Sightings of a bowhead whale (*Balaena mysticetus*) in the Gulf of Maine and its interactions with other baleen whales

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ABSTRACT

Bowhead whales generally migrate into high Arctic waters in the summer months and move to lower latitudes in the wintertime. During the 1800s and early 1900s commercial whaling greatly reduced the numbers of bowhead whales in waters adjacent to the North Atlantic Ocean. In recent decades their numbers have been increasing. Thirteen sightings of a bowhead whale were recorded in four areas of the Gulf of Maine in 2012, 2014, and 2017 between latitudes 44°43'N and 41°36'N, far south of the normal range (54°N) for this species. Photographs obtained during these sightings were compared by experienced photo analysts and, based on scarring patterns, the sightings were confirmed to be of the same individual. The bowhead whale was observed alone, in addition to interacting in a social group and engaged in coordinated feeding with other mysticetes at times. The feeding and social behaviour of the bowhead whale was typical for the species but well south of its normal Arctic waters range and in the absence of conspecifics.

KEYWORDS: BOWHEAD WHALE; ATLANTIC OCEAN; FEEDING; PHOTO-ID; GULF OF MAINE

The bowhead whale (*Balaena mysticetus*) is an ice-adapted species with a circumpolar distribution in Arctic waters (Shelden and Rugh, 1995). Bowhead whales are generally assessed as four separate geographical populations: two in the northern Atlantic (the Eastern Canada-West Greenland stock and the Svalbard-Spitsbergen/Barents Sea stock) and two in the northern Pacific (the Bering-Chukchi-Beaufort Seas stock and the Okhotsk Sea stock) (IWC, 2009; Rugh and Shelden, 2009; Ferguson *et al.*, 2010; Lydersen *et al.*, 2012; Laidre *et al*., 2015). This paper describes multiple sightings of an individual bowhead whale far south of its present-day range and its interactions with two other mysticete species in the western North Atlantic. This bowhead whale was observed on 13 separate occasions during 2012, 2014, and 2017 in four areas of the Gulf of Maine (GOM) between latitudes 44°43'N and 41°36'N (Fig. 1).

These are the southernmost confirmed sightings of a bowhead whale in the western North Atlantic, approximately 1,800km (~1,000 nautical miles) from the southern extent of the closest population's range, but they are not the only records of bowhead whales south of the known present-day range. Four dead bowhead whales were documented in Newfoundland, Canada (one each year in 1998, 2005, 2008, and 2014) as far south as 47°14'N (Ledwell *et al.,* 2007, 2014; Ledwell and Huntington, 2009). A small live individual (~4m) judged to have been a calf of the year was observed in Trinity Bay, Newfoundland in August 2014 (47°35'N; Ledwell *et al.*, 2014). There are also several verified records in the eastern North Atlantic Ocean, as follows (all body lengths estimated by eye and reported by the observer): one whale (~8m long) observed in February 2015 off Isles of Scilly, Cornwall, England (49°57'N; James, 2015); a set of three sightings, thought to be of the same ~7m individual (de Boer *et al.*, 2017), in May 2016 near Bénodet, Brittany, France (47°51'N; Anonymous, 2016), a week later, near Long Rock, Cornwall, England (50°06'N; de Boer, 2016), and finally in late May 2016 skim feeding outside the Carlingford Lough mouth, Ireland (54°00'N; Whooley, 2016); one animal possibly entangled in fishing gear seen on two days in March 2017 off the Flemish coast near Middelkerke, Belgium (51°11'N; Andersen, 2017); and another animal seen almost two weeks later in Dutch waters off of Vlissingen, Netherlands (51°26'N'; Pieters, 2017). The majority of these eastern North Atlantic sightings were made near shore (some of them from shore). A vessel log dated April 1998 from the central North Atlantic describes the sighting of a small group of bowhead whales (43°23'N, 38°24'W; Anonymous, 1999); but in the absence of supporting photographic, genetic, or other documentation this record must remain unconfirmed. The southernmost confirmed sighting of a bowhead whale anywhere was in the North Pacific in Osaka Bay, Japan at 34°32'N in June 1969 (Nishiwaki and Kasuya, 1970).

