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Washington Department of FISH AND WILDLIFE

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Executive Summary

In 2001 and 2002, we studied the distribution, abundance, size, and trophic relationships of juvenile salmonids in the marine nearshore environment of Sinclair Inlet, Washington. This study was initiated to increase our understanding of how salmonids use shoreline environments in Puget Sound and how shoreline development may impact these species, information that is needed to help management agencies develop effective recovery strategies now required under the Endangered Species Act.

We focused our study on sub-yearling juvenile Chinook salmon (*Oncorhynchus tshawytscha*) because this species has been listed within Puget Sound as Threatened under the Endangered Species Act, and represents an important local economic, recreational and cultural resource. In 2001 and 2002, we conducted studies to increase our understanding of the use of nearshore habitat and food resources by juvenile salmonids in Sinclair Inlet, a narrow embayment located in central Puget Sound bordering Bremerton, Washington. Specific objectives of this study were to:

- Assess the spatial and temporal use of littoral (nearshore, shallow water) habitats by juvenile Chinook salmon and other juvenile salmonids during the time these fish occur in the Inlet;

- Assess the use of offshore (i.e., non-littoral) habitats by juvenile Chinook salmon;

- Determine how long cohorts of hatchery-produced juvenile Chinook salmon reside in Sinclair Inlet; and

- Examine aspects of the trophic ecology of juvenile Chinook in Sinclair Inlet by evaluating their diets and the diets of potential predators and competitors.

For purposes of this study, juvenile Chinook salmon were considered to be of hatchery origin if they had an identifying mark (clipped adipose fin, unclipped fish with coded wire tags (CWTs) and other identifying external marks). Juvenile Chinook salmon were classified as originating from natural production (i.e., "wild") if they had no identifying marks. Because not all hatchery juvenile Chinook salmon were distinctly marked in 2001 and 2002, the number of hatchery-produced fish obtained in our samples was underestimated.

In both 2001 and 2002, juvenile salmonids and other fishes occurring in littoral habitats of Sinclair Inlet were collected using beach seines. In both years, twenty-one sites were sampled throughout the three study areas to track spatial and temporal patterns of fish distribution in regular beach seine surveys (RBS) from February through September. Most of our analyses were based on a limited number of regularly sampled sites; eight in 2001 and thirteen in 2002. Both day and night sampling was conducted under various tidal conditions. In 2002, we conducted additional beach seining to recapture florescent pigment marked juvenile Chinook salmon in order to estimate their residence time in Sinclair Inlet. This sampling was referred to as Mark Recapture (MR) sampling. Catches of fish by beach seine were reported as numbers of fish in a beach seine haul, and represented as catch per unit of effort (CPUE).

A tow net (or two boat surface trawl) was used to sample the upper 3m of the water column of study sites within Sinclair Inlet in 2002 only. Tow net samples were collected monthly from May to August 2002 during day and night hours along both shorelines and offshore. Inshore tows generally followed the 5 m contour line while offshore tows were made in the deepest sections, which were generally 10 m or deeper. Tow net data is reported as catch per 10-minute tow (CPUE).

Juvenile chum salmon (*Oncorhynchus keta*) and several species of forage fish (Pacific herring- *Clupea harengus pallasi*, Pacific sandlance- *Ammodytes hexapterus*, and surf smelt- *Hypomesus pretiosus*) were present from March through the completion of sampling in September in both years. Few juvenile coho salmon (*Oncorhynchus kisutch*) were caught in either year. We did not capture pink (*Oncorhynchus gorbuscha*) or sockeye salmon (*Oncorhynchus nerka*). We observed no temporal pattern in the occurrence of forage fish. Juvenile chum catches peaked in littoral areas in April and May and in offshore areas in May and June (note that offshore areas were not sampled in April so the two data sets are not directly comparable). There was a steady increase in size of juvenile chum salmon from February through the end of sampling (September) indicating that juvenile chum salmon were rearing in Sinclair Inlet.

No bull trout (*Salvelinus confluentus)* were caught in either year. However, bull trout may have been present but not susceptible to our sampling methods.

A major source of both naturally produced and hatchery Chinook salmon in the study area was Gorst Creek, at the terminus of Sinclair Inlet. In addition, juvenile Chinook salmon originated from a large number of sources outside the study area.

In general, about 10% of the juvenile Chinook salmon collected each year and in each habitat type (i.e. offshore and littoral) were unmarked subyearlings and possibly the progeny of naturally spawning fish (“wild”). There was little difference in patterns of distribution, abundance, and size of hatchery origin and “wild” fish, suggesting: 1) hatchery and wild fish behave similarly, or 2) most of what we were calling “wild” fish were actually unmarked hatchery fish. The presence of juvenile Chinook salmon < 50 mm FL (these are too small to be hatchery fish) in 2001 suggests that natural production is occasionally successful in the area. In 2002, juvenile Chinook salmon were not caught in the beach seine or in the tow net until after the hatchery releases into Gorst

Creek began in late May. Juvenile Chinook salmon were caught in littoral areas of Sinclair Inlet from April to September, 2001 and May to September 2002. Chinook salmon were present on the last date of sampling in September each year. Peak catches in littoral and surface waters occurred in early summer (June-July) for both years. The size of juvenile Chinook salmon increased from June until September in both habitat types.

Abundance and size of fish can be a function of conditions under which samples are collected (e.g., tide, amount of floating vegetation, and time of day) as well as characteristics of the habitat at the collection site. Further, some of these variables may interact. In littoral habitats, there was not a clear effect of tide or time of day on CPUE of either wild or hatchery origin juvenile Chinook salmon. The size of juvenile Chinook salmon varied with time of collection (daytime vs. nighttime) of both hatchery and "wild" origin in littoral (inshore) and neritic (offshore) habitats. In general, we captured larger fish during nocturnal sampling efforts, which may reflect avoidance of sampling gear during daylight hours. Alternatively, larger juvenile Chinook salmon may occupy deeper habitats during the day and move into the range of our sampling gears at night. However, differences in size and abundance of juvenile Chinook with respect to tidal stage or daytime/nighttime were not consistent and therefore, we did not separate these data in our analyses.

Habitat characteristics along Sinclair Inlet shorelines were assessed qualitatively for a variety of habitat factors including Area of capture (as defined in the study by three east-west regions in the inlet), north or south shoreline, type of substrate, amount of upland and submersed vegetation, shoreline modification, and slope. We evaluated the effect of the habitat characteristics on both CPUE and size of juvenile Chinook salmon. Of these variables, only Area of capture had a clear effect on abundance of juvenile Chinook salmon in littoral habitats. Highest abundances were found in the area closest to the terminus of Sinclair Inlet and generally declined with increasing distance from Gorst Creek. However, fish abundance was not significantly different in surface waters of the three areas of capture during tow net sampling. Area of capture also appeared to correlate with size of fish in each habitat type with larger fish generally occurring in the eastern end of the inlet (Area 3) compared to the other two areas. We could not detect an effect of any other habitat factor on size or abundance. There are several plausible explanations for these results. First, habitat factors may not influence fish abundance substantially at the site scale. At larger spatial scales (e.g., area of capture), our observations suggest that habitat is an important determinant is segregating chinook salmon life history stages. Second, our approach to measuring habitat may have been insufficient since we simply assessed habitat qualitatively. Third, other factors that we did not measure may have had an effect on where fish were found.

We marked and released juvenile Chinook salmon with three colors of fluorescent pigment and CWTs into Gorst Creek to estimate residence time in Sinclair Inlet. We developed an approach to mark juvenile Chinook salmon using various colors of fluorescent pigment that allowed us to follow cohorts of Chinook salmon during their migration through Sinclair Inlet. Residence time estimates were made for six groups of fish released into Gorst Creek using beach seine sampling in littoral zone habitats. Mean residence time (average of separate estimates of the six marked groups) in Area 1 (west end of inlet) and Area 2 (middle section of inlet) was 6.2 days and 8.3 days, respectively. The estimated maximum residence time for any group released into Sinclair Inlet was 59 days.

Juvenile Chinook salmon with CWTs recovered from Sinclair Inlet in 2002 originated from 14 different watersheds and from as far away as the Fraser River in Canada. A total of 77% of the total recoveries originated from the Gorst Creek hatchery. Fish released into the Green River were recovered in Sinclair Inlet within 11 days of release, while fish released at Grovers Creek (approximately 25 km swimming distance) were recovered within 48 hours of their release. We found that Gorst Creek hatchery fish comprised nearly 100% of the CWT recoveries until mid-summer, dropping to only 40% of the total recoveries after mid-summer through early fall. This is consistent with residence time estimates, suggesting that fish from Gorst Creek migrate rapidly through Sinclair Inlet and are subsequently replaced by non-natal fish. We believe it is reasonable to assume that because hatchery fish from outside of Sinclair Inlet migrate into the area, wild (i.e. naturally spawning) fish also exhibit similar behavior.

The diet of juvenile Chinook salmon in both years was similar with individual fish tending to eat a small number of relatively large prey. There was not evidence of consistent differences in diet of hatchery origin and wild juvenile Chinook salmon. In general, juvenile Chinook salmon appear to be primarily surface and mid water feeders while juvenile chum salmon were foraging primarily in mid waters to the bottom. The dominant prey of juvenile Chinook salmon in both years and in both habitat types (littoral versus neritic) consisted of a diverse mixture of aquatic and terrestrial insects, decapod crustaceans, amphipods, polychaetes, and barnacle larvae. Most decapods were either pinnotherid or porecellanid crab zoea. Crab zoea and other planktonic prey were generally more prevalent in diets in June and early July whereas polychaetes were more important in diets in late July and August. At least fifty insect families were identified in the stomach contents of juvenile salmon. We also noted that the type of insects consumed varied with time. While the origin of any prey and where it was consumed cannot be precisely determined in many cases, it is noteworthy that many of the insects that were eaten came from terrestrial sources and it is likely they were eaten off the surface of the water.

We inventoried intertidal habitat along the southern shoreline of the western portion of the inlet and both the northern and southern shoreline in the eastern portion of the inlet. The remaining shoreline is highly impacted by rock riprap and has limited intertidal habitat. Estimates based on aerial photographs indicate shoreline armoring along this unsurveyed shoreline at nearly 100%. Of the 10 km shoreline surveyed in the field, shoreline armoring was present along 78% of the shorline. We estimate that 91% of the entire 26 km of shoreline had armoring or was modified from natural conditions.

The findings of this study indicate that Sinclair Inlet is used by three major groups of juvenile Chinook salmon.

- The first group consists of hatchery origin fish released into Gorst Creek, typically in late May through the end of June. The fish disperse throughout the Inlet (appearing to use both inshore and offshore habitats), with most of the fish rapidly leaving the Inlet.

- Second, hatchery fish from sources outside the Inlet migrate into Sinclair Inlet. This group is present from July to September. Some of these fish may reside for an extended period of time in Sinclair Inlet, although we were unable to determine this from our data.

- Third, wild juvenile Chinook salmon use the Inlet. These fish could be naturally spawning fish from Gorst Creek or nearby local systems, or move into the Inlet from other river systems similar to hatchery fish. The only way to identify wild fish was by a lack of marks or tags identifying them as hatchery fish. It is possible that unmarked fish are of hatchery origin. We did not detect different patterns of distribution, growth patterns, or diet composition between hatchery and "wild" Chinook. However, this may be due to the unmarked hatchery component of the "wild" group or the low numbers captured of "wild" fish overall. Alternatively, the two groups may behave similarly during their early life history in Sinclair Inlet.

The focus of these studies was on juvenile Chinook salmon, especially subyearling fish, because they are classified as Threatened under the Endangered Species Act. Juvenile Chinook salmon are present in Sinclair Inlet littoral habitats from early spring through early fall, at a minimum. Clearly, Sinclair Inlet shorelines are host to juvenile Chinook salmon from throughout the Puget Sound during late spring and summer months, and likely include both hatchery origin and natural origin. Therefore, proper management of nearshore habitats is important not only for local origin fish, but also for those that originate from a considerable distance.

I. Introduction

During their passage from freshwater spawning and rearing habitats to ocean feeding grounds, juvenile Pacific salmon (*Oncorhynchus* spp.) use a system of estuarine and shoreline habitats (Stober and Salo 1973; Healey 1979, 1980, 1982; Salo et al. 1980; Simenstad et al. 1982; MacDonald et al. 1988; Levings et al 1991; Duffy 2003; Brennan et al. 2004). We refer to this system of estuarine and shoreline habitats as the *nearshore*. In general, the functions of nearshore habitats are to provide juvenile salmonids with abundant prey resources that sustain high growth rates; provide a shallow water refuge from some predation; provide a physiological transition zone from freshwater to fully saline, oceanic waters; and to serve as a migration route toward marine rearing areas (Healey 1982; Simenstad et al. 1982). The importance of each of these functions varies between and within salmon species. One attribute that has an important influence on use of nearshore habitats is size; smaller fish (regardless of species) are generally associated with nearshore habitats for longer periods than larger fish (Healey 1982; Simenstad et al. 1982; Bottom et al. 2005; Fresh et al. 2005)

The transition between freshwater spawning and rearing areas and oceanic foraging habitats is a critical period for many salmon populations, as conditions occurring during this period of life can significantly affect overall survival rates and subsequent numbers of returning adults (Peterman 1978; Healey 1979, 1980; Bax 1983; Nickelson 1986; Mortensen et al. 2000; Magnusson and Hilborn 2004). The survival and growth of juvenile salmon during their passage through nearshore areas is directly or indirectly affected by a variety of biotic and abiotic factors, including predation, climate, salmon hatchery practices, cycling of organic matter in food webs, upwelling, amount of freshwater inflow from coastal rivers, and currents (Nickelson 1986; Arkoosh et al. 1998; Mortenson et al. 2000). For example, temperature is strongly related to growth rates of juvenile pink salmon (*O. gorbuscha*), which is correlated with marine survival rates (Mortensen et al. 2000).

Of particular concern within the urbanizing Puget Sound basin are the effects of human alterations of nearshore ecosystems on salmon populations. As the human population of the region has expanded, significant loss, modification and degradation of nearshore ecosystems has occurred (Haas and Collins 2001; PSWQAT 2002). For example, much of the intertidal salt marsh habitat in Puget Sound has been lost due to diking, dredging, filling, and armoring of shorelines; in several estuaries (the Duwamish and Puyallup estuaries), nearly all of the marsh habitats have been lost (Bortelson et al. 1978). A recent survey by the Washington Department of Natural Resources found that approximately one third of the shoreline of Puget Sound is now modified by some form of human development, including shoreline armoring, placement of overwater structures, dredging, or filling (PSWQAT 2002).

In general, little is known about how human alterations of nearshore habitats affects the survival and growth of juvenile salmonids. This lack of knowledge about the impacts of human development hinders our ability to manage salmon and their habitats throughout Puget Sound. For example, without knowing when juvenile salmon are found in a particular area, it is difficult to establish time periods for marine construction activities that minimize risk of impacts to salmon juveniles. In addition, in order to develop effective protection and restoration strategies it is necessary to know what habitats juvenile salmon use, when they use these habitats, where they are located, and how long they use them (e.g., residence time).

Of particular importance to management agencies is how the nearshore ecosystems of Puget Sound are used by the species that have been formally listed as threatened or endangered under the Endangered Species Act. Within Puget Sound, this includes all 22 populations of Chinook salmon (*O. tshawytscha*) (Myers et al. 1998) and the eight populations of chum salmon (*O. keta*) that spawn during the summer and early fall in Hood Canal and the eastern Strait of Juan de Fuca. Knowledge of how these species use the shoreline environments of Puget Sound and how shoreline development may impact them is needed to help management agencies develop effective recovery strategies.

Sinclair Inlet, a large, partially enclosed embayment, is one area of Puget Sound that has been significantly modified by humans. Loss and alteration of shallow water habitats, degradation of sediment quality, degradation of water quality, and loss of riparian vegetation along the shoreline are some of the impacts to the nearshore ecosystems in Sinclair Inlet that have occurred. Much of the changes in the area have been associated with road construction along the shoreline of the Inlet, the development of the Naval Base Kitsap - Bremerton and Puget Sound Naval Shipyard and Intermediate Maintenance Facility (Shipyard), and the commercial and residential development associated with the cities and ports of Bremerton and Port Orchard.

Few studies of fish use in Sinclair Inlet, including use by juvenile salmonids, have been conducted (Wildermuth 1993, Penttila 2000). In 2001 and 2002, studies were conducted to increase our understanding of the use of Sinclair Inlet by juvenile salmonids and other selected species. The focus of these studies was on Chinook salmon and bull trout (*Salvelinus confluentus)* because of their ESA listed status, although information is provided on use of the Inlet by coho salmon (*O. kisutch*), chum salmon, cutthroat trout (*O. clarki*) and several species of forage fish (Pacific herring- *Clupea harengus pallasi*, Pacific sandlance- *Ammodytes hexapterus*, and surf smelt- *Hypomesus pretiosus*). This report presents the results of studies conducted in both 2001 and 2002.

Pilot studies were conducted in 2001 to help guide and develop studies planned for subsequent years. These pilot studies focused on: identifying sizes and species of juvenile salmon that were present; where, when, and how to sample salmon in littoral areas; determining the types and amounts of different types of littoral habitats; and assessing how important littoral habitats might be to juvenile salmon using the Sinclair Inlet area.

In 2002, we expanded the scope and scale of ecological studies of juvenile Chinook salmon in Sinclair Inlet to include four major objectives. The first was to assess the spatial and temporal use of littoral habitats by juvenile Chinook throughout the time these fish occur in the Inlet. We focused on the littoral zone because this is an area that we know is used by juvenile Chinook salmon, is a focal point of habitat protection, and has been heavily modified by humans. It is also an area that has been targeted for protection and restoration actions to benefit juvenile salmon.

Our second objective was to assess the use of offshore (i.e., non-littoral) habitats by juvenile Chinook salmon. The third objective was to determine how long cohorts of juvenile Chinook salmon were present in Sinclair Inlet. Our evaluation of residence time included the use of hatchery fish because there were insufficient numbers of naturally produced Chinook salmon in Sinclair Inlet to use in this study. Clearly, a key assumption in using hatchery fish to study residence time is that their behavior is similar to wild fish.

The final objective was to examine aspects of the trophic ecology of juvenile Chinook salmon in Sinclair Inlet by evaluating diets of naturally produced juvenile Chinook salmon and some of their potential predators and competitors. We included natural and hatchery produced juvenile Chinook salmon, chum salmon, coho salmon and cutthroat trout in the diet studies.

II. Description of Study Area

All sampling occurred within Sinclair Inlet, a narrow embayment located in Central Puget Sound on the eastern shore of the Kitsap Peninsula. Our sampling area boundaries were the southwest portion of Port Orchard at the bridge to East Bremerton, the western entrance of Rich Passage and the southwest tip of Bainbridge Island (Figure 1). Within this region, we defined three sampling areas. Area 1 extends from the western limit of Sinclair Inlet to a line running from Ross Creek to the outlet of the Sewage Treatment Plant (Figure 2) and covers an area of 335.4 hectares. The north shore of Area 1 is 4.50 km in length and mostly comprised of steeply sloping riprap protecting historic filled shoreline. Little upper beach remains along most of this shoreline. The south shore of Area 1 is 4.80 km in length, is also mostly armored in the upper intertidal, and consists of a mix of residential, light commercial (e.g., marinas), and roads with few undeveloped portions. Much of the south shore of Area 1 has low gradient, mud/sand beaches below the armored areas, especially in the extreme western end. The deepest portion of Area 1 is about 7 m at mean lower low water (MLLW).

Area 2 extends from the eastern boundary of Area 1 to a line from the Annapolis Dock to the east end of the PSNS/NSB. Area 2 covers an area of 508.3 hectares. The north shore including the railway and PSNS/NSB is steeply sloping, armored with riprap, contains only a limited amount of shallow subtidal and intertidal habitat, and is 3.51 km in length. Land use along the 3.47 km south shore is dominated by commercial development in the City of Port Orchard, including several large marinas and some residential development. Shallow subtidal and intertidal habitat is more extensive along the south shore. Offshore depth in Area 2 extends to 15 m MLLW and is maintained by periodic dredging.

Area 3 encompasses 886.8 hectares and consists of the remainder of the study region extending east and north of Area 2. The north shore of Area 3 is 3.90 km long and consists of heavy commercial development associated with the City of Bremerton, the ferry dock and dense residential shoreline development on Pt. Herron. Steep, largely undeveloped bluffs extend northwest of Pt. Herron. Land use along the south shore is primarily light residential with bulkheads along many of the properties, although several undeveloped portions of the 6.21 km shoreline remain. Intertidal areas along both shorelines in Area 3 are extensive and primarily sand/small gravel. Offshore areas exceed 25 m in depth and are deeper in the eastern end of the Area.

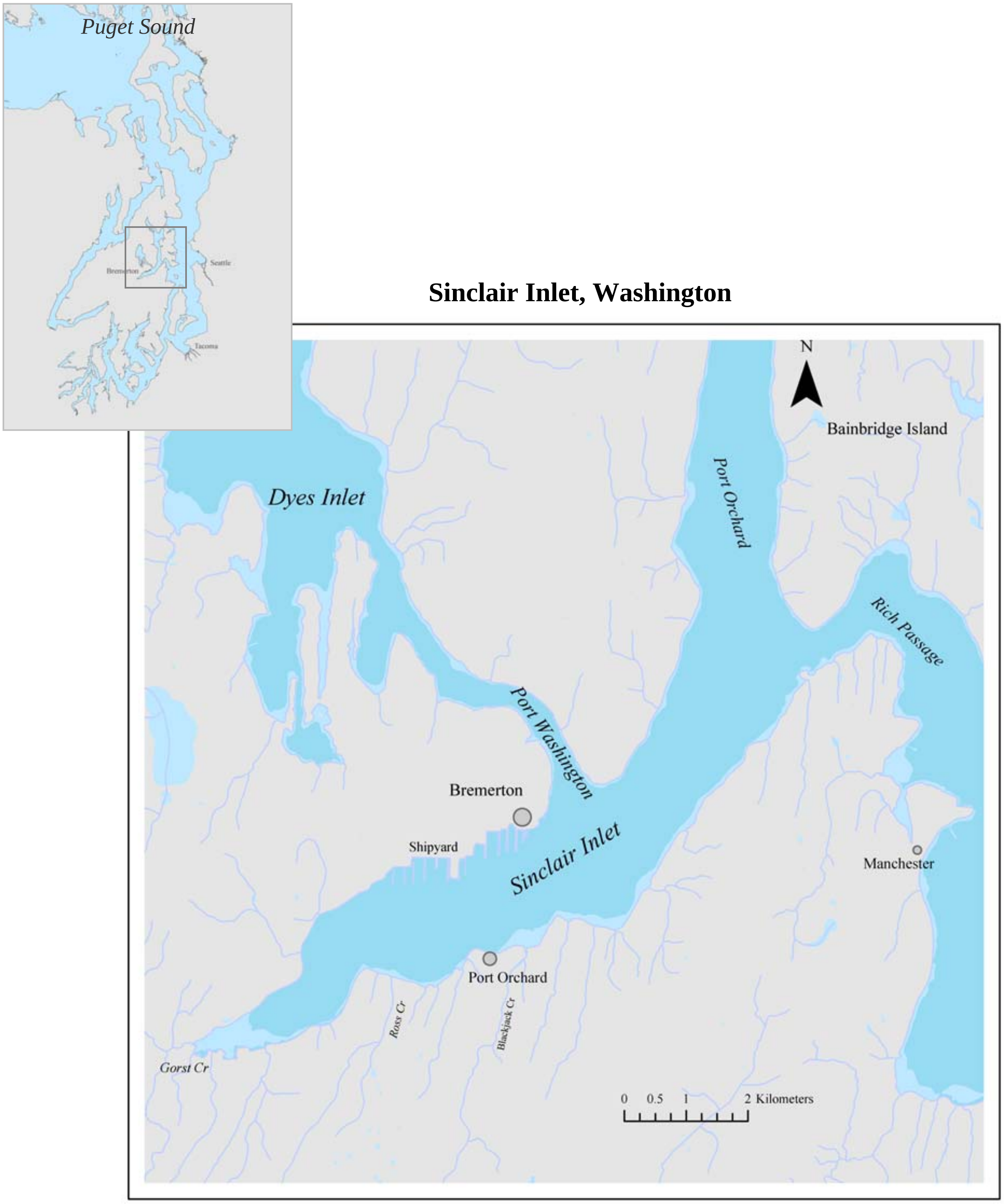


Figure 1. Study location of Sinclair Inlet, Washington, an embayment in central Puget Sound.

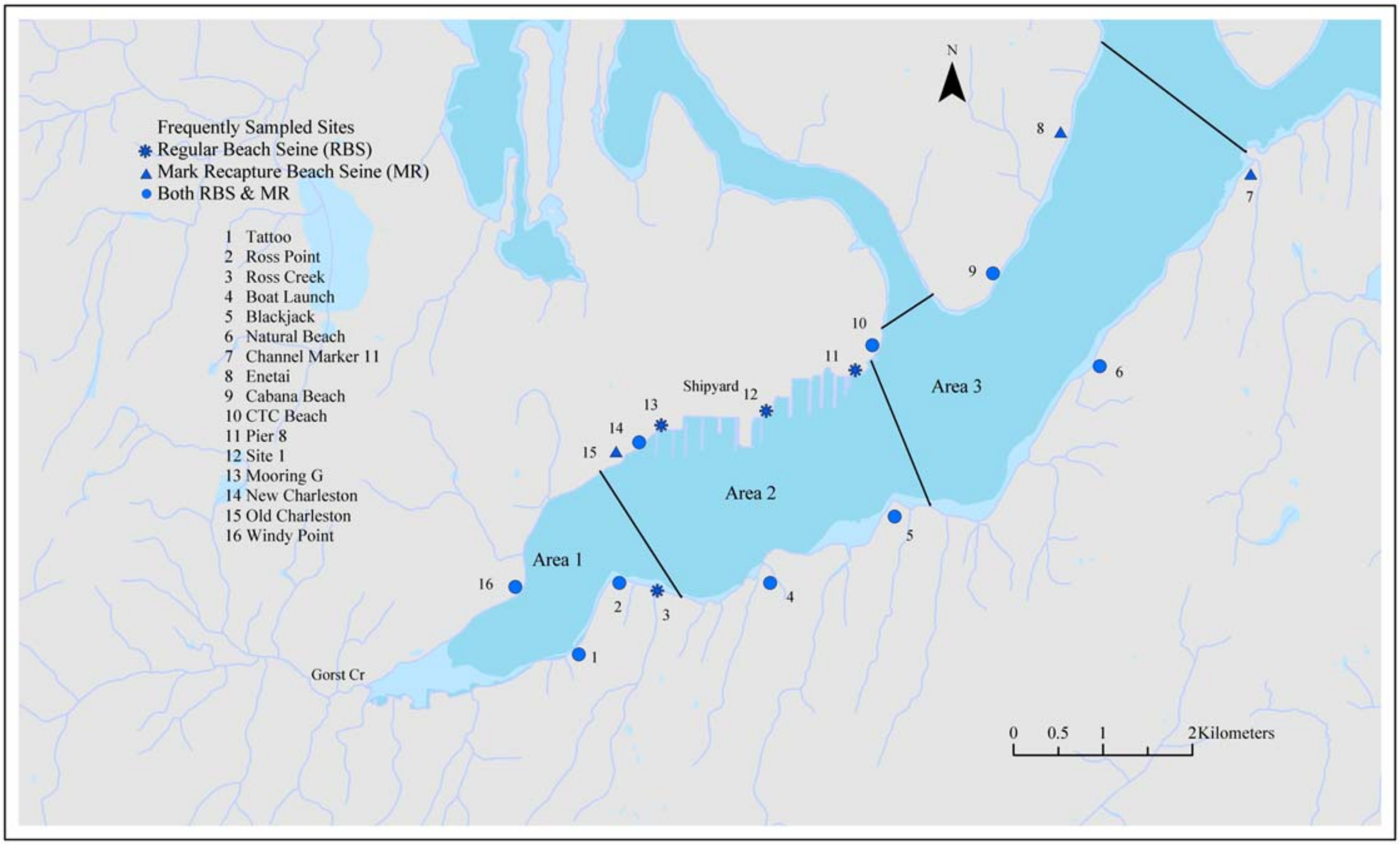


Figure 2. Locations of frequently sampled sites for regular beach seines (RBS) and mark recapture (MR) beach seines in Sinclair Inlet.

III. Methods

III. A. Sources of Wild and Hatchery Salmon using Sinclair Inlet

Juvenile salmonids that use Sinclair Inlet can potentially be naturally produced or hatchery produced and can originate from local streams or from distant locations such as the large rivers draining the west slopes of the Cascades Mountains. The following briefly describes some of the potential sources of salmonids that use Sinclair Inlet.

III. A. 1. Naturally spawning salmonids in Sinclair Inlet

Numerous streams drain the Kitsap Peninsula that are relatively small in size (drainages under 4,500 hectares) and are typical of lowland streams found throughout the Puget Sound Basin. In general, these streams can be very productive, supporting chum and coho salmon, as well as some steelhead trout (*O. mykiss*) and cutthroat trout.

While independent populations of Chinook salmon have not been identified in East Kitsap Peninsula streams, Chinook salmon spawn in low numbers in some of the larger streams, including Gorst Creek and Blackjack Creek, which are tributaries to Sinclair Inlet. Chinook salmon spawning in Gorst Creek has increased in recent years, due in part to a reduction in the terminal fishing effort in the area. Most of these fish are believed to be returns from hatchery Chinook salmon released from the Gorst Creek rearing ponds (Jay Zischke, Suquamish Tribe, personal communication). An escapement of over 17,000 Chinook salmon to the Inlet (fishery harvests plus stream escapement) in 2002 was the largest on record, with over 10,000 adult Chinook salmon in Gorst Creek. Returns to the stream in the previous three years averaged about 2,400 adult Chinook salmon. An outmigrant trap recently installed at rkm (River Kilometer) 1.4 on Gorst Creek (upstream of the hatchery) captured 1,352 juvenile Chinook salmon in 2001 and 324 juvenile Chinook salmon in 2002 (Jay Zischke, Suquamish Tribe, unpublished data).

Coho salmon occur in most Kitsap Peninsula streams. Sinclair Inlet streams known to support coho salmon include Gorst Creek, Blackjack Creek, Ross Creek, Anderson Creek and numerous other small creeks. Coho salmon escapement to Area 10E (a state-tribal fishery management designation used for the waters of East Kitsap) was approximately 1,700 in 1999 and 13,600 in 2000. Based on freshwater habitat availability, approximately 30% of these coho are thought to return to Sinclair Inlet (Jay Zischke, Suquamish Tribe, personal communication). Escapement to Area 10E (East Kitsap) from 1990 – 1999 averaged 2,414 coho salmon (Chuck Baranski, WDFW, unpublished data). The Gorst Creek outmigrant trap captured 2,033 coho salmon smolts in 2001 and 1,165 in 2002 (Jay Zischke, Suquamish Tribe, unpublished data). Most coho salmon spawn upstream of the trap.

Chum salmon spawn in the lower reaches of most Kitsap Peninsula streams. In Sinclair Inlet, chum salmon are known to spawn in Blackjack Creek (normal-timing and summer run), Ross Creek, Anderson Creek, and Gorst Creek (late-fall timing). Dyes Inlet, particularly Chico Creek, has significant chum runs that typically make up 50-70% of the chum salmon escapement to Area 10E (Jay Zischke, Suquamish Tribe, personal communication). Total chum salmon escapements in Area 10E streams were 7,897 chum salmon in 2000 and 57,262 chum salmon in 2001. Average escapements for 1990 – 1999 were 63,100 for even years and 37,700 for odd years. In 1998, over 130,000 chum salmon returned to East Kitsap streams (Area 10E, Chuck Baranski, WDFW, unpublished data). Chum salmon fry were also captured in the Gorst Creek outmigrant trap, but most of the chum spawning occurs downstream of the trap.

III. A. 2. Hatchery sources of salmonids in Sinclair Inlet

Chinook, coho and chum salmon are released from hatcheries or rearing facilities throughout Puget Sound (Table 1, Appendix A). Local sources of hatchery Chinook salmon include Gorst Creek, Grovers Creek near Suquamish, rearing ponds on local streams (e.g., Clear Creek and Dogfish Creek) and large releases from Green River hatcheries. The Gorst Creek rearing ponds released over one million juvenile Chinook salmon in 2001 and over two million in 2002. The Grovers Creek Hatchery released over 450,000 juvenile Chinook salmon in 2001 and 670,000 in 2002. Puget Sound hatcheries released over 40 million subyearling and over 2 million yearling juvenile Chinook salmon into Puget Sound in the same years (Appendix A).

Coho salmon are infrequently planted into local streams as fry, although Sinclair Inlet and Dyes Inlet tributaries were not planted in 2000 or 2001. Yearling coho salmon are released from Agate Pass net pens directly into saltwater: 199,400 and 322,700 yearling coho salmon in 2001 and 2002, respectively. As with Chinook salmon, millions of juvenile coho salmon are released into Puget Sound from hatcheries outside the area (Appendix A).

Chum salmon populations in the area are supplemented with fish from the Cowling Creek Hatchery in North Kitsap. This facility releases over one million chum salmon juveniles into Puget Sound each year from egg boxes. No egg boxes were operated in Sinclair Inlet streams during 2001 or 2002. About 300,000 chum fry were released into Dyes Inlet streams in 2002. Puget Sound hatcheries released over 27 million chum salmon in 2001 and 55 million in 2002.

Table 1. Hatchery Chinook salmon released within 50 km swimming distance of Sinclair Inlet in 2001 and 2002 (in thousands). Release data are available at the Regional Mark Processing Center of the Pacific States Marine Fisheries Commission website (www.rmis.org).

	CWT tag		no CWT tag			Percent	
	ad clip	unclip	ad clip	unclip	Total	Unmarked*	Release dates
Subyearlings released in 2001							
Gorst Cr rearing ponds	0	0	1275	13	1288	1.0%	5/03 -6/07/01
Grovers Cr Hatchery	204	209	25	14	452	3.1%	5/11/01
Dogfish Cr (Liberty Bay)	0	0	0	160	160	100%	3/25 - 4/27/01
Clear Cr (Dyes Inlet)	0	0	0	55	55	100%	4/27 - 4/30/01
Soos Creek Hatchery	194	206	2945	50	3395	1.5%	5/18 - 6/11/01
Keta Creek (Duwamish R)	0	0	538	50	588	9%	3/20 - 3/27/02
Total release within 50 km	*398*	*415*	*4783*	*342*	*5938*	***5.8%***	
Yearlings released in 2001							
Gorst Cr rearing ponds	0	0	110	0	110	0%	3/12-3/26/01
Icy Cr (Duwamish R)	0	0	241	0	241	0%	5/01 - 5/04/01
Total release within 50 km	*0*	*0*	*351*	*0*	*351*	***0%***	
Subyearlings released in 2002							
Gorst Cr rearing ponds	265	0	1909	92	2266	4.1%	5/19 - 6/20/02
Grovers Cr Hatchery	204	205	260	3	672	0.4%	5/20 - 5/29/02
Dogfish Cr (Liberty Bay)	0	0	146	2	148	1.4%	5/25/02
Clear Cr (Dyes Inlet)	0	0	25	25	50	50%	5/11 - 5/17/02
Soos Creek Hatchery	178	162	3143	18	3501	0.5%	5/23 - 6/07/02
Keta Creek (Duwamish R)	0	0	503	0	503	0%	3/20 - 3/27/02
Total release within 50 km	*647*	*367*	*5986*	*140*	*7140*	***2%***	
Yearlings released in 2002							
Gorst Cr rearing ponds	0	0	106	0	106	0%	3/11 - 3/19/02
Icy Cr (Duwamish R)	0	0	309	0	309	0%	5/21/02
Total release within 50 km	*0*	*0*	*415*	*0*	*415*	***0%***	

* Percent "unmarked" fish refers to the percentage of the total number of hatchery origin salmon that were released without a coded wire tag (CWT) or a clipped adipose fin. "Ad clip" refers to fish marked by removal of the adipose fin.

III. B. Sampling Littoral Zone Habitats

III. B.1. Regular beach seines (RBS)

In both 2001 and 2002, juvenile salmonids and other fishes were regularly collected from the littoral habitats of Sinclair Inlet with a floating beach seine. These collections are referred to in this report as regular beach seining (RBS). Additional beach seine collections were focused on recovery of marked Chinook salmon and are described in section III.B. 2.

The beach seine used was 36 m long and ranged from a width of 2 m in the wings to 3.1 m at the bag. Mesh sizes were 3 cm in the wings and 3.2 mm knotless nylon in the bag. Floats arrayed along the cork line kept the net from sinking. The net was set about 33 m from and parallel to shore using a 6 m boat with outboard motor. A line attached to each end of the net was used to pull the net to shore. Crew hauling from each side brought in the net at the same pace and, when the net was about 10 m from shore, the two ends were pursed together to force fish into the bag. Under ideal conditions, the net sampled an area of about 1,200 m^2; actual area and volume sampled was variable and depended upon the slope of the beach, the depth of water, where the net was set, boat wakes, and tides. All beach seine catch data is reported as catch in a seine haul (catch per-unit-effort= CPUE; unit of effort is a seine haul). Mean or average CPUE was calculated as the total number of fish caught in a space/time strata (e.g., all sites in Area 1 for one month) divided by the number of sets occurring in that strata.

All captured salmonids were removed from the catch as quickly as possible. All non-salmonids were counted and released, although some specimens that were considered to be potential salmonid predators or competitors were occasionally preserved for subsequent stomach analysis. Large catches of juvenile Chinook salmon were subsampled to limit the total number of processed fish to between 100 and 200 fish. All retained Chinook salmon were then anesthetized using MS-222, measured for fork length, checked for the presence of an adipose fin and then released; in 2002, the fish were also examined for the presence of a coded-wire tag (CWT) and fluorescent pigment. When available, the stomach contents of five specimens in each of five size categories (<50mm, 51mm-75mm, 76mm-100mm, 101mm-150mm, >150mm) were obtained for both hatchery (clipped adipose fin and/or CWT) and "wild" (unclipped and no CWT) Chinook salmon using gastric lavage. Stomach contents were preserved in formalin for later analysis. Chinook salmon juveniles that contained a CWT were preserved for later extraction of the tag, except for those that were also marked with fluorescent pigment, which were processed and released. When catches were sufficiently large, we sub-sampled the CWT portion of the catch.

Cutthroat trout captured in the beach seine were anesthetized, measured, and released. Juvenile coho salmon were separated into those that were adipose clipped and unclipped, anesthetized, checked for a CWT, measured, and released. Coho salmon that contained a CWT were preserved. The stomach contents of some coho salmon and cutthroat trout were also obtained using gastric lavage. Juvenile chum salmon were anesthetized, measured, and up to 11 were preserved in formalin for later stomach analysis; the remainder were counted and released.

In 2001 and 2002, littoral zone fish were sampled at least once at 24 sites in the three study areas (Figure 2). However, only a limited number of these sites were sampled consistently (Table 2, Appendix B). These sites were selected because they could be sampled consistently (e.g., under variable tidal conditions), represented the major habitat conditions that occurred in each area, and provided broad spatial coverage of Sinclair Inlet.

In 2001, sampling began in April and continued, after missing May, approximately monthly from June through early October, while in 2002, collections were made approximately every three weeks from mid-February through early September. During both years, samples were collected during daytime and nighttime. Because of logistical constraints, we were unable to standardize sampling according to tidal conditions (e.g., always sample sites on an ebb or flood tide). The number of sites sampled and the number of times they could be sampled depended upon a number of factors, including tidal conditions and the relative amount of day and night. Some sites had enough available beach that they could be sampled with beach seines under any tidal conditions while others could only be sampled at a particular tidal range. Other factors that affected our ability to seine any site included weather, amount of macroalgae that was present, and magnitude of catches (large catches took longer to process). For example, large amounts of mud and sea lettuce (*Ulva* spp.) precluded extensive sampling in the extreme west end of the Inlet. In general, we usually sampled sites from west to east.

Table 2. Summary of all sites sampled during regular beach seine (RBS) and mark recapture (MR) sampling in 2001 and 2002. Frequently sampled sites were used for data analysis.

