file

PORT DICK CREEK TRIBUTARY RESTORATION PROJECT

EVOS Project #97139-A2 to #00139-A2

By

Geoff Coble, Coble Geophysical Services
910 East End Rd, Suite #1, Homer, Alaska 99603

Mark Dickson, Alaska Dept. of Fish and Game
3298 Douglas Place, Homer, Alaska 99603

This summary report describes how the *EVOS Port Dick Project* currently characterizes the 1996 Port Dick Creek Tributary Salmon Rehabilitation after long-term monitoring. The principle benefits of this project are given in *Section 6.0, Potential for Technology Transfer and Further Rehabilitation Research.*

1.0 Introduction

In 1991, the Alaska Department of Fish and Game (ADF&G) Commercial Fisheries Management and Development Division, conducted restoration surveys on the outer coast of the Kenai Peninsula to identify pink salmon *Onchorynchus gorbusca* and chum salmon *Onchorynchus keta* spawning systems that would benefit from instream habitat restoration. Port Dick Creek, located within Kachemak Bay State Wilderness Park approximately 25 miles southeast of Homer (Figure 1) was chosen because: 1) the 1964 earthquake reduced the available spawning habitat, 2) Port Dick Creek is considered one of the more important wild pink and chum salmon production streams in the Lower Cook Inlet area, and 3) the minimum spawning escapement goal at Port Dick Creek for chum salmon had not been met since 1994, which could (without restoration) ultimately mean the extinction of a genetic stock of salmon. The goal of the project was to restore the decline in native stock abundance and provide for a harvestable surplus of pink and chum salmon, as a mitigative measure in response to the Exxon Valdez Oil Spill (EVOS).

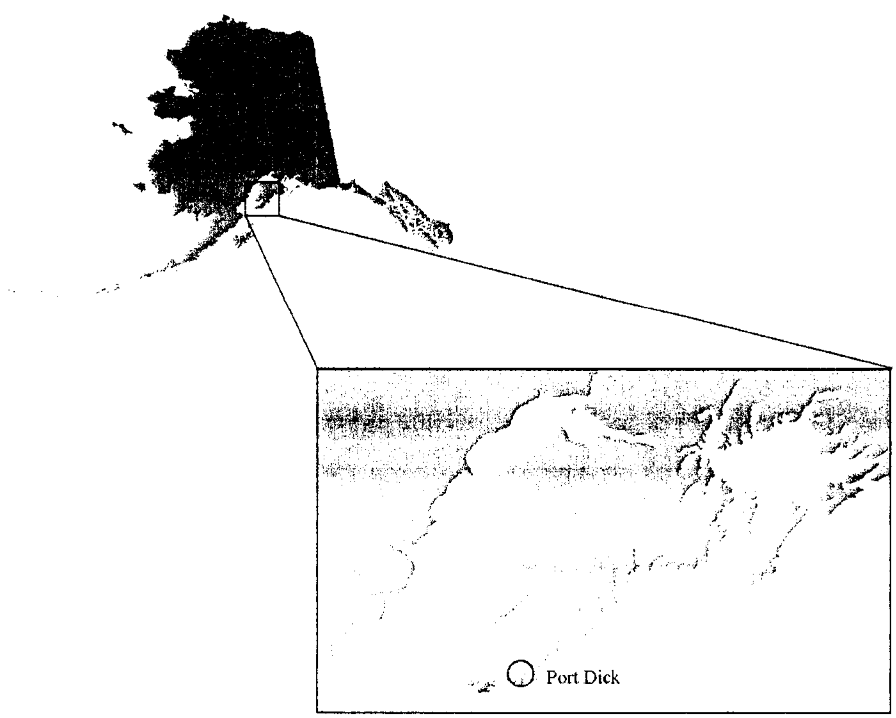


Figure 1. Map showing the location of the Port Dick Creek Project site.

To accomplish this goal, two spawning channels were designated and constructed in the spawning grounds known to have been uplifted from the 1964 earthquake. The two channels were designed from discharge information collected prior to their installation in June of 1996. Biologic, hydrologic and sedimentologic monitoring had been undertaken since the inception of the project to determine the relative performance of the constructed spawning channels and ways to improve the spawning channels. The monitoring included surveying the movements of cobble-sized numbered tracers (>700), surveying eight channel cross sections, monitoring discharge rates, temperature, conductivity, scour chains and riffle elevations.

The project needs gradually changed with changes in the channels in the years following rehabilitation, and consequently other types of monitoring were added voluntarily. Extensive efforts were made to understand these channel enhancements through this 0additional data collection, including data to define the hydrogeologic setting.

2.0 Hydrogeologic Setting

The Port Dick restoration project is contained in the cobbles and gravel of an alluvial fan (Figure 2). Alluvial fan deposits are abundant in the Gulf of Alaska, although they can be covered with vegetation and uplifted to a point where they are difficult to discern using aerial photographs. The present-day surface water expression of this alluvial fan is represented by a single intermittent stream, although two areas along the base of the fan contained visible springs, which indicate preferential groundwater pathways.

There is a relationship between the present-day groundwater pathways and the initial formation of the alluvial fan. When the alluvial fan was first formed, there was a lack of well established surface vegetation and braided streams fanned out over the entire circled area of Figure 2, depositing the coarse alluvium in the fan shape shown. This fact is hydrologically important to salmon spawning channel enhancements during low runoff periods, since the alluvial fan continues to distribute groundwater (or base flow) in a fan shape, and in particular using remnants of the better-established drainage patterns.