Bowhead whales can be individually identified based on unique marks and scarring patterns (Rugh and Braham, 1992; Koski *et al*., 1988). Although the individual documented in the GOM was not particularly well-marked, aerial and vessel photographs examined by experienced

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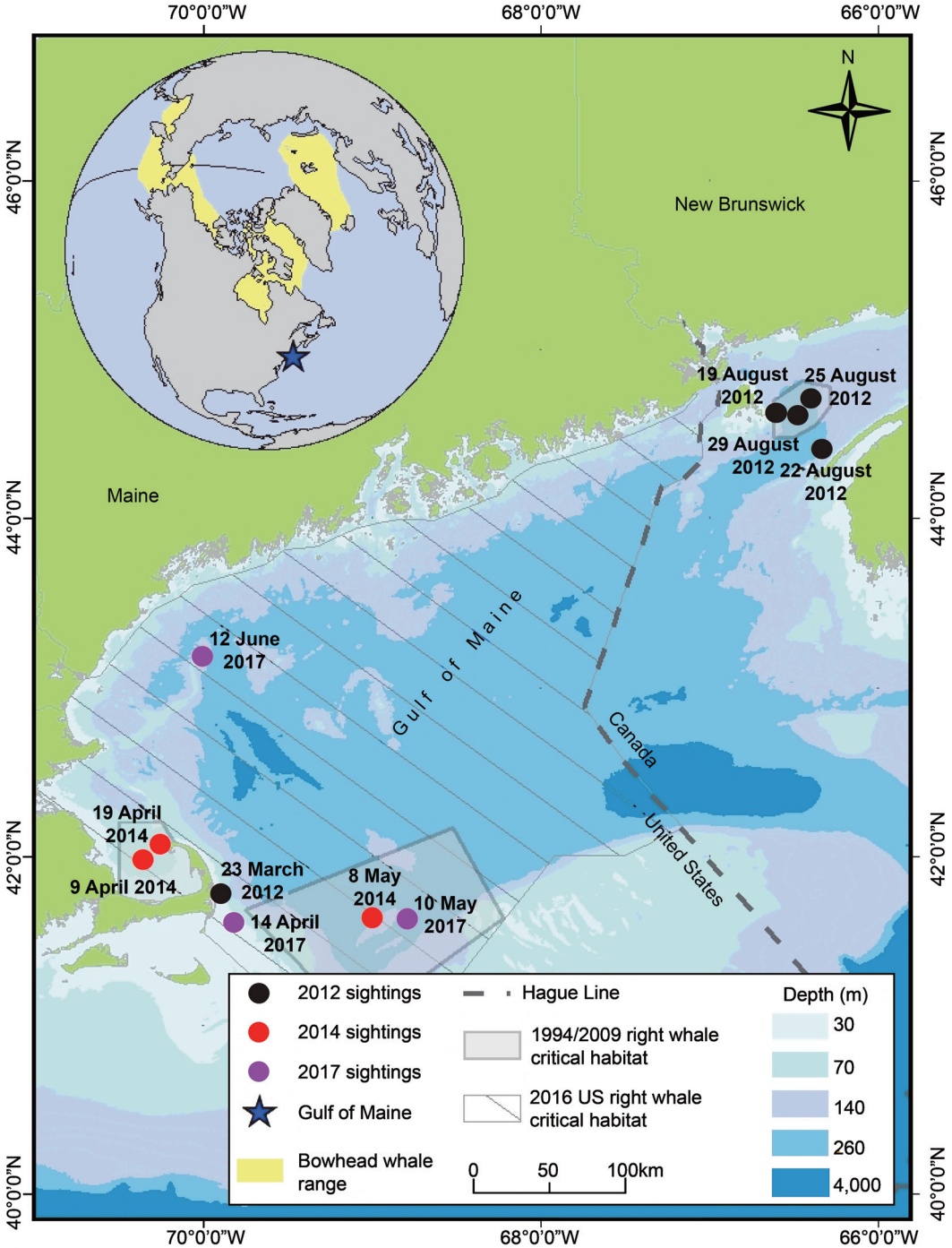

Fig. 1. Information on bowhead whale sightings in the Gulf of Maine during 2012, 2014 and 2017. The inset map displays the typical range of bowhead whale stocks (IUCN, 2012) in relation to the Gulf of Maine.

bowhead whale and North Atlantic right whale (*Eubalaena glacialis)* photo analysts and judged by scarring patterns, including scars that appear to be from a prior fishing gear entanglement (Philo *et al*., 1992; Knowlton *et al*., 2012; George *et al*., 2017), confirmed that all sufficiently photographed sightings were of the same individual bowhead whale.

