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Juvenile Salmonid Stranding in the Lower Columbia River, 1992 and 1993

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National Marine Fisheries Service

NOAA Technical Memorandum NMFS

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Juvenile Salmonid Stranding in the Lower Columbia River, 1992 and 1993

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U.S. DEPARTMENT OF COMMERCE
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ABSTRACT

Stranding of juvenile salmon (*Oncorhynchus* spp.) on beaches of the lower Columbia River was studied during April-September 1992 and March-July 1993. Stranding was documented as a significant cause of juvenile salmon mortality by the Washington Department of Fisheries (WDF) in 1974 and 1975 and occurs when the surges and wakes of deep-draft vessels wash fishes onto beaches. Eight sites where stranding had been documented by WDF were studied. Data collected at each site included characteristics of passing vessels (type, speed, surge, and wake height), physical attributes of each beach (slope and distance from the navigational channel), and the number of fishes utilizing the water adjacent to the beach. After a vessel passed a site, the beach was searched for stranded fishes. Eleven stranded fish were found during the study; however, six of these may not have been stranded by passing vessels. Various physical factors such as river-surface elevation, beach slope, vessel design and speed, and the distance between the passing vessel and the beach, and biological factors such as fish condition, may need to interact for stranding of juvenile salmonids to occur. Our observations indicated that stranding of juvenile salmonids is not presently a significant cause of juvenile salmonid mortality in the lower Columbia River.

CONTENTS

INTRODUCTION

In 1975, an estimated 145,000 chinook (*Oncorhynchus tshawytscha*), 1,359 coho (*O. kisutch*), and 4,771 chum (*O. keta*) salmon, and 537 trout (*Oncorhynchus* spp.), all juvenile fishes, were stranded on lower Columbia River beaches due to ship wakes from deep-draft vessels traveling in the navigation channel, (Bauersfeld 1977). Stranding occurs when juvenile salmonids, residing or migrating in shallow subtidal habitats, are carried by a ship's wake or surge onto beaches above the normal water line. The water from the wake or surge then recedes or is absorbed quickly on the beach, leaving the fish stranded. Factors that can affect stranding include vessel hull design, draft and speed; channel depth and distance from shore; river height; tide stage; and beach slope, width, and shape.

Several of the U.S. Army Corps of Engineers' (COE) beach nourishment dredged-material disposal sites have been identified as stranding sites. The COE has 89 designated dredged-material disposal sites between the mouth of the Columbia River and River Kilometer (RKm) 161. In 1992 and 1993 the National Marine Fisheries Service conducted a study to document the extent of juvenile salmonid stranding in the lower Columbia River and the physical attributes of beaches which may contribute to stranding. Eight beach sites where stranding of salmonids had been observed in the past were studied. Four sites are frequently used (within the past 5 years) as COE dredged-material disposal sites and four are infrequently used (not used within the past 5 years).

Our objectives were to determine if stranding was still a serious source of juvenile salmonid mortality and if so determine the causes and recommend ways to eliminate it.

METHODS

Sampling

From April through September 1992 and March through July 1993, eight potential juvenile salmon stranding sites were sampled several times a month (Fig. 1, Appendix Figs. 1-8). Sampling consisted of an initial search of a site immediately upon arrival, to find any fishes already on the beach. After a vessel passed the site, an extensive search for stranded fish was initiated by walking as much of the beach as feasible (up to 1.6 km). Occasionally the search was expanded to the opposite shores. Sites were visited during the time of day when the majority of deep-draft vessels were expected to pass by. Vessel schedules were obtained from the Columbia River Bar Pilots Association to minimize field time and maximize observations. Sites were occupied during various tide stages and times of day.

Data collected during each sampling effort included: date, time, river height, tide stage, estimated vessel speed, vessel direction, size of vessel-caused surge, size of vessel-caused waves, stern position (in or out of the water), type of vessel, and number of fishes stranded. We measured the slopes, widths, and heights of the beaches in August 1992. Five of the sampling sites had both a dredged-material disposal site beach and a "natural" beach in proximity. Both beach types were searched for stranded fish during each sampling effort.

Beach seining was usually conducted at each of the eight sites to document the species, numbers, and sizes of fishes utilizing the water adjacent to the beaches. Three species of Pacific salmon (*Oncorhynchus* spp.) in the Columbia River system are listed under the Endangered Species Act (ESA) of 1973, necessitating a collection permit prior to any beach seining. In 1992, seining was limited until an ESA permit to collect juvenile salmonids was received in late August. In 1993, beach seining was conducted from March through July.

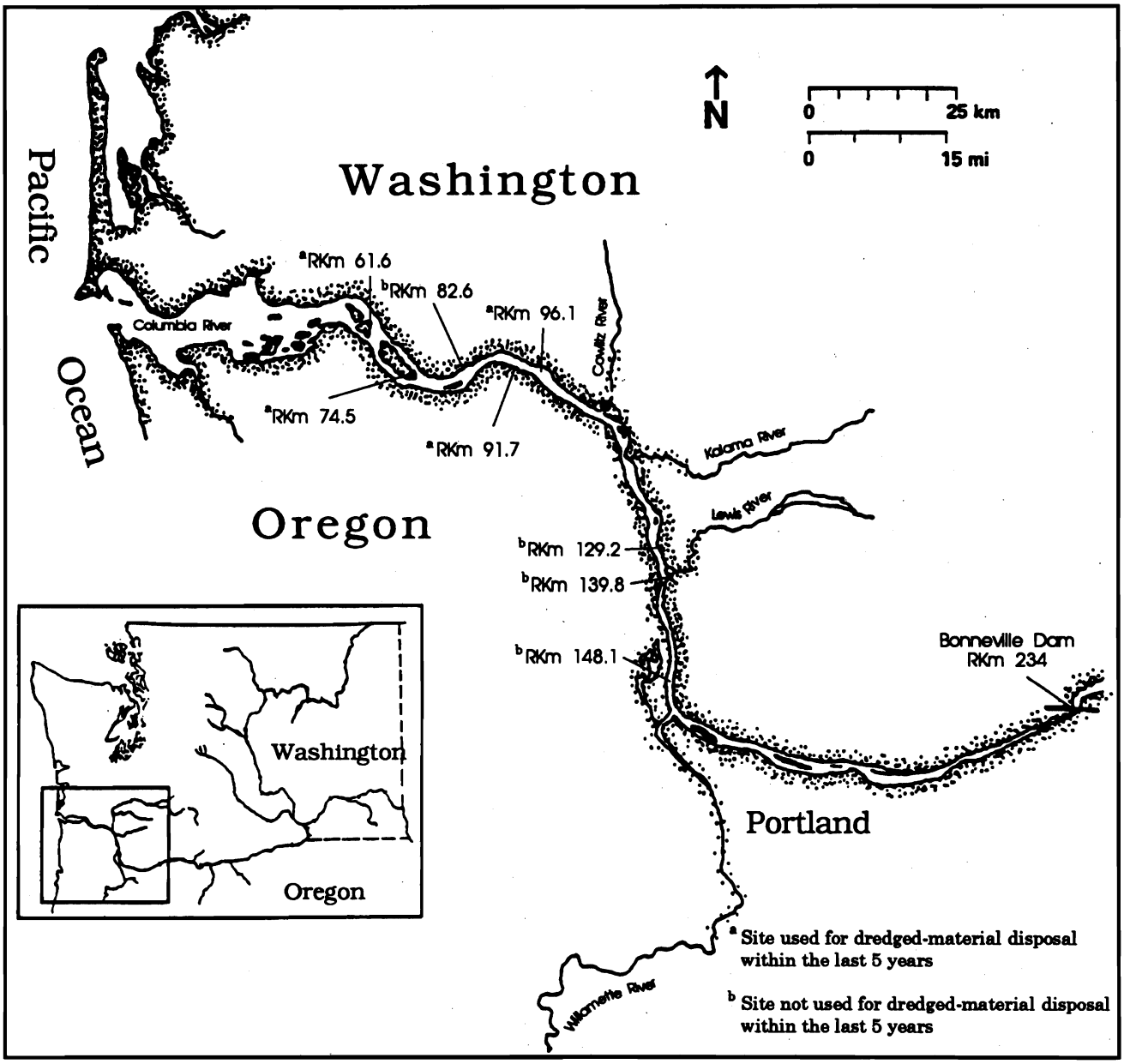

Figure 1.--Eight potential juvenile salmonid stranding sites surveyed along the lower Columbia River, April-September 1992 and March-July 1993.

The seining was done with a 50-m variable mesh (19.0-, 12.7-, and 9.5-mm) beach seine with knotless web in the bunt to reduce descaling of fish. One end of the seine was anchored in dry sand, then using a 5-m boat, the net was fully extended along the shoreline and pulled offshore in a wide arc, completing a half-circle upon returning to the beach. Collected fishes were identified, counted, and a maximum of 50 individuals of each species was measured (total length, TL, in mm) and weighed (g). For salmonids, measurements included TL, fork length (FL), and weight (g). When more than 50 individuals of a species were collected at a site, the excess was counted and weighed as a group. Juvenile salmonids were anesthetized using a benzocaine (ethyl-*p*-aminobenzoate) solution prior to being measured and weighed.

Data Analysis

For each beach seine effort, individual species and total fish densities (number/ha) and weights (g/ha) were estimated using the catch data and area sampled. The estimated area sampled by the beach seine was 2,540 m^2 (Hinton et al. 1990). Two community structure indices were also calculated for each sampling effort. The first was Diversity (H), which was determined using the Shannon-Wiener function (Krebs 1978):

$$H = -\sum_{i=1}^{s} p_i \log_2 p_i$$

where $p_i = n_i / N$ (n_i is the number of individuals of the *i*th taxon in the sample, and N is the total number of individuals in the sample) and s = number of taxa. The second community structure index was Equitability (E), which measures the proportional abundances among the various taxa in a sample (Krebs 1978):

$$E = H/\log_2 s$$

where H = Shannon-Wiener function and s = number of taxa. Equitability can range from 0.00 to 1.00, with 1.00 indicating that all taxa in the sample are numerically equal.

RESULTS

In 1992, each of the eight potential juvenile salmonid stranding sites was occupied at least twice between late June and September. In 1993, each site was visited at least three times between late March and early July. We observed 74 (1992) and 71 (1993) deep-draft vessels, most of which produced surges and waves capable of stranding juvenile salmon (Appendix Table 1). One stranded fish was found in 1992 and 10 stranded fish in 1993 (Table 1); however, six of the fishes found in 1993 were already partially decayed and the cause of their stranding could not be attributed to any passing vessel we observed. All the fish we found stranded were juvenile chinook salmon.

The most common vessels observed during the survey were regular freighters (30%) and car ships (20%) (Fig. 2). About 50% of the vessels were traveling between 22 and 26 km/h (Fig. 3). Stern position, which can have an effect on the size of surges and waves, was most often observed to be in the water. The majority of surges produced by passing vessels were less than 0.25 m in height (54%), and the majority of the waves (47%) were between 0.5 and 1.0 m in height (Fig. 3). Surge and wave height are also affected by beach slope and the distance between the beach and the vessel. Topographies at the eight sites ranged from nearly flat to extremely steep, with several areas having both types (Appendix Figs. 1-8).

Fifteen fish taxa were captured by beach seine during the 1992-93 juvenile salmonid stranding survey (Appendix Table 2). Dominant fishes captured throughout the study included chinook salmon, threespine stickleback (*Gasterosteus aculeatus*), starry flounder (*Platichthys stellatus*), peamouth (*Mylocheilus caurinus*), and coho salmon (Appendix Table 3). Fish densities ranged from 43 to 2,248 fish/ha (Table 2). Overall,

Table 1.--Lengths and weights of juvenile chinook salmon found on Columbia River beaches, 1992 and 1993.

Date	RKm	Total length (mm)	Fork length (mm)	Wt.(g)
8 Jul 92	148.1	80	73	5
13 Apr 93	96.1	33	32	1
15 Apr 93	129.2	*119	110	14
		*46	42	1
		*42	38	1
		42	38	1
23 Apr 93	148.1	*74	68	4
		*46	42	1
		45	42	1
30 Apr 93	96.1	*56	52	2
18 May 93	74.5	50	47	1

* Fish were partially decayed, cannot attribute presence to any passing vessel.

