

RIGHT WHALES (*EUBALAENA GLACIALIS*) ON JEFFREYS LEDGE: A HABITAT OF UNRECOGNIZED IMPORTANCE?

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ABSTRACT

North Atlantic right whales (*Eubalaena glacialis*) are known to spend the majority of the year between the Great South Channel southeast of Cape Cod, and the Nova Scotian shelf. We examined sightings of right whales on and around Jeffreys Ledge, a 54-km-long glacial deposit off the coast of northern Massachusetts, New Hampshire, and Maine. Sightings on Jeffreys Ledge were extracted from three data sets: (1) a systematic survey of the entire north-eastern continental shelf between 1979 and 1982, (2) whale-watch and research-cruise sighting data from 1984 to 1997, and (3) a collaborative database of sightings collected by organizations conducting right whale research and all other available sources. Each database supported two seasonal sighting peaks. During summer (especially July and August) sightings were primarily of mother-calf pairs. Several cow-calf pairs were seen over several days to weeks. Several females were resighted in more than one year, but only when calves were present. During October, November, and December, sightings included all age classes, surface-feeding behavior was frequently observed, and some animals were resighted over several weeks. Given the relatively reduced sighting effort during fall, this number of sightings is surprising. During the 20 yr of observations, 52 of 374 photo-identified North Atlantic right whales (13.9%) were seen at least once on Jeffreys Ledge. We suggest that Jeffreys Ledge may be a more important right whale habitat than previously believed, and that it may play an important role in annual movements and distribution of this population.

Key words: right whale, *Eubalaena glacialis*, Jeffreys Ledge, whale migration,

The northern right whale (*Eubalaena glacialis*) is the world's most endangered large whale species. Some 300–350 animals currently live in the western North Atlantic Ocean (Knowlton *et al.* 1994), and remnant populations persist in the North Pacific (Scarff 1986). This species was hunted extensively until the early part of the 20th century but has been protected from commercial whaling officially since 1935 (Brownell *et al.* 1986).

In the past two decades, intensive surveys in certain high-use habitats have revealed a basic annual pattern of movements of the North Atlantic population (Winn *et al.* 1986, Kraus and Kenney 1991). During winter, a portion of the population (primarily mothers with newborn calves, and some juveniles) occurs off the coast of the southeastern U.S. During late winter, these whales move northward and join other right whales, first in Cape Cod Bay and, shortly after, in the Great South Channel (between Cape Cod and Georges Bank) (Hamilton and Mayo 1990, Kenney *et al.* 1995). From there, many animals move north to the Bay of Fundy and the Nova Scotian shelf for the summer, remaining until at least early autumn (Mitchell *et al.* 1986, Kraus *et al.* 1988, Murison and Gaskin 1989, Gaskin 1991).

Between the early fall disappearance of right whales from the Bay of Fundy and winter occurrence of calving females and juveniles off the southern U.S. and late winter appearance of all segments of the population in Cape Cod Bay, little is known of their distribution and almost nothing is known of their movements.

While the distribution and occurrence of right whales is well documented in high-use habitats such as the southeastern U.S. (Kraus *et al.* 1988, Kraus and Kenney 1991), the Great South Channel (Kenney *et al.* 1995), Cape Cod Bay (Hamilton and Mayo 1990, Kraus and Kenney 1991), and the Bay of Fundy and Scotian shelf (Mitchell *et al.* 1986, Kraus *et al.* 1988, Murison and Gaskin 1989, Gaskin 1991), little is known outside those areas. Survey and other research effort has been highly biased towards areas of known use. In this paper we examine sighting records of right whales on and around Jeffreys Ledge, an underwater shoal located off the New England (especially New Hampshire and Maine) coastline, which has not been previously identified as an important habitat for northern right whales.

