

**Identification
of Seasonal Area
Management Zones
for North Atlantic
Right Whale Conservation**

by

**Richard L. Merrick, Phillip J. Clapham,
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and Richard M. Pace, III**

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**U.S. DEPARTMENT OF COMMERCE
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EXECUTIVE SUMMARY

Despite 30 years of protection under the Endangered Species Act, the North Atlantic right whale (*Eubalaena glacialis*) has shown little recovery. This lack of recovery is partially the result of continued anthropogenic mortality, primarily due to ship strikes and entanglement in fixed fishing gear. Between 1997 and 2000, NMFS and the Atlantic Large Whale Take Reduction Team (ALWTRT) developed and implemented an Atlantic Large Whale Take Reduction Plan to reduce interactions with fishing gear. Some of the approaches in the Plan deal with fishing gear modifications, while others involve fishing time and area closures in right whale critical habitats. In February 2000, NMFS and the ALWTRT began to consider additional time and area gear restrictions to further reduce anthropogenic interactions.

NMFS has proposed to implement these additional gear restrictions using a two-pronged strategy. First, areas with predictable annual concentrations of right whales will be considered for Seasonal Area Management (SAM). Such areas would have specific boundaries and pre-designated closing and opening dates. Specification of additional SAM zones continues the management approach used in 1997 in establishing the Cape Cod Bay and Great South Channel Restricted Areas for right whale conservation (62 FR 39157). Second, areas without predictable concentrations may be considered for Dynamic Area Management (DAM). In these areas, restrictions would not be invoked unless concentrations of right whales had been found by qualified observers. Once concentrations were seen, NMFS could invoke a minimum two week restricted area around the animals.

Herein, we present GIS analyses for defining SAMs based on the procedures used by Clapham and Pace (2001) in defining DAMs. These analyses used right whale sighting data collected on dedicated surveys conducted by NMFS during March-July 1999-2001. In these surveys, 1,307 right whales were observed in a total 784 different sightings.

The analytic process was to: (1) identify right whale sightings which met the DAM trigger criteria during 1999-2001; (2) define and map a core area around these sightings that also included a 15 nm radius buffer for animal movements; (3) define SAMs for each of the three years, by drawing polygons around the circular buffer zones, and joining overlapping polygons; (4) overlay all of the SAMs, identify and eliminate SAM areas that were unique (i.e., only occurred in a single year, and draw an outline around the aggregate SAM area; and (5) smooth the aggregate SAM area to match existing closures and zone systems.

A Core SAM zone stretching from Cape Cod eastward to the Hague Line was generated from the analyses. This zone could potentially be divided into eastern and western zones based on observed seasonal differences in right whale distribution during 1999-2001. A separate Northern SAM zone was also elucidated but needs confirmation with additional future survey effort.

INTRODUCTION

Despite 30 years of protection under the Endangered Species Act, the North Atlantic right whale (*Eubalaena glacialis*) has shown little recovery. Indeed, recent analyses suggest that survival rates and population abundance levels have declined (Caswell et al. 1999). Lack of recovery is partially due to continued anthropogenic mortality, due primarily to ship strikes and entanglement in fixed fishing gear (National Marine Fisheries Service [NMFS] 1991). The 1994 amendments to the Marine Mammal Protection Act provided for the development of take reduction plans to reduce interactions with commercial fishing gear. On July 22, 1997, NMFS published an Atlantic Large Whale Take Reduction Plan and also interim final regulations implementing this Plan (62 FR 39157). The Plan contained a number of approaches to reducing gear interactions. Some dealt with modifications to fishing gear, while others dealt with fishing time and area closures in critical right whale habitat areas. Since 1997, NMFS and the Atlantic Large Whale Take Reduction Team (ALWTRT) have monitored right whale-fishing gear interactions. Significant changes to the gear modifications included in the Plan were made in February 1999 (64 FR 7529) and in December 2000 (65 FR 80368). In February 2000, NMFS and the ALWTRT began to consider additional time and area gear restrictions to further reduce interactions.

NMFS has proposed to implement these additional gear restrictions using a two-pronged strategy. First, areas with predictable annual concentrations of right whales will be considered for Seasonal Area Management (SAM). Such areas would have specific boundaries and pre-designated. Specification of additional SAM zones continues the management approach used in 1997 in establishing the Cape Cod Bay and Great South Channel Restricted Areas for right whale conservation (62 FR 39157). Second, areas without predictable concentrations may be considered for Dynamic Area Management (DAM). In these areas, restrictions would not be invoked unless concentrations of right whales had been found by qualified observers. Once concentrations were seen, NMFS could invoke a minimum two week restricted area around the animals.

One of the first steps in developing area closures is to determine a suitable threshold density of right whales which would trigger implementation of such closures. Following considerable discussion by the ALWTRT and completion of a research study by NMFS scientists (Clapham and Pace 2001), the threshold density trigger was specified as a minimum of 3 right whales within a 75nm² area (ca. 0.04 right whales per nm²). Also specified was the size of an area necessary to contain a right whale's movements over a 1-2 week period. This was a 15nm radius zone.

The Clapham and Pace (2001) study was used to design DAM zones. Here we present additional analyses for defining SAMs. First, we provide a brief summary of the 1999-2001 NMFS North Atlantic right whale survey results. Secondly, we define geographic areas in the Gulf of Maine, based on the trigger and buffer size analyses of Clapham and Pace (2001), that could be considered as potential North Atlantic right whale Seasonal Area Management zones.

METHODS

Surveys

Directed aerial surveys for North Atlantic right whales were conducted by NMFS during March-July, 1999-2001 in the area from south of Nantucket, MA northward to the Bay of Fundy, and from the New England coast eastward to the Hague Convention Line (Fig. 1). The surveys were accomplished using two high-wing, twin-engine fixed wing aircraft. One was a NOAA DeHaviland Twin Otter, and the other was a chartered amphibious Grumman Widgeon (1999) or Goose (2000-2001). Surveys were flown at ca. 230 m (1999-2000) or 310 m (2001) altitude, and 100 kts (185 km/hr). Flights were conducted by at least one aircraft on virtually all days when sighting conditions were Beaufort 3 or better, but were not performed when visibility was poor or obscured (snow, rain or fog).

During 1999-2000, flights were either flown along tracklines developed for SCOPEX (South Channel Ocean Productivity Experiment; Beardsley et al. 1993; Kenney 1993) in the Great South Channel area, or were directed towards areas of reported or suspected right whale concentrations. In 2001, one aircraft flew a monthly series of east-west track lines which overlaid the entire study area, while the second aircraft surveyed the Great South Channel area and other offshore areas.

Survey protocols for the two aircraft were similar. Each typically carried two observers and a recorder (in addition to two pilots). The observers made continuous observations out of both sides of the aircraft, with all sightings recorded on a laptop computer by the recorder. When right whales, other marine mammals, marine turtles, sharks, or fish schools were seen, the observer provided the recorder with the number of animals observed by species, and other ancillary information. Because the computer software had a direct GPS link, the location, date, and time of all sightings were automatically recorded when observations were entered. When right whales were seen, the aircraft typically broke off the survey path to obtain 35 mm or digital photographs of the animals for photo-identification.

Post-survey, the electronic survey data sets were audited /corrected based on in-flight notes and edited for reasonableness. The data were then reformatted for analysis.