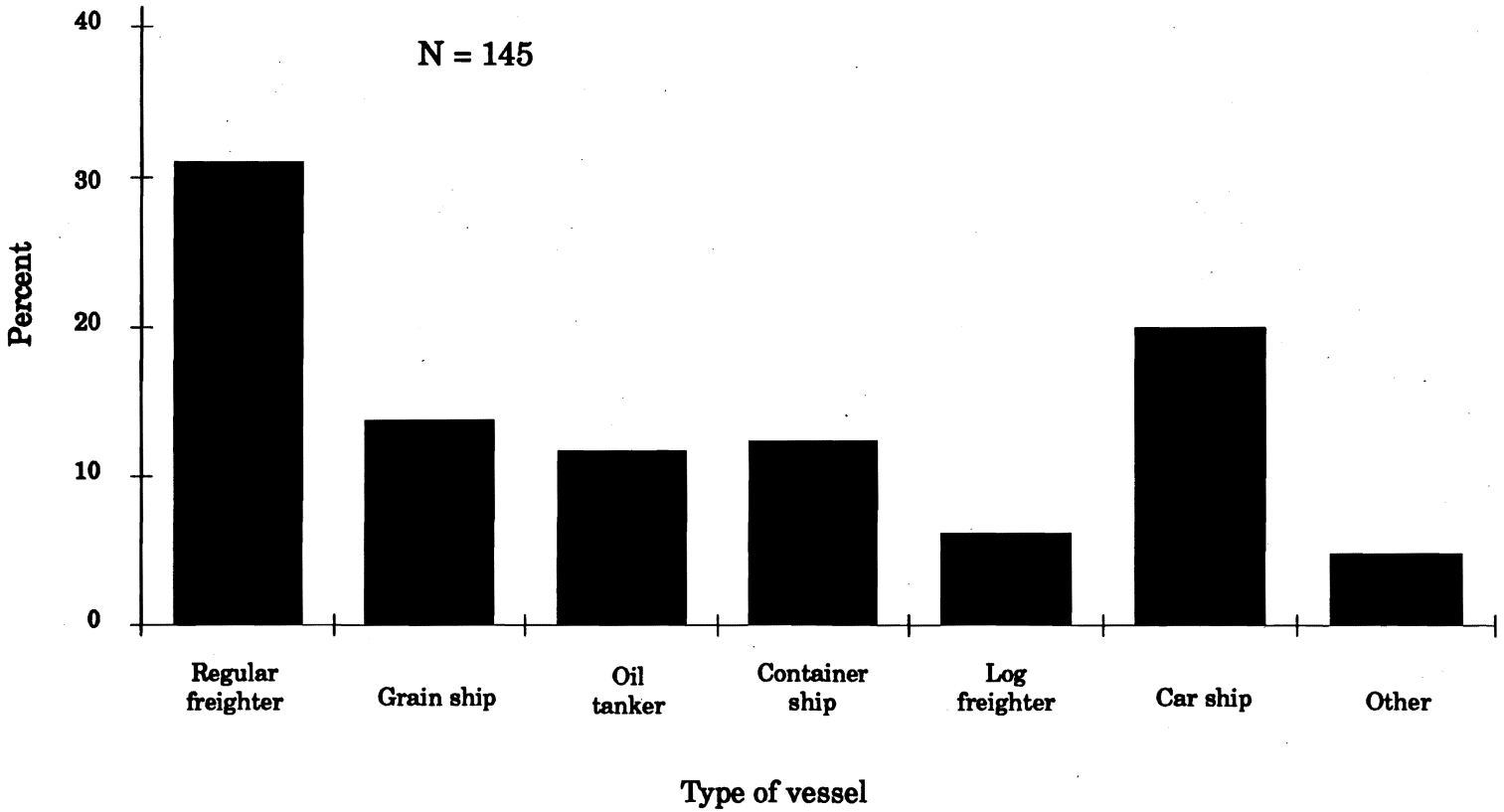

Figure 2.--Types of vessels observed passing the eight potential juvenile salmonid stranding sites surveyed along the lower Columbia River in 1992 and 1993.

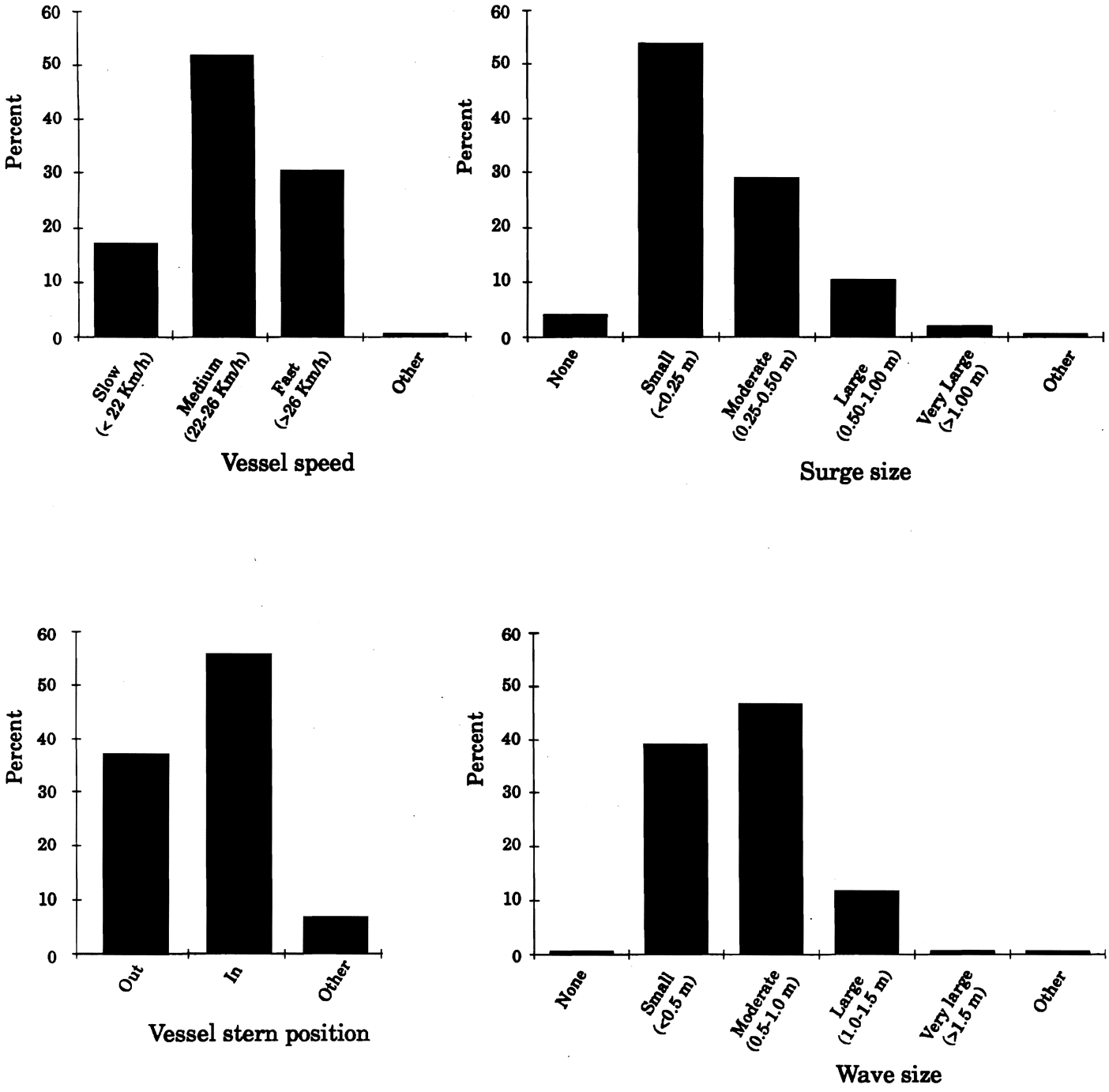

Figure 3.--Characteristics of vessels and their associated wakes observed while passing potential juvenile salmonid stranding sites along the lower Columbia River, 1992 and 1993. One hundred and forty-five vessels were observed.

Table 2.--Summary of fish catches during the stranding survey at eight sites along the Columbia River, 1992 and 1993.

RKm	Date	No./ha	Wt. (g/ha)	H[a]	E[b]
		1992			
61.6	17 Sep	2,248	7,508	1.69	0.73
	17 Sep	823	6,013	1.06	0.41
74.5	11 Jun	898	8,433	0.80	0.34
148.1	18 Sep	79	291	1.54	0.77
		1993			
61.6	14 Apr	269	-[c]	1.83	0.65
	14 May	367	-	1.59	0.53
	14 May	1,268	-	0.59	0.23
	24 Jun	1,067	3,881	1.68	0.56
74.5	29 Apr	815	2,969	1.14	0.44
	18 May	556	31,449	1.86	0.66
	9 Jun	292	12,267	1.92	0.68
82.6	28 Apr	440	-	1.23	0.62
	25 Jun	165	535	0.70	0.70
91.7	7 May	1,622	-	2.19	0.69
	2 Jun	1,308	-	0.88	0.29
	2 Jul	1,319	48,355	1.30	0.46
96.1	13 Apr	107	-	1.70	0.85
	30 Apr	178	12,519	1.66	0.59
	9 Jun	473	54,469	2.12	0.71
129.2	15 Apr	43	122	1.10	0.69
	12 May	697	-	0.90	0.39
139.8	16 Apr	736	1,859	0.51	0.22
	6 May	590	-	1.40	0.60
148.1	23 Apr	107	1,323	1.05	0.45
	27 Apr	301	9,166	1.62	0.54

[a]Diversity.
[b]Equitability.
[c] no weights were recorded.

diversity (H) was low, ranging from 0.51 to 2.19 and equitability (E) was moderate, ranging from 0.22 to 0.85. Together H and E indicate few fish species were caught per seine and the numbers of two or more of these species were numerically similar.

Juvenile salmonids were present in 100% of the beach-seine efforts conducted during June-September 1992 and 1993 (Table 3), with densities ranging from 70 to 1,053 salmonids/ha. This indicated that the juvenile salmonids were utilizing the nearshore areas and were therefore potentially exposed to stranding conditions generated by a passing vessel.

All the chinook salmon were juveniles, with most between 45 and 105 mm TL from April through July (Figs. 4, 5). The mean length of these salmonids increased during the sampling season, with few fish less than 75 mm TL by July. Coho salmon captured in April and May 1993 were usually between 140 and 170 mm TL and showed no change in length over the 2-month period (Fig. 6).

DISCUSSION

In 1974 and 1975, juvenile salmonid stranding caused by deep draft vessels was a notable source of mortality, with daily estimates at some Columbia River beach sites as high as 117 fish per vessel (Bauersfeld 1977). However, in 1992 and 1993, only five juvenile salmonids were found stranded in association with passing deep-draft vessels. It is unclear why so few fish were stranded in 1992 and 1993.

The stranded fishes found in 1974 and 1975 may have been influenced by dissolved gas supersaturated river water, caused by spilling of water at upstream hydropower dams. In 1974 and 1975, river flows and the dissolved gas saturation values were higher than those observed during our survey (Fig. 7). Dissolved gas levels above 106% decrease juvenile chinook salmon swimming performance (Schiewe 1974). In 1975, dissolved gas levels in the Columbia River were above 106% at Prescott, Oregon (RKm 115) from 22 April through 15 July (Park et al. 1976). Fishes stranded during this period (peak

Table 3.--Summary of salmonids captured by beach seine at the eight potential juvenile salmonid stranding beaches along the Columbia River, June-September 1992 and April-July 1993. All salmonids (chinook salmon, coho salmon, steelhead, cutthroat trout) were combined for each beach seine. When more than one beach seine was made, the no./ha values are means.

Sampling period	RKm	No. of seine efforts	Frequency of occurrence (%)	Density (no./ha)
1992				
June	139.8	1	100	811
September	61.6	2	0	-
	74.5	1	0	-
1993				
April/May	61.6	3	100	70
	74.5	2	100	195
	82.6	1	100	397
	91.7	1	100	823
	96.1	2	100	87
	129.2	2	100	360
	139.8	2	100	612
	148.1	2	100	160
	Mean	2	100	338
June/July	61.6	1	100	287
	74.5	1	100	87
	82.6	1	100	134
	91.7	2	100	1,053
	96.1	1	100	256
	*129.2	1	100	339
	*148.1	1	100	602
	Mean	1	100	345

*Seine efforts were made on shore opposite from original site.

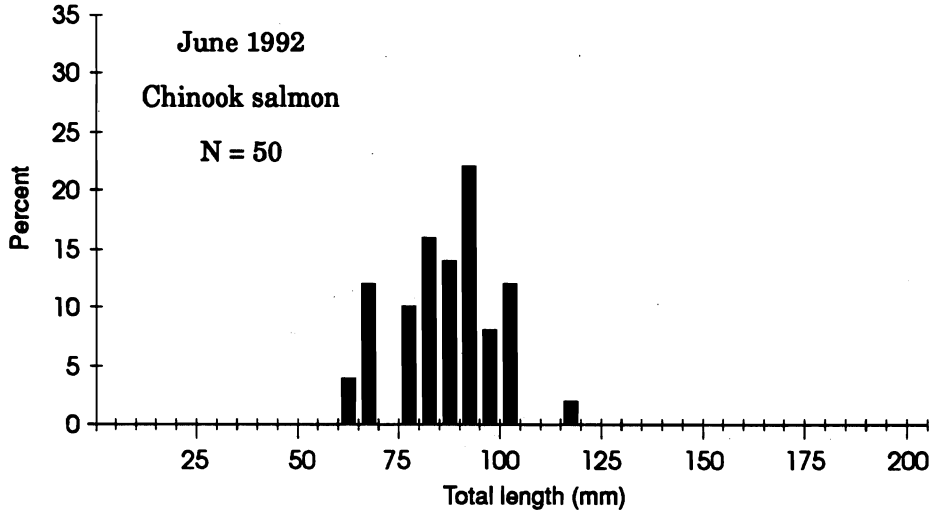

Figure 4.--Length frequency distribution of juvenile chinook salmon captured by beach seine in the Columbia River, June 1992.

