Coastal Cutthroat Trout (*Oncorhynchus clarki clarki)* Diet

In South Puget Sound, Washington 1999 – 2002

by

Joseph M. Jauquet

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This Thesis for the Master of Environmental Studies Degree

by

Joseph M. Jauquet

has been approved for

The Evergreen State College

by

____

David Milne, Ph.D.
Member of the Faculty

____

C. Jeff Cederholm, M.S.
Salmon Biologist
Washington Department of Natural Resources

____

Date

ABSTRACT

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The coastal cutthroat trout has not received as much research attention, particularly in estuarine waters, as have the other six species of Pacific Northwest salmon (*O.* spp). Reasons for the relative lack of knowledge are probably because the coastal cutthroat has not been fished commercially and is somewhat difficult to capture by typical methods in marine waters. The coastal cutthroat was recently proposed for protection under the Federal Endangered Species Act, however it was not listed. Federal listing could have afforded this species increased protection in the face of rapidly advancing human development activities.

Coastal cutthroat life history involves use of estuary and nearshore marine waters before sexual maturity, and after their freshwater spawning runs. This species of Pacific salmon can survive spawning and is not known to migrate to the offshore open ocean. Because cutthroat reside in estuaries and nearshore waters, this gives them temporal and spatial opportunities to feed on a variety of marine fish and invertebrates. They are also known to actively feed on the eggs and fry of other salmon species.

This study explored the extent to which coastal cutthroat prey on salmon eggs and salmon young in estuaries, and discusses the ecological implications of this behavior for salmon and coastal cutthroat management. From July 1999 to April 2000, 115 coastal cutthroat were captured by non-lethal hook-and-line angling methods in four inlets of South Puget Sound. Basic fish length and scale information was collected, and their stomach contents were collected by lavage. Of the 94 stomach samples saved for analysis, the wet weight of principal diet items were salmon eggs and chum salmon fry

46%), followed by other non-salmon fishes (23%) and polychaetes (12%). Invertebrates such as amphipods, isopods, shrimp and clam necks together constituted 17% of the cutthroat diet, and other items made up 2%. The most important non-salmon fishes in the diet were shiner perch (*Cymatogaster aggregata)*, Pacific herring (*Clupea harengus pallasi)*, Pacific sand lance (*Ammodytes hexapterus)* and arrow goby (*Clevelandia ios)*. Coastal cutthroat diet preferences differed when salmon were present versus when salmon were absent. The length of coastal cutthroat when salmon were present in the estuary was not significantly different (Chi-square = 0.11, 2 df) from when salmon were not present. It appears that coastal cutthroat preferentially select salmon eggs and chum salmon fry when they are present in the estuary, despite the abundance of alternative food items, and shift to these alternative items at other times.

Interspecies feeding is an important part of cutthroat life history, especially in locales where mass-spawning Pacific salmon are abundant. Increased fitness and fecundity of coastal cutthroat is likely the result of successful evolution of life history traits such as feeding behavior. Coastal cutthroat could serve as a biological indicator species for estuary function and process because they have been found to be the first species to disappear after environmental degradation, and the estuaries are a primary habitat during their adult and pre-adult life. Measures of coastal cutthroat regional population size may be directly related to salmon escapement and habitat quality in estuaries. Setting ecologically-based escapement goals for Pacific salmon is an important action managers could take to support interspecies feeding opportunities for coastal cutthroat.

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Coastal Cutthroat Trout (*Oncorhynchus clarki clarki*) Diet in South Puget Sound, Washington 1999-2002

Joseph M. Jauquet
Evergreen State College
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Introduction

Recent developments, including habitat losses, over-harvest and inattention to wild stocks, have made it increasingly important to understand the early juvenile ecology of Pacific salmon, some stocks of which have been recently listed as "threatened or endangered" under the Federal Endangered Species Act (ESA). One aspect of juvenile salmonid development that is presently not well understood is their interspecies interactions in estuaries. In particular, to what extent do coastal cutthroat (*Oncorhynchus clarki clarki)* prey upon young salmon, or compete with them for resources? This thesis explores this question and discusses the ecological implications for salmon and cutthroat management policies that may stem from these findings.

I researched the diet of 115 coastal cutthroat trout that were sampled and released in four inlets of South Puget Sound (Eld, Totten, Skookum, and Hammersley Inlets) between 1999 and 2002. This research was intended to characterize the estuarine diet and size of coastal cutthroat inhabiting estuaries with emphasis on interactions between coastal cutthroat and other Pacific salmon, especially the relatively abundant chum salmon *(O. keta)*.

The abundance of prey is one factor that could influence the distribution and survival of coastal cutthroat in estuaries and near-shore marine waters. Relatively little is known about the diet of estuary dwelling coastal cutthroat, especially as pertains to their complex interspecies interactions with other Pacific Northwest salmon (*Oncorhynchus* spp.). There has been relatively little research focused on coastal cutthroat diet in Puget Sound; the few studies that describe their estuarine diets were mainly carried out in other states and the Columbia River (Giger 1972b; Armstrong 1971; Loch and Miller 1988; Pearcy 1997).

Data on coastal cutthroat are relatively scarce because these fish have not been defined as a commercial species on the Pacific coast (Trotter 1997). For that reason, fisheries research and reporting have not been routinely performed. From a fisheries management perspective, coastal cutthroat are vulnerable to over-fishing by recreational fishers mainly because they are highly accessible during their residence in marine near-shore and beach areas (Giger 1972a, 1972b; Behnke 1992; Trotter 1987; Wydoski and Whitney 1979). Knowledge of their estuarine diet is valuable because they spend most of their marine lives in estuaries and nearshore areas, and these areas may be heavily affected by human development activities.

Unlike other Pacific salmon, coastal cutthroat usually do not migrate far offshore in the Pacific Ocean (Trotter 1997; Johnston 1982). They live mostly within a few kilometers of shorelines and migrate to the upper-most, high gradient reaches of small freshwater streams for spawning. The life history of anadromous cutthroat feeding in salt water and returning to spawn in fresh water can involve migrations between fresh and marine waters before maturity to feed, and after maturity to feed and spawn (Garrett, A. 1998). The presence of cutthroat sub-adults and adults in estuaries probably allows seasonal feeding opportunities on the eggs, carcass flesh, fry, and smolts of other Pacific salmon, such as the abundant chum salmon (*O. keta*).

The coastal cutthroat trout could be used as a biological indicator species for Pacific salmon ecosystem functions **(**Behnke 1987). The coastal cutthroat ranges to the highest reaches of freshwater streams, yet spends much of its adult life in estuaries and nearshore areas, where food resources are abundant (Johnston 1982). Information about its presence or absence relative to food supplies, and its abundance, could provide valuable information for environmental managers of watersheds and estuaries.

In estuarine and freshwater habitats, the abundance of the other six species of Pacific Northwest salmon may be an important influence on coastal cutthroat abundance. Coastal cutthroat predation may have impacts on Pacific salmon and the abundance of Pacific salmon may influence cutthroat populations. For example, estuarine cutthroat are dependent on the local food base, which probably includes other Pacific salmon during some seasons. Salmon managers could use coastal cutthroat diet data for better management of all Pacific salmon because a direct nutritive relationship has been found, in rivers, between salmon runs and subsequent salmon production (Michael 1995).

The final and probably decisive impact on coastal cutthroat is from human recreational fishing and commercial fisheries by-catch (Giger 1972b; Emmett et al. 1991). Recently, in the Southwest Washington and Columbia River Evolutionarily Significant Unit, coastal cutthroat trout were proposed for threatened status under the ESA, but a decision was made not to list the species as threatened (USFWS 2002). The decision was based on field surveys that showed small, widely distributed, resident stream-dwelling cutthroat that were genetically similar to coastal cutthroat, thus providing a stable contribution to anadromous populations. The U.S. Fish and Wildlife Service petition was coincident with current (2002) Washington State fishing regulations that allow consumption of coastal cutthroat in some of the areas of concern. Coastal cutthroat will be of increased management concern in the future, because the species faces many problems similar to ESA-listed salmon species (Brown and Craig 2002; Nehlson et al. 1991).

All juvenile salmon use estuaries as sources of preferred food organisms, for refuge from predators, and as an area of physiological transition (osmoregulation) to life in salt water (Simenstad et al. 1982). Coastal cutthroat frequent estuaries and nearshore areas in much of their life history, therefore estuary resources would probably be more decisive in maintaining healthy cutthroat populations, and might shed light on the deleterious effects on all salmon that result from losses of ecologically functional estuarine habitats.

Most Pacific Northwest estuaries have been changed, some drastically, since Europeans settled western North America. In Puget Sound, 42% of the coastal tidal wetlands, 71% of the estuaries, and 70% of the eelgrass have been reported as lost (Simenstad and Thom 1992). Many of the prey species of juvenile salmon originate in the land/sea margin of the salt marshes and eelgrass beds of estuaries (Simenstad et al. 2000). The interactions between organisms and their physical and ecological habitats may determine the productive capacity and population composition of Pacific salmon (Simenstad et al. 2000).

In summary, improved data on the diet and habits of coastal cutthroat trout in estuaries could stimulate alternative management strategies that meet coastal cutthroat's biological needs. The focus of my research has three main points: to sample 1) diet and 2) length of coastal cutthroat in estuaries, and 3) to seek evidence of interspecies interaction between coastal cutthroat trout and other Pacific salmon.

The Ecology and Biology of Coastal Cutthroat Trout in Estuaries

An estuary has been defined as "a semi-enclosed coastal body of water, which has a free connection with the open sea, and within which sea water is measurably diluted with fresh water derived from land drainage" (Pritchard 1967). This description generally applies to the Pacific Northwest. However, on the high-energy outer coastlines, wave action can temporarily block medium and small river mouths with sand. Thus connection with the open sea is usually free and seawater typically could be measurably diluted by freshwater. A working definition of a Pacific Northwest river-mouth estuary is the area from the head of tidal influence (as defined by historic forested riverine habitat delineation) to the seaward interface where freshwater fluvial processes are no longer dominant over marine processes. The nearshore component of an estuary system is the marine waters outside river-mouth estuaries that are adjacent to land, and are generally less than 20 meters deep at mean lower low water, and encompass the area where benthic photic production occurs. This working definition also includes the riparian zones, wetlands, and uplands adjacent to the shore. The nearshore areas may receive inputs from seeps and/or small streams, but riverine processes are minor.

The zone of transition between the Pacific Ocean and the coastal temperate rain forest has been called a terrestrial-marine "ecotone," an area characterized by a multitude of energy convergences and discharges of water, sediments, organic matter, nutrients and debris (Simenstad et al. 1997). In the terrestrial-marine ecotone there is constant flux between the rivers, tides, weather, and organisms (Simenstad et al. 1997). At the interface of tidal fresh water and brackish water, salmon smolts must osmoregulate (make a biochemical adjustment to living in saltwater), find new forms of prey, and avoid predators (Healey 1982). In freshwater tidal habitats, complex assemblages of sloughs, dendritic channels, marshes, swamps, and forests efficiently collect organic matter, provide for primary production in the estuarine food web, and are especially important as rearing and overwintering areas for coastal cutthroat trout (Simenstad et al. 1997).

Six of the seven species of Pacific Northwest salmon, pink (*O. gorbuscha*), chum (*O. keta*), coho (*O. kisutch*), sockeye (*O. nerka*), chinook (*O. tshawytscha*) and steelhead (*O. mykiss*), rely on safe passage through estuaries in the smolt stage (Groot and Margolis 1991). After feeding and using estuary habitats for varying periods of time, they continue their outward migration to the open ocean to begin their adult lives. They also migrate inward to freshwater, when they return as adults on their spawning runs.

By contrast with the other six species of Pacific salmon, coastal cutthroat have relatively lengthy early life histories in fresh water and their preferred primary habitats are the estuary and nearshore (Trotter 1997). Cutthroat usually do not migrate far offshore, preferring to stay close to their natal stream (Trotter 1989; Johnston 1982). Estuaries and nearshore areas are important, if not key, habitats of coastal cutthroat for most of their pre-adult and adult lives. Based on their extended life history in freshwater, the estuary provides them with key feeding, refuge, and residence/migration areas; thus, there is no need to make long ocean migrations.

At the early stages of marine migration, salmon smolts, including coastal cutthroat, take advantage of many estuary food sources and refuge areas. Whether they take up somewhat longer residence, as do chinook salmon, or move quickly through estuarine areas, as do chum and pink salmon, all juvenile salmon must eventually move through a mosaic of habitat types, interacting with changing estuary landscapes (Pearcy 1992; Simenstad et al. 2000). Estuary habitat features that affect the rate of salmon movement include: tidal-freshwater and brackish rearing zones, low-velocity refugia, migratory corridors, and foraging patches (Cederholm et al. 2000). The landscape features that link these habitat elements influence the flow of dissolved and suspended nutrients. Emerging evidence shows that the edges of marsh vegetation in dendritic tidal rivulet and channel systems may play a particularly important role in juvenile salmon production (Cederholm et al. 2000; Simenstad et al. 2000).

Estuary habitat use by the fry and juveniles of Pacific salmon varies by species and fish size as the salmon move into deeper, more open water. Dietary differences among juvenile salmon in the ecotone suggests evolutionary "partitioning" of the available prey species (Simenstad et al. 2000). Most small juvenile salmon (30-60 mm) use shallow-water tidal areas extensively for migration, feeding, and refuge (Cederholm et al. 2000). Many of the prey species of juvenile salmon originate in the land/sea margins of the salt marshes and eelgrass beds of estuaries (Simenstad et al. 2000). The strengths of interactions between estuary inhabitants and their physical and ecological habitats may determine the productive capacity and population composition of Pacific salmon, which are at the top of estuarine fish food webs (Simenstad et al. 2000). For coastal cutthroat that frequent estuaries and nearshore areas throughout much of their life history, the estuary food and habitat resources may be even more decisive in maintaining healthy populations than for other Pacific salmon species.

The coastal cutthroat, because of its lengthy residency in estuaries, may be more susceptible than other species of Pacific salmon to a wide range of human-caused impacts on estuary and nearshore areas, such as those caused by fishing, urbanization, industry, and direct physical reconfiguration, such as diking and dams. The abundance and distribution of cutthroat could indicate key estuarine functions (e.g. prey abundance, refuge) for all species of Pacific salmon because most cutthroat live near shorelines, rarely venturing more than a few kilometers into salt water (Trotter 1997). Investigation of the extent to which coastal cutthroat in estuaries interact with other salmon will provide evidence of the interspecies effects that the declines of other salmon populations may have on the abundance of coastal cutthroat (Cederholm 1998).

Coastal Cutthroat Life History

Coastal cutthroat trout have several life history forms. The anadromous forms develop as juveniles in fresh water for two to seven years, and migrate to sea where many live for varying portions of their lives, and return to freshwater for annual feeding runs, and for spawning, most often, at age three to five (Trotter 1997; Johnston 1982).

Various cutthroat groups exhibit other specialized life styles. A sub-part of the anadromous group is also described as "amphidromous," that is, river and lake rearing fish that migrate between fresh water and sea water not exclusively for breeding but also regularly at some other stage of the life cycle (Garrett, A. 1998). These cutthroat are not all sexually mature at their first or second return to freshwater (Garrett, A. 1998). Many cutthroat returning to freshwater after spending time in saltwater do not sexually mature until they spend another year at sea (Trotter 1989). They do not frequently travel into the open ocean, but concentrate in bays, estuaries and along the coast, where they can grow up to 25 mm per month (Behnke 1992).

The river-rearing cutthroat live primarily in rivers and tributaries but mature in marine waters, while the lake-rearing fish may use lakes, ponds, bogs, and sloughs during their freshwater rearing period (Garrett, A. 1998).

In Puget Sound, coastal cutthroat smolts generally migrate to seawater at age two or three, and in coastal marine waters at age three to five (Wydoski and Whitney 1979). In Washington and Oregon seaward migration starts in March and peaks in mid-May (Giger 1972a; Lowry 1965; Michael 1989; Trotter 1989). In Hammersley Inlet, 68% of the smolts from Mill Creek migrated to saltwater at age two and 32% at age three (Peoples et al. 1988). The smolt migration spanned April 15 to May 12 and peaked on April 21 in Mill Creek (Peoples et al. 1988). The two year old smolts in Mill Creek ranged in fork length from 140-204 mm, averaging 175 mm, and the three year olds ranged from 186-234 mm and averaged 206 mm (Peoples et al. 1988).

In contrast, coastal stream smolts usually migrate at age three to five and are of a larger average size than those from protected estuary areas, giving them improved chances for survival, such as escape from predators and increased ability to capture larger prey items (Johnston 1982). In three Olympic Peninsula watersheds, 23% of the smolts were age three, 59% were age four, and 18% were age five (Fuss 1984). Three year old smolts ranged in fork length from 162-259 mm, averaging 204 mm, four year olds ranged from 150-225 mm and averaged 215 mm, and five year olds ranged from 198-289 mm and averaged 253 mm (Fuss 1984).

Coastal cutthroat smolts form schools, just before saltwater entry, that remain intact until they return to freshwater (Giger 1972a, 1972b; Trotter 1989). Schools of 5-15 sub-adult cutthroat can be found foraging opportunistically off gravel beaches, oyster beds and eel grass on a variety of small fish and invertebrates. In the spring, in estuaries and lower tidal reaches of some rivers, cutthroat are known to feed on outmigrating trout and salmon fry (Trotter 1987).

Substantial movements of adult cutthroat have been reported in fresh water or, with the tide, in and out of narrow estuary areas starting in August (Royal 1972; Trotter 1987). In Puget Sound, adult cutthroat did not move up Minter Creek and enter a weir trap a few hundred feet above high tide until their upstream spawning migration started in December (Royal 1972). In Oregon coastal rivers, cutthroat ran upstream several miles in July and stayed in deep holes until the fall and winter rains stimulated their spawning migration (Sumner 1962). In Washington, maturing cutthroat have also been observed in the estuaries and lower river areas of most coastal streams during late summer, often as early as July.

Adult cutthroat return to streams in Puget Sound from October to January, typically migrating upstream from the first week of October through February, and peaking in November (Wydoski and Whitney 1979; Sumner 1962). Spawning occurs from December through May and peaks in February in Washington, and as late as April or May in Alaska (Johnston 1982; Trotter 1989). At Snow Creek, Washington, two cutthroat run times have been described, a late entry stock (winter and spring) generally associated with small drainages, as contrasted with early entering stocks (August) in large river systems (Michael 1989).

