

# Winter sighting of a known western North Atlantic right whale in the Azores

MÓNICA A. SILVA<sup>\*+</sup>, LISA STEINER<sup>#</sup>, IRMA CASCÃO<sup>\*</sup>, MARIA JOÃO CRUZ<sup>\*</sup>, RUI PRIETO<sup>\*</sup>, TIM COLE<sup>\*\*</sup>, PHILIP K. HAMILTON<sup>§</sup> AND MARK BAUMGARTNER<sup>†</sup>

Contact e-mail: monica@uac.pt

## ABSTRACT

A right whale (*Eubalaena glacialis*) from the western North Atlantic population, sighted in the Azores, was subsequently found to have moved back to the northwest Atlantic. The whale was sighted in the Azores on 5 January 2009 travelling in a west-south westerly direction at a constant speed. A photographic match was found to an adult female in the North Atlantic Right Whale Catalogue. The whale's previous last sighting, on 24 September 2008 in the Bay of Fundy, Canada, implies movement to the Azores of at least 3,320km in 101 days. It was subsequently resighted in the Bay of Fundy on 2 September 2009, 237 days after being seen in the Azores. This appears to be the only documented evidence of a western North Atlantic right whale outside its normal range in winter, and provides additional evidence of the potential for interbreeding between western North Atlantic right whales and the remnant eastern population.

KEYWORDS: NORTH ATLANTIC RIGHT WHALE; ATLANTIC OCEAN; EUROPE; MOVEMENTS; DISTRIBUTION; STOCK IDENTITY; MANAGEMENT; NORTHERN HEMISPHERE

## INTRODUCTION

The North Atlantic right whale (*Eubalaena glacialis*) was severely depleted by centuries of exploitation and in the 1950s the species was considered extinct or very nearly so (Kraus and Rolland, 2007). However, right whales used to be common and wide ranging along coastal waters on both sides of the North Atlantic, from Florida and West Africa in the south, to the Labrador Sea and Norway in the north, extending to waters off southern Iceland and Greenland (Kraus and Rolland, 2007). The severe reduction in population size was accompanied by a considerable contraction in the species' range and by its virtual disappearance from what were once important habitat areas. In the northeast Atlantic, records of right whales in former whaling grounds, such as the Bay of Biscay, Cape Farewell, the British Isles and northern Norway, are now rare and scattered. Between 1900 and 1982, fewer than 140 right whales were captured in European waters, the majority of which were taken off the British Isles to 1923 (Brown, 1986). In addition, eight right whales were sighted in various locations in the eastern North Atlantic (Jacobsen *et al.*, 2004). The southernmost records from the 20th century are from the Canary Islands (Vidal Martin, pers. comm.) and a winter survey off West Africa failed to detect any right whales in Cintra Bay (Morocco), thought to be the only historical calving ground in the eastern Atlantic (Notarbartolo di Sciara *et al.*, 1998). Historical whaling records suggest that right whales also occupied a wider range in the northwest Atlantic. The low number of sightings during the 20th century in Newfoundland and in the Labrador Sea suggests right whales are now

infrequent in these former whaling grounds (Knowlton *et al.*, 1992).

Eastern and western North Atlantic right whales have always been considered as two separate management stocks (IWC, 1986). Recently, mitochondrial DNA analysis of archaeological and museum specimens has suggested that the eastern and western populations were not genetically differentiated (Rosenbaum *et al.*, 2000). Nonetheless, the paucity of sightings in the eastern Atlantic and the lack of recovery there have been interpreted as an indication of population subdivision over centuries of exploitation persisting to the present day.