METHODS

Jeffreys Ledge is a complex, shallow glacial deposit, characterized by depths of 45–61 m and a length of approximately 54 km (Fig. 1). Depths of 85–120 m occur on the west side of the Ledge ("Scantum's Basin") and 100–150 m to the east. Bottom substrate is a mixture of rocks, sand and gravel, and mud, both on the Ledge itself and in the deeper basins. We defined the Jeffreys Ledge "region" for sightings data as lying between 43°20'N and 42°35'N, and west of 69°50'W to the shoreline.

Sighting data for this paper were collected from three programs: (1) a comprehensive cetacean survey program conducted off the northeastern United States (1979–1981), (2) commercial whale watch (1982–1996) and dedicated

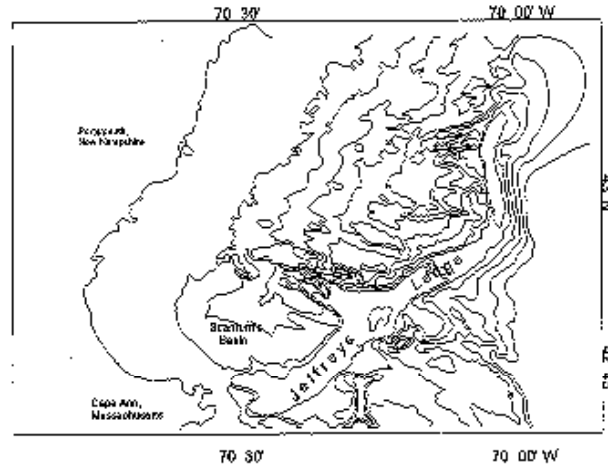


Figure 1. Bathymetric contour plot of Jeffreys Ledge area.

vessel coverage (1984–1997); and (3) a comprehensive database of all reported sightings of North Atlantic right whales from any available source through 1994. Details of these programs are as follows:

(1) The Cetacean and Turtle Assessment Program (CETAP) was conducted by the University of Rhode Island (URI) from late 1978 through early 1982 for the continental shelf of the United States from Cape Hatteras to Nova Scotia (CETAP 1982). It included dedicated surveys from air and shipboard, a platforms-of-opportunity (POP) survey program in which trained observers were placed aboard a wide variety of aircraft and ships working in the study area, and collection of opportunistic sightings from all available sources, including historical data which existed prior to the study. CETAP data are archived at URI (see below). Trackline and environmental information included with the dedicated and POP survey data can be used to quantify survey effort as length of survey trackline completed within defined criteria (observers on watch, sea state of Beaufort 3 or below, visibility at least two nautical miles, and aircraft altitude 305 m or lower). For details of the CETAP surveys or the SPUE methods, see CETAP (1982), Kenney and Winn (1986), and Shoop and Kenney (1992).

(2) The Cetacean Research Unit (CRU) in Gloucester, Massachusetts, collected right whale sighting data from commercial whale watches between 1984 and 1996. Whale-watch vessels working out of Gloucester were used exclusively from 1984 to 1991, covering only the southern half of Jeffreys Ledge. In 1992 CRU instituted a sighting network of whale-watch boats from a number of ports in New Hampshire and southern Maine, which covered all of the Ledge regularly. Whale watches typically allowed two hours on or around the Ledge. Whale-watch cruises took place from May until October, with a heavy emphasis on the months of June through September. Whale

watches usually targeted areas where humpback whales were most common (see Weinrich *et al.* 1997 for additional details on whale-watch methodology).

Dedicated-vessel coverage by CRU took place aboard a 6.7-m vessel (1984–1992) or an 8.3-m vessel (1993–1997) departing from Gloucester, Massachusetts. Each cruise was 7–13 h long. These excursions took place from 1 April to 15 November in each year, with emphasis on work in April, October–November, and during opportunistic periods of reported whale concentration during May to September.

(3) Since 1986 a number of research groups and institutions have joined in a cooperative program, informally called the right whale "consortium." One aspect of the program is data sharing, with all sighting data being incorporated into a common database (the "consortium database"), which is managed and archived at URI. The original core of the database was the CETAP data. A copy of the photo-identification database from a right whale catalog is also maintained at URI, and the two databases are cross-referenced. Both the consortium and catalog databases include contributions from a wide variety of sources and so are the broadest available record of right whale occurrence in the western North Atlantic. Because of the varied nature of the data, it was impossible to quantify effort. However, all records for the Jeffreys Ledge area were extracted and summarized for analysis.

