A comparative study of three river systems leading into Nootka Sound, British Columbia: implications for winter salmon populations

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Abstract

Data collection consisted of plankton tows, and temperature, pH, and salinity readings taken at multiple stations within the Tahsis, Zeballos, and Gold Rivers located in Vancouver Island, British Columbia in December, 2015. These samples and data from previous research were used to analyze which river system could best support juvenile, winter salmon. Salinity and pH do not appear to be driving factors in these river systems in respect to salmon prey abundance, while temperature could affect salmon survival. All three rivers were composed of like species with the Tahsis and Zeballos rivers having the most similar compositions of organisms. Salmon prey of interest included species of Plecoptera, Cladocera, Nauplii, and copepods from the orders Calanoida and Cyclopoida. Species richness and diversity varied across all three areas of study. All three rivers could be suitable for winter salmon, but the Tahsis River could best support winter salmon populations if temperature and prey composition are the most influential factors on salmon growth and survival.

Introduction

Within the field of aquatic sciences there is much research focused on the life history and survival of anadromous species of fish, such as salmon. Anadromous fish are hatched in freshwater rivers and lakes, migrate out to salt water estuaries and the open ocean, then return to spawn in their natal rivers at maturity. All species of Pacific salmon spawn in autumn or early winter with most eggs hatching in early spring, but different salmon exhibit complex life history strategies that can be unique to a given species or individual (Duffy 2005, Fresh 2006). Salmon can be classified into four life history schemes based on the timing at which they migrate. Fish can be classified as fry migrants if they migrate to the ocean within 1-10 days of hatching, delta fry migrants if they leave freshwater streams within 1-10 days but then spend months in the local estuary and parr migrants if they spend up to six months in freshwater rivers. Some individuals are classified as yearlings if they remain in their natal stream for at least one year (Fresh 2006). In addition to these migratory strategies, some salmon are classified as residents because they never migrate out of fresh water (Rohde 2014). About 3.4% of Pacific salmon remain in rivers as residents which are often smaller in size than their migratory counterparts (Rohde 2014). Winter is a critical time of year for resident and yearling salmon residing in fresh water because temperatures are cold and primary productivity is low.

There are five common species of salmon along the west coast of North America: Sockeye, Chinook, Coho, Pink, and Chum. Each species exhibits unique life history traits related to spawning and emergence from fresh water rivers into nearby estuaries and the open ocean. Juvenile sockeye salmon rear extensively in lakes while juvenile Coho rear for at least one year in natal streams. In comparison, once pink and chum salmon emerge from their eggs they transition directly from freshwater rivers into saline estuaries (Fresh 2006). Depending on the individual, Chinook salmon can leave natal streams immediately after hatching or spend up to a year in freshwater. Water temperatures, water flow, oxygen levels, and food availability within the stream can all influence when an individual leaves freshwater (Fresh 2006).

Salmon are an important food source and support the economy of many communities. The complex life history of salmon needs to be studied because many populations of Pacific salmon are reaching critically low levels due to the pressures of fishing and climate change (Fresh 2006). Previous studies have shown that salmon growth and maturation correlate with characteristics such as water quality, temperature, pH and food availability (Budy 2007, Herbinger 1992, Saunders et al 1983). Water temperatures above 7°C have been shown to increase the metabolic rates of salmon causing them to gain higher percentages of weight, attain longer fork lengths, and have an overall better body condition compared to salmon that were raised in temperatures below 7°C (Herbinger 1992). The majority of studies on Pacific salmon examine early juvenile growth, as well as the return of adult salmon to spawn in their natal streams. In order to understand why species and individuals adopt such drastically different life history strategies there needs to be comprehensive data about their natal streams. Early development and genetic differences could hold the answer as to why some individuals stay in fresh water for longer periods of time and how that decision may affect growth and survival.

Scientific research is often focused in areas of higher populations in an attempt to see how anthropogenic impacts are changing natural processes and how changes in the ecosystem may impact future actions and profits. Much of the research conducted off of the coast of

British Columbia is centered in the Strait of Georgia, along the east coast of Vancouver Island, where human populations are highest (Fig 1). Due to this research bias there is little known about the estuarine systems that lead into the open ocean along the west coast of Vancouver Island. In order to gain more knowledge about this area, research was conducted during December within the Zeballos River, Tahsis River, and Gold River. All three rivers feed into estuarine inlets which lead to the Pacific Ocean (Fig 2).

Nootka Sound is characterized by dry summers and mild, wet winters with a mean annual temperature of 9° C (Jackson 1999). Mean December air temperatures in Nootka Sound range between 1.5-5° C with the mean December temperature being lowest at the town site of the Gold River. Average December rainfall for the area is 472.9 mm with the Gold River receiving below average rainfall of 438 mm and the Tahsis River receiving above average rainfall of 620 mm (Jackson 1999). Rainfall and snow melt contribute to the size and discharge rate of the three river basins. The Gold River has the largest drainage area and discharge rate with a total drainage area of 1010 km^2 and a mean December discharge rate of 133,840 liters/sec. The Zeballos River had the second highest drainage volume but is considerably smaller than the Gold River with a volume of 189.1 km^2 and an average December Discharge rate of 39,310 liters/second. The Tahsis River is the smallest of the three rivers with a discharge volume of 77.3 km^2 and average December discharge rate of 15,305 liters/second (Jackson 1999).

Native peoples have inhabited Nootka Sound for centuries and have relied on the areas natural resources for subsistence. The largest village in the area is located at the mouth of the Gold River and is composed of just over 2,000 people. Smaller villages are also located at the mouths of the Tahsis and Zeballos Rivers. Trades in the area include logging and mining, as well as recreational tourism (Jackson 1999). In the past decade Nootka Sound has been put on the map by sports fishermen as a hot spot for salmon fishing. There have been community efforts to clean up local waters and successful salmon farming to boost Chinook populations that are critically low (Minister 2014). Despite local attempts to boost fish populations, little is known about how suitable the local rivers are for anadromous fish species such as salmon and sea trout.

