Executive Office of Energy and Environmental Affairs
Massachusetts Office of Coastal Zone Management

HABITAT

Work Group Report

2014 Massachusetts Ocean Management Plan Update

March 31, 2014

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SECTION ONE: INTRODUCTION

The Massachusetts Oceans Act of 2008 required the creation of a comprehensive ocean management plan (Plan) for Massachusetts waters by December 2009. The foundation of the Plan was the identification of management areas within state waters with specific siting and performance standards established to protect existing natural resources as well as commercial and recreational uses. Twelve habitat types were determined to be Special, Sensitive, or Unique (SSU) natural resources deserving of protection and were mapped for the 2009 Plan using the best data available at that time.

The 12 SSU resources mapped in the 2009 Massachusetts Ocean Management Plan are:

- North Atlantic right whale core habitat
- Humpback whale core habitat
- Fin whale core habitat
- Roseate Tern core habitat
- Special concern (Arctic, Least, and Common) tern core habitat
- Long-tailed Duck core habitat
- Leach's Storm-Petrel important nesting habitat
- Colonial waterbirds important nesting habitat
- Hard/complex seafloor
- Eelgrass
- Intertidal flats
- Important fish resource areas

Habitat Work Group's Charge

The Oceans Act requires that the Plan be reviewed at least every five years. In order to inform the five-year review, in the summer of 2013, the Massachusetts Office of Coastal Zone Management (CZM) convened four sessions of the Habitat Work Group to discuss how to update the maps of SSU habitats in the Plan. The four sessions included specialists in the fields of wetland, sea turtle, marine mammal, and avifauna habitat mapping, respectively. The discussions in each of the four sessions involved:

1. Identifying any new data to add to or change the spatial extent of SSU resource areas from what was mapped in the 2009 Plan.
2. Characterizing notable trends in the condition of resources and uses covered in the Baseline Assessment (contained in Volume II of the 2009 Plan).
3. Revealing any new science that might advance the characterization of the ocean planning area.
4. Reviewing the steps toward addressing the science and data priorities in the 2009 Plan and making recommendations for priority research and data acquisitions to be included in the 2014 Plan.

Habitat Work Group Members

- Robert Buchsbaum, Massachusetts Audubon, seagrass and bird specialist
- Erin Burke, Massachusetts *MarineFisheries*, sea turtle and whale specialist
- Todd Callaghan, Massachusetts Office of Coastal Zone Management
- Phil Colarusso, U.S. Environmental Protection Agency, seagrass specialist
- Charles Costello, Massachusetts Department of Environmental Protection, seagrass specialist
- Pam DiBona, Massachusetts Bays National Estuary Program
- Kara Dodge, University of New Hampshire, sea turtle specialist
- Lisa Berry Engler, Massachusetts Bays National Estuary Program
- Tay Evans, Massachusetts *MarineFisheries*, seagrass specialist
- Tom French, Massachusetts Natural Heritage and Endangered Species Program
- Emily Huntley, Massachusetts Office of Coastal Zone Management
- John Kachmar, The Nature Conservancy, seagrass specialist
- Bob Kenney, University of Rhode Island, whale specialist
- Scott Kraus, New England Aquarium, whale specialist
- Stormy Mayo, Provincetown Center for Coastal Studies, whale specialist
- Nick Napoli, Northeast Regional Ocean Council
- Robert Prescott, Massachusetts Audubon, sea turtle specialist
- Jooke Robbins, Provincetown Center for Coastal Studies, whale specialist
- Dan Sampson, Massachusetts Office of Coastal Zone Management
- Dick Veit, College of Staten Island City University of New York, bird specialist
- Tim White, College of Staten Island City University of New York, bird specialist

Habitat Work Group Recommendations

The discussions from the Habitat Work Group were used to establish a list of recommendations to CZM to assist in updating the existing Plan as well as keeping the science behind the Plan current. The recommendations were divided into three categories based upon the level of priority. “Near-term actions” involve using existing data to update the Plan by the 2014 deadline. “Long-term actions” are those that will likely take a year or more to complete, but could potentially be developed enough to be evaluated for inclusion in a future version of the Plan. “State-supported research and reporting” relates to activities that the Habitat Work Group members think are important for the state to support, either directly or indirectly, in order to better understand habitat resources in Massachusetts and how they might change in the future.

CZM’s Draft Proposed SSU Updates

After responding to the Work Group’s recommendations, which involved acquiring data and performing additional analyses, CZM brought its proposed SSU updates to the Science Advisory Council (SAC) for additional feedback. CZM’s draft proposed updates to SSU areas integrate the most recently available data with the recommendations of resource experts on the Work Group, as well as the SAC.

SECTION TWO: WETLANDS

There are three wetland resources mapped in the 2009 Plan: eelgrass, intertidal flats, and hard/complex seafloor. To focus the discussion, only eelgrass and intertidal flats maps were discussed in the wetlands session. Hard/complex seafloor was discussed by the Sediment Work Group. The 2009 Plan included eelgrass mapping data from 1995 and 2001. These maps were derived from aerial photographs by the Massachusetts Department of Environmental Protection (MassDEP). Several more years (2006/2007, 2010, 2012, 2013) of data are now available from MassDEP and were used to update the eelgrass SSU map (Figure 1). MassDEP has also updated the intertidal flats data, which will be incorporated into the 2014 Plan (Figure 2).

Two additional data sources for eelgrass mapping that were identified by the Work Group are data obtained by divers and data derived from sidescan sonar. CZM agreed to accept Global Positioning System (GPS) coordinates demarcating eelgrass patches from state and federal divers. Thirteen small eelgrass patches have already been mapped in this way, including beds adjacent to Calf Island, Great Brewster Island, Peddocks Island (three beds), and Governors Island Flats in Boston Harbor; beds adjacent to Fort Pickering, Woodbury Point (two beds), Middle Ground, and Juniper Point Beach in Salem Sound; a bed off of Winthrop Beach; and the first known eelgrass bed north of Cape Ann found in Essex Bay. There were no readily-available eelgrass maps derived from sidescan sonar at the time of the Work Group meeting, but there may be data from Massachusetts Division of Marine Fisheries (*MarineFisheries)* and Provincetown Center for Coastal Studies (PCCS) at some point in the future.

Given that an eelgrass patch's characteristics (shape, density, deepwater edge) are highly variable, the SAC, and eelgrass experts attending the meeting, suggested that the more-refined MassDEP polygons (e.g., Figure 3) projected a false sense of accuracy in the actual extent of eelgrass patches. In addition, determining eelgrass patches by aerial photography and subsequent ground-truthing can in some cases be limited by low water clarity and low eelgrass shoot density, and thus does not always capture an eelgrass patch's deepwater edge well (Phil Colarusso, personal communication). Further, in a good growing year, eelgrass can spread vegetatively about a meter in any given direction (even greater expansion of a meadow can result from a mass seeding event, but those tend to be rare).[1] A linear change in the edge of a meadow of a meter or less is well within the range of error for even differential GPS. A small linear change over a large meadow can result in a large acreage change that could go undetected. For these reasons, and in order to have a margin of safety in the ocean plan maps for the purpose of project review and permitting, it was recommended that CZM continue to map the eelgrass SSU using a gridding technique as was used in 2009 (e.g., Figure 4). In this way, the maps can serve as a conservative management tool that alerts project proponents and permitting agencies to the likely presence of eelgrass in the general vicinity of the mapped SSU area.

The SAC recommended that CZM investigate if a grid other than that used in the 2009 Plan (250 m x 250 m) would better capture the temporal variability in eelgrass patches while not unnecessarily inflating the size of the management area. CZM used MassDEP's published variability in eelgrass patch sizes over

[1] Dawes, C.J. 1998. Marine Botany 2nd edition. John Wiley & Sons, Inc. New York, NY, 480 pp.

time to determine a grid cell size that would encompass the expansion of an eelgrass patch between mapping events. MassDEP aerial photographs taken between the months of May and August were used to identify 33 eelgrass regions that were mapped over three time periods (t_1 = 1994-1996, t_2 = 2000-2002, and t_3 = 2006-2007).[2]

The largest increase in eelgrass coverage between any two time periods (~ five years) was 35 hectares in the salt ponds of Martha's Vineyard from t_2 to t_3, or seven hectares per year (Table 1). Thus, the largest change that has been documented is about 70,000 m^2 per year, which would be captured by a 265 m x 265 m grid. The existing 250 m x 250 m grid cell size (62,500 m^2) used in the 2009 Plan would roughly capture this level of annual change but not the five-year change (which also corresponds to the mandated frequency of Plan updates), which would require a 592 m x 592 m grid. Of the other beds that increased, six out of 11 increased less than 6.25 hectares over five years (< 62,500 m^2), which can be captured by a 250 x 250 m grid. Thus, mapping eelgrass beds with the existing 250 m x 250 m grid would buffer the beds enough to capture the rate of increase that has been documented in six of 11 cases in the last 20 years. The average increase in bed size between t_2 to t_3 was 10.4 hectares (N = 11, Table 1). Gridding at a scale of 322 m x 322 m would be needed to capture the average eelgrass bed increase. Eelgrass loss rates are not important to the grid cell size question because a shrinking bed would still be captured by the gridded polygon which described its former extent (i.e., would occur within the mapped SSU area).

When gridding at a 250 m x 250 m resolution, 69 of the resulting eelgrass polygons had gaps within them (i.e., small areas that would not be protected by the surrounding SSU area). Most of the gaps were only one 250 m x 250 m grid cell in size, but several were much larger (Table 2). To address the issue of gaps within the eelgrass SSU, CZM investigated using a smoothing technique to remove gaps of a certain size. However, when overlaying these gridded gaps on top of orthophotos and the MassDEP eelgrass polygons (e.g., Figures 5 and 6), it became clear that most of the gaps probably did in fact represent bare sediment and should not be smoothed out. For example, some gaps were centered in known bare patches and others were even on land (Figure 6). For these reasons, CZM is not proposing to remove the gaps from gridded eelgrass coverage when mapping the eelgrass SSU.

Table 1. The five-year (2002-2007) increase in eelgrass bed size in Massachusetts as mapped by MassDEP. Only 11 of 33 beds increased in size.

Eelgrass Bed Location	Eelgrass Bed Size Increase (hectares)
Cape Poge, Pocha and Caleb Pods	34.77
Boston Harbor	20.07
East/West Branch Westport River	19.23
Lynn Harbor	12.81
New Bedford Harbor	8.52

[2] Costello, C.T. and W.J. Kenworthy. 2010. Twelve-Year Mapping and Change Analysis of Eelgrass (*Zostera marina*) Areal Abundance in Massachusetts (USA) Identifies Statewide Declines. Estuaries and Coasts 34:232-242. http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/egtrends.pdf.

Gloucester Harbor	6.09
Morris Island	5.37
Salem Harbor	4.84
Ryders Cove/Crow Pond/Bassing Harbor	2.01
West Falmouth	0.21
Madaket Harbor	0.16
Mean	**10.37**

Table 2. The size and frequency of gaps in gridded Massachusetts eelgrass coverage.

Gap Size (# 250 m x 250 m grid cells)	Count
1	42
2	9
3	7
4	3
5	2
8	1
9	1
10	2
11	1
13	1
Total	**69**

CZM's Draft Proposed Updates to the Eelgrass and Intertidal Flats SSUs

CZM's proposal for mapping the eelgrass SSU area in the 2014 Plan is to grid the combined MassDEP eelgrass coverage from 1995, 2001, 2006/2007, 2010, 2012, and 2013 and the coverage delineated by diver surveys onto a 250 m x 250 m grid. The proposed eelgrass SSU can be found in Figure 7. The CZM proposal and rationale on eelgrass mapping are captured in Table 3. CZM's proposal for mapping the intertidal flats SSU is to plot the 2013 MassDEP intertidal flats data without gridding. CZM's proposal for the intertidal flats SSU can be found in Figure 8 and the rationale is summarized in Table 4.

Wetlands Work Group Recommendations

Near-term Actions for 2014 Plan Update[3]

- Incorporate the 2006/2007, 2010, 2012, and 2013 eelgrass survey and mapping data from MassDEP in the 2014 Ocean Plan update.
- Incorporate the 2013 MassDEP changes to the intertidal flats maps in the 2014 Plan update.

[3] All of the wetlands near-term actions have been achieved as of November 2013.

- Obtain additional information on the presence of eelgrass meadows from *MarineFisheries* (Tay Evans) and U.S. Environmental Protection Agency (Phil Colarusso).
- Ensure that recent eelgrass restoration sites are part of the eelgrass SSU layer.

Long-term Actions for Future Ocean Plan Updates

- Create maps of potential and historical eelgrass habitat.
- Map oyster restoration sites and add them to a SSU layer.
- Map *Asabellides* reefs and consider adding them as a SSU resource area.
- Consider if older MassDEP eelgrass maps (e.g., 1995) are still appropriate to include in an ocean plan SSU and how to address the situation where the eelgrass SSU no longer represents current eelgrass extent.

State-Supported Research or Reporting

- Continue support of the MassDEP aerial seagrass mapping effort to capture larger eelgrass patches and trends; encourage finer-scale mapping efforts via divers and vessel-based remote sensing.
- Track the aerial extent of intertidal flats in the future as they are susceptible to sea level rise.
- Continue mapping shallow water sediment types to assist in eelgrass restoration site models.
- Create embayment-specific eelgrass restoration site selection models for the entire coast.
- Identify eelgrass genotypes that might best result in transplanting success.
- Continue research on invasive tunicates on eelgrass and their effect on survivorship.
- Continue surveys at SeagrassNet sites to reveal long-term trends in eelgrass health.
- Conduct research on the importance of certain biogenic habitats (e.g., *Crepidula* reefs, *Asabellides* reefs, oyster reefs, artificial reefs, and coral aggregations).

Table 3. Eelgrass mapping: comparison of the 2009 Ocean Plan to the proposed 2014 Ocean Plan.

	2009 Ocean Plan	CZM Proposal for 2014 Ocean Plan
Data Source	MassDEP eelgrass beds mapped using photo interpretation of aerial digital imagery from 1995 and 2001.	MassDEP eelgrass beds mapped using photo interpretation of aerial digital imagery from 1995, 2001, 2006/2007, 2010, 2012, and 2013. New data also include several eelgrass patches mapped from EPA and *MarineFisheries* diver surveys. The additional years help capture the variation in eelgrass habitat as patches grow and shrink within and across years. The addition of diver-surveyed patches helps to capture smaller eelgrass patches that are not visible via aerial photography.
Data Description	MassDEP hand-delineated eelgrass polygons from aerial photography. CZM combined the extents of the 1995 and 2001 eelgrass beds.	MassDEP hand-delineated eelgrass polygons from aerial photography. CZM combined the extents of the 1995, 2001, 2006/2007, 2010, 2012, and 2013 MassDEP eelgrass beds with several eelgrass patches from diver surveys. Adding these various sources together helps to capture the interannual variability in the extent of eelgrass patches.
Data Extent	Massachusetts state waters.	Massachusetts state waters.
Data Adjustment and Pre-processing	None.	None.
Data Analysis	Polygons were gridded onto a 250 m x 250 m grid (i.e., where an eelgrass polygon touched a grid cell, the entire grid cell was included in the map).	Polygons were gridded onto a 250 m x 250 m grid. Gridding was done because using the original MassDEP polygons provides a false sense of accuracy in actual extent of eelgrass beds. Gridding inherently provides a buffer around eelgrass beds which are known to grow or shrink by as much as 6% per year or about 7 hectares per year (Costello and Kenworthy 2010). Other gridding scales were investigated but the chosen one captures the maximum annual increase recorded as well as 6 of the 11 5-year increases in patch size. Gridding at a scale to capture the largest 5-year increase would increase the grid to a scale (592 m x 592 m) that would unreasonably inflate the extent of most eelgrass beds.
Data Classification	No classification necessary.	No classification necessary.
Selection of SSU Area	All gridded eelgrass from 1995 and 2001.	All gridded eelgrass from all MassDEP flights and diver surveys.

Table 4. Intertidal flats mapping: comparison of the 2009 Ocean Plan to the proposed 2014 Ocean Plan.

	2009 Ocean Plan	**CZM Proposal for 2014 Ocean Plan**
Data Source	MassDEP intertidal flats mapped using photo interpretation of aerial digital imagery from spring 2005 during non-tide specified times at a resolution of 0.5 m.	MassDEP intertidal flats mapped using photo interpretation of aerial digital imagery from spring 2005 during non-tide specified times at a resolution of 0.5 m plus digital low tide imagery at a resolution of 0.4 m, flown during the spring/summer of 2006-2010**.** The addition of low tide data adds significantly to this layer since the intertidal flats in several regions were not captured in the 2009 Plan because the imagery was not taken at low tide.
Data Description	MassDEP hand-delineated intertidal flats polygons from aerial photography.	MassDEP hand-delineated intertidal flats polygons from aerial photography.
Data Extent	Massachusetts state waters.	Massachusetts state waters.
Data Adjustment and Pre-processing	None.	None.
Data Analysis	Polygons were gridded to 250 m x 250 m (i.e., where an intertidal flat polygon touched a grid cell, the entire grid cell was included in the map).	There are no data to suggest that intertidal flats change dimensions as rapidly as eelgrass beds do, thus intertidal flats polygons were mapped in their native format (polygons were not gridded).
Data Classification	No classification necessary.	No classification necessary.
Selection of SSU Area	All gridded intertidal flats.	All intertidal flats.

SECTION THREE: SEA TURTLES

There are four endangered sea turtles that regularly utilize Massachusetts coastal waters: leatherback, loggerhead, green, and Kemp's ridley. Hawksbill turtles are extremely rare visitors, documented in strandings records in only three years: 1909, 1968, and 1989 (Tom French, personal communication). When the 2009 Plan was promulgated, there was no spatial data with which to map important habitat areas for these species. In 2013, we still do not have the data with which to demarcate specific areas as candidates for protection as SSUs. There are three potential data sources for mapping sea turtle hotspots in Massachusetts. The first is a Mass Audubon database of opportunistic sea turtle sightings (i.e., not from a structured survey) that has inherent limitations because the data are not effort-corrected. Thus, areas that have more search effort are more likely to have the greatest number of sea turtle observations, irrespective of the area's importance as turtle habitat. These data are not currently digitized, so the Work Group recommended that a long-term action be to digitize these data for use in a future version of the Plan. The second potential data source is the surveys conducted by the New England Aquarium for the Massachusetts Clean Energy Center (CEC) in support of the Massachusetts offshore Wind Energy Area (WEA). While the WEA is outside of state waters, observations are recorded while transiting state waters (e.g., Buzzards Bay, the Islands). CZM is working with the CEC to obtain and map these data. The third potential data source is the aerial survey data gathered by Mass Audubon in support of the Cape Wind project. CZM obtained the Mass Audubon sea turtle sightings data and although the data were not effort-corrected, CZM plotted the locations (Figure 9). In addition to the sea turtle surveys, there is a tagging project conducted by Kara Dodge to monitor fine-scale movements of leatherback turtles in Massachusetts and surrounding waters. Kara already has coarse-scale (i.e., mapped via 669 km^2 hexagons) data on the movements of 19 GPS-tagged leatherback turtles from the Gulf of Maine to South America, but the scale is too large for ocean planning. The finer-scale work will allow her to map leatherback locations over 24-hour time blocks. This tagging study has a very small sample size, thus it most likely will not be a main source of mapping information, although, it could help corroborate mapping boundaries. Because of the limitations of the data available, CZM is not recommending a sea turtle SSU for the 2014 ocean plan.

CZM's Draft Proposed Updates for Sea Turtles

At this time (December 2013), there is no effort-corrected sea turtle data that can be used to identify or agreement among sea turtle researchers on a sea turtle SSU area in Massachusetts waters.

Sea Turtle Work Group Recommendations

Near-term Actions for 2014 Plan Update

- Obtain the effort-corrected Mass Audubon aerial survey data.
- Obtain the Kara Dodge leatherback turtle tagging data (available sometime in early 2014).

Long-term Actions for Future Ocean Plan Updates

- Work with Mass Audubon to digitize records of turtle sightings, especially in Nantucket Sound.

