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ORIGINAL PAPER

Growth and sexual maturity of the northern propellerclam (*Cyrtodaria siliqua*) in Eastern Canada, with bomb radiocarbon age validation

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Abstract The northern propellerclam *Cyrtodaria siliqua* is a common bycatch in the Arctic surfclam, *Mactromeris polynyma* fishery on Banquereau Bank in Eastern Canada. Samples of the propellerclam from this exploited fishery were used to determine the life history characteristics of the population. The age structure of the population is dominated by old animals to ages exceeding 100 years. We validated the age estimates for the propellerclam through analysis of bomb-produced radiocarbon in the shell growth increments deposited before, during and after the atmospheric atomic bomb testing periods of the 1950s and 1960s. Radiocarbon from shells with presumed birth dates between the late 1950s and 1970s clearly reflected the sharp increase in oceanic radiocarbon attributable to previous nuclear testing, indicating that age estimates based on shell increment counts are accurate. Estimates of von Bertalanffy growth parameters revealed that the growth rate of the population was relatively rapid for the first 20 years of life, slowing down to very low growth rates thereafter. Sexual maturity was estimated as being reached at 28.6 mm in length and 4.7 years in age. Size–weight morphometric relationships were also calculated.

Introduction

The northern propellerclam, *Cyrtodaria siliqua* Spengler, 1793, is one of two members of a genus belonging to family Hiatellidae, the other member being *C. kurriana* Dunker, 1862 (Nesis 1965; Simonarson 1974). *C. siliqua* is a large cylindrical bivalve which can reach up to 110 mm in length and 50 mm high. It lives in deep waters and completely buries itself in fine sand (Nesis 1965). The species is limited in its distribution to the northern Atlantic throughout the Gulf of St Lawrence right up to the Strait of Belle Isle, on the Newfoundland Banks, off Nova Scotia, in the Gulf of Maine and on Georges Bank (Nesis 1965), while the southern boundary of its range extends southwest of Cape Cod (Yonge 1971; Roddick and Lemon 1992; DFO 1997; Kenchington et al. 2001). The eastern distribution limit is extended to Norway (Laudien et al. 2007). In Eastern Canada, the northern propellerclam is found in high abundance on Banquereau Bank on the Scotian Shelf and on the Grand Banks (Lilly and Meron 1986; Gilkinson et al. 2003, 2005) where the species is collected as bycatch in the Arctic surfclam, *Mactromeris polynyma*, fishery (Roddick 2005).

Few studies have been done on the biology of the propellerclam. However, some studies have investigated the importance of the northern propellerclam as part of the diet of species such as the American plaice, *Hippoglossoides platessoides*, in eastern Newfoundland (Keats 1991); the Atlantic cod, *Gadus morhua*, in the southern Gulf of St Lawrence (Hanson and Chouinard 2002) and the sea star *Asterias vulgaris* in the northern Gulf of St Lawrence (Gaymer et al. 2004). Sauvé et al. (2002) used *C. siliqua* and other bivalve species to measure non-specific immune function in molluscs.

The age structure of a population is of key importance since it forms the basis for calculations of growth and mortality rates and age at maturity, and thus the reference points for fisheries management. Nevertheless, the age and longevity of the propellerclam have never been reported.

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Bivalves are normally aged by counting the presumed annual rings, either on the external shell surface as in the scallop (Roddick and Mohn 1985), on the hinge region of a cross section as in the Greenland smoothcockle, *Serripes groenlandicus* (Kilada et al. 2007b) or on the acetate peel of shell cross section as in the ocean quahog, *Arctica islandica* (Ropes et al. 1984; Ropes 1985; Kilada et al. 2007a). However, the annual deposition of growth rings needs to be validated before the absolute age of the animal can be determined (McFarlane and Beamish 1983). Annual deposition can be confirmed by methods such as the release and recapture of marked individuals of known age (Campana 1999, 2001); marginal increment analysis (Gartner Jr 1991; Kilada et al. 2007b) and bomb radiocarbon (Kalish 1993; Campana et al. 2002; Kilada et al. 2007a). The latter method had proven to be one of the best available age-validation techniques available for long-lived marine organisms such as corals, bivalves and fish (Campana 2001).

Here we present the first report of the validated age structure and growth of the northern propellerclam. In addition to estimating the age and size of sexual maturity, we assessed the morphometric relationships between length, height and shell weight. This information should be of value in developing fishery models and in improving fishing gear selectivity.

