

DISCUSSION / DISCUSSION

Comment on "Genetic analysis of 16th-century whale bones prompts a revision of the impact of Basque whaling on right and bowhead whales in the western North Atlantic"¹

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Abstract: Rastogi et al. presented their genetic analysis of 16th-century whale bones found on a Basque whaling ship excavated from Red Bay, Labrador Peninsula, Canada. Based on the results from a very small sample, these authors concluded that whaling populations were already depleted before the onset of whaling. This is in direct contradiction to historical data. They also implied that the Basques were the only Europeans whaling in the North Atlantic before the onset of Yankee whaling and that there was a belief that Basque whalers historically killed equal numbers of right and bowhead whales. Here we present data based on historical and archaeological records generated by several authors using different methodologies, which clearly show that (i) Basques were not the only whalers that impacted cetacean populations in the North Atlantic; (ii) the number of whales killed by different peoples for approximately two centuries indicates that both right and bowhead whale population levels were much higher than typically assumed; and (iii) for many years there have been records published indicating that the Basques and others killed more bowhead whales than right whales, at least in the western North Atlantic.

Résumé : Rastogi et al. ont présenté une analyse génétique des os de baleines du 16^e siècle retrouvés sur un baleiner basque enfoui à Red Bay, péninsule du Labrador, Canada. D'après les résultats obtenus d'un très petit échantillon, les auteurs concluent que les populations de baleines étaient déjà épuisées avant même le début de la chasse à la baleine. Cette affirmation est en contradiction directe avec les données historiques. Les auteurs présument que les basques étaient les seuls européens à chasser la baleine dans l'Atlantique nord avant le début de la chasse par les yankees; ils supposent aussi qu'il existe un consensus voulant que les basques aient tué dans le passé un nombre égal de baleines franches du Nord et de baleines franches boréales. Nous présentons ici des données basées sur des travaux historiques et archéologiques de plusieurs auteurs utilisant des méthodologies différentes qui montrent clairement que (i) les basques n'étaient pas les seuls chasseurs à avoir affecté les populations de cétacés dans l'Atlantique nord, (ii) le nombre de baleines tuées par les différents peuples pendant environ deux siècles indique que les densités de population, tant des baleines franches du Nord que celles des baleines franches boréales, étaient beaucoup plus élevées qu'on ne le croit habituellement et (iii) depuis de nombreuses années, il existe des publications qui indiquent que les basques et les autres peuples tuaient plus de baleines franches boréales que de baleines franches du Nord, au moins dans l'ouest de l'Atlantique nord.

[Traduit par la Rédaction]

Introduction

Rastogi et al. (2004), while examining the impact of Basque whaling on right and bowhead whales in the western North Atlantic, assumed that the Basques were primarily responsible for the anthropogenic impact on the populations of these whales, and they repeated assumptions by Gaskin (1991) and others that the pre-exploitation population size of North Atlantic right whales was very low. Gaskin (1991)

reported a pre-exploitation estimate for Northern right whales of between 12 000 and 15 000. Based on an extremely small sample (21 whale bone specimens from a single ship), Rastogi et al. (2004) concluded that "the major loss of genetic diversity occurred prior to the onset of whaling, rather than the hypothesis of a dramatic decline resulting from whaling". We believe a number of assumptions and conclusions made by these authors are inconsistent with the historical record of the whale fishery in the western

Received 2 February 2006. Accepted 24 May 2006. Published on the NRC Research Press Web site at <http://cjz.nrc.ca> on 25 August 2006.

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¹Appears in *Can. J. Zool.* **82**(10): 1647–1654.

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North Atlantic. Furthermore, Rastogi et al. (2004) seem to draw conclusions about whaling activities for the entire North Atlantic based on data from Red Bay and the Strait of Bell Isle alone.

In this article we provide an overview of the history of whaling in the North Atlantic, which indicates whaling activities were both intensive and practiced for a very long time. We also show that the Basques were not the only ones engaged in the North Atlantic whale fishery. In addition, we show that the number of whales landed was much higher than previously hypothesized; therefore, the original populations must have been much larger than the figures assumed by Rastogi et al. (2004). Given all of these, we further indicate, by providing specific figures, that samples from a single whaling ship cannot be considered representative of such a massive activity carried out by many nations for several centuries.

