Developing and Evaluating Methods to Determine Abundance and Trends of Northwest Atlantic Loggerhead Turtles

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U.S. Department of Commerce
National Oceanic and Atmospheric Administration
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EXECUTIVE SUMMARY

The National Marine Fisheries Service, Office of Protected Resources, convened a Workshop November 15-17, 2016 with the following objective: determine whether an in-water sampling plan for Northwest Atlantic loggerhead sea turtles (*Caretta caretta*) in neritic foraging habitats can or cannot be practically designed and implemented to provide long-term, statistically robust population abundance estimates to assist in monitoring population trends over time. The Workshop was hosted by the United States Fish and Wildlife Service and was held at the United States Geological Survey St. Petersburg Coastal and Marine Science Center, 600 4th St S, St. Petersburg, FL 33701. Experts in sea turtle biology, sea turtle in-water and aerial survey monitoring techniques, and experts in assessing abundance and trends in terrestrial and non-sea turtle marine taxa participated in the Workshop.

The Workshop opened with presentations and discussions on current abundance sampling methodologies and analytical approaches for sea turtles and other taxa. These presentations included line transect methodologies (aerial- and vessel-based) and capture surveys (capture-mark-recapture and catch-per-unit-effort analyses). Occupancy and density modeling were also discussed. Biological and ecological constraints and challenges were presented and discussed for the various methodologies.

Workshop participants discussed and coalesced around the development of a sea turtle-focused aerial survey research methodology as the most feasible approach to estimating in-water abundance and monitoring population trends of Northwest Atlantic loggerheads over time. Workshop participants discussed sampling plans and identified the most important next steps toward developing a robust, sea turtle-focused aerial survey research methodology. These next steps are intended to guide survey design development.

Following the Workshop, the conveners requested additional input from Dr. Trent McDonald regarding his recommendations to use a rotating panel design aerial survey to provide long-term population trend information for the Northwest Atlantic loggerhead population. Dr. McDonald presented an outline for such a study design, presented in Part III of this Workshop report.

PART I: SUMMARY OF A WORKSHOP TO DEVELOP AND EVALUATE METHODS TO DETERMINE ABUNDANCE AND TRENDS OF NORTHWEST ATLANTIC LOGGERHEAD TURTLES

INTRODUCTION

The Workshop was convened by National Marine Fisheries Service Office of Protected Resources and hosted by the United States Fish and Wildlife Service; November 15–17, 2016[1]. The Workshop was held at the offices of the United States Geological Survey St. Petersburg Coastal and Marine Science Center, 600 4th St S, St. Petersburg, FL 33701. The Participant List and Workshop Agenda can be found in Appendix 1 and Appendix 2, respectively.

The purpose of the Workshop was to determine whether an in-water sampling plan for Northwest Atlantic loggerhead sea turtles (*Caretta caretta*) in neritic foraging habitats can or cannot be practically designed and implemented to provide long-term, statistically robust population abundance estimates to assist in monitoring population trends over time. If a sampling methodology was determined to be feasible, the secondary objective was to outline a sampling plan, including sampling methodologies, location, and frequency.

In preparation for the Workshop, NMFS convened a small Steering Committee to structure the agenda, identify candidate participants, and develop materials for use before and during the Workshop. Members of the Steering Committee are indicated on the Participant List (Appendix 1). Background literature on abundance estimates, population monitoring, trend analysis, and survey methodology was provided to participants to review in advance of the Workshop.

The Workshop began with the introduction of participants and a review of the meeting agenda and goals. The Workshop format provided an opportunity to explore participants' knowledge and insights, gather information and brainstorm methodologies to conduct in-water surveys of the Northwest Atlantic loggerhead sea turtle population. The Workshop was not chartered under the Federal Advisory Committee Act and as such was not a consensus-seeking meeting.

SUMMARY OF WORKSHOP PRESENTATIONS

Overview of the Workshop

B. Schroeder summarized the Workshop background and purpose. The goal of determining long-term population abundance and trends is to meet the management need for information regarding population status and recovery trajectory. Robust population trend information is needed for U.S. Endangered Species Act of 1973 (ESA) status reviews, ESA Section 7 Consultations, ESA Section 10 permits, regulatory actions, and recovery action evaluations. Historically, standardized surveys have evaluated loggerhead abundance on nesting beaches.

While critically important, abundance trends of nesting females are only one aspect of the overall

[1] The information included in this document (which is dated 2020) was current as of the date of the Workshop.

population trend (i.e., they do not directly reflect juvenile or adult male abundance/trends). There has been a universal call to understand the abundance and population trends of sea turtles away from the nesting beaches (i.e., in-water). The Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle includes recovery actions that recommend in-water sampling to assist in determining abundance and trends to aid in assessing population recovery. Knowledge of abundance and trends is needed to evaluate progress toward recovery as specified in the Demographic Recovery Criteria of the Recovery Plan:

> “(2) Trends in abundance on foraging grounds: A network of in-water sites, both oceanic and neritic, distributed across the foraging range is established and monitoring is implemented to measure abundance. There is statistical confidence (95%) that a composite estimate of relative abundance from these sites is increasing for at least one generation.”

Surveys examining loggerhead abundance in neritic habitats are challenging for several reasons, including that the species is widespread across habitat types and ocean basins, they live in shallow to deep water, and there are divergent opinions on the statistical robustness of various in-water survey methodologies. The purpose of this Workshop was to determine whether an in-water sampling plan of juvenile and adult (>45cm straight carapace length, SCL) Northwest Atlantic loggerheads in neritic foraging habitats (including inshore and offshore continental shelf waters, < 200m depth) can be practically designed and implemented to provide long-term and statistically robust population abundance and trend data. If a survey methodology that could yield sufficient statistical power to detect trends was determined to be feasible, then Workshop participants were asked to participate in developing a sampling plan.

Overview of the Biology and Ecology of Northwest Atlantic Loggerheads

A. Bolten summarized the loggerhead sea turtle as a generalist species with an extensive, heterogeneous geographic range (Canada to Mexico), not limited to a specific habitat type (e.g., bays, estuaries, coastal areas, inland waterways, soft bottom, hard bottom, seagrass beds, coral reefs) and with a generalized diet. Loggerheads have extensive developmental and seasonal movement patterns, undergo extensive reproductive migrations, and have a complex life history. Loggerheads generally recruit into neritic habitats between 7 and 12 years of age and at a straight carapace length (SCL) of 45-65cm. Northwest Atlantic loggerheads reach sexual maturity at 30–35 years, adult males and females migrate inshore during the breeding season, and females return to their natal beach to lay their eggs. There is some evidence of site fidelity to neritic foraging grounds but little is known about developmental migrations. The Northwest Atlantic loggerhead population consists of 8 or 9 specific haplotypes/sub-populations; however, estimating the abundance of these subpopulations with current technologies is not practical due to mixing of these subpopulations on the foraging grounds. A survey of the entire continental shelf from Canada to Mexico must take into consideration the generalist nature of the species, as well as spatial and temporal movements inherent to their complex life history.