Materials and methods

Age determination

Ages of 253 specimens were determined. A sample of 165 specimens were collected as bycatch from the commercial Arctic surfclam fishery on Banquereau Bank (44°30′ N, 58° W) between 1998 and 2002. An additional 88 propellerclams were collected for investigation of sexual maturity during an offshore clam survey of the same area in July 2004. The length of each animal was measured to the nearest 0.1 mm and the shell was separated from the flesh and air dried. The two valves appeared identical, but for consistency, the right valve was chosen for ageing if intact, otherwise, the left shell was used in the study.

Since the present study represents the first report of age and growth of the northern propellerclam, different preparation methods were assessed. *C. siliqua* shell is characterized by the presence of a black periostracum layer which hides the growth rings on the external shell surface. As a result, counting the growth increments on the external shell is not an option. A thin section was prepared by cutting the shell from the ventral margin through the umbo with a low-speed Isomet saw mounted with two diamond blades, 2 mm apart. The thin section was mounted on a glass slide and ground down to 0.3 mm thickness with a Buehler PETRO-THIN thin sectioning system. The section surface was hand ground using the same grit size as before, rinsed with tap water and left to dry. As a second method, each shell was prepared by cutting from the ventral margin through the umbo with a low-speed saw mounted with a single diamond blade. After embedding in epoxy resin, the sections were ground with silicon carbide grinding powder of successively finer grit size (240, 400 and 600) and then polished with a commercial polishing compound. Shell thin sections and shell halves which were embedded in epoxy resin were then examined using a Nikon binocular microscope using reflected light at 40× magnification. The number of translucent bands was counted along both the entire section and in the hinge region.

The von Bertalanffy growth curves for all age–length data were fit by non-linear regression using the statistical package SYSTAT (1997):

$$L_t = L_\infty \left(1 - \mathrm{e}^{[-k(t-t_0)]}\right)$$

where L_t is the length-at-age t; k is a growth coefficient; L_∞ is the asymptotic length and t_0 is the theoretical age at 0 length.

Age validation

Validation of the periodicity of shell deposition using the bomb radiocarbon method requires samples of aragonitic shell material which are believed (based on growth band counts) to span the period of atomic bomb testing in the 1950s and 1960s. Four clams meeting this requirement were collected in 2002 and 2003 from Banquereau Bank and ranged in age between 54 and 86 years. A section (1.0–1.5 mm thick) of each shell was prepared as described earlier. Digital images of each section were taken at a minimum resolution of 1,280 × 1,024 and enhanced using Adobe Photoshop CS2. Growth bands for assay were selected based on the age and year of formation inferred from increment counts. Shell material for bomb radiocarbon assay was extracted from the outer prismatic layer with a Merchantek computer-controlled micromilling machine using steel cutting bits and burrs. Three samples were extracted from each individual from bands presumed to be deposited between the 1950s and early 1980s. Since sample weights from individual growth bands were insufficient for assay, pooled samples from adjacent bands (three to four bands) were extracted so as to bring the total sample weight to at least 3 mg. To minimize the possibility of surface contamination, all samples were sonified in Super Q water after extraction. After drying, the sample was weighed to the nearest 0.1 mg in preparation for assay with accelerator mass spectrometry. All samples were also assayed for δ^{13}C which was used to correct for isotopic fractionation effects. Radiocarbon values were subsequently reported as Δ^{14}C, which is the per mil (‰) deviation of the sample from the radiocarbon standard (nineteenth century wood), corrected for sample decay prior to 1950 according to methods outlined by Stuiver and Polach (1977).

The onset of nuclear testing in the late 1950s resulted in a marked and widespread increase in Δ^{14}C in marine dissolved inorganic carbon which is easily detected in all marine carbonates growing in surface waters during the 1960s (Druffel 1989; Campana and Jones 1998). To assign dates of formation to an unknown sample, it is essential that the Δ^{14}C of the sample be compared with a Δ^{14}C chronology for the area based on known-age material (a reference chronology). The reference Δ^{14}C carbonate chronology for the Northwest Atlantic was derived from assays of known-age fish otoliths and bivalves formed between 1939 and 2000 (Campana et al. 2008). The Δ^{14}C chronology of aragonitic fish otoliths in the NW Atlantic parallels that of North Atlantic corals and bivalves (Campana 1997), and thus is a good proxy for the Δ^{14}C history of propellerclam growing in the upper 200 m of the water column on the Scotian Shelf.

