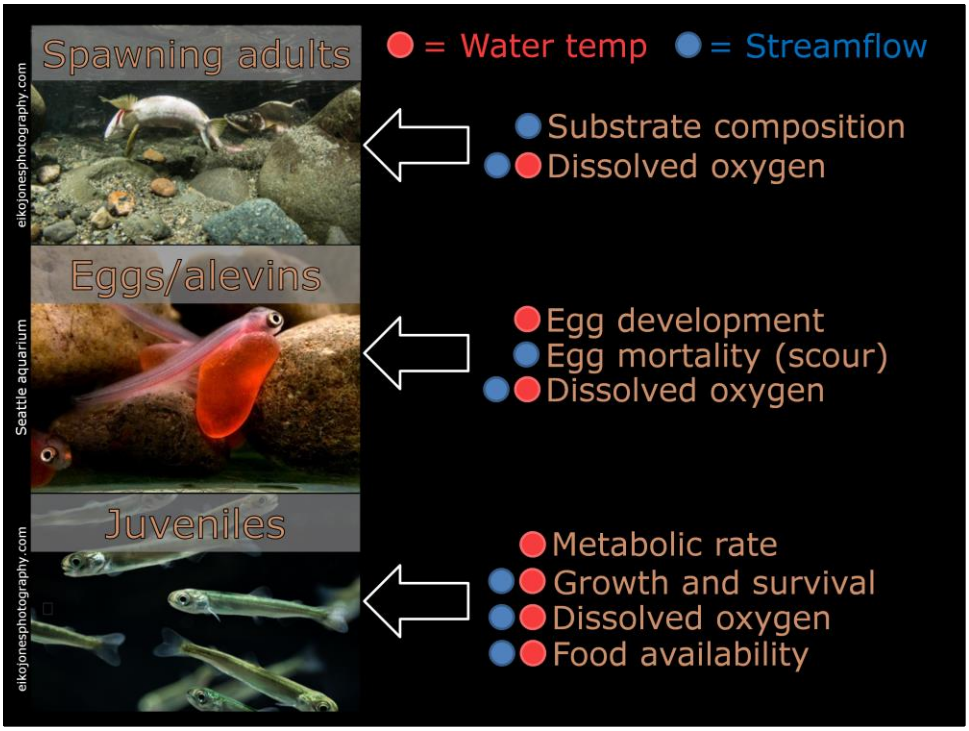
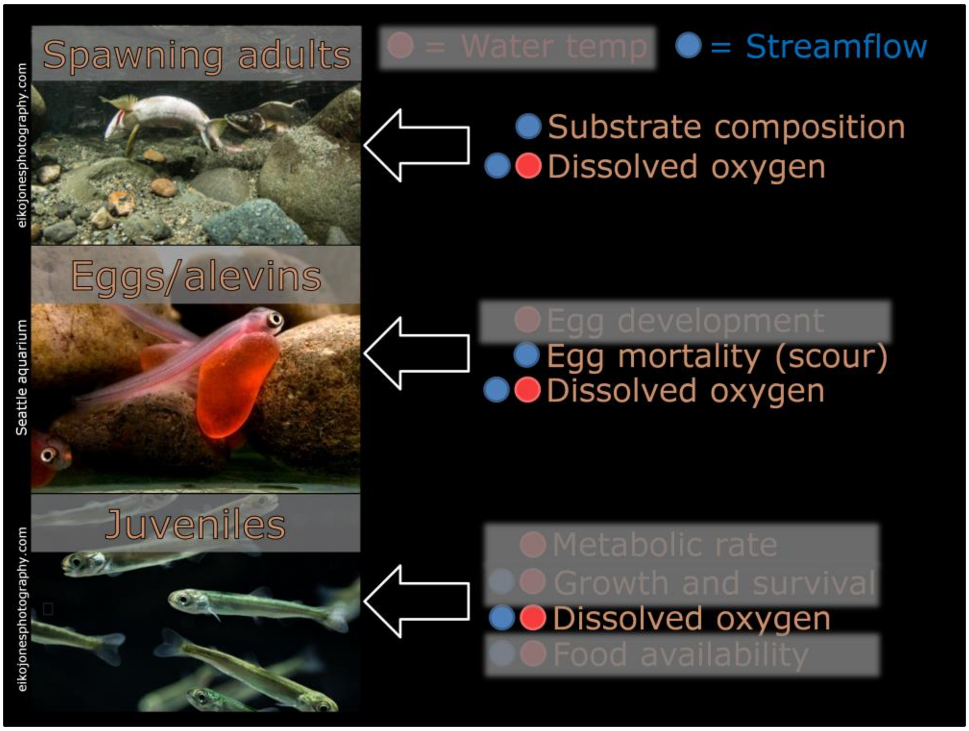
I'll be presenting one small slice of a recently funded Sea Grant project led by my advisor at UAF, Jeff Falke, and the other co-PIs on this project. Broadly, this project is focused on how changes to streamflow and water temperature will affect the freshwater life stages of salmon in Southeast Alaska, and today I'll focus mainly on streamflow. This talk is mainly an overview of recent research from this region, and my hope is that this will generate discussion of how some of the scientific tools presented here can be used to support restoration and other conservation activities.

