Revised 10/14/02

## BOWHEAD WHALE (*Balaena mysticetus*): Western Arctic Stock

### STOCK DEFINITION AND GEOGRAPHIC RANGE

Bowhead whales are distributed in seasonally ice-covered waters of the Arctic and near-Arctic, generally north of 54°N and south of 75°N in the western Arctic Basin (Braham 1984). For management purposes, five stocks are currently recognized by the International Whaling Commission (IWC 1992). Small stocks occur in the Sea of Okhotsk, Davis Strait, Hudson Bay, and the offshore waters of Spitsbergen. These small bowhead stocks are comprised of only a few tens to a few hundreds of individuals (Braham 1984, Shelden and Rugh 1995). The largest population, and the only stock that is found within U. S. waters, is the Western Arctic stock (Fig. 38). The majority of the Western Arctic stock migrates annually from wintering areas (November to March) in the northern Bering Sea, through the Chukchi Sea in the spring (March through June), to the Beaufort Sea where they spend much of the summer (mid-May through September) before returning again to the Bering Sea in the fall (September through November) to overwinter (Braham et al. 1980, Moore and Reeves 1993). The bowhead spring migration follows fractures in the sea ice around the coast of Alaska, generally in the shear zone between the shorefast ice and the mobile polar pack ice. There is evidence of whales following each other, even when their route does not take advantage of large ice-free areas, such as polynyas (Rugh and Cubbage 1980). As the whales travel east past Point Barrow, Alaska, their migration is somewhat funneled between shore and the polar pack ice, making for an optimal location from which to study this stock (Krogman 1980). Most of the year, bowhead whales are closely associated with sea ice (Moore and Reeves 1993). Only during the summer is this population in relatively ice-free waters in the southern Beaufort Sea, an area often exposed to industrial activity related to petroleum exploration and extraction (e.g. Richardson et al. 1985, Treacy 2002). During the autumn migration, bowheads select shelf waters in all but "heavy ice" conditions, when they select slope habitat (Moore 2000). Sightings of bowhead whales do occur in the summer near Barrow (Moore 1992, Moore and DeMaster 2000) and are consistent with suggestions that certain areas near Barrow are important feeding grounds. Some bowheads are found in the Chukchi and Bering Seas in summer, and these are thought to be a part of the expanding western Arctic stock (Rugh et al. 2000).

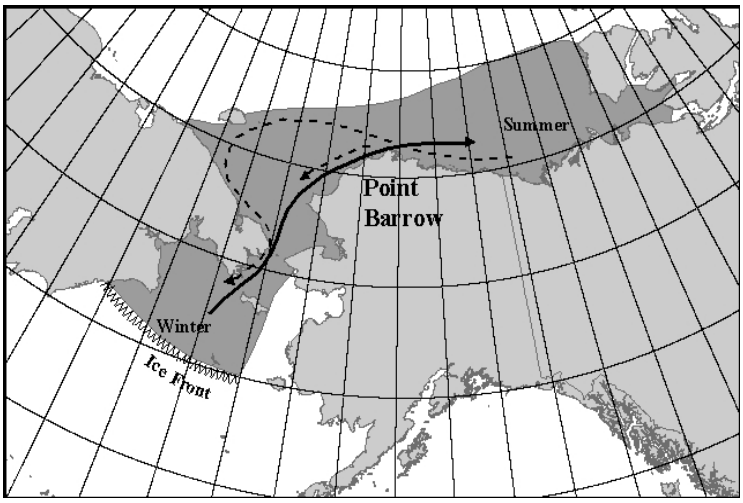


**Figure 38.** Approximate distribution of the Western Arctic stock of bowhead whales (shaded area). Winter, summer, and spring/fall distributions are depicted (see text).

### POPULATION SIZE

All stocks of bowhead whales were severely depleted during intense commercial whaling prior to the 20th century, starting in the early 16th century near Labrador and spreading to the Bering Sea in the mid-19th century (Braham 1984). Woodby and Botkin (1993) summarized previous efforts to approximate how many bowheads there were prior to the onset of commercial whaling. They reported a minimum worldwide population estimate of 50,000, with 10,400-23,000 in the Western Arctic stock (dropping to less than 3,000 at the end of commercial whaling).