Size and age at sexual maturity

A sample of 88 clams was collected in July 2004 and used to estimate the size and age at sexual maturity. To ensure that the sample collection included small clams, the dredge cage and codend were fitted with a loose cover made of 38 mm shrimp mesh. Each animal was fixed in 10% formaldehyde in sea water after capture, and the preserved samples were transported to the laboratory where the foot portion, which contains the gonads, was removed. The tissue was fixed in 10% formaldehyde for at least 48 h and was then dehydrated by immersion in a graded series of ethanol, dealcoholized in butanol and embedded in wax. Wax blocks were sectioned to a thickness of 6–10 μm and the sections were stained in Harris's haematoxylin and counter-stained in eosin (Humanson 1979; Drummond et al. 2006). The prepared microscope slides were examined under 40× magnification to determine the sex and reproductive stage of each specimen (Ropes 1968). The proportion of mature individuals was plotted against size aggregated into 5 mm intervals. A logistic regression was fit to the data by maximum likelihood using the S-PLUS statistical package (Insightful Corporation 2003). The logistic curve is:

$$P = \frac{e^{(a+bL)}}{(1 + e^{(a+bL)})}$$

where P is the proportion of mature individuals in the sample, L is the shell length (mm) and a and b are model parameters. The clam length corresponding to 50% mature individuals was calculated as: $L_{50} = -a/b$. The shells were subsequently aged with thin sections as described earlier. A logistic curve was also fit to the age at maturity data using the maximum likelihood method described above.

Morphometric relationships

A sample of 2,075 individuals was collected from the bycatch of the commercial Arctic surfclam fishery between 2001 and 2006. The sample was used to establish the morphometric relationships between length (mm) and shell height (mm), total dry tissue weight (g) and dry shell weight (g).

The length–height relationship was described by a linear regression:

$$Y = a + bX$$

where Y is the clam height (mm) and X is the length (mm). Length–weight relationships were calculated using the equation:

$$Y = a \times X^{b}$$

where Y is a weight variable [dry shell weight (g) or total dry tissue weight (g)] and X is the shell length (mm); a and b are model parameters.

In order to assess if the b value obtained in the linear and non-linear regressions was significantly different from the isometric value of $b = 1$ and 3, respectively, a t-test (H_0: $b = 1$) with a confidence level of 95% ($\alpha = 0.05$) was applied. Calculated b values of 1 (length–height) or 3 (length–weight) were defined as being in the isometric range, while $b < 1$ (3) was defined as negative allometry and $b > 1$ (3) as positive allometry.

Results

Age validation

The year of formation in the extracted samples from the propellerclam shell cores was estimated in two ways: through age determination based on increment counts of polished shell sections, and through comparison of shell core Δ^{14}C values with the values known to be present in the marine environment at the time (reference chronology curve). The period of increasing Δ^{14}C values in the shell cores can then be compared to the known-age and dated reference values to determine the date of formation. Where the increment-based and Δ^{14}C-based dates are in agreement, the increment-based age interpretations must be (on average) correct.

Table 1 Summary of $\delta^{13}C$ and $\Delta^{14}C$ assay results for growth increment samples of northern propellerclam shells collected from Banquereau Bank in 2002 and 2003

Sample ID	Shell length (mm)	Age (years)	Assumed period of deposition	$\delta^{13}C$	$\Delta^{14}C$
C5-1	85.3	57	1986.5	−2.4	47.5
C5-2	85.3	57	1972.5	−2.11	74.8
C5-3	85.3	57	1954.5	−0.09	−47.6
C7-1	94.7	61	1975	−1.48	73.3
C7-2	94.7	61	1961.5	−1.36	13.4
C7-3	94.7	61	1950.5	0.07	−38.1
C12-1	88.0	86	1975	−0.93	54.3
C12-2	88.0	86	1961.5	−1.61	−32.4
C12-3	88.0	86	1950	−0.99	−56.1
C1-1	82.3	54	1987	−2.24	52.7
C1-2	82.3	54	1972		70.7
C1-3	82.3	54	1952	0.53	−54.3

The clam $\delta^{13}C$ values (Table 1) were relatively constant with a mean value of -1.15 (SE = 0.29). In contrast, the $\Delta^{14}C$ values varied between −56 and 70 (Table 1; Fig. 1), similar to reported values of other marine carbonates formed in the 1950s and 1960s. The $\Delta^{14}C$ from the shell increments were similar to those in the reference chronology, with a sharp increase from the pre-bomb period before 1959 and peak values in the early 1970s (Fig. 1).

