Fishery Science
And its Use in Bellevue
Shoreline Management

A Compendium of Materials by

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Compiled by
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Bellevue, WA
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Washington
Sensible
Shorelines
Association

To: The Bellevue Planning Commission Nov. 28th, 2012

From: Martin Nizlek, WSSA Board Member

RE: Review of Fishery Science and SMP Best Available Science

Introduction

During the course of your deliberations on the Shoreline Master Program (SMP), at several points fisheries scientist Dr. Gil Pauley provided input. At your recent meetings his input was discussed and I felt it important not only to put his comments into perspective, but also to package them conveniently.

Dr. Pauley's most recent input was in May, 2011. His submission at that meeting of the Commission is included in the compendium. His earlier, comprehensive presentation was in March, 2010 at the Forum sponsored by WSSA for the Commission and the public. His testimony as transcribed by the City's transcription service is included. Please note that I've take the liberty to integrate the slides from his presentation into the transcript as well as his abstracts of the scientific papers reviewed.

Table of Contents

City of Bellevue Planning Commission, Bellevue, WA May 25, 2011

RE: Shoreline Management Program Fishery Science

As the Commission completes its deliberation of the Shoreline Master program, I'd like to reiterate the concerns I presented to the Planning Commission last year regarding several aspects of the science provided to you by staff and the City consultants. Since several of you were not present for my presentation, I will present a little of my background. I've lived on Lake Sammamish since the mid-80s, and, for over forty years I spent my professional life as a fishery scientist and teacher. Twenty-four of those years were as a professor at the University of Washington. I also served as the Federal Court Technical Advisor on all their salmon and steelhead issues for fourteen years under the *US v Washington* Case, or the Boldt decision. I have authored or coauthored approximately 175 scientific papers in over 20 peer reviewed journals.

I reviewed three major documents[1] prepared for the City of Bellevue by consultants with respect to the fishery science contained therein. Although I found some concerns in all of the reports, I concentrated my comments on the BEST AVAILABLE SCIENCE (2005) report, because this report had a considerable amount of material regarding fisheries and associated recommendations that would supposedly be of value to the salmon fisheries in the three lakes that fall under Bellevue's purview (Lake Sammamish, Lake Washington, and Phantom Lake [which has no salmon]). I also found the BEST AVAILABLE SCIENCE (2005) report to be the most problematic report and the one that appears to have been relied upon very heavily by the Bellevue Staff in developing their SMP.

I found the 2005 BAS report has both errors of omission and commission in my opinion. Much of the information presented is based upon scientific studies done in streams and in the salt water environment. These studies have not been shown to be directly applicable to the shorelines of these three Bellevue Lakes. One of the major tenets of this BAS report is that it makes recommendations supposedly aimed at increasing the salmon populations of the lakes. However, many of these recommendations are based on information that is subjective, speculative, non-existent or actually erroneous with respect to the scientific literature. This report states on page 7-43, "…available pertinent literature is limited. Nonetheless, inferred and hypothetical associations can be made based on available scientific literature." As I read the report, it appears that a lot of the conclusions and recommendations related to fisheries aspects in the report are inferred and hypothetical. In many cases, there is scientifically valid information that leads to different conclusions than those views expressed in the BAS report –however, these alternative views are not presented, which leads me to believe the report has been written with an agenda in mind rather than presenting all of the scientific facts and options available.

Major examples of this are the recommended planting of large trees near the shoreline and introduction of large woody debris (LWD) along the shoreline. These are championed with the idea of increasing the type of habitat cover needed for young salmon to utilize during their out-migrations from the lakes. However, there is no mention that trees and LWD also will act as structure that will provide hiding places for both smallmouth bass (SMB) and largemouth bass (LMB) as predators to ambush young salmon in Lake Sammamish and Lake Washington. In fact, there are scientific papers that demonstrate increases in the amount of LWD in lakes will increase the populations of these predatory bass. Introduction of LWD in lakes and reservoirs is a common management tool used in many states to enhance both smallmouth bass and largemouth bass populations—this aspect of LWD was not presented in the BAS report. Shoreline trees were mentioned as a contributing source of terrestrial insects utilized as food by the young salmon. However, in large lakes, terrestrial insects are not a major food source of the young salmon, because they predominately eat aquatic insects and crustaceans on their journey to saltwater.

In the same report, over-water structures (docks) are vilified as places that harbor fish species that prey on young salmon, when in reality docks are simply acting as a surrogate for natural cover. The use of flow through decking on the top of existing docks would further simulate natural cover and should be encouraged by easy permitting. The degree to which predation under and around docks may impact the number of out-migrating salmon is unknown. The bass in Lake Sammamish and Lake Washington do not target the out-migrating young salmon, but merely appear to be opportunistic feeders on them as they pass through the lakes on their way to the ocean. However, increased LMB and SMB populations associated with enhanced LWD in the two lakes could be expected to lead to an increase in the total number of young salmon eaten. This view regarding enhanced LWD on shorelines is not presented in the BAS report.

Page 7-36 states, "In order to avoid habitat alterations and stop the loss of shoreline areas and functions, bulkheads needing **any type** of maintenance, repair, and/or retrofitting should be considered for removal or replacement with vegetative and large woody debris structures as shoreline protection alternatives. This recommendation is based on a conservative interpretation of the best available science." Yet on the previous page 7-35, the report states that the effectiveness of alternative shoreline armoring (bioengineering) techniques is unknown…." Here the report is making a recommendation which is far from conservative based on an unknown efficacy of the techniques suggested. Additionally, removal and replacement would be extremely expensive to property owners with no mention of this.

Most egregious are errors that misstate the facts. For example on page 7-45, the BAS report states that, "No studies were found that address the cumulative effects of in- and over-water structures on Bellevue's Lake WA, Lake Sammamish, and Phantom Lake shorelines." Then on page 7-46, it is stated, "….it is known that the effects of docks and piers (and associated in- and over-water structures) are incremental and cumulative in nature (Jennings et al., 1999)…." The Jennings paper (1999) does not mention either docks or piers—it is a study of rock rip-rap and concrete retaining walls. So this conclusion is not valid based on both the statement on 7-45 and the erroneous citation of Jennings. The use of rock rip-rap tapered to 45 degrees has much less impact on the environment and it results in considerable species richness because of its complex habitat with interstitial spaces according to Jennings—but this positive aspect of rock rip-rap and its ability to dissipate wave action as compared to concrete walls were not discussed in the BAS report when it discussed bulkheads.

Multiple points of view will exist on any topic. The more important the issue, the more important is the need to assure that all and any opposing views are presented to the fullest extent—not just those scientific ideas that support a given agenda. The promulgation of policy, rules and regulation related to science must pass the transparency test of being based upon sound scientific principals—only then will the public view them as fair. I feel very strongly that the BAS report done for Bellevue does not always give any or enough scientific documentation to support many of the views it presents, which makes them speculative at best in many situations presented. Additionally, the BAS report often does not present scientifically valid information which supports an alternative view or approach that may be in opposition to a view they are championing.

In Summary, the City of Bellevue's Best Available Science Report (2005) frequently:

1. Failed to present opposing science, alternative views and alternative options
2. Used a considerable amount of non-peer (colleague) reviewed science
3. Misinterpreted and misquoted scientific citations
4. Made conflicting statements, recommendations and conclusions
5. Made conclusions and recommendations without supporting science

What is essential for truly Best Available Science is:

6. A better understanding of the dynamics of the systems
7. Controlled evaluation and testing in advance
8. Inclusion and consideration of opposing science
9. Consideration of alternative actions and options
10. True peer review of the relevant science reports

The Shoreline program will affect many homeowners and the shoreline environment. Your decisions with respect to these regulations should be fact-based to assure both an equitable and an effective program is established. Thus, I think it important that you consider my comments of last year, which are equally valid at this time and are summarized herein.

Thank you,

Gilbert Pauley, PhD

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[1] (1) "A Summary of the Effects of Bulkheads, Piers, and Other Artificial Structures and Shorezone Development on ESA-Listed Salmonids in Lakes", T. Kahler, et al, 2000. (2) "Best Available Science (BAS) Review", Herrera Environmental Consulting, 2005, (3) "Shoreline Analysis Report – Analysis and Characterization", Watershed Co., 2009.

Fishery Science and Its Use in Bellevue Shoreline Management
Dr G.P. Pauley Testimony
Bellevue Planning Commission - March 24, 2010

Fishery Science Basics

So what I'd like to start out with tonight is to kind of discuss just a little bit of basic science to people like Mike that are just going to go oh my gosh, because it's very basic, but many of you that don't fish or haven't read any stuff on fisheries, hopefully it'll kind of get you to where I can talk with you then about a couple of concepts that are little more complex, and hopefully you'll understand them. And then what I'd like to do is kind of try and relate this to things I've read in the best available science report and then make some recommendations at the end.

Okay, what I'd like to do as I mentioned is talk about the basic science and then talk about how the science is used and hasn't been interpreted correctly. Much of the science that's been done is fine, it just hasn't been interpreted right. Or there isn't any of it.

So to start out with fisher basics, our lakes here have a variety of fish in them. Some of these are desirable, and some of these that are desirable are food fish to be eaten, others are sport fish.

Among the desirable ones that we have in the lakes, and not all of these necessarily exist in all three lakes that we're going to talk about, we have the salmon in the lakes, the various trout, we have two bass, we have yellow perch, and black crappie. We also have a number of less desirable fish which are non-edible, non-sport fish. Many of these are predatory on young salmon. Two of those that are what are called Cottids or sculpins. You may think of them, you've heard the term bullhead. Scientifically, though, a bullhead is a small catfish, and this is a different fish. Also the pikeminnow which used to be called the squawfish.

Desirable Fish

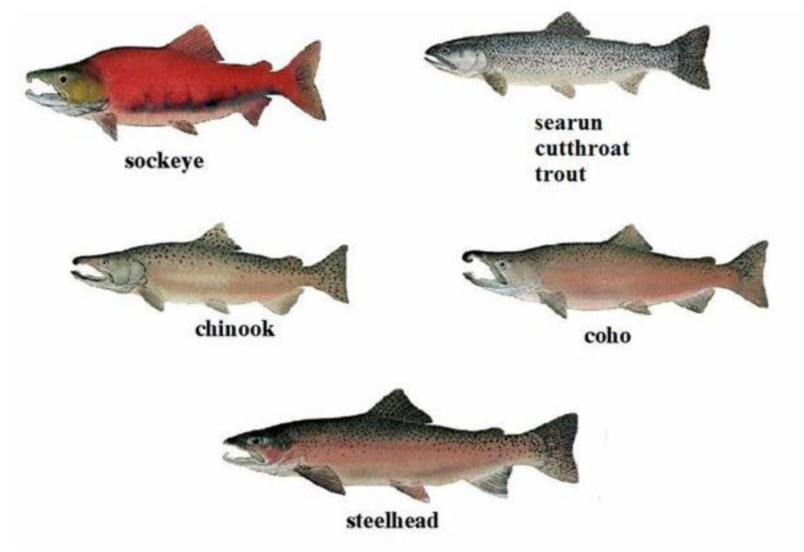
(food source, sport fishing, etc.)
- **Salmon** (Chinook, Coho, Sockeye)
- **Trout** (Cutthroat, Rainbow, Bull Trout)
- **Bass** (Small & Largemouth)
- **Yellow Perch**
- **Black Crappie**

Less Desirable

(non-edible, non-sport, predatory, etc.)
- **Cottids** (Sculpins)
- **Pikeminnow**

In the lakes we also have a number of ocean-going fish called anadromous fish, and they go out to sea and then come back into fresh water. And these include a variety of salmon and trout that are found in lakes Washington and Sammamish. Other ones that we have in the lakes are the sockeye salmon, the Chinook salmon, the Coho, sea run cutthroat trout, and the steelhead, which is an ocean-going rainbow trout.
And in these lakes we have some stocks of fish that are threatened, such as the Chinook. We also have Kokanee which are being reviewed to be listed as endangered. And we also have fish in addition to the

anadromous fish that spend their entire lives in the lakes or in sometimes the streams that run into the lakes that we term as resident fish. And among all these fish, there are a lot of fish that eat each other, okay, and these fish are called Piscivores fish, or predators.



