Surveillance, Monitoring and Management of North Atlantic Right Whales, *Eubalaena glacialis*, in Cape Cod Bay, Massachusetts: January to Mid-May, 2000.

Final Report

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Contract No. SCFWE3000-8365027

October 15, 2000

Executive Summary

The Cape Cod Bay Critical Habitat Area and adjacent waters are an important winter and spring feeding areas for the North Atlantic Right Whale. Right whales, first recorded in Cape Cod Bay in the 1600s, have been the subject of research efforts by scientists at the Center for Coastal Studies since 1984. An intensive surveillance and monitoring program has been carried out for the last three years (1998,1999 and 2000) as part of the Massachusetts Division of Marine Fisheries Right Whale Conservation Plan. In 2000, the right whale surveillance team was in position on Cape Cod for 138 days from 1 January to 17 May 2000. Aerial surveys were conducted on 37 days in Cape Cod Bay (33 days) and adjacent waters (4 days). Vessels were on the waters of Cape Cod Bay for a total of 29 days.

The pattern of seasonal residency of right whales in Cape Cod Bay was somewhat different to previous years. The right whales arrived later than the last two years, were present in typical numbers in February and March, then departed abruptly around 11 April. The first right whale was seen in Cape Cod Bay on 20 January. The first full aerial survey was not conducted until Jan 20 because of extremely bad weather conditions that exceeded our safety requirements. The vessel was out on the water in Cape Cod Bay on 6 January, but no right whales were seen. There were a total of 425 photographed sightings of right whales collected during 33 aerial survey days and 81 photographed sightings of right whales collected during 29 vessel days in Cape Cod Bay. During our aerial survey efforts in adjacent waters (Great South Channel and Georges Basin), after right whales had departed from Cape Cod Bay, we obtained 44 photographed sightings of right whales. Thus there were a total of 550 photographed right whale sightings analyzed for this report. All sightings were reported promptly at the completion of each survey to the National Marine Fisheries Service Ship Advisory System.

To date, of those 550 photographed sightings, 470 (85%) have been matched to a total of 112 individual right whales. Of these 112 right whales, 86 individuals were seen in Cape Cod Bay and 26 in the Great South Channel. Of the 86 right whales identified in Cape Cod Bay, eight of those right whales had not previously been identified in the waters around Massachusetts. There are an additional 10 whales that have yet to be matched to an individual in the catalog that are different from the 86 whales, so the minimum count for right whales in Cape Cod Bay is 96 in 2000.

In 2000, between 1 January and mid-May, there were two reports of entangled right whales (#s 1130 and 1167) seen during surveillance flights by DMF/CCS and NMFS/NERO. Neither of these whales was successfully disentangled in Cape Cod Bay, despite our best efforts. One of these, #1167, was seen on three days in the Bay of Fundy in August 2000 and appears to be free of gear. There were two more whales (#s1301 and 00-31) that we realized were entangled when photographs were being examined for individual identification. In both cases the entanglement was not obvious during any aerial observations, marks were observed from the airplanes that were interpreted to be line scars. It was only upon close examination of the photographs that it was determined that the scars were actually line or wire wrapped around the whale just behind the flippers. An effort to disentangle these whales will be mounted as soon as these whales are seen again. Given these examples, greater effort will be directed in future surveys to right whales observed with what appear to be line scars, by decreasing altitude and circling for several surfacings of the whale, to look for any evidence of entanglement.

Since 1980, 72% of the cataloged right whales have been seen in Cape Cod and Massachusetts Bays. Research efforts in Cape Cod Bay alone in just the last three years (1998, 1999 and 2000) have identified 143 different right whales, which represents 66% of the portion seen both

Cape Cod and Massachusetts Bays. The Cape Cod Bay Critical Habitat Area is clearly established as an important area for right whales from early December through mid-May.

Acknowledgments

We are most grateful to all of our dedicated colleagues who spent the winter and spring in planes and on boats in Cape Cod Bay to make this work possible. Aerial observers included Lisa Conger (NEAq), Carolyn Hogg, Bill Hoffman (DMF), Rob Johnston (DMF), Brian Kelly (DMF), Amy Knowlton (NEAq), Brenna Kraus (NEAq), Erin LaBrecque (NEAq), Stephanie Martin (NEAq), Dan McKiernan (DMF), Melissa Morrow (CCS intern), and Cathy Quinn (NEAq). Thank you to Philip Hamilton and Amy Knowlton at the New England Aquarium with for help with data analysis and confirming matches of right whales to the NEAq catalog. Special appreciation is extended to Chandler Lofland and John Ambroult who kept our plane flying smoothly all season, and landing safely despite the winter conditions that prevailed in January. We would also like to extend our thanks to Captain Russell Webster of the USCG for providing us with a pre- and post-flight call-in service to make sure we landed safely and on hard ground. Special thanks to Ed Lyman who, in addition to his research and other duties, kept all the boats shipshape under winter conditions with help from Ken Perry.

Dr. Stormy Mayo, associate scientist Ed Lyman and Amy DeLorenzo conducted the oceanographic sampling and photo-identification efforts aboard R/V *Shearwater* with the assistance of Captain Ken Perry. We would also like to thank Michael Moore for a day of biopsy darting and photo identification on the M/V *Hannah T.* Many thanks to Charlie Westcott for keeping everything running smoothly on the administrative end of the project. Thank you to Stephanie Martin for preparing the cover page and photograph. Special thanks to Jennifer Beaudin Ring who worked so diligently to prepare the figures for this report despite me sending her an email virus at the crucial time.

These vessel and aerial surveys were conducted under a Scientific Permit to Take Marine Mammals No. 633-1483-01 issued by the NMFS to Dr. Charles Mayo. This permit is valid until 31 March 2004. A report of our research activities for 2000 will be submitted to NMFS permitting office. This work was supported primarily by a contract from the Massachusetts Division of Marine Fisheries, the habitat portion of the program was supported by a grant to Dr. Mayo from the Massachusetts Environmental Trust.

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Abbreviations used in the text: **ESA** – Endangered Species Act; DMF - Massachusetts Division of Marine Fisheries; **CCS** - Center for Coastal Studies; **NEAq** - New England Aquarium; **URI** - University of Rhode Island; **USCG** - United States Coast Guard; **NM** - nautical mile, **NMFS** -

National Marine Fisheries Service; **NEFSC** - Northeast Fisheries Science Center; **NERO** - Northeast Regional Office; **SAS** - Ship Advisory System; **WHOI** - Woods Hole Oceanographic Institution.

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Introduction

The northern right whale, *Eubalaena glacialis,* one of the rarest large whales in the world, is listed as "endangered" under the Endangered Species Act (ESA) of 1972. It is estimated that no more than 350 remain in the western North Atlantic (CeTAP 1982, Brownell *et al.* 1986, Kraus *et al.* 1988, NMFS 1991, Knowlton *et al.* 1994) despite international protection from commercial hunting since 1937. Scientists and conservationists have long been concerned about the status of the North Atlantic right whale population and its slow rate of growth (about 2.5% per year in the 1980s, Knowlton *et al.* 1994). Recent analyses showing a decrease in the reproductive rate, an increase in the calving interval (Kraus *et al.* In press), and a decline in the survival rate (Caswell *et al.* 1999) suggest we should view the present situation in the 1990s with greater concern.

The apparent failure of this population to recover has been attributed to a variety of factors including mortality from collisions with ships and entanglements in fixed fishing gear (Kraus 1990, Kenney and Kraus 1993, Knowlton and Kraus In press). There have been 46 right whale deaths reliably documented since 1970. Of those 46, 16 right whale fatalities were due to ship strikes, and three were the result of entanglement in fixed fishing gear (Knowlton and Kraus In press), 13 were of natural causes (calf mortalities) and 14 of unknown cause (NEAq unpublished data). Ship collisions kill more right whales than any other documented causes of mortality and one half of the ship collision mortalities have been recorded in the 1990s.

Right whales are known to occur in Cape Cod Bay, Massachusetts, and adjacent waters* in all months of the year, with the peak of occurrence from February through April (Schevill *et al.* 1986, Winn *et al.* 1986, Hamilton and Mayo 1990, Payne *et al.* 1990, Brown 1994). Surveillance and monitoring efforts over the last three years have demonstrated that Cape Cod Bay is an important winter and spring feeding and socializing area from December through mid May (Brown and Marx 1998, 1999).

The Cape Cod Bay ecosystem is one of five known seasonal high-use habitat areas for this species in the western North Atlantic. Cape Cod Bay was federally designated a Critical Habitat for the North Atlantic right whale in 1994 (Federal Register 59 FR 28793, Figure 1). This is in recognition of its seasonal importance as an area for feeding, socializing and as a nursery area for cows and calves (Kraus and Kenney 1991), including a number of cows that are rarely seen in the other three northern habitat areas (Knowlton *et al.* 1992, Brown 1994).

Right whales are slow moving (particularly when accompanied by a calf), they are difficult to see when feeding at or just below the surface, and do not always avoid approaching vessels, especially when socializing or feeding near the surface. These factors, set against the moderate level of ship traffic in the region, make the right whale vulnerable to collisions with vessels in Massachusetts waters. Knowlton and Kraus (in press) have documented two right whales that have been killed by ships near this area, one in 1986 (found off Provincetown), the second in 1996 (found near Wellfleet). A third right whale was found dead in Cape Cod Bay in April 1999. A necropsy was performed and the cause of death was blunt trauma, likely the result of a collision with a ship (Brown and Marx 1999). This number of mortalities, however, is the minimum count because not all carcasses are found and recovered.

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* Adjacent waters includes the federal waters of the Cape Cod Bay Critical Habitat and those waters over- and adjacent to-Stellwagen Bank in Massachusetts Bay (e.g. Stellwagen Basin), as well as waters east of Cape Cod.

Right whales are also at risk of entanglement in fixed fishing gear in the area. Some fishing activity is either prohibited (gill nets) or use of modified gear is required in the Cape Cod Bay Critical Habitat area. These modification include sinking ground line between lobster pots, at least two pots per vertical line, twin orange flag markers on buoy stick and a 500lb break away link at the buoy (322 CMR 12.05 Critical Habitat gear restrictions during January 1 to May 15). Most of the fixed fishing gear in the Cape Cod Critical Habitat Area is located in the northern margins along tracklines one, two and three (Table 1, Figure 1) in depths greater than 30 fathoms. There is fixed fishing gear set to the west of the western margin of the Critical Habitat, that is not subject to the above modifications because it is outside the Critical Habitat area. A few right whales have been reported west of the Critical Habitat area in the past (Brown and Marx 1998, 1999).

Photographic identifications of right whales in Cape Cod Bay date from 1959 to the present (Hamilton *et al*, 1997, Brown and Marx 1998, 1999), however, whaling records provide evidence of right whales in this area from at least the early 1600s. Over the last twenty years, 72% of the cataloged population of right whales have been photo-documented in Cape Cod and Massachusetts Bays at some time during their lives (CCS and NEAq, unpublished data). These photographic data have been collected during by various means. Recent survey efforts include twice weekly aerial surveillance flights and weekly vessel-based habitat studies from January to mid-May in 1998, 1999 and 2000 (Brown and Marx 1998, 1999 and this report). Prior to 1998, there were weekly vessel surveillance and limited aerial surveys in the winter and spring in 1997 (Hamilton *et al.* 1997, Mayo 1997) and annual studies on foraging of right whales in the winter and spring since 1984 (Mayo and Marx, 1990). Researchers gathered opportunistic sightings from whale watching vessels from April through October until 1996. The latter platform, which yielded many valuable sightings of right whales (including some rarely seen mothers with calves) in the late spring, summer and fall, and reports of entanglements (NEAq unpublished data), is no longer available due to a 500 yard exclusion zone around right whales for non-permitted vessels.

While the use of the Cape Cod Bay ecosystem by right whales has occurred for hundreds of years, human activities have only impacted the area relatively recently. In order to gain a better understanding of both the spatial and temporal distribution of individually identified right whales in Cape Cod Bay, an extensive surveillance and monitoring research program was undertaken in the winter and spring of 1998 (Brown and Marx 1998), 1999 (Brown and Marx 1999) and 2000 (this report). The Massachusetts Division of Marine Fisheries, and the Massachusetts Environmental Trust support this effort. The research directly addresses concerns identified by the Right Whale Conservation Plan submitted by the Commonwealth of Massachusetts to federal courts in 1996, the Northeast Implementation Team; and supported goals in the federal Atlantic Large Whale Take Reduction Plan, the Right Whale Recovery Plan (NMFS 1991), and the ESA. The objectives of the 2000 surveillance, monitoring and management program were:

I) To document the right whales in the Cape Cod Bay Right Whale Critical Habitat area and adjacent waters from January through mid-May, 2000, using photo-identification techniques to identify individual whales. These data provide information on the age, sex, reproduction, distribution, abundance and patterns of habitat use (residency) of right whales in Cape Cod Bay and help refine long-term, range-wide analyses on presumed mortality, incidence of scarring and demographics. Photographic and sighting data were integrated into the right whale photo-identification catalog at the New England Aquarium and the sighting database at the University of Rhode Island.

II) To provide sighting data to the National Marine Fisheries Ship Advisory System. Sighting locations of right whales were reported promptly to NMFS/SAS at the completion of each survey. The goal was to ultimately reduce the probability that right whales will be killed by collisions with large vessels by providing near "real-time" sighting data within Massachusetts waters to port authorities, commercial and military vessels, and other maritime operations.

III) To monitor right whales in the study area for evidence of entanglement. Each right whale encountered was examined visually for any evidence of attached gear. The disentanglement team is on standby was ready for immediate dispatch in the event an entangled whale was reported.

IV) To describe the distribution and abundance of any other marine mammals and shipping activity in Cape Cod Bay and adjacent waters from January through mid-May, 2000.

V) To collect oceanographic information on weekly vessel cruises, from January to mid-May, 2000, designed to develop an understanding of the characteristics of the habitat to which right whales respond. These oceanographic data, combined with data from past habitat studies in Cape Cod Bay by the Center for Coastal Studies, provide additional information on the conditions which are believed to cue the movements and activities of right whales in Cape Cod Bay and adjacent waters.

Here we report on the results of the research activities in 2000 as described above in objectives I through IV. All photographs of right whales collected during oceanographic sampling (objective V) have been incorporated with the analysis of aerial photographs and their identifications are included in this report. The data and results of the oceanographic sampling program (objective V) are contained in Mayo, Lyman and DeLorenzo (2000) Monitoring the Habitat of the North Atlantic Right Whale in Cape Cod Bay in 2000 and Comparison of Seasonal Caloric Availability in Cape Cod Bay with North Atlantic Right Whale Calving Rates: 1984 - 2000.

Methods

I) Aerial Surveys

Aerial surveys were conducted from January through mid May in the Cape Cod Bay Critical Habitat and adjacent waters (Figure 1). The aerial survey protocol for Cape Cod Bay as described in Kraus *et al* (1997) was adopted with some modifications (Brown and Marx 1998, 1999). Fifteen tracklines were flown latitudinally (east - west) at 1.5 nautical mile (nm) intervals from the mainland to the Cape Cod shoreline (Figure 1). An additional trackline, 25 nm in length, paralleled the outer coast of Cape Cod from east of Chatham to the eastern end of trackline one at a distance of about three nm from shore (Figure 1). The east-west flight pattern in Cape Cod Bay was chosen for scientific and safety reasons. In these latitudes, winter aerial surveys are hampered by low sun angles in the early and latter portions of a survey day and glare is a significant factor in sightability of marine mammals. On east-west tracklines, although glare was a factor in one of the forward quadrants, there was always a section of the survey swath that could be observed without being compromised by glare. It was also safer to have the aerial survey tracklines begin and end near land. A total of 320 nm of 'on-trackline' miles were flown during each completed survey (Table 1). "On-trackline" miles are those miles flown while surveying due east or due west in Cape Cod Bay and along the eastern side of Cape Cod, but excludes all miles flown between tracklines or while circling.

The surveys were flown under VFR (visual flight rules) conditions up to and including Beaufort sea state four. Surveys were aborted in Beaufort sea state five and/or when visibility decreased below two miles in fog, rain or snow. All aerial surveys were conducted in a Cessna 337 Skymaster (5382S), a twin engine high-wing aircraft. The aircraft was equipped with GPS (global positioning system) and LORAN-C navigation systems, full IFR (instrument flight rules) instrumentation, marine VHF radio with external antenna, a life raft, four survival suits, signal flares, a medical kit, a waterproof VHF radio, a portable EPIRB, and an aircraft mounted ELT (emergency locator transmitter). All occupants wore aircraft approved PFDs (personal floatation device) during the entire flight.

Surveys were conducted at a standard altitude of 750 feet (229 meters) and a ground speed of approximately 100 knots, using methodology developed by CeTAP (Scott and Gilbert 1982, CeTAP 1982). The survey team consisted of a pilot, data recorder, and two observers positioned on each side of the aircraft in the rear seats. The two rear seat observers scanned the water surface from 0° - 90°, out to at least two nautical miles and reported sightings when they were abeam of the aircraft. In order to maintain a standardized sighting effort, the pilot and data recorder were instructed not to alert the observers to any sightings until after it had been passed by the aircraft and clearly missed by the observers.

All sightings of marine animals except birds were recorded. Sightings identified as species other than right whales were counted, logged and passed without breaking the trackline and circling in order to maximize flight time available for investigating right whale sightings. Sightings of all vessels in the area were recorded by location and type. At sightings identified as right whales, as well as sightings of large whales, which were not immediately identified by species, the aircraft broke track at right angles to the sighting and circled for photographs. Photographs were obtained of as many individual right whales within a given aggregation as possible. For each right whale, behavior and interaction with any nearby vessels was noted. In a few instances, when right whales were spotted from the plane in close vicinity to R/V *Shearwater*, the vessel was contacted from the plane and photographs were taken from the vessel so that the plane could devote more time to surveying. The right angle distance of each sighting from the flight track was determined from GPS positions.

At the conclusion of photographic work at each sighting, the aircraft returned to the trackline at the point of departure using the GPS right angle sighting position recorded in the log. These methods conform to research protocols followed by the North Atlantic Right Whale Consortium (CCS, NEAq, URI, and WHOI) and approved by the U.S. NMFS. Trackline and sighting data from the daily logs were entered into the Right Whale Initiative DBase program designed for compatibility with the Right Whale Consortium database. Copies of the daily logs from the aerial surveys are on file at CCS.

II) Vessel Surveys

CCS maintains two research vessels: the 40' (12m) twin diesel engine R/V *Shearwater* and the 28' (8.5m) twin outboard engine R/V *Gannet.* The R/V *Shearwater* has been used successfully for photo-identification and oceanographic sampling in the winter surveillance program in Cape Cod Bay, 1997 - 1999. The R/V *Gannet* (and one trip the R/V *Hannah T*) was used for additional photo-identification and biopsy sampling. In addition we used the F/V *Dixie II* to investigate sightings in Provincetown harbor in December 1999.

Dr. Charles 'Stormy' Mayo, associate scientist Ed Lyman and research assistant Amy DeLorenzo conducted the oceanographic sampling at no cost to this contract. (The collection and analysis of the oceanographic samplings outlined below was made possible by a grant to Dr. Mayo by the Massachusetts Environmental Trust. DMF supported the vessel time. See Mayo, Lyman and DeLorenzo, 2000, for details on data collection and results in 2000.) The R/V *Shearwater* was equipped with oceanographic sampling equipment including a CTD (conductivity, temperature, depth), plankton nets, surface plankton pump, and flow meter. These basic oceanographic data will be used to develop an understanding of the characteristics of the habitat to which the right whales respond.

Although the primary objective of these vessel cruises was habitat sampling, some photographs were collected opportunistically of any right whales in the vicinity during sampling and on transits to and from sampling sites. Photographs of right whales obtained during habitat studies were integrated with the photographs collected during aerial surveillance and included in analyses of residency, capture rates, demographics, and life history. The vessel sighting data were included in the report to the NMFS/SAS system. Sighting data from the daily vessel logs were entered into the Right Whale Initiative DBase program as opportunistic surveys.

CCS is the only institution on the U.S. east coast with federal authorization from NMFS to perform disentanglements of large whales, and in 1996 the Center developed a Rapid Response Rescue Program with the US Coast Guard to enable disentanglement of whales at sea (funded by NMFS). In the event that an entangled whale was seen during aerial surveys, CCS was to be contacted from the aircraft and the vessel dispatched immediately to assess the situation and proceed with disentanglement protocols. During vessel surveys in which the R/V *Shearwater* was used, the equipment required for response to a disentanglement was on board at all times.

Additional vessel trips were conducted using R/V *Gannet* to provide supplemental photo-identification and collect biopsy samples (see below). Surveys on the R/V *Gannet* followed systematic north – south tracklines, they were conducted at a speed of 12 knots, in sea conditions with visibility of greater than two nm and sea state of Beaufort four or less. The team consisted of three or four experienced right whale researchers. Positions included a helmsperson/data recorder and two observers on watch. Watch positions were rotated as required to reduce fatigue and exposure to cold. The two observers were positioned on the flybridge or at the bow and each one scanned the water surface out from the bow, to the port and starboard respectively, to a perpendicular distance of three nm. All sightings of marine animals (except birds) were counted and recorded. The location of each sighting was determined using a GPS navigation system.

III) Notification of Agencies

Following the completion of each aerial survey and vessel trip, the number of right whales seen and the location of these sightings were reported to the person responsible for the NMFS Ship Advisory System, for dissemination by fax, Navtex, and marine weather radio to the appropriate agencies and mariners. Prior to reporting to the NMFS/SAS, any other whale research vessels operating in Cape Cod Bay and adjacent waters were contacted, any additional sightings were added to the report if from an area not already included in the CCS report. A daily summary of the location and number of right whale sightings was faxed to DMF and to the NMFS/SAS coordinator in Woods Hole, MA.

