

Growth of Chinook salmon in Redwood Creek estuary and its correspondence to environmental variability during 1980-1995

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Objectives

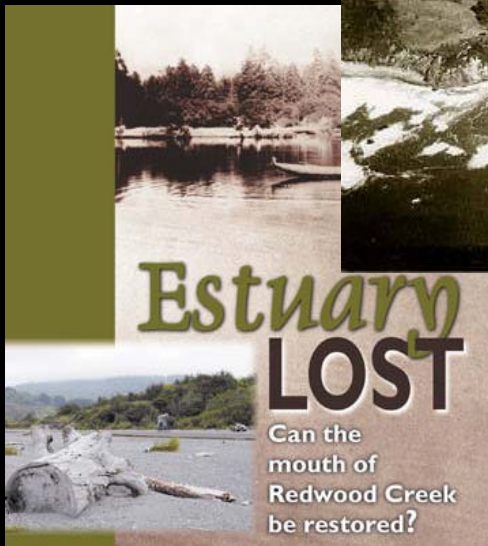
1. Model growth of Chinook salmon juveniles during their residence in the estuary before ocean emigration
2. Relate growth dynamics to various environmental variables
3. Discuss future directions and data sources/needs

Obvious changes have occurred in the estuary over the years

1948



~ now



Methods

Collections

1980 – 1995 juveniles were collected around the estuary during the spring and summer (we removed hatchery fish and Prairie Creek collections from the samples).

In addition, Joe McKeon sampled juveniles in the stream and as they moved into the estuary during 1982, 1983, and 1984.

Methods

Scales from 2700 fish were collected during the 15 years of sampling. Each was used to estimate inter-circuli spaces, estimate size-selective mortality, back-calculate growth and determine differences in growth between years.



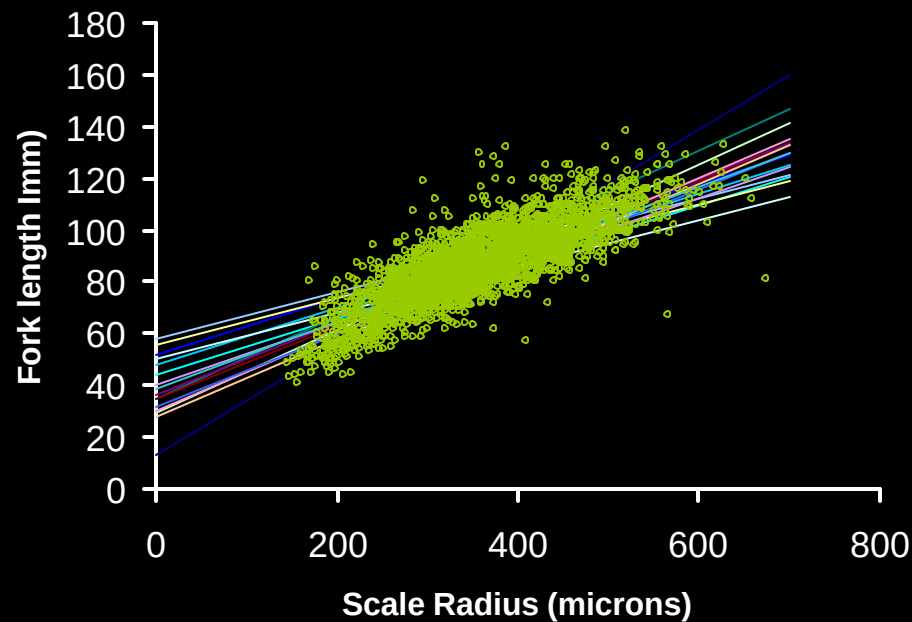
Methods

We need to take care of some book keeping before running into a growth model

1. Demonstrate that there is a linear relationship between scale radius and fork length.
2. Demonstrate a linear relationship between circuli count and fork length (and scale radius).
3. Demonstrate that circuli count linearly relates to date.
4. Demonstrate that there is no size-selective mortality across the season.