Figure 2. Aerial Photograph of Port Dick Creek Tributary Restoration Project Alluvial Fan

The transition from mountain stream to a higher order stream in the coastal Gulf of Alaska is often characterized by tributary alluvial fan deposits. The Port Dick Creek tributary alluvial fan also follows the typically pronounced change in slope between alluvial fan and alluvial plain sedimentary deposits. This change in slope becomes important in stabilizing enhancement projects and keeping an enhancement from braiding and reducing the spawning area. For example, Chum salmon are typically found below the first barrier of any significance in a river (*Groot & Margolis,* 1991; *Dickson and Coble,* 2000), which can be directly controlled by stream slope.

Another characteristic of alluvial fan deposits that can have implications for salmon rehabilitation projects is a rapid downstream fining of the alluvium. The size of gravel and suitability of an alluvial fan deposit for enhancement can depend on the degree to which the higher order stream system has truncated the base of the fan (in this case Port Dick Creek of Figure 2).

3.0 Spawning Channel Optimization: Numerical Modeling

The Port Dick Creek restoration project was essentially two channels constructed into the variable flow conditions within the base of an alluvial fan deposit. In the Primary Channel, which was the original path of surface water discharge, a large amount of material was removed, followed by the construction of a 7-foot high seepage face and numerous bank stabilization areas. The Secondary Channel was constructed in a relatively low-grade area primarily as a spring-fed system, though significant surface water enters the system during high runoff periods. Very little bank stabilization was required in the Secondary Channel due to the shallow depth of construction (typically less than 1 meter) and the presence of dense vegetation.

The Primary and Secondary Channels were constructed in a relatively high- and low-surface water energy environments, respectively. The performance of the two channels has varied considerably using both biologic and sedimentologic data, particularly during periods of low runoff. The objectives to improve and optimize the spawning channel design depend on examining that data for these low flow periods where the spawning area is most limited. Figure 3 and 4 show stream channel cross section elevations for the mouths of the Primary and Secondary Channels, respectively, for each year from 1996 to 1999. The vertical scale has been exaggerated to show detail.

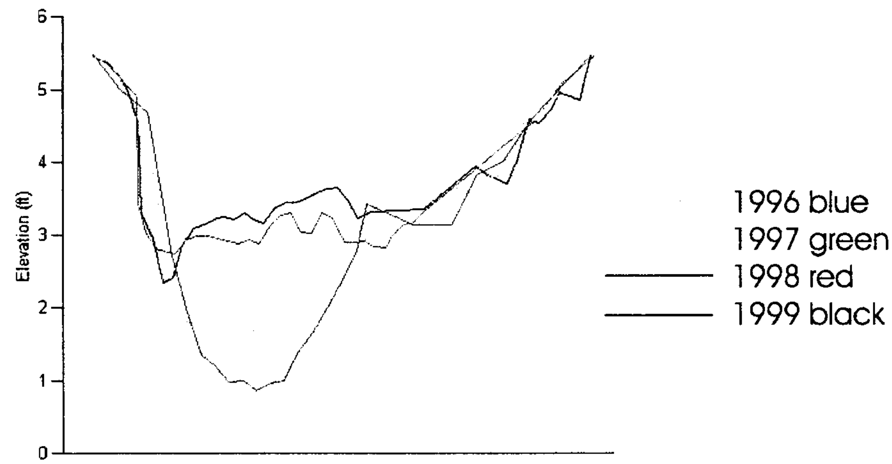


Figure 3. Primary Tributary Streambed Elevation Cross Sections

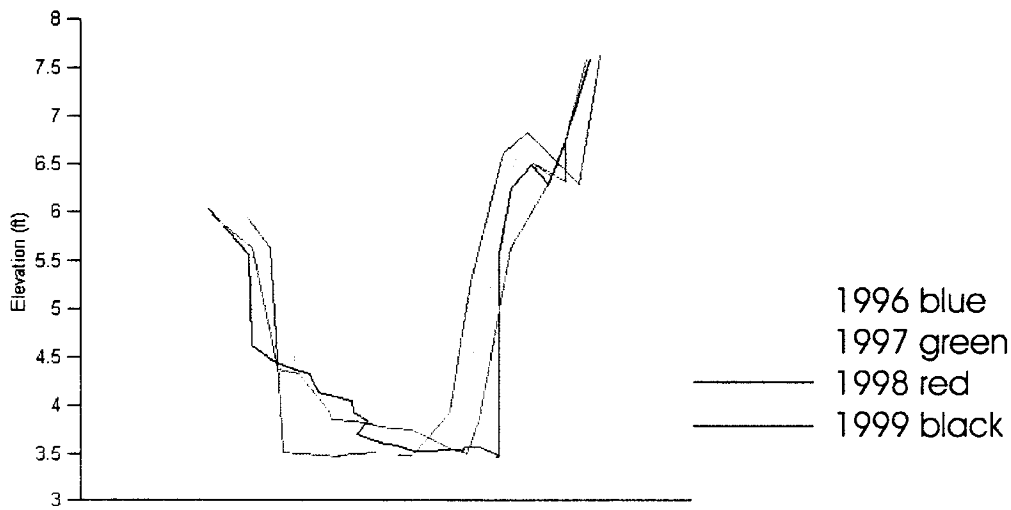


Figure 4. Secondary Tributary Streambed Elevation Cross Sections

The wetted cross sectional area that a salmon would see has not changed significantly in the secondary channel (Figure 4), however the surface area has been reduced significantly in the higher-energy primary channel due to channel widening as well as from sediment in-filling (Figure 3).