From October 1986 to March 1987 in Eld Inlet, 79% of adult cutthroat sampled from McLane Creek, a South Puget Sound tributary near my study area, were age two and 18% were age three, by scale analysis (Peoples et al. 1988). Mature females in McLane Creek ranged in length from 285 to 572 mm, with an average length of 432 mm, while immature females ranged from 229 to 338 mm, averaging 293 mm. Mature males ranged 248 to 458 mm, averaging 335 mm (Peoples et al. 1988). In October only immature female cutthroat and small mature male cutthroat were captured, and on November 13, large mature females were first captured (Peoples et al. 1988). From January 15-19 the peak of entry of mature females was observed, and spent females were observed from January 15 to February 26 (Peoples et al. 1988). Mature cutthroat were captured until February 26 and a significant decrease in migrants was observed after that (Peoples et al. 1988).

In Minter Creek, South Puget Sound, the spawning migration starts in December and ends in early April, with a peak in January to March (Royal 1972). In November 1986 to January 1987, Minter Creek mature female cutthroat ranged in length from 273 to 533 mm, averaging 400 mm, while mature males ranged from 267 to 470 mm, averaging 357 mm (Peoples et al. 1988). In Minter and McLane Creeks, 30% of the mature male and female cutthroat had returned to freshwater at least three times, and in McLane Creek some individuals had returned up to five times (Peoples et al. 1988).

In Oregon, the downstream migration of coastal cutthroat “kelts” (live, spawned-out adults) starts in March and ends by mid-June, peaking with stream flows around May 1 (Sumner 1948, 1962). Cutthroat kelts move out of the streams with the smolts of cutthroat and steelhead, although the kelt movement is intitated before the smolt movement (Royal 1972). In Washington the return of spawned out adult cutthroat to saltwater peaks in late March to early April, about one month before the peak downstream migration of cutthroat smolts (Trotter 1989). This movement also precedes the peak period of downstream migration of fall spawned pink and chum salmon fry (Trotter 1989). However the chum fry from the earlier spawning summer chum salmon migrate in January to March (Michael, pers. comm. 2002). Natural selection has probably favored this timing because it positions the cutthroat kelts to intercept schools of pink and chum salmon fry in estuaries (Johnston 1982; Trotter 1989; Giger 1972).

Coastal cutthroat in Oregon and Alaska were found to live to a maximum age of 10 years (annuli and otolith) and to attain a weight of 1.3 kg (Sumner 1962; Armstrong 1971). In Washington, the sport-caught state record coastal cutthroat is reported as a 2.7 kg fish, 6l5.9 mm long, caught in Carr Inlet in May 1943 (Byrd, WDFW, pers. comm. 2002). In view of their predatory nature and long maximum life span (i.e. 10 years), one scientist commented that it was unusual that coastal cutthroat of 8-9 kg or more were unknown (Behnke 1992).

Although these small differences in life histories are not detected by genetic analysis, they do have a hereditary basis and they are adaptive (Behnke 1997). For example, anglers in South Puget Sound, Hood Canal, and Southern British Columbia know that all coastal cutthroat "…in those waters do *not* spend the winter in fresh water; many remain in the estuaries,…" and winter is the time many anglers prefer to fish for coastal cutthroat in those waters (Raymond 1996).

The life history adaptation of freshwater entrance and proximity to nearshore marine waters, such as estuaries, could allow opportunistic feeding on the fry and smolts of other salmonids (Wydoski and Whitney 1979; Trotter 1989). This is probably especially true of coastal cutthroat trout in estuaries where abundant out-migrations of chum and pink salmon smolts occur (Johnston 1982; Trotter 1989). Movement of coastal cutthroat to nearshore marine areas probably confers a selective advantage, by reducing time spent in fresh water for reproduction and early rearing, thus allowing larger fish to seek other habitats where food resources are more abundant and available (Northcote 1997, Johnson et al. 1999). While feeding in salt water can result in increased body size and fecundity, this migratory behavior exposes coastal cutthroat to additional risks compared to those found in fresh water. The risks include high energy demands, stress during osmoregulation, potential loss to predators, parasites, competitors, and eventually the migratory exposure while locating suitable freshwater spawning habitat (Northcote 1997; Palmisano 1997).

Estuary Feeding and Prey of Coastal Cutthroat

The diet of estuary dwelling coastal cutthroat is made up of a wide variety of small marine fish, invertebrates and terrestrial insects. This variety of food items indicates that coastal cutthroat are opportunistic feeders, and can be highly predaceous (Wydoski and Whitney 1979; Behnke 1992). Some of the estuary and nearshore food items are amphipods, isopods, shrimp, and small fish including stickleback, sand lance, and sculpins, and in the spring of the year include outmigrating juvenile salmonids (Wydoski and Whitney 1979; Trotter 1987). In offshore coastal waters, fishes were found to be the dominant prey based on the biomass consumed (75%), with relatively few juvenile salmon taken (Pearcy et al 1990). However, the size of cutthroat kelts confers a predatory advantage over the outmigrating juveniles of other Pacific salmon species, allowing cutthroat to prey on these fish in freshwater and estuaries (Pearcy et al. 1990).

The importance of the marine phase of coastal cutthroat may vary across large geographic areas, depending on estuary and nearshore conditions (Reeves et al. 1997). The marine life history of coastal cutthroat usually keeps them in close proximity to fresh water and can be very important to coastal cutthroat in providing opportunities for growth and dispersal to neighboring drainages (Johnson et al. 1999). The entry to and exit from freshwater for refuge and feeding gives them advantages of opportunistic access to seasonal food sources, such as insects and salmon eggs, carcass material, fry or juveniles. Freshwater re-entry for spawning, feeding, or refuge, places coastal cutthroat in and near salmon spawning streams in the fall, when salmon eggs and carcass flesh are available.

The use of eggs and carcass material provides a significant late fall growth advantage to juvenile coho, steelhead and cutthroat in streams (Bilby et al. 1998, Bilby et al. 1996). Based on substantial consumption by cutthroat on carcass material and eggs in freshwater, it is reasonable to expect that cutthroat will also consume these items when they are available in saltwater.

Predation on juvenile salmonids in freshwater habitats by cutthroat and other salmon species can be significant under some conditions. Simenstad et al. (1982) found relatively few juvenile salmon in cutthroat and steelhead stomachs in freshwater. However Fransen et al. (1993), found age one and older cutthroat in freshwater were frequently feeding on small coho fry until the fry grew too large to capture. In a predation experiment in lower Big Beef Creek, a sample of 31 cutthroat trout had an average of three chum salmon fry in their stomachs. There, the most effective predator on chum salmon fry was the more numerous, large rainbow trout, which had consumed an average of six chum fry each (Fresh and Schroder 1987). This difference in predation between rainbow and cutthroat trout could have resulted from differences in preferred stream habitat (Bisson et al. 1982), or interspecific interactions (Allee 1982) that provided feeding advantages to the rainbow trout.

During spawning season, cutthroat could be expected to feed on drifting eggs displaced by upstream spawning activities. In Oregon's Sand Creek, a small coastal stream, "trout" were observed eating chum salmon eggs that were dug up by spawning chums (Sumner 1953). In Oregon's lower Kilchis River, an important chum spawning stream on the northern coast, the stomachs of large cutthroat caught in the spring were full of chum salmon fry (Sumner 1972). In Oregon streams where chum salmon were not so abundant, such as at the Nestucca and Wilson Rivers, the consumption of fish was reduced, and cutthroat fed mainly on aquatic and terrestrial insects (Sumner 1972). Similarly, in South Puget Sound, a coastal cutthroat trout was observed actively feeding on drifting, displaced chum salmon eggs in 1998 in Fiscus Creek, a small tributary of Kennedy Creek which enters Totten Inlet (Pittman, WDFW, pers. comm. 2000).

Coastal cutthroat were also observed (Dickason, Squaxin Tribal Fisheries, pers. comm. 1998) feeding much more aggressively on chum salmon eggs in the marine waters of Kennedy Creek, Washington, where a coastal cutthroat was "bumping the chum hens"(females). The cutthroat's behavior was to swim around a gravid female chum salmon and drive its nose into the side of the salmon, forcing the release of a few eggs. The cutthroat would immediately "scoop up the eggs and repeat the process." This chain of events was observed repeatedly in one situation.

Aggressive feeding by coastal cutthroat in fresh water in the fall has not been consistently observed throughout their range. In Oregon, coastal cutthroat entering the Alsea River estuary in the fall to spawn had stopped feeding. Tagged and recaptured fish were documented as losing weight (Giger 1972b), and apparently did not resume active feeding until after they had spawned. An alternative possibility for this condition is that these cutthroat were feeding but were not getting enough food to produce a weight gain (Michael Jr., pers. comm. 2002). A small sample of downstream migrant Alsea River cutthroat fed primarily on sand shrimp and a variety of small fish, but salmon fry were not noted in their diets (Giger 1972a, 1972b).

The out-migration of the cutthroat kelts in Minter Creek, Washington, peaked in the first week in April, and smolt out-migration peaked in May. This timing places the kelts in position to intercept migrating schools of pink and chum salmon fry in the estuary (Johnston 1982). Presumably the pre-smolt cutthroat in streams would also be in an advantageous position to feed on emerging salmon fry, particularly chum salmon fry, in creeks and rivers of South Puget Sound, Washington.

Evidence for significant predation by coastal cutthroat on salmonids in estuaries and nearshore marine waters in Washington is lacking (Simenstad et al. 1982). All juvenile salmon use estuaries as sources of preferred food organisms, for refuge from predators, and as an area of physiological transition (osmoregulation) to life in salt water (Simenstad et al. 1982). Presumably the opportunistic-feeding cutthroat would also feed heavily in salt water if abundant chum salmon fry were present. When juvenile chum and pink salmon enter the estuary, they first use shallow sublittoral habitats, then move into neritic habitats. The salmon use shallow sublittoral areas, and eelgrass, especially in contained embayments, for 6-23 weeks in Washington, making them very available as coastal cutthroat prey (Simenstad et al. 1982).

Naturalists and sportsmen have observed that the normal range of coastal cutthroat is probably 2-3 km beyond the extent of the river channel into saltwater, moving out on the ebb tide and coming back with the flood tide. Haig-Brown (1939) makes the following comment about British Columbia coastal cutthroat movements:

> *"There is not much doubt that the cutthroat trout of the lower reaches of nearly all coast streams move down to tidal water from time to time. They are not a truly migratory fish in the sense that the winter steelhead and the Atlantic and Pacific salmon are. They move down and often out to sea in search of food; they make by far the major proportion of their growth in salt or brackish water; but when there is food for them in fresh water they move up to find it, whether or no they are driven at the same time by the urge of maturity."* (p 160)

The coastal cutthroat, according to Haig-Brown (1947) may move out into the ocean as far as five or ten miles from the mouth of the river, and may school with other coastal cutthroat to feed off the mouth of a stream distant from the "home" river. Although they wander, there seems to be a sharp break between saltwater and fresh water life. Coastal cutthroat feed as opportunists, making good use of their environment, following tides, the salmon runs and insect hatches as Haig-Brown closely observed (1947):

> *"He may return to the fresh-water pools of his river at any time: in spring when the salmon fry hatch, in fall when the ripe salmon run, in summer when the sedge nymphs crawl thickly over the round rocks of the stream bed."* (p 130)

Locating coastal cutthroat in nearshore waters has proved difficult in various studies that used beach seining and purse seining. Cutthroat have been caught infrequently or incidentally by these methods, perhaps because of their ability to easily escape capture by seines (Fresh et al. 1979; Meyer et al. 1981**)**. The few captures of coastal cutthroat by seining that are reported in the literature show differences in the selection of salmonid juveniles by these fish (Simenstad and Eggers 1981; Meyer et al. 1981; Pearce et al. 1982**).**

A small sample of coastal cutthroat was collected from the Nisqually Reach area in 1977-78. The stomach contents of the cutthroat are reported in Table 1 (Fresh et al. 1979). The fish consumed included two salmon fry (see *, Table 1), "…probably chum salmon," and Fresh and colleagues (1979) commented that among all salmon captured, only the cutthroat indicated any significant predation upon fish, based primarily on percent of total biomass. In the Duwamish Estuary (Green River) in April-July 1980, beach seining captured nine coastal cutthroat, one of which had preyed on four juvenile fish, none of which were identified as salmonids (Meyer et al. 1981).

Food Items	Percent Total Abundance	Percent Biomass
Gammarid amphipods	46.2%	19.3%
Euphausiids	21.7%	14.2%
Callianassid shrimp	20.3%	26.2%
Fish (includes 2 salmon fry)	4.2%	39.5% *
Fresh et al. 1979, for 4 juveniles and 2 adults		

Table 1: Food items of coastal cutthroat trout from Nisqually Reach

It is assumed that the plentiful food resources in estuarine and nearshore marine waters are sufficient to offset the survival risks of coastal cutthroat living there. The coastal cutthroat life history that encompasses regular movement between feeding, wintering, and spawning habitats is a response to environmental variability and, in the case of prey, might be a response to resource predictability (Northcote 1997). The adaptive significance of a population partitioned into a broad migratory/resident spectrum is characterized as a species' "bet hedging" for long term continuity (Northcote 1997). The abundance of food is one factor that could determine the habitat distribution of coastal cutthroat trout in estuaries and nearshore marine waters. Similarly, prey availability has been found primarily to determine distribution and abundance of resident, adult cutthroat trout in streams at summer temperatures (Wilzbach 1985).

In most marine studies of salmon it is apparent that coastal cutthroat have been incidental subjects of scientific inquiry, perhaps due to their dispersed populations or their lack of value as a commercially exploited species (Raymond 1996). While species residence times (total time that a juvenile salmon of a particular species occurs in estuarine habitat) are available for the other species of Pacific salmon and steelhead, there are fewer data available for coastal cutthroat residence times (Simenstad et al. 1982).

Two factors-- feeding habits and refuge areas-- give empirical clues to coastal cutthroat whereabouts. First, the feeding habits can be related to the areas in which coastal cutthroat frequently find their prey and (in the case of other salmonid prey), to fairly distinct nearshore and/or estuary areas, often proximal to stream mouths. Second, refuge areas can be inferred from the cutthroats' preference for certain gravel beach or other substrate habitats from the limited scientific research, and from the observations of recreational anglers (Johnston 1982; Trotter 1989; Raymond 1996).

Observations of the occurrence and rate of coastal cutthroat predation on salmonids in salt water, especially on chum fry, have not been consistent (Groot and Margolis 1991), and may be limited to specific locations (Sumner 1972; Trotter 1997). In the life history of chum salmon juveniles, mortality due to predation by larger salmon and fish-eating birds is more likely than lack of food (Meehan and Bjornn 1991).

In a wilderness area of Alaska, 83 coastal cutthroat captured at the outlet of Eva Lake (July-August 1964), had fed on salmon young and insects (Armstrong 1971). These cutthroat reportedly had "fed heavily" on sockeye fry, and on coho fry and fingerlings (Armstrong 1971). Thirty-five percent of the 83 Eva Lake cutthroat examined had eaten young salmon. A saltwater sample of 12 cutthroat (average length=240 mm, range 203-270 mm) was also captured at that time, and they had fed on pink and chum salmon fry, and amphipods (Armstrong 1971). In salt water, Armstrong (1971) found that amphipods and young salmon were the principal food items of cutthroat, and these prey items were primarily found in shallow water habitats.

Loch (1982) found that the American shad was the most numerous prey species of adult coastal cutthroat in the Columbia River estuary. There are now about 4,000,000 shad spawning in the Columbia River. A diet sample of 67 cutthroat was taken between August and September, when migrating salmon smolts would have been larger in size and less numerous. Chum and pink salmon fry were not prevalent in the Columbia River, presumably due to their depressed or extinct stock conditions (Michael Jr., WDFW, pers. comm. 1999). Another Columbia River estuary sample of 11 coastal cutthroat taken from April to June found amphipods (*Corophium salmonis*) and adult insects to be the most important prey (Bottom et al. 1984).

In the Pacific Ocean area of the Columbia River freshwater "plume", Loch and Miller (1988) also found no juvenile salmonids in the stomachs of coastal cutthroat when large numbers of juvenile chinook and coho salmon were present. Pearcy (1997) reported that the main coastal cutthroat prey were small non-salmonid fishes and only occasional juvenile salmonids off the coast near the Columbia River mouth.

Approximately half the stomachs of 23 coastal cutthroat sampled in April 1979, in South Puget Sound just north of the mouth of the Nisqually River, contained chum salmon juveniles. In the same study, 11% of coho salmon sub-adults contained chinook salmon (Fresh et al. 1981). In a Hood Canal study, Trotter (1997) noted that salmon fry made up 11% of the total prey of coastal cutthroat, and commented that predation in salt water on juvenile salmon by cutthroat is probably localized in certain areas (situational), based on opportunity during high-density fry migrations.

A recent literature review mentioned that coastal cutthroat smolts and adults pass through estuaries during migration and inhabit shallow coastal waters (Atkin 1998). The reviewer notes that some smolt and adult cutthroat live in estuaries and feed mainly on out-migrating salmon fry. Another reviewer of Nisqually Estuary fishes commented that coastal cutthroat in Puget Sound stay close to their natal rivers, and that juveniles feed on insects, crustaceans and some fish, "…while subadults and adults are highly piscivorous in the marine estuaries and fresh waters" (Cook-Tabor 1999, p 11).

Another reviewer notes the importance of salt marshes, tidal sloughs, tide flats and shallow shorelines as initial nursery grounds for juvenile salmon, and comments that few investigations have been done on the contribution to overall survival from feeding in these areas (Meyer 1979). He notes general acceptance of an inverse relationship between juvenile salmon body size at the time of entrance to marine waters, and mortality, and he adds: “Therefore, extensive feeding and rapid growth in estuarine and shallow inshore areas could be decisive in total marine survival” (Meyer 1979, p 15). Atkin (1998) notes that the preferred estuarine habitats for juvenile salmon are vegetated, heavily channelized with a moderate slope, and offer a wide range of water salinities. The salmon, and also presumably coastal cutthroat, are provided with low-water-velocity refuge at low tide, vegetative cover, large woody debris, and a good prey base (Atkin 1998).

The extended fresh water rearing period of coastal cutthroat means that they may make downstream feeding migrations to estuaries for at least one to three years before they spawn for the first time. First and second-time cutthroat spawners usually live in estuaries because of abundant food supplies. Adult and pre-adult cutthroat typically enter fresh water in late summer through winter, and may spend the winter in the stream, returning to salt water in the late winter through early summer. They have been called “opportunistic feeders” because they have been observed in fresh or salt water locations that have the most abundant, high quality food at the time (Simenstad et al. 1982; Fresh et al. 1981; Fresh and Schroder 1987).

Spring and summer, through early fall, is probably the most likely time for adult coastal cutthroat to be found in estuaries, because the food supplies there are much more abundant than those available in fresh water. In some estuaries coastal cutthroat enter the intertidal zone every day, and use the estuary tidal channels frequently, especially if other salmon are present. Most estuaries probably have some coastal cutthroat present at all times (Hunter, WDFW, pers. comm. 2001). Beginning with the runs of fall-spawning salmon, the estuarine coastal cutthroat begin their feeding migration up the streams for eggs, dislodged insects, and carcass flesh before they spawn in late winter or spring and return to the salt water to feed and recover.