Since 1978, counts of bowhead whales have been conducted from sites on sea ice north of Point Barrow during the whales' spring migration (Krogman et al. 1989). These counts have been corrected for whales missed due to distance offshore (through acoustical methods, described in Clark et al. 1994), whales missed when no watch was in effect, and whales missed during a watch (estimated as a function of visibility, number of observers, and distance offshore; Zeh et al. 1994). A summary of the abundance estimates determined using ice-based census techniques corrected by acoustic methods is provided in Table 30. However, these estimates of abundance have not been corrected for a small portion

of the population that may not migrate past Point Barrow in spring. In 1993, the census resulted in a population estimate of 8,000 (CV = 0.073), with a 95% confidence interval from 6,900 to 9,200 (Zeh et al. 1994). A refined and larger sample of acoustic data from 1993 resulted in an estimate of 8,200 animals (CV = 0.069; 95% CI = 7,200-9,400), which is considered the best estimate for the population in 1993 (IWC 1996, Zeh et al. 1995). The bowhead census in 2001 resulted in a preliminary estimate of 9,860 (95% CI = 7,700-12,600; CV = 0.12), despite poor visibility conditions, an increase in whale distance from shore, and an increase in variability in offshore distribution relative to conditions during the 1993 census (George et al. 2002). This estimate will be further refined by incorporating additional information on acoustic locations.

Aerial photo-identification of bowhead whales and a capture-recapture analytical approach provides an alternative method for estimating abundance. This approach provided estimates of 4,719 (95% CI = 2,382-9,343) to 7,022 (95% CI = 4,701-12,561), depending on the model used (daSilva et al. 2000). These population estimates and their associated error ranges are comparable to the estimates obtained from the combined visual and acoustic estimates of 6,039 and 7,734, for 1985 and 1986, respectively (Raftery and Zeh 1994). Although this study does not provide an update to the abundance estimate provided in Zeh et al. (1995), it does demonstrate that the use of aerial photo-identification to estimate a population size for bowhead whales provides a reasonable alternative to the traditional approach of using ice-based and acoustic census techniques.

**Table 30:** Summary of population abundance estimates for the western Arctic stock of bowhead whales. The 95% confidence interval, when available, is provided in parentheses. The historical estimates were made by back-projecting a simple recruitment model. All other estimates were developed by correcting ice-based census counts using acoustic methods. An asterisk (*) identifies those estimates which result from an ice based census, but are not corrected by acoustic methods. Other methods have been used to estimate population size; these are discussed in the text.

| Year | Population Estimate (95% CI) | Source |
|---|---|---|
| Historical estimate | 10,400-23,000 | Woodby and Botkin 1993 |
| End of commercial whaling | 1000-3000 | Woodby and Botkin 1993 |
| 1978 | 5,189 | Raftery et al. 1995 |
| 1980 | 4,198 | Raftery et al. 1995 |
| 1981 | 4,956 | Raftery et al. 1995 |
| 1982 | 7,074 | Raftery et al. 1995 |
| 1983 | 6,747 | Raftery et al. 1995 |
| 1985 | 6,039 (3,300-11,100)* | Zeh et al. 1995 |
| 1986 | 10,300 (8,100-12,900) | Raftery and Zeh 1994 |
| 1988 | 6,579 (5,300-8,200) | Raftery and Zeh 1994 |
| 1993 | 8,200 (7,200-9,400) | Zeh et al. 1995 |
| 2001 | 9,860 (7,700-12,600)* | George et al. 2002 |

**Minimum Population Estimate**

The minimum population estimate ($N_{MIN}$) for this stock is calculated from Equation 1 from the PBR Guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the preliminary population estimate (N) of 9,860 and its associated CV(N) of 0.124, $N_{MIN}$ for the Western Arctic stock of bowhead whales is 8,886.

**Current Population Trend**

Raftery et al. (1995) reported the Western Arctic stock of bowhead whales increased at a rate of 3.1% (95% CI = 1.4-4.7%) from 1978 to 1993, during which time abundance increased from approximately 5,000 to approximately 8,000 whales. This rate of increase takes into account whales that passed beyond the viewing range of the ice-based

observers. Inclusion of the revised 1993 abundance estimate results in a similar, though slightly higher rate of 3.2% population increase (95% CI = 1.4-5.1%) during the 1978-93 period (IWC 1996). The inclusion of the new preliminary estimate for 2001 results in a rate of increase of 3.3% (95% CI 2-4.7%), which is essentially identical to previous estimates. The count of 121 calves during the 2001 census was the highest yet recorded, was likely caused by a combination of variable recruitment and the large population size (George et al. 2002), and provides corroborating evidence for a healthy and increasing population.

## CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

The current estimate for the rate of increase for this stock of bowhead whales (3.3%) should not be used as an estimate of ($R_{MAX}$) because the population is currently being harvested and because the population has recovered to population levels where the growth is expected to be significantly less than $R_{MAX}$. It is recommended that the cetacean maximum theoretical net productivity rate ($R_{MAX}$) of 4% be employed for the Western Arctic stock of bowhead whale (Wade and Angliss 1997).

## POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) level is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5 rather than the default value of 0.1 for endangered species because population levels are increasing in the presence of a known take (see guidelines Wade and Angliss 1997). Thus, PBR = 89 animals ($8,886 \times 0.02 \times 0.5$). The development of a PBR level for the Western Arctic bowhead stock is required by the MMPA even though the subsistence harvest is managed under the authority of the International Whaling Commission (IWC). Accordingly, the IWC bowhead whale quota takes precedence over the PBR estimate for the purpose of managing the Alaska Native subsistence harvest from this stock. For 2002-07, a block quota of 280 bowhead strikes will be allowed, of which 67 (plus up to 15 unharvested in the previous year) could be taken each year. This quota includes an allowance of 5 animals to be taken by Chukotka Natives in Russia.

## ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

### Fisheries Information

Several cases of rope or net entanglement have been reported from whales taken in the subsistence hunt, including those summarized in Table 28 (Philo et al. 1993). Further, preliminary counts of similar observations based on reexamination of bowhead harvest records indicate entanglements or scarring attributed to ropes may include over 20 cases (Craig George, pers. comm., Department of Wildlife Management, North Slope Borough). There are no observer program records of bowhead whale mortality incidental to commercial fisheries in Alaska. Logbook data are available for part of 1989-94, after which incidental mortality reporting requirements were modified. Under the new system, logbooks are no longer required; instead, fishers provide self-reports. Data for the 1994-95 phase-in period is fragmentary. After 1995, the level of reporting dropped dramatically, such that the records are considered incomplete and estimates of mortality based on them represent minimums (see Appendix 7 for details).

New information on entanglements of bowhead whales indicate that animals do have interactions with crab pot gear (Table 31). There have been two confirmed occurrences of entanglement in crab pot gear, one in 1993 and one in 1999; the average rate of entanglement in crab pot gear for 1997-2001 is 0.2.

**Table 31.** Reported scarring of bowhead whales attributed to entanglement in ropes and description of observations collected during subsistence harvests in Alaska since 1978 (Philo et al. 1993; * D. Rugh, personal communication, National Marine Fisheries Service; ** C. George, personal communication, North Slope Borough

| Year | Number of Whales | Location | Description |
|---|---|---|---|
| 1978 | 1 | Wainwright | 6 scars on caudal peduncle |
| 1986 | 1 | Kaktovik | Scars on caudal peduncle and anterior margin of flukes |

| | | | |
|---|---|---|---|
| 1989 | 1 | Barrow | 12 scars on ridges of caudal peduncle |
| 1989 | 1 | south of Gambell | Rope wrapped around head, through mouth and baleen |
| 1989* | 1 | Barrow | Rope ~32m long trailing from mouth |
| 1990 | 1 | Barrow | Scars on caudal peduncle; 2 ropes trailing from mouth. |
| 1991* | 1 | Barrow | Apparent rope scar from mouth, across back |
| 1993** | 1 | Barrow | Large female; with crab pot line wrapped around flukes |
| 1998** | 1 | NW of Kotzebue; near Red Dog Mine dock | Stranded - dead with line on it |
| 1999** | 1 | Barrow | Whale entangled in confirmed crab gear. Line wrapped through gape of mouth, flipper, and peduncle. Severe injuries. |

**Subsistence/Native Harvest Information**

Eskimos have been taking bowhead whales for at least 2,000 years (Marquette and Bockstoce 1980, Stoker and Krupnik 1993). Subsistence takes have been regulated by a quota system under the authority of the IWC since 1977. Alaska Native subsistence hunters take approximately 0.1-0.5% of the population per annum, primarily from nine Alaska communities (Philo et al. 1993). Under this quota, the number of kills has ranged between 14-72 per year, depending in part on changes in management strategy and in part on higher abundance estimates in recent years (Stoker and Krupnik 1993). The following statistics were compiled from animals taken in the subsistence harvest between 1973 and 1992: 1) the sex ratio of bowheads taken in the hunt was equal; 2) the proportion of adult females taken in the hunt increased from 5% in the early 1970s to over 20% in the late 1980s and early 1990s; 3) approximately 80% of the catch was immature animals prior to 1978 and since has been approximately 60%; and 4) modern Native whalers appear to harvest larger bowheads than precontact (prior to 1849) Native whalers (Braham 1995).

