Investigation into the Historic Status of Cannery Pond and its Potential as a Future Pocket Estuary

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Abstract

Pocket estuaries in the Puget Sound basin are proving to be valuable rearing habitats for juvenile out migrating salmon and important nursery grounds for some other marine fish species. Many pocket estuaries have been adversely impacted by development and lost as rearing habitats. There is speculation that Cannery Pond, now a freshwater pond system and located next to the Washington State Ferry Terminal on northwest Fidalgo Island, was once a pocket estuary before a railroad berm was constructed on its beachfront. The goal of this project was to conduct research designed to answer the question: "Was Cannery Pond historically a pocket estuary with a channel connection to the marine waters of Guemes Channel?" During this project we attempted to answer this question by researching various archival sources and by collecting sediment cores in the pond to ascertain sediment types and the presence or absence of marine indicator species (e.g., clam, mussel or snail shells). We also conducted background research into the physical and chemical nature of Cannery Pond and offshore waters, characterized the flora and fauna of Cannery Pond, and monitored offshore marine fish species with a special eye to use of this area by juvenile salmonids. Our findings suggest that Cannery Pond has likely always been predominantly a freshwater wetlands system and that there is little evidence that it served as a historical pocket estuary, although it may have been periodically affected by temporary channels connecting it to Guemes Channel or by high tide storm surges. Results of beach seine sampling showed that juvenile salmon, which could use Cannery Pond if it were a pocket estuary, are present in the marine waters offshore of the Cannery Pond area. Several scenarios are presented regarding possible future "restoration" of Cannery Pond.

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INTRODUCTION

Background

Cannery Pond, located west of the Anacortes, Washington is a freshwater system a little larger than one hectare in size. The pond is located on Western Washington University's Shannon Point Marine Reserve situated on the northwestern tip of Fidalgo Island (Fig. 1). Cannery Pond is bordered to the north by Guemes Channel and to the east by a Washington State Ferry Terminal, which provides transportation to the San Juan Islands and Vancouver Island, Canada.

In 1891, a berm was built by the Burlington Northern Railway on the northern perimeter of the pond along Guemes Channel (Fig. 2). The base of the berm was built approximately at the Ordinary High Water Line (OHW), and varies in height between 3-5 m. There are historical remnants of railroad track running along the top of the berm, which is approximately 3 m across. The remaining boundaries on the northwest and southwest sides of the pond are dense forest areas primarily consisting of secondary growth, shrubs and wetland species, all of which lie within the Shannon Point Marine Reserve.

Research Question

Small coastal bays, lagoons and dendritic delta channels located along the shores of Puget Sound and connected to it by channels are known as pocket estuaries. These pocket estuaries are important feeding and resting habitats and refuges from predation for juvenile out migrating salmon (Fresh 2006; Beamer et al. 2003, 2005; Simenstad et al. 1982) and various marine fishes.

Since 1891, Cannery Pond has been completely isolated from the marine waters of Guemes Channel by the construction of a berm to support railway tracks. Prior to this construction, the wetlands of Cannery Pond may or may not have been connected to Guemes Channel by a permanent or transient channel. However, evidence of a possible connection has been elusive. In 2008, MacLennan and Johannessen (2008), during their investigation of the Guemes Channel area of Fidalgo Island, noted that Cannery Pond "is an intriguing coastal wetland, the historic configuration of which is largely unknown." These authors further state:

> "Similarly configured coastal wetlands are frequently observed throughout the region; however, it is very rare for a naturally occurring bank of moderate height to be observed water ward of a wetland, and the genesis of such a coastal feature is highly questionable. For these reasons and using the best professional judgment acquired from (cumulative) decades of local costal expertise, it is the preliminary opinion of CGS staff that this "Lake" was originally an estuarine embayment. The restoration of the tide channel seems entirely feasible, though additional research should be undertaken to document and assess its historic condition, the appropriate tide channel configuration, and to determine the approximate tidal elevation to which it should be restored."

It was the goal of this project to research the question regarding the possibility that Cannery Pond was once a pocket estuary versus a freshwater pond or wetlands.

History

In the summer of 1890, a deal was closed between the Northern Pacific Railroad and the Oregon Improvement Company to expand railroad lines to connecting lines both east/west and north/south in the northwestern Washington area. This prompted the small town of Anacortes consisting of 40 people to grow to nearly 3000 people in only a few months. At that time rail lines already stretched from Seattle to Fairhaven, but were yet to be constructed further westward to Fidalgo Island, and ultimately Anacortes. As part of the Oregon Improvement Company deal, a stretch of roughly 20 miles of track was placed between Sedro Woolley and Anacortes, which was slated to be the biggest Pacific Coast terminus of the railway system. On August 5th, 1890 the first regularly scheduled passenger train ran the tracks from Anacortes eastward to Sedro Woolley, Washington.

In 1891 a railroad extension was constructed, connecting Ship Harbor to Burrows Bay (Fig. 3). The ultimate plan was to tie the Port Townsend Southern Railway to the Seattle & Northern Railway by ferry between Port Townsend and Ship Harbor or Burrows Bay (Armbruster 1999). The route extension of only 2.5 miles in length ran around Ship Harbor, west around Shannon Point and south through the historic Havecost farm. It was this track that prompted the building of the berm bordering the northern portion of Cannery Pond. This extension of the track was never used, and in 1897 the rail line was sold and removed. The rail line from Ship Harbor to Burrows Bay was reconstructed by Great Northern Railway in 1929 to connect to the E.K. Wood Mill at Burrows Bay and was used until 1952 (Slotemaker 2007).

During the late 1800's and early 1900's there was much talk of Anacortes developing into a high-density coastal city. The area had already seen major growth with commercial fishing and the forest industry. By 1893 the first cannery was established and numerous fishing vessels were based out of Anacortes. The commercial fishing industry during the late 1800's began to see the better development of technical fishing equipment, which allowed for a larger harvest of fish with less physical effort. It was during these years that Puget Sound saw the first gas-powered motor, which made purse seining much easier. Before some of the newer inventions were seen, set traps, reef netting, gill netting and small purse seines were used for fishing. In 1903, Edmond Augustine Smith developed the first automatic fish processing machine, which allowed canneries to mechanically scale, debone and pulverize salmon for canning purposes at a rate 10 times faster than any person. By 1900 there were 6 canneries operating in Anacortes along with 2 cod curing plants. Only 15 years later in 1915, 11 of the 40 canneries along the Washington Coast from Bellingham to Olympia were in Anacortes.

Importance

Estuaries are located along coastal waters, where hydrologic and geologic conditions help to form a system in which fresh and marine waters mix. Estuaries vary in size, some of the smallest being pocket estuaries. Pocket estuaries are often formed behind coastal shores created from sediment deposition. They also form around small creek outlets or are associated with groundwater mixing, reduced salinity and also often contain vegetation linked to low energy environments.

Pocket estuaries fall under the Marine Science Panels' definition of Nearshore Habitat, which is described as "intertidal and shallow subtidal marine waters, unvegetated zones, rocky shores, sand and mudflats, and eelgrass, kelp and intertidal algal beds." Nearshore habitats are further grouped into nine categories, with pocket estuaries falling within the "Rock-Gravel Habitats", which dominate beaches throughout Puget Sound (Lynn 1998). These tidal areas provide spawning grounds for surf smelt, habitat for other invertebrate species, as well as habitat for shorebirds, ducks, seals, raccoons, deer and other fish species. They also are habitats for large populations of amphipods, a major food source for juvenile salmonid species. As part of a Skagit Bay study, juvenile Chinook salmon were found to prefer non-natal pocket estuaries compared to other nearshore habitats (Beamer et al. 2003). It was also found that Chinook salmon experience improved growth and higher survival rates than those in non-protected areas. Estuaries are also known to serve as nurseries for other fish including surf smelt, which are vital salmon prey.

Because of its geographic location, Cannery Pond may have been the last in a long chain of pocket estuaries running from the southeast side to the northwestern tip of Fidalgo Island (Fig. 4), some of which need restoration to be functional once again. Each of these pocket estuaries is important in that the alteration of one forces migrating juvenile salmonids to travel further between resting and feeding areas. There has been considerable nearshore habitat loss over the last century, primarily from anthropogenic causes. Fidalgo Island, like much of the Puget Sound shoreline, has seen significant human activity. Lynn (1998) listed some anthropogenic activities impacting nearshore environments, the most important for Cannery Pond include land filling, shoreline armoring, diking, clearing, grading and water flow alteration.

The Pacific Northwest has seen large declines in salmon populations along with commercial fisheries around the world. This can primarily be attributed to habitat loss and degradation (Nehlsen et al. 1991). Salmon use a wide variety of habitats throughout their lives. As nearshore land is further developed, the diversity of habitats is lost, becoming fragmented and patched, thusly contributing to the decline in useable landscape for migrating juvenile salmon. Pocket estuaries offer vital protected habitat for feeding and resting areas in which juvenile salmonids and other fish species can take refuge while migrating towards marine waters (Beamer et al. 2003).

Previous Studies

Previous biological research completed on the Cannery Pond system is limited. A cursory wetland delineation assessment was conducted, likely in the 1960s or 1970s by an unknown party. In April of 1999, Western Washington University (WWU) students used Cannery Pond as a research study site. The information gathered in this short-term study included the sampling of vegetation and fish, bird and mammal surveys (WWU 1999). A second similar WWU class study (Muller 2010) was conducted in 2010 and focused on the pond fishery resources and stomach contents of largemouth bass.

Project Goal

The goal of this project was to determine if Cannery Pond was once a pocket estuary connected tidally to Guemes Channel. Fidalgo Island and the pocket estuaries located along its shoreline play an important role in salmon habitat, providing a sanctuary for development and eventual migration to sea. Cannery Pond may be especially important as it might possibly be the last pocket estuary along the Fidalgo Island shoreline (Fig. 4), providing a safe haven for salmon and other fish species to feed, rest and grow before their final move into open waters. The research conducted throughout this project helped to determine the historical condition of Cannery Pond and if there are future possibilities for “restoration” to a pocket estuary.

Climate Change

Global climate change is currently one of the most studied areas in environmental research. It is predicted that as a result of climate change, sea temperatures will increase, sea levels will rise, ultraviolet light will intensify, salinity will increase and seawater pH values will decrease around the globe (Bindoff et al. 2007). These global changes may have a strong impact on local systems. One question worth considering specifically for Cannery Pond is what impacts these predicted changes (especially sea level rise) might have on the pond, with or without any restoration efforts.

MATERIALS AND METHODS

Geology and Geography

The geology of the Cannery Pond area was investigated through background research of the area utilizing information gathered from public archives from the City of Anacortes, the Anacortes Library, Anacortes Museum, Western Washington Map Archives, USGS and NOAA hydrological surveys. The area surrounding the pond was explored extensively and the berm was studied and measured in order to determine the historical and current condition as well as identify the materials used to construct the berm. Pond depths were measured at a series of 20 locations in the pond with those location documented by GPS coordinates (Table 1).

Sediments

Sediment core samples of the pond floor were collected and analyzed. Preliminary investigations indicate that bottom material primarily consists of decaying organic matter; however, sediment samples will help better elucidate the current and historical conditions of the pond floor. Of special interest will be the presence or absence of marine fauna (e.g., clam shells) in the sediment core samples.

Cannery Pond is well buffered on all sides by thick vegetation, making it very hard to access. A small channel was cut through a thicket of cattails on the northwest corner of the pond, allowing access to the water with a small boat. Sediment cores were collected from a 3 m flat-bottomed aluminum boat (Fig. 5A) provided by Shannon Point Marine Center. Because most sediment coring devices are designed for larger vessels and mechanically powered, it was necessary to design a smaller hand powered coring device, which could be used from a small boat. Multiple designs were considered, and 2 prototypes were constructed, one of which was used after a few minor adjustments (Fig. 5A).

Core samples were collected on 3 different occasions, December 1st, 9th and 16th of 2010, along the northern shoreline of Cannery Pond. On December 1st, 15 samples were collected, on December 9th, 8 samples were collected and on December 16th, 9 samples were collected. All sample locations were recorded using a hand-held GPS unit and all samples were extracted from the core and analyzed on the day following their collection. Sediment cores were analyzed to determine the characteristics of the bottom material. They also helped to determine if there was a historical presence or absence of marine invertebrates.

