The Leatherback Turtle in the Atlantic:
a Review of an Assessment by the
Turtle Expert Working Group

Michael Kingsley

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Report prepared for the University of Miami
System for Independent Peer Review

Review of: Turtle Expert Working Group Assessment of the Atlantic Populations of the Leatherback Turtle, *Dermochelys coriacea*

Executive Summary.

Kingsley, M.C.S. 2007. The leatherback turtle in the Atlantic: a review of an assessment by the Turtle Expert Working Group. Report prepared for the University of Miami system for Independent Peer Review Unpublished. 24 pp.

The review is comprehensive. It would profit from including sections on 'Conservation', to include descriptions of organisations and activities, and on 'Distribution', to gather material on beaches, beach movement, relative importance, qualitative estimates of numbers, etc. It would also profit from having unused citations gathered into an annotated bibliography.

The assessment could be improved by more attention to the details of quantitative analyses. Results are presented, but the data on which they are based are often invisible, and in many cases the report presents the Expert Working Group's—no doubt expert—conclusions with little to support them. This is especially obvious in the section on estimating adult numbers, which would command more confidence if the parameter values that enter into the estimation procedures were easier to trace elsewhere in the report. More complete descriptions of methods for both collecting and analysing data would increase confidence in the assessment.

The methods for the analysis of data that are described are for the most part unexceptionable, although the method for estimating population growth rate ascribed to Morris and Doak may not be entirely appropriate for all the data series, and the quantitative assessment of trends and numbers is sound, provided that the data are good. A more rigorous critical examination of the data and description of the methods would reduce the degree to which the quality of the data has to be taken on trust.

The report as a whole could be improved by increasing the emphasis on different aspects of the biology as a basis for its structure and reducing the emphasis on data sources.

The recommendations for further research constitute a general prescription for continuation of present activities. They could be made more relevant if they drew more directly on the knowledge gaps mentioned in the assessment to pinpoint needs for new or widened knowledge.

Review of: Turtle Expert Working Group Assessment of the Atlantic Populations of the Leatherback Turtle, *Dermochelys coriacea*

Background

This document is a review of a report on the status of the Leatherback Turtle in the Atlantic, the product of four meetings of the Turtle Expert Working Group from November 2004 to March 2006. The terms of reference for the working group were: ‘to convene a team of population biologists, sea turtle scientists and life history specialists to compile and examine information on the status of sea turtle species.’ A joint assessment document for Kemp’s ridley and the loggerhead turtle in the Western North Atlantic had been produced by the Expert Working Group in 1998 and updated two years later.

Description of the review.

Review activities consisted of carefully reading the report, and clarifying thoughts by summarising the different sections. Calculations were re-worked and checked as appropriate. Internet searches were carried out to check on some of the analytical methods and to check references, and to aid in visualising the geography of the breeding habitat.

This report has been a pleasure to read. The language is clear, unpretentious, grammatical, and easy to follow, and the Expert Working Group’s enthusiastic interest in its subject is plain to see.

The report comprises:

- a short section on stock structure, concluding that there are seven useful (usable) stocks (defined by (aggregations of) nesting beaches);
- a short section on life history, sex ratio, aging, growth, mortality;
- stock status, stock by stock and in some cases subdivided by smaller groups of nesting beaches, essentially based on nesting counts on beaches;
- trend analysis of the stock status (nesting beach) data, with results for each stock;
- estimation of numbers, by stock, from nest counts;
- ’in-water data’: comprising (satellite) tag tracks and sighting surveys, both aerial and shipborne;
- a qualitative model of stock structure and age- and breeding-related movements;

- threats; by stock, and in some cases by beach;
- and a short synthesis of the information.

Summary of findings

Evaluate the adequacy, appropriateness and application of data used in the assessment.

The data used in this review comprise, apparently, most of the data that are available. This reviewer is not in a position to say whether there are substantial bodies of data that are not included in the report; however, it seems most likely that this expert group would at least have known of any such collections, and would have noted any that were not made available for the assessment. There is mention of unsurveyed islands, e.g. in the northern Caribbean, and a general lack of information from western equatorial Africa. An overall tabulation of potential breeding areas—perhaps in a section on 'General Distribution'—with state of knowledge would help.

The data that are included in any detail in this report consists largely of annual beach counts of nests. There are some tag data from flipper tags or implanted passive transponder tags, in some cases leading to estimates of annual numbers of nesting females. Direct estimates of total numbers are not available, and estimates of total numbers may not be consequential to status assessments of marine turtles. Results of genetic analyses of stock structure are included, and there is a small quantity of data from aerial surveys near shore and from satellite-linked radio tags.

Data pertaining to stock structure.

Data are generally not presented. The stock structure section presents brief conclusions, mostly from molecular data, partly from tagging. Northern South America, from French Guiana at least to Trinidad, is considered one stock from molecular data, supported by tagging, and an extension of this stock to Venezuela is also supported by tagging data. Central America (Costa Rica and western Panama, but possibly Colombia–Honduras) is distinct, as is a third western Atlantic stock—'northern Caribbean' so far based on genetic data from St Croix. A Florida stock is also considered distinct, although the reasoning behind this is not stated. Preliminary molecular data suggest that Brazil is also distinct. On the eastern side of the Atlantic some data suggests that West Africa is distinct (from the western Atlantic?) as is a southern African breeding area in Natal.