SECTION FOUR: MARINE MAMMALS

Cetaceans

There are three marine mammal habitat maps in the 2009 Plan: North Atlantic right whale core habitat, humpback whale core habitat, and fin whale core habitat. These maps were derived from whale observations from several databases spanning 1970-2005. There has been a recent (i.e., since 2002) shift in the use of Cape Cod Bay by North Atlantic right whales (Stormy Mayo, personal communication), so the Work Group felt it prudent to analyze and re-map the North Atlantic right whale core habitat using the most recent observational data (1998-2013) for the 2014 Plan. Whale specialists in the Work Group did not believe that re-analyzing humpback or fin whale data would result in any patterns different than those presented in the 2009 Plan. However, CZM did re-map the distribution of fin and humpback whales using the 1998-2013 timeframe for consistency.

Two recommendations of the Marine Mammal Work Group were: 1) conduct an investigation of the unusual distribution of North Atlantic Right Whales (NARW) on the western side of Cape Cod Bay in 2013, and 2) update the NARW core habitat map for the 2014 Plan. To pursue these two recommendations, CZM first consulted with two NARW experts from the Work Group, Scott Kraus from the New England Aquarium (NEAQ) and Stormy Mayo of PCCS, who directed CZM to the North Atlantic Right Whale Consortium (NARWC) database, managed by Bob Kenney from the University of Rhode Island. CZM hired Bob Kenney to determine the sightings per unit effort (SPUE) of NARW from the NARWC database.

CZM requested two sets of NARW SPUE data, one spanning 1998-2012 and the other representing 2013 alone. A start date of 1998 was chosen for the analysis because: 1) it was the beginning of regular, concentrated aerial surveys of Cape Cod Bay by PCCS and 2) work by PCCS has shown a statistically significant increase in the use of Cape Cod Bay by NARW from 2002 to 2013 (Stormy Mayo, unpublished data).

Bob Kenney provided CZM with NARW SPUE data in an area covering a similar region as the NARW for the 2009 Plan, with the exception of some additional columns of data to the west of the study area in order to capture all of Massachusetts state waters and several additional rows of data to the south in order to capture the Massachusetts Wind Energy Area (Figure 10). As in the 2009 Plan, the SPUE data were binned into 5 minute x 5 minute grid cells (roughly 7 km x 9 km) with the sightings data assigned to the centroid of each cell. The gridded SPUE data were then interpolated using the Natural Neighbor tool in ArcGIS 10.2. CZM investigated other methods of interpolation (Kriging, Inverse Distance Weighting) and determined that Natural Neighbor had the best fidelity to the original data and required the least amount of subjective tinkering associated with applying the interpolation algorithm.

The interpolated NARW SPUE data were then classified into five classes, including observations of zero whales (Figure 11). CZM also performed the same data analysis on the 2013 NARW data, as requested by the Work Group (Figure 12). It is clear that more whales were using the western side of Cape Cod Bay in 2013. The 2013 data were included in the overall analysis (Figure 13), with the result that the NARW SSU (the top two classes in the NARW density map) now includes more area in western Cape Cod Bay

(Figure 14) than in the 2009 ocean plan. The re-analysis of the fin and humpback whale density data resulted in only minor shifts in their core habitats (Figure 15 and 16, respectively).

Pinnipeds

Seal haul-out sites were mapped by the 2008 Habitat Work Group but did not become SSU areas in the 2009 Plan. The current Habitat Work Group again discussed concentrations of seals in Massachusetts and the significance of these habitat areas. PCCS is conducting a tagging study of 18 adult grey seals caught on either North Beach in Chatham or Jeremy Point in Wellfleet. These data on seal behavior may be useful for ocean planning purposes in the future.

Marine Sound

Since the 2009 Plan, there has been research on underwater sound and detection of marine mammals using marine acoustic recording units in or near Massachusetts waters. However, those data are most useful for detecting the presence/absence of species. Thus, it was decided that acoustic data would not be adequate for mapping the geographical boundaries of core use areas as is needed in the 2014 Plan. The Habitat Work Group recommended that CZM investigate creating marine sound maps and consider including marine sound in future iterations of the Massachusetts ocean management plan.

CZM's Draft Proposed Updates to Whale SSUs

CZM's proposed core habitat SSU areas for North Atlantic right, fin, and humpback whales in the 2014 Plan are comprised of the top two classes of the SPUE for each of three whale species from 1998-2013 (the red areas in Figures 14-16). The top two classes were chosen to remain consistent with the protocol in the 2009 ocean plan. The area of NARW SSU in the 2009 Plan is 668 km^2 or 12% of the ocean planning area. The proposed area of the NARW SSU for the 2014 Plan is 1,375 km^2 (a two-fold increase) covering 25% of the ocean planning area, reflecting the growing importance of Cape Cod Bay to NARW in the last decade. The changes in fin and humpback whale SSU area were minor. A summary of the choices CZM made in determining the proposed whale SSU areas for the 2014 Plan is presented in Table 5.

Table 5. North Atlantic right whale core habitat mapping: comparison of the 2009 Ocean Plan to the proposed 2014 Ocean Plan.[4]

	2009 Ocean Plan	CZM Proposal for 2014 Ocean Plan
Data Source	NOAA NCCOS report[5] which used data from the North Atlantic Right Whale Consortium (NARWC) and Manomet Bird Observatory Databases 1970-2005.	NARWC Data 1998-2013. These years were chosen because PCCS directed studies for Cape Cod Bay began in 1998. In addition, NARW experts have detected a significant increase in NARW use of Cape Cod Bay since 2002 (Stormy Mayo, unpublished data).
Data Description	Sightings per unit effort (SPUE) in 5 min x 5 min grid by Bob Kenney. This was the grid cell spacing chosen for the NOAA NCCOS report.	SPUE in 5 min x 5 min grid by Bob Kenney. CZM kept this grid cell spacing as it allows for comparison with previous studies.
Data Extent	1,378 grid cells. This was the extent chosen by NOAA for its regional analysis.	1,871 grid cells. CZM had Bob Kenney add several columns of data to the western edge of the grid used in the 2009 analysis in order to capture all of Massachusetts waters. CZM also had Bob Kenney add several rows of data to the southern extent of the grid in order to capture the Massachusetts Wind Energy Area
Data Adjustment and Pre-processing	Cells with < 2.5 km effort were removed. This was a decision made by NOAA to eliminate potentially spurious results from cells with very little search effort.	Cells with < 2.5 km effort were removed.
Data Interpolation	Inverse Distance Weighting. This was the method chosen by NOAA.	Natural Neighbor analysis. A different interpolation method was used by CZM because Natural Neighbor analysis makes no a priori assumptions regarding the data's distribution, bias, or autocorrelation. Since it adapts locally to the structure of the input data, it requires no input from the user pertaining to search radius, sample count, or shape and works equally well with regularly and irregularly distributed data. Natural Neighbor analysis is one of the standard analysis tools available to CZM via ArcGIS.
Data Classification	CZM received the classified data directly from NOAA. NOAA placed zero values in one class and then classified the remaining data into four quartiles.	CZM placed zero values in one class and then classified the remaining data into four quartiles.
Selection of SSU Area	The top two classes were chosen as the SSU. CZM extracted these areas based on best professional judgment to delineate core habitat for this large and highly mobile species.	The top two classes were chosen as the SSU in order to be consistent with the 2009 protocol.

[4] Fin and humpback whale analyses followed the same protocol.
[5] http://ccma.nos.noaa.gov/products/biogeography/stellwagen/

Marine Mammal Work Group Recommendations

Near-term Actions for 2014 Plan Update

- Using the NARWC's data, map the distribution of North Atlantic right whales found in Massachusetts waters from 1998-2013, and separately in 2013.[6]

Long-term Actions for Future Ocean Plan Updates

- Review the PCCS seal research when it is available.
- Address aquaculture siting in the Ocean Plan, particularly kelp, floating oyster cages, and mussel long lines.[7]
- Investigate creating marine sound maps as part of the Ocean Plan. Create an inventory of marine activities and their potential sound effects (e.g., frequencies, travel distances, intensities).

State-Supported Research or Reporting

- Investigate the cause(s) behind the unusual distribution of North Atlantic right whales along the western side of Cape Cod Bay in spring 2013. For example, why were they concentrated about three miles from the shore on the western side of Cape Cod Bay, from the Cape Cod Canal to the southern end of Plymouth Bay, when in most of the previous 25 years they had concentrated on the eastern side of Cape Cod Bay in spring?
- Support/promote future research on the physical and biological processes that drive whale distributions and ecology. This work should strive to identify the locations that are more critical to whales than others (e.g., a space in Cape Cod Bay might not be inherently important, but the concatenation of several processes might create the conditions that provide a critical resource).

[6] This near-term action for marine mammal data has been achieved as of November 2013.
[7] *MarineFisheries* will be working on a long line policy for Massachusetts waters, but first it is waiting to see how the National Marine Fisheries Service regulations on vertical lines evolve before it moves forward with a Massachusetts policy.

SECTION FIVE: AVIFAUNA

There are five avifauna habitat areas mapped in the 2009 Plan: Roseate Tern core habitat, special concern (Arctic, Least, and Common) tern core habitat, Long-tailed Duck core habitat, Leach's Storm-Petrel important nesting habitat, and colonial waterbirds important nesting habitat. After considering research and mapping efforts in the last five years, the Work Group decided that there were no additional data with which to update the tern, Storm-Petrel, or colonial waterbirds maps. However, there has been a significant amount of work to document diving ducks in and near Massachusetts waters since 2009. The Long-tailed Duck core habitat in the 2009 Plan was based solely upon satellite telemetry data from Mass Audubon. Since that time, several studies have been undertaken to better understand how seabirds use the marine waters of the East Coast.

Research on seabirds and personal observations from Work Group members suggest that Massachusetts waters are of regional importance to Common Eiders that forage for mussels from November to March, are an important seasonal foraging area for three species of scoters, and are an important migration staging area for Red-throated Loons and Red-necked Grebes. In general, large aggregations of sea ducks have been observed in Massachusetts waters south of Cape Cod, especially in Nantucket Sound, Muskeget Channel, and south of Nantucket Island.

Researchers from the College of Staten Island, City University of New York (CUNY) have been observing seabirds by airplane in an area that includes the waters between and south of Martha's Vineyard and Nantucket. That work is being funded by the Massachusetts Clean Energy Center (CEC) to survey seabirds in the Massachusetts Wind Energy Area south of Martha's Vineyard and Nantucket Islands. Those data were not available for analysis by the Habitat Work Group. In addition to the CEC-funded work, there are several avian studies related to the siting of the Cape Wind project, a joint U.S. Geological Survey (USGS) and Bureau of Ocean Energy Management (BOEM) Outer Continental Shelf (OCS) Study[8] referred to as the "Compendium," U.S. Fish and Wildlife Service (USFWS) surveys from 2008-2012, various Mass Audubon reports, a synthesis report produced by Applied Science Associates (ASA) for CEC, and an upcoming USFWS Monitoring Avian Productivity and Survivorship (MAPS) survey funded by BOEM that will be documenting seabirds along the same transect lines used in the 2008-2012 work.

CZM reviewed several seabird studies (Table 6) that suggested that the waters of Nantucket Sound and south of the Islands are regional hotspots and ecologically important for the foraging of eiders and scoters as well as Long-tailed Ducks. Two studies in particular were useful because of their regional extent. The first was the USGS/BOEM Compendium, a compilation of 65 datasets and over 400,000 seabird occurrences from studies between Florida and Canada in the time period 1978-2009. The data in the USGS/BOEM Compendium report are effort-corrected sightings for each species and are gridded into 15 minute x 15 minute cells (roughly 21 km x 28 km). The second useful report was a 2013 paper

[8] O'Connell, A.F., B. Gardner, A.T. Gilbert, and K. Laurent, 2009, Compendium of Avian Occurrence Information for the Continental Shelf Waters along the Atlantic Coast of the United States, Final Report (Database Section - Seabirds). Prepared by the USGS Patuxent Wildlife Research Center, Beltsville, MD. U.S. Department of the Interior, Geological Survey, and Bureau of Ocean Energy Management Headquarters, OCS Study BOEM 2012-076.

from USFWS.[9] The data from the USFWS report were gathered via winter aerial surveys ranging from Georgia to Canada between 2008 and 2012. These data were effort-corrected and mapped as coded transects indicating specific bird densities and interannual count variability.

CZM obtained the effort-corrected sightings data from USGS and plotted the densities of several bird species from New York to Maine including: Roseate Terns (Figure 17), Special Concern Terns (Figure 18), Long-tailed Ducks (Figure 19), Common Eiders (Figure 20), and Scoters (Figure 21). These data were useful for demonstrating, on a broad scale, how important Massachusetts waters are for these species. However, the scale of these data was too coarse for ocean planning on the Massachusetts level.

After obtaining and plotting the USFWS bird sightings data, CZM decided to use these data to map avian SSU resource areas because: 1)they allow for an investigation into the regional importance of Massachusetts waters to seabirds, 2) there are multiple years of data using the same methodology, 3) the study area covers all of Massachusetts waters (whereas many studies only cover Nantucket and Vineyard Sound), 4) the data are the most current observations published and therefore are most likely to represent the current use of Massachusetts waters by seabirds, and 5) the sightings data are on a scale that is useful for mapping SSUs. While the USGS/BOEM data were not used to map any of the SSUs because of their coarser scale, they were used to corroborate the results from the USFWS data.

For the purpose of determining regional hotspots, CZM used sightings data from the USFWS surveys flown from New York to Maine, a region that is also contiguous with ocean planning work by the Northeast Regional Ocean Council, which is in the process of a regional marine resource mapping effort. The waters around Nantucket are of regional importance to Common Eiders and scoters, as well as Long-tailed Ducks, so the mapped sightings data for all three were merged to create one sea duck layer. CZM effort corrected the USFWS data to map the relative density of observed sea ducks in winter from 2008–2012 (Figure 22). CZM chose to analyze data from just the winter surveys since Long-tailed Ducks are primarily found in Massachusetts from November to April.[10] Both the Compendium and the USFWS data documented that the three species of scoters and Common Eider tend to be found in highest abundances in Massachusetts in the winter months also. Thus, data from one survey conducted in summer and one survey conducted in fall were removed from the dataset provided to CZM by USFWS. The remaining five surveys were conducted in January through March.

To effort correct the data, first, the point density[11] of the sea duck sightings that fall within a 7-km radius of each 250 m x 250 m grid cell in the study area was calculated (Figure 23). This cell size was selected to be consistent with the grid used in the 2009 Plan. The radius size was chosen based on the spacing of the aerial survey transects, which were flown at 5-minute intervals of latitude (which are spaced approximately 9.26 km apart in Massachusetts). A 7-km radius is large enough so that the density of sea

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[9] Silverman E.D., D.T. Saalfeld, J.B. Leirness, and M.D. Koneff. 2013. Wintering sea duck distribution along the Atlantic coast of the United States. Journal of Fish and Wildlife Management 4(1):178–198; e1944-687X. doi: 10.3996/122012-JFWM-107

[10] White, T.P., R.R. Veit, and M.C. Perry. 2009. Feeding Ecology of Long-tailed Ducks *Clangula hyemalis* wintering on the Nantucket Shoals. *Waterbirds* 32(2):293–299.

[11] Silverman, B. W. Density Estimation for Statistics and Data Analysis. New York: Chapman and Hall, 1986.

ducks in cells between aerial transects (i.e., where there were no observations or effort) is calculated using data from the transects directly north and south of the cell (e.g., point B in Figure 23), but small enough so that the density of seabirds in cells adjacent to an aerial transect is calculated using only data from that transect (e.g., point A in Figure 23).

Table 6. Comparison of various sea duck surveys reviewed by CZM.

Report/Study	Source of Data/Study	Data Units	How Are Data Portrayed Spatially	How Are Data Portrayed Temporally	Seasons	Species
USFWS Silverman et al. 2013. Wintering Sea Duck Distribution Along the Atlantic Coast of the U.S.	Surveys Jan 23-Mar 2 over four years: 2008-2011.	Count/effort in six density categories (low to high) determined via SKATER in Arc 10.0; density is for an entire transect.	Entire transects colored variously to indicate density. Horizontal transects from NC north to ME/Canada border.	Data averaged over three years. Density and category also portrayed by year. Report variability in density in a given transect over the three years.	NA: Winter only.	Common Eider, Surf Scoter, White-winged Scoter, Black Scoter, Long-tailed Duck.
USGS/BOEM "Compendium" 5/28/10.	Several studies compiled.	Count/effort	Gridded 0.25 degrees x 0.25 degrees (~21 km x 28 km).	Seasonally.	Winter = Dec-Feb; Spring = Mar-May; Summer = Jun-Aug; Fall = Sept-Nov.	All sea ducks and seabirds.
Galagan et al. (ASA). 10/21/10. Marine Use and Resource Data Acquisition and Processing Final Results for Avian Data.	Several studies compiled.	Count/effort	Gridded 5 km x 5 km.	Seasonally and annually.	Winter = Nov-Mar; Spring = Apr, May; Summer = Jun-Aug; Fall = Sept, Oct.	Common Eider, Scoters (lumped), Long-tailed Duck.
Sea Duck Joint Venture/Mass Audubon 2006.	12 aerial surveys Oct 28, 2005-March 29, 2006.	No units on map but it looks like counts per km^2	Bubbles representing counts along vertical transects across Nantucket Sound and Islands area.	NA	NA: "Winter" only.	Common Eider, Scoters (lumped), Long-tailed Duck.
Perkins et al. 2004. Relative Waterfowl Abundance within Nantucket Sound, MA During the 2003-2004 Winter Season. Mass Audubon.	13 aerial surveys December 1, 2003 - April 8, 2004.	Count/mile surveyed	Table showing % of each species found over each area of interest (e.g., non-shoals vs. various shoals).	Bar graph showing # birds observed/mile by species on each date.	NA "Winter" only; but, surveys divided into four "periods".	Common Eider, Scoters (lumped), Long-tailed Duck, "Waterfowl Species".
Veit, White, Perkins.2013. Draft Seabird Abundance off Southeastern MA, 2011-2012, Based on Aerial Transects. A Report to the CEC.	15 aerial surveys Nov 22, 2011 to Nov 12, 2012.	Average count/km^2	Bubbles representing count/km^2 along vertical transects across Nantucket Sound and Islands area.	NA: Counts were averaged over the year.	NA: Counts were averaged over the year.	Eider, 3 Scoters, Long-tailed Duck, Greater Shearwater, Wilson Storm-Petrel, Northern Gannet, Black-legged Kittiwake, Common and Roseate Tern.

Next, effort was calculated from the line density of the survey tracklines that fall within a 7-km radius of each 250 m x 250 m grid cell in the study area. Finally, the sightings density data was divided by the effort density data in each cell to create a dataset of SPUE. The SPUE data were classified into quartiles using class breaks derived from the data in the Massachusetts ocean planning area only (Figure 24).

Classification into quartiles is consistent with how Important Fish Resources Areas and High Effort and Value Commercial Fishing were mapped in the 2009 Ocean Plan and how Concentrated Recreational Boating Activity is proposed to be mapped for the 2014 Plan. "Core habitat," for the purpose of mapping the proposed sea duck SSU area that was presented to the SAC, was defined as the top quartile of effort-corrected, gridded sightings data (Figure 25). Using the top quartile was a best professional judgment decision by CZM because there was no classification applied to bird data in the 2009 Ocean Plan and a classification scheme had to be chosen (e.g., the bird SSU areas in the 2009 Plan were either known nesting sites buffered by 0.3 nautical miles or polygons hand-drawn by bird experts that attempted to capture core foraging habitat).