Basque whaling

The first Europeans to undertake whaling on a commercial scale were the Basques. The Basque country encompasses several provinces in Spain and France around the Bay of Biscay in the North Atlantic (Fig. 1). The Basques learned whaling techniques from the Normans, who in turn had learned them from the Vikings from Norway and Iceland (Du Pasquier 2000).

Basques began using whales by butchering stranded animals, but sometime between 1052 and 1059 they began harpooning them off the Basque coastal waters of France and in 1150 on the Spanish side. Initially they almost exclusively hunted right whales, *Eubalaena glacialis* (Müller, 1776), but would occasionally capture sperm whales, *Physeter macrocephalus* L., 1758, and possibly gray whales, *Eschrichtius robustus* Lilljeborg, 1861. As early as 1423 the Basques were using whaling ships, essentially shalloops and pinnaces, thus developing the first pelagic whaling enterprise in the Western Hemisphere. This intense whaling activity rapidly led to a scarcity of animals in the Bay of Biscay that by 1521 had become so acute that Charles I, King of Spain, enacted a law prohibiting foreigners from whaling off Spanish coasts. 1567 was the last year whales were killed by Basques in French waters and in the 19th century only four whales were killed on the Spanish side (Ciriquiaian-Gaiztarro 1961, pp. 75, 163–167; Aguilar 1986).

Owing to this depletion, Basque whalers expanded their operations into other areas. Spanish Basque whaling in Newfoundland started around 1526 (Ciriquiaian-Gaiztarro 1961, pp. 183–185, 206). The peak of Spanish Basque whaling in Newfoundland occurred in the second half of the 16th century. Between the 1560s and 1570s, an average of 40 whaling ships sailed annually to those waters. By 1580 there were more than 200 Basque whaling ships headed for Newfoundland whaling grounds.

From the 1580s on, Spanish Basque whaling in Newfoundland declined owing to a combination of factors: (i) Spain's embargo on all available vessels (including whaling ships) and crews for Spanish maritime adventures such as the conquest of Portugal, the expedition to the Strait of Magellan, and the conquest of the Azores; (ii) the Anglo-Spanish War (1585–1604) and the French-Spanish War (1595–

1598), which also required whaling ships and crews; (iii) the constant and disruptive attacks by the Dutch, Rochelais, and North African corsairs; and (iv) the depletion of the whale populations. During that time, French Basque whalers took over most of the operations in Newfoundland. Spanish Basques tried to revive their industry in 1611 by whaling in Greenland and in 1613 by attempting to whale in the waters of the recently discovered grounds of Spitsbergen (Svalbard), but such attempts were rejected by the English and the Dutch, who claimed exclusive rights to whale in those waters (Markham 1881; Sanger 1991a; Barkham 1994).

By 1681 there were only between 13 and 20 Basque whaling ships. To compensate for the decline in their number of ships, the Basques developed techniques aimed at improving their productivity, such as processing the animals on board despite space limitations and the danger of fire (Cleirac 1661; Ciriquiaian-Gaiztarro 1961, pp. 219–220; Ambrose 2000). This new technology allowed the ships to continue seeking whales while processing the last kill.

According to Aguilar (1986), between 1530 and 1610 the Basques took between 25 000 and 40 000 whales in the North Atlantic. Based on a large number of contemporary documents, Aguilar was able to show how Basques shifted to new whaling grounds as different stocks appeared to be depleted. He documented that the target species was the right whale but that the Basques also hunted bowheads (*Balaena mysticetus* L., 1758) as they started to whale off Newfoundland and Labrador. His calculations are based on a conservative estimate of 10–12 whales caught per vessel per season (20–30 whaling ships working in Newfoundland per season is also conservative).

Du Pasquier (2000), based on a rather large sample of historical documents, calculated that between 1667 and 1766 Basques captured 8134 bowheads, 2346 right whales, and 150 sperm whales. Du Pasquier based his numbers only on documents available to him and did not take into consideration whales struck and killed but not recovered, a common occurrence in whaling, particularly at that time. If we combine figures from Aguilar (1986) and Du Pasquier (2000), we come up with at least 35 000 right and bowhead whales killed by the Basques between 1530 and 1620 and between 1667 and 1766. It is important to note that these estimates do not include any figures prior to 1530 or for the period 1621–1666. Therefore, this total is very conservative and contradicts Gaskin's (1991) estimates.

