Length at birth and at independence in humpback whales

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ABSTRACT

This paper reviews published and unpublished data on length at birth and at independence in the humpback whale (*Megaptera novaeangliae*). The available data indicate that humpback whale calves are 3.96-4.57m (13 to 15ft) in length at birth, and approximately 8 to 10m (26.25 to 30.48ft) at independence. Timing is important in such assessments: because of the strong seasonal breeding cycle of this species, for young calves (i.e. those observed or taken in winter on the breeding grounds), length data alone are sufficient to determine whether an animal is a calf. In cases where actual length data are unavailable or unreliable, apparent length relative to that of an accompanying adult (i.e. the possible mother) may be used to define a calf, but only for young animals (<3 months of age) during winter. Simulations based upon available length frequencies are used to calculate probabilities associated with such a ratio; the results indicate that any animal whose length appears to be less than 63% of that of an accompanying whale is probably a calf.

KEYWORDS: HUMPBACK WHALE; WHALING-ABORIGINAL; WHALING-MODERN; REPRODUCTION; MORPHOMETRICS; PARTURITION; SEXUAL MATURITY

INTRODUCTION

Following discussion in the IWC Scientific Committee of a small humpback whale (*Megaptera novaeangliae*) taken in the St. Vincent fishery in 1998, the first author was requested to provide a review of the size distribution of calves of this species (IWC, 1999, p.36). Inherent in any such review is the definition as to what is to be considered a calf. In a management context, whaling regulations have long used the term 'calf'. For example, the first Schedule[1] to the International Convention for the Regulation of Whaling (IWC, 1950) states that :

> 'It is forbidden to take or kill calves or suckling whales or female whales which are accompanied by calves or suckling whales'.

This wording remained until 1975 when, after consideration within the Scientific Committee, it was amended to read:

> 'It is forbidden to take or kill suckling calves or female whales accompanied by calves'.

Also at this time, a definition of 'lactating' was added to the Schedule (IWC, 1977). Interestingly, the Schedule does not define the term 'calf', whilst providing considerable detail as to how (by examining the carcass) a female is to be determined to have been lactating or not.[2] The ability to identify calves in the field is clearly important if it is to be used in management, as is the case under present IWC regulations.

From a biological point of view, a humpback whale calf can be loosely defined as any first-year whale accompanied by its mother (i.e. over a period encompassing birth to independence). However, this is not a particularly practical field definition. More specifically, calves can be defined in the context of one or more of four 'measures':

(i) absolute length;
(ii) length relative to that of a larger whale (i.e. the mother) with which the animal is closely associated;
(iii) the presence of milk in the stomach; and
(iv) sole and often close association with a lactating female.

Each of these measures has some limitations. Absolute and relative lengths do not take into account individual variation. The former is easier to measure for a carcass whilst the latter is perhaps easier to estimate in the field. While the presence of milk in the stomach certainly identifies a nursing animal, its absence does not necessarily indicate that the animal was weaned; instead, it may simply reflect the time (and completion of digestive processes) since the animal's last feeding. It is clearly difficult to determine whether there is milk in the stomach in the field unless perhaps the calf is actually being suckled at the time. Similarly, determination of lactation on the part of an accompanying adult is very difficult in the field, and some time limit would need to be introduced with respect to 'sole and often close association'. Overall, absolute length can be considered the most reliable indicator of whether an animal is a calf or not, although this applies largely to young calves since the reliability of length-based determinations will decrease as the animal approaches independence. This paper reviews available data on length frequencies of humpback whale calves, both at birth and at independence, and presents some practical suggestions for the definition of a calf in a management context.

Humpback whales have a strongly seasonal reproductive cycle: the great majority of both mating and calving occurs in low latitudes in winter (Kellogg, 1929; Chittleborough, 1965; Dawbin, 1966; Whitehead, 1981). Most calving occurs between December and April in the Northern Hemisphere, with a peak in February (Nishiwaki, 1959; Whitehead, 1981; Mikhalev, 1997). Given the seasonal opposition of the hemispheres, most Southern Hemisphere humpback whales calve between June and October, with a

[1] The Schedule to the Convention contains IWC regulations concerning whaling - See Donovan (1999).
[2] Taking a lactating whale is not strictly against IWC regulations. However, it was traditionally assumed by whaling countries, in the absence of positive evidence to the contrary, that if a lactating female was taken it had been accompanied by a calf and whalers would have lost their catch bonus for such whales - hence the definition of lactating in the Schedule (Donovan, pers. comm.).