			All Sampled Sites			Frequently Sampled Sites		
Location	**Area**	**Shoreline**	**RBS (2001)**	**RBS (2002)**	**MR (2002)**	**RBS (2001)**	**RBS (2002)**	**MR (2002)**
Blackjack	2	south	X	X	X	X	X	X
Boat launch	2	south		X	X		X	X
Cabana Beach	3	north	X	X	X	X	X	X
Channel Marker #11	3	south	X	X	X			X
CTC Beach	3	north	X	X	X	X	X	X
Enetai Beach	3	north	X	X	X			X
Evergreen Beach	1	south	X					
Monkey Tree	1	south	X					
Mooring G	2	north	X	X			X	
Natural Beach	3	south	X	X	X	X	X	X
New Charleston	2	north		X	X		X	X
Nursery Beach	1	south		X				
Old Charleston	2	north	X		X	X		X
Overpass Culvert	1	north	X					
Pier 8	2	north	X	X			X	
Quarry Beach	1	north	X					
Rockpile Beach	3	south	X	X				
Ross Creek	2	south	X	X			X	
Ross Point	1	south	X	X	X	X	X	X
RR/Kitsap Muffler	1	north	X					
SE Channel Mk #11	3	south	X					
Site 1	2	north	X	X			X	
Tattoo Beach	1	south	X	X	X	X	X	X
Windy Point	1	north	X	X	X	X	X	X
Wright Creek	1	north	X					

III. B. 2. Mark recapture beach seines (MR)

In addition to RBS sampling, beach seine sampling was conducted specifically to recover marked juvenile Chinook salmon in key locations using consistent sampling effort. The mark recapture beach seine (MR) sampling was conducted using the same net and with the same sampling protocols as the RBS collections. The primary difference between the MR and RBS sampling was how the catch was processed in the field. For the RBS, the catch was always processed in its entirety. During MR collections, the focus was on processing juvenile salmon, while processing other species as time permitted.

MR sampling began two days after the first marked group of juvenile Chinook salmon was released from Gorst Creek and continued biweekly for three weeks and then weekly for three weeks. MR sampling was conducted at twelve sites during daylight hours with three of these sites in Area 1, four sites in Area 2, and five sites in Area 3 (Figure 2, Table 3).

All non-salmonids were removed from the catch and enumerated if time permitted. Coho and chum salmon were also enumerated and released. Large catches of juvenile Chinook salmon were sub-sampled so we had approximately 100-200 fish to process. Retained juvenile Chinook salmon were anesthetized using MS-222, measured for fork length, and checked for the presence of a coded wire tag (CWT), adipose fin, and fluorescent pigment. Chinook salmon with a CWT were preserved for later extraction of the tag, except for those that were also marked with fluorescent pigment, which were released after processing. For subsampled catch, marked fish recaptures were expanded by the proportion of the catch of juvenile Chinook salmon that was subsampled. For example, say we only examined 100 of 500 (20%) of the juvenile Chinook salmon in a haul for the presence of CWTs and found 10 tagged fish. We would assume that there were 50 tagged fish in the total catch: Number of CWTs in the haul = 10 CWTs x 5 = 50. Similar calculations were used to expand total catch when large numbers of salmonids were present.

Table 3. Mark recapture (MR) beach seine sites and sampling dates for Sinclair Inlet in 2002.

	Area	Shoreline	5/21	5/24	5/28	5/31	6/4	6/11	6/18	6/25
Tattoo Beach	1	south	x	x	x	x	x	x	x	x
Ross Point	1	south	x	x	x	x	x	x	x	x
Windy Point	1	north	x	x	x	x	x	x	x	x
Boat launch	2	south	x	x	x	x	x	x	x	x
Blackjack	2	south	x	x	x	x	x	x	x	x
New Charleston	2	north	x	x	x	x	x	x	x	x
Old Charleston	2	north	x	x	x	x	x	x	x	x
Natural Beach	3	south	x	x	x	x	x	x	x	x
Channel Marker 11	3	south	x	x	x	x	x	x	x	x
CTC Beach	3	north	x	x	x	x	x	x	x	x
Cabana Beach	3	north	x	x	x	x	x	x	x	x
Enetai	3	north	x	x	x	x	x	x	x	x

III. C. Sampling Offshore Habitats

III. C. 1. Surface tow nets (STN)

A tow net (or two boat surface trawl) similar to the net used by Fresh (1979) and others (e.g., Fresh et al. 1979) was used to sample the upper 3m of the water column along transects in Sinclair Inlet. The tow net had a 3.3 m x 6.6 m mouth opening, was 16.5 m long and was constructed of mesh tapering from 8 cm stretch mesh at the mouth to a narrow zippered bag at the rear made of 3 mm knotless nylon mesh. The net was towed between two boats and the mouth was kept open by two 4 m long, vertical, pipes attached to each side of the net. A large float was attached to the top of the pipe and a 4.5 kg weight attached at the bottom. The top of the tow net was strung with floats to help maintain the net at the surface and keep the mouth of the net open while the bottom of the net opening was constructed of lead line. Boat operators used radios to communicate in order to stay parallel to each other and the shoreline, to maintain a constant net opening, and a constant boat speed.

Upon completion of a tow, the two boats reduced speed and closed the net. The net was then pinched at the mid-section using a line around the net, the net was lifted, and the catch worked back into the net to minimize fish escape. The cod end was then brought aboard, the bag unzipped, the catch emptied into a large tote, and fishing was resumed. Captured fish were processed using the same protocols as RBS sampling.

Tow net samples were collected during May, June, July, and August 2002 (Table 4) during day and night hours. Tows were conducted along both shorelines and in the center (Figure 3). Inshore tows generally followed the 5 m contour line, while offshore tows were made in the deepest sections of each area, which was generally >10 m. The center of Area 1 was less than 7 meters deep and offshore tows were rarely done in this area after May. We attempted to begin a tow series for each area in approximately the same location (using GPS to locate start points). All tows were 10 minutes in duration, with the exception of several tows during May that were reduced to 5 minutes due to high catches of ctenophores (jellies).

Volume of water strained by the tow net during a standard 10 minute tow varied according to a number of factors, including wind speed and direction, tidal currents, ctenophore catches, and shape of the shoreline. Thus, some variability in catch between tows can be expected to occur because of these and other factors. We did not attempt to estimate volume fished for each tow. However, our record of GPS start and end points indicated that most tows covered approximately the same distance.

Tow net data is reported as catch in a 10-minute tow (CPUE= catch per tow). As a result, we expanded catch from any tow less than 10 minutes to 10 minutes. We also expanded any subsampled catch by the subsampling proportion. Mean or average CPUE was calculated as the total number of fish caught in the strata in a month divided by the number of tows occurring in that month.

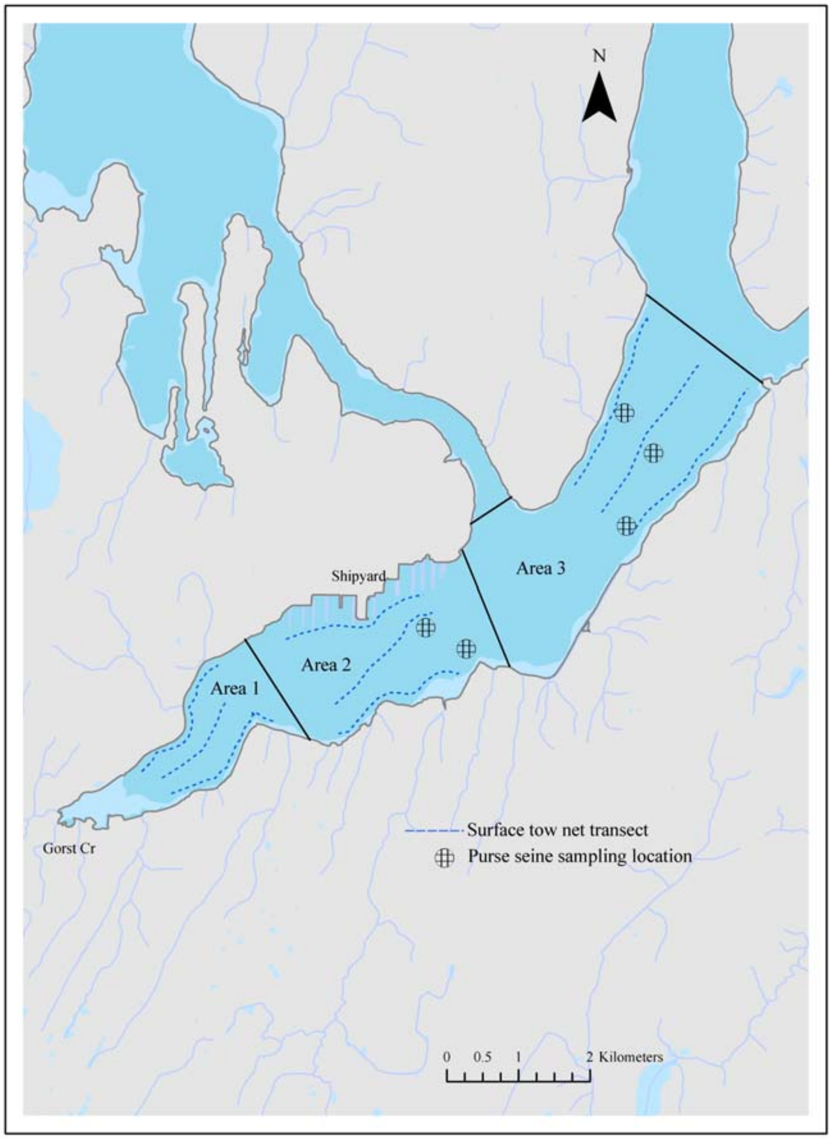


Figure 3. Location of surface tow net transects and purse seine sampling sites in Sinclair Inlet.

Table 4. Summary of sampling effort by Area during surface tow net sampling for Sinclair Inlet in 2002. All data was standardized to 10-minute tows for data analysis.

	May 13 - 15		**May 13-15**		**June 13 -14**		**July 16 - 18**		**Aug 13 - 14**		
	day	**night**	**day**	**night**	**day**	**night**	**day**	**night**	**day**	**night**	
Area 1	**5 minute tows**		**10 minute tows**		**10 minute tows**		**10 minute tows**		**10 minute tows**		**Totals**
Center	5	5					1		1		**12**
North		4		2	2		3	2	2		**15**
South		4			2		1	2	2		**11**
Area 2											
Center		3		2	2	2	2	5	3	3	**22**
North		11			2	2	2	2			**19**
South				3	2	2	2	3	3	5	**20**
Area 3											
Center				4	2		2	3	3	3	**17**
North				4			2	2			**8**
South				4	2		4	4	3	3	**20**
Totals	**5**	**27**		**19**	**14**	**6**	**19**	**23**	**17**	**14**	**144**

III. C. 2. Purse seines

A purse seine was used to collect fish in Sinclair Inlet on July 19 and 20, 2002. The 18.2 m trawler, *F/V Chasina,* was used to fish a 221 m long purse seine, constructed of 1.75 cm nylon knotless mesh, with 113 gram floats spaced at one-foot intervals along the float line, and a lead line along the bottom. The boat end of the net was 4.9 m deep slanting to 9.2 m in the first 7.6 m of run. The 9.2 m bottom extended for 68.6 m, and then tapered from 9.2 m to 3.8 m at the opposite end over the remaining 144.8 m. A seine skiff was used to make a round haul after which the net was pursed, the catch brought on board, and emptied into a livewell. The catch was processed using the same method as RBS. In addition, a portion of the lower caudal fin of all unclipped Chinook salmon was removed for future genetic analysis.

Five sites were sampled with the purse seine during daylight hours on July 19 and again during nighttime on July 20, 2002 (Figure 3). Sites and areas that could be sampled were limited by the requirement that water depth exceed 10 m. Two sites were sampled in Area 2 and three in Area 3. For three of the sites, the net was set as close to shore as possible (inshore). For one site each in Area 2 and 3, the net was set in the middle of the channel (offshore).

III. D. Residence Time and Migratory Behavior of Hatchery Chinook Salmon

III. D. 1. Marking methods

To study migratory behavior of juvenile Chinook salmon in Sinclair Inlet, we used fluorescent pigment to mark groups of hatchery fish. The fish were then released from several locations, but predominantly into Gorst Creek, at the terminus of Sinclair Inlet. Marks were recovered using beach seines, surface tow nets and purse seines.

The method used to mark fish, fluorescent pigment, met the primary requirements of the study: a readily visible mark, the ability to mark many fish quickly with little or no damage, low cost, and portability of the marking system. Fluorescent pigment was originally developed as a tool to mass mark juvenile salmonids in the 70’s and 80’s (Phinney and Mathews 1969). Bax (1983) and Bax and Whitmus (1981), for example, used fluorescent pigment to estimate mortality of juvenile chum salmon in the Hood Canal in the late 1970’s while Fresh and Schroder (1987) used this approach to study predation on juvenile chum salmon in a small stream entering Hood Canal.

The basic principle employed to mark fish is to use compressed air to force pigment granules to adhere to the fish. The pigment used in former studies was unavailable in sufficient quantities for the numbers of fish we desired to mark. However, we located a different density, polymeric base (plastic) fluorescent pigment that was available in sufficient quantities. Because of differences in characteristics of the new pigment, it was necessary to redesign and construct new equipment to apply the pigment. In addition, we conducted studies to determine what settings the new equipment (e.g., compressed air pressure) needed to mark fish and minimize mortality associated with marking and handling.

A marking trough was built with a rotating spray bed to allow quick movement of fish in and out of the spraying operation. The spraying apparatus was created out of a quart sandblasting gun, with a modified internal pickup designed to facilitate positive pigment intake. One critical change from earlier designs was the use of two nozzle tips to fit over the end of the spray nozzle to throw the pigment more evenly out to the sides of the trough. Parameters evaluated included the PSI (pounds per square inch) of compressed air, distance from the fish, characteristics of the nozzles, number of fish to be sprayed, and how long to spray. Mortality and mark retention estimates were used to evaluate different combinations of marking parameters. Ultimately, we found that two passes over a group of fish at a distance of 48.2 cm and 120 PSI was optimal, and gave us a mark retention of > 96 % with < 1% mortality, seven days after marking.

III. D. 2. Release groups

Over 120,000 juvenile Chinook salmon were marked with fluorescent pigment; fish were released in discrete groups for purposes of this study (Table 5). For all groups, the numbers of marked fish released were estimated as the number of fish marked, less known mortalities, and multiplied by the estimated mark retention for that group (usually estimated 2-7 days post marking). We believe this is a reasonable estimate of release numbers of marked fish for the following reasons. First, the time between marking and release of the fish was less than 30 days. While some mortality in hatchery ponds can be expected as part of normal operations, the numbers lost over the last 30 days before release should be low. In addition, our studies showed that most of the mortality specifically due to marking occurred within 48 hrs. Second, our retention estimates 2-7 days after marking were consistently around 97%. In addition, we spray marked a group of 6,400 juvenile Chinook salmon reserved for the yearling program to evaluate long term retention and found that pigment retention of this group was 95% two months after marking and 90% four months after marking.

Two groups of juvenile Chinook salmon were marked with chartreuse pigment and held at the Gorst Creek rearing ponds, located at about rkm 1.4 on Gorst Creek at the west end of Sinclair Inlet (Figure 1). One group of 25,900 was added to an experimental pond that contained fish that had been reared according to NATURE's protocols (an acronym that describes a fish culture approach designed to produce more "natural" fish than traditional salmon culture practices). This pond featured floating lattice structures and simulated predators within the pond. A group of

25,700 fish was added to the control (normal rearing procedures) pond at Gorst Creek. Of the 1,106,300 total juvenile Chinook salmon in the NATURE's rearing pond, 105,829 received a coded wire tag unique to this pond. In the control pond, 103,343 of the 1,103,400 Chinook received a different coded wire tag. The spray marking was done independently such that none of the chartreuse fish had CWTs. The sprayed fish were inspected five days after marking and mark retention was 97% with less than 1% mortality. Fish in the Gorst Creek rearing ponds were volitionally released beginning the evening of 5/20/02 with the ponds fully drained on 6/21/02. We estimate that 49,020 chartreuse fish were released from the rearing ponds beginning 5/20/02 (Table 5).

A group of 67,200 juvenile Chinook salmon was held in a raceway separate from the main ponds at Gorst Creek. Of these fish, 55,800 received a CWT unique to this raceway and 26,000 were also spray marked with red pigment. Another 11,400 Chinook salmon without CWTs were also spray marked with red pigment and kept in the raceway. All fish in this raceway were forced out into Gorst Creek the evening of 5/19/02. We estimated that 35,530 red fish were released from Gorst Creek of which 24,700 also had CWTs.

Another spray-marked group of juvenile Chinook salmon was held in a rearing pond on the West Fork Clear Creek that enters Dyes Inlet. A total of 26,900 fish were spray marked with orange pigment at Gorst Creek and added to the Clear Creek pond with 23,800 unmarked Chinook. None of the Clear Creek fish received a CWT. Forty-eight hours after marking, mark retention was 97% and mortality < 1%. The pond was opened and drained on 5/25/02. We estimated that 25,650 orange fish were released from Clear Creek on 5/25/02 (Table 5).

Approximately 2,500 fish were also spray marked orange and released during equipment testing at Grovers Creek Hatchery. Overall mark retention of these fish was about 80% in test runs and mortality was about 5%. We estimated that 1,875 unclipped orange fish were released 5/20/02-5/29/02 during the main Grovers Creek Hatchery release.

To estimate residence time, we added the number of days since release for each marked fish that was recaptured and divided that total by the total number of marked fish recaptured during the six week period. We estimated residence time in Sinclair Inlet independently for each of six groups, including pigment marked fish and groups of CWT marked fish (Appendix K).

Table 5. Summary of fluorescent marked juvenile Chinook salmon used for the mark-recapture study for Sinclair Inlet in 2002.

Pigment Color	Date Sprayed	Number Sprayed	Location of release	CWT	Release Date	Total # fish at site	Estimate of number of marked fish released[1]
Orange	19-Apr	27,000	W. Fk. Clear Cr	no	5/25/02	50,700	25,650
Chartreuse	25-Apr	25,700	Gorst pond (control)	no	5/20 – 6/21/02	1,103,400	24,415
Chartreuse	30-Apr	25,900	Gorst pond (NATUREs)	no	5/20 – 6/21/02	1,106,300	24,605
Red	8-May	11,400	Gorst (raceway)	no	5/19/02	67,200	10,830
Red	8-May	26,000	Gorst (raceway)	**yes**	5/19/02	67,200	24,700
Orange	April	~2500	Grovers Cr hatchery	no	5/20 – 5/29/02	671,400	1,875[2]
Red	8-Jul	2100	Gorst (raceway)	0	5/03 (yearling)	6,400[3]	
Chartreuse	8-Jul	2200	Gorst (raceway)	0	5/03 (yearling)	6,400[3]	
Orange	8-Jul	2100	Gorst (raceway)	0	5/03 (yearling)	6,400[3]	

[1] less than 1% mortality and 95% mark retention
[2] less than 5% mortality and 80% mark retention
[3] held for yearling release, 95% mark retention at 2 months, 90% mark retention at 4 months. Released in 2003.

III. D. 3. Mark detection

Marked juvenile Chinook salmon were recaptured in Sinclair Inlet by beach seining and with the two boat surface trawl. To determine if fish captured in the field were marked with fluorescent pigment, a box that contained fluorescent lights and blocked out outside light was built. Black light wavelengths differed between individual light bulbs so all black lights used for mark detection were checked against fish known to be marked to ensure their accuracy in the field. After a fish was anesthetized with MS-222, it was placed in the box and inspected on each side. At some sites in Sinclair Inlet, it was dark enough at night that we did not have to use the box and could use a hand held light. When a marked fish was found, the pigment color was checked via a key that could be held next to the fish to ensure an accurate color match.

III. D. 4. CWT recovery and analysis

A number of juvenile salmon with coded wire tags (CWT) were found in fish collected from Sinclair Inlet in 2002. We did not have a CWT detector available in 2001. CWTs extracted from fish in the lab were sent to the WDFW coded wire tag lab in Olympia. Codes were matched to the Pacific States Marine Fisheries Commission Regional Mark Information System (RMIS) database and verified by contact with individual hatcheries, fish biologists within WDFW, and biologists at the Northwest Indian Fisheries Commission.

Occasionally, to avoid killing large numbers of Chinook salmon with CWTs, we subsampled catches, especially during late May and June when Gorst Creek CWT fish were abundant in the area. As with dye marked fish, we adjusted numbers to reflect subsampling proportions.

III. E. Analysis of Catch Data

Analysis of catch data focused primarily on juvenile Chinook salmon and were conducted with the 2001 RBS, 2002 RBS, 2002 MR, and 2002 STN (surface tow net) data sets. For all analyses of abundance and length, we assumed that hatchery origin juvenile Chinook salmon were any Chinook salmon 1) without an adipose fin, 2) with an adipose fin and CWT, or 3) with an external mark (e.g., fluorescent pigment). Fish with unclipped adipose fins, no CWT, or external mark were potentially naturally-produced (also referred to as natural origin recruits or "wild"), although a proportion of the unmarked fish are undoubtedly hatchery fish (Table 1, Appendix A). In 2001, we did not test fish for CWT. While all CWT Gorst Creek hatchery Chinook salmon were also fin clipped, some of the CWT hatchery Chinook salmon (e.g. a proportion of the Grovers Creek release) were part of a double index study and had intact adipose fins (Table 1, Appendix A). However, in 2002, all fish were tested for CWT. These fish are therefore labeled in our results as

"**Wild" or "unclipped"** for 2001 (adipose fin intact, no test for CWT), and
"**Wild" or "unmarked**" for 2002 (adipose fin intact, no CWT, no pigment mark) and 2001/2002 combined data sets

Our analyses of beach seine data focused on the 19 sites (between both years) that had the highest effort (Appendix B). Eight sites were sampled at least eight times in 2001 while 13 sites were sampled at least eight times in 2002. In order to make data analysis as consistent as possible, analyses of catch trends excluded infrequently sampled sites from each year and focused on these sites with the highest effort (sampled at least 8 times). Complete records of catch at all sites are included in the appendices.

We did not identify all of the smaller sculpins, larval and post larval forage fish, and postlarval flatfish to species level because of the time involved in doing this accurately. In addition, during several of the mark recapture seine samples, we were unable to process the non-salmonid portion of the catch because of the need to examine large numbers of Chinook salmon for the presence of marks. As a result, the number of species caught each year should be considered minimum values.

As part of this study, we considered effects of three categories of variables on the distribution, size and abundance of juvenile Chinook salmon in littoral and offshore Sinclair Inlet. First, we examined differences in abundance and size of juvenile salmon in Sinclair Inlet separately for marked and unmarked fish, i.e. "hatchery" and "wild". Because of the well-known differences that have been documented in behavior and ecology of hatchery and wild fish (e.g., Fresh 1997), we hypothesized that hatchery and "wild" fish might exhibit different patterns in abundance and size in Sinclair Inlet. Second, we examined the influence of sampling time of day and tidal stage on abundance. Third, we assessed the potential relationship between selected habitat variables associated with sampling sites on abundance and size. For MR sites, we considered 8 variables in littoral habitats (primary substrate, secondary substrate, slope, aquatic vegetation, riparian vegetation, shoreline development, beach slope, sampling area, and shoreline orientation). All variables were qualitatively assessed at individual sites. For the RBS sties, we only evaluated effects of Area and shoreline of capture. For surface tow nets, we only considered Area (i.e. 1, 2, 3) and shoreline (north vs. south) as habitat variables.

We focused our analyses on making large scale and temporal comparisons (e.g. pooling data from all sites in one year to examine effects of tide, pooling all catch data from one shoreline to compare to the other shoreline). We did this in part because of highly uneven sampling effort and large differences in the numbers of fish measured which occurred as the data were divided into smaller spatial/temporal units (e.g. year/month/site/Area/shoreline). For example, we made a relatively small number of sets around slack tide but had much greater effort during ebbing or flooding tides. We also adopted this approach because testing for large-scale differences were more consistent with the objectives of this study. We recognize that there may be finer scale differences that we would not be able to detect that occurred as a result of interactions between such factors as time of year and Area. Thus, there may be days, weeks, or months when there is a size difference between the two shorelines. Similarly, catch may vary between tidal stages in particular shoreline areas because of slope, currents, and other factors.

To test hypotheses about differences in juvenile Chinook catch and size as a function of the above variables, statistical comparisons of catch and length data were conducted. Because of limitations in the distribution of samples and numbers of fish that could be measured, we only made large-scale comparisons (e.g., pooling data from all sites and collections to examine effects of tide in 2001). We analyzed each of the four data sets separately (2001 RBS, 2002 RBS, 2002 MR, and 2002 STN) and only made comparisons using abundance data when number of samples exceeded 10; tests of length differences were made when there was at least 24 fish measured in a treatment. Pair wise comparisons were made using two tailed, unpaired t-tests and for $k > 2$, one-way ANOVAs. In order to meet the assumptions of ANOVA, e.g. data approaches normality, all catch data were transformed using the square root transformation; no adjustments were made to fork length data. This transformation is recommended for data that are counts because such data are often distributed in a Poisson fashion where the variance and mean are not independent (Sokal and Rohlf 1981). We examined several subsets of the data and found that this transformation helped improve the relationship of mean and variance. Where one-way ANOVAs yielded a significant result, multiple comparisons were made using Tukey's HSD test to determine differences between treatments. All tests were conducted with a p = 0.05.

III. F. Habitat Inventory

Methods to assess habitat characteristics were developed and tested on two sections of shoreline in 2002. The first section started at Ross Point and continued west approximately 3.5 km to the mouth of Anderson Creek. The second section was from the sampling site Natural Beach west 2.7 km to Annapolis dock. Subsequently in 2003, the habitat of the entire Inlet was characterized. Habitat characteristics were measured in the field for 10 km of the total 26 km shoreline length of Sinclair Inlet. Shoreline sections along the north shore of Sinclair Inlet in Areas 1 and 2 (approximately Gorst to the ferry terminal) were not directly measured in the field, as shoreline armoring is nearly 100% and intertidal habitat essentially absent.

Transects were taken at intervals of approximately 100 m or when the substrate composition of the shoreline significantly changed. A portable Digital GPS, (DGPS) accurate to about 0.5 m, was used to record the position of substrate changes. Once a starting position at the high water mark was recorded with the DGPS, we established a transect down the beach perpendicular to the waters edge. When a change in substrate was found the position was recorded, until -1 m MLLW was reached. All transects ended at –1 m MLLW.

Substrate materials were divided into six categories using methodology similar to Dethier (1990), and the shoreline was classified as natural or armored/altered. Substrate included in classifications included riprap, sand mixed with gravel, sand, cobble, bedrock/boulders, gravel, vegetation, and mud. Riparian and upland vegetation was noted and described at each shoreline change. The slope of the shoreline was categorized as low, medium or steep. The locations and types of development present were also noted and mapped (e.g., docks, rip-rap, concrete bulkhead).

The coordinates of substrate changes and shorelines were mapped using the GIS mapping package MAPINFO. Aerial photographs were used where possible to evaluate upland vegetation. MAPINFO was then used to estimate the surface area of each substrate class, and amount of shoreline armoring.

III. G. Diets of Juvenile Chinook Salmon and Potential Competitors and Predators

The stomach contents of selected juvenile Chinook salmon were removed from fish in the field using gastric lavage; in addition, some fish (e.g., mortalities and some hatchery fish with CWTs) were retained as whole specimens. Gastric lavage involves inserting a tube in the esophagus of an anesthetized fish and then flushing the contents out onto a screen using water. Gastric lavage was also used to obtain cutthroat trout stomach contents. Juvenile chum salmon stomachs were saved by placing whole fish in a jar with formalin. Stomach samples were obtained from fish collected in littoral habitats in 2001 and 2002 and in offshore habitats in 2002.

An inventory of all stomach samples was created and fish were selected from this list for processing. Processing consisted of first weighing the fish if there was a whole fish carcass available. Stomach content samples were sieved with a 75 mm screen and the total contents weighted. If a whole fish was processed, the fullness of the stomach was scored. Prey were identified, sorted into appropriate taxa groups, counted and weighed to the nearest 0.0001g. The level of identification of each prey item depended upon a number of factors including the specific taxa and the stage of digestion. Small benthic and planktonic crustaceans could often be identified to species but many of the other major prey such as insects and polychaetes could only be identified to order or family.

In order to facilitate diet analyses, prey were grouped into one of five general taxonomic categories based upon the primary habitats the prey occupied (Table 6). These categories are not definitive for some taxa that have complicated life histories. For example, chironomids have larval, pupal and adult stages associated with benthic, water column and neustonic habitats. In addition, many of the terrestrial origin insects may be eaten off the surface of the water.

Diet was analyzed based upon frequency of occurrence (FO), numeric composition (NC), and gravimetric composition (GC) of prey items. Frequency of occurrence indicates the proportion of stomachs containing a specific prey item. Numeric composition indicates the proportion in numbers, while gravimetric composition is the proportion of the weight of stomach contents. The Index of Relative Importance (IRI) was also calculated to measure the contribution of each prey type to the sample as a whole and the likelihood of that prey type occurring in the stomach of an individual predator (Pinkas et al. 1971). IRI is calculated as:

$$IRI = (\%NC+\%GC)*\%FO$$

where %NC = percent numerical composition, %GV = percent gravimetric composition and %FO = frequency of occurrence.

All of the IRI values were combined for whatever data set was being evaluated, e.g. all Chinook salmon from tow net catch, to yield a total IRI value. The relative importance of any prey item was evaluated by computing the %IRI of prey item *i*. The relative importance of prey *i* was defined as its %IRI which was calculated as the IRI value for prey *i* divided by the total IRI value. In addition, we combined all metrics into one graph in order to view all three measures of diet simultaneously.

To compare diet between groups of fish, the similarity index, PSI (Percent Similarity Index) was calculated using the gravimetric composition as the metric. A PSI value is calculated by summing the smallest percent by weight for each taxa pair in the data sets being compared, e.g. site A vs. site B in 2001 RBS seines. A value of 1 indicates complete overlap in diet while a value of 0 indicates no overlap.

Table 6. Prey taxa representative of ecological prey categories used in the analysis of juvenile salmonid diets.

Ecological Prey Category	Major Taxa Represented
Terrestrial	Insects, spiders and mites
Marine Planktonic-Neritic	Decapod larva, hyperiid amphipods, calanoid copepods, fish and fish eggs
Marine Benthic-Epibenthic	Gammarid amphipods, polychaetes, harpacticoid copepods, cumaceans
Plant Matter	Aquatic and terrestrial plant matter
Other	Inorganic material, beach hoppers (Talitridae) and other supralittoral taxa

IV. Results and Discussion

IV. A. Littoral Zone Habitats

IV. A. 1. Characteristics of sampled sites

Nineteen sites in Sinclair Inlet were sampled consistently in 2001 and 2002 and formed the basis for most of our analyses of catch data (Table 2, Appendix B). Of these, 14 sites (74%) had some type of shoreline alteration associated with them. Gravel and sand substrates were rated as the primary substrate type at 14 of the 19 sites. Sites primarily composed of mud were all located in the shallow west end of the Inlet. Although sea lettuce (*Ulva* spp.) was common at many sites, most of it was unattached. The only site that had significant attached vegetation was the CTC site with macroalgae attached to the large cobbles at the site (Appendix B). Littoral zone habitats of Area 1 were completely lined with riprap along the north shore and lightly developed with some riprap along the south shore. In Area 2, much of the littoral zone has been eliminated due to fill and armoring (i.e., addition of riprap) of the shoreline associated with the Shipyard, and the cities of Bremerton, and Port Orchard. In Area 3, a large portion of the littoral zone is relatively unchanged with the major human related impact due to bulkheads associated with single-family residential property.

IV. A. 2. General species composition

During 2001, we caught 29,159 fish representing 29 species in 120 beach seine hauls from mid-April to late September (Table 7, Appendix C). During RBS sampling in 2002, we caught 33,872 fish representing 29 species in 180 beach seine hauls made from mid-February to mid-September (Table 7, Appendix D); of this total, 98.1% were from the most consistently sampled sites where we had sampled at least 8 times (Table 7). During MR beach seining in 2002, we caught 10,584 fish representing 20 species in 96 seine hauls (Table 7, Appendix E). The catches of non-salmonids in MR samples are approximate values, as we did not enumerate catches of non-salmonids in some hauls due to time constraints. All species captured in 2002 were also captured in 2001. In general, the species found in Sinclair Inlet and their relative abundances were comparable to other studies associated with littoral areas elsewhere in Puget Sound (e.g., Miller et al. 1977; Fresh et al. 1979; Brennan et al. 2004).

The most abundant species caught both years was shiner perch (*Cymatogaster aggregata*). For example, during the RBS sampling conducted in 2002, 35.6% of the total catch was shiner perch (Appendix D). Most shiner perch caught through July were adults while juveniles became the dominant life history stage in August and September. Three species of forage fish were also caught in life history stages from postlarval to adult: Pacific herring, surf smelt, and Pacific sandlance. In 2001, 2,578 forage fish were collected (Table 8) while in 2002, 11,096 forage fish were caught in all beach seine hauls combined (Table 9). The total in 2002 includes an estimated 10,000 post larval sandlance captured in one beach seine haul at Pier 8. Because the postlarval stages of forage fish were of a size that could only be effectively caught by the mesh used in the bag, the number of postlarval forage fish present in the area was greatly underrepresented by our seine catches. Surf smelt and sandlance are documented to spawn along beaches of Sinclair Inlet, while herring spawn in nearby Dyes Inlet. There were no consistent patterns in spatial or temporal distribution of the forage fish in either year.

The most numerous salmonid occurring in littoral habitats of Sinclair Inlet in both 2001 and 2002 was juvenile chum salmon. The origin of these fish cannot be precisely determined but they are likely from a variety of sources, including naturally produced fish from streams draining into the Sinclair Inlet area and natural production from local East Kitsap embayments (e.g., Dyes Inlet). In 2001, juvenile chum salmon were caught at 8 of 11 sites where more than 2 beach seine hauls were made (Appendix C, Table 8) and in 2002, juvenile chum salmon were caught at all sites where at least four beach seine hauls were made during both MR and RBS sampling (Appendix D, Appendix E, Table 9). Chum salmon appeared to be more abundant in 2001 than in 2002. Overall CPUE (using only RBS data from frequently sampled sites) of chum salmon juveniles in 2001 was approximately twice that in 2002 (2001 mean CPUE= 52.5, SD=288.2, 120 hauls; 2002 mean CPUE = 23.2, SD=87.4, 176 hauls). In addition, CPUE of juvenile chum salmon in April 2001 was over an order of magnitude greater than in April 2002 (Figures 4 and 5). A lower, overall mean CPUE is not unexpected in 2002 compared to 2001 because more effort occurred in months in 2002 when chum abundance would be expected to be low (Figures 4 and 5). Large catches of juvenile chum salmon occurred occasionally, including several of over 2,000 fish in a single haul.

The only month in either year when juvenile chum salmon were not caught was in February 2002 (Figures 4 and 5). The most complete littoral sampling for juvenile chum salmon occurred in 2002 because sampling did not begin until April in 2001 and no collections were made in May 2001, a month when juvenile chum salmon are typically abundant. Chum salmon juveniles were first captured in early March. In 2002, most juvenile chum salmon were caught from April to June, with May having the highest CPUE (Figure 5). CPUE of juvenile chum salmon in 2002 was low prior to April, reached a peak from April-June, and then declined to low levels in July-September. The highest CPUE values of juvenile chum salmon in 2002 (all data combined) occurred in April (mean CPUE= 32.5, SD= 58.6, 27 hauls) and May (mean CPUE= 41.5, SD= 138.8, 62 hauls) (Figure 5).

There was a general increase in size of juvenile chum salmon using the Inlet over time (Figure 6). Mean size of juvenile chum salmon in 2002 increased from 39.3 mm FL in April to 139.7 mm FL in early September. The fork lengths of juvenile chum salmon were not consistently measured in

2001. However, the average size of chum salmon juveniles in late August (when all fish were measured) was 151.0 mm FL which was comparable to early September in 2002. Because juvenile chum salmon do not rear in freshwater, the occurrence of increasingly larger chum salmon over time suggests that: 1) chum salmon from local streams may be rearing and growing in the Inlet for extended periods, or 2) larger juvenile chum salmon may be entering the Sinclair Inlet area from other regions during their migration to North Pacific feeding grounds.

Few juvenile coho salmon were caught in either year. In 2001, only 5 juvenile and 5 adult coho salmon were caught (Table 8). In 2002, 304 juvenile coho salmon were caught (Table 9) of which 49.1% were adipose clipped. Coho salmon juveniles were generally distributed throughout the study area and did not appear to be associated with a particular site, shoreline or area. In 2002, peak juvenile coho salmon catches occurred in May and June (mean CPUE in all months < 3.0 fish haul); 93.2% of the coho salmon that were caught during the study were captured in these two months (Figure 7). Juvenile coho salmon captured were of the size range associated with yearling fish, with mean fork length of unclipped coho salmon of 120.4 mm in May 2002 (SE= 2.5, range 99 – 165 mm, n=43), 127.4 mm in June 2002 (SE= 2.3, range 94 – 196 mm, n=65) and 134.1 mm in July 2002 (SE= 5.3, range 90 – 157 mm, n=14). The small numbers of juvenile coho salmon occurring in the Inlet after July suggests that: 1) few coho salmon remain in Sinclair Inlet area for an extended time period, 2) few coho salmon migrate into this area from the main basin of Puget Sound, or 3) coho salmon may shift to deeper, more offshore habitats by summer months and are unavailable to our sampling methods.

Small numbers of sea run cutthroat trout were caught in beach seine hauls throughout the study (Appendices C, D and E). Average catch of cutthroat trout (all years and hauls combined) was 1.3 fish/haul. Natural Beach and Tattoo Beach were the most consistent producers of cutthroat trout during RBS sampling in both years while the CTC and West Channel Marker 11 sites had high catches during the limited mark recapture sampling. No seasonal pattern in CPUE of cutthroat trout was obvious. Fork lengths of measured cutthroat trout ranged from 90 mm to 490 mm.

Table 7. Catch composition for all gear types. For the regular beach seines (2001 and 2002), only frequently sampled sites are included. Total catch for infrequently sampled sites is indicated on the last row of the table. Species caught only at sites sampled infrequently are indicated in the table as "infrequent".

Common Name	Species Name	RBS 2001	RBS 2002	MR 2002[d]	STN 2002	Purse Seine 2002	Total
Chinook salmon	*Oncorhynchus tshawytscha*	732[a]	798	3,673	1,892	663	7,758
Coho salmon	*Oncorhynchus kisutch*	2	266	25	19	46	363
Chum salmon	*Oncorhynchus keta*	5,713	4,090	1,931	504	708	12,946
Cutthroat trout	*Oncorhynchus clarki*	78	177	190	1		446
Steelhead trout	*Oncorhynchus mykiss*		1		2	1	4
Atlantic salmon	*Salmo salar*				1		1
Big skate	*Raja binoculata*	1	4		1		6
Pacific herring	*Clupea pallasii*	539	386	1	89	20	1,035
Surf smelt	*Hypomesus pretiosus*	1,294	383	306	15	11	2,009
Plainfin midshipman	*Porichthys notatus*	121	8	2	198		329
Threespine stickleback	*Gasterosteus aculeatus*	19	1,180	2	683	30	1,914
Tubesnout	*Aulorhynchus flavidus*	7	4				11
Bay pipefish	*Syngnathus leptorhynchus*	10	11	11	15		47
misc. greenling	*Hexagrammidae*	7	5				12
Staghorn sculpin	*Leptocottus armatus*	864	412	268	2		1,546
Buffalo sculpin	*Enophrys bison*	2	125	17			144
Tadpole sculpin	*Psychrolutes paradoxus*	infrequent	0				infrequent
Irish lord	*Hemilepidotus sp,*	infrequent	0				infrequent
misc. sculpins	*misc. Cottidae*	230	1,029	361	4		1,624
Shiner perch	*Cymatogaster aggregata*	12,960	11,982	3,509	159		28,610
Striped perch	*Embiotoca lateralis*	260	88	36			384
Pile perch	*Rhacochilus vacca*	194	1,011	26			1,231
misc. perch	*Embiotocidae*	4	0				4
Snake prickleback	*Lumpenus sagitta*	169	543	29	17		758
Crescent gunnel	*Pholis schultzi*	8	11		4		23
Saddleback gunnel	*Pholis ornata*	2	50		66		118
Penpoint gunnel	*Apodichthys flavidus*	9	30	2	4		45
misc. gunnel	*Pholidae*	44	60	94			198
Pacific sandlance	*Ammodytes hexapterus*	231	10017[c]	2	83		10,333
misc. forage fish		70	0		23		93
Pacific sanddab	*Citharichthys stigmaeus*		17				17
Starry flounder	*Platichthys stellatus*	187	415	44	5		651
Rock sole	*Lepidopsetta bilineata*	7	11	3			21
English sole	*Pleuronectes vetulus*	9	56	1	1		67
Sand sole	*Psettichthys melanostictus*	9	18				27
CO turbot	*Pleuronichthys coenosus*	infrequent	14				14
misc. flatfish	*misc. Pleuronectidae*	172	29	50			251
# fish from infrequent sites		5,200	641				5,841
	Total number of fish	**29,154**	**33,872**	**10,583**	**3,788**	**1,479**	**78,881**
	Total number of species	**29**	**29**	**20**	**20**	**7**	**32**

[a]- *Includes 38 adult Chinook salmon*
[b]- *Includes 5 adult coho salmon*
[c]- *Includes 10000 juvenile sandlance in a singe haul*
[d]- *Non-Chinook salmon catch was estimated during MR beach seines.*
[Infrequent]- *species were recorded only at infrequently sampled sites*

Table 8. Summary of coho salmon, chum salmon, and forage fish (Pacific herring, surf smelt, Pacific sandlance) caught during regular beach seine sampling (RBS) in Sinclair Inlet in 2001. Totals are grouped by site for frequently sampled sites only. Unidentified and larval forage fish were not included in totals.

