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FIN WHALE (*Balaenoptera physalus*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The Scientific Committee of the International Whaling Commission (IWC) has proposed stock boundaries for North Atlantic fin whales. Fin whales off the eastern United States, Nova Scotia and the southeastern coast of Newfoundland are believed to constitute a single stock under the present IWC scheme (Donovan 1991). Although the stock identity of North Atlantic fin whales has received much recent attention from the IWC, the current stock boundaries remain uncertain. The existence of a subpopulation structure was suggested by local depletions that resulted from commercial overharvesting (Mizroch *et al.* 1984).

A genetic study conducted by Bérubé *et al.* (1998) using both mitochondrial and nuclear DNA provided strong support for an earlier population model proposed by Kellogg (1929) and others. This postulates the existence of several subpopulations of fin whales in the North Atlantic and Mediterranean with limited gene flow among them. Bérubé *et al.* (1998) also proposed that the North Atlantic population showed recent divergence due to climatic changes (i.e., postglacial expansion), as well as substructuring over even relatively short distances. The genetic data are consistent with the idea that different subpopulations use the same feeding ground, a hypothesis that was also originally proposed by Kellogg (1929). More recent genetic studies have called into question conclusions drawn from early allozyme work (Olsen *et al.* 2014) and North Atlantic fin whales show a very low rate of genetic diversity throughout their range excluding the Mediteranean (Pampoulie *et al*. 2008).

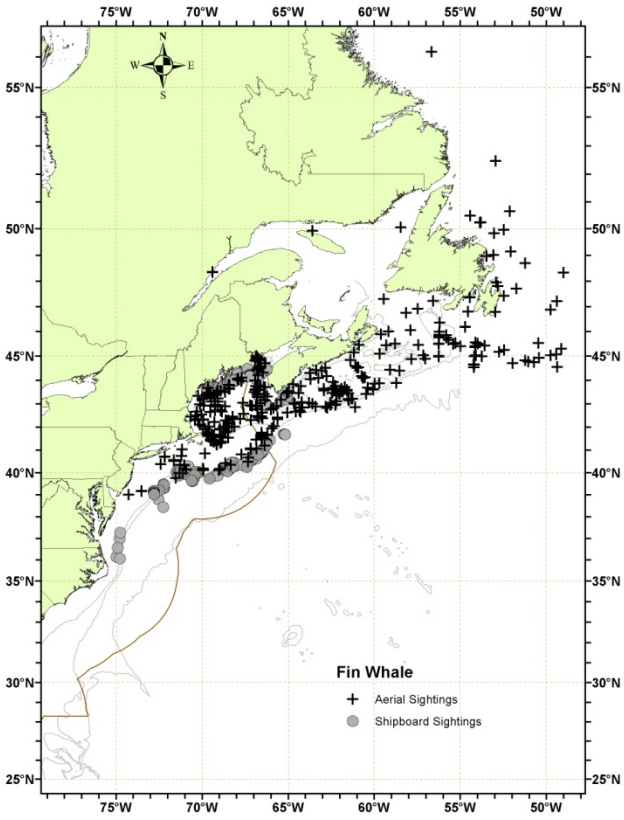

Figure 1. *Distribution of fin whale sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008, 2010 and 2011 and DFO's 2007 TNASS survey. Isobaths are the 100-m, 1000-m and 4000-m depth contours.*

Fin whales are common in waters of the U. S. Atlantic Exclusive Economic Zone (EEZ), principally from Cape Hatteras northward (Figure 1). Fin whales accounted for 46% of the large whales and 24% of all cetaceans sighted over the continental shelf during aerial surveys (CETAP 1982) between Cape Hatteras and Nova Scotia during 1978–82. While much remains unknown, the magnitude of the ecological role of the fin whale is impressive. In this region fin whales are the dominant large cetacean species during all seasons, having the largest standing stock, the largest food requirements, and therefore the largest influence on ecosystem processes of any cetacean species (Hain *et al.* 1992; Kenney *et al.* 1997).

