A Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in U.S. Waters of the western North Atlantic Ocean

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Atlantic Coast Joint Venture

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Summary

The National Oceanic and Atmospheric Administration (NOAA), Minerals Management Service (MMS), U.S. Fish and Wildlife Service (FWS) and the US Navy propose to develop models and associated tools to provide seasonal, spatially-explicit density estimates of marine mammals, turtles and seabirds in the western North Atlantic Ocean. Underlying these will be the collection of broad-scale data over multiple years on the seasonal distribution and abundance of these taxa using direct aerial and shipboard surveys conducted by scientists from NOAA Fisheries and the US Fish and Wildlife Service. Depending on available funding, these data will be collected at increasing degrees of temporal resolution over a five-year period ranging from the status quo (Tier I) which is basically a single, summer survey every 3 years, through Tier II which includes seasonal, coast-wide surveys in year 1, with summer surveys in years 3 and 5, to Tier III which includes seasonal, coast-wide surveys in years 1 and 2, with summer surveys scheduled in year 4. Tiers II and III also include a variety of associated finer scale surveys of specific taxa and areas, telemetry studies, passive acoustic monitoring, and development of alternatives survey methodologies. Costs will vary depending on the Tier selected for implementation. Tier I is estimated to cost around $13.7M over the period FY10-14 ($6.2M is currently unfunded). Tier II, which appears to be the minimum needed to meet NOAA's partner's needs, will cost $28.9 M, which will require $18.8M in additional funding. Finally, Tier III will cost an estimated $36.7M over FY10-14, and will require $23.2M in additional funding. Next steps in the process will be for the four Agencies to decide on which Tier to implement, set up implementation working groups, and host a workshop of involved parties to finalize key elements of the project.

Background

The assessment program described here is a comprehensive effort to collect data required to estimate abundance and develop seasonally specific, localized density estimates for marine mammals, marine turtles, and seabirds. The program will coordinate the data collection and analysis efforts of the NMFS Northeast and Southeast Fisheries Science Centers and the U.S. Fish and Wildlife Service Division of Migratory Birds to accomplish five primary objectives:

1) Collect broad-scale data over multiple years on the seasonal distribution and abundance of marine mammals (cetaceans and pinnipeds), marine turtles, and sea birds using direct aerial and shipboard surveys of coastal U.S. Atlantic Ocean waters;

2) Collect similar data at finer scales at several (~3) sites of particular interest to NOAA partners using visual and acoustic survey techniques;

3) Conduct tag telemetry studies within surveyed regions of marine turtles, pinnipeds and seabirds to develop corrections for availability bias in the abundance survey data and collect additional data on habitat use and life-history, residence time, and frequency of use;

4) Explore alternative platforms and technologies to improve population assessment studies;

5) Assess the population size of surveyed species at regional scales; and

6) Develop models and associated tools to translate these survey data into seasonal, spatially-explicit density estimates incorporating habitat characteristics.

Achieving these objectives will provide enhanced data to managers by addressing data gaps that are essential to supporting conservation initiatives mandated under the National Environmental Policy Act (NEPA), Marine Mammal Protection Act (MMPA), Migratory Bird Treaty Act (MBTA), and Endangered Species Act (ESA).

This proposal outlines a comprehensive research program to assess the abundance and spatial distribution of marine mammals, marine turtles, and sea birds in U.S. waters of the western North Atlantic Ocean. Under the MMPA and the ESA, the National Marine Fisheries Service (NMFS) is charged with assessing the population status of protected species within U.S. waters. These Acts require periodic assessment of population status relative to management and recovery benchmarks and evaluation of threats to species and populations due to anthropogenic activities. The NEPA, as well as the MMAP and ESA, requires Federal agencies to evaluate and mitigate the impacts of their activities, or those they oversee, on protected species. Detailed assessments of species abundances are a critical component of accomplishing these mandates. For NMFS, particularly under the MMPA, it is essential to have both accurate and precise estimates of population size for a given management unit or population stock. For risk assessment and mitigation of impacts, it is necessary to have information on the seasonal and inter-annual variability in distribution at smaller spatial scales to estimate the potential for mortality or other impacts on protected species due to localized activities (e.g., military exercises, energy exploration, shipping traffic, etc.). The Migratory Bird Treaty Act (MBTA)

implements a series of bilateral agreements between the U.S. and neighboring countries that require the parties to protect migratory birds. The MBTA prohibits, through criminal sanctions, the taking of birds protected by the treaties. An opinion by the Department of Interior Deputy Associate Solicitor in 2001, concluded that the MBTA does apply in national waters within three miles, and in international waters out to 200 miles, and applies to U.S citizens, and any person aboard a U.S-flagged vessel.

The primary tools for the assessment of population abundance and spatial distribution are aerial and shipboard line-transect surveys. These surveys typically employ visual detection of animals at the surface, though more recently passive acoustic monitoring has been incorporated into these surveys to improve detection of marine mammals. Within U.S. Atlantic waters, the NMFS Northeast and Southeast Fisheries Science Centers have jointly and independently conducted broad-scale aerial and vessel surveys to support stock assessments (Appendix Table 1). Regional aerial surveys have primarily been used to assess marine mammals and turtles within waters over the continental shelf to just beyond the shelf break (Figure 1). The deeper waters of the continental shelf and the inner continental slope to the U.S. EEZ are most typically surveyed using large vessels and provide data primarily on marine mammals and sea birds (Figure 2). For NMFS, both aerial surveys and vessel surveys have primarily been conducted during summer months with occasional surveys in the winter. In general, the goals of the surveys were to provide abundance estimates over large spatial scales, and they have often focused on specific stocks of management interest. These survey programs have provided critical information supporting stock assessment and management of protected species and form the basis for spatially explicit models used in impact assessments. The FWS conducts aerial surveys to monitor waterfowl and seabird populations. The current incarnation of the Atlantic Coast Sea Duck survey was initiated in 2008. The 2008-10 surveys represent a “proof of concept” effort that will hopefully lead to an operational survey. While focused primarily on sea ducks, the survey also collects data on other diving ducks, looks and other seabirds. The survey has a primary objective of estimating population sizes of wintering sea ducks and seabirds, assessing yearly variation and trends, and determining habitat associations and areas of special significance. More recently, the survey has been providing information on the distributions of seabirds and near shore aquatic birds.

There are critical gaps in the data available for population assessments. First, there are very limited data available outside of summer months (June-August). The last comprehensive, year-round surveys of the Atlantic coast were conducted during the late 1970’s and early 1980’s in the form of the SETS and CeTAP surveys of the southeast and northeast Atlantic coast, respectively. The lack of data, particularly during spring, winter, and fall, severely limits the ability to predict seasonal spatial distribution, especially for seabirds which disperse widely during the “nonbreeding” season. There are large and important differences for seabird use of the marine environment between summer and winter. Therefore, surveys for seabirds need to be uniformly distributed throughout the year.