IV) Photographic Methods

i) <u>Identification Photographs</u>

During aerial and shipboard surveys, photographs were taken on Kodak Kodachrome 200ASA color slide film, using hand-held 35-mm cameras equipped with 300-mm telephoto lenses and motor drives. From the air, photographers attempted to obtain good perpendicular photographs of the entire rostral callosity pattern and back of every right whale encountered as well as any other scars or markings. From the boat, photographers attempted to collect good oblique photographs of both sides of the head, the body and the flukes. The data recorder on both platforms was responsible for keeping a written record of the roll and frame numbers shot by each photographer in the daily log.

ii) Photo-analysis and Matching

Photographs of right whale callosity patterns are used as a basis for identification and cataloging of individuals, following methods developed by Payne *et al* (1983) and Kraus *et al* (1986). The cataloging of individually identified animals is based on using high quality photographs of distinctive callosity patterns (raised patches of roughened skin on the top and sides of the head), ventral pigmentation, lip ridges, and scars (Kraus *et al* 1986). NEAq has curated the catalog since 1980 and to the best of their knowledge, all photographs of right whales taken in the North Atlantic since 1935 have been included in NEAq's files. This catalog allows scientists to enumerate the population, and, from resightings of known individuals, to monitor the animals' reproductive status, births, deaths, scarring, distribution and migrations. There are currently 19,019 sightings of 406 individual right whales of which 299 are thought to be alive, as of December 1999 (A. Knowlton, NEAq, pers. comm.)

Photographs taken during sightings of right whales were separated into individuals and inter-matched within the season. To match different sightings of the same whale, composite drawings and photographs of the callosity patterns of individual right whales are compared to a limited subset of the catalog that includes animals with a similar appearance. For whales that look alike in the first sort, the original photographs of all probable matches are examined for callosity similarities and supplementary features, including scars, pigmentation, lip crenulations, and morphometric ratios. A match between different sightings is considered positive when the callosity pattern and at least one other feature can be independently matched by at least two experienced researchers (Kraus *et al* 1986). Exceptions to this multiple identifying feature requirement include whales that have unusual callosity patterns, large scars or birthmarks, or deformities so unique that matches from clear photographs can be based on only one feature. Preliminary photo-analysis and inter-matching was carried out at CCS, with matches confirmed using original photographs cataloged and archived at NEAq. All matches to the catalog were integrated into the right whale database at NEAq.

iii) Photographic Data Archiving

Upon completion of the matching process, all slides will be returned to CCS and incorporated into our own catalog of identified right whales to update existing files, using the same numbering system as NEAq, in archival quality slide sheets. NEAq will archive copies of photographs representing each sighting taken during the course of this work. Copies of photographs of individuals that are better than existing records, and photographs of newly identified whales, will be included in the NEAq master files as "type specimens" for future reference. The master files are maintained in fireproof safes at NEAq and are cataloged by a numbering system. All catalog files are available for inspection and on-site use by contributors and collaborators.

V) Collection of Biopsy Samples

Techniques for the collection of skin and blubber biopsy samples from individually identified right whales is well established (Brown *et al* 1991). All biopsy sampling efforts were carried out in conjunction with photo-identification efforts. Immediately after adequate photographs for individual

identification were obtained, the boat approached the whale for a biopsy attempt. A slow parallel approach, similar to that used to obtain identifying photographs, has been shown to cause minimal disturbance to the whale (Brown *et al* 1991). Cylindrical biopsy tips, made of stainless steel were used. They have a flared rim with a stop collar to prevent deeper penetration. The stop collar also ensures rebound or release from the whale. Biopsy tips were attached to an arrow and sterilized prior to sampling to eliminate risk of infection. Right whales were darted at a range of about 5-15 meters (~15-50') using a crossbow with a draw weight of 68kg (150 lbs.). Arrows were retrieved either by an attached line or through the use of floatation collars. Tissue samples were extracted from the dart using sterile forceps, the skin portion was diced and placed immediately in a sterile, labeled tube, half filled with a preservative solution of saturated salt and 20% DMSO (dimethylsulfoxide).

Each right whale encountered on a particular day received a field identification number (e.g. "A" 30 AUG 97), which is used to identify the sample until the whale is matched to a specific individual in the right whale catalog. Upon return to shore, samples were stored in a refrigerator until shipped to the laboratory at McMaster University (Hamilton, Ontario) to be incorporated into ongoing genetic analyses funded, in part, by NMFS. Occasionally, there was a portion of blubber attached to the skin biopsy. The blubber portion was halved with a scalpel, one section was frozen in a glass vial and the other was frozen wrapped in tin foil. These samples were sent to Sara Wetmore at UMass, Boston and to Sara Iverson at Dalhousie University (Halifax, Nova Scotia) to be integrated with their studies on stable isotopes and fatty acid aging respectively.

VI) Data Management, Analysis, and Interpretation

i) Data Management

Aerial survey data and sighting data from vessel trips were transcribed from standardized field forms and recorded in computerized DBase files for each of the daily surveys in on-site computers. Copies of the daily logs and computerized data files have been sent to URI for entry into the Right Whale Consortium database. Data are proofed twice, once in the field from printouts made immediately after data-entry was completed, and the second time after they are processed at URI.

ii) Data Analysis and Interpretation

All sightings have been incorporated into the right whale catalog and Consortium database to be integrated with existing data on life histories for each individual identified. Integration of the sighting data collected during these surveys with previously collected data were used to describe the number, age, sex, and reproductive status of the right whales using the Cape Cod Bay habitat area in 2000. Transect data from the aircraft were charted to establish patterns of distribution and assess the seasonal and spatial residency patterns of the Critical Habitat and adjacent waters. The data on vessel locations were charted and compared with the locations of right whales to assess the level of overlap between right whales and vessels in the area. The exact location of fishing activity was not recorded during the aerial surveys, rather the trackline and beginning and end of the fixed gear were noted. Following discussions between the contractor and state biologist Dan McKiernan, it was determined that the counting and recording of fishing activity, that was already documented by other agencies, would take away observer effort from obtaining marine mammal sightings and identification photographs of right whales.

We used the individual identifications of right whales obtained during this study, to examine capture rate, residency and number of days between first and last sighting in Cape Cod Bay. An analysis of the age and sex composition of the winter and spring population was carried out using data from all CCS surveys to assess demographics and habitat use patterns. Right whales, first identified as

calves, ranging in age from one to eight years of age were classified as juveniles, individuals age nine or older were classified as adults. Whales that were not first sighted as calves were classified as unknown age for the first eight years of their sighting history and as adults thereafter. All females who have calved are classified as adult. Sexes were assigned based on one of three methods: 1) direct observation of the genital area; 2) by association with a calf; 3) by the testing of biopsy samples with a sex specific DNA marker (Brown *et al* 1994).

Results

Aerial Surveys

In 2000, the right whale aerial surveillance team was in position in Cape Cod Bay for 138 days from 1 January through 17 May. Our first flight was conducted on 7 January to verify the report of three right whales socializing at the surface east of Cape Cod off Nauset light in Orleans (Figure 2). We were unable to get airborne for a complete survey of Cape Cod Bay before 20 January when only one right was seen. Despite the slow start due to weather conditions that were unsafe for flying, there were a total of 37 aerial surveys conducted for the season, 33 of those flights were in the Cape Cod Bay Critical Habitat Area (Figures 2-6, Table 2). The last day on which we saw right whales in Cape Cod Bay was 11 April, for a minimum residency time of 83 days. There were also four flights in adjacent waters after the departure of right whales from Cape Cod Bay, three in the Great South Channel (Figure 7, 8a,Table 2) and one on Georges Basin (Figure 8b, Table 2). The total flight time and tracklines miles for the 2000 season were 151 hours to cover 10,098 nm of trackline.

The aerial survey team spent a total of 131 hours in the air surveying over 8,800 nm of trackline searching for right whales in Cape Cod Bay. The systematic pre-set tracklines in the Cape Cod Bay Critical Habitat Area (Figure 1, Table 1) were surveyed on average in approximately 4 hours and 30 minutes for those surveys that were not aborted due to an increase in wind speed, sea state (above Beaufort 4) or decrease in sighting conditions (to visibility less than two nm). Completed surveys ranged in duration from about three and a half to seven hours depending on the number of right whales encountered and the amount of circling required obtaining photographs (Table 2). The turn at the end of each trackline was initiated and completed about 1.5 nm from shore in Cape Cod Bay to maximize the opportunity to observe any whales near shore.

An additional 20 hours of flight time were directed to aerial surveys in adjacent waters following the departure of right whales from Cape Cod Bay (Table 2). The three flights in the Great South Channel (3, 4 and 12 May) were conducted in coordination with the NEFSC and NERO of the National Marine Fisheries Service using the tracklines laid out for the SCOPEX project (South Channel Ocean Productivity Experiment, Kenney *et al.* 1995). The flight to Georges Basin was based on previous sightings of right whales in this area in May 1998 and 1999.

The DMF provided state biologists to fill one of the observer positions on over half of the flights during the season. These biologists were trained in aerial observation techniques for marine mammals, aerial photography techniques for right whales and data collection. The following roster provides the number of flights and accumulated hours during the season for each observer. These researchers could be called upon to verify and document an out-of-season (mid May to December) right whale event.

State biologist	Number of flights	Hours flown
B. Hoffman	6	22.3
R. Johnston	3	7.6
B. Kelly	8	29.5
D. McKiernan	3	11.2
Total	20	70.6

Vessel Surveys

In 2000, the right whale habitat sampling team was in position in Cape Cod Bay for 136 days from 1 January through 15 May. There were a total of 29 vessel days in Cape Cod Bay in 2000 (Table 3). Shipboard surveys for habitat sampling were carried out on board the R/V *Shearwater* on 24 days and 18 of these occurred on the same day as an aerial survey. There were five additional cruises: two vessel trips were used to verify reports of right whales in Provincetown Harbor in December aboard the R/V *Gannet* and the F/V *Dixie II*. No right whales were located. The R/V *Gannet* was used on two more days to provide additional photo-identification effort in Cape Cod Bay, collect biopsy samples from individual right whales and verify sightings of right whales reported opportunistically in Provincetown Harbor. An additional biopsy sampling trip was conducted with Dr. Michael Moore of the Woods Hole Oceanographic Institution aboard the M/V *Hannah T* (Table 3).

The primary purpose of these habitat sampling cruises was to collect oceanographic data in the Cape Cod Bay Critical Habitat area weekly for 19 weeks. The results and discussion of the oceanographic sampling and an evaluation of the influence of food resources on whale distribution and occurrence are contained in the attached report (Mayo, Lyman, and DeLorenzo 2000).

In addition to their primary objective of habitat sampling, the research team on board the R/V *Shearwater* recorded all marine mammals observed and collected identification photographs of right whales as the opportunity presented itself (Table 3). The vessel crew located the first right whales on 8 February and the last ones were recorded on 11 April (Table 3). The photos collected on the vessel have been compared to the ones obtained from the aircraft and were taken through the same matching process as detailed above.

Sightings and Photo-identifications

There were a total of 425 photographed sightings of right whales collected during 33 aerial survey days and 81 photographed sightings of right whales collected during 29 vessel days in Cape Cod Bay (Tables 2 and 3). Additional 44 photographed sightings of right whales were obtained during three aerial surveys of the Great South Channel (3, 4 and 12 May) and one aerial survey of Georges Basin (May 17). Thus there were a total of 550 (425 + 81 + 44) photographed right whale sightings analyzed for this report.

To date, of those 550 sightings, 470 (85%) have been matched to a total of 112 individual right whales whose identification has been confirmed by NEAq researchers (Appendices I, II and III). Of these 112 right whales, 86 individuals were seen in Cape Cod Bay, and 26 were seen in the Great South Channel (Appendices II and III). Nine of those 26 whales were seen in both survey areas. Of the remaining 80 photographed sightings, 29 (5% of the total) of those have not yet been identified but these photographs do fit the criteria for matching and at this time are thought to represent another 10 individuals in Cape Cod Bay. These photographs are either of low quality, or the whale is only partially photographed and may only be matched if we collect other photographs of those whales in the future. These photographs will be reexamined for possible matches as more photos are added to the catalog. The final 51 photographed sightings (10% of all sightings) are not of sufficient quality to be matched, in most cases the whale was photographed while submerged subsurface feeding so the details of the callosity pattern are somewhat distorted by the water. Thus the total minimum count of right whales for the 2000 winter and spring surveillance program (as of 29 September, 2000) is 96 individuals identified in the Cape Cod Bay Critical Habitat area between January and mid-May.

A single right whale was seen on the first aerial survey on 20 January 2000 (Figure 2) so it is not possible to establish the date of their entry into Cape Cod Bay. The last two right whales were seen on 11 April (Figure 6) and neither the plane nor the vessel saw any on 14 April, so this likely represents the end of winter/spring residency period. The peak in sightings of right whales occurred between late February and late March (Tables 2, 3 and 4, Appendix II). There were no sightings of mother calf pairs this year in Cape Cod Bay and adjacent waters. The count of mother calf pairs was very low in the southeast U.S. calving ground, only one pair was seen between December, 1999 and March, 2000. This was the fourth year (other years were 1995, 1998, 1999) and the third year in a row since studies began in 1984 that no mother calf pairs have been sighted in Cape Cod Bay in the winter and spring.

Of the 86 right whales identified in Cape Cod Bay and matched to an individual in the catalog, eight of those right whales had not previously been identified in the waters around Massachusetts prior to 2000: #s 1624, 1630, 1817, 1971, 2540, 2608, 2617, and 2709. There were eight other right whales who had returned to Cape Cod Bay after a three to 14 year gap in their sighting record for this area (Appendix I): #s 1112 (last seen 1995), 1167 (last seen 1986), 1311 (last seen 1997), 1403 (last seen 1996), 1409 (last seen 1995), 2040 (last seen 1990), 2143 (last seen 1997) and 2602 (last seen 1996 as a calf)).

There were nine first time residents identified in 1999: #s 1716, *1812*, 1981, 2710, 2740, *2750* and three (3) new whales that did not have a catalog number: 99-5 (now *2760*), 99-42 and 99-183 The three italicized whale were seen again in 2000. There were nine first time residents of Cape Cod Bay identified in 1998 (1162, 1270, *1701*, *1968*, *2223*, 2240, *2271*, 2503, and *2705*). The five italicized whales were seen again in 1999, the underlined whales were seen in 2000, and appear to have become regular visitors to the Cape Cod Bay habitat area (Appendix I). Of the 143 right whales to have been documented in Cape Cod Bay in the last three years, 19 % (n= 27) have been seen for three years in a row.

Sightings outside the Cape Cod Bay Critical Habitat

There were a number of right whales documented just outside the margins of the Cape Cod Bay Critical Habitat area. Three whales were recorded off Nauset Light in Orleans on 7 January. No identifications were obtained because the animals were upside-down in a social group during the observation, which was shortened by unsafe flying weather.

1. On 1 Feb, right whale #1114 (adult female) was seen outside the eastern margin of the critical habitat area (Figure 3b). This was the first of a total of 7 sightings, the remaining six sightings were all in the critical habitat area.
2. On 11 March, right whale #2430 (female, unknown age) was seen west of the critical habitat area (Figure 4a). This was her first sighting, the next three sightings were all in the critical habitat area.
3. Two whales were seen east of the critical habitat off Truro on 31 March (Figure 5a). Right whales # 1407 (adult female) and #1317 adult male. The first whale was seen the next day back inside the critical habitat feeding along a slick with eight other right whales, all of her previous eight sightings has occurred in the critical habitat area. Whale #1317 was not seen again during the season, her previous six sightings were all in the Bay.
4. The last two sightings outside of the critical habitat area were on the 1 April (Figure 5a), right whales #2320 (adult female) and #1027 (adult female). The first whale was seen again on 7 April

feeding along the slick off Race Point that persisted for about a week. Whale #1027 was not seen again that season and all of her earlier sightings had been in the critical habitat.

In total there were at least seven right whales seen outside of the critical habitat area. All of these whales have been seen in Cape Cod Bay in past years, and only one, #2320, was seen in the Great South Channel after leaving the Bay.

There were aerial survey efforts undertaken in other known right whale habitat areas along the east coast in the winter and spring - in the southeast U.S. right whale calving ground (NEAq) and in the Great South Channel (NMFS/NERO and NEFSC, Nantucket Sound (NMFS/NERO), Platts Bank and Jeffereys Ledge (NMFS/NEFSC). Photo-analysis has been completed for the photographs submitted from the southeast U.S. sightings and 10 of the 29 right whales seen in the southeast were also seen in during our flights, nine were seen in Cape Cod Bay and one in Georges Basin. All of these right whales except 1971 have been seen in Cape Cod Bay in previous years. Of note were two whales seen on 23 January in Cape Cod Bay, #s1971 and 2010, their sightings are listed below. Of note is whale #2010, first seen in Florida, then seen only 10 days later in Cape Cod Bay, returned to Georgia and Florida and back to Cape Cod Bay again. Ten days is the shortest transit time between the two areas documented to date.

Catalog Number	southern sighting (days between sightings)	Northern sighting (days between sightings)
1311 (adult male)	03-Feb-00 GA	23-Mar-00 CCB (47 days)
1423 (adult unknown)	12-Feb-00 GA	17-May-00 GOM (94 days)
1603 (adult male)	22-Jan-00 Fl	20-Feb-00 CCB (28 days)
1971 (adult male)		23-Jan-00 CCB
opposite direction	29-Feb-00 Fl (36 days)	
2010 (adult male)	12-Jan-00 Fl	23-Jan-00 CCB (10 days)
	16-Feb-00 GA (23 days)	
two migrations	29-Feb-00 Fl	23-Mar-00 CCB (22 days)
2135 (adult male)	22-Jan-00 Fl	20-Feb-00 CCB (28 days)
2143 (adult female age 9)	02-Feb-00 GA	23-Mar-00 CCB (49 days)
2223 (juvenile female)	31-Deb-99 Fl	11-Mar-00 CCB (70 days)
2430 (female unknown age)	15-Dec-99 GA	11-Mar-00 CCB (86 days)
2645 (juvenile female)	15-Dec-99 GA	08-Feb-00 CCB (54 days)

Photographs from the other aerial survey efforts by researchers at the NERO and NEFSC of NMFS have not yet been fully analyzed thus it was not possible to document movements of right whales between Cape Cod Bay and nearby waters at this time. We are able to document movements for the right whales that were seen in the Great South Channel and Georges Basin from the DMF/CCS plane. The results of the three aerial surveys in the Great South Channel on 3, 4, and 12 of May and on Georges Basin 17 May are shown in Appendix III. Of the 26 whales seen offshore, nine were previously seen in Cape Cod Bay in 2000. Of the remaining twenty whales, only three have been seen in Cape Cod Bay in the last three years (#s 1609, 2140, and 2303) and seven (#s 1028, 1055, 1156, 1233, 1423, 1950 and 1960) have never been seen in Cape Cod Bay at any time during their sighting history.

It is worth mentioning the observations of right whale #1133 over the last year. Right whale #1133 is an adult male, who was photographed in the Great South Channel on May 23, 1999 during a DMF/CCS flight. The same whale was next observed and photographed between 17 and 28 September 1999, in the Norwegian fiord Kvaenangen near Nordkapp (North Cape), Norway (69°57'N x 21°38'E), a distance of approximately 2400 nm from the Great South Channel, four months later. The whale was photographed again this winter in Cape Cod Bay on the 2 and 5 March.

Capture Rates and Residency

Of the 86 right whales identified or captured in Cape Cod Bay and matched to an individual in the catalog, 14 (17 %) were photographically captured on just one day (see below). The greatest number of days on which a single whale was captured was 12; four whales had this sighting profile. These long residency whales include # 1802, a 12 year old adult female, #1911, an 11 year old female, #2320, a female of unknown age, and #1608, a 14 year old adult female. Their Cape Cod Bay sighting histories respectively spanned 68 days from 30 January to 7 April, 58 days from 3 Feb to 31 March, 60days from 8 Feb to 7 April, and 45 days from 10 Feb to 25 march. This last whale, #1608, was seen 11 out of 12 survey days (Appendix II). Three of the five other whales that were seen more than eight times in the Bay were adult females, of the other two, one was a male of unknown age and the second of unknown sex and the age.

Days Photo'd	1	2	3	4	5	6	7	8	9	10	11	12
No. Photo'd (n = 86)	15	9	11	10	12	9	10	1	0	4	1	4

There were 71 right whales captured on more than one day (Appendix II). The number of days between first and last sighting was calculated for all right whales seen more than once that were not seen elsewhere between their first and last sighting in Cape Cod Bay. The number of days between first and last sighting for 71 right whales ranged from 2 to 68 days, with the mean being 28 days (S.E. = 19 days).

Demographics

Of the 86 right whales, there were slightly more males (42) than females (36) identified in Cape Cod Bay (8 of unknown sex), but there was no significant difference from a one to one sex ratio ($P = 0.497$). When these data were compared with the sex of right whales identified in this area in 2000 with those seen in 1999 or 1998, there was no significant difference in either case ($P = 0.763$, Brown and Marx 1999; $P = 0.654$, Brown and Marx 1998). With respect to age, the sample was dominated by adults, with 74 % adults (n = 64), 17% juveniles (n = 15) and 8% of unknown age (n = 7). This age structure is not significantly different from that of the right whale catalog ($P = 0.259$, Hamilton *et al* 1998) or from the age structure observed in Cape Cod Bay in 1999 ($P = 0.125$, Brown and Marx 1999) or in 1998 ($P = 0.809$, Brown and Marx 1998). The details of the demographic structure of the population in bi-weekly intervals are presented in Table 4.

Biopsy Samples

Biopsy samples were collected on two days in Cape Cod Bay in 2000 (March 7, March 14). A total of three samples were collected from right whales, #s1310, 1407, and 1911. A portion of the skin from these samples will be incorporated into ongoing genetics analyses. The remaining portion of the skin and blubber has been distributed to collaborators at two other institutions for ongoing studies on stable isotopes and fatty acid aging.