The adult salmon spawning period in this system is typically between July and September, a period frequented by low precipitation and often low discharge events. The objective to improve and optimize the spawning channel design depends on examining these low flow periods when the spawning area is most limited. Since alluvial gravels are among the most permeable of sedimentologic facies, it was therefore critical to define the groundwater-surface water interaction. The alluvial deposits are so permeable at the tributary enhancement area that the headwaters become subterranean in at most 100 meters during typical flows after entering the alluvial deposits.

Therefore, groundwater data was deemed necessary to understand the Port Dick Creek tributary project. Groundwater information was also necessary to calculate optimal rehabilitation conditions, and to facilitate transfer of design information for future rehabilitation and enhancement projects to other areas. A voluntary field effort to define groundwater potential was conducted using twenty-one temporary piezometers distributed over the wooded alluvial fan. Each piezometer was accurately surveyed for elevation and position back to the bedrock datum established for the project in September, 1999.

Surface water elevations were measured concurrently to groundwater measurements on 9/24/99, and a vertical gradient was determined at five locations to confirm the apparent recharge and discharge patterns using nested piezometers. Streambed elevation measurements were also taken to augment those regularly measured at the site for modeling purposes.

The piezometers confirmed that the project headwaters on 9/24/99 experienced large groundwater recharge potentials into the permeable alluvium immediately upon entering the tributary fan. The stable headwater discharge at low runoff periods was one reason why the site was selected for rehabilitation, yet much of this discharge was immediately redistributed as groundwater. Greater than 60% of the low flow discharge entering the alluvial fan was discharged as base flow from the fan directly into Port Dick Creek (9/99).

A numerical model was assembled to further understand the system and to design improvements that could help boost chum salmon spawning area. The groundwater potentials were used to calibrate a groundwater-surface water interaction model using the USGS MODFLOW finite difference model (numerical modeling is very well suited to homogeneous alluvial deposits). The Primary, Secondary, and Port Dick Creek stream flows were represented in the model using 210 nodes at 8-meter intervals as shown in Figure 5 within a groundwater model grid of 5040 nodes over a modeled area of 0.15 square kilometers.

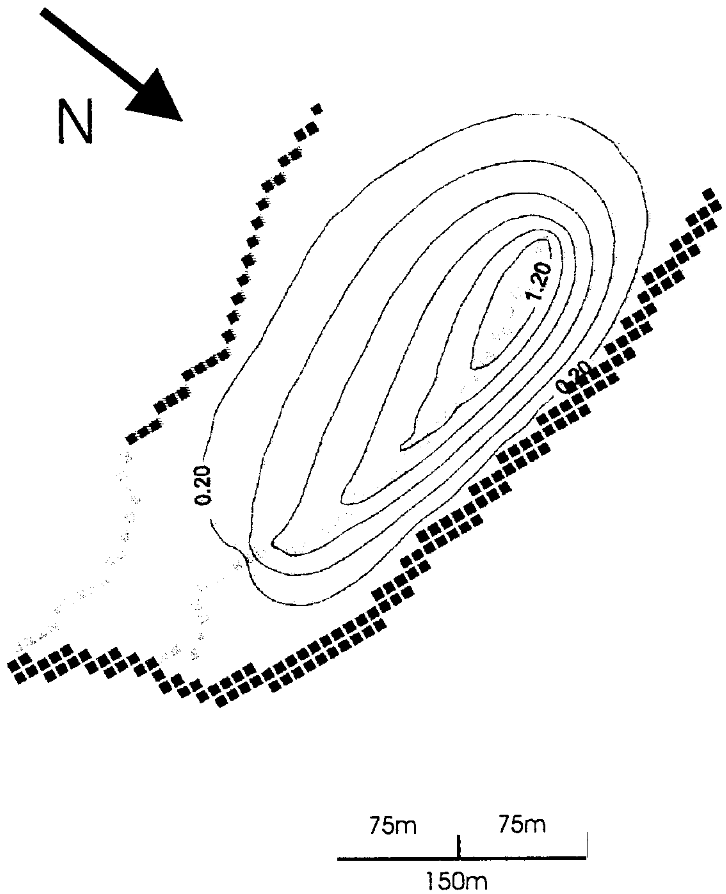


Figure 5. Groundwater-Surface Water Numerical Model showing effects of the optimized Secondary Channel enhancement (light blue) on the modeled groundwater potentials of 9/24/99. Black contours are drawdown in feet, dark blue = Port Dick Creek, green = original rehabilitation, red = native primary channel.

Surveyed dimensions of streambeds and streambed elevation and surface water potential were interpolated and used within each node. Alluvial gravel hydraulic conductivity was approximately 85m/day after calibration assuming a homogeneous aquifer. The barrier boundaries to the model were considered bedrock, and several bedrock locations were surveyed in the field to support the numerical model. Constant head boundaries were used in a steady state model calibrated to the actual potentials to within 0.2 ft of head while maintaining model homogeneity.

The numerical model was then used to optimize a channel position, dimension and elevation that would increase the 'low flow period' discharge of the more stable Secondary Channel exclusively through alluvial base flow. The specifications for construction of this enhancement are precise due to the extremely high hydraulic conductivity of the alluvial matrix, and include a streambed slope of 0.003.

The changes in groundwater potentials caused by the new enhancement are shown in Figure 5 (in feet). This enhancement quadrupled the low flows of the Secondary Channel, while reducing the flow in Port Dick Creek by less than 1 percent.

