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SEX RATIOS OF GREEN TURTLES STRANDED IN THE HAWAIIAN ISLANDS

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BACKGROUND

All sea turtles exhibit temperature-dependent sex determination during egg incubation. Knowledge of natural sex ratios is therefore essential for formulating conservation strategies and understanding evolutionary processes (Magnuson et al. 1990, Mrosovsky 1994). Determining the sex of dead sea turtles salvaged after stranding provides a valuable means to estimate sex ratios in the wild. This method is particularly useful as it gives insight into a broad range of size classes representing many years of reproductive output for a given population. The sex ratio of immature Hawaiian green turtles, Chelonia mydas, has previously been estimated using a serum androgen sexing technique (Wibbels et al. 1993). Sixty-three healthy animals were sampled alive from coastal foraging pastures in this study and no significant variation from a 1:1 sex ratio was found.

Nearly all nesting by green turtles in the Hawaiian Islands occurs at the remote islets of French Frigate Shoals located at 24°N, 166°W (Balazs 1976, 1980, 1983). Incubation temperatures have thus far not been studied at this somewhat northerly site for green turtle reproduction. However, based on known air and seawater temperatures, and the near absence of vegetative shading on the nesting beaches, there is no reason to suspect excessively cool or warm nest conditions that could consistently bias hatchling sex ratios.

The present study is based on 421 stranded turtles that were salvaged and necropsied during 1984-94. The incidence of strandings in the Hawaiian Islands increased considerably over this 11-year period. For example, during 1984-86 an average of 54 cases occurred each year, while in 1992-94 the annual average was 200 (see also Balazs 1991). Factors thought to be responsible for this increase include the affliction of many turtles with an enigmatic tumorous disease known as fibropapillomatosis (Herbst 1994), and an overall increase in the number of turtles residing in coastal benthic habitats, especially juveniles and subadults. The latter phenomenon is believed to reflect the population's positive response to 16 years of protection under the U.S. Endangered Species Act (Balazs et al. 1994a, 1994b; Wetherall and Balazs, submitted). Necropsies to determine the sex of both non-tumored and tumored turtles in this study provide the first known opportunity to see if a sex bias exists relative to fibropapillomatosis.

METHODS

Turtles found dead throughout the Hawaiian Islands were salvaged and transported to the Southwest Fisheries Science Center's Honolulu Laboratory where they were stored in freezers until necropsy. During 1984-94, 1,387 cases of stranded green turtles were documented, 421 of which were necropsied and the sex determined by visual inspection of the gonads, as described by Rainey (1981). Only turtles that showed clear differentiation of ovaries or testes were included in this sample.

The 421 turtles originated from the islands of Oahu (80.8%), Maui (8.6%), Kauai (5.2%), Hawaii (3.5%), and Lanai/Molokai (1.9%). These percentages are generally proportional to the human population of each island. Consequently, there is a far greater probability of a stranded turtle on Oahu being found and reported. In addition, there is a concomitant level of adverse human impacts to turtles in the nearshore waters of each island (e.g., gill netting, vessel traffic) that can cause stranding.

RESULTS AND DISCUSSION

Of the 421 turtles, 226 were females and 195 males. The resulting sex ratio of 1.16F:1.00M was not significantly different from 1:1 (replicated goodness of fit test, $P > 0.05$). Assigning the 421 turtles into seven 10 cm size classes (30-90 cm) on the basis of straight carapace length also resulted in unbiased sex ratios ($P > 0.05$), except for turtles 90.0-99.9 cm (Fig. 1). This size class of mature adults had a significantly female-biased sex ratio of 6.00F:1.00M ($P < 0.01$).

Unbiased sex ratios have also been found in studies of green turtles in the Masirah Channel, Indian Ocean (Ross 1984) and in the Southern Bahamas (Bolten et al. 1992). However, female-biased sex ratios in green turtle populations have been reported in east central Florida (Schroeder and Owens 1994) and at Moreton Bay in Queensland, Australia (Limpus et al. 1994).

For statistical purposes, the 421 turtles were partitioned into non-tumored (49.2%) and tumored (50.8%), and each group was divided into seven 10 cm size classes (Fig. 2 & 3). The non-tumored group had an unbiased sex ratio of 1.01F:1.00M (replicated goodness of fit test, $P > 0.05$). None of the size classes in the non-tumored group were significantly different from a 1:1 sex ratio ($P > 0.05$). In contrast, the group of tumored turtles exhibited a sex ratio of 1.32F:1.00M that was significantly female biased (replicated goodness of fit test, $P < 0.05$). However, when size classes were analyzed, only turtles 90.0-99.9 cm showed a significant ($P < 0.05$) female bias (7.00F:1.00M). A significant female biased sex ratio among tumored turtles (1.26F:1.00M), and an unbiased ratio in non-tumored turtles (0.97F:1.00M), also existed when the statistical analysis was conducted deleting all turtles in the 90.0-99.9 cm size class. No explanation can be offered for the apparent female bias of turtles with fibropapillomatosis. However, this new finding needs to be further investigated in view of the importance of the disease to affected populations, such as in the Hawaiian Islands.