Analysis

Analysis of the right whale sightings data involved the following steps: :

1. Identify those right whale sightings which met the trigger criteria (= events)
2. Define and map the core area
3. Define a 15 nm radius buffer around the core
4. For each year, draw polygon around the circular buffer zones, and join overlapping polygons
5. Overlay the SAM areas from all three years, eliminate the SAM areas that occurred only once during the three years, and draw an outline around the remaining SAM areas
6. Smooth the remaining areas to account for existing closures and zone systems

Sightings from every survey day during 1999-2001 were reviewed to identify events sufficient to trigger a Dynamic Area Management closure. The trigger used was a sighting of three or more right whales sufficiently close to one another to achieve a density of 0.04 right whales/nm² (Clapham and Pace 2001). This is equivalent to a minimum of 3 whales within a 75 nm² area. The latitude, longitude, number of animal involved, and date and time of each event) were recorded in a dBase data set, and the events plotted using ARCVIEW 3.1.

Whales sighted in an event were assumed to occupy a circular core area with an average density of 0.04 right whales/nm². This core area was mapped by defining a circle around the centroid of the event. The core area varied directly with the number of animals sighted. That is, if 3 whales were sighted in an event the core area was ca. 75 nm² (4.9 nm radius), with the area increasing to 100 nm² (5.6 nm radius) for 4 animals, 125 nm² (6.3 nm radius) for 5 whales, etc.

A 15 nm radius buffer was then drawn around each core area to account for animal movements (Clapham and Pace 2001). An event with 3 animals and a core area of 75 nm² (4.9 nm radius) would then have a full circular protection zone of 1,244 nm² (4.9 nm radius + 15nm radius = 19.9 nm radius; full protection circular zone area = $\pi r^2 = 1,244 \text{ nm}^2$).

SAM zones were mapped for each analysis year (1999-2001) by drawing a simple polygon around each buffer area. Overlapping or adjoining polygons were joined. This produced three annual sets of SAM zones.

What distinguishes DAM and SAM is the predictability of whale concentrations. The Cape Cod Bay and Great South Channel Restricted Areas are examples of SAM zones as they were based on sightings of right whales reoccurring year after year in these areas. In our analyses, an area was considered to be a candidate SAM area if right whales were observed in this area during spring in all three years. If whales were observed in an area in only one year or in different months in different years, then this area was not considered as a candidate SAM area. We overlaid all three years of SAM areas, eliminated areas which were applicable to only one year, and drew boundaries around zones for the aggregate of years.

Finally, it was recognized that a number of groundfish and protected species management areas already exist in the Gulf of Maine. NMFS and the New England Fishery Management Council typically use a quarter degree square grid to align these zones (for ease of interpretation). The final boundaries of the SAM areas were therefore reconfigured somewhat so as to align with these with existing management areas.

Areas of the SAMs were calculated in ARCVIEW 3.1 using the U.S. referenced Albers Equal Area Conical Projection.

RESULTS

Sightings

A total of 1,307 right whales were enumerated in 784 sightings during the 1999-2001 NMFS aerial surveys (Table 1). This total does not include sightings by the Center for Coastal Studies which surveyed the Cape Cod Bay Restricted Area. As a result, the NMFS surveys contain very few sightings of right whales in Cape Cod Bay, even though right whales commonly occur in the Bay during late winter-early spring.

Few animals were seen outside of Cape Cod Bay in March (1.8%) or July (5.6%; Table 2). Most animals were seen in May (43.8%), June (32.3%) and April (16.4%), due in part to greater sighting effort in these months.

Survey sightings in March-April (Figures 1-3) tended to be in the areas surrounding Cape Cod, MA (e.g., Provincetown Slope). By May, however, right whales were regularly sighted along the northern edge of Georges Bank and in the Great South Channel. Animals were consistently seen in all three years in these areas and in the Wilkinson Basin through June, with a tendency for animals to be seen further north as the season progressed. During April and June in 1999 and 2000, right whale concentrations were observed in the Cashes Ledge area. However, similar concentrations were not found in any month during 2001 (despite survey coverage of the Cashes Ledge area in three months).

Events

Concentrations of right whales meeting the triggering criteria occurred 149 times during 1999-2001. This included 38, 42, and 69 events in 1999-2001, respectively (Table 1). The number of events peaked in May (67 events or 45%), followed by June (44 events or 30%) and April (23 events or 15%) (Table 2). The fewest events occurred in July (9 events, 6%) and March (6 events, 4%).

The number of whales in events that met the trigger criteria ranged from 3 to 29 (Fig. 4). The average number of whales in an event was 6.2 and average group size varied little among years (5.7 to 6.7; Table 1). Average group size was smallest in March (3.8), and ranged between 5.8 and 7.3 during April through July (Table 2).

Seasonal Area Management Zones

A geographic zone drawn to encompass all 149 events (without buffers) during March-July 1999-2001 enclosed a total area of about 10,200 nm² (Fig 5). Enlarging the zone to include the buffer areas around the events (Fig. 6) increased the zone size to 17,000 nm² (Fig. 6).

Comparing SAM zones among the three years (Fig. 7) revealed a consistent pattern in habitat use in areas outside of the Great South Channel and Cape Cod Bay. Whales were consistently seen in all three years in the area from Cape Cod eastward to the Hague Line, but only sporadically occurred to the north (e.g., the Cashes Ledge Area).

Aggregating the three annual SAM zones together (but excluding areas where animals were seen only once in the three years), yielded the aggregate SAM zone shown in Figure 8. Almost all of 784 right whale sightings during the 1999-2001 NMFS aerial surveys occurred within this aggregate zone.

Smoothing and realigning the aggregate SAM boundaries with existing management areas produced two possible SAM zones (Fig. 9). One is the Core zone (ca. 7,000 nm²) which extends eastward from Cape Cod to the Hague Line and is where right whales were consistently sighted in all three years. The other area is the Northern zone (ca. 1,700 nm²), located to the north of the Core zone, where right whale sightings occurred sporadically in some months in two of the three survey years.

The Core zone, in combination with the existing Cape Cod Bay (CCB) and Great South Channel (GSC) Restricted Areas, encompasses 134 (90%) of the 149 events during 1999-2001. Of the 15 events not included, 4 were from 1999 (3 April, 1 May), and 11 from 2000 (all June). All events from 2001 occurred in the combined Core/Restricted Area zone. Of the 784 sightings, only 94 (12%) occurred outside of this zone, with 64 of these sightings of single animals.

Within the Core zone, right whale events occurred more frequently in the western part of the area (near Cape Cod Bay and the Great South Channel) in March-April than in May-July (Fig. 10). During March-April, 13 of the 15 events outside of the CCB and GSC restricted areas occurred in the Core SAM zone west of 69.4° W longitude. Conversely, during May-July all of the events within the Core SAM zone which were not in the GSC closure, were east of 69.4° W longitude. Hence, a possible break point is suggested in the seasonal distribution of right whales in this area.

DISCUSSION

Apart from Cape Cod Bay and the Great South Channel, there are several other areas in the Georges Bank/Gulf of Maine region where North Atlantic right whales consistently aggregate each spring. Despite less complete survey coverage in the Core SAM zone than in the GSC area (Fig. 8), the number of right whale events (49) in the SAM zone during 1999-2001 was comparable to that in the GSC (66). As such, implementation of the Core SAM zone would afford significant additional protection to right whales from interactions with fishing gear and ship strikes.

