IN-WATER MONITORING OF SEA TURTLE AGGREGATIONS IN ST. EUSTATIUS NATIONAL MARINE PARK

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Acronyms and Abbreviations

CITES – Convention on the International Trade of Endangered Species

CMS – Convention on Migratory Species

CPUE – Catch per Unit Effort

IUCN – International Union for the Conservation of Nature

SPAW – Specially Protected Areas and Wildlife – Annex of the Cartagena Convention

SSN – Species Survival Network

STENAPA – St. Eustatius National Parks Foundation

STRAP – Sea Turtle Recovery Action Plan

TRAFFIC – TRAFFIC International, joint with WWF and IUCN, monitors the worlds wildlife trade

WWF – World Wildlife Fund

Summary

All species of sea turtles in the Caribbean have come under threat in recent years due to a multitude of factors. Habitat destruction and modification are playing a larger and larger role in current population declines. Trends projected from data of nesting females are useful in predicting potential shifts in populations, but such changes may not appear in adult female populations until it is too late to protect them. Changes in the populations of juveniles are a much earlier and more accurate indicator to assess the future of the population as a whole. In-water surveys of sea turtle foraging grounds are the best tool to monitor such changes in juvenile and sub-adult populations so that they can be more quickly and effectively protected.

In-water surveys began in the Statia National Marine Park in January 2008 in order to asses the current status and distribution of foraging turtle aggregations (greens, *Chelonia mydas*, and hawksbills, *Eretmochelys imbricata*) in the surrounding waters. Surveys yielded a total catch per unit effort (CPUE) of 1.17 turtles per hour, with an average CPUE of 0.67 for greens and 0.50 for hawksbills. Greens and hawksbills were found to occupy different areas in different densities, with more greens in the less protected sea grass beds of the harbors and more hawksbills on the reefs of the reserves. Size and gender data indicate a healthy juvenile and sub-adult population for both species. Future monitoring is needed to assess any changes in this population, and active protection of the foraging grounds of these species is essential to their continued existence within the marine park.

Introduction

Sea Turtles in the Caribbean

Sea turtle populations in the Caribbean are currently under stress for a growing number of reasons. Turtles throughout the Caribbean, including the Netherlands Antilles, have historically been hunted for their meat and shells, and populations around the time of colonization were most likely depleted for this reason (Fukui 2007). There are four main species of turtles nesting and foraging in the Eastern Caribbean region – the leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta)*, green (*Chelonia mydas*), and hawksbill (*Eretmochelys imbricata*). Among these species, the hawksbill turtle has experienced "the longest and most sustained history of commercial exploitation" (Parsons, 1972), as their tortoiseshells are considered the most beautiful and prized of all turtles. However, in the last decade, there is little evidence of international trade in or poaching of turtles in the Netherlands Antilles, and there are currently no communities dependent on sea turtles for their subsistence. Now the main driving factor of sea turtle population depletion is destruction and/or modification of habitat—nesting beaches have been degraded by sand mining as well as commercial and tourist development, while foraging grounds have been altered or destroyed by development, pollution, increased shipping traffic, and recreational activity (Sybesma 1992). Because there are no good records of turtle populations existing before the past few decades, the extent to which turtle populations in the Caribbean have already been displaced can never really be known. Best estimates indicate that current turtle populations in the Caribbean represent 3–7% of pre-exploitation populations (Jackson et al. 2001). In order to prevent further population declines, it is important to assess, understand and protect the turtles still remaining in Caribbean waters.

Sea turtles are migratory species, and for that reason it is imperative to have consistent international laws governing their protection because they will likely enter many different jurisdictions in their lifetimes. The average distance of most post-nesting sea turtle migrations is approximately 370 km—in the case of the Greater Caribbean region, comprised of island nations that are relatively close to one another, this average post-nesting migration distance would typically involve crossing international borders

(CITES 2001). The first official, wide-range legislation protecting turtles in the Caribbean came about in 1973 with the Convention of International Trade in Endangered Species of Wild Flora and Fauna (CITES). All species of sea turtles have been completely protected by member parties to the convention since 1981 when they were listed in Appendix I of CITES, making commercial trade of turtles or turtle products illegal (CITES 2001). In 1990, the Specially Protected Areas of Wildlife Protocol (SPAW) of the Cartagena Convention was brought into force, not only protecting turtles against poaching but also protecting critical habitats such as beaches and foraging grounds (SSN 2002). Leatherbacks and hawksbills were listed as critically endangered species on the IUCN Red List of Threatened Species in 1994; green turtles were included on the list as endangered in 2001 (Meylan et al. 1999). Hawksbills, leatherbacks, and greens, in addition to loggerheads, are all listed in Appendix I and Appendix II of the Convention on Migratory Species (CMS), which affords the strictest protection to those species as well as their migratory habitats. Despite this amount of protection on an international level, there is often a lack of compliance or lack of enforcement among member parties, and countries not party to the conventions or treaties often have minimal or no laws protecting turtles. St. Kitts, for example, still has an open season for turtle hunting (Fukui 2007).

