Final Project Report: Marine Species Density Data Gap Assessments and Update for the AFTT Study Area, 2015-2016 (Base Year)

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1. Introduction

In the United States, national laws protect cetaceans. The Marine Mammal Protection Act (MMPA) prohibits intentional or incidental killing, injuring, or harassment of marine mammals and specifies the circumstances and rules under which permits may be issued for such activities. The Endangered Species Act (ESA) prohibits harm to species threatened with extinction and requires conservation of their habitat. The National Environmental Policy Act (NEPA) specifies a process by which U.S. national government agencies must evaluate the potential environmental effects of their actions, consider alternatives, and conduct public reviews. Agency actions that involve decisions to issue permits under the MMPA or ESA are usually subject to this process.

The US Navy is responsible for compliance with a suite of federal environmental and natural resources laws and regulations that apply to the marine environment, including MMPA, ESA, the Magnuson-Stevens Fishery Conservation and Management Act, the Marine Protection, Research and Sanctuaries Act (MPRSA), Clean Water Act (CWA), Executive Order 13089 on Coral Reef Protection, and NEPA/Executive Order 12114 (EO 12114). Additionally, Federal Activities that have the potential to affect the state coastal zone are required to be consistent with respective state coastal zone management plans mandated by the Coastal Zone Management Act (CZMA).

To evaluate the potential effects of proposed activities on marine mammal populations, the Navy, federal regulators, and other stakeholders require a detailed understanding of the spatiotemporal distributions of these populations. To facilitate spatiotemporally-explicit descriptions of marine mammal distributions in U.S. waters, government organizations such as the National Marine Fisheries Service (NMFS) have conducted visual line-transect surveys of marine mammals for over 35 years, resulting in various studies that estimated the abundance, density, and distributions of cetacean populations.

The last decade as seen the rise of a two-stage analysis method known as density surface modeling (Hedley & Buckland 2004; Miller et al. 2013). In this method, traditional distance sampling (Buckland et al. 2001) is coupled to a regression model (e.g., Wood 2006), allowing absolute density (individuals km^{-2}) to be modeled from spatiotemporally-varying correlates, yielding gridded maps of absolute density. In 2007, as part of the Atlantic Fleet Training and Testing (AFTT) Phase II Environmental Impact Statement (EIS), the Navy funded development of the first such density surface models for the western North Atlantic and Gulf of Mexico (Department of the Navy 2007a, 2007b, 2007c), known as the Navy OPAREA Density Estimates (NODEs).

For the AFTT Phase III EIS, the Navy funded us (Duke Marine Geospatial Ecology Lab) to develop new density surface models to replace NODEs. We established collaborations with survey teams at five U.S. federal, state, and academic institutions and acquired nearly 1.1. million linear km of aerial and shipboard line transect survey data (Fig. 1, Table 1). We split the polygon enclosing this well-surveyed region at 80.5°W into two analysis regions, the East Coast (EC) and Gulf of Mexico (GOM) and developed density models for 26 species and 3 multi-species guilds, using updated methodology and covariates (Roberts et al. 2016). These are known variously as the *EEZ models* (although they extend beyond the U.S. EEZ in several places), the *CetMap models* (referring to their use in NOAA's CetSound initiative), the *Duke 2015 models* (referring to the year we finalized the results) and the *Roberts et al. 2016 models*. The model predictions in GIS-compatible format as well as taxon-specific supplementary reports are available at http://seamap.env.duke.edu/models/Duke-EC-GOM-2015/.

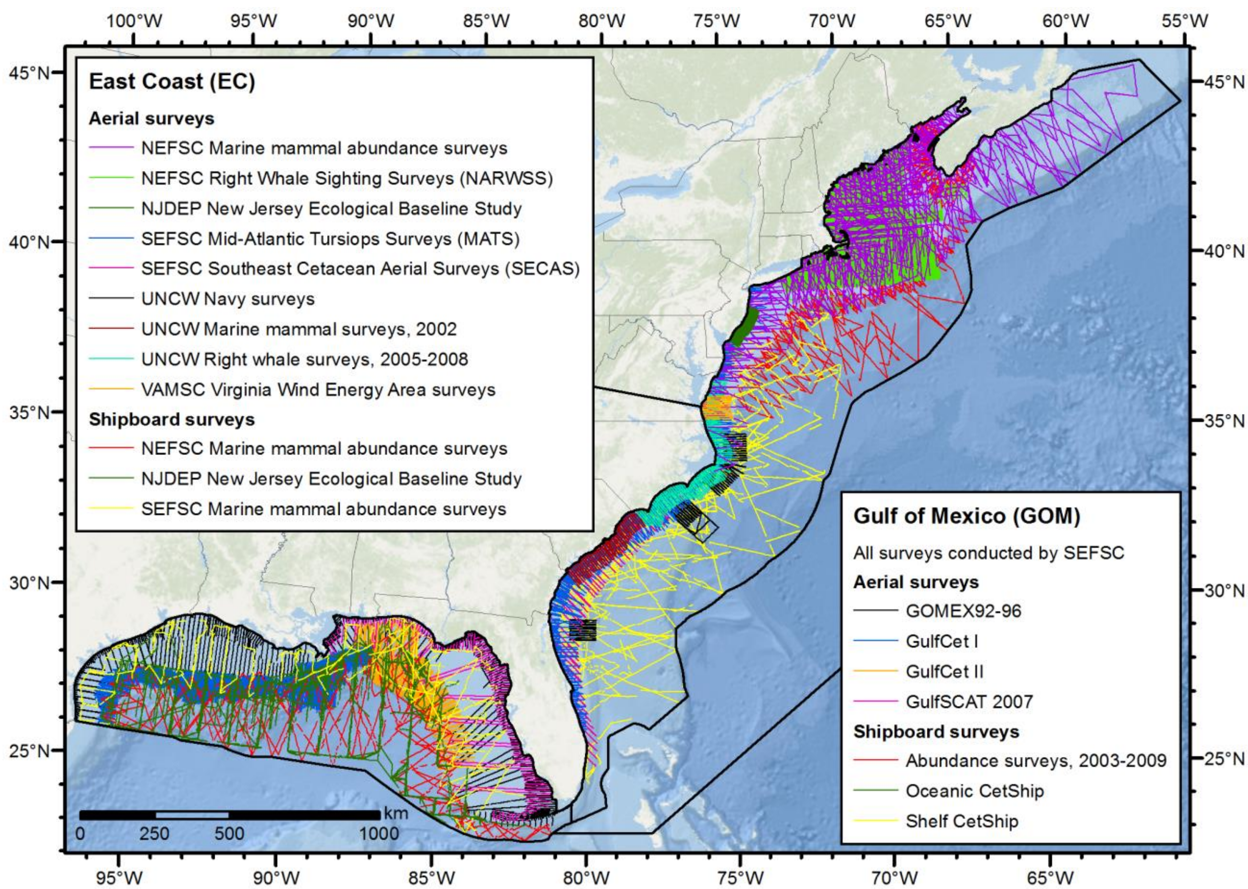

Figure 1. Line transect surveys used in the EEZ models, a.k.a. CetMap or Roberts et al. 2016 models. Figure taken from Roberts et al. (2016).

To model the wider AFTT area we sought to supplement the surveys used in the EEZ models with additional surveys conducted in other parts of the North Atlantic. We established domestic and international collaborations with teams that surveyed parts of the Caribbean, Europe, and the mid-Atlantic ridge, which collectively contributed an additional 54,000 linear km of surveys (Fig 2., Table 2), improving coverage of under-represented biomes. We modeled density for 29 cetacean taxa and 1 pinniped taxon with a methodology explicitly designed to produce plausible extrapolations given available data. This resulted in density surface models for 15 cetacean taxa published in Mannocci et al. (2016); model predictions in GIS-compatible format and taxon-specific supplementary reports will available in late 2016 at http://seamap.env.duke.edu/models/.

Table 1. Line transect surveys used in the EEZ models, a.k.a. CetMap or Roberts et al. 2016 models.