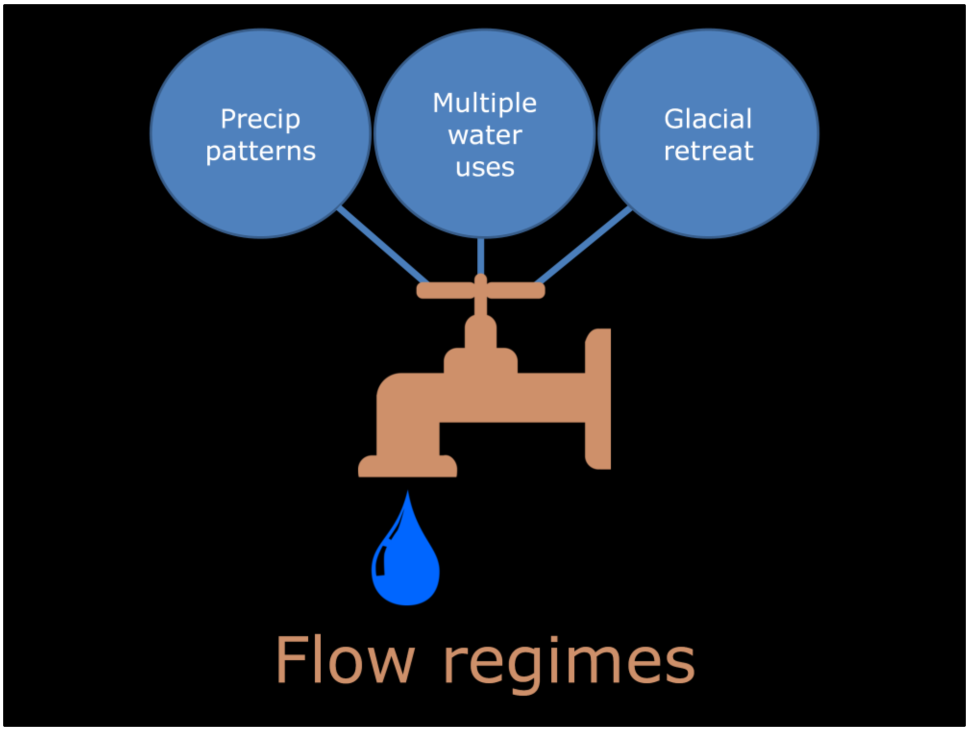
As people that live in salmon country already know, salmon populations bounce up and down, and even within the same year we can have good news and bad news. In a place like SEAK, with literally thousands of streams and rivers with spawning salmon, I believe it is important for scientists to help predict when and where the bad and good news will occur, and therefore help focus monitoring and conservation efforts. In the past decade, some really nice research is emerging that describes what changes we might expect to flow and water temperature patterns and how that affects salmon. Flow and temperature are two very basic characteristics of streams that we all know have a profound effect on the organisms that live in them. While salmon populations in SE AK from a regional perspective may be resilient to future environmental change because of diverse landscapes and minimal development, there will always be individual watersheds that don't do as well in the future, and this is important to the people that benefit from specific watersheds near where they live.



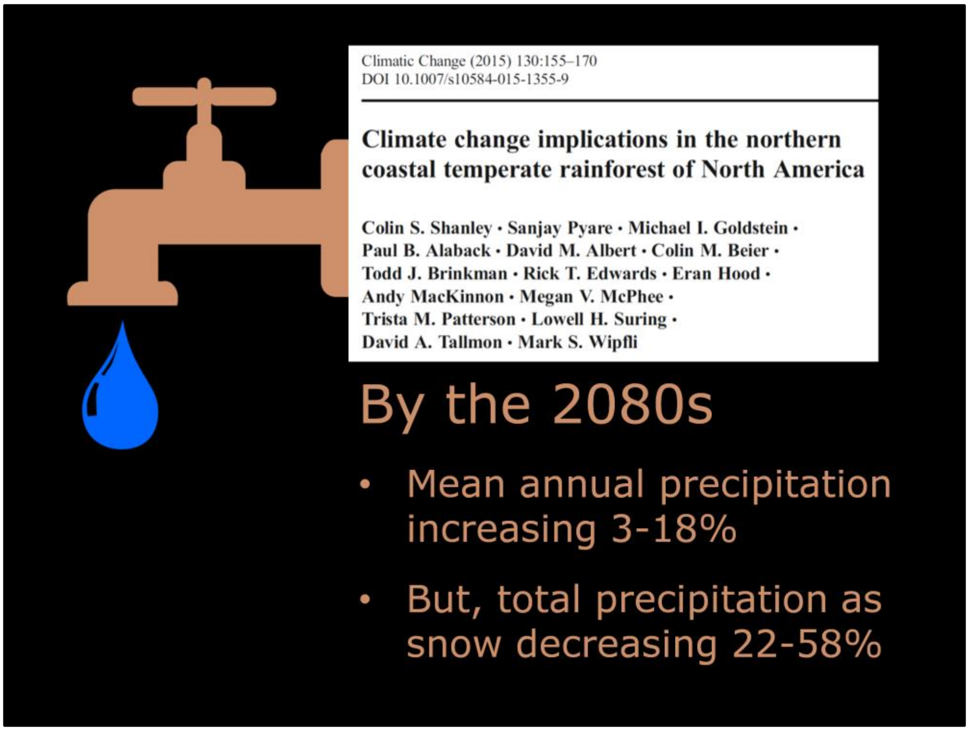
Before I dive into the specific part of my presentation on streamflow categories, I want to take a look at the bigger picture of our Sea Grant project; we expect thermal and flow patterns to change in SE AK streams over the coming decades, and these changes will have a direct influence on the freshwater life stages of Pacific salmon. Here are some examples: blue dots signify processes affected by streamflow, while red dots signify processes affected by water temperature. Our eventual goal with this project is to consider this full suite of pressures on the freshwater life stages of salmon using a life cycle model.