Further measurements would be required to determine if an enhanced Secondary Channel would have sufficient stream power over its entire reach during a high runoff period to promote adequate sediment transport. This aspect of the approach to stream rehabilitation and enhancement can save considerable costs in construction, including minimizing costs of excavation and conservation of materials, which are very important considerations for rehabilitation of remote salmon spawning systems.

4.0 Biological Performance Monitoring

Suitability of the restored tributaries to salmon spawning was measured through fry production. Pink and chum salmon fry were captured in fry traps each spring as they emerged from the tributaries. The fry traps were located at the downstream end of each tributary. Salmon fry were identified by species, counted daily and graphed for each year since the inception of the project. These results are summarized in Figure 6, where linear interpolation was used for days when the traps were removed due to high discharge events.

The area available for spawning was determined by use of streambed elevation measurements taken near the mouth of each tributary. Changes in the area available for spawning for each tributary such as shown in Figures 3 and 4 are just one of many factors to consider when interpreting Figure 6. The available spawning area within the secondary tributary remained stable for the period while decreases were documented for the primary tributary. Correspondingly, pink and chum fry production in the primary tributary steadily declined as shown in Figure 6 regardless of spawner abundance, while pink and chum salmon fry production in the secondary tributary (shown above) increased from 48,140.

In addition, the adult escapement levels of chum salmon have improved, as shown in Figure 7. No study directly linking this result to the stream rehabilitation project was pursued, however, which would be necessary for such conclusions since many other factors are involved in adult escapement levels.

5.0 The Significant Role of Tectonic Uplift

Coarse-grained alluvial deposits are sometimes indicative of areas of tectonic uplift, in this case uplift at a continental margin (*Rust*, 1983). Coarse-grained alluvial deposits are abundant in the entire Gulf of Alaska region, which is tectonically defined by a continental margin. This region contains numerous important salmon spawning systems, making it likely that the Port Dick project results have broad applicability. Some of the highest continuous rates of land surface uplift in the world are in this area, as shown in Figure 8.

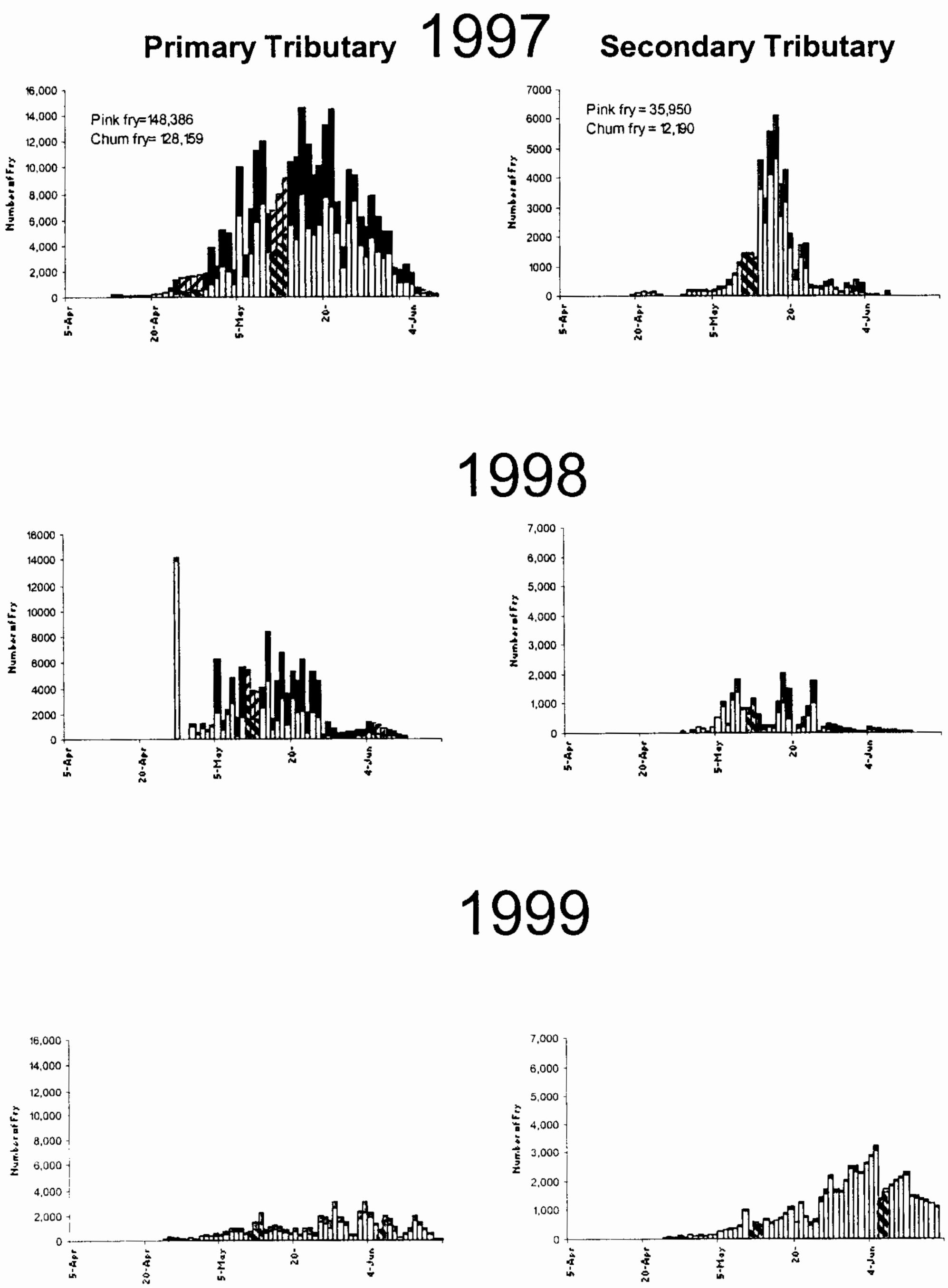


Figure 6. Pink and chum salmon fry emigrant numbers from the primary (left column) and secondary tributaries at Port Dick Creek, Alaska. Emigrant numbers were linearly interpolated (diagonal bars) for days when the fry traps were not fishing. The dark bars represent chum fry.

