Micronesica 37(1):97-118, 2004

Green Turtles and Their Marine Habitats at Tinian and Aguijan, with Projections on Resident Turtle Demographics in the Southern Arc of the Commonwealth of the Northern Mariana Islands

Steven P. Kolinski[1], Larry Itibus Ilo[2] and John M. Manglona[2]

[1]*Department of Zoology, University of Hawaii*
2538 The Mall, Edmondson 152, Honolulu, HI 96822

[2]*Division of Fish and Wildlife, Department of Lands and Natural Resources,*
P.O. Box 10007, Lower Base Area, Saipan, MP 96950

Abstract—An estimated 351 individual green turtles were observed via 448 sightings in 27 surveys covering roughly 59% of the total shore and outer reef perimeter of Tinian, Commonwealth of the Northern Mariana Islands. Fourteen green turtles were observed during tow surveys covering 95% of Aguijan's shore and reef perimeter. No other sea turtle species were sighted. Juvenile turtles of various sizes dominated in all surveyed environments, and observations of turtles with estimated straight carapace lengths below 45 cm suggested recent and continuing recruitment at both Tinian and Aguijan. Twenty-four species of algae noted as green turtle forage in other regions of the world were identified at Tinian in this and previous surveys.

Projections of turtle densities and abundances based on data from recent surveys of all southern-arc islands in the Commonwealth of the Northern Mariana Islands suggest the small uninhabited islands of Farallon de Medinilla and Aguijan sustain tens of turtles, while turtle numbers around the larger inhabited islands of Rota, Saipan and Tinian range from the very low to high hundreds. The Commonwealth portion of the southern arc is estimated to support between 1000 and 2000 mainly immature resident green turtles. Turtle density and abundance appear highest at Tinian despite its smaller size relative to Saipan and its apparent paucity of potential seagrass forage.

Introduction

The distribution and status of sea turtles at many Pacific island localities has yet to be determined, but is of concern as continuing human expansion and coastal development throughout the region has great potential to negatively impact local sea turtle populations through increased harvests, incidental catch, and the degradation of nesting and critical nearshore and pelagic habitats (see Lutcavage et al. 1997, Bjorndal 1997, NMFS & USFWS 1998a-d). The lack of specific island and archipelago information hinders efforts to understand not only local, but also the large-scale regional dynamics of turtle populations, and reduces the ability to effectively plan development and human activities to minimize impacts and to manage sustainable utilization of turtles as a resource.

Recent efforts to investigate and document sea turtle activities within the United States Commonwealth of the Northern Mariana Islands (CNMI) (McCoy 1997, Pultz et al. 1999, Kolinski et al. 1999, 2001, Dollar & Stefasson 2000, Ilo & Manglona 2001, 2002) provide preliminary baseline information that is relevant to estimating and understanding turtle demographics within the region. Such information is likely to be key to decision makers and managers as island populations and tourist development expands, and local public and political interest continues in gaining legal exemption under the U.S. Endangered Species Act to allow for traditional harvests of sea turtles (see McCoy 1997). Although far from complete, evidence to date suggests very limited turtle nesting on CNMI shores (Pritchard 1977, 1982, Johannes 1986, Wiles et al. 1989, 1990, D. Grout unpubl., McCoy 1997, Pultz et al. 1999, Kolinski et al. 2001). Anecdotal reports of turtles in nearshore marine habitats exist (Pritchard 1977, 1982, Johannes 1986, Wiles et al. 1989, 1990, McCoy 1997), however focused assessments of the resident sea turtle population(s) are only recently being made (Pultz et al. 1999, Kolinski et al. 1999, 2001, Dollar & Stefasson 2000, Ilo & Manglona 2001, 2002).

The present study expands the focus on assessing the status of resident green turtles *(Chelonia mydas)* and their habitats within CNMI waters. Data specific to the islands of Tinian and Aguijan are presented, and a summary of available information from known surveys within the region was used to construct a projection of present day turtle demographics for islands within the southern arc of the archipelago.

Study Area

The Mariana Archipelago has 15 islands and various submerged banks and is oriented south to north from 13º to 20º5'N and 144.5º to 146ºE (Figure 1). The Philippine Sea borders the western shores and the Pacific Ocean the east. Islands of the Marianas are located on two separate arcs. An inner, northern arc supports the volcanically active or recently active islands of Farallon de Pajaros (Uracas), Maug, Asuncion, Agrihan, Pagan, Alamagan, Guguan, Sarigan and Anatahan (the Northern Marianas). Islands on the frontal, southern arc are capped or surrounded by limestone terraces and include Farallon de Medinilla, Saipan, Tinian, Aguijan, Rota and Guam (the Southern Marianas; Wells & Jenkins 1988, Birkeland 1997). The archipelago is divided politically between the United States territory of Guam and the United States Commonwealth of the Northern Mariana Islands. Approximately 69,000 humans inhabited the CNMI as of 2000, with more than 99.99% found in the Southern Marianas, the vast majority living on Saipan (Evans et al. 2002).

Tinian Island

Tinian (15º00'N, 145º38'E) is a raised, relatively flat 102 km^2 limestone island reaching heights of 170 m (Figure 1; Eldredge 1983, Wells & Jenkins 1988). It is located 5 km southwest of Saipan and 9 km northeast of Aguijan. The majority of shoreline consists of low to high limestone cliffs with sea-level caverns, cuts, notches and/or slumped boulders, commonly bordered by intertidal benches (Doan et al. 1960, Eldredge & Randall 1980, Eldredge 1983). Thirteen beach areas have been defined (Pultz et al. 1999), 10 at west coast locations and 3 (one distinct and

