they would not migrate seaward. Such a conclusion has received support from the results of very recent experiments conducted in cooperation with Dr. Harry Wagner of the Oregon State Game Commission. In these experiments the timing of parr-smolt transformation was regulated by varying photoperiod regimens and the migratory behavior of fish released into a freshwater stream was tested. We found that fish migrated downstream only during periods of elevated adenosine triposphatase activity and ceased to migrate as soon as the activity fell, even if the decrease occurred during what is considered the normal migratory season.

The Federal Water Pollution Control Administration has suggested a provisional maximum temperature of 68°F (20°C) as compatible with the migration of salmonids (*8*). The report recommended that "during any month of the year, heat should not be added to a stream in excess of the amount that will raise the temperature of the water by more than 5°F (based on the minimum expected flow for that month)" (*8*). We propose that a temperature of 68°F is much too high for migrating juvenile steelhead, although adults migrate upstream in waters of this temperature. With respect to using the recommended 5°F elevation limit, we urge caution. The temperature of the Columbia River at Bonneville Dam, for example, reached 54°F on 7 May 1971 (*9*). An increase of 5°F would have resulted in a river temperature of 59°F (15°C). Steelhead smolts entering waters of this temperature from upstream may experience a reduction in adenosine triphosphatase activity and revert to the nonmigratory parr stage.

On the basis of the experiments reported herein we show only that the parr-smolt transformation may not occur or persist at some temperature between 10° and 15°C. We have conducted other experiments, however, which indicate the limiting temperature to be near 13°C. Pending further investigation, we suggest 12°C (about 54°F) as an upper limit for waters used by migrating juvenile steelhead.

Steelhead are now being reared in state and federal hatcheries in warmer waters (up to 15°C) in an effort to produce larger fish for increased survival during seaward migration. On the basis of the results of these studies, we suggest that steelhead reared under these conditions will need to be exposed to cooler environmental temperatures (6° to 10°C) for a period of 1 to 2 months prior to migration in order to allow parr-smolt transformation.

We recognize that laboratory tests such as those reported here are not identical to situations encountered in the natural environment. However, we believe that they can serve as good indices for establishing upper limits for temperatures of waters used by steelhead for seaward migration.

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13 September 1971; revised 4 February 1972 ■

Tidal Growth Increments in the Cockle Clinocardium nuttalli

Abstract. *Sets of growth lines in the shell of* Clinocardium nuttalli *are extinguished every 13 or 14 increments only to be replaced by other sets, half an increment out of phase with the first. This can be explained only by assuming that the lines are deposited during periods of exposure at low tide. The average duration of an increment is 24 hours and 50 minutes.*

It has been demonstrated that the skeletal parts of many animals contain a record of their growth pattern. Daily increments have been reported from the epitheca of corals (*1*), mollusk shells (*2, 3*), and fish otoliths (*4*). Pannella and MacClintock (*3*) examined more than 40 species of recent and fossil bivalve shells and conducted detailed experiments on *Mercenaria mercenaria*. They concluded that all the forms they looked at exhibited daily increments. It is the purpose of this report not to question the findings of these workers but to sound a note of caution by pointing out that the basic growth increments of some clams are not daily but tidal in nature.

In bivalves two types of daily increments are recognized, simple and complex (*3*). The former are bounded by two sharp surfaces with a wide, relatively homogeneous layer between. The latter are also bounded by two sharp surfaces but show a pronounced inner surface that divides the increment into two parts. In *M. mercenaria* and other bivalves with a prismatic outer layer the boundaries are thin layers of conchiolin with aragonite between.

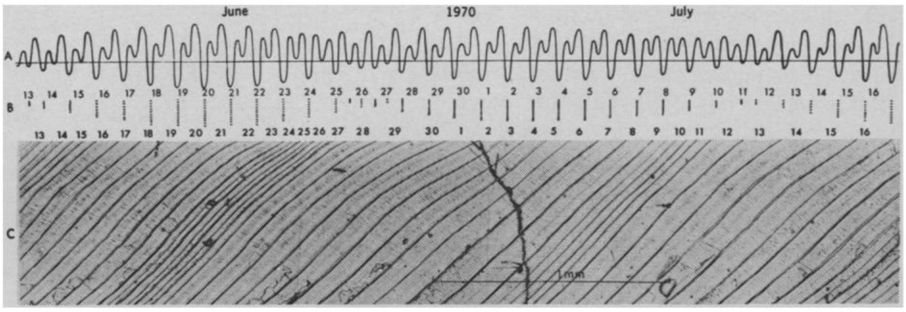

Fig. 1. (A) The fluctuating line shows the predicted tidal movements from 13 June to 16 July at Empire, Oregon. The extremes for the period were experienced on 19 and 20 June (+2.3 to −0.7 m). The straight line passes through the +0.6-m level at which *Clinocardium nuttalli* is thought to live. The dates are located at the noon position for each day. (B) Predicted time and extent of exposure. The dotted and solid lines represent the two alternating sets of low tides, which are half a period out of phase with each other. (C) A portion of the shell deposited during this period. Each equivalent date is placed above the part of the shell thought to be deposited at noon of that day. The time scale is distorted because of the variable rate of growth of the shell.