Sea Turtle Conservation on St. Eustatius

St. Eustatius, commonly referred to as "Statia", is one of three islands that make up the windward Netherlands Antilles. Statia is surrounded by coral reefs built up on the remains of ancient lava flows from the Quill volcano (dormant) and Boven volcanic complex (extinct), in addition to other marine habitats such as sea grass beds, rocky shores, sand, and wrecks. In 1996, the Marine Environment Ordinance of St. Eustatius brought about the creation of the Statia Marine Park and the St. Eustatius National Parks Foundation (STENAPA) (established in 1988) was mandated by the island government to manage the marine park and other protected areas on Statia. Statia Marine Park was formally recognized as having National Park status in the Netherlands Antilles in December 2007.

The marine park extends around the complete island of Statia from the high water mark to a depth of 30 meters (100ft) and contains two actively managed reserves (Northern and Southern Reserves) where anchoring and fishing are not permitted in order to protect pristine coral reef (McRae et al. 2007) (Figure 1). In addition to sheltering populations of sharks, rays, conch, lobster, and diverse fish species, the marine park also provides excellent foraging grounds for juvenile and sub-adult turtles. The two most commonly observed turtle species in the marine park are hawksbill and green turtles (Figure 2). Loggerhead sightings have been reported on rare occasions by dive centers, and leatherbacks, in addition to greens, hawksbills, and possibly loggerheads, use the island's beaches for nesting.

