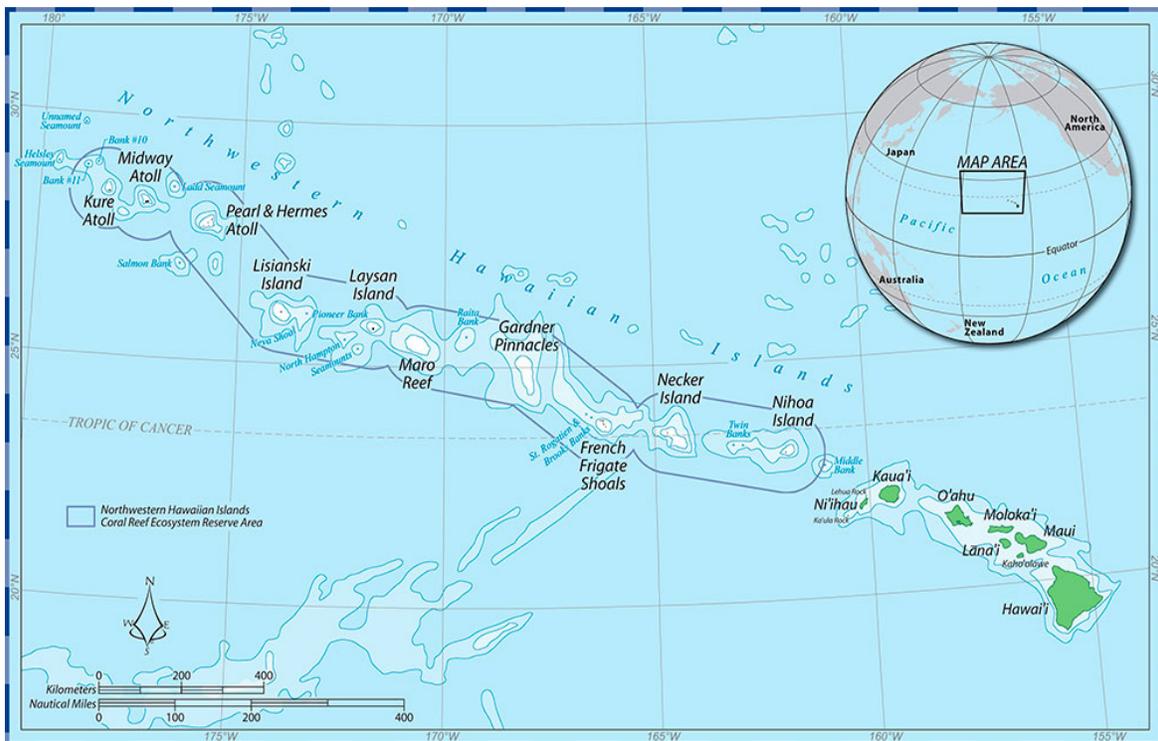




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Forty Years of Research: Recovery Records of Green Turtles Observed or Originally Tagged at French Frigate Shoals in the Northwestern Hawaiian Islands, 1973-2013



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ABSTRACT

In 1983 the publication of the NOAA Technical Memorandum titled “Recovery records of adult green turtles observed or originally tagged at French Frigate Shoals, Northwestern Hawaiian Islands” authored by George Balazs included tagging and sighting data for 294 individual turtles witnessed in association with the Hawaiian green turtle’s main rookery of French Frigate Shoals (FFS). Herein we bring that report up to date and include some novel ways to present the information gathered in more than 40 years of systematic monitoring at FFS. We used tagging and tag recovery data for the 5,806 turtles that have been encountered at FFS at least once including all age classes and both genders. We analyzed tag recovery data gathered from turtles that were encountered nesting, basking or stranded along the Hawaiian Islands’ shorelines, as well as turtles that were captured during targeted ocean-capture field work expeditions. Furthermore, we examined some of the patterns that emerge from the data and chose a few ways to display them to highlight their exceptional value.

