Atlantic Large Whale Take Reduction Team
Scarring Rates Work Group
November 9, 2009
9:30am-4:00pm

KEY OUTCOMES MEMORANDUM

I. Background:
On November 9, 2009, NMFS convened the Atlantic Large Whale Take Reduction Team (ALWTRT) Scarring Rates Work Group. This work group was established in response to a request from the ALWTRT Northeast Subgroup, at its April 2009 meeting, to look into scarring rates as one of the metrics in NMFS' proposed approach to monitor the effectiveness of the Atlantic Large Whale Take Reduction Plan (ALWTRP). (See Attachments 1 and 2 for the draft agenda, and participant and observer lists, respectively.) The meeting focused on the primary purpose to:

- Discuss how scarring rates can be considered as an additional measure in the NMFS Northeast Fisheries Science Center's proposed approach to monitor the Atlantic Large Whale Take Reduction Plan (ALWTRP).

This document summarizes the various presentations and discussion points at the meeting:

II. Presentation Overview:
The meeting began with presentations which provided the participants with the appropriate background information to frame the discussions. Dr. Richard Pace first presented an overview of the current approach to monitoring the effectiveness of the ALWTRP, including the rationale for selecting appropriate metrics and statistical models. Dr. Jooke Robbins and Amy Knowlton then provided an overview of the existing scarring data available on Gulf of Maine humpback whales and North Atlantic right whales, respectively, and the ways in which these data are currently being analyzed as well as their potential for being used to monitor effectiveness of the ALWTRP. A summary of each presentation follows:

<u>Measuring Biological Consequences of the TRT Rules – Dr. Richard Pace, Northeast Fisheries Science Center (NEFSC)</u>
Pace provided an overview of the current approach to monitoring the effectiveness of the ALWTRP. His presentation outlined the various biological metrics that could be used and the caveats and limitations of each approach. Many of the potential metrics and statistical approaches are limited by the small number of data points available and/or unknown factors such as the probability of detecting an entanglement in the first place.

Pace presented several potential statistical models that could be used to detect trends in the data over time. Statistical models are useful because they can incorporate concepts of uncertainty, randomness (chance), and expected variability in counts from year to year. Pace discussed the different metrics that could be used—event counts, event intervals (time since last event), or waiting times (arrival times since start) and the models that could be applied to each metric. He then presented the results of simulation runs to test the power of each statistical model given the amount and type of data available. Although all models had relatively low power to detect trends, the model using waiting times showed slightly more power. Pace also noted that an important advantage to using Poisson processes is that they are summable, meaning data from various species can be combined to increase the power of the test, even if the rates of entanglement are not the same for all species.

Next, Pace explained change point analyses in detail and presented preliminary results obtained from running a change point analysis on recent data for four different metrics: counts of entanglements, counts of serious injuries and mortalities, intervals between entanglements, and intervals between serious injuries and mortalities. The results showed mixed results, including decreased rates of entanglement and serious injury and mortality for right whales, but increased rates of entanglement and serious injury and mortality for humpback and minke whales. When the data from all species are combined, the increased humpback and minke rates override the decrease in right whale rates, resulting in an overall conclusion of no strong signal for efficacy of management measures. However, there are confounding factors that must be considered. For example, if gear modifications are improving the ability of whales to break free, there may be an increase in the number of whales seen swimming with gear attached and therefore an increase in the number of whales counted as a serious injury/mortality or entanglement, when previously, without gear improvements, the whale may have remained anchored in gear and drowned undetected.

Pace also presented a change point analysis using the number of whales sighted by aerial surveys between detected entanglements. This option helps address changes in effort because the survey data are effort corrected. This model also yielded mixed results and no strong signal for efficacy. However, Pace noted that it may have potential for shorter term (3-5 years) review.

Pace concluded by presenting a negative binomial model using the number of encounters before a "success," or entanglement event. The advantages of this model are that it is not as subject to effort and may be better at handling variance. However, this model is probably not useful for serious injury and mortality data, but may be useful when looking at the scarring data.