But today, I'm going to concentrate on categorizing patterns in streamflow and how this first phase of research fits into our bigger project picture. In the context of salmon and habitat restoration in SE AK, categorizing streams based on their flow patterns—which is a major driver of physical and biological patterns in streams, like these listed here— allows us to begin considering which groups of streams among the thousands are most like each other and therefore most likely to respond similarly to future climate change and other pressures on freshwaters.

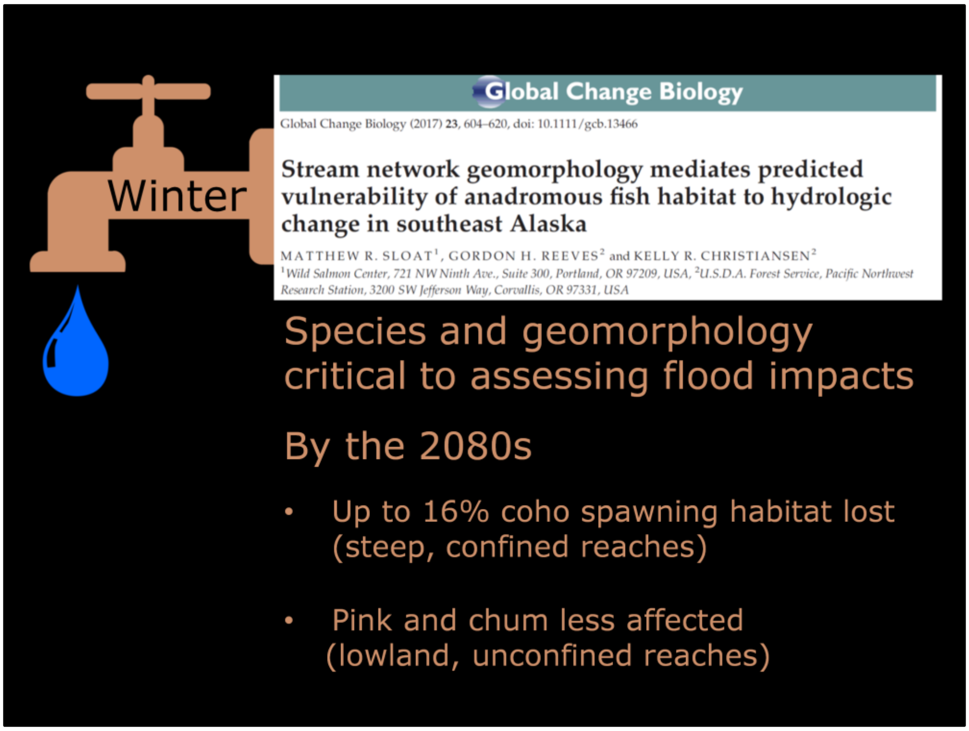


Three major categories will affect flow regimes in the future: precipitation patterns (rainfall and snowfall), multiple water uses such as hydropower or other municipal use, and glacial retreat. Several papers conducted in Southeast Alaska illustrate these potential changes nicely, and I would like to spend a few minutes summarizing them. These are some of the main studies that are driving our Sea Grant project work.

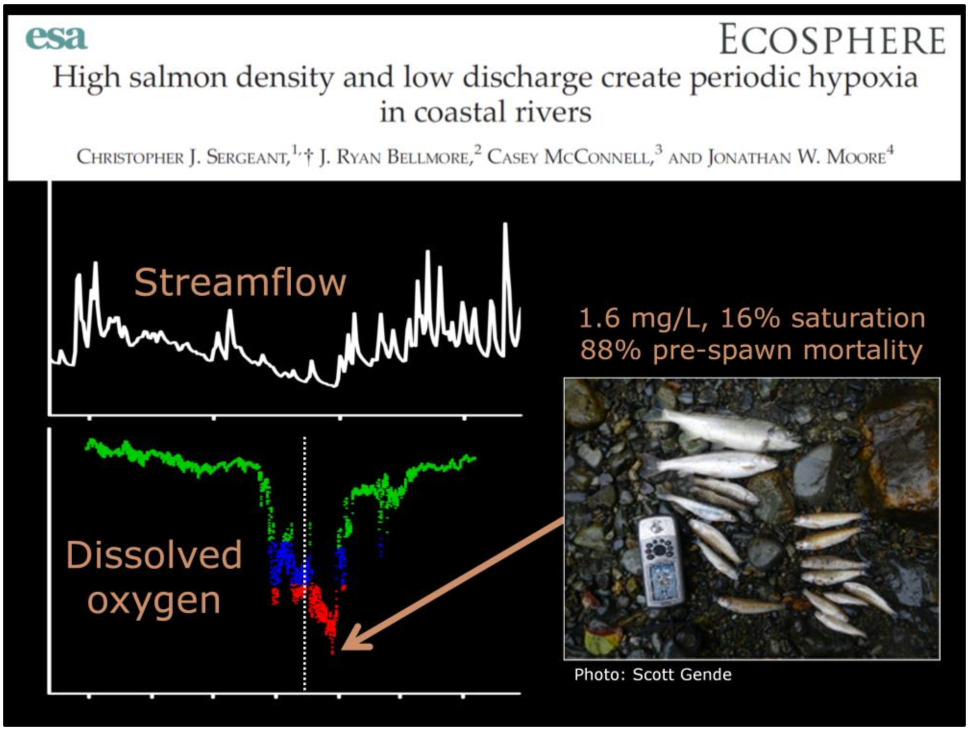


Colin Shanley led the effort on a complementary pair of recent papers discussing climate change and flow regimes in our region; although predictions state that precipitation may generally be increasing, our snow pack will likely be decreasing, leading to flashier watersheds acting more rain-driven systems in the winter with more frequent high flow events that rise and fall quickly instead of locking up in the form of snow up in the mountains.