Tag data that, showing some females sometimes to travel long distances between beaches both within and between nesting seasons, undermines clear distinctions between nesting stocks is sketched and selectively presented, but it is not clear how comprehensive the presentation is.

Data pertaining to life history.

Data on stage definition are not presented, and it is not clear whether stage boundaries based on length are being proposed, although later tabulations define 'small' or 'small juvenile' as those below 50 cm CCL, subadults as 100–145 cm, and adults as over 145 cm[1]. The diagram of Figure A would be clearer if we knew whether the probabilities proposed are annual period-wise probabilities, instantaneous rates, or simply overall probability. This model is not developed to the point of attaching values to the parameters.

In contrast to the section on stock structure, data on sex ratios of stranded leatherbacks, notably on the Atlantic and Gulf coasts of the U.S.A. but also including some data from other areas, are comprehensively presented, but there is little in the way of a synthesis or conclusions. Sex ratio estimates for hatchlings are in several cases indirect, inferred from temperature, with the caveat that 'there is no validation for these methods'. Data on the length distribution of strandings are presented elsewhere in the report, but would be appropriately included here.

Data pertaining to age, growth and survival.

No data on growth are presented; results of previous analyses are summarised. No parametrised growth curve is proposed. Methods of aging are briefly discussed, but it is evidently difficult to age turtles and further study is needed.

Some estimates of survival are presented, but no synthesis or summarising model to support their likelihood. Two estimates presented give life expectancy at maturity for females at 10 years, and an estimate of 60% annual survival for juveniles, which if nine years is the minimum age at maturity corresponds to survival of about 1½% *after* the first year. It would be worthwhile to generate a simple life-history model to give a rough check on the consistency of the various estimates of various life-history parameters. A ten-year life expectancy at maturity seems inconsistent with the longevity ascribed to marine turtles.

Data pertaining to Stock Status.

There is presented a wealth of information. Beaches, beach configuration, stability, mobility, access and so on are carefully described, as are the activities of conservation organisations to guide tourists, train observers, protect turtles, and so on. There are tabulations of annual numbers of nests; in some cases counts, in some cases estimates. Survey methods are generally not described; nor are estimation methods, methods for filling in missing survey nights, the quantitative results of tagging programmes, the estimation of female numbers from tagging, etc. Effort measures are not often tabulated, and it is not always clear how variable effort has been

A major problem with this section of the report is that it also contains much material besides the quantitative results of monitoring studies, some of which is more useful than other, and some of which belongs more appropriately in other parts of the report. As a result, it has been difficult for the authors to ensure that they have given a coherent, systematic account of the collection and analysis of data from nesting beaches.

Florida. Tabulated data for the Statewide Nesting Beach Survey. Methods described in the cited web-site indicate that the survey is not directed at leatherbacks, nor covers all nesting beaches. Methods may however be fairly consistent.

Northern Caribbean–Puerto Rico. Tabulated data (1978–2005) is minimum nests per year on all surveyed beaches; effort not given, and no indication of whether effort, surveyed beaches, or methods in general were consistent.

Northern Caribbean—U.S. Virgin Islands. Tabulated data from one beach at St Croix National Wildlife Refuge, with a strong statement that methods were consistent and coverage (of a fairly short beach) complete.

Northern Caribbean—British Virgin Is.lands (Tortola) Tabulated data (1987–2004) for one island from previously published reports; there is no statement in this document about methods or their consistency.

Western Caribbean . Discursive treatment of monitoring data and methods, general statements about the significance of the coast of this part of Central America as nesting beaches for leatherbacks, tabulated data (1985–2005) for index beaches Tortugero, Pacuare and Gandoca wildlife refuges in Costa Rica. No data from other important beaches in this nesting area. References to locations of nesting beaches and conservation projects, with a map of Costa Rica beaches and western Panama. An (undated) overall estimate for Costa Rica and western Panama. Graphics of remigration and re-nesting intervals, no quantitative results.

Southern Caribbean—Guianas. Not much detail about Guyana, with summary table of small nesting. For Suriname, much discussion of beach dynamics and other subjects. Table 12 gives useful concise descriptions of the most important beaches in eastern Suriname and their histories. For French Guiana, there is only a list of beaches, with no description or rating of their importance. There is, however, an unusual amount of detail on methods, including detailed descriptions of the estimation procedure for filling in missing observations, and the tabulated data for three groups of beaches have been assigned a quality-rating system.

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[1] On this basis, those from 50 to 100 cm CCL would presumably qualify as ’large juvenile’.

