Green Turtle Tagged in Okinawa Found 19 Years Later Nesting on Guam

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Green sea turtles (*Chelonia mydas*) are widely distributed in Japan from the south of Muroran, Hokkaido, to the southernmost tip of the Nansei Islands (Suganuma 1994). This includes nesting sites on the Ogasawara Islands and part of the Nansei Islands south of Yakushima Island, plus foraging habitats on the coasts of the Japanese Archipelago (Uchida & Nishiwaki 1982; Kamezaki 1989; Suganuma 1994; Kameda *et al.* 2013; Nishizawa *et al.* 2013; Oki *et al.* 2019). Yaeyama Islands, the southernmost islands in the Ryukyu Archipelago (Okinawa Prefecture; Fig. 1) host abundant foraging habitat, yet little is known about the migration and long-term growth rates of green turtles residing in this region. To fill this gap in knowledge and collect the baseline data needed to study green turtle growth and migration, capture-mark-recapture (CMR) efforts were conducted during 2001 to 2004 on Ishigaki Island in the Yaeyama Islands.

CMR studies rely on the recognition of previously tagged sea turtles to answer biological and conservation questions (Reisser *et al.* 2008; Omeyer *et al.* 2019). Therefore, identification tags should ideally persist for a long period of time to allow multiple recaptures throughout the lifetime of the turtle. However, many factors contribute to the high rate of tag loss, which includes the length of time after application, experience of the tagger, the application site on the turtle, and tag material and design (Balazs 1982; Limpus 1992; Bjorndal *et al.* 1996; Bellini, Godfrey & Sanches 2001). Further, metal tag loss may ensue due to failure of the locking-mechanism, tissue necrosis, tearing, abrasion, and corrosion (Balazs 1982). Therefore, if a turtle loses all metal tags and/or if the tag is illegible, then the turtle cannot be re-identified (Gibbons & Andrews 2004; Omeyer *et al.* 2019). Overall, tag loss is a challenge for long-term CMR studies because it is confounded with turtle mortality (Casale *et al.* Salvemini 2016) and it decreases the return rate (Broderick *et al.* 2003), especially for juvenile turtles during the critical 'lost years' pelagic phase (Casale *et al.* 2017). On nesting beaches, Ehrhart *et al.* (2014) found a steep decline in the chances of encountering a flipper-tagged nesting loggerhead sea turtle (*Caretta caretta*) more than seven years after its first encounter. Further, the chances of recapturing a previously tagged turtle are also decreased due to sparse detection capacity by monitoring teams (Casale & Ceriani 2020). For example, remigration events for nesting hawksbill sea turtles (*Eretmochelys imbricata*) go undetected in the Main Hawaiian Islands due to limited funding as well as staff safety concerns (Gaos *et al.* 2021). Despite these limitations, metal tag recapture for long-term CMR studies can benefit sea turtle management by providing key information on behavior, demography, foraging patterns, growth, movements, population size, reproductive biology, residency, stranding, and survivorship (Bellini *et al.* 2001; Reisser *et al.* 2008; Foley *et al.* 2021). In this report, we are focusing on the turtles tagged in the Yaeyama Islands feeding area within the 2001-2004 timeframe. Here, we describe the first recapture on Guam obtained 19 years after initial tagging.

A juvenile green sea turtle was caught on 20 March 2003 by a licensed fisherman in the waters around the Yaeyama Islands (Fig. 1). Size and weight measurements were obtained. The turtle's straight carapace length (SCL) was 49.5 cm, straight carapace width (SCW)

Figure 1. Location of the tagging and release site of the juvenile green turtle on Ishigaki Island (red circle), Japan, and the turtle's recapture location while nesting on Cocos Island (red triangle), Guam 19 years later. The map was created by processing the digital map Ninomap.

Figure 2. At initial capture and tagging, the turtle's SCL=49.5 cm. A metal tag was placed on each of the turtle's two front flippers and two hind limbs (left panel). The juvenile green turtle was released on Ishigaki Island, Japan on 23 March 2003..

was 42.1 cm, curved carapace length (CCL) was 53.5 cm, and curved carapace width (CCW) was 49.3 cm. The turtle weighed 14.4 kg. Following standard practice in sea turtle studies, metal flipper tags were applied to the turtle (Fig. 2; Godley *et al.* 1999; Omeyer *et al.* 2019) on the front left: KK1 0128 (Fig. 3a) and right: KK1 0129 (Fig. 3b) flippers and hind limbs (left: KK3 0096; right: KK3 0095). The titanium tags were made by Stockbrands Co., Pty. Ltd (Osborne Park, Western Australia). The identifying alphanumeric codes and contact information (email address, phone number) were stamped onto the metal tags. After all data were collected, the turtle was released on 23 March 2003 (Fig. 2) from the northeastern coast of Ishigaki Island (24.507535 °N, 124.283162 °E; Fig. 1).

