The Status of Loggerhead, *Caretta caretta*; Kemp's Ridley, *Lepidochelys kempi*; and Green, *Chelonia mydas*, Sea Turtles in U.S. Waters: A Reconsideration

Assessing the status of widely distributed marine species can prove difficult because virtually every sampling technique has assumptions, limitations, and biases that affect the results of the study. These biases often are overlooked when the biological and nonbiological implications of the results are discussed. In a recent review, Thompson (1988) used mostly unpublished population census data derived from studies conducted by the National Marine Fisheries Service (NMFS) to draw conclusions about the status of Kemp's ridley, *Lepidochelys kempi*; Atlantic coast green turtles, *Chelonia mydas*; and the loggerhead sea turtle, *Caretta caretta*.

We briefly critique Thompson's data and conclusions with respect to the presentation of incorrect information, inadequate citation of pertinent published literature, reliance on unpublished and nonpeer-reviewed reports to assess population size and status, and development of conclusions that do not follow from the data. The point of this letter is not to criticize the need to review data but rather to point out that many of the assumptions and techniques discussed by Thompson (1988) have not been evaluated in the peer-reviewed literature.

The limitations of aerial survey techniques to estimate population size in murky Atlantic waters have never been rigorously examined. For example, Marsh and Saalfeld (1989) were unable to identify individual sea turtle species during aerial surveys of clear waters of the Australian Great Barrier Reef. Attempts to standardize data for perception and availability biases were not successful. How would perception and availability biases influence population assessment in offshore waters of the southeastern United States where visibility is poorer?

One of our primary concerns is the reliance on unpublished information to support statements about status or population size. Thompson ignored published research and in so doing missed the opportunity to make comparisons among studies. For example, aerial surveys of the Gulf Stream and inshore waters of the Atlantic Ocean and Gulf of Mexico were conducted prior to the surveys mentioned by Thompson (Hoffman and Fritts, 1982; Fritts et al., 1983). By ignoring references, the review disregarded the contributions of other researchers. In some cases, published research by NMFS biologists was not mentioned, e.g., Schroeder and Thompson (1987). A second concern is that assumptions were not justified beyond references to unpublished reports. Thompson stated that the mean number of loggerhead turtles present during the peak spring/summer survey from North Carolina to Key West was 387,594 (95% C.I. $\pm$ 20,154). She does not acknowledge any limitations in applying radio-telemetry data obtained in one spatially limited study (at Canaveral Ship Channel, Fla.) to determine the below-surface turtle numbers over the entire area from North Carolina to Key West. We cannot determine from data whether extrapolation between studies is behaviorally or temporally justified, Other information (Byles, 1988; Byles and Dodd, 1989) suggests that the amount of time loggerheads spend at the surface varies greatly with activity, temperature, depth, and season.

Thompson derived independent loggerhead mortality estimates for the Atlantic Ocean and Gulf of Mexico by multiplying the published (no citation given) value of turtle catch per 1,000 pounds of shrimp landed by the total amount of the shrimp catch. In neither case was the geographical limits of the estimate given. The assumption is that mortality can be estimated despite nonrandom spatial and seasonal sampling using experimental excluder trawl surveys, observers on shrimp vessels, and "intermittent 1973-78 shrimp discard observations." We suspect that the standard errors of such estimates may be large although there is no way to tell. There seems little justification for Thompson's contention that there have been between 10,000 and 23,000 turtles killed yearly since 1973. Henwood and Stuntz (1987) estimated that approximately 10,000 sea turtles died from shrimp trawling based on data gathered in 1983, although they did not extrapolate their findings to other years. Henwood and Stuntz (1987) provided a sound rationale and basis for the derivation of a mortality estimate. If Thompson applied Henwood and Stuntz' (1987) methodology to data from other years, why not say so? If she didn't, how were her mortality figures derived?

When assessing the "status of stocks" of loggerheads, various figures were provided without an adequate explanation as to how the figures were derived or whether underlying assumptions were valid. The survivorship requirements assumed that 387,000 loggerheads constitute a "unit stock." The assessment assumed a mortality figure of 10,000-23,000 per year during shrimp trawling. According to Thompson, between 0.8% and 5.2% of hatchlings entering the water must survive to maintain population stability. Although often cited, a hatchling survivorship value of 1% to maintain a stable population has no basis in empirical data (Frazer, 1986, 1987). Such estimates were derived from theoretical considerations and are based on assumptions, such as a stationary population, that may not be valid for today's turtle populations (Frazer, 1986).

