

Growth of the harbour porpoise (*Phocoena phocoena*) in eastern Newfoundland, Canada

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ABSTRACT

Although the stock relationships among harbour porpoise (*Phocoena phocoena*) in the Northwest Atlantic are unknown, it has been postulated that there are 4 local populations: Bay of Fundy/Gulf of Maine, Gulf of St. Lawrence, Newfoundland, and west Greenland. Data on the Newfoundland population are extremely limited. To determine growth rates and examine if these animals can be differentiated from other sub-populations on the basis of growth characteristics, 94 porpoises caught incidentally in fishing gear along the southeast coast of Newfoundland during the summers of 1990 and 1991 were examined. Most porpoises (56%) were ≤ 4 years of age. Maximum age was 9 for females and 12 for males. Growth rates were similar for both sexes until one year of age, after which females grew longer and weighed more than males of similar ages. Using the Gompertz growth model, asymptotic values for body length were 156.3 cm for females and 142.9 cm for males. Asymptotic weights were 61.6 kg and 49.1 kg for females and males respectively. With the exception of West Greenland porpoise that were shorter and females from Norway that were lighter, Newfoundland porpoises could not be differentiated from animals collected in other areas based on growth data. However, differences in dental deposition patterns were noted suggesting that Newfoundland porpoise may belong to a separate population.

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INTRODUCTION

The harbour porpoise, *Phocoena phocoena*, (Linnaeus 1758), is one of the smallest oceanic odontocetes, rarely exceeding a length of 1.8 m (Harrison 1971). Average adult lengths and weights are 1.6 m and 50 kg, respectively (Gaskin 1992). Although distributed widely throughout the Arctic, North Atlantic, and North Pacific Oceans, harbour porpoise popu-

lations in many regions are thought to be declining due to direct and/or indirect exploitation, habitat degradation in the form of pollution, ship traffic disturbance, and/or a diminished food source (Read and Gaskin 1988, Lien 1989, Gaskin 1992). In 2001, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the western North Atlantic harbour porpoise population as being of special concern.

Gaskin (1984) proposed 3 major global harbour porpoise populations: 1) North Pacific, 2) North Atlantic, and 3) Black Sea. The North Atlantic population is divided into west Atlantic and east Atlantic populations based on skull measurements (Yurick and Gaskin 1987), allele frequency (Andersen 1993), and haplotype frequency (Rosel *et al.* 1995, 1999). Mitochondrial DNA data (Wang *et al.* 1996) and organochlorine contaminant composition (Westgate and Tolley 1999) support the existence of 3 local sub-populations of harbour porpoise in eastern Canadian waters: 1) Bay of Fundy/Gulf of Maine, 2) Gulf of St. Lawrence, and 3) Newfoundland and Labrador (Gaskin 1984, IWC 1996, Wang *et al.* 1996, Rosel *et al.* 1999).

While the Bay of Fundy/Gulf of Maine, population has received extensive study (*e.g.* Read 1990, Palka 1995, 2000, Trippel *et al.* 1996, Bisack 1997, Read and Tolley 1997) and some data are available on the Gulf of St. Lawrence population (*e.g.* Fontaine *et al.* 1994, Kingsley and Reeves 1998), information on the Newfoundland population is extremely limited. Sergeant and Fisher (1957) describe harbour porpoise distribution around Newfoundland and Labrador, while morphological data are limited to lengths and weights of a small number of samples (Sergeant and Fisher 1957, Williamson 1963, Sergeant *et al.* 1970). To date, no harbour porpoise abundance surveys have been conducted in Newfoundland waters.

The objective of the present study is to describe growth parameters of harbour porpoises in Newfoundland to improve our limited knowledge of this sub-population. These results are compared with those from other regional populations to determine if this population can be distinguished. Understanding growth parameters is also essential for developing effective management strategies, should they have to be implemented for this population.

METHODS

Harbour porpoises, incidentally caught in bottom-set gillnets, were collected from fishermen in eastern Newfoundland during July-August 1990 and June-August 1991. The majority (86%) were collected from the southeast region of the

island. Each porpoise was examined externally and routine necropsies including standard morphometric measurements (American Society of Mammalogists 1961) were conducted. Teeth were removed from the mid-section of the lower jaw from each porpoise, decalcified, sectioned longitudinally, stained in Ehrlich's hematoxylin, differentiated in acid alcohol, and mounted in a synthetic medium (Eukitt). Tooth sections were viewed using a dissecting microscope (compound, when necessary) under transmitted light and the dentinal growth layer groups (GLGs) were counted to estimate age to the nearest year. Each GLG was assumed to represent a single year's growth (Nielsen 1972, Hohn 1980, Hohn *et al.* 1989).