CONTENTS

Abstract.....	iii
Introduction.....	1
History of Tagging.....	2
Results.....	5
Long-distance Migrations	5
Tag Recovery Information and Newly Tagged Turtles	6
Nesting Lifespan	8
Current State of Surveys	9
Literature Cited	10
Abbreviations	11
Acknowledgments.....	12
Photographs.....	13

INTRODUCTION

The Hawaiian green turtle (*Chelonia mydas*) is a genetically discrete subpopulation of the species inhabiting the waters surrounding the Hawaiian Archipelago (Dutton et al., 2008), and one that has shown a consistent increase in the number of nesting females over the past 4 decades (Fig. 1), albeit with year-to-year fluctuations (Balazs and Chaloupka, 2006; Tiwari, 2010).

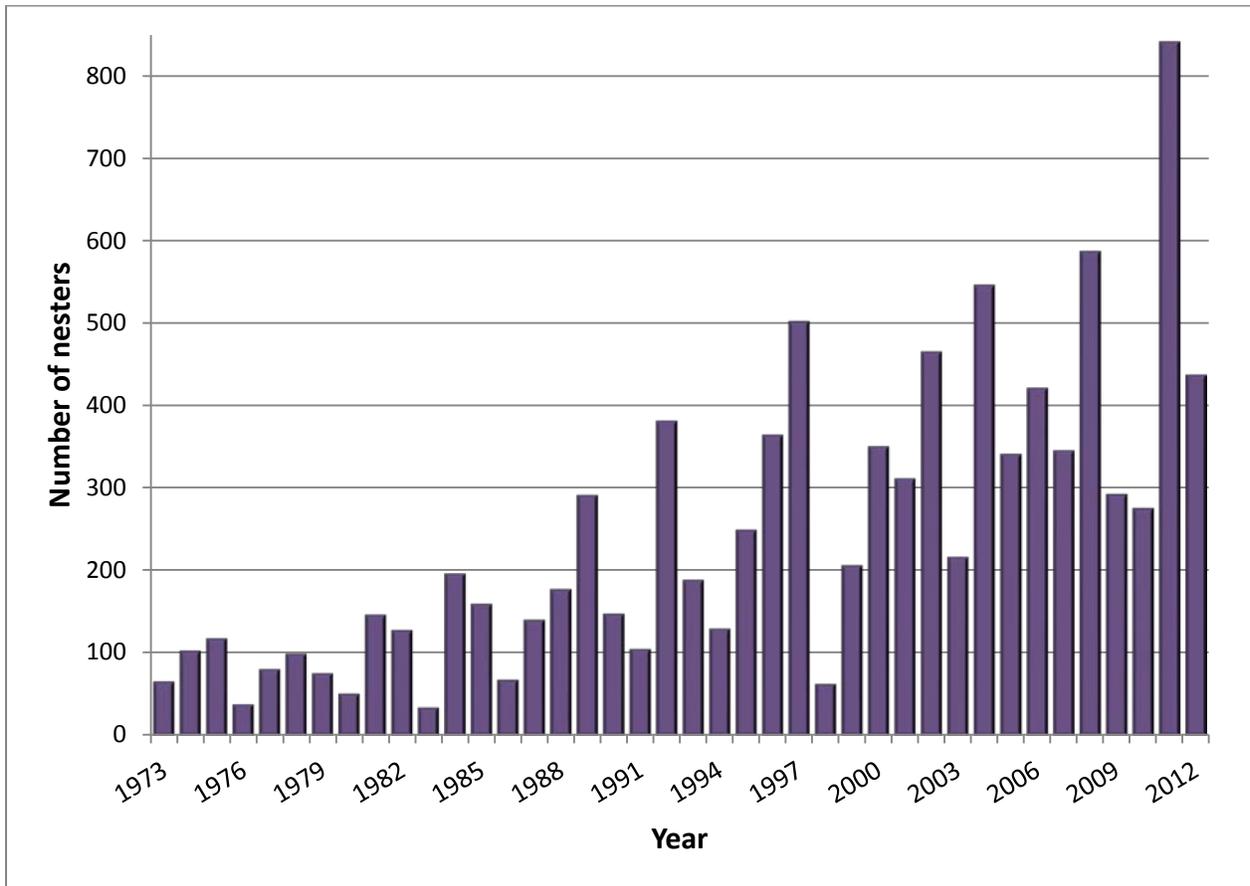


Figure 1.--Estimated number of nesting Hawaiian green turtles on East Island, FFS, 1973-2012 (PIFSC).