<u>Scar-based Studies of Humpback Whale Entanglement – Dr. Jooke Robbins, Provincetown Center for Coastal Studies (PCCS)</u>

Robbins began by describing the limitations of and potential bias in observer-based entanglement reports, which is the primary motivation for using scarring data as an alternate method of tracking entanglement events. Robbins provided a brief background

on the existing knowledge and ongoing studies about humpback whale entanglement scarring which NMFS has supported. For humpback whales, the posterior tail stock and leading edges of the flukes are the best indicator of past entanglements because almost all whales reported as entangled have injuries there, even if the entanglement was reported in the mouth or around the flipper. Furthermore, the tail is systematically presented during dives so that photographs can be systematically obtained from individuals in a population and screened for the presence or absence of entanglement-related injuries. Although the necessary coverage is not part of standard photo-identification for this species, dedicated sampling has been performed in the Gulf of Maine (GOM) annually since 1997. Additionally, a multi-decade photo-ID catalog maintained by PCCS is the source of individual IDs and life history information, both for documented entanglements and for events inferred from scarring.

Robbins described the methods and criteria used to identify, interpret, and code photographed scars. She also discussed the current applications for scar data, including investigation of temporal trends, demographic classes affected, reporting rates, spatial patterns, mortality estimates, and population comparisons. Data have been obtained from over 800 individual humpback whales in the GOM population since 1997. Three metrics have been used to compare results among years, age classes and areas: 1) the % of individuals with healed injuries (baseline inference), 2) the % of individuals with new injuries (acquired between sampling periods), and 3) the % of individuals with unhealed injuries likely obtained within the prior year. These investigations show that more than half of the individuals entering the study show evidence of a prior entanglement. Between 1997-2007, an average of 12.6% of individuals studied acquired new entanglement injuries from one year to the next, but there is high inter-annual variability. There have been 291 scar-inferred entanglement events through 2007, and juveniles have a greater frequency of entanglement injuries than adults. There are mark-recapture statistical analyses in progress to better estimate entanglement rate, incorporate survival and detection probability, and to provide an infrastructural test of support for the annual variation and trends. The scar data indicate a 3-10% successful reporting rate. Robbins briefly described spatial trends/patterns which are beginning to be looked at using scar inferences. There was a question regarding whether spatial analysis of this type could begin to look at differentiating between Canadian and US entanglements. However, Robbins clarified that, as with most observed entanglements, it will not be possible to know where individual entanglement injuries were obtained. However, a scar-based approach has the potential to yield general spatial patterns that are not biased by the distribution of potential eye-witnesses.

Robbins also discussed the limitations of scar-based studies. These approaches under-estimate entanglement rate to a certain degree because some entanglements do not involve the caudal peduncle/flukes and because some individuals die from their entanglement before they can be sampled. However, she described a new analytical approach in which scar-based inference can contribute to an estimate of entanglement mortality. This approach is still being refined, but preliminary estimates indicate that total entanglement mortality may be an order of magnitude greater than observed deaths would suggest. With regard to the ALWTRP, she noted that scar-based inference is

currently more informative for management initiatives that reduce the frequency of entanglements (like the recent ground line regulations) versus those that simply reduce the severity of entanglement events. This is because even minor entanglements produce injuries that can be reliably tracked, but lethal humpback whale entanglements do not necessarily generate more severe external injuries than non-lethal ones.

Robbins concluded by discussing the power of these analyses to detect changes and the time needed to detect trends. Scar data can provide a baseline upon which to evaluate management initiatives, but probably at the level of pre-regulation vs. post-regulation rather than an annual basis. She estimated that a change in entanglement rate of less than 50% would probably be difficult to confirm using these methods, but that this requires further investigation. She also noted that it is important to consider the differential effect of entanglement on age classes. Because juveniles are more frequently entangled than adults, tracking age classes independently, where possible, should reduce ambiguity in entanglement trends. Finally, she concluded that given the caveats inherent in each data set (scar-based inference and documented events), taking multiple, independent approaches to monitoring effectiveness may be useful.