At present, the eastern population is presumed functionally extinct and the remnant population of right whales, consisting of about 400 whales (Pettis, 2009), is mostly restricted to the coastal waters of United States and Canada (Hamilton *et al.*, 2007). Five critical habitats or conservation areas have been identified, including four feeding and one calving ground. In spring and early summer, right whales usually concentrate in the Great South Channel (east of Cape Cod) and Cape Cod Bay, whereas in summer and fall, they are mainly found in the Bay of Fundy and Roseway Basin (south of Nova Scotia) (Fig. 1). The calving ground, located off the coast of Florida and Georgia, is mainly visited in winter by pregnant females and a few calves and non-calving females (Kraus and Rolland, 2007). While a considerable part of the population seems to aggregate seasonally in these habitats, several whales appear, regularly or occasionally, to use areas other than the typical foraging and calving grounds (Jacobsen *et al.*, 2004; Knowlton *et al.*, 1992). To date, these alternative habitats

\* Centro do Instituto do Mar (IMAR) da Universidade dos Açores, Departamento de Oceanografia e Pescas, 9901-862 Horta, Portugal

† Biology Department, MS#33, Woods Hole Oceanographic Institution, Woods Hole MA02543, USA

# Whale Watch Azores, Estrada da Caldeira, No 2, Horta, 9900-089, Faial, Portugal

\*\* NOAA Northeast Fisheries Science Center, 166 Water Street, Woods Hole, MA 02543, USA

§ New England Aquarium, Central Wharf, Boston, MA 02110, USA

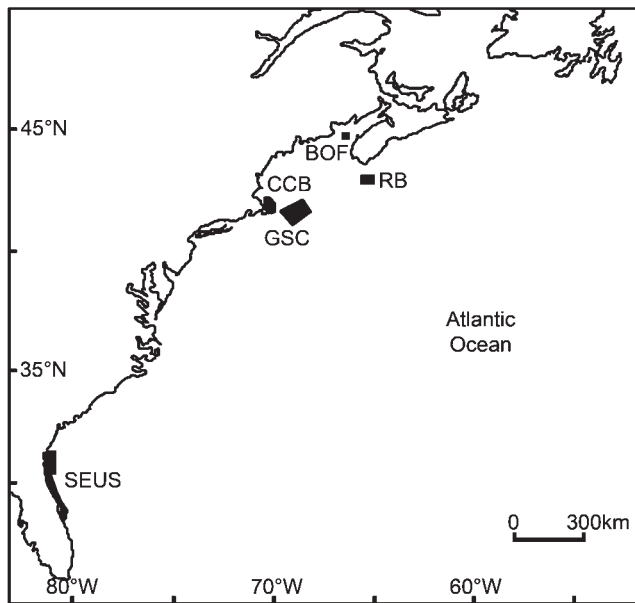


Fig. 1. Critical habitats or conservation areas of western North Atlantic right whales: SEUS = Southeast United States, GSC = Great South Channel, CCB = Cape Cod Bay, BOF = Bay of Fundy, RB = Roseway Basin.

have not been identified and the ranging behaviour of a segment of the population remains poorly understood. A wintering area for non-calving whales has only recently been discovered in the central Gulf of Maine (Tim Cole, pers. comm.) but it is unclear whether other wintering areas exist. The identification of these habitats and knowledge of the movements between them is crucial to ensure the protection of this highly endangered population throughout all its range.

This paper reports the sighting off the Azores of an individually identified right whale from the western North Atlantic population and documents its movement back to the northwest Atlantic. Long range match is examined in light of historic and present knowledge of the distribution and movements of the species and potential implications for population structure and management are discussed.

## MATERIALS AND METHODS

The Archipelago of the Azores (Portugal) is located between 37° and 41°N and 25° and 31°W, extending more than 600km along a northwest–southeast axis and crossing the Mid-Atlantic Ridge. It is the most isolated archipelago in the North Atlantic, situated 1,500km west of mainland Portugal and 3,200km from the eastern coast of the United States (Fig. 2). The archipelago is characterised by an absence of continental slope and the occurrence of deep waters (>2,000m) at short distance from the coast with scattered seamounts. It is situated at the northern edge of the North Atlantic Subtropical Gyre. The Gulf Stream feeds the area, and its southeastern branch generates the eastward-flowing Azores Current. The Gulf Stream, North Atlantic and Azores currents, and the dynamic Azores Front, are responsible for creating a complex pattern of ocean circulation, with strong seasonal and annual variations, resulting in high salinity, high temperature and low-nutrient waters (Santos *et al.*, 1995).