The timing of salmon spawning and egg hatching occurs between spring and early fall, meaning there are few studies focused on salmon life history during the winter months. Based on the time of year this research occurred, it was expected that there should be eggs buried in sediment, as well as delta fry migrants, parr migrants, and residents within the fresh water of the rivers. In fresh water we could expect to find Coho salmon, and based on an individual's life strategy, we could also anticipate the presence of Chinook salmon. In the more saline environments of the rivers and inlets we could expect pink or chum salmon. The goal of this study is to profile the biological and chemical characteristics of each river system in an attempt to help scientists and salmon farmers better understand which rivers are suitable for juvenile salmon and where future populations can be best supported. Rivers that best support winter salmon would have a high enough discharge to aerate eggs, viable food sources for juvenile fish, and warmer temperatures to minimize energy expenditures.

Methods

Research was conducted in and around the Zeballos, Tahsis, and Gold Rivers the 14th, 15th, and 16th of December 2015, respectively. The small boat the R/V *Welander* was deployed off of the R/V *Thomas G Thompson* in the morning once there was sufficient light to navigate.

Samples were taken in each river basin between 9:30 am to 12:00pm ensuring that all samples were taken during the same time in the tidal cycle. Sampling started at low tide which was progressing into flood tide. The R/V *Welander* first navigated as far up the mouth of each river as possible where sampling began to ensure that the freshest possible water was attained. Sampling proceeded out of the mouth of each river with four to six samples taken in each river basin (Fig 3). A YSI meter was used to take surface measurements of salinity, pH, and temperature at each station (Table 1). The YSI was lowered into the water at a depth of 0.5-1 meter and held until readings began to stabilize.

In addition to abiotic measurements, plankton tows were also conducted off the side of the R/V *Welander*. Latitude, longitude, salinity, pH, and temperature were recorded at each station before the start of the plankton tow. After initial measurements were recorded the plankton tow was conducted with the start time and end time, as well as end salinity, pH, and temperature being recorded. A 0.25 meter plankton net with a 64 micron mesh size was lowered over the side of the boat and left to collect plankton on the surface of the water for five minutes. In the Gold River, where currents were strongest, the boat was positioned so the current provided water movement through the net. In both the Zeballos River and Tahsis River currents were not strong enough to circulate water through the net so the boat was moved in a circular motion at approximately 1.9 knots for the duration of the five minute plankton tow.

Once the five minute plankton tow concluded, the samples were collected and stored upon the R/V *Welander* until our return to the R/V *Thomas G. Thompson.* The samples were removed from the cod end of the plankton net and transferred into 750 mL plastic containers which were labeled with river name and sample number. A handheld sprayer was used to rinse the cod end into the container a minimum of three times to ensure that all of the organisms were collected. After rinsing the plankton net, the container was filled with water from that station to avoid adding water of a different salinity which could burst or shrivel cells. The samples were transferred onto the R/V *Thomas G Thompson* and fixed using 60 mL of 5% buffered formalin and stored in tote boxes for the remainder of the trip.

Upon arrival back to the University of Washington the plankton samples were stored until they were analyzed a month later. The samples were filtered through a 100 micron mesh in a hooded range to filter out phytoplankton and debris. The remaining organisms were then rinsed out of the mesh and transferred to a beaker. Every organism present in a sample was counted by placing the sample in a glass petri dish with a quarter-inch grid pattern. The organisms were identified and counted using a dissecting scope, counting from the bottom of the petri dish to the top to ensure that individuals were not counted more than once. Zooplankton were identified with the book "Coastal Marine Zooplankton" (Todd 1996). For this analysis, organisms were identified down to order. Once counts for each station were completed, Shannon Weiner species diversity and species evenness calculations for each station were performed (Table 2). Taking into account all of the organisms counted across stations, species richness and diversity was calculated for each of the three rivers (Fig 4, Fig 5).

Shannon Weiner Indices

$$H = -\sum p_i (\ln p_i) \qquad E_H = H/\ln(S)$$

Where H is the diversity index, p_i is the proportion of the total population that an organism represents, E is how evenly different organisms are distributed, and S is the total number of different organisms at each station.

Analyses were conducted on each sampled station to see if the spread of organisms was being constrained by environmental factors. The dominant organisms, as a percent of the total population, for each station and the rivers as a whole were computed (Table 3, Fig 6). Linear correlations comparing prey abundance to salinity, pH, and temperature were performed for five of the most prevalent and important prey species for salmon (Fig 7, Fig 8, Fig 9). These individuals included copepods from the orders Calanoida and Cyclopoida, as well as Plecoptera, Cladocera, and nauplii.

Results

Organismal dominance varied across individual stations within each river. The first three stations in the Gold River were dominated by Cladocera while the final station was dominated by Cyclopoid copepods (Table 3). Half of the stations in the Tahsis River were dominated by Calanoid copepods while the other half were dominated by Cyclopoid copepods (Table 3). The Zeballos River had the most complex species dominance. The first station and last station were dominated by Cyclopoid copepods while the second and fourth stations were dominated by Calanoids. The third station was dominated by Chironomidae (nematoceran flies) which were not present in any of the Gold or Tahsis River samples. The fifth station in the Zeballos River was dominated by nauplii (Table 3).

Shannon Weiner diversity and evenness indices also varied across stations within each river. All three rivers tended to have higher species diversity in the first stations where salinity was lowest with values across all of the stations ranging between 0.956 and 1.804 (Table 2). Evenness at each river station typically ranged from 0.7 to 0.9 with only a few abnormalities (Table 2). Both station 6 within the Tahsis River and station 4 within the Zeballos river had unusually low indicators of species evenness with values of 0.554 and 0.491 respectively (Table 2). The average station diversity index for each of the rivers was 1.318 in the Gold River, 1.334 in the Tahsis River, and 1.393 in the Zeballos River (Table 2).