The age of the four clams used in the radiocarbon assays was between 54 and 86 years. If the increment-based ages are assumed to be correct and are used to determine the year of core formation, a plot of $\Delta^{14}C$ against the year of formation shows a curve similar to that expected of all marine carbonates: low values prior to 1955, increasing sharply to an asymptote in the late 1960s and early 1970s (Fig. 1). The comparison of the assay values with the accurately dated reference $\Delta^{14}C$ curve indicates that the increment-based age determinations must be close to accurate: pre-bomb and post-bomb values are correctly assigned to periods before 1958 and after 1970, respectively. The two assays on the ascending portion (1958–1967) of the bomb curve are the most useful for detecting consistent age under- or over-estimation, yet the two assay values bracket the reference chronology. Taken as a whole, these results indicate accurate age estimation based on increment counts, although individual sample ages differing by <3 years from the correct age would have been difficult to detect.

Age and growth

Thin sections which were fixed on glass slides were difficult and time consuming to grind by hand and therefore this method was not applied to the rest of the clam shells. On the other hand, shells which were embedded in epoxy resin were easy to handle and produced sections having clear growth increments in both the hinge region and elsewhere on the section. The growth increments were clear on the hinge region only in individuals younger than about 18 years; therefore it was decided not to use this area in the age determination. Growth increments were clear along the clam section edge at all ages (Fig. 2) and increment counts in this region were consistent between independent readers (CV = 5%).

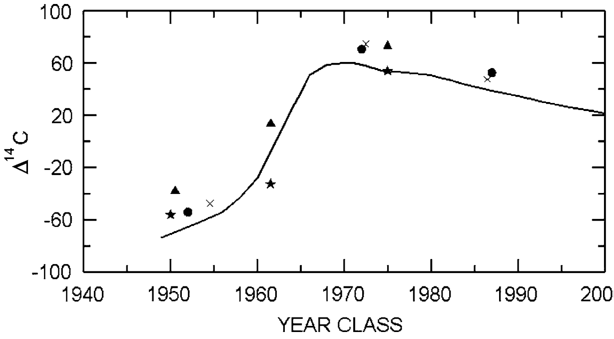

Fig. 1 $\Delta^{14}C$ in growth increments of four northern propellerclams in relation to the year of formation estimated from counts of presumed annular bands. *Dots* of same *symbol* indicate the $\Delta^{14}C$ assay results from the same individual, whereas the *line* shows the $\Delta^{14}C$ of the reference chronology fitted with a LOWESS curve

Length-at-age estimates for the propellerclam with a fitted von Bertalanffy growth curve is shown in Fig. 3 and the von Bertalanffy growth parameters are given in Table 2. The growth curve showed rapid growth (about 3 mm $year^{-1}$) in clams <20 years in age, declining to <0.5 mm $year^{-1}$ when clams were about 60 years old. The oldest clam was estimated to be 105 years, which was found in a 106.1-mm clam. Clams of larger size (110.4 mm) were collected in the survey but were not aged because of a broken shell.

