Management Plan for Bermuda's Resident Green and Hawksbill Sea Turtles (*Chelonia mydas, Eretmochelys imbricata*)

Government of Bermuda
Ministry of Health, Seniors and Environment
Department of Conservation Services

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Prepared in Accordance with the Bermuda Protected Species Act 2003

Funded in part by:

Department of Conservation Services
Bermuda Zoological Society
OTEP

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Maps were prepared by Robert Hardy (Florida Fish and Wildlife Conservation Commission Fish, U.S.A.) and Mandy Shailer (Department of Conservation Services, Bermuda)

Published by

Government of Bermuda
Ministry of Health Seniors and Environment
Department of Conservation Services

"To conserve and restore Bermuda's natural heritage"

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Literature citation of this document should read as follows: Sarkis, S. and Outerbridge, M.E. Management plan for Bermuda's Resident Green and Hawksbill Sea Turtles *(Chelonia mydas, Eretmochelys imbricata)*. Government of Bermuda. Department of Conservation Services, 33 pp.

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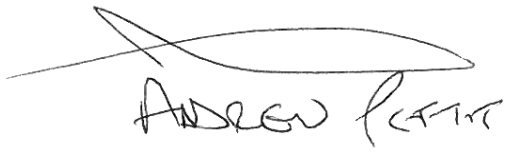

Director
Department of Conservation Services
Government of Bermuda

26th SEPTEMBER 2014.

Date

ACKNOWLEDGEMENTS

The drafting and publication of this management plan was supported by an OTEP grant BDA 202, for which we are grateful. Additionally we wish to thank Jennifer Gray, former head of the Bermuda Turtle Project, who has shared her knowledge and data on Bermuda's resident marine turtles. The information reported in this plan is a result of the joint efforts of the Department of Conservation Services, the Sea Turtle Conservancy (formerly the Caribbean Conservation Corporation), and the Bermuda Zoological Society. Finally, our thanks are due to Dr Karen Eckert (executive director of WIDECAST) and Drs Anne and Peter Meylan (scientific directors of the Bermuda Turtle Project and research associates of the Sea Turtle Conservancy) for their expert review of this plan.

EXECUTIVE SUMMARY

Current species status:
This management plan addresses the need for actions to conserve two native species of marine turtle; the green turtle *Chelonia mydas*, and the hawksbill turtle *Eretmochelys imbricata*. Current legal protection for green and hawksbill turtles is provided by the Fisheries Order (1978), the Protected Species Act (2003), and the Protected Species Amendment Act (2011). Following IUCN criteria, green turtles are listed as 'Endangered' (EN, A1b,d) and hawksbills are listed as 'Critically Endangered' (CR, A1b,d) under the Protected Species Order (2012).

Habitat requirements and threats:
Green and hawksbill turtles have a complex life cycle that requires many different habitats often involving many different nations. Generally, adult females use beaches for nesting, neonate and young juveniles use convergence zones in the open ocean during the epi-pelagic phase of their life cycle, and both juveniles and adults use the benthic environments of coastal areas as feeding grounds. Only immature green and hawksbill turtles are resident on the Bermuda Platform; green turtles are associated with seagrass meadows whereas hawksbill turtles favour the coral reef environment. Tagging studies (using both flipper and satellite tags) performed by the Bermuda Turtle Project since 1992 have indicated that immature green turtles reside in Bermuda waters continuously throughout the year for extended periods time (possibly as long as 20 years) during which they usually occupy specific sites. Turtles in Bermuda are most negatively affected by collision with boats and entanglement in discarded monofilament fishing line. Both hazards are associated with high levels of mortality.

Management objective:
The principal aim of this management plan is to protect the species and their habitats in Bermuda, and contribute to national, regional and global conservation of marine turtles through sharing of knowledge and participation in international agreements.

Management criteria:
Sustainable management status for resident turtle populations in Bermuda will be achieved when there is:

- An accurate assessment of the current population status of green and hawksbill turtles.
- Protection and enforcement of critical sea turtle habitats in Bermuda supported by legislation.
- Increased public education regarding the human threats towards sea turtles and their critical habitats in Bermuda.
- An increase in the number of international agreements signed by Bermuda pertaining to the regional management and protection of sea turtles.
- An improved Sea Turtle Stranding and Salvage Network Program.
- Monitoring carried out at potential nesting sites to determine results of previous restocking experiment.

- Evidence of a sustained increase of nesting populations at the source sites of Bermuda's resident turtles over a 25-year monitoring period.

Actions needed:

1. Determine trends in abundance of resident green and hawksbill turtles, evaluate changes in sex ratio and genetic composition, and investigate habitat relationships of different age/size/sex classes.
2. Identify habitats critical to sea turtle survival on the Bermuda Platform (e.g. foraging grounds).
3. Define boundaries and regulations for critical habitats to sea turtles.
4. Continued examination of anthropogenic impacts to sea turtle survival within Bermuda's territorial waters.
5. Foster public awareness of anthropogenic threats.

Regular monitoring of turtles caught in Bermuda will provide further information on the origin of the juveniles coming to feed and grow in Bermuda, which helps establish collaborative conservation programs with source countries. In addition, these efforts will also contribute to expanding knowledge on habitat use of resident turtles, establishing baseline data on health, and maintaining quality and quantity of feeding habitats. Addressing identified threats and protecting critical habitats will further assist global conservation efforts with a potential positive impact at the source sites.

Management costs:
The total cost of management actions cannot be defined at this point. Funding needs to be secured through non-governmental organizations (NGO's), overseas agencies, and other interested parties for implementing the necessary research and monitoring studies on the ecology of green and hawksbill sea turtles residing on the Bermuda Platform. Developing budgets for each action are the responsibility of the leading party as outlined in the work plan.

Date of management:
Obtaining a better understanding of the population dynamics of both green and hawksbill turtles and their habitat requirements at all stages is a first step in identifying critical habitats and formulating suitable management and legislative measures. Further understanding of all potential threats will also be necessary to ensure long term conservation of the species. Success in achieving this is dependent on the funding of a well structured programme. At least 5 years will be allocated to achieve this. The effects of conservation efforts in Bermuda on the source sites will require a much longer time frame given the natural reproductive cycle of both turtle species, and a minimum of 25 years is anticipated before any repercussion is observed.

PART I: INTRODUCTION

A. Brief Overview

Five species of marine turtle – green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), loggerhead turtle (*Caretta caretta*), leatherback turtle (*Dermochelys coriacea)* and Kemp's ridley (*Lepidochelys kempii*) – are native to Bermuda's territorial waters. All have been protected under national law since 1972 and, more recently, the first 4 species have also been listed under the Protected Species Act (2003) as 'Critically Endangered' or 'Endangered' following IUCN criteria. The Kemp's ridley was nominated for inclusion on Bermuda's Protected Species Act in 2012.