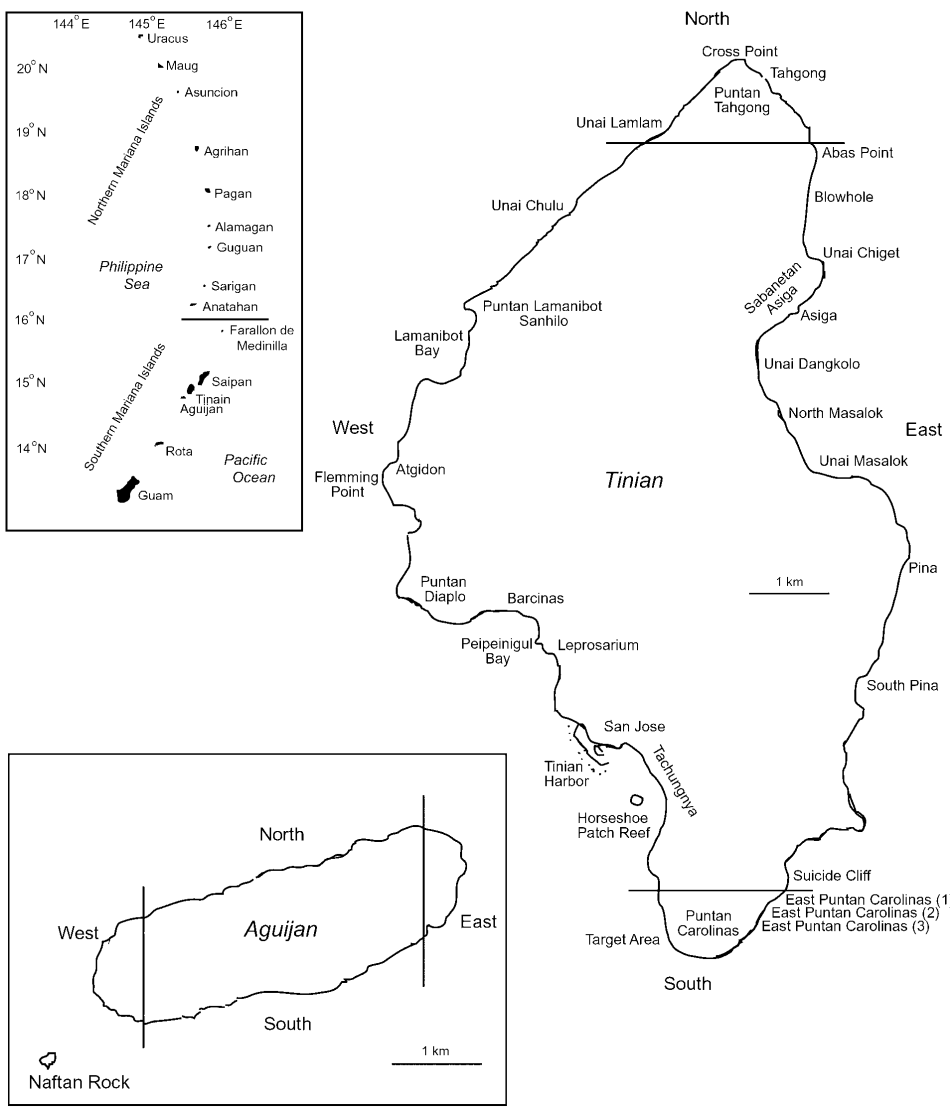

Figure 1: The Mariana Archipelago and Tinian and Aguijan Islands, CNMI

two discontinuous beach complexes) along the east coast. Beach deposits consist mainly of medium to coarse grain calcareous sands, gravel and rubble interspersed amongst exposed limestone rock (Doan et al. 1960). All beaches reportedly support turtle nesting activities (Wiles et al. 1989, Pultz et al. 1999).

The north, east, and south coasts of Tinian have very limited fringing or apron reef development that is most conspicuous at Unai Dangkolo (Doan et al. 1960, Eldredge & Randall 1980, Maragos 1985). Submarine topography is mainly characterized by limestone pavement with interspersed coral colonies and occasional zones of submerged boulders. Coral reef development is more prevalent at various west coast locations, with fringing coral reef habitats present inside Lamanibot and Peipeinigul Bays. A patch and small barrier reef system (altered as a breakwater for the harbor) is located within the Tinian Harbor area (Doan et al. 1960, Eldredge & Randall 1980, Eldredge 1983, Maragos 1985). Human development is concentrated mainly along the west coast at San Jose. The 2000 census identified 3540 residents (Evans et al. 2002). Tourism and agriculture are the main industries.

Aguijan Island

Aguijan (14º51'N, 145º34'E) is a raised, steeply cliffed, 168 m high, nearly flat-topped limestone plateau approximately 7.2 km^2 located 9 km southwest of Tinian (Figure 1; Eldredge 1983, Wells & Jenkins 1988). Its nearest neighbor to the southwest is Naftan Rock (1 km) and beyond that, 90 km to the south, is Rota. There are no sand beaches and bench development is limited (Eldredge & Randall 1980). Benthic topography is characterized by steeply sloping limestone pavement with scattered boulders and limited coral development around most of the island (Tsuda et al. 1971, Eldredge & Randall 1980, Maragos 1985, Randall 1985, Wells & Jenkins 1988). Along the east coast an 18 m deep pavement platform extends roughly 300 m offshore and contains scattered corals, grooves and sand deposits. Along the west coast a topographically diverse platform connects Aguijan to Naftan Rock. This platform is characterized by limestone rock, live coral and sand, and reaches depths of from nine to 18 m. There is no permanent human settlement on the island, however the nearshore waters are regularly fished by CNMI residents.

