Alaska Fisheries Technical Report Number 2

SURVEY OF FISHERY RESOURCES IN THE PORT MOLLER-BALBOA BAY PIPELINE CORRIDOR

December 1988

Region 7
U.S. Fish and Wildlife Service
Department of the Interior

SURVEY OF FISHERY RESOURCES IN THE PORT MOLLER-BALBOA BAY PIPELINE CORRIDOR

by

Teresa A. Wagner

King Salmon Fishery Assistance Office
U.S. Fish and Wildlife Service
P.O. Box 277
King Salmon Alaska 99613

ABSTRACT

A fishery inventory of Herendeen Bay streams was conducted during two field seasons (1985-1986) to provide baseline data on physical, chemical and biological characteristics that may be relevant to assessing potential impacts from a proposed oil transportation system in the area. Inventory objectives were: 1) to determine species composition, distribution and condition of fish; 2) to determine the timing of salmonid migrations; 3) to identify salmon spawning and rearing areas and 4) to obtain physical and hydrological descriptions of Herendeen Bay streams. This information will be used in planning for final corridor selection and alignment, construction timing, and mitigaton of possible negative impacts. Fish were collected by gill net, minnow trap, fyke net, electrofishing, and hook and line. Habitat characteristics were noted during foot surveys.

Adult and (or) juvenile chum salmon (Oncorhynchus keta), coho salmon (O. kisutch), Dolly Varden char (Salvelinus malma), coastrange sculpin (Cottus aleuticus), and threespine stickleback (Gasterosteus aculeatus) were commonly found in Herendeen Bay streams. Pink salmon (O. gorbuscha), sockeye salmon (O. nerka), ninespine stickleback (Pungitius pungitius), eulachon smelt (Thaleichthys pacificus), Alaska blackfish (Dallia pectoralis), sharpnose sculpin (Clinocottus acuticeps) and rainbow smelt (Osmerus mordax) were present but less abundant, and starry flounder (Platichthys stellatus) and rock sole (Lepidopsetta bilineata) were captured in Herendeen Bay (salt water). Fork length condition factor ranged from 0.3 - 1.7 for juvenile coho salmon.

The sampled seaward migration of chum salmon was highest on 31 May 1985 and 5 May 1986 with an average of 35 and 41 fish-per-fyke-net-hour respectively. Juvenile chum salmon continued to migrate out through both study periods. Chum

salmon spawning migrations commenced 4 July 1985 and continued through the study session. Small, spring-fed tributaries, where both resident and anadromous fishes were found, may provide overwintering habitat. Streams in the area are short and steep with clear, high velocity, shallow water. Considerations for impact assessment should include: 1) the small size of the sockeye and coho salmon runs in Herendeen Bay streams and 2) the utilization of fresh water areas for juvenile salmonid residence.

TABLE OF CONTENTS

	Page
ABSTRACT	i
TABLE OF CONTENTS	iii
LIST OF FIGURES	iv
LIST OF TABLES	v
LIST OF APPENDIX TABLES	v
INTRODUCTION	1
STUDY AREA	5
METHODS	5
RESULTS	11
DISCUSSION	20
CONCLUSION AND RECOMMENDATION	30
ACKNOWLEDGMENTS	31
LITERATURE CITED	32

LIST OF FIGURES

Figure		Page
1.	Locational map of identified transportation corridors (Bristol Bay Coastal Resource Service Area Board, 1984) and the 1985-1986 study area at Herendeen Bay, Alaska.....	2
2.	Expanded study area map showing locations of the 1985-1986 study area, base camp and proposed transportation corridor routes.....	3
3.	Fish distribution and discharge/water quality sampling sites on the west arm of Herendeen Bay, Alaska from the 1985-1986 fishery inventory.....	7
4.	Fish distribution and discharge/water quality sampling sites on the east arm of Herendeen Bay, Alaska from the 1985-1986 fishery inventory.....	8
5.	Distribution of anadromous and resident fish species documented during the 1985-1986 fishery inventory of Herendeen Bay, Alaska.....	12
6.	Length frequency histogram (fork length, mm) of juvenile coho salmon sampled from Herendeen Bay streams during the 1985 study period.....	14
7.	Length frequency histogram (fork length mm) of juvenile coho salmon sampled from Herendeen Bay streams during the 1986 study period.....	15
8.	Catch-per-unit-effort (CPUE) from the Herendeen Bay Doe Creek fyke net sample, 1985-1986.....	19
9.	Stream elevation, length, discharge, and sinuosity (stream km/valley km) of selected streams in Herendeen Bay, Alaska. Discharge measured 25-29 June, 1985.....	22

LIST OF TABLES

Table		Page
1.	Age specific mean length, weight and condition factor for juvenile coho salmon sampled from Herendeen Bay, Alaska during the 1985-1986 inventory	16
2.	Sex, age, and mean length (mid-eye to fork) statistics of chum salmon sampled from Herendeen Bay, Alaska, 1985	17
3.	Water quality and discharge statistics from Herendeen Bay, Alaska	21

LIST OF APPENDIX TABLES

Appendix		Page
A.	Length and weight for fishes of Herendeen Bay, Alaska	34
B.	Fyke net catches from Herendeen Bay, Alaska	35

INTRODUCTION

In 1985, a two year investigation was initiated in the Port Moller area to assess fishery resources and stream habitat conditions along one of the proposed oil transportation corridors located on the Alaska Peninsula (Figure 1). These corridors would be used to transport oil from prospective off-shore oil and gas lease site development in the Bristol Bay/Aleutian Islands areas of the Alaska Peninsula. Inventory objectives were: 1) to determine species composition, distribution and condition of fish; 2) to determine the timing of salmonid migrations; 3) to identify salmon spawning and rearing areas; and 4) to obtain physical and hydrological descriptions of Herendeen Bay streams. This investigation also helps to satisfy mandates set forth in the Alaska National Interest Lands Conservation Act, Section 304, which requires a basic fishery inventory of refuge lands. This baseline information will be used as a basis for fishery resources management.

