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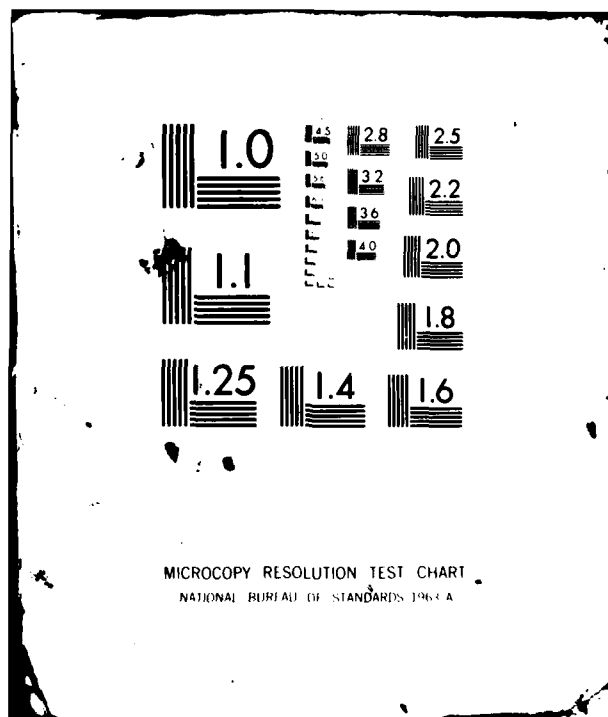
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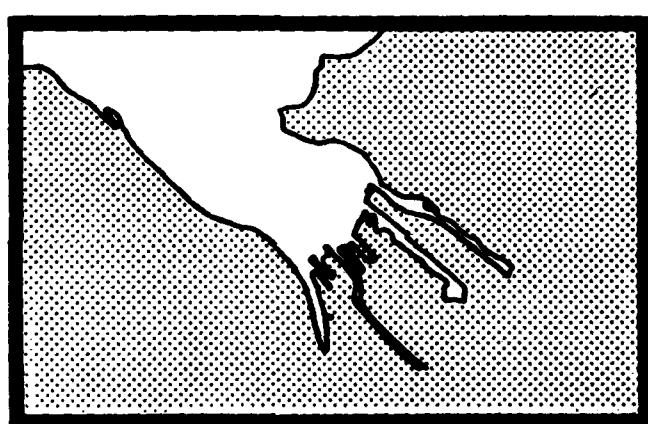
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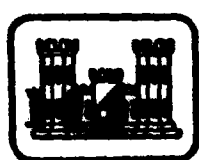
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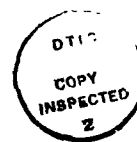
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In the 20-month period ending December 1981, Dames & Moore (Seattle) assisted by four subcontractors completed a Phase I effort to collect baseline data and provide a detailed description of the natural and human systems of the Commencement Bay area in the southern Main Basin of Puget Sound in Washington State.			

Data, interpretations, and conclusions in this report are those of the authors.



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COMMENCEMENT BAY STUDIES
TECHNICAL REPORT

VOLUME III

- FISH
- WETLANDS

for

U.S. Army Corps of Engineers
Seattle District

December 1981

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TECHNICAL REPORT

FISH

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1.0 INTRODUCTION

Development activities along the shorelines of Commencement Bay have the potential for affecting the fish resources that reside in or pass through this body of water. These fish resources include anadromous salmonids and resident marine fish that are harvested by sports fishermen, Indian fishermen, and commercial fishermen. As such, the fish represent an important social and economic resource that is to be protected where possible and enhanced if practical. It is the basic objective of this study to collect existing information and field data that will increase the understanding of the basic characteristics and requirements of these fish resources in order that more effective planning of the shoreline development and preservation may occur. This basic objective most likely cannot be fully achieved with existing scientific technology and monetary resources; however, several more limited objectives were outlined in the Corps's Statement of Work (Section 3.3) for the Commencement Bay Studies (COBS) that are directed toward the basic goal. These defined objectives* are:

1. Establish the residence time of anadromous fish within the study area.
2. Characterize the migration seasons, patterns, and distribution of the anadromous fish species.
3. Characterize the seasonality, distribution, and abundance of marine fish; map fish distribution by habitat type.

The fish resources to be addressed include two basic types, the anadromous salmonids and the resident marine fish. The anadromous salmonid populations that migrate through and rear in the nearshore environment of Commencement Bay originate, for the most part, in the

*Note--A fourth objective "Determine the feeding habitats/requirements of the resident and anadromous fish, based upon results of stomach analyses" was completed on samples collected in the fish program but analyzed as part of the invertebrate studies (see Invertebrate Studies Technical Report).

Puyallup River, Hylebos Creek, and Wapato Creek which enter southeastern Commencement Bay (Figure 1) although salmonids from other Puget Sound streams may also use the Commencement Bay shoreline. These streams support both natural runs and artificially reared salmonid populations. The Puyallup River is the major salmonid source having populations of spring and fall races of chinook salmon, coho salmon, chum salmon, pink salmon, steelhead trout, and probably cutthroat trout. Hylebos Creek historically supported runs of both coho and chum salmon but now has limited production (Williams et al. 1975). Hatchery reared chinook, coho, and chum salmon, as well as steelhead trout, are also planted into these streams by the Washington Department of Fisheries and the Puyallup Nation.

Although Commencement Bay is most likely inhabited throughout its entirety by marine fish, our study was designed to investigate only those fish inhabiting the nearshore shallow water habitat of Commencement Bay. This nearshore shallow water habitat and its associated fish populations are most likely to be affected by shoreline development activities.

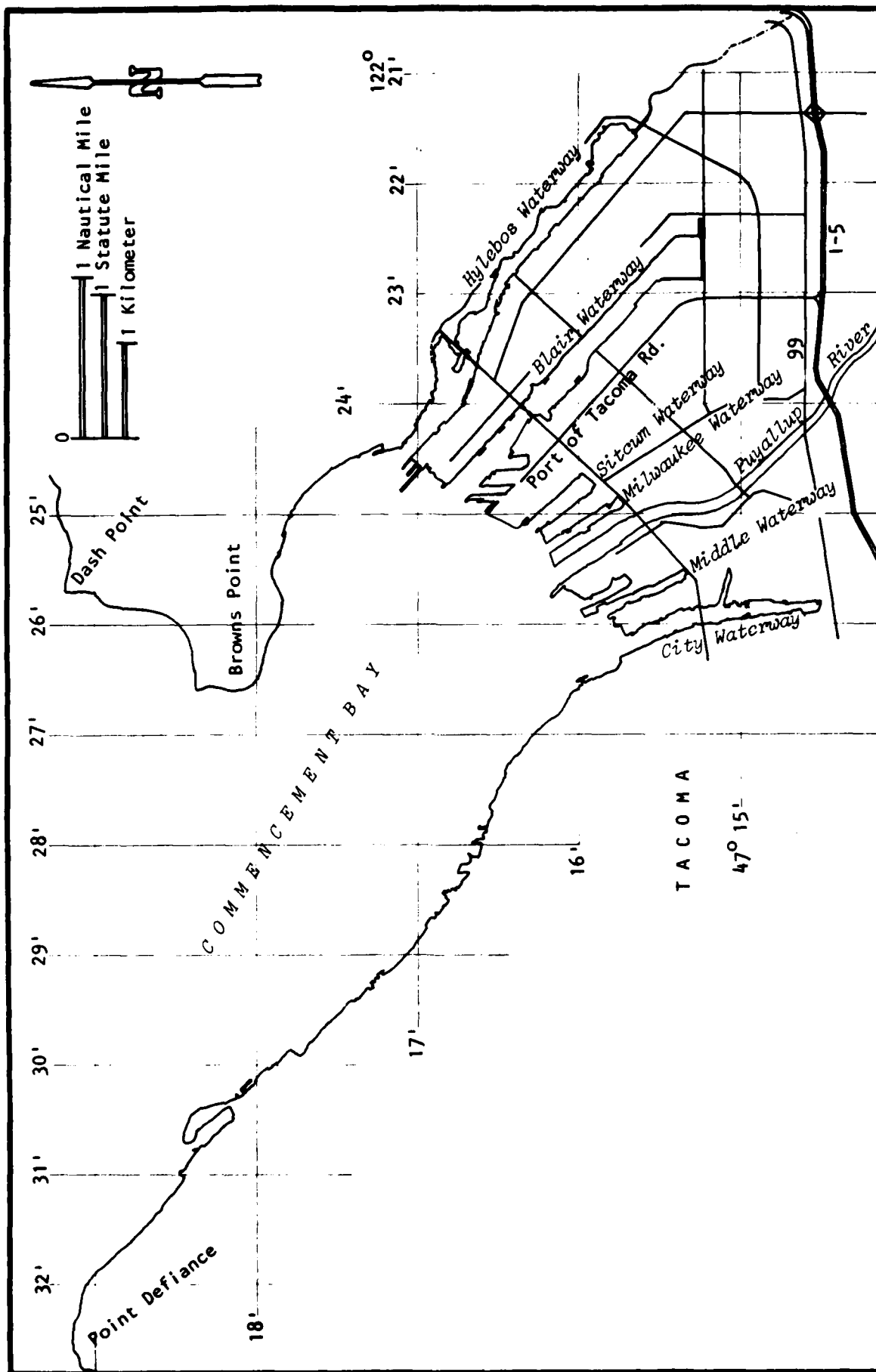


Figure 1
COMMENCEMENT BAY STUDY AREA

2.0 JUVENILE SALMONID STUDY

2.1 INTRODUCTION

The juvenile salmonid portion of the study was designed to describe timing, patterns, and distribution of juvenile anadromous fish passing through the nearshore environment of Commencement Bay. The juvenile salmonids use Commencement Bay as a migration route, a saltwater adaptation area, and as a rearing area prior to their offshore migration. The COBS sampling effort was designed to determine which species were present at what time along the several shoreline habitats in Commencement Bay. COBS studies were also designed to determine the residence time of the juvenile chum salmon which are thought to have the most restrictive shoreline habitat requirements. Juvenile salmon were also collected for analysis of stomach contents under a separate work task.*

The COBS study of juvenile salmonids consisted of a single-year study period including only one spring migration period. As such, the study has the limitations inherent in any study of fish behavior that only encompasses a single season. Budget limitations precluded the study of the spring migration during additional years. An attempt has been made to expand the interpretation of 1980 COBS data where possible by using 1980 data from a similar study conducted by the Puyallup Nation. Although 3 years of data (1979-1981) have been generated by the Puyallup Nation, the limited scope of the Puyallup study in 1979 and the limited analysis of their 1981 data available at the time of COBS report preparation precluded its use in this study.

2.2 METHODOLOGY

2.2.1 STUDY AREA

The juvenile salmonid study area included the shoreline of Commencement Bay and its associated industrial waterways. Fifteen stations were initially established for the sampling of juvenile salmonids. Eight of

*See Results in Invertebrate Studies Technical Report.

these stations were sampled with a beach seine and seven were sampled with a purse seine. An eighth purse seine station was added in Blair Waterway midway through the study. The location of these stations are shown in Figure 2. Detailed descriptions of station locations are provided in Appendix A.

Four of the eight beach seine stations were located in the waterways and four were located in Commencement Bay. Substrate characteristics at these beach seine stations ranged from entirely soft mud to entirely rocky (Table 1). Two beach seine stations were located in Hylebos Waterway. One Hylebos station (B-2), located just southeast of the 11th Street Bridge, could only be sampled during low tide conditions. This beach had a moderate slope and was composed entirely of sandy mud. The second Hylebos beach seine station (B-1), was located on the west side of the lower turning basin on a beach having large boulder riprap on the upper intertidal level with a steep sloped mid and lower intertidal area riprapped with cobble-sized broken rock. Station B-7 was located at mid-channel on the west side of Middle Waterway on a beach having a gently sloping sandy mud shoreline. The fourth waterway beach seine station (B-6) was located in City Waterway at the northwest corner of its confluence with Wheeler-Osgood Waterway. The beach was moderately sloped and predominantly rocky in the mid intertidal level and muddy at the lower intertidal level.

Two of the four beach seine stations in Commencement Bay were located near the mouth of waterways (B-3 and B-8). Station B-3 was located on the west side of the mouth of the Hylebos Waterway. This gently sloping beach was composed of soft sandy mud that was accessible for sampling only during high tides. Station B-8 was located directly between Sitcum and Milwaukee Waterways on the Port of Tacoma's boat launch ramp. This station was a concrete slab from the high tide level to below mean-low water where the bottom was predominantly compact muddy sand with scattered large rocks.

Two beach seine stations were sampled along the exposed or open shoreline of Commencement Bay (B-4 and B-5). Station B-4 was located on

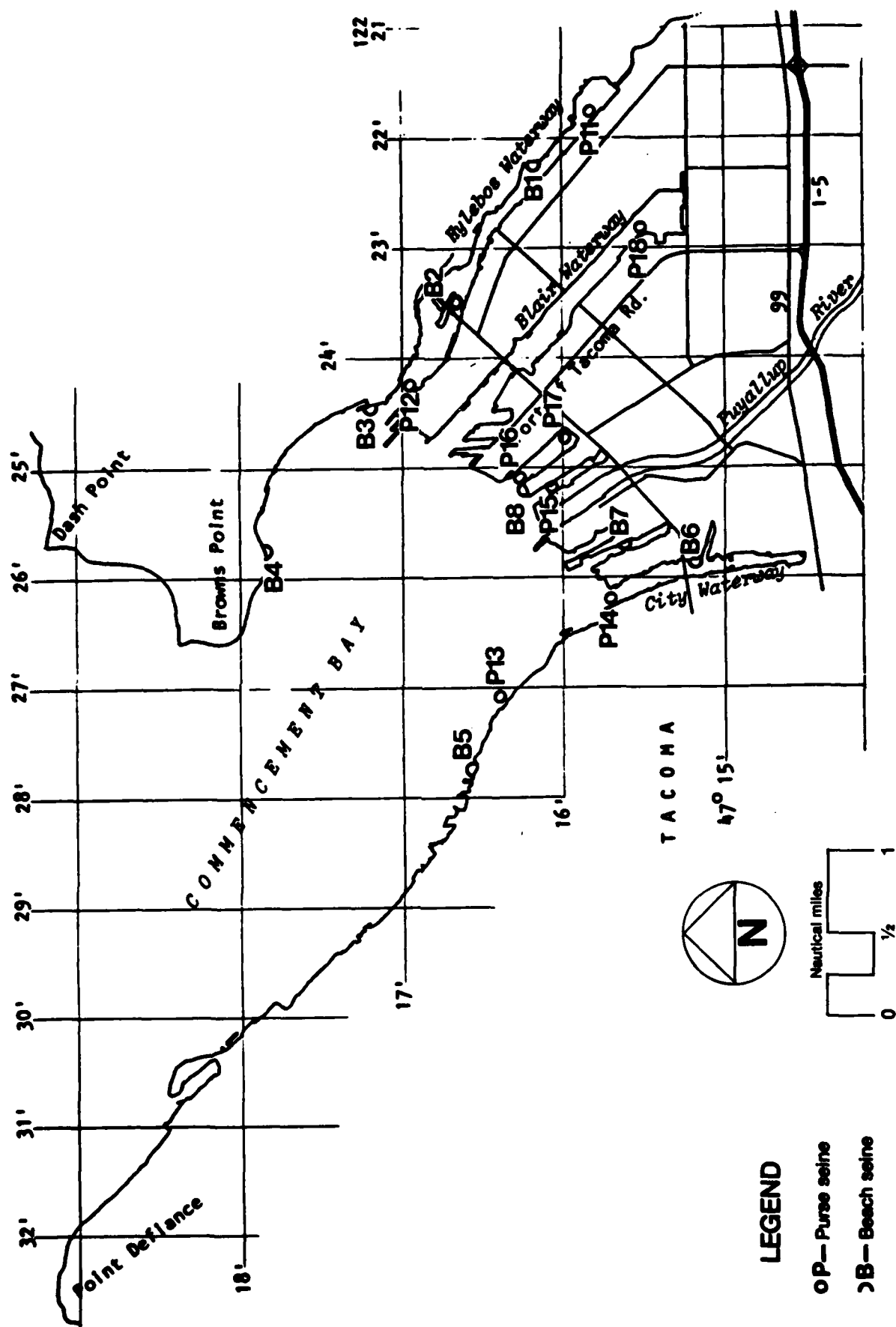


Figure 2 Location of purse seine and beach seine sampling stations in Commencement Bay.

Table 1. Description of beach seine sampling stations.

<u>Station No.</u>	<u>Substrate Description</u> ^(a)
B-1	Steep sloped cobble size broken rock beach with large rock riprap at higher tide level.
B-2	Moderate slope composed of sandy mud.
B-3	Gentle slope, entirely soft muddy sand.
B-4	Moderately sloped, gravel and cobbles with compact sand at lower intertidal level.
B-5	Compact muddy sand with scattered rocks at higher intertidal with numerous cobbles and small boulders at lower intertidal level.
B-6	Predominantly cobble size broken rock and mud with rock riprap at higher tide level.
B-7	Gentle slope, predominantly sandy mud.
B-8	Concrete slab at mid and upper intertidal levels with compact muddy sand and scattered cobbles at lower intertidal level.

(a) Alternate substrate descriptions for the same or adjacent sites are provided in Appendix B.

the northwest side of the bay directly below the Cliff House restaurant. The station was located on a long stretch of moderately sloped rocky beach with scattered logs at extreme high water level. Station B-5 was located in a small cove on the south side of Commencement Bay just south of the public fishing pier. The cove's beach is predominantly firm muddy sand with scattered large rocks above mean water level and with many large rocks below mean water level.

All of the purse seine stations, except P-13, were located in the various waterways adjacent to pier aprons supported by either wood or concrete piles (Table 2). Station P-13 was located on the east side of Commencement Bay along the face of an older wooden pile-supported pier occupied by a boathouse. The closely spaced wood piles provide a relatively dark shoreline habitat as compared to the more widely spaced concrete piles.

Two purse seine stations were established in the Hylebos Waterway (P-11 and P-12). Station P-11 was located along the face of a wooden pier apron in the upper turning basin. Due to moorage of ships at this apron, the set was frequently (about 50 percent of the time) adjacent to a log boom located just north of the pier apron. Station P-12 was also located along the face of the wooden pier apron near the mouth of the waterway.

Two purse seine stations were also established in Sitcum Waterway (P-16 and P-17). Both stations were adjacent to pile supported aprons; however, they appeared to provide considerably different habitats. Station P-17 was located at the head of the waterway along the face of a typical concrete pile-supported apron. Station P-16 was located near the mouth of the waterway, between the rock riprap shoreline and a narrow isolated apron parallel to the shoreline. This latter situation offered complete exposure to sunlight along the shoreline. The site was also quite exposed to wave conditions present in the open waters of Commencement Bay.

Table 2. Description of purse seine sampling stations.

<u>Station No.</u>	<u>Waterway</u>	<u>Pier Type</u>
P-11	Hylebos	Wood pile/log boom
P-12	Hylebos	Wood pile
P-13	Commencement Bay	Wood pile
P-14	City	Wood pile
P-15	Milwaukee	Wood pile
P-16	Sitcum	Concrete pile
P-17	Sitcum	Concrete pile
P-18	Blair	Wood pile/log boom

One purse seine station (P-15) was located near the mouth of Milwaukee Waterway along the face of a wooden pier. A similar station (P-14) was established at the mouth of City Waterway. Station P-18 was located in Blair Waterway at the northwest corner of the last turning basin along a wooden pier. As at Station P-11, this set frequently had to be made along a nearby log boom because of ships moored at the pier.

2.2.2 SAMPLING GEAR AND SCHEDULE

The sampling of juvenile salmonids in Commencement Bay and its associated waterways was conducted using two types of gear; beach seine and purse seine. All purse and beach seine sampling stations were sampled within a period of 8 hours for each date.

Sampling began on March 31, 1980 and continued approximately 1-1/2 times per week through the end of May. For the months of June and July, after the peak migration of juvenile salmonids through the study area, sampling frequency was reduced to once a week. Sampling ended on July 23, 1980. Sampling was conducted on 19 dates during this period.

Beach seine collections were made with a net 30.5 m (100 ft) long by 3 m (9 ft) deep. The net was constructed of 9.5 mm (3/8 in) stretched mesh knotless nylon netting dyed green. Sets were made by placing one end approximately 15 m (50 ft) from shore with a line to a person on the shore. The net was then released from the bow of a boat backing in a shallow arc parallel with the beach. After the net had been set, it was retrieved by pulling each end of the net to the shore and gradually working the net into a small pocket at the center. Fished in this manner, the net covered a surface area of approximately 280 m² (355 yd²) or approximately 20 lineal meters (70 feet) of shoreline. The catch was removed from the small pocket and placed in a plastic bucket. Fish were then anesthetized with tricane methane sulfonate (MS-222). All fish were identified to species and enumerated. Fork length measurements were taken from juvenile salmonids collected. To facilitate sample handling when large numbers of juvenile salmonids were taken, a random subsample of 50 fish of each salmonid species was measured where more than 50 fish

of a salmonid species were caught. Length measurements were not taken from non-salmonids. Following processing, the anesthetized fish were placed in fresh bay water to recover and were returned to the water at the place of their capture with the exception of those retained for stomach content analysis. Fish retained for stomach content analysis were preserved in a 10 percent buffered formalin solution and delivered to Dames & Moore at a later date.

Purse seine collections were made using a research seine 38 m (125 ft) long by 4.5 m (15 ft) deep. The net was constructed of 9.5 mm (3/8 in) stretched mesh knotless nylon netting. Sets were made by attaching one end of the net to a wooden or concrete pile. The remainder of the net was released from the bow of the boat by backing the boat in an open arc adjacent to the pier apron. A set would be completed by joining the last end out to the end originally tied to the piling. The net is then pursed and brought back aboard the vessel. The net set by this method fished a surface area of approximately 230 m² (275 yd²). All fish captured were processed in the same manner as described for the beach seine.

2.2.3 MARK AND RECAPTURE TECHNIQUES

The length of juvenile salmonid residence time in an area, and their migration patterns, were studied through mark and recapture techniques. Marking was accomplished with fluorescent pigments applied to captured fish using a modification of the technique described by Phinney et al. (1967). We applied the granular fluorescent pigment using an air pressure of 60 psi rather than the 80 psi found to be effective by Phinney et al. (1967) or the 70 psi found to be effective by Hennick and Tyler (1970). To compensate for the reduced safe working pressure of our equipment, we reduced the application distance to 10-12 inches from the recommended distance of 16-18 inches (Phinney et al. 1967, Hennick and Tyler 1970). Fish destined for marking were retained in a small dip net (about 15 at a time) at a distance of 10-12 inches from the spray gun nozzle for 3-5 seconds. After recovery from the marking procedure, the fish were released in the immediate vicinity of their capture. This procedure was

found to be adequate for mark retention on juvenile salmonids recovered 2 to 24 days after marking in a similar study (Weitkamp and Schadt 1981). Recovered marked fish showed numerous pigment granules present on each of these fish, indicating the 60 psi working pressure at a distance of 10-12 inches had been adequate to cause the fluorescent granules to penetrate the epidermis of the fish. No detailed study of mark retention under these conditions of application has yet been made. The possibility therefore exists that mark retention would have been significantly less than 100 percent.

Marking began on April 21 and continued on subsequent sampling dates through May 20. An attempt was made to mark all juvenile salmonids sampled in the Hylebos Waterway. No marks were applied to any fish captured at stations outside Hylebos Waterway. Two colors of fluorescent pigment, red and orange, were used during the 4 weeks of marking. Each color was applied for approximately 2 weeks or 3 sampling dates.

Detection of recaptured marked fish was accomplished using a portable long wave ultraviolet light. All target species captured at all stations (both Hylebos and non-Hylebos stations) after April 21, the first day of marking, were passed under the ultraviolet light for detection of marks. All recaptured marked fish were noted and then released in the vicinity of their capture. Marked fish could commonly be detected with close visual inspection prior to use of the ultraviolet light.

The original intent of this task was to mark large numbers of juvenile chum salmon reared by the Puyallup Nation. Technical problems precluded this, necessitating the marking of collected fish.

2.3 RESULTS

2.3.1 GENERAL

COBS sampling of the Commencement Bay shoreline collected significant numbers of three species of juvenile salmon. These species are chinook, pink, and chum salmon, each of which is presented separately in this section. Small numbers of juvenile coho salmon and trout were also

collected; data are briefly presented below. The data presented for the three most abundant species include numbers collected, temporal distribution, areal distribution, comparisons of catch per unit effort (cpue), and frequency of occurrence.

The collections of juvenile salmonids were made with two different gear types (beach seine and purse seine) because of major differences in the habitats sampled. Because of differences in these two gear types it was necessary to convert data obtained from one gear type to a form comparable to data obtained for the other gear type. Beach seine samples were established as a unit of effort and purse seine catches were converted to a comparable effort. This conversion was made on the basis of surface area fished by the two gear types. Beach seine sets sampled a calculated average area of 280 m² while the purse seine sampled a calculated average area of 230 m². This conversion assumes that each gear type equally sampled the majority of the juvenile salmonids present in the water column. The 9-foot deep beach seine reached from the surface to the bottom over most of the area at each shoreline site where it was used. The purse seine reached to a depth of 15 feet in deeper water sites. This should be adequate to collect the majority of the surface-oriented young salmon but offers a greater opportunity for fish to avoid capture. Thus, the purse seine collections may underestimate the number of juvenile salmon present at the sites where it was used relative to the beach seine sites. Beach seines may have different collection efficiencies when used over different substrate types. Our beach seine sites were selected to minimize such differences, particularly those caused by large rocks and other snags.

Both the beach and the purse seine were constructed of 3/8-inch stretch mesh netting. This size mesh will permit some of the smallest (less than 30 mm) salmonids to escape. However, we observed no fish to escape during the Commencement Bay sampling program. We have previously observed some, but by no means all, of the smallest salmon to escape through the mesh in other sampling programs. These very small fish escape only when the net has been pursed into a small bag causing the fish to actively seek a way through the net. We did not observe this problem in Commencement Bay.

2.3.2 JUVENILE SALMONIDS

2.3.2.1 Chinook Salmon

Juvenile chinook were sampled in greater numbers (1,808) than all other species of juvenile salmon combined (918). Catch data for all stations, dates, and species are presented in Appendix C. They were first caught in the study area on April 7 but were not taken in large numbers until May 12. Catch results for both beach seine and purse seine indicate the peak numbers of juvenile chinook occurred in the study area during late May (Figure 3). Juvenile chinook were still present in the study area on July 23, the last day of sampling, but only in very small numbers. After the first week of July, numbers of juvenile chinook sampled dropped off sharply.

Beach seine catches accounted for 70 percent of the total number of juvenile chinook sampled and the majority of these beach seine catches were taken by May 20. From May 28 through late June, the numbers of juvenile chinook collected by purse seine were equal to or greater than the numbers collected by beach seine. Prior to May 28, the chinook collected in COBS beach seine sets fluctuated between 50 and 63 mm in length (Figure 4) (Station B-8 was used in our beach seine length analysis over time because the larger number of fish captured there provided the most reliable results). After May 28, those captured in beach seines averaged 70-75 mm and those captured in purse seines averaged 70-83 mm. Before May 28, purse seine catches were too low to calculate reliable mean lengths.

A much larger number of chinook entered the nearshore habitat in mid-May according to the data shown in Figure 3. It should be noted, however, that the majority of these chinook were taken at a single station, B-8.

Catches at the various beach seine and purse seine stations were compared by calculating catch per unit effort (cpue) and frequency of occurrence for the total catch at each station. The frequency of occurrence is the percentage of times that a given species occurred in a number of sets. For example, if in 10 sets we captured chinook in

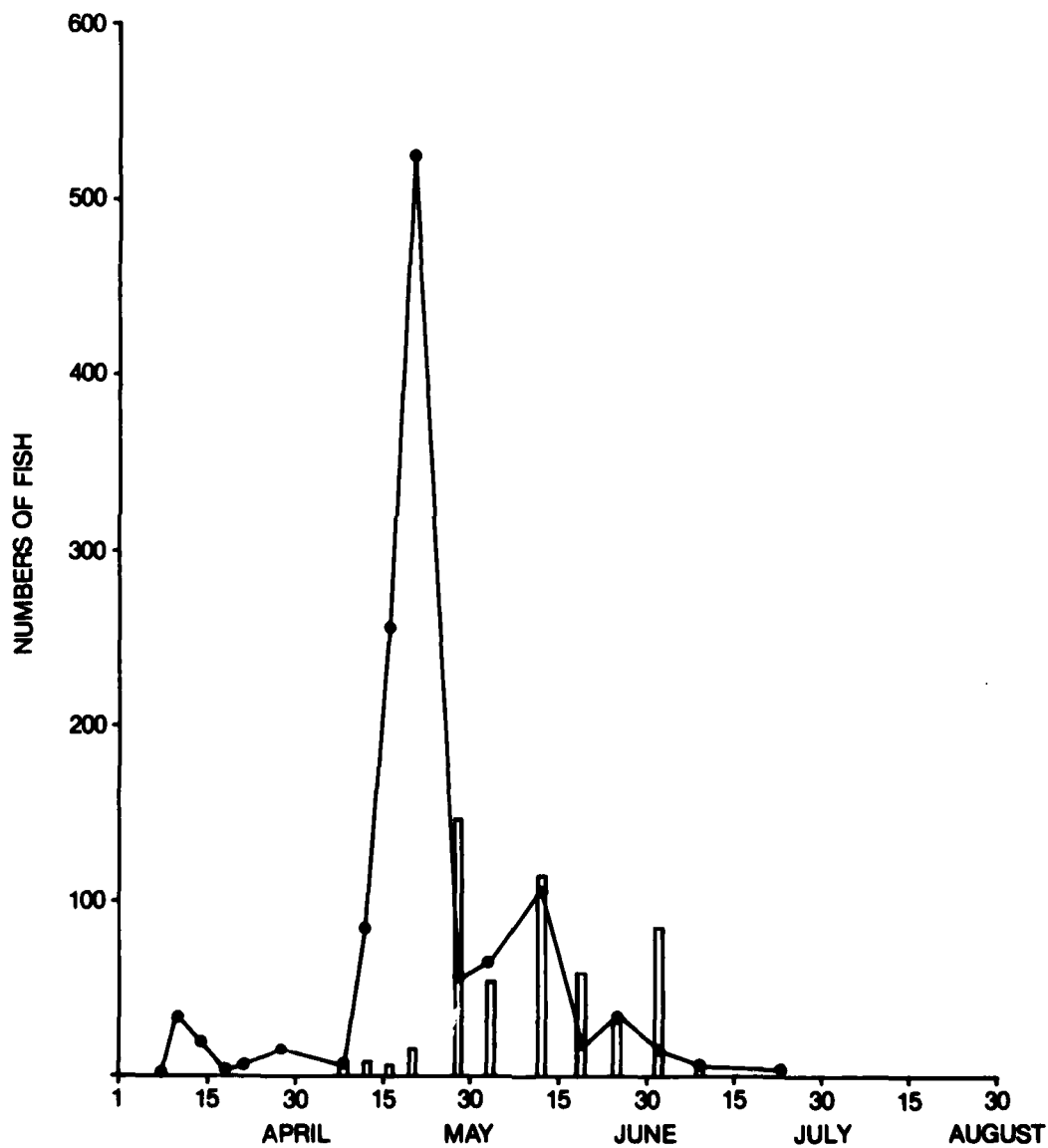


Figure 3 Numbers of juvenile chinook captured at beach seine stations (—•—) and purse seine stations (▮) in the Commencement Bay study area.

