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Asjley Barratclough, Paul D. Jepson, Philip K. Hamilton, Carolyn A. Miller, Kenady Wilson, Michael J. Moore

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How much does a swimming, underweight, entangled right whale (*Eubalaena glacialis*) weigh? Calculating the weight at sea, to facilitate accurate dosing of sedatives to enable disentanglement

Ashley Barratclough,[1] Zoological Society of London, Regents Park, London, NW1 4RY, United Kingdom and Royal Veterinary College, Royal College Street, London, NW1 0TU, United Kingdom; **Paul D. Jepson**, Zoological Society of London, Regents Park, London, NW1 4RY, United Kingdom; **Philip K. Hamilton**, New England Aquarium, Central Wharf, Boston, Massachusetts 02110, U.S.A.; **Carolyn A. Miller**, Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, Massachusetts 02543-1050, U.S.A.; **Kenady Wilson**, Duke University, Box 90328, Durham, North Carolina 27708-0328, U.S.A.; **Michael J. Moore**, Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, Massachusetts 02543-1050, U.S.A.

Despite commercial whaling of the North Atlantic right whale ceasing in 1935, the population numbers are still struggling to recover (Kraus *et al*. 2005). The current population estimate is 450 individuals (Waring *et al*. 2013). The two main anthropogenic causes of mortality to the population are entanglement in fishing gear and vessel collisions (Knowlton *et al*. 2001). Increasing Allee effects of such a small population in a large environment may be slowing the reproductive recovery (Fujiwara and Caswell 2001).

Entanglement in fishing gear has been defined as the presence of line, rope, netting, and other materials encircling the whale (Benjamins *et al.* 2012). Mortality as a result of entanglement can be a chronic process with the average time entangled, lasting six months and the maximum known extending to eighteen months (Moore and van der Hoop 2012). How quickly the whale succumbs to the entanglement is a result of the extent of the entanglement and the anatomy involved (Knowlton *et al.* 2001). The baleen has been found to be the most frequently entangled area in the right whale (Johnson *et al.* 2005), impairing foraging and resulting in death due to emaciation and starvation (Cassoff *et al.* 2011). Increased energy requirements from towing large amounts of gear with excessive drag can speed up the demise (Moore

[1]Corresponding author (e-mail: ashley_2486_b@yahoo.com).

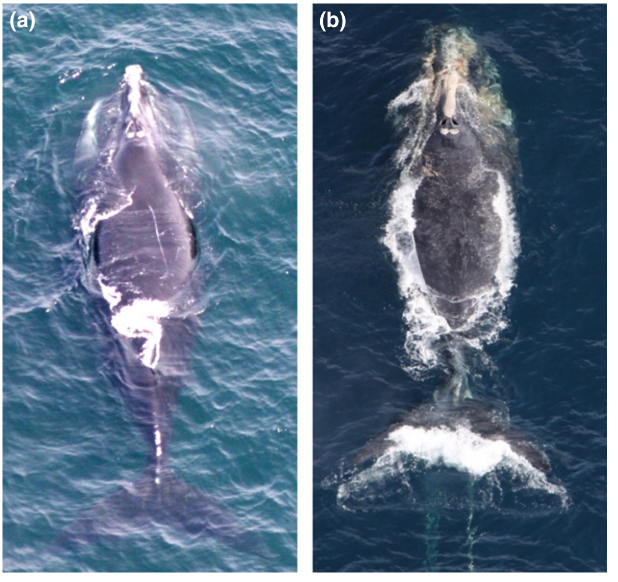

Figure 1. Aerial image of a North Atlantic right whale Eg 3311 demonstrating the rapid weight loss which can occur due to chronic fishing gear entanglements. (a) Eg 3311 21 April 2008 demonstrating good body condition. (b) Eg 3311 6 March 2009 loss of body condition noted by decreased width.

et al. 2006), and increase the susceptibility to death from other causes such as vessel collisions, starvation, and predation (Kot *et al*. 2009). The effects of fishing gear entanglement on body condition are clearly apparent in Figure 1.

Case Eg 3311(Fig. 1) was successfully disentangled *via* the use of sedation with midazolam and butorphanol, although it is thought the animal subsequently died from entanglement sequelae (Moore *et al*. 2010). Comparison between the two images demonstrates a clear reduction in body condition when the animal is entangled.