The Port Moller/Balboa Bay corridor is the western most and shortest trans-peninsula corridor identified for development (Anonymous 1985, Bristol Bay Coastal Resource Service Area Board 1984) and follows a previously utilized pack trail in Portage Valley (Figure 2). This route was used in the 1880's to transport supplies between Albatross Anchorage and Herendeen Bay where three known coal mines were operating in the area (Conwell et al. 1978). This and the alternate routes cross the Alaska Peninsula from Herendeen Bay to deep water bays on the south side.

Aerial spawning surveys have been conducted by the Alaska Department of Fish and Game (Department) on Herendeen Bay streams since 1960, but no ground based studies of species composition or distributions have been made. Aerial surveys are conducted to evaluate chum salmon (Oncorhynchus keta), sockeye

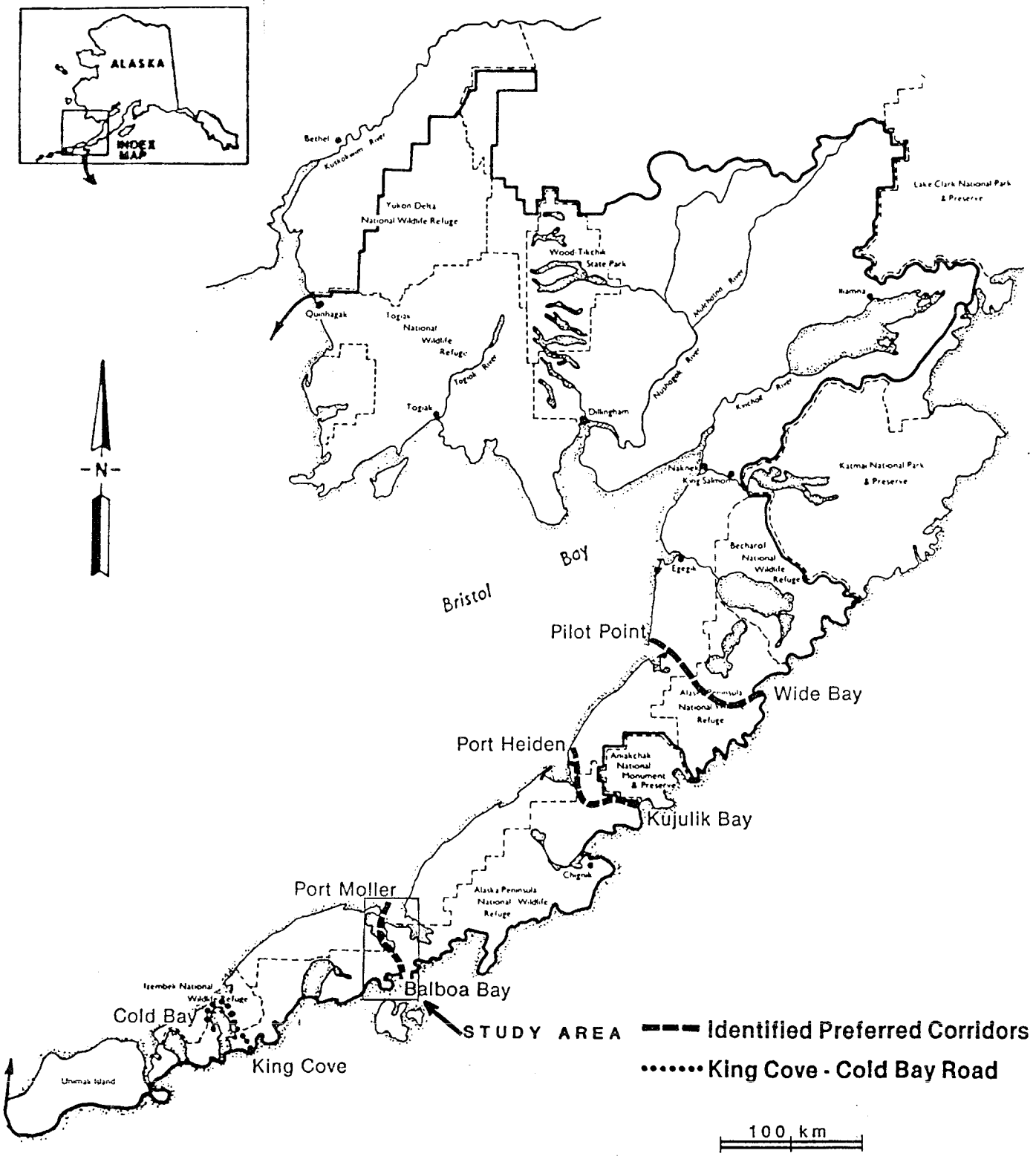


FIGURE 1. Locational map of identified transportation corridors (Bristol Bay Coastal Resource Service Area Board, 1984) and the 1985-1986 study area at Herendeen Bay, Alaska.