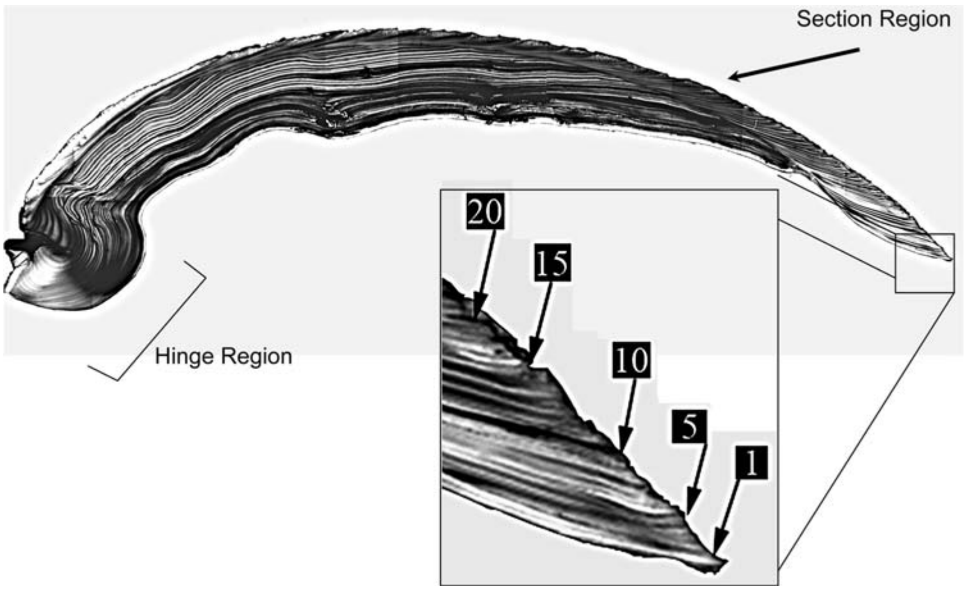

Fig. 2 Transverse section of a propellerclam (shell length 86.0 mm) presumed to be 86 years old. *Insert* shows a magnified section tip, in which the annual growth bands (indicated by *arrows*) tend to be clear

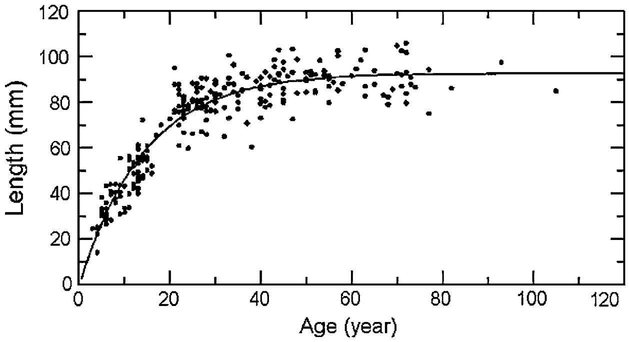

Fig. 3 Growth curve of northern propellerclam ($n = 254$; $r^2 = 0.88$) collected from Banquereau fitted with a von Bertalanffy growth equation. The growth parameters are shown in Table 2

Size and age at sexual maturity

The northern propellerclam is dioecious. Out of the 88 clams, hermaphrodite clams were absent while 15 clams were unsexed and considered immature for both males and females. Besides these clams, there were 5 immature females as well as 44 and 29 individuals having male and female gonads, respectively. Clams used to estimate the length and age at sexual maturity ranged in length between 13.9 and 73.0 mm (mean of 45.0 ± 1.4 mm) and in age between 3 and 40 years (mean of 12.2 ± 0.81 years). There were 44 and 24 mature specimens in the male and female samples, respectively, plus 5 with immature female gonads. About 22% of the whole samples had immature gonads. The largest immature clam was 47.8 mm in size and 13 years old (Table 3). Meanwhile, the smallest mature clam was male and was 24.4 mm in size and 3 years old. The mean size and age at sexual maturity was estimated to be 28.6 mm and 4.7 years, respectively (Fig. 4).

Table 2 von Bertalanffy growth parameters for northern propellerclam from Banquereau Bank

Parameter	Value	95% Confidence limits	
		Lower	Upper
L_∞ (mm)	92.9	90.6	95.1
k	0.07	0.06	0.08
t_0 (years)	0.18	−0.79	1.14

L_∞ asymptotic length, k growth coefficient, t_0 theoretical age of clam at 0 length ($n = 254$)

Morphometric relationships

The shell length range of all propellerclam used in this study was between 42.7 and 110.4 mm (mean of 81.5 ± 0.2), while the shell height range was 15.6–51.8 mm (mean of 35.6 ± 0.1). The dry shell weight ranged between 3.4 and 98.7 g (35.2 ± 0.3) and the total dry weight had a range of 1.0–38.4 g (mean of 134.4 ± 0.1). There was negative allometric growth in shell height/length ($b < 1$, $P < 0.05$) and in the growth of total dry tissue weight and length ($b < 3$, $P < 0.05$). The relationship between dry shell weight and shell length exhibited isometric growth ($b = 3$, $P < 0.05$; Table 4; Fig. 5).

