CONDITION OF EDMONDS STREAMS FOR SALMON:

WATER QUALITY MONITORING AND SALMON STEWARDSHIP

EDMONDS -WOODWAY HIGH SCHOOL
STUDENTS SAVING SALMON

July 2017

EDMONDS STREAM TEAM

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EXECUTIVE SUMMARY

Students Saving Salmon participated in the Edmonds Stream Team which was formed to fill gaps in information on the quality of Edmonds streams and conditions for salmon. Edmonds-Woodway High School students in the Students Saving Salmon club volunteered to participate in the Edmonds Stream Team citizen science project to collect monthly water quality measurements from several streams that flow through or near the downtown area of Edmonds and the Edmonds Marsh.

From August 2015 to June 2017, the Edmonds Stream Team monitored upstream and downstream sites in Willow Creek, Shell Creek, Shellabarger Creek, and the Edmonds Marsh for water quality parameters that are important for aquatic organism survival. Water samples were also collected seasonally for lab analysis for dissolved metals, petroleum-derived compounds, and fecal coliform bacteria.

A multiparameter instrument was used to collect standard water parameters such as water temperature, dissolved oxygen, pH, and conductivity. Water parameters were evaluated against the Washington State Water Quality Criteria for freshwater aquatic life (see Washington Administrative Code 173-201A-030).

Water temperature in the three Creeks exhibited the expected trend of decreasing temperatures in the fall (average of 52.8°F) to winter lows averaging 47.3°F and then increasing to an average of 54.5°F in the spring and 57.8°F in the summer. The highest summer average temperature was 60.1°F in lower Hindley Creek. These temperatures are below the maximum temperature requirement of 63.5°F for salmonid spawning, rearing and migration in the Washington Administrative Code.

Dissolved oxygen in the three Creeks was generally higher in the winter with colder water temperatures and lower in the summer. Average dissolved oxygen levels in the three creeks ranged from a low of 10.0 mg/L in summer to a high of 11.3 mg/L in the winter. The lowest average was 9.3 mg/L in the south fork of upper Shellabarger in the summer. These are well above the 8.0 mg/L for salmonid spawning, rearing and migration in the Washington Administrative Code. Further, the measured dissolved oxygen levels in lower Shell Creek, where salmon spawn, averaged above 11.0 mg/L in the fall and winter which is an optimum level for salmon eggs in the gravel.

Water temperature in the Edmonds Marsh exhibited the expected trend of decreasing temperatures in the fall/winter and increased temperatures in the spring/summer. Average water temperatures at all sites in the Marsh ranged from 45.5°F in the winter to 62.2°F in the summer; all of which are below the maximum temperature requirement of 63.5°F for salmonid spawning, rearing and migration in the Washington Administrative Code. However, the water exiting the Marsh exceeded the standard in the spring and summer of 2016 with a high of 73.2 in June 2016. The north edge of the Marsh along Harbor Square also exceeded the standard in all summer months. Increased vegetation in/around the Marsh may be beneficial.

The main water body flowing through the Edmonds Marsh (from Shellabarger inlet at the Hwy 104 culverts to the Marsh outlet) had dissolved oxygen averaging a low of 8.1 mg/L in the summer to a high of 10.6 in the winter. However, dissolved oxygen measured on the northern edge of the Marsh along Harbor Square averaged below 3.8 mg/L with a low of 0.3 in the spring. These low levels are lethal to salmon and other aquatic organisms. Improved water circulation in the Marsh may be beneficial to address this problem.

Salinity measurements in the Marsh from December to early March reflected the low salinity of the incoming freshwater from the Shellabarger inlet and lower Willow Creek. But, when the tide gate is secured open by the City from mid-March to mid-October, the salinity measurements were significantly greater in the Marsh. The ecological functions and environmental benefits of this estuarine wetland would be enhanced by keeping the tidegate secured open year-round to allow tidal flow.

Counts of fecal coliform bacteria colonies cultured from water samples collected varied considerably by location/season/day. There are no Washington Water Quality Standards for fecal coliform for freshwater aquatic life. However, if we use the Washington criteria for water contact recreation (i.e., levels must not exceed a geometric mean value of 100 colonies/100 mL) as an indicator of a potential bacteria problem, then there are a number of samples that are of concern. Fecal coliform counts appear to be higher after a period of rain and we will be analyzing this further.

Pollutant sampling revealed an area of concern. Twenty-two water samples collected over seven seasons were analyzed by the ALS Laboratory in Everett for 18 different polycyclic aromatic hydrocarbons (PAHs) that are identified as priority pollutants for analysis by the EPA. Only 10 of these PAHs had WA water quality standard (human health criteria) designated, and five PAHs were found in water samples at levels that exceeded those standards. Sixteen of the 22 samples had at least one of these five carcinogenic PAHs (cPAHs) that exceeded the standard. Benzo(a)pyrene occurred above standard in all of these 16 samples. All water samples (total of 4) collected from the north edge of Marsh (along Harbor Square) had cPAHs that exceeded standards, whereas only 2 of the 4 samples collected at same time from the east edge of Marsh at the storm drain had cPAHs that exceeded standards.