The protection afforded to right whales by the Northern SAM zone is less clear, as it is presently uncertain as to whether the events in this zone are reflective of predictable distribution patterns. The 1999-2001 NMFS aerial surveys in this area only detected right whale concentrations in April-May 1999 and in June 2000. No such concentrations occurred in 2001, despite increased survey effort. Aerial survey work in 2002 and 2003 should help clarify right whale distribution patterns in the Northern Zone area.

During 199-2001, NMFS survey coverage was adequate in the Core SAM zone and in the GSC area and was supplemented by excellent survey coverage in the CCB area by the Center for Coastal Studies. Outside of these areas/zones, annual coverage during 1999-2001 included only

occasional surveys of reported right whale “hot spots” (e.g., the Cashes Ledge area). Thus, the lack of observations of right whales outside of the well-covered survey areas may be as much a function of survey effort as it is the absence or presence of right whales. It is hoped that the surveys planned for 2002-2003 will resolve this issue.

Since all of the aerial survey effort to date has been limited to late March-early July period, the distribution of right whales in other months has not been captured. While it is well known that some right whales are present in Cape Cod Bay and the Georgia-Florida critical habitat area during December-March, most right whales are elsewhere at the winter period. Even in mid-summer and early fall when many right whales are concentrated in the Bay of Fundy, large number of whales occur elsewhere. New survey efforts need to be conducted in the Gulf of Maine during the fall-winter period to determine whether right whales are using this habitat during this time of year.

The lack of synoptic spatial and temporal coverage becomes obvious when sighting observations are corrected for sighting effort. Such an analysis (R. Pace, unpubl. data) yields a checkerboard of blank cells interspersed with a few cells with observations. One point seems clear, however, high whale densities occur in the GSC in part because of the large sighting effort in this area. Ongoing work at the NEFSC and the New England Aquarium to correct sightings for effort, coupled with additional surveys, should provide improved estimates of right whale habitat use.

Despite several shortcomings with the existing survey data, it is evident that there are areas (i.e., the Core zone) where right whale persistently aggregate which are outside of the areas officially designated as critical habitat. Such areas should be considered for inclusion as critical right whale habitat and as prime candidates for Seasonal Area Management.

ACKNOWLEDGMENTS

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Table 1. North Atlantic right whale surveys and sightings by year--1999-2001.

	Survey Year			
	1999	2000	2001	Total
Surveys				
First survey	March 3	March 23	March 22	
Last survey	June 30	July 6	July 16	
Sightings				
Right whale sightings	220	241	323	784
Total individual whales	302	350	655	1307
Average number whales per sighting	1.4	1.5	2.0	1.7
Events				
Sightings meeting DAM trigger criteria (events)	38	42	69	149
Total individual right whales seen in events	216	250	462	928
Average number whales per event	5.7	6.0	6.7	6.2

Table 2. North Atlantic right whale sightings and events by month.

	Month					Total
	March	April	May	June	July	
Sightings						
Right whale sightings	19	151	360	211	43	784
Total individual whales	24	215	573	422	73	1307
Average number whales per sighting	1.3	1.4	1.6	2.0	1.7	1.7
Events						
Sightings meeting DAM trigger criteria (events)	6	23	67	44	9	149
Total individual whales seen in events	23	143	388	319	55	928
Average number whales per event	3.8	6.2	5.8	7.3	6.1	6.2

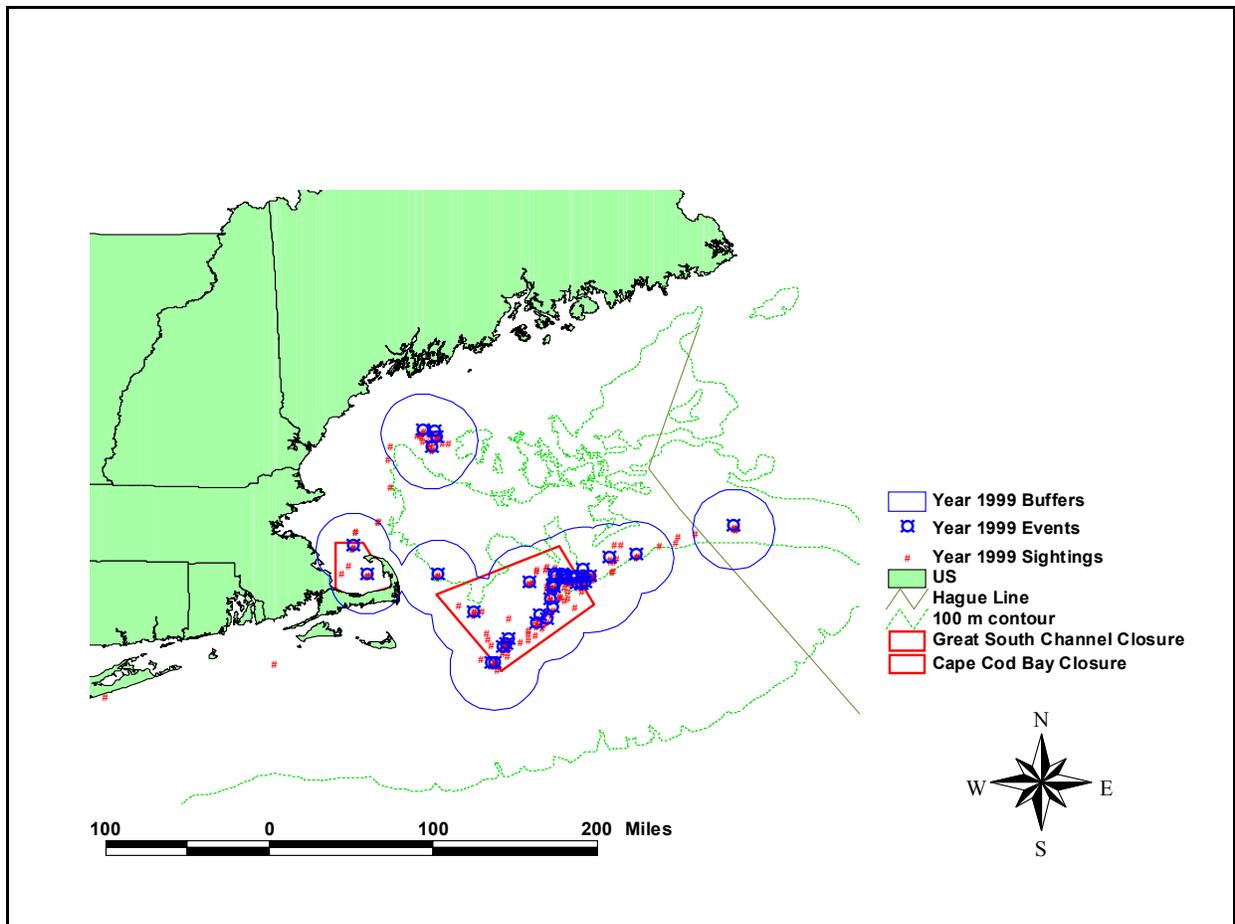


Figure 1. Sightings, events, and buffers for 1999.

