Surveillance, Monitoring and Management of North Atlantic Right Whales, *Eubalaena glacialis*, in Cape Cod Bay, Massachusetts: January to Mid-May, 1998.

Final Report

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Table of Contents

List of Figures

List of Tables

List of Appendices

Introduction

The northern right whale, *Eubalaena glacialis,* is one of the rarest large whales in the world, and is listed as "endangered" under the Endangered Species Act (ESA) of 1972. Estimates indicate that no more than 350 remain in the western North Atlantic (CeTAP 1982, Brownell *et al* 1986, Kraus *et al* 1988, Knowlton *et al* 1994, NMFS 1991), despite international protection 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), but recent analyses showing a decrease in the calving rate, an increase in the calving interval, and an increase in the number of presumed deaths (a right whale not seen for six consecutive years is presumed dead) suggest we should view the present situation with greater concern (Knowlton *et al* 1994, New England Aquarium, NEAq, unpublished data). The apparent failure of the 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) . Of the 17 anthropogenic right whale mortalities documented since 1970, 15 were due to ship strikes, and two were the result of entanglement in fixed fishing gear (Kraus 1990, Kenney and Kraus 1993, NEAq unpublished data). Ship collisions kill more right whales than any other documented causes of mortality.

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). The Cape Cod Bay ecosystem, one of five known seasonal high-use habitat areas for this species in the western North Atlantic, was federally designated a Critical Habitat for the North Atlantic right whale in 1994, (Federal Register 59 FR 28793, Figure 1) in recognition of its seasonal importance as a feeding area 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). Right whales are slow moving (particularly when accompanied by a calf), they are difficult to see, and do not always avoid approaching vessel, 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. At least two right whales have been killed by ships in this area since 1986 (A. Knowlton pers. comm). Although some fishing activity is prohibited in the Cape Cod Bay Critical Habitat during the winter and spring (January through mid-May), fixed fishing gear is set outside along the western margin of the Critical Habitat, an area where right whales have been reported opportunistically .

Photographic identifications of right whales in Cape Cod Bay date from 1959 to the present (Hamilton *et al*, 1997), however, whaling records provide evidence of right whales in this area from at least the early 1600s. Over the last fifteen years, about 60% of the entire catalogued population of right whales are known to have used Cape Cod Bay and adjacent waters at some time during their lives (Center for Coastal Studies, CCS, and NEAq, unpublished data). These photographic data have primarily been collected during annual studies on surface-foraging of right whales in the winter and spring (Mayo and Marx, 1990), by researchers on whale watching vessels from April to

* 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.

October until 1996, and in 1997 during weekly vessel surveillance and limited aerial surveys in the winter and spring (Hamilton *et al*. 1997, Mayo 1997).

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 research program was undertaken in the winter and spring of 1998 with support from the Division of Marine Fisheries (DMF), Commonwealth of Massachusetts. This research directly addressed concerns identified by the ESA, the Right Whale Recovery Plan (NMFS 1991) and the Northeast Implementation Team and supported goals in the federal Large Whale Take Reduction Plan and the Right Whale Conservation Plan submitted by the Commonwealth of Massachusetts to federal courts in 1996. The objectives of the 1998 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, 1998, 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 catalogue at NEAq and the Consortium database at University of Rhode Island (URI).

II) To provide sighting data to the National Marine Fisheries (NMFS) Early Warning System (EWS). Data on the sighting location of right whales were reported promptly to NMFS/EWS 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 "real-time" sighting data within Massachusetts waters to port authorities, commercial and military vessels, and other maritime operations.

III) To collect oceanographic information on weekly vessel cruises, from January to mid-May, 1998, 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.

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.

Here we report on the results of the research activities described in objectives I, II, and IV. All photographs of right whales collected during oceanographic sampling (objective III) have been incorporated with the analysis of aerial photographs. A copy of the final report on the results of the habitat study, funded in part by Massachusetts Environmental Trust (MET, objective III), will be submitted to DMF upon completion.

Methods

I) Aerial Surveys

Aerial surveys were conducted from January through mid-May in the Cape Cod Bay Critical Habitat and adjacent waters. The aerial survey protocol for Cape Cod Bay as described in Kraus *et al* (1997) was adopted with some modifications. Fifteen tracklines were flown latitudinally (east-west) at 1.5 nautical mile (nm) intervals from the mainland to the Cape Cod shoreline (Figure 1). This east-west flight pattern 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 293.2 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, and excludes all miles flown between tracklines or while circling. Starting with the survey on February 9, 1998, and continuing for the remainder of the season, an additional trackline 25 nm in length was added that approximately paralleled the eastern side of Cape Cod at a distance of about three nm from shore (Figure 1 and Table 1).

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. All aerial surveys were conducted in a Cessna 337 Skymaster (5382S), a twin engine high-wing aircraft (the type of aircraft which has been used for many right whale aerial surveys since 1979). It was equipped with a GPS and LORAN-C navigation systems, full IFR (instrument flight rules) instrumentation, marine VHF radio with external antenna, a liferaft, four survival suits, signal flares, a medical kit, a waterproof VHF radio, a portable EPIRB, and an aircraft mounted ELT. All occupants wore aircraft approved PFD's 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 transect 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 on each sighting, the aircraft returned to the trackline at the point of departure using the LORAN-C or 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 Woods Hole Oceanographic Institute, WHOI) and approved by the U.S. NMFS. Trackline and sightings 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 were provided to DMF in hard copy format at the completion of the field season.

II) Vessel Surveys

CCS maintains two research vessels: the 40' (12m) twin diesel engine R/V *Shearwater* and the 21' (6.5m) single outboard engine R/V *Orion*. Both of these vessels had been used successfully for photo-identification and the R/V *Shearwater* had been used for oceanographic sampling in the winter surveillance program in Cape Cod Bay, 1997.

Dr. Charles Mayo (CCS) and his assistant advised and assisted in the oceanographic sampling at no cost to this contract. (The collection and analysis of these oceanographic samplings outlined below was made possible by a grant to Dr. Mayo by the Massachusetts Environmental Trust. DMF supported the vessel time.) The R/V *Shearwater* was equipped with oceanographic sampling equipment including a CTD, 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. A copy of the final report on the habitat studies prepared for the MET will be submitted to DMF by Dr. Mayo, upon completion.

Although the primary objective of these vessel cruises was habitat sampling, 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. Sightings data from the vessel daily logs were entered into the Right Whale Initiative DBase program.

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 Coast Guard to disentangle whales at sea. 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 disentanglement was on board at all times.

Additional vessel trips were conducted using R/V *Orion* to provide supplemental photo-identification and collect biopsy samples (see below). Surveys on the *Orion* 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 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

As soon as possible following the completion of each aerial survey and vessel trip, a summary of the location and number of right whale sightings was faxed to DMF. In order to provide the most thorough information possible, we contacted any other whale research vessels operating in Cape Cod Bay and adjacent waters, and added additional sightings from them that were not encountered in our surveys. A copy was faxed to the NMFS/EWS coordinator in Woods Hole, MA, for dissemination to the appropriate agencies and mariners.

IV) Photographic Methods

i) Identification Photographs

During aerial and shipboard surveys, photographs were taken on Kodak Kodachrome 200 or Ektachrome 400 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 oblique photographs of the entire rostral callosity pattern of every right whale and any other scars or markings that are obvious. From the boat, photographers attempted to collect good perpendicular 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 used by each observer in the daily log.

ii) Photo-analysis and Matching

Photographs of right whale callosity patterns are used as a basis for identification and cataloguing of individuals, following methods developed by Payne *et al* (1983) and Kraus *et al* (1986). The cataloguing 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). The catalogue has been curated by NEAq 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 catalogue allows scientists to enumerate the population, (there are currently 12,687 sightings of 388 individual right whales of which 316 are thought to be alive, A. Knowlton pers comm) and, from resightings of known individuals, to monitor the animals' reproductive status, births, deaths, scarring, distribution and migrations.

Photographs taken during the 1998 Cape Cod Bay field effort 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 catalogue 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 which 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 catalogued and archived at NEAq. All matches to the catalogue 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 catalogue of identified right whales to update existing files. NEAq will archive copies of photographs representing each sighting taken during the course of this work, in archival quality slide sheets. 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 catalogued by a numbering system. All catalogue 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 are well established (Brown *et al* 1991). All biopsy sampling efforts were carried out in conjunction with photo-identification efforts (see above). 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 catalogue. 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 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 fixed in formalin and the other was frozen in a chemically treated glass vial. These samples were sent to Dr. Michael Moore at WHOI to be integrated with his on-going study on toxin exposure.

VI) Data Management, Analysis, and Interpretation

i) Data Management

Aerial survey data and sightings 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 catalogue and Consortium database to be integrated with existing data on life histories for each individual identified. Integration of the sightings 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 1998. The 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. Fishing activity was not recorded during the aerial surveys. 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.

From the individual identifications of right whales obtained during this study, we examined the 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

Surveys

The survey effort in 1998 spanned 132 days from the 4th of January until the 15th of May. Aerial surveys were conducted on 33 days in the Cape Cod Bay Critical Habitat and adjacent waters when sea state was Beaufort four or less and visibility was greater than two miles. The described area (Figure 1) was surveyed on average in approximately 4 hours and 50 minutes for those surveys that were not aborted due to an increase in wind speed, sea state or decrease in sighting conditions. Surveys ranged in duration from about four hours to just over seven hours depending on the number

of whales encountered (Table 2). The turn at the end of each trackline was initiated and completed about 1.5 nm from shore to maximize the opportunity to observe any whales near shore. After the first month of surveying, an additional trackline, (No. 16, Figure 1, Table 1) was added to the survey following reports from fishermen of marine mammal sightings along the eastern side of the Cape.

The DMF provided state biologists to fill one of the observer positions on most 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.

State biologist	Number of flights	Hours flown
K. Creighton	3	13.9
B. Glenn	2	9.8
B. Hoffman	4	20.3
R. Johnston	6	32.1
P. Kelliher	2	11.1
J. King	4	16.5
D. McKiernan	5	21.8
L Sherwood	1	3.3
Total	28	128.8

In addition to the observers on contract, additional observers from CCS with experience in right whale research were trained in aerial survey techniques, aerial photography of right whales and data collection. These researchers could be called upon to respond to off-season events.

CCS personnel	Number of flights	Hours flown
Pam Hudson	2	5.6
Ed Lyman	4	15.6
Jooke Robbins	4	20.3
Shannon Wagner	10	46.3
Total	20	87.8

Shipboard surveys were carried out on 26 days and 17 of these occurred on the same day as an aerial survey. Vessel surveys were conducted primarily on R/V *Shearwater* which was used to collect oceanographic data in the Cape Cod Bay Critical Habitat area weekly for 19 weeks. The preliminary results of the oceanographic sampling are contained in the interim report submitted to MET, a copy of which was submitted to DMF in July, 1998 (Mayo 1998). In addition to their primary objective of habitat sampling, marine mammals were recorded and identification photographs of right whales were obtained as the opportunity arose (Table 3). These photos have been compared to the ones obtained from aerial surveillance and were taken through the same matching process as detailed above.

The R/V *Orion* was used on six days to provide additional photo-identification effort in Cape Cod Bay, collect biopsy samples from those individuals not already sampled and verify sightings of right whales usually reported opportunistically from the beach between Long Point and

Race Point or by boaters in Provincetown Harbor (Table 3). On the biopsy sampling trips, only three right whales were encountered that had not already been sampled, and a sample was obtained from two of those. These samples will be distributed to the appropriate collaborators. Our zodiac was deployed late one afternoon (March 2nd, Table 3) to verify sightings of right whales near Wood End, reported to us by the Coast Guard. Two whales were photographed in the failing light.

Sightings and Photo-identifications

There were a total of 406 photographed sightings collected during 33 aerial survey days and 26 vessel days. To date, of those 406 sightings, 308 (76%) have been matched to 75 individual right whales whose identification has been confirmed by NEAq researchers (Appendix I). Of the remaining 98 sightings, 31 sightings have been attributed to 20 different individuals, but these are awaiting confirmation to the right whale catalogue. Thus the total minimum count of right whales for the 1998 winter and spring surveillance program (as of 30 September, 1998) is 95 individuals, of which 91 were identified in the Critical Habitat area between January and the end of April and four in adjacent waters in April.

All of the photographs that comprise the remaining 67 sightings have been inspected by at least two qualified researchers. Fifty of the unmatched sightings, comprising 18 different right whales, are either of low quality or 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 catalogue. The final 17 sightings (4% of all sightings) do not have photographs that are not of sufficient quality to be matched.

Right whales were seen on the first aerial survey on January 4th (Figure 2) so it is not possible to establish the date of entry into Cape Cod Bay. The last right whale was seen on April 30th (Figures 3-6) and this likely represents the end of the typical winter/spring residency period. The peak in sightings of right whales occurred between mid-February and mid-March (Tables 2 and 3, Appendix II). There were no sightings of mother calf pairs this year in the Bay, an unusual occurrence. The count of mother calf pairs was very low in the southeast U.S. calving ground, only 5 pairs were seen between December, 1997 and March, 1998, plus one calf that is known to have died. This is the first year since studies began 14 years ago that no mother calf pairs have been sighted in Cape Cod Bay in the winter and spring.

Of the 75 whales matched to the catalogue, nine whales had never been previously seen in any of the waters around Massachusetts prior to 1998 including: #'s1162, 1270, 1701, 1968, 2223, 2240, 2271, 2503, and 2705. Of particular interest was #1270, a male that was last seen in 1990 and had been presumed dead since 1996 (Appendix I). Its status will now be changed to alive with this winter's sighting. There were four days on which, following completion of the Cape Cod Bay tracklines, the plane flew additional surveys to Wildcat Knoll, Stellwagen Bank and the northern portion of the Great South Channel. Four whales were documented outside of Cape Cod Bay on these aerial surveys of which three have been confirmed: NEAq #'s 1050, 1162 and 1513 (Figure 7). None of these whales were seen in Cape Cod Bay in 1998.