Salmon Basics

Anadromous fish, the ones that go out to saltwater and come back, return to their natal birth waters to spawn. And they all have a different cycle. That timing of this is based on the different species of the fish and the geographic location. And in any given river, for example, for example the Queets River out on the Pacific Coast, has I think it's five different species of anadromous fish, and within those there are various races of the fish that come in at different times. The progeny of these fish, or the young fish, they will return back to the ocean, they'll rear and grow to an adult size, and then come back into fresh water to spawn. And then the adults, once they spawn and they have young fish that go back out into the ocean, the cycle is completed and it starts over again.

ANADROMOUS FISH FACTS

- **Anadromous fish return to their natal waters to spawn**
- **Timing varies by species and geographic location**
- **Progeny return to the ocean and become adults**
- **Adults return to spawn and the cycle starts again**

Now one thing you should keep in mind is we don't have to have crystal clear water and tree-lined banks to have salmon. This is a picture from the Copper River, and you'll see it's a very kind of ugly color because it's glacier fed.

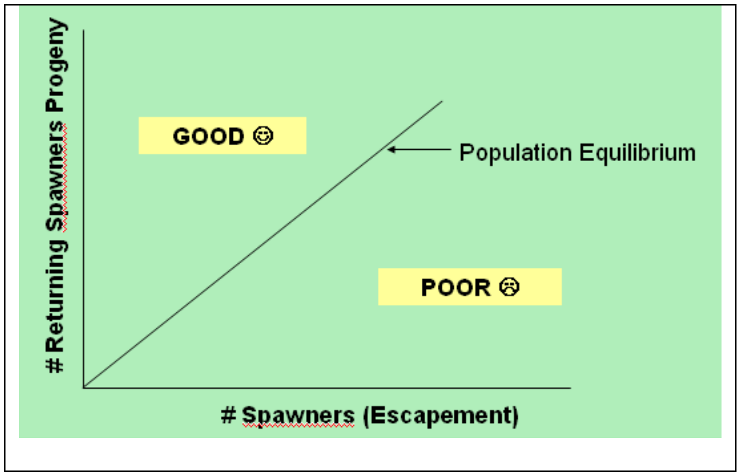
There aren't very many trees around it. It has probably the finest run of sockeye salmon that we know of in North America. In fact it's the only river that I know of that when the fish come into this area for sale they name them by the river of origin. And I'm sure a lot of you have bought Copper River sockeye, right? Okay, and they sure don't say Hoh River salmon when they bring those over here, so this is a very famous river. It also has Chinook and Coho in it.

So now I'm going to talk a little bit about a little more complex thing, because sometimes we'll get upset because one, the salmon runs aren't the same every year, or they're not going up constantly in numbers, okay? Salmon runs fluctuate every year for every species in every river system. It's just a basic fact of life. And there's a lot of things that influence that fluctuation, and a lot of things of those influencing factors we don't know a thing about, okay? Now where a species is threatened, often we've instituted hatcheries in some cases, such as the Chinook on Issaquah Creek that comes and flows into Lake Sammamish. So the key to survival is the ability of the fish to return to their home waters to spawn, to have their progeny survive and reproduce back in that same water after they've been in the ocean. Very simple process.

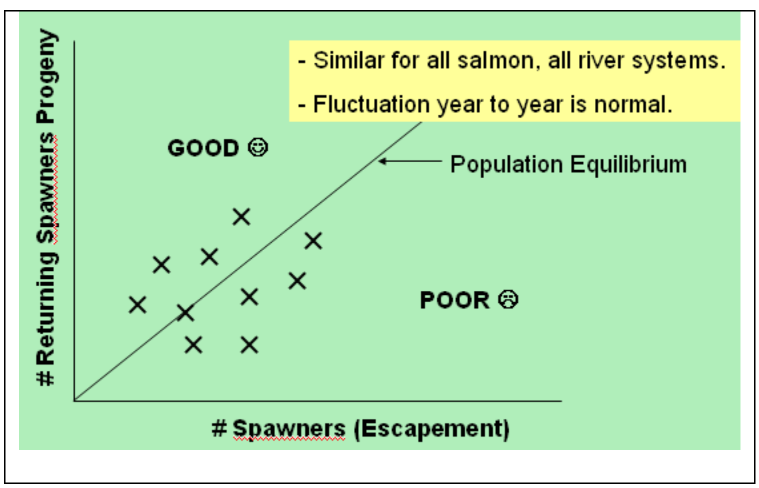
SALMON POPULATION FACTS

- **Populations will vary widely year to year**
- **Many factors influence the population (many not understood)**
- **Where a species is threatened, we have instituted hatcheries for some such as the Chinook**
- **Key to survival is - the ability to return to home waters to spawn, and to have their progeny survive to reproduce.**

This is what's called a spawner recruit curve, and it's a tool that's used to predict what salmon runs will look like. It's a very valuable tool that was used in all the years I worked with the Corps. It's used for every single species of salmon and steelhead in every single river. And on the bottom here we have the spawners that come in in any given year.



And I've left numbers off of here because I want you to try and understand the concept. The numbers really don't matter. But if you had five hundred or ten thousand here, it doesn't matter, the concept is the same. And then these are the young fish that are the progeny of these spawners on this line. And what you have to have, regardless if you have five hundred fish that come in as spawners, to have equilibrium in the population, this line right here, you have to have that same number of fish coming back as progeny. So when you have this line like this, that means your population's in equilibrium, if you have five hundred here and five hundred coming back. Okay?



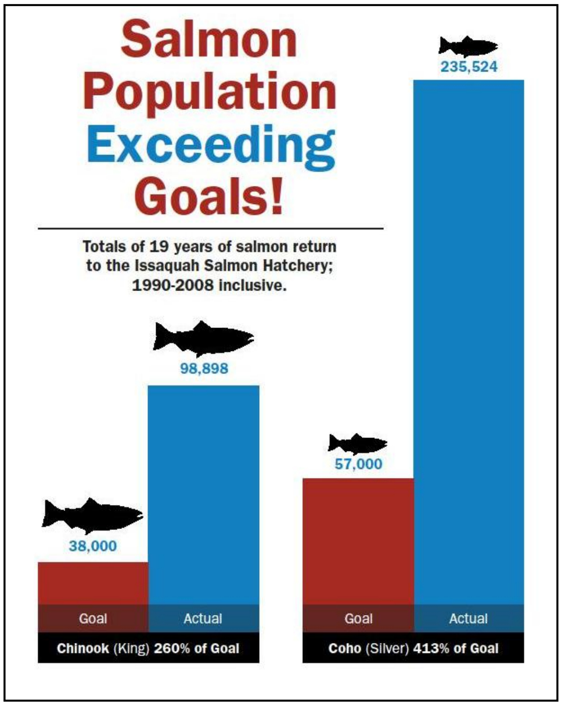
So, the thing here is that each of these points is two years. That X up there is a sample point for two years. In other words, that represents the spawners of one year that came in and spawned, and then the number of fish that came back later and spawned in subsequent years. And that time is variable, again depending on the species of fish, what river it's in, and geographic location. So there's a lot of stuff that goes into that. But each data point here is two years, okay? It's the adults that spawn, say today, and the ones that come back two years from now, or three, whatever the point is we're looking at. Anything above that line is good. That means that's excess fish and we can keep those, we can fish for those, we can eat them. Whatever we want to do. The bottom under that means it's poor, the returns were not as good. So right on the line you've got equilibrium in the population, but under that is not good.

So what you have is some years are good, some years are poor. And if you look at a diagram of any river system over a period of years, this scatter dash right here will look exactly the same. The numbers on the two axis will be different, but where the points are is going to be almost the same. Doesn't matter if you have five hundred, ten thousand, doesn't matter. If you do Bear Creek, if you do the Skagit River, you're still going to have sets of points on here, and the ones above means the runs were good that year, and the ones below means we had a bad return. Okay? But the thing that I want you to do here and look at is the take-home lesson here, is that this is a tool that's used in all river systems for all salmon and steelhead, and there is fluctuation in all of those fish every year. That's just normal.

So again, to repeat that, all salmon species have fluctuations year to year. These fluctuations occur in all salmon streams year to year. And the fluctuations in some years result in good returns above equilibrium, sometimes poor returns below, and in a few instances right at equilibrium.

SALMON SUMMARY

- **All salmon species have fluctuations year to year**
- **Fluctuations occur in all salmon streams year to year**
- **Fluctuations result in good returns above equilibrium**
- **Fluctuations result in poor returns below equilibrium**



This is the same diagram or bar graph you saw in Brian's timeline. And here you can see that this is actually the expectation the hatchery would like to have, and this is a total of nineteen years, or eighteen years, on the hatchery returns for Chinook salmon. And you can see that the totals of the salmon that came in actually exceeded those goals over that nineteen years by three times the estimated amount that they wanted. In fact, this last year the goal was met and then they released several thousand fish into the upper Issaquah Creek to spawn naturally, and there are also fish to spawn naturally on the lower part of the creek below before they get to the hatchery. Coho, the same thing. They had an expectation for the goals for the fish, and that goal was exceeded by four times in that time span.

Kokanee - Our Non-anadromous Sockeye

Now they just briefly mention Kokanee, which is a non-anadromous sockeye. In other words it doesn't go out to the salt water, it's landlocked. And the primary spawning areas for Kokanee and in Lake Sammamish are on the east side of Lake Sammamish. The Bellevue shorelines do not, I emphasize not, have Kokanee spawning grounds. It requires a upwelling in the area to wash the eggs and get enough oxygen to them, and so that doesn't exist on the Bellevue shoreline. I talked with Hans Berge whose done I think twelve years of work on Kokanee on Lake Sammamish and he indeed indicated that that is the case. So there is no spawning of Kokanee on Bellevue shorelines. They do exist. There's a small run that goes (used to go?) into Vasa Creek in Bellevue.