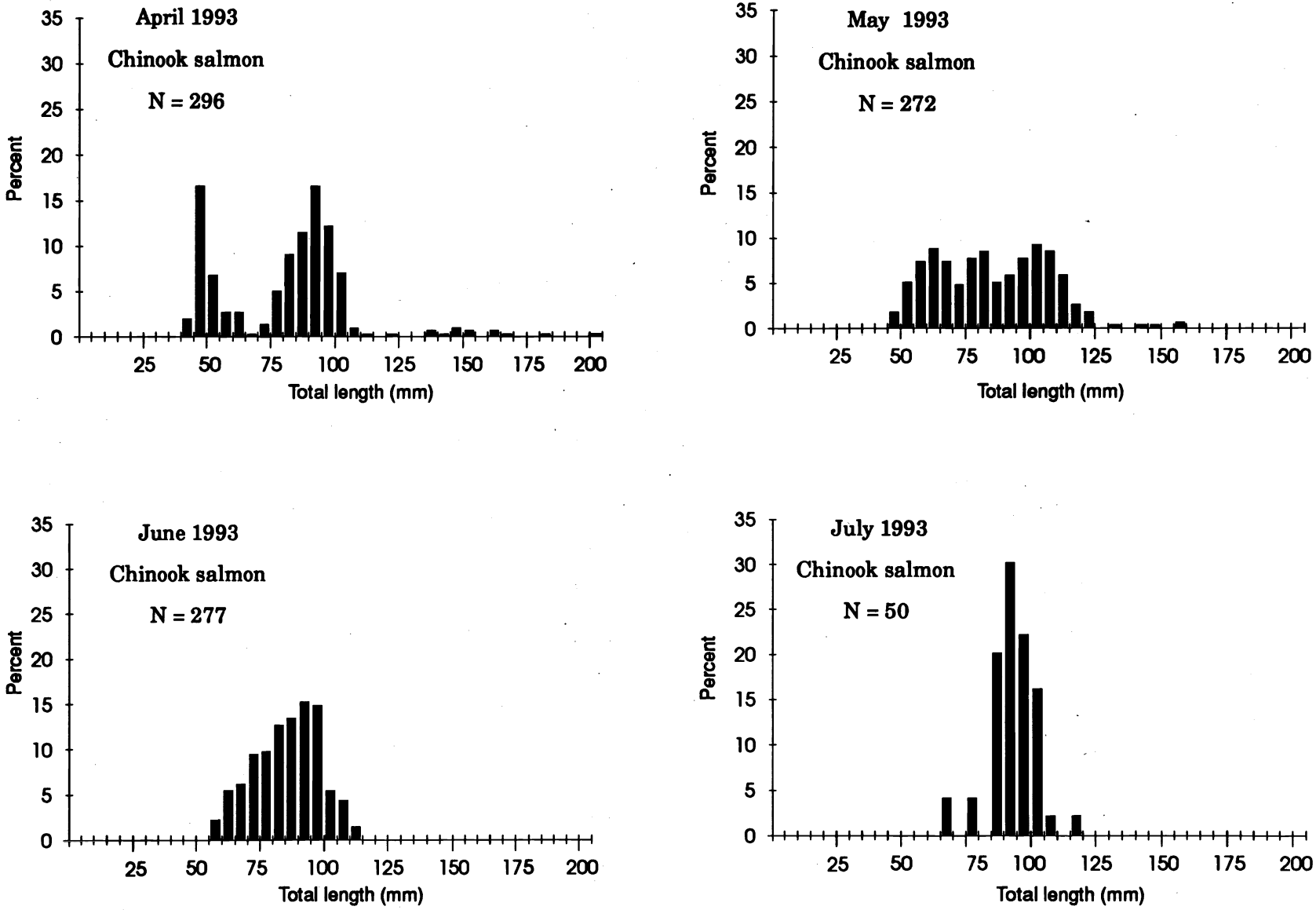

Figure 5.--Length frequency distributions of juvenile chinook salmon captured by beach seine in the Columbia River, 1993.

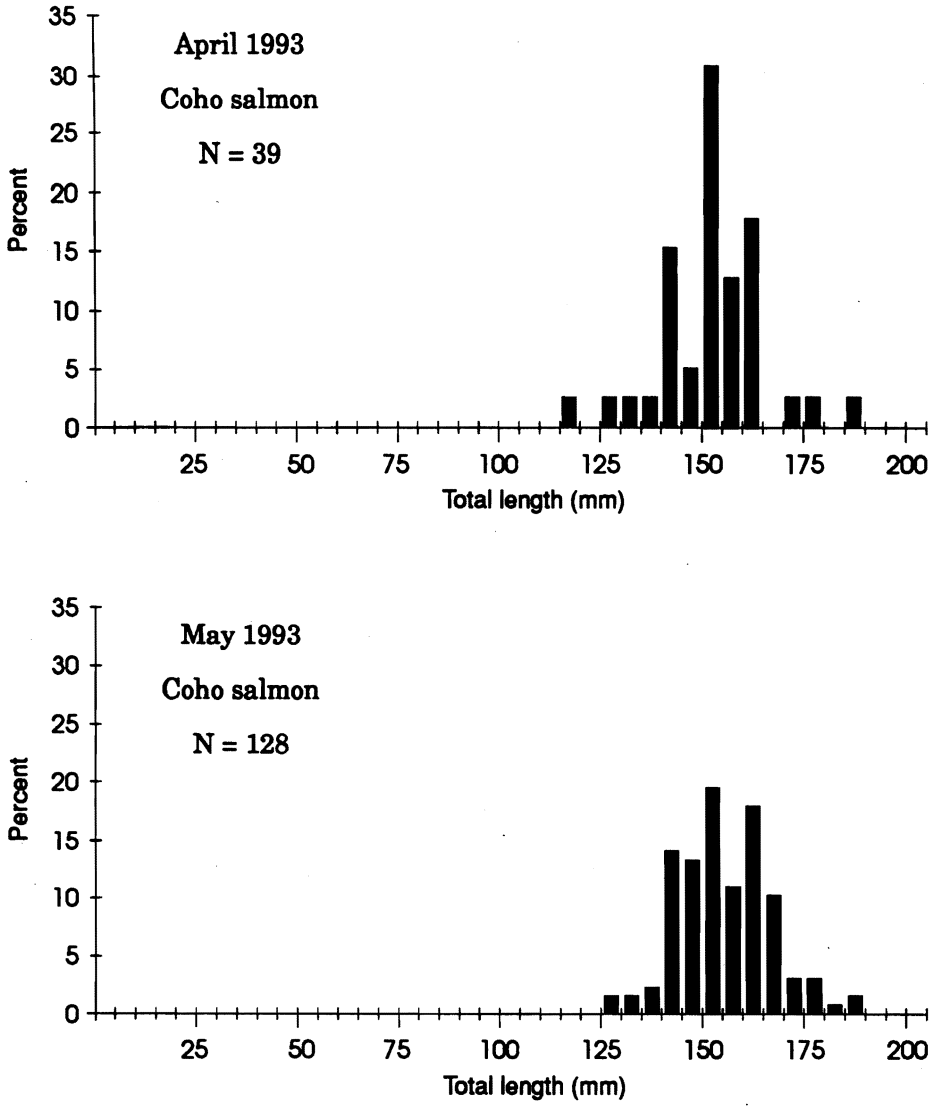

Figure 6.--Length frequency distributions of coho salmon captured by beach seine in the Columbia River, 1993.

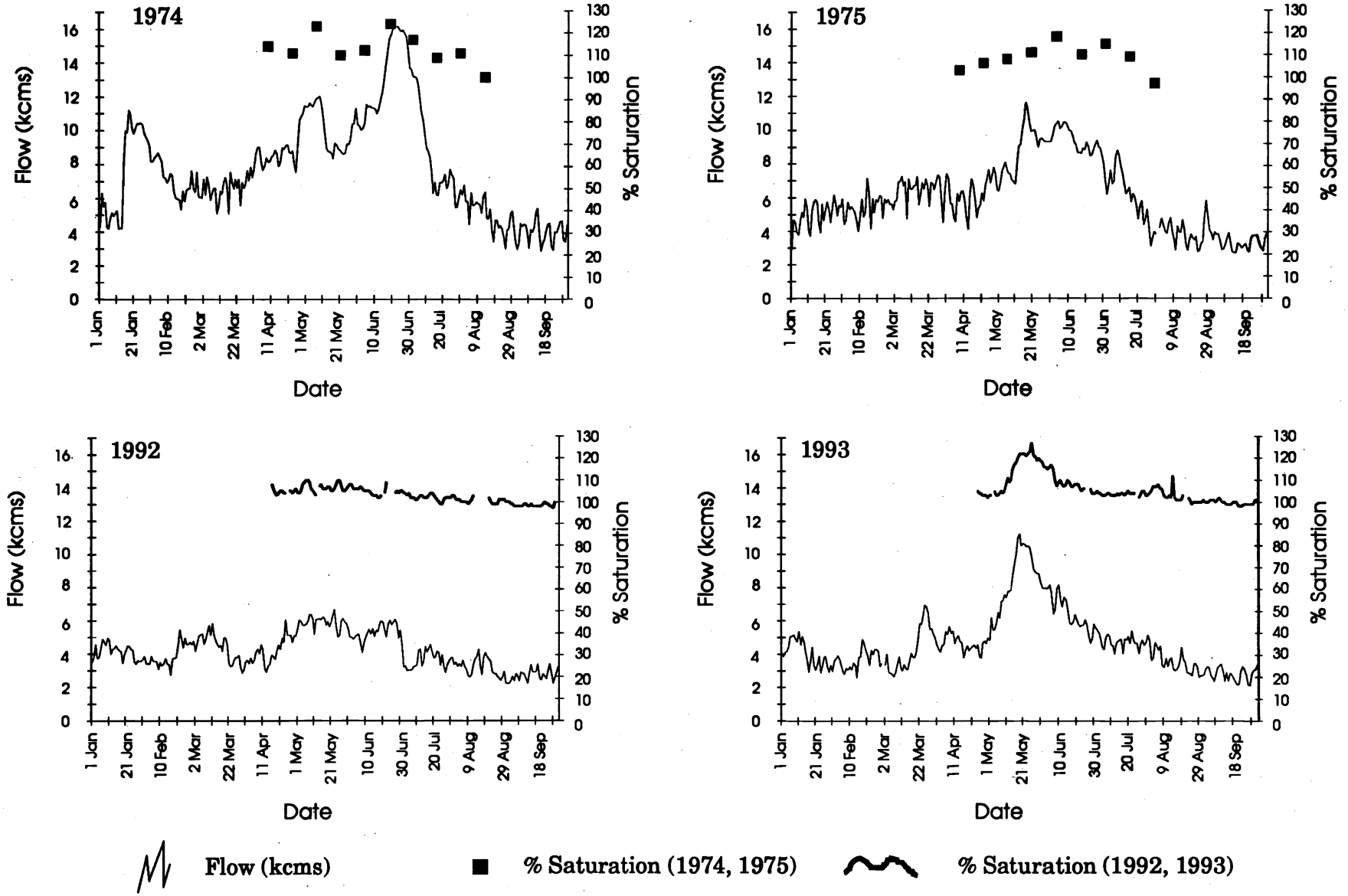

Figure 7.--Average daily spill (kcms) and dissolved gas readings (% saturation) at Bonneville Dam. Saturation values for 1974 and 1975 are single readings; 1992 and 1993 saturation values and flow values for all years are 24-hour means.

migrational period) may have been weakened by the high dissolved gas concentrations and therefore became susceptible to stranding.

Stranding also can occur during low flow years (Earl Dawley, NMFS, Northwest Fisheries Science Center, Seattle, WA pers. commun.). Dawley observed stranding of large numbers of subyearling chinook salmon (approximately 20 to 100 fish) three different times in 1977, after a large vessel passed Jones Beach, Oregon (RKm 75). Dawley also observed about 200 subyearling chinook salmon stranded at one time during a low tide in 1984 at Jones Beach, Oregon. Dawley believes that most of these stranded fish had been recently released from a hatchery and were not physiologically prepared for migration.

Although juvenile salmon can become stranded on beaches along the lower Columbia River, it presently does not appear to be a common event. Apparently, many factors must act simultaneously for stranding to occur. Vessel speed and shape, distance of vessel from beach, tide stage, beach slope, salmon abundance and condition, and river flow conditions, in any combination may have to interact for salmon to become stranded. In 1977, the Washington Department of Fisheries made four recommendations that we believe are generally being followed today.

1) All dredge disposal berms facing the navigation channel shall be contoured with a minimum 9% gradient immediately after disposal.
2) 1 March to 30 June - All deep draft ships shall travel less than 26 km/h from RKm 33.7 to RKm 162.5.
3) 1 July to 31 July - All deep draft ships shall travel less than 26 km/h from RKm 33.6 to RKm 109.4 from 10 p.m. through 6 a.m. each day.
4) 1 March to 31 July - If Columbia River stage continually ranges above 2.1 m as measured at the Rainier, Oregon gauge, the above recommendations would not apply.

Though stranding is presently not a serious problem on the lower Columbia River, fishery resource agencies should occasionally survey lower Columbia River beaches during the peak juvenile salmon migration to insure that vessels are complying with the above guidelines and salmon are not stranded.

ACKNOWLEDGMENTS

We thank Sheila Turner, Beverly Heskiss, Margaret Toner, and George McCabe, Jr., for their assistance in data collections, and the Columbia River Bar Pilots Association for providing vessel identifications and schedules. Funding for this study was provided by the NMFS-COE Habitat Restoration Program.

