Impacts of Piscivorous Predation on Juvenile Chinook (*Oncorhynchus tshawytscha*) and other Salmonids in Salmon and Shilshole Bays of Puget Sound, King Co. WA

By Brian Footen

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Environmental Studies

The Evergreen State College

2001

Approved by

Co-chairpeople of the Supervisory Committee

______________________ Date Oct 15 '01

______________________ Date 10/15/01

______________________ Date 10/15/01

Master of Environmental Studies Director

______________________ Date 8 April 2002

Impacts of Piscivorous Predation on Juvenile Chinook (*Oncorhynchus tshawytscha*) and other Salmonids in Salmon and Shilshole Bays of Puget Sound, King Co. WA

Brian Footen
The Evergreen State College
Master of Environmental Studies Program

Abstract

The following report is the last step in a series of investigations into the impacts of piscivorous predation on juvenile salmon in the Lake Washington Basin located in King County, Washington. Lake Washington empties into the Salmon Bay estuary in the Central Puget Sound adjacent to King County, which has not been investigated previously for piscivorous predation on juvenile salmon. Predation by piscivores in the freshwater areas of the Lake Washington basin has been widely investigated, from the Cedar River to the Government Locks. The purpose of this study was to continue research on piscivores in the Lake Washington system providing some insight into the level of predation by piscivores on juvenile chinook (*Oncorhynchus tshawytscha*) and other salmonid smolts occupying the nearshore areas of the marine waters of Salmon and Shilshole Bays. Electivity of habitat by smolts and piscivores was investigated to determine if habitat played a role in piscivore and smolt overlap. The manipulation of freshwater flow into the marine waters of Salmon Bay by the Government Locks may affect the behavior of chinook and other smolts in the nearshore areas resulting in piscivore prey overlap increasing piscivorous predation potential.

Piscivores were caught by beach seine, and stomach contents taken using gastric lavage. Stomach contents were frozen and analyzed in the lab. The catch rate of piscivores was small, located primarily in the Inner Bay. Chinook smolt numbers were robust in the Inner Bay and not as numerous in the Outer Bay. Significant predator prey overlap was limited to the Inner Bay, with the highest probability of chinook consumption occurring at the Railroad Bridge sample location nearest the Government Locks.

Chinook smolts were present in the diets of cutthroat trout (*Oncorhynchus clarki*), char (*Salvelinu sp.*) and staghorn sculpin (*Leptocottus armatus*) in the Inner Bay and were not present in the piscivores sampled in the Outer Bay. Sandlance and chum were the most frequently observed preyfish in piscivore stomachs in both bays, even as chinook densities increased in the nearshore areas. Consumption estimates of chinook and other smolts by the primary piscivores cutthroat trout, char and staghorn sculpin were small as estimated populations for these piscivores in the nearshore habitat of the study area were not high.

Table of Contents

List of Figures and Tables and Appendixes

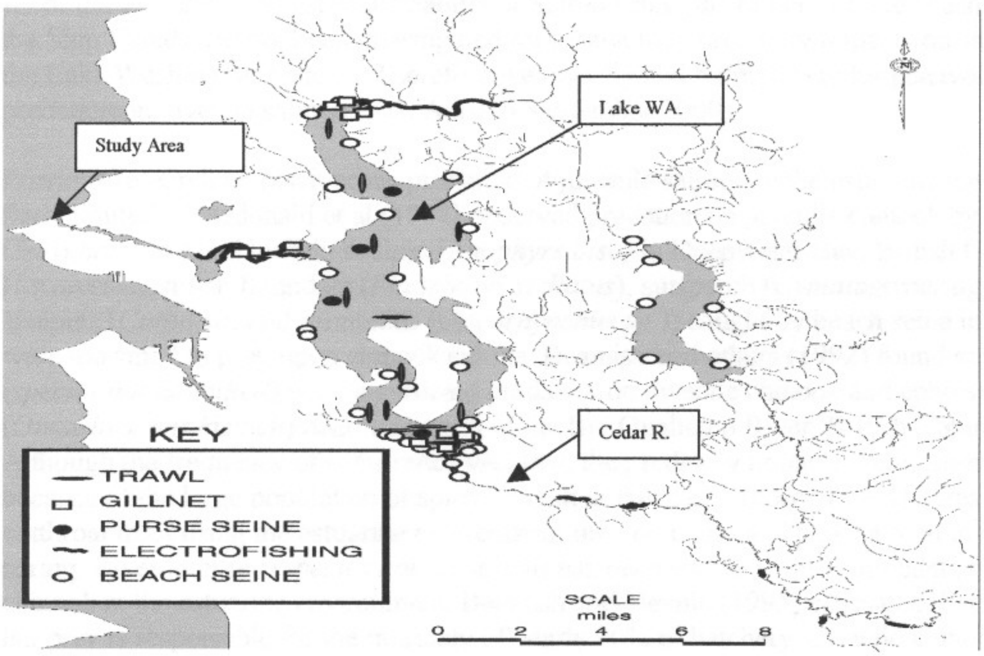
Introduction

Introduction

The following report is the last step in a series of investigations into the impacts of piscivorous predation on juvenile salmon in the Lake Washington Basin located in King County, Washington. Since 1996 piscivorous predation in Lake Washington has been studied cooperatively by USFW (U.S. Fish and Wildlife Service), UW (University of Washington), WDFW (Washington Department of Fish and Wildlife) and the MITFD (Muckleshoot Indian Tribe Fisheries Department), (Brocksmith, 1999; Fayram, 1996; Tabor and Chan, 1996,1997 ;Tabor, 1999; Warner and Footen, 1997,1999). One theory for the poor freshwater survival of juvenile sockeye (*Oncorhynchus nerka*) in Lake Washington is predation by piscivores. Dams and development of the Columbia River watershed have caused an increase in piscivorous predation of juvenile salmon (Vigg, 1991). It is possible that anthropogenic activities have caused similar problems at the outlet of Lake Washington where a dam (the Army Corps of Engineers Government Locks) separates the fresh and saltwater interface.

Predation in the Lake Washington basin has been widely investigated. From the Cedar River (the primary tributary to Lake Washington) to the Government Locks, piscivorous fishes have been sampled in an attempt to quantify predatory impacts on salmonid freshwater survival (Figure 1).

Figure 1. Areas and Gear Types Used to Sample for Piscivorous Predation in the Lake Washington Basin.



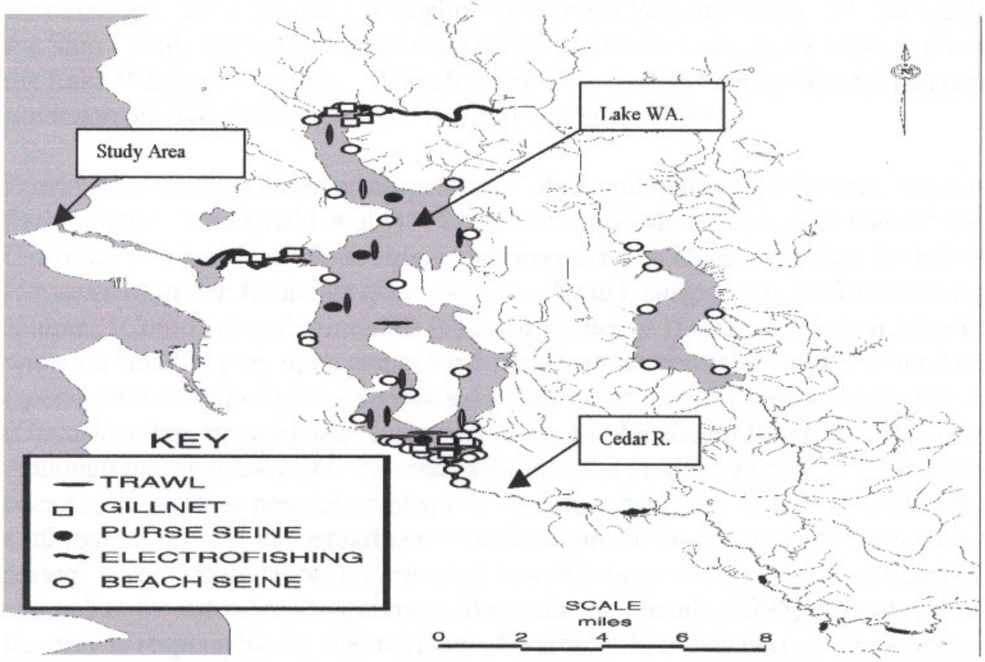
Results from these studies indicate that predation on sockeye presmolts by the primary predators in Lake Washington may be exceeding the upper limit of predation mortality expected during juvenile sockeye freshwater life history. Typically sockeye freshwater survival averages between 20 and 25% during their freshwater phase, however in Lake

Introduction

The following report is the last step in a series of investigations into the impacts of piscivorous predation on juvenile salmon in the Lake Washington Basin located in King County, Washington. Since 1996 piscivorous predation in Lake Washington has been studied cooperatively by USFW (U.S. Fish and Wildlife Service), UW (University of Washington), WDFW (Washington Department of Fish and Wildlife) and the MITFD (Muckleshoot Indian Tribe Fisheries Department), (Brocksmith, 1999; Fayram, 1996; Tabor and Chan, 1996,1997 ;Tabor, 1999; Warner and Footen, 1997,1999). One theory for the poor freshwater survival of juvenile sockeye (*Oncorhynchus nerka*) in Lake Washington is predation by piscivores. Dams and development of the Columbia River watershed have caused an increase in piscivorous predation of juvenile salmon (Vigg, 1991). It is possible that anthropogenic activities have caused similar problems at the outlet of Lake Washington where a dam (the Army Corps of Engineers Government Locks) separates the fresh and saltwater interface.

Predation in the Lake Washington basin has been widely investigated. From the Cedar River (the primary tributary to Lake Washington) to the Government Locks, piscivorous fishes have been sampled in an attempt to quantify predatory impacts on salmonid freshwater survival (Figure 1).

Figure 1. Areas and Gear Types Used to Sample for Piscivorous Predation in the Lake Washington Basin.



Results from these studies indicate that predation on sockeye presmolts by the primary predators in Lake Washington may be exceeding the upper limit of predation mortality expected during juvenile sockeye freshwater life history. Typically sockeye freshwater survival averages between 20 and 25% during their freshwater phase, however in Lake

Washington survival has been as low as 2%. In 1996 and 1997, Tabor and colleagues initiated predatory research by investigating piscivorous predation on sockeye fry in the lower Cedar River. Tabor found a high frequency of occurrence of sockeye fry in sculpin (*Cottid sp*) and cutthroat (*Onchorhynchus clarki*) sampled. In 1997, 1998, and 1999, Brocksmith, Fayram, Warner and Footen expanded this research, investigating predation by piscivorous fishes in the littoral and pelagic zones of Lake Washington. During the spring of 1997 electrofishing, gillnetting and beach seines were used to capture piscivores in the littoral zone of the Lake and Ship Canal. These data showed cutthroat were the primary predator of sockeye fry in the Lake's littoral zone. Predation on sockeye presmolts was observed in the pelagic zone of the Lake in 1998 and 1999. Warner and others (1999) used gillnets, bottom trawling and purse seining to capture piscivores. Results from these data indicated cutthroat were the primary predator on sockeye juveniles in the Lake's limnetic habitat and sculpin were the major sockeye presmolt consumers on the Lake's bottom.

In 1997 and 1999, significant levels of predation were observed on juvenile chinook (*Oncorhynchus tshawytscha*) by smallmouth bass (*Micropterus dolomieui*) in the Ship Canal, which connects Lake Washington to the marine waters of Puget Sound. Fayram (1996) observed predation by smallmouth bass on juvenile chinook migrating through the eastern part of the Ship Canal. Warner and others observed predation on chinook smolts throughout most of the nearshore habitat in the ship canal. Tabor continued this work in 1999, expanding the scope of the research. Tabor's work confirmed the initial findings of Fayram and Warner, that indeed smallmouth bass are preying on migrating young chinook and the frequency of occurrence is high. In addition, Tabor found that northern pikeminnow (*Ptychocheilus oregonensus*) is a significant predator on migrating salmon in the Ship Canal. As of the year 2000 the estuarine habitat of Salmon Bay (the outlet of Lake Washington and the Ship Canal) had not been investigated for piscivorous predatory impacts on salmonids in the Lake Washington system. Therefore we investigated Salmon Bay for piscivorous predation on juvenile salmon from April to September 2000.

Previous research on piscivorous predation of juvenile salmon in the estuarine environment is fairly limited. Macdonald et al (1988) observed predation on juvenile chinook by char (*Salvelinus sp.*) and buffalo sculpin (*Enophyrs biso)* in Deepwater Bay, British Columbia. However most fish flounders (*Platichthys stellatus*), surfperch (*Cymatogaster aggregata*), sculpins (*Cottid sp*) and salmonids (*Oncorhynchus sp.*)) caught by beach seine in the estuary were too small to prey upon chinook smolts. Beamish and others (1992) found spiny dogfish (*species not identified*) to be significant predators on juvenile chinook and coho smolts (*Oncorhynchus kisutch*) near the mouth of the Big Qualicum River, British Columbia. Although the frequency of occurrence was low, the predatory impacts were estimated as high because of the large population of spiny dogfish in the area. Thorpe (1994) notes that cutthroat trout using the estuarine environment prey on chum and pink salmon in the early spring. River lamprey (*species not identified*) has been shown to be significant predators on chinook in the estuarine environment. Beamish and Neville (1995) estimated that river lamprey is responsible for the mortality of nearly 90% of hatchery and wild chinook production in the Fraser River plume.

Most of the above mentioned research was conducted in relatively undeveloped systems. Salmon Bay, the area of study, has undergone significant alterations and urbanization over the years. In undisturbed estuaries, mixing takes place between the fresh and saltwater environments. Federal regulations require the elevation of Lake Washington be maintained at a consistent level; therefore the flow of freshwater into the study area of Salmon Bay varies throughout the year (ACOE, 2000). In addition, the Cedar River, the primary input of freshwater into Lake Washington, is used for municipal purposes by the City of Seattle and also plays a role in how much water flows into the study area. This is important because Lake Washington and the Cedar River are the primary inputs of freshwater into the marine waters of the area of study (Figure 1). Therefore the habitat below the locks within Salmon Bay considered an estuary was investigated for functionality.

Locks Operations, Estuary Function and a Listed Species

Recently Puget Sound Chinook were listed as threatened by the National Marine Fisheries Service (NMFS, 1999). Chinook populations have been declining significantly in the Lake Washington basin for the last 20 years (MITFD, 1999). At least one of the two stocks of wild Chinook in the basin are being considered as critical to the recovery of the endangered species unit or ESU, Puget Sound (NMFS, 2000). In light of that, chinook recovery efforts are going forward in the Cedar River, the primary tributary to the Lake Washington Basin. Furthermore activities that are considered to be harmful to chinook survival, or chinook "take", are being scrutinized by the NMFS. This scrutiny comes in the form of permit applications for all development activities within and around the waterways of the Lake Washington basin and the rest of the ESU. There are two types of permits depending on the type of activity that is to take place. For minor construction and recreational activities, parties must apply for what is called a section seven exception. Under section seven an environmental impact statement is developed and a biological opinion of the potential take that is incidental by the activity is provided by the NMFS. This biological opinion either allows for or denies the activity based upon whether or not that activity would jeopardize the stock (NMFS, 2000). Many times the biological opinion will also contain a recommendation for mitigation to minimize the impacts of the activity to the habitat. For activities that result in an intentional take a 4(d) permit must be approved. Approval for 4(d) exceptions undergo significantly more scrutiny than a section 7 exception because the applicant is admitting that some fish will be killed by the activity. Currently the Army Core of Engineers, which operates the Locks, is undergoing negotiations with the NMFS for a section seven exception (AOCE, 2001).

The operation of the locks affects the ecology of the study area as it relates to chinook survival in many ways. One of the primary theories behind this study is that artificial manipulation of the freshwater inputs into the estuary is impacting chinook survival. By limiting freshwater into the system the freshwater lens (and thus the amount of preferred habitat for chinook smolts) is reduced. Chinook smolts typically prefer water with salinities between 8 and 12 parts per thousand while undergoing osmoregulation (Simenstad, per com., 2001) Salinities of these types in the study area are found in a limited zone directly adjacent to the locks (Houck, 2000). The reduction of this important habitat feature may be inducing mortality due to exposure to high salinities. Although the locks have altered operations in recent years in an attempt to increase smolt survival through the facility, no research has been conducted that would show how to mitigate habitat loss in the study area as a result of limited freshwater inputs. There are many protocols that are required to allow the locks to continue to function as a free and unlimited boat passage facility, and it is clear in the draft section seven permit application that these protocols are going to be excepted under section seven with mitigation recommendations that do not address the impacts to estuarine function and chinook survival in the study area (ACOE, 2001).

The City of Seattle also plays a role in the amount of freshwater available to the study area. Because the Cedar River, the primary tributary to Lake Washington, is used for municipal purposes, flows from the river to the Lake are also artificially manipulated. This manipulation in turn limits the amount of water available to the locks for operational purposes. In light of the listing of Puget Sound chinook the City of Seattle underwent another process by which chinook take can be negotiated with the NMFS. The City developed a Habitat Conservation Plan that was approved in 1999. Under this plan the City was able to maintain its water right which allows for instream flows in the Cedar River to be kept at a minimum level necessary for chinook survival in the system (NMFS and City of Seattle, 1998). However these minimum flows were developed for the Cedar River only and were not required to consider how flows from the Cedar River would impact these same fish rearing in the Lake and estuarine waters of Salmon Bay. Reduced flow of water into Lake Washington further limits the water available to operate the locks providing no surplus to help create functional habitat in the estuary.

Estuaries that allow for a transition zone between fresh and saltwater are important to the osmoregulatory process and chinook survival (Fisher, 1989; Healy, 1982; Kreeger, 1992; Levings, 1986; Mac Donald, 1988). MacDonald (1988) released chinook smolts into three different saltwater habitats, representing three different salinities. Results from these releases indicated that juvenile chinook released directly into seawater had higher stress levels and greater mortality than those released into estuarine transition zones. Other research has shown that chinook that emerge and rear in the upper habitat of rivers and therefore have extrapolated travel times in freshwater are more likely to experience adverse impacts from high saline environments. Kreeger (1992) showed that chinook smolts reared in a riverine environment had a higher mortality than did chinook that reared in estuarine habitat when treated with oceanic type salinities of 32 parts per thousand.

In addition to the physiological impacts a disturbed estuary can have on migrating salmonid smolts, reduced or controlled freshwater inputs can limit the area of functional estuarine habitat. Transitioning smolts become vulnerable to predation from birds and larger marine piscivores because they are forced to occupy either a shallow freshwater lens, or emigrate into deeper saline waters at a small size where they become susceptible to predation by larger piscivores (Warner and Fritz, 1995). Estuaries are considered to be a significant refuge from avian and piscivorous predators because smolts can utilize freshwater inputs that allow for vertical distribution while maintaining physiological processes facilitating migration into more saline habitat (Healy, 1982). As well as refuge from predators, natural estuaries can provide juvenile salmon a place to rear and grow. Fisher (1989) observed juvenile chinook utilizing the nearshore areas of Coos Bay, Oregon for up to 83, days during which chinook grew up to .5mm per day.

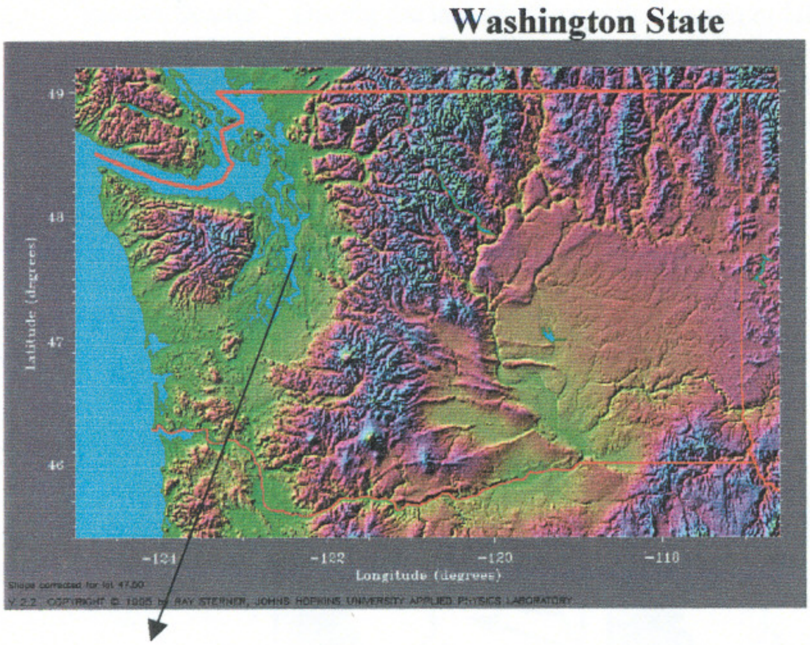
<u>Purpose</u>
The purpose of this study was to continue research on piscivores in the Lake Washington system, providing some insight into the level of predation by piscivores on juvenile chinook and other salmon smolts occupying the nearshore areas of the marine waters west of the Locks. In addition nearshore habitat types and fish use were quantified in order to provide baseline data to further assess how the artificial manipulation of freshwater inputs into the estuary effects the nearshore distribution of chinook and other smolts.

Study Site

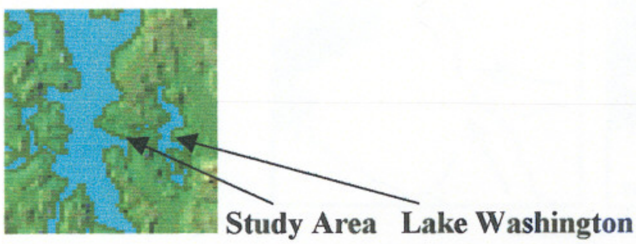
<u>Study Area Location</u>

Salmon and Shilshole bays are located in the Central Puget Sound Lowland adjacent to the north end of the City of Seattle, King Co. WA (Figure 2).

Figure 2. The Central Puget Sound.