KOKANEE FACTS

Primary spawning areas – east side of Lake Sammamish

Bellevue shorelines are NOT Kokanee spawning grounds

Vasa Creek is known for Kokanee spawning

Kokanee do not feed on terrestrial insects

Another thing is, and I want to mention this right now because I'm going to talk a little bit about trees. Terrestrial insects supposedly are fed into the lakes by trees. Kokanee do not feed on terrestrial insects. They eat small crustaceans, which are related to the shrimp family. The ones they primarily eat in Lake Sammamish are the daphnia and one other little critter over in Lake Washington.

Now, like Diane was saying it's really pretty amazing that these little guys can get through the maze that they have to go through to go through from Issaquah Creek, let's take that one because it's the furthest away, go down through Lake Sammamish, go out through the Sammamish Slough, through Lake Washington, through Portage Bay, through Lake Union, through the Chittenden Locks, into Elliot Bay, out into Puget Sound, through the Straits of Juan de Fuca, and into the ocean and grow, and then come back through all that and spawn and repeat the cycle. And along the way they have all these things that they have to meet. So the Bellevue shoreline is really a miniscule part of this whole process.

PREDATORS OF SALMON

- Birds of prey – (eagles, etc.)
- Sea Lions, Otters, Killer Whales
- Fishermen – (commercial, sport, tribal)
- Toxins, sewage, heavy metals, etc.
- Diseases
- Lack of food
- Water temperature
- Other environmental threats (silting, floods)

Predation

They have to go through all kinds of birds of prey, they are attacked by sea lions, otters and killer whales. And then we have the biggest predator of all, fishermen, both commercial, sport and the tribal fisheries. They encounter toxins, sewage, heavy metals. They have diseases and parasites which actually was one of my specialties when I was doing research and teaching in addition to fisheries management. They run into lack of food in certain situations, and in talking with Hans he said he thinks that's one of the problems with the Kokanee in Lake Sammamish, they get a squeeze because of the lake stratification and they don't have enough to eat.

Water temperatures are a problem, and there are a lot of other environmental things. When these fish get into the river, there's silting, there's flooding. And one thing that a lot of you don't realize is that fish when they come into the river, they have to have a certain amount of water to get into the river. Because if the river's too low they can't get in either. So it isn't just a case of flooding. So actually the fishermen when they net fish, for example, they need to have what they call freshets, or new water going out, and raising the level of the river to get those fish in.

Now, we come from that into the fish predators in the two lakes, okay? And as you heard earlier, the cutthroat trout, which is a very desirable sport fish, is a huge predator of young salmon, both in the lakes and out in salt water. Rainbow trout are big predators of young salmon. The Cottids, those little guys, the bullheads, they are huge predators of young, little tiny salmon, the fry and very, very small sockeye.

FISH PREDATORS OF SALMON

- Cutthroat Trout & Rainbow Trout

- Cottids

- Pikeminnow

- Smallmouth Bass* & Largemouth Bass*

- Black Crappie*

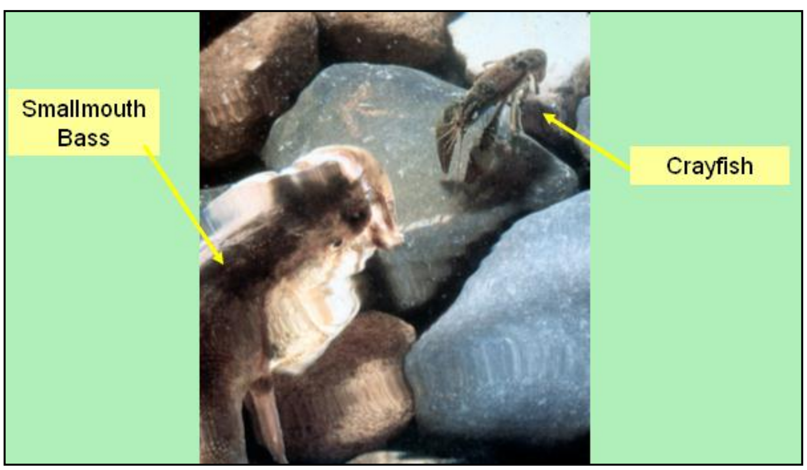
Pikeminnow, which was introduced into the lakes by the government, they are huge predators, all along in our lakes and also along the Columbia River and Snake River systems. And then we have the smallmouth bass and the largemouth bass and the black crappie in Lake Washington. Those bottom three are members of the centrarchidae family, which is the sun fishes, and they also eat their young. So if they get hungry they just cannibalize the little guys.

Okay? And that's kind of important for a concept I'm going to show you in a minute.

So all of these fish have been put into the lakes, with the exception of the native trout, and probably the Cottids. The Cottids also – there's a different cottid called staghorn sculpin that is a predator in the estuaries as the fish enter saltwater. So there's a lot of Cottids out there eating these guys, too. Another thing now to keep in mind is predation is a very, very natural phenomenon in nature. That's just the way life is there, okay? And if we have an imbalance in one fish species, it's going to affect another fish species. And that balance was impacted many years ago when the two bass species were introduced into our lakes here, Lake Sammamish, Lake Washington, and in Phantom Lake where they have only the largemouth bass.

This a photograph I took many years ago when I was a young man back on Lake Sammamish. And we were doing a study there. The fish on the top is a smallmouth bass, you can tell it by the vertical bars and the sort of dusky belly on it. It also has a very small mouth. The large mouth has a big long line down the side, a silvery belly, and a very large mouth. Both are predators, okay? But, this is an interesting thing, they don't target salmon, okay? But they're very opportunistic. It's sort of like if you were sitting somewhere and you had to go out and run around and look for your meal and you had, you know, McDonald hamburgers, and all of a sudden these filet mignons started coming by, which ones are you going to take, okay?

But in the absence of young salmon, in our lakes here and in many other lakes, crayfish are the preferred item. That's the big diet item of small mouth, and to some degree largemouth bass. In Lake Sammamish, Cottids that I mentioned, they eat salmon. Well guess what, the bass eat the Cottids too, so they are actually doing a good thing in there, they are not all bad. Besides that, they're a real good sport fish, okay? So the diet items when the salmon aren't there are primarily crawfish and Cottids, and to some degree aquatic insects, not terrestrial insects. I want to make that point very clear.



This is a picture I took, again when I was a young man on Lake Sammamish, and this shows a smallmouth bass heading up, taking his favorite diet item here, a crawfish. And they would sit and eat those all day if they had access to them on a regular basis. But when the salmon come by, they are just too easy to get, so they shift to those for a little while.

But now, one thing has to happen – in effect, three things have to happen for the bass to eat the young salmon, and all three of these things have to happen at the same time, okay? And one is – and it really doesn't have a lot to do with docks, I might add too, okay?

That the salmon have to be in the area at the time the small mouth are getting ready to become active and spawn in the spring, and that's at a time when the water temperature gets around fifty-nine or sixty degrees, okay, or fifteen degrees centigrade. Also, it occurs at a time when the little salmon are moving out along the shoreline and the bass are moving in from deeper water into the shoreline to spawn, okay? The third item that has to happen is the fish have to be small enough that the bass will eat them, and generally that means they have to be under about four inches. On occasion they'll eat a bigger one, but their preferred food size is about three to four inches, okay, or even smaller. So all three of those things have to happen or they are not going to be attacking salmon. This in fact that been shown by both Dave Pflug and myself, we published a paper in 1984 on this, on Lake Sammamish, and it's also been shown by a number of other authors, Fritz and Pearsons in 2006.

FACTORS ESSENTIAL TO BASS – SALMON PREDATION

- Salmonid migration coincides with increased SMB activity when lake temperatures are at ~15°C (~59°F) . . .

. . . resulting in overlapping use of the same nearshore areas during a 6 week out migration window. . .

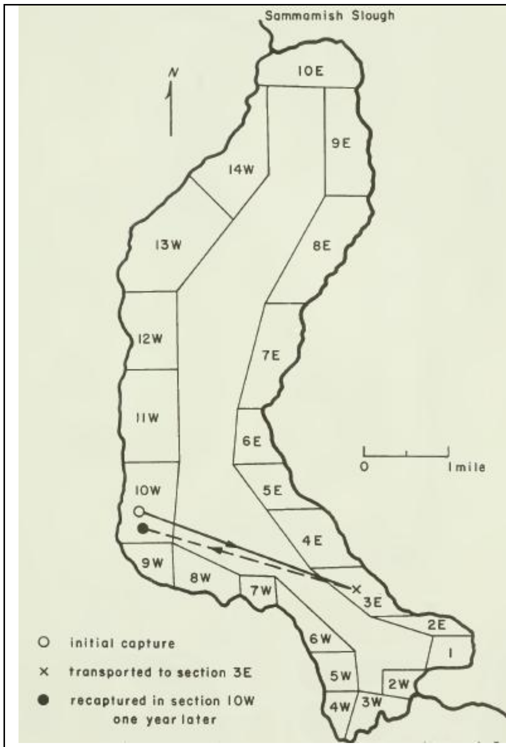
. . . and the young salmonids are an acceptable size to the bass (< 4 inches)

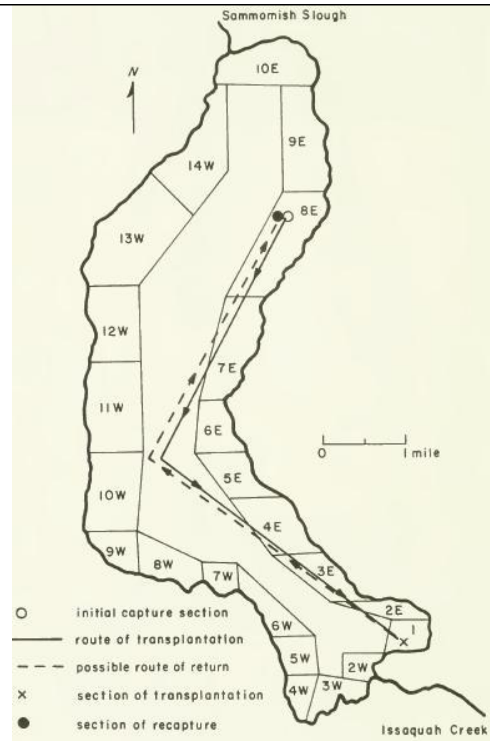
There's been a lot of work on this on the Snake River, which has both salmon and smallmouth bass.
Okay, one thing we need to be careful of is what are the actions that we might take that may alter or impact the predator/prey balance, okay? One thing you have to keep in mind, though, before we talk about that is it really is not practical to eliminate the bass. In fact, it's impossible. It's not just impractical, it's impossible. And the reason is the lakes are too large. The populations are too well established. And they're a very popular sport fish. And if you tried to eliminate them you'd have four times as many people in this room as there are here tonight.

In the predation balance, the things that we know from my and Dave Pflug's studies on Lake Sammamish and those of other scientists are that the black basses, which are the small mouth and the large mouth, are territorial. In other words, at a very young time in life they set up a territory, imprint on that, and they defend it. They move down into deeper water and come back, but they defend their territory. They orient very heavily to structures. And those structures can be manmade like the docks, but they also orient very heavily to trees, rocks, logs, drop-offs, anything that's natural in the lake, because they're in a lot of lakes that don't have docks, okay?

