INSTAR IDENTIFICATION AND LIFE HISTORY ASPECTS OF JUVENILE DEEPWATER SPIDER CRABS, *CHIONOECETES TANNERI* RATHBUN

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ABSTRACT

For the deepwater spider crab, *Chionoecetes tanneri*, seven instars from first crab stage (3.8 mm carapace width (CW)) to instar VII (26.8 mm CW) are identified from size-frequency histograms. The average growth per molt for the first seven instars is 39% and the time from egg to instar VII is estimated to be 20 months.

Measurements of chela length, abdomen width and carapace width were used to define two growth phases for *C. tanneri* and to determine size at maturity for males (142.7 mm CW) and females (102.3 mm CW). The unequal sex ratio of adults (29% males) and presence of chitinoclastic lesions on 76% of the adult females as compared with only 29% of the adult males suggest that adult females are anecdysic.

In this study of material collected off the southern Oregon coast, the mean adult carapace widths for males and females is very close to the sizes reported for adult males and females (148.9 and 102.5 mm CW respectively) from the northern Oregon coast. The similarity in size extends to the material collected from near the type location (Gulf of the Farallons) where instars VI and VII are 19.4 and 27.3 mm CW compared with 19.8 and 26.7 mm CW for the same instars from the southern Oregon coast. The biotic stability at depths of maximum abundance (500-775 m) contributes to this uniformity.

The spider (or tanner) crab, *Chionoecetes tanneri* Rathbun, is similar in size and morphology to the better known and commercially harvested species *C. bairdi* and *C. opilio*. Unlike *C. bairdi* and *C. opilio* which are typically encountered in shallow waters and are not reported deeper than 400 m in the eastern Pacific, *C. tanneri* is a deep-water species which ranges to 1,925 m and has its maximum abundance at 500-775 m (Pereyra 1972).

Although *C. tanneri* is not likely to be fished commercially because of its deep-water habitat and certain aspects of its biology, Somerton (1981) suggested that fluctuating supplies of Alaskan crab species might promote more economical methods for fishing in deep water. Red crab, *Geryon quinquedens*, taken from depths of 257-1,000 m between Georges Bank and Cape Hatteras are landed commercially in limited numbers on the eastern seaboard (Lux et al. 1982; U.S. National Marine Fisheries Service Fisheries Statistics 1985).

In part, because of its deep-water habitat, certain life history aspects of *C. tanneri* are not well known. Pereyra (1966, 1968) determined size at maturity and described the seasonal distribution of adult and late juvenile crabs. Egg development follows a yearly cycle with release of matured eggs and ovulation of new eggs during the winter (Pereyra 1966). After hatching, the total larval (pelagic) phase (prezoea, zoea I, II and megalopa) is estimated to be 80 d (Lough 1974). Samples collected mainly from a series of cruises off the Oregon coast from 1972 to 1975 have provided us with *C. tanneri* specimens from the first crab stage to adult. These specimens have made it possible to identify a series of early instars and to determine juvenile growth rates; they also provided life history information on size at maturity and adult and juvenile sex ratios for comparison with earlier work. In addition, observations of the carapace condition of adults helped to substantiate the anecdysic condition of adult females.

METHODS

Sampling

Samples of *C. tanneri* were collected off the continental shelf and slope areas adjacent to Coos Bay, OR (lat. 42°25′N, long. 124°50′W) in depths ranging from 300 to 1,200 m during 10 cruises between April 1973 and March 1975. A total of 1,625 crabs

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of both sexes ranging in size from 10 to 165 mm carapace width (CW) were captured using two types of trawl gear: a 9 m semi-baloon Gulf of Mexico shrimp trawl and a 3 m beam trawl (Carey and Heyamoto 1972). The stretched dimension of the mesh for both trawl nets was 38 mm (1.5-in), and the cod ends were lined with 12.7 mm (0.5-in) mesh. In addition 47 of the smallest crabs (3-10 mm CW) were found in the gut contents of sable fish, *Anoplopoma fimbria*, and Dover sole, *Microstomus pacificus*, caught in these trawls. The Smithsonian Institution provided another 306 juvenile tanner crabs taken near the type location for *C. tanneri* west of the Farallon Islands (lat. 37°30′N, long. 122°59′W) (Rathbun 1925) at 500-783 m.