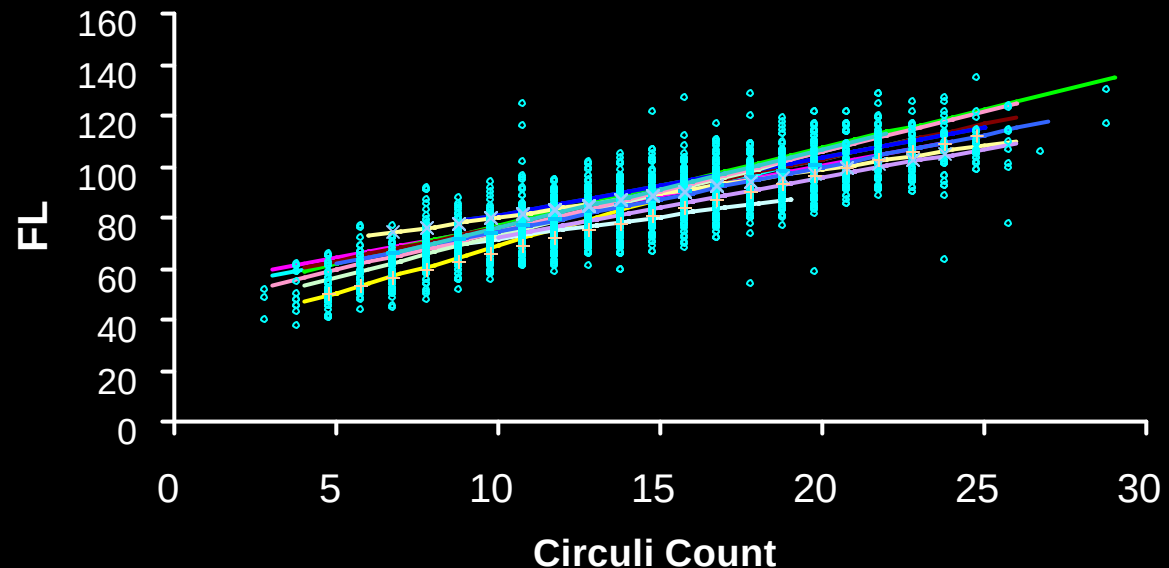
1. Demonstrate that there is a linear relationship between scale radius and fork length

The relationship between scale radius and fork length was significant and linear. However, the relationships were different between years meaning back calculations of size will have to be based on year-specific curves.



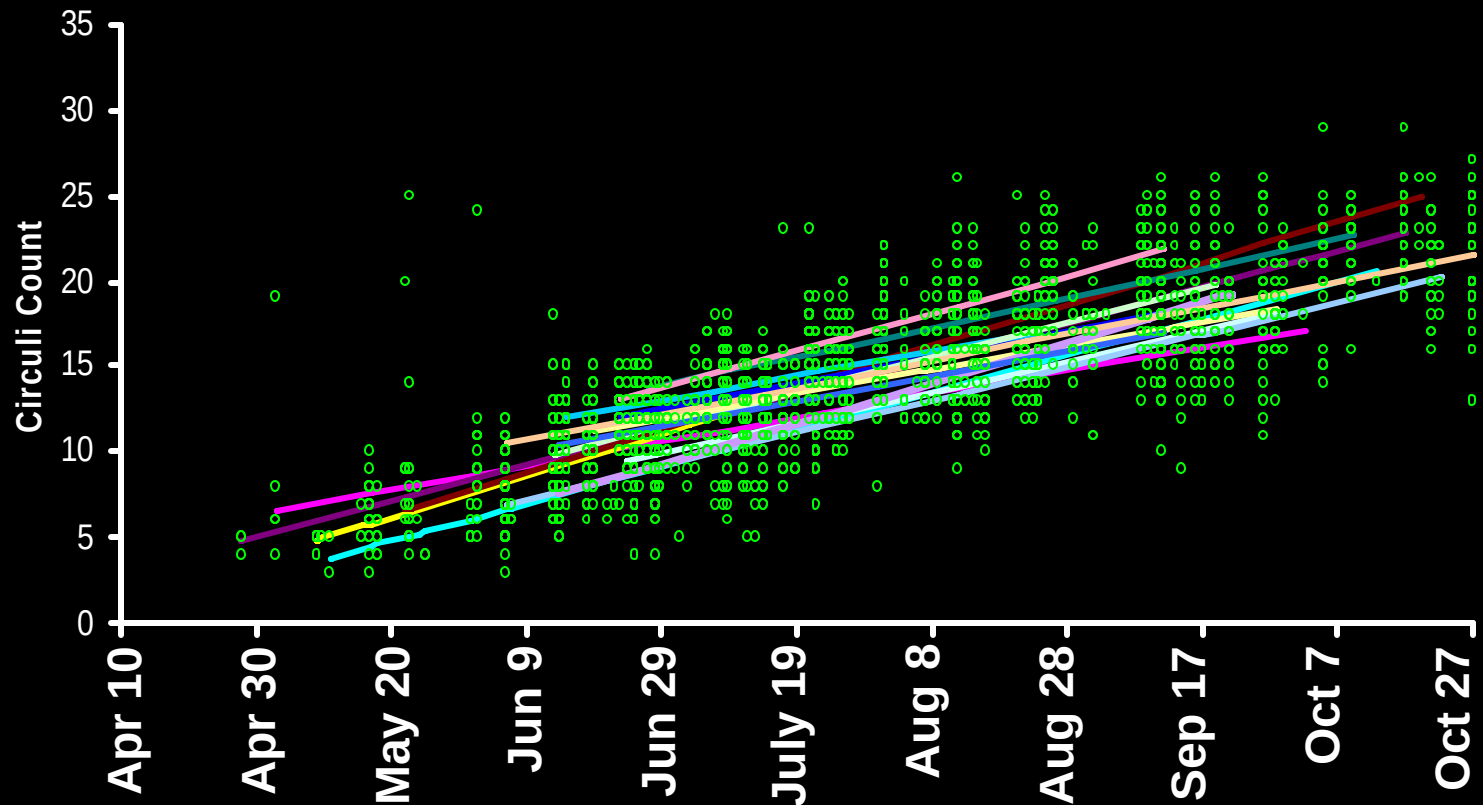
2. Demonstrate a linear relationship between circuli count and fork length (and scale radius).