On 19 May 2022 (19 years after release), this turtle was observed nesting on Cocos Island (or *Islan Dåno'* in Chamorro), which is a small island (1.93 km in length and 0.15 km in width) located 1.6 km off the southwestern coast of Guam (13.444304 °N, 144.793732 °E; Fig. 1). After the turtle completed oviposition, the Guam researchers collected data and biological information, which included examining the turtle for existing identification tags, applying short- and long-term identification tags, obtaining size measurements, and collecting skin tissue samples for genetic and stable isotope studies.

All four flippers were examined for any existing metal tags. Two metal tags were found on the front flippers of the turtle. The alphanumeric identification on the upward facing portion of the tag read KK1 0128 for the left tag (Fig. 4) and KK1 0129 for the right tag. On the bottom of both tags was an email address with the internet domain name for Japan, which is ".jp." All this information matched the description of the titanium tags applied by the Japan researchers in 2003. The metal tags on the left and right hind limbs were no longer present during the recapture.

As demonstrated by the tag loss before recapture, technologies other than external metal tags are clearly needed to maximize success of long-term CMR studies. Passive Integrated Transponder (PIT) tags, an internal identifier, are more commonly used for sea turtles (Balazs 1999) because they greatly increase recapture rates (Wyneken *et al.* 2010) due to relative permanency and durability

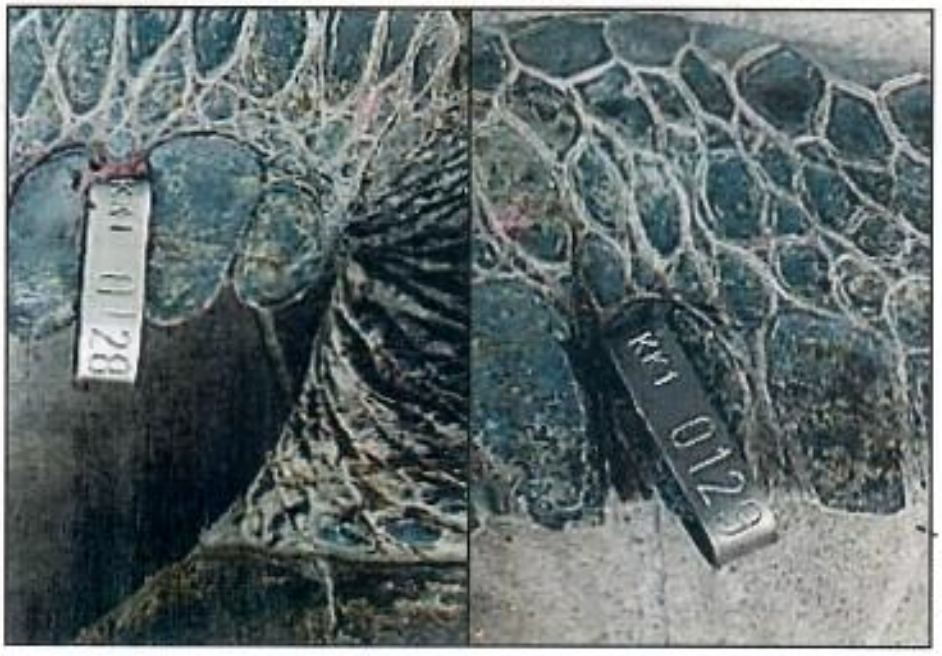

Figure 3. Metal tags were attached to the juvenile green turtle's front left flipper with tag number KK1 0128 (left panel) and front right flipper with tag number KK1 0129 (right panel).