Contingent upon continued support from the City and grants, the Edmonds Stream Team plans to continue the citizen science project into 2018 with new high school students that will replace the graduating seniors. Plans are to continue monthly monitoring utilizing Students Saving Salmon club members and the quarterly collection of water samples for Lab analysis.

Students Saving Salmon plans to continue the Shell Creek Salmon Stewardship project because the outreach to streamside residents and restoration efforts should benefit existing and future salmon that utilize Shell Creek. We plan to continue placing juvenile coho salmon (from the Willow Creek Salmon Hatchery in Edmonds) in the upper areas of Shell Creek (above an impassable barrier – a 5-foot waterfall) to bolster the lower Shell Creek salmon population. We also plan to continue pursuing avenues (such as grants) to determine the feasibility and cost of undertaking a restoration project that removes the impassable barrier (a 5-foot waterfall) and allows salmon passage to the upper reaches of Shell Creek.

INTRODUCTION

Students Saving Salmon is an Edmonds-Woodway High School club formed by students that are concerned about their environment, especially salmon and their habitat. To achieve their goal of fostering and reestablishing salmon runs in Edmonds, students in the club are learning about Edmonds watersheds and conservation/restoration efforts so they can encourage measures that will make the local environment better for people and salmon. Students Saving Salmon objectives are to collect and disseminate scientific information on salmon habitat and Edmonds watersheds; conduct outreach on salmon habitat and water quality; and, participate in city government processes and community habitat enhancement efforts.

The City of Edmonds has several creeks draining into Puget Sound that may support salmon, but unfortunately there is little baseline data on water quality in these streams nor information on whether stormwater and other runoff may be affecting the ability of these streams to support salmon. There was one instance of a die-off of juvenile coho salmon in May of 2004 at the Willow Creek Hatchery that was attributed to potential stormwater pollutants in Willow Creek after a rainstorm, but no water quality data was available to evaluate it (Seattle Times, May 26, 2004). To address the lack of water quality data, Students Saving Salmon is participating in the Edmonds Stream Team, a citizen science project designed to collect high quality data on the condition of Edmonds creeks and the Edmonds Marsh utilizing volunteer high school students.

Stream monitoring programs are essential for assessing current conditions and tracking changes in water quality over time to identify potential problems and/or determine if community actions have been successful. Good water quality is essential to maintaining the presence of salmon in streams. When a stream falls outside healthy levels, it can have detrimental effects on aquatic organisms. The influx of stormwater is one factor that can quickly change water quality to the detriment of salmonids. Unfortunately, city and state staff and funding resources are limited, and stream monitoring in urban areas such as Edmonds cannot be implemented without volunteer support. Thus, the Edmonds Stream Team citizen science project was designed to provide important baseline information to city and state government agencies to assist in environmental assessments and decision-making. The Edmonds Stream team not only collected data on basic water parameters, but also conducted bacterial monitoring for fecal coliform, biomonitoring using macroinvertebrates, and sampling water for dissolved metals and petroleum-derived compounds. This citizen science project also provides a great opportunity for high school students to be actively involved in field science to gain a greater understanding of environmental issues.

This report presents results of the Edmonds Stream Team monitoring since 2015 of three creeks in Edmonds (Shell Creek, Willow Creek and Shellabarger Creek) and the Edmonds Marsh. A preliminary report (Scordino et. al 2016) on this project was provided to the Edmonds City Council in June 2016. This report also presents more recent efforts by Students Saving Salmon to better understand the dynamics of the salmon occurring in Shell Creek and implement a Shell Creek Salmon Stewardship project.

STUDY AREA

Edmonds Watersheds and Creeks

Watersheds in the City of Edmonds are made up of small creeks or underground pipes that drain directly to Puget Sound or to the east into Lake Ballinger (which flows to Lake Washington and then to Puget Sound). The creeks originate from natural springs with input from rainfall and underground pipes that collect flows from storm drains located along paved streets and parking lots. In some Edmonds watersheds, water flows in underground pipes most of the way to Puget Sound. Edmonds also has several wetlands that provide wildlife habitat including the Edmonds Marsh, Good Hope Pond, Shell Creek Marsh, and wetlands adjacent to the creeks.

All Edmonds creeks are designated as Type F (streams that contain fish habitat) in the Edmonds City Development Code (EDCD 23.90.010). None of the Edmonds creeks are designated as "shorelines of the state" because they do not meet the 20 cubic-foot-per-second annual flow threshold for classification as a water of the state (Sea Run Consultants et al. 2007). EDCD 23.90.010 lists Willow Creek, Shellabarger Creek, Shell Creek, Hindley Creek, Perrinville Creek, and Lunds Gulch Creek as having anadromous fish species (fish born in freshwater that migrate to the ocean to grow into adults, and then return to spawn in freshwater streams).

The Edmonds Marsh is currently the focus of a major City of Edmonds restoration project, called the “Willow Creek Daylighting” project (Shannon and Wilson, Inc. 2013). Thus, the Edmonds Stream Team citizen science project was designed to focus on the Edmonds Marsh and the two creeks (Willow and Shellabarger) that flow into the Marsh so that pre-restoration baseline data are collected. By including Shell Creek, which currently has spawning salmon return each year, the project covers water quality for the downtown area of Edmonds.