Notification of Agencies

At the completion of each survey, the information on the number of right whales and their location that day was sent to the DMF office in Boston and the NMFS/SAS office in Woods Hole. A total of 45 faxes were sent to the DMF and copied to NMFS/SAS coordinator, one fax for each day in which Cape Cod Bay and adjacent waters were surveyed by either plane or vessel or both. In order to expedite the distribution of the information to the marine community, the number and location of right whales was relayed by cell phone at the completion of each aerial survey. For vessel surveys, positions of right whales were relayed at noon and at the completion of each vessel survey. The NMFS/SAS distributed faxes to the marine community after the noon report and again after the last report of the day. The faxes were sent following the completion of mapping the data (using the Andren LoranGPS software program). On days when both the vessel and plane surveyed, sightings were combined into one fax. Daily sightings of right whales were incorporated, as available, from other researchers operating in Cape Cod Bay and adjacent waters including: Dr. M. Moore (WHOI, M/V *Hannah T*). The information contained in the fax included the location of each right whale sighting, the number of right whales per sighting and a chart showing the location of the sightings (Appendix IV).

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Sighting Distances

The perpendicular distance from the aircraft at which right whales were sighted was determined by recording the exact position on the trackline when whales were initially sighted and then recording the exact position as the first pass was made directly over the animals. The number of sightings within each distance in $1/10^{th}$ nm intervals is shown in Figure 13. A total of 125 sightings were used in this analysis (secondary sightings that were made after the plane had already broken track were not included). Sighting distances ranged from the trackline to 2.8 nm away. The average sighting distance was 0.67 nm. Seventy-four percent of the sightings were made with in one nm of the trackline and 13 percent were made between one and one and a half nm, and 13 percent at between 1.5 nm and 2.8 nm.

Other sightings

There were at least five other species of cetaceans, one species of pinniped and one species of shark sighted while performing these surveys (Tables 2 and 3, Figures 9 and 10). Fin whales, *Balaenoptera physalus*, were the most numerous other large whale encountered and white-sided dolphins, *Lagenoryhnchus acutus*, the most numerous toothed whale. Sightings of all marine mammals and sharks were entered into the database after each survey.

This database also contains coded entries for vessel traffic observed in the area. Commercial and military vessel traffic were compiled and plotted on a single chart to show their distribution relative to right whale sightings and the critical habitat area (Figure 11).

Human Impacts

a) Entanglement Reports

In the winter and spring, 2000, there were four right whales identified that were entangled in fishing gear. The details of the entanglement and the action taken in each case are described below. Two of the four right whales (#s1130 and 1167) were recognized as being entangled during a sighting from the airplane. In the other two cases (#s1301 and 00-31), the evidence of entanglement is similar and very subtle and was not obvious during field observations. The entanglement was only discovered

when examining the photographs for individual identification. For additional information relating to disentanglement, log onto the CCS web page at the following address (www.coastalstudies.org).

1. Right whale number #1130 (named Zebra)

This whale was first sighted in Cape Cod Bay at 41° 58.0 N x 70° 26.6 W on 1 March 2000, during a routine aerial survey. The whale was entangled, trailing a yellow and white bullet buoy about 200 feet behind. Aerial photos indicated that the line was wrapped around the left flipper, which was visibly discolored, there was no gear around the tail. The whale had last been sighted in the Bay of Fundy on 19 August 1999. There was no evidence of an entanglement at that time.

The aerial survey team notified the crew on board R/V *Shearwater* via marine radio. The vessel was already at sea conducting a habitat research cruise in another part of Cape Cod Bay. The survey plane stayed with the whale until the R/V *Shearwater*, three Massachusetts Environmental Police vessels, and a USCG 47' cutter arrived to begin the disentanglement effort. The plane stayed on site for another 105 minutes before having to leave the scene to refuel. It returned to the entangled whale at the request of the R/V *Shearwater* to confirm that the whale was still entangled, as gear was not visible from the rescue vessels. The Center for Coastal Studies personnel spent approximately 6 hours attempting to grapple the line with no success; no lines were cut and no telemetry buoys were attached. There have been no subsequent sightings of this whale as of September 2000.

2. Right Whale number #1301

First sighted on 23 March 2000 at 42°00.8 N x 70°11.8 W, and subsequently on 25 and 27 March (all in CCB). This whale was entangled in all of these sightings, but the entanglement was not discovered until mid-season photo-analysis. There appears to be some kind of gear, perhaps a single line or piece of wire, wrapped around her body, just behind the flippers, perhaps embedded in the blubber. The CCS rescue team was put on alert, ready to mount a disentanglement effort at her next sighting. Although she was photographed by the National Marine Fisheries Service (NMFS) aerial survey in the Great South Channel (GSC), on 3 May and 26 May, her entanglement went unobserved (though it is still apparent in the photos); thus, no disentanglement was attempted. This whale was previously seen 21 July 1999 in the Bay of Fundy, with no entanglement. There have been no subsequent sightings of this whale as of September 2000.

3. Right Whale number #1167

This whale was first sighted on 27 March 2000 during a NMFS survey over GSC (41° 05.3 N x 70° 58.0 W). The whale was entangled with approximately 200' of line with a red buoy. The gear appeared to be wrapped around the flipper or through the mouth; there is no gear on the tail. This whale had previously been sighted in the Bay of Fundy on 20 August 1999. There was no evidence of an entanglement at that time.

On 31 March 2000, #1167 was sighted in Cape Cod Bay at 42° 04.0 N x 70° 22.3 W; however, this identification was not confirmed until the post-season photo-analysis, and the entangling gear is barely visible in the photographs (the buoy appears to be deep underwater to the left of the peduncle). The NMFS survey plane resighted #1167 on 8 May, and a disentanglement effort was commenced. The Center for Coastal Studies rescue team successfully attached a telemetry buoy. The telemetry buoy came free from the whale on 10 May, but was retrieved on 12 May; no entangling gear was attached.

Right whale #1167 was seen in the Bay of Fundy this year on three occasions; 1, 11 and 22 August 2000, no gear was observed on the animal in the field and there is not any gear visible in the photographs.

4. Right Whale number #00-31 (not yet identified to a cataloged whale)

This whale was photographed on five different days during the season: 8 February 1, 5 and 27 March, and on 7 April. During post-season photo-analysis, it was discovered that the whale is entangled in the last sighting, on 7 April. It was definitely not entangled in any of the four previous sightings. The entanglement is very similar to that of #1301 (see above), i.e. there appears to be a single line wrapped around the whale, behind the flippers. But unlike #1301, the gear on #00-31 seems to be wrapped tightly enough to create an indentation. Right whale #00-31 appears to be a juvenile, and is perhaps a new whale to the population, thus we have no prior sighting record. There have been no subsequent sightings of this whale as of September 2000.

Ship interactions

There were no known collisions between ships and right whales in the winter and spring, 2000. On 1 March, there was a tug and tow observed with a right whale in front and one on each side. Observers on the DMF/CCS plane tried to radio in the tug on VHF channel 16, but there was no response from the tug. This was reported to Pat Gerrior, the person responsible for the NMFS/SAS and she followed up on the information. The company was based out of Staten Island, NY. They provided the name of the captain of the tug and had the captain call Ms Gerrior when he returned to Staten Island. The captain related that he and the mate of the tug were aware of the right whales around them that day. They had been off the Canal entrance since approximately 10AM 'running slow', that is, doing big circles by the CC buoy waiting for the weather to moderate and the tide to change. They transited the Canal later that day at about 5PM. The tug was standing by on VHF channels 13 and 14, but not channel 16.

Discussion

The data on right whales collected over the last three years have established Cape Cod Bay as an important right whale habitat area in the winter and spring to a significant portion of the population. Forty eight percent of the cataloged population has been documented in Cape Cod Bay in the last three years. Looking at all of the sighting data back to 1980, only 28 percent (n=83) of the active catalog of 299 right whales have not been seen in Cape Cod or Massachusetts Bays at some time in their lives. Although there have been research efforts since 1984, the last three years were far more intensive in terms of the length of the research season (January to mid-May), the numbers of hours spent surveying in airplanes and vessels, and the amount of data collected on individual animals. One of the more valuable products of this work is the increased awareness generated throughout the maritime community about the presence of right whales in these waters and the conservation efforts in Cape Cod Bay to foster their recovery. For example, in late April 2000, a number of fishing boats with officers from the Massachusetts Environmental Police on board, combed Cape Cod Bay for several days looking for ghost gear. A local fisherman, Gary Ostrom, spearheaded this effort. We are hopeful that a similar effort can be undertaken in January of 2001 to get the ghost gear out of the water before the right whales arrive.

In 2000, a total of 96 right whales were identified in Cape Cod Bay of which 86 have been matched to an individual in the right whale catalog. When the identification data from 1998, 1999 and 2000 were combined, a total of 143 different right whales have been documented in Cape Cod Bay.

Although right whales have been seen in Cape Cod Bay every month of the year, it was previously thought that this area was of prime importance between February and April (Schevill *et al.* 1986, Winn *et al.* 1986, Hamilton and Mayo 1990, Payne *et al.* 1990, Brown 1994). That period of time still represents the peak of occurrence of right whales. The data collected over the last three years, however, clearly establish Cape Cod Bay as a primary winter and spring feeding area for right whales from December through early May.

The subset of 86 individuals recorded in 2000 was used to examine the demographic profile of the winter and spring residents (Table 4). There were slightly more males seen than females, but the ratio was not significantly different from the cataloged population. More adults (74%) were seen than juveniles (17%) were. The percentages closely reflect that of the cataloged population which, uncharacteristically for a baleen whale, contains more adults than juveniles (Hamilton *et al.* 1998).

The demographic profile of right whales using the Cape Cod Bay habitat area had previously been described as one dominated by females and the regular seasonal presence of mother calf pairs in the late spring (Brown 1994, Winn *et al.* 1986). The last three years have been characterized by very low calf output. The annual count for the calving area in Florida was only six calves in 1998, four in 1999 and one in 2000. There were no mother calf pairs seen in Cape Cod Bay in 2000, the fourth such year (the others being 1995, 1998 and 1999) since 1982. The only mother with a calf seen in 2000 was right whale #1334 and those sightings occurred only on the calving ground in Florida and Georgia. This female has never been seen in Cape Cod Bay, or in any of the other traditionally nearshore habitat areas and is classified as an offshore mother (one who has never brought any calves to the Bay of Fundy in the summertime).

In 2000, as in 1999 and 1998, both the sex ratio and age structure of the winter and spring residents mirrored the demographics of the cataloged population. This suggests that all segments of the population use the region and that earlier demographic profiles may have been biased by a shorter field season (usually February through April) or that the more recent profile of the last three years is biased by the low number of calves born. A week by week demographic analysis is planned to investigate if there are seasonal patterns of habitat use by different segments of the population.

Right whales were in residence in Cape Cod Bay for at least 83 days, 58 days shorter than documented in 1999 and 25 days shorter than in 1998. This is due, in part, to an extension of the 1999 season with the first whales being seen on a pre-season flight on 13 December 1998 and a shortening of the 2000 season by a late start on 20 January 2000 due to unsafe weather conditions for flying. In comparison to the 1999 season, this effectively shortened the 2000 season by 38 days. The last two right whales were seen on 11 April. Although the aerial survey effort continued in good conditions with six more flights from 14 April through 8 May, no more right whales were seen in Cape Cod Bay. The mean minimum residency time (number of days between first and last sighting) was 28 days, about 10 days shorter than that recorded for 1999 (38.6days) and six days shorter than recorded for 1998 (33.9 days). However, despite the short season in 2000, the mean residency time was still twice as long as the mean of 11.8 days recorded for all right whales sighted between 1978 and 1986 (Hamilton and Mayo 1990), likely a result of increased effort in recent years.

The value of this expanded survey effort is underscored by the low number of whales that were only seen on one occasion in 2000. In 2000, only 17% of the whales were seen only once, in contrast to 1999, where 34% of the whales were seen on only one occasion, similar to that recorded for 1998 (31%). Whereas in 1997, over half (57%) of the whales were only seen once (Hamilton *et al.* 1998).

This is in contrast to the two previous years where it appeared that some whales may be moving through the area more quickly at different times during the season and thus less likely to be recorded on more than one survey. Due to the vagaries of winter weather it is always possible that some animals with short residency times could be missed. These data, however, will need to be corrected for effort to properly assess residency patterns in the area within a season.

The longest time to elapse between the first and last sighting of an animal was only 68 days, 40 days less than the longest residency in 1999 (108 days, possibly biased in length because of early sightings in December 1998 and a late start to the 2000 season). Of note is one whale, #2010, that was seen in Cape Cod Bay on 23 January and later in the season as well from 23 March until the 7 April. The sighting history spanned 76 days, but was not included in the mean residency time because this whale was seen in Florida both before the January 23 sighting and again in mid February before returning to Cape Cod Bay in late March. Only 10 days elapsed between the 12 January sighting in Florida and the 23 January sighting in Cape Cod Bay. This kind of pattern raises a number of questions about residency. We know this whale was not in Cape Cod Bay for the entire period, it exited and reentered the Bay at least twice. Many of the whales recorded in a single field season have long gaps between sightings. Gaps in sighting records within a season of two to four weeks in duration, despite the thorough survey coverage of the Bay, suggests there may be substantial movement in and out of Cape Cod Bay during a season. It is not generally known where right whales travel to when they depart the Bay in the winter months. The only other known winter habitat area is the southeast US calving ground and this is the first time we have documented a right whale moving back and forth between the two areas, with a migration time of only ten days in the case of #2010. Several have been recorded in Cape Cod Bay about a month after being sighted on the calving ground (Brown and Marx 1998, 1999 and this report, see above).

Our knowledge of medium-scale movements (medium-scale is defined as movements within an habitat area) both within Cape Cod Bay and within the larger area broadly defined as adjacent waters (i.e. Great south Channel, Jeffrey's Ledge, Wildcat Knoll), is quite poor and confounds our ability to understand how individual right whales use this area during their stay. It is important to understand the nature of right whale movements in the area to assess if there are some individuals or certain times during the season when animals are at increased risk from entanglement or ship collision from travels outside of the critical habitat area. The lack of knowledge about medium scale movements of right whales within Cape Cod Bay and in and out of the Bay to nearby areas was highlighted in 1999 by the death of right whale #1014 in late April (Brown and Marx 1999). This whale was seen in Cape Cod Bay on nine different survey days during an 89 day span. The blunt trauma she sustained that is believed to have resulted in her death was estimated to have taken place 7-10 days pre-mortem, and her last sighting in Cape Cod Bay was five days prior to the discovery of her carcass (20 April). She was likely already fatally injured at her last sighting alive, but there were no obvious signs of any injury.

In 2000, right whale #00-31 was photographed on five different days during the season: 8 February 1, 5 and 27 March, and on 7 April. During post-season photo-analysis, it was discovered that the whale is entangled in the last sighting, on 7 April. It was definitely not entangled in any of the four previous sightings. It was not possible to identify the gear from the photographs and without any idea of her movements between 27 March and 7 April, it is not possible to determine where the whale became entangled. Similarly, right whale #1301 was seen several times from the air by two different survey teams, but its entanglement was only discovered in post-season photoanalysis. In both cases, marks were observed from the airplanes that were interpreted to be line scars. It was only upon close examination of the photographs that it was determined that the scars were actually line or wire wrapped

around the whale just behind the flippers. Given these examples, greater effort will be directed in future surveys to right whales observed with what appear to be line scars, by decreasing altitude and circling for several surfacings of the whale, to look for any evidence of entanglement.

The questions surrounding residency and medium-scale movements and can really only be addressed when whales are tagged with a radio-monitored transmitter (satellite-monitored transmitters are useful only on much larger scales) and followed around in a vessel for as long as the weather and tag attachment permits. In addition, subsequent sightings of the tagged animal(s) in Cape Cod Bay during regular aerial surveys also would give us some measure of the frequency of sighting whales that are known to be in the survey area. For example, right whale #1608 was seen on 10 consecutive surveys days over a 26 day period in 1999 (Brown and Marx 1999). In 2000, she was seen on 11 out of 12 survey days over a 33 days period (Appendix II). Did she actually remained in the Bay the entire time and what were her movements were within the Bay. Tagging is a difficult task on right whales and we may have to wait until technology can overcome the risk to the animal and the problem with the animals knocking the tags off in social groups.

In Cape Cod Bay, the area with the greatest potential overlap between vessels and right whales occurs at the eastern end of the Cape Cod Canal. Although right whales are usually found in the middle and eastern portions of the Bay, there are records of right whales west of the western boundary of the critical habitat area (Figure 4a and Brown and Marx, 1998) and to the east off Truro (Figures 3b and 5a). Operators of the canal receive regular reports on the distribution of right whales in Cape Cod Bay and adjacent waters from NMFS/SAS, which they in turn relay to transiting ships. It was encouraging that the captain and mate of a tug and tow were aware of right whales in their midst (see above). In the absence of a technical solution to the problem of vessel collisions with whales, the only available options are governmental regulation to minimize the probability of collisions and voluntary efforts by those who operate vessels.

The aircraft based surveillance and photo-identification effort has proved to be a useful and effective survey platform in this habitat area. All but one (#2617) of the identified right whales were seen from the airplane, the additional identification of right whale #2617 was from photographs taken opportunistically from the R/V *Shearwater* during habitat sampling cruises. This was the only day this whale was observed. Photographs collected from the research vessel were an important part of the photo-identification effort. Vessel-based photographs are very useful for: identifying animals not seen from the air for getting good photographs of scars and lesions, assessing the health of whale, and to assist in the matching of animals photographed from the air but for which no previous aerial photographs exist. While more data on the identification of the whale and any associated scars or marks are collected from a vessel-based photograph (NEAq unpublished data), on several occasions whales were seen from the aircraft that were not visible to observers on a nearby boat because the whales were sub-surface feeding. Some of these whales were photographed from the airplane while their callosity pattern was submerged and in some cases the photographs were of sufficient quality to be matchable. This photographic technique, however, was not always successful, in some instances the whale was either too deep, the surface of the water was too rough or the water not clear enough to permit individual identification. Thus it is important to maintain the photographic effort from both vessel and aerial based platforms.

The next task with these three years of data combined is to assess the existing boundaries of the critical habitat area. The boundaries of the critical habitat were established based on sighting records collected prior to 1993. Our surveys over the last three years extend beyond the boundaries of

the critical habitat area. In other words, do the existing boundaries represent the distribution of animals we have seen over the last three years? This analysis will be carried out this winter by developing density maps using a sightings per unit of effort analysis (similar to Kenney *et al* 1995) to locate the densest concentrations of right whales in the survey area. The sighting data will be compared to fishing effort and the movements of ships in the area to identify if the area of coverage by the existing critical habitat boundaries is adequate to afford right whales the greatest protection possible or are modifications required. A second analysis will be conducted to examine the individuals that use this area to assess why a segment of the right whale population spends a portion of its year feeding in Cape Cod Bay. This demographic information will be compared to food density, life history data, annual sighting histories and reproduction. These two analyses will provide managers with information to refine conservation strategies and dynamic management plans to provide protection to right whales while minimizing impact to human activities in the area.

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Table 1. Aerial survey tracklines flown over Cape Cod Bay, January – mid May, 2000. (Tracklines end approximately 1.5 nm from land). For location of tracklines, cross reference by trackline number with figure 1.

Trackline number	Latitude	Longitude West End	Longitude East End	Trackline length (nm)
1	42 06.5	70 38.0	70 10.0	21
2	42 05.0	70 37.0	70 14.0	17
3	42 03.5	70 38.0	70 15.0	17
4	42 02.0	70 36.0	70 07.7	21
5	42 00.5	70 34.3	70 06.9	21
6	41 59.0	70 35.2	70 06.6	22
7	41 57.5	70 34.4	70 06.6	21
8	41 56.0	70 31.6	70 06.3	19
9	41 54.5	70 30.8	70 03.1	21
10	41 53.0	70 30.0	70 03.1	20
11	41 51.5	70 30.0	70 02.1	21
12	41 50.0	70 30.0	70 02.1	21
13	41 48.5	70 30.0	70 02.2	21
14	41 47.0	70 29.0	70 04.1	20
15	41 45.5	70 26.0	70 11.0	11
Subtotal trackline miles in Cape Cod Bay, tracks 1-15				294
16*	41 45.5		69 53.0	26
Total trackline miles, tracks 1-16				320

*Trackline 16 begins at this point, east of Chatham, continues northeast parallel to the outer coast of Cape Cod about 3 nautical miles offshore, and joins the eastern end of trackline 1.

Table 2. Number of marine mammals seen, hours and trackline miles surveyed, during aerial surveillance of Cape Cod Bay, January – May, 2000, and in adjacent waters (Great South Channel and Georges Basin) May 2000.