Bird experts in attendance at the SAC meeting pointed out that using the top quartile of sea duck sightings did not capture a known major diurnal "commuting" area for Long-tailed Ducks across the southwestern part of Nantucket. This commuting area had been captured by the Long-tailed Duck SSU polygon in the 2009 Plan (the stippled polygon in Figure 25), as inferred from the 2008 satellite telemetry data. To address this concern, CZM obtained and plotted the Mass Audubon 2008 satellite telemetry data from Simon Perkins (Figure 26). When overlaid on top of the USFWS survey data (Figure 27), the Mass Audubon Long-tailed Duck telemetry data approximate the top quartile of observations (the area in red). However, they also identify a cluster near the western end of Nantucket where the USFWS data did not have as many sightings, but specialists know to be a major diurnal flyway. In order to try to capture this commuting area, CZM analyzed the telemetry data by calculating the point density of the Long-tailed Duck locations within a 7-km radius of each 250 m x 250 m grid cell. The radius and grid cell size were selected to be consistent with the analysis of the USFWS data. The telemetry data were then classified into quartiles using class breaks derived from the data in the planning area only (Figure 28). Finally, the top quartile of the Mass Audubon data was extracted and merged with the top quartile of the USFWS data to represent sea duck core habitat (Figure 29). A summary of the choices CZM made in determining the draft proposed sea duck core habitat SSU is presented in Table 7.

Proposed Updates to Avifauna SSUs

CZM proposes no changes to the Roseate Tern core habitat, special concern (Arctic, Least, and Common) tern core habitat, Leach's Storm-Petrel important nesting habitat, and colonial waterbirds important nesting habitat SSU areas.

CZM proposes that the Long-tailed Duck core habitat SSU include the Mass Audubon telemetry data as well as Long-tailed Duck, Common Eider, White-winged Scoter, Black Scoter, and Surf Scoter distributions from the USFWS 2008-2012 surveys as one sea duck core habitat SSU (Figure 29).

Avifauna Work Group Recommendations

Near-term Actions for 2014 Plan Update[12]

- Use the USFWS aerial surveys (2008-2012) from New York to Maine to plot sea duck (Long-tailed Duck, Common Eider, White-winged Scoter, Black Scoter, and Surf Scoter) and tern densities and to identify persistent hotspots in Massachusetts waters.
- Use additional sources of sea duck and tern data (e.g., Cape Wind data, Mass Audubon data, ASA Report for CEC, CUNY aerial surveys for CEC) to corroborate results from the USFWS survey.

Long-term Actions for Future Ocean Plan Updates

- Add the USFWS MAPS survey data to the sea duck and tern maps when they become available.
- Map concentrated Razorbill, Red-throated Loon, and Red-necked Grebe foraging habitat.[13]
- For all existing SSU foraging and nesting areas, determine the months when these locations are important for each species (i.e., develop a temporal component to each SSU).

[12] These near-term actions for mapping avifauna have been achieved as of November 2013.
[13] CZM mapped the distribution of these three species in and around Massachusetts using the USGS/BOEM Compendium data and did not find any apparent regional hotspots in Massachusetts waters for these species.

Table 7. Long-tailed Duck core habitat mapping: comparison of the 2009 Ocean Plan to the proposed 2014 Ocean Plan.

	2009 Ocean Plan	CZM Proposal for 2014 Ocean Plan
Data Source	Mass Audubon unpublished Long-tailed Duck (LTDU) telemetry data, 2008–2009. These data were collected to learn more about the migration routes of LTDU near Nantucket Island and captured the diurnal “commute” of LTDU from Nantucket Sound to Nantucket Shoals.	Two sources were used. First, data from U.S. Fish and Wildlife Service (USFWS) aerial surveys from 2008–2012 between New York and Maine (Silverman et al. 2013) were selected because they cover all of Massachusetts waters, were collected in multiple years using the same methodology, and can be effort corrected. Second, the Mass Audubon telemetry data from 2008–2009 were used to characterize "commuting" areas not captured by the USFWS data.
Data Description	LTDU were captured near Nantucket in winter 2008, outfitted with tracking devices, and tracked from Dec. 6, 2008 to Apr. 1, 2009 by Mass Audubon. The Natural Heritage and Endangered Species Program (NHESP) drew a polygon around the greatest concentration of tracked locations to create a map of LTDU core habitat.	Sea duck sightings per unit effort (SPUE) data were developed by CZM from the USWFS data. These data represent the relative density of observed sea ducks within a 7-km radius of each 250 m x 250 m grid cell. The waters around Nantucket are of regional importance to Common Eiders and scoters, so Common Eiders, scoters, and LTDU were all mapped to create one sea duck layer. To characterize LTDU "commuting" areas, CZM calculated the density of the Mass Audubon telemetry data within a 7-km radius of each 250 m x 250 m grid cell.
Data Extent	Waters surrounding Nantucket Island south to Nantucket Shoals.	USFWS data: New York to Maine. This area was selected because it captures the region where sea ducks are most prevalent and covers enough geography to determine regionally important areas. Mass Audubon data: waters surrounding Nantucket Island south to Nantucket Shoals.
Data Adjustment and Pre-processing	None.	Data from two USFWS surveys conducted in summer and fall were removed. LTDU are primarily found in Massachusetts from November to April, so CZM only analyzed data from these months. Telemetry data beyond 50 nautical miles of the planning area were removed to focus the analysis on Massachusetts and adjacent federal waters.
Data Analysis	The NHESP LTDU core habitat polygon was clipped to the Massachusetts ocean management planning area.	CZM effort corrected the USFWS data. First, the point density of the sea duck sightings that fall within a 7-km radius of each 250 m x 250 m grid cell in the study area was calculated. This cell size was selected to be consistent with the grid used in the 2009 Plan. The radius size was chosen based on the spacing of the aerial survey transects, which were flown at 5-minute intervals of latitude (~9.26 km). A 7-km radius is large enough so that the density of cells between transects is calculated using data from the transects directly north and south of the cell, but small enough so that the density of cells adjacent to a transect is calculated using only data from that transect. Next, the line density of the survey tracklines that fall within a 7-km radius of each 250 m x 250 m grid cell in the study area was calculated. Finally, the sightings density data were divided by the effort density data in each cell to create a SPUE dataset. CZM also analyzed the Mass Audubon telemetry data by calculating the point density of the LTDU locations within a 7-km radius of each 250 m x 250 m grid cell. The radius and grid cell size were selected to be consistent with the analysis of the USFWS data.
Data Classification	No classification was performed.	For both datasets, CZM classified the data into quartiles using class breaks derived from the data in the planning area only. Quartiles were chosen because they are also used to determine important areas for other resources and uses in the 2009 Ocean Plan.
Selection of SSU Area	The full extent of the hand-drawn polygon, clipped to the planning area, was used as the core habitat area.	CZM extracted and merged the top quartile of the USFWS data and the top quartile of the Mass Audubon data to represent sea duck core habitat.

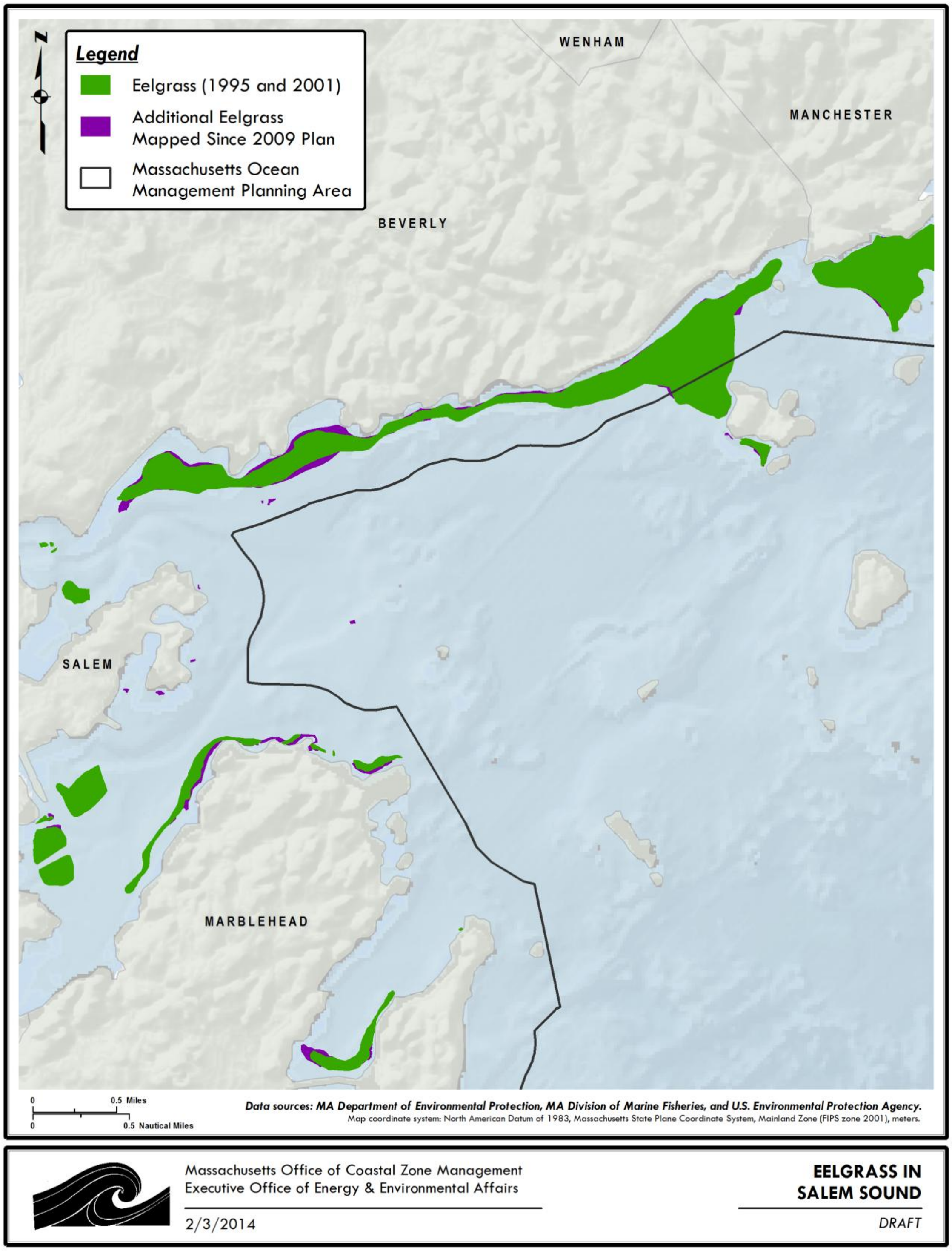

Figure 1. An example of how data from additional eelgrass surveys (2006/2007, 2010, 2012, 2013) have augmented the eelgrass SSU area mapped in the Ocean Plan. Eelgrass mapped for the 2009 Ocean Plan is shown in green. Eelgrass from additional surveys is shown in purple.

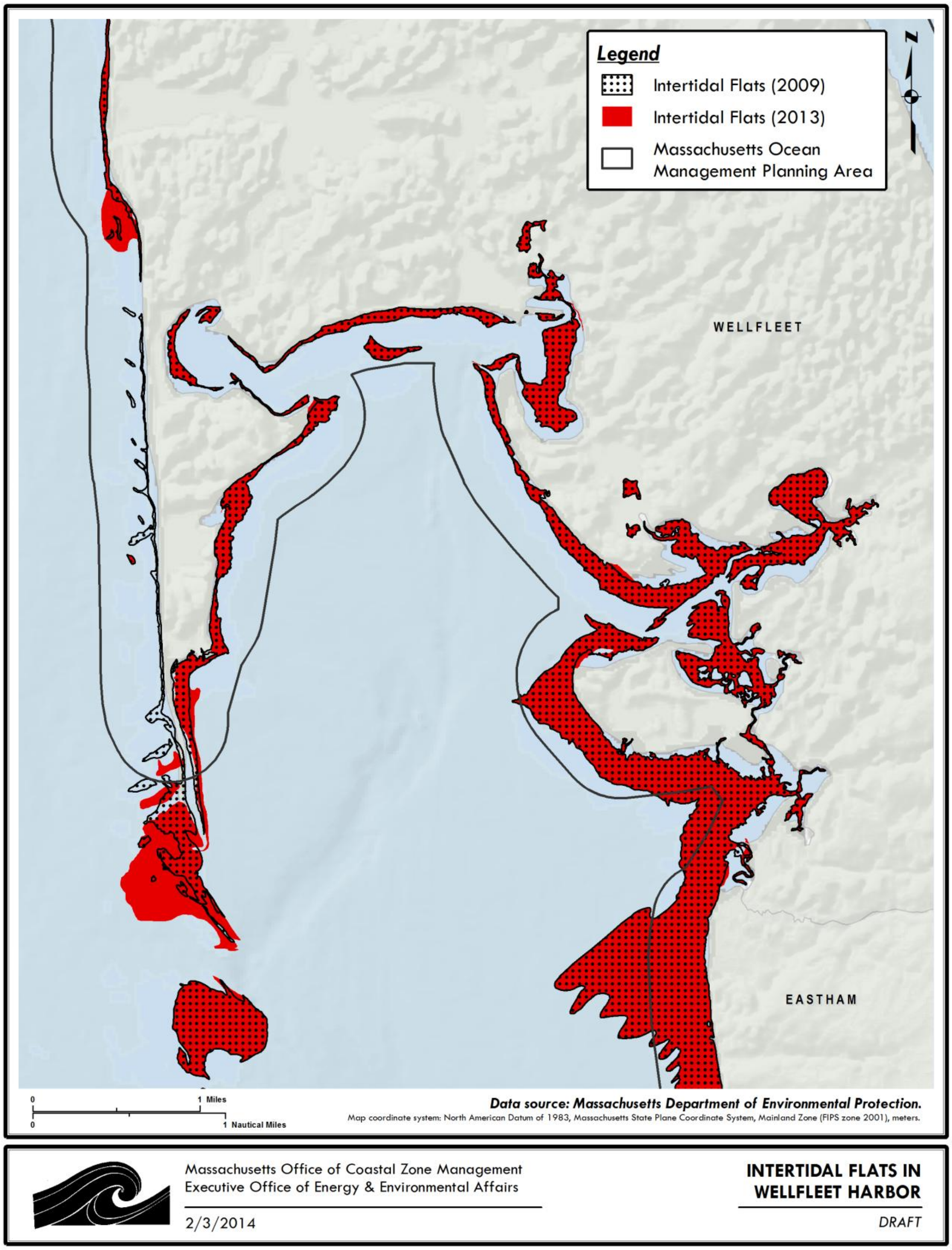

Figure 2. An example of how the updated intertidal flats data has augmented the intertidal flats SSU area mapped for the 2014 Ocean Plan. Intertidal flats mapped in the 2009 Ocean Plan are stippled. The proposed coverage for the 2014 ocean plan is shown in red.

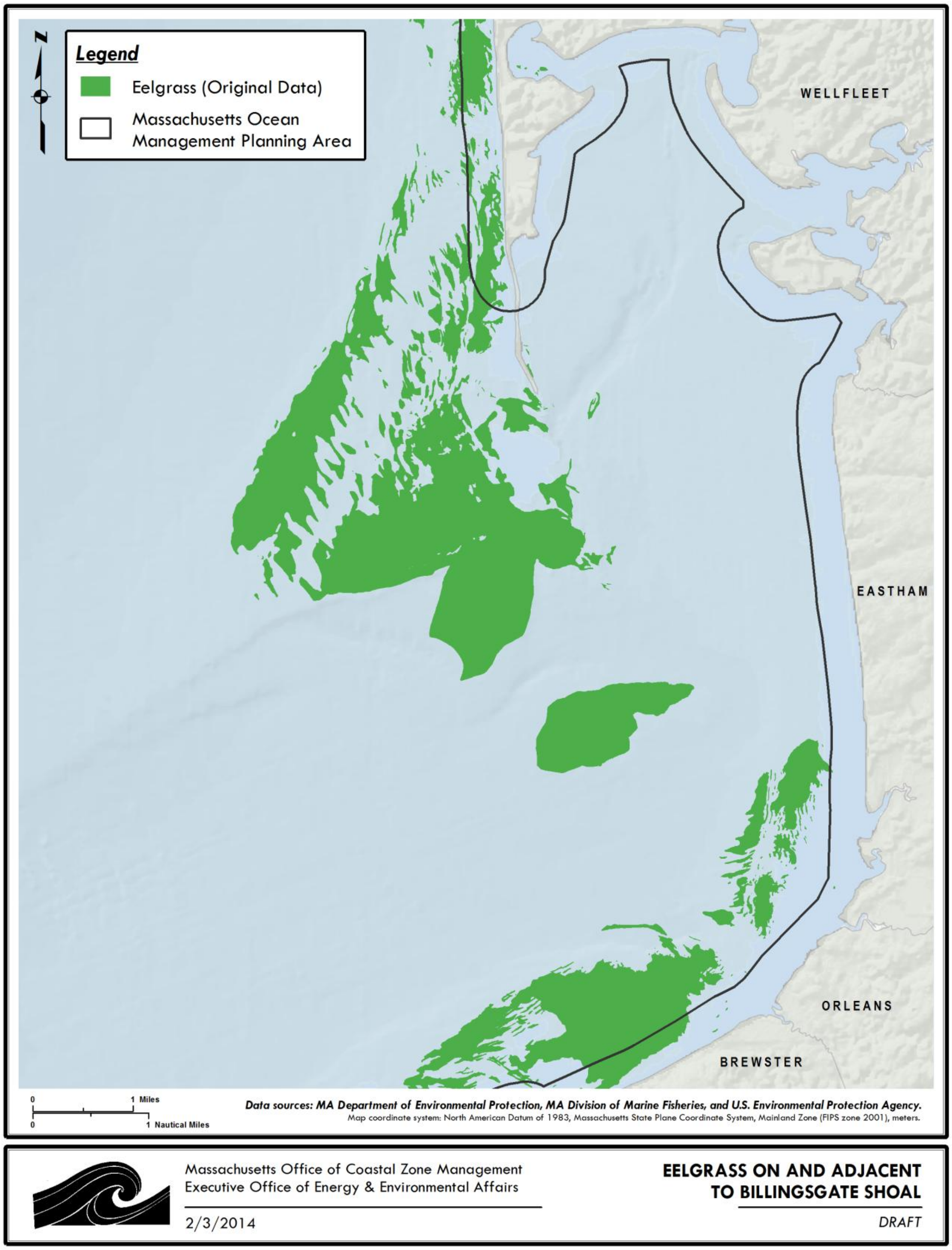

Figure 3. An example of detailed eelgrass bed coverage (in green) mapped using the original data as hand-delineated by MassDEP.

