

**Center of Independent Experts Review of
Leatherback Turtle Expert Working Group Report
February 12, 2007**

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Executive summary

The Leatherback Turtle Expert Working Group (TEWG) was convened by the National Marine Fisheries Service's (NMFS) Southeast Fisheries Science Center (SEFSC) to assess the status of leatherback turtles in the North Atlantic Ocean. The working group's report was developed over a series of four meetings during 2004 to 2006. Review of this report by the Center of Independent Experts consisted of a desk review focusing on the adequacy and appropriateness of the data, methods and population models used to assess the status.

The expert working group is to be commended on their success in bringing together the many and diverse data sets in this document. While the data contained in this report are the best available for assessing the current status of leatherback turtles, there are a number of issues with respect to using these data to assess the population status of these turtles. The report contains thorough discussion on many of the potential biases with these data. However, the greatest problem with using the nest/nesting female monitoring data is the lack of information on the amount of associated monitoring effort. In almost all areas, survey effort on nesting sites has been increasing over time. Not having monitoring effort information casts serious doubt on whether population trends can be disentangled from trends in monitoring effort.

The working group recommends interpreting the results of the analyses of these data with caution keeping in mind the explicit assumptions given in the text. Each of the methods used to analyze trend or population size at best gave only part of the picture. The trend analyses assumed monotonically changing populations with minimal life history information included. Comments given here and in the report on the Bayesian analysis suggest that assuming constant rates of increase may be violated by changes in monitoring effort. In fact in contrast to assuming a constant rate of increase, population levels may oscillate in areas as a function of turtles not returning to the same nesting site, variable remigration rates and changes in survival rates for juveniles, etc.

The population size method only used data in a one or two-year period and was designed to include a range of life history information that was available. While restricting the analysis to one or two years may avoid issues with temporal changes in monitoring effort, this method appears to have underestimated the true variability of the population estimates. As a result the minimum estimate is likely to be below the estimated 34,000 adults. The biological implications of this minimum for the status of the leatherback population are not clear.

All of the research recommendations in the report are in support of obtaining better life history information. In addition, the use of the conceptual framework proposed in the report to develop a stochastic simulation model could be useful for prioritizing the research. Further attempts to obtain monitoring effort data is encouraged so that the nest/nesting female data will be more useful for studying trends.

Background

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. The working group was comprised of scientists from NMFS, NGOs, academia, and foreign governments with expertise in leatherback biology and data analysis. 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 majority of nesting and foraging sites for leatherback turtles occur outside of the U.S. As a result, there was extensive international participation in the TEWG, in particular to account for the major nesting assemblages in French Guiana/Suriname and western Africa.

Review Activities

This review consisted of a desk review of one document, the Leatherback TEWG (Turtle Expert Working Group) draft report, which was developed over four meetings starting in November 2004 in Miami, Florida and ending in March 2006 in Halifax, Nova Scotia. This report (114 pages) contains the compilation and analyses of data sets from a number of researchers representing jurisdictions throughout the Atlantic Ocean. These data form the basis for determining the status of leatherback turtles in the North Atlantic Ocean Basin.

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.

Summary of the findings

The review of the TEWG report is organized according to the terms of reference laid out by the Center for Independent Experts. I treated data and methods as one because the majority of the methods used were for the population status and trends estimates which are treated in a separate term of reference.

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

The expert working group is to be commended on their success in bringing together the many and diverse data sets in this document. I have to assume that this is the first time that this has been done for leatherback turtles and the results of this exercise will only lead to improved research, better estimates and more collaboration in the future. To the best of my judgment, the data contained in this report are the best available for assessing the current status of leatherback turtles. That being said, there are a number of issues with respect to using these data to assess the population status of these turtles.

The report lays out quite well the potential biases of the Sea Turtle Stranding and Salvage Network (STSSN), growth information and various nest/nesting females monitoring programs. One of the main issues in interpreting the nest/nesting female data is the lack of information on the amount of monitoring effort expended to get these observations. In the one case (Florida, Table 6) where we do have an estimate of survey effort the relationship with the number of nests observed is very pronounced (Fig. 1). Note that the survey effort has been increasing over time in Florida which appears to be case for many of the other nesting sites reported in the TEWG report. Not having monitoring effort information for the other areas casts serious doubt on whether population trends can be disentangled from changes in monitoring effort.