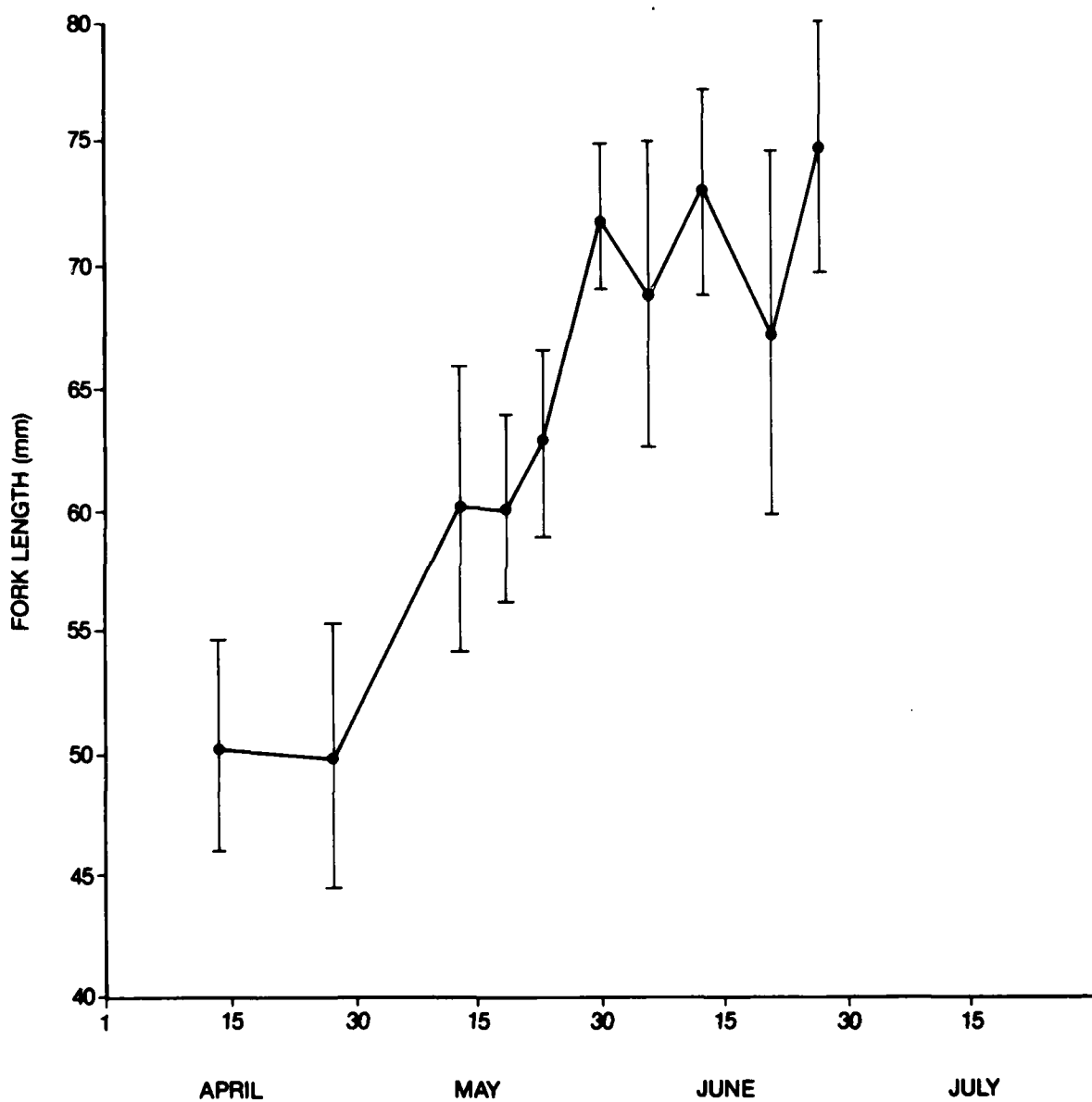


Figure 4 Mean fork lengths and standard deviations of juvenile chinook salmon collected at station B-8, Commencement Bay.

6 of those sets, then the frequency of occurrence of chinook would be 60 percent. This statistic was used in comparing results between our stations in addition to cpue because a single large catch can inflate a cpue and cause a location to appear that fish were consistently present in large numbers when, in fact, they were only caught once or twice in extremely large numbers. The period of time over which these two statistics were calculated was from the first date a salmonid of the target species was captured through the last date it was captured. For chinook this period was April 7 through July 23. As mentioned above, a conversion factor was used in calculating the cpue for purse seines. This conversion factor expanded the purse seine catches by a factor of the surface areas fished by the two gear types. It should be noted that the two gear types fish in a different manner and sample different volumes of water. However, it is important to compare the results at the different habitats these two gear types sample and therefore we chose the conversion factor as the "best possible" means of comparison. The cpues for juvenile chinook taken in beach seines and purse seines are presented in Figure 5. Of the 1,265 chinook sampled by beach seine, 916 (72 percent) were taken at Station B-8 and 716 of these were collected on May 16 and 20 (Appendix C). The cpue for chinook at Station B-8 was 57.3, approximately one order of magnitude greater than at any other station. Purse seine stations P-15 and P-17 in Milwaukee and Sitcum Waterways are in close proximity to B-8 and had the second highest catches (cpue 11.0 and cpue 10.9, respectively). The cpue at other stations in Commencement Bay was generally between 1 and 6. Most of the stations in Blair and Hylebos Waterways were notable in that they had relatively small catches (cpue 1.0-1.8) with the exception of Station B-2 which had a cpue of 5.2. Station B-2 is located on the edge of extensive mud flats immediately south of the 11th Street Bridge over Hylebos Waterway. In Hylebos, which had generally low catches, Station B-2 had a considerably higher catch rate (cpue 5.2) than Station B-3 (cpue 1.2) which was located on a similar habitat at the mouth of Hylebos Waterway.

The catch rate at B-4 along the northeast side of Commencement Bay was moderate with a cpue of 7.3. Most of the chinook collected at B-4 were taken between May 20 and June 12, during the peak of the migration.

Stations west of the Puyallup River generally had moderate catch rates (cpue 2.8 to 6.2) with the exception of Station B-5 (cpue 0.8). In this area, the purse seine stations had higher catch rates (6.0-6.2) than the beach seines although the beach seine station in Middle Waterway (B-7) had a comparable cpue (5.1).

The frequency of occurrence of juvenile chinook taken in sets at each Commencement Bay station are presented in Table 3. Chinook salmon was the only salmonid species caught at each of the stations. In general, beach seine stations tended to have a higher frequency of occurrence than did purse seine stations. The frequency of occurrence for beach seine stations was the highest at Stations B-2, B-1, B-8, and B-7 (64-80 percent) and was lowest at B-3 and B-5 (35-38 percent). For the purse seine stations, the highest frequency of occurrence was calculated for Stations B-17, P-15, and P-18 (50-61 percent). Purse seine stations P-12, P-16, and P-13 (19-22 percent) had the lowest frequency of occurrence for chinook.

The frequency of occurrence of juvenile chinook was also calculated for weekly intervals for all beach seine stations and for all purse seine stations. These calculations indicate that the beach seine stations had a greater frequency of occurrence of chinook (30-80 percent) than the purse seine stations during the period of April through mid-May. From mid-May through June the frequency of occurrence was approximately the same for the beach seine stations and for the purse seine stations. The frequency of occurrence of chinook was relatively high (60-100 percent) at all stations during this period. In July, the beach and purse seine stations remained nearly equal but showed a steadily decreasing frequency of occurrence from about 50 to 20 percent.

2.3.2.2 Pink Salmon

A total of 723 pink salmon were collected during the study (Appendix C). Juvenile pink salmon were present along the Commencement Bay shoreline when COBS sampling began on March 31, 1980 as indicated by the single individual taken at Station B-3 in Hylebos Waterway. A few pinks (9) were collected at several beach seine stations (B-2 through B-6) the

Table 3 Frequency of occurrence, percentage, and number of sets, n, for juvenile salmon in sets made at all beach seine and purse seine stations.

<u>Station</u>	<u>Chinook</u>		<u>Pink</u>		<u>Chum</u>	
	<u>%</u>	<u>n</u>	<u>%</u>	<u>n</u>	<u>%</u>	<u>n</u>
B-1	72	(18)	17	(18)	18	(17)
B-2	80	(15)	31	(16)	36	(14)
B-3	38	(13)	29	(14)	0	(13)
B-4	47	(15)	27	(15)	14	(14)
B-5	35	(17)	29	(17)	6	(16)
B-6	56	(16)	31	(16)	13	(15)
B-7	64	(11)	9	(11)	0	(10)
B-8	69	(16)	20	(15)	20	(15)
P-11	28	(18)	6	(18)	0	(17)
P-12	22	(18)	6	(17)	6	(17)
P-13	19	(16)	13	(15)	7	(15)
P-14	44	(18)	22	(18)	24	(17)
P-15	56	(18)	6	(18)	18	(17)
P-16	21	(14)	7	(14)	0	(13)
P-17	61	(18)	6	(18)	12	(17)
P-18	50	(8)	0	(7)	0	(7)

following week, April 7. The peak of the juvenile pink presence along the Commencement Bay shoreline occurred in mid or late April, according to beach and purse seine collections. By the end of April the pinks were again collected only in small numbers and few were taken in May and June. The distribution of the juvenile pink salmon was not uniform in either time or location. Over 90 percent of the pink salmon sampled were taken by beach seine. With the exception of four sets, the number caught per set was relatively small. Over 82 percent of the total number of juvenile pinks were caught in four sets during April. The mean fork lengths of these fish ranged from 35 to 41 mm. The first large catch of pinks occurred at Station B-5 on the south side of Commencement Bay on April 10. Two of these sets occurred in Hylebos at Station B-2 on April 18 and 21. On April 18, a large catch of 316 pinks was also taken at Station B-4 along the north side of Commencement Bay. These four catches are responsible for the relatively high cpue at Stations B-2, B-4, and B-5 (Figure 6).

The catch rates at the remainder of the stations were quite low. The cpue at most purse and beach seine stations was less than 1.0. The juvenile pink salmon were not present in significant numbers in any of the waterways with the exception of the mud flats at B-2 on Hylebos.

The frequency of occurrence of juvenile pink salmon in beach seine sets was much higher than in purse seine sets (Table 3). Frequency of occurrence ranged between 8 and 31 percent in beach seine sets and was typically about 25-30 percent. At purse seine stations the range was 0-22 percent and juvenile pinks were typically caught in 6-8 percent of the sets that were made.

2.3.2.3 Chum Salmon

Only 136 chum were collected by beach and purse seine during our 1980 study (Appendix C). The majority (80 percent) of chum salmon were taken by beach seine. Most of these chum were collected at two sites (B-2 and B-4) where the the cpue was greater than 1 (Figure 7). The mud flats south of the 11th Street Bridge on Hylebos Waterway (Station B-2) was the only location within a waterway where significant numbers of chum salmon were collected. All of the cpues for purse seine stations were less than 0.3 with the exception of P-14 which had a cpue of 1.3.

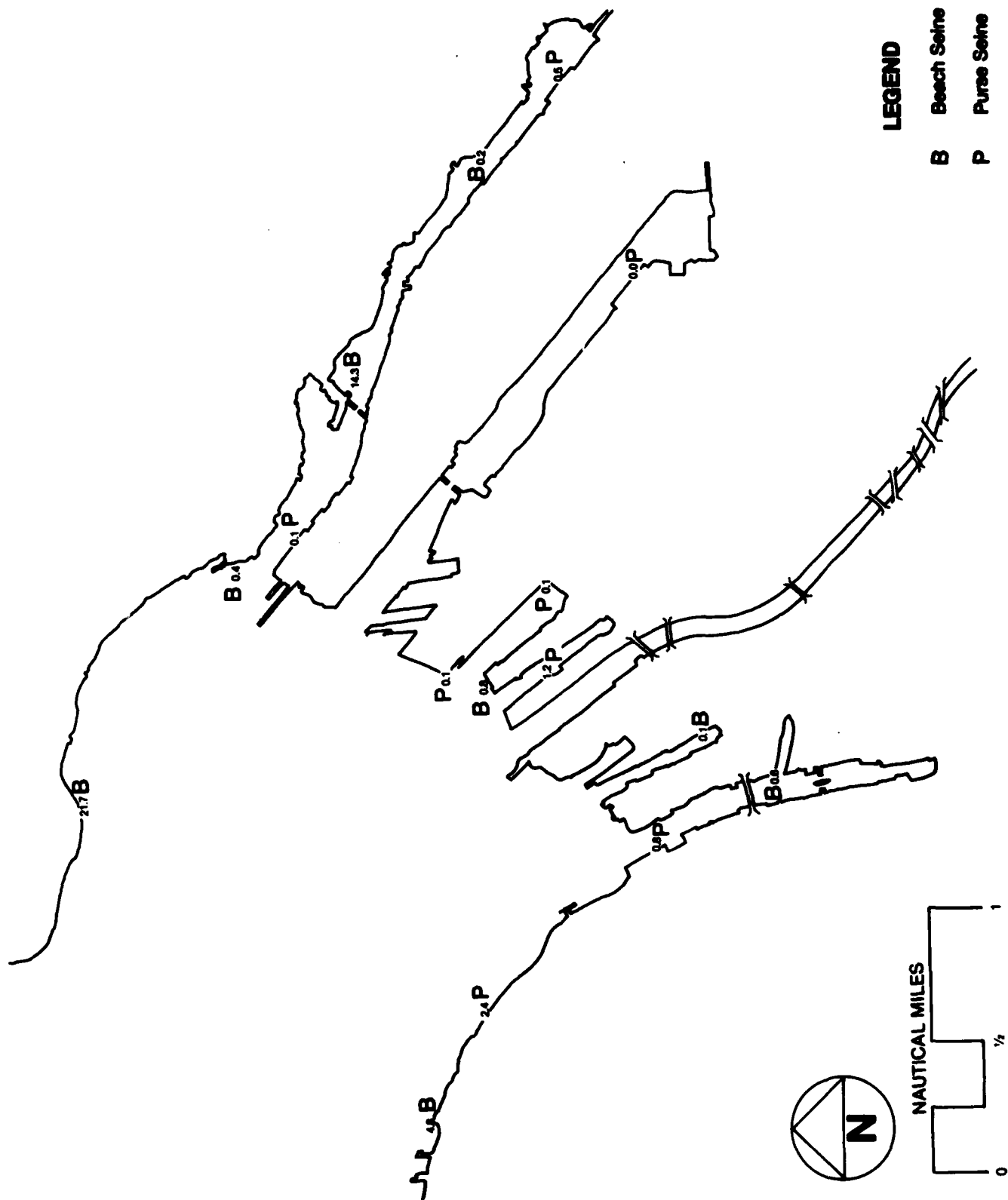


Figure 6 Juvenile pink salmon catch per unit effort, Commencement Bay, 1980.

There was no significant peak in the small numbers of juvenile chum salmon collected in Commencement Bay during 1980. Chum were present by early April (Appendix C) and were taken in beach seines through May. In April and May when most of the chum were collected by beach seine, nearly all were less than 50 mm. In June and July, the few chum collected were taken primarily by purse seine. The few fish taken in June and July were all 54 mm in fork length or greater.

The frequencies of occurrence of juvenile chum in sets by both gear types were low. Beach seine sets tended to have a slightly higher frequency of occurrence than purse seine sets (Table 3) although this difference is small.

2.3.2.4 Coho Salmon

Only 68 juvenile coho were caught during the entire COBS study (Appendix C). The majority (84 percent) were caught during the month of May. During this month, mean length of coho ranged from 110-122 mm. By the end of May, juvenile coho were essentially absent from the study area. These catches of coho occurred at various locations throughout the study area but too few fish were collected to provide any useful information.

2.3.2.5 Trout

Anadromous trout species were collected in extremely low numbers during the study. Twenty cutthroat trout and five steelhead were sampled. All of the trout were taken in beach seine sets with the exception of one steelhead. The majority of the trout were collected at Station B-4, on the north side of Commencement Bay, and at Station B-8 located on the Port of Tacoma's boat ramp facility. Only three trout were collected at stations southwest of the Puyallup River mouth.

2.3.3 NON-SALMONID SPECIES

Various species of fish, other than the target salmonid species, were frequently captured in beach seine and purse seine sampling (Table 4). Those fish sampled most frequently at beach seine stations were sculpins, shiner perch, starry flounders, English sole, and snake pricklebacks.

Table 4 Non-Salmonid Fish Sampled at Beach Seine and Purse Seine Stations in the Commencement Bay Study Area

Common Name	Scientific Name
Pacific herring	<u>Clupea harengus pallasii</u>
surf smelt	<u>Hypomesus pretiosus</u>
three spine stickleback	<u>Gasterosteus aculeatus</u>
bay pipefish	<u>Syngnathus leptorhynchus</u>
shiner perch	<u>Cymatogaster aggregata</u>
striped seaperch	<u>Embiotoca lateralis</u>
pile perch	<u>Rhacochilus vacca</u>
snake prickleback	<u>Lumpenus sagitta</u>
crescent gunnel	<u>Pholis laeta</u>
red gunnel	<u>Pholis schultzi</u>
Pacific sand lance	<u>Ammodytes hexapterus</u>
Pacific staghorn sculpin	<u>Leptocottus armatus</u>
flathead sole	<u>Hippoglossoides elassodon</u>
English sole	<u>Parophrys vetulus</u>
starry flounder	<u>Platichthys stellatus</u>

The purse seine stations frequently sampled herring and occasionally smelt and sandlance in addition to the target species. The numbers of non-salmonids collected commonly exceeded the number of salmonids (Appendix C). These non-salmonids were usually too small to be predators on the salmonids collected.

2.3.4 MARK AND RECAPTURE STUDY

Residence time and migration patterns were studied using mark and recapture techniques since it was not possible to mark hatchery released chum as originally planned. Marking was conducted at Hylebos Waterway beach seine and purse seine stations during a 4-week period between April and May. Two different mark groups were established over this 4-week period, a red mark group between April 21 and May 8 and an orange mark group between May 8 and May 20.

The total number of fish receiving marks was too low (178) to provide an adequate marked population (Table 5). Juvenile pink salmon received 80 percent of the total marks placed on all salmonid species. Only 4 chum, 8 coho, and 24 chinook salmon received marks. Fish were examined for marks at all stations in the study on sampling dates subsequent to April 21, the first day of marking. No recoveries were made of any marked fish by Parametrix; however, the Puyallup Nation recovered two marked coho at a station in City Waterway near the mouth of Wheeler Osgood Waterway.

2.4 DISCUSSION

Our sampling of juvenile salmon in Commencement Bay was designed to document use of the shoreline habitats during a single season. The discussion of the data from the COBS study and the conclusions drawn also rely on available data collected by the Puyallup Nation in 1979, 1980, and 1981. The Puyallup study included beach seine sampling of a large number of sites on an intermittent schedule. The Puyallup sampling covered a longer period of the year than the COBS study. The beach seine used by the Puyallup Nation was of the same length (100 feet), but was 3 feet shallower (6 feet deep) and was constructed of a smaller mesh size (1/8-inch stretch mesh) than the net used in the COBS study (3/8-inch stretch mesh).

Table 5. Number of juvenile salmonids marked in the Hylebos Waterway.

<u>Date, Color</u>	<u>Chinook</u>	<u>Pink</u>	<u>Chum</u>	<u>Coho</u>
4/21-5/8 Red	6 Beach 0 Purse	139 Beach 0 Purse	1 Beach 0 Purse	0 Beach 0 Purse
	6 Total	139 Total	1 Total	0 Total
5/12-5/20 Orange	16 Beach 2 Purse	3 Beach 0 Purse	3 Beach 0 Purse	8 Beach 0 Purse
	18 Total	3 Total	3 Total	8 Total

The possibility exists that the 3/8-inch net used did not quantitatively sample the smallest juvenile chum and pink salmon when they first enter the estuary. A comparison of minimum size fish captured by the two different mesh sizes was made. The results indicate that the net constructed of 3/8-inch mesh was generally able to capture fish of the same size as the smallest fish captured by the net constructed of 1/8-inch mesh. The comparison did not provide an indication of whether the net with the larger mesh size was able to capture the smaller fish as efficiently as the net with the smaller mesh size. Concern was also expressed regarding the use of spreader bars at the ends of the Puyallup beach seine and the absence of them from our beach seine. The crews employed in the COBS studies were trained to keep the lead line of the 9-foot deep beach seine on the bottom as the net is retrieved, negating the need for a spreader bar. Spreader bars on the ends of the 6-foot deep nets may be more useful.

In addition to differences in gear types, there was also a difference in sampling schedules. The COBS schedule consisted of approximately weekly (depending on time of run) sampling at the same 16 stations from March 31 through July 23. The Puyallup study included more than 50 sampling stations and was conducted from February 28 to September 15. Due to the large number of stations sampled under the Puyallup study, each individual site was not sampled as regularly as under the COBS effort. When comparisons of results at similar sites are being made, factors such as gear type, sampling schedule, tidal cycle, and sampling technique must be taken into consideration.

The species of juvenile salmonids collected and the timing of their occurrence in Commencement Bay was as expected based on existing information of the study area and the basic biology of the salmonids. Juvenile chinook, pink, chum, and coho salmon all occur in the study area during the spring and early summer.

Juvenile chinook salmon were sampled in larger numbers than all other species of juvenile salmon in the Commencement Bay study area during the spring of 1980. A total of 1,807 juvenile chinook were

sampled between early April and late July. These fish were not uniformly distributed throughout the time of the study. The majority of the chinook were taken during late May at the beach seine station immediately east of the Puyallup River. This station is located at the head of the peninsula between Milwaukee and Sitcum Waterways on the Port of Tacoma's boat ramp facility and is a short distance (about 400 m) northeast of the mouth of the Puyallup River. It appears that the majority of these chinook represent the outmigration from the Puyallup River rather than a rearing population of juvenile fish. This conclusion is compatible with the generally greater abundance of chinook throughout the nearshore environment of Commencement Bay from the end of May through June.

Following the chinook peak on about May 20, the juvenile chinook became well dispersed through most of the Commencement Bay study area for a period of approximately 1 month. The temporal distribution of the juvenile chinook shown by our sampling does not agree with the timing shown by the simultaneous sampling conducted by the Puyallup Nation (Miyamoto et al. 1980). The Puyallup Nation's beach seine sampling collected few chinook salmon prior to the end of May. Their catches showed a major peak at the end of May with moderate catches of chinook in June and early July. Based on catch per unit effort (cpue), the Puyallup Nation's catches in late May, June, and early July were comparable to ours. This assumes that the 100 beach seines fished by both groups sampled about the same surface area. It appears that the sampling by the Puyallup Nation did not detect the early portion of the peak of the chinook run entering Commencement Bay that was detected by our sampling at the stations immediately east of the Puyallup River between May 16 and 20.

COBS sampling indicates that the habitat used by the juvenile chinook varied during the duration of their presence in Commencement Bay. The few chinook in the bay during April and early May were only found along the beach habitat and not along the face of piers. This was also true of the majority of the chinook when they first entered the bay in late May. However, by the end of May the chinook were also sampled along the piers in numbers equal to those along the beaches. This movement into more open and deeper water is indicated by the frequency of occurrence of chinook in our beach seine and purse seine sets as well as cpue when

these two statistics are analyzed over time. Also, the chinook collected in COBS purse seine sets were slightly larger than those in the beach seine sets. This phenomenon of movement to deeper waters as chinook grow larger has been documented in other estuary studies (Meyer et al. 1981).

The juvenile chinook used all the specific locations sampled in Commencement Bay as evidenced by moderate to high levels of frequency of occurrence at all COBS stations. This ubiquitous trend was not seen in any other species of juvenile salmon. Although juvenile chinook were captured at all stations, some shoreline areas appeared to be more favorable than others. The beach and waterways (Milwaukee and Sitcum) immediately east of the Puyallup River were the locations with the highest densities of juvenile chinook in COBS sampling. Beach seine sampling by Salo and McComas (1980) conducted during April in Milwaukee Waterway collected 114 juvenile chinook in 21 sets. The majority of these fish (104) were collected in 7 sets made in mid-April. Other areas of relatively high importance in the COBS sampling included the mud flats near the 11th Street Bridge and Hylebos Waterway, Middle Waterway, Browns Point, City Waterway, and the pier along Old Tacoma. Surprisingly, the beach at Old Tacoma appeared relatively unimportant to the juvenile chinook. The Puyallup Nation's sampling indicated highest cpues in sets made in Middle Waterway, City Waterway, and at a station located at the head of the peninsula located between City and Middle Waterway. Also, they had relatively large cpues for the stations they sampled along Ruston Way. The areas where the Puyallup Nation had their highest cpues, with the exception of Ruston Way, correspond well with the areas where moderately high cpues occurred in the COBS studies. In the areas where COBS indicated the highest cpues (Milwaukee and Sitcum Waterways), the Puyallup Nation either did not have a station or sampled too infrequently to provide reliable results.

The lowest chinook cpue for the COBS beach seine stations occurred along Ruston Way (B-5), near the head of Hylebos Waterway (B-1), and at the mouth of Hylebos Waterway (B-3). The Puyallup Nation's lowest cpues occurred at several of their Hylebos Waterway stations where they had cpues of 0-0.5 at two stations and 3.7-4.9 at three stations. The cpues

of 3.7-4.9 were higher than most of the cpues for pink and chum salmon at all stations.

In Hylebos Waterway, the chinook appeared to prefer the mud flats near the 11th Street Bridge. They were also present along the piers and the steep rocky beach of B-1, but in lower numbers. The numbers collected on the mud flats at the mouth of the Hylebos were also relatively low as compared to the 11th Street Bridge area. It appears that the chinook are able to use the wide variety of shoreline habitats that are present in Commencement Bay but use certain locations more heavily than others. These areas of greater use could not be easily predicted on the basis of the apparent habitat provided. Dissimilar areas of high use such as the Hylebos mud flats (B-2), Browns Point (B-4), Port of Tacoma ramp (B-8), Sitcum Waterway (P-17), and the Old Tacoma Marina pier (P-13) provide individual habitats that are similar to areas that are not heavily used (B-3, B-6, P-11, P-12). The distribution of the juvenile chinook within Commencement Bay is apparently related to less obvious and more complex factors than simply the physical configuration of the shoreline.

Specifically, the large catches at the Port of Tacoma ramp (B-8), Milwaukee Waterway (P-15), and Sitcum Waterway (P-17) appear to be related to the close proximity to the Puyallup River mouth. However, close proximity to the Puyallup River mouth is not adequate to ensure heavy use as indicated by low catches at P-16 near the mouth of Sitcum Waterway. Mud flat habitat also does not appear to be sufficient to assure high use. In Hylebos Waterway, the 11th Street Bridge mud flats were heavily used while the mud flats at the mouth of the waterway apparently received much lighter use. There are no obvious explanations for these discrepancies. On the contrary, the Puyallup Nation data indicated that the two areas received comparable use by juvenile chinook salmon.

The sources of the juvenile chinook sampled during the COBS study were both hatchery and natural production. All juveniles collected appeared in good condition, and we could not readily differentiate hatchery from wild fish. The Washington Department of Fisheries (WDF)

operates a salmon hatchery on Voight Creek, a tributary to the Puyallup River basin. During the spring of 1980 they made several large plants of juvenile chinook salmon into the Puyallup basin (Table 6) and other basins that drain into Commencement Bay (Table 7). The major chinook releases occurred three times during the spring; April 8, May 7-8, and May 23. These releases provide no definable contribution to our catches and probably contributed to the peak numbers collected in late May. On May 23, over 1,200,000 chinook were released. The subsequent samplings on May 28 and June 5 did not indicate peak catches as might be expected for this large release. The largest chinook catches occurred on May 16 and 20, prior to the large May 23 release. These catches may well be due to the outmigration of the large number of chinook released on April 8 and May 7-8.

