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SEI WHALE (*Balaenoptera borealis*): Nova Scotia Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Mitchell and Chapman (1977) reviewed the sparse evidence on stock identity of northwest Atlantic sei whales, and suggested two stocks - a Nova Scotia stock and a Labrador Sea stock. The range of the Nova Scotia stock includes the continental shelf waters of the northeastern U.S., and extends northeastward to south of Newfoundland. The Scientific Committee of the IWC, while adopting these general boundaries, noted that the stock identity of sei whales (and indeed all North Atlantic whales) was a major research problem (Donovan 1991). In the absence of evidence to the contrary, the proposed IWC stock definition is provisionally adopted, and the "Nova Scotia stock" is used here as the management unit for this stock assessment. The IWC boundaries for this stock are from the U.S. east coast to Cape Breton, Nova Scotia, thence east to longitude 42° W.

Indications are that, at least during the feeding season, a major portion of the Nova Scotia sei whale stock is centered in northerly waters, perhaps on the Scotian Shelf (Mitchell and Chapman 1977). The southern portion of the species' range during spring and summer includes the northern portions of the U.S. Atlantic Exclusive Economic Zone (EEZ) - the Gulf of Maine and Georges Bank. The period of greatest abundance there is spring, with sightings concentrated along the eastern margin of Georges Bank and into the Northeast Channel area, and along the southwestern edge of Georges Bank in the area of Hydrographer Canyon (CETAP 1982). NMFS aerial surveys in 1999, 2000 and 2001 found concentrations of sei and right whales along the Northern Edge of Georges Bank in the spring. The sei whale is often found in the deeper waters characteristic of the continental shelf edge region (Hain *et al.* 1985), and NMFS aerial surveys found substantial numbers of sei whales in this region, south of Nantucket, in the spring of 2001. Similarly, Mitchell (1975) reported that sei whales off Nova Scotia were often distributed closer to the 2,000 m depth contour than were fin whales.

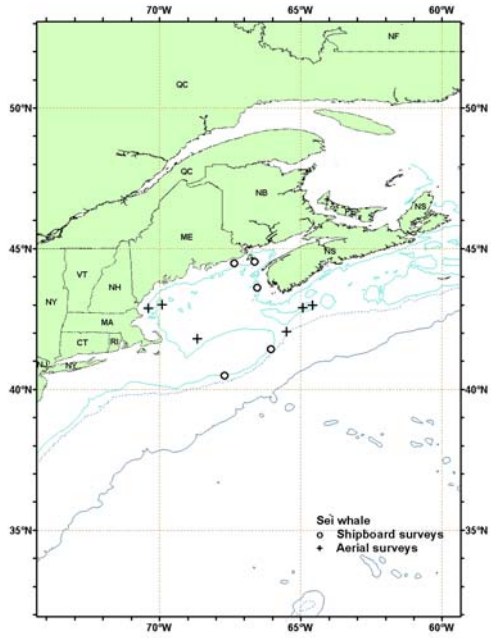

Figure 1. *Distribution of sei whale sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1998, 1999, 2002, 2004 and 2006. Isobaths are the 100-m, 1000-m and 4000-m depth contours.*

This general offshore pattern of sei whale distribution is disrupted during episodic incursions into more shallow and inshore waters. Although known to take piscine prey, sei whales (like right whales) are largely planktivorous, feeding primarily on euphausiids and copepods (Flinn *et al.* 2002). In years of reduced predation on copepods by other predators, and thus greater abundance of this prey source, sei whales are reported in more inshore locations, such as the Great South Channel (in 1987 and 1989) and Stellwagen Bank (in 1986) areas (R.D. Kenney, pers. comm.; Payne *et al.* 1990). An influx of sei whales into the southern Gulf of Maine occurred in the summer of 1986 (Schilling *et al.* 1993). Such episodes, often punctuated by years or even decades of absence from an area, have been reported for sei whales from various places worldwide (Jonsgård and Darling 1977).