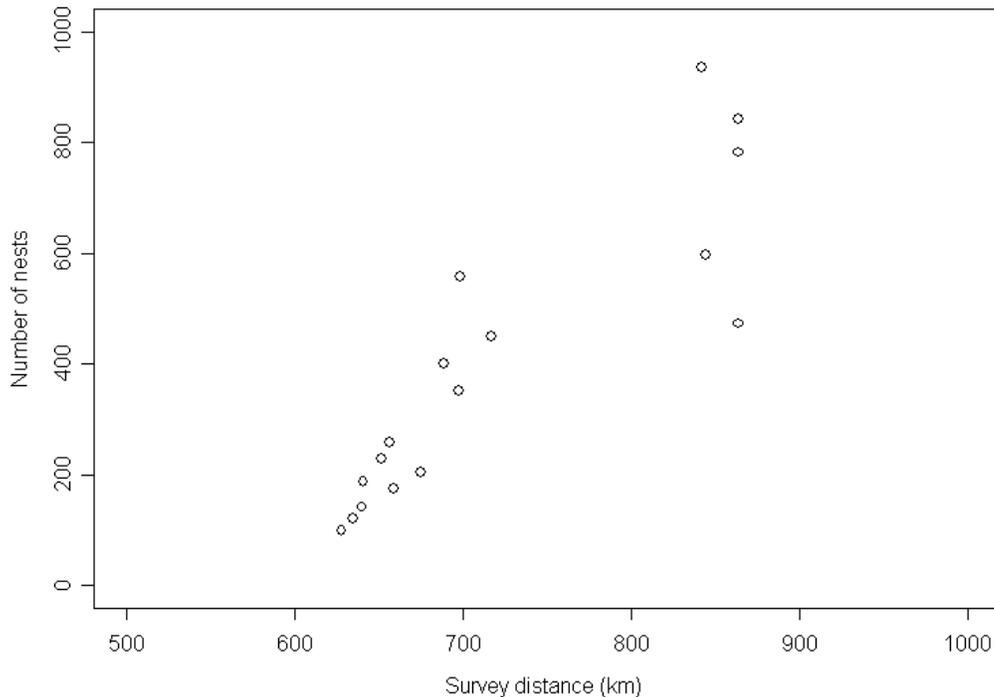


Figure 1. Scatter plot of the number of leatherback nests observed and the amount of survey effort in distance covered for Florida nesting beaches.

I have a few minor comments on the data used in this report. The definition of sex ratio is confusing to the reader as it really refers to the proportion of females in the population rather than the odds of being a female (or male). On page 11, bottom paragraph, there is a short discussion about inferring sex ratios of hatchlings from sand temperatures with a reference to Table 1. This sentence should refer to Table 5.

In the modeling of the relationship between curved and straight carapace measurements from the STSSN data it was not explicitly stated that paired observations of the two types of measurements were available. Why was N equal to 185 when there were 1734 curved measurements available? The text also refers to Figures X and Y.

2. Evaluate the adequacy, appropriateness, and application of the methods used to project population status and trends.

The population modeling begins on page 14 with the description of the regression model used. It would be helpful to the reader if this section started out with explicitly stating what the population model was i.e., after Dennis et al. (1991)¹,

¹ Missing from list of references in TEWG report but cited on page 42.

$$N_{t+\tau} = N_t \exp(\mu\tau + \varepsilon),$$

where ε is assumed to be normally distributed with mean 0 and variance $\sigma^2\tau$. Then it could be stated that all of the methods used here (regression and Bayesian) were applied to this model.

The trend analysis was based on either the number of nests or nesting females. However, the majority of datasets were comprised of the number of nests. The working group assumed that on the average there were five nests per female but this conversion factor was stated to be immaterial to the trend analysis because it was assumed to be constant over all areas and times. However, for the case of Matura Beach in Trinidad, numbers of observed nests were used to estimate the number of nesting females from 1994 to 1999 while actual numbers of nesting females were used for 2000 to 2005 (excluding 2002). Certainly the assumption of a constant conversion factor was not immaterial for this case.

The authors used the three year running sum method to account for remigration intervals — I'm assuming that this interval was set at three years. However, the observed remigration intervals available for Tortuguero, Costa Rica (Figure 2 in TEWG) and Suriname were two years. Holmes (2001) notes that the running sum method can severely overestimate the variance when sampling error is present. This may explain the wider confidence intervals for the M&D regression results in Table 17 of the report.

In Table 17, it was stated that there were 23 years of data for Puerto Rico covering the period 1978 to 2005. In fact, there were only 22 continuous years because there are no data between 1978 and 1984. The US Virgin Islands data set does not have 29 years of continuous data as indicated in Table 17 and the text on page 44 indicates that only 1986 to 2004 were used for the analysis. There were not 30 years of data for Matura Beach in Trinidad as indicated in the Table 17.

