FRI-UW-8908
November 1989

FISHERIES RESEARCH INSTITUTE
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DISTRIBUTION OF JUVENILE SALMONIDS IN COMMENCEMENT BAY, 1983

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FINAL REPORT

TO

THE PORT OF TACOMA

Approved

Submitted 11-24-89

R.C. Francis

Director

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

DEDICATION

This report is dedicated to the memory of Ernest Olavi Salo (1919-1989). The authors of this report knew him as a teacher, a colleague and a friend. We mourn his passing and celebrate his life.

INTRODUCTION

Commencement Bay contains the estuarine delta of the Puyallup River. With the growth and development of Tacoma, its port, and the surrounding region, the delta has been subjected to dramatic environmental changes, primarily from dredging and filling to create the waterways. Past development activities along the shorelines of Commencement Bay have affected, and future activities may affect, the habitat and fish that use it.

In anticipation of future development of the Port of Tacoma, the Fisheries Research Institute designed and executed a sampling program to evaluate use of Commencement Bay and the associated waterways by juvenile salmonids (*Oncorhynchus* spp.). The study had two primary objectives:

1. establishment of the residence time of the population of migrating juvenile salmonids within the study area; and
2. characterization of the migration timing, patterns and distribution of juvenile salmonids.

A third objective was the determination of the feeding habits of juvenile salmonids based upon results of stomach content analyses. That element is reported upon separately in a draft report (Simenstad et al., unpublished).

The study was designed to evaluate salmonid use of the shorelines and the offshore areas of the bay, as these habitats are the most likely to be affected by development. The definition of shoreline and offshore habitat is arbitrary and based on sampling gear. These definitions are not consistent with any other recognized habitat definitions. Both areas could be considered nearshore, but the distinction between them is important when evaluating patterns of use and potential impacts of port expansion projects. The shoreline habitat is considered to extend 30 m from shore (the length of the beach seine leads). The offshore habitat extends from the 30 m mark out several hundred meters (the limit of the townet sampling). The latter has no defined outer limit, but the sampling program was not specifically designed to assess use in the middle of Commencement Bay. By this definition, the area inside the waterways, beyond 30 m, is considered offshore.

In addition to the salmonid sampling, marine fish were captured at the beach seine sites. However, no sampling targeted these species.

Juvenile salmonid use of Commencement Bay and its associated waterways during their early saltwater outmigration period has been documented by Miyamoto et al. (1980), Weitkamp and Schadt (1982), Meyer et al. (1981), Ratté and Salo (1985),

and Jones and Stokes (1988). Resident marine fish in Commencement Bay have been described by Malins et al. (1980), Weitkamp and Schadt (1982) and Tetra Tech (1985). In addition, the Puyallup Tribe's Fisheries Division conducted concurrent beach seine sampling during our study in 1983 and has continued this effort through 1988. The major difference between the present study and those that preceded it is the emphasis on sampling offshore habitat.

This report compares results with previous studies where appropriate. Results of comparisons made among these data sets must be tempered by consideration of the seasonal and annual variability inherent in biological systems (i.e., the salmonid run timing, magnitude and species composition may vary dramatically from year to year).

METHODS

Study Area

The study area included the nearshore areas of Commencement Bay and its associated waterways. Fifteen sites were established for sampling by beach seine (Figure 1 and Table 1). Selection of sites was dependent upon such factors as: site representation of the surrounding habitat, area available for efficient sampling, strategic waterway location and existence of previous data.

Four of the fifteen beach seine sites were located along the exposed shoreline of Commencement Bay, nine were located in the waterways and two were located adjacent to the mouths of the waterways. The substrates at these sites ranged from soft mud to rock, while gradient varied from flat beach to steep slope (Table 1).

To assess salmonid utilization of the offshore environment, sampling by townet was conducted. Sampling transects were established in four waterways and various regions of Commencement Bay (Figure 1).

Sampling Techniques

Beach Seine

Beach seining was conducted weekly over the 16-week study period between Julian day 83 and 188 (March 24 to July 7).

The beach seine was 37-m long by 1.5-m deep with 18-m, 3-cm stretch mesh wings and a 0.6-m x 2.3-m bag of 6-mm stretched mesh. The seine was set from an outboard skiff 30 m from, and parallel to, the shore. The seine was pulled toward

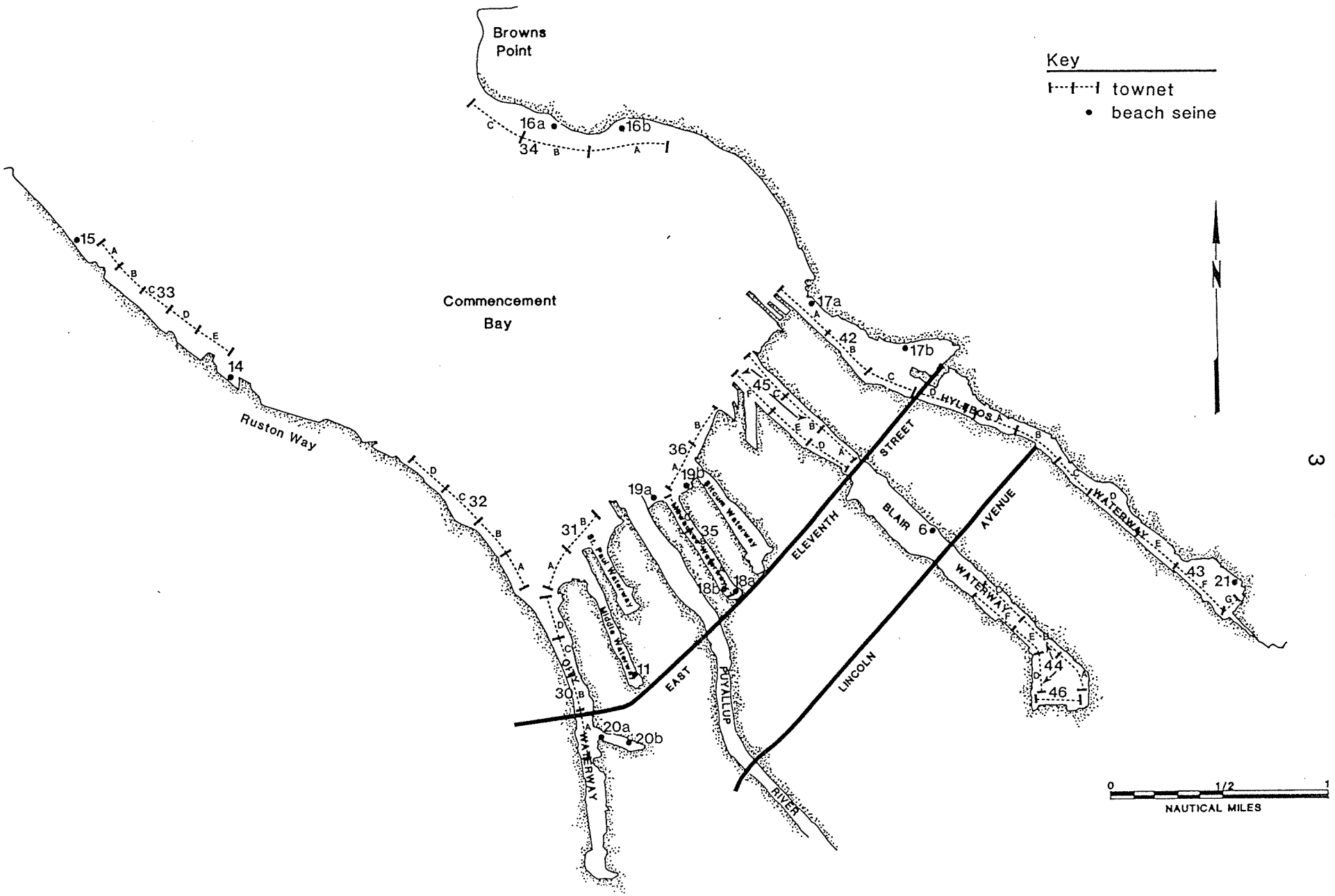


Figure 1. Beach seine sites and townet transects in Commencement Bay, 1983.

Table 1. Description of beach seine sampling sites.

6	Moderate gradient with large rock to boulders
11	A shallow gradient beach of mud and small rock
14	Shallow gradient beach composed of sand with eelgrass at low-tide level and rock rip-rap at higher-tide level
15	Shallow gradient beach with sand substrate, eelgrass in low-time region and rock rip-rap at high-tide region
16a	Moderate gradient beach comprised of small- to cobble-sized rock
16b	Moderate gradient beach comprised of small- to cobble-sized rock
17a	Shallow gradient beach composed of sandy mud
17b	Shallow gradient beach composed of sandy mud and small rock at high-tide region
18a	Steep gradient, comprised of "Ruston Way" fill
18b	Steep gradient beach, composed of cobble-sized rock
19a	Steep gradient beach, composed entirely of silty sand
20a	Shallow gradient beach
20b	Shallow gradient beach composed entirely of soft mud
21	Steep gradient, earthen bank of waterway

shore as swiftly as possible without submerging the top of the seine. The wings of the seine were converged when the net was 10 m from shore, thus funneling the catch into the bag.

Day-to-day sampling was not consistent with regard to the time of day (limited to daylight hours) or tide state (i.e., ebb or flood). Tide height served as our scheduling "constant" to minimize the degree of variation in the area and character of the sites. Hence, the same habitat was routinely sampled at each site on each occasion.

Surface Townetting

Offshore sampling was conducted weekly throughout most of the study period using a surface trawl towed between two boats (the 11.6-m TENAS and the 7.9-m

NARWAL). The mouth opening of the net measured 6.1-m wide by 3-m deep. Stretch mesh sizes ranged from 76 mm at the mouth to 5 mm at the bag. The wings of the net were spread vertically by two 3.75-cm diameter galvanized pipes, which were connected with a short nylon bridle to single warps leading to each vessel. The net was towed at intervals ranging from 0.9 to 1.1 m/sec. The speed was adjusted slightly during each tow and under different tide conditions to insure that the ends of the head rope would just break the surface of the water. Generally, tows were made in the direction of the prevailing current flow and were of 5-minute duration. At the end of each tow, two crewmen in an outboard skiff pursed the cod-end of the net and removed all fish and debris. This technique allowed continuous sampling of the offshore transect pattern.

Processing of Samples

All captured fish were sorted and enumerated immediately. Subsamples of no greater than 20 juvenile salmonids were taken from each haul. The remaining fish were released.

The subsamples were preserved in 10% buffered saltwater formalin and retained for several days before length and weight measurements were made. Mean fork length (nearest mm) and weight (to 0.00 g) were measured for all preserved samples.

Environmental Data Collection

Environmental data were taken 10-15 m from shore after each beach seine set. When time permitted, observations were made along the path of the townet transects. Salinity and temperature were measured at 0.1 m and 1.0 m depths. Water visibility was measured with a 31-cm Secchi disc. Weather and sea conditions were recorded at each set and during each haul.

Data Analysis

Catch data were analyzed based on frequency of occurrence and catch-per-unit-effort (CPUE).

Frequency of occurrence is the percentage of sampling sets a species was collected at a site or transect. The absolute numbers of fish caught, as well as sampling effort, are ignored as variables in this measure. For example, if chum salmon were collected during eight of ten samples, the frequency of occurrence would equal 80%. Since sampling was generally performed weekly, the frequency of occurrence is roughly the percentage of weeks that a species was captured at a site.

For townet transects comprised of several tows, each tow is considered a sample. Therefore, frequency of occurrence is corrected for differing sampling efforts at the transects.

Catch data were recorded as CPUE for each salmonid species, where a unit of effort was defined as a 5-min tow of the surface trawl or one beach seine set. The geometric CPUE (nth root of the product of n elements) was used when possible because it is less affected by extreme high or low catches than arithmetic CPUE. Individual townet tows were combined as transects. The individual tows comprised the replicates upon which the transect geometric means were calculated. Figure 1 shows the breakpoints between the tows and the transects, and which beach seine sites were combined. Where geometric CPUE could not be calculated (because of lack of replicate sets), the data were reported as catch. The units of effort for the two gear types were not directly comparable since they sampled in a different manner and in different regions of the water column. However, it was important to contrast the results of the two sampling gears to examine shifts in habitat preference by outmigrating salmonids.

Imperfect beach seine sets or townet hauls were excluded from the data analysis. Statistical procedures follows Zar (1974).

RESULTS

Juvenile Salmonids

General Comments

During the 16-week sampling season, a total of 14,602 juvenile salmonids were captured by beach seine and townet within the study area. The catch was primarily of three species: chinook salmon (*Oncorhynchus tshawytscha*), chum salmon (*O. keta*) and coho salmon (*O. kisutch*). Pink salmon (*O. gorbuscha*) were also present in the sampling area, but only during the spring of even-numbered years. The catch and CPUEs of each species by sampling location and gear type for each sampling period is presented in Appendix A. Upon observation, the data in these tables reveal two significant facts:

1. chinook figured predominantly in catches, representing 90% of the total catch, and
2. the majority (60%) of the fish sampled were caught with the townet.

The frequency of occurrence Figures (Figures 2 and 3) show that juvenile salmonids were routinely captured throughout the study area, but with varying incidence. On the basis of the frequency of occurrence for beach seining and townetting, juvenile salmon were distributed throughout the study area.

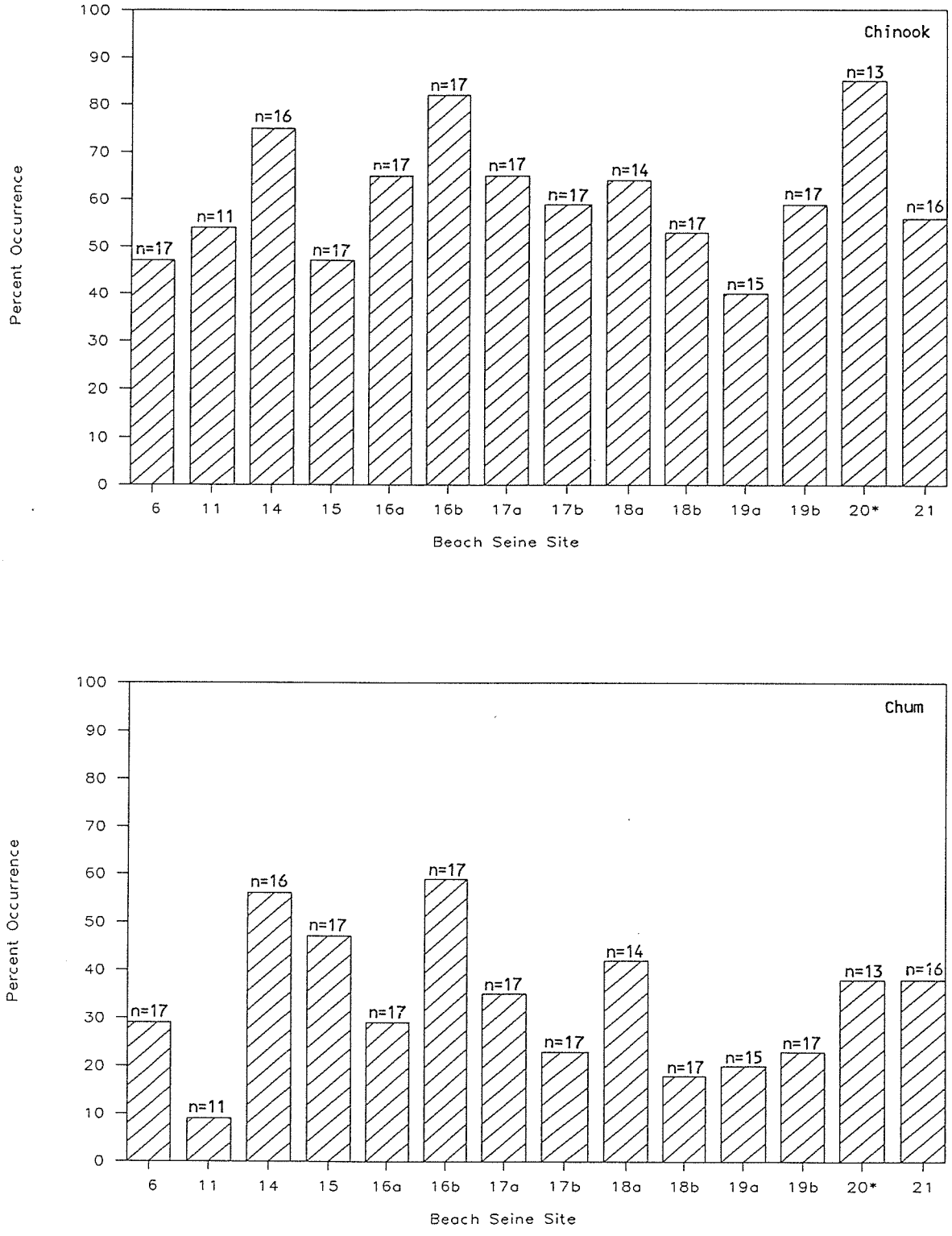
Chinook Salmon

Juvenile chinook salmon were the most abundant species captured: a total of 13,127 were caught by both sampling techniques, with the majority (86%) taken in a 4-week period from Julian day 135 to 162 (May 15 to June 11). Chinook were present in the area when sampling began on day 83 (March 24), peaked in late May and early June, and were present in low numbers at the conclusion of sampling on day 190 (July 9).

Of the 5,244 chinook captured by beach seine, 3,188 (59%) were taken at Site 19 (areas outside and adjacent to Milwaukee Waterway), and 2,171 of these were taken on day 148 (May 28). The sampling sites within the Milwaukee and City waterways had moderate catch rates, while the sites in the Blair and Hylebos waterways had relatively low catch rates. The beach seine site in Middle Waterway was unavailable during the peak outmigration; however, the available data indicated a catch trend similar to the other waterways.

Beach seine sampling sites along the north and south shores of Commencement Bay showed relatively high catch rates without the dramatic fluctuations exhibited by the sites close to the mouth of the Puyallup River. The sites along the Ruston Way shoreline and Browns Point shorelines showed peak catches approximately 10 days later than the waterway sites. Juvenile chinook showed no distinct preference for either the north or south shorelines of Commencement Bay during early rearing and outmigration.

Townet catches accounted for 60% (7,833) of the total number of juvenile chinook salmon sampled. Only four chinook were captured during the first 3 weeks of sampling (late April through early May). Catch rates increased in mid-May and peaked in the second week of June, followed by a rapid decline. The first increase in townet catch was observed near the mouth of Blair Waterway. Catches next exhibited bimodal peaks, at relatively high catch rates, at transects near the mouth of the Puyallup River and within Milwaukee and City waterways. As with beach seine catches, townet catches in Hylebos Waterway and along Ruston Way and Brown's Point shorelines peaked approximately 10 days later than those sites close to the Puyallup River.



* Data from sites 20a and 20b have been combined due to alternate sampling and close proximity.

Figure 2. Frequency of occurrence of chinook salmon and chum salmon at the beach seine sites, 1983.

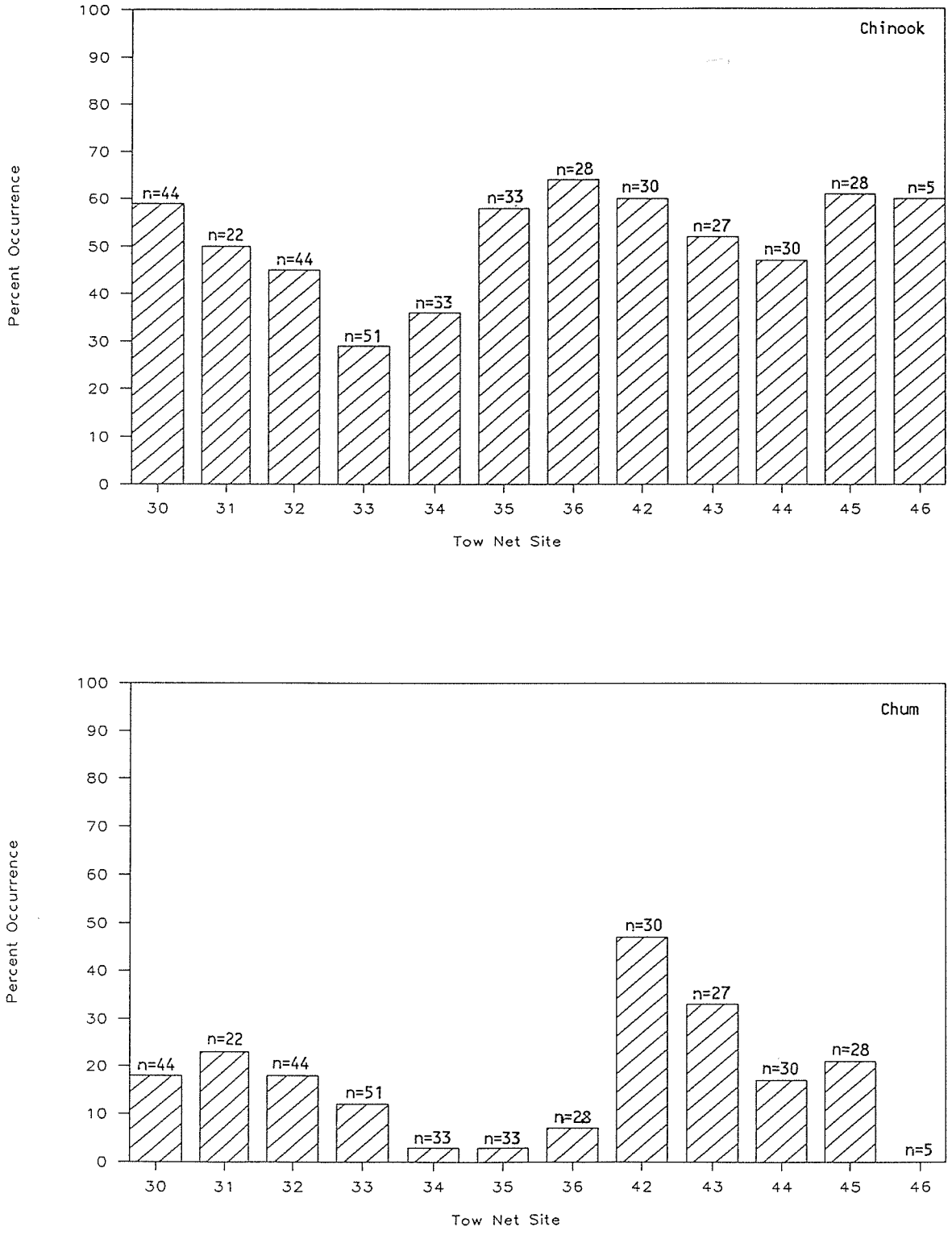


Figure 3. Frequency of occurrence of chinook salmon and chum salmon at the townet transects, 1983.

Chinook salmon captured by beach seine ranged from 60 to 100 mm, and those captured in the townet ranged from 70 to 90 mm. A three-way analysis of variance of length by gear by location by week indicated that fish size was not dependent on gear type, sampling location or sampling week ($F = 2.312$, $P = 0.06$) (Appendix Figures B-1, B-2 and B-3). Additional length data by site and sampling date are presented in Appendix Figures B-4 through B-10.

Some trends in fish lengths became apparent in gear type and location comparisons over time. Larger fish appeared to be collected in the townet at Ruston Way and Brown's Point. In Milwaukee Waterway, smaller fish were captured early in the sampling period while larger fish were caught later.

The following discussion presents a description of chinook catches by waterway.

City Waterway. Chinook salmon first appeared in the beach seine catch inside City Waterway on Julian day 121 (May 1), showing light use in the shoreline areas (Appendix Figure A-1). Catches increased greatly by day 140 (May 20) as fish were present inside and adjacent to the waterway. The beach seine and townet figures show two simultaneous peak catches, the first on day 143 (May 23) and the second on day 161 (June 10) (Appendix Figure A-6). Chinook were present in low numbers until the end of the sampling period on day 190 (July 9).

In summary, chinook salmon appear to use the shorelines early in May and are present along the shore and offshore throughout the waterway and adjacent areas after mid-May.

Middle Waterway. Catches peaked on day 160 (June 9) in Middle Waterway. On the basis of catches in adjacent waterways, the peak catch would have been expected earlier. Insufficient sampling during the expected peak period precludes detailed analysis of chinook usage in Middle Waterway.

Milwaukee Waterway. Chinook salmon were present in low numbers in the beach seine catches at sites outside Milwaukee Waterway as early as day 83 (March 24) and did not appear inside the waterway until day 113 (April 23) (Figure 4). Townet catches both inside and outside the waterway did not begin until day 130 (May 10) (Figure 5). Both beach seine and townet catches increased by day 140 (May 20) and peaked on day 143 (May 23). Low numbers of chinook were present at the conclusion of sampling on day 190 (July 7).

The data indicate that chinook salmon appear to use the shoreline outside Milwaukee Waterway early in the spring. Fish were found throughout the shoreline and offshore areas of the waterway after mid-May. Beach seine and townet catches outside the waterway were generally a minimum of two times greater than inside.

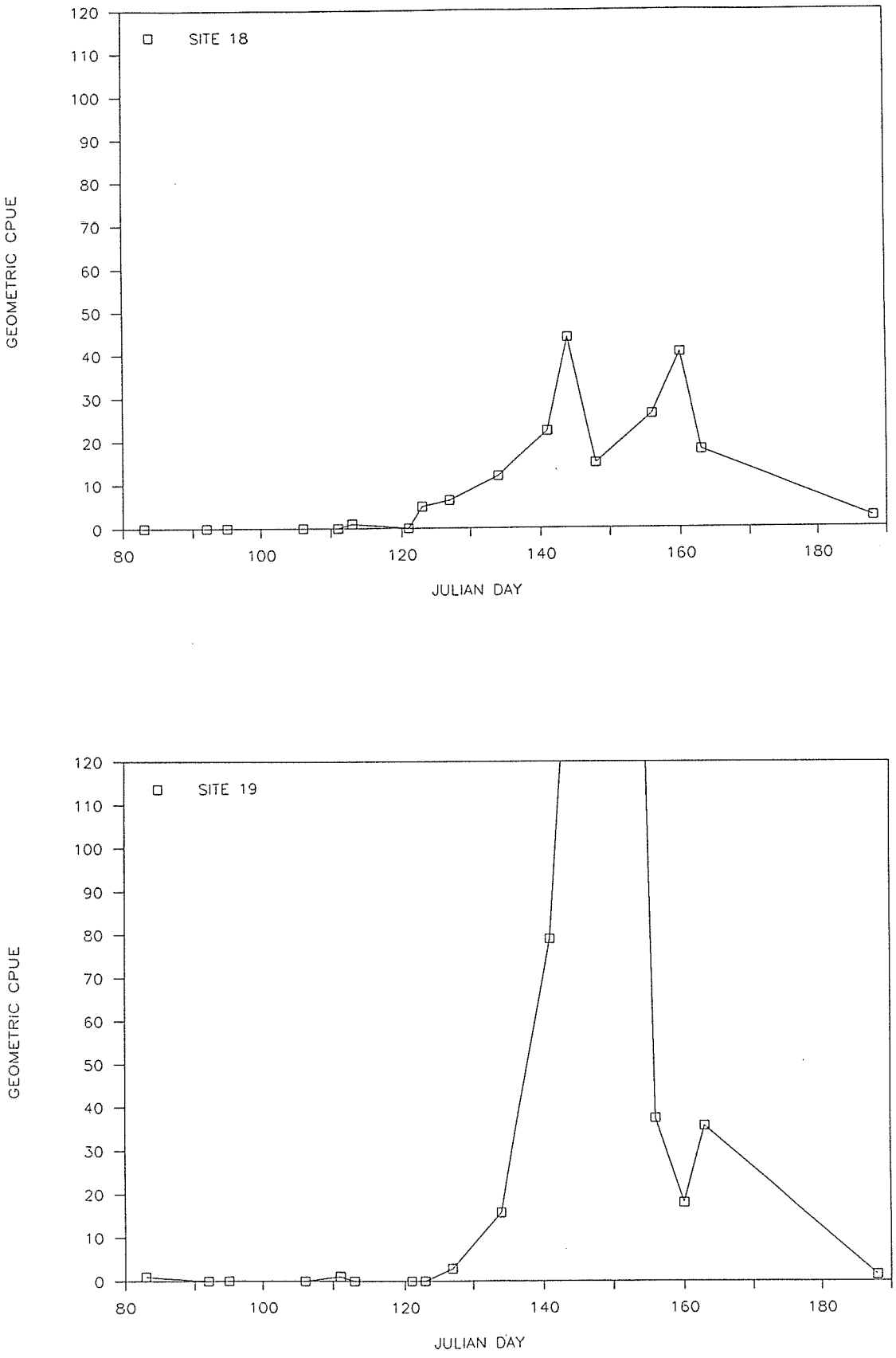


Figure 4. Beach seine catch of chinook salmon inside Milwaukee Waterway (Site 18) and outside Milwaukee Waterway (Transect 36), 1983.

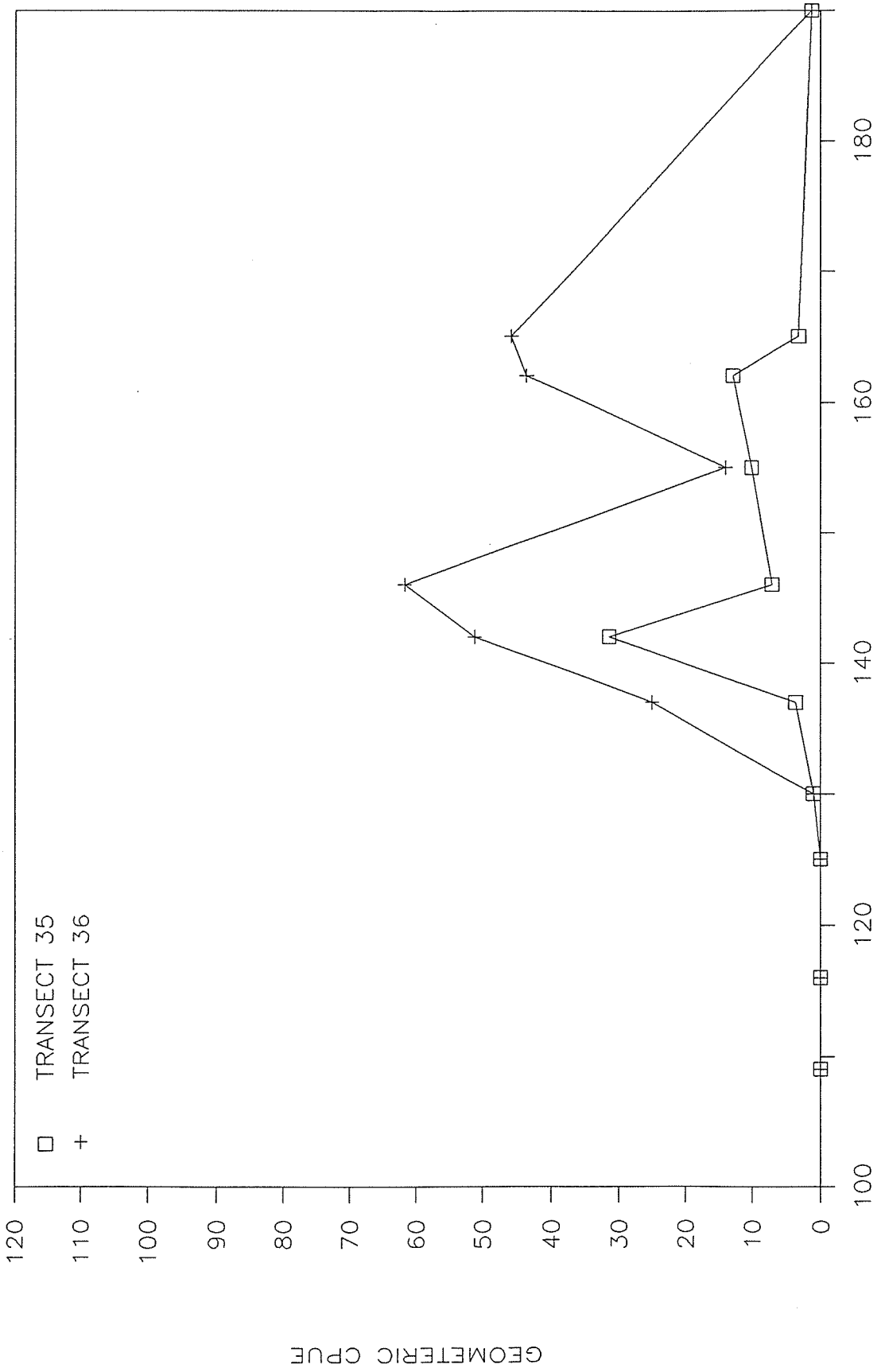


Figure 5. Townet catch of chinook salmon inside Milwaukee Waterway (Transect 35) and outside Milwaukee Waterway (Transect 36), 1983.