Venezuela, Trinidad, Dominica, and the remainder of Caribbean. For Venezuela, mention of beaches, and one count of females; for Trinidad, a couple of pages of descriptions of conservation activities, listing and descriptions of several beaches—for most of which there are no data—and for one beach a tabulation of nests from 1992 through 1999 and of female numbers from 1998–2006. For the rest of the Caribbean, there is a tabulation of estimated nests, but no source or quality indication.

Brazil. Some detailed biological data are presented about a relatively small annual number of nests in Espirito Santo.

West Africa. Qualitative information about distribution of nesting, which highlights a lack of quantitative data about what may be an important breeding area: the minimum annual number of nests is given as 30 000 to 35 000 based on information from only two countries.

Evaluate the adequacy, appropriateness, and application of methods used in the assessment.

Methods applied for stock differentiation: these methods were not presented. It is implied that moderately standard methods of stock differentiation by molecular methods were used, but the report includes no information on haplotype frequencies, statistical tests, etc. Some results derived from tagging are also presented.

Methods for monitoring nesting beaches: Monitoring methods for nests or females are not presented in detail. In view of the importance of nest data in assessing the status of marine turtles, it would be useful to have a more complete description of the methods used: how, how often, by whom, for how long, at what time of day, etc. It's important information and it ought to be here. Methods of converting raw counts from nesting beaches to the tabulated numbers of nests are also described only sketchily, if at all.

Methods for estimating growth rates in numbers of nests or of nesting females[2]: Variation in monitoring effort is mentioned in the report as affecting the estimation of growth rates, but the data on effort is deficient, and so no correction for effort has been attempted. However, the Research Recommendations do not include improving or standardising beach monitoring procedures or the collection of better data on effort. Comments on the growth-rate analyses have therefore the caveat that effort change over time could be a confounding factor.

Estimating growth rates of nesting activity in periodically nesting marine turtles is complicated by the question of nesting synchrony. This question is not raised at all in this document, and may not be an issue for leatherbacks, but in the context of estimating trends it is important.

Three methods of estimating growth rates are used. They are underlain by different statistical models and have different objectives.

The first—linear regression of the log of numbers against time—assumes exponential growth with homoscedastic and independent variation in log space. It is probably well adapted to summarising these data sets, but a check on serial correlation in the residuals would be appropriate. I have reworked the data for the U.S. Virgin Islands, for the British Virgin Isldsa and for Florida, using simple exponential regression, and get slightly different results (with bias correction, my estimates of lambda are 1.102 (1.082–1.121) compared with 1.09 (1.07–1.12); 1.195 (1.096–1.294) cf 1.2 (1.09–1.32) and 1.138 (1.109–1.168) cf. 1.16 (1.13–1.20)).

The description of the Morris and Doak method seems incorrect. The log of the change in size should be regressed against the interval, not against its square root; this would also be consistent with Morris and Doak's own MATLAB coding for these calculations. This method is underlain by a model of population growth as a random-walk in which consecutive estimates are correlated, and seems more appropriate to problems of predicting future risks than to summarising past trajectories. From Holmes's publication on the method[3] it seems that considerable care is needed in using this method, and that structural and observational variations can pose problems in estimating process parameters. It would be reassuring if the assessment report gave more indication that the data series to which this model has been applied do in fact show evidence of having been produced by that type of population-change process. The way in which the use of this analysis method has been described does not engender confidence that it has been used with full understanding of the assumptions about the population-dynamic process that underlie it, or with careful checking that it has been applied to appropriate data sets.

The BUGS coding for the Bayesian model of growth in numbers looks acceptable. More complex Bayesian models could usefully be developed to analyse further aspects of the dynamics of turtle nesting.

Method for estimating total numbers: The equation X.1 on p. 50 is worrying. It is described as a standard method for estimating the number of adults. But regardless of anything else, and all else equal, the greater the remigration interval, the more adults there must be in the population. So why is remigration in the bottom line? And sex ratio is given elsewhere in the report as the proportion of females, and the smaller this proportion, the bigger the number of adults for a given number of females must be, so why is sex ratio in the top line? And why are eggs present in the top line, when there are no eggs anywhere else to cancel them out? If this is the equation that was really used to generate estimates

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[2] see also Appendix III
[3] Holmes, E.E. 2001. Estimating risks in declining populations with poor data. Proc. Nat. Acad. Sci. 98(9): 5072–5077.

of the number of adults, I do not have any confidence in it. My idea of an appropriate equation to estimate the number of adults supporting a single nesting beach would look like:

Adults = ((nests.per.year) / (nests.per.fem.per.migration)) ***** *remigration.interval / adult.sex.ratio*

with sex ratio on the bottom line, remigration interval on the top line, and no eggs anywhere. I do not believe that the equation given in the report can have been used, but it is there, and where is the equation that was used? The description given under 'Methods' on p. 51, where the bulleted parameters are the ones that are needed, makes more sense[4].