Linear regressions show very weak correlations when comparing species abundance to salinity, pH, and temperature. The Gold River had an average temperature of 4.73°C, the Zeballos River had an average temperature of 6.37°C, and the Tahsis River had an average temperature of 7.21°C (Table 1). All three analyses showed highest correlations between the abundance of Cladocera and Plecoptera compared to the river variables (Fig 7, Fig 8, Fig 9). The highest correlations occurred between Cladocera abundance compared to salinity and temperature with R^2 values of 0.4909 and 0.6097, respectively (Fig 7, Fig 9). R^2 values comparing Plecoptera abundance to the variables of salinity, pH, and temperature ranged from 0.2188 to 0.3624. R^2 values for the other organisms ranged from 0.0009 to 0.202 (Fig 7, Fig 8, Fig 9).

When taking into account the river as a whole, the Tahsis River and Zeballos River were both dominated by species of copepods, followed by an abundance of nauplii and Plecoptera (stone flies). 70% of the organisms in the Zeballos River were species of copepods, while the Tahsis River was characterized by more than 83% copepods (Fig 6). The Tahsis and Zeballos Rivers were made up of similar percent compositions of Cyclopoid and Calanoid copepods while the Gold River did not contain any Cyclopoid copepods (Fig 6). The Gold River had a different species composition compared to the other rivers. The Gold River was dominated by Cladocera (water fleas), followed by copepods and Plecoptera. Species dominance was not as skewed in the Gold River with Cladocera only representing 42% of the population (Fig 6). Species within the "other" portion of the population graphs included polychaetes, gastropod larvae, insects from the order Chironomidae, and barnacle molts (Fig 6).

Richness and diversity also varied when looking at each river as a whole entity. The number of identified organisms present in each river ranged from eight to twelve with the Zeballos River having the highest number of different organisms and the Gold River having the least amount of different organisms present (Fig 4). The Gold River and Zeballos Rivers had similar Shannon Weiner diversity values of 1.47 and 1.49 respectively. The Tahsis River had the lowest diversity index with a value of 0.85 (Fig 5). All three rivers were composed primarily of copepods (Calanoids and Cyclopoida), Cladocera (water fleas), Nauplii, and Plectopera (stone flies) (Fig 6, Table 3). Diversity values ranged from 0.956 to 1.758 with evenness values ranging from 0.554 to 0.943 at individual river stations (Table 2).

Discussion

Analysis by Station

Changes in prey composition across stations could be due to multiple factors. With a R^2 coefficient of 0.4909, nearly 50% of the change in cyclopoid abundance could be caused by changes in salinity (Fig 7). This suggests that the change in composition from Cladocera to Cyclopoids within the Gold River could have been due to the large increase in salinity at the fourth station (Table 1). The change in dominance across stations within the Tahsis and Zeballos Rivers are not driven by changes in salinity, pH, or temperature because Calanoids, Cyclopoids, and nauplii have very low correlation coefficients for each of the variables (Fig 7, Fig 8, Fig 9). Organisms are often clustered in groups where fast reproducing organisms outcompete larger, slower reproducing predators forcing them to move to other areas (Margalef 1979).

Chironomidae dominance at station 3 in the Zeballos River could be due to sampling bias or predator prey interactions at that site.

Shannon Weiner richness and diversity indices can be indicators of the ecological health of a river. Station 4 within the Zeballos River had the lowest species evenness while station 4 within the Tahsis River had the lowest species diversity (Table 2). Differences in diversity and evenness indices could be due to differences in nutrient or chemical concentrations especially since station 4 in Zeballos was located outside of the Little Zeballos River in a more marsh-like area (Fig 3). Richness and diversity can indicate what kind of food webs are present by the lack of or abundance of certain species. Low species richness or diversity at a station is not necessarily indicative of poor prey availability because there could be an abundance of salmon's preferred food source. Furthermore, having different quantities and kinds of food can be beneficial for juvenile salmon because they have been shown to utilize different food sources on a monthly basis (Minakawa 1999).

Overall, there were weak correlations between prey abundance compared to salinity, pH, and temperature (Fig 7, Fig 8, Fig 9). Higher R^2 values can be interpreted to mean that variables are more correlated. The highest correlations occurred with Cladocera having just over 60% of abundance explained by a change in temperature and nearly 50% of abundance explained by a change in salinity (Fig 7, Fig 9). The correlation between Plecoptera abundance and temperature was also fairly high with changes in abundance being accounted for by changes in temperature 36% of the time (Fig 9). All other R^2 values were small enough that the correlation could have been due to random chance or sampling error. The fact that salinity, pH, and temperature are not strongly correlated with abundance could be an indicator that another influence could be the driving factor of the system or that many influences are contributing to species abundance and spread at the same time. Factors contributing to the abundance of an organism at a given location could include the presence of predators or differences in nutrient abundance, but further research is required to determine this.

Analysis by River

Analyzing each river as a whole can be critical in determining which river is the most suitable habitat for winter salmon. Species diversity for the Gold River as a whole was higher than most of the individual station diversity values. The Tahsis and Zeballos Rivers exhibited the opposite trend where the rivers had an overall lower diversity than the average diversity of the stations in the river (Table 2, Fig 5). Discrepancies in the average station diversities and the full river diversities could be due to the way that the Shannon Weiner diversity index is calculated. Diversity is found by calculating the proportion of the population that each organism represents. When dealing with a single station, there are far fewer individuals so the proportion of the population that an organism represents is likely to be high. However, when taking into account the abundance of that organism across all of a river's stations the proportion is likely to be smaller because of the increased number of individuals. The presence of skewed dominance in the Tahsis River and Zeballos River is what contributes to low species diversity, while the more even spread of species dominance in the Gold River leads to high diversity.