Central Puget Sound

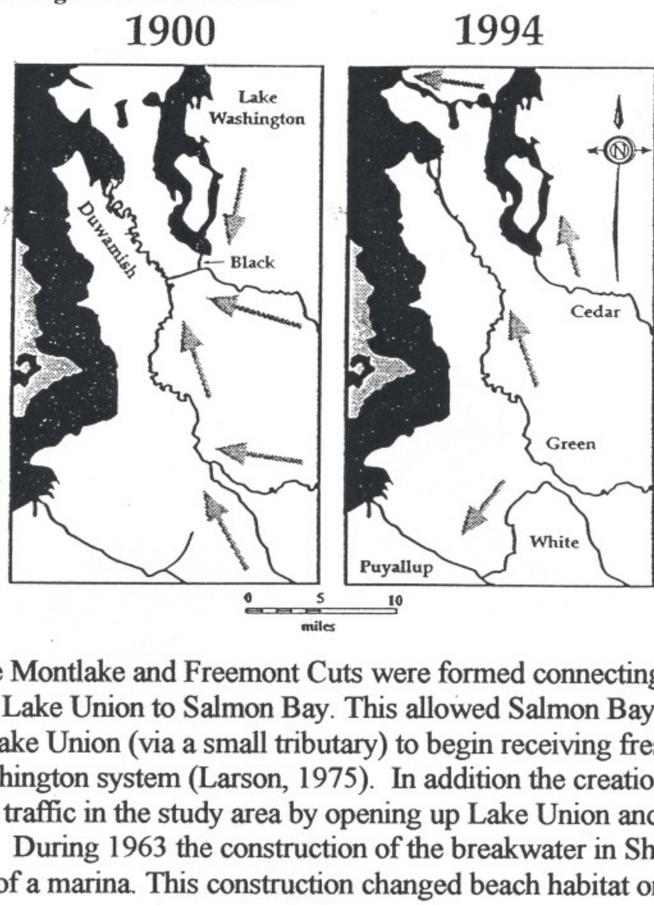


The Central Puget Sound, a glacially formed marine waterway, receives chemical and biological inputs from the Pacific Ocean via the Strait of Juan de Fuca at the northern end of the Sound. Flanked by the Cascade Mountains to the east and the Olympic Mountains to the west, the Central Sound stretches from North Seattle to Commencement Bay adjacent to Tacoma and drains several watersheds (Willis, 1898). The Lake Washington watershed drains into the study area of Salmon Bay, and is a glacially formed lowland lake located east of Seattle in King County Washington. Currently Lake Washington has a surface area of 87.6 km^2, is 29.6 km long, with an average depth of 33 m and a maximum depth of 67 m (Woody, 1972). The primary tributary to the Lake is the Cedar River, which has a mean winter flow of 800 c.f.s. and a mean summer flow of 250 c.f.s.. Other drainages included in the Central Puget Sound are minor tributaries from Kitsap and King counties and several major watersheds, including the Skykomish River, and the White and Green Rivers

History of Study Area

The study area, stretching from the Government Locks at the southeast end to Golden Gardens Park at the northern end, is tidal. It has a mean tide of 8 feet and a range of 11.7 feet (City of Seattle, 1983). The study area has been changed from its natural state by the construction of the Locks in 1917, which included dredging for a shipping lane, the construction of a marina breakwater in 1963, and significant shoreline development for private and commercial use. The Lake Washington watershed has undergone many transformations from anthropogenic activities over the last 100 years, and has become "greater Seattle". During the late 1800's the fluctuation of lake levels and the adjacent areas submerged by high waters made farming and other development activities in the fertile lowland areas of the Lake Washington basin very difficult. Therefore flood control measures were initiated in the first years of the twentieth century, culminating in the construction of the Government or Hiram Chittendon Locks (Bagley, 1929). The implementation of the Locks dramatically altered the drainage pattern of the Lake Washington basin (Chrzastowski, 1983). The Lake level was lowered by eight feet, severing the Lake from the Black and Green Rivers located at the Lake's southern end, originally the Lake's only outlet (Figure 3).

Figure 3. Lake Washington Past and Present.



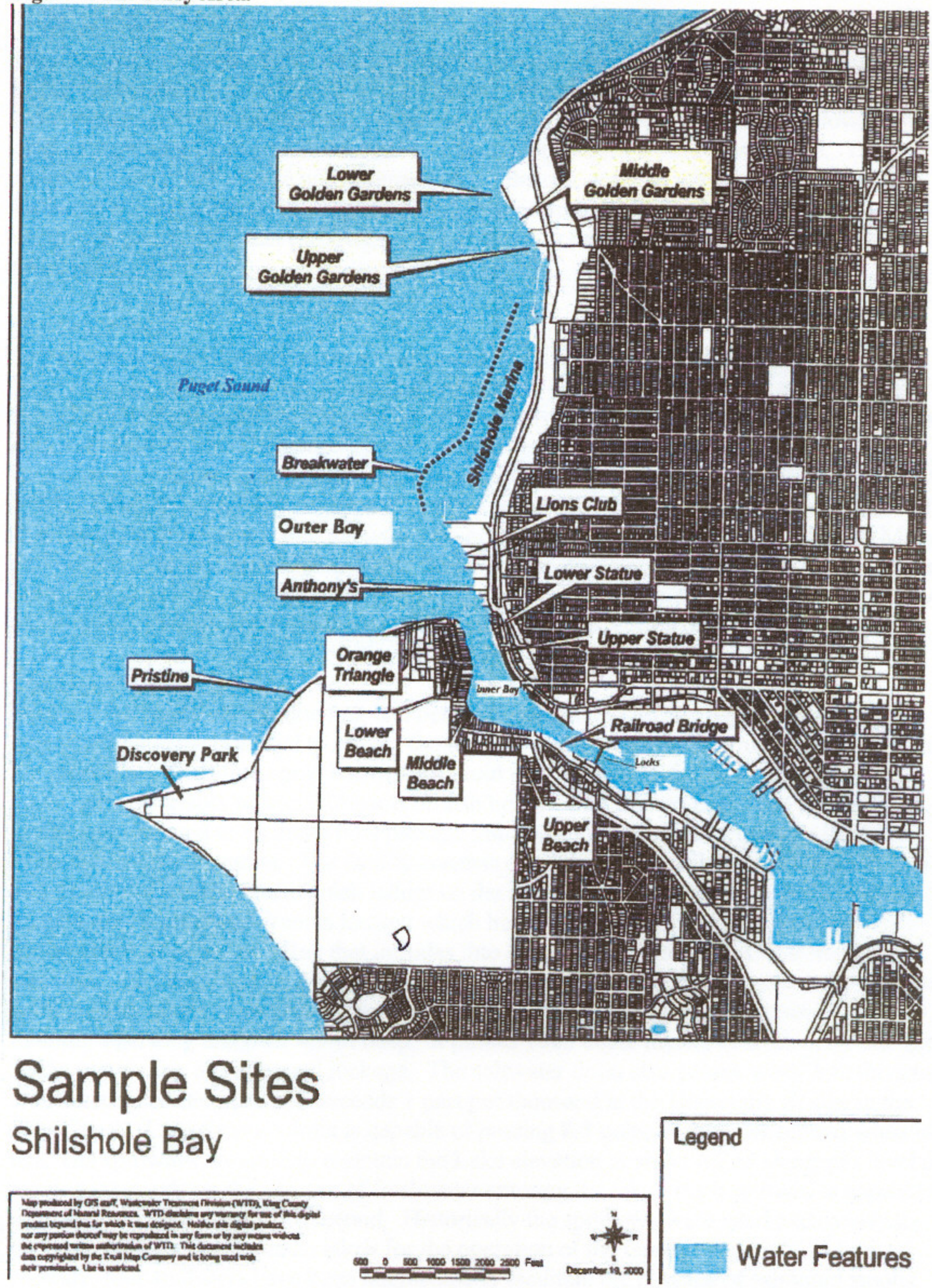
Concurrently the Montlake and Freemont Cuts were formed connecting Lake Washington to Lake Union and Lake Union to Salmon Bay. This allowed Salmon Bay, once only receiving drainage from Lake Union (via a small tributary) to begin receiving freshwater from the entire Lake Washington system (Larson, 1975). In addition the creation of the Locks also increased vessel traffic in the study area by opening up Lake Union and Lake Washington to saltwater traffic. During 1963 the construction of the breakwater in Shilshole Bay allowed for the building of a marina. This construction changed beach habitat on the east shoreline of Shilshole Bay into a protected moorage facility. Additional shoreline development has taken place over the years as well, occupying nearly all the shoreline in the study area with the exception of Golden Gardens Park and a small stretch of beach on the north end of Discovery Park adjacent to the south end of Shilshole Bay.

The study area was broken down into two locations; the inner bay or Salmon Bay and the outer bay, Shilshole Bay. Each location had seven sample sites (Table 1;Figure 4).

Inner Bay	Outer Bay
1. Railroad Bridge	1. Pristine
2. Upper Beach	2. Lower Golden Gardens
3. Mid Beach	3. Mid Golden Gardens
4. Lower Beach	4. Upper Golden Gardens
5. Orange Triangle	5. Breakwater
6. Lower Statue	6. Lions Club
7. Upper Statue	7. Anthony's

Table 1. List of Study Locations in the Inner and Outer Bays.

Figure 4. The Study Area.



The criterion for separating the Inner and Outer bays was exposure. The criterion for choosing a sample site was governed strictly by beach availability (Mumford et al, 1991).

The Inner Bay

The Inner Bay (Salmon Bay) is a protected area between Shilshole Bay (Outer Bay) and the Locks encompassing 2,610 meters of shoreline. It receives freshwater discharge from the Lake Washington system via the Locks. The beaches of the Inner Bay have shallow sloping gradients ranging from 6 to 12 % and sediment compositions from silt to cobble. The shoreline consists of private and commercial residences, some of which overhang into the wetted area during high tide. The Inner Bay, bissected by a dredged shipping lane, has a maximum depth of 47 feet (NOAA, 1984). Bulkheads or riprap armor nearly 90% of the shoreline.

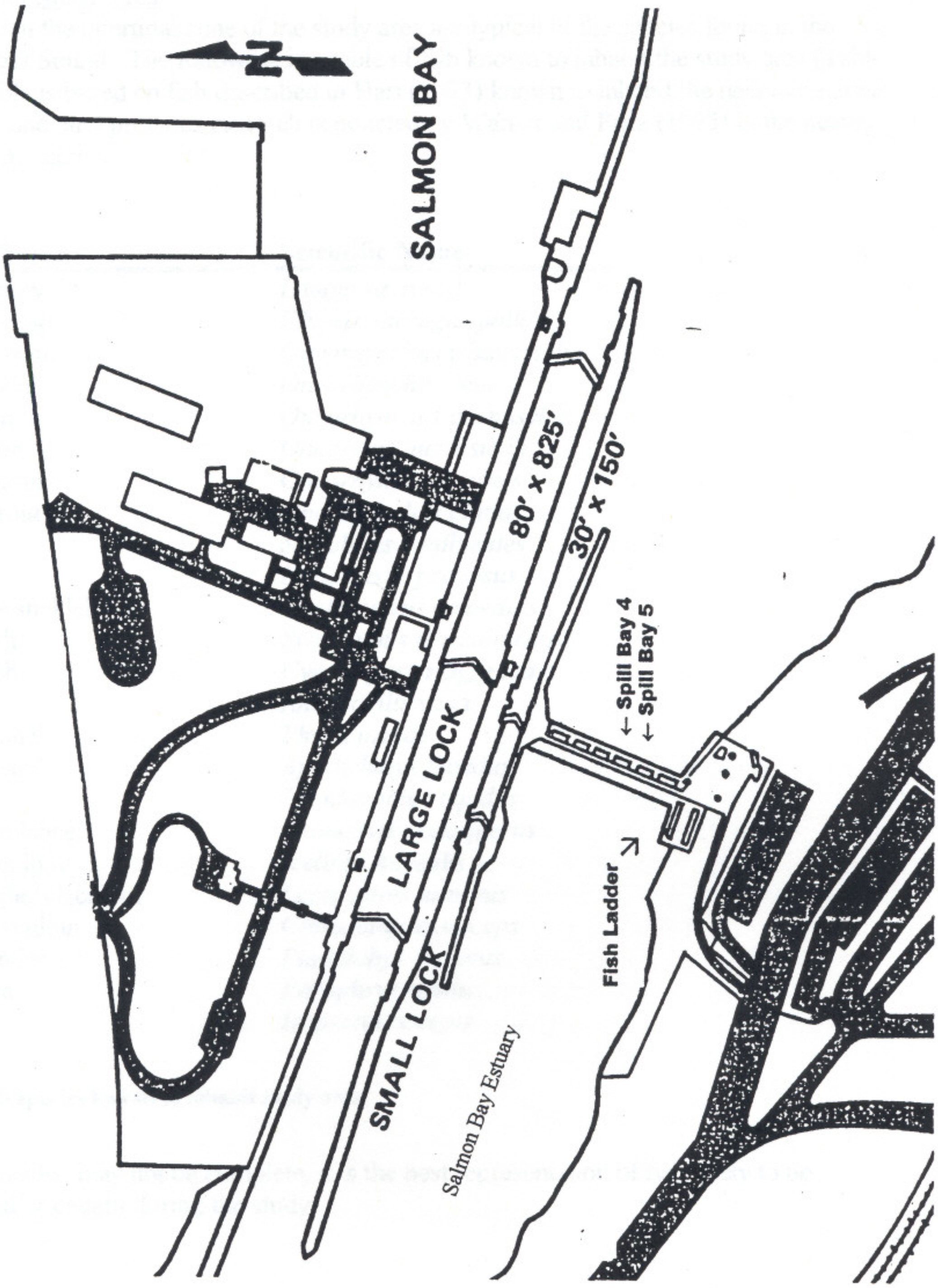
The Outer Bay

The Outer Bay (Shilshole Bay) is an exposed area of Central Puget Sound extending from West Point at Discovery Park at the southern end, to Golden Gardens Park at the northern end. The shoreline used for the purpose of this study encompasses 5,015 meters of inter-tidal area including exposed beach area on the west side of the marina breakwater. A shipping lane with a maximum depth of 47 feet bissects the south and north areas of the bay (NOAA, 1984). Beaches sampled were limited to the western shoreline adjacent to the north end of Discovery Park, a beach along the west side of the breakwater that protects Shilshole Marina, and the beach at Golden Gardens Park. Shilshole beaches also had shallow sloping gradients no greater than 10%. Substrate composition ranged from sand to cobble. A small tributary enters the study area at the southern end of Golden Gardens (City of Seattle, 1983).

The Government Locks

Because the Locks are the dividing line between salt and freshwater habitats, Locks operations have the potential to impact the ecology of the estuarine environment, located in the Inner bay. Therefore some knowledge about the make up of the facility is important when trying to assess potential impacts on fish behavior in Salmon Bay. The Government Locks were created to facilitate boat passage into Lake Union and help manage Lake Washington lake elevation. The facility consists of a large and small lock on the north side and a series of spill bays and a fish ladder on the south side. At the bottom of the spillbay holding area a saltwater drain is located which helps remove any saltwater from the freshwater part of Salmon Bay that intrudes into Lake Washington Ship Canal during boat passages. The large lock is 24.4 m wide, 81m long and 9.1 m deep and passes about 18,000 cubic meters of water into the study area during a westbound lockage. The small lock is 9.1 m wide, 40m long and over 4.9 m deep. It passes 1800 cubic meters of freshwater into the study area during a westbound lockage. The saltwater drain also passes water into the study area when saltwater intrusion exceeds 1 part per thousand at the University Bridge in the Ship Canal. The saltwater drain is capable of passing 8.3 cubic meters per second when in use. The spillways are used to maintain the Lake elevation at about 6.7 m above sea level and their use depends on the amount of freshwater entering the lake. Each spillway is capable of spilling 515 cubic meters per second. Historically the spillways were used exclusively to maintain the lake elevations to allow for the operation of the facility (Figure 5). More recently, four spillways have been augmented to facilitate the passage of salmonid smolts. These augmentations also included PIT tag detectors. In the year 2000, smolts were tagged and released throughout the Lake Washington system in an attempt to assess smolt survival through the system and the facility during smolt migration to the marine waters of Salmon and Shilshole Bay. Water demands by the facility often result in the need to store water by late June or early July in most years. This need not only has the potential to affect smolt

Figure 5. Plan view of the Government Locks.



migration through the facility, but may also impact smolt behavior and survival in the study area (ACOE, 2000).

Inhabitants of Study Area

Vertebrates in the intertidal zone of the study area are typical of the species found in the Central Puget Sound. The following is a table of fish known to inhabit the study area (Table 2). This table is based on fish described in Hart (1973) known to inhabit the nearshore areas of Puget Sound, and previous research conducted by Warner and Fritz (1995) in the nearby Duwamish Estuary.

Common Name	**Scientific Name**
River Lamprey	*Lampetra ayresi*
Pacific Herring	*Clupea harengus pallasi*
Chinook salmon	*Oncorhynchus tshawytscha*
Chum salmon	*Oncorhynchus keta*
Pink salmon	*Oncorhynchus gorbuscha*
Coho salmon	*Oncorhynchus kisutch*
Steelhead trout	*Oncorhynchus mykiss*
Cutthroat trout	*Oncorhynchus clarki*
Bull trout	*Salvelinus confluentes*
Surf smelt	*Hypomesus pretiosus*
Three spine stickleback	*Gasterosteus aculeatus*
Bay pipefish	*Syngnathus griseolineatus*
Shiner perch	*Cymatogaster aggregata*
Pile perch	*Rhacochilis vaca*
Cresent gunnel	*Pholis ornate*
Penoint gunnel	*Apodichthys flavidus*
Bay goby	*Lepidogobius lepidus*
Pacific sand lance	*Ammodytes hexapterus*
Northern sculpin	*Icelinus borealis*
Pacific staghorn sculpin	*Leptocottus armatus*
Sharpnose sculpin	*Clinocottus acuticeps*
Starry flounder	*Platichthys stellatus*
English sole	*Parophrys vetulus*
Butter sole	*Isopsetta isolepis*

Table 2. Fish species known to inhabit study area.

Although this list may not be complete, it is the best representation of fish likely to be encountered or caught during the study.

Methods

Fish collection

We sampled 3870.96 meters of shoreline in the Inner Bay and 1584.96 meters of shoreline in the Outer Bay from April to September 2000. The sampling comprised of 127 beach seine sets in the Inner Bay and 52 sets in the Outer Bay. For the times and locations of each beach seine set please see Appendix I.

Sampling was conducted during the first high slack tide of the day. Each study location was sampled twice a week, twice a month. Fish were caught using a beach seine identical to those used in past Lake Washington nearshore sampling efforts (Martz et al, 1995). The seine net was 33 m long with a central bag 2 m deep and wings tapering to 1 m deep. The bag measured 2 m long by 2 m deep by 2 m wide. Wing mesh was 1 cm and bag mesh was 3.2 mm. Thirty- three-meter lines were tied to each end of the seine. Crew people were dropped off at one end of the beach holding the end of a line from one end of the seine. The skiff then traveled away from the beach until the line was paid out. The net was then released horizontal to the beach from the bow of a 12m skiff until the end of the net was reached. The skiff was then driven to shore, releasing the remainder of the line. Once on shore, both lines were towed by hand toward the beach. When the net reached the shore the ends of the seine were brought together and the cork and lead lines pulled in simultaneously. Caution was taken to keep the lead lines as close to the beach as possible to avoid any fish escaping.

Once caught, fish were kept in plastic tubs and buckets, identified to species, measured to fork length and either tallied or sampled for stomach contents based on suspected level of piscivory. Stomach contents were removed using gastric lavage as described in Foster (1977). Stomach contents were bagged and put on ice to be taken to the lab. At the lab the samples were frozen for later analysis. Fish considered to be non-piscivorous were tallied and released.

Salmonid smolt downstream transport through the Locks was being investigated during the study using PIT tag technology (ACOE, 2001). All smolts (chinook, coho, and sockeye) were identified to species, and checked for PIT tags and missing adipose fins. Missing adipose fins on coho and chinook smolts indicate fish of hatchery origin. Although many of the sockeye and chum smolts are also of hatchery origin these fish are not marked externally at the hatchery. In addition to detection of tags at the facility, the nearshore beach seining also provided an opportunity to look for PIT tagged fish residing in study area. A hand held Destron-Fearing PIT tag detector was used to look for PIT tagged smolts in the study area. The detector was placed over a bucket and each smolt caught (with the exception of chum smolts) was passed through the detector. Each PIT tag number detected was stored in the detection unit and copied into the field notes. Because adipose fins from hatchery fish in the system had been removed, hatchery smolts were tallied separately from wild smolts.

Habitat measurements

Habitat data were also collected at each study site. Wolman's (Wolman, 1954) pebble counts were used to provide a coarse resolution of intertidal substrate composition at each study site. Counts were conducted at low tide so as to encompass the area covered by the beach seine. A vertical axis was created every three meters along the horizontal stretch of the beach adjacent to the water line. Pebble counts were then made once every meter along each vertical axis. Beach gradient, length, width, percent *Ulva* and *Fucus* cover and number of significant pieces of woody debris were also tabulated at each study site. For all data relating to habitat measurements see Appendix II.

Laboratory analysis

Stomach sample contents were sorted and identified in the lab. Each stomach sample was thawed and placed under a dissecting microscope. Stomach contents were separated into individual organisms, identified to one of 21 pre-set prey classifications, and grouped with like items. Marine invertebrates were identified to order, fish to species. Each prey group was blotted for ten seconds on a paper towel and weighed to the nearest thousandth of a gram.

Prey fish were identified to species using gillraker data, pyloric caeca counts, and vertebral morphology. Prey fish in the more advanced stages of digestion were identified by using diagnostic bones as described by Hansel et al (1988). When in tact, prey fish were weighed individually and fork lengths measured to the nearest mm. If fork lengths could not be taken, original prey fork lengths were estimated using standard length, nape to tail length, or diagnostic bone measurements taken with an ocular micrometer.

All stomach contents were archived in 80% ethanol in individual vials. Analyses outside of the scope of this project, such as otolith analysis of smolts and other specific analyses of diet can still be performed on these samples in the future, if needed. Samples are located at the Muckleshoot Indian Tribe Fisheries Department.

Diet Analysis

For the diet analysis, percentages of prey items by wet weight were calculated. Population estimates of the piscivores were calculated by multiplying catch per unit effort by meters of shoreline sampled. These were used in simple consumption estimate calculations where the frequency of occurrence of the specified prey item in predator stomach samples was multiplied by the population estimate and the number of days that the specified prey were present in the intertidal areas of the estuary. The following equation describes consumption calculations, $C = (Fn)T$ were C = consumption, F = the average number of salmonids consumed per salmonid consuming predator stomach, n = the estimated population of predators and T = the number of days the preyfish are present in the study location. Based on the low numbers of salmonid consuming predators further calculations using gastric evacuation rates and temperature data were not conducted. Other consumptions estimate models include information about how long it takes different species of piscivores to digest different prey items. These models are much more involved than the model used to estimate consumption in this study. A simple model was used because the data available to estimate consumptions were limited.

Data analysis

A t-test (alpha = .05) was used to test for significant differences in the frequency of occurrence of chinook in the diets of piscivores. To test for significant differences in the catch of smolts and piscivores between sample locations, a chi square test was used (Zarr, 1985). Ivlevs electivity index was used to test for habitat preferences by chinook smolts and piscivores (Ivlevs, 1987).

Results

Chinook smolts were present in the diets of cutthroat trout, char and staghorn sculpin in the Inner Bay and were not present in the piscivores sampled in the Outer Bay. Sandlance and chum were the most frequently observed preyfish in piscivore stomachs in both bays, even as chinook densities increased in the nearshore areas. Coho and sockeye smolts were not identified in the diets of piscivores sampled in the study area. Consumption estimates of chinook and other smolts were not high, as estimates for piscivorous populations in the nearshore habitat of the study area were low.

Overall the catch rate of piscivores was small. Most piscivores were caught in the Inner Bay. Chinook smolt catches were robust in the Inner Bay and not as prevalent in the Outer Bay. Significant predator prey overlap was limited to the Inner Bay, with the greatest overlap of predator and chinook smolts occurring at the Railroad Bridge sample location.

Catch

Overall, 23,816 fish were caught. Of the non-piscivores in the Outer Bay Sandlance were most abundant with the catch peaking on July 4th. In the Inner Bay herring made up the majority of the non-piscivorous catch. Sandlance were more abundant than shown but were not available to the gear because of their small size. The catch of herring peaked in mid to late June (Table 3; Figure 6).