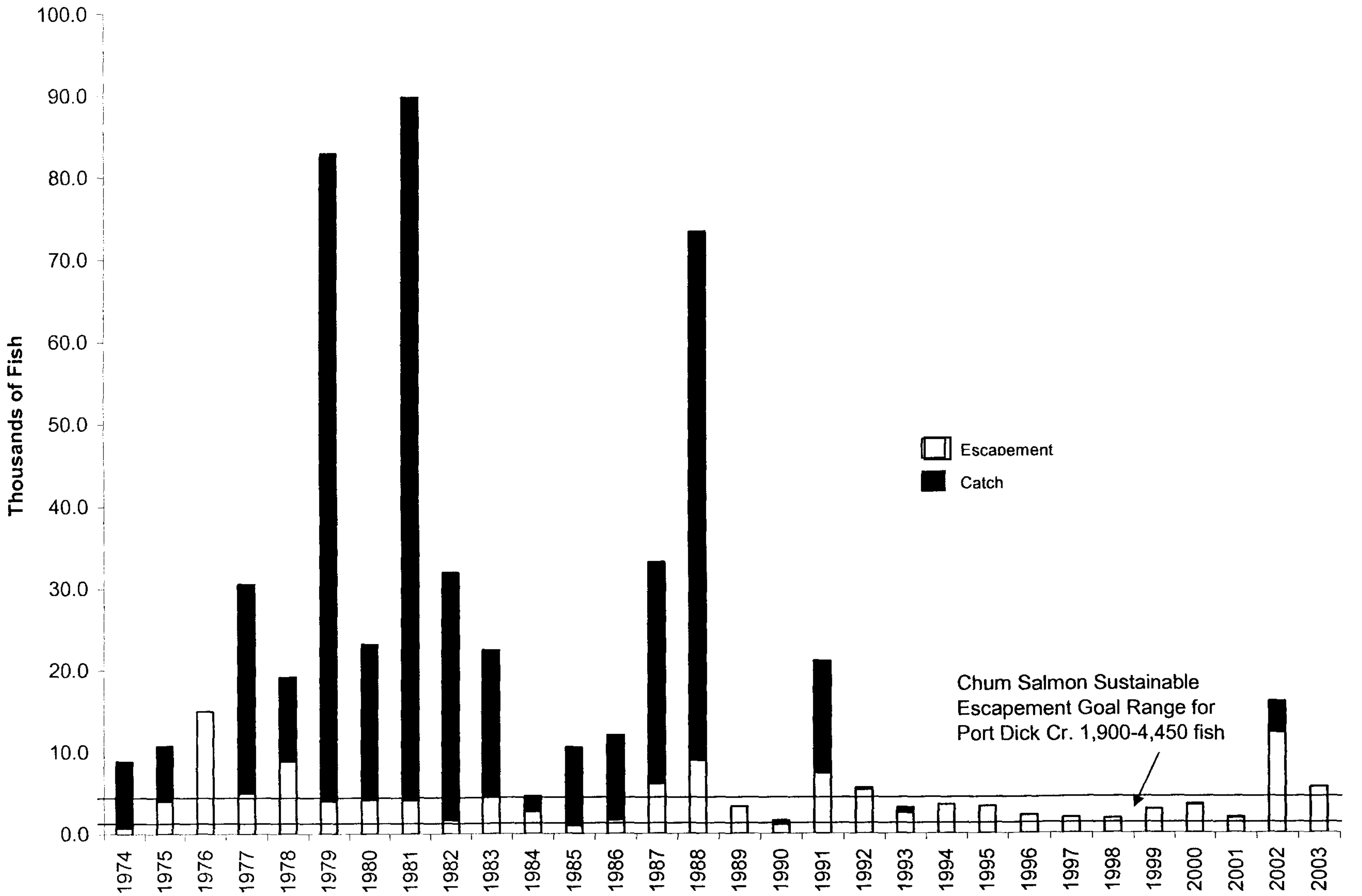


Figure 7. Total return (catch and escapement) of Port Dick salmon, 1974-2003.