Based on analysis of records from the Blandford, Nova Scotia, whaling station, where 825 sei whales were taken between 1965 and 1972, Mitchell (1975) described two "runs" of sei whales, in June-July and in September-October. He speculated that the sei whale population migrates from south of Cape Cod and along the coast of eastern Canada in June and July, and returns on a southward migration again in September and October; however, such a migration remains unverified.

POPULATION SIZE

The total number of sei whales in the U.S. Atlantic EEZ is unknown. However, five abundance estimates are available for portions of the sei whale habitat: from Nova Scotia during the 1970s, in the U.S. Atlantic EEZ during the springs of 1979-1981, and in the U.S. and Canadian Atlantic EEZ during the summers of 2002, 2004, and 2006. The August 2006 abundance estimate (207 CV=0.62) is considered the best available for the Nova Scotia stock of sei whales because it is the most recent. However, this estimate must be considered extremely conservative in view of the known range of the sei whale in the entire western North Atlantic, and the uncertainties regarding population structure and whale movements between

surveyed and unsurveyed areas. Estimates for animals identified as sei whales were generated independently from estimates of animals identified as either fin or sei whale. The final estimate of sei whales was the sum of the estimate of animals identified as sei whales and a portion of the estimate of animals identified as fin or sei whales, where the portion was defined as the percent of sei whales out of the total number of positively identified fin whales and sei whales.

Earlier abundance estimates

(Mitchell and Chapman 1977), based on tag-recapture data, estimated the Nova Scotia, Canada, stock to contain between 1,393 and 2,248 sei whales. Based on census data, they estimated a minimum Nova Scotian population of 870 sei whales. An abundance estimate of 280 sei whales was generated from an aerial survey program conducted from 1978 to 1982 on the continental shelf and shelf edge waters between Cape Hatteras, North Carolina and Nova Scotia (CETAP 1982). The estimate is based on data collected during the spring when the greatest proportion of the population off the northeast U.S. coast appeared in the study area. This estimate does not include a correction for dive-time or for *g(0)*, the probability of detecting an animal group on the track line. The CETAP report suggested, however, that correcting the estimated abundance for dive time would increase the estimate to approximately the same as Mitchell and Chapman's (1977) tag-recapture estimate. As recommended in the GAMMS Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable and should not be used for PBR determinations.

Recent surveys and abundance estimates

An abundance estimate of 71 (CV=1.01) sei whales was obtained from an aerial survey conducted in August 2002 which covered 7,465 km of trackline over waters from the 1000 m depth contour on the southern edge of Georges Bank to Maine (Table 1; Palka 2006). The value of *g(0)* used for this estimation was derived from the pooled data of 2002, 2004 and 2006 aerial survey data.

An abundance estimate of 386 (CV=0.85) sei whales was derived from a line-transect sighting survey conducted during 12 June to 4 August 2004 by a ship and plane that surveyed 10,761 km of trackline in waters north of Maryland (38ºN)(Table 1; Palka 2006). Of this, 6,180 km of trackline was within known sei whale habitat, from the 100 m depth contour on the southern Georges Bank to the lower Bay of Fundy. The Scotian shelf south of Nova Scotia was not surveyed. Shipboard data were collected using the two independent team line-transect method and analyzed using the modified direct duplicate method (Palka 1995) accounting for biases due to school size and other potential covariates, reactive movements (Palka and Hammond 2001), and *g(0)*, the probability of detecting a group on the trackline. Aerial data were collected using the Hiby circle-back line transect method (Hiby 1999) and analyzed accounting for *g(0)* and biases due to school size and other potential covariates (Palka 2005).

An abundance estimate of 207 (CV=0.62) sei whales was obtained from an aerial survey conducted in August 2006 which covered 10,676 km of trackline in the region from the 2000 m depth contour on the southern edge of Georges Bank to the upper Bay of Fundy and to the entrance of the Gulf of St. Lawrence. (Table 1; Palka pers. comm.)

Table 1. Summary of recent abundance estimates for Nova Scotia sei whales. Month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation (CV).