Growth curves were fit to cross-sectional length at age and weight at age data for male and female harbour porpoises separately by repeated iterations of the nonlinear regression program of SYSTAT Version 5.1 (Wilkinson 1989). Both Gompertz and von Bertalanffy growth models were used to allow for comparisons with other studies. The regression equation for the Gompertz model is as follows:

$$\text{Length} = A * \exp(-b * \exp(-k * \text{age}))$$

where:

length = straight line distance from snout to fluke notch (cm)

A = asymptotic length (cm)

b = fitted constant (no units)

k = growth rate constant (years⁻¹)

age = age (years).

The von Bertalanffy model has the form:

$$\text{Length} = A * (1 - b * \exp(-k * \text{age}))^3$$

RESULTS

A total of 94 porpoises (59 males; 35 females) ranging in age from 0 to 12 years were examined. The oldest female was 9; the oldest male was 12. The majority of the porpoises (55.9%) were 4 years of age or less.

Mean length of 3 male (93.7 cm, SE = 1.7) and 2 female (88.5 cm, SE = 7.0) calves (porpoises less than 1 year of age) were compared. There

Table 1: Parameter estimates for the Gompertz and von Bertalanffy growth curves from cross-sectional length-at-age data for male (n = 59) and female (n = 33) harbour porpoises from Eastern Newfoundland. Standard errors are in parentheses. A = asymptotic length (cm), b = fitted constant (no units), k = growth rate constant (yr⁻¹).

		A	b	K
Gompertz	Males	142.9 (1.2)	0.419 (0.03)	0.747 (0.09)
	Females	156.3 (2.9)	0.558 (0.06)	0.735 (0.13)
von Bertalanffy	Males	143.0 (1.2)	0.131 (0.01)	0.719 (0.09)
	Females	156.5 (2.9)	0.171 (0.02)	0.696 (0.12)

was no significant difference between male and female calf length ($t = -0.9095$, $P = 0.43$, $df = 3$).

The relationship between length and age was described using both Gompertz and von Bertalanffy growth models for males and females separately. Parameter values and standard errors estimated for both models are given in Table 1. Asymptotic values were not significantly different between the 2 models ($t = 0.049$, $P > 0.9$, $df = 64$ for females; $t = 0.058$, $P > 0.9$, $df = 116$ for males), so only Gompertz models are illustrated (Fig. 1). Both sexes exhibit a rapid increase in growth during the first 3 years followed by a plateau occurring at approximately

age 4. The asymptotic value was significantly higher for females than for males (females: 156.3 cm; males: 142.9 cm; $t = 4.97$, $P < 0.001$, $df = 90$). The longest female recorded was 162.0 cm and the longest male was 155.5 cm.

Gompertz and von Bertalanffy growth models were also fit to weight at age data for both sexes (Table 2). Asymptotic values were not significantly different between the 2 models ($t = 0.096$, $P > 0.9$, $df = 64$ for females; $t = 0.104$, $P > 0.9$, $df = 116$ for males). Gompertz curves for male and female weights are presented in Fig. 2. An initial rapid increase was followed by a plateau at approximately age 5 for males and 1 year