Edmonds Marsh

The Edmonds Marsh, located on the west side of Highway 104 south of downtown Edmonds, receives drainage from Shellabarger Creek Basin (378 acres), the Willow Creek Basin (393 acres), and another 61 acres from local areas (i.e., Harbor Square, adjacent Highway 104 storm drains, and the old UnoCal fuel tank farm site) that drain into the Marsh (Herrera Environmental Consultants Inc. and City of Edmonds 2010). The Edmonds Marsh drains to Puget Sound through a channelized portion of Willow Creek at the southwest end of the Marsh. The channel passes through two large culverts under the railroad tracks into an open basin and then into an approximately 1,660-foot 48-inch pipe that passes through a tide gate before draining into the lower intertidal area of Marina Beach. The tide gate functions to prevent tidal saltwater intrusion into the Marsh from mid-October through mid-March to avoid flooding potential when high tides coincide with heavy rainfall. During the spring and summer months the tide gate is secured open so that the Marsh is tidally influenced. The 23-acre Edmonds Marsh is a City of Edmonds Park managed by the Parks, Recreation and Cultural Services Department.

Willow Creek

Willow Creek flows through a largely residential area draining a 393-acre basin area of which 183 acres are in Edmonds and the remaining acreage in Woodway (Herrera Environmental Consultants Inc. and City of Edmonds 2010). Willow Creek starts in Edmonds and flows through Woodway before draining into the Edmonds Marsh on the west side of SR 104 just north of Pine Street (adjacent to the Willow Creek Hatchery).

Coho salmon, cutthroat trout, and, historically, chum salmon occur in Willow Creek (CH2M HILL 2004). Juvenile salmon were observed in Willow Creek in 2016, and they were likely releases from the Willow Creek Hatchery. The 1,660-foot entrance pipe to Willow Creek/Marsh from Puget Sound (in subtidal area) likely precludes most adult salmon passage into the Marsh and creeks.

Shellabarger Creek

Shellabarger Creek drains a 378-acre basin area (called the "Edmonds Bowl") and flows into the Shellabarger Marsh (a name we have coined for the marsh located within several private properties on the east side of Highway 104) which then drains into the Edmonds Marsh through two large culverts under Highway 104. The Shellabarger Creek corridor is heavily developed. The stream passes through culverts in many locations and most of the open reaches are located in landscaped residential areas (Herrera Environmental Consultants Inc. and City of Edmonds 2010).

Information on fish use of Shellabarger Creek is limited; WDFW has not conducted fish surveys in the creek. Resident cutthroat are likely present, and the creek is accessible to anadromous fish that use Edmonds Marsh (Sea-Run Consulting et al. 2007). Similar to Willow Creek though, the 1,660-foot pipe outlet to Puget Sound likely precludes most adult salmon from entering the Marsh and thus upstream to Shellabarger Creek. However, there was a possible adult salmon occurrence in the upper middle fork of Shellabarger Creek in the fall of 2014 based on the description of a fish observed upstream of 7th Avenue; it was either a coho salmon or a large cutthroat trout (My Edmonds News article; February 14, 2015).

Shell Creek

The Shell Creek basin comprises a drainage area of 821 acres, which includes the 178-acre Hindley Creek subbasin (Herrera Environmental Consultants Inc. and City of Edmonds 2010). Hindley Creek empties into Shell Creek west of Brookmere Drive just north of Caspers Street. Both Shell Creek and Hindley Creek have diversion structures that convey high flows directly to Puget Sound via a pipe system. The Shell Creek diversion structure and a fish ladder are located on Daley Street east of 7th Avenue. The Hindley Creek bypass begins at 9th Avenue N and Hindley Lane, where it enters the same pipe used for the Shell Creek bypass. Shell Creek flows through several undeveloped areas including Yost Park at the upper end of the creek and an open area on private property at the terminal end of the creek just east of the railroad tracks. The Shell Creek Marsh is located just north of Shell Creek at its terminal area east of the tracks.

Adult chum and coho salmon are observed in lower Shell Creek each year. Lower Shell Creek residents (north of Glen Ave.) have reported seeing adult salmon in Shell Creek each year from late October to early December and they were confirmed to be chum and coho salmon by the Edmonds Stream Team. Salmon passage north of Glen Ave. Is blocked by a 5-foot manmade/natural waterfall.

METHODS

Monitoring sites were selected to provide representative locations for upper and lower reaches of Shellabarger, Willow and Shell Creeks and various locations including incoming/outgoing flow sites in the Edmonds Marsh. Selection criteria included easy and safe access to creek sites and property owner permission. Shellabarger Creek has three geographically separated forks in the upper creek area and the upper end of each fork was monitored. Shellabarger Creek monitoring included the Shellabarger Marsh where it flows under Highway 104 into the Edmonds Marsh. The Marsh was a challenge to establish sites since only the edges of the Marsh were easily accessible and the western and southern edges were not accessible (Burlington Northern Railroad property and old UnoCal site). Chevron denied access to the old Unocal site. Fortunately, the City allowed access to the fenced Marsh outlet basin (west of railroad tracks) in the Marina parking lot which was an ideal location to sample outgoing water from the main body of the Marsh.