Size at Maturity

The size at maturity for both male and female *C. tanneri* was based on allometric measurements. Allometry compares the difference in the proportions of specific body parts with changes in absolute size of a major body axis (Gould 1966). In Brachyura the allometric growth of secondary sex characters is well documented (Tessier 1960; Hartnoll 1969). In the genus *Chionoecetes* it takes the form of differential enlargement of the abdomen and modification of pleopods in females whereas the size and shape of the chelae are modified in the males (Watson 1970; Brown and Powell 1972).

Carapace width for both male and female crabs was measured at its widest part (mesobranchial region) exclusive of spines (Fig. 1A). The male carapace width was compared with the length of the chelar propodus (CPL) which is measured from the joint between the carpus to the tip of the fixed finger of the propodus (Fig. 1B), whereas the female carapace width was compared with the width of the abdomen (AW) which is measured at its widest part (fifth segment) (Fig. 1C). Males with worn or broken chelipeds were not used. All measurements were made to the nearest 0.01 mm using precision dial calipers, and numbers were rounded to the first decimal for plotting. Plots of the measurements of CW vs. CPL and CW vs. AW were used to identify size at maturity for males and females.

Size-Frequency Histograms, Growth, and Sex Ratio

Measurements of the carapace width were taken from the 1,978 crabs available. Size-frequency histograms were constructed and seven juvenile instars were identified from dominant modes. Adult *C. tanneri* are sexually dimorphic with respect to body size (Pereyra 1972). Since we did not know at which molt this size dimorphism was first evident, the data for males and females was shaded differently in the size-frequency histogram. The juvenile sex ratio was

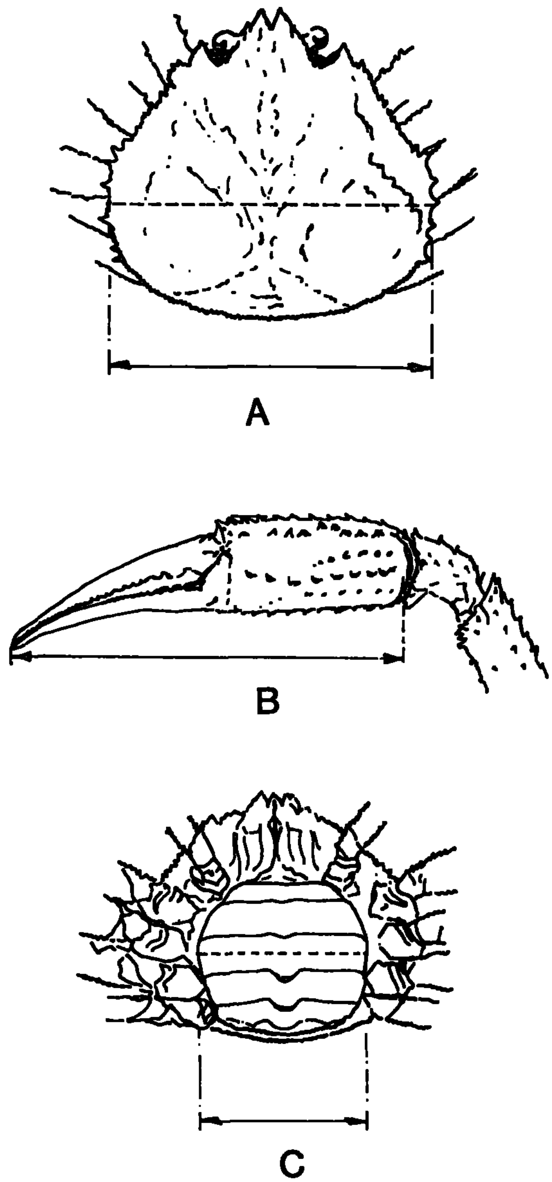

FIGURE 1.—Body dimensions of *Chionoecetes tanneri* measured for size-frequency and allometric analyses. (A) Carapace width (♂ and ♀) measured at its widest part across the mesobranchial region and exclusive of spines. (B) Chelar propodus length (♂) measured from the joint between the carpus and the tip of the fixed finger of the propodus. (C) Abdomen width (♀) measured at its widest part, across the fifth segment.