It should be noted that the three data sources utilized in this paper are not independent. At least some occurrences of right whales in the Jeffreys Ledge area are recorded in more than one. For example, when a right whale was sighted by CRU observers and photographed, the photos are contributed to NEA and incorporated into the catalog, and all catalog records not already included in the consortium database are added during annual updates. Wherever possible, we separated overlapping data by comparing sighting lists for duplication by day, location, or observer.

Individual right whales were identified through photography (usually using 35-mm cameras and 200–400-mm maximal focal length zoom lenses) of the callosities on the whale's head and additional scars or distinctive markings (Kraus *et al.* 1986). Photographs were matched against a collaborative catalog maintained at the New England Aquarium (NEA) (Kraus *et al.* 1986, Crone and Kraus 1990), and assigned numbers accordingly (listed as RWC (Right Whale Catalog) #). Life history details reported here originate from previous sighting information detailed in the catalog.

RESULTS

CETAP Data

There were 13 sightings of 22 right whales on Jeffreys Ledge during the CETAP surveys (Table 1). Of these, 11 (84.6%) sightings of 18 (81.8%) whales were between October and December, during 35% of the total Jeffreys Ledge survey effort. December had both the greatest number of sightings (9) and the greatest number of individuals (15), all seen on 7 December 1978 (Fig.

Table 1. Effort and sightings data for right whales on Jeffreys Ledge from each of three data sets. Because the different data sets were not directly comparable, different summary variables are used for each.

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Cetacean data													
Survey hours	11.4	460	417	489	137.2	618.1	340.6	490.4	303.2	382.9	797.7	568.9	5,016
Sightings	0	0	0	0	0	1	1	0	0	1	1	9	13
Individuals	0	0	0	0	0	1	3	0	0	1	2	15	22
Cow/calf pairs	0	0	0	0	0	0	0	0	0	0	1	0	1
CRU data													
Vessel days	0	0	0	23	69	151	249	234	174	108	0	0	1,008
Sightings	0	0	0	2	0	0	7	8	13	15	0	0	43
Individuals	0	0	0	2	0	0	9	9	19	27	0	0	66
Cow/calf pairs	0	0	0	1	0	0	2	2	0	4	0	0	9
Consortium data													
Sightings	3	0	3	8	13	4	83	34	21	34	11	17	231
Individuals	3	0	7	13	19	5	103	69	31	50	22	26	348
Cow/calf pairs	0	0	0	1	3	1	18	14	5	2	1	0	45
Catalog records	0	0	0	0	3	1	44	15	17	17	1	2	101
Different animals ID'd	0	0	0	0	3	1	21	12	12	16	1	2	52*
Cow/calf pairs ID'd	0	0	0	0	2	0	20	5	3	2	0	0	33

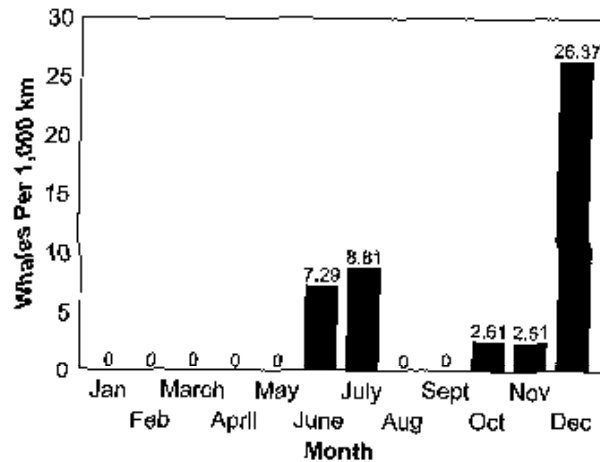


Figure 2. Sightings of right whales per 1,000 km for CETAP database, 1978–1981.

