Revised 11/17/2011

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

STOCK DEFINITION AND GEOGRAPHIC RANGE

Western Arctic bowhead whales are distributed in seasonally ice-covered waters of the Arctic and near-Arctic, generally north of 60°N and south of 75°N in the western Arctic Basin (Braham 1984, Moore and Reeves 1993). For management purposes, four stocks of bowhead whales have been recognized worldwide by the International Whaling Commission (IWC 2010a). Single small stocks occur in the Sea of Okhotsk and the offshore waters of Spitsbergen, comprised of only a few tens to a few hundreds of individuals (Shelden and Rugh 1995, Wiig et al. 2009, Zeh et al. 1993). Bowheads occur in western Greenland (Hudson Bay and Foxe Basin) and eastern Canada (Baffin Bay and Davis Strait) stocks, and recent evidence suggests that these should be considered one stock based on genetics (Postma et al. 2006; Heide-Jørgensen et al. 2010; Wiig et al. 2010; Bachmann et al. 2010), aerial surveys (Cosens et al. 2006), and tagging data (Dueck et al. 2006; Heide-Jørgensen et al. 2006; IWC 2010a, 2011a).This stock, previously thought to include only a few hundred animals, may number over a thousand (Heide-Jørgensen et al. 2007, Wiig et al. 2011), and perhaps over 6,000 (IWC 2008a). The only stock found within U. S. waters is the Western Arctic stock (Figs. 40 and 41), also known as the Bering-Chukchi-Beaufort stock (Rugh et al. 2003) or Bering Sea stock (Burns et al. 1993). Although Jorde et al. (2007) suggested there might be multiple stocks of bowhead whales in US waters, several studies (George et al. 2007, Rugh et al. 2009, Taylor et al. 2007) and the IWC SC concluded that data are most consistent with one bowhead stock that migrates throughout waters of northern and western Alaska (IWC 2008b).

The majority of the Western Arctic stock migrates annually from wintering areas (December to March) in the northern Bering Sea, through the Chukchi Sea in the spring (April through May), to the Beaufort Sea (Fig. 40) where they spend much of the summer (June through September) before returning again to the Bering Sea (Fig. 41) in the fall (October through December) to overwinter (Braham et al. 1980,

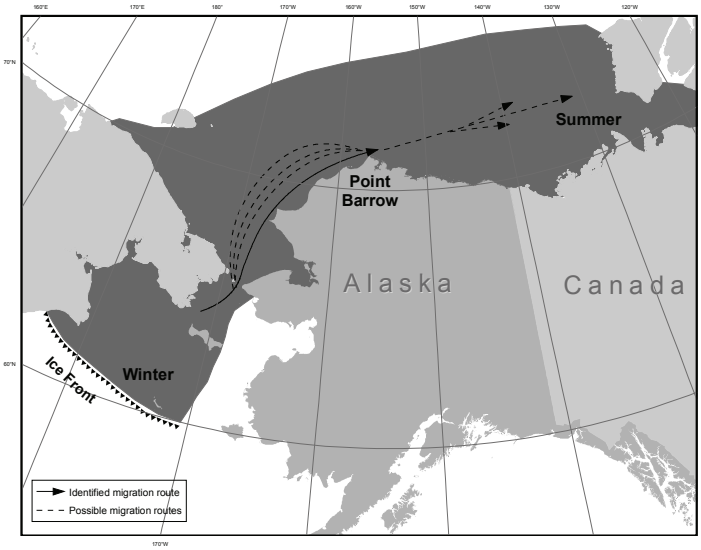

Figure 40. Dark areas depict the approximate distribution of the western Arctic stock of bowhead whales. The spring migration represented here by lines and arrows follows a route from the Bering Sea wintering area to the Beaufort Sea summering area, mostly along a coastal tangent that constricts somewhat as it goes east past Point Barrow.