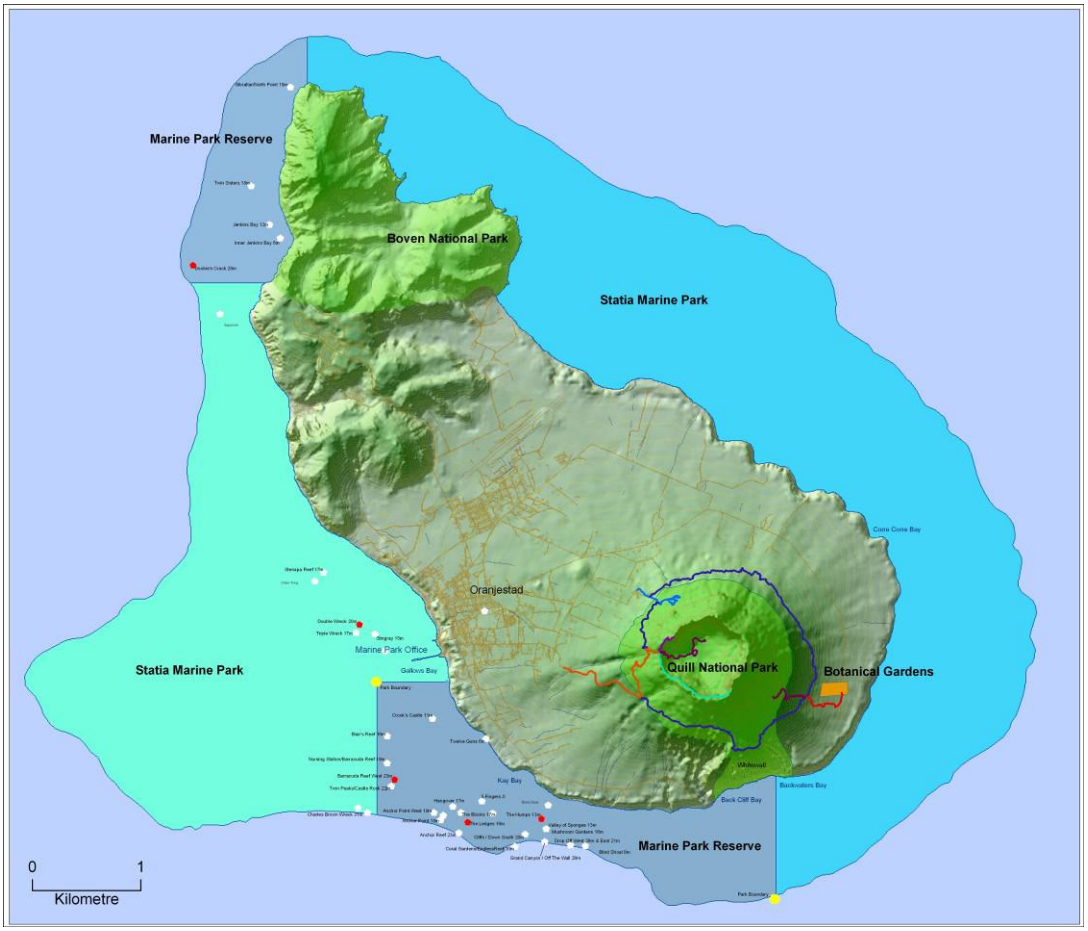

Figure 1: *Map of the protected areas of St. Eustatius, including the Statia National Marine Park, which extends around the entire island from the high water mark to a depth of 30 meters. Within the Marine Park are 2 actively managed no-take marine reserves where anchoring and fishing are not permitted.*

Prior to the founding of the Marine Park, there was no local protection of turtles in Statia's waters, despite international treaties and laws. In 1996, the Marine Environmental Ordinance of St. Eustatius, Article 6, limited the take of sea turtles to 2 per person per season with a closed season during nesting (1 April – 10 November) and complete protection of nests and eggs. This law was superseded by the 2001 National Nature Conservation Ordinance of the Netherlands Antilles, which conferred complete protection of sea turtles and their nesting areas and prohibited any take of juvenile, sub-adult, and adult turtles or turtle eggs. The Sea Turtle Conservation Program was initiated by STENAPA in 2002 with the main focus of nightly monitoring on Zeelandia beach, the most commonly used nesting beach on the island.

Figure 2: *Both green turtles* (Chelonia mydas) *[left] and hawksbill turtles* (Eretmochelys imbricata) *[right] reside in the Statia National Marine Park*

Qualified STENAPA staff members were granted special police status in 2005 to assist in enforcing laws protecting sea turtles. There is currently no market for turtle shells and very little demand for turtle meat on the island and the only violation of international laws is the continued occurrence of sand mining on Zeelandia beach (Bräutigam et al. 2006). At present, the biggest threat to turtle populations on Statia is habitat modification—this includes not only sand mining, but also land-based sources of pollution (i.e. rubbish from Smith's Gut landfill), discharge from ships, coastal and industrial development such as the Statia pier and oil terminal jetty, all of which have drastically changed the natural character of the shallow harbors surrounding Statia (Sybesma 1992). An additional threat to turtles around Statia is lost or discarded fishing gear. Turtles tangled in loose fishing nets can easily become trapped underwater and

drown, as was the case of a female hawksbill washed up on Zeelandia beach 6 July 2008 (Figure 3).

Figure 3: *Dead female hawksbill entangled in fishing net, 6 July 2008.*

In-Water Surveys

Most current population studies of sea turtles are based on information gathered from nesting beaches. While this information can be useful in projecting future population trends, nesting surveys only really monitor one sector of the population – adult females. Because it takes decades for sea turtles to reach maturity and return to beaches, overall declines in population may not be reflected in nesting females for a number of years. In order catch changes in the population early and provide enough time to take protective action, it is imperative to not only monitor nesting females but also juveniles and sub-adults as well. Monitoring juvenile life stages can provide more accurate projections for the entire population and early warnings of changes in juvenile survival (Bjorndal et al, 2005).

In-water surveys of sea turtle foraging grounds are the best tools with which to monitor juvenile turtles. Because turtles from different genetic stocks are likely to coexist on the same foraging grounds, juveniles and adults observed in such environments are not considered to be a population (such as nesting females) but are rather regarded as an aggregation (van Dam 2005). Turtles tend to remain in aggregations on the same foraging grounds for most of their lives, migrating every 2-4 years to their respective nesting beaches once they reach maturity (CITES 2001).

Foraging ground surveys can contribute important data on population status and dynamics, ecology, disease, and other critical knowledge of sea turtle biology necessary in creating protective management plans. In-water surveys in the Statia National Marine Park will not only provide baseline information for resident turtle aggregations (greens and hawksbills), but will also identify those areas of the marine park most used by foraging turtles. This information will make future monitoring easier and more effective and can contribute to the creation of a management plan that not only affords protection to nesting beaches but also to key foraging grounds surrounding the island.

Materials and Methods

A total of 35 in-water turtle surveys took place in the Statia National Marine Park between January and June 2008. Surveys were carried out on SCUBA at a number of marked and unmarked sites around the island (Appendix I). GPS coordinates were taken for the start and end points of each survey. For marked dive sites, the start and end points were the same (the location of the buoy) and surveys were carried out along a specified heading, with divers swimming out along one heading and then back along the reciprocal heading about 15 meters away from the original path. For unmarked sites, divers were dropped by boat at one point and swam or drifted in one direction for the complete dive, ending at a different location down current. For surveys of unmarked sites, surface marker buoys were used to allow the boat to follow divers from the surface.

