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Migrations and Conservation Implications of Post-Nesting Green Turtles from Gielop Island, Ulithi Atoll, Federated States of Micronesia*

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Abstract— Post-nesting migrations of thirteen green turtles tagged at Gielop Island, Ulithi, Yap State, Federated States of Micronesia, were tracked by satellite transmitters in 2005-2007. Eight of the turtles traveled west to the Philippines with an average distance of 2600 km. One turtle migrated nearly 6000 km through Philippines and Vietnamese waters to Malaysia, and three migrated north to Japan. Consistent site transmissions exceeding 30 days suggest turtles had reached their feeding destinations. Results of satellite tracking data indicate substantial green turtle resource connectivity between Gielop Island nesting areas and Philippine and Japan feeding habitats, in support of previous flipper tag recoveries. Satellite telemetry offers the advantage of real time monitoring of turtle movements and migration, enhancing opportunities for public education and international cooperation in resource conservation and management.

Introduction

In Ulithi Atoll, Yap State, Federated States of Micronesia, green turtles (*Chelonia mydas*) are legally used as a protein-rich food source and have considerable cultural and natural resource value. Historically, Ulithi's traditional resource managers regulated access to and harvesting of green turtles on Ulithi islands by limiting access to sites where they predominantly nest (Lessa 1984). Gielop Island (Fig. 1) hosts the highest known concentrations of Ulithi's nesting turtles. In 1991, more than 400 turtles were tagged at Gielop (Kolinski 1995). Numbers tagged from 2005 through 2013 exceeded 400 turtles annually (Cruce, unpubl. data), suggesting Gielop and adjacent islands may constitute the largest remaining green turtle rookery within Micronesia.

Although resident turtles occur in Yap State waters (Kolinski, unpubl. data), most green turtles observed at Ulithi appear seasonally for nesting. Until recently, recovery of metal flipper tags provided the only means of identifying potential feeding areas for Ulithi's nesting turtles (Kolinski 1995; Miyawaki et al. 2000). Information provided by metal tag recoveries can be valuable and

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relatively inexpensive to achieve. However, large numbers of turtles need to be tagged to enhance the likelihood of tag recoveries, and uncertainty remains regarding migration routes taken to reach final feeding destinations.

In the Pacific, satellite telemetry is being used to better understand turtle migration paths, feeding grounds and resource connectivity (Balazs 1994; Balazs & Ellis 2000; Craig et al. 2004; Hatase et al. 2002, 2006; Limpus & Limpus 2001; Luschi et al. 2003; Polovina et al. 2006; Whiting et al. 2007; Parker et al. 2009), to help manage human-turtle interactions (Hays et al. 2003; but see Chaloupka et al. 2004; Kennett et al. 2004; Polovina et al. 2004, 2006) and to further promote turtle conservation through public education. Such satellite tagging efforts were extended to Ulithi Atoll, with results reported herein from 2005 through 2007.

Methods

Study Area

Gielop is an uninhabited island located in a small atoll locally referred to as Meteral, approximately 15 km east of Ulithi Atoll in Yap State, Federated States of Micronesia (Fig. 1; 9°56.837' N; 139°54.591' E). The island is roughly 0.07 km^2 in size and consists of a densely vegetated interior rimmed by coarse-grained sand and coral rock. Meteral and a nearby sub-marine ridge system support a cluster of five small islands just outside Ulithi Atoll that are traditionally referred to as "turtle islands". Gielop has been observed by indigenous people of Ulithi to host the largest numbers of green turtles nesting within the "turtle islands" region.