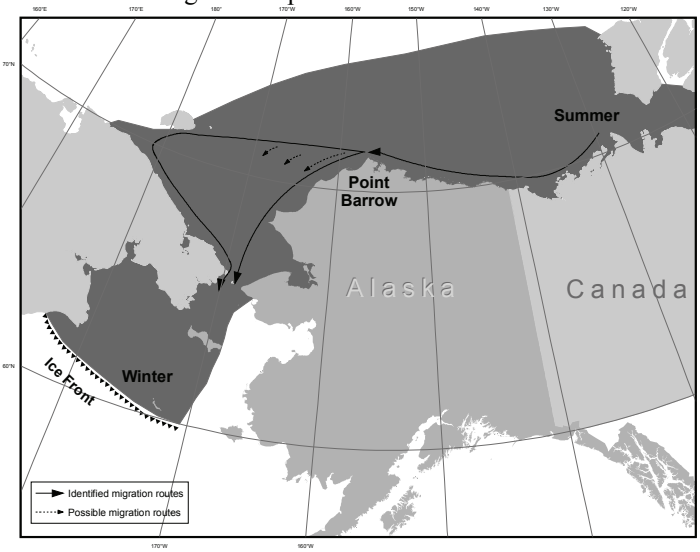

Figure 41. Dark areas depict the approximate distribution of the western Arctic stock of bowhead whales. The fall migration is represented here by lines and arrows showing generalized routes used to travel from the Beaufort Sea (summering area) to the Bering Sea (wintering area).

Moore and Reeves 1993, Quakenbush et al. 2010a). 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. 2003).

Most of the year, bowhead whales are closely associated with sea ice (Moore and Reeves 1993, Quakenbush et al. 2010a). 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 pack ice. During the summer, most of the population is 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. 1987, Davies 1997). During the autumn migration, bowheads select shelf waters in all but "heavy ice" conditions, when they select slope habitat (Moore 2000). Bowheads on wintering grounds in the Bering Sea often use areas with 100% sea ice cover, even when polynas are available (Quakenbush et al. 2010a).

Evidence suggests that bowhead whales feed on concentrations of zooplankton throughout their range. Likely or confirmed feeding areas include Amundsen Gulf; central and western U.S. Beaufort Sea; Wrangel Island; the coast of Chukotka, between Wrangel Island and the Bering Strait; and the western Bering Sea (Quakenbush et al. 2010a, Quakenbush et al. 2010b, Lowry et al. 2004, Clarke and Ferguson 2010a, Ashjian et al. 2010, Okkonen et al. 2011). Bowheads have also been observed feeding during the summer in the northeastern Chukchi Sea (Clarke and Ferguson 2010b).

POPULATION SIZE

All stocks of bowhead whales were severely depleted during intense commercial whaling, starting in the early 16th century near Labrador (Ross 1993) and spreading to the Bering Sea in the mid-19th century (Braham 1984, Bockstoce and Burns 1993, Bockstoce et al. 2007). Woodby and Botkin (1993) summarized previous efforts to estimate 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). Brandon and Wade (2004) used Bayesian model averaging to estimate that the Western Arctic stock consisted of 10,960 (9,190-13,950; 5th and 9th percentiles, respectively) bowheads in 1848 at the start of commercial whaling.

Table 42. Summary of population abundance estimates for the western Arctic stock of bowhead whales. The historical estimates were made by back-projecting using a simple recruitment model. All other estimates were developed by corrected ice-based census counts. Historical estimates are from Woodby and Botkin (1993); 1978-2001 estimates are from George et al. (2004) and Zeh and Punt (2004).

Year	Abundance estimate (CV)	Year	Abundance estimate (CV)
Historical estimate	10,400-23,000	1985	5,762 (0.253)
End of commercial whaling	1000-3000	1986	8,917 (0215)
1978	4,765 (0.305)	1987	5,298 (0.327)
1980	3,885 (0.343)	1988	6,928 (0.120)
1981	4,467 (0.273)	1993	8,167 (0.017)
1982	7,395 (0.281)	2001	10,545 (0.128)
1983	6,573 (0.345)		

Since 1978, systematic counts of bowhead whales have been conducted from sites on sea ice near 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 since the mid-1980s, described in Clark et al. 1994), whales missed when no watch was in effect (through interpolations from sampled periods), and whales missed during a watch (estimated as a function of visibility, number of observers, and distance offshore; Zeh et al. 1993). A summary of the resulting abundance estimates is provided in Table 42 and Figure 42. However, these estimates of abundance have not been corrected for a small portion of the population that may not migrate past Point Barrow during the period when counts are made. Attempts to count migrating whales near Point Barrow in 2009 and 2010 were unsuccessful due to sea ice conditions (IWC 2010b, George et al. 2011). A count was successful in 2011, and the data are currently being analyzed (pers. comm.. J.C. George, North Slope Borough, Barrow, AK). The most recent ice-based abundance estimate, in 2001, was 10,545 (CV = 0.128) (updated from George et al. 2004 by Zeh and Punt 2004).