The whale was detected by two experienced land-based observers (cliff lookouts) employed by whalewatching companies. At the time, one lookout was collecting

information for the Department of Oceanography and Fisheries of the University of the Azores (DOP/UAç) on the presence of cetaceans off the southern coast of the islands of Faial and Pico (Fig. 2). The lookout searched for cetaceans in an area of approximately 800km<sup>2</sup>, extending from the coastline up to 22km offshore, using 15×80mm mounted binoculars with a compass. Observations were carried out from 1 February 2008 until 29 September 2009, whenever visibility and weather conditions allowed. Data on sighting effort, environmental and visibility conditions were collected for each period of continuous observation (ranging from 1–3 hours) and whenever weather conditions changed. For each sighting the lookout recorded the initial time and approximate location, the species, estimated number of individuals, behaviour and composition of the school. All information was recorded on standardised data sheets.

The lookout immediately contacted DOP/UAç to report the sighting and directed a research vessel to the site. The whale was followed for approximately one hour, until the sun set at 17:41. Every time the whale surfaced, its position, heading and behaviour were recorded. Photographs of the head, flanks and a partial fluke were taken with a Nikon F-70S digital camera equipped with a 70–300mm lens, and a Canon 30D equipped with a 100–400mm lens. The best photographs were sent to the North Atlantic Right Whale Catalog maintained at the New England Aquarium to see if the whale was known.

## RESULTS AND DISCUSSION

From February 2008 to September 2009, the lookout carried out 2,607 hours of observations in 474 days. During that period, 1,769 cetacean sightings were recorded. The whale was sighted on 5 January 2009 at 15:44, less than one nautical mile south of the island of Pico, heading westwards at a steady pace (Fig. 2). At 16:37 the DOP/UAç research vessel approached the whale and biologists onboard confirmed the identification as a right whale. The individual showed normal swimming behaviour, appeared to be in good physical conditions and had no obvious injuries that would suggest it was in distress. Over one hour, the whale travelled in a west-south westerly direction (mean course = 265°; SD = 21°) at an average speed of 7.1km h<sup>-1</sup> (SD = 3.1km h<sup>-1</sup>). Dives ranged from 4 to 12 min and the time interval between dives varied from 2 to 4 min.

Examination of the lookout's sighting records on the days prior to and after the sighting suggested the right whale did not remain in or return to the area. Although visibility conditions at that time of year are usually poor, the lookout scanned the area every day from 31 December 2008 to 10 January 2009. Thirty-three cetacean schools were recorded in the area during those days but there were no sightings of baleen whales.

Photographs taken were compared to the NARW Catalogue and a match was found to right whale no.3270. The whale was named *Pico* after the island near where it was seen. According to information from the Catalog website<sup>1</sup>, before being observed in the Azores, *Pico's* last sighting was on 24 September 2008, in the Bay of Fundy, Canada. This

<sup>1</sup> Sighting history available from the North Atlantic Right Whale Catalog (<http://www.neaq.org/rwcatalog>)