It is interesting to note that the proportion of large whales captured by Basques for the period 1667–1766 was bowhead whales, 76.53%; right whales, 22.07%; and sperm whales, 1.41%. A rough estimate would be that for each right whale captured, the Basques captured 3.47 bowheads. These historical data, based on a large sample, demonstrate not only that Basques hunted right whales but also that as they expanded their area of operations, they included bowheads as well; therefore, it is not surprising, as Rastogi et al. (2004) stated, that they took large numbers of the latter.

Given that the Northern right whale and the bowhead whale are close relatives, it is pertinent to ask how early whalers were able to differentiate one species from the other. According to historical documents summarized by Ciriquiaian-Gaiztarro (1961) and Du Pasquier (2000), the

Fig. 1. Map of the North Atlantic with localities mentioned in the text.

Basques were well aware of the morphological, migratory, and oil yield differences between the two species to the point that they used different common names for them: for the Northern right whale they used *sarde* (French) and *ballena franca* or *ballena vizcaína* (Spanish), and for the bowhead whale they used *baleine franche du Groenland* or *baleine de Grande-Baie* (French) and *ballena boreal* (Spanish).

Dutch whaling

As Basque whaling activities declined, both the Dutch and the English took over whaling operations in the North Atlantic, which began with the discovery of Spitsbergen (in the Archipelago of Svalbard) in 1596 (Fig. 1). William Barentsz (or Barendsz) is credited with the discovery of these islands while looking for the Northeast Passage to China (Hacquebord 2003). This discovery did not generate great interest until Henry Hudson, after a voyage to those islands in 1607, reported numerous whales off the coast (Jørgensen 1997). Given the great demand for whale oil in Holland's internal market, the Dutch started sending whalers to the area between Greenland and Novaya Zemlya and to northern Scandinavia in 1612 (Braat 1984).

The initial whaling efforts by the British (through the Muscovy or Russia Company created in 1610) and the Dutch (through the Noordsche Compagnie established in 1612) to whale off Spitsbergen and Newfoundland were not

successful owing to, by all accounts, the lack of technical expertise. To remedy this problem, both the British and the Dutch hired Basque whalers to help with the operations.

In 1597 there were two Basque sailors on British vessels and 12 on each of the two Dutch vessels; of those 12, three were harpooners, three were master pilots of shalloops, and the rest were experts in cutting the blubber and boiling the whale oil (Ciriquiaian-Gaiztarro 1961, p. 209).

Spanish officials tried to prevent "technological transfer" after at least 1613, realizing that such transfer would create undesirable competition. Because of this, in 1614 there was a royal edict prohibiting Basques from serving on foreign ships, an offense punishable by death. Yet, Basque whalers were still being hired as late as 1660 (Braat 1984).

Dutch whaling went through three phases: (1) shore whaling (until 1670), (2) pelagic whaling (1635–1670), and (3) whaling around floes (after 1670). During these periods, the Dutch built numerous whaling settlements on the coasts of Svalbard and Jan Mayen Island and on Amsterdam Island (Braat 1984).

By 1619, Dutch activity was so intense that a whaling station was erected on a beach at Amsterdamøya in the north-west corner of Spitsbergen (Hacquebord 1980). In addition, the Dutch whaled around Jan Mayen Island. During that time no more than 20–30 ships were involved, with an average crew of 50. Around 1640 the whaling monopoly, in the hands of the Dutch company, was eliminated and free enter-

prise was introduced, which allowed the Dutch to expand their whaling operations to Greenland. Dutch whaling peaked between 1680 and 1740, with more than 250 whaling ships sailing in a single year. By 1770 the activity was in decline and by 1800 it had almost disappeared (for example, Bruijn and van Eyck van Heslinga 1984).

Thus, the Dutch dominated the whaling scene for about 130 years largely because of their lower operational costs and the fact that they were more aggressive in looking for new hunting grounds than the British (Davis et al. 1987).

All calculations of the number of takes by Dutch whalers are consistent with each other. According to Jenkins (1921), between 1670 and 1794 (i.e., nearly 60 years after the Dutch began whaling) the Dutch killed at least 64 888 whales (an average of 519 whales per year), of which 53 383 were in Greenland, and most were bowheads. Du Pasquier (2000) also collected numbers for "cetaceans" killed by Dutch whalers between 1667 and 1766, and the total was 58 596 (an average of 586 whales per year). According to Gulløv (1985), between 1675 and 1721 the Dutch carried out 5886 voyages and caught 32 907 whales (an average of 715 whales per year). Therefore, we can conclude that the Dutch killed more whales than the Basques at least for the post-1500 era.