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peak in August (Chittleborough, 1965). Although calves can begin to feed independently at about six months of age, they are not fully weaned until they are 10-12 months old (Chittleborough, 1965; Clapham and Mayo, 1987; Baraff and Weinrich, 1993). The great majority of calves separate from their mothers at or towards the end of their natal year (Clapham and Mayo, 1990; Baraff and Weinrich, 1993).

METHODS

Data sources

Length frequency data for humpback whale calves come primarily from two sources: commercial catches and stranded or incidentally caught animals. As noted above, the taking of calves has long been prohibited, thus length at birth has generally been inferred from near-term foetuses in pregnant females taken in the commercial fishery. Additional catch records relate to calves taken in error, or under special permits (e.g. Chittleborough, 1965, p.68). The catch data summarised here come from a review of relevant publications from both hemispheres, rather than an examination of the original records, apart from a few records from the Smithsonian Institution database discussed below.

Notwithstanding the usual cautions associated with them (e.g. see IWC, 1986), stranding records can represent a valuable supplement to catch data, and involve animals of various ages. In some cases, ancillary information (such as the presence of milk in the stomach, or the presence of an unhealed umbilicus) increase the level of certainty of a calf determination. The largest sample of stranding data reviewed here comes from the Smithsonian Institution's database; although most records in this database pertain to events in North American waters, additional information is available for humpback whale strandings, incidental catches and directed takes in other regions of the world. Other records were available from additional sources. In all cases, records involving estimated lengths were excluded. Lengths refer to the standard measurement from the tip of the rostrum to the notch of the flukes. The strandings data used are summarised in Table 1.

Length at birth

Method 1

Length at birth was determined by a critical review of published estimates in the whaling literature (generally derived from data concerning near-term foetuses or young calves), as discussed below. Additional stranding records were examined to evaluate consistency with the published values.

Method 2

An alternative method of estimating mean length at birth was also used. This involved taking the length of the shortest known calf and the longest recorded foetus and calculating the mean length for all records (foetuses or neonates) within this range. This is probably the method employed by Matthews (1937), although as noted below it is not entirely clear how his values were derived.

Length at independence

While independence (separation from the mother) and weaning may not be simultaneous events in the life of a calf (i.e. a calf may remain with its mother for some time after it has ceased to nurse), the two terms are often treated as interchangeable in the literature. Since association between a female and calf is considered a sufficient criterion to prohibit killing of either, length at independence is probably the most relevant measurement in the present management context.

Observations of cessation of nursing (weaning) or separation between mother and calf are rarely available, especially with associated data on calf length; precise estimates of length at these life stages are thus rare. However, a survey of whaling and stranding records can be used to obtain a range of possible values for length at independence.

Relative length

As noted above, assessment of whether an animal is a calf using relative length (length relative to that of an accompanying adult, i.e. the possible mother) has some problems. However, such a method can be of value under certain circumstances, e.g. where a hunter is attempting to judge whether a potential target whale can be legally caught.

Relative length ceases to be a reliable measure as a calf grows during its natal year and is thus not applicable to calves that have migrated to the feeding grounds. It should thus be used only during the winter breeding season in tropical or subtropical waters, and even there its reliability as a field measure will diminish as the calf grows and approaches the maximum value given below. However, the method will be more reliable in cases where relative lengths of both mother and calf are determinable from observations or where photographs/videotape of their (landed) carcasses is available.

In order to determine this measure, data on length at birth and length at sexual maturity have been considered. The ratio of length at birth to length at sexual maturity is variable because of natural variability in both quantities. In order to calculate the probabilities associated with this ratio, a normal distribution for sexually mature females was derived using mean and standard deviation values (mean = 11.73m/38.5ft, SD = 0.51m/1.66ft, $n = 77$) given by Chittleborough (1955). A distribution for probable length at birth using foetal and live calf records summarised below was also developed (mean = 4.35m/14.27ft, SD = 0.23m/0.75ft, $n = 17$; see Table 1). Although the sample size for the latter is not large, the values involved are clearly consistent with all other data reviewed here. The distribution of the ratio was then determined by simulation. To do this, 1,000 samples each, with replacement, were drawn from the distributions of length at birth and at female sexual maturity. These two samples were divided to obtain 1,000 ratios, and the distribution of these ratios examined.

Calves are rarely observed immediately after birth, and thus ratio probabilities were calculated for calf lengths up to three months of age (on the assumption that any calf observed in a breeding area will be at most three months old). The von Bertalanffy growth curve[3] estimated by Stevick (1999) was used to interpolate body length increments between birth and one, two and three months post-partum. The simulation was repeated using the distribution of lengths at birth increased by the interpolated increments.