Students Saving Salmon members joined one of four teams with each team responsible for monitoring four to five sites on one day each month. This ensured that the upper and lower portion of each creek and the incoming/outgoing sites at the Marsh were monitored on the same day.

A rugged, high quality handheld multiparameter instrument, a YSI Professional Plus (YSI ProPlus), was used by students to collect water quality data. The YSI ProPlus is equipped with a 4-meter (12 foot) cable (to allow monitoring off low bridges) with an attached probe that holds four user replaceable sensors for temperature/conductivity, dissolved oxygen, pH and nitrate measurements. The instrument was calibrated by the project leader each month just prior to that month's monitoring. A YSI ProDSS meter, that holds four user replaceable sensors for temperature/conductivity, dissolved oxygen, pH/oxygen reduction potential and turbidity, was purchased in December 2016 as a backup to the YSI ProPlus and used periodically in 2017.

Water quality parameters

There are many parameters that can be monitored to assess a stream's condition or trends in water quality. The Edmonds Stream Team chose to emulate the Washington State Department of Ecology's ambient water quality monitoring program (Von Prause 2014) which collects monthly data in rivers and streams throughout Washington. We were however limited on available equipment and laboratory access to collect all of the State's standard parameters. Our monthly collection included dissolved oxygen, pH, temperature, conductivity, salinity, total dissolved solids, nitrates and turbidity (periodically). We did not have the capacity to collect ammonia, total phosphorus, total nitrogen, fecal coliform and total suspended solids data as the State does at all stations each month though we collected samples for fecal coliform analysis quarterly.

Water temperature is the most critical factor influencing biological and chemical conditions in water. The solubility of oxygen, other gases and some compounds change with water temperature thus changing their effects on aquatic organisms. Water temperature was recorded to the nearest tenth degree (0.1) Fahrenheit (°F) and also reported (converted) in Celsius (°C) in the database. Measured temperatures were evaluated against Washington's Water Quality Standards (WAC 173-201A-210) which sets aquatic life standards (7-day average of daily maximum temperatures) at 63.5°F (17.5°C) for salmonid spawning, rearing and migration.

Dissolved oxygen (DO) is a very important parameter in assessing water quality because of its influence on the organisms living within a body of water. Aquatic organisms use dissolved oxygen in respiration, similar to organisms using air on land. Dissolved oxygen levels were recorded to the nearest tenth (0.1) mg/L of oxygen at each monitored site. Measured dissolved oxygen levels (mg/L) were evaluated against

Washington's Water Quality Standards (WAC 173-201A-210) which sets a minimum of 8.0 mg/L for salmonid spawning, rearing and migration; and, 6.5 mg/L for salmon rearing and migration only.

The pH of a stream determines the solubility of nutrients and chemicals in the water thus affecting the aquatic organism in the water. pH is the measure of the hydrogen ion concentration in water with 7.0 being neutral, above 7.0 basic or alkaline, and below 7.0 acidic. pH was reported to the nearest hundredth (0.01) on pH scale of 0 to 14. Measured pH values were evaluated against Washington's Water Quality Standards (WAC 173-201A-210) which sets all aquatic life pH criteria to be within a range of 6.5 to 8.5.

Conductivity is a measure of water's ability to pass an electrical current which is directly related to the concentration of ions in the water from dissolved salts and inorganic materials. Conductivity was recorded to the nearest tenth micro Siemens per centimeter (μS/cm) and also recorded as specific conductance which is the conductivity measurement corrected to 25°C (77°F) thus allowing direct comparisons of different sites/dates. The conductivity sensor on the ProPlus and ProDSS meters also reports total dissolved solids (TDS) in grams per liter (g/L) and salinity in parts per thousand (ppt). There are no Washington Water Quality Standards for these parameters.

Nutrients are elements required for the growth of organisms. Nitrogen, phosphorus, and carbon are the three most important nutrients for aquatic plants. Although nitrogen compounds are essential for plant and animal life, high levels of nutrients in a body of water may cause plant life and algae to flourish causing blooms that can choke out other organisms. To monitor nutrients, a nitrate sensor on the YSI ProPlus instrument was used. Nitrate concentration expressed as nitrate-nitrogen (NO_3-N) was recorded in mg/L. There are no Washington Water Quality Standards for nitrates though levels below 5.0 mg/L are considered good.

Lab analysis for dissolved metals and petroleum compounds

Water samples were collected and delivered to an accredited water analysis laboratory for petroleum-derived compounds and dissolved metals testing four times per year (once each season - winter, spring, summer, fall) and during storm events if possible. Stormwater samples were to be 'first flush' samples collected during a rainstorm with a forecast of 0.25 inches or greater after three days of no rain. The number of sites, frequency of collection and number of pollutants analyzed was restricted due to costs of laboratory analysis and availability of grant funds to conduct the laboratory analyses. Samples were collected in sterile bottles provided by the Lab. One sample was collected during a rainstorm and others were collected on a seasonal basis (fall, winter, spring, summer).