And our work on Lake Sammamish, we did a study – tagging study – which hopefully you'll find interesting. I'll show you a couple of pictures from that in a moment. Ahrenstorff just published a paper in 2009 that's really an excellent paper on this issue of orienting on structures and territorialism. Stein in Lake Washington in 1970, he actually found largemouth bass prefer rocks and logs over docks. Isn't that interesting? And trees. So, what do I mean by orient? As I said earlier, they imprint. In other words at a very young age they imprint. Birds imprint. Fish imprint. Lots of animals imprint.

Bass Migration Study



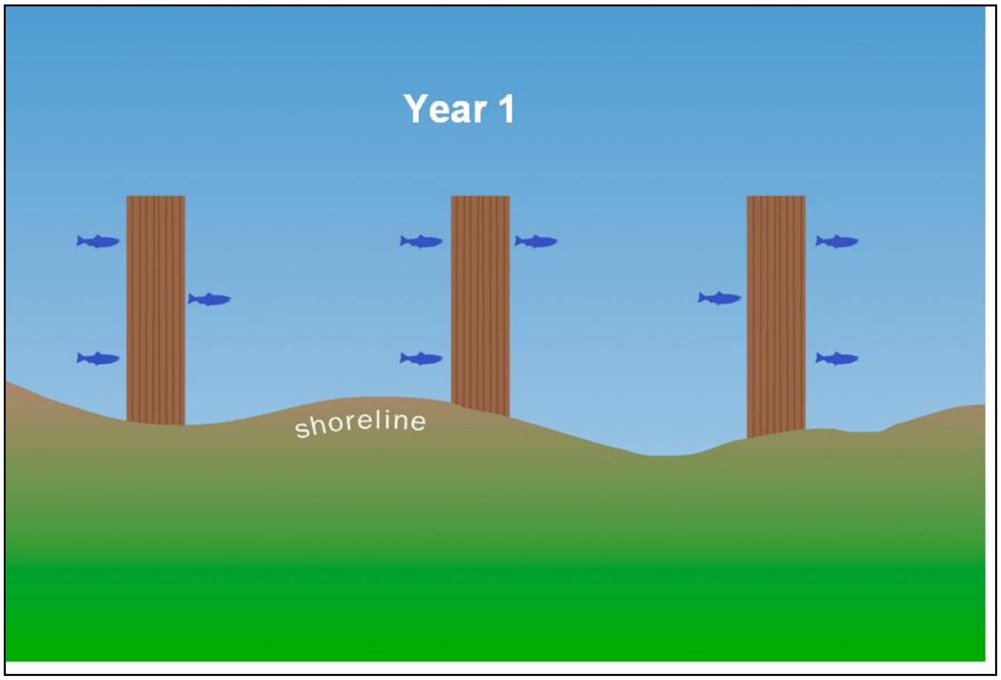


These are two pictures of maps from our study on Lake Sammamish. And this work was published in the California Fish and Game Journal in 1983. And what we did was we sampled 240 smallmouth bass in Lake Sammamish and we tagged those bass with tags that are kind of primitive by today’s standards. But we moved those fish, those 240 fish, all over the lake. Now those sections that you see up on the lake, those are our sections. They’re artificial; they’re not the bass sections, okay? We defined those sections based on the type of vegetation that was present, the type of substrate, and how steep and fast the bank and the water dropped off in depth. We found – the largemouth bass were found primarily up in Ten E and this Fourteen West area, and then down in here in the southwest area.

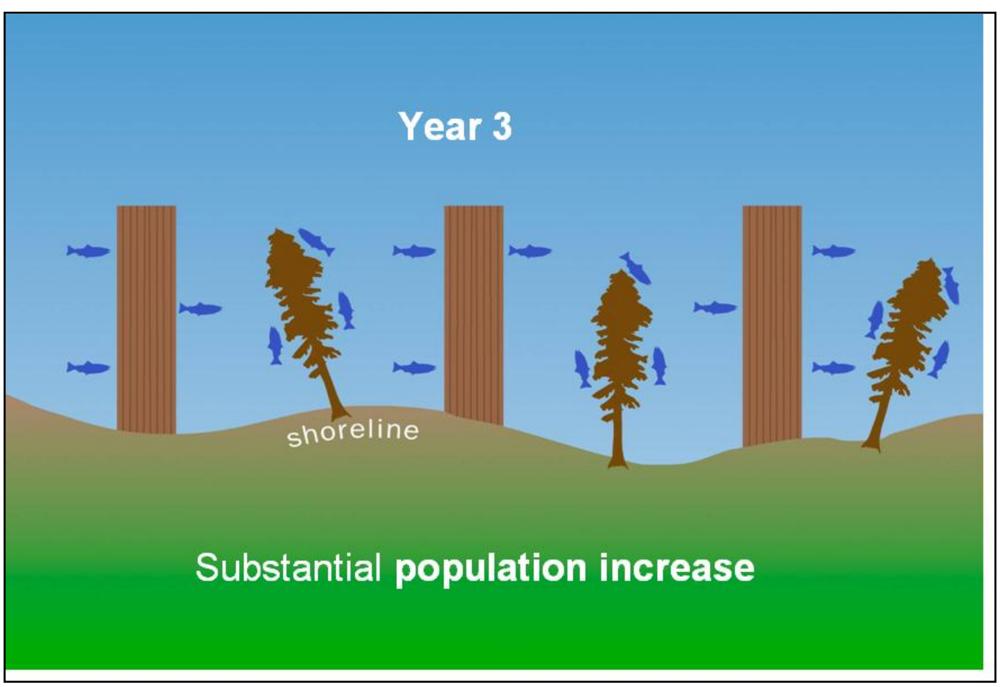
And then there is an overlapping area in these three areas down in the south over here – I don’t know if you can see it, this is where they overlap over here. The rest of the lake is predominantly small mouth. And so we took fish from almost every section and moved them around in varying distances. And we also took another 238 fish that we tagged and put them right back where we caught them. Okay? And in this experiment where we moved them around, what you’ll see here is that this fish moved from Ten West, we moved it over to Three East. And when we recovered that fish guess what, he was back in Ten West right near where we caught him. This fish we moved from Eight East down to One where the boat launch is. That’s where all the tournament fish went, the small mouth largemouth bass, after a tournament. This fish went all the way back up to Eight East. We caught that fish on the very same fallen tree that was in the water up there when we retrieved it with its tag.

And this was pretty much the situation. A little over 40 percent of the bass we got back – and I think we got back about 150 bass with tags – about forty percent of them were either in the area in which we originally caught them, or what we called moving toward it and were in the adjacent area between where we let it out and where we originally caught it. Hope that makes sense. Of the ones that we released back into the same area, so let's say that if we had released a fish, caught fish in this area and released them back here, and caught them in this area and released them right back in that area, eighty percent of those fish stayed in the area. And I believe all but one fish that we retrieved was in an adjacent area on each side. So they stay very tight to their home range. And the reason we did this study was the Department of Game at that time, which the state had two different departments, and Game was responsible for freshwater fish, they thought that all these bass that were being released might just camp out in front of Issaquah Creek and eat the little young salmon that are coming out of the creek. It wasn't happening. They were going right back where we got them.

So now, let's take a hypothetical example with the things I've explained to you and see what might happen if we change the shoreline, okay. Now let's take a shoreline that has nothing on it except three docks. And in year one we have an established – that's a hypothetical year one, it could be ten years ago, it could be today, it could be five years from now, it doesn't matter.



And those docks all have established populations of smallmouth bass because they've imprinted on those docks, and that population is there. And if one dies, another one will go in there and take its place, okay, but there's some equilibrium there.



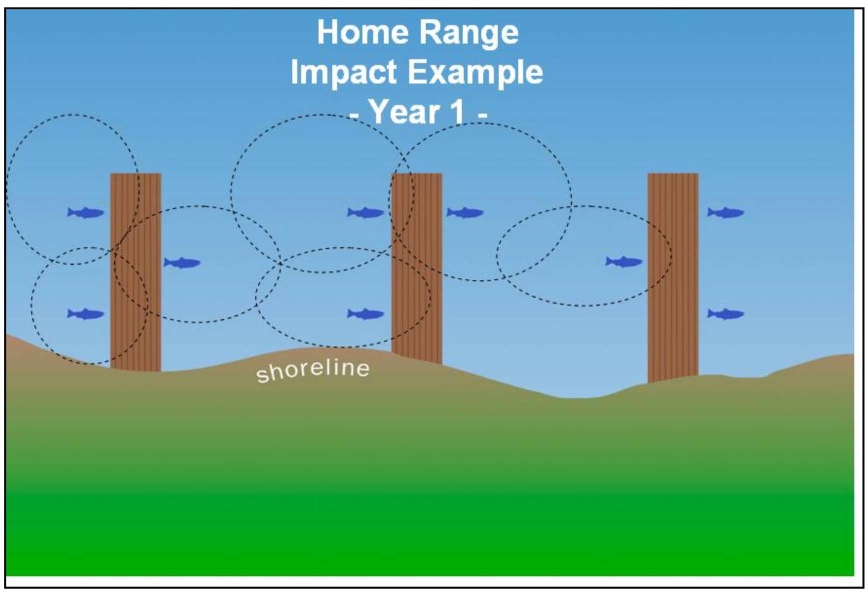
Now, what happens in year three? We probably still have about the same population because there are only so many places those fish can set up as territories. And that's the carrying capacity of the body of water, okay? Now guess what? If you do what the City of Bellevue wants you to do and put trees in the water, now what's that going to do? Or large woody debris as it's called.

Okay, in the first year, it depends on when you put it in, you may or may not have a fish on the trees, alright? But in year three after the populations are established, and you have nice ten- to twelve-inch smallmouth bass in the lake, this is an established principle, you will have an increase in the number of bass because they like trees and logs and rocks as well if not better than they like docks.

Okay, so some important things to remember about large woody debris, or trees – it has a lot of names in the literature, course woody debris, course woody habitat, small woody debris, I mean on and on and on and on. It's all the same stuff, okay, it's putting trees and branches and logs and things in the water. The best paper that I've seen recently is this one by Ahrenstorff that was just published in 2009. And this is a very good scientific paper and statistically valid. That's another thing, that for science to be valid it needs statistics, okay? When you put large woody debris or trees in the water, it will increase the number of bass in the lake. That's a given.