It should be noted that some females in the population will be larger than at their attainment of sexual maturity. The calculated probabilities will not apply to mother/calf pairs involving large mothers, for which calves will represent a smaller proportion of the mother's length. This represents a conservative approach that will maximise the probability that all calves are identified.

[3] von Bertalanffy, 1938.

Table 1

Records of humpback whale foetal or calf mortalities (from strandings, and incidental or directed catches) from the Smithsonian Institution database and other sources. Hem = Hemisphere (North or South). Ground = feeding ground (F), breeding ground (B) or ground classification unclear (U). Ocean: NA = North Atlantic, SA = South Atlantic, NP = North Pacific, SP = South Pacific, SI = Southern Indian Ocean. Sex: M (male), F (female), U (undetermined).

Date	Hem.	Ground	Location	Ocean	Length (m)	Sex	Notes	Source	Reference
8 Apr. 1986	N	B	Puerto Rico	NA	4.57	M		SI database	MME01947
Mar. 1979	N	B	Hawaii	NP	4.27	U		SI database	SEAN4161
22 Feb.1981	N	B	Hawaii	NP	4.63	M		Mazzuca *et al.* 1998	
20 Mar. 1987	N	B	Hawaii	NP	4.6	U	Decomposed	SI database	MME02157
27 Jan. 1989	N	B	Hawaii	NP	4.01	M		SI database	MME04726
27 Mar. 1992	N	B	Hawaii	NP	4.27	U		SI database	MME09227
1 Feb. 1996	N	B	Hawaii	NP	4.42	M		Mazzuca *et al.* 1998	
16 Feb. 1991	N	B	Hawaii	NP	4.0	F		SI database	MME09218
17 Mar. 1991	N	B	Hawaii	NP	4.75	F	Decomposed	SI database	MME09219
9 Jul. 1988	N	F	Alaska	NP	6.0	U		SI database	MME03989
3 Aug. 1991	N	F	Alaska	NP	7.5	M		J. Straley, *in litt.*	
21 May 1979	N	F	Virginia	NA	6.06	M		SI database	USNM 504947
23 Aug. 1985	N	F	Scotland	NA	5.99	F		SI database	Sheldrick 1989
1 Jan. 1985	N	F	Massachusetts	NA	9.85	F	Photo-id'd known 1984 calf; milk	SI database	MME01103
8 Nov. 1988	N	F	Massachusetts	NA	8.09	M	Possibly a known 1988 calf	SI database	MME04199
Dec. 1987	N	F	Massachusetts	NA	8.84	M	Photo-id'd known 1987 calf	SI database	MME03081
May 1998	N	F	Massachusetts	NA	10.21	M	Photo-id'd known 1997 calf	J. Robbins, *in litt.*	
30 Aug. 1988	N	F	Maine	NA	8.8	M	Photo-id'd known 1988 calf	SI database	MME05542
25 Oct. 1995	N	F	Nova Scotia	NA	8.8	F		D. Tobin, *in litt.*	
5 Mar. 1995	N	F	N. Carolina	NA	7.97	M		SI database	MME10797
30 Jan. 1978	N	U	N. Carolina	NA	6.7	M		SI database	SEAN3005
28 Mar. 1993	N	U	Spain, Galicia	NA	4.9	M		J. Valeiras, *in litt.*	
14 Jun. 1920	S	U	S. Africa	SA	4.11	M		SI database	USNM 237259
14 Dec. 1980	S	U	Australia, lat. 38°S	SP	6.37	F		SI database	VI024956
9 Aug. 1987	S	U	Australia, lat. 44°S	SP	4.0	U	Umbilicus attached	SI database	Anon. 1989
3 Oct. 1987	S	U	Australia, lat. 36°S	SP	5.0	U		SI database	Anon. 1989
9 Oct. 1987	S	B	Australia, lat. 26°S	SI	5.0	F		SI database	Anon. 1989
17 Oct. 1989	S	B	Australia, lat. 25°S	SP	4.2	M		SI database	Paterson and Van Dyck 1991
19 Jul. 1991	S	B	Australia, lat. 27°S	SP	4.7	F	'Neonate'	SI database	Paterson *et al.* 1993
22 Aug. 1938	S	B	Australia, Shark Bay	SI	3.56	M	Foetus; commercial catch	SI database	USNM 268359
26 Aug. 1938	S	B	Australia, Shark Bay	SI	4.72	F	Foetus; commercial catch	SI database	USNM 268360
15 Aug. 1938	S	B	Australia, Shark Bay	SI	4.34	F	Foetus; commercial catch	SI database	USNM 268361
7 Aug. 1938	S	B	Australia, Shark Bay	SI	4.39	M	Foetus; commercial catch	SI database	USNM 268362
3 Aug. 1939	S	B	Australia, Shark Bay	SI	4.29	M	Foetus; commercial catch	SI database	USNM 268363
26 Aug. 1938	S	U	Australia, area unknown	SI	3.68	M	Foetus; commercial catch	SI database	USNM 268367
12 Aug. 1938	S	B	Australia, Shark Bay	SI	4.42	F	Foetus; commercial catch	SI database	USNM 268368
Apr. 1998	S	B	Peru, lat. 13°S	SP	5.70	F		J. Reyes, *in litt.*	