The main rookery for the population is East Island (23°47'12.50" N, 166°12'32.80" W), a 3-hectare island within French Frigate Shoals (FFS) (Tiwari, 2010). FFS is a 35-km long, crescent-shaped atoll (Amerson, 1971) approximately 900 km northwest of Honolulu and 1300 km southeast of Kure Atoll. The turtles' migratory pattern between FFS and the main Hawaiian Islands (MHI) for reproductive purposes has been previously documented (Balazs, 1976), and research has shown that approximately 90% of all Hawaiian green turtle breeding occurs at FFS (Balazs, 1980). The FFS lagoon contains two exposed volcanic rocks and nine low sandy islets, comprising 27 hectares of land and 9307 hectares of associated coral reef habitat thereby making FFS the largest atoll in the Northwestern Hawaiian Islands (NWHI).

We present an update on the information published in the 1983 NOAA Technical Memorandum (TM) titled “Recovery records of adult green turtles observed or originally tagged at FFS, Northwestern Hawaiian Islands” authored by George Balazs. It is not our intention to extrapolate any biological data about the species or speculate on the associated statistical analyses at this stage. Rather, we present a synopsis of information, as it has become available and in comparison to the 1983 TM, a publication that marks its 30th anniversary. The 1983 document covered data from the 1965–1983 period which included records for 294 turtles that had been tagged or re-sighted at FFS. Today, after 40 years of systematic monitoring (1973–2012) of nesting females at FFS, we are able to provide records for 5806 turtles that have been either tagged or encountered at FFS. We have updated the information using data currently existing in the Oracle Turtle Database Processing System (OTDPS) of the Pacific Islands Fisheries Science Center¹. We used complete data from the 2012 nesting season, and all re-sighting information available as of August 2013. This includes information gathered during the 3- week survey of the entire NWHI chain completed in the summer of 2013 in lieu of the historical monitoring at FFS (Spring, 2014). The focus of this report will, however, be aimed at records for turtles tagged in or after 1973, when systematic monitoring at East Island began. At least 1640 research days have gone into accrual of the data presented here (Table 1). We examined recovery information for the 4480 turtles that have been seen more than once and present updated summary information about many categories discussed in the 1983 document, while including new information on long-distance migrations and longevity.

HISTORY OF TAGGING

Although the majority of the data examined in this report refers to females tagged during the nesting process, we are also able to present a prominent data set about males found within the breeding colonies. This is because the Hawaiian green turtle displays a rare terrestrial basking behavior: turtles of both sexes will, at times, crawl out of the water during daylight hours (and occasionally at night) to rest along the shorelines for hours at a time, thus providing an opportunity for scientists to tag them. Prior to 1973, tagging was done by the State of Hawaii Division of Fish and Game in the early 1960s (currently known as the State of Hawaii Division of Aquatic Resources), and then shortly thereafter by the U.S. Bureau of Sport Fisheries and Wildlife, now the U.S. Fish and Wildlife Service.

In June 1973 one of us (GHB), working for the University of Hawaii’s Institute of Marine Biology arrived on East Island and set up a small, one-man tent, ready to find answers to the several questions about Hawaiian green turtles that were pending at the time. GHB spent 48 days and nights at FFS that year, and would return another 36 times over the span of the next 4 decades. In combination, the authors have spent 22 seasons and 590 nights in the field monitoring and collecting a portion of the data presented here and overseeing other field workers. In Table 1, we present a list of expeditions made to East Island between 1973 and 2012.