On each sampling occasion, core samples were extracted from the tubing, examined and subsamples taken on the day following the coring. The first coring event occurred on December 4, 2010 and cores were analyzed December 5, 2010. The first fourteen sediment cores were examined for content, material and make-up. The second group of eight cores was sampled on December 9, 2010 and analyzed on December 10$^{th.}$ The third grouping of seven sediment cores were sampled on December 17th, 2010 and analyzed on December 18th.

Subsamples were taken from each core to conduct further research including grain size analysis. The subsamples were taken from the area just below the overlying organic material to the end of the core sample, representing a full vertical profile of each core. The samples were placed in zip-lock bags, homogenized and frozen until they were used for grain size analysis.

Grain Size Analyses

The sediment core subsamples were analyzed for grain size in the weeks following the final sediment core collection day. A small portion of each homogenized sub-sample (roughly 3-4 tablespoons) was placed in a smaller zip-loc bag along with 100 ml of distilled water and shaken vigorously in order to allow the muddy clumps to loosen up and the watery sample to become homogenous. Each sample was then poured through a 63 µm sieve placed within a large funnel. The funnel was set inside a 1000 ml graduated cylinder in order to collect the runoff from the sample. The sediment was rinsed thoroughly with a squirt bottle in order to remove any final small particles and fill the graduated cylinder to 1000 ml with water. The 1000 ml graduated cylinder was then covered with Parafilm and set aside.

The sample fractions larger than 63 µm were transferred from the sieve onto a piece of filter paper (Fig. 5D), labeled, and placed in a vacuum apparatus and vacuum applied for five minutes. When the samples were finished in the vacuum, they were placed in a drying oven overnight. Once the samples on the filter paper were completely dry, they were separated into grain-size classes.

The fractioning of the >63 µm grain size samples into classes was done using a shaker table and sieves (Fig. 5B). The shaker apparatus is a stack of sieves that decrease in size from the uppermost sieve. The sieve sizes were 4 mm, 2 mm, 1 mm, 500 um, 250 um, 125 um, and 63 um from largest to smallest. The dried sample fraction from the filter paper was carefully brushed off of the filter paper into the largest sieve. The motor was then turned on and the stack of sieves shook the sample vigorously, each retaining their subsequent size fractions. Each sieve fraction was then carefully brushed into a pre-weighed weigh boat and weighed to determine the percentage of each size fraction of the whole sample.

The fraction of sample smaller than 63 µm was added to the graduated cylinder and separated out by gravitational settling velocity (Fig. 5C). The finer sediment was separated into size fractions by first inverting the graduated cylinder for three minutes. The cylinder was then turned back over and immediately sampled. A 20 ml sample from each 1000 ml cylinder was taken at a depth of 20 cm and placed within a pre-weighed glass beaker. Subsequent 20 ml samples were taken at the following intervals: 5 min 32 sec, 22 min 4 sec, and lastly 1 hr 28 min. The beakers were then placed in a drying oven overnight. Once the beakers were completely dry, a final weight was taken. The initial weight of each beaker was then subtracted from the final weight in order to calculate the mass of dry sediment.

The data were collected and used to create a grain-size profile for each sample. A map was created and the coordinates of each sediment core taken were placed with their corresponding grain-size profile.

Wetland Identification and Area Biology

A vegetation survey was conducted in November 2009 as well as follow-up surveys in Spring 2010. A partial delineation of the wetland was performed in order to help better classify the wetland system and determine the physical boundaries. Measurements were taken around the perimeter of the pond and along the berm. Depth measurements were taken at various locations in the pond in order to determine the maximum and average depths of the pond.

Physical and Chemical Properties

The physical and chemical properties of the pond system were monitored throughout 2010. Temperature, salinity and dissolved oxygen (DO) were measured weekly for the entirety of the project in order to monitor pond properties throughout the year and develop a profile for the full year. Physical and chemical characteristics of the shore waters of Guemes Channel were measured throughout 2010 coincident to the beach seine sampling for marine fish. These data help to characterize the system and give further insight into current conditions.

Birds and Mammals

Bird and mammal surveys were conducted throughout the year in order to determine resident species utilizing Cannery Pond. Some mammal species previously spotted in the area include deer, coyote, raccoons, beaver or nutria, and river otter. Known shore birds in the area include cormorant, grebe, marbled murrelet, gulls, heron, mallards and other ducks. Surveys were developed and conducted with the help of Audubon and Beach Watcher volunteers. These surveys were used to help better describe and understand the current system and area and the habitat usage of the local species present.

Freshwater Fish and Amphibians

The composition of freshwater fish residing in Cannery Pond was assessed via data contained in two previous reports, both the result of WWU class projects (WWU 1999; Muller 2010). No new fish sampling was deemed necessary since these projects have occurred in about the last decade, with one being only a year old.

Marine Fish

Marine fish were sampled monthly from January 2010 through December of 2010. A 37-meter beach seine net was used to collect nearshore fish species offshore of Cannery Pond (January and February) and Ship Harbor (March through December), just southeast of Cannery Pond (Fig. 6, top). The beach seining was conducted according to a protocol established by the EPA (Becker et al. 1990) and modified for salmonid species (Skagit River System Cooperative 2003). The beach seine surveys of the intertidal region helped to determine current use by local fish species. This information also helped to establish baseline data for continuing studies of fish populations and species in the area. Of particular interest to this study are juvenile salmonids that are known to migrate through Guemes Channel. Beach seining was used to help assess species diversity and numbers of salmon and forage fish that may use the pond if it were to be converted to a pocket estuary (Beamer et al. 2005b). All marine fish data collected during this project will be forwarded to the Skagit River System Cooperative for inclusion in their regional fish database.

Beach seining took place each month throughout 2010. The dates and times were chosen according to the best tidal conditions. The ideal conditions for each sample date were chosen based on a two hour period with daylight during a high tide (+7-8 feet MLLW) period. Sampling took place roughly in the middle of each month and three replicate seine samples were collected on each sample date.

The *RV Flora* or *Fauna* from Shannon Point Marine Center were used as the seining vessels because of their maneuverability and size. Upon arrival at the seining site, the net was unloaded onto the beach with the help of multiple volunteers. The net was then aligned, the lead-weighted end roped off to the bow of the boat, and the other end anchored to a secure place on the beach as low to the ground as possible in order to limit any gaps between the water and the net. Once the net was fixed firmly, the boat pulled out the net perpendicular to the beach until it was taut (Fig.6, middle). The boat then motored in place in order to minimize drift for four minutes. After the four minute sample period, the boat pulled the net into the current in an arching motion towards the beach, forming a “purse” (Fig. 6, top). When the boat was within wading proximity to shore, two people retrieved the boat lines, bringing them into shore.

The lines were then pulled by multiple hands to bring in the net. The net pulling speed was monitored in order to limit any fish escape, net flipping and loss of lines. The top line was pulled in somewhat faster than the bottom line, creating a billowing effect within the net. Both ends of the line were then brought together creating the purse effect. Once the purse was at a reasonable size, the area within the net was cleared of seaweed and other debris in order to find the fish better. Buckets filled with seawater collected at the site were then used to hold the fish that were found within the net. Once the net was clear of all fish, it was aligned once again for another sample run.

The fish collected from each replicate seine sample were counted, measured and identified to genus or species. Each fish was handled by only one person as swiftly as possible in order to limit their time in the confining buckets. Once a fish was brought out of the water, it was placed gently in a fish measuring board, the species and length recorded, and the fish was then placed in another bucket of fresh seawater. When all of the fish were counted and measured from each seining sampling session, they were taken about 300 meters down the beach and released in order to minimize any re-catch.

RESULTS

Literature and Photograph Search

Searches of local museums, libraries and various archives resulted in finding references to the building (and later dismantling) of the railroad line from Anacortes to Ship Harbor and Burrows Bay but we were unable to locate any articles that described the nature of Cannery Pond (or wetlands at the time). A series of historical photographs and charts were found that covered the period of 1885 to 2006. The 1885 chart (Fig. 7) suggests that the pond area was at one time (pre-railroad berm) swampy wetlands with relatively little water in it. Subsequent photographs from 1956 through 2006 (Figs. 8-12) suggest that there has been a progression towards increasing amounts of water in the pond. These same figures also show the very substantial amounts of vegetation covering the pond, including floating mats of organic material, cattails (*Typha latifolia*) and other flora.

Wetland Characteristics

According to the City of Anacortes Shoreline Master Plan (City of Anacortes 1990), Cannery Lake receives most of its water from underground springs and nearby drainage ditches. Little is known about the lake in regards to its watershed characteristics, as there is not a large quantity of research material available on this site (Muller 2010). A basic wetlands delineation map from Shannon Point Marine Center archives, probably from about the 1970's, is shown in Figure 13.

The central portion of the pond is generally open water (with seasonal algal mats present), with floating vegetative mats extending along the southern portion of the pond (Fig. 14). The mats are dominated by cattails and have smaller shrubs such as coontail, pondweed, duckweed, and mats of blue-green algae (Parsons 1997). The cattails also form smaller mats that are interspersed on and submerged under the lake surface. Clusters of lily pads are present along the eastern portion of the pond. Students also conducted surveys of the buffer area around the pond and found that tree species included red alder (*Alnus rubra*) and cottonwood (*Populus balsamifera*) (WWU 1999).

Pond depths range down to a depth of a little over 12 feet, with the shallowest depths being to the south and the deepest area being toward the northwest (Fig. 15). The depth contours do not provide any suggestions that there was once a channel connecting the pond with Guemes Channel.

Railroad Berm Structure

The northern edge of Cannery Pond is bordered by about a 200 meter fill area (berm) sitting on top of the original upper sandy shoreline. The berm fill material is composed of unconsolidated soils and some rock, with occasional riprap reinforcement, although substantial erosion and wave undercutting of the berm are evident in some sections of the filled area (Fig. 16). The eastern and western ends of the fill materials abut native consolidated sandstone/gravel bluffs measuring about 4-6 meters in height (Fig. 17). The winter water level in Cannery Pond was estimated to be about 1 to 1.5 meters higher than the highest elevation of the original sandy shoreline, with about 1-2 liters/minute of seepage through the berm on the western end of the filled area (Fig. 18).

Physical and Chemical Properties

Temperature measurements taken weekly throughout the year fluctuated seasonally consistent with weather conditions. The shallow depth of the pond and limited area allowed for the temperature of the water to change more rapidly than other freshwater systems. Water temperature ranged from a low of 3.3 °C in mid January to a high of 23.6 °C in mid September (Table 2).

Cannery Pond proved to be a strict freshwater system with very low salinity values, indicating essentially no saltwater intrusion into the system despite its very close proximity to Guemes Channel. Salinity values ranged from a low of 0.1 ‰ to high of only 0.5 ‰ (Table 3).

Sediment Core Samples

The lengths of the sediment core samples collected from Cannery Pond ranged in length from 40 to 69 cm (Table 4). The characteristics found in most of the sediment samples were quite similar. The most common characteristic found in all samples to varying degrees was the amount of organic material in the profile. All samples had 15 or more cm of broken down organic matter at different stages on top of which sat a few cm of leafy matter. The cores became more solid as the organic matter was condensed and consisted of finer particles. The layers below that ranged from larger, coarse mineral material to fine sand and clay (Fig. 19). Generally, the longer the core was, the more varied the strata were within it. The apparent differences from the first step in sediment analysis indicated that the substrata varied from east to west along the pond shoreline (Table 4).

Sediment samples along the eastern side of the pond were much harder to collect with our coring device due to the inherent nature of the subsurface sediments. Sampling proved rather difficult because there tended to be coarse fill material present just under the organic material in the area bordering the Washington State Ferry Terminal. We suspect that fill material (generally 0.5-2 inch coarse gravel) was used during either the construction of the railroad, or more likely the construction of the Ferry Terminal parking areas. Approximately 1/3 of the samples collected in the northeastern corner of the pond were either unusable, or uncollectible.

Although fill material was dominant in the eastern area, good cores taken in the area past the fill material showed higher percentages of sand once below the organic material. The most probable explanations for this occurrence could be 1) the possible historical presence of a tidal stream, 2) sand that was washed into the pond during high tide storm events or 3) sand may also have been used as fill material during the railroad and ferry terminal construction projects.

Results of the sediment grain size analyses of the sediment cores indicated a varying substrate type related to their geographical location shown in Figure 20. The upper ends of all cores (i.e., from the pond floor surface) contained leaves and fine organic materials indicative of ongoing input from vegetation growing on or around Cannery Pond. The lower sections of core samples collected from the western side of Cannery Pond (green polygon in Fig. 20) were especially rich in unconsolidated organic materials ("muck") together with dense clay and/or a mineral matrix in the lower sections of the cores (Table 4).