Site	Effort	Coho	Chum	Forage Fish
Blackjack	9	0	0	1,159
Cabana Beach	8	0	6	65
CTC Beach	12	0	24	207
Natural Beach	13	0[1]	1,060	86
Old Charleston Beach	12	1	2,279	15
Ross Point	14	0	2,088	44
Tattoo Beach	13	0	184	461
Windy Point	14	1	72	27
other site totals	25	3	587	514
Total	120	5	6,300	2,578

[1]Five adult coho salmon also caught at Natural Beach (not included)

Table 9. Summary of coho salmon, chum salmon, and forage fish (Pacific herring, surf smelt, Pacific sandlance) caught during beach seines in Sinclair Inlet 2002 for both regular beach seines (RBS) and mark recapture beach seines (MR). Totals are grouped by sites and only frequently sampled sites are included. Unidentified and larval forage fish are not included in species totals.

	Regular Beach Seine 2002			
Site	Effort	Coho	Chum	Forage Fish
Blackjack	13	4	42	76
Boat launch	14	79	647	9
Cabana	17	10	163	131
CTC Beach	15	2	19	16
Mooring G	8	1	895	1
Natural Beach	18	6	27	88
New Charleston	14	8	130	151
Pier 8	8	7	831	10,001
Ross Creek	10	16	21	17
Ross Point	20	56	551	74
Site 1	8	21	90	1
Tattoo Beach	14	17	649	213
Windy Point	17	39	25	8
Total for frequently sampled sites	**176**	**266**	**4,090**	**10,786**
Other sites	4	13	498	1
Total for all sites	**180**	**279**	**4,588**	**10,787**

	Mark Recapture Seine 2002			
Site	Effort	Coho	Chum	Forage Fish
Blackjack	8	5	125	2
Boat launch	8	0	112	4
Cabana	8	2	52	0
CTC Beach	8	3	756	0
Enetai	8	0	671	0
Natural	8	4	54	1
New Charleston	8	2	53	0
Old Charleston	8	1	16	0
Ross Point	8	0	22	301
Tattoo	8	3	11	0
West Channel Mk 11	8	4	37	0
Windy Point	8	1	22	1
Total	**96**	**25**	**1,931**	**309**

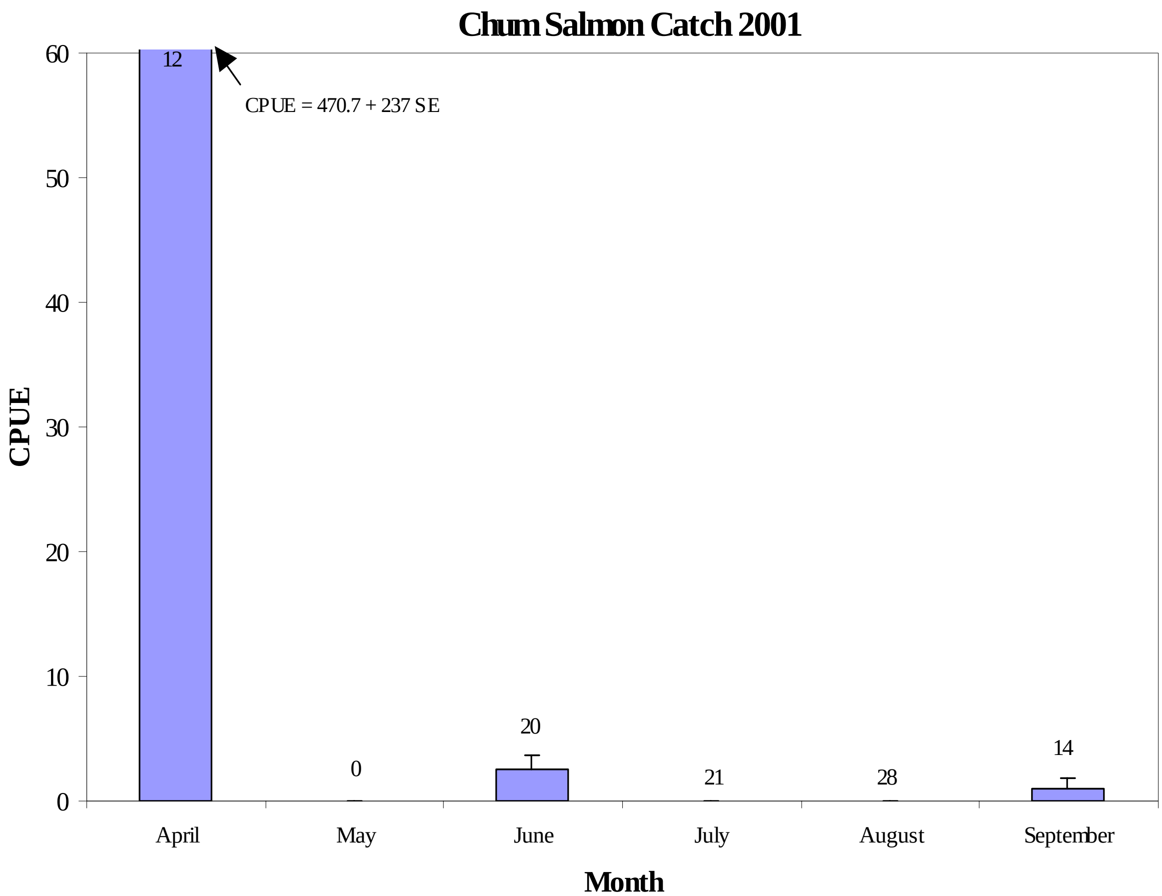


Figure 4. Monthly catch per unit effort (CPUE) of juvenile chum salmon caught during regular beach seine sampling in Sinclair Inlet in 2001. Numbers above bars represent number of hauls. Error bars indicate +1 SE.

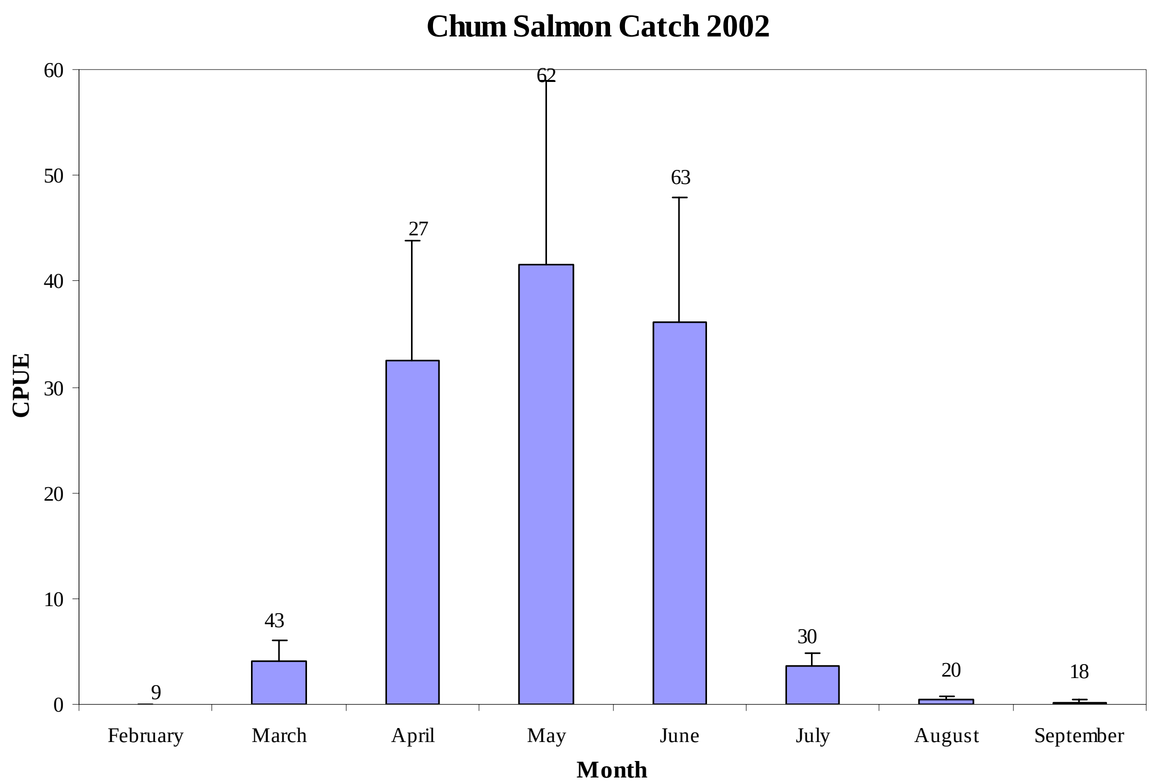


Figure 5. Monthly catch per unit effort (CPUE) of juvenile chum salmon caught during regular beach seine and mark recapture sampling in Sinclair Inlet, 2002. Catch is adjusted for subsampling. Numbers above bars represent number of hauls. Error bars indicate +1 SE.

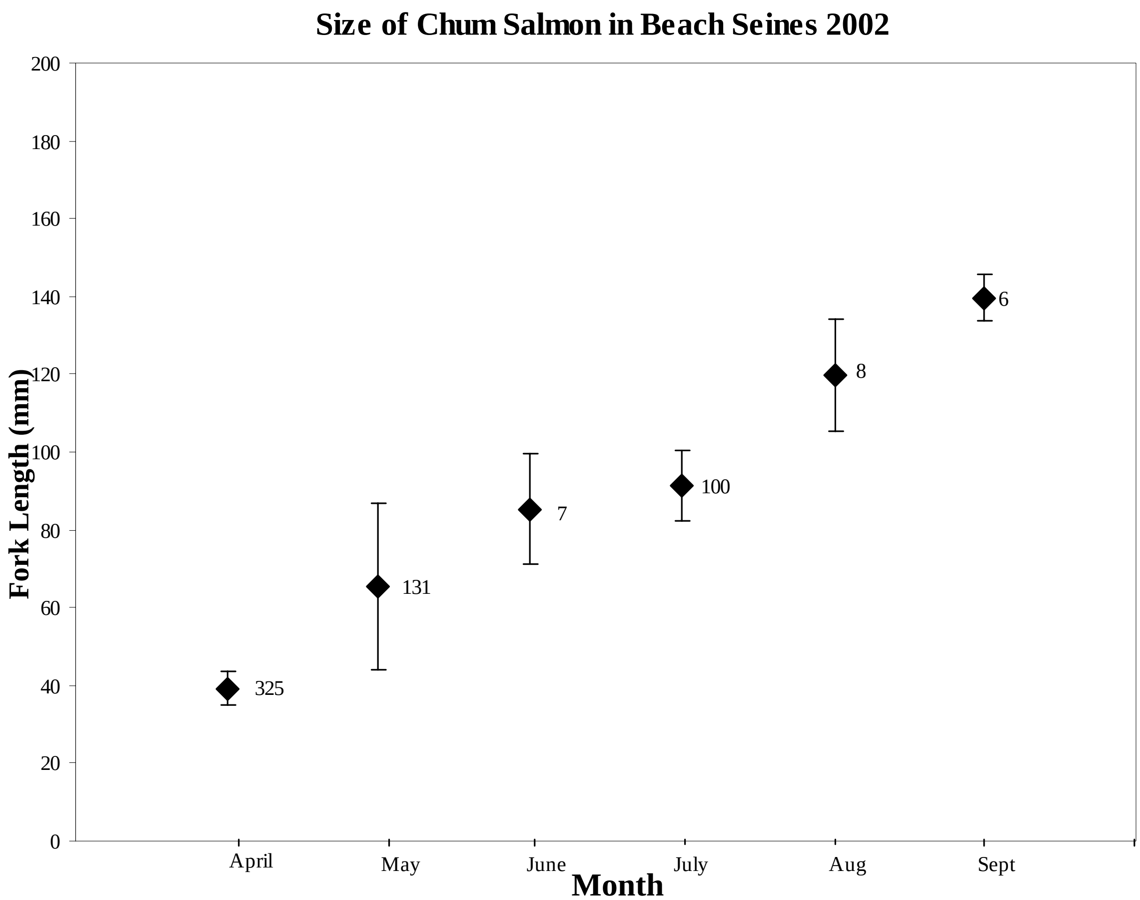


Figure 6. Size of juvenile chum salmon collected by month during regular and mark recapture beach seine sampling periods in Sinclair Inlet, 2002. Numbers represent sample size. Error bars indicate +1 SE.

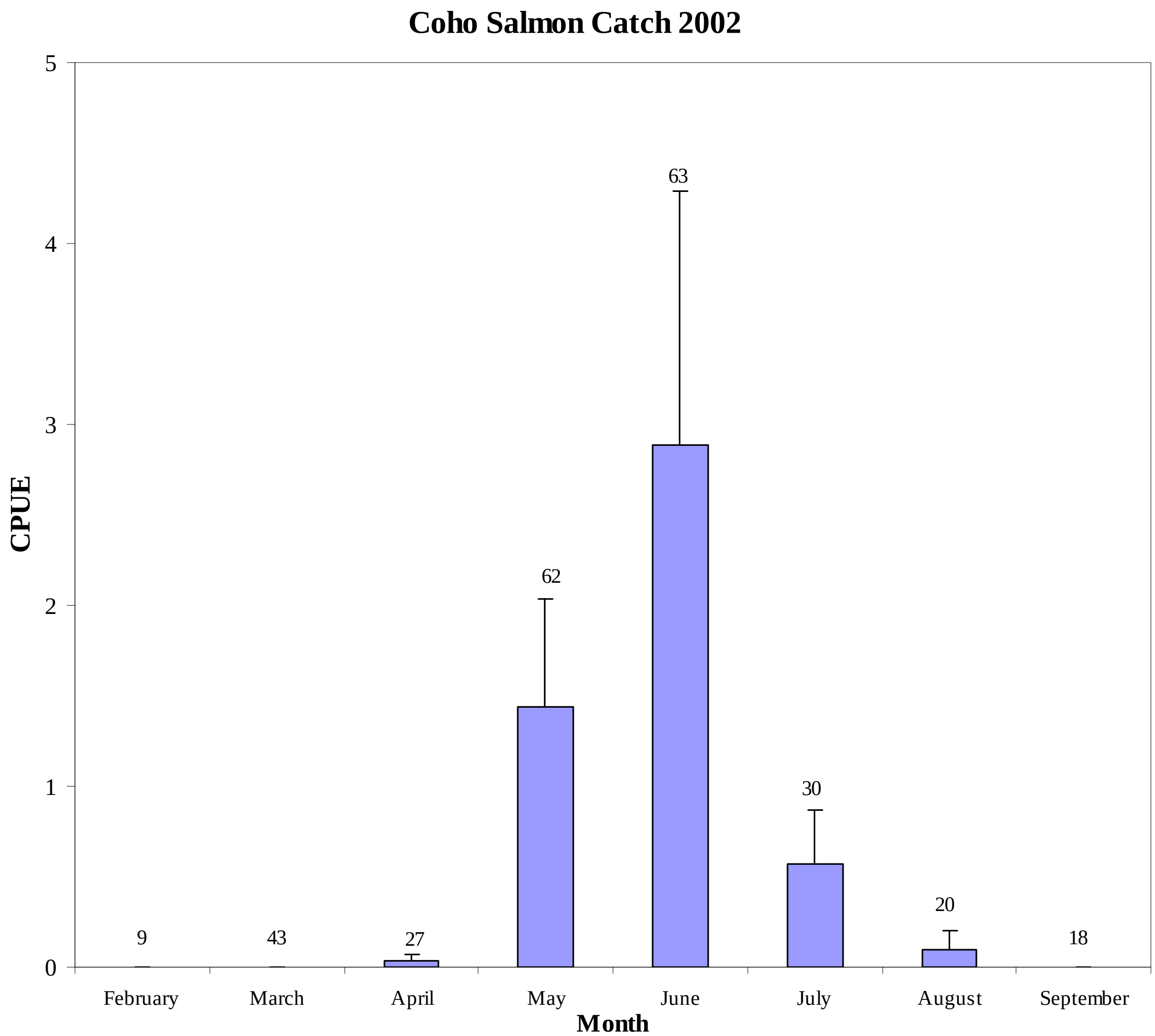


Figure 7. Monthly catch per unit effort (CPUE) of juvenile coho salmon caught during regular beach seine and mark recapture sampling in Sinclair Inlet, 2002. Numbers above bars represent number of hauls for frequently sampled sites. Error bars indicate +1 SE.

IV. A. 3. Juvenile Chinook salmon: abundance patterns

General

In 2001, 732 juvenile Chinook salmon were caught during beach seining (including frequently sampled sites only) of which 89 had intact adipose fins (12.2%), indicating they might be naturally produced (Table 10). During 2002, a total of 798 Chinook salmon juveniles were caught in the RBS sampling (frequently sampled sites only) (Table 10). Of these, 717 or 90.6% were known to have originated from a hatchery while 75 (9.4%) were unmarked (i.e. intact adipose fin, no CWT, no pigment mark) and so could potentially be naturally produced fish. During mark recapture sampling in 2002, we collected 3,673 juvenile Chinook salmon of which 3,252 (88.5%) were of hatchery origin; 11.5% of these were "wild" (i.e. unmarked).

Table 10. Summary of Chinook and coho salmon catch for all types of gear during sampling in 2001 and 2002. The summary does not include infrequently sampled sites for RBS 2001 or RBS 2002. Catch summary for all RBS sites is included in Appendix B and C.

	Chinook salmon			Coho Salmon			
	Total	**"Wild"**	**Hatchery**	**Total**	**"Wild"**	**Hatchery**	**Effort**
Regular Beach Seine (RBS) 2001	732[a]	89	605	2[b]	1	1	120
Regular Beach Seine (RBS) 2002	798	75	717	266	138	128	180
Mark Recovery Seine (MR) 2002	3,673	421	3,252	25	14	5	96
Surface Tow Net (STN) 2002	1,892	188	1,704	19	15	4	144
Purse Seine 2002	663	49	614	46	31	15	10

[a]- *38 adult Chinook salmon also captured (not included)*
[b]- *5 adult coho salmon also captured (not included)*

Effects of Tide and Time of Day

During RBS sampling in both 2001 and 2002, samples were collected during both day and night and at different tidal stages. Mark recapture collections only occurred during the daytime but during both flood and ebb tides. We used these data to examine differences in juvenile Chinook salmon catch as a function of time of day (day versus night) and tidal stage (slack tide sets were considered to be those started within one hour of slack tide). Data from the frequently sampled sites from both 2001 and 2002 was used separately in this analysis.

Using the RBS data sets, we were unable to detect differences in overall abundance of hatchery or "wild" juvenile Chinook salmon with respect to stage of tide in either 2001 or 2002 (Table 11; unpaired t tests, $p > 0.05$). Some of the differences in means were considerable. For example, the catch of hatchery origin fish during flood tides in 2001 was nearly 10 times larger than catch during high slack tidal stages. This, usually, was due to several hauls with large catches. There was a large amount of variability (high coefficient of variation), especially associated with the hatchery fish data, which may have obscured any differences. In 2002, we divided the data into day and night data sets to evaluate interaction between tidal stage and time of day and retested the effects of tidal stage. Again, we found no differences for either hatchery or “wild” fish (Table 11).

In contrast to tidal stage, our analyses revealed some differences between daytime and nighttime catches of juvenile Chinook salmon (Table 12). In 2001, there was no difference in catch of hatchery origin juvenile Chinook salmon (unpaired t test, $p > 0.05$) from daytime and nighttime collections but we did find a difference for unclipped (“wild”) juvenile Chinook salmon (unpaired t-test, $t = -2.1$, $p < 0.05$). For the 2002 RBS data set, we found no effect of time of day on juvenile Chinook salmon CPUE for all tidal stages (frequently sampled sites only). In 2002, we had sufficient samples to test for day-night differences in juvenile Chinook salmon catches during flood and ebb tides separately (Table 12). Sample sizes for collections made around slack tide were too small to analyze separately. When data were partitioned in this way, we found significantly higher catches of “wild” fish occurred at night during ebb tide ($t = -2.2$, $p = 0.03$) but no other differences were found (Table 12). These results suggest that combining data collected at different tidal stages and times of day would not result in significant biases when examining spatial and temporal patterns in abundance.

Table 11. Effect of tide on beach seine catch of juvenile Chinook salmon in Sinclair Inlet, 2001 and 2002, using data sets (A) 2001 RBS and (B) 2002 RBS. Pair wise comparisons were unpaired t-tests for n=2 and one-way ANOVA for n>2. Multiple comparisons were made with Tukey's HSD (honestly significant difference) test.

A- 2001 RBS	***N of Hauls***	***Mean CPUE***	***SD***	***Statistic***	***Significance***	***df***
"Wild"						
Ebb	26	1.2	2.5	F = 0.69	p =0.50	2
Flood	45	1.0	1.8			
High Slack	18	0.5	0.9			
Hatchery						
Ebb	26	3.5	4.9	F = 1.00	p = 0.37	2
Flood	45	10.0	37.9			
High Slack	18	1.1	1.6			

B- 2002 RBS		***Mean***				
"Wild"	***N of Hauls***	***CPUE***	***SD***	***Statistic***	***Significance***	***df***
Overall						
Ebb	76	0.5	1.1	F = 0.31	p = 0.74	2
Flood	69	1.4	1.0			
Low Slack	21	0.8	2.4			
Day						
Ebb	31	0.1	0.3	t = -1.28	p = 0.21	63
Flood	34	0.3	0.6			
Night						
Ebb	45	0.6	1.2	t = -0.12	p = -0.91	78
Flood	35	0.6	1.2			
Hatchery						
Overall						
Ebb	76	4.8	9.3	F = 0.01	p = 1.00	2
Flood	69	4.5	12.2			
Low Slack	21	6.5	22.1			
Day						
Ebb	31	1.4	3.6	t = -0.53	p = 0.60	63
Flood	34	2.5	6.9			
Night						
Ebb	45	5.0	10.0	t =-0.1	p = 0.92	78
Flood	35	6.5	15.6			

Table 12. Effect of time of day on beach seine catch of juvenile Chinook salmon in Sinclair Inlet, 2001 and 2002, using data sets (A) 2001 RBS and (B) 2002 RBS. All data was square root transformed. Pair wise comparisons were made using unpaired t-tests.

A- 2001 RBS	***N of Hauls***	***Mean CPUE***	***SD***	***Statistic***	***Significance***	***df***
"Wild"						
Day	74	0.8	1.8	t= -2.1	p = 0.04	93
Night	21	1.6	2.2			
Hatchery						
Day	74	7.3	30.0	t = 0.3	p = 0.79	93
Night	21	2.8	4.6			

B- 2002 RBS	***N of Hauls***	***Mean CPUE***	***SD***	***Statistic***	***Significance***	***df***
"Wild"						
Overall						
Day	79	0.3	1.3	t = -1.32	p = 0.19	174
Night	97	0.5	1.1			
Ebb						
Day	31	0.1	0.3	t = -2.15	p = 0.03	74
Night	45	0.6	1.2			
Flood						
Day	34	0.3	0.6	t = -1.34	p = 0.18	67
Night	35	0.6	0.2			
Hatchery						
Overall						
Day	79	3.2	12.3	t = -1.11	p = 0.27	174
Night	97	4.7	11.8			
Ebb						
Day	31	1.4	3.6	t = -1.84	p = 0.07	74
Night	45	5.0	10.1			
Flood						
Day	34	2.5	6.9	t = -1.22	p = 0.23	67
Night	35	6.5	15.6			

Differences Between North and South Shorelines

The CPUE of Chinook salmon caught along the north shore of the Inlet was compared to the CPUE of Chinook salmon caught along the south shore of the study area in both 2001 and 2002 (Table 13). In 2002, we made this comparison separately using the RBS and MR data sets (using the frequently sampled sites only). With the exception of unclipped juvenile Chinook salmon caught during the RBS sampling in 2001, the overall CPUE of juvenile Chinook salmon (both hatchery origin and unclipped fish) was consistently greater along the north shore than along the south shore. The greatest difference occurred for the MR data set in 2002 where the overall CPUE of hatchery juvenile Chinook salmon for north shore sites was about 54% greater than the CPUE of south shore sites (Table 13). However, none of the differences were significant for either hatchery or wild fish in any of the data sets (two tailed unpaired t-tests, $p > 0.05$) indicating differences in CPUE between shorelines were not significant.

To further investigate this trend, we tested the effect of shoreline on Chinook salmon catch, we tested two time periods individually. We considered the possibility that the hatchery releases from Gorst Creek and other hatchery fish entering the Inlet may have had different behaviors because of their origins and different amounts of time they had been in Puget Sound before entering Sinclair Inlet. We considered that juvenile Chinook salmon entering the system from Gorst Creek might respond differently to current patterns and water movements in the study area because of where they enter the Inlet (i.e., in the extreme west end). Using the 2002 RBS data set, we tested the effect of shoreline on Chinook salmon abundance during two time periods: 1) June and early July (when the Gorst Creek hatchery releases were most abundant in the Inlet), and 2) late July to September when our mark recapture results indicated the Gorst Creek fish had left the Inlet. However, despite separating the data into different time period, we still could not detect a difference (two tailed unpaired t-tests, $p > 0.05$) in the catch of juvenile Chinook salmon associated with the two shorelines.

Table 13. Effect of location (shoreline and area) on beach seine catch (CPUE) of juvenile Chinook salmon in Sinclair Inlet, 2001 and 2002. Data sets used were (A) 2001 RBS, (B) 2002 RBS, and (C) 2002 MR. Data was square root transformed. Pair-wise comparisons were unpaired t-tests for n=2 and one-way ANOVA for n > 2. For significant ANOVAs, Tukey's HSD test was used to determine differences between treatments at p = 0.05.

A- 2001 RBS	***N of Hauls***	***Mean CPUE***	***SD***	***Statistic***	***Significance***	***df***	***Treatment Differences***
"Wild"							
North	46	0.9	2.3	t = -0.73	p = 0.47	93	
South	49	1.0	1.4				
Hatchery							
North	46	7.8	34.9	t = 0	p = 0.99	93	
South	49	5.0	15.6				
"Wild"							
Area 1	41	1.6	2.5	F = 5.20	p = 0.007	2	Area 1> Area 2
Area 2	33	0.4	0.9				
Area 3	21	0.5	0.9				
Hatchery							
Area 1	41	12.7	39.7	F = 4.5	p = 0.01	2	Area 1 > Area 2
Area 2	33	1.2	2.2				
Area 3	21	2.1	4.1				

B- 2002 RBS	***N of Hauls***	***Mean CPUE***	***SD***	***Statistic***	***Significance***	***df***	***Treatment Differences***
"Wild"							
North	87	0.6	1.6	t = 1.5	p = 0.14	174	
South	89	0.3	0.7				
Hatchery							
North	87	5.1	15.3	t = 1.0	p = 0.33	174	
South	89	3.0	7.7				
"Wild"							
Area 1	61	0.4	0.9	F = 0.15	p = 0.86	2	
Area 2	80	0.5	1.5				
Area 3	35	0.3	1.1				
Hatchery							
Area 1	61	3.5	7.5	F = 0.71	p = 0.49	2	
Area 2	80	5.3	15.9				
Area 3	35	2.2	6.9				

C- 2002 MR	***N of Hauls***	***Mean CPUE***	***SD***	***Statistic***	***Significance***	***df***	***Treatment Differences***
"Wild"							
North	48	5.6	15.7	t = 1.19	p = 0.24	94	
South	48	3.2	9.6				
Hatchery							
North	48	46.4	111.3	t = 1.31	p = 0.19	94	
South	48	21.3	39.3				
"Wild"							
Area 1	24	9.0	16.2	F = 7.92	p = 0.007	2	Area 1> Area 3
Area 2	32	5.7	17.0				Area 2 > Area 3
Area 3	40	0.6	0.9				
Hatchery							
Area 1	24	55.3	72.5	F = 9.90	p < 0.0001	2	Area 1> Area 3
Area 2	32	53.8	125.7				Area 2 > Area 3
Area 3	40	4.7	5.6				

Temporal Trends

In 2001, we caught small numbers of juvenile Chinook salmon when we began RBS sampling in April (Figure 8). We did not sample in May and when we resumed sampling in June, we encountered peak catches; catches then declined rapidly in July and then remained at generally low levels until the end of sampling in September. In 2002, we began sampling in February but did not catch Chinook salmon until late May, which coincided with the first releases of fish from the Gorst Creek rearing ponds (Figure 9). Abundance of juvenile Chinook salmon in littoral areas of our study area in 2002 peaked in May and then declined in subsequent months. In both years, some juvenile Chinook salmon were still present in Sinclair Inlet on the last day of sampling (9/27/01 and 9/4/02). With the exception of August, the mean CPUE of juvenile Chinook salmon was similar in the same month when comparing between years (Figures 8 and 9). For example, the CPUE of hatchery juvenile Chinook salmon in 7/02 was 2.3 fish/haul and in 7/01 it was 1.9 fish/haul.

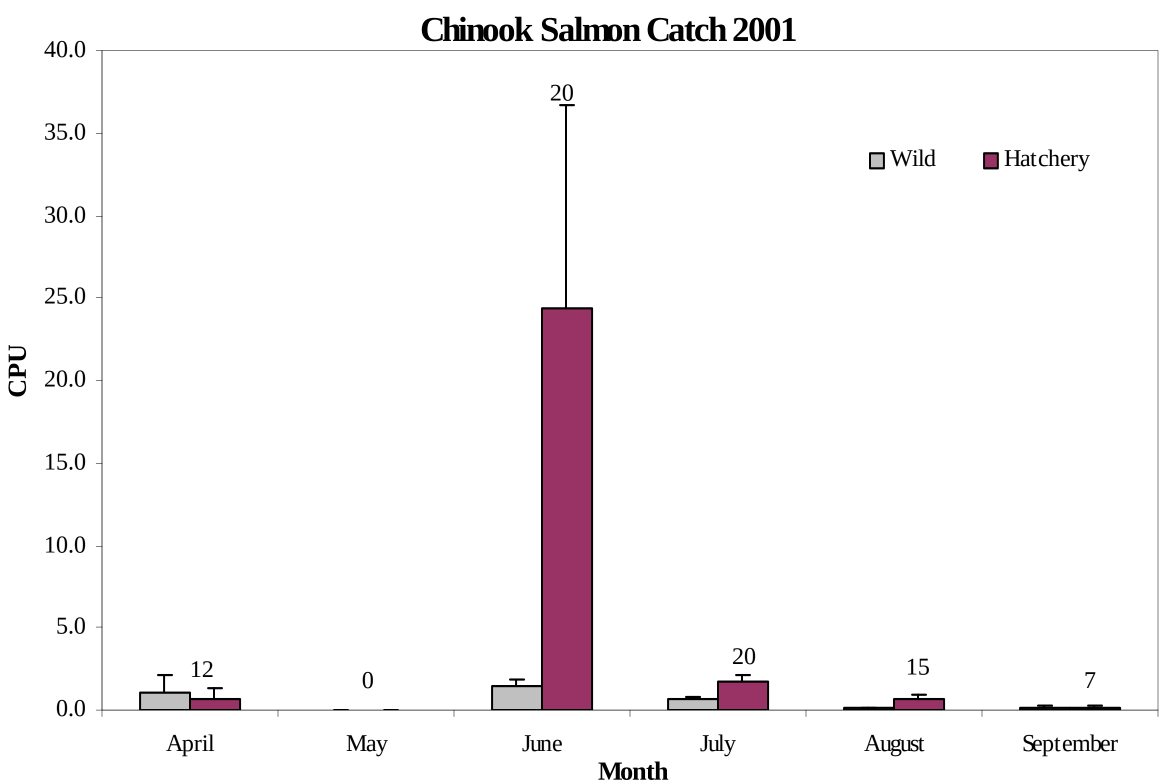


Figure 8. Monthly catch per unit effort (CPUE) for juvenile Chinook salmon during regular beach seine sampling in Sinclair Inlet, 2001 for daytime sampling only. Numbers above bars represent total number of hauls for frequently sampled sites. Error bars indicate +1 SE.

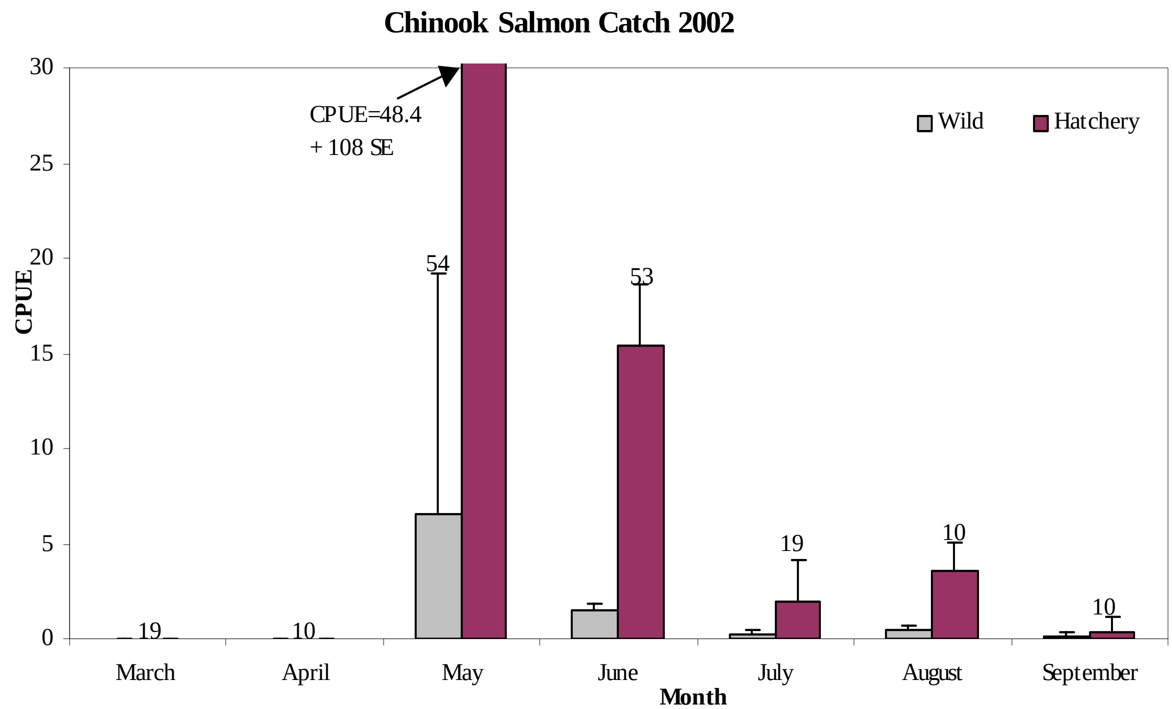


Figure 9. Monthly CPUE for juvenile Chinook salmon during regular beach seine and mark recapture beach seine sampling in Sinclair Inlet, 2002 for daytime sampling only. Numbers above bars represent total number of hauls for frequently sampled sites. Error bars indicate +1 SE.

Differences Between Sites: Effects of Littoral Zone Habitat Characteristics

There were considerable differences in catches of both hatchery origin and "wild" juvenile Chinook salmon between individual sites during both years (Appendices F and G). For example, mean CPUE in the MR data set ranged from 133.6 fish/haul at New Charleston to 2.3 fish/haul at Channel Marker 11 (Table 14). The mark/recapture beach seine data set from 2002 provided the best opportunity to examine differences between sites since: 1) we had consistent effort between sites (8 hauls at each of the 12 sites), 2) the effect of long term temporal variability was reduced because samples were collected over a five week period, 3) all data were obtained during daytime collection, and 4) juvenile Chinook salmon were abundant in Sinclair Inlet during the time period over which these samples were collected. We used a Kruskill-Wallis non-parametric statistical analysis to test for differences in CPUE of hatchery origin juvenile Chinook salmon among the 12 sites using this data set. The results of this analysis indicated that CPUE was significantly different among sites ($H = 20.9$, $p < 0.05$).

As noted previously, we examined effects of 8 different habitat factors that we could measure that we hypothesized could help account for between site variability in juvenile Chinook salmon catches (Table 14). The most important factor affecting Chinook salmon catches was location in the study area (i.e., whether the site was in Area 1, 2, or 3). For example, the five sites with the lowest average CPUE values of hatchery origin juvenile Chinook salmon (range= 2.1 - 9.1 total juvenile Chinook salmon/haul) occurred in Area 3 while three of the five sites with the highest mean CPUE values (range= 25.6 – 133.8 juvenile Chinook salmon /haul) came from Area 1 (Table 14). For both the 2001 RBS and 2002 MR data sets, there was a significant effect of Area on catch of both "wild" and hatchery origin juvenile Chinook salmon (one way ANOVAs, $p < 0.05$) (Table 13). The results of the Tukey's HSD comparisons suggested that abundance in Area 3 was generally lower than in the other areas (Table 13). We cannot explain why no relationship was detected in the 2002 RBS data set.

The lack of a clear relationship between most of the habitat variables we considered and juvenile Chinook salmon abundance could either reflect that no relationship exists or our qualitative assessment of these variables was an inadequate measure of these attributes. Other variables that we did not measure may also affect between site differences in juvenile Chinook salmon use.

Table 14. Effect of habitat characteristics on CPUE and size of hatchery juvenile Chinook salmon in Sinclair Inlet 2002.

Site	Dominant Substrate	Secondary Substrate	Shore	Upland Veg	Subtidal Veg	Slope	Shore	Area	CPUE (#/haul)	Mean Fork Length (mm)
New Charleston	gravel	sand	natural	yes	no	steep	South	2	133.8	83.3
Windy Point	gravel	cobble	riprap	no	no	steep	North	1	84.2	82.2
Ross Point	gravel	cobble	bulkhead	yes	no	medium	South	1	56.1	80.9
Old Charleston	sand	gravel	riprap	no	no	medium	North	2	47.3	82.4
Tattoo Beach	mud	sand	riprap	yes	no	gentle	South	1	25.6	79.6
Blackjack	gravel	cobble	riprap	no	no	medium	South	2	17.6	81.3
Boat launch	cobble	gravel	riprap	no	no	medium	South	2	17.1	80.9
Natural Beach	sand	gravel	natural	yes	no	gentle	South	3	9.1	83.4
Cabana Beach	gravel	cobble	bulkhead	no	no	steep	North	3	4.9	88.7
CTC Beach	gravel	cobble	natural	yes	sparse	medium	North	3	4.8	86.1
Enetai Beach	cobble	gravel	natural	yes	no	medium	North	3	3.8	91.4
Channel Marker #11	sand	gravel	riprap	no	no	gentle	South	3	2.3	82.4

IV. A. 4. Juvenile Chinook salmon: Size Trends

In April 2001, we caught juvenile Chinook salmon that were adipose clipped as small as 54 mm FL and unclipped Chinook salmon as small as 47 mm; the source of any of these fish cannot be determined precisely. The mean length of unclipped juvenile Chinook salmon in April 2001 was 55 mm FL, suggesting they were the progeny of naturally spawning Chinook salmon that emigrated into Sinclair Inlet soon after emergence. The mean fork length of adipose clipped (hatchery origin) Chinook salmon in April 2001 was approximately 20 mm larger (Figure 10a and 10b). This appeared to be primarily due to the presence of a number of adipose clipped fish present in the Inlet in April 2001 that were > 130 mm FL; these larger juvenile Chinook salmon were likely yearling fish reared at NOAA Fisheries Manchester that had been released recently at the Gorst rearing ponds. In 2001, the mean length of both hatchery and "wild" (unclipped) Chinook salmon steadily increased during the study from approximately 80 mm FL in June to approximately 130 mm FL in August (Figure 10a and 10b). Overall in RBS sampling, the mean fork length of hatchery-origin juvenile Chinook salmon in 2001 was 105.6 mm (SD= 29.9, N= 189) and the mean fork length of "wild" juvenile Chinook salmon was 102.9 mm (SD= 27.8, N= 75); this difference was not significant (two tailed, unpaired t-test, $p > 0.05$) (Table 15).