Overview Presentations on Currently Employed Sampling Methodologies and Analytical Methods for Sea Turtles

Line-Transect Methodologies (aerial and vessel surveys)

L. Garrison described the methodology and potential biases of line-transect methodologies from aerial and vessel surveys. Line-transect surveys for sea turtle assessment are efficient and can include multiple species, provide broad-scale synoptic estimates of abundance, generate data to support spatial and temporally explicit density models, and have a well understood statistical basis for sampling and estimation. To obtain accurate and precise abundance estimates, these potential sources of bias must be minimized to the extent possible in either the design and execution of the survey, application of the statistical models for estimating abundance, or by integrating additional data collected external to the survey. Potential biases include: availability (the animal may be below the surface; dive behavior varies seasonally and spatially), detection probability / perception (the animal is on the surface but not seen), distance from the trackline must be measured accurately, animals may avoid the survey vessel/aircraft, in some aircraft observation near the trackline may be more difficult than observing to either side, small animals are more difficult to detect (40-45cm SCL for sea turtles is the minimum reliable size), and species identification can be difficult. Methodologies to increase the robustness of a Distance model based on line-transect data include: deploying two fully independent observer teams to estimate perception bias, integrating satellite tag data to characterize dive-surface behavior, ensuring that platform configuration provides adequate visibility near the trackline, employing accurate tools to measure distance from the trackline, and using experienced, well trained observers. Photographic or video-based data collection methods may also be useful in verifying species identification and potentially allowing estimation of animal size. Approximately 60 observations are needed to fit a reliable distance detection function. Additionally, tracklines should be uniformly spaced with a random starting point and be oriented perpendicular to environmental gradients or bathymetric contours (i.e., across instead of along areas of particularly high or low animal density). Spatial modeling is used to integrate observation data with habitat variables to predict spatial and temporal variations in population density. Several large scale, multiple year aerial survey sampling programs have been recently completed or are ongoing (Atlantic Marine Assessment Program for Protected Species - AMAPPS, Deepwater Horizon Natural Resource Damage Assessment - NRDA, and Gulf of Mexico Marine Assessment Program for Protected Species - GoMMAPPS) although they are currently limited to two per season on the Atlantic coast and the surveys of the Gulf of Mexico are under development.

Capture-Mark-Recapture Analyses (in-water capture surveys)

T. Eguchi described the main advantages, challenges, and statistical methods associated with capture-mark-recapture (CMR) in-water surveys for determining population trends in loggerhead turtles. Advantages of CMR studies include ability to directly adjust captures for detection probability and captured animals can be physically tagged and sampled (e.g., blood, health assessment, size, age). Abundance can be estimated from multiple capture occasions per time period, but this requires that the population in the survey area remain closed to systematic movements in and out of the area, or that there are enough capture periods and recaptures to model the movement in and out of the area. Abundance can be estimated from a single capture occasion per year, although with reduced precision, if survival, immigration, and emigration across years are properly accounted for. While estimating abundance through CMR survey is possible at localized study areas, it is unlikely that CMR is a feasible approach for sampling the widespread geographic and temporal distribution of the Northwest Atlantic loggerhead population. Cost would be prohibitive to achieve adequate samples and to implement an appropriate design that would meet model assumptions for a CMR survey to estimate abundance of the neritic stage.

Capture Per Unit Effort (CPUE, trawler capture surveys)
M. Arendt described the four main categories of data collected in ongoing trawl capture surveys covering four regions off the southeast US coast: species composition, relative abundance, spatial distribution, and demographics (including genetics, sex determination, and health assessments). In addition, trawl surveys can be used to capture animals for acoustic or satellite telemetry tagging. Some of the limitations associated with CPUE trawl surveys include incompatibility with hard-bottom habitat, infrequent captures (77% of effort results in no captures), and Generalized Linear Model parameters (including explanatory factors describing temporal and spatial variation, habitat type, prey, and environmental factors) that do not account for the variance in the collected data. In addition, recapture rates are low (~3%), surveys are expensive, and surveys can have permitting and planning requirements that may be restrictive.

Capture Per Unit Effort (CPUE, non-trawler capture surveys: tangle nets, hand capture)
R. Hardy reviewed non-trawler capture survey methods including set netting, strike netting, dip netting, hand capture and incidental capture. Drawbacks of these methods for measuring abundance include difficulty and expense of in-water work and their restriction to shallow water. Additionally, varying research objectives among non-trawler capture study designs complicate data collection for abundance monitoring as most projects are designed to maximize efficiency and focus on population hotspots. The methodology of non-trawler capture surveys is often tailored to specific study area conditions; i.e., changing habitat types may require a different capture method.

Occupancy and Density Models
B. Kendall discussed the use of occupancy models to determine population trends. Occupancy estimation provides a measure of the proportion of the sample area that is occupied by conducting multiple independent surveys of species presence within a specific geographic area. If these repeated surveys across geographic areas include counts, N-mixture models can be used to estimate abundance, if abundance in each area can be assumed to come from a Poisson or negative binomial distribution and that the detection ability is the same for each survey. To generate occupancy or abundance estimates, detectability needs to be corrected for in the model, spatially and temporally. Telemetry can provide useful additional information for modeling dynamics of change in relative abundance among survey areas with the assumption that movements between areas are constant over time. Collection of covariate data of factors that influence detection is useful to stabilize the model results and more precisely define the abundance estimate generated from occupancy estimates.

Overview Presentations on Population Abundance/Trend Monitoring for Other Taxa

Manatee Surveys
C. Fonnesbeck gave an overview of the methodology used to conduct aerial surveys to determine

a statewide estimate of the Florida manatee (*Trichechus manatus*) population in Florida. Some key points included: (1) the survey area should be stratified by habitat type and survey effort should focus on habitat strata that are likely to contain manatees, (2) observation and availability bias must be accounted for in order for aerial surveys to be relevant monitoring tools (3) appropriate survey design is conditional on spatial scale, habitat configuration and survey resources, and (4) population estimates should complement independent estimates of population vitality rates for conservation decision support. In an effort to estimate availability, an experiment using a submerged wooden manatee replica was conducted to determine the depths and distances at which manatees can be seen by observers.

Bird Surveys

J. Sauer reviewed the various methodologies used to conduct North American bird surveys. In recent years, many new approaches for population estimation have been developed, and most of these methods are used for bird surveys. He described the various scenarios in which design based surveys versus model based approaches are used. He noted that the main challenges in developing surveys include (1) determining spatial structuring and (2) addressing sparse sampling when abundance is low. Regardless of the survey methodology (ground count, aerial survey, transect, or roadside), models used to estimate population abundance and change need to either directly model detectability, or control for the effects of factors influencing detection. Collection of replicate counts, or of covariates such as distance data, observer data, or environmental conditions on counts, provide essential information needed for detectability estimation.