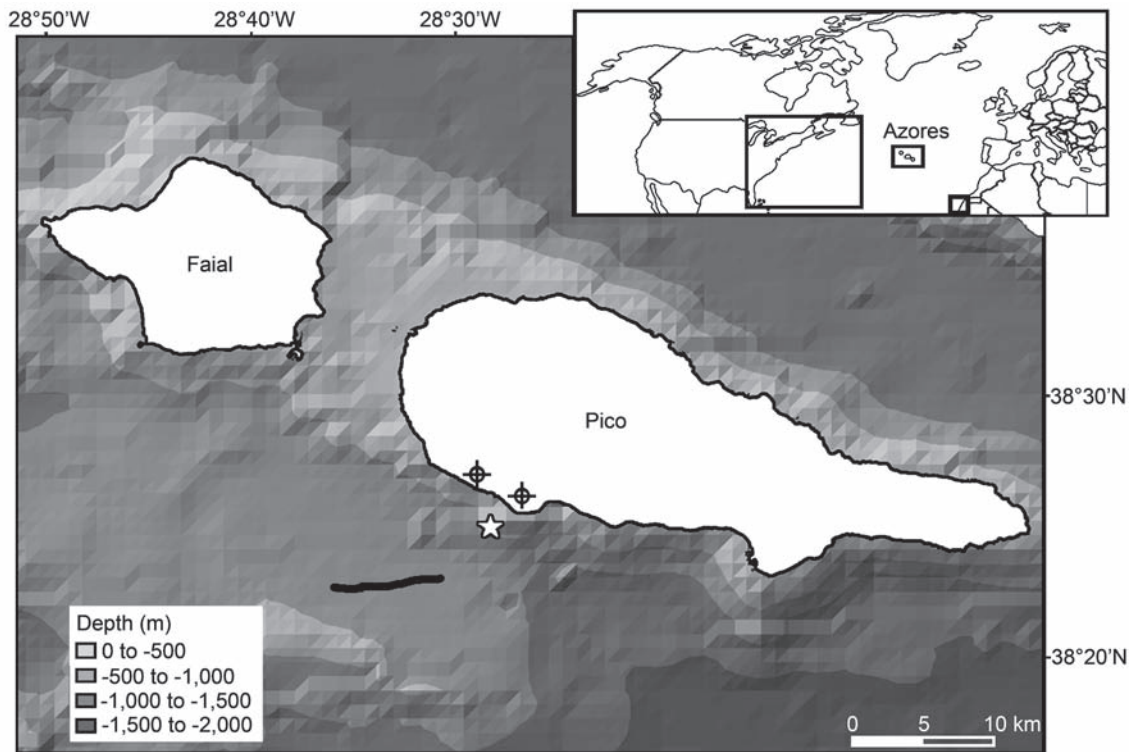


Fig. 2. Sighting of the North Atlantic right whale in the Azores: the star indicates the approximate position of the initial sighting reported by the lookouts and the line shows the reconstructed path of the whale. Inset shows the location of the Azores relative to the habitats of right whales in the western North Atlantic and to the historical wintering ground in Cintra Bay, Morocco.

means that *Pico* travelled at least 3,320km in 101 days. *Pico* was resighted in the Bay of Fundy on 2 September 2009, 237 days after being seen in the Azores. *Pico* appeared to be in good physical condition apart from a healed scarring that wrapped around the entire tail stock, strongly suggesting the whale had been recently entangled in fishing gear.

*Pico* is an adult female, first photographed in June 2002, in the Great South Channel, about 100km east of Cape Cod. *Pico* was then observed every year, except 2004, in the typical northern habitat of the western North Atlantic population. From March through July, *Pico* was frequently encountered in the Great South Channel; she was observed twice in August, in Roseway Basin and on George’s Bank. Since 2006, *Pico* has been regularly found in the Bay of Fundy in August through late September. *Pico* has been rarely sighted during autumn and winter and her movements at this time of the year are not well documented. From 2002 to 2008, she was observed three times in November, January and February, always in the Gulf of Maine.

*Pico*’s sighting in the Azores is the only record of the species in the area within the last 60 years. Combining all the information available on catches and sightings, we found a total of 11 records of right whales in the area. Clarke (1981) reported that seven right whales were captured between 1873 and 1888 by the Azorean open-boat whaling industry, which targeted sperm whales (*Physeter macrocephalus*). Another right whale was reportedly struck in 1914 but it proved difficult to capture and was cut loose (Brown, 1986). In his checklist of cetaceans from the Azores, Chaves (1924) claims to have seen right whales off the Azores twice but he gives no details on these observations. The last unconfirmed sighting occurred sometime between 1939 and

1949 and was reported by a whaling land-based lookout (Clarke, 1981).