The first sighting of the bowhead whale in the GOM was on 23 March 2012, 12km (7 nautical miles) northeast of Chatham, Massachusetts, USA. The bowhead whale was in a social group with four right whales (Figs 1 and 2, Table 1). This type of aggregation, known as a surface active group (SAG), is observed in both species and has been described as involving copulatory behaviour (Everitt and Krogman, 1979; Kraus and Hatch, 2001). The main conception season of bowhead whales (in Alaskan waters) is late winter and spring (Koski *et al*., 1993; Reese *et al*., 2001), but SAGs of bowhead whales may involve 'practice mating' behaviour or play a role in social bonding, as is believed to be the case with right whales (Kraus and Hatch, 2001; Parks *et al*., 2007). All of the right whales in this SAG were identified from the North Atlantic Right Whale Consortium Identification Database to be males, most of them juveniles (Right Whale Consortium, 2015). There is no data-derived estimate of the body size of the Gulf of Maine bowhead whale but its length relative to known-aged right whales was judged to be approximately 10m. Such a body length, this bowhead whale's head profile, and its lack of markings suggest that it was a large sub-adult

Fig 2. A bowhead whale and North Atlantic right whales in a surface active group during the 23 March 2012 sighting, east of Cape Cod. The rostrum, chin, and back of the bowhead whale are visible at the top of the image along with the associated four right whales below. [Center for Coastal Studies Image, NOAA Permit 14603]

Table 1

Details for the bowhead whale sightings in the Gulf of Maine during 2012, 2014 and 2017.

Date	Location	Position	Behaviour	Observer	Association with other species
23 Mar. 2012	East of Cape Cod	41°46'N; 69°53'W	Social activity	Center for Coastal Studies	Right whales
19 Aug. 2012	Bay of Fundy	44°36'N; 66°28'W	Mud on head	New England Aquarium	–
22 Aug. 2012	Bay of Fundy	44°24'N; 66°19'W	–	Pirate's Cove Whale Watch	–
25 Aug. 2012	Bay of Fundy	44°42'N; 66°23'W	–	Coastwise Consulting	–
25 Aug. 2012	Bay of Fundy	44°43'N; 66°22'W	–	Coastwise Consulting	–
29 Aug. 2012	Bay of Fundy	44°37'N; 66°35'W	–	Whales-n-Sails Adventure Ltd	–
09 Apr. 2014	Cape Cod Bay	41°58'N; 70°20'W	Skim feeding	Center for Coastal Studies	–
19 Apr. 2014	Cape Cod Bay	42°04'N; 70°14'W	Echelon skim feeding	NE Fisheries Science Center	Right whales
19 Apr. 2014	Cape Cod Bay	42°05'N; 70°12'W	Skim feeding	Center for Coastal Studies	–
08 May 2014	Great South Channel	41°37'N; 68°59'W	Coordinated skim feeding	NE Fisheries Science Center	Sei whales
14 Apr. 2017	Great South Channel	41°36'N; 69°49'W	Coordinated skim feeding	NE Fisheries Science Center	Sei whales
10 May 2017	Great South Channel	41°37'N; 68°47'W	Skim and subsurface feeding	NE Fisheries Science Center	–
12 Jun. 2017	Jeffreys Ledge	43°11'N; 70°00'W	–	Granite State Whale Watch, Blue Ocean Society	–

(Koski *et al*., 1993; Sironi *et al.*, 2005). Bowhead whales attain sexual maturity when they are 12–14m in length (Koski *et al*., 1993; George *et al.*, 1999). They are long-lived animals (George and Bockstoce, 2008) and are difficult to age from body length alone (Lubetkin *et al*., 2008).

Sightings of a bowhead whale were reported on four separate days from 19 to 29 August 2012 in the Bay of Fundy (located between New Brunswick and Nova Scotia, Canada). Photographic confirmation of the species identification is available for three of the sightings and for two of the sightings photographs show that it was the same individual as documented earlier in the year in the GOM. While right whales were present in the lower Bay of Fundy at the time, the bowhead whale was observed alone and not in close association with any other mysticetes (Fig. 1, Table 1).