Month/Year	Area	N_{best}	CV
Aug 2002	S. Gulf of Maine to Maine	71	1.01
Jun-Jul 2004	Gulf of Maine to lower Bay of Fundy	386	0.85
Aug 2006	S. Gulf of Maine to upper Bay of Fundy to Gulf of St. Lawrence	207	0.62

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by (Wade and Angliss 1997). The best estimate of abundance for sei whales is 207 (CV=0.62). The minimum population estimate for the Nova Scotia stock of the sei whale is 128.

Current Population Trend

There are insufficient data to determine population trends for this species.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. For purposes of this assessment, the maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a "recovery" factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size is 128. The maximum productivity rate is 0.04, the default value for cetaceans. The "recovery" factor, which accounts for endangered, depleted, threatened stocks, or stocks of unknown status relative to optimum sustainable population (OSP) is assumed to be 0.10 because the sei whale is listed as endangered under the Endangered Species Act (ESA). PBR for the Nova Scotia stock of the sei whale is 0.3.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

For the period 2002 through 2006, the minimum annual rate of human-caused mortality and serious injury to sei whales was 0.6 per year. This value includes incidental fishery interaction records, 0.2, and records of vessel collisions, 0.4 (Glass *et al.* 2008). The first ship-strike record within the period was an 11-meter male discovered 19 February 2003, outside of Norfolk Naval Base in Norfolk, Virginia. A large gash into muscle tissue extended from behind dorsal midline on left side almost all the way around to the ventral midline on the right sides through blubber layer and into some muscle. Histopathology results supported perimortem trauma. Another ship-strike mortality was reported when a fresh sei whale carcass was brought in on the bow of a ship 17 April 2006 to Baltimore, Maryland. The fishery entanglement serious injury was discovered on Jeffreys Ledge on 16 September 2006. Previous NMFS records of human-caused sei whale mortalities include one from 17 November 1994, when a sei whale carcass was observed on the bow of a container ship as it docked in Boston, Massachusetts, and one from 2 May 2001 when the carcass of a 13-meter female sei whale slid off the bow of a ship arriving in New York harbor.

Fishery Information

No confirmed fishery-related mortalities or serious injuries of sei whales have been reported in the NMFS Sea Sampling bycatch database. A review of the records of stranded, floating or injured sei whales for the period 2002 through 2006 on file at NMFS found one record with substantial evidence of fishery interactions causing serious injury (Table 2), which results in an annual rate of serious injury and mortality of 0.2 sei whales from fishery interactions. While these records are not statistically quantifiable in the same way as the observer fishery records, they give a minimum count of entanglements for the species.

Table 2. Confirmed human-caused mortality and serious injury records of Nova Scotian sei whales, 2002- 2006.

Date[a]	Report Type[b]	Age, Sex, Length	Location[a]	Assigned Cause: P=primary, S=secondary		Notes/Observations
				Ship strike	Entang./ Fsh inter	
2/19/03	mortality	age unknown Male 11.0m	Norfolk, VA	P		Large gash into muscle, hematoma and abrasions
4/17/06	mortality	Juvenile Male 10.9m	Baltimore, MD	P		Brought in on bow of ship, freshly dead; massive hemorrhaging on right side; large blood clot behind head; several broken ribs

9/16/06	serious injury	age & sex unknown	Jeffreys Ledge		P	Constricting wrap cutting into skin; no gear recovered

a. The date sighted and location provided in the table are not necessarily when or where the serious injury or mortality occurred; rather, this information indicates when and where the whale was first reported beached, entangled, or injured.

b. National guidelines for determining what constitutes a serious injury have not been finalized. Interim criteria as established by NERO/NMFS (Nelson *et al.* 2007) have been used here. Some assignments may change as new information becomes available and/or when national standards are established.

STATUS OF STOCK

The status of this stock relative to OSP in the U.S. Atlantic EEZ is unknown, but the species is listed as endangered under the ESA. There are insufficient data to determine population trends for sei whales. The total level of U.S. fishery-caused mortality and serious injury for this stock derived from the available records is not less than 10% of the calculated PBR, and therefore cannot be considered insignificant and approaching the ZMRG. This is a strategic stock because the average annual human-related mortality and serious injury exceeds PBR, and because the sei whale is listed as an endangered species under the ESA. A Recovery Plan for sei whales has been written and is awaiting legal clearance.

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