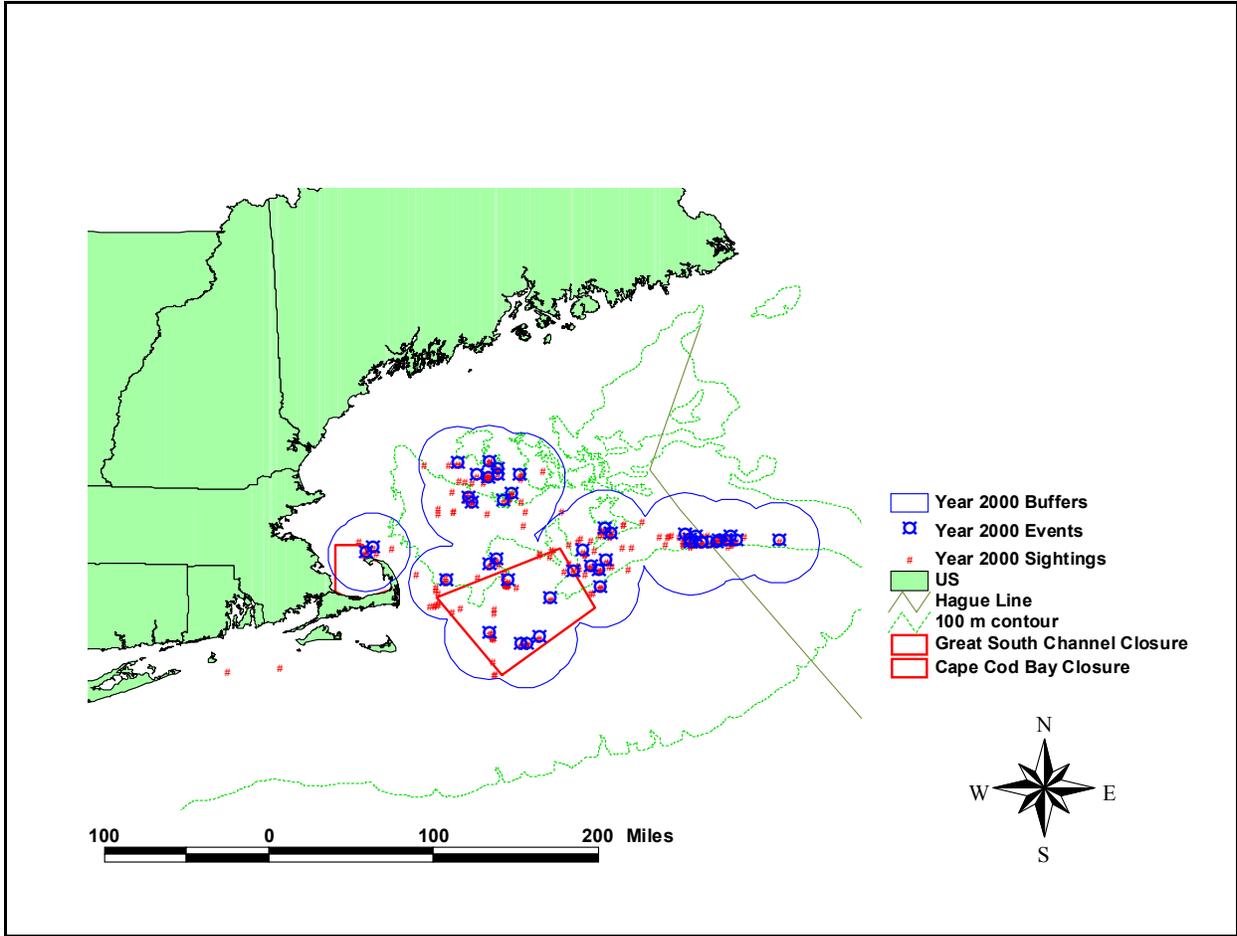


Figure 2. Sightings, events, and buffers for 2000.

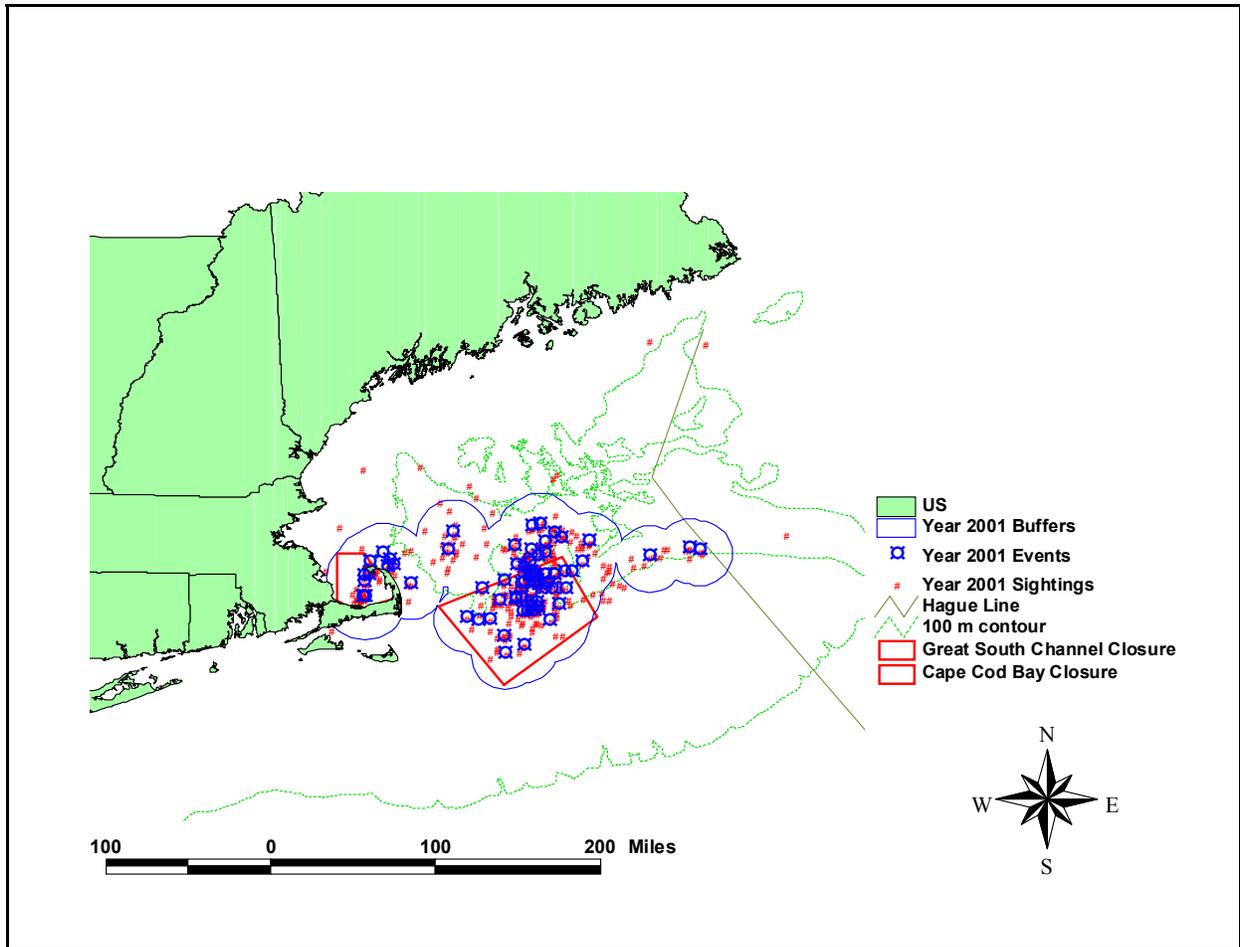


Figure 3. Sightings, events, and buffers for 2001.