Region	Platform	Surveyor	Survey program	Years	Length (10^3 km)	Hours
EC	Aerial	NEFSC	Marine mammal abundance surveys	1995-2008	70	412
			Right Whale Sighting Survey	1999-2013	432	2330
			NARWSS harbor porpoise survey	1999	6	36
		NJDEP	New Jersey Ecological Baseline Study	2008-2009	11	60
		SEFSC	Mid-Atlantic Tursiops Surveys (MATS)	1995, 2004-5	35	196
			Southeast Cetacean Aerial Surveys (SECAS)	1992, 1995	8	42
		UNCW	Cape Hatteras Navy surveys	2011-2013	19	125
			Jacksonville Navy surveys	2009-2013	66	402
			Marine mammal surveys, 2002	2002	18	98
			Onslow Bay Navy surveys	2007-2011	49	282
			Right whale surveys, 2005-2008	2005-2008	114	586
		VAMSC	Virginia Wind Energy Area surveys	2012-2014	9	53
			Total:	1992-2014	837	4622
	Shipboard	NEFSC	Marine mammal abundance surveys	1995-2004	16	1143
		NJDEP	New Jersey Ecological Baseline Study	2008-2009	14	836
		SEFSC	Marine mammal abundance surveys	1992-2005	28	1731
			Total:	1992-2009	58	3710
GOM	Aerial	SEFSC	GOMEX92-96	1992-1996	27	152
			GulfCet I	1992-1994	50	257
			GulfCet II	1996-1998	22	124
			GulfSCAT 2007	2007	18	95
			Total:	1992-2007	117	628
	Shipboard	SEFSC	Oceanic CetShip	1992-2001	49	3102
			Shelf CetShip	1994-2001	10	707
			Marine mammal abundance surveys	2003-2009	19	1156
			Total:	1992-2009	78	4965

Length and hours are the cumulative linear distance and duration observers were on effort for each survey program (references given). See Fig. 1 for spatial effort. Surveyors: NOAA NMFS Northeast Fisheries Science Center (NEFSC), New Jersey Department of Environmental Protection (NJDEP), NOAA NMFS Southeast Fisheries Science Center (SEFSC), University of North Carolina Wilmington (UNCW), Virginia Aquarium & Marine Science Center (VAMSC). Table taken from Roberts et al. (2016); see that publication for references describing each survey.

The remaining 14 cetacean models and 1 pinniped model required special treatment, owing to taxon-specific complexities or a lack of sufficient sightings, and thus were not included in Mannocci et al. (2016). In general, these models either used the same density surface modeling methodology as Mannocci et al. (2016) with a reduced number of covariates, or were stratified models developed with the methodology described in Roberts et al. (2016). Full details for each model were given in taxon-specific reports delivered to the Navy in 2015 with the initial version of the Phase III Navy Marine Species Density Database (NMSDD). Collectively, the 30 models spanning the AFTT area are known as the *AFTT models* or *Mannocci et al. 2016 models*.

After the EEZ and AFTT models were finalized, we produced a customized overlay of the models for the Phase III NMSDD. In short, we overlaid the EEZ models on the AFTT models (they used the same grid and map projection), converted them to polygon features, and spatially extrapolated them to fill nearshore slivers of the Navy's AFTT polygon. For bottlenose dolphins, we added density predictions for estuarine stocks, derived from various sources. Roberts et al. (2015) documents these procedures. These 30 blended models are known as the *Phase III NMSDD* models.

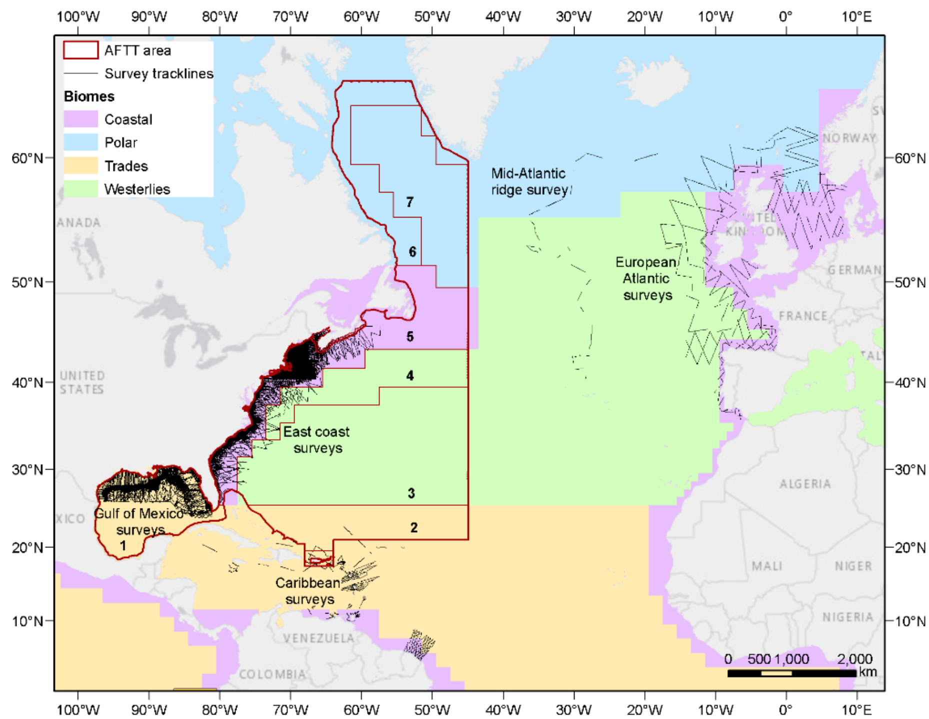

Figure 2. Map of the North Atlantic basin showing the AFTT study area (thick red outline), line transect surveys included in the analysis (black lines), and color-coded biomes from Longhurst's classification (2007) (available at http://www.marineregions.org). Longhurst biogeographical provinces are shown within the study area. 1: Caribbean; 2: North Atlantic tropical gyre; 3: North Atlantic subtropical gyre; 4: Gulf Stream; 5: northwest Atlantic shelves; 6: Atlantic Arctic; 7: boreal polar.

Table 2. Line transect surveys used in the AFTT models, a.k.a. Mannocci et al. 2016 models.

Region	Platform	Surveyor	Effort (km)	Survey years
East coast (EC)	Shipboard and aerial	NEFSC, NJDEP, SEFSC, UNCW, VAMSC	887,963	1992–2014
Gulf of Mexico (GOM)	Shipboard and aerial	SEFSC	194,715	1992–2009
	Shipboard	SEFSC	8,975	2000, 1995
	Aerial	University of La Rochelle	15,289	2008
European Atlantic (EU)	Shipboard	Partners of the CODA Program	9,584	2007
	Shipboard	Partners of the SCANS-II Program	17,942	2005
Mid Atlantic Ridge (MAR)	Shipboard	Partners of the MAR-ECO Program	2,424	2004
Total			1,136,892	1992-2014

SCANS-II = Small Cetacean Abundance in the North Sea and adjacent waters-II, CODA = Cetacean Offshore Distribution and Abundance in the European Atlantic, MAR-ECO = Mid-Atlantic Ridge Ecology Program. Table taken from Mannocci et al. (2016); see that publication for references describing each survey.

2. Important Data Gaps

The focus of the 2015-2016 performance period was to identify and fill significant data gaps that impacted the development of the models developed thus far, and prepare these data for producing updated models that would reduce uncertainty and improve confidence for locations, seasons, and taxa that were particularly affected. This section of the report highlights what we found to be the most important data gaps.

The Navy indicated that the Atlantic was a particular priority for the first batch of model updates, and the Gulf of Mexico was not a priority. Therefore, we focused our attention on the Atlantic, setting aside the Gulf for the future. From a data availability perspective this prioritization was logical, as substantially more new surveys were available in the Atlantic (e.g. the 2010-2014 Atlantic Marine Assessment Program for Protected Species (AMAPPS) surveys) than in the Gulf, and NOAA was planning an intensive survey program for the Gulf for upcoming years (the Gulf of Mexico Marine Assessment. Program for Protected Species (GoMMAPPS) surveys).

2.1. Seasonal bias in survey effort

The Atlantic surveys used in the models developed thus far showed a strong seasonal bias in effort, with summer receiving the most effort (Fig. 3). Areas surveyed only in summer included most waters beyond the continental slope, in Canada, and the shelf of New York. The Blake Plateau, considered here as part of the continental shelf, received only sparse effort in non-summer seasons.