calculated for each instar, and when it was clear from the equal sex ratio that juvenile males and females were not dimorphic, the percent increase in carapace width per molt was computed as

$$\text{Percent increase in CW (mm)} = \frac{\text{Postmolt CW (mm)} - \text{Premolt CW (mm)}}{\text{Premolt CW (mm)}} \times 100$$

In one series of size-frequency histograms from samples collected in June, July, and August 1974 and January and March 1975, the progression of modes (representative of instars of the small juveniles from fish gut contents) was used to estimate growth rate. The next larger instar (CW = 10 mm) was the first to be consistently sampled by the trawl gear. Starting with the 10 mm CW instar from April 1973, growth of juvenile tanner crabs was followed through August, October, and November 1973 and March 1974.

Carapace Condition

Detailed observations were made of the carapace on each specimen and included hardness, amount of attached fauna, and general condition. Darkened and softened or weakened areas on the carapaces were similar to those caused by chitinoclastic bacteria (Sindermann 1970) and were thought to be associated with age. Adult female *C. tanneri* were especially subject to carapace deterioration.

RESULTS AND DISCUSSION

Since a high degree of correlation between gonad maturity and external morphology has been shown for the genus *Chionoecetes* (Brown and Powell 1972; Donaldson et al. 1981), a plot of carapace width and chela length (Fig. 2) was used to define adult males. Specimens with chelae longer than 85 mm (corresponding to carapace width >118 mm) were assumed to be sexually mature males. Those females