In 2002, the smallest juvenile Chinook salmon caught during the RBS sampling was larger than in 2001: 62 mm FL ("wild") and 71 mm FL (hatchery origin). The mean length of marked and unmarked juvenile Chinook salmon was comparable in each month and followed the same trends (Figure 11a, 11b). The average size of both types of fish was approximately 80 mm FL in May and June and increased by about 20 mm between June and July. A similar increase in size between June and July also occurred in 2001 (Figure 10). As in 2001, there were no differences in size of hatchery-origin and "wild" juvenile Chinook salmon in either the RBS or MR data sets in 2002 using unpaired t-tests ($p > 0.05$) (Table 15). For example, during mark recapture sampling the mean fork length of hatchery-origin juvenile Chinook salmon was 82.3 mm (SD= 6.4, N= 1,860) and the mean fork length of "wild" juvenile Chinook salmon was 81.6 mm (SD= 7.7, N= 243). The fork length of hatchery origin juvenile Chinook salmon caught during RBS sampling in 2002 was significantly smaller than in 2001 (2001: mean= 105.6 mm, SD= 29.9; 2002: mean= 97.6, SD= 18.5; unpaired t-test, $t= 4.6$, $p< .0001$). There was no difference in size of "wild" fish between 2001 and 2002 (t test, $p>0.05$)

Because the number of hatchery juvenile Chinook salmon measured during 2002 sampling was larger than in 2001, we focused our analysis of size using only data from 2002. Sample sizes of "wild" fish were not large enough to test. During RBS sampling, hatchery origin juvenile Chinook salmon caught during night time collections were significantly larger than juvenile Chinook salmon collected during day time sampling (Table 16). Because the net is likely more visible to the fish during the day, larger fish may be more successful at avoiding the net during daytime collections. During RBS sampling in 2002, we compared the average FL of hatchery origin juvenile Chinook salmon collected during ebb, flood, and low slack tides (we lacked sufficient sampling during high slack to include this in the analysis) (Table 16). The results of a one-way ANOVA of this data were highly significant ($F = 76.0$, $p < 0.0001$). Hatchery origin juvenile Chinook salmon collected during flood and low slack tidal conditions tides were not different in size but were significantly smaller than fish collected during ebb tides (Table 16). When the data was separated into day and night time collections and the effect of tide analyzed for each time period separately, fish caught during ebb tides at night were significantly larger than fish caught during flood tides by ($t = 14.0$, $p < 0.00001$) (Table 16). No difference was found for fish caught during the day ($p > 0.05$).

Comparisons of mean lengths at sites sampled during the MR study suggested that there was a relationship between Area and size of juvenile Chinook salmon. Juvenile Chinook salmon caught in Area 3 tended to be larger than juvenile Chinook salmon caught in Areas 1 and 2 (Table 14). For example, the average size of hatchery origin juvenile Chinook salmon caught at Enetai Beach, one of the eastern most sites, was the largest that we found (mean = 91.4 mm FL) during MR sampling. In contrast, the average size of hatchery origin juvenile Chinook salmon caught at Tattoo Beach (the western most site) over the same time period was the smallest found during the MR sampling (mean = 79.6 mm FL). When size data from sites in each Area in 2002 were compared using ANOVA (comparisons were done separately for MR and RBS data sets), the same pattern was observed. Juvenile Chinook salmon from Area 3 were larger than fish caught in the other two areas (Table 17). For example, hatchery fish caught during MR sampling in Area 3 average 86.8 mm FL, Area 2 averaged 82.3 mm FL, and Area 1 averaged 81.2 mm FL (ANOVA, $F = 53.0$, $p = 0.0005$, Tukey's Test: Area 3>Area 2> Area 1) (Table 17).

Using data from the RBS 2002 sampling, we found the fork length of hatchery juvenile Chinook salmon caught in Area 3 was not significantly different than fish collected in Area 1 but fish in both Areas were significantly larger than fish collected in Area 2 (Table 17) (one-way ANOVA, Tukey's HSD test, $p < 0.00001$). We then divided the data into two time periods (June to early July and mid-July to September) to account for dominance of the Gorst Creek releases in early summer and analyzed each time period separately (Table 17). Results of these analyses indicated that there was an effect of both time and Area on fish size. During the peak release (June/early July time period), the average size of hatchery-origin juvenile Chinook salmon collected in Area 3 was significantly larger than the average size of fish in either of the two other Areas (mean fork length during June/early July: Area 1 = 88.5 mm, Area 2 = 85.9 mm, Area 3 = 100.7 mm). During the mid-July September time period, there was no difference in size in each of the three areas (mean fork length: Area 1 = 119.9 mm, Area 2 = 116.4 mm, Area 3 = 115.5 mm). One explanation of these results is that in June and early July when fish from Gorst Creek dominate in Sinclair Inlet (see Section IV D), the juvenile Chinook salmon entering the Inlet from Gorst Creek are increasing in size as they move through and out of the Inlet. Thus, fish in Area 3 are larger than either of the two Areas because they are growing.

Both the MR and RBS data sets indicate that there were differences in size of juvenile Chinook salmon based upon the shoreline they were collected from, although these differences were < 5.0 mm in average size in all cases (Table 18). During MR sampling, both hatchery origin and “wild” juvenile Chinook salmon collected along the north shore were significantly larger (t-test, $p < 0.002$) than fish collected along the south shore (Table 18). During RBS sampling, we found no difference in size of “wild” origin fish (although sample sizes were low) based upon shoreline of capture whereas hatchery origin juvenile Chinook salmon captured along the south shore were significantly larger than fish captured along the north shore (t test, $t = -3.6$, $p<0.0001$, Table 18).

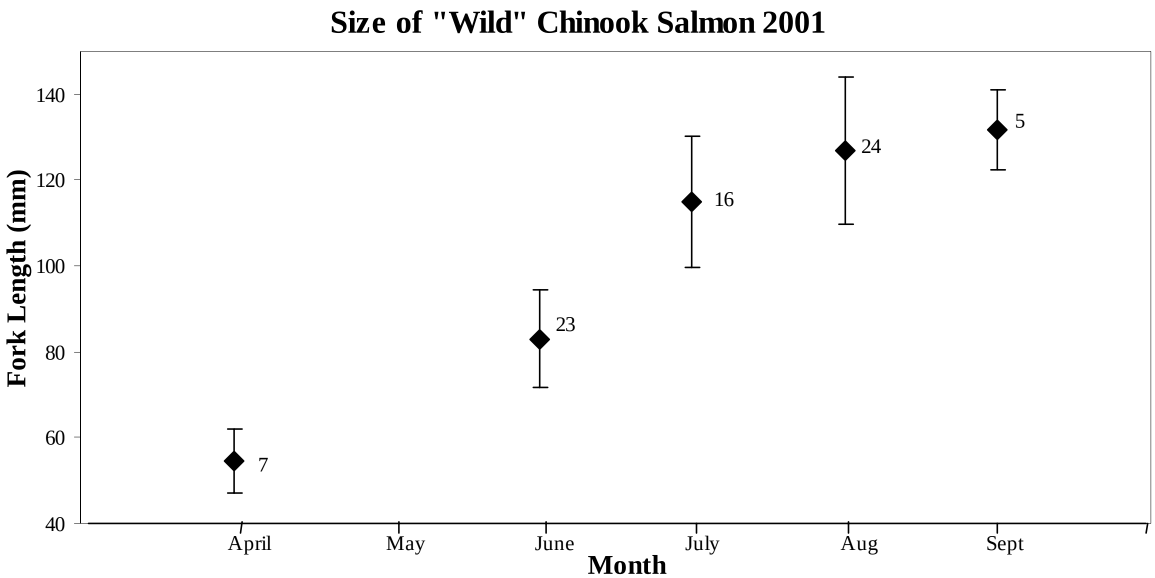


Figure 10a. Size trends for "wild" juvenile Chinook salmon collected in regular beach seine sampling in Sinclair Inlet in 2001. Numbers represent total fish measured. Error bars indicate +1 SE.

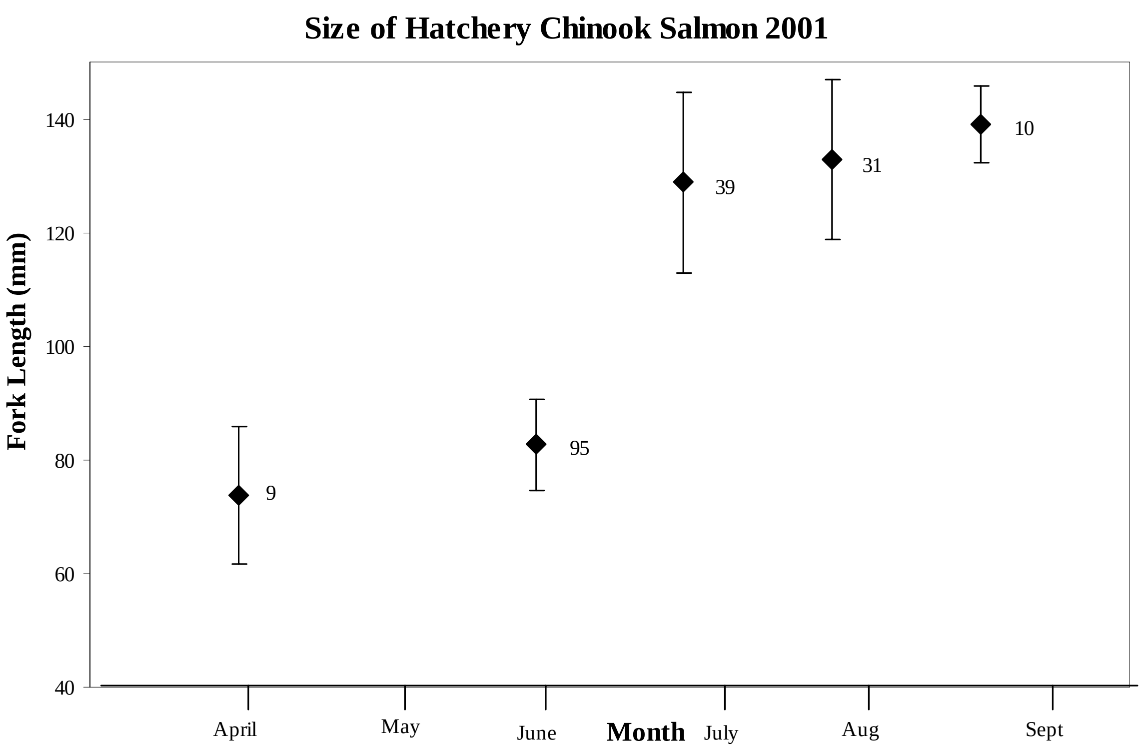


Figure 10b. Size trends for hatchery juvenile Chinook salmon collected in regular beach seine sampling in Sinclair Inlet 2001. Numbers represent total fish measured. Error bars indicate +1 SE.

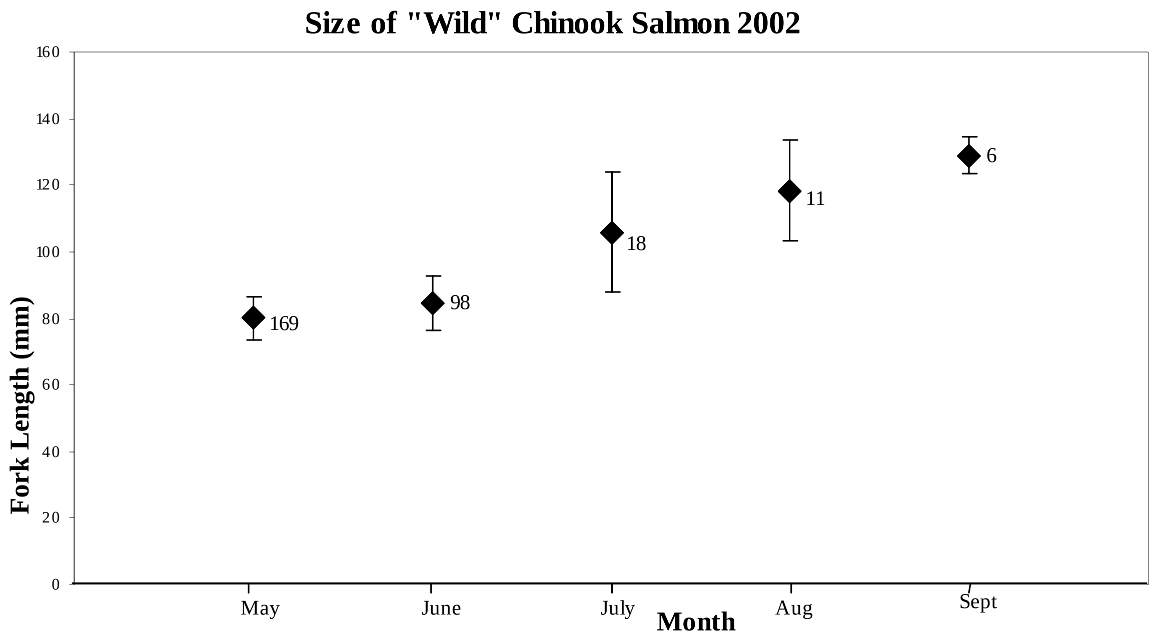


Figure 11a. Size trends for "wild" juvenile Chinook salmon in Sinclair Inlet in 2002. Regular and mark recapture sampling efforts were combined and all sites were pooled. Error bars indicate + 1SE.

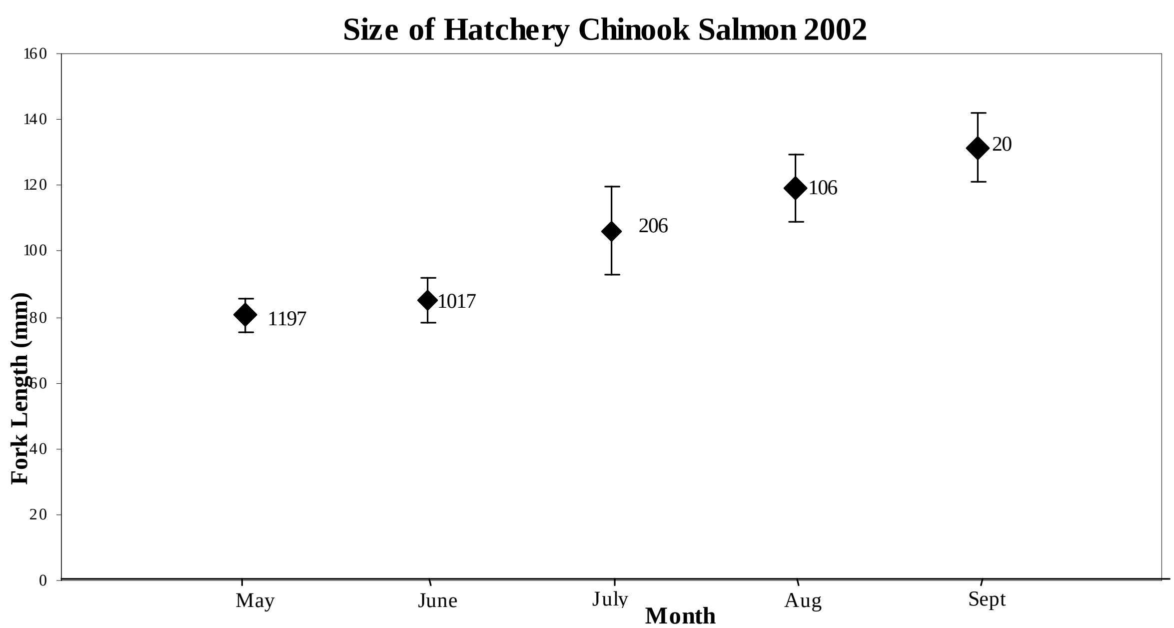


Figure 11b. Size trends for hatchery juvenile Chinook salmon in Sinclair Inlet in 2002. Regular and mark recapture sampling efforts were combined and all sites were pooled. Error bars indicate + 1SE.

Table 15. Comparisons of the overall size of hatchery and "wild" juvenile Chinook salmon in Sinclair Inlet from the 2001 RBS, 2002 RBS, and 2002 MR data sets. Pair-wise comparisons were made using unpaired t-tests.

	N of Fish	Mean FL (mm)	SD	Statistic	Significance	df
2001 RBS						
"Wild"	75	102.9	27.8	t = 0.29	p = 0.77	262
Hatchery	189	105.6	29.9			
2002 RBS						
"Wild"	64	100.1	20.6	t = -1.05	p = 0.29	782
Hatchery	719	97.6	18.5			
2002 MR						
"Wild"	243	81.6	7.7	t =1.58	p = 0.11	2100
Hatchery	1860	82.3	6.4			

Table 16. Comparison of time of day and tidal stage on size of juvenile Chinook salmon in Sinclair Inlet in 2002 using the 2002 RBS data set. Pair-wise comparisons were unpaired t-tests for n=2 and one-way ANOVA for n>2. Multiple comparisons were made with Tukey's HSD test. Not enough unmarked ("wild") fish were measured during the 2002 RBS to make comparisons with these fish.

	N of Fish	Mean FL (mm)	SD	Statistic	Significance	df	Treatment Differences
Hatchery							
Day	245	94.5	19.5	t = -3.15	p < 0.002	717	
Night	474	98.9	16.6				
Hatchery							
Flood	316	90.9	13.7	F = 76.0	p < 0.0001	2	Area 2>Area 1
Ebb	279	106.7	17.5				Area 2>Area 3
Low Slack	119	93.1	18.5				
Hatchery							
Day-Ebb	45	99.7	22.7	t = 1.7	p = 0.09	129	
Day-Flood	86	93.4	18.5				
Night-Ebb	234	108.0	16.1	t = 14.0	p < 0.0001	462	
Night-Flood	230	90.0	11.3				

Table 17. Comparison of location (Area) on size of juvenile Chinook salmon in littoral zone samples from Sinclair Inlet, 2002. Data sets used were 2002 RBS and 2002 MR data. One-way ANOVA was used to make comparisons; multiple comparisons were made with Tukey's HSD test. Not enough "wild" fish were caught during 2002 RBS to make comparisons.

	N of Fish	Mean FL (mm)	SD	Statistic	Significance	df	Treatment Differences
2002 RBS							
Overall Hatchery							
Area 1	218	102.5	18.2	F = 31.0	p < 0.0001	2	Area 3>Area 1
Area 2	407	93.1	16.8				Area 3>Area 2
Area 3	90	104.7	14.8				
June/ early July Hatchery							
Area 1	121	88.5	8.8	F = 60.8	p < 0.0001	2	Area 3>Area 1
Area 2	312	85.9	9.4				Area 3>Area 2
Area 3	66	100.7	13.6				
Jul -Sept Hatchery							
Area 1	97	119.9	10.1	F = 2.2	p = 0.11	2	
Area 2	95	116.7	14.0				
Area 3	24	115.5	12.5				
2002 MR							
"Wild"							
Area 1	153	80.5	7.0	F = 7.9	p = 0.0005	2	Area 3>Area 2
Area 2	64	82.2	7.4				Area 3>Area 1
Area 3	25	86.8	9.7				
Hatchery							
Area 1	760	81.2	5.9	F = 53.0	p < 0.0001	2	Area 3>Area 2
Area 2	895	82.4	6.0				Area 3>Area 1
Area 3	205	86.3	8.2				Area 2>Area 1

Table 18. Comparison of the effect of location (shoreline) on size (fork length) of juvenile Chinook salmon from littoral zone collections in Sinclair Inlet in 2002. Data sets used were 2002 RBS and 2002 MR data. Pair-wise comparisons were made using unpaired t-tests.

	N of Fish	Mean FL (mm)	SD	Statistic	Significance	df
2002 RBS						
"Wild"						
North	35	101.2	19.7	t = 0.27	p = 0.79	62
South	29	99.8	21.8			
Hatchery						
North	405	95.3	16.7	t = -3.6	p < 0.0001	713
South	310	100.2	18.7			
2002 MR						
"Wild"						
North	81	83.7	8.5	t = 3.1	p = 0.002	240
South	161	80.6	7.0			
Hatchery						
North	1083	83.3	7.0	t = 7.9	p < 0.0001	1858
South	777	81.0	5.3			

IV. B. Offshore Habitats

IV. B. 1. Surface Waters: Surface tow net collections

A total of 144 surface tow net (STN) hauls made from mid-May to mid-August resulted in the capture of 3,788 fish representing 20 different species (Table 7, Appendix H). The dominant species, representing 49.9% of the total catch, was juvenile Chinook salmon (Table 7). A total of 9.9% of the juvenile Chinook caught were unmarked (potentially wild fish), similar to the percentage of unmarked fish observed in littoral areas (e.g. Table 10). Threespine sticklebacks were the second most numerous species and accounted for 18.0% of the total catch. Only 19 juvenile coho salmon were found in nearshore surface waters (Table 20), suggesting juvenile coho salmon are rare in this habitat in Sinclair Inlet. A total of 504 juvenile chum salmon were caught during surface tow net sampling (Table 7); most of these fish were caught in Area 3 in the months of May and June (Table 19). The relatively low catches of juvenile chum salmon may have been a function of when we began sampling. STN sampling began in May, several months after juvenile chum salmon were first present in the Inlet. CPUE of juvenile chum salmon in beach seine sampling was greatest in April, suggesting the STN sampling began after the peak of juvenile chum salmon had occurred in the Inlet. In both Areas 2 and 3, CPUE of juvenile chum salmon was greater along the north shore than in the center of the Inlet or along the south shore (Table 20).

Juvenile Chinook salmon were not captured in STN hauls in May 2002. This is consistent with beach seine collections and further indicates that juvenile Chinook salmon were not present in the Inlet in 2002 until after the releases of hatchery fish into Gorst Creek. Peak CPUE of both “wild” and hatchery origin juvenile Chinook salmon occurred in July (Table 21) when fish were widely distributed throughout the study area. By August, relatively few juvenile Chinook salmon remained in surface waters (Table 21).

As with beach seining in littoral habitats, we analyzed day / night differences in catch of juvenile Chinook salmon with the tow net (Figure 12, Table 22). We did not consider the effect of tide as previous research suggests that there is no consistent effect of tide on tow net catches (Fresh 1979). We found that catches of hatchery origin juvenile Chinook salmon were greater at night than during the day (unpaired t-test, $t=-2.93$, $p < 0.02$). Average CPUE of hatchery origin juvenile Chinook salmon at night was over twice as large as during the day (Table 22). There was no difference in catch of “wild” juvenile Chinook salmon in surface trawls with respect to time of day (Table 22).

Differences in juvenile Chinook salmon abundance in nearshore surface waters with respect to area and shoreline were also examined (Table 23). Because some tows were made in the center of the Inlet in Areas 2 and 3, we included a stratum for Center of the Inlet tows. Combining all data, we found no difference in catch for either hatchery origin or “wild” juvenile Chinook salmon with respect to shoreline or Area of capture (Table 23). We had sufficient samples to separately analyze effects of Area and shoreline for July when fish were abundant but found similar results. Neither area nor shoreline were related to CPUE of hatchery origin and “wild” juvenile Chinook salmon in July (one-way ANOVAs, $p > 0.05$).

Not surprisingly, the average size of both hatchery origin and “wild” juvenile Chinook salmon increased with month (Table 24). For example, average size of “wild” juvenile Chinook salmon increased from 87.3 mm FL in June to 112.0 mm FL in August (Table 24). There was little difference in average size of “wild” and hatchery origin juvenile Chinook salmon in June (hatchery = 86.6 mm FL; “wild” = 87.3 mm FL). However, by August, the mean FL of hatchery origin juvenile Chinook salmon was 7.7 mm larger than that of “wild” juvenile Chinook salmon (hatchery = 119.7 mm FL; “wild” = 112.0 mm FL). There was an effect of the time of day that samples were collected on size of juvenile Chinook salmon for both “wild” and hatchery origin fish (Table 25). However, hatchery origin juvenile Chinook salmon caught at night were larger than hatchery origin fish caught during the day ($t = -3.95$, $p < 0.001$) while the size of “wild” juvenile Chinook salmon collected during the day was larger than fish collected at night ($t = 2.28$, $p = 0.02$).

Collection location appeared to be related to juvenile Chinook salmon size (Table 26). Hatchery origin juvenile Chinook salmon collected in the center of the Inlet were larger than fish collected along either shoreline (one-way ANOVA, $F = 33.3$, $p < 0.0001$). No difference was found for “wild” juvenile Chinook salmon (Table 26). Similar to fish associated with littoral habitats, juvenile Chinook salmon collected from surface waters in Area 3 were larger than those collected in Area 1 or 2 (Table 26). For example, “wild” juvenile Chinook salmon collected in Area 3 average nearly 9.0 mm longer than fish collected in Area 2 (Table 26; $t= -4.2$, $p < 0.0001$; sample size was insufficient in Area 1).

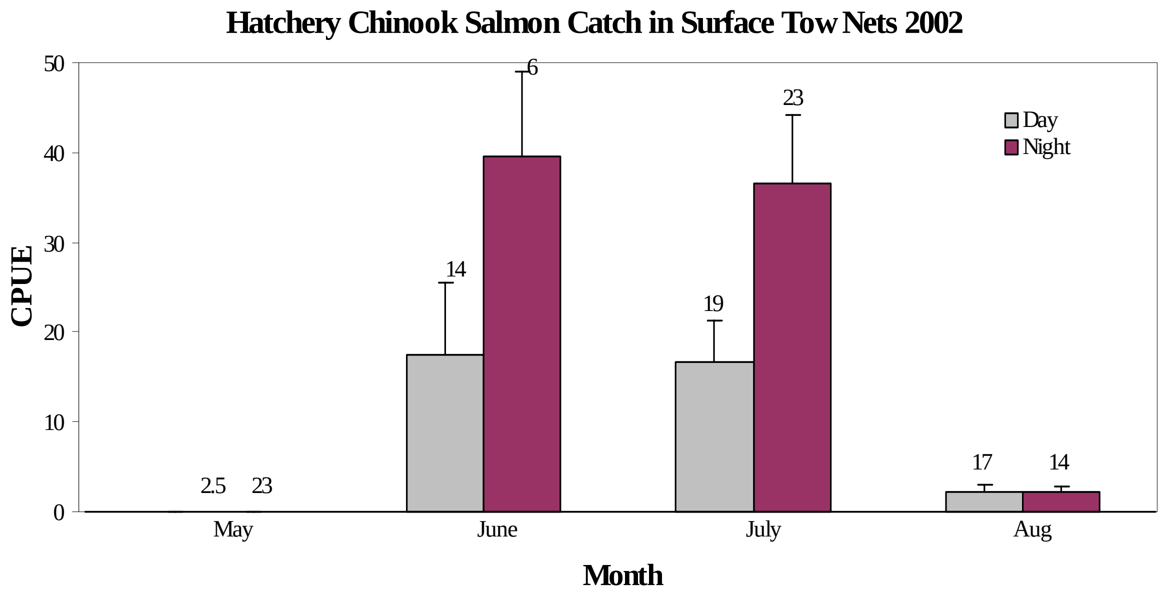


Figure 12a. Monthly day and night trends of hatchery juvenile Chinook salmon during surface tow net sampling in Sinclair Inlet in 2002. All sites were pooled. Numbers above bars represent number of hauls.

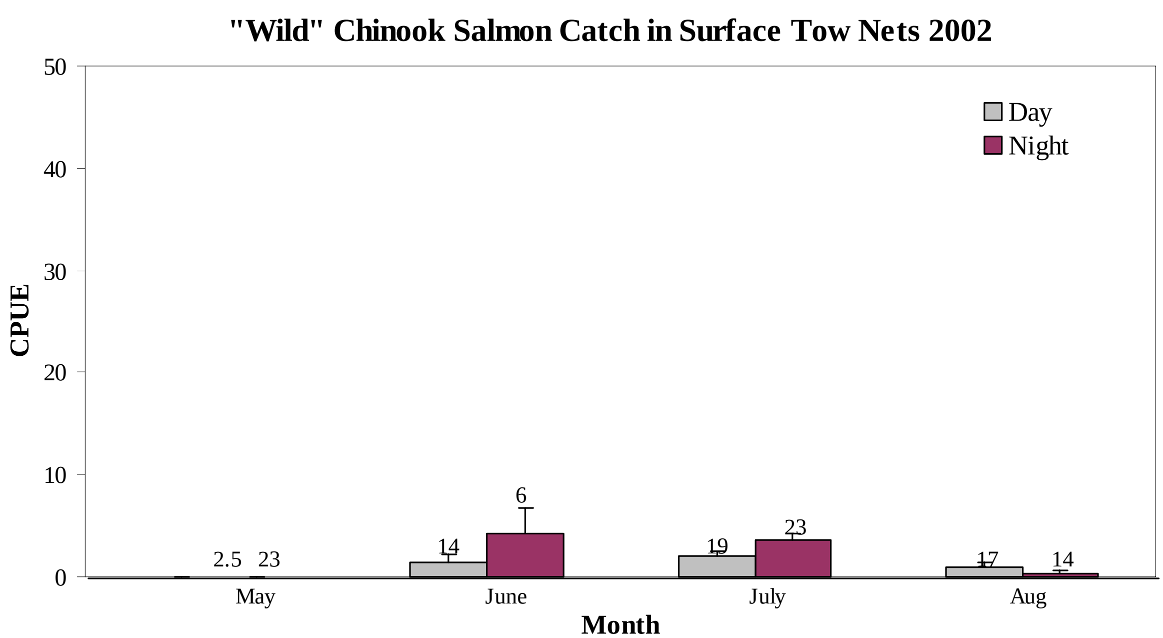


Figure 12b. Monthly day and night trends of "wild" juvenile Chinook during surface tow nets sampling in Sinclair Inlet in 2002. All sites were pooled. Numbers above bars represent number of hauls.

Table 19. Total numbers caught, effort, and CPUE of chum salmon, coho salmon and forage fish (Pacific herring, surf smelt, and Pacific sandlance) during surface tow net (STN) sampling in Sinclair Inlet, 2002.

		Chum Salmon		Coho Salmon		Forage Fish[1]	
Month	**Effort**	**Numbers**	**CPUE**	**Numbers**	**CPUE**	**Numbers**	**CPUE**
May	51	193	3.8	3	0.1	32	0.6
June	20	117	5.9	2	0.1	14	0.7
July	42	172	4.1	13	0.3	111	2.6
August	31	22	0.7	1	0.0	30	1.0

Forage fish[1] Excludes larval stage forage fish.

Table 20. Total catch of chum salmon, coho salmon and forage fish (Pacific herring, surf smelt and Pacific sandlance) by location and shoreline during surface tow net (STN) sampling in Sinclair Inlet 2002.

Location	Shore	Effort	Chum	Coho	Forage fish[1]
1	center	12	6	1	31
1	north	15	60	2	47
1	south	11	53	1	8
2	center	22	19	1	17
2	north	19	50	6	7
2	south	20	18	0	56
3	center	17	125	2	0
3	north	8	110	2	17
3	south	20	63	4	4

Forage fish[1] Excludes larval stage forage fish.

Table 21. Monthly abundance trends of juvenile Chinook salmon for inshore and offshore sites during surface tow net sampling in Sinclair Inlet in 2002.

Day		**June**			**July**			**August**		
Area	**Shore**	**Effort**	**"Wild"**	**Hatchery**	**Effort**	**"Wild"**	**Hatchery**	**Effort**	**"Wild"**	**Hatchery**
1	inshore	4	2	64	4	2	17	4	1	3
1	offshore	0	0	0	1	0	4	1	0	1
2	inshore	4	16	171	4	14	91	3	6	23
2	offshore	2	0	8	2	8	99	3	8	6
3	inshore	2	2	2	6	10	62	3	0	3
3	offshore	2	0	0	2	4	42	3	2	1

Night		**June**			**July**			**August**		
Area	**Shore**	**Effort**	**"Wild"**	**Hatchery**	**Effort**	**"Wild"**	**Hatchery**	**Effort**	**"Wild"**	**Hatchery**
1	inshore	0	0	0	4	16	123	0	0	0
1	offshore	0	0	0	0	0	0	0	0	0
2	inshore	4	25	194	5	15	136	5	2	8
2	offshore	2	0	43	5	8	95	3	1	2
3	inshore	0	0	0	6	25	204	3	2	9
3	offshore	0	0	0	3	19	281	3	0	12

Table 22. Comparison of time of day (day / night) and catch (CPUE) of juvenile Chinook salmon with the surface tow net in Sinclair Inlet 2002. Pair-wise comparisons were made using unpaired t-tests.

	N of Hauls	***Mean CPUE***	***SD***	***Statistic***	***Significance***	***df***
"Wild"						
Day	50	1.5	2.2	t = -1.83	p = 0.07	91
Night	43	2.6	3.7			
Hatchery						
Day	50	11.9	19.7	t= -2.93	p = 0.02	91
Night	43	25.7	30.8			

Table 23. Comparison of location (Area and shoreline) and catch (CPUE) of juvenile Chinook salmon with the surface tow net in Sinclair Inlet in 2002. Comparisons were made using one-way ANOVA. Tukey's HSD test was used to determine differences between treatments.

	N of Hauls	Mean CPUE	SD	Statistic	Significance	df
"Wild"						
North	21	2.3	2.6	F= 1.6	p = 0.20	2
South	40	2.3	3.3			
Center	32	1.6	2.9			
Hatchery						
North	21	26.2	28.2	F= 1.1	p = 0.36	2
South	40	14.0	16.7			
Center	32	18.6	33.3			
"Wild"						
Area 1	18	1.2	2.1	F = 1.61	p = 0.20	2
Area 2	42	2.4	3.3			
Area 3	33	1.9	3.0			
Hatchery						
Area 1	18	11.8	17.2	F= 1.4	p = 0.27	2
Area 2	42	20.8	24.0			
Area 3	33	18.7	32.4			

Table 24. Monthly size trends of juvenile Chinook salmon collected with the surface tow net in Sinclair Inlet, 2002.

	N of Fish	Mean FL (mm)	SD
"Wild"			
June	36	87.3	8.3
July	102	105.4	8.8
August	22	112.0	8.5
Hatchery			
June	383	86.6	6.3
July	1087	109.2	8.9
August	68	119.7	9.5

Table 25. Comparison of time of day (day / night) and size of juvenile Chinook salmon collected with the surface tow net in Sinclair Inlet in 2002. Pair-wise comparisons were made using unpaired t-tests.

	N of Fish	Mean FL (mm)	SD	Statistic	Significance	df
"Wild"						
Day	67	104.7	12.3	t=2.28	p = 0.02	157
Night	92	100.4	15.9			
Hatchery						
Day	553	102.3	13.6	t= 3.95	p < 0.0001	1534
Night	983	105.1	13.0			

Table 26. Comparison of location (Area and shoreline) and size of juvenile Chinook salmon collected with the surface tow net in Sinclair Inlet, 2002. Pair-wise comparisons were unpaired t-tests for n=2 and one-way ANOVA for n>2. Tukey's HSD test was used to compare between treatments. ISS= Insufficient Sample Size.

	N of Fish	Mean FL (mm)	SD	Statistic	Significance	df	Treatment Differences
"Wild"							
North	39	102.4	11.9	F = 2.56	p = 0.08	2	
South	82	100.5	12.9				
Center	39	105.6	10.1				
Hatchery							
North	481	100.4	14.5	F = 33.3	p < 0.0001	2	Center>South
South	569	104.6	13.1				Center>North
Center	486	107.1	11.2				South>North
"Wild"							
Area 1	ISS	ISS	ISS				
Area 2	86	98.9	12.1	t = -4.2	p < 0.0001	137	
Area 3	53	107.2	9.9				
Hatchery							
Area 1	213	102.2	13.5	F= 143.8	p < 0.0001	2	Area 3>Area 1
Area 2	784	99.7	13.3				Area 3>Area 2
Area 3	539	111.2	9.6				Area 1>Area 2

IV. B. 2. Offshore: Purse seine collections

On July 19 and 20, 2002, we made 10 hauls with a large purse seine in Areas 2 and 3. Juvenile chum salmon were the most abundant of the seven species captured (47.9% of the total catch) followed by juvenile Chinook salmon (Table 7, Appendix I). These two species accounted for 92.7% of the fish caught during purse seining. “Wild” juvenile Chinook accounted for 7.4% of the juvenile Chinook that were caught (Table 10).

There were not enough “wild” fish caught to compare sizes of hatchery and “wild” juvenile Chinook salmon in the purse seine samples. Although there were some differences in mean size of “wild” juvenile Chinook salmon at each site, there were no clear patterns in these differences (Table 27).

Table 27. Size of juvenile Chinook salmon collected in purse seine samples in Sinclair Inlet 2002.

		"Wild"		Hatchery	
Location	**Shore**	**Fish Length (mm)**	**SD**	**Fish Length (mm)**	**SD**
Annapolis	inshore	90.1	10.1	95.1	9.3
Enetai	inshore	n/a	n/a	100.6	11.9
Enetai	offshore	n/a	n/a	101.8	11.2
Natural	inshore	n/a	n/a	98.4	10.1
Shipyard	offshore	93.3	10.1	93.7	8.7

IV. C. Residence Time of Hatchery Chinook Salmon Released From Gorst Creek

The average residence time of hatchery origin juvenile Chinook salmon from Gorst Creek was estimated from the MR sampling effort with a combination of fish spray marked with fluorescent pigment and fish with CWT. Average residence times were only computed for Areas 1 and 2 because few recaptures were made in Area 3. Recaptures made during STN or RBS sampling were not included in computing average residence time because so few marked fish were caught during sampling with these gear types and because effort was inconsistent; we did, however, use STN and RBS sampling to assess maximum residence time.

We were able to examine the behavior of six different release groups of juvenile Chinook, three of which were released on one date and three of which were released volitionally (Table 28, Appendix K). Computing residence times from the volitional releases is complicated by the fact fish emigrate over a period of time rather than on one date. To compensate for this, we used 5/23/02 for the release date for these three groups. This is three days after the ponds were opened and our observations of fish remaining in the ponds indicate that most fish had emigrated from ponds within 7-10 days after release. In addition, the catch of all groups of marked fish dramatically decreased after 5/31/02.

We caught relatively few marked fish despite considerable efforts to recapture these fish. For example, we only recaptured 117 of an estimated 35,000 red-marked fish released into Gorst Creek. Orange marked fish from Clear Creek also had a low recapture rate but this was expected (Appendix J) as they were released into Dyes Inlet. The recapture of several of these fish in Area 2 indicates some fish from Dyes Inlet move southwest upon entering the Sinclair Inlet area.

Despite differences in type of mark used and how the fish were released, average residence time of the six groups was short and consistent between groups. We estimated that average residence time of the hatchery Chinook salmon ranged from 5.4 to 7.6 days in Area 1 (mean residence= 6.2 days) and from 6.8 to 9.3 days in Area 2 (mean residence= 8.3 days) (Table 28). The longer residence time in Area 2 reflects the time taken by the fish to migrate to this area from the release site and then pass through this area. We speculate that the low overall recapture rate of fish is thus most likely a result of the short residence time of juvenile Chinook salmon in Sinclair Inlet. Because residence time was so short, most fish were only vulnerable to the beach seine for a short period near the beginning of the MR sampling.

Maximum residence time in littoral areas of the three release groups forced out of Gorst Creek on 5/19/02 was 36 days. Including the STN samples of these same three groups released on 5/19/02, our estimate of maximum residence time of hatchery juvenile Chinook salmon in Sinclair Inlet increased to 59 days. The latest date of recapture for any pigment-marked fish in Sinclair Inlet was one chartreuse fish on 8/7/02.

Although the number of marked fish we were able to measure was small, there was a general pattern of fish increasing in fork length from Area 1 to Area 2 (Table 29), which is consistent with what we observed for "wild" fish as well (see section: Juvenile Chinook salmon: size trends).

Table 28. Summary of marked juvenile Chinook salmon caught during MR beach seine sampling in Sinclair Inlet in 2002. Adjusted for subsampling.

		Average Residence Time (days)		
Color	**2002 Release dates**	**Area 1**	**Area 2**	**Area 3**
Red pigment[1]	5/19	5.4	9.1	12.0
Red pigment w/CWT[1]	5/19	7.2	7.6	0.0
CWT Gorst raceway[1]	5/19	5.5	9.3	22.0
Gorst ponds chartreuse pigment[2]	5/20 - 6/21	7.2	6.8	20.2
CWT Gorst pond (control)[2]	5/20 - 6/21	6.3	8.5	13.6
CWT Gorst pond (NATUREs)[2]	5/20 - 6/21	7.6	7.8	14.5

[1] Forced release on 5/19/02
[2] Volitional release; used 5/23 for residence time calculation

Table 29. Mean fork length of marked juvenile Chinook salmon caught with all recapture methods (RBS, MR, STN, and large purse seine) in Sinclair Inlet in 2002. All sites in each Area were combined.