The total take by Alaska Natives, including struck and lost, was reported to be 66 in 1997, 54 in 1998, 47 in 1999, 47 in 2000, and 75 in 2001 (Alaska Eskimo Whaling Commission, unpubl. data, AEWC, P. O. Box 570, Point Barrow, AK 99723; 2001 data provided by Suydam et al. 2002). Canadian Natives are also known to take whales from this stock. Hunters from the western Canadian Arctic community of Aklavik killed one whale in 1991 and one in 1996. The annual average subsistence take (by Natives of Alaska and Canada) during the 5-year period from 1997 to 2001 is 58 bowhead whales. One animal was harvested by Russian subsistence hunters in each of 1999 and 2000 (IWC, In press).

**Other Mortality**

Pelagic commercial whaling for bowheads principally occurred in the Bering Sea from 1848 to 1919. Within the first two decades of the fishery (1850-1870), over 60% of the stock was harvested, although effort remained high into the 20th century (Braham 1984). It is estimated that the pelagic whaling industry harvested 18,684 whales from this stock (Woodby and Botkin 1993). During 1848-1919, shore-based whaling operations (including landings as well as struck and lost estimates from U. S., Canadian, and Russian shores) took an additional 1,527 animals (Woodby and Botkin 1993). An unknown percentage of the animals taken by the shore-based operations were harvested for subsistence, and not commercial purposes. The estimated mortality likely underestimates the actual kill as a result of under-reporting of the Soviet catches (Yablokov 1994), and the lack of reports on struck and lost animals.

## STATUS OF STOCK

Based on currently available data, the estimated annual mortality rate incidental to commercial fisheries (0.2) is not known to exceed 10% of the PBR (8.9) and, therefore, can be considered to be insignificant and approaching a zero mortality and serious injury rate. The annual level of human-caused mortality and serious injury (58) is not known to exceed the PBR (89) nor the IWC quota (67). The Western Arctic bowhead whale stock has been increasing in recent years; the current preliminary estimate of 9,860 is between 43% and 95% of the estimated pre-exploitation abundance of 10,400-23,000. However, the stock is classified as a strategic stock because bowhead whale is listed as "endangered" under the Endangered Species Act (ESA), and therefore also designated as "depleted" under the MMPA. The development of criteria for recovery of large whales in general (Angliss et al. 2002) and bowhead whales in particular (Shelden et al. 2001) and will be used in the next 5-year evaluation of stock status.

### Habitat Issues

Increasing oil and gas development in the Arctic will lead to an increased risk of various forms of pollution to bowhead whale habitat, including oil spills, toxic and nontoxic waste, and noise due to higher levels of traffic as well as exploration and drilling operations. Evidence indicates that bowhead whales are sensitive to noise from offshore drilling platforms and seismic survey operations (Richardson 1995; Davies 1997), and that the presence of an active drill rig (Schick and Urban 2000) or seismic operations (Miller et al. 1999) will cause bowhead whales to avoid the vicinity. Figure 2b in Schick and Urban (2000) demonstrates, however, that the area of disturbance is localized. However, since the bowhead whale population is approaching its pre-exploitation population size and has been increasing at a roughly constant rate for over 20 years, the impacts of oil and gas industry on individual survival and reproduction are likely to be minor.

Another element of concern is the potential for Arctic climate change, which will probably affect high northern latitudes more than elsewhere. There is evidence that over the last 10-15 years, there has been a shift in regional weather patterns in the Arctic region (Tynan and DeMaster 1997). Ice-associated animals, such as the bowhead whale, may be sensitive to changes in Arctic weather, sea-surface temperatures, or ice extent, and the concomitant effect on prey availability. There are insufficient data to make reliable predictions of the effects of Arctic climate change on bowhead whales.

On 22 February 2000, NMFS received a petition from the Center for Biological Diversity and Marine Biodiversity Protection Center to designate critical habitat for this stock. Petitioners asserted that the nearshore areas from the US-Canada border to Barrow, Alaska should be considered critical habitat. On 22 May 2001, NMFS found the petition to have merit (66 FR 28141).On 30 August 2002 (67 FR 55767), NMFS announced the decision to not designate critical habitat for this population. NMFS found that designation of critical habitat was not necessary because the population is known to be approaching its pre-commercial whaling population size, the population is increasing, there are no known habitat issues which are slowing the growth of the population, and because activities which occur in the petitioned area are currently managed to minimize impacts to the population.