Second, visual line-transect surveys suffer from known negative biases. Historical surveys typically have not attempted to correct for these biases, limiting the ability to conduct comparative studies to evaluate trends in population size. Most surveys conducted over the last 5-10 years have included approaches to correct for the ability of observers to see animals at the surface. However, in the case of marine turtles, along with deep diving marine mammals, it is particularly important to account for the availability of animals at the surface. Corrections for dive-surface intervals are a critical gap in assessments of population status. Finally, there has

been relatively limited assessment of seabird and pinniped (e.g., harbor seal, gray seal) abundance in U.S. Atlantic Ocean waters. Both of these taxa have the potential to be impacted by offshore energy projects and require dedicated assessment efforts.

Project Spatial Extent And Timeline

The program proposed here will update the available data for marine mammals, turtles, and seabirds, and address critical information gaps in their assessments. The spatial scope of the program includes the U.S. western North Atlantic Ocean coast from the shoreline to the U.S. EEZ. Waters of major estuarine systems (e.g., Delaware Bay, Chesapeake Bay, and Pamlico Sound) may also be covered during aerial surveys. We propose four implementation options (Table 1) for dedicated aerial and vessel surveys of these areas:

a. Tier I – Summer-only, coast-wide surveys, scheduled every 2-3 years. No site specific surveys.
b. Tier II – Within a five-year cycle, conduct seasonal, coast-wide surveys in the first year and summer-only surveys in years 3 and 5. Conduct site-specific surveys simultaneously with seasonal surveys.
c. Tier III – Within a five-year cycle, conduct seasonal, coast-wide surveys in years 1 and 2, with summer-only surveys scheduled in year 4. Then in subsequent five-year cycles, conduct seasonal surveys in year 1, and summer-only in years 3 and 5. Conduct site-specific surveys simultaneously with seasonal surveys.
d. Tier IV – Within <u>every</u> five-year cycle, conduct seasonal, coast-wide surveys in years 1 and 2, with summer-only surveys scheduled in year 4. Conduct site-specific surveys simultaneously with seasonal surveys.

Tier I (the Status Quo) is the most achievable at existing funding levels, but is inadequate to meet the data needs of the four partner agencies and misses collecting data during the seasons most important for seabirds. Tier II is likely the minimum needed. Tier II will also lead to a significant increase in the accuracy of the model's predictions, while Tiers III and IV will also improve the precision.

Within the larger area, there are a number of locations where we propose to conduct fine-scale visual and/or passive acoustic surveys to provide enhanced resolution of densities by season. These data will also provide additional information for testing of the density estimation models to be developed under the 6th objective. These include at least the VACAPES and Mayport areas, in addition to other sites to be determined by the MMS. Fine-scale surveys will be incorporated into the surveys effort, as appropriate, within Tiers II-IV.

Seabird data will be collected in several ways. We propose that ongoing USFWS coastal aerial sea duck and seabird surveys be expanded spatially (northward and seaward to ~30 nm), and seasonally to provide detailed estimates of seabird abundance and distribution. Seabird observers will also be deployed on NMFS survey vessels conducting marine mammal and turtle line transect surveys as well as on other NMFS fishery cruises as Platforms of Opportunity to obtain data on offshore distribution and abundance of seabirds. For seabird surveys conducted from vessels, surveys should go to the shelf break.

Data collection is proposed to begin during summer 2010 with vessel and aerial surveys in the Northeast and Southeast Atlantic Regions.

Table 1. Data collection timeline for FY10 through FY19 by tier and fiscal year.

	Tiers			
Year	**I**	**II**	**III**	**IV**
10	Summer only	Summer only coast wide	Summer only – coast wide	Summer only – coast wide surveys
11		Fall thru spring coast wide & site-specific surveys	Fall thru summer coast wide & site-specific surveys	Fall thru summer coast wide & site-specific surveys
12	Summer only	Summer only – coast wide & site-specific surveys	Fall-spring coast wide & site-specific surveys	Fall-spring coast wide & site-specific surveys
13				
14	Summer only	Summer only – coast wide & site-specific surveys	Summer only – coast wide & site-specific surveys	Summer only – coast wide & site-specific surveys
15		Fall-spring coast wide & site-specific surveys	Fall-spring coast wide & site-specific surveys	Fall -summer coast wide & site-specific surveys
16	Summer only	Summer only – coast wide & site-specific surveys	Summer only – coast wide & site-specific surveys	Fall-spring coast wide & site-specific surveys
17				
18	Summer only	Summer only – coast wide & site-specific surveys	Summer only – coast wide & site-specific surveys	Summer only – coast wide & site-specific surveys
19				

Expected Outcomes And Analytical Products

The over-arching goal of the project is to improve the assessment of population status and to provide analytical products to improve environmental planning, threats assessment, and management by regulating federal agencies. Tiers II-IV of this proposed program will result in the first synoptic, seasonal assessment of abundance and spatial distribution of these species in U.S. Atlantic waters since the early 1980's (Table 1). Beyond the survey datasets, four primary data products will support these goals:

1) Development of models and data tools for users that can provide seasonal, spatially-explicit density estimates based upon survey data, as well as environmental data collected *in-situ* and from remotely sensed products (e.g., patterned after the Spatial Decision

Support System developed by NMFS for the USN) available to partners within a NOAA firewall;

2) Estimates of seasonal population abundance and density within surveyed areas;

3) Comparisons between contemporary and historical abundance and distribution;

4) Distribution of geospatial databases incorporating survey data results, collected habitat data, and spatial model results. These products may be incorporated into existing systems such as OBIS-SEAMAP.

In addition, the proposed tag telemetry studies for sea turtles and seabirds will provide additional detailed information on movements and habitat use. Pilot studies to evaluate the utility of advanced technologies will be incorporated into a strategic plan for continuing assessment efforts.

Technical Proposal

Objective 1: Data collection using aerial and vessel surveys

To estimate the seasonal abundance and describe the distribution and habitat of cetaceans, seals, marine turtles and seabirds, we propose to conduct dedicated seasonal shipboard and aerial abundance surveys, supplemented with an expansion of USFWS sea duck and seabird surveys and Platform of Opportunity surveys on other NMFS vessel surveys to collect additional distribution and abundance data specifically targeted for seabirds.

Broad scale transect surveys: NOAA vessel surveys will include 4 teams of data collectors: 1) visual sighting teams for cetaceans, and turtles using two-team line transect methods; 2) a separate visual sighting team for seabirds using standard strip transect methods supplemented with distance data; 3) a team collecting acoustic detections of marine mammals using passive acoustic towed arrays, and 4) a team collecting data on plankton and other trophic levels using Visual Plankton Recorders, bongo nets, ADCP, and split-beam and/or multi-beam scientific echosounders. Both surface layer and vertical profiles of environmental data (e.g., temperature, salinity, chlorophyll) will be collected using flow-through systems or hydrographic profilers. These surveys will be conducted aboard large (>150 ft.) research vessels, primarily the NOAA vessels available to the Northeast and Southeast Fisheries Science Centers (i.e., NOAA Ships *Bigelow, Pisces,* and *Gordon Gunter*). Vessel surveys are typically 60 days in duration and focus on waters of the outer continental shelf and continental slope to the US EEZ.