Information summarised from 19<sup>th</sup> century American whaling logbooks has led to the possibility of a right whale summer ground in the central North Atlantic (Reeves, 2001). That area, which included the whole Azores archipelago and extended further west (to 48°W) and north (to 43°N), was depicted on charts representing locations where right whales were sighted, killed or struck by whaling vessels. However, Reeves *et al.* (2004) later reported that nearly all the occurrences of right whales in those charts has been incorrectly identified from the original logbooks and dismissed the idea that the area may have been an alternative offshore foraging ground for right whales. Similarly, there is no evidence that the Azores was an important historic whaling ground for European whalers before the nineteenth century (Aguilar, 1986; Reeves *et al.*, 2007; Smith *et al.*, 2006). Thus, it seems unlikely that right whales were ever abundant in the Azores, although sporadic catches and sightings show they occasionally occurred there.

Most of the whales known from the NARW Catalogue are regularly seen at least in one of the five well studied key habitats. Yet, several catalogued whales show sighting frequencies well below the average of the rest of the population (Hamilton *et al.*, 2007). Some of these ‘irregular’ whales were photographed in the Gulf of St. Lawrence, off Newfoundland, in the Labrador Basin and off Iceland (Knowlton *et al.*, 1992). *Pico*, on the other hand, was seen consistently in the population’s foraging habitats and would probably be classified as a ‘regular’ whale. *Pico*’s documented excursion to the Azores and back supports previous photo-identification and satellite-telemetry studies

showing that even 'regular' whales may range widely, sometimes over relatively short periods of time (Knowlton *et al.*, 1992; Mate *et al.*, 1997). Perhaps the most extreme example comes from *Porter*, an adult male known and frequently photographed in the western North Atlantic since 1981. In 1999, *Porter* travelled over 5,000km from the Great South Channel, where he was last seen in May, to northern Norway, where he spent more than one month, between August and September, foraging in the fjords. Less than five months later, *Porter* was back in the western North Atlantic (Jacobsen *et al.*, 2004).

Distant sightings of right whales from the western population have all occurred in summer and fall (between July and October), in well-known historical whaling grounds. This has led to the suggestion that some of these sites may represent alternative summer foraging (Smith *et al.*, 2006) or nursery areas (Knowlton *et al.*, 1992) for some whales. To the best of our knowledge, the sighting of *Pico* in the Azores during January is the only documented sighting of a western North Atlantic right whale outside the population's normal range in winter. The lack of information on winter movements of this population lends additional interest to this excursion to offshore waters, although we can only speculate on the reason for its occurrence.

The time of *Pico's* sighting in the Azores agrees with previous, albeit scarce, information on the occurrence of right whales in the region. The three dated records of right whales caught in the Azores are from January, March and April (Clarke, 1981), and all recent sightings in the eastern North Atlantic south of or at the latitude of the Azores have been in January and February (4 in Madeira, 3 in the Canary Islands and 1 south of Portugal) (Brown, 1986; Jacobsen *et al.*, 2004; Vidal Martin, pers. comm.). These sightings could not be matched to whales from the western population and were presumed to be of whales from the eastern population. It should be stressed that survey effort in the region during winter is usually low because of poor weather and right whales may occur more frequently than suggested by the sighting data.

As noted by Baumgartner *et al.* (2007), apart from the migration of pregnant females to calving grounds, long-distance movements of right whales are likely motivated by their need to find food. The diving behaviour, constant speed and heading, indicate *Pico* was travelling and not foraging when observed in the Azores. Moreover, the biological productivity of the waters around the Azores is low in winter (Woods and Barkmann, 1995). Inspection of remotely-sensed surface chlorophyll and temperature data in the months and weeks prior to the sighting did not reveal any unusual bloom of primary productivity capable of supporting important aggregations of zooplankton that might have attracted a right whale. Thus, it is unlikely that the presence of the whale in the Azores was caused by food availability. This does not exclude the hypothesis that *Pico's* extensive movement was associated with feeding opportunities elsewhere in offshore waters.