The reason for the significant female bias in the largest (and presumably oldest) turtles is unknown. The total numbers involved are small, i.e., 12F and 2M or 3.3% of 421 turtles sampled. One possible explanation for the bias could involve the documented taking of adult males and females for commercial and other purposes while the migrant turtles were basking ashore at French Frigate Shoals (Balazs 1980). This exploitation at the breeding grounds was stopped during the early 1960's, when stricter enforcement of the area's wildlife refuge status came into effect. Some (and possibly many) males are known to migrate to breed at French Frigate Shoals on an annual basis, while the females only breed every two or more years (Balazs 1983). Consequently, greater impact may have resulted to the male population from the killing of basking adults at this location during consecutive years. Intensive commercial hunting of all size classes of green turtles in Hawaiian waters (excluding French Frigate Shoals >1960) continued until being legally banned just 21 years ago in 1974. It is therefore possible that a depletion of large slow-to-mature males happening decades ago may still be evident today, as the population continues to recover.

It is interesting to note that there were only two turtles (both males) in the 30.0-39.9 cm size class of tumored turtles. In contrast, in the non-tumored group there were 56 turtles (28F & 28M) in this same size class (Fig. 2 & 3). These data support the hypothesis that the smallest green turtles (30-39.9 cm) recruiting to Hawaiian coastal foraging areas from pelagic habitats apparently arrive free of fibropapillomatosis (Aguirre et al. 1994, Balazs 1991). The agent, or triggering mechanism, responsible for the disease is therefore most likely found in coastal waters where the turtles establish residency and grow to maturity over several decades.

CONCLUSIONS

Two bodies of data, one based on serum androgen sexing (N=63) and the other from necropsies of stranded turtles (N=421), have demonstrated an unbiased sex ratio of 1:1 for Hawaiian green turtles in coastal waters. Among the various size classes examined, only turtles 90.0-99.9 cm differed significantly in favor of females. Non-tumored turtles had an unbiased sex ratio, while tumored turtles were significantly female

biased. The unbiased sex ratio of turtles without tumors, and the female biased sex ratio of turtles with tumors, existed even when turtles in the 90.0-99.9 cm size class were excluded from the statistical analysis. The exact nature of this apparent female sex bias needs to be determined in relation to the etiology, mode of transmission, and susceptibility of Hawaiian green turtles to fibropapillomatosis.

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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. Wild. Diseases 30(1):8-15.

Balazs, G.H. 1976. Green turtle migrations in the Hawaiian archipelago. Bio. Conserv. 9:125-140.

Balazs, G.H. 1980. Synopsis of biological data on the green turtle in the Hawaiian Islands. U.S. Dep. Commer. NOAA Tech. Memo. NMFS-SWFC-7, 141 p.

Balazs, G.H. 1983. Recovery records of adult green turtles observed or originally tagged at French Frigate Shoals, Northwestern Hawaiian Islands. U.S. Dep. Commer. NOAA Tech. Memo. NMFS-SWFC-36, 42 p.

Balazs, G.H. 1991. Current status of fibropapillomas in the Hawaiian green turtle, Chelonia mydas. In: Research plan for marine turtle fibropapilloma. G.H. Balazs and S.G. Pooley (eds.) U.S. Dep. Commer. NOAA Tech. Memo. NMFS-SWFSC-156, p. 47-57.

Balazs, G.H., W.C. Dudley, L.E. Hallacher, J.P. Coney, and S.K. Koga. 1994a. Ecology and cultural significance of sea turtles at Punalu'u, Hawaii. Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. U.S. Dep. Commer. NOAA Tech. Memo. NMFS-SEFSC-351, p. 10-13.

Balazs, G.H., R.K. Miya, and M.A. Finn. 1994b. Aspects of green turtles 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.

Bolten, A.B., K.A. Bjorndal, J.S. Grumbles, and D.W. Owens. 1992. Sex ratio and sex-specific growth rates of immature green turtles, Chelonia mydas, in the Southern Bahamas. Copeia 1992:1098-1103.

Herbst, L.H. 1994. Fibropapillomatosis of marine turtles. Annual Review of Fish Diseases 4:389-425.

Limpus, C.J., P.J. Couper, and M.A. Read. 1994. The green turtle, Chelonia mydas, in Queensland: population structure in a warm temperate feeding area. Memoirs of the Queensland Museum 35(1):139-154.