The Gulf of Maine bowhead whale was re-sighted, almost two years after its initial sighting in the southern GOM, on two days, 9 and 19 April 2014, in the vicinity of Cape Cod Bay (CCB) and once on 8 May 2014 in the Great South Channel (GSC), 80km (43 nautical miles) east of Cape Cod (Fig. 1, Table 1). Photographs confirmed the first sighting to species and the later sightings as matches to the 2012 individual. During these sightings the bowhead whale was observed feeding at or near the surface, either alone or among right whales or sei whales (*Balaenoptera borealis*). The times when this bowhead whale was observed coincided with the peak season in which right whales typically form feeding aggregations (April in CCB: Hamilton and Mayo, 1990; Nichols *et al.,* 2008; May in GSC: Wishner *et al.*, 1988; Kenney *et al.*, 1995; Pershing *et al.*, 2009). During the 19 April 2014 sighting, the bowhead whale was participating in 'echelon skim feeding'[9] with at least one right whale within an aggregation of surface-feeding right whales (Fig. 3) of both sexes and which included a range of age classes (Right

[9] Whales swimming at the surface with at least part of the rostrum exposed above the surface are considered to be skim feeding (Würsig *et al*., 1989); if they are moving in a tightly coordinated 'V' formation, they can be described as 'echelon skim feeding' (Würsig *et al*., 1985; Fish *et al.*, 2013).

Fig. 3. A bowhead whale echelon skim feeding with a North Atlantic right whale during the 19 April 2014 sighting, northeast of Cape Cod. The bowhead whale is at the bottom of the image, with the left side of its head clearly visible above the surface and its back and flukes visible below the surface. [Northeast Fisheries Science Center Image, NOAA Permit 17355]

Fig. 4. A bowhead whale (top right) skim feeding in close proximity to a sei whale and a North Atlantic right whale during the 14 April 2017 sighting. The bowhead whale has its rostrum above the surface and the rest of the head and body are visible below the surface. [Northeast Fisheries Science Center Image, NOAA Permit 17355]

Whale Consortium, 2015). During the 8 May 2014 sighting the bowhead whale was feeding alone and participating in coordinated skim feeding[10] with two sei whales within an aggregation of feeding right whales and sei whales.

Almost three years after the last sighting mentioned above, the Gulf of Maine bowhead whale was re-sighted on two days, 14 April and 10 May 2017, in the GSC, and on 12 June 2017 near Jeffreys Ledge (Fig. 1, Table 1). Photographed markings on the 2017 individual confirmed all sightings as matches to the 2012/2014 Gulf of Maine bowhead whale. During the first two sightings the bowhead whale was observed high-skim and subsurface feeding in close proximity to right whales and coordinated skim feeding with sei whales (Fig. 4). During the 12 June 2017 sighting the bowhead whale was in the vicinity of several fin whales (*Balaenoptera physalus*) and one humpback whale (*Megaptera novaeangliae*); the behaviour of the bowhead whale, characterised by dives of approximately 20 minutes and random surfacings, is consistent with subsurface feeding but as this was a vessel-based sighting, such an interpretation cannot be considered definitive.

[10] If multiple whales, during skim feeding, are turning at the same time while directly in line or side by side they can be described as 'coordinated skim feeding' (Würsig *et al.*, 1985).

Zooplankton collected by surface and oblique conical net tows (standard 333-micrometer mesh) and vertical pumps as part of a regular right whale habitat monitoring program in CCB on 9 April 2014, and during the subsequent two weeks, consisted primarily of the copepod *Calanus finmarchicus*. During the 19 April 2014 sighting, a zooplankton surface dip sample collected in the feeding path of the bowhead whale indicated that it was feeding on a mixture of mainly calanoid copepods, *C. finmarchicus* (72%) and *Pseudocalanu*s spp. (25%) (Burke and Cunningham, 2014). In the Arctic, calanoid copepods are among the most important prey of bowhead whales (Lowry, 1993; Finley, 2000; Laidre *et al.*, 2007; Pomerleau *et al*., 2011; Walkusz *et al*., 2012; Heide-Jørgensen *et al*., 2013) and the same is true of right and sei whales in the North Atlantic (Mayo and Marx, 1990; Wishner *et al*., 1995; Baumgartner and Fratantoni, 2008; Baumgartner *et al*., 2011).

Although acoustic recordings were obtained in the vicinity of the CCB bowhead whale sightings, all of the balaenid calls detected were attributed to right whales and no bowhead whale vocalizations could be distinguished (C.W. Clark, pers. comm.[11]). Bowhead whales, like many large cetaceans, produce a variety of sounds (Clark and Johnson, 1984; Würsig and Clark, 1993; Johnson *et al*., 2015). Some of the bowhead whale sightings in 2014 were within range of an array of acoustic buoys specifically deployed to record low-frequency (< 1000Hz) baleen whale sounds. Recordings from those buoys were analysed by specialists on days when the bowhead whale was seen in the vicinity of CCB. The simple, low-frequency, frequency-modulated calls of North Atlantic right whales and humpback whales, which also regularly occupy these waters during the same season, are similar to bowhead whale calls (Clark and Clark, 1980; Clark and Johnson, 1984; Würsig and Clark, 1993; Baumgartner *et al.*, 2013); however, the structure and other features of bowhead whale vocalizations are sufficiently distinct that they can usually be distinguished from those of the other species (Stafford *et al.*, 2012).