Monitoring the effectiveness of ALWTRP in reducing entanglement levels and severity in North Atlantic right whales – Amy Knowlton, New England Aquarium (NEAq)
Knowlton discussed three different ongoing projects that could be used to monitor the effectiveness of the ALWTRP for right whales: a scar coding project, a reverse engineering project, and a survival and fecundity analysis (also mentioned by Robbins).

Knowlton suggested that the scar coding study could be used to evaluate the annual rate of entanglement using:

- annual % of sighted animals with newly detected scars and
- annual % adequately photographed animals seen over a given two year period with new entanglement scars by year two
- Goal is to see a reduction in annual entanglement rates

All photographed sightings of catalogued animals in the North Atlantic right whale (NARW) population have been reviewed for evidence of scars and gear from entanglement. Timeframe of occurrence was analyzed in order to determine the number of unique entanglement events represented, and each interaction was entered into a database. Knowlton described the process of coding for scars and the general format of the data. The database currently contains 625 unique entanglement events from 1980-2004. 72.6% of the population has been entangled at least once, and calves and juveniles appear to be entangled more often than adults. Knowlton also described two different approaches to monitoring annual rates of entanglement using the scar data: the annual proportion of sighted animals with newly detected entanglement scars and the percentage of annually photographed right whales seen over a 2-year time period with new entanglement scars.

Knowlton presented a preliminary study on scarring severity in relation to rope manufacturing changes. Each entanglement interaction was coded as either minor or severe. Results showed evidence that severity has been increasing over the past three

decades, which may be related to changes in rope manufacturing in the early 1990s. There was a question regarding changes in fishing effort over the same time period. Knowlton noted that there had been an increase in lobster fishery tags, but that might not necessarily equate to an increase in effort. Also, because the increase in severe entanglements was in proportion to all entanglements for a given timeframe, the increase in fishing effort is not relevant. The study on severity highlights the difference between the two goals (and therefore the two different measures of effectiveness) of trying to eliminate entanglements or reduce the severity of entanglements.

2005/2006 data will be coded by February 2010; 2007/2008 coding will begin in Spring 2010 and continue over the course of one year.

Knowlton then discussed a reverse engineering study that could be used to categorize severity and evaluate gear parameters that may influence severity

- Monitor annual frequency of different severity categories
- Define gear parameters that lead to different severity levels
- Goal is to see if the number of moderate or severely injured animals is reduced when scientifically informed gear changes are put in place

In this study, gear removed from whales will be analyzed for rope type, breaking strength, and other gear characteristics and compared to the complexity and severity of the entanglement. Fishermen who have been fishing over multiple decades would also be interviewed to gain insight into how gear has changed over time. Rope manufacturing standards would also be investigated, and findings would be presented regarding the potential role of rope parameters in entanglement severity. Coordination meetings for this study will begin in December 2009, and the study will be conducted over the course of two years.

Finally, Knowlton discussed an entanglement impacts study that could be used to determine the impacts of severity level on survival and fecundity

- Determine whether severity levels are impacting these life history parameters
- Use findings of this and reverse engineering study to provide guidance for gear modifications based on solid scientific evidence
- Continue to monitor life history parameters in relation to severity
- Goal is to see an improvement in survival and fecundity as effective gear modifications are put in place

This study (the same study referenced by Robbins) will compare survival rates between animals with injuries coded as minor, moderate, and severe, as well as impacts on fecundity, using multi-state mark-recapture models. A photo archive of moderate and severe injuries will also be developed for distribution to collaborators and other interested parties. This study just received funding and will be conducted over a two-year period.

III. Key Outcomes:

NMFS provided an overview of the meeting purpose. NMFS is currently developing an approach to monitor the ALWTRP including looking at the effectiveness of the ALWTRP, as well as compliance with the ALWTRP. NMFS convened the Scarring

Rates Work Group to better inform the ALWTRP Monitoring Plan and the effectiveness component. NMFS is considering various metrics to evaluate whether the ALWTRP is effective, including serious injury/mortality numbers and entanglement detections, but would like to further discuss whether scar data could also be considered as a metric of effectiveness. NMFS convened the group which consisted of ALWTRT members, as well as scientists who have expertise in these issues. NMFS asked the group to discuss the available data, how it is currently being used, what does the data indicate, how to best use and interpret the data, as well as consider the various caveats surrounding the data. If NMFS and the ALWTRT determine that scarring data are a good indicator of effectiveness, NMFS asked the group to consider the best way to utilize the data, as well as what type of studies would be important to continue.