Shows that, within a year, incremental growth is continuous through the growth season (if it were non-linear it would mean we would require a more complicated back-calculation regression).



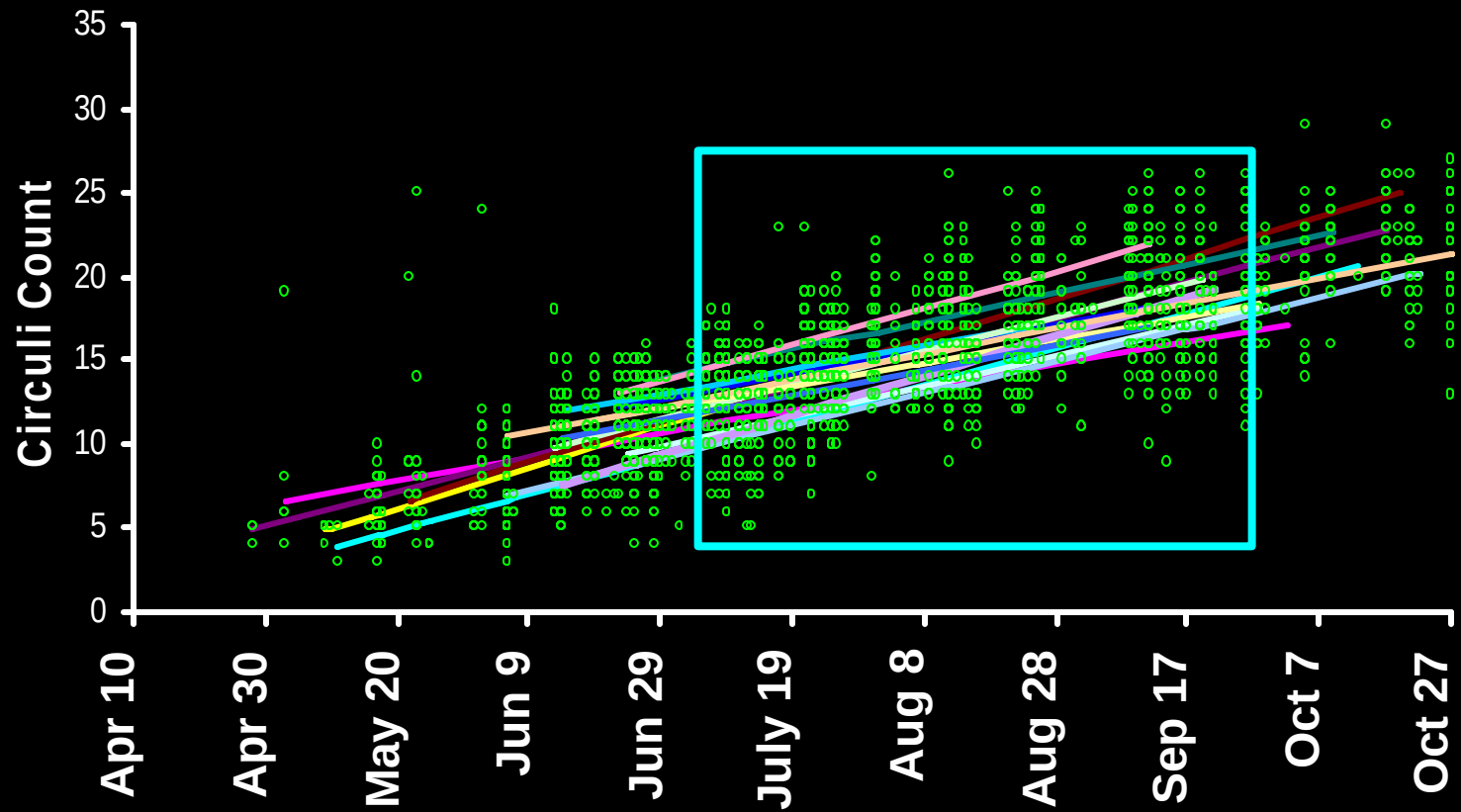
3. Demonstrate that circuli count linearly relates to date.