Core samples collected from the northern area of the pond (red polygon in Fig. 20) contained materials similar to those from the west side of the pond except that cores from the eastern portion of this area (cores 7C and 8C) had higher sand contents in the lower core sections (Table 4). The contents of cores collected from the eastern side of the pond (blue polygon in Fig. 20) were variable by core but many contained high sand and/or rock/gravel fractions (Table 4). Indeed the amount of rock and gravel in this area made it difficult to collect good cores and the rejection rate was high. This eastern area of the pond is adjacent to the Washington State Ferry Terminal parking lot. The rock, gravel and sand found in the cores from this area may be indicative of fill materials used in the parking lot construction, although the possibility remains that some or all of the sandy substrate may be associated with an old channel opening to Guemes Channel or may have originated from periodic storm surge events that pushed beach sands into the northeast area of Cannery Pond.

A further investigation compared samples of beach sand collected on the outside of the railroad berm (Guemes Channel side) with the sand collected in the core samples. The comparison indicated that both samples were very similar and had approximately the same quartz and mineral contents. However, one thing completely lacking in all of the core samples was any sign of marine-based invertebrate species (e.g., clam, mussel or marine snail shells). This suggests that any input of seawater and sandy materials from Guemes Channel were not routine enough to maintain populations of estuarine animals in the pond.

Birds and Mammals

Bird and mammal surveys were conducted throughout the year in order to determine species using the Cannery Pond habitats. Surveys were developed and conducted with the assistance of Audubon and Skagit Beach Watcher volunteers. Avian surveys conducted by Audubon in the eastern area of the pond between September 1998 and February 2004 recorded 106 bird species (Table 5). Three avian surveys conducted during this study in 2010 recorded 39 bird species (Table 6), of which three species were new (red breasted nut-hatch, oyster catcher and marbled murrelet) compared to the list of 106 Audubon recorded birds (Table 5).

Many mammal species have been spotted over the years near and around the Shannon Point Marine Center which include black-tailed deer, owl, muskrat, coyote, raccoons, porcupine, beaver or nutria, and river otter. Staff, faculty and students of the marine center provided multiple eye-witness accounts of most of the above species. While conducting field work throughout the season, a local river otter colony was seen multiple times in the pond, generally spotted in the southern portion of the pond. A beaver or nutria was also seen multiple times in pond waters, including a report by Summers (1999, as reported by WWU 1999); however, positive identification was difficult because the animal was never seen out of the water. It is however important to note that beavers are often found in the same habitat as river otters because beavers inadvertently create ideal habitats in which otters can live. On a few occasions while on the beach side of the berm, harbor seals and sea lions were spotted as well.

Cannery Pond provides ideal habitat for both birds and other mammals. Although it is in rather close proximity to a Washington State Ferry Terminal, a high-use area, it is well buffered on the eastern side from any intrusion and on all other sides it is well buffered by new growth forest and upland wetlands. The only access to the pond, a few small trails, limits intrusion by people and also limits any boat access other than a small non-motorized boat.

Freshwater Fish and Amphibians

A 1999 WWU student study of Cannery Pond used trap nets (24 hour sets) and electrofishing to assess the fish composition. A total of 54 fish were caught, 96% of their catches being largemouth bass (*Micropterus salmoides*) with the remaining 4% being brown bullhead catfish (*Ameiurus nebulosus)* (WWU 1999).

A second WWU class study of the pond in 2010 used fyke and gill nets to sample fish. The nets were set for about 24 hours in nine different locations in the pond and caught several species of fish and amphibians. A total of 84 individuals were caught, the composition of the catches being largemouth bass (55%), brown bullhead catfish (26%), bullfrog tadpoles (8%), rough skinned newts (7%) and northwest salamanders (4%). The largemouth bass ranged in size from about 60 mm to a little over 250 mm, were 1 to 3 years in age and had been feeding on insects, amphipods and, on one occasion, a smaller largemouth bass.

Marine Fish

A total of 36 beach seine samples (3 per month for 12 months) caught a total of 2,957 fish of at least 16 species of fish (Table 7). The four most abundant fish species in the samples were shiner perch (44.0% of total), staghorn sculpin (25.8%), juvenile English sole (12.3%) and surf smelt (5.2%). A total of 50 salmon were caught (1.7% of total) composed of three species: 4 juvenile Chinook, 2 juvenile coho and 44 juvenile chum salmon (all chum were caught in May 2010). All species caught in the seine samples are very common fish in the Puget Sound region. Size-frequency histograms for 12 of the most commonly caught fish species are presented in Figs. 21-24.

Seawater temperatures and salinities measured monthly in 2010 at the Ship Harbor beach seining site were in the normal range for Puget Sound waters. Temperatures ranged from a low of 7.4 °C in December to a high of 14.6 °C in June. Salinities ranged from a low of 28.6 ‰ in October to a high of 30.1 ‰ in May (Table 8).

Volunteer Hours

Skagit Beach Watcher, Audubon and community volunteers, assisted by Shannon Point Marine Center students and Skagit River System Cooperative personnel assisted with various phases of this project including beach seining, sediment core collections and laboratory analyses, bird and mammal surveys and data analyses and progress/final report preparation. The number of volunteers contributing to this project was 36. The total estimated number of hours that volunteers contributed to the project was 385.

DISCUSSION

The goal of this project was to answer the question: Was Cannery Pond once a pocket estuary connected via a channel to Guemes Channel? And, if so, what is the potential for restoring a connection to marine waters?

Pocket estuaries function as important “rest stops” for some species of juvenile salmon during their out migration to the ocean. These “rest stops” provide opportunities for resting and foraging food in habitats that minimize predation by larger fish. During this project we documented that juvenile salmon were migrating past Ship Harbor and Shannon Point (Table 7). Cannery Pond would be an attractive “rest stop” for these juvenile salmonids as it is the last in a string of current or potential pocket estuaries on the east and north sides of Fidalgo Island (Fig. 4 – McBride and Beamer 2007). These same pocket estuaries also serve as nursery and foraging grounds for other fish species including surf smelt, juvenile sole and several species of perch and sculpin.

Although the idea of “restoring” Cannery Pond to a pocket estuary is an intriguing one, evidence collected during this project suggests that Cannery Pond has always been a freshwater pond system or, perhaps, a shallow freshwater wetlands (e.g., bog) prior to construction of the railroad berm on the shoreline bordering Guemes Channel. Evidence for this conclusion includes the following:

1. Lack of any textual or photographic evidence in local/regional archives that suggest that the pond was anything other than a freshwater system.

2. The only drawing of Cannery Pond (1885 T-sheet, U.S. Coast and Geodetic Survey – Fig. 8) pre-railroad construction appears to indicate that Cannery Pond was historically a boggy wetlands with no clear channel connecting it to Guemes Channel.

3. The flora (especially the massive floating rafts of vegetation) and fauna (especially the mature freshwater fish populations) suggest that Cannery Pond is a mature freshwater system and has been so for quite a long time (although this does not preclude an estuarine environment pre-1890).

4. Sediment core samples collected from the northern end of the pond contained high amounts of organic materials and no indications of marine-based invertebrate species (e.g., clam, mussel or marine snail shells) in the cores. Cores with substantial amounts of sand were found on the northeastern side of the pond, suggestive of either construction fill materials or sands deposited in the pond during high tide storm surge events. If from construction materials, they would likely have had to come from the railroad berm construction in 1891. A 1970 photograph of Cannery Pond (Fig. 9) taken shortly after construction of the ferry terminal parking area indicates that there was little, if any, impact to the pond itself since the vegetation surrounding the pond remained in place.

The results of this study failed to find any conclusive evidence that Cannery Pond was once a pocket estuary connected via a channel to Guemes Channel. Current evidence suggests that prior to construction of the railroad berm in 1891, Cannery Pond was most likely a boggy freshwater wetlands separated from Guemes Channel by a no bank sandy shoreline. There is little, if any, evidence of a permanent channel connecting Cannery Pond with Guemes Channel, although intermittent channels may have occurred when Cannery Pond filled with water. It is also likely that the pre-1891 Cannery Pond wetlands were occasionally affected by high tide storm surges that temporarily pushed seawater (and beach sand) into the freshwater wetlands.

In considering the future of Cannery Pond, there are three possible scenarios that might be considered:

1. **Do nothing.** This option would cost nothing and maintain Cannery Pond as a freshwater system for most of the 21st century. The railroad berm is gradually being eroded away by high tides and storm surges and the shoreline will eventually return to its historic condition of a sandy shoreline that entrains the freshwater bog system. With the eventual erosion of the railroad berm, the water level in Cannery Pond will be lowered by about 1-2 meters. Currently, the treed and vegetated berm does provide shade for any surf smelt spawn that might be deposited in the upper intertidal sands and gravels, which is quite possible since surf smelt spawn has been documented at several locations in the Ship Harbor/Shannon Point area (NWSC 2002). Additionally, the vegetated railroad berm helps restrict access to Shannon Point Marine Center by ferry terminal users, which is considered a plus by Western Washington University managers.

2. **Remove the railroad berm to reestablish the original shoreline configuration.** This option would likely require expenditures of several hundred thousand dollars but would immediately restore the shoreline to its original configuration. The water level in

Cannery Pond would drop by 1-2 meters and the salinity of the pond periodically increase as storm surges send seawater into the pond. The impact of fluctuating salinities on the current flora and fauna is unknown. Additionally, the shade from the trees growing on the berm would be lost, possibly resulting in slightly increased summer time surf smelt egg mortalities if surf smelt do indeed spawn along the berm area. A further consequence of this option would be that Shannon Point Marine Center grounds would be less buffered from ferry terminal users.

3. **Engineer a new pocket estuary.** The Cannery Pond wetlands represent a nearshore depression that, with proper engineering, could likely be transformed from a freshwater pond system to a pocket estuary with routine tidal exchanges through a channel connected to Guemes Channel. Clearly, this option would result in the destruction of the current freshwater system and replacement with an estuarine one. The cost of this option would be substantial and would likely require dredging Cannery Pond to establish channels and estuarine water flows and construction of a channel connecting the pond to Guemes Channel (which may need periodic maintenance). This option would provide Shannon Point Marine Center with an interesting pocket estuary education and research "facility" on its property, albeit at the expense of the current freshwater system.

Currently, Skagit MRC takes no position on which of the three options presented above is the best one. These options will need to be evaluated by a host of resource agencies and interested parties, not the least of which is the current property owner (Western Washington University).

Global Warming

The three possible options outlined above have ignored the issue of global warming and the consequences of sea level rise. Given predictions of sea level rises of several feet by the end of the 21st century, it is likely that erosion of the railroad berm will substantially increase, thereby decreasing the time to "restore" the area to its original shoreline. However, increasing seawater levels will also likely hasten the demise of the current freshwater pond system, gradually changing it to a more estuarine one, with the possible evolution of a channel connecting the pond to Guemes Channel.

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Table 1. GPS coordinates where depths in Cannery Pond were measured in 2010.

Measurement Number	Latitude	Longitude
1	48^o 30’ 28.77” N	122^o 40’ 51.29” W
2	48^o 30’ 29.04” N	122^o 40’ 52.79” W
3	48^o 30’ 28.98” N	122^o 40’ 53.57” W
4	48^o 30’ 28.71” N	122^o 40’ 53.75” W
5	48^o 30’ 28.56” N	122^o 40’ 54.70” W
6	48^o 30’ 27.79” N	122^o 40’ 51.11” W
7	48^o 30’ 28.10” N	122^o 40’ 52.99” W
8	48^o 30’ 28.13” N	122^o 40’ 53.10” W
9	48^o 30’ 28.10” N	122^o 40’ 52.99” W
10	48^o 30’ 27.71” N	122^o 40’ 55.60” W
11	48^o 30’ 27.56” N	122^o 40’ 53.92” W
12	48^o 30’ 28.10” N	122^o 40’ 52.99” W
13	48^o 30’ 26.91” N	122^o 40’ 50.82” W
14	48^o 30’ 26.64” N	122^o 40’ 53.92” W
15	48^o 30’ 26.57” N	122^o 40’ 56.04” W
16	48^o 30’ 27.10” N	122^o 40’ 56.36” W
17	48^o 30’ 26.52” N	122^o 40’ 54.55” W
18	48^o 30’ 26.16” N	122^o 40’ 52.10” W
19	48^o 30’ 25.49” N	122^o 40’ 54.56” W
20	48^o 30’ 25.91” N	122^o 40’ 50.91” W

Table 2. Weekly and average monthly Cannery Pond water temperatures (°C) in 2010.