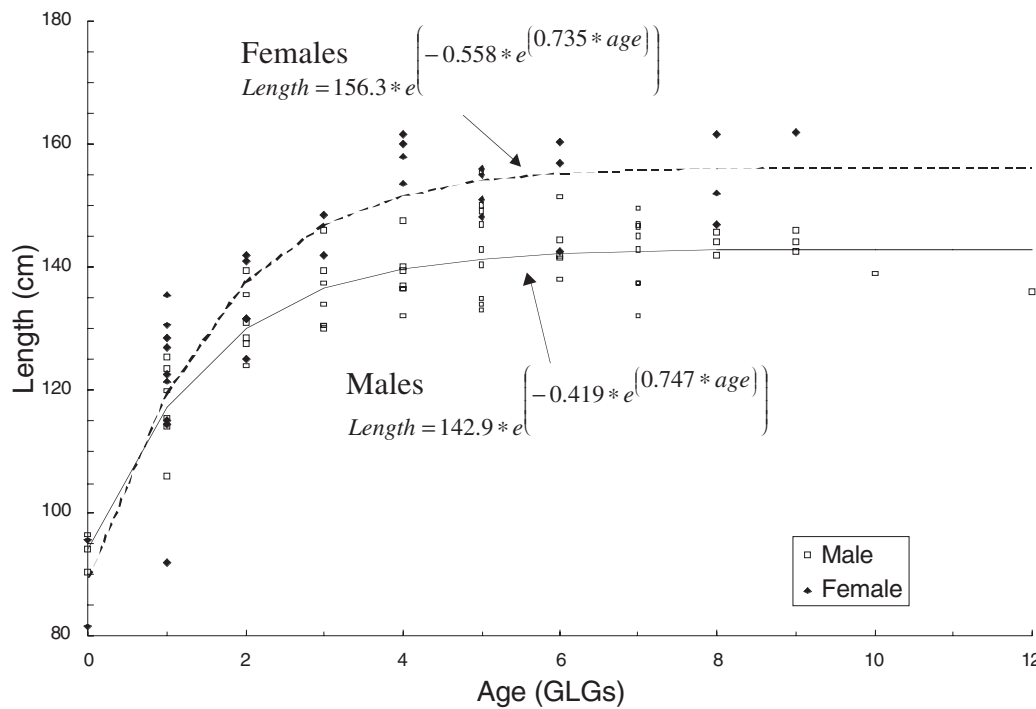


Fig. 1: Gompertz growth curves fit to length at age data for male and female harbour porpoises incidentally caught in eastern Newfoundland, 1990-1991.

Table 2: Parameter estimates for the Gompertz and von Bertalanffy growth curves from cross-sectional weight-at-age data for male (n = 59) and female (n = 33) harbour porpoises from Eastern Newfoundland. Standard errors are in parentheses. A = asymptotic length (cm), b = fitted constant (no units), k = growth rate constant (yr⁻¹).

		A	b	K
Gompertz	Males	49.1 (1.3)	1.069 (0.15)	0.658 (0.13)
	Females	61.6 (3.6)	1.284 (0.18)	0.554 (0.15)
von Bertalanffy	Males	49.3 (1.4)	0.306 (0.04)	0.598 (0.11)
	Females	62.1 (3.8)	0.360 (0.04)	0.495 (0.13)

later for females. The asymptotic value for females was significantly higher ($t = 6.70$, $P < 0.001$, $df = 90$) than that for males. The heaviest female recorded was 71.0 kg while the heaviest male was 58.0 kg.

The relationship between length and weight was examined using both linear and quadratic models. The quadratic model explained significantly more variation than the linear model ($F_{(2,87)} = 29.78$, $P < 0.01$), which was expected given the later age of attainment of the weight asymptote in the growth models. The regression lines for males and females were parallel ($F_{(2,87)} = 3.0$, $P > 0.05$), but statistically different ($F_{(1,89)} = 9.04$, $P < 0.01$). The length at weight relationship is illustrated in Fig. 3 and is described by:

$$L = 53.2 + 2.9W - 0.02W^2, \text{ for males and}$$

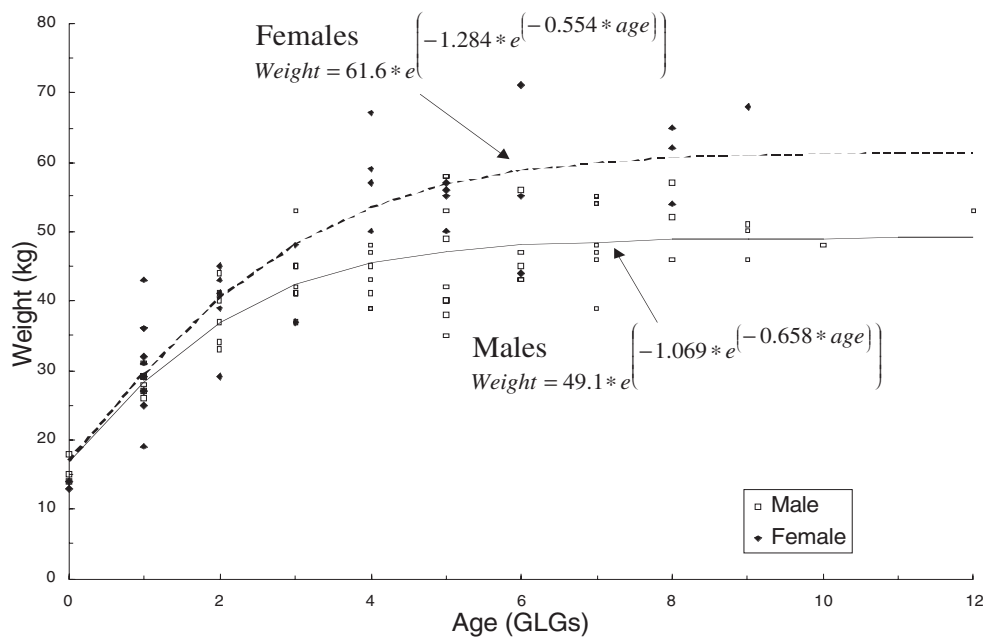
$$L = 52.8 + 2.9W - 0.02W^2, \text{ for females}$$

where length (L) is in cm and weight (W) in kg.

DISCUSSION

The majority of the animals examined were young, *i.e.* four years or less, although calves were under-represented in the sample. One would expect calves to be present as a number of the females collected during this period were lactating (Richardson 1992). The timing of seasonal reproduction in Newfoundland appears to

Fig. 2: Gompertz growth curves fit to weight at age data for male and female harbour porpoises incidentally caught in eastern Newfoundland, 1990-1991.



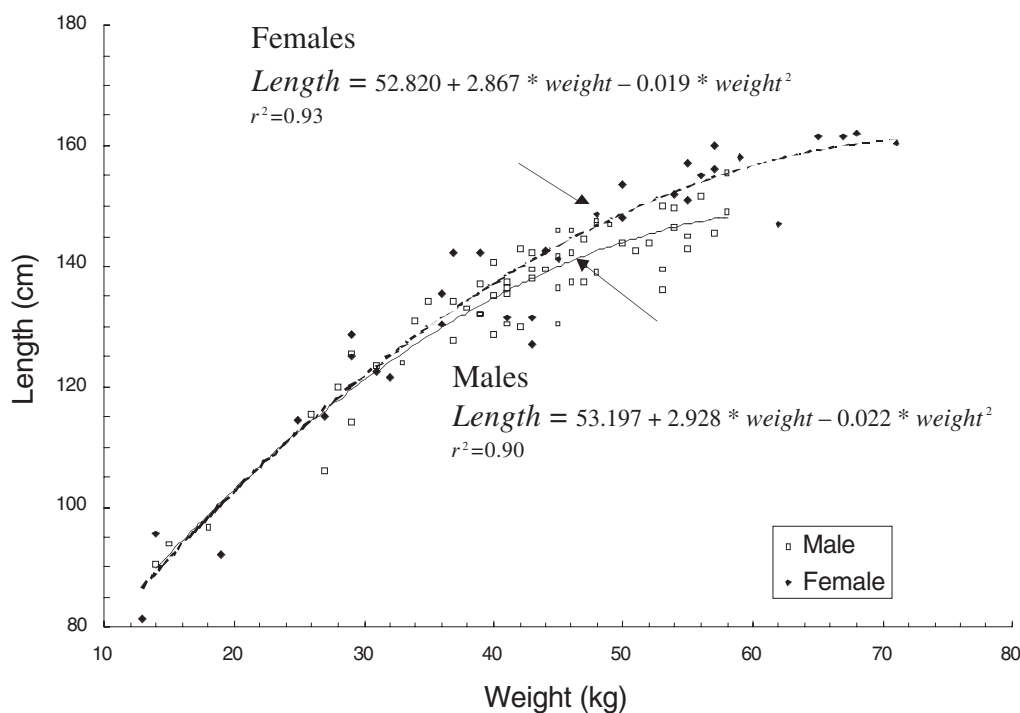


Fig. 3: Length and weight data for male and female harbour porpoises incidentally caught in fishing gear in eastern Newfoundland, 1990-1991.

be similar to that of the Bay of Fundy (Read and Hohn 1995) and West Greenland (Lockyer *et al.* 2003b) where calves were observed during the sampling period. Young calves may be underrepresented because these animals appear to stay in close proximity to their mother and while travelling in her care may benefit from her experience and knowledge of the environment including the presence of nets.