Survey#	Date 2000	Eg Sighted	Eg Photo'd	Bp	Mn	Ba	UNBA	UNLW	La	UNDO	Cm	Hours Surveyed	Trackline Miles	Tracks Completed
CCS182	7-Jan	3	3	0	0	1	0	0	0	0	0	1.3	n/a	Off Nauset Light
CCS183	20-Jan	1	1	1	0	0	0	1	2	3	0	3.7	320	1-16
CCS184	23-Jan	4	4	1	1	0	0	0	0	0	0	3.5	320	1-16
CCS185	27-Jan	1	1	1	1	0	0	0	0	0	0	3.5	320	1-16
aborted	29-Jan	0	0	0	0	0	0	0	0	0	0	0.4	0	None, bad weather
CCS186	30-Jan	3	3	1	0	0	0	0	0	0	0	3.7	320	1-16
CCS187	3-Feb	11	10	0	0	0	0	0	0	0	0	3.7	320	1-16
CCS188	8-Feb	10	10	0	0	0	0	0	0	0	0	3.9	320	1-16
CCS189	10-Feb	14	14	0	0	0	0	0	0	0	0	4.1	283	1-14
CCS190	13-Feb	12	10	0	0	1	0	0	0	0	0	4.0	309	1-14, 16
CCS191	18-Feb	5	3	0	0	0	0	0	0	0	0	0.7	31	14, 15
CCS192	20-Feb	21	17	1	0	0	0	0	0	0	0	4.6	282	3-16
CCS193	22-Feb	16	14	0	1	0	0	0	0	0	0	4.5	320	1-16
CCS194	24-Feb	16	14	0	1	0	0	1	0	0	0	4.5	320	1-16
CCS195	1-Mar	44	8	0	1	0	0	0	0	0	0	5.8	248	1-6, 10-14, 16
CCS196	2-Mar	26	20	0	1	0	0	0	0	0	0	4.3	190	1, 8-14, 16
CCS197	5-Mar	16	16	3	1	0	0	0	30	0	0	7.3	309	1-14, 16
CCS198	7-Mar	18	17	1	1	0	0	0	0	0	0	4.8	320	1-16
CCS199	8-Mar	31	27	2	3	0	0	0	0	0	0	5.2	320	1-16
CCS200	11-Mar	17	17	3	1	0	0	0	0	0	0	3.9	180	1-9
CCS201	14-Mar	16	13	0	0	0	0	0	0	0	0	2.2	104	10-14
CCS202	23-Mar	43	38	9	4	0	0	0	0	0	0	4.2	256	3-15
CCS203	25-Mar	25	23	9	1	0	0	0	0	0	0	4.6	268	1-12,16
CCS204	27-Mar	44	44	12	3	0	0	0	0	12	0	4.5	245	3-14
CCS205	31-Mar	27	27	16	5	0	0	1	0	5-Jan	0	4.7	320	1-16
CCS206	1-Apr	35	34	21	2	0	0	1	500	0	0	5.4	309	1-14,16
CCS207	7-Apr	36	34	19	0	0	0	1	0	500	0	5.3	309	1-14,16
CCS208	11-Apr	3	3	12	2	2	0	1	0	1	0	3.4	305	1-14, most of 16
CCS209	14-Apr	0	0	20	1	0	0	0	300-425	0	0	3.6	309	1-14,16
CCS210	25-Apr	0	0	2	27	0	0	1	0	0	0	3.0	320	1-16
CCS211	27-Apr	0	0	8	1	0	0	2	0	0	0	3.3	320	1-16
CCS212	28-Apr	0	0	14	27	0	0	2	0	195	0	3.7	320	1-16
CCS213	1-May	0	0	2	17	0	0	0	0	0	0	2.9	119	1-6
CCS216	8-May	0	0	3	0	0	0	0	0	5	0	3.0	283	1-14
Total Cape Cod Bay		498	425	161	102	4	0	11	830-955	720	0	131.1	8819	
Adjacent waters														
CCS214	3-May	27	20	35-65	30-40	3	0	0	0	600-800	6	6.4	433	Great South Channel, see figure 7
CCS215	4-May	19	14	6	22	0	4	0	0	5	1	5.0	278	Great South Channel, see figure 7
CCS217	12-May	1	1	34	59	4	0	0	25	500-700	9	4.0	188	Great South Channel, see figure 8
CCS218	17-May	9	9	31	0	0	0	1	0	0	7	4.9	380	Georges Basin, see figure 8b
Total adjacent waters		56	44	106-136	111-121	7	4	1	25	1100-1500	23	20.3	1279	
Total all surveys		554	469	267-297	213-223	11	4	12	855-980	1820-2220	23	151.4	10,098	

Legend: Eg – right whale, Bp – fin whale, Mn – humpback whale, Ba – minke whale, UNBA – unidentified balaneopterid, UNLW – unidentified large whale, La – white sided dolphin, UNDO – unidentified dolphin, Cm – basking shark.

Table 3. Number of marine mammals seen during vessel-based habitat sampling cruises of Cape Cod Bay, December 1999 and January – May 2000.

Survey	Date	Eg sighted	Eg photo'd	Bp	Mn	Ba	UNLW	La	Pp	Pv	UNSE	Hours Surveyed
GT005	16-Dec	0	0	2	0	0	0	0	0	0	0	1.6
DX001	20-Dec	0	0	3	1	0	0	0	0	0	0	5.0
SW133	6-Jan	0	0	4	1	0	1	30	0	1	0	7.3
SW134	13-Jan	0	0	0	0	0	0	0	0	0	0	0.5
SW135	19-Jan	0	0	0	0	0	0	0	0	0	0	0.5
SW136	20-Jan	0	0	0	0	0	0	0	0	7	2	3.3
SW137	10-Feb	8	1	0	0	0	0	0	0	3	0	7.0
SW138	13-Feb	17	4	0	0	0	0	0	0	12	0	11.0
SW139	18-Feb	0	0	0	0	0	0	0	0	0	0	5.0
SW140	22-Feb	22	5	0	0	0	3	0	0	0	0	10.3
SW141	24-Feb	12	3	0	0	0	0	0	0	3	0	8.0
SW142	1-Mar	10	4	0	1	0	1	0	0	2	0	10.5
SW143	5-Mar	16	3	0	1	0	0	0	0	3	0	8.6
SW144	7-Mar	17	9	0	1	0	0	0	0	2	0	6.5
HT001	14-Mar	6	6	0	0	0	0	0	0	0	0	2.2
SW145	14-Mar	6	0	0	1	0	0	0	0	1	0	2.3
SW146	23-Mar	14	4	0	5	0	0	0	3	2	0	11.6
SW147	25-Mar	16	4	0	1	0	0	75	1	1	1	7.0
SWST01	26-Mar	6	0	0	0	0	0	0	0	0	0	1.3
GT102	26-Mar	18	0	0	0	0	0	0	5 - 10	0	0	1.5
GT101	27-Mar	7	2	8	0	0	0	50	0	0	0	2.8
SW148	27-Mar	7	2	0	0	0	0	0	0	0	0	6.0
SW149	31-Mar	7	5	0	0	0	0	0	0	0	0	12.0
SW150	1-Apr	21	10	27	2	0	0	270-540	1	1	0	8.8
SW151	3-Apr	5	5	3	1	0	0	0	3	0	0	5.0
SW152	7-Apr	15	13	4	1	1	0	0	1	0	0	6.0
SW153	11-Apr	3	1	2	3	0	7	5 - 10	1	1	0	8.5
SW154	14-Apr	0	0	9	1	1	0	0	0	1	0	5.0
SW155	25-Apr	0	0	0	1	0	0	0	0	0	0	5.7
SW157	3-May	0	0	0	0	0	0	0	0	0	0	10.5
Totals		233	81	62	21	2	12	365-640	15 - 20	40	3	181.2

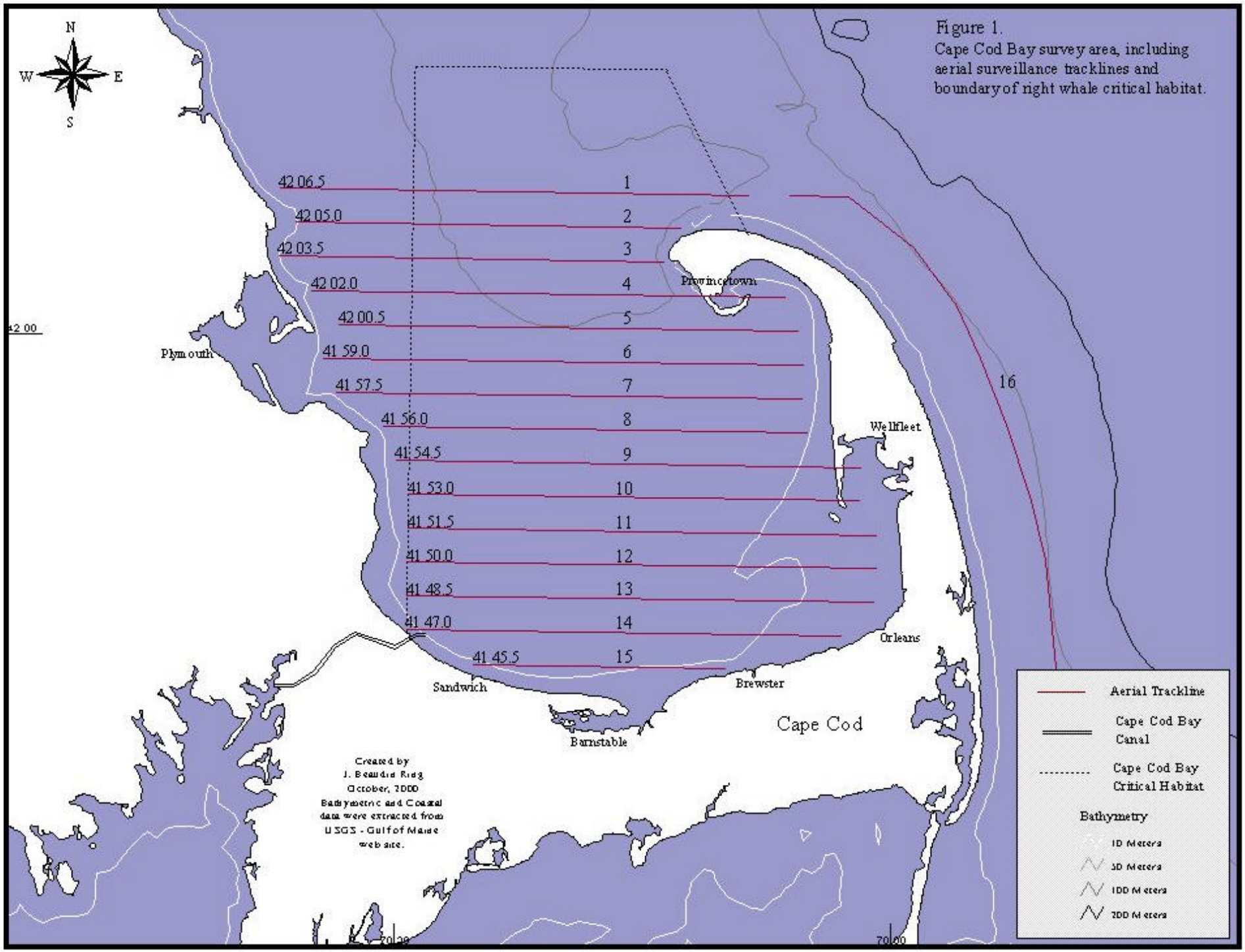
DX – F/V Dixie II, GT – R/V Gannet, HT – R/V Hannah T, SW – R/V Shearwater, SWST – Shearwater Ship Transit (not a survey). (see table 2 for species abbreviations)

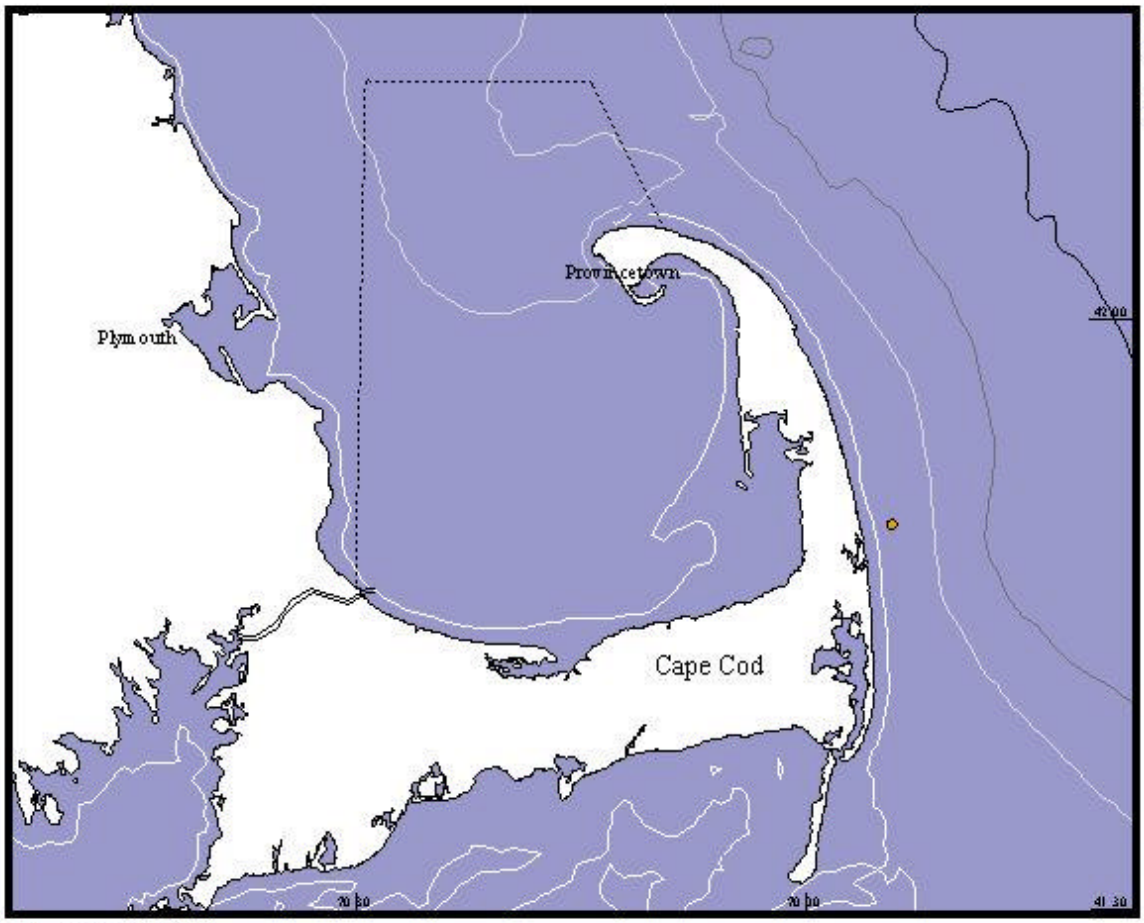
Table 4. Number of surveys, demographic composition and number of right whales identified in Cape Cod Bay from aerial and shipboard surveys in two-week intervals during late December 1999, and from January and Mid-May, 2000.

Two week intervals	Dec, 1999	1-14 Jan	15-28 Jan	29 Jan-11 Feb	12-25 Feb	26 Feb-11 Mar	12-25 Mar	26 Mar-8 Apr	9-22 Apr	23 Apr-6 May	7-15 May *	Total
a) Surveys												
Aerial		1	3	4	5	6	3	4	2	4	1	33
R/V *Shearwater*		2	2	1	4	3	3	6 **	2	2		24
R/V *Gannet*	1							2				3
R/V *Hannah T*							1					1
F/V *Dixie* II	1											1
b) Demographics												
Male			3	6	14	22	31	0				
Female			0	12	13	24	31	2				
Unknown sex			0	3	5	5	6	0				
Juvenile			0	5	8	10	13	2				
Adult			3	13	21	37	48	0				
Unknown age			0	8	3	4	7	0				
c) Resightings												
New Sightings			3	20	15	18	30	0				
Resightings			0	1	17	33	38	2				
Total right whales id'd in Cape Cod Bay	0	0	3	21	32	51	68	2	0	0	0	

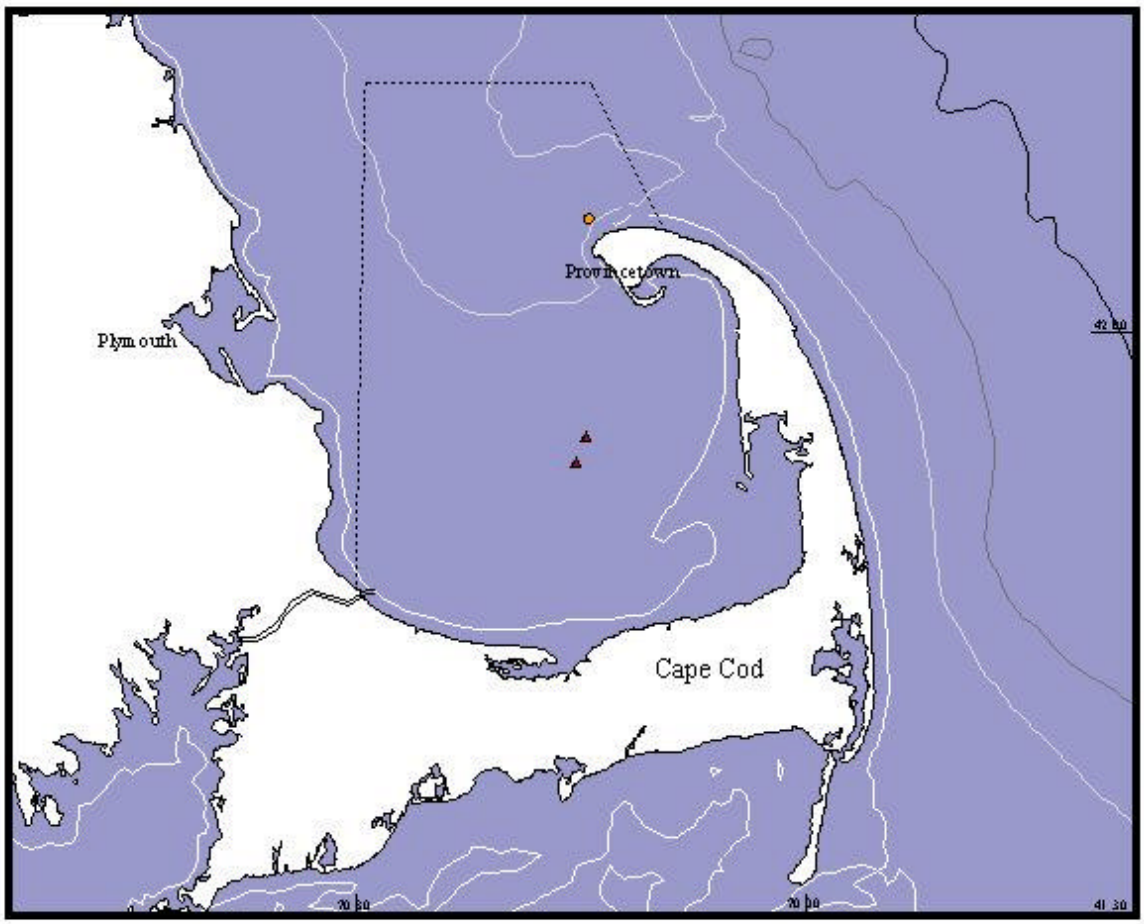
* This interval represents one week.

** This includes one ship transit for repairs that was not a formal survey.


N
W
E
S
Figure 1.
Cape Cod Bay survey area, including aerial surveillance tracklines and boundary of right whale critical habitat.
42 06.5
1
42 05.0
2
42 03.5
3
42 02.0
4
42 00.5
5
41 59.0
6
41 57.5
7
41 56.0
8
41 54.5
9
41 53.0
10
41 51.5
11
41 50.0
12
41 48.5
13
41 47.0
14
41 45.5
15
42 00
Plymouth
Provincetown
16
Wellfleet
Orleans
Brewster
Sandwich
Barnstable
Cape Cod
Created by
J. Beaudoin Ring
October, 2000
Bathymetric and Coastal data were extracted from USGS - Gulf of Maine web site.
70 30
70 00
Aerial Trackline
Cape Cod Bay Canal
Cape Cod Bay Critical Habitat
Bathymetry
10 Meters
30 Meters
100 Meters
200 Meters

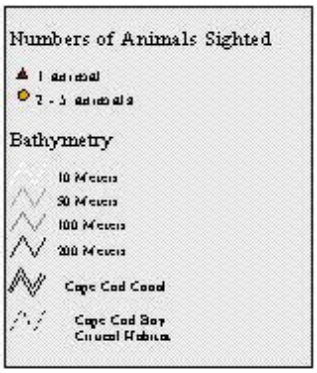


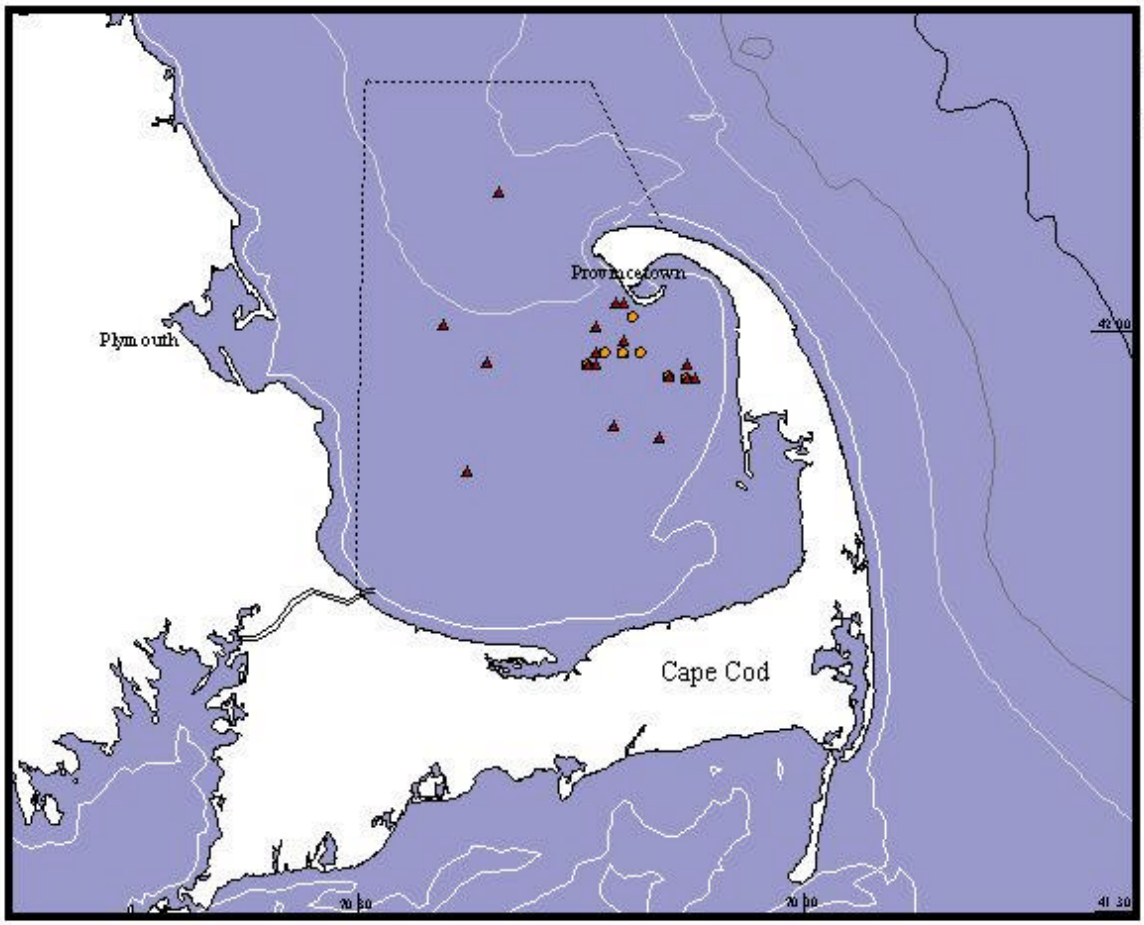
a. 1 - 14 January, 2000.



