Disentangling maternal and environmental effects on the early life history dynamics of a viviparous fish, the redtail surfperch (*Amphistichus rhodoterus*)

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Brief Fishery Background:

In general, very little research that is relevant to management has been conducted on surfperch (Embiotocidae) in California, despite the fact that this family supports a large state-wide recreational fishery as well as a small commercial fishery in northern California. Redtail surfperch, the most popular sport-caught surfperch species locally, is currently managed by two recreational restrictions; a daily bag limit of 10 fish and a 10.5 inch minimum legal size. A small-scale commercial fishery for redtail also exists, which has no restrictions aside from a three month seasonal closure during the summer to protect aggregations of parturating (i.e. live-birthing) fish. As of December 2012, three State Marine Conservation Areas (SMCA's) went into effect in the north coast region (Samoa SMCA, Reading Rock SMCA, and Pyramid Point SMCA) that prohibit the take of surfperch in locations where they were previously encountered by the recreational and/or commercial beach fisheries. Currently, my project is engaged in several research efforts focused on evaluating the effectiveness of the current regulations, species and region-specific population health, and generally the science needed to support management decisions in the future. The goals of this particular project are aimed at learning more about how surfperch populations may respond to varying ocean conditions, and whether managing for an older age structure may help mitigate the effects of poor ocean conditions on survival during early life.

Study Overview:

Surfperch (Embiotocidae) are a viviparous (live-bearing) family of fishes that provide a unique model species for examining environment-maternal relationships since several months of growth data can be linked to an individual mother. Since 2012, we have collected gestating female surfperch along northern California beaches and have collected condition and age information from each maternal surfperch. The neonatal surfperch (embryos), which are up to 3 months old, were retained from each female and evaluated for their condition. We also removed the otoliths from the neonates, and retained them for age and growth analysis. Aging the neonates, by examining their daily growth rings using a high resolution microscope, is essential to evaluating the maternal effects on offspring condition. It will both allow offspring condition to be standardized by age (to avoid bias), and will allow us to recreate the offspring's growth history so that we may relate it to environmental conditions.

Aging neonatal surfperch otoliths is a relatively slow process, and having a student work through a sub-set of samples has helped us develop the preliminary data needed to justify the time needed to analyze the full dataset in the future, and potentially pursue a larger grant to fund a full-time graduate student. Thomas Adams was selected to perform this work. He is an Oceanography and Fisheries major at Humboldt State University, and has prior experience working with larval and juvenile rockfishes at the National Marine Fisheries Services' Southwest Fisheries Science Center as a summer student/volunteer.

He is approximately ¾ of the way through meeting his obligations to the project, and so far contributions have been very helpful in determining the merits of a further research effort. His accomplishments include: 1.) completion of a training period where he demonstrated an ability to produce reliable data using advanced microscopy methods, 2.) providing preliminary data to validate daily growth rings in surfperch otoliths, 3.) showing observed growth patterns for developing surfperch embryos, and 4.) helping us determine if maternal age and/or environment appear to influence observed growth patterns, and if pursuing a larger research effort is warranted. The progress in these categories to date is described below.

1.) <u>Student Training:</u>

There is a steep learning curve to developing the skills necessary to analyze otoliths for daily growth. Thomas worked through approximately 20 "extra" embryo otoliths, under the direction of myself and/or Eric Bjorkstedt, before we were confident in using the data for analytical purposes. Analyzing an otolith involves using a very fine-grit abrasive film to gently thin the surface of the otolith structure while it is mounted on a microscope slide. This allows light from the microscope to penetrate through the otolith so that it is visible under the microscope at 1000x magnification. This process generally needs to be repeated several times throughout the reading of a single otolith since the thickness varies. The process continues by counting the number of rings (age estimate), and measuring their width (growth estimate) across a standardized transect that begins in the center and extends across the longest axis to the otolith edge.