Month	Week 1	Week 2	Week 3	Week 4	Average
January	3.9	3.3	4.1	4.3	3.9
February	5.6	7.2	4.4	3.6	5.2
March	6.2	5.3	6.1	5.4	5.8
April	7.8	8.9	8.5	7.2	8.1
May	8.4	9.2	8.2	9.4	8.8
June	9.6	10.2	11.9	12.8	11.1
July	20.4	18.4	20.1	21	20.0
August	20.9	20.1	18.7	19.1	19.7
September	21.3	19.5	23.6	18.9	20.8
October	16.9	17.2	16.1	15.4	16.4
November	13.1	12.2	9.5	6.1	10.2
December	4.3	7.6	6.4	5.2	5.9

Table 3. Weekly and average monthly Cannery Pond salinity (‰) values in 2010.

Month	Week 1	Week 2	Week 3	Week 4	Average
January	0.2	0.2	0.1	0.1	0.2
February	0.2	0.3	0.2	0.2	0.2
March	0.2	0.3	0.2	0.1	0.2
April	0.1	0.2	0.1	0.2	0.2
May	0.1	0.2	0.2	0.1	0.2
June	0.2	0.1	0.2	0.1	0.2
July	0.2	0.2	0.4	0.4	0.3
August	0.3	0.3	0.5	0.5	0.4
September	0.3	0.2	0.2	0.2	0.2
October	0.1	0.1	0.1	0.2	0.1
November	0.3	0.2	0.1	0.1	0.2
December	0.1	0.1	0.2	0.1	0.1

Table 4. Summary of the contents of the sediment core samples.

Core #	Core Length, cm	Latitude (N)	Longitude (W)	Material-U	Material-M	Material-B	Notes
East side of Cannery Pond (Blue Polygon, Figure 5)							
2A	16	48^o 30.425'	122^o 40.843'	fine organic matter	fine organic matter	mineral plug	dense organic muck w/large pieces of mineral w/large pieces of quartz
2B	20	48^o 30.434'	122^o 40.823'	fine organic matter	fine organic matter	mineral plug	dense organic muck w/large pieces of mineral w/large pieces of quartz
3B	19	48^o 30.427'	122^o 40.822'	fine organic matter	thick clay/mineral content with heavy gleying	80% mineral	dense organic muck w/large pieces of mineral w/large pieces of quartz
4B	22	48^o 30.420'	122^o 40.818'	fine organic matter	thick clay/mineral content with heavy gleying	60% mineral	rich/dense organic muck with large pieces of mineral w/pyrite and quartz
5B	n/a	48^o 30.421'	122^o 40.817'	fine organic matter	fine organic matter	fine organic matter	DUD
6B	24	48^o 30.428'	122^o 40.825'	fine organic matter	thick clay/mineral content with heavy gleying	50% mineral	rich/dense organic muck with large pieces of mineral w/pyrite and quartz
1C	16	48^o 30.422'	122^o 40.818'	fine organic matter	mixed, runny organic matter	dense organic matter with rocks	dense organic matter with rocks
2C	25	48^o 30.425'	122^o 40.820'	fine organic matter	fine organic matter	Sand plug	thick organic muck w/large rocks and 6 inch sand plug
3C	25	48^o 30.427'	122^o 40.824'	fine organic matter	fine organic matter	Sand plug	thick organic muck w/large rocks and 6 inch sand plug

4C	19	48° 30.431'	122° 40.821'	fine organic matter	MTO 1/1	Sand plug with rocks	runny organic muck w/large rocks and 3 inch sand plug with rocks
5C	25	48° 30.435'	122° 40.821'	fine organic matter	MTO 1/1	Sand plug with rocks	runny organic muck w/large rocks and 6 inch sand plug with rocks
6C	22	48° 30.440'	122° 40.829'	fine organic matter	dense organic/clay mix	Sand plug with rocks	thick organic muck w/large rocks and 6 inch sand plug and strong sulfur odor

West Side of Cannery Pond (Green Polygon, Figure 5)

1A	19	48° 30.465'	122° 40.964'	fine organic matter	MTO 1/1	80% mineral	dense organic muck w/large pieces of mineral w/large pieces of quartz
8A	26	48° 30.487'	122° 40.866'	fine organic matter	dense organic matter and mixed clay	rich clay	rich/dense organic muck mixed with clay and dense clay plug
9A	20	48° 30.489'	122° 40.873'	fine organic matter	fine organic matter	rich clay, 20% mineral	rich/dense organic muck mixed with clay and dense clay plug
10A	25	48° 30.491'	122° 40.878'	fine organic matter	dense organic matter and mixed clay	rich clay-gleyed	strong sulfur odor
11A	24	48° 30.490'	122° 40.888'	fine organic matter	dense organic matter and mixed clay	rich clay-gleyed	strong sulfur odor
12A	25	48° 30.497'	122° 40.902'	fine organic matter	MTO 1/3	rich clay-gleyed	rich/dense organic muck with large pieces of mineral
13A	25	48° 30.495'	122° 40.905'	fine organic matter	MTO 1/3	rich clay-gleyed	rich/dense organic muck with large pieces of mineral
14A	28	48° 30.499'	122° 40.921'	fine organic matter	MTO 1/3	rich clay-gleyed	rich/dense organic muck with large pieces of mineral

North Side of Cannery Pond (Red Polygon, Figure 5)

3A	24	48° 30.455'	122° 40.845'	fine organic matter	MTO 1/1	80% mineral	rich/dense organic muck with large pieces of mineral w/pyrite

4A	24	48° 30.459'	122° 40.851'	fine organic matter	MTO 1/1	80% mineral	rich/dense organic muck with large pieces of mineral w/pyrite
5A	28	48° 30.469'	122° 40.848'	fine organic matter	MTO 1/1	rich clay	rich/dense organic muck with large pieces of mineral w/pyrite
6A	16	48° 30.475'	122° 40.846'	fine organic matter	fine organic matter	mineral plug	3 inch mineral plug fine organic matter throughout
7A	n/a	48° 30.482'	122° 40.852'	fine organic matter	fine organic matter	fine organic matter	DUD
1B	24	48° 30.447'	122° 40.838'	fine organic matter	MTO 1/1	80% mineral	rich/dense organic muck with large pieces of mineral w/pyrite
7B	n/a	48° 30.448'	122° 40.836'	fine organic matter	fine organic matter	fine organic matter	DUD
8B	24	48° 30.459'	122° 40.849'	fine organic matter	thick clay/mineral content with heavy gleying	50% mineral	rich/dense organic muck with large pieces of mineral w/pyrite and quartz
7C	26	48° 30.446'	122° 40.838'	fine organic matter	dense organic/sand mix	sand/mineral mix	6 inch sand plug was mixed with larger mineral pieces
8C	27	48° 30.450'	122° 40.838'	fine organic matter	dense organic/sand mix	sand/mineral mix	7 inch sand plug was mixed with larger mineral pieces

NOTES

CL = core length (below organic matter to end of core)
DTF = depth to pond floor

DUD = sample contained only organic material
Material - U = core upper material

Material - M = core middle material

Material - B = core bottom material

MTO = Mineral to Organic ratio

Table 5. Results of avian surveys conducted in the area of Cannery Pond by the Audubon Society between September 1998 and February 2004.

Common Loon (*Gavia immer*)	Green-winged Teal (*Anus crecca*)
Pied-billed Grebe (*Podilymbus podiceps*)	Harlequin Duck *(Histrionicus histrionicus)*
Horned Grebe (*Podiceps auritus*)	Surf Scoter *(Melanitta perspicillata)*
Red-necked Grebe (*Podiceps grisegena*)	Bufflehead *(Bucephala albeola)*
Western Grebe (*Aechmophorus occidentalis*)	Common Goldeneye *(Bucephala clangula)*
Double-crested Cormorant *(Phalacrocorax auritus*)	Barrow's Goldeneye *(Bucephala islandica)*
Pelagic Cormorant (*Phalacrocorax pelagicus*)	Hooded Merganser *(Lophodytes cucullatus)*
Great Blue Heron (*Ardea herodias*)	Common Merganser *(Mergus merganser)*
Green Heron (*Butorides virescens*)	Red-breasted Merganser *(Mergus serrator)*
Canada Goose (*Branta canadensis*)	Osprey *(Pandion haliaetus)*
Wood Duck (*Aix sponsa*)	Bald Eagle *(Haliaeetus leucocephalus)*
Gandwall *(Anas strepera)*	Northern Harrier *(Circus cyaneus)*
Eurasian Widgeon (*Anas penelope*)	Sharp-shinned Hawk *(Accipiter striatus)*
American Wigeon (*Anas americana*)	Red-tailed Hawk *(Buteo jamaicensis)*
Mallard (*Anas platyrhyncos*)	Merlin *(Falco columbarius)*
Blue-winged Teal (*Anas discors*)	Peregrine Falcon *(Falco peregrinus)*
Cinnamon Teal (*Anas cyanoptera*)	Western Wood-pewee *(Contopus sordidulus)*
Northern Shoveler (*Anas clypeata*)	Willow Flycatcher *(Empidonax traillii)*
California Quail *(Callipepla californica)*	Eastern Kingbird *(Tyrannus tyrannus)*
Virgina Rail *(Rallus limicola)*	American Crow *(Corvus brachyrhynchos)*
Sora *(Porzana carolina)*	Common Raven *(Corvus corax)*
American Coot *(Fulica americana)*	Purple Martin *(Progne subis)*
Killdeer *(Charadrius vociferous)*	Tree Swallow *(Tachycineta bicolor)*
Spotted Sandpiper *(Actitis macularius)*	Violet-green Swallow *(Tachycineta thalassina)*
Western Sandpiper *(Calidris mauri)*	Northern Rouch-legged Swallow *(Stelgidopteryx serripennis)*
Wilson's Snipe *(Gallinago delicate)*	Bank Swallow *(Riparia riparia)*

Table 5. Continued.

Franklin's Gull *(Larus pipixcan)*	Cliff Swallow *(Petrochelidon pyrrhonota)*
Heerman's Gull *(Larus heermanni)*	Barn Swallow *(Hirundo rustica)*
Mew Gull *(Larus canus)*	Black-capped Chickadee *(Poecile atricapillus)*
Ring-billed Gull *(Larus delawarensis)*	Chestnut-backed Chickadee *(Poecile rufescens)*
California Gull *(Larus californicus)*	Bushtit *(Psaltriparus minimus)*
Herring Gull *(Larus argentatus)*	Brown Creeper *(Certhia americana)*
Glaucous-winged Gull *(Larus glaucescens)*	Bewick's Wren *(Thryomanes bewickii)*
Rock Pigeon *(Columba livia)*	Winter Wren *(Troglodytes troglodytes)*
Mourning Dove *(Zenaida macroura)*	Marsh Wren *(Cistothorus palustris)*
Rufous Hummingbird *(Selasphorus rufus)*	Golden-crowned Kinglet *(Regulus satrapa)*
Belted Kingfisher *(Megaceryle alcyon)*	Song Sparrow *(Melospiza melodia)*
Lewis's Woodpecker *(Melanerpes lewis)*	White-throated Sparrow *(Zonotrichia albicollis)*
Downey Woodpecker *(Picoides pubescens)*	White-crowned Sparrow *(Zonotrichia leucophrys)*
Northern Flicker *(Colaptes auratus)*	Golden-crowned Sparrow *(Zonotrichia atricapilla)*
Pileated Woodpecker *(Dryocopus pileatus)*	Dark-eyed Junco *(Junco hyemalis)*
Ruby-crowned Kinglet *(Regulus calendula)*	Black-headed Grosbeak *(Pheucticus melanocephalus)*
Swainson's Thrush *(Catharus ustulatus)*	Red-winged Blackbird *(Agelaius phoeniceus)*
Hermit Thrush *(Catharus guttatus)*	Western Meadowlark *(Sturnella neglecta)*
American robin *(Turdus migratorius)*	Brown-headed Cowbird *(Molothrus ater)*
Varied Thrush *(Ixoreus naevius)*	Purple Finch *(Carpodacus purpureus)*
Cedar Waxwing *(Bombycilla cedrorum)*	House Finch *(Carpodacus mexicanus)*
European Starling *(Sturnus vulgaris)*	Pine Siskin *(Carduelis pinus)*
Orange-crowned Warbler *(Vermivora celata)*	American Goldfinch *(Carduelis tristis)*
Yellow Warbler *(Dendroica petechia)*	House Sparrow *(Passer domesticus)*
Yellow-rumped Warbler *(Dendroica coronata)*	Spotted Towhee *(Pipilo maculates)*
Common Yellowthroat *(Geothlypis trichas)*	Savannah Sparrow *(Passerculus sandwichensis)*
Wilson's Warbler *(Wilsonia pusilla)*	Fox Sparrow *(Passerella iliaca)*

Table 6. Bird species recorded during three seasonal surveys at Cannery Pond during 2010 with the help of Audubon volunteers.