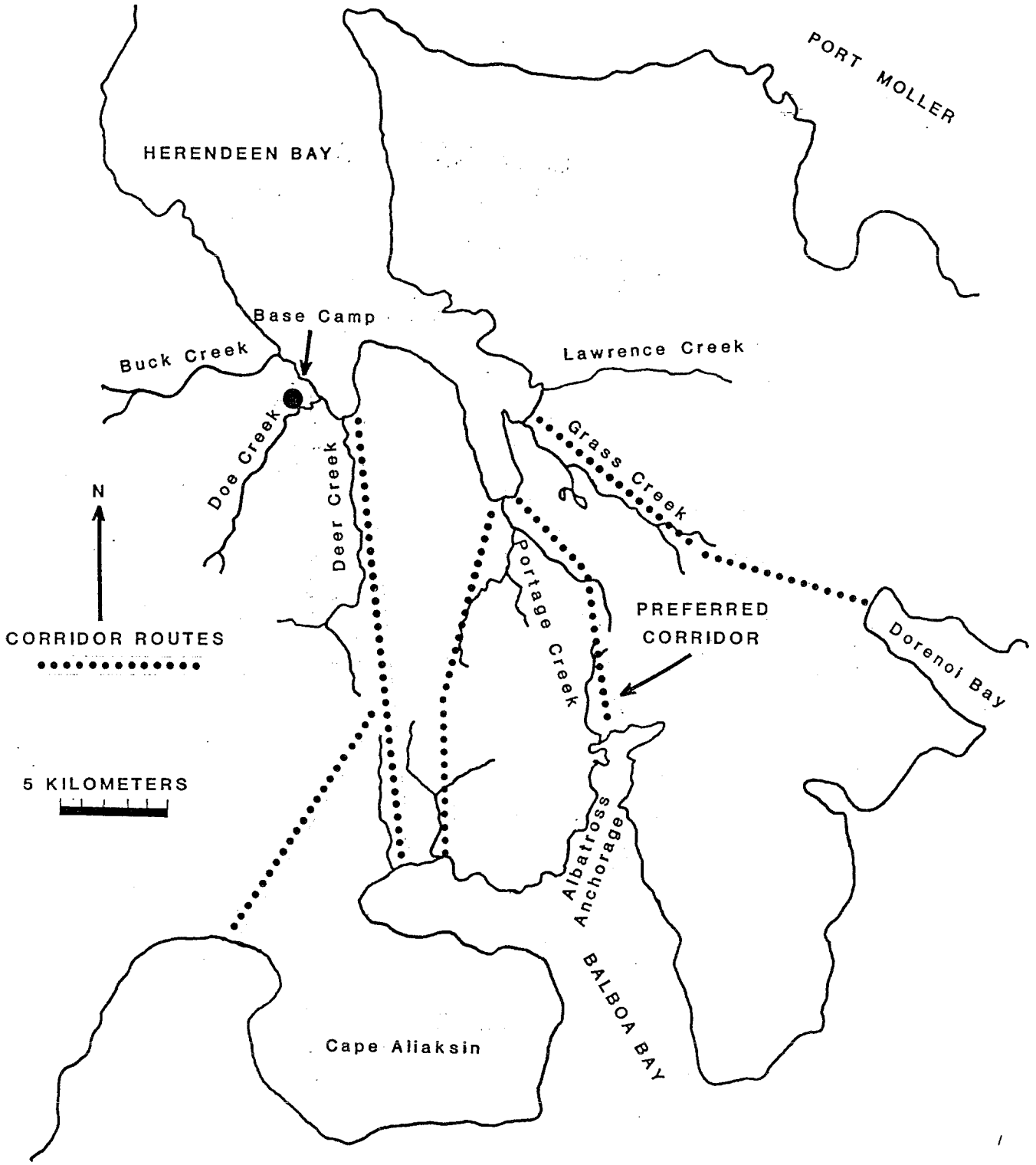


FIGURE 2. Expanded study area map showing locations of the 1985-1986 study area, base camp and proposed transportation corridor routes.

salmon (O. nerka) and pink salmon (O. gorbuscha) escapement levels and are usually completed prior to the later occurring runs of coho salmon (O. kisutch). Because of these limited observations, little is known about distribution, movement or utilization of fresh water spawning and rearing areas by coho salmon in Herendeen Bay streams. There is a viable chum salmon fishery in the area, with commercial gill netters arriving as early as 1 July. Several cannery ruins in the area indicate previous commercial fishery use. Department commercial fisheries biologists (Department) estimated the total Herendeen Bay chum salmon run size for 1985 to be in excess of 338,000 fish and in 1986 the run was estimated at over 83,000 (Anonymous 1985, 1986). Balboa Bay chum salmon escapement estimates range from 8,200 fish in 1974 to 100,000 fish in 1966. Pink salmon escapements into Balboa Bay streams range in size from 1,100 to 187,200; however, very few pinks have been observed on the Herendeen Bay side.

Aquatic habitat descriptions from this inventory provide qualitative baseline information about Herendeen Bay fishery resources prior to potential corridor development. Possible impacts to the fishery resulting from development of transportation corridors include increased sediment loads, dewatering of tributaries, and increased human presence (Cederholm, et al. 1979; Hanley 1981). Information gathered will be used in selecting final corridor alignment, construction timing, management strategies for possible increases in human use, and for the mitigation of possible adverse effects of corridor development.

STUDY AREA

Port Moller and Herendeen Bays are deeply incised, salt water inlets running in a south easterly direction from the Bering Sea in the Aleutian sub-region of the Alaska Peninsula. The Alaska Peninsula, consisting of the steep Aleutian Range and coastal lowlands, is approximately 24 km wide near Herendeen Bay. Up to 75 percent (100 percent on mountain tops) of the land surface is composed of steep bedrock with little or no vegetation. The remaining 25 percent is predominately very gravelly soils (Selkregg 1976). Most of the vegetation communities in this area are classified as alpine tundra and barren ground or high brush, with interspersed muskegs and willow/alder riparian associations (Anonymous 1985). The climate is moderate and is classified as a transition zone between the continental and maritime climatic zones (Selkregg 1976). Average annual precipitation is 109 cm (including 248 cm of snow), and the mean annual maximum high and low temperatures are 15°C and -6°C respectively (Selkregg 1976). United States Geological Survey topographic maps (1:63,360) indicate stream gradients of up to 171 m/km and stream lengths of 9-16 km in the study area. Streams are second and third order (Strahler 1957).

METHODS

The base camp was located on the west arm of Herendeen Bay (Figure 2). An unnamed stream, hereafter "Doe Creek", was selected to serve as a representative of the several short streams in the study area. "Doe Creek" was selected for biological and hydrological sampling because 1) it was close to the base camp and 2) it has physical characteristics similar to other streams

situated along the proposed corridors. This stream was used to document the seaward migration timing of juvenile salmonids, spawning migration timing of adult salmonids, and physical and hydrological characteristics (stream morphology, discharge and water quality). In addition to Doe Creek, Grass and Portage Creeks were sampled for discharge and water quality data. Fish distribution sampling was conducted at Buck, Driftwood, Deer, Lawrence, Grass, and Portage Creeks.

Standard minnow traps baited with salted salmon roe were set in pools, ponds and sloughs to determine distribution and species presence. The traps were also used to collect rearing coho salmon specimens for age and growth determination and to estimate the number of coho salmon rearing in two small, spring-fed tundra ponds near the base camp. Fish were marked by clipping the left pelvic fin with scissors and released into the original capture site. A single census (Lincoln-Petersen) estimate was used on the mark-recapture data obtained from these ponds (Everhart et al. 1953).

