

# A note on biological data from the hunt of bowhead whales in West Greenland 2009–2011

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## ABSTRACT

One male and six female bowhead whales were taken for subsistence in Disko Bay, West Greenland, in April–May 2009–2011. All of these whales were sexually mature with body lengths exceeding 14m. One female was pregnant with a 3.87m foetus and three others presumably had small foetuses that were not detected in the field. Another female that showed no signs of recent pregnancy had a minimum of 7–8 *corpora albicantia* but no mature follicles. One 14.10m male with a 42kg testis was classified as sexually mature. Estimated ages of the whales were between 37 and 50 yrs. The observations on growth and reproduction were consistent with data on bowhead whales in Alaska. Four of the whales had recently been feeding as their stomachs contained calanoid copepods, especially *Calanus hyperboreus*.

KEYWORDS: BOWHEAD WHALE; FOOD/PREY; COPEPODS; REPRODUCTION; AGE DISTRIBUTION; SEX RATIO

## INTRODUCTION

Except for three known catches, bowhead whales, *Balaena mysticetus*, were virtually protected from hunting in West Greenland from around 1915 (Reeves and Heide-Jørgensen, 1996) until 2009. Based on recent abundance estimates (Heide-Jørgensen *et al.*, 2007), the IWC Scientific Committee (2008) concluded that removals of 5 bowhead whales per year for 5 years would be sustainable. This advice was accepted by the IWC but a strike limit of 2 per year was set for the years 2008–2012. The strike limit of two per year was not implemented in West Greenland until 2009 when the Greenland authorities decided the unused quota of two from 2008 would be added to give a total strike limit of four whales that year. Three whales were taken in 2009, so one was transferred to 2010 when three were taken. One whale was taken in the spring hunt in 2011.

Before 2009, the available biological material from bowhead whales in West Greenland consisted of two skeletons and one foetus from the 19th century deposited at the State Natural History Museum of Denmark. Ancient (>1,000 yrs old) vertebrae, skulls and bone fragments from bowhead whales in East, North and West Greenland are also held in museums in Greenland and Denmark (e.g. Bennike, 2008). About 500 skin biopsies were collected in West Greenland from 2000–2011 (Heide-Jørgensen *et al.*, 2010) but no biological samples other than the above-mentioned skeletons and foetus were collected from the relatively large number of bowhead whales taken in West Greenland since the 17th century.

The initiation of small-scale bowhead whaling in 2009 provided an opportunity to collect biological samples and data. Here we report on the biological data collected from seven bowhead whales that were taken in Disko Bay, in April and May 2009–11. No post mortem examinations of bowhead whales had been conducted in this area previously.

## MATERIAL AND METHODS

The length of the whales was measured in a straight line from the tip of the rostrum to the notch between the flukes. Distance between fluke tips was measured in a straight line. Circumference was measured at the axilla, umbilicus, and anus when feasible either as the full circumference when the whale was still in the water or as half the circumference when it was hauled up on land for flensing. Blubber thickness was measured at four locations: dorsally behind the blowhole and at the posterior part of the whale about 1m anterior to the tail and ventrally between the flippers and near the umbilicus. The thickness of the flensed blubber was measured with a ruler perpendicular to the skin surface.

Testes and ovaries were collected and measured for length, width, thickness and weight. Ovaries were also examined externally for *corpora lutea* and *corpora albicantia*. The diameter of mature follicles was measured.

Samples of baleen, skin, blubber, liver, kidney and muscle were collected and stored as frozen samples for future research.

Eyeballs were stored at –20°C immediately after collection and one of these per whale was used for age estimation. In the laboratory, lenses were dissected out of the eyes and lens layers surrounding the nucleus were removed by slowly rolling the lens on paper. All remaining layers were removed under a stereoscope. Age estimation was facilitated by the aspartic acid racemization (AAR) technique following methods described in Garde *et al.* (2007). Estimates of individual D/L ratios were converted to age estimates by the equation:

$$\text{Age (yrs)} = \frac{\ln\left(\frac{1+D/L}{1-D/L}\right) - \ln\left(\frac{1+(D/L)_0}{1-(D/L)_0}\right)}{2k_{\text{asp}}}$$

where an average racemization rate ( $k_{\text{asp}}$ ) from bowhead whales in Alaska from Rosa *et al.* (2011) was used. The

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average of both eyes from one fetus measured in this study was used to estimate the  $(D/L)_0$  or  $D/L$  ratio at age 0 (includes the  $D$  present at birth + the racemization that occurs during hydrolysis) together with the average of two full-term bowhead whale fetuses from Alaska (Rosa *et al.*, 2004).