The Bayesian model offers the opportunity for estimating N_t but it appears that this model was only used for estimating λ ($=\exp(\mu\tau + \varepsilon)$). Remigration rates seem to be important life history parameters for loggerheads but these were not incorporated into this model. There is confusion in the text in paragraph 6 of page 43 where the 95% credibility region (called posterior probability interval in the text) is stated as a measure of uncertainty around the median of the posterior distribution. This region (interval) is not a measure of uncertainty around the median as an estimate, instead the bounds of the interval represents the uncertainty around lambda as a random variable.

On page 44, there is reference to testing to see if the model was appropriate for the observed data by simulating data from the “joint posterior distribution”. Actually, the data are replicated from the posterior predictive distribution and the usual diagnostic calculates the probability that these replicated data are more extreme than the actual observations (Gelman et al. 2004). If the replicated data, based upon the parameters estimated for the posterior, are consistent with the observed data then this probability should be around 0.5. An example using the Puerto Rico data from 1984 to 2005 is

presented below in Figure 2². While all probabilities fall within 0.025 and 0.975 (criterion used on page 44), the 1997 observation raises some questions. A total of 848 nests were observed that year, close to the number observed in 2003 after 6 years of the population growing by 10 percent. Was there more effort expanded in 1997 or were new areas added (offshore islands)?

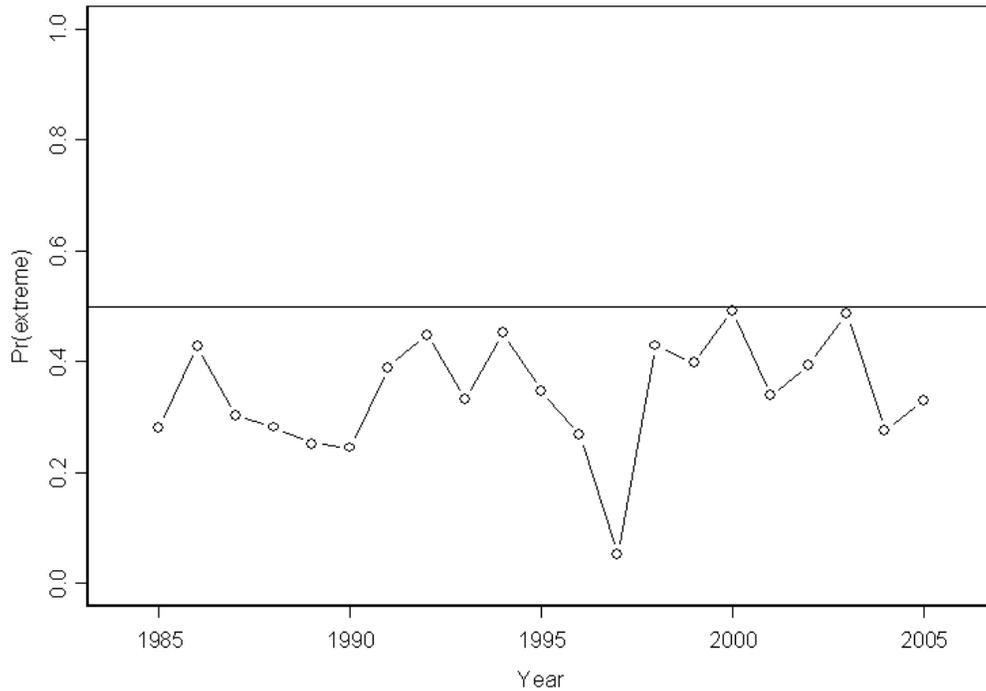


Figure 2. Probability of obtaining a more extreme number of leatherback turtle nests replicated from the posterior predictive distribution than observed for each year. Puerto Rico records of the number of nests.

In the Bayesian model (Appendix 2 of TEWG), the observed number of nests ranges from 0 to the total number of nests in the population at time t . This upper bound will increase with time by λ . A ratio of the observed number of nests to the estimate of the total number of nests in the population, N_t might offer insight as a measure of detectability. This ratio looks very similar to the probability of obtaining a more extreme value in Figure 2 (Figure 3). The observed number of nests in 1997 is flagged again as being unusual. Do we expect detectability to vary like this (partly as a consequence of assuming a constant growth rate over time)? Is detectability a function of varying observation effort? The discussion section did acknowledge that ignoring monitoring effort for the trend analysis as being something that should be addressed in future studies.