Other capture techniques employed to reduce species, size, or age bias included dip nets and a gasoline-powered, backpack electroshocker. Electrofishing was used exclusively to sample Grass Creek in 1986.

A floating 2.7 cm stretched mesh gill net and hook and line were used to capture adult salmonids for age, sex, weight and length determinations. Aerial survey information on adult distributions was obtained from Department aerial spawning survey log books (A. Shaul, Alaska Department of Fish and Game, personal communication) and the Atlas to the Catalog of Waters Important for Spawning, Rearing and Migration of Anadromous Fishes (Anonymous 1982). In addition, a single aerial spawning survey was conducted on 16 October 1986. Figures 3 and 4 show fish distribution and discharge/water quality sampling sites.

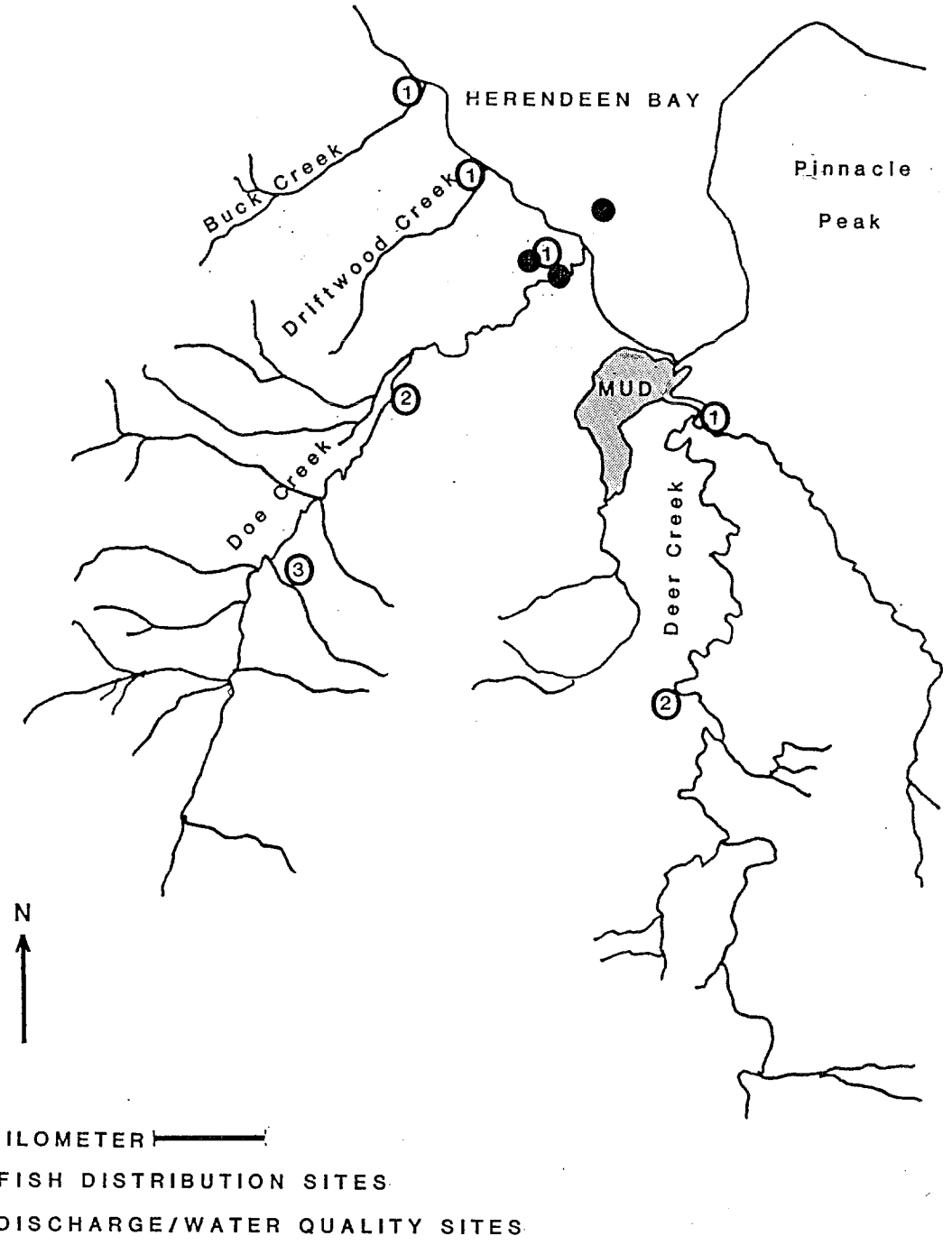


FIGURE 3. Fish distribution and discharge/water quality sampling sites on the west arm of Herendeen Bay, Alaska from the 1985-1986 fishery inventory.