This study focuses on underweight right whales, those that are emaciated or that have a reduced body condition. A right whale can be defined as emaciated *via* observing one or more of the following criteria (adapted from Weller *et al.* 2003 and Pettis *et al.* 2004): the presence of concavities around the blowholes and head with the presence of a postcranial hump along the dorsal surface, clear subdermal protrusion of the scapulae with associated thoracic depressions at the anterior and posterior insertion points of the pectoral flipper, protrusion of the neural or dorsal spine, protrusion of the ribcage. Reduced body condition can be defined as whales exhibiting a slight to moderate dip in the profile of the back behind the nuchal crest.

Current entanglement mitigation methods include modification of the fishing gear used, such as the presence of weak links to facilitate breaking of gear if a whale becomes entangled, sinking ground lines, seasonal closures of fishing areas and attempting disentanglement (Johnson *et al.* 2005). Sedation has been shown to facilitate approaching an entangled whale to enable complex disentangling (Moore *et al*. 2012). However for sedation to be as safe as possible accurate weights need to be obtained to calculate the correct sedative dose for the whale. The key to a safe anesthetic and good sedation control to facilitate disentanglement is accurate dosing according to weight. Due to the fact that cetaceans are voluntary breathers, too much sedation may impair the whale's ability to breathe. Overdosing an already compromised animal could increase the anesthetic risk of loss of consciousness, potentially resulting in a failure to locomote in the aquatic species ultimately leading to apnea due to the inability to remain at the surface. Too little sedation will be ineffective, decrease the likelihood of successful disentanglement and put the disentanglement team at greater risk.

Producing a simple, accurate method of establishing a body weight will facilitate more accurate sedative dosing, reducing the associated risks. Improving techniques will encourage increased use of sedation to assist disentangling if the whale is identified early, rather than intervening when the whale has already deteriorated too far. North Atlantic right whales are the least tractable species to disentangle due to their persistent and successful avoidance of close-approaching vessels (Moore *et al.* 2010). Due to their increased muscle strength compared to other species right whales have been shown to be less tolerant to the additional drag placed upon them during a disentanglement effort (Johnson *et al.* 2005). Effective sedation methods are therefore even more applicable to this species to facilitate approach. However, no matter how well the disentanglement process is developed, the only lasting solution to the entanglement problem is avoidance of entanglement in the first place.

Estimation of the weight of entangled right whales is also a necessary step in understanding the energetic costs of chronic entanglement (van der Hoop *et al.* 2014).

Previous weight estimation techniques involved the use of the formula $W = aL^b$ where W is mass in kg, L is length in cm and a and b are constants (Lockyer 1976). Using length alone to estimate weight would not account for chronically entangled whales, which are often underweight (Schultz 1938). A formula combining length (cm) and circumference (cm) data to estimate weight (kg) has been used successfully in harbor porpoises (*Phocoena phocoena*):

$$W = 4.74 \times 10^{-5} L^{1.68} (C_1 + C_2)^{1.05}$$

C_1 is the circumference rostral to the pectoral fins and C_2 is a measurement of the circumference caudal of the pectoral fins (Kastelein and Battum 1990). Porpoises are, however, significantly smaller than right whales and could therefore be weighed accurately in their entirety to facilitate identification of the constants.

Previous weight calculations such as those from graphs of lengths and weights of healthy animals (Geraci and St. Aubin 1979), do not account for underweight animals. Comparing the weights between healthy robust right whales and those which were underweight due to entanglement proved significantly different therefore an accurate way in determining the weights of these animals is required (Cassoff *et al.* 2011).

The relationship between length and circumference in right whales, following their rapid growth rate as calves, has been shown to have a linear correlation (Miller *et al.* 2012). We hypothesize that if the width and length of right whales are linearly related, then the use of an allometric model to determine the weight at sea of right whales could be established. By establishing an accurate method to estimate the weight, correct dosing of sedatives could be achieved. The main limitation of the current methods used to estimate weight is failing to account for underweight whales as a result of chronic entanglement (Fortune *et al.* 2012).

Postmortem reports from the North Atlantic Right Whale Consortium Database extending back to 1970 were examined for morphometric measurements. Snout to tail notch body length, axillary circumference and accurate weights obtained or weight estimations undertaken at the time of postmortem were recorded. Accurate weights were obtained when the entire carcass was weighed whole *via* a loading crane weight sensor or *via* a truck on a weighing station. Estimates of weights were achieved *via* a sum of parts after the necropsy had taken place with an additional 6.8% added to account for blood loss (Lockyer 1976). However in some cases only an estimate of weight was given with no explanation into the method used to obtain the weight. These cases were not used to create the algorithms due to the data being potentially inaccurate.

