STATISTICAL METHODS FOR GREEN TURTLE NESTING SURVEYS IN THE HAWAIIAN ISLANDS

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SURVEY STRATEGY

Since 1973, annual nesting surveys have been conducted at East Island, French Frigate Shoals, in the Northwestern Hawaiian Islands, to monitor the status of the threatened population of green turtles, Chelonia mydas. French Frigate Shoals is part of the Hawaiian Islands National Wildlife Refuge, managed by the U.S. Fish and Wildlife Service. The surveys are a cooperative project between the NMFS Honolulu Laboratory and the FWS.

In spring or early summer, adult green turtles migrate to East Island from inshore foraging pastures throughout the Hawaiian Islands. The females emerge at night to dig nests and deposit eggs in a series of distinct multi-night nesting episodes over the course of the summer breeding season. While ashore the nesters are counted by field personnel and tagged for later identification. Typically, partial-season surveys are conducted. These cover a few weeks during peak nesting activity and are designed to monitor all nesters coming ashore. Until recently, these partial-season surveys produced only simple annual indices of the nesting population size. During a series of saturation surveys in 1988-92, however, complete coverage of the nesting season at East Island was achieved. The saturation surveys provided detailed information about nesting emergence patterns. As described below, such data led to rigorous statistical methods to estimate the nesting population each year on the basis of partial-season survey data (Fig. 1).

NESTING POPULATION ESTIMATORS

Assume that N turtles emerge to nest over a complete nesting season. During a partial-season nesting census the total number of nesters emerging, C, is observed. In addition, the number of individual nesters emerging during the survey, M, is determined by applying unique flipper tags to each nester upon her first observed emergence. The partial-season nesting census provides sample statistics which are raised to estimate N. Two estimators, N1 and N2, are employed:

Method 1: $N1 = C/U$
where U = expected number of emergences per nester during the partial-season survey;
Method 2: $N2 = M/P$
where P = probability that a nester emerges and is sighted ashore at least once during the partial-season survey.

The parameters U and P for a specified partial-season survey schedule depend on nesting emergence patterns, as determined by nightly emergence probabilities. The latter were estimated from the 5-yr series of saturation surveys, in which virtually all turtles coming ashore to nest were identified.

Applied to historical survey statistics, the estimators yield similar results, but Method 2 has generally given slightly lower estimates; statistical and systematic biases of each estimator are the subject of ongoing research. Both estimators, however, show an encouraging upward trend in the nesting population which we attribute to protection of green turtles throughout the Hawaiian Islands under the U.S. Endangered Species Act (Fig. 2).

EMERGENCE TIME MODEL

Saturation survey data also enabled modeling of the probability distribution of nesting emergence time and component stochastic processes. In particular, parsing of emergence histories for 1,115 nesters over 145 nights led to estimates of the probability distributions for nesting frequency, nesting episode duration, and internesting interval. These three processes combine in complex ways to determine the probability that a nester will be present on the nesting beach and resighted on a given night after her initial emergence at East Island. The latter probabilities also were estimated each year directly from saturation survey tag resighting data. A fourth component of the emergence time model is the probability distribution of the arrival time, the date a nester comes ashore to begin her first nesting episode of the season. Assuming the arrival time is a random variate with a gamma distribution, we derived a statistical model of the expected number of nesters ashore on each night of the season, conditional on the resighting probabilities. Then we estimated the arrival distributions for 1988-92 by fitting the expected nester counts to annual survey observations by least squares (Fig. 3 shows results for the 1990 survey).

SURVEY DESIGN

The precision of each nesting population estimator, as measured by its coefficient of variation (CV), depends largely on U and P, and thus on the survey schedule. We estimated bootstrap CVs of N1 and N2 by resampling the saturation survey nesting histories under various combinations of survey start date and survey duration (Fig. 4). We determined that satisfactory precision in N1 and N2 can be achieved by conducting a 30-night survey at East Island beginning about June 1 of each nesting season.

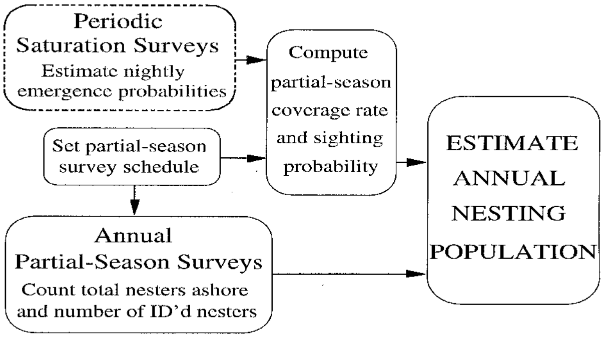

Figure 1. Strategy for monitoring the nesting population.

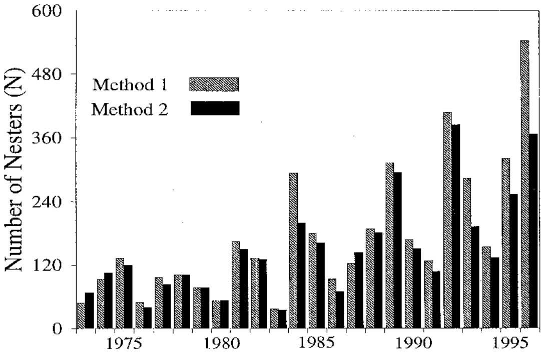

Figure 2. Estimates of East Island green turtle nesting population, 1973-1996.