As a whole, the Gold River had the lowest richness but had a species diversity index comparable to that of the Zeballos River (Fig 4, Fig 5). This indicates that the Gold River had the lowest number of total organisms but the abundance of each species was similar. The Zeballos River had the highest counts of different organisms and shared a similar spread of organisms as the Gold River. The Tahsis River had an intermediate richness index compared to the other rivers but it also had the lowest diversity (Fig 4, Fig 5). The species composition of the Tahsis and Zeballos rivers looks very similar but they had differing diversity indices because the Zeballos River had three additional types of organisms and the Tahsis River had over 4.5 times more individuals. Low diversity in the Tahsis River can be explained by the overwhelming dominance of copepods (Fig 5, Fig 6). Larger samples sizes and spaces could help minimize sampling error and increase the odds of capturing true population proportions because organism patchiness is dependent on sample size (Margalef 1979). In this study, richness is a not as important in determining which river would best support winter salmon populations because the number of different prey available is not as important as the kind of prey available.

River characteristics such as salinity, temperature, pH, and bed type can all be used to determine if a river is capable of supporting salmon. Studies have found that salmon prefer spawning in areas with upwelling groundwater, which typically have lower water velocities, as well as areas that are a mix of gravel and sand (Lorenz 1989). The Gold River had the highest discharge and the sampled station river beds were characterized by larger rocks and boulders. This would suggest that the Gold River would not be ideal for spawning salmon unless individuals traveled further up in the river where the substrate might be different. Both the Tahsis and Zeballos River were characterized by lower discharge rates and smaller substrate particles compared to the Gold River. The Tahsis and Zeballos Rivers could be suitable for spawning salmon for these reasons, which could suggest that both rivers might support higher abundances of juvenile salmon in the winter months.

One of the most important indicators of a river's ability to support winter salmon populations is the availability of nutritionally beneficial food sources because of the reduction of food in the winter months. The winter diets of Coho juveniles in Baker Creek, Washington were examined to bridge the gap about what scientists know about wintering salmon in streams. The study observed stomach contents of salmon on four dates between November and January. The study found that salmon were mostly utilizing springtails (Isotomidae) as their main food source from early November to mid-December (Minakawa 1999). No organisms from this family were observed in any of the three rivers. In mid-December Coho salmon were eating Chironomidae larvae but they only accounted for 3% of the salmon's diet, however, by mid-January nearly one-third of the salmon's diet was composed of Chironomidae and over one-quarter of their diet was composed of Plecoptera nymphs (Minakawa 1999).

The Zeballos River was the only river in which Chironomidae adults were found, while the Gold River had the highest concentration of Plecoptera nymphs (Fig 6). Chironomidae where mostly concentrated at station 3 in the Zeballos River, with a total of 17 individuals found throughout the stations. Due to the small abundance of Chironomidae in the rivers we can assume that salmon in Nootka Sound are not utilizing these individuals in the same way that salmon further south are. In comparison, plecoptera could be a major prey source for juvenile salmon in Nootka Sound Rivers. The high abundance of Plecoptera in the Gold River could point to good prey availability for winter salmon. The low abundance of Plecoptera in the Zeballos River and Tahsis River could mean that there was once a high abundance of the organism which has been depleted by salmon that are relying on that organism as their main food source.

Many species of copepods and nauplii are also important food sources for juvenile salmon. Cyclopoid copepods are abundant in a variety of temperatures and salinities making them an important food source for a variety of animals (Turner 2004). Some salmon preferentially feed on species of cyclopoid copepods because they have a higher nutritional content which means salmon can consume a smaller number of individuals during the winter when prey numbers are naturally lower (Karpenko 2012). Either the Tahsis or Zeballos River could support winter salmon populations due to their high abundance of copepods and nauplii. If higher winter water temperatures are indicative of increased growth and survival for juvenile salmon then this study could further solidify that the Tahsis River could best support winter salmon populations. Both food availability and water temperature could affect where salmon are reared and could impact their growth and survival.

Conclusion

By analyzing both the physical and biological characteristics of streams and rivers in the winter months, scientists can begin to get a better understanding of how different species of salmon could utilize rivers throughout the year. While some species of salmon go through smoltification immediately after being hatched, other species spend a year or more in natal rivers. The majority of salmon growth occurs in the open ocean before the individual returns to spawn but the growth that occurs while the juvenile salmon is in the river is just as important, if not more important, because early stages of life are the most susceptible to mortality and determine fitness of the individual later in life. After analyzing water temperature, pH, salinity, substrate type, and food availability, I conclude that any of the rivers could support viable winter salmon populations with the best salmon habitat possibly being the Tahsis River due to higher water temperatures and suitable prey compositions.

Many factors could be simultaneously driving productivity which makes isolating one cause difficult or impossible. Collected data could contain sampling bias which could alter results. Samples were taken using five minute plankton tows at discrete stations along each river inlet. There could be spatial sampling bias because organisms could have been clumped in areas that were not sampled. The tows were also performed at relatively low velocities which could have allowed small or quick swimming individuals to be excluded from the net. Methods for collecting organisms were also different across the rivers. The Tahsis and Zeballos samples were collected in a similar fashion with the boat accelerating to provide enough water movement through the net. In the Gold River the boat was stationary because the current of the river was sufficient to support the plankton net. Differences in collection methods could skew the numbers of organisms collected if a greater volume passes through the net with one of the methods. One of the biggest limitations of this study was the inability to travel further up the rivers to collect samples from habitats that would be most ideal for juvenile salmon.

Future research is needed to get a better understanding of the biotic and abiotic characteristics of these river systems. Future studies could look at bed type across each river to determine optimal areas for salmon to lay eggs. In order to adequately compare rivers for suitable salmon habitat, data needs to be collected throughout the seasons and across multiple years to detect variations in temperature and prey abundance. Samples could also be conducted during multiple points within the tidal cycle to see if tides could be playing a role in prey abundance. Ideally, future researchers could catch salmon at intervals throughout the year then analyze otoliths and stomach contents to see what species are present in different rivers throughout the year, how old individuals are, how salmon growth and time of smoltification varies across rivers, and how predator-prey interactions change throughout the year.