There were aerial surveys being undertaken in other 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 and Nantucket Sound (NMFS). Photo-analysis has been completed for the photographs submitted from the southeast U.S. sightings and there were six whales seen in Cape Cod Bay that had previously been seen in the southeast U.S. All of these whales were of known age, two 11 year olds, two seven year olds, one six year old and one whale age one. Only two of these whales (1706, 1709), had been seen as calves with their mothers in Cape Cod.

Catalogue Number	southern sighting	northern sighting (days between sightings)
1706	21-Dec-97, Georgia	16-Feb-98 CCB (56 days)
1709	21-Jan-98, Florida	20-Feb-98, CCB (30 days)
2123	10-Jan-98, Georgia	04-Feb-98, CCB (44 days)
	18-Jan-98, Florida	
2158	10-Jan-98, Georgia	04-Feb-98, CCB (52 days)
2215	25-Jan-98, Florida	06-Feb-98, CCB (39 days)
2705	03-Jan-98, Georgia	28-Feb-98, CCB (55 days)

Photographs from the other aerial survey effort have only just been received at NEAq thus it was not possible to document movements of right whales between Cape Cod Bay and nearby waters at this time.

Capture Rates and Residency

Of the 75 right whales identified to an individual in the catalogue, 23 (31 %) were photographically captured on just one day (see below). Of these 23 single day sightings, 13 (57%) occurred in March. The greatest number of days on which a single whale was captured was 11, # 2140, a 7 year old male, whose sighting history spanned from the first survey on January 4th to February 17th (Appendix II). This whale was seen on nine consecutive survey days, the most consecutive sightings of any whale this season. The second most frequently sighted whale was # 2050, a female of unknown age, who was seen 10 times between January 30th and March 25th. Whale # 1241, a 16 year old reproductive female, was seen nine times between January 22nd and March 6th.

Days Photo'd	1	2	3	4	5	6	7	8	9	10	11
No. Photo'd (n = 75)	23	5	13	8	9	4	6	4	1	1	1

There were 52 right whales captured on more than one day. Minimum residency times were calculated for all whales seen more than once. The minimum residency times for 52 right whales ranged from 2-88 days, with the mean being 33.885 (S.E. = 24.741) days. There were four whales with residency periods of longer than 75 days. The longest, 88 days by # 1704, was an 11 year old female due to give birth in 1999, who was sighted on eight days between January 22nd and April 19th. The second longest was # 2479, a four year old of unknown sex, who was seen four times over an 85 day period. Whale #1310, a reproductive female who is resting from producing a calf in 1997, was seen seven times over an 80 day period and #1407, also reproductive female but one who hasn't had a calf for five years, was seen eight times over a 75 day period (Appendix II). There were only seven whales whose multiple day sighting record spanned less than 10 days and these

were all see in the months of March and April (Appendix II).

Demographics

Of the 75 right whales, there were more females (38) than males (28) identified in Cape Cod Bay (nine of unknown sex, Table 4), but there was no significant difference from unity ($P = 0.383$). When these data were compared with the sex of the catalogued whales and the sex of the whales documented in this area in 1997, there was also no significant difference in either case ($P = 0.225$, Hamilton *et al* In press and $P = 0.304$, Hamilton *et al* 1998 respectively). With respect to age, the sample was dominated by adults, with 77% adults (n = 58), 20% juveniles (n = 15) and 3% unknown (n = 2). This age structure is not significantly different from the right whale catalogue ($P = 0.790$,
n = 374, Hamilton *et al* In press) or from the age structure observed in Massachusetts waters in 1997 ($P = 0.406$, n = 61, Hamilton *et al* 1998). There were however, many right whales of unknown age (n = 33, 44 %) that were classified as adults based on the length of their sighting histories, or, in the case of females, because they were known mothers (Appendix 1).

Notification of Agencies

A total of 42 faxes were sent to the DMF and copied to NMFS/EWS coordinator in Woods Hole, one for each day in which Cape Cod Bay was surveyed by either plane or vessel or both. Faxes were sent following the completion of the survey and return to CCS, usually between 3:00pm and 6pm. 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, R/V *Hannah T*) and David Wiley (International Wildlife Coalition, F/V *Wavelength*). 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 III).

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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 ¼ nm intervals are shown in Table 5. A total of 146 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 six nm away. The average sighting distance was 0.83 nm. Eighty-six percent of the sightings were made with in one nm of the trackline and nine percent were made between one and one and a half nm. There were four sightings made at greater than three miles from the track.

Other sightings

At least five species of cetaceans and two species of pinnipeds were sighted while performing these surveys (Tables 2 and 3, Figure 8). Fin whales, *Balaenoptera physalus*, were the most numerous other large whale encountered and white-sided dolphins, *Lagenoryhnchus acutus*, the most numerous dolphin. Sightings of all marine mammals 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 charted (Figure 9) to show their distribution relative to

right whale sightings and the critical habitat area.

Human Impacts

There were no whales photographed that showed any evidence of an entanglement in fishing gear. One whale, seen on the first survey day, the 4th of January, was #2027, an eight year old male. This whale had last been seen on 12 September, 1997, in the Bay of Fundy with a new entanglement (one that had occurred since the previous Bay of Fundy sighting on 26 August, 1997). At that time some of the trailing gear was removed (about 400 feet) and two buoys were attached to the remaining gear, one contained a radio-monitored transmitter and the second a satellite-monitored transmitter. The whale quickly moved out of the Bay of Fundy and there were no further attempts to disentangle it. The tag stopped transmitting 21 September, 1997. At that time the whale was approximately 100 miles south of Yarmouth, Nova Scotia. When # 2027 was seen in Cape Cod Bay in January, there was no evidence of any gear on the whale. Although it is not known when the gear fell off # 2027, the buoy with the radio-monitored transmitter had been returned to the New England Aquarium earlier in the winter. It had been found by a fisherman on a beach in southern Nova Scotia.

There were no reports of any interactions between vessels and right whales during the field season. Of note, however, was whale # 2705, a one year old animal of unknown sex, who was seen in Cape Cod Bay 55 days after being sighted in the waters along Georgia (see above). This whale, who is missing its entire left fluke blade (probably from a vessel strike), was also seen in the Bay of Fundy in August of 1998 (NEAq unpublished data), but does not appear to be seriously impeded by its injury.

Discussion

The surveillance program in 1998 represents the most extensive survey effort ever in Cape Cod Bay, both in terms of the length of the field season and the number of hours spent in boats and airplanes looking for right whales. More detailed data were collected in this increased effort as is highlighted by the 95 right whales identified so far, the highest number of identifications recorded in Massachusetts waters since studies began in 1984. By incorporating photo-identification and oceanographic sampling, Cape Cod Bay is now the most thoroughly investigated right whale habitat area. This research opportunity has provided a great deal of information on the natural history of this population as it relates to its use of Cape Cod Bay as a winter and spring feeding area, and data from the photo-identification effort will help refine long-term, range-wide analyses on presumed mortality, incidence of scarring and regional demographics.

Right whales were in residence for at least 108 days. The mean minimum residency time of 33.9 days is almost three times the mean of 11.8 days recorded for all right whales sighted between 1978 and 1986 (Hamilton and Mayo 1990), this however could well be a reflection of the increased effort in 1998. The first right whales were seen feeding near or at the surface during the first survey on January 4th, the earliest documented sighting of a right whale in the winter months. Whales were seen exhibiting this behavior during most aerial surveys until April 21st. This last sighting occurred one month later than the last sighting 1997 (Hamilton *et al* 1998), a year that was characterized by an early departure from Cape Cod Bay thought to be brought on by a decrease in the available food for right whales (Mayo 1997). Although survey effort continued through May 15th, there were no more right whales seen.. These data clearly establish the Cape Cod Bay Critical Habitat as a winter and

spring feeding area for right whales. 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). In 1998, January was also a high-use month.

Of the 95 right whales identified, 75 have been matched to an individual in the catalogue as of September 30th and this subset of the animals seen was used to examine the demographic profile of the winter occupants. There were more females seen than males, but the numbers were not significantly different from the entire catalogued population. Although the percentage of adults in the region seems high, 77% closely reflects the percentage of adults in the entire population (Hamilton *et al* In press). The Cape Cod Bay habitat area had previously been described as a nursery area for mothers and calves, based on the regular seasonal presence of mothers and calves (Brown 1994, Winn *et al* 1986). Between 1980 and 1992, significantly more females were seen than males (Brown 1994). In 1998, there were no sightings of any mother calf pairs, and given that both the sex ratio and age structure of the whales in Cape Cod Bay mirrors the demographics of the catalogued population suggests that all segments of the population are now using this region.

Aerial surveillance has been shown to be a useful survey platform in this habitat area. All of the identified right whales were seen from the airplane, there were no additional identifications of right whales from the vessel surveys. Although photographs collected from the research vessels were often of great assistance in assigning an identify to an aerial sighting if the whale in question had not previously been photographed from the air. We were initially concerned that long dive times and extended periods of sub-surface swimming associated with feeding, and typical of right whales in Cape Cod Bay, would hinder aerial photographic identification as it has photo-identification from vessels in the past. On several occasions whales were seen from the air that were not visible to observers on a nearby boat. They were feeding below the surface, surfacing to breathe only once every 10-15 minutes and not showing their flukes on sounding. Some of these whales were photographed from the airplane while their callosity pattern was submerged and 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 from the photographs.

The value of this expanded effort is made more evident by the number of whales that were seen on multiple occasions. In 1997, over half (57%) of the whales were seen on only one occasion (Hamilton *et al* 1998), while in 1998, a lower percentage of the whales (31%), were seen just once, and 57% of those sightings occurred in March and April. This suggests that whales may be moving through the area more quickly at different times during the season and thus less likely to be recorded, however, the data will need to be corrected for effort in order to properly assess residency patterns in the area. The longest time to elapse between the first and last sighting of an animal was 88 days, but this individual was only seen eight times during that period. This raises a number of questions about residency, was the whale in the Bay for the entire period, but not recorded in our surveys, or did it exit and reenter the Bay a number of times. For example, of two whales seen on the first day, one was not seen again until March 5th, 59 days later, and a second whale seen on January 4th and 12th was not sighted again until March 4th, 51 days later (#s 2479 and 1622 respectively, Appendix II). Our knowledge of fine-scale movements both within Cape Cod Bay and within the larger area broadly

defined as adjacent waters, 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. There were some animals that were seen on every survey day over a shorter period, one for nine survey days in a row (Appendix II), but both airplane and vessel surveys are very limited at documenting residency. Even if a whale is seen on consecutive surveys, those surveys may be days apart. The questions surrounding residency and fine-scale movements 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 literally followed around in a vessel for as long as the weather and tag attachment permits. In addition, subsequent sightings of the tagged animal(s) during regular aerial survey also would give us some measure of the frequency of sighting whales that are known to be in the survey area.

The photo-identification data were compared with the some of the oceanographic data from the habitat sampling work to assess if there were any correlation between the number of whales and the type of food that was available during the season. The numbers of right whales in Cape Cod Bay steadily increased for the first two and a half months of the study (Table 4) with the maximum number of identifications for the year being obtained on March 4th (Appendix II). The dominant zooplankton during this period was *Pseudocalanus minutus* and *Centropages* spp.(Mayo 1998). After the middle of March, the number of right whale started to decrease, although there were animals new to the area for the season recorded right up until the last survey. The dominant zooplankton species identified after the middle of March and for the remainder of the field season was *Calanus finmarchicus*, the species thought to be of importance to right whales. These data suggest that, as has been expected for some time, *C. finmarchicus* may not be as universally important to right whales as previously thought, there may be some individual right whales that prefer different types of prey which would explain late season movements into Cape Cod Bay coinciding with the increased dominance of *C. finmarchicus* (C. Mayo pers comm). The mid-March departure of some whales from Cape Cod Bay coincided with the first sighting of right whales in the Great South Channel (P. Gerrior pers comm). The last sighting of right whales in Cape Cod Bay (Table 2) occurred the same week as an unusual number of sightings of right whales in the traffic lanes approaching Newport Rhode Island and Buzzard's Bay (P. Gerrior pers comm). Analysis of these photographs obtained by other investigators in the Great South Channel and approaches to Newport/Buzzard's Bay may reveal if these were the same animals that had been seen in Cape Cod Bay in the winter.

The sightings of right whales were compared with the sightings of large vessels in Cape Cod Bay to examine the overlap between the two. During the first two weeks of surveys, right whales were generally distributed in the middle of the Bay near the western boundary of the Critical Habitat Area (Figure 2a). This is the area where there is the greatest overlap with vessel traffic that is entering and exiting the Bay through the Cape Cod Canal (Figure 7). There was one report of a right whale to the west of the boundary near Plymouth harbor (D. Wiley pers comm). Although there were no such sightings from the aircraft, large vessels do transit the Bay to and from the Canal inside the critical habitat boundary (Figure 7). By the last two weeks of January, right whales were seen more on the eastern side of the Bay, the distribution was generally oriented from north to south between

Provincetown Harbor and Scituate, with the number of sightings near the beach between Long Point and Race Point increasing in late February through March (Figures 2b - 5). Some vessels transit across Cape Cod Bay, entering or exiting the Bay around Race Point (Figure 7).