2). Survey effort was greatest in June, November, and December, with substantial coverage in all months except January and May (Table 1). Only one cow/calf pair was seen (in November) during the CETAP surveys.

CRU Data

There were 43 sightings of 66 individuals on Jeffreys Ledge (Table 1). Of these, 34 (79.0%) sightings of 55 (87.3%) individuals were seen between August and October. September and October had the greatest number of sightings (13 in each month), with more individuals (27) being seen in October than in any other single month (Fig. 3). By comparison, survey effort was greatest during July and August (when 47.9% of total survey effort took place), with secondary peaks in June and September (Table 1). The single highest daily count was seven whales photographed on 31 October 1994. Nine of the 43 (20.9%) sightings were of cow/calf pairs: one (11.1%) in April, two (22.2%) in July, two (22.2%) in August, and four (44.5%) in October.

Consortium Database

There were 231 sightings of 348 whales on Jeffreys Ledge between 1972 and 1994 (Table 1). Whales were seen in all months except February. More whales were seen in July than any other month, when 103 (29.6%) animals were recorded. Other months with high totals were August (69 individuals, or 19.8%), and October (50 individuals, or 14.3%). Between 22 and 31 whales also were seen in each of September, November, and December. In total, 301 whales were seen between July and December, while there were only 47 animals between January and May. Cow/calf pairs were seen on 45 occasions, of

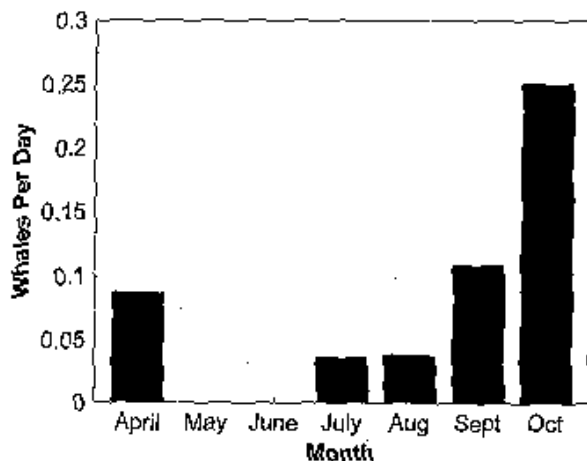


Figure 3. Sightings of right whales per day, CRU database 1984-1997.

which 32 (71.1%) were seen during July and August, and only 8 (17.7%) during September through December.

In total, there are 101 catalog records from Jeffreys Ledge (0.93% of the total 10,833 catalog records) of 52 different individuals, or 13.9% of the 374 photographed whales. Out of the twenty cow/calf catalog records from Jeffreys Ledge in July, 18 (90%) were of only five females. Several whales were resighted on Jeffreys Ledge both within the same year and between years. RWC #1266 was photographed on eight occasions in three years: twice in July 1982, five times in July and August 1985, and once in July 1988 (all years in which she had a calf). RWC #1152 (a male) was seen on Jeffreys Ledge on five occasions in October 1983 and September 1984. RWC #1505 (then a 9-yr old male) was seen on 10, 11, and 18 September 1994. A mother-calf pair (RWC #1412 and #1413) were photographed on Jeffreys Ledge on 6 October and 21 October 1984, a 15-day sighting interval. This female was rephotographed with a different calf on 4 and 5 October 1997; no other sightings of this whale exist in the catalog, either from the calving grounds or any of the other known high-use areas.

DISCUSSION

The sighting data from all three sources suggest that Jeffreys Ledge may be a more important habitat for right whales, both in terms of numbers of animals and consistency of occurrence, than has been previously recognized. The area appears to be one where right whales are seen on a regular basis, especially when animals may be moving to and from more northern waters. Furthermore, the records from Jeffreys Ledge represent the greatest number of sightings during the fall, when the movements of right whales are poorly known.