All sightings of the bowhead whale in the GOM were made during systematic aerial and vessel surveys targeting other species, particularly right whales, or during whale watching tourism cruises (Fig. 1, Table 1). At the time of the 2012/2014 sightings most of the Gulf of Maine bowhead whale sightings were within right whale critical habitat areas (Fig. 1), two legally designated in US waters (US Federal Register, 1994) and one identified in Canadian waters (Brown *et al.*, 2009; Fisheries and Oceans Canada, 2014). Since the time of these sightings the right whale critical habitat in the northeastern US was expanded (US Federal Register, 2016), encompassing all of the locations of the bowhead whale sightings in US waters of the GOM.

Efforts to match this individual bowhead whale to all known photographic catalogues from the range of each population have yielded no positive results to date. Attempts to obtain a skin biopsy for genetic analysis were unsuccessful. During all documented sightings the animal appeared to be healthy and in good condition (Pettis *et al*., 2004; Hunt *et al.*, 2013). Sighting and life history data from the North Atlantic Right Whale Consortium Identification and Sightings Databases (RWC, 2015) were examined but no consistent association was found between the bowhead whale and the various individually identified right whales. While regular surveys have continued in all areas where the bowhead whale was observed, there have been no further sightings of this animal to date.

Bowhead whales and right whales do not typically occur in the same areas at the same time, however some geographical overlap in their range has been noted in historical whaling records (McLeod *et al*., 2008; Reeves *et al*., 2008), and at least one brief observation has been reported of a North Pacific right whale (*Eubalaena japonica*) and bowhead whales occupying the same habitat at the same time in the Okhotsk Sea (Shpak and Paramonov, 2012). We are not aware of any previous reports of interactions between bowhead whales and sei whales but North Atlantic right whales and sei whales are frequently observed in the same habitat (Mitchell *et al*., 1986; Horwood, 1987; COSEWIC, 2003; Baumgartner *et al.*, 2011).

Bowhead whales were occasionally taken by whalers or found stranded in both the North Pacific and North Atlantic in the mid-50s°N latitude (Bockstoce *et al.*, 2005; McLeod, 2008; Higdon, 2010). Their normal range in the western North Atlantic, and specifically in the Gulf of St. Lawrence, appears to have extended as far south as 48°N during the late 16th century, a period of climatic cooling often referred to as the Little Ice Age (McLeod *et al*., 2008). In very recent years there has been a shift in the distribution and density of North Atlantic right whales away from areas where they were regularly observed from the 1980s to early 2000s (Burke and Cunningham, 2014; Khan *et al*., 2014), and this has coincided with an increase of sightings in latitudes somewhat further north to at least 48°40'N (Khan *et al.*, 2014; New England Aquarium and Northeast Fisheries Science Center unpublished data, 2015 and 2016), still well south of what has been regarded as the southern limit of the bowhead whale's current range (Moore and Reeves, 1993; Mellinger *et al.*, 2011).

Bowhead whale sightings in the GOM, as well as in Newfoundland and European waters in recent years, together with the changes observed in North Atlantic right whale distribution and density, are of great interest as they may represent the early stages of shifting ranges. Populations of bowhead whales and North Atlantic right whales had been decimated by commercial whaling by the early 20th century (Reeves *et al.*, 2007; Higdon, 2010). Since then the populations of both species have increased (Heide-Jørgensen *et al*., 2007; Boertmann *et al*., 2015; Pettis and Hamilton, 2015) although in recent years North Atlantic right whales have been experiencing a decline in overall population health and fecundity (Kraus *et al*., 2016, Pace *et al*., 2017). In the last decade, sightings of North Atlantic right whales (Jacobsen *et al*., 2004; Hamilton *et al.*, 2007; Silva *et al.*, 2012) and bowhead whales (Heide-Jørgensen *et al*., 2007; 2011) have been documented outside the limits of their assumed ranges. While the feeding and social behaviour of the Gulf of Maine bowhead whale was typical of the species, its occurrence south of the species' supposed range and its associations with right whales and sei whales were unusual.

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