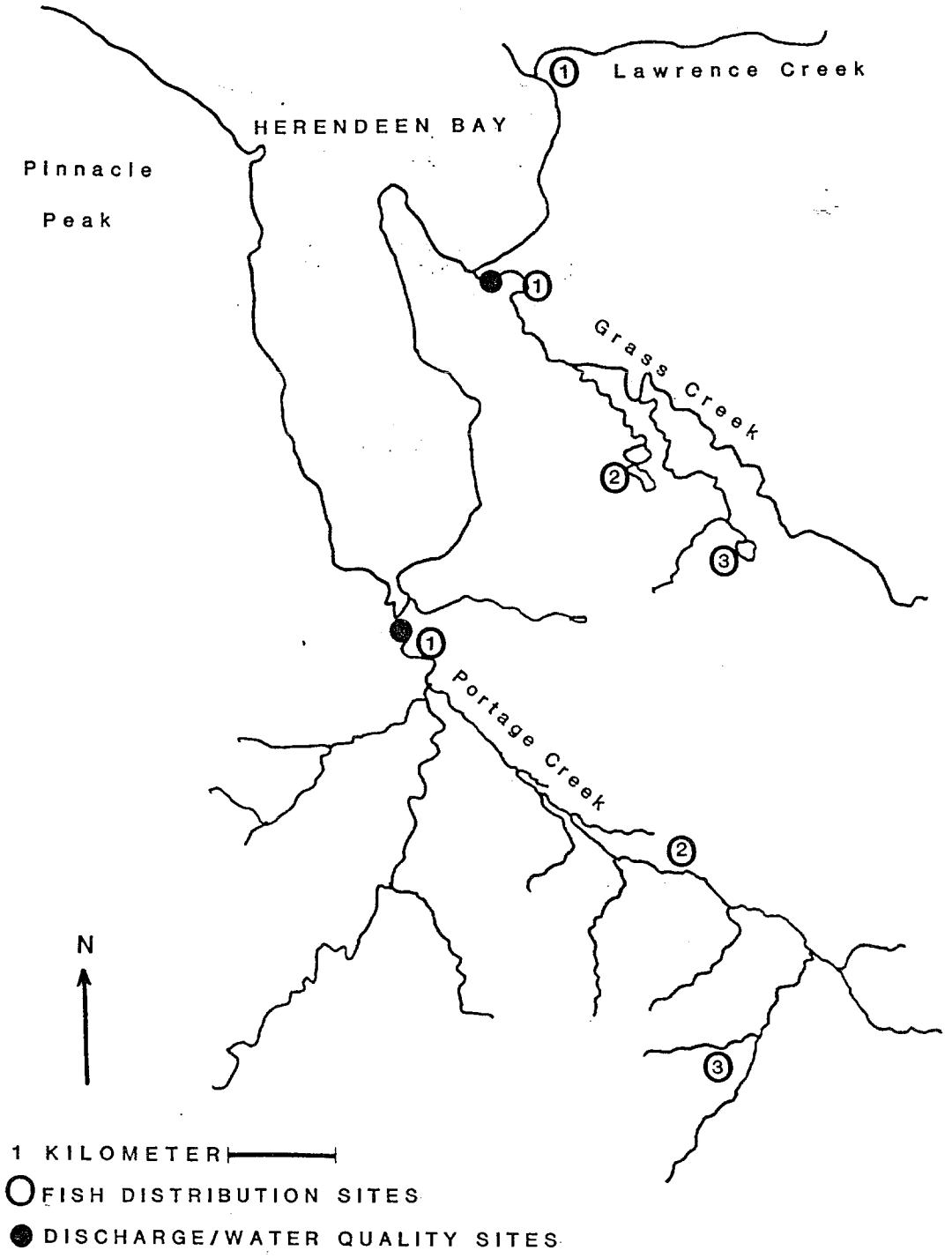


FIGURE 4. Fish distribution and discharge/water quality sampling sites on the east arm of Herendeen Bay, Alaska from the 1985-1986 fishery inventory.

Fork length measurements (mm), weight measurements (g), and scale smears were taken from a subsample of juvenile coho salmon. The subsample consisted of fishes >50 mm in length and with sufficient scale development to enable scale sampling. Condition factors were calculated for known age juvenile coho salmon. Condition factor was taken from Carlander (1969).

Adult salmon were weighed on spring scales and weights were recorded in kilograms. Mid-eye to fork length was used to decrease any bias in length measurements caused by development of secondary sexual characteristics. Sex was determined from secondary sexual characteristics in adult salmonids when possible. Scale samples were taken from above the lateral line,posterior to the dorsal fin. The scales were magnified up to 60x on a microfiche reader and aged according to techniques described by Koo (1962). Anadromous fish ages are reported using the European method (e.g., a 0.4 fish has 0 freshwater winters and 4 saltwater winters). Juvenile salmonids are reported with a single Arabic numeral representing freshwater winters (post emergence).

A 0.9 x 0.9 m fyke net with 1.5 mm mesh was placed in the main channels of Doe and Deer Creeks to capture juvenile salmonid out-migrants. The Doe Creek fyke net was fished three times-per-week and checked hourly during 7 hour periods from 29 May through 12 July 1985 and from 2 May through 18 June 1986. The Deer Creek net was fished once each week in May 1986 to identify any species composition differences between the two streams (i.e., to determine presence of sockeye salmon smolts). The Doe Creek fyke net was also fished once each week in May 1986 for 3 hour intervals starting at sundown, usually from 2200 to 0100 hours, to determine any species composition differences between day and night seaward migration. Catch-per-unit-effort (CPUE), defined as mean catch-per-hour per-net-day, was used to determine the peak seaward migration of salmonids. CPUE data were compared with staff gauge readings

taken in Doe Creek using a correlation analysis (Zar 1984) to determine any relationships between rate of migration and stream discharge.

A staff gauge was installed in Doe Creek to record water level fluctuations. Discharge was calculated using the partial cell technique described in Trihey and Wegner (1983). Discharge measurements were taken on four occasions at a permanent transect site to represent low, medium and high discharge levels. Stream profiling and habitat variables (substrate and cover) were adapted from Trihey and Wegner (1983). Water quality measurements (dissolved oxygen, pH, alkalinity, turbidity, conductivity, salinity) were recorded on the same dates using a Hach field kit (Model AL-36T), a Yellow Springs Instruments conductivity meter and a VWR Portable Turbidimeter[1]. Water temperatures were monitored throughout the study using hand held thermometers. Discharge and water quality parameters were measured at Portage, Deer, and Grass Creeks. Habitat variables described at these streams include: stream width, depth, substrate, clarity, bank pattern and stability and pool/riffle/run ratios. Daily weather conditions (high and low air temperature, precipitation, wind direction and speed) were recorded for general information, and are on file at the King Salmon Fishery Assistance Office.

