GROWTH OF THE COLUMBIA RIVER LIMPET,
FISHEROLA NUTTALLI (HALDEMAN),
IN NORMAL AND REACTOR-WARMED WATER

C. C. Coutant and C. D. Becker

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GROWTH OF THE COLUMBIA RIVER LIMPET,
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by

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Aquatic Ecology Section

15 August 1970

¹Based on work performed under United States Atomic Energy Commission contract AT(45-1)-1830 with Battelle Memorial Institute. This study was coordinated with the interagency Columbia River Thermal Effects Study.

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GROWTH OF THE COLUMBIA RIVER LIME
FISH (LIMNOSTOMA) (LIMNOSTOMA)
IN FRESH AND HEAVY-METAL-CONTAMINATED WATER

G. C. GOWAN and G. H. BAKER

Advanced Ecology Section

15 August 1971

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C. C. Coutant and C. D. Becker

ABSTRACT

Limpet snails (Fisherola nuttalli) were collected through 1969-70 at locations above and below thermal additions from reactor discharges in the central Columbia River above Richland, Washington. Temperatures of the mixed river water below the reactor operations were increased about 0.5 to 2.5 C. Limpet sizes and growth rates at any collecting period did not differ significantly between the two areas.

Growth of young limpets was most rapid from July to October when Columbia River temperatures were high. Growth rates stabilized during the fall and winter when temperatures dropped and became minimum, then increased with warming temperatures of early spring. Adult limpets collected from downstream areas and held in the warmed water in the laboratory reproduced successfully. Deposition of egg cases by mature limpets occurred on rising temperatures in April, May and June during the period of maximum river flows. High mortality occurred among mature limpets during and following the reproductive period. The Columbia River limpet, like many other gastropod molluscs, has a predominantly one year life cycle.

GROWTH OF THE COLUMBIA RIVER LIGGETT
LEUCISCEUS (MILNE-EDWARDS)
IN NORMAL AND HIGH FLOOD WATERS

L. E. Condit and C. H. Becker

ABSTRACT

..... Liggett was collected from 1935-1940 at
locations above and below thermal effluents from power plants in the
central Columbia River above Richland, Washington. Temperature of the water
river water before the power operations were initiated about 17.1 to 21.5 C.
Liggett size and growth rates at any collecting period did not differ
significantly between the two areas.
Growth of young liggett was most rapid from July to October when Columbia
River temperatures were high. Growth rates established during the fall and
winter when temperatures dropped and became minimum, then increased with
varying temperatures of early spring. Small liggett collected from lower
stream areas and held in the warm water in the laboratory, developed
apparently, a period of rapid growth by spring liggett occurred in
spring temperatures in April, May and June during the period of maximum
river flow. High mortality occurred among young liggett during and
following the spring freshet. The Columbia River liggett, like many
other aquatic organisms, has a predominantly one year life cycle.

GROWTH OF THE COLUMBIA RIVER LIMPET, FISHEROLA NUTTALLI (HALDEMAN),

IN NORMAL AND REACTOR-WARMED WATER

INTRODUCTION

The limpet snail, Fisherola nuttalli (Haldeman), contributes to the biomass of invertebrate organisms forming benthic communities in the Columbia River between Priest Rapids Dam and Richland, Washington. The anatomy and distribution of this organism (Gastropoda: Lencidae) was described by Morrison (1955), but little has been published of its life history. Basch (1959) reported on the development and reproduction of a closely related species, Ferrissia shimekii of the family Ancyliidae, from the northcentral United States. F. nuttalli is apparently restricted in distribution to the Columbia River system, and other members of the genus Fisherola are known only from coastal rivers south of the Columbia (Henderson, 1929; Morrison, 1955). Such a restricted distribution suggests that the family Lencidae is an old relict type and that the species are now largely endemic. If this is the case, the Columbia River limpet might be a sensitive indicator of environmental alterations occurring in recent decades throughout the Columbia system.

Temperatures of the central Columbia are modified as the river flows through the Hanford area of the U. S. Atomic Energy Commission. Descriptions are available of the operation of plutonium production reactors, the discharge of heated water (used in cooling) to the river, and the extent of natural heating in summer (Nakatani, 1969; Coutant, 1969b). Various environmental impacts of the reactors have been studied in order to clarify onsite effects and to predict future effects of heated discharges from additional thermal electric generating stations proposed for construction on the river system.