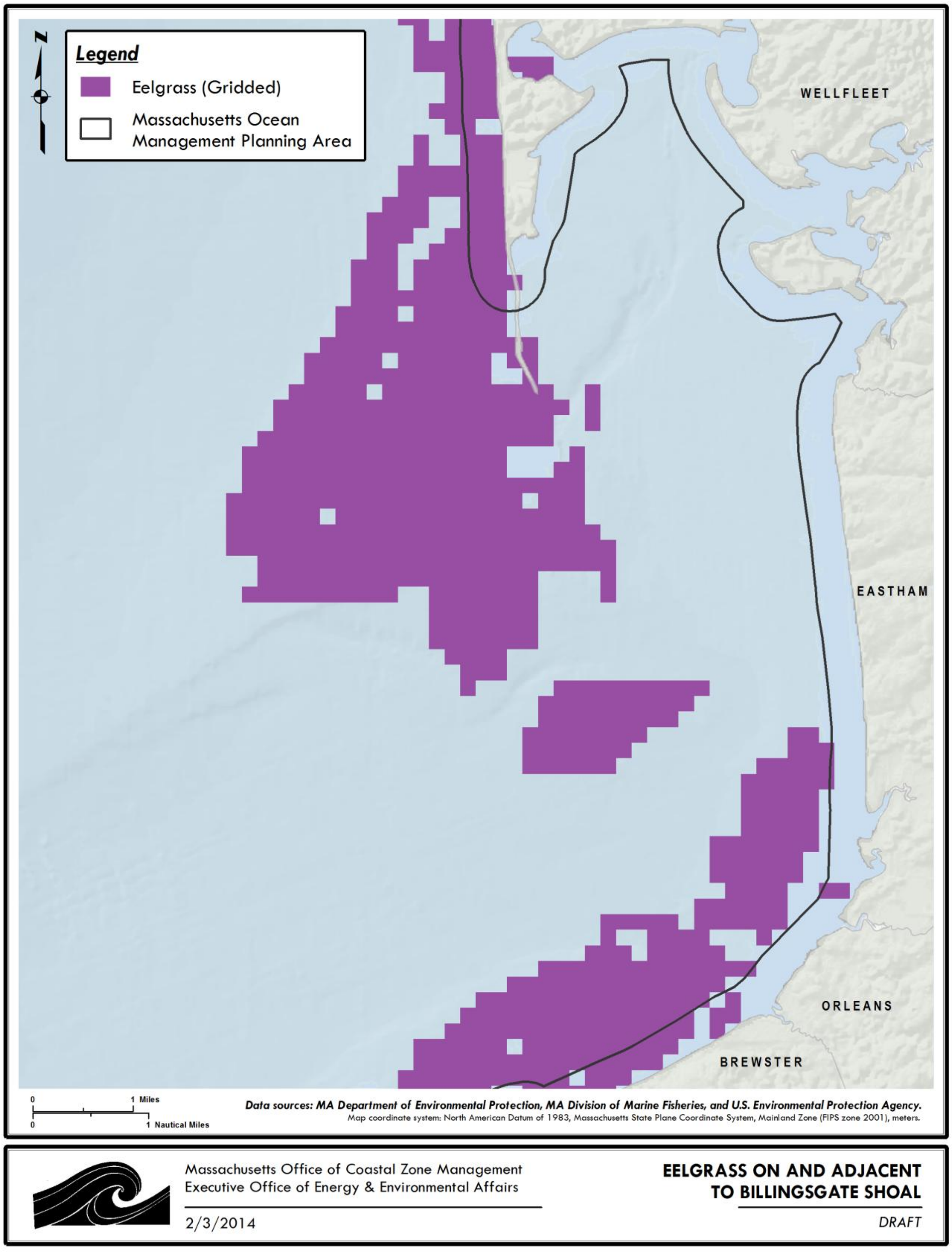

Figure 4. An example of eelgrass (in purple) mapped to a 250 m x 250 m grid.

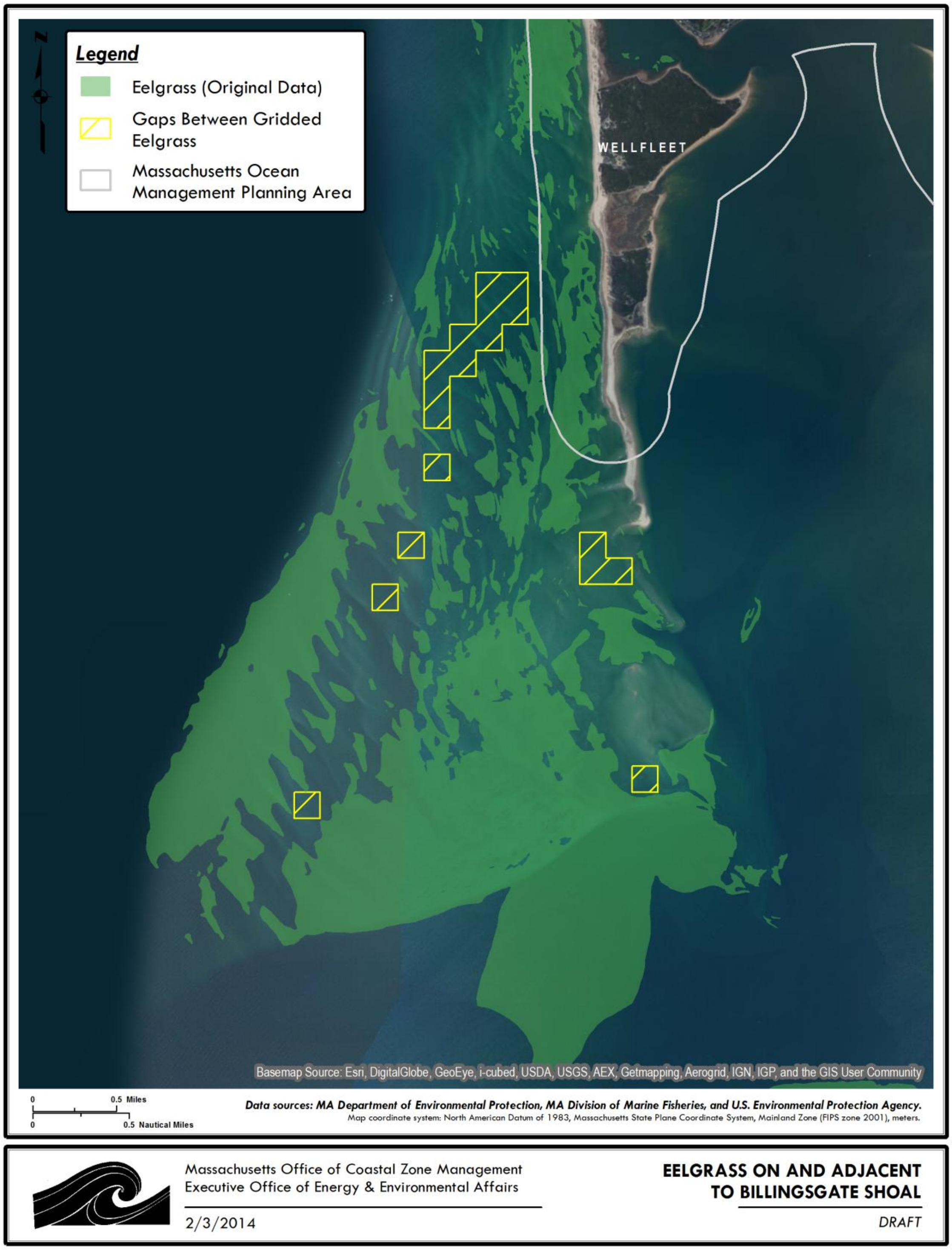

Figure 5. Gaps in the gridded eelgrass coverage of Billingsgate Shoals, Wellfleet (yellow cross-hatched areas) relative to the MassDEP eelgrass polygons (green). In this figure there are five 1-cell gaps, one 3-cell gap, and a 10-cell gap.

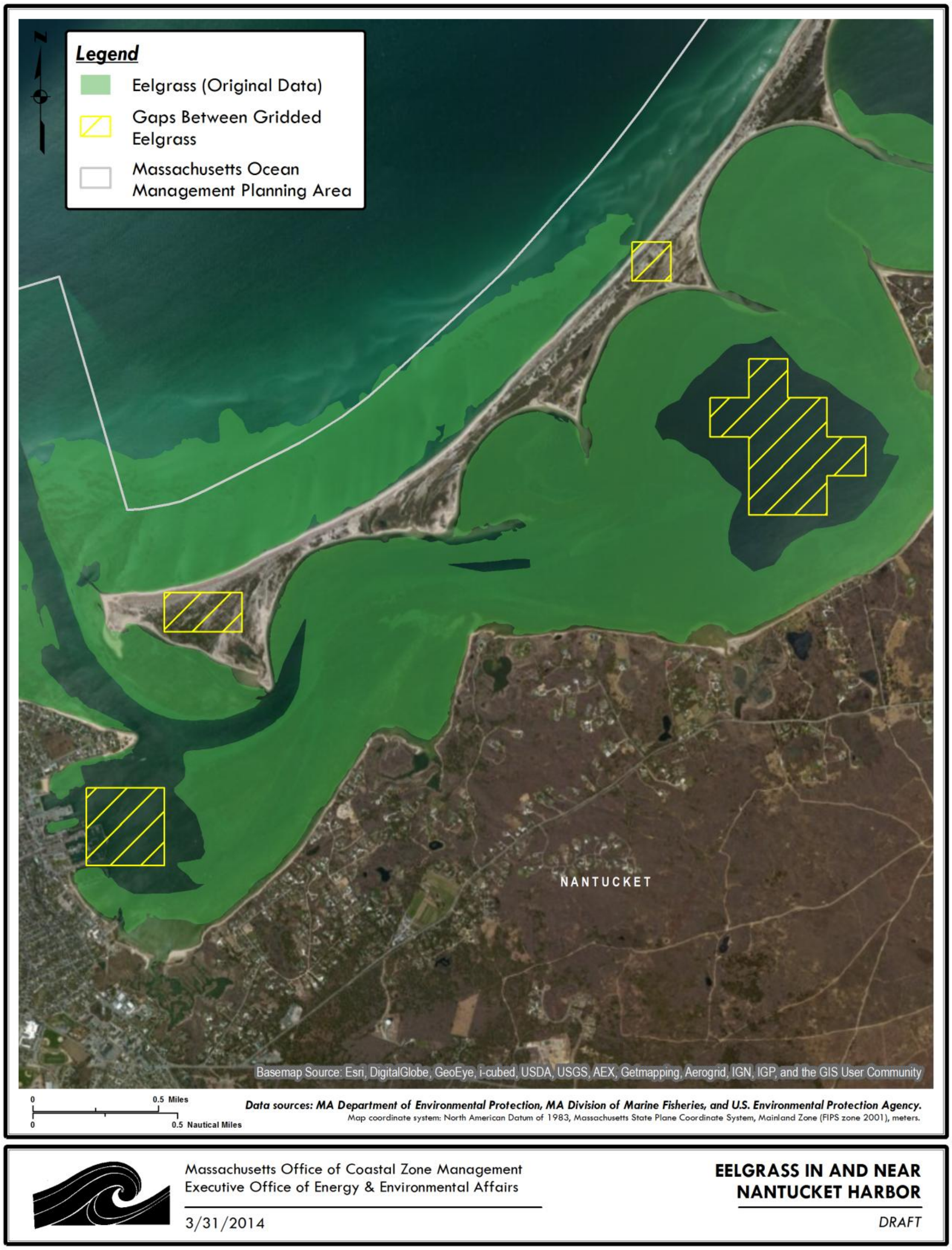

Figure 6. Gaps in the gridded eelgrass coverage of Nantucket Harbor (yellow cross-hatched areas) relative to the MassDEP eelgrass polygons (green). In this figure there is a 1-cell gap (on land), a 2-cell gap (also on land), a 4-cell gap (near the ferry pier), and a 10-cell gap (in the center of Nantucket Harbor).

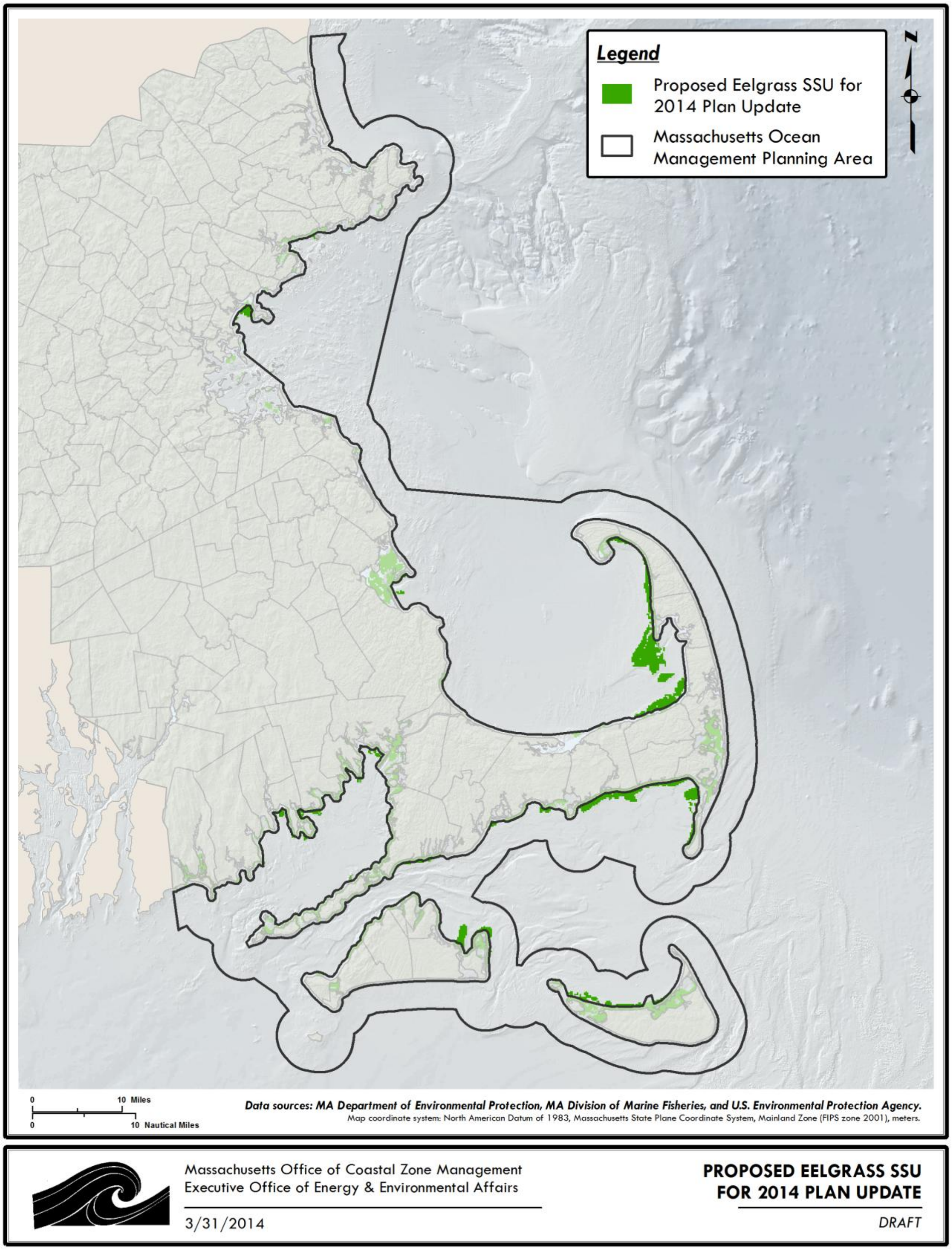

Figure 7. Proposed eelgrass SSU area for the 2014 Ocean Plan.

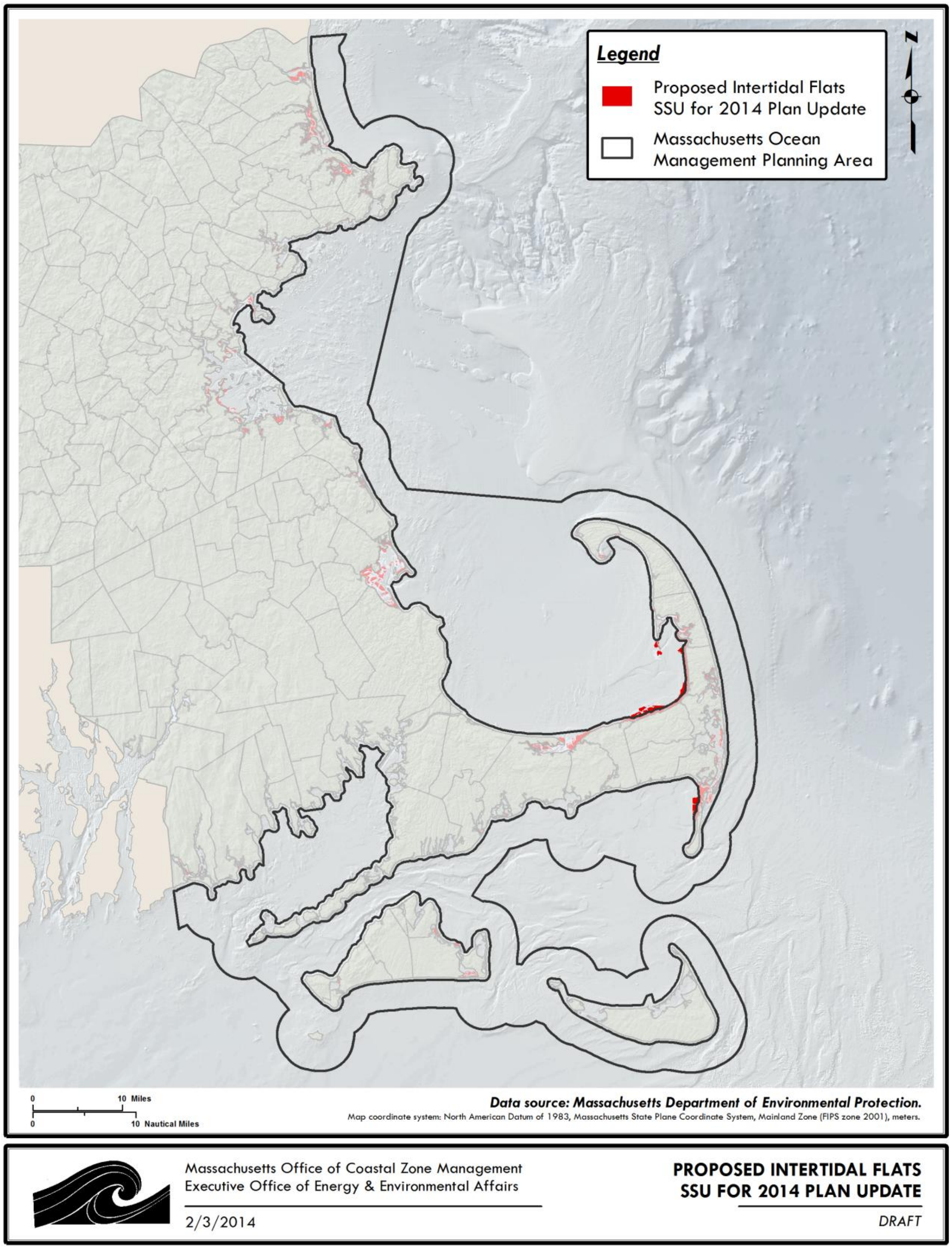

Figure 8. Proposed intertidal flats SSU area for the 2014 Ocean Plan.

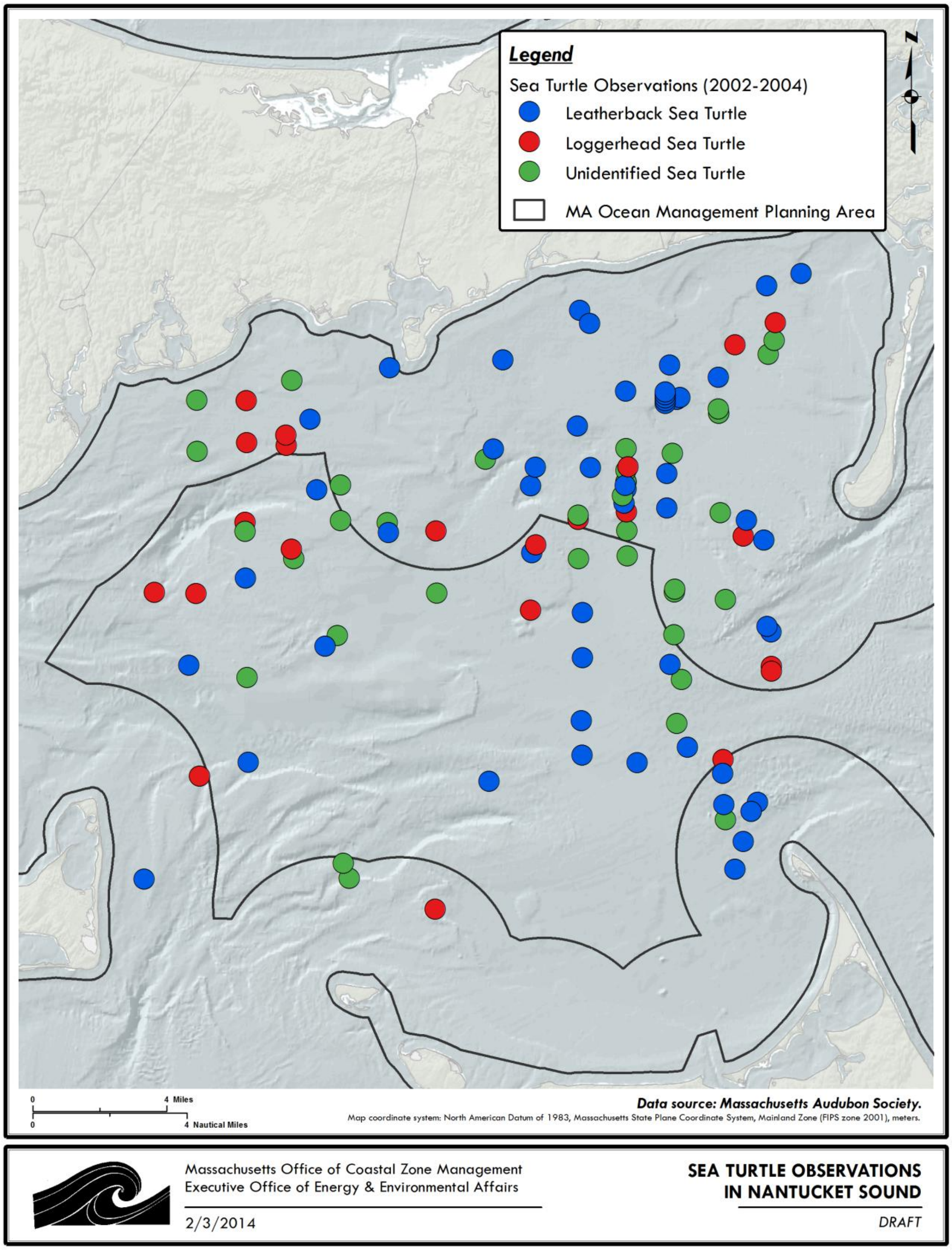

Figure 9. Mass Audubon sea turtle sightings in Nantucket Sound from aerial surveys 2002-2004. Blue = Leatherback Turtle, Red = Loggerhead Turtle, Green = Unidentified sea turtle.