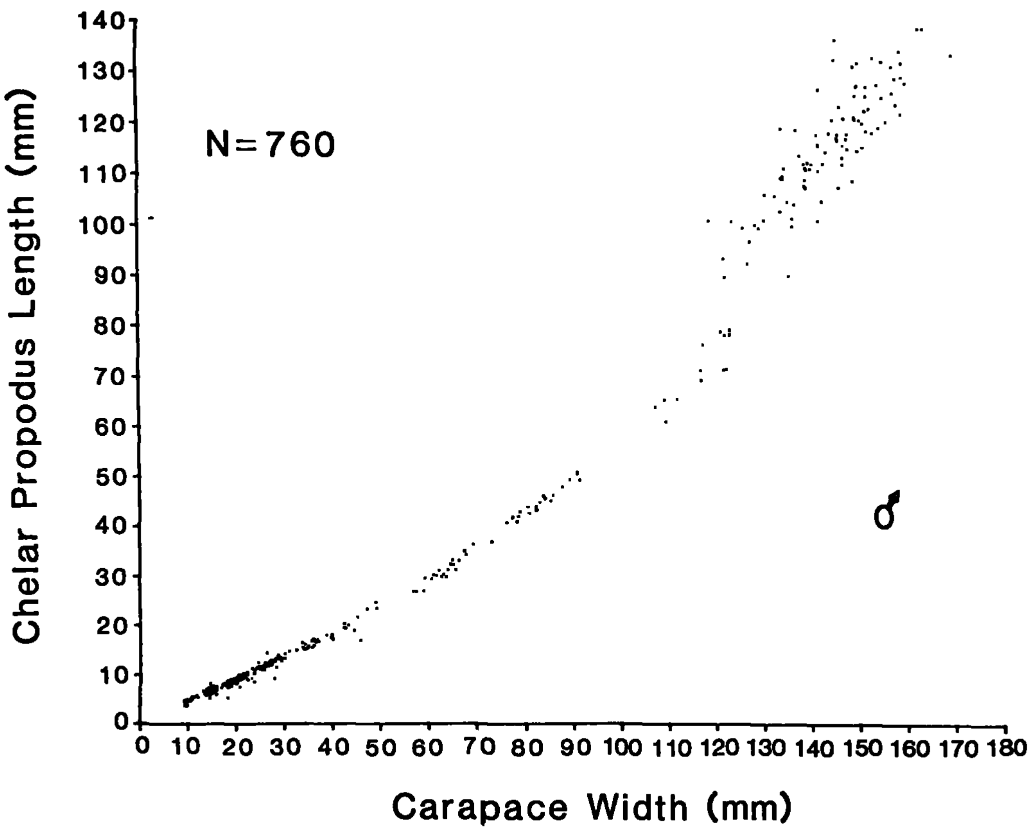

FIGURE 2.—Relationship between carapace width and chelar propodus length for juvenile and adult male *Chionoecetes tanneri*.

with abdomen widths > 50 mm (corresponding to carapace widths >85 mm) form a well-defined group (Fig. 3) of adults. The mean carapace width for adult male and female crabs in this study was 142.7 and 102.3 mm respectively and was compared with the mean carapace widths of 148.9 and 102.5 mm for females given by Pereyra (1972) for adult *C. tanneri* collected south of the Columbia River mouth. Brown and Powell (1972) reported a similar correspondence in adult carapace widths for *C. bairdi* collected from locations in Alaska. The large variation in size of mature male *C. bairdi* in the eastern Bering Sea was clearly related at the clinal variation temperature (Somerton 1981).

Seven modes representing juvenile instars are evident from the size-frequency histograms (Fig. 4). The mean carapace widths for each juvenile instar were calculated and subsequently the increase in CW per molt was computed (Table 1). The average increase at each molt for instars I-VII is 39% and there is no difference in growth increment of juvenile males and females In a laboratory study using *C. opilio*, Miller and Watson (1976) reported that growth per molt for immature females was significantly greater than for immature males. But the findings of Hilsinger et al. (1975) agree with ours. They found no difference in growth rate for juvenile male and female *C. bairdi* and reported a constant growth rate of 27% for juvenile females. The change in the slope of the regression lines of the log-log plots of the allometric measurements of *C. tanneri* (Fig. 5) indicated a change in the rate of growth only at sexual maturity. *Chionoecetes tanneri*, like *C. opilio* (Watson 1970), showed two growth phases, one for juveniles and one for adults.

If *C. tanneri* eggs hatch predominantly in winter (January-March) and the total larval life is 80 d, the recruitment of the smallest crab stage (CW = 4) to the population in June-July is in agreement with our findings. Instars can be followed from 4 mm CW (instar I) in June and July 1974, to 5.5 cm CW (instar II) in August 1974, to 7.5 mm CW (instar III) in January 1975 (Fig. 6). The smallest specimens sampled by the trawls were about 10 mm CW, and there were relatively large numbers of these instar IV specimens in April 1973 which molted to instar V by August and to instar VI in October 1973 (Fig. 7). No growth of these instar VI crabs is evident from the November 1973 or March 1974 data. We estimate approximately 20 mo from egg hatching to instar VII (CW = 26.8 mm) (Fig. 8).

Observations on general carapace condition and abundance of epifauna indicate that adult male *C. tanneri* do molt frequently enough to maintain their