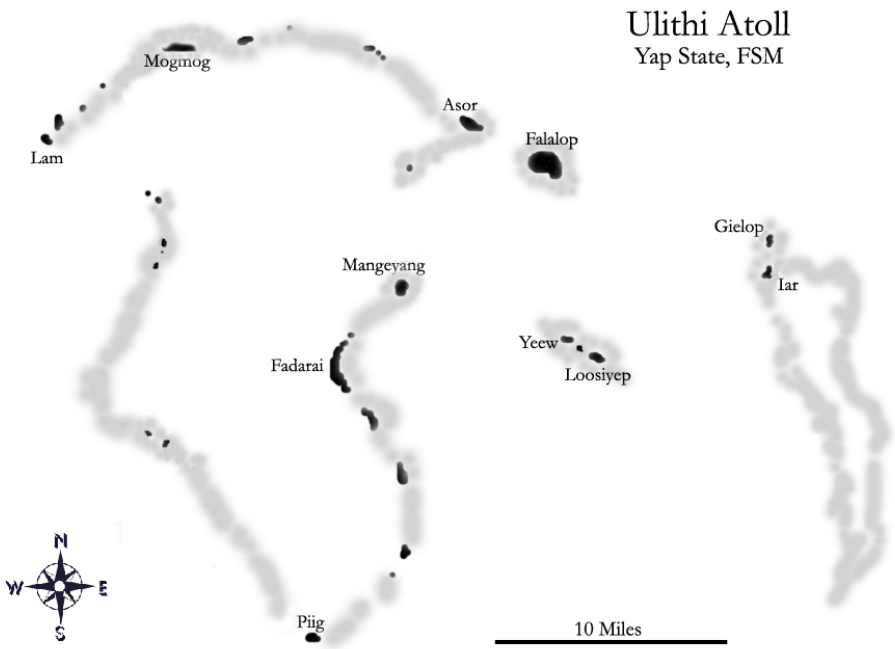

Fig. 1: Illustration of Ulithi Atoll, Yap State, Federated States of Micronesia (FSM).

SATELLITE TRANSMITTER DEPLOYMENT

Thirteen (13) Telonics ST-20 model A-1010 ARGOS-linked satellite transmitters (duty cycle 12 hr on, 48 hr off) were deployed on nesting green turtles in August 2005 (1), August 2006 (6), and August 2007 (6). Turtles were identified by two Titanium flipper tags and selected based on monitoring records that indicated turtles had nested multiple times to minimize damage to transmitters during internesting intervals. Transmitters were attached safely and securely with polyester resin and fiberglass to turtle carapaces using protocols described in Balazs et al. (1996) with slight modifications in 2005 to accommodate heavy rains and high humidity, which included using low heat to expedite the drying process. Mean turtle size was 105 cm curved carapace length (range 100–107 cm). All turtles appeared in excellent health prior to and during release.

Geographic positions of turtles and estimates of location accuracy were provided by Argos (CLS-America, Inc. 2007). Dive and temperature data were not collected. Turtle movements were determined by plotting the single, most accurate rated position (geographic coordinates) for each transmission cycle when available, with position data closest to noon being selected when multiple positions of "equivalent" accuracy existed. Location-accuracy classifications were based on positions of receiving satellites and the quantity of transmissions they received (CLS-America, Inc. 2007). Travel distances were measured in ESRI ArcMap® along plotted migration pathways with origin and destination site retention data removed. Mean travel speed was estimated along each migration pathway from date and point of rookery area departure to first point and date of arrival at presumed feeding grounds.

Results

Satellite-tagged turtles remained in the Ulithi region up to 37 days following tag deployment. Eight turtles migrated westward to the Philippines, one traveled an extended route through Philippine and Vietnamese waters to Malaysia, and three migrated north to Japan (Figs. 2, 3, 4). On average, these turtles traveled 2948 km at a rate of 50 km day^{-1} with transit times ranging from 41 to 110 days. The Malaysia-bound turtle traveled nearly 6000 km (Table 1). All tracked migrations led to coastal habitats. Consistent localized transmissions for periods exceeding 30 days suggest these turtles had reached destined feeding areas (Parker et al. 2009; Shaver et al. 2013). One turtle, named Malomel (ID #: 22181), did not depart the Ulithi region during 37 days of active transmission and may have continued to nest prior to migration (Table 1).

Discussion

Satellite telemetry suggests the Philippines and Japan are prominent feeding regions for green turtles that nest at Gielop Island, which is consistent with recoveries of flipper tags applied to turtles at Gielop in 1991 and 2009 (Table 2) (Kolinski 1995; Cruce, unpubl. data). The recent tracking and tag recoveries indicate that coastal habitats are scattered throughout the Philippines, including sites in the Sulu Archipelago close to the Philippines and Malaysia Turtle Island Heritage Protected Area (Document 2002), a prominent green turtle foraging and nesting region. Our telemetry also expands current knowledge of Yap State's international resource connectivity with inclusion of a turtle feeding area off peninsular Malaysia. These areas in Australasia appear to support a mix of genetically distinct green turtle populations (Dethmers et al. 2006). To date, post-nesting turtles in Yap State fitted with flipper tags and satellite transmitters have been recovered or tracked locally within Yap State and the Republic of Palau, and fairly distant in the Marshall Islands, Papua New Guinea (south across equatorial currents), Japan, Malaysia and the Philippines (Cruce, unpubl. data; Kolinski 1995; Miyawaki et al. 2000). Although data remain limited, green turtles from rookeries surveyed in western Yap State (Ngulu Atoll and Gielop Island) appear to migrate mainly to Philippine feeding areas. Recoveries of tags applied to turtles at eastern rookies (Olimarao and Elato Atolls) are less numerous and do not display a dominant foraging area pattern