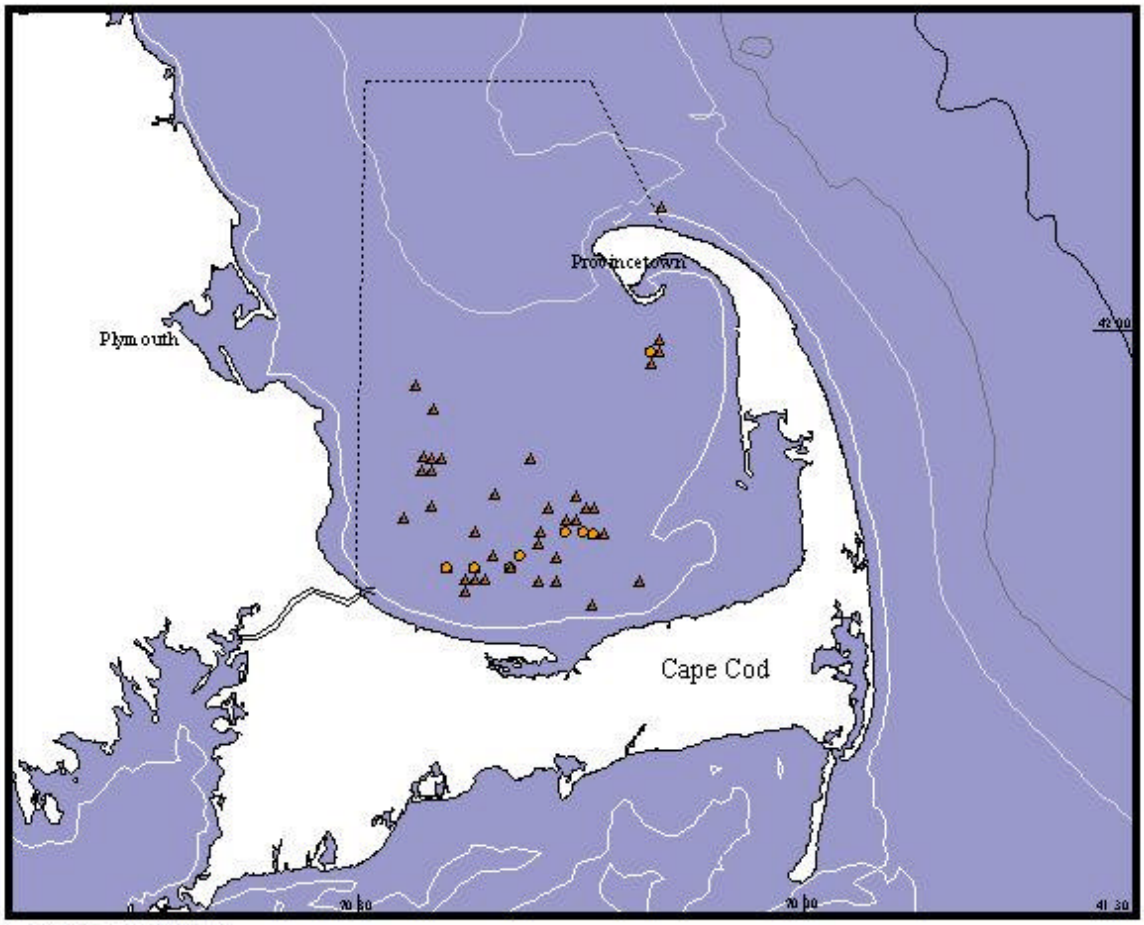
b. 15 - 28 January, 2000.

Figure 2.
Sightings of right whales from aerial surveys in Cape Cod Bay, 1 - 28 January, 2000.



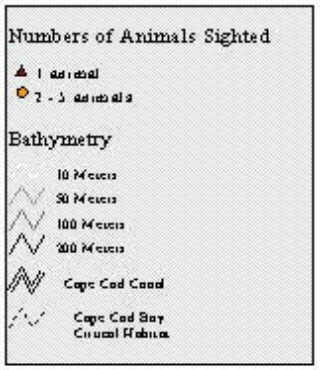


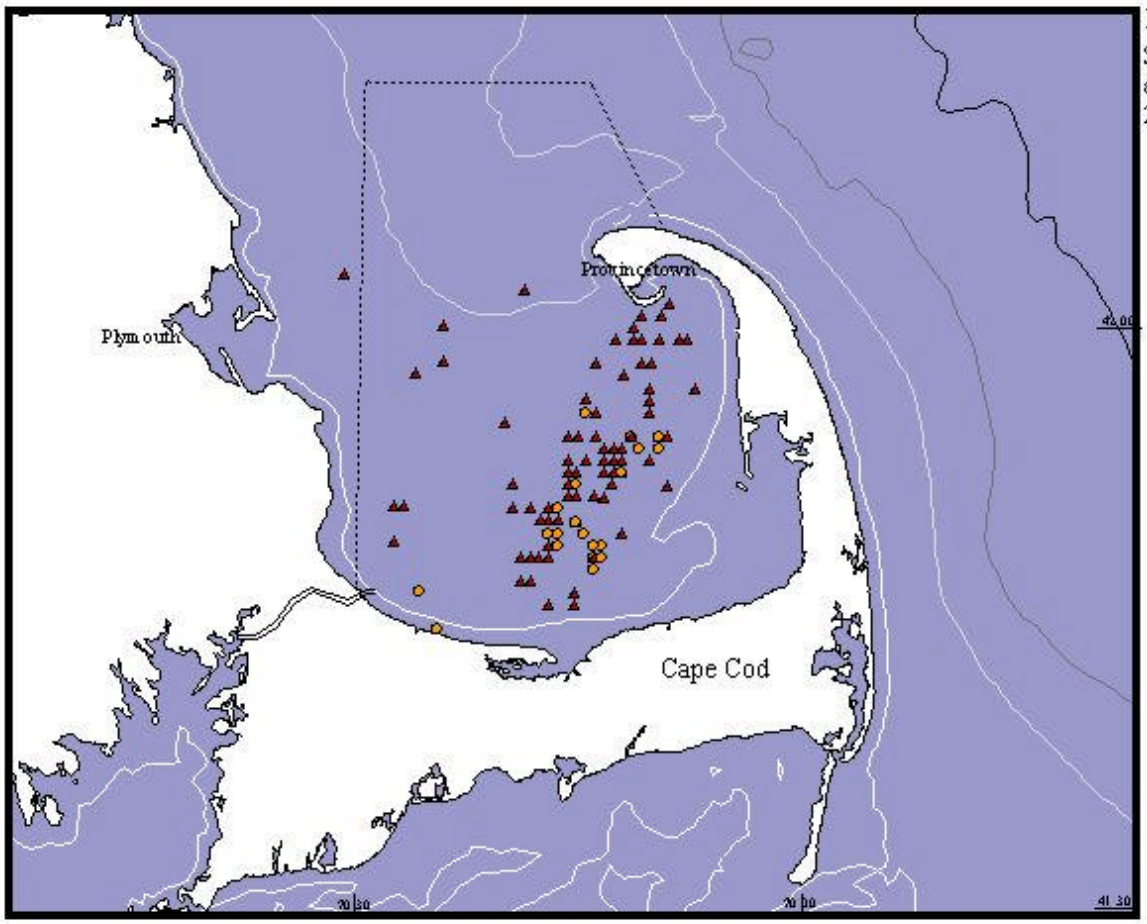
a. 29 January - 11 February, 2000.



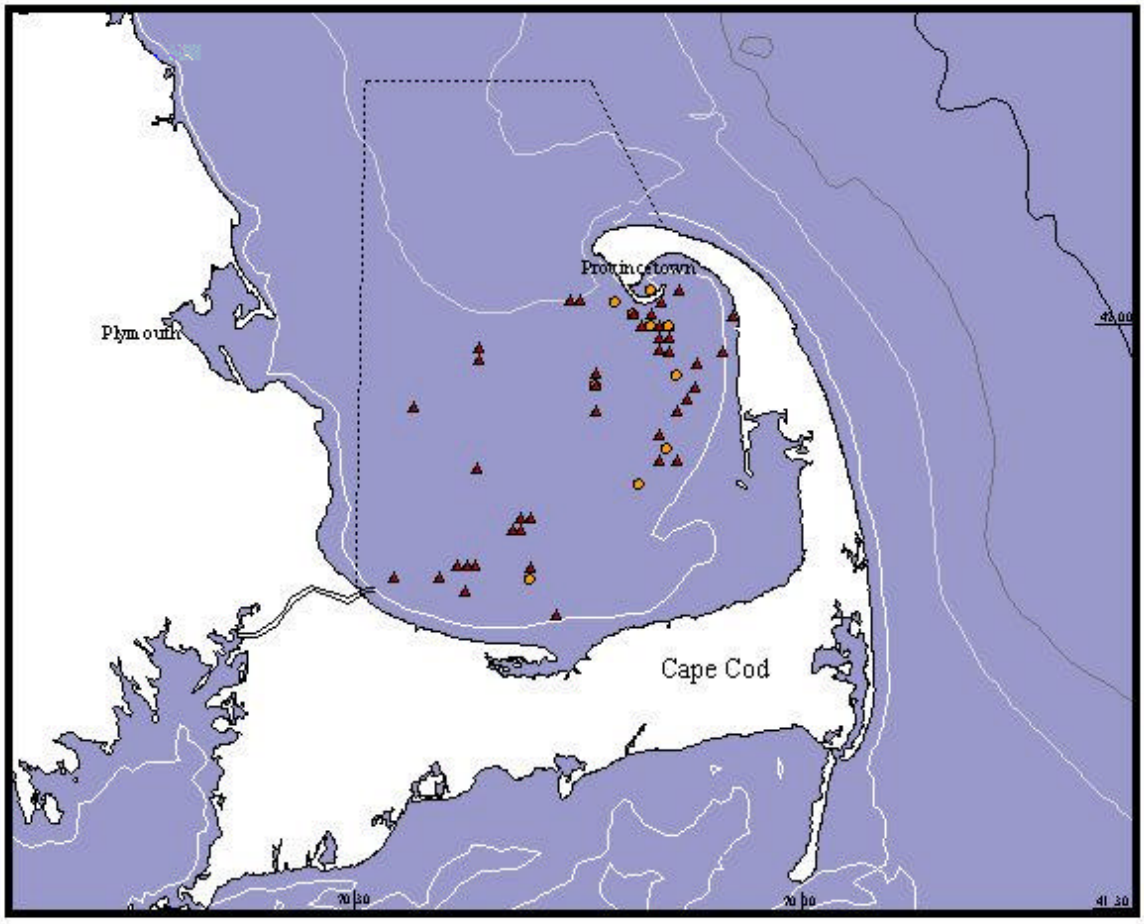
b. 12 - 25 February, 2000.

Figure 3.
Sightings of right whales from aerial surveys in Cape Cod Bay 29 January - 25 February, 2000.



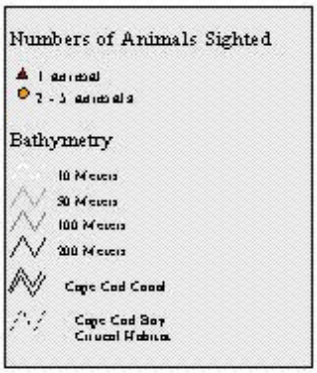


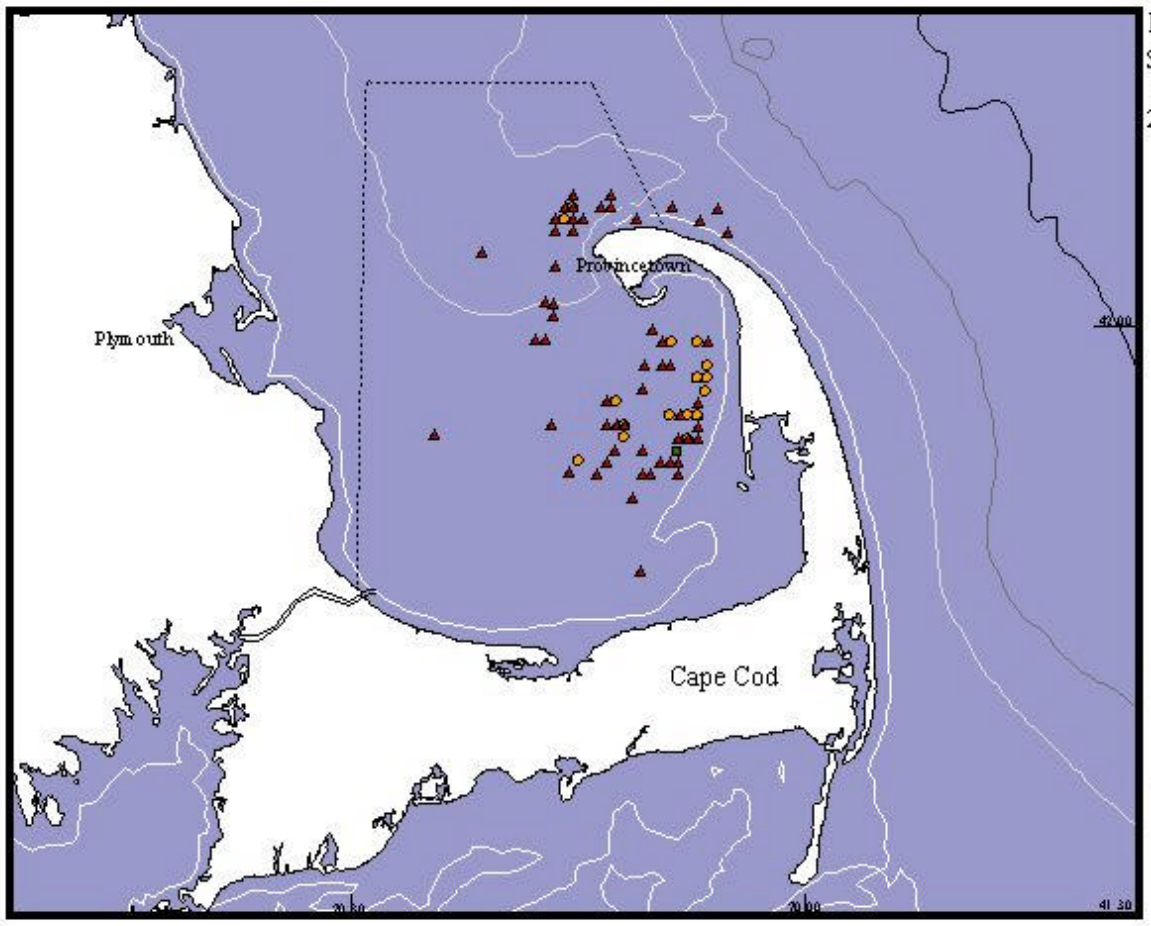
a. 26 February - 11 March, 2000.



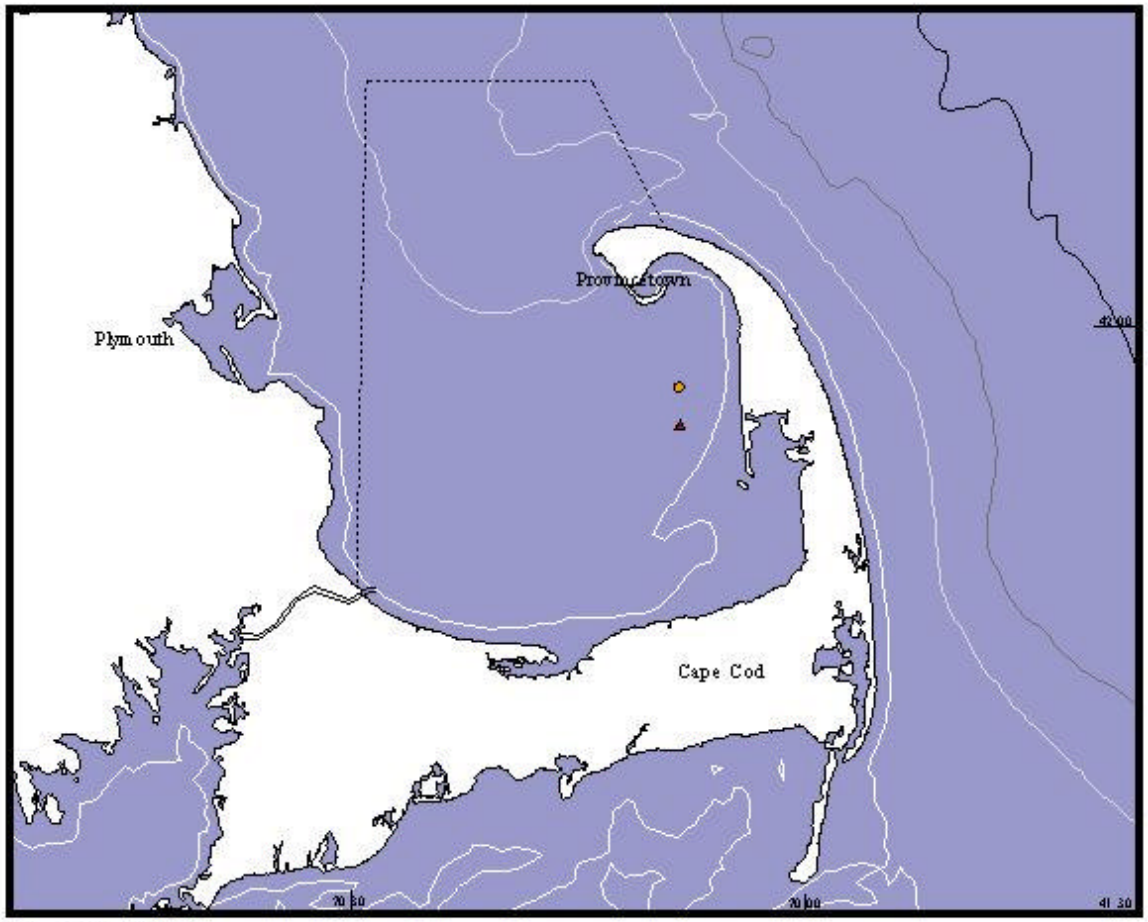
b. 12 - 25 March, 2000.

Figure 4.
Sightings of right whales from aerial surveys in Cape Cod Bay, 26 February - 25 March, 2000.



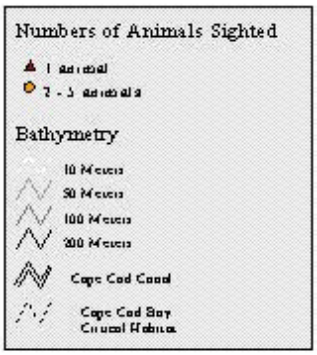


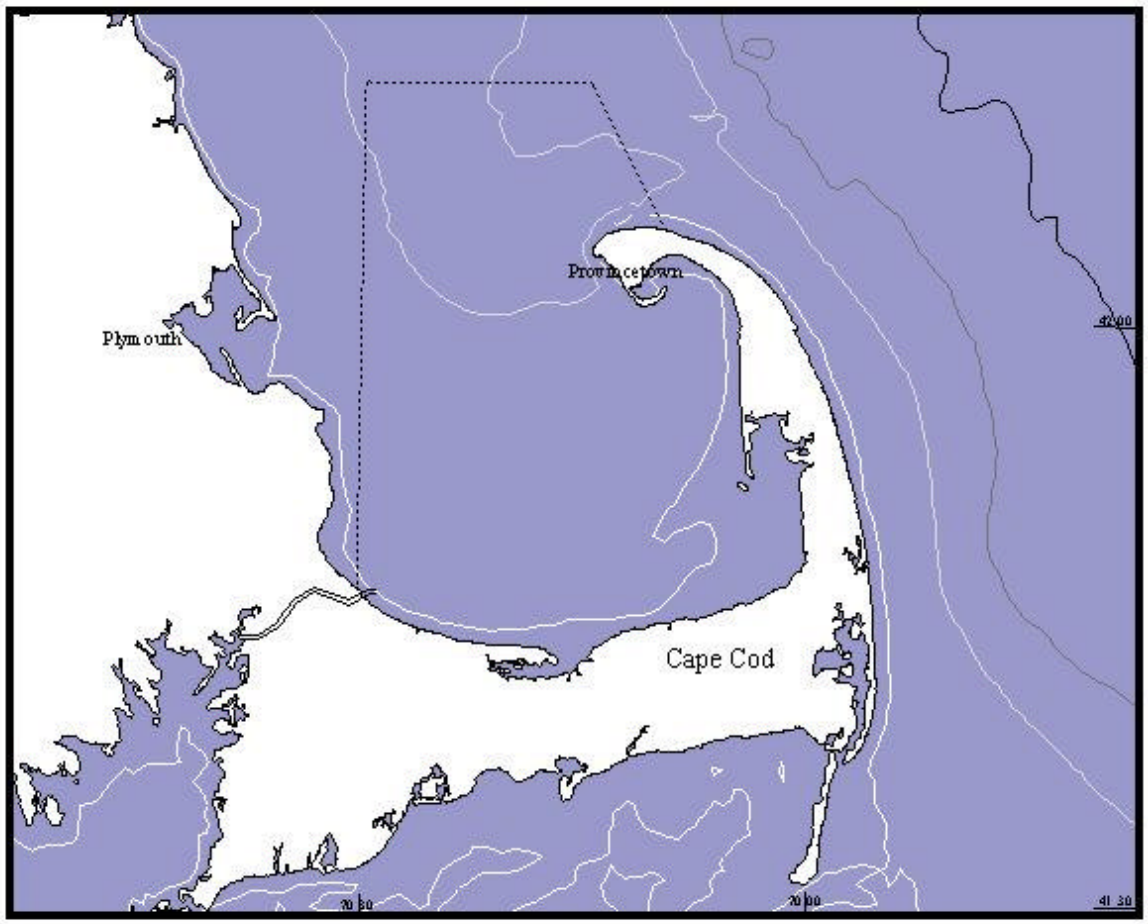
a. 26 March - 8 April 2000.