Stomach contents were sampled from four of the whales. About a litre of the content of the forestomach was fixed in 4% buffered formaldehyde after rinsing in 500µm mesh sieves. Subsamples of stomach contents were examined microscopically and characterized according to size categories and when possible to species.

## RESULTS

Seven bowhead whales were taken inside Disko Bay or just west of the islands in the entrance of the Bay (Fig. 1). The whales were flensed at Qeqertarsuaq, Aasiaat and Ilulissat, partly in the water while run aground close to shore and/or on the rocky shore. In 2009 the initial flensing of two of the whales (IDNO 322 and 323) took place in shallow water at the base of the cliffs in the harbour of Qeqertarsuaq, and whales IDNO 325 and 503 were flensed under difficult conditions in an ice covered rocky bay (Rodebay) north of Ilulissat. In 2010 most of the blubber from IDNO 500 and 501 was removed while they were secured alongside the 40 ton whaling cutters. These whales were partly opened at sea and it was therefore difficult to measure the circumference, sample the forestomach, and retrieve the entire reproductive

tract. The third whale from 2010 (IDNO 502) was flensed on shore at Rodebay (Fig. 1).

In 2009 two females and one male were taken and in 2010 three females were taken. One female in 2009 had a male foetus of 3.87m and it was the only whale that was taken from a group of two. The others were solitary whales when hunted. Three of the whales bore scars from killer whales (*Orcinus orca*) on the tail (IDNO 323, 501) and on one or both flukes (IDNO 507, 501). Whale IDNO 322 had a stainless steel tip (3cm long) from a satellite transmitter embedded in the blubber. This is a triangular blade mounted at the tip of the satellite transmitter, to cut through the skin. This model of cutting tips was used in Canada in 2004 and in Disko Bay in 2005. The steel tip was found by the hunters while flensing the whale and they provided no reports of any related tissue trauma.

## Reproduction

One ovary was secured from IDNO 323 and one from 501 (Fig. 2). Both whales had *corpora lutea* and IDNO 323 had a near-term foetus (ovary weight = 2,900g). It was not possible in the field to detect the foetus in IDNO 501 (ovary weight = 3,820g), which must have been small, i.e. <10cm. The *corpus luteum* of IDNO 501 was 180 × 100 mm in diameters. This whale had 4 *corpora albicantia* (ca. 50 × 30mm) in the same ovary and >15 large follicles of which the largest was 30mm.