Methods

Sea Turtle Assessments

The nearshore marine habitats of Tinian were surveyed from 12–21 March 2001 by investigators of the University of Hawaii, the Saipan Division of Fish and Wildlife and the Tinian Department of Land and Natural Resources. Aguijan was surveyed on 20 March 2001. Various members of the community, including Department of Land and Natural Resources representatives, local fishermen and other local observers, provided information regarding notable sea turtle habitats believed worthy of investigation (which included most of the nearshore marine habitat surrounding Tinian Island). Methods for turtle and marine habitat assessments were similar to those described in Kolinski et al. (2001). Approximately 59% of Tinian's, and 95% of Aguijan's outer reef and shoreline perimeter were examined using one or more of the following three methods:

1. Tow surveys were conducted along portions of the north, south and the majority of the west coast of Tinian and all of Aguijan, as permitted by ocean conditions. Two boats (a 9.4 m Fountain and a 4.5 m Whaler) were used to survey parts of the north and west regions of Tinian. Two to three people using snorkeling gear were surface towed, with the Whaler surveying shallower environments maintaining distances from shore approximately 20 to 100 m, and the Fountain surveying deeper environments 30 to 50 m offshore of the Whaler. Surveyed depths ranged from two to roughly 70 m (estimated limit of visibility). When a turtle was sighted the boat was stopped and the species, size, sex (when discernable), activity, time, depth and habitat characteristics were relayed to a recorder on the boat. Latitude and longitude were noted at the location where each turtle was encountered using a Garmin hand-held GPS unit. In addition, observers on the boats searched the water's surface for turtle ascents, which were also recorded. Communication of turtle sightings between boats ensured multiple reports of individual turtles did not occur. Aguijan and part of southern Tinian were surveyed in a similar manner using only the 9.4 m Fountain.
2. In a single snorkeling survey four observers swam an imaginary transect along the perimeter of a Tinian patch reef maintaining observer distances of approximately 10 m in a straight line perpendicular to the transect. Turtle species, size, activity, time, depth and habitat characteristics were relayed to a single person for recording on underwater writing paper. Latitude and longitude at the beginning and end of the transect were recorded.
3. Surveys from the shoreline of nearshore waters were conducted mainly along the northeast, east, and southern coasts of Tinian that were inaccessible to the water-based methods. Observers sketched the shoreline and prominent submerged benthic features within their range of visibility. When a turtle was sighted on the surface or underwater, the time was noted and binoculars were used to identify species and estimate size. Features such as approximate length of tail and any identifying marks were recorded when observed. The estimated surfacing time and behavior of each turtle was noted when possible, and the location and/or route of each turtle was plotted on the map sketch and numbered. The location of each observer was measured using a GPS unit. Environmental conditions and location factors deemed relevant were recorded.

Visual estimates of straight carapace length were used to categorize turtles as juveniles (≤ 70 cm), juvenile/adults (70 cm < ≥ 90 cm) and adults (> 90 cm). Numbers of turtles were estimated for each transect by adjusting for re-sightings on the basis of an individuals distinguishing features (if any), time and specific locations and/or routes. These data were used to calculate estimates of total turtle abundance for each island by multiplying the mean number of turtles per kilometer from surveyed regions by total kilometers in similar non-surveyed areas, and then summing for each island. Estimates from single boat tow surveys were adjusted using a correction factor determined from multiple boat tow surveys (average % increase in turtles from deep water tows). Total island estimates were made for the five CNMI southern islands based on information from this and previous surveys (Kolinski et al. 1999, 2001, Dollar & Stefansson 2000, Ilo & Manglona 2001). These estimates were used to make a general projection of turtle abundance in the CNMI portion of the southern arc.

Assessment of Potential Sea Turtle Forage

Algae and seagrass samples were collected as a means to identify potential green turtle forage along five established west and east coast transects and from various areas along the south and west coasts of Tinian where assessable. Samples were not collected from Aguijan due to safety concerns and limited available time. All specimens were identified by Jennifer E. Smith (Department of Botany, University of Hawaii at Manoa, Honolulu, Hawaii). In addition, a literature review was conducted and a species list of potential green turtle forage was compiled, along with locations and references. Hirth (1997) was utilized as a guideline for listing only those species identified as turtle forage in other parts of the world.

Results

Tinian

An estimated 351 individual green turtles were observed via 448 sightings in 27 surveys covering roughly 59% of Tinian's 55 km of total shore and outer reef perimeter (Table 1). No other turtle species were sighted. Sixty-nine percent (242 turtles) of the turtles were juveniles, 17% (61 turtles) were categorized as juvenile/adult, and 11% (40 turtles) appeared to be of adult size. Size determinations could not be made for eight (2%) of the turtles. Numbers of turtles categorized by size and general location are shown in Figure 2. Juveniles predominated along all coastlines. The proportion of adults to other turtles was greatest along the south (14%) and west (13%) coasts. A minimum of 11 small juveniles with estimated straight carapace lengths (SCLs) below 45 cm was observed, suggesting recent recruitment to the resident population (see Zug et al. 2002).

Seven percent (24 turtles) of the turtles were observed at northern locations, 38% (134 turtles) at east coast sites, 17% (58 turtles) along the south coast, and 38% (135 turtles) within west coast habitats. Total projected numbers of turtles per kilometer for the entire perimeter of each region are shown in Table 2. Projected turtle densities along the east coast appear to be nearly 1.7 times that of the south, twice that of the north, and 4.6 times that of west coast habitat. Other than general differences in wind and current exposure (Jones et al. 1974) and the presence of a small barrier and patch reef and limited port and human development along the west coast, no major habitat differences were noted between island regions. Survey techniques did, however, differ between regions (Table 1). The

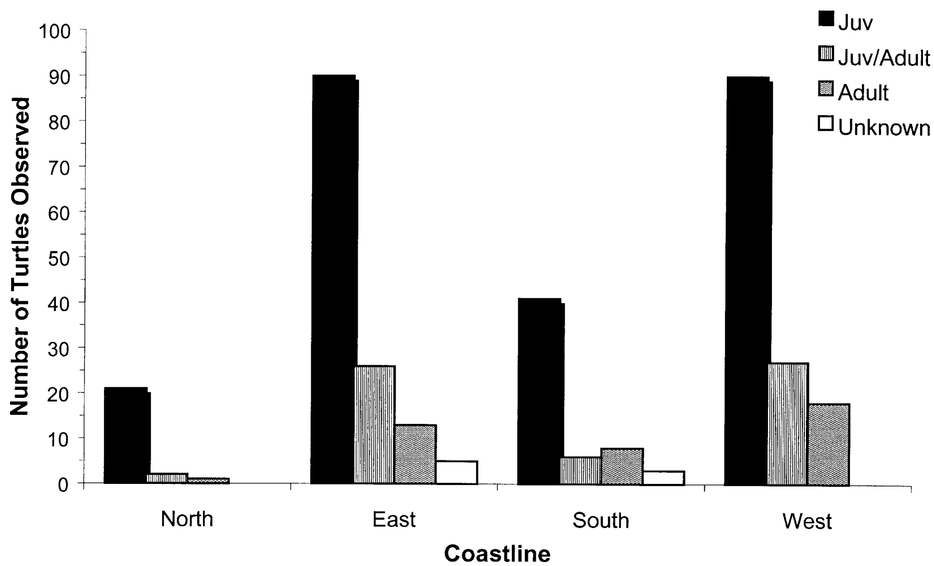

Figure 2: Estimated number of green turtles observed at Tinian Island categorized by size and location.

total number of green turtles inhabiting Tinian's nearshore environments was projected to be approximately 800 turtles.