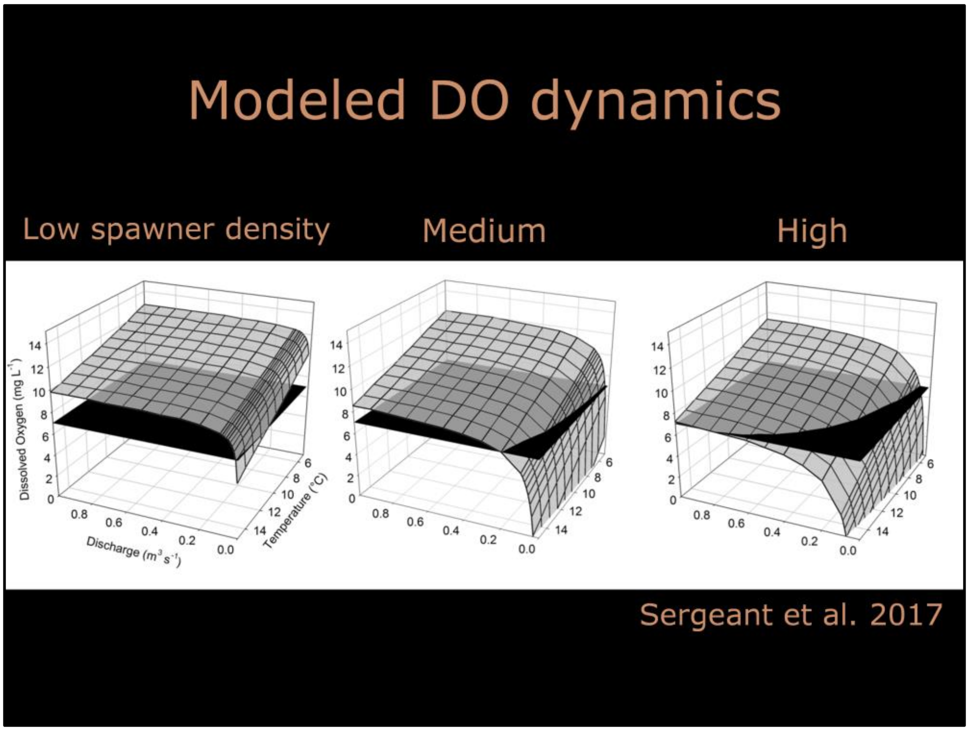
These climate predictions were used to develop an index of salmon habitat sensitivity within any given watershed during the wintertime. By looking at the average increase in monthly discharge during salmon spawning and egg incubation, the authors were able to show that not all habitat is created equal and some watersheds will be more susceptible to riverbed scour that harms salmon eggs. Landscape features such as glacial or wetland coverage will greatly influence a watershed's susceptibility to change. This kind of modeling exercise can help prioritize watersheds for future restoration efforts that help prevent or offset the negative consequences of scour



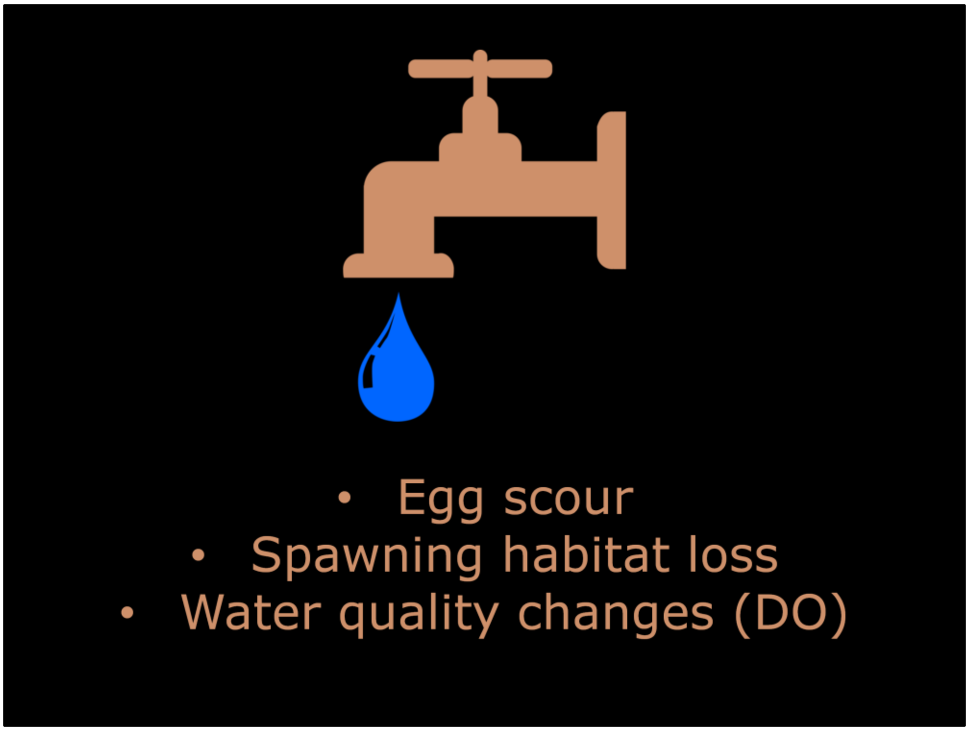
So, it’s clear that considering change at the watershed scale is important, but even within a given watershed different stream reaches will respond differently to climate change. Sloat and others drilled further into the watershed and developed a stream reach-level look at winter flood impacts on eggs and spawning habitat by integrating both geomorphology and species differences into the picture. If you’re a coho salmon spawning higher in the watershed, habitat quality may be changing more rapidly that it is in lower reaches where pinks and chum mainly spawn.