Blair Waterway. Chinook salmon appeared in very low numbers in the beach seine catches at sites in Blair Waterway on day 83 (March 24) and in the townet catches on day 109 (April 19) (Figures 6 and 7). Both beach seine and townet catches increased by day 130 (May 10) and peaked on day 143 (May 23).

As in the Milwaukee Waterway, chinook salmon use the shorelines early in the spring, but use occurs nearshore and offshore throughout the waterway and adjacent areas after mid-May. Comparison of townet catches in different areas of the waterway indicates up to three times greater use near the mouth of the waterway than near the head (Figure 7).

Hylebos Waterway. Low numbers of chinook salmon were caught in the beach seine in Hylebos Waterway on day 92 (April 2) (Appendix Figures A-3 and A-4). Chinook were present in townet catches on day 130 (May 10) (Appendix Figures A-7 and A-8). Catches increased by day 140 (May 20) and peaked near the shoreline on day 148 (May 28) and in the offshore area on day 155 (June 4). Fish were present in low numbers at the end of sampling on day 190 (July 9).

On the basis of this data, it would be reasonable to conclude that shoreline areas are used early in the spring, and these show peak catches earlier than the offshore areas. Comparison of townet data indicates two times greater utilization near the mouth of the waterway than near the head.

Browns Point. On day 92 (April 2), low numbers of chinook salmon appeared in the beach seine catch (Figure 8). By day 127 (May 7), catches increased with a peak on day 156 (June 5). Chinook appeared in the townet catch by day 138 (May 18) and peaked on day 155 (June 4) (Figure 9). Chinook were absent at the conclusion of sampling on day 190 (July 7).

In this case, chinook salmon appear to use the shoreline areas exclusively early in the spring; by mid-May higher use occurs in offshore areas. Beach seine and townet catches peak simultaneously at a later date than sites close to the Puyallup River.

Ruston-ASARCO. Chinook salmon were present early in the beach seine catch, increased by day 121 (May 1) and then declined by day 130 (May 10) (Appendix Figure A-5). Beach seine catches increased again on day 141 (May 21), showing a peak catch on day 148 (May 28). Townet catches increased by day 137 (May 17), declining by day 142 (May 22) (Appendix Figure A-9). Townet catches increased again on day 155 (June 4), showing a peak catch on day 162 (June 11). Chinook were caught in low numbers up to the end of sampling on day 190 (July 9).

At this location, chinook salmon use the shoreline during March and April in low numbers. Only after the releases of hatchery chinook were fish present in shoreline

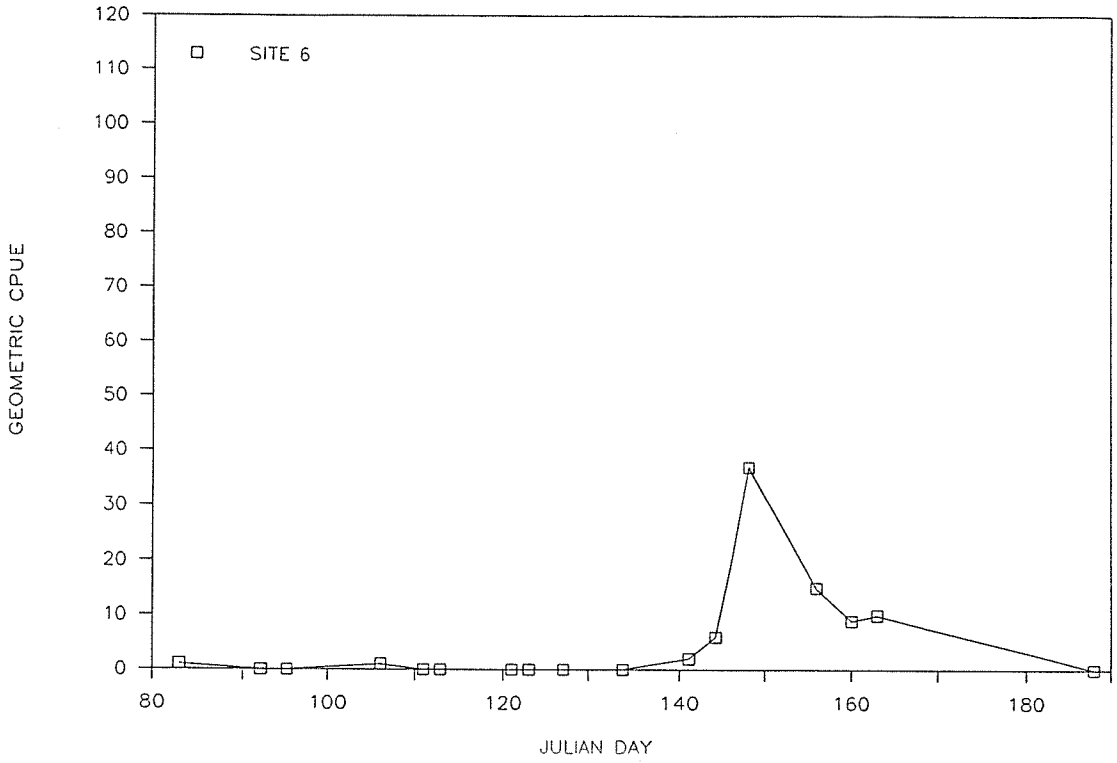


Figure 6. Beach seine catch of chinook salmon in Blair Waterway (Site 6), 1983.

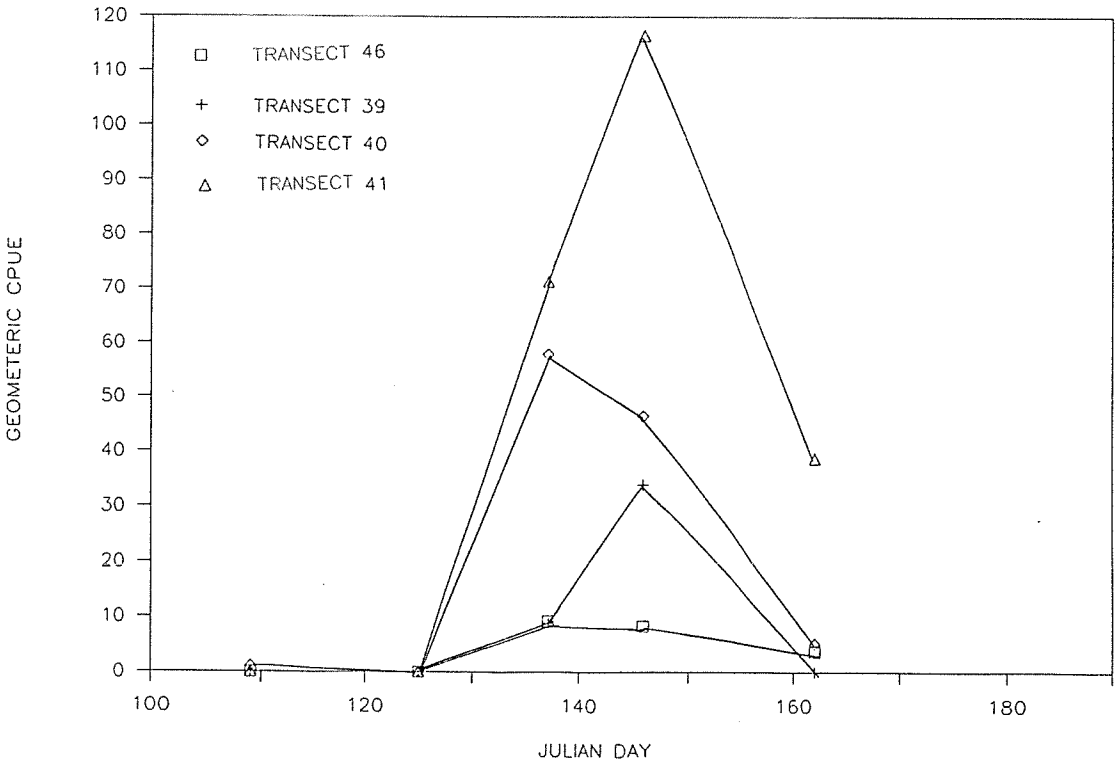


Figure 7. Townet catch of chinook salmon in the mouth Transects 40 and 41 at the head (Transect 46) of Blair Waterway, 1983.

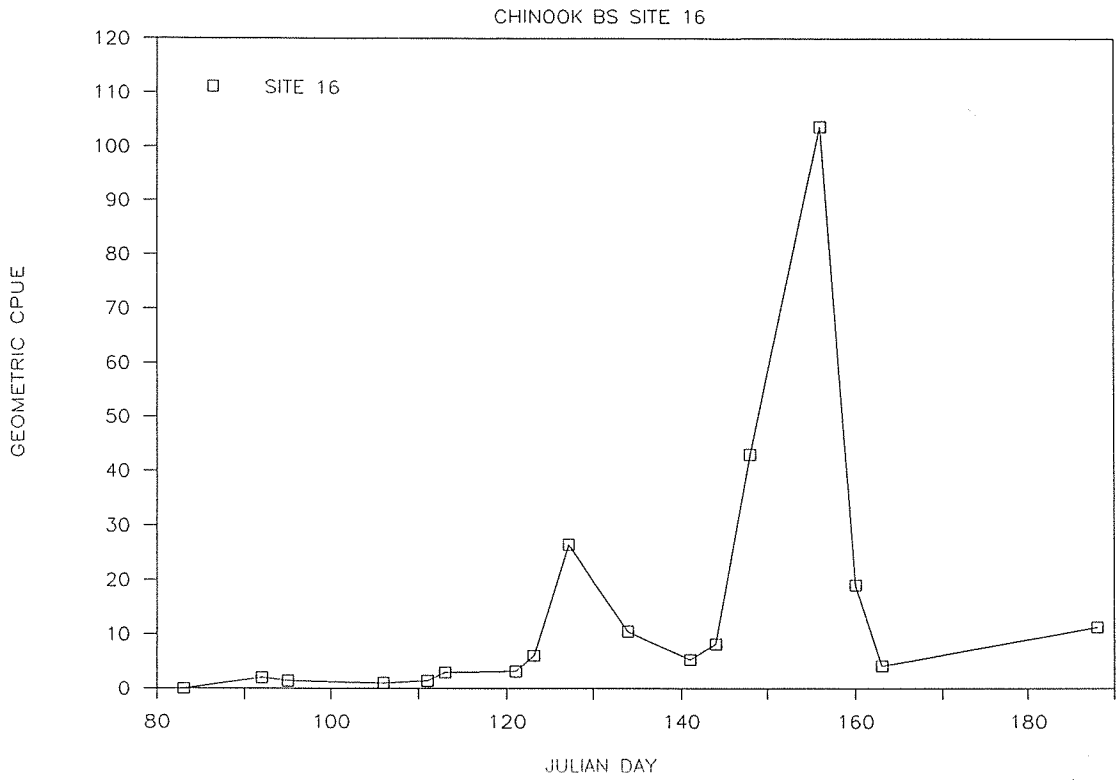


Figure 8. Beach seine catch of chinook salmon along the Brown's Point shoreline (Site 16), 1983.

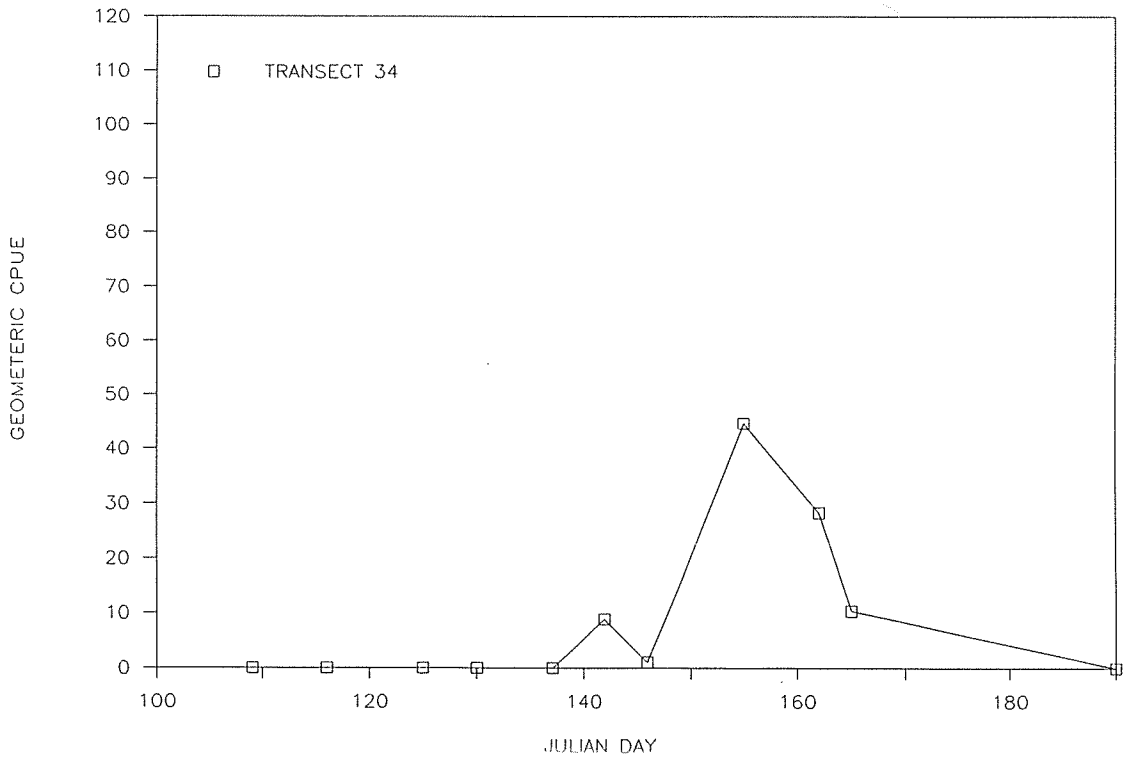


Figure 9. Townet catch of chinook salmon along the Brown's Point shoreline (Transect 34), 1983.

and offshore areas. In comparison, then, peak usage offshore is later than at sites closer to the Puyallup River.

Chum Salmon

A total of 607 chum salmon juveniles was caught during the sampling period. Catches are presented in Appendix Figures A-10 through A-26. Chum were present over the entire sampling season, and the majority (67%) were taken by beach seine. Most of these fish were collected near Brown's Point (Site 16) and along Ruston Way (Sites 14 and 15). The mudflat site in Hylebos Waterway (Site 17) was the only site within a waterway where relatively large numbers of chum salmon were caught. Townet catches indicated a relatively low and even distribution of chum salmon throughout the sampling area. CPUE rarely exceeded 2.0, although beach seine catches as high as 78 were recorded.

Comparisons of the entire data set indicate that chum were present along the shorelines early in the sampling period and later in the offshore areas . There appears to be no clear-cut peak in the numbers of juvenile chum salmon sampled. Comparisons of data from within a waterway to the mouth and adjacent areas indicate a general trend of usage inside the waterway early in the sampling period, moving out toward the mouth and adjacent areas later. Fish ranged from 50 to 67 mm in length, with the smaller fish captured early in the period. Sample sizes were too low to allow detailed length-frequency analysis.

Coho Salmon

A total of 1,068 juvenile coho salmon was collected by beach seine and townet over the sampling period. Catches are presented in Appendix Figures A-27 thru A-43. Coho were present in the study area when sampling began, but were not taken in large numbers until Julian day 125 (May 5). During the 3-week period (May 1-21), 61% and 75% of the townet and beach seine catch were taken, respectively. Coho were rarely caught after day 148 (May 28). Geometric mean CPUE was generally below 2.0 except during the 3-week period of peak outmigration.

The bulk of beach seine and townet catches was along the north and south shorelines of Commencement Bay (Sites 13, 14 and 15, and Transects 33 and 34) and near the mouth of the Puyallup River (Sites 18, 19 and 20, and Transects 30, 31, 32, 35 and 36). Peak catches occurred near the mouth of the Puyallup River at approximately day 130 (May 10) and in Commencement Bay at approximately day 145 (May 25). During

this peak outmigration, the fish averaged 125 mm in length and ranged from 80 to 149 mm.

Marine Fish

Over 25 species of marine fish (summarized by family and location in Table 2) were captured by beach seine. The association of bottom-dwelling fishes with low-gradient, sandy beaches and pelagic fishes to the higher gradient, rocky sampling sites is evident in this data (Table 2).

Table 2. Incidence of resident marine fishes encountered during beach seining.

Species	6	11	14	15	16a	16b	17a	17b	18a	18b	19a	19b	20a	20b	21
Sculpins (family Cottidae)			x	x	x	x	x					x			
Surf perch (family Embiotocidae)		x	x	x								x	x		
Flatfishes (families Pleuronectidae and Bothidae)		x	x	x			x				x				
Threespine stickle-back (*Gasterosteus aculeatus*)	x														
Gunnels (family Pholididae)		x	x												
Snake prickleback (*Lumpenus sagitta*)		x	x	x										x	
Sand lance (*Ammodytes hexapterus*)					x	x			x						
Surf smelt (*Hypomesus pretiosus*)	x	x						x							
Herring (*Clupea harengus pallasi*)	x	x													x

Only threespine sticklebacks, sand lance and herring were routinely encountered during townetting. The greatest density (i.e., juvenile herring, numbering in the thousands per catch) was found in the waterways on June 4, 1983.

All marine fish caught were considered incidental, since gear types and effort were concentrating on juvenile salmonids.

Environmental Parameters

Water visibility and salinity fluctuated dramatically throughout the sampling season and study area (Appendix C). Low visibility of <1 m was recorded in the discharge plume of the Puyallup River on several occasions, while high readings (i.e., >8 m) were made along Ruston Way and Browns Point. As a general trend, water visibility decreased during the sampling season, with the lowest values recorded during planktonic blooms in May and June. Salinity varied from 8.0 (recorded at the source of Hylebos Waterway) to >20 (at most sampling locations in Commencement Bay proper). Empirically, salinity in the waterways appeared to be a function of tide stage, with low readings recorded at the slack water of an ebb tide and high values corresponding to flood tide conditions.

Temperature exhibited variation throughout the study period with a range of 10° to 16°C.

The environmental parameters exhibited variation that might be expected from an area that is composed of sheltered waterways and exposed shoreline, and subjected to tidal influences and differing amounts of freshwater input.

DISCUSSION

Beach seine and townet sampling during the spring of 1983 documented the use of nearshore and offshore habitats within Commencement Bay by juvenile salmon. Chinook salmon were present from the first day of sampling (March 24) until the last day (July 7), with greatest use occurring between May 15 and June 11. Chum salmon were caught throughout the sampling period, but catches were so low as to limit the inferences that can be drawn regarding use. Coho salmon were present for the shortest period (3 weeks), and the pattern of use suggests rapid offshore movement.

Chinook Salmon

Juvenile chinook salmon were sampled in larger numbers than all the other species of Pacific salmon. Initially, these fish were uniformly distributed in low abundance

near the shoreline. In mid-May, catches increased substantially near the mouth of the Puyallup River and Milwaukee Waterway. We believe that a large percentage of the chinook captured adjacent to the mouth of Milwaukee Waterway is of hatchery origin owing to the timing of the peak catch relative to documented releases of chinook smolts from Voight Creek hatchery (Figure 10). This observation is supported by the increase in abundance of chinook throughout the study area subsequent to the large catches near the mouth of the Puyallup River and Milwaukee Waterway. The presence of large numbers of hatchery fish confounded the analysis of habitat use and timing by the early segments of the population, which were more dependent upon the nearshore habitats. A conventional model of use by chinook (Healey 1982) would postulate shoreline residence of small fish in the early spring with movement offshore as the individuals increase in size. This pattern of use was indicated by the initial beach seine catches and lack of townet catches. However, when the hatchery fish were released, this pattern may have been masked. The fate of the earliest releases of chinook (prior to day 130, Figure 10) is unknown. However, many of these fish probably reared in the river prior to entering the bay. There was no indication that a large number of the early releases were using the bay soon after release.

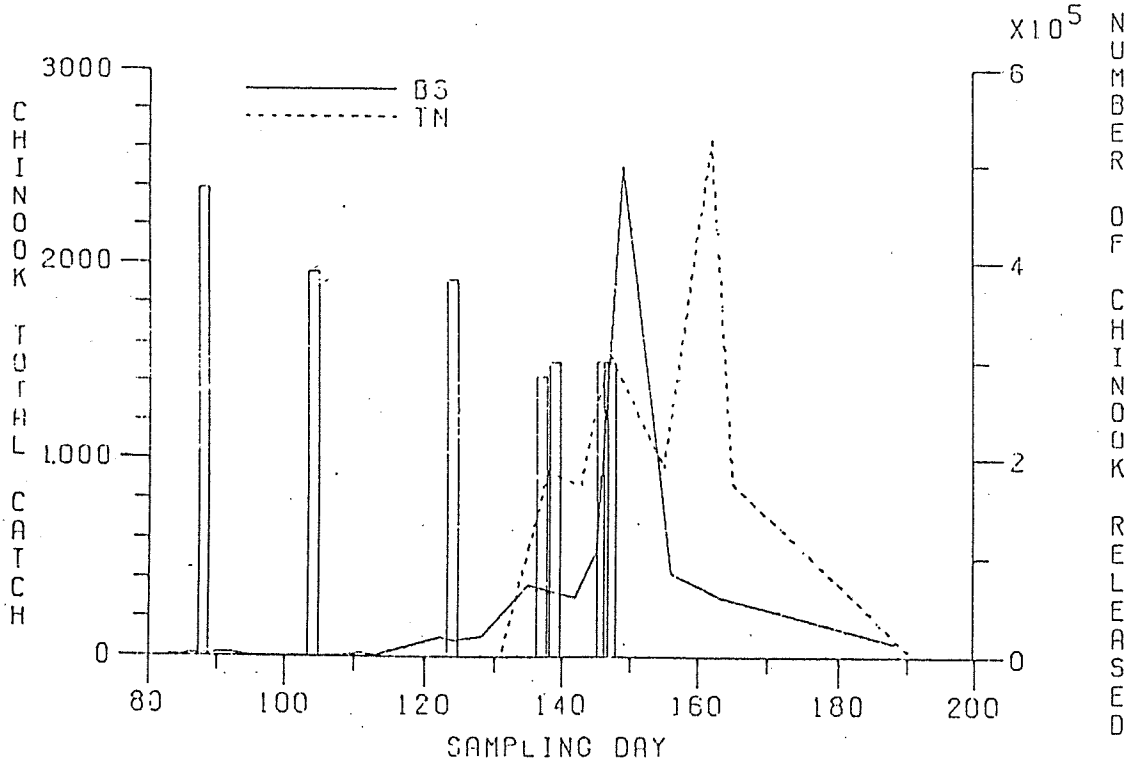


Figure 10. Overall beach seine and townet catch of chinook salmon compared to release dates of hatchery chinook salmon, 1983 (WDF data only).

A comparison of the overall beach seine catches to the overall townet catches indicates that the townet catches peaked about 10 days to 14 days later (Figure 10). This could indicate a consistent shoreline residence period by all chinook followed by movement offshore. However, when beach seine and townet catches were compared for individual sites, the peaks typically occurred simultaneously. This suggests that the hatchery fish have no preference for the shoreline; instead, they use all available areas. An alternative explanation is that the released fish have a preference for the shoreline, but the numbers of individuals overwhelm the habitat and force a large segment of the rearing population into the deeper water offshore. This appears unlikely, however, because the fish appear large enough at the time of release to make the shift to feeding on pelagic prey (mean about 80 mm, see Appendix B). The shift is postulated to occur between 65-75 mm by Healey (1982) and Simenstad et al. (1982). This indicates that the fish in the offshore areas may be in their preferred habitat. Further, the beach seine catches were not typically high enough to indicate densities that would precipitate offshore movement. It is very difficult to draw robust conclusions from the beach seine data regarding dependence upon intertidal habitats because the beach seine actually sampled the intertidal areas and the zone just beyond the intertidal. Therefore, it is not known which habitats were actually occupied by the fish during sampling.

A trend that is clear is the migration outward over time from near the mouth of the Puyallup River towards the north and south shores of the bay. The peak catches near the river occurred 10 to 12 days prior to the peaks along the Ruston Way and Browns Point shorelines. This may represent the minimum time of nearshore residence necessary for acclimation to saltwater.

Our model of Commencement Bay use by chinook salmon in 1983 is presented in Figures 11 and 12. These figures were developed by interpolating the catch data presented in the results section. Figure 11 shows use of shoreline areas prior to the hatchery releases, while Figure 12 shows use after the releases. In summary, juvenile chinook salmon used nearshore areas throughout Commencement Bay early in the outmigration, peaked with uniform distribution in all areas, and move offshore and towards the outskirts of the bay later. There appeared to be no clear-cut preference of north or south shorelines during outmigration.

The distribution of chinook salmon in the shoreline areas of the bay was similar to that shown by Weitkamp and Schadt (1982), Miyamoto et al. (1980) and Meyer et al. 1981. Each of these studies documented widespread use of shoreline habitats by juvenile chinook. Weitkamp and Schadt's work corroborates ours regarding use of the

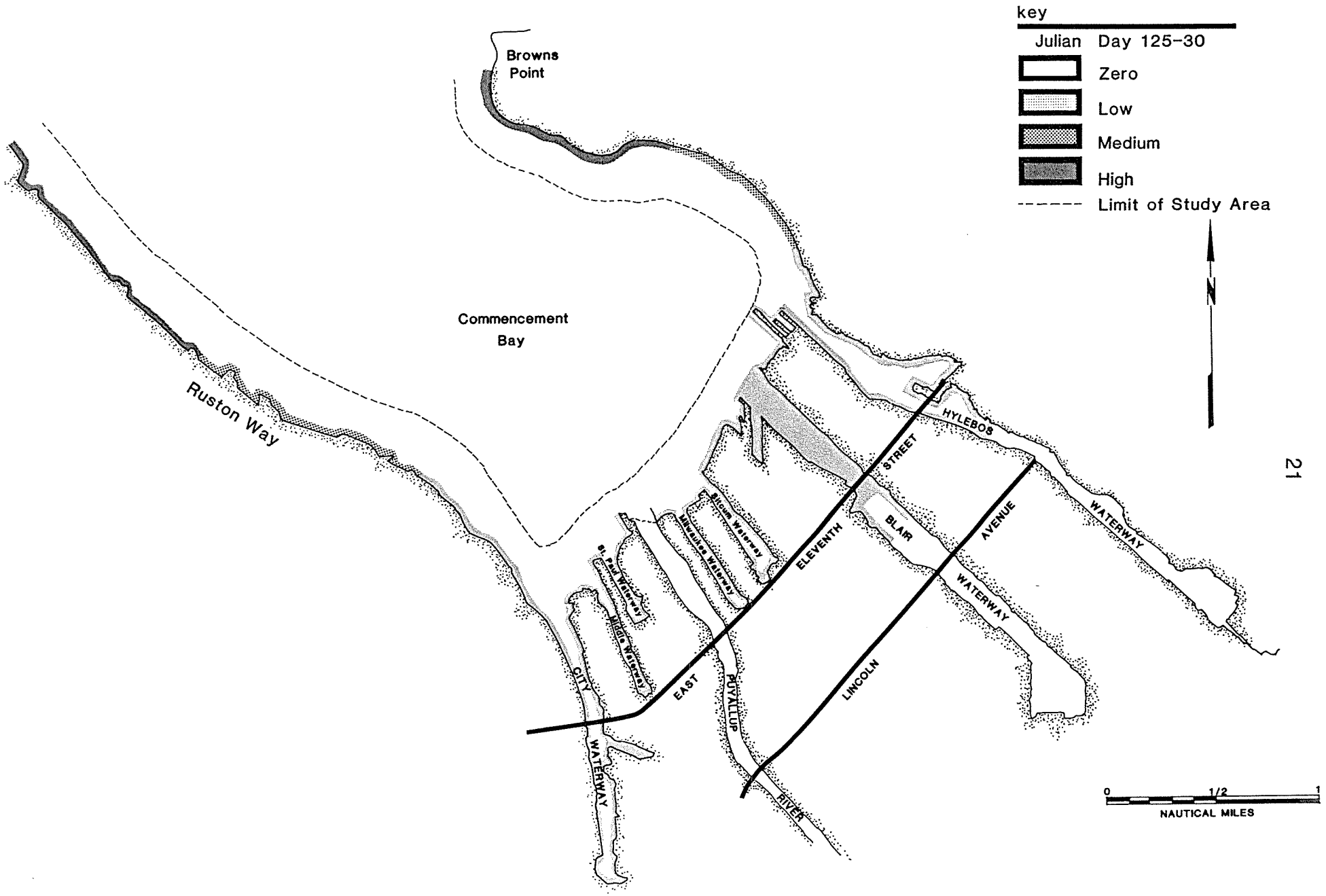


Figure 11. Relative abundance of juvenile chinook salmon in Commencement Bay prior to release of hatchery fish.

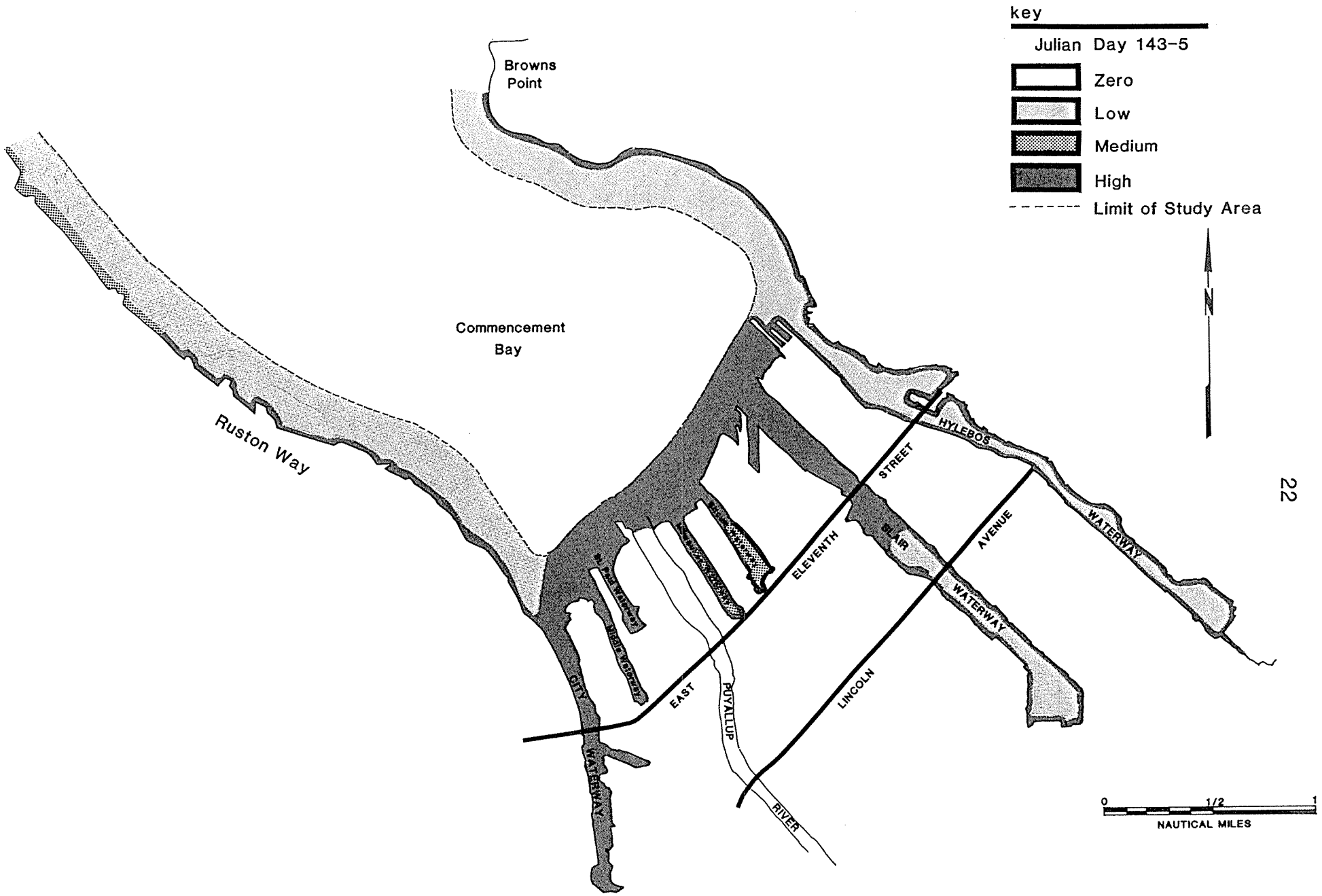


Figure 12. Relative abundance of juvenile chinook salmon in Commencement Bay after release of hatchery fish.

longer waterways (Blair and Hylebos). Both studies show that these waterways are used more heavily near their mouths than near their heads.

