December 2011

SEI WHALE (*Balaenoptera borealis 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 International Whaling Committee (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^{o} W.

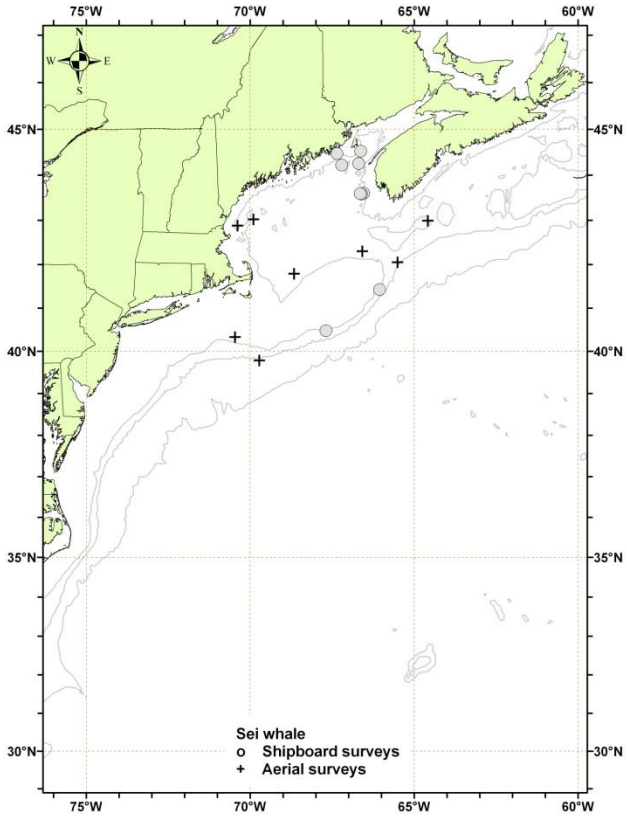

Figure 1. *Distribution of sei whale sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1998, 1999, 2002, 2004, 2006 and 2007. Isobaths are the 100-m, 1000-m and 4000-m depth contours.*

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. Spring is the period of greatest abundance in U.S. waters, 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 from 1999 on have 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, in particular 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.

This general offshore pattern of sei whale distribution is disrupted during episodic incursions into shallower, more inshore waters. Although known to eat fish, sei whales (like right whales) are largely planktivorous, feeding primarily on euphausiids and copepods (Flinn *et al.* 2002). A review by prey preferences by Horwood (1987) showed that in the North Atlantic sei whales seem to prefer copepods over all other prey species. In Nova Scotia sampled stomachs from captured sei whales showed a clear preference for copepods between June and October, and euphasiids were taken only in May and November (Mitchell 1975). 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 2004 abundance estimate (386) is considered the best available for the Nova Scotia stock of sei whales. However, this estimate must be considered 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. The abundance estimates of sei whales include a percentage of the estimate of animals identified as fin/sei whales (the two species being sometimes hard to distinguish). The percentage used is the ratio of positively identified sei whales to the total of positively identified fin whales and positively identified sei whales.

Earlier abundance estimates

Please see appendix IV for earlier abundance estimates. 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 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). There were 6,180 km of trackline within known sei whale habitat, from the 100-m depth contour on 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). The value of *g(0)* used for this estimation was derived from the pooled 2002, 2004 and 2006 aerial survey data.

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.). The value of *g(0)* used for this estimation was derived from the pooled 2002, 2004 and 2006 aerial survey data.

Table 1. Summary of recent abundance estimates for Nova Scotia sei whales with 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
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 the Nova Scotia stock sei whales is 386 (CV=0.85). The minimum population estimate is 208.

Current Population Trend

A population trend analysis has not been done 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 208. 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 0.4.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

For the period 2005 through 2009, the minimum annual rate of human-caused mortality and serious injury to sei whales was 1.2. This value includes incidental fishery interaction records, 0.6, and records of vessel collisions, 0.6 (Henry *et al.* 2011). Annual rates calculated from detected mortalities should not be considered an unbiased estimate of human-caused mortality. Detections are haphazard, incomplete and not the result of a designed sampling scheme. As such they represent a minimum estimate of human-caused mortality which is almost certainly biased low.

Fishery-Related Serious Injury and Mortality

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 2005 through 2009 on file at NMFS found 3 records with substantial evidence of fishery interactions causing serious injury (Table 2), which results in an annual rate of serious injury and mortality of 0.6 sei whales from fishery interactions.

Table 2. Confirmed human-caused mortality and serious injury records of Nova Scotian sei whales, 2005 - 2009.