New England waters represent a major feeding ground for fin whales. There is evidence of site fidelity by females, and perhaps some segregation by sexual, maturational or reproductive class in the feeding area (Agler *et al.* 1993). Seipt *et al.* (1990) reported that 49% of fin whales sighted on the Massachusetts Bay area feeding grounds were resighted within the same year, and 45% were resighted in multiple years. The authors suggested that fin whales on these grounds exhibited patterns of seasonal occurrence and annual return that in some respects were similar to those shown for humpback whales. This was reinforced by Clapham and Seipt (1991), who showed maternally-directed site fidelity for fin whales in the Gulf of Maine.

Hain *et al.* (1992), based on an analysis of neonate stranding data, suggested that calving takes place during October to January in latitudes of the U.S. mid-Atlantic region; however, it is unknown where calving, mating and wintering occurs for most of the population. Results from the Navy's SOSUS program (Clark 1995) indicate a substantial deep-ocean distribution of fin whales. It is likely that fin whales occurring in the U.S. Atlantic EEZ undergo migrations into Canadian waters, open-ocean areas, and perhaps even subtropical or tropical regions. However, the popular notion that entire fin whale populations make distinct annual migrations like some other mysticetes has questionable support in the data; in the North Pacific, year-round monitoring of fin whale calls found no evidence for large-scale migratory movements (Watkins *et al*. 2000).

POPULATION SIZE

The best abundance estimate available for the western North Atlantic fin whale stock is 1,618 (CV=0.33). This is the estimate derived from the 2011 NOAA shipboard surveys and is considered best because it represents the most current data in spite of the survey not including all of the stock's range.

Earlier abundance estimates

Please see Appendix IV for earlier abundance estimates. As recommended in the GAMMS II 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 of 2,269 (CV=0.37) fin whales was estimated 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; D. Palka, NEFSC, Woods Hole, MA, pers. comm.). 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 3,522 (CV=0.27; J. Lawson, DFO, pers. comm.) fin whales was generated from the TNASS in July–August 2007. This aerial survey covered the area from northern Labrador to the Scotian Shelf, providing full coverage of the Atlantic Canadian coast (Lawson and Gosselin 2009). The abundance estimates from this survey have been corrected for perception and availability bias, when possible. In general this involved correcting for perception bias using mark-recapture distance sampling, and correcting for availability bias using dive/surface times, as reported in the literature, and the Laake (1997) analysis method (Lawson and Gosselin 2011).

An abundance estimate of 1,595 (CV=0.33) fin whales was generated from a shipboard and aerial survey conducted during June–August 2011 (Palka 2012). The aerial portion that contributed to the abundance estimate covered 5,313 km of tracklines that were over waters north of New Jersey from the coastline to the 100-m depth contour, through the U.S. and Canadian Gulf of Maine and up to and including the lower Bay of Fundy. The shipboard portion covered 3,107 km of tracklines that were in waters offshore of North Carolina to Massachusetts (waters that were deeper than the 100-m depth contour out to beyond the U.S. EEZ). Both sighting platforms used a double-platform data collection procedure, which allows estimation of abundance corrected for perception bias of the detected species (Laake and Borchers 2004). Estimation of the abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the multiple covariate distance sampling (MCDS) option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009). The abundance estimates of fin 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 fin whales to the total number of positively identified fin whales and positively identified sei whales; the CV of the abundance estimate includes the variance of the estimated fraction.