RESULTS AND DISCUSSION

Length at birth

Catch data review

The most reliable data on length at birth are those from commercial catches summarised by Chittleborough (1958) for the Southern Hemisphere and Nishiwaki (1959) for the North Pacific, respectively. Chittleborough (1958) examined 249 near-term humpback foetuses taken off western Australia and found their mean length to be 13ft 8in (4.17m); he concluded that this would slightly underestimate length at birth. Near-term foetal lengths from this sample were almost normally distributed around a modal length of 14ft (4.27m), and the author considered this to be a reliable value for mean length at birth. He also reported an observation of a new-born calf, determined from the unhealed umbilicus and condition of the mother's uterus to be approximately one week old; the length of this animal was 15ft 3in (4.65m).

Chittleborough's (1958) calculations agree closely with those of Nishiwaki (1959), who estimated mean length at birth at 13-14ft (3.96-4.27m) from foetal length data collected primarily from catches made near the Aleutian Islands. Nishiwaki also included information from other (unspecified) areas but sample sizes were not broken down by source. He noted that the values for various biological parameters for North Pacific humpback whales are 'quite identical' to those obtained from the Southern Hemisphere by Chittleborough.

Additional Southern Hemisphere whaling catch data are contained in the Smithsonian database (Table 1), and include seven records of foetuses, all taken off western Australia in the month of August of either 1938 or 1939. The range of lengths of these foetuses was 3.56 to 4.72m (11.68 to 15.49ft), with a mean of 4.2m (13.78ft). Since August is the peak birth month for Southern Hemisphere humpback whales, these values are broadly consistent with Chittleborough's (1958) estimate of 14ft (4.27m) as the mean length at birth.

Other whaling catch data are more questionable, but generally supportive of the values given above. Matthews (1937) examined humpback foetuses from the South Atlantic (primarily South Georgia), and also collected data from other Southern Hemisphere sources. He calculated mean length at birth (defined as 'about the mean of the longest foetus and the smallest recorded living young') to be about 4.5-5.0m. However, this estimate is problematic because it is not clear whether it is simply based upon a sample of two animals (one foetus, one living) as the definition implies.

Although observations from earlier periods are rather anecdotal in nature, they are worth noting. Ingebrigtsen (1929) noted that pregnant female humpback whales killed off Finnmark in winter contained 'large foetuses', and he cites Collett as stating that foetal length was between 12 and 14ft (3.66 to 4.27m). Hjort (1902) cites a communication from Eschricht, who apparently observed a 45ft (13.7m) female humpback stranded near Stavanger in April 1846 'in the process of giving birth' to (i.e. possibly aborting) a 14ft (4.27m) foetus. Ommanney (1933) commented that many of the female humpbacks migrating south past the Bay of Islands, New Zealand, were accompanied by new-born calves measuring about 15ft in length.

Stranding record review

Stranding records from the Smithsonian database and other sources are summarised in Table 1. This database contains (in addition to the seven foetal lengths discussed above) seven stranding records of calves or presumed calves from Australia ($n = 6$, all but one from the east coast) and the Atlantic coast of South Africa ($n = 1$). These animals range in length from a 4.11m (13.48ft) individual recorded in June to a 6.37m (20.9ft) whale documented in the month of December. Three other records of 4.2, 5.0 and 5.0m (13.78, 16.40 and 16.40ft, respectively) come from October. The remaining two records are of a 4.7m (15.42ft) animal observed in July and described as a neonate, and a 4.0m (13.12ft) specimen recorded with umbilicus still attached in August.

