Assessment of Sea-Turtle Status and Trends

Integrating Demography and Abundance

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

Summary

INTRODUCTION AND BACKGROUND

Long lifespans and wide-ranging migrations make the seven species of sea turtles difficult to monitor. They are susceptible to many sources of mortality, including direct and incidental "takes" (basically any potential effect on a turtle or its behavior [50 CFR 17.3]) resulting from coastal and oceanic human activities. All six of the species that occur in U.S. waters[1]—loggerhead (*Caretta caretta*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricate*), Kemp's ridley (*Lepidochelys kempii*), olive ridley (*Lepidochelys olivacea*), and leatherback (*Dermochelys coriacea*)—are listed as endangered or threatened under the Endangered Species Act so their direct harvest is prohibited although incidental take is permitted under some circumstances. (The seventh sea-turtle species is the flatback [*Natator depressus*], which is found only in the waters around Australia, Papua New Guinea, and Indonesia.) Accurate assessments are necessary to evaluate the status and trends of populations and the effects of incidental takes and to assess the value of implemented protections of specific populations.

Sea turtles migrate across whole ocean basins; therefore, population assessments require an international context. Activities throughout the world's oceans—including development on nesting beaches, killing of turtles for food, and incidental capture in commercial and subsistence

[1] U.S. waters not only refers to waters around U.S. states but also waters around U.S. territories, such as American Samoa, Puerto Rico, Northern Mariana Island, Guam, the U.S. Virgin Islands, and Palmyra Atoll.

fisheries—contribute to sea-turtle declines and affect populations in U.S. waters. Data needed for accurate assessments of most populations are not available, and this prohibits diagnostic evaluation that can benefit management. In light of that problem, the National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration asked the National Research Council's (NRC) Ocean Studies Board for advice on methods for improving sea-turtle population assessments. See Box S.1 for the committee's full statement of task.

In response, the NRC appointed a committee of experts. The committee held two public meetings during which it received briefings from NMFS, the U.S. Fish and Wildlife Service (USFWS), and a number of other experts in sea-turtle biology and population assessments. In addition, the committee reviewed the available literature, met in closed sessions, and participated in several conference calls to complete work on its report. The report is intended to help NMFS and USFWS to improve population assessments of sea turtles; NMFS is responsible for the management of sea turtles in the water, and USFWS is responsible for sea turtles on land.

The committee was asked to evaluate current and emerging population assessment techniques that are being applied to provide advice to managers of sea turtles in the United States. Unlike the charge to the committee that prepared the 1990 NRC report (*Decline of the Sea Turtles: Causes and Prevention*), the charge to the present committee was not to review the wide array of threats and management actions related to sea turtles in the United States but rather to focus on the steps necessary to improve the assessments required for federal sea-turtle monitoring and management. This report describes a variety of assessment types and techniques, including beach samples, in-water surveys, genetic analyses, demographic[2] analyses, bycatch (incidental take) information, and aerial surveys; reviews assessment methods; identifies information gaps; and suggests improvements for data collection. The fundamental theme underlying this report is that abundance assessment is essential but that abundance information alone is insufficient to understand the causes underlying trends in sea-turtle populations or to predict future trends. In addition to reliable abundance estimates, it is necessary to understand key demographics. To date, sufficiently complete demographic information has not been used in population assessments of sea turtles in the United States, in large part because it has not been available.

The committee believed that it was beyond its charge to discuss major stresses on sea-turtle populations, such as interactions with fisheries, and

[2] Demographic or vital-rate parameters, such as birth and survival rates, indicate the potential for changes in a population.

Box S.1
Statement of Task

This study will review recent assessments on the status and trends of sea-turtle populations that occur in U.S. waters during all or a portion of their life cycle. The study will evaluate the state of the science and research in terms of population assessment capabilities and data required to improve assessments. The study will review the utility of existing research programs that provide information for assessing and managing sea-turtle populations in the context of current recovery plans. The report will include a discussion of current methods used to assess the status of sea-turtle populations and to estimate known mortality. Recommendations will focus on the research, monitoring, and data needed to improve sea-turtle population assessments in the short- and long-term, such as genetic analyses, telemetry, and mark-recapture studies, taking into account the effectiveness, cost, and timeliness of various data collection methods. The committee will also recommend improvements to existing models, highlight limitations in current methods, identify potential new avenues for modeling, and suggest methods for making sea-turtle population data available for incorporation into a wide range of models and meta-analytical studies.

the potential effects of environmental conditions or external stresses; to detail environmental conditions or regime changes; and to assess the costs of its recommendations. Additionally, this report does not review specific assessments comprehensively, except as illustrative examples of methods and data gaps but does provide a summary of methods used. The committee was not asked to conduct its own assessments of sea-turtle populations but was asked to evaluate the methods used to assess sea-turtle status and trends. That critical distinction was confirmed with NMFS by project staff. As a result, the report does not provide information on the status of sea-turtle populations. The committee recognizes the importance of taking an ecosystem approach to managing sea-turtle populations, but its report focuses on population assessments of single species. Before agencies can undertake ecosystem-based approaches to assessments of sea-turtle populations, substantial information at the single-population or single-species level is needed, as described in this report.