The Puyallup Nation operates a hatchery on Diru Creek, a tributary to the Puyallup River basin, and also released juvenile salmon into the Puyallup basin and other drainages to Commencement Bay. The Puyallup Nation's releases were considerably smaller than those made by WDF and would not be distinguishable in our catches (Tables 6 and 7).

Juvenile salmon of species other than chinook were collected in much lower numbers. Because of hatchery release of chum and coho salmon in the Commencement Bay tributaries, greater catches of these species were anticipated. Greater numbers of juvenile pink salmon were also anticipated because of the odd year run of adults that spawned the previous autumn. Catches of these species were much greater in a comparable simultaneous study conducted in Elliott Bay and the Duwamish River using the same sampling gear (Weitkamp and Schadt 1981).

Juvenile pink salmon were the second most abundant species of salmon sampled during the study but were not particularly numerous. A total of 723 pinks were sampled. Although pink salmon were collected from the beginning of the study (March 31) through the end of the sampling period (July 23), the majority of the juvenile pink were taken in April. Between April 10 and 21, over 95 percent of the pinks were collected. This is an indication that the migration of juvenile pink salmon through Commencement Bay occurs over a period of only several weeks in late April and that no extended rearing occurs in the nearshore waters.

Table 6. Hatchery produced juvenile salmon planted by WDF and Puyallup Nation in the Puyallup River Basin during the spring of 1980 (Seidel, 1981; and Coleman and Rasch, 1981).

<u>Date Released</u>	<u>Number Released</u>	<u>Weight (No. lb)</u>	<u>Estimated¹ Fork Length</u>	<u>Brood Year</u>	<u>Location of Plant</u>
WDF					
<u>Chinook</u> Jan 3	48,500	950	35.1	1979	Voight Ck.
Feb 7	10,000	1,000	34.5	1979	Voight Ck.
Mar 26	251,000	965	34.9	1979	Voight Ck.
Apr 8	312,144	336	50.0	1979	Voight Ck.
Apr 8	343,865	485	43.9	1979	Voight Ck.
Apr 8	332,860	445	45.2	1979	Voight Ck.
Apr 8	332,500	475	44.2	1979	Voight Ck.
May 7	203,850	225	56.7	1979	Voight Ck.
May 7	159,750	213	57.7	1979	Voight Ck.
May 8	115,500	231	56.2	1979	Voight Ck.
May 23	64,238	150	64.9	1979	Voight Ck.
May 23	1,176,954	139	66.5	1979	Voight Ck.
<u>Coho</u> Mar 27	150,700	1,300	31.6	1979	Clearwater, Rv.
Mar 27	150,400	1,300	31.6	1979	Greenwater Rv.
Apr 21	105,350	1,075	33.7	1979	Kapowsin Ck
Apr 21	31,500	21	125.0	1978	Kapowsin Ck.
Apr 21	217,140	1034	34.1	1979	S. Prairie Ck.
Apr 22	36,750	21	125.0	1978	Boise Ck.
Apr 23	124,375	995	34.5	1979	Unnamed
Apr 23	72,890	985	34.6	1979	Boise Ck.
Apr 23	19,935	21	125.0	1978	Voight Ck.
Apr 25	31,520	985	34.6	1979	Strawberry Ck.
Apr 30	542,795	20	127.0	1978	Voight Ck.
May 10	337,921	17	135.7	1978	Voight Ck.
May 22	51,040	440	45.3	1979	Fennel Ck.
May 23	46,640	440	45.3	1979	Niesson Ck.
<u>Pink</u> Mar 30	302,000	1565	N/A ²	1979	Voight Ck.
PUYALLUP NATION					
<u>Chinook</u> Apr 7	22,279	467	44.4	1979	Swan Ck.
Apr 7	20,884	454	44.9	1979	Fennel Ck.
Apr 7	28,193	454	44.9	1979	Canyon Fall Ck.
Apr 8	10,589	467	44.4	1979	Unnamed
Apr 8	37,273	454	44.9	1979	South Prairie Ck.
Apr 8	19,431	454	44.9	1979	Kapowsin
Apr 15	4,333	467	44.4	1979	Unnamed
<u>Coho</u> Jul 4	12,390	269	53.4	1979	Clarks Ck.
<u>Chum</u> Apr 7	23,135	485	N/A	1979	Swan Ck.
Apr 8	9,700	485	N/A	1979	Unnamed
Apr 9	3,364	485	N/A	1979	Unnamed
Apr 15	4,845	485	N/A	1979	Unnamed

¹ Fork length estimates based on Bowen, 1970. A condition factor of 4×10^{-4} was chosen based on communications with Kevin Amos of WDF (1981).

² Not Available

Table 7. Hatchery produced salmonids planted by WDF and Puyallup Nation in tributaries to Commencement Bay other than the Puyallup River Basin during the spring of 1980 (Seidel, 1981; and Coleman and Rasch, 1981).

<u>Date Released</u>	<u>Number Released</u>	<u>Weight (No. lb)</u>	<u>Estimated Fork Length</u> WDF	<u>Brood Year</u>	<u>Location of Plant</u>
<u>Chinook</u>					
Feb 7	35,000	1,000	34.5	1979	Hylebos Cr.
<u>Coho</u>					
Mar 10	22,437	1,300	31.6	1979	Hylebos Ck.
Mar 11	61,100	1,300	31.6	1979	Wapato Ck.
Mar 12	22,437	1,300	31.6	1979	Hylebos Ck.
May 31	24,552	23	121.2	1978	Commencement Bay
Puyallup Nation					
<u>Chinook</u>					
Apr 5	22,652	467		1979	Hylebos Ck.
Apr 7	4,148	467		1979	Hylebos Ck.
Apr 7	10,964	467		1979	Wapato Ck.
Apr 8	19,947	467		1979	Hylebos Ck.
<u>Chum</u>					
Apr 5	23,523	485	N/A	1979	Hylebos Ck.
Apr 7	12,064	485	N/A	1979	Hylebos Ck.
Apr 7	11,386	485	N/A	1979	Wapato Ck.
Apr 8	20,713	485	N/A	1979	Hylebos Ck.

The simultaneous study by the Puyallup Nation showed similar results (Miyamoto et al. 1980). Their catches of pink salmon showed a distinct peak in late April with a few pinks remaining in the area during early May. Their catches also showed pinks present in Commencement Bay during late March. Beach seine sampling by Salo and McComas (1980) in Milwaukee Waterway also collected only 4 pink salmon in 5 to 6 sets on each of 3 days in April.

Our sampling indicated that the pink salmon show a strong preference for the mudflat and beach shorelines and were seldom present along the pier aprons. The 11th Street Bridge mud flats in Hylebos Waterway (B-2), Browns Point (B-4) and the Old Tacoma sandy beach (B-5) were the three sites where the greatest cpue for pinks occurred. However, it would not be appropriate to place great emphasis on these three sites based only on our data. The relatively large numbers of pinks taken at these three sites were collected in a total of only four beach seine sets. This small number of data points may only reflect a chance encounter with four individual schools of juvenile pinks at these sites. The cpue for juvenile pinks tended to be smallest at all purse seine sites, and were also low at beach seine stations in City Waterway (B-6), Middle Waterway (B-7), and at the head of Hylebos Waterway (B-1). The combined cpue for beach seine catches was 5.40 compared to a combined cpue for purse seine catches of 0.67, or a ratio of 8.06:1. This is an indication that the pink salmon are very shoreline-oriented.

The concurrent Puyallup Nation study results indicate a high cpue for pinks in City Waterway, an area where COBS studies indicated a relatively low cpue. Another area where the Puyallups had relatively high cpues was the mud flats near the 11th Street Bridge in Hylebos Waterway, where COBS also indicated a high cpue. Areas with low cpues in the Puyallup sampling include Milwaukee Waterway and a portion of Hylebos Waterway located about midway between the 11th Street Bridge and the mouth of the waterway. COBS sampled no beach seine stations in either of the areas where the Puyallups had relatively low cpues.

There was little variation in frequency of occurrence of pinks in beach seine sets at most of the COBS stations. There was no obvious area

with a high frequency of occurrence. Five of our eight beach seine stations had values that ranged from 27-31 percent. Stations at the head of Hylebos (B-1) and between Milwaukee and Sitcum (B-8) were moderate (17-20 percent) and the station in Middle Waterway was the lowest (9 percent). The frequency of occurrence of pink salmon at our purse seine stations were all low with only two sites (P-13 and P-14) being above 10 percent.

Puyallup Nation beach seine sites had frequency of occurrence that were similar to COBS in that their highest values ranged from 17-31 percent. These values occurred at Ruston Way Park, along the northeast shore of Commencement Bay, and in Hylebos Waterway midway between the mouth and the 11th Street Bridge. COBS sampling had similar frequencies of occurrence at the Ruston Way Park site and along the northeast shore of Commencement Bay.

The pinks collected during April and May had mean fork lengths of 35 to 41 mm. This is slightly larger than the size at which pink salmon commonly enter salt water. Gerke and Kaczynski (1972) reported that juvenile pink salmon enter the estuaries of Puget Sound in April and early May at a length of about 30 mm. It appears that the Commencement Bay pinks enter salt water at a slightly greater size since neither COBS samples nor those of the Puyallup Nation indicate any significant saltwater rearing occurred prior to mid-April.

The number of chum salmon collected in the COBS sampling (136) is not adequate to provide much useful information. These low numbers are in part due to the low adult brood year run size in 1979. The adult return in 1979 was the lowest in the past 12 years. The 1979 return was only 33 percent of the past 12-year average (Ames 1980). The chum were collected throughout the study period with the largest numbers taken between mid-April and mid-May. Catches of juvenile chum by the Puyallup Nation were similarly very low with a small peak in mid-May. Salo and McComas (1980) collected no chum salmon in their sampling of Milwaukee Waterway and the Port of Tacoma ramp during April. Based on these results it appears that few chum salmon entered the Commencement Bay study area during the spring of 1980. The few chum that were present

tended to use the shoreline mud flats and beaches during April and May. All of our beach seine catches of chum occurred from April 7 through June 5. This agrees very well with the Puyallup results in which 90 percent of all their chums were taken between April 16 and June 10. After early June, there was a shift from chum presence along shorelines to the deeper waters along the pier aprons. After June 5, chum were only caught in our purse seine sampling, and after June 18 no chum were taken by the Puyallups, who only sampled with beach seines. The beach seine to purse seine shift was also seen in similar type studies conducted in the Duwamish estuary (Meyers et al. 1980, Weitkamp and Schadt 1981). Data are not sufficient to determine if these chum represent one or several separate populations.

The combined cpue for beach seine catches of chum was 0.96 compared to a combined cpue for purse seine catches of chum (0.28). This ratio of 3.43:1 indicates that the chum are more shoreline oriented than the chinook (beach:purse combined cpue ratio of 2.02:1) and coho (beach:purse combined cpue ratio of 1.26:1).

The fork lengths of chum sampled provides some indication of residence time. Chum lengths varied considerably between sampling dates. On April 18, a group of 17 chum were sampled at the Cliff House restaurant beach (B-4) that averaged 48.6 mm in length. Approximately 1 month later, on May 26, 29 chum (averaging 41.4 mm) were sampled at the same location. This indicates two distinctly different groups of chum were migrating through the study area. Unfortunately, catches were too low to make this comparison at any other stations. Weitkamp and Campbell (1980) also detected different groups of outmigrating chum in the Duwamish estuary during the 1978 outmigration, with chum ranging between 50 and 55 mm during periods of peak outmigration in that estuary. This was approximately the size of chum salmon we collected in COBS sampling in late April, June, and July when the chum were collected primarily along the pier aprons.

Other studies in the Duwamish estuary during the 1980 outmigration (Meyers et al. 1980, Weitkamp and Schadt 1981) found peak catches of juvenile chum in April and May. This corresponds to the timing of the

chum in Commencement Bay. The chum salmon collected in the Duwamish estuary with the same gear were taken in much greater numbers than in Commencement Bay (Weitkamp and Schadt 1981).

Juvenile coho were likewise collected in numbers too small to be suitable for drawing reliable conclusions. During the study only 59 coho were sampled. This low number is unexpected for two reasons. The Puyallup watershed is a substantial coho producer (see Section 3.0 below). Natural and artificial annual spawning ground escapement to the Puyallup basin has been estimated to be about 700 and 3,600, respectively (WDF 1981a). Due to this abundance of adult spawners, one would anticipate a large number of juveniles might be sampled. Also, WDF planted large numbers of coho in the Puyallup watershed during the spring of 1980 (Table 6). These plants included both 1978 and 1979 brood year fish. Perhaps one possible explanation is that the 1978 brood year plants, and those migrating naturally (also predominantly 1978 brood year), do not inhabit the shallow water sampled by our gear for more than a brief time due to their large size (approximately 120-130 mm). Dawley et al. (1979) estimated the travel time of coho through the Columbia River estuary as 1 day. A number of other studies have also suggested that schools of coho probably move rapidly through estuaries, as evidenced by the rapid increase and decrease in abundance (Bostick 1955, Weitkamp and Campbell 1980, Meyer et al. 1980).

Those few coho that were sampled in COBS were taken almost exclusively during the month of May. Before and after May, coho were essentially absent from our catches. During the month of May, the mean length of coho in our sampling fluctuated from 110 to 122 mm; this is comparable to what the Puyallups sampled. This size of fish indicates we sampled 1978 brood year fish. Of the 59 coho sampled, only 3 were of a length comparable to 1979 brood year, yet almost 1 million 1979 brood year coho were planted into the Puyallup system. The majority of these 1979 brood year coho quite likely remained in the Puyallup River for a year as coho commonly do.

The Puyallup Nation (Miyamoto et al. 1980) also sampled relatively low numbers of coho with the exception of a sharp peak that occurred about the second week of May. Their beach seine catches included about

20 times more coho than our catches. The majority of these coho were taken in a single catch at a Ruston Way station. This quite likely involved collection of a single large school of coho. Salo and McComas (1980) collected no coho in Milwaukee Waterway during April. Seining studies in the Duwamish estuary (Weitkamp and Campbell 1980, Meyer et al. 1980, Weitkamp and Schadt 1981) indicate the peak outmigration of coho occurs primarily in May and to a lesser extent in early June. Coho sampled in these studies ranged between 120 and 140 mm in length, also indicative of 1978 brood year fish.

Cutthroat and steelhead trout (juveniles) were sampled in extremely low numbers during the study. We encountered both species in our sampling after the first of May until sampling ended. They were sampled in such small numbers that it appears they make very little use of the Commencement Bay shorelines.

2.5 CONCLUSIONS

The COBS objective to characterize the timing, patterns, and distribution of juvenile anadromous fish presence along the Commencement Bay shoreline in 1980 was achieved in part by this portion of the study. The information collected provides a fairly thorough description for chinook but only minimum data for pink, chum, and coho salmon. COBS data and that collected by the Puyallup Nation indicate that several areas of Commencement Bay shoreline are important to juvenile salmonids. Some of the mudflat and beach shoreline areas such as the 11th Street Bridge area of Hylebos and the Browns Point area may be significantly more important than other areas to juvenile salmon when they first enter the Commencement Bay area. Chinook salmon were significantly more abundant in our collections than other species of salmon. The chinook used a variety of shoreline habitat types as they had a relatively high frequency of occurrence at all stations. However, the chinook did appear to favor the sites near the mouth of the Puyallup River. The three highest cpue figures for chinook were in and around the periphery of Milwaukee and Sitcum Waterways (Stations B-8, P-15, and P-17). This is likely due to their proximity to the mouth of the Puyallup River, the major source of juvenile salmon in Commencement Bay. The juvenile chinook may be utilizing

these areas of close proximity as staging areas before they disperse throughout the bay. Data collected by the Puyallup Nation indicate that portions of the southwest shoreline (Ruston Way area) that are north of our sample site (B-5) are more heavily used by young chinook and coho salmon than indicated in COBS data. Each of these areas, if not required, is at least a shoreline area favored by the juvenile salmonids. Early in the migration period the chinook appear to favor the shallow shoreline habitat. During the second half of the migration period, chinook were nearly equally distributed between the shallow shoreline habitat and the deeper areas sampled by the purse seine.

In general, the chum and pink salmon were more shoreline oriented than the chinook salmon. Juvenile chum and pink salmon showed a preference for several of the sites sampled in our study. The mudflat south of the 11th Street Bridge area of Hylebos Waterway (B-2) and the Browns Point area (B-4) provided the largest numbers of chum and pink salmon in our samples. The presence or absence of juvenile chum and pink salmon could not be predicted on the basis of observable physical features of the sites sampled.

The information collected provides little evidence regarding residence time. A few pink, chum, and chinook salmon were present as early as March according to the Puyallup Nation data. The majority of the juvenile chinook were along the Commencement Bay shorelines in May and June. Juvenile chum were prevalent from mid-April through May. Pink salmon were intermittently collected from March through June. A few individuals of each species were taken later in the summer (July-September). For all four species of salmon, the length frequency variations during the periods each species was present and the changes in numbers of salmon present within short periods of time (days-weeks) indicate that few of the juveniles were rearing at any specific site for long periods of time (weeks-months). Circumstantial evidence provides the basis for the above conclusions due to the inability to mark a significant portion of the population.

The basic objective of these studies was to increase the general understanding of the characteristics and requirements of the juvenile

salmonids in order to provide a basis for more effective planning of shoreline development. A considerable number of recent studies have demonstrated the importance of shallow shoreline habitat to juvenile chum, pink, and chinook salmon (Reimers 1971, Gerke and Kaczynski 1972, Kaczynski et al. 1973, Mason 1974, Dunford 1975, Sibert 1975, Feller and Kaczynski 1975, Schreiner et al. 1977, Congleton 1978, Simenstad and Kinney 1978, Fresh et al. 1979, Healey 1979, Levey et al. 1979, Meyer et al. 1980, Weitkamp and Campbell 1980). These studies have shown that chinook, chum, and pink salmon commonly use shallow shoreline habitats when they first enter marine environments. These studies also show that the small salmon commonly feed on epibenthic organisms found in these shallow shoreline habitats. Although some studies such as Simenstad and Kinney (1978) and Healy (1979) have shown small chum feed preferentially on harpacticoid copepods, others such as Dunford (1975), Congleton (1978), and Levy and Levings (1978) have shown that young salmon in shallow shoreline habitats use other food sources such as insect larvae (of benthic origin) and other pelagic prey.

It appears likely that young salmon utilize different food sources in different locations. This conclusion is demonstrated in part by Gerke and Kaczynski (1972) and Feller and Kaczynski (1975) who found chum salmon at three different geographical locations did not show the same food preference. These authors found chum preferred epibenthic prey at one location, pelagic prey at a second location, and both epibenthic and pelagic prey at a third location. A number of other studies have shown that small salmon utilize pelagic prey in fresh water and when they first enter the marine environment (Lavanidov 1955, Neave 1966, Sparrow 1968, LeBrasseur 1969, Manzer 1968, Herman 1971, Okada and Taniguchi 1971, Mason 1974, Bailey et al. 1975). Mason (1974) found chum can move back and forth between freshwater and marine environments feeding on epibenthic and pelagic prey. Bailey et al. (1975) found chum feed on planktonic prey in an Alaskan estuary where shallow shoreline habitat is essentially absent.

The available information provided by the referenced studies indicates that shallow shoreline areas and the epibenthic prey they provide are important to young salmon such as chum, pink, and chinook when they first

enter the marine environment. The information also indicates that the young salmon can and do use pelagic prey as an alternative to epibenthic prey. It appears likely that the young salmon prefer shallow shoreline habitat when it is available such as in portions of Commencement Bay. In some other estuaries such habitat has been demonstrated to not be a requirement. Young pink, chum, and chinook salmon may be opportunistic feeders that prefer shallow shoreline habitats. COBS data generally support these other studies to the extent that they demonstrate that shallow shoreline habitat is important to juvenile salmon in Commencement Bay.

3.0 ADULT ANADROMOUS SALMONID CHARACTERISTICS

3.1 INTRODUCTION

The Commencement Bay study area (Figure 1) is used as a migration route by four species of adult Pacific salmon during various times of the year. The Pacific salmon include spring and fall chinook (Oncorhynchus tshawytscha), coho (O. kisutch), chum (O. keta), and pink (O. gorbuscha). A fifth species, sockeye (O. nerka) has been observed in Kapowsin Creek (a tributary to the Puyallup) by Puyallup Nation biologists (Miyamoto 1981a). Two species of adult anadromous trout, steelhead (Salmo gairdneri), and searun cutthroat (Salmo clarki), are also present at certain times in the study area. These species of salmon and trout migrate through Commencement Bay as they return to fresh water to spawn.

There are three freshwater drainages flowing into Commencement Bay that support anadromous salmon populations. The largest and most important in terms of salmon production is the Puyallup River basin. This basin represents an extensive network of 728 rivers and streams (1,287 lineal miles) that support the four salmon species including both spring and fall races of chinook salmon (Williams et al. 1975). In addition to the population of wild fish, this system supports substantial populations of hatchery-reared coho, chinook, and chum salmon that are planted in the Puyallup River system. The origin of these hatchery-produced salmon is the Washington Department of Fisheries salmon hatchery located on Voight Creek, a tributary to the Carbon River which is a tributary to the Puyallup River; and the Puyallup Nation's hatchery located on Diru Creek, a tributary to Clarks Creek, which is a tributary to the Puyallup River. The WDG operates a steelhead hatchery on Clarks Creek. The Puyallup River receives steelhead plants from this source and tribal sources as well (Miyamoto 1981a). Two other relatively small drainages to Commencement Bay are the Hylebos and Wapato Creeks drainages. Together they amount to about 14 lineal miles of accessible stream. The Hylebos system has coho and chum populations. The Wapato system has historically had coho and chum populations, but recently production has been limited (Williams et al. 1975). Both creeks receive coho, chinook, and chum plants from tribal and WDF sources (Miyamoto 1981a).

The sections below present existing information available that describes the time of occurrence of these adult species in the Commencement Bay study area as depicted through commercial and sport catches as well as agency management schemes. The abundance of adult salmon in the study area and their migration patterns through the area as they approach their freshwater destiny. No field studies of adult salmonids were completed.

3.2 TIME OF OCCURRENCE AND ABUNDANCE

3.2.1 FALL CHINOOK

The Washington Department of Fisheries (WDF) has designated periods of time when the commercial fishery is intensely managed for a given species. This period of intense management is correlated with the period of peak occurrence of a given species and is determined from historical catch data. WDF has determined a management period for fall chinook in their marine management area 11A* (Figure 8), which has essentially the same boundaries as the Commencement Bay study area. This management period begins the first week of July and ends the first week of September (Stern 1981). The exact starting and ending dates fluctuate yearly as they are adjusted to Sunday and Saturday, respectively. For fall chinook, determining the end of the management period is not totally dependent on the presence or absence of fall chinook in the area. The end of the management period is determined by the need for a tradeoff in managing the fall chinook fishery and the fishery for the more abundant coho which begins by the first week of September.

Commercial fishing in area 11A has been conducted predominantly by treaty Indians with occasional openings to all commercial fishermen. The Puyallup Nation is the only Indian nation whose usual and accustomed fishing area includes this management area. Specific timing histogram data of adult commercial catches in management area 11A has been published by WDF for 1975, 1976, 1977, and 1978 (Fraser 1978; Washington Department of Fisheries 1977, 1979, 1981b). Timing histograms indicate catches occur from early August through mid-October (Figure 9). In 1975 relatively

*Note that the latest boundary of WDF Marine Area 11A has changed in 1981 to a straight line between Browns Point and Ruston Way.

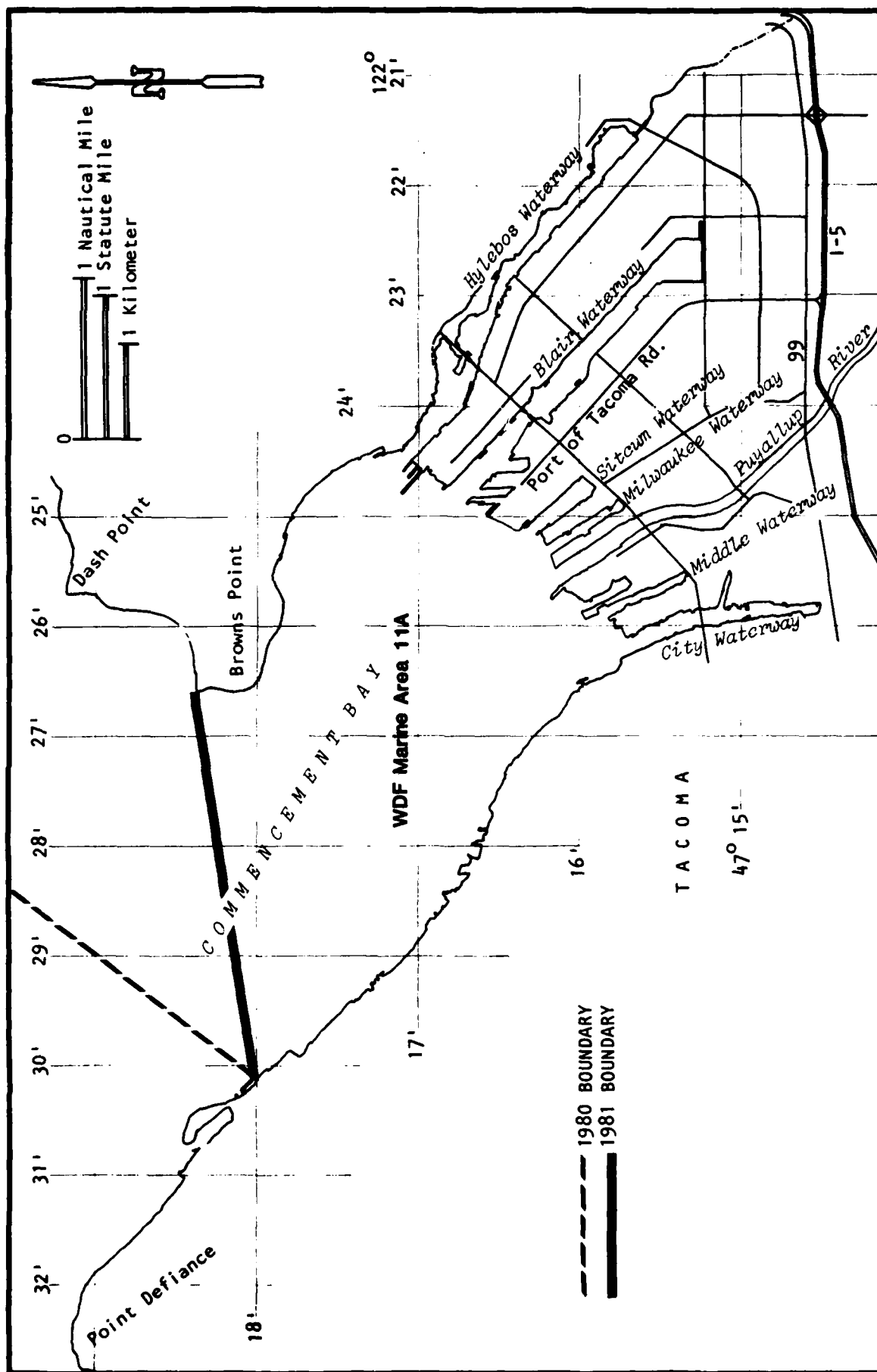


Figure 8
WDF MARINE AREA 11A

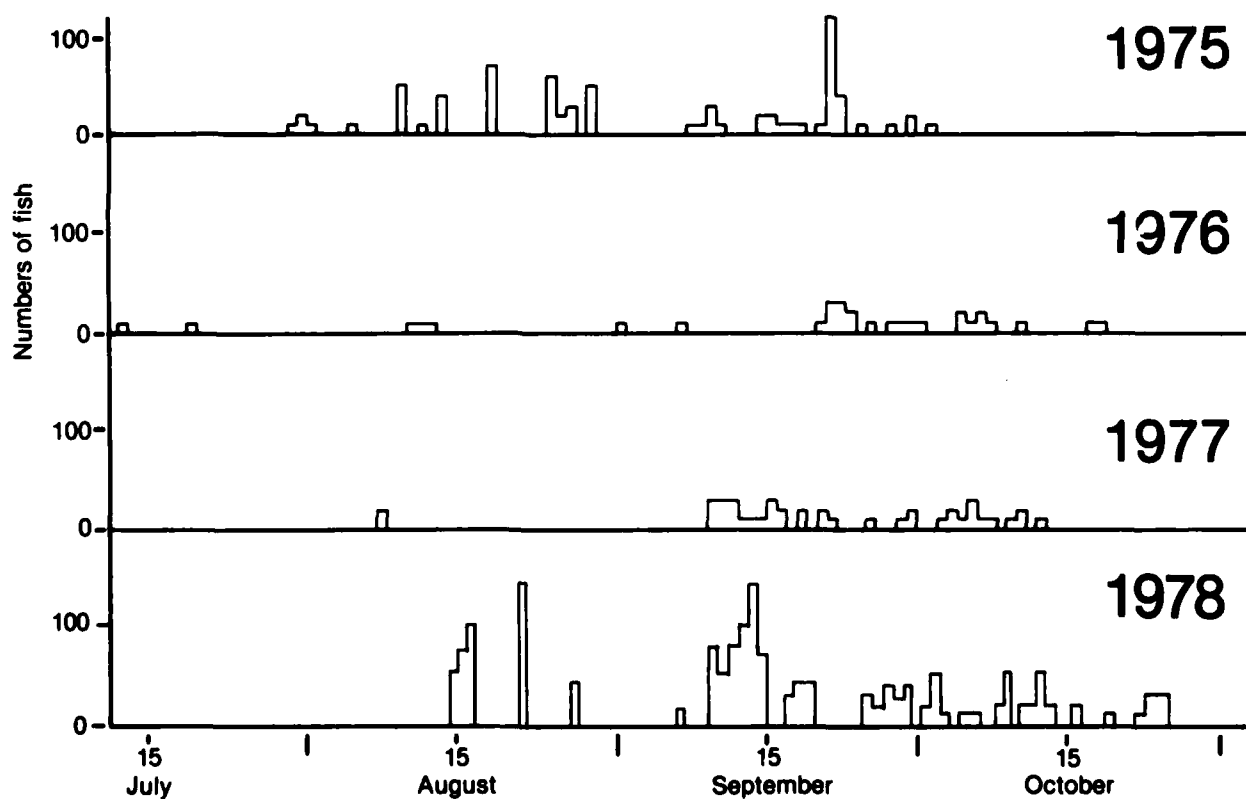


Figure 9 Timing histograms for commercial catches of adult chinook salmon in Washington Department of Fisheries management area 11A.