Thompson claimed the number of nesting females and the number of turtles in the water indicated a stable population since 1980, but gave no supporting data. In contrast, the long-term studies in coastal Georgia indicate an overall 3% annual decline in the number of nesting females since the early 1970's (Frazer, 1983, 1986). Over the past few years, the decline has been much greater, approaching 9% (J. Richardson, personal commun.). Similar declines are occuring in South Carolina. Considering the increased development and disruption of nesting beaches and the continued heavy shrimping activity undertaken until recently without Turtle Excluder Devices (TED's), we believe it unlikely that offshore sea turtle populations have not been impacted. If "we do not have an adequate data base to evaluate these [population estimate of 387,000 plus likely detrimental impacts from shrimping] conflicting effects on the population dynamics of this species" (p. 19), it

would seem impossible to conclude that "there is no apparent risk of major declines over the next 10 years."

Contrary to Thompson's assertion that no historical records of green turtle nesting in the United States are available, Dodd (1982) summarized nesting records in Florida and first suggested that the population might be increasing. Significant references to the turtle fishery in Florida (Witzell, 1987) and Texas (Doughty, 1984) were overlooked, as were citations to the original literature on which much of the discussion in this section was based. And while the spatial limits of the Florida population cannot be ascertained at present, the results of Bowen et al. (1989) suggest that the population is more "closed" than Thompson states. Although small green turtles will accept animal matter in captivity and the nutritional habits and requirements of wild adults and juveniles are reasonably well known (Mortimer, 1981; Bjorndal, 1985), there is no basis to say that green turtles pass through an omnivorous dietary stage, or that this transition occurs at age 3.

Estimating time to extinction in long-lived animals is fraught with model assumptions and should not be presented without thorough discussion. Thompson's estimate of 208 years for the nesting population of *L. kempi* to become extinct is difficult to accept because a minimum viable population size has never been established for the species. Thompson contradicts herself by stating on p. 22 that the Rancho Nuevo population will be extinct in 208 years if a 3% population decline continues and then stating on page 23 that 100 nesting females will remain in 2196 at the same rate of decline.

Biologists reviewing complex and often contradictory information face dilemmas about the extent of coverage a review should give, whether to use data not generally available to colleagues, and space limitations. These factors may have influenced Thompson's (1988) review. However, important background and supporting information should not have been omitted. We believe that the status of these species has received superficial coverage. Several reviews of biological data now have been published (Dodd, 1982, 1988; Ehrhart and Raymond, 1987; Ross et al., 1989) on these species which give a better picture of their status in U.S. waters. Future reviews should focus on the need for publication in peer-reviewed journals with clear presentation of techniques, assumptions, and results which follow from the data. Accepting estimates of population size, mortality, and trends are not justified until these conditions are met.

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A Response to Dodd and Byles

Dodds and Byles (1991) raise several questions regarding the quality of the data and validity of the conclusions presented in my review paper (Thompson, 1988). As a point of reference, this paper was the result of a collaborative effort in 1986 with myself, and T. A. Henwood and W. E. Stuntz who subsequently and independently published their estimates of turtle mortality from offshore commercial shrimp trawling (Henwood and Stuntz 1987; Thompson, Henwood and Stuntz 1986[1]). Since that time, as Dodd and Byles (1991) note, there have been several review publications which include new information on the status of sea turtles in U.S. waters (Dodd, 1988; Hopkins-Murphy and Murphy, 1988; Ross et al., 1989; Marquez, 1990; Magnuson et al., 1990). Herein, I will address

[1] Thompson, N. B., T. Henwood, and W. E. Stuntz. 1986. A summary of information on three species of marine turtles in U.S. waters. Coast. Fish. Resour. Div., Miami Lab., SEFC, NMFS, Contrib. ML1-86-57, 35 p.

the most critical concerns, in my opinion, of Dodd and Byles (1991).

The value of pelagic aerial surveys to derive a synoptic index of abundance for marine turtles has been debated over the past 13 years or so since this technique was first applied by the University of Rhode Island (CeTAP, 1982). The CeTAP report (1982) describes the pelagic aerial and vessel effort to census cetaceans and turtles in North Atlantic waters off the northeast U.S. coast. While statistically evaluating the CeTAP marine turtle data, Thompson and Shoop[2] (1981) concluded that the aerial survey approach was appropriate to count large loggerhead and leatherback turtles at the surface of the water. Our results[2] formed the basis of the NMFS surveys of the North Atlantic off the southeast U.S. coast and reported by me. Notably, the sampling design and preliminary results from our surveys were reviewed at the First and Second Stock Assessment Workshops held at the NMFS Southeast Fisheries Center, Miami, Fla., in August 1982 and 1984, respectively (Powers, 1983; Powers, 1985). These workshops convened scientists inside and outside of NMFS to review stock assessment information and evaluate the research which provided this information for fishery and protected resources under the purview of the NMFS Southeast Fisheries Center. Since the first stock assessment workshop, results of our surveys have been regularly presented (Thompson, 1983; Thompson, 1984a, b; Schroeder and Thompson, 1987).