The green turtle population that once used the beaches of Bermuda for nesting was driven to extinction due to overharvest. In 1620 Bermuda passed legislation for the protection of juvenile green turtles less than 18 inches in shell diameter, but this protection did not extend to larger turtles including, most significantly, the breeding adults (Garman, 1884). The hunting pressure on the local breeding population continued so that by the end of the eighteenth century the commercial harvest of green turtles was no longer profitable, thereby forcing the Bermudian turtle boats to fish as far-afield as Ascension Island (Parsons, 1962). In 1902 there were only 8 boats commercially fishing turtles in Bermuda, which became further reduced to 2 boats by 1937 (Babcock, 1938). By 1970 there were only a handful of part-time turtle fishermen with a total recorded annual catch of 26 green turtles (Rebel, 1974). Legal turtle harvests in Bermuda continued until 1972, when a 5 year moratorium on sea turtle fishing was imposed by the Bermuda Government. This moratorium was never lifted but rather replaced with the Fisheries Protected Species order of 1978. Unfortunately the early laws failed to halt the destruction of Bermuda's breeding colony, with the result that the last observed nesting of green turtles in Bermuda occurred during the 1930's (Babcock, 1938).

Between 1967 and 1977, a restocking experiment was attempted by the Bermuda Government in collaboration with the Caribbean Conservation Corporation (now known as the Sea Turtle Conservancy) in an effort to re-establish a viable breeding population of green turtles in Bermuda. A total of 25,000 eggs collected from Costa Rica and Suriname were transported to Bermuda and buried on the south beach of Nonsuch Island and Howard's Bay beach on Castle Point. From those eggs, approximately 18,000 hatchlings emerged and swam out to sea (Godley *et al.*, 2004). It is uncertain whether conditions during that attempt were optimal for the re-establishment of a breeding population. It may be that an insufficient number of hatchlings were released, or that an inappropriate sex ratio was produced (given that gender is determined by temperature), or it is possible that the hatchlings did not get the necessary behavioural cues required for them to return to Bermuda (Godley *et al.*, 2004). No green turtle nesting has been confirmed on Bermuda since the restocking experiment was attempted.

The current aggregations of hawksbills and green turtles that are resident on the Bermuda Platform consist of immature individuals occupying developmental habitat and originate mostly from rookeries throughout the Caribbean and Central America (Meylan *et al.*,

2011). Loggerheads, leatherbacks and ridleys do not normally use the Bermuda Platform but are occasionally encountered either as moribund individuals or in deep waters offshore of the island (Outerbridge *et al.*, in prep).

Population estimates are not available for hawksbills in Bermuda, however the immature green turtle population has been calculated to be somewhere between 2,000 and 7,500 individuals (Vierros *et al.*, 2002). Juvenile greens remain in Bermuda waters for at least 14 years (Meylan *et al.*, 2011). The importance of the Bermuda Platform as a developmental habitat and foraging ground to greens and hawksbills has been determined (Meylan *et al.*, 2011). Loggerhead juveniles are not known to inhabit the Bermuda Platform, but pelagic-phase juveniles sometimes strand on beaches, often in association with winter storms and rafts of *Sargassum* weed. Leatherbacks have been sighted off the edge of the Bermuda Platform, and in the past 2 decades, 3 individuals have stranded on the island's shores. Only 2 Kemp's ridleys have been recorded as strandings since 1983 (Outerbridge *et al.*, in prep).

On a global scale, analyses of historic and recent abundance information by the IUCN/SSC Marine Turtle Specialist Group indicate that extensive subpopulation declines of green turtles and hawksbill turtles have occurred in all major ocean basins over the past 100-150 years (Seminoff, 2004; Mortimer and Donnelly, 2008). The 2 species included in this management plan (green and hawksbill turtles) are on the IUCN Red List of Threatened Species.

This management plan discusses conservation efforts, distribution, habitat requirements, biology and threats for Bermuda's resident populations of green and hawksbill turtles. The plan recommends the continuation of sea turtle research in Bermuda. It also recommends the identification and legal protection of important sea turtle habitats on the Platform, and enhancement of the Sea Turtle Stranding and Salvage Network (STSSN). The identification of anthropogenic threats would feed into conservation and legislative measures, and addressing these would contribute to the overall success of management. Furthermore, beach monitoring to determine the results of past restocking efforts and the protection of Bermuda's beaches should be a continuing concern in order to ensure their potential as nesting sites for natural re-establishment of nesting populations. These measures are expected to contribute to the well-being of both the resident sea turtle populations and to international conservation action.

B. Current Protection Status

International protection:
Green and hawksbill turtles are protected by various international treaties and agreements as well as national laws. International trade of all marine turtle species is prohibited through the Convention of International Trade in Endangered species of Wild Flora and Fauna (CITES). Both species are also listed in Appendices I and II of the Convention on Migratory Species (CMS) and are protected under the following instruments of CMS: the Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA) and the

Memorandum of Understanding Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa. Sea turtles are protected under Annex II of the Specially Protected Areas and Wildlife (SPAW) Protocol of the Cartagena Convention. The U.S.A. is a party to the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC), which is the only binding international treaty dedicated exclusively to marine turtles. Additionally, sea turtles are protected by the Memorandum of Understanding under the Association of Southeast Asian Nations (ASEAN) Sea Turtle Conservation and Protection as well as by the Memorandum of Agreement on the Turtle Islands Heritage Protected Area (TIHPA).

National protection:
Current legal protection for green and hawksbill turtles is provided by the Protected Species Act (2003) and the Protected Species Amendment Act (2011). Following IUCN criteria, green turtles are listed as 'Endangered' (EN, A1b,d) and hawksbills are listed as 'Critically Endangered' (CR, A1b,d) under the Protected Species Order (2012). These acts consider the willful destruction, damage, removal or obstruction of sea turtle habitats and nests, and the taking, importing, exporting, selling, purchasing, transporting or having in possession any sea turtle an offence. Offenders are liable to a fine of up to $25,000 or 2 years imprisonment. Furthermore, green and hawksbill turtles are also protected under the 1978 Fisheries (Protected Species) Order in accordance with section 5 of the Fisheries Act (1972). This order is a statutory instrument (BR 8/1978) and prohibits the taking of any of the listed species, whether dead or alive, anywhere within Bermuda's 200 mile Exclusive Economic Zone.

The seagrass and coral reef environments where green and hawksbill turtles forage and reside are afforded various levels of protection in Bermuda. All seagrasses are listed under the Protected Species Amendment Act (2011) as level 2 protected. The willful destruction or removal of any seagrasses in Bermuda carries with it a fine of up to $15,000 or 1 year imprisonment. The collection of all types of stony and soft corals is banned under the Fisheries Order (1978), and the Coral Reef Preserves Act (1966) protects marine flora and fauna within 2 separate areas representing 24% of the Bermuda Platform (calculated to the 10 meter depth contour); the South Shore Coral Reef Preserve and the North Shore Coral Reef Preserve (M. Shailer, personal communication). This act considers it an offense to remove, damage or be in possession of plants and animals (whether dead or alive) which are attached to any reef, the sea-bed or the coast in the 2 preserves.