	Pigment	**Size of fish (mm)**	***SD***	**# of fish**
Area 1	Red	80.6	*3.6*	12
	Chartreuse	83.0	*8.0*	9
	Red w/CWT	78.7	*3.9*	21
	Orange	94.0	*0.0*	1
Area 2	Red	85.6	*5.3*	14
	Chartreuse	87.8	*11.6*	40
	Red w/CWT	85.4	*16.0*	16
	Orange	109.0	*29.0*	3
Area 3	Red	95.0	*15.0*	3
	Chartreuse	87.9	*14.1*	9
	Red w/CWT	109.0	*0.0*	1
	Orange	0.0	*0.0*	0

IV. D. Recoveries of Coded Wire Tagged Chinook and Coho Salmon

Throughout this study, a number of Chinook salmon juveniles with CWT were caught in 2002 that had been released from outside the Sinclair Inlet study area (Figure 13, Table 30). Overall (including Gorst Creek), we caught hatchery Chinook salmon with CWT released from 14 different watersheds from as far away as Canada (Figure 13 and 14, Table 30). Not surprisingly, most of these (76.7%- based upon numbers expanded for sub-sampling) were from Gorst Creek. Fish from Grovers Creek, Big Soos (Green River drainage), and Nisqually River were the next most abundant. Fish from Grovers Creek (about 25 km to the North- Figure 13) were present in the study area on 5/28/02, within several days after they had been released (Appendix I). This indicates a rapid dispersal of these fish following their release. The first fish from Big Soos Creek Hatchery was recaptured on 6/14/02; 7 - 11 days after these fish were released from hatchery ponds into the Green River. Fish from the Nisqually River were first captured on 6/19/02 in the large purse seine. Most of the fish with CWT released from sites outside the study area were recaptured after the fish from Gorst Creek had left Sinclair Inlet (Appendix I). From 5/21/02 to 6/15/02, 90.5% of the CWT fish caught in Sinclair Inlet came from the Gorst Creek ponds. From 7/16/02 to 8/15/02, 36.9% of the CWT fish captured in Sinclair Inlet were from Gorst Creek.

The recoveries of juvenile Chinook salmon with CWT in Sinclair Inlet that originated from release sites located outside the Inlet indicates this area functions as rearing habitat for non-local hatchery fish (i.e. not released from a local area). Brennan et al. (2004) also reported the same type of pattern (use of an area by non-local hatchery fish) for central Puget Sound. We believe it is reasonable to hypothesize that naturally produced Chinook salmon from non-local streams are also rearing in this area. Clearly, this assumption depends upon whether hatchery fish at this time and at this size are a reasonable analog for wild fish at this stage of their life (Myers and Horton 1982; Levings et al. 1986) and that what we are measuring is not simply an artifact of the hatchery environment (e.g., the result of domestication effects). It is not possible to test this assumption without having CWT groups of wild fish or conducting an analysis of DNA of recovered unclipped Chinook salmon. Given that these hatchery fish are entering estuarine waters at the same time as some of the wild smolts, we think this assumption is reasonable.

Yearling coho salmon with CWT were captured in low numbers during the study. These fish were generally released from mid-Puget Sound facilities in April or May of 2002 (Table 31). No patterns in distribution or timing could be detected due to low sample size.

Table 30. Release locations and numbers of recaptured juvenile Chinook salmon with coded wire tags (CWTs) in Sinclair Inlet in 2002.

	Chinook w/CWT		
Release sites	**(Raw #)**	**(Adjusted for subsampling)**	**2002 Hatchery release dates**
Gorst Cr rearing pond (control) (Sinclair Inlet)	104	234	5/20-6/21
Gorst Cr rearing pond (NATUREs protocol)	101	330	5/20-6/21
Gorst Cr raceway (spray mark)	51	157	5/19
Grovers Cr (unclip) (north Kitsap)	38	77	5/20-5/29
Grovers Cr (ad clip)	31	41	5/20-5/29
Big Soos (2 codes) (Green R)	35	41	6/3-6/7
Nisqually R (6 codes)	16	21	5/7-6/4
Wallace R (2 codes) (Skykomish R)	8	9	6/15
Cowskull & Rushingwater Pond (Puyallup R)	5	5	6/14
Diru Cr (Puyallup R)	1	1	5/17-5/31
Hupp Springs (Minter Cr)	6	7	6/3
White River (subyearling)	5	5	5/29-5/31
White River (yearling)	1	2	4/1-4/30
Slater Slough (Lummi Sea Ponds)	2	3	5/15-5/17
Tulalip Cr (Whidbey Basin)	2	3	5/14
Chilliwack R (lower Fraser R)	1	1	5/27-5/31
Friday Cr (Samish R)	1	1	5/24
Gray Wolf (Dungeness R)	1	1	5/28
Whitehorse Springs (Stilliguamish R)	1	1	5/20-5/24
Total	**410**	**940**	

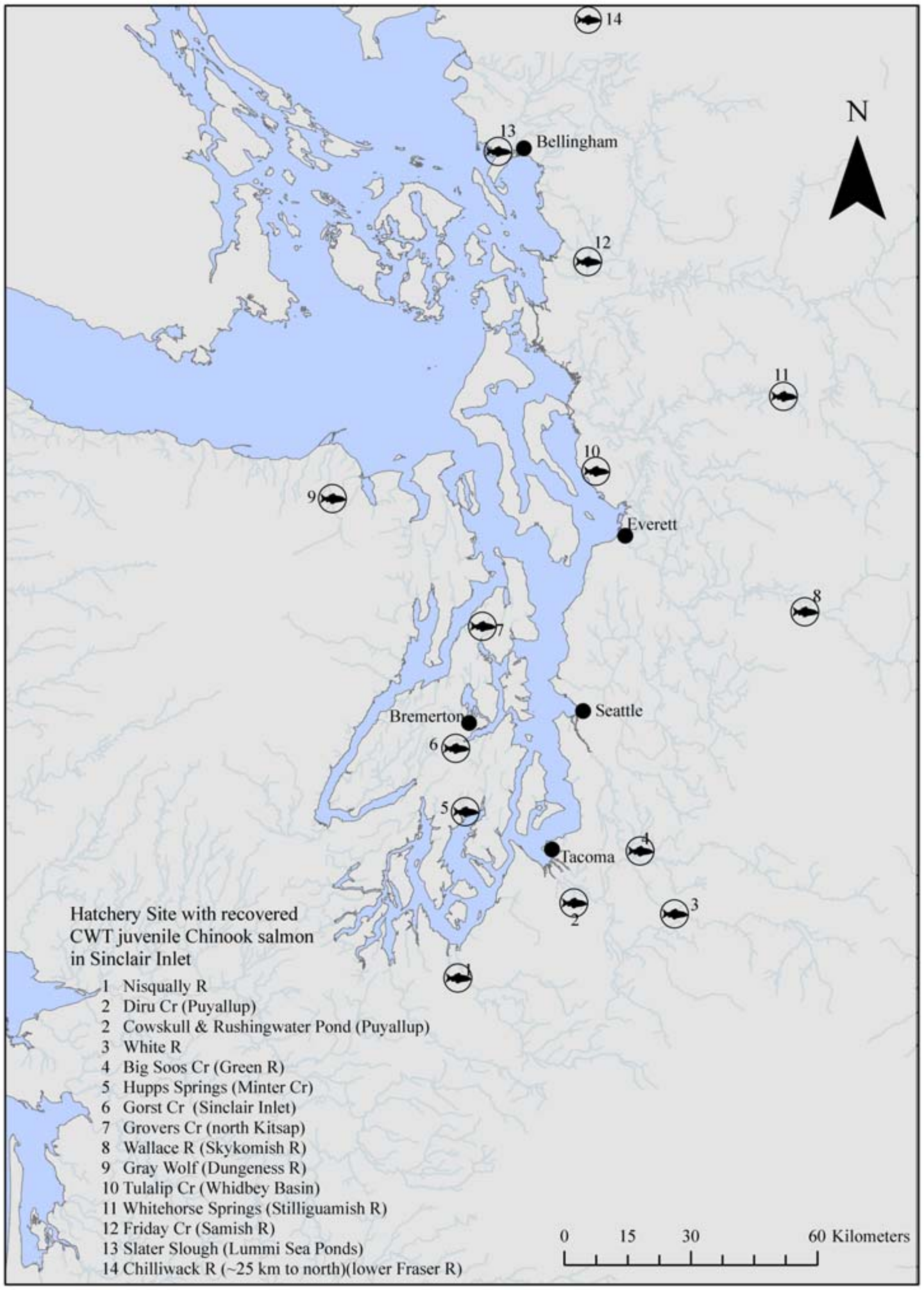


Figure 13. Hatchery release locations for juvenile Chinook salmon with coded wire tags (CWTs) captured in Sinclair Inlet in 2002.

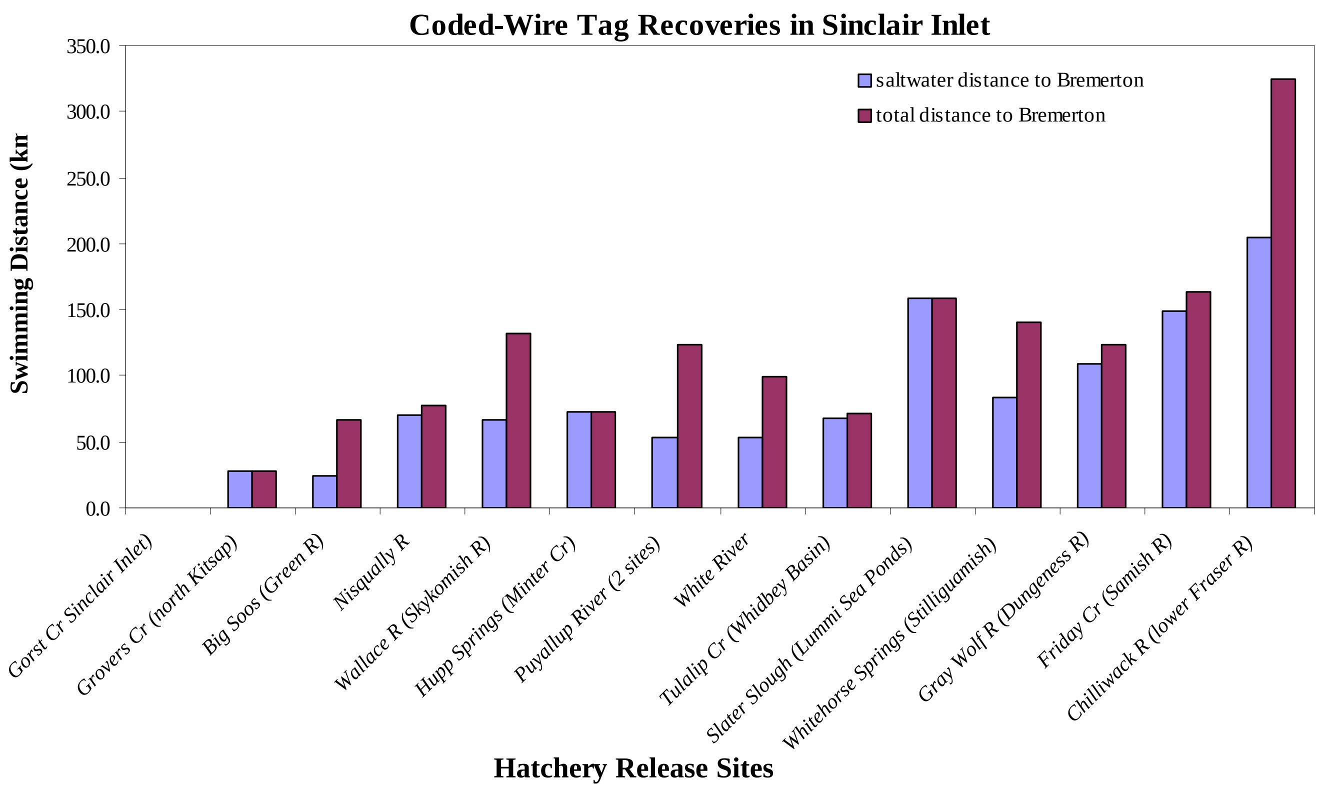


Figure 14. Distance between the Bremerton ferry dock and hatchery release sites for juvenile Chinook salmon captured with CWT in Sinclair Inlet in 2002. Saltwater distance is the estimated swimming distance from Bremerton to the nearest saltwater point for the release site. Total distance includes both saltwater distance and river mileage (when released upstream of the saltwater connection) for the release location.

Table 31. Origin of coho salmon yearlings recovered with coded wire tags (CWTs) in Sinclair Inlet during 2002.

Date	Recovery Location	Area	Capture Method	Release site	Release date
5/15/2002	CTC Beach	3	beach seine	Big Soos Cr (Green R)	4/6/02
5/16/2002	CTC Beach	3	beach seine	Issaquah Cr	4/15/02
5/16/2002	CTC Beach	3	beach seine	Issaquah Cr	4/15/02
5/16/2002	Enetai	3	beach seine	Issaquah Cr	4/15/02
5/24/2002	West Marker 11	3	beach seine	Crisp Cr (Green R)	5/6 - 5/10/02
6/4/2002	Natural	3	beach seine	Agate Pass net pens	5/21/02
6/5/2002	Ross Point	1	beach seine	Voights Cr. (Puyallup R)	4/29 - 5/06/02
6/6/2002	New Charleston	2	beach seine	Agate Pass net pens	5/21/02
6/6/2002	Boat launch	2	beach seine	Crisp Cr (Green R)	5/6 - 5/10/02
6/11/2002	Old Charleston	2	beach seine	Issaquah Cr	4/15/02
6/12/2002	CTC Beach	3	beach seine	Big Soos Cr (Green R)	4/6/02
6/12/2002	West Marker 11	3	beach seine	Crisp Cr (Green R)	5/6 - 5/10/02
7/3/2002	Cabana	3	beach seine	Peale Passage	5/15 - 5/30/02
7/17/2002	Center 3	3	tow net	Rushingwater (Puyallup)	5/6 - 5/7/02

IV. E. Habitat Surveys

We surveyed 10 km of the 26 km) of shoreline in the study area and categorized 646 hectares of intertidal habitat. Sand was the dominant substrate type, accounting for 205 hectares, or 32% of the habitat surveyed (Table 32). Sand with gravel was the second most dominant substrate accounting for 17% of the area surveyed. The dominant substrate in each area was different with mud the dominant substrate on the south shore of Area 1 and sand as the dominant substrate for most of Area 2 (south) and Area 3 (Table 32). Only 21.5% of the 10 km of shoreline surveyed was classified as natural; the remainder was armored with riprap, concrete, wood or rock (Table 32).

We field inventoried much of the intertidal habitat in the field along the south shoreline of Areas 1, 2 and 3, and the north shoreline in Area 3. The remaining shoreline is highly impacted by rock riprap, upland development and therefore has limited intertidal habitat. Evaluation of aerial photographs indicated that shoreline armoring was present for nearly 100% of the unsurveyed shoreline. Some form of shoreline armoring impacted 78.5% of the 10 km shoreline surveyed in the field; we estimate shoreline armoring covers 91% of the full 26 km of shoreline.

Table 32. Shoreline characteristics of field surveyed sections of Sinclair Inlet in 2002-03. Substrate characteristics were measured using GPS points at transects along shoreline from extreme high tide to –1 meter tidal elevation. Shoreline armoring was also recorded by GPS.

Substrate	**Area 1, South shoreline (west to Anderson Cr)**	**Area 2, South shoreline Annapolis to Natural Beach**	**Area 3, South shoreline (Natural Beach to Waterman)**	**Area 3, North shoreline (Manette to Enetai)**
Mud	73.9%			
Sand mixed with Gravel	5.1%	14.5%	15.4%	26%
Sand	0.1%	65.8%	31.3%	13.7%
Mixed Fines			10.9%	
Gravel	17%		5.1%	32%
Bedrock/Boulder	2.8%		17.3%	
Mixed Coarse			5.8%	26%
Large Rock		0.2%		1.6%
Cobble		18.5%	14.2%	
Sand w/ large rock		1%	0.1%	0.2%
Marsh Vegetation	1.1%			
Total area field surveyed	**95,343 m^2**	**207,332 m^2**	**121,639 m^2**	**222,541 m^2**
% of shoreline armoring				
Sloping riprap	49.9	93.4	42.1	5.7
Concrete/cement	29.8	1.9	19.8	64
Wood	8.3			1.3
Vertical rock riprap	2.8			
Unmodified/natural	9.2	4.7	38.1	29
Surveyed shoreline length	**2035 m**	**2668 m**	**3081 m**	**2568 m**
Total shoreline length	**4800 m**	**3470 m**	**3900 m**	**6210 m**

IV. F. Food Habits of Juvenile Chinook Salmon, Juvenile Chum Salmon and Cutthroat Trout

Food habits studies focused on characterizing the prey eaten by both hatchery and wild juvenile Chinook salmon in the littoral and offshore habitats of Sinclair Inlet. In addition, we examined stomach contents of juvenile chum salmon since they were one of the most abundant species present in the area. Stomachs of cutthroat trout were also examined as potential predators of juvenile Chinook salmon.

IV. F. 1. General diet characteristics

Juvenile Chinook Salmon

The stomach contents of 139 juvenile Chinook salmon (15 of which were empty) were analyzed from catch samples obtained from littoral habitats in 2001 while 163 stomachs (29 of which were empty) were analyzed from littoral habitats in 2002 (Table 33). From tow net samples obtained in 2002, we analyzed 92 stomachs, of which 15 were empty.

As described earlier, to simplify the analyses of diet data, prey were grouped into five different categories. Each of these categories was created to represent prey that were generally similar in the habitats they occupied (Table 6; Appendix M; Appendix N). For example, prey were classified as terrestrial if they occupied terrestrial habitats during their life histories; these were almost all insects. It is not possible to know more specifically where most 'terrestrial' prey originated. Terrestrial prey could come from distant areas on land and be transported by wind, their own wings, or streams; they could also originate from shorelines and vegetation adjacent to marine waters. Pelagic/neustonic prey were generally associated with the water column and surface layer. Although many terrestrial prey are probably eaten off the water surface, we distinguish terrestrial prey from pelagic/neustonic by the fact that pelagic prey do not commonly occupy habitats on land.

The diet of juvenile Chinook salmon in littoral habitats in both 2001 and 2002 included prey that were terrestrial, pelagic/neustonic, and benthic/epibenthic (Table 34). While we cannot determine precisely where any particular prey was consumed, the presence of such a diverse array of prey suggests juvenile Chinook salmon are feeding in a variety of microhabitats. Many of the insects are probably eaten directly off the surface while the crustaceans (e.g., crab zoea) likely are eaten in the water column. Amphipods and polychaetes are probably eaten from on or near the benthic surface.

Gravimetrically, the composition of each of the three dominant prey classes was similar in 2001 and 2002 with benthic/epibenthic prey types comprising 53.2% and 59.9% of the prey biomass eaten in 2001 and 2002, respectively (Table 34). However, the numeric composition of the three prey types differed between the two years (Table 34). The main difference between the two years was that marine benthic prey items were more abundant in diets in 2002 compared to 2001.

In littoral habitats, the most frequently occurring prey items in juvenile Chinook salmon stomachs in 2001 were psocopteran adults (bark lice) and pinnotherid crab (33.1% of full stomachs analyzed in 2001); in 2002, porcellanid crab were the most occurring prey (37.8% of full stomachs analyzed in 2002) (Figure 15 and 16; Table 34). Almost all the prey classified as terrestrial were insects, from one of 47 different taxa (Figure 15 and 16). At least five different types of crab (mostly zoea and megalopa stages) comprised the majority of pelagic type prey found in juvenile Chinook salmon stomachs: paguridae, grapsidae, porecellanidae, pinnotheridae, and *Cancer* sp. Nereid worms were the dominant prey type gravimetrically in both years. In 2001, nearly half of the biomass of all prey eaten consisted of nereid worms while they only comprised 1.8% numerically of all prey eaten (Table 34). In 2002, nereid worms comprised 19.6% of the prey biomass eaten. The numerically dominant prey in 2001 was pscopterans (25% of the prey eaten) and, in 2002, gammarid amphipods (23.5%) (Table 34).

In general, the juvenile Chinook salmon analyzed from offshore habitats in 2002 ate the same types of prey categories as fish from littoral habitats (Figure 17; Table 34). Pelagic/neustonic prey were the most important prey type in offshore habitats comprising 72.9% of the prey eaten numerically and 54.2% gravimetrically (Table 34). This suggests most of the fish occurring in offshore habitats were feeding in the water column. Porcellanid crab zoea were the dominant prey item eaten in offshore habitats, as they were the most frequently occurring prey item (58.0% of the full stomachs analyzed), numerically dominant (28.6%) and gravimetrically dominant (26.9%) (Figure 17; Table 34).

One unexpected result was the presence of plant material in numerous juvenile Chinook salmon stomachs. For example, nearly one-third of the full stomachs analyzed from offshore habitats had plant material. The juvenile Chinook salmon could indirectly consume plant material as they were foraging on prey associated with plants (e.g. sea lettuce, *Ulva spp.*).

Table 33. Number of full and empty stomachs and average size of specimens analyzed for stomach contents by species, habitat and year collected in Sinclair Inlet in 2001 and 2002.

			Full Stomachs		Empty Stomachs	
Year	***Habitat***	***Species***	***n***	***Length (mm)***	***n***	***Length (mm)***
2001	Littoral	Chinook salmon	124	105.5	15	131.4
2002	Littoral	Chinook salmon	134	99.1	29	105.2
2002	Offshore	Chinook salmon	77	102.5	15	111.8
2001/02	Littoral	Chum salmon	41	73.7	5	115.2
2001/02	Littoral	Cutthroat Trout	34	244.3	11	237.7

Table 34. Summary of major prey items eaten by juvenile Chinook salmon in littoral and offshore habitats in 2001 and 2002 based upon percent frequency of occurrence (FO), percent numeric composition (NC), and percent gravimetric composition (GC). Where one prey taxa was associated with several categories, we placed it into the dominant category for those taxa. Unknown prey types are not included. A "0" indicates <0.1% composition, and a "-" indicates that the prey item was not identified in stomachs.

		2001 Littoral *n=124*			**2002 Littoral** *n=134*			**2002 Offshore** *n=77*		
Ecological Category	**Prey Taxa**	**FO**	**NC**	**GC**	**FO**	**NC**	**GC**	**FO**	**NC**	**GC**
Terrestrial										
	Araneae	10.5	0.9	0.2	8.1	0.4	0.2	14.3	0.4	0.5
	Psocoptera	33.1	25.0	1.4	15.6	1.5	0.3	28.6	3.7	2.1
	Sciaridae	16.1	0.9	0.1	8.9	0.5	0.1	15.6	1.0	0.2
	Hodotermitidae	8.9	0.9	10.8	-	-	-	-	-	-
	Hymenoptera	8.1	0.2	0	5.2	0.2	0.3	11.4	0.3	0.2
	Formicidae	19.4	5.9	5.9	6.7	4.6	4.0	19.5	0.8	3.0
	Psyilldae	9.7	0.4	0.1	2.2	0.1	0	20.9	3.4	2.3
	Aphipods	22.3	1.2	0.1	14.1	1.1	0.2	31.2	2.9	0.8
	Mirridae	3.2	0.1	0	8.9	0.3	0.3	11.7	1.1	1.2
	Other	-	7.1	1.8	-	4.9	5.7	-	6.8	9.1
	Total	**-**	**42.5**	**20.4**	**-**	**12.6**	**11.1**	**-**	**20.4**	**19.4**
Pelagic-Neustonic	Paguridae	15.3	1.7	0.4	5.2	0.8	0.3	2.6	0	0
	Pinnotheridae	33.1	12.1	1.2	33.6	2.7	1.5	16.9	1.7	1.5
	Brachyura	14.5	1.1	0.1	20.9	7.2	0.6	39.0	22.0	3.6
	Grapsidae	3.2	0.4	0	5.9	2.9	0.4	22.1	6.0	1.3
	Porcellanidae	22.6	12.3	3.2	37.8	20.2	7.9	58.0	28.6	26.9
	Cancer sp.	2.4	0.4	0.4	3.7	0.3	0	33.8	11.2	3.3
	Mysidacea	4.8	0.8	5.6	4.4	0.5	1.6	-	-	-
	Hyperiidae	2.4	0.3	0.5	2.9	0.2	0.3	18.1	0.6	4.4
	Cirripidea	30.6	9.8	0.6	31.3	6.8	0.7	20.8	0.7	10.2
	Fish	5.7	0.1	13.4	4.4	0.3	12.3	7.8	0.3	2.1
	Other	-	3.6	3.5	-	4.9	0.6	-	1.8	0.9
	Total	**-**	**42.6**	**25.7**	**-**	**46.8**	**26.2**	**-**	**72.9**	**54.2**
Benthic-Epibenthic	Polychaeta	9.7	0.5	0.7	6.7	0.3	7.4	14.5	0.5	12.6
	Nereidae	16.9	1.3	48.3	10.4	0.9	19.6	1.3	0.1	0.1
	Caprellidae	10.4	1.4	0.6	10.4	1.4	0.6	3.9	0	0.9
	Hippolytidae	2.1	0.1	0.4	1.5	2.2	16.0	-	-	-
	Gammaridea	31.4	4.6	2.8	29.1	23.5	10.3	24.7	0.3	0.7
	Cumacea	13.0	1.8	0.1	11.9	3.0	0.2	3.9	0	0
	Tanaidae	4.8	0.2	0	-	-	-	2.6	3.0	1.0
	Other	-	2.2	0.3	-	9.0	5.8	-	2.0	8.1
	Total	**-**	**12.1**	**53.2**	**-**	**40.3**	**59.9**	**-**	**5.9**	**23.4**
Plant										
	Plant Material	14.5	0.3	0.1	4.4	0.1	1.9	31.2	0.5	1.7

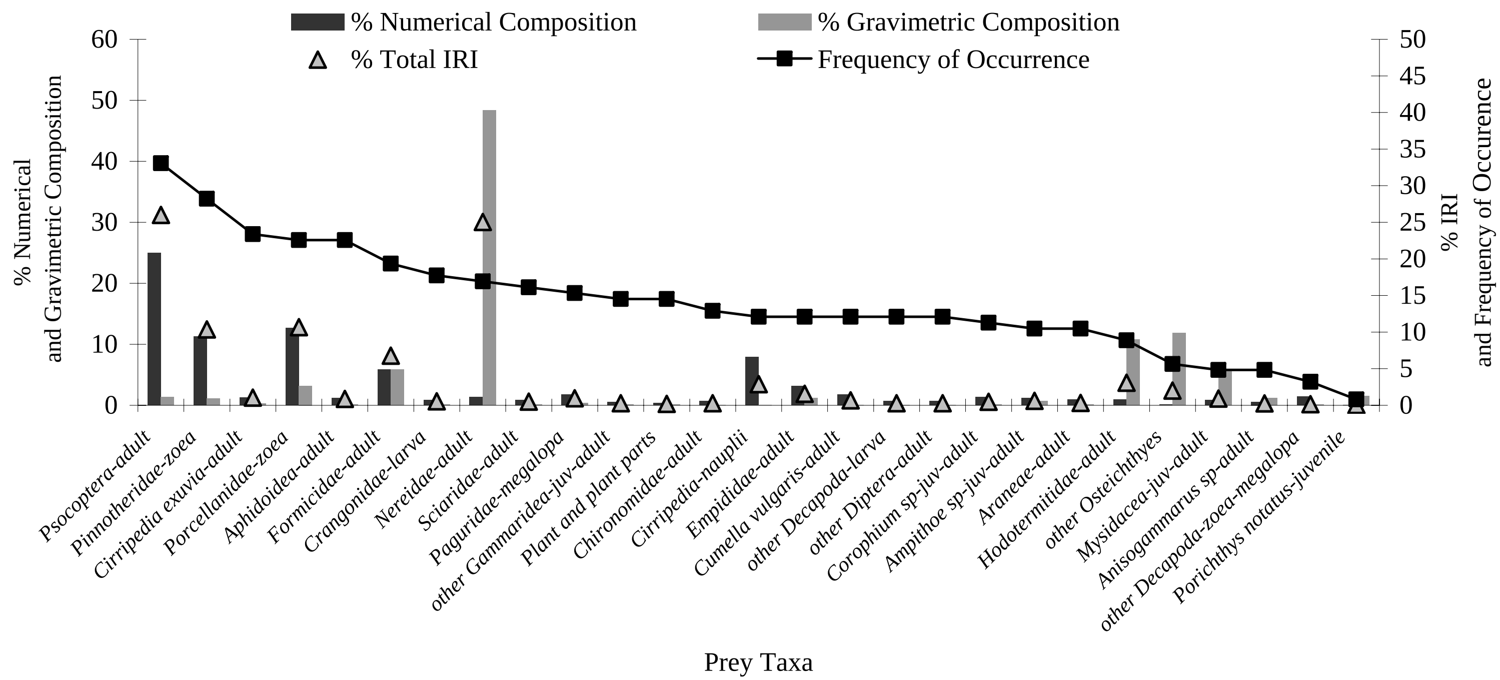


Figure 15. Diet of nearshore juvenile Chinook salmon in Sinclair Inlet in 2001 (n=124, FL 58-185mm, mean 105.5mm). Note: refer to the left axis for % composition and the right axis for frequency of occurrence and % IRI.

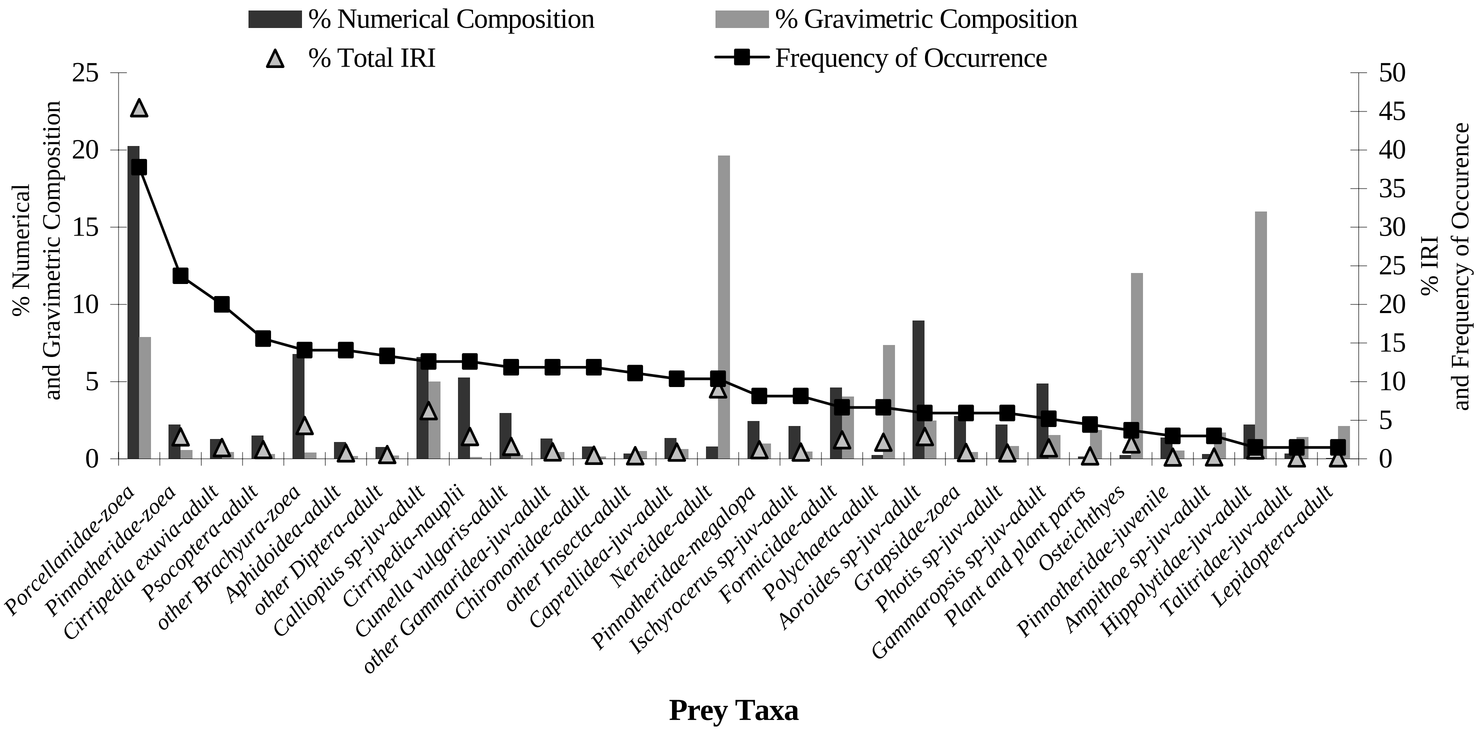


Figure 16. Diet of nearshore juvenile Chinook salmon in Sinclair Inlet in 2002 (n=134, FL 73-161mm, mean 99.1mm). Note: refer to the left axis for % composition and the right axis for frequency of occurrence and % IRI.

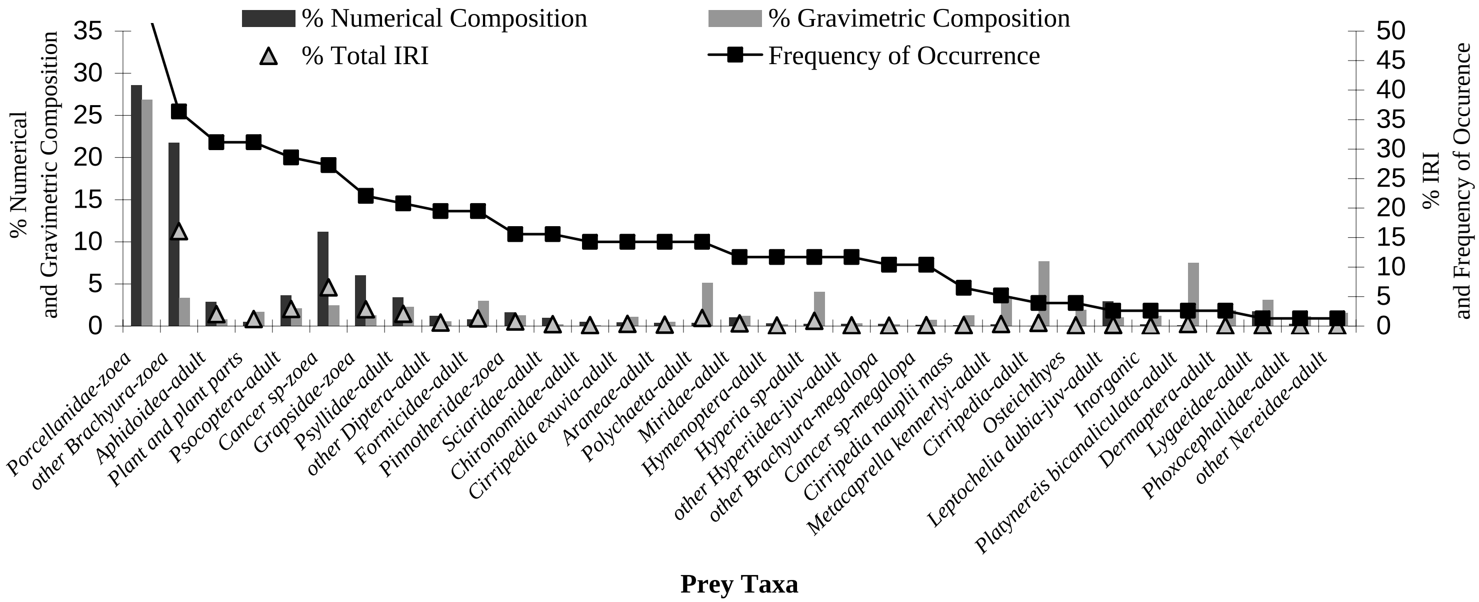


Figure 17. Diet of offshore juvenile Chinook salmon in Sinclair Inlet in 2002 (n=77, FL 70-135mm, mean 102.5mm). Note: refer to the left axis for % composition and the right axis for frequency of occurrence and % IRI.

Juvenile Chum Salmon

A total of 46 juvenile chum salmon stomachs were analyzed from 2001 and 2002 littoral collections of which 5 were empty (Table 33). Average size of the 41 fish with full stomachs was 73.7 mm FL. Although the number of samples was limited in 2002, diet of juvenile chum salmon from both years was nearly identical (Figures 18 and 19). In both years, larvaceans were the dominant prey numerically and gravimetrically and occurred in nearly all the juvenile chum salmon that were analyzed (Figures 18 and 19). Some of the prey types eaten by juvenile chum salmon and juvenile Chinook salmon were the same (e.g., crab zoea and gammarid amphipods). A major difference in diet of the two species was the consumption of larvaceans by juvenile chum salmon. Larvaceans were rare in juvenile Chinook salmon stomachs.

Cutthroat Trout

A total of 45 cutthroat trout stomachs, of which 11 were empty, were analyzed from 2001 and 2002 littoral collections (Table 33). All but one of the cutthroat were obtained in 2001. Average fish size for the 34 full stomachs was 244.3 mm FL. Fish were the primary prey of cutthroat trout, occurring in 59% of stomachs and accounting for 72.0 % of the prey biomass eaten (Figure 20). Fish did not comprise a large portion of the numbers of prey eaten (Figure 20) as the most abundant prey types were formicid insects (ants) and nereid worms. One juvenile Chinook salmon and one unidentified salmonid were found in the cutthroat trout stomachs.

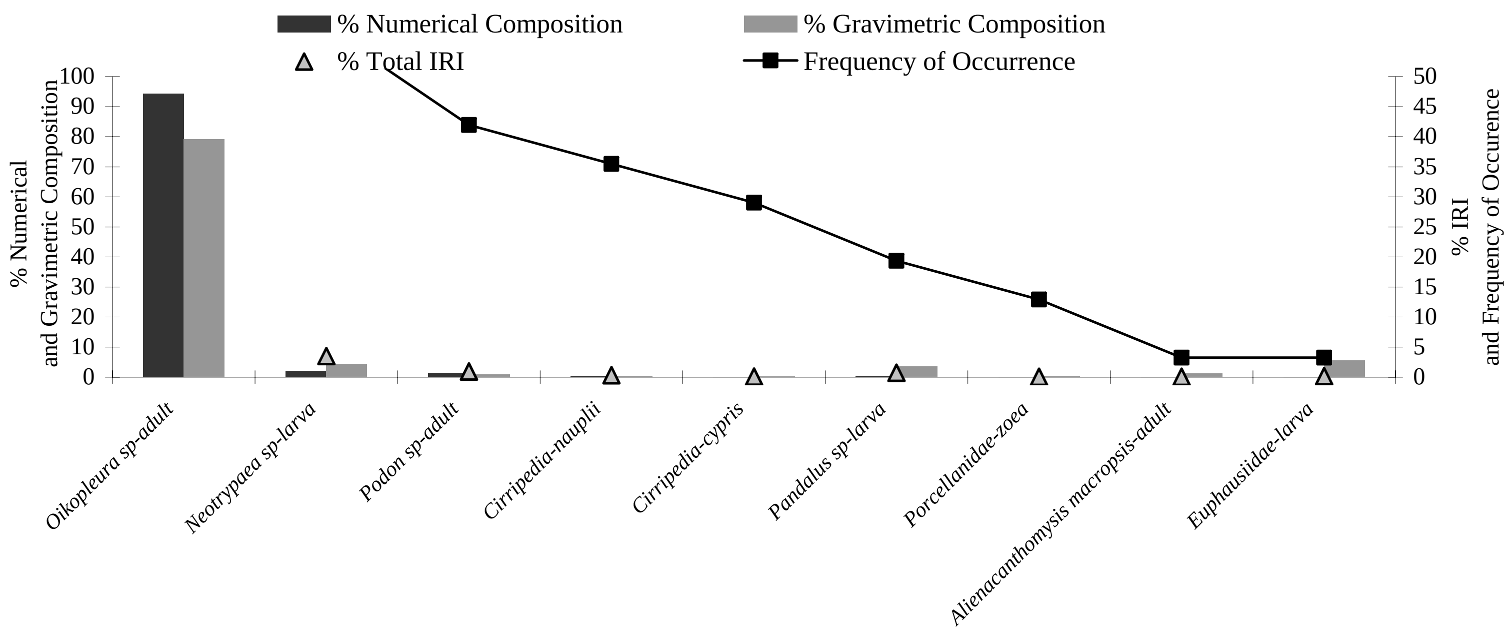


Figure 18. Diet of nearshore juvenile chum salmon in Sinclair Inlet in 2001 (n=31, FL 64-86mm, mean 76.4mm).