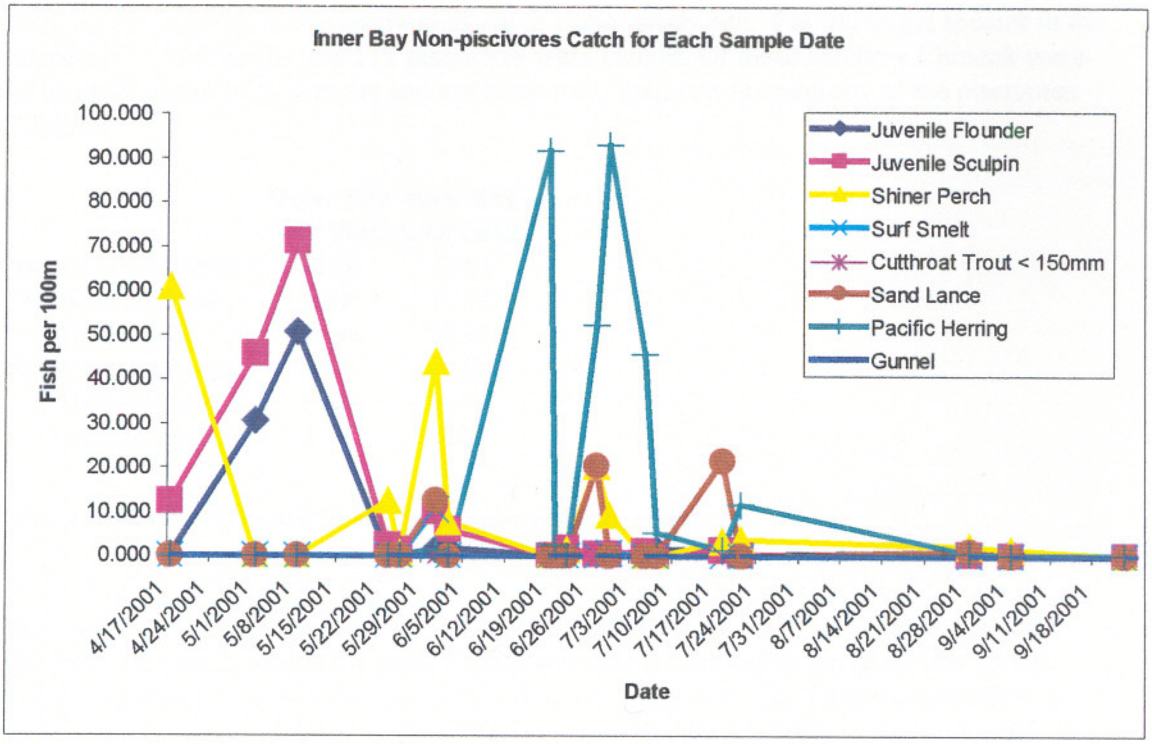
Outer Bay

	Gunnel	Perch	Juvenile Sculpin	Smelt	Sandlance	Juvenile flounder	Stickleback
% Of Catch	1.73	32.43	5.69	9.65	38.12	12.13	0.25

Inner Bay

	Juvenile cutthroat	Gunnel	Herring	Perch	Juvenile sculpin	Smelt	Sandlance	Juvenile flounder
% Of Catch	0.07	0.05	33.77	28.80	13.66	2.85	13.55	7.25

Table 3. Percentage of Catch for Non-Piscivores in the Inner and Outer Bays.



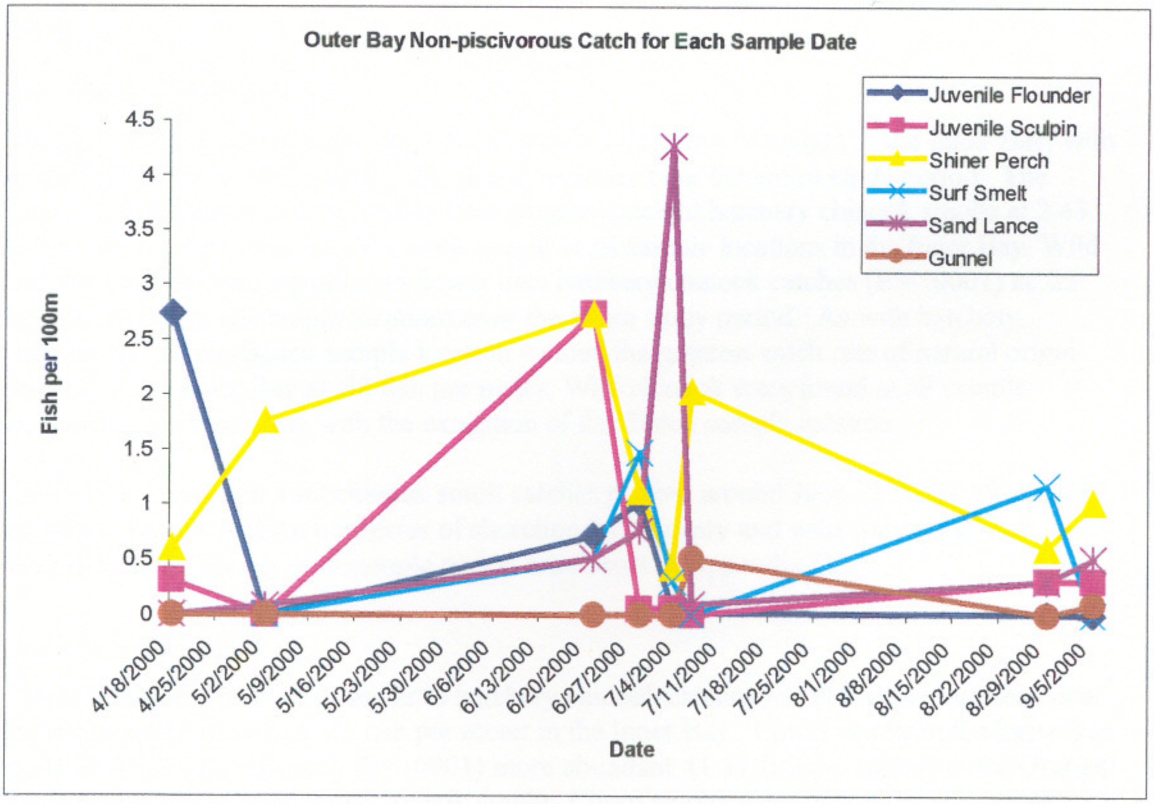


Figure 6. Catch of Non-Piscivores in the Inner and Outer Bays for Each Sample Date.

For the target species in the Outer Bay 2,726 smolts and 33 piscivores were caught. Chum smolts made up the majority of the smolt catch in the Outer Bay while two-year old chinook made up the majority of the piscivorous catch at that study site. For the target species in the Inner Bay 10,576 smolts and 112 piscivores were caught. Of these hatchery Chinook were the most abundant of the smolts and cutthroat trout made up the majority of the piscivores (Table 4).

	Outer Bay % Of Catch	Inner Bay % Of Catch
Chinook smolt hatchery	16.30	37.63
Chinook smolt wild	8.59	12.13
Chum smolt	55.96	33.85
Coho smolt hatchery	5.04	4.43
Coho smolt wild	11.37	4.75
Sockeye smolt	2.74	7.21

Table 4. Catch Percentage of Smolts in the Inner and Outer Bays.

Inner Bay

The following catch results for smolts and piscivores are limited to the Inner Bay as the majority of smolt consumption was detected at this study site. For further information of smolt and piscivorous catches in the Outer Bay, the data are available in Appendix III.

Smolts

Oncorhynchus tshawytscha

Hatchery chinook smolts were the most abundant of the smolts caught in the Inner Bay, with a catch of 1.11 fish per meter for all sample locations over the entire study period. The Upper Beach sample location yielded the greatest catch of hatchery chinook smolts at 2.43 fish per meter. Hatchery chinook were caught at all sample locations in the Inner Bay. Wild chinook catches were significantly lower than hatchery chinook catches ($P = .0001$) at .23 fish per meter for all sample locations over the entire study period. As with hatchery chinook, the Upper Beach sample location yielded the greatest catch rate of natural origin chinook in the Inner Bay at .48 fish per meter. Wild chinook were found at all sample locations in the Inner Bay with the exception of the Statue sample location.

Hatchery chinook and wild chinook smolt catches peaked around June 22nd for all sample locations (Figure 7). Fish per meter of shoreline for hatchery and wild chinook at each sample location during each sample period are shown in Appendix IV.

Oncorhynchus keta

Chum smolts catches were similar to hatchery chinook catches for all sample locations over the entire study period, at .91 fish per meter in the Inner Bay. Chum smolts in the Inner Bay study area were significantly ($p=. 0001$) more abundant (1.11 fish per meter) at the Orange Triangle sample location than Chinook smolts. Chum smolts were present at all sample locations in the Inner Bay and catches peaked in early May (Figure 8). Fish per meter of shoreline for chum at each sample location during each sample date are shown in Appendix IV (*total fish caught can be calculated by multiplying total effort from appendix III by rate of catch shown in catch appenixes*).

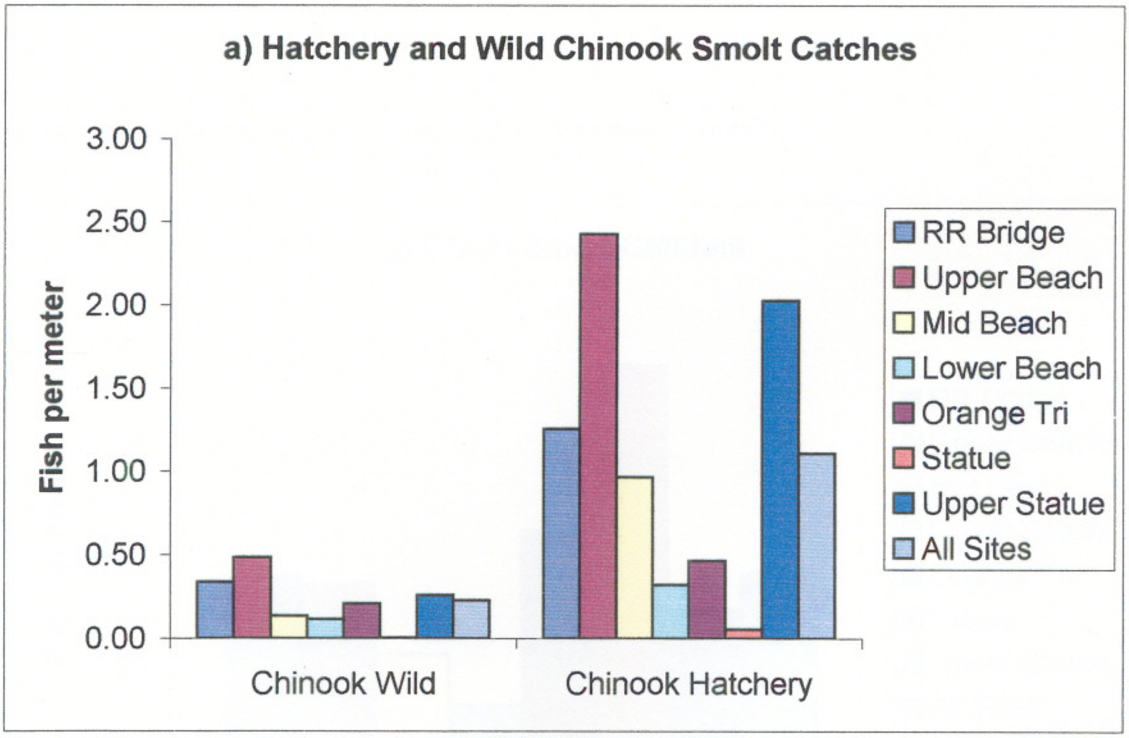
Oncorhynchus kisutch

Coho smolts were not as abundant as chum or chinook smolts but were present at all sample locations in the Inner Bay. Significantly more hatchery coho (.21 fish per meter) were caught than wild coho (.06 fish per meter) (p=. 0001). Upper Beach and the Railroad Bridge sample locations had the greatest catch of hatchery and wild coho smolts. Hatchery and wild coho catches peaked between June 19th and June 22nd (Figure 9). Fish per meter of shoreline for hatchery and wild coho at each sample location during each sample period are shown in Appendix IV.

Oncorhynchus nerka

The overall catch of sockeye was .14 fish per meter. The highest catch of sockeye smolts at .39 fish per meter occurred at the Railroad Bridge sample location. Sockeye smolts were caught at all sample locations except for Upper Beach. Sockeye catches peaked during mid June but decreased to nearly zero for the rest of the study period (Figure 10). Fish per meter of shoreline for sockeye at each sample location during each sample period are shown in Appendix IV.

Figure 7. Catch of chinook smolts in the Inner Bay a) by location b) by date.



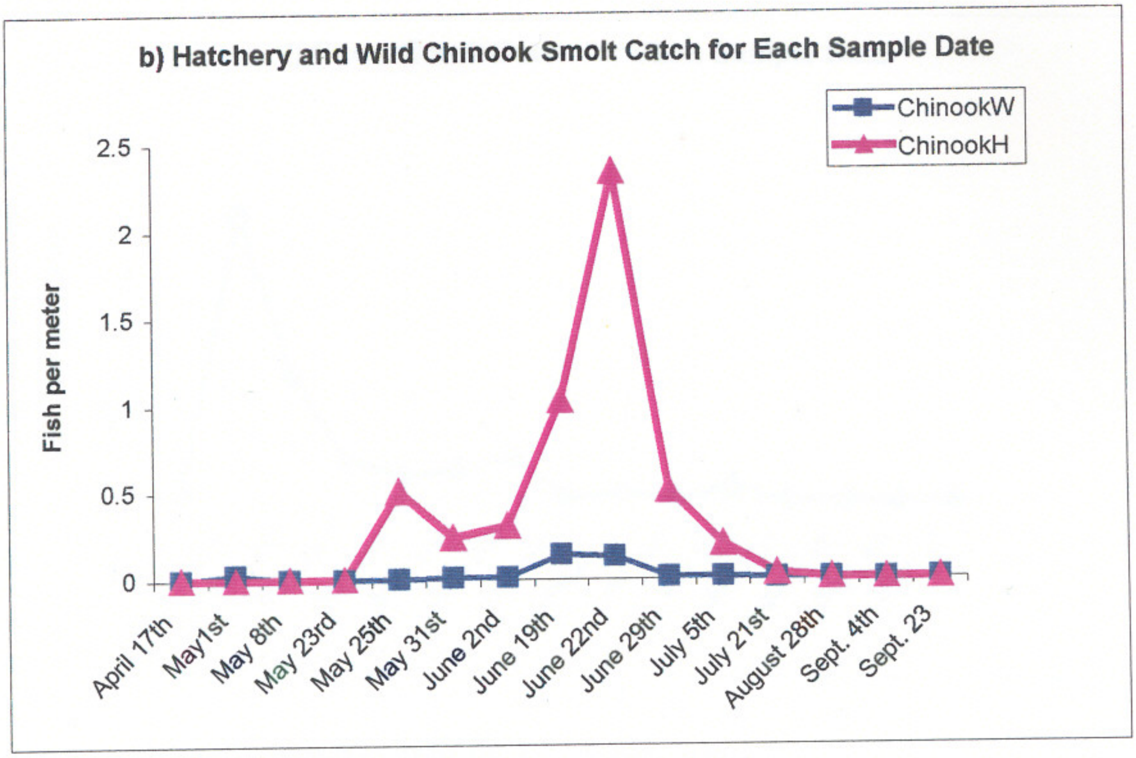
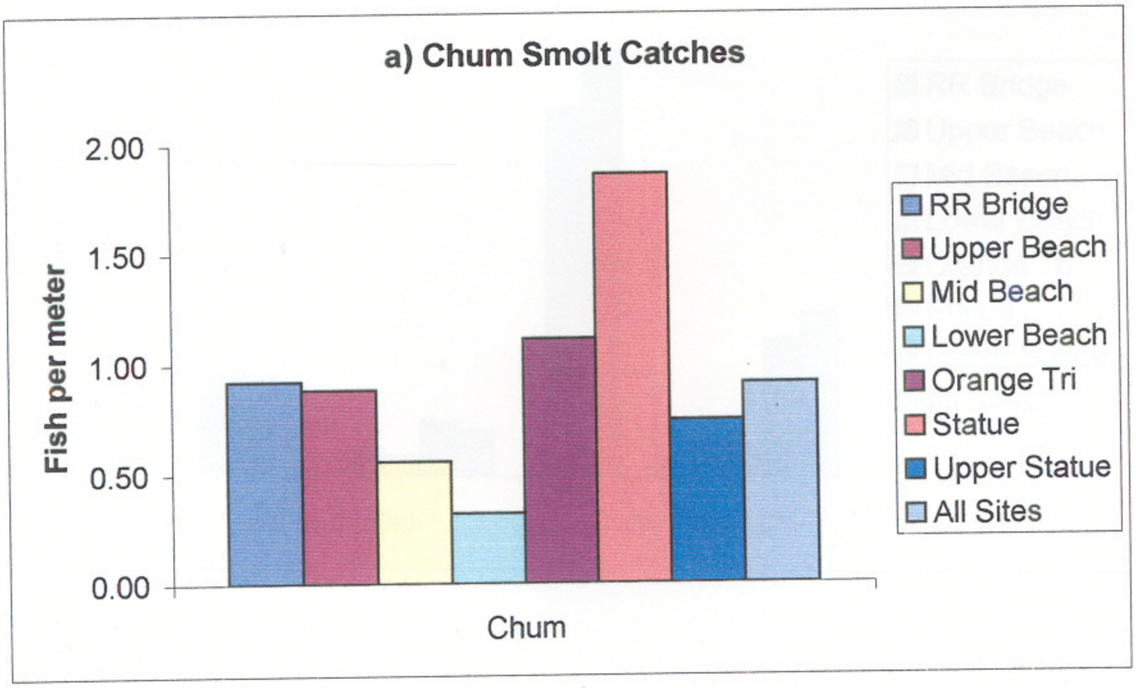


Figure 8. Chum smolt catches in the Inner Bay a) by location b) by date.



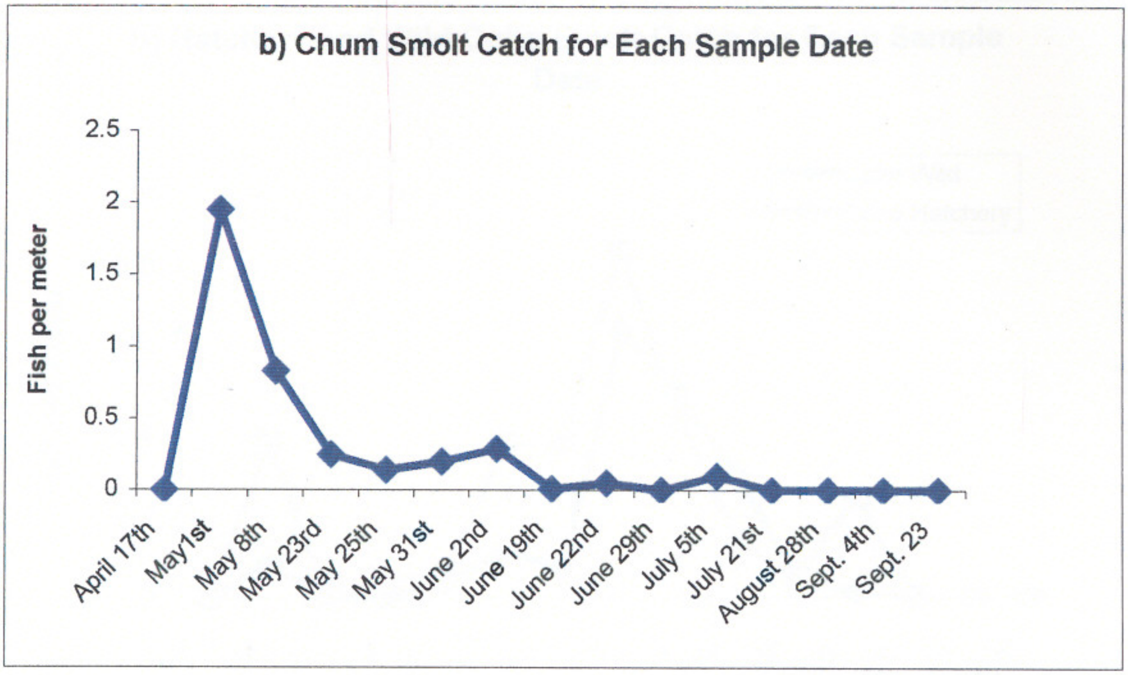
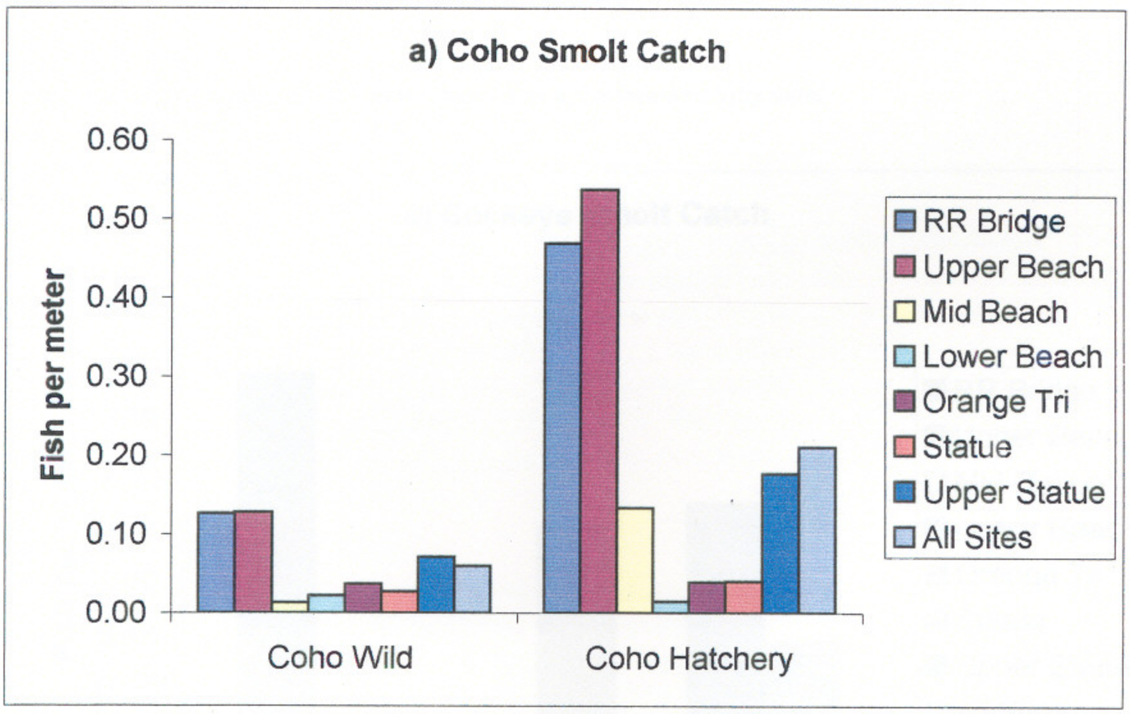


Figure 9. Coho smolt catches in the Inner Bay a) by location, b) by date.