Right whales are difficult to see, especially from some of the larger vessels that frequent these waters. The present NMFS/EWS distributes a Right Whale Alert via fax with information the location of right whale sightings and the same information is announced on the local marine weather radio. Due to the nature of the surveys and present system of communicating sightings to the NMFS/EWS at the completion of the survey day, the amount of time that elapsed between seeing a whale and the notice being distributed was several hours. It was possible to contact vessels from the airplane via marine VHf radio, but time in the air is precious and limited, circling and communicating with vessels would compromise our ability to surveillance work in the Bay in a single day. Due to the time delay between sightings and alerts, our poor understanding of fine-scale movements, and the overlap between whales and vessels, the data suggest that a system where sightings are relayed to transiting vessels at the time of the sighting would be more effective at reducing the potential for collision between vessels and whales. This could be accomplished in Cape Cod Bay using a system similar to the one used in the southeast US Critical Habitat EWS surveys. When a right whale is seen, a message goes out over a pager and is relayed to marine users in the area. In the case of Cape Cod Bay, sighting locations could be sent via pager to marine traffic operators that are in contact with vessels entering and exiting the Cape Cod Canal. This would make the valuable sighting information available to mariners on a more “real time” basis without reducing the time required for surveillance and photo-identification.

During the field season, we received reports of right whales along the southern side of Nantucket Island near the airport. In past years, there have also been similar reports from residents walking on the beach and pilots flying for Cape Air. Many of the sightings have been of whales located just south of the airport. Although several of these were investigated in 1998, no right whale were sighted, likely a result of the sightings being several hours to several days old by the time we received them. There is also some danger to the survey aircraft from working in this area on an ad hoc basis because of the necessity to circle near the end of the runway of the Nantucket airport. In order to maximize this sighting information in the future, we suggest setting up a network among residents of Nantucket that frequently walk the beaches, the pilots of Cape Air and the air traffic controllers at the Nantucket airport to report sightings directly to CCS so that the aerial team can fly out to investigate quickly and safely.

The data on temporal occurrence, residency and distribution will greatly enhance right whale conservation strategies for this region. Perhaps the most valuable product of this work is the increased awareness it’s generated throughout the maritime community about the presence of right whales in these waters. These surveys are a valuable component of the right whale conservation effort in Cape Cod Bay in the winter and spring, but it is important to understand the realistic limitations of the system so that we can continue to strive for improvement. We will try and implement measures described above in 1999 for the sole purpose of increasing the safety of right whales in state waters.

Acknowledgments

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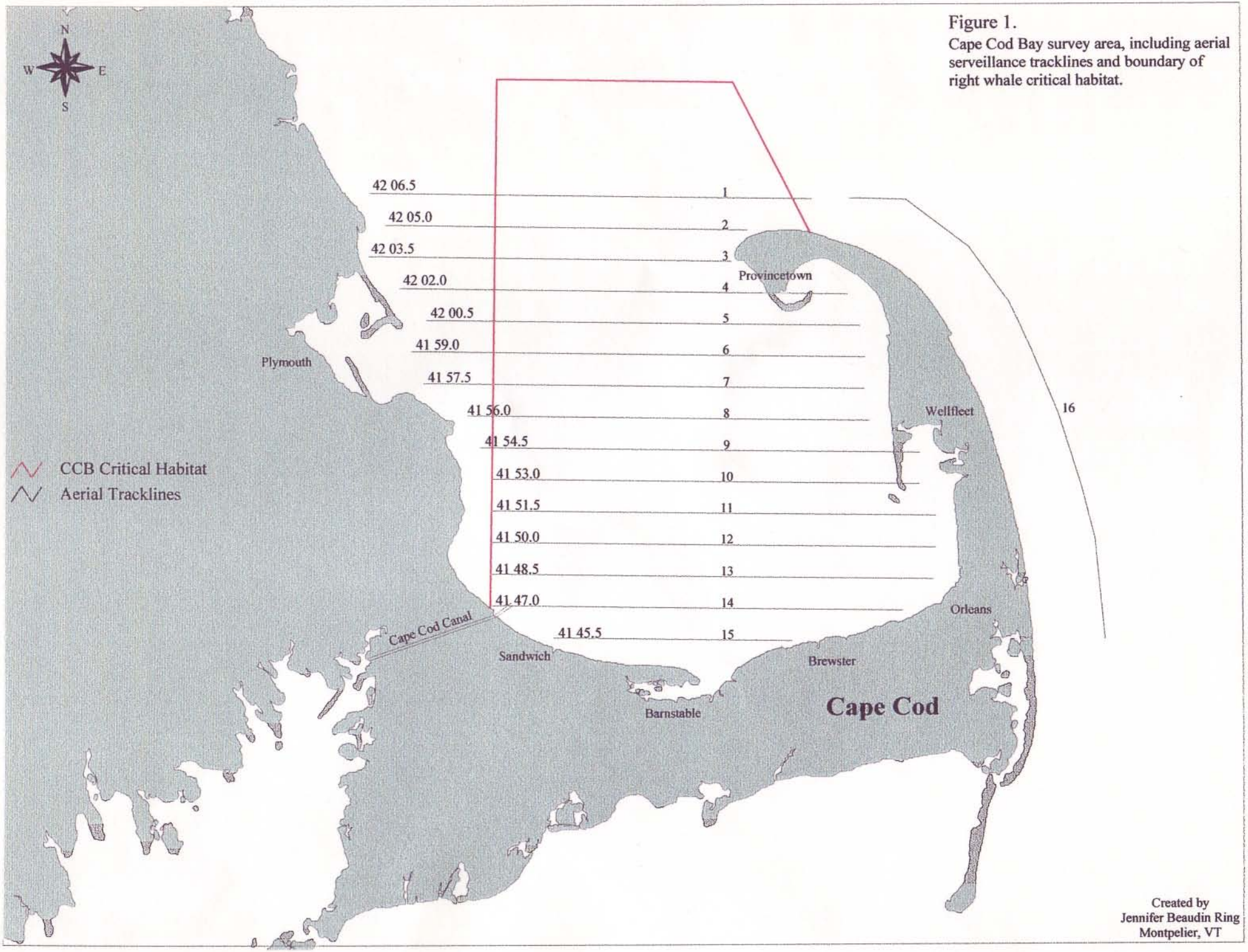
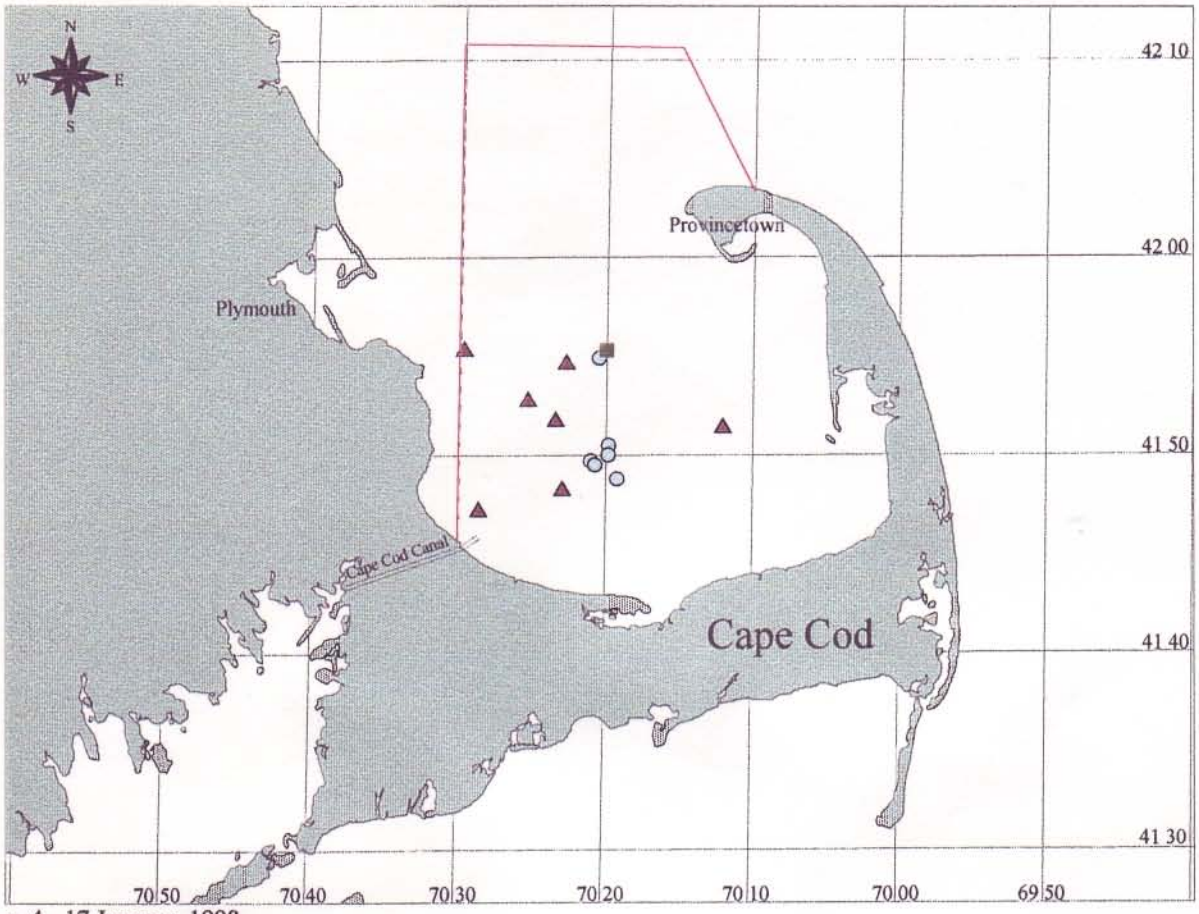


Figure 1.
Cape Cod Bay survey area, including aerial serveillance tracklines and boundary of right whale critical habitat.

Created by
Jennifer Beaudin Ring
Montpelier, VT

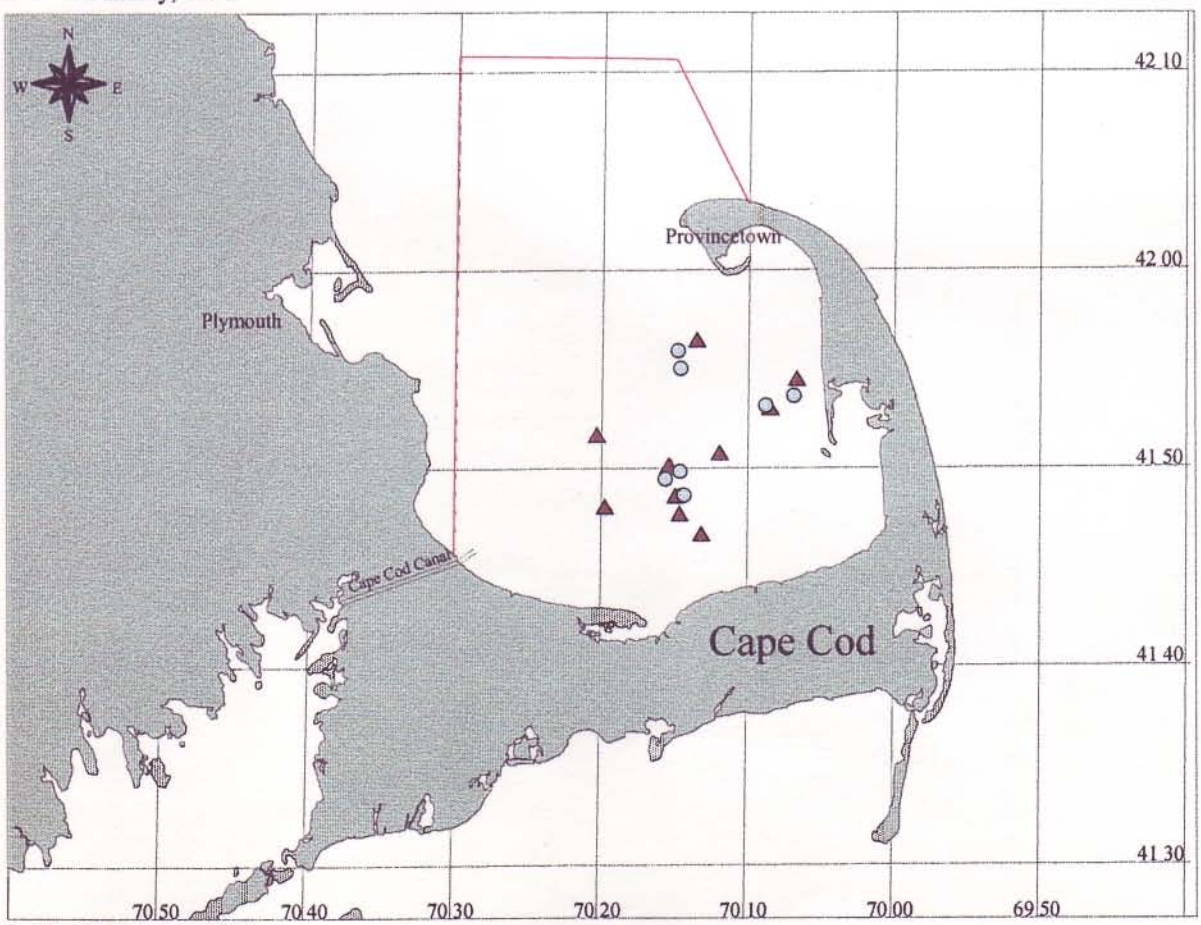
Figure 2.
Sightings of right whales from aerial surveys in Cape Cod Bay, January, 1998.



CCB Critical Habitat

Sightings:
4 - 17 January
- 1 animal
- 2 - 5 animals
- 6 - 10 animals

a. 4 - 17 January, 1998.



CCB Critical Habitat

Sightings:
18 - 31 January
- 1 animal
- 2 - 5 animals
- 6 - 10 animals

b. 18 - 31 January, 1998.