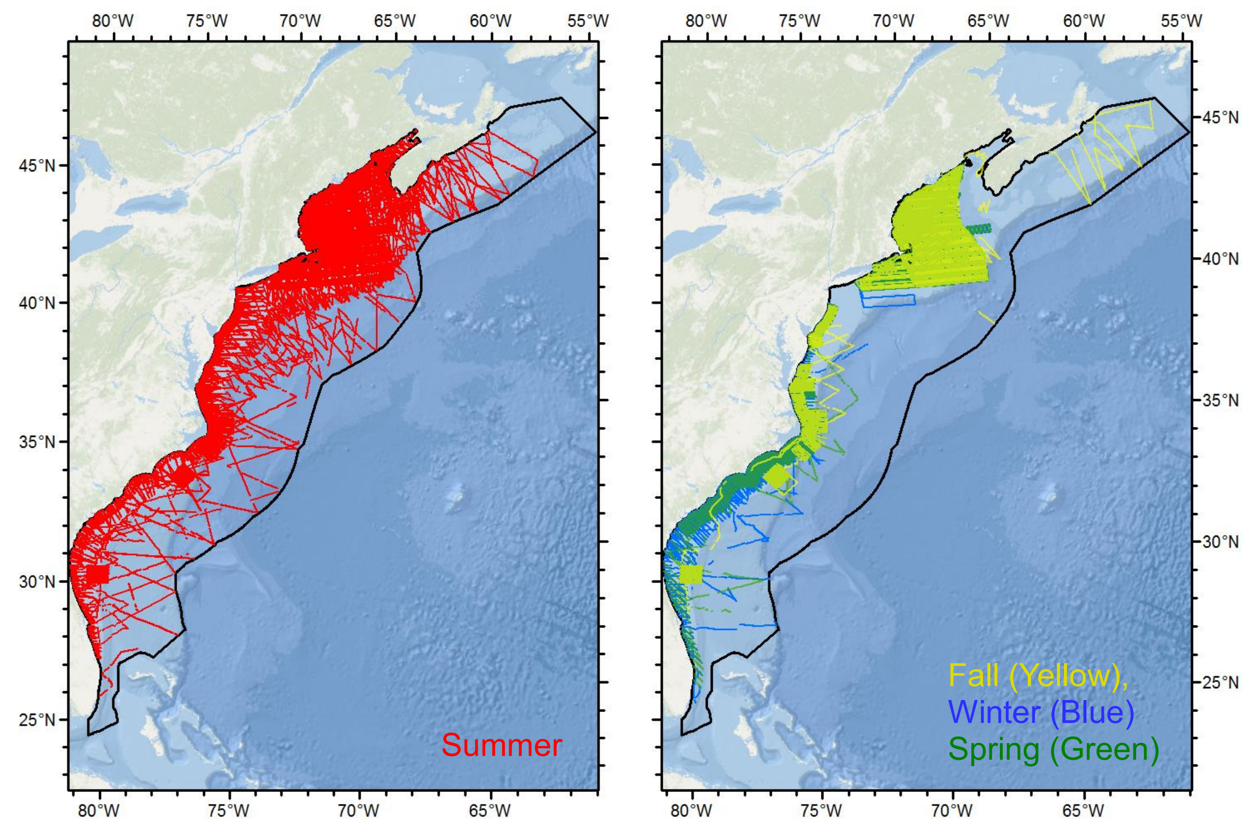

Figure 3. Tracklines of surveys utilized in the EC region, coded by color to highlight seasonal biases in survey effort. The only areas surveyed well in all seasons were the Gulf of Maine, surveyed by NOAA NARWSS, and the two Navy study areas in North Carolina and one in Florida, surveyed by UNCW.

2.2. Few sightings of North Atlantic right whales on winter calving grounds

The critically-endangered North Atlantic right whale is of particular concern to all users of U.S. Atlantic waters, especially the Navy, which conducts training and testing exercises out of a base in Jacksonville, Florida, where right whales migrate each year to calve. In the line transect survey data utilized in the models developed thus far, only ~20 right whale sightings were reported south of the Nantucket Shoals (Fig. 4).

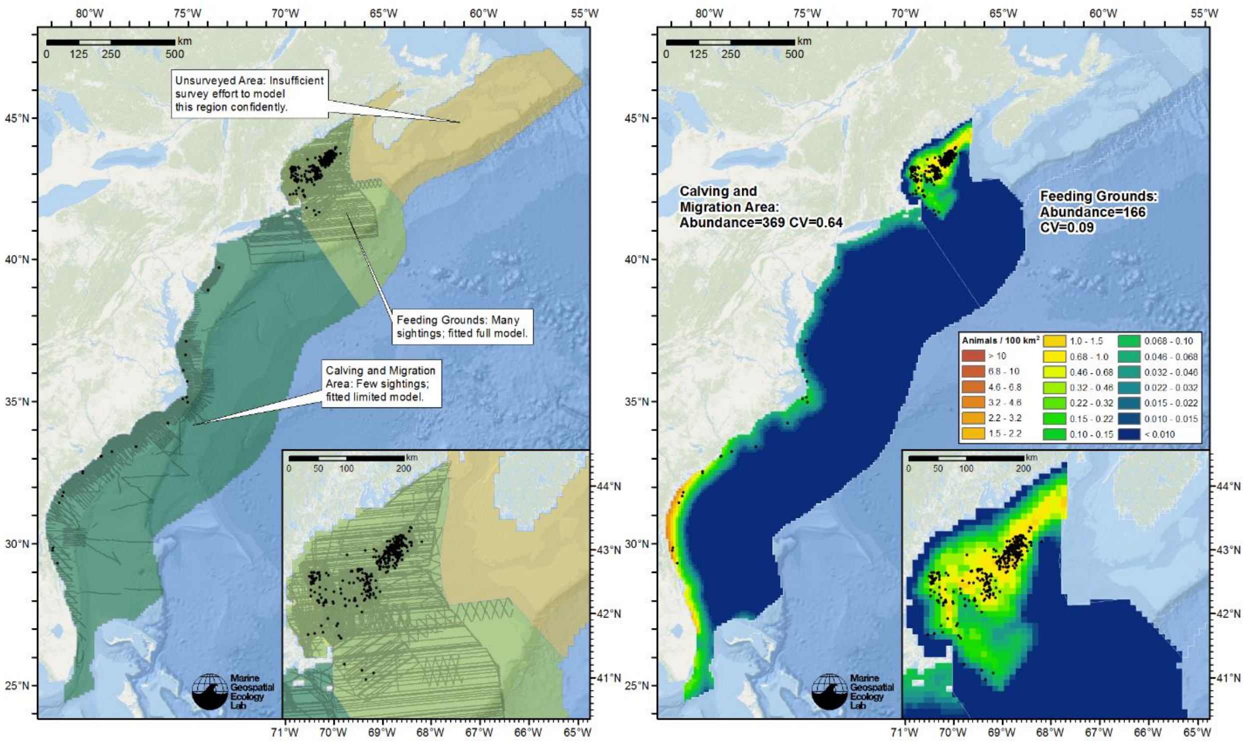

Figure 4. Schematic for the EC North Atlantic right whale winter season (November-February) model (left), showing the limited number of sightings available in the southern calving grounds, and resulting density prediction (right). Figures taken from the North Atlantic right whale supplementary report version 5.6 (2016-04-21) from Roberts et al. (2016).

Of the surveys utilized, only several SEFSC broad scale aerial and shipboard surveys covered the core calving grounds in Florida and Georgia during calving season. When so little data were available for other species, our standard procedure was to fit stratified models that estimated mean density over broad areas. For right whales, as an precautionary measure designed to yield models that better reflected their known distributions on the calving grounds, we fitted a limited density surface model instead (Roberts et al. 2016). While this model visually concurred with prior habitat modeling studies (e.g. Gowan & Ortega-Ortiz 2014), it suffered from high conceptual and numerical uncertainty, and may have overestimated density within the overall southeast region.

2.3. No data north of the Scotian Shelf, east of the Atlantic EEZ, or south of the Gulf of Mexico EEZ

These areas (Fig. 2) represented major data gaps for the broader AFTT study area modeled primarily through extrapolation (Mannocci et al. 2016). Although we understand from the Navy that most training and testing exercises occur within U.S. waters, it is a standing priority to reduce extrapolation, improve confidence, and reduce uncertainty in density predictions across distant regions of the AFTT, where exercises may occasionally occur.

2.4. No data for Long Island Sound

The eastern half of Long Island Sound is of particular interest to the Navy, which may conduct training and testing exercises from bases in the region (e.g. Connecticut). None of the surveys used in published models had ever surveyed Long Island Sound, a large estuary ecologically distinct from the Atlantic continental shelf beyond its mouth; for the NMSDD models, and we spatially extrapolated into this area from the shelf (Roberts et al. 2015).

3. New Surveys Incorporated

Pursuant to filling these gaps we canvassed colleagues and the literature to identify candidate line transect surveys and contacted data holders to establish collaborations. This section describes the new surveys we were able to acquire, prepare for analysis, and incorporate into our modeling infrastructure.

3.1. AMAPPS Surveys, 2010-2014

Funded by the Bureau of Ocean Energy Management (BOEM) and the Navy and conducted jointly by NOAA NEFSC and SEFSC, the 2010-2014 Atlantic Marine Assessment Program for Protected Species (AMAPPS) surveys spanned the U.S. Atlantic EEZ as well as the Canadian Gulf of Maine, Bay of Fundy, and Scotian Shelf. A primary goal of AMAPPS was to conduct broad-scale line transect surveys over multiple years and seasons to facilitate development of seasonal, spatially-explicit density estimates of marine mammals.

Although most of the AMAPPS surveys were conducted before our analysis started, NOAA was not ready to contribute AMAPPS to it until March 2015, two months after we finalized our results for the 2016 publications, precluding the use of AMAPPS in those models. Over 2015-2016, NOAA collaborators contributed all AMAPPS surveys from the 2010-2014 period plus the aerial surveys from 2015 (but, as of this writing, not the 2015 shipboard survey). The final datasets were delivered to us in April 2016.

In total, the surveys comprise 132,038 linear km, representing a 12% increase to the roughly 1.1 million linear km utilized in our 2016 publications. More aerial effort was conducted over the first half of the 2010-2015 period, while more shipboard effort was conducted over the second half (Table 3). Aerial effort occurred in all seasons but was biased to spring and summer months (Table 4). Shipboard effort was strongly biased to summer months, with no effort occurring in winter months (Table 4).

Table 3. AMAPPS survey data incorporated, by year.