Source Fraser, 1978 and Washington Department of Fisheries, 1977, 1979, and 1981

large catches occurred in late August and late September. In 1976 and 1977 the distribution of the numbers caught per day was very widespread. There were no distinct peaks of occurrence in any of the 1976 or 1977 catches. This widespread distribution may be in part due to the low numbers caught (Table 8). The 1978 histogram is similar to 1975 with relatively large catches in late August and mid-September. It should be noted that these timing histograms are generated from data that do not represent a constant sampling effort from day to day. The number of individuals fishing and the hours fished vary from day to day. Also, short-term closures and openings of management area 11A have an effect on the distribution of catches within the timing histograms. However, these histograms do provide the most useful information available indicating the timing of adult salmon in the study area. Histograms for catches in the Puyallup River are not included in this report as they provide no additional information.

There are two locations within the Commencement Bay study area that are intensively fished by sport fishermen. The first, and most intensive of the two, is Point Defiance. This location supports a very large sport fishery. The second location is the mouth of the Puyallup River. Although not as heavily fished as Point Defiance, this area still supports a large sport fishery. A third location that is popular, but not to the extent of Point Defiance and the mouth of the Puyallup River, is the Browns Point area.

Washington Department of Fisheries has published sport catches of adult salmon by species in terms of number caught on a weekly basis (Nye et al. 1975, Nye et al. 1976, Hoines et al. 1977, Hoines et al. 1978). The marine area where sport catches are reported is not specific to the Commencement Bay study area (i.e., it is not management area 11A). In addition to Commencement Bay, the catch report area includes Puget Sound waters north of Commencement Bay extending to the northern tip of Vashon Island, and Puget Sound waters south of Commencement Bay to just south of the Narrows Bridge. Although this area will obviously include catches of fish destined for freshwater areas other than the three drainages to Commencement Bay, the data may provide another indication of timing of salmon presence in the study area that is worth considering.

Table 8. Number of commercially harvested salmon in WDF marine area 11A for 1975, 1976 and 1977. (Fraser, 1978 and WDF, 1977, 1979, 1981, and Geist, 1981).

	<u>Fall Chinook</u>	<u>Coho</u>	<u>Chum</u>	<u>Pink</u>	<u>Sockeye</u>
1975	729	39,925	205	1,731	2
1976	368	21,436	1,120	0	0
1977	551	46,717	2,303	361	0
1978	1,698	18,326	345	0	0
1979	3,773	43,104	61	12,149	0
1980	1,192	42,102	4,462	0	0

The sport catch estimates of chinook salmon taken in marine area 11A are reported according to the estimated age of the weekly catch. The estimated sport fish catches for the years 1975 through 1978 do not show definitive peaks of occurrence of chinook. During these years 2-year-old chinook were commonly taken in the sport catch throughout each year. These chinook catches most likely include immature blackmouth rearing in Puget Sound and jacks (precocious adults) returning to the tributaries of Commencement Bay and adjacent areas. The estimated catches of 3- and 4-year-old chinooks most likely represent adults returning to the area's streams. These estimates of 3- and 4-year-old chinook indicate that some adult chinook are also present in the Commencement Bay area throughout the year. The data do not indicate where these fish might be in the study area or what their migratory routes might be.

The expected natural adult escapement of summer/fall chinook to the Puyallup basin has been estimated to be about 1,400 annually (WDF 1981c). The expected escapement of adult chinook to the WDF hatchery has been determined to be about 1,800 fish annually (WDF 1981c). Escapement figures of adult salmon to the Puyallup Nation hatchery are not available for two reasons. First, the hatchery employs a practice of planting hatchery-reared juveniles off-station. Therefore, they do not have an adult trap facility at the hatchery. Secondly, their station has only recently begun operation and estimates of adult production are not feasible at this time (Miyamoto 1981b).

3.2.2 SPRING CHINOOK

Spring chinook are present in the study area earlier in the year than the other races and species of salmon. WDF has determined the management period for spring chinook in the study area to be from the middle of April through the end of June. This management period has been closed to fishing in recent years to protect the low numbers of returning spring chinook spawners (Stern 1981). Because of these low returns and closure to commercial fishing no catch data of spring chinook are available. The expected adult escapement of spring chinook to the Puyallup River system is undetermined (WDF 1981d).

3.2.3 COHO

Coho salmon is the predominant species in terms of numbers caught commercially and with sport gear in the Commencement Bay study area. A management period from the first week of September to the first week of November has been established by WDF for coho in management area 11A. The ending date during the first week of November was established with consideration of the need to manage the chum salmon fishery which begins at that time (Stern 1981).

The commercial harvests of coho in management area 11A ranged from 21,000 to 46,000 fish annually between 1976 and 1978 (Table 8). Timing histograms indicate peak abundance occurred in mid-September and late September-early October during 1975 (Figure 10). In 1976 peak abundance appeared to occur slightly later than 1975. The largest catches in 1976 occurred from late September through mid-October. In 1977 the trend was closer to 1975 with peak catches occurring in mid-September and large catches continuing through the first week of October. A similar trend was shown by the 1978 catches (Figure 11).

Sport harvest of coho in the Commencement Bay-Vashon Island vicinity indicates peak catches have occurred from as early as June to as late as mid-October. In 1976 and in 1978 peak catches appeared to occur earlier in the summer (June and July) than in 1977. In 1977 the peak of the sport harvest occurred relatively late during September.

Natural spawning ground expected escapement of coho to the Puyallup River basin has been estimated to be about 700 fish annually (WDF 1981a). Expected escapement of adult coho to the Voight Creek hatchery has been determined to be about 3,500 fish annually (WDF 1981a).

3.2.4 CHUM

Chum occur in the study area later in the year than any of the other species of salmon. A management period for chum from the first week of November to the first of the following year has been established

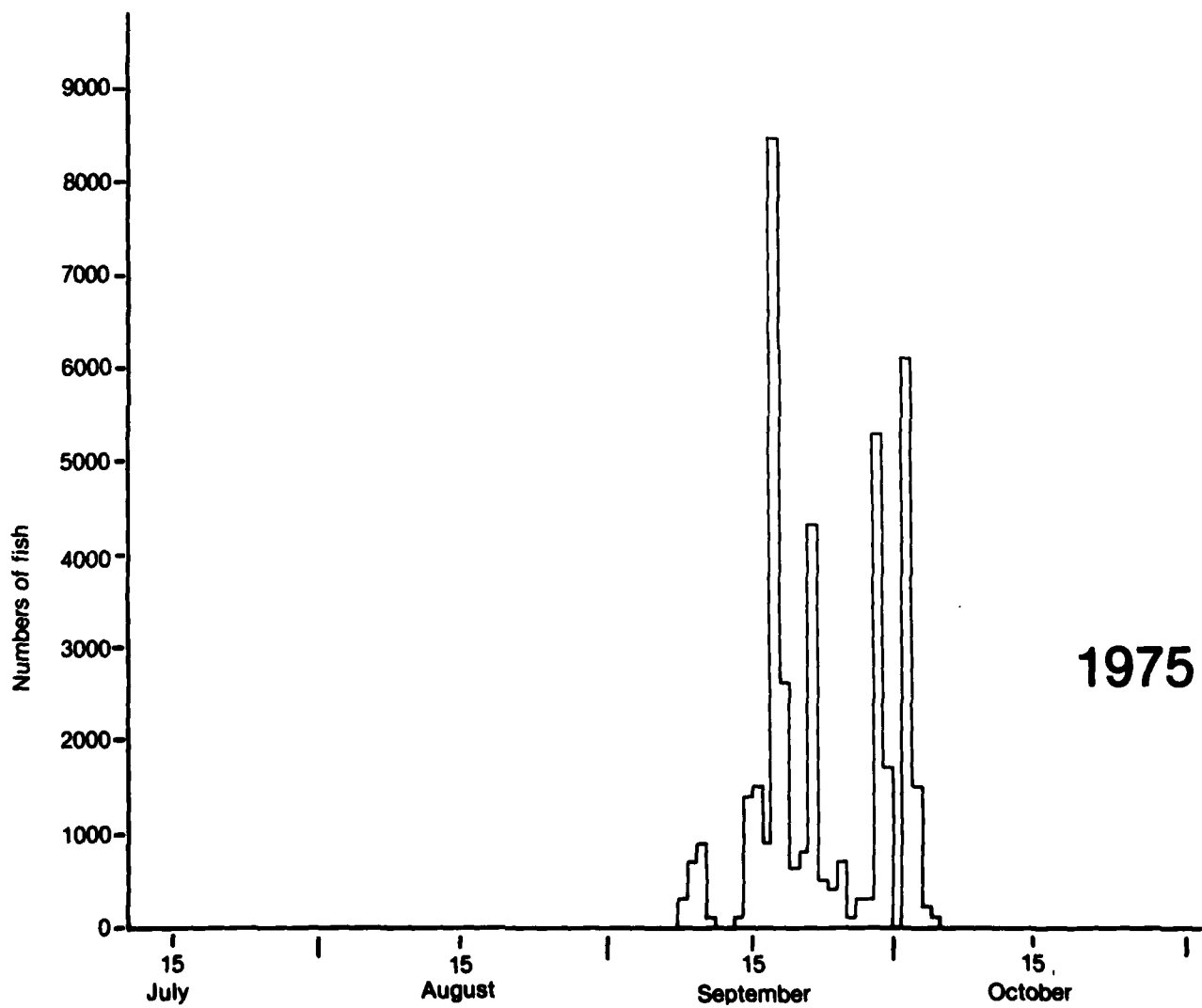


Figure 10 Timing histogram for commercial catches of adult coho salmon in Washington Department of Fisheries management area 11A.

Source: Fraser, 1978.

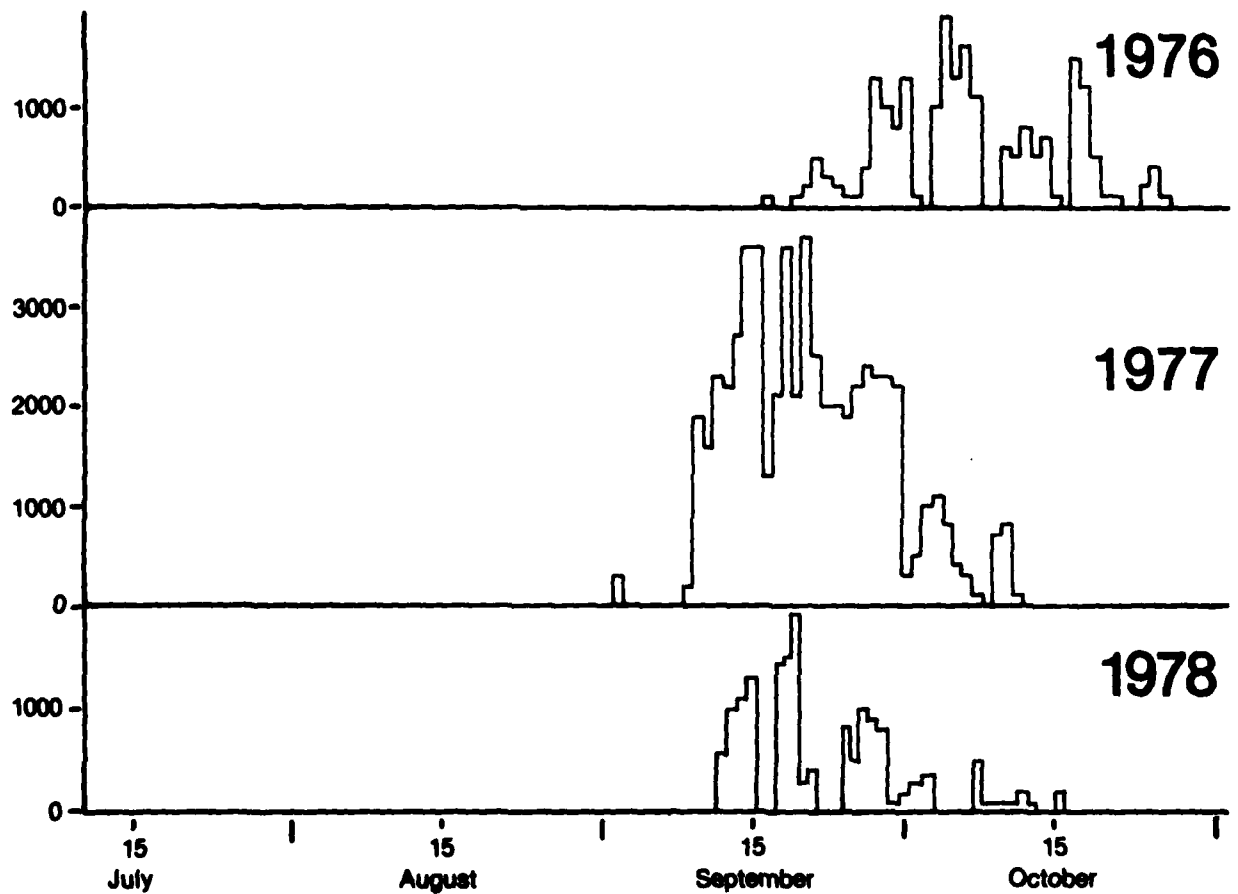


Figure 11 Timing histograms for commercial catches of adult coho salmon in Washington Department of Fisheries management area 11A.

Source: Fraser, 1978 and Washington Department of Fisheries, 1977, 1978, and 1981.

by WDF for management area 11A. Commercial harvests of chum in area 11A have ranged between 205 and 2,303 for the period of 1975 to 1977 (Table 8). Catches during 1975 were too small to provide any useful information (Figure 12). In 1976, there was a small peak at the end of November, but a larger peak occurred about the end of September. The timing histograms for 1977 indicates peak catches occurred from the middle of November to the end of November (Figure 12). The 1978 histogram is comparable to 1975 in that too few chum were caught to provide useful information.

Harvest of chum by sport fishermen has been extremely low. This is as expected because of the behavior of chum salmon which seldom strike lures. The few catches that have been reported tend to occur mainly in December, later than the peak of the commercial catch.

Expected annual escapement of naturally produced chum to the Puyallup basin has been estimated to be about 1,900 fish during non-pink (even numbered) years (WDF 1980). Expected escapement for hatchery produced chum during non-pink years is estimated to be 3,700 fish annually (WDF 1980).

3.2.5 PINK

Adult pink salmon runs through Commencement Bay occur primarily during odd years. During 1975 and 1977 the commercial harvest of pink salmon in Commencement Bay was 1,731 and 361, respectively. WDF has determined a management period extending from the end of July to the middle of September for pink salmon in area 11A. A histogram for commercial catches during 1975 indicated peak abundance of pinks occurs from mid- to late August. In 1977 the peak abundance of pink salmon occurred in mid-September (Figure 13).

Sport catch records for pink salmon in 1977 indicate they are present in the study area vicinity from April through mid-September. Peak catches occurred during August at the time of the peak commercial catches.

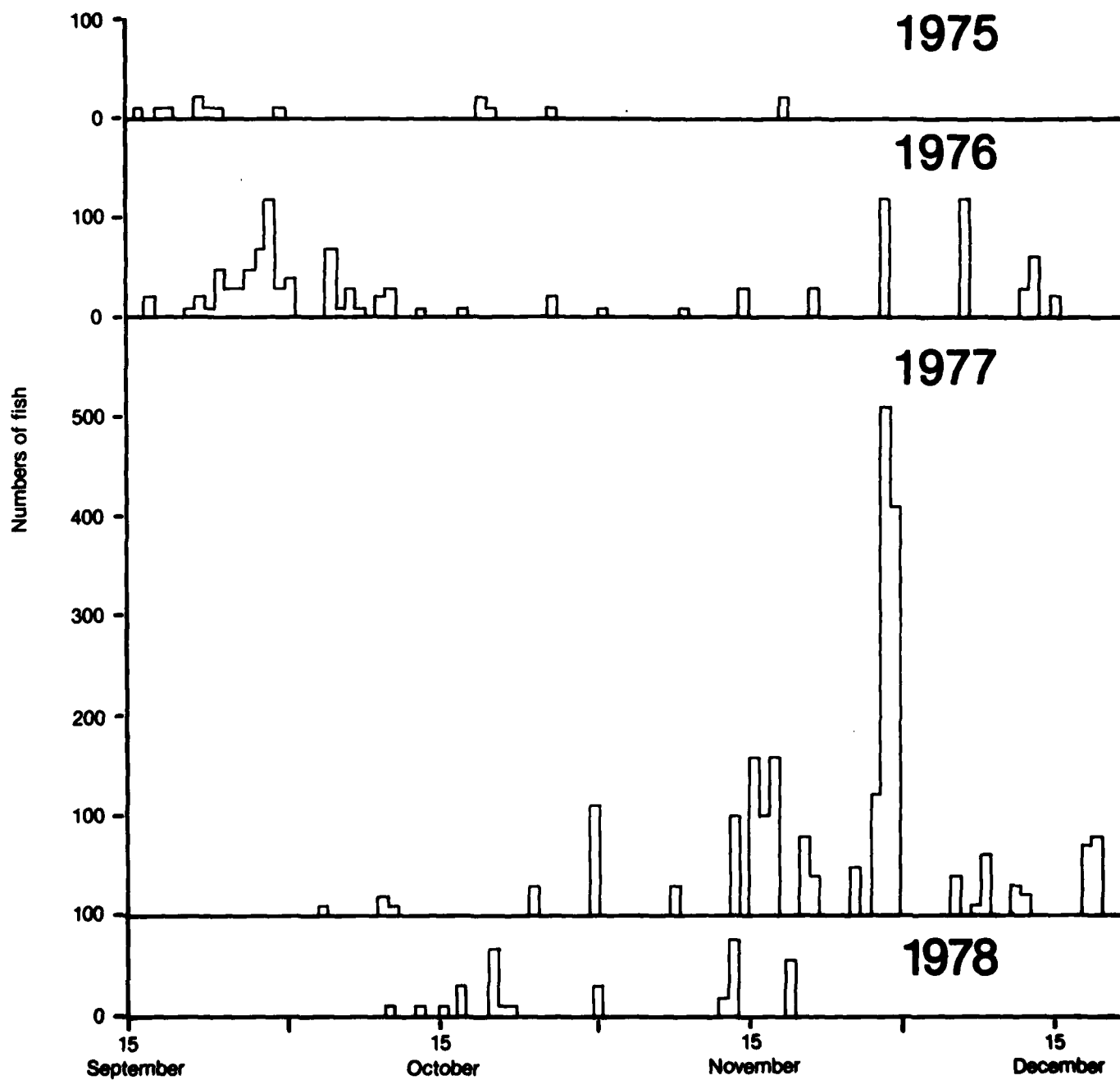


Figure 12 Timing histograms for commercial catches of adult chum salmon in Washington Department of Fisheries management area 11A.

Source: Fraser, 1976 and Washington Department of Fisheries, 1977 and 1981.

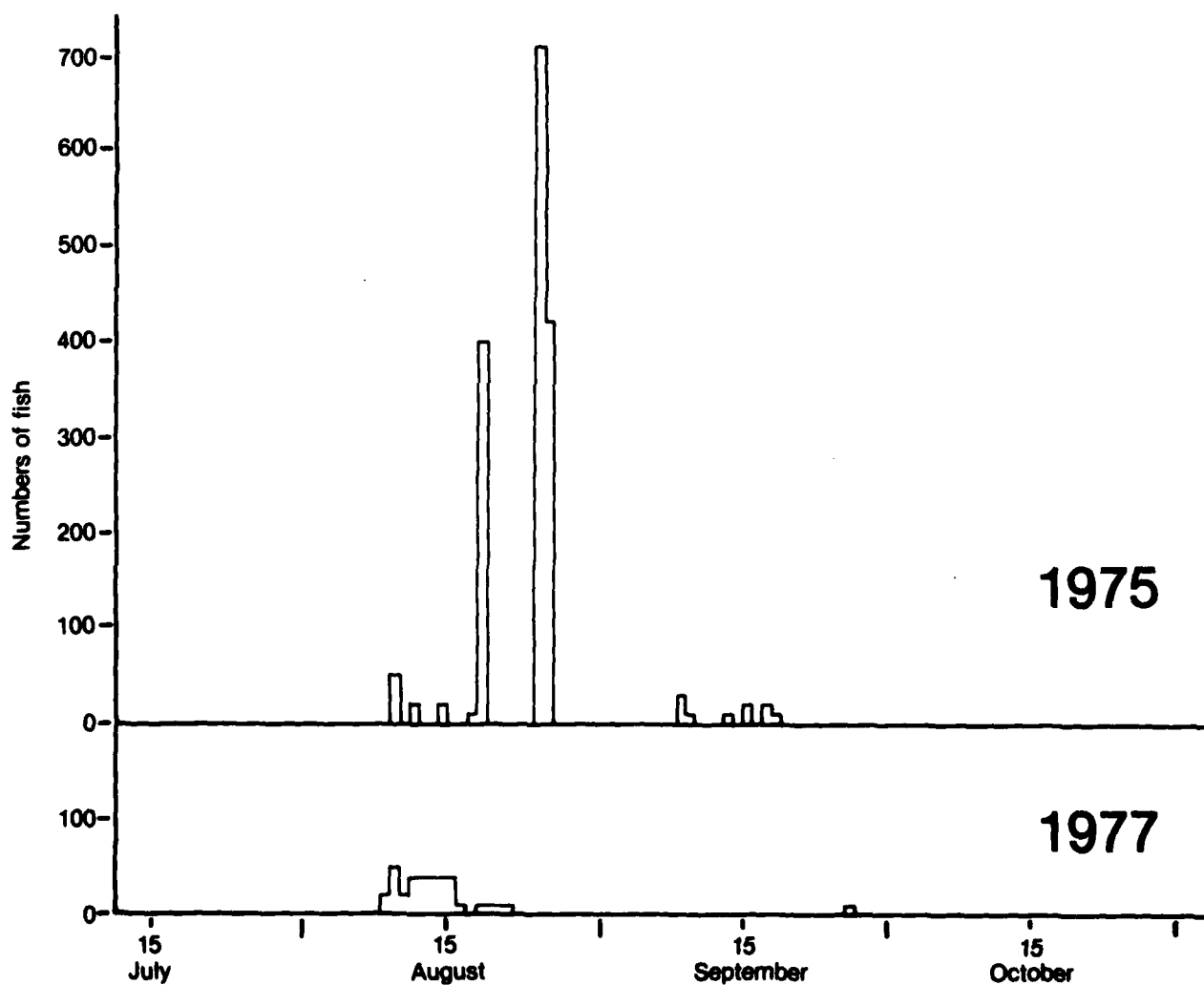


Figure 13 Timing histograms for commercial catches of adult pink salmon in Washington Department of Fisheries management area 11A.

Source: Fraser, 1978 and Washington Department of Fisheries, 1977, 1978, and 1981.

Expected escapement of naturally produced pink to the Puyallup basin has been estimated to be about 19,000 fish annually during odd years (WDF 1981c). Expected escapement of hatchery produced pink salmon is 400 fish annually during odd years (WDF 1981c).

3.2.6 STEELHEAD

Adult steelhead are present in the study area primarily during the winter months. They are harvested commercially by the Puyallup Nation in management area 11A and the Puyallup River basin. The Washington Department of Game (WDG) has published Indian commercial harvest data from management area 11A and the Puyallup River basin since 1975 (Table 9). The commercial harvest that occurs in the Puyallup basin is likely to occur in the lower portions of the main stem Puyallup River. The data indicate that the winter run in marine area 11A extends from November to January with the peak in December. Since the marine area 11A is not frequently open to commercial Indian fishing, there are little commercial saltwater data to support this. However, freshwater commercial and sport catches do indicate a peak during December.

Sport harvest data have been published by WDG for the Puyallup, White, and Carbon Rivers, all tributaries of the Puyallup basin, since 1975 (Table 10). These data indicate peak catches of steelhead in freshwater areas occur in December and January. Allowing a 1- to 2-week period (depending on flows) for steelhead to move from the marine environment to the freshwater environment (Gibbons 1981), these peak freshwater sport catches would correlate with what has been seen in marine commercial catches.

A race of wild steelhead occurs in the study area much later than the majority of fish that peak in December. This late wild race has had historical peak counts at Buckley Dam (on the White River) during the last week of April, first week of May (Hahn 1981). Allowing approximately 2 weeks travel time to freshwater, this race would peak in the Commencement Bay study area during early April.

Table 9 Number and timing of commercially harvested winter run steelhead
in management area 11A and the Puyallup River for the period
1975-1980 (Washington Department of Game, 1975-80)

Marine Area 11A

<u>Year</u>	<u>Nov</u>	<u>Dec</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>Total</u>
1975-76		20	5				25
1976-77	1	375					376
1977-78	5	20					25
1978-79		NO CATCH REPORTED					
1979-80		NO CATCH REPORTED					
TOTAL	6	415	5				426

Puyallup River

<u>Year</u>	<u>Nov</u>	<u>Dec</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>Total</u>
1975-76	526	1,862	472	12			2,872
1976-77	396	596					992
1977-78	44	18					62
1978-79	3	194					197
1979-80					21		21
TOTAL	969	2,670	472	12	21		4,144

Table 10 Number and timing of sport harvested winter run steelhead from the Puyallup, White and Carbon Rivers for the period of 1975-80 (Washington Department of Game, 1975-1980).

Puyallup River

<u>Year</u>	<u>Nov</u>	<u>Dec</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>Total</u>
1975-76	83	575	216	113	166		1,153
1976-77		121	1,452	242			1,815
1977-78	39	1,339	1,982	1,027	694	9	5,090
1978-79	205	1,363	707	375	237		2,887
1979-80	27	292	728	717	350		2,114
TOTAL	354	3,690	5,085	2,474	1,447	9	13,059

White River

<u>Year</u>	<u>Nov</u>	<u>Dec</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>Total</u>
1975-76		41	41	21	9		112
1976-77		16					16
1977-78		70	182	6		3	261
1978-79		79	24				103
1979-80		3	14				17
TOTAL		209	261	27	9	3	509

Carbon River

<u>Year</u>	<u>Nov</u>	<u>Dec</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>Total</u>
1975-76		23	14	32			69
1976-77	4	37	11				52
1977-78		82	45				127
1978-79		28	28				56
1979-80		10	24				34
TOTAL	4	180	122	32			338

3.3 CONCLUSIONS

The existing data describing the timing of adult salmon occurrence in Commencement Bay are less than desirable but do provide some useful information. These commercial and sports catch data indicate that some salmon of at least catchable size occur in Commencement Bay year round. There are, however, fairly definite peaks for some species when the adults will be migrating to the mouth of the Puyallup River and perhaps Hylebos and Wapato Creeks. The general range and peak occurrence of these species is summarized in Table 11. This summary is based on all existing data that were available to us.

Based on this information, it appears that many adult salmon can be expected in Commencement Bay from August through November. These salmon will be concentrated near the mouth of the Puyallup River at times during this period. This autumn period covers the peak of migration of the fall chinook, coho, pink, and chum salmon. Only the spring chinook and steelhead trout can be expected to be present in large numbers outside this period. Adults of these two species which are not as numerous may be present in winter and spring months.

Essentially no information is available describing the routes of adult salmon migration through Commencement Bay. We unsuccessfully attempted to arrange interviews with Indian fishermen who presently conduct the majority of the harvest in Commencement Bay. These fishermen and sports fishermen most likely have the best knowledge of where the adult salmon migrate through Commencement Bay.

Since we were unable to interview commercial fishermen, we can only rely on sport fishing activity. This activity indicates catchable size salmon are most available in the vicinity of Point Defiance, near the mouth of the Puyallup River, and perhaps to some degree near the Browns Point shoreline. We have found no indication that any of the salmon species follow well defined nearshore routes that might be influenced by shoreline activities.

Table 11 Timing of adult salmonid migrations through Commencement Bay and estimates of escapement to the Puyallup River.