Thirty-nine water samples from 12 sites were collected in sterile bottles provided by the Lab. All were delivered to the ALS Environmental Laboratory in Everett for analysis. The samples were analyzed for heavy metals (arsenic (As), cadmium (Cd), chromium (Cr), cooper (Cu), iron (Fe), lead (Pb), mercury (Hg), and zinc (Zn)), BTEX (benzene, toluene, ethylbenzene, and xylenes), TPH (total petroleum hydrocarbons), and PAH (polycyclic aromatic hydrocarbons). Due to the costs of some of the Lab tests, not all samples were analyzed for all of the metals/compounds; only 22 samples were analyzed for PAH because of the high cost. Funding for the Lab analyses was provided through grants issued to EarthCorps and Sound Salmon Solutions. Lab results were evaluated against Washington's Water Quality Standards (WAC 173-201A-240) for toxic substances.

Lab analysis for fecal coliform bacteria

In January 2016, the City of Edmonds agreed to analyze water samples for fecal coliform several times a year at the Edmonds Wastewater Treatment Plant Lab. Since then, water samples have been collected in sterile Whirl-Pack bags from monitoring sites each season (winter, spring, summer, fall). Each water sample was stored on ice during field collection and delivered to the Lab within 2 hours of collection. The Lab processed each sample using the Membrane Filter Procedure (mFC/Rosalic Acid Broth). There are no Washington Water Quality Standards for fecal coliform for freshwater aquatic life. However, there are criteria in the Washington Administrative Code (173-201A-260) for water contact recreation which sets a 'primary contact recreation' criteria that fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies /100 mL. A 'secondary contact recreation' criteria is the same except the 100 colonies value is set at 200 colonies and the not more than ten percent for the 200 colonies value is set at 400 colonies.

Collecting and identifying macroinvertebrates

Sound Salmon Solutions conducted macroinvertebrate identification training with EWHS IB Science classes in 2016 and Honors Biology classes in 2017. Macroinvertebrate water samples were collected by students using dip nets in Shell Creek. Macroinvertebrates identified were classified into three groups based on their pollution tolerance. Group 1 macroinvertebrates, consisting of caddisfly larvae, mayfly nymph, stonefly larvae are intolerant of pollution; Group 2 macroinvertebrates, consisting of scud, crane fly larvae, are partially tolerant of pollution; and, Group 3 macroinvertebrates, consisting of aquatic worm, blackfly larvae, midge larvae are tolerant of pollution.

RESULTS

From August 2015 to June 2017, water temperature, dissolved oxygen and pH trends observed were as expected with water temperatures changing with season and dissolved oxygen levels fluctuating with water temperature (i.e., higher dissolved oxygen levels with colder waters). For the purposes of this report (since monitoring occurred in early part of each month), winter is defined as early January to early March; spring is early April to early June, summer is early July to early September, and fall is early October to early December.

Water Temperature in Creeks

Average water temperatures in the three creeks ranged from 52.8°F in the fall to 47.3°F in the winter to 54.5°F in the spring and 57.8°F in the summer (Table 1). The highest summer average temperature was 60.1°F in lower Hindley Creek. All of the recorded monthly water temperatures were below the maximum temperature requirement of 63.5°F for salmonid spawning, rearing and migration in the Washington Administrative Code.

Table 1. Seasonal Water Temperatures in Creeks (in degrees Fahrenheit)					
	Fall	spring	summer	winter	average
Lower Hindley Creek	53.1	56.4	60.1	46.4	53.1
Lower Shell Creek	51.8	53.3	57.1	46.9	51.9
Middle Shell Creek	51.4	52.5	54.7	46.9	51.2
Upper Shell Creek	50.9	52.1	53.1	47.2	50.7
Lower Shellabarger Creek	54.1	55.5	59.9	47.5	53.8
Shellabarger Creek - Upper middle fork	52.8	55.9	58.7	48.4	53.3
Shellabarger Creek - Upper north fork	53.1	56.7	--	47.9	51.9
Shellabarger Creek - Upper south fork	53.2	54.7	58.5	47.2	53.2
Lower Willow Creek	52.6	53.5	57.7	45.9	52.2
Upper Willow Creek	53.8	53.7	56.6	50.4	53.3

Water Temperature in Edmonds Marsh

Average water temperatures at all sites in the Marsh ranged from 53.9°F in the fall to 45.5°F in the winter to 57.1°F in the spring and 62.2°F in the summer (Table 2); all of which are below the maximum temperature requirement of 63.5°F for salmonid spawning, rearing and migration in the Washington Administrative Code. However, the water exiting the Marsh exceeded the standard in the spring and summer of 2016 with a high of 73.2 in June 2016. The north edge of the Marsh along Harbor Square exceeded the standard in all summer months.

Table 2. Seasonal Water Temperatures in Edmonds Marsh (in degrees Fahrenheit)					
	Fall	spring	summer	winter	average
East edge at storm drain	53.2	54.3	60.8	43.1	53.1
Eastern edge	52.8	54.8	60.2	46.3	52.6
Eastern edge at Hwy 104 Culvert	53.7	55.7	59.5	47.2	53.9
Harbor Square east culvert	55.6	57.6	65.4	45.9	56.1
Harbor Square west culvert	55.4	58.3	64.6	46.1	56.0
Marsh outlet	52.6	61.4	62.7	44.0	54.1

Dissolved Oxygen in Creeks

Average dissolved oxygen levels in the three creeks ranged from a low of 10.0 mg/L in summer to a high of 11.3 mg/L in the winter (Table 2). The lowest average was 9.3 mg/L in the south fork of upper Shellabarger in the summer. These are well above the 8.0 mg/L for salmonid spawning, rearing and migration in the Washington Administrative Code. Further, the measured dissolved oxygen levels in lower Shell Creek, where salmon spawn in fall and winter, were above 11.0 mg/L which is an optimum level for salmon eggs in the gravel.