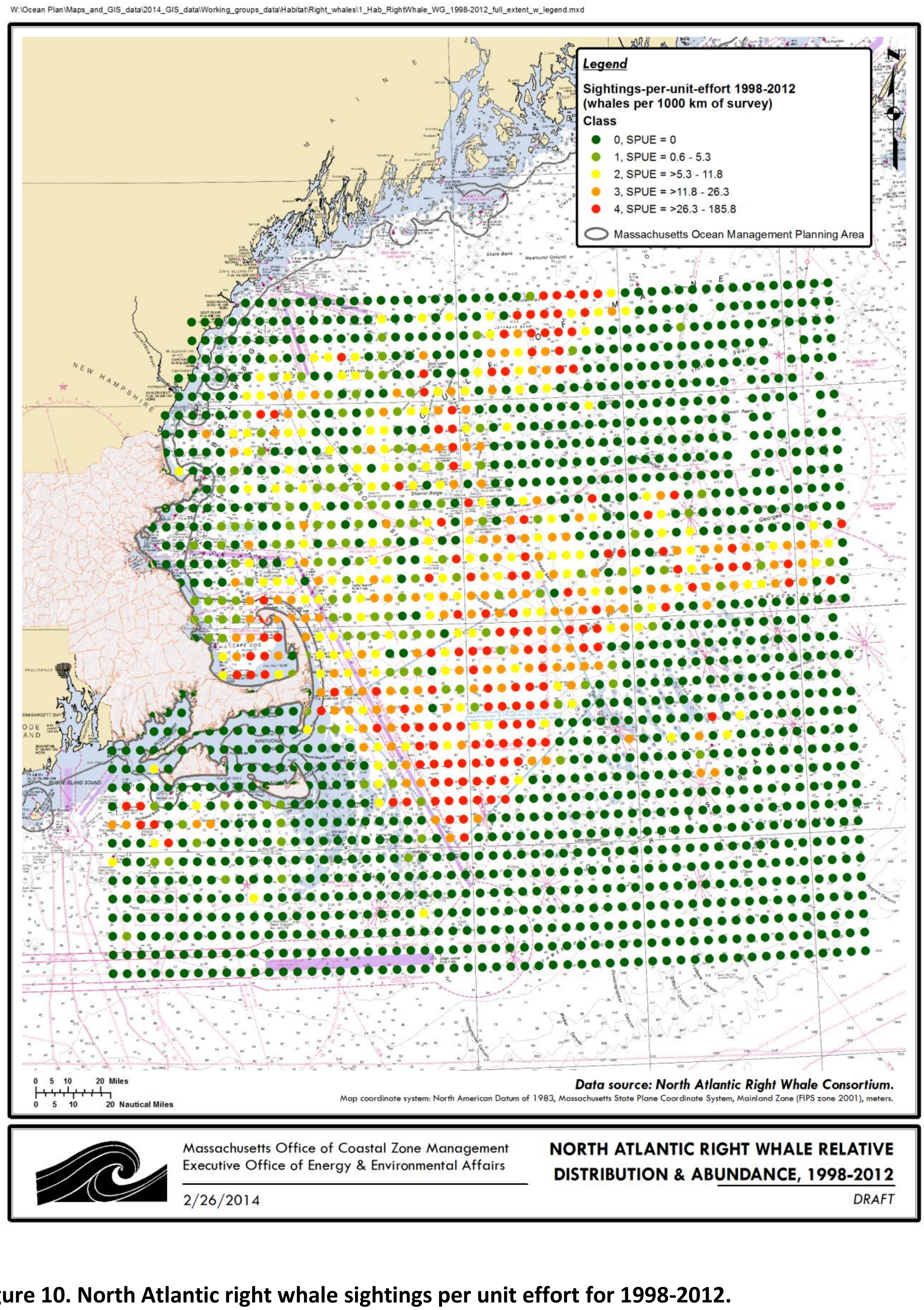

Figure 10. North Atlantic right whale sightings per unit effort for 1998-2012.

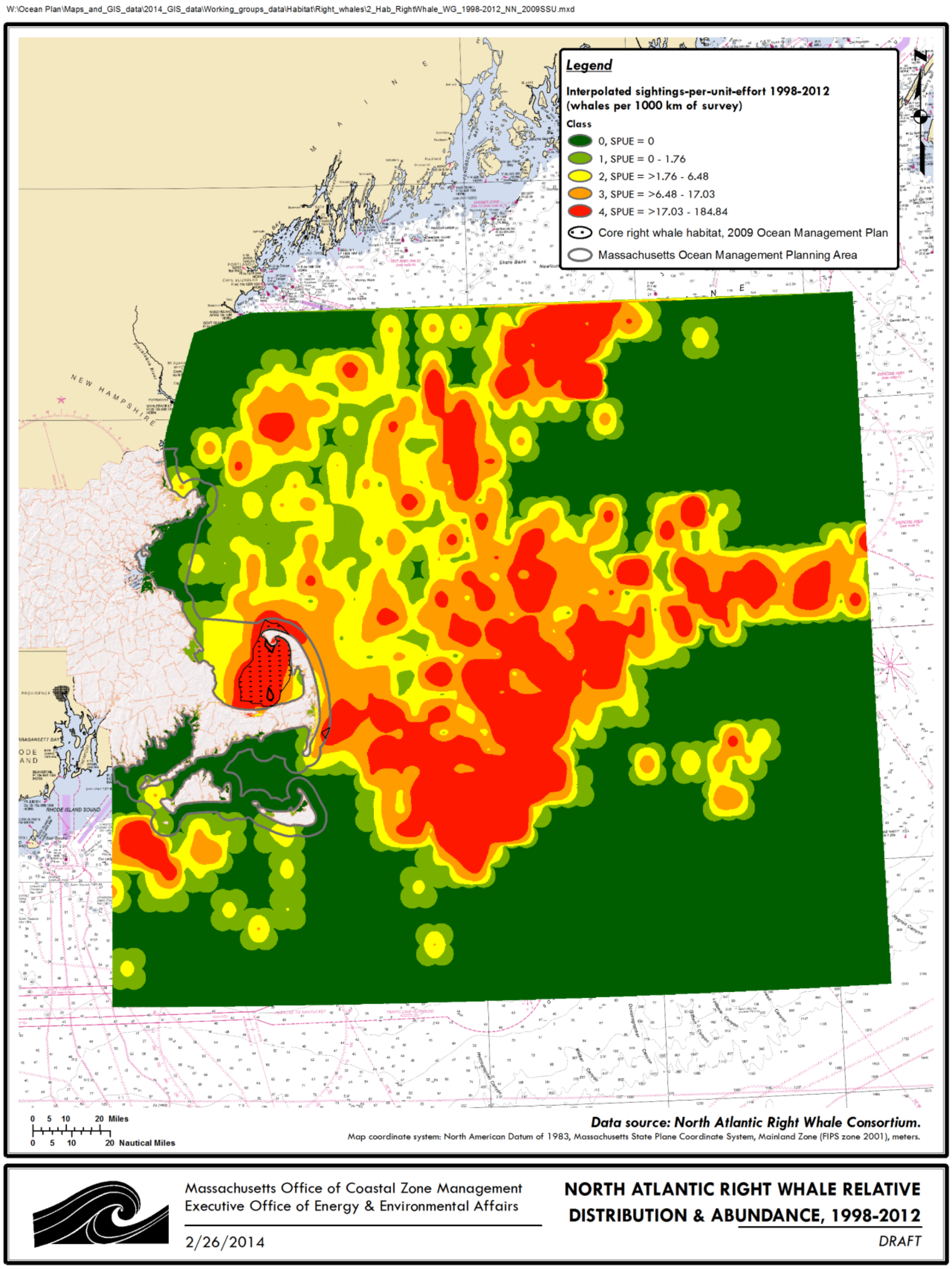

Figure 11. Interpolated North Atlantic right whale sightings per unit effort for 1998-2012. The stippled area is the North Atlantic right whale SSU area in the 2009 Ocean Plan.

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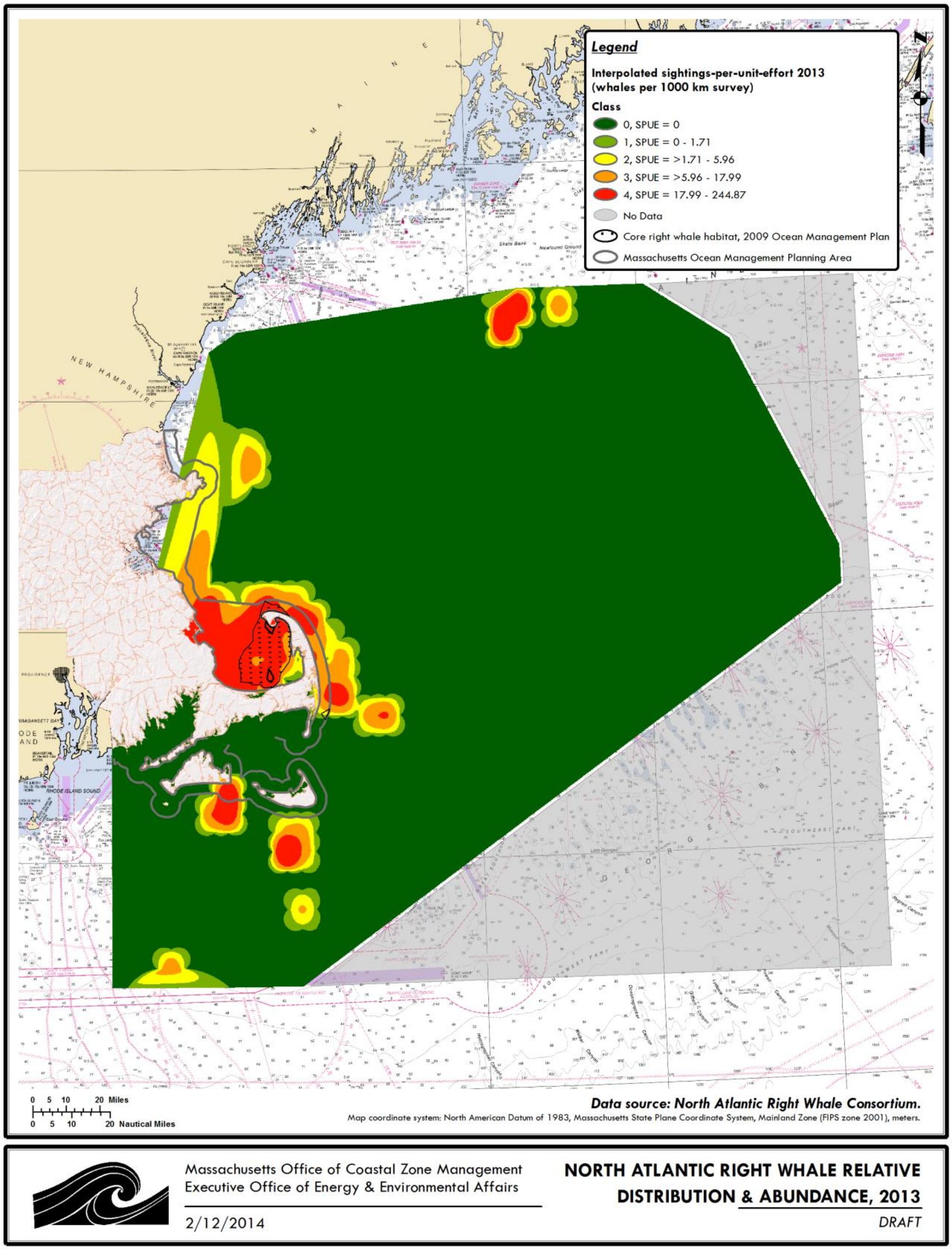

Figure 12. Interpolated North Atlantic right whale sightings per unit effort for 2013. The stippled area is the North Atlantic right whale SSU area in the 2009 Ocean Plan.

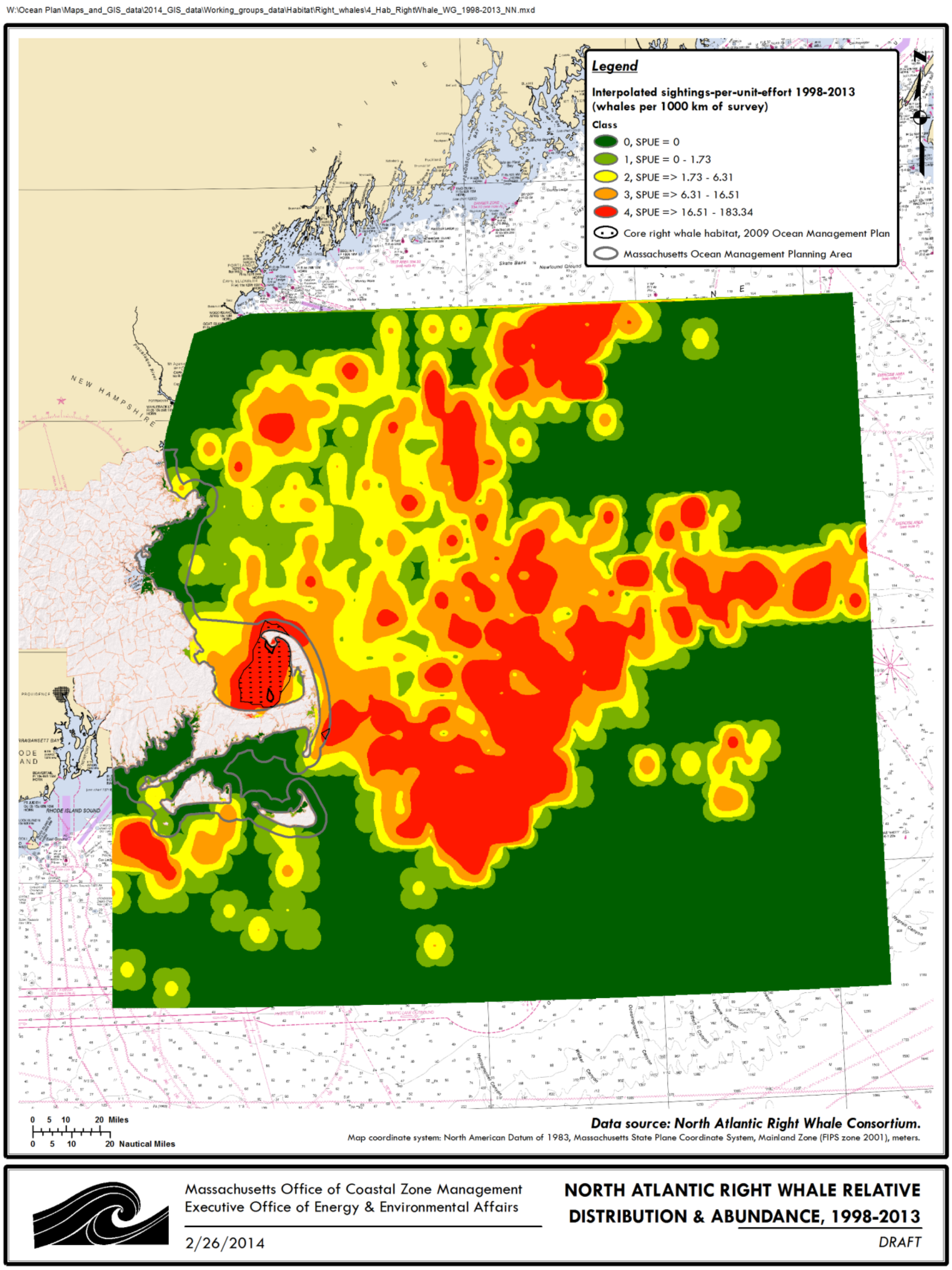

Figure 13. Interpolated North Atlantic right whale sightings per unit effort for 1998-2013. The stippled area is the North Atlantic right whale SSU area in the 2009 Ocean Plan.

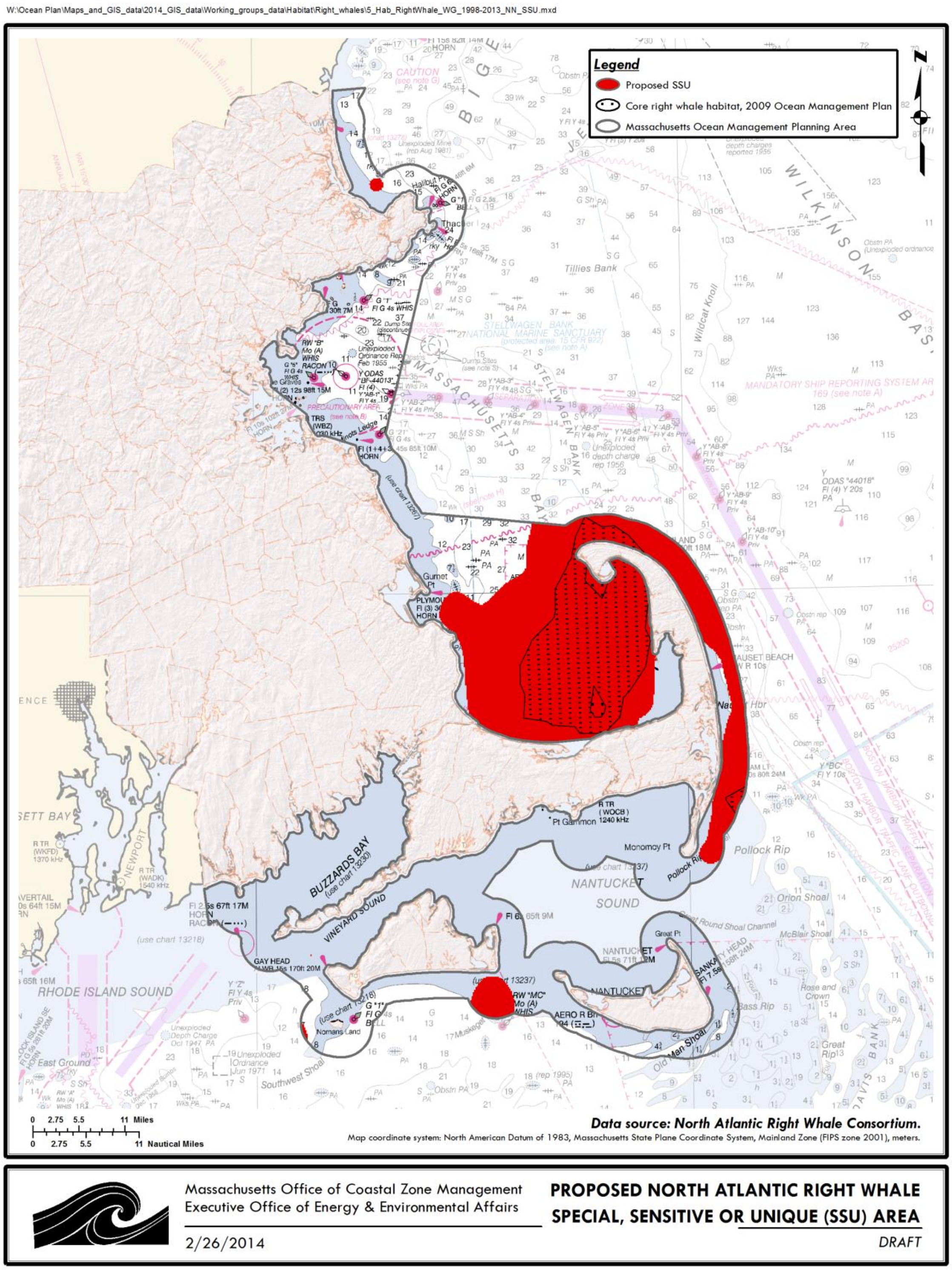

Figure 14. Proposed North Atlantic right whale core habitat SSU area for the 2014 Ocean Plan (in red). The stippled area represents the NARW SSU area in the 2009 Ocean Plan.