Alternatively, and given the timing of this sighting, *Pico's* excursion could have been triggered by reproductive events. *Pico's* date of birth is unknown but the shape of her head suggests she was at least two years old in 2002 when first sighted and photographed, meaning she would have been

over nine years old when seen in the Azores. Female North Atlantic Right whales reach sexual maturity at an average age of nine years (Hamilton *et al.*, 1998). Therefore, although *Pico* has never been photographed in the calving ground, nor has she ever been seen with a calf in 2009, she could have been sexually mature or be close to reaching sexual maturity. A recent study has shown that adult, reproductively available (i.e. not already calving or resting) females do not travel to the calving grounds in winter unless pregnant (Browning *et al.*, 2010). If *Pico* was pregnant we would have to assume that she had lost her calf before being observed in the Azores. On the other hand, Kraus *et al.* (2007) suggested that, as females approach sexual maturity, they are more likely to be found on the mating grounds than on the calving grounds. The location of the mating grounds is unknown but given that calves are born in December – March and gestation is assumed to last approximately one year (Best, 1994), mating must occur where whales winter.

The Azores are located in a straight trajectory between the western North Atlantic foraging areas, where *Pico* was last seen, and the only wintering and possibly calving ground known in the northeast Atlantic, situated off northwest Africa, in the region of Cintra Bay. During the nineteenth century, American whaling vessels captured or sighted at least 13 right whales in Cintra Bay in November, February and March (Schevill and Moore, 1983). The three most recent sightings of cow and calf pairs in Madeira (February 1967), south of Portugal (February 1995) (Jacobsen *et al.*, 2004), and in the Canary Islands (1976 and January 1999) (Vidal Martin, pers. comm.) support the notion of a winter calving ground to the south of these areas and suggest the area may still be visited by a few whales. Although a 25 day winter survey in 1996 in the region did not find any right whales, the visibility was poor and the survey effort may have been insufficient to detect whales that certainly are rare and scattered (Notarbartolo di Sciara *et al.*, 1998).

Recently, paternity analyses have shown that the majority of calves from the western population were not fathered from males that have been genetically sampled and that the remaining unsampled males that are catalogued cannot account for all the unidentified paternities (Frasier *et al.*, 2007). These findings and results from other analyses suggest the population size must be higher than the current estimate from photo-identification data (Frasier *et al.*, 2007). Considering the intensive sampling carried out throughout the typical range of the population, it is likely that these unidentified whales use habitats that have not yet been discovered.

Whether *Pico's* long excursion was motivated by feeding needs or reproduction, there is no reason to believe that the Azores was the destination. It is possible that the Azores and their location on the Mid-Atlantic Ridge served as a navigation landmark to *Pico* in this offshore area. It is also plausible that the whale used the proximity of the Azores Front that originates from the Gulf Stream as a navigational cue. Though a link between western right whales and the remnant eastern population has yet to be established, the sighting of *Pico* in the Azores provides additional evidence of the potential for interbreeding between whales from each side of the Atlantic.

Despite nearly 75 years of protection, the North Atlantic right whale remains one of the most endangered baleen whales in the world. Although in recent years the population appears to have been increasing (Waring *et al.*, 2009), the recovery has been slow, mainly due to low reproductive rates and high mortality from entanglements in fishing gear and vessel collisions (Kraus *et al.*, 2007). The death of only a few females per year can endanger the survival of this species (Fujiwara and Caswell, 2001). Throughout the years, distinct management measures have been enforced to protect right whales in their western North Atlantic habitats. However, the recent sighting in the Azores and others made elsewhere (Jacobsen *et al.*, 2004; Knowlton *et al.*, 1992) suggest that at least some whales may have ranges that extend beyond the coastal waters of North America, to areas where they may be subject to various threats. Given the current status of this population, increased attention should be paid to these apparently exceptional long range movements.