C. Taxonomy and Description of Species

Green turtle:
Kingdom: Animalia
Phylum: Chordata
Class: Reptilia
Order: Testudines
Family: Cheloniidae
Genus: *Chelonia*
Species: *mydas*

Figure 1. Juvenile green turtle
Photos by Ron Lucas (L) and Jennifer Gray (R)

The green turtle was described by Linnaeus in 1758 as *Testudo mydas* with Ascension Island as the type locality. Schweigger first applied the binomial nomenclature we use today, *Chelonia mydas*, in 1812. There is believed to be minimal genetic exchange among isolated breeding colonies, thus, these colonies deserve recognition as separate management units. Although trinomials have been applied to various populations in the past, they are generally not in use today. Advances in molecular genetics are resolving population level relationships. Taxonomic questions for the green turtle remain in the Pacific, but not in the Atlantic. Hirth (1980) discusses the systematics in greater detail.

Green turtles are among the largest of all the hard-shelled sea turtles. Characteristics that distinguish the green turtle from other marine turtle species include a smooth carapace with non-overlapping scutes, a single pair of elongated prefrontal scales between the eyes and a strongly serrated lower jaw (see Figure 1 above and Figure 3 in the Appendix). Adult males can be distinguished from females by the presence of a long, thick tail that extends beyond the carapace and by possessing well developed, re-curved claws on the fore flippers. Adult female greens encountered on the nesting beaches of Florida can be as large as 114 cm straight carapace length (SCL) (Witherington, 1986) and 177 kg in

mass (Ehrhart, 1980). Hatchlings from Florida are reported to range in size from 4.4 – 5.8 cm SCL and 21 – 37 g (Ehrhart, 1980). Hatchlings are strongly counter-shaded in colouration, with the dorsal surface of the carapace being black and the ventral surface white. The colouration of Atlantic green turtles changes as they grow in size, whereby the scutes on the carapace takes on brown, green, black and yellow radiating streaks and the plastron changes from white to light yellow and then to a darker yellow as they reach adulthood (Witherington *et al.*, 2006).

Hawksbill turtle:
Kingdom: Animalia
Phylum: Chordata
Class: Reptilia
Order: Testudines
Family: Cheloniidae
Genus: *Eretmochelys*
Species: *imbricata*

Figure 2. Juvenile hawksbill turtle
Photos by Ron Lucas

The hawksbill turtle was originally described by Linnaeus as *Testudo imbricata* in 1766. It was moved into the genus *Eretmochelys* by the Austrian zoologist Leopold Fitzinger in 1843. Two subspecies, *Eretmochelys imbricata squamata* in the Atlantic Ocean and *Eretmochelys imbricata imbricata* in the Pacific Ocean, have been described on the basis of differences in coloration and carapace shape (see Witzell, 1983 for review). These criteria have proven unreliable in distinguishing the 2 forms and subspecies designations are not in current use.

Hawksbills are easily distinguished from other sea turtles by virtue of a sharp, pointed beak, the over-lapping nature of the carapace scutes and the serrated appearance of the posterior half of the shell margins (see Figure 2 above and Figure 3 in the Appendix). As in green turtles, adult male hawksbills males can be distinguished from females by the

presence of a long, thick tail that extends beyond the carapace and well developed, re-curved claws on the fore flippers (Witzell, 1983). Nesting female hawksbill turtles in the Caribbean are reported to average between 79.8 and 83.5 cm SCL (Pritchard, 1969; Bjorndal *et al.*, 1985; Diez and van Dam, 2002; Lagueux *et al.*, 2003) and approximately 60 kg in mass (Pritchard, 1969; Bjorndal *et al.*, 1985), but are known to reach a mass of 127 kg (Lewis, 1940). Hatchlings are reported to average 4.1 cm SCL and 14-19.5 g (Hillis and Mackay, 1989; Eckert, unpublished data). The dorsal surface of the hawksbill shell has an amber background patterned with an irregular combination of light and dark streaks, with predominantly black and mottled brown colors radiating to the sides. The ventral surface typically is whitish-yellow and sometimes has darkly pigmented blotches (Meylan and Redlow, 2006).

D. Ecology

General information on the ecology of green and hawksbill turtles has been summarized from the literature, and data more specific to Bermuda have been incorporated when available for each species.

Habitat requirements:
Green and hawksbill turtles have a complex life cycle that involves many different habitats often involving many different nations. Generally, adult females use beaches for nesting, neonate and young juveniles use convergence zones in the open ocean during the epi-pelagic phase of their life cycle, and juveniles, sub-adults and adults use the benthic environments of coastal areas as feeding grounds. After emerging from the nest, hatchlings are believed to live for several years drifting in the open ocean (Carr, 1987) feeding near to the surface on a variety of pelagic plants and animals (see Witherington *et al.*, 2006 and Meylan and Redlow 2006 for reviews). Once juveniles in the Atlantic reach 22-30 cm SCL (Musick and Limpus, 1997; Meylan and Redlow, 2006), they leave the pelagic environment and recruit to neritic foraging grounds. After moving to these coastal benthic habitats they make dietary shifts and then remain there as juveniles for up to 2 decades before making the next ontogenic shift and departing as sub-adults for their natal regions (Meylan *et al.*, 2011). Upon reaching adulthood, males and females spend the rest of their lives migrating between foraging areas and mating/nesting areas, travelling hundreds or thousands of kilometers each way. Bermuda's resident juvenile green turtles (size range 22.3-81 cm SCL) are typically found on *Thalassia* and *Syringodium* seagrass meadows, which serve as feeding grounds (Vierros *et al.*, 2002; Fourqurean *et al.*, 2010; Meylan *et al.*, 2011), whereas the resident juvenile hawksbill turtles (size range 17.6-66.5 cm SCL) use the coral reef environment as their developmental habitat (Meylan *et al.*, 2011).

Feeding:
Post-hatchlings of both species feed within the epi-pelagic zone of oceanic waters upon a wide diversity of plant and animal material as well as plastics and tar (Meylan, 1984; Witherington *et al*, 2006; Boyle and Limpus, 2008). Neritic green turtles are unique among sea turtles in that they are primarily herbivorous, feeding on seagrasses (particularly turtle grass *Thalassia testudinum* and manatee grass *Syringodium filiforme*) and macro-algae (Holloway-Adkins, 2001); however, there is evidence that they also

forage upon a wider spectrum of dietary items that can include gelatinous macro-plankton (Burkholder *et al.,* 2011). Neritic hawksbills, in contrast, feed primarily upon sponges from the class Demospongiae (Meylan, 1988) but are also known to consume zooanthids (Mayor *et al.,* 1998) and coral-like anemones known as corallimorpharians (Leon and Bjorndal, 2002). Some of the sponges that hawksbills are known to eat, such as *Aaptos aaptos, Chondrilla nucula, Tethya actinia, Spheciospongia vesparum* and *Suberites domuncula,* are highly (often lethally) toxic to other organisms (Meylan, 1988).

Reproduction:
Generally, adult sea turtles travel long distances between their feeding grounds and the areas where they mate and nest (Stickney, 2000). Each mated female hauls herself from the water, usually at night, and crawls up the beach to a location above the high tide mark in order to dig a hole in the sand with her rear flippers. Females will deposit anywhere from 90 to 200 eggs (depending on the species and the size of the female) in the nest cavity, after which they cover the nest with sand and return to the ocean. Females may return to the beach at regular intervals (typically 9-15 days) to deposit subsequent clutches of eggs, which might be performed up to 5 times during a nesting season and the number of years between successive migrations to a nesting beach by reproductive females ranges from 2-5 years (Hirth, 1997).