There are several possible reasons for the differences in findings that I found about coastal cutthroat predation on salmon. First, the time of study by various authors varied in reference to the availability of massed chum or pink salmon fry, or the fry were not present. Second, the presence or absence of chum salmon fry varied in the study areas because of depressed runs of Puget Sound chum salmon in the late 1970’s and early 1980’s. Third, depressed populations of coastal cutthroat probably resulted in the netting of small samples of coastal cutthroat in South Puget Sound field studies. Larger standing stocks of predators of larger size classes would probably increase predation on juvenile salmon, and steelhead and coastal cutthroat typically have the highest number of juvenile salmon in their diets (Simenstad et al. 1982). Fourth, the larger, piscivorous cutthroat have adapted to other more abundant and/or more vulnerable food sources, such as the American shad in the Columbia River estuary (Loch 1982). Shad have a much greater smolt biomass, are extremely abundant, and are smaller and easier prey than juvenile salmon during the late spring months. There are presently almost no pink or chum salmon in the Columbia, and smolts of coho, steelhead and chinook are larger-sized and harder to catch than shad (Michael Jr., WDFW, pers. comm. 2000). Fifth, predation data from a pristine wilderness (Armstrong 1971) is not comparable to that from systems experiencing the cumulative effects of human development and recreational fishing in freshwater, nearshore and estuary habitats, which is a likely contributor to the decline of coastal cutthroat stocks. Sixth, different salmonid life history characteristics will mean that stocks have different behavior and habitat preferences, such as in the shallow water, nearshore feeding areas in estuaries, in contrast to the turbid and deep conditions in the Columbia River. In estuaries, coastal cutthroat would probably encounter chum salmon juveniles more frequently than other potential salmon predators, because the cutthroat tend to live in shallow waters (Michael Jr., WDFW, pers. comm. 2000).

An explanation for the inconsistencies in research observations is probably the intervention of human-caused degradations all through the terrestrial and aquatic system (Michael Jr., WDFW, pers. comm. 2000). Although observations of coastal cutthroat predation on salmon fry are not consistent, the following characteristics of coastal cutthroat emerge.

1. Opportunistic- Coastal cutthroat are frequent consumers of pink and chum salmon fry when fry are available, especially *en-masse*, in fresh and salt water.
2. Prey size is a factor, but predator size is a more important factor, since larger coastal cutthroat (and rainbow) had greater rates of predation on salmon fry.
3. Life history advantages of freshwater feeding runs, spring spawning and iteroparous spawning allow coastal cutthroat age 1+ and older fish to have seasonal feeding opportunities on chum salmon eggs, carcass flesh and fry.

4. Survival advantages such as fecundity and fitness could be significant in streams and lakes for cutthroat, and in near-shore marine waters with reference to the “niche feeders” of Johnston (1982) and the “bet hedging” of Northcote (1997).
5. Complex interspecific interactions and dependencies between salmon in aquatic ecosystems probably shape coastal cutthroat life history (Johnston 1982; Cederholm 1998).

In summary, the key ecological functions provided in estuaries for all Pacific salmon during the critical smolt migration phase include prey production, feeding, refuge from predation, and a zone of osmoregulatory transition. For coastal cutthroat the key ecological functions of estuaries and the nearshore are particularly important because coastal cutthroat are highly dependent on these habitats for most of their subadult and adult lives. The life cycles of Pacific salmon and coastal cutthroat overlap in estuaries, where the salmon fry and smolts are seasonally important prey for coastal cutthroat.

Chapter 2
Research Methods

This study began as a cooperative project between myself and the Washington Department of Fish and Wildlife (WDFW), to investigate the interspecies feeding behavior of coastal cutthroat on salmon in South Puget Sound. The WDFW issued a sampling permit during the study that allowed me and one additional angler to take non-lethal samples by hook and line. Sampling was carried out in four inlets of South Puget Sound (Figure 1, Table 2). I chose locations that had reasonable access and were known as coastal cutthroat habitat.

Locations and sampling sites in each of the four inlets were based on the availability of boat or beach access, the time available to fish, fishing opportunity, major tide cycles, low light conditions, and barometric stability. Beach fishing access in most of the sample area was limited by private ownership of developed shoreline residences. The exact beach locations in the respective inlets are being withheld to protect private landowners from trespass, and to safeguard the coastal cutthroat from over-fishing.

The sample inlets were also selected because WDFW genetic scientists requested tissue samples from South Puget Sound coastal cutthroat, incidental to the collection of stomach and scale samples. Genetic samples of 30 fish from each of Eld, Totten and Skookum Inlets will be provided to the WDFW, but no genetic samples were taken at Hammersley Inlet. (As of this report the Totten Inlet genetic sample is <30, and is still being collected.) The distribution of samples by inlet is shown in Table 2.

Sampling was done by experienced anglers with single barbless-hook artificial flies, mostly from estuary beaches and occasionally from a small boat. Handling of captured cutthroat was careful and rapid, with major emphasis placed on fish survival. Angling was selected as the method of sampling because of the relative lack of success of other techniques, such as beach seining, for this species (Fresh et al. 1979; Simenstad et al. 1981; Meyer et al. 1981). Angling also gave the opportunity to observe natural history behaviors that a more composite capture technique such as seining would not have afforded.

The samples of coastal cutthroat stomach contents used in this study came from fish collected between 24 July 1999 and 8 April 2002. By year, the numbers of coastal cutthroat sampled are as follows: 13 in 1999, 11 in 2000, 39 in 2001 and 52 in 2002. The

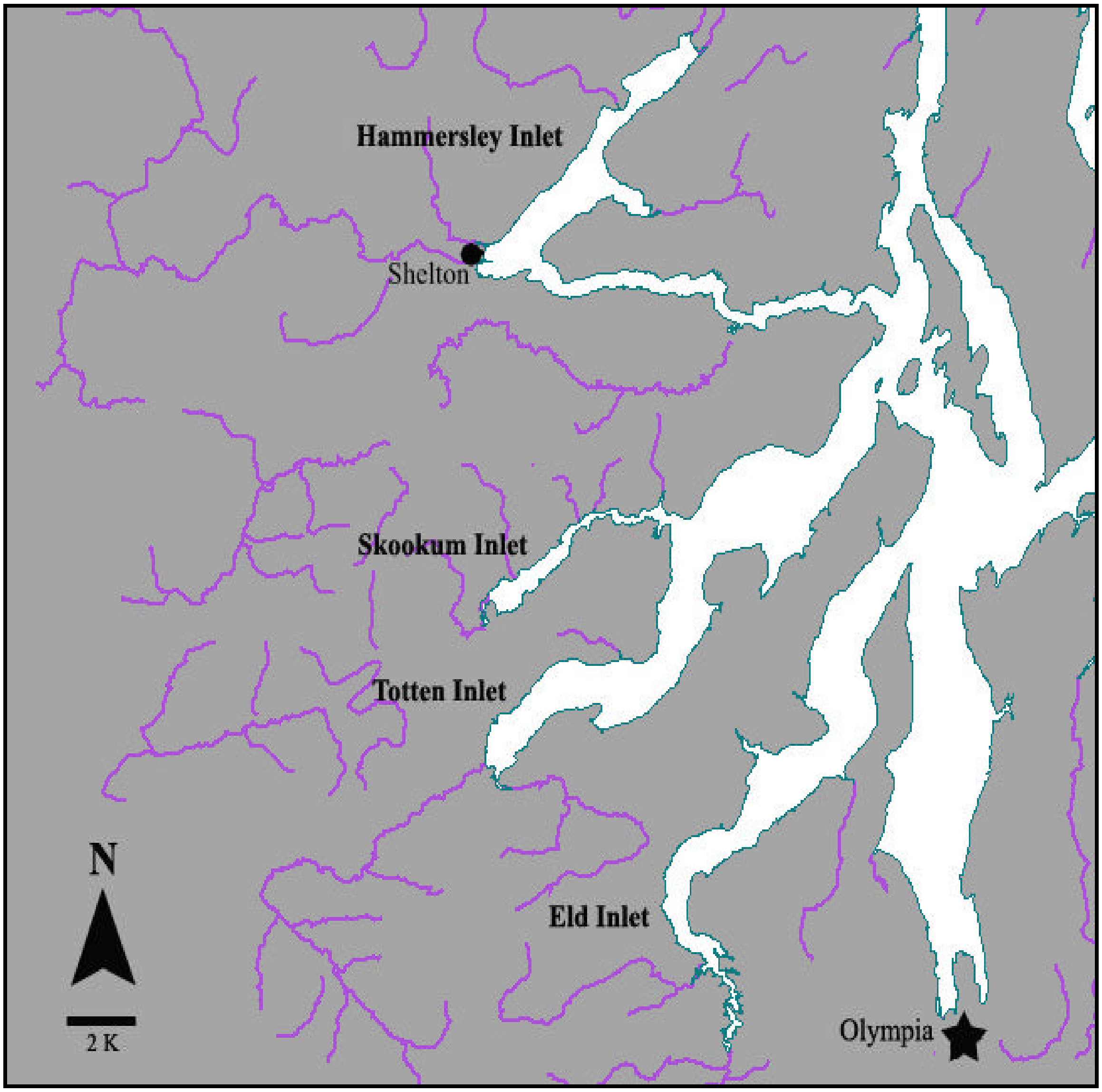

Figure 1**:** South Puget Sound inlets and salmon-bearing streams

reasons for the increasing trend in catch is due to increased sampling effort and increased sampling efficiency. Sampling was purposive with regard to selections of season, weather, time, location and field conditions. Field activity was also constrained by my occupational and academic schedules.

Fish captured were immediately placed in a bucket of seawater, unhooked and anesthetized with the chemical M.S. 222 (Tricaine methanesulfonate), a respiratory anesthetic. Approximately 0.5 g of M.S. 222 was used in two gallons of water to anesthetize the fish (Bell, 1984).

In the field, each cutthroat was measured (fork length) to the nearest millimeter, and scale and anal fin samples were removed. The fish stomach was lavaged with 60cc of seawater to remove stomach contents, using accepted methods (Hyslop 1980; Meehan and Miller 1978). The fish were then immediately placed in a full bucket of seawater for revival. Samples of scales, fin tissue and stomach contents were put in separate labeled containers and recorded in a field log. Fish were released gently as soon as they showed signs of vigorous recovery. Once I gained fish-handling experience, the cutthroat were processed from anesthetic, through sample collection and into a revival bucket in 40-50 seconds, and released into Puget Sound within a few minutes after that.

Inlet	**Number of Fish**
Eld	38
Totten	22
Skookum	31
Hammersley	24
Total	115

Table 2: Distribution of coastal cutthroat trout catches in four South Puget Sound Inlets

Stomach content samples were stored in 99% isopropyl alcohol and refrigerated, except for the last 31 samples, which were stored at room temperature in a 10% formalin solution. The change was made on advice from a WDFW biologist because the stomach contents could be better maintained. The formalin solution was later decanted, the samples were rinsed in water and then stored in 99% isopropyl alcohol.

Comments were recorded in a field book that included angling effort, any other uncaptured coastal cutthroat that were positively observed, and any other fish caught or observed. I also noted any other predators or other wildlife (marine, avian or mammal), and other biological or ecological features of interest, such as weather and tide conditions, and any other influences on sampling (fishing) conditions.

Laboratory Analysis of Stomach Contents

Samples were analyzed in the laboratories at Washington Department of Fish and Wildlife and Evergreen State College, using the same procedure for stomach sample analysis. Sample jars were emptied into a Fischer Scientific Co. sieve of size #35-39, with a mesh opening of 500 microns. The sample was rinsed with water, and placed in a petri dish with water, and observed with a 40x dissecting microscope with auxiliary light. The samples were separated into invertebrate, vertebrate, vegetative, and other groups of material, and identified using various resources, including keys and the help of marine experts. For fish the following source books were used: Hart 1973; Garrison and Miller 1982; Fujita 1990; Miller and Lea 1972; Miller et al. 1980; Lamb and Edgell 1986; Harvey et al. 2000. For marine invertebrates the sources were: Butler 1980; Brusca 1980; Gardner and Szabo 1982; Kozlof 1996 and 1993; Smith 1975; Todd et al. 1996. For insect identification the sources were: Bland and Jaques 1978; Borror et al. 1989.

Each stomach item was identified to species (if possible), and length (mm) and weight (g) measurements were recorded. Prey fish were identified to genus and species, while invertebrates were usually identified to order. Wet weight was obtained after placing identified prey on absorbent brown laboratory towels (Kimberly-Clark Professional WypALL L10 Kimtowels) to remove surface water before weighing on an electronic scale (Mettler BB244 Deltarange) (±0.001g).

Some samples in advanced states of digestion were taken to experts for help in identification, at the University of Washington, the National Marine Fisheries Service, and the WDFW marine mammal lab. Special care was taken to identify prey fishes, to try to distinguish between salmonid and non-salmonid fish. Reference collections and special keys were used, and I constructed a small reference collection of common Puget Sound prey fish.

Scale samples were analyzed for age, saltwater entry and spawning experience at the WDFW, under the supervision of John Sneva (chief salmon age scientist). The scales were mounted on standard scale cards, lightly dyed for visibility and analyzed under 40x magnification. The WDFW scientist supervised the work and reviewed all age determinations given for all samples (Appendix 1).

Data Reporting Plan

Prey data were analyzed by percent frequency of occurrence (%FO), percent numerical composition (%N), and percent contribution to the total weight of prey (%W) (Bowen 1996). Weight to the nearest 0.001 g, and lengths of prey fish items and larger invertebrate prey were recorded. Prey species for non-fish items were grouped into higher categories for analysis.

With emphasis on salmon eggs and fry, analysis was aimed at detecting seasonal patterns in diet contents of cutthroat of different sizes, by location.

Chapter 3

Results

The lengths of the 115 sampled coastal cutthroat ranged from 195 – 485 mm fork length (Figure 2). Of the 115 cutthroat sampled, 94 (82%) provided observable diet samples for analysis. The remaining 21 (18%) samples were discarded in the field, because no visibly significant contents were observed. This may have resulted in underestimating small, unidentified fish bones or other microscopically detectable material such as the spines of polychaetes. The overall cutthroat stomach contents contained 25 different categories of diet items (Table 3; Appendix 2). The aggregated diet items were examined in the laboratory and summarized using the percent frequency

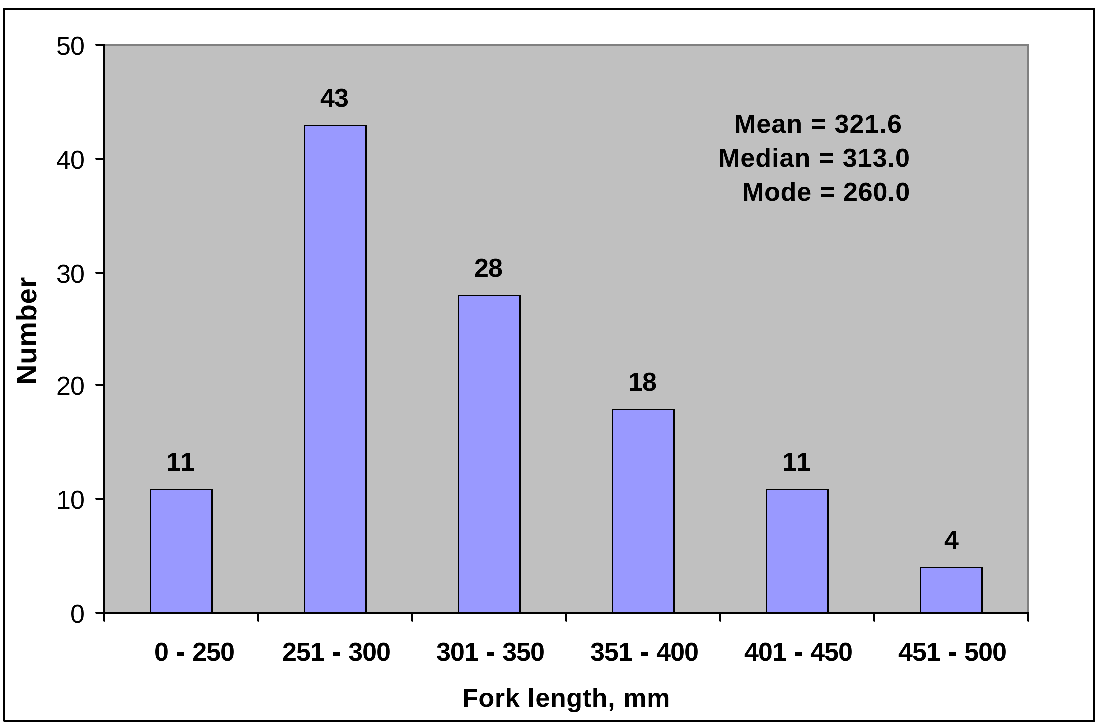

Figure 2: Sample size and fork length of coastal cutthroat trout (N=115)

1. Salmon Eggs (*Oncorhynchus spp*)
2. Chum Salmon Fry (*Oncorhynchus keta*)
3. Pacific Sand Lance (*Ammodytes hexapterus*)
4. Pacific Herring (*Clupea harengus pallasi*)
5. Three-spine Stickleback (*Gasterosteus aculeatus*)
6. Pacific Staghorn Sculpin (*Leptocottus armatus*)
7. Arrow Goby (*Clevelandia ios*)
8. Shiner Perch (*Cymatogaster aggregata*)
9. Surf Smelt (*Hypomesus pretiosus pretiosus*)
10. Unidentified Fish
11. Polychaetes (several taxonomic families)
12. Gammarid Amphipods
13. *Corophium* Amphipods
14. Copepods
15. Isopods
16. "Shrimp" (both mysids and eucarideans)
17. Crabs
18. Barnacle Larvae
19. Clam Necks (*Macoma nasuta*)
20. Molluscs (gastropods and bivalves
21. Insects (*Diptera, Arachnida*)
22. Unidentified flesh
23. Unidentified bone
24. Vegetable Matter
25. Stones

Table 3: Diet items of coastal cutthroat trout in South Puget Sound, 1999-2002

of occurrence (%F), the percent number (%N) and the percent weight (%W) of each diet category listed in Table 3. The diet of coastal cutthroat is summarized by these measures in Table 4, where F is the number of stomachs (out of 94) that contained the diet item, N is the total number of items of that category seen in all stomachs, and W is the total weight (g) of that item seen in all stomachs. By weight, the overall diet of coastal cutthroat trout was dominated by salmon eggs and chum salmon fry (46%), followed by non-salmonid fish (23%), polychaetes (12%), other invertebrates (i.e. amphipods, isopods, shrimp and clam necks) (17%), and other items (2%). In descending order, by weight, the most important non-salmonid fishes in the diet were shiner perch, followed by Pacific herring, Pacific sand lance and arrow goby. The most important invertebrates

Diet items	F	%F	N	%N	W (g)	%W
Salmon Eggs	3	0.88%	187	8.13%	25.55	25.63%
Chum Fry	10	2.93%	111	4.83%	20.16	20.23%
Pacific Sand Lance	7	2.05%	8	0.35%	2.88	2.89%
Pacific Herring	3	0.88%	3	0.13%	4.01	4.02%
Three-spine Stickleback	1	0.29%	1	0.04%	0.27	0.27%
Pacific Staghorn Sculpin	3	0.88%	21	0.91%	1.17	1.17%
Arrow Goby	11	3.23%	16	0.70%	2.40	2.40%
Shiner Perch	4	1.17%	5	0.22%	9.19	9.22%
Surf Smelt	1	0.29%	1	0.04%	2.65	2.66%
Unidentified fish	17	4.99%	17	0.74%	0.16	0.16%
Polychaetes	40	11.73%	52	2.26%	12.00	12.04%
Gammarid Amphipods	50	14.66%	555	24.14%	4.81	4.83%
Corophium Amphipods	7	2.05%	27	1.17%	0.11	0.11%
Copepods	6	1.76%	6	0.26%	0.03	0.03%
Isopods	29	8.50%	351	15.27%	2.20	2.21%
“Shrimp”	32	9.38%	73	3.18%	6.68	6.70%
Crabs	10	2.93%	10	0.43%	0.59	0.59%
Barnacle larvae	7	2.05%	18	0.78%	0.04	0.04%
Clam necks	6	1.76%	721	31.36%	2.71	2.72%
Mollusc	8	2.35%	9	0.39%	0.12	0.12%
Insects	3	0.88%	3	0.13%	0.00	0.00%
Unidentified flesh	44	12.90%	44	1.91%	1.25	1.25%
Unidentified bone	14	4.11%	14	0.61%	0.05	0.05%
Vegetative matter	17	4.99%	18	0.78%	0.14	0.14%
Stones	8	2.35%	28	1.22%	0.51	0.51%
Totals	341	100.00%	2299	100.00%	99.68	100.00%

Table 4: Diet items by percent frequency of occurrence (%F), percent number (%N), and percent weight (%W) of coastal cutthroat trout (*Oncorhynchus clarki clarki*) captured in South Puget Sound, Washington, 1999-2002

by weight were gammarid amphipods, shrimp, isopods, and clam necks.