Spotted Towhee *(Pipilo maculates)*	Harlequin Duck *(Histrionicus histrionicus)*
Swainson's Thrush *(Catharus ustulatus)*	Surf Scoter *(Melanitta perspicillata)*
Bewick's Wren *(Thryomanes bewickii)*	Bufflehead *(Bucephala albeola)*
Winter Wren *(Troglodytes troglodytes)*	Common Goldeneye *(Bucephala clangula)*
Marsh Wren *(Cistothorus palustris)*	Wood Duck (*Aix sponsa*)
Red breasted nut-hatch (*Sitta canadensis*)	Spotted Sandpiper *(Actitis macularius)*
Pileated Woodpecker *(Dryocopus pileatus)*	Western Sandpiper *(Calidris mauri)*
Violet-green Swallow *(Tachycineta thalassina)*	Oyster Catcher **(***Haematopus bachmani*)
Bank Swallow *(Riparia riparia)*	Marbled Murrelet (*Brachyramphus marmoratus*)
Barn Swallow *(Hirundo rustica)*	Double-crested Cormorant *(Phalacrocorax auritus*)
Tree Swallow *(Tachycineta bicolor)*	Pelagic Cormorant (*Phalacrocorax pelagicus*)
Black-capped Chickadee *(Poecile atricapillus)*	Franklin's Gull *(Larus pipixcan)*
Chestnut-backed Chickadee *(Poecile rufescens)*	Heerman's Gull *(Larus heermanni)*
Golden-crowned Sparrow *(Zonotrichia atricapilla)*	Mew Gull *(Larus canus)*
Red-winged Blackbird *(Agelaius phoeniceus)*	Ring-billed Gull *(Larus delawarensis)*
Western Meadowlark *(Sturnella neglecta)*	California Gull *(Larus californicus)*
Common Raven *(Corvus corax)*	Herring Gull *(Larus argentatus)*
Osprey *(Pandion haliaetus)*	Glaucous-winged Gull *(Larus glaucescens*
Bald Eagle *(Haliaeetus leucocephalus)*	Great Blue Heron (*Ardea herodia)*
Red-tailed Hawk *(Buteo jamaicensis)*	

Table 7. Summary by month of the numbers of all fish species or group of species caught in the beach seine samples at Cannery Pond (Jan.-- Feb.) and Ship Harbor (March – December) in 2010.

Species	All Months	Jan	Feb*	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook salmon, *Oncorhynchus tshawytscha*	4			1				2		1			
Coho salmon, *Oncorhynchus kisutch*	2	1						1					
Chum salmon, *Oncorhynchus keta*	44					44							
Surf smelt, *Hypomesus pretiosus*	153			4		138				1		10	
Pacific sandlance, *Ammodytes hexapterus*	8				1	1	2				1	2	1
English sole, *Parophrys vetulus*	363				10	23	106	137	77	9	1		
Starry flounder, *Platichthys stellatus*	109			9	27	6	15	3	10	6	7	10	16
Shiner perch, *Cymatogaster aggregata*	1304					33	10	200	400	501	160		
Bay pipefish, *Syngnathus griseolineatus*	4					2	2						
Snake prickleback, *Lumpenus sagitta*	24					21	2		1				
Greenling[1], *Hexagrammos spp.*	18	1		8	3				2	1	1		2
3-spined stickleback, *Gasterosteus aculeatus*	57			1			33	16			1	5	1
Gunnel[1], *Pholis spp*.	100				2	1	35	8	18	24	12		
Staghorn sculpin[2], *Leptocottus armatus*	764			25	67	198	253	71	44	73		9	24
Great sculpin, *Myoxocephalus polyacanthocephalus*	2				2								
Sharpnose sculpin, *Clinocottus acuticeps*	1	1											

*Substantial net hang ups on rocks likely contributed to no fish being caught in Feb. The seine site was changed to Ship Harbor after this date.

[1]Identified to genus only.

[2]May include a few other species of sculpins.

Table 8. Monthly temperature and salinity values for seawater at the beach seining site at Ship Harbor, April-December, 2010.

Month	Temperature, °C	Salinity, ‰
April	8.2	29.1
May	12.2	30.1
June	14.6	29.4
July	13.2	28.9
August	13.2	29.7
September	12.2	29.6
October	11.7	28.6
November	9.2	29.2
December	7.4	29.6

Figure 1. Cannery Pond, located on the northwestern point of Fidalgo Island in the eastern San Juan Islands of northwest Washington State (Google Earth, 2009).

Figure 2. Overhead view of Cannery Pond situated between the Anacortes Washington State Ferry Terminal (left) and the Shannon Point Marine Center laboratories (lower right). The red oval shows the area where the shoreline was filled in 1891 to support railroad tracks running from Anacortes to Burrows Bay. Source: WDOE Shoreline Photo.

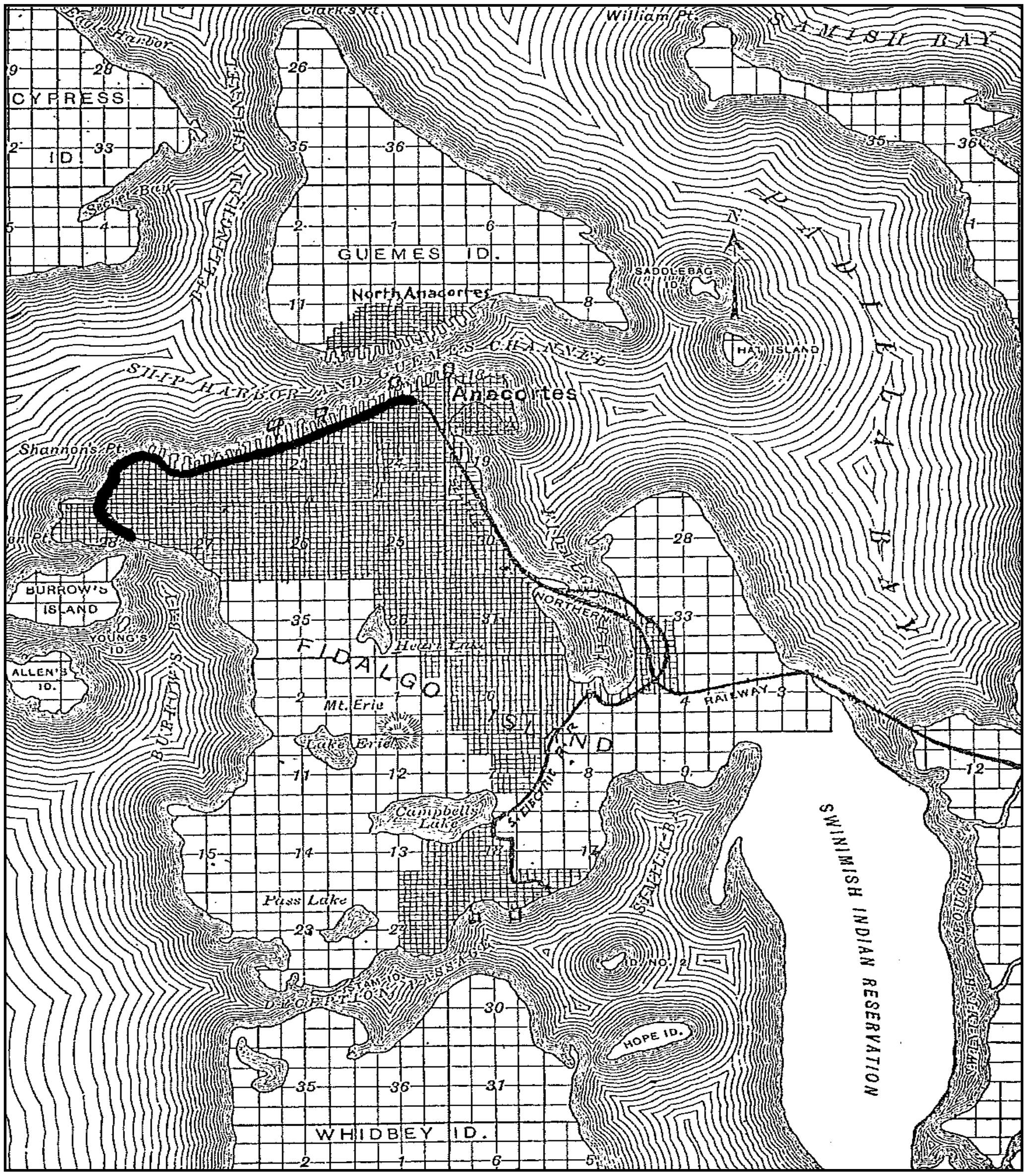

Figure 3. Map of the Anacortes area showing the railroad route constructed from Anacortes to Burrows Bay in 1891 (dark black line).

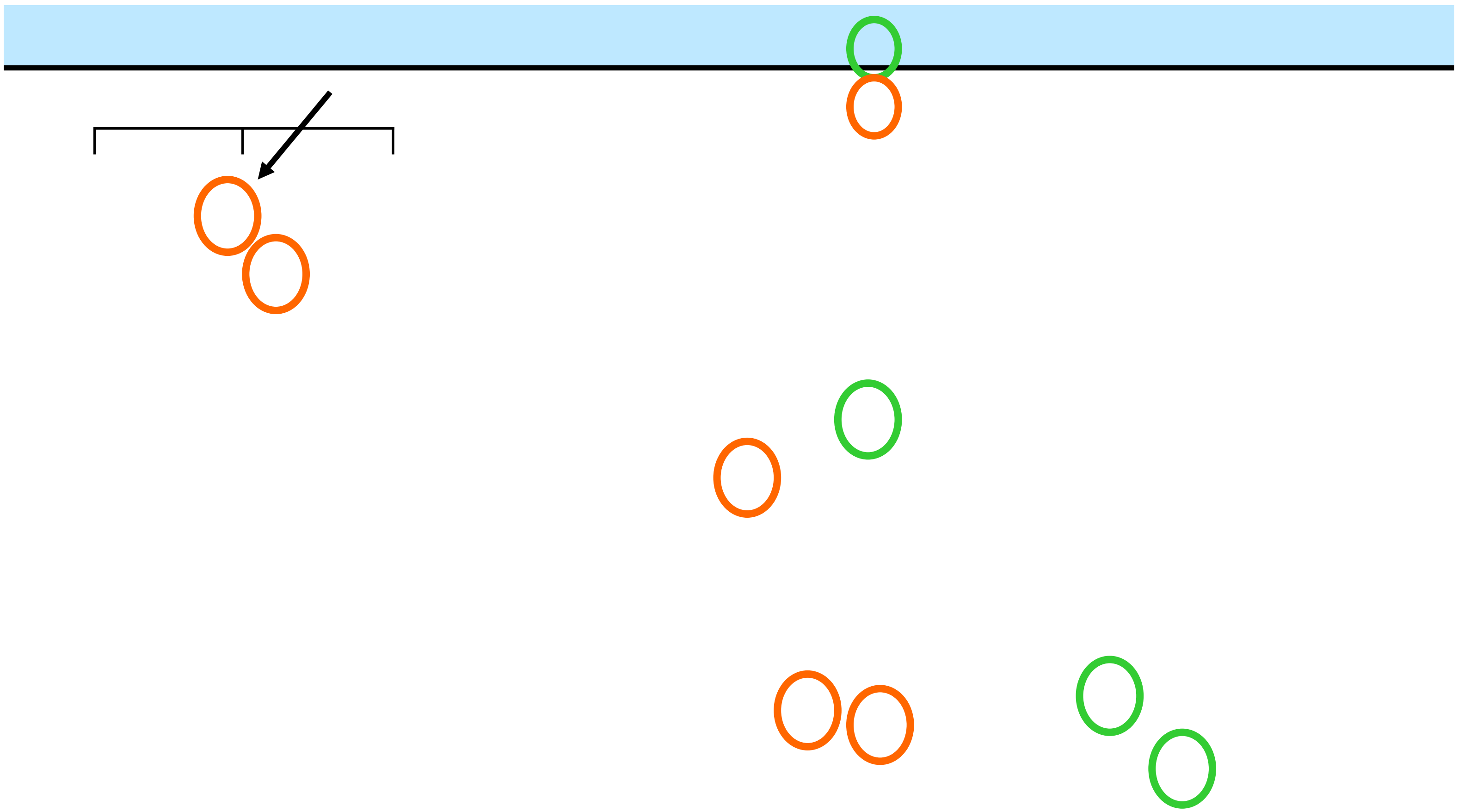

Figure 4. Current (green circles) and potential (orange circles) pocket estuaries on the northern shores of Fidalgo Island and the pathway that juvenile out migrating salmon use (pink line). The arrow points to the location of Cannery Pond. From McBride and Beamer 2007.