Of the previous studies, only Weitkamp and Schadt sampled specifically for juvenile salmonids in offshore habitats. They used a purse seine and confined themselves to sites very close to shore. No sampling was conducted beyond the waterway mouths. The conclusion one would draw from their study is that offshore use is not extensive except inside some of the waterways (notably Milwaukee and City). The results of the present study indicate use of more of the available area within the bay than was indicated by previous sampling. Apparently most of this use is by hatchery fish.

Chum Salmon

Juvenile chum salmon were captured in lower numbers than the other salmonid species, but were present in most areas throughout the sampling period. Similar to chinook, chum use the shoreline areas early, moving offshore and towards the outskirts of Commencement Bay later in the migration. Low CPUEs make peak timing and length-frequency analysis impractical. The low beach seine catches appear to be inconsistent with the experience of Jones & Stokes Associates (1988) staff, who have documented generally much higher beach seine catches of juvenile chum salmon along the shoreline of the waterways in recent years. We suspect that differences in net mesh sizes, fishing technique and habitat characteristics could contribute to the differences in catches between these studies.

Coho Salmon

Coho were caught during a 3-week period in May. The timing and size of the individuals suggest that many were hatchery fish. The catches indicate coho are moving offshore rapidly relative to chum and chinook. The results of the study are consistent with previous studies, which indicated rapid movement and a short overall period of use of the estuary by this species.

SUMMARY

- Juvenile salmon use the shorelines, waterways, and open-water areas of Commencement Bay.
- Juvenile chinook are present in Commencement Bay from March into July, but peak use occurs from mid-May to mid-June.

- Juvenile chinook salmon smolts entering the bay from the Puyallup River use offshore habitats as well as shoreline habitats.
- Juvenile chum salmon were captured in low numbers throughout the study area, and they appear to be more closely associated with the shoreline than were the chinook.
- Juvenile coho salmon appear to exit Commencement Bay soon after entering salt water.

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APPENDIX A—CATCH AND CPUE DATA: 1983

Table A-1. Beach Seine Catch of Juvenile Salmonids by Julian Week in Commencement Bay, Tacoma, Washington, 1983.

Julian Week / Julian Days	12 78-84			14 a,b 92-98			16 a,b 106-112			17 113-119			18 a,b 120-126			19 127-133			20 134-140			21 a,b 141-147			22 148-154		
Site	Chum	Coho	Chin	Chum	Coho	Chin	Chum	Coho	Chin	Chum	Coho	Chin	Chum	Coho	Chin	Chum	Coho	Chin	Chum	Coho	Chin	Chum	Coho	Chin	Chum	Coho	Chin
BS-6	0	0	1	0, 0	0, 0	0, 0	0, 0	0, 0	1, 0	2	0	0	0, 0	0, 2	0, 0	0	3	0	1	9	0	1, 1	0, 0	2, 6	0	7	37
BS-11	0	0	0	0, 0	0, 0	0, 0	-, 0	-, 0	-, 0	0	0	0	1, 0	0, 1	1, 8	0	0	1	-	-	-	-, -	-, -	-, -	-	-	-
BS-14	0	0	1	-, 2	-, 6	-, 1	0, 78	0, 0	0, 10	0	0	0	8, 5	10, 0	35, 10	0	0	0	1	2	4	1, 18	0, 0	25, 9	23	13	62
BS-15	2	0	0	0, 0	0, 0	0, 0	0, 0	0, 0	0, 0	0	0	0	9, 0	1, 0	39, 0	0	9	0	1	0	0	0, 1	0, 0	12, 1	2	6	23
BS-16a	0	0	0	0, 0	0, 0	0, 0	0, 0	0, 0	0, 0	0	0	9	0, 0	2, 0	10, 2	6	69	32	1	5	22	0, 1	0, 1	2, 4	7	1	49
BS-16b	0	0	0	0, 0	0, 0	4, 2	2, 0	0, 0	1, 2	0	0	0	0, 26	0, 3	0, 37	20	34	22	7	6	5	1, 1	0, 1	14, 17	3	0	38
BS-17a	0	0	0	0, 1	0, 0	11, 1	1, 21	0, 0	0, 6	0	0	0	11, 5	32, 0	11, 0	0	0	0	0	6	0	1, 0	0, 0	13, 7	0	0	31
BS-17b	0	0	0	1, 0	0, 0	3, 0	0, 0	0, 0	6, 0	0	0	0	0, 32	0, 0	0, 0	0	0	0	2	1	5	0, 2	1, 0	5, 3	0	0	30
BS 18a	-	-	-	-, -	-, -	-, -	0, 0	0, 0	0, 0	0	0	0	0, 4	0, 0	0, 25	2	3	41	0	0	18	2, 7	1, 0	56, 122	1	0	15
BS-18b	0	0	0	0, 0	0, 0	0, 0	0, 0	0, 0	0, 0	3	0	1	0, 0	0, 0	0, 0	0	0	0	4	77	8	0, 0	4, 7	9, 16	0	1	15
BS-19a	0	0	0	1, 0	0, 0	0, 0	0, 0	0, 0	0, 0	-	-	-	0, 0	0, 0	0, 0	0	0	0	0	1	0	1, 0	0, 8	72, 183	11	3	1989
BS-19b	0	0	1	0, 0	0, 0	0, 0	2, 0	0, 0	0, 1	0	0	0	0, 0	0, 0	0, 0	0	5	8	1	3	284	1, 0	0, 0	87, 132	7	0	182
BS-20a	-	-	-	-, -	-, -	-, -	-, -	-, -	-, -	-	-	-	-, -	-, -	-, -	-	-	-	1	36	16	1, 0	0, 1	18, 25	2	2	35
BS-20b	0	0	11	0, -	0, -	0, -	-, -	-, -	-, -	2	0	3	-, 1	-, 5	-, 3	0	0	0	-	-	-	-, -	-, -	-, -	-	-	-
BS-21	-	-	-	1, 0	0, 0	0, 0	0, 1	0, 0	0, 0	2	0	0	6, 1	6, 0	1, 0	0	0	0	1	2	3	0, 0	0, 1	3, 7	0	0	1

* Dashes (-) indicate that no sampling occurred during this period.

Table A-1, cont'd.

Julian Week Julian Days	23 a,b 155-161			24 162-168			27 183-189		
Site	Chum	Coho	Chin	Chum	Coho	Chin	Chum	Coho	Chin
BS-6	1, 0	0, 0	15, 9	0	0	10	0	0	0
BS-11	-, 0	-, 0	-, 55	0	0	53	0	0	6
BS-14	0, 3	0, 0	20, 33	0	0	10	0	0	0
BS-15	8, 8	0, 0	10, 14	4	0	15	0	1	16
BS-16a	0, 1	0, 1	92, 12	0	1	9	0	0	8
BS-16b	3, 1	0, 0	117, 30	0	0	2	2	0	16
BS-17a	0, 0	0, 1	6, 13	0	0	10	0	0	3
BS-17b	0, 0	0, 0	6, 15	0	0	15	0	0	2
BS-18a	1, 0	0, 0	21, 66	0	0	25	0	1	6
BS-18b	0, 0	0, 0	33, 25	1	0	13	0	0	0
BS-19a	0, 0	0, 0	52, 18	0	1	58	0	0	0
BS-19b	0, -	0, -	27, -	0	0	22	0	0	2
BS-20a	-, 0	-, 0	-, 51	-	-	-	0	0	9
BS-20b	0, -	0, -	9, -	0	0	60	-	-	-
BS-21	0, 0	1, 0	14, 20	0	0	5	0	0	4

Table A-2. Townet Catch of Juvenile Salmonids by Julian Week in Commencement Bay, Tacoma, Washington, 1983.

Julian Week	16			17			18			19			20			21 a,b			23			24 a,b			28		
Julian days	106-112			113-119			120-126			127-133			134-140			141-147			155-161			162-168			190-196		
Townet	chum	coho	chin	chum	coho	chin	chum	coho	chin	chum	coho	chin	chum	coho	chin	chum	coho	chin	chum	coho	chin	chum	coho	chin	chum	coho	chin
TN-30a	1	0	1	0	0	0	0	0	0	0	0	0	0	0	7	0, 0	0, 0	7, 29	1	0	17	0, 0	0, 0	4, 5	0	0	2
TN-30b	0	0	0	0	0	0	0	0	0	0	0	0	0	3	12	0, 5	1, 4	74, 148	1	0	5	1, 0	0, 0	51, 16	0	0	0
TN-30c	0	0	0	0	0	0	0	1	0	0	29	0	0	4	0	1, 0	10, 1	58, 49	0	0	65	15, 0	0, 0	195, 18	0	0	1
TN-30d	0	0	0	0	0	0	0	0	0	0	0	0	0	62	1	0, 0	4, 0	12, 61	0	0	1	7, 0	1, 0	170, 13	0	0	0
TN-31a	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	2, 0	10, 2	66, 88	0	1	4	0, 1	0, 0	12, 31	0	0	0
TN-31b	0	0	0	0	0	0	0	1	0	0	0	0	1	6	11	0, 0	23, 0	123, 112	1	0	15	5, 0	4, 0	293, 131	0	0	0
TN-32a	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0, 0	1, 7	25, 126	0	0	0	3, 0	0, 0	51, 277	0	0	0
TN-32b	0	0	0	0	0	0	0	0	0	0	0	0	0	3	8	0, 0	13, 3	38, 8	0	0	2	2, 1	0, 0	185, 32	0	0	0
TN-32c	0	0	0	0	1	0	0	0	0	0	3	0	0	1	1	0, 0	31, 0	15, 0	0	0	41	6, 0	0, 0	491, 0	2	0	10
TN-32d	0	0	0	0	0	0	0	0	0	1	1	0	0	2	1	0, 0	20, 0	53, 8	0	0	0	3, 0	0, 0	37, 0	0	0	0
TN-33a	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0, -	0, -	0, -	0	0	0	0, 0	0, 0	6, 0	0	0	0
TN-33b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	0, -	0, -	0, -	0	0	3	6, 0	1, 0	335, 0	0	0	0
TN-33c	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0, -	0, -	0, -	0	0	77	5, 0	2, 0	237, 0	0	0	0
TN-33d	0	0	0	0	0	0	0	0	0	0	4	0	0	0	2	0, -	1, -	0, -	0	1	4	1, 0	0, 0	9, 1	0	1	0
TN-33e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	1, -	0, -	7, -	0	0	43	1, 0	0, 0	17, 0	0	0	0
TN-33f	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-, -	-, -	-, -	-	-	-	-, -	-, -	-, -	-	-	-
TN-34a	0	0	0	0	2	0	0	26	0	0	0	0	0	0	0	0, 0	1, 0	25, 1	0	0	56	0, 0	0, 0	29, 0	0	0	0
TN-34b	0	0	0	0	0	0	0	84	0	0	0	0	0	0	0	0, 0	2, 0	7, 0	0	1	43	0, 0	0, 0	17, 63	0	0	0
TN-34c	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0, 0	3, 0	4, 0	0	1	37	3, 0	0, 0	46, 18	0	0	0
TN-35a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0, 0	0, 0	13, 4	0	0	2	0, 0	0, 0	3, 0	0	0	0
TN-35b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0, 1	0, 0	33, 86	0	0	30	0, 0	0, 0	19, 8	0	0	2
TN-35c	0	0	0	0	0	0	0	0	0	0	23	1	0	0	9	1, 0	0, 0	73, 1	0	0	17	2, 0	0, 1	38, 4	0	0	0

* Dashes (-) indicate that no sampling occurred during this period.

Table A-2, cont'd.

Julian Week	16			17			18			19			20			21 a,b			23			24 a,b			28		
Julian days	106-112			113-119			120-126			127-133			134-140			141-147			155-161			162-168			190-196		
Townet	chum	coho	chin	chum	coho	chin	chum	coho	chin	chum	coho	chin	chum	coho	chin	chum	coho	chin	chum	coho	chin	chum	coho	chin	chum	coho	chin
TN-36a	0	0	0	0	0	0	0	0	0	0	48	0	0	0	16	0, 0	0, 0	64, 76	0	0	39	2, 0	0, 0	15, 21	0	0	2
TN-36b	0	0	0	0	0	0	0	0	0	0	23	1	0	0	39	0, 0	4, 0	41, 86	0	0	5	0, 0	0, 0	45, 90	0	0	1
TN-36c	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-	-, 0	-, 1	-, 36	0	0	0	2, 0	0, 0	123, 51	-	-	-
TN-42a	-	-	-	0	0	0	-	-	-	3	0	0	-	-	-	0, -	11, -	72, -	2	2	180	-, 0	-, 0	-, 0	0	0	2
TN-42b	-	-	-	0	0	0	-	-	-	3	0	0	-	-	-	1, -	15, -	17, -	5	1	106	-, 0	-, 0	-, 2	0	0	2
TN-42c	-	-	-	1	0	0	-	-	-	0	0	0	-	-	-	1, -	1, -	6, -	1	2	44	-, 0	-, 0	-, 9	0	0	7
TN-42d	-	-	-	0	0	0	-	-	-	0	0	0	-	-	-	0, -	2, -	6, -	4	0	35	-, 2	-, 0	-, 16	0	0	0
TN-42e	-	-	-	26	0	0	-	-	-	1	0	0	-	-	-	1, -	0, -	3, -	2	0	16	-, 0	-, 0	-, 13	0	0	3
TN-43a	-	-	-	5	0	0	-	-	-	1	0	0	-	-	-	0, -	0, -	9, -	0	0	49	-, 0	-, 0	-, 7	0	0	0
TN-43b	-	-	-	2	0	0	-	-	-	0	0	0	-	-	-	0, -	0, -	4, -	0	0	21	-, 0	-, 0	-, 11	0	0	1
TN-43c	-	-	-	6	0	0	-	-	-	0	1	0	-	-	-	0, -	2, -	0, -	-	-	-	-, 0	-, 0	-, 7	0	0	0
TN-43d	-	-	-	5	0	0	-	-	-	0	3	0	-	-	-	4, -	6, -	6, -	-	-	-	-, 0	-, 0	-, 14	-	-	-
TN-43e	-	-	-	3	0	0	-	-	-	1	5	0	-	-	-	7, -	1, -	4, -	-	-	-	-, 0	-, 0	-, 9	-	-	-
TN-43f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-, -	-, -	-, -	-	-	-	-, 0	-, 0	-, 10	-	-	-
TN-43g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-, -	-, -	-, -	-	-	-	-, 0	-, 0	-, 3	-	-	-
TN-44a	0	0	0	-	-	-	1	0	0	-	-	-	2	4	4	-, 0	-, 0	-, 9	-	-	-	0, -	0, -	2, -	-	-	-
TN-44b	0	0	0	-	-	-	0	0	0	-	-	-	0	1	2	-, 0	-, 0	-, 2	-	-	-	1, -	0, -	2, -	-	-	-
TN-44c	1	0	0	-	-	-	0	0	0	-	-	-	1	3	9	-, 0	-, 0	-, 8	-	-	-	0, -	0, -	9, -	-	-	-
TN-44d	0	0	0	-	-	-	0	0	0	-	-	-	1	16	38	-, 0	-, 1	-, 42	-	-	-	0, -	0, -	0, -	-	-	-
TN-44e	0	0	0	-	-	-	0	0	0	-	-	-	0	3	18	-, 0	-, 5	-, 36	-	-	-	0, -	0, -	0, -	-	-	-
TN-44f	0	0	0	-	-	-	1	0	0	-	-	-	0	0	0	-, 0	-, 0	-, 26	-	-	-	0, -	0, -	0, -	-	-	-
TN-45a	-	-	-	-	-	-	0	0	0	-	-	-	5	12	227	-, 0	-, 0	-, 94	-	-	-	0, -	0, -	0, -	-	-	-
TN-45b	0	0	0	-	-	-	0	0	0	-	-	-	2	2	21	-, 0	-, 0	-, 90	-	-	-	4, -	0, -	66, -	-	-	-
TN-45c	0	0	1	-	-	-	0	1	0	-	-	-	0	3	41	-, 1	-, 0	-, 12	-	-	-	0, -	0, -	2, -	-	-	-
TN-45d	0	0	0	-	-	-	0	1	0	-	-	-	0	1	25	-, -	-, -	-, -	-	-	-	0, -	1, -	46, -	-	-	-
TN-45e	0	0	0	-	-	-	0	0	0	-	-	-	0	7	130	-, 0	-, 1	-, 230	-	-	-	2, -	0, -	61, -	-	-	-
TN-45f	0	0	0	-	-	-	0	0	0	-	-	-	0	7	112	-, 0	-, 0	-, 59	-	-	-	3, -	0, -	21, -	-	-	-
TN-46	0	0	0	-	-	-	0	0	0	-	-	-	0	15	101	-, 0	-, 0	-, 33	-	-	-	0, -	0, -	5, -	-	-	-

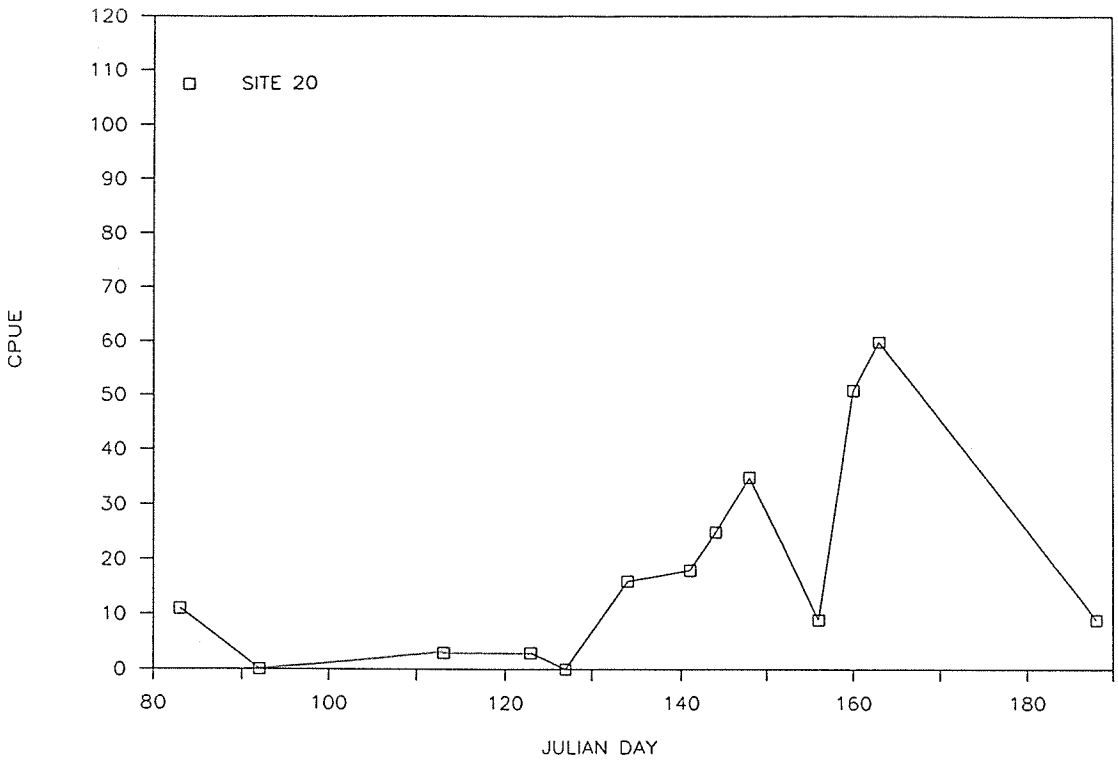

Figure A-1. Beach Seine Catch of Chinook Salmon in City Waterway (Site 20), 1983.

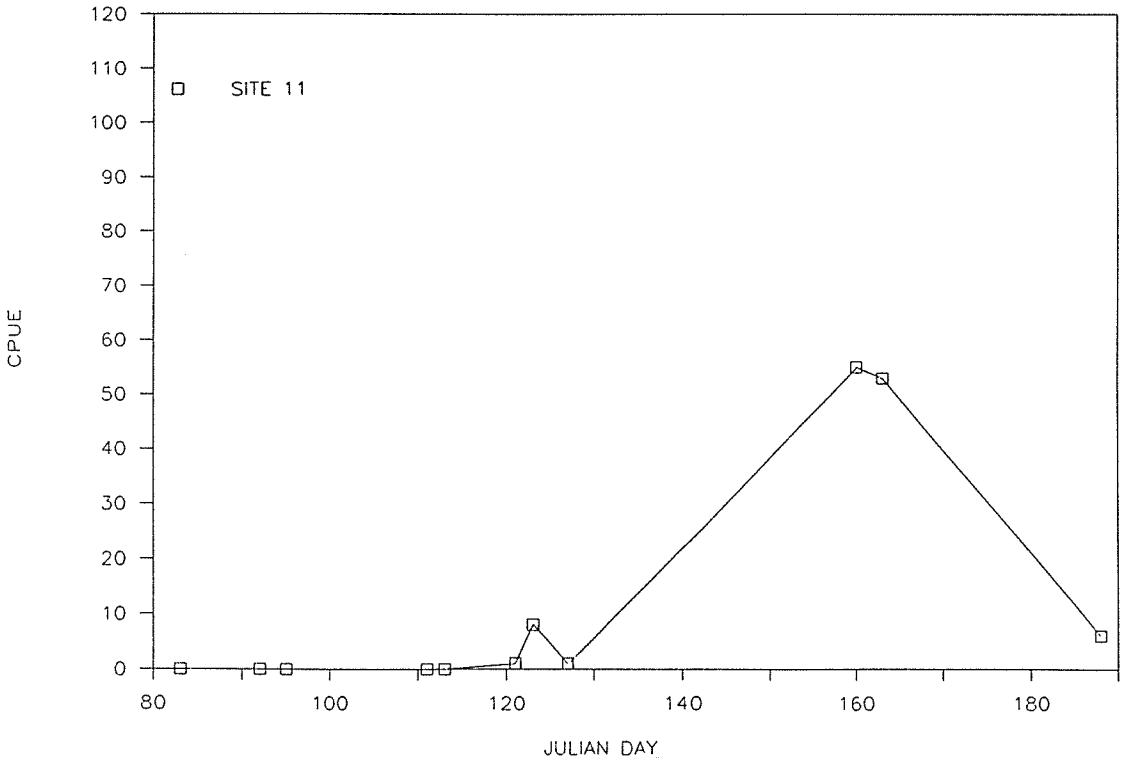

Figure A-2. Beach Seine Catch of Chinook Salmon in Middle Waterway (Site 11), 1983.

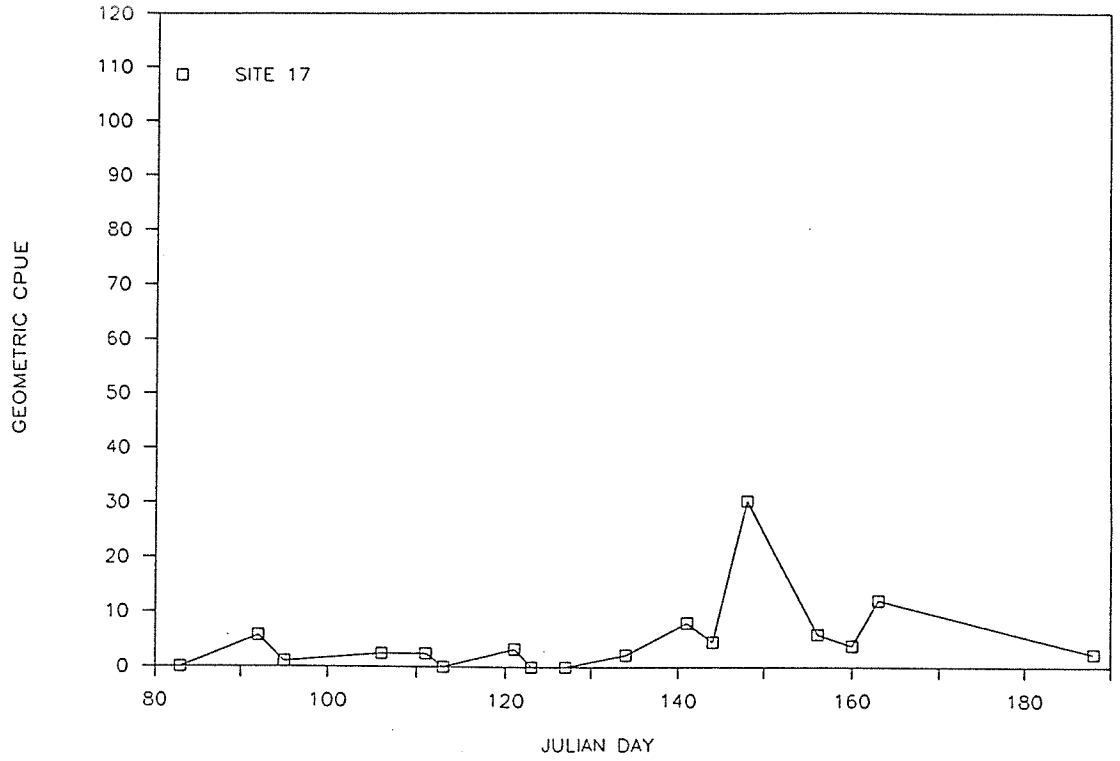

Figure A-3. Beach Seine Catch of Chinook Salmon in the Mouth of Hylebos Waterway (Site 17), 1983.

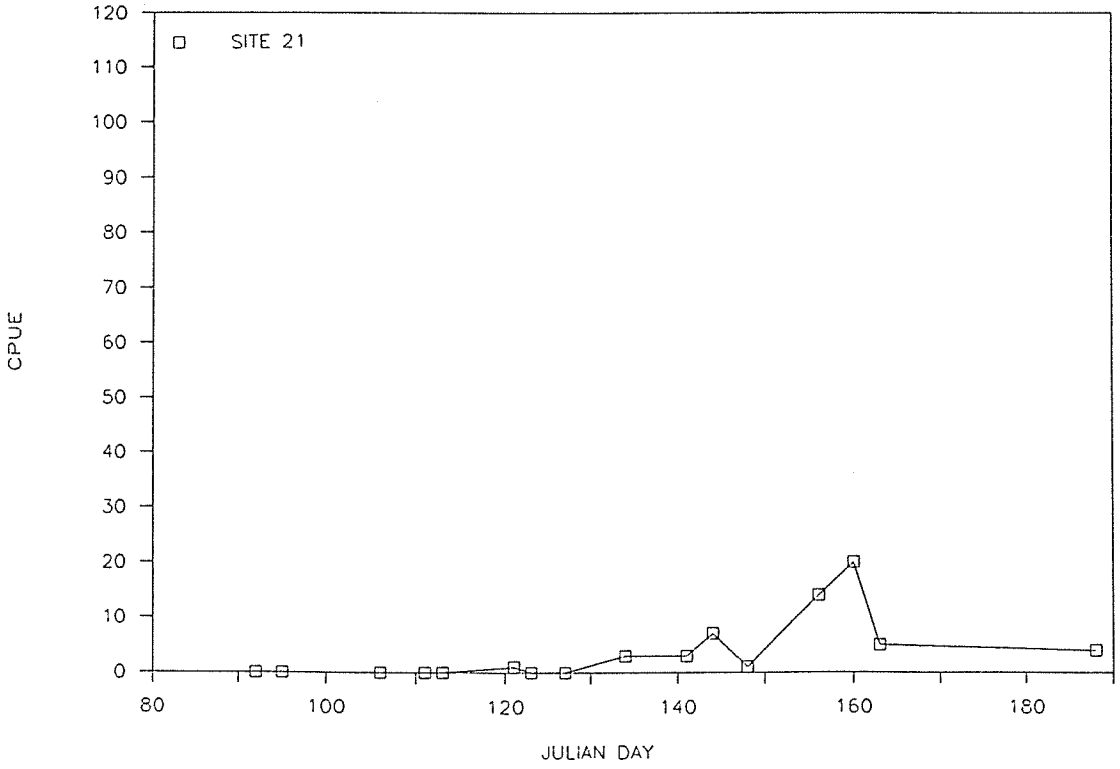

Figure A-4. Beach Seine Catch of Chinook Salmon at the Head of Hylebos Waterway (Site 21), 1983.

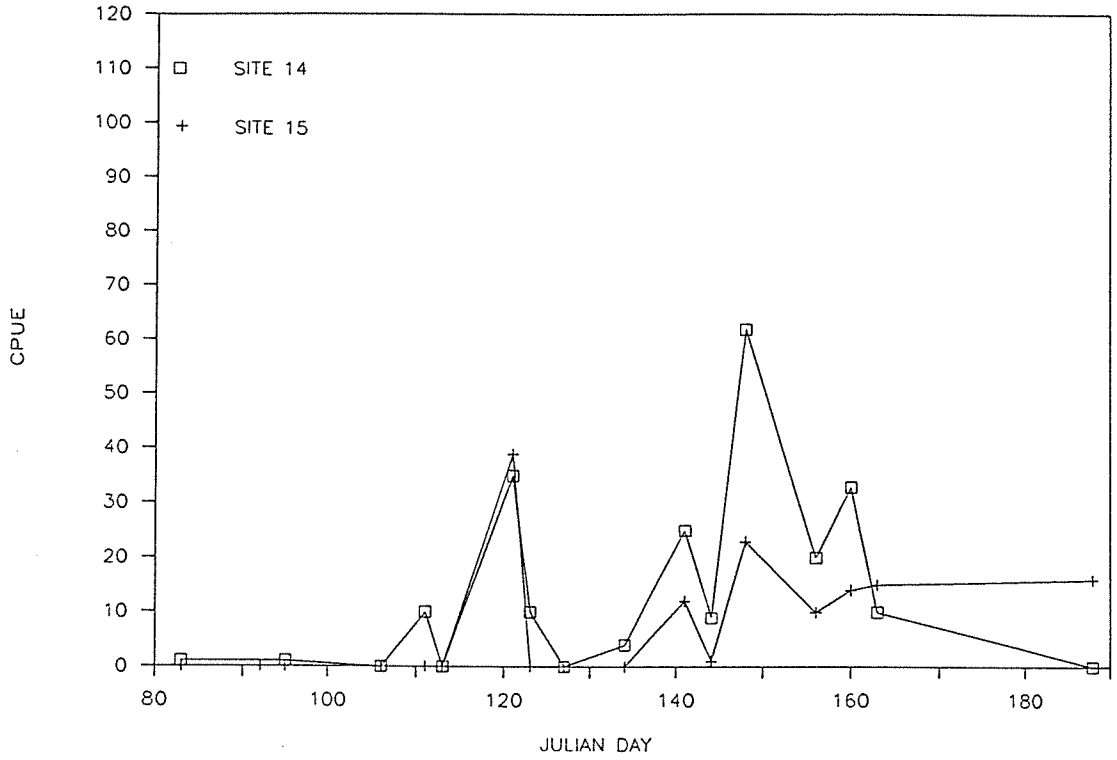

Figure A-5. Beach Seine Catch of Chinook Salmon Along the Ruston Way Shoreline (Site 14 and 15), 1983.

