Temperature and Growth of Maturing *Haliotis kamtschatkana* Jonas

BY

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(4 Text figures)

INTRODUCTION

THE PINTO ABALONE, *Haliotis kamtschatkana* Jonas, 1845, supports a small commercial fishery along the outer coast of southeast Alaska, but its restricted distribution and low population densities preclude large-scale expansion of the fishery. On a world wide basis the demand for abalone meats, which generally exceeds supply, has generated interest in expanding the harvest of these gastropods. In areas of Japan and the state of California (U.S.A.) where *Haliotis* spp. have been overharvested, small hatchery-reared abalone are used to supplement natural reproduction. Similar techniques could be used along the inner coast of southeastern Alaska to expand natural or domesticated populations of abalone. To be economically successful, the culture of domesticated abalone must rely on selection of habitats suitable for rapid growth.

Currently, little information is available on the relationship of temperature and the various biological functions of pinto abalone. This species spawns in the spring when the water temperature reaches approximately 9° C (QUAYLE, 1971; PAUL *et al.*, 1977) and thermal death occurs if individuals are kept at 16° C to 17° C (unpublished data). The objective of this study was to observe shell growth of maturing pinto abalone at different temperatures. Maturing individuals were selected because they grow rapidly and individual differences in growth are pronounced. The temperatures examined are typical of southeastern Alaska during the spring and summer growth period.

METHODS

Mean sea water temperatures of 5.5 ° C (standard deviation 0.8), 8.5° C (standard deviation 0.6), 11.5° C (standard deviation 0.8) and 13.5° C (standard deviation 0.5) were maintained in 4 tanks by adjusting the flow rates of the incoming water. Sea water salinity was naturally between 32‰ and 33‰. Two size groups of *Haliotis kamtschatkana* with shell lengths of 48.0 mm to 50.4 mm, and 50.5 mm to 52.5 mm were introduced into each tank. Individual tanks contained 6 abalone from each size class.

The abalone in each tank were provided with the following species of algae as food: *Enteromorpha linza* (Linnaeus) J. Agardh, *Ulva lactuca* Linnaeus, *Laminaria groenlandica* Rosenvinge, *Nereocystis luetkeana* (Mertens) Postels & Ruprecht, *Alaria marginata* Postels & Ruprecht, and *Rhodymenia palmata* (Linnaeus) Greville. These species of algae were selected because they produced good growth rates when fed to pinto abalone in an earlier study (PAUL *et al.*, 1977). The amount of algae in each tank was far in excess of daily consumption rates. At the end of 60 days of growth, shell length and shell width were remeasured and compared with the initial measurements. Individuals held at 11.5° C and 13.5° C were measured again on the 105th day of growth. A linear regression was used to find the mathematical relationships between temperature and growth. The validity of the correlation coefficient (r) was measured using the formula $t = \sqrt{vr/(1-r)}$; where $v = n-2$. The 95% confidence was used in determining significance.

RESULTS

At 5.5° C the abalone in both size groups exhibited very little growth (Table 1, Figure 1) with changes in average length of less than 1%. At 8.5° C there was a 1.5 mm or 3.0% and 0.6 mm or 1.2% increase in shell length and width for the 48.5 to 50.4 mm pinto abalone held for 60 days (Table 1, Figures 1 and 2). This size abalone kept at 13.5° C exhibited 4.6 mm or 9.4% and 3.7 mm or 7.5%

Table 1

Average increase in shell length and width in mm of *Haliotis kamtschatkana* kept at 5.5, 8.5, 11.5 and 13.5 degrees centigrade.
($\bar{x}$ = mean, SD = standard deviation, R = range)