Discussion

The present study represents the first report of age and growth of the northern propellerclam. Our work confirmed that the species is a long living bivalve and it can live up to age exceeding 100 years. We were able to validate the annual deposition of the growth increments and found that

Table 3 Mean length (mm) and age (years) of northern propellerclam individuals used in the sexual maturity estimation

Maturity stage	Mean (mm)		SE		Minimum (mm)		Maximum (mm)		*n*	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Length (mm)										
Unsexed (immature)	34.71		2.37		13.9		47.8		15[a]	
Not active (immature)		37.94		2.27		33.40		43.50		5[b]
Early active	30.39	45.60	1.73	2.15	24.40	37.80	48.70	65.00	13	12
Late active	52.07	56.74	2.96	4.27	29.00	46.60	72.9	70.80	18	5
Mature	47.20	–	–	–	47.20	–	47.20	–	1	0
Ripe	54.64	56.33	1.25	1.02	47.7	52.90	61.10	59.50	10	6
Partially spent	40.40	0	–	–	40.40	–	40.40	–	1	0
Spent	43.20	73.00	–	–	43.20	73.00	43.20	73.00	1	1
Total									59	44
Age (years)										
Unsexed (immature)	7.67		0.81		4		13		15[a]	
Not active (immature)		8.4		1.03		6		11		5[b]
Early active	6.00	13.33	0.65	1.86	3	7	12	32	13	12
Late active	15.11	19.00	1.95	4.51	6	14	33	37	18	5
Mature	13	–	–	–	13	–	13	–	1	0
Ripe	15.90	13.67	2.51	0.33	11	13	38	15	10	6
Partially spent	8	–	–	–	8	–	8	–	1	0
Spent	10	40	–	–	10	40	10	40	1	1
Total									59	44

[a] The 15 un-identified gonads were considered as immature clams in both sexes

[b] Besides the 15 un-identified gonads (immature), there were 5 immature female gonads increasing the total number of immature females into 20

the clam's growth rate is very slow. Knowledge of growth variability is essential to the understanding of a stock's population dynamics. To achieve an accurate assessment of these characteristics, several issues need to be addressed. Foremost, is a rigorous approach to the validation and precision testing of age estimates (Tracey and Lyle 2005). Among the different age-validation techniques which are available (for review see Campana 2001), bomb radiocarbon assays to detect the signal from atmospheric nuclear testing in the 1950s and 1960s provides one of the best validation techniques for long living aquatic animals (Dwyer et al. 2003; Kilada et al. 2007a).

The interpretation of the Δ^{14}C chronology in the propellerclam shells is straightforward; the Δ^{14}C chronology of the shell should match the reference chronology from the same region as long as the growth band counts are correct. Any under-ageing would phase-shift the shell Δ^{14}C chronology towards more recent years, while over-ageing would phase-shift it towards earlier years. The Δ^{14}C in propellerclam samples increased sharply between 1959 and 1974, with a timing and magnitude which was very similar to that of the reference chronology. The correspondence between the two ^{14}C chronologies indicates that the growth bands in the propellerclam from Banquereau Bank were deposited yearly and that the number of bands corresponds to the absolute age of the propellerclam. Therefore, these results confirm the annual deposition of growth bands and subsequently validate our age interpretations of *C. siliqua* on the Scotian Shelf.

The propellerclam is a long-lived clam reaching more than 100 years in age. The growth rate of the northern propellerclam appeared to be rapid for the first 20 years of life slowing substantially thereafter. The Pacific geoduck (*Panopea abrupta*) and the Arctic hiatella (*Hiatella arctica*), which are members of the same family as the propellerclam (Hiatellidae), are also long-lived bivalves. The Pacific geoduck can reach 145 years in age at a length of 184 mm (Bureau et al. 2003), while the maximum age of *Hiatella arctica* was recorded as 134 years (reached at 34.4 mm in length) in Greenland, based on a mark-recapture experiment to validate the annual deposition of the growth bands (Sejr et al. 2002). The von Bertalanffy growth parameters of *C. siliqua* ($L_\infty = 92.9$, $k = 0.07$ and $t_0 = 0.175$) can be compared to those of *Arctica islandica*, which has a similar L_∞ (92.0, Kilada et al. 2007a), but a lower k (0.04), indicating that the initial growth rate is much faster for *C. siliqua*.

The estimated L_∞ may be affected by the clam size range in the sample. The sample used in the age determination work was collected by means of hydraulic dredge.