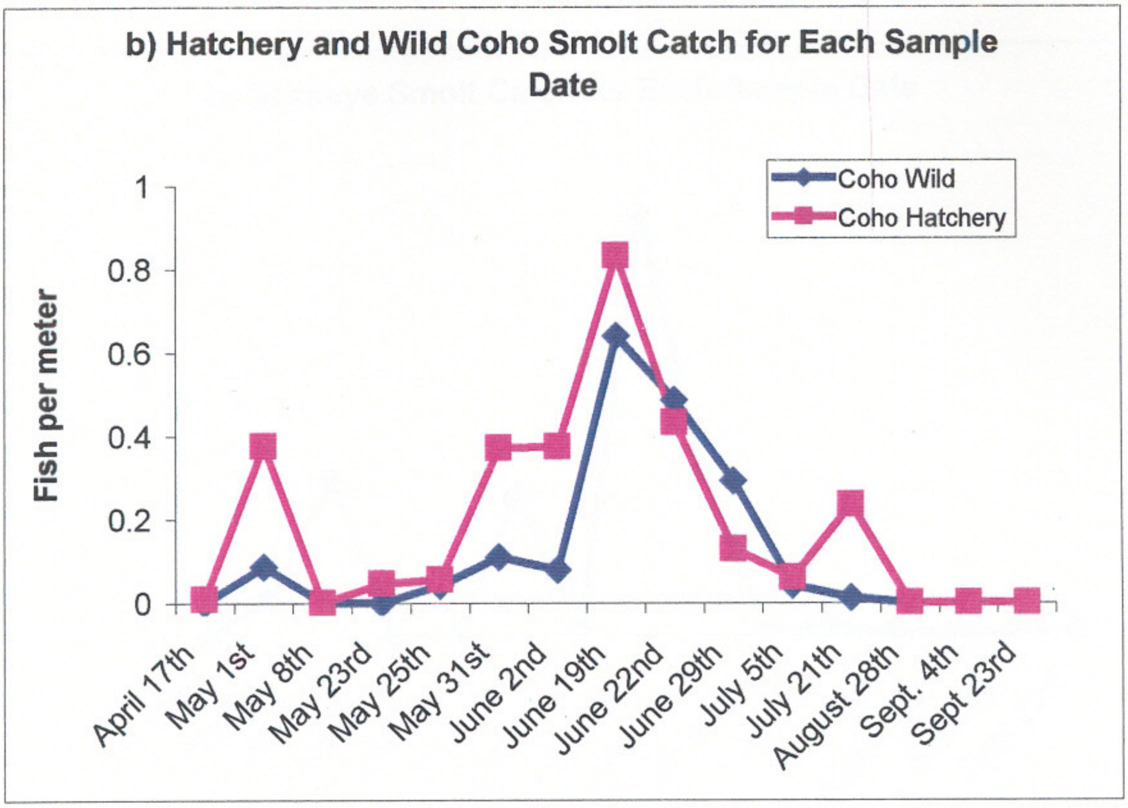
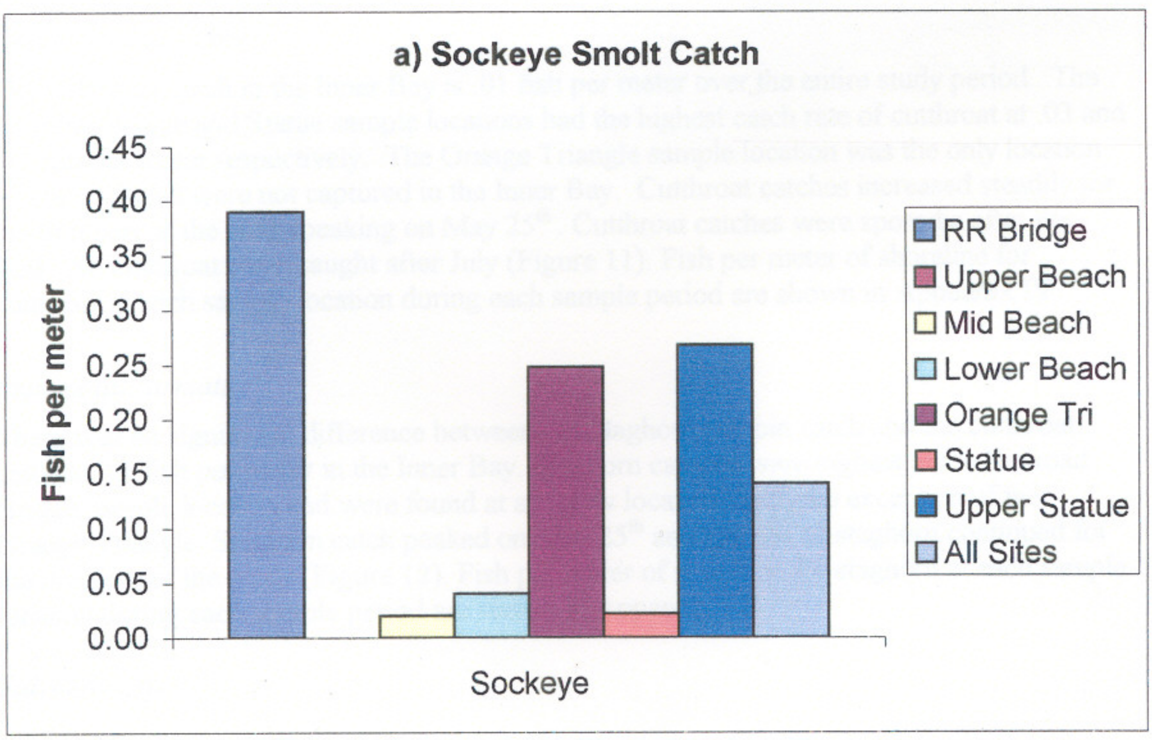
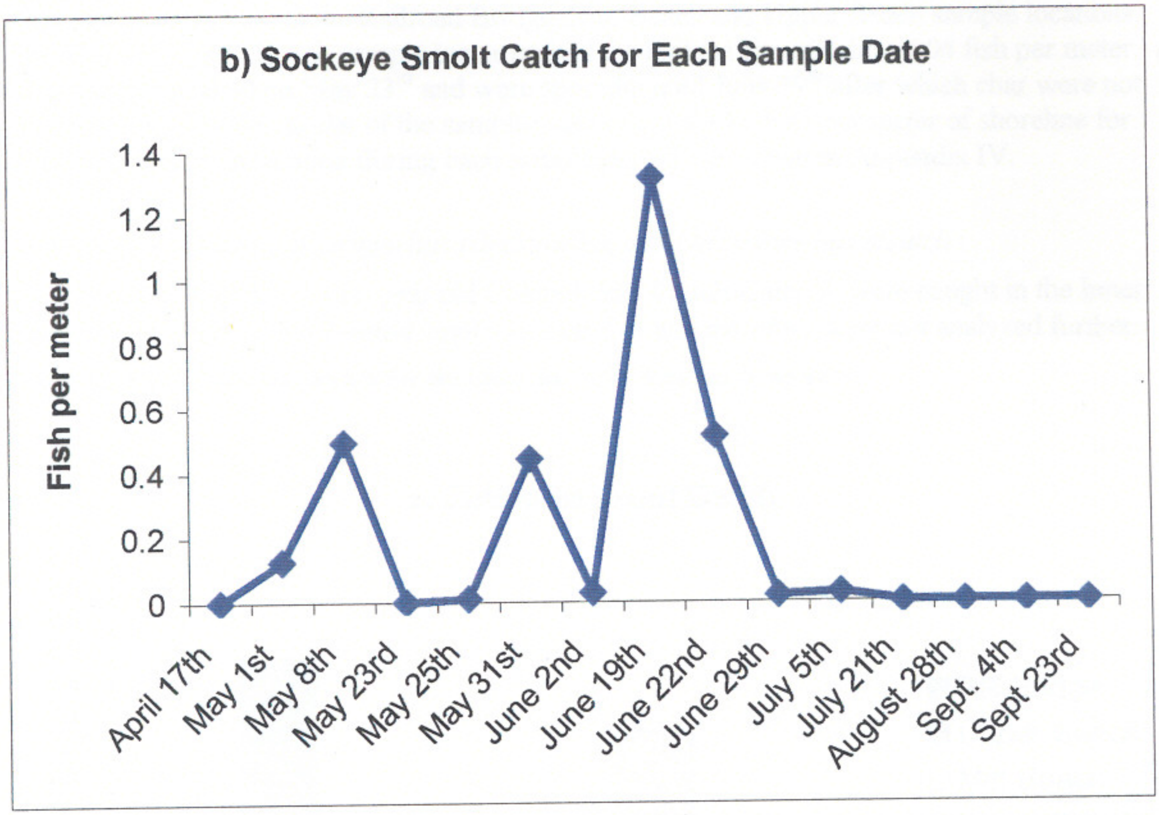


Figure 10. Sockeye smolt catches in the Inner Bay a) by location, b)by date.





Piscivores

Oncorhynchus clarki

The Cutthroat catch in the Inner Bay is .01 fish per meter over the entire study period. The Railroad Bridge and Statue sample locations had the highest catch rate of cutthroat at .03 and .02 fish per meter respectively. The Orange Triangle sample location was the only location where cutthroat were not captured in the Inner Bay. Cutthroat catches increased steadily for the first part of the study peaking on May 25th. Cutthroat catches were sporadic after the peak. No cutthroat were caught after July (Figure 11). Fish per meter of shoreline for cutthroat at each sample location during each sample period are shown in Appendix IV.

Leptocottus armatus

There was no significant difference between the Staghorn sculpin catch and the cutthroat catch at .01 fish per meter in the Inner Bay. Staghorn catches were highest at the Railroad Bridge sample location and were found at all study locations with the exception of the Orange Triangle. Staghorn catch peaked on May 25th and catches of staghorn continued for the duration of the study (Figure 12). Fish per meter of shoreline for staghorn at each sample location during each sample period are shown in Appendix IV.

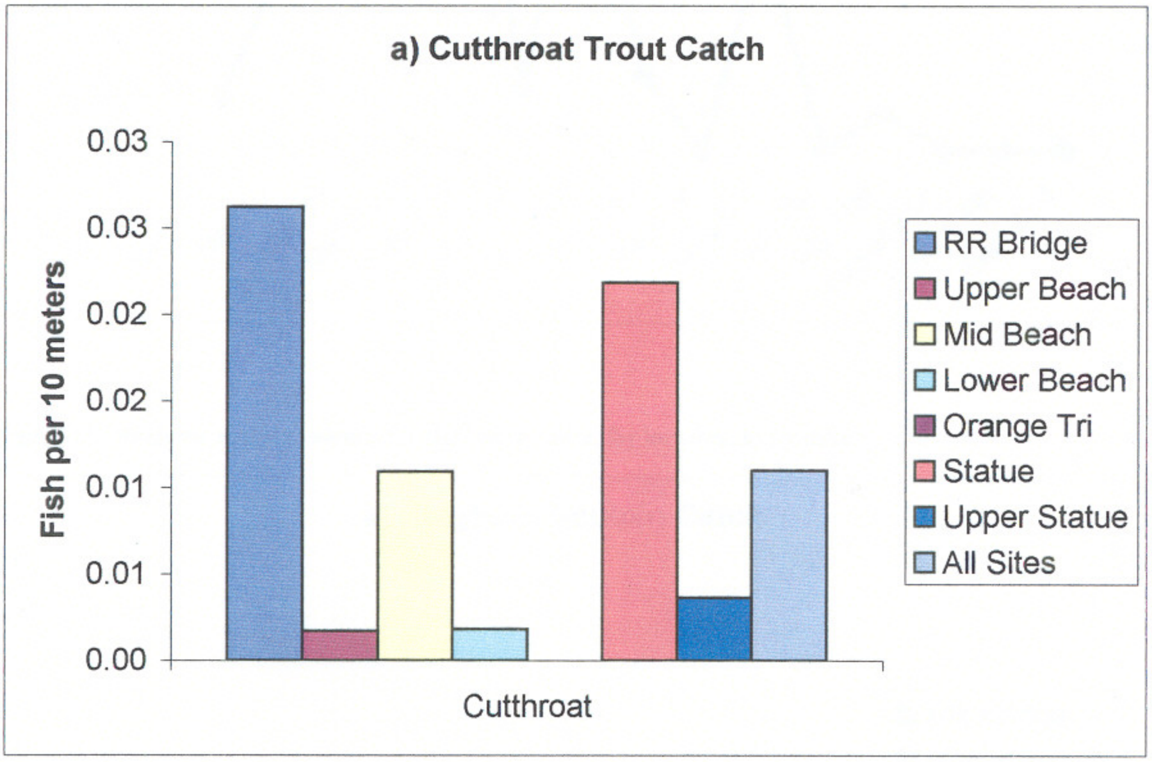
Salvelinus sp.

The char catch was the smallest of all the piscivores at .002 fish per meter in the Inner Bay. Char was present only at the Railroad Bridge, Mid Beach and Upper Beach sample locations. The Mid and Upper Beach sample locations had the highest char catch at .004 fish per meter. Char catches peaked on May 23rd and were sporadic until June 29th after which char were not present during the remainder of the sample dates (Figure 13). Fish per meter of shoreline for char at each sample location during each sample period are shown in Appendix IV.

Platichthys stellatus, Oncorhynchus tshawytscha, and *Oncorhynchus kisutch*

Twelve starry flounder, 1 two-year old Chinook and 4 adult Chinook were caught in the Inner Bay, none of which had salmonid smolts in their diet and therefore were not analyzed further.

Figure 11. Cutthroat trout catches for the Inner Bay a) by location, b) by date.



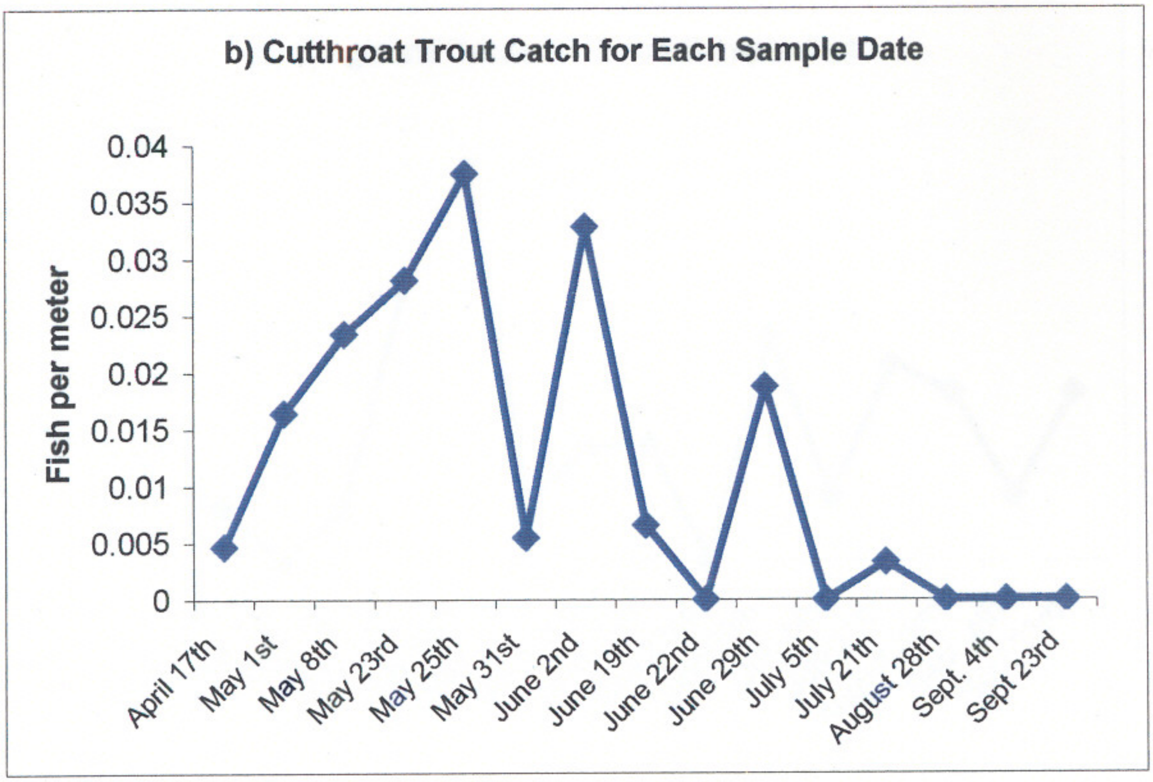
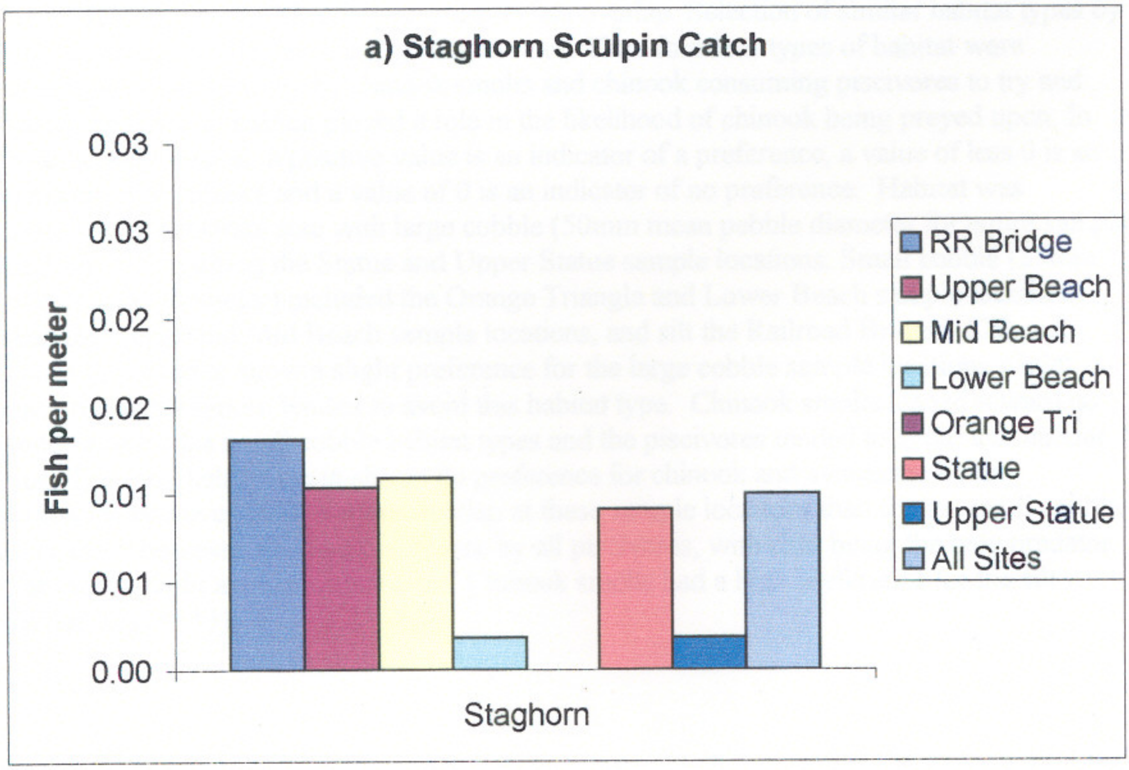
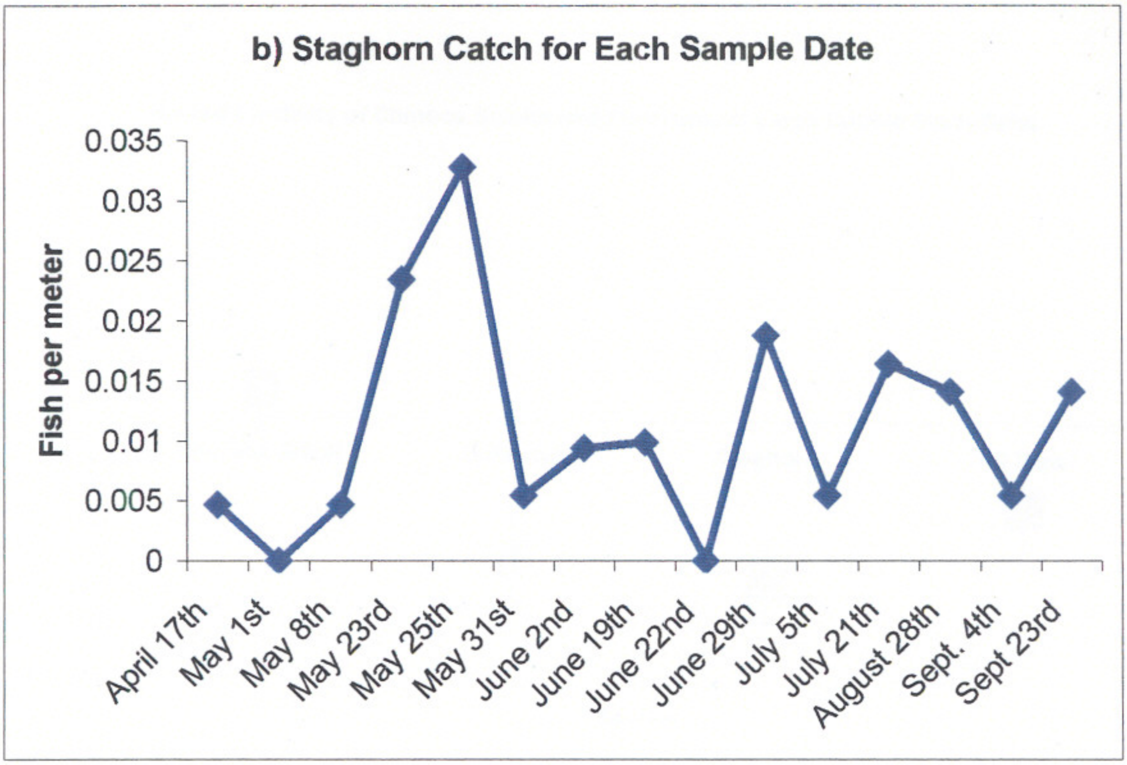


Figure 12. Staghorn sculpin catches for the Inner Bay a) by location, b) by date.