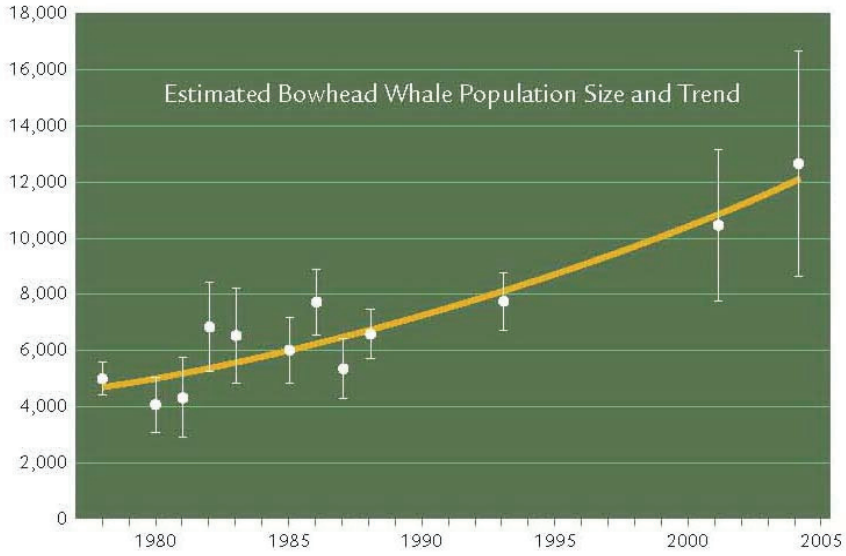

Figure 42. Population abundance estimates for the western Arctic stock of bowhead whales, 1977-2004 (George et al. 2004, Koski et al. 2010), as computed from ice-based counts, acoustic locations, and aerial transect data collected during bowhead whale spring migrations past Barrow, AK. The 2004 estimate is based on sight-resight results. Vertical bars show +/- 1 standard error.

Bowhead whales were identified from aerial photographs taken in 1985 and 1986, and the results were used in a sight-resight analysis. This approach provided estimates of 4,719 (95% CI: 2,382 - 9,343; SE 1,696) to 7,022 (95% CI: 4,701 - 12,561; SE 2,017), 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 ice-based visual and acoustic data for 1985 (6,039; SE 1,915) and 1986 (7,734; SE 1,450; Raftery and Zeh 1998). Aerial photographs provided another sampling of the bowhead population in 2003 and 2004. Sight-resight results provided estimates of 8,250 whales (95% CI: 3,150 to 15,450) in 2001 (Schweder et al. 2009) and 12,631 whales (95% CI: 7,900 to 19,700) in 2004 (Koski et al. 2010), estimates that are consistent with trends in abundance estimates made from ice-based counts.

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 2004 population estimate (N) of 12,631 and its associated CV(N) of 0.2442, N_{MIN} for the Western Arctic stock of bowhead whales is 10,314.

Current Population Trend

Based on concurrent passive acoustic and ice-based visual surveys, George et al. (2004) reported that the Western Arctic stock of bowhead whales has increased at a rate of 3.4% (95% CI = 1.7-5.0%) from 1978 to 2001, during which time abundance doubled from approximately 5,000 to approximately 10,000 whales. Schweder et al. (2009) estimated the yearly growth rate to be 3.2% (95% CI = 0.5-4.8%) between 1984 and 2003 using a sight-resight analysis of aerial photographs. The count of 121 calves during the 2001 census was the highest yet recorded and was likely caused by a combination of variable recruitment and the large population size (George et al. 2004). The calf count provides corroborating evidence for an increasing population.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

The current estimate for the rate of increase for this stock of bowhead whales (3.2-3.4%) 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 used 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 has been set at 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 = 103 animals (10,314 × 0.02 × 0.5). The calculation of a PBR level for the Western Arctic bowhead stock is required by the MMPA even though

the subsistence harvest quota is established under the authority of the IWC based on extensively tested strike limit algorithms. The quota is based on subsistence need or the ability of the bowhead population to sustain a harvest, whichever is smaller. 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 2008-2012, the IWC established a block quota of 280 landed bowheads. Because some whales are struck and lost, a strike limit of 67 (plus up to 15 previously unused strikes) could be taken each year. This quota includes an allowance of 5 animals to be taken by Chukotka Natives in Russia. A new quota (for 2013 to 2017) will be considered at the 2012 meeting of the SC.