A more significant problem with the section on estimating total adult numbers is the difficulty of finding out where the numbers in Table 18 come from. Some of them can be identified: the nest number of 737 for Florida can be traced back—give or take 45 nests—to an entry in Table 6. But in spite of 28 pages of stock status, most of the entries in Table 18 are a mystery. For the northern Caribbean, the minimum confidence limit for the *annual average* nests—1000—is about equal to the minimum of the reports in Tables 7–9 for the last 7 years, and these represent 'the minimum number of nests each year' for Puerto Rico, St Croix Natialon Wildlife Refuge, and Tortola *alone*. For West Africa, the confidence interval for annual mean nests is given as 30 000 to 35 000, yet on p. 40 both these values are described as 'minimum'. If 35 000 is a minimum on p. 40, how does it become a maximum on p. 52? Fig ure8 describes the averaging of nests/female for 'high-activity' and 'low-activity' females in French Guiana, but the status section for French Guiana contains nothing on such a classification, no support for the evident assumption that the two classes are equally numerous, and no source for the tabulated means and standard deviations of their numbers of nests. Mean remigration intervals are given as 2.2 years for Florida, 2.5 years for the Northern Caribbean, and 2.8 years for the Western Caribbean, but these different values cannot be traced back to statements—still less to supporting data—in the corresponding status sections of the report. And so on. Table 18 is of value; it would be worth while to overhaul the Stock Status sections of the Assessment so that the sections give Table 18 appropriate quantitative support.

The approach to deducing uncertainty by Monte Carlo sampling is quite in order. Given that the Expert Working Group is familiar with WinBUGS, I would recommend this as a platform for this kind of analysis (but I have not tried PopTools). The Assessment report takes this procedure only as far as the estimation of numbers for each population, then summing the minima to produce a minimum total and the maxima to produce a maximum. However, this would overestimate the uncertainty of the ocean-wide total, and the method could neatly have been extended to summing the breeding-area estimates (see

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[4] and my reworking from the data, with the equation I have given, yields results close to those in the Assessment (see Appendix IV).

Appendix IV); care would be needed to ensure that the errors of non-independent estimates (sex ratio is a possible example) were appropriately treated. There is a problem with the statement on p. 55 that 'mean values were always less than the medians'. The reverse should be true, generally in population estimation, but here especially in the light of the skewnesses evident in Figure 10 (as well as the results tabulated in Appendix IV). It is implicitly assumed in this procedure that the errors in the estimates of the different parameters are independent. It would be as well to make this explicit and to explain why the assumption is valid. It is possible that the estimates of total number of nests and nests per female are not independent; the methods for either are not well enough explained to be sure.

To the extent that the overall total is important—and it may not be, as the well-being of each individual stock could supersede it—it would be of value to analyse the contributions of the uncertainties of the various parameters of the various stocks to the uncertainty of the overall total. This might help to form future research priorities.

The sections on Tagging and on Surveys (data sources) could be combined into a section on 'Distribution and Movements' (an aspect of the biology), and the information on 'Strandings' (a data source), as well as that derived from 'Sightings' (another) could be dispersed into 'Life History' (length distributions and sex ratios), 'Distribution and Movements' (tag recoveries and distributions of strandings and sightings) and 'Threats' (causes of death, pathologies and foreign objects).

The assessment of 'Threats' is for the most part subjective. 'Oil exploration activities' are mentioned as a threat, but there is no mention of any related mortality; ship or boat strikes are surprisingly little mentioned. This section would be much easier to follow if it was organised by threat rather than by breeding area, assembling directed takes legal or illegal, by-catch and incidental take, egg-collecting, nest predation, and high-lighting the areas where these threats are most prominent. A tabulation might display the information more accessibly.

<u>Evaluate the adequacy, appropriateness, and application of the methods used to project population status and trends.</u>

Methods for life history analysis: these have not been presented in any detail. Aging methods are treated very briefly—for example, aging by reading marks on the scleral ossicles. There is apparently no method in sight for aging live turtles, and there is no reference to any attempt to produce a quantitative growth curve for the species. Information on sex ratio in the adult population comes largely from strandings (sex ratios in strandings comes under 'Life History', while the length distribution of stranded turtles comes under 'Strandings'). There are some references to estimates of survival for different life history stages, but no review of the estimation methods, and no attempt to build even an approximate quantitative model to reconcile possible parameter values with observed rates of change of nesting numbers.

Population trends have been explored by simple methods, basically fitting exponential trend lines to counts of nests or of nesting females for (groups of) beaches with long enough series of consistent counts. The methods used for getting the basic data are not described. Three methods for fitting the trend lines are presented, but it would be just as useful to go with one. The second of the three, ascribed to Morris and Doaks, is not convincingly explained, and I have some reservations about its applicability to this assessment. The summarising of past data on nest counts has not at this point been extended to 'project population trends', and I doubt if the Expert Working Group would be wise to try. Synchronous nesting affects the precision with which population change can be estimated and deserves to be systematically investigated and reported. Some of the data sets analysed for trend show some periodicity, and correlograms of nesting series and a systematic analysis of serial correlations would be worthwhile to present.

There is no report of any investigation of changes in any other life-history variable, such as fecundity, remigration interval, etc., and the population analyses are to some extent based on an assumption that these are more or less constant. More information about life-history variables such as these would be needed before any projection of population trends could be attempted.