On the basis of its review of the methods used in assessments (see Table 1.2), the committee concludes that most of the modeling and analysis that has been done constitutes a valiant effort to compensate for a debilitating lack of data. The assessment methods that have worked in fishery biology are less successful for turtles because the available data generally are not as complete as they are for many commercial fish species. Filling the large gaps in the available data has far greater promise for improving

sea-turtle assessments than refinement of analytical methods. The committee therefore decided that the greatest focus needs to be on the data problem both for the committee's report and for the future activities of the agencies. Developing a rigorous process for assessment of sea-turtle populations is a high priority, but assessments can be more profitably reviewed and refined after better data and a transparent framework for scientific review become available.

ASPECTS OF SEA-TURTLE ASSESSMENTS

Units of Assessment

Understanding the units of assessment in sea turtles requires clarity in the definition of nesting populations. Females show affinity for specific nesting sites, and this potentially causes subpopulations to be vulnerable to extinction. Males breed with females that can have various nesting-site affinities and thus provide male-mediated gene flow among the subpopulations. Because male gene contribution may occur on a larger geographic scale than female gene contribution, that scale defines the geographic upper limits of the nesting populations.

The natural history of sea turtles includes several phases that are difficult to observe directly. In particular, the long generation time and the oceanic habitat of juveniles present major obstacles to studies of immature stages. The genetic identification of populations therefore takes on heightened importance because the alternative methods (usually tagging) can be logistically and financially daunting. The details of sea-turtle life history and population structure complicate the definitions of assessment units and management units. Chapter 2 of the report reviews the current genetic methods for resolving units of assessment for sea-turtle populations (units for evaluation of status and trends) and their applications in resolving management units and strategies (units for regulation and policy that may be based on geographic location). The major challenges associated with the complex population structure of sea turtles are still being resolved so the genetic issues addressed in the report are at the forefront of conservation genetics.

A Conceptual Model of Sea-Turtle Life History

A conceptual model linking population abundance with the key demographic processes in a single coherent framework is needed because species with a long lifespan are subject to influences beyond population changes (e.g., climate, magnitude of exploitation, type of fishing effort).

The environment could change, but the population effects (in the absence of demographic information) would not be seen for a very long time if only abundance of nesting turtles were monitored. That is, the environment could become lethal to sea turtles, but the abundance data would still show no population decline so it would be difficult to interpret abundance changes and estimate population parameters accurately.

A conceptual model of loggerhead sea-turtle abundance and demography is described in Chapter 3. The model provides a simple but effective graphic device for capturing a coherent and integrated framework for the key demographic processes and anthropogenic hazards facing a sea-turtle population. The causal-loop model not only helps to identify knowledge gaps but also provides a blueprint for simulation models of sea-turtle population dynamics and for the development of population-assessment models and risk-analysis tools. It is provided as an example of what could be developed for U.S. sea-turtle populations.

Measuring Sea-Turtle Populations on Nesting Beaches and in the Water

Population sampling on nesting beaches is a valuable source of information, but authors generally do not provide detailed justifications for their data-collection techniques. Techniques for measuring abundance and other demographic parameters of sea turtles both on nesting beaches and in the water vary widely in the type of sampling, what is counted, how counts are made, and how the data are used for estimates. The techniques vary with species-specific or life-stage–specific behaviors, water depth and clarity, currents and sea state, accessibility of habitat, personnel and equipment availability, and funding. Some of the efforts use standardized methods to ensure that current datasets are compatible with older ones.

Few individual research projects are designed to collect population-wide demographic information. Most are focused on local groups of turtles and on the collection of information applied to local management issues. Other research projects collect demographic information on turtles observed or captured incidentally because of other activities, such as fisheries and power-plant operations. Thus, the location, timing, and nature of the research projects are determined by the operations that provide access to sea turtles. Variations between in-water projects notwithstanding, U.S. waters have a broadly distributed array of research that targets sea turtles. Chapter 4 reviews methods of sampling sea turtles on land and at sea and provides recommendations concerning the conditions under which they are best used and the further development of techniques.