By weight, there were seven prominent items, each constituting 4% or greater of the diet, totaling almost 83% of the overall diet (Figure 3). Salmon eggs and chum fry were the most important diet items, followed by polychaetes, shiner perch, shrimp, amphipods and Pacific herring. The figures in parentheses show the number of items observed in all stomachs. The number of shiner perch (5) as compared with the number of amphipods (555) is illustrative of the relative contributions of large and small items

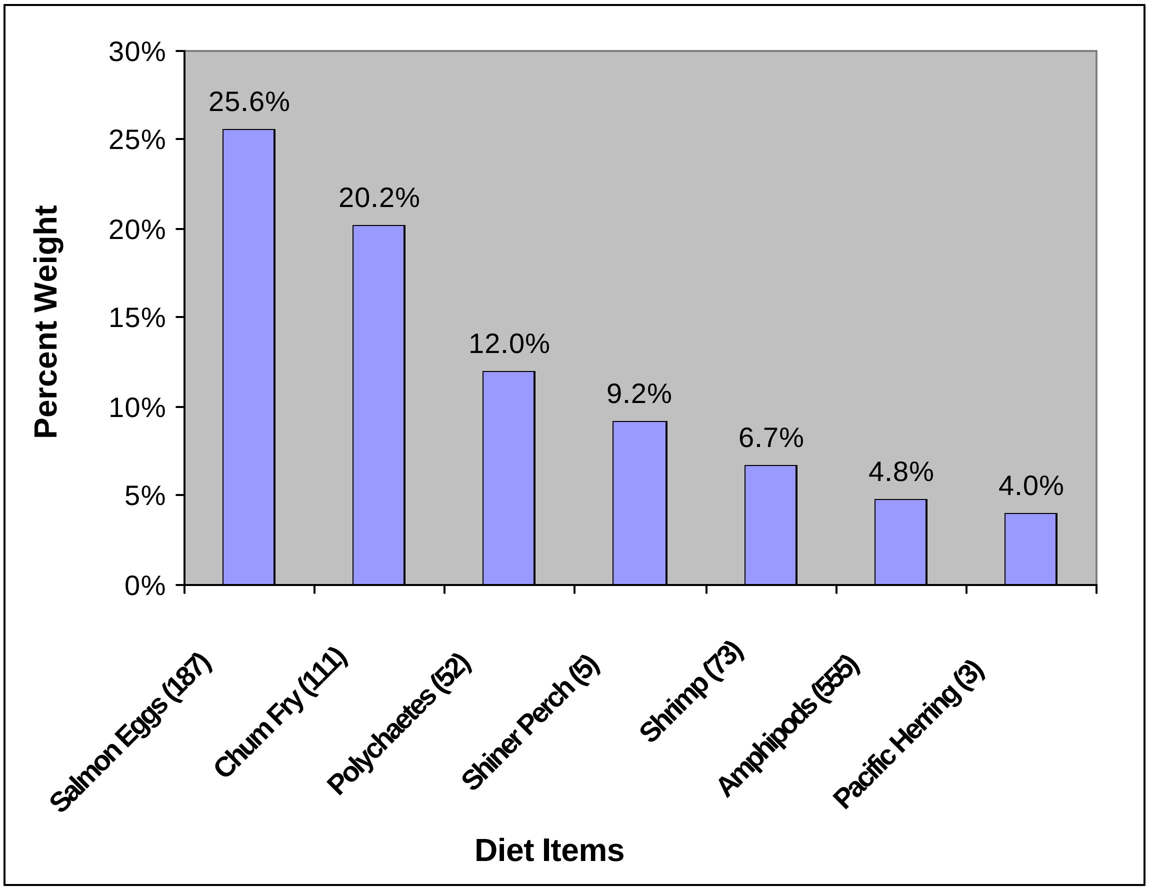

Figure 3: Major diet items for estuarine coastal cutthroat trout, from 94 stomachs (82.7% of total diet weight)

to the coastal cutthroat diet. The importance of non-salmonid prey fish, such as shiner perch (5) and Pacific herring (3), in the overall coastal cutthroat diet is partly based on the relatively large prey size. Conversely, certain numerous but relatively small diet items, such as isopods (351) and clam necks (721), were below 4% by weight of the overall diet of coastal cutthroat.

Patterns in Coastal Cutthroat Diet Variability by Season

The diet data were examined for variations based on the seasonal availability of salmon eggs and chum salmon fry, relative to the size of coastal cutthroat. For the purpose of the analysis by seasons, the sample of cutthroat was separated into fork length intervals as shown in Table 5.

Cutthroat Size, mm	Salmon Present	Salmon Absent	Total
0-300	27	27	**54**
301-400	31	15	**46**
401-500	11	4	**15**
Total	**69**	**46**	**115**

Table 5: Size of coastal cutthroat in the estuary when chum salmon are present/absent, (N=115).

In order to proceed with the analysis of seasonal diet variability, an assumption was made about the months that chum salmon adults are at the peak of their spawning run, and the months that chum salmon smolts are at the peak of their presence in the estuary following their downstream migration.

The general seasonal availability of salmon eggs and chum salmon fry to coastal cutthroat trout in the study area fluctuates with the fall chum salmon spawning runs, and the spring emergence and downstream movement of chum salmon fry. Annually, in the inlets studied, the chum salmon spawners are present in abundance from October to January, and the migrating chum salmon fry are present in abundance in the inlets in March and April. The chum salmon spawners and fry are not present in abundance in the inlets during the months of February, and May to September, although there may be some chum fry presence or that of other salmon species.

Other Pacific salmon, such as coho, steelhead and chinook may also have small populations of spawning adults in the study inlets, but are not considered here because their numbers are small to non-existent. These species were not observed during sampling, while the adult chum salmon were frequently observed in schools during their November spawning run and their carcasses were observed at several estuary locations.

The number of days of sampling effort when chum salmon were assumed to be present (28), and absent (25), were nearly equivalent, a result of purposive (i.e. deliberate choice) temporal distribution of the angling effort. More coastal cutthroat were captured when salmon were present (69), particularly cutthroat of intermediate

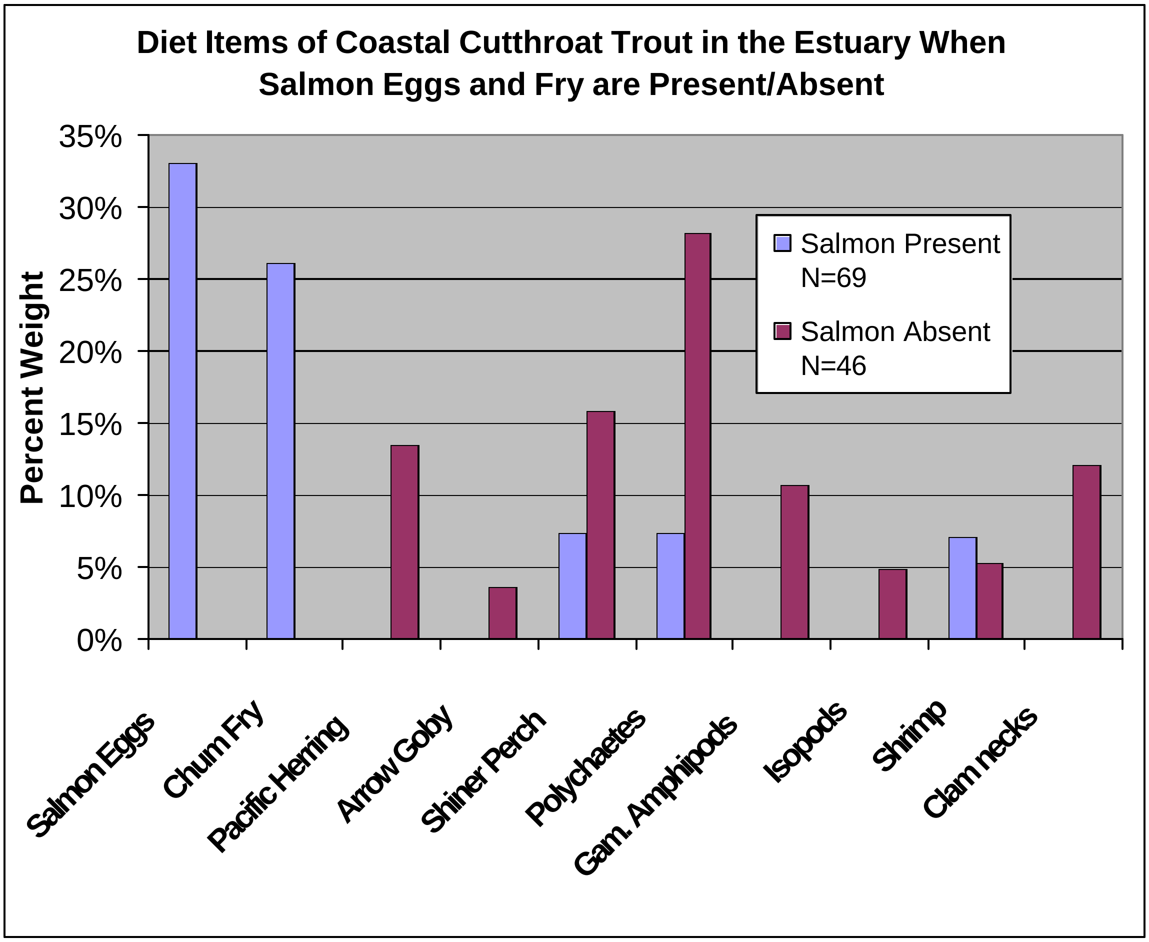

Figure 4: Diet Items 4% or more, by weight, of coastal cutthroat trout in the estuary when salmon eggs and fry are present / absent, (N=115).

size (301-400mm, N=31), and larger (401-485mm, N=11). Based on these observed differences in the sample, a Chi-square test of significance was done. The Chi-square with 2 degrees of freedom is 4.41, with a probability of 0.1103; the threshold of Chi-square alpha=.05 is 5.9915. Thus, the distribution of cutthroat sizes is not significantly different during times when salmon prey are available, from that during times when salmon prey are absent. Figure 4 illustrates the differences in coastal cutthroat diet items that constitute 4% or more by weight when chum salmon are present and absent in the study inlets.

When salmon are present, the major coastal cutthroat diet items, constituting 4% or more of the total weight, (including salmon eggs and fry) represent 81% of the overall diet. However, when salmon are not present the major diet items in Figure 4 represent 94% of the overall cutthroat diet. In other words, the coastal cutthroat acquire proportionally less food from a greater number of minor items (< 4% by weight) when salmon are present than when salmon are absent. It appears that the cutthroat foraging behavior is overall more focused on salmon eggs and fry when salmon are present, and less on other prey.

The relative importance of salmon eggs and fry in the coastal cutthroat diet is also illustrated by the weight of shiner perch, which numbered five (5) specimens in total, four (4) when the salmon were present and one (1) when salmon were not present. Thus, four shiner perch made up 7% of the diet when salmon were present, while one shiner perch made up 16% of the diet when salmon were absent. In somewhat parallel fashion, polychaetes numbered 32 (7% of diet) when salmon were present, and 20 (28% of diet) when salmon were absent, again showing the relative importance of the weight of salmon eggs and fry in comparison to other diet items. The numbers of shrimp (73) and clam necks (721) were relatively high, although most of the clam necks were consumed by two coastal cutthroat less than 300 mm in length. During field sampling, as the individual coastal cutthroats' diets were observed during collection, some variation in diet by cutthroat length was apparent.

Patterns of Coastal Cutthroat Diet Variability by Length

The overall coastal cutthroat diet also varied by cutthroat length during the months chum salmon were present and absent as illustrated in Figures 5 and 6. The diet items constituted 4% or more by weight, of the cutthroat of each feeding period, for the three length categories used for this analysis. The two groups of larger cutthroat, measuring 301-500 mm fork length, consumed all of the salmon eggs and most chum fry, and also consumed most of the non-salmonid fish. The smaller coastal cutthroat, measuring 195-300 mm fork length, consumed a few chum fry and non-salmonid fish, while a larger proportion of their diet weight consisted of various invertebrates, such as polychaetes, amphipods and isopods.

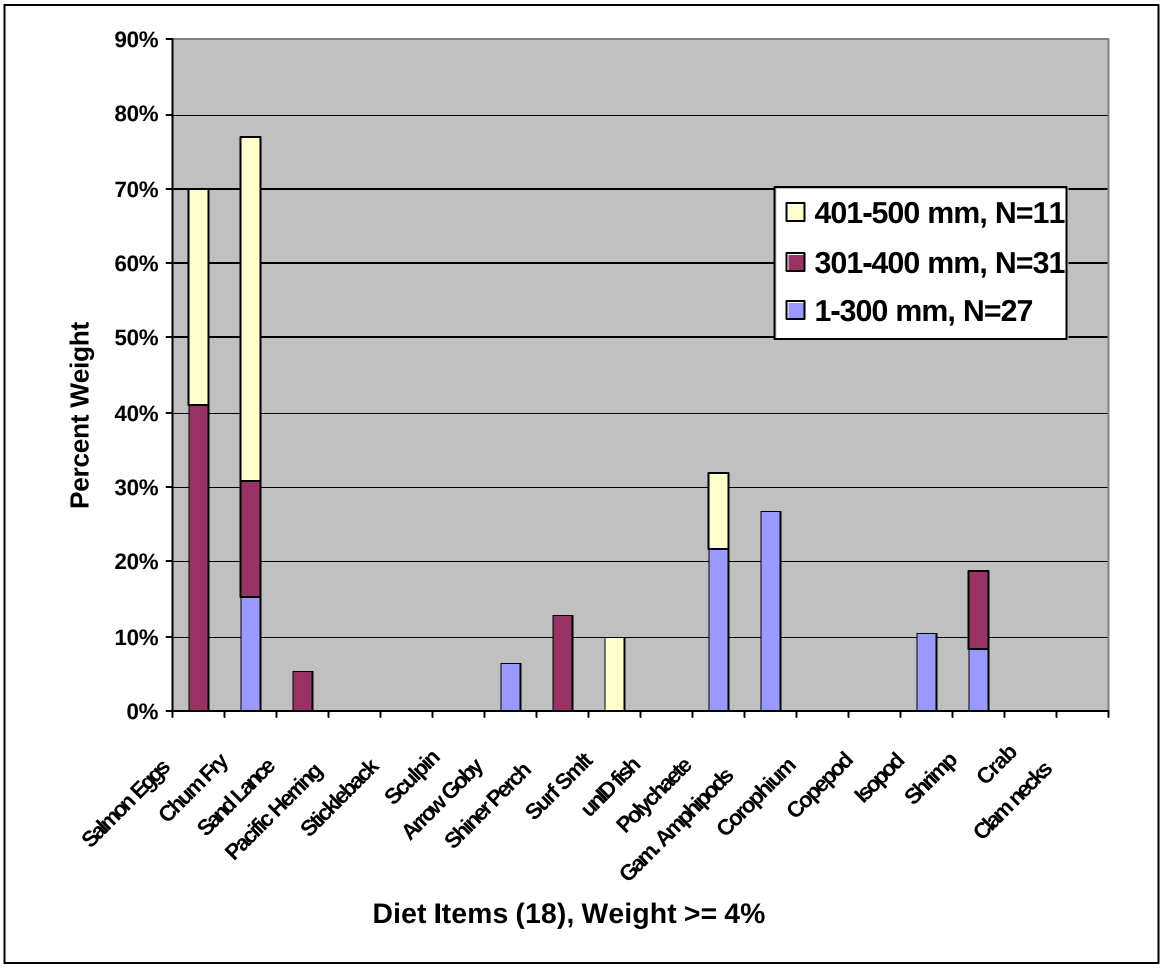

Figure 5: Diet items related to cutthroat length for months when salmon eggs and fry are present (October – January, March and April)

In Figure 6, polychaetes are a major item in the weight of diets of all sizes of sampled coastal cutthroat when salmon eggs and fry are not present. There is also some consumption of non-salmonid fish and a slight increase in consumption of invertebrates. Inferences about the relationship between prey size and cutthroat length, or seasonal shifts in the diet are limited by the small samples in the three length categories. Pacific sand lance, Pacific herring, arrow goby and shiner perch are utilized by one or more length categories of coastal cutthroat and clam necks were utilized by the smaller cutthroat.