Terrestrial Species Surveys

T. McDonald focused his presentation on lesser prairie chicken (*Tympanuchus pallidicinctus*) aerial surveys, noting several parallels between loggerhead sea turtle and lesser prairie chicken characteristics, including: large geographic range, elusive, mobile, and cryptic. He described the multiscale occupancy model used in this survey, which included creating survey blocks in a defined area, selecting a Balanced Acceptance Sample of those blocks, flying two transects within each block, and using two independent observers per aircraft. He recommended referencing Mordecai, R.S. et al. (2011)[2] for further information on survey development to measure mobile species distributions.

Additional Presentations on Current Sampling Methodologies and Abundance Data for Sea Turtles

Over the course of the three-day Workshop, participants offered to present the results of their own research to help address information gaps, point out information needs, and help the group to build on current efforts. Presentations included:

L. Garrison: Loggerhead Broad Scale Abundance Data 2011-2012

At the start of Day 2, L. Garrison presented data on loggerhead broad scale abundance data collected during surveys conducted as part of the Deepwater Horizon NRDA injury assessment by season (Winter, Spring, Summer, Fall) in the Gulf of Mexico in 2011 and 2012. Data were

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[2] Mordecai, R. S.; Mattsson, B. J.; Tzilkowski, C. J. and Cooper, R. J. 2011. Addressing challenges when studying mobile or episodic species: hierarchical Bayes estimation of occupancy and use. Journal of Applied Ecology 48: 56-66.

corrected for sea turtle dive and surface behavior, sighting, and encounter rates. The estimates of abundance are approximately 30-50% lower in the Spring and Summer. Participants responded that the significant drop in abundance in the Spring and Summer seems unrealistically high and cannot be fully accounted for by seasonal changes in dive behavior, turtle availability for detection, or seasonal migration. L. Garrison noted that dive behavior does not vary dramatically by water temperature based on a sample size of approximately 60 turtles. He also noted that as part of the developing Bureau of Ocean Energy Management (BOEM) funded GoMMAPPS program, additional aerial surveys and tagging studies are planned[3]. These additional studies may shed light on the marked differences in the estimates of seasonal abundance from the 2011-2012 surveys.

R. Ahrens: Confidence Intervals and Population Trends

At the start of Day 2, R. Ahrens lead a discussion on the impact of the coefficient of variation (CV) on determining the confidence in detecting a population trend. As the amount of data collected over time increases, the confidence of detecting a specific measure of change, directionality, and magnitude also increases. For conservation purposes, a 5% change or less with a 95% confidence interval for one generation (50 years) is the detection goal. However, to evaluate conservation actions, it would be beneficial to be able to detect smaller scale changes in a shorter time frame. The preliminary data from ongoing aerial surveys (AMAPPS and NRDA studies) indicate that broad scale aerial survey design can yield a 0.1-0.15 CV while incorporating known variability (dive behavior, availability, movement, season) and random effects into the statistical analysis of abundance. These abundance estimates are then incorporated into a model to detect oscillations in the population. Additionally, there are historical aerial survey data that could be explored for inclusion in population analysis.

Workshop Discussions

Following the formal presentations, the Workshop format was structured into a series of discussion topics, each with guiding questions to facilitate robust discussion (see Agenda, Appendix 2). The discussions surrounding each of the topics are summarized below. Prior to the topical discussions, participants discussed the need to determine the desired survey precision to answer conservation management questions and touched on availability of funding.

The relevant demographic recovery criterion from the Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle was discussed:

> "(2) Trends in Abundance on Foraging Grounds: A network of in-water sites, both oceanic and neritic, distributed across the foraging range is established and monitoring is implemented to measure abundance. There is statistical confidence (95%) that a composite estimate of relative abundance from these sites is increasing for at least one generation."

In order to help develop conservation management strategies and evaluate their effectiveness for recovery of the Northwest Atlantic loggerhead population, participants noted that it would be

[3]Gulf-wide aerial surveys were conducted as part of GoMMAPS during summer 2017, winter 2018 and fall 2018. Additional loggerhead turtle telemetry data are also being collected as part of the GoMMAPPS study.

important to be able to detect a 5% change within a 10-year period. It was noted that a 0.15 CV is achievable based on results from GoMMAPPs surveys, and that this CV may be further reduced with a modified sampling design.

In addition to the discussion regarding survey precision, it was acknowledged that it is not possible to predict the amount of federal, state, or other source funding that might be available to study neritic loggerhead abundance over the next few years or decades. However, the development of sound methodology is needed to estimate survey budgets and to support efforts to seek, identify, and leverage federal, state, or other source funds. Sharing of existing survey platforms (e.g., AMAPPS, GoMMAPPS, existing marine mammal surveys) could aid in reducing cost.

Survey Methodologies

The Challenge: To date various survey methodologies have been implemented across the neritic range of the Northwest Atlantic loggerhead, and many of these surveys have generated count/abundance information. The types of surveys include non-capture surveys (i.e., aerial and boat-based line transect surveys) and capture surveys (e.g., trawler, tangle net, hand-capture). These various survey methodologies all have their respective pros, cons, and challenges. The ideal survey methodology to determine population trends will be population-scale relevant, result in high confidence that the derived estimates are a true representation of the population, address the biological and ecological constraints/challenges, and be logistically and economically feasible. Participants discussed the pros, cons, and challenges of the various survey types that have been implemented across the range of the Northwest Atlantic neritic loggerhead range.

Aerial Surveys (With Observers):

- *Altitude:* Participants discussed the best altitude for conducting aerial surveys. The AMAPPS surveys are typically flown at an altitude of 600 feet, high enough that turtles are less likely to dive in response to the airplane, but low enough that observers are able to identify smaller turtles. NOAA’s Southwest Fisheries Science Center surveys to assess loggerhead abundance typically fly between 500-600 feet of altitude.

- *Aircraft Type and Availability:* Participants agreed that the best aircraft to conduct aerial surveys is a dual-pilot high wing plane (de Havilland Twin Otter), due to low aircraft noise, maneuverability, safety, stability, and observer positioning. The NOAA fleet includes 4-5 Twin Otters but these are aging and may not be available in 10-15 years. Aircraft availability is an important part of ensuring the success of an aerial survey design. There are private fleets that contract Twin Otters with bubble windows; however, private contracted planes may be more expensive depending on configuration and location. It may be possible to schedule regular airtime in advance to ensure regular use of planes to guarantee a baseline level of sampling.

- *Pilot and Observer Skill and Consistency:* NOAA pilots must meet detailed skill and safety criteria. For contracted planes and pilots, identifying pilots who are skilled at flying Twin Otters at low altitude is a key safety concern. Observer training and consistency are also critical elements of a sound survey design.

- *Transect Design:* It was suggested that aerial surveys using zigzag lines rather than horizontal transect lines may result in airtime efficiency. However, zigzag lines could introduce other concerns. Participants agreed that alternate transect designs could be evaluated (modeled) for efficiency once the other elements of the sampling design are finalized.