The objective of this study was to quantify differences in growth rates, if any, of limpet populations at sites above and below the main discharge locations. Growth of poikilothermous aquatic invertebrates is generally responsive to small changes in environmental temperatures (Vernberg, 1963; Coutant 1969a, 1970). For example, slight thermal differences at Hanford are presumably responsible for an earlier emergence of adult caddisflies below the heated reactor discharges than from river reaches above (Coutant, 1968).

Initial data on the life cycle and growth pattern of F. nuttalli were obtained by the senior author in the course of periodic sampling of benthic river organisms during 1966 and 1967 at a site about 20 miles north of Richland below the reactors (Watson, et al. 1970). Limpets were collected at approximately three week intervals from a reach of shallow, fast-flowing water along the Benton County shore near river mile 368. These samples comprised about 4 ml volume and were analyzed for gamma-emitting radionuclides.

Average weights of Columbia River limpets in these samples (obtained from total weight and number of snails) are presented in Figure 1. No data are available for the annual spring freshet (May, June, July) when water flows more than doubled and the bottom became inaccessible for sampling, nor for variability in weights among individual limpets. These data seemed to represent two year-classes. The first and larger year-class included all individuals collected before the high water period and some collected immediately after return to normal river flows. The second year-class included most individuals collected after the high water period. The absence of large snails of the first year class from October through December strongly indicated negligible carryover of mature limpets from year to year. Thus F. nuttalli appeared to have a predominantly one year life cycle. Pennak (1953) indicated that 9 to 15 months is the usual life span for the majority of

gastropod species. However, Hunter (1961) pointed out that the life cycles of various gastropod mollusks do differ considerably even though essentially the same in duration.

Observations of limpet egg masses were obtained during high water in June and July, 1966. Artificial substrates were placed on the river bottom prior to the spring freshet and these were removed periodically when the bottom was inaccessible. Egg masses containing developing limpets were abundant on these substrates.

Data on the growth of individual limpets above and below the reactor discharges were obtained in 1969 and 1970, when four reactors were operating, and are presented herein.

METHODS

Eight stations were initially selected to study temperature effects on growth rates during the 1969-70 growing season (Figure 2). Four stations (1-4) were located below the effluent discharges (1 and 2 in the zone of complete mixing, 3 and 4 in the lower reaches of the incompletely mixed thermal "plume"), and four stations (5-8) were located above.

Limpets were abundant underneath rocks in shoreline zones swept by swift currents. Samples were obtained by hand, or by collecting stones with the aid of a grapple. Daily and weekly fluctuations in water levels imparted at Priest Rapids Dam (above Hanford) prevented consistent sampling of the same intrastation populations throughout the study. Sampling was necessarily destructive, and data obtained at each station represent different limpets residing within the general area (within 10-20 meters of shoreline). No limpets were collected from rocks exposed by fluctuating water levels because of possible retardation of growth. This restriction necessitated early termination of sampling at some stations.

Thirty individuals were collected at each station. At least two days were required to complete collections at all eight stations due to the short daily period of low river flow (3-4 hrs in early morning) created by the hydroelectric power cycle. Shell length and width of live, undamaged limpets were measured in the field to the nearest 0.1 mm. Length and width of each limpet were combined to obtain a parameter that reduced variability due to changes in shape. (Some limpets were long and slender while others were nearly round.) Mean sizes and 95 percent confidence limits were calculated for each sample of 30 limpets.

Water temperatures were monitored at two locations, one above Hanford at Priest Rapids Dam, and the other below all effluent discharges at the BNW Aquatic Ecology facility (100-F Area). The latter recorded temperatures of river water supplied to the laboratory, which differed only slightly from actual river temperatures.

Observations on reproduction and natural deaths among mature limpets during the spring freshet were made in the laboratory. Stones with attached limpets were collected and placed in rectangular troughs before the spate. The troughs were supplied with constantly flowing river water, recirculated by pump to simulate river currents, and lighted with neon lamps (cool white) to stimulate algae growth on which the limpets feed. Temperatures in the troughs corresponded to those in the river below the effluent discharges.

RESULTS AND DISCUSSION

Averages of daily high and low river temperatures, and average sizes of Columbia River limpets per sample (with 95% confidence limits) are presented in Figure 3. Water temperatures differed between upstream and downstream recorders by less than one-half to 2.5° C throughout the study.

Temperatures at stations 3 and 4, below reactors but above the point of complete mixing (checked by hand thermometer) were within 0.2°C of the daily average when limpet samples were taken. Other data (unpublished) on dispersion of heated effluents suggests that average temperatures at these stations should have been slightly higher, however.