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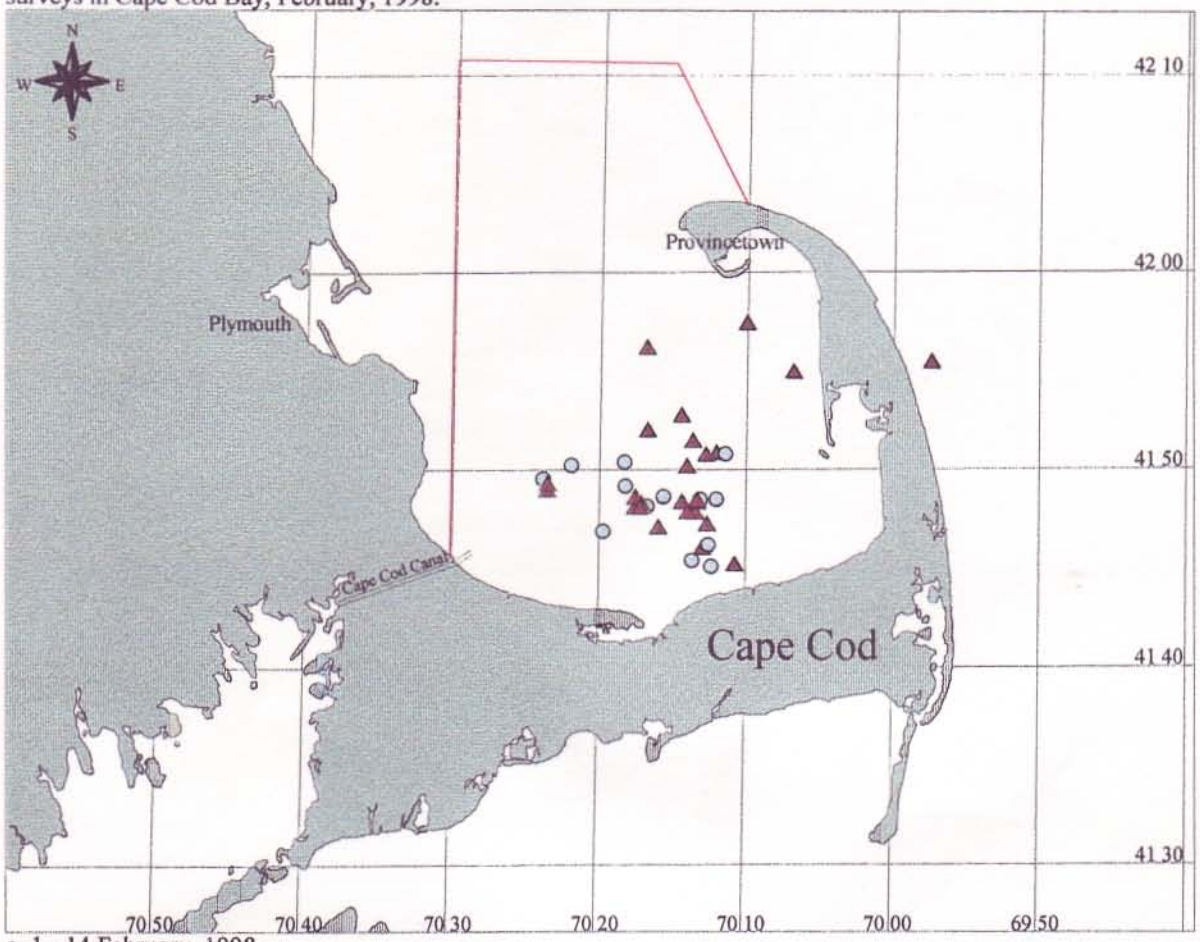
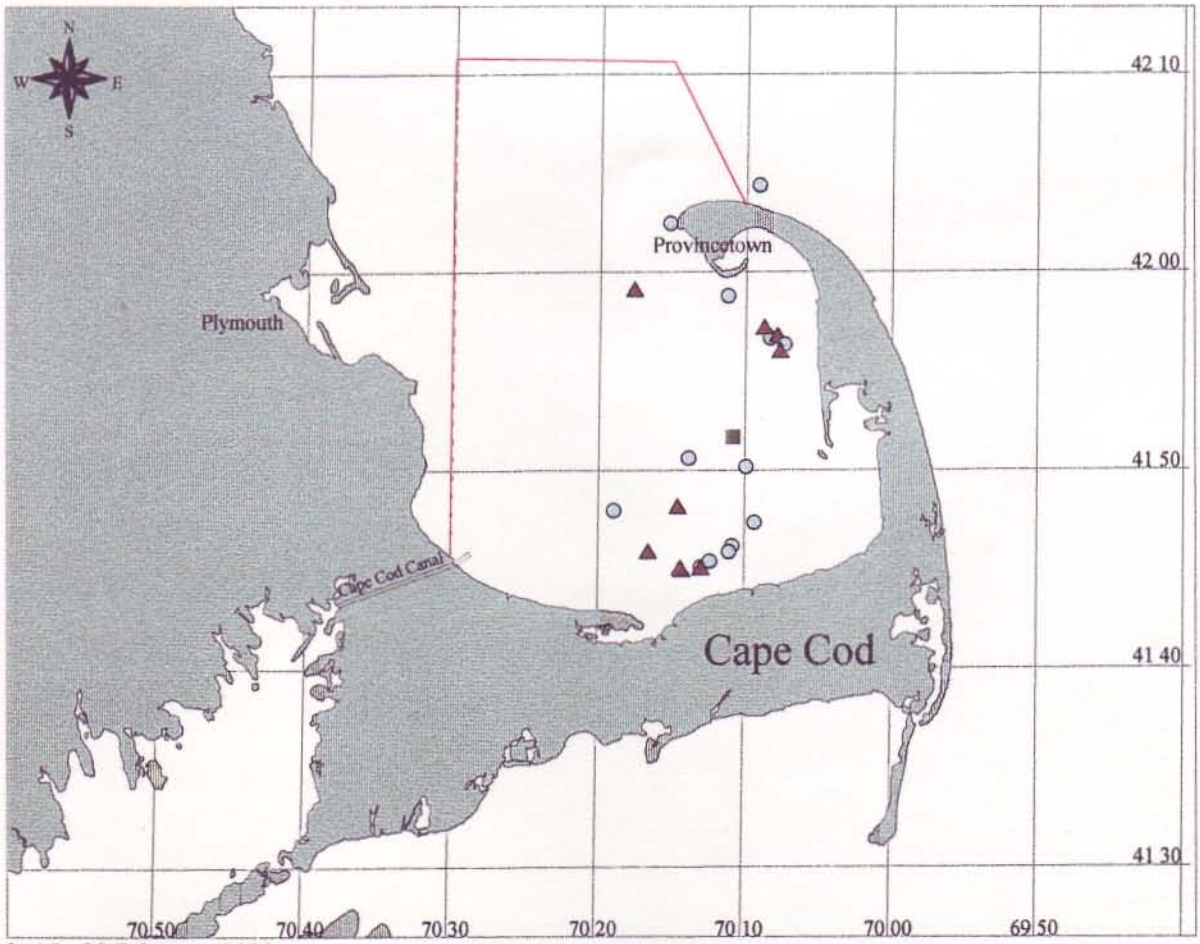
Montpelier, VT

Figure 3.

Sightings of right whales from aerial surveys in Cape Cod Bay, February, 1998.



a. 1 - 14 February, 1998.



b. 15 - 28 February, 1998.

Created by
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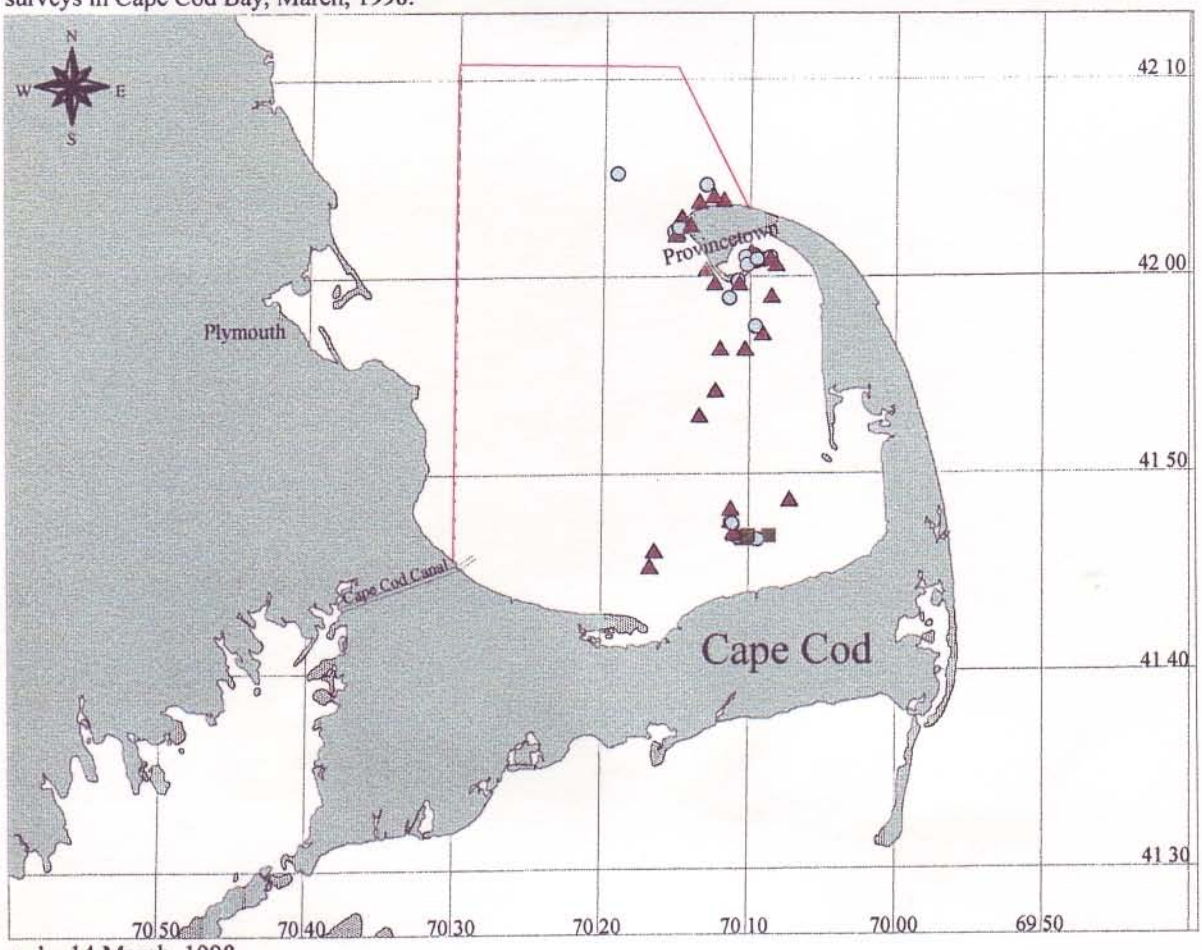
Montpelier, VT

Figure 4.

Sightings of right whales from aerial surveys in Cape Cod Bay, March, 1998.



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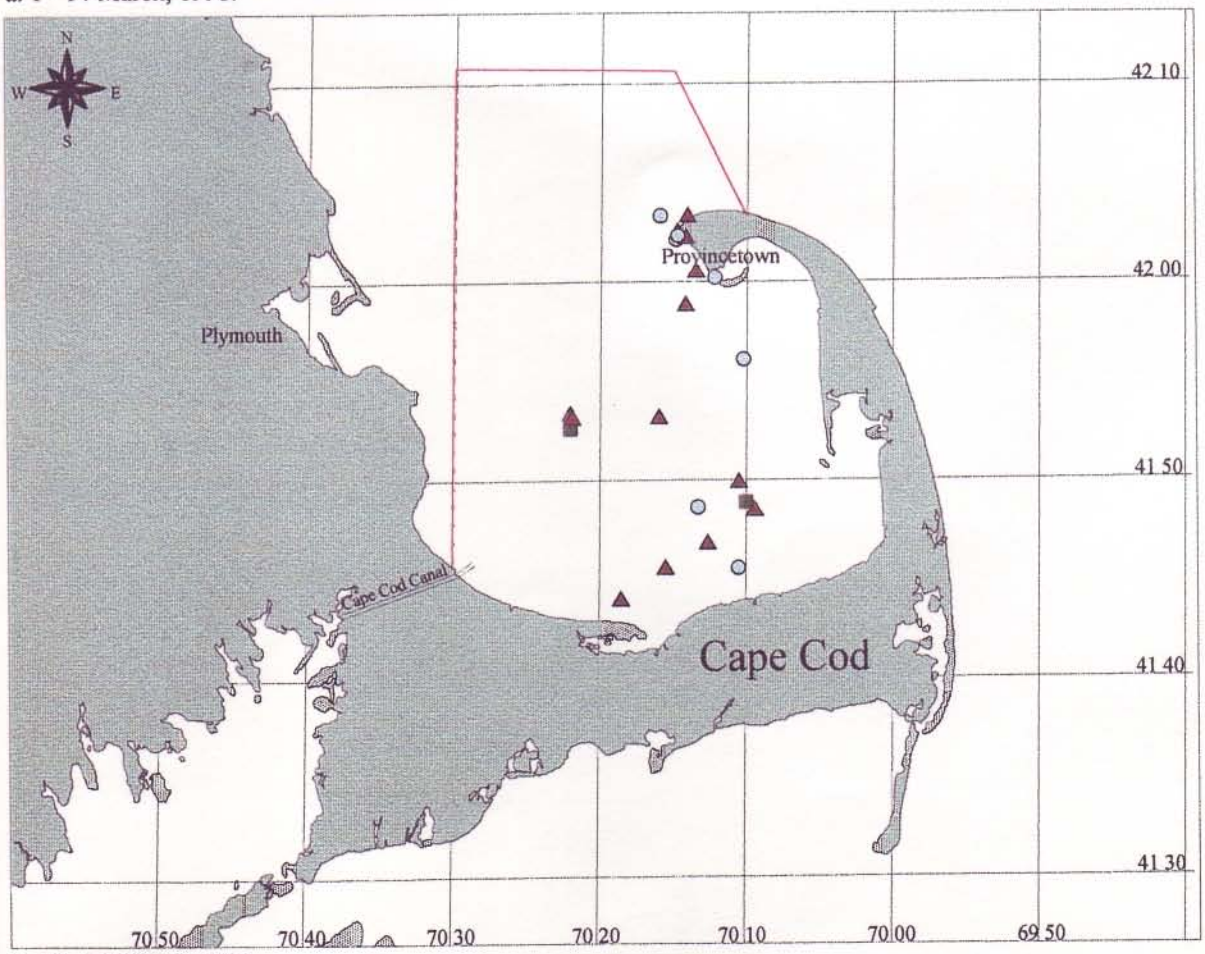

b. 15 - 28 March, 1998.