Table 1 also contains nine stranding records of calves from Northern Hemisphere tropical areas, eight from Hawaii and one from Puerto Rico; some of the Hawaiian records are also summarised in Mazzuca *et al.* (1998; Table 1). All nine records occurred during the winter breeding season, from January to April. The mean length of the nine animals was 4.39m (14.40ft), with a standard deviation of 0.26m (0.85ft).

Method 1 estimate

Although overall, Southern Hemisphere balaenopterids are slightly larger than Northern Hemisphere conspecifics, these differences are small in foetuses and neonates and are not evident in any of the data reviewed above. Similarly, although adult female humpback whales are typically 1-1.5m longer than males (Chittleborough, 1965), this difference is negligible in neonates. Overall, the data from both sources (catches and strandings) are consistent with the view that the approximate mean length at birth in humpback whales is between 3.96 and 4.57m (13-15ft), and that this range is applicable to populations from both hemispheres.

Method 2 estimate

Applying Method 2 to the relevant data in Table 1 yields a range for length at birth of 4.0m (13.12ft, length of the smallest record calf) to 4.72m (15.49ft, length of the largest record foetus). The mean length of the records falling within this range is 4.35m (SD 0.23 m, $n = 17$) (14.27ft, SD 0.75ft), which is consistent with the values given above.

Length at independence

Catch data review

From growth curves, Chittleborough (1965) calculated mean lengths at independence for male and female humpback whales as 32.44ft (9.89m) and 31.82ft (9.70m), respectively. However, he examined five yearlings taken under special permit, or taken in error (by harpoons intended for their mothers), and found that the mean length of these whales was 29.92ft (9.1m). From this he concluded that the growth curve extrapolations were inaccurate for the period of early growth, and that his calculated lengths at independence were slight overestimates. Nishiwaki (1959) reported that weaning (= independence) occurred at an average length of 28ft (8.5m), but this estimate is based upon a growth curve extrapolation rather than on empirical data from examined carcasses.

Matthews (1937) used values up to 9.0m to distinguish calves of the year from older animals. He also gave a range of 7.0-8.0m for length at weaning, and calculated from baleen growth that this was attained at about five months of age. However, there is insufficient detail in the paper to verify these values; data from dead and living whales clearly indicate that five months is an underestimate of both the age at which nursing ceases (Chittleborough, 1965), and the age at independence (Clapham and Mayo, 1987; Baraff and Weinrich, 1993).

Stranding records review

The stranding records (Table 1) contain several whales known or presumed to be older calves of the year, or of a previous year; some of these are also described in Stevick (1999; Table 1). Of particular interest are four whales from the Gulf of Maine region of the North Atlantic, which were known (or, in one case, thought) from photo-identification studies to have been calves less than one year old (i.e. they had been repeatedly observed in association with their mothers during the previous summer). Three of the four calves were found dead near the end of their natal year, in November, December and early January; their recorded lengths were 8.09, 8.84 and 9.85m, respectively. The fourth calf, an 8.8m male, died in August. It is assumed that at least the first three of these four calves had become independent shortly before they died; in one case, (the 1 January 1988 animal), the whale had been observed with its mother only a few days before its death. Assuming that all four were representative of newly independent animals (an assumption that must be considered questionable given their evident poor health), a reasonable value for length at independence in this species may be close to the mean of the four, which is 8.89m (29.17ft). This value is consistent with another stranding record, involving an 8.8m (28.87ft) female which died in Nova Scotia in late October 1988. A sixth record involved a 10.21m (33.5ft) animal which stranded in May 1998, and which was known from photoidentification to have been in its second year. However, while the timing of the first five of these records is consistent with assumptions regarding separations between mothers and calves occurring at or towards the end of the year in the Northern Hemisphere, it should be reiterated that the assumption of recent independence of these animals may be invalid.

Reported lengths for other calf mortalities, recorded at various times of year in breeding or feeding grounds, are broadly consistent with these results (Table 1).

Estimate

Although length at independence is more difficult to determine than length at birth, an estimate can be obtained from the available records. From the above data, length at independence appears to lie between approximately 8 and 10m (26.25 to 32.81ft). That this range is quite broad and approximate (and not a point value) reflects natural variability, as well as various uncertainties which must be borne in mind when considering these data. In particular, it is impossible to determine whether many of the records (from either whaling or strandings) pertain to nutritionally independent animals. Furthermore, it is not clear whether stranded animals constitute a representative sample of the population. Nonetheless, the various data (particularly those from known-age animals) are broadly consistent with growth curve extrapolations in yielding the range given above.