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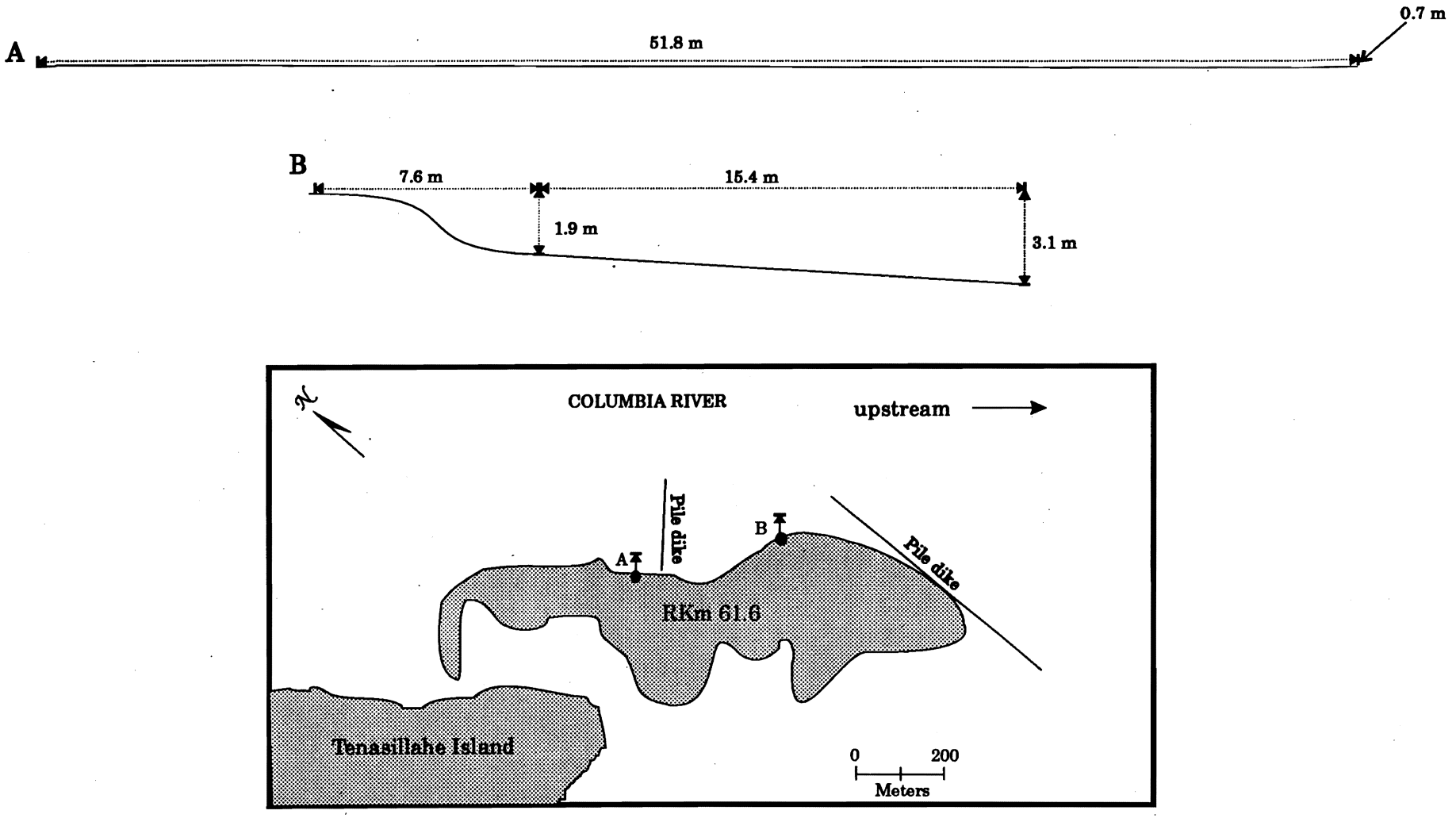
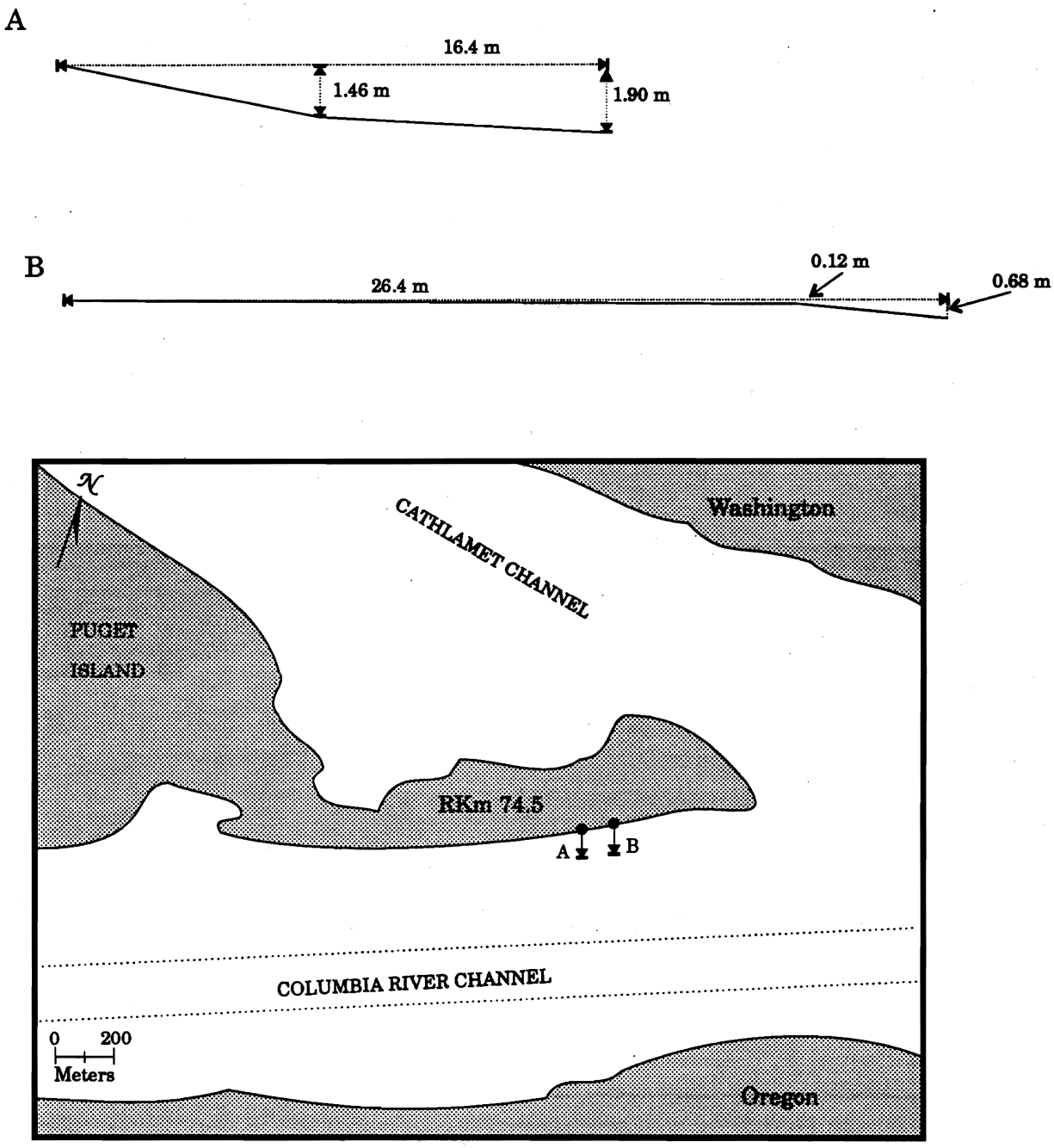
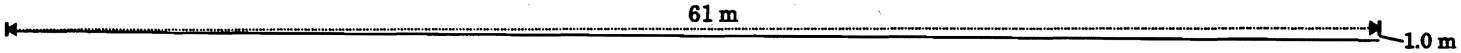
APPENDIX FIGURES

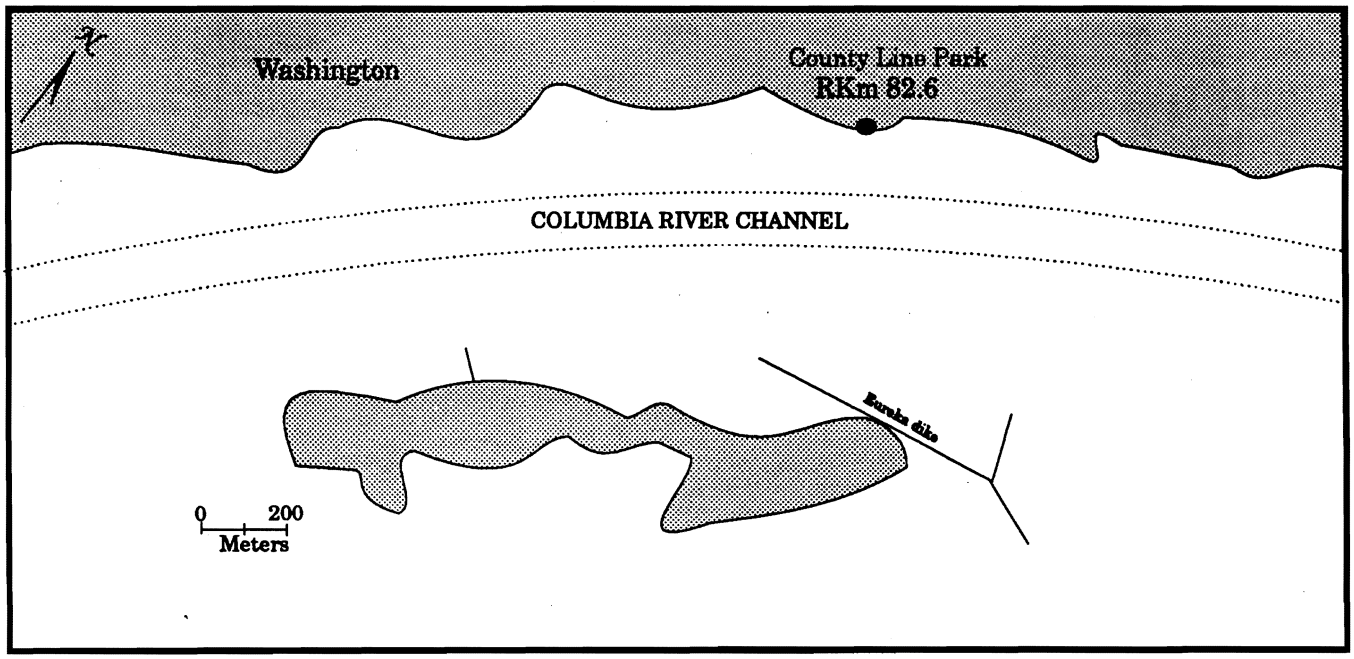


Appendix Figure 1.--General topography of the area at RKm 61.6 (Tenasillahe Island), Columbia River, selected for observation during the juvenile salmonid stranding survey, 1992 and 1993.

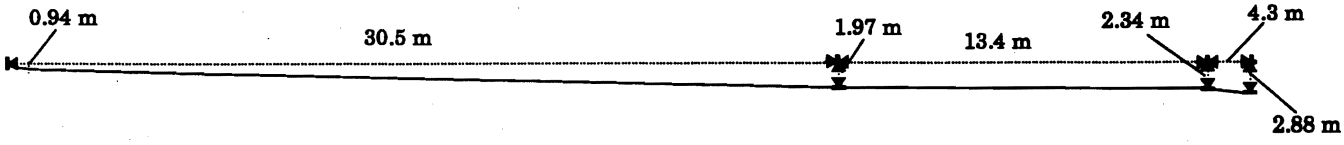


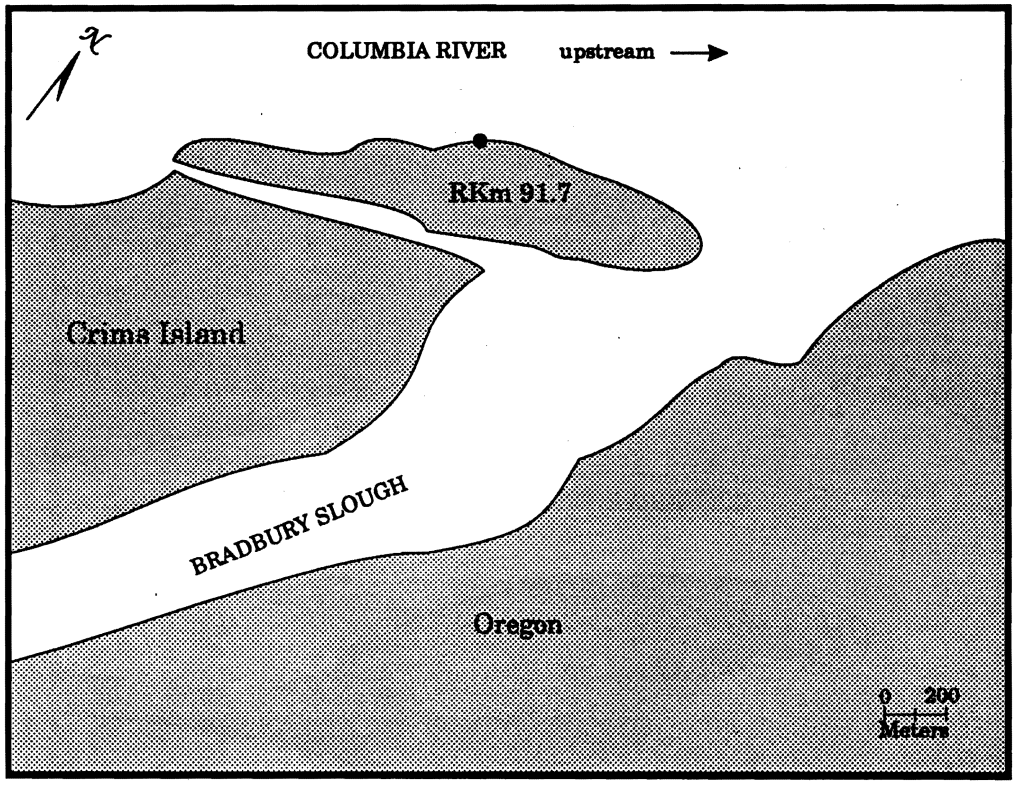
Appendix Figure 2.--General topography of the area at RKm 74.5 (Puget Island), Columbia River, selected for observation during the juvenile salmonid stranding survey, 1992 and 1993.