Water temperature °C	Initial length (mm) $\bar{x}$/SD/R	Added length (mm) at day 60 $\bar{x}$/SD/R	Initial width (mm) $\bar{x}$/SD/R	Added width (mm) at day 60 $\bar{x}$/SD/R	Added length (mm) at day 105 $\bar{x}$/SD/R	Added width (mm) at day 105 $\bar{x}$/SD/R
5.5	49.8	0.4	35.4	0.3	–	–
	0.6	0.2	1.0	0.2	–	–
	48.2 - 50.0	0 - 1.0	34.0 - 37.6	0 - 0.6	–	–
8.5	49.5	1.5	35.9	0.6	–	–
	0.4	0.7	1.1	0.6	–	–
	48.8 - 50.0	0.5 - 2.4	35.2 - 36.6	0 - 1.4	–	–
11.5	49.2	1.9	35.2	2.0	3.7	3.1
	1.0	0.4	1.0	1.4	0.4	2.1
	48.5 - 50.4	1.5 - 2.4	34.5 - 36.2	0 - 3.3	3.3 - 4.1	0.5 - 5.5
13.5	48.9	4.6	35.0	3.7	5.0	4.5
	0.7	1.2	0.8	1.0	1.7	1.5
	48.5 - 50.0	3.3 - 6.1	34.4 - 35.6	3.1 - 5.3	2.5 - 6.6	3.2 - 6.6
5.5	51.2	0.5	36.5	0.2	–	–
	0.5	0.2	1.3	0.2	–	–
	50.6 - 52.0	0.3 - 0.7	34.0 - 37.0	0 - 0.4	–	–
8.5	51.0	1.1	36.4	1.5	–	–
	0.6	0.7	1.1	1.0	–	–
	50.6 - 51.8	0 - 1.6	35.9 - 38.2	0 - 2.4	–	–
11.5	51.2	3.8	36.2	2.1	6.2	3.8
	1.7	1.2	1.3	0.8	1.9	1.6
	50.6 - 51.9	3.0 - 4.7	34.4 - 37.2	1.4 - 3.3	4.5 - 8.5	1.8 - 5.3
13.5	51.3	3.8	36.5	2.6	6.0	3.9
	0.5	1.7	0.9	1.6	1.6	1.5
	51.0 - 52.3	2.8 - 6.7	35.2 - 37.5	1.3 - 5.1	2.9 - 7.8	2.3 - 6.1

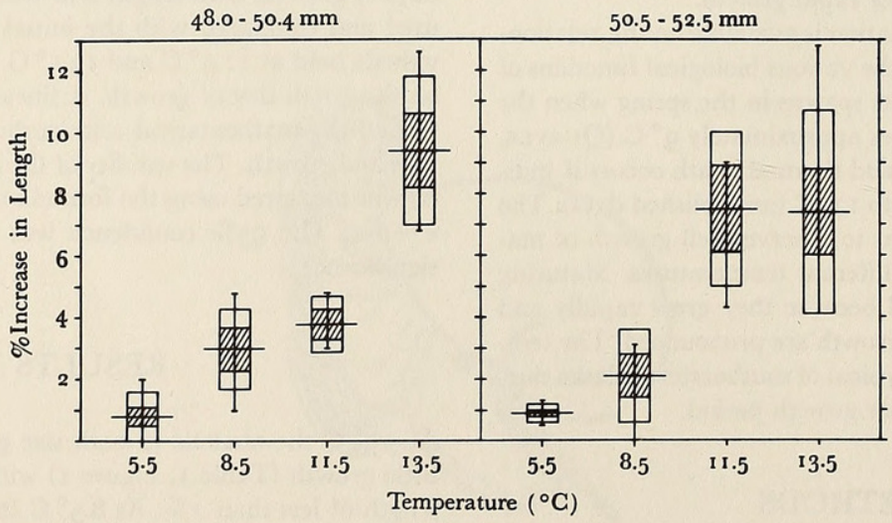

Figure 1

The percent increases in shell length of two groups of *Haliotis kamtschatkana*, initial shell lengths 48.0 mm to 50.4 mm, and 50.5 mm to 52.5 mm, held at 5.5°C, 8.5°C, 11.5°C and 13.5°C for 60 days.