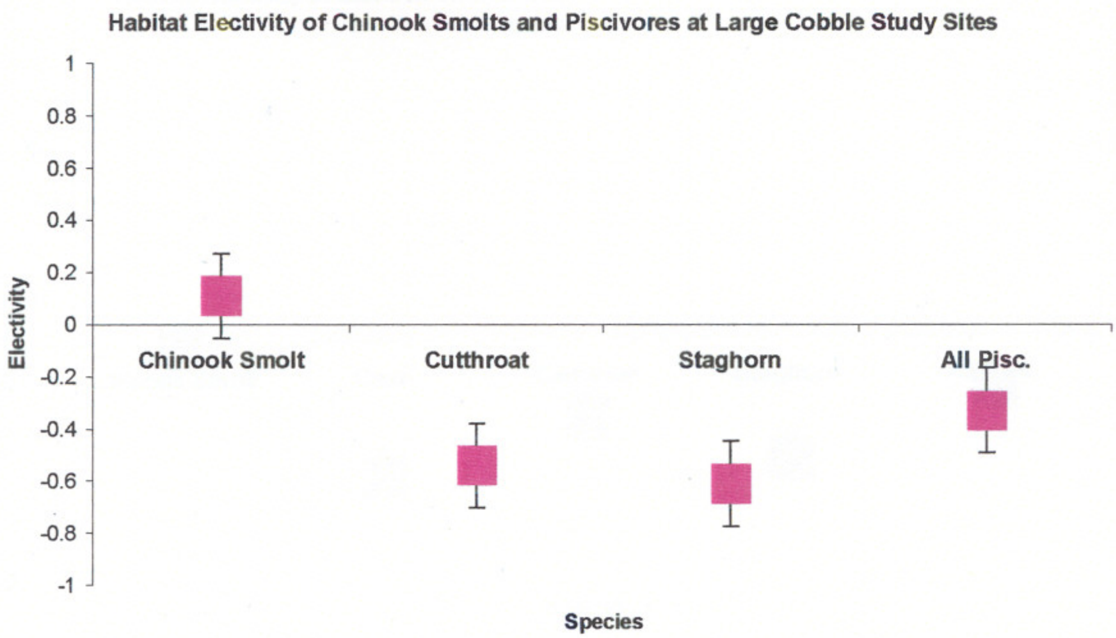




<u>Electivity Indexes</u>

Habitat electivity was investigated to indicate areas where consumption of smolts would be more likely as a result of piscivore and preyfish overlap. Selection of similar habitat types by prey and predator may increase predation rates. Therefore four types of habitat were investigated for electivity by chinook smolts and chinook consuming piscivores to try and determine whether habitat played a role in the likelihood of chinook being preyed upon. In the following figures, a positive value is an indicator of a preference, a value of less 0 is an indicator of avoidance and a value of 0 is an indicator of no preference. Habitat was classified by substrate size with large cobble (50mm mean pebble diameter for entire sample location) representing the Statue and Upper Statue sample locations. Small cobble (25mm mean pebble diameter) included the Orange Triangle and Lower Beach sample locations, sand the Upper and Mid Beach sample locations, and silt the Railroad Bridge. Chinook smolts appeared to show a slight preference for the large cobble sample locations while cutthroat and staghorn tended to avoid this habitat type. Chinook smolts leaned toward no preference for the small cobble habitat types and the piscivores tended to avoid that habitat type. The sand habitat again shows no preference for chinook and avoidance by the piscivores however there is more overlap at these sample locations than for the small cobble. Silt habitat however shows a preference by all piscivores, with char being the only predator that shows slight avoidance behavior. Chinook smolts had a high preference for the silt habitat (Figure 13).

Figure 13. Electivity of Smolts and Piscivores at the Large Cobble, Small Cobble, Sand and Silt Sample Locations.



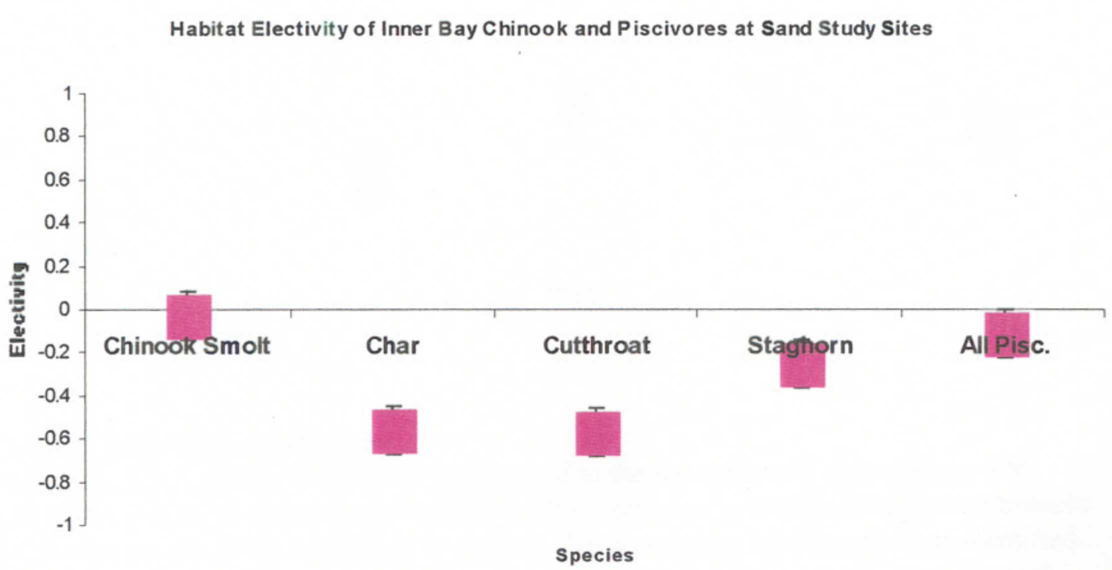
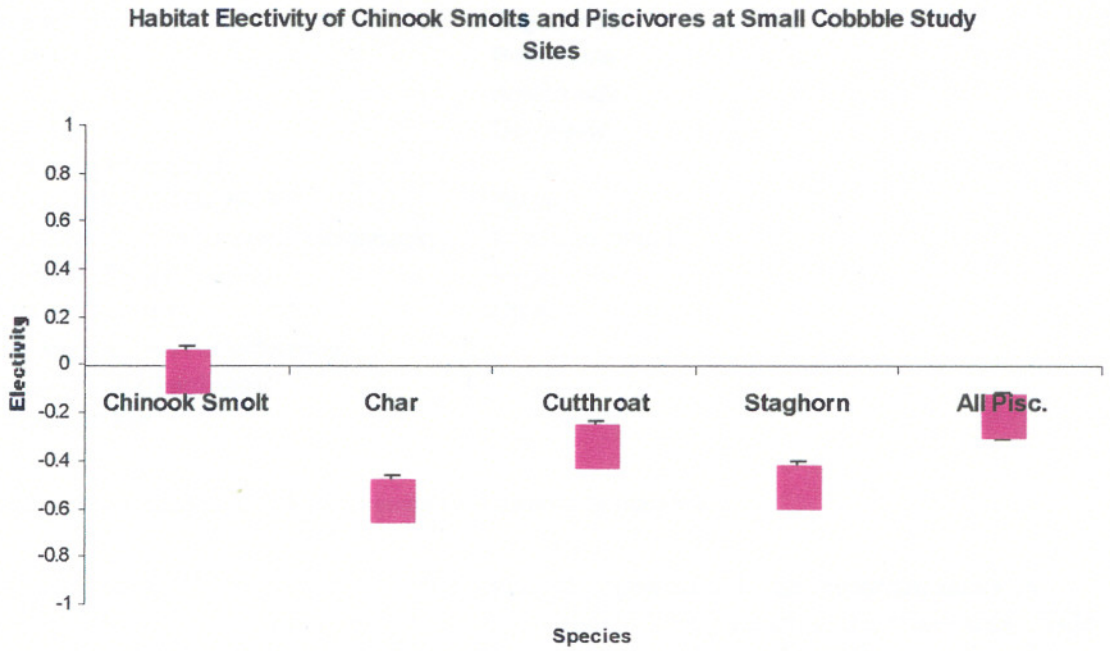
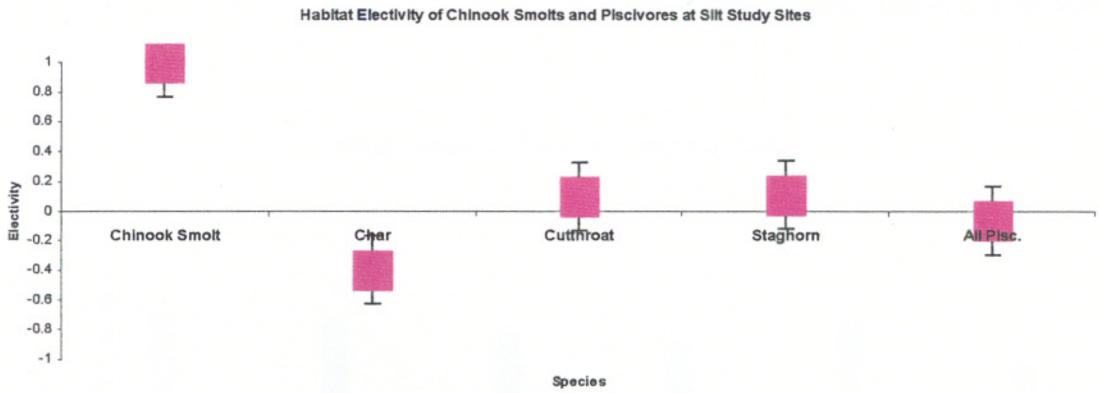


Figure 13. Continued.





Diet and Consumption Estimates

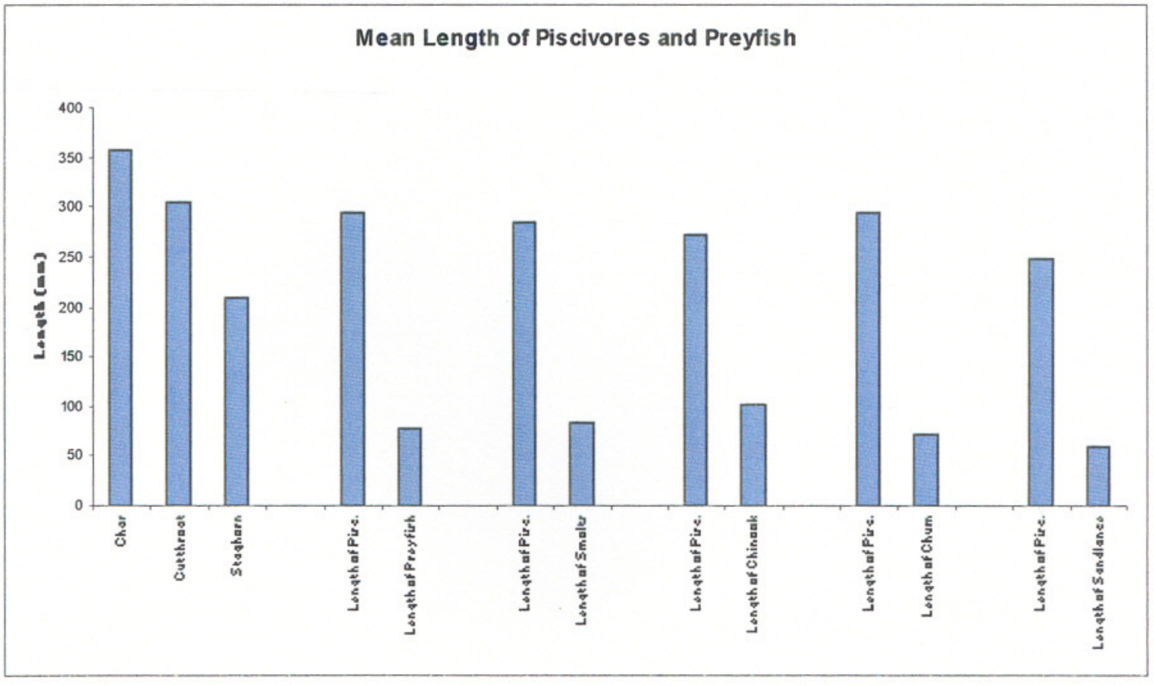
Because the consumption of chinook was limited to the Inner Bay the diet analysis was limited only to predators from that study site. The items were identified in piscine stomachs sampled during the study are shown in Table 6. For a complete list of prey items identified with wet weights and measurements of contents and prey fish for each piscivore stomach sample see Appendix V.

Salmonids	Marine Invertebrates
Unidentified smolt	Bivalvia
Chinook smolt	Gastropoda
Coho smolt	Oligochaeta
Chum smolt	Polychaeta
	Amphipoda
Other Fish	Decopoda
Osmeridae (Surf smelt)	
Embiotocidae (Shiner perch)	**Other**
Gasterosteidae (Three-spine stickleback)	Rocks and sand
Clupeidae (Pacific herring)	Vegetation
Cottidae (Sculpins)	Other
Plueronectiformes (Sole/flounder)	
Ammodytidae (Sandlance)	
Unidentified fish	

Table 6. Items identified in stomach samples of piscivores sampled.

For the majority of preyfish consumed, forklength appeared to be an important factor in preyfish selection. Sandlance and chum, the smallest of the preyfish in the study area, made up the majority of the preyfish observed in predator stomach samples. Chum and sandlance had a mean length of about 55mm, while the predator lengths ranged from 270mm to 290mm. Mean chinook lengths, however were significantly longer (P=. 0007), nearly double the mean of chum and sandlance (Figure 14).

Figure 14. Lengths of Piscivores, Chinook smolts, chum smolts,and sandlance sampled in the Inner Bay.



This observation is reflected in the diet composition of the piscivores. The diet of piscivores was divided into only a few categories to simplify the presentation of the data. The category "other smolts" is made up of chum and unidentified salmonid smolts, "other fish" comprised sandlance, surfperch, smelt, sculpin, flounder, and unidentified non-salmonids. For cutthroat, other smolts (primarily chum) and other fish (primarily sandlance) represent 88% of the diet composition. For char the trend is simmilar with other smolts (chum and unidentified smolts) and other fish (sandlance, surfperch, smelt, sculpin, flounder, and other unidentified non-salmonids) making up 73% of the char for the entire study period. Although over 50% of the staghorn diet composition is chinook smolts, these data are heavily weighted by one very fresh sample. Staghorn also had a higher percentage of marine invertebrates (23%) in their diet than the other predators. Still 27% of the staghorn diet was made up of primarily chum and sandlance (Figure 15).

Because the population estimates for piscivores sampled in the Inner Bay were so low consumption estimates were also low. The following table shows the results for consumption estimates by the primary piscivores in the Inner Bay (Table 7).

	Cutthroat	Char	Staghorn
Chinook Frefquency of Occurrence	0.09	0.43	0.19
Other Smolt Frequency of Occurrence	0.3	0.43	0.06
Total Smolt Frequency of Occurrence	0.39	0.86	0.25
Population Estimate	31	5	26
Smolt Consumption Estimate	850	501	744

Table 7. Consumption estimates for primary piscivores in the Inner Bay.

Figure 15. Diet Composition of a) Cutthroat Trout, b) Staghorn Sculpin and c) Char Caught in the Inner Bay.

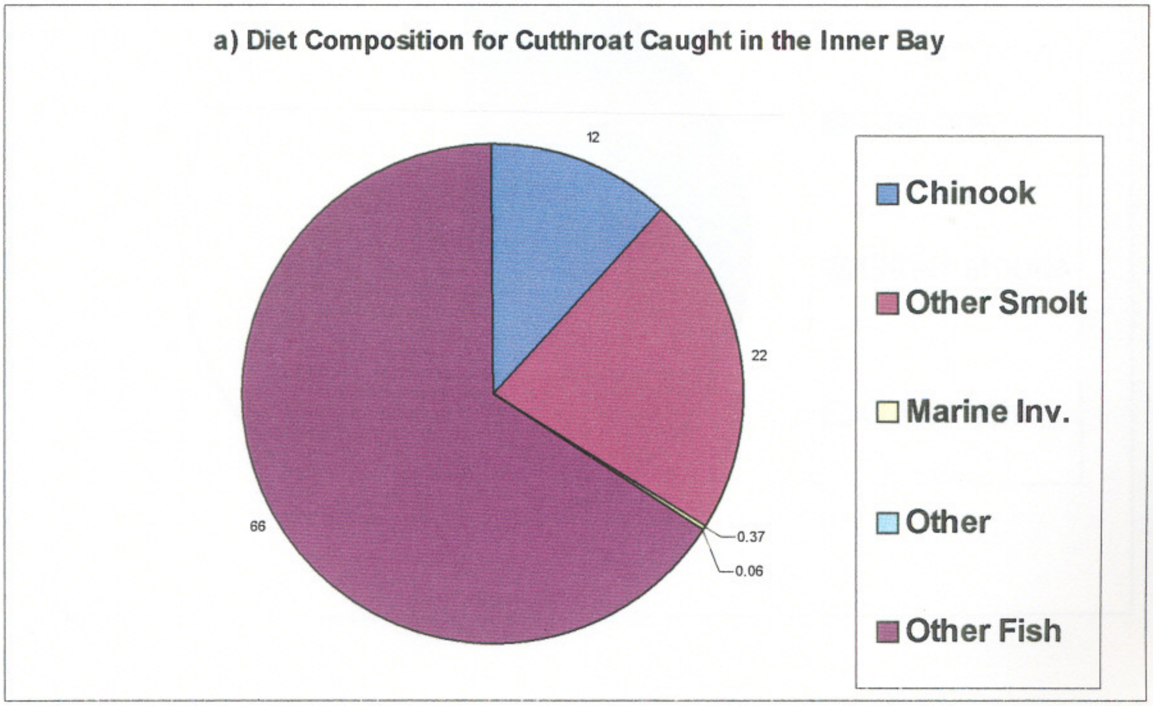
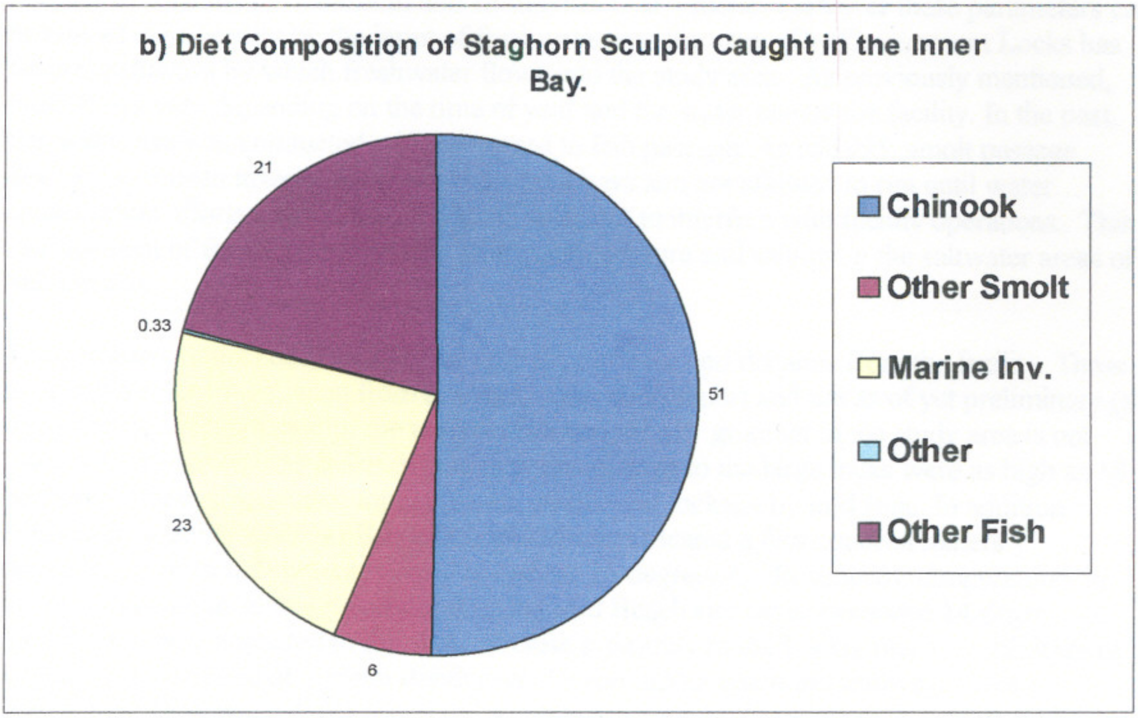
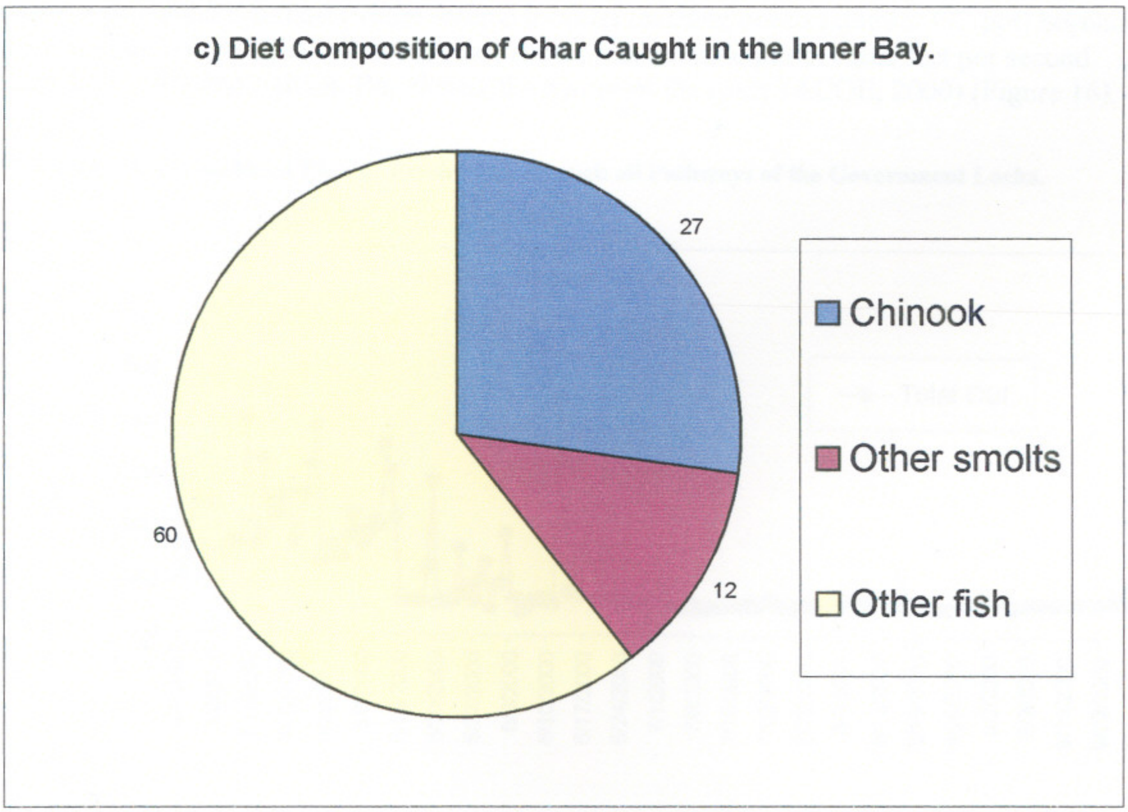


Figure 15.Continued



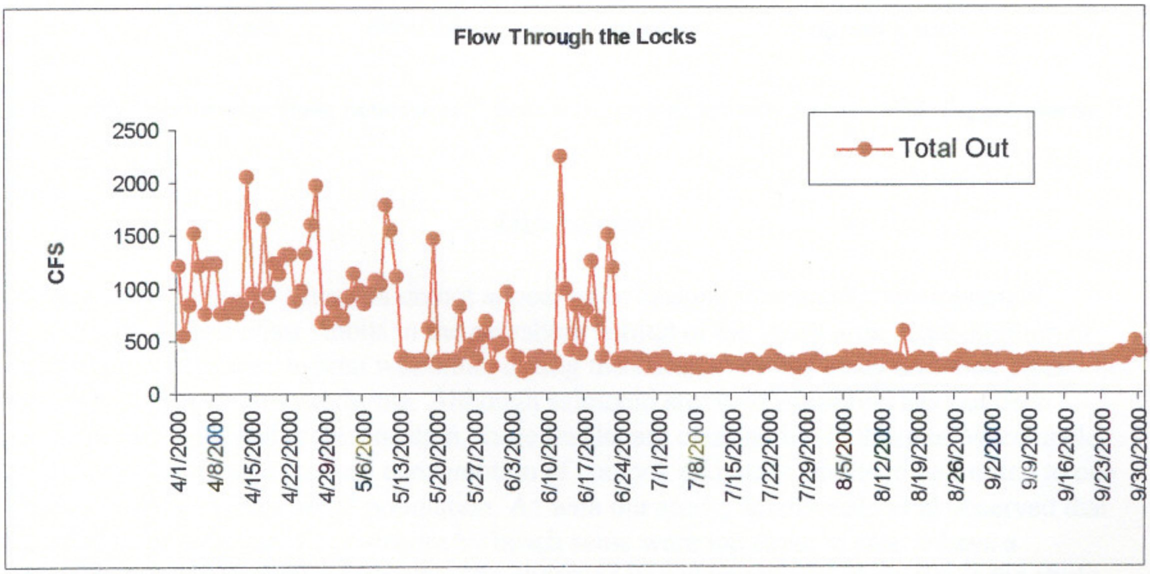


Environmental Data

Overall salinity and temperature in the nearshore areas of Central Puget Sound remain fairly constant at 32 parts per thousand and 13 degrees C at 1 meter. However these parameters can be altered significantly by the input of freshwater into the area. The Government Locks has several pathways by which freshwater flows into the study area. As previously mentioned, these flows vary depending on the time of year and the water use by the facility. In the past, this water use was conducted without regard to fish passage. As of 1995, smolt passage devices have been inserted in a few of the spill bays and are allowed to run until water conservation efforts need to be introduced so as not to interfere with facility operations. This management of freshwater flow also affects temperature and salinity in the saltwater areas of Salmon Bay.