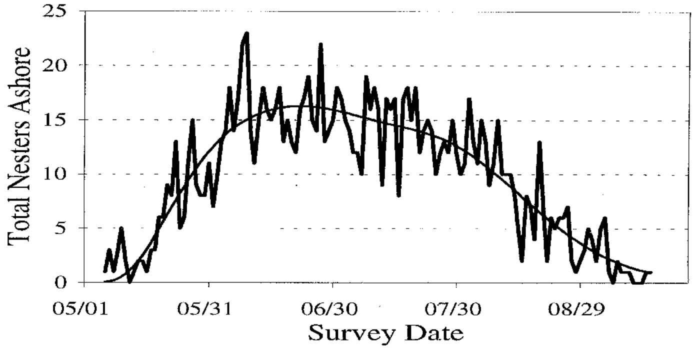

Figure 3. Observed number of nesters ashore and fitted model for the 1990 saturation survey.

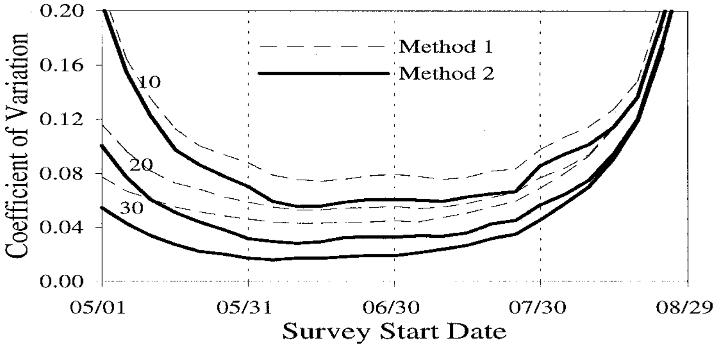

Figure 4. Coefficient of variation of nesting population estimates for surveys with various start dates and durations of 10-30 nights (assumes nesting population of 200 turtles).

STATUS OF THE DEVELOPMENT OF A MULLERIAN INHIBITING HORMONE SEXING TECHNIQUE FOR HATCHLING SEA TURTLES

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INTRODUCTION

Like many other reptiles, sea turtles possess temperature-dependent sex determination in which the incubation temperature of the egg determines the sex of the hatchling (reviewed by Mrosovsky, 1994). This type of sex determination can result in biased hatchlings sex ratios, and previous studies suggest that such biases could

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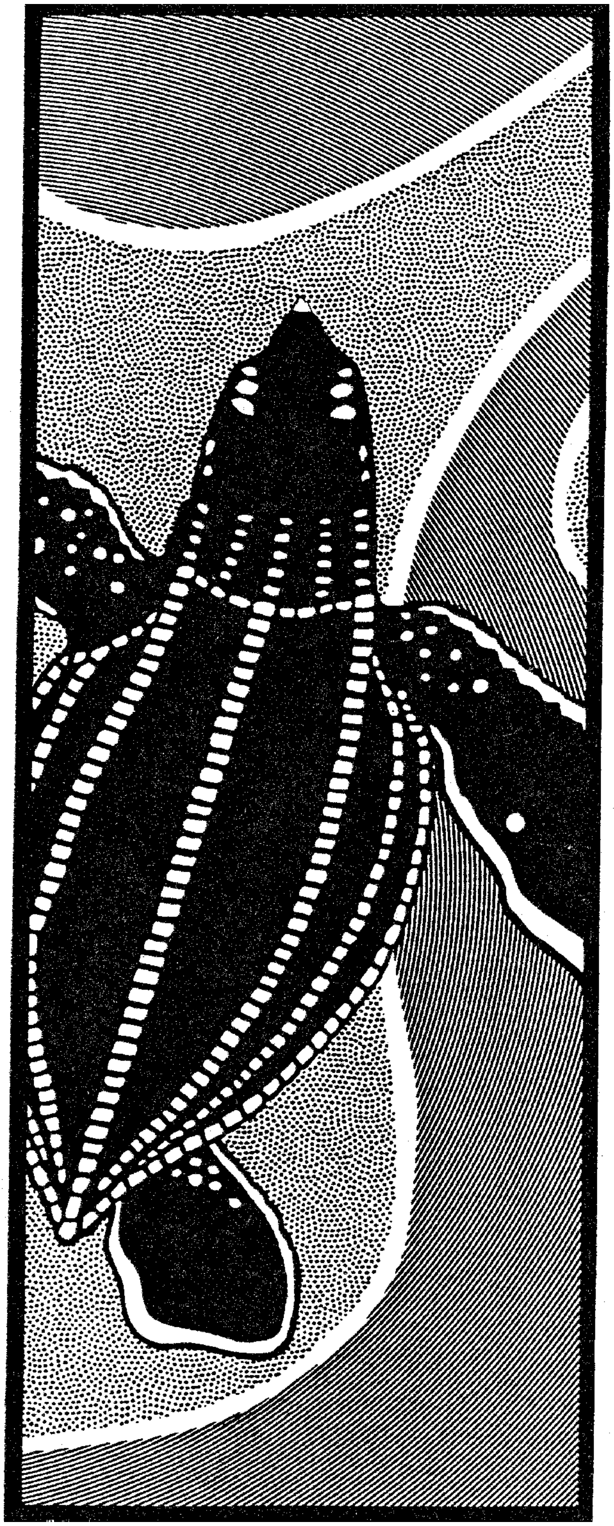

PROCEEDINGS OF THE SEVENTEENTH ANNUAL SEA TURTLE SYMPOSIUM

4-8 March 1997
Orlando, Florida, U.S.A.

Compilers:
Sheryan P. Epperly
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