Date[a]	Report Type[b]	Age, Sex, Length	Location[a]	Assigned Cause: P=primary, S=secondary		Notes/Observations
				Ship strike	Entang./ Fsh inter	
04/17/06	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
09/16/06	serious injury	age & sex unknown	Jeffreys Ledge		P	Constricting wrap cutting into skin; no gear recovered
05/30/07	mortality	Adult Female 14.4m	off Deer Island, MA	P		Broken left flipper, 8 vertebral processes, and 4 ribs; right flipper sheared off; lower jaw dislocated; hemorrhaging and/or edema associated with lower jaw and left

						flipper region
04/09/08	serious injury	age & sex unknown	Great South Channel		P	Constricting wrap on fluke; skin sloughing; no gear recovered
06/29/08	mortality	age & sex unknown 15m (est)	Slacks Cove, New Brunswick		P	Extensive entanglement evident; no gear present
5/19/2009	mortality	Juvenile Male 12.7 m	off Rehobeth Beach, DE	P		Posterior portion of skull & right mandible fractured; hemorrhaging dorsal to left pectoral

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.

Other Mortality

For the period 2005 through 2009 files at NMFS included three records with substantial evidence of vessel collisions causing serious injury or mortality (Table 2). 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 m female sei whale slid off the bow of a ship arriving in New York harbor.

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 U.S. fishery-related 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.

REFERENCES CITED

Barlow, J., S.L. Swartz, T.C. Eagle and P.R. Wade 1995. U.S. marine mammal stock assessments: Guidelines for preparation, background, and a summary of the 1995 assessments. NOAA Tech. Memo. NMFS-OPR-6. 73 pp.

CETAP 1982. A characterization of marine mammals and turtles in the mid- and north Atlantic areas of the U.S. outer continental shelf, final report. Bureau of Land Management. Washington, DC #AA551-CT8-48. 538 pp.

Donovan, G.P. 1991. A review of IWC stock boundaries. Rep. Int. Whal. Comm. (Special Issue) 13: 39-68.

Flinn, R.D., A.W. Trites and E.J. Gregr 2002. Diets of fin, sei, and sperm whales in British Columbia: An analysis of commercial whaling records, 1963-1967. Mar. Mamm. Sci. 18(3): 663-679.

Henry A.H., T.V.N. Cole and M. Garron 2011. Mortality and serious injury determinations for baleen whale stocks along the United States eastern seaboard and adjacent Canadian Maritimes, 2005-2009. Northeast Fish Sci Cent Ref Doc. 11-xx. xx pp.

Hain, J.H.W., M.A. Hyman, R.D. Kenney and H.E. Winn 1985. The role of cetaceans in the shelf-edge region of the northeastern United States. Mar. Fish. Rev. 47(1): 13-17.

Hiby, L. 1999. The objective identification of duplicate sightings in aerial survey for porpoise. Pages 179-189 *in*: G. W. Garner, S. C. Amstrup, J. L. Laake *et al.*, (eds.) Marine Mammal Survey and Assessment Methods. Balkema, Rotterdam.

Horwood J. 1987. The Sei Whale: Population Biology, Ecology & Management. Croom Helm, London. 375 pp.

Jonsgård, Å. and K. Darling 1977. On the biology of the Eastern North Atlantic sei whale, *Balaenoptera borealis* Lesson. Rep. Int. Whal. Comm. (Special Issue) 1: 124-129.

Mitchell, E. 1975. Preliminary report on Nova Scotia fishery for sei whales (*Balaenoptera borealis*). Rep. Int. Whal. Comm. 25: 218-225.

Mitchell, E. and D.G. Chapman 1977. Preliminary assessment of stocks of northwest Atlantic sei whales (*Balaenoptera borealis*). Rep. Int. Whal. Comm. (Special Issue) 1: 117-120.

Palka, D.L. 1995. Abundance estimate of Gulf of Maine harbor porpoise. Rep. Int. Whal. Comm. (Special Issue) 16: 27-50.

Palka, D.L. 2005. Aerial surveys in the northwest Atlantic: estimation of g(0), Pages 12-17 *In*: Thomsen, F., F. Ugarte and P.G.H. Evans, eds. Proceedings of a Workshop on Estimation of g(0) in Line-Transect Surveys of Cetaceans. European Cetacean Society's 18th Annual Conference; Kolmården, Sweden; Mar. 28, 2004.

Palka, D.L. 2006. Summer abundance estimates of cetaceans in US North Atlantic Navy Operating Areas. Northeast Fish. Sci. Cent. Ref. Doc. 06-03. 41 pp.
http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0603/crd0603.pdf

Palka, D.L. and P.S. Hammond 2001. Accounting for responsive movement in line transect estimates of abundance. Can. J. Fish. Aquat. Sci 58: 777-787.

Payne, P.M., D.N. Wiley, S.B. Young, S. Pittman, P.J. Clapham and J.W. Jossi. 1990. Recent fluctuations in the abundance of baleen whales in the southern Gulf of Maine in relation to changes in selected prey. Fish. Bull. 88: 687-696.

Schilling, M.R., I. Seipt, M.T. Weinrich, S.E. Frohock, A.E. Kuhlberg and P.J. Clapham 1993. Behavior of individually identified sei whales, *Balaenoptera borealis*, during an episodic influx into the southern Gulf of Maine in 1986. Fish. Bull. 90(4): 749-755.

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