Relating Bivalve Growth Shutdown to Latitude and Temperature

Dan Killam[1], Matthew Clapham[1] and Sarah Sullivan[2]

1. University of California, Santa Cruz, 2. Los Gatos High School

The Problem

Most bivalve species form seasonal light and dark growth bands, corresponding to fast and slow growth ("growth cessation").

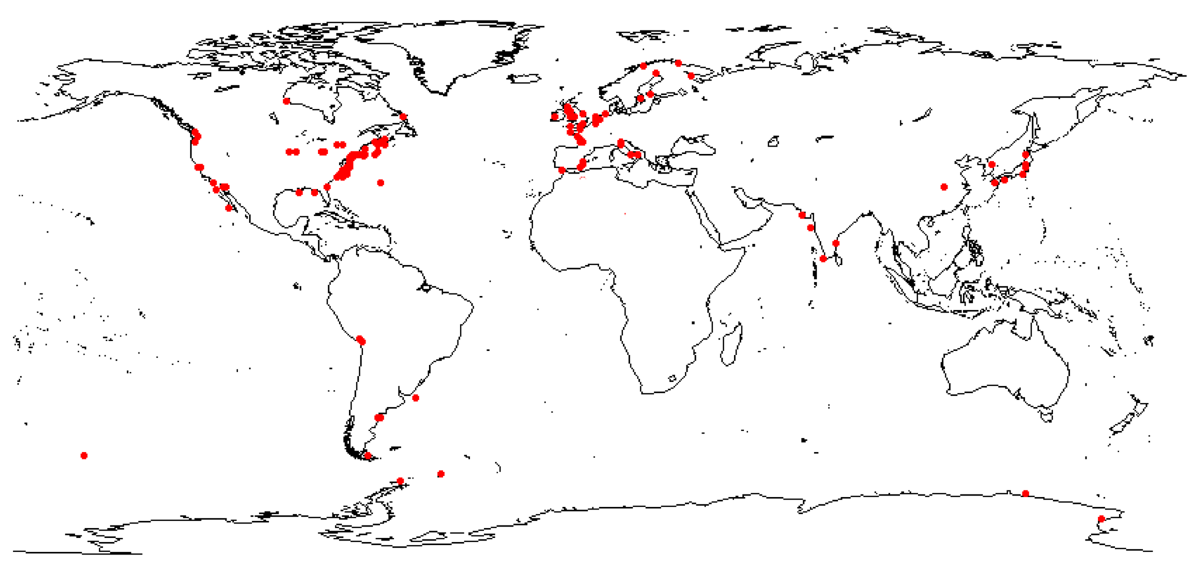
Shell cross section of *Eurydesma,* (Permian), showing light and dark growth bands.

Temperature stress, food supply, reproductive resource allocation and other factors proposed as main determinant of shutdown season. Can we gather data to determine which factor is dominant cause of seasonal growth shutdown?

Hypothesis: temperature is the dominant cause of seasonal shutdown.

Our Approach

Aggregated 279 distinct observations (map below) of bivalve growth season, coordinates, months/temperature of shutdown, local temperature range, depth, optimum growth season/temperature.



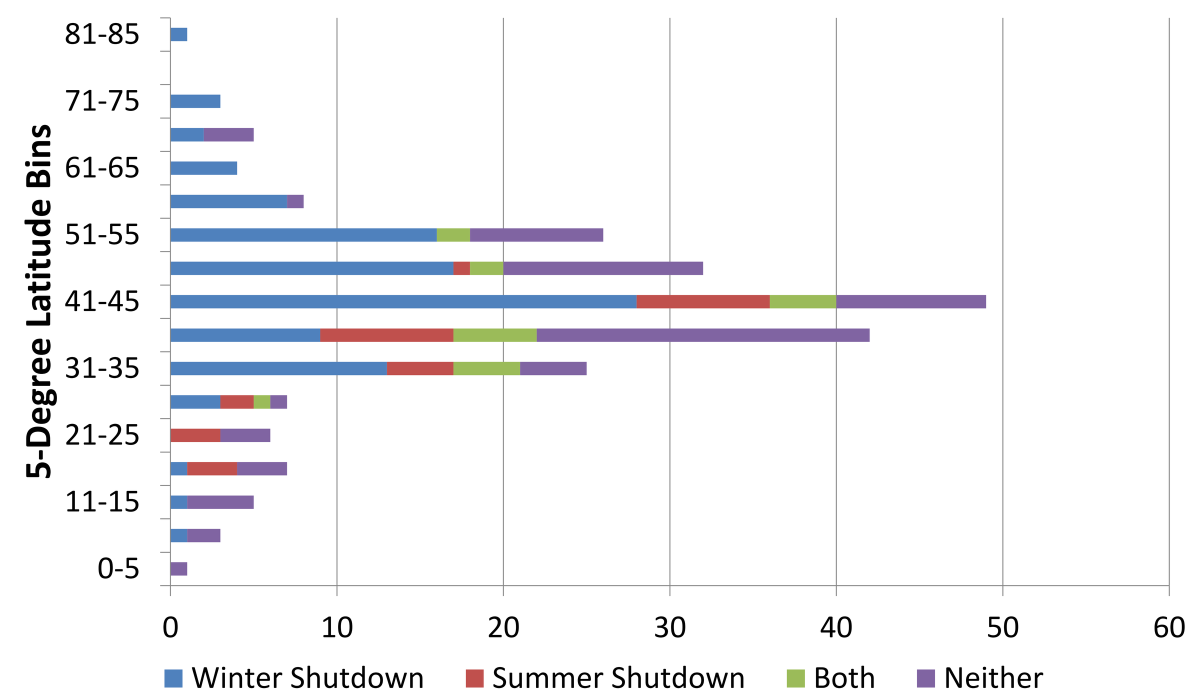
Used logistic regression to relate a binary dependent variable (shutdown or no shutdown) to continuous independent variable (absolute/normalized latitude, temperature).