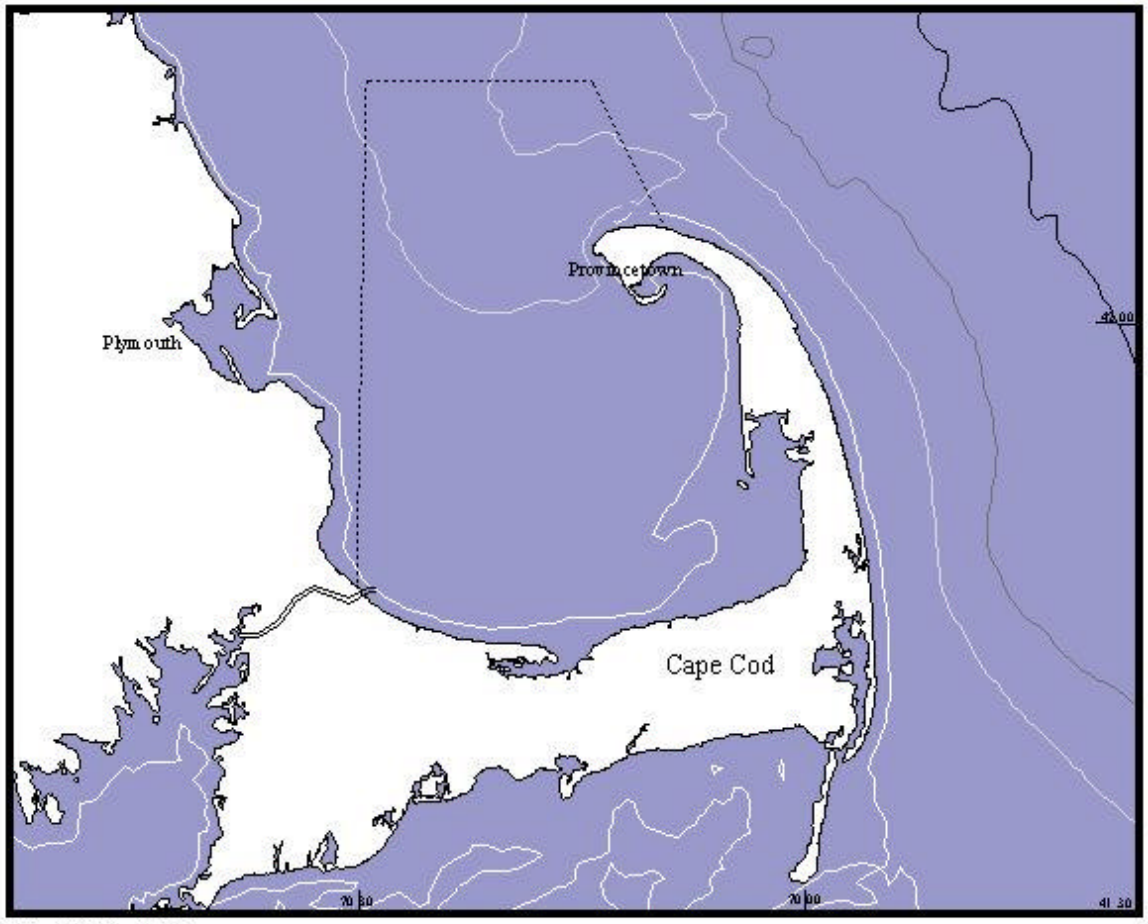
b. 9 - 22 April, 2000.

Figure 5.
Sightings of right whales from aerial surveys in Cape Cod Bay 26 March - 22 April, 2000.



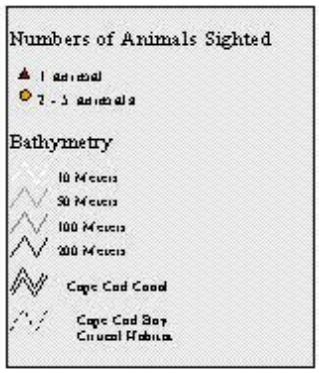


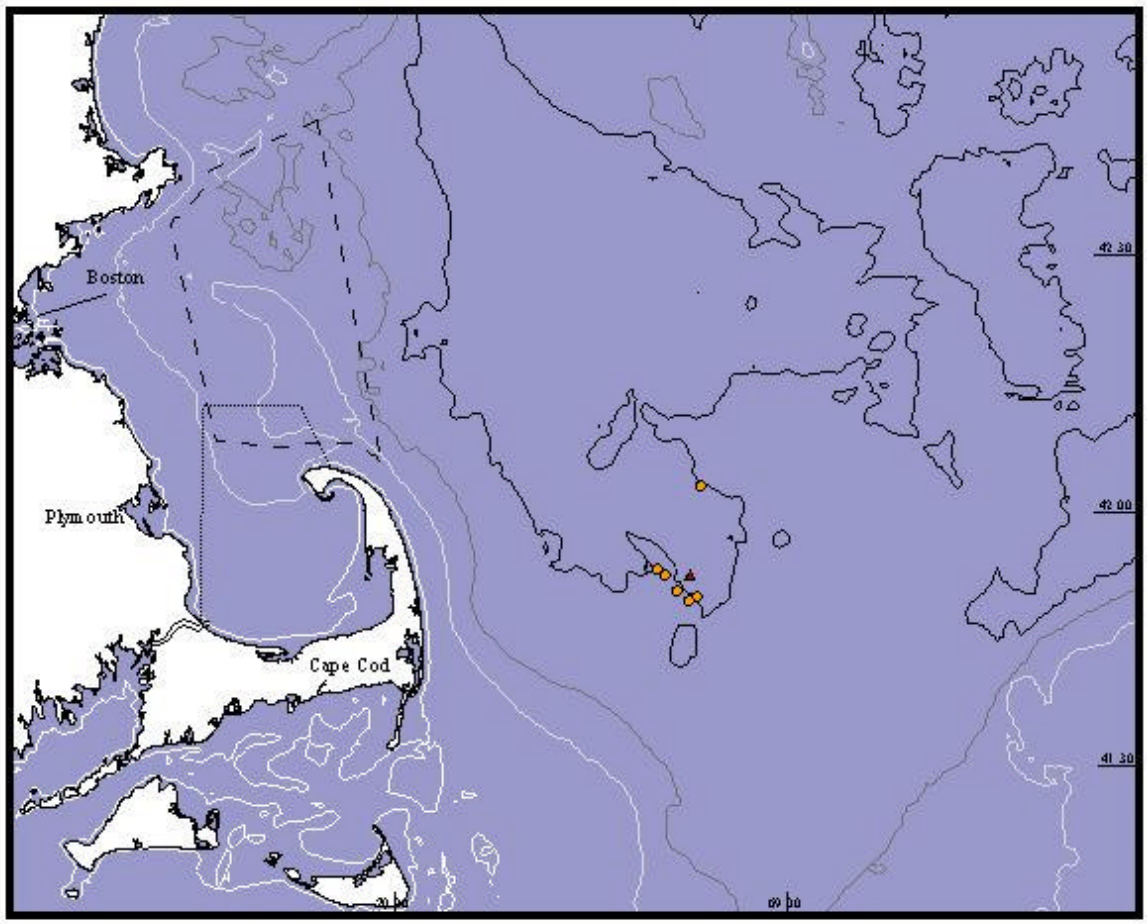
a. 23 April - 6 May, 2000.



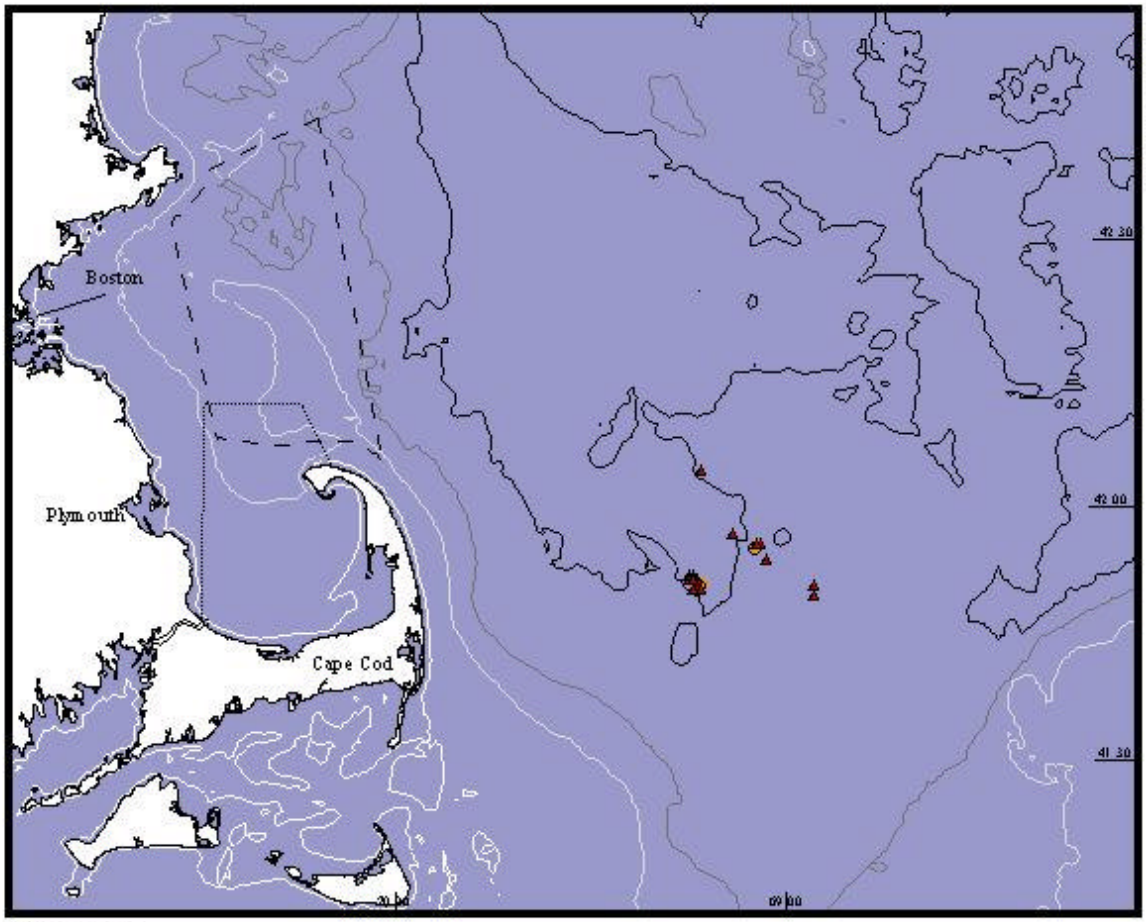
b. 7 - 15 May, 1999.

Figure 6.
Sightings of right whales from aerial surveys in Cape Cod Bay 23 April - 15 May, 2000.



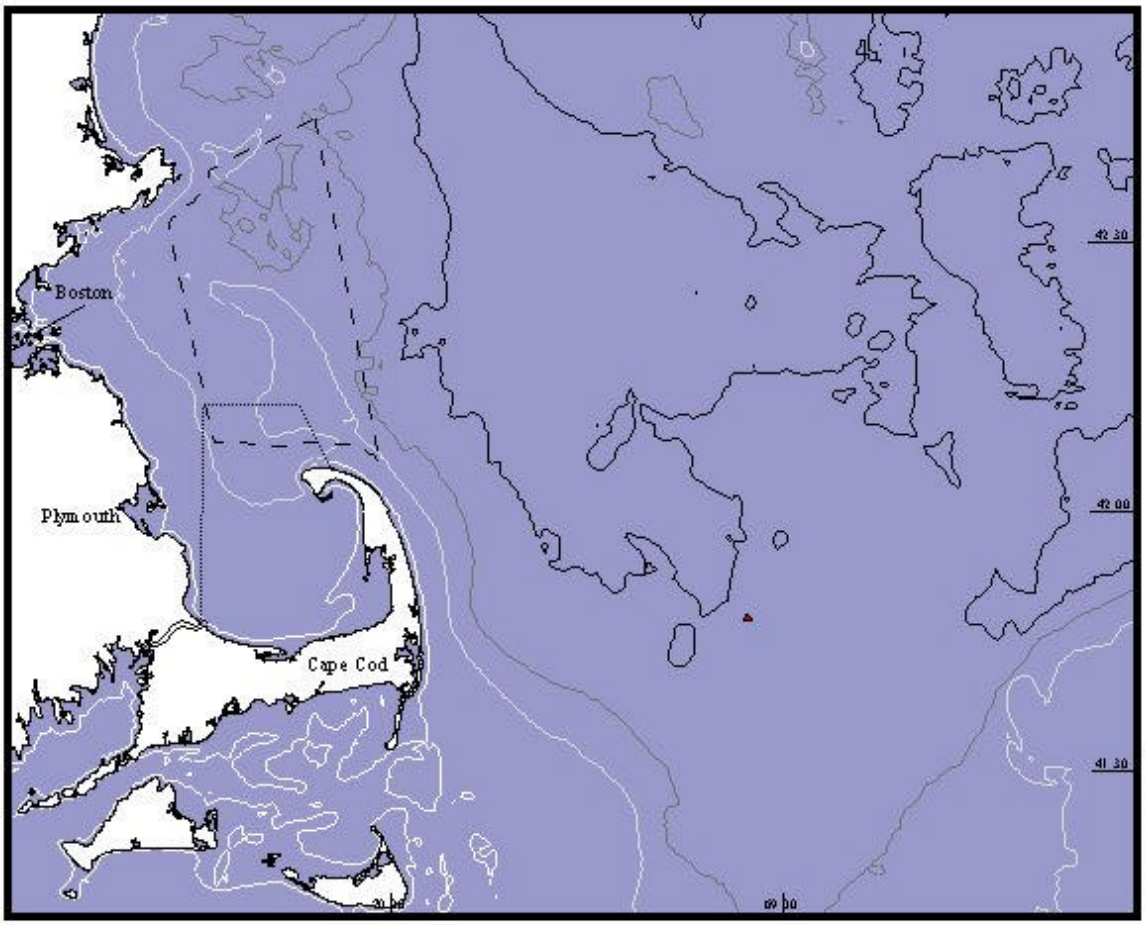


a. 3 May, 2000.

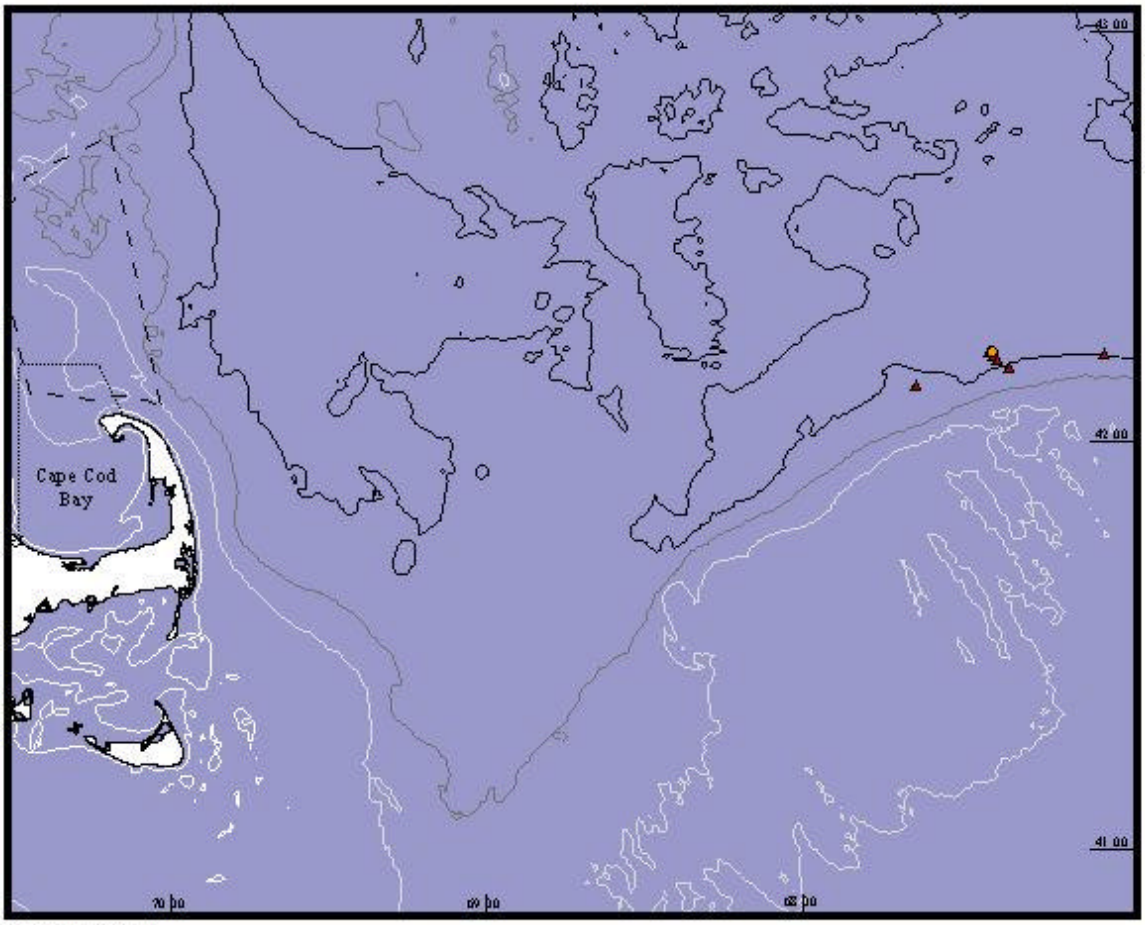


b. 4 May, 2000.

Figure 7.
Sightings of right whales from aerial surveys in the Great South Channel, 3 - 4 May, 2000.



a. 12 May, 2000.



b. 17 May, 2000.

Figure 8.
Sightings of right whales from aerial surveys in the Great South Channel, 12 &17 May, 2000.

Numbers of Animals Sighted

1 animal

2 - 3 animals

Bathymetry

10 Meters

50 Meters

100 Meters

200 Meters

Cape Cod Canal

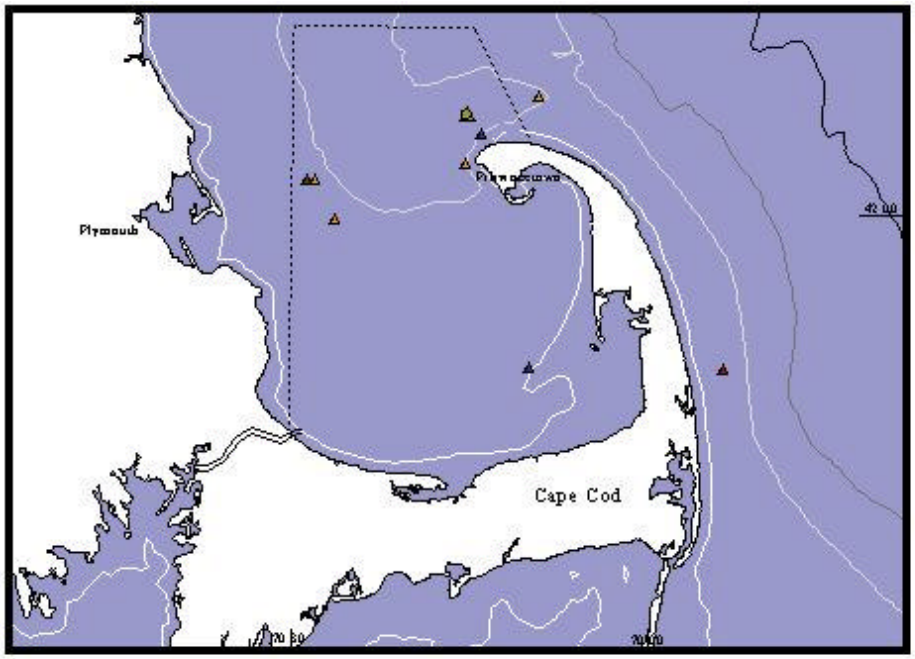
Cape Cod Bay Critical Habitat

Stellwagen Bank National Marine Sanctuary

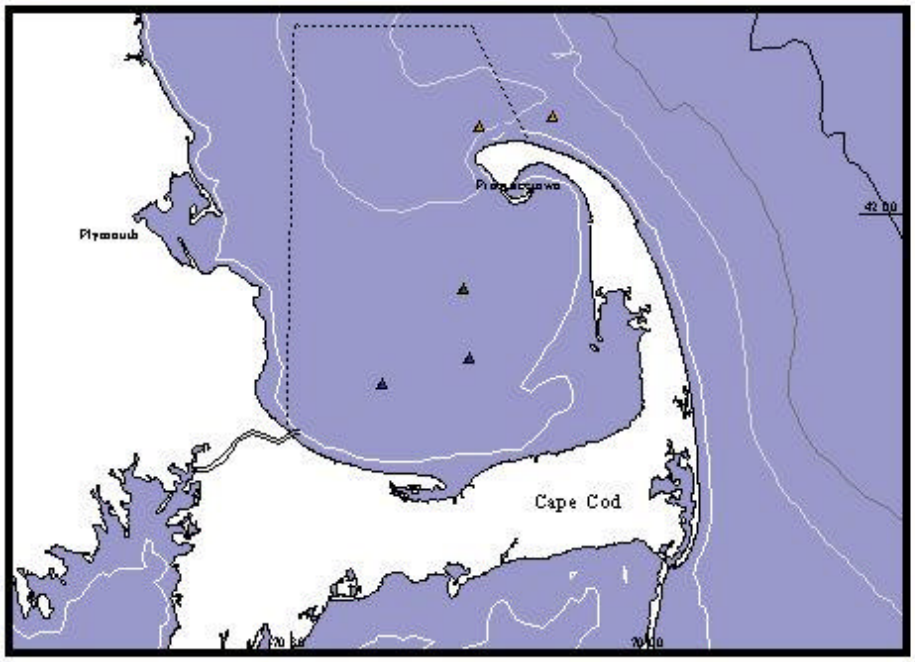
Created by
J. Beaudin Ring
October, 2000
Bathymetric and Coastal data were extracted from USGS - Gulf of Maine web site.