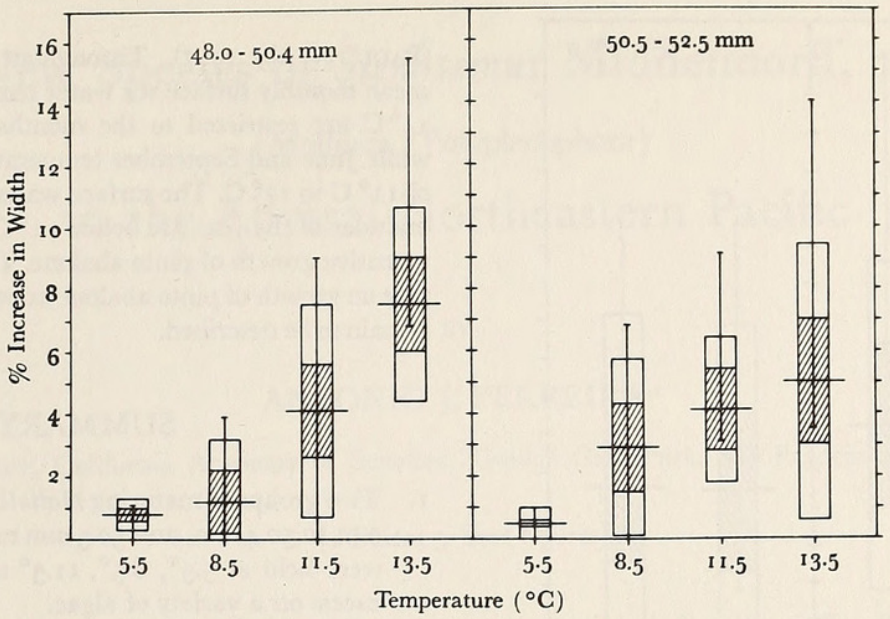

Figure 2

Concurrent percent increases in shell width of the two size groups of *Haliotis kamtschatkana* in Figure 1 after being reared at 5.5°C, 8.5°C, 11.5°C and 13.5°C for 60 days.

change in these same dimensions. At 11.5° C growth rates of abalone in this size group were intermediate between those held at 8.5° C and 13.5° C (Table 1, Figures 1 and 2). The regression analysis for the relationship between temperature and increase in shell length of 48.0 mm to 50.4 mm pinto abalone resulted in a positive correlation coefficient (9.7) and the t-distribution was significant.

At 8.5° C the mean increase in shell length in 50.5 mm to 52.5 mm pinto abalone was only 1.1 mm or 2.1% as compared to 3.8 mm or 7.4% for abalone maintained at 13.5° C (Table 1, Figure 1). Similar changes in shell width were observed (Table 1, Figure 2). The 3.8 mm and 2.1 mm increase in shell length and width for this size abalone held for 60 days at 11.5° C were almost identical to the change in size of their cohorts kept at 13.5° C (Table 1, Figures 1 and 2). The t-distribution determined by regression analysis of change in length after 60 days for 50.5 mm to 52.5 mm specimens kept at all 3 water temperatures was not significant. Similar calculations with 60 day growth data from just the 8.5° C and 13.5° C group, and then only the 11.5° C and 13.5° C group resulted in t-distributions that were significant and not significant, respectively.

After 105 days the 48.5 to 50.4 mm pinto abalone held at 11.5° C increased an average of 3.7 mm or 7.5% in length and 3.1 mm or 6.3% in width while their cohorts held at 13.5° C increased 5.0 mm or 10.2% and 4.5 mm or 9.2% in length and width respectively (Table 1, Figures 3 and 4). The 50.5 mm to 52.5 mm abalone kept at 11.5° C and 13.5° C for 105 days exhibited average increases in