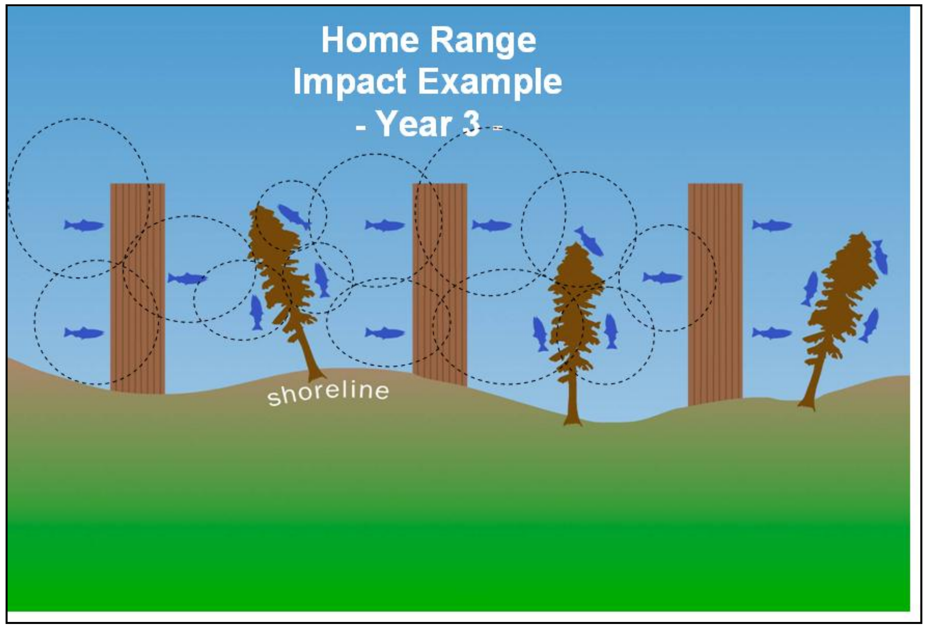
It will also reduce the home range of the bass. So all of those bass that are hanging around the dock, they have some home range that they'll move around in. We don't know exactly what it is for any one bass, but it's there and they will move around, and they won't go outside that home range. They'll stay inside of it.

And so here's what we might look at as some hypothetical home ranges of those fish we looked at. And they will have overlapping areas, okay? But they will still have a home range that's associated with the major piece of structure they imprint on. And what they will do here is they will forage in these areas for their favorite food, the crawfish. And these will come in here and forage for crawfish, okay?



Now, what happens when we plant those trees they want us to plant, okay? Look, the population increases, the home range is smaller, it overlaps but it's smaller. These bass in here now aren't going to go in here because these guys are territorial and will drive them off. So now their home range and cruising area is reduced in terms of getting their preferred food, okay? And so we've created additional ambush points for the salmon.

And we did one other thing, because now they can't cruise and get the crawfish which they really like, so now they really become opportunistic when the salmon come by and they are going to eat more. Because the crawfish is very high energy for them relative to the salmon, and now they have to go out and feed and get more food, so they are actually going to eat more salmon. Okay, so they become more selective on salmon because they can't cruise for the crawfish. And again, that's an established principle with bass. So they are going to increase their consumption on the available prey, which now becomes salmon more in those restricted areas.



Now, a couple other points about trees. We talk about trees and docks, and we talk about trees give shade, but docks give shade too. In fact, Chapman in his paper in 2007 he says docks are just a surrogate for trees as shade, okay? And if you actually use the type of docking that allows the light to go through it, that's really much like a diffused tree shade.

Okay, terrestrial insects. Remember I talked about that, I wanted you to remember that? They contribute almost nothing to the salmon's diet throughout their life. And Dr. Tessa Francis gave a talk to the Planning Commission last year and she indicated about insects coming out of streams and into a couple of lakes. Two things. Terrestrial insects are more important in the streams. They are virtually non-important in the two big lakes. They make up an insignificant amount of the food of the salmon and trout in Lake Sammamish and Lake Washington. Also, the two – Now, she did a very good study, I'm not criticizing her study, but she worked on small lakes that have no anadromous fish in them. And resident trout tend to eat terrestrial insects more than do anadromous fish. Again, it's not the major part of their diet either. But salmon of all species eat virtually no insects, okay?

Okay. Another thing that's talked about is well if you plant great big trees with the idea that they'll fall in the lake later, that that'll influence the shoreline temperature. It isn't going to influence the shoreline temperature in a lake this size. It just isn't. You've got too much wave action, wind action, and streams coming into the lake, and a variety of things that influence the temperature. That small amount of shade that a tree gives, or a dock even, isn't going to change the temperature very much, if any. Another thing that a lot of people don't realize is that some kinds of trees are toxic. Cedar in particular. How many of you put cedar paneling in your closet? You know why you do that? To kill the insects, okay?

So, the take-home message here is that docks offer shade like trees, terrestrial insects that are going to come from the trees are going to be an insignificant amount of diet of salmon in these two lakes. They aren't going to influence the temperature in the lake. And depending on the type you plant, you may end up planting a somewhat toxic tree. So, docks themselves aren't really the problem. Remember I told you there are certain events have to happen, all those three events have to happen. None of those involve a dock being there, if you'll recall. Because it can happen if you have rocks, trees, logs, whatever. There have been studies on the Wells Dam reservoir in the Willamette River that indicate development and docks aren't that big a problem for salmon, okay? One of the things is they move through the area very, very rapidly. And again if you'll remember the big lifespan we talked about, going through all the lakes and the locks and out into the Strait of Juan de Fuca and out into the ocean and back again, their time in the fourteen percent of shoreline of Lake Sammamish that Bellevue's is miniscule, it's like a drop in a big fifty-five gallon drum. It's real small.

Okay. The bass will orient on other structures. So it doesn't matter if docks are there or not. If you pulled out every dock on Lake Sammamish, or just in the city of Bellevue, and you put trees back in, they're going to just hang out on the trees. They're going to hang out on any rock that bigger than a foot in diameter out there. They're going to hang out on the drop-offs. They're going to hang out on the points. In other words, they hang out on structures. And docks just happen to be a structure. But it's not really the problem. Remember we talked, they're opportunistic feeders. They do like crayfish, but if they see a bunch of salmon swim by they'll eat them. There's no doubt about that. So if you increase the number of bass in the lake, you're going to increase the predation rate on those young salmon, and that is going to happen if you put trees in the water, or large woody debris.

Important Points about Increased LWD –

- Increases number of Bass in the lake.
- Reduces the Bass' home range (HR).
- Creates additional ambush points.
- Prey selectivity is reduced with smaller HR size.
- Increases consumption of available prey.

Predation Wrap-up

- Docks themselves are not the problem.
(Wells Dam Reservoir and Willamette River studies*)

- Bass will orient on other structures (rocks, stumps, fallen trees) whether docks are present or not.

- Smallmouth bass are opportunistic feeders on young salmon.

* (*See Chapman, 2007; Ward et al, 1994; Friesen et al, 2007; Pflug & Pauley, 1984; Fayram & Sibley, 2000)

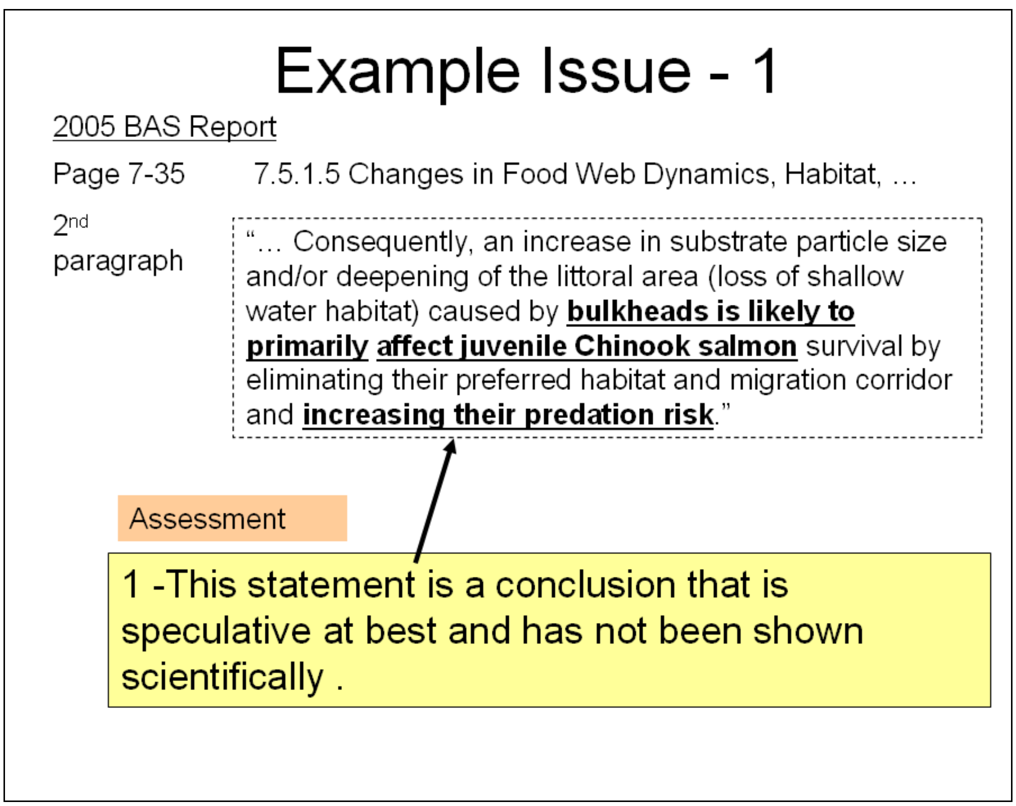
City Documents and Fishery Science Review

So I spent quite a bit of time reading several of the documents of the city's. I'm going to focus – I looked at the dock and pier report, which is actually a pretty good report. And then I looked at the best available science and I looked at the update for 2009. There's not a lot of update on the science in 2009, so I'm going to focus mainly on the 2005 report, which I think is the one that's been used to promulgate the regulations in Bellevue.

Okay, one of the things I see is a failure to present opposing science in the scientific views. They use an enormous amount of non peer-reviewed literature. It's called colleague reviewed but it's very different from peer reviewed. And you're going to have just a little short talk about what peer reviewed means. But it's very important that science be peer reviewed. It has no validity really if it isn't. There's a lot of misinterpretations of scientific citations in that report. There're inconsistent statements and conclusions. And there's conclusions without supporting science.

So following are just a few examples, because I don't have time to go through all of them. But there's a few I'd like to show you that I found in that report. And the way it's set up, if you look at it, it shows a report name up here. I do have one from the dock and pier report. And then the page over here and the topic here. Okay, the bolding and underlining is mine. Other than that, they are verbatim quotes from the best available science report given to the city in 2005.