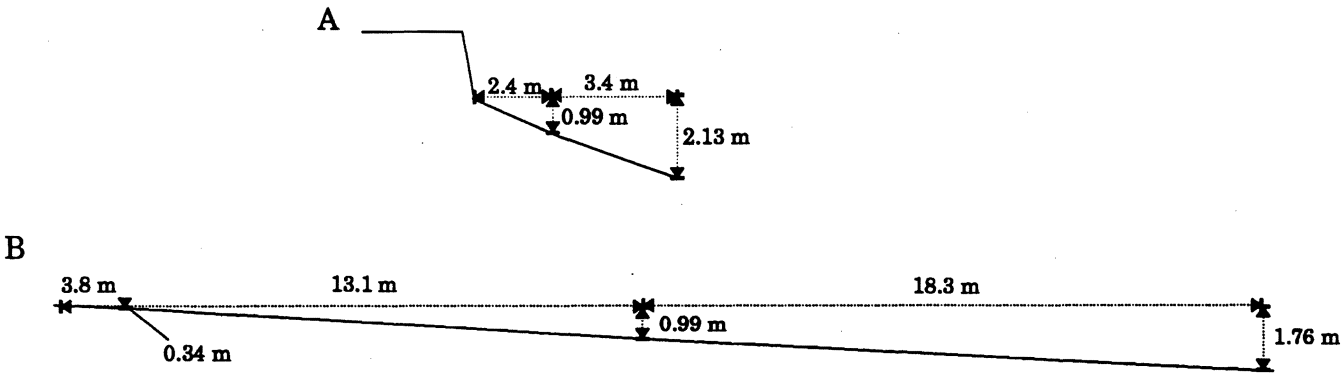


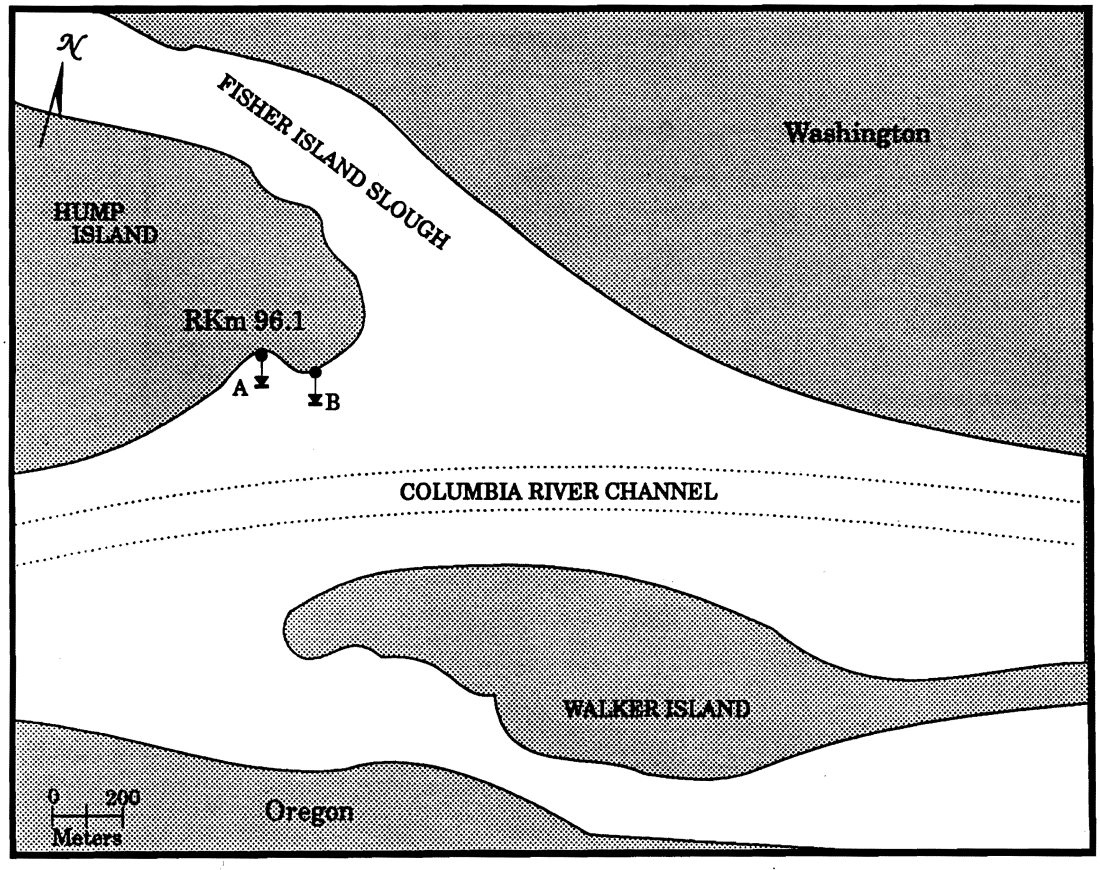
Appendix Figure 3.--General topography of the area at RKm 82.6 (County Line Park), Columbia River, selected for observation during the juvenile salmonid stranding survey, 1992 and 1993.



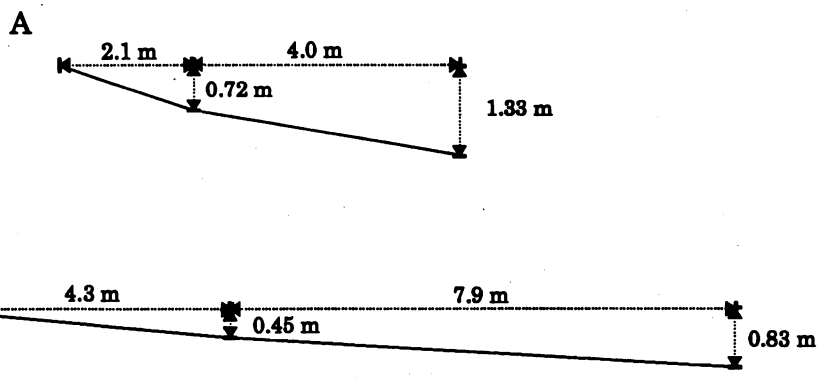


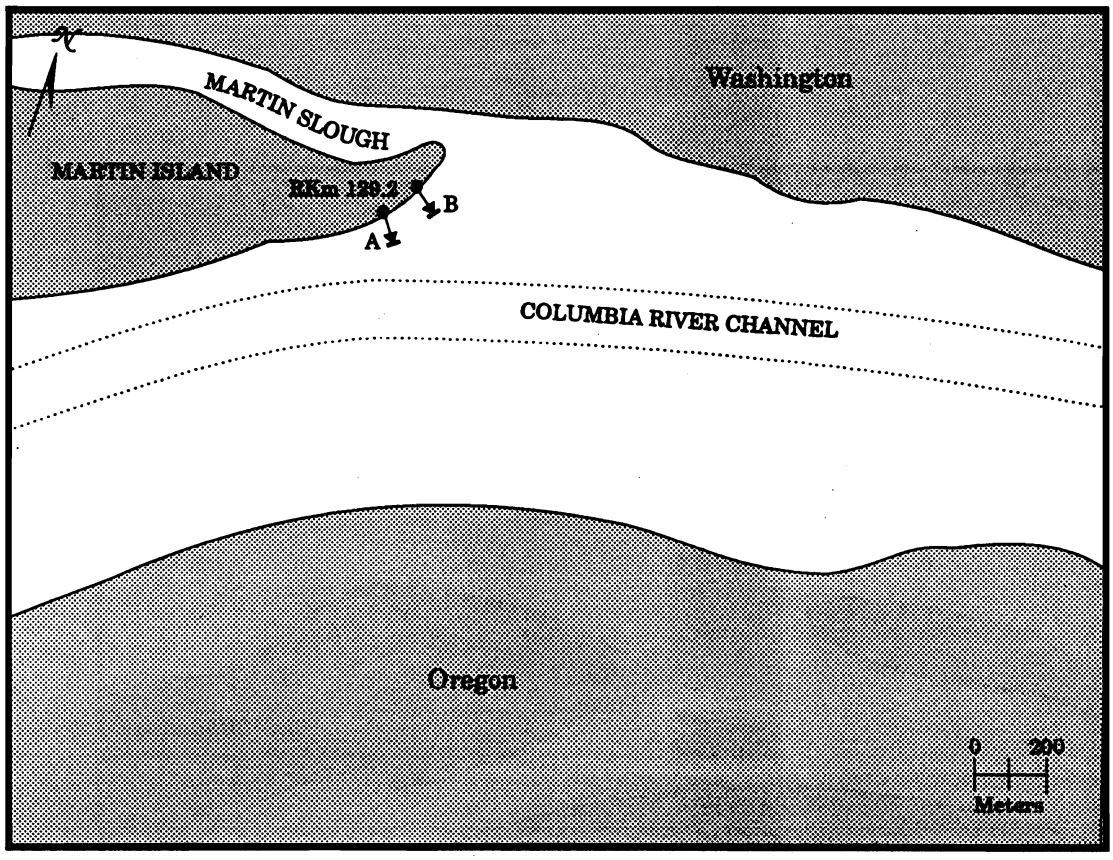
Appendix Figure 4.--General topography of the area at RKm 91.7 (Hoagy's Bar), Columbia River, selected for observation during the juvenile salmonid stranding survey, 1992 and 1993.



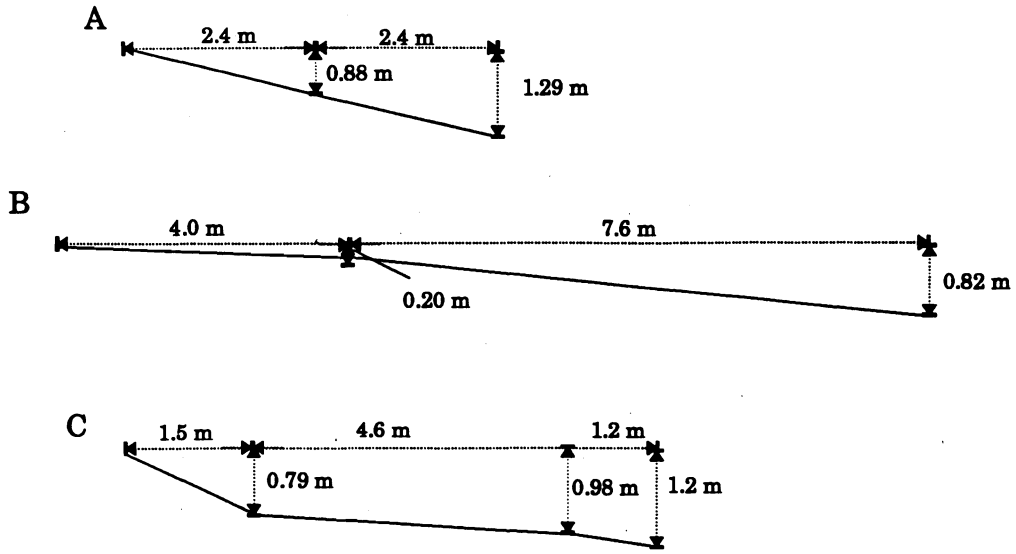


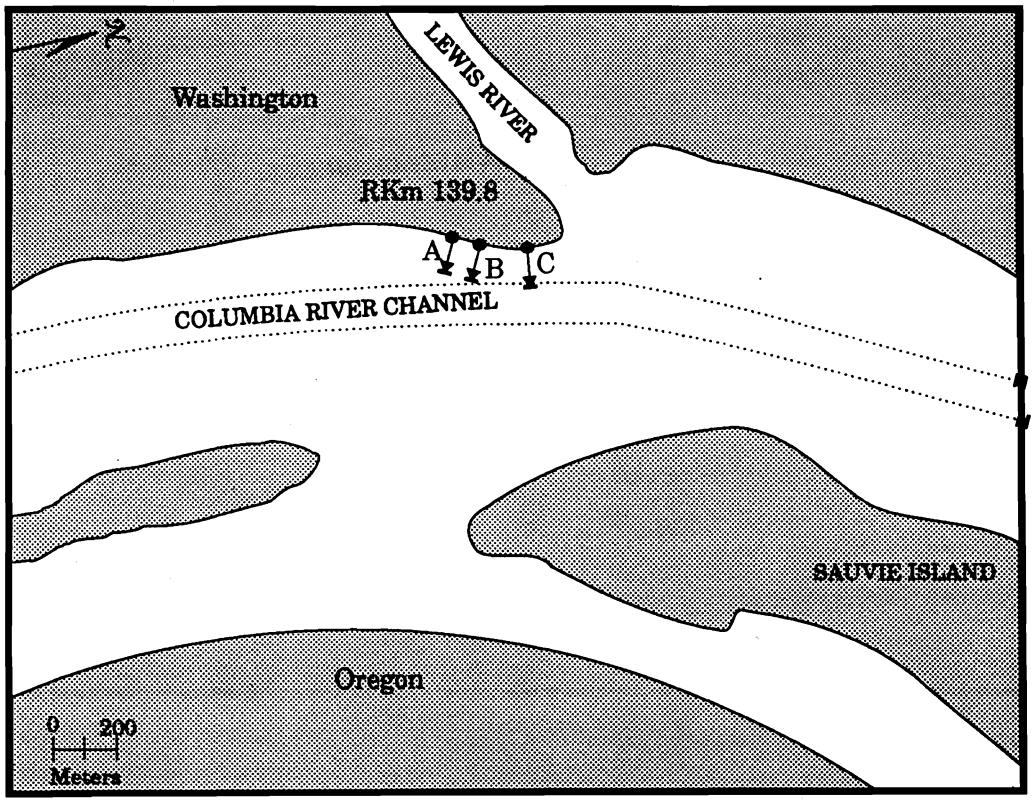
Appendix Figure 5.--General topography of the area at RKm 96.1 (Hump Island), Columbia River, selected for observation during the juvenile salmonid stranding survey, 1992 and 1993.