- *Turtle Size and Detectability:* Neritic-stage sea turtles with carapace length of 40-45cm and larger can likely be spotted by an observer in an airplane flying at altitude of 600 feet. However, participants agreed that additional experimental modeling incorporating various sighting conditions (sea state, glare, cloud cover) could be useful to ensure that aerial surveys are in fact able to consistently sight sea turtles in the 40-45cm size range. Beaufort 0-1 pristine conditions are needed to accurately estimate turtle size from an aerial survey, and even under these conditions size classification can be difficult.

- *Sharing Survey Platform with Marine Mammal Surveys:* Partnering with marine mammal aerial surveys would help to reduce costs on both sides. However, this could reduce the accuracy and precision of surveys as they are not designed specifically for loggerhead turtles.

Aerial Surveys (With High Resolution Aerial Photogrammetry)[4]:
Participants discussed the pros, cons, and challenges of using high-resolution aerial photogrammetry (still photography and/or videography) during aerial surveys in coordination with, or in place of observers to record turtle sightings. Challenges to implementing aerial photogrammetry studies during aerial surveys in conjunction with observers include: 1) ensuring high quality photographs takes away from observer survey time; and 2) an observer position on the aircraft is lost to a photographer. It was recommended that comparative studies be undertaken to determine detectability of turtles using photogrammetry vs. observers. Some pros of this technology are that planes could fly at an altitude of 1,000 feet, which further reduces the potential for impacting turtle behavior. However, if the plane is flying quickly and at high altitude, it is impossible to capture images of turtles underwater, although this technology is likely to improve over time. It was emphasized that the post-processing of videos takes time and because of this the cost of aerial photogrammetry is currently more expensive than that of aerial surveys using observers only. Machine learning and artificial intelligence technology may improve over the next ~5 years making the cost of analyzing photogrammetry footage more affordable. The machine learning that is current being used to identify manatees in Australian aerial surveys uses Google face algorithms to recognize this species, although error rates are still comparable to those of observer coverage (~80%). It was suggested that it may be worth collecting video footage now to analyze at a later date when the technology has advanced. The cost of collecting video images (both the opportunity cost if observers are displaced and the financial cost of the computer and video technology) needs to be considered.

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[4] This is an active area of research and a lot has changed since the Workshop was held in 2016. For example, it is now relatively affordable to conduct surveys with a fixed camera and review of imagery can be conducted by experts via computer. Further, machine learning is increasingly being used for such endeavors (e.g., seal detection from aerial photography).

Satellite Telemetry:
Participants noted that satellite tracking of sea turtle movement is a valuable complement to aerial surveys, particularly when the survey designs are complementary. Satellite telemetry studies can collect data on dive behavior, movement, and migration (seasonality), and can help define critical habitat, examine site fidelity, and other factors that affect density and abundance estimates. Some participants noted that aerial and telemetry surveys should coordinate and account for availability bias due to weather conditions, time of day, and other variables. However, it was mentioned that some current models to estimate abundance have not benefited from addition of environmental conditions and it was noted that the greater number of parameters introduced into a model can result in unrealistic estimates. Additionally, more information is needed from these surveys on the accuracy of depth recording and to determine the maximum depth a turtle can be observed. It was emphasized that in order for satellite tagging data to assist the model in addressing availability bias, dive data must be both spatially and temporally representative within the survey area. There are a variety of capture methods for accessing turtles for transmitter deployment and that once the key variables for the telemetry survey (location, time of year, size class, and others) have been defined to be complementary to an aerial survey design, the cheapest method for capture can be selected.

Workshop participants also noted that satellite telemetry data could be used to develop an adaptive aerial survey design by identifying turtle location and selecting sampling units in areas of greater density in order to increase sampling precision. It was noted that the distribution of tagged turtles is highly dependent upon when and where they have been tagged, and that if this design were used, a more rigorous method of tagging would need to be put in place. It was suggested that AMAPPS surveys might provide information on density and distribution once the analysis is complete.

Trawl Capture Surveys:
Participants noted that, unlike aerial surveys, trawl surveys are able to obtain data from captured turtles such as size structure, sex, genetics, and health. Most trawl surveys are limited to relatively small survey areas, have a depth range of up to 50 feet, and are restricted from accessing sensitive hard bottom habitat. Participants commented that trawl surveys are limited in their geographic range and take far more units of effort to collect data than aerial surveys. It was agreed that trawl surveys could potentially be used to complement other methodologies, but should not be pursued as the primary methodology to determine abundance and monitor trends in abundance for Northwest Atlantic loggerheads range wide. Avoidance of the trawl by turtles in the survey area is not known but may bias estimates from trawl surveys. Trawl survey catch rates vary and are often low. Substantial sample sizes are required to achieve relative precision (confidence interval half-widths) that is comparable to other methods. It was also agreed that CPUE is not an appropriate metric to use for abundance estimates as it is a single, non-reproducible data point.

Non-Trawl Capture Surveys (Net and Hand Capture):
Participants noted that as compared with trawl surveys, non-trawl capture surveys can access diverse habitats, and are cheaper per unit effort. As compared with aerial, these surveys can examine characteristics including size class structure, behavior, habitat, health, etc. Each of the non-trawl capture survey methods cover relatively small shallow water sites and past studies

have been set up to answer local questions. When asked whether it is possible to adapt this methodology to determine abundance trends over time, participants agreed that traditional CMR studies could not logistically be scaled up to provide abundance data on a rangewide scale given the cost and time parameters of this survey. However, these studies could be used to complement aerial surveys if characteristics beyond abundance are needed.

Occupancy Modeling:
It was explained that occupancy modeling accommodates for both perception and availability bias, as long as site fidelity exists. Additionally, surveys tend to be less costly, because after one animal of the species of interest is identified (site is occupied), observers can move on to the next site. The mobility and migration patterns of sea turtles would be difficult to account for when choosing sampling units and time of year for an occupancy survey. It was noted that if there is a somewhat even distribution of turtles, occupancy modeling would not provide appropriate data for estimating abundance.

Some participants stated that occupancy modeling might be able to supplement long-term monitoring. Additionally, it was noted occupancy models could have utility in surveying inland bays and sounds not captured by aerial surveys due to their small size. However, participants agreed that these methods cannot detect the primary trends needed for long-term loggerhead conservation management.

Elements of a Successful Sampling Methodology
Following discussion of the various survey methodologies, it was agreed by the Workshop participants that aerial surveys should be the focus for further discussion. The remainder of time was spent discussing and developing appropriate elements for an aerial survey.

Survey Geographic Scale
The Challenge: The Northwest Atlantic loggerhead population encompasses a large geographic region that includes diverse habitats, ranging from shallow inshore bays and sounds to deep continental shelf waters. Surveys to date have ranged from geographically small (i.e., several km^2) to large (thousands of km^2). Geographically small surveys have primarily focused in areas where loggerhead turtles are present in sufficient numbers to justify sampling.