The highest number of right whale sightings in the consortium database for Jeffreys Ledge was during July and August (49.8% of total sightings). This is a period when most, if not all, animals have departed the Great South Channel (Kenney *et al.* 1995) and are arriving in the Bay of Fundy (Winn *et al.* 1986, Kraus and Kenney 1991). Except for mother-calf pairs, whales apparently remained on the Ledge for only short periods of time. This suggests that many of the Jeffreys Ledge sightings were of transient whales moving toward the Bay of Fundy and the Scotian Shelf, which lies approximately 200 km to the northeast of Jeffreys Ledge. There may be little energetic advantage to remaining for extended periods in the Jeffreys Ledge area during the summer, given the high probability that richer prey resources are available in the Nova Scotian feeding grounds.

Mother-calf pairs were disproportionately represented on the Ledge during this time. This is not unexpected since right whale mother-calf pairs are sighted in many areas throughout the Gulf of Maine during the late spring and early summer.¹ It is possible that mothers may also be exposing their calves to "traditional" feeding habitats at this time and may be bringing their calves to Jeffreys Ledge for this reason. Radio-tagging studies have shown that mother-calf pairs traverse unusually large distances when compared to other classes of whales (Mare *et al.* 1997), and studies of humpback whales have shown that calves are more likely to return to a specific location if they were first sighted there as calves (Weinrich 1998). Certainly this is supported by animals such as #1266 and #1412, who have each been seen on multiple occasions in multiple years when they had a calf, but not in intervening years.

Perhaps more surprising is the number and consistency of sightings of right whales on Jeffreys Ledge during the fall. This is a period where observer effort is at its lowest, especially in the CRU database. Whale-watching boats all terminate their season by the end of October for insurance reasons and greatly reduce their number of trips after the start of September. One would therefore expect a strong bias towards summer sightings. Despite this, September and October were the months at which sightings peaked in the CRU data. CETAP data show a similar peak, much of which can be attributable to a cluster of nine sightings of 15 whales on a single December day. This shows that large concentrations of whales have occurred at times when coverage in other areas may have not recorded them at all.

It is striking that in the fall we do not see the disproportionate number of mother-calf pairs that we do during summer sightings, as evidenced in both the CRU and consortium database. Calves may be weaned and separated from their mother by this time. In humpback whales weaning occurs as early as mid-October in a few mother-calf pairs (Baraff and Weinrich 1993), and right whale calves can survive weaning by this time (Hamilton *et al.* 1996). However, we believe it is unlikely that weaning alone would account for the lower proportion of cow-calf pairs. Rather, this may simply be an important feeding

¹ Personal communication from Scott Kraus, New England Aquarium, Central Wharf, Boston, MA 02110, January 1998.

area for the population as a whole following their departure from the Bay of Fundy, with the number of mother-calf pairs representative of the population as a whole. During the summer most right whales are passing through en route towards rich feeding grounds in the Bay of Fundy/Scottian Shelf area, while mothers with calves are lingering for longer periods.

Jeffreys Ledge may also be an important feeding habitat for right whales during the fall. Surface skimming and apparent near-surface feeding (whale leaving slicks constantly on the surface while spending prolonged periods of time (up to several hours) in areas less than 1 km diameter) were commonly seen during fall sightings. Typically during July and August whales were observed traveling, and we have no observations of surface-feeding behavior. The low level of observer coverage and photo-identification effort would greatly underestimate length of stay during the fall period, but our data show several individuals (including the only residency of any animals besides cow/calf pairs) who were resighted for at least a week within the same year.

Further evidence for prolonged occupation of Jeffreys Ledge in the fall comes from satellite tagging data (Mate *et al.* 1992, 1997). An adult male right whale tagged in the Bay of Fundy on 15 October 1989 left the Bay shortly after being tagged and then spent at least 10 d on or near Jeffreys Ledge (25 October–5 November 1989). Tag transmissions ceased while the whale was still around the Ledge, so this was a minimum occupancy period.