Figure 1: Southern Vancouver Island and surrounding areas

(http://www.emersonkent.com/images/nootka_sound_map.jpg)

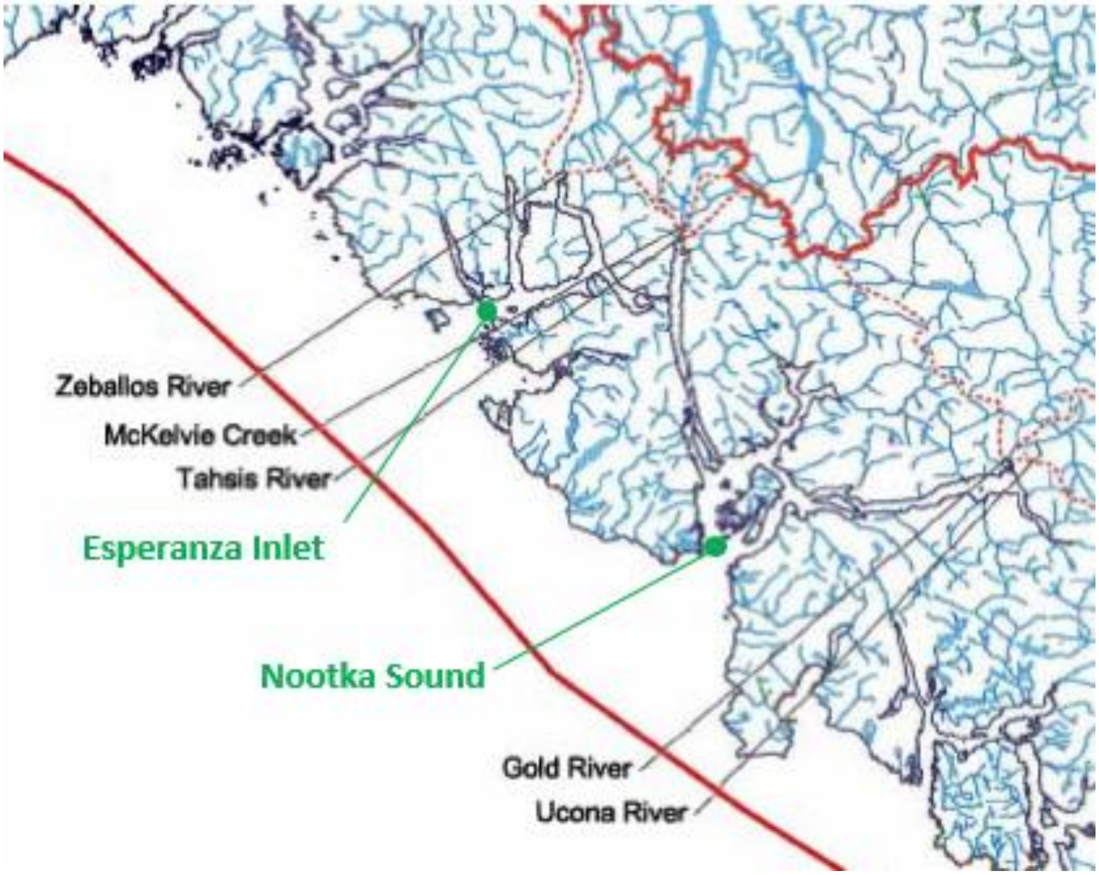

Figure 2: Rivers and inlets of interest (Adapted from Jackson 1999)

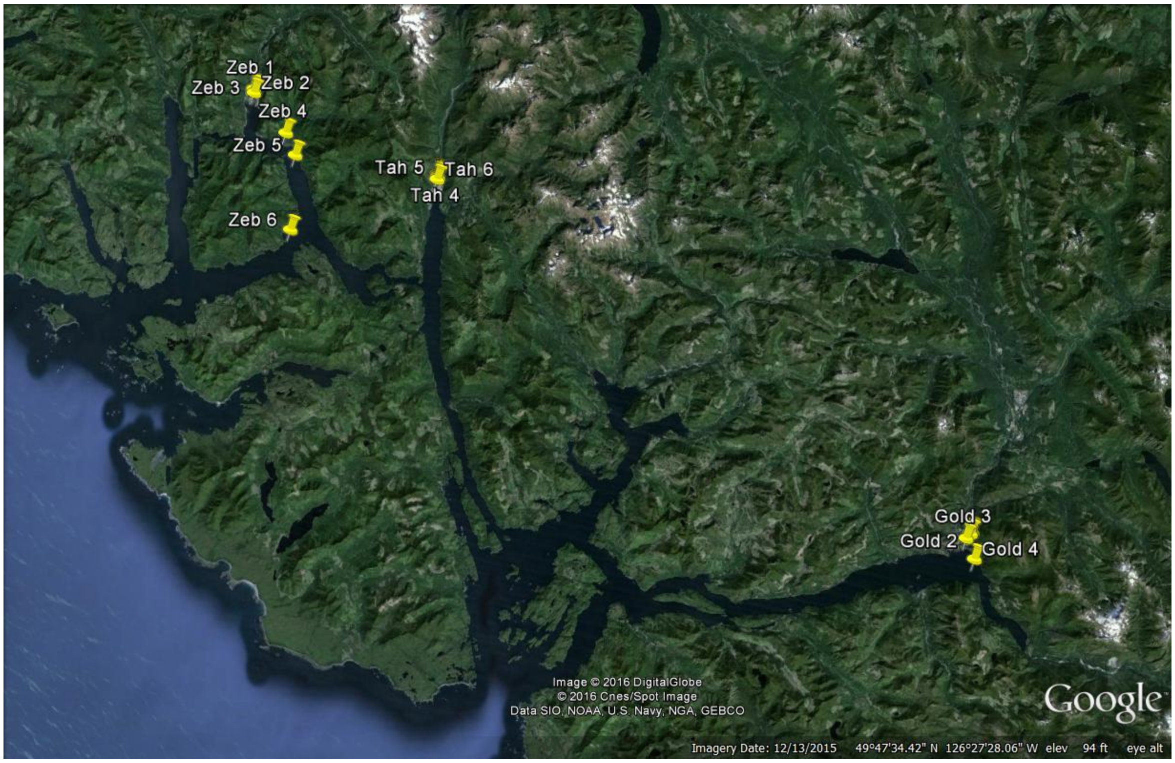

Figure 3: Station map for each of the river systems. The Tahsis and Gold River samples were started as far up the river as the boat could navigate then proceeded down to the mouth of the river. The Zeballos stations established more of a salinity gradient with samples also taken outside of the Little Zeballos River (Zeb 4 and 5) and a sample taken at the end of the inlet.