Note that there was little discussion of what the upper bound on the number of nests or females actually represented. Given that remigration rates were not explicitly

² All estimates from the Bayesian model were obtained by using the code in Appendix 2 in OpenBugs and the data provided in the report.

incorporated into this model, these upper bounds may represent the total number of nests if all females nested or the total number of females, nesters and non-nesters. In that case, Figure 3 could represent the proportion of females nesting in any one year.

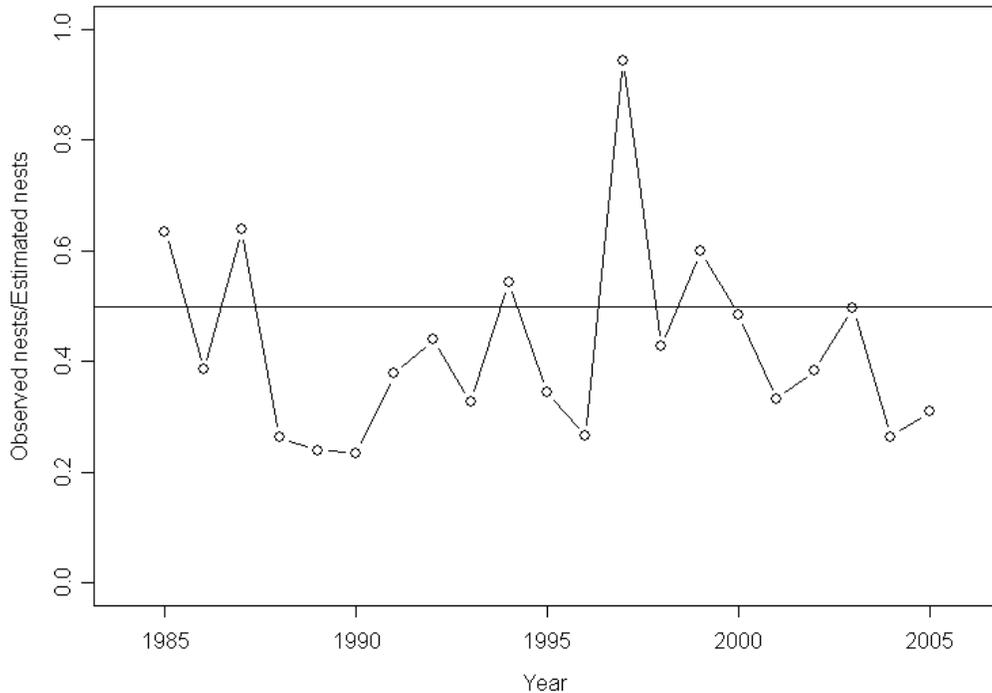


Figure 3. Ratio of observed number of nest to the estimate of total number of leatherback turtle nests in the population. Bayesian geometric population model for nest data from Puerto Rico.

The discussion section (page 46) presents a good summary of the assumptions made for the trend analysis estimates. The fact that the geometric population model only allows for a constant and monotonic trend was also noted and in fact population levels may oscillate in areas as a function of turtles not returning to the same nesting site, variable remigration rates and changes in survival rates for juveniles, etc.

More care needs to be taken in writing the population model on pages 50 (equation X.1) and 51 (equation X.2). The term (nests/females) needs to be identified as a distinct ratio because in its current form, one is lead to believe that the number of females is available — also implied by having the remigration term in the denominator of X.1. The components of the model should be estimated as follows.

$$\text{Females} = (\text{Nests}/\text{NPF}) * \text{remigration}$$

where NPF is the number of nests per females.

As noted earlier, the term sex ratio is misleading as it refers to the proportion of the population that is female.

$$\begin{aligned}\text{Proportion of females} &= (F/(M+F)) \\ &= \text{PropFem}\end{aligned}$$

Therefore,

$$\begin{aligned}\text{Adults} &= \text{Females} + \text{Males} \\ &= (\text{Nests/NPF}) * \text{remigration} * \text{PropFem}^{-1}\end{aligned}$$

Note that the equation on page 50 does not match the above as it has the remigration rate in the denominator, the so-called sex_ratio term should be inverted and the term (eggs/nest) is included. What does the latter term have to do with estimating the number of adults? Note that the errors in equation X.1 for remigration rate and sex_ratio are corrected in the text on page 51 in the bulleted list. A quick check of the calculations for the results in Table 19, using the estimates in Table 18 indicates that the actual population estimates appear to be calculated correctly.