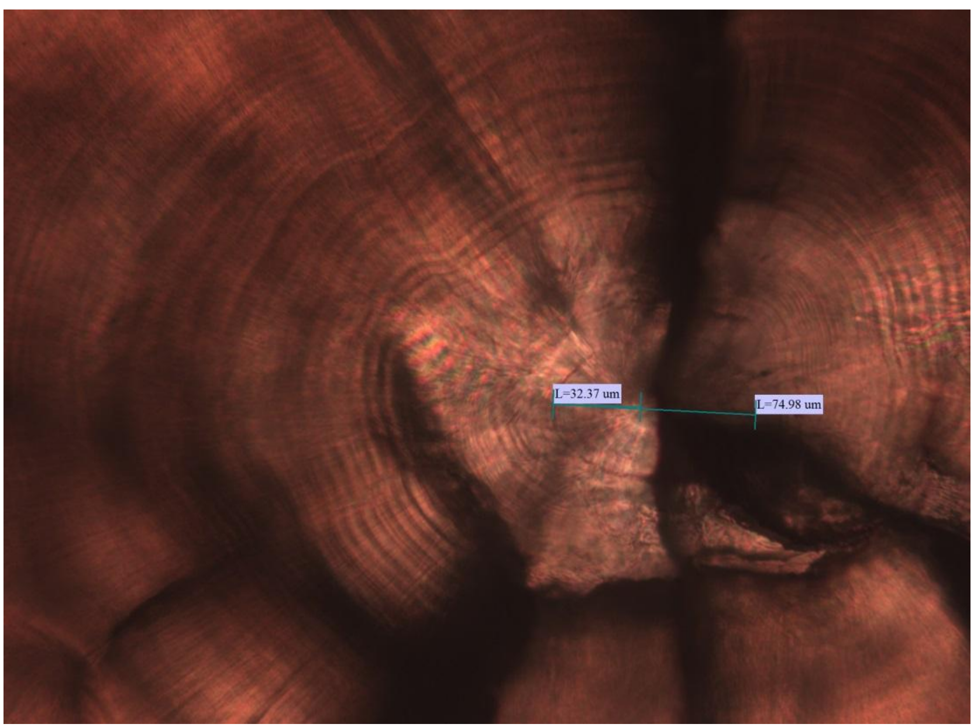


Figure 1. Image of a redtail surfperch embryo otolith taken at 200x magnification shows the center of the otolith, with concentric rings extending outward. The first day of growth is recorded around the very center of what is called the 'nucleus'; each subsequent ring represents an additional days' growth.

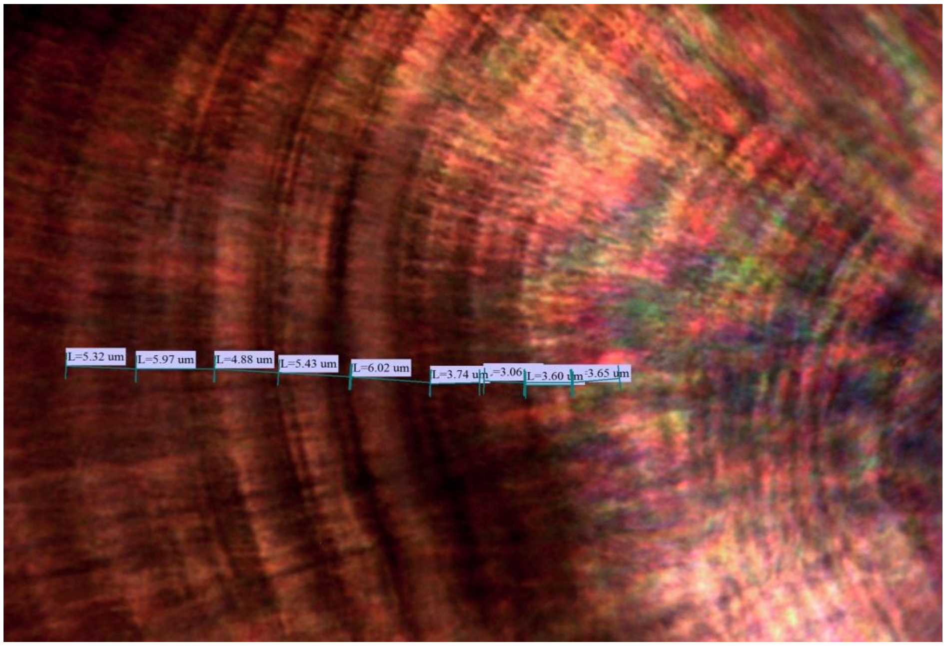


Figure 2. Image of a redtail surfperch embryo otolith taken at 1000x magnification shows daily growth rings at the magnification under which they are measured. The rings generally are smaller towards the center, and width increases as they age since the bigger they are, the faster they tend to grow.