Magnuson, J.J., K.A. Bjorndal, W.D. Dupaul, G.L. Graham, D.W.Owens, C.H. Peterson, P.C.H. Pritchard, J.I. Richardson, G.E. Saul, and C.W. West. 1990. Decline of the sea turtles: causes and prevention. National Academy Press, Washington, D.C., 259 p.

Mrosovsky, N. 1994. Sex ratios of sea turtles. J. Exp. Zool. 270:16-27.

Rainey, W.E. 1981. Guide to sea turtle visceral anatomy. U.S.Dep. Commer. NOAA Tech. Memo. NMFS-SEFC-82, 82 p.

Ross, J.P. 1984. Adult sex ratio in the green sea turtle. Copeia 1984(3):774-776.

Schroeder, B.A. and D.W. Owens. 1994. Sex ratio of immature green turtles in an east central Florida developmental habitat. Proceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation. U.S. Dep. Commer., NOAA Tech. Memo NMFS-SEFSC-341, p. 157-160.

Wetherall, J.A. and G.H. Balazs. Submitted. Historical trends in the green turtle nesting colony at French Frigate Shoals, Northwestern Hawaiian Islands. Mar. Ecol. Prog. Ser.

Wibbels T., G.H. Balazs, D.W. Owens, and M.S. Amoss. 1993. Sex ratio of immature green turtles inhabiting the Hawaiian Archipelago. J. Herp. 27(3):327-329.

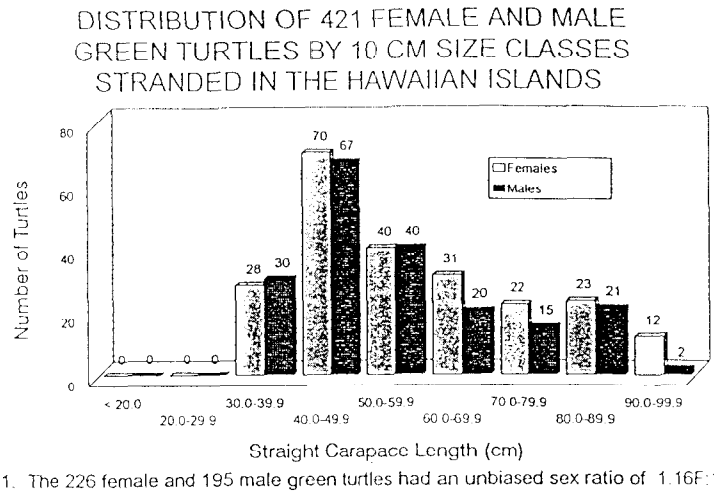

Figure 1. The 226 female and 195 male green turtles had an unbiased sex ratio of 1.16F:1.00M ($P > 0.05$).

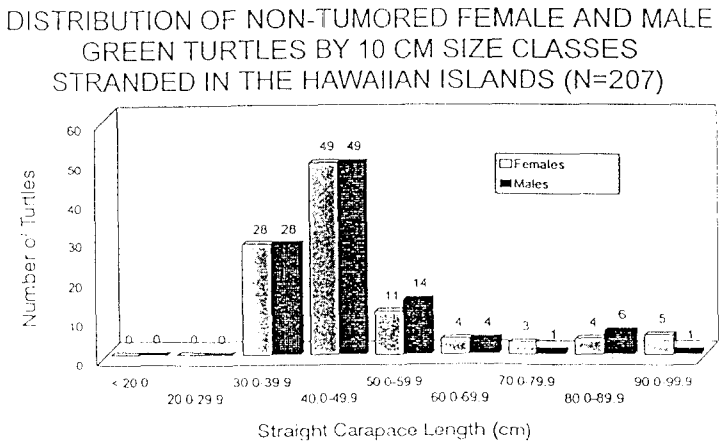

Figure 2. The 104 female and 103 male non-tumored green turtles had an unbiased sex ratio of 1.01F:1.00M ($P > 0.05$).

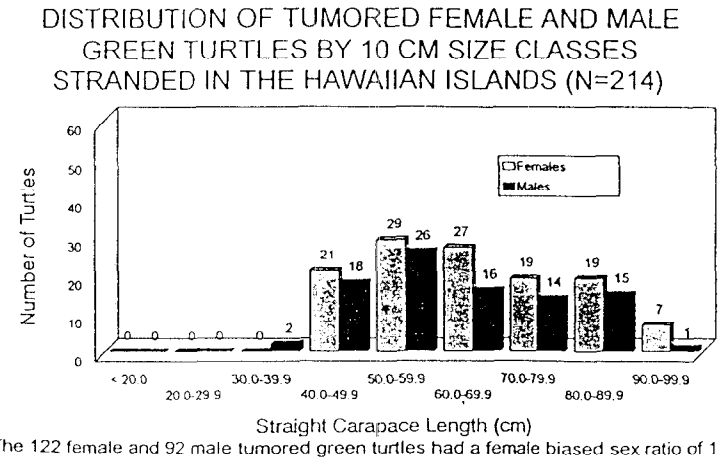

Figure 3. The 122 female and 92 male tumored green turtles had a female biased sex ratio of 1.32F:1.00M ($P < 0.05$).