Actual numbers of turtles observed and estimates of turtles per kilometer for each transect suggested multiple relatively high density turtle areas including Puntan Tahgong and Tahgong at north Tinian, all east sites surveyed (with the possible exception of Blowhole and Unai Masalok), East Puntan Carolinas (1), Target Area at Puntan Carolinas and the Target Area to N14º56.149 at south Tinian, and the reef area outside of Tinian Harbor, Leprosarium and Barcinas, and Puntan Lamanibot Sanhilo, west Tinian (Table 1).

AGUIJAN

Only 14 individual green turtles were observed at Aguijan during tow surveys covering approximately 95% of Aguijan's roughly 13 km of total shore and outer reef perimeter (Table 3). No other turtle species were observed. Twelve of the 14 turtles (86%) were juveniles and the remaining two turtles (14%) were classified as adults. Six of the turtles were very small with at least two having estimated SCLs below 45 cm. Twenty-nine percent of the turtles were located on both north and east sides of the island (4 turtles each), while 21% (3 turtles each) were encountered in south and west side environments.

Total projected numbers of turtles per kilometer for the entire perimeter of each region of Aguijan are shown in Table 4. Both observed and projected turtle densities were low and differed little between general island regions. The total number of green turtles inhabiting Aguijan's nearshore environment at the time of the survey was projected to be a mere 20 turtles.

Table 1: Observations of green turtles, *Chelonia mydas*, at Tinian Island, CNMI. (* = numbers not included in final sum as likely noted in repetitive surveys.)

Site	Date	Max. Time (hrs:mins)	Method	Transect Length (km)	Number of Observations					Estimated Number of Turtles Observed					
					Juv.	Juv./ Adult	Adult	Unknown	Total	Juv.	Juv./ Adult	Adult	Unknown	Total	Turtles per km
North Tinian															
Puntan Tahgong to Lamlam (northwest)	03/15/01	0:45	DoubleTow	2.45	1	0	0	0	1	1	0	0	0	1	0.4
Puntan Tahgong (Cross Point)	03/16/01	1:30	Shoreline	0.30	10	1	2	0	13	8	1	1	0	10	33.3
Tahgong (northeast)	03/19/01	1:16	Shoreline	0.44	18	1	0	0	19	12	1	0	0	13	29.5
Subtotal:		3:31		3.19	29	2	2	0	33	21	2	1	0	24	7.5
East Tinian															
Abas Point, Sabanetan Tahgong	03/16/01	1:40	Shoreline	0.44	11	6	0	5	22	8	6	0	4	18	40.9
Blowhole, Sabanetan Chiget	03/17/01	1:16	Shoreline	0.15	4	0	0	1	5	3	0	0	1	4	26.7
Sabanetan Asiga	03/16/01	1:15	Shoreline	0.40	6	3	3	0	12	6	2	2	0	10	25.0
North Masalok	03/19/01	1:15	Shoreline	0.63	12	1	1	0	14	11	1	0	0	12	19.2
Unai Masalok	03/18/01	1:15	Shoreline	0.16	2	0	0	0	2	2	0	0	0	2	12.5
Pina	03/19/01	1:31	Shoreline	0.86	50	2	3	0	55	28	2	2	0	32	37.2
South Pina	03/21/01	1:20	Shoreline	1.32	34	18	12	0	64	25	14	7	0	46	34.8
Suicide Cliff	03/13/01	1:37	Shoreline	0.80	9	2	3	0	14	7	1	2	0	10	12.5
Subtotal:		11:09		4.76	128	32	22	6	188	90	26	13	5	134	28.2
South Tinian															
East Puntan Carolinas (1)	03/17/01	1:25	Shoreline	0.22	5	1	2	2	10	3	0	2	2	7	31.8

East Puntan Carolinas (2)	03/17/01	1:18	Shoreline	0.22	1	0	0	0	1	1	0	0	0	1	4.5
East Puntan Carolinas (3)	03/12/01	0:50	Shoreline	0.22	1	0	0	0	1	1	0	0	0	1	4.5
Target Area, Puntan Carolinas	03/13/01	1:20	Shoreline	0.52	35	5	10	1	51	24	4	6	1	35	67.3
Target Area to N14º56.149 Puntan Carolinas	03/14/01	0:53	SingleTow	1.27	12	2	0	0	14	12	2	0	0	14	11.0
Subtotal:		5:46		2.45	54	8	12	3	77	41	6	8	3	58	23.7
West Tinian															
N14º56.149 Puntan Carolinas to Horseshoe Patch Reef	03/14/01	0:40	SingleTow	1.41	3	0	0	0	3	3	0	0	0	3	2.1
Horseshoe Patch Reef	03/14/01	1:00	Snorkle	1.14	3	0	2	0	5	3	0	2	0	5	4.4
Inner Tinian Harbor	03/14/01	0:05	Boat	0.93	3	0	0	0	3	2	0	0	0	2	2.2
Inner Tinian Harbor	03/15/01	0:05	Boat	*0.93	0	1	0	0	1	*0	*1	*0	*0	*1	
Inner Tinian Harbor	03/20/01	0:05	Boat	*0.93	1	0	0	0	1	*1	*0	*0	*0	*1	
Outside Tinian Harbor	03/14/01	0:41	DoubleTow	2.48	19	7	8	0	34	19	7	8	0	34	13.7
Leprosarium and Barcinas	03/14/01	1:32	DoubleTow	3.03	29	14	6	0	49	29	14	6	0	49	16.2
Puntan Lamanibot Sanhilo to Puntan Diablo	03/15/01	2:41	DoubleTow	9.63	29	4	0	0	33	29	4	0	0	33	3.4
Flemming Point	03/13/01	1:18	Shoreline	*0.36	2	0	0	0	2	*2	*0	*0	*0	*2	5.6
Puntan Lamanibot Sanhilo	03/13/01	1:15	Shoreline	*0.57	5	1	4	0	10	*5	*1	*2	*0	*8	14.0
Lamlam to Puntan Lamanibot Sanhilo	03/15/01	0:51	DoubleTow	4.98	5	2	2	0	9	5	2	2	0	9	1.8
Subtotal:		10:13		23.58	99	29	22	0	150	90	27	18	0	135	5.7
TOTALS:		30:39		33.97	310	71	58	9	448	242	61	40	8	351	10.3