The method used to estimate adult numbers from the nesting-beach data is valid, but has the problem that the parameter values that enter into the calculations are not adequately sourced and documented; many (most) are untraceable.

<u>Review research recommendations provided in the report and make any additional recommendations warranted.</u>

The research recommendations in the report are unexceptionable, but not inspiring—'more of the same'. There is little in the way of pinpointing of priority subjects, stocks, threats, or aspects of the biology as requiring special or urgent attention.

Suggestions for research recommendations.

- Review the methods used for nesting beach surveys and the tagging and recognition of nesting females, mark-recapture estimation of numbers of adult females, &c; design and recommend systematic, quantitative procedures for recording effort and observations; review and standardise methods for filling in missing observation nights, extrapolating to unsurveyed beaches, &c; analyse series of nightly data to find out how accurate sampling (instead of nightly monitoring) could be.
- Get much more, and much better, data on by-catches, both numbers and mortality; surveys and genetic sampling, on the missing islands in the (central?) Caribbean; surveys in (equatorial) W. Africa; better description of distribution and quantitative estimates of nest(ing) numbers.
- Validate hatchling sex ratios and the effect of temperature; improve the prediction of hatchling sex ratio;
- Investigate the effects of organochlorines (and other pollutants?) in beaches on the viability of eggs and the vigour of hatchlings.
- Continue research on aging, refine aging methods, work on growth curves and growth analysis, age at maturity etc.; if large-scale marking of hatchlings with dated tags could yield enough recoveries to contribute to validating age determinations, building growth curves, estimating age at first nesting, etc., pursue that.
- Build a simple population dynamics model, relating survival to age or stage; consider the combinations of values for life-history parameters that could be consistent with the observed rates of population change.
- Review the question of synchrony in leatherback nesting at all geographic scales, time-series analysis, autocorrelation and cross-correlation of breeding beach data series; examine the effect of breeding synchrony on the estimation of population rates of change.
- Improve models for estimating population size from nesting statistics; investigate the effect of imprecision in individual statistics on the precision of overall estimates.
- Develop a Bayesian model relating population trajectory to breeding-beach counts, including process error, synchronous periodic breeding behaviour, and observational errors; investigate use of such a model for forward projections;
- Carry out a (possibly short-term) survey of pathology, parasites, diseases, in a selected breeding area, from sampling, by-catch, and stranding;

- Analyse breeding-beach data to look for changes over time or with numbers in the values of life history parameters such as length:weight ratios of breeding females, nests per breeding migration, fecundity, remigration interval, etc.

Conclusions and recommendations

Recommendations on the report itself

Organisation

It would have been profitable to include two other sections, to gather information, scattered through the 'stock status' sections, that is relevant to a general view of the species, but encumbers the quantitative treatment of data from the monitoring of nesting beaches: a section on **distribution generally** to include much of the information on the characteristics of beaches, their movement and history, and relative importance; this could introduce the section on stock structure, adumbrate possible groupings into breeding areas and could also list the beaches for which nesting data would be presented under stock status; and a section on **conservation**, gathering the information on agencies and activities for the conserving of nesting beaches and the protection of the turtles that use them. Alternatively, such a section might form an expansion of the section on 'Threats'. Although these conservation activities must be an important factor in assessing status they get no synthesis because the descriptions are dispersed, and conservation activities are not mentioned in the final synthesis in the Assessment.

There is a section on 'Strandings' which implies an emphasis on the data source itself rather than on the different uses of the information it contains. The length-distribution data from this section could be included in **'Life History'** (with the sex-ratio data from the same source), the information on by-catch and causes of mortality in a section on **Mortality, Diseases, Parasites** &c, and the sightings data with satellite tag and survey data in a section on **Distribution and Movements**. The report would be improved by emphasising a structuring by subject, in place of emphasising the bodies of data furnishing it.

A further suggestion would be for an **annotated bibliography**: many references are cited with no use made of the information they contain, except to record that it has been collected and published and is available. The substantive sections of the status assessment would be clearer if these citations were gathered out into a classified and annotated bibliography.

Scientific Quality

The scientific quality of the report could be improved if there were a clearer trail from the results of the wide-area analyses, estimating trends or numbers, back through identifiable, clear, quantitative statements in the individual stock status sections on the methods that were used, the counts or measurements that were made, the analyses that were carried out, and the summary statistics that were produced. And to repeat comments made elsewhere, while it may be appropriate to list data sources, the report would be better structured by aspects of the biology of the species or components of the assessment.

Conclusions on the Assessment

The Assessment is probably somewhat optimistic in its estimate of precision, perhaps pessimistic in its estimates of total numbers both of nests and of adults, and, at least qualitatively, not far out in its assessment of recent rates of change of nesting numbers (subject always to cautions on possible change in effort).