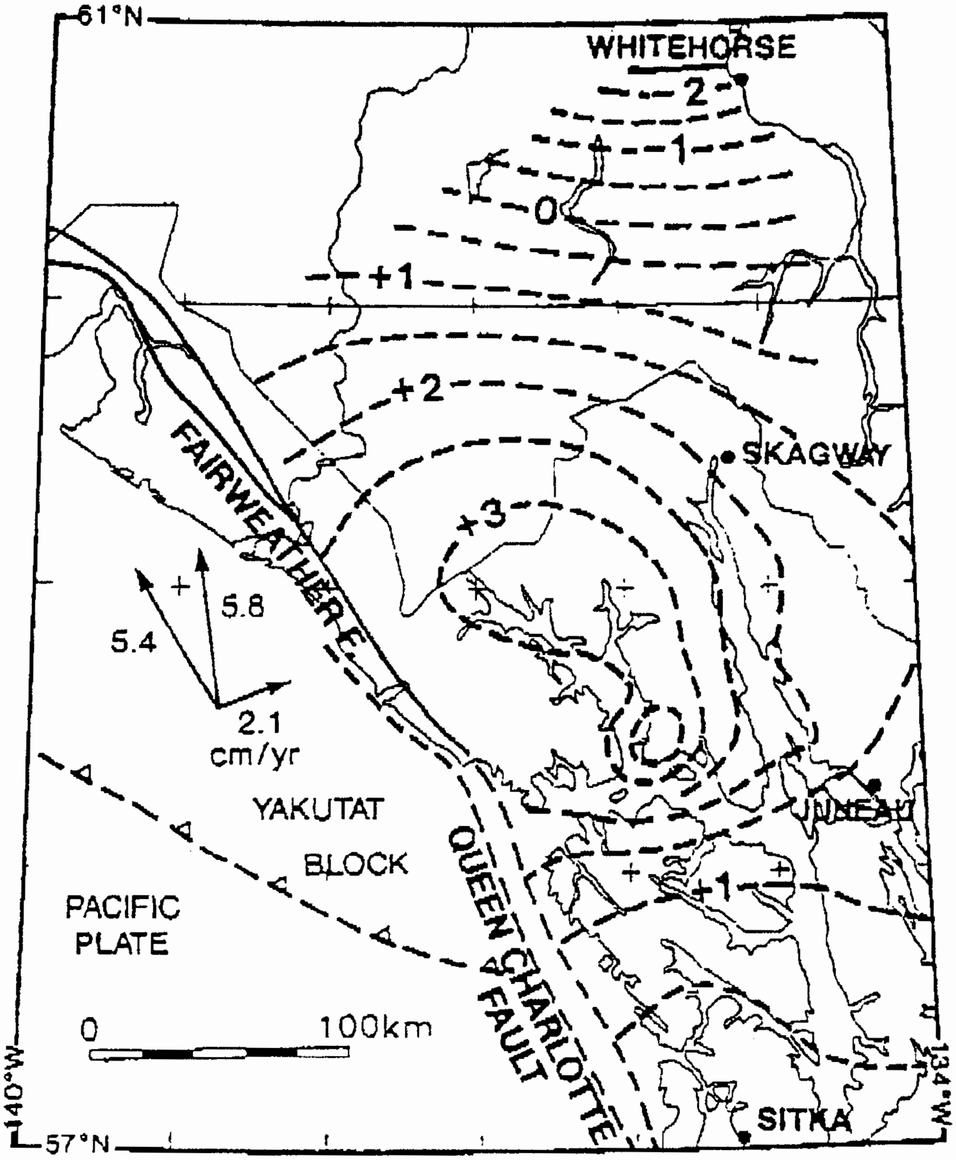


Figure 8. Tectonic uplift rates in the Gulf of Alaska Region (cm/year)

Increased knowledge of seismic activity in the area has more recently indicated that tectonic activity may be a greater factor for the emergence of land surface with respect to sea level than rebound from deglaciation.

6.0 Potential for Technology Transfer and Further Rehabilitation Research

Pressing issues that cause severe salmon declines will occur, requiring methods of enhancement for preservation of genetic stock of whole systems, as is the case for Port Dick Creek. Examples of this within Port Dick include the salmon genetic stock for Island Creek, which has also had salmon stocks in serious decline. Geologic similarities in the alluvial deposits of Island Creek as shown in Figure 9 compared to the Port Dick Creek tributary restoration alluvial deposit of Figure 2 make it one of many potential candidates for technology transfer of enhancement for preservation of genetic stock of salmonids. Technology transfer goals can be accomplished by characterizing the hydrogeologic setting of a site to determine rehabilitation or enhancement parameters, and by creating a numerical model designed to establish and optimize spawning channels in alluvial deposits.

Specific examples abound in coastal South-central and Southeast Alaska where natural processes are creating uplift (and consequent emergence of land relative to sea level), which can produce dewatered and unstable surface water spawning grounds similar to the Port Dick Creek tributaries.

For example, land surface uplift in the Mendenhall Valley is likely to have impacted the groundwater system, including subsequent ncision or aggradation of stream channels which also affect the altitude of the water table. Groundwater-fed streams, such as Jordan Creek and Duck Creek, are sensitive to fluctuation in watertable elevation. Both of these streams have reaches that are routinely subjected to dewatering. Some lowering of groundwater levels could be expected as a result of continued incision of the Mendenhall River. Other salmon enhancement projects in Southeast Alaska are in need of a groundwater evaluation for better enhancement designs, which include Ophir Creek near Yakutat (a cooperative effort between USGS, USFWS, USFS and ADF&G) and Duck Creek near Juneau, Alaska which is principally a groundwater-fed stream that has reduced streamflows as a result of dewatering of the channel (*Neal*, 2000).