¹ <https://inport.nmfs.noaa.gov/inport/item/2709>

Expedition No.	Year	No. Survey Nights	Survey Date Range
1	1973	43	June 1 - July 19
2	1974	59	May 30 - August 15
3	1975	30	June 6 - August 7
4	1976	13	June 28 - July 12
5	1977	9	June 20 - July 3
6	1978	11	June 5 - June 21
7	1979	13	June 10 - June 30
8	1980	20	June 6 - July 1
9	1981	23	May 25 - June 18
10	1982	19	June 5 - June 26
11	1983	17	June 3 - August 3
12	1984	20	June 2 - June 26
13	1985	18	June 10 - June 30
14	1986	29	June 9 - July 21
15	1987	26	May 26 - July 15
16	1988	101	April 30 - August 29
17	1989	143	May 3 - September 22
18	1990	133	May 6 - September 15
19	1991	119	May 1 - August 30
20	1992	129	April 26 - September 17
21	1993	31	May 13 - June 30
22	1994	26	June 8 - July 7
23	1995	31	June 8 - July 8
24	1996	31	June 4 - July 4
25	1997	33	May 30 - July 1
26	1998	32	May 30 - June 30
27	1999	31	June 1 - July 1
28	2000	33	May 28 - July 2
29	2001	31	June 4 - July 7
30	2002	34	June 3 - July 12
31	2003	41	May 22 - July 1
32	2004	38	June 1 - July 13
33	2005	40	May 31 - July 12
34	2006	35	June 7 - July 11
35	2007	33	June 6 - July 8
36	2008	43	June 3 - July 29
37	2009	36	May 13 - June 17
38	2010	23	May 21 - June 13
39	2011	35	June 12 - July 26
40	2012	28	June 20 - July 26
Total		1640	

Table 1.--List of systematic green turtle nesting monitoring expeditions made to East Island, FFS and corresponding research days 1973–2012. Highlighted in bold are saturation tagging years, that is, expeditions covering the entire green turtle nesting season. The actual survey nights fall within the indicated date range. However, it should be noted that in some years monitoring did not occur every night within the range due to logistics, weather conditions, etc.

In 1973, as well as sporadic taggings starting in the 1960s, Monel alloy flipper tags made by the National Band and Tag Company of Newport, Kentucky, were used at FFS. In 1976, the use of these tags was discontinued and Inconel 625 alloy tags No. 681 were applied to the inguinal area of the right and left hind flippers as well as the proximal left and right front flippers (Balazs, 1983, 1999). In 1998, the use of subcutaneous Destron tx1406L Passive Integrated Transponder (PIT) tags, inserted in both the right and left hind flippers, supplemented and eventually replaced the application of external metal tags. These magnetically encoded tags have a much higher retention rate but require the use of electronic scanners to detect and display the tag numbers. In addition to PIT or metal tags, some turtles were equipped with satellite tags and/or time depth recorders (TDRs) during their migration to and from FFS; the data regarding these individuals are included in our summaries as part of the tag recovery information.

Systematic monitoring at East Island is performed by a lone technician who walks the entire island six times each night in a clockwise direction. Turtles are marked with temporary paint or, starting in 1991, a light shell etching (mototool) filled in with paint to visually distinguish one individual from another (Balazs, 1992). Time and activity of the turtle are also noted. The primary goal of each circuit around the island is to count all turtles that come ashore, and one circuit is typically completed within 2 hours. As time allows, turtles are checked for existing tags, new tags are applied when applicable, measurements are taken, and a visual assessment of the turtles' overall health (with focus on symptoms of fibropapillomatosis) is performed. Once all information is collected for an individual, these data are not collected again so as to minimize disturbance, but all encounters with an individual are recorded and their activity level noted throughout the season.

Within FFS, monitoring of both basking and nesting turtles has also occurred at Tern Island and Whale-Skate Island (albeit intermittently and at times opportunistically). Although historical accounts and our records describe that a considerable number of turtles nested and basked at Whale-Skate Island (Lautenslager, 1985), no personnel conducted turtle tagging there after 1992, and Whale-Skate has been washed over and completely submerged since 1997, so it does not appear in summaries thereafter. On Tern Island, in addition to turtle technicians monitoring and tagging turtles routinely and for training purposes during the nesting season, data were collected by the USFWS personnel previously stationed there year-round starting in 1978 until December 2012.