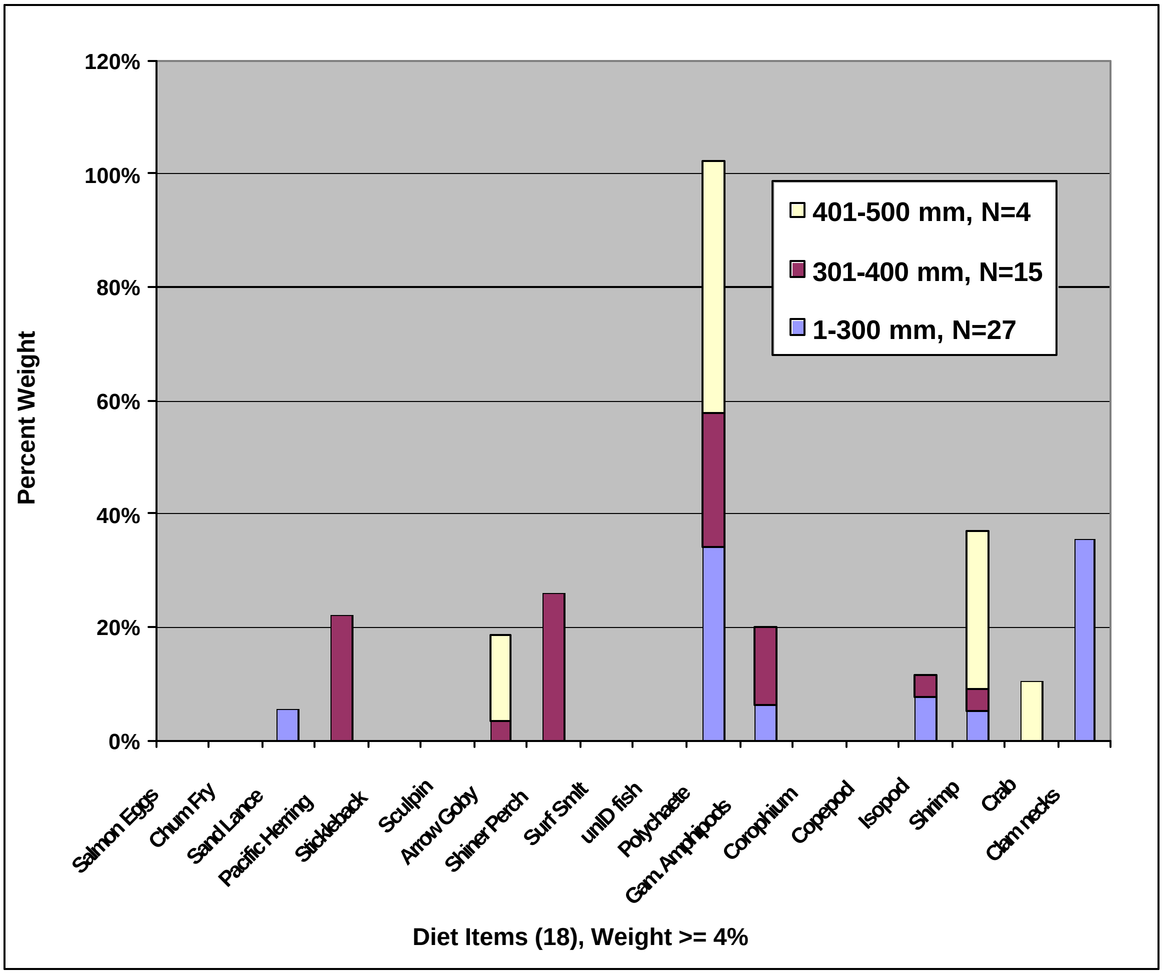

Figure 6: Diet items related to cutthroat length for months when salmon eggs and fry are not present (February, and May – September)

Field and Lab Data: Appendices

The raw field data, detailed stomach contents data, and stomach contents summaries when salmon were present and absent, are listed in full in Appendices 1-3. Coastal cutthroat field data items appearing in the appendices that were not the focus of this report are the following: scale-based estimates of age, estimate of sex based on observation, presence/absence of adipose fin, sampling time, angler effort time, number of anglers, and number of escaped coastal cutthroat that were positively identified.

Summary of Results

1. The overall diet of 115 coastal cutthroat had a large proportion (46%), by weight, of salmon eggs and chum salmon fry, in four inlets of South Puget Sound.
2. The length of coastal cutthroat is a factor that differentiates their diet items, with cutthroat larger than 300 mm consuming most of the salmon eggs and chum salmon fry, and a large proportion of non-salmonid fish. Conversely, coastal cutthroat under 300 mm consumed more invertebrates, some non-salmonid fish, relatively few chum salmon fry and no salmon eggs. The length difference by season of coastal cutthroat in the estuaries is not significant at P(0.11) for Chi square with 2 df.
3. Apparently coastal cutthroat focus on salmon eggs and chum salmon fry when they are available in the estuary and shift to alternative food items when they are absent. This behavior occurs in an environment that has numerous other prey items available. Sample sizes for comparison of coastal cutthroat for salmon presence/absence and length were too small to permit statistical inference techniques for prey selection or diet shifts.

Chapter 4

Discussion

The coastal cutthroat is seasonally dependent on salmon-based diet items, as shown by my sample of 115 estuary dwelling coastal cutthroat that had ingested significant amounts of salmon eggs and chum salmon fry. My findings show that salmon eggs and fry are probably preferred by the larger, more mobile, aggressively feeding cutthroat. Studies of predation by coastal cutthroat on salmon are few but they consistently show that cutthroat feed on the eggs and fry of salmon when the opportunity arises (Trotter 1989; Sumner 1972; Armstrong 1971; Dimick and Mote 1934). This and other information indicates a seasonal reliance by cutthroat on the eggs and fry of Pacific salmon, as has been noted in the literature (Giger 1972a; Armstrong 1971; Loch and Miller 1988). Alternatively, when salmon are not present as a food source, coastal cutthroat shift their diet preferences in systematic ways, to non-salmon fish, polychaetes and other invertebrates.

The cutthroat feeding behaviors observed in this study demonstrate successful life history adaptations that have been recognized as important (Johnston 1982). The focused seasonal salmon egg and fry feeding behaviors of coastal cutthroat are synchronized with two periods of high energy demands, shortly before and soon after spawning. In the coastal cutthroat life cycle, regular movement between fresh and marine waters is probably the end result of successful evolution in the presence of other Pacific salmon in nearshore and estuary habitats (Northcote 1997). The ecological significance of this kind of interspecies interaction has recently become recognized by salmon and estuarine scientists (Cederholm et al. 2001; Cederholm 1998; Simenstad et al. 1982).

The evolution of life history traits by all Pacific salmon is respective to success in species run timing and other behavioral traits (Groot and Margolis 1991). The coastal cutthroat has positioned itself to feed heavily on salmon eggs shortly before its own spawning run in January-March, and to feed on chum (or pink, where available) salmon fry after its spawning run (Armstrong 1972; Johnston 1982). Increased coastal cutthroat fitness and fecundity probably results from this successful adaptation to the movements of other salmon (Northcote 1997).

Prey species availability can be episodic, seasonal, or inter-annual events of high abundance; therefore, when cutthroat have the ability to capture prey they will certainly take the opportunity to do so (Wydoski and Whitney 1979; Trotter 1989). I observed cutthroat feeding behaviors on chum fry that were distinctive, because they were close to shorelines and frequently on or at the surface. In these intensive feeding situations, the chum fry were concentrated by specific biological and physical conditions. Biologically, they were observed schooled and feeding within 2-3 m of shorelines; and physically, there were strong currents that swept the fry along the shoreline and into deeper water where the cutthroat attacked them. Of ten cutthroat captured with chum fry in their stomachs, their aggressive feeding caused them to ingest the artificial flies more deeply than was usually observed. In two cases this resulted in mortality of the cutthroat.

The chum fry in the diets of ten cutthroat were relatively undigested, especially among the larger cutthroat. The largest cutthroat (430 mm) contained 57 relatively undigested chum fry, and, surprisingly, one fry was alive, unmarked and freely swimming in the collection bowl after being lavaged from the cutthroat stomach. The smaller cutthroat had fewer chum fry in their stomachs and these fry were usually around 50% digested or more. This suggests different feeding behaviors by cutthroat trout, such as those based on their size, mobility, speed or ranging behavior, as has been observed in lake populations (Beauchamp et al. 1992; Cartwright et al. 1998; Nowak 2002). Some behaviors of the larger cutthroat that were observed were more aggressive, and more frequent feeding in the best feeding lanes for capturing chum salmon fry.

Salmon eggs were found in three cutthroat, and whole, undigested eggs were somewhat more numerous than empty chorion material (the tough protective egg covering). Two of these cutthroat were collected in mid-November 2001, at the height of the chum salmon run, so the eggs they had consumed were almost certainly chum eggs. One of these fish contained a chunk of undigested salmon eggs still attached to the ovarian tissue, indicating it had scavenged a dead salmon. The liquefied egg yolk and other partly digested egg material were not weighed because they could not be separated from the water bath used to examine samples.

One cutthroat contained 16 small staghorn sculpins that showed a succession of digestion from almost bare bones to a complete specimen. This cutthroat had apparently been feeding on these sculpins over a period of time, to produce the stepwise range of digestion that I observed. This predator revealed its feeding behavior of rooting the sculpins out of benthic sediments, as evidenced by the collection of small gravel in its stomach. Other benthic-feeding cutthroat were those that consumed arrow gobies and crabs (*Scleroplax*), both of which normally hide in the burrows of other organisms. On the other hand, feeding on mysids and some amphipods high in the water column was indicated when cutthroat were observed feeding, on several occasions, at the water surface. It is an unusual adaptation and utilization of estuary resources for the cutthroat to use the entire water column for feeding during the same time period; this surface-oriented behavior has also been observed off the Washington coast (Brodeur et al. 1987). This suggests a freshwater ontogeny for this species, as their habits are known to be more limited in fresh water (Bisson et al. 1982).

The relative amounts of digested diet contents were not recorded, because I had no standard for comparison at the beginning of my analysis. By observation, polychaetes were usually near complete digestion in most cutthroat, compared with other diet items, and would have been a greater component of total diet weight (12%) had they been less completely digested. For example, polychaetes were identified in about one-third of the diet samples by the presence of two or more black spines, in the near absence of any residual tissue. Most of the non-salmon fish were significantly digested, in the range of 10-40%, with some individual prey items almost whole and others reduced to vertebral columns or individual bones.

Comparison of the stomach contents of a sample of 28 coastal cutthroat captured by fyke net, gill net and angling (Armstrong 1971), and a second sample of 326 coastal cutthroat taken from lakes and streams by nets and angling (Dimick and Mote 1934), found no differences in the amount or kind of prey items in their stomachs. Based on the small sample sizes collected by others, using beach seining techniques for sample collection, I assumed that angling methods would be a more effective sampling tool. I used single, barbless hook artificial flies, to minimize injury to the fish, but it is possible that small metallic spinners and lures would have been equally or more effective at capture, while maximizing survival of released fish. I do not recommend using organic bait for this kind of sampling.

Historically, before the 1860's, abundant salmon runs provided substantial nutritive advantages for estuary dwelling cutthroat, as they did for a large host of other terrestrial and aquatic species (Cederholm et al. 2001). Based on estimates of the historic salmon biomass returning to the Pacific Northwest, less than 10% of the former marine-derived nutrients are currently reaching the rivers (Gresh et al. 2000). Thus, the decline of Pacific salmon has likely had a negative effect on the populations of cutthroat trout. This evolutionary niche that cutthroat occupy is a significant factor in their long-term survival, and has likely been another cause of their population decline in Puget Sound. In this regard, the declines of coastal cutthroat trout may mirror the declines of other Pacific salmon species.

In recent years the carcasses of salmon have been found to be an important source of nutrition for many forms of terrestrial and aquatic life (Cederholm, 2001; Bilby et al. 1998). In a large river system, Michael Jr. (1995) found a direct relationship between mass-spawning pink salmon and the production of coho salmon of the previous brood year. This study indicated that the pink salmon carcasses of one year were a major food source for the overwintering juvenile coho. This kind of trophic relationship probably operates for estuary dwelling cutthroat, given their heavy use of salmon eggs and chum fry observed in this study. I speculate that opportunistic feeding on salmon eggs and fry in estuaries would be significantly increased, with a significant increase in the number of salmon allowed to spawn and die in streams (Reimchen 1984).

Ecologically-based escapement is a new concept in salmon harvest management. It is in direct competition with the existing paradigm of maximum sustained yield (MSY) (Cederholm et al. 2001). Maximum sustained yield has failed to account for the long-term importance of salmon carcass nutrients as a driving force in salmon productivity (Schmidt et al. 1998). Schmidt et al. (1998) suggest a positive-feedback mechanism directly related to the size of the spawning escapement as the only consistent explanation of long- and short-term population trends for sockeye salmon. This feedback mechanism partially explains the population fluctuations of estuary dwelling cutthroat, as well as, perhaps, other salmon species.

Declines in the number of spawning salmon reduces carcass nutrient availability, and thus may limit freshwater and estuarine production of cutthroat (Johnson et al.1999, Thompson 2001). Bilby et al. (1996) reported significant growth in juvenile cutthroat when salmon carcasses were experimentally added to streams, and Bilby et al. (1998) found a direct relationship between the addition of salmon carcasses to streams and the growth of juvenile steelhead. Pittman (personal communication, 2002) observed coastal cutthroat eating loose eggs from a chum salmon spawning bed in Kennedy Creek. These findings lend support to the idea that anadromous salmon evolved in an interspecific way, that included behavior aimed at direct and indirect use of salmon-generated nutrients, while resident fish above barriers to anadromy could not.

In my Totten Inlet study area, Thompson (2001) found that spawning salmon and spawned-out carcasses significantly increased estuary concentrations of ammonium. This study suggested that these nutrients were important for production of harpacticoid copepods, an important food source of estuary rearing chum salmon fry (Simenstad et al. 1980; Wissmar and Simenstad 1988). If these chemical nutritive links between adult chum salmon and their subsequent fry are true, then coastal cutthroat survival is also ecologically linked to chum salmon by their reliance on migrating chum salmon fry as prey.

It could be argued that coastal cutthroat trout predation on ESA-listed salmon species in Puget Sound would be considered a detriment, working against management decisions to increase coastal cutthroat abundance; however, an alternative approach is to view applications of ecosystem-based salmon escapement goals (Michael Jr. 1998) that have already demonstrated direct, positive relationships between abundant salmon spawners of one species and future generation benefits to other salmon species (Michael Jr. 1995). In Puget Sound and other Pacific Northwest estuaries, increased abundance of Pacific salmon spawners, especially the mass spawning chum, pink and sockeye, would likely be directly related to increases in coastal cutthroat populations. For sockeye and pink salmon fry, coastal cutthroat have already been well established as successful lake-based predators (Beauchamp et al. 1982; Cartwright et al. 1998; Nowak 2002). Thus, the entire nutritive chain that supports cutthroat and other salmon species, from freshwater to estuary, would benefit from increases of naturally spawning Pacific salmon.

Coastal cutthroat success in nearshore areas is dependent on high quality habitat. However, Pacific Northwest estuaries have experienced 150 years of negative habitat change caused by the settlement of European man (Simenstad and Thom 1992; Johnson et al. 1999). All the major river-mouth estuaries of Washington have been impacted by human development (Simenstad and Thom 1992). Estuary habitat loss over this period has been caused by the cumulative effects of many human activities, such as agriculture, logging, mining, dams, grazing, urbanization, industry, introduction of exotic species and aquaculture (Simenstad and Thom 1992, Emmett et al. 1991).

In Washington, overall area loss of coastal tidal wetlands is 42%, of Puget Sound estuaries is 71%, and of Puget Sound eelgrass is 70% (Simenstad and Thom 1992). Some Puget Sound estuaries such as the Duwamish River and Commencement Bay are 99-100% degraded (Johnson et al. 1999; Bortelson et al. 1980). Since 1948 the Columbia River estuary habitat was degraded by the loss of 70% of its tidal wetlands (Garrett et al. 1998). The Nisqually River estuary has experienced approximately 55% loss. Although reliable quantitative data are unavailable, the least-changed estuaries appear to be the small river mouth estuaries away from major population centers on the western Olympic Peninsula. These latter estuaries include such rivers as the Quinault and Hoh Rivers, and small streams such as Kalaloch Creek, Goodman Creek and many others.

Thurston County, Washington, a rapidly urbanizing area, increased the length of shoreline armoring by greater than 100% between 1977 and 1993, resulting in negative impacts to riparian vegetation, upper beach areas, wave energy and sediment movement along many South Puget Sound shorelines (Johnson et al. 1999). Alterations to shorelines can increase natural mortality of salmon fry and smolts, because predator populations often are enhanced with habitat alterations of this kind (Fresh et al. 1979).

Alterations to fluvial geomorphology can also cause changes in biological characteristics, and may especially influence estuarine food-webs (Simenstad et al. 2000). The exchange of sediments and water at the terrestrial-marine ecotone is affected by human land use practices, such as clearcut logging, which increases sediment delivery (Cederholm et al. 1981); and modifications to river hydrodynamics decreases seasonal water and sediment pulses (Simenstad et al. 1997).

Declines in woody debris in estuaries have been substantial (Maser and Sedell 1994), which may reduce coastal cutthroat populations through temperature increases and refuge site losses (Johnson et al. 1999). Human-caused changes in water flows, quality, or timing, can have a wide range of negative effects on primary and secondary estuarine productivity, can increase stress on migrating or feeding salmon, and cause low flow obstructions to smolt migrations (Simenstad et al. 2000; Johnson et al. 1999).

Many of the estuary changes and losses noted can have direct effects on the key ecological functions (prey availability, refuge, osmoregulation) that estuaries provide in support of species assemblages including Pacific salmon (Simenstad et al. 1982). Although it is clear that all Pacific salmon are adapted to estuarine habitats, there is "*…no information which directly ties changes in quantity and quality of Washington's estuaries to changes in abundance of Pacific salmon, because there are too many confounding factors"* (Simenstad et al. 1982, p 359). Salmon are just one part of the terrestrial-marine ecotone, and to manage them effectively requires an understanding of natural variability and "*the tendency of habitat alteration to magnify impacts*" (Simenstad et al. 1997, p 178).

