

MANIFESTATION OF FIBROPAPILLOMATOSIS AND RATES OF GROWTH OF GREEN TURTLES AT KANEOHE BAY IN THE HAWAIIAN ISLANDS

George H. Balazs¹, Shawn K. K. Murakawa², Denise M. Ellis², and A. Alonso Aguirre²

¹National Marine Fisheries Service, Southwest Fisheries Science Center, Honolulu Laboratory, 2570 Dole Street, Honolulu, Hawaii 96822-2396, U.S.A. gbalazs@honlab.nmfs.hawaii.edu

²Joint Institute for Marine and Atmospheric Research, 2570 Dole Street, Honolulu, Hawaii 96822-2396, U.S.A.

Kaneohe Bay, located at 21°31'N, 158°51'W on the island of Oahu, is the largest bay in the Hawaiian Islands encompassing 13 km of warm (24–27°C) coastal waters <10 m in depth protected 4 km seaward by a barrier reef. All size-classes of green turtles (honu), *Chelonia mydas*, presently occur here in abundance, ranging from post-pelagic juveniles 35 cm in straight carapace length (SCL) to adults >85 cm. Foraging takes place on several kinds of benthic algae (*Acanthophora*, *Hypnea*, *Codium*, *Amansia*) as well as *Halophila hawaiiiana*, the sole sea grass in the Hawaiian Islands. Green turtles in Kaneohe Bay rest underwater in muddy channel bottoms and in crevices associated with patch-reef pinnacles and other calcareous habitats (Brill *et al.*, 1995). Numerous smooth depressions and undercuts have been created in the coral from repeated use by resting turtles. Buoyant fecal pellets from turtles inhabiting Kaneohe Bay regularly wash ashore, occasionally in great numbers (Balazs *et al.*, 1993).

Over the past 50 years Kaneohe Bay has been subjected to an array of impacts including dredging, sewage discharge, siltation, increased vessel traffic, and elevated nutrients in freshwater runoff associated with human use and habitation of the surrounding landscape. As elsewhere in the main Hawaiian Islands, green turtles in Kaneohe Bay were legally hunted until 1978 when full protection was provided under the U.S. Endangered Species Act. Since that time there have been encouraging signs of population recovery as shown by systematic annual counts of adult females at the Hawaiian nesting colony of French Frigate Shoals (Figure 1).

Fibropapillomatosis (FP), a tumor-forming and debilitating transmissible disease of sea turtles, has emerged in recent years as a serious threat in the Hawaiian Islands, Australia, Florida, and the Caribbean. A herpes virus and retrovirus have been identified in association with FP, but the etiology of the disease, the environmental co-factors required for its occurrence, and modes of transmission in the wild have not been determined. The earliest verifiable case of FP from the Hawaiian Islands involved a green turtle in Kaneohe Bay killed by fishermen in 1958 (Balazs, 1991). However, the disease has been known from Florida since at least the 1930's when it was first reported in the scientific literature as a rare occurrence. The manifestation of FP at high prevalence in both Hawaii and Florida occurred almost simultaneously during the mid-1980's.

METHODS

Study techniques used in Kaneohe Bay since 1989 have included the harmless hand-capture of turtles by diving from

a slow moving boat in shallows where foraging occurs, and by snorkeling or scuba diving with stealth to hand-capture turtles resting in bottom habitats. Capture efforts have been focused mainly in areas of the bay used by immature turtles during the daylight hours. Turtles were held for a short time to record morphometrics, apply external Inconel flipper tags and/or injectable internal PIT tags, to conduct FP health screening including oral exams and assignment of a subjective FP affliction category (0=no external tumors, 1=light, 2=moderate, 3=heavy), and to collect blood and biopsies. In addition, a comprehensive Hawaiian sea turtle stranding and salvage research program has been conducted since 1983 that includes collection of dead or FP-debilitated animals bordering Kaneohe Bay. Turtles derived from this effort have been utilized by veterinary and other collaborators to achieve maximum benefit for research (including viral screening and tissue banking), diet determinations, DNA stock identification, and age estimates by skeletochronology. Kaneohe Bay constitutes one of several important long term in-water research sites that have been established in the Hawaiian Islands to monitor FP prevalence and obtain baseline data on the biology, ecology and life history of green turtles (*e.g.*, see Balazs *et al.*, 1994; Aguirre *et al.*, 1994). A goal of this work is to gain insight into habitat-related and other environmental co-factors possibly associated with and responsible for the distribution and prevalence of FP.