Table 2: Projected green turtle densities and abundance for Tinian Island.

Region	Total Perimeter (km)	Estimated No. Turtles Observed	Perimeter Surveyed (%)	Projected No. Turtles / km	Total Projected No. Turtles
North	4.35	24	73.3	13.9	60
East	20.90	134	22.8	26.6	555
South	4.50	58	54.4	16.0	72
West	24.83	135	88.7	5.8	145
Total:	54.58	351	59.4	15.2	832

Table 3: Observations of green turtles, *Chelonia mydas*, at Aguijan Island, CNMI.

Region	Date	Max. Time (hrs:mins)	Method	Transect Length (km)	Number of Observations Juv.	Juv./Adult	Adult	Total	Turtles per km
North	03/20/01	1:07	Tow	3.69	4	0	0	4	1.1
East	03/20/01	0:44	Tow	2.56	2	0	2	4	1.6
South	03/20/01	0:57	Tow	3.63	3	0	0	3	0.8
West	03/20/01	0:22	Tow	2.16	3	0	0	3	1.4
	Total:	3:10		12.04	12	0	2	14	1.2

Table 4: Projected green turtle densities and abundance for Aguijan Island.

Region	Total Perimeter (km)	Estimated No. Turtles Observed	Perimeter Surveyed (%)	Projected No. Turtles / km	Total Projected No. Turtles
North	3.69	4	100	1.4	5
East	2.56	4	100	2.1	5
South	3.63	3	100	1.1	4
West	2.76	3	78.3	1.8	5
Total:	12.64	14	95.3	1.5	19

Table 5: Size distributions of green turtles, *Chelonia mydas*, at CNMI southern arc islands.

Island	No. Turtles	Percentage of Turtles Observed Juv.	Juv./ Adult	Adult	Unknown	Reference
Farallon de Medinilla	9	100	0	0	0	Dollar and Stefansson (2000)
Saipan	169	60	22	12	6	Kolinski et al. (1999, 2001)
Tinian	351	69	17	11	2	This study
Aguijan	14	86	0	14	0	This study
Rota	56	77	9	14	0	Ilo and Manglona (2001)
Total:	599	68	17	12	3	

Summaries and Projections for CNMI Southern Arc Islands

Presuming limited migration between islands occurred, 599 individual green turtles have been observed in surveys at the five CNMI southern arc islands between 1999 and 2001 (Table 5). Overall, juvenile turtles have accounted for 68% of the turtles observed, juvenile/adults for 17%, and adult-sized turtles for 12%, with sizes of 3% of the turtles remaining unclassified. Juveniles dominated in all island surveys and their relative proportions were significantly negatively correlated with total island and reef perimeters (Pearson's $r = -0.9571$, $P = 0.0106$; see Table 6 for perimeter estimates). The proportion of adult-sized turtles was below 15% for all islands and was not significantly related to island and reef circumference (Pearson's $r = 0.5032$, $P = 0.3875$).

Total projected numbers of turtles per kilometer for the perimeters of each island are shown in Table 6. Projected densities and abundances are highest for the large islands of Tinian and Saipan and are comparatively low for Rota,

Table 6: Projected green turtle densities and abundances at CNMI southern arc islands. Calculations for Farallon de Medinilla, Saipan and Rota based on data from Dollar and Stefansson (2000), Kolinski et al. (1999, 2001) and Ilo and Manglona (2001).

Island	Total Perimeter (km)	Estimated No. Turtles Observed	Perimeter Surveyed (%)	Projected No. Turtles / km	Total Projected No. Turtles
Farallon de Medinilla	6.7	9	94.6	1.5	10
Saipan	75.2	169	47.7	7.6	574
Tinian	54.6	351	59.4	15.2	832
Aguijan	12.6	14	95.3	1.5	19
Rota	50.1	56	94.4	1.8	92
Total:		599			1527

Table 7: Tinian marine algae listed by Hirth (1997) as green turtle forage.

Classification	Location and Reference
Chlorophyta	
Bryopsis pennata	Horseshoe Patch Reef[3], Tachungnya region[3], West Tinian
Caulerpa cupressoides	Unai Chiget[4], Unai Dangkolo[4], East Tinian Tachungnya region[3], Peipeinigul Bay[1], West Tinian
Caulerpa racemosa	Unai Dangkolo[1, 4], Unai Masalok[4], East Tinian Puntan Carolinas Target Area[4], South Tinian Horseshoe Patch Reef[3, 4], Inside San Jose Harbor[1, 4], Peipeinigul Bay[1], Atgidon[2], West Tinian
Caulerpa sertularioides	Inside San Jose Harbor[1], Peipeinigul Bay[1], West Tinian
Caulerpa urvilliana	Unai Dangkolo[1], East Tinian
Codium arabicum	Cave Beach[2], West Tinian
Codium edulae	San Jose Harbor Entrance[4], Barcinas Region Peipeinigul Bay[4], Puntan Lamanibot Sanhilo[4], West Tinian
Dictyosphaeria cavernosa	Puntan Masalok[2], East Tinian Inside San Jose Harbor[1], Atgidon[2], Unai Chulu[4], West Tinian
Dictyosphaeria versluysii	Unai Dangkolo[1], East Tinian Horseshoe Patch Reef[3], Tachungnya region[3], Outside San Jose Harbor[1], Peipeinigul Bay[1], Atgidon[2], Lamanibot Bay[1], West Tinian
Ulva lactuca	Tachungnya region[3], West Tinian
*Valonia aegagropil*a	Tachungnya region[3], West Tinian
Phaeophyta	
Hydroclathrus clathratus	Inside San Jose Harbor[1], West Tinian
Padina australis	Unai Chiget[4], East Tinian
Turbinaria ornata	Horseshoe Patch Reef[3], Peipeinigul Bay[1], Atgidon[2], Unai Chulu[4], West Tinian
Rhodophyta	
Acanthophora spicifera	Unai Dangkolo[4], East Tinian Inside San Hose Harbor[4], West Tinian
Amansia glomerata	Atgidon[2], West Tinian
Centroceras clavulatum	Tachungyna region[3], Peipeinigul Bay[1], West Tinian