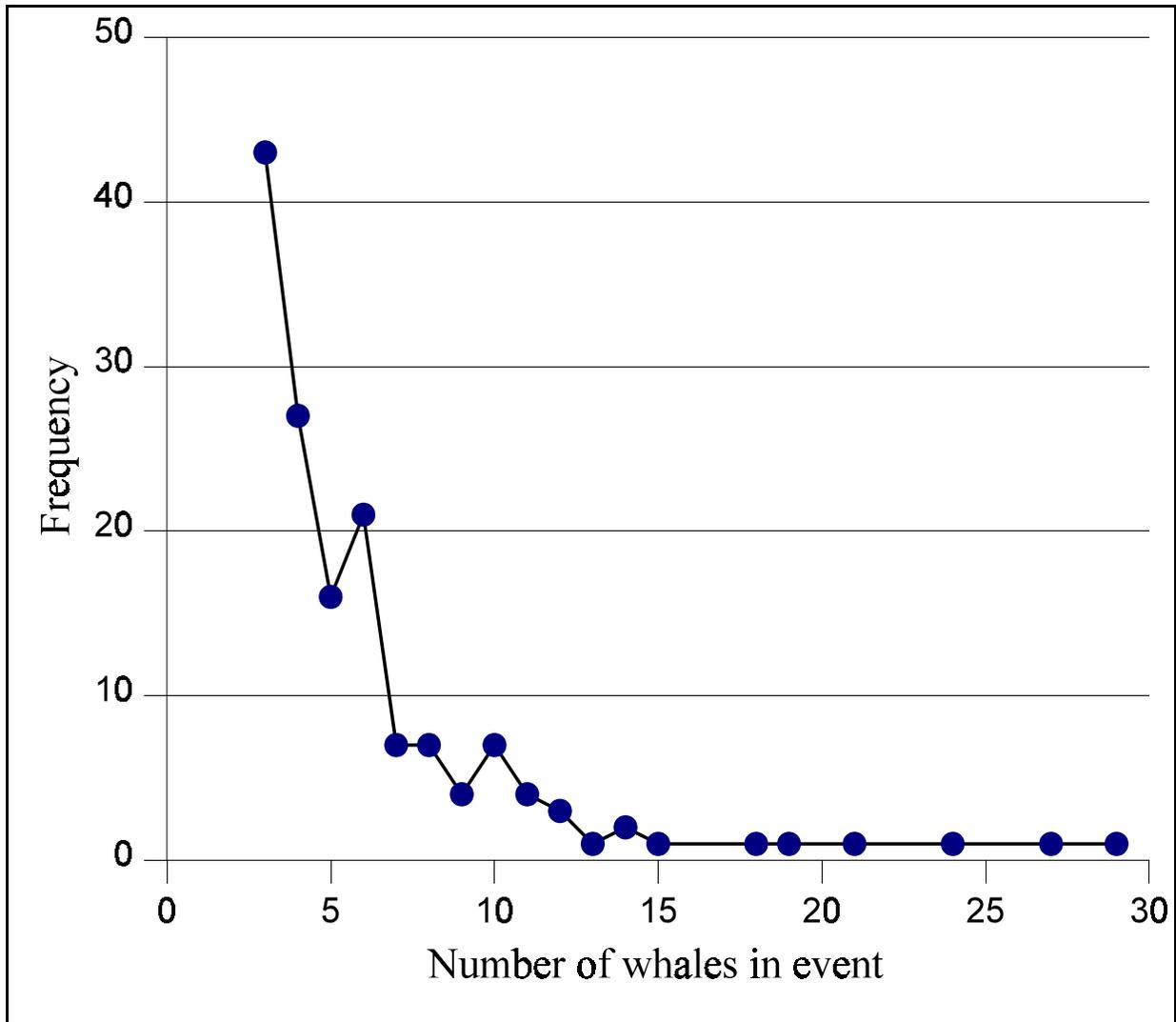


Figure 4.—Frequency of events by size

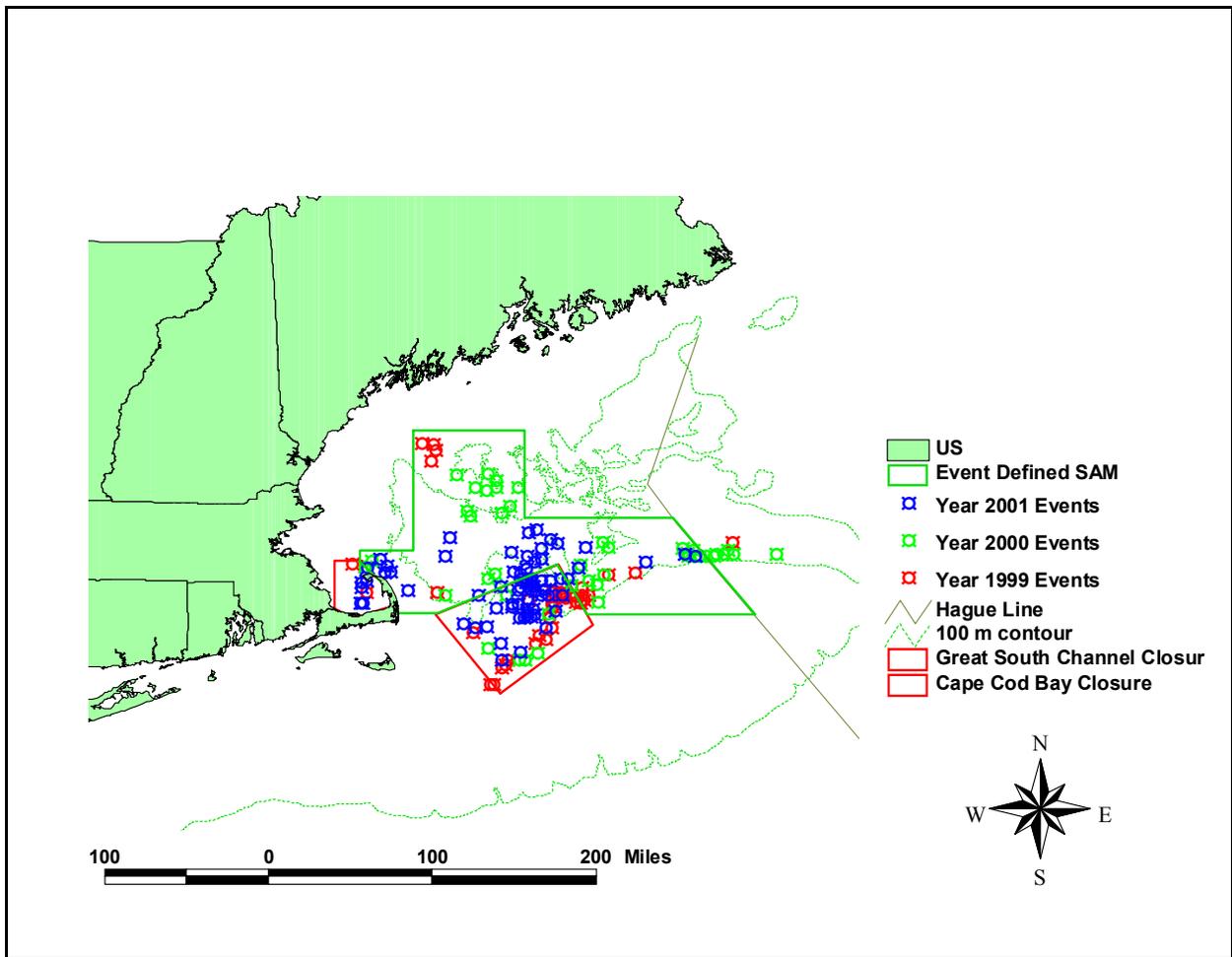


Figure 5. Overall SAM definition based on 1999-2001 events.