	Linear effort (km)	
Year	Aerial	Shipboard
2010	17,231	0
2011	22,984	8,932
2012	37,031	0
2013	7,372	10,298
2014	16,850	4,017
2015	7,325	N/A
Total	108,792	23,246

Table 4. AMAPPS survey data incorporated, by month.

	Linear effort (km)	
Season	Aerial	Shipboard
Winter	20,926	0
Spring	38,010	4,017
Summer	27,163	17,139
Fall	22,693	2,090
Total	108,792	23,246

Seasons defined according to month boundaries: Winter: Dec-Feb, Spring: Mar-Apr, Summer: Jun-Aug, Fall: Sep-Nov.

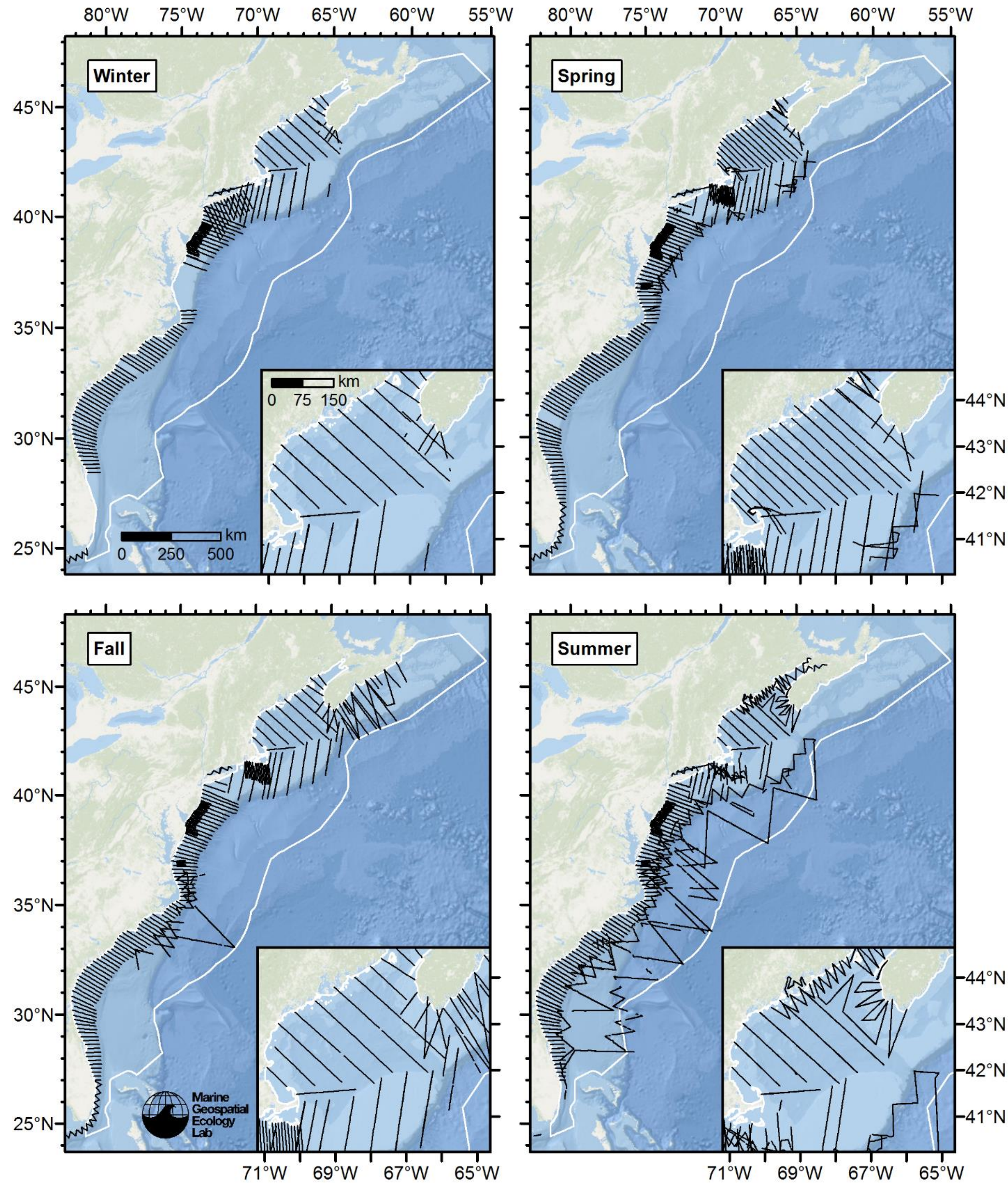

Figure 5. AMAPPS combined aerial and shipboard survey effort, 2010-2015, by season. Seasons defined according to month boundaries: Winter: Dec-Feb, Spring: Mar-Apr, Summer: Jun-Aug, Fall: Sep-Nov.

The spatial distribution of seasonal effort fills important seasonal gaps, but not all of them. South of Cape Hatteras, the continental shelf received coverage in all seasons. From Cape Hatteras to the southern tip of Nova Scotia, the continental shelf and shelf break received coverage in all seasons, except in Virginia and northern North

Carolina. (Fortunately, this area was covered extensively by other surveys so there is no gap here.) The Scotian Shelf was covered only in Fall, and only about halfway to the Laurentian Channel.

Beyond the shelf break, surveying was restricted to summer months, except for a small area of the southeast which was surveyed in September, still during astronomical summer, but counted in this analysis as Fall. Offshore areas can only be surveyed by ship, and this summertime bias reflects the logistical difficulty of conducting shipboard surveys in non-summer seasons, when weather and light levels are not conducive to visual observations. The one non-summer cruise, GU-14-02 conducted by NEFSC in March-April of 2014, was restricted to the shelf and shelf break.

While we appreciate the difficulties of surveying distant offshore areas in non-summer seasons, the continuing lack of data in these months represents an unfilled gap that will be present in our updated models, affecting confidence in non-summer predictions for offshore species. We will continue to lobby NOAA to prioritize surveying offshore areas in non-summer seasons. We note that SEFSC did conduct the OT-92-01 survey in January-February of 1992 and the GU-02-01 cruise in February-April of 2002 (Garrison et al. 2003), demonstrating that such surveying is not impossible.

3.2. Southeast Right Whale Aerial Surveys, 2003/04 - 2014/15

In the southeast U.S., NOAA, the Navy, state agencies, and others have funded nearshore aerial surveys for right whales from November to April of every winter for over 20 years. Surveys flew throughout the region, usually concentrated from Florida at 28°N north to the South Carolina border at 33°N, usually on all clear days in December through March, as funding permitted. The surveys usually extended out from shore no more than 65 km (40 mi) and were spaced 5-7 km apart. Survey teams included the Florida Fish and Wildlife Research Institute / Florida Fish and Wildlife Commission, New England Aquarium, Wildlife Trust, and Sea to Shore Alliance.

The surveys have been previously used to characterize and model habitat of calving right whales (Keller et al. 2006, 2012; Gowan & Ortega-Ortiz 2014), producing relative estimates of density such as sightings per unit effort (SPUE), but not absolute density (individuals per unit area). As far as we know, Roberts et al. (2016) provided the first published right whale absolute density surface for the southeast U.S. published. But as we noted, our density models did not incorporate the southeast right whale surveys. The reason is twofold:

First, it initially proved difficult to obtain permission to use the surveys. This difficulty was eventually overcome after our paper was published, at the initiative of Barb Zoodsma who communicated with data holders on our behalf. Second, the surveys were conducted with the primary goal of finding and photographing right whales, to track the history and behavior of individual whales and to estimate population parameters with photographic capture-recapture methods. Although the survey protocols were fairly compatible with the distance sampling methodology that our analysis was based upon, there were some critical differences that necessitated various preparatory treatments before the data could be used. While some of these could be automated, some could not. The large aggregate size of these surveys obligated a substantial commitment of time to complete the manual steps. After obtaining and preparing all of the 1.1. million km of data we used in our published models, no time remained to consider the right whale surveys.

After Zoodsma helped us establish a collaboration that permitted access to the data, we acquired surveys for the period spanning the 2003/04 through the 2014/15 survey seasons (Fig. 6, 7), with substantial assistance of Tim Gowan and Katie Jackson, who performed some critical data preparation and formatting steps. We selected 2003/04 as the oldest season after learning from Gowan that this was the season that many aspects of the survey protocol were standardized across the survey teams, and that prior to this season there were important protocol differences (e.g. flight altitude, number of observers), and the differences were not always known or coded in the data. 2014/15 was the most recent season for which data were initially available. (We were recently provided with data for the 2005/16 season, which we will incorporate into the model update, if at all possible.)

Survey protocol required observers to circle and identify all sightings suspected to be large whales. Approximately 2300 right whale groups were sighted, along with 52 humpback and 5 fin whale groups. We anticipate utilizing these surveys for all large whale species. We do not believe these surveys will be usable in models of other species, as observers did not consistently record sightings of species other than large whales.