Appendix I: Bibliography of materials provided for the review of the Leatherback TEWG draft report

References:

Turtle Expert Working Group. 1998. An Assessment of the Kemp's Ridley (*Lepidochelys kempii*) and Loggerhead (*Caretta caretta*) Sea Turtle Populations in the Western North Atlantic. NOAA Technical Memorandum. NMFS-SEFSC-409, 96 p.

Turtle Expert Working Group. 2000. Assessment Update for the Kemp's Ridley (*Lepidochelys kempii*) and Loggerhead (*Caretta caretta*) Sea Turtle Populations in the Western North Atlantic. NOAA Technical Memorandum. NMFS-SEFSC-444, 115 p.

Appendix II: Copy of the CIE Statement of Work.

Consulting Agreement between the University of Miami and Dr. Michael Kingsley

January 31, 2007

Center of Independent Experts Review of
Leatherback Turtle Expert Working Group Report

TEWG Overview

The National Marine Fisheries Service's (NMFS) Southeast Fisheries Science Center (SEFSC) convened a Leatherback Turtle Expert Working Group (TEWG) to assess the status of leatherback turtles in the North Atlantic Ocean. Scientists from NMFS, NGOs, academia, and foreign governments with expertise in leatherback biology and data analysis comprised this group. All members contributed their expertise to the group, with the goal of producing a draft report that assesses leatherback status in the Atlantic.

The TEWG concept was established by the SEFSC at the behest of NMFS in 1995 to assess the status of turtle species in the Atlantic. The first two TEWGs were convened to address loggerhead and Kemp's Ridley turtles (TEWG 1998, TEWG 2000). The leatherback TEWG was initiated to address the assessment of leatherbacks. Also, the recent Endangered Species Act Section 7 Consultation Biological Opinion for Highly Migratory Species (BiOp), completed in 2004, specifically required the SEFSC to convene a leatherback TEWG by December 31, 2004 to assess the status of leatherbacks in the Atlantic (Terms and Conditions 9.4a.). The TEWG met in November 2004, April 2005, October 2005, and March 2006.

The SEFSC has the lead for conducting stock assessments on Atlantic sea turtles, and assembled an international group of government scientists, academics, NGOs and industry representatives to assess the status of leatherbacks. The leatherback TEWG required more international participation than previous TEWGs, because the majority of nesting (>90%) and foraging occurs outside of the U.S. The location of major nesting assemblages in French Guiana/Suriname and western Africa required extensive cooperation with our European and South American counterparts that have established research programs in those areas.

CIE Review

The Center for Independent Experts (CIE) shall provide an independent peer review of the TEWG leatherback stock assessments. The reviewers shall be responsible for determining whether the best possible assessment was provided through the TEWG process. The reviewers' tasks are specified in the Terms of Reference (below).

The CIE shall appoint three reviewers. Required expertise includes quantitative skills and an understanding of the life histories of large, long-lived, highly migratory marine vertebrates, including but not limited to, sea turtles.

Each reviewer's duties shall occupy a maximum of 5 work days for reviewing the Leatherback TEWG draft report (approximate length 120 pages) and preparing their individual peer review report. The reviews will be conducted in the reviewers' home offices, so no travel is required. The reviews shall be completed in February 2007, with the due date depending on when the TEWG draft report is provided to the reviewers (see below for schedule).

Please contact Chris Sasso (TEWG Coordinator; 305-361-4279 or chris.sasso@noaa.gov) for additional details.

Review Tasks

The reviewers shall evaluate the draft North Atlantic assessment report of the Leatherback TEWG. Their primary responsibility is to ensure that assessment results are based on sound science. The reviews shall consider input data, assessment methods, and results. To assist in this determination, reviewers may request copies of background documents, such as references cited in the TEWG draft report. If a reviewer finds the assessment to be deficient, then he/she shall recommend remedial measures, including an appropriate approach for correcting and subsequently reviewing the assessment. The evaluation shall explicitly address the following Terms of Reference.

Terms of Reference

Each reviewer shall develop their own independent review report that addresses the following terms of reference.

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.
2. Evaluate the adequacy, appropriateness, and application of methods used in the assessment.
3. Evaluate the adequacy, appropriateness, and application of the methods used to project population status and trends.
4. Review research recommendations provided in the report and make any additional recommendations warranted.
5. Prepare a Peer Review Report as described in Annex 1, summarizing the CIE Reviewer's evaluation of the Leatherback TEWG report and addressing each Term of Reference, including a statement on whether the assessment was based on sound science, appropriate methods, and appropriate data.

Roles, Responsibilities, and Schedule

1. In January 2007, the CIE Reviewers shall be provided with the Leatherback TEWG report and supporting documents.
2. Each reviewer shall read the TEWG report.
3. No later than two weeks after receipt of the TEWG report, each reviewer shall provide a draft independent Reviewer's Report meeting the requirements specified above to the CIE[5]. This report shall be addressed to the "University of Miami Independent

[5] All reports will undergo an internal CIE review before they are considered final.

System for Peer Review," and sent to Dr. David Sampson, via email to David.Sampson@oregonstate.edu, and to Mr. Manoj Shivlani, via email to mshivlani@rsmas.miami.edu. See Annex 1 for complete details on the report outline.