Figure 3. Thomas Adams concentrating very hard on removing the otoliths from a very small embryo at Trinidad Marine Lab.

2.) **<u>Daily Age Validation</u>**

Since redtail surfperch embryo otoliths have never been studied previously, we needed to determine that each ring we were observing did actually represent one days' worth of growth, as they do for many (but not all) other species. This is often overlooked because it's quite difficult to validate outside of performing a complex aquarium experiment (which have had mixed success). We attempted to do this by comparing our estimates of age-at-length from this study, to observations from our field collection data. We have several years' worth of observations showing when larvae begin showing up in the population, and can track the average population-level growth rate over the course of a season by examining what size embryos are at what time. We've compared the expected age-at-length from the otolith data to the expected age-at-length from the field data below. If the otolith-based estimates of age are reliable, we would expect the two relationships to be very similar.

The figure below depicts the two relationships; the red line is fit to the otolith-based estimates of age (blue diamonds) from this project, and the purple dashed line is the estimated age-at-length relationship from our field observations. They appear to mirror each other very closely, but diverge a bit as age increases. This could be a result of only having two data points at the higher age range, and so we'll need to obtain more samples to be sure that otoliths produce reliable age estimates. That being said, it is clear that age estimated by counting the number of otolith rings is at least in the ballpark of what we're seeing in the field, which is very promising.

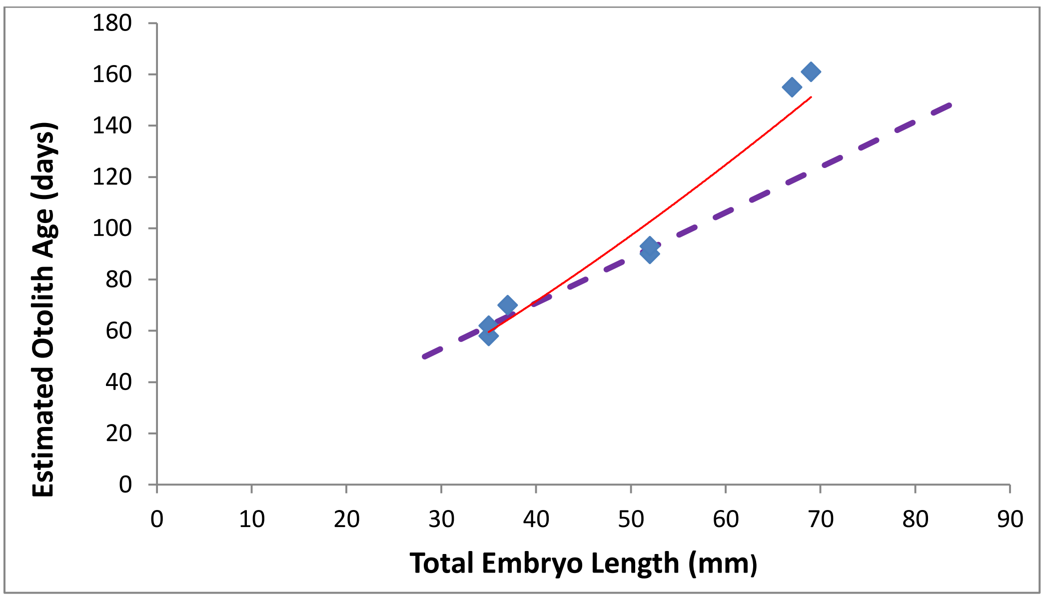
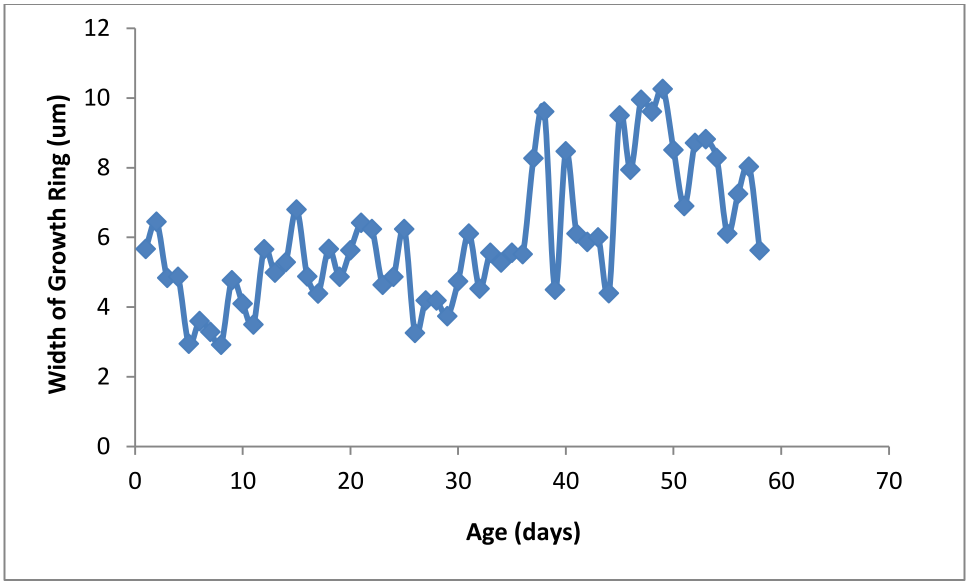