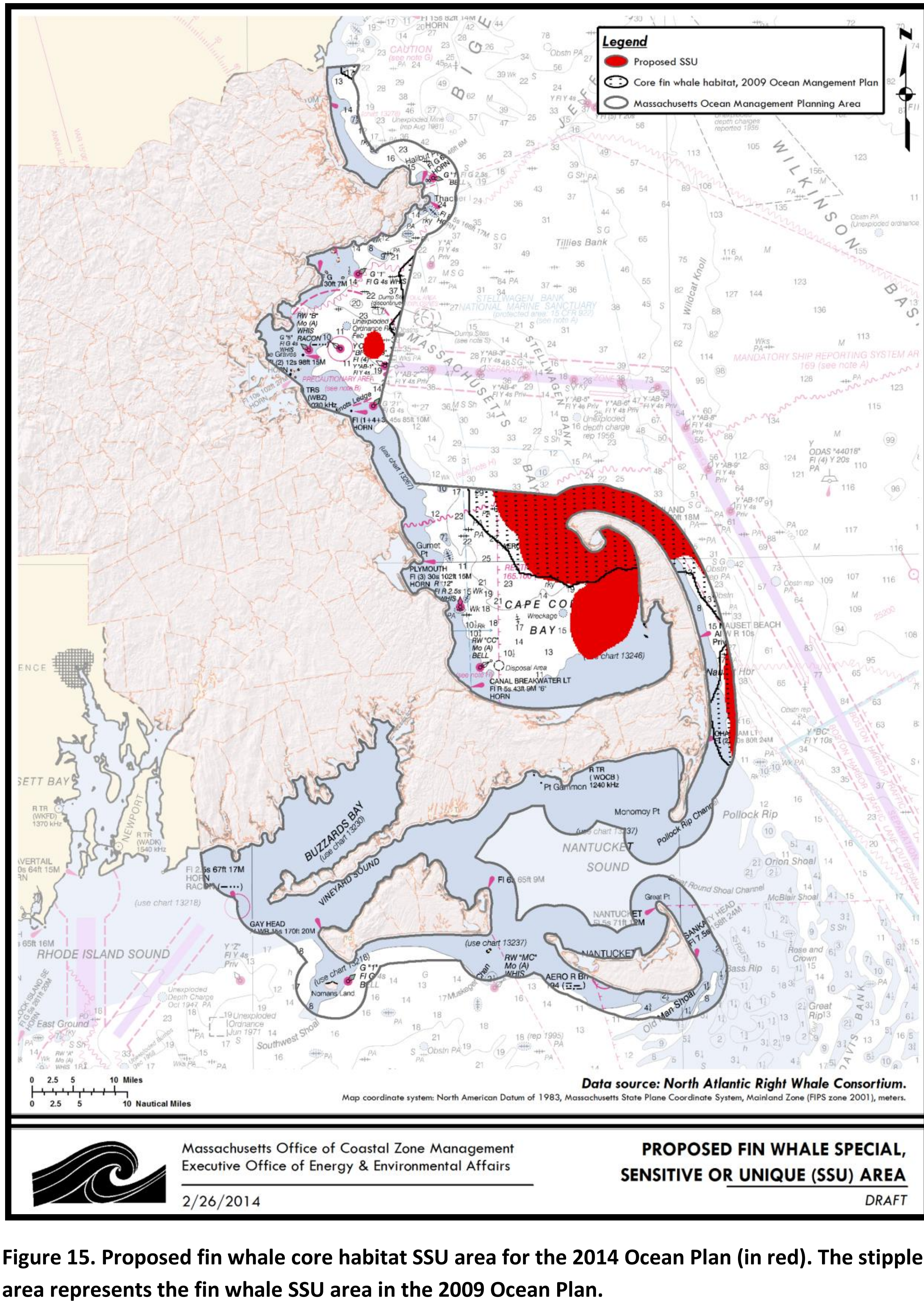

Figure 15. Proposed fin whale core habitat SSU area for the 2014 Ocean Plan (in red). The stippled area represents the fin whale SSU area in the 2009 Ocean Plan.

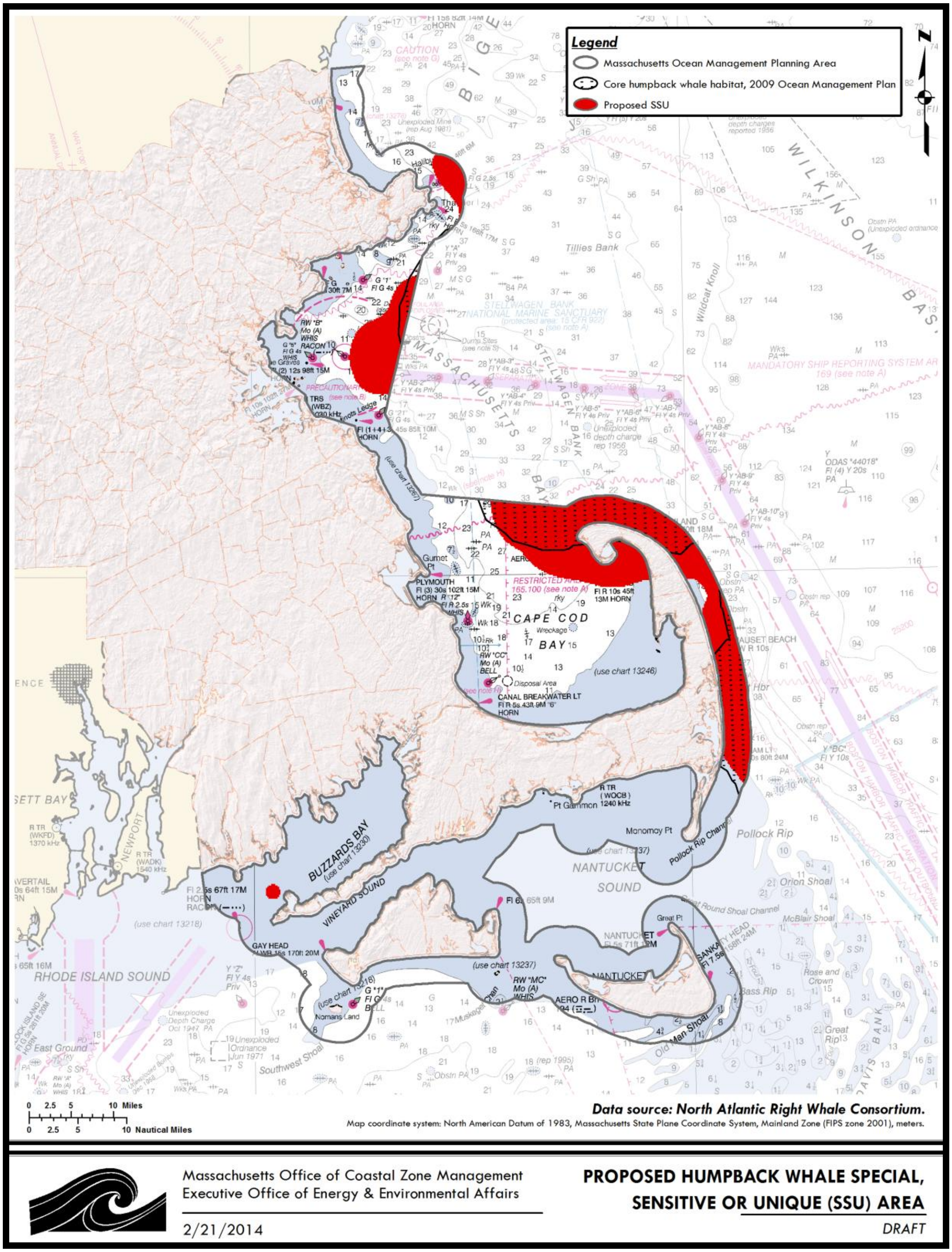

Figure 16. Proposed humpback whale core habitat SSU area for the 2014 Ocean Plan (in red). The stippled area represents the humpback SSU area in the 2009 Ocean Plan.

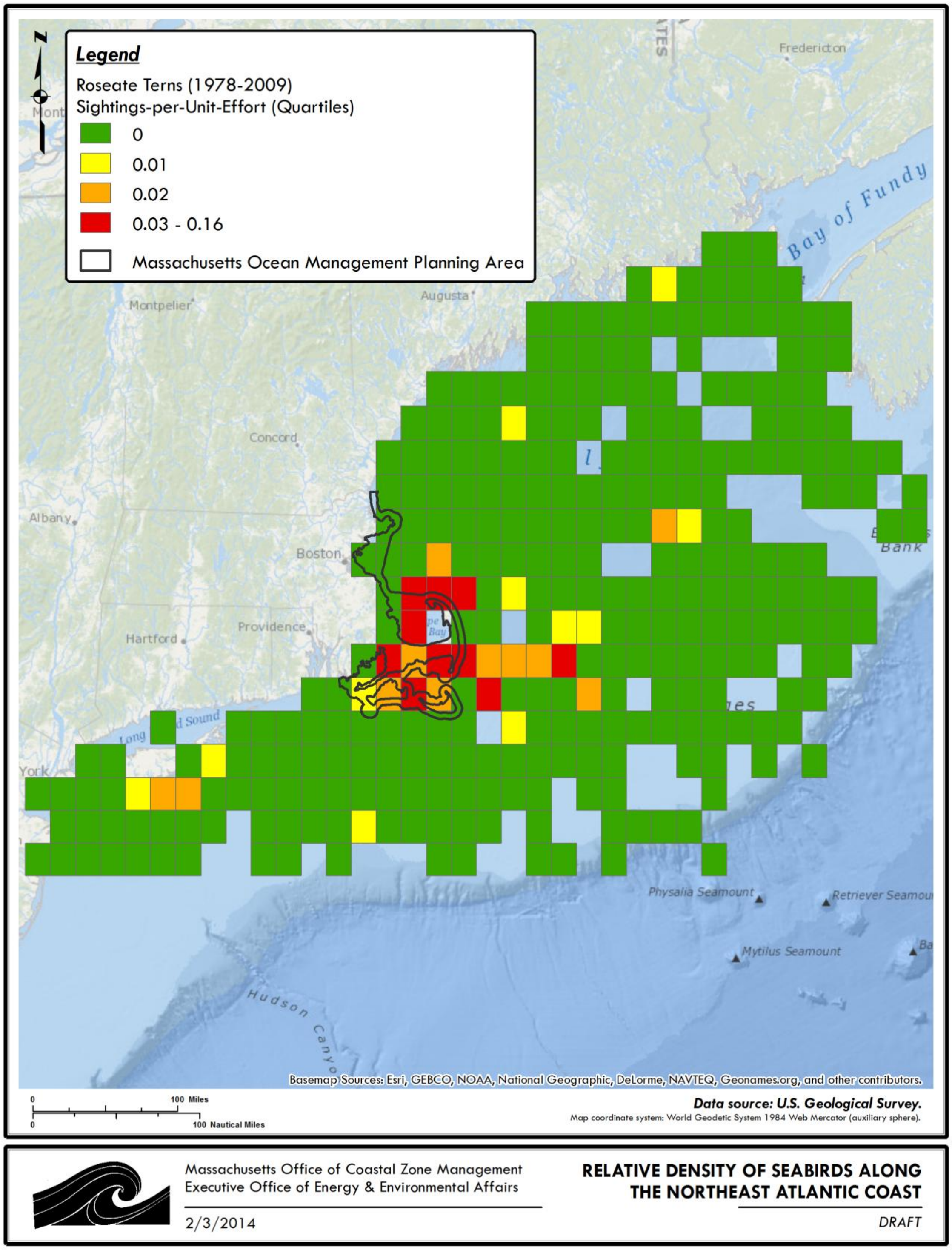

Figure 17. Roseate Tern densities from the USGS/BOEM Compendium applied to a 15 minute x 15 minute grid and classified into quartiles.

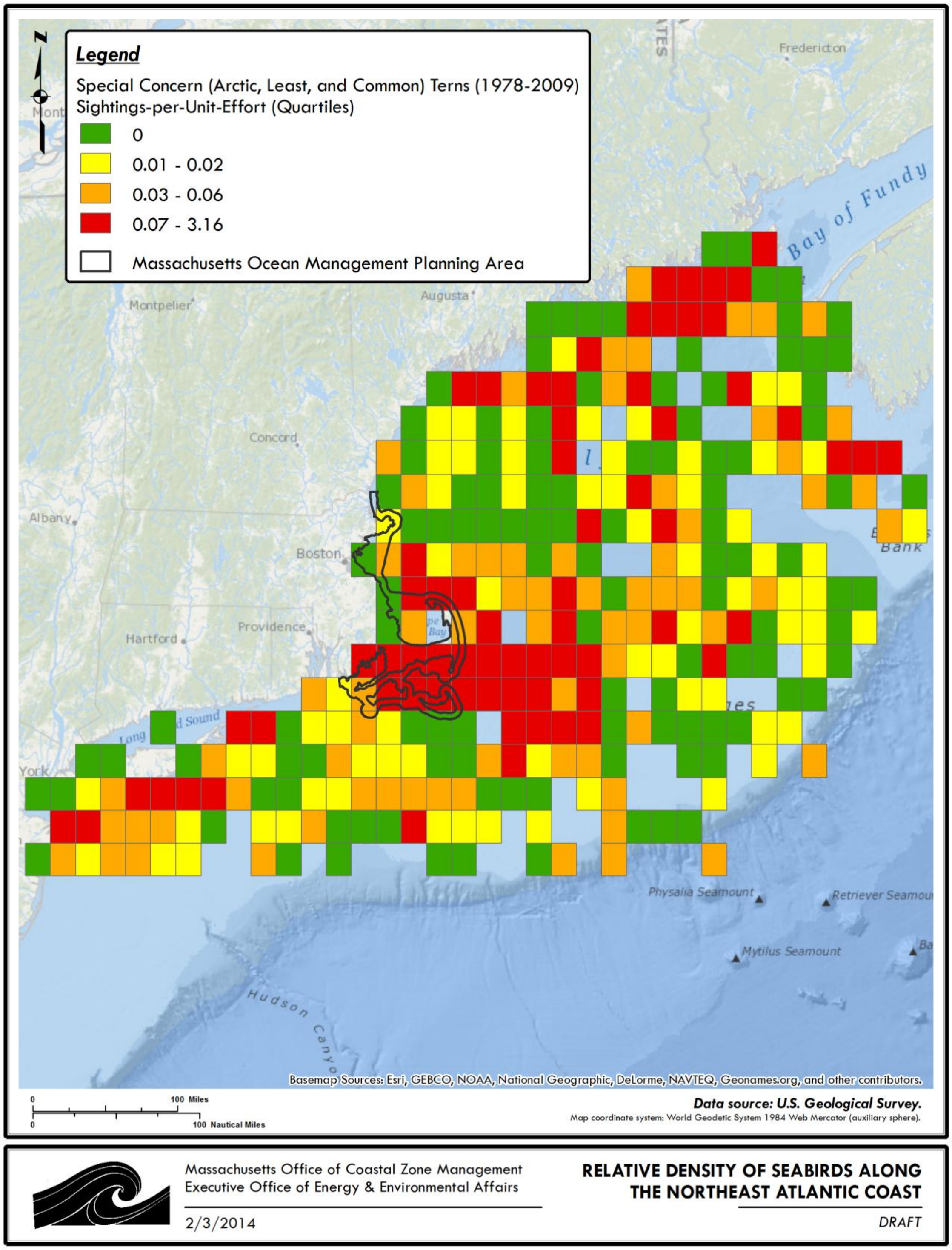

Figure 18. Special Concern (Arctic, Least, and Common) Tern densities from the USGS/BOEM Compendium applied to a 15 minute x 15 minute grid and classified into quartiles.

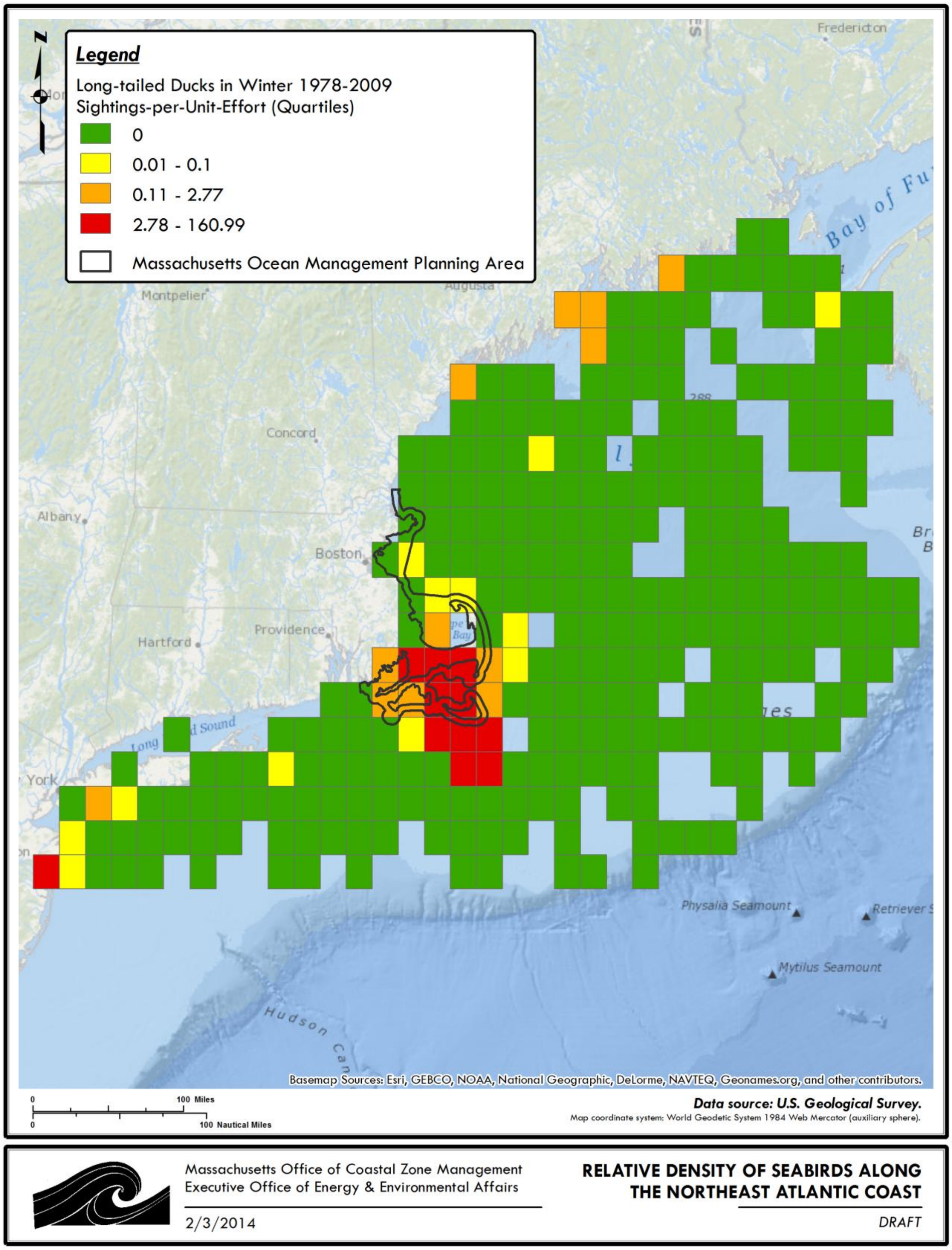

Figure 19. Long-tailed Duck densities from the USGS/BOEM Compendium applied to a 15 minute x 15 minute grid and classified into quartiles.