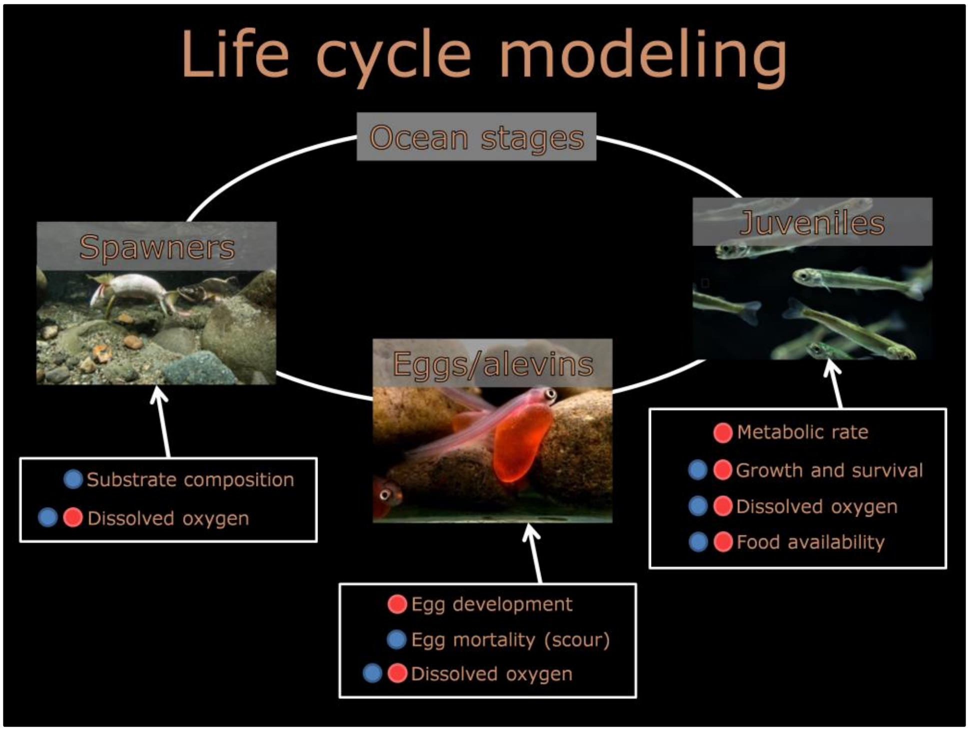
In our region, scientists have mainly concentrated on changes to winter flows, but the potential for reduced snow pack will not just create more egg scouring flows in the winter time, but also carry over to the summer spawning season by affecting the amount of water available later in the year. This can have some serious implications for salmon. In a recent study I was a part of, we found that the combination of low summertime streamflow and high salmon density combined to create critically low levels of dissolved oxygen, even in a stream with relatively cold water (12°C/54°F or less). This is an example from the Indian River in Sitka: streamflow bottoms out at the same time peak spawning occurred (hundreds of thousands of fish in river represented by vertical dashed line); DO plummeted; resident fish and pre-spawn salmon mortality occurred. While this was an exceptionally bad year for DO in the Indian River, we expect to see these low DO events happen more and more if climate change predictions come true. Thanks to the high resolution DO data we collected, which are fairly rare, we were able to accurately model dissolved oxygen fluctuations based on water temperature, flow, and salmon density. These models performed very similarly to what we observed in the field…



…so we plan to use this model across the region to predict low DO risk within individual streams based on differing combinations of salmon density, water temperature, and streamflow (represented by the 3D graphs). That will be a future aspect of my PhD work I hope to start tackling within the next year. The black planes represent the hypoxia threshold of 7 mg/L, where we expect salmon to begin struggling to migrate and behave normally.