Table 3. Seasonal Dissolved Oxygen in Creeks (in mg/L)					
	fall	spring	summer	winter	average
Lower Hindley Creek	10.1	10.2	9.8	11.5	10.5
Lower Shell Creek	11.0	10.8	10.5	11.7	11.0
Middle Shell Creek	11.3	11.1	11.1	12.0	11.4
Upper Shell Creek	9.9	10.0	9.8	10.5	10.1
Lower Shellabarger Creek	10.1	9.9	9.5	11.2	10.3
Shellabarger Creek - Upper middle fork	10.9	10.3	10.5	11.5	10.8
Shellabarger Creek - Upper north fork	10.4	9.9	--	10.8	10.4
Shellabarger Creek - Upper south fork	10.1	9.9	9.3	11.2	10.1
Lower Willow Creek	10.7	10.3	10.4	11.6	10.8
Upper Willow Creek	10.2	10.4	10.4	10.7	10.4

Dissolved Oxygen in Edmonds Marsh

Dissolved Oxygen - The main flow of water through the Edmonds Marsh (from Shellabarger inlet at the Hwy 104 culverts to the Marsh outlet) had dissolved oxygen averaging over 9.2 mg/L which exceeds the 8.0 mg/L minimum for salmonids in the Washington Administrative Code. However, dissolved oxygen measured on the northern edge of the Marsh along Harbor Square and portions of the eastern edge of the Marsh along Highway 104 were below standards. The northern edge of the Marsh along Harbor Square averaged 2.3 mg/L of dissolved oxygen and was below 2.0 mg/L (which is lethal to most aquatic organisms) except during periods of rainfall. The eastern edge of the Marsh, south of the Shellabarger inlet culverts, averaged 1.5 mg/L of dissolved oxygen.

Table 4. Seasonal Dissolved Oxygen in Edmonds Marsh (in mg/L)					
	Fall	spring	Summer	winter	average
East edge at storm drain	1.0	1.7	1.7	1.6	1.5
Eastern edge	5.9	6.1	5.4	8.9	6.8
Eastern edge at Hwy 104 Culvert	9.0	8.9	8.2	10.6	9.2
Harbor Square east culvert	1.9	0.3	1.1	2.3	1.4
Harbor Square west culvert	2.7	0.8	2.2	3.4	2.3
Marsh outlet	8.7	10.2	8.1	10.5	9.5

pH

All of the observed pH levels in the Creeks were within the pH 6.5 to 8.5 range that is suitable for salmon and within the Washington Water Quality Standards for aquatic life. pH levels ranged from 6.54 to 8.26 with an overall average of 7.7. The Edmonds Marsh had an average pH of 7.0 for all sites with the incoming/outgoing water averaging 7.3 and the north edges along Harbor Square more acidic with pH averaging 6.5. Measured pH was below the Water Quality pH standard of 6.5 on several occasions on the northern edge of the Marsh site along Harbor Square.

Conductivity

Conductivity measurements in all three creeks stayed relatively constant except during periods of rainfall which lowers the conductivity of water since rainwater is generally low in ions (thus low in conductivity). The conductivity measurements in the Marsh were affected by the opening of the tidegate with high conductivity levels recorded during saltwater intrusion. High conductivity readings in the Marsh are not unexpected since saltwater has much more dissolved ions and solids than freshwater.

Nitrates

Nitrate levels in all three creeks averaged 1.6 mg/L which is considered good. High nitrate levels can cause algal blooms which can deplete dissolved oxygen levels in water thus impacting fish and other aquatic organisms.

Salinity in Edmonds Marsh

The salinity of the water in the Marsh is affected by a tidegate located downstream of the Marsh outlet. The tidegate functions to prevent saltwater intrusion into the Marsh from mid-October to mid-March (to prevent flooding during periods of coinciding high rainfall and high tides). In mid-March, the tidegate is secured in an open position to allow full tidal exchange of saltwater through the spring/summer months. The salinity measurements at the Marsh outlet (which is representative of the main body of the Marsh) from December to early March (averaging 0.15 ppt) reflect the low salinity of the incoming freshwater from the Shellabarger inlet and lower Willow Creek. When the tide gate is secured open, the salinity measurements were significantly greater in the Marsh with an average of 6.36 ppt salinity. The Marsh outlet salinity measurements during months when the tide gate is secured open are affected by when in the tidal cycle the measurements are taken. The spring/summer monitoring protocol for the Marsh outlet calls for monitoring during low tide to avoid sampling incoming saltwater from Puget Sound, and thus results in variably lower salinity readings (due to mixing with freshwater) than would be observed during incoming tidal saltwater (since saltwater has a salinity of about 35 ppt).