Champia parvula	Outside San Jose Harbor[1], Unai Chulu[4], West Tinian
Gelidiella acerosa	Horseshoe Patch Reef[3], Tachungyna region[3], West Tinian
Halymenia floresia	Atgidon[2], West Tinian
Hypnea cervicornis	Horseshoe Patch Reef[3], Tachungyna region[3], Inside San Jose Harbor[1], Outside San Jose Harbor[1], Lamanibot Bay[1], West Tinian
Leveillea jungermannioides	Unai Chiget[4], Unai Dangkolo[1, 4], East Tinian San Jose Harbor Entrance[4], Unai Chulu[4], West Tinian
Spyridia filamentosa	Inside San Jose Harbor[1,4], Atgidon[2], West Tinian
Tolypiocladia glomerulata	Outside San Jose Harbor[1], Peipeinigul[1], West Tinian

[1] = Jones et al. 1974; [2] = Jones et al. 1974 with location identified by R. Tsuda pers. comm.; [3] = Sonoda 1990; [4] = present study.

Aguijan and Farallon de Medinilla. Turtle densities at Tinian are estimated to be twice that of Saipan and nearly an order of magnitude greater than Rota, Aguijan and Farallon de Medinilla. The estimated abundance of Tinian turtles is 1.4 times that of Saipan, 9 times that at Rota, 44 times that at Aguijan and 83 times that at Farallon de Medinilla. Island and reef perimeter were not significantly correlated with projected turtle densities (Pearsons r = 0.5981, P = 0.2867) or abundance (Pearson's r = 0.7414, P = 0.1493). Roughly 1500 green turtles are estimated to inhabit nearshore environments of the surveyed southern arc islands. Suggested resident green turtle population structures based on projected abundances and size distributions are presented in Figure 3.

Algae and Seagrasses Identified in Tinian's Nearshore Environment

A compilation of data from this and previous seagrass and algae surveys indicated the presence of at least 24 species of algae that have been identified as green turtle forage in other parts of the world (Table 7). Eleven (46%) of the species are Chlorophytes, 3 (13%) are Phaeophytes, and 10 (42%) are Rhodophytes. Eight (33%) of the species were located at east coast survey areas, one species (4%) at a south coast site, and 22 (92%) were noted along the west coast.

The presence of seagrasses in Tinian's nearshore environment is limited. Small beds of *Enhalus acoroides* exist in the narrow embayment at Unai Chiget (Eldredge & Randall 1980, pers. obs., see also Fosberg et al. 1987 and Tsuda & Kamura 1990). *Halophila minor* was identified in localized patches inside Tinian/San Jose Harbor by Jones et al. (1974, see also Maragos 1985, Tsuda & Kamura 1990). However, neither species is reported by Hirth (1997) to have been identified in the diet of green turtles (though *Halophila* is listed and might be expected to be utilized, G. Balazs, pers. communication).

Pertinent literature examined made no reference to seagrass or algae species which likely serve as green turtle forage in Tinian's north and south coast nearshore areas (Jones et al. 1974, Gilbert 1978, Itono 1980, Tsuda & Wray 1977,

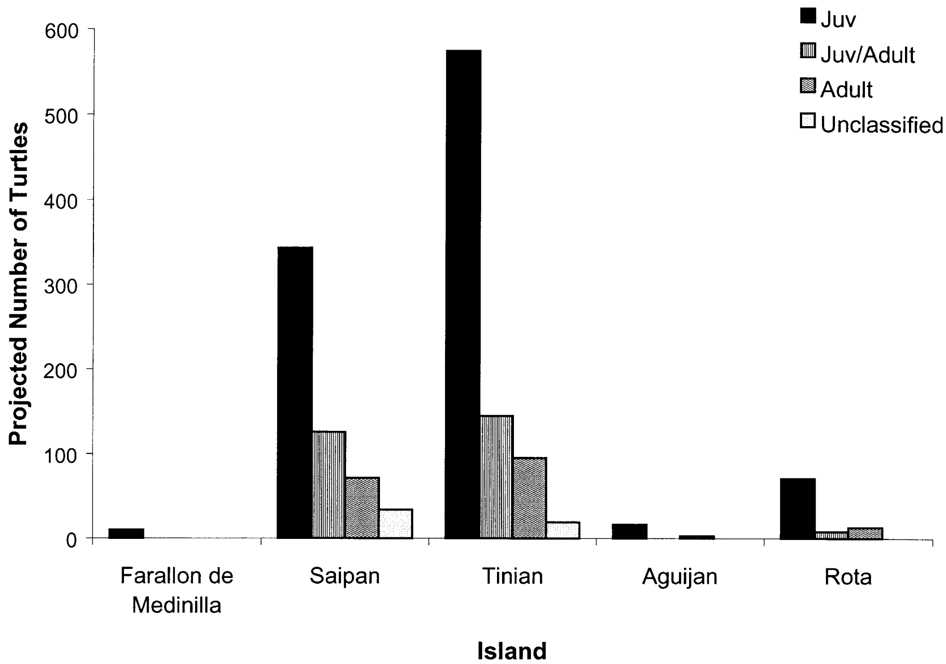

Figure 3: Projected population structures of *Chelonia mydas* at surveyed CNMI southern arc islands.