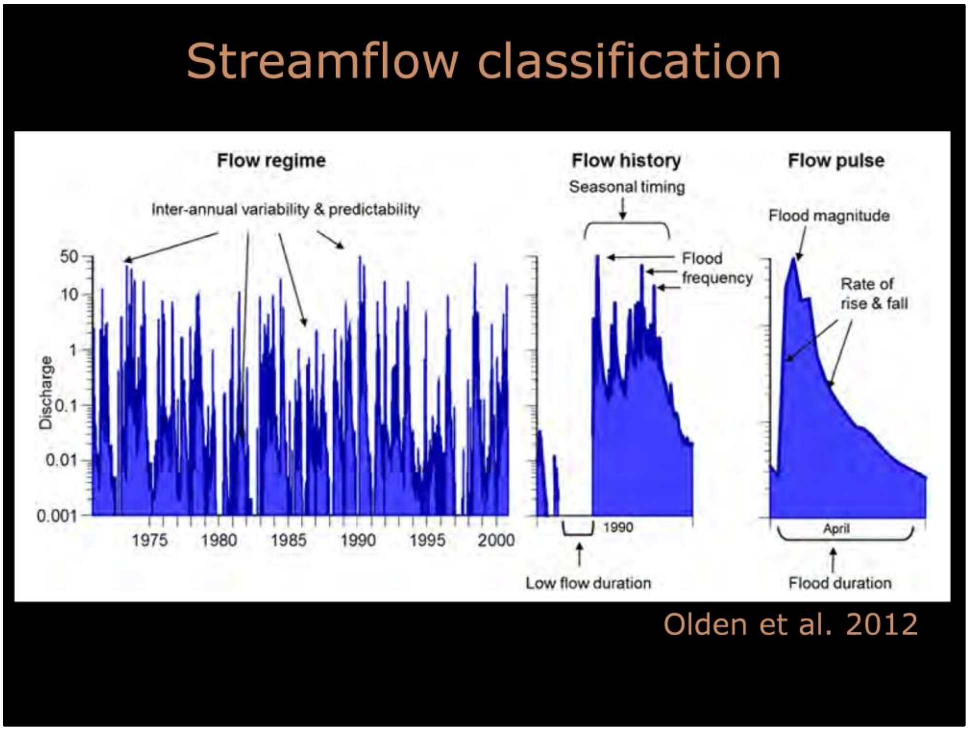


So, a number of studies are illuminating some chronic pressures on the freshwater life stages of salmon… what to do next?

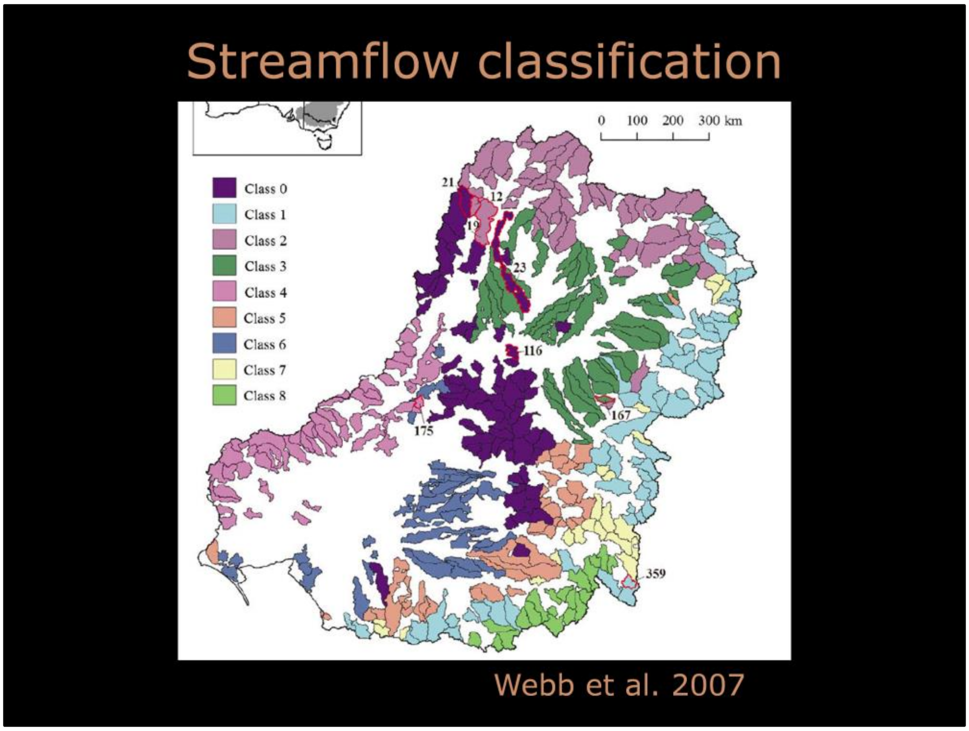


It is important to examine how these pressures might scale up to population-level effects; surprisingly, even though a lot of this has been done in the Lower 48, there are few examples of this modeling in Alaska. This ties back to one of the ultimate objectives our Sea Grant project. We will also be creating a user-friendly interface where people can run their own scenarios in freshwaters to see how that might affect salmon survival.

We can do a good job with these models in watersheds where we have a good amount of data, but it won't work as well in data poor watersheds. How do we take a huge area like SEAK and figure out where to use our current knowledge (the studies I've just summarized) when we obviously don't have good data from every place?