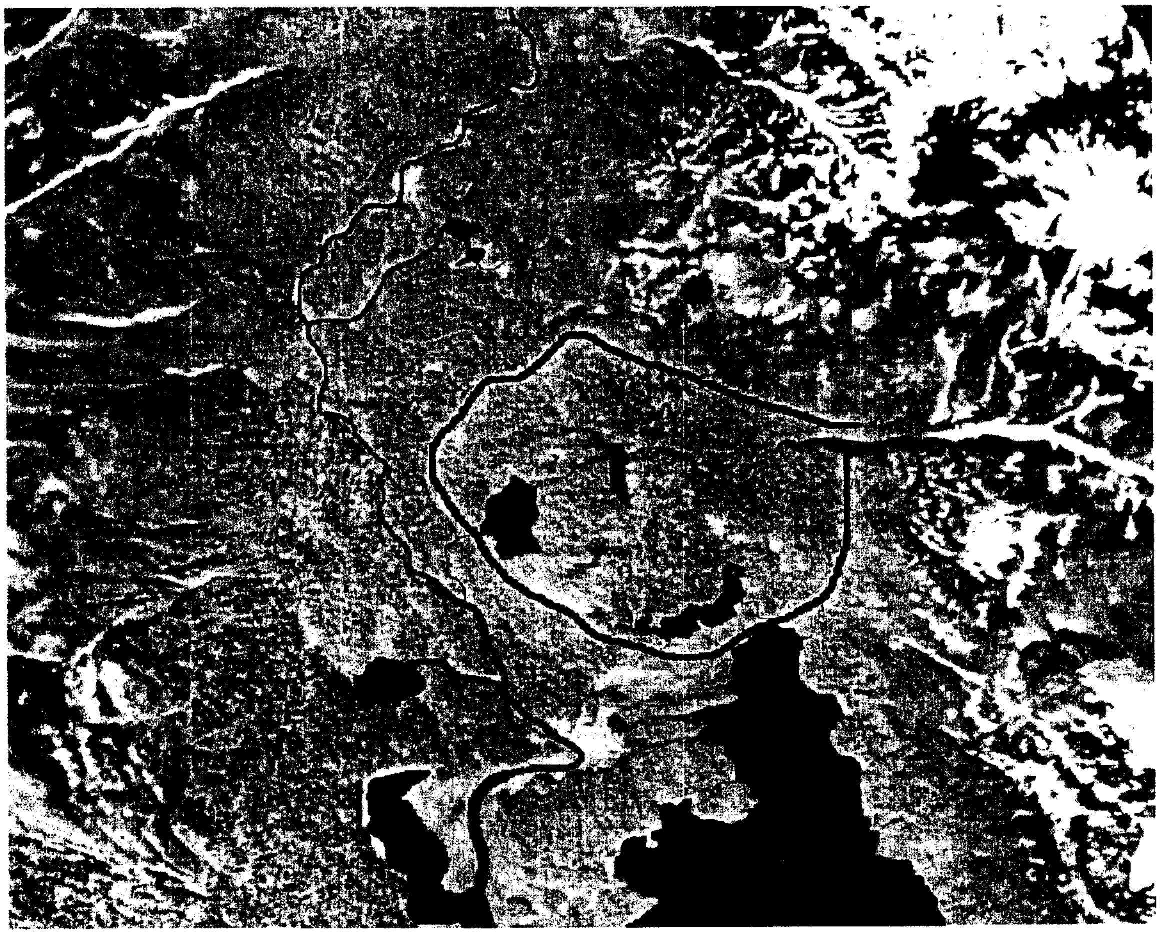


Figure 9. Island Creek Alluvial Fan, Port Dick, Alaska

Geoff Coble CGS
5/24/2004

Summary Timeline for CGS Involvement in the Port Dick Tributary Rehabilitation Project