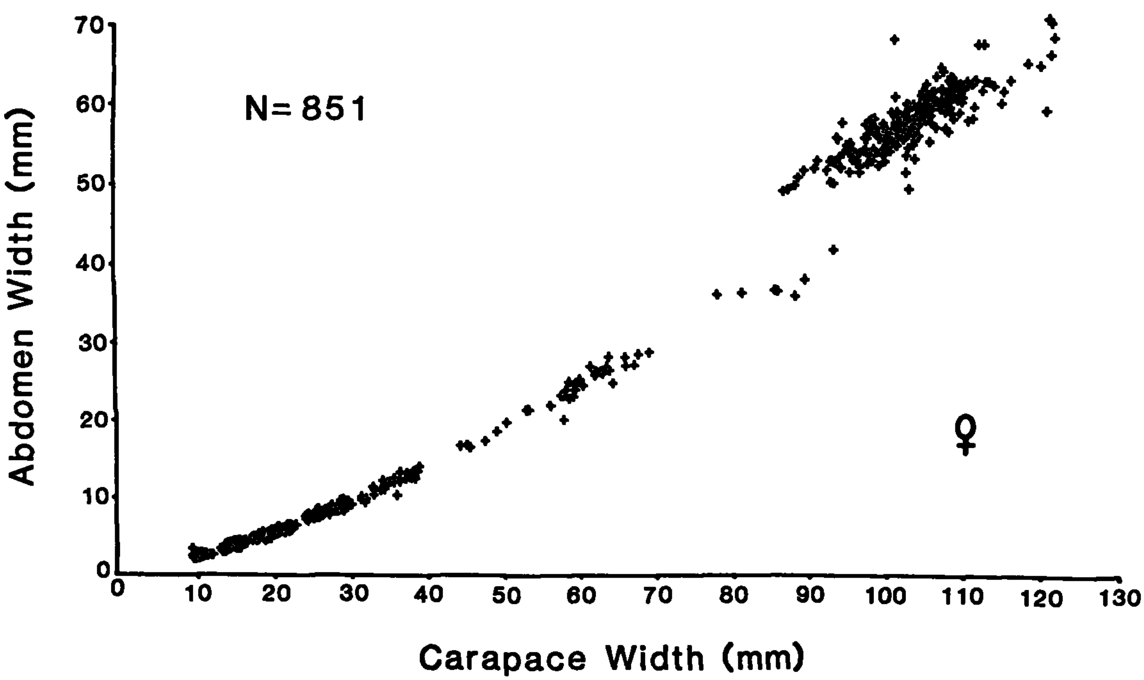

FIGURE 3.—Relationship between carapace width and abdomen width for juvenile and adult female *Chionoecetes tanneri*.