In this habitat context, the size of adult coastal cutthroat populations could be a biological indicator of fresh and saltwater ecosystems. Coastal cutthroat potential as a biological indicator species was first suggested by Behnke (1987) in a comment he made about cutthroat being the "canary in the mine." He said they are the first species to disappear after environmental degradation. However, other findings indicate that degraded urban stream habitats may shift beyond the adaptive capabilities of some species, reducing diversity, and support cutthroat better than other salmon species, such as coho (Lucchetti and Fuerstenberg 1993; Ludwa et al. 1997). Lucchetti (personal communication, 2002) found that a coho:cutthroat ratio of 4:1 may indicate a healthy, unurbanized system. Lucchetti (personal communication) observed that degraded low gradient streams with adequate temperatures and reduced channel complexity may behave more like headwater systems, and therefore support less coho and more cutthroat.

The adult coastal cutthroat may be a good indicator of properly functioning salmon ecosystems because they spend so much of their lives in estuaries and nearshore environments. Cutthroat also ascend the highest reaches of streams, reaching gradients of over 33% (Pittman, WDFW, pers. comm. 2001). The coastal cutthroat, therefore, has particular value as a biological indicator species for nearshore and estuary condition, as well as the far reaches of the watershed. Thus, if the adult coastal cutthroat populations are in good condition, other Pacific salmon populations, especially the chum salmon in South Puget Sound, are probably also healthy, and vice-versa.

The following conclusions can be reached for estuary dwelling coastal cutthroat trout regarding the conditions of estuarine habitats:

1. Coastal cutthroat use estuaries for key life functions (i.e. feeding, refuge, residence areas, and osmoregulation) common to all species of Pacific Northwest salmon.
2. The number of adult coastal cutthroat could be an indicator species for the overall condition of freshwater and estuary habitats.
3. Estuarine and nearshore areas are decisive habitats in the total marine survival of coastal cutthroat (Meyer 1979).

In urbanized shoreline areas, coastal cutthroat are vulnerable to over-fishing by recreational anglers because they are relatively accessible and easy to catch (Emmett et al. 1991; Trotter 1997; Raymond 1996). In Washington, recreational fishing was "*…probably a significant source of mortality in the past…*," but recent restrictions have resulted in some local population increases in coastal cutthroat (Johnson et al. 1999).

Recreational fishing regulations, such as gear restrictions for single-barbless artificial lures and catch-and-release, may produce only limited gains in coastal cutthroat abundance compared with the possible gains that could come from ecosystem-based salmon escapement goals. In South Puget Sound, catch-and-release regulations have been in place for coastal cutthroat for about ten years, and have resulted in some apparent gains in cutthroat populations, though no definitive population estimates exist. These regulations are likely to produce only limited population increases because of seasonal cutthroat reliance on other Pacific salmon for critical nutrition.

Other contributors to coastal cutthroat mortality in the heavily developed inlets that I studied are: commercial by-catch, illegal recreational fishing, improper handling methods when fish are released, and predation by seals, birds and fish. In field observations, several sample cutthroat had been marked by characteristic seal and bird attacks, and one cutthroat was closely pursued by a harbor seal while it was being brought into the boat.

Field research questions put forth by Seliskar and Gallagher (1983) on salmon estuarine ecology that are still applicable to current practitioners are:

1. Do estuary and tidal marsh resident fish have better survival rates than those that do not take up residency?
2. What are the populations in tidal marsh areas?
3. What proportion of migrating fry live in estuaries and marshes?
4. Which river stocks contribute to estuary residents?
5. If survival rates are better in estuaries, how can estuaries be recovered for fish production?

I end this report with the following question: What are the trophic dynamics and the food webs leading to coastal cutthroat? A comparison of the distribution and growth patterns of coastal cutthroat, including their predators and prey in various estuarine habitat areas, would yield broad functional knowledge of the terrestrial-marine ecotone. Perhaps this would allow managers to begin to understand the coastal cutthroat and it's place in the dynamic estuarine mosaic. The data presented in this study contributes to the beginning of this understanding.

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Appendices

Appendix 1: Coastal cutthroat field data, 5 pages. (See key at end for code interpretation)												
Date: Day-Month-Year	Sample ID Number	Sample Location	Fork Length mm	Scale Data	Sex Observed	Adipose Present	Tissue Vial Number	Stomach Contents Present	Sample Time in Seconds	Hours of Effort	Number of Anglers	Known CCT Escaped
4-Mar-99	0	Totten								3	2	
7-Mar-99	0	Totten								2.25	1	
24-Jul-99	1	Hope Island	336	R.+F+	1	1	99xa-1	1	0			
24-Jul-99	2	Hope Island	300	2.+	1	1	99xa-2	2	0			
24-Jul-99	3	Hope Island	260	3.+	1	1	99xa-3	2	0			
24-Jul-99	4	Hammersley	400	2.+F+	1	1	99xa-4	1	0			
24-Jul-99	5	Hammersley	231	2.+	2	1	99xa-5	1	0			
24-Jul-99	6	Hammersley	289	2.+F+	1	1	99xa-6	1	0			
24-Jul-99	7	Hammersley	195	2.+	2	1	99xa-7	1	0			
24-Jul-99	8	Hammersley	272	2.+F+	2	1	99xa-8	1	0			
24-Jul-99	9	Hammersley	385	R.+S+	1	1	99xa-9	2	0	9.5	2	5
8-Aug-99	10	Hammersley	319	2.+	1	1	99xa-10	1	75			
8-Aug-99	11	Hammersley	266	2,+F+	2	1	99xa-11	1	65			
8-Aug-99	12	W. Squaxin	289	R,+	2	1	99xa-12	1	110			
8-Aug-99	13	W. Squaxin	348	2,+	2	1	99xa-13	1	100	4.75	2	2
8-Apr-00	1	Eld	325	2,+F+1	1	1	99xa-14	1	0			
8-Apr-00	2	Eld	313	1,+F+	1	1	99xa-15	1	85	3	2	1
20-Apr-00	3	Eld	395	2,+F+S+1	1	1	99xb-3	1	70	2.25	3	
7-May-00	0	Eld								2.25	1	1
18-May-00	4	Eld	360	2+F+	1	1	99xb-4	1	85			
18-May-00	5	Eld	230	3,+	2	1	99xb-5	1	70	2	3	6
19-May-00	6	Eld	285	2,+F+	1	1	99xb-6	2	55			
19-May-00	7	Eld	410	R,+S+S+	2	1	99xb-7	1	65	3	1	3
4-Jun-00	8	Eld	260	2,+	2	1	99xb-8	1	40	1.5	1	2
16-Jun-00	0	Eld								1.75	2	2
18-Jun-00	9	Eld	235	2,+	2	1	99xb-9	1	60	2	1	1
18-Jun-00	10	Eld	485	2,+F+S+	1	1	99xb-10	2	45			
4-Jul-00	0	Eld								2	1	1
31-Aug-00	11	Eld	385	R,+F+	1	1	99xb-11	1	40	1.75	1	
9-Feb-01	12	Eld	275	1,+1	1	1	99xb-12	1	43	1.5	2	4
9-Feb-01	13	Eld	260	2,+1	2	1	99xb-13	2	40			

Appendix 1: Coastal cutthroat field data, continued (See key at end for code interpretation)												
Date: Day-Month-Year	Sample ID Number	Sample Location	Fork Length mm	Scale Data	Sex Observed	Adipose Present	Tissue Vial Number	Stomach Contents Present	Sample Time in Seconds	Hours of Effort	Number of Anglers	Known CCT Escaped
9-Feb-01	14	Eld	320	2,+1	2	1	99xb-14	2	55			
10-Mar-01	15	Eld	290	2,+1	1	2	99xb-15	1	40	1.25	2	1
9-May-01	0	Eld								2.25	2	1
7-Jun-01	0	Eld								1.25	1	
6-Jul-01	0	Eld								1.5	2	1
30-Sep-01	16	Eld	315	2,+	1	1	99xb-16	1	40	2.5	2	1
30-Sep-01	17	Eld	300	2,+	2	1	99xb-17	1	50			
6-Oct-01	18	Eld	455	2,+F+S+	2	1	99xb-18	1	45	1.75	1	1
7-Oct-01	0	Eld								3	1	
14-Oct-01	1	Skookum	440	2,+F+S+	2	1	99xc-1	1	50	3.25	2	3
14-Oct-01	2	Skookum	305	2,+	2	1	99xc-2	2	40			
21-Oct-01	14	Totten	305	2,+F+	1	1	99xa-14	1	40	4	2	5
21-Oct-01	15	Totten	250	2,+	2	1	99xa-15	2	45			
21-Oct-01	16	Totten	335	R,+F+	2	1	99xa-16	2	50			
21-Oct-01	17	Totten	280	2,+	2	1	99xa-17	1	50			
25-Oct-01	21	Skookum	340	R,	1	1	99xc-21	2	50	4.25	1	2
25-Oct-01	22	Skookum	327	2,+S+	2	1	99xc-22	2	50			
25-Oct-01	23	Skookum	308	2,+F+	2	1	99xc-23	1	50			
25-Oct-01	24	Skookum	279	3,+	2	1	99xc-24	2	45			
25-Oct-01	25	Skookum	365		1	1	99xc-25	1	45			
25-Oct-01	26	Skookum	354	R,+F+	1	1	99cx-26	1	40			
28-Oct-01	27	Skookum	298	2,+F+	1	1	99xc-27	2	50	3.75	3	
28-Oct-01	28	Skookum	279	2,+F+	1	1	99xc-28	1	45			
31-Oct-01	29	Skookum	292	3,+F+	1	1	99xc-29	2	30	2.25	2	4
31-Oct-01	30	Skookum	278	R,+	1	1	99xc-30	1	35			
31-Oct-01	3	Skookum	328	3,+	1	1	99xc-3	1	40			
31-Oct-01	4	Skookum	337	2,+	2	1	99xc-4	1	45			
4-Nov-01	5	Skookum	405	1,+F+	2	1	99xc-5	2	45	5	2	12
4-Nov-01	6	Skookum	292	2,+F+	2	1	99xc-6	1	40			
4-Nov-01	7	Skookum	335	R	2	1	99xc-7	1	40			
4-Nov-01	8	Skookum	231	1,+	2	1	99xc-8	1	35			
4-Nov-01	9	Skookum	315	3,+	2	1	99xc-9	1	45			
4-Nov-01	10	Skookum	472	R,	1	1	99xc-10	2	40			

Appendix 1: Coastal cutthroat field data, continued (See key at end for code interpretation)												
Date: Day-Month-Year	Sample ID Number	Sample Location	Fork Length mm	Scale Data	Sex Observed	Adipose Present	Tissue Vial Number	Stomach Contents Present	Sample Time in Seconds	Hours of Effort	Number of Anglers	Known CCT Escaped
4-Nov-01	11	Skookum	213	R,	2	1	99xc-11	1	35			
4-Nov-01	12	Skookum	282	2,+F+	2	1	99xc-12	1	45			
4-Nov-01	13	Skookum	338	2,+F+	1	1	99xc-13	1	45			
4-Nov-01	14	Skookum	255	2,+	2	1	99xc-14	1	40			
4-Nov-01	15	Skookum	261	2,+F+	2	1	99xc-15	1	45			
4-Nov-01	16	Skookum	354	R,	1	1	99xc-16	2	50			
6-Nov-01	0	Totten								1.25	2	1
5-Dec-01	17	Skookum	348	2,+	1	1	99xc-17	1	45	2.75	2	0
5-Dec-01	18	Skookum	341	2,+F+	1	1	99xc-18	1	40			
6-Jan-02	19	Eld	345	2,+1	2	1	99xb-19	1	35	3.5	1	6
6-Jan-02	20	Eld	278	2,+1	2	1	99xb-20	1	30			
8-Jan-02	21	Eld	475	2,+S+1	2	1	99xb-21	1	50	4.2	1	1
8-Jan-02	22	Eld	291	2,+1	1	1	99xb-22	1	40			
11-Jan-01	23	Eld	410	R,+F+1	2	1	99xb-23	1	50	2	1	
11-Jan-02	24	Eld	448	1,+F+S+1	1	1	99xb-24	1	45			
11-Jan-02	25	Eld	269	R,+1	1	1	99xb-25	1	40			
11-Jan-02	26	Eld	295	2,+F+1	2	1	99xb-26	1	40			
12-Jan-02	19	Skookum	284	2,+1	1	1	99xc-19	2	45	2.25	2	0
13-Jan-02	20	Skookum	382	3,+S+1	1	1	99xc-20	2	50	2	1	1
26-Jan-02	18	Totten	260	1,+1	2	1	99xa-18	1	35	3.1	1	0
26-Jan-02	19	Totten	440	1,+F+S+1	2	1	99xa-19	1	45			
26-Jan-02	20	Totten	425	2,+F+S+1	2	1	99xa-20	1	50			
26-Jan-02	21	Totten	385	2,+F+1	2	1	99xa-21	1	45			
27-Jan-02	27	Eld	358	2,+1	1	1	99xb-27	1	40	2.4	2	9
27-Jan-02	28	Eld	266	1,+1	2	1	99xb-28	1	40			
27-Jan-02	29	Eld	291	1,+1	2	1	99xb-29	1	45			
27-Jan-02	30	Eld	281	1,+1	2	1	99xb-30	1	40			
27-Jan-02	31	Eld	289	1,+1	2	1		1	35			
1-Feb-02	0	Totten								2	1	
2-Feb-02	22	Totten	378	2,+F+1	2	1	99xa-22	1	50	4	1	2
2-Feb-02	23	Totten	253	2,+1	2	1	99xa-23	1	40			

Appendix 1: Coastal cutthroat field data, continued (See key at end for code interpretation)											
Date: Day-Month-Year	Sample ID Number	Sample Location	Fork Length mm	Scale Data	Sex Observed	Adipose Present	Tissue Vial Number	Stomach Contents Present	Sample Time in Seconds	Hours of Effort	Number of Anglers	Known CCT Escaped
2-Feb-02	24	Totten	279	2,+F+1	2	1	99xa-24	1	45			
2-Feb-02	25	Totten	382	R,+1	1	1	99xa-25	1	55			
2-Feb-02	26	Totten	239	R,	2	1	99xa-26	1	45			
2-Feb-02	27	Totten	272	2,+1	2	1	99xa-27	1	45			
2-Feb-02	28	Totten	248	1,+F+1	2	1	99xa-28	2	40			
3-Feb-02	0	Totten								1	1	0
8-Feb-02	29	Totten	402	2,+F+1	2	1	99xa-29	1	40	1.9	1	0
8-Feb-02	30	Totten	357	R,	2	1	99xa-30	1	35			
9-Feb-02	32	Eld	289	2,+F+1	2	1		1	35	2.25	1	0
9-Feb-02	33	Eld	298	R,	1	1		1	30			
9-Feb-02	34	Eld	319	R,+F+1	2	1		1	35			
9-Feb-02	35	Eld	296	2,+F+1	2	1		1	35			
9-Feb-02	36	Eld	329	R,+F+1	2	1		1	35			
9-Feb-02	37	Eld	205	2,+1	2	1		1	40			
10-Feb-02	1	Totten +	420	R,+F+1	1	1	02al-1	1	40	2	2	1
15-Feb-02	38	Eld	288	2,+1	2	1		1	30	2.75	2	2
16-Feb-02	2	Totten +	288	2,+F+	2	1	02al-2	1	35	3.5	3	2
17-Feb-02	3	Totten +	328	2,+1	1	1	02al-3	1	45	3	3	2
18-Feb-02	0	Totten +								2	3	0
23-Feb-02	4	Totten +	268	1,+F+1	2	1	02al-4	1	35	2.5	1	0
23-Mar-02	0	Hammersley								1	2	1
5-Apr-02	31	Skookum	280	R,+1	2	1		1	40	2.75	1	2
6-Apr-02	14	Hammersley	295	R,+1	2	1		1	40	3	2	0
6-Apr-02	15	Hammersley	360	2,+F+	1	1		1	45			
6-Apr-02	16	Hammersley	430	3,+F+1	1	1		1	45			
7-Apr-02	17	Hammersley	338	R,+F+1	1	1		1	50	4.25	2	4
7-Apr-02	18	Hammersley	330	1,+F+1	2	1		1	40			
7-Apr-02	19	Hammersley	390	1,+F+S+	1	1		1	45			
7-Apr-02	20	Hammersley	362	R,+S+	1	1		1	45			
7-Apr-02	21	Hammersley	326	R,	2	1		1	45			

Appendix 1: Coastal cutthroat field data, end (See key on this page for code interpretation)

Date: Day-Month-Year	Sample ID Number	Sample Location	Fork Length mm	Scale Data	Sex Observed	Adipose Present	Tissue Vial Number	Stomach Contents Present	Sample Time in Seconds	Hours of Effort	Number of Anglers	Known CCT Escaped
7-Apr-02	22	Hammersley	410	R,	1	1		1	50			
8-Apr-02	23	Hammersley	330	2,+F+1	2	1		1	40	3	1	2
8-Apr-02	24	Hammersley	203	2,+	2	1		1	35			
9-Apr-02	0	Totten +								2	2	0
12-Apr-02	5	Totten +	392	R,+S+1	2	1	02al-5	1	40	2.75	2	0

Key to Data Codes:

1. Sample ID Number: CCT sample number for that inlet respective date; "0" signifies no cutthroat caught.
2. Sample location: Hope Is.#1-3 And W. Squaxin #12-13 are reported as Hammersley; "Totten+" signifies sample # restarts at "1."
2. Fork length in mm of CCT.
3. Scale data: number =years; R=regenerated; F=freshwater entry; S=spawning check.
4. Sex: CCT sex estimated by observation only; 1=Male; 2=Female.
5. Adipose present: adipose fin of CCT present; 1=present; 2=absent.
6. Tissue Vial Number: genetic tissue samples taken from 30 fish from Eld, Totten, Skookum Inlets. Archived at WDFW, Olympia.
7. Stomach Contents Present: Contents samples and saved for analysis; 1=Yes; 2=No.
8. Sample Time in Seconds: CCT handling time; removal from anesthetic to placing in revival bucket; "0" signifies not measured.
9 .Hours of effort: Time angling to capture CCT; for CPUE calculation multiply (hours) x (N. of anglers).
10. Number of anglers: N anglers sampling CCT on that date.
11. Known CCT Escaped: N of CCT hooked and identified but escaped capture on that date.

Appendix 2: Coastal Cutthroat Diet by Date, Sample #, Location, 15 pages. (See Note this page, and key at end for code interpretation). Item number, N = count of items in stomach. Item weight, W = wet weight in grams.