Allows us to put a date on the circuli and, therefore, calculate growth rate. Slope can be used to determine that deposition rates are one circuli per 9 – 14 days. This is inline with Coho and Atlantic salmon. And, the y-intercept tells us that the scale forms the final week of December to first week of January when the fish is ~40mm (from previous regression intercept)



3. Demonstrate that circuli count linearly relates to date.

We will use samples from only July 15 – September 30. This is the period with near complete coverage across years, it represents complete emigration into the estuary, and there is a closed bar (i.e., closed population)



4. Demonstrate that there is no size-selective mortality across the season.

I back-calculated the size of fish at Circuli #12 captured from the last two weeks of July until Sept 30 each year using the Scale-FL relationships developed earlier. 12 circuli was the maximum average number of circuli for the last fish migrating into the estuary in Joe McKeon's trap samples during the early 80's. Also, during the years with samples collected during the third week of July within the estuary the average number of circuli on scales was 12.

I then simply regressed the back-calculated size of fish at circuli 12 across the season from July to Sept 30. A positive relationship would indicate mortality of smaller fish and a negative relationship would indicate that smaller fish were more successful. Fortunately, there was no relationship at all ($P > 0.10$). Therefore, all fish collected across the season could be used for growth rate estimation



Collected 1 Sept 82

Methods

1. Demonstrate that there is a linear relationship between scale radius and fork Length. **YES**
2. Demonstrate a linear relationship between circuli count and fork length (and scale radius). **YES**
3. Demonstrate that circuli count linearly relates to date. **YES**
4. Demonstrate that there is no size-selective mortality across the season. **YES**