A few primary discussion points included the following:

1. Scarring data can provide an estimate of encounters with gear (i.e. the frequency of entanglement events). Scarring studies have looked at changes over time for an individual which can be extended to look at population impacts. Analysis is also based on sampling theory as opposed to opportunistic, haphazard entanglement reports. Spatial impacts/patterns can also be investigated with further development.
2. Scar-based studies are most appropriate for evaluating the effectiveness of ALWTRP gear modifications that reduce the frequency of entanglement events. However, some management initiatives that reduce serious injury/mortality to large whales may not reduce the frequency with which they encounter gear (e.g. weak links). This poses a challenge for monitoring programs because animals that might have otherwise died will be detected alive, either carrying gear or scars from gear. In such cases, the apparent severity of the interaction (i.e., serious injury) is particularly important to track.
3. There are relatively few entanglement events documented each year, and therefore not much power in the data sets currently being considered to look at effectiveness of the ALWTRP. It is going to take a dramatic change in the metrics being considered in order to detect a change. It will take up to five years to determine whether the ALWTRP is effective using the metrics proposed by NMFS. The metrics are not dependent on how much effort (e.g. aerial surveys) occurs, but how much is seen. Scar data can also be used to track entanglement rates over time. Scarring data may be able to provide information earlier than five years.
4. The availability of humpback and right whale scarring data analysis is currently on approximately the same schedule as the NMFS serious injury/mortality determinations (i.e. approximate 2-3 year lag).
5. Workshop members discussed the apparent increase in entanglement rate reported by Pace for both humpbacks and right whales between 2002 and 2003. Scar-based analyses also suggested an increase during that time period, but a decrease in right whale entanglements. Because the same effect was noted for humpback whales in both reporting data and scar based, it is unlikely an artifact of effort, but could be due to reasons such as environmental factors (e.g. whales and gear overlapped more than in other years).

6. Currently, scar-based entanglement rates are estimated as the proportion of individuals with new entanglement injuries out of the total observed. Mark-recapture statistical analyses (such as multi-state models) can provide a robust estimate of entanglement rates. PCCS is already implementing this approach for humpback whales. It may be more feasible for humpback whales than right whales, given the larger sample sizes.
7. Mark-recapture studies provide important information on impacts on survival and fecundity. PCCS, Woods Hole Oceanographic Institution (WHOI), and NEAq are partnering on a survival and fecundity study to look at entanglement impacts. The data can be used to compare impacts before and after management actions, as well as changes over some time intervals. However, it is unlikely that there would be enough data to make yearly survival and fecundity comparisons. Entanglement wounds can persist in an unhealed state for a few months to a year. Thus, the effects of management actions may be difficult to detect on a fine time frame. Assessments of impact can potentially be compared to populations in other areas (e.g. humpback whales in Alaska, right whales in South Africa).
8. Under the Marine Mammal Protection Act (MMPA), NMFS is required to consider commercial fishery impacts as it relates to the number of serious injury/mortality numbers related to Potential Biological Removal (PBR) levels. Under the Endangered Species Act (ESA), NMFS is required to ensure that actions do not affect the ability of a population to survive and recover.
9. Population-wide coverage is important for unbiased estimates of entanglement. When funding is limited, sampling may also be more spatially limited and this may cause bias and reduce precision.
10. Information on fishing effort (amount, timing and spatial distribution) is critical to evaluating changes in entanglement rates and therefore ALWTRP effectiveness.
11. Determining fishery type involved in an interaction is important. Disentanglement teams prioritize the retrieval of gear that is removed from entangled animals. However, gear is not always successfully retrieved and sometimes retrieval requires additional, separate field efforts (as when the gear is particularly heavy). It may be productive to consider the latter, auxiliary recovery efforts as a necessary part of monitoring the ALWTRP, rather than a part of the disentanglement program.
12. Studies of entanglement survival and fecundity noted above will consider the apparent severity of the events and may therefore help NMFS to refine existing large whale serious injury/mortality determinations.
13. NMFS is working with the ALWTRT on a vertical line reduction strategy for implementation. To support this, NMFS is developing a target for vertical line risk reduction.