English whaling

The Muscovy Company was created by the English initially to exploit walrus, but two small whales were killed in 1610. Because of their lack of expertise as whalers, in 1611 the English employed six Basque harpooners whom they put in charge of the teaching of whaling to the English in Spitsbergen. Archaeological evidence suggests that the first British whaling stations at Spitsbergen were profoundly influenced by Basques, given that their design was very similar to that of the Basque stations in the Labrador Peninsula at the same time (Hacquebord 1988).

The British gradually took over North Atlantic whaling operations from the Dutch in the 1780s (Sanger 1988). This was due to the increased internal demand for whaling products in Britain and its colonies owing to the progressive urbanization requiring more fuel for lighting. At that time the British government created economic incentives that encouraged the trade of whale products.

Massive whaling of bowheads in the Davis Strait did not begin until 1719, and the Dutch and the English began to exploit those grounds in 1725. This operation peaked in the 1730s, with up to 137 vessels sailing in 1732. English ships were heavily engaged in the bowhead whale fisheries in Greenland, with 90 whalers off the West Greenland coast in 1778 and 48 in 1815 (Duncan 1977–1978; Vaughan 1986).

There are no estimates of the total number of whales landed by the British in the North Atlantic, in part owing to loss of records (the fire of London of 1666 alone destroyed all the records of the Muscovy Company). However, given the large number of vessels employed (up to 137 per year) and the length of the period of operations (from 1610 to 1815), the impact of the British must have been considerable. By 1828, the British had brought the Greenland stock of bowhead whales to the brink of extinction (Allen and Keay 2001).

German whaling

Germans were also involved in whale fisheries in the North Atlantic. They were in the North Atlantic at least as early as 1643 (Brandt 1940, p. 45), whaling in Greenland waters from 1694 through 1826. By 1721 they were employing 79 ships in Greenland and Davis Strait (Gulløv 1985, pp. 77–79; Vaughan 1986). According to Brandt (1940, p. 208), between 1670 and 1789 alone they killed 16 530 whales.

Danish whaling

After the discovery of Spitsbergen, Danish whaling ships began visiting Iceland with the Basques, arriving there maybe as early as 1604 but for sure by 1613. In 1616, the King of Denmark claimed Greenland as part of his country and prohibited foreigners from whaling in those waters. The Danes also whaled off the Faroe Islands until the 1930s. Data on this is, however, sketchy.

Scottish whaling

By the 1780s the Dutch has been supplanted by the English, who were in turn supplanted in 1824 by the Scots, who introduced steam-powered whaling vessels (Sanger 1988). This fishery continued until around 1913 and had its peak in the 1860s. The East Greenland fishery was conducted off Spitsbergen and later along the ice edge in the Greenland Sea. Similarly, "Davis Strait whaling" included the Strait, Baffin Bay, and an ice edge operation (Southwest whaling) off the entrance to Hudson Strait, sometimes extending south to Labrador. The total number of whales landed by the Scots during this fishery was, at a minimum, 2440 (Sanger 1980, 1991*b*; C.W. Sanger, personal communication (2005)).

Yankee whaling

After the American Revolution, Yankee whaling was not in the best condition, first because the Royal Navy was capturing Yankee ships and later because of high protective tariffs against US whaling products. Despite this, the Americans maintained high levels of activity: between 1785 and 1818 more than 125 ships returned from northern whaling grounds every year, where they concentrated on the sperm whale fishery (Davis et al. 1987). That activity continued after the War of 1812. After the Treaty of Ghent, Yankee whaling expanded from 1820 until 1860. The British lost their competitive advantage because of their failure to renovate ship design, their lack of appropriate seamen, the high cost of vessels, and the loss of government subsidies; between 1820 and 1850, whaling in Britain had become a marginal economic activity (Barrow 1998). By 1850 the American whaling fleet numbered about 700, while the British one numbered only 27 (Davis et al. 1987).

Best (1987) calculated that US whalers landed 30 313 bowhead whales between 1805 and 1909. According to Reeves et al. (1999), about 2500 right whales were removed by shore-whalers on the eastern coast of the United States between 1696 and 1734 alone, and according to Best (1987), American vessels took 182 right whales in the North

Table 1. Summary statistics on major whaling operations in the North Atlantic.