Each survey was carried out with no visual or temporal limit, but dive time was recorded for every survey. Surveys were carried out with 2 observers swimming 5-10 meters apart from one another. Data from every dive, recorded on an underwater slate, included: observers, date, time, weather, sea condition, visibility, and water temperature. For surveys in which turtles were encountered, the following data was recorded for each turtle: species, size, tail length, ectobiota (barnacles, remora, algae), depth, location (bottom, water column, surface), activity (resting, swimming, foraging), environment (reef, sea grass, wreck), condition (alive, injured, dead), and presence/absence of tags (See Appendix II – Data Sheet). Results were analyzed for catch per unit effort (CPUE), which was calculated by dividing the number of turtles observed (catch) by the cumulative survey time (effort). A spatial analysis was achieved using the GPS coordinates of the surveys—all GPS points were plotted and color-coded on a map to reveal the spatial distribution of turtles within the marine park.

Results

A total of 28 turtles (16 greens and 12 hawksbills) were observed during 23 hours and 59 minutes of dive time, yielding a CPUE of 1.17 within the marine park. CPUE was higher for greens (0.67) than for hawksbills (0.50).

CPUE was generally higher outside the reserve (1.25) than inside (1.04), but for hawksbills alone, CPUE was higher within the reserve (0.62) than outside (0.42). For greens alone, CPUE was still higher outside the reserve than inside (0.83 and 0.42, respectively) (Figure 4).

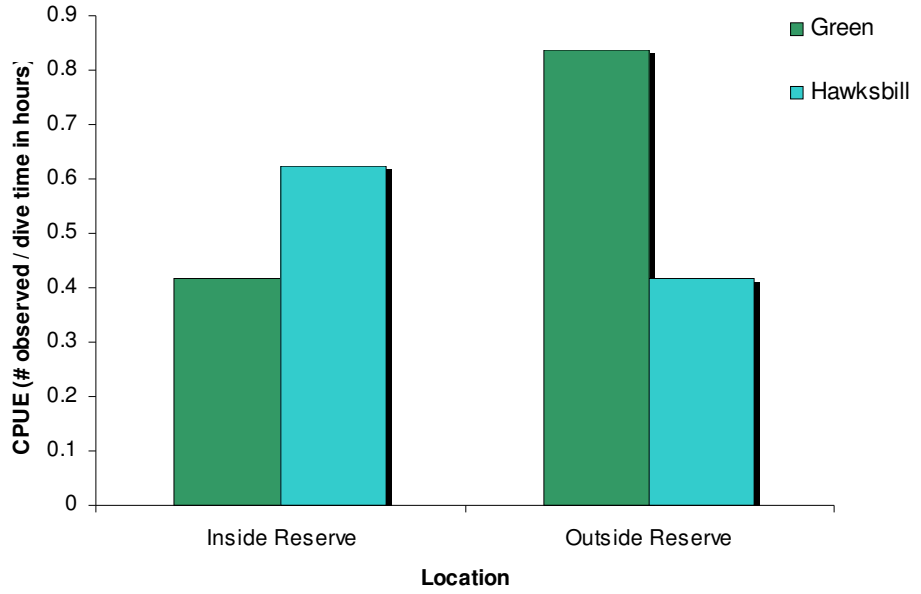

Figure 4: *Catch per unit effort (CPUE) of greens and hawksbills comparing sites inside and outside the reserve*

CPUE was generally higher on the Caribbean side of the island (1.37) than on the Atlantic (0.7), but for hawksbills alone, CPUE was slightly higher on the Atlantic (0.56) than on the Caribbean side (0.46). CPUE for greens followed the general trend, remaining higher on the Caribbean side (0.89) than on the Atlantic (0.14) (Figure 5).