The information presented for locations other than East Island was gathered by a number of collaborating NOAA and USFWS personnel, sometimes opportunistically as part of other duties.

On the MHI, data were primarily collected by the Turtle Research Program (TRP) of the National Marine Fisheries Service's Pacific Islands Fisheries Science Center (formerly Honolulu Laboratory of the Southwest Fisheries Science Center) during targeted fieldwork expeditions, and from stranded turtles fortuitously reported by the public and recovered by TRP staff and partners in the sea turtle stranding network started in the mid-1980s.

RESULTS

We examined 48,040 records spanning the years between 1965 and 2013 representing 5806 individual turtles that were encountered and tagged at FFS at least once. Of those, 441 (7.6%) were males and 5115 (88.1%) were females. If the gender was not determined during the observations or was inconsistent for multiple sightings, we considered it “unknown” and removed it from further gender specific counts and summaries: this was the case for 250 (4.3%) individuals. We included all size classes and both genders in our summaries, where applicable. Recovery information for turtles re-sighted during the same expedition (at the same location and during the same year) is not presented.

Twenty-three percent (1326) of the turtles were encountered only once, as the remainder (4480) were seen multiple times. The turtle that was encountered the most (turtle Seq. 11685 or ID 3140) was seen 115 times in 29 years. She was first tagged in 1979, last seen in 2008, and only ever encountered on East Island.

Out of the 4480 turtles that were encountered more than once, 2536 were seen again either at a different location, or in a different year. Of those, 100 were males (4%), 2386 were females (94%), and for 50 the gender was not determined (2%). The bias toward female turtles is the result of the monitoring method, which, starting in 1973 was focused on nesting adult females. Subsequently, we examined the geographic location at which the sightings occurred and summarized information for the 339 turtles that were seen both at FFS and another location (NWHI and/or MHI and Johnston Atoll).

The complete data set used for this report is available upon request from the PIFSC.

Long-distance Migrations

Table 2 summarizes records for turtles of both sexes and all size classes collected from 1965 to August 2013. A total of 339 turtles, 15 males and 324 females were seen at both FFS and another island within the Hawaiian chain. Nine of the 339 turtles were seen at multiple islands. We excluded these nine from the counts in the tables, and discussion below, since they were all multiple sightings within the MHI, whereas our focus here is the migration to and from FFS.

For the remaining 330 turtles, 167 were originally tagged at FFS, and of these, 140 were re-sighted at one of the MHI (Kauai, Molokai, Oahu, Maui, Hawaii), while 27 were subsequently seen elsewhere along the NWHI (Kure, Midway, Pearl and Hermes Reef, Laysan, Lisianski, Necker) or at Johnston Atoll. Considering the opposite direction of movement, 163 turtles were first tagged in the Hawaiian chain somewhere other than FFS and subsequently seen nesting within FFS. More specifically, 42 migrated to FFS from another island in the NWHI, and 121 were originally tagged at one of the MHI.

In Table 2 below, we present the breakdown by island for the 330 turtles seen both at FFS and another island within the Hawaiian chain, dividing the geographic areas between the MHI and NWHI to highlight the directionality. We realize that the bias toward the higher numbers

recorded in the MHI is most likely due to the disparity in presence of people available to make the observations.

ISLAND	FROM FFS	TO FFS
MHI		
HAWAII	16	21
MAUI	52	2
LANAI	0	2
MOLOKAI	2	55
OAHU	58	37
KAUAI	12	4
NWHI		
NECKER	0	2
LAYSAN	8	2
LISIANSKI	9	8
PEARL & HERMES	6	18
MIDWAY	4	7
KURE	0	1
JOHNSTON	0	4

Table 2.--Number of turtles observed migrating between FFS and the MHI, 1965–2013. Note: the numbers in the tables above add up to 330. The remaining 9 individuals were seen at 2 separate islands in addition to FFS, namely: 2 turtles were seen on Maui and Oahu, 3 seen on Molokai and Maui, 1 on Molokai and Kauai, 2 on Hawaii and Maui, 1 on Molokai and Lanai.