The incubation period is generally 50-65 days in duration, but can take as long as 4 months during cool periods (see Witherington *et al.,* 2006). The incubation temperature affects the sex of the developing embryos: warmer temperatures produce females, while cooler temperatures produce males (Mrosovsky *et al.,* 1995). Most of the eggs that hatch in a nest do so over a brief time span. Hatchlings climb to the surface in a synchronous fashion over a period of days, using one another as "stepping stones" to move upward, in a virtual ball of baby turtles (Carr and Hirth, 1961). Once they reach the surface of the sand, they crawl down the beach to the ocean in a relatively short period of time.

Data suggest that most females faithfully nest on the same stretch of beach where they were hatched (e.g. Carr et al., 1966), although the mechanisms by which individuals find their way back to their respective natal beaches is still poorly understood.

Table 1 Summary of the breeding parameters for green turtles (see Witherington *et al.,* 2006 for review)

Nesting season	Highly variable throughout range
Years between nesting	2 years (FL*) and 2-5 years (worldwide)
Sexual maturity	20-40 years (worldwide)
Nesting interval within season	9-15 days (worldwide)
Average number of clutches per season	3.6 (FL) and 2.0-5.5 (worldwide)
Clutch size	136 eggs/nest (FL) and 104-147 (worldwide)
Incubation period	52-56 days (FL)
Hatchling size	4.4-5.8 cm SCL*; 21-37 g (FL)

*Note: FL = Florida; SCL = straight carapace length

Table 2 Summary of the breeding parameters for hawksbill turtles (see Meylan and Redlow, 2006 for review)

Nesting season	Highly variable throughout range
Years between nesting	2-4 years (worldwide)
Sexual maturity	25 years (worldwide)
Nesting interval within season	14.5 days (worldwide)
Average number of clutches per season	3–5 (worldwide)
Clutch size	132 eggs/nest (FL*); 151 eggs/nest (western Atlantic); 130 eggs/nest (worldwide)
Incubation period	48-91 days (FL)
Hatchling size	4.2 cm SCL* (western Atlantic)

*Note: FL = Florida; SCL = straight carapace length

E. Current Threats

International:
General threats to turtles from a global perspective can be classified as threats to the marine environment and threats to the nesting environment. The global decline of green and hawksbill turtles is attributed in great part to overfishing and harvest of eggs from nesting beaches (see Meylan and Donnelly, 1999; Seminoff, 2002).

Threats to turtles within the marine environment are extensive and include destruction or modification of important foraging habitats (e.g. dredging), incidental capture in gill net and longline fisheries, entanglement and ingestion of marine debris, predation and disease (most notably fibropapillomatosis – a infectious condition that produces tumor growths on the skin and internal organs). The green turtle is the most desirable species for human consumption (Stickney, 2000), and the principal cause of the historical, worldwide decline of the green turtle is long-term harvest of eggs and adults on nesting beaches and juveniles and adults on feeding grounds (Seminoff, 2002). These harvests continue in some areas of the world and compromise efforts to recover this species. Hawksbills, in contrast, are mainly fished for their shell, which is used for decorations, jewelry and eyeglass frames (Schafer, 1962; Meylan and Donnelly, 1999). Japan is the largest consumer of tortoiseshell, or 'bekko', products with an estimated 2 million hawksbills imported during the second half of the twentieth century (SWOT report volume 3). The harvest of female hawksbills from nesting beaches and the take of adults and juveniles from feeding grounds has, in the past, and continues to contribute to the global decline of this species. In fact the illegal international trade of hawksbill shell is now regarded as the single greatest threat to hawksbills around the globe (Eckert, 1995).

Threats to the nesting environment include coastal development, beach erosion, beach armoring, beach nourishment, artificial lighting, beach cleaning, increased human presence, recreational beach equipment, beach vehicular driving, exotic dune and beach vegetation, nest loss to abiotic factors (e.g. temperature and rainfall), and harvest of meat

and eggs for human consumption (NMFS, 1992; NMFS 1991a, NFMS, 1991b). Furthermore, there are various predators which will dig up and consume turtle eggs, including crabs, insects, reptiles, mammals and birds (Stickney, 2000).

National:
The greatest perceived threats to sea turtles on the Bermuda Platform are collision with boats and entanglement in discarded monofilament fishing line. Both hazards are associated with high levels of mortality. Stranding records maintained by the Bermuda Turtle Project (BTP) show that between July 1983 and December 2007 392 sea turtle stranding events were reported, including 193 green turtles and 118 hawksbills. Half (49.7%) of animals for which the probable cause of stranding could be inferred were directly attributed to anthropogenic causes; 46 to boat-related injuries, 31 to entanglement (a significant number of which involved monofilament fishing line left in the marine environment by local shoreline fishers), 11 to fish hooks embedded in flippers, mouth cavities, esophagus's, or stomachs, and 6 to entrapment in the cooling water intake of Bermuda's only mass burn incinerator (Outerbridge *et al.*, in prep). It is important to note that stranding records given above represent a minimum estimate of mortality, given that not all dead, sick or injured animals wash up on shore, or were found or reported. In Bermuda, it is relevant to note that the first and only record indicating the presence of fibropapilloma disease occurred in 2007 (Herbst, pers. comm.)

Furthermore, green turtles in Bermuda are threatened by loss of seagrass habitat through anthropogenic disturbance (e.g. coastal development, dredging activities, damage from boat moorings and propellers) as well as ecological processes. For example, Murdoch *et al.* (2007) reported large-scale declines (*ca.* 53%) in offshore seagrass meadows in the recent past which were partially attributed to chronically low primary productivity, while Fourqurean *et al.* (2010) suggested that repeated and intense grazing from green turtles of *Thalassia testudium*-dominated seagrass meadows had a detrimental effect on them and may explain losses from broad areas of the Bermuda Platform.

F. Current Status

Global Distribution:
Both green and hawksbill turtles have a global distribution whose ranges include foraging areas, migration corridors and nesting beaches. Both species are generally found in tropical and subtropical waters and nest between 30° North and 30° South (Meylan and Redlow, 2006; Witherington *et al.*, 2006). Green turtles are thought to inhabit coastal areas of more than 140 countries and nest in over 80 countries, whereas hawksbills are thought to inhabit the coastal areas of 108 countries (Baillie and Groombridge, 1996); however, most of the hawksbill populations are considered to be small and declining (Meylan and Donnelly, 1999).

Green turtles are found in inshore and nearshore waters on the U.S. Atlantic Coast and Gulf of Mexico waters, from Texas to Massachussetts, the U.S. Virgin Islands and Puerto Rico, with important feeding areas in Florida with some nesting (200-1,100 females annually), but a more important nesting activity on the Caribbean coast of Costa Rica. In

the Pacific, green turtles occur most commonly south of California, feeding and nesting throughout the main Haiwaiian Islands, and on the Great Barrier Reef in Australia (22,500-18,000 females per season).