Date	S #	Sample Location	Contents Present	Salmon Eggs		Chum Fry		Sand Lance		Pacific Herring		Stickle-back		Staghorn Sculpin		Arrow Goby		Shiner Perch		Surf Smlt	
					Wt	N	Wt	N	Wt	N	Wt	N	Wt	N	Wt	N	Wt	N	Wt	N	Wt
4-Mar-99	0	Totten																			
7-Mar-99	0	Totten																			
24-Jul-99	1	Hope Island	1					1	0.005												
24-Jul-99	2	Hope Island	2																		
24-Jul-99	3	Hope Island	2																		
24-Jul-99	4	Hammersley	1																		
24-Jul-99	5	Hammersley	1					2	0.409												
24-Jul-99	6	Hammersley	1																		
24-Jul-99	7	Hammersley	1																		
24-Jul-99	8	Hammersley	1																		
24-Jul-99	9	Hammersley	2																		
8-Aug-99	10	Hammersley	1																		
8-Aug-99	11	Hammersley	1																		
8-Aug-99	12	W. Squaxin	1																		
8-Aug-99	13	W. Squaxin	1																		
8-Apr-00	1	Eld	1																		
8-Apr-00	2	Eld	1							1	0.988										
20-Apr-00	3	Eld	1							1	0.015										
7-May-00	0	Eld																			
18-May-00	4	Eld	1																		
18-May-00	5	Eld	1																		
19-May-00	6	Eld	2																		
19-May-00	7	Eld	1																		
4-Jun-00	8	Eld	1																		
16-Jun-00	0	Eld																			
18-Jun-00	9	Eld	1																		
18-Jun-00	10	Eld	2																		
4-Jul-00	0	Eld																			

Note: Each CCT sampled is represented on three pages in Appendix 2. The first page shows diet items from "salmon eggs" to "surf smelt," the second "unidentified fish" to "barnacle larvae," the third "clam necks" to "stones." E.G. CCT #1, Hope Island is shown on p.1, p. 6 and p. 11.

Appendix 2, p 2; Coastal Cutthroat Diet

Date	S #	Sample Location	Contents Present	Salmon Eggs N	Salmon Eggs Wt	Chum Fry N	Chum Fry Wt	Sand Lance N	Sand Lance Wt	Pacific Herring N	Pacific Herring Wt	Stickle-back N	Stickle-back Wt	Staghorn Sculpin N	Staghorn Sculpin Wt	Arrow Goby N	Arrow Goby Wt	Shiner Perch N	Shiner Perch Wt	Surf Smlt N	Surf Smlt Wt
31-Aug-00	11	Eld	1									1	0.272								
9-Feb-01	12	Eld	1																		
9-Feb-01	13	Eld	2																		
9-Feb-01	14	Eld	2																		
10-Mar-01	15	Eld	1																		
9-May-01	0	Eld																			
7-Jun-01	0	Eld																			
6-Jul-01	0	Eld																			
30-Sep-01	16	Eld	1																		
30-Sep-01	17	Eld	1																		
6-Oct-01	18	Eld	1																		
7-Oct-01	0	Eld																			
14-Oct-01	1	Skookum	1																		
14-Oct-01	2	Skookum	2																		
21-Oct-01	14	Totten	1											15	0.904						
21-Oct-01	15	Totten	2																		
21-Oct-01	16	Totten	2																		
21-Oct-01	17	Totten	1											5	0.242						
25-Oct-01	21	Skookum	2																		
25-Oct-01	22	Skookum	2																		
25-Oct-01	23	Skookum	1																		
25-Oct-01	24	Skookum	2																		
25-Oct-01	25	Skookum	1																		
25-Oct-01	26	Skookum	1					1	0.211												
28-Oct-01	27	Skookum	2																		
28-Oct-01	28	Skookum	1					1	0.063												
31-Oct-01	29	Skookum	2																		
31-Oct-01	30	Skookum	1																		

Appendix 2, p 3; Coastal Cutthroat Die

Date	S #	Sample Location	Contents Present	Salmon Eggs N	Salmon Eggs Wt	Chum Fry N	Chum Fry Wt	Sand Lance N	Sand Lance Wt	Pacific Herring N	Pacific Herring Wt	Stickle-back N	Stickle-back Wt	Staghorn Sculpin N	Staghorn Sculpin Wt	Arrow Goby N	Arrow Goby Wt	Shiner Perch N	Shiner Perch Wt	Surf Smlt N	Surf Smlt Wt
31-Oct-01	3	Skookum	1															2	3.765		
31-Oct-01	4	Skookum	1													2	0.495	1	1.883		
4-Nov-01	5	Skookum	2																		
4-Nov-01	6	Skookum	1																		
4-Nov-01	7	Skookum	1					1	0.101												
4-Nov-01	8	Skookum	1													2	0.172				
4-Nov-01	9	Skookum	1	18	1.437																
4-Nov-01	10	Skookum	2																		
4-Nov-01	11	Skookum	1																		
4-Nov-01	12	Skookum	1																		
4-Nov-01	13	Skookum	1																		
4-Nov-01	14	Skookum	1																		
4-Nov-01	15	Skookum	1					1	0.000												
4-Nov-01	16	Skookum	2																		
6-Nov-01	0	Totten																			
5-Dec-01	17	Skookum	1															1	0.018		
5-Dec-01	18	Skookum	1	62	#####			1	2.095							1	0.261				
6-Jan-02	19	Eld	1											1	0.024						
6-Jan-02	20	Eld	1																		
8-Jan-02	21	Eld	1																	1	2.647
8-Jan-02	22	Eld	1																		
11-Jan-01	23	Eld	1																		
11-Jan-02	24	Eld	1	107	7.721																
11-Jan-02	25	Eld	1																		
11-Jan-02	26	Eld	1																		
12-Jan-02	19	Skookum	2																		
13-Jan-02	20	Skookum	2																		
26-Jan-02	18	Totten	1																		

Appendix 2, p 4; Coastal Cutthroat Diet

Date	S #	Sample Location	Contents Present	Salmon Eggs N	Salmon Eggs Wt	Chum Fry N	Chum Fry Wt	Sand Lance N	Sand Lance Wt	Pacific Herring N	Pacific Herring Wt	Stickle-back N	Stickle-back Wt	Staghorn Sculpin N	Staghorn Sculpin Wt	Arrow Goby N	Arrow Goby Wt	Shiner Perch N	Shiner Perch Wt	Surf Smlt N	Surf Smlt Wt
26-Jan-02	19	Totten	1													1	0.018				
26-Jan-02	20	Totten	1													3	0.252				
26-Jan-02	21	Totten	1																		
27-Jan-02	27	Eld	1																		
27-Jan-02	28	Eld	1																		
27-Jan-02	29	Eld	1																		
27-Jan-02	30	Eld	1																		
27-Jan-02	31	Eld	1													1	0.133				
1-Feb-02	0	Totten																			
2-Feb-02	22	Totten	1																		
2-Feb-02	23	Totten	1																		
2-Feb-02	24	Totten	1																		
2-Feb-02	25	Totten	1																		
2-Feb-02	26	Totten	1																		
2-Feb-02	27	Totten	1													1	0.176				
2-Feb-02	28	Totten	2																		
3-Feb-02	0	Totten																			
8-Feb-02	29	Totten	1													1	0.155				
8-Feb-02	30	Totten	1																		
9-Feb-02	32	Eld	1																		
9-Feb-02	33	Eld	1																		
9-Feb-02	34	Eld	1							1	3.002										
9-Feb-02	35	Eld	1																		
9-Feb-02	36	Eld	1																		
9-Feb-02	37	Eld	1																		
10-Feb-02	1	Totten +	1																		
15-Feb-02	38	Eld	1																		
16-Feb-02	2	Totten +	1																		

Appendix 2, p 5; Coastal Cutthroat Diet

Date	S #	Sample Location	Contents Present	Salmon Eggs N	Salmon Eggs Wt	Chum Fry N	Chum Fry Wt	Sand Lance N	Sand Lance Wt	Pacific Herring N	Pacific Herring Wt	Stickle-back N	Stickle-back Wt	Staghorn Sculpin N	Staghorn Sculpin Wt	Arrow Goby N	Arrow Goby Wt	Shiner Perch N	Shiner Perch Wt	Surf Smlt N	Surf Smlt Wt
17-Feb-02	3	Totten +	1													2	0.474	1	3.526		
18-Feb-02	0	Totten +																			
23-Feb-02	4	Totten +	1																		
23-Mar-02	0	Hammersley																			
5-Apr-02	31	Skookum	1													1	0.178				
6-Apr-02	14	Hammersley	1			4	0.800														
6-Apr-02	15	Hammersley	1			7	0.916														
6-Apr-02	16	Hammersley	1			57	11.522														
7-Apr-02	17	Hammersley	1			17	2.380														
7-Apr-02	18	Hammersley	1			2	0.259														
7-Apr-02	19	Hammersley	1			10	1.841														
7-Apr-02	20	Hammersley	1			7	1.236									1	0.083				
7-Apr-02	21	Hammersley	1			1	0.140														
7-Apr-02	22	Hammersley	1			4	0.743														
8-Apr-02	23	Hammersley	1																		
8-Apr-02	24	Hammersley	1			2	0.325														
9-Apr-02	0	Totten +																			
12-Apr-02	5	Totten +	1																		
			(N)(W)	187	#####	111	20.162	8	2.884	3	4.005	1	0.272	21	1.170	16	2.397	5	9.192	1	2.647
			(F)	0mar01		10		7		3		1		3		11		4		1	

Appendix 2, p 6; Coastal Cutthroat Diet

Date	S #	Sample Location	Contents Present	Unidentified fish N	Unidentified fish Wt	Polychaetes N	Polychaetes Wt	Gammarid Amphipods N	Gammarid Amphipods Wt	Corophium Amphipods N	Corophium Amphipods Wt	Copepods N	Copepods Wt	Isopods N	Isopods Wt	"Shrimp" N	"Shrimp" Wt	Crabs N	Crabs Wt	Barnacle Larvae N	Barnacle Larvae Wt
4-Mar-99	0	Totten																			
7-Mar-99	0	Totten																			
24-Jul-99	1	Hope Island	1																		
24-Jul-99	2	Hope Island	2																		
24-Jul-99	3	Hope Island	2																		
24-Jul-99	4	Hammersley	1	1	0.016																
24-Jul-99	5	Hammersley	1																		
24-Jul-99	6	Hammersley	1					1	0.004												
24-Jul-99	7	Hammersley	1																		
24-Jul-99	8	Hammersley	1	1	0.028																
24-Jul-99	9	Hammersley	2																		
8-Aug-99	10	Hammersley	1			1	0.006														
8-Aug-99	11	Hammersley	1																	1	.000
8-Aug-99	12	W. Squaxin	1					1	0.001												
8-Aug-99	13	W. Squaxin	1									1	0.002							4	0.008
8-Apr-00	1	Eld	1			1	0.001	2	0.012												
8-Apr-00	2	Eld	1			2	0.170	1	0.003							1	0.642				
20-Apr-00	3	Eld	1													1	0.004				
7-May-00	0	Eld																			
18-May-00	4	Eld	1																		
18-May-00	5	Eld	1													1	0.003				
19-May-00	6	Eld	2																		
19-May-00	7	Eld	1													1	0.286				
4-Jun-00	8	Eld	1			1	0.002									1	0.003				
16-Jun-00	0	Eld																			
18-Jun-00	9	Eld	1													1	0.002				
18-Jun-00	10	Eld	2																		
4-Jul-00	0	Eld																			

Appendix 2, p 7; Coastal Cutthroat Diet

Date	S #	Sample Location	Contents Present	Unidentified fish N	Unidentified fish Wt	Polychaetes N	Polychaetes Wt	Gammarid Amphipods N	Gammarid Amphipods Wt	Corophium Amphipods N	Corophium Amphipods Wt	Copepods N	Copepods Wt	Isopods N	Isopods Wt	"Shrimp" N	"Shrimp" Wt	Crabs N	Crabs Wt	Barnacle Larvae N	Barnacle Larvae Wt
31-Aug-00	11	Eld	1													1	0.001				
9-Feb-01	12	Eld	1					5	0.030	1	0.003										
9-Feb-01	13	Eld	2																		
9-Feb-01	14	Eld	2																		
10-Mar-01	15	Eld	1			1	0.012	12	0.081	2	0.012			1	0.019						
9-May-01	0	Eld																			
7-Jun-01	0	Eld																			
6-Jul-01	0	Eld																			
30-Sep-01	16	Eld	1													2	0.025				
30-Sep-01	17	Eld	1			1	0.000									1	0.031				
6-Oct-01	18	Eld	1											1	0.002	1	0.001				
7-Oct-01	0	Eld																			
14-Oct-01	1	Skookum	1					1	0.002												
14-Oct-01	2	Skookum	2																		
21-Oct-01	14	Totten	1													1	2.833				
21-Oct-01	15	Totten	2																		
21-Oct-01	16	Totten	2																		
21-Oct-01	17	Totten	1					1	0.000												
25-Oct-01	21	Skookum	2																		
25-Oct-01	22	Skookum	2																		
25-Oct-01	23	Skookum	1																		
25-Oct-01	24	Skookum	2																		
25-Oct-01	25	Skookum	1					1	0.000			1	0.000			1	0.018				
25-Oct-01	26	Skookum	1																		
28-Oct-01	27	Skookum	2																		
28-Oct-01	28	Skookum	1	1	0.054	1	0.069									1	0.062				
31-Oct-01	29	Skookum	2																		
31-Oct-01	30	Skookum	1																		

Appendix 2, p 8; Coastal Cutthroat Diet

				Unidentified fish		Polychaetes		Gammarid Amphipods		Corophium Amphipods		Copepods		Isopods		"Shrimp"		Crabs		Barnacle Larvae	
Date	S #	Sample Location	Contents Present	N	Wt	N	Wt	N	Wt	N	Wt	N	Wt	N	Wt	N	Wt	N	Wt	N	Wt
31-Oct-01	3	Skookum	1			1	0.000					1	0.020					1	0.214		
31-Oct-01	4	Skookum	1															1	0.047		
4-Nov-01	5	Skookum	2																		
4-Nov-01	6	Skookum	1													1	0.043				
4-Nov-01	7	Skookum	1									1	0.003								
4-Nov-01	8	Skookum	1					1	0.009												
4-Nov-01	9	Skookum	1											1	0.000						
4-Nov-01	10	Skookum	2																		
4-Nov-01	11	Skookum	1					1	0.012					1	0.080						
4-Nov-01	12	Skookum	1									1	0.001							5	0.032
4-Nov-01	13	Skookum	1	1	0.009																
4-Nov-01	14	Skookum	1													1	0.000				
4-Nov-01	15	Skookum	1					1	0.000									1	0.028	1	0.000
4-Nov-01	16	Skookum	2																		
6-Nov-01	0	Totten																			
5-Dec-01	17	Skookum	1																		
5-Dec-01	18	Skookum	1	1	0.026									1	0.034						
6-Jan-02	19	Eld	1					11	0.022					1	0.001	1	0.005				
6-Jan-02	20	Eld	1			1	0.000	4	0.009					1	0.006	2	0.085				
8-Jan-02	21	Eld	1																		
8-Jan-02	22	Eld	1					27	0.064							4	0.027				
11-Jan-01	23	Eld	1											1	0.031						
11-Jan-02	24	Eld	1													1	0.122				
11-Jan-02	25	Eld	1					20	0.098					1	0.000			1	0.006		
11-Jan-02	26	Eld	1			1	0.026	7	0.020	5	0.008					30	0.386				
12-Jan-02	19	Skookum	2																		
13-Jan-02	20	Skookum	2																		
26-Jan-02	18	Totten	1					1	0.009					18	0.060						

Appendix 2, p 9; Coastal Cutthroat Diet

Date	S #	Sample Location	Contents Present	Unidentified fish N	Wt	Polychaetes N	Wt	Gammarid Amphipods N	Wt	Corophium Amphipods N	Wt	Copepods N	Wt	Isopods N	Wt	"Shrimp" N	Wt	Crabs N	Wt	Barnacle Larvae N	Wt
26-Jan-02	19	Totten	1			4	2.001	1	0.014					11	0.097	3	0.298				
26-Jan-02	20	Totten	1			1	0.038														
26-Jan-02	21	Totten	1	1	0.001	1	0.020									1	0.091				
27-Jan-02	27	Eld	1					1	0.036												
27-Jan-02	28	Eld	1			2	1.227	11	0.166	1	0.011										
27-Jan-02	29	Eld	1			1	0.000	82	0.720					37	0.410			1	0.032		
27-Jan-02	30	Eld	1	1	0.000			122	0.318	2	0.001			7	0.038						
27-Jan-02	31	Eld	1			1	0.256	1	0.029					4	0.047						
1-Feb-02	0	Totten																			
2-Feb-02	22	Totten	1	1	0.000	1	0.003	109	1.770					67	0.468			1	0.126		
2-Feb-02	23	Totten	1	1	0.000			1	0.001					28	0.055						
2-Feb-02	24	Totten	1	1	0.000	1	0.000	4	0.048					74	0.193			1	0.009		
2-Feb-02	25	Totten	1					1	0.009					3	0.037						
2-Feb-02	26	Totten	1	1	0.000	1	0.000	2	0.032					57	0.238						
2-Feb-02	27	Totten	1	1	0.006			1	0.035												
2-Feb-02	28	Totten	2																		
3-Feb-02	0	Totten																			
8-Feb-02	29	Totten	1			1	0.435	3	0.012									1	0.106		
8-Feb-02	30	Totten	1	1	0.002	1	0.139	11	0.101					1	0.001	2	0.480				
9-Feb-02	32	Eld	1			1	0.013	18	0.173			1	0.000	2	0.059	2	0.151	1	0.019		
9-Feb-02	33	Eld	1	1	0.015	1	0.159	4	0.086					2	0.043	1	0.001				
9-Feb-02	34	Eld	1			1	0.032	1	0.000												
9-Feb-02	35	Eld	1			1	0.057	1	0.024							1	0.000				
9-Feb-02	36	Eld	1	1	0.000	1	0.000	1	0.011												
9-Feb-02	37	Eld	1					2	0.001												
10-Feb-02	1	Totten +	1			1	0.022														
15-Feb-02	38	Eld	1			1	1.155	2	0.018												
16-Feb-02	2	Totten +	1			2	1.203									3	0.201				