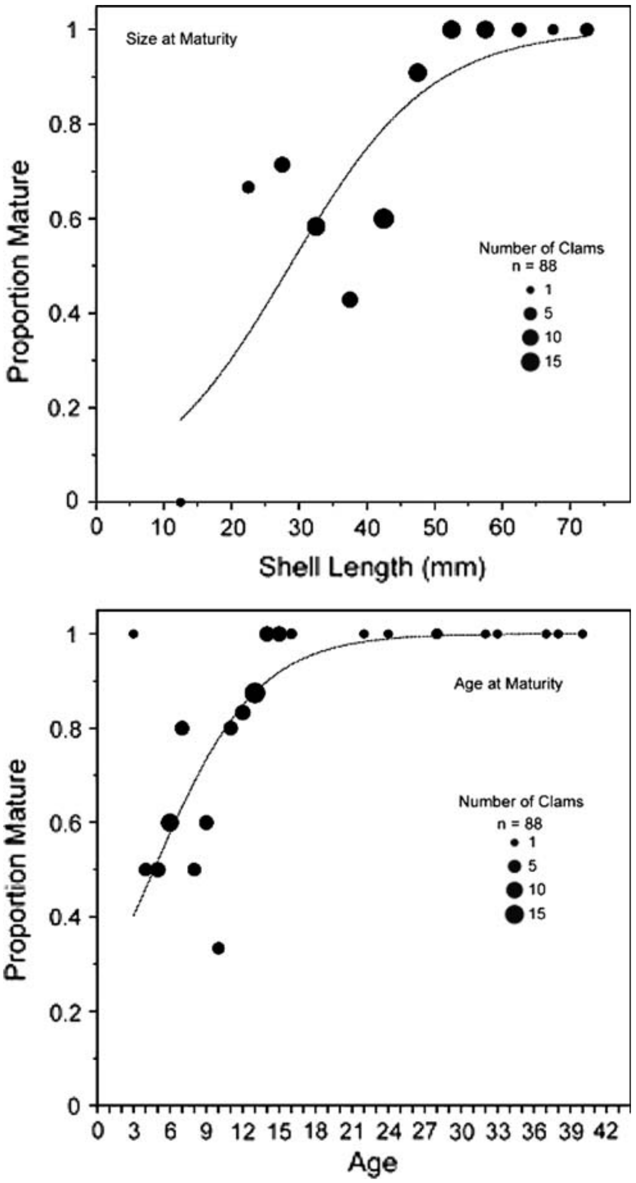

Fig. 4 Length and age at sexual maturity of northern propellerclam. *Solid line* is maximum likelihood fit to the logistic equation and $-a/b$ is the 50% length and age at sexual maturity. For the size at maturity: $a = -2.754$, $b = 0.096$ and $-a/b = 28.64$ mm. For the age at maturity: $a = -1.104$, $b = 0.236$ and $-a/b = 4.7$ year

The average bar spacing in the cage section was 23 mm on the top and sides, and 28 mm on the bottom. The bar spacing in the dredge cage determines the size of the retained clams. In commercial fisheries, after using the dredge for long time, the bar spacing becomes uneven and as a result, large clams may escape from the cage. This may suggest that bigger clams were not included in the present study even they exist on the Banquereau Bank.

Besides age and growth, our study provides the first documentation of the size and age of maturity. With a size and age of 50% maturity of 28.6 mm in size and 4.7 years in age, this species differs from that of the other members of the family Hiatellidae. The Arctic hiatella (*Hiatella arctica*), attains sexual maturity in the White Sea in northern Russia during the 1st year of life at a shell length of 14 mm (Matveeva and Maksimovich 1977). On the other hand, the Pacific geoduck was found to reach sexual maturity at 59.4 mm and 2.5 years (Campbell and Ming 2003).

There is no published literature on the reproductive biology of the northern propellerclam. The presence of ripe and spent individuals in our samples may indicate the presence of some spawning activity during the sampling time in July 2004. If this conclusion is confirmed, it will be similar to the spawning season of the Arctic hiatella clam. A study on the settlement of bivalve spat including *Hiatella arctica* on artificial collectors in North Iceland found that the spat of this species was more abundant between August and October (Garcia et al. 2003). This may suggest that its spawning season may be in June or July of the same year. In Western Canada, it was found that the geoduck clam (*P. abrupta*), which is the third member of the same family, had a spawning season between June and July, prior to the highest seawater temperatures in August (Sloan and Robinson 1984). The authors stated that spawning for the geoduck clam was synchronous between sexes and occurred annually. They also found ripe gonads in clams as old as 107 years. This suggests that the species may be capable of reproducing for over a century. Our findings cannot confirm if this is the case with the propellerclam and further investigations are required to reach the final conclusion.