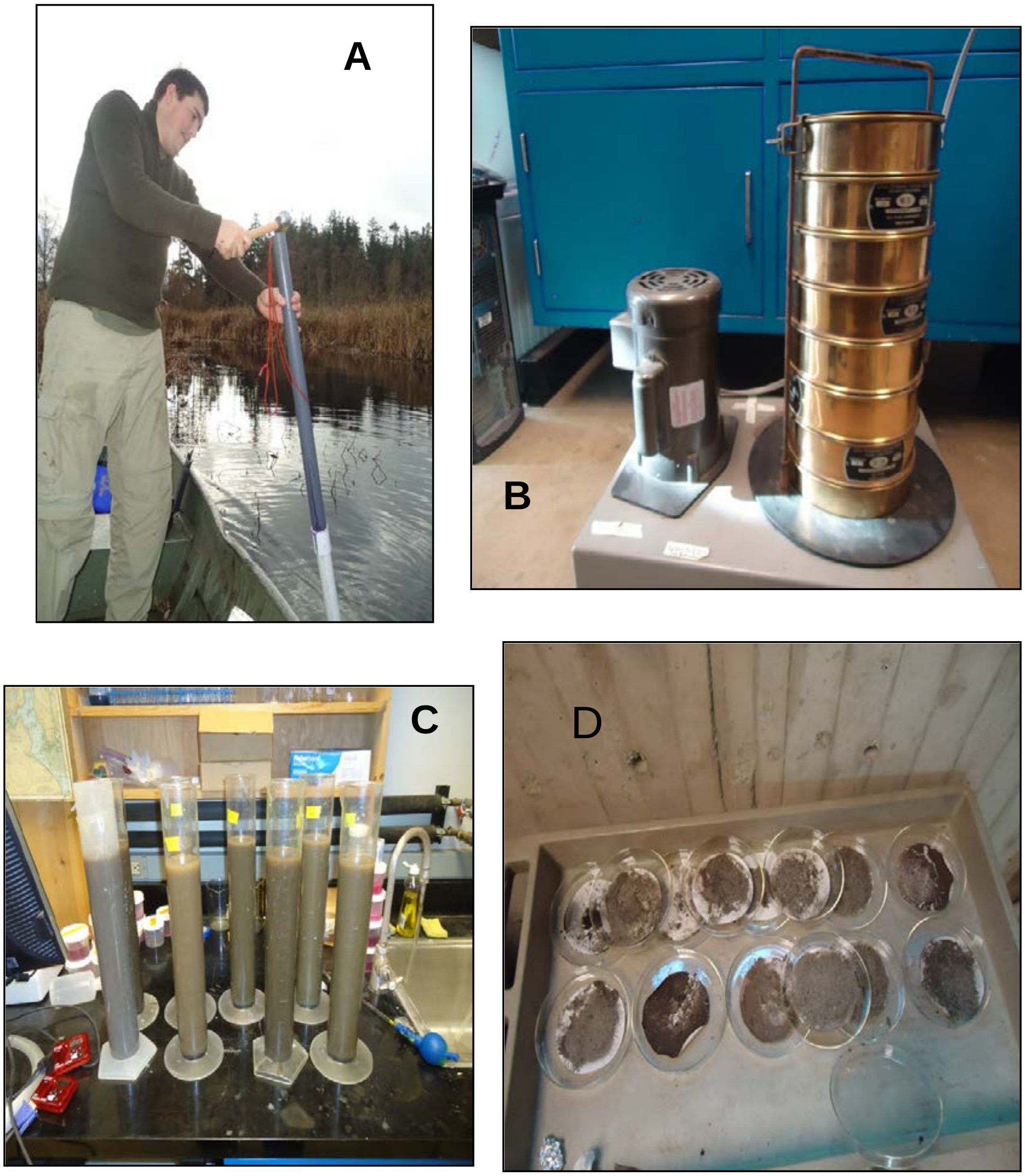

Figure 5. A. Collecting core samples from the bottom of Cannery Pond. B. Shaker screens used to separate various sediment grain sizes from the sediment cores. C. Cylinders used to settle various fractions of the core sediments. D. Sediments of grain size >63 µm drying on filter paper for later separation by shaker screens.

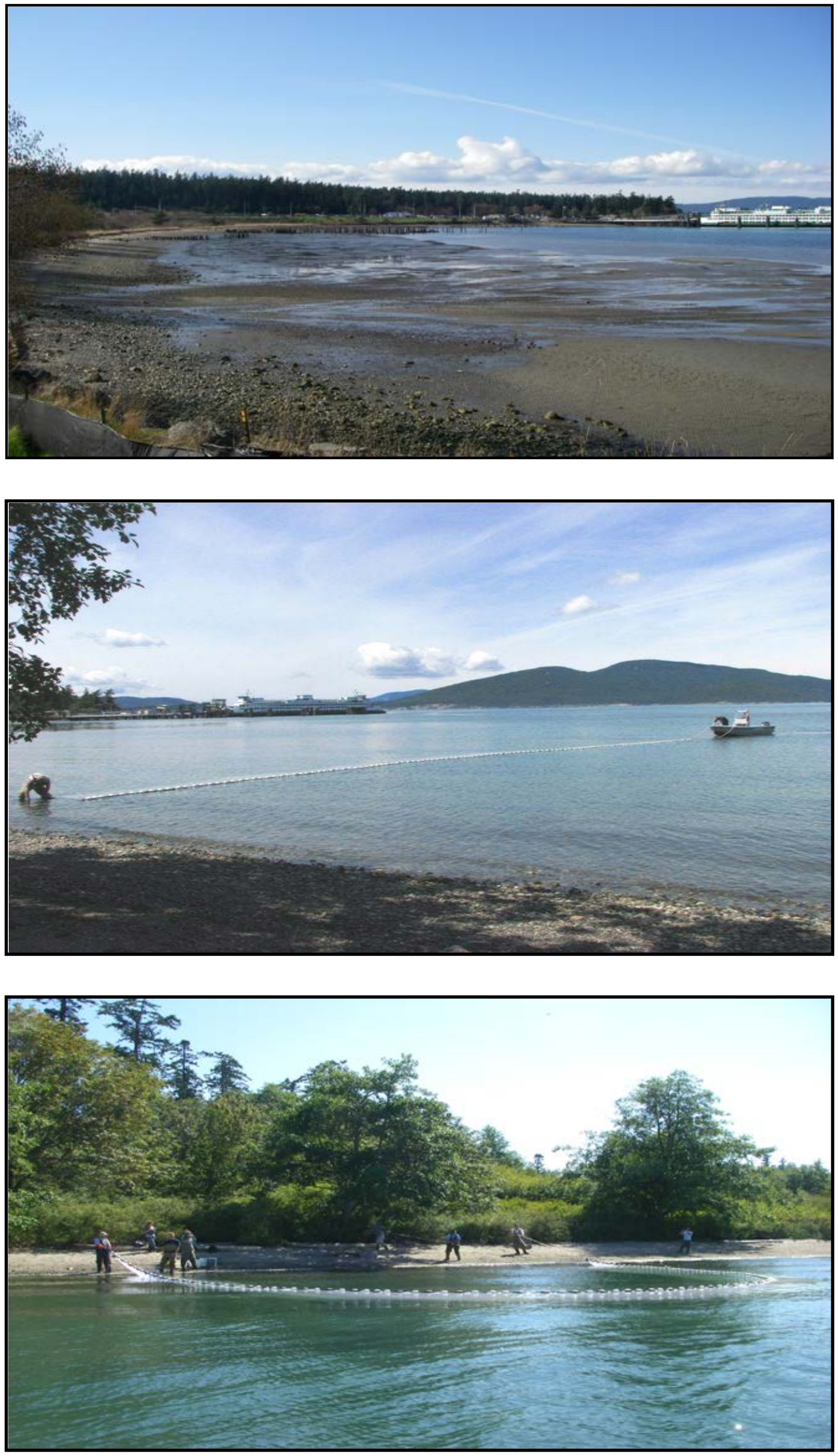

Figure 6. Photographs of the beach seine sampling at Ship Harbor (top). The middle photo shows the net set perpendicular to the shoreline (for four minutes) after which it is “pursed” and retrieved by volunteers on the shore (bottom).

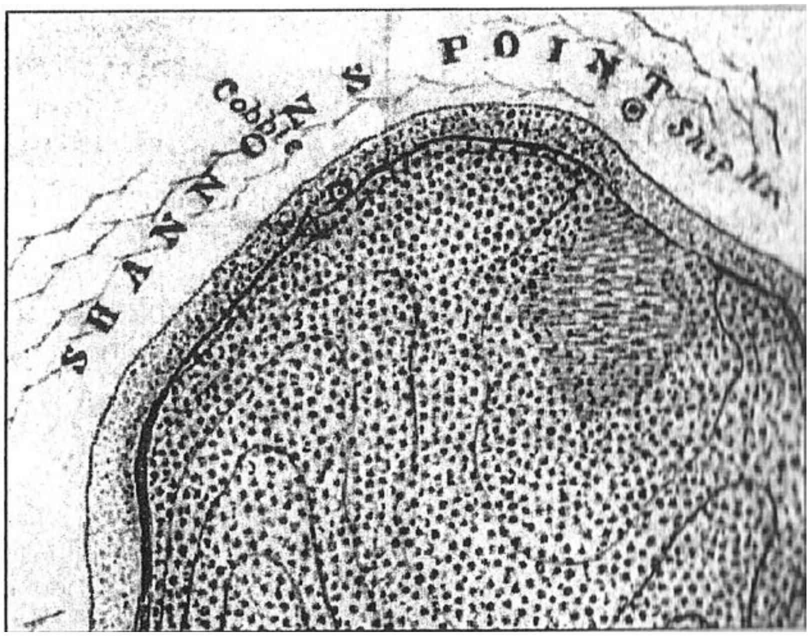

Figure 7. Historic T-sheet number 1667 showing the configuration of Cannery Pond wetlands in 1885 (U.S. Coast and Geodetic Survey, 1885 – from MacLennan and Johannessen 2008).

Figure 8. 1956 photograph of Cannery Pond, which shows the remnants of the railway line constructed through Ship Harbor and around Shannon Point in the late 1800s. Source of the photograph is unknown.

Figure 9. 1970 photograph of Cannery Pond showing the recent construction of the San Juan Island Ferry Terminal between Shannon Point and Ship Harbor. Source unknown.

Figure 10. 1994 photograph of Cannery Pond showing an expanded San Juan Island Ferry Terminal. Source unknown.

Figure 11. 2001 photograph of Cannery Pond. Source unknown.

Figure 12. 2006 photograph of Cannery Pond. Source unknown.