The procedure for estimating the mean (sic) distribution of nests per females in Figure 8 seems to assume that the proportion of frequent and infrequent nesters in the population are equivalent. Is this really the case? No data were presented one way or the other.

What does the truncated distribution in Figure 9 refer to? Was that the distribution actually used to avoid problems with low numbers (and zeroes) of nests? Was the density of the resultant distribution rescaled to sum to 1.0 (also for nests per female in Figure 8)? Truncation of distributions for each parameter (top of page 55) probably resulted in final estimates of standard deviations and associated confidence intervals being underestimated relative to the levels of variation put into the model in the first place.

On page 55, it is stated that there were 34,000 to 94,000 (95,000 in Table 19) leatherbacks in the North Atlantic based upon conditions in 2004/2005. These limits seemed to be obtained by summing the 5th and 95th percentiles across the individual areas (and in some cases, rounding has occurred). If these estimates were based on standard statistical distributions, the confidence intervals would be based on summing the point estimates and their associated variances. Hence the total would have a higher variance than any of its components and the confidence intervals would be wider than a simple sum of intervals across components. Based on this I would have to say that the actual 90 percent interval is wider than 34,000 to 94,000.

I am not entirely sure about the purpose of the conceptual model section. Do the researchers intend to use it to develop something like a stochastic simulation model (*sensu* Chaloupka and Limpus 2002, Chaloupka 2002) that could be used to prioritize future research with respect to the most critical parameters?

The working group recommends interpreting the results of the analyses of these data with caution keeping in mind the explicit assumptions given in the text. I have to agree with

this sentiment noting that each of the methods used to analyze trend or population size at best gave only part of the picture. The trend analyses assumed monotonically changing populations with minimal life history information included. Comments given here and in the report on the Bayesian analysis suggests that assuming constant rates of increase may be violated by changes in monitoring effort.

The population size method was designed to include a range of life history information that was available but probably underestimated the true variability of the population estimates. As a result the minimum estimate is likely to be below 34,000 adults. The biological implications of this minimum for the status of the leatherback population are not clear.

3. Review research recommendations provided in the report and make any additional recommendations warranted.

The following research recommendations were presented in the document.

1. Continue nesting beach surveys, including flipper and PIT tagging of nesting females.
2. More effort required for remigration rates, number of nests per season and sex ratio of hatchlings.
3. More information on number of nesting females obtained from mark-recapture.
4. In-water surveys to look at distribution in space and time. Satellite tracking.
5. Validation of age and growth.
6. Estimate mortality from fishery interactions and egg poaching.
7. Genetic sampling.

All of these recommendations are warranted. To this list I would add investigating the reconstruction of some metric for monitoring effort. This could involve evaluating area covered or time spent (times the number of people involved). In addition, there should be the development of the conceptual model towards a stochastic simulation model that could be used to prioritize where the research should be done. One of the things that this turtle expert working group demonstrates is that this research needs to be international in focus and having a common set of research priorities would allow for efficient use of limited funding.

Respectfully submitted on 12 February, 2007,

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Appendix 1: References

- Chaloupka, M.Y. and Limpus, C.J. 2002. Survival probability estimates for the endangered loggerhead sea turtle resident in southern Great Barrier Reef waters. *Mar. Biol.* 140: 267–277.
- Chaloupka, M., 2002. Stochastic simulation modelling of southern Great Barrier Reef green turtle population. *Ecol. Model.* 148:79–109
- Dennis, B., Munholland, P.L. and Scott, J.M. 1991. Estimation of growth and extinction parameters for endangered species. *Ecol. Monogr.* 61: 115–143
- Gelman, A., Carlin, J.B., Stern, J.B. and Rubin, D.B. 2004. *Bayesian data analysis*. 2nd Edition. Chapman & Hall/CRC. New York.
- Holmes, E. E. 2001. Estimating risks in declining populations with poor data. *Proceedings of the National Academy of Sciences.* 98: 5072–5077.
- TEWG. 2007. An assessment of the leatherback turtle population in the Atlantic Ocean. A report of the turtle expert working group.

Appendix 2: CIE Statement of work

Consulting Agreement between the University of Miami and Stephen Smith

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 CIE³. This report shall be addressed to the "University of Miami Independent System for Peer Review," and sent to Dr. David Sampson, via email to David.Sampson@oregonstate.edu, and to Mr. Manoj Shivilani, via email to mshivilani@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)

³ All reports will undergo an internal CIE review before they are considered final.

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>