The preponderance of younger or juvenile specimens is similar to results found in other samples of incidentally caught harbour porpoises (Lockyer and Kinze 1999, Hohn and Brownell MS 1990, Kinze 1994, Lockyer *et al.* 2001). This may indicate that their capture reflects behaviour patterns that predispose them to capture and are presently not yet identified or a lack of experience in navigating waters with nets present. Northridge and Lankester (MS 1990) compared the size range of porpoises caught in gillnets versus other sources of samples (trawls and strandings) and found that smaller porpoises were more likely to become entrapped in gillnets than were larger animals. Kinze (1994) also reported that gillnet-caught specimens are younger than those taken in the drive fishery, indicating that gillnet-caught specimens may

not be representative of the age structure of the population. Although the samples may not be representative of the total age structure, net samples do provide a good sampling of the younger, growing animals that are required for good estimates of growth rates.

The present study provides the first description of growth rates for harbour porpoises in Newfoundland. Lengths are similar for male and female harbour porpoises up until approximately 120 cm in length, which is about 1 year of age. After this time, females grow faster than males and appear to remain larger throughout life (Fig. 1). Both males and females continue to gain weight after reaching their maximum lengths (Fig. 2). These findings are consistent with studies conducted in other locations (Fisher and Harrison 1970, van Bree 1973, Gaskin *et al.* 1974, Gaskin and Blair 1977, van Utrecht 1978, Read and Tolley 1997, Hohn and Brownell MS 1990, Martin *et al.* MS 1990, Bjørge *et al.* MS 1991, Sørensen and Kinze 1994, Lockyer 1995, Lockyer *et al.* 2001). Adult females from Newfoundland were not significantly longer than females from the Bay of Fundy ($t = 0.38$, $0.9 > P > 0.5$, $df = 58$) and not dissimilar to females from Norway (Bjørge *et al.* MS 1991).

Similarly, males from Newfoundland were not significantly longer than Bay of Fundy males ($t = 0.51$, $0.9 > P > 0.5$, $df = 177$) and were similar in length to Norwegian males (Bjørge *et al.* MS 1991). In contrast both male and female harbour porpoise from eastern Newfoundland were found to be longer in length than porpoise from West Greenland (Lockyer *et al.* 2003b). These data are consistent with findings by Lockyer (2003) who found adult porpoise from West Greenland to be shorter in length than porpoise from other eastern North Atlantic regions and the Canadian Atlantic coast.

Comparable data for porpoise from Newfoundland are limited; Sergeant and Fisher (1957) reported a 127 cm male while Sergeant *et al.* (1970) examined two porpoises, a female weighing 50 kg and a juvenile of unidentified gender at 18 kg. A porpoise, 79 cm long and 7.7 kg was found in the stomach of a Greenland shark, *Somniosus microcephalus*, caught on the Grand Banks of Newfoundland (Williamson 1963). Although limited, these measurements are within the range observed in this study.

Our finding that the asymptotic weight of females is greater than males in Newfoundland is in agreement with those of Read and Tolley (1997, Bay of Fundy) and Lockyer *et al.* (2001, West Greenland). In contrast, Bjørge *et al.* (MS 1991) reported that asymptotic weight values were higher for males than for females in Norwegian waters. Males from Norwegian waters were similar in weight to males from Newfoundland, but the females weighed less (49.4 kg versus 61.6 kg). Asymptotic weight values were higher for both males and females from West Greenland waters than for Newfoundland porpoise (Lockyer *et al.* 2003b). Intrinsic differences in weights between porpoise from different areas may account for the difference observed in females, but would not explain the similarities observed between males.