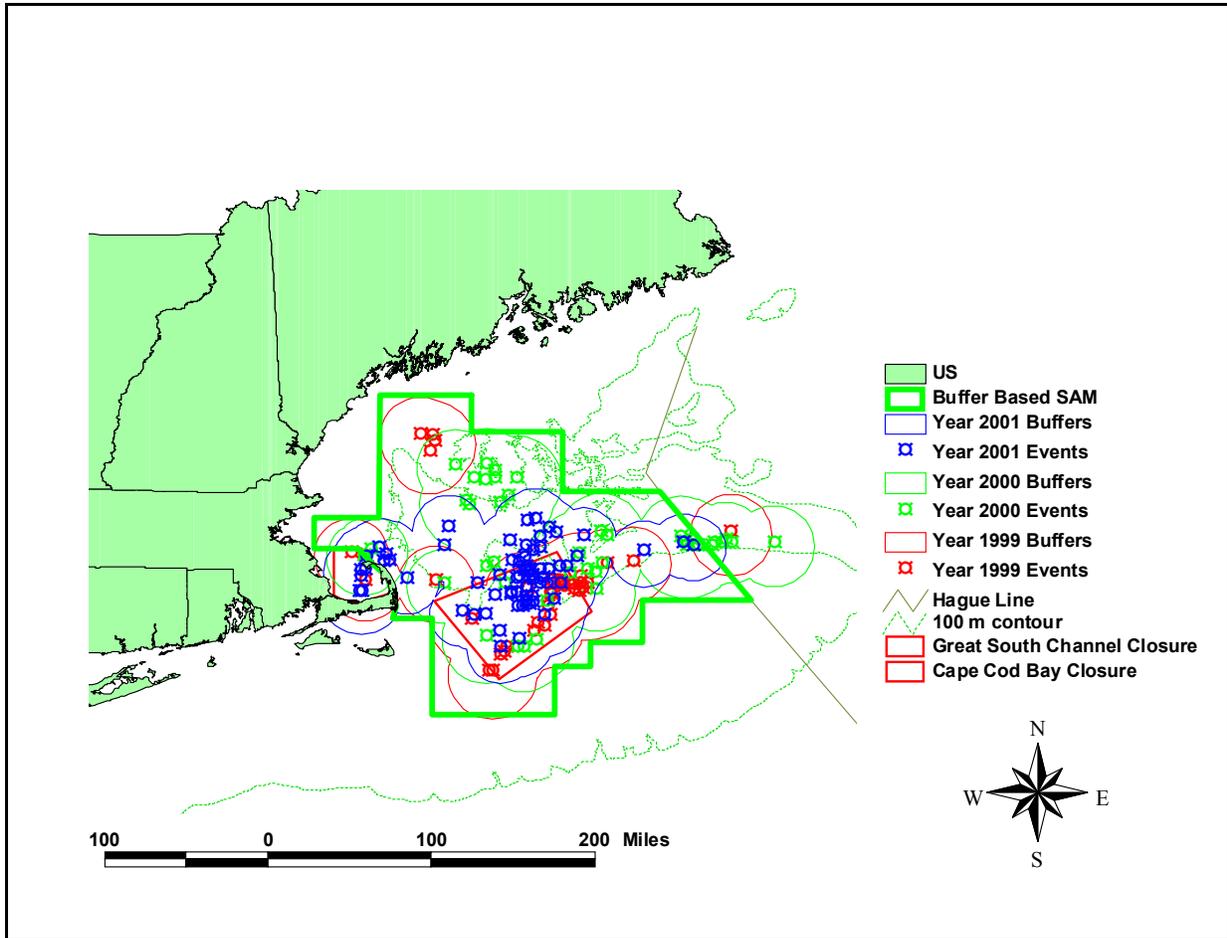


Figure 6. Overall SAM definition based on 1999-2001 buffers.

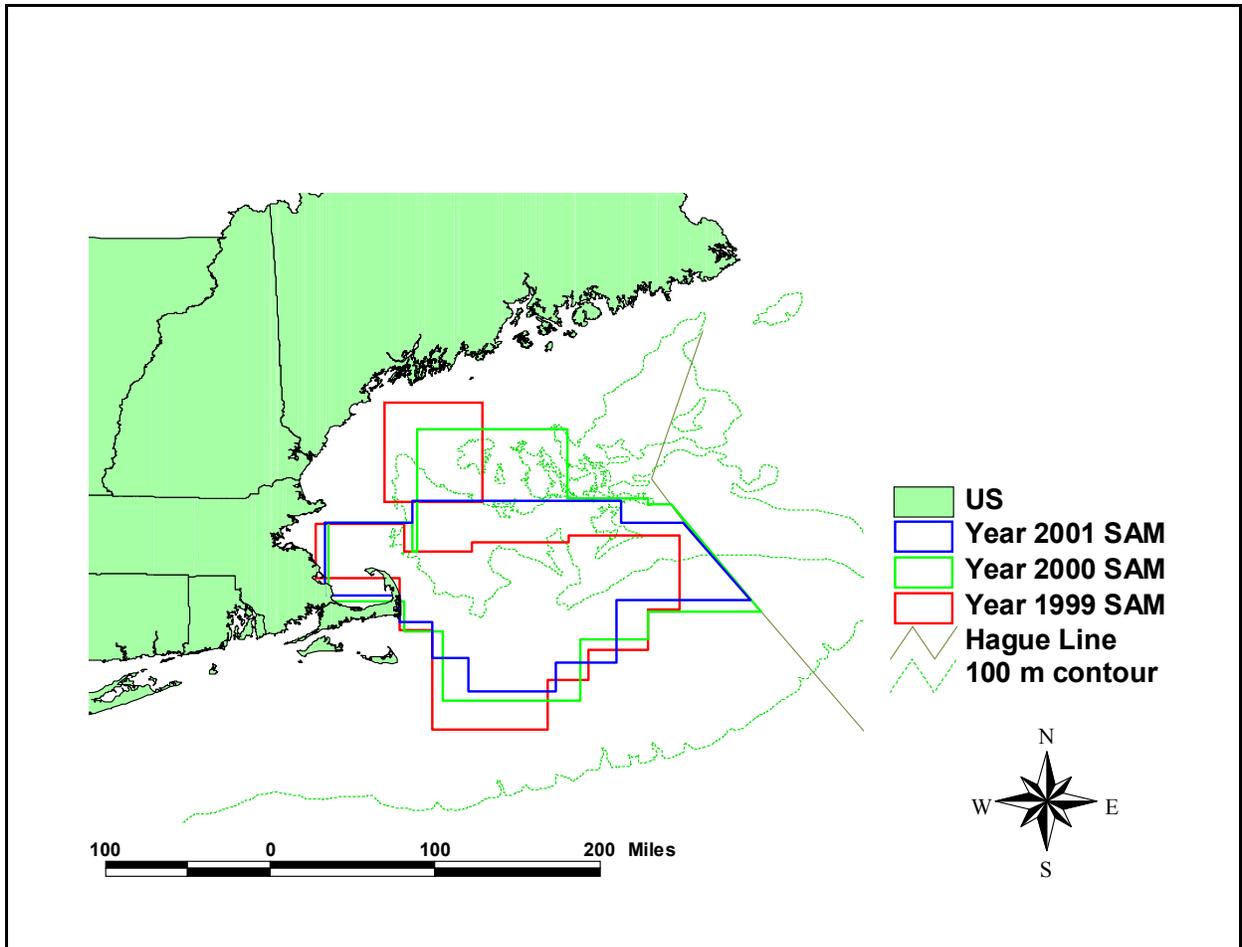


Figure 7. Annual SAM definitions for 1999-2001.