Logistic regression relies on a link function with formula:

$$F(x) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x)}}$$

F(x) = probability of the dependent variable between 0 and 1, $\beta 0$ = regression equation intercept, $\beta 1$ = regression coefficient multiplied by independent variable (absolute latitude, or distance in degrees from the equator)

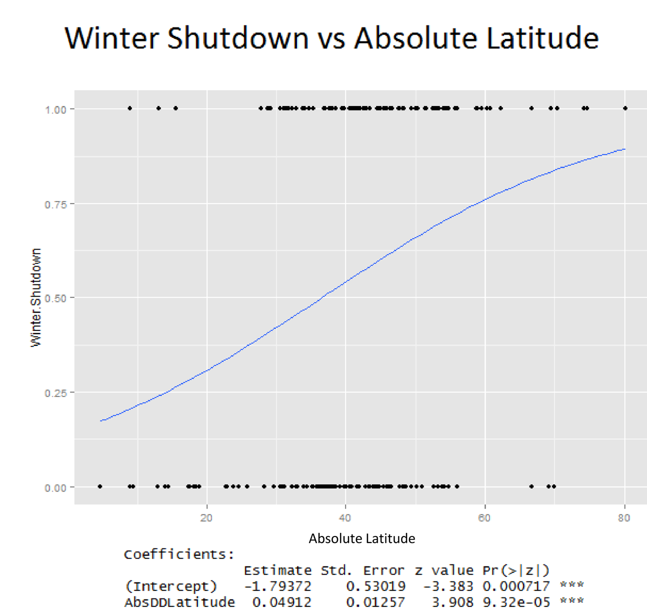
Shutdown Distribution

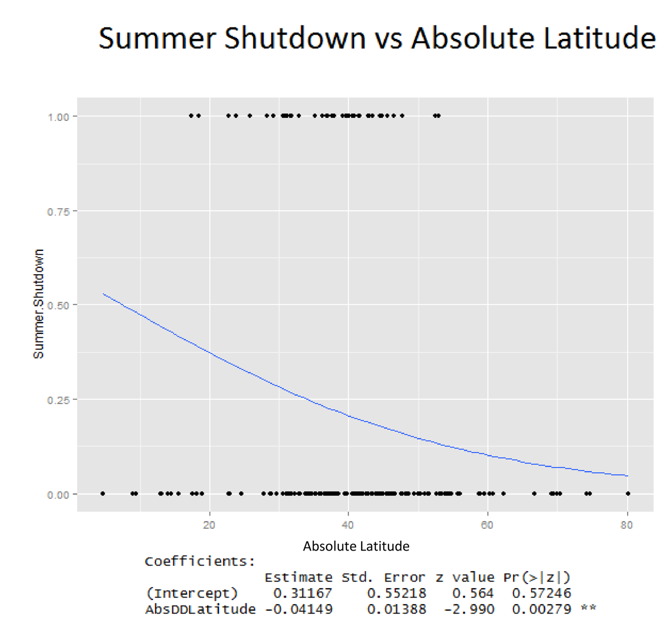


When grouped in 5-degree bins, winter shutdowns are present for species above 30° latitude.

Summer shutdowns are present between 15 and 50°, though none are present in the equatorial latitudes.

Species with year-round growth (no shutdown) are found throughout, and there is a small group in the temperate zone with both winter and summer shutdowns.