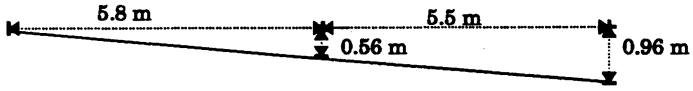


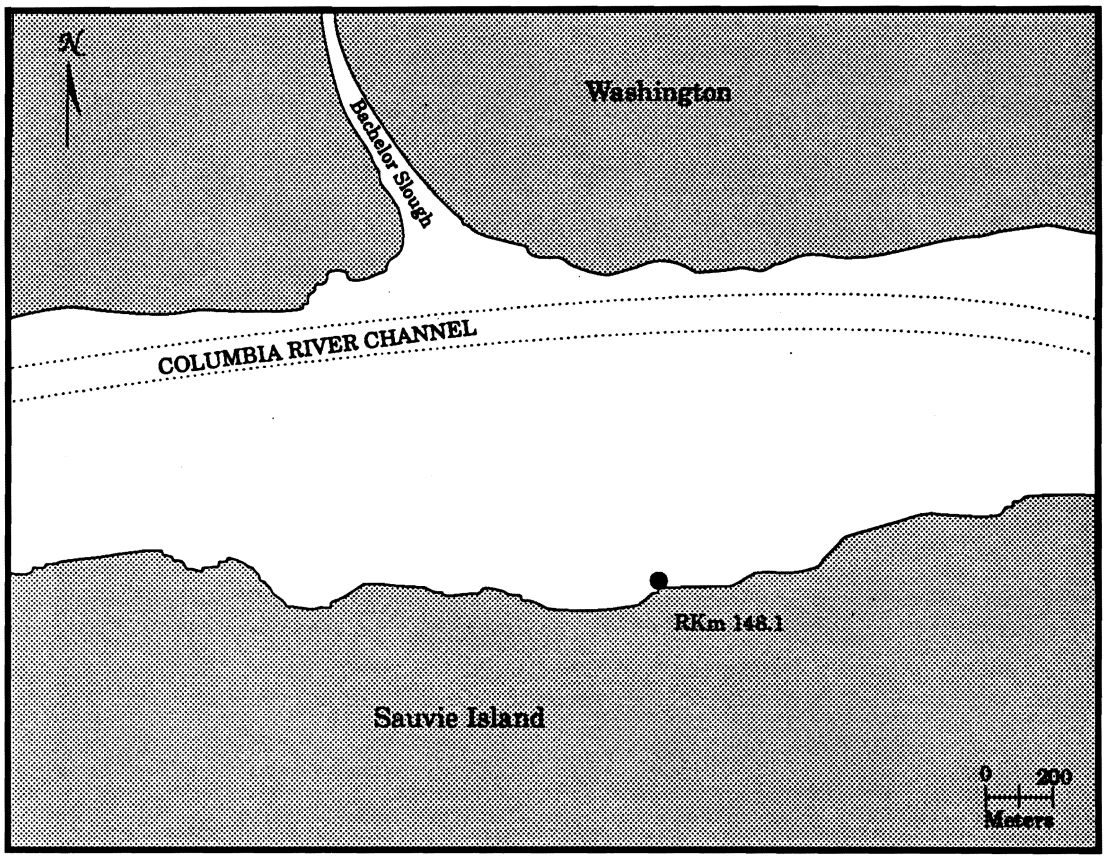
Appendix Figure 6.--General topography of the area at RKm 129.2 (Martin Island), Columbia River, selected for observation during the juvenile salmonid stranding survey, 1992 and 1993.





Appendix Figure 7.--General topography of the area at RKm 139.8 (Austin Point), Columbia River, selected for observation during the juvenile salmonid stranding survey, 1992 and 1993.





Appendix Figure 8.--General topography of the area at RKm 148.1 (Sauvie Island), Columbia River, selected for observation during the juvenile salmonid stranding survey, 1992 and 1993.

APPENDIX TABLES

Appendix Table 1.--Summary of vessels and their characteristics, observed during the juvenile salmonid stranding survey, April-September 1992 and March-July 1993.

DATE ddmmyy	LOCATION	RIVER Km	RIVER MILE	TIME	TIDE STAGE	SHIP NAME	SHIP TYPE	DIRECTION	EST. SPEED Km/h	SURGE HT. (m)	WAVE HT. (m)	STERN	STRANDING
040692	Tenasillahae Island	61.6	38.3	1420	flood	CONVEYOR	reg. freighter	down	22-26	0.25-0.50	0.5-1.0		
	Tenasillahae Island	61.6	38.3	1505	flood	HANDY ACCORD	log freighter	up	22-26	0.25-0.50	0.5-1.0		
080692	Sauvie Island	148.1	91.6	1229	unknown	CENTURY HIGHWAY 1	car ship	up	22-26	0.25-0.50	0.5-1.0		
	Sauvie Island	148.1	91.6	1233	unknown	USS LOCKWOOD	Navy	down	>26	<0.25	1.0-1.5	in	
	Sauvie Island	148.1	91.6	1240	unknown	USS JOUETT	Navy	down	>26	0.25-0.50	0.5-1.0	in	
	Sauvie Island	148.1	91.6	1300	unknown	USS HARRY W. HILL	Navy	down	>26	0.25-0.50	0.5-1.0	in	
	Sauvie Island	148.1	91.6	1400	unknown	OVERSEAS PHILADELPHIA	oil tanker	down	>22	<0.25	<0.50	out	
090692	Hoagy's Bar	91.7	57.0	1040	high slack	PESTOVO	reg. freighter	up	22-26	<0.25	0.5-1.0		
	Hump Island	96.1	59.7	1100	high slack	PESTOVO	reg. freighter	up	22-26	<0.25	0.5-1.0		
	Hump Island	96.1	59.7	1236	early ebb	DON CARLOS	reg. freighter	up	22-26	0.25-0.50	0.5-1.0		
	Hump Island	96.1	59.7	1400	ebb	LION OF CALIFORNIA	oil tanker	up	22-26	0.25-0.50	0.5-1.0	in	
	Hump Island	96.1	59.7	1415	ebb	USS MORGANTHAL	Coast Guard	down	>26	<0.25	0.5-1.0	in	
	Hump Island	96.1	59.7	1430	ebb	PACMERCHANT	reg. freighter	up	22-26	<0.25	0.5-1.0		
110692	Austin Point	139.8	86.9	1440	flood	CORNICOPIA	oil tanker	up	22-26	<0.25	1.0-1.5		
	Austin Point	139.8	86.9	1600	flood	QUEEN ACE	car ship	down	22-26	0.5-1.0	0.5-1.0		
	Austin Point	139.8	86.9	1626	late flood	COAST RANGE	oil tanker	down	22-26	<0.25	<0.50	out	
160692	Puget Island	74.5	46.3	1700	high slack	AMISTAD	reg. freighter	up	>26	<0.25	1.0-1.5	out	
	Puget Island	74.5	46.3	1745	early ebb	OCEAN CROWN	grain ship	down	22-26	none	<0.50	in	
	Puget Island	74.5	46.3	2045	ebb	FAREAST VANGARD	reg. freighter	up	>26	none	<0.50	out	
	Puget Island	74.5	46.3	2120	late ebb	VERNER	reg. freighter	down	22-26	none	<0.50	in	
170692	County Line Park	82.6	51.3	1715	high slack	OCEAN LILY	log freighter	down	22-26	<0.25	0.5-1.0	in	
	County Line Park	82.6	51.3	1830	early ebb	SEA LANTERN	log freighter	down	22-26	<0.25	0.5-1.0	in	
	County Line Park	82.6	51.3	2100	ebb	PAN QUEEN	reg. freighter	down	22-26	<0.25	<0.50	in	
	County Line Park	82.6	51.3	2115	ebb	PACIFIC HOPE	reg. freighter	up	22-26	<0.25	<0.50	out	
	County Line Park	82.6	51.3	2210	late ebb	OCEAN BEAUTY	reg. freighter	down	>26	0.25-0.50	0.5-1.0	in	
240692	Tenasillahae Island	61.6	38.3	1130	high slack	PAC NOBLE	reg. freighter	up	22-26	none	0.5-1.0	out	
	Tenasillahae Island	61.6	38.3	1330	ebb	STAR GRINDANGER	container	up	22-26	0.25-0.50	0.5-1.0	in	
	Tenasillahae Island	61.6	38.3	1445	late ebb	CORNICOPIA	oil tanker	down	>26	0.5-1.0	0.5-1.0	in	
	Tenasillahae Island	61.6	38.3	1615	low slack	HANEI STAR	reg. freighter	down	22-26	0.25-0.50	<0.50	in	
	Tenasillahae Island	61.6	38.3	1645	low slack	DEISHO MARU	grain ship	up	>26	0.5-1.0	0.5-1.0	in	
	Tenasillahae Island	61.6	38.3	1730	early flood	SOUTHERN CROSS 1	grain ship	down	22-26	<0.25	none	in	
060792	Martin Island	129.2	80.3	1630	low slack	BELFOREST	container	up	>26	0.5-1.0	0.5-1.0	out	
	Martin Island	129.2	80.3	1700	low slack	HARBOUR BR	container	down	>22	0.5-1.0	<0.50	in	
	Martin Island	129.2	80.3	1859	early flood	EVERGATHER	container	down	>26	>1.0	0.5-1.0	in	
080792	Sauvie Island	148.1	91.6	1624	late ebb	FAYROUZ IV	reg. freighter	down	>26	<0.25	<0.50	in	
	Sauvie Island	148.1	91.6	1900	low slack	KOREAN TPZ	reg. freighter	down	>22	0.25-0.50	0.5-1.0	in	

Appendix Table 1.--Continued.

DATE ddmmyy	LOCATION	RIVER Km	RIVER MILE	TIME	TIDE STAGE	SHIP NAME	SHIP TYPE	DIRECTION	EST. SPEED Km/h	SURGE HT. (m)	WAVE HT. (m)	STERN	STRANDING
	Sauvie Island	148.1	91.6	2120	flood	STAR MASS.	oil tanker	up	>26	>1.0	1.0-1.5	in	YES
090792	Puget Island	74.5	46.3	1943	flood	ALDEN CLSN	oil tanker	down	22-26	<0.25	<0.50	out	
	Puget Island	74.5	46.3	2045	flood	STAR DAVANGER	container	up	22-26	<0.25	<0.50	out	
160792	County Line Park	82.6	51.3	1930	early ebb	CHEVERON O	oil tanker	up	22-26	<0.25	0.5-1.0	in	
	County Line Park	82.6	51.3	1945	early ebb	PHILA. SUN	oil tanker	up	22-26	<0.25	0.5-1.0	out	
	County Line Park	82.6	51.3	2245	late ebb	OCEAN NOBE	reg. freighter	up	22-26	<0.25	<0.50	out	
230792	Hoagy's Bar	91.7	57.0	1715	early flood	NADA II	car ship	down	22-26	0.25-0.50	1.0-1.5	in	
	Hump Island	96.1	59.7	1923	flood	TOKYO HIWY	car ship	up	22-26	0.5-1.0	0.5-1.0	in	
	Hump Island	96.1	59.7	2015	late flood	NEPTUNE GT	container	up	>26	>1.0	1.0-1.5	in	
180892	Puget Island	74.5	46.3	2006	early ebb	SANKO SPLENDOR	reg. freighter	up	22-26	<0.25	<0.50	out	
	Puget Island	74.5	46.3	2230	late ebb	LOUISIANNA MAMA	reg. freighter	up	>22	<0.25	<0.50	in	
190892	Hoagy's Bar	91.7	57.0	2300	late ebb	CALIFORNIA LUNA		up	22-26	<0.25	0.5-1.0	in	
210892	County Line Park	82.6	51.3	0930	early ebb	MAERSK SUN	car ship	up	>26	0.25-0.50	1.0-1.5	in	
	County Line Park	82.6	51.3	1045	ebb	SKAUBRYN	car ship	up	>22	0.25-0.50	1.0-1.5	in	
	County Line Park	82.6	51.3	1315	late ebb	CAPE BLANCO	reg. freighter	down	22-26	<0.25	<0.50	out	
	County Line Park	82.6	51.3	1335	late ebb	SHARPNES	reg. freighter	up	22-26	<0.25	<0.50	out	
240892	Tenasillahae Island	61.6	38.3	1015	late flood	HUNDIA 108	car ship	up	22-26	0.25-0.50	0.5-1.0	in	
	Tenasillahae Island	61.6	38.3	1100	late flood	TOYOFUGI 10	car ship	up	22-26	0.25-0.50	0.5-1.0	in	
	Puget Island	74.5	46.3	1200	high slack	HELIOPOLIS	grain ship	down	22-26	<0.25	<0.50	in	
250892	Martin Island	129.2	80.3	1400	late flood	PACKING	grain ship	down	22-26	0.25-0.50	0.5-1.0	out	
	Austin Point	139.8	86.9	1437	high slack	TOYOFUJI 10	car ship	down	>26	0.25-0.50	0.5-1.0	out	
	Sauvie Island	148.1	92.0	1530	early ebb	HUNDAI 108	car ship	down	>26	0.25-0.50	0.5-1.0	out	
280892	Puget Island	74.5	46.3	1110	low slack	PACKING		down	>26	<0.25	0.5-1.0	out	
	Puget Island	74.5	46.3	1125	early flood	ARCO ANCHORAGE	oil tanker	down	>26	0.25-0.50	0.5-1.0	out	
	County Line Park	82.6	51.3	1240	flood	POMOTOKRATIC	grain ship	down	22-26	<0.25	<0.50	in	
	Hoagy's Bar	91.7	57.0	1320	late flood	MA-GAUN-HAI	grain ship	down	22-26	<0.25	<0.50	in	
	County Line Park	82.6	51.3	1400	late flood	MA-GAUN-HAI	grain ship	down	22-26	<0.25	0.5-1.0	in	
	Austin Point	139.8	86.9	1300	late ebb	COASTAL NEW YORK	oil tanker	down	22-26	0.5-1.0	1.0-1.5	out	
	Austin Point	139.8	86.9	1445	early flood	STAR DIEPPE	grain ship	up	22-26	0.25-0.50	0.5-1.0	in	
	Austin Point	139.8	86.9	1500	early flood	ASTART	grain ship	up	22-26	0.25-0.50	0.5-1.0	out	
170892	Tenasillahae Island	61.6	38.3	1030	ebb	STAR MASS.	oil tanker	up	22-26	<0.25	<0.50	in	
	Tenasillahae Island	61.6	38.3	1145	late ebb	PAC MERCHANT	grain ship	up	22-26	0.5-1.0	0.5-1.0	out	
	Tenasillahae Island	61.6	38.3	1305	low slack	NEPTUNE JADE	reg. freighter	up	>26	0.25-0.50	1.0-1.5	in	
	Tenasillahae Island	61.6	38.3	1310	low slack	TAL	grain ship	up	>26	<0.25	<0.50	out	
180892	Puget Island	74.5	46.3	0940	ebb	CENTURY HIGHWAY 1	reg. freighter	up	>26	0.25-0.50	1.0-1.5	out	
	Puget Island	74.5	46.3	1040	ebb	CORNUCOPIA	grain ship	down	>26	<0.25	1.0-1.5	in	
	Puget Island	74.5	46.3	1130	ebb	YEON EUN	grain ship	down	22-26	none	none	in	
	Puget Island	74.5	46.3	1223	late ebb	SALAVAT	grain ship	up	22-26	<0.25	0.5-1.0	out	

Appendix Table 1.--Continued.