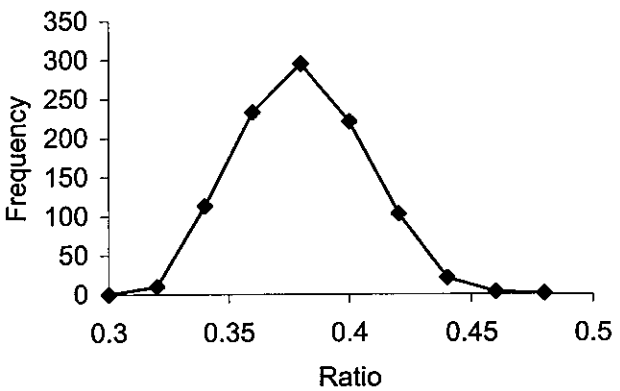

Fig. 1. The frequency distribution of the ratio of the length of calves at birth to the length of females at sexual maturity, as determined by simulations based upon length distribution data.

Relative length

The length frequency simulation method described above indicated that the distribution of the ratio of the length at birth to the length at sexual maturity varies between 0.30 and 0.44, with a mean of 0.37 (SD 0.025). The distribution (Fig. 1) is not normal (KS test = 0.031, $p = 0.025$), being slightly asymmetrical and having wider tails than a normal distribution. The probability of a more extreme value drops slowly with increasing value of the ratio (Fig. 2). For example, the probability of a ratio exceeding 0.41 is 5%.

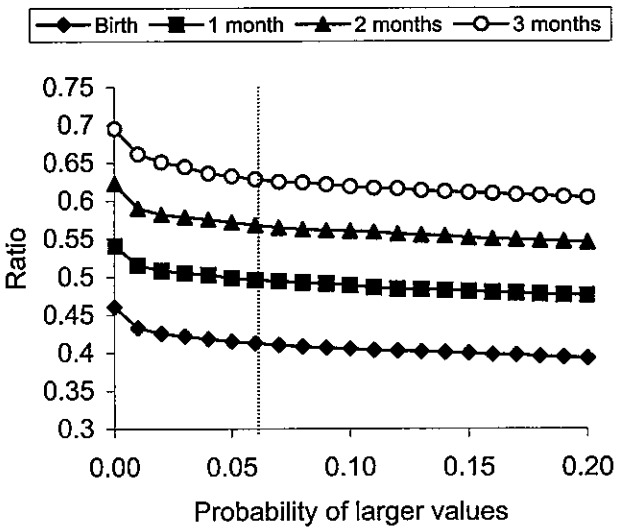

Fig. 2. The probability of a more extreme value of the ratio of length of calves at birth to length of females at sexual maturity. Values having a probability of 0.05 are denoted with the dotted line.

The upper bounds on the ratio distributions increase to 0.46, 0.55, 0.62, and 0.69 for birth, one, two and three months, respectively (Fig. 2). The values of the ratios where the probability of a more extreme value is 0.05 increase to 0.50, 0.57, and 0.63 for one, two and three months, respectively. Therefore, any animal in winter which appears to be less than 63% of the length of an accompanying adult can, with high probability, be considered a calf.

CONCLUSIONS

The data summarised here indicate that humpback whale calves from both hemispheres are 3.96 to 4.57m (13 to 15ft) in length at birth, and approximately 8 to 10m (26.25 to 30.48ft) at independence. Although any whale whose length falls within these ranges will likely be a calf, confidence in such a judgement will inevitably be negatively correlated with the size of the animal concerned. Timing is a key element in any determination of whether a whale is a calf or not. However, given the strongly seasonal breeding cycle of this species, length data alone are sufficient to identify young calves (i.e. those observed or taken in winter on the breeding range). Classifying calves based on relative length is a more practical field measure and is unequivocal for small animals in winter; it will be far less reliable on the feeding grounds, especially towards the end of the year as an animal

approaches independence. In such cases, data on absolute length, or on the presence of milk in the stomach, may be necessary to determine status.

ACKNOWLEDGEMENTS

We thank Dee Allen, Julio Reyes, Jooke Robbins, Mary Sternfeld, Peter Stevick, Deb Tobin and Julio Valeiras for providing data records, Melissa Groo for suggestions on references, and Richard Merrick, Fred Serchuk (Northeast Fisheries Science Center), Peter Best (South Africa Museum), Greg Donovan (IWC) and an anonymous reviewer for helpful comments on the manuscript.

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