving turtles may have returned to the rookery of origin of one or both parents.

A traditional marine turtle fishery still exists in the Cayman Islands. The open season for the fishery occurs between 1 November and 30 April. There are 25 individuals with the right to apply for a marine turtle fishing license, 13 of which are current. No individual fishermen may take more than six turtles per season, and each turtle must weigh more than 120 lbs (54.5 kg) if a green turtle, or more than 80 lbs (36.4 kg) if a loggerhead or hawksbill turtle (Cayman Islands Government, 1996). The laws governing the fishery were implemented in 1986. Estimates made by marine enforcement officers and marine turtle fishermen suggest that since 1986 approximately 10 adult turtles are taken legally and more than 10 are taken illegally per year. The illegally harvested turtles include all post-pelagic size classes and not predominantly adults.

The processes that regulate the size of marine turtle populations remain elusive. It would be expected that the survival of individuals within populations is in some way density-dependent, so that small populations are able to expand until a maximum carrying capacity is achieved. In theory, density-dependent mortality might occur at any stage within a turtle's life history; for example during the incubation of the eggs, hatchling survival, survival of juveniles on either their pelagic or coastal feeding grounds, or through the longevity of adults. Our understanding of the factors that influence turtle mortality in these different stages is only rudimentary. Recently, however, evidence for density-dependence has been found for the growth rate and body condition of immature green turtles at coastal foraging grounds in the Caribbean, with both these indices being lower in years where the density of turtles was higher (Bjorndal *et al.*, 2000).

Given that the abundance of turtles in the Caribbean is only a fraction of former levels, it would be expected that, with density-dependent processes operating, both individual survival and population growth rates would be relatively high. However, while green turtle nesting numbers in Costa Rica have increased in recent decades (Bjorndal *et al.*, 1999), it is clear that nesting numbers in the Cayman Islands are still very small. A key difference between these nesting sites is that, despite exploitation, the numbers of nesting turtles in Costa Rica has always been substantial (several thousand), but may have been reduced to only a handful of individuals (or fewer) in the Cayman Islands. Although different regional nesting populations have been shown to share common developmental and foraging habitats (see Musick & Limpus, 1997 for review), it may be that turtles from Cayman Islands have been exposed to relatively higher levels of directed or incidental catch, with a greater proportion being exposed to harvest in nearby waters where turtle fisheries are active or have only been closed in recent decades, e.g. Cuba (Carrillo *et al.*, 1999) and Mexico (Garduno-Andrade *et al.*, 1999).

Alternatively, the Cayman Islands population may be too small to recover. It is well known that for many species the ability to recover depends on the minimum numbers following exploitation, and at very low numbers populations may become non-viable. If a similar pattern is found in marine turtles, it might be that recovery of the nesting populations in the Cayman Islands might require chance 'seeding' of nesting beaches from turtles originating elsewhere. Indeed, this must be the process by which new nesting areas are colonized. Regardless of the exact methods by which recolonization might occur, the clear finding from the current study is that on the Cayman Islands, despite the fact that the heavy exploitation of nesting turtles occurred centuries ago, the population has still not recovered to any great degree. The key conservation message that must be learnt from the Cayman Islands is that conservation measures for sea turtles need to be implemented before massive reductions in populations occur. The sharp (and on-going) declines that have been noted recently for some sea turtle populations (Chan & Liew, 1996; Spotila *et al.*, 2000) are therefore cause for great concern.

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Biographical sketch

The Cayman Islands Department of the Environment undertakes monitoring, conservation and research related to all aspects of the ecosystems in the Cayman Islands. This publication is the first to result from their Marine Turtle Project. The Marine Turtle Research Group, University of Wales, Swansea is active in both fundamental and applied research related to marine turtles both in the UK and internationally. Additional current projects underway include those in Ascesnion Island, Brazil, Guinea Bissau and Northern Cyprus.