We assume that right whales remain in the Bay of Fundy as long as prey is sufficient. Once prey availability falls below a certain level, however, the whales will likely abandon that area and may begin a migration toward their winter habitats, either the southeastern United States coast (especially for pregnant females and juveniles) or other destinations still unknown. If this movement is, in fact, triggered by lack of prey and there is another area nearby where prey resources may be sufficient, the whales may at least investigate that region briefly on their way out of the Gulf of Maine. If right whales feed little, or even fast completely for prolonged periods during the winter, it would make adaptive sense for them to stay in that area as long as prey resources remain sufficient.

All of the known high-use feeding areas for right whales have geological features which appear to favor concentration of plankton, especially calanoid copepods, through interactions with hydrographic conditions (Mayo and Marx 1990, Kraus and Kenney 1991, Kenney *et al.* 1995). The topography of Jeffreys Ledge, and the counter-clockwise current throughout the Gulf of Maine influences the oceanography of the Ledge (Apollonio 1979), placing this area in the same broad category.

We do not know on what prey right whales feed while on Jeffreys Ledge. In other habitats North Atlantic right whales feed primarily on copepods, especially *Calanus finmarchicus* (Kenney *et al.* 1985, 1986; Murison and Gaskin 1989; Kenney and Wishner 1995), with some variation when other species are abundant (including *Pseudocalanus minutus*, *Centropages* spp., or larval barnacles; Mayo and Marx 1990). Copepod productivity in the Gulf of Maine is highest in spring and decreases during summer and fall (Apollonio 1979), so

the time that right whales are on Jeffreys Ledge should be that of lowest copepod availability. It is possible that the oceanographic features of Jeffreys Ledge aggregate available copepods into levels which attracts right whales. There is, however, an alternate source of prey which right whales may also use which is uniquely present on Jeffreys Ledge during this time. During the fall, Jeffreys Ledge is the largest spawning ground for the Gulf of Maine herring (*Clupea borengus*) stock (Boyar *et al.* 1973, Cooper *et al.* 1975, Sinclair and Tremblay 1984). Herring eggs hatch into 5–7-mm planktonic larvae after 1–3 wk, grow approximately 2 mm/mo until the following spring, and are generally retained within the area of hatching for at least several months (Iles and Sinclair 1982, Townshend *et al.* 1989). While there are no records of herring larvae density which approach the levels of 1,000/m³ found as a feeding threshold by Mayo and Matx (1990), few actual measurements have been made.² Our understanding of the feeding ecology of right whales on Jeffreys Ledge, therefore, might benefit from more intensive studies of habitat use and prey.

Jeffreys Ledge may be an important fall feeding area for right whales and an important nursery area during summer. The presence of considerable concentrations of whales during fall, sighted over several years despite very low observer effort, and the indication of some extended whale residencies appears to indicate a habitat which plays an important role in the annual cycle of this population. More dedicated surveys during the fall and early winter and studies of the physical and oceanographic characteristics of the area itself would provide more insight into the importance of Jeffreys Ledge as habitat for right whales in the Western North Atlantic.

ACKNOWLEDGMENTS

We thank numerous Cetacean Research Unit staff and interns over the years who have helped collect this information, especially Cindy Belt, Mark Cappellino, Rachel Griffiths, Malcolm Martin, and Mark Schilling; members of the Jeffreys Ledge Sighting Network, including Leo Axtin, Dane Badders, Jenny Bove, Jon Gwalthney, Jen Hafner, Nancy Miller, Elizabeth Phinney, Diana Schulte, and others; Scott Mercer for his contributions to the consortium database; and Marty Crone, Amy Knowlton, and Scott Kraus who aided in photographic matching at the New England Aquarium. Phil Clapham and an anonymous reviewer made many constructive criticisms of the manuscript. Portions of this work were conducted under Marine Mammal and Endangered Species Research Permits #681 and #959 issued to the Cetacean Research Unit.

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² Personal communication from Mark H. Tupper, School of Marine Sciences, University of Maine, Orono, ME 04469, March 1998.

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Received: 24 March 1998

Accepted: 30 August 1999