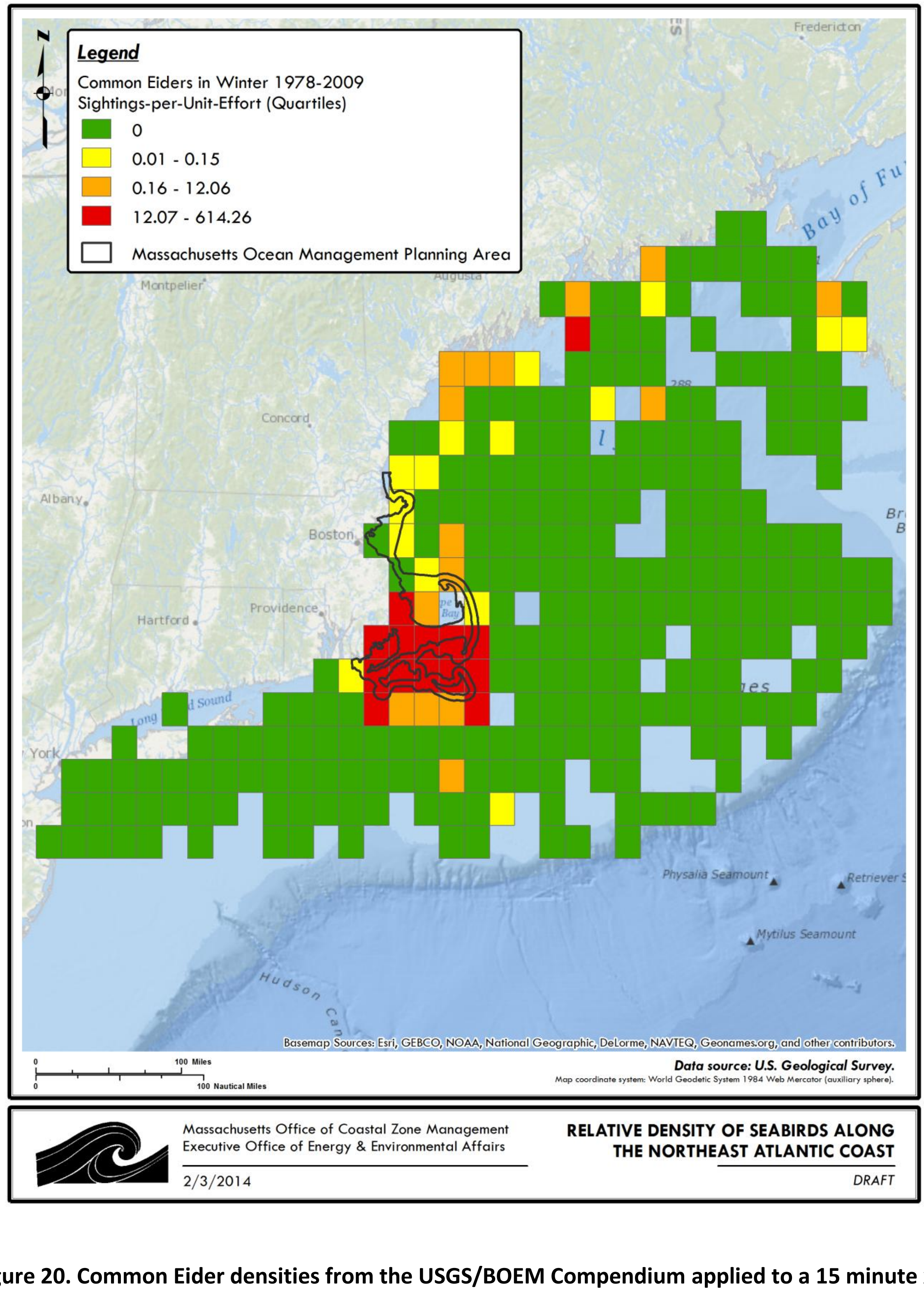

Figure 20. Common Eider densities from the USGS/BOEM Compendium applied to a 15 minute x 15 minute grid and classified into quartiles.

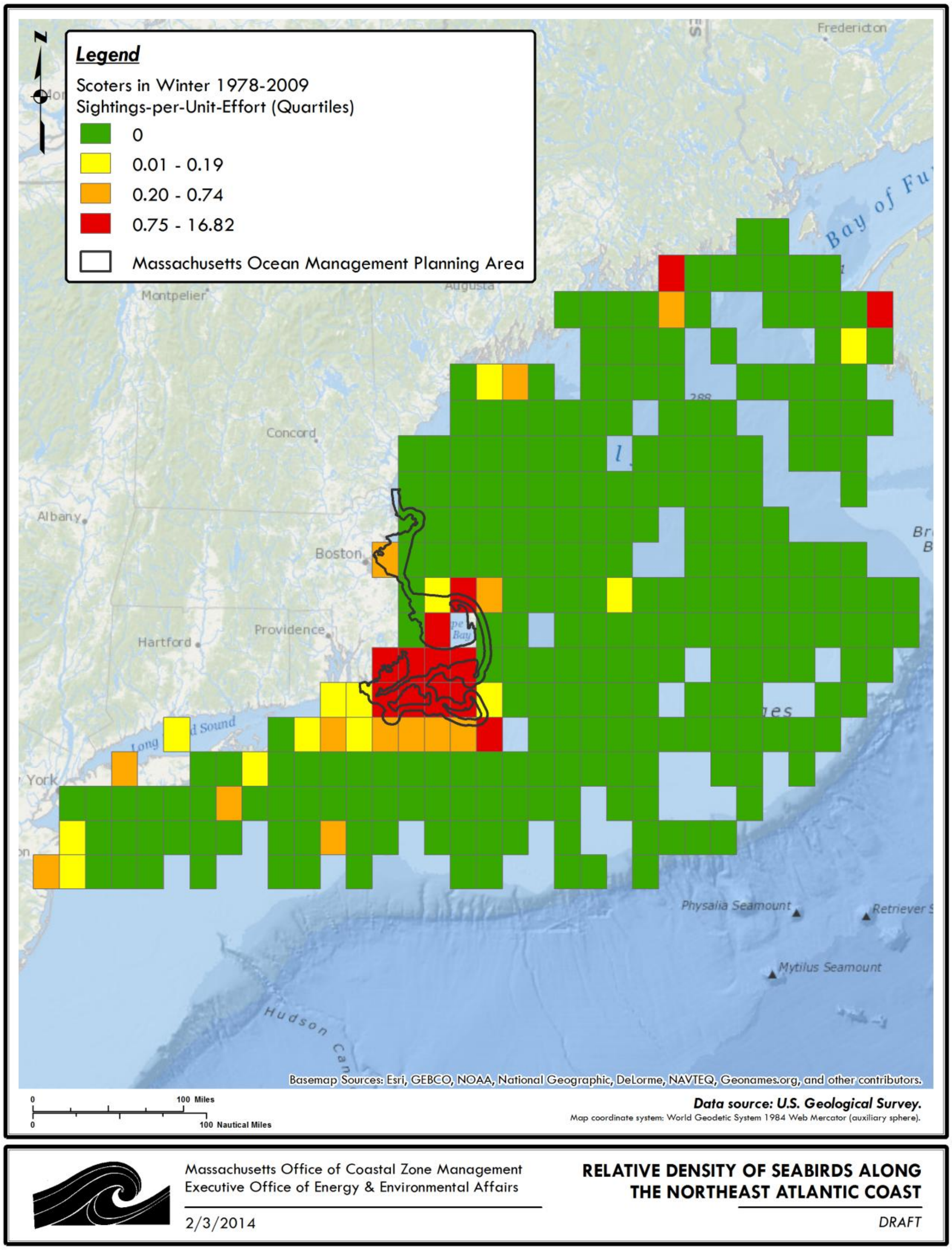

Figure 21. Combined scoter (Surf Scoter, White-winged Scoter, Black Scoter) densities from the USGS/BOEM Compendium applied to a 15 minute x 15 minute grid and classified into quartiles.

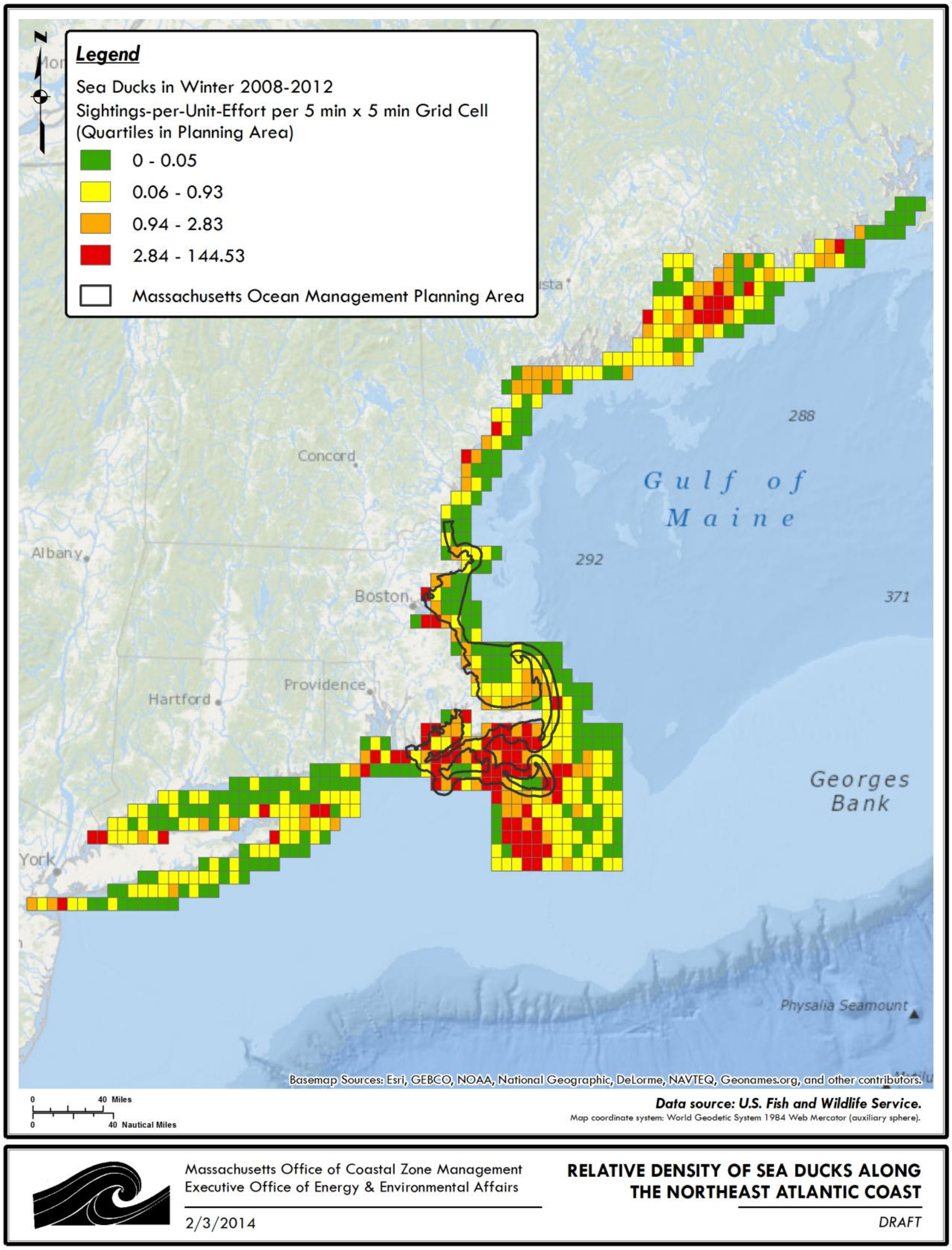

Figure 22. Combined sea duck (Long-tailed Duck, Common Eider, Surf Scoter, Black Scoter, White-winged Scoter) densities from the 2008-2012 USFWS aerial surveys applied to a 5 minute x 5 minute grid and classified into quartiles.

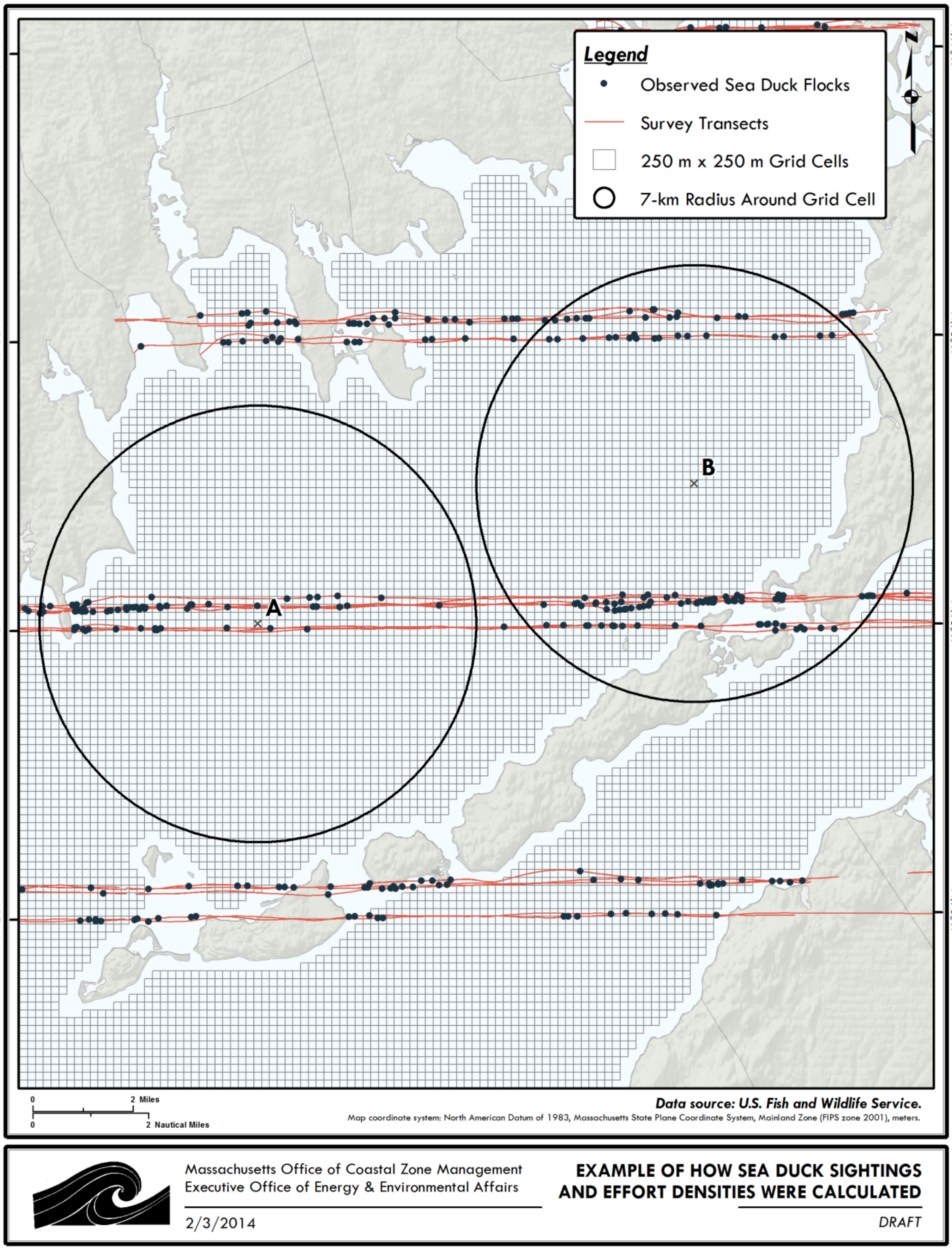

Figure 23. An example of how a moving 7-km window was used to determine sea duck densities in each 250 m x 250 m grid cell: A) along aerial survey lines and B) between aerial survey lines.

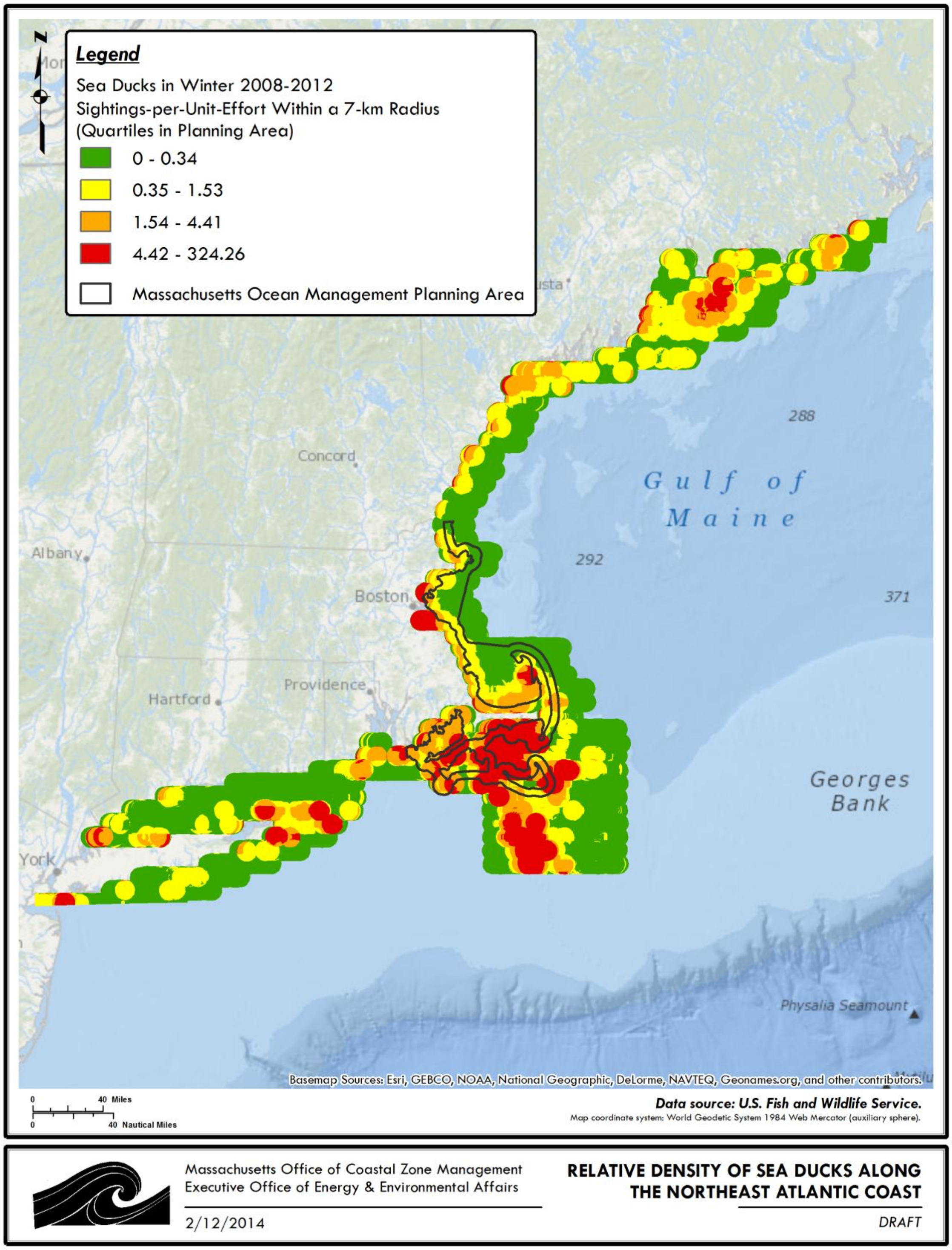

Figure 24. Interpolated sea duck (Long-tailed Duck, Common Eider, Surf Scoter, Black Scoter, White-winged Scoter) densities from the 2008-2012 USFWS study.