## CITATIONS

Angliss, R. P., G.K. Silber, and R. Merrick. 2002. Report of a workshop on developing recovery criteria for large whale species. U. S. Dept. Commer., NOAA Tech. Memo. NMFS-OPR-21. 32p

Braham, H. W. 1984. The bowhead whale, *Balaena mysticetus*. Mar. Fish. Rev. 46(4):45-53.

Braham, H. W. 1995. Sex and size composition of bowhead whales landed by Alaskan Eskimo whalers. Pp. 281-313, *In* A. P. McCartney (ed.), Hunting the largest animals: Native whaling in the western Arctic and subarctic. Studies in whaling No. 3, Occ. Publ. No. 36, Canadian Circumpolar Institute, Univ. of Alberta, Alberta, Canada. 345 pp.

Braham, H. W., M. A. Fraker, and B. D. Krogman. 1980. Spring migration of the western Arctic population of bowhead whales. Mar. Fish. Rev. 42(9-10):36-46.

Clark, C. W., S. Mitchell, and R. Charif. 1994. Distribution and behavior of the bowhead whale, *Balaena mysticetus*, based on preliminary analysis of acoustic data collected during the 1993 spring migration off Point Barrow, Alaska. Unpubl. doc. submitted to Int. Whal. Comm. (SC/46/AS19). 24 pp.

daSilva, C. Q., J. Zeh, D. Madigan, J. Laake, D. Rugh, L. Baraff, W. Koski, G. Miller. 2000. Capture-recapture estimation of bowhead whale population size using photo-identification data. J. Cetacean Res. Manag. 2(1):45-61.

Davies, J. R. 1997. The impact of an offshore drilling platform on the fall migration path of bowhead whales: a GIS-based assessment. Unpubl. MS Thesis, Western Washington Univ., Bellingham, WA. 51 pp.

George, J. C., J. Zeh, R. Suydam, C. Clark. 2002. Population size of the Bering-Chukchi-Beaufort Seas stock of bowhead whales, *Balaena mysticetus*, based on the 2001 census off Point Barrow, Alaska. Paper SC/54/BRG5, presented to the IWC Scientific Committee, Shimonoseki, Japan, 27 Apr - 9 May 2002. 13 p.

International Whaling Commission. 1992. Chairman's Report of the forty-third annual meeting. Rep. Int. Whal. Comm. 42:11-50.

International Whaling Commission. 1996. Report of the Scientific Committee. Rep. Int. Whal. Comm. 46:51-97.

International Whaling Commission. 1997. Report of the Sub-committee on Aboriginal Subsistence Whaling. Rep. Int. Whal. Comm. 47:153-162.

International Whaling Commission. In press. Report of the Scientific Committee. J. Cet. Res. Manage. V. 4 Supplement

Krogman, B. D. 1980. Sampling strategy for enumerating the western Arctic population of the bowhead whale. Mar. Fish. Rev. 42(9-10):30-36.

Krogman, B., D. Rugh, R. Sonntag, J. Zeh, and D. Ko. 1989. Ice-based census of bowhead whales migrating past Point Barrow, Alaska, 1978-1983. Mar. Mammal Sci. 5:116-138.

Marquette, W. M., and J. R. Bockstoce. 1980. Historical shore-based catch of bowhead whales in the Bering, Chukchi, and Beaufort Seas. Mar. Fish. Rev. 42(9-10):5-19.

Miller, G. W., R. E. Elliot, W. R. Koski, V. D. Moulton, and W. J. Richardson. 1999. Whales. *In* W. J. Richardson (ed.). Marine Mammal and Acoustical Monitoring of Western Geophysical's Open-Water Seismic Program in the Alaskan Beaufort Sea, 1998.

Moore, S. E. 2000. Variability in cetacean distribution and habitat section in the Alaskan Arctic, autumn 1982-91. Arctic. 53(4):448-460.

Moore, S. E. 1992. Summer records of bowhead whales in the northeastern Chukchi Sea. Arctic. 45(4):398-400.

Moore, S. E. and R. R. Reeves. 1993. Distribution and movement. Pp. 313-386, *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The bowhead whale. Soc. Mar. Mammalogy, Spec. Publ. No. 2.