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NEWS FROM THE BAYOUS—LOUISIANA SEA TURTLE STRANDING AND SALVAGE NETWORK

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In 1992 the Aquarium of the Americas, a non-profit public aquarium which opened in the fall of 1990, took over the administration and coordination of the Louisiana Sea Turtle Stranding and Salvage Network (LA-STSSN) from the Louisiana Universities Marine Consortium (LUMCON), Cocodrie, LA. Currently, the Aquarium of the Americas serves to clarify stranding information and acts as a conduit for stranding information.

METHODS

Reports of sea turtle strandings were received in accordance with National Marine Fisheries Service (NMFS)/National STSSN guidelines. The NMFS-Galveston and Creole, LA. office, and the Louisiana Department of Wildlife and Fisheries-Grand Terre and Lafayette laboratories were major contributors to the network. Reports were also obtained from universities and the general public. STSSN reports from 1990 through 1994 were examined for trends in the data.

RESULTS

For the five years examined, 373 sea turtles were registered with the LA-STSSN. Of these, 268 (71.8 %) were Kemp's ridley sea turtles, 45 (12.1%) Loggerhead, 10 (2.7%) Greens, 8 (2.1%) Leatherbacks, 1 (.3%) Hawksbills and 41 (11%) unidentified (figure 1).

Of the nine parishes that have direct access to the Gulf of Mexico, all but two reported strandings (St. Mary's and Vermillion parishes). Three parishes reported 93.3 % of all strandings for the years examined. Cameron Parish, located at the west end of the state reported 222 strandings (59.5 %), Jefferson and Lafourche parishes, located towards the eastern half of the state tallied 95 strandings (25.5%) and 31 strandings (8.3%) respectively (figure 2).

The greatest number of sea turtle strandings reported to the LA-STSSN was in 1994 when 178 reports were recorded. The previous high for turtle strandings was 94 animals in 1993. During the previous three years, strandings ranged from 31 to 39 turtles. Sea turtle strandings occurred in each month during the period examined with 83.9 % of the strandings reported between May and September (figure 3).

The greatest number of strandings during several consecutive days occurred from May 28 to June 4, 1993. During this Memorial Day Weekend, 52 Kemp's ridleys washed ashore on Grand Isle in Jefferson Parish. In addition to these registered turtles, another 20-30 turtles may have

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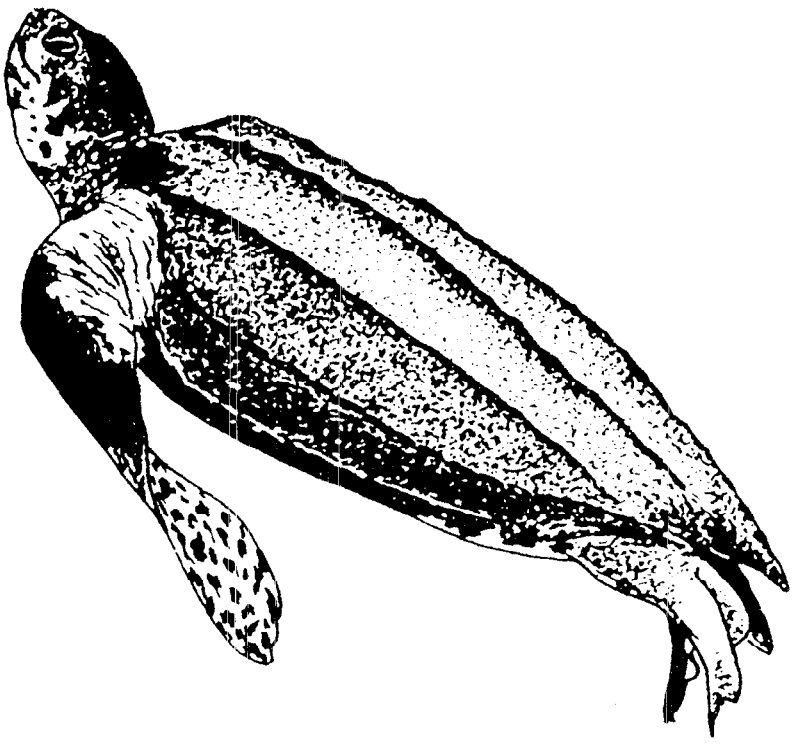

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