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 (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, Department of Wildlife Management, North Slope Borough, pers. comm.).

There are no observer program records of bowhead whale mortality incidental to commercial fisheries in Alaska. However, some bowhead whales have historically had interactions with crab pot gear. There are several documented cases of bowheads having ropes or rope scars on them. In 2003 a bowhead whale was found dead in Bristol Bay entangled in line around the peduncle and both flippers; the origin of the line is unknown. In 2004 a bowhead whale near Point Barrow was observed swimming slowly with fishing net and line around the head. One dead whale was found floating in Kotzebue Sound in early July 2010 entangled in crab pot gear similar to that used by commercial crabbers in the Bering Sea (Suydam et al. 2011). The minimum average annual entanglement rate in U.S. commercial fisheries for the 5-year period from 2006-2010 is 0.2; however, the overall rate is currently unknown.

Subsistence/Native Harvest Information

Eskimos have been taking bowhead whales for subsistence purposes 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 eleven Alaska communities (Philo et al. 1993; Suydam et al. 2011). Under this quota, the number of kills has ranged between 14 and 72 per year, the number depending in part on changes in management strategy and in part on higher abundance estimates in recent years (Stoker and Krupnik 1993). Suydam and George (2004) summarized Alaskan subsistence harvests of bowheads from 1974 to 2003 and reported a total of 832 whales landed by hunters from 11 villages with Barrow landing the most whales (n = 418) while Little Diomede and Shaktoolik each landed only one. Alaska Natives landed 31 bowheads in 2006 (Suydam et al. 2007), 41 in 2007 (Suydam et al. 2008), 38 in 2008 (Suydam et al. 2009), 31 in 2009 (Suydam et al. 2010), and 45 in 2010 (Suydam et al. 2011). The number of whales landed at each village varies greatly from year to year, as success is influenced by village size and ice and weather conditions. The efficiency of the hunt (the percent of whales struck that are retrieved) has increased since the implementation of the bowhead quota in 1978. In 1978, the efficiency was about 50%, the mean for 2000-2009 was 77% (SD=7%), and in 2010 it was 63% (Suydam et al. 2011).

Canadian and Russian Natives are also known to take whales from this stock. Hunters from the western Canadian Arctic community of Aklavik harvested one whale in 1991 and one in 1996. Eight whales were harvested by Russian subsistence hunters between 1999-2005 (Borodin 2004, 2005; IWC 2007). No catches were reported by either Canadian or Russian hunters for 2006-2007 (IWC 2008b) or by Russia in 2009 (IWC 2010b), but two bowheads were taken in Russia in 2008 (IWC 2009), and in 2010 (IWC 2011a,b). The annual average subsistence take (by Natives of Alaska, Russia, and Canada) during the 5-year period from 2006 to 2010 was 38 bowhead whales.

Other Mortality

Pelagic commercial whaling for bowheads was conducted from 1849 to 1914 in the Bering, Chukchi, and Beaufort seas (Bockstoce et al. 2007). During the first two decades of the fishery (1850-1870), over 60% of the estimated pre-whaling abundance was harvested, and 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 the U. S., Canada, and Russia) 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. Estimates of mortality likely underestimate the actual harvest as a result of under-reporting of the Soviet catches (Yablokov 1994) and incomplete reporting of struck and lost animals.

Transient killer whales are the only known predators of bowhead whales. In a study of marks on bowheads taken in the subsistence harvest, 4.1% to 7.9% had scars indicating that they had survived attacks by killer whales (George et al., 1994).