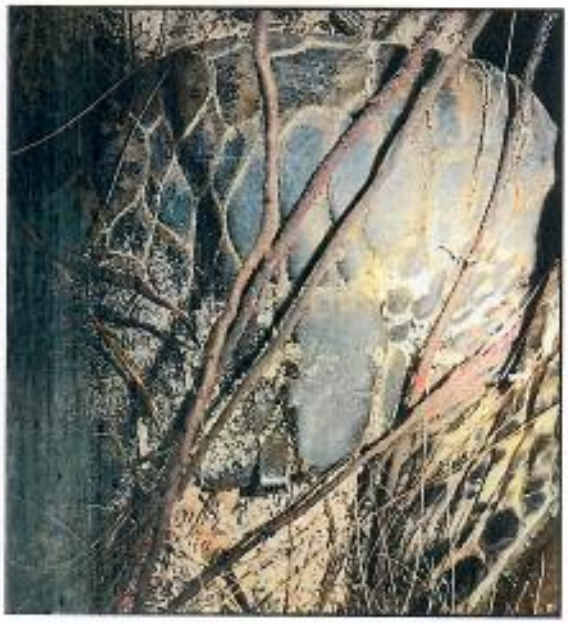

Figure 4. The metal tags KK1 0129 on the front left flipper (tag number: KK1 0128) of a green turtle nesting on Cocos Island, Guam19 years after its tagging and release on Ishigaki Island, Japan. Photo courtesy of Clark Kent Hoshino.

Figure 5. The green turtle with metal flipper tags originating from Ishigaki Island, Japan was observed nesting on Cocos Island, Guam 19 years later. The turtle's straight carapace length was 91.7 cm at the time of recapture.

over metal tags (Gibbons & Andrew 2004; Ondich & Andrews 2013; Omeyer *et al.* 2019). PIT tag limitations include cases wherein the tag may migrate within the turtle's tissue (Wyneken *et al.* 2010) or be expelled from the turtle before the application site heals (Godley *et al.* 1999). Also, various types of PIT tags require specific hand-held readers to be identified; therefore, a PIT-tagged turtle cannot be recognized without the appropriate PIT tag reader (James *et al.* 2007; Epperly *et al.* 2015). Nonetheless, these limitations are outweighed by the higher retention rate of PIT tags over metal flipper tags. For this reason, the Guam researchers use PIT tags as a second identifier. A Biomark, Inc. hand-held reader (Model No. GPR+; Boise, Idaho, USA) is used by the Guam turtle team to detect PIT tags. PIT tags were not found in any potential PIT tag sites on the recaptured turtle (left and right shoulder muscle, left and right front flippers, left and right hind flippers, neck; Eckert & Beggs 2006). Considering the loss of two of the four metal tags, the turtle was double tagged with PIT tags in each of the hind flippers to ensure that this individual can be identified in the future (Gaos *et al.* 2021). Eckert & Beggs (2006) recommend this location specifically for nesting females because: (1) it is located away from the turtle's head and thus reduces the chances of disturbance, (2) it is associated with less bleeding compared to application in the front flipper, (3) discomfort is minimized during the tag application, and (4) the chances of injury to researchers are reduced. Additionally, the rear hind flippers were selected because PIT tags in the shoulder and front flippers may be more difficult to detect for future scanning opportunities (Foley *et al.* 2021).

The Guam researchers utilize a third identifier, a temporary shell marking, to differentiate between individual nesting females during the nesting season. This short-term marking is etched onto the carapace and painted with white, non-toxic paint to identify each turtle from afar. The alphanumeric identifier assigned to this turtle was GU12 located on the fourth lateral scute on the right side of the turtle's carapace (Fig. 5). The first two letters indicate the nesting location; "GU" is the shorthand for Guam. The last two numbers differentiate between encountered individuals since the start of the ongoing nesting sea turtle research. Therefore, this individual was the twelfth recorded nester on Guam since the beginning of near-saturation tagging in 2021.

At the time of recapture in Guam, part of the turtle's supracaudal scute was missing, but that did not affect carapace length measurements. The turtle's most recent SCL was 91.7 cm, SCW was 71.7 cm, CCL was 98.5 cm, and CCW was 90.9 cm. The annual growth rate, from this turtle's release (2003) to recapture (2022) across 19 years, was 2.2 cm in SCL, 1.5 cm in SCW, 2.4 cm in CCL, and 2.2 cm in CCW. This is consistent with the findings of Kameda *et al.* (2017) which reported that juvenile green turtles around the Yaeyama Islands had an annual growth rate of 2.7 cm $year^{-1}$ for turtles captured between 1995-2003. They also found that these green turtles had a mean SCL of 51.5 cm, which is similar to the SCL measurement of 49.5 cm during the initial tagging on Ishigaki Island. Here, we confirmed that a juvenile green turtle with a <50 cm SCL was observed breeding after approximately 19 years. Within this timeframe, the recaptured turtle reached sexual maturity and successfully migrated to the nesting site in Guam.