For carcasses that had been towed up the beach a 9% deduction of length was undertaken due to the stretching of the carcass which occurs during hauling (George and Zeh 2004).

Additional morphometric data were obtained from the Miller *et al.* 2012 study, which measured length (snout to fluke notch) and width at 8 locations along the length of free swimming right whales using aerial photogrammetry. We selected axillary width (40% of body length), as this is a standard point along the length of the body to which a width can be selected, and it can be assumed that the circumference is approximately spherical at this point (Miller *et al.* 2012). Although Miller *et al.* (2012) observed that width was most variable between individuals at 60% of the body length, when weight loss occurred, a conversion from width to circumference could not easily be achieved here and insufficient circumference data at this point prevented calculation. The circumference can be calculated by using the equation:

$$\text{Circumference} \ = \pi(\text{Width})$$

As photographs yielded width measurements and postmortem yielded circumference data it was important to be able to convert between the two.

Photographic data obtained from healthy adults provided a comparison between underweight animals of similar lengths, which for example had suffered chronic entanglements and were weighed postmortem. Figure 2 shows all the available photogrammetry data combined with the postmortem reports. It facilitates a comparison between weights from healthy right whales (blue) and from underweight right whales (red). The red data points are consistently lower in weight for a given length compared with the healthy blue data points. The starting neonatal calf length is clear at ~420 cm.

Weights were available for 17 out of 64 postmortem reports. Of these 17, eight were direct weights, three were sums of parts and the remaining six were weight estimates. Body weights ranged from 909 to 52,640 kg. Total length from snout to fluke notch was available for all 64 cases, ranging from 355 cm to 1729 cm. Axial circumference measurements were present for 18/64 cases ranging from 260 to 930 cm. Lack of circumference data was mainly due to decomposition leading to either excessive bloating or deflation and therefore measurements inconsistent with *in vivo* body shape.

From the 64 cases 34% were the direct result of entanglements, 34% were due to collisions with vessels and the remaining 32% were either neonates, no parsimonious cause of death was determined or no necropsy was performed. As the aim of this pro-

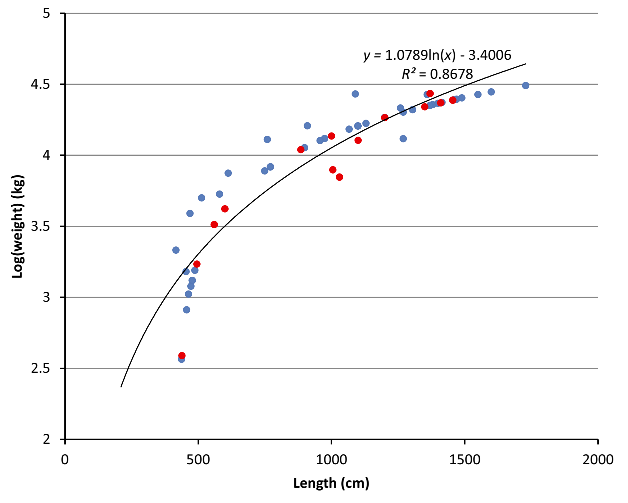

Figure 2. Length *vs.* log (weight) of all available data, from photogrammetry measurements and nonentanglement postmortem cases of North Atlantic right whales. The red data points indicate the underweight cases; the blue points are the additional postmortem cases from non-entanglement cases and photogrammetry data where the weight has been calculated from the regression equation.

ject is to facilitate sedation of animals with chronic entanglements, it was important to create the formula based on underweight animals as this will give a more accurate representation. Neonatal animals that had not fed, with fetal folds still present, were also included as again had poor body condition and subsequently reduced circumferences. Further details of the underweight cases are presented in Appendix S1. Cases defined as "other" included other underweight whales that had a cause of death other than entanglement such as euthanasia or died as a result of chronic vessel collision injuries. They were included due to poor body condition. Comparison between weights for a given length for those whales which died acutely *via* vessel strike against a chronic entanglement revealed on average a 28% reduction in weight in the underweight cases.

Multiple linear regression analysis was used to calculate the weight of each whale from length and circumference data. This was performed initially on the cases having direct weight data. Only postmortem data measurements from underweight whales were used to create the formula, therefore 47 of 64 postmortem cases were discounted.

