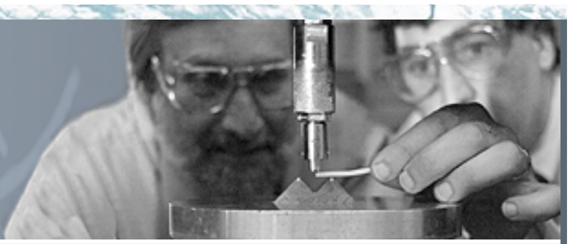

Estimates of Growth Rate of Tusks

Hay (1984) undertook a pioneering study of narwhal tusk growth and recognized that young individuals displayed a faster growth rate than adults. This has been confirmed by a recent study of narwhal growth based on aspartic acid racemization in the nuclei of eye lenses (Garde et al., 2007). Here we use the data presented in their Appendix 1, which includes not only age estimates but also tusk length.

Ring color	Ring number	$\delta^{13}C$	$\delta^{18}O$	$\delta^{15}N$
D	1	11.83	17.26	**19.37**
L	2	11.28	17.13	18.56
D	3	11.38	17.02	**19.33**
L	4	11.11	16.33	19.08
D	5	11.49	17.02	**19.43**
L	6	11.31	16.92	18.88
D	7	11.96	17.19	**19.39**
L	8	11.16	17.30	18.72
D	9	11.33	17.06	**19.56**
L	10	11.42	17.01	18.40
D	11	11.49	16.94	**19.39**
L	12	11.86	16.75	18.96

Table 1. *Stable carbon, oxygen and nitrogen isotope ratios obtained from a sequence of 12 rings, from 1 (inner ring) through to 12 (outer ring) in Monodon monoceros tusk MM2 (Fig. 4). D: dark rings. L: light rings. Dark rings are associated with relatively high nitrogen isotope ratios values (mean $\delta^{15}N = 19.41 \pm 0.07$ parts per mil, n = 6 shown here in bold). By contrast, light rings are associated with lower $\delta^{15}N$ values ranging between 18.40-19.08 parts per mil, with a mean $\delta^{15}N$ value of 18.76 parts per mil (±0.23,* n = *6).*

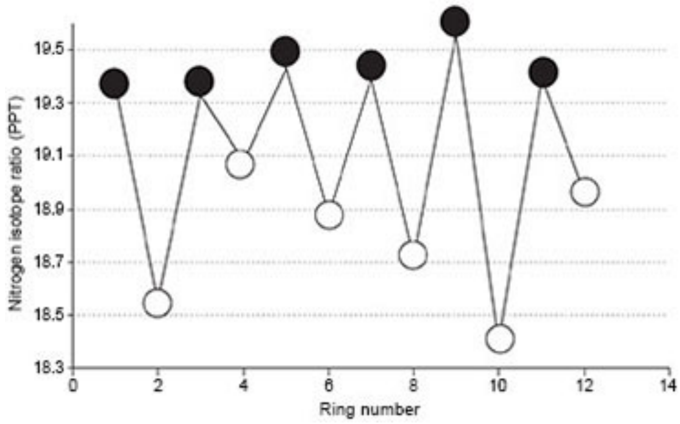

Figure 5. *Variability in nitrogen isotope ratios (ppt) in light rings (open circles) and dark rings (solid circles) in sectioned narwhal tusk MM2. Dark rings are associated with relatively high and almost invariant nitrogen isotope ratios. By contrast, light rings are associated with lower and more variable $\delta^{15}N$ values.*

For example, specimen Q 11 has a tusk length of 675 mm, and is estimated to be 6.6 years old, giving an estimated tusk growth rate of 102mm per year. Similar calculations have been done for 26 tusks. The relationship between age and growth rate (on a logarithmic scale) is shown in Fig. 6. The relationship can be expressed by the following equation:

$Log_{10}GRT = -0.0086AGE + 1.990$ (r = 0.867),

where GRT refers to growth rate of tusk in mm per annum, and AGE is expressed in years.