<u>SPECIES</u>	<u>TIMING</u>		<u>ESTIMATED ESCAPEMENT</u>	
	<u>Peak</u>	<u>Range</u>	<u>avg (range)</u>	
chinook (spring)	?	April-June	1,100 ¹	(800-1,500)
chinook (fall)	late Aug-Sept	July-Sept	3,400 ¹	(2,500-4,000)
			685 ²	(241-1,519)
coho	mid Sept-early Oct	June-Oct	50,000 ¹	(42,000-70,000)
			11,989 ²	(8,544-14,333)
chum	late Sept-Nov	Sept-Dec	17,000 ¹	(10,000-25,000)
pink	mid Aug-mid Sept	July-Sept	26,000 ¹	(16,000-40,000)
steelhead (winter)	late Nov-early Jan	Nov-Feb	Data	Not Available

¹: natural; ²: hatchery

4.0 MARINE FISH STUDY

4.1 INTRODUCTION

The marine fish study was designed to characterize the seasonality, distribution, and abundance of marine fish within the Commencement Bay study area. These marine fish reside, and often complete entire life cycles, within the study area, as opposed to the salmonids that only utilize the area for short periods during their life cycle. Our sampling effort was designed to gather baseline information regarding the species present, their abundance relative to each other and to various habitats, and the seasonal fluctuation of these species. Marine fish were also collected for analysis of stomach contents under a separate work task.*

4.2 METHODOLOGY

4.2.1 SAMPLING LOCATIONS AND SCHEDULE

Twenty-two stations were established for marine fish bottom trawling in the study area (Figure 14). All stations were located shoreward of the 60-foot contour line. This nearshore shallow water habitat was chosen because it is most likely to be affected by shoreline development activities. At least one station was located in each waterway. Some waterways (Blair and Hylebos) had up to three stations sampled. Eight stations were established outside the waterways along the shoreline of Commencement Bay. Five of these occurred along the eastern shoreline and three along the western shoreline. One station along the western shoreline (O-20) was frequently inaccessible because of log booms, and ships moored in the area prevented us from sampling in less than 60 feet of water.

The otter trawl sampling efforts were conducted quarterly for 1 year occurring in July and October of 1980, and January and April of 1981. Sampling commonly was conducted over a 3-day period for each sampling effort.

*See results in Invertebrate Studies Technical Report.

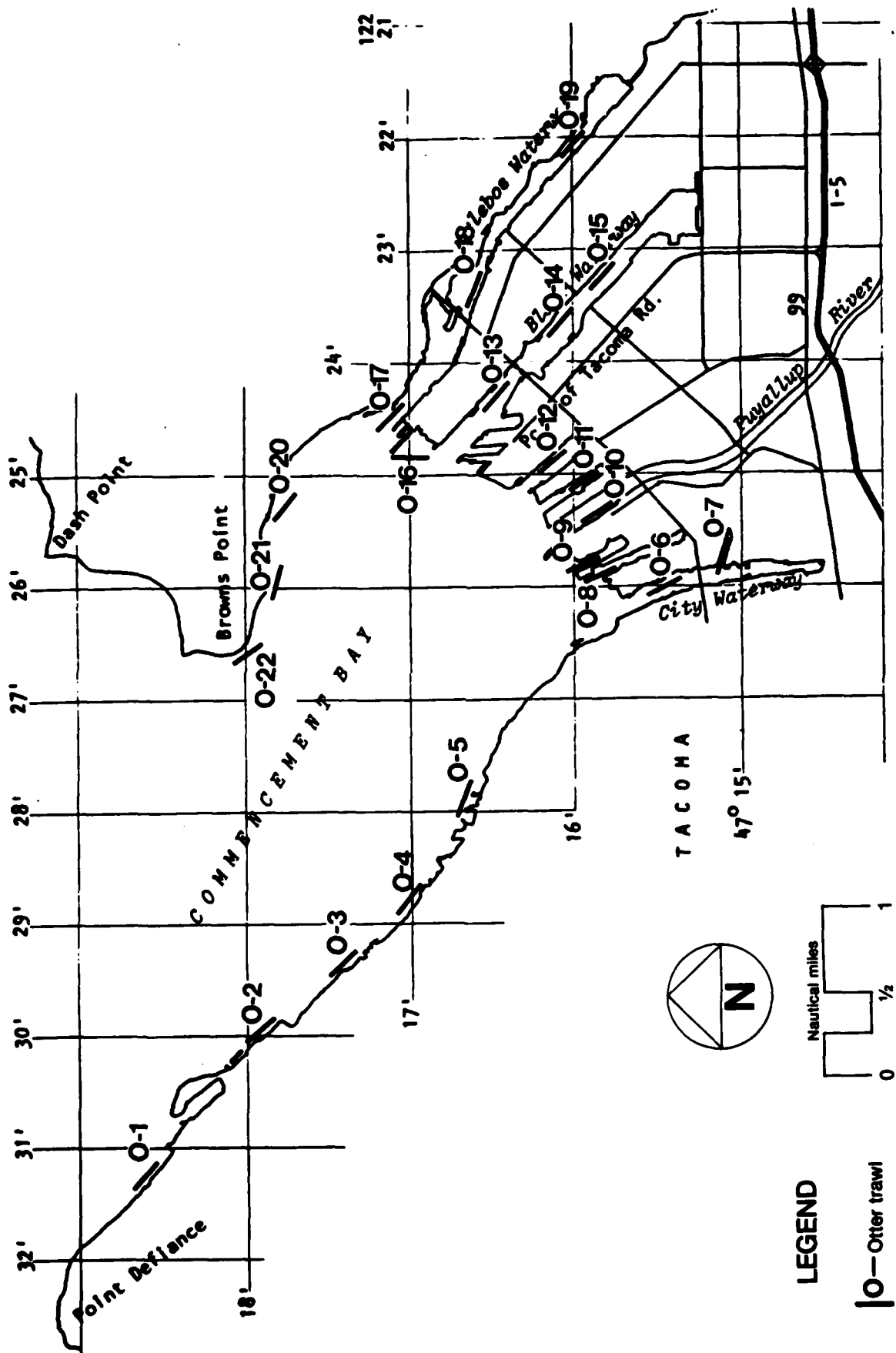


Figure 14 Location of otter trawl sampling stations in Commencement Bay.

4.2.2 SAMPLING GEAR

Sampling was performed with a research otter trawl having a mouth opening of approximately 27.5 square feet while fishing. The body was composed of 1-1/2-inch stretched mesh knotted nylon netting. The bag (cod) end was composed of 1-1/4-inch stretched mesh knotted nylon netting with a liner of 1/2-inch stretched mesh knotless nylon netting. The length of the net was 20 feet. Sampling was done by lowering the net off the stern of the vessel until it fished the bottom. It was then towed approximately 1/4 mile. After retrieval, all fish captured were identified to species and enumerated. Standard lengths were taken on all fish of each species caught up to a maximum of 50 of each species at each sampling site. Also, representative samples of each species were preserved and later delivered to Dames & Moore for stomach content analysis. The remainder of the catch was released in the area the set was made.

4.3 RESULTS AND DISCUSSION

4.3.1 SPECIES COMPOSITION AND ABUNDANCE

Twenty-nine different species of marine fish were collected throughout the sampling at all stations in the Commencement Bay study area. Of these, approximately 12 species were consistently collected on each sampling effort. Table 12 presents the various species captured and the season in which they were collected.

Flatfish of the family Pleuronectidae were by far the most abundant fishes in terms of number and frequency sampled. English sole, rock sole, flathead sole, C-O sole, sand sole, starry flounder, and speckled sanddab were commonly collected at all stations and on all sampling efforts. Other fish that were commonly collected, but in smaller numbers, included Pacific staghorn sculpin, Pacific tomcod, ratfish, copper rockfish, and snake prickleback. A complete list of marine fish collected at each station on each sampling date is provided in Appendix D.

Table 12 Marine fish collected by otter trawl in Commencement Bay study area from July 1980 to April 1981.

<u>Common Name</u>	<u>Scientific Name</u>	<u>Season Collected</u>			
		<u>Sm</u>	<u>A</u>	<u>W</u>	<u>Sp</u>
longnose skate	<u>Raja rhina</u>		-		
ratfish	<u>Hydrolagus colliei</u>	+	+	-	-
Pacific Herring	<u>Clupea harengus pallasii</u>		+	+	
surf smelt	<u>Hypomesus pretiosus</u>	+	+	+	
plainfin midshipman	<u>Porichthys notatus</u>		-		
Pacific Hake	<u>Merluccius productus</u>		-		
Pacific tomcod	<u>Microgadus proximus</u>				
blackbelly eelpout	<u>Lycodopsis pacifica</u>	+	+	-	
tube-snout	<u>Aulorhynchus flavidus</u>		-		
shiner perch	<u>Cymatogaster aggregata</u>	-	+		
striped seaperch	<u>Embiotoca lateralis</u>	-	-		
pile perch	<u>Rhacochilus vacca</u>		+		
northern ronquil	<u>Ronguillius jordani</u>				-
snake pricklyback	<u>Lumpenus sagitta</u>	+	+	-	-
red gunnel	<u>Pholis schultzi</u>		-	-	
copper rockfish	<u>Sebastes caurinus</u>	+	-	-	-
whitespotted greenling	<u>Hexagrammos stelleri</u>	-	-	-	
Pacific staghorn sculpin	<u>Leptocottus armatus</u>	+	+	+	+
grunt sculpin	<u>Rhamphocottus richardsoni</u>		-		
cabezon	<u>Scorpaenichthys marmoratus</u>		-		-
sturgeon poacher	<u>Agonus acipenserinus</u>	-	-		
speckled sanddab	<u>Citharichthys stigmaeus</u>	+	+	+	+
flathead sole	<u>Hippoglossoides elassodon</u>	+	+	+	-
rock sole	<u>Lepidopsetta bilineata</u>	+	+	+	+
Dover sole	<u>Microstomus pacificus</u>	+	-		
English sole	<u>Parophrys vetulus</u>	+	+	+	+
starry flounder	<u>Platichthys stellatus</u>	+	-	+	+
C-O sole	<u>Pleuronichthys coenosus</u>	-	-	+	-
sand sole	<u>Psettichthys melanostictus</u>	-	-	-	+

1

A plus (+) indicates more than five fish were collected or that they were caught at more than three different stations.

A minus (-) indicates this species was caught, but less than six fish were caught, and they were not collected at four different stations.

A blank indicates no fish were caught.

Comparison of catches made at stations inside the waterways versus stations along the Commencement Bay shoreline indicates differences in species composition and abundance. Catch per unit effort (cpue) was used to compare the relative abundance of fish in each area. A cpue was calculated for the species that were consistently caught on each sampling effort and had relatively large catches. Results indicate that English sole, flathead sole, and Pacific staghorn sculpin occur in greater abundance in the waterways than along the shoreline of Commencement Bay (Table 13). The cpue for rock sole indicates they are more abundant in Commencement Bay than in the waterways. The distribution of abundance of speckled sanddab appeared to vary with the season of the sampling effort. Pacific tomcod and starry flounder were also collected in relatively large numbers in the waterways, but they were never caught at stations along the Commencement Bay shoreline.

Other species of marine fish showed preferences toward the waterways or Commencement Bay, but were collected in much smaller numbers than the above-mentioned species. Dover sole and ratfish were predominantly collected in waterway stations. Rockfish were most commonly taken at stations along the Commencement Bay shoreline, and C-O sole were only caught at Commencement Bay stations.

Table 13. Catch per unit effort for marine fish commonly collected at waterway stations (WW) and stations along the shoreline of Commencement Bay (CB)

	<u>Summer</u>		<u>Autumn</u>		<u>Winter</u>		<u>Spring</u>	
	<u>WW</u>	<u>CB</u>	<u>WW</u>	<u>CB</u>	<u>WW</u>	<u>CB</u>	<u>WW</u>	<u>CB</u>
English sole	15.9	4.5	8.4	2.0	7.4	0.9	7.0	1.0
rock sole	0.5	13.1	1.2	2.9	0.4	3.1	0.4	2.9
flathead sole	3.7	1.5	3.0	0.3	1.5	0.1	0.2	0.0
speckled sanddab	0.3	0.1	0.3	0.9	0.1	0.7	0.0	0.6
Pacific staghorn sculpin	1.6	0.5	4.5	0.6	1.9	0.0	0.3	2.3

Several stations were established at locations that could not be classified as open shoreline or enclosed waterways. One of these occurred between Hylebos and Blair Waterways (O-16) and the other at the mouth of Hylebos Waterway (O-17). Catches at these stations were predominantly

English sole and rock sole with some flathead sole, staghorn sculpin, tomcod, and speckled sanddab. These stations appeared to have a mixture of the species that were found to be predominant in the waterways and Commencement Bay.

One station (O-11) was also sampled in the Puyallup River. The freshwater influence of this station was indicated in our catches by the dominance of starry flounder and staghorn sculpin. These two marine species are known to adapt well to fresh water such as occurs in the Puyallup River mouth.

With the exception of the summer sampling effort, seasonal variations in abundance and species composition of the catches were minimal. The summer sampling effort collected much larger numbers of fish than any other sampling effort (Table 13). In general, the increase in numbers caught was observable in all species. It was particularly evident in snake prickleback and black eelpout. These two species were essentially absent from our winter and spring sampling. Tomcod were also observed in much smaller numbers during the winter and spring sampling.

4.3.2 SIZE DISTRIBUTION

Size distribution was examined to detect if preference to a particular habitat was related to size. Also, age class structure of the population we sampled was examined based on length frequency data. These analyses were conducted only on English sole because it was most prevalent in our sampling. Other species were collected in too small numbers to warrant such analyses.

The length of English sole collected in COBS sampling ranged from 58 to 370 millimeters. Mean lengths of the large numbers of English sole captured at waterway stations were compared to mean lengths of the few English sole taken at stations along the shoreline of Commencement Bay (Table 14).

Table 14. Mean lengths of English sole collected at waterway stations (WW) and Commencement Bay stations (CB) throughout the year (average length (mm)/n)

	<u>Summer</u>		<u>Autumn</u>		<u>Winter</u>		<u>Spring</u>	
	<u>WW</u>	<u>CB</u>	<u>WW</u>	<u>CB</u>	<u>WW</u>	<u>CB</u>	<u>WW</u>	<u>CB</u>
English sole	<u>204.6</u> 175	<u>215.1</u> 36	<u>167.9</u> 91	<u>231.7</u> 14	<u>188.9</u> 91	<u>232.5</u> 6	<u>228.6</u> 77	<u>154.1</u> 7

Mean lengths of fish collected at Commencement Bay stations were larger than the lengths of English sole collected at waterway stations on three of the four sampling periods. Only during the spring season were Commencement Bay sole smaller than the waterway sole. English sole are known to spawn mainly from January to March (Hart 1973). As a result of this, we might anticipate a recruitment of smaller fish in our summer and perhaps autumn sampling. No noticeable decrease in mean length was observed in our sampling. Although fish collected at waterway stations in the autumn tended to be smaller than at other times of the year, perhaps these smaller fish prefer a more shallow water habitat than what was sampled and therefore COBS catches do not reflect their presence.

Miscellaneous marine fish were frequently taken, incidental to the target salmonids, in our beach and purse seine sampling (Table 4). English sole and starry flounder were the two most common species of flatfish we sampled while beach seining. Their size was typically much smaller (100-150 mm) in beach seine collections than otter trawl collections. Other marine fish commonly taken in beach seines were sculpins, snake pricklebacks, shiner perch, and pile perch. On June 12, 32 pile perch were sampled at the Middle Waterway beach seine station (B-7). Included in the 32 pile perch were many large females nearly ready to give birth. Pacific herring and sand lance were the most common marine fish sampled at purse seine stations.

Holland (1969) performed length-age relationship studies on English sole stocks of Carr Inlet, Puget Sound. These results indicate the fish we sampled ranged in age class from I to VIII. The predominant age classes of English sole in our sampling were probably II, III, and IV. Females are known to enter the spawning population at 295 mm (IV and V age class), and males at 260 mm (V age class) (Hart 1963). COBS results indicate that the population of English sole is predominantly immature, but does have some fish of mature size.

4.3.3 FISH CONDITION

Three species of Pleuronectidae were occasionally found to be infested with the nematode worm Philometra. The incidence of Philometra was highest in English sole but it also occurred in rock sole and flathead sole. The highest incidence of Philometra in English sole occurred during our winter sampling effort when 32 percent of the English sole sampled were found to be infested with the nematode. The lowest incidence occurred during summer when 18 percent of the English sole were infested. The incidence of Philometra was much lower in the rock sole and flathead sole, never reaching above 7.5 percent and generally below 5 percent.

Holland (1969) found Philometra americana to be more prevalent in English sole in southern Puget Sound than in middle Puget Sound. Holland did not provide any figures indicating frequency of occurrence for either area. Amish (1976) studied the occurrence of Philometra americana in English sole and rock sole of central Puget Sound. Amish's sampling locations included Pully Point, approximately 26 kilometers north of Commencement Bay, and Carr Inlet, approximately 23 kilometers south of Commencement Bay. He found 20.8 percent of the English sole sampled at Pully Point to be infested with Philometra. Rock sole had a much higher frequency occurrence (42.5 percent) at Pully Point than in Commencement Bay (generally less than 5 percent). English sole sampled in Carr Inlet has the highest frequency of occurrence (89.7 percent) than any area studied. There was no explanation for this unusually high figure.

Resident marine fish from Commencement Bay have been found to contain other, non-parasitic lesions. Malins et al. (1980) found various liver lesions to occur in English sole, rock sole, Pacific tomcod, and staghorn sculpin from Commencement Bay. The incidence of liver lesions was generally highest in fish from areas having the highest levels of sediment-associated contaminants. Our study did not include any internal examination of any fish and therefore provides no additional information on this issue. Juvenile salmon collected in our study were provided to the National Marine Fisheries Service for internal examination. The results of their examination will be provided in a report not yet released.

Externally visible tumors, such as epidermal papillomas, were not observed on any fish collected in our study. We have previously collected numerous young flatfish with this lesion from sampling in the Duwamish Estuary (Weitkamp and Schadt 1981). Flatfish bearing epidermal papillomas do occur in both Commencement Bay and Elliott Bay according to Malins et al. (1980).

4.4 CONCLUSIONS

COBS sampling did not indicate an obvious preference of marine fish toward any specific waterway or any area of shoreline along Commencement Bay. A variety of species was found to be present in all areas sampled, including each waterway.

Although each waterway presents a relatively enclosed industrialized area, as opposed to Commencement Bay stations, there is a variety of habitats among these waterways. These habitats encompass a wide range including very shallow water (Wheeler Osgood), substrates with high organic content (Sitcum), and high concentrations of fresh water (Puyallup River). A cursory analysis of results at these individual waterways provided no obvious differences. Therefore, these waterways were grouped together in comparing catches with the shoreline area of Commencement Bay. The Commencement Bay shoreline stations included undeveloped shoreline, residential, developed shoreline, and industrial development.

English sole, flathead sole, and Pacific staghorn sculpin were found to be in greater abundance in the waterways than along the shorelines of Commencement Bay. Rock sole showed an opposite preference and were more abundant in Commencement Bay. Other species, which were sampled in much lower numbers, also were more abundant in waterway catches or Commencement Bay catches. Those being more abundant in the waterways include eelpouts, tomcod, shiner surfperch, and snake prickleback. Those being more abundant in Commencement Bay include C-O sole, speckled sanddab, and white/spotted greenling. Perhaps this difference in abundance indicates a preference of one type of habitat versus another.

COBS sampling indicated much higher numbers of fish present during summer than any other season of the year. Autumn was slightly higher than winter and spring which were comparable to each other in terms of number caught. The size of fish caught was not found to vary much from season to season. We did not see a recruitment of smaller fish into the flatfish population after their late winter spawning season. Perhaps the young juveniles prefer a more shallow water habitat. Flatfish collected in beach seine sampling conducted in the Commencement Bay study area were typically found to be less than 100 millimeters, a size comparable to juveniles.

The overall condition of fish sampled appeared to be good. The nematode worm Philometra americana was present occasionally in some species of flatfish, but in no greater abundance than comparable areas of Puget Sound.

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APPENDIX A

**LOCATIONS OF FISH SAMPLING STATIONS
IN COMMENCEMENT BAY, 1980**

APPENDIX A

Sheet 1 of 2

JUVENILE SALMONID SAMPLING STATIONS

<u>Station</u>		<u>Longitude</u>	<u>Latitude</u>
Beach Seine			
B1	Hylebos Near Head	122°22'15"	47°16'10"
B2	11th Street Bridge	122°23'20"	47°16'40"
B3	Hylebos Mouth	122°24'25"	47°17'20"
B4	Browns Point	122°25'40"	47°17'45"
B5	Old Tacoma	122°27'40"	47°16'30"
B6	City Waterway	122°25'50"	47°15'10"
B7	Middle Waterway	122°25'40"	47°15'35"
B8	Port of Tacoma Boat Ramp	122°25'10"	47°16'15"
Purse Seine			
P11	Head of Hylebos	122°21'50"	47°15'50"
P12	Hylebos Mouth	122°24'15"	47°16'55"
P13	Old Tacoma	122°27'5"	47°16'20"
P14	City Waterway	122°26'10"	47°15'40"
P15	Milwaukee Waterway	122°25'10"	47°16'5"
P16	Mouth of Sitcum	122°25'5"	47°16'15"
P17	Head of Sitcum	122°24'40"	47°16'0"
P18	Blair Waterway	122°22'50"	47°15'30"

Marine Fish Otter Trawl Stations

<u>Station</u>	<u>Start/End</u>	<u>Longitude</u>	<u>Latitude</u>
O-1, Point Defiance	Start	122°31'20"	47°18'40"
	End	122°31'10"	47°18'35"
O-2, Asarco Pier	Start	122°30'5"	47°18'0"
	End	122°29'50"	47°17'50"
O-3, Measured Mile	Start	122°29'30"	47°17'30"
	End	122°29'15"	47°17'20"
O-4, Klinkerdagger's	Start	122°28'55"	47°17'5"
	End	122°28'40"	47°17'0"
O-5, Old Tacoma	Start	122°28'0"	47°16'42"
	End	122°27'40"	47°16'38"
O-6, City Waterway	Start	122°26'5"	47°15'35"
	End	122°25'55"	47°15'25"
O-7, Wheeler-Osgood W.W.	Start	122°25'35"	47°15'5"
	End	122°25'55"	47°15'8"
O-8, Middle W.W.	Start	122°25'50"	47°15'45"
	End	122°25'55"	47°15'55"
O-9, St. Paul W.W.	Start	122°25'45"	47°15'50"
	End	122°25'50"	47°16'3"
O-10, Puyallup River	Start	122°25'25"	47°15'55"
	End	122°25'18"	47°15'45"
O-11, Milwaukee W.W.	Start	122°25'0"	47°15'50"
	End	12°25'10"	47°16'0"
O-12, Sitcum W.W.	Start	122°24'47"	47°16'5"
	End	122°25'0"	47°16'13"
O-13, Blair W.W. 11th St. Br.	Start	122°24'10"	47°16'25"
	End	122°24'25"	47°16'30"
O-14, Blair W.W. Concrete Mfg.	Start	122°23'35"	47°16'0"
	End	122°23'45"	47°16'8"
O-15, Blair W.W. Head	Start	122°23'10"	47°15'45"
	End	122°23'20"	47°15'52"
O-16, Between Hylebos & Blair	Start	122°24'50"	47°16'52"
	End	122°24'50"	47°17'5"
O-17, Mouth of Hylebos	Start	122°24'20"	47°17'2"
	End	122°24'35"	47°17'10"
O-18, Hylebos 11th St. Br.	Start	122°23'13"	47°16'32"
	End	122°23'32"	47°16'37"
O-19, Hylebos Head	Start	122°21'58"	47°15'55"
	End	122°22'5"	47°16'5"
O-22, Brown's Pt. Marina	Start	122°25'10"	47°17'40"
	End	122°25'25"	47°17'48"
O-21, Cliff House Restaurant	Start	122°25'48"	47°17'45"
	End	122°26'5"	47°17'50"
O-22, Browns Pt.	Start	122°26'30"	47°17'55"
	End	122°26'40"	47°18'5"

APPENDIX B

SUBSTRATE DESCRIPTION OF COBS BEACH SEINE SITES
OR ADJACENT SITES*

*As described by Puyallup Nation Biologists

Appendix B: Substrate description of COBS beach seine sites
or adjacent sites

<u>COBS Station No.</u>	<u>Equivalent Puyallup Station No.</u>	<u>Substrate Composition, Site Location, Availability</u>
B-1	HY-22	Moderate to steep slope of large cobble rock and concrete riprap. Area below approximately +2 ft MLLW heavily interspersed with silt and clay. Site located on northeast side of Hylebos Waterway near Marine Technical Services. Site available at all tidal levels. Special Note: Numerous metal and debris snags at site.
B-2	HY-18	Moderately sloped with a small vertical bank above approximately +8 ft MLLW. Area from approximately +8 ft to -6 ft MLLW primarily washed sand and clay. Vertical drop to approximately -6 ft MLLW. Site located just inside the 11th Street Bridge. Site available only at tidal levels below approximately +8 ft MLLW. Special Note: Beach seine fishes over dredged channel.
B-3	HY-1 and 2	Shallow sloped with primarily washed sand above approximately +2 ft MLLW. Below approximately +2 ft MLLW, substrate is primarily soft wash sand combined with a limited amount of soft silt. Attached algae and eelgrass at greatest depths. Sites located along northeast mouth of Hylebos Waterway. Sites available at all tidal levels.

<u>COBS Station No.</u>	<u>Equivalent Puyallup Station No.</u>	<u>Substrate Composition, Site Location, Availability</u>
B-4	CH-1	Moderately sloped with well washed cobble rock and gravel. Area below approximately -2 ft MLLW primarily well compacted sand. Sand area has a high amount of attached algae. Site located below the Cliff House Restaurant, Marine View Drive. Site available at all tidal levels.
B-5	RW-1	Gradually sloped with cobble rock and gravel. Area below approximately -2 ft MLLW compacted sand intermixed with cobble. Site located at Ruston Way Park and available at all tidal levels.
B-6	CW-1	Area above approximately +5 ft MLLW concrete riprap with silt/mud, mud intermixed with sand. Area below approximately 0 ft MLLW soft mud with intermixed organic debris and attached algae. Site located at the mouth of Wheeler-Osgood Waterway. Available only at tide below +5 ft MLLW.

<u>COBS Station No.</u>	<u>Equivalent Puyallup Station No.</u>	<u>Substrate Composition, Site Location, Availability</u>
B-7	MD-3	Overall gentle sloped, area above approximately +4 ft MLLW mud intermixed with sand and scattered cobble, small riprap chunks. Area below approximately +4 ft MLLW soft mud lightly intermixed with sand. Attached algae and organics (primarily wood) present. Site located on west side of Middle Waterway next to large boat house. Area available at tides lower than approximately +8 ft MLLW. Area completely under water at tides above +8 ft MLLW.
B-8	ML-5	Gentle sloped concrete slab above approximately +2 ft MLLW. Area below approximately +2 ft MLLW washed sand and mud with scattered cobbles and small concrete chunks. Attached algae to concrete slab and intermixed rocks and chunks. Site located on the end of land between Milwaukee and Sitcum Waterways. Site available at all tidal levels.

APPENDIX C

BEACH SEINE/PURSE SEINE SAMPLING DATA

Appendix C. Numbers of chinook salmon caught at each purse seine and beach seine station.

Dates	B1	B2	B3	B4	B5	B6	B7	B8	P11	P12	P13	P14	P15	P16	P17	P18	Total
3-31								-	-	-	-	-	-	-	-	-	0
4-7	1							-									1
4-10	7	24	2	3													36
4-14	1	-	-	-	1		1	14									17
4-18	1	1					-								1	-	3
4-21	5+				1	2							2				10
4-28	1						-	15							1	-	17
5-8	1+	-	-	-	-	3	-	-					6	-			10
5-12		15*	-	-		4	-	64					9				92
5-16		1*	-	14		-	-	244					2	-	5	-	266
5-20	-			33	5	9	10	472	2*			5	8	-	2	-	546
5-28	4	20		10	1	15	-	5		2	-	47			96	2	202
6-5	1	2	8	12	2	-	2	40	7	1	-	3	39	-	2	3	122
6-12	6	3	4	36		1	19	40	2	1	11	11	76	4	7	3	224
6-19		3	-		3	3	-	8	4	10	1	5	3	2	32	3	77
6-25	3	2				3	15	13	1			8	14	2	6		67
7-2	1	3	1			4	7	1			67	6	4		8		102
7-9	1	2	1				2					6					12
7-23		2	-	1											1		4
TOTAL																	1808

- = Not sampled
+ = Marked with red pigment
* = Marked with orange pigment

Appendix C. Numbers of pink salmon caught at each purse seine and beach seine station.

<u>Dates</u>	<u>B1</u>	<u>B2</u>	<u>B3</u>	<u>B4</u>	<u>B5</u>	<u>B6</u>	<u>B7</u>	<u>B8</u>	<u>P11</u>	<u>P12</u>	<u>P13</u>	<u>P14</u>	<u>P15</u>	<u>P16</u>	<u>P17</u>	<u>P18</u>	<u>Total</u>
3-31		1						-		-	-					-	1
4-7		1	1	5	1	1		-								-	9
4-10		4	3	4	73					26	4					-	114
4-14		-	-	-	1	2								1		-	4
4-18		70		316	6		-	4	8							-	404
4-21		138+					1	7				6	17			-	169
4-28		1	1				-									-	2
5-8	1+	-	-	-	-	2	-	-						-	1	-	4
5-12		2*	-	-		3	-									-	5
5-16		-	-	1		-	-							-		-	1
5-20	1*	-				1		1						-		-	3
5-28					1		-			1	-						2
6-5						-					-			-			0
6-12												1					1
6-19		-					-										0
6-25																	0
7-2										3							3
7-9												1					1
7-23			-														0

TOTAL

723

- = Not sampled
+ = Marked with red pigment
* = Marked with orange pigment

Appendix C. Numbers of chum salmon caught at each purse seine and beach seine station.