Of the underweight cases 5 of 12 postmortem reports contained circumference measurements, in addition to accurate length and weight. Table 1 presents the data for five underweight right whales, with complete data sets. This included ID, date, sex, length, circumference, and actual weight. Actual weights, not estimates were achieved *via* weighing the carcass whole either with a crane or a weigh station. Although case #1223 necropsy's report concluded cause of death as a vessel collision, she had a previous history of three minor entanglements, and had been nursing a calf for at least 8 mo prior to death and therefore will also have been in poor body condition (Miller *et al*. 2011).

Table 1. Complete underweight North Atlantic right whale mortality cases with accurate length, circumference, and weight data present. Weights were achieved by weighing the carcass whole either with a crane or weigh station.

ID	Sex	Length (cm)	Axial circumference (cm)	Weight (kg)
Eg 1223	F	1,360	920	32,670
Eg 2366	M	1,030	541	9,055
Eg 0803 Hubbs	M	470	302	1,315
MH_89424	M	425	224	1,225
RKB 1451	F	455	265	1,130

Simple linear regression between length and circumference (using data only from Table 1) yielded the first equation:

$$\text{Circumference} = 0.668 \times \text{length} - 48.919 \tag{1}$$

Equation 1 was used to calculate predicted circumference for those cases (5/11) which had length and weight data but not circumference. These data are presented in Table 2 which displays the data for all the underweight right whales with a given weight and length, as well as the real circumference if available or a calculated circumference if not.

Using only whole weight measurements (not estimates or sums of parts), a multiple linear regression analysis was performed using SPSS with weight as the dependent variable and length and measured circumference as the independent variables to obtain Equation 2:

$$\text{Weight} = (-26.429 \times \text{length}) + (75 \times \text{circumference}) - 6,333.431 \tag{2}$$

Due to the significant variation between the juvenile and adult lengths separate regressions were subsequently performed. Therefore if length only is

Table 2. The length, axial circumference and weight data for all underweight North Atlantic right whale mortality cases with a given weight. The predicted circumferences were produced *via* using Equation 2. Predicted weights were produced from Equation 1. W = whole weight, S = sum of parts, and E = estimate.

ID	Length (cm)	Axial circumference (cm)	Predicted circumference (cm)	Weight (kg)	Predicted weight (kg)
Eg 1223	1,360	920	860	32,670 (W)	26,723
Eg 2030	1,350		853	14,785 (S)	21,962
Eg 2366	1,030	541	639	9,055 (W)	7,020
Eg Jan_30_04	478		270	1,800 (E)	1,284
NEFL 0704	401		219	749 (W)	-506
Eg 0803 Hubbs	470	302	265	1,315 (W)	3,895
KLC_022	495		282	1,586 (W)	1,734
MH_89424	425	224	235	1,225 (W)	-766
RKB 1425	473		267	1,134 (E)	1,191
RKB1449	417	260	230	909 (E)	2,146
Jan0296 calf	478		270	1,151 (S)	1,516
RKB 1451	455	265	255	1,130 (W)	1,284

available on a juvenile and it is <600 cm then the following algorithm will be more accurate:

$$\text{Weight} = (0.6675 \times \text{length}) - 48.919 \tag{3}$$

This was formulated *via* a simple linear regression of the known juvenile weights and lengths. Variation in the circumference at such short lengths is much less, and therefore the equation including only length is sufficient. Also most juveniles of this length which strand or die are malnourished, and therefore all have small circumferences.

To produce an alternative equation to estimate weight from available length and circumference data we used a Bayesian analysis (Gelman *et al.* 2013). Bayesian frameworks have been used in marine mammals to investigate complex growth patterns (McFee and Schwacke 2010). The following Bayesian formula was developed using R (available at www.cran.r-project.org/web/packages/arm/arm.pdf):

$$\begin{aligned} \text{Weight} = 6044.79 - 17.88 \times (\text{length}) - 9.14 \times (\text{circumference}) \\ + 0.05 \times (\text{length} \times \text{circumference}) \end{aligned} \tag{4}$$

The default priors were used, which are normal priors for the means and inverse gamma for the covariance. The weight output results from Equations 2 and 4 were compared by an independent *t*-test and found to be significantly different with a value of $P < 0.049$ with Equation 4 being more accurate. The weight estimates for this equation for a given length and circumference are presented for practical application in Appendix S2. This table facilitates the weight calculation from Equation 4 to be easily obtained for a given length and width or circumference. The weight estimate can then be used to calculate the correct sedative dose. Bayesian analysis provided closer estimates to the actual weights than the simple linear regression outputs. At the smaller lengths Equation 2 actually produced negative values, which is why Equation 3 should be used for juveniles. This is demonstrated in the final two columns in the table in Appendix S1. For future reference Equation 3 should be used for juveniles where circumference is not available and Equation 4 should be used for adults.