An abundance estimate of 23 (CV=0.87) fin whales was generated from a shipboard survey conducted concurrently (June–August 2011) in waters between central Virginia and central Florida. This shipboard survey included shelf-break and inner continental slope waters deeper than the 50-m depth contour within the U.S. EEZ. The survey employed two independent visual teams searching with 25× bigeye binoculars. A total of 4,445 km of tracklines was surveyed, yielding 290 cetacean sightings. The majority of sightings occurred along the continental shelf break with generally lower sighting rates over the continental slope. Estimation of the abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

Table 1. Summary of recent abundance estimates for western North Atlantic fin 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
Aug 2006	S. Gulf of Maine to upper Bay of Fundy to Gulf of St. Lawrence	2,269	0.37
July-Aug 2007	N. Labrador to Scotian Shelf	3,522	0.27
Jun-Aug 2011	Central Virginia to lower Bay of Fundy	1,595	0.33
Jun-Aug 2011	Central Florida to Central Virginia	23	0.76
Jun-Aug 2011	Central Florida to lower Bay of Fundy (COMBINED)	1,618	0.33

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 fin whales is 1,618 (CV=0.33). The minimum population estimate for the western North Atlantic fin whale is 1,234.

Current Population Trend

A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval. For example, the power to detect a precipitous decline in abundance (i.e., 50% decrease in 15 years) with estimates of low precision (e.g., CV > 0.30) remains below 80% (alpha = 0.30) unless surveys are conducted on an annual basis (Taylor *et al.* 2007).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. Based on photographically identified fin whales, Agler *et al.* (1993) estimated that the gross annual reproduction rate was 8%, with a mean calving interval of 2.7 years.

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 1,234. The maximum productivity rate is 0.04, the default value for cetaceans. The recovery factor, which accounts for endangered, depleted, or threatened stocks, or stocks of unknown status relative to optimum sustainable population (OSP), is assumed to be 0.10 because the fin whale is listed as endangered under the Endangered Species Act (ESA). PBR for the western North Atlantic fin whale is 2.5.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

For the period 2008 through 2012, the minimum annual rate of human-caused mortality and serious injury to fin whales was 3.35 per year. This value includes incidental fishery interaction records, 1.55; and records of vessel collisions, 1.8 (Table 2; Cole and Henry 2015). Annual rates calculated from detected mortalities should not be considered an unbiased representation of human-caused mortality, but they represent a lower bound. Detections are haphazard 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.

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious

injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998; Andersen *et al*. 2008; NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*." All injury determinations for this stock assessment were performed under the new guidelines. The new process involves proration of serious injury determinations where there is uncertainty regarding the severity or cause.

Fishery-Related Serious Injury and Mortality

No confirmed fishery-related mortalities or serious injuries of fin whales have been reported in the NMFS Sea Sampling bycatch database. A review of the records of stranded, floating or injured fin whales for the period 2008 through 2012 on file at NMFS found 3 records with substantial evidence of fishery interactions causing mortality (Henry *et al*. 2014). Serious injury determination of non-fatal fishery interaction records yielded a value of 4.75 (Cole and Henry 2015). The resultant estimated minimum annual rate of serious injury and mortality from fishery interactions for this fin whale stock is 1.55. These records are not statistically quantifiable in the same way as the observer fishery records, and they almost surely undercount entanglements for the stock.

Table 2. Confirmed human-caused serious injury and mortality records of Fin Whales (*Balaenoptera physalus*) where the cause was assigned as either an entanglement (EN) or a vessel strike (VS): 2008-2012[a]

Date[b]	Injury Determination	ID	Location[b]	Assigned Cause	Value against PBR[c]	Country[d]	Gear Type[e]	Description
7/2/2008	Mortality	-	off Barnegat Inlet, NJ	VS	1	US	-	Vertebral fractures w/ associated hemorrhaging. Hemorrhaging around ball joint of right pectoral
4/27/2009	Prorated Injury	-	off Portsmouth, NH	EN	0.75	XU	NR	Entanglement configuration unknown.
9/9/2009	Prorated Injury	-	off Campobello Island, New Brunswick	EN	0.75	XC	NR	Partial disentanglement, but final entanglement configuration unknown.
10/1/2009	Mortality	-	off Jersey City, NJ	VS	1	US	-	Fresh carcass w/ broken pectoral, hematomas, & abrasions.
10/9/2009	Prorated Injury	-	off Long Island, Nova Scotia	EN	0.75	XC	GU	Configuration unknown. Cannot confirm gear free. Indication of poor health, but incomplete description and no photos.
3/18/2010	Mortality	-	South Delaware Bay Beach, DE	VS	1	US	-	Fractured skull w/ associated hemorrhaging. Abrasion mid-dorsal consistent