NOAA aerial surveys will include up to 6 scientists surveying for cetaceans, seals, turtles, and perhaps seabirds using either the circle-back or two-team data collection methods. *In-situ* sea surface temperature will also be collected when equipment are available. The aircraft used for the surveys may be twin engine, high-winged, turbo-prop aircraft (e.g., DeHavilland Twin Otter). Surveys will be flown at an altitude of 600 ft. and a speed of ~100 knots to optimize for both marine mammals and marine turtles. Photogrammetric methods will be explored to estimate the size-distribution of observed animals. Aerial surveys will cover waters from the shoreline to

the outer continental shelf and shelf break, and may take up to 45 survey days. Along the Atlantic coast, major estuarine systems may be included in the aerial survey design.

FWS is expecting to have five new Kodiak amphibious aircraft by the end of calendar year 2010. These airplanes will be capable of floating in the event of a water ditching and flying for up to six hours. Each aircraft will be equipped with six seats (5 observer seats) and will be pre-equipped with aerial telemetry antennas and connections, clear Plexiglas windows and routed exhaust to facilitate oblique photography. There will be opportunities to use these aircraft for missions surveying cetaceans, seals, and turtles, in addition to sea ducks and seabirds.

Line-transect derived abundance estimates suffer from known negative biases. A critical assumption is that all animals on the track line are observed. However, some animals are not available to be detected if they are beneath the surface or are too small to detect (i.e., availability bias) and some animals, though available to be detected, may be missed due to observer error and other factors (i.e., perception bias). During the surveys, we propose to address some of these biases by a) employing two team approaches for cetaceans and turtles to estimate *g(0)*, the probability of detecting an animal on the track line, thus at least partially accounting for perception bias and for availability bias of short-diving species, b) incorporating acoustically detected cetaceans to at least partially account for availability bias for some cetacean species, c) collecting sperm whale group sizes over 90-minute time periods to account for availability bias for this species, and d) collecting photogrammetric information on the size of turtles counted during aerial surveys to account for one type of availability bias. It would be useful to coordinate bird and mammal data collection to statistically quantify bird/mammal co-occurrence. Such information is potentially important to conservation decisions, as bird foraging success likely depends on cetaceans and fishes driving prey to surface.

The protocols for aerial seabird and sea duck surveys are well established and can be reviewed at http://mbdcapps.fws.gov. In general, fixed-wing aircraft will be flown at 100 knots and 200 ft above sea level while an observer and pilot-observer count seabirds from both sides of the aircraft. All observations within a 400m-width strip transects will be recorded along with a GPS location. A measure of glare from the sun reflecting off the water will be recorded as a covariate. Additional covariates recorded will include a measure of cloud cover, air temperature and wind speed.

Embedded within these broadscale aerial and vessel surveys will be a limited number of fine-scale surveys. The fundamental difference will be in spacing of line transects.

Seal surveys: Dedicated harbor seal abundance aerial surveys will be conducted during the peak pupping period (late May to early June 2011 and 2014) along the coast of Maine (e.g., Maine/New Hampshire to Maine/Canadian borders). Aerial surveys will involve two platforms: one aircraft will circle pre-selected haul-out sites during mid-day low tides and conduct oblique photography, and a second aircraft will monitor the location of VHF tagged animals.

Gray seal pup production surveys (5 flights/pupping season) will be conducted from 2010 to 2014 during the period mid-December to mid-February on the three major New England pupping colonies (e.g., Muskeget Island and Monomoy in Nantucket Sound, and Seal and Green Islands off mid-coast Maine).

Dedicated seal seasonal monitoring surveys would be conducted from October to May in all 4 years and will involve aerial photographs of a designed sample of haul-out sites from Maine/New Hampshire to Massachusetts/Rhode Island borders for both harbor and gray seals. In

addition, at-sea seal sightings collected during the above dedicated aerial and shipboard surveys can be used to augment these monitoring surveys.

Seabird surveys: We propose to collect data on seabird distribution and abundance in three ways. First, we propose to expand the spatial extent of existing USFWS coastal sea birds aerials surveys to cover the entire Atlantic coast from Florida to Maine. This will provide data on distribution, abundance, densities, seasonal changes in abundance and distribution, habitat associations, and identification of important foraging and loafing sites for sea ducks and seabirds. Secondly, we will place a separate visual sighting team for seabirds using standard strip transect methods on board all of the broad scale sightings cruises described above. These surveys will provide data on offshore seabird distribution. Finally, we will expand the existing Platform of Opportunity seabird observing program to place 1 (or 2, space allowing) observers on NMFS cruises targeting other species, such as the NEFSC spring and fall groundfish surveys, NEFSC Atlantic herring hydroacoustic surveys, Gulf of Mexico groundfish surveys, and Gulf of Mexico ichthyoplankton surveys. Observer(s) would use standard strip-transect survey methods for seabirds.

Stock structure: For marine mammals, a critical component of assessment is the identification and delineation of population stocks. In addition, for several common taxa, it is often not possible to visually distinguish between species at sea. On the Atlantic coast, these include distinction between the short-finned and long-finned pilot whales, the offshore and coastal form of bottlenose dolphins, and the offshore and coastal form of Atlantic spotted dolphins. The collection and genetic analysis of biopsy samples during at-sea data collection is therefore critical to accurate estimation of abundance and spatial distribution. Skin from biopsy samples may also be used for stable isotope analysis to evaluate trophic relationships, and blubber samples can be used to examine tissue concentrations of pollutants. During all vessel surveys, biopsy samples will be collected from target species either from the bow or on dedicated small boat deployments. These samples will be genetically identified to species/stock to better inform the estimation of abundance.

Objective 2: Collect sighting data at finer scales at several (~3) sites of particular interest to NOAA partners using visual and acoustic survey techniques

The goal of the modeling exercise in objective 6 is to provide density estimates for areas throughout the Atlantic Coastal region. However, these models can only provide a minimum resolution, which may at times be to coarse for the needs of NOAA's partners in their preparation of Environmental Assessments. Because of this need, we propose to conduct a limited number of fine scale surveys to be embedded within the seasonal coastwide surveys. The fundamental difference from the broadscale surveys will be the closer spacing of vessel and aerial transects. We anticipate that these surveys will take an additional 1-2 days of effort for each area. A second use of these data will be as a test to confirm model results.

We also propose to consider the deployment of moored passive acoustic arrays at one or more of these sites for a year or more to monitor year around use of the site. Work here would follow that of the protocols used by NOAA in its monitoring work in the Stellwagen Bank NMS and off the coast of North and South Carolina. Multiple bottom mounted autonomous recording units would be deployed by vessel for three month period, then retrieved, data downloaded, and

he instruments redeployed. Initial analyses for the presence of marine mammals would be conducted by NOAA acousticians used existing software (e.g., RAVEN, XBat), but would also be available in databases accessible by other scientists through NOAA at the NEFSC/SEFSC.