The period of maximum shell growth occurred from July to October 1969 when river temperatures were near the seasonal peak ($17-20^{\circ}\text{C}$). Growth rates stabilized during the fall and winter when temperatures dropped and became minimum ($4-6^{\circ}\text{C}$), then increased with warming temperatures in early spring of 1970 when reproduction of the limpet age class commenced.

At no times were the sizes of limpets above and below the reactors significantly different (Figure 3). There was significant but not great variability among some stations at either location, however. Environmental factors peculiar to each particular collecting site thus apparently influenced growth to a greater extent than did differences in river temperature. These factors probably included (but were not necessarily restricted to) current speed, amount of algal growth on rocks (food) and microenvironment temperatures near the shoreline during low water periods, none of which were measured during the study.

All populations exhibited essentially the same growth pattern through the year. There was no evidence of altered timing of development to maturation such as observed for caddisflies (Coutant, 1968). Timing of availability of young limpets in the summer differed because of collecting problems, rather than because of detectable differences in interstation populations.

Mature limpets established in the laboratory deposited egg masses in an apparently normal manner during April, May and June 1970 when observations in the field were handicapped by high flows (more than twofold increase) of the spring freshet. Examination of all stones on 26 June indicated that about 50%

of the young limpets had hatched, whereas various stages of embryonic forms were evident within the remaining egg capsules. Counts of embryos in 65 egg capsules averaged 6.5 (range 1-12). Mortalities of mature limpets exceeded 95% on this date when trough (and lower river) temperatures had climbed to 17.3 C. Although these mortalities apparently corresponded to natural mortalities of adult limpets in nature following reproduction, some losses undoubtedly were due to handling injury. Mortalities precluded calculation of mean numbers of young produced per adult.

Egg capsules were transparent, gelatinous and suboval in form. There was an outer membrane and a series of inner membranes, each enclosing a developing embryo. Before hatching, young limpets were minatures of the adults, moving slowly within their individual eggs. Emergence occurred following perforation of the outer membrane.

CONCLUSION

These data clearly demonstrate that the Columbia River limpet has a dominant one year life cycle, and that growth and reproduction is closely related to the annual cycle of ambient river temperature.

There were no detectable differences in mean sizes, growth rate, or stages of maturity of limpets that could be attributed to thermal additions to the Columbia River by operating Hanford reactors. Limpets with a rearing history of temperatures 0.5 to 2.5° C above normal reproduced successfully at the elevated temperatures. Since this ancient species apparently is limited in distribution to the Columbia River system, it may be sensitive to small environmental changes. The temperature modifications experienced at Hanford, however, appear to be less than the sensitivity of growth responses of this species.

The Columbia River limpet is a suitable invertebrate for laboratory experimentation in studies of thermal effects. Its normal life cycle is complete in one year. Growth and development corresponds to the seasonal cycle of temperature changes in the river. Although the relatively low thermal increments measured in situ in this study imparted no detectable effects, thermal addition of greater magnitude may well regulate growth, embryonic development, reproduction and mortality. Since the limpet is a relic species, it may well be low in adaptive plasticity that reflects temporal and spatial peculiarities in the freshwater environment. However, its limited geographic distribution restricts its value as a sensitive indicator of pollution largely to the Columbia River system.

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FIGURE 1. AVERAGE WEIGHTS OF LIMPETS (FISHEROLA NUTALLI) COLLECTED FROM THE CENTRAL COLUMBIA RIVER 1966 and 1967.

FIGURE 2. COLLECTING SITES FOR LIMPETS BELOW (NO. 1-4) AND ABOVE (NO. 5-8) THE HANFORD REACTOR DISCHARGES, AND LOCATIONS OF THE TEMPERATURE MONITORING STATIONS (T_1 AND T_2). SHORELINE AREAS WERE SAMPLED EXCEPT AT 3 AND 4, THAT WERE ON OPPOSITE SIDES OF AN ISLAND LOCATED IN THE MAIN RIVER CHANNEL.

FIGURE 3. WATER TEMPERATURES ABOVE AND BELOW REACTOR DISCHARGES AND MEANS OF COMBINED LENGTHS AND WIDTHS (WITH 95% CONFIDENCE LIMITS) OF LIMPETS (*FISHEROLA NUTALLI*). (THIRTY LIMPETS PER SAMPLE: A = ABOVE REACTORS, B = BELOW REACTORS)

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