Because of the unique tagging opportunity offered by basking males, we highlight here results for the 15 males observed moving between FFS and other atolls or islands as follows: 4 were observed at Pearl and Hermes reef, 5 on Oahu, 2 on the Island of Hawaii, and 1 each on Lisianski, Molokai, Kauai and Johnston Atoll.

Tag Recovery Information and Newly Tagged Turtles

We are not presenting an update on the tag loss rates in the same fashion as the 1983 TM; however, the longest record we found for a metal tag to date is 29 years. The Inconel tag was put on the second scale of the left front flipper of a nester at East Island in 1982 (turtle Seq. 16555 or ID 6034), first tagged in 1973 with a Monel tag. The Inconel tag was still on the turtle in 2011, 29 years later.

We were also interested in the number of turtles that came ashore to nest that had been previously tagged vs. those that had no tags. Because of the systematic standardized monitoring in place at FFS, we chose the time frame between 1973 and 2012, and compared numbers of females specifically seen exhibiting nesting behavior at FFS. We subsequently singled out East

Island to further increase the quality of the comparison (where monitoring, tagging, and tag reading procedures are standardized).

We did not use the total number of turtles that were counted (mototooled or temporarily identified) during a given year, but rather those that were identified by new or existing tags. Turtles without a positive ID (tags) are not included in the OTDPS database. Occasionally when new PIT tags are applied, the researcher was not able to check for existing metal tags, thus the number of “newly tagged” turtles may be slightly inflated.