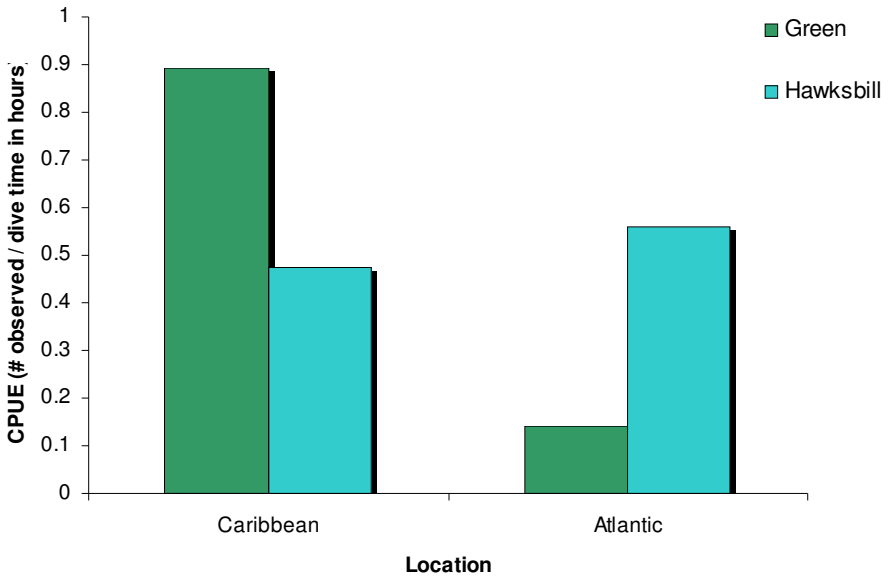

Figure 5: *Catch per unit effort (CPUE) of greens and hawksbills comparing sites on the Caribbean and Atlantic sides of the island*

The majority of green turtles (75%) were between 50 and 100 cm in length, and of the other 25%, 12.5% were 10-50 cm and 12.5% were over 100 cm. For hawksbills, the size range was more evenly distributed, with 33.3% of observed turtles falling in the 10-50 cm category, 33.3% in the 50-100 cm range, and 33.3% being over 100 cm (Figure 6).

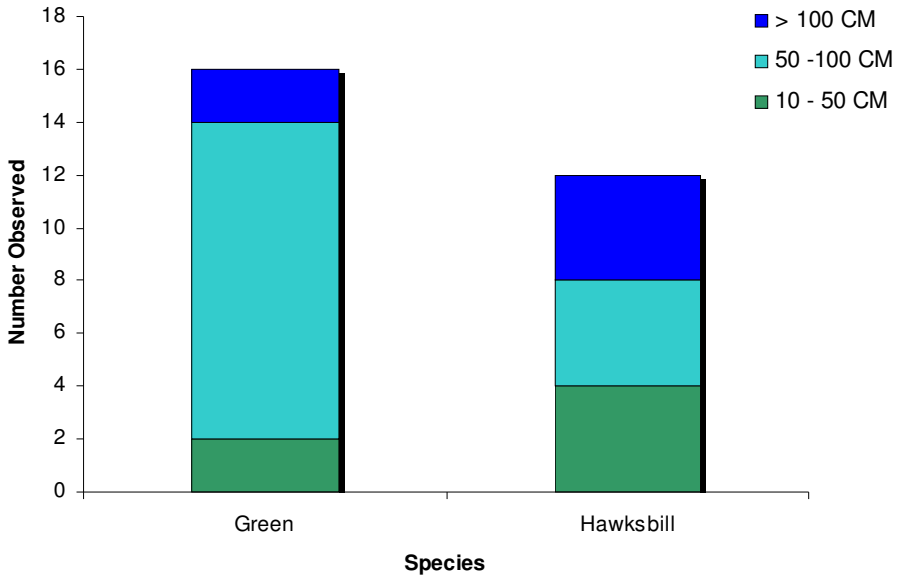

Figure 6: *Size ratio of observed turtles in the Statia National Marine Park*

Gender could not be determined for approximately half of the turtles, but out of those turtles for which gender could be determined, 87% were female and 13% were male (Figure 7).