Objective 3: Conduct tag telemetry studies within surveyed regions of marine turtles, pinnipeds and seabird to (1) develop corrections for availability bias in the abundance survey data (2) collect additional data on habitat use, and (3) address large intra- and inter-annual variation in distribution and abundance of seabirds.

Telemetry studies - Density estimates of seals, marine turtles and some seabirds from visual surveys suffer from severe negative biases (approaching 90% in some cases) associated with either their absence frm haul-outs or their long dive times. In addition, there is a high degree of seasonal and regional variability in diving and foraging behavior that may impart additional uncertainty in abundance/density estimates.

Turtles - The turtles, the NEFSC and SEFSC will use satellite tag data to assess dive behavior for a 12-month duration to provide the necessary correction factors during the time periods of the aerial surveys. The tags will be programmed to remain attached long enough to bridge the seasonal surveys, as the time spent on the surface varies as a function of behavior (e.g., foraging versus migrating), water temperature, species, size class, and region. Tag telemetry studies will be conducted on loggerhead, Kemp's ridley, green, and hawksbill turtles in the Atlantic. The deployment of tags will be stratified regionally and seasonally to account for variation in dive behavior among different habitats and life-history stages. For each species, we propose to gather data on dive behavior to provide estimates of time at the surface in space and time. These data will also provide NMFS with a greater understanding of the habitat use and spatial distribution of sea turtles in the U.S. Atlantic. In addition, we will be gathering information on loggerhead young of the year to provide an estimate of stage duration before recruitment to the coastal U.S. This will only be done for loggerheads because this is the one species for which we have access to young of the year (in the Azores and on the Grand Banks) and because of the continued concern over the decline in nest numbers and the potential change in listing status from threatened to endangered. These data will allow us to estimate the number of young age classes that are not present along the U.S. coast.

Limited tagging studies will be conducted on large sub-adult and adult leatherback turtles captured via hoop net in the eastern Gulf of Mexico. For Atlantic waters, there is an extensive data set of leatherback turtle tagging information available from other researchers, and these data could be used to develop dive time corrections.

In addition to dive-surface intervals, tag telemetry studies provide important information on life-history and habitat use. Movements can be associated with data on oceanographic and meteorological conditions to develop state-space models for sea turtles. These models will be useful for predicting where and under what conditions turtles are likely to be present. These analyses will augment spatially explicit models developed from survey data.

Seals - Similar problems limit the ability to estimate seal populations from aerial counts at haul-out sites. VHF and satellite tagging studies provide data on the availability of seals to count surveys and additional information on habitat use. These studies will involve first radio-tagging a sample (n=60) of sub-adult and adult seals with VHF tags 1-2 months prior to the count

surveys and then during the count surveys a separate aircraft will search for tagged seals to estimate the correction factor. In addition, three adult seals would be fitted with satellite tags to understand seal movements with the count survey sampling units.

Data from individual tracking efforts allow for direct assessment in variability of movements and use patterns and for the measurement of residence or first-passage time (Suryan et al. 2006), fidelity to specific locations (Hamer et al. 2001), and the relationship between use areas and area of origin (which allows for any impacts to be assessed in relation to breeding locations and population trends at the breeding grounds). Telemetry studies designed to enhance our understanding of habitat use of seabirds in areas targeted for surveys must consider two fundamental design questions: which species to tag and which tag technology to use. These two issues are strongly interrelated.

Seabirds - In the Northwest Atlantic pelagic seabirds may be categorized as northern breeders, southern breeders, or wanderers. A thorough tagging program would target species from each of these groups to enhance our understanding of how various marine regions support seabirds that originate from beyond the scale of the survey area. Here we focus on the two former categories as an active tagging project is underway for one of the more common wandering pelagic species, the Great Shearwater. Depending on the size of the species targeted, either platform transmitting devices (PTTs or satellite tags) or global location sensors (GLSs or geolocators) can be deployed. Examples of northern breeders that would be ideal for deployment of PTTs include Northern Gannets (breeds in Newfoundland) and Razorbills (breeds in Maine, maritime provinces). Each species winters throughout the proposed survey area, has been used in current or previous tagging efforts (although not extensively enough to provide the data sought), and is large enough to carry the payload of a PTT. Examples of southern breeders that would be ideal for deployment of GLSs include Audubon's Shearwaters (breeds in the Bahamas) and White-tailed Tropicbirds (breeds in the Bahamas and Bermuda). Each species winters throughout the intended survey area but are not large enough to carry PTTs (although new 5g PTTs may be used on some larger tropicbirds). Preliminary GLS studies are underway for both species, however, and indicate extensive distribution of both species throughout pelagic waters of the northwest Atlantic during the nonbreeding season. Two other southern breeders that may be important with respect to habitat use, particularly as it pertains to potential impacts to endangered seabirds, are the Cahow and Black-capped Petrel. The Cahow is the focus of an ongoing tagging project (GLSs were deployed in 2009). There is considerable interest in deploying PTTs on Black-capped Petrels to determine their wintering ranges as well as to locate breeding sites. However, this species would require at-sea capture and the logistics of initiating a tagging project are hence elevated.

Habitat data - Extensive environmental data will be collected during the surveys (particularly vessel surveys) to provide data on the oceanographic conditions underlying the habitats of megafauna taxa. In the surface layer, data are collected continuously while underway on temperature, salinity, and chlorophyll concentration. Hydrographic profiling tools (underway CTD, CTD casts, and XBTs) provide additional information on the vertical structure of the water column that can have a strong influence on the distribution of marine species. These include features such as mixed layer depth and thermocline intensity that are associated with transitions between water masses and frontal zones (e.g., the shelf-break front) that result in local increases in primary and secondary production. The *in-situ* collection of data on secondary productivity

from scientific echosounders, visual plankton recorders, and bongo trawls provides additional measures of productivity that may drive megafauna distributions. Finally, remotely sensed data and hydrographic model output are available that can be used both in the development of models retrospectively and in the development of predictions or short-term forecasts.

Objective 4: Explore alternative platforms and technologies to improve population assessment studies

While aerial and shipboard surveys are the current tool for generating abundance estimates, technology is advancing such that in the future it might be possible to conduct these studies from alternative platforms and remote systems. Examples of technology that show promise are: aircraft equipped with instrumentation to record high definition pictures, and autonomous underwater vehicles recording marine mammal vocalizations, high-frequency acoustic backscatter, chlorophyll fluorescence and oceanographic conditions. We propose to investigate these technologies (together with our partners at MMS, USN and academic institutions) by implementing a pilot project for proof of concept which compares the remotely recorded information to data collected by traditional methods.