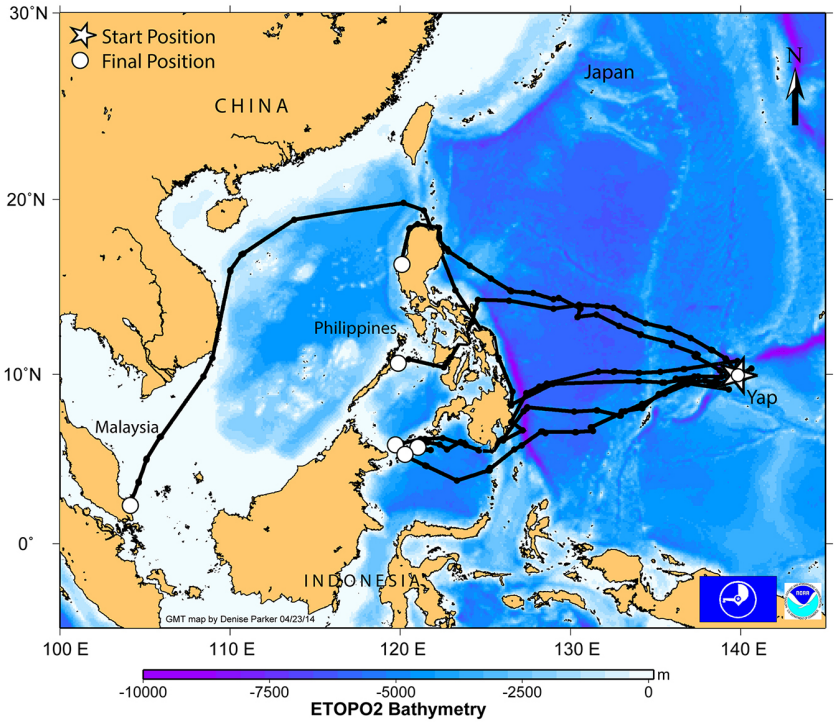

Fig. 2: 2005 and 2006 green turtle migration routes following nesting activities at Gielop Island as indicated by satellite telemetry.

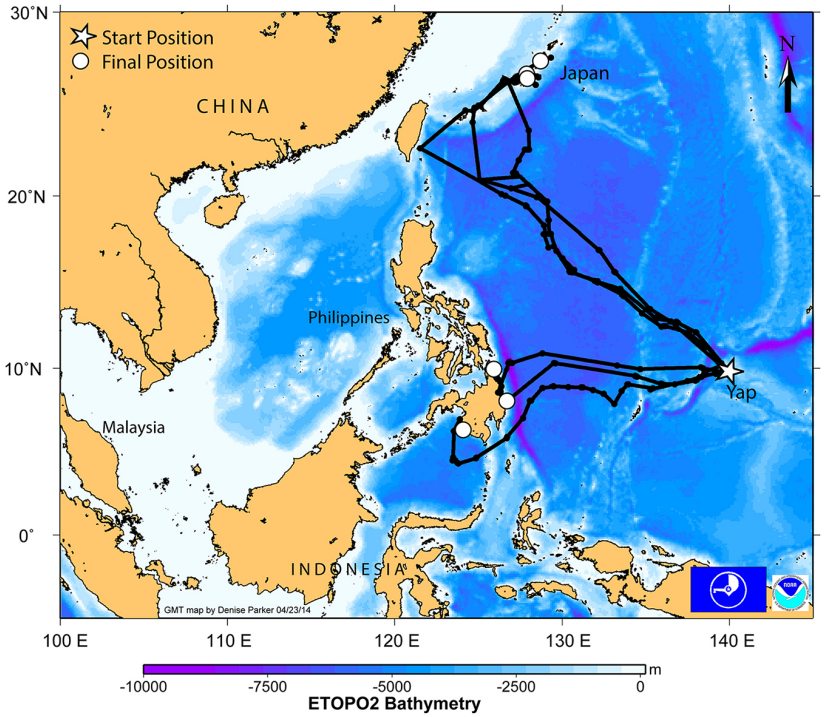

Fig. 3: 2007 green turtle migration routes following nesting activities at Gielop Island as indicated by satellite telemetry.

with localized or national concentration (see Tables 1 & 2; Kolinski 1995; Cruce unpubl. data).