Discussion points related to next steps not already underway or planned (as identified in the presentations) included the following:

1. Entanglement reports are opportunistic data and may vary over time based on factors other than the actual rate of entanglement events. However, it is conceivable that the variability in reporting might be reduced by stratifying reports by the type of observer, area of report, or other factors. One study has

already confirmed that some categories of entanglement reporters are more reliable than others (Robbins et al. 2007) and some areas have a more consistent coverage by reliable observers than others. For example, the large number of commercial whale watching operators in the Stellwagen Bank area may detect and report more of the entangled whales that pass through that area than other areas (including those where whales are preferentially distributed). Since the probability of detecting an entanglement that has occurred depends on the distribution of observers and what platforms are used, NMFS should investigate whether survey designs and analyses that account for these factors might improve understanding of entanglement rate.

2. NEAq and PCCS are collaborating on a NMFS-funded study to look at the behavioral factors that lead to entanglement (e.g. dive behavior, depth). They will also consider entanglement complexity (e.g. how many body parts involved) to address questions such as why right whales have serious mouth entanglements and humpback whales less so. Information from such a study will help inform future discussions.
3. It was noted that determining the exact location where a whale became entangled is extremely difficult, if not impossible, if the gear is not recovered and identified to a specific fisher. For humpback whales, it may be possible to explore more general spatial patterns by looking at the known distribution patterns of entangled individuals and apparent the timing of the events. However, this type of approach is unlikely to be useful for right whales, as evidence shows they may travel thousands of miles in a short period of time after an entanglement. Additionally, PCCS has undertaken preliminary spatial analysis of humpback whale entanglement based on the distribution of whales with unhealed (recent) entanglement injuries, as a percentage of the total individuals examined per unit area. Additional work is required to complete this analysis and NEAq might evaluate whether a similar approach would be appropriate/useful for right whales.
4. Robbins and Knowlton will attempt to estimate how quickly scar-based entanglement data can detect changes in entanglement rate and will report back to the group.
5. It was noted that the interval analysis currently used by NMFS to analyze entanglement report data may also be applied to events detected from scarring. Linking data to individuals would also allow additional demographic parameters to be considered (such as age and sex). It may be particularly important to stratify entanglement data by age class because juveniles of both species have a higher probability of entanglement than adults. Further discussion is needed to determine whether this is feasible and necessary, and if so, what will be done and who will work on it.

NMFS asked the group to discuss additional data collection efforts that might be required to support the metrics noted above. Discussion points that were raised related to data needs are noted below. However, since no decisions were made regarding which metrics should be used, further discussion will be needed to determine which of the following data collection efforts are necessary once the metrics have been determined:

1. Continued support of scarring rate analyses.

2. Additional/continued vessel survey support needed to obtain data for scar analysis (e.g. Bay of Fundy, Great South Channel and Jeffreys Ledge for right whales; Gulf of Maine [US & Canada] for humpback whales). In the case of right whales, it was discussed that if funding were limited, a 2-3 day vessel survey of one important area (like the Great South Channel) might be informative. Aerial surveys may inform vessel based field efforts by identifying aggregations where data can be obtained rapidly.
3. Continued health assessment studies for right whales (and the development of meaningful criteria for humpbacks) are important to assess these populations.
4. Continued/additional analysis of the timing and nature of healing of entanglement injuries would help to clarify the timing of scar-based events.
5. Studies of entanglement survival and fecundity are valuable and should be pursued to the degree possible. Analyses should consider potentially important factors such as age class. NEAq noted the need for analytical support for these and other statistical approaches.
6. If possible, spatial analyses should be undertaken with scarring data to identify possible entanglement hotspots.
7. Routine data collection for scar studies should be expanded to other areas, such as the mid-Atlantic states and the southeast US. However, it was noted that humpback data collection has been attempted, but is difficult because the animals are typically observed in shallow, murky water where they rarely fluke.
8. Better data on fishing effort (timing, intensity and spatial distribution) is needed to put the scar data into context, and to understand entanglement rates more generally. Support is needed for gear retrieval from documented entanglements, particularly heavy gear.