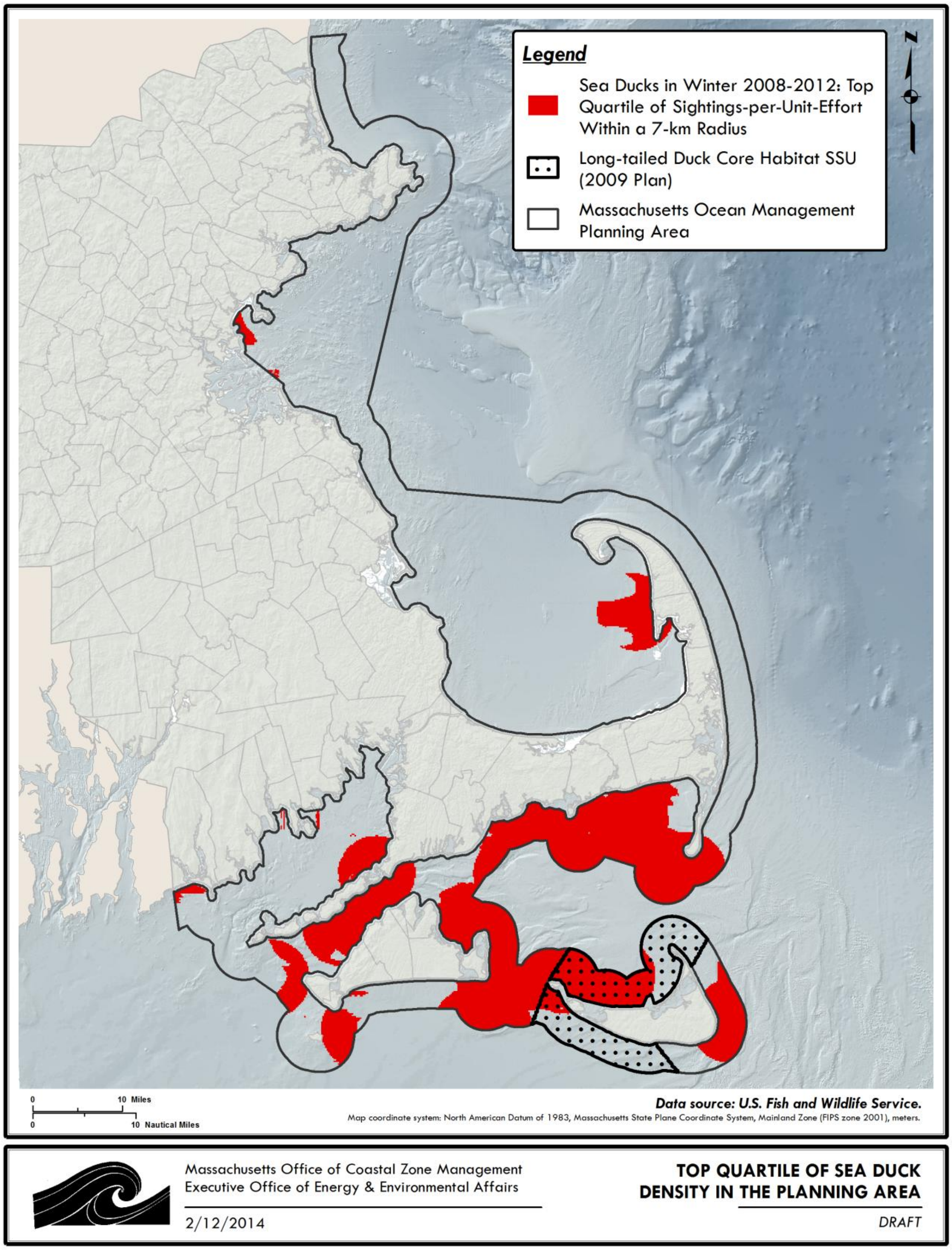

Figure 25. Top quartile of sea duck (Long-tailed Duck, Common Eider, Surf Scoter, Black Scoter, White-winged Scoter) sightings per unit effort from 2008-2012. The stippled area represents the Long-tailed Duck SSU area in the 2009 Ocean Plan.

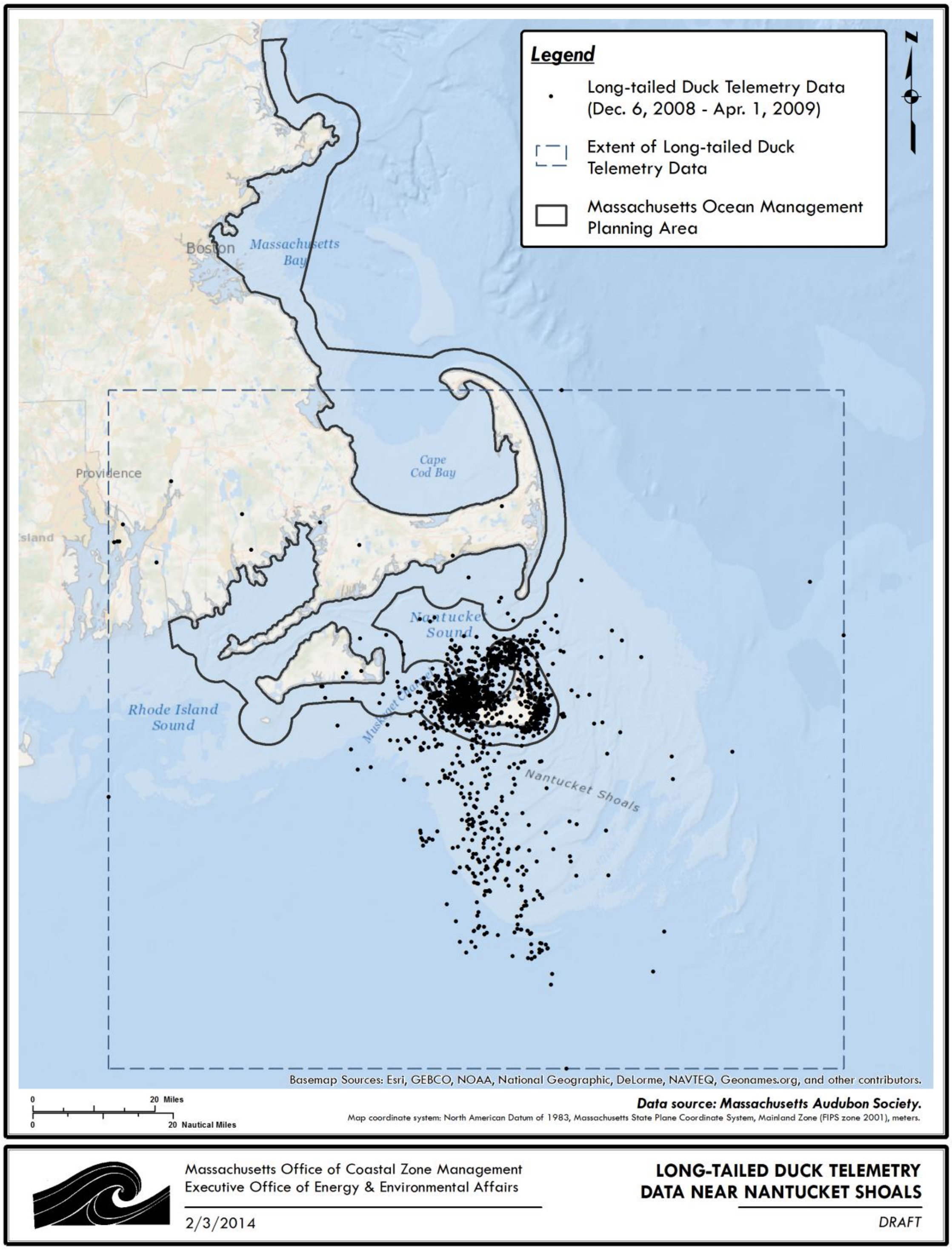

Figure 26. Mass Audubon satellite telemetry signals from several Long-tailed Ducks tracked from December 6, 2008 to April 1, 2009. The dashed box represents the spatial extent of data from the tagging study.

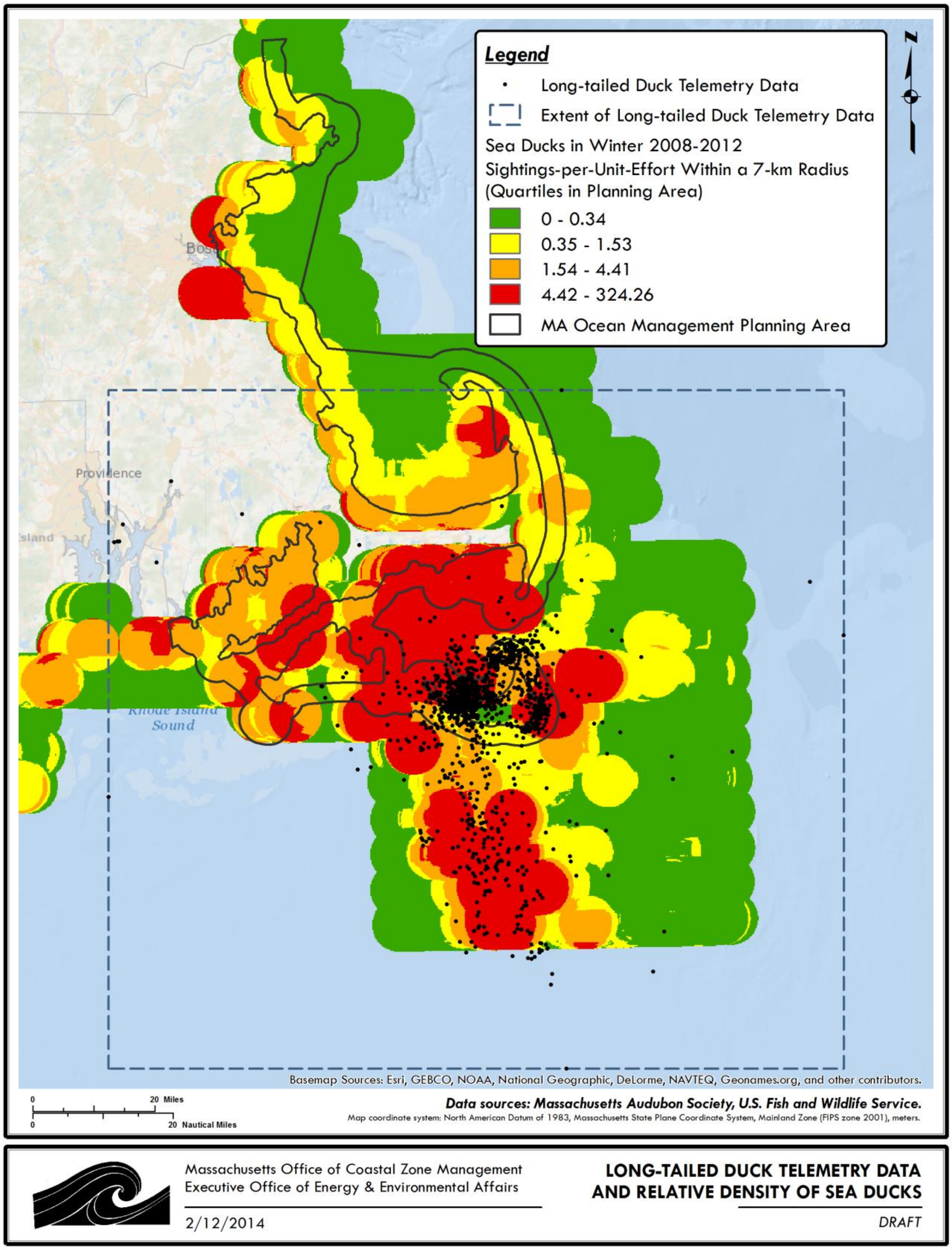

Figure 27. Mass Audubon Long-tailed Duck telemetry data points (2008/2009) overlaying USFWS aerial survey data from 2008-2012 for sea ducks. The dashed box represents the spatial extent of data from the tagging study.

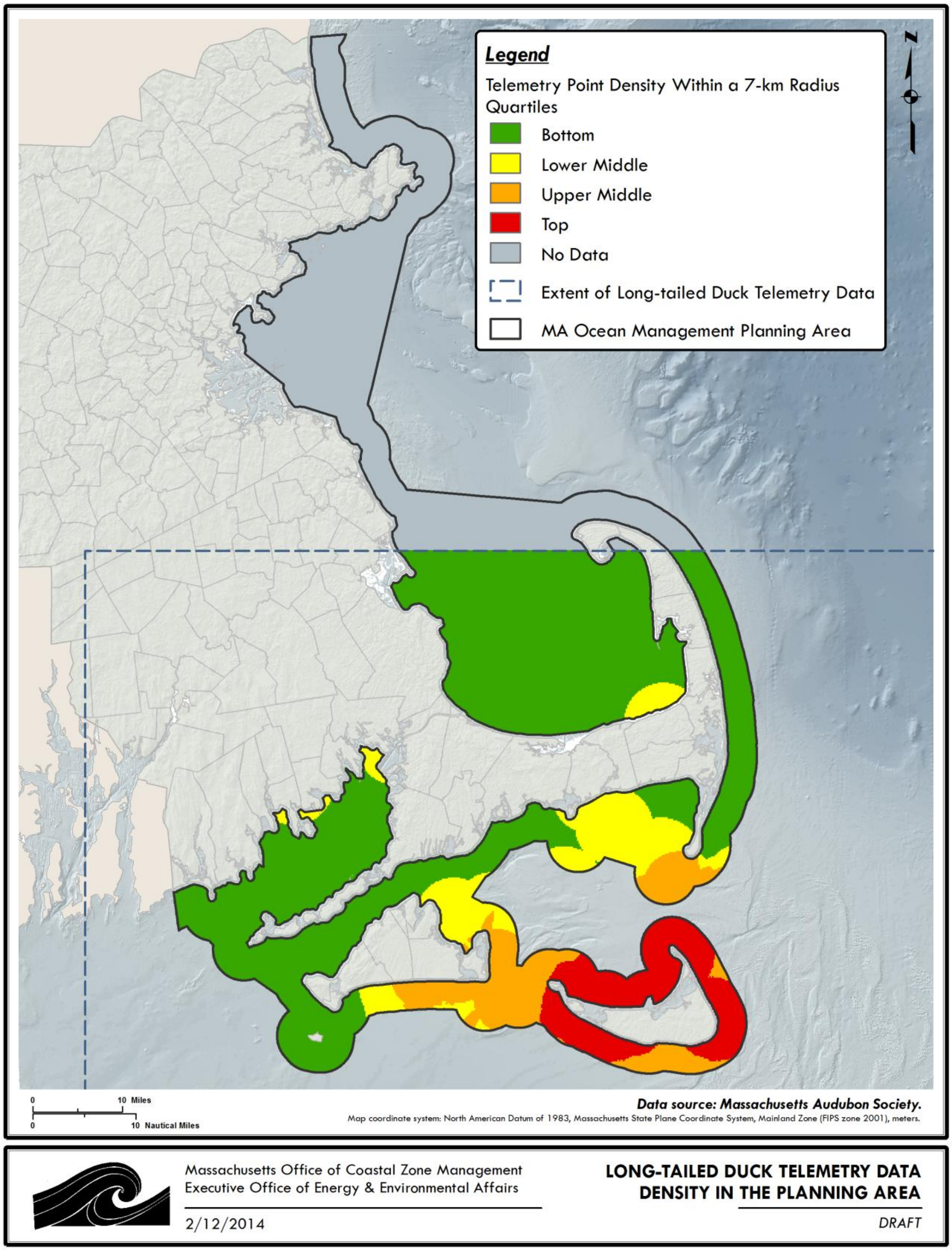

Figure 28. Results of the 7-km moving window analysis on the Mass Audubon Long-tailed Duck telemetry data points (2008/2009). The dashed box represents the spatial extent of data from the tagging study.

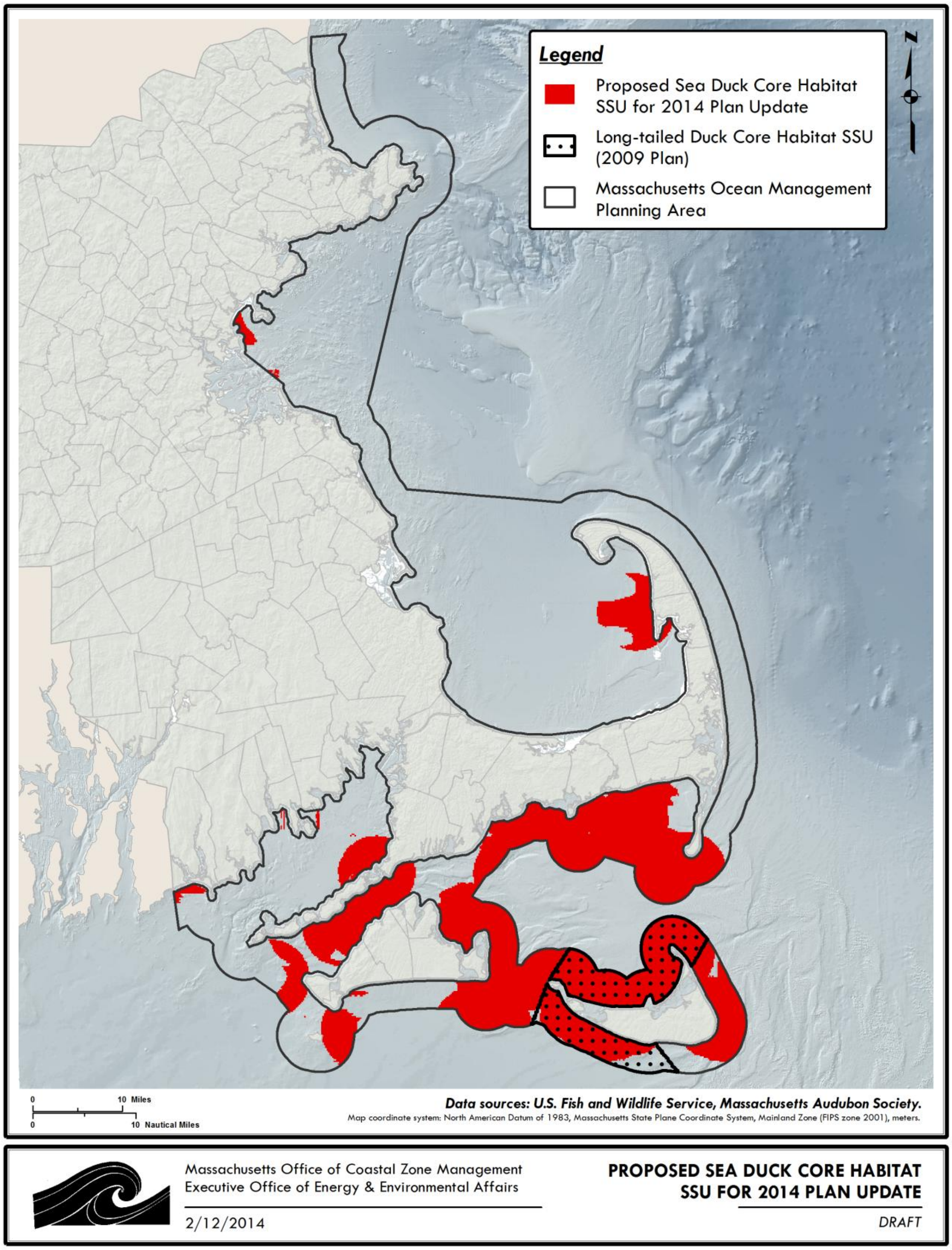

Figure 29. Proposed sea duck core habitat SSU area for the 2014 Ocean Plan (in red). The stippled area represents the Long-tailed Duck SSU area in the 2009 Ocean Plan.