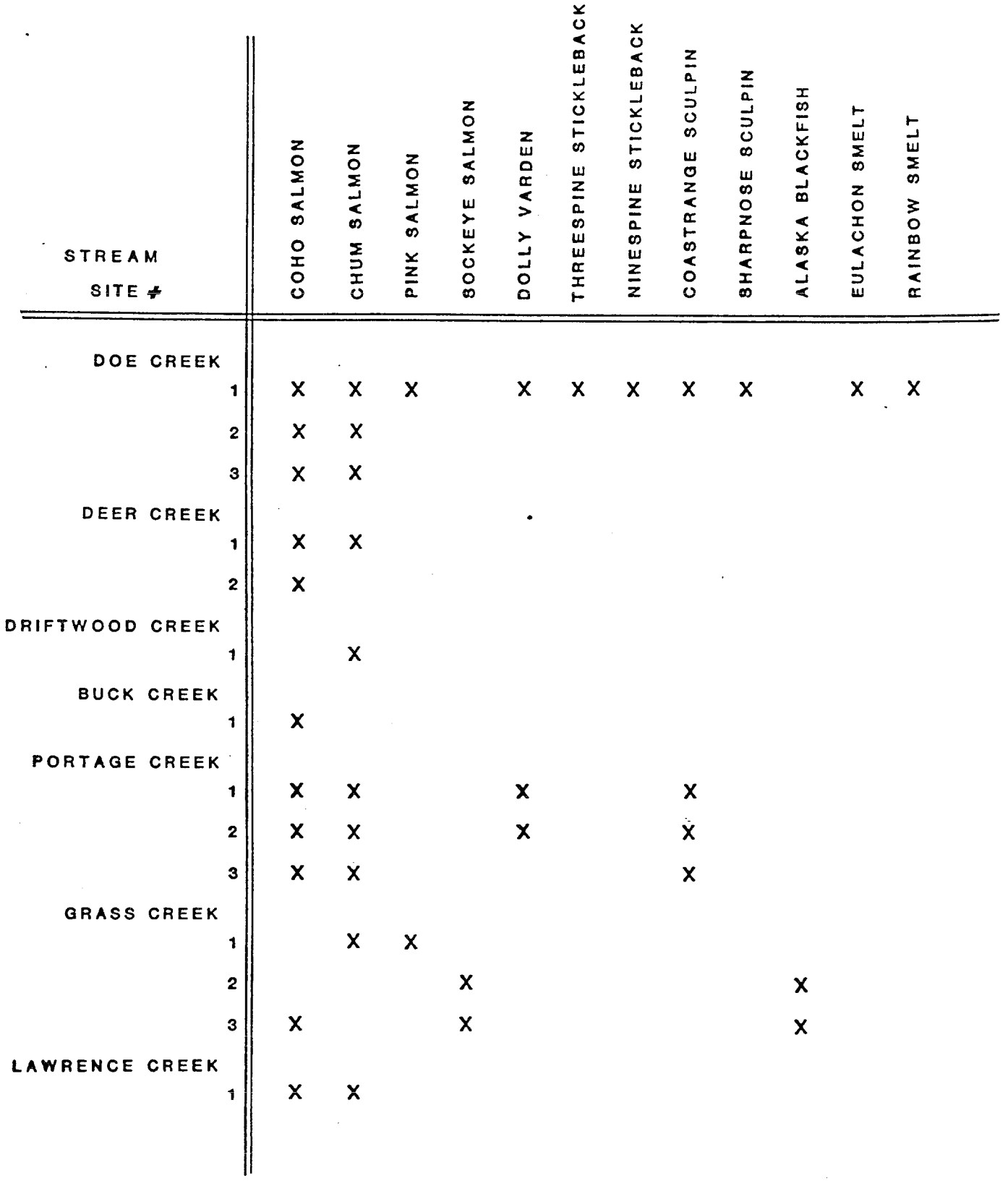
[1]Use of trade names is for reader information only, and does not constitute endorsement by the U.S. Government of any commercial product or service.

RESULTS

Four species of Pacific salmon (coho, chum, sockeye and pink) were found in Herendeen Bay streams. Dolly Varden char (Salvelinus malma), threespine stickleback (Gasterosteus aculeatus), ninespine stickleback (Pungitius pungitius), coastrange sculpin (Cottus aleuticus), sharpnose sculpin (Clinocottus acuticeps), Alaska blackfish (Dallia pectoralis), rainbow smelt (Omerus mordax) and eulachon smelt (Thaleichthys pacificus) were also collected. Starry flounder (Platichthys stellatus) and rock sole (Lepidopsetta bilineata) were captured in gill nets set in the littoral areas of Herendeen Bay (Figure 5). A chum X sockeye salmon hybrid may exist in the Port Moller area (J. McCullough, Alaska Department of Fish and Game, personal communication) but no hybrids were found during the study.

Species captured in minnow traps included coho salmon, Dolly Varden char, threespine stickleback, ninespine stickleback, sharpnose and coastrange sculpin. The number of rearing coho salmon in Stickleback Pond was estimated to be 353 $\pm$ 32 fish (P = .95) using the single census method. This pond is approximately .16 hectare in size and generally less than one meter in depth. Fluctuating water level and close association with Doe Creek make the assumption of geographic closure questionable in the second pond sampled for rearing coho population estimates. It was quite small and ranged in surface area from 4.6 m^2 to 14 m^2. The single census estimate of N for this pond is 209 $\pm$ 89 fish (P = .95).

Age analysis of juvenile coho salmon and Dolly Varden char scales indicate the rearing fish are from 0-2 years old. Length frequency histograms from 1985 indicate that young-of-the-year (age 0) coho salmon grew 10 mm or more in 60 days. This diagram also indicated that the one and two year old coho salmon



STREAM SITE #	COHO SALMON	CHUM SALMON	PINK SALMON	SOCKEYE SALMON	DOLLY VARDEN	THREESPINE STICKLEBACK	NINESPINE STICKLEBACK	COASTRANGE SCULPIN	SHARPNOSE SCULPIN	ALASKA BLACKFISH	EULACHON SMELT	RAINBOW SMELT
DOE CREEK												
1	X	X	X		X	X	X	X	X		X	X
2	X	X										
3	X	X										
DEER CREEK												
1	X	X										
2	X											
DRIFTWOOD CREEK												
1		X										
BUCK CREEK												
1	X											
PORTAGE CREEK												
1	X	X			X			X				
2	X	X			X			X				
3	X	X						X				
GRASS CREEK												
1		X	X									
2				X						X		
3	X			X						X		
LAWRENCE CREEK												
1	X	X										

FIGURE 5. Distribution of anadromous and resident fish species documented during the 1985-1986 fishery inventory of Herendeen Bay, Alaska.

migrated from the ponds sometime after 27 June 1985 (Figure 6). Few age 0 coho salmon were captured in 1986 ($n < 4$) and are not included in the 1986 length frequency histogram (Figure 7). A sample of 80 age 0 coho salmon ranged in size from 32 to 36 mm with an average length of 34 mm. Weights and condition were not calculated for age 0 fish due to measurement constraints in the field. The weight scale used measured in grams and it took approximately six age 0 coho to weigh one gram. A sample of 459 age 1 coho salmon ranged in size from 51 to 114 mm with an average length of 71 mm. Weight ranged from 1 to 13 g and condition factor ranged from a low of .28 to 1.68. Age 2 juveniles showed an overlap in length and weight ranges with age 1 fish (e.g., length range 72 to 150 mm, weight range 2 to 14 g). Condition factors for age 2 coho salmon ranged from .27 to 1.03 (Table 1). Average length and weight of resident fish and other salmonids are shown in Appendix A.