Dates	B1	B2	B3	B4	B5	B6	B7	B8	P11	P12	P13	P14	P15	P16	P17	P18	Total
3-31								-	-	-	-	-	-	-	-	-	0
4-7		4						-								-	4
4-10	2	19														-	21
4-14		-	-	-				1								-	1
4-18		20		17												-	37
4-21		1+						4				2	2			-	9
4-28	2							-				1				-	3
5-8		-		-	-	1	-	-						-		-	1
5-12		2*	-	-		4	-	1								-	7
5-16			-	29		-	-							-		-	29
5-20	1*	-								1				-		-	2
5-28								-			-						0
6-5					1	-					-					1	1
6-12												1			1		2
6-19			-					-							2		2
6-25												5					5
7-2											1		1				2
7-9												10					10
7-23			-														0
TOTAL																	136

- = Not sampled
+ = Marked with red pigment
* = Marked with orange pigment

Appendix C. Numbers of coho salmon caught at each purse seine and beach seine station.

<u>Dates</u>	<u>B1</u>	<u>B2</u>	<u>B3</u>	<u>B4</u>	<u>B5</u>	<u>B6</u>	<u>B7</u>	<u>B8</u>	<u>P11</u>	<u>P12</u>	<u>P13</u>	<u>P14</u>	<u>P15</u>	<u>P16</u>	<u>P17</u>	<u>P18</u>	<u>Total</u>
3-31								-	-	-	-	-	-	2	2	-	2
4-7					1			-								-	1
4-10																-	0
4-14					1											-	1
4-18																-	0
4-21										3						-	3
4-28					1			-								-	1
5-8								-		1						-	1
5-12		8*			2	1		3								-	14
5-16		1		2											1	-	4
5-20				3		1	4				15				1	-	24
5-28		4			1											-	5
6-5							1									-	1
6-12																-	0
6-19																-	0
6-25																-	0
7-2												1				-	1
7-9								1								-	1
7-23																-	0

TOTAL

59

not counted

AD-A112 554

DAMES AND MOORE SEATTLE WA*

F/G 8/1

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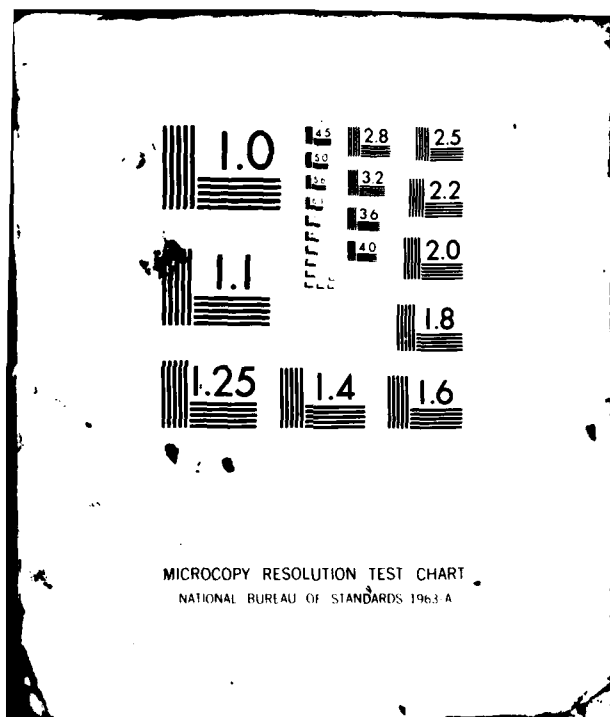
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APPENDIX D

OTTER TRAWL SAMPLING DATA

Station numbers

[illegible]

1 = one-half tow length

Sampling Period 10/13/80 to 10/16/80
Otter trawl, Commencement Bay

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Total
longnose skate									1										*				1
ratfish											3					3		1	*				7
Pacific herring						1					2		3	1		3			*				10
surf smelt											3	3		4	1				*				11
plainfin midshipman											1								*				1
Pacific hake						1					1				1				*				3
Pacific tom cod						14					8		2	4			1	1	*				40
blackbelly eelpout						13					6	1	3	2			1		*				26
tube-snout						2													*				2
shiner perch						33			2		5	1	1	6	2		6	3	*		1		60
striped seaperch	2							1											*				4
pile perch						4											2		*				7
snake prickleback						34					1					1	5	2	*				43
red gunnel																			*		1		1
Copper rockfish																			*				1
Whitespotted greenling																			*				3
Pacific staghorn sculpin			1		2	14	1	2	2	2	9	1	2	4	1		1	3	*	1		1	62
grunt sculpin																	7	10	*			2	2
unidentified sculpins																			*	1			1
cabezon																			*				1
Sturgeon poacher -																			*				1
speckled sanddab	1							3											*				1
flathead sole		1	1			4					17		3	8	1	1	1		*				11
rock sole	2		2	1	1	1		2	10							2	18		*				41
Dover sole											3		1						*	2	3		53
English sole	5		1			31	4		26		9	5	5	5	1	2	18	11	*				4
starry flounder											1						1		*	4			126
C-O sole	1																		*		1		2
sandsole											1								*			3	5
																			*				1

* = Nothing caught water too deep

Species	Station numbers																						Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
ratfish											2	+							*				
Pacific herring						105		9				+						2	1	*			
surf smelt						3		1		1		+							*				
Pacific tom cod								1				+							7	*			
blackbelly eelpout	1											+		1					*				
snake prickleback						1						+						2	*				
red gunnel												+						1	*				
Copper rockfish												+					1		*		1		
Whitespotted greenling		1										+							*				
Pacific staghorn sculpin								2	3		5	+						1	10	*			
unidentified sculpins	1											+								*	2		
speckled sanddab	1			1	1							+					2			*	1		
flathead sole						3						+	5	2	1					*			
rock sole	4			5	1	6			1			+				4			1	*	6		
English sole					5	18	7	5	8		30	+	8	1	1	3		2	11	*	1		
starry flounder							2	1		8		+					1		*				
C-O sole	1											+							*		1		
sandsole								1				+	2				1		*				
												+					1		*				

* = Nothing caught, net off bottom

+ = no catch, net hung at end of tow

l = one-half tow length

Sampling Period 3/31/81 to 4/2/81
Otter trawl, Commencement Bay

Species	Station numbers																						
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>	<u>17</u>	<u>18</u>	<u>19</u>	<u>20</u>	<u>21</u>	<u>22</u>	Total
ratfish							1			1			*								1	3	
Pacific tom cod													*			1							1
northern ronquill		2											*										2
snake prickleback					1								*										1
Copper rockfish									1				*									2	3
Pacific staghorn sculpin	2	8	1					1					*		2		1			2	3		20
unidentified sculpins													*				1						1
cabezon	1												*										1
speckled sanddab			3	1									*			1	1						6
flathead sole			9	7	2	1		2		1			*			2	3						2
rock sole													2	*								2	29
Dover sole			2			15	5	3	21		21	1	3	*	1	1	2	1	6	2	1	1	1
English sole						1	3			6	1		*	*								2	87
starry flounder			3										*	*								2	11
C-O sole								3			4		*	*								2	5
sandsole													*	*	1								8

* = Nothing caught, net was on bottom.

TECHNICAL REPORT

WETLANDS

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1.0 INTRODUCTION

The scope of the Wetlands Technical Report is responsive to Section 3.5 of the Corps' Commencement Bay Studies (COBS) Statement of Work (SOW), which establishes that the purpose of the wetlands study is to:

- Identify, classify, and map the wetlands within the study area.
- Evaluate the functional characteristics of those wetlands.
- Identify locations within the study area where wetlands might be created or enhanced.

The basic intent of this study is to identify wetlands remaining within the Commencement Bay study area and to provide information necessary to determine the ecological significance of these habitat types. With these data, it is possible to determine the more valuable habitats within the area.

The last objective in the wetlands study involves the evaluation of locations within the study area in which wetlands might be created or enhanced. This effort involved both the general approach to wetlands enhancement and creation, as well as the discussion of some specific sites suited to now-known creation and enhancement methods. The scope of this study was not intended to go into the depth of evaluation required to fully understand the tradeoffs involved in wetlands creation or enhancement at any particular site. It is important to recognize that while wetlands creation or enhancement may occur in the future, extensive data collection and experimentation, as well as consensus among the resource/regulatory agencies and the Puyallup Nation, will be necessary to confirm the value of such activities.

The Wetlands Technical Report is divided into two major sections: the first is an inventory of wetlands within the Commencement Bay study area; the second investigates areas which might be converted to wetlands habitats should a future requirement exist to enhance existing wetlands or replace wetlands lost in development activities in the study area.

The general history of the filling of wetlands in the Commencement Bay study area is described in Section 1.5.3 of the Land and Water Use Technical report.

2.0 METHODS

The study was initiated by reviewing 1:12,000 color aerial photographs of the area taken on April 20, 1979. These were analyzed for the colors and textures (signatures) which might indicate the presence of wetland habitat types. Field investigations were then conducted in July and August 1980 to confirm the presence of wetland habitat types. During field investigations, wetlands were mapped on 1:6,000 base maps, plant species were collected and identified, and functional characteristics, such as wildlife use or hydrologic characteristics, were noted.

From information gathered in the field, finished maps and descriptions of the habitat types were developed. The size of these maps, which comprise Figures 1 through 13, and the level of detail with which the wetlands are depicted precludes reduction of these maps to a size suitable for presentation in this report. However, the maps are located at the offices of the Environmental Resource Section of the U.S. Army Corps of Engineers, Seattle District. Habitat type descriptions can be found in the Results section of this report.

3.0 RESULTS

3.1 HABITAT TYPES

Commencement Bay is a large deepwater embayment located in southern Puget Sound and forming the northern edge of the City of Tacoma. The study area includes the entire bay, to Point Defiance and Browns Point, and adjacent land to the north and south. Also included in the study area are the lowlands southeast of the bay; these are the historic floodplains of Hylebos Creek and the Puyallup River, both of which empty into Commencement Bay.

Commencement Bay, Tacoma, and the adjacent lowlands have a long history of serving as port facilities. Historically, finger piers extended to deep water, providing moorage and sometimes warehouse facilities for cargo vessels. Since the late 1940s, extensive filling and dredging activities have occurred in the mudflats and floodplains of the area, creating the broad expanses of flat land necessary for modern port facilities. Prior to industrialization, the then-pristine Puyallup River delta was important to both fish and wildlife as well as the people of the Puyallup Nation who then inhabited the study area.

Six major wetland habitat types have been recognized in the Commencement Bay study area. These are:

- Open Water
- Unvegetated Intertidal Areas
- Salt Marsh
- Brackish Marsh
- Fresh Marsh
- Swamp

Through the course of the study, most of these categories have been subdivided to reflect the variations in habitat type noted within the study area. In the following discussion, each category will be discussed in general terms, followed by a detailed description of each habitat type.*

*Several recent sources have indicated that the wetlands described herein, which are based upon the July-August 1980 field surveys, have been partially or completely filled since 1980. An expanded field survey will be required to accurately map the extent of this new fill and associated wetland losses.

The location of each wetland habitat type has been mapped on Figures 1 through 13 which, as indicated in Section 2.0, are located in the Corps offices. A summary of each habitat type is presented in Table 1.*

Field reconnaissance and map investigations indicated that shorelines were mostly very steep, and were mostly bulkheaded or riprapped. Vegetation is limited to macroalgae; invertebrate organisms appear to dominate most of the rock, piling, or concrete substrate.

3.1.1 OPEN WATER

3.1.1.1 General

Open water areas may be covered by 1 to 100 feet of either salt or fresh water. When influenced by tidal action, the upper limit of this type of habitat is defined by mean lower low water (MLLW). Generally, such areas have few vascular plants; attached or floating algae may be common in shallow sites. Eelgrass may occur at scattered sites in this habitat. Two extremely small (probably less than 0.5 acre total area) eelgrass areas have been reported by the Puyallup Nation (Deming 1981). They are located at the mouth of Hylebos Waterway and between the mouths of City and Middle Waterways. Large concentrations of eelgrass and attached red and brown algae have been reported by the Puyallup Nation along the Ruston Way shoreline (Thayer 1981).

3.1.1.2 Open Water, Bay

This habitat consists of all the subtidal marine waters of Commencement Bay, including the various waterways of the Port of Tacoma. Water depth may vary to 100 feet or more in the center of the bay. In shallow nearshore areas, some attached algae may be found but in general, the habitat type is unvegetated.

*The southwest shoreline of the bay from the mouth of City Waterway to Point Defiance has not been included in the mapping project.

TABLE 1

COMMENCEMENT BAY STUDY AREA HABITAT TYPES

Sheet 1 of 3

Habitat Type (a)	Vegetative Composition (b)		NWI Classification (c)	Areal Extent (acres)
	Common Name	Scientific Name		
Open water, bay	unvegetated		Marine (d), subtidal unconsolidated mud bottom	--
Isolated pond	unvegetated		Palustrine, unconsolidated bottom, semi-permanently seasonally flooded	10.6
Pond	unvegetated		Palustrine, unconsolidated bottom, permanently flooded	3.6
Tidal rivers/creeks	unvegetated		Riverine, tidal, unconsolidated mud bottom	117.4
Intertidal flat	some may support heavy populations of green algae		Estuarine, intertidal unconsolidated shore, regularly flooded	94.4

(a) Each community is titled after dominant and characteristic plant species and/or major geographic or hydrologic characteristics.

(b) Major vegetation in each community are those of high dominance or frequency. Not all plants of the community are listed. Generally, the plants are listed in order of importance. Occ or occasional refer to frequency of occurrence within this habitat.

(c) National Wetlands Inventory (NWI) classification is given for each community. Divisions of the hierarchical classification are listed in descending order--system, subsystem, class; subclass, water regime modifiers; other modifiers (Cowardin et al. 1979).

(d) Puget Sound and adjacent bays might be classed as either marine or estuarine according to NWI. No determination on this has been made yet by U.S. Fish and Wildlife Service.

TABLE 1 (Continued)

Sheet 3 of 3

Habitat Type (a)	Vegetative Composition (b)		NWI Classification (c)	Areal Extent (acres)
	Common Name	Scientific Name		
Intertidal beach	unvegetated		Marine (d), intertidal unconsolidated shore, regularly flooded	3.0
Salt marsh, high	pickleweed saltgrass jaumea (occ) (e) baltic rush (occ) bulrushes (occ) sedge (occ)	<u>Salicornia virginica</u> <u>Distichlis spicata</u> <u>Jaumea carnosa</u> <u>Juncus balticus</u> <u>Scirpus</u> spp. <u>Carex</u> sp.	Estuarine, intertidal persistent emergent, regularly flooded	5.4
Salt marsh, low	arrowgrass pickleweed (occ) saltgrass (occ)	<u>Triglochin maritimum</u> <u>Salicornia virginica</u> <u>Distichlis spicata</u>	(same as above)	0.7
Salt marsh, mixed	includes both high and low salt marsh vegetation		(same as above)	4.5
Brackish marsh	cattail canarygrass sedge willow silverweed	<u>Typha</u> spp. <u>Phalaris arundinacea</u> <u>Carex</u> spp. <u>Salix</u> spp. <u>Potentilla pacifica</u>	Estuarine, intertidal persistent emergent, regularly or irregularly flooded	2.9
Cattail marsh	cattail	<u>Typha</u> spp.	Palustrine, persistent emergent, intermittently exposed or semiper- manently flooded	11.9

(e) Occasional.

TABLE 1 (Continued)

Habitat Type (a)	Vegetative Composition (b)		NWI Classification (c)	Areal Extent (acres)
	Common Name	Scientific Name		
Redtop/rush marsh	redtop	<u>Agrostis alba</u>	Palustrine, emergent persistent, seasonally flooded-saturated	8.6
	soft rush	<u>Juncus effusus</u>		
	spike rush (occ)	<u>Eleocharis palustris</u>		
Mixed seasonal fresh marsh	redtop	<u>Agrostis alba</u>	Palustrine, emergent persistent, seasonally flooded	53.0
	saltgrass	<u>Distichlis spicata</u>		
	baltic rush	<u>Juncus balticus</u>		
	soft rush	<u>Juncus effusus</u>		
	velvet grass (occ)	<u>Holcus lanatus</u>		
	ladies tresses	<u>Spiranthes</u>		
	(occ)	<u>romanzoffiana</u>		
Reedgrass marsh	reedgrass	<u>Phragmites communis</u>	Palustrine, emergent persistent, seasonally flooded-saturated	2.4
Seasonal pond/ spike rush	small spike rush	<u>Eleocharis parvula</u>	Palustrine, emergent persistent, seasonally flooded	5.6
	common spike rush	<u>Eleocharis palustris</u>		
Fresh marsh, tidal	cattail	<u>Typha</u> spp.	Palustrine, emergent persistent, regularly flooded	10.1
	canarygrass	<u>Phalaris arundinacea</u>		
	common spike rush	<u>Eleocharis palustris</u>		
	redtop	<u>Agrostis alba</u>		
	saltgrass (occ)	<u>Distichlis spicata</u>		
Shrub swamp	spiraes	<u>Spiraea douglasii</u>	Palustrine, scrub-shrub wetland, broad-leaved deciduous, seasonally flooded-saturated	1.8
	common spike rush	<u>Eleocharis palustris</u>		
	redtop	<u>Agrostis alba</u>		

3.1.1.3 Isolated Pond

Numerous isolated ponds, encompassing a total of about 11 acres, are scattered around the Commencement Bay study area. They are generally shallow; although designated as open water at the time of investigation (June 1980), many may go dry by late summer. Rainfall and local runoff are the only source of water for these sites. Substrate may vary, but it often consists of dredged material or "hog fuel" (wood waste). In the study area, isolated ponds often serve as catch basins and may be highly polluted from upland runoff associated with industrial activities, particularly chemical plants and logging operations.

3.1.1.4 Pond

In addition to the isolated ponds, there are other ponds with a regular input of fresh water. They may be large drainage ditches, or portions of a small creek where flow velocities are extremely low. The creek supplying these areas may go dry during late summer, but probably not every year. These habitat types are frequently characterized by open water surrounded by cattails. About 4 acres of this habitat type were found in the study area.

3.1.1.5 Tidal Rivers and Creeks

All of the Puyallup River within the study area exhibits tidal fluctuation; however, only the lower reaches of Hylebos Creek are tidal. Despite tidal fluctuations, surface waters are generally not saline due to freshwater runoff. These tidal freshwater areas have little vegetation except in the shallow intertidal areas where cattails and canarygrass (Phalaris arundinacea) may thrive. Freshwater flows appear to be great enough in both these watercourses to preclude the establishment of brackish vegetation anywhere but at the mouth. Tidal creeks and rivers comprise 117 acres of the study area.

3.1.2 UNVEGETATED INTERTIDAL AREAS

3.1.2.1 General

Unvegetated intertidal areas are regularly exposed and inundated by tidal waters. They are usually unvegetated or contain sparse populations of attached algae.

3.1.2.2 Intertidal Flats

These flat areas, generally located above MLLW are probably exposed and inundated at least once a day. They are found only in protected low energy locations. The substrate is usually mud or sand and may support extensive algal populations in some areas; benthic invertebrates dominate the community. About 94 acres were mapped within the study area. Many of the largest areas are impacted by log rafting. In this study, the intertidal flat/open water boundary has been based on an interpretation of current NOS charts; substrates are constantly changing and exact boundaries may fluctuate.

3.1.2.3 Intertidal Beach

The sloping intertidal shore area is an unvegetated transition zone between upland and open water, bay habitat types (above MLLW). The well-exposed and moderate-energy (relative to Puget Sound) habitat, is most common along the north shore of the bay, where sea walls and residential construction constitute an abrupt edge to the aquatic environment. The substrate may vary from sand to gravel or cobble and usually supports little vegetation, either vascular or macroalgal.

3.1.3 SALT MARSH

3.1.3.1 General

In more protected and higher intertidal areas, salt marsh communities may occur. Generally found only in the upper 2 feet of the intertidal zone, these communities are most common in Hylebos Waterway. Even there, however, they account for only about 11 acres.

3.1.3.2 Salt Marsh (High)

This community is characterized by a mixture of pickleweed (Salicornia pacifica) and saltgrass (Distichlis spicata), with occasional scattered areas of jaumea (Jaumea carnosa) and baltic rush (Juncus balticus). The upper reaches of the community may contain some bulrushes (Scirpus spp.) or sedge (Carex sp.), especially in areas with upland runoff. This salt marsh is generally inundated about once a day.

3.1.3.3 Salt Marsh (Low)

At lower elevations, this salt marsh community is dominated by arrowgrass (Triglochin maritimum), although saltgrass and pickleweed may be present in small amounts. The arrowgrass marsh is generally dense at high elevations in the community but sparse in the lower reaches. The community is probably inundated twice a day.

3.1.4 BRACKISH MARSH

Tidal areas with extensive freshwater influence are identified as brackish marshes. Although they are tidal, any saline intrusion is probably minimal and limited to low flow situations in late summer. Thus, the vegetation tends to be that often associated with freshwater marshes. Cattails (Typha spp.) and canarygrass are the most common species, although sedge and willow (Salix spp.) may also be found. At the lowest elevations, silverweed (Potentilla pacifica) may also be present, though never as a major component. The two brackish marshes in the study are cover about 3 acres.

3.1.5 FRESH MARSH

3.1.5.1 General

Isolated freshwater marshes are the most common and diverse vegetated wetland type in the study area, covering a total of 92 acres. Many of these marshes, especially between the waterways, are found in isolated depressions in the undeveloped fill within the port area. Some of these

areas are inundated or saturated throughout the year; others have only seasonal open water with surface water drying up in summer. Climatic cycles and trends are a key influence on the seasonality and extent of surface water in these marshes. The diversity of plant communities is probably a function of the variations in hydrologic characteristics.

3.1.5.2 Cattail Marsh

Cattails may be the best known of the freshwater wetland plants. They are common in drainage ditches, adjacent to or interspersed within ponds and elsewhere where water levels remain at between 6 inches and 2 feet through much of the year. Cattail stands tend to be monotypic with few, if any other, species present; they cover 11.9 acres.

3.1.5.3 Redtop/Rush Marsh

These are apparently seasonal wetlands found occasionally in the study area. Redtop (Agrostis alba) and soft rush (Juncus effusus) are the dominant species here. Spike rush (Eleocharis palustris) may also be common. Although the area is only wet for a portion of the year, that time is evidently sufficient to preclude the weedy upland grasses which are prevalent in adjacent areas. About 9 acres of this marsh type were identified in the study area.

3.1.5.4 Mixed Seasonal Marsh

In the eastern portion of the study area are several sites containing a mixed community of redtop and saltgrass, totaling 53 acres. Large patches of baltic rush and clumps of soft rush are widely scattered. Smaller patches of stunted sedge may also be found. Velvet grass (Holcus lanatus), dandelions, and the delicate orchid, ladies tresses (Spiranthes romanzoffiana) may be sparsely distributed. These sites are seasonally wet and notably inundated with runoff throughout the winter and spring.

3.1.5.5 Reedgrass Marsh

Reedgrass (Phragmites communis) is found in small monotypic stands in several locations around the study area, totaling about 2.5 acres. Inundation is probably seasonal in most of these areas.

3.1.5.6 Seasonal Pond/Spike Rush Marsh

In the study area, 6 acres of this wetland type occur in low-lying, central portions of mixed seasonal marshes. In winter and spring, rainfall and storm water runoff fill these low spots, creating an isolated open-water pond habitat. By mid- to late summer, surface water evaporates, the water table drops, ponds dry up, and mudflats are exposed. Where a salty crust or filamentous algal mat is present to slow evaporation of subsurface water, the small spike rush (Eleocharis parvula) and common spike rush may invade the area, encroaching from the edge of the pond. In the lowest spots, deep polygonal cracking may become a key feature as drying occurs.

3.1.5.7 Tidal Freshwater Marsh

Tidally influenced wetlands in the study area are associated with the Puyallup River; they occupy 10 acres. These areas are affected daily by tidal changes. A more detailed discussion of this major expanse of tidal freshwater marsh, identified as the 11th Street Bridge Tidal Marsh, occurs in the following section, Description of Particular Sites. Cattail, common spike rush, redtop, and occasionally saltgrass can be found here. Tidal marsh also occurs in small bands along the banks of the river; canarygrass and cattail cover this area.

3.1.6 SWAMP

Wetlands which are dominated by woody vegetation are referred to as swamps. Although surface water and/or saturated soils may be present during portions of the winter and early spring, swamps can become quite dry in the summer months. The shrub, spiraea (Spiraea douglasii), dominates the almost 2 acres of small, isolated swamps scattered within the Commencement Bay study area. Common spike rush or redtop may be found in association with these spiraea swamps.

3.2 DESCRIPTIONS OF PARTICULAR SITES

3.2.1 GENERAL

There are several wetland areas within the Commencement Bay study area that have been identified as having unique or otherwise important functional characteristics, such as wildlife habitat, collection and storage of urban and storm water runoff, potential water quality enhancement, or detrital export. These have been identified as:

- Bonneville Power Administration wetlands (Figure 4)*
- 11th Street Bridge tidal marsh (Figure 10)
- Milwaukee Way seasonal marsh (Figure 10)
- Port of Tacoma land seasonal marsh (Figures 4, 5, 8)
- Tacoma City Light wetland complex (Figure 3)
- Hylebos salt marshes and intertidal flats (Figures 2, 3)
- Pacific Highway cattail marsh/pond (Figure 11)

Some of these areas contain several wetland types while others contain expanses of a particular wetland type. A general description of these areas follows. Detailed mapping is shown on the figure identified in parentheses following each site listed above.

3.2.2 BONNEVILLE POWER ADMINISTRATION (BPA) WETLANDS

Two wetland complexes were found near the BPA power substation. An isolated, seasonal pond marsh complex is located southeast of the substation near the intersection of Marshall Avenue and the East-West Throughway. It covers 4.5 acres and is situated in a depression in hog fuel fill and dredged material. Clumps of emergent vegetation, such as spike rush, cattail, and soft rush, are interspersed throughout the pond. A dike separates the pond from a seasonal marsh. This marsh is covered mainly by spike rush and redtop, although rushes and sedges also occur. An area of unvegetated fill abuts this marsh. The pond and marsh appear to provide important waterfowl nesting and feeding habitat; passerines, shorebirds, and wading birds such as the great blue heron also feed or rest in this area.

*As indicated in Section 2.0, Figures 1 through 13 are located in the Corps Seattle District offices.

Southwest of the substation is a 7-acre wetland system composed of open water, cattail marsh, and seasonal marsh. Most of the area is diked and drains into Hylebos Waterway. Although adjacent to both the substation and Kaiser, this wetland appears to be well used by waterfowl for feeding and nesting. Herons were also observed feeding in the shallows around the edges. The seasonal marsh is probably used for feeding by shorebirds in the winter and spring. Small mammals may also be common in and around the area.

3.2.3 11TH STREET BRIDGE TIDAL MARSH

This freshwater tidal wetland lies east of 11th Street and behind the dike which runs along the northeast shore of the Puyallup River, encompassing 9.6 acres.* Cattail, spike rush, bulrush, redtop, and occasional saltgrass cover the marsh areas and border the relict tidal channels. Scrubby upland areas of blackberry, curlydock, teasel, and smartweed occupy the central and peripheral areas; in addition, deciduous trees occur on the dike and at the north end of this site (cottonwood is the main species). A broken tidegate and culvert under the dike connect this wetland to the Puyallup River and allow a daily inflow and outflow of tidal river waters. Because of its tidal character, water quality enhancement (i.e., sediment removal) and detritus export are probably significant in this wetland. The presence of adult and juvenile mallards indicate the importance of this area in providing waterfowl habitat for nesting and feeding. Passerine and wading birds may also utilize this area for food. Interspersion of shrub and wooded upland habitat provide nesting and cover for many species of birds and small mammals, several of which may require both wetland and upland habitats.

3.2.4 MILWAUKEE WAY SEASONAL MARSH

An expanse of seasonal freshwater marsh extends south from Marshall Avenue along the west side of Milwaukee Way; at the northern end, seasonal marsh also occurs east of Milwaukee Way. In all, it covers

*Thayer (1981) reports these wetlands are presently filled to some degree which would reduce these July-August 1980 area measurements.

about 25 acres.* Broad flat areas of spike rush and redtop are interspersed with small shallow ponds, mudflats, and a cattail marsh. Resting and feeding use by shorebirds, wading birds, and waterfowl is expected, due to the seasonal supply of water and expanse of mudflats. Sign of raccoon were noted. Its seasonal nature also indicates its potential value in urban runoff storage, although storm sewer drainage near this marsh has not been assessed.

3.2.5 PORT OF TACOMA LAND SEASONAL MARSH

To the south of the East-West Throughway/Marshall Avenue intersection lies a broad expanse (12 acres) of seasonal marsh.* Redtop and saltgrass cover most of the marsh with large patches of rushes interspersed; occasional clumps of sedges, common spike rush, and velvetgrass are scattered across the site. This area appears to be an important storage area for storm water runoff from the surrounding uplands. The presence of open water during the winter and early spring is valuable to waterfowl for resting and feeding. As the marsh dries out by mid-summer, its value as cover and nesting habitat for small mammals such as shrews and field mice increases.

3.2.6 TACOMA CITY LIGHT (TCL) WETLAND COMPLEX

A series of diverse habitat types is located between Taylor Way and Alexander Avenue near the TCL substation. Spiraea swamp and a small seasonal marsh of spike rush and redtop occupy the northeast portion of this site. Southwest of the swamp there is upland habitat of grasses and cottonwoods. An expanse of cattail marsh occupies the northwestern end of the area, and the southeastern portion is a seasonal wetland of spike rush and soft rush, with small patches of young willow and cottonwood interspersed. The seasonal availability of standing water, the combination of wetland and upland habitats, and the diversity of vegetation types (i.e., herbage, shrubs, and trees) all combine to provide valuable habitat for a diversity of wildlife. Passerine birds that forage on insects and seeds utilize the cattail marsh and shrub

*Thayer (1981) reports this wetland is presently filled to some degree which would reduce these July-August 1980 area measurements.

swamp; wintering waterfowl may utilize the open water areas for resting and feeding; small mammals, including squirrels, muskrat, and raccoons, may find both food and nesting habitat in this diverse area. Wetlands on this site cover a total of 4.1 acres, including 1.7 acres of spiraea swamp and 1.8 acres of cattail marsh.