Despite there being extensive morphometric data available for the right whale, accurate body weights still remain extremely sparse. We have shown that weight estimations can be obtained from morphometric data for both mesomorphic and underweight right whales. Due to logistics and practicalities weighing the carcass of a right whale is extremely challenging, however in several reports the whole carcass was transported and the use of a weigh station could have been employed. Improving the quantity of data by including other species such as the data obtained from bowhead whales from the hunts in Alaska or from southern right whales was not a viable option due to their completely different morphology in terms of circumference to length relationship. Also the majority of data that are available from other species are also for healthy robust individuals: it is data from underweight entanglement cases that we are lacking.

An additional factor resulting in a lack of available data is the loss of carcasses. Due to chronic entanglements debilitating the body condition, resulting in reduced blubber reserves, the whales are negatively buoyant, and therefore will more likely sink after death than float (Moore 2009). Whales with acute entanglements will be more likely to have good blubber reserves than those with chronic entanglements. However, despite this they still have a low detection probability as the heavier fishing gear causing acute entanglements is located further offshore beyond the shipping lanes. Carcasses are therefore more likely to drift further out to sea due to the offshore currents and winds than come ashore and be identified (Moore *et al*. 2004).

Due to logistics it is much easier to weigh a calf or juvenile whale than a fully grown adult, which could weigh up to 100,000 kg. As a result the available data were skewed with a higher percentage below 2,000 kg. Consequently the data are likely to be more accurate for juveniles, than older age classes. As the aim of this study is to facilitate weight estimates for entangled animals to enable accurate sedation, including only underweight animals allows narrower confidence intervals. Other available growth curves likely overestimate the weight of an entangled animal relative to the mass at length predictions (Fortune *et al.* 2012). The age bias of the data is useful as it will improve the estimate accuracy in a time period of rapid growth. Body length appears to reach an asymptote at approximately 12 yr of age (Moore *et al*. 2004). Variation in length in older whales is therefore reduced, which is why incorporating the circumference into the equation is so important (Fortune *et al.* 2012).

The main challenge of this project was the small sample size due to the lack of available data. Any additional weight information gleaned from future postmortem reports will therefore likely have a large influence on the regression equation. However, despite the data paucity, for now, these are the only information upon which the weight of an underweight right whale can be estimated, thus this analysis is inherently valuable as a management tool. Figure 3 demonstrates the close relationship between morphometrics despite the low sample size.

Previously, to estimate the weight of the chronically entangled Eg3911, aerial images of body length and width morphometrics were compared with those from healthy whales (Miller *et al*. 2012) and weights at age data (Moore *et al*. 2012). The whale was estimated to be around 7,000 kg (van der Hoop *et al*. 2014). Using

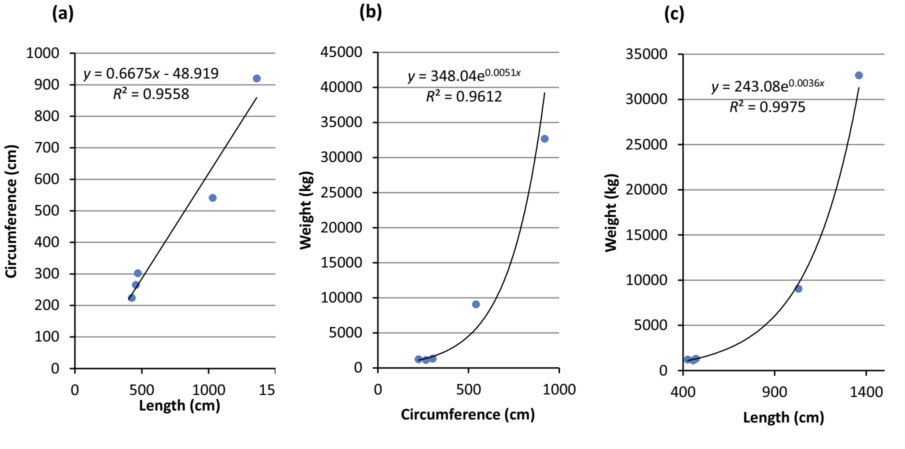

Figure 3. (a) Represents the linear relationship between length and circumference for the 5 complete underweight North Atlantic right whale cases. (b) shows the growth curve which is present between circumference and weight, again for the 5 complete underweight cases. (c) shows the close relationship between length and weight for the same 5 cases.