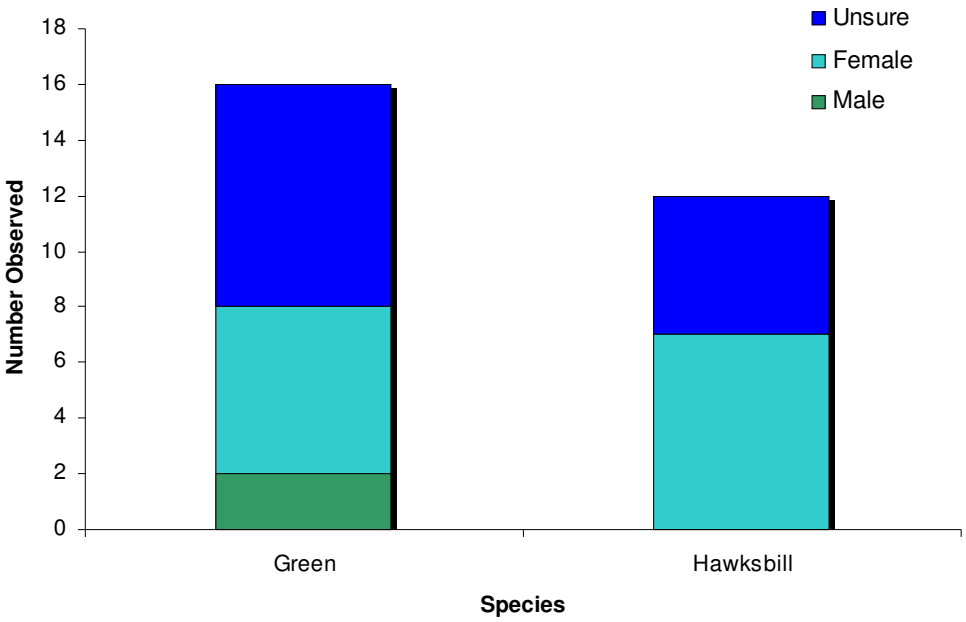

Figure 7: *Gender composition of observed turtles in the Statia National Marine Park*

The spatial distribution map (Figure 8) shows more green turtles in the sea grass beds of the harbors and bays on the Caribbean side, in addition to Zeelandia Bay on the Atlantic side, while hawksbills are more spread out over the reefs of the southern reserve and along the northern Atlantic coast.

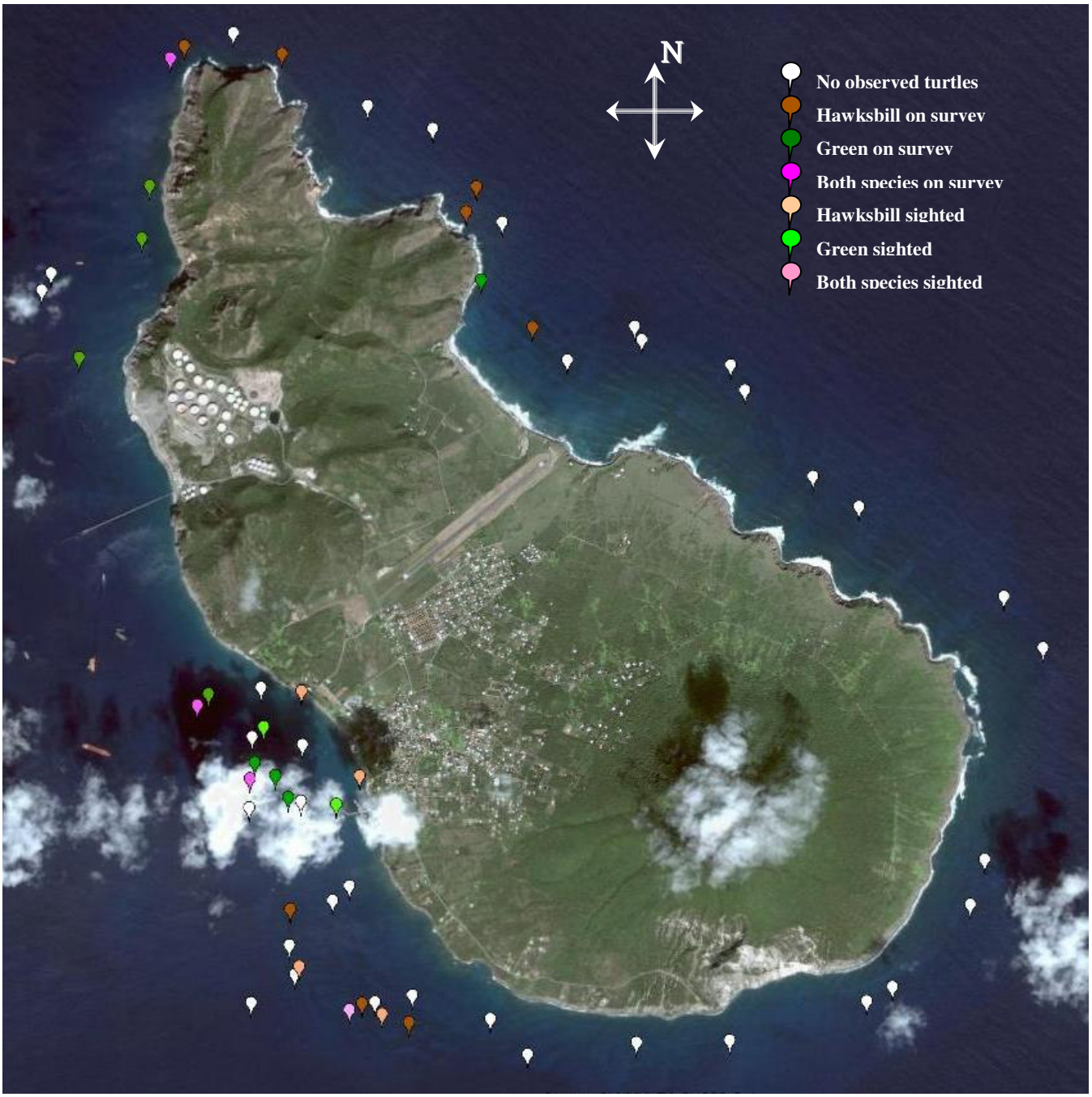

Figure 8: *Map of turtle survey dives completed January - June 20008. In addition to data from the surveys, also included on the map are reported turtle sightings from the local dive centers*