## ACKNOWLEDGMENTS

We are very grateful to Antero Soares and Carlos Norberto Silva for the endless hours they spent in the lookouts searching for whales and for providing the information on this and many other sightings. We also would like to thank our skipper, Norberto Serpa, for his willingness and cooperation. We are grateful to the North Atlantic Right Whale Consortium, an inspirationally collaborative group of right whale biologists and managers, for access to Pico's complete sighting history. We acknowledge Marilyn Marx and Luís Freitas for their comments on an early draft of the paper. This work was funded by the Portuguese Science and Technology Foundation (FCT), under the TRACE project (PTDC/MAR/74071/2006). M.A.S. was supported by an FCT postdoctoral grant (SFRH/BPD/29841/2006). I.C. and R.P. were supported by FCT doctoral grants (respectively SFRH/BD/41192/2007 and SFRH/BD/32520/2006). IMAR-DOP-UAç is the R&D Unit #531 and part of the Associated Laboratory ISR funded through the Pluri-annual and Programmatic funding schemes of FCT-MCTES and DRCT-Azores. This research was conducted under license of the Environment Directorate of the Regional Government of the Azores.

## REFERENCES

Aguilar, A. 1986. A review of old Basque whaling and its effect on the right whales (*Eubalaena glacialis*) of the North Atlantic. *Rep. int. Whal. Commn (special issue)* 10: 191–99.

Baumgartner, M., Mayo, C. and Kenney, R. 2007. Enormous carnivores, microscopic food and a restaurant that's hard to find. pp.138–71. In: Kraus, S. and Rolland, R.W. (eds). *The Urban Whale: North Atlantic Right Whale at the Crossroads*. Harvard University Press, Cambridge, 576pp.

Best, P.B. 1994. Seasonality of reproduction and the length of gestation in southern right whales *Eubalaena australis*. *J. Zool. (Lond.)* 232: 175–89.

Brown, S.G. 1986. Twentieth-century records of right whales (*Eubalaena glacialis*) in the northeast Atlantic Ocean. *Rep. int. Whal. Commn (special issue)* 10: 121–27.

Browning, C.L., Rolland, R.M. and Kraus, S.D. 2010. Estimated calf and perinatal mortality in western North Atlantic right whales (*Eubalaena glacialis*). *Mar. Mammal Sci.* 26: 648–62.

Chaves, F.A. 1924. Cetáceos que aparacem nos mares does Acores. *Pesca Marit., Lisboa* 15: 41–44. [In Portuguese].

Clarke, R. 1981. Whales and dolphins of the Azores and their exploitation. *Rep. int. Whal. Commn* 31: 607–15.

Frasier, T., McLeod, B.A., Bower, R., Brown, M. and White, B.N. 2007. Right whales past and present as revealed by their genes. pp.200–31. In: Kraus, S. and Rolland, R. (eds). *The Urban Whale: North Atlantic Right Whales at the Crossroads*. Harvard University Press, Cambridge, MA, USA. 576pp.

Fujiwara, M. and Caswell, H. 2001. Demography of the endangered north Atlantic right whale. *Nature* 414: 537–41.

Hamilton, P.K., Knowlton, A.R., Marx, M.K. and Kraus, S.D. 1998. Age structure and longevity in North Atlantic right whales (*Eubalaena glacialis*). *Mar. Ecol. Prog. Ser.* 171: 285–92.

Hamilton, P.K., Knowlton, A.R., Marx, M.K. and Kraus, S.D. 2007. Right whales tell their own stories: the photo-identification catalog. pp.75–104. In: Kraus, S. and Rolland, R. (eds). *The Urban Whale: North Atlantic Right Whales at the Crossroads*. Harvard University Press, Cambridge, MA, USA. 576pp.

International Whaling Commission. 1986. Report of the Workshop on the Status of Right Whales. *Rep. int. Whal. Commn (special issue)* 10:1–33.

Jacobsen, K.O., Marx, M. and Øien, N. 2004. Two-way trans-Atlantic migration of a North Atlantic right whale (*Eubalaena glacialis*). *Mar. Mammal Sci.* 21(1): 161–66.