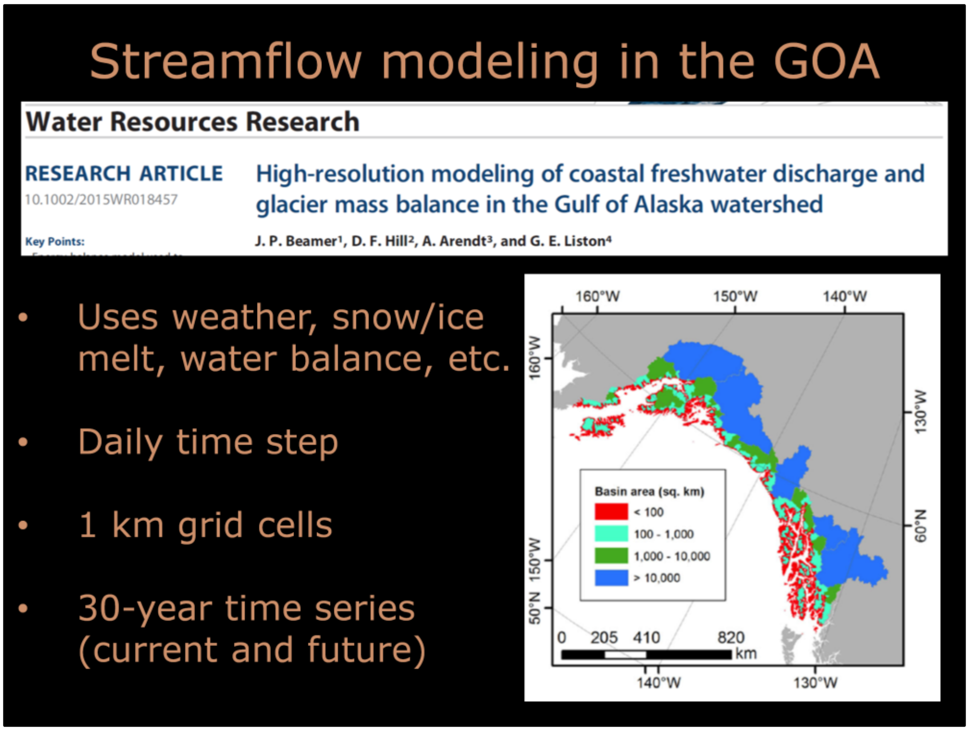


This is where I get to actually categorizing streamflows, which is also known as classification. Streamflow classification is a widely applied practice with lots of approaches, but its fundamental goal is to arrange streams into a logical set of categories based on their flow characteristics. In places where streamflow gage data are available, researchers can look at a time series of flow, like this one, calculate different metrics describing that time series (shown above) and then use multivariate statistics to create logical categories of streamflow.



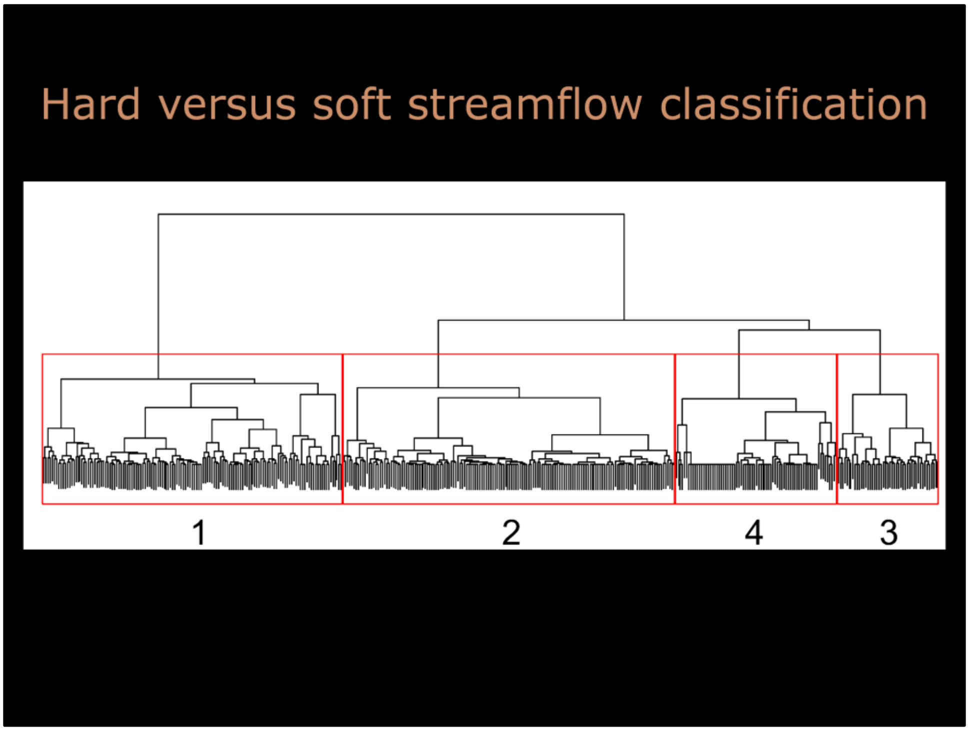
The output looks something like this, where each color within a watershed boundary represents a certain category of streamflow, like winter-rain dominated systems.

This is nice for places with lots of streamgages, But, as we know, in all of Alaska, there aren't the number of streamgages like we see in other places. So, the usual form of classification based on real streamflow data is possible, but more difficult.