Juvenile coho salmon and Dolly Varden char were found up to the 30 meter (m) elevation line in Portage Valley. Juvenile coho salmon found in Deer, Doe and Portage Valleys inhabited the spring-fed tributaries and ponds which characterize these valleys. Age 0 sockeye salmon were found in the small lake system of Grass Creek.

Many adult chum salmon showed what was thought to be a false winter check before the assumed true winter check (D. Bill, Alaska Department of Fish and Game, personal communication). This false annulus was not counted during age analysis. Sampled adult chum salmon represented three age classes (3 to 5 year olds) with the majority (66.5 percent) being age 4. All adult samples were collected in 1985 (Table 2).

In 1985 a total of 676 fish were captured in the Doe Creek fyke net (including three non-salmonids), and mean catch rates ranged from 1.4 to 35.6 fish-per-hour, all species combined. Over 5,000 fish were captured in the Doe

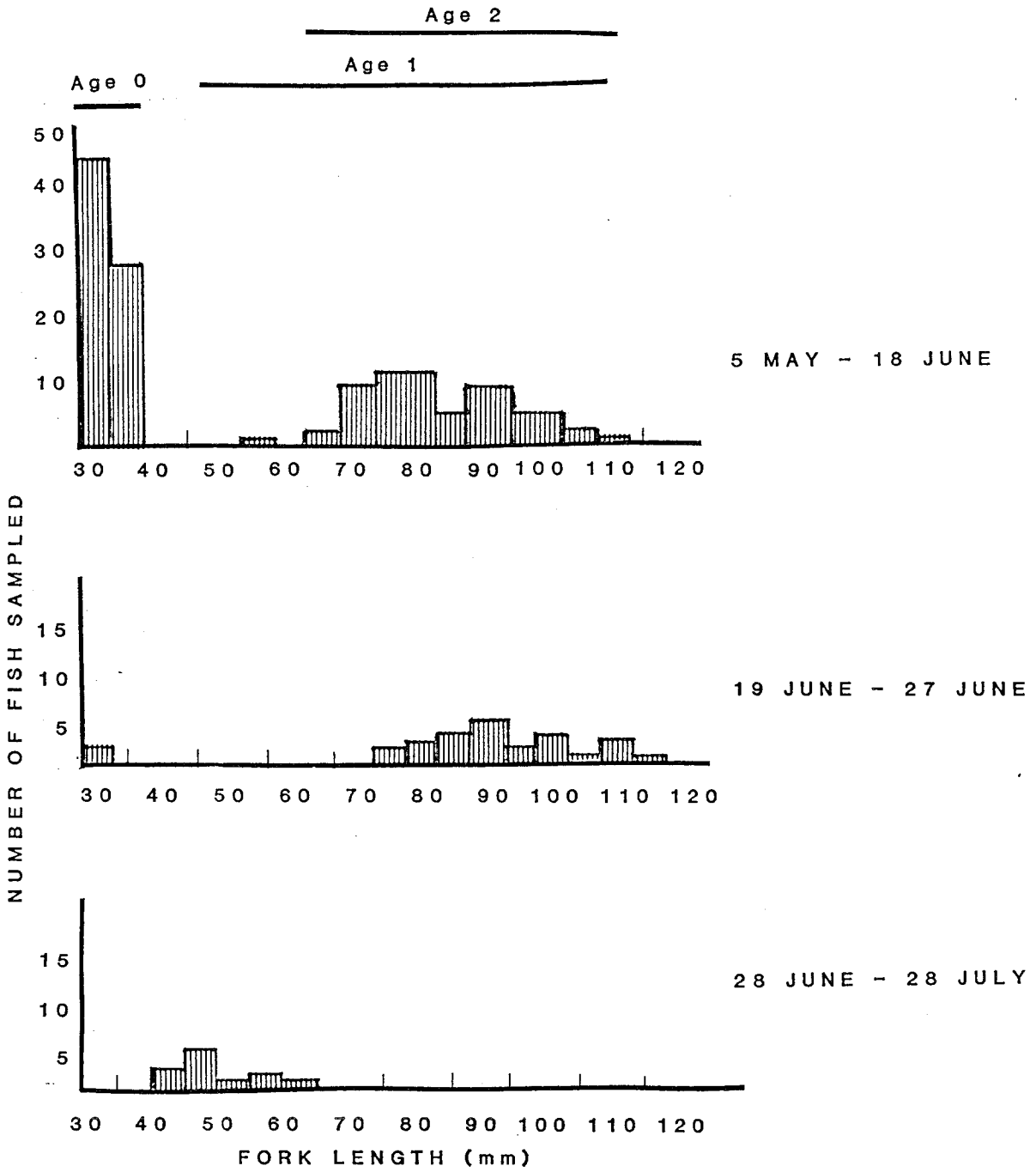


FIGURE 6. Length frequency histogram (fork length, mm) of juvenile coho salmon sampled from Herendeen Bay streams during the 1985 study period.