Fecal Coliform Bacteria

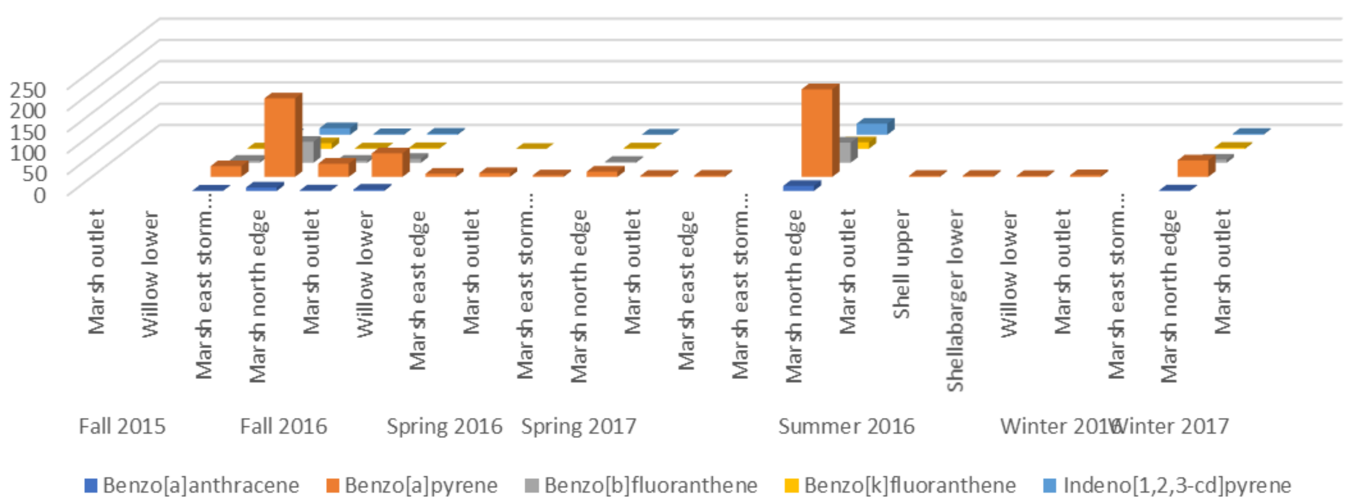
Counts of fecal coliform bacteria colonies cultured from water samples collected varied considerably by location/season/day. There are no Washington Water Quality Standards for fecal coliform for freshwater aquatic life. However, if we use the Washington criteria for water contact recreation (i.e., levels must not exceed a geometric mean value of 100 colonies/100 mL) as an indicator of a potential bacteria problem, then there are a number of samples that are of concern. Fecal coliform counts appear to be higher after a period of rain and we will be analyzing this further

Pollutants

Water samples were collected over seven seasons for analysis by the ALS Laboratory in Everett for heavy metals and petroleum derived compounds. Due to the high cost of pollutant analyses, not all sites could be samples nor were all tests run on each sample collected.

Twenty-two water samples were analyzed for 18 different polycyclic aromatic hydrocarbons (PAHs) that are identified as priority pollutants for analysis by the EPA. Only 10 of these PAHs had WA water quality standard (human health criteria) designated, and five PAHs were found in water samples at levels that exceeded those standards. The five carcinogenic PAHs (cPAHs) that exceeded standards in the samples were Benzo(a)Anthracene, Benzo(a)Pyrene, Benzo(b) Fluoranthene, Benzo(k) Fluoranthene, and Indeno(1,2,3-cd) Pyrene. Sixteen of the 22 samples had at least one of these five carcinogenic PAHs that exceeded the standard. Figure 1 shows the percentage over the standard for each of the CPAHs at each site sampled. Benzo(a)Pyrene occurred above standard in all of the 16 samples. All water samples (total of 4) collected from the north edge of Marsh (along Harbor Square) had cPAHs that exceeded standards, whereas only 2 of the 4 samples collected at same time from the east edge of Marsh at a storm drain had cPAHs that exceeded standards (i.e., Harbor Square edge is more polluted than the Marsh edges near Hwy 104).

Figure 1. cPAHs - Percentage over standard/criteria



Thirty-nine water samples were analyzed for heavy metals. All samples had low levels of arsenic, cadmium, chromium, cooper, and lead. Mercury was not detected at any of the sites. Iron and zinc had higher levels detected than the other metals. Further analysis of the occurrence of heavy metals relative to water quality and aquatic organism tolerance are ongoing.

Water samples were also analyzed for total petroleum hydrocarbons (TPH) and BTEX (Benzene, Ethylbenzene, Toluene, and Xylenes). TPH and BTEX were detected in some, but not all samples. These data will be further analyzed after collection of additional samples.

Macroinvertebrates

Students scanned the water samples collected at upper, middle and lower Shell Creek in 2016 and 2017 and identified the macroinvertebrates in the samples using a dichotomous key. The identified macroinvertebrates were then assigned to their respective pollution tolerance groups. The number of different types of macroinvertebrates in each group were summed and multiplied by a weighting factor (3 for Group 1, 2 for Group 2, and 1 for Group 3). The sum of the all the weighted values was then divided by the total number of macroinvertebrate types resulting in an index. The index value was compared to a quality ranking of 2.7+ being excellent; 2.0 to 2.6 being good; 1.6 to 1.9 being fair, and 0 to 1.5 being poor. Resulting student index scores fell in the 'good' quality ranking.