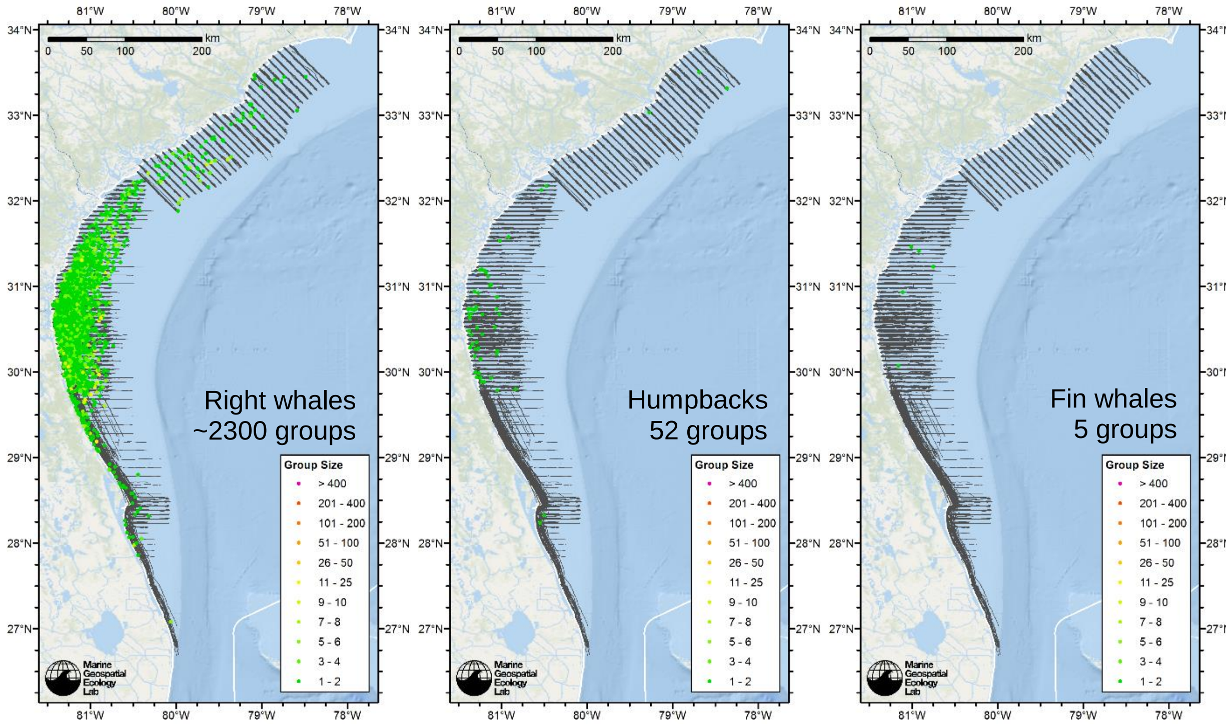

Figure 6. Southeast U.S. right whale aerial survey effort, 2003/04 - 2014/15, overlaid with sightings of right whales (left), humpback whales (center), and fin whales (right).

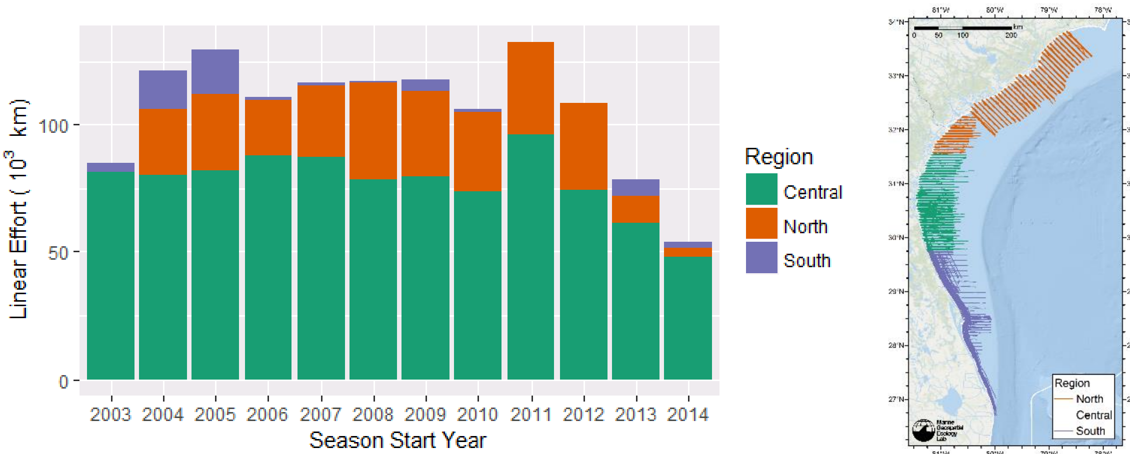

Figure 7. Southeast U.S. right whale aerial survey effort, by region and year. Note: the regions here are not exactly the same as the right whale Early Warning System (EWS) regions. Here, the North region is the same as the EWS SCGA region. The Central region spans 29.75-31.55°N, which encompasses most of the NEWS, CEWS, and SEWS regions. The South region comprises the most southerly surveys flown much less frequently than those in the other EWS regions.

In aggregate, these surveys total more than 1.2 million linear km of survey effort (Fig. 7). Their inclusion will more than double the effort available for modeling the density of large whales. In the central and northern regions covered by these surveys, survey transects were flow perpendicular to the shoreline, following standard distance sampling practice (Buckland et al. 2001). Funding limitations precluded extensive surveying in the southern region, and surveys were flown parallel to shore as a cost-saving measure. While we usually do not use shore-paralleling transects in our density models, we will likely use some of them from the southern region, as very few perpendicular transects were flown there, leaving us little choice if we want data for this region. (We will still discard shore-paralleling transects elsewhere; Fig. 7 omits them.)

3.3. NEFSC North Atlantic Right Whale Sighting Surveys (NARWSS), November 2013-December 2015

In our published models, the NOAA NEFSC NARWSS program contributed the most aerial survey data—432,000 linear km, about as much as all of the other east coast surveys combined—spanning the period of March 1999-July 2013. For the updated models, NARWSS extended the survey record through December 2015, adding the remaining 5200 km of effort for 2013 that we did already have, plus 25,900 for 2014, and 39,500 for 2015. These surveys provide additional year-round coverage in the Gulf of Maine, and in 2014 and 2015, they include surveys of parts of the Scotian Shelf and the Gulf of St. Lawrence. These transects, prompted by unexpectedly low abundance of right whales in the Gulf of Maine, boost coverage in the northernmost part of our EC study area, and should prove useful for modeling northerly, shelf-associated species.