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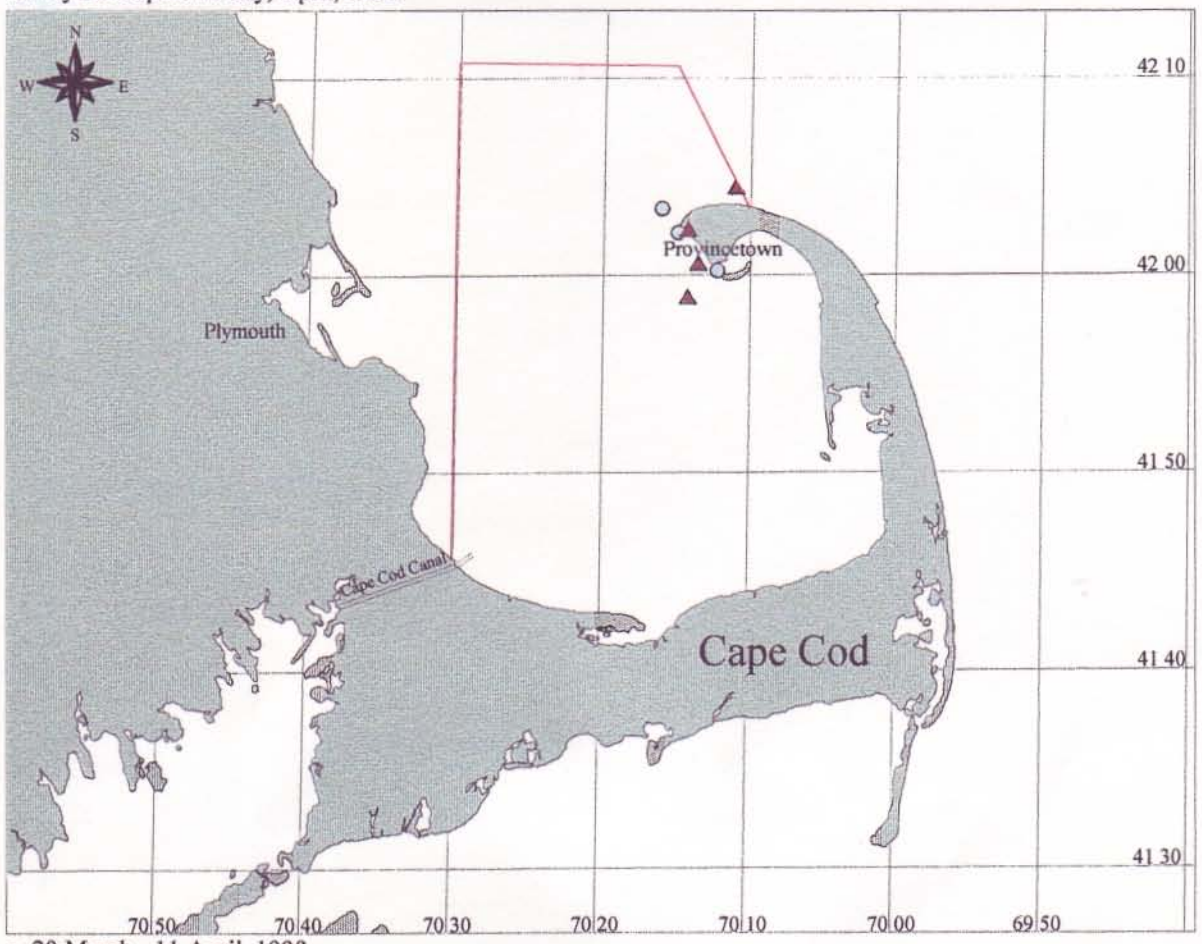
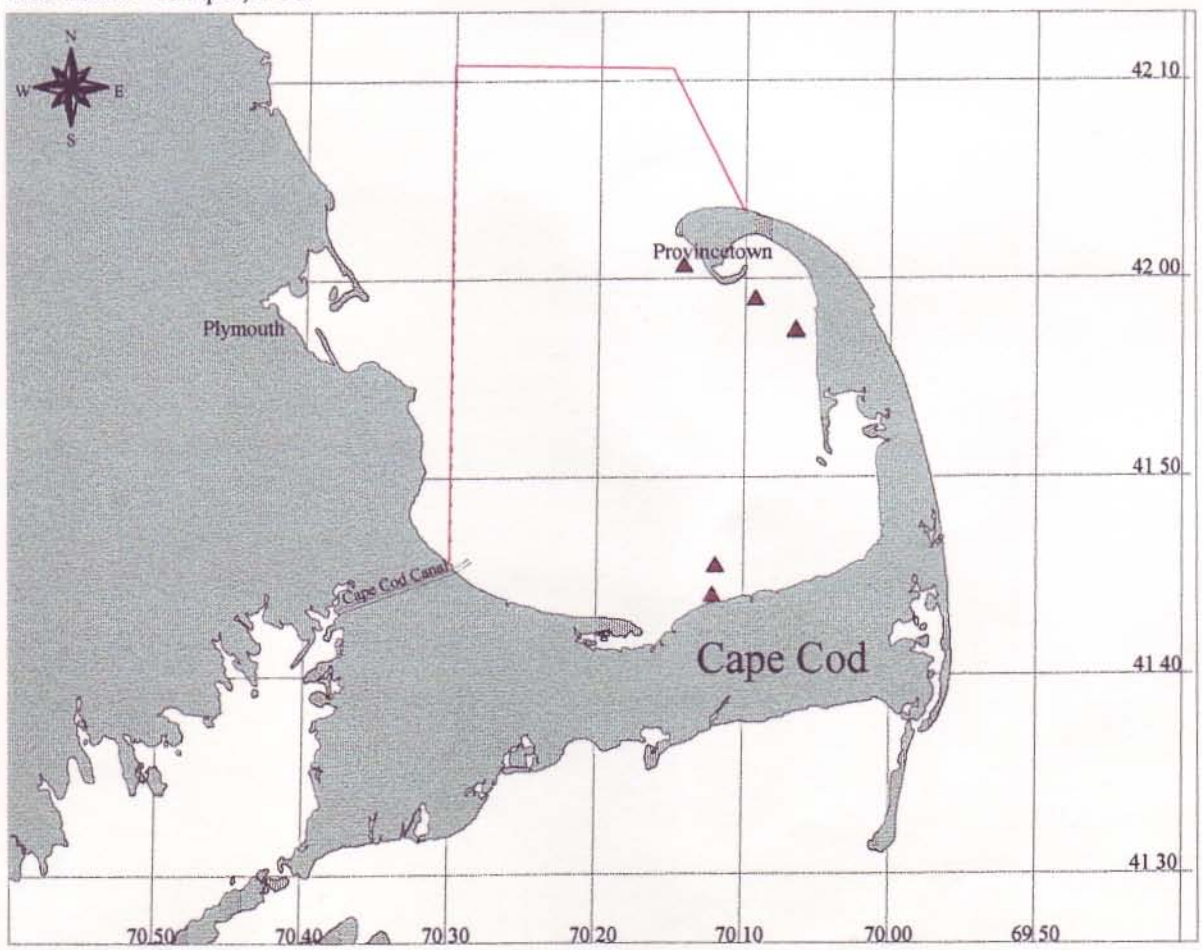
Montpelier, VT

Figure 5.
Sightings of right whales from aerial surveys in Cape Cod Bay, April, 1998.



a. 29 March - 11 April, 1998.

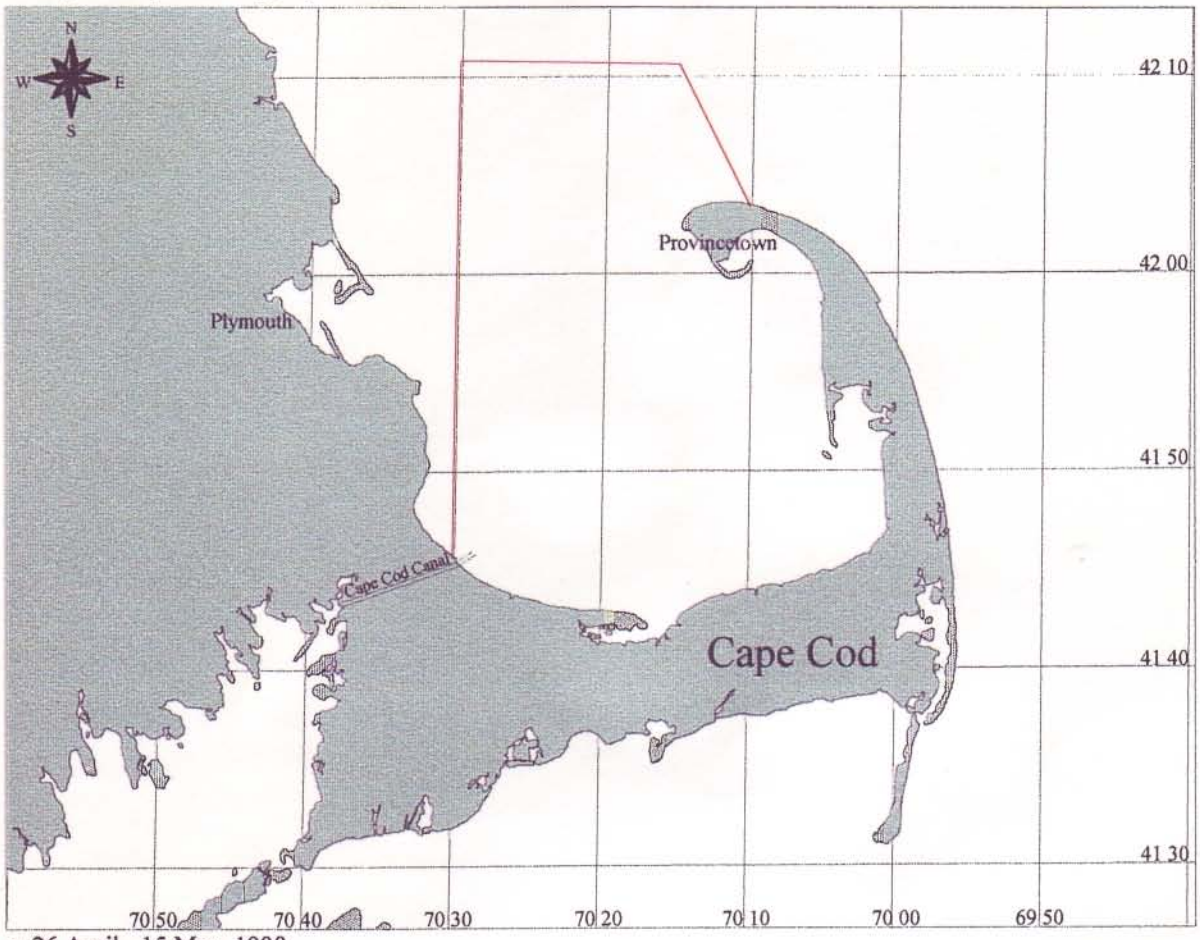


b. 12 - 25 April, 1998.

Created by
Jennifer Beaudin Ring
Montpelier, VT

Figure 6.

Sightings of right whales from aerial surveys in Cape Cod Bay, April/May, 1998.



a. 26 April - 15 May, 1998.