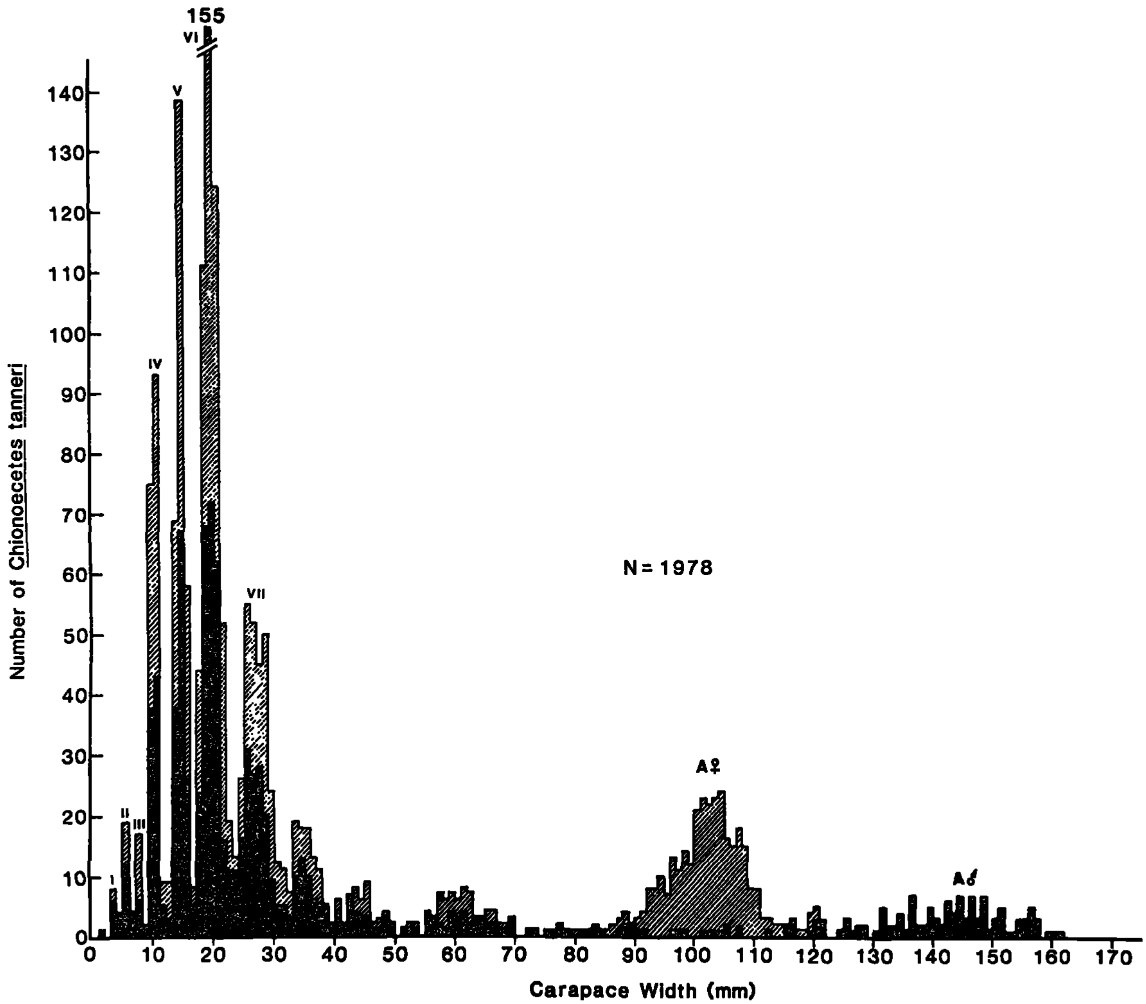

FIGURE 4.—Size-frequency histograms representing all specimens of *Chionoecetes tanneri* collected off the Oregon coast 1973-75 and from the Gulf of the Farallons. Instars I-VII are indicated. Males are shown in solid color.

carapaces relatively free of epifauna and lesions caused by bacterial infections (Baross et al. 1978). Of the 290 adult female specimens examined, 87% showed exoskeleton lesions and these adult females also had the highest diversity and abundance of epifauna on their exoskeletons. Only 29% of the 124 adult males observed showed the effect of chitinoclastic bacterial infection. No lesions or epifauna were found on any of the 1,447 juveniles examined. In contrast to the findings of Hartnoll (1969) who worked with shallow-water spider crabs, observations of the carapace condition of adult male and female *C. tanneri* suggests adult males continue to molt after maturity while adult females are anecdysic, a finding consistent with Watson's (1970) data for *C. opilio*. The unequal adult sex ratio (29% males, Table 1) is also an indication that males may be subjected to the differential mortality of continued molting.

The agreement of mean CW for adults collected off the Oregon coast in the study and that of Pereyra's (1966) work has an interesting corollary in the material collected from near the Farallon Islands. The mean carapace width of instars VI and VII for *C. tanneri* collected west of the Farallon Islands is 19.4 and 27.3 mm respectively. The carapace widths for the same instars collected from Oregon is 19.8 and 26.7 mm. Childress and Price (1978) credited the constant increase in size between each pair of instars in the deep-living, midwater