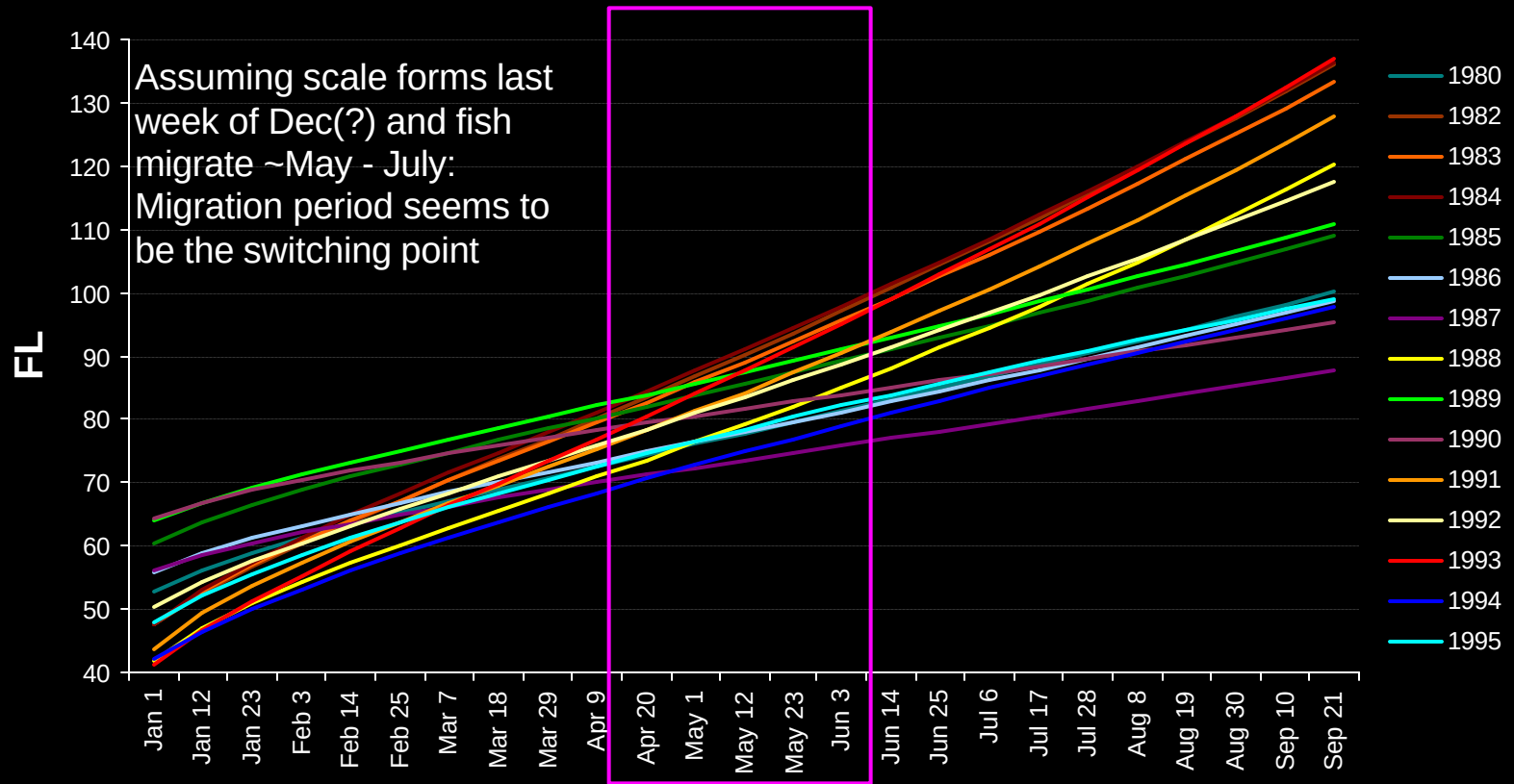
Now we are ready to look at growth. About time, eh?

Again we restrict our analysis to the closed population (July 15 – Sept 30).

We fit repeated measures regressions to the back-calculated sizes at each day (assigned by known circuli formation rate; 9 -14 days depending on year) of each year.

McKeon also let's us back-calculate to the earliest circuli, as he demonstrated that circuli deposition in the river was the same as in the estuary. We confirm this somewhat with our samples as well. Specifically, we have some fish that were collected before entering the estuary and the deposition timing still fits (across the range of circuli 3 – 25).