4. By February 12, 2007, the CIE shall provide the final reports to the NMFS COTR for acceptance.

Submission and Acceptance of CIE Reports

The CIE shall provide the final individual reviewer reports for review and approval to the NMFS COTR, Dr. Stephen K. Brown, via e-mail (Stephen.K.Brown@noaa.gov), on February 21, 2007. Approval by the COTR shall be based on compliance with this Statement of Work. The COTR shall notify the CIE via e-mail regarding acceptance of the reports. Following the COTR's approval, the CIE shall provide pdf-formatted copies of the reports to the COTR via e-mail.

Distribution of Reviewer Reports

Once finalized and accepted by the COTR, the reviewers' reports shall be distributed by the COTR to:

TEWG Chair, NEFSC Acting Director: Nancy Thompson, NMFS Northeast Fisheries Science Center, 166 Water Street, Rm. 312, Woods Hole, MA 02543-1097 (email, nancy.thompson@noaa.gov)

SEFSC Acting Director: Alex Chester, NMFS Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, FL 33149 (email, alex.chester@noaa.gov)

TEWG Coordinator: Christopher Sasso, NMFS Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, FL 33149 (email, chris.sasso@noaa.gov

References:

Turtle Expert Working Group. 1998. An Assessment of the Kemp's Ridley (Lepidochelys kempii) and Loggerhead (Caretta caretta) Sea Turtle Populations in the Western North Atlantic. NOAA Technical Memorandum. NMFS-SEFSC-409, 96 p.

Turtle Expert Working Group. 2000. Assessment Update for the Kemp's Ridley (Lepidochelys kempii) and Loggerhead (Caretta caretta) Sea Turtle Populations in the Western North Atlantic. NOAA Technical Memorandum. NMFS-SEFSC-444, 115 p.

ANNEX 1. Contents of CIE Reviewer's Report

1. The reviewer's report shall be prefaced with an executive summary of findings and/or recommendations.

2. The main body of the reviewer's report shall consist of a background, description of the review, summary of findings, and conclusions/recommendations. The summary of findings shall address each Term of Reference. Reviewers are also encouraged to provide any criticisms and suggestions for improvement of the TEWG process.

3. The reviewer's report shall include as separate appendices the bibliography of materials provided for the review of the Leatherback TEWG draft report and a copy of the CIE Statement of Work.

Please refer to the following website for additional information on report generation: http://www.rsmas.miami.edu/groups/cie/cierevrep.htm

Appendix III: A note on the analysis of population trajectories.

The trajectories of numbers have been analysed using three models.

The first assumes that the process is deterministic:

$N(t) = N(0) * lambda \wedge t$

and that there is observational error so that

$O(t) = N(t) * epsilon(t)$

where the *epsilon* are independently log-normal with parameters[6] 0 and *sigma-squared*. Under this model, an unbiased estimate *r.hat* of ln(*lambda*), and its standard error *var.err,* can be obtained by a simple linear regression of ln(*O*) against *t,* and an unbiased estimate of *lambda* is then given by exp(*r.hat* + *var.err*/2). The assumptions of this model can be checked to some level: it predicts, for example, that the residual scatter of points about the straight regression line will be uncorrelated and homoscedastic, and departures from these conditions will give a warning that the model may not be appropriate. This model is apt for summarising data sets, estimating past population growth rates from observational data for comparison with rates estimated from population-dynamic models, and perhaps for making limited, short-term future predictions.

If there is periodic variation, such as occurs in nesting numbers of some species of marine turtle, this model becomes more complicated. Periodic variation could be smoothed by taking running sums, but this would also smooth the random error and lead to under-stating the uncertainty of the growth-rate estimate. It would be more appropriate to add to the model an explicit term for the periodic variation.

The Dennis-Holmes model, on the other hand, assumes that the process is stochastic: that it is a random walk from state to state:

$N(t) = N(t\text{-}1) * iota(t\text{-}1)$

where the *iota* are log-normally distributed with parameters *mu* and *sigma-squared*. Observations of such a process, if analysed by the simple regression model, will show serial correlation of residuals. Time series analysis methods are available, allowing *mu* and *sigma-squared* to be estimated.

This model, by regarding the process as stochastic, takes a more pessimistic view of the ability to project future trajectories than the earlier model and may be more apt for this purpose—its compounding uncertainties will rapidly, and perhaps realistically, set limits on the time horizon of predictions. Provided that the model is appropriate, the parameters can be estimated, and the assumption that their values are stable over time is valid, the model could be a useful tool in population viability analysis.