Tsuda et al. 1977, Eldredge & Randall 1980, Tsuda 1981, Fosberg et al. 1987, Tsuda 1988, Tsuda & Kamura 1990, Sonoda 1990). Algae were collected from none of the north coast transects, and only one south coast site in this survey. No listings of relevant algae collections from Aguijan were found.

Discussion

There are four species of turtles *(Chelonia mydas, Eretmochelys imbricata, Dermochelys coriacea,* and *Lepidochelys olivacea)* previously reported from CNMI southern-arc waters (Pritchard 1982, NMFS & USFWS 1998a, 1998c), but observations of the green turtle predominate in recent years (Pultz et al. 1999, Kolinski et al. 1999, 2001, Dollar & Stefansson 2000, Ilo & Manglona 2001, this study). Hawksbill turtles were not observed at Tinian, Aguijan or Saipan (Kolinski et al. 2001) in recent surveys, but have sporadically been seen at Farallon de Medinilla (John Naughton pers. comm.), may have recently been observed at Rota (Ilo & Manglona 2001), and may occur in relatively high numbers around islands within the northern arc of the archipelago (Ilo & Manglona 2002). The apparent paucity of hawksbill turtles in southern-arc waters is discouraging given their highly endangered worldwide status (NMFS & USFWS 1998b). There is, however, no evidence to suggest this species occurred in high numbers in this region in the past (McCoy 1997, Kolinski et al. 2001, see also Wiles et al. 1990). While green turtles may be common to certain CNMI southern-arc waters, hawksbills should presently be classified as rare. Leatherback presence within the region is pelagic and transient (NMFS & USFWS 1998c), and olive ridelys are presumed to be transients or waifs (see NMFS & USFWS 1998d).

The findings at Tinian and Aguijan correspond well with reported local observations of relative turtle abundance and distributions (Kolinski 2001). However, it is important to impress that error associated with the estimates and projections in these surveys is difficult to ascertain without replication of transects, strict comparisons of differing methodologies and determination of error associated with each method in different habitats. Undoubtedly the estimates presented would benefit greatly if combined with long-term tagging/marking studies. Nevertheless, some understanding of turtle demographics within the region is gained. In general, the small uninhabited islands of the CNMI southern arc appear to support tens of turtles, turtle numbers around the larger inhabited islands range from the very low to high hundreds, while the CNMI portion of the southern arc likely supports between 1000 and 2000 resident turtles. Estimates of turtle numbers in the remainder of the archipelago, including Guam and islands of the northern arc are, for the most part, lacking. Resident turtles (Prichard 1982, Eckert 1993, McCoy 1997, Ilo & Manglona 2002) and various types of potential forage (e.g. Taylor 1964, 1966, Tsuda 1981, 1982, 1988, Tsuda & Tobias 1977a, 1977b, Tsuda & Wray 1977, Tsuda et al. 1977, Fosberg et al. 1987, Tsuda & Kamura 1990) have been noted at these localities.

The predominance of juveniles at each of the five islands is interesting and in need of further investigation through direct tagging and measurement of turtles. The structure of resident green turtle populations in other areas of the world varies and includes populations which are overwhelmingly juvenile, those which are well mixed, and some which are primarily adult (reviewed by Hirth 1997). The absence of equitable numbers of adults in this survey may reflect size-age-survivorship relationships, migration of breeding adults to distant home rookeries, and/or differential distributions of size classes into different habitats amongst the islands. Anatahan Island, CNMI, for example, has been reported to host proportionately high numbers of large, presumably adult, green turtles (McCoy 1997, Ilo & Manglona 2002). Observations of turtles estimated to be below 45 cm in SCL suggest recent recruitment to the Tinian and Aguijan resident turtle population(s). A predominance of juveniles of various sizes supports a conclusion of recurrent recruitment.

A comparison of turtle distributions within and between Tinian and Saipan (see Kolinski et al. 2001) in relation to the types of forage available, in combination with direct observations of turtle feeding at Tinian (Kolinski 2001) and reported seagrass and relevant algae distributions within the CNMI (e.g. Tsuda 1969, 1981, 1982, 1988, Jones et al. 1974, Tsuda & Tobias 1977a, 1977b, Tsuda & Wray 1977, Tsuda et al. 1977, Fosberg et al. 1987, Randall & Smith 1988, Smith et al. 1989, Tsuda & Kamura 1990, Sonoda 1990, Kolinski et al. 2001), strongly suggests that marine algae act as the predominant source of nutrition for the majority of green turtles within the region (note: the extent of animal matter in CNMI green turtle diets is, perhaps wrongly, presumed to be minimal; see Bjorndal 1997, Hirth 1997). Although migration to west Saipan or Guam seagrass pastures is possible, such activity by high numbers of turtles would undoubtedly be observed and no reports of such have been encountered. In addition, studies on resident turtles in other Pacific populations suggest long-term site fidelity to local resting and foraging areas having sizes on the order of two to tens of km^2 (Balazs 1980, 1982, Balazs et al. 1987, Limpus et al. 1994, Musick & Limpus 1997). Diets consisting primarily of algae are quite common for green turtles in other areas of the world (reviewed by Mortimer 1982, Bjorndal 1997, Hirth 1997). However, this doesn't negate a role for seagrasses in CNMI green turtle ecology. Examination of the stomach contents from a single deceased turtle located in Tanapag lagoon on Saipan's west shore found nearly 100% of the locally abundant seagrass *Halodule uninervis* with only trace elements of the algae species *Acanthophora spicifera* and *Acrochaetium* sp. (identified by Dr. Dennis J. Russell, American University of Sharjah, United Arab Emirates). In addition, examination of cropped blades in *Halodule uninervis* pastures in Garapan lagoon Saipan suggested green turtle feeding on this seagrass (pers. obs.). A potential to migrate to alternative habitats as size increases (see Hirth 1997) may mean that, over time, various turtles may be in a position to utilize CNMI seagrass resources. Bjorndal (1997) indicates that the adaptation of gut microbial communities to either algae, seagrass or some combination of both may influence diet selection but is not likely to overwhelm optimal foraging strategy. Turtles likely feed selectively on what is locally available, and distributions of turtles may be driven primarily by availability and proximity of suitable foraging and resting habitats (see Balazs et al. 1997), the conditions of which may be subject to change with time.