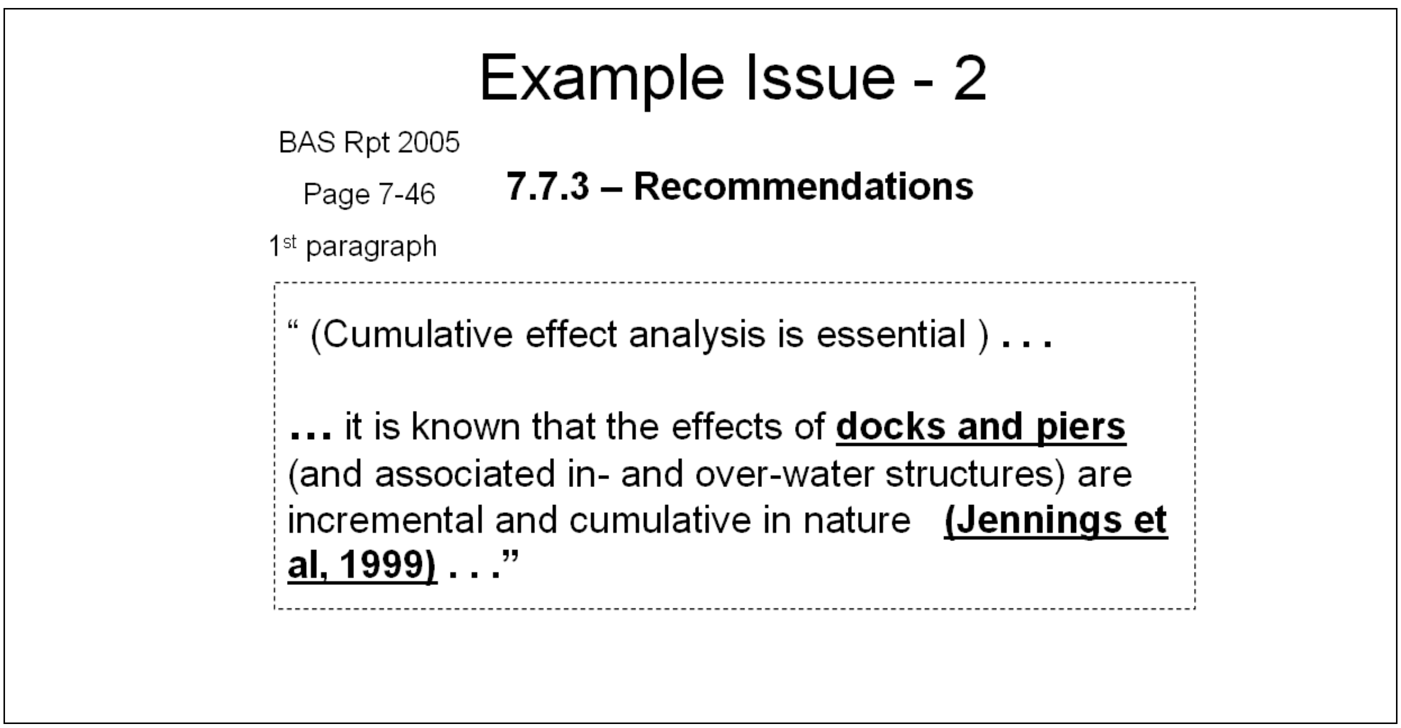
Okay, in this particular one it says bulkheads is likely to primarily affect chinook salmon, increasing their predation risk. That statement is a conclusion that's speculative at best.



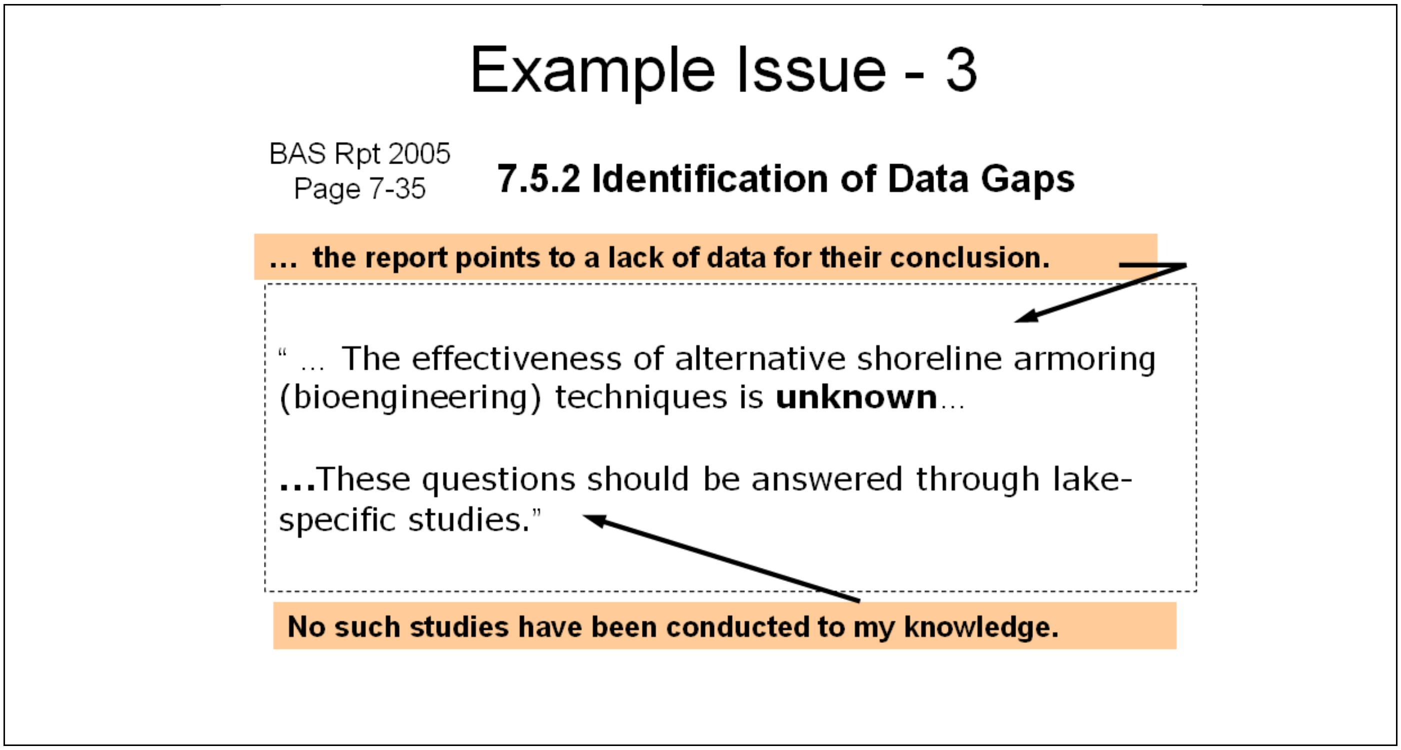
There is not a single paper that I have found that says bulkheads will increase the predation on salmon, okay? Also, it also talks about an increase in substrate particle size, and then it says it primary affects – it's likely to primarily affect – the juvenile Chinook salmon survival by eliminating their preferred habitat. And then there's a contradictory statement in the report itself following that, and the authors immediately question whether they have the facts needed to draw that earlier conclusion. Do bulkheads in Lake Washington and Lake Sammamish and Phantom Lake cause increased sediment size or coursing, thus eliminating Chinook rearing habitat, and sockeye, so on and so forth. Okay, so they just questioned what they said was a fact.

This same example – Bulkheads are in-water structures, okay? A rock wall on a lawn is not a bulkhead. A concrete wall or riprap bulkhead sits in the water. And so they in this same thing under identification of data gaps, okay, they say no studies were found that address the cumulative effects of in-water structures, also over-water but I'm emphasizing in here because of the bulkhead, structures in Bellevue's Phantom Lake, Lake Washington and Lake Sammamish.

Okay? This is example two under recommendations. The cumulative effect analysis is essential. It is known that the effects of docks and piers are incremental and cumulative in nature, and they cite Jennings et al, 1999. I read that paper three times and I cannot find a single reference to a dock or pier in that paper. So any conclusions drawn from that statement are totally invalid.



Example three, okay? Bulkheads needing any, I want to emphasize the word any, type of maintenance – I mean if you move a rock or something, okay, repair it, retrofit, whatever – should be considered for removal and replacement with vegetative large woody debris, which is called bioengineering, okay? And you'll see that term in the next slide. This recommendation is based on a conservative interpretation of the best available – that's not conservative in my mind. It's a huge expense to any landowner that's going to do that, okay?



Then the report says – there's a lack of data for this, because the effectiveness – on a subsequent page – the effectiveness of alternative shoreline armoring – which is bioengineering or the large woody debris stuff – the techniques are unknown. And they say that in their own report. And then they go on to say these questions should be answered through lake-specific studies. I don't know of any studies that've been done on these lakes regarding that, and I've looked through the literature and I can't find them.

Example four. This is from the bulk and piers report. I'm not so upset with the statement here, I'm upset more with the interpretation of it. The permanent removal of woody debris during bulkhead or pier construction reduces the availability of complex refuge for small fish. True. That's a true statement. But what's not stated is that woody debris also houses large predators, so if you take that out you've essentially gotten rid of some habitat for large predators too, and that part of the equation is not put in this statement, okay? As I pointed out earlier, the habitat for predators is also the same.

(Continued, next page)

Example Issue - 4

Bulkhead & Piers Rpt

Page 3 #13

Potential Impacts

"…The permanent removal of woody debris during **bulkhead and/or pier construction reduces the availability of complex refuge habitat** for small fish, and attachment surfaces for periphyton."

As I've pointed out earlier, woody debris will provide increased predator habitat.

Example five. Over-water structures create habitat for species that prey on salmon. Tabor et al, and they cite two reports from 2004. Tabor is a very good scientist, okay, I don't doubt his work, I doubt the interpretations. Conflicting statement in the same paragraph. However, no studies were found that specifically examine salmon mortality due to predation associated with over-water structures. Interesting. Same paragraph.

Example Issue - 5

BAS Rpt 2005

Pg 7-43

7.7.1.2 Over-Water Structures

"**Over-water structures** also generate indirect impacts through modifying aquatic habitat features. One of the most significant is by **creating habitat for species that prey on salmonids** (Tabor et al, 2004a & 2004b)."

Conflicting statement in same paragraph

"However, **no studies were found** that specifically examined **salmon mortality** due to predation associated with **over-water structures.**"

Okay, example six. Available pertinent literature is limited, that means it probably wasn't there. Nonetheless, inferred and hypothetical associations can be made based upon available scientific literature. Well that implies there was at least one paper, okay? And this is conjuncture of science, and it's not really based on science when they're saying they are inferring hypothetical associations. This goes on throughout the report, this type of statement. And it's all the way through the report.

Example Issue - 6

BAS Rpt 2005

Pg 7-43

" . . . available **pertinent literature is limited**. Nonetheless, **inferred and hypothetical associations** can be made based on **available** scientific literature."

THIS IS CONJECTURE NOT BASED ON SCIENCE!

Throughout the documents the authors fail to acknowledge that the opposite or different conclusions can be inferred as well.