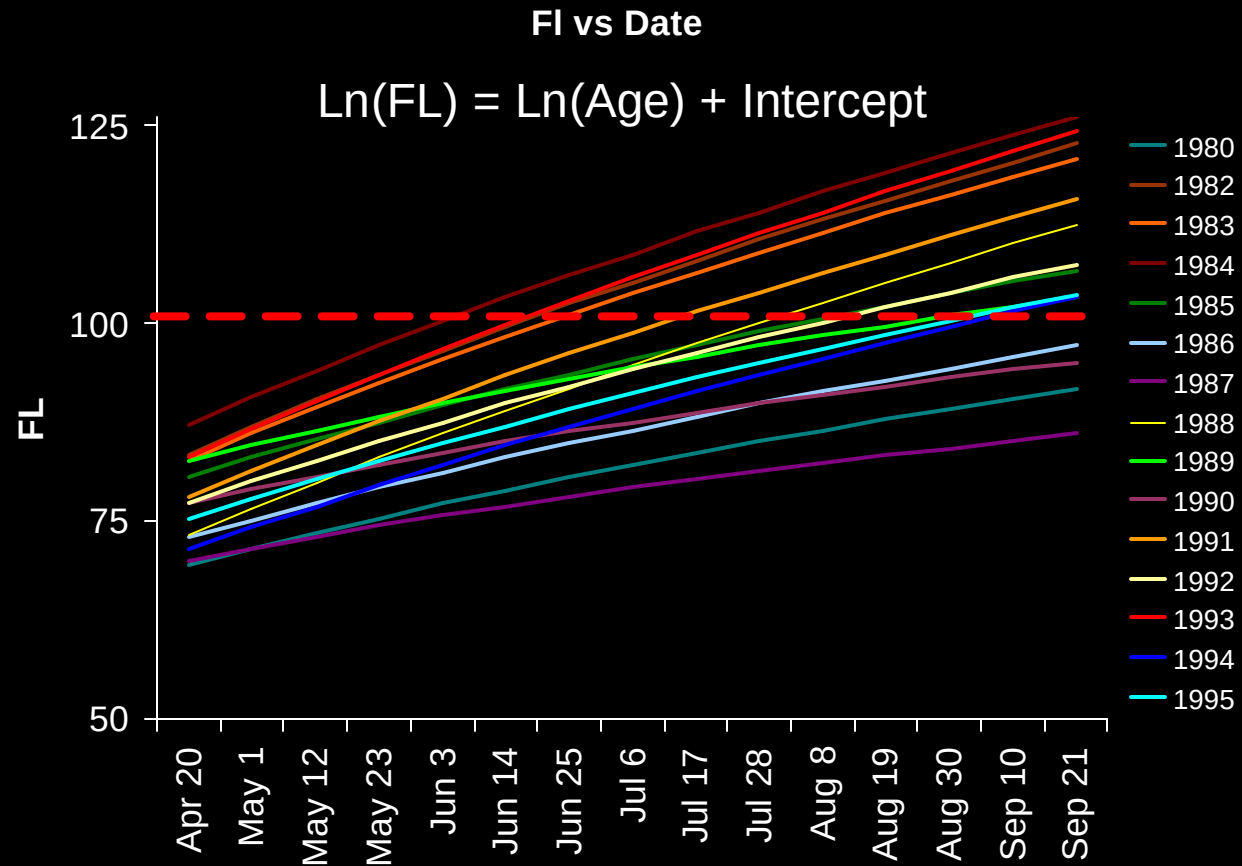
FL vs Age (projected from circuli/day estimate)



Basic curve: $FL = \beta (\text{age}) + ? (\text{vage}) + d (\text{age}^2) + \text{error}$

These components represent different aspects of growth: linear trend, leveling off as the fish enters the estuary and/or poor conditions, and the final acceleration