Conveners asked participants to consider how a survey methodology might be developed that is small enough to be economically and logistically feasible, and yet captures the heterogeneity of resources and habitats so that results can be scaled up to provide a robust abundance estimate of the entire Northwest Atlantic loggerhead population. Participants were asked how large of a geographic area should be sampled to be confident that the sample provides an appropriate proxy of abundance, as opposed to changes in distribution. Participants were also asked to consider whether any areas along the Atlantic coast can be dismissed from the survey in order to develop an economically feasible yet robust determination of abundance trends over time. Participants noted that there are a variety of statistical approaches to optimizing a study over a large survey area.

- *Inshore (Bays and Estuaries):* Conveners asked participants whether the movement of loggerheads off the coast during the winter, and the lower abundance observed in inshore areas, eliminates the need to cover these inshore areas. Participants commented that the literature demonstrates that the number of turtles in the bays and estuaries is much smaller than that in the ocean and stated that the offshore population of turtles could be used as an acceptable proxy of overall population. It was mentioned that larger bays and sounds could be included in the larger sampling units as they are of sufficient size to fly track lines. It was noted that AMAPPS surveys have not covered bays and estuaries, which may be leaving a gap in the research. It was also noted that while loggerheads vacate some bays and estuaries in the winter, particularly at the northern extent of their range, additional data are needed to validate these migratory patterns throughout their range.

- *Northern Latitudes:* Participants agreed that in the winter, a large amount of the loggerhead population moves south of Cape Hatteras, North Carolina, so by surveying in the winter the northern range could be eliminated from the survey. In the spring and summer sightings are clustered both north and south of Cape Hatteras with fewer sightings in the middle of the range.

- *Gulf of Mexico:* L. Garrison reported that sightings in the Gulf of Mexico demonstrate a possible seasonal east-west migration. There was some discussion of whether the loggerhead population originating from Mexican waters may be migrating northward to influence this trend as well. Participants agreed that further research to arrive at meaningful abundance estimates in this area is a research priority.

Survey Block Design
Participants discussed the possibility of dividing the geographic area into three larger blocks to be surveyed at varying frequency or levels of intensity. Participants noted that a variety of geographic block designs could be simulated, and the impacts on management considered, before settling on a block design. Participants discussed a variety of ways to break up the geographic range, including:

- Atlantic:
    - (1) North of Long Island; (2) Mid Atlantic Bight (MAB): Long Island to Cape Hatteras; (3) South Atlantic Bight (SAB): Cape Hatteras to Cape Canaveral (a very high-density turtle area); (4) South North Western Atlantic (SNWA).
    - (1) North Atlantic (break below Long Island); (2) Mid-Atlantic North (Cape Cod to Delaware); (3) Mid-Atlantic South (Delaware to Cape Hatteras); South Atlantic (Cape Hatteras to Cape Canaveral).

- Gulf of Mexico: Eastern, Western, and Northern

It was noted that there is a break in loggerhead abundance just north of the tip of Long Island. There are occasional aerial surveys in Canadian waters where loggerhead turtles occur in lower densities therefore any sampling conducted here could be far less intensive. It was also mentioned that it might not be necessary to separate the northern blocks into separate regions.

Survey Temporal Scale

The Challenge: The Northwest Atlantic loggerhead population is highly migratory. Adult males and females are relatively faithful to foraging areas but in higher latitudes they may make seasonal migrations in response to water temperature. Additionally, both adult males and females undertake reproductive migrations/movements. Adult males may migrate short or long distances to breed or may remain resident on their foraging grounds. These movements may change over time. Adult females migrate to their nesting beaches, but not every year. These "remigration" intervals can change over an individual's lifetime. Reproductive migrations result in significant changes in local abundance of adult males and females during the breeding season. Juvenile neritic loggerheads may make seasonal migrations, and may make developmental migrations among and/or between foraging areas. These juvenile movements are not well understood at the population level.

- *Sampling Duration:* Participants discussed the survey duration and frequency likely needed to resolve long-term abundance trends. Generation time for loggerheads can be 50 years or more. It was stated that based on the survey designs discussed (aerial with contemporaneous in-water surveys, rotating panel design), it may take a minimum of 10 years of surveying to detect trends of desired magnitude with statistical confidence.

- *Preferred Sampling Season:* Participants discussed which season(s) should be chosen for a survey to ensure accurate abundance measures. It was noted that the same time should be chosen every year, with a good weather window, to eliminate noise in the sampling data. Data presented by L. Garrison on loggerhead abundance estimates in the Gulf of Mexico showed that winter has the lowest CV. Some participants were concerned that (1) turtle availability may be lower in the winter due to longer dive times and (2) winter weather conditions are less predictable/favorable raising the time and expense of sampling.

- *Availability and Detectability Due to Seasonal/Environmental Conditions:* Participants discussed the degree to which environmental conditions including water temperature and cloud cover affect dive behavior and availability. Water clarity can affect detectability, especially nearshore where turbidity is more common. Availability and detectability can also be influenced by season.

- *Winter Weather Conditions Impact on Sampling Efficiency and Accuracy:* Because bad weather is more common in winter than in other times of the year, planes need to be booked for a longer window of time to ensure that the full area can be sampled, increasing expense. Wintertime surveys are also less efficient because flying occurs in more marginal weather. However, there are statistical methods to account for sea state and perception bias that occurs because of the season. However, it was noted that if surveys were done in the southern blocks in the winter, they would capture turtles from the northern blocks that had migrated south, possibly eliminating the need to survey the northern blocks.

Habitat Suitability and Prey Abundance/Composition

Some participants suggested that maps of sea floor types could be combined with ecosystem information to develop inferences about loggerhead habitat. It was noted that BOEM and Army Corps of Engineers have significant habitat maps. However, it was noted that it is important for the abundance modeling that the survey design not be tied to a certain habitat, but rather that the monitoring include a full distribution of habitat types.

Rotating Panel Sampling Design

Participants discussed a rotating panel design that contains two components. One component captures frequent data on a small subset of sites (index sites) for trend estimation, while the other component surveys novel geographic areas less frequently to increase geographic coverage.

The design suggested in Part III (below) contains rotating panels of survey effort. This rotating panel sample design allows for 60-80% of the population to have been sampled at least once by year 30 of the sampling period. Assuming annual effort and that three to five blocks can be placed into each panel of the design, the goal would be to achieve approximately 80% power to detect a 5-10% change in a region over 10 years. Greater variation between sites than within sites is expected.

To improve resolution of data, participants suggested coupling aerial surveys with contemporaneous surface surveys (e.g., AMAPPS, GoMMAPPS). It was further noted that the more sites that can be sampled every year, the more quickly abundance trends can be detected with higher levels of confidence. Prior to actual implementation, this and other design strategies should be simulated to identify the best survey/sampling design.