Example Issue - 7

BAS Rpt 2005

Pg 7-11

7.3.3.1 Lake WA and Lake Samm. Ecological Function

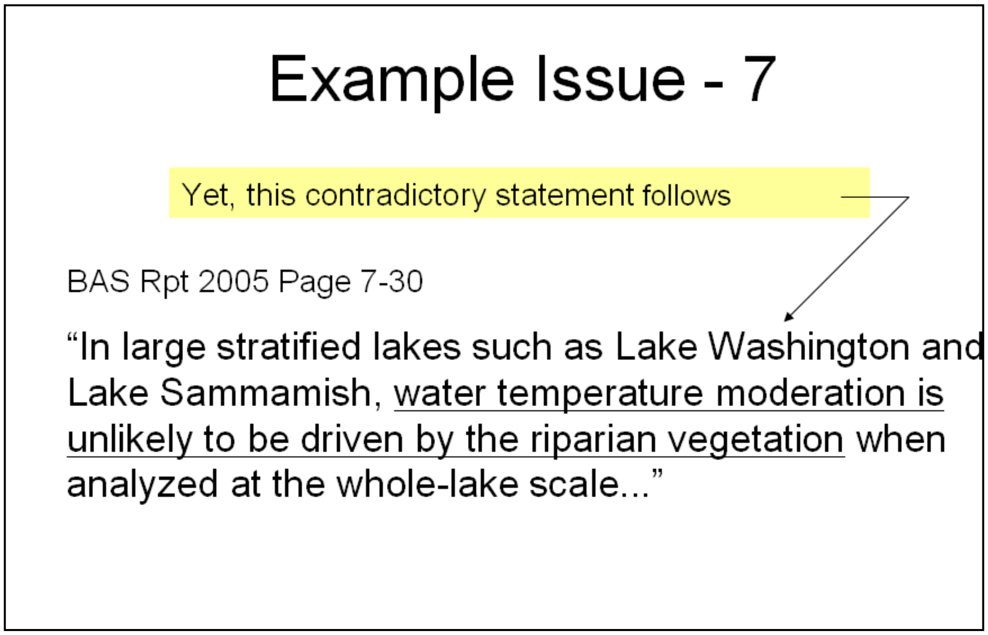
"Canopy and shade (from remnant natural unarmored areas): Shading by lake vegetation can moderate water temperature along the shoreline . . ."

And my last example goes back to the shade and trees. And that is that canopy and shade by lake vegetation – and they're talking about trees here – can moderate water temperature along the shoreline.

And this is up on page seven of eleven under Lake Washington and Lake Sammamish ecological functions.

Then, in the bass report on page 730 it says in large stratified lakes like Lake Washington and Lake Sammamish water temperature moderation is unlikely to be driven by riparian vegetation.

And that's the truth. That statement's true. The one before it isn't, okay?



So in summary, in this report – it has not been peer reviewed, that's one of the big problems, okay? It doesn't have enough science either in it to make these promulgations to rules. It's failed to present opposing science and opposing science views. It hasn't used peer-reviewed literature. It's misinterpreted scientific citations. It's made inconsistent statements and conclusions. And it's made conclusions without supporting science.

In summary, frequently the City's science reports:

- ***Failed to present opposing science***
- ***Used non-peer (colleague) reviewed science***
- ***Misinterpreted scientific citations***
- ***Made inconsistent statements & conclusions***
- ***Made conclusions without supporting science***
- ***Used inapplicable science***

What's Essential before Adopting Regulations!

So what's essential before adopting some regulations? Okay, I think most landowners, they want a nice beach, they want a nice environment, and they'll probably be happy to work with the city, but the regulations should be reasonable and based on good science. Okay, a better understanding of the dynamics of the system is important, okay? I just read something by Hans Berge who worked on the Kokanee I think for twelve years. He's got twelve years of data and he makes the statement that I need more data because I don't really have enough to make the statements that really are definitive. He's a really good scientist, and he's got twelve years of data and he's saying there's some tentativeness to his science, even after twelve years of data. I think that's important. There should be a more rigorous balanced approach to the science and its interpretation, and not just what's on the agenda, what are the conclusions that we want.

Okay, inclusion and consideration of the opposing science should be – and consideration for alternative actions. In other words, if you take that bulkhead out, maybe you just terrace it. Because you know that same paper they cited about docks and piers, they actually in that paper talk about riprap bulkheads and they indicate that a bulkhead that's vertical, and if you taper it to forty-five degrees, you have much less of an impact on the environment and you actually have an increase in biodiversity in the rocks because of the critters that will go inside those crevices. And also I might add that riprap rocks are not the same as a concrete wall because riprap rocks have crevices that absorb wave action, and so the force of the wave is dissipated in those cracks. A concrete wall is a very different thing. And I think in here they're using everything to be like a concrete wall.

And we should have controlled testing and evaluation. And that means experimental and control areas with statistical tests as the hypothesis. Is it or is it not? And true peer review of the relevant reports that come out. And that means people that aren't related to the city, and you say boy, that's going to cost the city a lot of money, well all these things you're putting on the landowners cost them a lot of money, okay? So this is something I think is really important. And in fact, when I would be on the committee for a PhD or a master's thesis, this is something that you do, you rigorously go through their work. And this probably wouldn't pass, okay?

Summary of What's Needed

- **A better understanding of the dynamics of the system**
- **A more rigorous, balanced approach to science**
- **Inclusion & consideration of opposing science**
- **Consideration of alternative actions**
- **Controlled evaluation and testing in advance**
- **True peer review of relevant science**

FISHERY AND SCIENCE REFERENCES
Used by Gilbert Pauley in Presentation to Bellevue City Planning Commission

Ahrenstorf, T.D., G.G. Sass and M.R. Helmus. 2009. The Influence of Littoral Zone Coarse Woody Habitat on Home Range Size, Spatial Distribution, and Feeding Ecology of Largemouth Bass (*Micropterus salmoides)*. Hydrobiologia, 623: 223-233.

Abstract: LMB utilize home ranges, utilize many structures (not just docks). LMB in lakes with lower amounts of coarse woody habitat (CWH) had larger home ranges, spent more time in deep water, were more selective predators, and showed lower consumption rates. Low CWH abundances correlated with a shift from sit-and-wait to actively searching for prey. High abundance of CWH exhibited the opposite patterns among LMB. Habitat influenced the predators distribution, movement patterns, and feeding habits. Areas with high CWH abundances had smaller more finite home ranges, spent more time in shallow water, were more efficient and less selective predators, and exhibited higher consumption rates of prey fish. In other words, woody habitat is a favorable condition for predator fishes.

Barwick, R.D, T.J. Kwak, R.L. Noble and D.H. Barwick. 2004. Fish Populations Associated with Habitat-Modified Piers and Natural Woody Debris in Piedmont Carolina Reservoirs. North American Journal of Fisheries Management, 24: 1120-1133.

Abstract: Observed fish responses over three seasons. The specific null hypotheses tested were (1) no significant difference will be detected in fish occurrence among piers with or without artificial habitat modifications and (2) no significant difference will be detected in fish occurrence among shorelines containing natural woody debris and residentially developed shorelines with habitat modified piers. The number of habs installed under study piers varied according to pier length. Biomass (kg/100 m2) followed similar trends as those of numerical catch rates. Total fish biomass was higher at brushed hab piers than at piers modified with hab modules or reference piers during all seasons. Cover, LWD, and habitat enhancement may lead to an increased availability of potential places for predator fish.

Berge, H.B. 2009. Effects of a Temperature-Oxygen Squeeze on Distribution, Feeding, Growth, and Survival of Kokanee (*Oncorhynchus nerka*) in Lake Sammamish, Washington. Master of Science Thesis, University of Washington, Seattle, WA, 84 pages.

Abstract: Kokanee are zooplanktivores and prefer Daphnia spp., and do not feed on terrestrial insects. Personal communication from H.B. Berge to G.B. Pauley: "There are no spawning areas for kokanee along the shoreline of Lake Sammamish within the City of Bellevue. Specific conditions are needed for shoreline spawning of kokanee and these do not exist in the shoreline of Lake Sammamish in Bellevue."

Bryant, G.J. 1992. Direct Observations of Largemouth and Smallmouth Bass in Response to Various Brush Structure Designs in Ruth Reservoir, California. USDA, Forest Service, Fish Habitat Relationship Technical Bulletin Number 10, 13 pages.

Abstract: Both SMB and LMB utilize home ranges and utilize structures such as brush piles in a large lake. Water temperature, water level, brush location and brush structure design were the most important factors influencing habitat utilization by both LMB and SMB. Brush structures were utilized by both LMB and SMB considerably more than shoreline areas without aquatic vegetation or woody debris.

Cartwright, M.A., D.A. Beauchamp and M.D. Bryant. 1998. Quantifying cutthroat trout (*Oncorhynchus clarki*) predation on sockeye salmon (*Oncorhynchus nerka*) fry using a bioenergetics approach. Canadian Journal of Fisheries & Aquatic Sciences, 55: 1285-1295.

Abstract: Cutthroat Trout are predators of sockeye salmon. Model results indicated that, by September, cutthroat trout consumed an estimated 34–51 and 32–100% of the 200 000 and 100 000 sockeye salmon fry stocked in May 1993 and 1994, respectively. All approaches to estimating cutthroat trout predation on stocked fry suggested that piscivores played a substantial role in the decline of sockeye salmon fry in Margaret Lake.

Chapman, DW. 2007. Effects of docks in Wells Dam Pool on subyearling Summer/Fall Chinook Salmon. Report to Douglas County Public Utility District. 2007. 18 pp.

Abstract: Discusses a variety of things related to docks and over water structures in Wells Dam Reservoir. He states that: ”Sub-yearlings (Chinook) prefer overhead cover in the form of overhanging vegetation. {However}, Docks may offer a surrogate for such cover.” “As sub-yearlings grow, they use deeper water at night, and the rate of downstream movement increases. With growth, more fish move downstream at night rather than inshore. After…sizes larger than 60 to 70 mm, their behavior greatly reduces their vulnerability to predators in littoral zones, hence their vulnerability around docks.” When sub-yearling Chinook move along the shoreline and encounter a dock, they move slightly into deeper water and EITHER pass directly under the structure or swim around it. {However}, “The degree to which predation under and around existing and proposed docks may reduce abundance of returning adult summer/fall Chinook is unknown.” April, May, and early June present the greatest potential for predation with relatively little by late June, due to increased salmon size, use of deeper water for migration, and more night movement downstream.

Fayram, A.H. and T.H. Sibley. 2000. Impact of Predation by Smallmouth Bass on Sockeye Salmon in Lake Washington, Washington. North American Journal of Fisheries Management, 20: 81-89.

Abstract: Smallmouth bass have a minor impact on salmon in Lake Washington. Ultrasonic tracking showed limited spatial and temporal overlap between smallmouth bass and juvenile sockeye salmon. Salmonids occurred in smallmouth bass stomachs only during the out-migration of smolts from Lake Washington to Puget Sound. For smallmouth bass larger than 150 mm total length, juvenile salmonids constituted 28% of the diet in the lake and 38% in the Lake Washington Ship Canal area during the out-migration. A bioenergetics model estimated an annual consumption of 76.7 g of juvenile salmonids by each smallmouth bass in the lake and 105.9 g of juvenile salmonids in the Ship Canal area. These data show little evidence that predation by smallmouth bass has increased over the past two decades.

Frey, A.P., M.*A*. Bozek , C.J. Edwards *and* S.P. Newman *2003.* Diet Overlap *and* Predation between Smallmouth Bass and Walleye in a North Temperate Lake. Journal of Freshwater Ecology, 18: 43-54.

Abstract: Crayfish are the preferred diet item during most months for smallmouth bass in many northern temperate lakes.

Friesen, T.A, J.S. Vile and A.L. Pribyl. 2007. Outmigration of Juvenile Salmon in the Lower Willamette River, Oregon. Northwest Science, 81: 173-190.