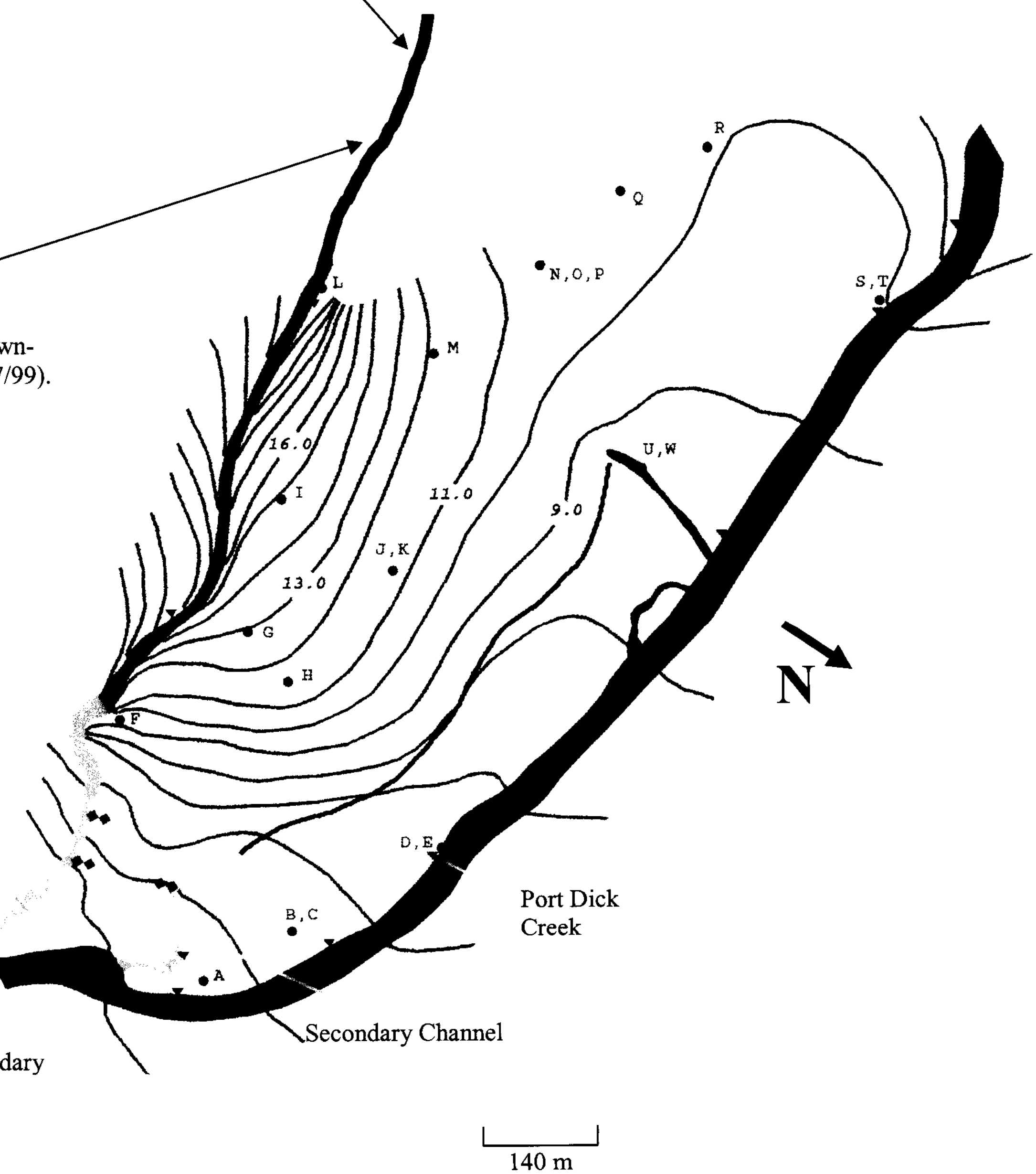
1990-1994	
•	The Port Dick enhancement was always something rehabilitation biologist Nick Dudiak (ADFG, 1977-1996) had wanted to do. The dry main tributary of Port Dick Creek was one in which local fishermen told him used to produce a lot of salmon prior to the 1964 earthquake. The 1989 oil spill occurred, and EVOS solicited Homer ADFG for projects that may have been injured by the spill; since the Port Dick genetic stock of chum salmon was in danger of extinction, the tributary enhancement project was initiated. EVOS funded helicopter trips to Port Dick for preliminary data collection. The headwater discharge to the main tributary was examined for consistency, and annual proposals were submitted to EVOS through ADFG.
1995	
•	CGS met Nick Dudiak after a slide show in Homer City Hall Chambers
•	November 11/13-11/14 CGS installed temporary monitoring equipment to assist in channel excavation and preliminary design work; EVOS told Homer to accept all of CGS work- incorporate all of his proposed work plan without any increase in budget; local office complained and budget was subsequently changed
1996	
•	**Summer**, channels constructed with CGS. ADFG administration determined that since CGS compensation was over 10K, the professional services had to go out to bid
•	CGS had proposed long-term physical monitoring of the channel enhancements
•	**Fall**, Monitoring project put out to bid; HDR, Shannon & Wilson and CGS bid on job, and no parties felt that the budget was adequate: CGS got the job, mostly to stand behind work done already, and because work was important (saving a genetic stock of salmon from extinction)
1997	
•	primary channel infilling, fry output a significant success; monitoring budget reduced
1998	
•	primary channel infilling, fry output reduced; monitoring budget reduced
1999	
•	primary channel infilling continues, primary fry output reduced, 2ndary steady, monitoring budget reduced.
•	ADFG completed the 3-year biological assay; CGS therefore needed to move to another lead agency
•	**September** CGS does extensive groundwater field work outside of contract to further define enhancement channel system, to look for ways to improve

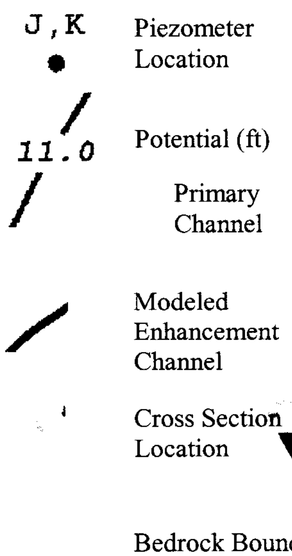
	spawning area and save Chum salmon genetic stock; groundwater numerical modeling 1999 Fall to 2000; State Parks visits 12/30/99
2000	
•	**Spring:** CGS submitted proposal 00540-BAA to EVOS through NOAA for reduced long-term monitoring. Proposal is not funded.
•	CGS submitted proposal 00539-BAA for technology transfer (a proposed emphasis on groundwater effects). Proposal is not funded.
•	Final report was put together using annual reports and original monitoring approach
•	**Fall**: photocopies of report submitted by ADFG for review for first time.
2001	
•	collect discharge data, download dataloggers, 2/22/01
2002	
•	collect datalogger data, discharge data, do stream cross sections, 11/08/02 – 11/10/02
•	Perform pumping tests using hand augurs and generator, complex data set
2003-present	
•	Monitoring equipment still in place, dataloggers still functioning with solar panel

Bedrock and water source directly above alluvial fan (photographed on 6/17/99).

Groundwater Potentiometric Surface (9/24/99), Aquifer Boundaries, and Proposed Channel Enhancement, Port Dick Creek Tributaries, Port Dick, Alaska.

Dry gravel streambed approximately 100 meters down-stream (photographed on 6/17/99).





COBLE GEOPHYSICAL SERVICES
hydrologic and geophysical consulting