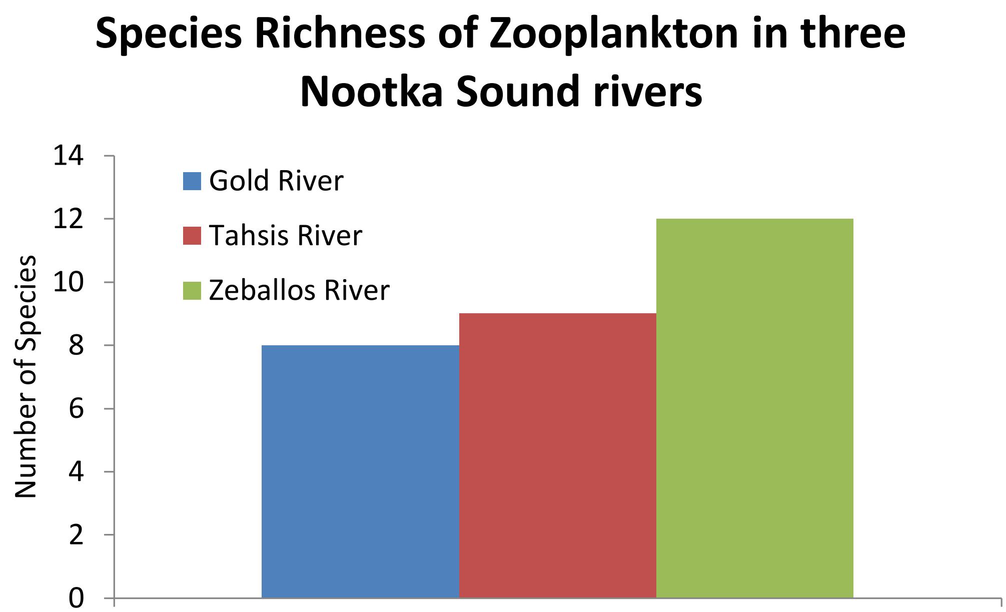

Figure 4: The total number of each species present in each river system

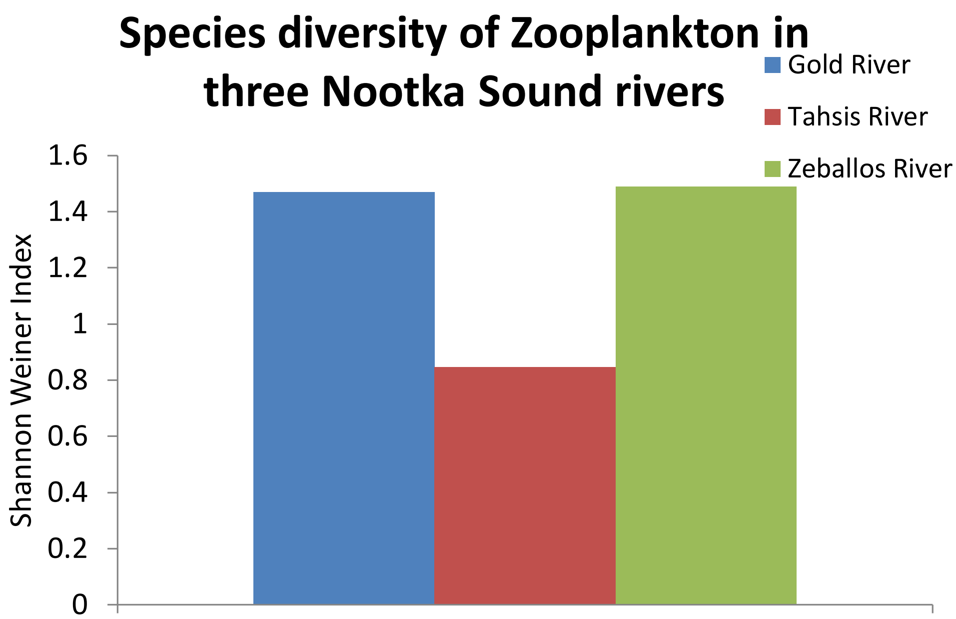

Figure 5: As species diversity increases the Shannon Weiner Index also increases. A Shannon Weiner index close to zero would represent a population that is dominated by one species.