Further Survey Design Considerations

- *Index Sites:* It was suggested to select enough index sites to cover 5-10% of the population and also to select index sites that are buffered against seasonal influences and provide more robust data. However, some participants responded that it is more statistically robust to select panels at regular intervals (e.g., every 5 years) than it is to hand select index sites. To sample abundance, the design needs to include units from each subpopulation across the geographic area.

- *Repeat Surveys:* It was suggested to implement a form of repeat survey to help compare and select the most accurate method (e.g., conducting the same survey with broad scale lines and compare this to the same survey with fine scale lines). Participants noted that repeat surveys within a close time period (2 days in a row) under the same conditions see incredible variability so repeat surveys may be limited in their usefulness. However, it was noted that if there is variance between days, it would likely be within the 95% CI.

PART II: DEVELOPING AN AERIAL SURVEY RESEARCH METHODOLOGY: NEXT STEPS

The third day of the Workshop was devoted to discussions regarding next steps that should be taken to move us forward toward developing an effective aerial survey sampling plan to monitor trends in abundance of Northwest Atlantic loggerhead sea turtles (*Caretta caretta*). The group recognized that while numerous aerial surveys have been conducted and some are currently ongoing, an aerial survey sampling plan specifically focused on determining long-term trends in abundance of Northwest Atlantic loggerheads does not yet exist. The following next steps were noted as important elements toward achieving that goal. The group recognized that securing long-term funding is a significant hurdle to accomplishing this goal.

- Define management needs relative to the ability of aerial surveys to detect changes in abundance across appropriate timeline(s). Define desired level of confidence in those abundance estimates.
- Establish the optimal survey altitude for sea turtles by conducting additional experiments at altitudes between 500–1,000ft to examine/understand the size of turtles that can be seen and turtle behavior relative to the survey platform.
- Conduct additional field testing to determine detectability of a range of turtle sizes under varying water clarity and sea state conditions.
- Explore the pros and cons of high definition aerial photogrammetry and use of automatic pattern recognition, considering likely improvements in the next 5-10 years. Establish whether calibration or ground-truthing is needed for aerial photogrammetry using side-by-side flights with both photogrammetry and observers.
- Ensure relevant aspects of sea turtle life history (e.g., seasonal migrations, behavioral state) are considered appropriately in the development of the survey design.
- Design and conduct an experiment to assess variability of abundance estimates through repeat aerial surveys.
- Explore whether existing satellite telemetry data are sufficient to assess the effects of sea state on surfacing behavior.
- Refine measures of surface availability
    - Take stock of satellite telemetry data and identify data gaps relative to location, life stage, and behavioral state (foraging, migrating, internesting).
    - Design appropriate satellite telemetry experiment(s) to fill identified data gaps.
    - Assess the value of repeated counts to inform surface availability; compare to satellite telemetry approach; integrate methods to improve surface availability estimation.
- Mine data from all relevant existing aerial surveys to inform a new survey design, including block identification if appropriate. Develop simulations to refine survey design.
- Coordinate survey design and implementation with other ongoing efforts to maximize efficiency and reduce duplication/overlap.
- Develop funding estimates and consider potential funding sources, including leveraging existing funding. Develop a plan for and approach to seek funds.

PART III: EXAMPLE OF A ROTATING PANEL AERIAL SURVEY STUDY DESIGN

Following the Workshop, the conveners requested additional input/elaboration from Dr. Trent McDonald regarding his recommendations at the Workshop to use a rotating panel design aerial survey to provide long-term population trend information for Northwest Atlantic loggerhead sea turtles (*Caretta caretta*). This section provides Dr. McDonald's outline of elements of such a study design. This section is intended to provide additional information to inform study design considerations as part of the next steps in planning for future surveys.

- If possible, the most useful population to study is the entire Northwest Atlantic continental shelf population, from Mexico to Maine

- The overall population should be divided into regions. Any workable definition of regions could be accommodated. As an example, a workable set of regions may be:

  1. West Gulf of Mexico (GoM) (TX to LA)
  2. Northern GoM (LA to FL)
  3. Eastern GoM (FL west coast)
  4. Southern Atlantic (east coast FL to Cape Hatteras (or Chesapeake Bay))
  5. Mid-Atlantic (Cape Hatteras to Long Island (or Cape Cod))
  6. North Atlantic (Long Island to Canada)

- Grid each region into survey blocks

  1. Survey block size should be based on logistics of aerial flights, with the idea that two or more transects will be defined in each block.
  2. Workshop participants floated the idea of survey blocks being 40 × 40 km.

- Randomly place two transects in each survey block

  1. The first transect should be randomly placed in one half of each block
  2. The second transect should be one-half block width from the first transect

- Draw a spatially balanced master sample (Robertson et al., 2013) of survey blocks across all regions. This master sample contains all survey blocks in spatially balanced order.

- Ideally, funding levels are sufficient to survey a few blocks in every region every year. If that level of funding is not possible, rotation among regions is workable. For example, sampling effort could rotate among 2 regions each year. For example, blocks in West GoM and Northern GoM could be surveyed during year 1. Northern GoM and Eastern GoM could receive sampling effort during year 2. Eastern GoM and Southern Atlantic could be sampled during year 3, and so on around the east coast.

- A rotating survey effort (rotating panel design) is recommended within regions. A reasonable rotating effort design defines two panels (i.e., sets) of survey blocks with rotation schemes equal to “always revisit” ([1-0]) and “two occasions on, three occasions off” ([2-3]) (Table 1). Blocks that are “always revisited” whenever survey efforts are in the region can be considered index blocks. Blocks that are surveyed “two occasions on, three occasions off” are considered rotating blocks, are important for increasing the geographic distribution of surveys, and inform trends estimated on index blocks. The rotation scheme among and within regions is flexible enough to allow years of no sampling (e.g., when funding is low), provided the overall rotation scheme is followed when sampling resumes.

- The reasons for recommending rotation of effort among blocks, rather than all index or all rotating blocks, are as follows:

  Trends are best estimated by revisiting previously surveyed blocks. Accuracy is enhanced when new unsampled blocks are surveyed. Rotating split-panel designs balance power to detect trends and accuracy of overall population size estimates. Most statisticians suggest allocating approximately 70% of annual effort to the [1-0] panel (index blocks) and 30% to the rotating panel [2-3]. Assuming 100 blocks can be surveyed every time survey effort returns to a region, this recommendation resurveys 70 blocks while thirty other blocks are surveyed twice in a row, then not for 3 occasions. After 5 visits to the region, a total of 70 (always revisit) plus 150 (rotating) blocks will have been surveyed.