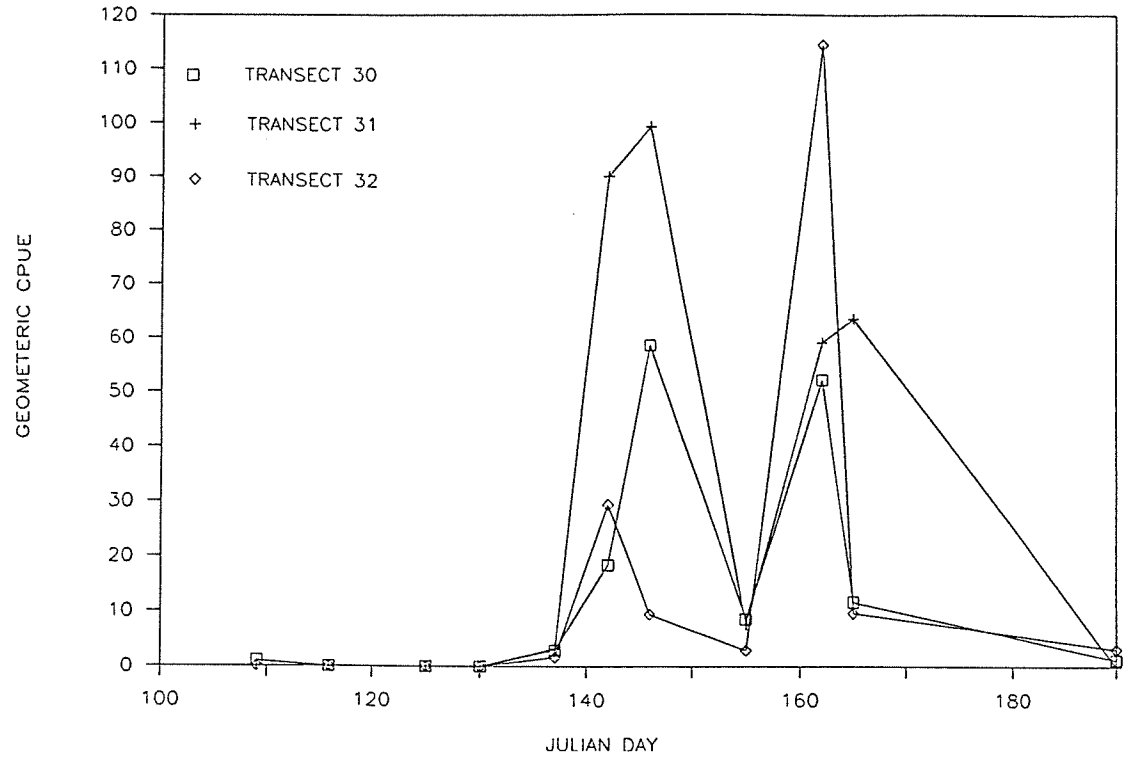

Figure A-6. Townet Catch of Chinook Salmon Inside City Waterway (Transect 30), Outside City Waterway (Transect 31) and near the Grain Elevator (Transect 32), 1983.

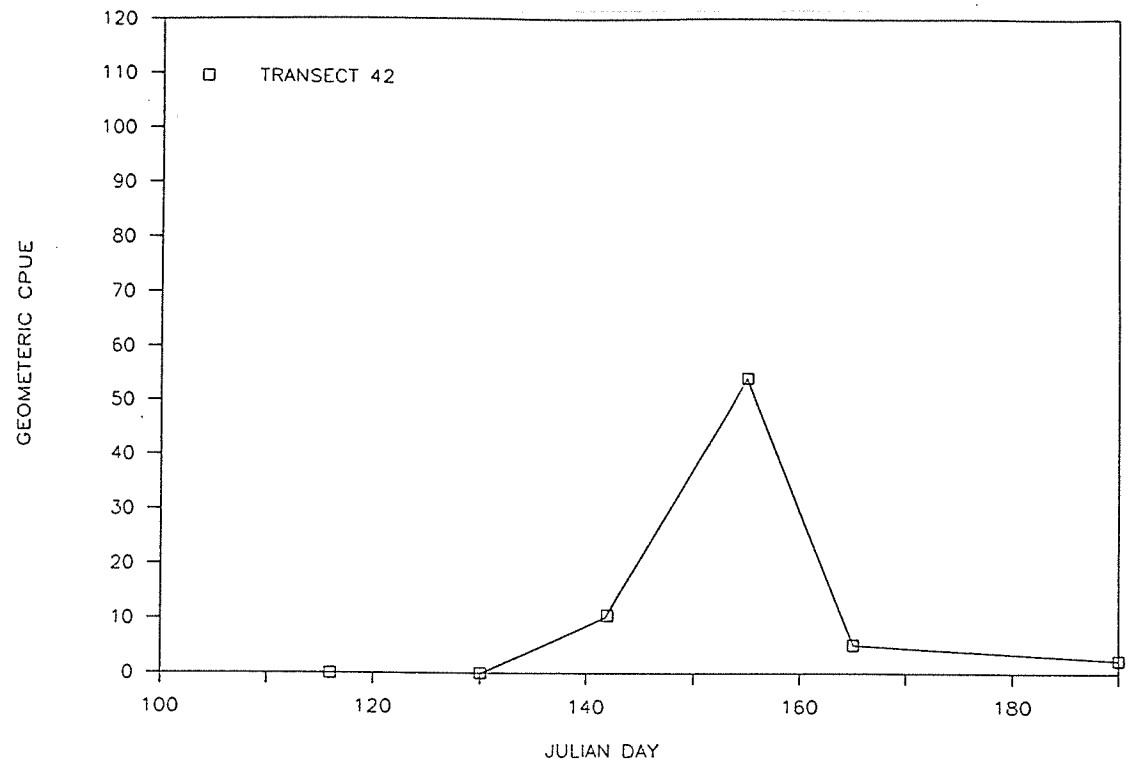

Figure A-7. Townet Catch of Chinook Salmon in the Mouth of Hylebos Waterway (Transect 42), 1983.

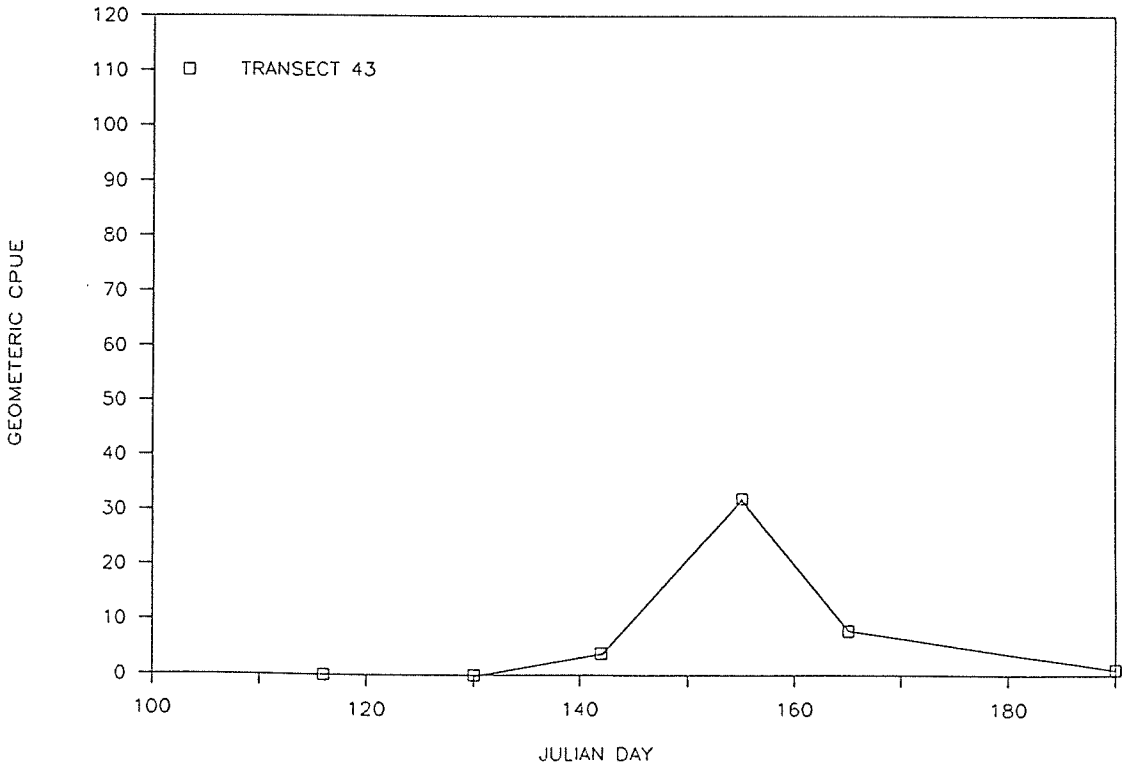

Figure A-8. Townet Catch of Chinook Salmon at the Head of Hylebos Waterway (Transect 43), 1983.

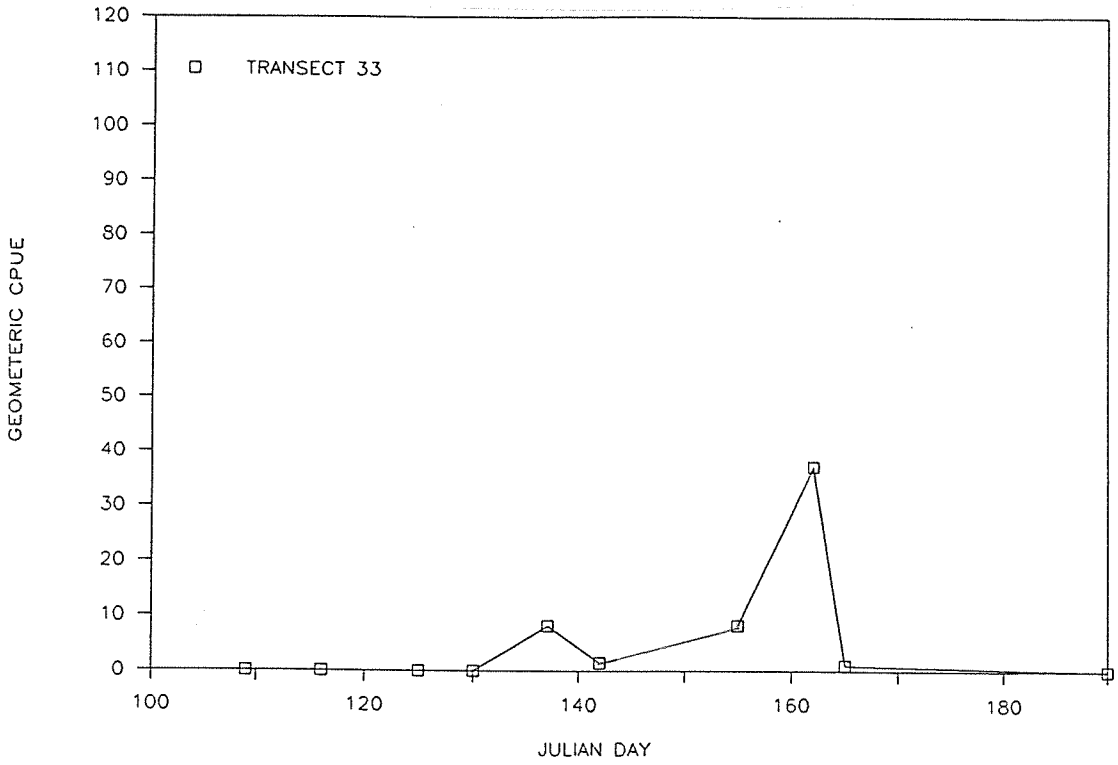

Figure A-9. Townet Catch of Chinook Salmon Along the Ruston Way Shoreline (Transect 33), 1983.

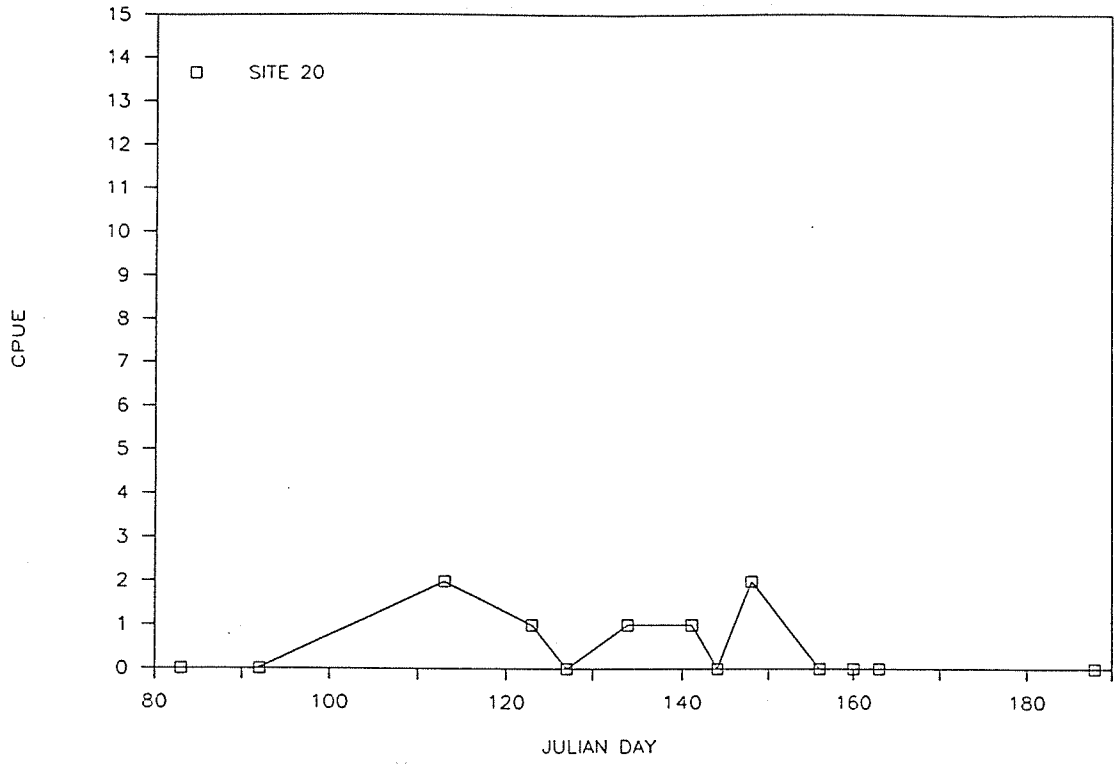

Figure A-10. Beach Seine Catch of Chum Salmon in City Waterway (Site 20).

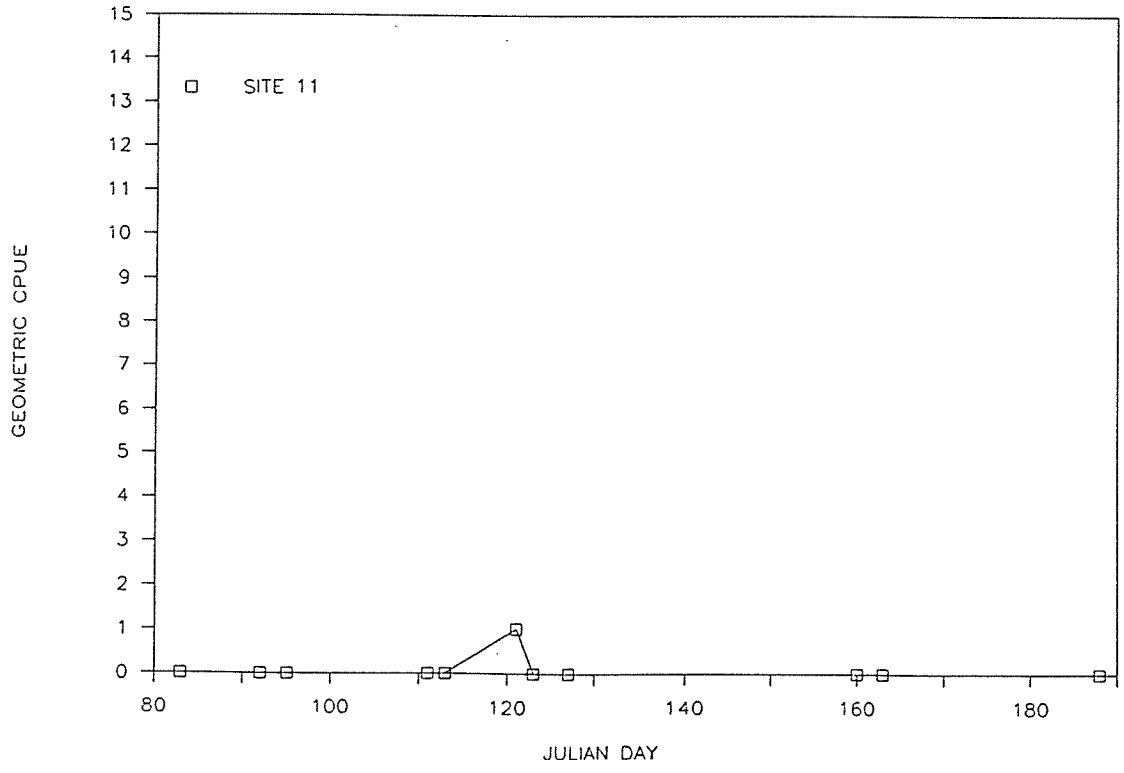

Figure A-11. Beacn Seine Catch of Chum Salmon in Middle Waterway (Site 11), 1983.

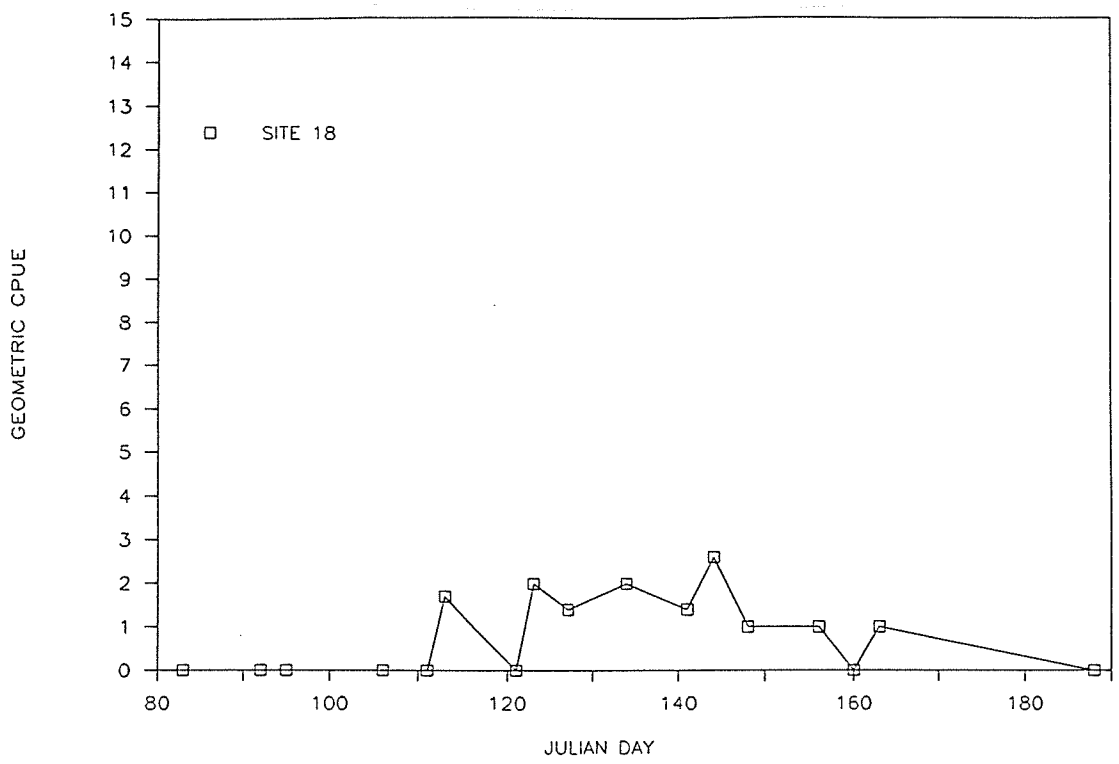

Figure A-12. Beach Seine Catch of Chum Salmon Inside Milwaukee Waterway (Site 18), 1983.

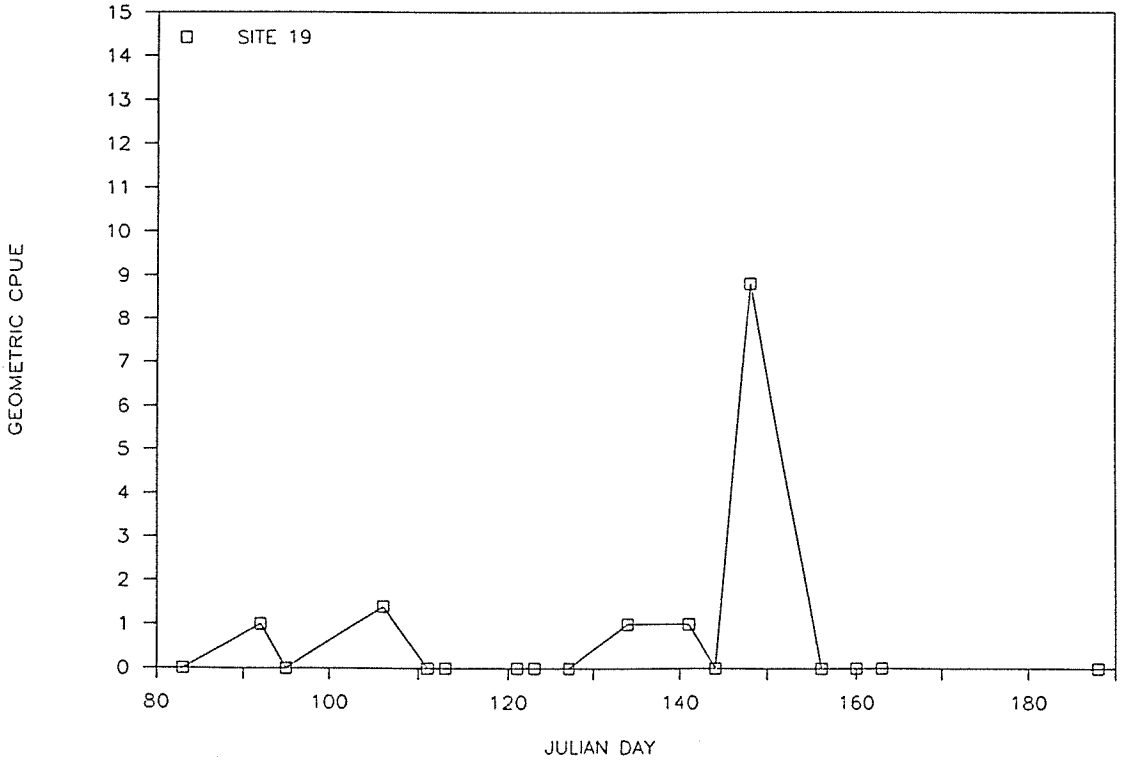

Figure A-13. Beach Seine Catch of Chum Salmon Outside Milwaukee Waterway (Site 19), 1983.

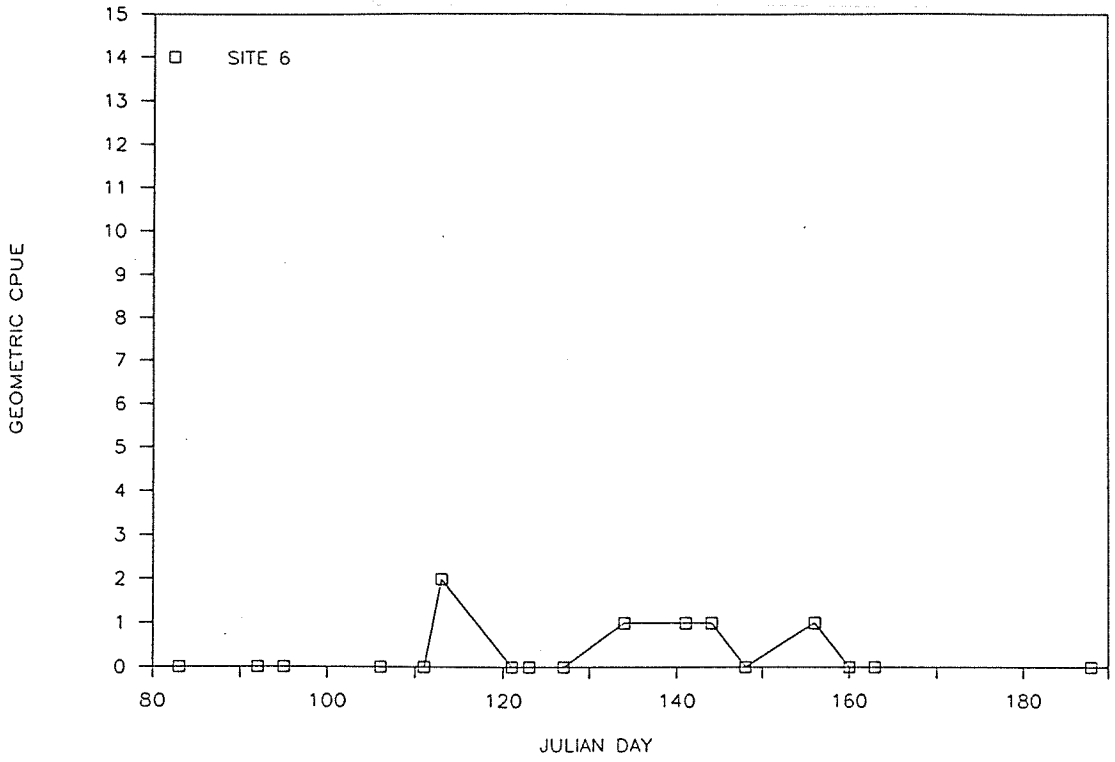

Figure A-14. Beach Seine Catch of Chum Salmon in Blair Waterway (Site 6), 1983.

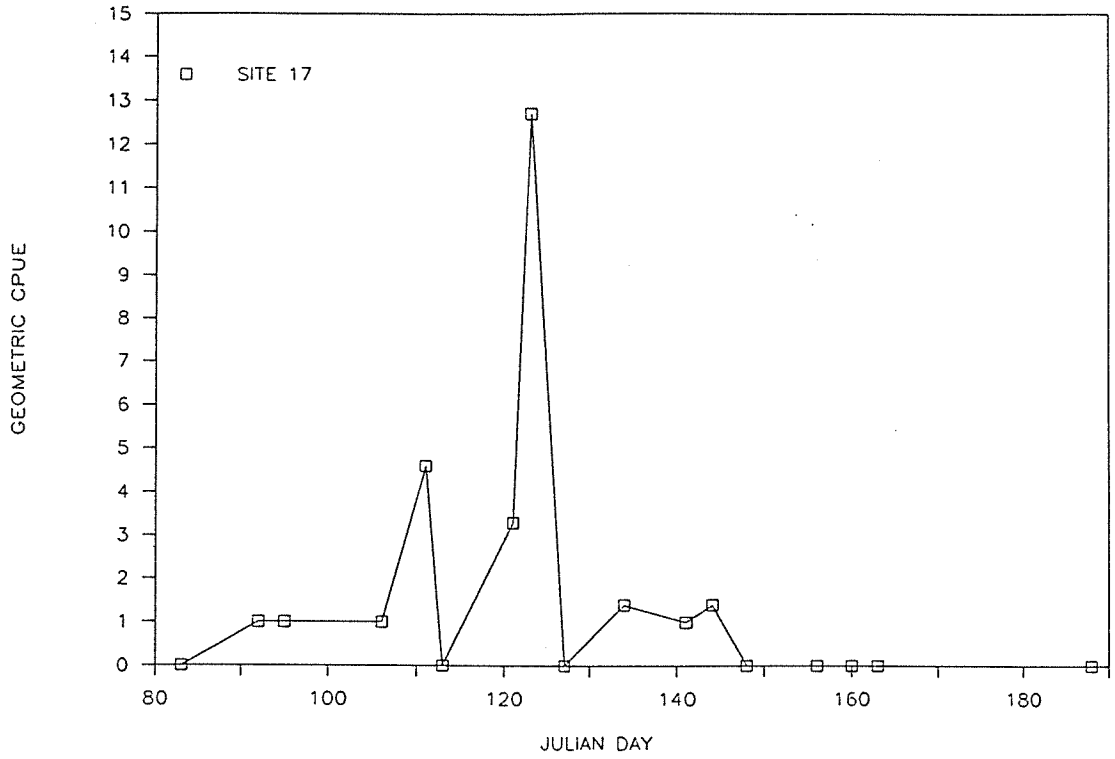

Figure A-15. Beach Seine Catch of Chum Salmon in the Mouth of Hylebos Waterway (Site 17), 1983.

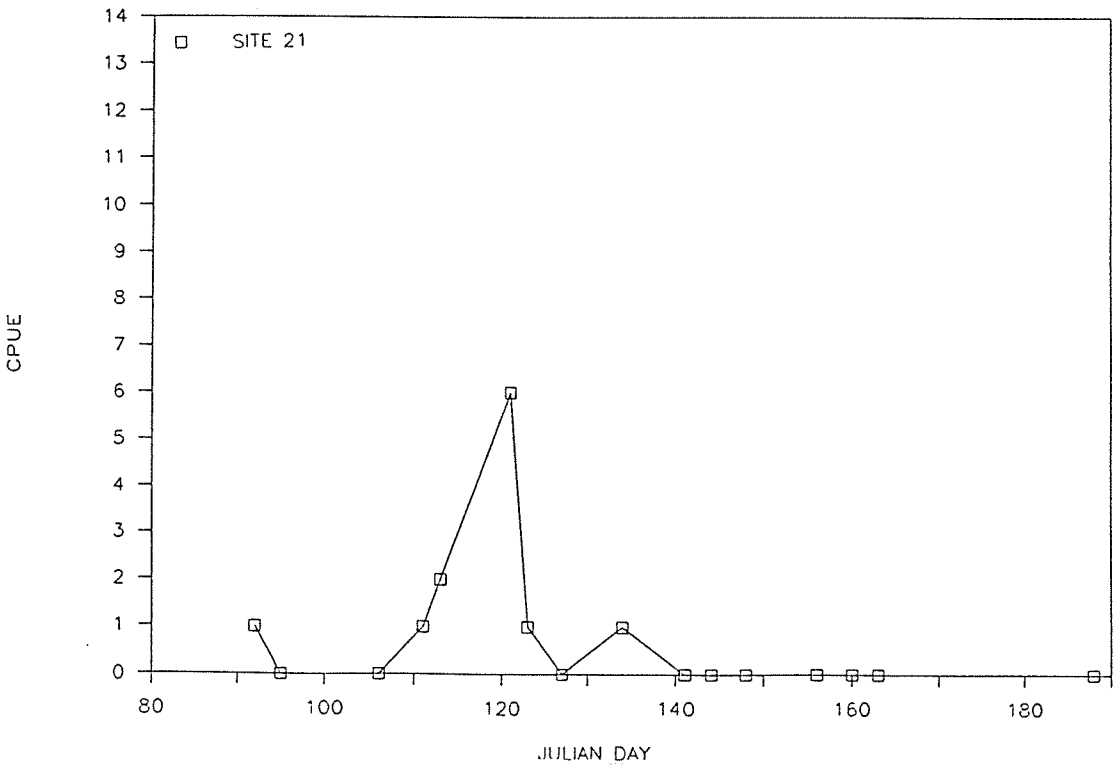

Figure A-16. Beach Seine Catch of Chum Salmon at the Head of Hylebos Waterway (Site 21), 1983.