N
W
E
S

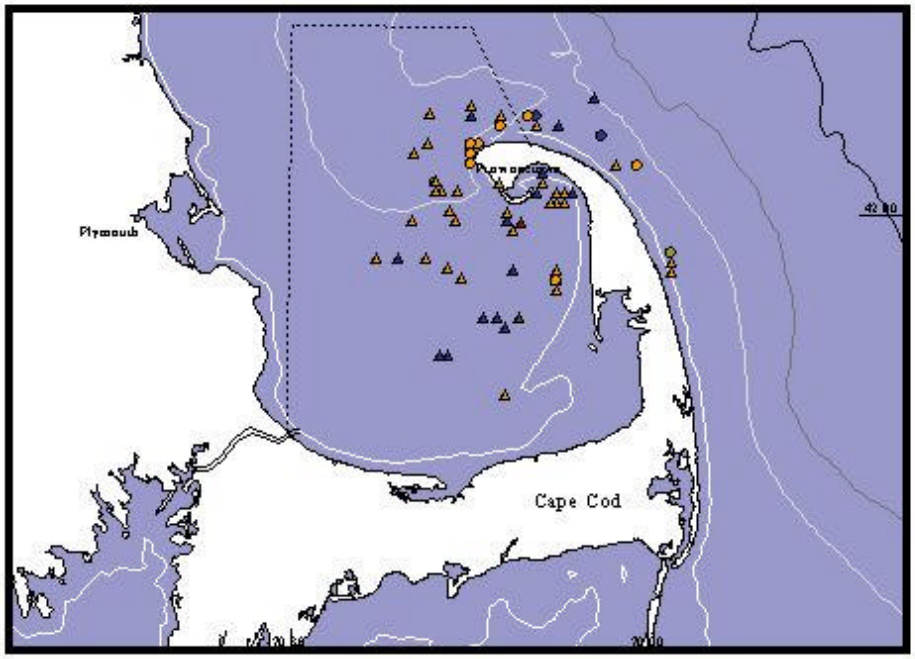
Figure 9.
Sightings of other large whales and dolphins from aerial surveys in Cape Cod Bay, January - March, 2000.



January, 2000.



February, 2000.



March, 2000.

Legend

Large Whales and Dolphins

- Fin Whale
- Sei Whale
- Minke Whale
- Humpback Whale
- Unidentified Balaenopterid
- Unidentified Large Whale
- White-Sided Dolphin
- Unidentified Dolphin
- Harbor Porpoise

Number of Animals Sighted

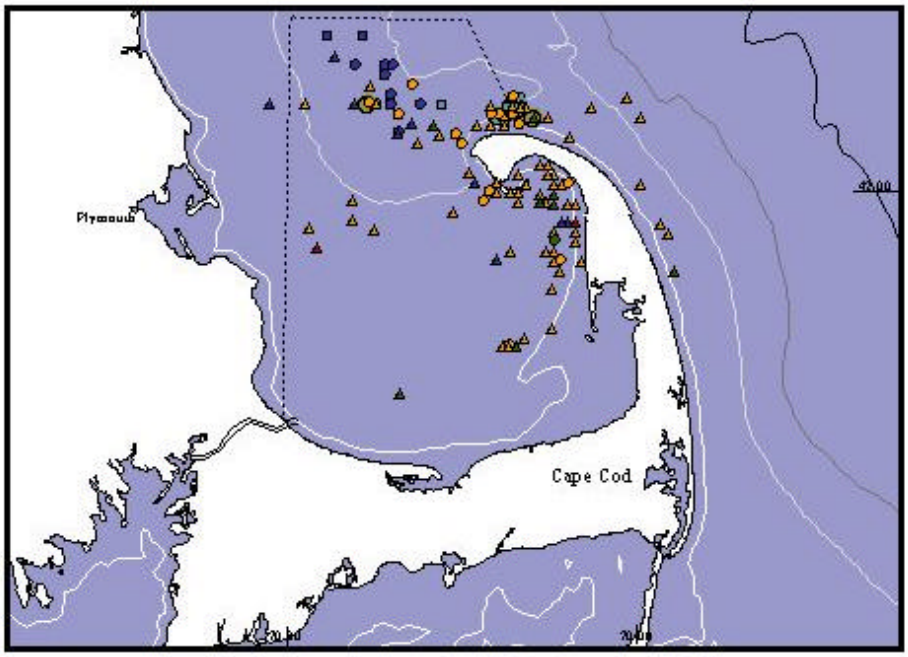
- 1 animal
- 2 - 5 animals
- 6 - 10 animals
- 11 - 100 animals
- > 100 animals

Bathymetry

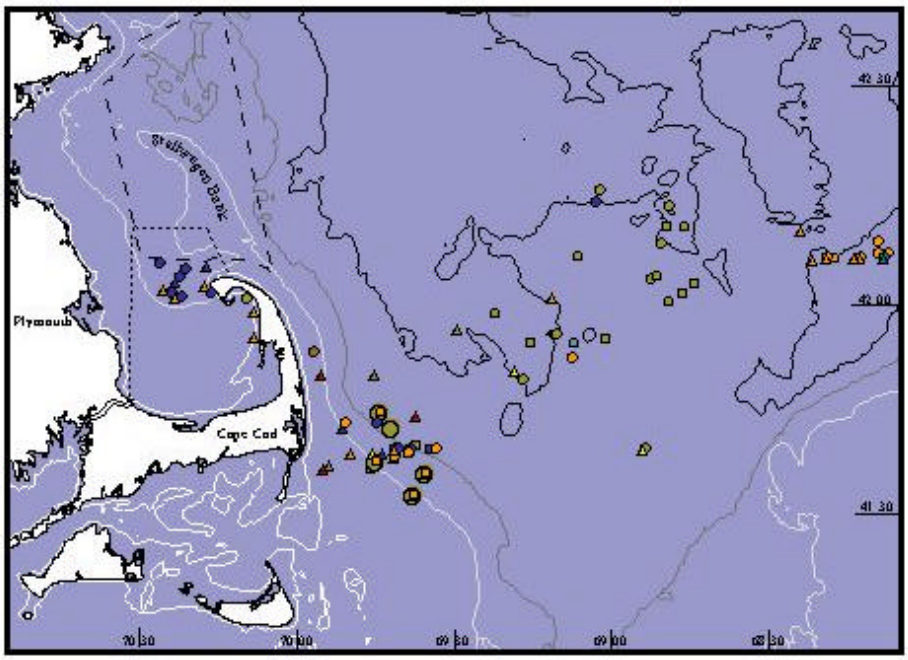
- 10 Meters
- 50 Meters
- 100 Meters
- 200 Meters

- Cape Cod Canal
- Cape Cod Bay Critical Habitat
- Stellwagen Bank National Marine Sanctuary

Figure 10.
Sightings of other large whales and dolphins from aerial surveys in Cape Cod Bay, April - May, 2000.



April, 2000.



May, 2000.

Legend

Large Whales and Dolphins

- Fin Whale
- Sei Whale
- Minke Whale
- Humpback Whale
- Unidentified Balaenopterid
- Unidentified Large Whale
- White-Sided Dolphin
- Unidentified Dolphin
- Harbor Porpoise

Number of Animals Sighted

- 1 animal
- 2 - 5 animals
- 6 - 10 animals
- 11 - 100 animals
- > 100 animals

Bathymetry

- 10 Meters
- 50 Meters
- 100 Meters
- 200 Meters

- Cape Cod Canal
- Cape Cod Bay Critical Habitat
- Stellwagen Bank National Marine Sanctuary

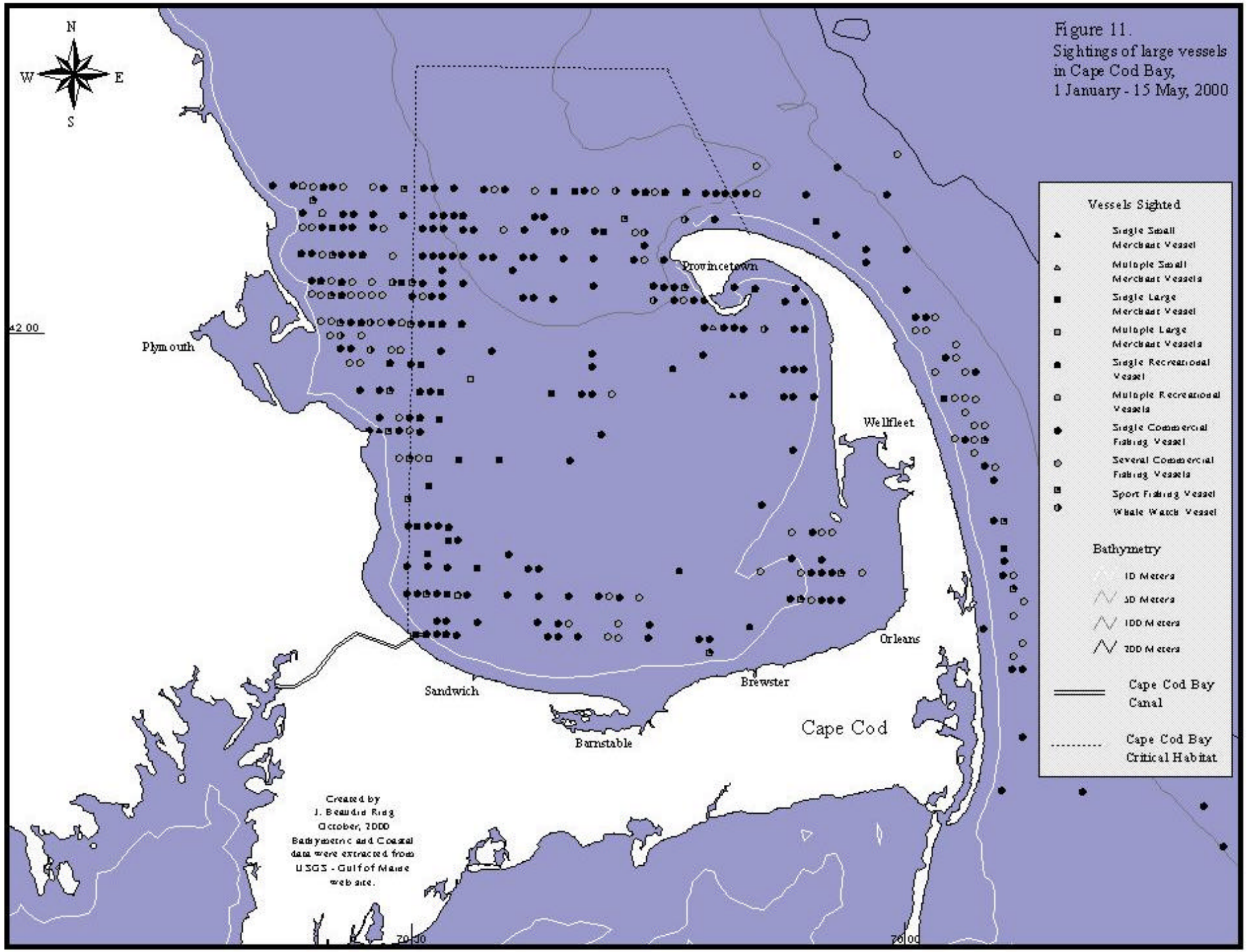
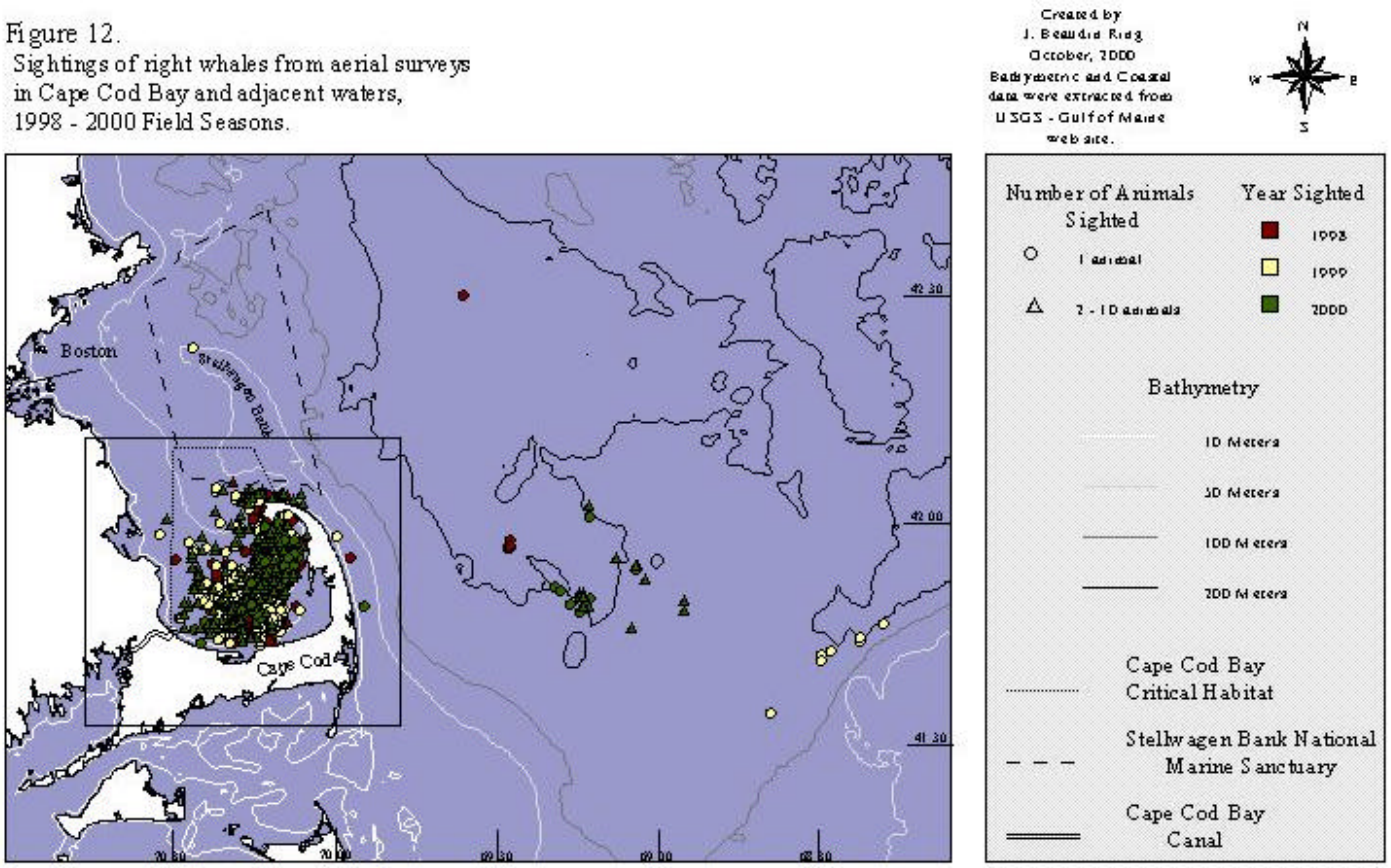
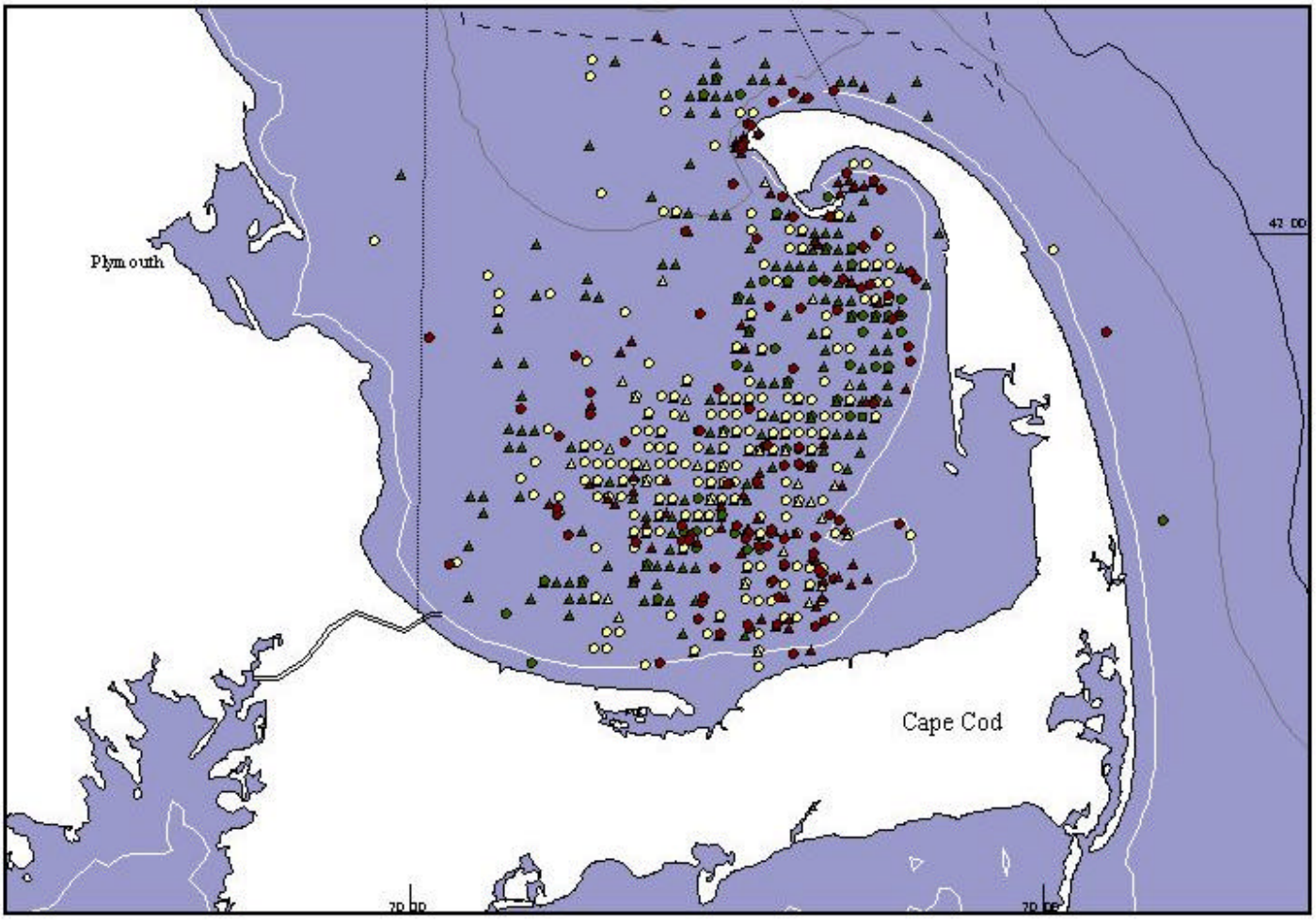

N
W
E
S
Figure 11.
Sightings of large vessels
in Cape Cod Bay,
1 January - 15 May, 2000
Vessels Sighted
Single Small Merchant Vessel
Multiple Small Merchant Vessels
Single Large Merchant Vessel
Multiple Large Merchant Vessels
Single Recreational Vessel
Multiple Recreational Vessels
Single Commercial Fishing Vessel
Several Commercial Fishing Vessels
Sport Fishing Vessel
Whale Watch Vessel
Bathymetry
10 Meters
30 Meters
100 Meters
200 Meters
Cape Cod Bay Canal
Cape Cod Bay Critical Habitat
Provincetown
Plymouth
Wellfleet
Orleans
Brewster
Sandwich
Barnstable
Cape Cod
42 00
70 00
Created by
J. Beaudin Ring
October, 2000
Bathymetric and Coastal
data were extracted from
USGS - Gulf of Maine
web site.

Figure 12.
Sightings of right whales from aerial surveys in Cape Cod Bay and adjacent waters, 1998 - 2000 Field Seasons.