Demographic Rates and Integrating Demographic and Abundance Estimates

Just as abundance estimates alone are not sufficient to predict or diagnose causes of population trends without estimating demographic parameters, estimates of demographic parameters without an understanding of the causes of variance and the regulating mechanisms that control them are not sufficient to understand and to mitigate adverse trends. Understanding the ecological context of demography—such key environmental mechanisms as resource availability, temperature, current systems, and oceanic productivity that influence demographic rates—is essential for an understanding of sea-turtle population status and trends. That knowledge is necessary to predict the changes in sea-turtle populations that will occur with climate change and with oceanic regime shifts that have profound effects on many critical sea-turtle habitats.

Using abundance measures for a single life-history stage can be misleading in diagnosing the status and trends of a population. Integrating abundance measures with demographic processes in a framework of modeling and data fitting provides a more robust basis for diagnosing trends, evaluating the effects of anthropogenic hazards, and defining recovery criteria. Chapters 5 and 6 review information about demography, techniques for estimating demographic parameters, some of the quantitative tools used in assessment of populations, and tools that have been applied to sea-turtle assessments; and they discuss the procedures routinely used in fishery assessments to ensure scientific rigor that could be adopted for future assessments of sea-turtle populations.

Data Management, Education, and Coordination

The fractured status and lack of coordination of sea-turtle databases are major impediments to the management and conservation of sea turtles. Throughout the United States, hundreds of projects (of varied duration) have been established to monitor sea-turtle populations or conduct research on sea-turtle biology. Projects have been conducted by federal and state agencies, universities, nongovernmental organizations, and private individuals. However, many of the data from the projects are either inaccessible or accessible only in summary formats. Consistent data collection would maximize the ability to combine and compare data among studies. Attempts have been made to standardize data-collection protocols for sea turtles, but the use of standardized protocols (e.g., description of fishing gear and operational modes, which affects estimates of incidental captures and mortality; description of handling techniques and injuries to released individuals, which affect survival estimates) is inadequate for a

number of reasons. In addition, better data archives, including the storage of tissue samples, are needed.

The committee has found broad consensus among researchers studying sea turtles that the permitting process is a greater obstacle to research than is necessary for the protection of sea turtles or for meeting the requirements of the Endangered Species Act. New research projects with innovative techniques will need to be initiated to meet the data needs outlined in this report, but in numerous examples presented during committee meetings, the U.S. permitting process delayed or denied research projects, particularly when innovative techniques were involved.

THE COMMITTEE'S PRINCIPAL CONCLUSIONS AND RECOMMENDATIONS

Overarching Conclusion: Although abundance estimates are critical for assessing sea-turtle populations, demographic or vital-rate parameters are critical for understanding and predicting trends in sea-turtle populations. The committee concludes that (1) in the United States, critical vital rates have not been adequately determined; (2) the most important procedural enhancements would be improved coordination in data collection and availability, a more efficient and transparent permitting process, and increased archiving of tissue samples; and (3) sea-turtle assessments have not been isolated from broader evaluations of status and threats and have rarely included scientists from other quantitative-modeling fields.

Overarching Recommendation: The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) should develop a coherent national strategy for sea-turtle assessments to improve the data-collection methods, data quality, and data availability and to develop a rigorous plan for external review of data and models used to assess population status and trends. The strategy would benefit from the focused attention of expert groups that include government officials, academics, and nongovernmental organization personnel. As recommended in all expert working group documents (see Table 1.2), research should emphasize vital-rate estimation (averages, annual variance, and ecological or environmental mechanisms that drive vital rates) and improvement in abundance estimates. The most serious demographic data gaps to be addressed include in-water abundance, hatchling-cohort production, survival of immature turtles and nesting females, age at sexual maturity, breeding rates, and clutch frequency.[3] More precise estimates of anthropo-

[3] Clutch frequency refers to the number of clutches deposited by an individual turtle in a nesting season.

genic mortality are needed to evaluate impacts. All sources of data should be evaluated for quality, consistency, spatial and temporal heterogeneity and trends, and data gaps.

Detailed suggestions for improving the collection, analysis, and synthesis of data are provided at the end of each chapter of this report , and Chapter 6 describes appropriate models and procedures for assessments. Because assessments will involve different circumstances and management needs, the committee cannot recommend one standardized set of priorities for all assessments beyond its strong recommendation for a greater focus on demographic parameters. Some specific conclusions and recommendations that elaborate on the overarching conclusion and recommendation and represent the highest-priority needs are presented below.