Hawksbills are most commonly encountered in the western Atlantic and Pacific regions as well as the Indian Ocean; less common in the eastern Atlantic and Pacific regions; and virtually absent in the Mediterranean Sea (for review see Meylan and Redlow, 2006). Hawksbill populations in the Atlantic can be seen as far west as the Gulf of Mexico (Boulon *et al*., 1993) and as far north as Long Island Sound (Pope, 1939). Their southern reach is known to the Cape of Good Hope in Africa. In the Caribbean, they are known from the Brazilian coast (specifically Bahia), southern Florida, and throughout the Caribbean Sea. They have been recorded on the beaches of Antigua and Barbuda, and Costa Rica (Tortuguero) (National Marine Fisheries Services, 2013), Cuba and Puerto Rico are known feeding grounds for the Caribbean hawksbill turtle population (Heppel and Crowder, 1996; Bowen *et al.,* 1996).

Local Distribution:
Between 1968 and 2005, the BTP captured 3,336 juvenile green turtles (representing 2,512 individuals) with a 2,000 foot long and 20 foot deep entrapment net in 39 different locations around the Bermuda Platform (see Figure 4 in the Appendix). Straight carapace length of these turtles at first observation varied from 22.3 - 81.0 cm (mean = 47.4 cm); weight ranged from 1.1-86.2 kg (mean= 18.6 kg) (Meylan *et al.,* 2011). Tagging studies (using both flipper and satellite tags) performed by the BTP have indicated that immature green turtles reside in Bermuda waters continuously throughout the year for extended periods time during which they usually occupy specific sites (Meylan *et al.*, 2011). Green turtle distribution appears to be a function of a combination of benthic habitat type (biotic) and abiotic factors such as temperature and light intensity. Seagrass type and quality is a significant factor in turtle distribution, but other factors are also involved which need to be investigated (Vierros *et al.,* 2002). The latter authors noted that Bermuda's calculated population size is well below the estimated carrying capacity of 1 turtle per 72 m^2. Although a small number of the green turtles captured by the BTP have been larger than the 76.7 cm SCL minimum size at sexual maturity reported for green turtles in Caribbean Panama (Meylan *et al.*, 2011; Meylan and Meylan, unpubl. data), none were deemed mature, based on external features or laparoscopy (Meylan *et al.*, 2011). Upon reaching a shell length of approximately 65-70 cm, green turtles depart from Bermuda and migrate to distant foraging grounds where they complete their development and become sexually mature (Meylan *et al.,* 2011).

Hawksbill turtles have been observed living in close association with in-shore, near-shore, and off-shore coral reefs around the Bermuda Platform. Figure 5 in the Appendix shows the locations of hand captured hawksbill turtles by the BTP. The size range of 68 hawksbills captured between 1970 and 2005 was 17.6–66.5 cm SCL (Meylan *et al.*, 2011). There is currently no evidence of mature hawksbills in Bermuda, or any record of hawksbills nesting in Bermuda, although epi-pelagic hawksbills have stranded on Bermuda beaches (Godley *et al.,* 2004; Outerbridge *et al.,* in prep.).

G. Current Conservation Action

National:
The BTP was initiated in 1968 by Dr H. Clay Frick II, trustee of the Caribbean Conservation Corporation (now known as the Sea Turtle Conservancy), in cooperation with the Bermuda government. Today, the primary objective of the project is to build capacity in the region by providing training to representatives from countries throughout the Atlantic basin via an annual taught course in Bermuda on the biology and conservation of sea turtles with hands-on learning of field techniques in sea turtle research. Participants are also given the opportunity to better understand how to improve monitoring and the collection of data specific to their country that will allow for better decision-making.

The BTP has worked to raise local public awareness about sea turtle conservation issues through public lectures, consultation with government officials, exhibits at the Bermuda Aquarium Museum and Zoo (BAMZ), as well as through educational materials provided to schools.

The Wildlife Rehabilitation Centre at BAMZ treats sick and injured sea turtles and monitors trends in threats to the local sea turtle population. The high prevalence of boat strikes in local waters has led to collaboration between the Bermuda Zoological Society and the Government's Department of Conservation Services to install 'Turtle Alert' signs in areas where heavy boating activity and turtle foraging overlap. These red-bordered cautionary signs were placed at 32 locations around the islands in 2004, mostly in near-shore and inshore locations where boating related injuries to sea turtles were found to occur most frequently, and encourage boaters to drive slowly.

Furthermore, in an effort to reduce the number of turtles that become entangled in discarded fishing line, the Bermuda National Trust has installed 14 monofilament recycling bins at popular fishing spots around the island, in conjunction with an awareness campaign highlighting the harmful effects that discarded fishing line has upon sea turtles. These bins, made from 6 inch PVC pipe, serve as waste receptacles for unwanted fishing line and are regularly emptied. Additional bins are to be installed across the islands.

PART II: MANAGEMENT

A. Management Goal

The principal aim of this management plan is to protect the species and their habitats in Bermuda, and contribute to national, regional and global conservation of marine turtles through sharing of knowledge and participation in international agreements.

The short-term goal (5 years) is to ensure the continuity of current conservation actions, to minimize identified threats to turtles on Bermuda's Platform that are linked to human activities and protect critical habitats. The ratification of the Inter-American Convention for the Conservation and Protection of Sea Turtles (IAC) will provide additional leverage for conservation of all sea turtle species native to Bermuda.

The long-term goal (25 years) is to monitor trends in abundance of resident turtles on the Bermuda Platform, enforce habitat protection, obtain comprehensive data on critical habitat use, verify the potential of Bermuda as a nesting sight, and assist in determining global connectivity in conservation measures.

B. Management Objective and Criteria

Sustainable management status for resident turtle populations in Bermuda will be achieved when there is:

- An accurate assessment of the current population status of green and hawksbill turtles.
- Protection and enforcement of critical sea turtle habitats in Bermuda supported by legislation.
- Increased public education regarding the human threats towards sea turtles and their critical habitats in Bermuda.
- An increase in the number of international agreements signed by Bermuda pertaining to the regional management and protection of sea turtles.
- An improved Sea Turtle Stranding and Salvage Network Program.
- Monitoring carried out at potential nesting sites to determine results of a past restocking experiment.
- Evidence of a sustained increase of nesting populations at the source sites of Bermuda's resident turtles over a 25-year monitoring period.

These overall objectives translate into specific targets outlined below:

1. Determine trends in abundance of resident green and hawksbill turtles, evaluate changes in sex ratio and genetic composition, and investigate habitat relationships of different age/size/sex classes.
2. Identify habitats critical to sea turtle survival on the Bermuda Platform (e.g. foraging grounds).

3. Define boundaries and regulations for critical habitats to sea turtles.
4. Continued examination of anthropogenic impacts to sea turtle survival within Bermuda's territorial waters.
5. Foster public awareness of anthropogenic threats.