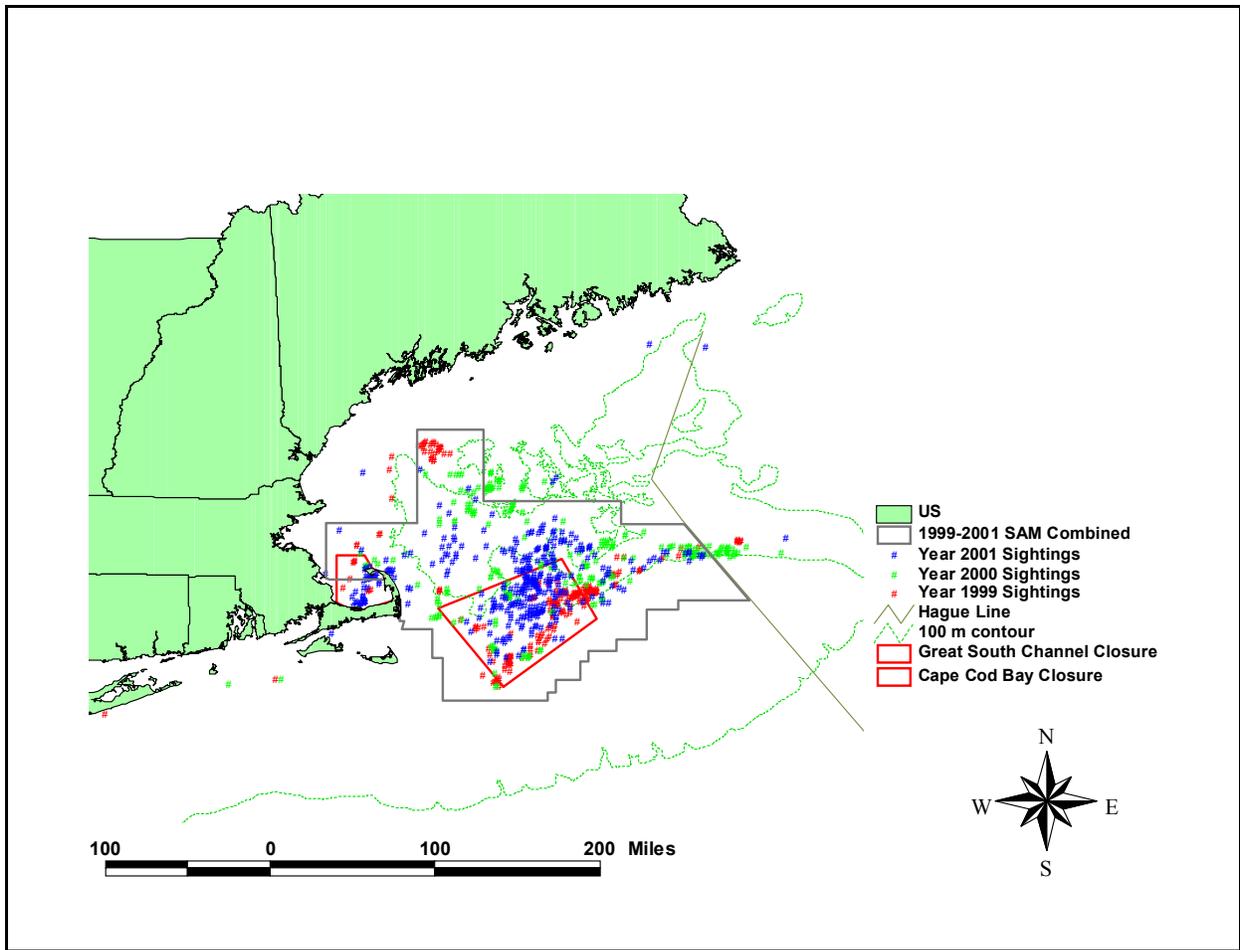


Figure 8. Aggregate SAM zone with 1999-2001 sightings overlaid.