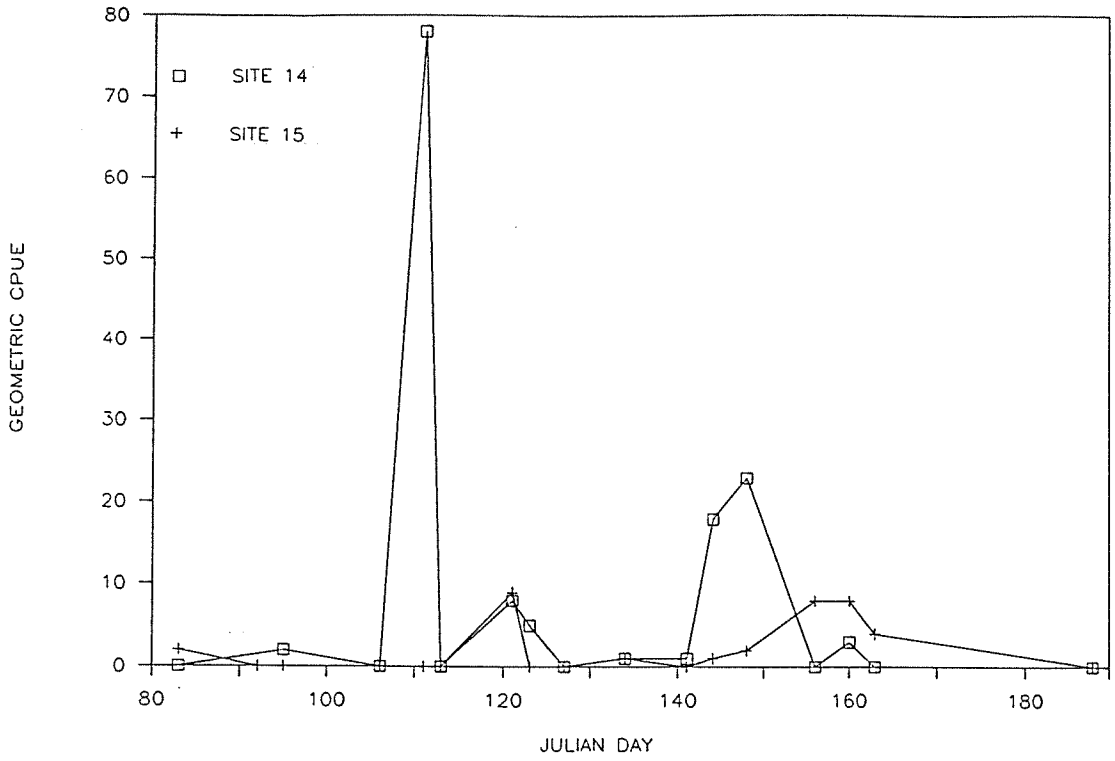

Figure A-17. Beach Seine Catch of Chum Salmon Along the Ruston Way Shoreline (Sites 14 and 15), 1983.

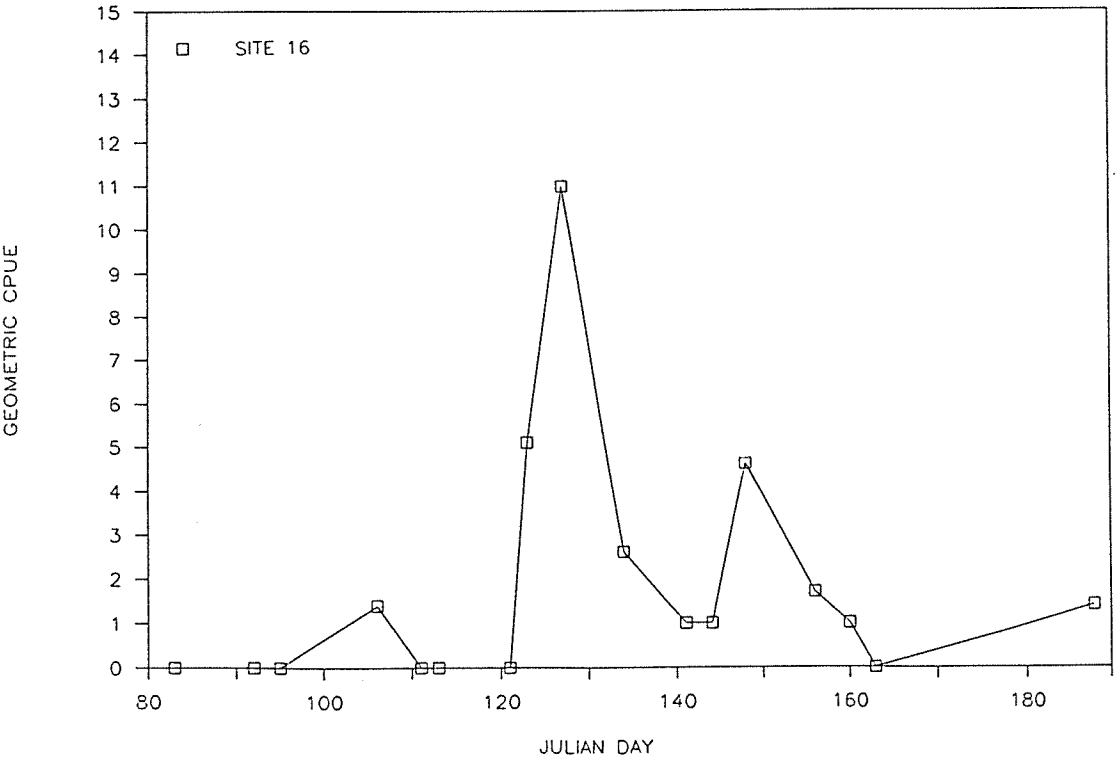

Figure A-18. Beach Seine Catch of Chum Salmon along the Browns Point Shoreline (Site 16), 1983.

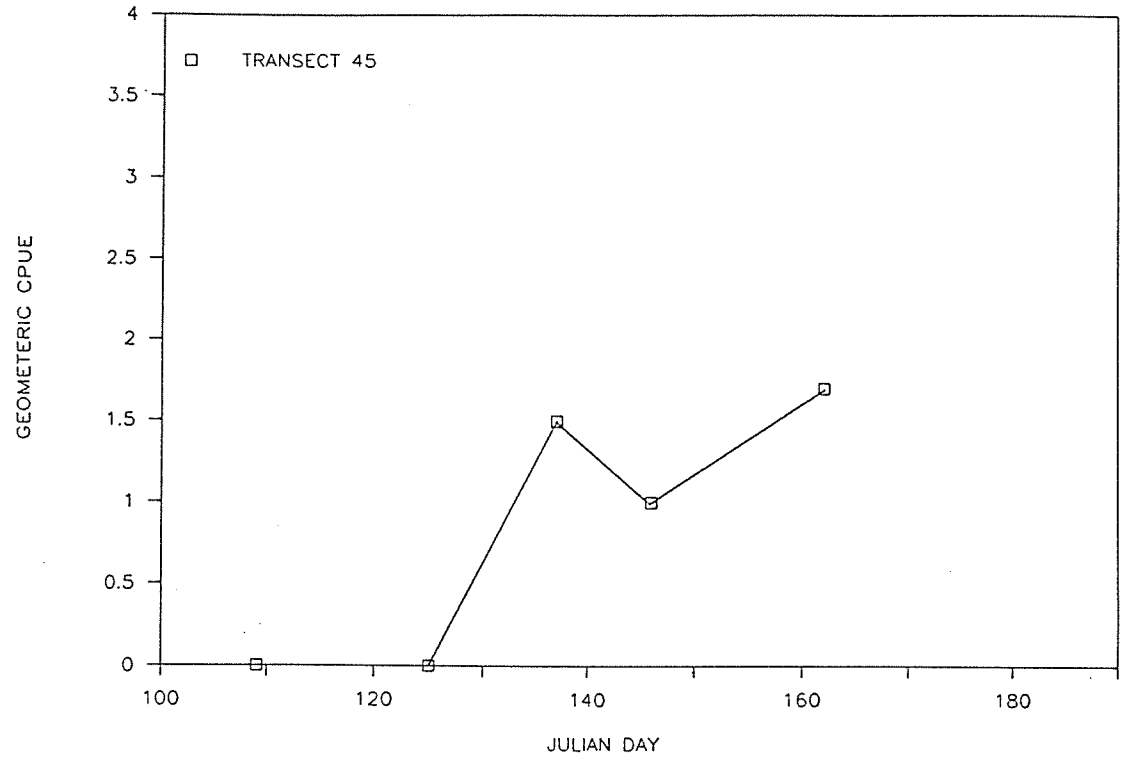

Figure A-21. Townet Catch of Chum Salmon in the Mouth of Blair Waterway (Transect 45), 1983.

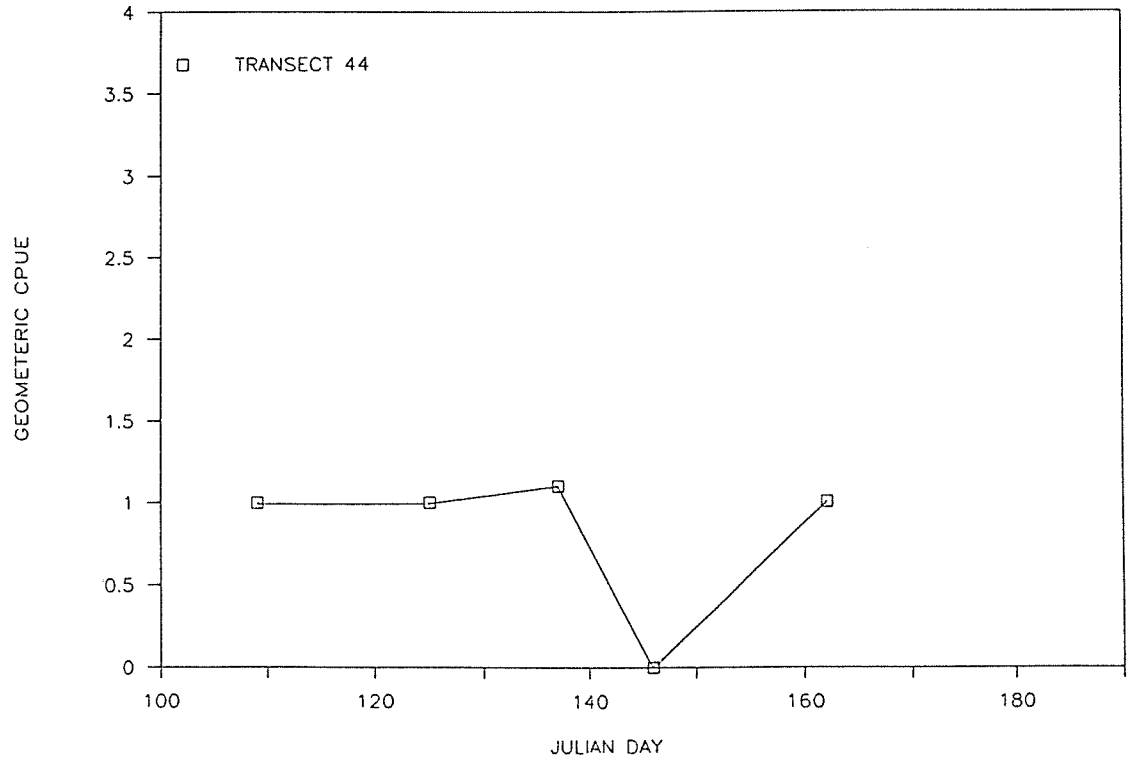

Figure A-22. Townet Catch of Chum Salmon at the Head of Blair Waterway (Transect 44), 1983.

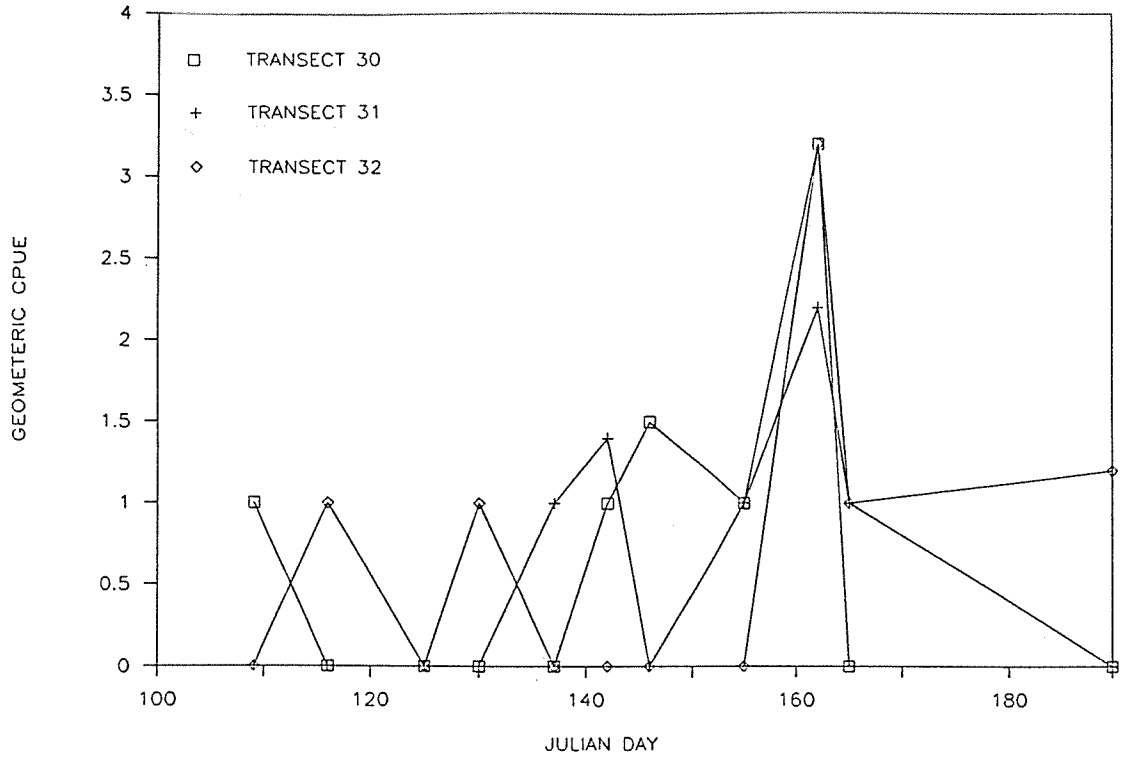

Figure A-19. Townet Catch of Chum Salmon inside City Waterway (Transect 30) Outside City Waterway (Transect 31), and Near the Grain Elevator (Transect 32), 1983.

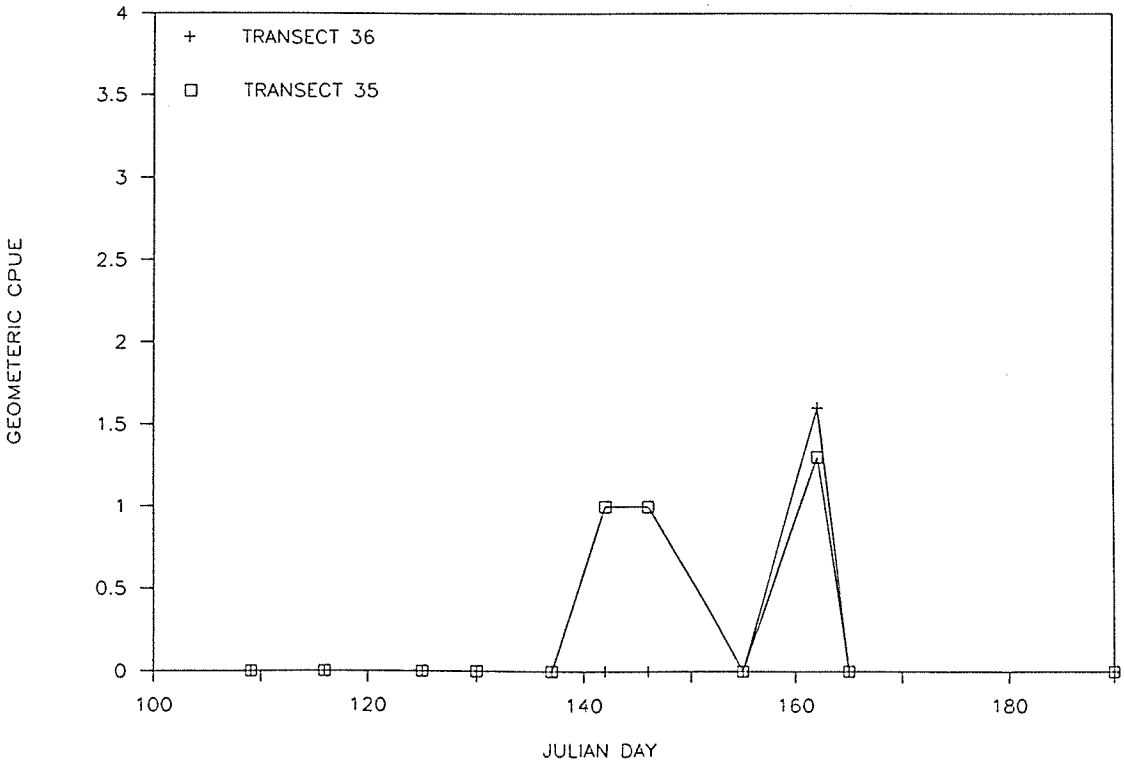

Figure A-20. Townet Catch of Chum Salmon Inside Milwaukee Waterway (Transect 35) and Outside Milwaukee Waterway (Transect 36), 1983.

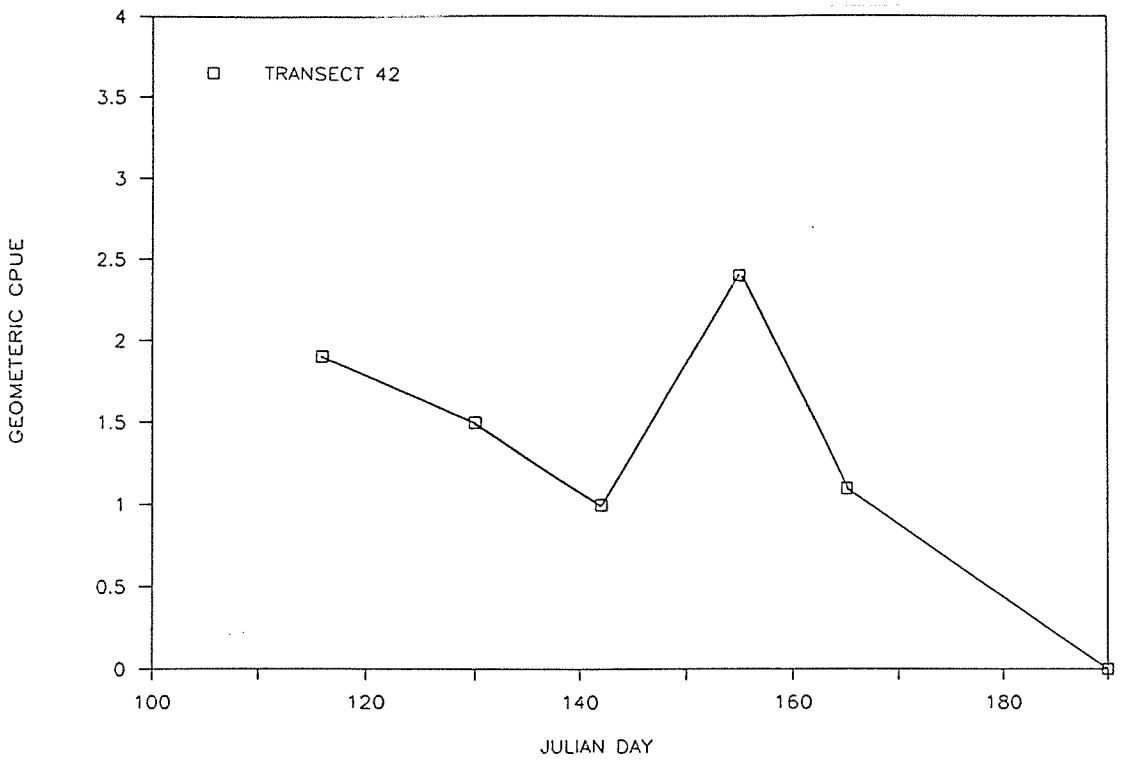

Figure A-23. Townet Catch of Chum Salmon in the Mouth of Hylebos Waterway (Transect 42), 1983.

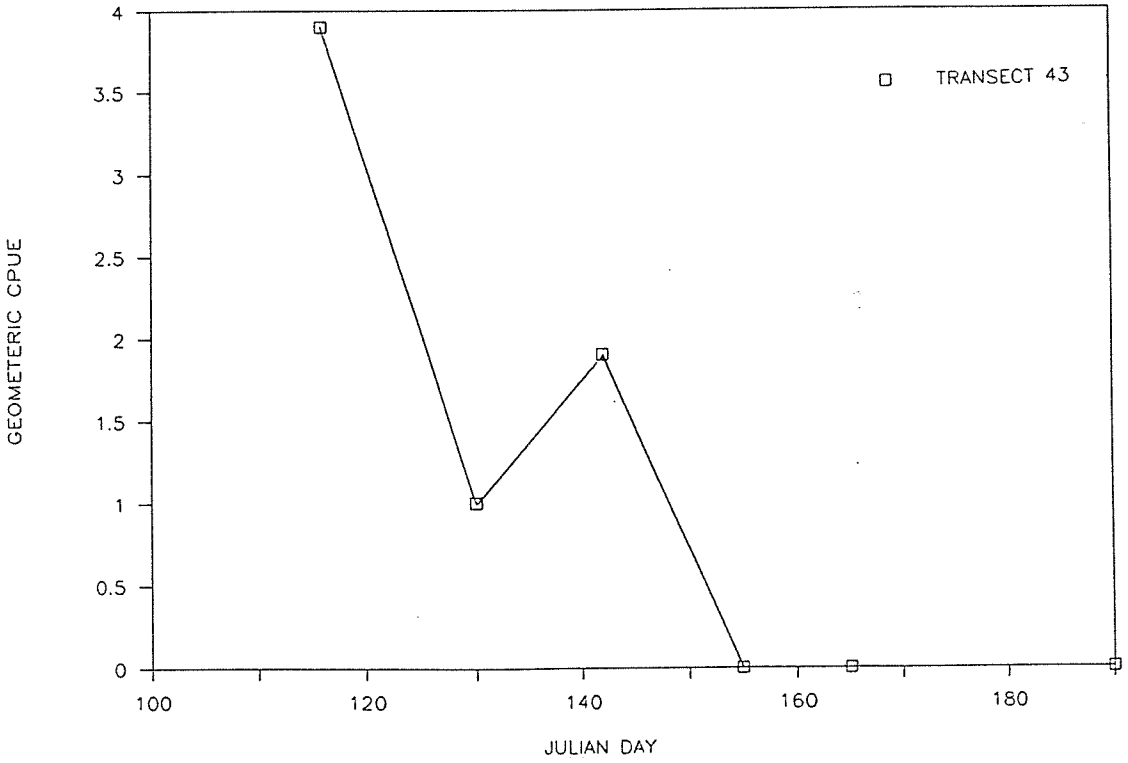

Figure A-24. Townet Catch of Chum Salmon at the Head of Hylebos Waterway (Transect 43), 1983.

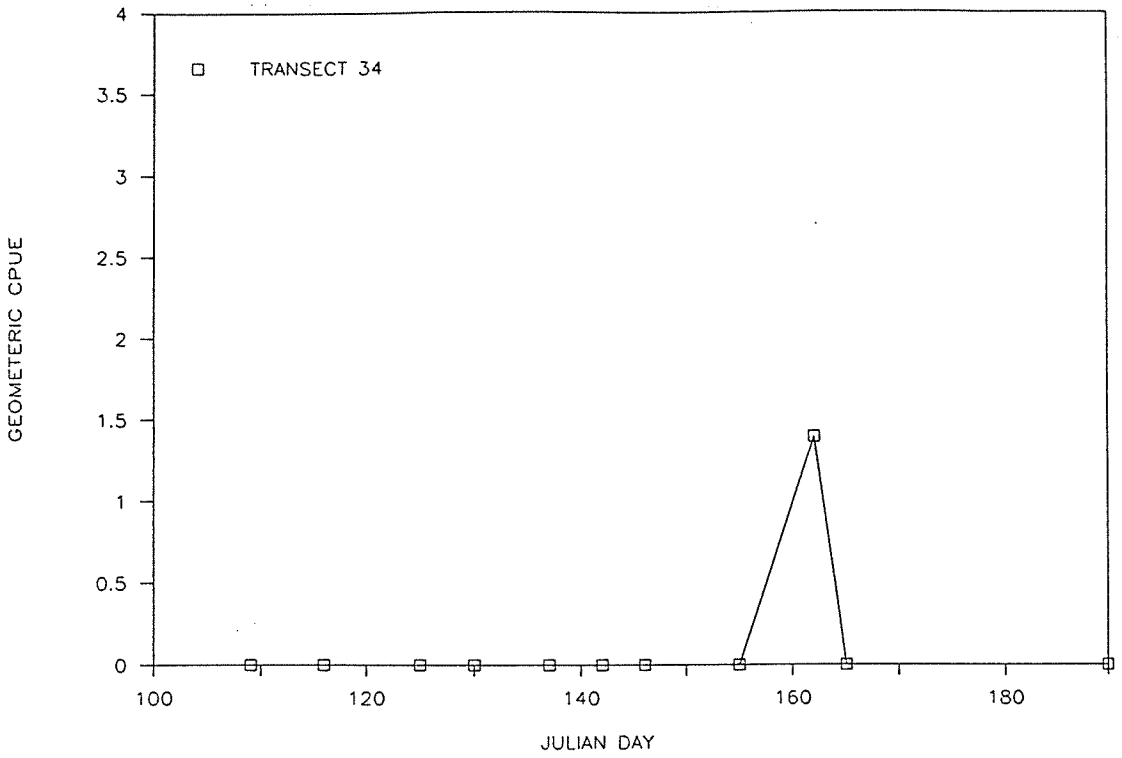

Figure A-25. Townet Catch of Chum Salmon Along the Browns Point Shoreline (Transect 34), 1983.

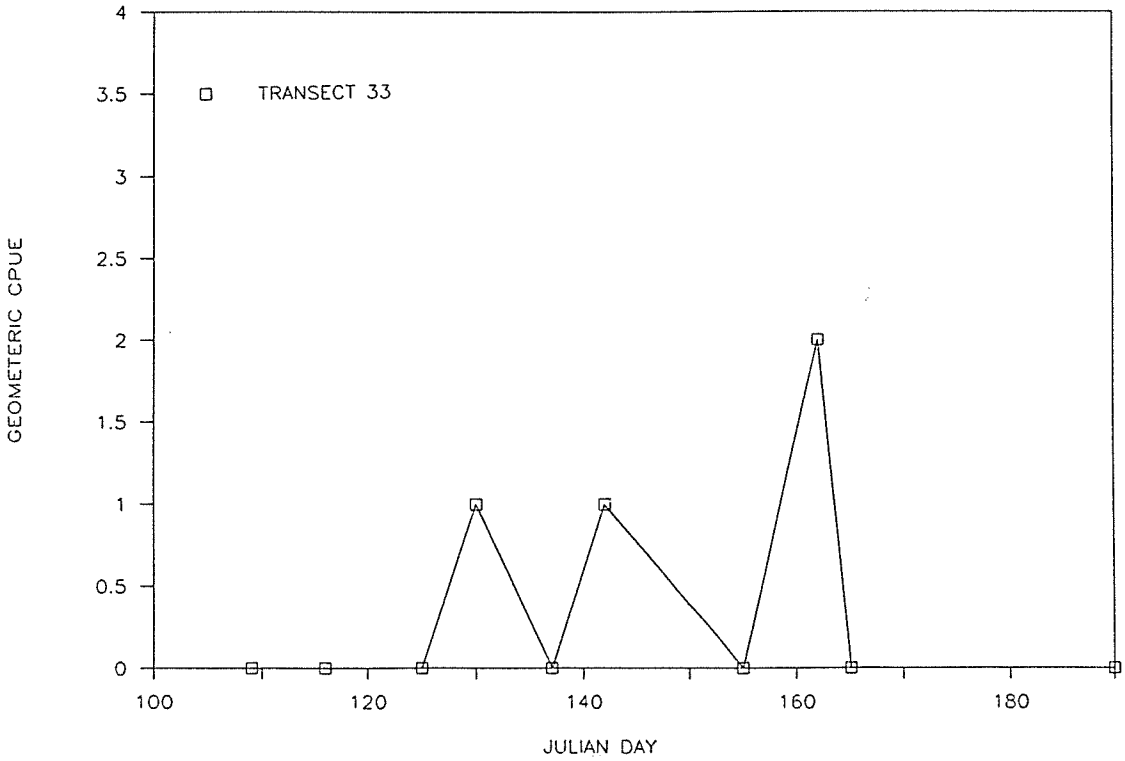

Figure A-26. Townet Catch of Chum Salmon Along the Ruston Way Shoreline (Transect 33), 1983.

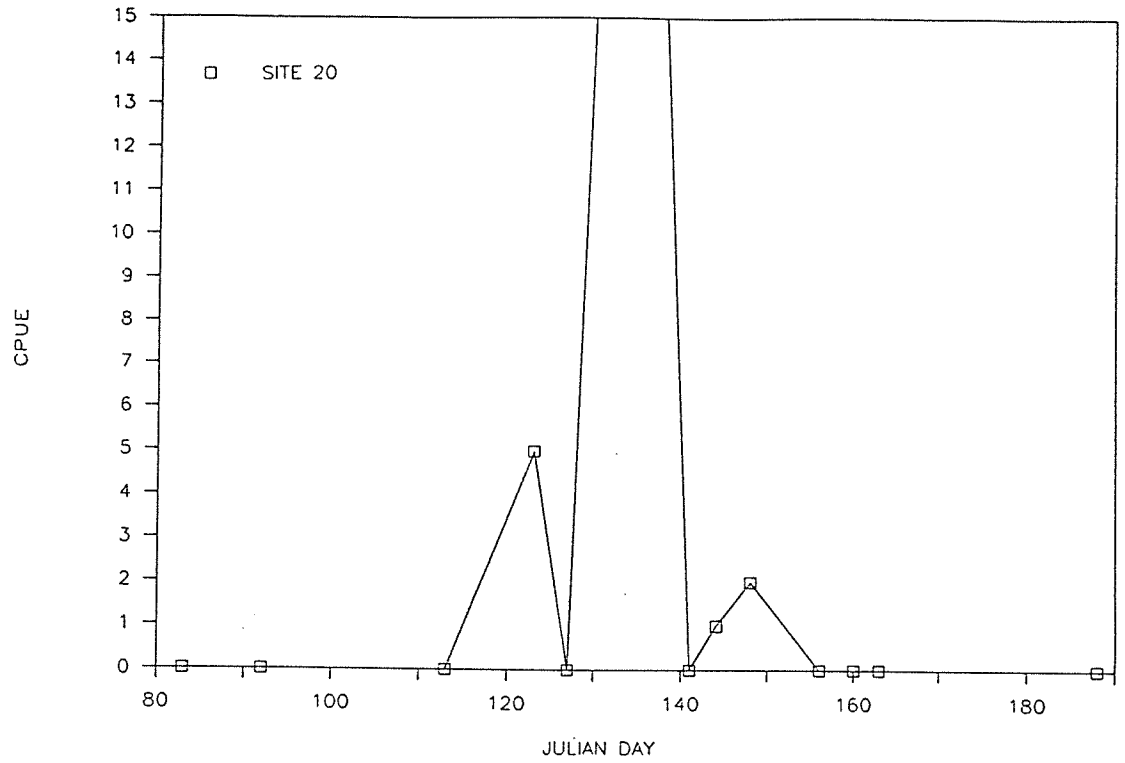

Figure A-27. Beach seine Catch of Coho Salmon in City Waterway (Site 20), 1983.