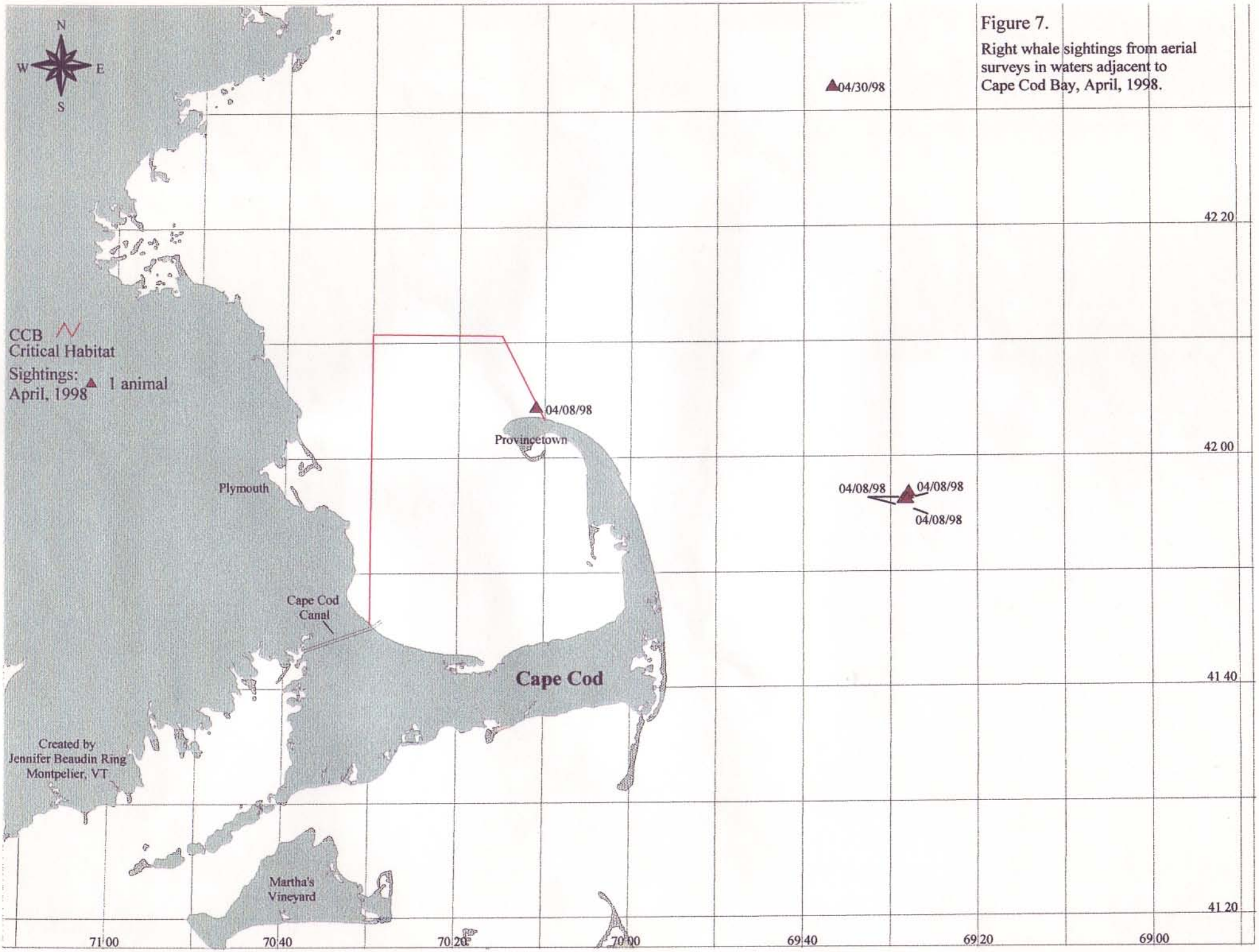
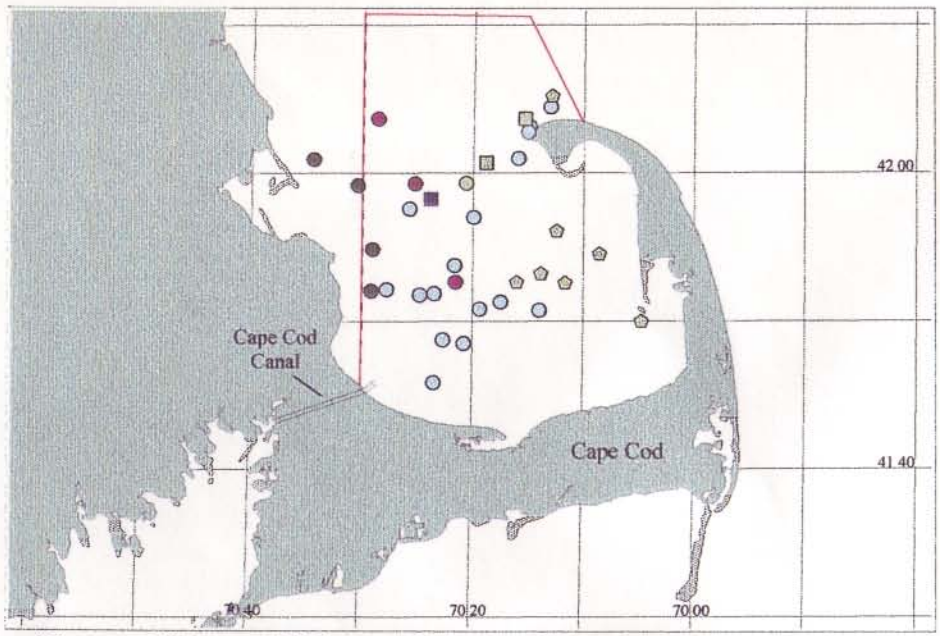


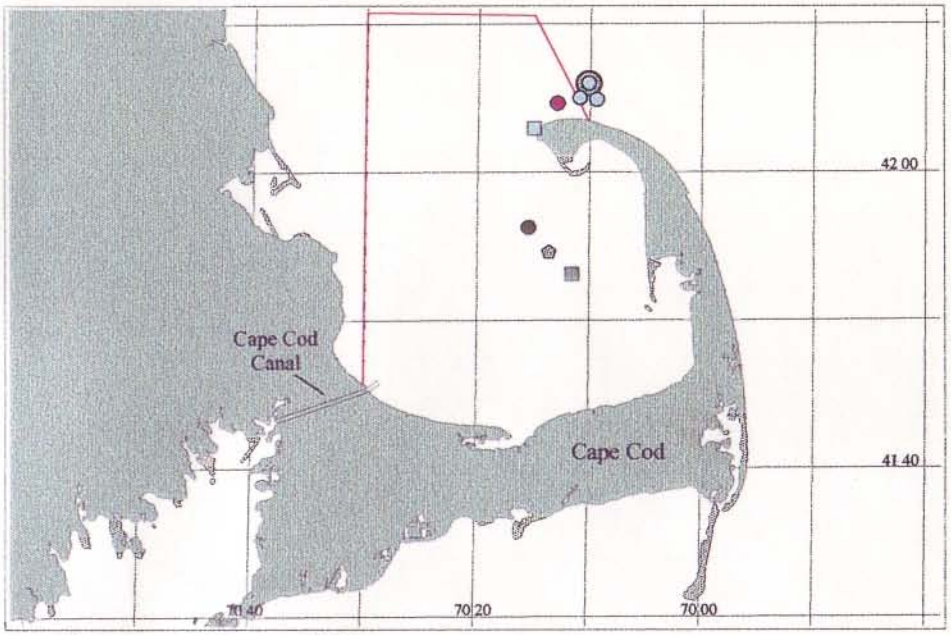
Figure 7.

Right whale sightings from aerial surveys in waters adjacent to Cape Cod Bay, April, 1998.

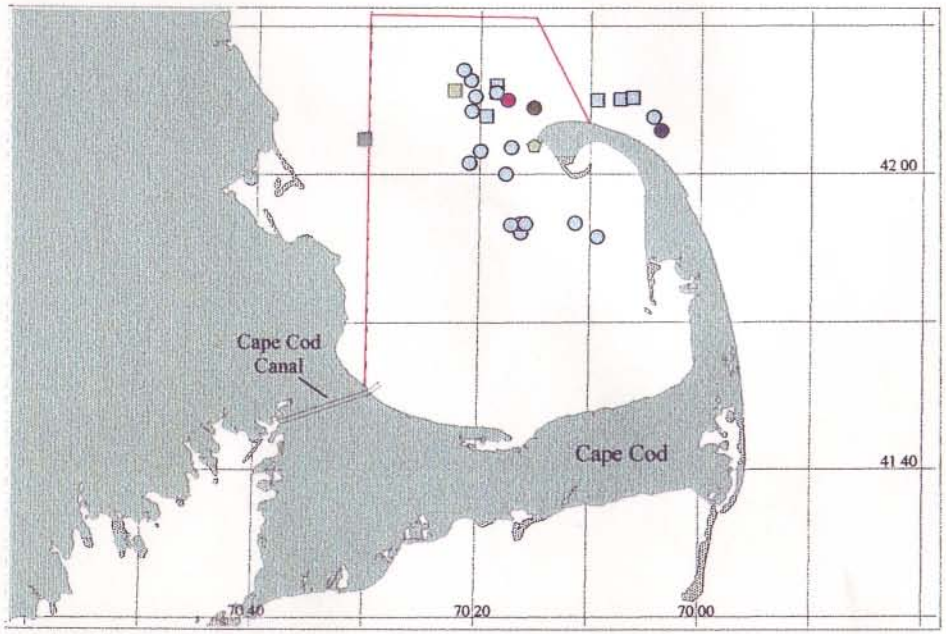
Figure 8.
Sightings of other large whales and dolphins from aerial surveys in Cape Cod Bay
4 January - 15 May, 1998.



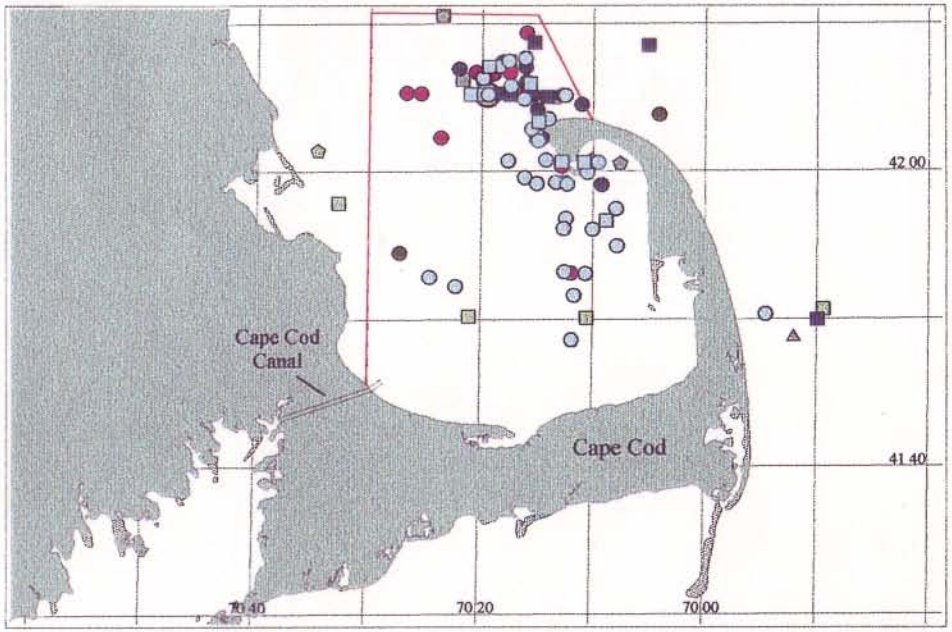
a. 4 January - 31 January, 1998.



b. 1 February - 28 February, 1998.

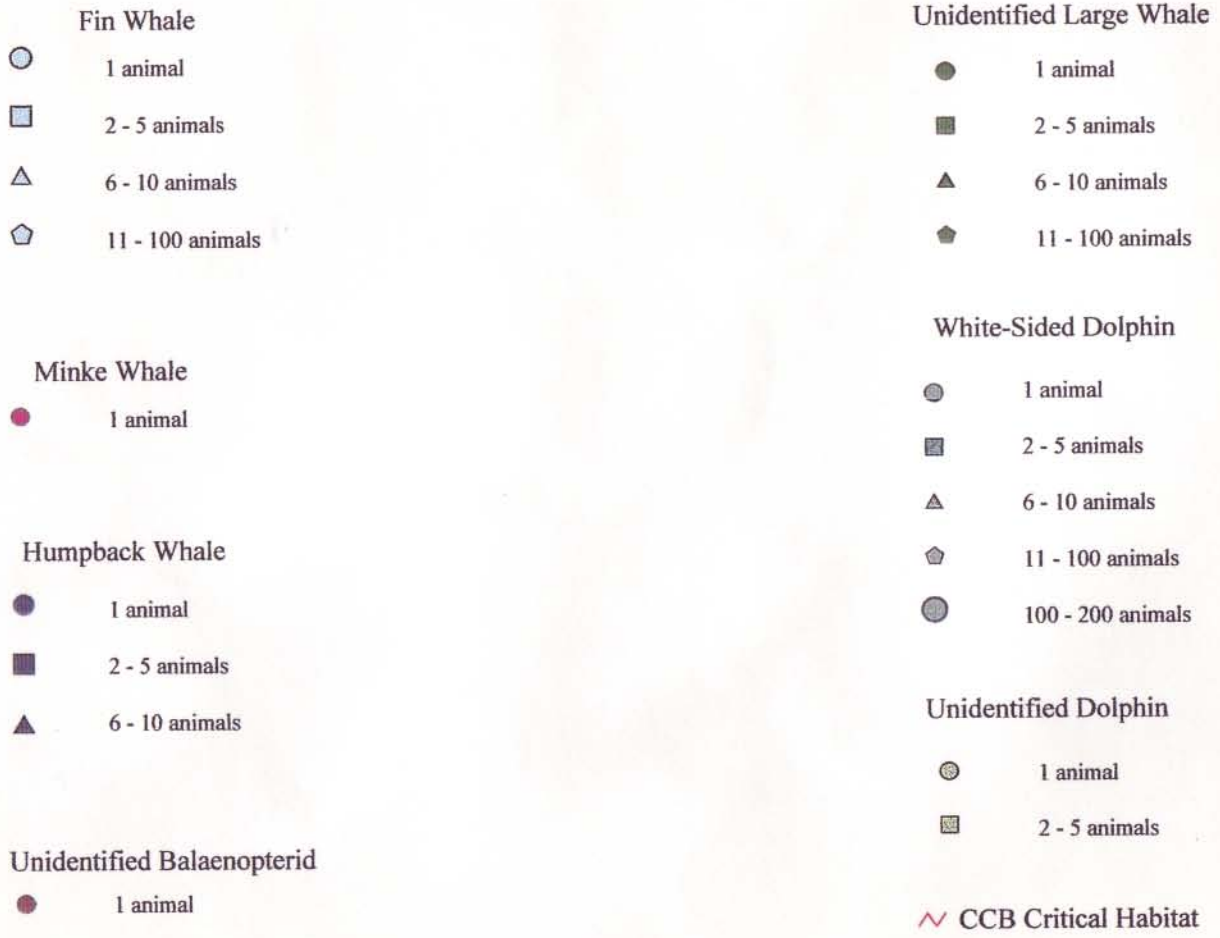


c. 1 March - 28 March, 1998.



d. 29 March - 30 April, 1998.