Discussion

Comparisons of catch per unit effort (CPUE) in different areas of the marine park illustrate the varying distribution of greens and hawksbills around the island. Hawksbills are most common around the southern Caribbean and northern Atlantic reefs, whereas greens are virtually absent from the Atlantic side and reside almost exclusively in the well developed harbors of the island (Oranje Bay, Tumble Down Dick Bay, Jenkins Bay). This distribution pattern is indicative of the different foraging requirements of the two species. Hawksbills feed mainly on sponges, soft-bodied invertebrates, and other reef-dwelling creatures, whereas greens feed primarily on sea grass such as *Thalassia* spp. (Sybesma 1992). Because the reserves are set up mainly around coral reefs, hawksbills are much more common in those areas than greens, which reside in the less protected sea grass beds of the harbors.

The differing CPUE is reflected on the distribution map, which not only shows the different habitats of greens and hawksbills, but also reveals turtles to be generally more concentrated along the northern and western coasts of the island virtually absent from the entire southeast coast. The areas where turtles are most common are also the most developed parts of the island—there is virtually no development and very little boat traffic along the southeastern coast of the island and no turtles were observed at any of those sites. Foraging aggregations of green turtles around Statia are at a slightly higher risk than hawksbills because they so often reside in busier, less protected parts of the marine park. On 28 April 2008, a local dive center reported a dead green turtle cut in half on STENAPA reef (Oranje Bay) during a night dive. This site, surrounded by sea grass beds, is in the middle of an area of heavy boat traffic, specifically from the Statia oil terminal. Given the nature of the injury, boat collision is the most likely cause of death.

Catch per unit effort (CPUE) for the two species in the Statia National Marine Park (0.67 for greens and 0.50 for hawksbills) is comparable to CPUE of those species in other marine parks in the Caribbean, but those values are often highly variable for a number of reasons. Surveys targeted at areas already known to be dense foraging grounds will obviously yield a higher CPUE, and in many shallower locations on other islands, in-water capture is carried out as part of the survey, thus altering the methodology as well as the resulting CPUE. In a case study at Kuna Yala, Panama,

CPUE for hawksbills was as low as 0.14, compared with other surveys in Dominican Republic and Puerto Rico, which yielded CPUE as high as 3.4 and 4.7, respectively (Diez et al 2002). The CPUE calculated for the turtles in Statia will most likely be more useful for comparing surveys in future years of the same areas using the same methodology rather than between other islands using different survey methodologies.

Size and gender data reflect healthy, stable foraging aggregations around the island. Most foraging green turtles in the marine park are juveniles and sub-adults (less than 1 meter in length), whereas the aggregation of hawksbills includes more resident foraging adults and is more evenly distributed among age classes. Because tail length was used to determine gender, only the largest turtles could be properly classified. A better method for identifying gender in juvenile turtles would be useful to get a better idea of the gender composition of the aggregations in the marine park. The concentration of juveniles and sub-adults found in the surveys likely indicates a stable future population for both species within the marine park, but should be monitored closely in order to compare data between years.

Conclusions and Recommendations

Given the life history parameters and continuing threats to all sea turtle species, it is imperative that long-term studies be continued to determine population trends. On-going in-water monitoring can be used to assess population trends as well as identify and mitigate threats. The Statia National Marine Park contains healthy foraging aggregations of both greens and hawksbills, and given the threatened status of these species worldwide, it is important to maintain and protect these populations as well as the habitats on which they depend. Because green turtles forage in areas of the marine park where there is less protection and more activity, it may be beneficial to change the management of these key foraging areas to offer stricter protection of the juvenile and sub-adult populations.

While the methodology used in this study is useful to ascertain a basic understanding of turtle aggregations in the marine park, it may be helpful to look into more dynamic techniques such as in-water capture and/or tagging. By identifying individual turtles through in-water tagging, it will be possible to track not only the movements of juveniles and sub-adults within the marine park, but also adult female nesting migrations. While most of the sites on Statia are too deep for standard methods of in-water capture, it may be feasible to capture turtles on the surface from the boat or in some shallower sites on snorkel.