3.2.7 HYLEBOS SALT MARSHES AND INTERTIDAL FLATS

Along the northern side of Hylebos Waterway, downstream of Lincoln Avenue, several areas of salt marsh and intertidal flats occur. (There are about 80 acres total, including 69.5 acres of intertidal flat and 10.5 acres of salt marsh.) The flats are unvegetated and in many spots are covered by log rafts. The main value of these salt marsh/intertidal flat areas is their uniqueness in the Commencement Bay study area. Their biological habitat value is presently limited due to the considerable impact from log rafting and storage operations. Frequent tidal inundation characteristically allows detrital export from the salt marsh to fish and aquatic invertebrates in the intertidal flats. In Hylebos Waterway, use of that food resource by invertebrates may be restricted since log storage severely impacts mudflat invertebrate populations (Smith 1977) and may also block detrital transport to open water areas. Both Meyer and Vogel (1978) and the COBS Invertebrate Studies Technical Report indicate high invertebrate production in mud substrate areas near the 11th Street Bridge in Hylebos. This area also appears to be feeding and resting habitat for geese and waterfowl; passerines, shorebirds, and wading birds are also found here.

Small intertidal flats exist in other areas such as Wheeler Osgood (see Section 3.5.7.2).

3.2.8 PACIFIC HIGHWAY CATTAIL MARSH/POND

This series of open water ponds surrounded by cattail marsh is located in an area of marginal agricultural land near Milwaukee Way and Pacific Highway. Since the ponds are all connected by creeks, they actually function together as a single, interconnected system which covers 3.9 acres. This setting provides isolation from nearby heavy

Industry. Cattails provide protective cover and food for many species of birds and animals. Wading birds (including green herons and great blue herons) rest in this area, and waterfowl probably nest and feed here. Muskrats commonly build lodges from, and feed on, cattails; raccoons probably forage here also.

3.3 WETLAND HABITATS - FUNCTIONAL CHARACTERISTICS

3.3.1 GENERAL

Functional characteristics of wetlands have been identified in Corps regulations (33 CFR 320.4) and further described in other Corps documents (Reppert et al. 1979, U.S. Army Corps of Engineers 1978). Those characteristics include:

Primary Functions

- Food chain production (primary and secondary production, detrital export)
- Habitat
- Aquatic study areas, sanctuaries, and refuges
- Hydrologic support
- Shoreline protection
- Storm and flood water storage
- Natural ground water recharge
- Water purification

Cultural Values

- Commercial fisheries
- Renewable resources and agriculture
- Recreation
- Aesthetics
- Other special values

Detailed descriptions of these functions may be found in the Snohomish Estuary Wetlands Study (U.S. Army Corps of Engineers 1978) and are appended to this report (Appendix A).

Not all functional characteristics identified by Corps regulations are well represented in any specific wetland. The following discussion attempts to describe, in a qualitative manner, the extent to which each

functional characteristic may be exhibited or performed by each wetland habitat type identified within the study area. Productivity, wildlife and fish utilization, aquatic interaction, and areal extent are major components of the discussion.

Some of the habitat types have been combined under a common heading. Because of their similarity in vegetation type and functions, the reedtop/rush, the mixed seasonal, and the seasonal pond/spike rush marsh types have been evaluated together under the title "Seasonal Marsh." Additionally, high, low, and mixed salt marshes are functionally similar and thus the section entitled "Salt Marsh" combines all three of these habitat types.

For a few habitat types, applicable productivity investigations have been performed. In many instances, however, the lack of specific investigations has resulted in a qualitative assessment of productivity. In this discussion, low productivity is defined as under 600 gm(dry)/m²/yr, medium is 600 to 1,200 gm(dry)/m²/yr, and high is over 1,200 gm(dry)/m²/yr.

3.3.2 OPEN WATER

3.3.2.1 Bay

The open water bay areas of the study site are generally unvegetated, thus primary productivity per unit area is limited to the low level (<600 gm(dry)/m²/yr) associated with the phytoplankton or algae. However, because of the large expanse of this habitat type, total production may be high. Consumers such as aquatic invertebrates and fish are supported by planktonic flora and fauna and by detritus exported to the bay from rivers and wetlands. Commencement Bay is along the migration route for Puyallup River salmonids and also serves as a rearing area for juveniles. Wintering waterfowl and shorebirds feed and rest on the bay. There is a large degree of human use on Commencement Bay for recreation such as sportfishing and boating. Eelgrass beds typically support a rich epiphytic fauna as well as providing food and shelter for a variety of fish and invertebrate species. Little is known about the extent or condition of the Commencement Bay beds; all resident fish species are observed in these eelgrass beds (Thayer 1981).

3.3.2.2 Isolated Ponds

Shallow, isolated ponds cover about 10.6 acres. Their lack of vegetation results in low primary productivity and seasonal wildlife habitat value. They offer a small degree of resting and feeding habitat for wintering waterfowl and in some cases spring and summer nesting habitat. Because they are isolated, they contribute little to the bay ecosystem in terms of organic material export or hydrologic support. For the most part, these ponds serve as catch basins for the storage of storm water and urban runoff.

3.3.2.3 Ponds

Ponds and stagnant ditches which have a regular input of fresh water occupy a very small portion of the study area (3.6 acres). Primary productivity is estimated at a low to moderate level, due mainly to nearby cattails which probably supply a small input of detrital material into this habitat type. A regular flow of water serves to flush the ponds and export organic material. Populations of stickleback and other spiny-rayed fish are probable here; also frog and other amphibians, which require water for reproduction and juvenile development, may find these small water bodies in the study area very important. The small fish, frogs, etc. serve as food for herons, waterfowl, and raccoons in the area. In addition, waterfowl have been noted utilizing these sites for nesting and feeding.

3.3.2.4 Tidal Rivers and Creeks

Transport of water, sediment, and organic production from uplands and wetlands to the nearby estuarine environment is an important contribution of this habitat type to the overall system. The lack of vegetation results in low primary productivity, so imported organic detritus serves as the main source of energy for this habitat type. The habitat value is probably important for wildlife such as waterfowl, which winter on rivers and creeks and may nest nearby. Shorebirds and passerines are also common. Additionally, salmon are known to migrate up the Puyallup River and Hylebos and Wapato Creeks in order to spawn. About 117 acres in the study area have been identified as tidal rivers and creeks.

3.3.3 UNVEGETATED INTERTIDAL AREAS

3.3.3.1 Intertidal Flats

Most of the intertidal flat habitat type in the Commencement Bay study area is unvegetated; therefore, primary productivity is low. Energy input is limited to diatoms, microscopic algae of the flats, and detritus imported from the bay, the river, adjacent salt marshes, and upland areas. Benthic invertebrate habitat over most of the flats has been severely impacted by log storage; thus overall food chain support for shorebirds, waterfowl, and wading birds is poor. Where log storage does not occur, secondary productivity may be high (Smith 1977) and may provide valuable food supply and general habitat for the previously mentioned wildlife; invertebrates may also serve as a food source for seaward migrating juvenile salmon. Several great blue herons were noted resting on the logs in storage.

3.3.3.2 Intertidal Beach

This exposed, often high energy (for Puget Sound), habitat is predominantly unvegetated, although attached algal vegetation may occasionally occur. Its importance in biological functions such as primary and secondary productivity, food chain support, and wildlife habitat is low. Shorebirds may rest here. Such an estuarine intertidal area, although regularly inundated, contributes little to water purification or export of organic material. Since it is unconsolidated and there is no vegetative cover to act as a binder or buffer, shoreline protection is also minimal. In many places, there are seawalls situated at the upper edge of the beach area to ensure protection of the shoreline and adjacent property. Beaches do, however, offer important aesthetic and recreational areas for residents in the Commencement Bay area. There are 3 acres of intertidal beach in the study area.

Thayer (1981) reports these beaches offer important feeding and predator protection for juvenile salmonids as well as habitat for feeding, brood rearing, and safety for waterfowl and shorebirds.

3.3.4 SALT MARSHES

Salt marshes in the study area are dominated by pickleweed, saltgrass, and arrowgrass. In a similar community in the Nisqually Delta, Thurston County, Washington, net primary productivity has been determined to be $790 \text{ gm(dry)/m}^2/\text{yr}$ (Burg et al. 1980). Daily inundation of these tidal wetlands serves to flush the marsh and export detrital material which contributes to food webs including juvenile salmon and aquatic invertebrates. These salt marshes probably support limited populations of shorebirds, wintering geese, and waterfowl, which feed on the vegetation. There are about 11 acres of salt marsh in the study area.

3.3.5 BRACKISH MARSH

The 3 acres of brackish marsh identified along the shores of the Puyallup River are predominately a dense cover of canarygrass and cattail, both of which commonly exhibit high rates of primary productivity (Reppert et al. 1979). This tall emergent vegetation type also provides cover, nesting sites, and/or food for waterfowl and possibly small mammals such as raccoon and beaver. The intertidal nature of the marsh allows detrital export to the saline system. At mean tide, water depth in this brackish marsh is probably less than 2 feet, but steep banks rise nearly 20 feet to the surrounding land surface. This indicates a potential for some storage of high volume flows and storm water runoff, although probably not significant in relation to the entire watershed. Vegetation in this wetland probably functions to remove some suspended sediments from water passing through, thus marginally improving water quality.

3.3.6 FRESHWATER MARSH

3.3.6.1 Cattail Marsh

Cattail marshes are considered highly productive systems which are important to wildlife. In a New Jersey marsh, Jervis (1969) measured primary productivity at $1,905 \text{ gm(dry)/m}^2/\text{yr}$. Cattail marshes, like those on the site, provide food and cover for nesting and rearing waterfowl

and other marsh birds, as well as supplying food and nesting materials for small mammals such as muskrat. Predators like the raccoon and mink may visit these marshes in search of food, including the resident birds and small mammals. Most cattail marshes in the study area occur adjacent to isolated ponds or drainage ditches where export of organic material occurs to a limited extent. Dense vegetative cover and high productivity of these wetlands (which often occur below non-point sources of pollution) offer a potential for water purification. About 12 acres of cattail marsh are found in the study area.*

3.3.6.2 Seasonal Marsh

These isolated marshes occupy approximately 67 acres. Storage of storm water runoff seems to be the major function in these wetlands; in fact, their presence appears to be dependent upon heavy seasonal rainfall. Primary productivity is probably moderate, with none of the main plant species being major producers. Export efficiency is low due to hydrologic isolation. The habitat value of seasonal marshes is, therefore, probably seasonal also; they provide feeding (seeds, vegetative growth, and insects) and nesting habitat for waterfowl and other bird species, and occasional small mammals, including raccoon, during winter and spring when water levels are high.

3.3.6.3 Reedgrass Marsh

Although uncommon in the study area, monospecific stands of reedgrass are considered highly prolific; their productivity has been estimated at 2,700 gm(dry)/m²/yr (Reppert et al. 1979). The dense tall stands provide food, cover, and nesting sites for birds. In the study area, any value to hydrologic support, storage, or water purification by reedgrass marshes is minimal due to their small size (2.4 acres total, over 6 individual stands) and hydrologic isolation.

*Thayer (1981) reports this wetland type is presently being filled to some degree which would reduce these July-August 1980 area measurements.

3.3.6.4 Tidal Fresh Marsh

These wetlands appear to exhibit a moderately high level of productivity with species, such as cattail and canarygrass, scattered throughout. The interspersation of wetland/upland areas produces a diverse 10-acre habitat in the study area, which supports a wide range of wildlife; waterfowl, wading birds, and passerines have been noted here and small mammals, such as raccoons, are possible. Daily inundation from the tidal reach of the Puyallup River is an important factor in this system. Export efficiency of organic production from the marsh is moderately high, providing a small food supply of detritus and marsh insects for migrating salmon in the river and bay. In addition, water purification is an important contribution by this habitat type in the study area; suspended sediments are apparently removed from the silt-laden Puyallup River water as it exits the marsh during receding tides.

3.3.7 SWAMP

Swamp habitats cover less than 2 acres of the Commencement Bay study area. Spiraea is the dominant species; primary productivity of this woody shrub is low to moderate. Vegetation diversity in this habitat type is also low, although density is high, supporting a diverse insect fauna and thus providing food along with good cover and nesting habitat for passerine birds. Even though runoff and seasonally heavy rains may accumulate in these hydrologically isolated shrub swamps, overall aquatic interaction is minimal and export of organic material is low. Swamp habitat can be seasonal. Mobile wildlife moves to other habitat types when swamp habitat is not seasonally available in the study area.

3.4 RELATIVE WETLAND VALUES

To establish a priority rating of wetland habitat types with respect to fish and wildlife and hydrologic importance, wetland evaluation concepts developed by Reppert et al. (1979) have been employed. These concepts are based on an evaluation of important biophysical characteristics that function in wetland ecosystems and emphasize the relative efficiency with which the functional characteristics are carried out in a particular wetland system.

Reppert et al. (1979) addresses the identification and evaluation of these physical, biological, and cultural functional characteristics. Two methods of analysis are suggested for wetlands ratings--a deductive method and a comparative method. The deductive analysis is a nonquantitative approach and is recommended for use in baseline evaluation of wetlands. The comparative method, which is employed in this report, is intended as a quantitative and systematic evaluation of the degree or efficiency with which two or more wetland areas under study satisfy criteria pertaining to functional characteristics and cultural values (Reppert et al. 1979, p. 57). The quantitative results are intended as a tool to compare the relative importance of site alternatives for proposed water resource development projects. We have applied this analysis in the Commencement Bay study area to determine the relative importance of various wetland habitat types.

It should be noted that Reppert et al. (1979) was originally intended to assess the relative value of a given habitat under alternative development strategies. We have attempted to use it to determine the relative value of different habitat types. In addition, the methodology is specifically oriented toward vegetated wetlands and may not evaluate open water or upland habitat types with equal effectiveness. Finally, the manual is much more specific in the criteria applied to hydrologic and physical characteristics than it is in the criteria for biological characteristics. (This is probably due, at least in part, to the relative ease with which physical and hydrologic characteristics can be measured.)

Table 2 shows the individual ratings determined for each functional characteristic. Each rating represents a synopsis of existing information and the professional judgment on the part of the investigators. In certain cases such as productivity, ratings are based on reported per-unit area values. The table also lists the sum of ratings, which represents an integration of the relative importance of each of the numerous functional characteristics. A detailed explanation of the "Wetland Functions" analyzed in Table 2 can be found in Chapter 2 of Reppert et al. (1979). "X" indicates the mean value of all categories within a function. "Mean sum" (see Table 2) indicates the mean value

TABLE 2

FUNCTIONAL CHARACTERISTICS OF COMMENCEMENT BAY WETLANDS(a)

Wetland Type	Biological Functions					Hydrologic Support					Shoreline Protection					Storm and Flood Storage					Water Purification					Mean Areal Sum(b)/Extent(c)				
	A					B					C					D					E									
	1	2	3	X	Y	1	2	3	X	Y	1	2	3	X	Y	1	2	3	X	Y	1	2	3	X	Y					
Open Water	1	3	2	2	2	2	MA(d)	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	2	2	---		
Bay	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	10.6			
Isolated Pond	1.5	2	1	1.5	2	1.7	1.5	2	1.7	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	4.4	1.46			
Pond with Creek	1	3	2	2	2	2	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	2	2	117.4		
Tidal Rivers and Creeks	1	3	2	2	2	2	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	2	2	---		
Intertidal	1	3	3	2.3	1	1.6	3	3	3	3	1	1	1	1	1	1	1.4	1	1	1	1	1	MA	MA	MA	7	1.75	94.4		
Intertidal Flats	1	3	1	1.6	1	1.3	3	3	3	3	1	1	1	1	1	1	2	1.5	1	1	1	1	MA	MA	MA	6.8	1.7	3.0		
Intertidal Beach	1	3	3	2.7	3	2.8	3	3	3	3	2	3	2.5	1	1	1	1.4	1	1	1	1	1	1	1.2	2	2	2	10.2	10.9	
Salt Marsh	2	3	3	2.7	3	2.8	3	3	3	3	2	2.5	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	2	6.8	1.7	2.9	
Brackish Marsh	2	3	3	2.7	3	2.8	3	3	3	3	2	2.5	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	2	6.8	1.7	2.9	
Freshwater Marsh	3	2	3	2.7	3	2.8	1.5	1.5	1.5	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	2	1.9	7.2	12.0	
Cattail Marsh	2	1	2	1.7	1	1.3	1	1	1	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	2	1.4	4.7	1.2	
Seasonal Marsh	3	1	3	2.3	1	1.6	1	1	1	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	2	1.7	5.3	1.3	
Needgrass Marsh	3	1	3	2.3	1	1.6	1	1	1	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	2	2.1	8.1	2.0	
Tidal Freshwater Marsh	2.5	2.5	3	2.7	3	2.8	2.5	2	2.2	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	2	2.1	8.1	2.0	10.1
Marsh	1.5	1	1	1.2	1	1.1	1	1	1	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	MA	2	1.5	5.6	1.4	1.8

(a) Following the methodology of Reppert et al. (1979), this comparative analysis of functional characteristics was prepared for wetland habitat types in the Commencement Bay study area. A detailed description of functional characteristics as defined in the methodology can be found in Chapter 2 of the manual. In the numerical evaluation, 3 is highest and 1 is lowest; therefore, a high "mean sum" indicates relatively high evaluation of that wetland type. Some values are assigned on a per-unit area basis. Letters and numbers listed in each functional category are defined on the following page.

(b) Mean sum = $\frac{\text{sum of } X \text{ values from 5 major functional characteristics}}{\text{number of applicable functional characteristics}}$

(c) Areal extent totals 127 acres.

(d) MA = Not applicable.

TABLE 2 (Continued)

Biological Functions

- A. Food Chain Products
 - 1. Net primary production
 - 2. Mode of detrital transport
 - 3. Food chain support
- B. Generalized and Specialized Habitat

Hydrologic Support

- A. Hydrologic Periodicity
- B. Location or Elevation Within Wetland System

Shoreline Protection

- A. Vegetation Characteristics
 - 1. Type of wetland vegetation
 - 2. Density of vegetation community
- B. Average Width of Wetland
- C. Fetch
- D. Cultural Development

Storm and Flood Storage

- A. Flood Storage Factor
- B. Flood Retardation Factor

Water Purification

- A. Wetland Type
 - 1. Hydroperiod
 - 2. Vegetation density
- B. Areal Relations
 - 1. Total area
 - 2. Proportion of open water
 - 3. Proportion of total water volume flowing through system
- C. Geographic and Other Location Factors
 - 1. Frost-free period
 - 2. Location with reference to known pollution sources

of all applicable functions for each habitat type. Certain functions or categories have not been considered because they are impossible to assess (e.g., relative BOD load) in the scope of this study. In some wetland habitat types, certain categories are not applicable (e.g., shoreline protection by open water, bay) and have been noted by "NA."

The "sum" value is not intended to indicate an absolute quantitative measure for a given wetland type, but only a comparative ranking. Other important factors which have not been computed into this value are areal extent and degree of degradation. The latter factor may be locally very important, especially in log storage areas. (Impacts of log rafting have been discussed in detail by Smith [1977].) The "sum" value also tends to overemphasize those habitat types with more applicable functional characteristics. "Mean sum" minimizes that overemphasis. The Reppert methodology tends to equate all functional characteristics; no judgment is made that any particular function is more important than others. It is left to the reader to emphasize biological, water quality, or other functions as they desire.

It is apparent that Table 2 suggests that tidal freshwater marshes and salt marshes, although relatively small, exhibit very significant functional values. Bay, tidal creeks and rivers, and intertidal flats are also very important habitat types and much more extensive. Cattail marshes and brackish marshes also appear to be functionally important. Conversely, seasonal freshwater marshes, reedgrass marshes, isolated ponds, and swamps exhibit less significant functional values as compared to the above wetland types.

It cannot be overemphasized that comparative analysis only offers a limited approximation of relative wetland value, and only on a per-unit area basis. Areal extent should always receive special consideration. Numerous, even less quantifiable factors, including regional uniqueness and degradation of the habitat (and potential restoration) should also be considered in any detailed site-specific analysis.

3.5 POTENTIAL WETLANDS RESTORATION SITES

3.5.1 GENERAL

The final objective of this investigation involved the evaluation of locations in the study area in which wetlands might be established or enhanced. This effort involved both the general approach to wetlands enhancement and creation, as well as the description of some specific sites with good physical engineering aspects suited to now-known creation and enhancement methods. This list of specific sites is not intended as an all-inclusive list for the area, nor is an overall ranking of these specific sites possible, since each would produce somewhat different wetland environments. Neither the Corps nor their consultants are recommending any of these sites for wetlands development. They are presented only as examples of areas with suitable physical characteristics.

Wetlands creation/enhancement theories need to be tested in controlled experiments in the Pacific Northwest before such activity would be accepted by regulatory agencies and other parties (such as the Puyallup Nation) as mitigation intended to create or improve habitat values. Modification of one habitat type into another always involves tradeoffs, losses, and gains of habitat functions. It is not the intent of this study to conduct the depth of evaluation necessary to fully understand the tradeoffs involved in wetlands creation or enhancement. Site-by-site evaluations of not only physical and biological environments, but also the human environment (and associated economic tradeoffs), would be required before wetland development could take place. The "state of the art" of habitat management in general, and wetlands enhancement in particular, is such that quantitative values of different habitat types to different fish and wildlife species cannot be easily estimated. The relative qualitative values of different habitat types from an overall perspective is a matter of professional judgment and agency responsibility. Agency positions are derived from considerations of the specific resources for which the agencies are responsible. Thayer (1981) noted that "Puyallup Nation's concerns for fisheries and other resources are protected by treaty and U.S. Supreme Court decisions." The ramifications of Phase II

of United States vs. State of Washington (506 F. Supp. 187) on current agency perspectives will not be known until this court ruling manifests itself in future legal actions.

3.5.2 ECOLOGICAL BACKGROUND

The importance of wetlands in the function of marine ecosystems has been noted by numerous researchers and become the subject of particular interest to coastal zone managers. In general, wetlands provide food chain support because of their high productivity and contact with the aquatic system, critical wildlife habitat for numerous species, shoreline protection for adjacent uplands, and water quality enhancement. These functional values have been outlined in federal regulations (33 CFR 320.4) and other federal documents (Reppert et al. 1978). The previous section evaluated the existing wetlands of Commencement Bay. However, wetlands in the area have been drastically reduced by the development of port and industrial facilities. In 1887, before development of the area began, approximately 1,830 acres of intertidal wetlands and 2,470 acres of subaerial wetlands (above mean high water) existed in the Puyallup estuary (Bortleson et al. 1980). Only about 108 acres of intertidal wetlands and 88 acres of all other vegetated wetland types remain in the study area. This small area performs only a small fraction of the functions that at one time occurred in the more extensive wetland area. The loss of wetlands probably translates into decreased productivity available for numerous organisms in the estuarine and marine ecosystem, a decrease in the habitat of bird, mammal, fish, and invertebrate populations, and loss of physical and hydrologic functions.

As development activities reduced wetland habitats around Commencement Bay, the balance of the various habitat types within the ecosystem has been disturbed. The variety of intertidal flats, salt and brackish tidal marshes, tidal and nontidal freshwater marshes, and swamps has been reduced. With the elimination of this variety of wetland, the balance of functions that was formerly provided has likewise been disturbed.

While large intertidal flats provide high value habitat for shorebirds, waterfowl, and juvenile salmonids, salt marshes exhibit high primary productivity and swamps may function as important floodwater storage areas. In order to provide all functions, a balance between the amount of these habitat types should be maintained. Unfortunately, the breadth and depth of ecological information does not provide adequate answers to define the proper balance of habitat types.

While a determination of the optimum balance of habitats is not attainable from existing information, it seems apparent that the balance between unvegetated intertidal flats and tidal marshes has migrated toward intertidal flats. An analysis of the major Puget Sound estuaries indicates that prior to development, the ratio of marsh to intertidal flats (predominantly unvegetated) was about 0.5 to 1.0 and perhaps higher (Bortleson et al. 1980); in Commencement Bay it was about 0.75. The existing ratio of marsh to unvegetated flats in Commencement Bay is much lower (approximately 0.25) and suggests that marsh restoration would return the system closer to an historical and, presumably, ecologically sound balance. Thus, the terms "wetlands creation" or "restoration," as used here, relate principally to marsh creation. Such rationale as a basis for marsh creation is not necessarily accepted by resource management agencies.

Restoration is the rehabilitation and return of part of the ecosystem, formerly altered or removed from the estuary, back to effective productivity (LaRoe 1979). The general goal of wetlands restoration would be to return to the ecosystem the various wetland habitat types in order to recreate the balance of wetland functions provided by habitats prior to disturbance. Restoration is considered appropriate for mitigation programs which compensate for adverse impacts associated with a particular activity, usually a development project (40 CFR 230.75). As we have used the term, restoration includes both rehabilitation of existing wetlands and creation of wetlands by alteration of some other habitat.

In order to accomplish restoration, positive actions which effectively add to the estuarine ecosystem must be taken. The remedial action must be of sufficient size and be properly designed to result in a positive contribution to the estuarine ecosystem. Single purpose marsh establishment goals have also been suggested by Garbisch et al. (1978) and include: (1) improving wildlife habitat, (2) shore erosion abatement, (3) new habitat development, and (4) biological waste treatment of water. While single purpose restoration projects may increase the value of some wetlands for a specific purpose, they may not increase the overall ecological value of the ecosystem if they work against a balance of ecological elements or functions.

Each type of restoration, wetlands creation and wetlands rehabilitation, has its own requirements for site suitability and distinct methods of construction. These two types of restoration are discussed in the following paragraphs and potential restoration sites are identified. Specific means to accomplish restoration are described, and an evaluation of the potential functions of the restored site is developed.

3.5.3 WETLANDS CREATION, ENVIRONMENTAL CONSIDERATIONS

Alteration of one habitat type to create another invariably results in environmental tradeoffs. Plant and animal species present in the initial habitat may not be adapted to survival in the subsequent habitat. Any plants located in a wetlands creation site will probably die due to a significantly altered water regime. Animals dependent on the site will remain if adapted to the new conditions. Otherwise, they will die or move to other suitable habitat. It is generally felt, however, that all habitat types are supporting the optimum number of species (i.e., they are utilized at full carrying capacity). Thus, any species which move from one habitat to another will die or replace other existing species. Altering a habitat undoubtedly will result in the displacement and loss of organisms.

At the same time, creation of a new and different habitat provides an opportunity for expansion of plant and animal species adapted to the new conditions. Pioneer plant species will quickly become established

(unless other species are planted). Animals will move into the area to take advantage of new feeding and nesting resources, and the new habitat type will eventually reach carrying capacity.

Thus, any change in habitat types associated with wetlands creation will result in environmental tradeoffs. Some species will be lost due to habitat loss, while others will flourish in the new habitat. Any tradeoff of this type must be carefully assessed before the acceptability of the project can be determined. For example, a major consideration entails the loss of juvenile salmonid habitat as a result of wetlands creation by increasing the elevation of an intertidal or shallow subtidal area. While no site-specific juvenile salmonid studies were undertaken in any of the sites identified for wetlands creation in Section 3.5.7 below, some tradeoff of the salmonid habitat for less suitable salmonid habitat is very probable.

3.5.4 WETLANDS CREATION, REGULATORY CONSIDERATIONS

The acceptability of establishing new habitat, or as is more often the case, artificial replacement of one habitat type with another, must be evaluated on a case-by-case, site-specific basis. In all cases, such a proposal will represent a tradeoff between habitat types. Requisite evaluations may involve collection of site-specific baseline data and pre- and post-construction monitoring to interpret the benefits (and losses) associated with the habitat replacement effort.

Required site-specific and project-specific evaluations normally will occur as part of a permit (local, state, or federal) procedure including pre-application planning/design. If habitat modification, replacement, enhancement, or creation is to be pursued for mitigation, it should be done so during the early stages of individual development proposals. Therefore, it is not the purpose of this portion of the wetlands report or the Commencement Bay study to judge which, if any, habitat management concept has merit in any specific instance or location.

Resource agency positions seem to range from pessimism to cautious optimism in terms of the acceptability of habitat management for mitigation

purposes. In some cases, specific policies on mitigation are available (e.g., from the Washington Department of Game and the U.S. Fish and Wildlife Service). Ultimately, acceptable mitigation must result in resource benefits which equal or exceed resource losses (as judged by the resource agencies and others). It is not clear, however, whether mitigation must result in overall resource benefit when considering the mitigation action plus the development action or whether some "unmitigated" impact is acceptable in consideration of and deference to the overall "public interest." The Puyallup Nation's role in such mitigation decisions would be framed by the Phase II of United States vs. State of Washington decisions that require that fishery habitats not be degraded. No legal actions have yet occurred to define the Puyallup's role in wetland mitigation and their influence on regulatory agencies.

The major problem is and will continue to be in making determinations of the relative benefits and losses related to a habitat management proposal. The key to assessing the viability of a mitigation approach is for proponents to coordinate early with agencies having resource and/or regulatory responsibility as well as the Puyallup Nation and other concerned parties.