Whaling nation	Period	Right whales	Bowhead whales	Other whales	Minimum total	Source
Basque	Began 1530				?	See text
	1530–1610				25 000	Aguilar 1986
	1611–1666				?	See text
	1667–1776	2 346	8 134	150	10 630	Du Pasquier 2000
Dutch	Began 1670				?	See text
	1670–1794				64 888	Jenkins 1921
English	1594–1828				?	See text
German	Began 1670				?	See text
	1670–1789				16 530	Jenkins 1921
Danish	1613–1930s				?	See text
Scottish	1824–1913				2 400	See text
American	Began 1805	2 500			?	Reeves 1999
	1805–1909	182	30 313			Best 1987
Totals		5 028	38 447		119 448	

Atlantic between 1804 and 1909, although this figure seems low for having so many ships out.

Summary statistics

Table 1 summarizes the information available on whaling in the North Atlantic. According to this summary, about 120 000 whales were taken, at a minimum. This is an extremely conservative number given the data missing from the table. Of those 120 000, more than 38 000 were bowhead whales (also an extremely conservative estimate). Hacquebord (1999) calculated that between 1610 and 1669 about 15 000 bowhead whales were killed and between 1669 and 1800, between the English, Dutch, and Germans and for Jan Mayen Island and Spitsbergen (where the Basques had little if any activity), 86 644 whales were killed. Taking into account the generally accepted (and conservative) hit and lost percentage of 20%, all these totals must be much higher. Hacquebord (1999) also stated that the pre-exploitation population was 46 000, based on a reproduction rate of 2%/year. Allen and Key (2006), using species-specific biological parameters, a delayed-difference recruitment model, and historical whaling records, estimated that in 1611 the population of bowheads between the east coast of Greenland and the island of Spitsbergen was 52 500. All these historical data are clearly inconsistent with some of Rastogi et al.'s (2004) assumptions and conclusions.

Conclusions

The history of whaling activities in the North Atlantic has been well researched in the last few decades, mostly by historians and archaeologists. Because the vast majority of their work has been published in journals of the humanities and social sciences, it has been largely ignored by biologists. As useful as molecular data can be, we know it is never precise, its interpretation depends upon methodologies and assumptions, and, more important, it provides indirect evidence only. Historical data, when available, provides both direct and contemporary evidence. When that evidence has been obtained from different sources (logbooks, tax records, and historical accounts) by different authors using different methodologies and still yields consistent results (as has

been the case for the North Atlantic), then it becomes very reliable. We may not have all historical data at hand (as in the case of English whaling), but there is little doubt that the pre-exploitation populations presented here are several orders of magnitude larger than those assumed by Rastogi et al. (2004).

As we have shown in this article, such information strongly indicates that, contrary to the findings of Rastogi et al. (2004), (i) the Basques were not the only ones whaling in the North Atlantic; (ii) the Basques killed many more bowheads than right whales; (iii) other European nations (particularly the Dutch) killed more whales than the Basques; and (iv) pre-whaling populations of both right whales and bowheads must have been much larger than has always been assumed and, therefore, we can safely conclude that whaling, not other unspecified factors, was responsible for their decline. The diverse information summarized in this article is comprehensive, consistent in terms of order of magnitude, and in sharp contrast with the data obtained by Rastogi et al. (2004) from a single Basque whaling vessel for an already depleted whale population in Red Bay. If molecular studies consider the 16th century as the beginning of large-scale whaling by Basques, they are ignoring nearly four centuries of exploitation carried out by those people prior to that date.

This does not mean that we have all major questions answered. There is still the mystery of the extinction of the North Atlantic population of gray whales. Both historical and archaeological data strongly suggest that this species became extinct in the 17th century, yet historical accounts and archaeological remains of this species are very scarce despite its wide distribution to both sides of the Atlantic (Mead and Mitchell 1984; Bryant 1995). This suggests that the gray whale population was small before the onset of European whaling. Two factors can be hypothesized to explain this: the first is intense exploitation by local human populations (including Native Americans, e.g., Acosta 1590; Clark 1887; Stackpole 1953, pp. 15–16) before c. 1500, that is, when printing allowed collection and dissemination of information. According to McCartney (1979), a group of Eskimos known as the Thule in eastern Canada killed at least 6301 whales before the onset of European whaling in

those waters. Europeans had also been whaling since the Neolithic (Slijper 1962; Proulx 1986; Marshall 2000; Reese 2005).