Pannella and MacClintock (*3*) report that tidal patterns in bivalves are widespread but not always readily recognizable. In *M. mercenaria* they are expressed by groups of thin daily increments alternating with groups of relatively thick ones, forming 14-day periodic patterns. The smaller the tidal fluctuation, the thinner the increment; thus, the narrow increments are related to neap tides. In *Tridacna squamosa* tidal patterns are clearly expressed. The two kinds of daily increments, simple and complex, are present and form marked patterns with a 14-day period.

Specimens of the basket cockle *Clinocardium nuttalli* were collected on 9 July 1971 in Coos Bay near Charleston, Oregon. They were in muddy sand at about the +0.6-m tide level. Radial sections of four shells were examined by the acetate peel method (*3*). Tidal information was obtained from the U.S. Coast and Geodetic Survey tide tables for 1970. Data from the Humboldt Bay, California, reference station were corrected for Empire, Oregon.

The shell margin of *C. nuttalli* is moderately reflected. The structure of the outer layer is prismatic, and the boundaries of the growth increments are usually sharply marked by thin layers of conchiolin. These lines form a repetitious pattern of simple and complex increments (Fig. 1C) similar to the pattern observed in *T. squamosa* (*3*).

Initially, I assumed that the lines marked the boundaries of daily increments. However, it was not possible to count the number of days in a tidal cycle, because a set of lines is lost as it passes through the area of complex increments only to be replaced by a new set that is half an increment out of phase with the first. The second set of lines form the median surfaces of the complex increments of the first set, and vice versa. This results in the loss of half a day in a 2-week period. To explain this, I hypothesized that the sharp lines represent growth stoppages due to exposure at low tide. Thus, the growth increments are considered "low tide increments" with an average period of 24 hours and 50 minutes.

The tidal predictions for Empire, Oregon, for 13 June to 16 July 1970 show the mixed semidiurnal pattern of the tidal cycle (Fig. 1A). This pattern, which is particularly well developed along the Pacific Coast of North America, has two highs and two lows of unequal amplitude each day. The lows are most different during periods of spring tides. These differences are reduced and finally eliminated by the next neap tide period. At this point, two sets of low tides cross over so that the low low tides of one fortnight become the high low tides of the next.

A line drawn through the tidal cycle at the +0.6-m level shows the probable pattern of exposure experienced by the cockle during this time (Fig. 1B). During spring tides a single exposure each lunar day (24.8 hours) would produce a simple increment, and during neap tides two exposures produce a complex increment. As one set of low low tides is replaced by another during neap tides, one set of lines is replaced by another in the region of the complex lines. In both cases there is a dislocation of the phase, by about 12.4 hours or by half an increment respectively.

The date at which part of the shell was deposited can be estimated by counting the number of sets of complex lines back from the leading edge and relating this to the number of neap tide periods. This can be done easily and accurately except for a few periods during the winter months where the growth increments are so narrow that reading is difficult. A photomicrograph of part of the shell, thought to be deposited during the period 13 June to 16 July 1970, shows lines which almost exactly coincide with the predicted tidal exposures (Fig. 1C).

Clinocardium nuttalli is probably a particularly sensitive recorder of tidal exposure because it lies just below the surface of the sand. Low tide increments can also be seen in *Protothaca staminea* (Veneridae), which lives in the same area but slightly deeper in the sand. Extinction of neighboring sets of lines in the area of complex increments can be seen, but the pattern is less clearly defined than in *C. nuttalli*. Specimens of *Penitella penita* boring into nearby rock at the same tide level do not exhibit this pattern of growth.

Low tide increments were recognized only because of the peculiar nature of the mixed semidiurnal tides along the eastern Pacific coasts. Where diurnal or semidiurnal tides predominate alternating groups of simple and complex increments would not occur, nor would sets of lines become extinguished every 14 days. The only other place I have seen this pattern is in a photomicrograph of a thin section of *T. squamosa* (*3*). Perhaps a closer look at this animal would also reveal low tide increments.

The demonstration of low tide increments indicates that workers should be cautious about claiming daily increments in the skeletal material they are examining. Paleontologists must demonstrate that they are actually counting daily increments before they draw conclusions about the number of days in a Mesozoic month or year.

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Ergot-Induced Inhibition of Pituitary Tumor Growth in Rats

Abstract. *Daily injections of ergocornine or ergonovine, for 3 weeks, into rats carrying a prolactin- and growth hormone–secreting pituitary tumor (MtW15) induced significant regression or inhibition of tumor growth, whereas ergocryptine had no significant effect. Ergocornine caused a decrease in cells and a disappearance or pycnosis of nuclei in the tumor tissue, and a reduced concentration of prolactin in blood.*

We have observed that an ergot derivative, ergocornine, can reduce the weight of the pituitary in the normal rat and prevent estrogen from increasing size of the pituitary and secretion of prolactin (*1*). We also found that ergocornine significantly inhibited prolactin secretion by a direct action on the pituitary (*1*) and by increasing the hypothalamic content of prolactin-inhibiting factor (PIF) (*2*). Ergocornine induces regression, in rats, of mammary tumors that are induced by cacinogens (*3*) or are spontaneous (*4*). We report here that