Temperatures in the study area varied with time of year and distance from the facility. These temperature data were taken from a King County draft report and are as of yet preliminary (a more detailed presentation of the temperature and salinity gradient in the study area is not available). Temperatures at 1m depths directly adjacent to the large locks were as high as 18 degrees C during freshwater inputs from a westbound lockage by mid June. In addition temperatures at the Railroad Bridge sample location located a few hundred meters downstream from the spillways were as high as 16 degrees C. In contrast, temperatures in the nearshore areas at one meter depth at the Mid Beach site never exceeded 14 degrees C. Salinity was also impacted in the areas of close proximity to the Locks, reaching salinities of 12 parts per thousand at 1 meter depth near the fish ladder when the spillways were operational. However salinity increased significantly to over 20 parts per thousand at one-meter depth at the Railroad Bridge sample location reaching ocean salinities (32 ppt) beyond the Railroad Bridge. The following chart shows freshwater input in cubic feet per second from the facility into Salmon Bay during the course of the study (ACOE, 2000) (Figure 16).

Figure 16. Total Combined Flow of Freshwater through all Pathways of the Government Locks.



PIT Tag Data

PIT tag data were important in helping assess how smolts were using the study area, specifically with respect to residence time. Of the smolts released directly into the study area, the maximum time to detection was 32 days and the minimum time was 4 days. A detection time of 2 days was observed from a fish released at Lake Union in the Ship Canal. From these data we can detect a minimum time chinook resided in the estuary by taking the weighted mean of the time to detection of the fish that were released directly into the study area. The mean detection time was fifteen days. The following table shows the number of days to recapture and recapture location of PIT tagged smolts detected in the study area (Table 7).

Species	Release Date	Recapture Date	Release Location	Recapture Location	Number of Days to Recapture
Chinook	5/19/2000	5/23/2000	Locks	Railroad Bridge	4
Chinook	5/19/2000	5/25/2000	Locks	Orange Triangle	6
Chinook	5/19/2000	6/20/2000	Locks	Mid Beach	32
Chinook	5/23/2000	5/25/2000	Lake Union	Railroad Bridge	2
Chinook	5/23/2000	5/25/2000	Lake Union	Railroad Bridge	2
Chinook	5/23/2000	5/31/2000	Lake Union	Lower Beach	8
Coho	5/23/2000	5/31/2000	Lake Union	Mid Beach	8
Chinook	5/26/2000	6/21/2000	Fremont Cut	Lions Club	26
Chinook	5/28/2000	6/22/2000	University of WA	Upper Statue	25
Chinook	5/28/2000	6/22/2000	Fremont Cut	Upper Statue	25
Chinook	5/28/2000	5/31/2000	Fremont Cut	Upper Beach	3
Chinook	6/1/2000	6/22/2000	Fremont Cut	Upper Beach	21
Chinook	6/2/2000	6/22/2000	Locks	Railroad Bridge	20
Chinook	6/8/2000	6/19/2000	Locks	Railroad Bridge	11
Chinook	6/13/2000	6/20/2000	Locks	Orange Triangle	7
Chinook	6/13/2000	6/19/2000	Locks	Lower Beach	6

Table 7. Number of Days from Detection at Locks to Recapture in Study Area of PIT Tagged Smolts.

Discussion

Overall, anthropogenic activities do not appear to be causing increased consumption of chinook smolts and other smolts in the nearshore habitat of the study area. Consumption of smolts in the nearshore habitat was small during the duration of this study and took place entirely in the Inner Bay study site. Although salmonid smolt consumption has not been previously investigated at this location, these results are comparable to those of MacDonald and others (1988) who showed consumption of chinook and other smolts to be limited to one primary predator with a small population. As with our study, MacDonald et al observed that the other piscivores caught nearshore by beach seine were too small in size to have a significant impact on chinook smolts. The observed low consumption of smolts in the study area appears to be the result of a few factors. 1) Peak catches of smolts and piscivores did not always correspond. 2) Predator/prey overlap as a result of similar habitat use was also limited and 3) there was an abundance of prey smaller than chinook, coho and sockeye smolts available to the piscivores.

Catch

Overall the catch rate of piscivores was low and sporadic. On only a few occasions did peak smolt and piscivore catches overlap. However there did seem to be some response by piscivores between early May and mid June when the primary prey items occupying the nearshore were chum and (on a few occasions) hatchery chinook. Not surprisingly, these periods are also when the frequency of occurrence of chinook in piscivore stomachs was highest. The low catch rate of piscivores in the nearshore area is surprising, given the abundance of smolts in the study area. At times the water was boiling with smolts in the littoral and pelagic zones. One possible explanation for low catch rates of piscivores in the nearshore is that foraging by larger fish may have been taking place in deeper water that was not accessible to the gear used in this study. Spiny Dogfish and other larger fish sampled with gillnets in the Big Qualicum River plume in British Columbia have been shown to have high consumption rates of juvenile chinook and coho because of large populations (Beamish et al, 1992). Other studies that have sampled in deeper water have documented higher piscivore catch rates than observed in this study (Macdonald et al, 1988). The mean fork length for piscivores caught during this study was small (280mm) and may be an indication that the gear is unable to successfully capture the larger, faster predators, considering the seine was towed during an outgoing tide most of the time. Warner (1999) caught cutthroat while beach seining in Lake Washington with a mean fork length of 240mm similar to 280mm cutthroat caught during this study. However, when gillnets were used nearshore in the 1997 Lake Washington study the mean cutthroat length approached 400mm. In Lake Washington smolts did not occur in cutthroat caught beach seining while there was some smolt presence in the stomachs of larger cutthroat caught in gillnets (Warner, 1999).

Predator/Prey Interaction

Habitat selection did not appear to play an important role in predator/prey overlap. The Railroad Bridge was the only sample location where predator and prey had significantly similar electivities. The reason for this may be a function of the sample locations' proximity to the locks, more so than a silt habitat selection by the fish. Although the freshwater lens is not large at this location, it is more significant than further downstream in the study area. In addition freshwater zooplankton were found in large amounts in the smolts sampled for stomach contents from this area in 1999 (Simenstad, per com., 2000). Both of these factors may have been contributing to increased residence times of smolts at the Railroad Bridge sample location, in turn attracting more piscivores. Not only did the Railroad Bridge have the highest catch rate of piscivores but it also had the highest frequency of occurrence of smolts in piscivore stomach samples.

Diet Composition and Consumption Estimates

Although staghorn sculpin had the highest percentage of chinook smolts in the diet this percentage is biased by one very fresh sample. Because wet weights are used, preyfish that have been eaten recently skew the diet composition percentages. Of the piscivores caught in the Inner Bay, char seemed to have the greatest potential to consume large amounts of preyfish. Char had the largest mean fork length of all the piscivores sampled and therefore would not be limited to smaller fish. In addition char were very selective in their diet, eating only fish. Char also had the highest frequency of occurrence of chinook in their diet. However, overall consumption estimates of chinook by char were lower than that by cutthroat and staghorn, probably a result of the small numbers of char caught during the study. Cutthroat appear to be the piscivore with the greatest potential to impact chinook populations in the study area. Although cutthroat had the smallest percentage of chinook in their diet, the cutthroat population was higher than that of the other salmonid consuming piscivores. Staghorn also have the potential to impact chinook rearing in the littoral zone of the Inner Bay study area, but again the estimated population may be too low for this impact to be significant.

These data seem to indicate that preyfish to predator size ratios had the greatest influence on consumption, and limited cutthroat and staghorn's ability to significantly impact chinook survival in the system. Although Warner (1999) has observed cutthroat and sculpin consuming preyfish nearly 80% of their size, the availability of smaller sandlance and chum in the study area during periods when chinook use was peaking appears to have provided a predation buffer for chinook and other smolts.

The Freshwater Lens

The availability of an estuarine environment is an area of concern that should be addressed in more detail in future studies in the saltwater area of Salmon Bay. The small area of a freshwater lens has the potential to negatively impact chinook smolts causing them to emigrate into deeper water before significant growth and rearing has taken place in the nearshore areas of the estuary. Early migration into deeper water could leave the smolts more vulnerable to the larger piscivores present in the deeper waters of the estuary.

Locks operations could diminish the size and availability of a freshwater lens to chinook rearing in the estuary. Continued research into freshwater needs for fish in the Inner Bay may lead to a recommendation by the NMFS for an augmentation of facility operations in light of the threatened status of Puget Sound chinook. At the moment there are no data to support an increase in chinook mortality below the locks as a result of an insignificant freshwater lens. Future research in the study area should be focused on quantifying freshwater needs for chinook in the saltwater areas of salmon bay.

Conclusions

Predation on chinook smolts by piscivores sampled during this study was minimal. It is possible that the gear used to capture fish in this study may have been biased towards smaller predators. Macdonald observed that most of the piscivores caught beach seining during sampling of Deepwater Bay were too small to prey on chinook smolts (Macdonald et al, 1988). In Salmon Bay, these small piscivores appeared to have been selecting prey that was abundant, smaller and easier to catch than the smolts with which they shared habitat temporally and spatially. Higher populations of larger piscivores may be present in the nearshore but were unavailable to the gear type being used and therefore were not sampled. In addition, sporadic catch rates of smolts nearshore made their availability to piscivores intermittent. This sporadic occupation of nearshore habitat may be explained by low residence times in the nearshore of Salmon Bay. Compared to other undisturbed estuaries where chinook smolts may spend as long as 90 days (Levings, 1986) in nearshore habitat, the minimum mean of fifteen days observed in Salmon Bay is small. This short residence time in the nearshore of Salmon Bay may rest in the lack of a significant freshwater lens in the study area. Emigration from nearshore to pelagic habitats may increase the vulnerability of chinook smolts to predation by larger predators. Further study is needed that selects for larger predators in the nearshore and pelagic habitats of Salmon Bay. In addition future fish friendly alterations of the City of Seattles' instream flow agreement and the Government Locks operations should include some protocol for maximizing the amount of freshwater available to the Salmon Bay Estuary.

References:

U. S. Army Corps of Engineers, 2000. PIT Tagging of Juvenile Salmon Smolts in the Lake Washington Basin:Year 2000 Pilot Study Results. Seattle District.

Army Corps of Engineers, 2001. Section 7 permit application. National Marine Fisheries Service. Department of the Interior. 143pp.

Bagley, 1929. History of King County Washington. Vol. 2. pp. 181-195. Seattle, The S. J. Clarke Publishing Company.

Brocksmith R. 1999. Abundance, feeding ecology, and behavior of native piscivore northern pikeminnow (*Ptychocheilus oregonensis*) in Lake Washington. University of Washington MS Thesis, Seattle WA.

Beamish R. J., B. Thomson, and G. McFarlane. 1992. Spiny dogfish predation on chinook and coho salon and the potential effects on hatchery produced salmon. Transactions of the American Fisheries Society 121: 444-455, 1992.

Beamish R. J. and C. Neville. 1995. Pacific salmon and pacific herring mortalities in the Fraser River plume caused by river lamprey (*Lampetra ayresi*). Canadian Journal of Auquatic Science. Vol. 52. pp. 644-650, 1995.

City of Seatle, 1983. Seattle's commercial and industrial shorelines: Inventory background report. Seattle Shoreline Master Program Revision Project. City of Seattle Department of Construction and Land Use. 1983.

Fayram, A. H. 1996. Impacts of largemouth bass (*Micropterus salmoides*) and smallmouth bass (*M. dolomieui*) on juvenile salmon populations in Lake Washington. MS Thesis, University of Washington, Seattle WA.

Fisher J.P. 1989. Distribution and residence times of juvenile fall and spring chinook salmon in Coos Bay, Oregon. Fishery Bulletin, Vol. 88: pp. 51-58.

Foster, J.R. 1977. Pulsed gastric lavage: an efficient method of removing the stomach contents of live fish. Progressive Fish-Culturist 39:166-169.

Hansel, H.C., S.D. Duke, P.T. Lofy, and G.A. Gray. 1988. Use of diagnostic bones to identify and estimate original lengths of ingested prey fishes. Transaction of the American Fisheries Society 117:55-62.

Healy, M. C. 1982. Utilization of the Nanaimo River estuary by juvenile chinook salmon, (*Oncorhynchus tshawytcha*). Fishery Bulletin Vol. 77, NO. 3, 1980.

Houck D., 2000. Salinity and temperature data for Salmon Bay. King County Metro Waste Water Treatment Division. Draft unpublished report. 2000.

Ivlevs J. H. 1987. A comparison of three electivity indexes. Transactions of the American Fishery Society, vol 34. pp 56-68.

Kreeger K. Y. 1992. Differences in the onset of salinity tolerance between juvenile chinook salmon from two coastal Oregon river systems. Canadian Journal of Fisheries and Aquatic Science. Vol. 52: pp. 623-630 1995.

Larson S. B. 1975. Dig the ditch: The history of the Lake Washington Ship Canal. The King County Department of Public Works. pp. 40.

Levings C. D., C. D. McAllister, and B. D. Chang.1986. Differential use of the Cambell River estuary, British Columbia, by wild and hatchery-reared chinook salmon (*Oncorhynchus tyshawytcha*). Canadian Journal of Fisheries and Aquatic Science. Vol. 43: pp. 1386-1397.

Martz, M., F. Goetz, J. Dillon, and t. Shaw. 1996 Study Element II: early lake life history of sockeye salmon (*Oncorhynchus nerka*) in Lake Washington, year 1: 1994. Final report, U.S. Army Corps of Engineers, Seattle District, Seattle, Washington.

Macdonald, J.S., C.D. Levings, C.D. McAllister, U.H.M. Fagerlund, and J.R. McBride (1988). A field experiment to test the importance of estuaries for chinook salmon (*Oncorhynchus tschawytscha*) survival: short term results. Canadian Journal of Fisheries and Aquatic Science. Vol. 45, pp. 1366-1377

Muckleshoot Indian Tribe Fisheries Department, 1999. Lake Washington Chinook Recovery Plan. Draft unpublished report in cooperation with Washington Department of Fish and Wildlife, and the Suquamish Indian Tribe Fisheries Department.

Mumford B., 1991. Puget Sound nearshore habitat inventory protocol. Puget Sound Research Proceedings: pp 220-230.

NOAA, 1984. Charts of Puget Sound. National Oceanic and Atmospheric Administration. Seattle Washington. 1984.

National Marine Fisheries Service, and City of Seattle 1998. Cedar River watershed habitat conservation plan. National Oceanic and Atmospheric Administration. Department of Comerce. Pp 1043.

National Marine Fisheries Service. 1999. Independent populations of chinook salmon in Puget Sound. Puget Sound TRT. Public Review Draft.

National Marine Fisheries Service, 2000. Endangered and threatened species: Threatened status for three chinook salmon Evolutionary significant units in Washington and Oregon, and endangered status of one chinook salmon ESU in Washington; final rule. National Oceanic and Atmospheric Administration. Department of Commerce.

Sheffler D., 1995. Shoreline armoring effects on biological resources and coastal ecology in Puget Sound. Puget Sound Research Proceedings 1995. pp 121-131.

Simenstad 1999. Diet of chinook and other smolts in the Salmon Bay estuary. University of Washington School of Ocean Sciences and Fisheries. Unpublished Draft. University of Washington, Seattle Washington.

Simenstad, C. A., K Fresh and E. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: An unappreciated function. Estuarine Companion. Academic Press. pp. 343-364.

Tabor, R.A. and J. Chan. 1996. Predation on sockeye salmon fry by cottids and other predatory fishes in the lower Cedar River, 1996. Miscellaneous report. U.S. Fish and Wildlife.

Tabor, R.A. and J. Chan. 1997. Predation on sockeye salmon fry by cottids and other predatory fishes in the lower Cedar River, 1996. Miscellaneous report. U.S. Fish and Wildlife.

Tabor, R.A. and J. Chan. 1997. Predation on sockeye salmon fry by cottids and other predatory fishes in the lower Cedar River, 1996. Miscellaneous report. U.S. Fish and Wildlife.

Tabor, R.A 1999. Bass predation on juvenile chinook and other smolts in the Lake Washington Ship Canal 1999. Miscellaneous report. U.S. Fish and Wildlife.

Thorpe J. E. 1994. Salmonid fishes and the estuarine environment. Estuarine Research Federation. Freshwater Fisheries Laboratory, Scotland United Kingdom. pp. 76-93.

Warner E. and B. Footen,. 1999. The Relationship of Piscivorous Fishes to Juvenile Salmon: Lake Washington, Lake Sammamish and the Ship Canal February - June, 1997. Draft miscellaneous report. Muckleshoot Indian Tribe Fisheries Department. Auburn Washington

Warner E. and R. Fritz.1995. The distribution and growth of Green River chinook salmon and chum salmon outmigrants in the Duwamish estuary as a function of water quality and substrate. Muckleshoot Indian Tribe Fisheries Department. Water Resource Division. Auburn Washington.

Woody, J. C. 1966. Sockeye salmon spawning grounds and adult returns in the Lake Washington watershed, 1965. Masters thesis. University of Washington, Seattle. 101 pp.

Wingert, R.C. and B.S. Miller. 1979. Distributional analysis of nearshore and demersal fish species groups and nearshore fish habitat associations in Puget Sound. Univ. Washington School of Fisheries, Fish. Res. Inst. FRI-UW-7901. 110 p.

Willis B. 1898. Drift phenomena of Puget Sound. Bulletin of the Geological Society of America. Vol. 9., pp 111-162.

Wolman, M.G. 1954. A method of sampling coarse river-bed material. Transactions American Geophysical Union 35:951-956.

Vigg S., 1991. Rates of consumption of juvenile salmonids and alternative prey fish by northern squawfish, walleyes, smallmouth bass, and channel catfish in the John Day Reservoir, Columbia River. Transactions of American Fisheries Society, vol. 120: pp. 421-438.

Zarr H. J., 1985. Biostatistical Analysis. Prentice Hall, Inc, Upper Saddle River, New Jersey. Pg. 662.

Appendixes

Appendix I. Meters of Shoreline Sampled for Each Date and Location for the Inner and Outer Bay.

Inner Bay

Date	RR Bridge	Upper Beach	Mid Beach	Lower Beach	Orange Tri	Statue	Upper Stat.
4/17/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48
5/1/2000	30.48	0	30.48	30.48	30.48	30.48	30.48
5/8/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48
5/23/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48
5/25/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48
5/31/2000	30.48	30.48	30.48	30.48	0	30.48	30.48
6/2/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48
6/19/2000	30.48	30.48	0	0	30.48	0	0
6/20/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48
6/22/2000	30.48	30.48	30.48	30.48	0	30.48	30.48
6/27/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48
6/29/2000	30.48	30.48	30.48	30.48	0	30.48	30.48
7/5/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48
7/7/2000	30.48	30.48	0	0	30.48	0	0
7/18/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48
7/21/2000	30.48	30.48	30.48	30.48	0	30.48	30.48
8/28/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48
9/4/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48
9/11/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48
9/18/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48

Outer Bay

Date	Pristine	Lower GG	Mid GG	Upper GG	Breakwater	Lions Club	Anthony's
4/18/2000	0	30.48	30.48	30.48	0	0	0
5/2/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48
5/24/2000	0	0	0	0	30.48	0	30.48
6/5/2000	30.48	30.48	30.48	30.48	0	0	0
6/21/2000	30.48	30.48	0	0	0	30.48	30.48
6/28/2000	30.48	30.48	30.48	30.48	0	30.48	30.48
7/3/2000	30.48	30.48	30.48	30.48	0	30.48	30.48
7/6/2000	30.48	30.48	30.48	30.48	0	30.48	30.48
8/29/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48
9/5/2000	30.48	30.48	30.48	30.48	30.48	30.48	30.48

Appendix II. Habitat Data.

Railroad Bridge West Side of Estuary
Habitat Data Inner Bay 9/11/2000
Low Tide 9:40
Time 9:52
0=Silt,1=Sand

Mean	6.2mm
Max	98mm
Min.	0

Substrate sizes:

0	1	<=25mm	<=50mm
<=150mm	<=300mm		

Beach Length 33.3m
Width 23.7m
Gradient 16%
% *Ulva* and *Fuca* 30%

Wood: 1piece attatched to bank
Comments: Rip rap on upstream end. 12 m of overhanging vegetation just downstrm of riprap. Large Alder overhanging on downstream end. No bulkheads. Musseles and barnacles attatched to larger substrate.

Upstream — Downstream

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7	Transect 8	Transect 9	Transect 10	Tideline
0	0	34	0	0	65	24	0	0	0	
98	0	30	21	0	0	0	0	0	0	
52	0	8	23	0	0	10	0	0	0	
0	0	19	18	11	0	14	0	0	0	
22	15	42	17	0	0	0	0	0	0	
47	0	0	9	20	0	0	0	0	0	
39	0	51	0	0	0	0	0	0	0	
0	0	0	0	0	20	0	0	0	0	
0	0	0	0	0	0	0	0	0	0	
0	0	0	26	15	0	0	0	0	0	
0	0	0	18	11	0	7	0	0	0	
0	0	0	0	13	0	0	0	0	0	
37	0	0	15	0	0	13	0	0	0	
0	0	0	0	0	0	11	4	0	0	
0	0	0	10	0	10	8	0	0	0	
0	0	25	16	21	16	10	1	1	0	
35	0	27	0	11	30	10	1	1	0	
0	0	36	0	10	47	1	1	1	0	
0	10	31	0	14	30	1	1	1	1	
29	9	29	0	0	1	1	1	1	1	
0	43	0	0	0	1	1	1	1	1	
0	0	0	0	0	1	1	1	1	1	
24	0	1	1	1	1	1	1	1	1	
1	1	1					1	1	1	

Mid Beach West Side of Estuary
Habitat Data Inner Bay 9/11/2000
Low Tide 9:40
Time 13:10
0=Silt,1=Sand

Mean	1
Max	1
Min.	1

Length	33.3m
Width	18.6m
Gradient	12%
% *Ulva* and *Fuca*	0%

Wood: None
Comments: A dock marks the upstream end of this site.
Very little complexity. No structure.
High tide mark is just sandy beach.