However, the paucity of archaeological records may indicate another reason: climatic change. We know that more than any other species of baleen whale, gray whales are highly dependent on coastal resources for their survival. We hypothesize that the "Little Ice Age", which dramatically changed both the contours and the ecology of coastal areas in the North Atlantic (Grove 1988), had a significant impact on this species before industrial whaling took place. Climate variability influences food availability, as has been demonstrated for right whales (Hacquebord 1999; Greene and Pershing 2004).

Acknowledgements

Chesley W. Sanger provided us with some of his raw data on Scottish whaling. Two anonymous reviewers read the manuscript and made valuable suggestions.

References

- Acosta, J. de. 1590. (1940). *Historia Natural y Moral de las Indias*. Fondo de Cultura Económica, México.
- 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. Comm. Spec. Issue No.* **10**: 191–199.
- Allen, R.C., and Keay, I. 2001. The first great whale extinction: the end of the bowhead whale in the eastern Arctic. *Explor. Econ. Hist.* **38**: 448–477.
- Allen, R.C., and Keay, I. 2006. Bowhead whales in the Eastern Arctic, 1611–1911: population reconstruction with historical whaling records. *Environ. Hist.* **12**: 89–113.
- Ambrose, E.R. 2000. Early whaling and the development of on-board trypots. *The Dukes County Intelligencer*, **42**: 87–90.
- Barkham, M.M. 1994. French Basque "New Found Land" entrepreneurs and the import of codfish and whale oil to northern Spain, c. 1580 to c. 1620: the case of Adam de Chibau, Burgess of Saint-Jean-de-Luz and "Sieur de St. Julien". *Newfound. Stud.* **10**: 1–43.
- Barrow, T. 1998. The decline of British whaling in Arctic Canada, 1820–1850: a case study of Newcastle Upon Tyne. *Northern Mariner*, **8**: 35–54.
- Best, P.B. 1987. Estimates of the landed catch of right (and other whalebone) whales in the American Fishery, 1805–1909. *Fish. Bull.* (Washington, D.C.), **85**: 403–418.
- Braat, J. 1984. Dutch activities in the North and the Arctic during the sixteenth and seventeenth centuries. *Arctic*, **37**: 473–480.
- Brandt, K. 1940. Whale oil. An economic analysis. Food Research Institute, Stanford University, Stanford, Calif.
- Bryant, P.J. 1995. Dating remains of gray whales from the eastern North Atlantic. *J. Mammal.* **76**: 857–861.
- Bruijn, J.R., and van Eyck van Heslinga, E.S. 1984. Seaman's employment in the Netherlands (c. 1600 – c. 1800). *Mariner's Mirror*, **70**: 7–20.
- Ciriquiaian-Gaiztarro, M. 1961. Los Vascos en la Pesca de la Ballena. Biblioteca Vascongada de los Amigos del País Vasco, San Sebastián, Spain.
- Clark, A.H. 1887. History and present condition of the fishery. *In* The fisheries and the fisheries industries of the United States. Section V. History and methods of the fisheries. Vol. II. *Edited by* G.B. Goode. Government Printing Office, Washington, D.C. pp. 3–218.
- Cleirac, E. 1661. Us et costumes de la mer. I.M. Millanges, Bourdeaux.
- Davis, L.E., Gallman, R.E., and Hutchins, T.D. 1987. Technology, productivity, and profits: British-American whaling competition in the North Atlantic, 1816–1842. *Oxf. Econ. Pap.* **39**: 738–759.
- Duncan, W.R.H. 1977. Aberdeen and the early development of the whaling industry, 1750–1800. *North. Scotl.* **3**: 47–59.
- Du Pasquier, J.T. 2000. Les baleiniers basques. S.P.M. Editions, Paris.
- Gaskin, D.E. 1991. An update on the status of the right whale, *Eubalaena glacialis*, in Canada. *Can. Field-Nat.* **105**: 198–205.
- Greene, C.H., and Pershing, A.J. 2004. Climate and the conservation biology of North Atlantic whales: the right whale at the wrong time? *Front. Ecol. Environ.* **2**: 29–34.