- There are three options for sampling seasons:

  1. Treat season (Winter, Summer) as two occasions in the panel rotation scheme. That is, occasion 1 occurs during winter, occasion 2 occurs during summer when survey efforts return to a region, and occasion 3 occurs during winter when effort returns to a region, and so on.
  2. When sampling in a region, sample all planned blocks during both Winter and Summer.
  3. Augment the AMAPPS/GoMMAPPS sampling. If AMAPPS/GoMMAPPS is sampling in region X during season Y, turtle surveys could sample all planned blocks of region X during season Y. If funding levels permit, turtle surveys could also sample the same region (i.e., X) during the other season of the same year.

Table 1: An example of the [1-0, 2-3] rotation scheme for a given survey region. An “x” indicates visiting all survey blocks in that panel (panel = set of survey blocks) that occasion. Ideally, occasions are years, but likely will be the occasion when survey efforts return to a region. The program allows 1 or more years of no sampling between occasions (e.g., if funding is low) provided the rotation scheme is followed when sampling resumes. A reasonable effort allocation scheme places 70% of annual sample effort in the [1-0] panel, and 30% of annual sample effort in each of the 5 [2-3] panels. The regional data collected under this rotation scheme can be analyzed using the methods of Piepho and Ogutu (2002).

Panel (set of survey blocks)	Sample occasion										
	1	2	3	4	5	6	7	8	9	10	11
1	X	X	X	X	X	X	X	X	X	X	X
2	X	X				X	X				X
3		X	X				X	X			
4			X	X				X	X		
5				X	X				X	X	
6	X				X	X				X	X

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APPENDIX I: PARTICIPANT LIST

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The meeting was facilitated by **Scott McCreary** and **Meredith Cowart** (CONCUR, Inc.)

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APPENDIX II: WORKSHOP AGENDA

DAY 1: NOVEMBER 15, 2016 (TUESDAY)

WORKSHOP START-UP AND GENERAL OVERVIEW

8:30 **Welcome** - Barbara Schroeder and AnnMarie Lauritsen

8:40 **Introduction of Participants, Agenda Review, Ground Rules, Logistics** - CONCUR

9:00 **Introductory/Background Presentation on Workshop Impetus and Purpose** - Barbara Schroeder

9:45 **Overview of the Biology and Ecology of NW Atlantic Loggerheads** – Alan Bolten

10:00 BREAK

BACKGROUND PRESENTATIONS – EXISTING TURTLE MONITORING/OTHER TAXA MONITORING *(Each presentation includes 10-15 minutes for clarifying questions)*

10:20 **Overview Presentations on Currently Employed Sampling Methodologies/Analytical Methods for Sea Turtles** (10-12 minutes each with 8-10 minutes for questions, use parking lot for in-depth discussions that are more appropriate later in agenda)

10:20-10:40: Line-Transect Methodologies (aerial and vessel surveys): Lance Garrison
10:40-11:00: Capture-Mark-Recapture Analyses (in-water capture surveys): Tomo Eguchi
11:00-11:20: CPUE (trawler capture surveys): Mike Arendt
11:20-11:40: CPUE/SPUE/C-M-R (non-trawler capture surveys: tangle nets, hand capture): Robert Hardy
11:40-12:00: Occupancy and Density Models: Bill Kendall

12:00 – 12:15 **Wrap Up Morning Session**

12:15 - 1:00 **LUNCH**

1:00 **Overview Presentations on Population Abundance/Trend Monitoring for Other Taxa** (10-12 minutes each with 8-10 minutes for questions)

- 1:00-1:20: Manatees – Chris Fonnesbeck
- 1:20-1:40: Birds – John Sauer
- 1:40-2:00: Terrestrial Species – Trent McDonald

BIOLOGICAL AND ECOLOGICAL CONSTRAINTS/CHALLENGES

2:00 – 4:30 **Discussion Session: Biological and Ecological Constraints/Challenges**

Topic 1: Survey Geographic Scale

The Challenge: The NW Atlantic loggerhead population encompasses a large geographic region that includes diverse habitats, ranging from shallow inshore bays and sounds to deep continental shelf waters. Surveys to date have ranged from geographically small (i.e., several km^2) to large (thousands of km^2). Geographically small surveys have primarily focused in areas where loggerhead turtles are present in sufficient numbers to justify sampling.

Discussion Questions:

1. How do we develop a survey methodology that is small enough to be economically and logistically feasible, and yet captures the heterogeneity of resources and habitats so that we can scale up to generate a robust estimate for the NW Atlantic loggerhead population?
2. How large must this geographic region be, i.e., how much of the species range should we aim to survey?
3. Can this be accomplished with a series of smaller survey areas that combine to produce the range-wide estimate?
4. If so, how would we select these smaller survey areas and are these "index sites"?
5. How large or small should these smaller survey areas be – what is optimal?
6. Are certain survey methodologies more able to address this challenge? Which ones?
7. Are these challenges present for non-turtle taxa and how are they addressed?

Topic 2: Survey Temporal Scale

The Challenge: The NW Atlantic loggerhead population is highly migratory. Adult males and females are relatively faithful to foraging areas but, in higher latitudes may make seasonal migrations in response to water temperature. Additionally both adult males and females undertake reproductive migrations/movements. Adult males may migrate short or long distances to breed or may remain resident on their foraging grounds. These movements may change over time. Adult females migrate to their nesting beaches, but not every year. These "remigration" intervals can change over an individual's lifetime. Reproductive migrations result in significant changes in local abundance of adult males and females during the breeding season. Juvenile neritic loggerheads may make seasonal migrations, and may make developmental migrations among and/or between foraging areas. These juvenile movements are not well understood at the population level.

Discussion Questions:

1. How do we design a temporal sampling scheme that addresses the changes in abundance resulting from the reproductive movements of adults?
2. How do we design a temporal sampling scheme that addresses the changes in abundance resulting from juvenile migrations/movements?
3. How frequently should we conduct surveys?
4. Are certain survey methodologies more able to address this challenge? Which ones?
5. Are these challenges present for non-turtle taxa and how are they addressed?

Topic 3: Habitat Suitability and Prey Abundance/Prey Composition

The Challenge: Changes in habitat suitability can have profound effects on loggerhead abundance, especially at smaller geographic scales. Habitat suitability is not well understood nor is it currently monitored. Changes in prey abundance/prey composition likewise can have profound effects on loggerhead abundance, again, especially at smaller geographic scales. Loggerhead prey and effects of changes in prey distribution/composition is not well understood.

Discussion Questions:

1. How do we design a sampling program that takes into account changes in suitability of habitats?
2. How do we design a sampling program that takes into account changes in prey abundance and prey composition?
3. Are certain survey methodologies more able to address this challenge? Which ones?
4. Are these challenges present for non-turtle taxa and how are they addressed?