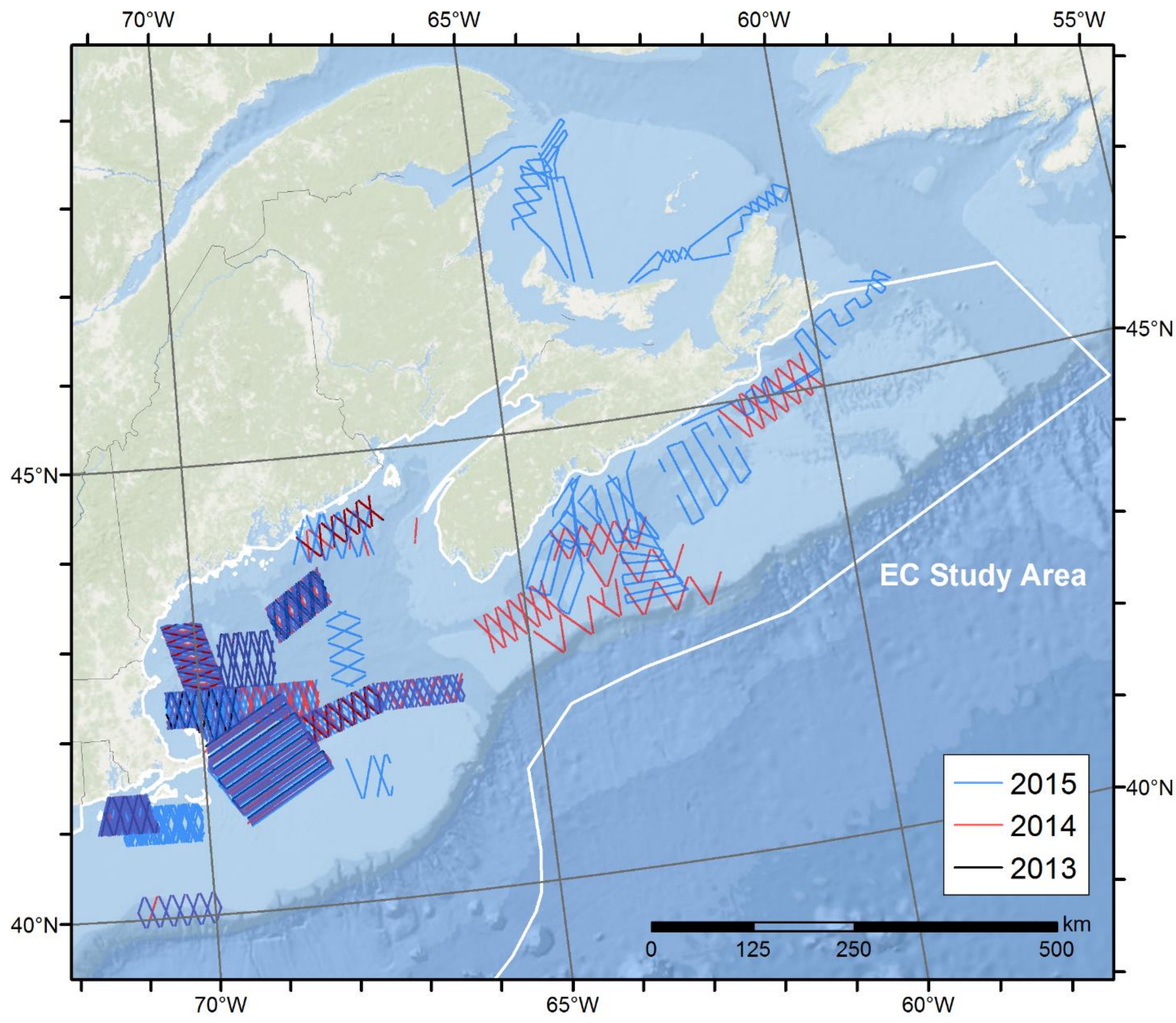

Figure 8. NEFSC NARWSS survey effort, November 2013-December 2015. Surveys overlapped substantially in the Gulf of Maine and southern New England. Because only two months of 2013 were included in this update (we already utilized the prior months of 2013 in our completed models), 2013 appears to be under-represented compared to 2014 and 2014.

3.4. UNC Wilmington Navy Aerial Surveys, 2014-2015

In 2014-2015, UNC Wilmington continued regular aerial surveys of Navy study areas off Jacksonville, Florida, and Cape Hatteras, North Carolina, and began a new series of surveys of the Norfolk Canyon area (Fig 9). In aggregate, these surveys totaled 32,000 linear km of survey effort, with Jacksonville receiving the most effort, followed by Cape Hatteras (Table 5). As with prior UNC Wilmington surveys, these surveys have the benefit of spanning the continental shelf break and a significant portion of the continental slope, both important habitats for cetaceans. We expect these surveys to be especially helpful for modeling species associated with the continental slope, such as beaked whales (31 sightings), pilot whales (51 sightings), sperm whales (8 sightings), and Risso's dolphins (14 sightings).

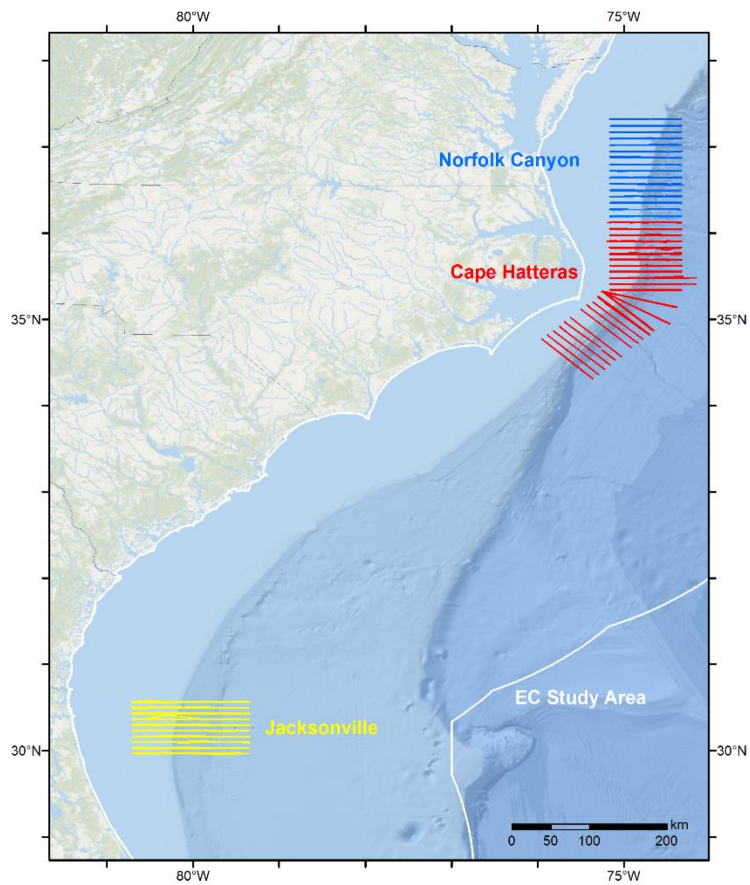

Figure 9. UNC Wilmington aerial survey effort in U.S. Navy study areas, 2014-2015.

Table 5. UNC Wilmington linear survey effort, by study area and year.

Study area	Year	Effort (km)
	2014	13.513
	2015	4,382
Cape Hatteras	2014	6,844
	2015	2,999
Norfolk Canyon	2015	4,462
Total		32,301

3.5. VAMSC Maryland Wind Energy Area Aerial Surveys, 2013-2015

Between July 2013 - June 2015, the Virginia Aquarium and Marine Science Center and the Riverhead Foundation for Marine Research and Preservation conducted monthly aerial surveys of the Maryland Wind Energy Area, on the inner continental shelf of northern Maryland and southern Delaware, completing over 16,000 linear km of effort (Barco et al. 2015) (Fig. 10). The surveys reported 453 sightings of dolphins (nearly all bottlenose dolphins), and 20 sightings of baleen whales (4 species identified). We believe these survey will prove useful in calibrating seasonal predictions of these species in the mid-Atlantic area.

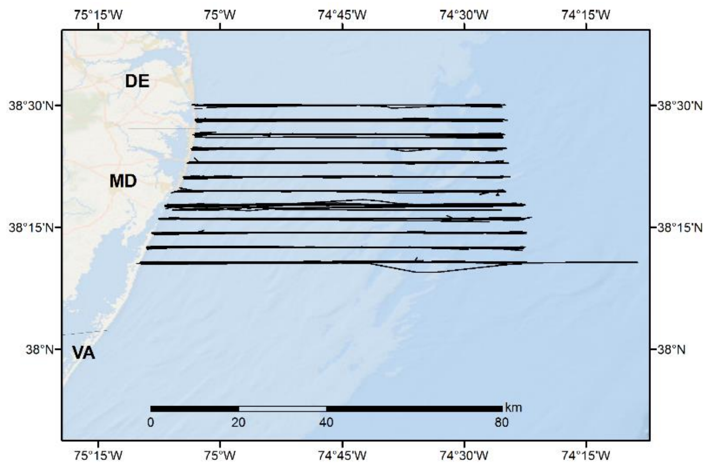

Figure 10. Maryland Wind Energy Area aerial survey effort, 2013-2015.

3.6. VAMSC Virginia Wind Energy Area Aerial Surveys, May 2014-November 2015

Between November 2012 - November 2015, the Virginia Aquarium and Marine Science Center conducted sub-seasonal aerial surveys of the Virginia Wind Energy Area, on the continental shelf outside of Chesapeake Bay. Between November 2012 - April 2014, 16 surveys were flown, covering approximately 9500 linear km (Mallette et al. 2014); we used these surveys in our initial models. The original survey program was then extended (Mallette et al. 2015), ultimately spanning May 2014 - November 2015, covering an additional 11,800 linear km along the same transects (Fig. 11). As with the Maryland Wind Energy Area surveys, we believe these additional surveys of the Virginia Wind Energy Area will prove useful in calibrating seasonal predictions of cetacean species in the mid-Atlantic area.

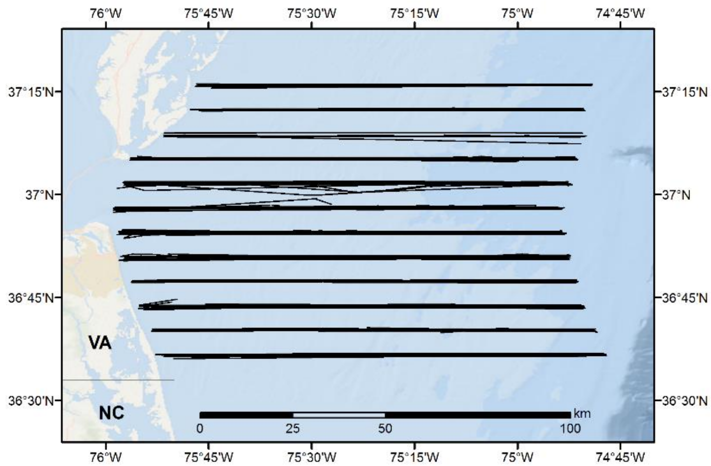

Figure 11. Virginia Wind Energy Area aerial survey effort, May 2014-November 2015.