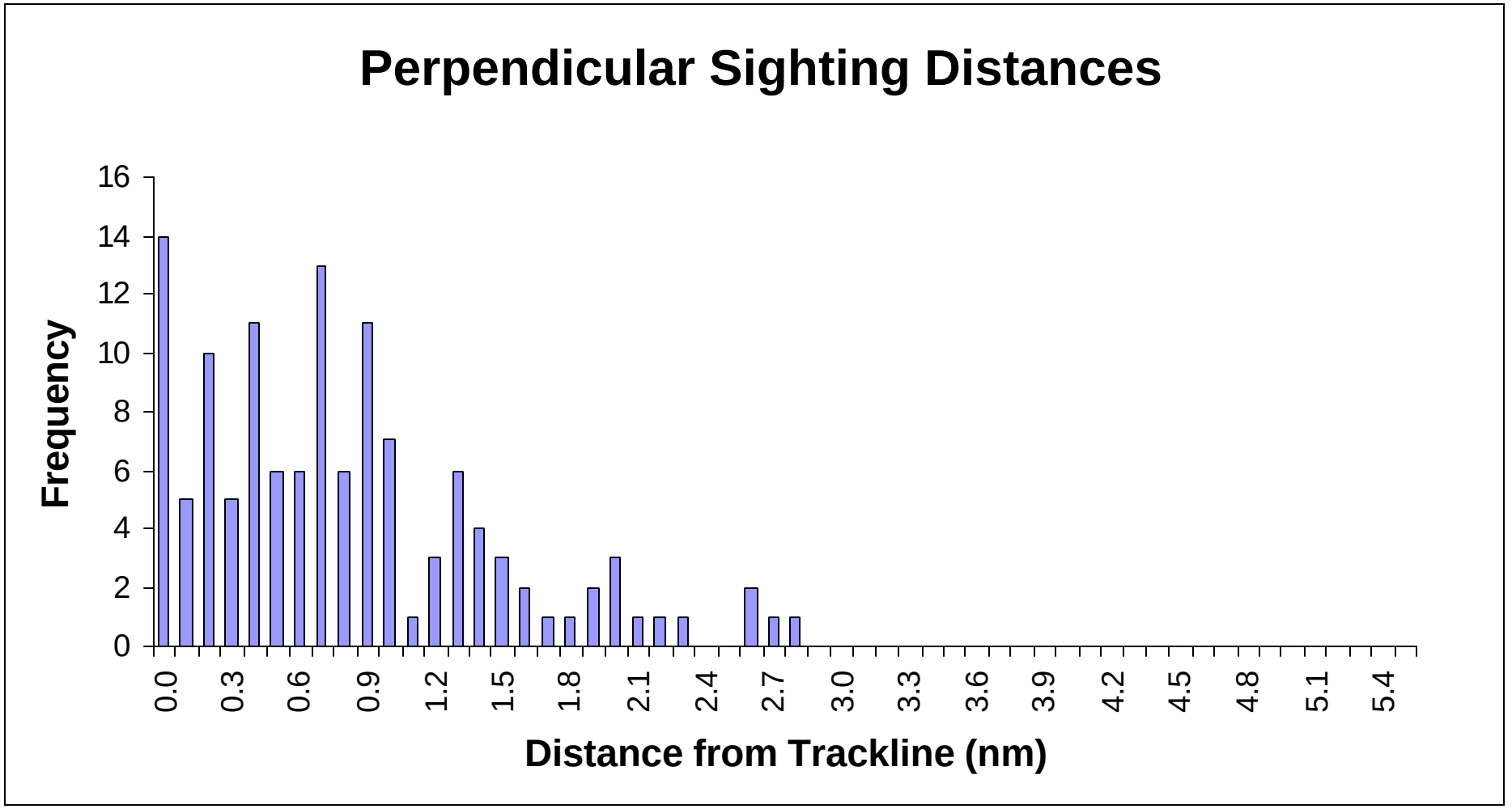


Full survey area.



Sightings recorded in Cape Cod Bay.

Figure 13. Perpendicular sighting distances from Cape Cod Bay Aerial Surveys, 2000.



Appendix I

Confirmed right whale identifications in Cape Cod Bay in 1998, 1999 and 2000 and the sighting histories of those 142 individuals. Abbreviations are listed below last sighting.

EGNO	Sex	Y1980	Y1981	Y1982	Y1983	Y1984	Y1985	Y1986	Y1987	Y1988	Y1989	Y1990	Y1991	Y1992	Y1993	Y1994	Y1995	Y1996	Y1997	Y1998	Y1999	Y2000
1004	F	OF					G		SMF		S	SFO			FS	S	M	S	SF	M		
1013	F	MF			M		SM				M					MJ		M	SM		M	M
1014	F	MF		M	MOF					MGF	M	MS	SM				M	MS	M	M	M	
1019	M	F		GB			MF	M	B	G			M		F		MF	MGF	M	MGN	MG	
1027	F	F		BF	BF	SA	MG	MGBF	B	MBF	SMF	B	B		MF	F	MF	MF	MGF	MF	MF	M
1033	M		M	B			M	B	B	B					F	M	M	MF		M		
1039	F	O						B			M	MS		M		M	M	SM	M	MF	F	
1042	U	GB	G		B			M	GB	B	GB		B					M	MO	MN	G	
1050	M	OG	G	G			G	B		G					F	F	F		F	GM		
1102	M	B	GO	B				B	G	B	B	B	B		F	F	MF	MF	F	MF		
1112	M	F	GF	BF	F	MJ	MO	B	F		FM	F		M	FJ	F	M	F	GF		F	M
1113	M		F	B		O		B	B	GB	B		B		M		M		B	N	F	M
1114	F		GF		B	F		GB	MB			SM	M	M	M	M	MFS	SMF	F	M		M
1121	M		GF	GB		MF			F	GF	GF	FB		F	F	MF	F	MFO	MF	M	F	
1123	F		F			F		GF	GB	B	SF	B	F			F	F	MF	SF	F	GF	
1130	M	GF	GF	F		M		B	B	GB	BJO	MF	B		F	F	FB	SMGF	MF	MF	MOF	M
1131	M		GF	GF	GB	F	MG			B	F	F	B		F	F	F	MF	F	O	MGF	M
1133	M		GF		B	BF	MG		B	GB	B			F	MF		M	F	F	AF	GN	M
1136	M		F	GF		F	G	B	B	GFB	B	F	MB	F	F	MFJ	F	MF	MF	F	M	
1140	F		GF	F				M	SMGF	G		SMFJ				SMF	M	M	M	M	M	M
1146	M	B	GF		M	MBF			MF	MGB	MGBF			F	F	FJ	F	MF	F	M		M
1150	M	O	MF	B	M		MF	F	B	FB	F		MFB	F	F	MF	F	FO	MF	MF	MGF	M
1152	M		F	F	GJ	J	GF	M	GF	GF	GJF	F		F	SF	F	F	SFO	F	F	MGF	
1158	F		F	F		MF		M	G	G	SGF	M	F	M	F	F	MF	S	MFS	SF	MGF	
1162	M	B	F										B			F	F		F	M	O	
1167	M		F	F			G	MB	B	GB	B		B	F	SF	F	SGF	F	F	F	F	M
1170	M		F	F	MF	MGF	F	M		GF	F	F	B	F	F	F	F	FO	MF	MAF	MGF	
1208	F		M				MG		G	GS	SAG	N	S				S	SF			M	
1209	F	M		M	B			B	F	F	SB	S	M		F	FJ	F	F	F	MF	GF	
1239	M		G	F				B	GB	GB	GB		B	M	F	F	F	MFO	F	G	MF	
1240	F			F			F			G	SB	S	F		F	F	F	F	SF	M	MF	M
1241	F			F	MF	MF	F	GF		JF	SF	F	MFB	M	F	FS	SF	M	MF	MOF	F	M
1245	F			F	MF	F	MFO	A	F	F	F	F		F	OFS	SF	FS	SAMF	F	M	F	M
1249	M			OF	F	MG	M	MB	B	GB	B	B	BF		MF	F	MF	MFO	F	MF	GF	M
1267	F			J	F			GBF	B	BF	GFB	FS	M		MF	MF	MF	SMF	MF	MF	M	
1270	M	G		B		B				B	B	B								M		
1271	M			B	B			MF		GB	B	B	B			F	F	OF	F	M		M

B-Browns Ban, F-Bay of Fundy, O-Gulf of Maine, G-Great South Channel, J-Jefferys Ledge, M-Cape Cod and Mass. Bays, A-Mid Atlantic, N-North, S-Southeast US.

Appendix I

Confirmed right whale identifications in Cape Cod Bay in 1998, 1999 and 2000 and the sighting histories of those 142 individuals. Abbreviations are listed below last sighting.

1280	U			GB		G	MB	MB	MB	B			M	M	M	M			M	M		M
1301	F				MF	AM		MB		BS	SF	M	B	BS		F	MF	MF	FS	S	MF	M
1306	M				MF		F	G	M	GF	GF	B	B	F	F	F	F	SFO	F	F	GF	M
1310	F				GF		G	MF				FJ		O				M	S	M		M
1311	M				GF		M	GB		GB	B		B	SB	F	MF	F		M		G	SM
1317	M				SM	MBJ		GB	B	M	SB		B			OF	F	F	MF	F	MGF	M
1327	M			MG	M	G	M	MBF	M	MB	B	B	GB	F	MF	F	F	FO	F	F	MGF	M
1328	U				G					B	F	B	G	MBF	F	F	M	M	F		M	M
1403	M					F		F		GB	B		B	MF		F	F	SM	F	F	GF	M
1405	F					SF	F			GF	F	F	F	F	F	F	F	SMF	SF	M	M	
1406	F					SMF	MOF			MB	FA		MF	MF	MFA	SMF	MF	M	MF	MF	MF	M
1407	F	B	G	M		SF				F	SMF				SOAF	F			M	M	O	M
1409	M					F		B	B	GB	B	B	B		SMF	F	MF	S				M
1411	M					SF		G		B	MB	B	B		F		F	F	MF	M		M
1424	M		M		B	B	S	M	G	GB	GB	M	B	M	MF	F	F	SMF	F	MAF	MF	
1425	F			G		F	M		M	B	M	M		M	MFS	SGAF	MF	MF	F	A	M	
1427	M					F	JM		GB	GB	B	B	B	MF	MF	F	MF	FO	MGF	FM	MG	
1428	M		G			MGO	M	GB		MG	F	FB	B	F	F	F	MF	SMF	F	M		M
1430	F					M	M	MB	MB	MG	B			SM	F	MF	MF	MNS	S	MGN	MO	M
1503	F						F	M	M	MB		F		M	F	F	SFM	MF	BF	MG	MF	M
1505	M						MF	AM		GOB	B	B	MF		MSF	FJ	MF	SMF	MF	MGF	M	
1507	M						JOF	M	GMF	GOF	F	FB	MB	F	MF	F	F	MFO	MF	MGFJ	MGF	M
1509	F	GB				M	M	SM		B	SJM	M	M	SMJ		M	MN	MNS	SF	M	MG	M
1511	M		G		B	G	M	MBF	B	B	B								F		M	M
1513	U						M	B	GB	MG			MB					M	M	GM	G	
1514	M						MG			MB	B	B	B				M			M		
1601	F							SF	M	GF	F	F	MB		S	F	MF	F	SF	M	G	
1602	F							SMF	MF	SMF	F		M	M	MFS	SF	MFS	SMFO	F	MF	GF	M
1603	M							SGJMF	M		B	S	M		SF	F	MF	F	F	M	MGF	M
1606	M							MF	G	F	B				F	F	F	SMF	F	M	MF	M
1608	F							SM	GM		F	F	MF	MF	F	F	MF	MFO	F	MF	MGF	M
1609	M							SM	F	F	F		B		F	F	F	SF			JMF	
1611	F							SM	SF	B	B		B			F	F	MFO	SF	MGF	MF	
1622	F							M	M	GBS	S	M	SM				F	MS	SMO	M	MG	M
1624	M							B		GB	GB				F	F			F		G	M
1630	U							B	B						F	F	F		F		F	M
1701	F								F	F	B	B	FB		FS	F	FS	SF	OF	M	MGF	

B-Browns Ban, F-Bay of Fundy, O-Gulf of Maine, G-Great South Channel, J-Jefferys Ledge, M-Cape Cod and Mass. Bays, A-Mid Atlantic, N-North, S-Southeast US.

Appendix I

Confirmed right whale identifications in Cape Cod Bay in 1998, 1999 and 2000 and the sighting histories of those 142 individuals. Abbreviations are listed below last sighting.

1703	F								F		F	F			SF	SF	F	SF	MF		SGF	M
1704	F								SMGF	SMF	F	BM	MF	MF	MF	MF	MOF	MFOS	SMF	M	M	
1706	F								SMF	F	F	F	F		SMF	FJ	SF	MF	MFS	MF	MGF	
1708	M								GB	B	B			M	M			M	F	F	MG	M
1709	M								M	JB	B	B	B	M	SF	F	F	F	F	SMF		
1711	F								SM	GB	MB						F	SMF	F	M	SMG	M
1712	M								SAM		B	B	B			F	F	F	M		MF	
1716	M								B	B	B		B		F	F	F	F	F	G	MF	
1802	F									MGF	MF	MF	MF	F	SMF	F	MF	MFS	F	MF	MGF	M
1803	M									JF		F	F	S	SMF	F	F	M	OF	S	MGF	
1804	M									GO	F	F	F	F	F	F	F	F	MF	SF	MGF	M
1812	F									B	B		B		SF	F	F	S	F		MGF	M
1817	F									B	SB		S	S	SF	SF	FS	SF	F	S	G	M
1820	U									B	B	B	B		M	F		SMF	MF	M	MF	M
1901	M										SGF		S	SF	SF	SF	SF	SMF	SMF	F	MGOF	
1909	F										SJM	MJ	B	M	SMF	F	SF	F	MF	MF	SMOGF	
1911	F										F	M				F	MF	M	MF	MF	SMGF	M
1934	F										SMO		B	M	SF	MF	MF	M	MF	MGF	MGF	
1968	F										GF		B	B	S	F	F	OF	F	M	M	M
1971	M										F	F		F	F	F	F	F	GF	F	GF	SM
1981	U										F	F			S	F	F	SOF	FS		MGF	
2010	M											FJ	M	M	S	F	F	SF	MF	SM	MG	M
2027	M											MJF			F	F	F	MFO	F	M	F	M
2040	F											MJF			F	F	F			O	G	M
2048	M											F	F		F	F	MF	M	F	F	MF	
2050	F											M		M	SM		MF	SMF	MF	MGF	MGF	M
2114	F											S	SB		M	F	MF		F	M	GF	
2123	F												F	MF	SF	FS	FS	SMFO	SMF	SMAF	MGF	M
2135	M												MF	MF	SF	F	F	SMOF	GF	M	MJOGF	M
2140	M											S	F	F	S	MF	F	SMF	F	MF	MGF	
2143	F												SF	F	F	F	F	FO	MF	F	GF	SM
2145	F												MF	F	MF	F	F	MOF	M	MF	MF	
2158	M												F	MF	F	F	MF	MF		SM	M	
2201	M													SF	SMF	F	MF	SFO	F	SF	MF	
2209	M													SMJ	M	F	MF	SMFO	F	AF	MGFS	M
2215	M													SB	MF	F	MF	SMFO	MF	SMF	MGOF	M
2223	F													F	F	F	F	O	F	MGF	MGFS	M

B-Browns Ban, F-Bay of Fundy, O-Gulf of Maine, G-Great South Channel, J-Jefferys Ledge, M-Cape Cod and Mass. Bays, A-Mid Atlantic, N-North, S-Southeast US.

Appendix I

Confirmed right whale identifications in Cape Cod Bay in 1998, 1999 and 2000 and the sighting histories of those 142 individuals. Abbreviations are listed below last sighting.

2240	F													SF	SF	F	F	SFO	F	MG	OGF	M
2271	M													SF	F	F	F	SMOF	F	M	MGF	
2303	M														SF	SMF	MF	SF	M	SAF	MGF	
2304	M														M	F	F	MF	F	F	MOF	M
2320	F														S	F	F	SF	SMF	S	GF	M
2340	M														F	F	M	F	F		MGF	M
2350	U														F	F	MF		F		MGF	
2406	U														A	SMF	M	F	F	MF	MGF	M
2425	F															SGAF	MF			M	MGF	M
2427	M															M	F	MFO	F	F	MGF	M
2430	F															F	MF	F	F	F	MGFS	M
2470	U															F	F	MF	F	M	MGF	M
2479	U															F	F	MF	MF	MF	MGF	M
2503	F																SFM	F	F	MF	F	M
2540	M																F	F	F	F	F	M
2602	M																	SMFOA	F	F	F	M
2608	M																	AF		F	F	M
2614	F																	SMF		M	MGF	
2617	U																	SF	SF		F	M
2630	U																	F	F	GM	MF	
2635	U																	SMF			M	
2645	F																	SAMF	SMF	F	MS	M
2705	U																		SF	SMF	MF	
2709	M																		SF	SF	F	M
2710	U																	S	SF	F	MF	
2720	U																		F	MF		M
2740	M																		SF	F	MF	
2750	M																		SF	F	MGF	M
2760	U																		F	GF	MOF	M
99-42	U																				M	
99-183	U																				MG	

B-Browns Ban, F-Bay of Fundy, O-Gulf of Maine, G-Great South Channel, J-Jefferys Ledge, M-Cape Cod and Mass. Bays, A-Mid Atlantic, N-North, S-Southeast US.

Appendix II

Sighting records of right whales (n=86) identified in Cape Cod Bay, January to mid May, 2000. F (female), M (male), A (adult), J (juvenile), U (unknown).

Id#	Sex	Age	23-Jan	27-Jan	30-Jan	3-Feb	8-Feb	10-Feb	13-Feb	18-Feb	20-Feb	22-Feb	24-Feb	1-Mar	2-Mar	5-Mar	6-Mar	7-Mar	8-Mar	11-Mar	14-Mar	23-Mar	25-Mar	27-Mar	31-Mar	1-Apr	3-Apr	7-Apr	11-Apr	# of days sighted
1971	M	11	x																											1
2010	M	10	x																			x	x	x			x	x		6
1317	M	17		x			x					x							x		x	x			x					7
1114	F	A			x				x	x		x	x					x						x						7
1802	F	12			x	x		x	x		x	x						x	x	x			x		x		x			12
1602	F	14			x		x	x				x						x			x									6
1406	F	16				x				x	x	x	x		x			x		x			x	x						10
1911	F	11				x		x		x	x	x			x			x	x	x	x	x			x					12
2027	M	10				x																								1
1306	M	A				x			x			x						x		x		x								6
2470	U	U				x	x	x	x		x	x							x				x	x		x		x		11
2645	F	4					x									x							x	x		x		x	x	7
2503	F	5					x	x							x	x						x								5
2709	M	3					x				x			x			x		x	x				x						7
2320	F	U					x	x	x			x	x		x	x			x	x		x				x		x		12
1140	F	A					x		x				x			x	x													5
2760	U	U					x	x	x		x		x			x		x					x	x	x					10
1241	F	18						x							x				x		x	x								5
2750	M	3						x			x		x			x			x					x	x			x		8
2479	U	6						x	x							x		x				x		x						6
1150	M	A						x	x		x	x	x		x				x											7
1608	F	14						x				x	x	x	x	x		x	x	x	x	x	x							12
1245	F	18						x	x		x				x			x	x					x	x	x		x		10
2602	M	4							x		x	x			x															4
2406	M	6							x		x	x			x			x			x	x								7
1027	F	A									x		x	x		x		x			x					x				7
2427	M	6									x			x					x		x	x		x	x					7
1603	M	14									x	x	x					x									x			5
1112	M	A									x	x				x		x		x										5
2135	M	9									x		x					x		x										4
2617	U	4										x																		1
1310	F	A										x				x			x		x	x								5
1624	M	A										x															x	x		3
1328	M	A											x			x		x												3
2304	M	7											x	x			x						x		x			x		6
1820	U	A											x	x		x		x												4
1407	F	A											x		x			x	x	x	x		x	x	x	x				10
2123	F	9											x		x				x			x				x		x		6
1130	M	A												x																1
1280	U	A												x										x						2
1133	M	A													x	x														2
1812	F	A													x						x									2
1503	F	15													x			x	x			x								4
2050	F	A													x			x				x	x	x	x					6
1428	M	A													x	x			x			x	x	x						6
2240	F	A																x		x		x	x	x						5
1131	M	A																x	x											2
1327	M	A																	x		x		x	x	x	x				6
1240	F	A																	x		x									2
2158	M	9																	x			x	x	x				x		5
1509	F	A																	x											1
2430	F	U																		x				x	x	x				4
2223	F	8																		x		x	x	x	x	x		x		7
1146	M	A																		x										1
1411	M	16																		x		x			x	x		x		5
1511	M	A																			x			x	x	x				4
1507	M	15																				x			x	x	x			4
1817	F	A																				x			x	x		x		4
2215	M	8																				x				x		x		3
1301	F	17																				x	x	x						3
1249	M	18																				x				x				3
1708	M	13																				x				x				3
2425	F	6																				x	x	x	x	x		x	x	7
2143	F	9																				x				x		x		4
2209	M	8																				x			x	x		x		5
1804	M	12																				x	x	x						3
1113	M	13																				x								2
1311	M	17																				x								1
1271	M	A																				x	x	x		x		x		5
2340	M	U																				x	x		x	x		x		5
1630	U	A																				x								1
1711	F	13																					x	x						2
2540	M	U																					x	x		x		x		4
1606	M	14																					x	x						2
1430	F	A																						x						1
1409	M	16																						x						1
1968	F	11																						x	x	x				3
1403	M	16																							x	x		x		3
1167	M	A																							x					1
2040	F	10																							x	x		x		3
1013	F	A																							x	x	x			3
1622	F	A																								x				1
2145	F	9																								x		x		2
1703	F	13																										x		1
2720	U	U																										x		1
2608	M	4																										x		1
d'd per day			2	1	3	6	9	13	12	3	16	18	16	8	17	15	3	22	22	15	14	35	22	36	25	30	5	27	2	

Appendix III.

Sighting records of right whales (n=26) identified in the Great South Channel, May, 2000.
F (female), M (male), A (adult), J (juvenile), U (unknown)

Id #	Sex	Age	3-May	4-May	12-May	17-May	# days sighted
1812*	F	A	x				1
1028	M	A	x				1
1960	M	A	x				1
2425*	F	U	x	X			2
2470*	U	U	x				1
2510	U	U	x				1
2304*	M	J	x				1
2303	M	J	x				1
1607	M	A	x				1
1140*	F	A	x				1
1950	F	A	x				1
2330	U	U	x				1
1609	M	A		X			1
2410	M	U		X			1
2140	M	A		X			1
1419	M	A		X			1
1233	F	A		X			1
1238	M	A		X			1
1802*	F	A		X			1
1145	F	A		X			1
1156	M	A		X			1
1428*	M	A		X			1
1311*	M	A			x		1
1423	U	A				x	1
1055	U	A				x	1
2320*	F	U				x	1
# id'd per day			12	11	1	3	

*These right whales were also seen in Cape Cod Bay in 2000, see Appendix I.

Appendix IV.

Appendix IV., a sample of the daily fax sent at the completion of a survey to report sightings and locations of right whales to DMF and NMFS/SAS, was not included in the electronic version of this document. If you would like to see a sample report, contact the Massachusetts Division of Marine Fisheries at (617) 626-1520, and request a copy of Appendix IV of the 2000 right whale surveillance and monitoring report be mailed to your attention.