DATE ddmmyy	LOCATION	RIVER Km	RIVER MILE	TIME	TIDE STAGE	SHIP NAME	SHIP TYPE	DIRECTION	EST. SPEED Km/h	SURGE HT. (m)	WAVE HT. (m)	STERN	STRANDING
230393	Tenasillahe Island	61.6	38.3	1020	flood	CENTURY HIGHWAY 5	car ship	up	22-26	<0.25	0.5-1.0		
	Tenasillahe Island	61.6	38.3	1345	high slack	PINE BEAUTY	reg. freighter	up	>26	<0.25	0.5-1.0	out	
	Tenasillahe Island	61.6	38.3	1520	high slack	HYUNDAI LEADER	reg. freighter	up	>26	0.5-1.0	0.5-1.0	out	
240393	Puget Island	74.5	46.3	1130	late ebb	CONTINENTAL WING	car ship	up	>22	<0.25	<0.50	out	
	Puget Island	74.5	46.3	1409	flood	JUFU	log freighter	down	22-26	none	<0.50	out	
	Puget Island	74.5	46.3	1450	high slack	DRAGON PROSPRTY	reg. freighter	up	22-26	0.25-0.50	0.5-1.0	out	
	Puget Island	74.5	46.3	1630	high slack	EMERALD SEA	log freighter	up	>22	<0.25	<0.50	out	
250393	County Line Park	82.6	51.3	1000	late ebb	SAGA OCEAN	container	up	22-26	0.25-0.50	0.5-1.0	in	
	County Line Park	82.6	51.3	1030	late ebb	WASH. RAINBOW	reg. freighter	up	22-26	<0.25	<0.50	out	
	County Line Park	82.6	51.3	1400	late flood	NEPTUNE GARNET	container	up	>22	<0.25	<0.50	out	
260393	Hoagy's Bar	91.7	57.0	0930	early ebb	HONEUTSU VENTURE	reg. freighter	up	>22	<0.25	<0.50	out	
	Hoagy's Bar	91.7	57.0	1118	ebb	FORUM WIND	log freighter	up	>22	<0.25	<0.50	out	
	Hoagy's Bar	91.7	57.0	1200	ebb	PHILADELPHIA SUN	reg. freighter	up	22-26	<0.25	<0.50	in	
	Hoagy's Bar	91.7	57.0	1230	ebb	OCEAN HIGHWAY	car ship	up	22-26	<0.25	<0.50	in	
	Hoagy's Bar	91.7	57.0	1250	ebb	ANNA	grain ship	up	22-26	<0.25	<0.50	out	
130493	Hump Island	96.1	59.7	1300	late ebb	CENTURY LEADER 3	car ship	up	>22	<0.25	<0.50	in	YES
140493	Tenasillahe Island	61.6	38.3	1100	ebb	IWANAMU MARU	container	down	22-26	<0.25	<0.50	in	
	Tenasillahe Island	61.6	38.3	1130	ebb	CALIFORNIA HERMES	container	up	22-26	0.25-0.50	0.5-1.0	in	
	Tenasillahe Island	61.6	38.3	1330	late ebb	ANSAC PROSPERITY	grain ship	down	>26	<0.25	<0.50	in	
150493	Martin Island	129.2	80.3	1430	ebb	CENTURY LEADER 3	car ship	down	>26	<0.25	<0.50	in	
	Martin Island	129.2	80.3	1619	ebb	MARINA ACE	car ship	down	>26	0.5-1.0	0.5-1.0	in	YES
	Martin Island	129.2	80.3	1630	late ebb	COAST RANGE	oil tanker	up	22-26	0.5-1.0	0.5-1.0	in	
	Martin Island	129.2	80.3	1700	late ebb	GOLDEN FARMER	reg. freighter	up	22-26	0.25-0.50	0.5-1.0	out	
160493	Austin Point	139.8	86.9	1518	late ebb	SUIJIN	car ship	down	22-26	<0.25	<0.50	out	
230493	Sauvie Island	148.1	91.6	0835	early ebb	CALIFORNIA LUNA	container	up	22-26	<0.25	0.5-1.0	in	YES
	Sauvie Island	148.1	91.6	0943	early ebb	SEA CATTEYA	reg. freighter	up	22-26	<0.25	<0.50	in	
270493	Sauvie Island	148.1	91.6	1310	early ebb	KEYSTONER	oil tanker	down	22-26	<0.25	<0.50	out	
	Sauvie Island	148.1	91.6	1400	ebb	OCEAN HIGHWAY	car ship	down	>26	0.25-0.50	0.5-1.0	in	
280493	County Line Park	82.6	51.3	1115	ebb	CONTINENTAL WING	car ship	up	>22	<0.25	<0.50	in	
	County Line Park	82.6	51.3	1315	late ebb	STELLAR BENY	log freighter	up	>22	<0.25	0.5-1.0	in	
290493	Puget Island	74.5	46.3	1235	late ebb	EVERGATHER	container	down	22-26	<0.25	0.5-1.0	in	
	Puget Island	74.5	46.3	1245	late ebb	PRAVDISNK	reg. freighter	up	22-26	<0.25	<0.50	out	
	Puget Island	74.5	46.3	1300	late ebb	USNS MERCURY	reg. freighter	down	>26	<0.25	0.5-1.0	out	
	Puget Island	74.5	46.3	1500	low slack	SEVASTOPOL	grain ship	up	>22	<0.25	0.5-1.0	out	
	Puget Island	74.5	46.3	1510	low slack	OREGON RAINBOW II	grain ship	down	>26	<0.25	<0.50	in	
	Puget Island	74.5	46.3	1538	low slack	AMISTAD	log freighter	down				in	

Appendix Table 1.--Continued.

DATE ddmmyy	LOCATION	RIVER Km	RIVER MILE	TIME	TIDE STAGE	SHIP NAME	SHIP TYPE	DIRECTION	EST. SPEED Km/h	SURGE HT. (m)	WAVE HT. (m)	STERN	STRANDING
300493	Hump Island	96.1	59.7	1418	ebb	PRINCESS BETTY	reg. freighter	up	22-26	0.25-0.50	0.5-1.0	out	
	Hump Island	96.1	59.7	1500	ebb	CENTURY HIGHWAY 5	car ship	up	>22	<0.25	<0.50	in	
	Hump Island	96.1	59.7	1542	late ebb	ATLANTIC SAPPHIRE	reg. freighter	up	22-26	0.25-0.50	<0.50	out	
	Hump Island	96.1	59.7	1605	low slack	SPRAYNES	reg. freighter	down	>26	0.5-1.0	0.5-1.0	in	
060593	Austin Point	139.8	86.9	1242	early ebb	CONSTITUTION	cruise ship	up	>22	0.25-0.50	0.5-1.0	in	
	Austin Point	139.8	86.9	1400	ebb	MAERSK SKY	car ship	up	>22	0.25-0.50	0.5-1.0	in	
	Austin Point	139.8	86.9	1530	ebb	MERCHANT PREMIER	container	up	>22	0.25-0.50	0.5-1.0	out	
070593	Hoagy's Bar	91.7	57.0	1145	late ebb	MERCHANT PREMIER	container	down	>26	<0.25	0.5-1.0	out	
	Hoagy's Bar	91.7	57.0	1255	late ebb	HATAKAZE	oil tanker	up	22-26	<0.25	<0.50	in	
	Hoagy's Bar	91.7	57.0	1411	late ebb	BORZESTI	oil tanker	up	>22	<0.25	<0.50	out	
120593	Martin Island	129.2	80.3	1600	early ebb	SAMICK PACIFIC	reg. freighter	down	>26	0.5-1.0	1.0-1.5	in	
	Martin Island	129.2	80.3	1700	early ebb	STAR RHODE ISLAND	oil tanker	up	>26	0.25-0.50	0.5-1.0	in	
	Martin Island	129.2	80.3	1730	early ebb	ETERNAL ACE	car ship	up	>26	0.25-0.50	0.5-1.0	out	
140593	Tenasillahe Island	61.6	38.3	1100	high slack	CALIFORNIA SATURN	container	down	>22	<0.25	<0.50	out	
180593	Puget Island	74.5	46.3	1130	flood	CLIPPER AMARYLLIS	reg. freighter	up	22-26	<0.25	<0.50	out	
	Puget Island	74.5	46.3	1250	late flood	WESTWOOD ANNTTE	container	up	22-26	0.25-0.50	0.5-1.0	in	YES
	Puget Island	74.5	46.3	1605	early ebb	HYUNDAI 109	car ship	up	22-26	<0.25	1.0-1.5	in	
020693	Hoagy's Bar	91.7	57.0	1630	high slack	MILKY WAY	grain ship	down	>26	<0.25	<0.50	in	
	Hoagy's Bar	91.7	57.0	1840	early ebb	RHEA	reg. freighter	down	>26	<0.25	0.5-1.0	in	
	Hoagy's Bar	91.7	57.0	2027	ebb	SILS	reg. freighter	down	>26	<0.25	<0.50	in	
090693	Puget Island	74.5	46.3	0940	ebb	BRAVE VENTURE	reg. freighter	down	>22	0.25-0.50	0.5-1.0	in	
	Puget Island	74.5	46.3	1030	late ebb	STAR DRIVANGER	reg. freighter	down	>26	<0.25	<0.50	out	
	Hoagy's Bar	91.7	57.0	1745	late flood	MANILA FELIZ	log freighter	down	>26	<0.25	<0.50	in	
	Hump Island	96.1	59.7	1920	high slack	NORTHERN DAWN	reg. freighter	down	>26	<0.25	0.5-1.0	in	
	Hump Island	96.1	59.7	1924	high slack	CALIFORNIA ZEUS	container	up	>22	<0.25	0.5-1.0	in	
	Hump Island	96.1	59.7	2006	early ebb	OCEAN BEAUTY	reg. freighter	down	>26	<0.25	1.0-1.5	out	
	Hump Island	96.1	59.7	2017	early ebb	PAN HOPE	reg. freighter	down	22-26	0.25-0.50	0.5-1.0	in	
100693	Austin Point	139.8	86.9	1515	ebb	CONTINENTAL WING	car ship	up	>22	<0.25	<0.50	in	
180693	Sauvie Island	148.1	91.6	1501	early flood	HYUNDAI 107	car ship	up	>22	0.25-0.50	<0.50	in	
240693	Tenasillahe Island	61.6	38.3	1330	late flood	NYK SURFWIND	container	up	>22	0.5-1.0	<0.50	in	
250693	County Line Park	82.6	51.3	0937	early ebb	PROMINA	reg. freighter	up	22-26	0.25-0.50	0.5-1.0	out	
	County Line Park	82.6	51.3	1050	ebb	CENTURY HIGHWAY 5	car ship	up	22-26	0.25-0.50	1.0-1.5	in	
290693	Martin Island	129.2	80.3	1600	early ebb	MAERSK SUN	car ship	down	>26	0.5-1.0	1.0-1.5	in	
020793	Hoagy's Bar	91.7	57.0	1315	late flood	HANOI SUN	car ship	up	22-26	<0.25	<0.50	out	
	Hoagy's Bar	91.7	57.0	1320	late flood	ATLANTIC	car ship	up	22-26	<0.25	<0.50	in	

Appendix Table 2.--Fish taxa captured by beach seine at potential juvenile salmonid stranding beaches along the Columbia River, June-September 1992 and March-July 1993.

Common name	Scientific name	1992	1993
Clupeidae			
American shad	*Alosa sapidissima*	x	x
Salmonidae			
Chinook salmon	*Oncorhynchus tshawytscha*	x	x
Coho salmon	*Oncorhynchus kisutch*	x	x
Rainbow trout (steelhead)	*Oncorhynchus mykiss*		x
Cutthroat trout	*Oncorhynchus clarki*		x
Cyprinidae			
Northern squawfish	*Ptychocheilus oregonensis*		x
Peamouth	*Mylocheilus caurinus*	x	x
Catostomidae			
Largescale sucker	*Catostomus macrocheilus*	x	x
Cyprinodontidae			
Banded killifish	*Fundulus diaphanus*	x	x
Gasterosteidae			
Threespine stickleback	*Gasterosteus aculeatus*	x	x
Percidae			
Yellow perch	*Perca flavescens*		x
Cottidae			
Prickly sculpin	*Cottus asper*	x	x
Pacific staghorn sculpin	*Leptocottus armatus*		x
Unidentified sculpin	Cottidae		x
Pleuronectidae			
Starry flounder	*Platichthys stellatus*	x	x

Appendix Table 3.--Summaries of individual fishing efforts (by station) conducted during June-September 1992 and March-July 1993 at eight beaches selected as potential stranding sites along the Columbia River. A dash (-) indicates data was not recorded. Diversity (H) and Equitability (E) are also presented for each effort.