Discussion and Conclusions

We suggest that alternating nitrogen isotope ratios, in a sequence of consecutively light and dark rings in a narwhal tusk (Table 1, Fig. 5), are associated with seasonal variability in diet (cod and shrimp in summer, contrasting with halibut in winter). The $\delta^{15}N$ isotopic results suggest that the dark rings may be associated with winter growth, related to the winter consumption of halibut which is higher in the food chain than shrimp. Growth rates for tusks are variable, in the order of 100 mm per year for individuals between six and seven years of age. Further analyses are in progress to test the preliminary findings of this exploratory study.

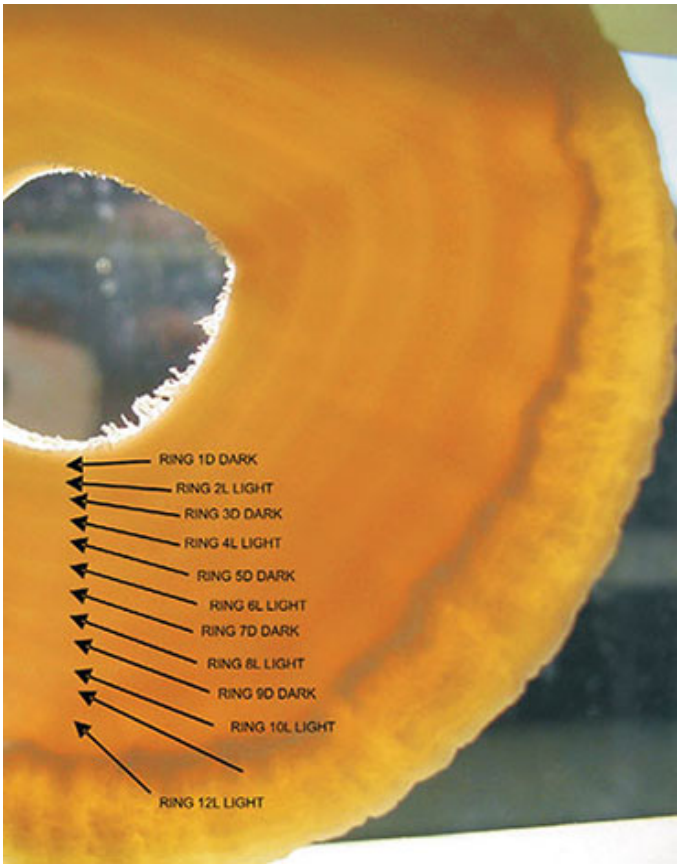

Figure 4. *Sectioned narwhal tusk (MM2) with light and dark rings. Nitrogen isotope ratios are relatively high in dark rings, contrasting with lower and more variable nitrogen isotope ratios in relatively thinner white rings.* Photograph: J. Lanham.

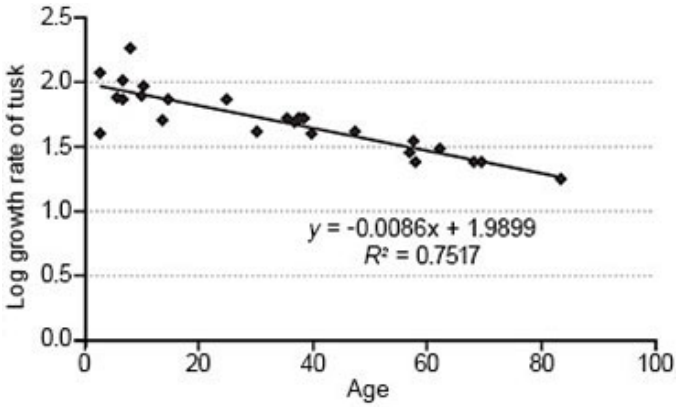

Figure 6. *Inverse relationship between estimated age of narwhal (years) and log-transformed growth rate of tusks (mm per year) based on data from Garde et al. (2007).*