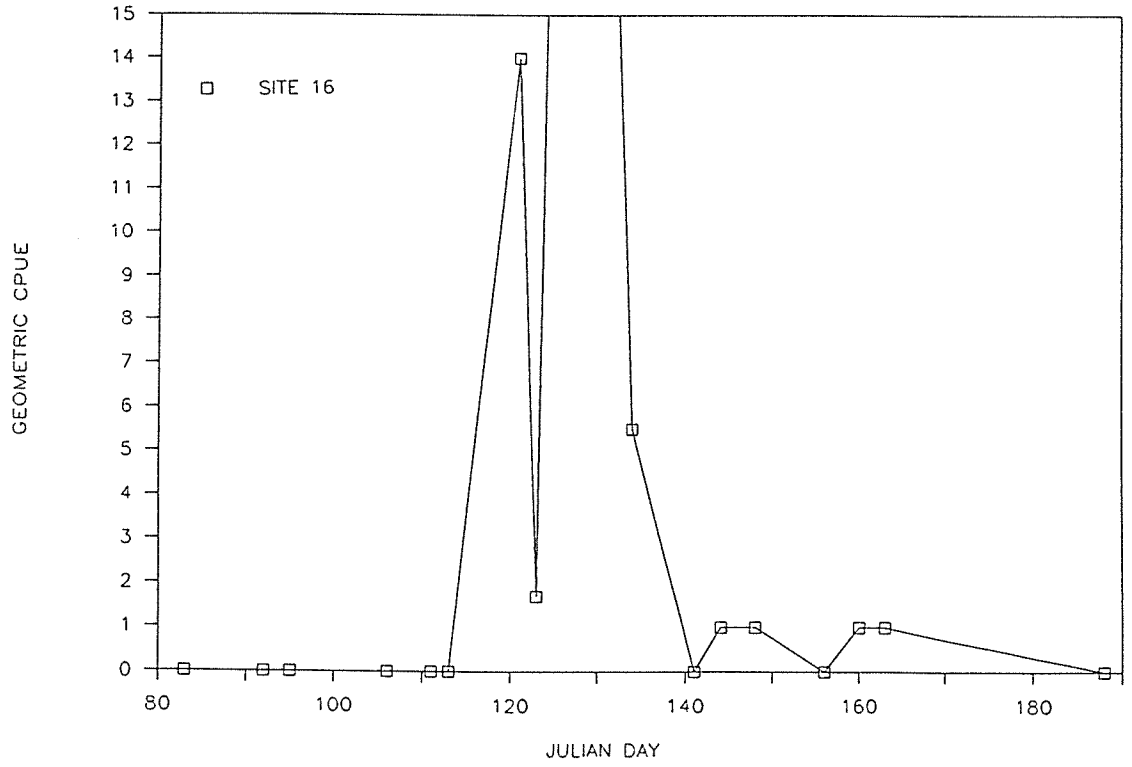

Figure A-28. Beach seine Catch of Coho Salmon along the Browns Point Shoreline (Site 16), 1983

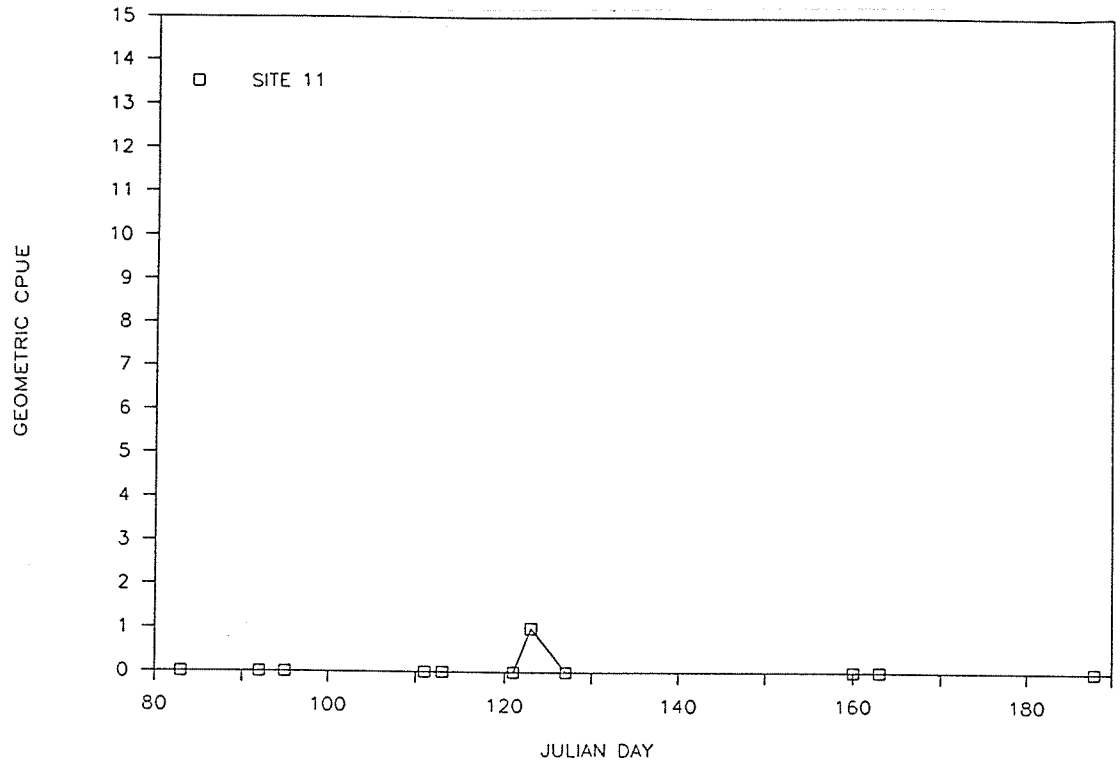

Figure A-29. Beach Seine Catch of Coho Salmon in Middle Waterway (Site 11), 1983.

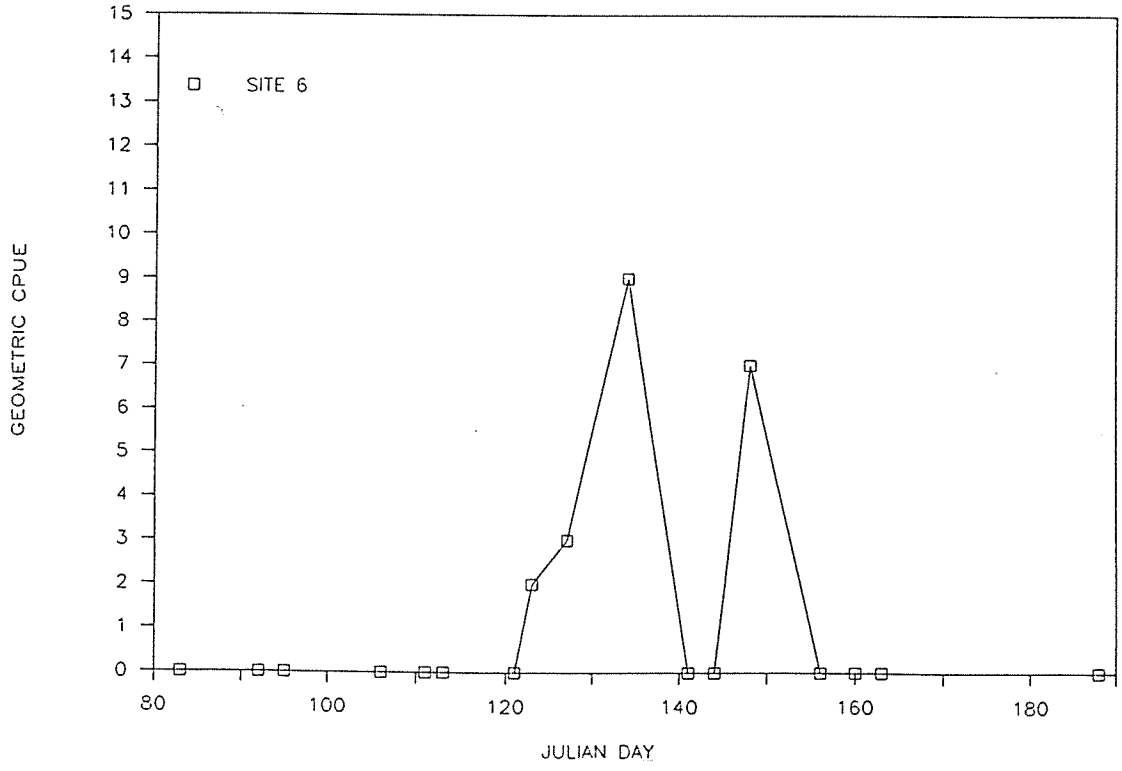

Figure A-30. Beach Seine Catch of Coho Salmon in Blair Waterway (Site 6), 1983.

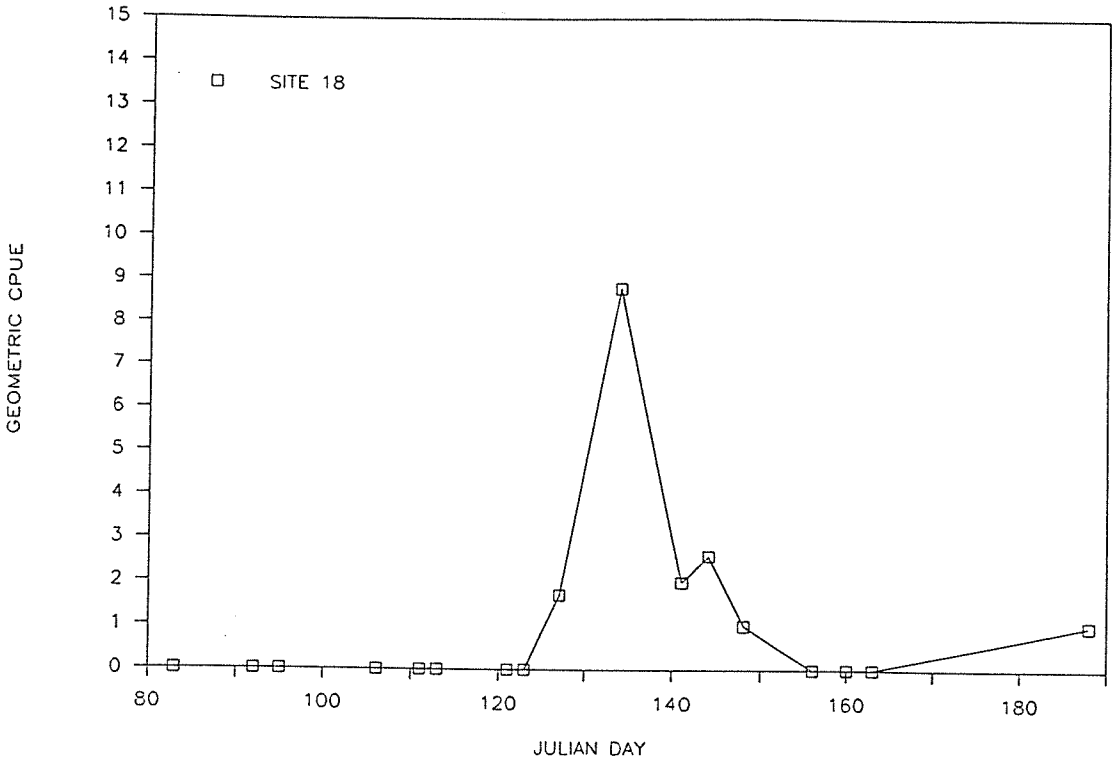

Figure A-31. Beach Seine Catch of Coho Salmon Inside Milwaukee Waterway (Site 18), 1983.

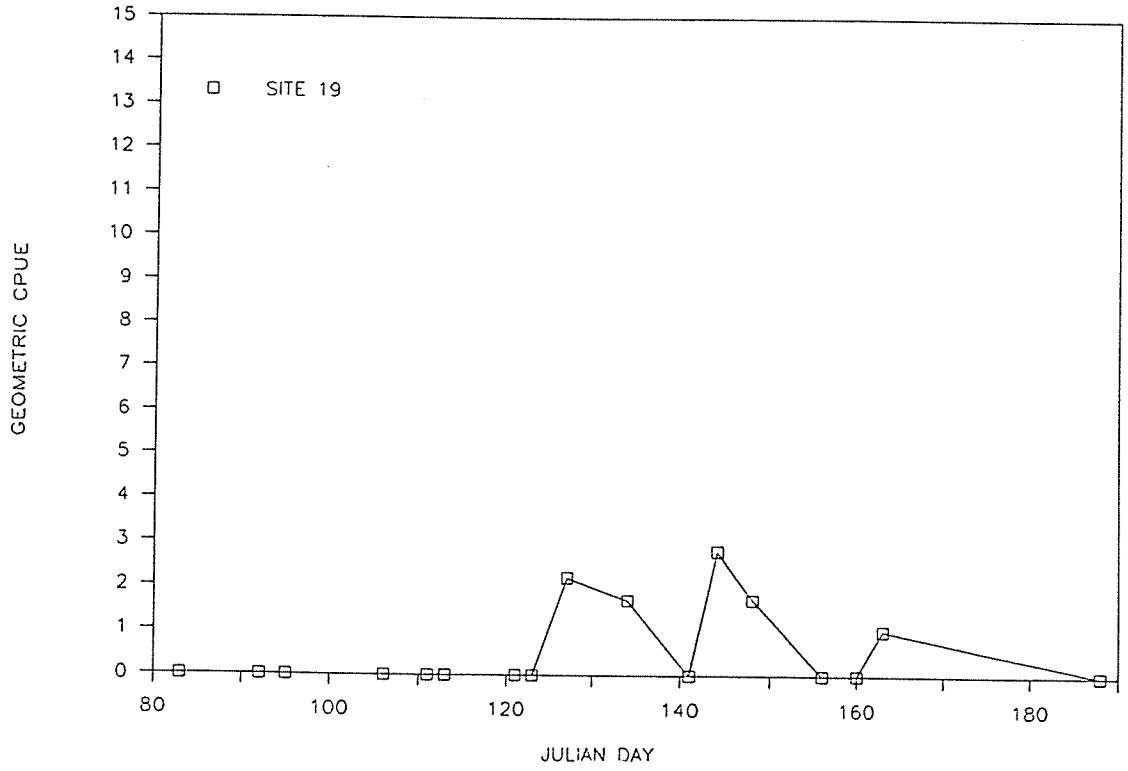

Figure A-32. Beach Seine Catch of Coho Salmon Outside Milwaukee Waterway (Site 19), 1983.

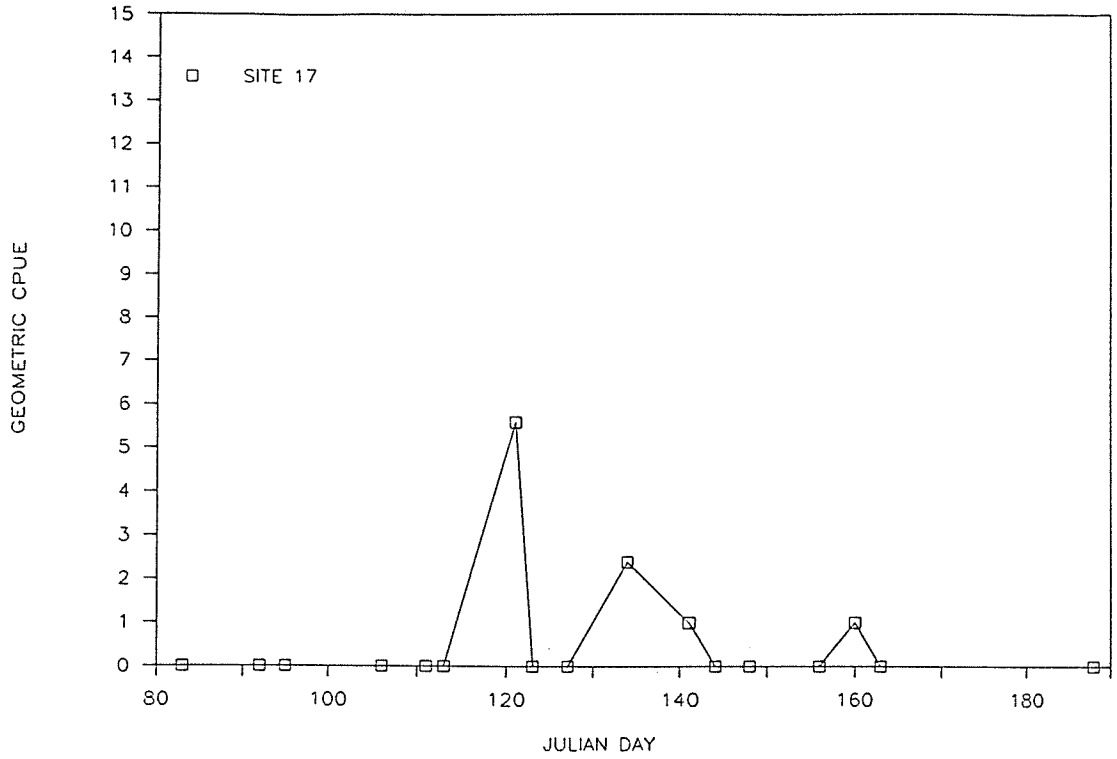

Figure A-33. Beach Seine Catch of Coho Salmon in the Mouth of Hylebos Waterway (Site 17), 1983.

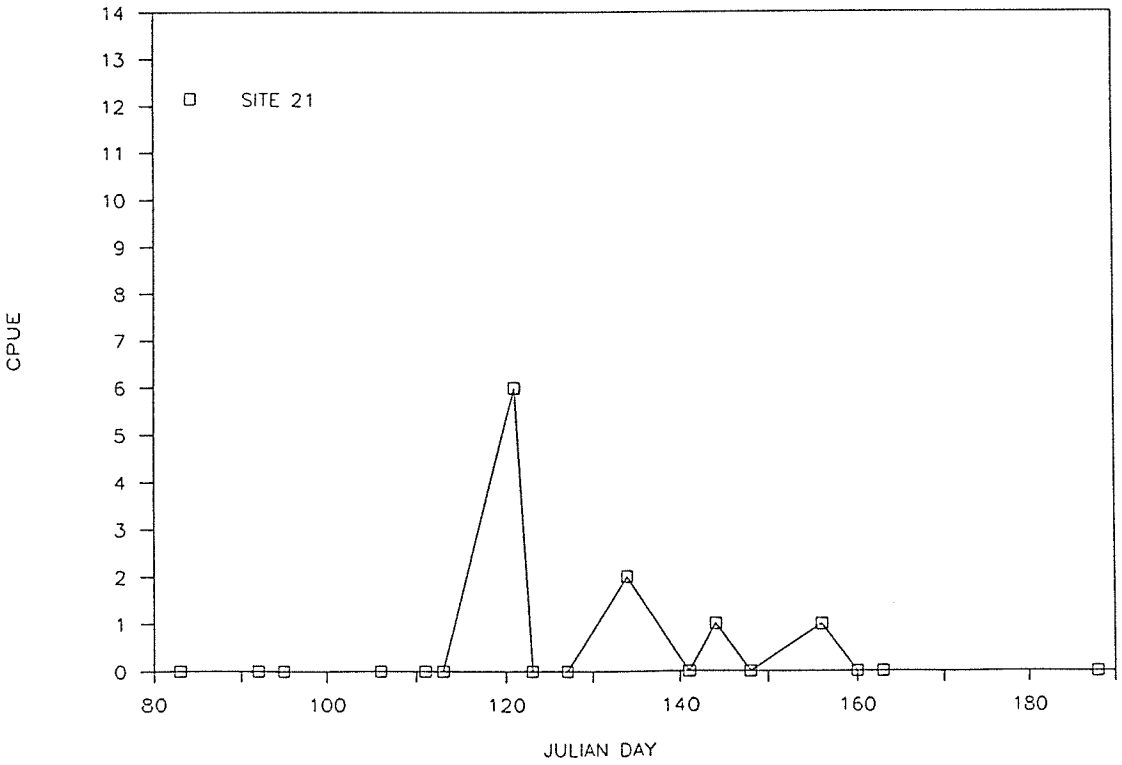

Figure A-34. Beach Seine Catch of Coho Salmon at the Head of Hylebos Waterway (Site 21), 1983.

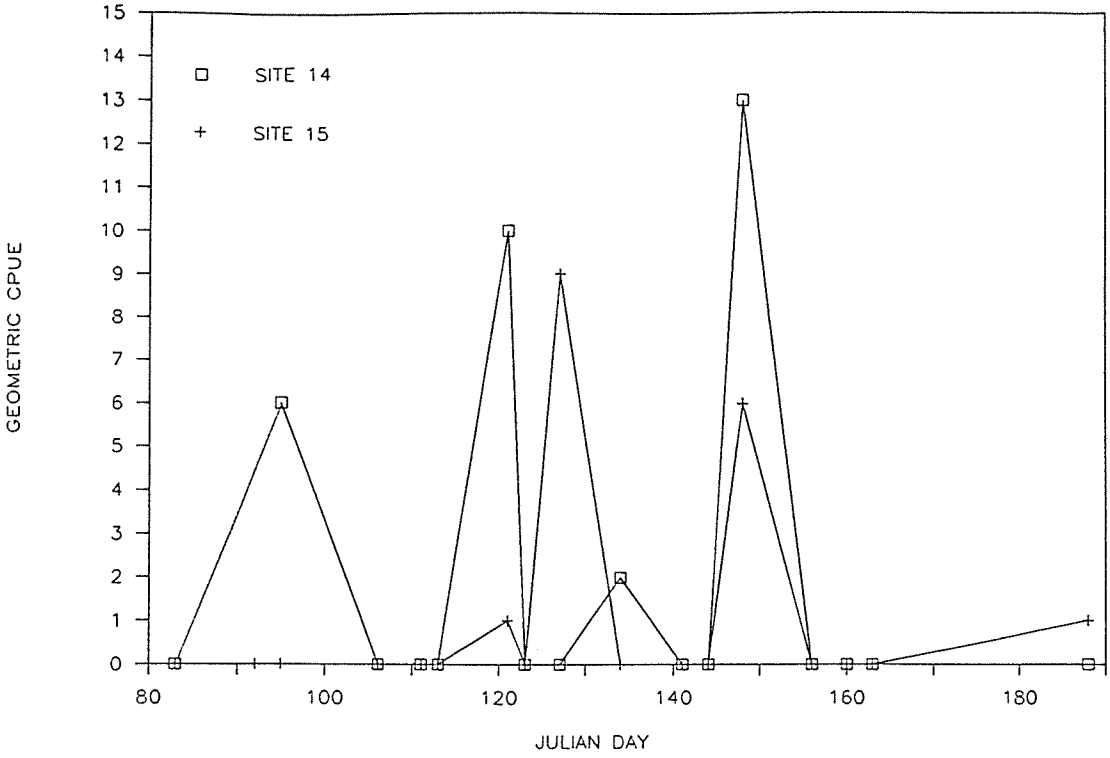

Figure A-35. Beach Seine Catch of Coho Salmon Along the Ruston Way Shoreline (Sites 14 and 15), 1983.

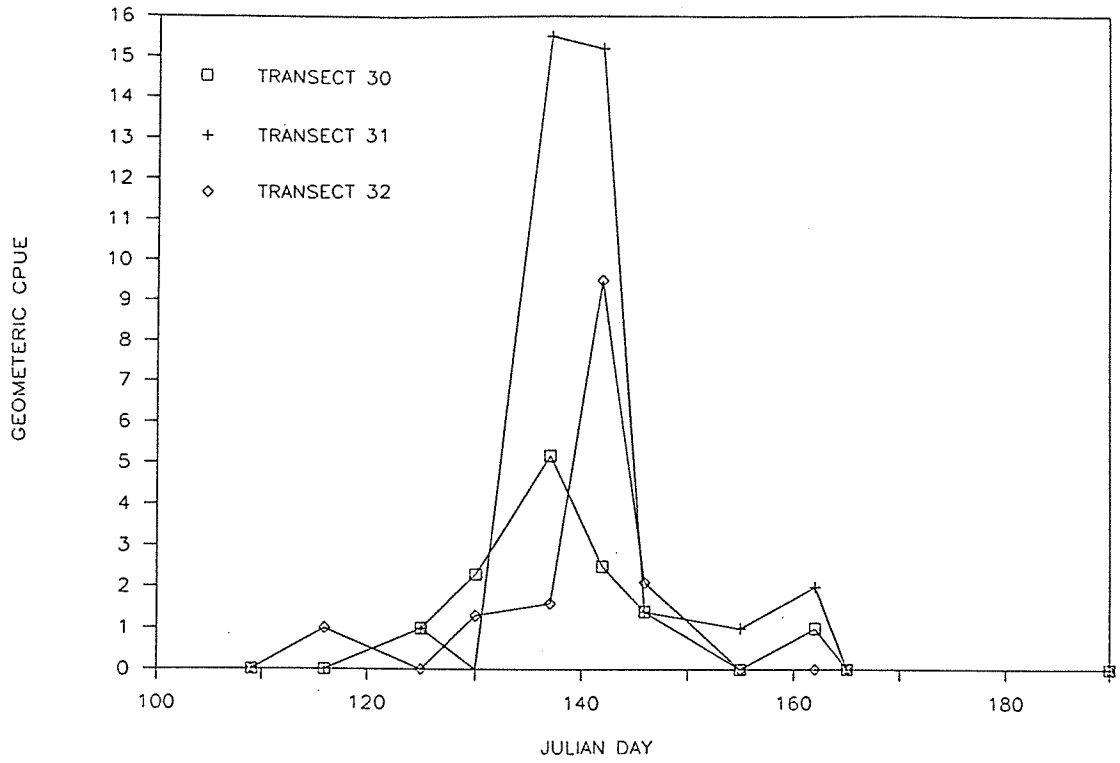

Figure A-36. Townet Catch of Coho Salmon Inside City Waterway (Transect 30), Outside City Waterway (Transect 31), and Near the Grain Elevator (Transect 32), 1983.

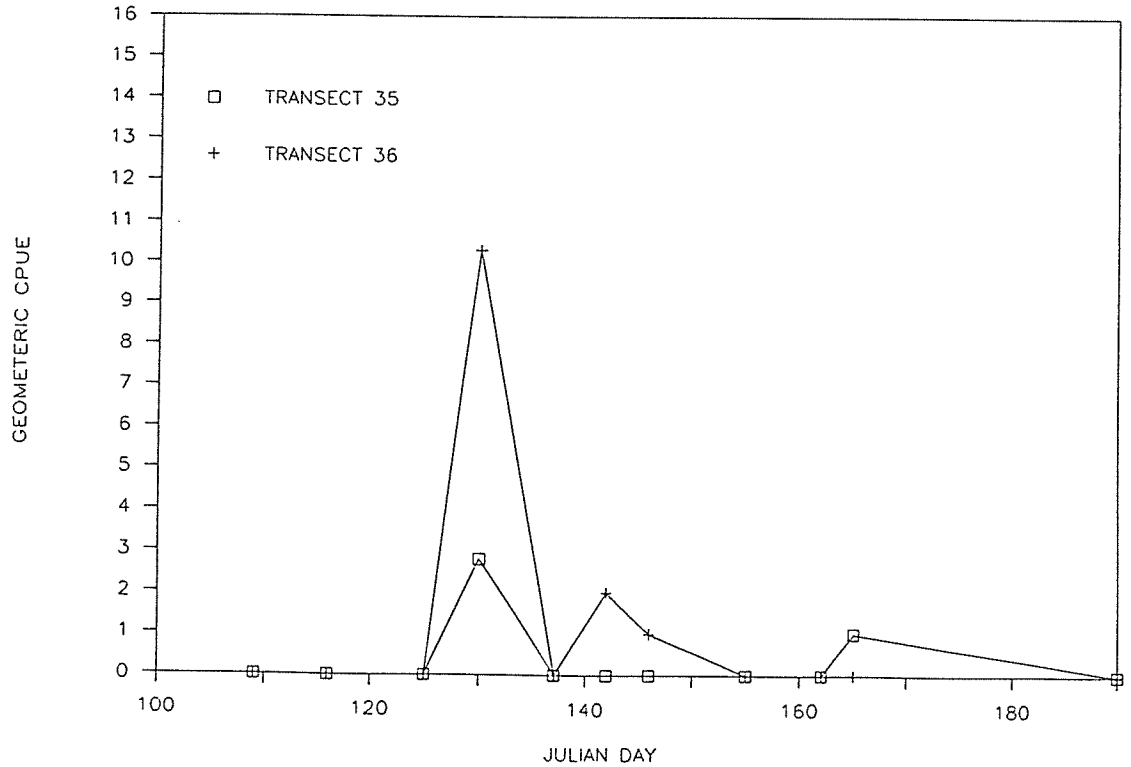

Figure A-37. Townet Catch of Coho Salmon Inside Milwaukee Waterway (Transect 35) and Outside Milwaukee Waterway (Transect 36), 1983.

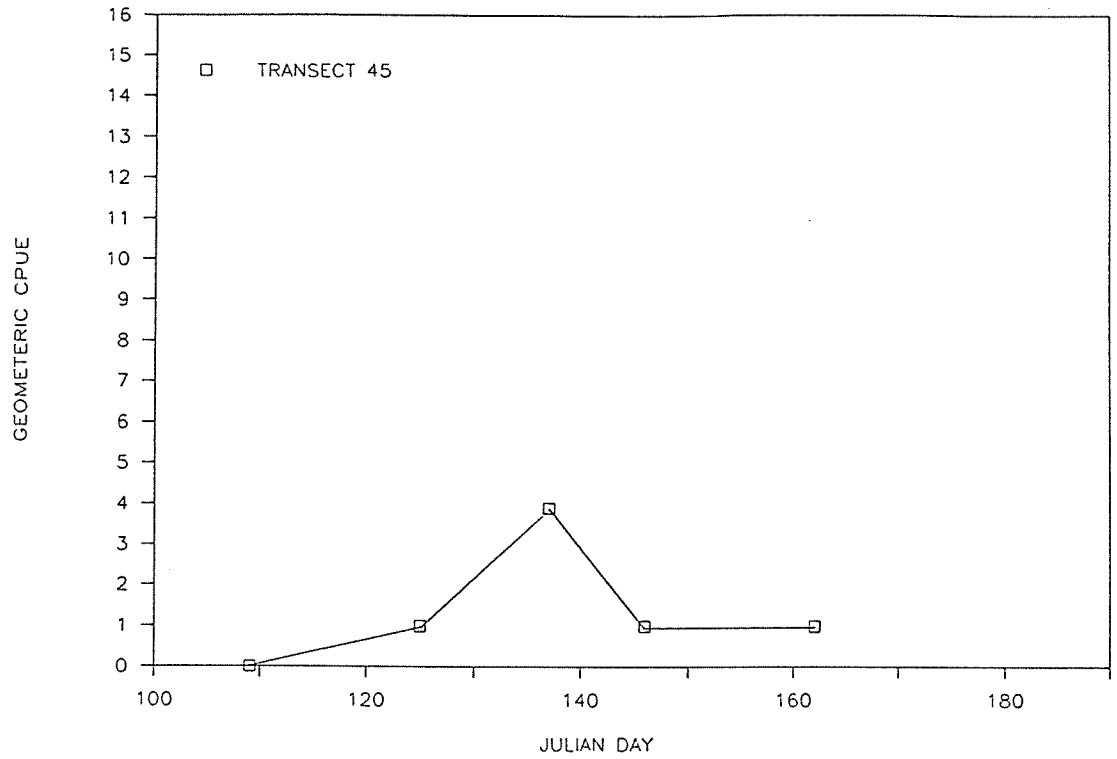

Figure A-38. Townet Catch of Coho Salmon in the Mouth of Blair Waterway (Transect 45), 1983.