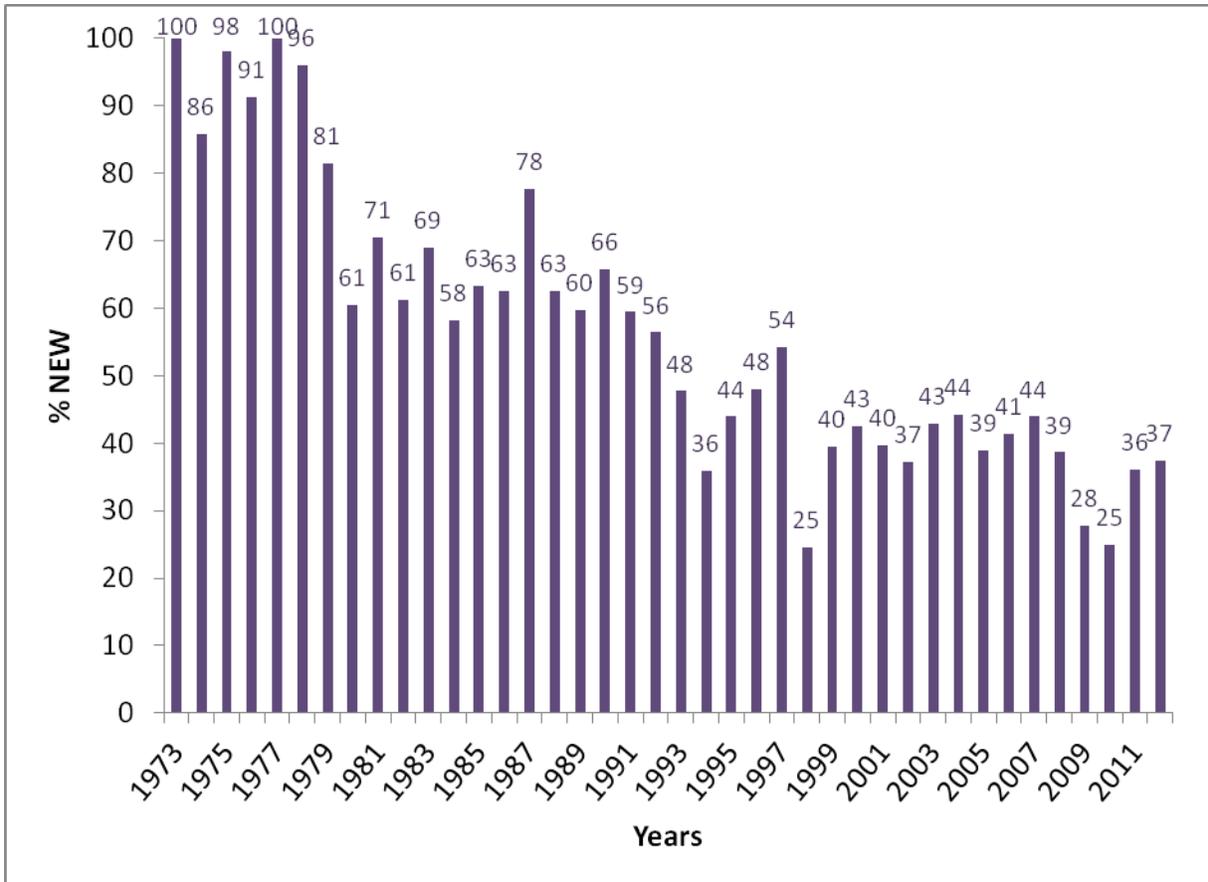


Figure 2.--Annual percent of newly tagged turtles at East Island, FFS, 1973-2012 (as percent of total turtles identified).

The apparent trend seems to show that the number of newly tagged turtles decreased over time until it reached a somewhat level state in the early 2000s. We surmise that there are three components to those numbers: 1) they consist of turtles that were “missed” during prior expeditions or 2) turtles that move between different islands within the atoll and had not nested on East Island. However, 3) we believe that it is safe to assume that the majority of these animals are true “new recruits”: turtles encountered and tagged as first time nesters. The exact numbers of total and newly tagged turtles for East Island, as well as all of FFS as a whole, are contained in the full dataset available upon request. For the reasons we mentioned, we did not plot results for turtles seen at islands other than East.

Nesting Lifespan

An interesting new category for our analysis that was not possible to be addressed by Balazs in the 1983 NOAA TM is the length of time elapsed between the first and the most recent time a female was seen at East Island as a nesting adult; we refer to this as the turtles' "nesting lifespan". We found this of high interest as it defines the length of time, known to date, that an adult female is actively reproducing. To do this, we examined data for the 2,138 females encountered at FFS as adults between 1965 and 2013. The "nesting lifespan" interval was found by calculating the number of years elapsed between the first and last time (year) an individual was seen. In Figure 3, on the y-axis, we plotted the number of turtles that fall within any given interval (x-axis). The higher number of turtles in the 3-5 interval range is a reflection of the increasing number over time of turtles that come ashore to nest as compared to earlier years.

The longest interval we documented is 38 years (Seq. 16555 or ID 6034). First tagged in 1973, this turtle has been encountered 62 times while nesting at East Island or basking at Trig Island. The last time she is known to have nested was in 2011 at East Island. Since we do not know if she was a new nester in 1973, her 38-year nesting lifespan is the minimum number of years she has been nesting. This evidence provides interesting and highly valuable information on life longevity of sea turtles as well: if, as the most recent research shows, nesters first breed around 24 years of age (Van Houtan et al., in press) then one could use the numbers in Figure 3 below and obtain the minimum age of that group of turtles at the time of their last sighting. So for example, for turtle ID 6034, (interval value of 38) we can say that she would have been at least 62 years old at the time she was last seen and still actively breeding.