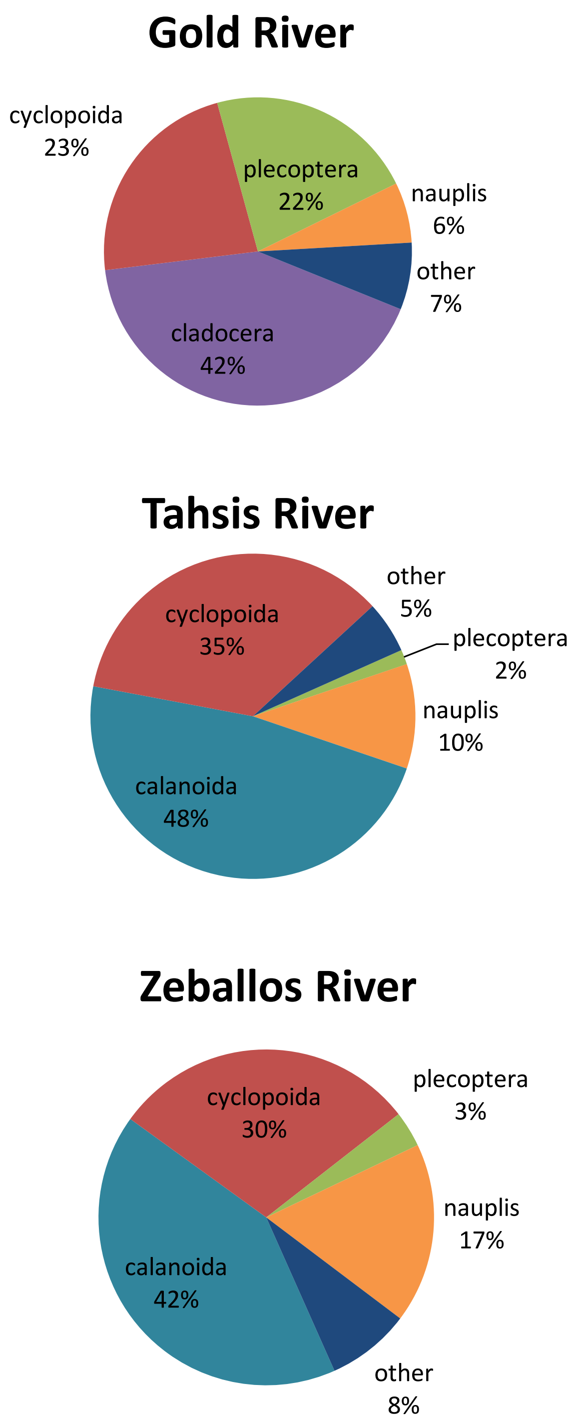

Figure 6: River populations represented as proportions of organisms present in all stations of each river system

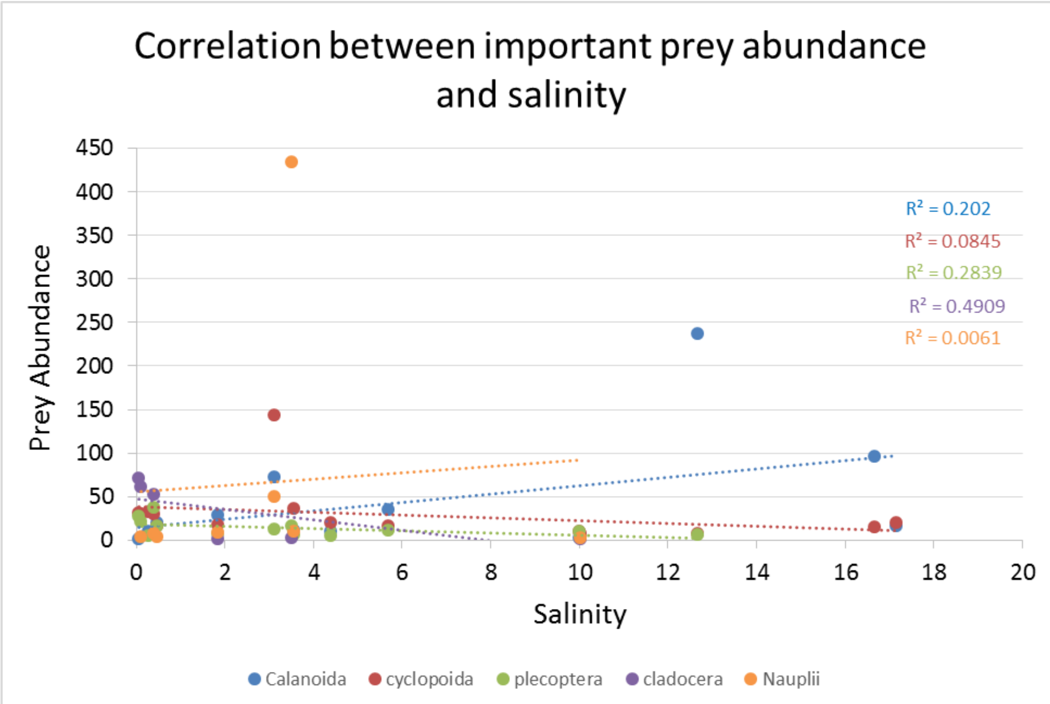

Figure 7: Five of the most abundant and most important salmon prey organisms were assessed to establish if there was a strong correlation between surface salinity and organism abundance