C. Management Strategy

It is critical that sea turtle research continues in Bermuda. Basic population estimates for green turtles have been made, however they should be updated and refined, and there is a lack of comparable data for hawksbills. The Bermuda Turtle Project has provided much information on various aspects of green sea turtle biology and ecology at the juvenile life history stage. Its ongoing work and availability of volunteers make it useful in the implementation of proposed management actions. The continued sampling of turtles caught in Bermuda will provide further information on the origin of the juveniles coming to feed and grow in Bermuda, thus helping to establish collaborative conservation programs with source countries, as well as contribute to expanding knowledge on habitat use of resident turtles and establishing baseline data on physical health parameters. The use of satellite and acoustic telemetry will help identify how turtles use foraging grounds and provide information on movement of the turtles on the Bermuda Platform to assist in the delineation of "critical habitat". Furthermore, projects related to sea turtle ecosystems, such as the Seagrass Management Program currently in operation at the Department of Conservation Services, can provide complementary information in explaining turtle abundance and movement on the Platform. The sharing of information is beneficial to all and would provide a more comprehensive understanding of the changes seen in the marine near-shore environment.

Since most of the threats to sea turtles in Bermuda are associated with human activities (e.g. disturbance on the feeding grounds due to jet skis and other watercraft, entanglement in discarded fishing line, ingestion of marine debris, and incidental catch in fisheries), it is recommended that efforts related to minimizing injuries and mortalities to resident turtles are continually evaluated in order to determine their effectiveness. The stranding network is a useful tool that provides complementary data on the occurrences of sea turtles within Bermuda's territorial waters, as well as information on threats from human activities. Whilst local legislation exists to protect all marine turtles from harvest and intentional harm, accidental and incidental causes still contribute to local mortality. Furthermore, the systematic pathological, microbiological, mycological, and parasitological examination of moribund turtles by professionals trained in veterinary medicine would greatly improve determining the absolute cause of death or stranding where obvious causes were not evident.

There is always the possibility that turtles may arrive on Bermuda beaches at night and nest. The 2 isolated loggerhead nesting events which were observed in the recent past (1990 and 2005) indicate the usefulness of a protocol optimizing nest protection and hatchling survival. Furthermore, a public educational outreach program that teaches the identification of turtle crawls and nesting in tandem with the systematic monitoring of beaches during potential nesting season would increase the likelihood of nesting events

being reported. These monitoring efforts should be implemented to evaluate the results of the 1967-1977 restocking attempt.

Currently Bermuda is part of several international networks; the North American Sea Turtle Stranding and Salvage Network (SSTSN), the Wider Caribbean Sea Turtle Conservation Network (WIDECAST), and IUCN/SSC Marine Turtle Specialist Group (represented by the Bermuda Turtle Project coordinator). To strengthen its international collaboration and expand its protection of sea turtles, it is recommended that Bermuda sign on to the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC).

D. Step-down narrative of work plan

Abbreviations:
DCS – Department of Conservation Services
BAMZ – Bermuda Aquarium, Museum and Zoo
BTP – Bermuda Turtle Project
BZS – Bermuda Zoological Society
IAC – Inter-American Convention for the Conservation and Protection of Sea Turtles

The actions needed to achieve management are as follows:

1. An accurate assessment of the current population status of green and hawksbill turtles.

Actions Proposed: Continued monitoring of green and hawksbill turtles to assess population trends, site fidelity and residency times, habitat use, migration patterns and shifts in genetic composition.
Integrate results with local management.

Work Team: DCS and collaborators for analyses
Team Leader: Ecologist
Assistance: Graduate students
Output: Better understanding of population status
List of Equipment: Nets, boats, etc.

2. Protection and enforcement of sea turtle critical habitats in Bermuda supported by legislation.

Actions proposed: Investigation of habitat relationships for different turtle age/size/sex classes.

Identification of important foraging habitats for resident turtle populations using satellite and acoustic telemetry.
Delineation of critical habitats under Protected Species Act 2003.
Restrict anthropogenic disturbance within critical habitats.
Better inform and educate judges and prosecutors about the seriousness of damaging and disturbing critical habitats.

Work Team: DCS and Marine & Ports (if habitats need to be marked)
Team Leader: Ecologist
Assistance: Members of the community
Outputs: Critical Habitat Protection, prevent degradation and/or destruction of habitat
List of Equipment: Acoustic tags and receivers and GPS satellite tags for turtle movement.

3. Increased education regarding the human threats towards sea turtles and their critical habitats in Bermuda.

Actions Proposed: Evaluation of stranding data for resident sea turtle populations.
Identify potential impact of coastal development (e.g. dredging operations and beachfront alteration) on feeding grounds such as seagrass beds and coral reefs.
Launch public awareness campaign highlighting the local causes of sea turtle stranding and damage to critical habitats (e.g. seagrass meadows, coral reefs).

Work Team (for identification of threats): DCS
Team Leader: Ecologist
Assistance: Research institute/graduate students
Outputs: Expanded public awareness. Development of regulations to minimize human caused injuries to turtles and damage to seagrass meadows/coral reefs. Development of a best practice guide for coastal development activities in relation to sea turtle habitat conservation.
List of Equipment: NA

4. Increase the number of international agreements signed by Bermuda pertaining to the regional management and protection of sea turtles.

Actions proposed: Bermuda becomes a signatory Party to the IAC

Work Team: DCS
Team Leader: Director
Assistance: NA
Outputs: Expanded international network and additional protection to sea turtles.
List of Equipment: NA

5. An improved Sea Turtle Stranding and Salvage Network Program.

Actions proposed: Train new BAMZ staff on care and rehabilitation of stranded animals.
Provide veterinary resources specific to sea turtle rehabilitation.
Improve upon the clinical evaluation of Bermuda's stranded turtles by performing pathological, microbiological, mycological, and parasitological examinations.
Ensure compliance for care and maintenance of turtles in captivity, including diet, water quality, and tank size.

Work Team: DCS, BAMZ
Team Leader: Ecologist
Assistance: BAMZ staff and local veterinarians
Outputs: Optimize survival rate of stranded turtles.
List of Equipment: Funds for dedicated staff will be required, namely a full time veterinary technician.

6. Monitoring carried out at potential nesting sites to determine results of past restocking experiment.

Actions proposed: Establish survey teams.
Development of survey protocols.
Develop protocols for the protection and monitoring of in-situ nests if/when found.

Work Team: DCS
Team Leader: Ecologist
Assistance: Community members and local schools
Outputs: Contribution to international conservation of species and to raising local awareness on importance of preserving natural beaches.
List of Equipment: NA

7. Evidence of a sustained increase of nesting populations at the source sites of Bermuda's resident turtles over a 25-year monitoring period.

Actions proposed: Establish criteria for the assessment of nesting populations.
Enhance collaboration with overseas institutions.
Exchange of information with source countries through meetings and forums.
Complete genetic analysis for clear understanding of source countries.

Work Team: DCS, and overseas institutions for information sharing and genetic analysis
Team Leader: Ecologist
Assistance: BTP, other collaborators (e.g. graduate students)

Outputs: Future recruitment rates of sea turtles to the Bermuda Platform holds steady or increases.
List of Equipment: Funds for meetings and genetic analyses

E. Estimated Date of Down-listing

The green and hawksbill turtle populations residing in Bermuda can be considered for delisting if the management criteria given in Part II (D) are met. It is anticipated that it will take 25 years to achieve sustainable management. During this time, the continued identification of the nesting sources of the residing turtle population will be performed, which will serve as the basis for the development of international collaboration with source countries.