RESULTS

As of October 1997, 581 green turtles ranging from 36.1 to 96.0 cm SCL have been captured and tagged in Kaneohe Bay during 87 daily visits since 1989. The recapture of tagged turtles over this nine year period resulted in a total of 777 turtle-capture events. For the 581 individuals identified, 43.9% had FP. The degree of affliction among three assigned FP categories was 1=30%, 2=31%, 3=39%. The annual prevalence of FP ranged from 33 to 60% with no apparent trend exhibited, although occurrence of the most severe cases (category 3) appears to have declined slightly during recent years. Similar findings were made when annual prevalence was examined for all 777 of the turtle-capture events. A significant finding was that 40% of the FP turtles had oral tumors, often associated with and adversely impacting the glottis. This life-threatening manifestation of FP has been documented in 61% of the FP turtles (N=222) necropsied after stranding in the Hawaiian Islands during recent years. No cases of oral tumors have been reported from Florida or elsewhere except for a few in Australia. The detection of changes in FP affliction in individuals over time

(mean 2.3 ± 1.8 years) was possible for 89 of the turtles tagged and recaptured in Kaneohe Bay. Only four turtles (4.5%) exhibited a decrease in FP category, while 61 (68.5%) increased in severity and 24 (27.0%) showed no apparent change. Remarkable cases included the FP regression from category 3 to 1 in 16 months of a 58 cm turtle with a concomitant SCL growth of 4.5 cm/yr; and the FP progression from category 1 to 3 in 11 months of a 47 cm turtle with no measurable increase in SCL.

Tumors were often found growing in the axillary of the flippers in addition to the eyes, neck, tail and mouth. Flipper tags were only attached at sites free of tumors after the application of betadine or alcohol. The examination of some tagged and recaptured turtles suggested that tumor growth had been enhanced at the piercing site of the tag. Similar observations were made by Wood and Wood (1993) in green turtles released from the Cayman Turtle Farm. To eliminate this confounding factor, the use of flipper tags has been discontinued in the Hawaiian Islands and replaced exclusively with PIT tags.

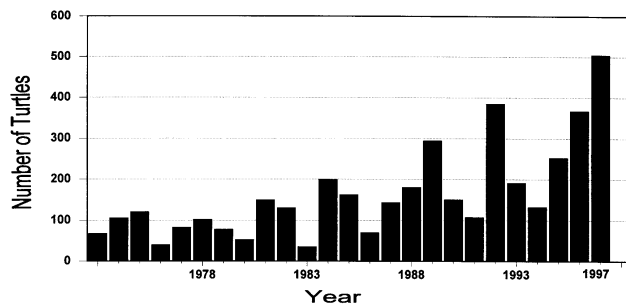


Figure 1. Historical trend for 25 seasons (1973-97) of green turtle nesting at East Island, French Frigate Shoals, in the Northwestern Hawaiian Islands. East Island accounts for 50% or more of all green turtle nesting in the Hawaiian Islands.