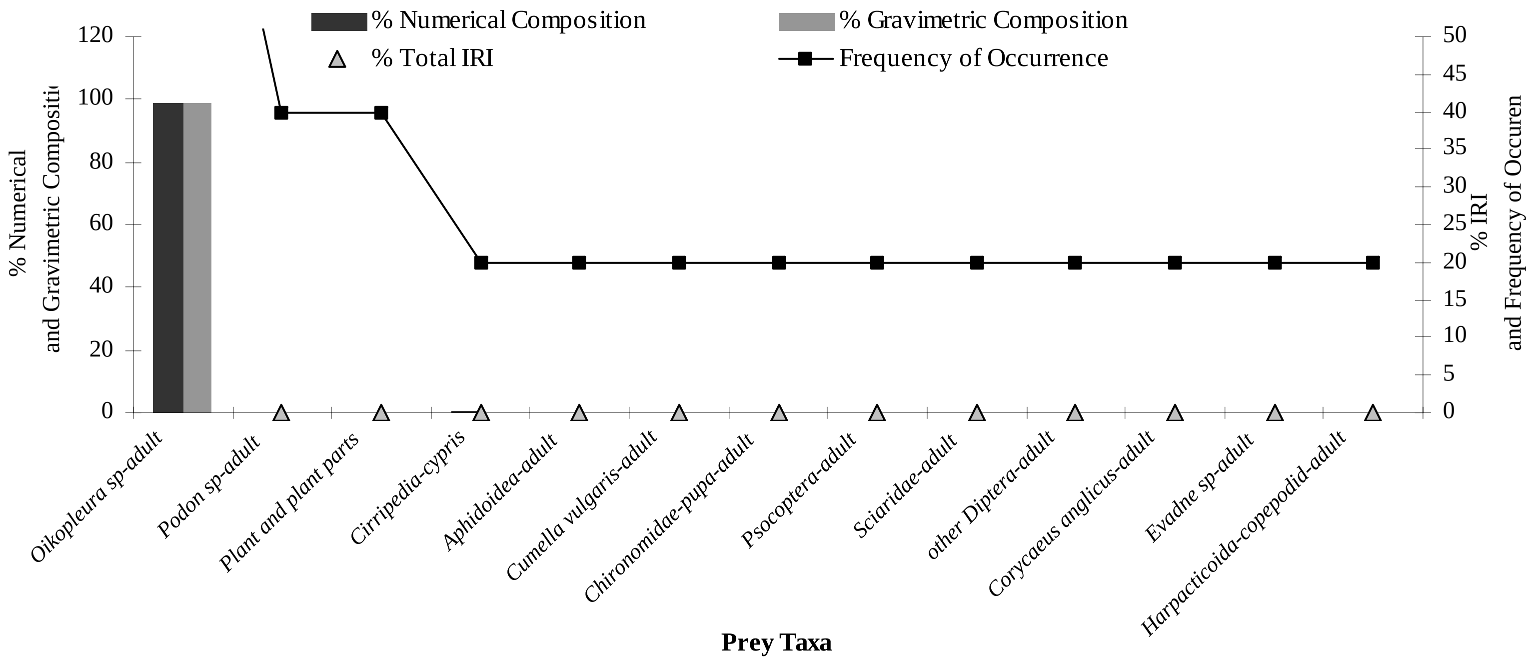


Figure 19. Diet of offshore juvenile chum salmon in Sinclair Inlet in 2002 (n=5, FL 62-72mm, mean 68.0mm).

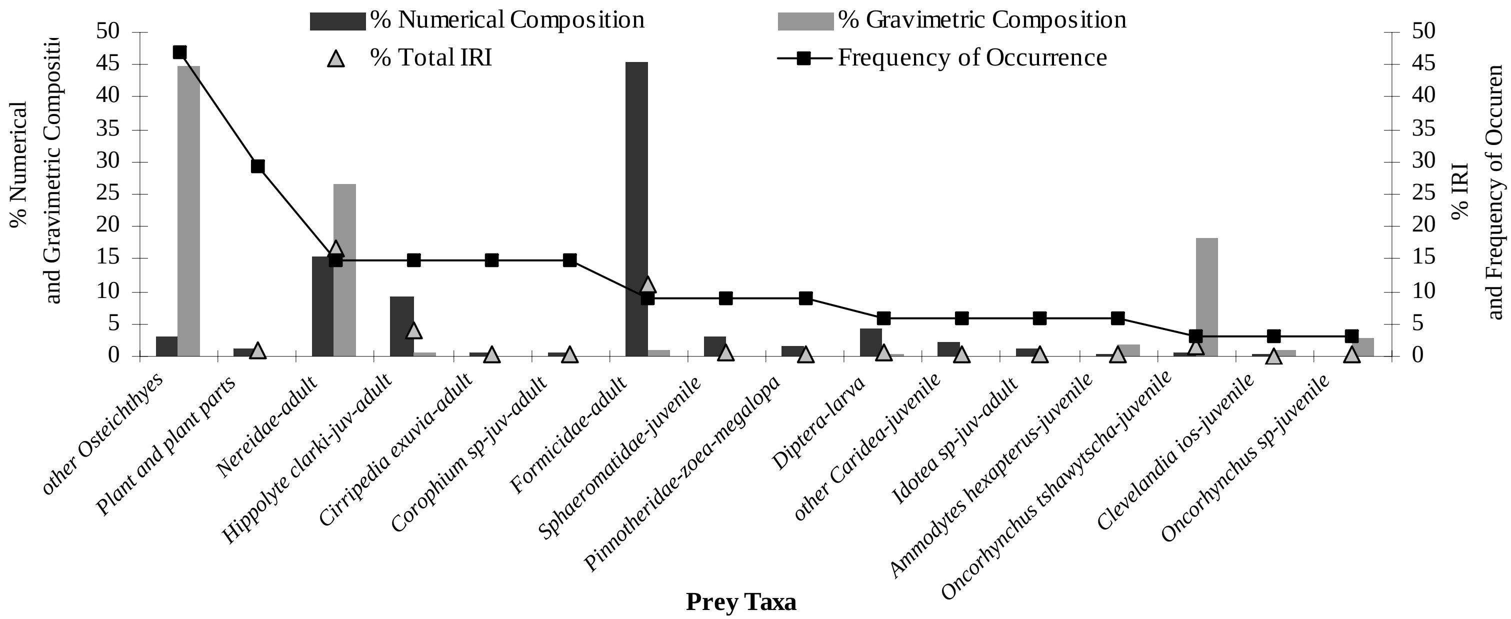


Figure 20. Diet of nearshore cutthroat trout in Sinclair Inlet in 2001 (n=34, FL 130-450mm, mean 244.3mm).

IV. F. 2. Factors affecting diet of juvenile Chinook salmon

A variety of factors can potentially affect what fish eat including their size, time of year, habitat they are feeding in, site, and origin (e.g. hatchery versus wild, or population). We used the percent similarity index (PSI) to conduct pair-wise comparisons of particular data sets. Comparisons of prey weight data were grouped into eight categories of prey: Insecta; Fish and fish parts; Decapod larvae; Barnacles and parts; Gammarid amphipods; Other crustaceans; Polychaetes; and "Other". We considered high overlap to be PSI values >66%, moderate overlap to be PSI values 34-65%, and low overlap to be PSI values <34%.

To compare the prey eaten by hatchery origin juvenile Chinook salmon and wild juvenile Chinook salmon, we conducted pair-wise comparisons of hatchery and "wild" fish (with sufficient sample sizes) where fish were of similar size, from the same location, and collected at the same approximate time. Thus, the primary difference was origin of the fish. There was not a strong indication that hatchery and "wild" fish had distinct feeding behaviors (as indicated by low overlap), as six of the 12 pair-wise comparisons indicated moderate levels of overlap, three comparisons showed low overlap, and three comparisons showed high overlap (Table 35).

To examine effects of fish size, we compared small fish (< 100 mm FL) and large fish (> 100 mm FL) collected at the same site at the same time. We were limited by sample size considerations in the number of comparisons we could make. For example, the number of fish in the small category in late summer was limited. Four of these five comparisons had PSI values < 18% indicating very low overlap while one comparison had high overlap (PSI= 83%). This indicates that fish size has a strong impact on diet of juvenile Chinook salmon. A main difference between small and large juvenile Chinook salmon was that polychaetes, which are relatively large prey, were primarily eaten by larger fish and less important in the diet of smaller fish.

Fish collection timing should clearly affect diets because of seasonal differences in production and availability of different prey items. As noted above, because fish size affects diet, comparisons between months should use similarly sized fish. Since fish are increasing in size over time, finding comparably sized fish in widely separated months is difficult (e.g., May versus September or June versus August). Windy Point and Ross Point provided the best data sets to examine seasonal differences in prey items (Table 36). When comparing similarly sized fish, we found varying degrees of overlap between months (Table 36). Of eight comparisons that were made, PSI values were low for four comparisons (< 34%) indicating seasonal differences in diet; overlap was high for two comparisons (high similarity) and moderate for two. Crab zoea and other planktonic prey were generally more prevalent in diets in June and early July whereas polychaetes were more important in diets in July and August. Terrestrial insects were eaten in all months but we could not detect any patterns for individual types.

Prey items were different between sampling sites, as we found moderate and low amounts of diet overlap in 13 of 14 comparisons when comparing fish of the same size class, origin, month, and year (Table 37). Although diet appears to vary between collection sites, we could not discern a pattern to this variation.

Table 35. Results of pair-wise comparisons of dietary overlap of hatchery and "wild" juvenile Chinook salmon from Sinclair Inlet, 2001 and 2002. Comparisons were made using the PSI (Percent Similarity Index) with High Overlap (H) considered to be > 66%, Medium Overlap (M) considered to be 34-66%, and Low Overlap (L) considered to be < 34%. All comparisons were made from littoral zone collections except for the Area 2 offshore samples collected by surface tow net in the deeper part of Area 2 of Sinclair Inlet. Comparisons were made using prey weight data grouped into the following categories: insecta, fish and fish parts, decapod larvae, barnacles and parts, gammarid amphipods, other crustaceans, polychaetes, and other prey. For this analysis, n = total number of fish examined.

Date	Site	Fish Length (mm)	n	PSI Value	Overlap
June 2001	Windy Point	72-95	7	58	M
June 2001	Natural Beach	70-106	8	61	M
June 2001	Windy Point	75-102	9	88	H
June 2001	Ross Point	63-102	8	83	H
July 2001	Ross Point	100-135	9	44	M
Aug 2001	Windy Point	105-160	9	6	L
Aug 2001	Blackjack	105-185	8	13	L
Aug 2001	Ross Point	120-137	10	63	M
June 2002	Windy Point	75-120	10	62	M
June 2002	Pier 8	80-100	10	18	L
July 2002	Ross Point	91-122	11	39	M
July 2002	Area 2 offshore	95-112	10	92	H

Table 36. Results of pair-wise comparisons of the diets of juvenile Chinook salmon collected during different months from littoral and offshore habitats of Sinclair Inlet in 2001 and 2002. Site and fish size were held constant in order to make these comparisons. The PSI (Percent Similarity Index) was used to compare diets with High Overlap (H) considered to be > 66%, Medium Overlap (M) considered to be 34-66%, and Low Overlap (L) considered to be < 34%. Comparisons were made using prey weight data grouped into seven categories of prey: insecta, fish and fish parts, decapod larvae, barnacles and parts, gammarid amphipods, other crustaceans, polychaetes, and other prey. For this analysis, n = total number of fish examined.

Comparison Site	Year	*n*	Months	Fish Size (mm)	PSI	Overlap
Windy Pt. littoral	2002	11	June vs. July	< 100	38	M
	2002	10	June vs. July	> 100	20	L
	2002	7	June vs. August	> 100	3	L
	2002	13	July vs. August	> 100	10	L
Ross Pt. littoral	2002	10	June vs. July	< 100	39	M
	2001	21	July vs. August	> 100	73	H
	2002	16	July vs. August	> 100	67	H
Tow net Offshore	2002	13	July vs. August	> 100	18	L

Table 37. Results of pair-wise comparisons of the diets of juvenile Chinook salmon from Sinclair Inlet 2001 and 2002. Comparisons were made to test effect of site of capture on diet. Time and fish size were held constant in order to make these comparisons. The PSI (Percent Similarity Index) was used to compare diets with High Overlap (H) considered to be > 66%, Medium Overlap (M) considered to be 34-66%, and Low Overlap (L) considered to be < 34%. Comparisons were made using prey weight data grouped into the following categories of prey: insecta, fish and fish parts, decapod larvae, barnacles and parts, gammarid amphipods, other crustaceans, polychaetes, and other prey. For this analysis, n = total number of fish examined.

Date	Sites Compared	Fish Size (mm)	*n*	Type	PSI	Overlap
June 2001	Windy Pt vs. Natural Beach	< 100	7	"Wild"	27	L
June 2001	Windy Pt vs. Natural Beach	< 107	8	Hatchery	57	M
June 2001	Windy Point vs. Ross Point	< 103	7	"Wild"	60	M
June 2001	Windy Point vs. Ross Point	< 100	10	Hatchery	72	H
June 2001	Natural Beach vs. Ross Pt	< 103	6	"Wild"	17	L
June 2001	Natural Beach vs. Ross Pt	< 107	10	Hatchery	44	M
Aug 2001	Ross Point vs. Windy Point	> 100	9	"Wild"	23	L
Aug 2001	Ross Point vs. Windy Point	> 100	10	Hatchery	38	M
Aug 2001	Ross Point vs. Blackjack	> 100	9	"Wild"	24	L
Aug 2001	Ross Point vs. Blackjack	> 100	8	Hatchery	4	L
Aug 2001	Windy Point vs. Blackjack	> 100	9	"Wild"	1	L
Aug 2001	Windy Point vs. Blackjack	> 100	8	Hatchery	7	L
June 2002	Windy Point vs. Pier 8	< 102	10	"Wild"	35	M
June 2002	Windy Point vs. Pier 8	< 100	10	Hatchery	9	L

IV. F. 3. General discussion of food habits

Juvenile Chinook salmon ate an exceptionally diverse array of prey items in Sinclair Inlet. Overall, we identified 172 taxa from the stomachs of juvenile Chinook salmon inhabiting Sinclair Inlet (Appendices M and N). Almost all prey were classified as: terrestrial, pelagic, and benthic/epibenthic, with a few freshwater types of prey. While there were some instances of low similarity in diet of hatchery and "wild" origin juvenile Chinook salmon, in general it appeared that these two types of Chinook salmon were eating similar prey items during the time they occupied Sinclair Inlet. High amounts of dietary and spatial overlap are often interpreted as being indicative of competition. However, without knowledge of how much food is available relative to the number of fish in Sinclair Inlet, it is not possible to draw inferences about whether competition between hatchery and wild fish is occurring. Only if food is limiting relative to the density of fish would competition occur that could affect growth and survival of the wild fish. The greatest risk to wild fish in Sinclair Inlet would likely be shortly after the Gorst Creek hatchery fish enter the system since density of salmon rapidly increases for several weeks following release. The tendency for juvenile Chinook salmon to eat such a diverse diet may help buffer them from the effects of a reduced abundance of one prey type since Chinook salmon could potentially switch to other prey types, assuming they were available.

Our results suggest that food habits of juvenile Chinook salmon depend upon size of the fish, time of year, and collection location. As all three of these factors can co-vary, it is difficult to separate the effects of one variable from the other. For example, as the fish increase in size, we would expect that larger prey (such as fish) would become more prevalent in diets (e.g., Fresh et al. 1981, Duffy 2003). However, fish were at times the major prey of both the large and small size classes of juvenile Chinook salmon. And, while larger Chinook salmon ate the larger polycheates, this was also occurring seasonally in July and August.

Clear seasonal trends that were identified in diet of juvenile Chinook salmon were the occurrence of polychaetes in July and August while several types of crab larvae more common in diets in June and July than in August. One reason for the lack of distinct seasonal patterns in diet is that the occurrence of some prey types may be a function of numerous environmental and biological factors operating at multiple scales of space and time. For example, it is likely that the occurrence of insects varies with local reproductive patterns, where in the landscape the insects are found, and variability in transport mechanisms (e.g. wind, streamflow). Another reason for the lack of a stronger temporal signal to the diet is that we only analyzed stomach contents over three months, due to availability of suitable numbers of fish. Other trends may have been more apparent if we had adequate numbers of fish stomachs available over a broader time period.

Collection site clearly had an effect on observed diet, but we could not detect any clear patterns in what was being eaten at different sites. Stomach contents of a fish at any moment in time reflects where the fish has been foraging and what is available in those areas where it is foraging. Fish potentially can consume prey from a much broader area than simply around the site where they were collected. This may complicate detecting a clear "site" signal in prey consumption. For example, Sinclair Inlet, especially in the western (Area 1) and central (Area 2) areas, is confined. Fish could feed along the north shore and then move rapidly to the south shore where they were caught without evacuating a significant portion of the prey eaten on the north shore. Another reason for the lack of clear patterns between sites is that wind and tidal currents may move some prey throughout the area. Thus, some prey types such as crab zoea may not be closely associated with a particular shoreline area.

Juvenile Chinook salmon appear to take advantage of prey sources from all segments of the water column rather than orient specifically to the surface, mid-water or substrate. It is not possible to know precisely where any prey item was consumed but each type of prey is generally available in certain microhabitats in the water column. Terrestrial prey, which were nearly all insects, were likely drifting on the surface of the water when they were encountered by the juvenile Chinook salmon. Pelagic prey could be available and eaten throughout the water column, and benthic/epibenthic prey items would be consumed on or near the benthic surface. In the case of benthic/epibenthic prey, different prey are also likely associated with different substrate types. Polychaetes prefer a softer substrate while some gammarid amphipods are generally more dense in coarser substrates. A number of the prey items eaten by juvenile Chinook salmon have complex life histories and can occupy two or more ecological categories; in some cases, juvenile Chinook salmon were consuming these multiple life history stages. For example, crab zoea and megalopae are pelagic while juvenile crab were likely eaten from the substrate or from some other surface (e.g., piers and pilings).

The origin (i.e., where on the land or within the water the prey came from) of each prey item is difficult to precisely determine. While terrestrial insects are produced from the "land", they could come from either habitats that are near marine waters (e.g., from the shoreline fringe) or distant from Sinclair Inlet (from forests) and be transported by air or water. Even within the water column, we do not know if crab are reproducing locally or reproducing in more distant areas (e.g., Port Orchard) with larvae transported into the study area.

Regardless, the presence of such diverse prey in juvenile Chinook salmon suggests that the food webs that support juvenile Chinook salmon depend upon diverse sources of organic matter and nutrients. Chinook salmon prey can potentially originate from food webs that derive organic matter from land, wetland/marsh complexes, or the marine water column (i.e., phytoplankton). Thus, from the perspective of juvenile Chinook salmon food webs, protection and restoration efforts should focus on supporting the diversity of prey types eaten by Chinook salmon as opposed to only specific prey types.

The food habits of juvenile Chinook salmon in Sinclair Inlet were comparable to other studies of juvenile Chinook salmon in similar habitats (e.g., Fresh et al. 1979; Fresh et al. 1981; Healey 1982; Simenstad et al. 1982; Duffy 2003, Brennan et al. 2004). These other studies have found the same type of broad spectra of insects, decapod crustaceans, and benthic/epibenthic prey that we found in Sinclair Inlet. A major difference between the results of our study and other work on Chinook salmon food habits was the lack of aquatic insects and *Corophium* (a gammarid amphipod) in juvenile Chinook salmon stomachs collected from Sinclair Inlet. In other studies, these prey items were often one of the major diet items (Dunford 1975; Healey 1982; Bottom and Jones 1990; Lott 2004). We hypothesize that this primarily reflects the lack of suitable habitat for these organisms in Sinclair Inlet. Dipterans (notably chironomids, i.e. midges) are aquatic insects that are usually found in diets of juvenile Chinook salmon associated with delta habitats where marshes are extensive. Salt marsh is limited to the west end of Sinclair Inlet. There may also be a seasonal component in the occurrence of dipterans. Lott (2004) found that chironomids were prevalent in diets in April-May; a time period for which we had insufficient numbers of stomachs for analysis. *Corophium* prefer brackish, soft bottom habitats, which are limited in Sinclair Inlet, other than in the extreme west end of the Inlet.

Throughout the Pacific Northwest, the diet of juvenile chum salmon during estuarine and early marine life has been well studied (e.g., Fresh et al. 1981; Healey 1982; Simenstad et al. 1982; Brennan et al. 2004). These studies have generally demonstrated a progression in diets based upon fish size with small fish feeding in littoral habitats on epibenthic amphipods and harpacticoid copepods and then shifting to pelagic prey such as copepods and larvaceans as the fish increase in size. Our limited sample of juvenile chum salmon is consistent with other studies, as fish of the size we analyzed would be expected to eat predominantly pelagic prey, including large amounts of larvaceans. In contrast, juvenile Chinook salmon of this size have a highly varied diet, consuming prey from the surface, water column and the substrate, with little overlap with the dominant chum salmon prey items.

V. Overall Discussion

The littoral and nearshore surface waters of Sinclair Inlet are utilized by a variety of fish species. The species composition is generally consistent with studies using similar methods (e.g., floating beach seines) in similar habitats in Puget Sound (Miller et al. 1977; Fresh et al. 1979; Fresh 1979; Duffy 2003; Brennan et al. 2004, Dorn and Namtvedt-Best 2005). Although there were a large number of species found in Sinclair Inlet, a few species were numerically dominant. For example, in littoral habitats, juvenile salmon and shiner perch are the numerically dominant species while in open water habitats juvenile salmon, forage fish, and threespine stickleback were the dominant species. In littoral areas, salmonids were abundant through late spring while shiner perch dominated after littoral waters warmed in late spring and early summer. Juvenile chum salmon were the most abundant salmonid in littoral habitats and were abundant early in the year through May/June. This is often the case in other parts of Puget Sound (Duffy 2003; Brennan et al. 2004).

There were several notable differences in the fish community found in Sinclair Inlet compared to other parts of Puget Sound. First, we found no pink salmon (*O. gorbuscha*) juveniles in Sinclair Inlet. In other areas of Puget Sound, including Hood Canal, juvenile pink salmon occur during even numbered years (e.g. 2002) and are often as abundant as juvenile chum salmon (Stober and Salo 1973; Salo et al.1978; Brennan et al. 2004). Pink salmon, except rare stray fish, do not spawn in Sinclair Inlet or East Kitsap streams. Limited numbers of pink salmon spawn in Puget Sound south of Seattle, although juvenile pink salmon were found along Bainbridge Island shorelines in 2004 (Dorn and Namtvedt-Best 2005) after an exceptional pink salmon escapement to the Puyallup and Green Rivers in 2003. However, Sinclair Inlet apparently does not function as a regular or important rearing or migratory habitat for pink salmon juveniles.

Second, we found relatively few yearling coho salmon. At least in May and June, coho salmon juveniles are common in the main basin of Puget Sound (Fresh et al. 1979; Duffy 2003; Brennan et al. 2004). Clearly, one reason coho salmon are not abundant in this area is the limited amount of natural or hatchery production in the area. In addition, even though millions of yearling coho salmon enter the main basin of Puget Sound, they do not appear to migrate into the littoral and surface water habitats in this area. It is possible that more coho salmon enter Sinclair Inlet than we captured, but may either be large enough to avoid capture by our gear or use habitats, e.g. deeper offshore, that we did not sample.

A third difference between Sinclair Inlet and other parts of Puget Sound was the relative scarcity of forage fish in nearshore surface waters. There are important local spawning beaches for surf smelt in Sinclair Inlet (and along much of the East Kitsap shoreline), herring in Port Orchard (from Agate Pass to the Illahee area), as well as Pacific sandlance. Surf smelt are of sufficient abundance during fall spawning periods near Ross Point to support a recreational and commercial fishery

(Wildermuth 1993). However, even though forage fish were among the most abundant fish in tow net samples, they were not as abundant as other studies have found (Miller et al.1980, Fresh 1979).

The focus of this study was on understanding use of Sinclair Inlet by juvenile Chinook salmon. Although we sampled during both day and night and under a variety of tidal conditions, we pooled all our data regardless of the conditions under which it was collected. Significant and consistent differences as a function of tidal conditions and time of day could affect our interpretations of results and suggest that our data analysis should account for such differences. We were unable to find consistent differences in CPUE of either "wild" or hatchery origin juvenile Chinook salmon in littoral habitats with respect to time of day or tidal stage. Similarly, in surface waters, time of day did not have an effect on CPUE. We did not test for an effect of tide in tow net catches as previous work by Fresh (1979) suggested that tide did not have a predictable effect on catches of fish in nearshore surface waters of the San Juan Islands.

We predicted that fish might be more concentrated at lower tidal stages or more likely to move around on one tidal stage or the other. For example, on ebbing tides fish might be moving out of the Inlet. This did not appear to be the case, however. Brennan et al. (2004) also did not find an effect of stage of tide on salmon catches in the main basin of Puget Sound. We also hypothesized that catches at night should be greater than during the day because fish would be less able to see the net at night and so would be more likely to be caught. Other studies have reported differences in abundance, as measured by CPUE, associated with time of day (e.g., Fresh 1979; Bax 1983). Fresh et al. (1979) did find differences in salmon abundance in the Nisqually Reach with respect to time of day samples were collected but differences appeared to be species specific. Perhaps the extensive lighting in the area from the naval facilities, ferry docks and marinas, or turbidity common in the shallow waters of the Inlet help to minimize differences in CPUE during day and night.

Although there were size differences of juvenile Chinook salmon as a function of the stage of tide during sampling, there were not clear trends. Time of day did appear to be related to size of juvenile Chinook salmon for both hatchery and "wild" origin in littoral and neritic habitats. In general, there was a tendency for juvenile Chinook salmon collected at night to be larger, although differences in mean size were relatively small. This may reflect avoidance of the sampling gear at night, as each type of gear we used should be less visible at night and therefore more likely to catch larger fish. It is also possible that larger fish reside in habitats we did not sample during the day and move inshore at night. Differences in size would be of concern if we consistently sampled some sites, areas, or shorelines only in the day or night. However, because sampling effort was distributed over both day and night (other than in the MR sampling where no night samples were collected), we do not believe this significantly affects interpretation of results.

We propose that use of Sinclair Inlet by juvenile Chinook salmon should be viewed from the perspective of three different groups of fish. The first group consists of subyearling hatchery origin fish released into Gorst Creek. Our studies suggest that these fish rapidly disperse throughout the Inlet after being released from Gorst Creek. Fish are initially concentrated in the west end of Sinclair Inlet. As the juvenile Chinook salmon move rapidly east, they become less concentrated, as indicated by the significant decline in catch from Area 1 to Area 3. Our residence time estimates indicate that the majority of these fish migrate very rapidly out of Sinclair Inlet, spending only days rearing in the Inlet. The presence of marked fish for nearly 60 days after release suggests, however, that some fish spend much longer rearing in the Inlet. We are unaware of any other studies of juvenile Chinook salmon residence in a bay similar to Sinclair Inlet so we do not know if such a rapid migration out of the bay is typical of newly released Chinook salmon in general or only characteristic of Sinclair Inlet. Rapid migration is consistent with studies of juvenile chum salmon migration in Hood Canal where juvenile chum salmon were migrating along the Hood Canal at 4-14 km/day (Bax and Whitmus 1981; Bax 1983). Despite a short residence time in the Inlet, Chinook salmon from Gorst Creek are clearly growing as they move from the western to eastern end of the Inlet.

The second group consists of hatchery produced juvenile Chinook salmon that originate from sources outside the Inlet. Based upon the recoveries of CWT, these fish come from a variety of locations both north and south of Sinclair Inlet indicating that this area serves as rearing habitat for numerous populations of hatchery produced Chinook salmon. Significant numbers of recoveries in the inlet came from the Green River, Nisqually River, and Grovers Creek hatcheries. This broad dispersal of CWT juvenile Chinook salmon was surprising and indicates a diversity in migratory behavior for this species in Puget Sound that has not been appreciated until recently. The few recoveries of CWT coho salmon yearlings or yearling Chinook salmon from sources throughout Puget Sound suggest that this broad dispersal of fish following release is characteristic of subyearling hatchery Chinook salmon. The pattern may not hold for yearling coho salmon or yearling Chinook salmon. Brennan et al. (2004) also found that juvenile Chinook salmon from release locations north of their sampling sites were using littoral habitats in central Puget Sound.

With the major exception of fish from Grovers Creek, most of the fish that originated outside of Sinclair Inlet, enter the Inlet after the fish from Gorst Creek leave and then remain in the area through at least September. Because we could not follow individual salmon, we do not know how long fish remained in the area. Some fish may reside for an extended period based upon the fact some CWT tag groups and pigment-marked Chinook salmon were present in Sinclair Inlet for over 60 days. Juvenile Chinook salmon in littoral habitats of Bainbridge Island and Vashon Island have been collected through the winter months in low numbers (Brennan et al. 2004, Dorn and Namtvedt-Best 2005), suggesting that some fish frequent the shallow nearshore in central Puget Sound throughout the year.

The third group of fish that uses Sinclair Inlet is natural origin fish or what we called "wild" fish. Naturally produced Chinook salmon could originate from a large number of locations, similar to hatchery-produced fish. The small Chinook salmon (< 50 mm FL) that we found in Sinclair Inlet in April 2001 are almost certainly from natural production somewhere in the area, with hatchery origin Chinook salmon spawning in Gorst Creek as the most likely source of fish. The lack of these small Chinook salmon in 2002 suggests that natural production is limited and possibly episodic in the Sinclair Inlet region.

We believe it is reasonable to hypothesize that naturally produced Chinook salmon from non-local streams are rearing in this area similar to the non-local hatchery fish. Clearly, this assumption depends upon whether hatchery fish at this time and at this size are a reasonable analog for wild fish at this stage of their life (Myers and Horton 1982; Levings et al. 1986) and that what we are measuring is not simply an artifact of the hatchery environment (e.g., the result of domestication effects). It is not possible to test this assumption without having CWT groups of wild fish or conducting an analysis of DNA of recovered unclipped Chinook. Given that these hatchery fish are entering estuarine waters at the same time as some of the wild smolts, we think this assumption is reasonable for at least this proportion of the wild fish. While wild salmon are likely to exhibit a wider range of life history strategies and sizes (Beamer et al. 2000) than hatchery fish, central Puget Sound Chinook salmon populations are dominated by the parr migrant life history (Puget Sound Action Team 2005 www.psat.org) and therefore may most closely resemble hatchery fish releases.

Regardless of method of capture or year, our work suggests that the number of naturally produced Chinook salmon using Sinclair Inlet is small (less than 10% of the total fish). The percentage of naturally produced fish is undoubtedly smaller than 10%. However, our only way to identify wild origin Chinook salmon was by a lack of any type of mark. We know that the hatchery marking rate is not 100% (e.g. marking rate for fish released from Gorst Creek was about 95% in 2002) and that not all hatchery populations of Chinook salmon are marked every year. Thus, some of the unmarked juvenile salmon were simply unmarked hatchery fish rather than naturally produced fish. In general, we found few differences in size, distribution, or abundance patterns between the "wild" and hatchery origin fish. This suggests that a) wild and hatchery fish are behaviorally the "same" or b) they are behaviorally different but so few wild origin fish are present that the "unmarked" hatchery fish mask any differences between these two types of fish.

With the continued expansion of the human population in the Pacific Northwest and the decline in abundance of many populations of salmon in the area (Stouder et al.1997), there is concern about the effects of human alterations of nearshore ecosystems on juvenile salmonids. Our study was designed primarily to provide information on distribution and abundance of juvenile salmon and not as a study of the effects of human alterations on salmon. Drawing inferences about potential impacts of shoreline development based on our study is problematic because: 1) we lacked a control or reference area (e.g., an unaltered bay comparable to Sinclair Inlet or pre-Shipyard data), 2) effects may depend upon scale and we could not sample at all relevant scales (e.g., we do not know at what scale shoreline armoring effects may occur), 3) we did not fully account for all effects in the area, and 4) many effects may depend upon the interactions of a number of factors which are difficult to detect with our type of study. Given the above limitation, our study can only provide broad scale indications of effects of alterations. For example, if fish were never captured along one shoreline, it might suggest avoidance of an area was occurring.

We did not identify patterns in distribution, size, diet, or abundance that could be related to human alterations of this ecosystem. We hypothesized that if salmon were significantly less abundant along one shoreline (e.g., the north shore, the location of Shipyard and the ferry terminal), it might indicate an effect of alteration of this shoreline on fish behavior or perhaps an effect of local oceanography on fish behavior. Regardless, we found no effect of shoreline on size or CPUE of Chinook salmon. It is possible that within the confined area of the bay, fingerling and larger Chinook salmon can move rapidly both horizontally and vertically in the bay (e.g., from one shore to the other) and may not be sensitive to physical habitat conditions in different areas. Further, other than Area, we found no effect of any of the habitat variables on juvenile Chinook salmon abundance or size. One interpretation of these results is that juvenile Chinook salmon are not sensitive to the habitat variables we measured. However, it is also possible that salmon may view habitat differently than at the site scale. While we measured habitat at the scale of our sampling unit (beach seine site), salmon might respond to shoreline habitat at larger scales. In addition, our method of measuring habitat may have been inadequate (qualitative versus quantitative) and other attributes that we did not measure could influence fish distribution. For example, local oceanography, which might be dynamic and depend on short term variation in winds and freshwater inflow, could have a considerable influence on where fish are found.

While we do not have data on growth of individual fish, we do know that the size of juvenile Chinook salmon and other salmonids present in the Inlet increased throughout the year. While this type of an increase in size is not conclusive evidence of growth in the Inlet (it could also be continuous recruitment of larger fish from outside the Inlet), this same type of an increase in size has been observed in other areas (Duffy 2003; Brennan et al. 2004). It was clear from our diet analyses that juvenile Chinook salmon were finding and consuming food. In both years, fish ate a considerable diversity of prey types that included insects of many taxa, zooplankton, fish, and polychaetes. An interesting aspect of this study is the presence of hatchery-reared fish from Gorst Creek using NATUREs protocols. While hatchery reared fish are typically oriented to receive food from the surface, the experimental rearing pond at Gorst using NATUREs protocols used more diverse feeding methods. Therefore, about half of the hatchery release at Gorst was atypical for normal hatchery rearing procedure (Flagg et al. 2000). In the field, other than the small portion of CWT fish, we could not differentiate between the two release groups from Gorst. Information on the overall survival of these fish is not yet available.

The diversity in prey types as seen in juvenile Chinook salmon in our study is generally not typical for other salmon species during their tenure in nearshore marine habitats. For example, juvenile chum salmon in Sinclair Inlet and elsewhere have a less diverse diet that consists of both pelagic and epibenthic copepods and amphipods (Simenstad et al. 1982). We could not determine where the prey originated or where the fish consumed the prey because of the complex life cycles of some organisms (e.g., chironomids). Potentially, prey could have originated from terrestrial, aquatic, and benthic sources that the fish could have eaten these items from the surface, in the water column, and on or near the bottom. For example, we found insects that were both aquatic and terrestrial in their origin. Chironomids spend a part of their life cycles in aquatic habitats while ants and aphids are terrestrial organisms that could be transported into Sinclair Inlet from upland areas by way of the small creeks that enter the area or from uplands associated with marine shorelines.

The types of prey eaten by juvenile Chinook salmon in Sinclair Inlet were generally the same types of prey eaten by juvenile Chinook salmon in other estuarine and shoreline habitats (Fresh et al. 1979; Simenstad et al. 1982; Duffy 2003; Brennan et al. 2004). Insects, in particular, show up consistently in Chinook salmon diets in both delta habitats as well as in more marine habitats such as Puget Sound. For example, Lott (2004) found chironomids were important dietary components in fish collected from the Columbia River estuary. There was a seasonal shift in prey with the chironomids important in May and other prey items showing up several months later. Brennan et al. (2004) found crab larvae and polycheates, two prey items important in Sinclair Inlet, were also important prey in central Puget Sound juvenile Chinook salmon diet.

While there was considerable variability in the data, there did not appear to be clear differences in what fish were eating based upon site or origin (“wild” versus hatchery fish). Much of the variability in diet appeared to be due to time of year a fish was collected and its size, which are somewhat correlated. For example, crab larvae appeared in diets in June and July but not earlier, probably reflecting reproductive behavior and timing of local crab populations.

VI. Recommendations

Our study represents the most comprehensive examination of the fish associated with the nearshore ecosystems of Sinclair Inlet conducted to date. In general, the fish communities associated with littoral and nearshore pelagic portions of Sinclair Inlet were comparable to other areas of Puget Sound. Despite being located distant from the main basin of Puget Sound, our results demonstrate that the nearshore of Sinclair Inlet is extensively used by juvenile Chinook salmon and juvenile chum salmon. In contrast we found few juvenile coho salmon and no pink salmon using this urban embayment. Our results show that there are three types of juvenile Chinook salmon using the Inlet: hatchery produced fish from local sources (i.e., Gorst Creek) that tend to pass quickly through the Inlet following their release, hatchery fish from release locations outside the local area (e.g., Nisqually River), and naturally-produced fish potentially from a variety of sources. Although the nearshore portion of Sinclair Inlet has been heavily modified, it does nevertheless function as habitat for salmon since we found that juveniles were present, feeding and growing during their residence in this system. We recommend that future studies:

1. **Determine the sources of naturally produced juvenile Chinook salmon using Sinclair Inlet.** With the development of a micro-satellite DNA baseline for Puget Sound Chinook salmon, the potential exists to identify some of the sources of naturally produced juvenile Chinook salmon found in Sinclair Inlet.

2. **Determine how hydrodynamic processes move and distribute juvenile Chinook salmon throughout Sinclair Inlet.** Throughout Puget Sound, we lack an understanding of how physical processes distribute fish. Most studies have focused on effects of physical and chemical habitat factors at relatively small scales. Such processes as tides and river flow may have an important influence on what habitats fish are able to use. The existence of hydrodynamic models, ability to mark and release fish, and the configuration of Sinclair Inlet makes this area suited to study these types of relationships.

3. **Determine origins of juvenile chum salmon present in Sinclair Inlet.** We found that juvenile chum salmon were abundant in Sinclair Inlet. It would be useful to know the relative contributions of local and non-local sources to Sinclair Inlet.

4. **Evaluate residence time of individual juvenile Chinook salmon in Sinclair Inlet.** Residence time information can be used to help evaluate such things as contaminant uptake, competitive interactions, and growth. Although we examined residence time of Gorst Creek fish, our study was limited in that we only examined a cohort so we lack

data on individual fish. Examination of otoliths and scales may provide a means of evaluating performance of individual fish.

5. **Use bioenergetics methods to evaluate growth efficiency of salmon in Sinclair Inlet.** It is clear that fish are feeding and, based upon the consistent increasing size in Sinclair Inlet, growing as well. Applying bioenergetics methods to estimate growth efficiency and then comparing this information to other published work would potentially allow us to draw inferences about how well fish were growing in this urban environment.

6. **Determine where terrestrial prey were coming from.** Interestingly, many of the food items eaten by the juvenile Chinook salmon were insects from terrestrial sources. This is comparable to other areas of Puget Sound. An understanding of where these prey items were coming from (e.g., marine riparian area or transported from inland areas by streams) would provide useful information to habitat managers.

7. **Evaluate prey communities associated with different habitat types in Sinclair Inlet.** It is difficult to relate fish diets with particular sites or areas because fish may not have been feeding near where they were captured. Therefore, understanding what types of habitats were producing the dominant prey types present in salmon stomachs would provide important information to protection and restoration efforts in this area.

Additional work to build on this research will allow better understanding of interannual variation in the spatial and temporal distribution of salmonids. In addition, these patterns may change over time as recovery efforts are implemented for wild Chinook salmon. Most if not all of the studies to date that have assessed nearshore use by juvenile salmonids have been largely independent efforts. Future efforts should be coordinated over larger geographic areas, if not over all of Puget Sound. To this end, a strategic approach to sampling nearshore habitats should be developed to provide the proper context for interpretation of results and a better understanding of how juvenile salmon utilize Puget Sound shorelines during their migrations to the ocean. This type of approach should provide an improved basis for decision-making in regard to salmon recovery efforts along Puget Sound shorelines thereby ensuring wise use of funds allocated to these effort.

VII. Literature Cited

Arkoosh, M. R, E. Casillas, P. Huffman, E. Clemons, J. Evered, J. E. Stein, and U. Varanasi. 1998. Increased susceptibility of juvenile chinook salmon (*Oncorhynchus tshawytscha*) from a contaminated estuary to the pathogen *Vibrio anguillarum*. Transactions of the American Fisheries Society 127:360-374.

Bax, N. 1983. Early marine mortality of marked juvenile chum salmon (*Oncorhynchus keta*) released into Hood Canal, Puget Sound, Washington, in 1980. Canadian Journal of Fisheries and Aquatic Sciences 40:426-435.

Bax, N., and C. J. Whitmus. 1981. Early marine survival and migratory behavior of juvenile chum salmon released from the Enetai Hatchery, Washington, 1980. University of Washington, Fisheries Research Institute Report 8109, 48 pp.

Beamer, E., J. Sartori, and K. Larsen. 2000. Skagit Chinook Life History Study Progress Report Number 3. Skagit System Cooperative, La Conner WA. 18 pp.