- Grove, J.M. 1988. The Little Ice Age. Routledge, London.
- Gulløv, H.C. 1985. Whales, whalers, and Eskimos: the impact of European whaling on the demography and economy of Eskimo society in West Greenland. *In* Cultures in contact. The impact of European contacts on Native American cultural institutions. *Edited by* W.W. Fitzhugh. Smithsonian Institution Press, Washington, D.C. pp. 71–96.
- Hacquebord, L. 1980. The Smeerenburg Project: an investigation of 17th century Dutch whaling settlements on Svalbard. *Polar Rec.* **20**: 284–287.
- Hacquebord, L. 1988. Three 17th century whaling stations in south-eastern Svalbard: an archaeological missing link. *Polar Rec.* **24**: 125–128.
- Hacquebord, L. 1999. The hunting of the Greenland right whale in Svalbard, its interaction with climate and its impact on the marine ecosystem. *Polar Res.* **18**: 375–382.
- Hacquebord, L. 2003. English and Dutch whaling trade and whaling stations in Spitsbergen (Svalbard) before 1660. *Int. J. Mar. Hist.* **15**: 117–134.
- Jenkins, J.T. 1921. A history of whale fisheries. H.F. & G. Witherby, London.
- Jørgensen, R. 1997. The first wintering in Svalbard. *Polar Rec.* **33**: 295–306.
- Markham, C.R. 1881. On the whale-fishery of the Basque provinces of Spain. *Proc. Zool. Soc. Lond.* 1881: 969–976.
- Marshall, R. 2000. Whaling in Norway. *Nordic Notes*, 2000(4) [online]. Available from <http://www.ssn.flinders.edu.au/scanlink/nornotes/vol4/articles> [accessed 24 December 2005].
- McCartney, A.P. (Editor). 1979. Whale bone assessment. *In* Archaeological whale bones; a northern resource. University of Arkansas, Fayetteville, Ark. pp. 21–70.
- Mead, J.G., and Mitchell, E.D. 1984. Atlantic gray whales. *In* The gray whale, *Eschrichtius robustus*. *Edited by* M.L. Jones, S.L. Swartz, and S. Leatherwood. Academic Press, Orlando, Fla. pp. 33–53.
- Proulx, J.-P. 1986. Whaling in the North Atlantic, from earliest times to the mid-19th century. Parks Canada, Ottawa, Ont.
- Rastogi, T., Brown, M.W., McLeod, B.A., Frasier, T.R., Grenier, R., Cumbaa, S.L., Nadarajah, J., and White, B.N. 2004. Genetic analysis of 16th-century whale bones prompts a revision of the impact of Basque whaling on right and bowhead whales in the western North Atlantic. *Can. J. Zool.* **82**: 1647–1654. doi:10.1139/z04-146.
- Reese, D.S. 2005. Whale bones and shell purple-dye at Motya (Western Sicily, Italy). *Oxf. J. Archaeol.* **24**: 107–114.
- Reeves, R.R., Breiwick, J.M., and Mitchell, E.D. 1999. History of whaling and estimated kill of right whales, *Balaena glacialis*, in the northeastern United States, 1620–1924. *Mar. Fish. Rev.* **61**: 1–36.
- Sanger, C.W. 1980. The 19th century Newfoundland seal fishery and the influence of Scottish whalers. *Polar Rec.* **20**: 231–251.

- Sanger, C.W. 1988. The Dundee-St. John's connection: nineteenth century interlinkages between Scottish Arctic whaling and the Newfoundland seal fishery. *Newfound. Stud.* **4**: 1–26.
- Sanger, C.W. 1991a. "On good fishing ground but too early for whales I think": the impact of Greenland right whale migration patterns on hunting strategies in the northern whale fishery, 1600–1900. *Am. Neptune*, **51**: 221–240.
- Sanger, C.W. 1991b. Changing resources and hunting grounds of Scottish whaling-sealing vessels in the second half of the nineteenth century. *Scott. Geogr. Mag.* **107**: 187–197.
- Slijper, E.J. 1962. *Whales*. Basic Books, New York.
- Stackpole, E.A. 1953. *The sea-hunters. The New England whalers during two centuries 1635–1835*. Lippincott, Philadelphia, Pa.
- Vaughan, R. 1986. Bowhead whaling in Davis Strait and Baffin Bay during the 18th and 19th centuries. *Polar Rec.* **23**: 289–299.