3.7. SEFSC GU-06-03 Shipboard Survey, 2006

On 19 June - 17 August 2006, NOAA SEFSC conducted a shipboard cetacean survey targeted primarily at the offshore mid-Atlantic, conducting approximately 4000 linear km of shipboard effort (Fig. 12) (Garrison 2006). This survey was not available from SEFSC for our original models but was made available for the updated models. Although this survey occurs in summer, a period for which we already have substantial data, it occurs on the shelf break and offshore in a region of high cetacean abundance and diversity and will contribute dozens of sightings of deep-water species, such as sperm whales, pilot whales, and striped dolphins. It also contributes several sightings of uncommon species, including Clymene dolphins, false killer whales, and *Kogia* species.

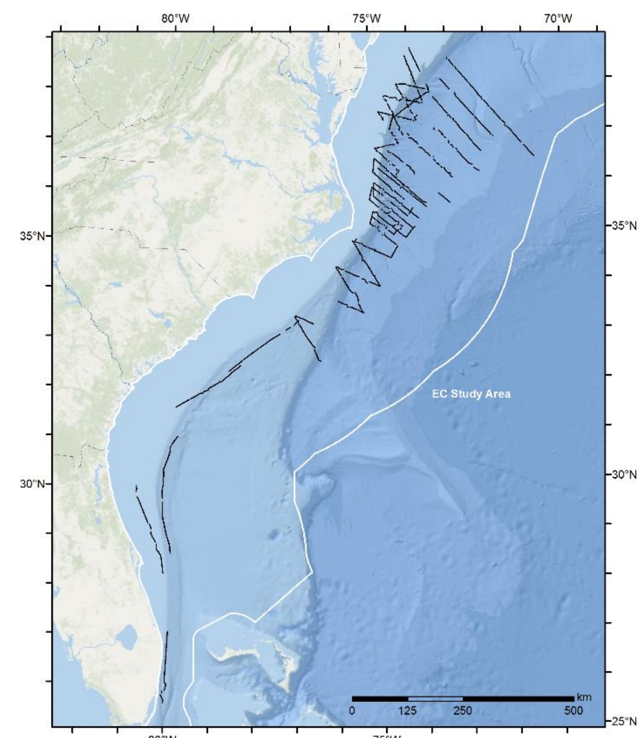

Figure 12. GU-06-03 survey effort.

3.8. *Suivi Aérien de la Mégafaune Marine en France Métropolitaine (SAMM) Aerial Surveys, 2011-2012*

The SAMM aerial surveys, contributed by Vincent Ridoux (Université de La Rochelle) and colleagues, covered waters around France, including the Bay of Biscay, the English Channel, and the Palagos marine sanctuary in the Mediterranean (Pettex et al. 2014) (Fig. 13). Two seasons were surveyed: winter (November-Feburary) and summer (May-August). We intend to consider these data for the AFTT model. If we use them, we will likely only include transects that occurred in the Atlantic. In winter, these spanned 20,814 linear km of effort; in summer, 22,977 km.

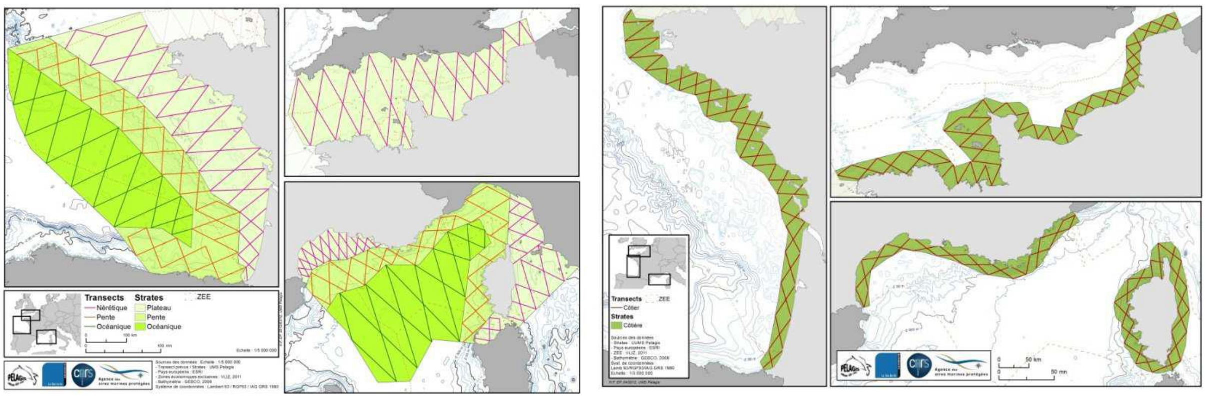

Figure 13. SAMM aerial survey broad-scale transects (left) and coastal transects (right), 2011-2012.

3.9. *Small Cetaceans in the European Atlantic and North Sea (SCANS-II) Aerial Survey, 2005*

Our published AFTT model incorporated shipboard effort from the SCANS-II survey. For our model update, we plan to incorporate the SCANS-II aerial effort (Fig. 14). The aerial survey, conducted June-August 2005, spanned 15,802 linear km of effort (Hammond et al. 2013).

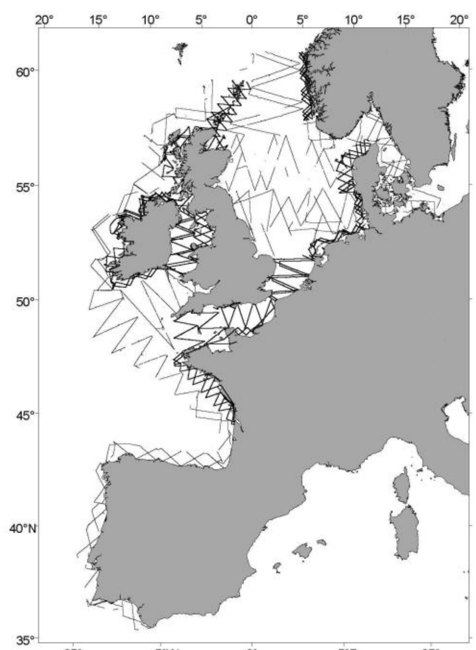

Figure 14. SCANS-II aerial (black) and shipboard (grey) transects surveyed on effort.

4. Surveys Not Incorporated

4.1. Canadian Trans North Atlantic Sightings Survey (TNASS), 2007

In 2007, Canada DFO conducted a large-scale aerial survey of Canadian waters of the Northwest Atlantic (Lawson & Gosselin 2009, 2011) (Fig. 15). We believe this survey might significantly improve model predictions in the northern parts of the EC and AFTT models. Unfortunately, the researchers who collected the data declined to contribute it to our model. We are hopeful they may change their mind sometime in the future, perhaps after they have had the opportunity to publish the results in the peer-reviewed literature.

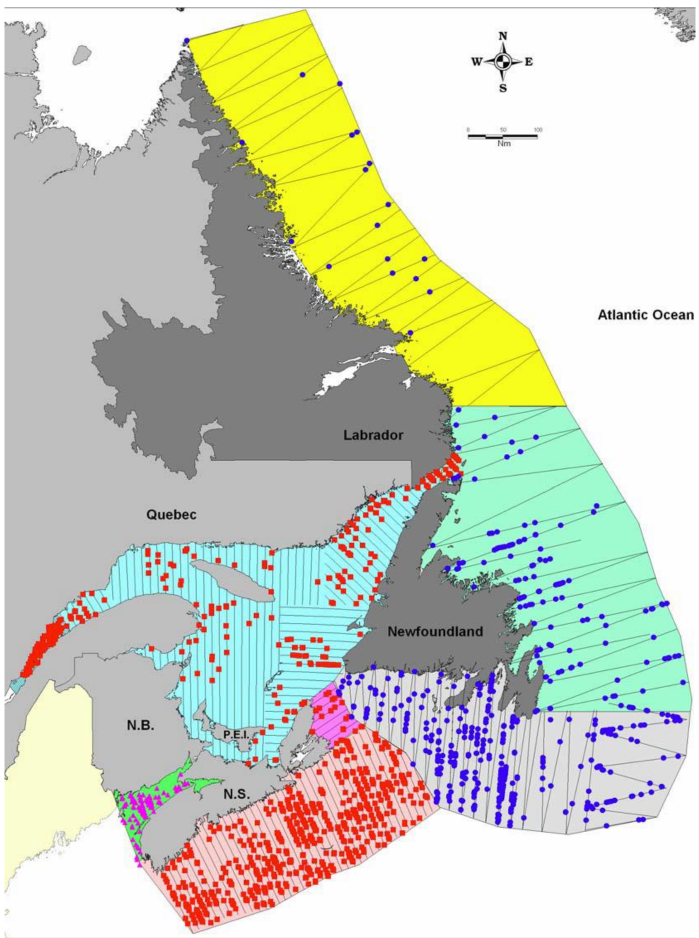

Figure 15. Aerial survey effort on the Canadian (TNASS) 2007 survey. Newfoundland and Labrador (yellow, light green, and light grey), Cape Breton (purple), Scotian Shelf (pink), and Gulf (light blue) blocks. Marine megafauna sightings made during the Canadian aerial survey effort are indicated with blue circles (Newfoundland and Labrador) and red squares (Cape Breton, Scotian Shelf, and Gulf). The darker green survey block in the Bay of Fundy was flown by NOAA; sightings collected during the NOAA survey are indicated with purple triangles. [This NOAA survey was utilized in our models.] Figure from Lawson & Gosselin (2009).