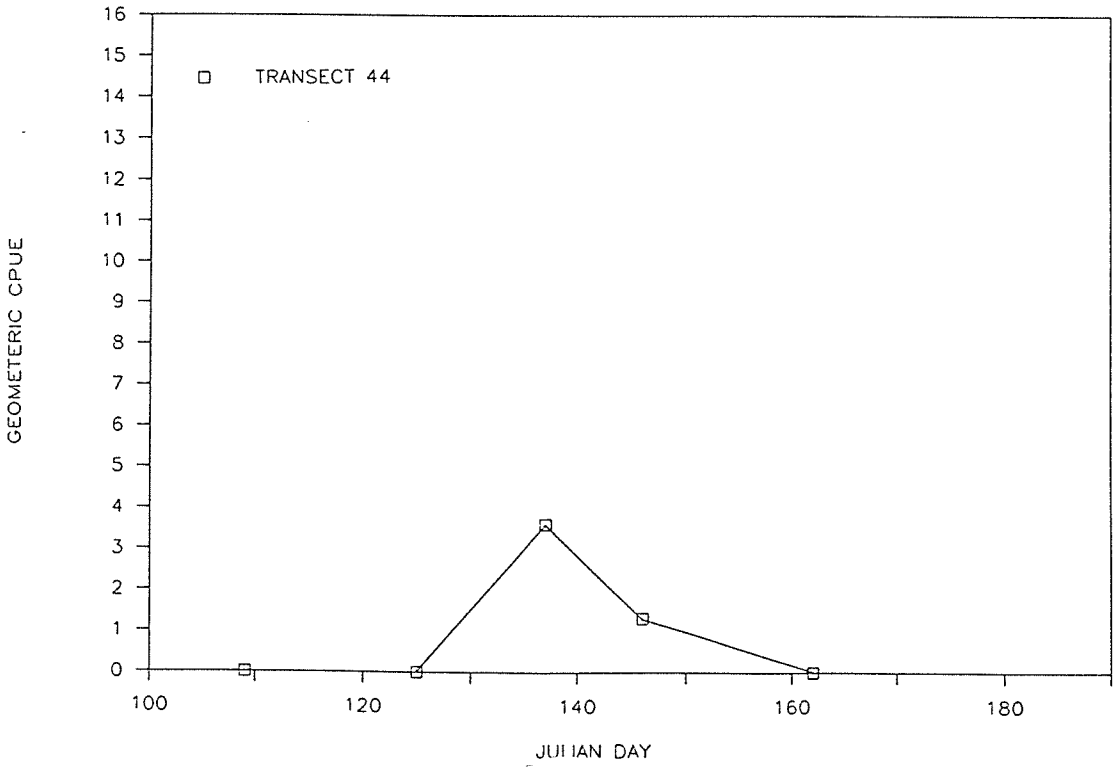

Figure A-39. Townet Catch of Coho Salmon at the Head of Blair Waterway (Transect 44), 1983.

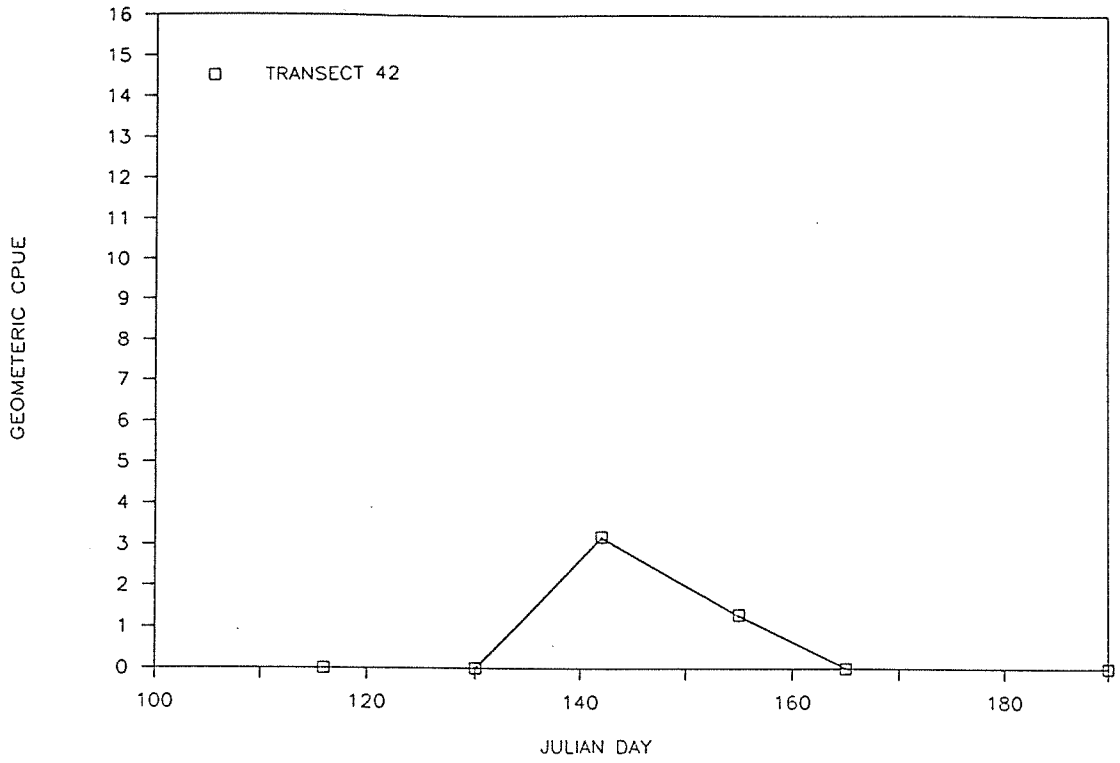

Figure A-40. Townet Catch of Coho Salmon in the Mouth of Hylebos Waterway (Transect 42), 1983.

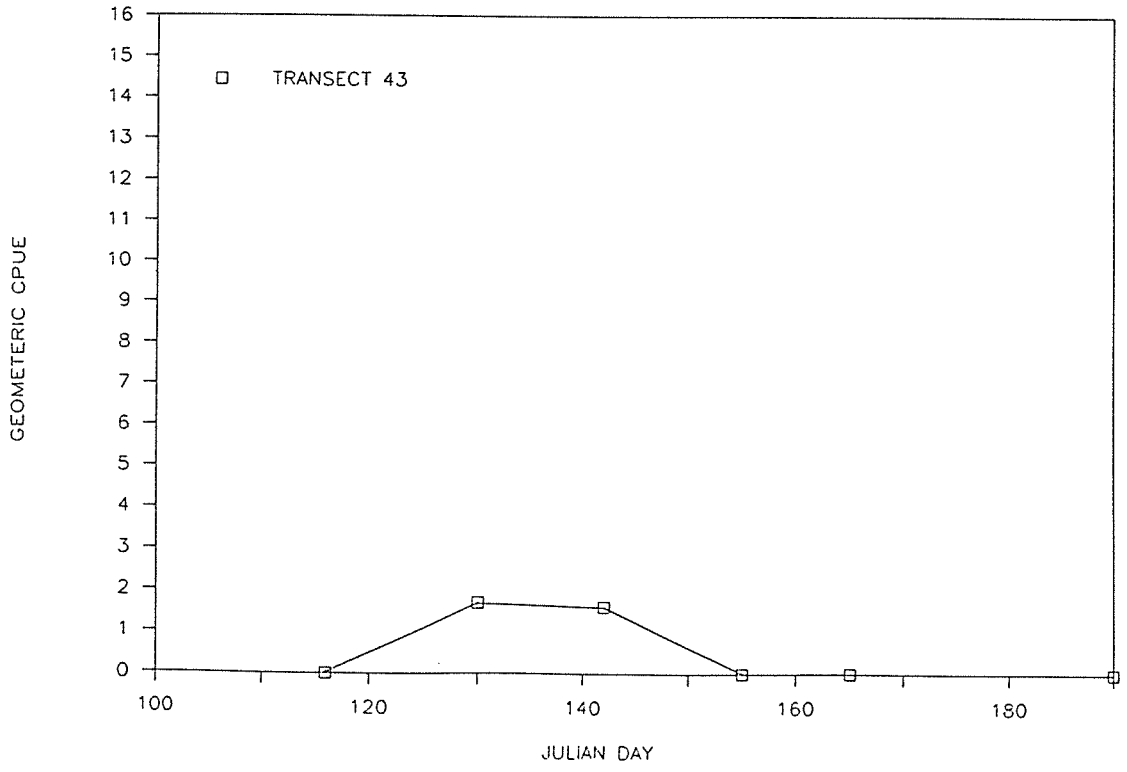

Figure A-41. Townet Catch of Coho Salmon at the Head of Hylebos Waterway (Transect 43), 1983.

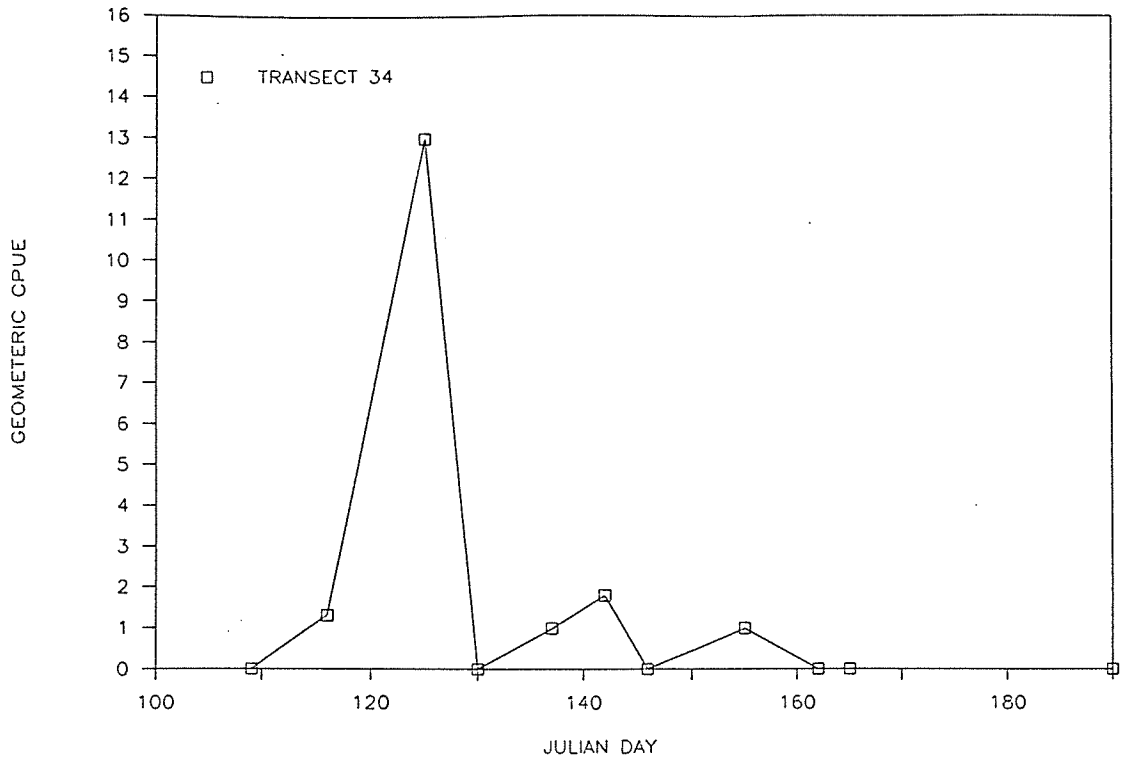

Figure A-42. Townet Catch of Coho Salmon Along the Browns Point Shoreline (Transect 34), 1983.

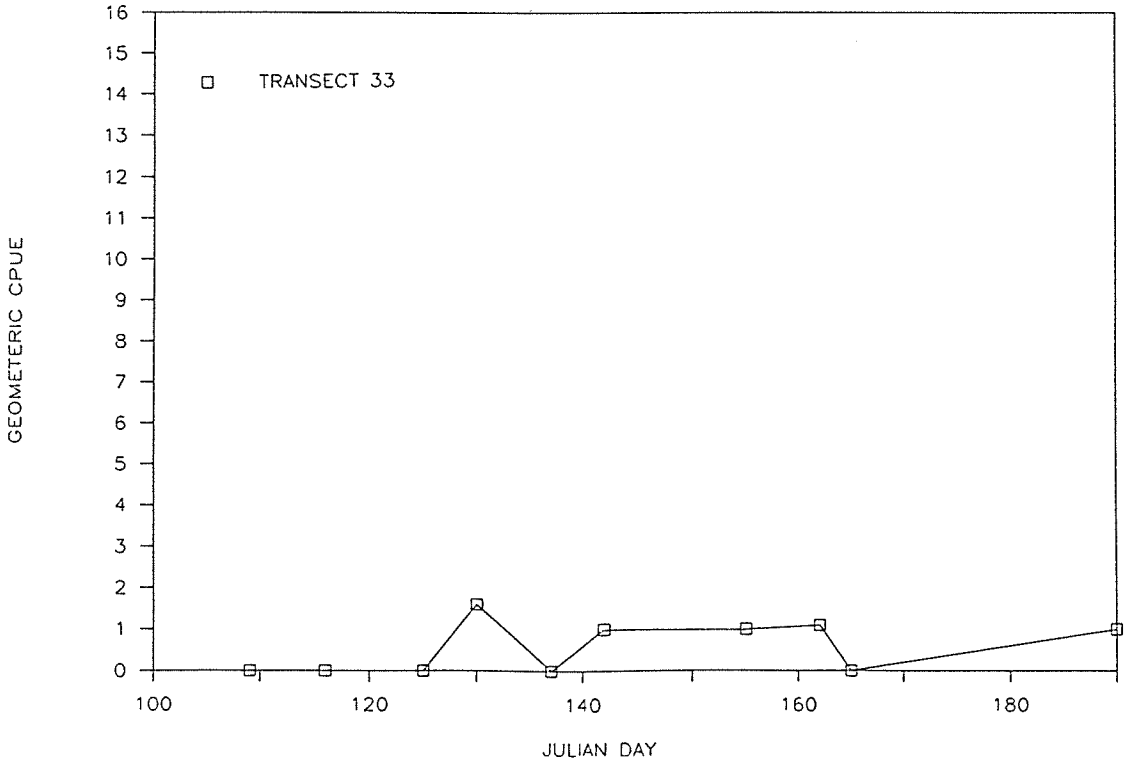

Figure A-43. Townet Catch of Coho Salmon Along the Ruston Way Shoreline (Transect 33), 1983.

APPENDIX B—LENGTH DATA: 1983

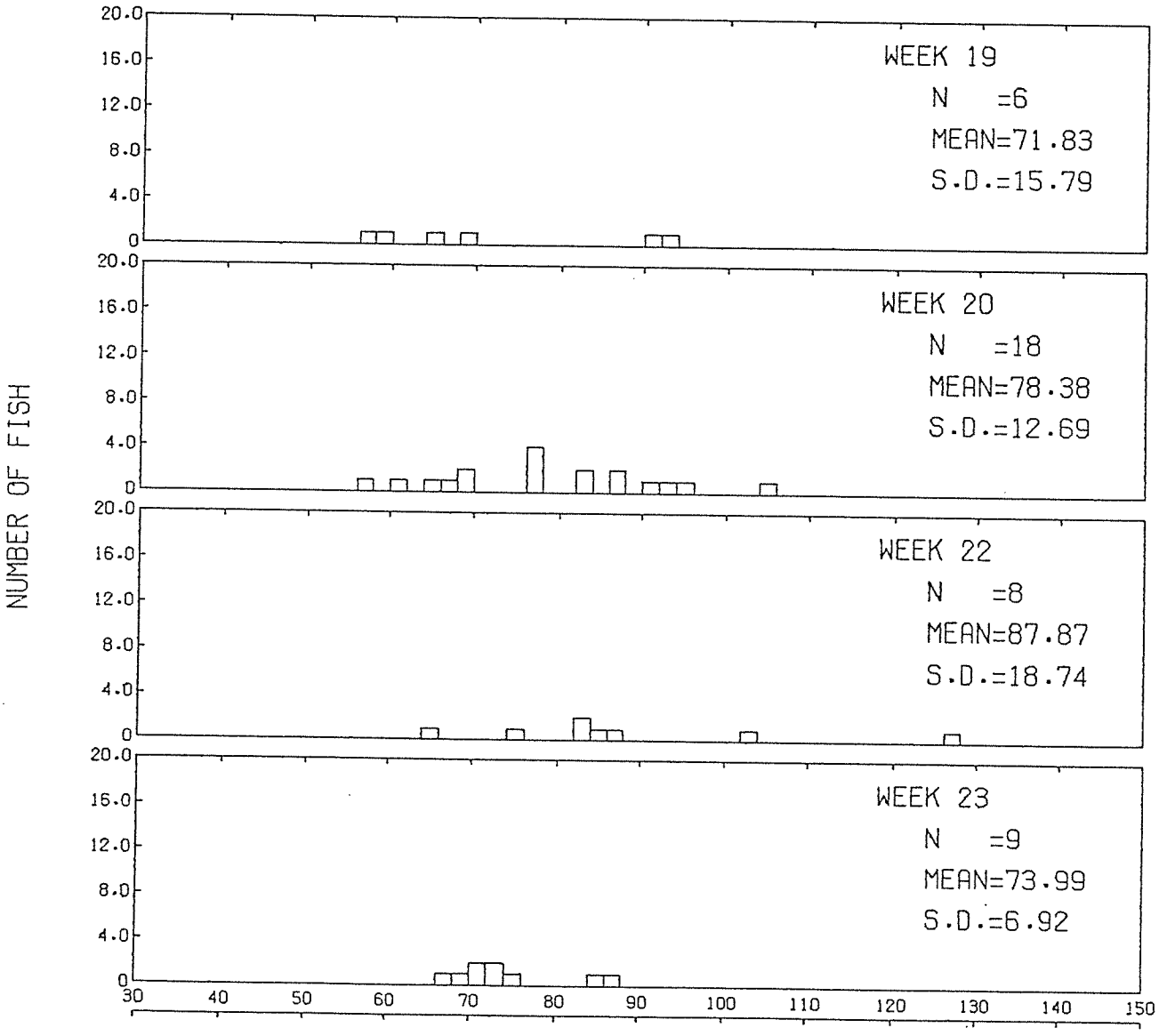

Figure B-1. Length of Beach Seine Caught Chinook Salmon in City Waterway, 1983 (length in 2mm increments).

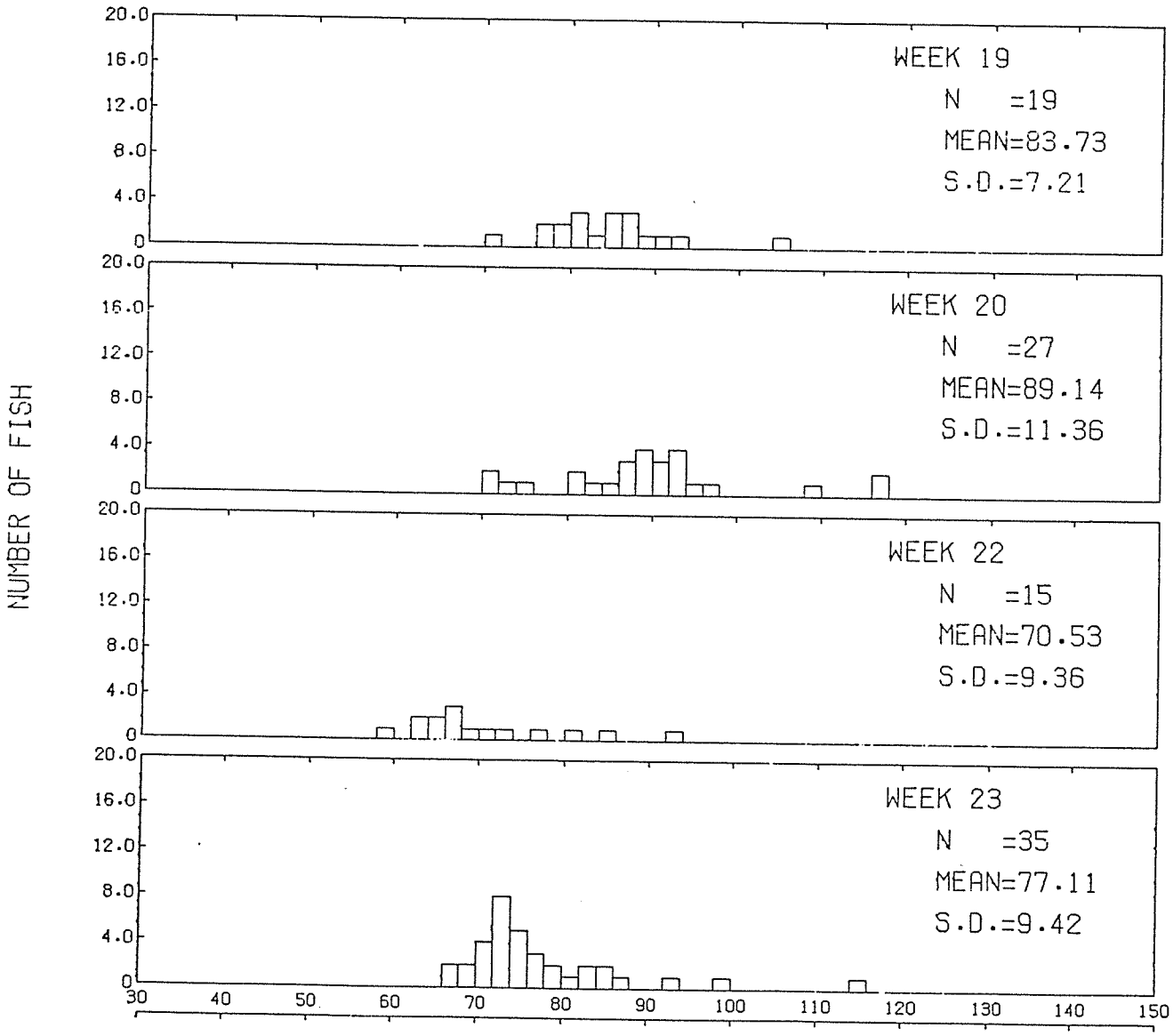

Figure B-2. Length of Townet Caught Chinook Salmon in City Waterway, 1983 (length in 2mm increments).

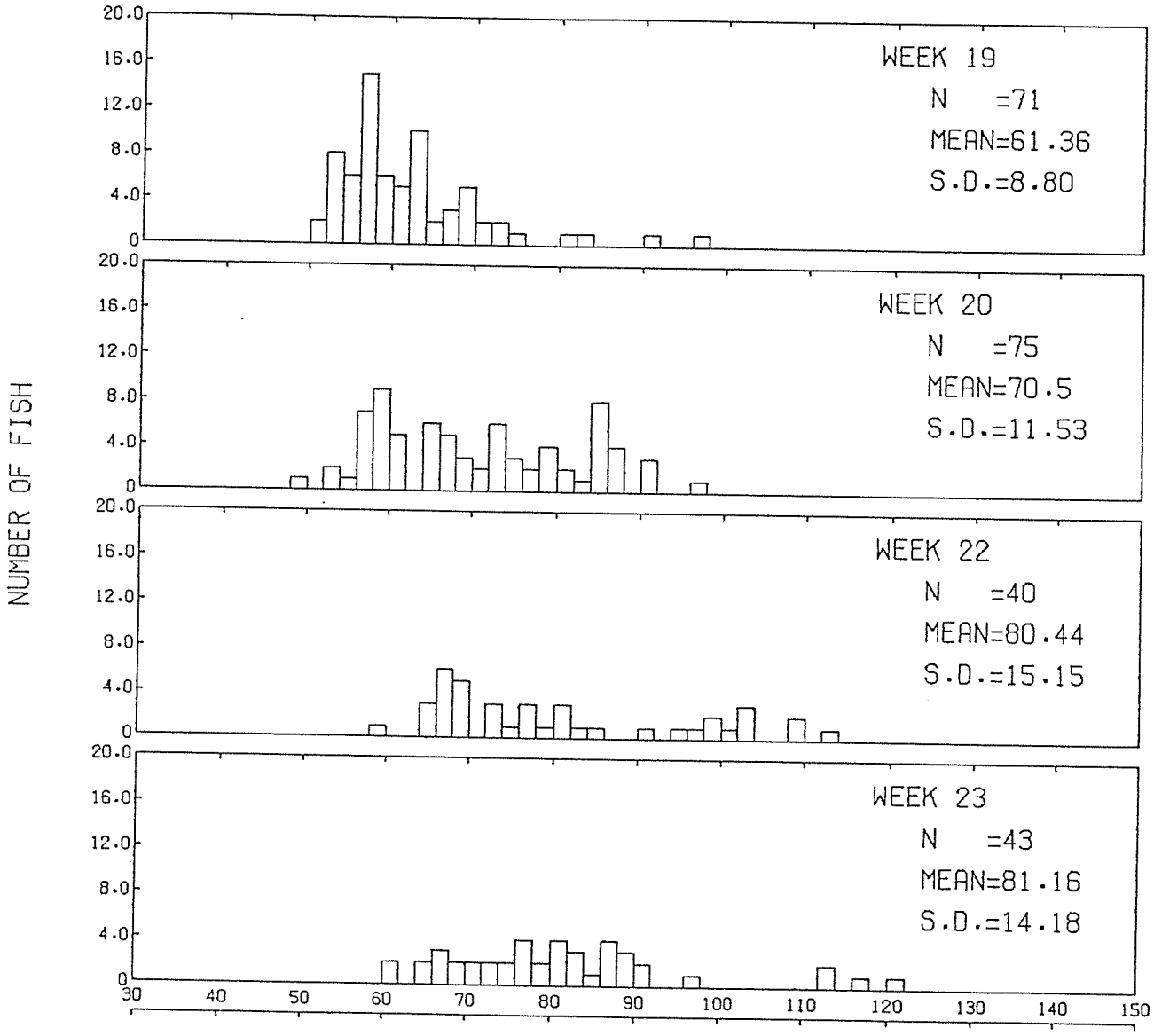

Figure B-3. Length of Beach Seine Caught Chinook Salmon in Milwaukee Waterway, 1983 (length in 2mm increments).

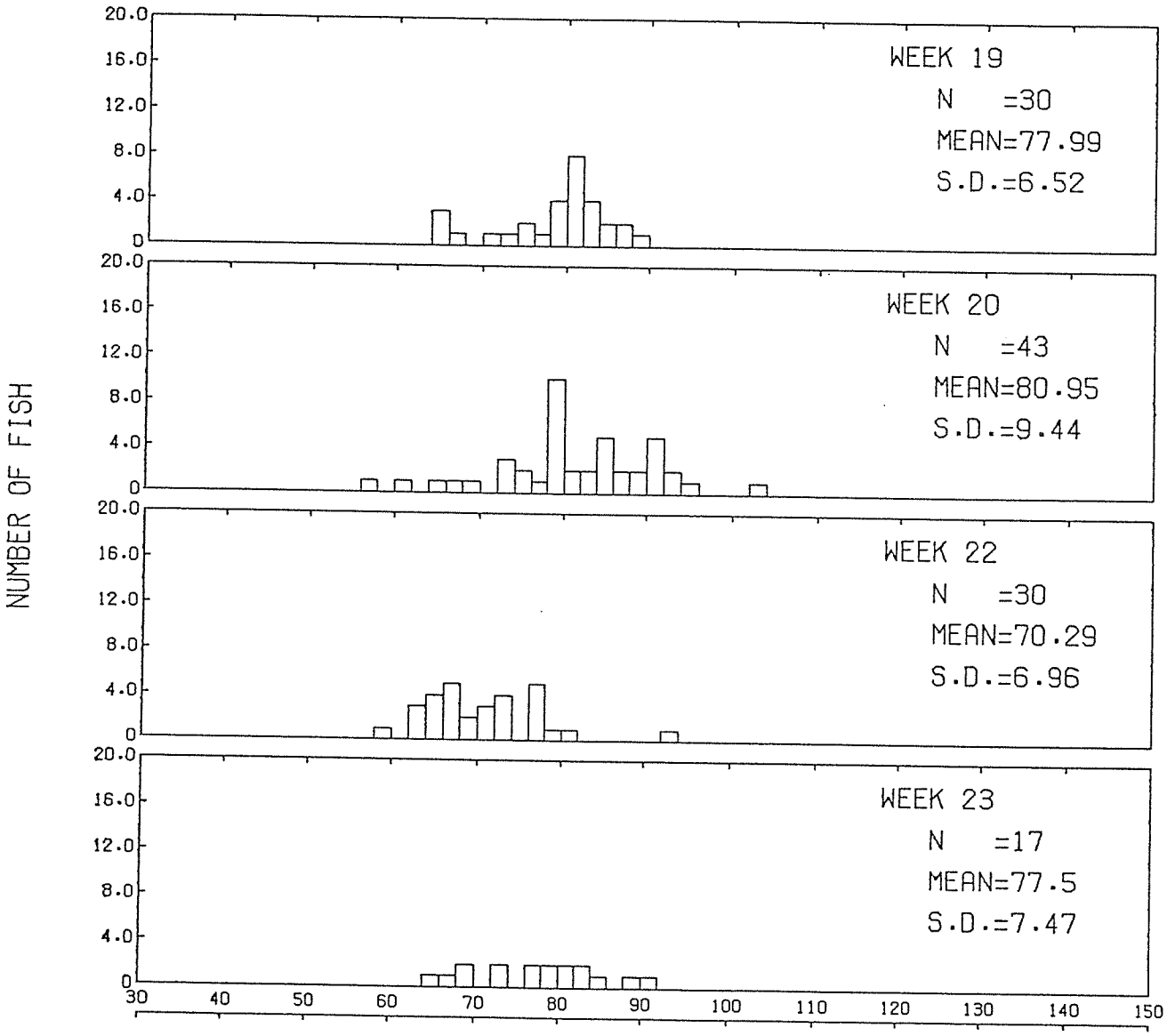

Figure B-4. Length of Townet Caught Chinook Salmon in Milwaukee Waterway, 1983 (length in 2mm increments).

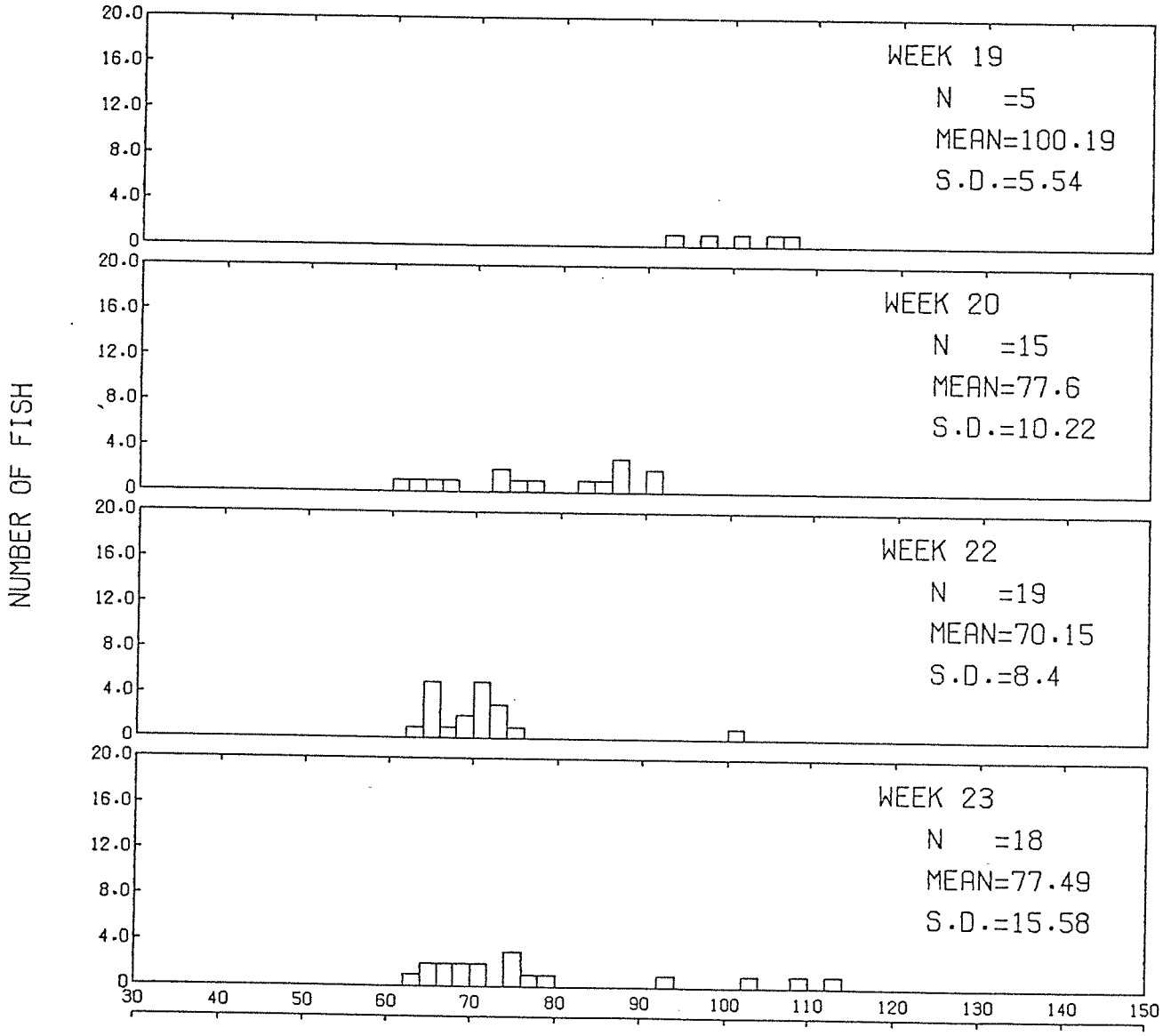

Figure B-5. Length of Beach Seine Caught Chinook Salmon in Hylebos Waterway, 1983 (length in 2mm increments).