equation with a length of 945 cm and a circumference of 559 cm the estimated weight is 10,451 kg. The whale did, however, respond well to the given sedation dose calculated for 7,000 kg at 0.1 mg/kg of butorphanol and midazolam at that weight (van der Hoop *et al*. 2014). At the higher weight calculated here, the actual dose may have been closer to 0.07 mg/kg for each drug. It is well known in small animal veterinary medicine that poor health status or old age prior to an anesthetic increases the efficacy of the anesthetic (Brodbelt and Hammond 2006). The presence of infection in dogs has been shown to increase anesthetic risk, therefore, if the entanglement wounds are chronically infected the whale will be an even higher risk candidate (Pelander *et al*. 2008). Entangled whales' sensitivity to the drugs will be higher therefore lower dosages should be selected. It appears from this case at least that the lower dose was effective.

Fishing gear entanglement represents a significant source of anthropogenic mortality in right whales (Glass *et al*. 2008). Consistent monitoring of the trends in entanglements has demonstrated a rise in the number of whales affected (Knowlton *et al*. 2012). The persistence of terminal entanglements demonstrates the urgent need to improve individual entanglement mitigation (Moore *et al*. 2012). Additional insight as to why large right whales become severely entangled will depend on continued monitoring (Johnson *et al.* 2005). We successfully created an allometric formula (Equation 4) relating length and circumference measurements obtained from carcasses to facilitate accurate weight estimation from photogrammetry images of entangled whales to enable sedative dosage calculations. Further research into the prevention of entanglements will be necessary to mitigate this anthropogenic cause of mortality in North Atlantic right whales (van der Hoop *et al*. 2012).

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Supporting Information

The following supporting information is available for this article online at http://onlinelibrary.wiley.com/doi/10.1111/mms.12132/suppinfo.

Appendix S1. Table of contents of all 25 underweight North Atlantic right whales. Body condition status determined by entanglement (E), neonate (N) or other (O). Weight determined by whole weight (W), sum of parts (S) or estimated (E).

Appendix S2. Table of North Atlantic right whale weights (kg) produced by length (cm) on the vertical axis and girth (cm) on horizontal axis from Equation 4. The color grading marks the increase in weight with red being the lightest and green the heaviest.

Appendix S1. Table of contents of all 25 underweight North Atlantic right whales. Body condition status determined by entanglement (E), neonate (N) or other (O). Weight determined by whole weight (W), sum of parts (S) or estimated (E).

Necropsy ID	Date	Minimum age	Sex	Length (cm)	Axial girth (cm)	Actual weight (kg)	Predicted weight Equation 2	Predicted weight Equation 4
Eg_NEFL 0802 (N)	15 February 2008	–	M	355	188	–	−1,599	1,318
Eg_NEFL 0704 (N)	27 January 2007	–	M	401	219	749 (W)	−510	1,264
RKB 1449 (N)	9 January 1997	0	M	417	260	909 (E)	2146	1,633
MH_89424 (N)	2 January 1989	0	M	425	224	1,225 (W)	−766	1,158
Eg Jan_26_70 (N)	26 January 1970	–	F	439	244	–	389	1,325
RKB 1451 (N)	10 January 1998	0	F	455	265	1,130 (W)	1,516	1,516
HNN_893_Dec (N)	30 December 1981	0	M	464	261	–	981	1,419
Eg 0803 Hubbs (N)	26 January 2008	–	M	470	302	1,315 (W)	3,895	1,978
RKB 1425 (N)	15 January 1993	0	F	473	267	1,134 (E)	1,194	1,462
Eg Jan_30_04 (N)	30 January 2004	–	M	478	270	1,800 (E)	1,312	1,489
Jan0296Calf (N)	2 January 1996	0	F	478	270	1,151 (S)	1,312	1,489
KLC_022 (N)	16 December 2008	–	M	495	282	1,586 (W)	1,715	1,592
Eg_NEFL 0603 (E)	22 January 2006	–	F	560	325	–	3,253	2,165
BRF 134 (E)	31 March 2007	–	M	772	467	–	8,272	5,992.7
Eg_NEFL 1235 (E)	18 December 2012	–	M	885	542	–	10,946	9,260
Eg 3911 (E)	1 February 2011	3	F	1,000	619	6,000 (E)	13,669	13,460
RKB 1420 (E)	12 March 1991	–	F	1,005	622	15–20,000 (E)	13,787	13,663
Eg 2366 (E)	17 July 1995	2.5	M	1,030	541	9,055 (W)	7,020	10,545
Eg 3107 (E)	13 October 2004	1	F	1,100	686	–	16,036	17,831
Eg 052106 (E)	23 May 2006	–	X	1,130	706	–	16,746	19,273
Eg 2220 (E)	9 March 1996	5	M	1,270	799	–	20,060	26,795
Eg 2030 (O)	20 October 1999	10	F	1,350	853	14,785 (S)	21,953	31,681
Eg 1223 (O)	5 September 1992	12	F	1,360	920	32,670 (W)	26,723	35,879
Eg 2301 (E)	3 March 2005	12	F	1,380	873	–	22,664	33,623