3.5.5 WETLANDS CREATION, ENGINEERING CONSIDERATIONS

Wetlands creation may involve a modification in surface elevation and, therefore, the water regime, to duplicate the proper elevation for marsh plant establishment in another habitat type. This can be done in upland habitats by surface excavation to the level of tidal influence or local water table. For the Commencement Bay study area, this method is not generally practical since fill covers much of the industrial area to depths which render excavation uneconomical. In addition, this method on a large scale generates large amounts of material which would require disposal nearby. Even with these disadvantages, excavation may be the only viable creation option if decisionmakers would not allow the removal or modification of an existing wetland type to create a more desirable wetland type.

Wetlands can also be created by increasing the amount of surface or ground water in a presently upland habitat. This was investigated in Commencement Bay. It was determined to be infeasible due to the distance between potential sites and available water at the appropriate elevation; fill activities have raised land levels well above nearby water levels.

Wetland (marsh) creation can also be accomplished by the deposition of material on inundated habitats, thereby raising substrate to an intertidal elevation; this method could be undertaken in the Commencement Bay study area. Sediments from dredging operations (if relatively uncontaminated) can be deposited in relatively protected, tidally influenced areas, reducing the water depth to a level at which intertidal flats are created or rooted marsh macrophytes could become established. While the deposition of dredged material in valuable intertidal or shallow water habitats is usually discouraged due to the resultant loss of these habitat types, such activity might be appropriate in Commencement Bay in order to maintain a balance between marshes, mudflats, and open water habitats (Armstrong et al. 1979). Such a tradeoff could be considered if the potential benefits were thought to outweigh the loss of intertidal or subtidal habitat. Establishing this balance might be a portion of an overall mitigation scheme. The deposition of relatively uncontaminated dredged material to create a new habitat may provide a beneficial alternative to other disposal methods.

In this form of wetlands creation, the deposition of dredge materials occurs either within a containment structure or, less frequently, as an unconfined disposal. A dike is usually built to contain the material and protect it from erosion. Engineering constraints can drastically limit the range of potential sites. The containment facility usually is built to a height of about 2 feet above high water levels. If water depth is too great, dike construction becomes uneconomical. Economic considerations for dike construction include characteristics of the foundation upon which the dike material and dredge material would be placed. Unconfined disposal is possible when dredge material is heavy enough to settle without unacceptable sloughing or erosion.

Important factors to be considered in wetland macrophyte establishment are salinity, substrate texture, and elevation. Consideration of these factors is essential where specific plant species are preferred. Water salinity may be controlled indirectly by location near freshwater sources such as rivers, creeks, or storm drains. Soil texture is dependent upon source selection or availability. Final elevation of the dredge disposal area can be controlled by substrate texture (heavy material will settle on a slope), by the height of the containment structure, and volume of material. While the autecology of many plant species is uncertain, Eilers (1975) provides observations of Oregon marshes with respect to elevation. Tolerance limits for physical and chemical conditions can be found in Armstrong et al. (1979) and Kadlec and Wentz (1974). Species desired will determine the tidal elevation of the area.

The water quality from dredge material disposal operations is often affected by contaminants and turbidity. Fine sediments may become resuspended, necessitating the use of silt curtains to control turbidity. Contaminants include nutrients, heavy metals, complex organic compounds, and others. Because some of these contaminants are highly toxic or lead to other water quality problems, the contamination of the sediments must be considered prior to any dredge or disposal operation.

Once the substrate is in place, propagation of marsh plants can be accomplished by seeding, planting, or natural colonization. The choice of propagation type is strongly influenced by the size of the site, the amount of physical stress the site receives, how soon after planting cover is desired, the amount of funding allocated to the project, and the plant species being used. Seeding is less expensive than planting; however, planting results in a more rapid marsh establishment and protection from physical stress. Planting is done either from sprigs or plugs removed from other marshes or with nursery seedlings. Natural colonization is perhaps the major option available since no marshes suitable for providing sprigs and plugs are present in the study area. Reliance on this method assures that the plants best adapted to site-specific conditions are established; however, selection of highly desirable or valuable species is not possible. With proper handling, sprigs or

plugs might be gathered from other marshes in the region, such as the Snohomish or Nisqually Deltas. The rates of natural colonization in the Pacific Northwest are unknown (Armstrong et al. 1979).

The suitability of a site for a marsh creation project is dependent upon several physical and socioeconomic criteria (adapted from Armstrong et al. 1979).

Physical Criteria

- 1) Foundation - the ability of the substrate to support a containment facility, equipment, and dredged material.
- 2) Proper habitat for vegetation ensuring local marsh species will become established (i.e., salinity, elevation, substrate texture).
- 3) Absence of existing critical habitat for any species or group of species (i.e., eelgrass beds or important documented juvenile salmon rearing habitat).

Socioeconomic Criteria

- 1) Distance from dredging operation.
- 2) Size of site must be large enough to result in positive benefit to estuary to offset costs.
- 3) Cost of containment structure.
- 4) Availability of land by lease, purchase, or donation.

Most of these criteria can be assessed on a general level only for each site chosen since a comprehensive analysis would require extensive data collection beyond the scope of this study. Available information will be used whenever possible.

3.5.6 WETLANDS CREATION, SITE DESCRIPTIONS

3.5.6.1 General

In the Commencement Bay study area, potential creation sites are located predominantly in intertidal or shallow subtidal areas. Because of deep draft dredging and navigation, feasible sites are restricted* to

*Thayer (1981) notes that "wetlands could be created along Blair Waterway by excavation." In fact, nearly any area in the study area could be so modified by excavation if the associated economics and spoils disposal problems are overcome.

portions of certain waterways where shallow depth already restricts navigation and would allow the construction of containment facilities. Depending on the texture of material and the method of placement, unconfined disposal might be feasible. Where slurry disposal of fine dredge material occurs, recommended containment structures would be built to about 2 feet above MHHW until the material consolidates sufficiently to allow removal of the dike top to the desired elevation.

Propagation of marsh plants in the study area would most likely be restricted to natural propagation. Only 11 acres of salt marsh are found in the study area, and each parcel is too small to allow harvesting of sprigs or plants. A consistent obstacle to wetlands creation in these sites is the location of storm water outfalls at intertidal elevation.

According to the Washington Coastal Zone Atlas (Washington Department of Ecology 1978), no critical habitat areas occur in or around Commencement Bay. The more recent evaluation of areas of major biological significance (Gardner 1981) also indicates that no such areas exist in the study area. However, information developed in the COBS bird study (see Bird Studies Technical Report) indicates that a falcon and an eagle nest site exist near the study area; some feeding by these endangered species likely occurs in the Commencement Bay study area. In addition, this same report indicates the existence of Barrow's goldeneye nest in the study area. This constitutes a unique condition in coastal areas of western Washington. The above information indicates that a detailed, site-specific study of any potential wetlands creation site would be required before value judgments about critical habitat present could be made.

Approximately 102 acres of potentially suitable creation sites were located around Commencement Bay. The sites are shown on Figures 2 through 13.* The largest is the Hylebos Flats (Site 7) area where extensive intertidal flats (34 acres) are currently utilized for log storage. Middle Waterway contains about 13 acres of intertidal log storage area as well. In both instances, discontinuation of log storage

*Available for review at the Seattle District Corps of Engineers.

on these flats would greatly improve their value to the estuary, especially rearing salmonids and perhaps, given proper elevation, allow marsh establishment by the removal of this source of mechanical damage.

In the following discussion, each potential site will be considered individually. Because the identified marsh creation sites occur in intertidal and shallow subtidal locations, their direct connection to the estuarine ecosystem is assured. The creation of marsh would provide numerous physical and biological functions and provide a balance of habitat types. At the same time, existing habitats and their functions would be lost. Specific planning of each site would require substantial research into the physical, biological, and socioeconomic factors; with a specific plan, the benefits and impacts to the ecosystem could be more accurately assessed.

Note that all sites discussed below (Sites 1 through 9) have some juvenile salmonid habitat present whose loss or adjustment would have to be factored into evaluations of the creation sites. Similar concern would occur for any eelgrass beds at these sites.

3.5.6.2 Wheeler Osgood Waterway (Site 1)

As an arm of City Waterway, Wheeler Osgood Waterway is not currently used for deep draft navigation. About 3 acres of intertidal and 2 acres of subtidal habitat occur. The waterway is long with a narrow mouth; approximate dimensions are 200 feet by 1,500 feet, or about 5-7 acres.

Several advantages for marsh creation are evident at this site. The narrow mouth of the site minimizes the length of the containment structure and protects the waterway from wave energy. Because of the ease of dike construction, staged wetland creation is possible. Fill material would be available from nearby City Waterway dredging operations. The silts in the sediments here may allow unconfined disposal with the utilization of turbidity curtains. A 3-foot diameter culvert empties into this waterway; culvert extension or a protected channel would be required.

3.5.6.3 City Waterway (Site 2)

The southern end of City Waterway may provide up to about 5 acres suitable for wetlands enhancement by filling a shallow subtidal area. In order to attain that elevation, a containment structure would need to be built in about 15 feet of water. To maintain navigation to a pier on Dock Street where several large vessels are currently stored would reduce the size of a potential site to 2 acres. Two 8-foot diameter culverts enter City Waterway here, indicating potentially large storm water flows.

Because of the depth and conflicting uses of the waterway, a long dike (300-400 feet) would be necessary to contain disposal material in a small area. Dike construction would be complicated by water depth. The large culverts would need to be extended or discharge pipe energy dissipation structures would be required to prevent erosion of the wetlands creation substrate. Because of the expense of these two measures and the small area of wetland creation that would result, this site is probably not feasible.

3.5.6.4 F Street (Site 3)

Intertidal and shallow subtidal habitat used for log storage is located between City and Middle Waterways at the end of F Street. The site is adjacent to the bay, and wave energy contributes to high erosion. Beach materials include sand and fine gravel.

Wetlands creation at this site would require dike construction around three sides of the intertidal area. Fairly rapid dropoff to depths precludes the expansion of the small intertidal area (3 acres). These constraints, along with the exposure to high wave energy, reduce the potential of this site. Additionally, although no eelgrass beds were noted in the Washington Coastal Zone Atlas (1978), a small patch is known to exist at this site; therefore, the impact of alteration of the eelgrass habitat may exceed the benefit of marsh creation.

3.5.6.5 Middle Waterway (Site 4)

The eastern half of Middle Waterway consists of intertidal flats with a very narrow band of salt marsh around the fringe. The intertidal flats are currently used for log storage, while the outer portion of the harbor is a dredged navigational channel.

The intertidal and shallow subtidal portions of Middle Waterway provide an excellent opportunity for marsh creation. The length of containment structure would be relatively short (300-400 feet) and inexpensive in relation to the size of the area gained for marsh creation. Depending on available material, unconfined disposal might be possible. Disposal of a veneer over the surface would raise a portion of the substrate up to a level suitable for the propagation of wetlands vegetation and maintain some intertidal flat. Potential nearby sources of dredge disposal material include City and Middle Waterways. The existing intertidal flat could probably provide important wildlife habitat; however, log storage activities considerably degrade the habitat value of the intertidal flat. Discontinuation of log storage alone would enhance the value of the existing habitat.

3.5.6.6 St. Paul Waterway (Site 5)

Both shallow subtidal and intertidal unvegetated flats occur in this waterway. Log storage activities appear to be the only commercial/industrial use of the waterway. Intensive industrial activities occur on the surrounding uplands. As with other waterways, this site is long with a narrow mouth, and with relatively good protection from wave energy and erosion potential.

St. Paul Waterway provides a fairly large area (5 acres) for marsh creation with a relatively low cost for a containment structure. Unconfined disposal may be possible utilizing silt curtains to control turbidity. Development of screening or buffer vegetation would be recommended because of the intensity of industrial activities. Salt marsh establishment and intertidal flat creation could be accomplished by creating an elevation gradient. Three storm drain culverts contribute runoff to St. Paul Waterway.

3.5.6.7 Puyallup River Mouth (Site 6)

Sediment deposition of sands northeast of a jetty here has created a large intertidal and subtidal bar. The site is currently unvegetated and defined on its eastern edge by the Milwaukee Waterway. The site is relatively isolated from current industrial activities.

Dredge disposal for marsh creation would require a containment structure on three sides, although with modification the existing jetty may serve as a containment facility on one side. The existing intertidal habitat could perhaps be expanded by lengthening the jetty structure so that natural accretion could continue seaward somewhat further. The silty or sandy nature of the bar would provide a stable foundation for a containment dike. Because of the high wave energy at this site, unconfined disposal is probably not possible. Milwaukee Waterway is probably the closest source of dredge material.

The harbor boundary landward and seaward of this site constitutes a potential constraint to wetland enhancement. The state constitution restricts the use of such designated areas to "landings, wharves, streets, and other conveniences of navigation and commerce" (see Section 2.3.1.1. of the Land and Water Use Technical Report).

3.5.6.8 Hylebos Flats (Site 7)

Near the 11th Street Bridge, a large intertidal flat is currently utilized for log storage. As always, removal of logs would undoubtedly enhance the existing habitat. Some salt marsh vegetation occurs along the upper margins of the flats and in small island patches. The dredged portion of the channel carries large vessels to log and chip handling facilities and chemical facilities.

The intertidal flat is partially enclosed by an upland spit. Several alternative containment structures are possible from the spit across to the shore along Marine View Drive, opening the possibility of a phased creation site. A 700-foot containment structure would enclose

approximately 19 acres. Unconfined disposal would be possible if appropriate material were available. Sediments near the site contain fine to medium sands. The existing salinity and tidal conditions would probably be appropriate for salt marsh establishment if the surface elevation is increased. Dredge material would be available from Hylebos Waterway dredging. The site is moderately well protected from wave energy; however, vessel wakes would contribute to erosion.

3.5.6.9 Hylebos Flats (Site 8)

Just south of Site 7, another intertidal flat of about 18 acres is located. Like Site 7, it is also utilized for log storage. A containment structure of about 1,500 feet would be necessary to enclose the entire 18 acres. Shorter structures would be possible and would enclose a smaller area. The presence of salt marsh along the margins of the flat indicates potential suitability for establishment of similar vegetation given appropriate elevation and substrate texture. A small storm drain discharges at the upper margin of this flat which dictates that a culvert extension be constructed or special allowances for an unobstructed channel be noted.

3.5.6.10 Hylebos Mouth (Site 9)

At the mouth of Hylebos Waterway, there lies an intertidal flat covering 16 acres. It does not appear to be used for log storage at this time, although past use and ongoing occasional storage is probable. A small freshwater seep was noted at the upper portion of the flats. About 1.5 acres of salt marsh occur on slightly higher elevations adjacent to the flats, suggesting that by selectively raising the elevation of the flats, additional salt marsh could probably become established. One of only two patches of eelgrass in the study area is located within this site at the margin of the dredged channel. Loss of this highly valued habitat may preclude alteration of this site.

Exposure of the site to the open water of Commencement Bay results in potential wave erosion problems; therefore, protective containment structures would be necessary. In order to enclose the entire 16-acre

intertidal flat, it would require up to 2,900 feet of dike; however, it is possible to enclose a smaller area with a shorter structure. A spit traverses all but about 150 feet at the north end of this area; a small dike could be built enclosing this portion in order to create about 5 acres of salt marsh. Dredge material would be available from the sediments of Hylebos Waterway.

3.5.7 WETLANDS REHABILITATION

Rehabilitation of altered or damaged elements of the wetland ecosystem is achieved through measures used to increase productivity and habitat area, and improve the general ecological value of the area. In existing freshwater marshes, water management (diversion of runoff from uplands or reintroduction of tidal influence) can improve circulation, flushing, productivity, and provide for interaction with aquatic portions of the ecosystem. Alteration of topography and soils can result in measured vegetation diversity and habitat diversity, which, along with vegetative buffers, can increase wildlife habitat value.

Rehabilitation can also be accomplished by the removal of existing influences which are detrimental to wetlands. Measures to control the adverse effects of erosion or wastewater discharge can be instituted where such impacts are present. In the Commencement Bay study area, a major impact on intertidal wetlands is log storage. Physical impact of log raft grounding can reduce benthic invertebrates by up to 95 percent of the population under grounded logs. Heavy concentrations of bark can also depress sediment dissolved oxygen (Smith 1977). Invertebrate populations can rebound with log raft removal.

Water management in marshes requires the integrated use of levees, culverts, and weirs. Maintenance and operation of such structures require continual effort. Where runoff water or tidal water is being introduced into a wetland, levees may be necessary to protect adjacent uplands from flooding. Alteration of topography within the wetland may be necessary in conjunction with or independent of water management measures. Excavation may increase access to the water table or increase water depths. Selective filling can create islands or other upland

habitats in close proximity to wetlands, providing a diversity of habitat. Removal of pollution sources in wetlands can be done with infrastructure (piping to disposal or treatment facilities) or diking to control leaching from nearby pollution sources.

Potential sites for wetland rehabilitation should be considered in light of the following criteria:

Physical Criteria

- 1) Potentially provides appropriate habitat for marsh hydrophyte establishment.
- 2) Existing wetland which is isolated or altered to the point where its contribution to the ecosystem is severely degraded.
- 3) Absence of critical habitat for any species or groups of species.

Socioeconomic Criteria

- 1) Size of potential site large enough to justify capital expenditures of facility installation and maintenance.
- 2) Cost of water management structures, topographic modification, and vegetation buffer establishment.
- 3) Availability of land for lease, purchase, or donation.
- 4) Proximity to water source.

3.5.8 WETLANDS REHABILITATION SITE DESCRIPTIONS

3.5.8.1 General

Because of the limited availability of fresh water, the high elevations of the fill, and lack of existing wetlands throughout the Commencement Bay area, potential wetlands rehabilitation sites are limited. Most existing wetlands are isolated from freshwater flow and are supplied with water by seasonal runoff. Creeks and drainages are at very low elevations with respect to most wetlands, and increasing water flow through these marshes would probably require pumping.

The two potential sites most suitable for wetlands rehabilitation were located: (1) approximately 10 acres available near the Puyallup River Bridge at 11th Street, and (2) a 28-acre seasonal marsh near

Milwaukee Way that provides a potential site for water management schemes to improve wetland value. These areas are indicated on Figure 10.*

The rehabilitation of tidal mudflats is also discussed in this section. Because of the impacts of log storage on intertidal organisms, removal of this activity would improve the quality of these habitats. Approximately 76 acres at 6 locations are currently involved. These sites are discussed in the Wetlands Creation section above.

The rehabilitation of wetland areas would be designed to provide improvement of existing habitat types. If properly done, rehabilitation projects can provide habitat for a larger population or a greater diversity of wildlife with little detrimental impact to the existing condition.

Additional benefits with respect to flood storage and water purification can be expected; in fact, wetlands rehabilitation design can incorporate specific measures to provide specialized as well as generalized functions. Any wetlands rehabilitation project would require site-specific research in the social and physical factors to provide the most beneficial design.

3.5.8.2 11th Street Bridge Tidal Marsh (Site 10)

Approximately 10 acres of existing fresh marsh occur at this site. Because of a broken tidegate on a small culvert (approximately 2 feet in diameter), a portion of this site experiences tidal inundation from low salinity waters of the river. Rehabilitation of this site should entail increasing the range of tidal inundation and, if feasible, the overall size of the marsh.

Because of the small size of the connection to tidal influence, the tide range is probably restricted by the flow capacity of the culvert connection. If this is the case, the extent of tidal action can be increased by enlarging the connection with the Puyallup River. A large diameter culvert may increase the height of flood tides sufficient to influence a larger portion of the existing wetland and increase flushing.

*Available for review at the Seattle District Corps of Engineers.

A larger area could also be introduced to tidal inundation by limited dredging or excavation activities. To increase tidal influence in the portions of the marsh farthest from the tidal source, a more efficient channel could be created to conduct the flooding tide. Where the elevation of the marsh or adjacent upland is very close to the elevation of available water, dredging or excavation could be used to lower the elevation slightly. Detailed information on elevations and the current tidal regime within the marsh would be necessary to design the optimum rehabilitation scheme. Within the complex, islands could be created with dredged or excavated material to increase habitat diversity. Buffer vegetation should also be considered between this marsh and adjacent intensive industrial activities.

3.5.8.3 Milwaukee Way Seasonal Marsh (Site 11)

This 28-acre area of predominantly seasonal mixed marsh could be rehabilitated by water management methods to increase water levels throughout the year; this would result in an increase in flushing to downstream systems, and an increase in primary productivity by encouraging other more productive vegetation.

The three areas divided by Milwaukee Way and a railroad track could be hydrologically connected using culverts and wiers to control water levels.* Elevation alteration within the marsh could be used to further increase habitat diversity. Further investigation into the local hydrology would be required to verify an adequate water source; however, no water sources of adequate elevation to provide gravity flow to the site were apparent.

3.5.8.4 Intertidal Log Storage Sites (Sites 3, 4, 5, 6, 7, 8)

The intertidal flats at Middle, Hylebos, and St. Paul Waterways and at the foot of F Street are currently used for log storage. (These sites are discussed in the Wetlands Creation Site Descriptions section.)

*Thayer (1981) reports that this area observed in July-August 1980 is undergoing some degree of filling which may negate this proposal.

The grounding of log rafts results in a reduction of benthic invertebrate populations, diversity, and abundance. The impact results from compression and "kneading" of the upper layer of sediments. Long-term log storage and dumping can result in the accumulation of bark and other organic material on and within sediments. Bark releases chemicals which can lead to depressed dissolved oxygen (Smith 1977).

Removal of log storage activities can alleviate these negative physical and chemical impacts on invertebrate populations. Recolonization by salt marsh-benthic invertebrates can occur rapidly following the removal of log rafts. In studies conducted in the Snohomish River Delta, most populations recovered to levels indistinguishable from unimpacted areas within 1 month after log removal (Smith 1977). The return of sediment dissolved oxygen to pre-log storage conditions can take somewhat longer due to the length of time bark can be incorporated in the sediments.

4.0 SUMMARY AND CONCLUSIONS

All wetlands in the Commencement Bay study area have been inventoried and mapped. Within the study area there are approximately 327 acres of wetlands, including about 131 acres of open water and ponds, 91 acres of intertidal flats, 11 acres of salt marshes, and 86 acres of freshwater marshes; swamps and brackish marsh cover less than 5 acres.

Almost 75 percent of the freshwater marshes are seasonal, their occurrence being dependent upon winter rains which flood or saturate these areas. In drier summer months, surface water evaporates, the water table drops, and these wetlands dry up. Thayer (1981) reports these areas are of "significant varying importance even when dried up."

The wetlands within the study area, although not numerous or expansive, appear to be of value to a diverse avian population. Waterfowl rely upon the wetlands for wintering, feeding, cover, and nesting. Great blue heron and other wading birds were frequently observed, as well as numerous shorebirds and passerines.

Our studies have revealed some potential sites in Commencement Bay for rehabilitation and/or creation of wetland habitat, either by increasing the flow of water to isolated seasonal marshes or, alternatively, by selective deposition of fill on intertidal flats and shallow marine areas to raise the elevation such that salt marsh habitat may be created.

Substantial additional site-specific studies would be required before these areas undergo such modifications. Special attention should be paid to the potential for loss of juvenile salmonid habitat in intertidal and subtidal areas in the design of any proposed wetland creation or rehabilitation activity.

Wetlands creation by excavation appears both uneconomical and requires a large spoils disposal site. Nearly any area in the study location could undergo some form of wetlands creation by excavation if decisionmakers were to decide that this constituted the only acceptable mitigation alternative.

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APPENDIX

FUNCTIONAL CHARACTERISTICS OF WETLANDS

Appendix

FUNCTIONAL CHARACTERISTICS OF WETLANDS

(from Snohomish Estuary Wetlands Study,
U.S. Army Corps of Engineers, 1978)

A. Natural Biological Functions

- 1a) Primary Productivity. Wetlands which have high natural rates of net primary productivity are considered highly valuable. This net primary productivity is the basic energy source for the entire food web in the estuary. Areas with high rates of productivity can support large and diverse populations of organisms. Highly productive areas include algal beds, salt marshes, brackish/freshwater marshes and swamps. This criterion should not be used alone, however. It is still a qualitative measure in the Snohomish estuary since no productivity measurements are available for the study area. The estimated level of aquatic interaction (see below) should be considered along with estimated net productivity. The combination of the two better describes the potential for a given area to be a source of energy for the major food webs in the estuary.
- 1b) Secondary Productivity. Aquatic lands with dense populations of benthic organisms have high secondary productivity. Benthic fauna store energy extracted from detritus, thus reintroducing it to the food chain.
- 2) Vegetation Density. Dense vegetation provides protective cover for a wide variety of animals. This is particularly important to small mammals, molting waterfowl, or other relatively defenseless animals. Dense vegetation also functions to slow water flow through the area, thus enhancing sedimentation of suspended solids and their associated nutrients and pollutants. Cattail, bulrush and mixed cattail/bulrush marshes are prime examples of dense vegetation.
- 3) Plant and Animal Diversity. The more diverse plant communities tend to support more diverse animal communities. More diverse animal communities in turn exploit the available energy resources more efficiently. Thus, in areas with more diverse animal populations, less of the energy stored as plant ma-

terial is lost. In addition, diverse populations are considered to be more resistant to changes in environmental conditions. Elimination of a single species does not result in the collapse of the community. Finally, the presence of diverse populations within a single trophic level results in inter-specific competition and co-evolution, thus strengthening the genetic character of the species involved (Ricklefs, 1973).

- 4) Threatened or Endangered Animal Species Habitats. Wetlands where there have been observations of a threatened or endangered or otherwise rare or unique animal species are considered important. Habitats containing locally vanishing or restricted species are also included here.

B. Natural Physical Functions

a. Ecosystem Support

This criterion refers to those areas the destruction or alteration of which would detrimentally affect natural drainage characteristics, sedimentation patterns, salinity distribution, flushing characteristics, current patterns or other environmental characteristics. For example, filling the mudflats in front of Maulsby Swamp might severely impact the flushing and hydraulic characteristics of that area.

- 1) Hydrologic Periodicity. The frequency and duration of inundation due to tides, river flow or runoff is a measure of the interaction between habitat types within an ecosystem. Subtidal algal and eelgrass habitat types exhibit continuous inundation, and therefore very high interaction with adjacent aquatic areas. Salt marshes and intertidal brackish/fresh-water marshes and swamps are usually inundated twice daily providing high aquatic interaction. Non-tidal marshes and swamps such as those behind dikes are inundated only by flooding and therefore have lower aquatic interaction with the estuarine ecosystem.
- 2) Location or Elevation. The location of a habitat is an important part of its contribution to the ecosystem. Proximity to the open water system is important when evaluating aquatic interaction. In addition, a wetland which is adjacent to other wetland areas contributes to a larger and more diverse wetland habitat.

Isolated habitats, surrounded by urban or agricultural areas, may not contribute as much to the total estuarine ecosystem, although they may be productive units in themselves. Elevation of a wetland is important in evaluating the extent of the aquatic interaction between the wetland and the open water ecosystem. Hydrologic linkages deteriorate as the depth of flooding decreases.

- 3) Areal Extent. The size value of an area can be very important either by itself or in combination with contiguous related areas. A large unit provides cover and protection for wildlife. It may also provide a functionally intact system, relatively free from outside disturbances. A large unit made up of a variety of habitat types provides a diverse habitat. The shape of a habitat can also be very important in increasing the wildlife value of an area. For example, swamps and riparian habitats possess high wildlife values in different configurations. A swamp serves identical productivity functions whether it be compact or linear. However, wildlife values to swamp species are greatly enhanced by a compact shape. The protection and security provided by the interior of a swamp are necessary for the survival of many animals which are very wary of, or cannot tolerate, human activity. In contrast, a riparian woodland has more value in a linear shape. The vegetation functions to support wildlife, provide shade for the stream or slough (maintenance of cool water temperature is important to fish habitat), provide a source of primary production to stream detritus feeders (through vegetation falling into the stream followed by decomposition), and provide habitat for insects, many of which become food for fish, or small birds. Also, dense stream or dike bank vegetation provides erosion protection.
- 4) Ecological Importance. This criterion refers to the characteristics of an area that make it valuable for resting, breeding or feeding. The characteristics required for each species are different, and include specialized nesting or spawning sites, security from predators, availability of nest sites and materials, and food sources. As knowledge of individual species requirements is refined, this criterion will become more valuable. For example, the use of the wetlands by browsing and foraging herbivores is well known. Also, the spawning and nesting of some spe-

cies are known to occur in the estuary, and identification and protection of these specific habitats is important to maintain the populations.

b. Physical Protection

Wetlands included here are those that are significant in shielding other areas from wave action, erosion, or storm damage. Good examples are Jetty Island and the Tulalip spit.

c. Storm and Floodwater Storage

Wetlands are valuable if they are able to store storm or floodwaters and thereby protect upland areas from erosion and save private property from destruction. This function is particularly critical for major floods such as occur in the Snohomish Basin every few years.

d. Natural Groundwater Recharge

Wetlands which serve as prime groundwater recharge areas are important. These areas help maintain the general groundwater table. There are no major groundwater recharge areas in the Snohomish estuary.

e. Water Filtration and Purification

Wetlands included here are those that serve to purify water through natural filtration processes. Suspended solids and associated contaminants are trapped in wetland sediments and may be released slowly through incorporation by wetland organisms. Recent studies have indicated that particular plant species and communities have the ability to concentrate or decompose contaminants, such as excess nitrogen and phosphorus compounds, heavy metals, and various hydrocarbons. For example, the cattail (*Typha latifolia*) has been shown to concentrate nitrogen, phosphorus and manganese by removing them from the sediment (Lee, et al, 1976). The wetland plant community thus incorporates free nutrients and releases them slowly as detritus.