Conclusion: Sea-turtle population assessments in the United States are based too heavily on estimates of abundance of adult females on nesting beaches. Although estimates of abundance of adult females are critical, without knowledge of accompanying changes in demographic rates at all life stages, the proximate and ultimate causes of population trends cannot be determined. Selection and evaluation of the best management options depend on an understanding of the basis of changes in population abundance.

Recommendation: NMFS and USFWS should ensure that estimates of abundance at life stages in addition to adult females are generated and that demographic rates are integrated with estimates of abundance in population assessments.

Conclusion: Inadequate information is available for population assessments because the data have not been collected or, if they have been collected, have not been analyzed or made accessible in a manner that allows them to be useful.

Recommendations:

- NMFS and USFWS should develop plans for the collection and analysis of data to address data gaps. The development should include outside experts who collect, analyze, and use the data.
- NMFS and USFWS should present a comprehensive assessment plan and a data plan to sea-turtle biologists to facilitate effective data collection for the integrated approach and to obtain input from them on improvement of the plans.
- NMFS and USFWS, with other government agencies and funding sources, should support the collection and analysis of those data.

- To avoid the overlooking of data sources, NMFS should create an on-line metadatabase[4] that identifies as many of the sea-turtle datasets in the United States and its territories as possible and that is similar to the document created for in-water projects in Florida (see Chapter 7). The database would provide information on available data, status of each dataset (e.g., computerized, hard-copy only, lost), and contact information but would not include the data. The database should be updated regularly.
- NMFS and USFWS should support a program to safeguard and make accessible as many sea-turtle databases as possible, past and present. There is some urgency to this task while data collectors are still available to provide essential metadata.
- NMFS and USFWS should partner with other government agencies, universities, and nongovernmental organizations to improve coordination among data holders. Incentives should be developed to encourage data sharing; these may include providing participating researchers with data-analysis services and data products, regional data summaries, data backup assurance, assistance with publication of results, and facilitation of collaborative relationships.
- NMFS and USFWS should arrange for a review of data now being collected under their auspices or with their support and evaluate the costs and benefits. For example, the sea-turtle stranding and salvage networks should be evaluated, perhaps with the assistance of the U.S. Geological Survey's National Wildlife Health Center.

Conclusion: Reviews of federal population assessments and research plans are not sufficiently rigorous and transparent.

Recommendations:

- NMFS and USFWS should develop a general framework for sea-turtle assessment procedures, including data evaluation, model review, and management-strategy evaluation.
- NMFS and USFWS should ensure that research plans generated in federal agencies are reviewed by panels that include federal and non-federal scientists. Using reviewers with quantitative skills, such as skills in population assessment and statistical analysis, is particularly important.

Conclusion: There are unnecessary obstacles to collection and analysis of critical data, including inadequate quantitative training of scientists and an inadequate process for issuing research permits.

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[4] A metadatabase manages data that provide information about other data or are derived from other data.

Recommendations:

- NMFS and USFWS should partner with other government agencies and universities to improve the quantitative skills of people who are involved in designing, reviewing, and implementing the projects and assessments that are generated under a comprehensive assessment plan. These efforts will be short term (e.g., recruiting quantitatively skilled experts, improving the quantitative skills of current personnel) and long term (e.g., improving quantitative training of students).
- NMFS and USFWS should convene a working group to evaluate the permitting process for research projects and develop methods to expedite the process while meeting legislative requirements and intent. Participants should include representatives of the permitting agencies and research scientists. The review should weigh unintended consequences of permitting delays and lost research opportunities, should review the potential risks and benefits to the listed species of changing permitting requirements and procedures, and should assess the extent to which scrutiny of research permits has resulted in substantial take reductions.

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Committee on the Review of Sea-Turtle Population Assessment Methods

Ocean Studies Board

Division on Earth and Life Studies

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Cover: The front cover images include five of the six species of sea turtles found in U.S. waters (from top to bottom and left to right): leatherback (provided by Guillaume Feuillet, Association Kwata), Kemp's ridley (provided by Selina Heppell, Oregon State University), hawksbill (provided by the National Oceanic and Atmospheric Administration), olive ridley (provided by Guillaume Feuillet, Association Kwata), and green (provided by Claire Fackler, National Oceanic and Atmospheric Administration). The back cover image is the sixth species, which is the loggerhead (provided by William Precht, National Oceanic and Atmospheric Administration).

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