More recently, our data were provided to the National Academy of Sciences and selected data are included in Appendix D of the Committee on Sea Turtle Conservation Report (Magnuson et al., 1990). Magnuson et al. (1990) concluded that aerial survey data were indeed "valuable for surveying large areas . . ." A variety of environmental factors will bias results, and many of these were examined statistically by Thompson and Shoop[2], re-examined by Powers (1983) and reiterated by Magnuson et al. (1990). The major problem in converting surface counts to total abundance via density estimation is applying a conversion factor to account for turtles under the water's surface. Stratification of this factor by species, size class, time, and space was noted in Powers (1983) and again pointed out by Dodd and Byles (1991). However, the consistent application of the best available estimate for this species within the sampling area and closest to the aerial survey sampling period was applied to our survey results (Powers, 1983). Unfortunately, Dodd and Byles (1991) offer no alternative to this methodology to census turtles in the water over a large area, which would provide a productive exchange.

I am particularly concerned about the criticism of the use of NMFS excluder trawl survey data, shrimp vessel observer data, and intermittent shrimp discard observation data. These were the data utilized by Henwood and Stuntz (1987) to estimate turtle mortalities and the basis for the National Marine Fisheries Service Turtle Excluder Device (TED) regulations (50 CFR Parts 217, 222, and 227 Sea Turtle Conservation; Shrimp Trawling Requirements; Final Rule, Federal Register, Vol. 52. No. 124, Monday, June 29, 1987, p. 24244-24262). These data on the incidental catch of turtles in commercial offshore shrimp trawls were also provided to Magnuson et al. (1990) who concluded that Henwood and Stuntz (1987) may have underestimated mortality attributable to offshore commercial shrimp trawling. Notably, I developed an independent estimate of shrimp trawl related mortality which is slightly higher than that of Henwood and Stuntz (1987). The purpose of this second analysis to estimate shrimp trawl mortalities was to underscore the validity of that of Henwood and Stuntz (1987) (Thompson et al.[1]). These independent estimates represent the "best available information" which form the basis for the subsequent analysis on stability conditions for the loggerhead turtle (Thompson and Powers 1986[3]). Apparently, I credit the reader in understanding the assumptions and limitations of this approach. It is only an attempt to determine the future of this species over the short term (10 years), does not imply that turtles have not been negatively impacted by shrimp trawling or any other anthropogenic cause of mortality, and represents a first step in evaluating a large body of data available on this species. In my opinion, the debate on the validity of our turtle mortality estimates from commercial shrimp trawling has been laid to rest. I do not believe that Dodd and Byles (1991) are interested in resurrecting this debate.

The question on the definition of stocks, particularly as it pertains to the green turtle, remains a subject of debate (Powers, 1983). It is hard to believe that any species such as the green turtle, that has persisted so long, does not demonstrate some movement between "populations." In the absence of stock boundary data, I advocated a management approach that favors the turtles; that total protection is still needed to effect recovery (Thompson, 1988).

I do not understand the contradiction that Dodd and Byles (1991) point out with my assessment of the status of the Kemp's ridleys. I identified some period of time to real extinction (zero females) vs. some rate to functional extinction (100 females). The point here is that under the conditions for the period 1978 through 1987, the index used to evaluate the status of this species, the number of nesting females at Rancho Nuevo, continued to decline. Under unchanging conditions, annual decline is expected. With the full implementation of the TED regulations, the conditions current in 1988, no longer exist. As an optimist, I believe this bodes well for the recovery of this species.

Quite honestly, one motive for pursuing publication of my overview paper was to provide some incentive to others to publish their information on the status of sea turtle stocks in U.S. waters. A regularly conducted assessment of the status of these populations is the only way we will be able to know how well we are doing in recovering these species. This means that evaluating the best information may alter previous conclusions. I am optimistic that the publication of

[2] Statistical analyses of sea turtles: Data derived from the 1979 Cetacean and Turtle Assessment Program. Univ. R.I., Kingston, Contr. NA-81-FA-C-000011, 33 p.

[3] Thompson, N. B., and J. E. Powers. 1987. An assessment of the status of the loggerhead turtle (*Caretta caretta*) in the U.S. Natl. Mar. Fish. Serv., Southeast Fish. Cent., Miami, Fla. Unpubl. manuscr.

information on the status of these stocks will continue. This is absolutely critical to the survival of these species.

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