Figure 4. The embryo otolith age-at-length relationship (red line) is compared to the relationship calculated from field observation data on the size and timing of larvae and embryos in captured surfperch (purple dashed line). The two produce similar results, except at the oldest ages.

3.) <u>Observed Growth Patterns</u>

The growth patterns for each individual fish were examined; one fish embryo is depicted in the figure below as an example. We assume that the width of each ring/increment was, based on a lot of supporting literature, proportional to how much that fish grew in terms of body size on that day. We can then, by looking at the patterns that we observed, notice where there were periods of time that growth was either slower or faster. This presumably is influenced by environmental conditions such as ocean temperature, or by the quality of feeding conditions encountered by the maternal fish. We noticed that there was less variability in daily growth rate when compared to other larval or embryonic fish that develop externally (such as the rockfishes), suggesting that developing internally provides a significant buffer against environmental conditions.



4.) <u>Maternal and Environmental Influence on Growth; Future Research</u>

After completing numerous “training” otoliths (which are not usable for analysis), Thomas has finished reading the otoliths from 10 fish that are now ready for analysis. This has given us enough data to begin looking through, and so far we can already tell that these fish are likely buffered against the environment to some extent by developing within their mothers. We have examined several surfperch embryos that came from mothers of different ages, and unfortunately there does not appear to be enough data yet to determine if maternal age has an effect. Thomas is not yet completed his work on the project, and so our hope is that the additional data he is providing will shed a bit more light on this potential phenomenon. If we are able to see some sort of signal, we will have enough information to pursue a larger research effort. We look forward to updating everyone with additional results in the near future!

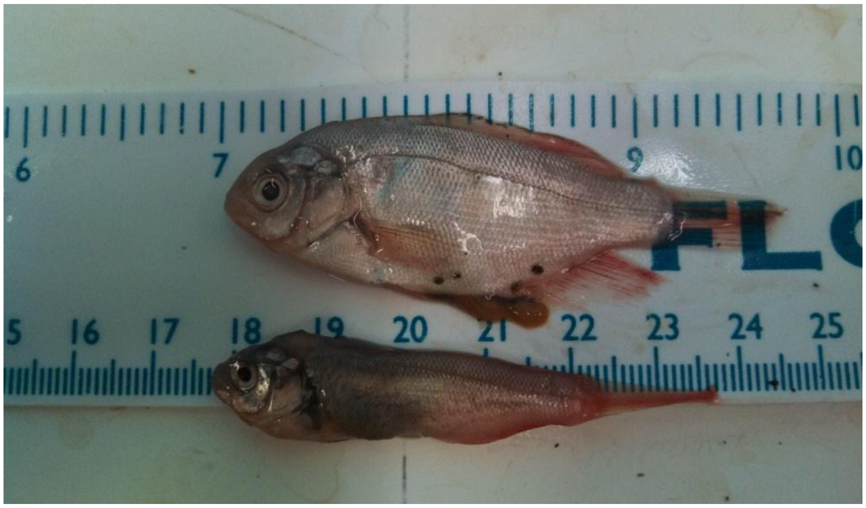


Figure 5. Two redtail surfperch embryos of similar length, but of very different conditions. The fish above is much more typical, but the one below may have poorly developed as a result of less favorable environmental conditions.