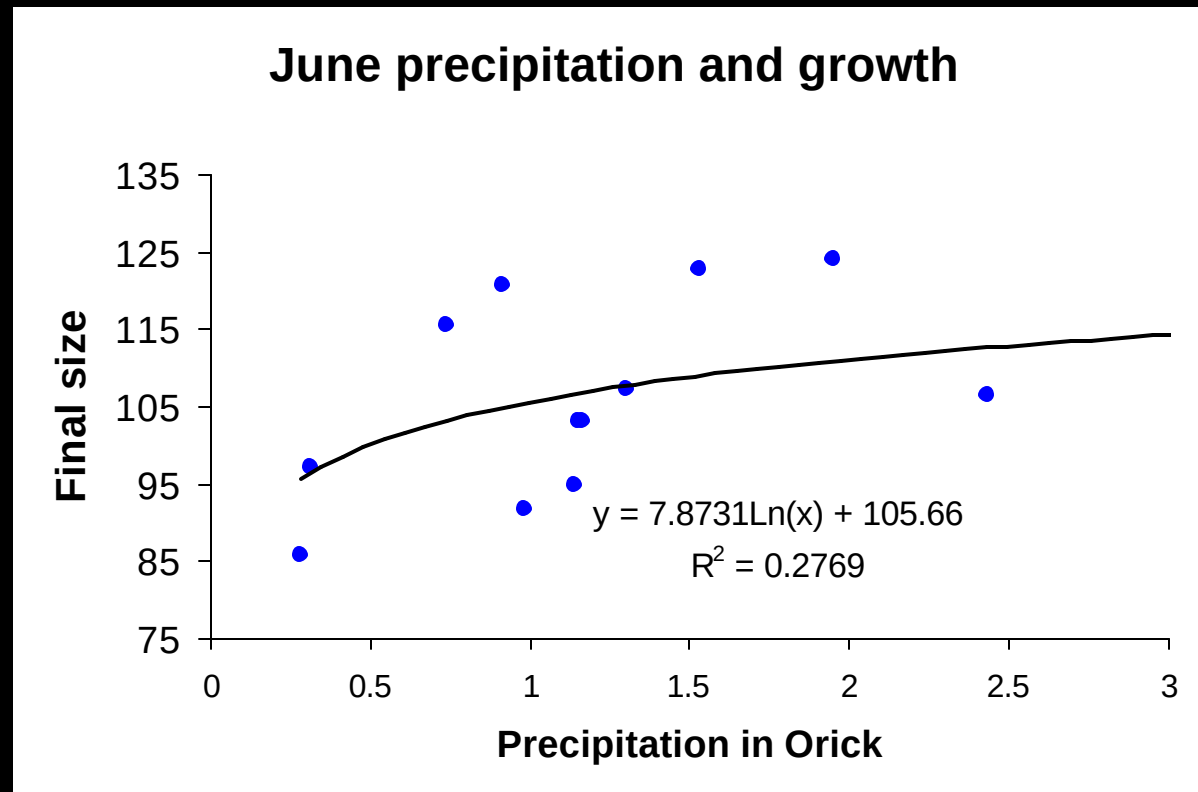
I now restrict the growth curves to just that growth in the estuary: post circuli 12.



Red line indicates ~100 mm dividing line.

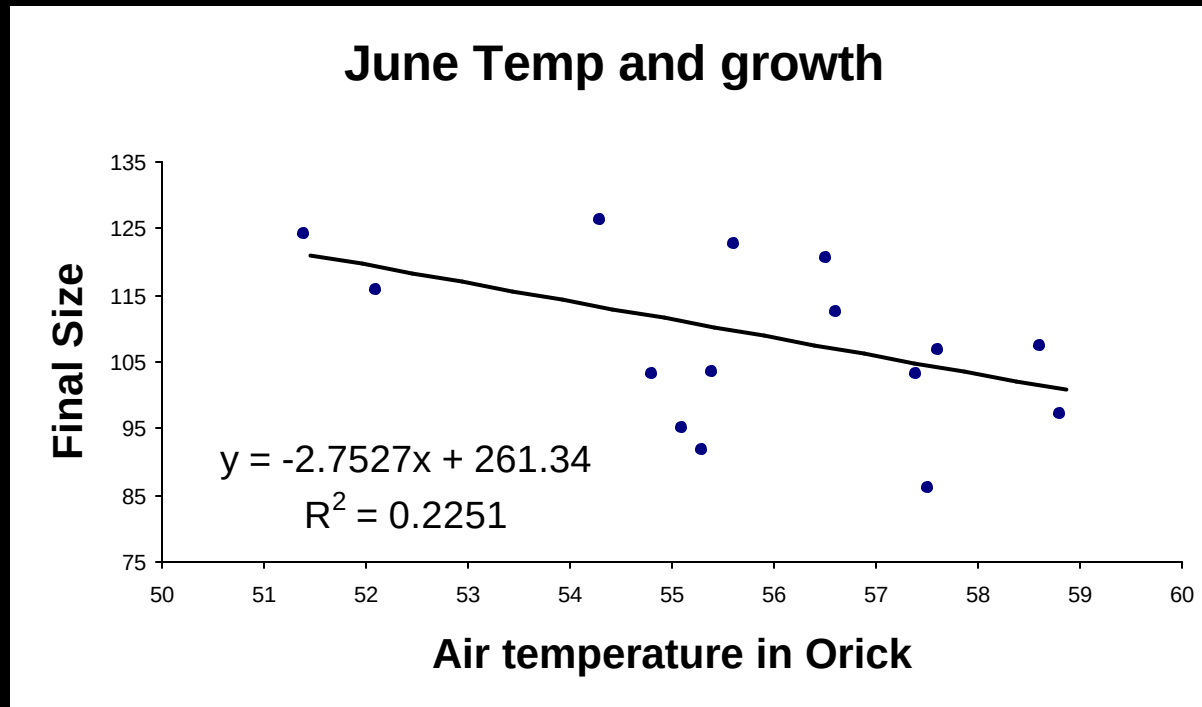
And, of course, the interesting question is “**Are there any environmental variables that can explain some of the variability in final size?**”