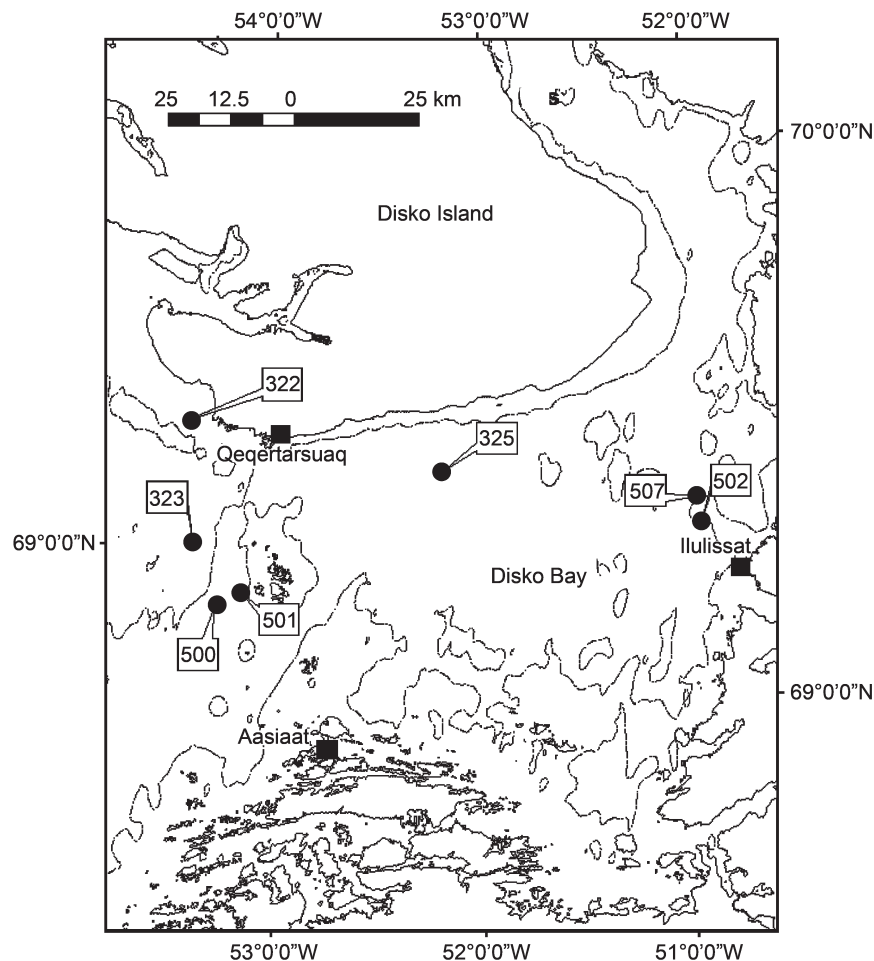


Fig. 1. Positions of bowhead whales caught in Disko Bay in April–May 2009–2011 shown with the 200m depth contour.



Fig. 2. (A) Ovary with corpus luteum from whale #501. (B) Ovary with large *c. luteum* from whale #502. (C) Uterus from whale #500. (D) Ovaries from whale #500.

Both ovaries and the entire reproductive tract were secured from IDNO 500, 502 and 507. No fetus, *c. luteum* or mature follicles were detected in IDNO 500 but there were 3 and 4 *c. albicantia* (ca. 50 × 30mm) in each of the ovaries. Lengths of the uterine horns were 82cm and 110cm each, with a diameter of 12mm, and the length of the uterine body was 65cm. IDNO 502 had 7–8 *c. albicantia* (ca. 50 × 40 mm) and a very large *c. luteum* in the left ovary (220 × 200mm). The ovary weights were 2640 and 2400 g (left). No foetus was detected. IDNO 507 had a *c. luteum* (120 × 100mm) together with two *c. albicantia* in left ovary and 9 *c. albicantia* in right ovary. The presence of *c. luteum* and *c. albicantia* suggests that all of the females were sexually mature. None of them (IDNO 323, 500–502) were lactating.

Dimensions of one testis from IDNO 322 were 98 × 38 × 94cm (length × width × circumference) and 42kg (weight). Dimensions of the other were 100 × 40 × 100cm.

#### Age estimation

One foetus was available for estimation of an average  $(D/L)_0 = 0.02558$  for both eyes and this combined with the  $(D/L)_0$  values from two foetuses presented in Rosa *et al.* (2004) gave an average  $(D/L)_0$  of 0.02658. Together with the racemization rate ( $k_{Asp} = 0.000977$ ) from Rosa *et al.* (2011) this value was used to estimate the ages of the whales. All of the whales were estimated to be between 37 and 51 yrs old (Table 1).

#### Feeding habits

Visual examination of the forestomachs from four of the whales (IDNOs 322, 323, 500, 501) revealed that they were between 50 and 100% full of prey items. However, this assessment was difficult due to the degree of fermentation of the stomach contents. In all stomachs the prey items were >99% copepods >3mm. In one stomach, where species determination was possible, most of the content likely consisted of *Calanus hyperboreus*.

#### DISCUSSION

Observations of the hunt in the field indicated that the whalers selected whales that were close to the flensing sites and no sex or size selection was apparent (GINR unpublished data). The sex and size classes of the bowhead whales sampled in Disko Bay in 2009 and 2010 were consistent with field observations and sex determinations based on skin biopsies obtained from 347 bowhead whales off West Greenland: primarily large, sexually mature whales (>14m), about 78% of them females, use Disko Bay in the winter and spring (Heide-Jørgensen *et al.*, 2006; Heide-Jørgensen *et al.*, 2010). One additional bowhead whale of 16.40m entangled in the rope from a crab trap and discovered on 10 May 2011 in Disko Bay provides additional evidence that primarily large whales occur in the bay (GINR, unpublished data).

The females in Disko Bay are rarely accompanied by calves and most are either pregnant or resting. Two of the

Table 1

Biological data from bowhead whales caught in West Greenland in 2009–11. Positions of the catches are given in Fig. 1.  $D/L$  = ratio between D and L form of aspartic acid; AAR = age estimation based on aspartic acid racemization. The counts of ovarian corpora are given for 1 or 2 ovaries as indicated in parenthesis under corpora albicantia.