Airplane-based advanced imagery tools using oblique high-resolution cameras are commercially available and have been applied in both intelligence gathering and land-use assessments. They use aerial platforms and an oblique high-resolution camera angle that allows for 3-D visualization (more applicable in terrestrial or urban environments) and straight-line measurements of target objects or between target locations. This imaging equipment can resolve measurable and identifiable objects as small as 4-12 inches, and more recent developments may further improve resolution. Integration with LIDAR technologies may allow visualization of subsurface animals. In the short term, these tools can be used to validate observer identification of species and general size class, provide size data on observed animals, and estimate the number of subsurface animals (in conjunction with in-water tracking data). In the longer term, photographic surveys could be conducted in some habitats that would obviate the need for large observer teams aboard an aircraft. Photographic surveys could also be conducted at higher altitudes, thereby increasing the amount of area surveyed. In this project, we propose to conduct pilot studies of these technologies on separate aerial platforms concurrent with traditional surveys in specific areas. The goal of these pilot studies will be to directly compare the resulting data between visual line-transect survey and high-resolution photographic/LIDAR surveys and assess the pros and cons of each approach.

Underwater autonomous vehicles (e.g., Slocum gliders) and wave gliders also offer the capability for high resolution, long term monitoring while reducing the need for expensive ship and person-time. We proposed to examine the utility of gilders for improving assessments of large whales and other cetaceans. The aim of this project is to explore the capability for autonomous gliders to provide real time locations of marine mammals as part of the NMFS's ongoing efforts to monitor and assess marine mammal stocks; this would build on existing research partnerships between NOAA, Woods Hole Oceanographic Institution, Scripps Institution of Oceanography, and other institutions. The distribution and habitat features of marine mammals will be mapped along set transect lines in the study area using gliders equipped with instrumentation to (1) record low and mid-frequency marine mammal vocalizations, (2) detect, classify, and remotely report particular vocalizations of interest, and (3) measure high-frequency acoustic backscatter, chlorophyll fluorescence and oceanographic conditions. The

acoustic data will be used to document the distribution of acoustically active marine mammals, and accompanying measurements will be used to characterize the oceanographic conditions in relation to acoustic activity. These studies will be conducted simultaneously with proposed aerial surveys to allow comparison between data sources.

Objective 5: Assess the population size of surveyed species at regional scales

Shipboard and aerial survey data will be analyzed to estimate the density and overall population size of species encountered within the surveyed regions. The primary statistical approach for these analyses will be Distance Analysis. Briefly, this method examines the distribution of sighted animals as a function of distance from the survey trackline to calculate the probability of seeing any particular animal or group of animals. This sighting probability is used as a correction factor to scale the encounter rate (sightings per unit survey effort) to an estimate of animal density (number per km^2) within the surveyed area. The sighting probability can be modeled as a function of viewing conditions (sea state, visibility, etc.) to further reduce the variability in the estimates and improve the comparability between different surveys. Two sources of bias (and variability) will be addressed within the proposed data collection programs. First, the two-team (or sight-resight) methods used during both aerial and vessel surveys will directly estimate the perception bias resulting from available animals missed by the survey teams. Second, information on dive-surface intervals for marine turtles will be incorporated into the estimation of sighting probability to correct for this significant negative bias. Similar dive-time corrections will be incorporated from existing data (and passive acoustic detections) for deep-diving whales (e.g., sperm whales). Sea bird sighting probability/density estimates will be calculated using similar methods. Distance data for seabirds is collected as part of survey protocols and will be used to quantify detection.

For marine turtles, the abundance estimates will not encompass the entire spatial range of any given species or population because these animals range over ocean basin scales. Rather, a proportion of each species will occur within the surveyed region in any given season and only a restricted size of those animals (typically >30 cm length) will be easily visualized by aerial surveys. In addition to correction for dive times, the tag telemetry studies will be critical for evaluating these large-scale habitat use patterns by the surveyed life-history stages. In general, population estimates for turtles will be minimum estimates of particular life-history stages rather than indicators of total population size.

The total population size of seals on the haul-out sites, will be estimated using the Hanson-Horvitz estimator, with the probability of selecting each surveyed haul out site and the count of animals at the sampled haul out sites. These estimates will then be corrected for the fraction of seals off the sampled haul-out sites using the radio-tag relocation data.

Comparison to historical data sets - The assessment program proposed here is the first comprehensive, seasonal data collection effort in U.S. Atlantic waters since the CeTAP and SETS surveys of the early 1980's. Until recently, systematic surveys of birds in the pelagic environment have not been conducted since the late 1970s and early 1980s. In addition, coast-wide Atlantic vessel surveys were conducted in the summers of 1998 and 2004 in addition to the surveys proposed for 2010 in this project. Analysis of these recent and historical data has the potential to evaluate trends in surveyed populations, or at least make comparisons between current and historical point estimates. If the habitat relationships identified in this assessment

program can be applied retrospectively, this may increase the ability to make historical comparisons. Therefore, the available historical data will be analyzed to provide a comparative baseline for the current data.

This analysis will initially focus on a few species such as sea turtles from the CeTAP, and SETS surveys and white-sided dolphins from the CeTAP and NEFSC surveys since 1991. A key analysis will focus on the abundance of loggerhead turtles in Northeast waters, where anecdotal data suggests abundance is increasing despite reports of declining nesting beach numbers in the Southeastern US. For seabirds, the U.S. Geological Survey (USGS), Patuxent Wildlife Research Center has spend the past few years developing a database of historical seabird records and is now working to model seabird distributions. Information coming out of this program will be incorporated into these efforts.

Objective 6: Develop models and associated tools to translate these survey data into seasonal, spatially-explicit density estimates incorporating habitat characteristics.

Both collected data from the surveys and available products (e.g., remote sensing data and hydrographic data) will be incorporated into survey databases. This suite of variables will be explored as explanatory factors in the development of habitat based spatially explicit density models of surveyed taxa. These models will be resolved seasonally and will provide predictive maps of animal density within the surveyed regions at spatial resolutions approaching 4 x 4 km. These spatial models typically include non-linear regression approaches (such as Generalized Additive Models) that can model complex uni- or multi-modal species-environment relationships. In addition, Bayesian spatial modeling tools will be explored as these approaches often are valuable in accounting for underlying spatial autocorrelation in animal distribution. These spatial models most directly examine the relationships between encounter rates and the underlying habitat variables. The sighting probability estimates from distance analysis (and tagging studies) are then incorporated into the models to develop absolute estimates of animal densities. The resulting models can be used in a retrospective or predictive mode to quantify the densities of megafauna likely to be encountered in smaller areas within the larger survey region.

Expected Products

The data collected during the shipboard/aerial surveys and tagging data will be incorporated into a comprehensive geospatial database. This will include the QA/QC'd sighting and telemetry data, survey effort, visual detections, passive acoustic detections, and ancillary habitat data collected during each survey. This comprehensive ORACLE database will be available within NOAA firewalls to its partners. Limited sightings information will also be made available outside the NOAA firewall to online data access systems such as OBIS-SEAMAP. The goal of these data management systems will be to provide ready access to the collected data for both public users and government agencies in support of environmental assessments. For seabirds, data will also be incorporated into the seabird database presently housed by U.S.G. S. at Patuxent Wildlife Research Center.