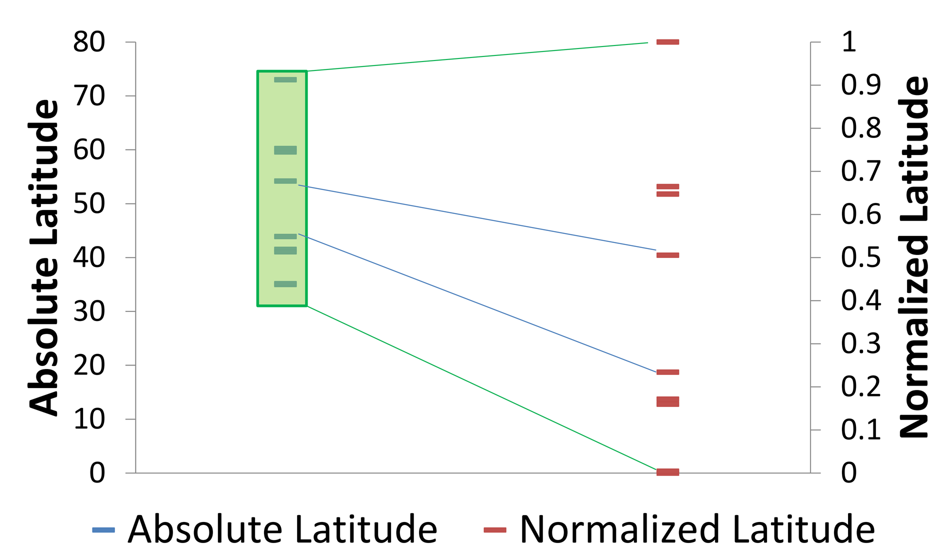


Logistic regression model: significant relationship between latitude and odds of winter shutdown, equal to about a 5% increase in odds per degree latitude.

Summer shutdowns, concentrated at low temperate latitudes, are not well-fitted by a logistic model.

Takeway: winter shutdown is correlated to latitude.

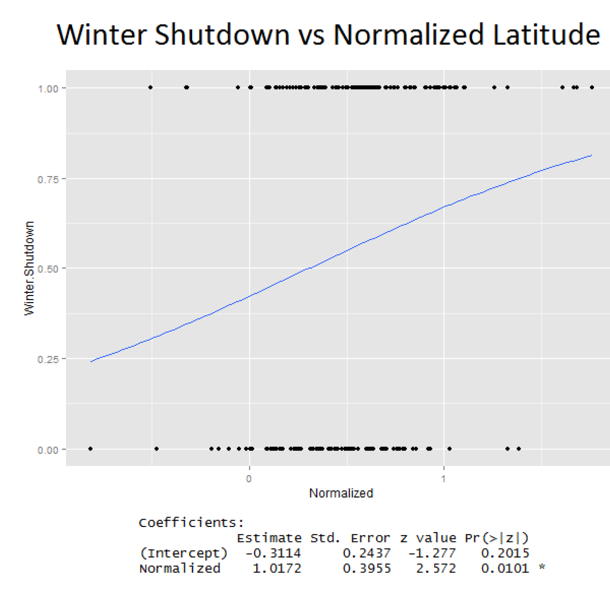
Normalization

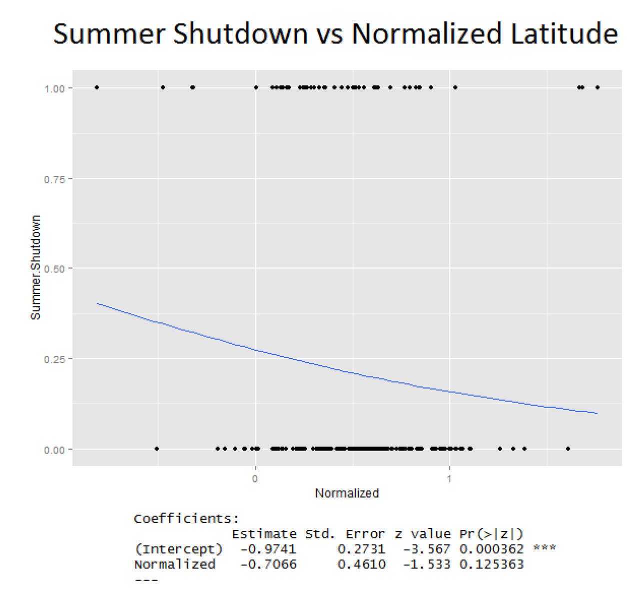


Latitude was normalized to a 0 to 1 scale, with zero representing an individual found at the lowest point of its native range and one representing an individual at the highest point, using formula:

$$N = {(L_{observed} - L_{lowest})}/{(L_{highest} - L_{lowest})}$$

Comparing Absolute and Normalized Latitude



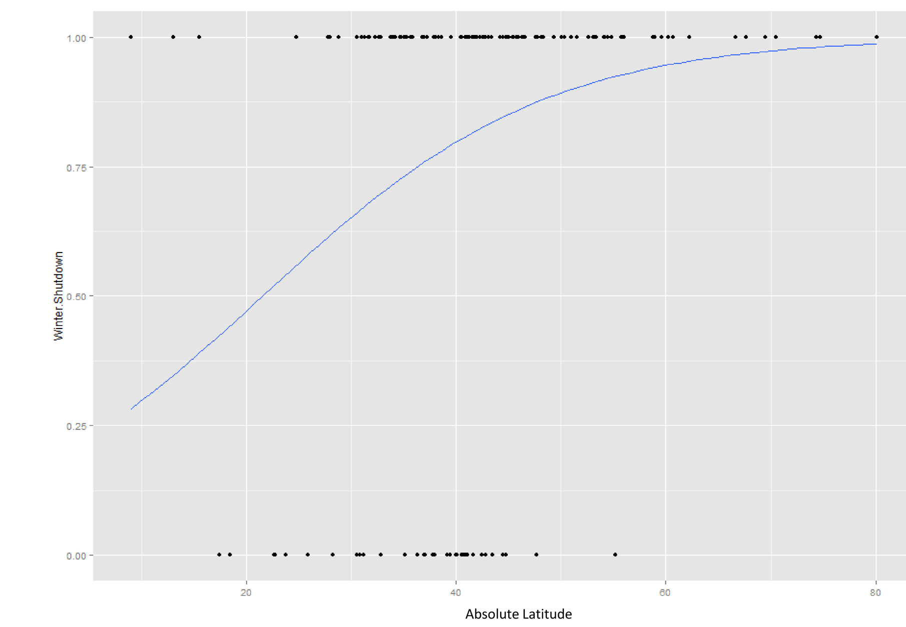


Normalizing latitude by species range, the winter shutdown trend is maintained, though with less certainty. The summer relationship largely disappears.

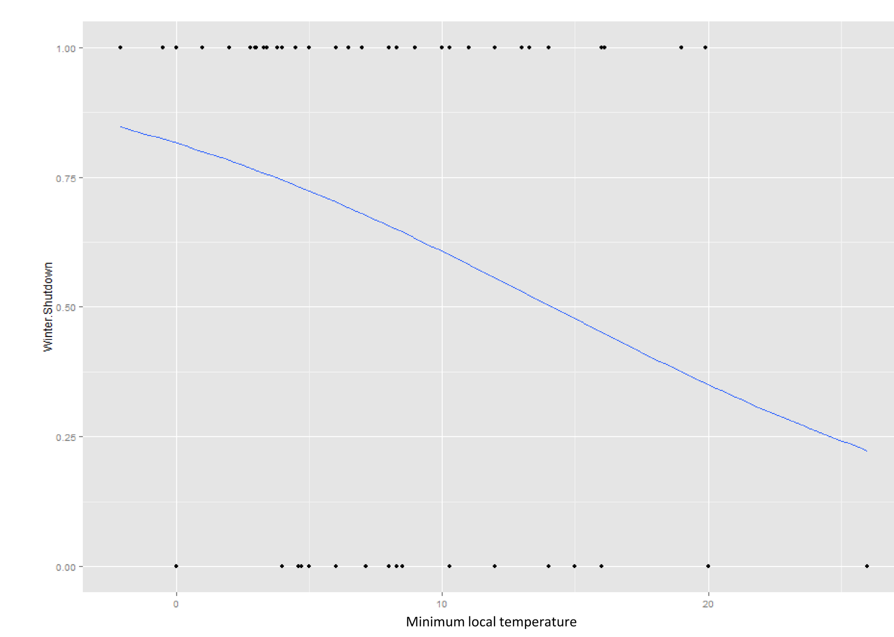
Low latitude species have more constricted ranges and experience smaller annual temperature range. High temperature stress may not be significant in determining seasonality of growth.

Takeway: winter shutdown trend still visible when controlling for species distribution.

Temperature and Food Supply: Future Work



Selecting for only observations with a clear winter or summer shutdown (above), we can see an even clearer spatial relationship than the winter shutdown chart to the left.



Weak relationship between recorded minimum temperature and incidence of winter shutdown can be observed.
Summer shutdown appears to have no relationship to maximum recorded temperature.

To Do: Compare shutdown probability to overall temperature range when more temperature data is accumulated.
Integrate remote sensing records of annual range of Chlorophyll A concentration as a proxy for local food supply