PART III: IMPLEMENTATION

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.
Priority 2: An action that must be taken to prevent a significant decline in the species population/habitat quality, or some other significant negative impact short of extinction.
Priority 3: All other actions necessary to provide for full management of the species.

Priority #	Task #	Task description	Task Duration	Responsible Party
1		**Assessment of current population status**	ongoing	
	1	Continued monitoring of population trends, site fidelity and residency times, habitat use, migration patterns and shifts in genetic composition	ongoing	DCS, BTP
	2	Integrate results with local management	ongoing	DCS
1		**Critical habitat protection**	3 years	
	3	Investigation of habitat relationships	3 years	DCS, BTP
	4	Identification of important foraging habitats for resident populations	3 years	DCS, BTP
	5	Delineation of critical habitats under Protected Species Act 2003	1 year	DCS
	6	Restrict anthropogenic disturbance within critical habitats.	1 year	DCS
	7	Educate judges and prosecutors	ongoing	DCS
1		**Increased education regarding human threats**	ongoing	
	8	Evaluation of stranding data for resident sea turtle populations	ongoing	DCS
	9	Identify potential impact of coastal development on feeding grounds	ongoing	DCS
	10	Public awareness campaign	ongoing	DCS, BZS, BTP
2		**International agreements**	1 year	
	11	Bermuda signs on to IAC	1 year	DCS
2		**Improve Sea Turtle Stranding and Salvage Network Program**	ongoing	
	12	Train new BAMZ staff on care and rehabilitation of stranded animals	annual	BAMZ
	13	Provide veterinary resources specific to sea turtle rehabilitation	ongoing	DCS, BAMZ
	14	Improve clinical evaluation of stranded	ongoing	BAMZ

		turtles		
	15	Ensure compliance with care and maintenance of captive turtles	ongoing	DCS
2		**Monitoring potential nesting sites**	15 years	
	16	Establish survey teams	annual	DCS
	17	Development of survey protocols	1 month	DCS
	18	Develop protocols for in-situ nests	1 month	DCS
3		**Increase nesting populations at source sites**	**25 years**	
	19	Establish criteria for the assessment of nesting populations.	annual	DCS
	20	Enhance collaboration with overseas institutions	ongoing	DCS
	21	Exchange of information with source countries through meetings and forums	annual	DCS, BTP
	22	Complete genetic analysis for clear understanding of source countries	5 years	DCS, BTP

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Appendix

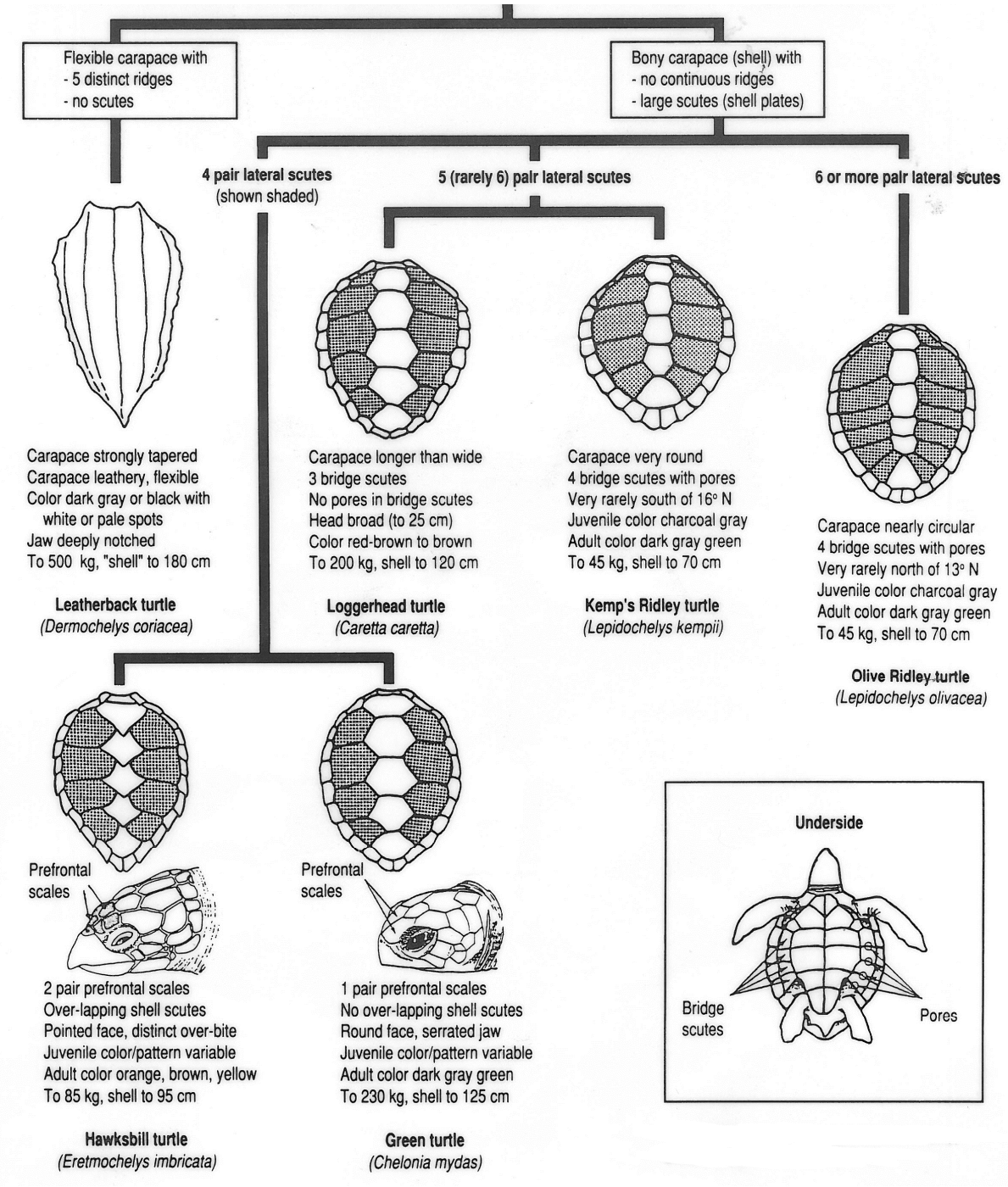

Figure 3. Marine turtle identification key for the species found in the wider Caribbean region.