In a fishing expedition, I landed on two variables that show a relationship: June Air Temp, and June Precipitation. These are both during the primary migration into the estuary and outside of these months there were no significant relationships.



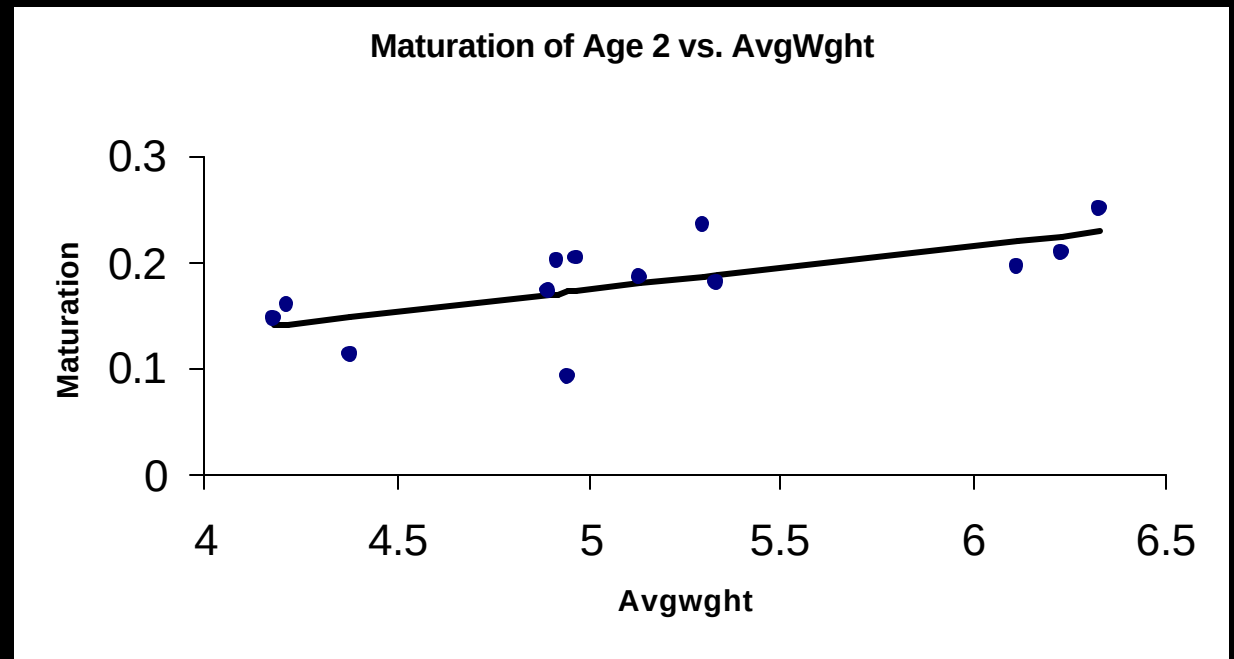
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Implications of variable growth rates. “What does it matter?”

1. Firstly, it has been shown previously that there is a relatively strong survival vs. ocean entry size relationship. Specifically fish should be larger than 100 mm for appropriate survival of population. This suggest that 1980, 1986, 1987, and 1990 may have not had sufficient average growth for ‘good’ survival.
2. Also, Klamath River releases demonstrate that size at release affect early maturation.



Conclusions

1. There is significant variability in growth between the years and some of that variability can be shown to relate to precipitation and temperatures during the primary migration period (June).
2. Additional findings include: there is no detectable size-related mortality in the estuary, in some years poor growth may reduce ocean survival substantially, and we can assign growth rates to circuli (very rarely ever done in the literature, if ever?).