Substrate sizes:

0	1	<=25mm	<=50mm
<=150mm	<=300mm		

Upstream — Downstream

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7	Transect 8	Transect 9	Transect 10	Tideline
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	

Appendix II. Continued.

Upper Beach West Side of Estuary
Habitat Data Inner Bay 9/11/2000
Low Tide 9:40
Time 11:20
0=Silt,1=Sand

Mean	5.23mm
Max	690mm
Min.	0

Length 33.3m
Width 18m
Gradient 15%
% *Ulva* and *Fuca* 10%

Wood: None
Comments: Bulkhead. Boat launch rails disect up and downstream ends of study site. Some bivalves present.

Substrate sizes:

0	1	<=25mm	<=50mm
<=150mm	<=300mm		

Upstream — Downstream

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7	Transect 8	Transect 9	Transect 10	Tideline
0	0	1	1	1	1	1	1	1	1	
0	0	0	1	1	1	1	1	1	1	
0	0	1	1	1	1	1	1	1	1	
0	1	1	1	1	1	1	1	1	1	
0	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	690	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1							

Lower Beach West Side of Estuasry
Habitat Data Inner Bay 9/12/2000
Low Tide 10:49
Time 10:50
0=Silt,1=Sand

Mean	18.15mm
Max	262mm
Min.	1

Length	33.3m
Width	24m
Gradient	12%
% *Ulva* and *Fuca*	70%

Wood: 1 piece
Comments:No bulkhead. Alder on upstream end overhanging. Bulkhead begins on upstream end. Exposed bank at hightide line. A few on downstream end. Barnacles and mussles present. Big boulder under alder tree. Strong septic smell.

Substrate sizes:

0	1	<=25mm	<=50mm
<=150mm	<=300mm		

Upstream — Downstream

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7	Transect 8	Transect 9	Transect 10	Tideline
18	1	14	1	1	1	25	8	1	1	
1	1	1	1	1	1	5	27	1	7	
19	19	1	1	49	9	12	9	9	5	
27	19	29	1	9	59	5	39	9	11	
5	1	6	7	38	65	6	5	15	7	
48	14	1	5	46	29	8	6	16	6	
12	1	31	19	55	24	11	9	1	10	
5	10	1	1	48	15	13	4	1	1	
14	9	34	17	52	42	29	1	6	4	
1	9	1	1	11	32	4	1	147	21	
36	15	15	12	19	25	11	1	6	1	
134	1	37	32	1	12	30	25	11	7	
31	15	1	14	13	20	45	14	262	1	
10	15	119	12	26	40	1	1	1	12	
1	43	5	10	8	12	14	5	19	6	
1	1	1	1	15	10	15	10	1	1	
56	5	1	5	1	21	9	15	1	1	
6	7	7	8	57	15	5	16	32	13	
9	1	12	135	14	9	4	8	3	7	
29	41	6	10	12	61	12	25	52	29	
18	15	6	7	12	3	22	5	20	1	
8	16	9	6	13	65	1	91	12	1	
84	11	16	11	36	11	1	60	89	1	

Appendix II. Continued.

Pristine West side of Estuary
Habitat Data Outer Bay
Low Tide 11:20
Time 12:30
0=Silt, 1=Sand
Mean 99.17mm
Max 1350mm
Min. 1

Length 33.3m
Width 27m
Gradient 9%
% *Ulva* and *Fuca* 90%

Wood: 11 pieces
Comments: Large boulders mark the upper and lower ends of this study site. This beach id part of Discovery Park and has overhanging trees and vegetation along the upper length. Large kelpbed offshore.

Substrate sizes:

0	1	<=25mm	<=50mm
<=150mm	<=300mm		

Upstream — Downstream

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7	Transect 8	Transect 9	Transect 10	Tideline
63	53	48	62	115	87	44	210	33	152	
47	58	58	204	124	32	76	45	97	67	
47	70	85	64	53	101	45	42	18	62	
102	75	50	60	73	74	112	25	28	55	
38	130	44	128	1	16	187	85	89	75	
63	85	1	1	58	245	114	54	60	41	
18	80	74	49	45	84	51	21	59	154	
82	85	91	86	59	88	74	91	22	69	
21	1	72	286	40	113	45	139	25	67	
13	1	78	1	24	63	115	98	110	139	
1	1	32	20	52	495	113	74	153	163	
97	1	85	57	615	123	125	38	82	172	
93	1	40	94	563	11	170	12	52	86	
1	55	32	6	142	66	208	52	114	98	
1	1	55	135	64	169	265	66	91	714	
1	60	22	127	40	61	122	292	28	45	
148	240	89	16	67	99	163	124	140	63	
1	50	195	1	59	102	10	94	315	117	
1	35	19	3	165	1	166	114	1025	47	
151	45	12	21	50	110	42	1350	34	52	
103	52	11	306	78	187	117	174	126	122	
19	220	125	1	124	165	150	114	79	33	
12	265	125	144	67	94	72	140	299	75	
93	305	134	29	90	88	33	139	155	39	
	132	81	12	60	52	59	148	151		
	25	78		130			21	90		
	72			112			57	98		

Statue of Liberty East Side of Estuary
Habitat Data Inner Bay 9/12/2000
Low Tide 10:49
Time 11:57
0=Silt, 1=Sand
Mean 45.6mm
Max 132mm
Min. 1

Length 33.3m
Width 24m
Gradient 10%
% *Ulva* and *Fuca* 100%

Wood: None
Comments: Bulkhead over entire study area. Lots of barnacles. Mussles also present.

Substrate sizes:

0	1	<=25mm	<=50mm
<=150mm	<=300mm		

Upstream — Downstream

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7	Transect 8	Transect 9	Transect 10	Tideline
78	65	76	52	45	45	9	28	28	15	
40	95	77	35	22	22	85	84	30	31	
23	31	90	84	20	30	71	26	24	99	
77	30	66	55	15	11	7	10	25	100	
60	30	35	77	16	31	25	24	1	52	
59	59	86	58	12	55	90	96	30	25	
90	14	35	25	40	76	87	3	32	48	
39	26	46	37	56	107	48	32	30	20	
14	25	1	42	97	28	54	21	104	32	
132	10	30	18	116	31	107	61	112	63	
5	7	70	65	36	82	74	8	88	38	
39	92	37	20	24	34	68	16	32	13	
95	104	15	40	65	20	32	50	60	39	
47	20	53	67	44	26	37	26	29	90	
24	17	20	12	16	25	24	16	40	45	
57	62	15	23	27	10	53	17	53	48	
40	15	57	44	52	42	62	40	45	60	
24	36	61	19	30	116	30	68	88	34	
44	16	72	45	35	54	53	54	44	66	
32	62	64	106	76	59	40	52	84	35	
14	10	47	43	62	90	63	39	78	58	
35	30	14	61	68	15	15	20	23	14	

Appendix II. Continued.

Lower Beach Golden Gardens
Habitat Data Outer Bay 9/13/2000
Low Tide 11:33
Time 11:07
0=Silt,1=Sand

Mean	1
Max	1
Min.	1

Length	33.3m
Width	16m
Gradient	10%
% *Ulva* and *Fuca*	None

Wood: None
Comments: This beach is located at Golden Gardens park on the east side of Shilshole Bay Very little complexity.

Substrate sizes:

0	1	<=25mm	<=50mm
<=150mm	<=300mm		

Upstream — Downstream

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7	Transect 8	Transect 9	Transect 10	Tideline
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	

Mid Beach Golden Gardens
Habitat Data Outer Bay 9/13/2000
Low Tide 11:33
Time 11:17
0=Silt,1=Sand

Mean	1
Max	1
Min.	1

Length	33.3m
Width	16m
Gradient	10%
% *Ulva* and *Fuca*	None

Wood: None
Comments: This beach is located at Golden Gardens park on the east side of Shilshole Bay Very little complexity.

Substrate sizes:

0	1	<=25mm	<=50mm
<=150mm	<=300mm		

Upstream — Downstream

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7	Transect 8	Transect 9	Transect 10	Tideline
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	

Appendix II. Continued.

Lower Beach Golden Gardens
Habitat Data Outer Bay 9/13/2000
Low Tide 11:33
Time 11:27
0=Silt,1=Sand

Length	33.3m
Width	16m
Gradient	10%
% *Ulva* and *Fuca*	None
Wood:	None

Comments: This beach is located at Golden Gardens park on the east side of Shilshole Bay Very little complexity.

Mean	1
Max	1
Min.	1

Substrate sizes:

0	1	<=25mm	<=50mm
<=150mm	<=300mm		

Upstream — Downstream

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7	Transect 8	Transect 9	Transect 1(	Tideline
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	

Breakwater East side of Estuary
Habitat Data Outer Bay 9/13/2000
Low Tide 11:33
Time 13:47
0=Silt,1=Sand

Length	33.3m
Width	16m
Gradient	10%
% *Ulva* and *Fuca*	None
Wood	None

Comments: This beach is located on the outer side of a large breakwater for Shilshole marina. Very little complexity.

Mean	1
Max	1
Min.	1

Substrate sizes:

0	1	<=25mm	<=50mm
<=150mm	<=300mm		

Upstream — Downstream

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7	Transect 8	Transect 9	Transect 10	Tideline
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	

Appendix II. Continued.

Lions Club East Side of Estuary
Habitat Data Outer Bay 9/13/2000
Low Tide 11:30
Time 14:15
0=Silt,1=Sand

Mean	1
Max	1
Min.	1

Length	33.3m
Width	23.4m
Gradient	11%
% *Ulva* and *Fuca*	10%

Wood: None

Comments: Behind Lions club this site has a bulkhead for the entire length. There are many pilings at the low tide mark. An apartment building begins the upper end and rip rap marks the lower end of the study site.

Substrate sizes:

0	1	<=25mm	<=50mm
<=150mm	<=300mm		

Upstream — Downstream

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7	Transect 8	Transect 9	Transect 1(	Tideline
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	
1	1	1	1	1	1	1	1	1	1	

Anthony's East Side of Estuary
Habitat Data Outer Bay 9/13/2000
Low Tide 11:30
Time 11:33
0=Silt,1=Sand

Mean	45.63mm
Max	1050mm
Min.	1

Length	33.3m
Width	24.7m
Gradient	9%
% *Ulva* and *Fuca*	90%

Wood: None

Comments: Riprap on up and downstream ends of study sight. Bulkhead head at high tideline.

Substrate sizes:

0	1	<=25mm	<=50mm
<=150mm	<=300mm		

Upstream — Downstream

Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7	Transect 8	Transect 9	Transect 10	Tideline
65	11	1	1	1	1	1	1	23	15	
1	16	1	1	1	1	1	1	1	15	
9	14	8	1	1	1	1	1	13	1	
8	1	1	1	1	1	1	1	1	10	
27	28	1	1	1	1	1	1	1	25	
19	90	91	1	12	1	1	1	16	20	
19	172	61	1	9	1	1	1	14	1050	
15	15	71	1	1	1	1	1	1	700	
14	14	54	1	1	1	1	1	1	600	
42	21	75	1	18	10	1	1	12	80	
15	38	140	52	26	1	1	1	12	110	
39	18	19	1	21	1	1	13	109	170	
12	23	40	25	1	1	1	1	20	119	
126	303	125	1	85	24	1	1	1	775	
70	35	31	1	38	1	1	1	320	109	
8	20	18	1	1	1	1	1	252	157	
38	17	55	20	26	14	1	1	310	729	
40	33	12	1	1	1	1	1	1	265	
22	57	110	42	1	21	1	1	1	182	
41	21	91	24	6	23	21	1	24	450	
275	19	1	39	1	1	1	1	26	500	
25	17	25	21	20	28	1	24	17	9	
40	19	1	12	1	1	1	10	1	1	
430	97	1	1	8	3	29	1	1	1	
15	110	1	11	12	1	1	1	1	1	
1	1	15	15	9	7	6	1	1	400	
14	1	1	16	1	1	5	1	1		
1	18	52	1	1	1	1	1			
	1	1	1	1		1				
	21	15	10			15				
			35							

Appendix III. Smolt and Piscivore Catches for the Outer Bay for all Sample Dates.

	Outer Bay	Pristine	Lower GG	Mid GG	Upper GG	Breakwater	Lions Club	Anthony's	Total All
Fish/m	Chinook Wild	0.020	0.080	0.024	0	0	0.529	0.996	0.235
Fish/m	Chinook Hatchery	0.020	0.174	0.110	0	0	1.377	0.684	0.338
Fish/m	Coho Wild	0.123	0.054	0.377	0	0	0.110	0.117	0.082
Fish/m	Coho Hatchery	0.032	0.007	0.065	0	0	0.386	0.193	0.097
Fish/m	Sockeye	0.086	0.021	0	0	0	0.004	0.159	0.038
Fish/m	Chum	0.660	0.204	0.315	1.558	0.820	0.557	3.001	0.019
Fish/100m	Cutthroat	0	0	0	0	0	0.468	0	0.066
Fish/100m	Staghorn	0	0.364	0	1.230	0.820	0.937	1.640	0.713
Fish/100m	Chinook 2yr.	0	0	0	0	10.66	0	0	1.523

Appendix III Continued. Fish Per Meter for Smolts and Piscivores Caught in the Outer Bay for Each Sample Date and Location.

Cutthroat trout

Date	Pristine	Breakater	Lower GG	Mid GG	Upper GG	Lions Club	Anthony's
4/18/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/2/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/24/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/5/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/21/2000	0.00	0.00	0.00	0.00	0.00	0.03	0.00
6/28/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/3/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/6/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8/29/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/5/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.03

Staghorn sculpin

Date	Pristine	Breakater	Lower GG	Mid GG	Upper GG	Lions Club	Anthony's
4/18/2000	0.000	0.000	0.000	0.00	0.098	0.000	0.000
5/2/2000	0.000	0.066	0.000	0.00	0.000	0.000	0.000
5/24/2000	0.000	0.000	0.000	0.00	0.000	0.000	0.000
6/5/2000	0.000	0.000	0.000	0.00	0.000	0.000	0.000
6/21/2000	0.000	0.000	0.000	0.00	0.000	0.000	0.000
6/28/2000	0.000	0.000	0.033	0.00	0.000	0.000	0.000
7/3/2000	0.000	0.000	0.000	0.00	0.000	0.066	0.000
7/6/2000	0.000	0.000	0.000	0.00	0.000	0.000	0.131
8/29/2000	0.000	0.000	0.000	0.00	0.000	0.000	0.000
9/5/2000	0.000	0.033	0.000	0.00	0.000	0.000	0.033

2 yr Old Chinook

Date	Pristine	Breakater	Lower GG	Mid GG	Upper GG	Lions Club	Anthony's
4/18/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/2/2000	0.00	0.43	0.00	0.00	0.00	0.00	0.00
5/24/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/5/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/21/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/28/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/3/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/6/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8/29/2000	0.00	0.07	0.00	0.00	0.03	0.00	0.00
9/5/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix III. Continued.

Chinook smolts

Date	Pristine Wild	Pristine Hatchery	Breakwater Wild	Breakwater Hatchery	Lower GG Wild	Lower GG Hatchery	Mid GG Wild	Mid GG Hatchery	Upper GG Wild	Upper GG Hatchery	Lions Club Wild	Lions Club Hatchery	Anthony's Wild	Anthony's Hatchery
4/18/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/2/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/24/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.36
6/5/2000	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00
6/21/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	9.19	0.46	2.03
6/28/2000	0.03	0.00	0.00	0.00	0.00	0.00	0.56	0.20	0.52	0.00	0.00	3.74	0.10	0.36
7/3/2000	0.10	0.07	0.00	0.00	0.10	0.03	0.00	0.00	0.00	0.00	0.07	0.20	0.20	0.56
7/6/2000	0.03	0.10	0.00	0.00	0.62	0.49	0.00	0.00	1.15	0.00	0.00	0.00	0.07	0.10
8/29/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
9/5/2000	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03

Coho smolts

Date	Pristine Wild	Pristine Hatchery	Breakwater Wild	Breakwater Hatchery	Lower GG Wild	Lower GG Hatchery	Mid GG Wild	Mid GG Hatchery	Upper GG Wild	Upper GG Hatchery	Lions Club Wild	Lions Club Hatchery	Anthony's Wild	Anthony's Hatchery
4/18/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/2/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/24/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.46
6/5/2000	0.00	0.03	0.00	0.00	0.00	0.00	0.26	0.26	0.00	0.00	0.00	0.00	0.00	0.00
6/21/2000	0.10	0.03	0.00	0.00	10.16	0.00	0.00	0.00	0.00	0.00	1.48	0.89	0.26	0.33
6/28/2000	0.92	0.23	0.00	0.00	4.35	1.09	2.53	0.30	2.85	0.52	0.66	0.20	0.20	0.13
7/3/2000	0.07	0.00	0.00	0.00	30.48	0.00	0.07	0.00	0.00	0.00	0.23	0.07	0.39	0.13
7/6/2000	0.03	0.00	0.00	0.00	243.84	30.48	0.10	0.03	0.00	0.03	0.00	0.00	0.00	0.07
8/29/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
9/5/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Chum smolts

Date	Pristine	Breakater	Lower GG	Mid GG	Upper GG	Lions Club	Anthony's
4/18/2000	0.00	0.00	0.03	1.51	11.55	0.00	0.00
5/2/2000	5.25	0.00	1.64	0.98	0.92	1.64	16.40
5/24/2000	0.00	0.00	0.00	0.00	0.00	0.00	4.92
6/5/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/21/2000	0.03	0.00	0.00	0.00	0.00	0.95	0.07
6/28/2000	0.00	0.00	0.07	0.03	0.00	1.28	0.95
7/3/2000	0.00	0.00	0.00	0.00	0.00	0.03	1.64
7/6/2000	0.00	0.00	0.10	0.00	0.00	0.00	0.00
8/29/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/5/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sockeye smolts

Date	Pristine	Breakater	Lower GG	Mid GG	Upper GG	Lions Club	Anthony's
4/18/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/2/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/24/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/5/2000	0.89	0.00	0.20	0.00	0.00	0.00	0.00
6/21/2000	0.00	0.00	0.00	0.00	0.00	0.03	0.00
6/28/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/3/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/6/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8/29/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/5/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendex IV. Fish Per Meter for Smolts and Piscivores Caught in the Inner Bay for Each Sample Date and Location.

Chinook smolts

Date	RR Bridge Wild	Railroad Bridge Hatchery	Upper Beach Wild	Upper Beach Hatchery	Mid Beach Wild	Mid Beach Hatchery	Lower Beach Wild	Lower Beach Hatchery	Orange Tri. Wild	Orange Tri. Hatchery	Statue Wild	Statue Hatchery	Upper Statue Wild	Upper Statue Hatchery
4/17/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/1/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/8/2000	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/23/2000	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
5/25/2000	3.44	4.12	0.00	0.00	0.00	9.42	0.36	0.00	0.00	5.01	0.22	0.00	0.00	0.00
5/31/2000	1.80	2.31	0.00	0.00	0.00	0.00	0.00	1.87	0.00	1.41	0.76	0.00	0.07	0.00
6/2/2000	0.07	1.78	1.05	2.10	0.16	3.21	0.19	0.00	0.10	0.00	0.00	0.00	0.00	0.00
6/19/2000	6.56	3.54	4.76	1.80	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.00	0.00
6/20/2000	1.77	1.14	0.00	14.53	0.69	1.37	0.00	0.00	2.00	0.00	0.03	0.26	0.06	7.67
6/22/2000	3.15	5.18	0.00	1.64	0.66	0.75	1.11	3.08	0.00	0.00	0.30	3.40	1.90	21.68
6/27/2000	0.79	3.58	0.00	0.82	0.07	0.00	0.36	0.00	0.03	0.49	0.42	0.00	0.29	0.86
6/29/2000	0.10	0.69	0.00	0.03	0.00	0.32	0.00	0.16	0.00	0.00	0.03	0.32	1.35	5.84
7/5/2000	0.33	0.30	0.00	0.07	0.98	2.19	0.19	0.06	0.29	0.16	0.49	0.26	0.13	0.22
7/7/2000	0.26	0.26	3.90	0.00	0.00	0.00	0.00	0.00	0.07	0.10	0.00	0.00	0.00	0.00
7/18/2000	0.08	0.15	0.30	0.00	0.00	0.00	0.07	0.07	0.07	0.00	0.07	0.03	0.06	0.00
7/21/2000	0.36	0.07	0.75	0.00	0.07	0.03	0.00	0.00	0.03	0.10	0.03	0.00	0.26	0.20
8/28/2000	0.79	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
9/4/2000	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/11/2000	0.10	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/18/2000	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Chum smolts

Date	RR Bridge	Upper Beach	Mid Beach	Lower Beach	Orange Tri	Statue	Upper Stat
4/17/2000	0.00	0.69	0.00	0.00	0.00	0.00	0.00
5/1/2000	1.64	0.00	0.00	0.00	13.12	26.25	3.39
5/8/2000	1.31	9.84	5.74	2.14	0.00	0.00	4.22
5/23/2000	5.74	0.07	1.12	0.00	0.00	0.00	0.00
5/25/2000	4.92	0.03	0.00	2.01	1.15	0.00	0.00
5/31/2000	0.43	0.00	0.32	1.32	1.31	1.64	2.46
6/2/2000	0.66	2.33	0.00	0.00	1.64	1.64	0.00
6/19/2000	0.95	0.00	2.62	0.00	0.07	0.00	0.00
6/20/2000	0.66	0.00	0.00	0.00	0.00	0.00	0.26
6/22/2000	0.23	0.00	0.03	0.07	0.00	1.83	0.30
6/27/2000	1.15	0.03	0.00	0.00	0.36	0.07	0.00
6/29/2000	0.75	0.00	0.00	0.00	0.00	0.00	1.80
7/5/2000	0.03	0.07	0.00	0.03	0.10	0.07	0.00
7/7/2000	0.00	0.30	0.00	0.00	0.07	0.00	0.00
7/18/2000	0.00	0.03	0.00	0.07	0.00	0.00	0.00
7/21/2000	0.00	0.03	0.00	0.00	0.00	0.00	0.00
8/28/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/4/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/11/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/18/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Coho smolts

Date	RR Bridge Wild	RR Bridge Hatchery	Upper Beach Wild	Upper Beach Hatchery	Mid Beach Wild	Mid Beach Hatchery	Lower Beach Wild	Lower Beach Hatchery	Orange Tri. Wild	Orange Tri. Hatchery	Statue Wild	Statue Hatchery	Upper Statue Wild	Upper Statue Hatchery
4/17/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00
5/1/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	2.26
5/8/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/23/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/25/2000	0.16	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.13	0.00	0.00	0.03	0.00	0.00
5/31/2000	0.72	0.69	0.03	0.00	0.00	0.00	0.00	1.34	0.39	0.00	0.30	0.00	0.07	0.00
6/2/2000	0.10	0.00	0.65	0.85	0.10	1.64	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
6/19/2000	4.10	2.46	3.20	3.30	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00
6/20/2000	0.95	0.00	1.02	0.72	0.03	0.07	0.20	0.00	0.43	0.00	0.00	0.00	0.32	0.16
6/22/2000	1.21	0.75	1.08	1.04	0.07	0.07	0.20	0.16	0.00	0.03	0.10	0.07	0.26	0.49
6/27/2000	0.33	0.26	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.26	0.07	0.03
6/29/2000	0.00	0.07	0.03	0.00	0.10	0.16	0.00	0.00	0.00	0.00	0.00	0.03	0.07	0.16
7/5/2000	0.03	0.03	0.23	0.26	0.03	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
7/7/2000	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
7/18/2000	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/21/2000	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.03	0.00
8/28/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/4/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/11/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/18/2000			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sockeye smolts

Date	RR Bridge	Upper Beach	Mid Beach	Lower Beach	Orange Tri	Statue	Upper Stat
4/17/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/1/2000	0.00	0.75	0.00	0.00	0.00	0.00	0.75
5/8/2000	0.00	3.33	0.20	0.00	0.00	0.00	0.00
5/23/2000	0.00	0.03	0.00	0.00	0.00	0.00	3.32
5/25/2000	0.00	0.20	0.00	0.00	0.69	0.03	0.03
5/31/2000	0.20	0.20	0.00	0.49	1.67	0.13	0.20
6/2/2000	0.23	0.03	0.10	0.07	0.00	0.00	0.00
6/19/2000	6.56	6.70	0.00	0.00	0.03	0.00	0.00
6/20/2000	0.59	0.23	0.00	0.00	1.47	0.00	0.23
6/22/2000	0.23	0.07	0.00	0.07	0.00	0.10	0.32
6/27/2000	0.00	0.00	0.00	0.00	0.07	0.00	0.00
6/29/2000	0.00	0.00	0.00	0.07	0.00	0.00	0.00
7/5/2000	0.00	0.00	0.00	0.00	0.03	0.13	0.00
7/7/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/18/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/21/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8/28/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/4/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/11/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/18/2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix IV. Continued.