Bortelson, G.C., M.J. Chrzastowski, and A. K. Helgerson. 1980. Historical changes of shoreline and wetland at eleven major deltas in the Puget Sound region, Washington. Atlas HA-617, Department of Interior, U.S. Geological Survey.

Bottom, D. L., and K. K. Jones. 1990. Species composition, distribution and invertebrate prey of fish assemblages in the Columbia River estuary. Progress in Oceanography 25:243–270.

Bottom, D. L., C. A. Simenstad, A. M. Baptista, D. A. Jay, J. Burke, K. K. Jones, E. Casillas, and M. H. Schiewe. 2005. Salmon at River's end: The role of the estuary in the decline and recovery of Columbia River salmon. NOAA Technical Memorandum NMFS-NWFSC- 68. 246pp

Brennan, J. S., K. F. Higgins, J. R. Cordell, and V. A. Stamatiou. 2004. Juvenile salmon composition, timing distribution, and diet in marine nearshore waters of central Puget Sound in 2001-2002. King County, Department of Natural Resources and Parks, Seattle WA. 164 pp.

Dethier, M.N. 1990. A Marine and Estuarine Habitat Classification System for Washington State. Washington Natural Heritage Program, Dept. Natural Resources, Olympia, WA 56 pp.

Dorn, P. D. and P. Namtvedt-Best. 2005. Integration of Joint City of Bainbridge Island/Suquamish Tribal Beach Seining Results into Shoreline Management and Salmon Recovery Efforts in Kitsap County, Washington. Proceedings of the 2005 Puget Sound Georgia Basin Research Conference. Puget Sound Action Team. Seattle, Washington.

Duffy, E. J. 2003. Early marine distribution and trophic interactions of juvenile salmon in Puget Sound. University of Washington, Thesis, Seattle, WA.

Dunford, W. E. 1975. Space and food utilization by salmonids in marsh habitats of the Fraser River estuary. M. S. Thesis, University of British Columbia, Vancouver, B.C.

Flagg T.A., B.A. Berejikian, J.E. Colt, W.W. Dickhoff, L.W. Harrell, D.J. Maynard, C.E. Nash, M.S. Strom, R.N. Iwamoto, and C.V.W. Mahnken. 2000. Ecological and behavioral impacts of artificial production strategies on the abundance of wild salmon populations. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC- 41, 92 pp.

Fresh, K.L. 1979. Distribution and abundance of fishes occurring in the nearshore surface waters of northern Puget Sound, Washington. M.S. Thesis, University of Washington, Seattle.

Fresh, K.L. 1997. The role of competition and predation in the decline of Pacific salmon and steelhead, pp. 245-276. In: D.J. Stouder, P. Bisson, and R. Naiman (eds.) Pacific Salmon and their Ecosystems. Status and Future Options. Chapman and Hall.

Fresh, K. L., R. D. Cardwell, and R. R. Koons. 1981. Food habits of Pacific salmon, baitfish, and their potential competitors and predators in the marine waters of Washington, August 1978 to September 1979. Wash. Dept. of Fisheries, Progress Report. No. 145. 58 pp.

Fresh, K. L., E. Casillas, L. Johnson, and D. L. Bottom. 2005. Role of the estuary in the recovery of Columbia River Basin Salmon and Steelhead: An evaluation of the effects of selected factors on salmonid population viability. NOAA Technical Memorandum NMFS-NWFSC- 69. 109pp.

Fresh, K. L., D. Rabin, C. A. Simenstad, E.O. Salo, K. Garrison, and L. Matheson. 1979. Fish ecology studies in the Nisqually Reach area of southern Puget Sound, Washington. University of Washington, Fisheries Research Institute, FRI-UW-7904, Seattle, WA

Fresh, K. L., and S. L. Schroder. 1987. Influence of the abundance, size, and yolk reserves of juvenile chum salmon (*Oncorhynchus keta*) on predation by freshwater fishes in a small coastal stream. Canadian Journal of Fisheries and Aquatic Sciences 44: 236-243.

Haas, A., and B. Collins. 2001. A historical analysis of habitat alterations in the Snohomish River Valley, Washington, since the mid-19^{th} Century: Implications for chinook and coho salmon. Report by the Tulalip Tribes and Snohomish County Public Works. 60 pp.

Healey, M.C. 1979. Detritus and juvenile salmon production in the Nanaimo estuary. I: Production and feeding rates of juvenile chum salmon (*Oncorhynchus keta*). Journal of the Fisheries Research Board of Canada 36:488-496.

Healey, M.C. 1980. Utilization of the Nanaimo River estuary by juvenile chinook salmon, *Oncorhynchus tshawytscha*. Fisheries Bulletin 77:653-668.

Healey, M. C. 1982. Juvenile Pacific salmon in estuaries: the life support system. Pages 315-341 in V.S. Kennedy, editor. Estuarine Comparisons. Academic Press, New York.

Levings, C. D. K. Conlin, and B. Raymond. 1991. Intertidal habitats used by juvenile chinook salmon (*Onchorhychus tshawytscha*) rearing in the North Arm of the Fraser River estuary. Marine Pollution Bulletin 22:20-26.

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

Lott, M. A. 2004. Habitat-specific feeding ecology of ocean-type juvenile Chinook salmon in lower Columbia River estuary. M. S. Thesis, University of Washington. Seattle, Washington.

Magnusson, A., and R. Hilborn. 2003. Estuarine survival rates of coho (*Oncorhynchus kisutch*) and chinook salmon (*Oncorhynchus tshawytscha*) released from hatcheries on the U.S. Pacific Coast. Estuaries 26 (4B):1094-1103.

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 tshawytscha*) survival: short-term results. Canadian Journal of Fisheries and Aquatic Sciences 45:1366-1377.

Miller, B. S., C. A. Simenstad, J. N. Cross, and K. L. Fresh. 1980. Nearshore fish and macroinvertebrate assemblages along the Strait of Juan de Fuca including food habits of the common nearshore fish. Final Contract Report to NOAA/MESA Puget Sound Project. EPA DOC Research Report EPA-600/7-80-027. (Also Fish. Res. Inst., Univ. Wash., Seattle, WA., FRI-UW-8001.) 211 pp.

Miller, B.S., C.A. Simenstad, L.L. Moulton, K.L. Fresh, F.C. Funk, W. A. Karp, and S.F. Borton. 1977. Puget Sound baseline program: Nearshore fish survey. University of Washington, Fisheries Research Institute, Final Report, FRU-UW-7710. 220 pp.

Mortenson, D., A. Wertheimer, S. Taylor, and J. Landingham. 2000. The relationship between early marine growth of pink salmon, *Oncorhynchus gorbuscha*, and marine water temperature, secondary production, and survival to adulthood. Fishery Bulletin 98:319-335.

Myers, K.W., and H.F. Horton. 1982. Temporal use of an Oregon estuary by hatchery and wild salmon. Pages 388-392 in V.S. Kennedy, editor. Estuarine Comparisons. Academic Press, New York.

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grand, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-35, 443 pp.

Nickelson, T. E. 1986. Influences of upwelling, ocean temperature, and smolt abundance on marine survival of coho salmon (*Oncorhynchus kistuch*) in the Oregon Production Area. Canadian Journal of Fisheries and Aquatic Sciences 43:527-535.

Penttila, D. E. 2000. Documented spawning seasons of populations of the surf smelt, Hypomesus, in the Puget Sound basin. Washington Department of Fish and Wildlife Marine Resources Division Briefing Report, October 2000. Olympia, Washington.

Peterman, R. M. 1978. Testing for density-dependent marine survival in Pacific salmonids. Journal of Fisheries Research Board Canada 35:1434-1450.

Phinney, D.E., and S. B. Mathews. 1969. Field test of fluorescent pigment marking and finclipping of coho salmon. Journal of Fisheries Research Board of Canada 26:1619-1624.

Pinkas, L. M., S. Oliphant, I. L. K. Iverson. 1971. Food habits of albacore, bluefin tuna, and bonito in California waters. California Department of Fish and Game, Fish Bulletin 152:1–64.

PSWQAT (Puget Sound Water Quality Action Team). 2002. Puget Sound Update: Eighth Report of the Puget Sound Ambient Monitoring Program. Puget Sound Water Quality Action Team, Olympia, Washington.

Puget Sound Action Team. 2005 Regional Nearshore and Marine Aspectsof Salmon Recovery in Puget Sound. Chapter by Puget Sound Action Team delivered to Shared Strategy for inclusion in regional salmon recovery plan. www.psat.wa.gov

Salo, E.O., N.J. Bax, T.E. Prinslow, C.J. Whitmus, B.P. Snyder, and C.A. Simenstad. 1980. The effects of construction of naval facilities on the outmigration of juvenile salmonids from Hood Canal, Washington. Final Rep. FRI-UW-8006. 159p.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: an unappreciated function. Pages 343-364 in V.S. Kennedy, editor. Estuarine Comparisons. Academic Press, New York.

Sokal, R. R., and F. J. Rohlf. 1981. Biometry. The principles and practice of statistics in biological research. W. H. Freeman. New York.

Stober, Q.J., and E.O. Salo. 1973. Ecological studies of the proposed Kiket Island nuclear power site. University of Washington, Fisheries Research Institute, FRI-UW-7304.

Stouder, D.J., P. Bisson, and R. Naiman (eds). 1997. Pacific Salmon and their Ecosystems. Status and Future Options. Chapman and Hall.

Wildermuth, D. 1993. Estimates of recreational harvest and spawn deposition for surf smelt (*Hypomesus pretiosus pretiosus)*, at Ross Point, Washington in 1991 and 1992. Washington Department of Fish and Wildlife Progress Report 309. Olympia, Washington.

APPENDIX A

Appendix A. Summary of 2001 and 2002 Puget Sound hatchery releases of juvenile Chinook and coho salmon

Appendix A. Summary of hatchery releases of juvenile Chinook and coho salmon in Puget Sound for 2001 and 2002. Regions are defined in the Regional Mark Information System (http://www.rmis.org) of the Pacific States Marine Fisheries Commision.

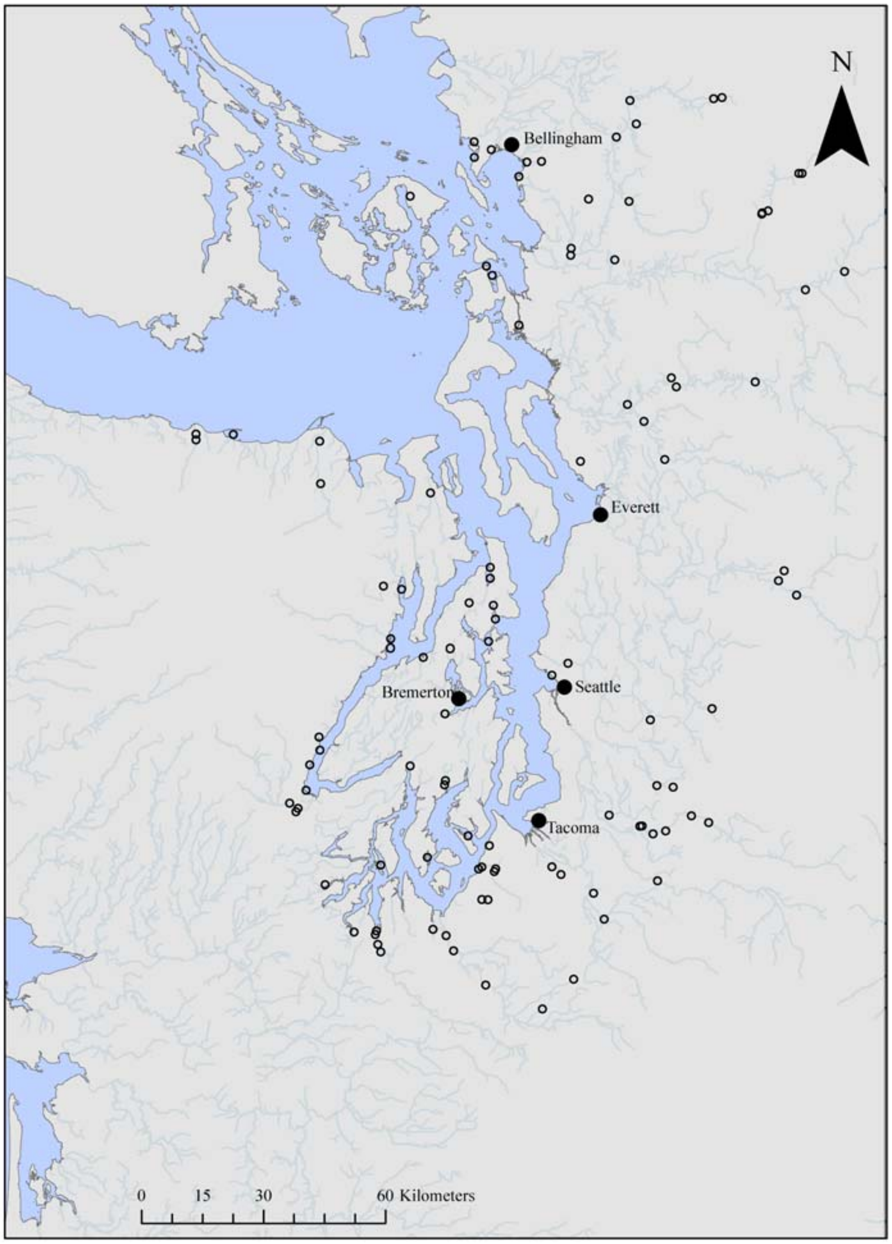
Hatchery release in 2001 (in thousands)

	CWT tag		no CWT tag			
	ad clip	**unclip**	**ad clip**	**unclip**	**Total**	**% unmarked**
Subyearling Chinook (BY00)						
North Puget Sound	1,148	961	4,030	2,725	**8,864**	30.7%
Strait of Juan de Fuca	231	101	183	4,298	**4,813**	89.3%
Hood Canal	223	227	0.5	6,445	**6,896**	93.5%
Mid Puget Sound	564	683	8,409	536	**10,192**	5.3%
South Puget Sound	602	430	10,464	555	**12,051**	4.6%
Puget Sound Total	**2,768**	**2,402**	**23,087**	**14,559**	**42,816**	34.0%
Yearling Chinook (BY99)						
North Puget Sound	109	75	721	7	**911**	0.7%
Strait of Juan de Fuca					**0**	0.0%
Hood Canal					**0**	0.0%
Mid Puget Sound		82	351	8	**441**	1.8%
South Puget Sound	68	86	678	55	**887**	6.2%
Puget Sound Total	**177**	**243**	**1,750**	**70**	**2,239**	3.1%
Yearling coho salmon (BY99)						
North Puget Sound	338	145	2,199	750	**3,432**	21.9%
Strait of Juan de Fuca	150	63	571	539	**1,323**	40.7%
Hood Canal	182	203	1,055	137	**1,577**	8.7%
Mid Puget Sound	307	99	2,787	204	**3,397**	6.0%
South Puget Sound	66	2	2,648	73	**2,789**	2.6%
Puget Sound Total	**1,043**	**512**	**9,260**	**1,703**	**12,518**	13.6%

Appendix A (cont.) Summary of hatchery releases of juvenile Chinook and coho salmon in Puget Sound for 2001 and 2002. Regions are defined in the Regional Mark Information System (http://www.rmis.org) of the Pacific States Marine Fisheries Commision.

	Hatchery release in 2002 (in thousands)					
	CWT tag		**no CWT tag**			
	ad clip	**unclip**	**ad clip**	**unclip**	**Total**	**%unmarked**
Subyearling Chinook (BY01)						
North Puget Sound	1,252	732	3,543	1,433	**6,960**	20.6%
Strait of Juan de Fuca	259	209	465	4,803	**5,736**	83.7%
Hood Canal	224	210	108	6,320	**6,862**	92.1%
Mid Puget Sound	868	606	9,532	240	**11,246**	2.1%
South Puget Sound	297	468	12,536	878	**14,179**	6.2%
Puget Sound Total	**2,900**	**2,225**	**26,184**	**13,674**	**44,983**	30.4%
Yearling Chinook (BY00)						
North Puget Sound	74	74	498	3	**649**	0.4%
Strait of Juan de Fuca	0	88	0	16	**104**	15.0%
Hood Canal	0	0	0	369	**369**	100.0%
Mid Puget Sound	0	83	415	6	**504**	1.1%
South Puget Sound	69	91	525	287	**972**	29.5%
Puget Sound Total	**143**	**336**	**1,438**	**680**	**2,597**	26.2%
Yearling coho salmon (BY00)						
North Puget Sound	426	120	2,473	175	**3,194**	5.5%
Strait of Juan de Fuca	172	72	564	417	**1,225**	34.0%
Hood Canal	184	206	1,052	134	**1,576**	8.5%
Mid Puget Sound	462	99	2,889	68	**3,518**	1.9%
South Puget Sound	277	16	3,442	957	**4,692**	20.4%
Puget Sound Total	**1,521**	**513**	**10,420**	**1,751**	**14,205**	12.3%

Puget Sound Hatcheries



Appendix B

Appendix B. Characteristics of frequently sampled sites for regular beach seine (RBS) and mark recapture beach seine (MR) sampling in Sinclair Inlet 2001 and 2002.

Appendix B. Characteristics of frequently sampled sites for regular beach seine (RBS) and mark recapture beach seine (MR) sampling in Sinclair Inlet 2001 and 2002.

			Method		GPS[1]		Dominant	Secondary	Shoreline	Upland	Subtidal	
Site	**Shoreline**	**Area**	**MR**	**HBS**	**Latitude**	**Longitude**	**Substrate**	**Substrate**	**Characteristics**	**Vegetation**	**Vegetation**	**Slope[2]**
Blackjack	south	2	X	X	N47° 32.868	W122° 37.239	gravel	cobble	rip rap	no	no	M
Boat Launch	south	2	X	X	N47° 32.476	W122° 38.372	cobble	gravel	rip rap	no	no	M
Cabana Beach	north	3	X	X	N47° 34.082	W122° 36.535	gravel	cobble	bulkhead	no	no	S
Channel Marker #11	south	3	X		N47° 34.988	W122° 34.217	sand	gravel	rip rap	no	no	G
CTC Beach	north	3	X	X	N47° 33.986	W122° 37.377	gravel	cobble	natural	yes	sparse	M
Enetai Beach	north	3	X		N47° 35.042	W122° 35.839	cobble	gravel	natural	yes	no	M
Evergreen Beach	south	1		X	N47° 31.745	W122° 40.776	mud	gravel	natural	yes	no	G
Monkey Tree	south	1		X	N47° 31.773	W122° 40.611	sand	gravel	bulkhead	yes	no	M
Mooring G	north	2		X	N47° 33.276	W122° 39.365	sand	gravel	rip rap	no	no	S
Natural Beach	south	3	X	X	N47° 33.711	W122° 35.674	sand	gravel	natural	yes	no	G
New Charleston	north	2	X	X	N47° 33.205	W122° 39.469	gravel	cobble	natural	yes	no	S
Old Charleston	north	2	X	X	N47° 33.031	W122° 39.780	sand	gravel	rip rap	no	no	M
Pier 8	north	2		X	N47° 33.631	W122° 37.674	cobble	gravel	rip rap	no	no	S
Quarry Beach	south	3		X	N47° 32.035	W122° 41.085	gravel	sand	rip rap	no	no	S
Ross Creek	south	2		X	N47° 32.355	W122° 39.402	sand	gravel	rip rap	no	no	G
Ross Point	south	1	X	X	N47° 32.406	W122° 39.682	gravel	cobble	bulkhead	yes	no	M
Site 1	north	2		X	N47° 33.461	W122° 38.340	sand	gravel	rip rap	no	no	S
Tattoo Beach	south	1	X	X	N47° 31.923	W122° 40.190	mud	sand	rip rap	yes	no	G
Windy Point	north	1	X	X	N47° 32.246	W122° 40.633	gravel	cobble	rip rap	no	no	S

[1]GPS- GPS coordinates for sites

[2]Slope G-gentle, M-moderate, S-steep

Appendix C

Appendix C. Summary of fish catch by sampling site during regular beach seine (RBS) sampling in Sinclair Inlet, 2001.

Appendix C. Summary of fish catch by sampling site during regular beach seine (RBS) sampling in Sinclair Inlet, 2001.

Location	Effort	Chinook (total)	Chinook (unclipped)	Chinook (clipped)	Chinook (adult)	Coho (unclipped)	Coho (clipped)	Coho (adult)	Chum	Cutthroat
Blackjack	9	14	6	8	0	0	0	0	0	0
Cabana Beach	8	1	0	1	0	0	0	0	6	0
CTC Beach	12	8	1	7	0	0	0	0	24	11
Enetai Beach	2	0	0	0	0	0	0	0	0	1
Evergreen Beach	2	6	3	3	0	0	0	0	517	3
Monkey Tree	2	0	0	0	0	0	0	0	0	1
Mooring G	1	1	1	0	0	0	0	0	0	0
N channel mk #11	3	6	0	6	0	3	0	0	0	9
Natural Beach	13	54	11	43	0	0	0	5	1060	17
Old Charleston Beach	12	34	6	24	4	0	1	0	2279	8
Overpass Culvert	1	0	0	0	0	0	0	0	26	0
Pier 8	1	4	2	0	2	0	0	0	2	0
Quarry Beach	2	0	0	0	0	0	0	0	3	0
Rockpile Beach	1	0	0	0	0	0	0	0	0	0
Ross Creek	4	21	2	19	0	0	0	0	39	1
Ross Point	14	177	22	155	0	0	0	0	2088	5
RR/Kitsap Muffler	1	18	3	15	0	0	0	0	0	0
SE channel mk #11	3	0	0	0	0	0	0	0	0	9
Site 1	1	0	0	0	0	0	0	0	0	0
Tattoo Beach	13	47	8	39	0	0	0	0	184	31
Windy Point	14	397	35	328	34	1	0	0	72	6
Wright Creek	1	0	0	0	0	0	0	0	0	0
Totals	**120**	**788**	**100**	**648**	**40**	**4**	**1**	**5**	**6300**	**102**

Appendix C (cont.). Summary of fish catch by sampling site during regular beach seine (RBS) sampling in Sinclair Inlet, 2001.

Location	Effort	Big skate	Pacific herring	Surf smelt	Plainfin midshipman	Threespine stickleback	Tubesnout	Bay pipefish	misc greenling
Blackjack	9	0	66	1083	1	0	1	1	0
Cabana Beach	8	0	1	64	0	0	1	0	0
CTC Beach	12	0	0	7	0	12	0	0	0
Enetai Beach	2	0	0	0	0	0	0	0	0
Evergreen Beach	2	0	0	12	0	0	0	0	0
Monkey Tree	2	0	0	75	0	0	0	0	0
Mooring G	1	0	0	0	0	1000	0	0	0
N channel mk #11	3	0	0	0	0	1	25	0	2
Natural Beach	13	0	11	62	0	1	1	3	6
Old Charleston Beach	12	0	3	12	0	0	3	3	0
Overpass Culvert	1	0	0	0	0	0	0	0	0
Pier 8	1	0	0	27	0	0	0	0	0
Quarry Beach	2	0	0	0	1	0	0	0	0
Rockpile Beach	1	0	0	0	0	0	0	0	0
Ross Creek	4	0	0	4	0	0	2	0	0
Ross Point	14	0	4	38	120	3	0	1	0
RR/Kitsap Muffler	1	0	0	15	0	0	0	0	0
SE channel mk #11	3	0	0	0	0	1	0	0	8
Site 1	1	0	0	0	0	0	0	0	0
Tattoo Beach	13	1	453	8	0	3	1	0	0
Windy Point	14	0	1	20	0	0	0	2	1
Wright Creek	1	0	0	0	0	0	0	0	0
Totals	**120**	**1**	**539**	**1427**	**122**	**1021**	**34**	**10**	**17**

Appendix C (cont.). Summary of fish catch by sampling site during regular beach seine (RBS) sampling in Sinclair Inlet, 2001.

Location	Effort	Stagorn Sculpin	Buffalo sculpin	Tadpole sculpin	Irish lord	misc sculpins	Shiner perch	Striped perch	Pile perch	misc perch	Snake prickleback
Blackjack	9	14	0	0	0	1	730	0	0	0	0
Cabana Beach	8	1	0	0	0	0	95	0	0	0	0
CTC Beach	12	21	1	0	0	0	760	123	5	0	0
Enetai Beach	2	5	0	0	0	0	67	0	0	0	0
Evergreen Beach	2	134	0	0	0	0	0	0	51	0	0
Monkey Tree	2	4	0	1	0	0	1000	0	14	0	5
Mooring G	1	2	0	0	0	2	0	0	0	0	0
N channel mk #11	3	24	0	0	0	0	231	0	0	0	12
Natural Beach	13	94	0	0	0	3	2386	38	96	4	3
Old Charleston Beach	12	86	1	0	0	184	2352	47	5	0	0
Overpass Culvert	1	1	0	0	0	0	0	0	0	0	0
Pier 8	1	2	0	0	0	1	1	0	0	0	0
Quarry Beach	2	12	0	0	0	0	0	0	0	0	0
Rockpile Beach	1	0	0	0	0	0	1	0	0	0	0
Ross Creek	4	105	0	0	0	6	711	0	0	0	0
Ross Point	14	102	0	0	0	6	1488	0	43	0	29
RR/Kitsap Muffler	1	0	0	0	0	0	0	0	0	0	0
SE channel mk #11	3	37	0	0	3	6	296	1	0	0	2
Site 1	1	0	0	0	0	6	0	0	0	0	0
Tattoo Beach	13	399	0	0	0	13	4127	2	34	0	133
Windy Point	14	147	0	0	0	16	1022	50	11	0	4
Wright Creek	1	6	0	1	0	0	0	0	0	0	0
Totals	**120**	**1196**	**2**	**2**	**3**	**244**	**15267**	**261**	**259**	**4**	**188**

Appendix C (cont.). Summary of fish catch by sampling site during regular beach seine (RBS) sampling in Sinclair Inlet, 2001.

Location	Effort	Crescent gunnel	Penpoint gunnel	Saddleback gunnel	misc gunnels	Pacific sandlance	misc forage fish
Blackjack	9	0	0	2	5	10	0
Cabana Beach	8	0	0	0	1	0	0
CTC Beach	12	0	0	0	1	200	0
Enetai Beach	2	0	0	0	1	0	0
Evergreen Beach	2	0	0	0	0	344	0
Monkey Tree	2	0	0	0	0	25	0
Mooring G	1	0	0	0	2	0	0
N channel mk #11	3	0	0	0	88	0	0
Natural Beach	13	0	3	0	18	13	20
Old Charleston Beach	12	8	0	0	4	0	50
Overpass Culvert	1	0	0	0	0	0	0
Pier 8	1	0	0	0	0	0	0
Quarry Beach	2	2	0	0	0	12	0
Rockpile Beach	1	0	0	0	0	0	0
Ross Creek	4	2	0	0	0	0	0
Ross Point	14	0	0	0	7	2	0
RR/Kitsap Muffler	1	0	0	0	0	0	0
SE channel mk #11	3	0	0	0	0	0	0
Site 1	1	0	0	0	0	0	0
Tattoo Beach	13	0	0	0	3	0	0
Windy Point	14	0	6	0	5	6	0
Wright Creek	1	0	0	0	0	0	0
Totals	**120**	**12**	**9**	**2**	**135**	**612**	**70**

Appendix C (cont.). Summary of fish catch by sampling site during regular beach seine (RBS) sampling in Sinclair Inlet, 2001.

Location	Effort	Starry flounder	Rock sole	English sole	Sand sole	CO turbot	misc flatfish	juvenile tidepool fish	Total
Blackjack	9	4	0	0	0	0	0	1	1933
Cabana Beach	8	1	0	0	0	0	0	0	171
CTC Beach	12	3	0	0	0	0	0	0	1176
Enetai Beach	2	0	0	0	0	0	0	0	74
Evergreen Beach	2	6	0	0	0	0	0	0	1073
Monkey Tree	2	10	0	0	1	0	0	0	1136
Mooring G	1	0	0	0	0	0	0	0	1007
N channel mk #11	3	2	0	1	0	0	0	0	404
Natural Beach	13	10	2	1	7	0	5	0	3918
Old Charleston Beach	12	17	0	0	1	0	5	2	5105
Overpass Culvert	1	0	0	0	0	0	0	0	27
Pier 8	1	0	0	0	0	0	0	0	37
Quarry Beach	2	10	0	0	0	0	0	0	40
Rockpile Beach	1	1	0	0	0	0	0	0	2
Ross Creek	4	29	0	6	0	0	0	0	926
Ross Point	14	26	5	8	1	0	3	0	4156
RR/Kitsap Muffler	1	22	0	0	0	0	0	0	55
SE channel mk #11	3	11	23	5	0	2	0	0	404
Site 1	1	0	0	0	0	0	0	0	6
Tattoo Beach	13	108	0	0	0	0	159	1	5707
Windy Point	14	18	0	0	0	0	0	3	1788
Wright Creek	1	1	0	0	0	0	1	0	9
Totals	**120**	**279**	**30**	**21**	**10**	**2**	**173**	**7**	**29154**

Appendix D

Appendix D. Summary of fish catch by sampling site during regular beach seine (RBS) sampling in Sinclair Inlet in 2002.

Appendix D. Summary of fish catch by sampling site during regular beach seine (RBS) sampling in Sinclair Inlet in 2002.

Site	Effort	Total Chinook	Sampled Chinook (unclip)	Chinook (clip)	Chinook (unclip w/cwt)	Chinook (clip w/cwt)	Chinook (cwt w/red)	Chinook (red)	Chinook (orange)	Chinook (chartreuse)	Chinook (adult)
Blackjack	13	14	2	10	2	2	0	0	0	1	0
Boatlaunch	14	71	4	67	0	10	0	0	0	3	0
Cabana	17	82	12	69	1	14	0	0	0	0	3
New Charleston	14	156	12	139	5	16	0	0	0	2	0
CTC Beach	15	8	0	8	0	0	0	0	0	0	2
Enetai	1	7	0	7	0	2	0	0	0	0	0
Mooring G	8	31	3	28	0	2	0	0	0	1	0
Natural Beach	18	8	0	7	1	3	0	0	0	0	0
Nursery Beach	1	0	0	0	0	0	0	0	0	0	0
Quarry	1	0	0	0	0	0	0	0	0	0	0
Pier 8	8	124	14	105	5	18	0	0	0	0	0
Ross Creek	10	30	2	28	0	4	0	1	0	0	0
Ross Point	20	132	12	117	3	15	0	0	0	2	0
Site 1	8	59	3	56	0	12	0	0	0	0	0
Tattoo Beach	14	39	5	33	1	4	0	0	0	1	1
West Marker 11	1	1	0	1	0	0	0	0	0	0	0
Windy Point	17	38	6	30	2	3	0	0	0	0	0
Totals	**180**	**800**	**75**	**705**	**20**	**105**	**0**	**1**	**0**	**10**	**6**

Appendix D (cont.). Summary of fish catch by sampling site during regular beach seine (RBS) sampling in Sinclair Inlet in 2002.

Site	Effort	Coho (unclip)	Coho (clip)	Coho unclip (w/ cwt)	Coho clip (w/ cwt)	Coho (adult)	Chum	Cutthroat	Steelhead	Big skate	Pacific herring	Surf smelt
Blackjack	13	3	1	0	0	0	42	1	0	0	70	6
Boatlaunch	14	26	53	0	2	0	647	23	0	0	0	8
Cabana	17	8	2	0	1	0	163	4	1	0	124	7
New Charleston	14	5	3	0	1	0	130	3	0	0	140	11
CTC Beach	15	1	1	0	0	0	19	19	0	0	10	6
Enetai	1	4	1	0	0	0	7	0	0	0	0	0
Mooring G	8	0	1	0	0	0	895	0	0	0	0	1
Natural Beach	18	3	3	0	0	0	27	49	0	1	14	59
Nursery Beach	1	0	0	0	0	0	463	0	0	0	0	1
Quarry	1	0	0	0	0	0	0	0	0	0	0	0
Pier 8	8	5	2	0	0	0	831	0	0	0	1	0
Ross Creek	10	5	11	0	0	0	21	3	0	0	5	12
Ross Point	20	33	23	0	1	0	551	14	0	2	16	58
Site 1	8	12	9	0	0	0	90	0	0	0	0	0
Tattoo Beach	14	12	5	0	0	0	649	36	0	1	4	209
West Marker 11	1	4	4	0	0	0	28	16	1	0	0	0
Windy Point	17	25	14	1	3	0	25	25	0	0	2	6
Totals	**180**	**146**	**133**	**1**	**8**	**0**	**4588**	**193**	**2**	**4**	**386**	**384**

Appendix D (cont.). Summary of fish catch by sampling site during regular beach seine (RBS) sampling in Sinclair Inlet in 2002.

Site	Effort	Plainfin midshipman	Threespine stickleback	Tubesnout	Bay pipefish	misc. greenling	Staghorn sculpin	Buffalo sculpin	Large sculpin	Small sculpin
Blackjack	13	0	34	0	1	0	26	1	1	30
Boatlaunch	14	0	22	1	2	1	33	2	9	44
Cabana	17	1	6	0	0	0	16	4	3	0
New Charleston	14	0	9	0	1	0	34	6	18	11
CTC Beach	15	1	1	0	0	0	5	5	1	2
Enetai	1	0	1	0	0	0	0	3	0	0
Mooring G	8	0	4	0	1	0	3	4	3	43
Natural Beach	18	6	8	2	3	2	45	11	7	31
Nursery Beach	1	0	0	0	0	0	0	0	0	0
Quarry	1	0	0	0	0	0	0	0	0	0
Pier 8	8	0	0	0	1	2	3	16	0	5
Ross Creek	10	0	1	0	0	0	9	32	45	82
Ross Point	20	0	1071	1	1	0	72	12	51	37
Site 1	8	0	0	0	0	0	0	0	1	12
Tattoo Beach	14	0	23	0	0	0	122	0	8	428
West Marker 11	1	0	0	0	0	0	10	0	0	2
Windy Point	17	0	1	0	1	0	44	32	1	156
Totals	**180**	**8**	**1181**	**4**	**11**	**5**	**422**	**128**	**148**	**883**

Appendix D (cont.). Summary of fish catch by sampling site during regular beach seine (RBS) sampling in Sinclair Inlet in 2002.

Site	Effort	Shiner perch	Striped perch	Pile perch	Snake prickleback	Penpoint gunnel	Crescent gunnel	Saddleback gunnel	misc. gunnels	Pacific sandlance
Blackjack	13	861	0	5	3	2	0	1	0	0
Boatlaunch	14	1357	5	19	14	3	6	0	11	1
Cabana	17	253	4	0	0	3	1	0	1	0
New Charleston	14	321	4	5	0	0	0	0	0	0
CTC Beach	15	309	34	4	0	0	0	0	1	0
Enetai	1	0	1	0	0	0	0	0	0	0
Mooring G	8	342	0	0	0	2	1	0	28	0
Natural Beach	18	3207	7	934	32	15	2	1	1	15
Nursery Beach	1	1	0	0	14	0	0	0	0	0
Quarry	1	0	0	0	0	0	0	0	0	0
Pier 8	8	253	18	0	0	2	0	4	9	10000
Ross Creek	10	980	0	0	2	0	0	0	0	0
Ross Point	20	1941	11	4	99	3	1	44	4	0
Site 1	8	2	0	0	0	0	0	0	1	1
Tattoo Beach	14	1625	1	16	390	0	0	0	0	0
West Marker 11	1	69	0	1	1	0	0	0	0	0
Windy Point	17	531	4	24	3	0	0	0	4	0
Totals	**180**	**12052**	**89**	**1012**	**558**	**30**	**11**	**50**	**60**	**10017**

Appendix D (cont.). Summary of fish catch by sampling site during regular beach seine (RBS) sampling in Sinclair Inlet in 2002.

Site	Effort	Pacific sanddab	Starry flounder	English sole	Rock sole	C. O. turbot	Sand sole	misc. flatfish	Total
Blackjack	13	0	38	0	1	0	0	0	1141
Boatlaunch	14	0	19	0	0	0	0	0	2377
Cabana	17	0	2	1	0	1	3	1	694
New Charleston	14	0	1	34	2	0	0	1	895
CTC Beach	15	0	0	0	0	0	0	0	429
Enetai	1	0	0	0	0	0	0	0	24
Mooring G	8	0	1	0	0	0	0	0	1360
Natural Beach	18	0	48	8	2	13	4	3	4571
Nursery Beach	1	0	0	0	0	0	0	0	479
Quarry	1	0	1	0	0	0	0	0	1
Pier 8	8	0	2	0	0	0	0	0	11278
Ross Creek	10	0	80	1	1	0	1	0	1321
Ross Point	20	17	73	4	1	0	9	24	4309
Site 1	8	0	0	0	0	0	0	0	187
Tattoo Beach	14	0	136	0	2	0	1	0	3708
West Marker 11	1	0	0	0	0	0	0	0	137
Windy Point	17	0	15	8	2	0	0	0	961
Totals	**180**	**17**	**416**	**56**	**11**	**14**	**18**	**29**	**33872**

Appendix E

Appendix E. Summary of fish catch totals by site during mark recapture beach seine (MR) sampling in Sinclair Inlet in 2002.

Appendix E. Summary of fish catch totals by site during mark recapture beach seine (MR) sampling in Sinclair Inlet in 2002. Non-salmonid fish counts are estimates.

Location	Effort	Total Chinook	Sampled Chinook (unclip)	Chinook (clip)	Chinook (unclip w/cwt)	Chinook (clip w/cwt)	Chinook (cwt w/ red)	Chinook (red)	Chinook (orange)	Chinook (chartreuse)
Blackjack	8	152	11	137	4	23	3	1	0	1
Boatlaunch	8	146	9	137	0	20	2	2	0	4
Cabana	8	46	7	36	3	8	0	0	0	1
CTC Beach	8	43	5	37	1	10	0	0	0	1
Enetai	8	33	3	27	3	9	0	0	0	1
Natural	8	79	6	71	2	11	0	1	0	3
New Charleston	8	1186	117	1069	1	180	13	15	0	7
Old Charleston	8	424	45	379	0	48	8	5	0	10
Ross Point	8	549	100	449	0	103	16	5	0	2
Tattoo	8	231	26	205	0	34	11	2	0	3
West Channel Mk 11	8	20	2	17	1	4	0	0	0	0
Windy Point	8	763	90	674	0	97	13	13	0	5
Totals	**96**	**3673**	**421**	**3238**	**15**	**547**	**66**	**44**	**0**	**38**

Appendix E (cont.). Summary of fish catch totals by site during mark recapture beach seine (MR) sampling in Sinclair Inlet in 2002. Non-salmonid fish counts are estimates.

Location	Coho (unclip)	Coho (clip)	Coho (unchecked)	Coho (w/cwt)	Chum	Cutthroat	Pacific Herring	Surf Smelt	Plainfin Midshipman	Threespine Stickleback	Bay Pipefish
Blackjack	5	0	0	0	125	13	0	0	0	0	0
Boatlaunch	0	0	0	0	112	12	0	4	0	0	3
Cabana	2	0	0	0	52	0	0	0	0	0	0
CTC Beach	0	0	3	0	756	17	0	0	0	1	1
Enetai	0	0	0	0	671	3	0	0	2	0	0
Natural	2	2	0	0	54	17	0	1	0	0	7
New Charleston	1	1	0	1	53	7	0	0	0	1	0
Old Charleston	0	1	0	0	16	13	0	0	0	0	0
Ross Point	0	0	0	0	22	9	0	301	0	0	0
Tattoo	0	0	3	0	11	34	0	0	0	0	0
West Channel Mk 11	3	1	0	1	37	33	0	0	0	0	0
Windy Point	1	0	0	0	22	32	1	0	0	0	0
Totals	**14**	**5**	**6**	**2**	**1931**	**190**	**1**	**306**	**2**	**2**	**11**

Appendix E (cont.). Summary of fish catch totals by site during mark recapture beach seine (MR) sampling in Sinclair Inlet in 2002. Non-salmonid fish counts are estimates.

Location	Staghorn Sculpin	Buffalo Sculpin	Large Sculpin	Small Sculpin	Shiner Perch	Striped Perch	Pile Perch	Snake Prickleback	Penpoint Gunnel	misc. Gunnels	Pacific Sandlance
Blackjack	25	0	0	0	240	0	3	0	0	8	2
Boatlaunch	18	2	1	10	273	4	3	1	2	0	0
Cabana	3	0	0	0	10	0	0	0	0	6	0
CTC Beach	1	10	0	0	129	17	4	0	0	2	0
Enetai	10	4	5	0	16	0	0	0	0	18	0
Natural	14	0	0	0	760	0	6	0	0	15	0
New Charleston	0	0	0	0	31	2	0	0	0	0	0
Old Charleston	5	0	9	201	84	1	0	0	0	35	0
Ross Point	20	0	0	1	286	0	0	0	0	0	0
Tattoo	114	0	3	100	662	0	2	26	0	0	0
West Channel Mk 11	37	0	3	4	248	1	0	2	0	7	0
Windy Point	21	1	0	24	770	11	8	0	0	3	0
Totals	**268**	**17**	**21**	**340**	**3509**	**36**	**26**	**29**	**2**	**94**	**2**

Appendix E (cont.). Summary of fish catch totals by site during mark recapture beach seine (MR) sampling in Sinclair Inlet in 2002. Non-salmonid fish counts are estimates.