III. Next Steps

Participants at the work group noted they would continue to collaborate on next steps identified at the meeting (see above), perhaps in a smaller technical working group. It was noted that it would be helpful for the participants to go back and lay out all of the existing types of data and/or ongoing or planned studies and determine what is feasible to do with each, i.e., how each might contribute to the ALWTRP effectiveness monitoring process. NMFS discussed setting up a meeting/conference call to further discuss/confirm next steps related to using scarring rates as one metric to monitor the ALWTRP. A meeting summary from this meeting will be distributed to the ALWTRT.

NMFS plans on meeting with the ALWTRT later in 2010. A presentation will be provided at the next meeting to talk more about the use of scarring data in the context of monitoring the effectiveness of the ALWTRP.

Attachment I.

Atlantic Large Whale Take Reduction Team
Scarring Rates Work Group
November 9, 2009
9:30am-4:00pm

AGENDA

Meeting Purposes:

- Discuss how scarring rates can be considered as an additional measure in the NMFS Northeast Fisheries Science Center's proposed approach to monitor the Atlantic Large Whale Take Reduction Plan (ALWTRP).

9:30-9:40am	**WELCOME, INTRODUCTIONS AND GETTING ORGANIZED** *(NMFS NERO)* ▪ Review meeting purpose and round robin greeting ▪ Opening comments ▪ Review and confirm agenda

9:40-10:00am	**OVERVIEW OF NMFS' CURRENT APPROACH TO MONITOR EFFECTIVENESS OF THE ALWTRP** *(NMFS NEFSC)* Objective: Provide context for discussions

10:00-11:15am **(WITH BREAK)**	**OVERVIEW OF SCARRING RATE DATA & CURRENT USAGE** Objective: Provide context for discussions ▪ Humpback whale (PCCS) ▪ Right whale (NeAq)

11:15am-12:30pm	**DISCUSS USE OF SCARRING RATES TO MONITOR EFFECTIVENESS OF THE ALWTRP** *(GROUP)* Objective: Discuss available data, status of current studies, possible incorporation of data with appropriate caveats, etc.

12:30-1:30pm	**LUNCH (DECIDE WHETHER TO BREAK FOR FULL HOUR OR COME BACK WITH A "LUNCH TO-GO")**

1:30-3:45pm **(WITH BREAK)**	**DISCUSS USE OF SCARRING RATES TO MONITOR EFFECTIVENESS OF THE ALWTRP** *(GROUP)* Continuation of above discussions.

3:45-4:00pm	**NEXT STEPS** ▪ What will be done with the product from this meeting? ▪ Recap of meeting and review next steps

Attachment II.

Participant & Observer List:

<u>Participants</u>

Moderator
1. Diane Borggaard (NMFS)

ALWTRT Members & Alternates
1. Jooke Robbins (Provincetown Center for Coastal Studies)
2. Scott Kraus (New England Aquarium)
3. Amy Knowlton (New England Aquarium)

NMFS
1. Richard Pace (NMFS)
2. Peter Corkeron (NMFS Contractor)

NON-TRT & NMFS
1. Richard Connor (UMASS Dartmouth)

<u>Observers</u>
1. David Gouveia (NMFS)
2. Mary Colligan (NMFS)
3. Kristen Koyama (NMFS)
4. Richard Merrick (NMFS)

Background Materials (To be provided):

1. Knowlton et al. 2008. Analysis of Scarring on North Atlantic Right Whales (*Eubalaena glacialis*): Monitoring Rates of Entanglement Interaction- 1980-2004. Final Report.
2. Robbins. 2009. Scar-Based Inference into Gulf of Maine Humpback Whale Entanglement: 2003-2006. Final Report.
3. "Key Outcomes Memorandum" from the 2009 Atlantic Large Whale Take Reduction Team Northeast and Mid/South Atlantic Subgroup meetings.