It is presently difficult to explain the contrast in projected turtle densities and abundances between CNMI islands in the southern arc. Turtle numbers at inhabited islands do appear highest along the east coasts (This study, Kolinski et al. 2001, Ilo & Manglona 2001) corresponding to relatively lower levels of human access and development. However, human numbers do not appear to be related to overall projected turtle densities or abundances at surveyed islands within the archipelago. In addition, island/reef perimeter is not significantly correlated with turtle densities or abundance. Rota and Tinian stand in greatest contrast. These islands are of similar size and support similar numbers of human inhabitants. However, the projected number of turtles at Tinian is almost an order of magnitude greater than the estimate for Rota. Low numbers and densities of turtles at the uninhabited islands of Farallon de Medinilla and Aguijan suggest factors other than island size and human habitation need be considered (G. Balazs, pers. communication, notes that some of the most dense aggregations of resident green turtles in the Hawaiian Islands occur where human concentrations are highest). Differences in food availability, habitat availability and preference, predator concentrations (including concentrations of human hunting), and/or relative exposure to recruitment, may act to determine distributions and thus confound any potential relationship that exists between levels and types of human development and nearshore turtle abundance. Yet even Farallon de Medinilla (a military bombardment range) and Aguijan (reportedly subject to turtle poaching) are not immune from human disturbance. Unfortunately, the number of islands surveyed within the region is too few. Full-scale assessments of resident turtles and habitats at Guam and islands in the northern arc may provide the data necessary to statistically examine regional human and turtle density relationships along with other potentially relevant factors.

The size of the resident green turtle population(s) at Tinian and Saipan greatly contrasts with the number of turtles believed to nest at these islands (Wiles et al. 1989, Pultz et al. 1999, Kolinski et al. 2001). Given the apparent status of all sea turtle species in the area, the suggestion that Rota supports few nesting turtles (Wiles et al. 1990, McCoy 1997, Ilo & Manglona 2001), and that beaches on Farallon de Medinilla and islands of the northern arc may be unsuitable for turtle nesting (McCoy 1997, Dollar & Stefasson 2000, Ilo & Manglona 2002), the CNMI as it relates to turtles might presently be classified as primary green turtle foraging habitat (modest) with a minor green turtle nesting component. Such classification in no way diminishes the importance of CNMI nesting habitat, but it does highlight a direction for future investigative focus.

The criteria for down-listing a sea turtle species from protected status for any geographic region covered under the U.S. Endangered Species Act of 1973 mandate an extensive understanding of local and regional turtle abundances, dynamics and habitat characteristics, with stable or increasing trends in population numbers (NMFS & USFWS 1998a, McCoy 1997; see Doremus & Pagel 2001 for issues concerning necessary background law). Repetition and expansion of surveys focusing on resident turtles and their marine habitats throughout the CNMI will thus be critical to determining the CNMI's status with regards to resident green turtle population "recovery". Localized concentrations of green turtles at Tinian and Saipan (Kolinski et al. 1999, 2001) appear accessible and high enough to support long-term investigative research in the dynamics of local abundance, growth rates, food preference and utilization, local and long-range migration, and identification of the genetic structure of the resident turtle population(s). Access to the majority of the remaining CNMI islands, however, may limit monitoring of turtle status in the remainder of the archipelago to infrequent short-term surveys. Additional assessments will be necessary to estimate food abundance and habitat stabilities for all islands within the CNMI. These suggested processes will require a long-term commitment of expertise and funding, but may begin to address the current concerns of local residents: many of whom would like to see turtle numbers remain or increase, but who also dislike the legal prohibition on access to turtles as a resource, especially given that prohibition appears to have been based at least partially (whether aptly or not) on a very anecdotal understanding of local availability.

Acknowledgments

This research was supported by a contract (40JJNF000136) from the National Marine Fisheries Service, Southwest Fisheries Science Center Honolulu Laboratory. We extend our fondest appreciation to the following people who participated in one or more aspects of this project: George Balazs (Honolulu, NMFS), Frank Rasa (Saipan, DFW Conservation Officer), Henry King (Tinian, DLNR Conservation Officer), Alfonso Reyes (Tinian, DLNR Conservation Officer), Don Reyes (Tinian, DLNR Conservation Officer), Elvin Masga (Tinian, DLNR Conservation Officer), Jesse Pangelinan (Tinian, DLNR Conservation Officer), Jennifer E. Smith (Phycologist, University of Hawaii), Ray Aldan (Boating Safety), Gus Dusalua (Fire Rescue), Wayne Villagomez (Sergeant Boating Safety), Mayor Francisco M. Borja (Tinian), Councilman Tony Borja (Tinian), Senator David Cing (Tinian), Former Senator Henry San Nicholas (Tinian, Personnel), Director Richard Seman (Saipan, DFW), Resident Director Norman Manglona (Tinian, DLNR), Director Peter Cruz (Tinian, DPS), Jack Borja (Tinian, Gaming Commission), Joe San Nicholas (Tinian, Gaming Commission), Henry Cabrera (Tinian, DLNR Conservation Supervisor), Joe Ruak (Saipan, Information and Education Specialist, DFW), Jacinto Taman (Saipan, DFW Fisheries Officer), Mike Trianni (Saipan, DFW Fisheries Biologist), Raymond dela Cruz (Tinian, Volunteer), Evelyn Cox (Hawaii Institute of Marine Biology), Roy Tsuda (University of Guam), Dennis J. Russell (Phycologist, American University of Sharjah), Denise Parker (La Jolla, NMFS), Mike McCoy (Kona, Hawaii, Biologist and Fisheries Consultant), the staff of the Saipan Division of Fish and Wildlife, Tinian Department of Land and Natural Resources, and Tinian Department of Public Safety. All are acknowledged and thanked for their contributions and assistance.

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Received 17 Jan. 2003, revised 29 June.