Location	Starry Flounder	English Sole	Rock Sole	misc. Flatfish	Total
Blackjack	2	0	0	0	575
Boatlaunch	4	0	0	0	595
Cabana	0	0	0	0	119
CTC Beach	0	0	0	0	984
Enetai	0	0	0	0	762
Natural	2	0	0	0	959
New Charleston	0	0	0	0	1283
Old Charleston	6	0	0	18	813
Ross Point	2	0	0	0	1190
Tattoo	21	0	0	30	1237
West Channel Mk 11	7	1	2	2	408
Windy Point	0	0	1	0	1658
Totals	**44**	**1**	**3**	**50**	**10583**

Appendix F

Appendix F. Summary of Chinook salmon catch for regular beach seine (RBS) sampling in Sinclair Inlet in 2001.

Appendix F. Summary of Chinook salmon catch for regular beach seine (RBS) sampling in Sinclair Inlet in 2001. Hatchery origin fish are determined from a clipped adipose fin, while all other fish are counted as "wild" fish. Fish were not tested for coded wire tags in 2001 sampling.

						CPUE			
Location	**Effort**	**Chinook (total)**	**Chinook ("wild")**	**Chinook (hatchery)**	**Chinook (adult)**	**Chinook (total)**	**Chinook ("wild")**	**Chinook (hatchery)**	**Chinook (adult)**
Blackjack	9	14	6	8	0	1.6	0.7	0.9	0.0
Cabana Beach	8	1	0	1	0	0.1	0.0	0.1	0.0
CTC Beach	12	8	1	7	0	0.7	0.1	0.6	0.0
Enetai Beach	2	0	0	0	0	0.0	0.0	0.0	0.0
Evergreen Beach	2	6	3	3	0	3.0	1.5	1.5	0.0
Monkey Tree	2	0	0	0	0	0.0	0.0	0.0	0.0
Mooring G	1	1	1	0	0	1.0	1.0	0.0	0.0
N channel mk #11	3	6	0	6	0	2.0	0.0	2.0	0.0
Natural Beach	13	54	11	43	0	4.2	0.8	3.3	0.0
Old Charleston Beach	12	34	6	24	4	2.8	0.5	2.0	0.3
Overpass Culvert	1	0	0	0	0	0.0	0.0	0.0	0.0
Pier 8	1	4	2	0	2	4.0	2.0	0.0	2.0
Quarry Beach	2	0	0	0	0	0.0	0.0	0.0	0.0
Rockpile Beach	1	0	0	0	0	0.0	0.0	0.0	0.0
Ross Creek	4	21	2	19	0	5.3	0.5	4.8	0.0
Ross Point	14	177	22	155	0	12.6	1.6	11.1	0.0
RR/Kitsap Muffler	1	18	3	15	0	18.0	3.0	15.0	0.0
SE channel mk #11	3	0	0	0	0	0.0	0.0	0.0	0.0
Site 1	1	0	0	0	0	0.0	0.0	0.0	0.0
Tattoo Beach	13	47	8	39	0	3.6	0.6	3.0	0.0
Windy Point	14	397	35	328	34	28.4	2.5	23.4	2.4
Wright Creek	1	0	0	0	0	0.0	0.0	0.0	0.0
Totals	**120**	**788**	**100**	**648**	**40**				

Appendix G

Appendix G. Summary of Chinook salmon catch for regular (RBS) and mark recapture (MR) beach seine sampling in Sinclair Inlet in 2002.

Appendix G. Summary of Chinook salmon catch for regular (RBS) and mark recapture (MR) beach seine sampling in Sinclair Inlet in 2002. Hatchery origin fish are determined from a clipped adipose fin or presence of a coded wire tag (CWT), while all other fish are counted as "wild" fish.

Regular Beach Seine							CPUE		
Location	**Effort**	**Total Chinook**	**Chinook ("wild")**	**Chinook (hatchery)**	**Chinook (Adult)**	**Total Chinook**	**Chinook ("wild")**	**Chinook (hatchery)**	**Chinook (Adult)**
Blackjack	13	14	2	12	0	1.1	0.2	0.9	0.0
Boatlaunch	14	71	4	67	0	5.1	0.3	4.8	0.0
Cabana	17	85	12	70	3	5.0	0.7	4.1	0.2
New Charleston	14	156	12	144	0	11.1	0.9	10.3	0.0
CTC Beach	15	10	0	8	2	0.7	0.0	0.5	0.1
Enetai	1	7	0	7	0	7.0	0.0	7.0	0.0
Mooring G	8	31	3	28	0	3.9	0.4	3.5	0.0
Natural Beach	18	8	0	8	0	0.4	0.0	0.4	0.0
Nursery Beach	1	0	0	0	0	0.0	0.0	0.0	0.0
Quarry	1	0	0	0	0	0.0	0.0	0.0	0.0
Pier 8	8	124	14	110	0	15.5	1.8	13.8	0.0
Ross Creek	10	30	2	28	0	3.0	0.2	2.8	0.0
Ross Point	20	132	12	120	0	6.6	0.6	6.0	0.0
Site 1	8	59	3	56	0	7.4	0.4	7.0	0.0
Tattoo Beach	14	40	5	34	1	2.9	0.4	2.4	0.1
West Marker 11	1	1	0	1	0	1.0	0.0	1.0	0.0
Windy Point	17	38	6	32	0	2.2	0.4	1.9	0.0
Total	**180**	**806**	**75**	**725**	**6**				

Appendix G (cont.). Summary of Chinook salmon catch for regular (RBS) and mark recapture (MR) beach seine sampling in Sinclair Inlet in 2002. Hatchery origin fish are determined from a clipped adipose fin or presence of a coded wire tag (CWT), while all other fish are counted as "wild" fish.

Mark Recapture		Sampled			CPUE		
Location	**Effort**	**Total Chinook**	**Chinook ("wild")**	**Chinook (hatchery)**	**Total Chinook**	**Chinook ("wild")**	**Chinook (hatchery)**
Blackjack	8	152	11	141	19.0	1.4	17.6
Boatlaunch	8	146	9	137	18.3	1.1	17.1
Cabana	8	46	7	39	5.8	0.9	4.9
CTC Beach	8	43	5	38	5.4	0.6	4.8
Enetai	8	33	3	30	4.1	0.4	3.8
Natural	8	79	6	73	9.9	0.8	9.1
New Charleston	8	1187	117	1070	148.4	14.6	133.8
Old Charleston	8	424	45	379	53.0	5.6	47.4
Ross Point	8	549	100	449	68.6	12.5	56.1
Tattoo	8	231	26	205	28.9	3.3	25.6
West Channel Mk 11	8	20	2	18	2.5	0.3	2.3
Windy Point	8	763	90	674	95.4	11.3	84.3
Total	**96**	**3673**	**421**	**3253**			

Appendix H

Appendix H. Summary of fish catch for surface tow net sampling in Sinclair Inlet in 2002.

Appendix H. Summary of fish catch for surface tow net sampling in Sinclair Inlet in 2002.

Area	Shore	Effort	Chinook (total)	Chinook (unclip)	Chinook (clip)	Chinook (unclip w/cwt)	Chinook (clip w/cwt)	Chinook (red)	Chinook (orange)	Chinook (chartruese)	Chinook (cwt w/ red)
1	Center	12	5	0	4	1	0	0	0	0	0
1	North	15	84	5	75	4	6	2	0	0	1
1	South	11	144	16	125	3	9	0	1	1	0
2	Center	22	278	25	246	7	22	0	0	1	0
2	North	19	410	33	375	2	32	1	1	4	0
2	South	20	291	45	242	4	23	1	2	5	1
3	Center	17	361	25	331	5	18	0	0	2	0
3	North	8	103	9	88	6	4	0	0	0	0
3	South	20	216	30	179	7	7	0	0	0	0
	Totals	**144**	**1892**	**188**	**1665**	**39**	**121**	**4**	**4**	**13**	**2**

Area	Shore	Effort	Coho (unclip)	Coho (clip)	Chum	Cutthroat	Steelhead	Atlantic salmon	Big skate	Pacific herring	Surf smelt	Plainfin midshipman	Threespine stickleback
1	Center	12	1	0	6	0	0	0	0	2	1	8	271
1	North	15	2	0	60	0	0	0	0	1	11	9	96
1	South	11	1	0	53	0	2	0	0	3	1	2	126
2	Center	22	1	0	19	0	0	0	0	12	0	36	34
2	North	19	5	1	50	0	0	0	0	5	2	3	38
2	South	20	0	0	18	1	0	0	0	47	0	131	89
3	Center	17	2	0	125	0	0	1	1	0	0	0	4
3	North	8	1	1	110	0	0	0	0	17	0	1	14
3	South	20	2	2	63	0	0	0	0	2	0	8	11
	Totals	**144**	**15**	**4**	**504**	**1**	**2**	**1**	**1**	**89**	**15**	**198**	**683**

Appendix H (cont.). Summary of fish catch for surface tow net sampling in Sinclair Inlet in 2002.

Area	Shore	Effort	Bay pipefish	Staghorn sculpin	Sculpin (small)	Shiner perch	Snake prickleback	Crescent gunnel	Saddleback gunnel	misc. gunnel	Pacific sandlance	unid. forage fish
1	Center	12	0	0	0	0	0	0	0	0	28	0
1	North	15	3	0	1	8	14	0	1	0	35	22
1	South	11	3	0	1	23	0	0	2	0	4	0
2	Center	22	0	0	0	2	0	0	1	0	5	0
2	North	19	6	0	0	0	0	4	0	0	0	0
2	South	20	3	0	0	24	0	0	0	0	9	0
3	Center	17	0	0	0	0	1	0	7	0	0	0
3	North	8	0	2	2	95	1	0	49	2	0	1
3	South	20	0	0	0	7	1	0	6	2	2	0
	Totals	**144**	**15**	**2**	**4**	**159**	**17**	**4**	**66**	**4**	**83**	**23**

Area	Shore	Effort	Starry flounder	English sole	Totals
1	Center	12	2	0	324
1	North	15	1	0	348
1	South	11	0	0	365
2	Center	22	0	0	388
2	North	19	0	0	524
2	South	20	1	0	614
3	Center	17	0	0	502
3	North	8	0	1	400
3	South	20	1	0	323
	Totals	**144**	**5**	**1**	**3788**

Appendix I

Appendix I. Summary of catch for purse seine sampling in Sinclair Inlet in 2002.

Appendix I. Summary of catch for purse seine sampling in Sinclair Inlet in 2002.

Location	Shore	Effort	Chinook (total)	Chinook (unclip)	Chinook (clip)	Chinook (unclip w/cwt)	Chinook (clip w/cwt)	Chinook (red)	Chinook (orange)	Chinook (chartruese)	Chinook (cwt w/ red)
Annapolis	inshore	2	200	21	172	7	21	1	0	1	0
Enetai	inshore	2	141	8	127	6	16	0	0	1	1
Enetai	offshore	2	24	2	20	2	2	0	0	0	0
Natural	inshore	2	40	4	36	0	6	0	0	0	0
Shipyard	offshore	2	258	14	240	4	24	0	0	6	0
	Totals	**10**	**663**	**49**	**595**	**19**	**69**	**1**	**0**	**8**	**1**

Location	Shore	Effort	Coho (unclip)	Coho (clip)	Chum	Steelhead	Pacific herring	Surf smelt	Three-spine stickleback	Totals
Annapolis	inshore	2	9	0	18	0	0	0	0	227
Enetai	inshore	2	11	5	584	0	10	11	16	778
Enetai	offshore	2	0	0	25	1	0	0	1	51
Natural	inshore	2	3	1	66	0	5	0	2	117
Shipyard	offshore	2	8	9	15	0	5	0	11	306
	Totals	**10**	**31**	**15**	**708**	**1**	**20**	**11**	**30**	**1479**

Appendix J

Appendix J. Summary of catch of juvenile Chinook salmon for all sampling efforts in Sinclair Inlet in 2002.

Appendix J. Summary of catch of juvenile Chinook salmon for all sampling efforts in Sinclair Inlet in 2002.

Date	Method	Time	Effort	Chinook (total)	(unclip)	(clip)	unclip (w/cwt)	clip (w/cwt)	red (w/cwt)	red	orange	chartreuse
2/5	RBS	night	9	0	0	0	0	0	0	0	0	0
3/4	RBS	day	10	0	0	0	0	0	0	0	0	0
3/5	RBS	night	9	0	0	0	0	0	0	0	0	0
3/25	RBS	day	10	0	0	0	0	0	0	0	0	0
3/26	RBS	night	9	0	0	0	0	0	0	0	0	0
3/27	RBS	night	6	0	0	0	0	0	0	0	0	0
4/15	RBS	day	10	0	0	0	0	0	0	0	0	0
4/16	RBS	night	9	0	0	0	0	0	0	0	0	0
4/17	RBS	night	9	0	0	0	0	0	0	0	0	0
5/9	SPS	night	6	0	0	0	0	0	0	0	0	0
5/13	STN	night	24	0	0	0	0	0	0	0	0	0
5/14	STN	night	27	0	0	0	0	0	0	0	0	0
5/15	RBS	night	8	0	0	0	0	0	0	0	0	0
5/17	RBS	day	6	0	0	0	0	0	0	0	0	0
5/21	MR	day	12	7	0	7	0	6	0	2	0	0
5/24	MR	day	12	584	50	534	0	126	42	27	0	4
5/28	MR	day	12	917	66	850	1	140	11	6	0	16
5/31	MR	day	12	1463	240	1215	8	196	10	9	0	9
6/4	MR	day	12	243	21	222	0	32	1	1	0	2
6/6	RBS	night	5	207	10	196	1	25	0	1	0	6
6/7	RBS	day	5	194	16	172	6	28	0	0	0	1
6/11	MR	day	12	303	21	279	3	33	1	0	0	5
6/12	RBS	night	7	31	4	27	0	3	0	0	0	1
6/13	STN	day	14	265	20	242	3	20	1	3	0	5
6/14	STN	night	6	263	25	233	5	25	1	0	1	3

Appendix J (cont.). Summary of catch of juvenile Chinook salmon for all sampling efforts in Sinclair Inlet in 2002.

Date	Method	Time	Effort	Chinook (total)	(unclip)	(clip)	unclip (w/cwt)	clip (w/cwt)	red (w/cwt)	red	orange	chartreuse
6/18	MR	day	12	61	8	51	2	10	0	0	0	2
6/19	LPS	day	5	325	32	281	12	37	1	0	0	0
6/20	LPS	night	5	338	17	314	7	32	0	1	0	8
6/25	MR	day	12	95	15	79	1	5	0	0	0	0
7/1	RBS	day	10	17	2	15	0	2	0	0	0	0
7/3	RBS	night	5	109	11	98	0	18	0	0	0	1
7/16	STN	day	19	353	38	301	14	20	0	1	1	2
7/17	STN	night	15	693	61	625	7	33	0	0	0	2
7/18	STN	night	8	229	22	203	4	20	0	0	2	1
7/22	RBS	day	9	24	2	22	0	5	0	0	0	0
7/24	RBS	night	6	74	12	56	6	9	0	0	0	0
8/6	RBS	day	10	41	5	35	1	4	0	0	0	0
8/7	RBS	night	6	32	3	28	1	3	0	0	0	1
8/8	RBS	night	4	45	4	38	3	7	0	0	0	0
8/13	STN	day	17	54	17	36	1	2	0	0	0	0
8/14	STN	night	14	36	5	26	5	1	0	0	0	0
9/3	RBS	day	10	5	1	3	1	1	0	0	0	0
9/4	RBS	night	8	21	5	15	1	0	0	0	0	0
	Total		**436**	**7029**	**733**	**6203**	**93**	**843**	**68**	**51**	**4**	**69**

Appendix K

Appendix K. Summary of marked Chinook salmon recaptured during the mark recapture (MR) beach seine sampling in Sinclair Inlet, 2002.

Appendix K. Summary of marked fish recapture during MR beach seine sampling in Sinclair Inlet, 2002. Recapture numbers are adjusted for subsampling. Fish from the first three groups (red pigment and/or CWT specific to Gorst raceway) were forced out of the raceway into Gorst Creek on 5/19. Fish marked with chartreuse pigment and in the Gorst rearing ponds (with and without NATURES treatment) were allowed to volitionally release from 5/20 – 6/21. A release date of 5/23 was used for residence time calculation for fish released volitionally.

	Release date	5/21	5/24	5/28	5/31	6/4	6/11	6/18	6/25	Mean residence time
Area 1										
Red	5/19	0	17	0	1	0	0	0	0	5.4
Red w/CWT	5/19	0	27	3	9	1	0	0	0	7.2
CWT Gorst raceway	5/19	14	42	11	0	0	0	0	1	5.5
Chartreuse	5/20 - 6/21	0	0	3	8	0	0	0	0	7.2
CWT Gorst control pond	5/20 - 6/21	0	29	10	28	2	5	3	0	6.3
CWT Gorst experimental pond	5/20 - 6/21	0	8	47	22	5	8	3	0	7.6
Area 2										
Red	5/19	0	8	6	9	1	0	0	0	9.1
Red w/CWT	5/19	0	14	8	2	0	1	0	0	7.6
CWT Gorst raceway	5/19	0	22	14	0	9	3	0	0	9.3
Chartreuse	5/20 - 6/21	0	4	13	15	1	2	0	0	6.8
CWT Gorst control pond	5/20 - 6/21	0	8	23	5	0	7	1	2	8.5
CWT Gorst experimental pond	5/20 - 6/21	0	9	28	115	6	0	2	2	7.8
Area 3										
Red	5/19	0	0	0	1	0	0	0	0	12.0
Red w/CWT	5/19	0	0	0	0	0	0	0	0	0.0
CWT Gorst raceway	5/19	0	0	0	0	2	0	2	0	22.0
Chartreuse	5/20 - 6/21	0	0	0	0	1	3	2	0	20.2
CWT Gorst control pond	5/20 - 6/21	0	0	0	3	4	2	1	0	13.6
CWT Gorst experimental pond	5/20 - 6/21	0	0	2	2	2	0	0	2	14.5

Appendix L

Appendix L. Summary of origin of juvenile Chinook salmon recovered with coded wire tags (CWT) by recovery location and time.

Appendix L. Summary of origin of juvenile Chinook salmon recovered with coded wire tags (CWT) by recovery location and time. Effort varies by month and location. Numbers adjusted for subsampling.

	Gorst control	Gorst nature's	Gorst spray mark	Grovers unclip	Grovers clip	Big Soos	Nisqually	Wallace R Skykomish	Cowski & Rushwater Ponds	Diru Cr (Puyallup)	Hupp Spr. (Minter)	White River	Slater Slough (Lummi)	Tulalip Cr	Friday Cr (Samish)	Gray Wolf R (Dungeness)	Whitehorse Springs	Chilliwack R (Fraser R)	*Total*	# hauls / tows
May 21-31																				
Area 1																				
beach	67	77	68																212	16
Area 2																				
beach	35	151	36	19															241	22
Area 3																				
beach	3	4	1	16	1														25	24
Total	***105***	***232***	***105***	***35***	***1***														***478***	
June 1 - 15																				
Area 1																				
beach	7	15	1																23	10
tow net	4	3																	7	4
Area 2																				
beach	27	19	17	9	2														74	14
tow net	21	14			2	3													40	12
Area 3																				
beach	6	2	5	3	6							yrlng*							22	16
tow net	6				1														7	4
Total	***71***	***53***	***23***	***12***	***11***	***3***													***173***	

yrlng* One yearling chinook from White River release. Subsampling adjustment to two fish (not included in total)

Appendix L (cont.). Summary of origin of juvenile Chinook salmon recovered with coded wire tags (CWT) by recovery location and time. Effort varies by month and location. Numbers adjusted for subsampling.

	Gorst control	Gorst nature's	Gorst spray mark	Grovers unclip	Grovers clip	Big Soos	Nisqually	Wallace R Skykomish	Cowski & Rushwater Ponds Diru Cr (Puyallup)	Hupp Spr. (Minter)	White River	Slater Slough (Lummi)	Tulalip Cr	Friday Cr (Samish)	Gray Wolf R (Dungeness)	Whitehorse Springs	Chilliwack R (Fraser R)	*Total*	# hauls / tows
June 16 - 30																			
Area 1																			
Beach	3	3																6	6
Area 2																			
Beach	1	4																5	8
Purse	19	5	12	10	8	2												56	4
Area 3																			
Beach	1	2	2	4		1												10	10
Purse	2	6	3	4	8	3	7						2					35	6
Total	***26***	***20***	***17***	***18***	***16***	***6***	***7***						***2***					***112***	
July 1 – 15																			
Area 1																			
Beach	1	2				1												4	5
Area 2																			
Beach	3	3																6	5
Area 3																			
Beach	1	3	1	1	1	1						1						9	5
Total	***5***	***8***	***1***	***1***	***1***	***2***						***1***						***19***	

Appendix L (cont.). Summary of origin of juvenile Chinook salmon recovered with coded wire tags (CWT) by recovery location and time. Effort varies by month and location. Numbers adjusted for subsampling.

	Gorst control	Gorst nature's	Gorst spray mark	Grovers unclip	Grovers clip	Big Soos	Nisqually	Wallace R Skykomish	Cowski & Rushwater Ponds (Puyallup)	Diru Cr (Puyallup)	Hupp Spr. (Minter)	White River	Slater Slough (Lummi)	Tulalip Cr	Friday Cr (Samish)	Gray Wolf R (Dungeness)	Whitehorse Springs	Chilliwack R (Fraser R)	*Total*	# hauls / **tows**
July 16 - 31																				
Area 1																				
beach		2			1	1	2	2							1		1		10	5
townet	10	2	1	1	1	2	1												18	9
Area 2																				
Beach	4		1	2					1			1				1			10	6
townet	12	8	3	1	5	10	2	1				3						1	45	16
Area 3																				
Beach						3													3	4
townet	5	3	1	6	3	10	5		1		5		2	1					42	17
Total	***31***	***15***	***6***	***10***	***10***	***26***	***10***	***3***	***2***		***5***	***4***	***2***	***1***	***1***	***1***	***1***	***1***	***129***	
August 1 - 15																				
Area 1																				
beach	2	2					1	1											6	7
townet																				5
Area 2																				
Beach	1			1	2	2	2		1			1							10	7
townet	1							1											2	14
Area 3																				
beach						1	1		1										3	6
townet						2		2			3								7	12
Total	***4***	***2***		***1***	***2***	***5***	***4***	***4***	***2***		***3***	***1***							***28***	

Appendix L (cont.). Summary of origin of juvenile Chinook salmon recovered with coded wire tags (CWT) by recovery location and time. Effort varies by month and location. Numbers adjusted for subsampling.

	Gorst control	Gorst nature's	Gorst spray mark	Grovers unclip	Grovers clip	Big Soos	Nisqually	Wallace R Skykomish	Cowski & Rushwater Ponds (Puyallup)	Diru Cr (Puyallup)	Hupp Spr. (Minter)	White River	Slater Slough (Lummi)	Tulalip Cr	Friday Cr (Samish)	Gray Wolf R (Dungeness)	Whitehorse Springs	Chilliwack R (Fraser R)	*Total*	# hauls / tows
August 16 - 31	no beach seines or tows																			
September 1 - 15																				
Area 1																				
beach								1											1	6
Area 2																				
beach								1		1									2	7
Area 3																				
beach																				5
Total								***2***		***1***									***3***	
Total CWT recoveries	242	330	152	77	41	42	21	9	4	1	8	5	3	3	1	1	1	1	942	

Appendix M

Appendix M. Summary of all prey items found in the diets of juvenile salmonids collected in Sinclair Inlet 2001-2002.

Appendix M. Summary of all prey items found in the diets of juvenile salmonids collected in Sinclair Inlet 2001-2002. Presence of prey in stomach contents is indicated by X in column for juvenile Chinook salmon, chum salmon and cutthroat trout. Ecological categories for diet data analysis are also listed: planktonic-neritic (P-N), benthic-epibenthic (B-EB), terrestrial (T), and plant material (PLA).

Phylum / **Class** / **Order** / **Family** / ***Genus species***	**Life History stage**	**Prey Ecology**	**Presence in Sinclair Salmonid Diet** Chinook n=335	Chum 41	Cutthroat 34
Annelida					
Polychaeta	larva	P-N	X	X	
	adult	B-EB	X		X
Cirratulidae	adult	B-EB	X		
Nereidae	adult	B-EB	X		
Platynereis bicanaliculata	adult	B-EB	X		
Opheliidae	adult	B-EB	X		
Spionidae	adult	B-EB	X		
Arthropoda					
Acari	adult	T	X	X	
Araneae	adult	T	X		X
Chilopoda	adult	T	X		
Psuedoscorpiones	adult	T	X		
subphylum Crustacea	larva	P-N		X	X
Branchiopoda					
subclass Cladocera					
Evadne spp	adult	P-N		X	
Podon spp	adult	P-N	X	X	
Malacostraca					
Decapoda	zoea	P-N	X		
	megalopa	P-N	X		
	larva	P-N	X		
	unidentified		X		
infraorder Anomura	zoea	P-N	X		
	megalopa	P-N	X		
	larva	P-N	X		
Paguridae	zoea	P-N	X		
	megalopa	P-N	X		
	juvenile-adult	B-EB		X	
Porcellanidae	zoea	P-N	X	X	
	megalopa	P-N	X		

Appendix M (cont.). Summary of all prey items found in the diets of juvenile salmonids collected in Sinclair Inlet 2001-2002.

Phylum **Class** **Order** **Family** ***Genus species***	**Life History stage**	**Prey Ecology**	**Presence in Sinclair Salmonid Diet** **Chinook n=335**	**Chum 41**	**Cutthroat 34**
infraorder Brachyura	zoea	P-N	X	X	
	megalopa	P-N	X		
	juvenile	B-EB	X		
Cancer spp	zoea	P-N	X		
	megalopa	P-N	X		X
Grapsidae	zoea	P-N	X		
	megalopa	P-N	X		
Majidae	zoea	P-N	X	X	
	megalopa	P-N	X		
Pinnotheridae	zoea	P-N	X	X	X
	megalopa	P-N	X		X
	juvenile	B-EB	X		
	adult	P-N	X		
Fabia subquadrata	adult	P-N			X
Xanthidae	zoea	P-N	X		
infraorder Caridea	larva	P-N	X	X	
	juvenile	B-EB	X		X
	adult	B-EB	X	X	X
Crangonidae	larva	P-N	X	X	
	juvenile	B-EB	X		
	adult	B-EB			X
Crangon spp	larva	P-N	X		
	adult	B-EB			X
Hippolytidae	larva	P-N	X	X	
	juvenile	B-EB	X		
	adult	B-EB			X
Heptacarpus spp	larva	P-N	X		
	juvenile	B-EB	X		
Hippolyte clarki	larva	P-N	X		
	juvenile	B-EB	X		X
	adult	B-EB	X		X
infraorder Thallassinidea					
Neotrypaea spp	larva	P-N	X	X	
Euphausiacea	larva	P-N	X	X	
	adult	P-N	X	X	
Euphausia pacifica	adult	P-N		X	

Appendix M (cont.). Summary of all prey items found in the diets of juvenile salmonids collected in Sinclair Inlet 2001-2002.

Phylum / **Class** / **Order** / **Family** / ***Genus species***	**Life History stage**	**Prey Ecology**	**Presence in Sinclair Salmonid Diet** Chinook n=335	Chum 41	Cutthroat 34
subclass Peracarida					
Amphipoda	juvenile-adult		X	X	
suborder Caprellidea	juvenile-adult	B-EB	X	X	X
Caprella spp	juvenile-adult	B-EB	X		X
Metacaprella spp	juvenile-adult	B-EB	X		X
suborder Gammaridea	juvenile-adult	B-EB	X	X	X
Corophium spp	juvenile-adult	B-EB	X	X	X
Allorchestes spp	adult	B-EB	X		X
Americhelidium spp	juvenile-adult	B-EB	X	X	
Ampelisca spp	adult	B-EB	X		
Amphilochus spp	adult	B-EB		X	
Amphilochus spp	adult	B-EB	X		
Ampithoe spp	juvenile-adult	B-EB	X	X	X
Anisogammarus spp	adult	B-EB	X		X
Aoroides spp	juvenile-adult	B-EB	X	X	
Cyphocaris challengeri	adult	P-N	X		
Eobrolgus sppinosus	adult	B-EB	X		
Eogammarus spp	juvenile-adult	B-EB	X	X	X
Ericthonius spp	juvenile-adult	B-EB	X		
Gammaropsis spp	juvenile-adult	B-EB	X	X	
Grandidierella japonica	adult	B-EB			X
Heterophoxus spp	adult	B-EB	X		
Hyale frequens	adult	B-EB	X		
Ischyrocerus spp	juvenile-adult	B-EB	X	X	
Jassa spp	adult	B-EB	X		X

Appendix M (cont.). Summary of all prey items found in the diets of juvenile salmonids collected in Sinclair Inlet 2001-2002.

Phylum / Class / Order / Family / *Genus species*	Life History stage	Prey Ecology	Presence in Sinclair Salmonid Diet: Chinook n=335	Chum 41	Cutthroat 34
Pontogeneia spp	juvenile-adult	B-EB		X	
Protomedeia spp	juvenile-adult	B-EB	X		
Synchelidium shoemakeri	juvenile	B-EB	X		
Tiron biocellata	adult	B-EB	X	X	
Westwoodilla spp	juvenile-adult	B-EB	X	X	
Calliopiidae	juvenile-adult	B-EB	X	X	
Calliopius spp	juvenile-adult	B-EB	X	X	
Phoxocephalidae	adult	B-EB	X		
Pleustidae	juvenile-adult	B-EB	X		
Stenothoidae	adult	B-EB	X		
Talitridae	juvenile-adult	T	X		X
suborder Hyperiidea	juvenile-adult	P-N	X	X	
Hyperia spp	juvenile-adult	P-N	X		
Parathemistos spp	juvenile-adult	P-N	X		X
Cumacea	adult	B-EB	X		
Cumella vulgaris	adult	B-EB	X	X	
Diastylis spp	adult	B-EB	X		
Diastylopsis spp	juvenile-adult	B-EB	X	X	
Lamprops quadriplicata	adult	B-EB	X	X	
Isopoda	juvenile-adult	B-EB	X	X	
Limnoria lignorum	adult	B-EB	X		
Idotea spp	juvenile-adult	B-EB	X		X
Sphaeromatidae	juvenile-adult	B-EB			X
Exosphaeroma spp	adult	B-EB			X

Appendix M (cont.). Summary of all prey items found in the diets of juvenile salmonids collected in Sinclair Inlet 2001-2002.

Phylum / **Class** / **Order** / **Family** / ***Genus species***	**Life History stage**	**Prey Ecology**	**Presence in Sinclair Salmonid Diet** Chinook n=335	Chum 41	Cutthroat 34
Gnorimosphaeroma oregonense	adult	B-EB	X		X
Mysidacea	juvenile-adult	P-N	X		X
Alienacanthomysis macropsis	adult	P-N	X	X	
Holmesimysis spp	adult	P-N	X		
Neomysis kadiakensis	juvenile-adult	P-N	X		
Neomysis mercedis	adult	P-N	X		
Tanaidacea					
Leptochelia dubia	juvenile-adult	B-EB	X		X
Maxillipoda (Copepoda)	copepodid-adult		X		
Calanoida	copepodid-adult	P-N	X	X	
Aetidius spp	adult	P-N		X	
Euchaeta media	adult	P-N	X		
Eurytemora spp	adult	P-N		X	
Paracalanus spp	adult	P-N	X		
Calanus spp	adult	P-N	X	X	
Epilabidocera spp	adult	P-N	X		
Harpacticoida	copepodid-adult	B-EB	X	X	X
Amphiascopsis spp	adult	B-EB		X	
Dactylopusia spp	adult	B-EB		X	
Diosaccus sppinatus	adult	B-EB	X		
Harpacticus spp	adult	B-EB	X	X	
Parathelestrus spp	adult	B-EB		X	
Porcellidium spp	adult	B-EB		X	
Scutellidium spp	adult	B-EB		X	
Tisbe spp	copepodid-adult	B-EB	X	X	
Zaus spp	adult	B-EB	X		
Laophontidae	adult	B-EB	X		
Ectinosomatidae	adult	B-EB	X		

Appendix M (cont.). Summary of all prey items found in the diets of juvenile salmonids collected in Sinclair Inlet 2001-2002.

Phylum / Class / Order / Family / *Genus species*	Life History stage	Prey Ecology	Presence in Sinclair Salmonid Diet: Chinook n=335	Chum 41	Cutthroat 34
Poecilostomoida					
Corycaeus anglicus	adult	P-N	X	X	
Cyclopoida	adult	P-N		X	
Diacyclops thomasi	adult	P-N	X		
infaclass Cirripedia	nauplii	P-N	X	X	
	cypris	P-N	X	X	
	adult	B-EB	X		X
	exuvia	B-EB	X	X	X
	nauplii mass	B-EB	X		X
Ostracoda	adult	B-EB	X		
Euphilomedes carcharodontoa	adult	B-EB	X		
Rutiderma lomae	adult	B-EB	X		
Hexapoda (Insecta)	larva	T	X		
	pupa	T	X		
	adult	T	X		X
Coleoptera	larva	T	X		
	adult	T	X		
Coccinellidae	adult	T	X		X
Melandryidae	adult	T	X		
Staphylinidae	adult	T	X		
superfamily Curculionoidea	adult	T	X		
Collembola	adult	T	X	X	
Dermaptera	adult	T	X		X
Diptera	larva	T	X		X
	pupa	T	X		X
	adult	T	X	X	
Sciaridae	adult	T		X	X
Cecidomyiidae	adult	T	X		
Ceratopogonidae	larva	T	X		
	adult	T	X		
Chironomidae	larva	T	X	X	
	pupa	T	X	X	
	adult	T	X	X	
Chloropidae	adult	T	X		

Appendix M (cont.). Summary of all prey items found in the diets of juvenile salmonids collected in Sinclair Inlet 2001-2002.

Phylum / Class / Order / Family / *Genus species*	Life History stage	Prey Ecology	Presence in Sinclair Salmonid Diet: Chinook n=335	Chum 41	Cutthroat 34
Dolichopodidae	adult	T	X		
Empididae	adult	T	X		
Ephydridae	adult	T	X		
Mycetophilidae	adult	T	X		
Psychodidae	adult	T	X		
Rhagionidae	adult	T		X	
Sciaridae	adult	T	X		
Sphaeroceridae	adult	T	X		
Tipulidae	adult	T	X		
Hemiptera	nymph	T	X		
	adult	T	X		
Anthocoridae	adult	T	X		
Lygaeidae	adult	T	X		
Miridae	adult	T	X		
Tingidae	adult	T	X		
Homoptera	nymph	T	X		
	adult	T	X		
superfamily Aphidoidea	adult	T	X	X	X
Delphacidae	adult	T	X		
Cercopidae	adult	T			X
Cicadellidae	adult	T	X		
Psyllidae	adult	T	X		
Hymenoptera	adult	T	X		X
Formicidae	adult	T	X		X
superfamily Chalcoidea	adult	T	X		
Dryinidae	adult	T	X		
Mymaridae	adult	T	X		
superfamily Ichneumonoidea	adult	T	X		
superfamily Proctotrupoidea	adult	T	X		
Isoptera	adult	T			X
Hodotermitidae	adult	T	X		X
Lepidoptera	larva	T	X		
	adult	T	X		
Neuroptera	adult	T			X
Coniopterygidae	adult	T	X		

Appendix M (cont.). Summary of all prey items found in the diets of juvenile salmonids collected in Sinclair Inlet 2001-2002.

Phylum / **Class** / **Order** / **Family** / ***Genus species***	**Life History stage**	**Prey Ecology**	**Presence in Sinclair Salmonid Diet** Chinook n=335	Chum 41	Cutthroat 34
Psocoptera	adult	T	X	X	X
Thysanoptera	adult	T	X		
Chordata					
superclass Osteichthyes	egg	P-N	X	X	
	larva	P-N	X		
	juvenile	P-N	X		X
	unidentified	P-N	X		X
Porichthys notatus	juvenile	P-N	X		X
Gasterosteus aculeatus	juvenile	P-N	X		
Ammodytes hexapterus	juvenile	P-N			X
Embiotocidae	juvenile	P-N			X
Clevelandia ios	juvenile	P-N			X
Oncorhynchus spp	juvenile	P-N			X
Cnidaria					
Hydrozoa		B-EB	X		
Cephalopoda					
Octapoda	juvenile	P-N	X		
Teuthoidea	juvenile	P-N	X		
Gastropoda	adult	B-EB	X	X	X
Urochordata					
Larvacea					
Oikopleura spp	adult	P-N		X	
Inorganic matter			X	X	X
Plant matter		PLA	X	X	X

Appendix N

Appendix N. Prey taxa representative of general prey categories used in juvenile salmon diet analysis. Those taxa which contributed most to the category by weight are emphasized.

Appendix N1. Prey taxa representative of general prey categories used in juvenile Chinook salmon diet analysis. Those taxa which contributed most to the category by weight are emphasized.

Prey Category	**Major Taxa Represented**
Insecta	All life history stages of insect prey, including: Termites (probably *Zootermopsis* sp.), ants (Hymenoptera, primarily winged), barklice (Psocoptera), Dance flies (Empididae), Gnats (Sciaridae) and other flies (Diptera), Moths and Caterpillars (Lepidoptera
Fish and fish parts	Three-spine stickleback (*Gasterosteus aculeatus*), juvenile Plainfin midshipmen (*Porichthys notatus*) and other unidentified fish and fish eggs.
Decapod larva	Porcellanid zoea (Porcelain crab), Cancrid (*Cancer sp.)*, Pinnotherid (Pea crab), Pagurid (Hermit crab), Grapsid (Shore crab) zoea and megalopa, and Caridean larva (Crangonid and Hippolytid)
Cirripedia and parts	Adult barnacles (apparently bitten off, sometimes with shell fragments but usually without) as well as molts, naupliar masses and individual planktonic nauplii and cypris
Gammaridea	Primarily *Calliopius sp.,Ampithoe sp., Aoroides sp., Anisogammarus sp., Gammaropsis sp., Photis sp., Jassa sp*. and Taltitrids (beach hoppers)
other Crustacea	Primarily juvenile and adult Mysids (*Neomysis sp., Holmesimysis sp.*) and Caridean shrimp (Hippolytidae). Also, Caprellid amphipods (*Metacaprella sp., Caprella sp.*) Hyperiid amphipods (*Hyperia sp.* and *Parathemisto sp.*), Cumaceans (*Diastylopsis sp. and* Cume)
Polychaeta	primarily Nereid polychaetes, species undetermined
other	Plant matter (aquatic and terrestrial), Inorganic matter (shell fragments, molts except barnacle molts), spiders (Araneae), ticks and mites (Acari), juvenile octopus and squid (Cephalopoda)

Appendix N2. Prey taxa representative of general prey categories used in juvenile chum salmon diet analysis. Those taxa which contributed most to the category by weight are emphasized.

Prey Category	**Major Taxa Represented**
Insecta	Dipteran flies (Rhagionidae, Chironomidae, Sciaridae), aphids (Aphidoidea), springtails (Collembola) and barklice (Psocoptera)
Fish and fish parts	Unidentified fish eggs
Decapod larva	Ghost shrimp larva (*Neotrypaea sp.*), caridean shrimp larva (Pandalidae, Hippolytidae, Crangonidae), porcellainid (Porcelain crab) and pinnotherid (Pea crab) zoea.
Cirripedia and parts	Primarily planktonic cypris stage barnacles, also some adult barnacles (apparently bitten off)
Gammaridea	Primarily *Gammaropsis sp., Aoroides sp. Photis sp., Ischyrocerus sp., Pontogeneia sp*. and *Calliopius sp.*
other Crustacea	Primarily harpacticoid copepods (*Tisbe sp., Harpacticus sp., Dactylopusia sp*.) and euphausid larva. Also, adult mysids (*Alienacanthomysis sp*.), euphausids (*Euphausia pacifica*), cladocerans (*Podon sp., Evadne sp*.), calanoid copepods (*Aetidius divergens*)
Polychaeta	primarily Nereid polychaetes, species undetermined
other	Larvaceans (*Oikopleura* sp), mites (Acari), plant matter, polychaete larva and inorganic matter.