Table 4 Morphometric relationships among shell length (*L*), height (*H*), dry shell weight (*Sh*) and total dry tissue weight (*T*) of the northern propellerclam collected from Banquereau Bank

	a	*b*	Isometry/allometry	r^2	*n*
$H = a + b \times L$	3.62 (2.84–4.40)	0.39 (0.38–0.40)	Negative	0.76	2,066
$\mathrm{Sh} = a \times L^b$	0.0001 (0.0001–0.00013)	2.97 (2.90–3.03)	Isometric	0.82	2,075
$T = a \times L^b$	0.0003 (0.0002–0.0004)	2.2916 (2.28–2.39)	Negative	0.52	2,075

Values of *a* and *b* are parameters of the equation, *r* is the regression coefficient and *n* is the sample number. Values between parentheses are the upper and lower 95% confidence intervals

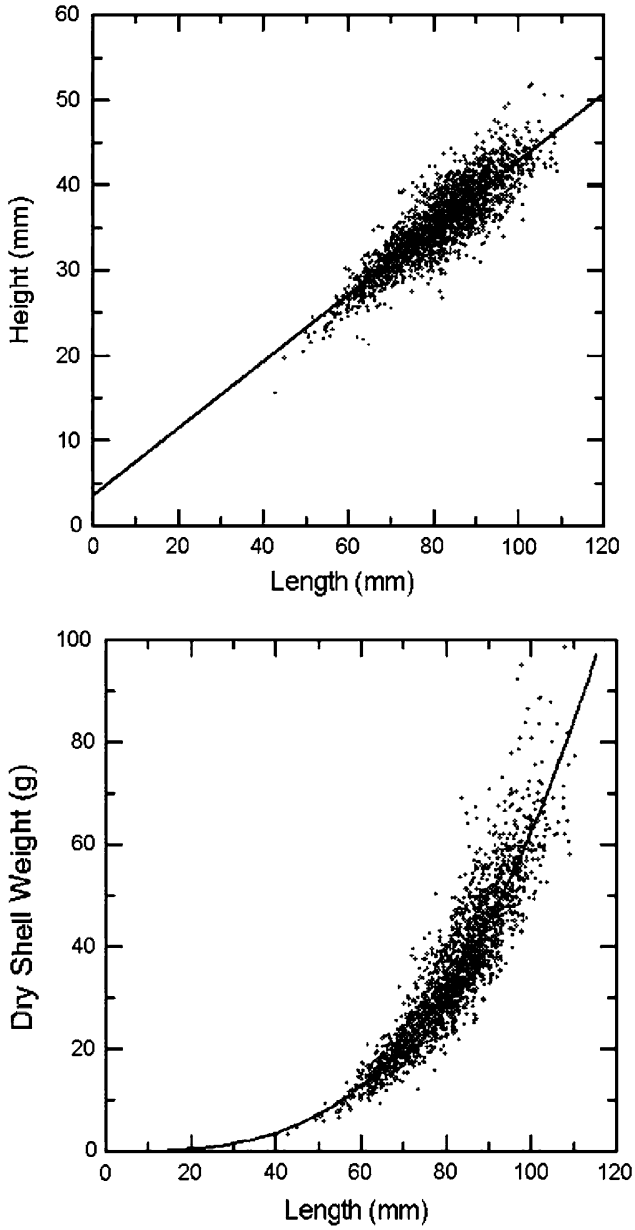

Fig. 5 Length/height and length/dry shell weight relationships of northern propellerclam collected from Banquereau Bank. The morphometric relationships are shown in Table 4

The northern propellerclam is characterized by an elongated shell with parallel and equally rounded dorsal and ventral edges. The left and right valves are symmetrical and have the same weight. There was negative allometry in the height/length relationship indicating that the growth in shell length is faster than that of shell width resulting in the elongated shape of the clam. The elongated form of some infaunal species like the northern propellerclam enables them to burrow deep with low energy requirements to escape from predators (Urban 1994). It is unknown whether the growth pattern of the propellerclam changes throughout its life. Another elongated bivalve, the razor clam *Ensis macha*, experiences an abrupt change in its growth pattern of height relative to length, from negatively allometric to isometric (Barón et al. 2004). This was attributed to the shift in the mode of life of individuals from subsurface dwelling spat to active digging juveniles and adults.

This study presents the first documentation of the validated age, growth and reproduction of the northern propellerclam in Eastern Canada. Although this information will be necessary to regulate the imminent fishing activity, more detailed studies are still necessary to allow for the development of a long-term management plan.

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