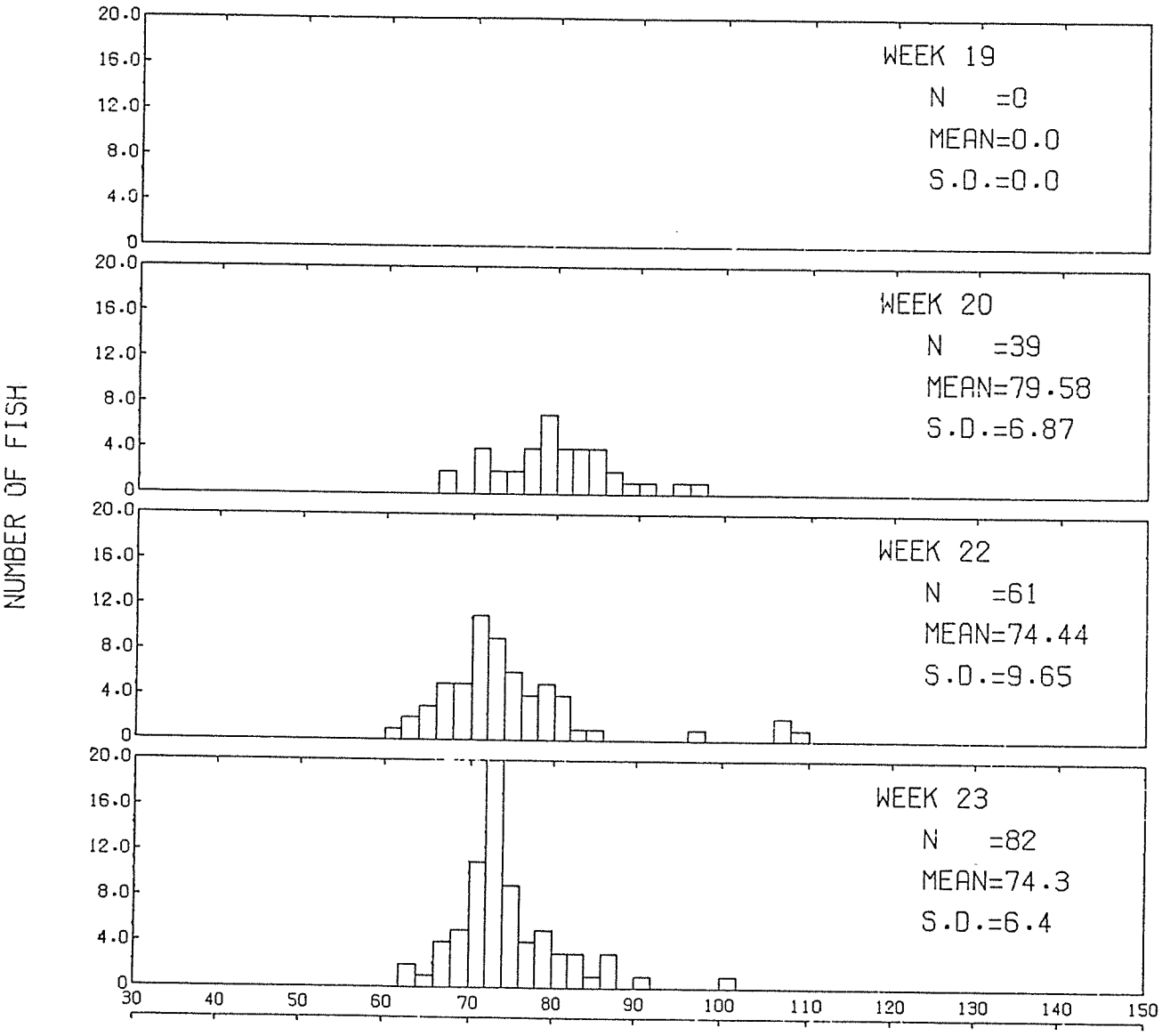

Figure B-6. Length of Townet Caught Chinook Salmon in Hylebos Waterway, 1983 (length in 2 mm increments).

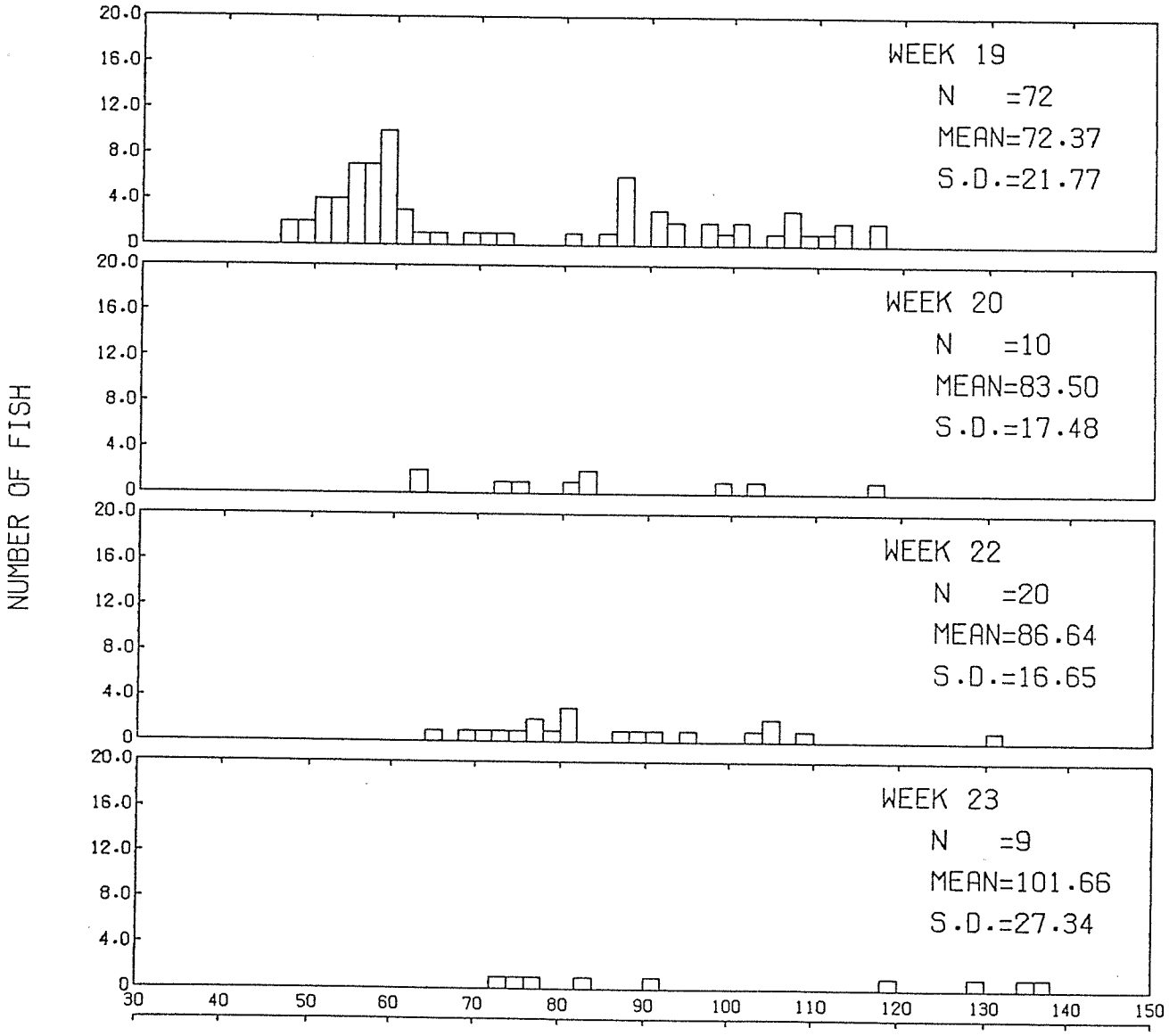

Figure B-7. Length of Beach Seine Caught Chinook Salmon along Browns Point Shoreline, 1983 (length in 2mm increments).

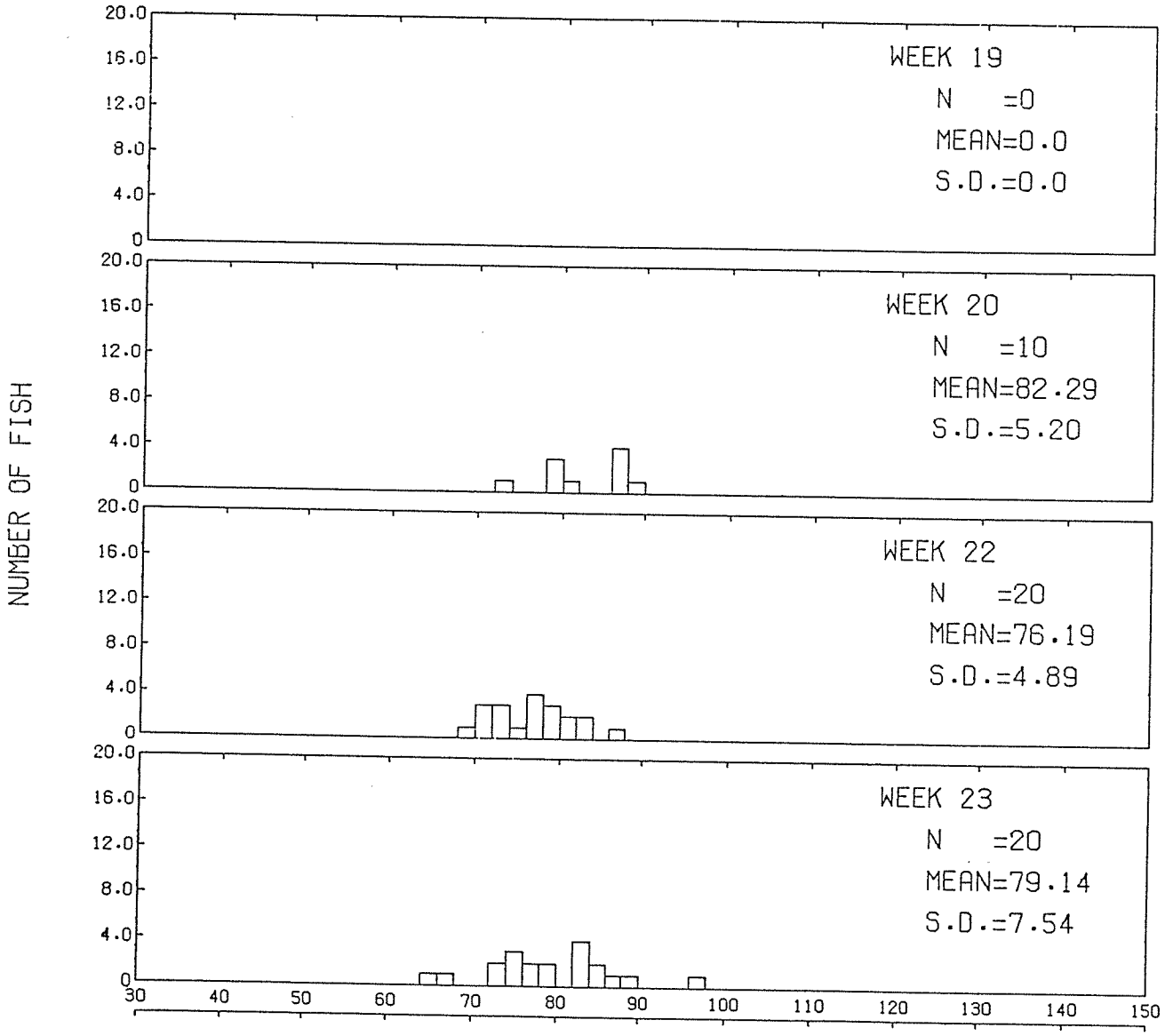

Figure B-8. Length of Townet Caught Chinook Salmon along Browns Point Shoreline, 1983 (length in 2mm increments).

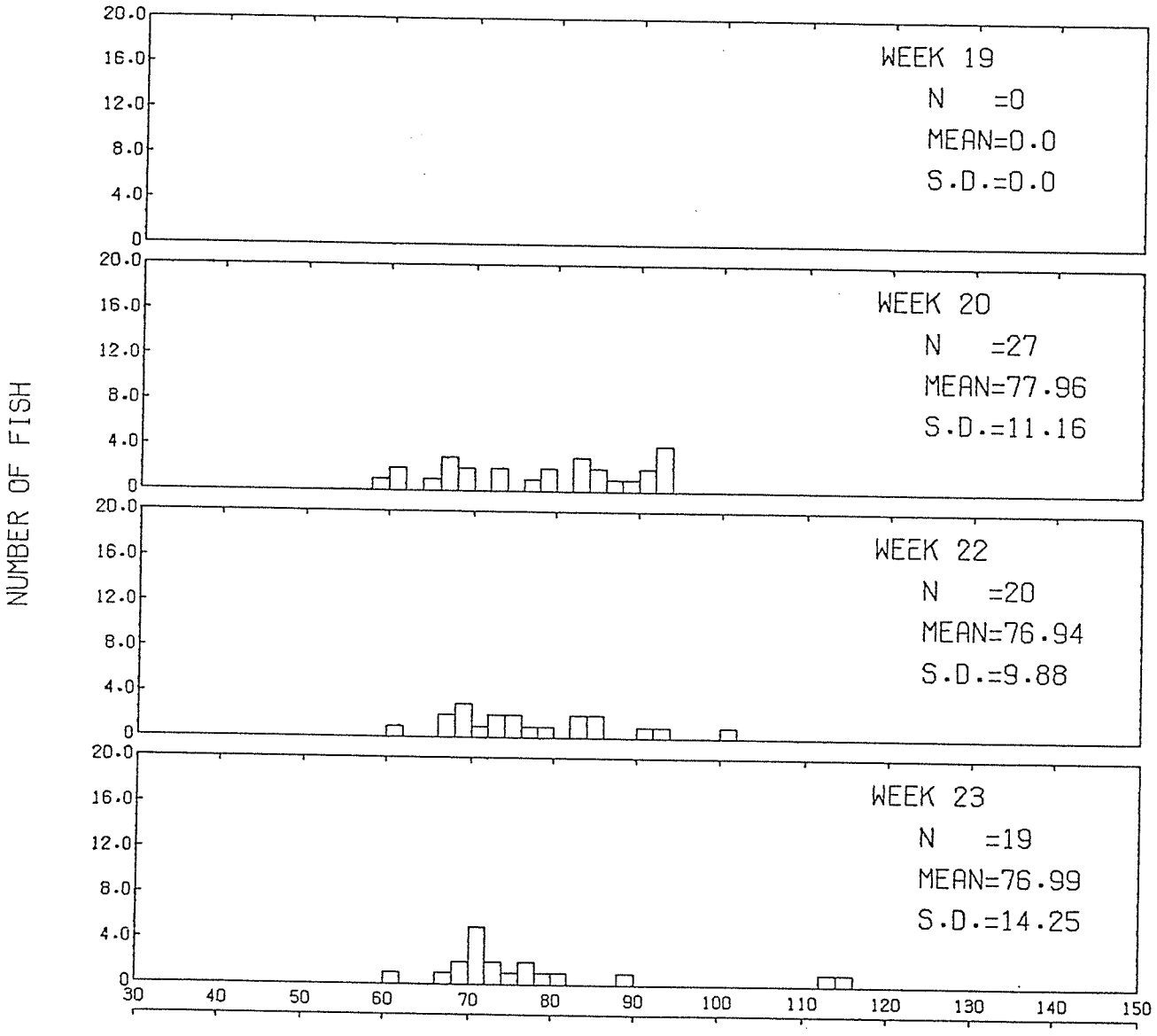

Figure B-9. Length of Beach Seine Caught Chinook Salmon along the Ruston Way Shoreline, 1983 (length in 2mm increments).

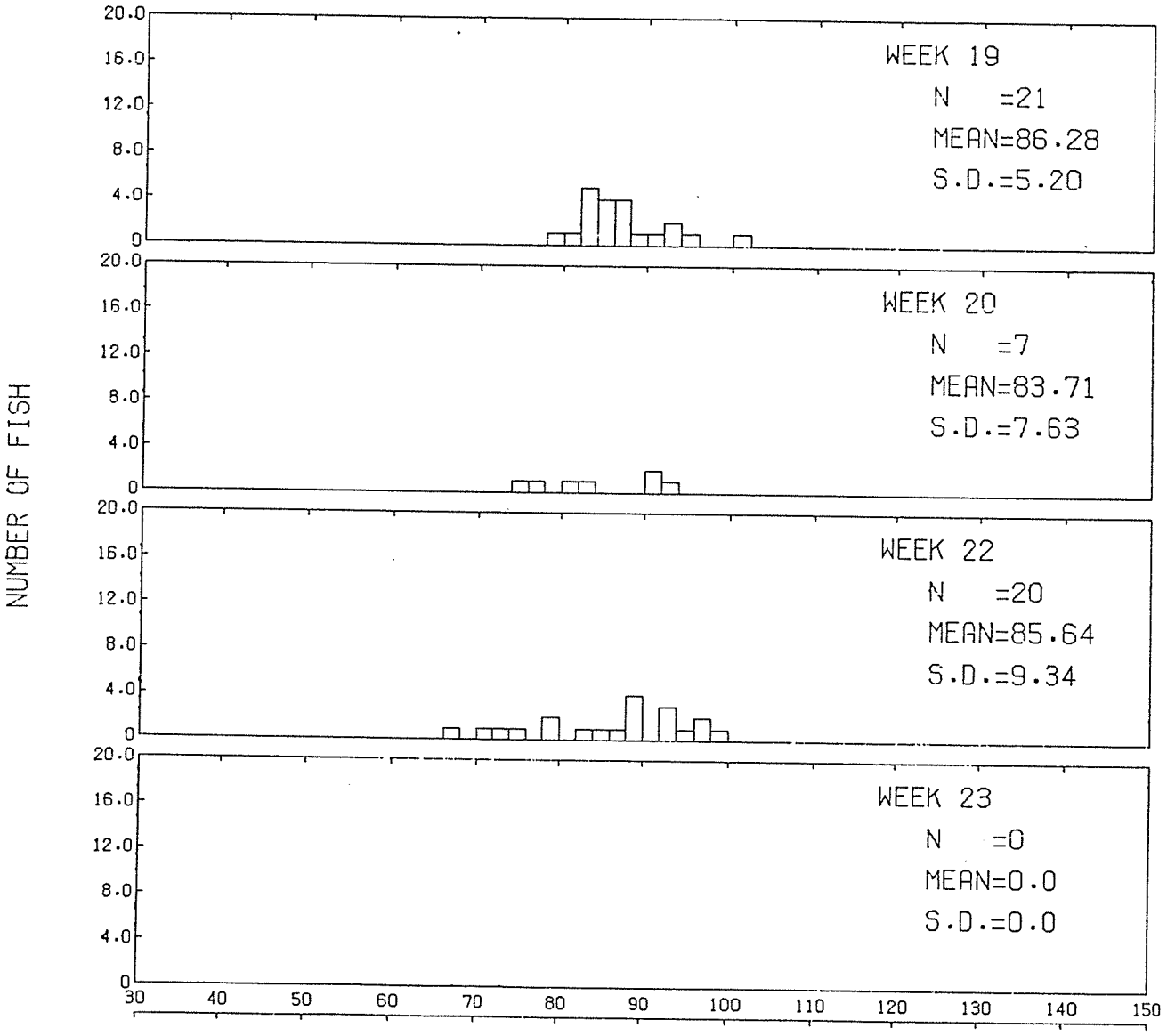

Figure B-10. Length of Townet Caught Chinook Salmon along the Ruston Way, Shoreline, 1983 (length in 2mm increments).

APPENDIX C—ENVIRONMENTAL PARAMETER DATA: 1983

Table C-1. Temperature, Salinity, and Secchi Disk Readings During Sampling, by Julian Week.

	Julian week 12 Julian day 83			Julian week 14a Julian day 92			Julian week 14b Julian day 95			Julian week 16a Julian day 106			Julian week 16b Julian day 111			Julian week 17 Julian days 113-116		
Site	Temp. (C)	Vis. (m)	Sal. (ppm)	Temp. (C)	Vis. (m)	Sal. (ppm)	Temp. (C)	Vis. (m)	Sal. (ppm)	Temp. (C)	Vis. (m)	Sal. (ppm)	Temp. (C)	Vis. (m)	Sal. (ppm)	Temp. (C)	Vis. (m)	Sal. (ppm)
BS- 6	10.8	3.0	18.0	10.6	0.8	19.0	11.6	---	22.0	13.5	---	25.0	13.6	2.0	21.0	12.2	2.8	----
BS-11	11.2	2.0	17.0	9.8	2.9	25.0	10.7	---	23.0	----	---	----	13.2	2.1	22.0	11.7	1.7	----
BS-14	10.8	3.9	13.0	9.4	8.0	24.0	13.2	---	11.0	11.6	---	24.0	11.4	6.7	26.0	11.2	2.7	----
BS-15	10.0	5.8	22.0	9.3	8.0	22.0	11.2	---	23.0	11.5	---	27.0	10.8	6.6	17.0	11.4	4.0	----
BS-16a	11.5	8.7	22.0	9.2	2.7	14.0	11.0	---	17.0	11.7	---	22.0	12.6	2.0	18.0	10.6	4.9	----
BS-16b	10.4	8.3	22.0	8.9	2.8	15.0	10.3	---	21.0	11.8	---	23.0	13.2	3.1	18.0	10.4	4.5	----
BS-17a	11.5	5.8	21.0	9.4	---	16.0	11.6	---	11.0	12.8	---	20.0	13.4	3.0	18.0	11.4	4.0	----
BS-17b	11.5	6.1	18.0	9.6	---	16.0	11.7	---	18.0	12.4	---	22.0	13.0	3.1	20.0	11.6	3.8	----
BS-18a	11.0	4.0	12.0	9.5	6.8	23.0	11.9	---	15.0	13.2	---	15.0	13.7	2.3	14.0	10.6	3.0	----
BS-18b	----	---	----	----	---	----	----	---	----	12.6	---	21.0	13.1	2.0	17.0	11.4	2.0	----
BS-19a	11.0	3.9	6.0	9.4	---	16.0	9.9	---	22.0	11.6	---	20.0	13.8	2.8	12.0	11.5	3.3	----
BS-19b	----	---	----	9.3	3.0	18.0	11.4	---	7.0	11.4	---	23.0	14.2	2.0	9.0	----	---	----
BS-20a	11.7	2.4	13.0	----	---	----	----	---	----	----	---	----	----	---	----	12.3	2.2	----
BS-20b	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----
BS-21	----	---	----	10.5	---	8.0	12.8	---	19.0	16.0	---	11.0	14.7	2.0	20.0	12.7	1.7	----
TN-30	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	10.6	3.8	23.0
TN-31	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	10.4	0.8	23.0
TN-32	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	10.6	7.1	27.0
TN-33	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	10.2	7.7	25.0
TN-34	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	11.3	4.5	24.0
TN-35	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	11.3	4.5	24.0
TN-36	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----
TN-42	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	12.0	3.0	21.0
TN-43	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	13.2	2.0	25.0
TN-44	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----
TN-44	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----
TN-45	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----
TN-46	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----

BS = Beach Seine
TN = Tow Net

Site	Julian week 18a Julian days 121-125			Julian week 18b Julian day 123			Julian week 19a Julian days 127-130			Julian week 20 Julian days 134-137			Julian week 21a Julian days 141-142			Julian week 21b Julian day 144		
	Temp. (C)	Vis. (m)	Sal. (ppm)	Temp. (C)	Vis. (m)	Sal. (ppm)	Temp. (C)	Vis. (m)	Sal. (ppm)	Temp. (C)	Vis. (m)	Sal. (ppm)	Temp. (C)	Vis. (m)	Sal. (ppm)	Temp. (C)	Vis. (m)	Sal. (ppm)
BS- 6	12.4	1.9	23.0	12.0	2.4	----	11.9	2.0	26.0	13.4	1.9	18.0	16.8	2.0	22.0	----	1.7	----
BS-11	11.6	1.9	24.0	11.3	2.6	----	11.2	3.6	26.0	----	---	----	----	---	----	----	---	----
BS-14	10.4	8.2	26.0	11.1	7.0	----	10.7	7.2	17.0	10.8	5.9	23.0	14.8	2.0	23.0	----	3.3	----
BS-15	10.6	8.5	27.0	11.0	8.0	----	10.5	7.3	17.0	10.8	4.3	22.0	12.7	3.1	26.0	----	4.0	----
BS-16a	11.9	3.9	17.0	11.7	4.5	----	10.9	3.4	23.0	12.0	2.3	17.0	13.3	3.2	26.0	----	2.5	----
BS-16b	12.2	4.1	17.0	11.7	4.0	----	11.1	4.5	22.0	12.4	2.2	12.0	13.5	3.0	24.0	----	2.5	----
BS-17a	12.2	3.8	18.0	12.0	3.9	----	10.6	4.3	20.0	12.2	3.0	16.0	13.9	2.9	21.0	----	2.1	----
BS-17b	12.3	3.0	19.0	12.2	3.9	----	11.2	3.9	21.0	13.0	2.3	18.0	15.5	2.1	20.0	----	1.9	----
BS-18a	11.8	3.1	19.0	11.2	4.5	----	10.8	3.8	22.0	11.3	2.5	22.0	13.9	2.3	23.0	----	3.3	----
BS-18b	11.8	4.0	20.0	11.3	5.0	----	10.9	4.1	22.0	11.5	2.6	23.0	14.0	2.2	24.0	----	2.6	----
BS-19a	12.2	3.3	18.0	11.8	3.9	----	10.7	4.3	21.0	12.2	2.6	18.0	16.7	2.7	17.0	----	3.4	----
BS-19b	12.0	2.8	16.0	12.0	3.0	----	10.7	4.1	23.0	12.6	2.5	13.0	14.8	2.3	23.0	----	2.2	----
BS-20a	----	---	----	12.3	3.5	----	11.4	2.6	26.0	11.8	2.7	21.0	----	---	----	----	2.0	----
BS-20b	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----
BS-21	13.3	2.2	22.0	12.8	1.7	----	12.8	1.9	20.0	14.1	1.4	16.0	17.7	1.6	20.0	----	1.8	----
TN-30	----	3.4	23.0	----	---	----	11.4	3.1	24.0	11.8	2.6	22.0	15.6	3.0	21.0	----	---	----
TN-31	----	0.6	22.0	----	---	----	11.9	2.9	22.0	12.1	2.2	24.0	----	---	----	----	---	----
TN-32	----	7.0	24.0	----	---	----	11.4	6.0	24.0	11.7	3.1	18.0	----	---	----	----	---	----
TN-33	----	10.0	14.0	----	---	----	11.2	5.4	23.0	11.0	5.2	25.0	12.8	6.4	28.0	----	---	----
TN-34	----	3.4	13.0	----	---	----	11.5	5.0	26.0	11.6	2.3	20.0	13.7	2.7	26.0	----	---	----
TN-35	----	3.7	22.0	----	---	----	11.6	2.1	20.0	11.8	3.7	22.0	13.3	2.0	18.0	----	---	----
TN-36	----	---	----	----	---	----	11.3	3.0	20.0	11.8	3.2	18.0	13.5	1.9	18.0	----	---	----
TN-42	----	---	----	----	---	----	11.6	3.0	20.0	----	---	----	14.6	2.1	16.0	----	---	----
TN-43	----	---	----	----	---	----	12.5	1.8	23.0	----	---	----	15.9	1.7	23.0	----	---	----
TN-44	----	---	----	----	---	----	----	---	----	12.0	2.2	20.0	----	---	----	----	---	----
TN-44	----	---	----	----	---	----	----	---	----	11.9	2.9	20.0	----	---	----	----	---	----
TN-45	----	2.0	16.0	----	---	----	----	---	----	11.6	2.4	10.0	----	---	----	----	---	----
TN-46	----	1.5	21.0	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----

BS = Beach Seine
TN = Tow Net

Site	Julian week 22 Julian day 148 Temp. (C)	Vis. (m)	Sal. (ppm)	Julian week 23a Julian days 155-156 Temp. (C)	Vis. (m)	Sal. (ppm)	Julian week 23b Julian day 160 Temp. (C)	Vis. (m)	Sal. (ppm)	Julian week 24a Julian days 162-163 Temp. (C)	Vis. (m)	Sal. (ppm)	Julian week 24b Julian week 165 Temp. (C)	Vis. (m)	Sal. (ppm)	Julian week 27 Julian week 188 Temp. (C)	Vis. (m)	Sal. (ppm)
BS- 6	----	1.6	----	----	---	----	----	1.2	----	----	1.9	----	----	---	----	----	1.3	----
BS-11	----	---	----	----	---	----	----	3.1	----	----	0.8	----	----	---	----	----	1.7	----
BS-14	----	2.1	----	----	0.6	----	----	6.2	----	----	1.2	----	----	---	----	----	1.8	----
BS-15	----	4.0	----	----	1.6	----	----	5.6	----	----	6.0	----	----	---	----	----	3.8	----
BS-16a	----	1.1	----	----	3.9	----	----	1.0	----	----	2.0	----	----	---	----	----	2.0	----
BS-16b	----	1.8	----	----	3.5	----	----	1.1	----	----	1.8	----	----	---	----	----	1.5	----
BS-17a	----	1.5	----	----	1.9	----	----	1.9	----	----	1.9	----	----	---	----	----	0.9	----
BS-17b	----	1.5	----	----	1.9	----	----	1.5	----	----	1.5	----	----	---	----	----	1.7	----
BS-18a	----	0.9	----	----	0.8	----	----	3.0	----	----	0.8	----	----	---	----	----	1.0	----
BS-18b	----	0.9	----	----	0.8	----	----	2.3	----	----	---	----	----	---	----	----	1.5	----
BS-19a	----	1.9	----	----	1.0	----	----	2.9	----	----	0.9	----	----	---	----	----	2.1	----
BS-19b	----	1.1	----	----	1.9	----	----	---	----	----	0.7	----	----	---	----	----	0.8	----
BS-20a	----	1.8	----	----	1.7	----	----	2.6	----	----	1.6	----	----	---	----	----	2.7	----
BS-20b	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	16.1	2.4	20.0
BS-21	----	1.3	----	----	0.7	----	----	1.1	----	----	1.5	----	----	---	----	----	1.6	----
TN-30	----	---	----	----	1.8	----	----	---	----	----	3.2	----	----	1.8	----	----	---	----
TN-31	----	---	----	----	1.2	----	----	---	----	----	1.4	----	----	1.1	----	----	---	----
TN-32	----	---	----	----	4.1	----	----	---	----	----	5.3	----	----	3.6	----	----	---	----
TN-33	----	---	----	----	9.0	----	----	---	----	----	9.0	----	----	6.4	----	----	---	----
TN-34	----	---	----	----	0.6	----	----	---	----	----	0.8	----	----	1.5	----	----	---	----
TN-35	----	---	----	----	0.7	----	----	---	----	----	1.6	----	----	1.0	----	----	---	----
TN-36	----	---	----	----	---	----	----	---	----	----	0.9	----	----	2.2	----	----	---	----
TN-42	----	---	----	----	1.4	----	----	---	----	----	---	----	----	2.2	----	----	---	----
TN-43	----	---	----	----	---	----	----	---	----	----	---	----	----	1.8	----	----	---	----
TN-44	----	---	----	----	---	----	----	---	----	----	2.9	----	----	---	----	----	---	----
TN-44	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----
TN-45	----	---	----	----	---	----	----	---	----	----	1.9	----	----	---	----	----	---	----
TN-46	----	---	----	----	---	----	----	---	----	----	2.6	----	----	---	----	----	---	----

BS = Beach Seine
TN = Tow Net