4.2. NEFSC HB-07-09 and HB-09-03 Shipboard Surveys

In the summers of 2007 and 2009, NOAA NEFSC conducted two shipboard surveys for marine mammals and other taxa (Fig. 16). NEFSC did not make these data available for either our original models or the planned updates. We presume the reason NEFSC has not provided them relates to the availability of NEFSC personnel to process and prepare them for our use. We continue to periodically request these data and hope that eventually they may be provided.

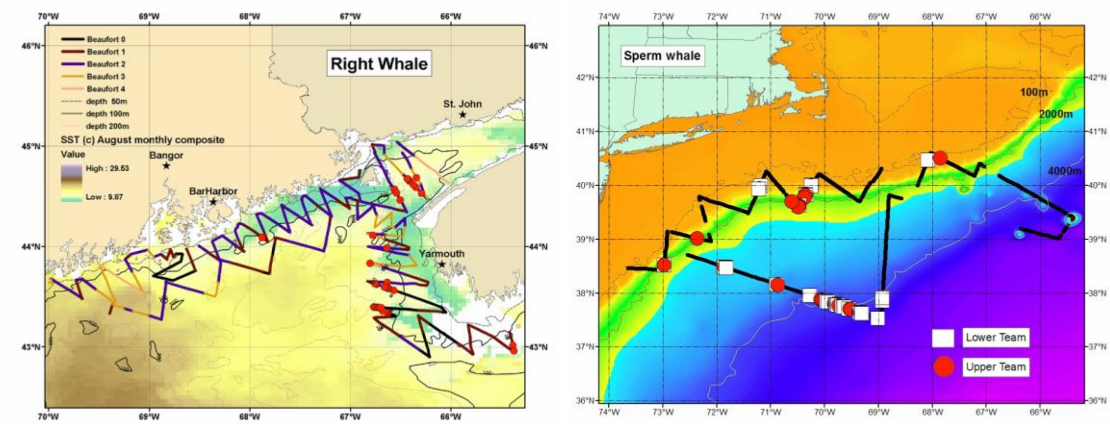

Figure 16. Survey tracklines of the HB-07-09 (left) and HB-09-03 (right) shipboard surveys, with sightings of right whales (left) and sperm whales (right) overlaid.

4.3. NEFSC Shipboard Large Whale Surveys, 1999-2013

Tim Cole of NEFSC requested that we incorporate NEFSC shipboard “Large Whale Surveys” into a future model update, if at all possible. These surveys, dating back to at least 1999, comprise 15-20 small scale shipboard studies of various areas of the Gulf of Maine and the Scotian Shelf. Many of them were conducted using distance sampling protocols similar to those used on NEFSC broad-scale marine mammal abundance surveys, and therefore would be usable with our methodology. Including these would boost the data available in Canadian waters, particularly in non-summer seasons.

In summer of 2016, Cole and Beth Josephson, also of NEFSC, began a process of combining and formatting these data for our use. As of this writing, the work is not done (we believe it is a relatively low-priority task for NEFSC). At the time of this writing, we do not expect to utilize these data in our next model update but anticipate that they might be available for future updates.

4.4. Collaborative Aerial Surveys of Massachusetts and Rhode Island Wind Energy Areas, 2011-2015

From 2011-2015, funded by the Massachusetts Clean Energy Center and the U.S. Bureau of Ocean Energy Management, a multi-institution collaboration conducted aerial surveys of the Massachusetts and Rhode Island Wind Energy Areas (Kraus et al. 2016) (Fig. 17). These surveys, while small in scale compared to our EC and AFTT study areas, were conducted in all seasons for multiple years, spanning over 42,000 linear km of on-transect effort. The surveys targeted large whales and yielded hundreds of sightings.

We believe these surveys would prove useful in improving the seasonal performance of models for large, shelf-inhabiting whales. Also, the area they surveyed was not covered as regularly by the NOAA NARWSS program as the Gulf of Maine. Because the surveys did not target smaller species, resulting in a large fraction of ambiguous identifications, we would probably not consider using them in models of smaller species.

Because the Navy did not indicate that this region was a high priority for updated models, we have not pursued these data, owing to the limited time available before updated models must be produced. But if the Navy revises its opinion regarding the importance of modeling density of large whales in this region, we remain option to this possibility. In any case, we recommend these data be utilized eventually in future models, if at all possible.

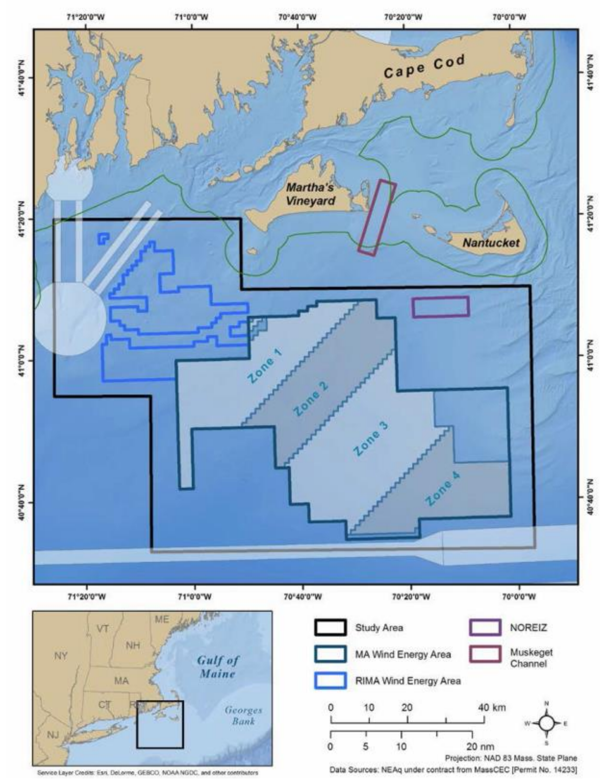

Figure 17. Study areas for the 2011-2015 collaborative aerial surveys of the Massachusetts and Rhode Island Wind Energy Areas. Figure from Kraus et al. (2016).

4.5. Opportunistic Shipboard Surveys of the Southern Gulf of Mexico and Yucatan Channel, 1997-1999

In 1997-1999, Joel Ortega-Ortiz conducted opportunistic surveys for cetaceans on six oceanographic cruises conducted in the southern Gulf of Mexico and the Yucatan Channel as part of his PhD dissertation (Ortega-Ortiz 2002) (Fig. 18). We obtained sightings for these surveys from Ortega-Ortiz. Unfortunately there was no effort data to accompany them; the best thing we have is the figure below. Lacking sufficient data, we are not able to use these studies except for qualitative model validation.

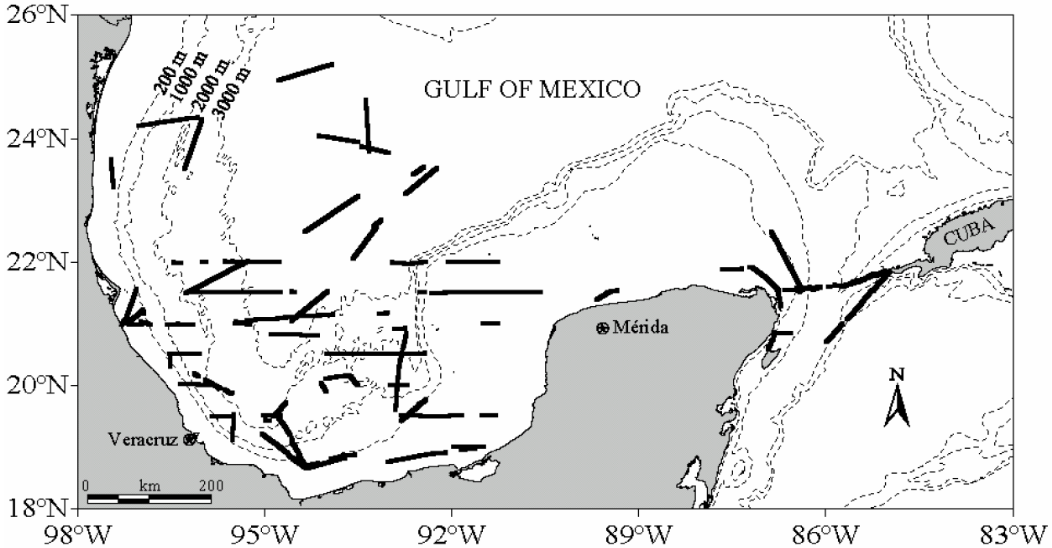

Figure 18. Cetacean survey effort completed during cruises in the southern Gulf of Mexico and Yucatan Channel. Thin dashed lines indicate the 200m, 1000m, 2000m, and 3000m isobaths. Figure from Ortega-Ortiz (2002).

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