Abstract: Direct sampling and radio telemetry were used to describe the outmigration of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in the lower Willamette River downstream of Willamette Falls from 2000 to 2003. Juvenile Chinook salmon were present all year, with peak densities occurring in winter and spring. Radio-tagged fish were distributed evenly across the river channel regardless of year, time of day, or origin (hatchery or naturally produced). Except for a possible affinity for pilings, the distribution of radio-tagged fish appeared to closely follow the proportional availability of near-shore habitat types, suggesting they do not select for specific habitats during their outmigration.

Fritts, A.L. and T.N. Pearsons. 2004. Smallmouth Bass Predation on Hatchery and Wild Salmonids in the Yakima River, Washington. Transactions of the American Fisheries Society, 133: 880-895.

Abstract: Smallmouth bass predation on all yearling salmonids never exceeded 0.6% of the annual production of hatchery and wild fish combined. We estimated that as much as 85% of the ocean-type Chinook salmon consumed by smallmouth bass in a given year were of natural origin. Estimated smallmouth bass consumption of hatchery ocean-type Chinook salmon has only comprised up to 4% of production in a single year. Our estimates of consumption on ocean-type Chinook salmon are likely to be underestimates because we did not sample throughout the entire rearing and emigration period of these fish. Our results indicate that smallmouth bass can have negative impacts on ocean-type Chinook salmon, particularly those that are naturally produced, which are generally smaller and available longer than hatchery fish.

Fritts, A.L. and T.N. Pearsons. 2006. Effects of Predation by Nonnative Smallmouth Bass on Native Salmonid Prey: the Role of Predator and Prey Size. Transactions of the American Fisheries Society, 135: 853-860.

Abstract: Predation by SMB is related to prey size. We found that native salmonid risk to predation by non-native smallmouth bass *Micropterus dolomieu* in the lower Yakima River, Washington, generally decreased with increasing size of both predator and prey. In addition, the relative length of salmonid prey decreased with increasing smallmouth bass size. Smallmouth bass generally ate salmonids at lengths that were less than 50% of predator capacity. In the Yakima River, SMB consumed fall Chinook salmon well below their bioenergetic potential, which indicates that they probably were not targeting the young Chinook salmon, but are simply opportunistic predators.

Koehler, M.E., K.L. Fresh, D.A. Beauchamp, J.R. Cordell, C.A. Simenstad and D.E. Seiler. 2006. Diet and Bioenergetics of Lake-Rearing Juvenile Chinook Salmon in Lake Washington. Transactions of the American Fisheries Society, 135: 1580-1591.

Abstract: During February through May, naturally produced juvenile Chinook salmon occupied littoral habitats and consumed mostly epibenthic prey, primarily chironomid pupae (Diptera). In June, they switched to a diet dominated by plankton, specifically *Daphnia* spp. This diet shift coincided with increasing temperature, a shift by the **fish** from littoral to limnetic habitats, the spring bloom of *Daphnia*, and increasing **fish** size. Terrestrial insects were not part of the diet.

Naughton, G.P., D.H. Bennett and K.B. Newman. 2004. Predation on Juvenile Salmonids by Smallmouth Bass in the Lower Granite Reservoir System, Snake River. North American Journal of Fisheries Management, 24: 534-544

Abstract: Observed that SMB were not a major predator of young salmonids in the Snake River and that crustaceans and non-salmonid fishes were the major diet items.

Nowak, G. M., R. A. Tabor, E. J. Warner, K .L. Fresh and T .P. Quinn. 2004. Ontogenetic Shifts in Habitat and Diet of Cutthroat Trout in Lake Washington, Washington. North American Journal of Fisheries Management, 24: 624–635.

Abstract: We studied aspects of the trophic ecology of naturally and hatchery-produced juvenile Chinook salmon rearing in the littoral zone of highly urbanized Lake Washington in Washington State. During February through May, naturally produced juvenile Chinook salmon occupied littoral habitats and consumed mostly epibenthic prey, primarily chironomid pupae (Diptera). In June, they switched to a diet dominated by plankton, specifically *Daphnia* spp. This diet shift from littoral prey to limnetic prey coincided with increasing temperature. Both naturally produced and hatchery-produced juvenile Chinook salmon were finding ample food in littoral habitats of Lake Washington. These results further reveal that hatchery-produced Chinook salmon did not compete with naturally produced fish and that this was probably a result of hatchery juveniles entering the lake during the spring *Daphnia* bloom when this prey is abundant.

Pauley, G.B. 1991. Anadromous Trout, pgs, 96-104. In "Trout-The Wildlife Series", Eds. J. Stolz and J. Schnell. Stackpole Books Publisher.

Abstract: Gives life histories of all anadromous salmon, trout and char in North America. Chart shows overlap in life history anadromy of the various species of salmonids.

Pflug, D.E. and G.B. Pauley. 1983. The Movement and Homing of Smallmouth Bass (*Micropterus dolomieui*) in Lake Sammamish, Washington. California Fish and Game, 69: 207-216.

Abstract: SMB have distinct home ranges in Lake Sammamish and stray very little from them. There was no evidence that SMB move toward areas where young salmonids would be concentrated such as the mouth of Issaquah Creek. They did not stay in that area when moved there from other areas, because they returned to their original area of capture.

Pflug, D.E. and G.B. Pauley. 1984. Biology of Smallmouth Bass (*Micropterus dolomieui*) in Lake Sammamish, Washington. Northwest Science, 58: 118-130.

Abstract: SMB preferred foods are crayfish and sculpins. They are only opportunistic feeders on young salmon in Lake Sammamish. Evidence indicates that SMB do not selectively seek out and feed on young salmonids, but that SMB are random feeders eating whatever prey items are available to them. Additionally, SMB exhibit a size relationship in their eating pattern, with their main food items in Lake Sammamish being crayfish and sculpins in most months, except May at the peak of young salmonid outmigration.

Sabo, J.L. and G.B. Pauley. 1997. Competition between stream-dwelling cutthroat trout and coho salmon: the evolution of competitive ability. Canadian Journal of Fisheries & Aquatic Sciences, 54: 2609-2617.

Abstract: Cutthroat trout are able to out compete coho salmon unless they are at a size disadvantage. Cutthroat trout will out compete coho salmon when they have size advantage and when they have equal size.

Savino, J.F. and R.A. Stein. 1989. Behavior of fish predators and their prey: habitat choice between open water and dense vegetation. Environmental Biology of Fishes, 24: 287-293.

Abstract: Behavior of largemouth bass, *Micropterus salmoides*, and northern pike, *Esox lucius*, foraging on fathead minnows or bluegills was quantified. Both predators spent most of their time in the vegetation. Largemouth bass searched for bluegills and ambushed minnows, whereas the relatively immobile northern pike ambushed all prey. Predator ability to capture prey while residing in dense cover may explain their residence in areas often considered poor for foraging.

Savino, J.F. and R.A. Stein. 1989. Behavioural interactions between fish predators and their prey: effects of plant density. Animal Behaviour, 37: 311–321.

Abstract: Structural complexity determines foraging success of predators. Largemouth bass switched predatory tactics from searching to ambushing as plant density increased whereas northern pike always used ambushing. At high plant density, both predators captured minnows. Structural complexity alone did not always provide refuge for prey; prey must use the structure to avoid predators. Predators may seek vegetated areas if appropriate.

Stein, J.N. 1970. A study of the largemouth bass population in Lake Washington. Master of Science Thesis, University of Washington, Seattle, WA, 69 pages.

Abstract: Population studies indicate that various types of natural cover in Lake Washington were heavily used by LMB. Natural cover included tree branches, logs and brush. There appears to be a preference by LMB for natural cover over the use of man-made docks even though LMB were found in some situations associated with docks.

Tabor, R.A., B.A. Footen, K.L. Fresh, M.T. Celedonia, F. Mejia, K.L. Low and L. Park. 2007. Smallmouth Bass and Largemouth Bass Predation on Juvenile Chinook Salmon and Other Salmonids in the Lake Washington Basin. North American Journal of Fisheries Management, 27: 1174-1188.

Abstract: Indicates smallmouth bass have a minor impact on salmon in Lake Washington. Concluded that predation by SMB and LMB had a minor impact on Chinook salmon and other salmonid populations in Lake Washington. They noted that both black bass species prey mostly on subyearlings of each salmonid species and that the vulnerability of these young fish occurs with a specific set of circumstances, which are the relatively small size of the salmonids; their tendency to migrate when water temperatures exceed 15 C coinciding with greater black bass activity (optimum SMB activity is at 17 C); and their use of the near-shore areas where overlap with the black basses is the greatest.

Ward, D.A., A.A. Nigro, R.A. Farr and C.J. Knutsen. 1994. Influence of Waterway Development on Migrational Characteristics of Juvenile Salmonids in the Lower Willamette River, Oregon. North American Journal of Fisheries Management, 14: 362-371.

Abstract: We investigated the effects of Portland Harbor development in the lower Willamette River on the migration and behavior of juvenile salmonids (*Oncorhynchus* spp.), the habitat occupied by juvenile salmonids, and predation on juvenile salmonids by northern squawfish *Ptychocheilus oregonensis*. Juvenile salmonids were abundant in the lower Willamette River during spring. Radio-tagged juvenile steelhead *O. mykiss* and yearling chinook salmon *O. tshawytscha* usually migrated through the harbor in 1–3 d. We did not detect any spatial pattern in the downstream migration of radio-tagged fish or any difference in behavior of radio-tagged fish among the developments. We caught more northern squawfish in areas without development, and we found no difference in the frequency of northern squawfish digestive tracts containing juvenile salmonids between developed and undeveloped areas. We concluded that waterway developments presented few risks to migrating juvenile salmonids. However, whenever possible, activities such as dredging and construction should be avoided in spring when juvenile salmonid abundance is high. The location of developments need not be weighted heavily when considering their effects on juvenile salmonids. Predation by northern squawfish in Portland Harbor is not enhanced by development.

Wydoski, R.S. and R.R. Whitney, 1979. "Inland Fishes of Washington." University of Washington Press.

Abstract: Gives life history including feeding information on all species of salmon and trout that occupy or utilize inland waters of the State of Washington.

Professional Resume - Dr. Gilbert Pauley

Education

BS – Univ. of WA – Salmon Management/Geology
MS – Univ. of WA – Shellfisheries Biology/ Invertebrate Zoology
PhD – Univ. of California – Biology/Microbiology & Immunology
MBA – Univ. of Puget Sound – Finance/Statistics

Professor – Univ. of Washington College of Fisheries – 24 years

Discipline - Recreational Fisheries Management, Fish Diseases
Chairman of 50 - 55 MS and PhDs in Fishery Science

Chairman - U.S. Fishery Advisory Board (FAB) – Salmon and Steelhead Issues – 14 yrs

- Federal Court Technical Advisor – Boldt Decision
- 27 Major Fishery Issue Trials - 92 FAB Arbitrator Recommendations

Professional Publications (Peer Reviewed)

- 175+ authored or coauthored scientific papers
- Published in over 20 scientific journals

Professional Honors

- US Dept of Interior Award for Superior Service
- Univ. of WA Gilbert Pauley Endowed Student Support Fund