Prolonged tracking of post-nesting turtles at apparent feeding grounds is critical to elucidating regions of potential residence. Site fidelity to specific feeding areas has been displayed by green turtles in Hawaii and Australia (Balazs and Chaloupka 2004; Limpus et al. 1992). However, there has been some suggestion that some migrating green turtles may pause to feed en route to resident feeding areas (Cheng 2000). Although one indirect migration route was observed, with a path west to the southern Philippines, north around the Philippines, then west and south through Vietnamese waters to Malaysia (Fig. 2), none of the turtles tracked from Gielop Island displayed evidence of prolonged pauses en route to their presumed feeding destinations. The satellite transmissions terminated so any substantial distances further traveled by these turtles, if they occurred, remain unknown. However, localized transmissions exceeding 30 days prior to signal termination indicate a potential importance of each coastal area identified to individual turtles and to the breeding population as a whole.

Our satellite tracking data clearly suggest that turtles nesting at Gielop Island use habitats on an international scale. In Ulithi, the migration information has greatly enhanced public interest in turtle research at Gielop Island, expanding opportunity for education and new views on conservation and management. Regionally, information on the migrations has been shared and formed some basis for discussion between Philippine, Malaysia, Japan and Federated States of Micronesia fisheries representatives. These informational outreach efforts should be broadened to include countries where exclusive economic zones were transited (Republics of Palau and Vietnam), particularly in relation to minimizing potential fisheries interactions. Additional research and outreach is needed to enhance our understanding and management of turtles as an international resource (Blumenthal et al. 2006; Kolinski 1995). Both the turtles and those who depend on them will benefit from collective resource stewardship in habitats highlighted by our migration data.

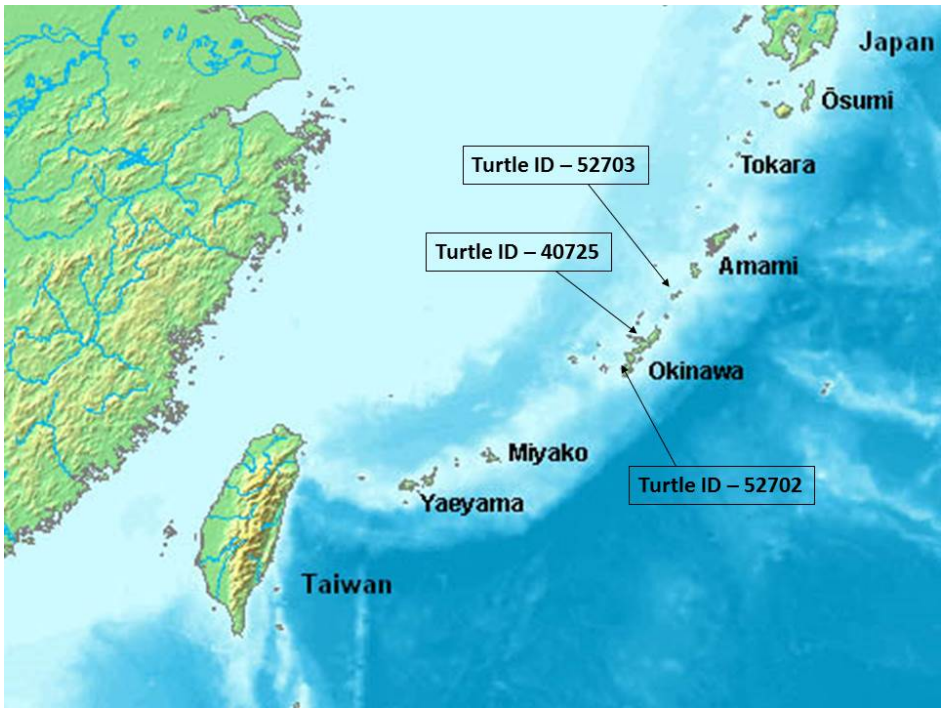

Fig. 4: Location of presumed foraging area in Ryukyu Islands, Japan for green turtles with turtle ID: 52703, 40725, and 52702.