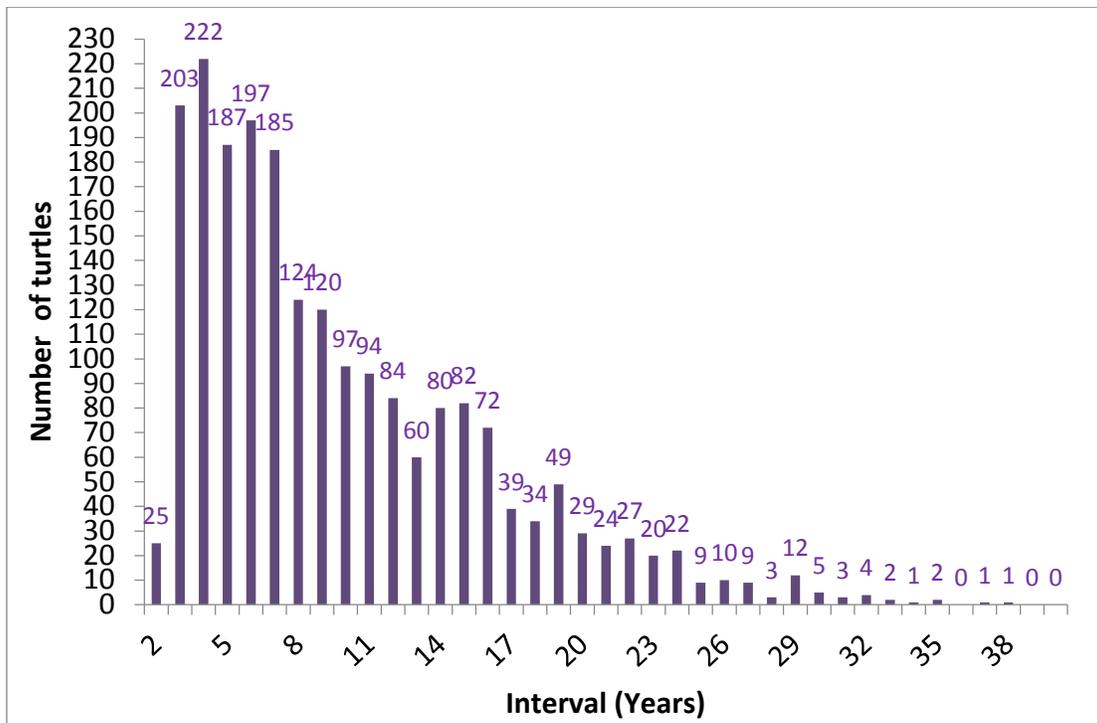


Figure 3.--Nesting Lifespan for green turtles encountered nesting at FFS, 1965-2013 ($n = 2138$).

CURRENT STATE OF SURVEYS

We are confident that the data presented here are and will continue to be exceedingly valuable both as a snapshot of the past, and a starting point for the future. This is especially true during times of transformation and transition such as the current ones: On December 13, 2012, all personnel at the Tern Island field station had to be evacuated after a microburst storm hit FFS, severely damaging the structures in which they were housed. Summer monitoring of nesting turtles as it had been carried out previously was no longer possible and the stream of continuous standardized data collection at FFS was interrupted. Although short-term deployments addressed the most pressing wildlife entrapment and environmental pollution concerns in 2013 (Spring, 2014), at present there is no human presence at FFS and it is unclear if, when, and under what terms and conditions the station may be manned on a continuing basis again. Hence, it is likely that the monitoring methods will have to be transformed in some fashion as research needs and capabilities change.

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ABBREVIATIONS

NOAA: National Oceanic and Atmospheric Administration

NMFS: National Marine Fisheries Service

USFWS: United States Fish and Wildlife Service

OTDPS: Oracle Turtle Database Processing System

FFS: French Frigate Shoals

MHI: Main Hawaiian Islands

NWHI: Northwestern Hawaiian Islands

TRP: Turtle Research Program

ACKNOWLEDGMENTS

We extend our sincere appreciation to the many field personnel that have dedicated time and effort to the collection of the data presented. The data we reported upon here are the result of an exceptional effort put together by the many field biologists that have dedicated part of their lives camping and working in some of the most remote, unforgiving and strikingly beautiful locations on earth. Exemplary inter-agency cooperation was and is necessary for such efforts to succeed.

Special thanks also go to the Turtle Research Program staff that have overseen, entered and checked the data over the years, and to the U.S. Fish and Wildlife Service for the logistical support and collaboration during the field work expeditions to French Frigate Shoals. The authors would like to especially thank Shawn K. K. Murakawa, Devon Francke, Stacy Hargrove, Kyle Van Houtan, Shandell Brunson, Austin M. Stankus and William M. Connor III for their help, assistance and encouragement.

All data collection reported upon herein was conducted under proper approved State of Hawaii and U.S. Federal permits.



Above: Author George Balazs, East Island, French Frigate Shoals (1974).



Above: Author Irene Nurzia Humburg, East Island, French Frigate Shoals (2006).

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