Figure Legend for Large Whales and Dolphins



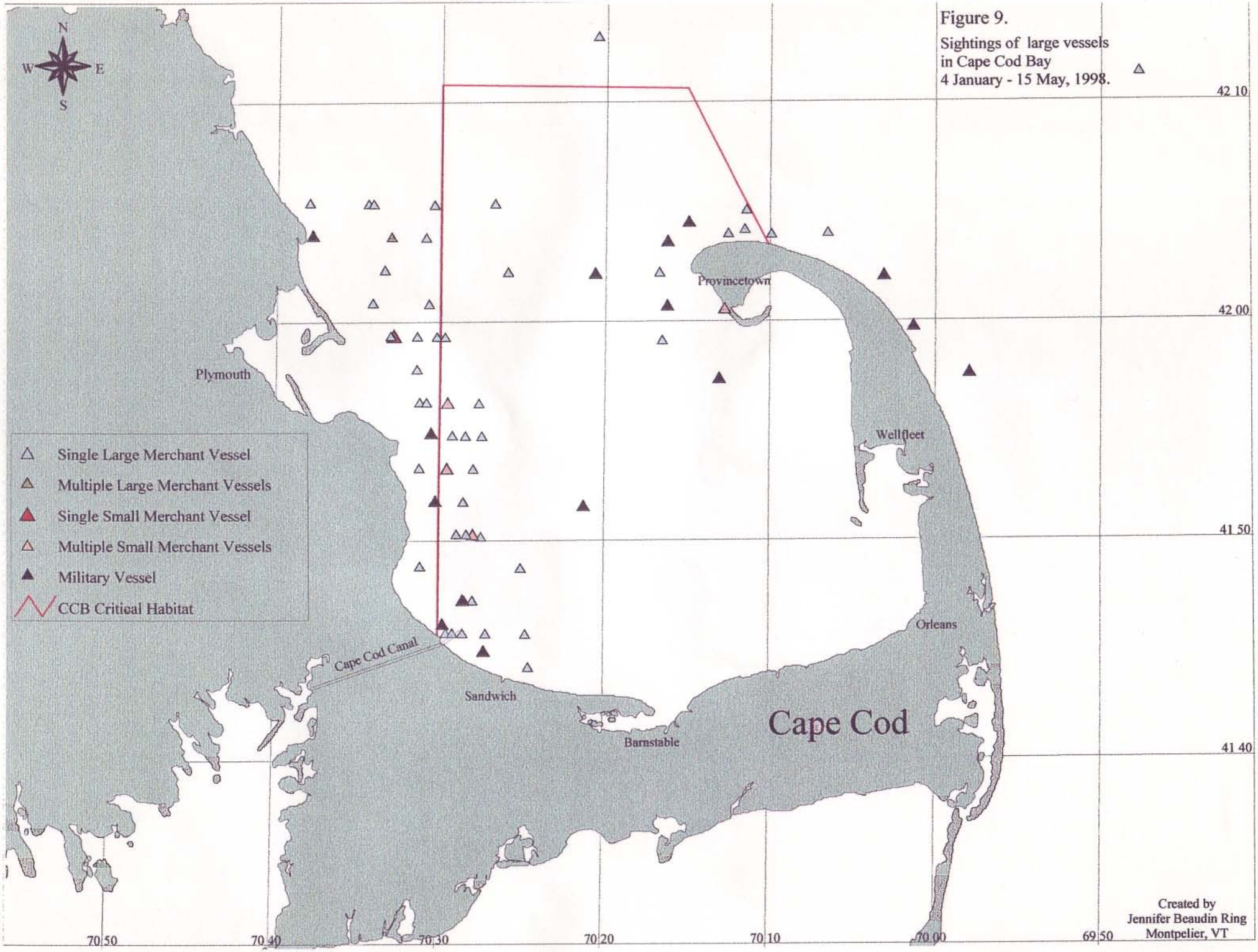


Figure 9.
Sightings of large vessels
in Cape Cod Bay
4 January - 15 May, 1998.
N
W
E
S
Single Large Merchant Vessel
Multiple Large Merchant Vessels
Single Small Merchant Vessel
Multiple Small Merchant Vessels
Military Vessel
CCB Critical Habitat
Provincetown
Plymouth
Wellfleet
Orleans
Cape Cod Canal
Sandwich
Barnstable
Cape Cod
42 10
42 00
41 50
41 40
70 50
70 40
70 30
70 20
70 10
70 00
69 50
Created by
Jennifer Beaudin Ring
Montpelier, VT

Table 1. Aerial Survey Tracklines in Cape Cod Bay: 1998.
(Tracklines end approx. 1.5 nm from land).

Trackline number	Latitude	Longitude West End	Longitude East End	Trackline length (nm)
1	42 06.5	70 38.0	70 10.0	21.0
2	42 05.0	70 37.0	70 14.0	17.3
3	42 03.5	70 38.0	70 15.0	17.3
4	42 02.0	70 36.0	70 07.7	21.2
5	42 00.5	70 34.3	70 06.9	20.6
6	41 59.0	70 35.2	70 06.6	21.5
7	41 57.5	70 34.4	70 06.6	20.9
8	41 56.0	70 31.6	70 06.3	19.0
9	41 54.5	70 30.8	70 03.1	20.8
10	41 53.0	70 30.0	70 03.1	20.2
11	41 51.5	70 30.0	70 02.1	20.9
12	41 50.0	70 30.0	70 02.1	20.9
13	41 48.5	70 30.0	70 02.2	20.9
14	41 47.0	70 29.0	70 04.1	19.4
15	41 45.5	70 26.0	70 11.0	11.3
Subtotal trackline miles, tracks 1-15				293.2
16*	41 45.5		69 53.0	25.0
Total trackline miles, tracks 1-16				318.2

* Trackline 16 starts at this point and runs northeast, paralleling the coast, ~3 miles offshore until the eastern end of trackline 1.

Table 2. Numbers of marine mammals seen, including right whales, hours and trackline miles surveyed, during aerial surveillance of Cape Cod Bay, 1998.

(Eg - right whale, Bp - fin whale, Mn - humpback whale, Ba - minke whale, Unba - unidentified balaenopterid Unlw - unidentified large whale, La - white-sided dolphin, Pp - harbor porpoise, Undo - unidentified dolphin, Pv - harbor seal, and Unse - unidentifed seal).

Date 1998	Number of Egs sighted	Number of Egs photoed	Bp	Ba	Mn	Unba	Unlw	La	Pp	Undo	Unse	Hours Surveyed	Trackline Miles
4-Jan	11	9	6	1	0	1	1	0	0	180-230	11	5:55	281.9
5-Jan	0	0	1	0	0	1	0	0	0	1	10	1:40	118.9
12-Jan	5	3	3	1	0	0	2	0	0	0	0	5:23	293.2
15-Jan	19	10	2	0	2	0	0	0	0	5	4	5:09	293.2
19-Jan	3	3	2	0	0	0	1	0	2	0	0	4:00	293.2
22-Jan	15	8	1	0	0	0	0	0	0	0	0	5:11	241.6
27-Jan	9	8	0	0	0	0	2	0	0	0	0	5:31	281.9
30-Jan	19	12	0	0	0	0	1	0	0	4	2	5:08	293.2
2-Feb	19	19	0	1	0	0	0	0	0	5	50	5:31	293.2
3-Feb	16	15	1	0	0	0	0	0	0	15-20	41	4:55	281.9
9-Feb	18	15	0	0	0	4	0	0	0	1	0	6:50	318.2
10-Feb	12	6	1	0	0	0	0	0	1	0	0	6:25	281.9
16-Feb	20	13	0	0	0	0	0	0	0	0	0	5:03	318.2
17-Feb	8	8	7	0	0	0	0	0	0	0	0	4:17	318.2
20-Feb	18	15	0	0	0	1	0	0	0	0	0	5:10	318.2
23-Feb	6	6	2	0	0	0	0	0	0	0	0	4:01	293.2
4-Mar	44	36	0	0	0	0	0	0	0	0	2	7:09	318.2
5-Mar	22	15	0	0	0	0	0	0	0	0	1	2:38	118.9
7-Mar	10	9	4	0	0	0	0	0	0	0	0	4:47	306.9
13-Mar	4	4	0	0	2	0	0	0	0	0	0	4:14	306.9
16-Mar	0	0	0	0	0	0	0	0	0	0	0	3:45	318.2
17-Mar	7	7	0	0	4	0	0	0	0	0	0	4:43	306.9
24-Mar	11	11	13	0	2	0	0	1	0	0	0	5:39	306.9
25-Mar	12	9	5	0	1	0	0	0	0	0	0	4:38	318.2
30-Mar	9	8	1	0	0	0	0	0	0	0	0	3:12	160.7
8-Apr	1	1	4	2	1	1	0	0	0	0	0	3:25	281.9
8-Apr*	4	4	0	0	2	0	0	30-40	0	12	0	1:15	n/a
14-Apr	2	2	3	0	2	0	0	3	0	0	4	3:12	318.2
14-Apr*	0	0	19	0	20	0	3	1	0	250-300	0	2:00	n/a
19-Apr	3	3	7	0	3	0	0	0	0	50-65	0	3:03	241.6
21-Apr	1	1	18	4	6	1	0	200	0	3	0	4:03	318.2
21-Apr*	0	0	10	8	5	0	0	200-275	0	0	0	1:00	n/a
26-Apr	0	0	14	0	19	0	0	120	0	0	0	3:56	318.2
29-Apr	0	0	8	0	8	0	1	50	0	5	0	3:21	318.2
30-Apr*	1	1	8	0	6	0	2	11	0	0	0	3:45	n/a
15-May	0	0	1	0	1	0	0	0	1	0	1	3:28	318.2
Total	329	261	141	17	84	9	13	615-700	4	531-651	122	153.37	9096.4

* On April 8, 14, 21 and 30, aerial surveys were flown in adjacent, offshore waters, following completion of the CCB survey.

Table 3. Number of marine mammals seen, including right whales, hours and miles surveyed during vessel surveillance of Cape Cod Bay, 1998. SW - R/V *Shearwater*, OR - R/V *Orion*, n/a - not applicable, see Table 1 for other abbreviation

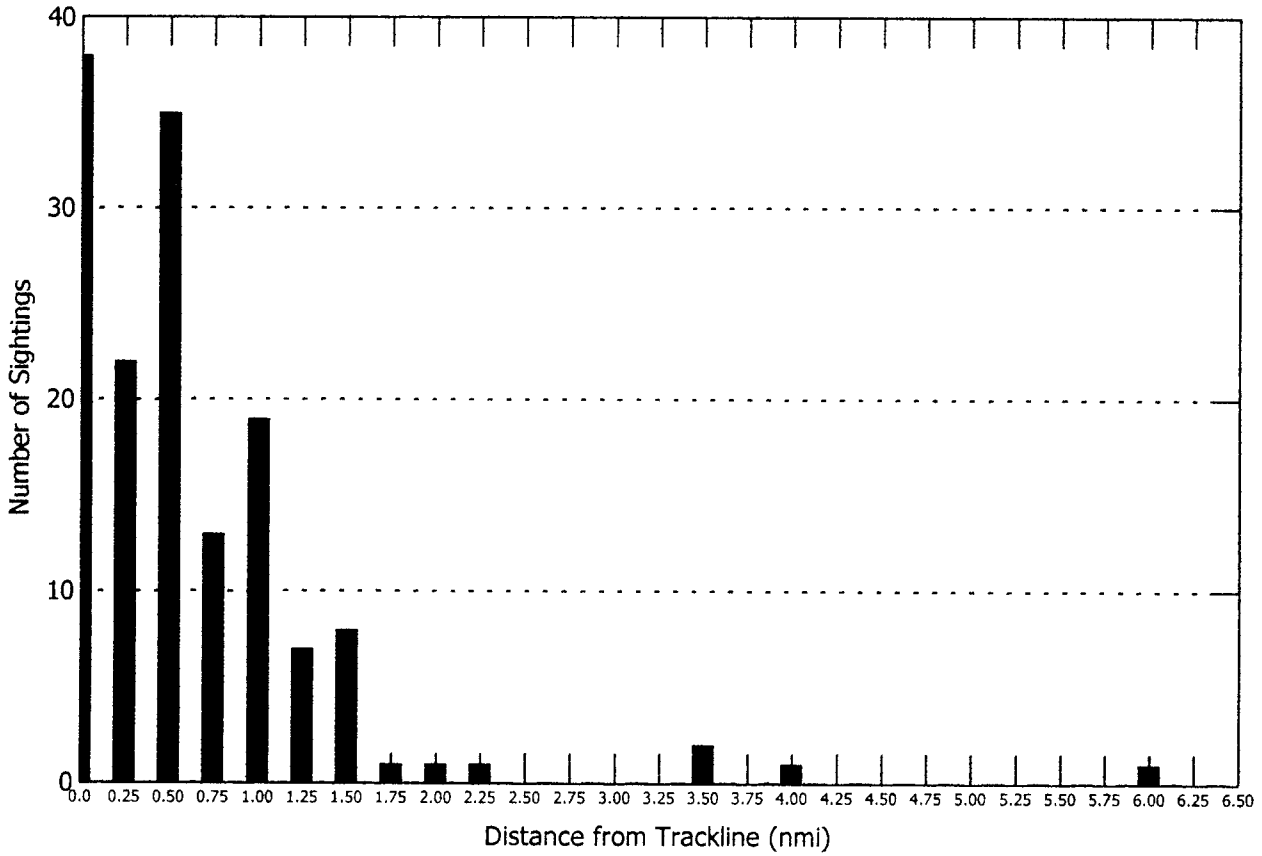
Date	Vessel	Number of Egs sighted	Number of Egs photo'd	Bp	Ba	Mn	Unlw	La	Pp	Pv	Hg	Unse	Hours Surveyed	Miles on Track
10-Jan	SW	0	0	0	0	0	0	0	0	0	1	0	4:45	55
15-Jan	OR	9	5	0	0	0	0	0	0	0	0	0	3:15	n/a
22-Jan	SW	6	4	0	0	0	3	0	0	0	0	0	5:09	30
27-Jan	SW	3	2	0	0	0	0	0	0	3	0	0	7:41	55
3-Feb	SW	14	9	0	0	0	0	0	11-16	2	0	0	9:08	49
9-Feb	SW	6	4	0	0	0	0	0	0	1	0	0	7:24	48
10-Feb	SW	9	8	0	0	0	0	0	0	3	0	0	7:08	109
16-Feb	SW	19	12	1	0	0	0	0	0	2	0	0	9:03	44
17-Feb	OR	10	8	4	0	0	0	0	2	1	0	1	6:57	n/a
23-Feb	SW	10	5	5	0	0	0	20-30	25	1	0	0	5:08	32.6
28-Feb	OR	21	12	0	0	0	0	0	1	3	0	0	6:50	n/a
2-Mar	Zodiac	2	2	0	0	0	0	0	0	0	0	0	0:29	n/a
4-Mar	SW	14	6	0	0	0	0	0	0	1	0	0	7:04	25.9
6-Mar	OR	27	24	0	0	0	0	10-15	4	1	0	0	6:24	n/a
17-Mar	SW	4	4	1	0	0	0	0	5	3	0	0	7:03	55.4
18-Mar	SW	1	1	0	0	0	0	0	4	3	0	0	3:36	25.3
24-Mar	SW	18	6	5	0	0	0	0	2	4	1	0	9:35	59
25-Mar	SW	10	7	0	0	0	0	0	0	0	0	0	10:05	55.8
30-Mar	SW	7	5	1	0	0	0	20-40	0	0	0	0	4:30	25.6
2-Apr	OR	0	0	0	0	0	0	10-20	0	0	0	0	1:10	n/a
3-Apr	SW	9	9	6	1	0	0	75-100	1	0	0	0	5:41	40.7
8-Apr	SW	3	3	0	1	0	0	10 15	3	6	0	0	9:50	102
12-Apr	OR	0	0	0	0	0	0	0	0	0	0	0	0:50	n/a
14-Apr	SW	2	1	11	5	0	0	0	1	1	1	0	10:39	92
22-Apr	SW	1	1	15	0	0	0	175-200	2	0	1	0	9	47.7
30-Apr	SW	0	0	5	1	11	0	200-300	2	0	0	0	9:01	66
Total		205	138	54	8	11	3	520-720	63-68	35	4	1	166.52	1018 (SW only)