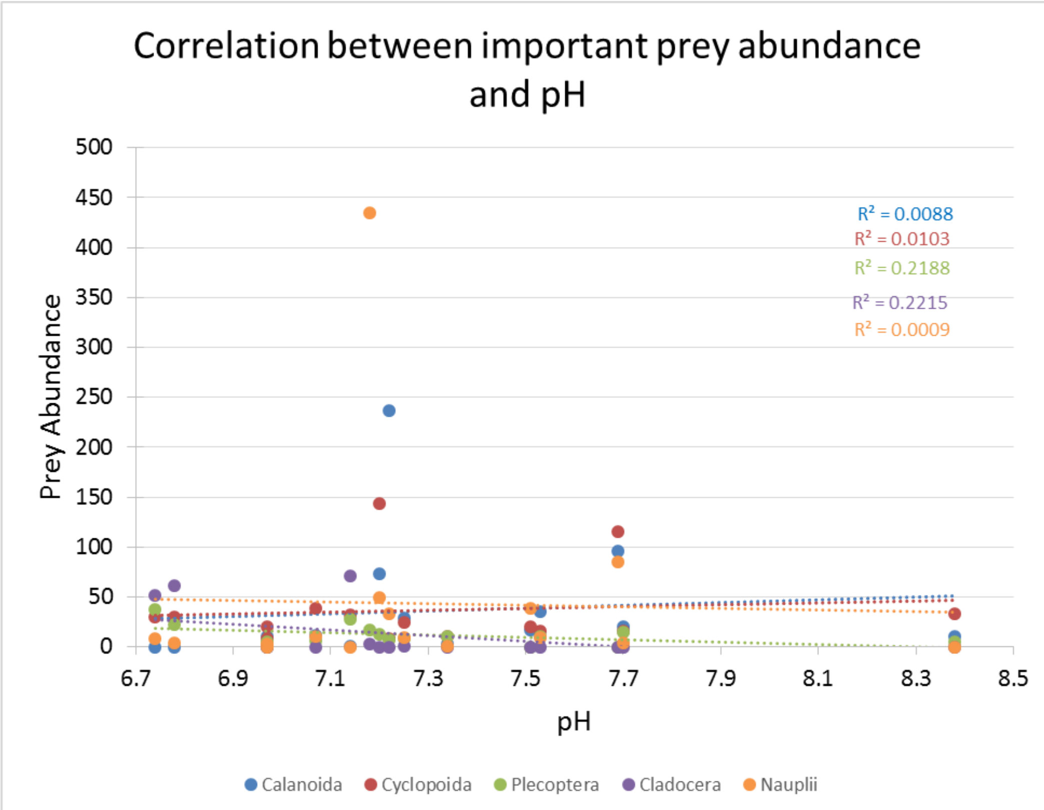

Figure 8: Five of the most abundant and most important salmon prey organisms were assessed to establish if there was a strong correlation between surface pH and organism abundance

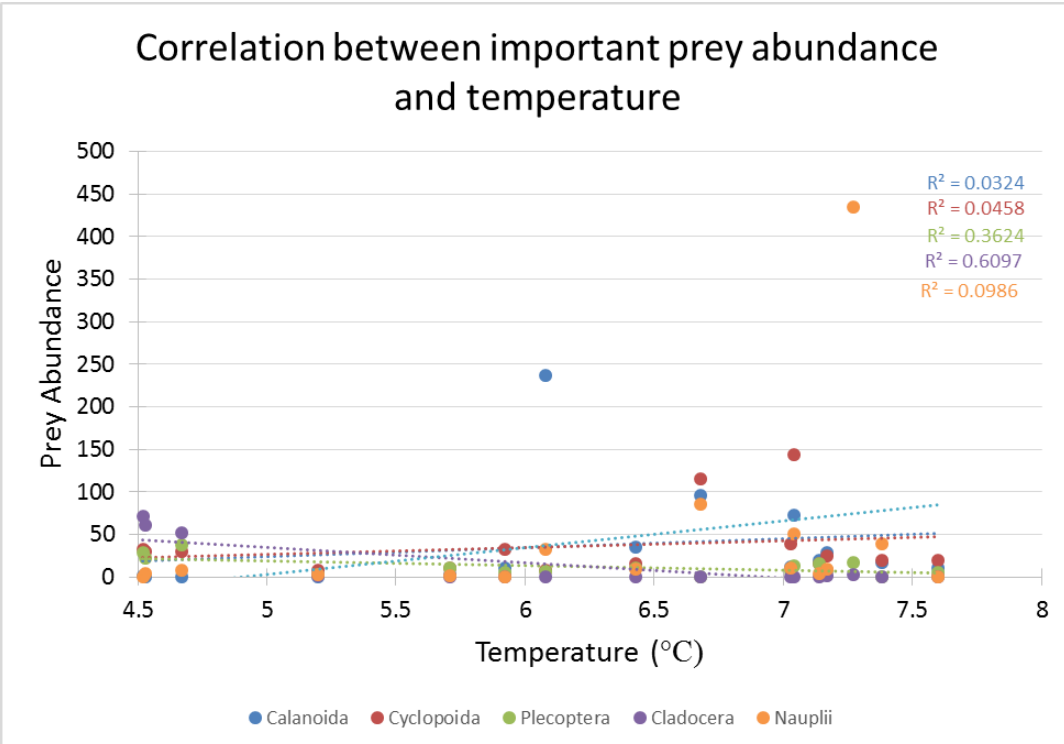

Figure 9: Five of the most abundant and most important salmon prey organisms were assessed to establish if there was a strong correlation between surface water temperature and organism abundance

Table 1: Salinity, pH, and Temperature readings at each river station

Salinity, Temperature, and pH at each river station with average river values									
	Gold River			Tahsis River			Zeballos River		
Station	Salinity	pH	Temperature (°C)	Salinity	pH	Temperature (°C)	Salinity	pH	Temperature (°C)
1	0.05	7.14	4.52	0.47	7.70	7.14	0.26	8.38	5.92
2	0.11	6.78	4.53	1.83	7.25	7.17	5.69	7.53	6.43
3	0.40	6.74	4.67	3.54	7.07	7.03	10.00	7.34	5.71
4	10.01	6.97	5.20	4.39	6.97	7.60	12.67	7.22	6.08
5	-	-	-	3.10	7.20	7.04	17.15	7.51	7.38
6	-	-	-	3.50	7.18	7.27	16.66	7.69	6.68
Average	2.64	6.91	4.73	2.81	7.23	7.21	10.41	7.61	6.37

Table 2: Shannon Wiener diversity and evenness values for each river station

Shannon Weiner Diversity and Evenness Indices for Each River Station						
	Gold River		Tahsis River		Zeballos River	
Station	Diversity	Evenness	Diversity	Evenness	Diversity	Evenness
1	1.365	0.701	1.518	0.943	1.508	0.775
2	1.507	0.775	1.758	0.800	1.620	0.779
3	1.240	0.894	1.339	0.747	1.804	0.868
4	1.160	0.836	0.956	0.870	1.079	0.491
5	-	-	1.278	0.713	1.204	0.748
6	-	-	1.152	0.554	1.142	0.710

Table 3: Dominant organism at stations across each river

Dominant Organism at Each Station			
Station	Gold River	Tahsis River	Zeballos River
1	Cladocera	Calanoida	Cyclopoida
2	Cladocera	Calanoida	Calanoida
3	Cladocera	Cyclopoida	Chironomidae
4	Cyclopoida	Cyclopoida	Calanoida
5	-	Cyclopoida	Nauplii
6	-	Calanoida	Cyclopoida

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