								w/ being folded over the bow of a ship.
9/3/2010	Mortality	-	Cape Henlopen State Park, DE	VS	1	US	-	Large laceration & vertebral fractures w/ associated hemorrhaging.
1/1/2011	Mortality	-	off Portland, ME	EN	1	XU	NP	Fresh carcass w/ evidence of constricting gear.
6/5/2011	Mortality	-	off Long Branch, NJ	VS	1	US	-	Extensive hemorrhage & soft tissue damage to the dorsal & right lateral thoracic region.
7/2/2011	Serious Injury	F100	Gulf of St. Lawrence	EN	1	CN	PT	Deep lacerations at peduncle. Unconfirmed if gear free.
7/24/2011	Mortality	-	Cheticamp, Nova Scotia	EN	1	CN	NP	Fresh carcass w/ evidence of extensive entanglement.
9/21/2011	Mortality	-	off Atlantic City, NJ	EN	1	US	NP	Fresh carcass w/ evidence of extensive entanglement.
1/23/2012	Mortality	-	Ocean City, NJ	VS	1	US	-	Hemorrhaging along right, midlateral surface.
2/19/2012	Mortality	-	Norfolk, VA	VS	1	US	-	Deep laceration on head. Skeletal fractures of rostrum and vertebrae. Extensive hemorrhaging.
7/16/2012	Prorated Injury	-	off Portland, ME	EN	0.75	XU	NR	Full configuration unknown.
7/30/2012	Prorated Injury	0631	off Portsmouth, NH	EN	0.75	XU	NR	Full configuration unknown.
8/10/2012	Mortality	-	Hampton Bays, NY	VS	1	US	-	Extensive bruising along right lateral and ventral aspects.
10/7/2012	Mortality	-	Boston Harbor, MA	VS	1	US	-	Deep mid-line impression with associated hemorrhaging consistent with being folded

								across bow of ship.
Five-year averages		Shipstrike (US/CN/XU/XC)			1.80 (1.80/ 0.00/ 0.00/ 0.00)			
		Entanglement (US/CN/XU/XC)			1.55 (0.20/ 0.40/ 0.65/ 0.30)			
a. For more details on events please see Cole and Henry 2015 and Henry *et al.* 2014.								
b. 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.								
c. Mortality events are counted as 1 against PBR. Serious injury events have been evaluated using NMFS guidelines (NOAA 2012)								
d. CN=Canada, US=United States, XC=Unassigned 1st sight in CN, XU=Unassigned 1st sight in US								
e. H=hook, GN=gillnet, GU=gear unidentifiable, MF=monofilament, NP=none present, NR=none recovered/received, PT=pot/trap, WE=weir								

Other Mortality

After reviewing NMFS records for 2008 through 2012, nine were found that had sufficient information to confirm the cause of death as collisions with vessels (Table 2; Henry *et al.* 2014.). These records constitute an annual rate of serious injury or mortality of 1.8 fin whales from vessel collisions

STATUS OF STOCK

This is a strategic stock because the fin whale is listed as an endangered species under the ESA. The total level of human-caused mortality and serious injury is unknown. NMFS records represent coverage of only a portion of the area surveyed for the population estimate for the stock. The total U.S. fishery-related mortality and serious injury for this stock derived from the available records is likely biased low and is still not less than 10% of the calculated PBR. Therefore entanglement rates cannot be considered insignificant and approaching a zero mortality and serious injury rate. 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 the population trend for fin whales. A final recovery plan for the fin whale was published in 2010 (NMFS 2010).

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