Eg 1238 (E)	3 November 2001	19	M	1,455	923	–	24,439	38,743

Appendix S2. Table of North Atlantic right whale weights (kg) produced by length (cm) on the vertical axis and girth (cm) on horizontal axis from Equation 4. The color grading marks the increase in weight with red being the lightest and green the heaviest.

Width (cm) →	80	95	111	127	143	159	175	191	207	223	239	255	271	286	302	318	334	350	366
Circumference (cm) →	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150
Length (cm) ↓																			
400	1608	2151	2694	3237	3780	4323	4866	5409	5952	6495									
450	1339	2007	2675	3343	4011	4679	5347	6015	6683	7351	8019								
500		1863	2656	3449	4242	5035	5828	6621	7414	8207	9000	9793							
550		1719	2637	3555	4473	5391	6309	7227	8145	9063	9981	10899	11817						
600		1575	2618	3661	4704	5747	6790	7833	8876	9919	10962	12005	13048	14091					
650			2599	3767	4935	6103	7271	8439	9607	10775	11943	13111	14279	15447	16615				
700			2580	3873	5166	6459	7752	9045	10338	11631	12924	14217	15510	16803	18096	19389			
750			2561	3979	5397	6815	8233	9651	11069	12487	13905	15323	16741	18159	19577	20995	22413		
800				4085	5628	7171	8714	10257	11800	13343	14886	16429	17972	19515	21058	22601	24144	25687	
850				4191	5859	7527	9195	10863	12531	14199	15867	17535	19203	20871	22539	24207	25875	27543	29211
900					6090	7883	9676	11469	13262	15055	16848	18641	20434	22227	24020	25813	27606	29399	31192
950					6321	8239	10157	12075	13993	15911	17829	19747	21665	23583	25501	27419	29337	31255	33173
1000					6552	8595	10638	12681	14724	16767	18810	20853	22896	24939	26982	29025	31068	33111	35154
1050						8951	11119	13287	15455	17623	19791	21959	24127	26295	28463	30631	32799	34967	37135
1100						9307	11600	13893	16186	18479	20772	23065	25358	27651	29944	32237	34530	36823	39116
1150						9663	12081	14499	16917	19335	21753	24171	26589	29007	31425	33843	36261	38679	41097
1200							12562	15105	17648	20191	22734	25277	27820	30363	32906	35449	37992	40535	43078
1250							13043	15711	18379	21047	23715	26383	29051	31719	34387	37055	39723	42391	45059
1300							13524	16317	19110	21903	24696	27489	30282	33075	35868	38661	41454	44247	47040
1350								16923	19841	22759	25677	28595	31513	34431	37349	40267	43185	46103	49021
1400								17529	20572	23615	26658	29701	32744	35787	38830	41873	44916	47959	51002
1450								18135	21303	24471	27639	30807	33975	37143	40311	43479	46647	49815	52983
1500									22034	25327	28620	31913	35206	38499	41792	45085	48378	51671	54964
1550									22765	26183	29601	33019	36437	39855	43273	46691	50109	53527	56945

1600	23496	27039	30582	34125	37668	41211	44754	48297	51840	55383	58926
1650		27895	31563	35231	38899	42567	46235	49903	53571	57239	60907
1700		28751	32544	36337	40130	43923	47716	51509	55302	59095	62888