Alternatively, the lighter weights of females in Norway may be accounted for by differences in reproductive status. If they had been lactating, and thus depleting fat reserves, for a longer period of time than the females in Newfoundland, adult weights may have been reduced. Approximately 69% of the Norwegian

sample were caught between late May and early July, but time of collection was not reported for the remainder of the sample. Rates of mass transfer from mother to calf during lactation are not known for the harbour porpoise, but Gaskin (1982) estimated that it is energetically costly. Yasui and Gaskin (1986) suggested that females may increase their food intake by up to 80% during lactation to offset the increased energy requirements. Maternal weight loss during lactation has been documented in fin whales *Balaenoptera physalus*, sei whales *B. borealis*, (Lockyer 1987) and a number of seal species (*e.g.* harp seals *Pagophilus groenlandicus*, grey seals *Halichoerus grypus* (Anderson and Fedak 1987, Kovacs *et al.* 1991), and hooded seals *Cystophora cristata* (Bowen *et al.* 1987)). Thus, it is possible that the discrepancies in weight between Norwegian and Newfoundland female porpoises can be explained by lactation. Comparisons between lactating and non-lactating females in the present study did not show any significant differences in body weight ($t = 1.05$, $P = 0.31$, $n = 15$). There were also no significant differences in blubber mass between lactating and non-lactating mature females from the Bay of Fundy (Read 1990). However, both studies collected samples in the summer months. It would be interesting to investigate the body condition of porpoises during other times of the year to determine whether prolonged demands of lactation cause females to draw upon their stored fat reserves.

In addition, it is important to take season of sampling into consideration for both male and female harbour porpoise as they are reported by Lockyer *et al.* (2003a) to have marked seasonal fluctuations in their body weight, girth and food intake. Lockyer *et al.* (2003a) found that the maximum and minimum seasonal weight for a male and female harbour porpoise maintained under human care could vary by 7-8 kg with no apparent deterioration in health. The porpoise were at maximum weight during winter months which may correlate with the need to maintain body heat. Conversely, body weights fell to their lowest during the summer months.

Reviews of the distribution of harbour porpoises in the Northwest Atlantic (Marine Mammal Investigation 1992) and studies by Gaskin

(1984), Wang *et al.* (1996), Westgate and Tolley (1999) and Rosel *et al.* 1999 suggests that north-west Atlantic porpoises occur in a series of local populations centred around the Bay of Fundy/Gulf of Maine, Gulf of St. Lawrence, Newfoundland and West Greenland. As described earlier, no differences were found between the asymptotic lengths of adults or the age at which this is reached in porpoise from Newfoundland and the Bay of Fundy although they were found to be longer than porpoise from Greenland. Unfortunately, no comparable data are available from the Gulf of St. Lawrence. Similar lengths were observed among porpoise from the eastern Atlantic suggesting that lengths may not vary significantly among most populations and that length may not be a useful indicator of stock identity for many areas.

Although inconclusive, there is some evidence suggesting the presence of a separate Newfoundland population (Westgate and Tolley 1999, Rosel *et al.* 1999). Richardson (1992) found that female harbour porpoise from Newfoundland mature at a younger age and at a larger size than females from the Bay of Fundy. Also, a number of differences in dentinal deposition patterns were noted while ageing the animals. The GLGs were not as clearly defined in the Newfoundland sample as they were in porpoise teeth from California and the Bay of Fundy (A. Read, Duke University, Beaufort, North Carolina personal communication). As a result, teeth from Newfoundland were harder to read and it was harder to achieve consensus between experienced readers. Secondly, a half-year mark laid down at approximately six months was common in the other populations, but completely absent, or extremely variable, in the Newfoundland sample. The inconsistency of this mark may suggest environmental fluctuations, mixing of stocks, or changes in diet. The Newfound-

land sample of teeth also had structural anomalies prevalent in the dentine that were not commonly seen in the other populations (A. Hohn, National Marine Fisheries Service, Beaufort, North Carolina, personal communication). These anomalies may be the result of some type of nutritional and/or physical stresses (A. Read, personal communication).

Variability in tooth markings by region may be a useful tool for consideration when differentiating porpoise from different locations and determining stock structure. Lockyer (1999) examined tooth characteristics (ultrastructure, GLG, mineralisation patterns and gross morphology) in harbour porpoise from the north Atlantic and Pacific. She found clear differences in tooth characteristics for harbour porpoise from different regions as well as differences between harbour porpoise from the same region in four instances. This suggests that analysis of tooth structure may be a useful tool in helping to identify stock structure of harbour porpoise (Lockyer 1999) and should be examined in more detail to determine if it can be used to differentiate populations in the Northwest Atlantic.

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