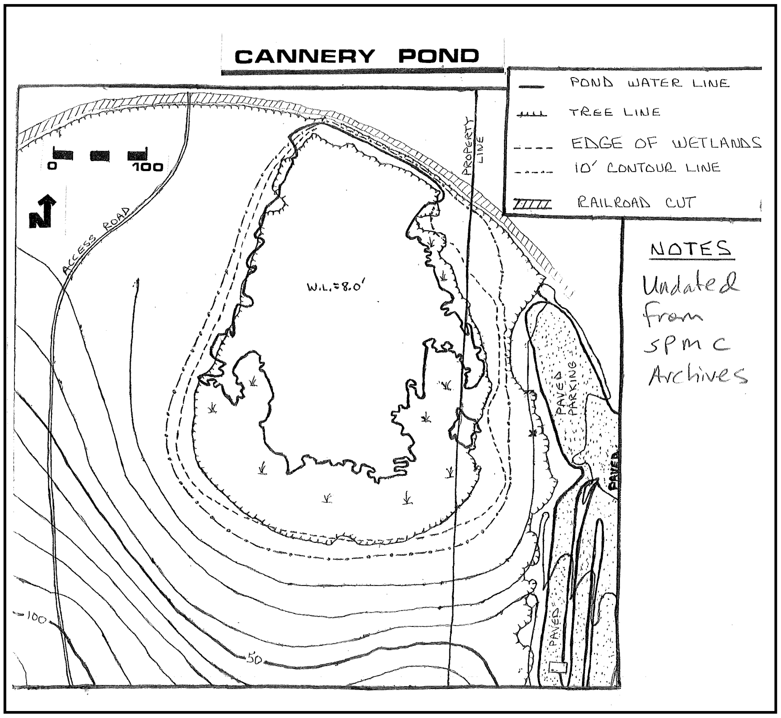

Figure 13. Copy of a basic wetlands delineation of Cannery Pond likely conducted in about the 1970's and archived at Shannon Point Marine Center. The source is unknown.

Figure 14. Photographs of Cannery Pond showing the central open portion of the pond (top) and the floating mats of vegetation dominated by cattails along the northern portion of the pond (bottom).

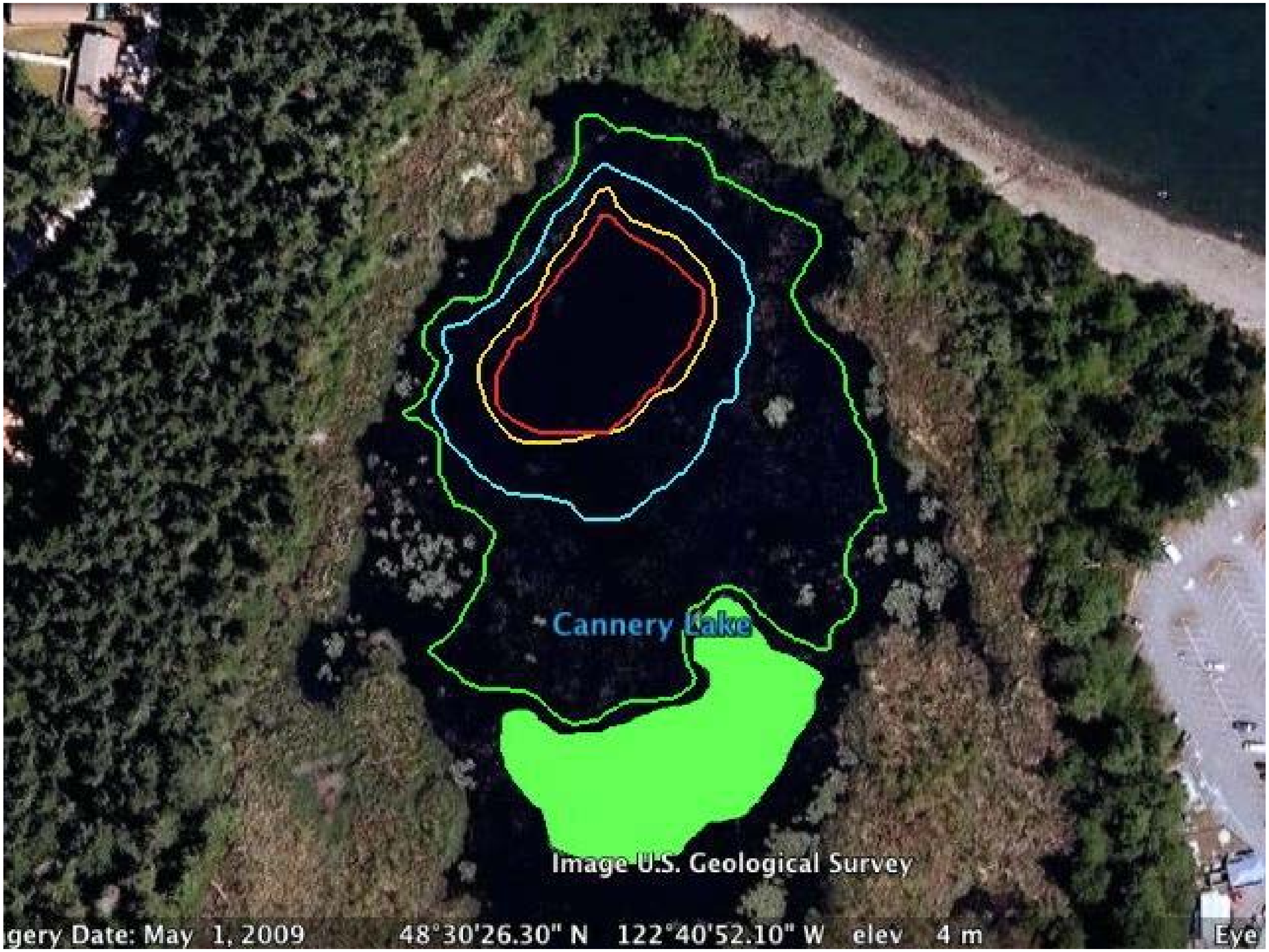

Figure 15. Photograph of Cannery Pond showing depth contours. Green = 0-4 ft, blue = 4-8 ft, yellow = 8-12 ft, red = 12+ ft, filled green = cattail *(Typha latifolia)*.

Figure 16. Series of photographs of the Guemes Channel side of the railroad berm showing the unconsolidated nature of the filled area that has been eroded as much as 3-4 meters in places (top), the presence of some riprap (middle) and undercutting of the berm caused by wave action (bottom).

Figure 17. Photographs of the eastern junction between native bluff materials and the beginning of the berm fill area (top) and the nature of the native consolidated sandstone/gravel bluff on the western end of the berm fill area (bottom).

Figure 18. Guemes Channel side of the railroad berm (top) showing the approximate water level (about 1 meter above the upper shoreline -- white dashed line) in Cannery Pond behind the berm. The bottom photo shows an area of seepage through the berm on the west end of the fill area. Seepage was estimated at about 1 to 2 liters/minute.

Figure 19. Photograph of a representative bottom core from Cannery Pond. The core surface (right) was typically loosely consolidated organic materials while the lower sections of the core was composed of organic materials, silt, and silt and or sand (varied by core).

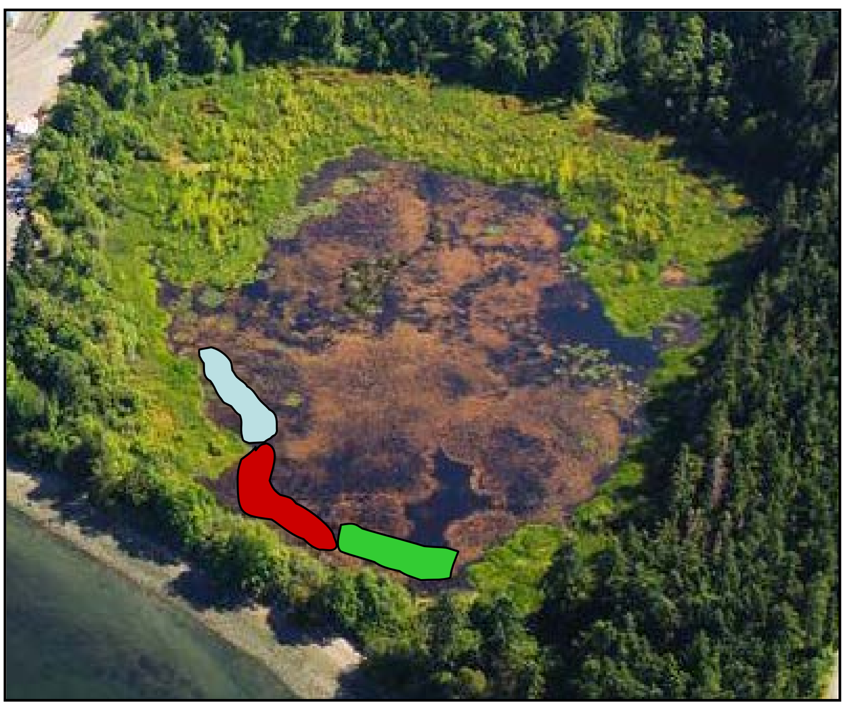

Figure 20. Overhead photograph of Cannery Pond showing the areas within which bottom sediment cores were collected.

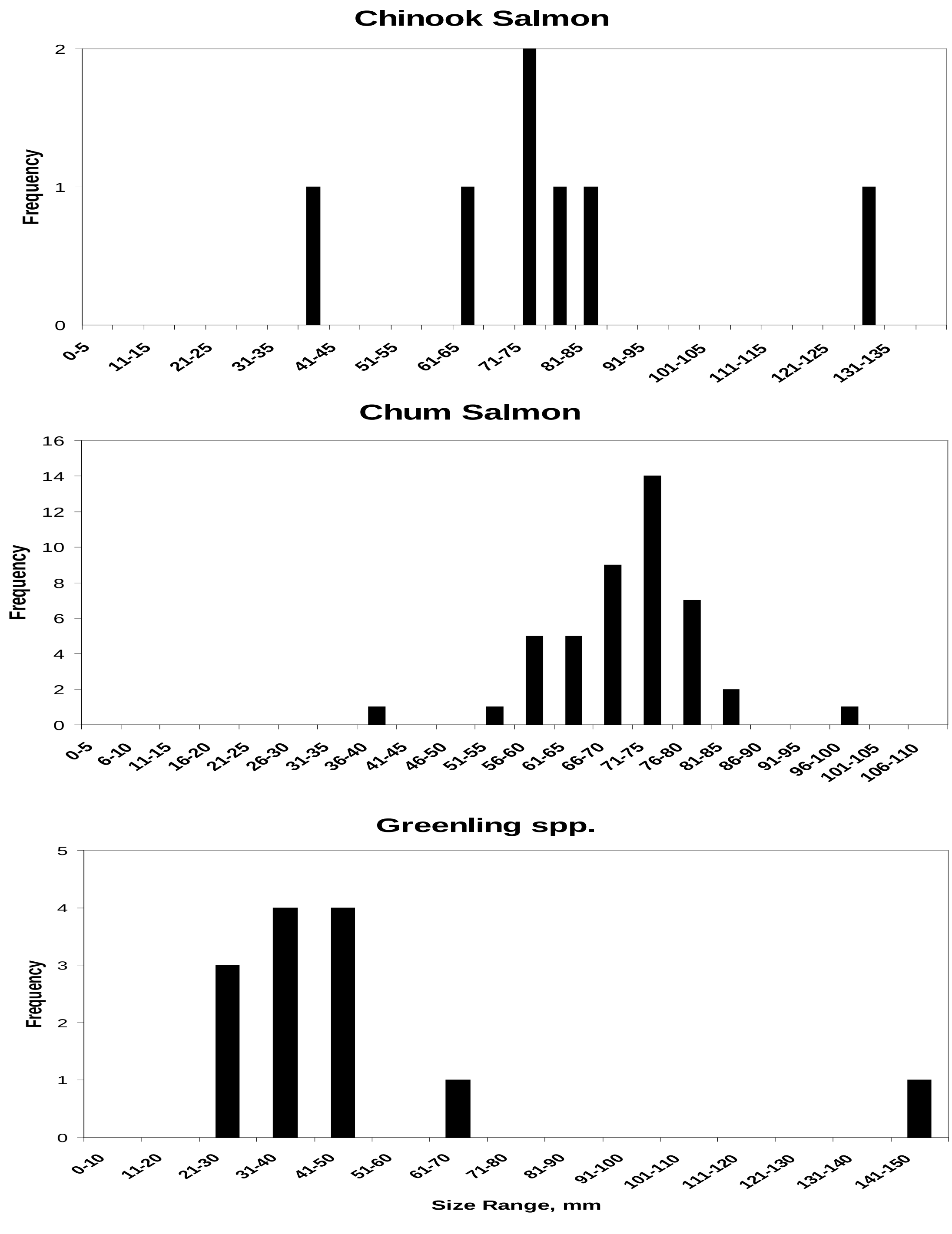

Figure 21. Length-frequency histograms for all Chinook salmon, chum salmon and greenlings caught in the beach seine samples at Cannery Pond (Jan.-- Feb.) and Ship Harbor (March – December) in 2010.