The spatial modeling efforts will also be integrated into online or distributed products. This may include static spatial maps of seasonal animal density represented as raster surfaces. These surfaces could then be queried to provide localized estimates of density (and associated

variance) from standardized models. In addition, the collected data will be incorporated into modeling efforts in an interactive manner to allow users to develop customized models for times and areas of interest. This effort will build off the Strategic Decision Support System developed jointly by NMFS-SWFSC and Duke University and funded by the Navy SERDEP program.

Paper products expected to be produced by the project include at a minimum: annual updates to the *Atlantic Ocean and Gulf of Mexico Marine Mammal Stock Assessment Report*, annual reports of survey results, and a peer reviewed journal manuscript describing the model development and results. Additional manuscripts will likely be available comparing change of abundance of various marine mammal and turtle populations in the NW Atlantic Ocean, and distribution and abundance of seabirds.

Implementation

We anticipate that this project will be jointly implemented between multiple Federal Agencies—NOAA, USN, MMS, USFWS and USGS/BRD. Three working groups will need to be formed:

- Model development – Primary participants will be NOAA (NEFSC, SEFSC and SWFSC) with USN and Duke (OBIS/SEAMAP) and USGS involvement
- Survey design – Primary participants will be NOAA, USFWS, and USGS/BRD with USN and MMS involvement
- User interfaces with data products – Primary participants will NOAA (science and management), MMS and USN with USFWS involvement

Should the participants agree that funds are available to support at Tier II survey effort, then a significant technical workshop will be held in spring-summer 2010 to pull together the three working groups.

Survey work is expected to begin during the summer of 2010. Model development will begin shortly afterwards with the first model results expected to be available in 2012.

Budget Proposal

Total expected cost for the project by Tier from FY10 through FY14 are estimated to be $13.7M ($6.2M in new funds), $29.9M ($18.8M in new funds), and $36.7M ($23.2M in new funds), for Tiers I through III, respectively. Funding for Tier IV will be the same as Tier III during FY10-14. Funding schedule by fiscal year, assuming a project duration for the first five-year cycle of June 2010 to March 2015, is as follows:

Table 2. AMAPPS total estimated costs by fiscal year for FY2010 through FY2014 for Tiers I-III. Includes both currently funded elements (e.g., ship time and existing FTEs) and new, unfunded costs.

Component	FY2010	FY2011	FY2012	FY2013	FY2014
Tier I					
Personnel	242	388	522	428	563
Data Collection	3759	0	3865	106	3850
Total	4001	388	4387	534	4413
Tier II					
Personnel	806	2380	2186	2189	2316
Data Collection	3865	7213	3865	156	3865
Total	4671	9593	6101	2345	6181
Tier III					
Personnel	561	2360	2357	2189	2366
Data Collection	3865	10922	6851	984	4282
Total	4426	13282	9208	3173	6648

Personnel

Additional personnel will be required at both the Northeast and Southeast Fisheries Science centers and FWS to support the additional data collection and data analysis requirements under Tiers II and III. Each of the following individuals will be required full-time throughout the project:

Northeast and Southeast Fisheries Science centers:

- 2 Sea bird survey leads/analysts (Shared)
- 1 Seal data processing technician (NEC)
- 2 Data managers/IT technicians (1 NEC, 1 SEC)
- 1 GIS technician (Shared)
- 4 Data analysts (2 NEC, 2 SEC)
- 2 Passive acoustics technicians/analysts (1 NEC, 1 SEC)

2 Survey leads (SEC)
1 Project coordinator (NEC)
1 Project manager (Shared)

The cost for these 16 additional staff is expected to be (with 50% overhead) $1,275K in FY11 and increase by 5% annually..

Thirteen existing survey staff at both the NEFSC and SEFSC will be expected to spend roughly 25% of their time during FY10-14 on the project, with a cost of $388 in FY11 and increasing by 5% per year.

FWS:

1 part-time seabird survey lead
1 part-time data manager
1 part-time GIS analyst
1 project manager/coordinator

The cost for these additional staff is expected to be $250,000 per year for FY11-14. Fifteen existing survey staff within the Division of Migratory Birds will be expected to spend approximately 20% of their time during FY 11-14 on the project.

Data Collection

Data collection costs include equipment, travel, and temporary staffing costs for each survey. For aerial survey, costs include hourly operational costs for aircraft (NOAA or contract).

Table 3. AMAPPS data collection costs.

Item	**Description**	**Total (FY10-FY14)**
Vessel surveys @ 3,100K for two 60 day surveys per season[1]	Tier I: 1 in FY10, 12, 14 Tier II: 1 in FY10, 11, 12, 14 Tier III: 1 in FY10, 2 in 1, 1 in 12 and 14	Tier I: $9300K Tier II: $12400K Tier III: $ 15,500K
Aerial surveys @ 500K two 45 day surveys per season[2]	Tier I: 1 in FY10, 12, 14 Tier II: 1 in FY10, 3 in 11, 1 in 12 and 14 Tier III: 1 in FY10, 4 in 11, 3 in 12, 1 in 14	Tier I: $1500K Tier II: $3000K Tier III: $4500K
FWS aerial surveys @ $159K per survey	Tier I: 1 in FY 10 (if funds available), 12, and 14 Tier II: 1 in FY10, 3 in FY 11, 1 in FY 12 and 14 Tier III: 1 in FY 10, 4 in FY11, 3 in FY 12 and 1 in	Tier I: $477K Tier II: $954K Tier III: $1431K

[1] Assumes vessel cost of $20K per day
[2] Assumes aircraft cost of $4K per 8 hr survey

Item	Description	Total (FY10-FY14)
	FY14	
The following are for Tiers II and III		
Harbor seal count surveys (@40K) and VHF tagging studies (@ 60K)	FY11 and FY13	200
Gray seal production survey @30K	1 Survey Annually FY11-FY14	120
Seal monitoring surveys @40K	1 Survey Annually FY11-FY14	160
Turtle tag telemetry study ~260 tags	FY10 - FY12 deployments	1,900
Seabird piggy-back surveys	Annual travel @ 106K per year for FY11-14	424
Advance technology pilot project – aerial imagery	FY11 and FY12	200
Advance technology pilot project – UAV	FY11 and FY12	250
Seabird Telemetry	FY 11- 14	$400K

Figure 1. Aerial line-transect surveys conducted by the Northeast and Southeast Fisheries Science Centers. Survey descriptions are provided in Appendix 1.