Of the 581 turtles tagged, 150 turtles (25.8%) ranging from 36.6 to 73.6 cm yielded SCL recapture data useful for determining rates of growth. A single growth increment was used for each turtle (*i.e.* increase between initial and most recent capture) resulting in an overall mean growth rate of 2.0 ± 1.5 cm/yr. The growth rates of tumored turtles (1.9 ± 1.5 cm/yr, $N=89$) and non-tumored turtles (2.2 ± 1.4 cm/yr, $N=61$) were not significantly different ($P < 0.05$). However, a significant difference was found when growth rates in the four FP categories were examined by ANOVA. Duncan-Waller analysis revealed significantly slower growth in FP category 3 (0.9 ± 1.2 cm/yr) in contrast to categories 0, 1 and 2 which were not significantly different from one another (Figure 2). The annual strandings of turtles along the shoreline of Kaneohe Bay from 1989 to 1997 accounted for 21% (range 17-25%) of all cases recorded each year throughout the Hawaiian Islands. The latter has ranged from 122 cases in 1989 to 251 cases in 1996, with an almost consistent annual upward trend. However, no trend has been displayed in the annual percentage of FP cases among these strandings (mean 59%, range 46-69%). The percentage of annual FP cases among the Kaneohe Bay strandings has been

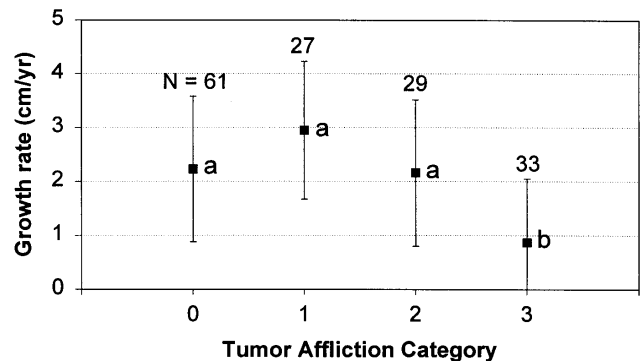


Figure 2. Mean and standard deviation for SCL rates of growth exhibited by four groups of green turtles tagged and recaptured in Kaneohe Bay. 0 = no external tumors, 1 = lightly tumored, 2 = moderately tumored, and 3 = heavily tumored. Means bearing the same alphabet letter (a, b) are not significantly different. No significant interactions were found between SCL 5-cm size classes (35 - 75 cm) and FP categories, hence growth rates shown for FP categories were not significantly influenced by SCL.

consistently higher (mean 73%, FP range 52-92%), but again no trend has been exhibited.

LITERATURE CITED

- Aguirre, A.A., G.H. Balazs, B. Zimmerman, and T.R. Spraker. 1994. Evaluation of Hawaiian green turtles (*Chelonia mydas*) for potential pathogens associated with fibropapillomas. *J. Wildl. Dis.* **30**(1):8-15.
- Balazs, G.H., R. Fujioka, and C. Fujioka. 1993. Marine turtle faeces on Hawaiian beaches. *Mar. Pollut. Bull.* **26**(7):392-394.
- Balazs, G.H. 1991. Current status of fibropapillomas in the Hawaiian green turtle, *Chelonia mydas*. In: G.H. Balazs and S.G. Pooley (Eds.), *Research plan for marine turtle fibropapilloma*, December 4-6, 1990, Honolulu, Hawaii, p. 47-57. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-156.
- Balazs, G.H., R.K. Miya, and M.A. Finn. 1994. Aspects of green turtle in their feeding, resting, and cleaning areas off Waikiki Beach. *Proceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation*. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-341, p. 15-18.
- Brill, R.W., G.H. Balazs, K.N. Holland, R.K.C. Chang, S. Sullivan, and J.C. George. 1995. Daily movements, habitat use, and submergence intervals of normal and tumor-bearing juvenile green turtles (*Chelonia mydas* L.) within a foraging area in the Hawaiian Islands. *J. Exp. Mar. Biol. Ecol.* **185**:203-218.
- Wood, F. and J. Wood. 1993. Release and recapture of captive-reared green sea turtles, *Chelonia mydas*, in the waters surrounding the Cayman Islands. *Herpetological Journal* **3**:84-89.