Adapted from a key produced by the Wider Caribbean Sea Turtle Conservation Network (WIDECAST)

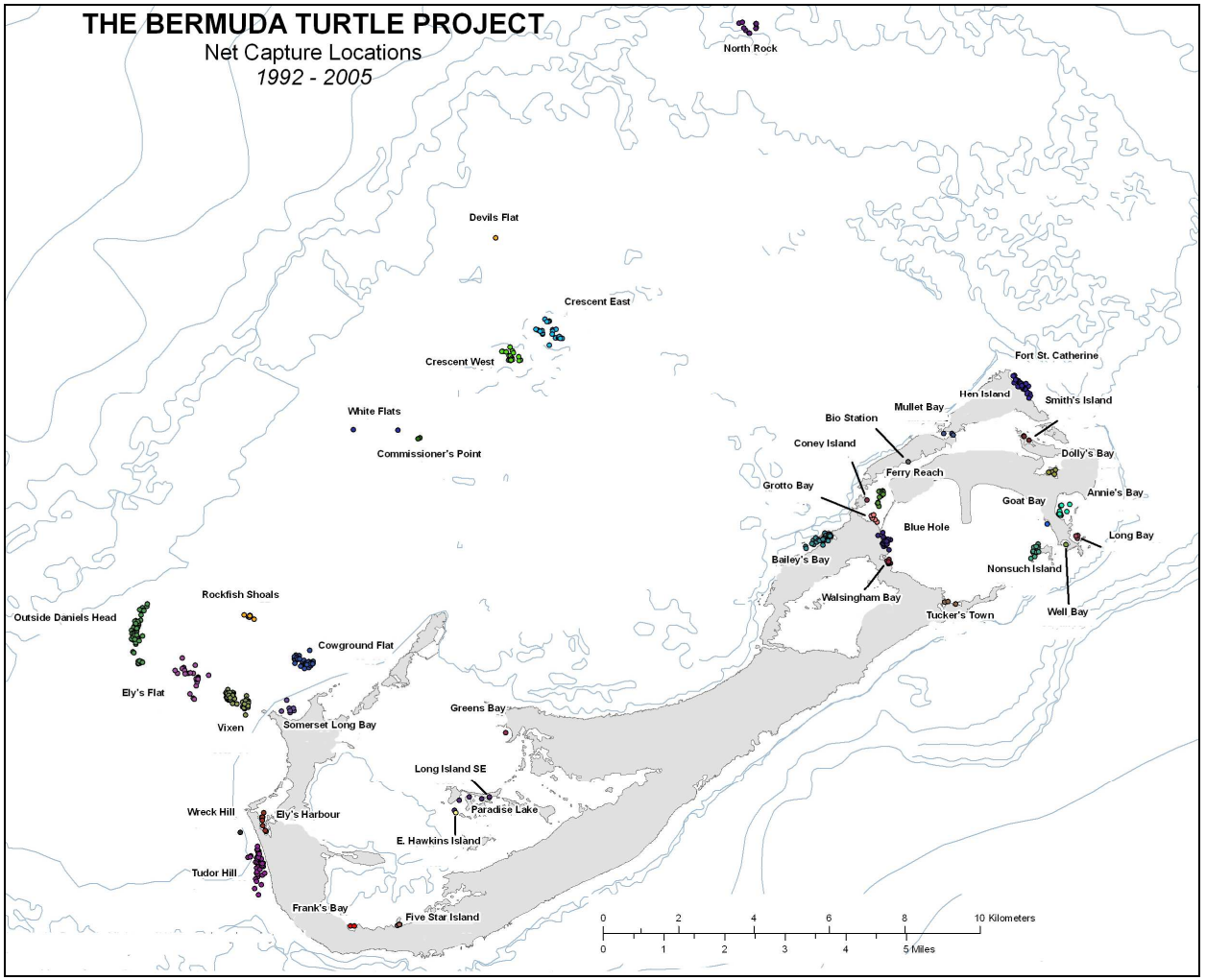

Figure 4. Bermuda Turtle Project capture locations of green turtles between 1992 and 2005
(Bathymetry courtesy of Bermuda Government; map digitized and produced by M. Shailer and R. Hardy)

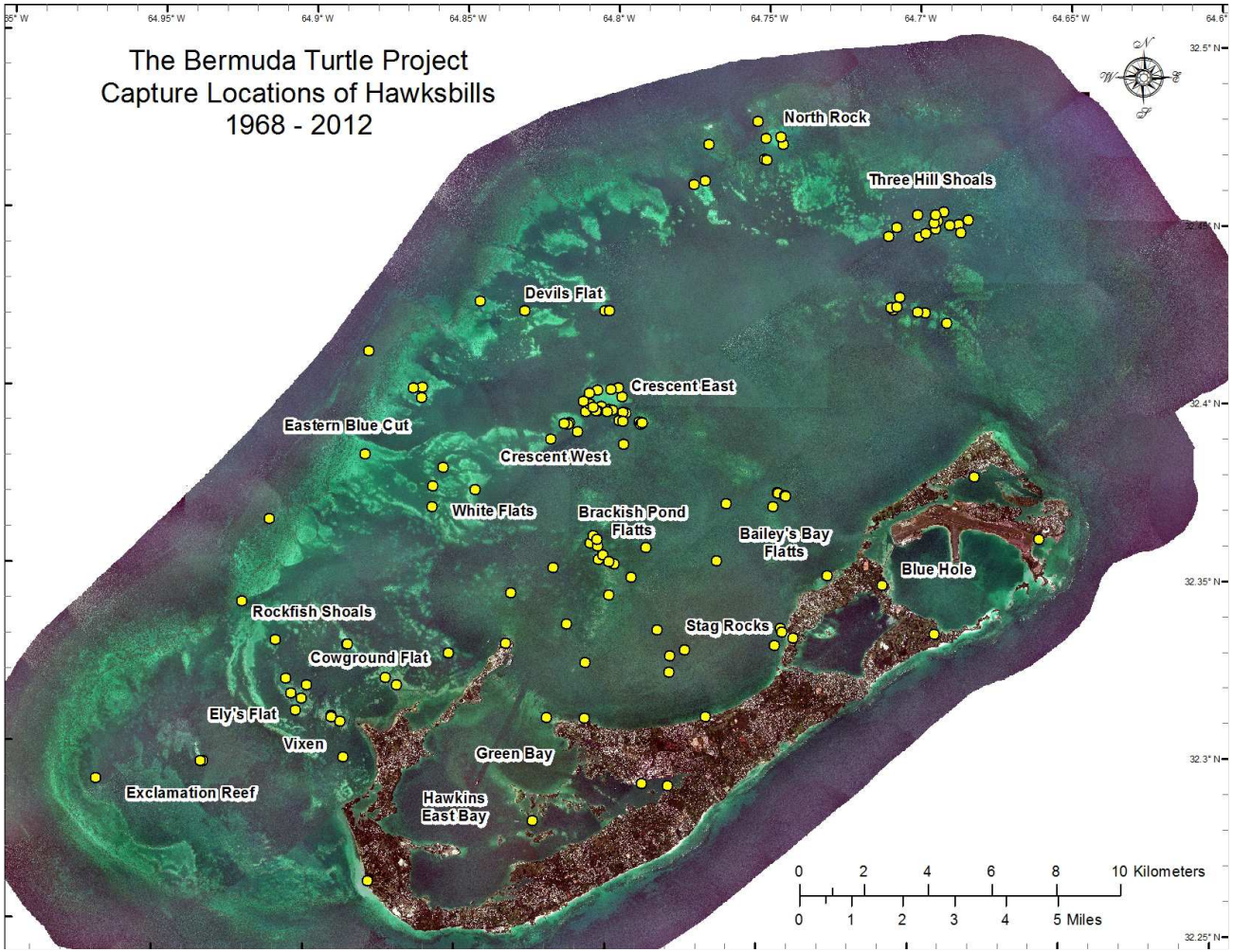

Figure 5. Bermuda Turtle Project capture locations of hawksbill turtles between 1968 and 2012
(map produced by R. Hardy)