No matter what the methodology, the most important activity is continued monitoring of the turtles in Statia's waters. Observation of juvenile and sub-adult aggregations on foraging grounds provides an important insight into the future of these populations not only in Statian waters, but also in other part of the wider Caribbean region.

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Appendix I – Survey Dive Coordinates

Site	GPS N - Start	GPS W - Start	GPS N - End	GPS W - End
Double Wreck	17 º 28.792'	62 º 59.641'	heading	N
Crook's Castle	17 º 28.318'	62 º 59.254'	heading	SW
Blair's Reef	17 º 28.227'	62 º 59.493'	heading	S
STENAPA Reef	17 º 29.055'	62 º 59.830'	heading	SE
Chien Tong	17 º 29.011'	62 º 59.875'	tour	-
Ledges	17 º 27.793'	62 º 59.069'	heading	NE
S. Harbor	17 º 28.644'	62 º 59.453'	17 º 28.862'	62 º 59.448'
Outer Jenkins Bay	17 º 30.812'	63 º 0.114'	heading	N
Venus Bay	17 º 31.244'	62 º 58.940'	17 º 31.331'	62 59.116'
Hangover	17 º 27.871'	62 º 59.147'	heading	S
Gibraltar	17 º 31.509'	63 º 0.004'	heading	S
S. of Corre Corre	17 º 28.950'	62 º 56.742'	17 º 29.112'	62 º 56.890'
Barracuda Reef (drift)	17 º 27.974'	62 º 59.472'	17 º 28.088'	62 º 59.495'
N. Harbor	17 º 28.890'	62 º 59.652'	17 º 29.914'	62 º 59.617'
Aquarium	17 º 30.351'	63 º 0.364'	tour	-
Drop Off West	17 º 27.673'	62 º 58.528'	heading	W, SW
Charles Brown	17 º 27.864'	62 º 59.648'	tour	-
Twin Sisters (drift)	17 º 31.016'	63 º 0.0841'	17 º 31.556'	62 º 59.948'
Humps	17 º 27.809'	62 º 58.680'	heading	S
S. Zeelandia	17 º 30.435'	62 º 58.088'	17 º 30.486'	62 º 58.117'
N. Zeelandia	17 º 30.884'	62 º 58.656'	17 º 31.012'	62 º 58.761'
N. Corre Corre	17 º 29.257'	62 º 56.455'	17 º 29.454'	62 º 56.615'
English Quarter	17 º 30.243'	62 º 57.669'	17 º 30.340'	62 º 57.727'
Five Fingers (drift)	17 2 º 7.898'	62 º 58.996'	17 º 27.161'	62 º 59.321'
The Cave	17 º 30.662'	62 º 58.740'	17 º 30.924'	62 º 58.802'
W. Whitewall	17 º 27.733'	62 º 57.711'	17 º 27.722'	62 º 58.009'
Doobie's Crack	17 º 30.609'	63 º 0.517'	17 º 30.675'	63 º 0.480'
North Man	17 º 31.5298'	62 º 59.502'	17 º 31.608'	62 º 59.750'
E. Whitewall	17 º 27.944'	62 º 57.054'	17 º 27.888'	62 º 57.158'
Atlantic	17 º 29.830'	62 º 57.181'	17 º 29.129'	62 º 57.391'
Zeelandia Bay	17 º 30.354'	62 º 58.388'	17 º 30.480'	62 º 58.530'
Anchor Point S.	17 º 27.865'	62 º 59.200'	heading	E
Blue Bead Hole	17 º 28.617'	62 º 59.662'	heading	SE
Triple Wreck	17 º 28.750'	62 º 59.660'	heading	SW, tour
Stingray City	17 º 28.742'	62 º 59.557'	tour	-

Appendix II – Data Sheet

Turtle In-Water Survey Form

Observer: Weather Condition: Visibility:		Date Time Sea Condition Water Temp:
Species:	Green Hawksbill	Loggerhead Leatherback
Size:	< 10cm 10 – 50cm	50 – 100cm > 100cm
Tail extend >15cm beyond shell?		
Yes		No
Condition:		
Alive	Injured	Dead
Describe injury:		
Ectobiota :	Remora Barnacles	Algae
Distance from turtle	< 3m 3 – 5m	5 – 10m > 10m
Where was the turtle?		
Surface	Bottom	Water column
Depth seen:		
Turtle Activity:		
Resting Eating		Swimming Mating
Environment:		Wreck
Sand Coral Reef		Sea Grass Other
Tags present?		
Yes	No	Unsure