ID no.	Date	Sex	Length (m)	$D/L$	AAR age (years)	Fluke width (cm)	Circumference (cm)				Blubber thickness (cm)				Counts of ovarian corpora	
							At flippers	Of umbilicus	Of anus	Of peduncle	Behind blowhole	On tail	Between flippers	At umbilical opening	Corpora albicantia	Corpus luteum
322	30/04/09	M	14.10	0.06902	44	557	850	528	170	32	30	30	23	n/a	n/a	n/a
323	08/05/09	F	14.80	0.06278	37	466	1,100	335	177	36	n/a	26	n/a	0 (1)	1	1
324	08/05/09	M	3.87	0.02558	n/a	118	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
325	10/05/09	F	15.50	0.07612	51	520	n/a	n/a	n/a	18	n/a	n/a	n/a	n/a	n/a	n/a
500	09/04/10	F	14.35	0.06970	44	528	790	n/a	200	26	23	25	16	7 (2)	0	0
501	09/04/10	F	15.85	0.07486	50	497	n/a	n/a	175	24	22	n/a	22	4 (1)	1	1
502	01/05/10	F	16.10	0.06540	40	520	n/a	n/a	885	19	34	n/a	n/a	8–9	1	1
503	08/05/11	F	16.10	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	31	n/a	11 (2)	1	1

females sampled in this study had a large *c. luteum* but no foetus was detected under the difficult sampling conditions; they were likely both pregnant with a small foetus. Bowhead whales are known to form a single large *c. luteum* during early phases of gestation (Tarpley and Hillmann, 1999) and the particularly large *c. luteum* in IDNO 502 probably supported a foetus too small to be detected. In addition to being a feeding ground, Disko Bay and adjacent areas off West Greenland are probably used as mating grounds for bowhead whales (Stafford *et al.*, 2008). This is despite the apparently low proportion of males present (Heide-Jørgensen *et al.*, 2010). Conception in bowhead whales is believed to occur within a one-month time window, with a mean date around 24 March (Reese *et al.*, 2001) when bowhead whales are present in Disko Bay in large numbers (Heide-Jørgensen *et al.*, 2007). Apparently not all females in Disko Bay are in estrus since some are either pregnant from the year before or resting and this reduces the fraction of females that are available for conception.

The data on sexual maturity of bowhead whales from West Greenland are consistent with information on reproduction in bowhead whales in Alaska. The estimated body length at sexual maturity for female bowhead whales examined in Alaska was 13.4m (George *et al.*, 2004), with a combined ovary weight of >2.90kg (Tarpley and Hillmann, 1999), and foetuses are near-term or very small in the spring (April – May) (Reese *et al.*, 2001). The corpora counts from the West Greenland whales appear consistent with those reported from Alaska (George *et al.*, 2004) for whales of similar age, however one whale (IDNO 502) seemed young (40 yrs) relative to its number of corpora (8–9). One female whose reproductive organs could not be collected (IDNO 325) had a body length of 15.50m, meaning it was likely also mature. The dimensions and mass of the testes from the male bowhead whale suggest it was mature, given that whales from Alaska reach maturity at body lengths of >12.7m and testis masses of >20kg (O'Hara *et al.*, 2002).

Ages were estimated based on a racemization rate developed specifically for bowhead whales (Rosa *et al.*, 2011) which must be considered preferable to previous methods that relied on racemization rates of humans and fin whales (George *et al.*, 1999; Rosa *et al.*, 2004). Recent studies have shown that racemisation rates are species-specific and likely influenced by the deep body temperature (Garde *et al.*, Submitted). The average estimated age of the six whales where age could be estimated was 44 yrs, and it confirms field observations (Heide-Jørgensen *et al.*, 2006) that it is mainly the mature segment of the population that is present in Disko Bay.

The stomach contents of the bowhead whales from Disko Bay suggest that they feed largely on calanoid copepods. This is in agreement with observations of diving behaviour and area utilization by whales instrumented with time-depth-recorders and satellite transmitters (Laidre *et al.*, 2007).

Continued sampling of the harvested whales in West Greenland is recommended to monitor reproductive status, assess changes in body condition, gather basic life history data, assess feeding habits, estimate age and expand the comparison of the findings with those from bowhead whales in northern Canada and Alaska.