5:00 **Day 1 Wrap-up and Overview of Day 2**

5:30 **Adjourn**

DAY 2: NOVEMBER 16, 2016 (WEDNESDAY)

8:30 Review Day 2 Agenda

SURVEY METHODOLOGIES

Discussion Session: Survey Methodologies

The Challenge: To date various survey methodologies have been implemented across the neritic range of the NW Atlantic loggerhead, many of these surveys have generated count/abundance information. The types of surveys include non-capture surveys (i.e., aerial and boat-based line transect surveys) and capture surveys (trawler, tangle net, hand-capture). These various survey methodologies all have their respective pros, cons, and challenges. The ideal survey methodology to determine population trends will be population-scale relevant, result in high confidence that the derived estimates are a true representation of the population, address the biological and ecological constraints/challenges discussed on Day 1, and be logistically and economically feasible.

8:45 – 10:00

Topic 4: Aerial Surveys

Discussion Questions:

1. What are the logistical requirements for aerial surveys and how do these affect results?
    a. Altitude (size of turtles observable?)
    b. Geographic Scale (inshore and offshore?)
    c. Environmental Conditions (e.g., sea state, glare)
    d. Extent of Habitat Surveyed?
2. How is detectability assessed and incorporated?
3. How are the biological constraints/challenges discussed above addressed?
4. Are habitat or prey changes incorporated?
5. Can the results be scaled up to the population?
6. What are the key pros and key cons?
7. Can the cons be overcome methodologically or analytically? If so, how?
8. Do repeat surveys generate similar results within the same survey timeframe and area?
9. Would it be feasible to structure a survey to determine if estimates of abundance derived are consistent/repeatable via the various methodologies?

10:00 – 10:30 BREAK

10:30 – 12:00
Topic 5: Trawl Surveys
Discussion Questions:

1. What are the logistical requirements for trawl surveys and how do these affect results?
   a. Geographic Scale (inshore and offshore?)
   b. Extent of Habitat Surveyed?
2. How is detectability assessed and incorporated?
3. How are the biological constraints/challenges discussed above addressed?
4. Are habitat or prey changes incorporated?
5. Can the results be scaled up to the population?
6. What are the key pros and key cons?
7. Can the cons be overcome methodologically or analytically? If so, how?
8. Do repeat surveys generate similar results within the same survey timeframe and area?
9. Would it be feasible to structure a survey to determine if estimates of abundance derived are consistent/repeatable via the various methodologies?

12:00 - 1:00 LUNCH

1:00 – 3:00
Topic 6: Capture Surveys

Tangle Set Net
Discussion Questions:

1. What are the logistical requirements for tangle net surveys and how do these affect results?
   a. Geographic Scale (inshore and offshore?)
   b. Extent of Habitat Surveyed?
   c. Environmental Conditions (e.g., sea state, wind, currents)
2. How is detectability assessed and incorporated?
3. How is abundance measured/calculated (e.g., CPUE, CMR)?
4. How are the biological constraints/challenges discussed above addressed?
5. Are habitat or prey changes incorporated?
6. Can the results be scaled up to the population?
7. What are the key pros and key cons?
8. Can the cons be overcome methodologically or analytically? If so, how?
9. Do repeat surveys generate similar results within the same survey timeframe and area?

10. Would it be feasible to structure a survey to determine if estimates of abundance derived are consistent/repeatable via the various methodologies?

Hand-Capture Surveys (including hand, dip-net, strike-net)
Discussion Questions:

1. What are the logistical requirements for hand-capture surveys and how do these affect results?
    a. Geographic Scale (inshore and offshore?)
    b. Extent of Habitat Surveyed?
    c. Environmental Conditions (e.g., sea state, visibility)
2. How is detectability assessed and incorporated?
3. How is abundance measured/calculated (e.g., CPUE, CMR)?
4. How are the biological constraints/challenges discussed above addressed?
5. Are habitat or prey changes incorporated?
6. Can the results be scaled up to the population?
7. What are the key pros and key cons?
8. Can the cons be overcome methodologically or analytically? If so, how?
9. Do repeat surveys generate similar results within the same survey timeframe and area?
10. Would it be feasible to structure a survey to determine if estimates of abundance derived are consistent/repeatable via the various methodologies?

3:00 – 3:30 BREAK

3:30 – 4:30
Topic 7: Occupancy and Density Modeling
Discussion Questions:

1. What are the input data needed for these modeling approaches?
2. Are these modeling approaches appropriate for sea turtles?
3. Can the results be scaled up to the population?
4. What are the key pros and key cons?
5. Can the cons be overcome methodologically or analytically? If so, how?

5:00 Day 2 Wrap-up and Overview of Day 3

5:30 Adjourn

DAY 3: NOVEMBER 17, 2016 (THURSDAY)

8:30 Review Day 3 Agenda

WHERE DO WE GO FROM HERE?

Developing a Successful Sampling Program

The Challenge: Numerous projects sampling NW Atlantic neritic loggerheads have been conducted in the past or are currently ongoing. These include line-transect surveys (aerial and vessel-based) and capture surveys (trawl, tangle net, dipnet, hand-capture). These projects span various geographic and temporal scales. Not all of these projects were designed to measure/monitor abundance and/or contribute to an index of abundance. Questions and divergent views exist as to whether any/all of these ongoing surveys are or can generate/ contribute to long-term population trend monitoring in their current form. There is currently a lack of integration among/across these surveys in terms of contributing to long-term population trend monitoring. Given the Day 1 and Day 2 discussions regarding the various methodologies for sampling, our challenge is to develop a comprehensive, effective sampling program to monitor long-term population trends of NW Atlantic neritic loggerheads.

8:45 - 12:00

Topic 8: Overarching Elements of a Successful Sampling Program

Discussion Questions:

1. What confidence level is needed regarding long-term population trend information to make effective conservation management decisions?
2. How much of the population do we need to 'sample' to be confident that our sample is an appropriate proxy?
3. How much of the neritic distribution of the population do we need to sample to be confident that our sample is an appropriate proxy?
    - Inshore areas (bays, sounds, estuaries)
    - Offshore areas (shelf waters offshore of the Atlantic/GOM coast)
4. What is the temporal frame within which we should be sampling the population to be confident that our sample is an appropriate proxy?

12:00 - 1:00 LUNCH

1:00-3:00

Topic 9: Toward a Successful Long-term Sampling Program

Discussion Questions and Tasks:

1. Are there ongoing surveys, in their present form, that are sampling the population in an appropriate way to be confident that our sample is an appropriate proxy for the NW Atlantic loggerhead population?
2. If current efforts are not sufficient, what changes/modifications or wholly new approach(es) would allow us to accomplish the goal of a long-term sampling strategy to confidently monitor trends in abundance, considering logistics and cost and meeting the criteria discussed above (confidence level, proportion of population surveyed, geographic range, and temporal frame).
3. Outline and draft the specific elements, including methodology(ies), geographic sampling area, temporal sampling plan, ground-truthing, estimated costs, and all other necessary elements to frame, in detail, a long-term sampling program for monitoring neritic NW Atlantic loggerhead population trends.

WRAP UP AND WORKSHOP CONCLUDES

3:00 Parking Lot Issues and Areas/Topics Requiring Further Work

3:30 Next Steps

4:00 Acknowledgements and Adjourn