Table 1. Migration data for post-nesting green turtles fitted with satellite tags at Gielop Island in 2005, 2006 and 2007. Shaded areas on the table indicates the turtle was located in or near a marine protected area. CCL = curved carapace length; Trans. = satellite tag transmission; *Transmissions from presumed feeding areas, n/a = not applicable, PPI = Philippines.

Turtle ID	Date Tagged	CCL (cm)	Total Trans. days	Maximum Days in Transit	Travel Distance (km)	Estimated Speed (km day^{-1})	Presumed Foraging Area	*Trans. Days Post - Arrival
53744	5 Aug. 2005	102	141	47	2475	53	Tawi-tawi Island, Sulu Archipelago, SW PPI	72
22278	4 Aug. 2006	104	109	44	2672	60	Pearl Bank, Sulu Archipelago, SW PPI	65
4807	4 Aug. 2006	100	150	42	2501	60	Cambingaan Island, Sulu Archipelago, SW PPI	86
22279	5 Aug. 2006	103	205	54	2639	49	Dumaran Island, Palawan, W PPI	151
4240	5 Aug. 2006	103	279	106	5940	56	Sibu Islands, Sibu Archipelago, SE Malaysia	148
4802	6 Aug. 2006	107	88	43	2636	61	Lingayen Gulf, Luzon, NW PPI	31
22181	6 Aug. 2006	103	37	n/a	n/a	n/a	Unknown	n/a
52700	8 Aug. 2007	111	215	110	2880	26	Panducan Island, Sulu Archipelago, SW PPI	90
52701	6 Aug. 2007	100	246	41	1905	46	Poneas Island, Surigao Del Norte, SE PPI	204
52702	3 Aug. 2007	105	394	93	3346	36	Okinawa Island, Ryukyu-Islands, Japan	301
52703	4 Aug. 2007	110	400	63	2783	44	Okinoerabu Island (Amami Islands), Ryukyu-Islands, Japan	337
52704	4 Aug. 2007	105	151	66	2519	38	Palimbang, Sultan Kudarat, SW PPI	85
40725	6 Aug. 2007	114	202	43	3085	72	Kouri Island (Okinawa Islands), Ryukyu-Islands, Japan	150
Average:		**105**	**215**	**63**	**2948**	**50**		**143**

Table 2: Metal tag returns associated with turtle monitoring activities in Yap State from 1991 (see Kolinski 1995) to 2009. PPI = Philippines, PNG = Papua New Guinea.

Original Date Tagged	Original Island Tagged	Tag numbers (RF/LF/PIT Tag)	Location (Island) Resighted	Approx. Distance (km)	Time since last sighting (days/date)
7/9/92	Ngulu Atoll	R3208/R3210	Camarines Norte, PPI	1690	84
7/14/92	Ngulu Atoll	R3220/R3221	Tawi-tawi, PPI	2020	< 217
2/29/91	Gielop Island	RMTP 641	South Cotabato, PPI	1700	212
7/30/91	Gielop Island	RMTP 704	Yap Island, Yap State	170	544
5/27/91	Gielop Island	RMTP 789	Majuro Island, Marshall Islands	3410	< 239
5/21/91	Gielop Island	RMTP 807	Camarines Norte, PPI	1950	139
8/01/91	Gielop Island	RMTP 885	Masbate, PPI	1840	279
6/04/91	Gielop Island	RMTP 898/P121	Northern Samar, PPI	1650	< 257
7/03/91	Gielop Island	RMTP 912	Suriago Del Norte, PPI	1550	530
5/14/90	Olimarao Atoll	X534/X535	Woleai Atoll, Yap State	200	912
8/02/92	Elato Atoll	R4048/R4049	Kavieng, PNG	1270	171
7/15/92	Elato Atoll	R4051/R4052	Woleai Atoll, Yap State	230	73
8/10/92	Elato Atoll	R4076/R4077	Quezon, PPI	2760	384
6/06/08	Gielop	R36975/R36974	Peleliu, Palau		536
7/16/09	Gielop	R45375/R41475	Palawan, PPI		109
6/18/09	Gielop	R45669/R45670/4B11172964	Lorengau, Manus Island, PNG	1578	427
2001	Barangay Porac, Botolan, Zambales, PPI	PH6236/PH6237/4A1065E0A	Gielop	2245	~2893
2002	Lihiman Island, Tawi-tawi, PPI	P3703/P3704/4A2F0C3E4B	Gielop	2020	~2615
2009	Yaeyama Islands, Japan	3575/R45628/R45629	Gielop	2305	~96

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