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## REFERENCES

- Bennike, O. 2008. An early holocene Greenland whale from Melville Bugt, Greenland. *Quaternary Research* 69: 72–76.
- Garde, E., Bertelsen, M.F., Heide-Jørgensen, M.P., Nielsen, N.H., Frie, A.K., Olafsdottir, D., Siebert, U. and Hansen, S.H. Submitted. Temperature-dependent racemization rates of aspartic acid in mammalian eye lenses – implications for age estimation and longevity. *Zoology*.
- Garde, E., Heide-Jørgensen, M.P., Hansen, S.H., Nachman, G. and Forchhammer, M.C. 2007. Age-specific growth and remarkable longevity in narwhals (*Monodon monoceros*) from west Greenland as estimated by aspartic acid racemization. *J. Mammal.* 88(1): 49–58.
- George, J.C., Bada, J., Zeh, J., Scott, L., Brown, S.E., O'Hara, T. and Suydam, R. 1999. Age and growth estimates of bowhead whales (*Balaena mysticetus*) via aspartic acid racemization. *Can. J. Zool.* 77: 571–80.
- George, J.C., Follman, E., Zeh, J., Sousa, M., Tarpley, R. and Suydam, R. 2004. Inferences from bowhead whale ovarian and pregnancy data: age estimates, length at sexual maturity and ovulation rates. Paper SC/56/BRG8 presented to the IWC Scientific Committee, July 2004, Sorrento, Italy. 12pp. [Paper available from the Office of this Journal]
- Heide-Jørgensen, M.P., Laidre, K., Borchers, D., Samarra, F. and Stern, H. 2007. Increasing abundance of bowhead whales in West Greenland. *Biology Letters* 3: 577–80.
- Heide-Jørgensen, M.P., Laidre, K.L., Jensen, M.V., Dueck, L. and Postma, L.D. 2006. Dissolving stock discreteness with satellite tracking: bowhead whales in Baffin Bay. *Mar. Mammal Sci.* 22(1): 34–45.
- Heide-Jørgensen, M.P., Laidre, K.L., Wiig, Ø., Postma, L., Dueck, L. and Bachmann, L. 2010. Large scale sexual segregation of bowhead whales. *Endangered Species Research* 13: 73–78.
- Laidre, K.L., Heide-Jørgensen, M.P. and Nielsen, T.G. 2007. The role of the bowhead whale as a predator in West Greenland. *Mar. Ecol. Prog. Ser.* 346: 285–97.
- O'Hara, T.M., George, J.C., Tarpley, R.J., Burek, K. and Suydam, R.S. 2002. Sexual maturation in male bowhead whales (*Balaena mysticetus*). *J. Cetacean Res. Manage.* 4(2): 143–48.
- Reese, S.C., Calvin, J.A., George, J.C. and Tarpley, R.J. 2001. Estimation of fetal growth and gestation in bowhead whales. *J. Am. Stat. Assoc.* 96(455): 915–38.
- Reeves, R.R. and Heide-Jørgensen, M.P. 1996. Recent status of bowhead whales, *Balaena mysticetus*, in the wintering grounds off West Greenland. *Polar Research* 15(2): 115–25.
- Rosa, C., George, J.C., Zeh, J., Botta, O., Zauscher, M., Bada, J. and O'Hara, T.M. 2004. Update on age estimation of bowhead whales (*Balaena mysticetus*) using aspartic acid racemization. Paper SC/56/BRG6 presented to the IWC Scientific Committee, July 2004, Sorrento, Italy (unpublished). 15pp. [Paper available from the Office of this Journal].
- Rosa, C., Zeh, J., George, J.C., Botta, O., Zauscher, M., Bada, J. and O'Hara, T.M. 2011. Age estimates based on aspartic acid racemization for bowhead whales (*Balaena mysticetus*) harvested in 1998–2000. Paper SC/63/BRG5 presented to the IWC Scientific Committee, June 2011, Tromsø, Norway (unpublished). 14pp. [Paper available from the Office of this Journal].
- Stafford, K.M., Moore, S.E., Laidre, K.L. and Heide-Jørgensen, M.P. 2008. Bowhead whales springtime song of West Greenland. *J. Acoust. Soc. Am.* 125(5): 3315–23.
- Tarpley, R.J. and Hillmann, D.J. 1999. Observations on ovary morphology, fetal size and functional correlates in the bowhead whale, *Balaena mysticetus*. Final report to the Department of Wildlife Management, North Slope Borough, P.O. Box 69, Barrow, Alaska.

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