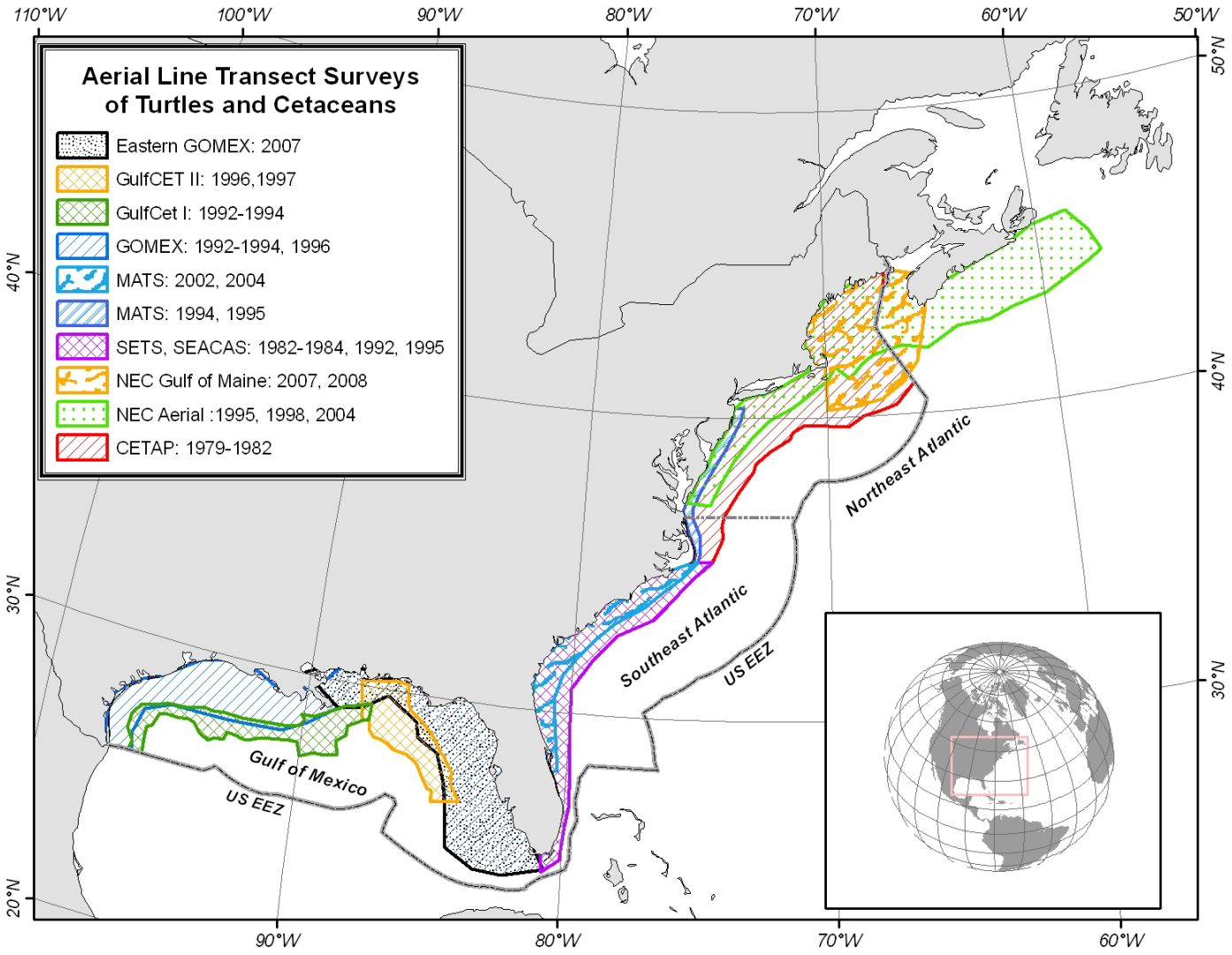


Figure 2. Shipboard line-transect surveys conducted by the Northeast and Southeast Fisheries Science Centers. Survey descriptions are provided in Appendix 1.