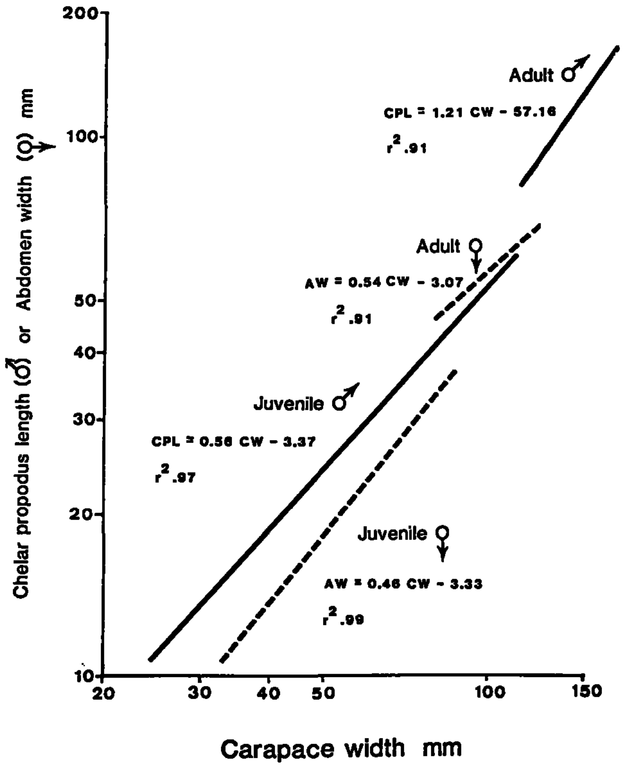

FIGURE 5.—Growth phases for juvenile and adult *Chionoecetes tanneri*. CPL = Chelar propodus length (mm); CW = Carapace width (mm); AW = Abdomen width (mm).

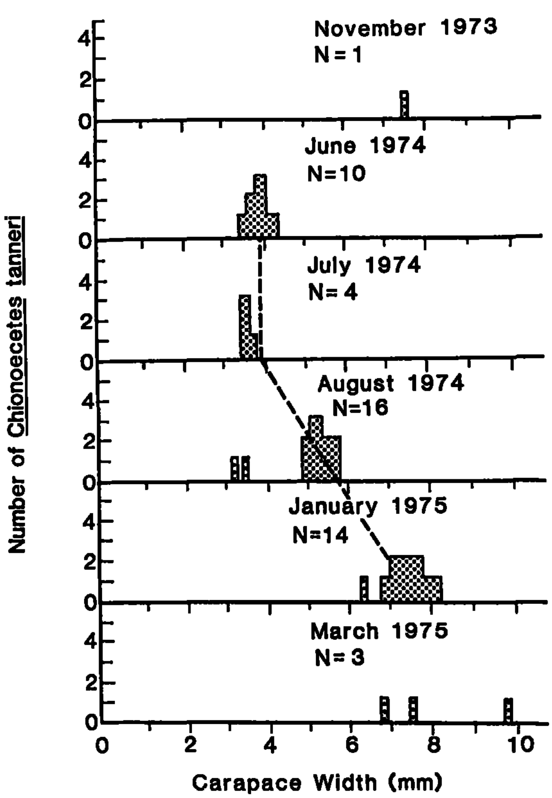

TABLE 1.—Percent increase in mean carapace width and sex ratio (males %) for successive instars of *Chionoecetes tanneri*.

Instar	N	Males (%)	Carapace width (mm) Mean	Carapace width (mm) s^2	Increase in carapace width (%)
I	16	53	3.80	0.25	
					48.4
II	19	—	5.64	0.62	
					35.8
III	18	53	7.66	0.53	
					31.7
IV	175	49	10.09	0.57	
					43.0
V	281	49	14.43	0.68	
					36.5
VI	499	50	19.69	1.18	
					36.6
VII	268	53	26.83	3.40	
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—					
Adults	411	29			

FIGURE 6.—Size-frequency histograms representing early juveniles with carapace widths < 9 mm. These samples were collected from stomachs of benthic fish. The dashed line represents the progression of instars through time with first crab stage in June to instar II in August and instar III in January.