STATUS OF STOCK

Based on currently available data, the estimated annual mortality rate incidental to U. S. commercial fisheries (0.2) is not known to exceed 10% of the PBR (10.3), and therefore can be considered to be insignificant. The annual level of human-caused mortality and serious injury (38) is not known to exceed the PBR (103) nor the IWC annual maximum quota (67). The Western Arctic bowhead whale stock has been increasing in recent years; the estimate of 12,631 is between 22% and 124% of the pre-exploitation abundance (estimates ranging roughly from 10,000 to 55,000), and this stock may now be approaching its carrying capacity (Brandon and Wade 2004, 2006). However, the stock is classified as a strategic stock because the bowhead whale is listed as "endangered" under the U. S. Endangered Species Act (ESA) and is therefore also designated as "depleted" under the MMPA. An ESA recovery plan has not been prepared for bowhead whales because: 1) only the Western Arctic stock occurs in U.S. waters and, therefore, a U.S. recovery plan for other stocks would not be appropriate; 2) all stocks are managed under the international authority of the IWC (of which the United States is a member); 3) cooperative agreements already exist between NOAA and the AEWC for purposes of protecting the bowhead whale and the Eskimo culture, promoting scientific investigations, and effectuating the other purpose of the MMPA, the Whaling Convention Act, and the ESA as these acts relate to aboriginal subsistence whaling; and, 4) a recovery plan is not needed to direct research and management necessary to promote the recovery of this stock. NMFS will use criteria developed for the recovery of large whales in general (Angliss et al., 2002) and bowhead whales in particular (Shelden et al., 2001) in the next five-year ESA status review to determine if a change in listing status is needed (Gerber et al., 2007).

Habitat Issues

Increasing oil and gas development in the Arctic has led to an increased risk of various forms of pollution to bowhead whale habitat, including oil spills, other pollutants, and nontoxic waste. Noise produced by increased seismic surveys and vessel traffic resulting from exploration and drilling operations and shipping are also of concern. Evidence indicates that bowhead whales are sensitive to noise from offshore drilling platforms and seismic survey operations (Richardson and Malme 1993, Richardson 1995, Davies 1997), and that the presence of an active drill rig (Schick and Urban 2000) or seismic operations (Miller et al. 1999) may cause bowhead whales to deflect away from the activity. Studies in the 1980s indicated that bowheads appeared to recover from these behavioral changes within 30-60 minutes following the end of seismic activity (Richardson et al., 1986b; Ljungblad et al., 1988). Monitoring studies of 3-D seismic exploration in the nearshore Beaufort Sea during 1996-1998 have demonstrated that nearly all bowhead whales will avoid an area within 20 km of an active seismic source and suggest that the offshore displacement may have begun roughly 35 km (19 n. mi. or 22 statute miles [st. mi.]) east of the activity and may have persisted more than 30 km to the west (Richardson et al., 1999). Richardson et al. (1986) observed that feeding bowheads started to turn away from a 30-airgun array with a source level of 248 dB re 1 µPa at a distance of 7.5 km (4.7 mi.) and swim away when the vessel was within about 2 km (1.2 mi.); other whales in the area continued feeding until the seismic vessel was within 3 km (1.9 mi.). More recent studies have similarly shown greater tolerance of feeding bowhead whales to higher sound levels than migrating whales (Miller et al. 2005, Harris et al. 2007). Data from an aerial monitoring program in the Alaskan Beaufort Sea during 2006-2008 also indicate that bowheads feeding during late summer and autumn did not exhibit large-scale distribution changes in relation to seismic operations (Funk et al., 2011). This apparent tolerance, however, should not be interpreted to mean that bowheads are unaffected by the noise. Feeding bowheads may be so highly motivated to stay in a productive feeding area that they remain in an area with noise levels that could cause adverse physiological effects (NMFS, 2010). They could be experiencing increased stress by staying in a location with very loud noise (MMS, 2008).

Another concern is climate change in the Arctic, which is affecting high northern latitudes more than elsewhere. Climate projections for the next 50–100 years produced by global climate models consistently show a pronounced warming over the Arctic, accelerated sea-ice loss, and continued permafrost degradation (IPCC, 2007; USGS, 2011). Within the Arctic, some of the largest changes are expected to occur in the Bering, Beaufort, and Chukchi seas (Chapman and Walsh, 2007; Walsh, 2008). 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. Laidre et al. (2008) concluded that on a worldwide basis, bowhead whales were likely to be moderately sensitive to climate change based on an analysis of various life history features that could be affected by climate. Currently, there are insufficient data to make reliable predictions of the effects of Arctic climate change on bowhead whales. A study reported in George et al. (2006) showed that landed bowheads had better body condition during years of light ice cover. This, together with high calf production in recent years, suggests that the stock is tolerating the recent ice-retreat at least at present.

On 22 February 2000, NMFS received a petition from the Center for Biological Diversity and Marine Biodiversity Protection Center to designate critical habitat for the Western Arctic bowhead stock. Petitioners asserted that the nearshore areas from the U. S.-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 increasing and approaching its pre-commercial whaling population size, there are no known habitat issues that are slowing the growth of the population, and activities that occur in the petitioned area are already managed to minimize impacts to the population.

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