Knowlton, A.R., Sigurjónsson, J., Ciano, J.N. and Kraus, S.D. 1992. Long-distance movements of North Atlantic right whales (*Eubalaena glacialis*). *Mar. Mammal Sci.* 8(4): 397–405.

Kraus, S.D., Pace, R.M., III. and Frasier, T.R. 2007. High investment, low return: The strange case of reproduction in *Eubalaena glacialis*. pp.172–99. In: Kraus, S.D. and Rolland, R.M. (eds). *The Urban Whale: North Atlantic Right Whales at the Crossroads*. Harvard University Press, Cambridge, MA, USA. 576pp.

Kraus, S.D. and Rolland, R.M. 2007. Right whales in the urban ocean. pp.1–38. In: Kraus, S. and Rolland, R. (eds). *The Urban Whale: North Atlantic Right Whales at the Crossroads*. Harvard University Press, Cambridge, MA, USA. 576pp.

Mate, B.R., Nieuwkerk, S.L. and Kraus, S.D. 1997. Satellite-monitored movements of the northern right whale. *J. Wildl. Manage.* 61(4): 1393–405.

Notarbartolo di Sciara, G., Politi, E., Bayed, A., Beaubrun, P.C. and Knowlton, A. 1998. A winter cetacean survey off southern Morocco, with a special emphasis on right whales. *Rep. int. Whal. Commn* 48: 547–50.

Pettis, H. 2009. North Atlantic right whale consortium annual report card (01 November 2007 – 30 April 2009). Paper SC/61/BRG11 presented to the IWC Scientific Committee, June 2009, Madeira, Portugal (unpublished). 7pp. [Paper available from the Office of this Journal].

Reeves, R.R. 2001. Overview of catch history, historic abundance and distribution of right whales in the western North Atlantic and in Cintra Bay, West Africa. *J. Cetacean Res. Manage. (special issue)* 2: 187–92.

Reeves, R.R., Josephson, E. and Smith, T.D. 2004. Putative historical occurrence of North Atlantic right whales in mid-latitude offshore waters: 'Maury's Smear' is likely apocryphal. *Mar. Ecol. Prog. Ser.* 282: 295–305.

Reeves, R.R., Smith, T.D. and Josephson, E. 2007. Near-annihilation of a species: right whaling in the North Atlantic. pp.39–74. In: Kraus, S. and Rolland, R. (eds). *The Urban Whale: North Atlantic Right Whales at the Crossroads*. Harvard University Press, Cambridge, MA, USA. 576pp.

Rosenbaum, H.C., Egan, M.G., Clapham, P.J., Brownell, R.L., Brown, M.W., White, B.N., Malik, S., Walsh, P.D. and DeSalle, R. 2000. Utility of North Atlantic right whale museum specimens in assessing changes in genetic diversity. *Conserv. Biol.* 14(6): 1837–42.

Santos, R.S., Hawkins, S., Monteiro, L.R., Alves, M. and Isidro, E. 1995. Marine research, resources and conservation in the Azores. *Aquat. Conserv.* 5: 311–54.

Schevill, W.E. and Moore, K.E. 1983. Townsend's unmapped North Atlantic right whales (*Eubalaena glacialis*). *Breviora* 476: 1–8.

Smith, T.D., Barthelmeß, K. and Reeves, R.R. 2006. Using historical records to relocate a long-forgotten summer feeding ground of North Atlantic right whales. *Mar. Mammal Sci.* 22(3): 723–34.

Waring, G.T., Josephson, E., Maze-Foley, K. and Rosel, P.E. 2009. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2009. NOAA Tech Memo NMFS NE 213, December 2009. 528pp. [Report available: <http://www.nmfs.noaa.gov>].

Woods, J.D. and Barkmann, W. 1995. Modelling oligotrophic zooplankton production: seasonal oligotrophy off the Azores. *ICES J. Mar. Sci.* 52: 723–34.

Date received: June 2010

Date accepted: October 2010