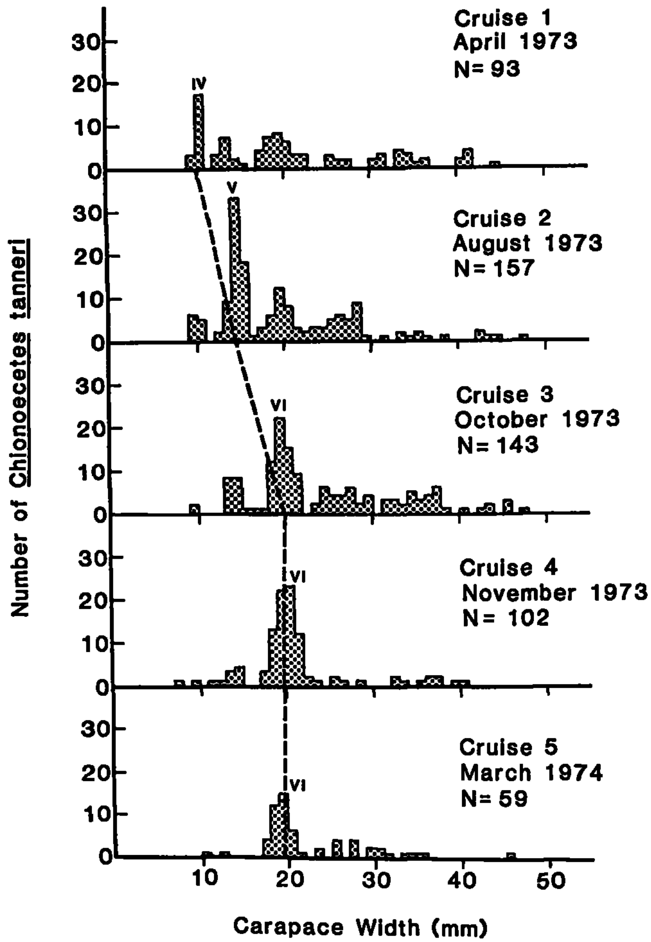

FIGURE 7.—Size-frequency histograms representing juveniles with carapace widths 10-50 mm wide. The dashed line represents progression of instars through time with instar IV in April, instar V in August and instar VI in October through March.

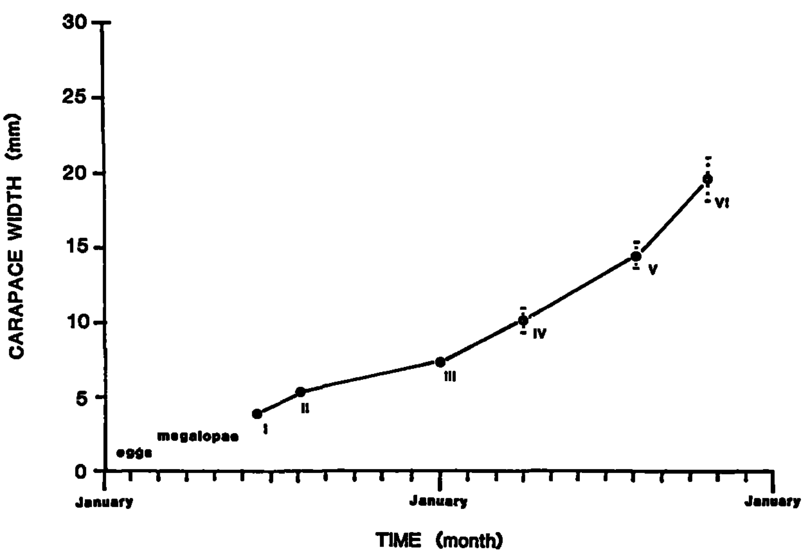

FIGURE 8.—Growth rate of *Chionoecetes tanneri* from egg to seventh instar is estimated to be at least 20 mo. Dotted lines indicate standard deviation.

mysid, *Gnathophausis ingens*, to the physical and biotic stability of this species' environment. Various environmental factors can alter both the dimensions and the number of molts in many species of crustaceans. At depths of maximum abundance (500-775 m) of *C. tanneri*, the annual water ranges from 2.3° to 5.6°C and certainly this uniform environment contributes to the consistency of instar size and size at maturity.

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