SHELL CREEK SALMON STEWARDSHIP

In the fall of 2016, in an effort to enhance the existing salmon populations in lower Shell Creek, students began a stewardship project working with streamside residents. Students conducted a door-to-door survey with residents to obtain local knowledge about the current and past salmon runs; obtain information on stream habitat (since all of the lower stream is on private property in back yards of residential homes) and willingness of residents to improve the habitat with native vegetation; provide handouts and informational material on salmon and their habitat to residents; gauge the willingness of residents to consider restoration projects to benefit salmon; and conduct direct observations of salmon to confirm numbers, species and conditions.

Students Saving Salmon worked in teams to visit and survey 28 of the 38 residences along lower Shell Creek (north of 7th and Glen Ave.). Survey data was entered into a database that is the start of an information base on the lower creek. Residents who expressed an interest in habitat restoration and having native shrubs added to their property were subsequently contacted to make arrangements for planting native shrubs that were made available free to residents through a Rose Foundation grant issued to Sound Salmon Solutions. About 320 native shrubs were planted by Students Saving Salmon at four residences along Shell Creek during the student's spring break in April 2017. An additional 80 native plants are planned for a fall planting on Holy Rosary Church property along Shell Creek.

In spring of 2017, WDFW gave permission to plant juvenile coho (raised in the Willow Creek Salmon Hatchery in Edmonds) into Shell Creek. All of coho raised in the hatchery are otherwise placed in the watersheds that drain into Lake Washington. Over 800 juvenile coho were planted in upper, middle and lower Shell Creek by Students Saving Salmon.

Students involved in the survey and plantings felt the project was a great opportunity for students to have an active role in the community in helping salmon. Students Saving Salmon plans to continue the Shell Creek Salmon Stewardship project into the future, including planting juvenile coho in the upper areas of Shell Creek each year.

RECOMMENDATIONS / CONCLUSIONS

The current water quality monitoring project should continue as is so that annual trends can be evaluated and baseline information established. Having a long-term data series will allow for future comparisons to potential environmental or pollutant driven perturbations and potential effects of climate change. We appreciate the support we've received from the Edmonds City Council and the City of Edmonds, and hope the $2,500 provided each year will continue as those funds are critical for obtaining the supplies necessary to conduct this project.

The project has demonstrated that a citizen science project utilizing volunteer high school students can be successful in collecting good quality scientific data and providing students hands-on experience in conducting field science. Students adhered to the field sampling protocols in spite of adverse weather in the winter and ensured quality data was collected throughout the year. From the student's perspective, the project has provided them valuable field science experience that they can/will apply in the future.

Water quality monitoring to date indicates the principal water parameters (temperature, dissolved oxygen, and pH) in the Creeks adhere to the requirements of the Washington Water Quality standards for salmon. We applaud the residents of Edmonds in helping keep our streams in good condition.

The Edmonds Marsh did not conform with the standards in all months monitored. The edges of the Marsh had low dissolved oxygen levels in most months and had more acidic water in some months. The Marsh also had higher in some summer months than are suitable for salmon. Better freshwater circulation, increased vegetation (trees and shrubs), and year-round tidal influx of saltwater may help alleviate the Marsh problems.

The occurrence of carcinogenic pollutants that exceed state standards and criteria is an area of concern that warrants further investigation by the City and the Port of Edmonds. It will also be important to continue collecting water samples for pollutant analyses - hopefully new grant funds will be available to the project after current funds are expended in November 2017.

Continued sampling for fecal coliform analysis needs to continue in order to obtain data to better understand when and why the spikes in bacterial counts occur. Although bacterial DNA testing is expensive, it may be beneficial to determine the source of the fecal coliform bacteria in the higher count samples (i.e., is it from dogs, birds, people, or other warm-blooded animals).

Students Saving Salmon plans to continue the Shell Creek Salmon Stewardship project because the outreach to residents and restoration efforts should benefit existing and future salmon that utilize Shell Creek. We plan to continue planting juvenile coho salmon (from the Willow Creek Hatchery) in the upper reaches of Shell Creek to bolster the resident population. We also plan to continue pursuing avenues (such as grants) to determine the feasibility and cost of undertaking a restoration project that removes the impassable barrier (a 5-foot waterfall) and allows salmon passage to the upper reaches of Shell Creek.

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We appreciate the encouragement from the Edmonds City Council, especially Diane Buckshnis, and Mayor Earling for funding support for operational expenses. The funding has allowed us to purchase critically needed calibration fluids, outreach materials, field supplies and equipment.

The project would not have been possible without Hubbard Foundation grant funds in 2015 that were used by the Edmonds School District to purchase the professional multiparameter water quality instrument. Special thanks to Dave Millette, Geoff Bennett and school district administration staff for helping secure the grant and purchase the water quality meter from YSI. Special thanks also to the Edmonds City Council, especially Diane Buckshnis, for funding the purchase of a new YSI meter for 2017.

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