Table 4. Number of surveys, demographic composition and sightings of whales from aerial and shipboard surveys during two-week intervals between January and mid-May, 1998.

Two week intervals	4-17 Jan	18-31 Jan	1-14 Feb	15-28 Feb	1-14 Mar	15-28 Mar	29 Mar-11 Apr	12-25 Apr	26 Apr - 15May*	Total
a) Surveys										
Aerial	4	4	4	4	4	4	2	3	4	33
Shearwater	1	2	3	2	1	4	3	2	1	19
Orion	1			2	1		1	1		6
Zodiac					1					1
b) Demographics										
Male	3	3	7	10	12	6	5	2	0	
Female	5	10	17	19	27	10	6	1	0	
Unknown sex	2	1	3	5	6	3	2	1	0	
Juvenile	4	1	5	8	11	4	3	1	0	
Adult	6	13	21	25	33	14	10	3	0	
Unknown age	0	0	1	1	1	1	0	0	0	
Total right whales id'd	10	14	27	34	45	19	13	4	0	75
c) Resightings										
New Sightings	10	10	9	14	14	8	5	1	0	
Resightings	0	4	18	20	31	11	8	3	0	

* This interval represents almost three weeks.

Table 5. Perpendicular Sighting Distance from aerial surveys in Cape Cod Bay: 1998



Appendix I.

Confirmed right whales identifications, Cape Cod Bay, 1998 (as of September 30, 1998). Abbreviations: M - male, F - female, U - unknown, Y - year, YOB - year of birth, A - adult, P - presumed dead.

EGNO	Sex	Cow	PRE	PRE2	Y80	Y81	Y82	Y83	Y84	Y85	Y86	Y87	Y88	Y89	Y90	Y91	Y92	Y93	Y94	Y95	Y96	Y97	Age	YOB	Mom
1004	F	Y	75		80					85		87		89	90			93	94	95	96	97	A	0	
1014	F	Y	74	77	80		82	83					88	89	90	91				95	96	97	A	0	
1019	M				80		82			85	86	87	88			91		93		95	96	97	A	0	
1027	F		79		80		82	83	84	85	86	87	88	89	90	91		93	94	95	96	97	A	0	
1033	M		78			81	82			85	86	87	88					93	94	95	96		A	0	
1039	U				80						86			89	90		92		94	95	96	97	A	0	
1042	U				80	81		83			86	87	88	89		91					96	97	A	0	
1050	M				80	81	82			85	86		88					93	94		96	97	A	0	
1102	M				80	81	82				86	87	88	89	90	91		93	94	95	96		A	0	
1114	F	Y	79			81		83	84		86	87			90	91	92	93	94	95	96	97	A	0	
1121	M					81	82		84			87	88	89	90		92	93	94	95	96	97	A	0	
1130	M				80	81	82		84		86	87	88	89	90	91		93	94	95	96	97	A	0	
1140	F	Y				81	82				86	87	88		90				94	95	96	97	A	0	
1146	M		77		80	81		83	84			87	88	89			92	93	94	95	96	97	A	0	
1150	M		79		80	81	82	83		85	86	87	88	89		91	92	93	94	95	96	97	A	0	
1162	M				80	81										91			94	95		97	A	0	
1170	M					81	82	83	84	85	86		88	89	90	91	92	93	94	95	96	97	17	81	1171
1209	F				80		82	83			86	87	88	89	90	91		93	94	95	96	97	A	0	
1241	F	Y					82	83	84	85	86		88	89	90	91	92	93	94	95	96	97	16	82	1240
1245	F	Y					82	83	84	85	86	87	88	89	90		92	93	94	95	96	97	16	82	1140
1249	M						82	83	84	85	86	87	88	89	90	91		93	94	95	96	97	16	82	1248
1267	F						82	83			86	87	88	89	90	91		93	94	95	96	97	16	82	1266
1270	M				80		82		84				88	89	90						P		P	0	
1271	M		78				82	83			86		88	89	90	91			94	95	96	97	A	0	
1280	U						82		84	85	86	87	88			91	92	93	94			97	A	0	
1310	F	Y	79					83		85	86				90		92				96	97	A	0	
1405	F	Y							84	85			88	89	90	91	92	93	94	95	96	97	14	84	1171
1406	F	Y							84	85			88	89		91	92	93	94	95	96	97	14	84	1135

Appendix I.

Confirmed right whales identifications, Cape Cod Bay, 1998 (as of September 30, 1998). Abbreviations: M - male, F - female, U - unknown, Y - year, YOB - year of birth, A - adult, P - presumed dead.

EGNO	Sex	Cow	PRE	PRE2	Y80	Y81	Y82	Y83	Y84	Y85	Y86	Y87	Y88	Y89	Y90	Y91	Y92	Y93	Y94	Y95	Y96	Y97	Age	YOB	Mom
1407	F	Y			80	81	82		84				88	89				93	94			97	A	0	
1411	M								84		86		88	89	90	91		93		95	96	97	14	84	1142
1424	M					81		83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	A	0	
1428	M					81			84	85	86		88	89	90	91	92	93	94	95	96	97	A	0	
1430	F	Y							84	85	86	87	88	89			92	93	94	95	96	97	A	0	
1503	F	Y								85	86	87	88		90		92	93	94	95	96		13	85	1240
1505	M									85	86		88	89	90	91		93	94	95	96	97	13	85	1222
1507	M									85	86	87	88	89	90	91	92	93	94	95	96	97	13	85	1266
1509	F	Y			80				84	85	86		88	89	90	91	92		94	95	96	97	A	0	
1513	U									85	86	87	88			91					96	97	A	0	
1514	M									85			88	89	90	91				95			A	0	
1601	F	Y									86	87	88	89	90	91		93	94	95	96	97	12	86	1281
1602	F	Y									86	87	88	89		91	92	93	94	95	96	97	12	86	1314
1603	M										86	87		89	90	91		93	94	95	96	97	12	86	1001
1606	M										86	87	88	89				93	94	95	96	97	12	86	1310
1608	F										86	87		89	90	91	92	93	94	95	96	97	12	86	1163
1611	F										86	87	88	89		91			94	95	96	97	12	86	1034
1622	F	Y									86	87	88	89	90	91				95	96	97	A	0	
1701	F	Y										87	88	89	90	91		93	94	95	96	97	11	87	1219
1704	F	Y										87	88	89	90	91	92	93	94	95	96	97	11	87	1140
1706	F											87	88	89	90	91		93	94	95	96	97	11	87	1135
1709	M											87	88	89	90	91	92	93	94	95	96	97	11	87	1127
1711	F											87	88	89						95	96	97	11	87	1710
1802	F												88	89	90	91	92	93	94	95	96	97	10	88	1014
1820	U												88	89	90	91		93	94		96	97	A	0	
1909	F													89	90	91	92	93	94	95	96	97	9	89	1509
1911	F													89	90				94	95	96	97	9	89	1001
1934	F													89		91	92	93	94	95	96	97	9	89	1034

Appendix I.

Confirmed right whales identifications, Cape Cod Bay, 1998 (as of September 30, 1998). Abbreviations: M - male, F - female, U - unknown, Y - year, YOB - year of birth, A - adult, P - presumed dead.

EGNO	Sex	Cow	PRE	PRE2	Y80	Y81	Y82	Y83	Y84	Y85	Y86	Y87	Y88	Y89	Y90	Y91	Y92	Y93	Y94	Y95	Y96	Y97	Age	YOB	Mom
1968	F													89		91	92	93	94	95	96	97	9	89	1168
2027	M														90			93	94	95	96	97	8	90	1127
2050	F														90		92	93		95	96	97	U	0	
2114	F															91		93	94	95		97	7	91	1314
2123	F															91	92	93	94	95	96	97	7	91	1123
2135	M															91	92	93	94	95	96	97	7	91	1135
2140	M															91	92	93	94	95	96	97	7	91	1240
2145	F															91	92	93	94	95	96	97	7	91	1145
2158	M															91	92	93	94	95	96		7	91	1158
2215	M																92	93	94	95	96	97	6	92	1315
2223	F																92	93	94	95	96	97	6	92	1223
2240	F																92	93	94	95	96	97	U	0	
2271	M																92	93	94	95	96	97	6	92	1171
2406	U																		94	95			4	94	1406
2425	F																		94	95			4	94	1425
2470	U																		94	95	96		U	0	
2479	U																		94	95	96	97	4	94	
2503	F																			95	96	97	3	95	1503
2705	U																					97	1	97	1405

Appendix II.

Sighting records of confirmed right whales (n = 75) by survey day in Cape Cod Bay,1998.

F or M - adult female or male, f or m - juvenile female or male, U or u - adult or juvenile of unknown sex.

Id No.	Sex	4-Jan	12-Jan	15-Jan	19-Jan	22-Jan	27-Jan	30-Jan	2-Feb	3-Feb	9-Feb	10-Feb	16-Feb	17-Feb	20-Feb	23-Feb	28-Feb	4-Mar	5-Mar	6-Mar	7-Mar	13-Mar	17-Mar	24-Mar	25-Mar	30-Mar	3-Apr	8-Apr	14-Apr	19-Apr	21-Apr
2140	m	x		x		x	x	x	x	x	x	x	x	x																	
1622	F	x	x															x							x						
2479	u	x																	x						x	x					
1014	F	x								x							x														
2027	m	x		x					x	x	x				x				x												
1310	F	x		x			x		x							x		x						x							
2406	u		x	x						x	x					x		x		x											
1411	M			x	x	x		x	x															x		x					
1802	F			x					x	x		x	x					x	x		x										
1407	F			x		x			x	x		x	x	x												x					
1405	F				x					x	x							x	x												
1704	F					x	x			x					x			x	x	x										x	
1424	M					x	x	x	x																						
1430	F					x		x		x	x							x													
1280	U					x			x				x					x			x		x				x				
1114	F					x			x	x																					
1241	F					x	x	x		x	x		x	x				x		x											
1406	F						x	x	x	x	x							x													
1245	F						x		x	x								x		x											
2050	F							x	x	x	x	x			x	x	x							x	x						
1911	F								x			x	x	x							x		x				x				
1146	M								x							x		x													
2135	m									x	x		x	x	x																
2503	f									x	x		x		x			x													
1039	U									x	x	x	x	x	x		x	x													
2240	f*										x	x		x	x		x			x	x										
1140	F										x		x					x		x											
1601	F											x				x	x		x												
1270	M											x	x	x		x		x		x											
2145	f												x		x	x		x		x											
1503	F												x					x		x			x								
1701	F												x		x																
1706	F												x	x	x	x		x		x											
1121	M													x	x		x														
1603	M													x				x		x											
1509	F														x					x											
1150	M														x			x	x												
1709	M														x																
1606	M															x															
1004	F															x	x		x												
1820	U																x		x	x	x										
2705	u																x			x											
2114	f																x		x			x									
1019	M																	x													
1602	F																	x													
1608	F																	x													
1711	F																	x		x	x										
1249	M																	x	x			x	x			x					
2123	f																	x	x		x		x								
2158	m																	x	x										x	x	x
1514	M																	x													
1267	F																	x		x											
2271	m																	x		x						x					
1102	M																	x													
1611	F																		x												
2215	m																			x											
1909	F																				x										
1027	F																					x		x	x						
2425	f																					x									
1428	M																							x							
1170	M																							x	x						
1507	M																							x	x			x			
2470	u**																							x	x						
1271	M																							x							
1934	F																							x							
2223	f																								x	x	x				
1968	F																									x					
1033	M																									x					
1505	M																									x					
1209	F																										x				
1130	M																										x				
1050	M																											x			
1513	U																											x			
1162	M																											x			
1042	U																													x	

* This female is of unknown age. ** This animal is of unknown age and sex.