But as Holmes points out, the analysis of observational data from such a process is complicated by other sources of variation. Firstly, the ratio between the numbers of the observed component of the population—an age, sex, or reproductive class—and the numbers of the target component—for example, all adults, or total population—may be variable within some limits from stage to stage; and secondly, the estimate of the observed component may be subject to observational error. The problem of the variable ratio may be addressed by taking running sums of observations, but there is an implication that the length of the run would be chosen, with regard to the life history or generation time of the species, to smooth out

[6] i.e. the mean and variance of the corresponding Normal distribution in log space.

exactly the problem variation; and running sums also smooth out the observational error. The observational error, for its part, imparts imprecision to all components of the analysis. As Holmes shows, these sources of variation can pose problems for the estimation of the basic parameters of the random-walk process model by analytical methods. This model may be apt for data sets that, when analysed by the simple regression model, demonstrate a pattern of non-cyclic serial correlation of the residuals. If the assessment report gave some evaluations of the fit of the regression model to the different data sets, and whether the residuals show evidence of being correlated or heteroscedastic, it would be easier to evaluate to what degree this model is appropriate.

The third model that has been used is a Bayesian version of a model with a deterministic exponential process in the target population component N:

$N(t) = N(0) * lambda \wedge t$

and a variable ratio between observed and target components:

$O(t)$ is uniformly distributed between 0 and $N(t)$

and no observation error; it approximates to the simple regression model. The model used is clear enough, but it is quite basic. It presents an opportunity for further development, of a Bayesian model of the observations of numbers either of nests, or of nesting females, that could include the features of the Dennis-Holmes model—process variability, variable ratio between observed and target population components, and observational error—as well as possible cyclic synchrony in nesting behaviour. An advantage of Bayesian methods is that they would allow estimation of the parameters of the process, by fitting to past observations, and use of those estimates in population projections—including uncertainty estimates—to be incorporated into a single modelling operation.

Appendix IV
BUGS code for estimating the number of adult leatherback turtles in the Atlantic-

```
model {
flor.adults <- flor.nests/flor.nests.per.female*flor.remigration.interval/flor.sex.ratio
flor.nests ~ dnorm(737, 0.0004) I(700,900)
flor.nests.per.female ~ dnorm(5, 1) I(2,7)
flor.remigration.interval ~ dnorm(2.2,4) I(1,3)
flor.sex.ratio ~ dunif(0.5,0.7)

n.carib.adults <-
n.carib.nests/n.carib.nests.per.female*n.carib.remigration.interval/n.carib.sex.ratio
n.carib.nests ~ dnorm(2500, 4.0E-6) I(1000,6000)
n.carib.nests.per.female ~ dnorm(4, 0.25) I(2,7)
n.carib.remigration.interval ~ dnorm(2.5,4) I(1,5)
n.carib.sex.ratio ~ dunif(0.5,0.7)

s.carib.adults <-
s.carib.nests/s.carib.nests.per.female.mean*s.carib.remigration.interval/s.carib.sex.ratio
s.carib.nests ~ dnorm(25000, 4.0E-8) I(15000,50000)
s.carib.nests.per.female.low ~ dnorm(1.4, 0.5102)I(2,20)
s.carib.nests.per.female.high ~ dnorm(9.8, 0.216) I(2,20)
s.carib.nests.per.female.mean <-  0.5*s.carib.nests.per.female.high + 0.5 *
s.carib.nests.per.female.low
s.carib.remigration.interval ~ dnorm(2.5,4) I(1,5)
s.carib.sex.ratio ~ dunif(0.5,0.7)

w.carib.adults <-
w.carib.nests/w.carib.nests.per.female*w.carib.remigration.interval/w.carib.sex.ratio
w.carib.nests ~ dunif(7000,9000)
w.carib.nests.per.female ~ dnorm(5, 1) I(3,6)
w.carib.remigration.interval ~ dnorm(2.8,4) I(1.5,5)
w.carib.sex.ratio ~ dunif(0.5,0.7)

w.africa.adults <-
w.africa.nests/w.africa.nests.per.female*w.africa.remigration.interval/w.africa.sex.ratio
w.africa.nests ~ dunif(30000,35000)
w.africa.nests.per.female ~ dnorm(4.5, 1) I(3,7)
w.africa.remigration.interval ~ dnorm(2.2,4) I(1.5,4)
w.africa.sex.ratio ~ dunif(0.5,0.7)

Atlantic.adults <- flor.adults + n.carib.adults + s.carib.adults + w.carib.adults + w.africa.adults

x[1] <-  Atlantic.adults
x[2] <-  flor.adults
x[3] <-  n.carib.adults
x[4] <-  s.carib.adults
x[5] <-  w.carib.adults
x[6] <-  w.africa.adults
}
```

node	mean	sd	MC error	5.0%	median	95.0%	start	sample
x[1]	56640.0	10530.0	19.16	41250.0	55610.0	75580.0	1	300000
x[2]	576.6	184.9	0.3352	325.0	551.1	913.6	1	300000
x[3]	2714.0	1250.0	2.147	1197.0	2444.0	5160.0	1	300000
x[4]	17290.0	6197.0	10.96	9049.0	16360.0	28730.0	1	300000
x[5]	8123.0	2222.0	4.167	5037.0	7818.0	12240.0	1	300000
x[6]	27930.0	8118.0	14.59	16790.0	26800.0	42950.0	1	300000