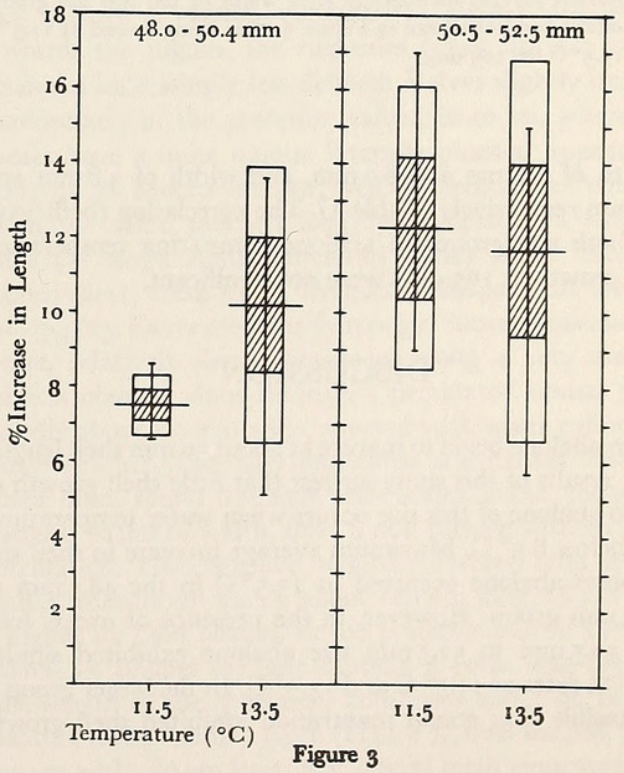

Figure 3

The percent increases in shell length of two groups of *Haliotis kamtschatkana,* initial shell lengths 48.0 mm to 50.4 mm and 50.5 mm to 52.5 mm, held at 11.5°C and 13.5°C for 105 days.

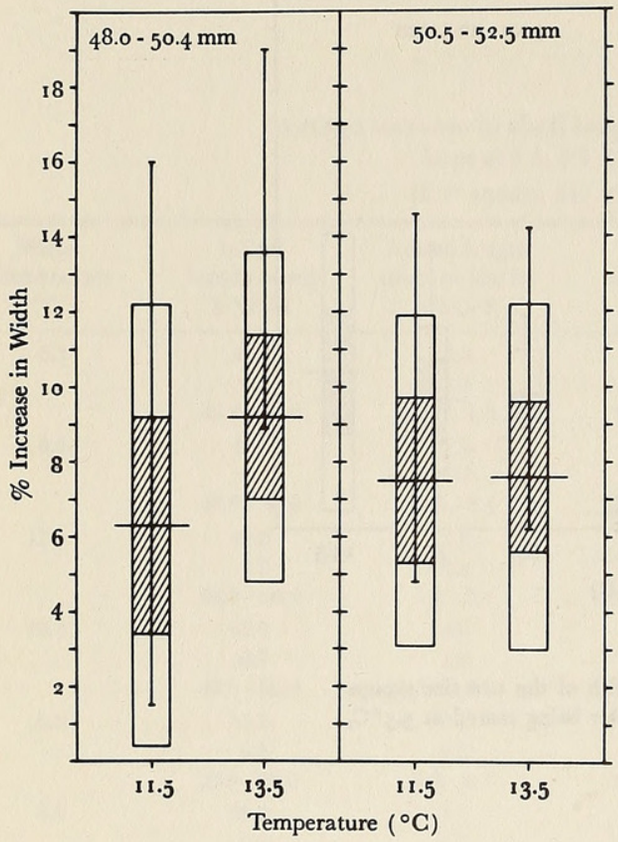

Figure 4

Concurrent percent increases in shell width of the two size groups of *Haliotis kamtschatkana* in Figure 3 after being reared at 11.5°C and 13.5°C for 105 days.

length of 6.2 mm and 6.0 mm, and width of 3.8 mm and 3.9 mm respectively (Table 1). The correlation coefficients for both size groups of abalone comparing temperature and growth in 105 days were not significant.

DISCUSSION

Pinto abalone begin to mature at about 50 mm shell length. The results of this study suggest that little shell growth of pinto abalone of this size occurs when water temperatures are below 8.5° C. Maximum average increase in shell size of pinto abalone occurred at 13.5° C in the 48.5 mm to 50.4 mm group. However, in the presence of excess food the 50.5 mm to 52.5 mm size abalone exhibited similar growth rates at 11.5° C and 13.5° C. In the larger group it is possible that gonad maturation inhibited shell growth (Paul, *et al.*, 1977). Throughout southeastern Alaska mean monthly surface sea water temperatures of 13° C to 14° C are restricted to the months of July and August while June and September temperatures are on the order of 11° C to 12° C. The surface water temperatures the remainder of the year are below 11° C and thus too low for extensive growth of pinto abalone. The effects of temperature on growth of pinto abalone at other stages of maturity remain to be described.

SUMMARY

1. Two groups of maturing *Haliotis kamtschatkana*, 48.0 mm to 50.4 mm, and 50.5 mm to 52.5 mm shell length were held at 5.5°, 8.5°, 11.5° and 13.5° C and fed to excess on a variety of algae.
2. Shell growth of pinto abalone was inhibited at 5.5° C and little growth occurred at 8.5° C.
3. Sea temperatures of 11.5° C were necessary before notable shell growth was observed in pinto abalone and maximum growth rates required 13° to 14° C.

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