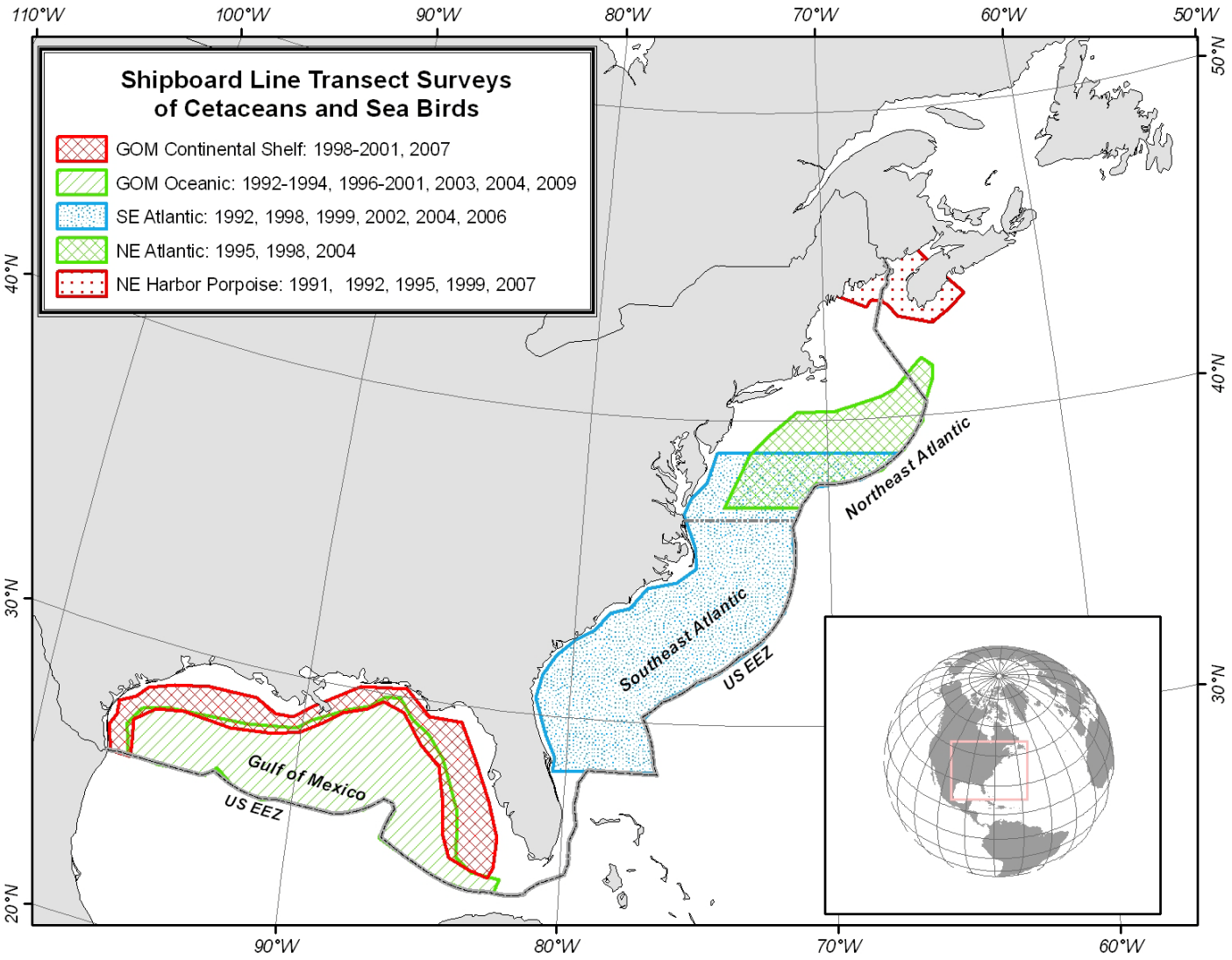
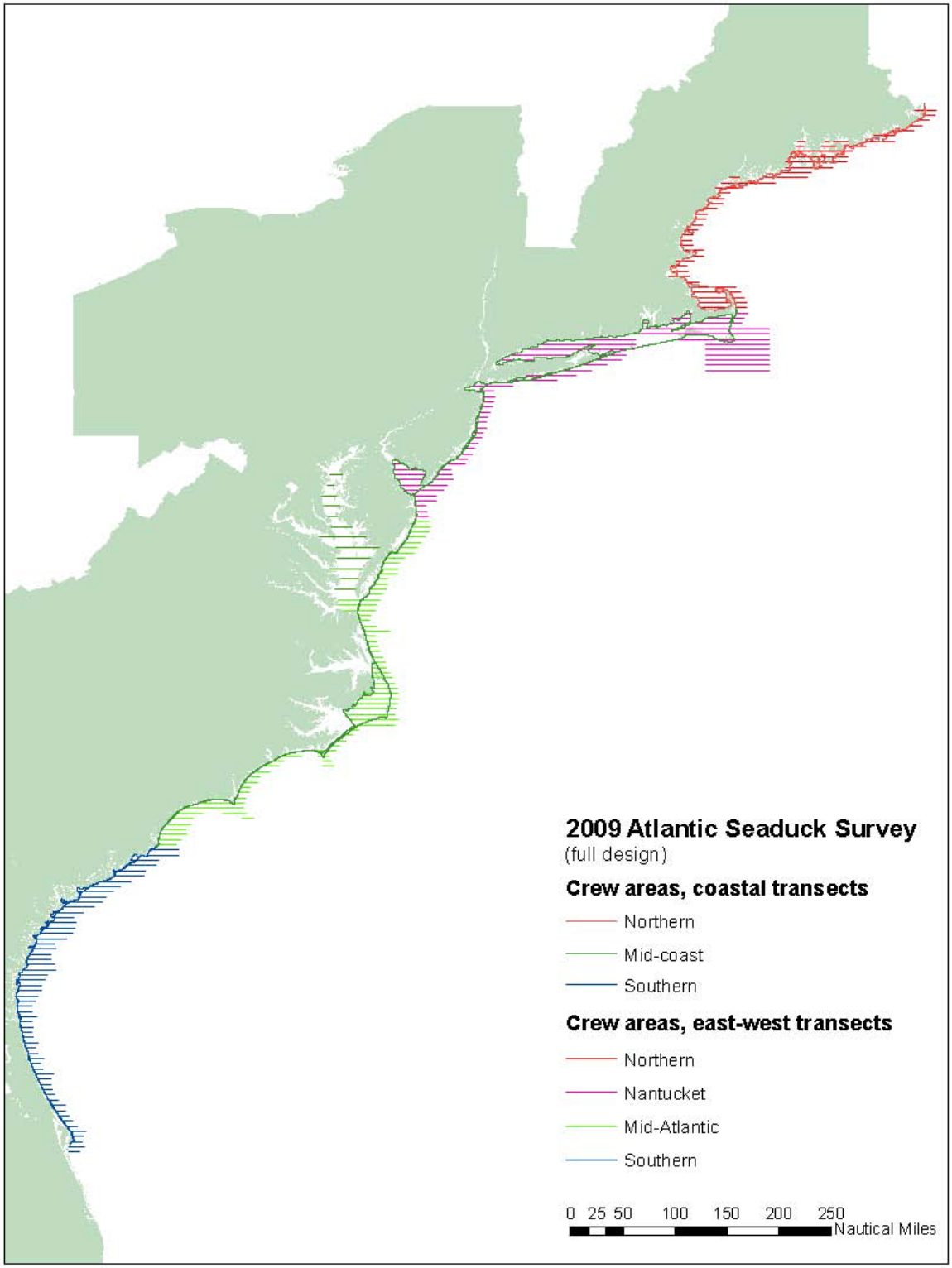


Figure 3. 2009 FWS sea duck and seabird aerial transects.



Appendix 1. Previous Line Transect Surveys

Survey	Years	Season(s)	Region	Offshore Range
Aerial Surveys				
CETAP	1979 - 1982	Win, Spr, Sum, Fal	NE Atlantic	Shore to 2,000 m isobath
NEC Aerial	1995, 1998, 2004	Sum	NE Atlantic (to Scotian Shelf in 1998)	Shore to Shelf Break (~200 m isobaths)
NEC Gulf of Maine	2007, 2008	Sum	Gulf of Maine	Gulf of Maine and Georges Bank
SETS	1982-1984	Win, Spr, Sum, Fal	SE Atlantic	Shore to Gulf Stream Edge
SECAS	1992, 1995	Win	SE Atlantic	Shore to Gulf Stream Edge
MATS	1994, 1995	Sum	NE Atlantic	Shore to 25m depth
MATS	2002, 2004	Sum, Win	SE/NE Atlantic	Shore to 40m depth
GOMEX	1992-1994, 1996	Fal	Gulf of Mexico	Shore to 200m depth
GulfCet I	1992-1994	Win, Spr, Sum, Fal	Gulf of Mexico	200 m to 2000 m isobath
GulfCet II	1996, 1997	Sum, Win	Eastern Gulf of Mexico	200 m to 2000 m isobath
GOMEX 2007	2007	Sum, Win	Eastern Gulf of Mexico	Shoreline to 200m isobath
Vessel Surveys				
NE Harbor Porpoise	1991, 1992, 1995, 1999, 2007	Sum	Gulf of Maine	
NE Atlantic	1995, 1998, 2004	Sum	NE Atlantic	Shelf break to U.S. EEZ
SE Atlantic	1992, 1998, 1999	Sum	SE Atlantic	Continental shelf to U.S. EEZ
SE Atlantic	2002	Spr	SE Atlantic	Continental shelf to U.S. EEZ
SE Atlantic	2004, 2006	Sum	SE Atlantic	Shelf Break to U.S. EEZ
GOM Oceanic	1992-1994	Win, Spr, Sum, Fal	Gulf of Mexico	200 m to 2000 m isobaths (GulfCet I)
GOM Oceanic	1996-1997	Win, Spr, Sum, Fal	Gulf of Mexico	200 m to 2000 m isobaths (GulfCet II)

Survey	Years	Season(s)	Region	Offshore Range
Vessel Surveys				
GOM Oceanic	1996-2001	Spr	Gulf of Mexico	200m to US EEZ (Ichthyoplankton)
GOM Oceanic	2003, 2004, 2009	Sum	Gulf of Mexico	200m to US EEZ
GOM Continental Shelf	1998-2001	Fal	Gulf of Mexico	20m to 200m isobath (Ichthyoplankton)
GOM Continental Shelf	2007	Sum	Gulf of Mexico	20m to 200m isobath