Station: RKm 139.8
Gear: 50-m beach seine
Date: 11 Jun 1992
Time: 1233
Tide stage: Late flood
Turbidity: - NTU
Temperature: -°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	194	1,176	764	4,630
Coho salmon	12	290	47	1,142
Peamouth	20	597	79	2,350
Starry flounder	1	78	4	307
Threespine stickleback	1	1	4	4
TOTALS	228	2,142	898	8,433

H = 0.80 E = 0.34

Station: RKm 61.6
Gear: 50-m beach seine
Date: 17 Sep 1992
Time: 1105
Tide stage: Low slack
Turbidity: - NTU
Temperature: -°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Peamouth	140	665	551	2,618
Threespine stickleback	212	386	835	1,520
Starry flounder	206	839	811	3,303
American shad	12	15	47	59
Prickly sculpin	1	2	4	8
TOTALS	571	1,907	2,248	7,508

H = 1.69 E = 0.73

Appendix Table 3.--Continued.

Station: RKm 61.6
Gear: 50-m beach seine
Date: 17 Sep 1992
Time: 1455
Tide stage: Late flood
Turbidity: - NTU
Temperature: -°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
American shad	164	1,357	646	5,343
Starry flounder	30	124	118	488
Banded killifish	2	4	8	16
Peamouth	3	16	12	63
Largescale sucker	1	7	4	28
Threespine stickleback	9	19	35	75
TOTALS	209	1,527	823	6,013

H = 1.06 E = 0.41

Station: RKm 74.5
Gear: 50-m beach seine
Date: 18 Sep 1992
Time: 0950
Tide stage: Early ebb
Turbidity: - NTU
Temperature: -°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Starry flounder	6	42	24	165
Peamouth	2	8	8	31
American shad	11	22	43	87
Threespine stickleback	1	2	4	8
TOTALS	20	74	79	291

H = 1.54 E = 0.77

Appendix Table 3.--Continued.

Station: RKm 96.1
Gear: 50-m beach seine
Date: 13 Apr 1993
Time: 1150
Tide stage: Ebb
Turbidity: - NTU
Temperature: -°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	3	-	12	-
Threespine stickleback	7	-	28	-
Prickly sculpin	3	-	12	-
Starry flounder	14	-	55	-
TOTALS	27	-	107	-

H = 1.70 E = 0.85

Station: RKm 61.6
Gear: 50-m beach seine
Date: 14 Apr 1993
Time: 1115
Tide stage: Early ebb
Turbidity: 13.0 NTU
Temperature: 9.5°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	20	-	79	-
Coho salmon	1	-	4	-
Largescale sucker	1	-	4	-
Threespine stickleback	7	-	28	-
Prickly sculpin	2	-	8	-
Pacific staghorn sculpin	2	-	8	-
Starry flounder	35	-	138	-
TOTALS	68	-	269	-

H = 1.83 E = 0.65

Appendix Table 3.--Continued.

Station: RKm 129.2
Gear: 50-m beach seine
Date: 15 Apr 1993
Time: 1200
Tide stage: High slack
Turbidity: 5.5 NTU
Temperature: 9.0°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	8	11	31	43
Coho salmon	1	16	4	63
Threespine stickleback	2	4	8	16
TOTALS	11	31	43	122

H = 1.10 E = 0.69

Station: RKm 139.8
Gear: 50-m beach seine
Date: 16 Apr 1993
Time: 1545
Tide stage: Early ebb
Turbidity: - NTU
Temperature: -°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	171	195	673	768
Coho salmon	1	14	4	55
Banded killifish	1	1	4	4
Threespine stickleback	1	1	4	4
Starry flounder	13	261	51	1,028
TOTALS	187	472	736	1,859

H = 0.51 E = 0.22

Appendix Table 3.--Continued.

Station: RKm 148.1
Gear: 50-m beach seine
Date: 23 Apr 1993
Time: 940
Tide stage: Flood
Turbidity: 7.5 NTU
Temperature: 10.0°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	22	200	87	787
Coho salmon	1	36	4	142
Peamouth	1	5	4	20
Largescale sucker	1	92	4	362
Threespine stickleback	2	3	8	12
TOTALS	27	336	107	1,323

H = 1.05 E = 0.45

Station: RKm 148.1
Gear: 50-m beach seine
Date: 24 Apr 1993
Time: 1430
Tide stage: Late ebb
Turbidity: - NTU
Temperature: 13.7°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	53	353	209	1,390
Coho salmon	3	79	12	311
Rainbow trout (steelhead)	2	148	8	583
Northern squawfish	2	95	8	374
Peamouth	7	488	28	1,921
Largescale sucker	1	1,014	4	3,992
Threespine stickleback	1	2	4	8
Starry flounder	7	149	28	587
TOTALS	76	2,328	301	9,166

H = 1.62 E = 0.54

Appendix Table 3.--Continued.

Station:RKm 82.6
Gear: 50-m beach seine
Date: 28 Apr 1993
Time: 1051
Tide stage: Ebb
Turbidity: - NTU
Temperature: 10.5°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	76	-	299	-
Coho salmon	25	-	98	-
Prickly sculpin	1	-	4	-
Starry flounder	10	-	39	-
TOTALS	112	-	440	-

H = 1.23 E = 0.62

Station: RKm 74.5
Gear: 50-m beach seine
Date: 29 Apr 1993
Time: 1030
Tide stage: Early ebb
Turbidity: - NTU
Temperature: 10.7°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	58	384	228	1,512
Coho salmon	2	58	8	228
Chum salmon	1	2	4	8
Threespine stickleback	141	277	555	1,091
Prickly sculpin	1	1	4	4
Starry flounder	4	32	16	126
TOTALS	207	754	815	2,969

H = 1.14 E = 0.44

Appendix Table 3.--Continued.

Station: RKm 96.1
Gear: 50-m beach seine
Date: 30 Apr 1992
Time: 1215
Tide stage: Early ebb
Turbidity: - NTU
Temperature: -°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	1	8	4	31
Coho salmon	5	149	20	587
Rainbow trout (steelhead)	30	2,581	118	10,161
Cutthroat trout	5	427	20	1,681
Threespine stickleback	1	2	4	8
Prickly sculpin	1	1	4	4
Starry flounder	2	12	8	47
TOTALS	45	3,180	178	12,519

H = 1.66 E = 0.59

Station: RKm 139.8
Gear: 50-m beach seine
Date: 6 May 1993
Time: 1428
Tide stage: Low slack
Turbidity: - NTU
Temperature: -°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	90	-	354	-
Coho salmon	46	-	181	-
Rainbow trout (steelhead)	3	-	12	-
Largescale sucker	2	-	8	-
Starry flounder	9	-	35	-
TOTALS	150	-	590	-

H = 1.40 E = 0.60

Appendix Table 3.--Continued.

Station: RKm 91.7
Gear: 50-m beach seine
Date: 7 May 1993
Time: 1407
Tide stage: Low slack
Turbidity: - NTU
Temperature: -°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	104	-	409	-
Chinook salmon (2+)	1	-	4	-
Coho salmon	103	-	406	-
Rainbow trout (steelhead)	1	-	4	-
Peamouth	41	-	161	-
Largescale sucker	2	-	8	-
Threespine stickleback	140	-	551	-
Unidentified sculpin	5	-	20	-
Starry flounder	15	-	59	-
TOTALS	412	-	1,622	-

H = 2.19 E = 0.69

Station: RKm 129.2
Gear: 50-m beach seine
Date: 12 May 1993
Time: 1550
Tide stage: Ebb
Turbidity: - NTU
Temperature: -°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	136	-	535	-
Coho salmon	38	-	150	-
Northern squawfish	1	-	4	-
Peamouth	1	-	4	-
Banded killifish	1	-	4	-
TOTALS	177	-	697	-

H = 0.90 E = 0.39

Appendix Table 3.--Continued.

Station: RKm 61.6
Gear: 50-m beach seine
Date: 14 May 1993
Time: 1038
Tide stage: High slack
Turbidity: 7.2 NTU
Temperature: 14.1°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	11	-	43	-
Coho salmon	1	-	4	-
Rainbow trout (steelhead)	3	-	12	-
Northern squawfish	1	-	4	-
Peamouth	2	-	8	-
Threespine stickleback	65	-	256	-
Unidentified sculpin	3	-	12	-
Starry flounder	7	-	28	-
TOTALS	93	-	367	-

H = 1.59 E = 0.53

Station: RKm 61.6
Gear: 50-m beach seine
Date: 14 May 1993
Time: 1136
Tide stage: Early ebb
Turbidity: - NTU
Temperature: -°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	15	-	59	-
Coho salmon	2	-	8	-
Threespine stickleback	294	-	1,157	-
Pacific staghorn sculpin	3	-	12	-
Unidentified sculpin	2	-	8	-
Starry flounder	6	-	24	-
TOTALS	322	-	1,268	-

H = 0.59 E = 0.23

Appendix Table 3.--Continued.

Station: RKm 74.5
Gear: 50-m beach seine
Date: 18 May 1993
Time: 1048
Tide stage: Early flood
Turbidity: 11.0 NTU
Temperature: 15.8°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	37	153	146	602
Coho salmon	1	20	4	79
Peamouth	54	6,935	213	27,303
Largescale sucker	1	750	4	2,953
Threespine stickleback	43	86	169	339
Pacific staghorn sculpin	1	1	4	4
Starry flounder	4	43	16	169
TOTALS	141	7,988	556	31,449

H = 1.86 E = 0.66

Station: RKm 91.7
Gear: 50-m beach seine
Date: 2 Jun 1993
Time: 1748
Tide stage: Early ebb
Turbidity: - NTU
Temperature: -°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
American shad	2	29	8	114
Chinook salmon (subyear.)	285	1,945	1,122	7,657
Coho salmon	2	42	8	165
Northern squawfish	2	0	8	0
Peamouth	17	514	67	2,024
Largescale sucker	3	0	12	0
Threespine stickleback	2	4	8	16
Starry flounder	19	212	75	835
TOTALS	332	2,746	1,308	10,811

H = 0.88 E = 0.29

Appendix Table 3.--Continued.

Station: RKm 74.5
Gear: 50-m beach seine
Date: 9 Jun 1993
Time: 1055
Tide stage: Ebb
Turbidity: 2.2 NTU
Temperature: 15.0°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
American shad	1	20	4	79
Chinook salmon (subyear.)	20	137	79	539
Coho salmon	2	71	8	280
Northern squawfish	1	48	4	189
Largescale sucker	3	2,580	12	10,157
Threespine stickleback	36	107	142	421
Starry flounder	11	153	43	602
TOTALS	74	3,116	292	12,267

H = 1.92 E = 0.68

Station: RKm 96.1
Gear: 50-m beach seine
Date: 9 Jun 1993
Time: 1845
Tide stage: Late flood
Turbidity: - NTU
Temperature: 15.0°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
American shad	1	16	4	63
Chinook salmon (subyear.)	58	298	228	1,173
Coho salmon	7	188	28	740
Northern squawfish	3	277	12	1,091
Peamouth	5	196	20	772
Largescale sucker	24	12,748	94	50,189
Prickly sculpin	20	78	79	307
Starry flounder	2	34	8	134
TOTALS	120	13,835	473	54,469

H = 2.12 E = 0.71

Appendix Table 3.--Continued.

Station: RKm 129.2 (Deer Island, Oregon)
Gear: 50-m beach seine
Date: 10 Jun 1993
Time: 1500
Tide stage: Ebb
Turbidity: - NTU
Temperature: -°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
American shad	15	-	59	-
Chinook salmon (subyear.)	85	-	335	-
Coho salmon	1	-	4	-
Peamouth	2	-	8	-
Starry flounder	1	-	4	-
TOTALS	104	-	410	-

H = 0.88 E = 0.38

Station: RKm 148.1 (Bachelor Island, Washington)
Gear: 50-m beach seine
Date: 18 Jun 1993
Time: 1330
Tide stage: Low slack
Turbidity: 5.0 NTU
Temperature: 19.0°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	153	771	602	3,035
Peamouth	17	456	67	1,795
Largescale sucker	1	34	4	134
Banded killifish	1	2	4	8
Threespine stickleback	12	21	47	83
Yellow perch	4	4	16	16
Prickly sculpin	13	178	51	701
Starry flounder	2	47	8	185
TOTALS	203	1,513	799	5,957

H = 1.36 E = 0.45

Appendix Table 3.--Continued.

Station: RKm 61.6
Gear: 50-m beach seine
Date: 24 Jun 1993
Time: 1232
Tide stage: Low slack
Turbidity: - NTU
Temperature: -°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	73	372	287	1,465
Northern squawfish	2	93	8	366
Peamouth	6	15	24	59
Largescale sucker	1	1	4	4
Threespine stickleback	155	294	610	1,157
Prickly sculpin	1	1	4	4
Pacific staghorn sculpin	23	122	91	480
Starry flounder	10	88	39	346
TOTALS	271	986	1,067	3,881

H = 1.68 E = 0.56

Station: RKm 82.6
Gear: 50-m beach seine
Date: 25 Jun 1993
Time: 1000
Tide stage: Ebb
Turbidity: - NTU
Temperature: 17.2°C

Species	No. captured	Total wt(g)	No. per hectare	Wt.(g) per hectare
Chinook salmon (subyear.)	34	128	134	504
Threespine stickleback	8	8	31	31
TOTALS	42	136	165	535

H = 0.70 E = 0.70

Appendix Table 3.--Continued.

Station: RKm 91.7
Gear: 50-m beach seine
Date: 2 Jul 1993
Time: 1345
Tide stage: Late flood
Turbidity: 6.9 NTU
Temperature: 18.0°C

Species	No. captured	Total wt.(g)	No. per hectare	wt.(g) per hectare
Chinook salmon (subyear.)	248	1,467	976	5,776
Northern squawfish	2	15	8	59
Peamouth	23	253	91	996
Largescale sucker	13	10,388	51	40,898
Threespine stickleback	44	74	173	291
Yellow perch	1	1	4	4
Starry flounder	4	84	16	331
TOTALS	335	12,282	1,319	48,355

H = 1.30 E = 0.46

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