Moore, S. E., and D. P. DeMaster. 2000. North Pacific right whale and bowhead whale habitat study: R/V *Alpha Helix* and CGC *Laurier* Cruises, July 1999. Annual Report. 3p.

Philo, L. M., E. B. Shotts, and J. C. George. 1993. Morbidity and mortality. Pp. 275-312, *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The bowhead whale. Soc. Mar. Mammalogy, Spec. Publ. No. 2.

Raftery, A.E. and J.E, Zeh,. 1994. Bowhead whale, *Balaena mysticetus*, population size estimated from acoustic and visual census data collected near Barrow, Alaska, in 1993. Paper SC/46/AS13 presented to the IWC ScientificCommittee (unpublished). 25pp.

Raftery, A., J. Zeh, and G. Givens. 1995. Revised estimate of bowhead rate of increase. Rep. Int. Whal. Comm. 45:158.

Richardson, W. J. 1995. Documented disturbance reactions. Pp. 241-324, *In* W. J. Richardson, C. R. Greene, C. I. Malme, and D. H. Thomson (eds.), Marine mammals and noise. Academic Press, San Diego, CA.

Richardson, W. J., R. A. Davis, C. R. Evans, and P. Norton. 1985. Distribution of bowhead and industrial activity, 1980-84. Pp. 255-306, *In* W. J. Richardson (ed.), Behavior, disturbance responses and distribution of bowhead whales, *Balaena mysticetus*, in the eastern Beaufort Sea, 1980-84. Rept. for U.S. Minerals Mgt. Serv. by LGL Inc., NTIS PB87 124376/AS. 306 pp.

Rugh, D. J., and J. C. Cubbage. 1980. Migration of bowhead whales past Cape Lisburne, Alaska. Mar. Fish. Rev. 42(9-10):46-51.

Rugh, D., D. DeMaster, A. Rooney, J. Breiwick, K. Shelden, and S. Moore. 2000. Review of studies on stock identity in the bowhead whale (*Balaena mysticetus*). Paper SC/52/SD4 presented to the IWC Scientific Committee in June 2000 (unpublished). 27pp.

Schick, R.S. and D.L. Urban. 2000. Spatial components of bowhead whale (Balaena mysticetus) distribution in the Alaskan Beaufort Sea. Can. J. Fish. Aquat. Sci. 57:2193-2200.

Shelden, K. E. W., D. P. DeMaster, D. J. Rugh, and A. M. Olson. 2001. Developing classification criteria under the U.S. Endangered Species Act: Bowhead whales as a case study. Cons. Bio. 15(5):1300-1307.

Shelden, K. E. W., and D. J. Rugh. 1995. The bowhead whale (*Balaena mysticetus*): status review. Mar. Fish. Rev. 57(3-4):1-20.

Stoker, S. W., and I. I. Krupnik. 1993. Subsistence whaling. Pp. 579-629, *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The bowhead whale. Soc. Mar. Mammalogy, Spec. Publ. No. 2.

Suydam, R.S., T.M. O'Hara, J.C. George, V.M. Woshner, and G. Sheffield. 2002. Subsistence harvest of bowhead whales by Alaskan Eskimos during 2001. Paper SC/54/BRG20, presented to the IWC Scientific Committee, Shimonoseki, Japan, 27 Apr - 9 May 2002. 5p.

Treacy, S.D. 2002. Aerial survey of endangered whales in the Beaufort Sea, Fall 2000. (OCS Study MMS 2002-014) U. S. Dept. Inter., Anchorage, AK, 111p.

Tynan, C. T., and D. P. DeMaster. 1997. Observations and predictions of Arctic climate change: potential effects on marine mammals. Arctic 50(4):308-322.

Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12, 93 pp.

Woodby, D. A., and D. B. Botkin. 1993. Stock sizes prior to commercial whaling. Pp. 387-407, *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The bowhead whale. Soc. Mar. Mammalogy, Spec. Publ. No. 2.

Yablokov, A. V. 1994. Validity of whaling data. Nature 367:108.

Zeh, J. E., J. C. George, and R. Suydam. 1994. Rate of increase, 1978-1993, of bowhead whales, *Balaena mysticetus*. Rep. Int. Whal. *Comm.*45:339-344.

Zeh, J. E., A. E. Raftery, and A. A. Schaffner. 1995. Revised estimates of bowhead population size and rate of increase. Unpubl. report submitted to Int. Whal. Comm. (SC/47/AS/10). 26 pp.