In this study, the turtle migrated approximately 2,500 km from its foraging areas at the Yaeyama Islands to the nesting beach on Guam. According to the natal homing hypothesis, which states that females return to their natal beach to nest (Bowen & Karl 2007; Lohmann *et al.* 2013; Brothers & Lohmann 2015), it is assumed that Cocos Island is this turtle's natal beach. Further, satellite telemetry confirms that post-nesting green turtles from the Mariana Islands (including Guam) migrate to Japan (Seminoff *et al.* 2015). This report further corroborates the connectivity between the Mariana Islands and Okinawa, Japan for green turtle migration patterns. In addition to Guam as a source of turtles, over 20% of the Yaeyama

Islands' foraging population originates in the Federated States of Micronesia (FSM) and close to 25% is sourced from Papua New Guinea (Nishizawa *et al.* 2013). Due to their migrations to respective nesting grounds in multiple countries, international approaches will be needed to protect Western Pacific green sea turtles.

Given that monitoring of nesting beaches in Guam has been sporadic until recently, it is our hope that this report marks the beginning of multiple recaptures of turtles tagged in the Yaeyama Islands and recovered in Guam. The information obtained through these tag recoveries, such as growth rates, migration, and movements will be important for long-term conservation benefits and protections in both Guam and Okinawa. The recovery of the two metal tags reiterates the importance of CMR studies, especially for data deficient populations such as the Central West Pacific (CWP) green sea turtles, which includes Guam's nesting green sea turtles. The CWP population is listed as Endangered under the U.S. Endangered Species Act (ESA). The most recent population status review by Seminoff *et al.* (2015) highlighted the need to fill knowledge gaps. Therefore, any baseline information that can be obtained via CMR studies such as this will help inform future population status reviews, critical habitat assessments, and management frameworks that will benefit the long-term conservation of this distinct population segment. In Okinawa Prefecture, sea turtles are part of the fishing industry with restrictions on the annual number and size of turtles caught. Therefore, information on the migration and growth of sea turtles from recaptures, such as the one described here, is useful in considering the conservation of sea turtles inhabiting Okinawan waters. Lastly, our observations are an additional example of the importance of a strong and collaborative network for the conservation of green sea turtles in the Western Pacific.

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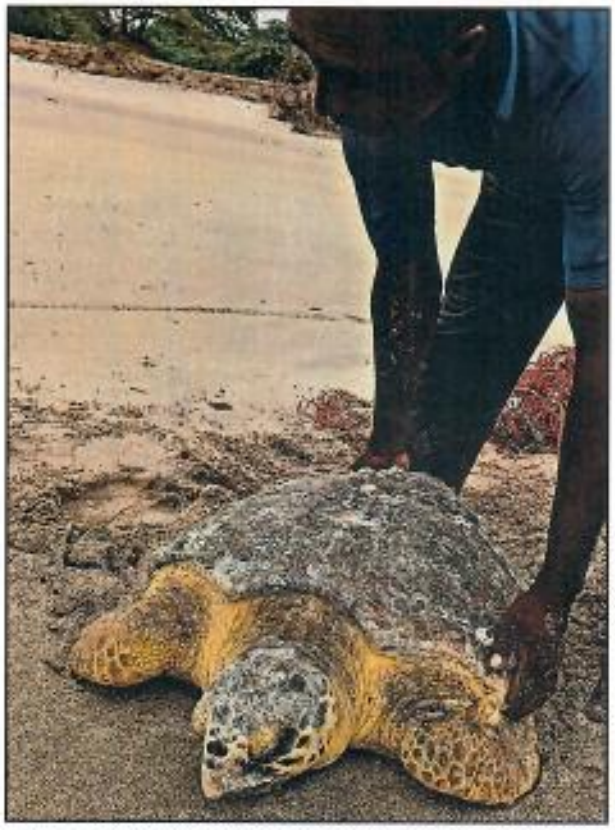

A fisherman of Kutch with his accidental catch, a loggerhead sea turtle, not recorded for 84 years from Mandavi Beach, Kutch, Gujarat. See pages 20-22.

Articles

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