Appendix 2, p 10; Coastal Cutthroat Diet

Date	S #	Sample Location	Contents Present	Unidentified fish N	Wt	Polychaetes N	Wt	Gammarid Amphipods N	Wt	Corophium Amphipods N	Wt	Copepods N	Wt	Isopods N	Wt	"Shrimp" N	Wt	Crabs N	Wt	Barnacle Larvae N	Wt
17-Feb-02	3	Totten +	1			3	3.047														
18-Feb-02	0	Totten +																			
23-Feb-02	4	Totten +	1					1	0.025									1	0.003		
23-Mar-02	0	Hammersley																			
5-Apr-02	31	Skookum	1			1	0.008	4	0.022					4	0.036	1	0.008			4	0.001
6-Apr-02	14	Hammersley	1	1	0.000	1	0.000	13	0.293					9	0.056						
6-Apr-02	15	Hammersley	1			1	0.163	14	0.166					9	0.118						
6-Apr-02	16	Hammersley	1			1	0.010														
7-Apr-02	17	Hammersley	1			1	0.016	2	0.027	1	0.009					1	0.028				
7-Apr-02	18	Hammersley	1			1	0.005	2	0.031					2	0.008	1	0.046				
7-Apr-02	19	Hammersley	1													1	0.000				
7-Apr-02	20	Hammersley	1																		
7-Apr-02	21	Hammersley	1			2	1.016	2	0.002												
7-Apr-02	22	Hammersley	1			1	0.667	17	0.123	15	0.066										
8-Apr-02	23	Hammersley	1	1	0.000			1	0.000					1	0.003					1	0.000
8-Apr-02	24	Hammersley	1			1	0.003	17	0.122					4	0.022						
9-Apr-02	0	Totten +																			
12-Apr-02	5	Totten +	1			4	0.023	5	0.023					2	0.042	2	0.799			2	0.000
			(N)(W)	17	0.157	52	12.004	555	4.814	27	0.110	6	0.026	##	2.204	73	6.682	10	0.590	18	0.041
			(F)	17		40		50		7		6		29		32		10		7	

Appendix 2, p 11; Coastal Cutthroat Diet

Date	S #	Sample Location	Contents Present	Clam Necks N	Clam Necks Wt	Molluscs N	Molluscs Wt	Insects N	Insects Wt	Unidentifi-ed Flesh N	Unidentifi-ed Flesh Wt	Unidentifi-ed Bone N	Unidentifi-ed Bone Wt	Vegetable Matter N	Vegetable Matter Wt	Stones N	Stones Wt
4-Mar-99	0	Totten															
7-Mar-99	0	Totten															
24-Jul-99	1	Hope Island	1							1	0.003						
24-Jul-99	2	Hope Island	2														
24-Jul-99	3	Hope Island	2														
24-Jul-99	4	Hammersley	1									1	0.001				
24-Jul-99	5	Hammersley	1							1	0.008	1	0.002	1	0.002		
24-Jul-99	6	Hammersley	1							1	0.001	1	0.001				
24-Jul-99	7	Hammersley	1							1	0.003	1	0.001				
24-Jul-99	8	Hammersley	1							1	0.004						
24-Jul-99	9	Hammersley	2														
8-Aug-99	10	Hammersley	1							1	0.001						
8-Aug-99	11	Hammersley	1									1	.000				
8-Aug-99	12	W. Squaxin	1														
8-Aug-99	13	W. Squaxin	1							1	0.000						
8-Apr-00	1	Eld	1							1	0.007			1	0.002		
8-Apr-00	2	Eld	1														
20-Apr-00	3	Eld	1	1	0.001					1	0.007						
7-May-00	0	Eld															
18-May-00	4	Eld	1									1	0.005				
18-May-00	5	Eld	1							1	0.003	1	0.000	1	0.001		
19-May-00	6	Eld	2														
19-May-00	7	Eld	1											1	0.007		
4-Jun-00	8	Eld	1														
16-Jun-00	0	Eld															
18-Jun-00	9	Eld	1														
18-Jun-00	10	Eld	2														
4-Jul-00	0	Eld															

Appendix 2, p12; Coastal Cutthroat Diet

Date	S #	Sample Location	Contents Present	Clam Necks N	Clam Necks Wt	Molluscs N	Molluscs Wt	Insects N	Insects Wt	Unidentifi-ed Flesh N	Unidentifi-ed Flesh Wt	Unidentifi-ed Bone N	Unidentifi-ed Bone Wt	Vegetable Matter N	Vegetable Matter Wt	Stones N	Stones Wt
31-Aug-00	11	Eld	1														
9-Feb-01	12	Eld	1	3	0.006	1	0.000			1	0.001						
9-Feb-01	13	Eld	2														
9-Feb-01	14	Eld	2														
10-Mar-01	15	Eld	1							1	0.007						
9-May-01	0	Eld															
7-Jun-01	0	Eld															
6-Jul-01	0	Eld															
30-Sep-01	16	Eld	1														
30-Sep-01	17	Eld	1							1	0.025						
6-Oct-01	18	Eld	1											1	0.073		
7-Oct-01	0	Eld															
14-Oct-01	1	Skookum	1							1	0.011						
14-Oct-01	2	Skookum	2														
21-Oct-01	14	Totten	1							1	0.006					20	0.338
21-Oct-01	15	Totten	2														
21-Oct-01	16	Totten	2														
21-Oct-01	17	Totten	1							1	0.000					1	0.000
25-Oct-01	21	Skookum	2														
25-Oct-01	22	Skookum	2														
25-Oct-01	23	Skookum	1					1	0.000	1	0.000	1	0.000				
25-Oct-01	24	Skookum	2														
25-Oct-01	25	Skookum	1							1	0.000						
25-Oct-01	26	Skookum	1														
28-Oct-01	27	Skookum	2														
28-Oct-01	28	Skookum	1							1	0.007						
31-Oct-01	29	Skookum	2														
31-Oct-01	30	Skookum	1							1	0.020						

Appendix 2, p 13; Coastal Cutthroat Diet

Date	S #	Sample Location	Contents Present	Clam Necks		Molluscs		Insects		Unidentifi-ed Flesh		Unidentifi-ed Bone		Vegetable Matter		Stones	
				N	Wt	N	Wt	N	Wt	N	Wt	N	Wt	N	Wt	N	Wt
31-Oct-01	3	Skookum	1							1	0.024						
31-Oct-01	4	Skookum	1							1	0.057						
4-Nov-01	5	Skookum	2														
4-Nov-01	6	Skookum	1							1	0.004						
4-Nov-01	7	Skookum	1							1	0.001						
4-Nov-01	8	Skookum	1							1	0.001						
4-Nov-01	9	Skookum	1									1	0.000	1	0.020		
4-Nov-01	10	Skookum	2														
4-Nov-01	11	Skookum	1											1	0.006		
4-Nov-01	12	Skookum	1											1	0.001		
4-Nov-01	13	Skookum	1							1	0.011	1	0.000	1	0.000		
4-Nov-01	14	Skookum	1							1	0.005	1	0.000	1	0.002		
4-Nov-01	15	Skookum	1			1	0.000	1	0.000					1	0.004		
4-Nov-01	16	Skookum	2														
6-Nov-01	0	Totten															
5-Dec-01	17	Skookum	1														
5-Dec-01	18	Skookum	1							1	0.622	1	0.017				
6-Jan-02	19	Eld	1											1	0.002		
6-Jan-02	20	Eld	1			1	0.011			1	0.001						
8-Jan-02	21	Eld	1							1	0.063	1	0.008				
8-Jan-02	22	Eld	1							1	0.025	1	0.017			1	0.000
11-Jan-01	23	Eld	1													1	0.000
11-Jan-02	24	Eld	1													1	0.046
11-Jan-02	25	Eld	1							1	0.000						
11-Jan-02	26	Eld	1	1	0.011									2	0.002	2	0.009
12-Jan-02	19	Skookum	2														
13-Jan-02	20	Skookum	2														
26-Jan-02	18	Totten	1														

Appendix 2, p 14; Coastal Cutthroat Diet

Date	S #	Sample Location	Contents Present	Clam Necks N	Clam Necks Wt	Molluscs N	Molluscs Wt	Insects N	Insects Wt	Unidentifi-ed Flesh N	Unidentifi-ed Flesh Wt	Unidentifi-ed Bone N	Unidentifi-ed Bone Wt	Vegetable Matter N	Vegetable Matter Wt	Stones N	Stones Wt
26-Jan-02	19	Totten	1			2	0.001										
26-Jan-02	20	Totten	1														
26-Jan-02	21	Totten	1			1	0.001										
27-Jan-02	27	Eld	1														
27-Jan-02	28	Eld	1														
27-Jan-02	29	Eld	1											1	0.007	1	0.068
27-Jan-02	30	Eld	1														
27-Jan-02	31	Eld	1														
1-Feb-02	0	Totten															
2-Feb-02	22	Totten	1			1	0.002							1	0.000		
2-Feb-02	23	Totten	1							1	0.001						
2-Feb-02	24	Totten	1														
2-Feb-02	25	Totten	1														
2-Feb-02	26	Totten	1														
2-Feb-02	27	Totten	1														
2-Feb-02	28	Totten	2														
3-Feb-02	0	Totten															
8-Feb-02	29	Totten	1														
8-Feb-02	30	Totten	1					1	0.002					1	0.004		
9-Feb-02	32	Eld	1			1	0.089									1	0.049
9-Feb-02	33	Eld	1														
9-Feb-02	34	Eld	1							1	0.049						
9-Feb-02	35	Eld	1	4	0.008					1	0.004						
9-Feb-02	36	Eld	1														
9-Feb-02	37	Eld	1	485	1.486									1	0.010		
10-Feb-02	1	Totten +	1														
15-Feb-02	38	Eld	1	227	1.197												
16-Feb-02	2	Totten +	1														

Appendix 2, p 15; Coastal Cutthroat Diet

Date	S #	Sample Location	Contents Present	Clam Necks N	Clam Necks Wt	Molluscs N	Molluscs Wt	Insects N	Insects Wt	Unidentifi-ed Flesh N	Unidentifi-ed Flesh Wt	Unidentifi-ed Bone N	Unidentifi-ed Bone Wt	Vegetable Matter N	Vegetable Matter Wt	Stones N	Stones Wt
17-Feb-02	3	Totten +	1														
18-Feb-02	0	Totten +															
23-Feb-02	4	Totten +	1														
23-Mar-02	0	Hammersley															
5-Apr-02	31	Skookum	1			1	0.011			1	0.111						
6-Apr-02	14	Hammersley	1														
6-Apr-02	15	Hammersley	1							1	0.092						
6-Apr-02	16	Hammersley	1							1	0.001						
7-Apr-02	17	Hammersley	1							1	0.006						
7-Apr-02	18	Hammersley	1							1	0.002						
7-Apr-02	19	Hammersley	1														
7-Apr-02	20	Hammersley	1							1	0.002						
7-Apr-02	21	Hammersley	1							1	0.049						
7-Apr-02	22	Hammersley	1														
8-Apr-02	23	Hammersley	1							1	0.000						
8-Apr-02	24	Hammersley	1							1	0.001						
9-Apr-02	0	Totten +															
12-Apr-02	5	Totten +	1														
			(N)(W)	721	2.709	9	0.115	3	0.002	44	1.246	14	0.052	18	0.143	28	0.510
Key to data codes:			(F)	6		8		3		44		14		17		8	

1. S#: CCT sample number for that inlet and respective date; "0" signifies no cutthroat caught.
2. Contents present: Stomach contents samples saved for analysis; 1=Yes; 2=No.
The order of coastal cuthroat is the same in Appendix 1 and Appendix 2.

Appendix 2A: Invertebrate diet items by species, genus or family, where known. (This table identifies species that were aggregated into broader categories in the main text.)

Diet Item	Fish #	Aggregated as
Neotrypaea sp.	2- Eld	shrimp
Upogebia pugettensis	5- Totten	shrimp
Crangon sp.	5- Eld	shrimp
Crangon sp.	7- Eld	shrimp
Crangon sp.	8- Eld	shrimp
Crangon sp.	9- Eld	shrimp
Crangon sp.	11- Eld	shrimp
Crangon sp.	16- Eld	shrimp
Crangon sp.	18- Eld	shrimp
Crangon sp.	22- Eld	shrimp
Crangon franciscorum	30- Totten	shrimp
Crangon franciscorum	32- Eld	shrimp
Hippolytidae	25- Skookum	shrimp
Hippolytidae	28- Skookum	shrimp
Hippolytidae	5- Totten	shrimp
Cumacea	31- Skookum	shrimp
Neomysis mercedis	17- Hammersley	shrimp
Neomysis mercedis	18- Hammersley	shrimp
Unidentified Thalassinoid	24- Eld	shrimp
Macoma nasuta	12- Eld	clam necks
Macoma nasuta	37- Eld (485)	clam necks
Macoma nasuta	38- Eld (227)	clam necks
Macoma nasuta	35- Eld	clam necks
Diptera Sciomyzidae	23- Skookum	insects
Diptera (wing)	15- Skookum	insects
Arachnida (spider)	30- Totten	insects
Hemigrapsus oregonensis	3- Skookum	crabs
Hemigrapsus oregonensis	29- Totten	crabs
Hemigrapsus oregonensis	4- Totten +	crabs
Paguridae (in littorinid shell)	15- Skookum	crabs
Scleroplax granulata	29- Eld	crabs
Scleroplax granulata	22- Totten	crabs
Scleroplax granulata	24- Totten	crabs
Mytilus sp.	20- Eld	molluscs
Armandia brevis	31- Skookum	polychaetes

Appendix 3:

b) Fry/eggs absent

(February and May-September) N=46 Coastal Cutthroat

Cutthroat Length, Subgroup Number

Diet Items	**1 - 300 mm, N=27 CCT**							**301 - 400 mm, N=15 CCT**					
	F	%F	**N**	%N	**W** (g)	%W		**F**	%F	**N**	%N	**W** (g)	%W
Salmon Eggs	0	0.00%	0	0.00%	0	0.00%		0	0.00%	0	0.00%	0	0.00%
Chum Salmon Fry	0	0.00%	0	0.00%	0	0.00%		0	0.00%	0	0.00%	0	0.00%
Sand Lance	1	1.37%	2	0.20%	0.409	5.37%		1	2.56%	1	0.43%	0.005	0.04%
Pacific Herring	0	0.00%	0	0.00%	0	0.00%		1	2.56%	1	0.43%	3.002	22.02%
3-Spi. Stickleback	0	0.00%	0	0.00%	0	0.00%		1	2.56%	1	0.43%	0.272	2.00%
Staghorn Sculpin	0	0.00%	0	0.00%	0	0.00%		0	0.00%	0	0.00%	0	0.00%
Arrow Goby	1	1.37%	1	0.10%	0.176	2.31%		1	2.56%	2	0.86%	0.474	3.48%
Shiner Perch	0	0.00%	0	0.00%	0	0.00%		1	2.56%	1	0.43%	3.526	25.87%
Surf Smlt	0	0.00%	0	0.00%	0	0.00%		0	0.00%	0	0.00%	0	0.00%
Unidentified fish	6	8.22%	6	0.61%	0.049	0.64%		4	10.26%	4	1.72%	0.018	0.13%
Polychaetes	9	12.33%	10	1.02%	2.589	33.99%		6	15.38%	8	3.43%	3.227	23.68%
Gammarid Amphipod	13	17.81%	43	4.38%	0.478	6.28%		5	12.82%	123	52.79%	1.891	13.87%
Corophium Amphipod	1	1.37%	1	0.10%	0.003	0.04%		0	0.00%	0	0.00%	0	0.00%
Copepod	1	1.37%	1	0.10%	0	0.00%		1	2.56%	1	0.43%	0.002	0.01%
Isopod	5	6.85%	163	16.62%	0.588	7.72%		3	7.69%	71	30.47%	0.506	3.71%
"Shrimp"	8	10.96%	11	1.12%	0.392	5.15%		3	7.69%	5	2.15%	0.506	3.71%
Crabs	3	4.11%	3	0.31%	0.031	0.41%		1	2.56%	1	0.43%	0.126	0.92%
Barnacle Larvae	1	1.37%	1	0.10%	0	0.00%		1	2.56%	4	1.72%	0.008	0.06%
Clam Necks	4	5.48%	719	73.29%	2.697	35.41%		0	0.00%	0	0.00%	0	0.00%
Molluscs	2	2.74%	2	0.20%	0.089	1.17%		1	2.56%	1	0.43%	0.002	0.01%
Insects	0	0.00%	0	0.00%	0	0.00%		1	2.56%	1	0.43%	0.002	0.01%
Unidentified flesh	9	12.33%	9	0.92%	0.05	0.66%		4	10.26%	4	1.72%	0.053	0.39%
Unidentified bone	5	6.85%	5	0.51%	0.004	0.05%		2	5.13%	2	0.86%	0.006	0.04%
Vegetable matter	3	4.11%	3	0.31%	0.013	0.17%		2	5.13%	2	0.86%	0.004	0.03%
Stones	1	1.37%	1	0.10%	0.049	0.64%		0	0.00%	0	0.00%	0	0.00%
Totals	73	100.0%	981	100.0%	7.617	100.0%		39	100.0%	233	100.0%	13.63	100.0%

Appendix 3:

b) Fry/eggs absent

(February and May-September) N=46 Coastal Cutthroat

Diet Items	**Cutthroat Length, Subgroup Number 401-500 mm, N=4 CCT**					
	F	%F	**N**	%N	**W** (g)	%W
Salmon Eggs	0	0.00%	0	0.00%	0	0.00%
Chum Salmon Fry	0	0.00%	0	0.00%	0	0.00%
Sand Lance	0	0.00%	0	0.00%	0	0.00%
Pacific Herring	0	0.00%	0	0.00%	0	0.00%
3-Spi. Stickleback	0	0.00%	0	0.00%	0	0.00%
Staghorn Sculpin	0	0.00%	0	0.00%	0	0.00%
Arrow Goby	1	14.29%	1	11.11%	0.155	15.15%
Shiner Perch	0	0.00%	0	0.00%	0	0.00%
Surf Smlt	0	0.00%	0	0.00%	0	0.00%
Unidentified fish	0	0.00%	0	0.00%	0	0.00%
Polychaetes	2	28.57%	2	22.22%	0.457	44.67%
Gammarid Amphipod	1	14.29%	3	33.33%	0.012	1.17%
Corophium Amphipod	0	0.00%	0	0.00%	0	0.00%
Copepod	0	0.00%	0	0.00%	0	0.00%
Isopod	0	0.00%	0	0.00%	0	0.00%
"Shrimp"	1	14.29%	1	11.11%	0.286	27.96%
Crabs	1	14.29%	1	11.11%	0.106	10.36%
Barnacle Larvae	0	0.00%	0	0.00%	0	0.00%
Clam Necks	0	0.00%	0	0.00%	0	0.00%
Molluscs	0	0.00%	0	0.00%	0	0.00%
Insects	0	0.00%	0	0.00%	0	0.00%
Unidentified flesh	0	0.00%	0	0.00%	0	0.00%
Unidentified bone	0	0.00%	0	0.00%	0	0.00%
Vegetable matter	1	14.29%	1	11.11%	0.007	0.68%
Stones	0	0.00%	0	0.00%	0	0.00%
Totals	7	100.0%	9	100.0%	1.023	100.0%

KEY:
N=Number of items eaten.
F=number of CCT that had eaten that item.
W=weight of item in grams.
Sum of (F) is greater than number of CCT because many fish had eaten more than one diet item.