Cutthroat Trout — Fish per 100 meters

Date	RR Bridge	Upper Beach	Mid Beach	Lower Beach	Orange Tri	Statue	Upper Stat.
4/17/2000	0	0	0	0	0	3.28	0
5/1/2000	0	0	0	0	0	9.83	0
5/8/2000	0	0	16.4	0	0	0	0
5/23/2000	0	0	0	0	0	9.83	6.56
5/25/2000	16.70	0	0	0	0	3.27	0
5/31/2000	0	0	0	3.28	0	0	0
6/2/2000	2.5	0	0	0	0	3.27	0
6/19/2000	0	0	0	0	0	0	0
6/20/2000	3.27	3.28	0	0	0	0	0
6/22/2000	0	0	0	0	0	0	0
6/27/2000	6.55	0	0	0	0	0	0
6/29/2000	0	0	0	0	0	6.55	0
7/5/2000	0	0	3.28	0	0	0	0
7/7/2000	0	0	6.55	0	0	0	0
7/18/2000	0	0	0	0	0	0	0
7/21/2000	0	0	0	0	0	3.28	0
8/28/2000	0	0	0	0	0	0	0
9/4/2000	0	0	0	0	0	0	0
9/11/2000	0	0	0	0	0	3.28	0
9/18/2000	0	0	0	0	0	0	0

Staghorn Sculpin — Fish per 100 meters

Date	RR Bridge	Upper Beach	Mid Beach	Lower Beach	Orange Tri	Statue	Upper Stat.
4/17/2000	0	3.28	0	0	0	0	0
5/1/2000	0	0	0	0	0	0	0
5/8/2000	0	0	0	0	0	0	0
5/23/2000	0	0	0	0	0	0	3.28
5/25/2000	0	6.56	13.12	0	0	0	0
5/31/2000	3.27	0	0	0	0	0	0
6/2/2000	3.27	0	0	3.28	0	0	0
6/19/2000	0	0	0	0	0	0	0
6/20/2000	0	6.56	3.28	0	0	0	0
6/22/2000	0	0	0	0	0	0	0
6/27/2000	4.28	0	0	0	0	0	0
6/29/2000	0	0	0	0	0	0	0
7/5/2000	0	0	0	0	0	3.27	0
7/7/2000	0	13.123	3.28	0	0	0	0
7/18/2000	3.27	3.28	0	0	0	3.27	0
7/21/2000	0	0	0	0	0	9.83	0
8/28/2000	0	0	0	0	0	0	0
9/4/2000	0	0	0	0	0	0	0
9/11/2000	0	0	0	0	0	0	0
9/18/2000	0	0	0	0	0	0	0

Char — Fish per 100 meters

Date	RR Bridge	Upper Beach	Mid Beach	Lower Beach	Orange Tri	Statue	Upper Stat.
4/17/2000	0	0	0	0	0	0	0
5/1/2000	0	0	0	0	0	0	0
5/8/2000	3.27	0	0	0	0	0	0
5/23/2000	6.55	0	0	0	0	0	0
5/25/2000	0	0	0	0	0	0	0
5/31/2000	0	0	0	0	0	0	0
6/2/2000	0	0	0	0	0	0	0
6/19/2000	0	0	0	0	0	0	0
6/20/2000	0	0	0	3.28	0	0	0
6/22/2000	0	0	0	0	0	0	0
6/27/2000	0	0	0	0	0	0	0
6/29/2000	0	0	0	3.28	0	0	0
7/5/2000	0	0	0	0	0	0	0
7/7/2000	0	0	0	0	0	0	0
7/18/2000	0	0	0	0	0	0	0
7/21/2000	0	0	0	0	0	0	0
8/28/2000	0	0	0	0	0	0	0
9/4/2000	0	0	0	0	0	0	0
9/11/2000	0	0	0	0	0	0	0
9/18/2000	0	0	0	0	0	0	0

Appendix V. Diet Data for all Fish Sampled in the Inner and Outer Bays for all sample Locations During Entire Study Period.

Date	Location	Species	Length (mm)	Prey Item	Preyweight (g)	Measure	units	Comments
4/17/2000	Mid Beach	Starry Flounder	415	Bivalvia	5.129			
4/17/2000	Upper Beach	Staghorn Sculpin	120	Cottidae	7.829	117	mm	
4/17/2000	Upper Beach	Starry Flounder	460	Uni. Invertebrate.	3.075			
4/17/2000	Statue	Cutthroat Trout	178					trace
4/18/2000	Mid Beach	Staghorn Sculpin	183	Rocks & Sand	3.210			
4/18/2000	Mid Beach	Staghorn Sculpin	161	Decopoda	1.159			
4/18/2000	Mid Beach	Staghorn Sculpin	161	Gastropoda	0.367			
4/18/2000	Mid Beach	Staghorn Sculpin	159					trace
5/1/2000	Railroad Bridge	Pacific Herring	220	Uni. Fish	0.463			
5/1/2000	Railroad Bridge	Adult Coho	363	Uni. Fish	0.294			
5/1/2000	Railroad Bridge	Adult Coho	310	Sandlance	3.844			Sandlance 22
5/1/2000	Railroad Bridge	Adult Coho	296	Sandlance	6.159			Sandlance TMC
5/1/2000	Statue	Cutthroat Trout	406	Sandlance	11.479			Sandlance TMC
5/1/2000	Statue	Cutthroat Trout	406	Uni. Smolt	1.758	78	mm	
5/1/2000	Statue	Cutthroat Trout	452	Sandlance	5.161			
5/1/2000	Statue	Cutthroat Trout	360	Sandlance	1.660			
5/8/2000	RR Bridge	Staghorn Sculpin	142	Cottidae	0.068			
5/8/2000	RR Bridge	Char	330	Sandlance	0.125			
5/8/2000	Lower Beach	Cutthroat Trout	400	Sandlance	8.860			50+ Sandlance
5/8/2000	Lower Beach	Cutthroat Trout	335	Sandlance	4.134			7 Sandlance
5/8/2000	Upper Statue	Starry Flounder	305	Bivalvia	0.711			
5/23/2000	RR Bridge	Char	365	Pacific herring	7.484	112	mm	
5/23/2000	RR Bridge	Char	365	Shiner perch	3.692	68	mm	
5/23/2000	RR Bridge	Char	341	Shiner perch	3.437	75	mm	
5/23/2000	RR Bridge	Char	341	Uni. Fish	0.811			
5/23/2000	RR Bridge	Char	341	Uni. Smolt	1.186	82	mm	
5/23/2000	RR Bridge	Cutthroat Trout	316	Chinook smolt	7.223	110	mm	
5/23/2000	RR Bridge	Cutthroat Trout	316	Chinook smolt	2.599			
5/23/2000	Lower Beach	Starry Flounder	265					trace
5/23/2000	Lower Beach	Starry Flounder	300					trace
5/23/2000	Mid Beach	Staghorn Sculpin	205	Decopoda	0.217			
5/23/2000	Mid Beach	Staghorn Sculpin	205	Rocks & Sand	0.007			
5/23/2000	Mid Beach	Staghorn Sculpin	195	Other	0.418			
5/23/2000	Mid Beach	Staghorn Sculpin	149	Decopoda	0.044			
5/23/2000	Mid Beach	Staghorn Sculpin	146	Chinook smolt	0.935			
5/23/2000	Mid Beach	Staghorn Sculpin	146	Chinook smolt	3.286			
5/23/2000	Mid Beach	Staghorn Sculpin	146	Chinook smolt	2.458			
5/23/2000	Statue	Cutthroat Trout	235	Uni. Fish	0.048			

Appendix V. Continued.

5/23/2000	Statue	Cutthroat Trout	205	Sandlance	0.092			
5/23/2000	Upper Statue	Cutthroat Trout	265	Uni. Fish	0.984			
5/23/2000	Upper Statue	Cutthroat Trout	235	Sandlance	0.942			
5/23/2000	Upper Statue	Staghorn Sculpin	210					trace
5/24/2000	Upper GG	Staghorn Sculpin	216	Sandlance	0.224			
5/25/2000	RR Bridge	Cutthroat Trout	340	Surf smelt	6.745	118	mm	
5/25/2000	RR Bridge	Cutthroat Trout	340	Surf smelt	3.318	103	mm	
5/25/2000	RR Bridge	Cutthroat Trout	455	Surf smelt	2.783	89	mm	
5/25/2000	RR Bridge	Cutthroat Trout	455	Surf smelt	0.780	70	mm	
5/25/2000	RR Bridge	Cutthroat Trout	455	Surf smelt	2.597	78	mm	
5/25/2000	RR Bridge	Cutthroat Trout	310	Other	0.377			
5/25/2000	RR Bridge	Cutthroat Trout	310	Uni. Invertebrate.	0.013			
5/25/2000	RR Bridge	Cutthroat Trout	258	Chinook smolt	1.117	80	mm	
5/25/2000	RR Bridge	Cutthroat Trout	218	Uni. Fish	0.050			
5/25/2000	RR Bridge	Cutthroat Trout	218	Rocks & Sand	0.003			
5/25/2000	RR Bridge	Cutthroat Trout	200	Chinook smolt				
5/25/2000	Mid Beach	Staghorn Sculpin	187	Decopoda	0.023			
5/25/2000	Mid Beach	Staghorn Sculpin	187	Uni. Fish	0.068			
5/25/2000	Mid Beach	Staghorn Sculpin	187	Uni. Invertebrate.	0.024			
5/25/2000	Mid Beach	Staghorn Sculpin	140	Other	1.817			
5/25/2000	Mid Beach	Staghorn Sculpin	140	Uni. Organic Matter	0.038			
5/25/2000	Lower Beach	Char	365	Chum smolt	2.370			
5/25/2000	Lower Beach	Char	365	Shiner perch	2.260			
5/25/2000	Statue	Cutthroat Trout	450	Chum smolt	1.500	68	mm	
5/25/2000	Statue	Cutthroat Trout	450	Uni. Fish	2.416	101	mm	
5/25/2000	Upper Beach	Staghorn Sculpin	175	Chinook smolt	4.211			
5/25/2000	Upper Beach	Staghorn Sculpin	175	Rocks & Sand	0.179			
5/25/2000	Upper Beach	Staghorn Sculpin	148	Decopoda	0.022			
5/25/2000	Upper Beach	Staghorn Sculpin	148	Cottidae	0.873			
5/31/2000	RR Bridge	Staghorn Sculpin	450	Bivalvia	0.110			
5/31/2000	RR Bridge	Staghorn Sculpin	450	Bivalvia	0.112			
5/31/2000	RR Bridge	Staghorn Sculpin	210	Uni. Fish	3.217			
5/31/2000	RR Bridge	Staghorn Sculpin	210	Decopoda	0.680			
5/31/2000	Statue	Cutthroat Trout	322	Uni. Smolt	2.079			
5/31/2000	Statue	Cutthroat Trout	322	Cottidae	0.082			
6/2/2000	RR Bridge	Staghorn Sculpin	210	Uni. Smolt	2.519			
6/20/2000	RR Bridge	Cutthroat Trout	325	Uni. Fish	0.124			
6/20/2000	Mid Beach	Staghorn Sculpin	205	Amphipoda	0.018			
6/20/2000	Mid Beach	Staghorn Sculpin	205	Rocks & Sand	0.010			

Appendix V. Continued.

6/20/2000	Upper Beach	Staghorn Sculpin	210	Decopoda	0.308			
6/20/2000	Upper Beach	Staghorn Sculpin	176	Pacific herring	1.220			
6/21/2000	Breakwater	2 Yr. Old Chinook	255	Sandlance	4.680			5 Sandlance
6/21/2000	Breakwater	Adult Sockeye	330	Bivalvia	0.055			
6/21/2000	Breakwater	Adult Sockeye	330	Decopoda	1.868			
6/21/2000	Breakwater	Adult Sockeye	330	Rocks & Sand	0.205			
6/21/2000	Breakwater	2 Yr. Old Chinook	263	Sandlance	0.681			
6/21/2000	Breakwater	2 Yr. Old Chinook	270	Chum smolt	0.223			
6/21/2000	Breakwater	2 Yr. Old Chinook	250	Uni. Fish	0.4800			
6/21/2000	Breakwater	2 Yr. Old Chinook	255	Sandlance	1.762			3 Sandlance
6/21/2000	Breakwater	2 Yr. Old Chinook	300	Sandlance	4.563			6 Sandlance
6/21/2000	Breakwater	2 Yr. Old Chinook	300	Oligochaeta	0.106			
6/21/2000	Breakwater	2 Yr. Old Chinook	270	Sandlance	3.979			7 Sandlance
6/21/2000	Breakwater	2 Yr. Old Chinook	268	Sandlance	0.306	58	mm	
6/21/2000	Breakwater	2 Yr. Old Chinook	268	Sandlance	0.256	55	mm	
6/21/2000	Breakwater	2 Yr. Old Chinook	268	Sandlance	0.261	52	mm	
6/21/2000	Breakwater	2 Yr. Old Chinook	245	Sandlance	2.072			12 Sandlance
6/21/2000	Breakwater	2 Yr. Old Chinook	278	Sandlance	8.424			7 Sandlance
6/21/2000	Breakwater	2 Yr. Old Chinook	305	Sandlance	4.834			6 Sandlance
6/21/2000	Breakwater	2 Yr. Old Chinook	305	Oligochaeta	0.028			
6/21/2000	Breakwater	2 Yr. Old Chinook	280	Sandlance	0.122			
6/21/2000	Breakwater	2 Yr. Old Chinook	290	Sandlance	5.570			10 Sandlance
6/21/2000	Breakwater	2 Yr. Old Chinook	290	Oligochaeta	0.022			
6/21/2000	Breakwater	Staghorn Sculpin	240	Sandlance	2.046			4 Sandlance
6/21/2000	Breakwater	Staghorn Sculpin	240	Rocks & Sand	0.024			
6/21/2000	Breakwater	Staghorn Sculpin	240	Uni. Invertebrate.	1.288			
6/21/2000	Breakwater	Staghorn Sculpin	240	Uni. Invertebrate.	0.554			
6/21/2000	Breakwater	Staghorn Sculpin	225	Sandlance	8.907			23 Sandlance
6/21/2000	Breakwater	Staghorn Sculpin	225	Uni. Invertebrate.	0.112			
6/21/2000	Mid GG	Staghorn Sculpin	175	Decopoda	0.924			
6/23/2000	Anthony's	Cutthroat Trout	182	Sandlance	1.028	68	mm	
6/23/2000	Anthony's	Cutthroat Trout	182	Sandlance	0.215	49	mm	
6/23/2000	Anthony's	Cutthroat Trout	182	Sandlance	0.041			
6/27/2000	RR Bridge	Staghorn Sculpin	242	Chinook smolt	16.659	117	mm	
6/27/2000	RR Bridge	Staghorn Sculpin	242	Chinook smolt	5.838	96	mm	
6/27/2000	RR Bridge	Staghorn Sculpin	242	Decopoda	4.464			
6/27/2000	RR Bridge	Staghorn Sculpin	242	Uni. Invertebrate.	0.490			
6/27/2000	RR Bridge	Staghorn Sculpin	242	Rocks & Sand	0.017			
6/27/2000	RR Bridge	Staghorn Sculpin	216	Decopoda	1.604			

Appendix V. Continued.

6/27/2000	RR Bridge	Staghorn Sculpin	216	Sandlance	0.076			
6/27/2000	RR Bridge	Staghorn Sculpin	230	Decopoda	4.073			
6/27/2000	RR Bridge	Cutthroat Trout	240	Chum smolt	2.279	77	mm	
6/27/2000	RR Bridge	Cutthroat Trout	225	Uni. Smolt	2.079			
6/27/2000	RR Bridge	Cutthroat Trout	225	Cottidae	0.082	18	mm	
6/27/2000	RR Bridge	Staghorn Sculpin	210	Uni. Smolt	1.336			
6/27/2000	RR Bridge	Staghorn Sculpin	210	Decopoda	0.048			
6/28/2000	Lower GG	Staghorn Sculpin	195	Sandlance	0.555	68	mm	
6/28/2000	Lower GG	Staghorn Sculpin	195	Decopoda	0.279			
6/28/2000	Lower GG	Staghorn Sculpin	195	Amphipoda	0.004			
6/28/2000	Lions Club	Cutthroat Trout	260	Chum smolt	0.349	73	mm	
6/28/2000	Lions Club	Cutthroat Trout	260	Chum smolt	0.295	76	mm	
6/28/2000	Lions Club	Cutthroat Trout	260	Chum smolt	0.289	68	mm	
6/28/2000	Lions Club	Cutthroat Trout	260	Chum smolt	0.221	50	mm	
6/28/2000	Lions Club	Cutthroat Trout	260	Chum smolt	1.154			
6/28/2000	Lions Club	Cutthroat Trout	260	Rocks & Sand	0.033			
6/29/2000	Lower Beach	Char	260	Uni. Smolt	0.091			
6/29/2000	Statue	Cutthroat Trout	248	Uni. Smolt	0.123			
6/29/2000	Statue	Cutthroat Trout	244	Uni. Smolt	1.059	98	mm	
6/29/2000	Statue	Cutthroat Trout	244	Rocks & Sand	0.043			
7/3/2000	Lower GG	2 Yr. Old Chinook	300	Sandlance	0.477			
7/3/2000	Lower GG	2 Yr. Old Chinook	300	Sandlance	0.089			
7/3/2000	Lower GG	2 Yr. Old Chinook	300	Sandlance	0.210			
7/3/2000	Lower GG	2 Yr. Old Chinook	317	Sandlance	1.625			3 Sandlance
7/3/2000	Lower GG	2 Yr. Old Chinook	317	Sandlance	10.198			26 Sandlance
7/3/2000	Lower GG	2 Yr. Old Chinook	285	Uni. Fish	0.106			
7/3/2000	Lower GG	2 Yr. Old Chinook	285	Decopoda	0.031			
7/3/2000	Mid GG	2 Yr. Old Chinook	311	Sandlance	0.493	65	mm	
7/3/2000	Mid GG	2 Yr. Old Chinook	311	Sandlance	0.493	65	mm	
7/3/2000	Mid GG	2 Yr. Old Chinook	311	Sandlance	0.449	62	mm	
7/3/2000	Mid GG	2 Yr. Old Chinook	311	Sandlance	0.069			
7/5/2000	Lower Beach	Staghorn Sculpin	130	Vegetation	0.064			
7/5/2000	Lower Beach	Staghorn Sculpin	130	Decopoda	0.058			
7/5/2000	Lower Beach	Staghorn Sculpin	130	Rocks & Sand	0.004			
7/6/2000	Pristine	2 Yr. Old Chinook	225	Sandlance	0.739	75	mm	
7/6/2000	Pristine	2 Yr. Old Chinook	225	Polychaeta	0.004			
7/6/2000	Lions Club	Cutthroat Trout	188	Sandlance	0.353	61	mm	
7/6/2000	Lions Club	Cutthroat Trout	188	Sandlance	0.292	55	mm	
7/6/2000	Lions Club	Cutthroat Trout	188	Sandlance	0.109	52	mm	

Appendix V. Continued.

7/6/2000	Lions Club	Cutthroat Trout	245	Sandlance	2.614			6 Sandlance
7/6/2000	Lions Club	Cutthroat Trout	245	Oligochaeta	0.023			
7/6/2000	Lions Club	Staghorn Sculpin	202	Stickleback	0.184			
7/6/2000	Lions Club	Staghorn Sculpin	202	Decopoda	0.029			
7/6/2000	Lions Club	Staghorn Sculpin	202	Rocks & Sand	0.005			
7/6/2000	Mid GG	Staghorn Sculpin	215	Rocks & Sand	0.768			
7/6/2000	Mid GG	Staghorn Sculpin	215	Uni. Invertebrate.	0.594			
7/6/2000	Mid GG	Staghorn Sculpin	192	Vegetation	0.372			
7/6/2000	Mid GG	Staghorn Sculpin	192	Decopoda	0.528			
7/6/2000	Mid GG	Staghorn Sculpin	192	Rocks & Sand	0.303			
7/6/2000	Mid GG	Staghorn Sculpin	165	Sandlance	0.224			
7/6/2000	Mid GG	Staghorn Sculpin	165	Uni. Invertebrate.	0.114			
7/6/2000	Mid GG	Staghorn Sculpin	152					trace
7/6/2000	Upper GG	Staghorn Sculpin	200	Decopoda	1.608			
7/6/2000	Upper GG	Staghorn Sculpin	170	Decopoda	1.231			
7/6/2000	Upper GG	Staghorn Sculpin	170	Rocks & Sand	0.350			
7/6/2000	Anthony's	Staghorn Sculpin	175	Decopoda	0.754			
7/6/2000	Anthony's	Staghorn Sculpin	185	Decopoda	0.487			
7/6/2000	Anthony's	Staghorn Sculpin	173	Sandlance	0.121			
7/6/2000	Anthony's	Staghorn Sculpin	173	Rocks & Sand	0.091			
7/6/2000	Anthony's	Staghorn Sculpin	170	Rocks & Sand	0.230			
7/6/2000	Anthony's	Staghorn Sculpin	170	Decopoda	1.763			
7/6/2000	Anthony's	Staghorn Sculpin	170	Uni. Invertebrate.	0.051			
9/18/2000	Upper Statue	Cutthroat Trout	245	Pacific herring	1.520	86	mm	
9/18/2000	Statue	Staghorn Sculpin	217	Uni. Fish	0.161			
9/18/2000	Statue	Staghorn Sculpin	217	Other	0.039			
9/18/2000	Statue	Staghorn Sculpin	217	Other	0.020			
9/20/2000	Statue	Cutthroat Trout	305	Pacific herring	6.397	101	mm	
9/20/2000	Statue	Cutthroat Trout	305	Pacific herring	3.623	95	mm	
9/20/2000	Statue	Cutthroat Trout	305	Pacific herring	2.396			
9/25/2000	Anthony's	Staghorn Sculpin	253	Decopoda	37.869			