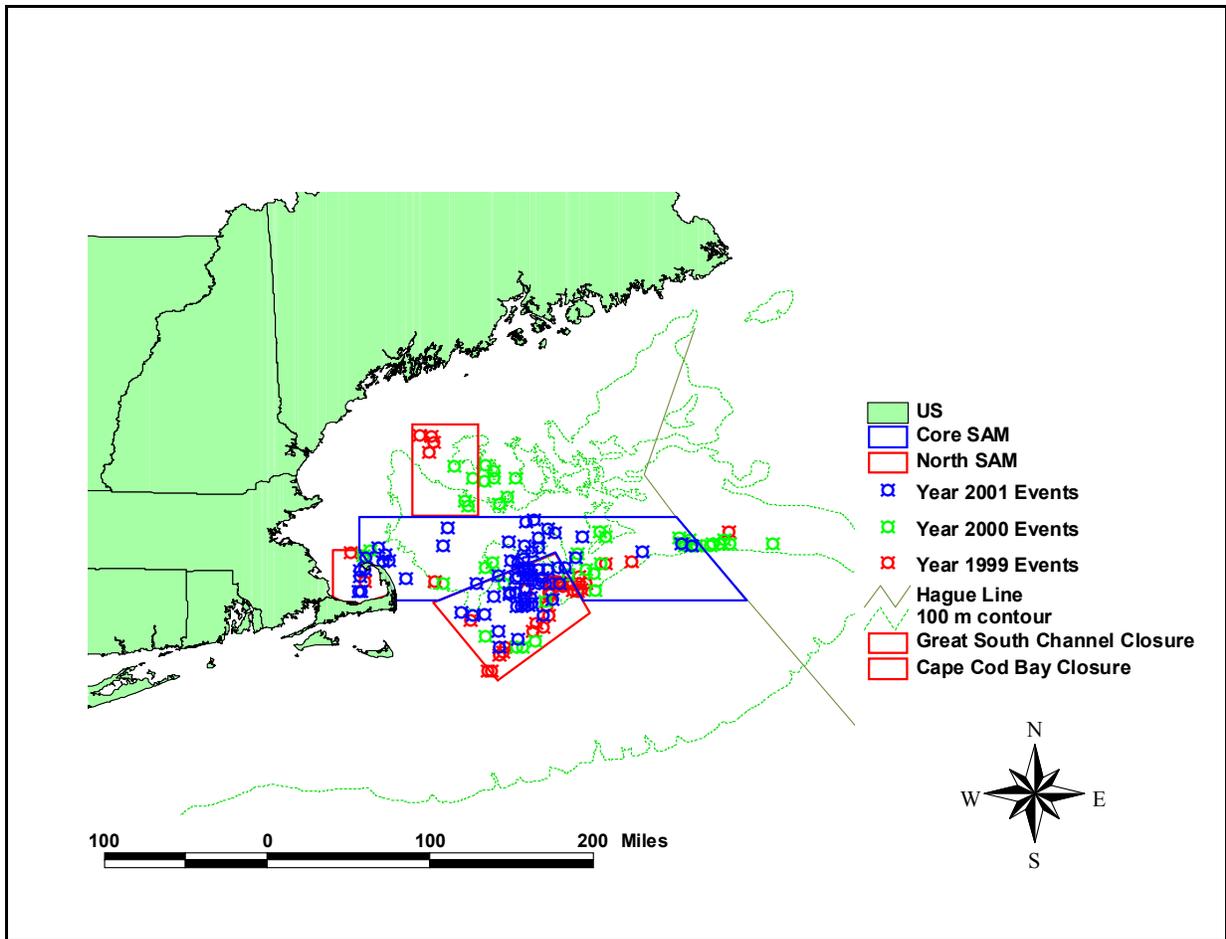


Figure 9. Two potential SAM zones with 1999-2001 sightings events overlaid.

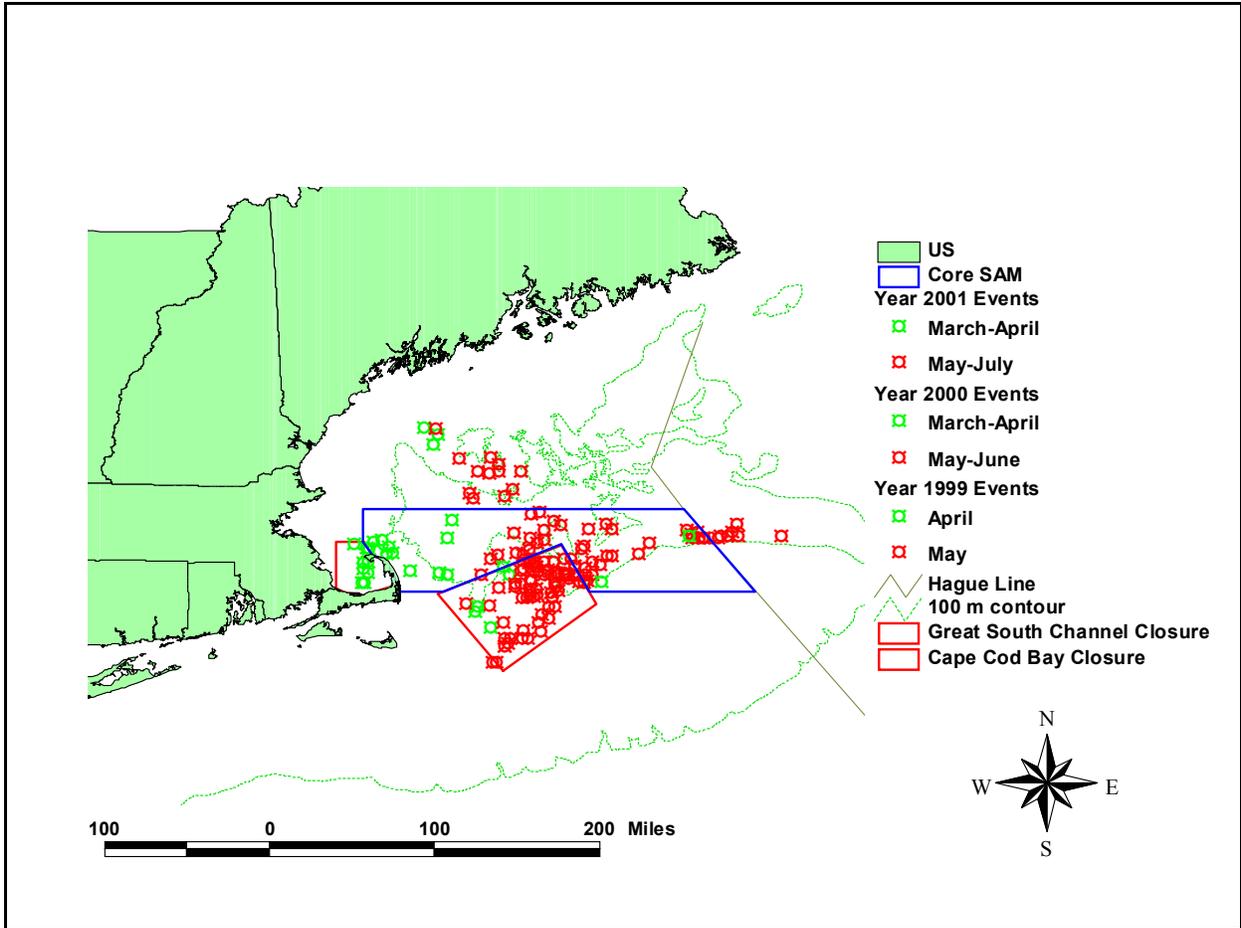


Figure 10. Seasonal distribution of right whale events with potential SAM zone overlaid.

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The mission of NOAA's National Marine Fisheries Service (NMFS) is "stewardship of living marine resources for the benefit of the nation through their science-based conservation and management and promotion of the health of their environment." As the research arm of the NMFS's Northeast Region, the Northeast Fisheries Science Center (NEFSC) supports the NMFS mission by "planning, developing, and managing multidisciplinary programs of basic and applied research to: 1) better understand the living marine resources (including marine mammals) of the Northwest Atlantic, and the environmental quality essential for their existence and continued productivity; and 2) describe and provide to management, industry, and the public, options for the utilization and conservation of living marine resources and maintenance of environmental quality which are consistent with national and regional goals and needs, and with international commitments." Results of NEFSC research are largely reported in primary scientific media (e.g., anonymously-peer-reviewed scientific journals). However, to assist itself in providing data, information, and advice to its constituents, the NEFSC occasionally releases its results in its own media. Those media are in four categories:

NOAA Technical Memorandum NMFS-NE -- This series is issued irregularly. The series typically includes: data reports of long-term or large area studies; synthesis reports for major resources or habitats; annual reports of assessment or monitoring programs; documentary reports of oceanographic conditions or phenomena; manuals describing field and lab techniques; literature surveys of major resource or habitat topics; findings of task forces or working groups; summary reports of scientific or technical workshops; and indexed and/or annotated bibliographies. All issues receive internal scientific review and most issues receive technical and copy editing.

Northeast Fisheries Science Center Reference Document -- This series is issued irregularly. The series typically includes: data reports on field and lab observations or experiments; progress reports on continuing experiments, monitoring, and assessments; background papers for scientific or technical workshops; and simple bibliographies. Issues receive internal scientific review, but no technical or copy editing.

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The Shark Tagger -- This newsletter is an annual summary of tagging and recapture data on large pelagic sharks as derived from the NMFS's Cooperative Shark Tagging Program; it also presents information on the biology (movement, growth, reproduction, etc.) of these sharks as subsequently derived from the tagging and recapture data. There is internal scientific review, but no technical or copy editing, of this newsletter.

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