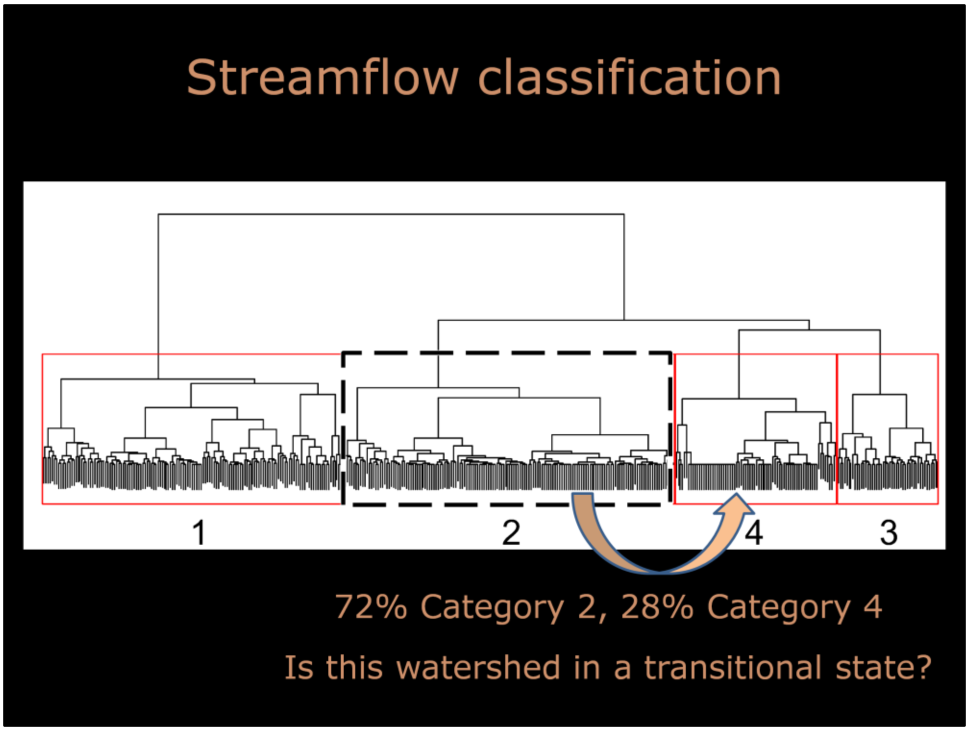


Luckily, researchers have recently created a hydrologic runoff model that predicts flow at 1km increments across all the watersheds draining into the Gulf of Alaska. I would like to leverage the results of this model and use its outputs like streamgaging stations.

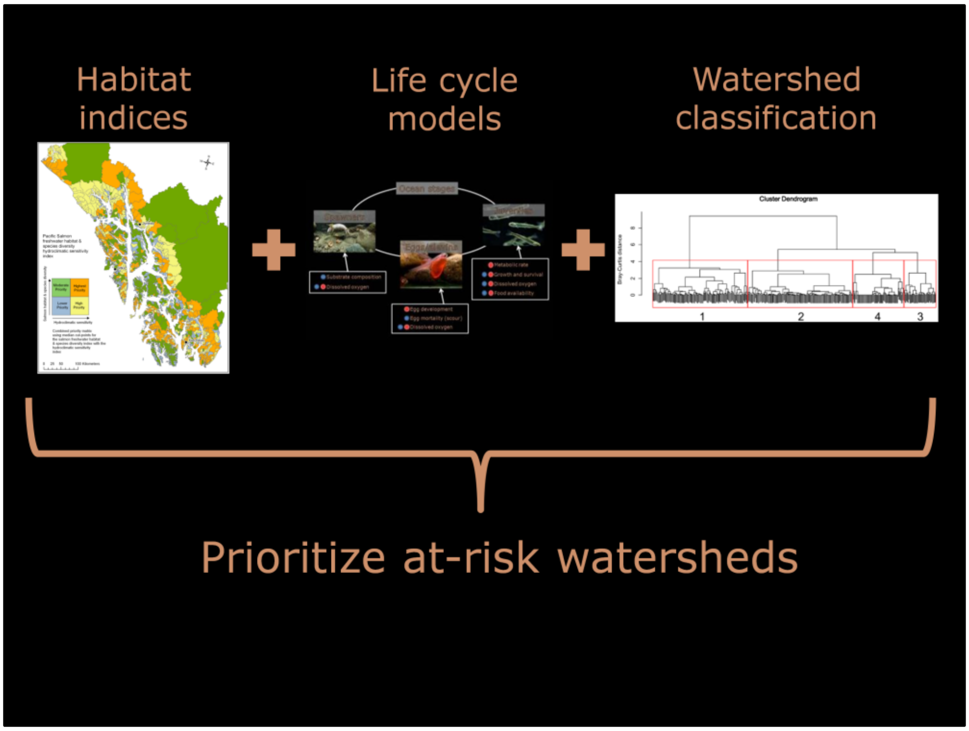
By doing this in SE AK, we can determine more accurately where things like egg scour or low DO are most likely to occur… based on categories of streams that maybe show consistent flooding in the wintertime or becoming quite low in the summer.



This is what a typical streamflow classification looks like, where each fine black line represents a single stream. In a "hard" classification like this, each stream belongs to one category, and one category only. But, this is a problem because we know streams are transitioning due to climate and landscape change, so we expect that some streams have a chance to truly belong to one or multiple categories.



So, another approach is to use a “soft” classification approach. Two tools available to do this are called fuzzy k-means clustering, and Bayesian mixture modeling. These approaches allow probabilities to be assigned to each stream belonging to one or more groups, and may be a valuable way to identify streams in transition, that may be switching from one flow pattern to another.



It's a great time to be studying salmon in this region: knowledge is improving quickly, but a lot of what we know is based on modeling; the time is ripe to use these modeling outputs to prioritize where more water quality and biological monitoring should be taking place, and to directly identify places where habitat restoration is most needed to hopefully offset the future change we're likely to see in this region.

Please email me with questions!