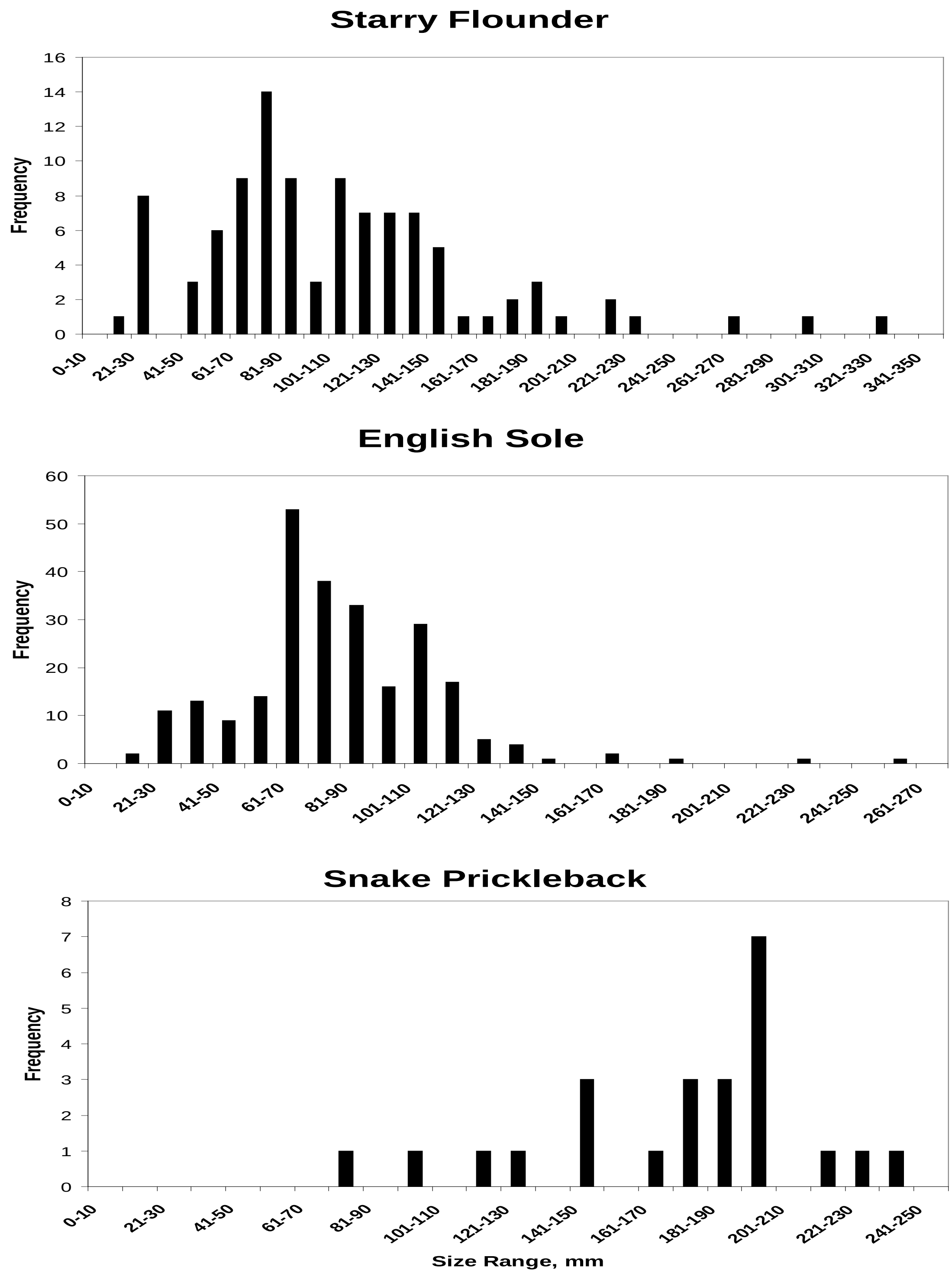

Figure 22. Length-frequency histograms for all starry flounder, English sole and snake prickleback caught in the beach seine samples at Cannery Pond (Jan.-- Feb.) and Ship Harbor (March – December) in 2010.

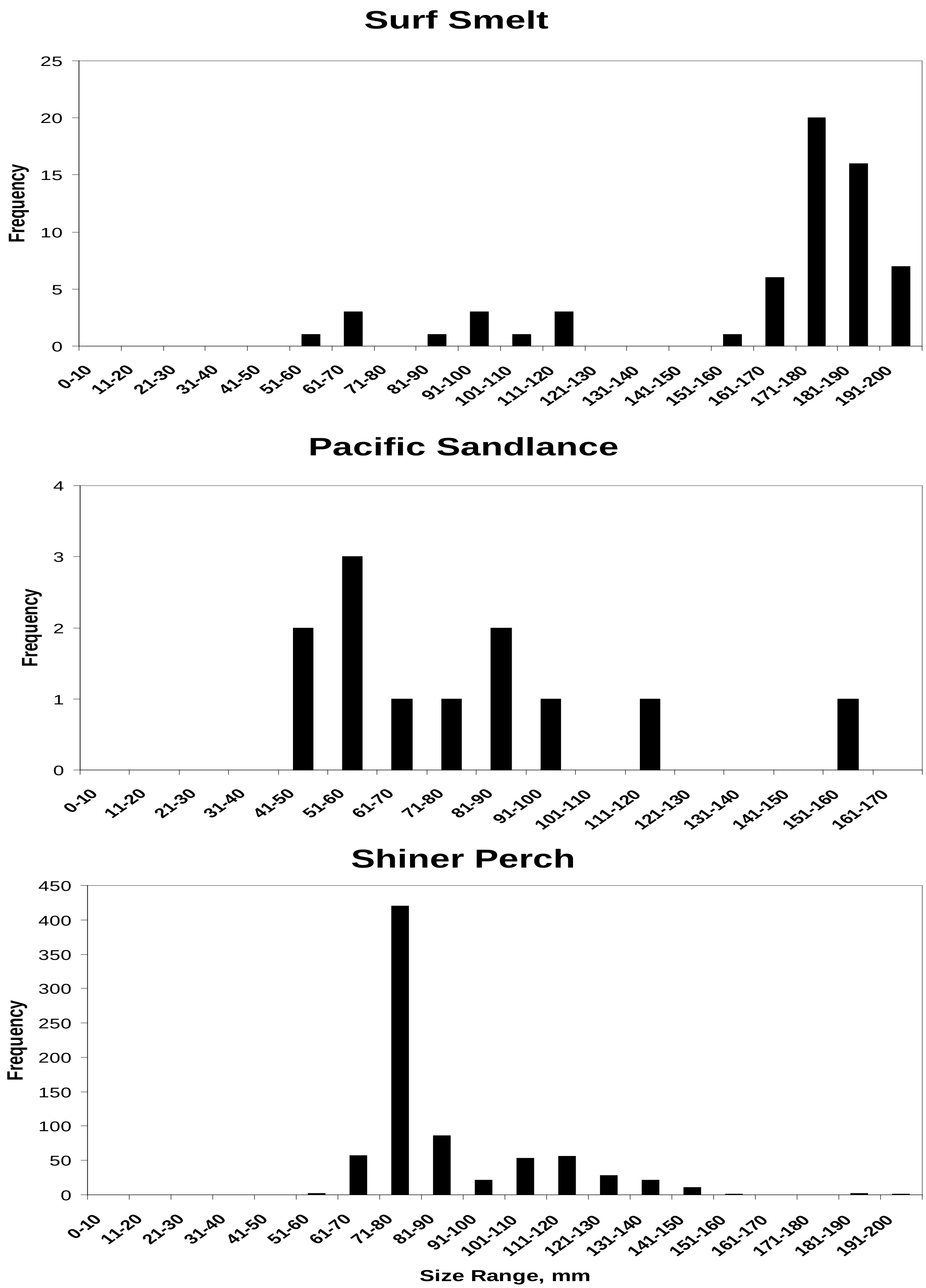

Figure 23. Length-frequency histograms for all surf smelt, Pacific sandlance and shiner perch caught in the beach seine samples at Cannery Pond (Jan.-- Feb.) and Ship Harbor (March – December) in 2010.

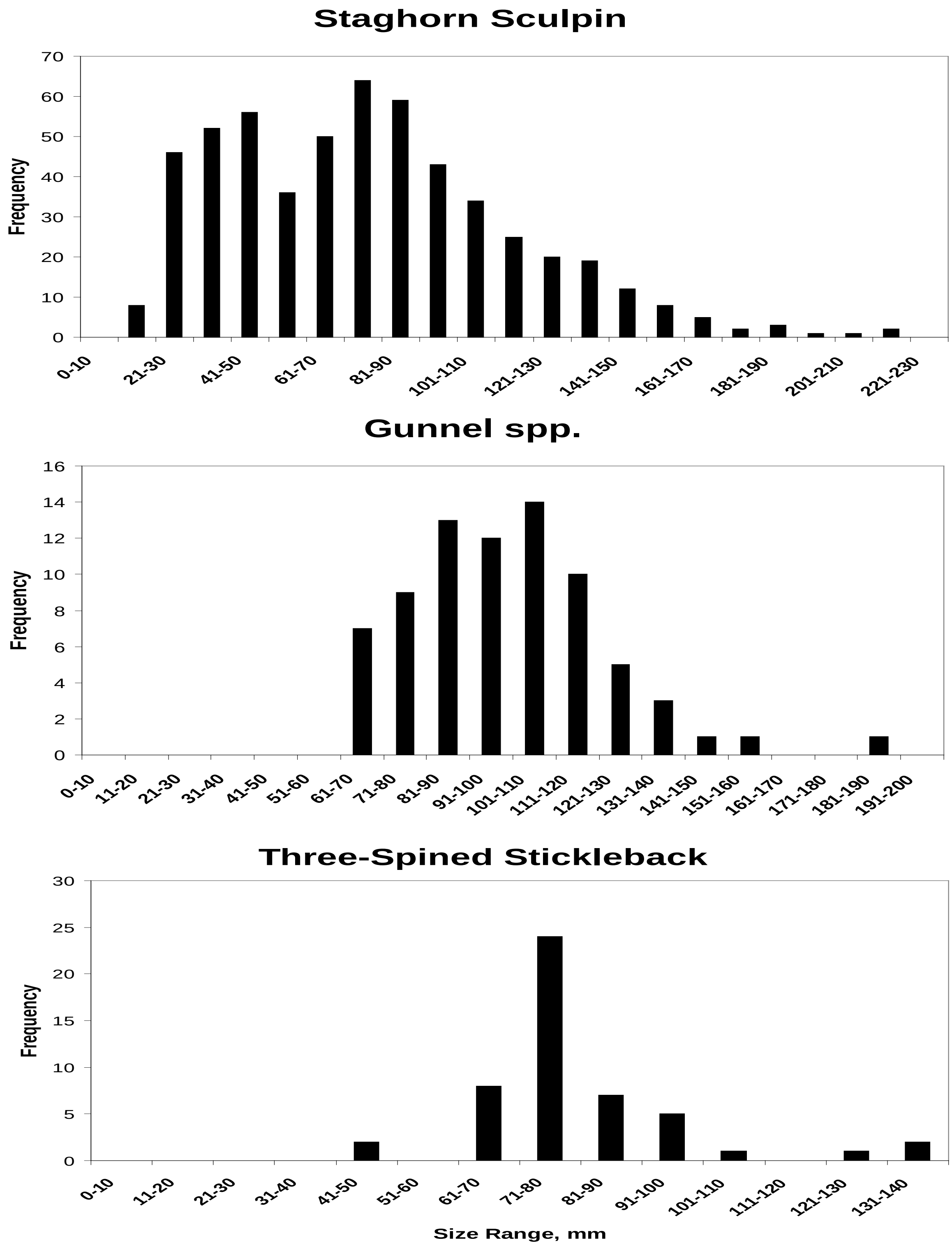

Figure 24. Length-frequency histograms for all Pacific staghorn sculpin, various species of gunnel and three-spined stickleback caught in the beach seine samples at Cannery Pond (Jan.-- Feb.) and Ship Harbor (March – December) in 2010.