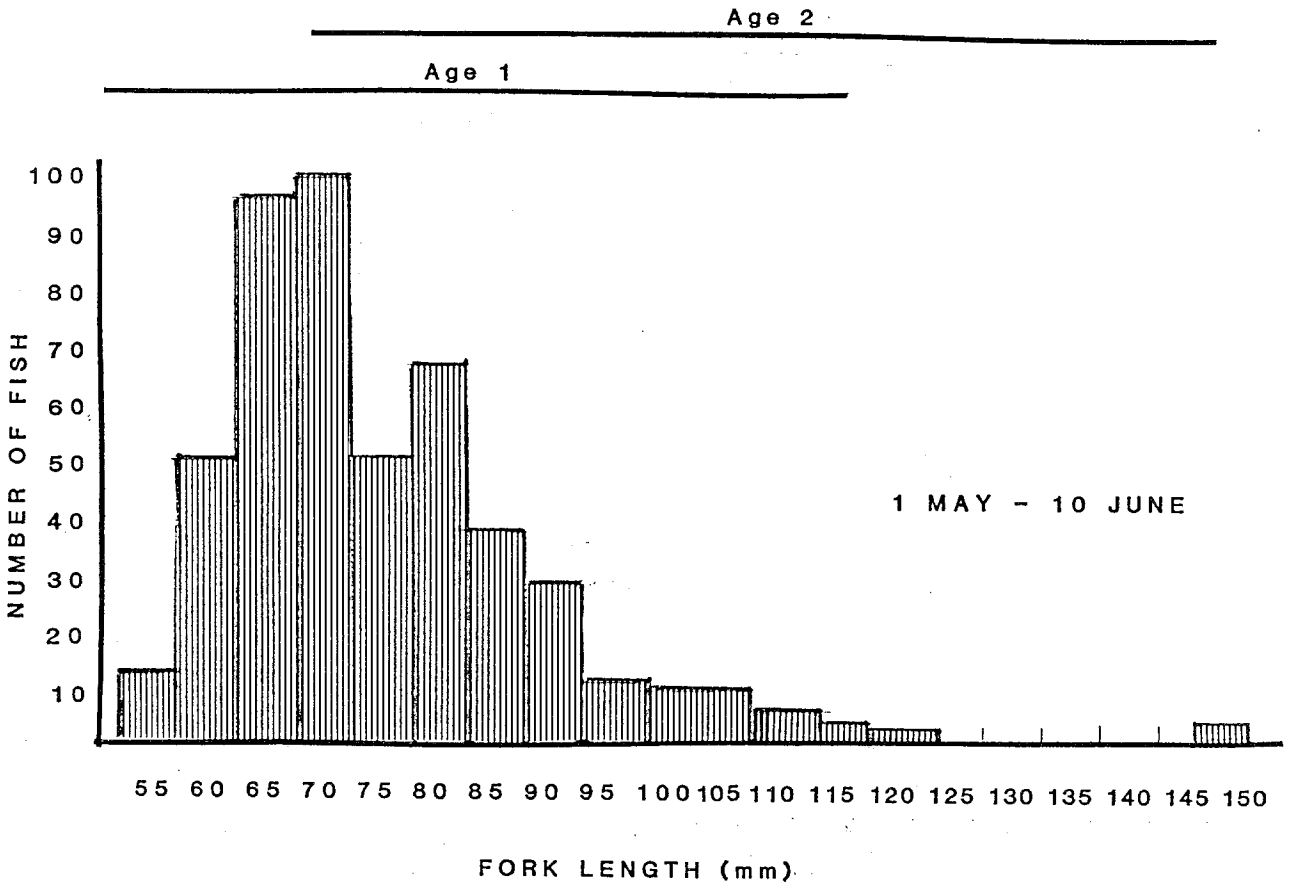


FIGURE 7. Length frequency histogram (fork length mm) of juvenile coho salmon sampled from Herendeen Bay streams during the 1986 study period.

Table 1.-Age specific mean length, weight and condition factor for juvenile coho salmon sampled from Herendeen Bay, Alaska during the 1985-1986 inventory.

Age Class	Length (mm)	Weight (g)	Condition factor (K_{FL})	N
Age 0	34	--	--	80
range	32-36			
Age 1	71	3.4	.92	459
range	51-114	1.0-13.0	.28-1.68	
Age 2	99	8.5	.85	46
range	72-150	2.0-14.0	.27-1.03	

Table 2.-Sex, age, and mean length (mid-eye to fork) statistics of chum salmon sampled from Herendeen Bay, Alaska, 1985.

	Age group			
	0.3	0.4	0.5	Total
Males				
X	597	608	660	
N	39	87	1	127
SE	0.9	0.3	0	
Females				
X	577	600	629	
N	22	40	2	64
SE	1.3	0.6	11.6	
Sexes combined				
X	589	606	639	
N	61	127	3	191
SE	0.7	0.2	8.2	

Creek fyke net in 1986 and catch rates ranged from 5.0 to 41.9 (Figure 8). Night fyke net catches were significantly higher in number than day catches (Appendix B), but no species differences were observed. The majority of these fish were chum salmon smolts. No significant correlation was found between fyke net CPUE and staff gauge readings ($r = -.04$ (1985) and .08 (1986), $P = .05$), however, a weak negative correlation was found in 1986 between CPUE and water temperature ($r = -.69$, $P = .05$).

Chum salmon smolts had begun migrating prior to the start of each field season and continued their seaward migration through 12 July 1985 when sampling ceased and through the sampling period (18 June) in 1986. There was a significant drop in the 1985 catch rate after 31 May. In 1986, however, there were several "peaks" with the largest occurring in mid-May. These data suggest that most juveniles migrate prior to June. Fyke net data (date, effort and catch) for the Doe and Deer Creek fyke net stations are shown in Appendix B. Only six juvenile pink salmon were captured.

Spawning populations of eulachon and rainbow smelt were present in Doe Creek, but the magnitude of the runs are unknown. Ripe eulachon smelt were captured in the fyke net on 26 June 1985 and a spent rainbow smelt was captured on 4 June 1986. Chum salmon spawning migrations began the first week of July 1985 in Doe and Deer Creeks. Pink salmon were seen in Herendeen Bay on 25 July 1985 but were not observed entering the streams, and no pink salmon were observed during 1986 aerial surveys (Anonymous 1986). Other adult salmonid species were not observed. No salmon were observed in Herendeen Bay streams during the October 1986 aerial survey; however, spawning coho salmon were observed in some Pacific side streams at that time.

Chum salmon spawning and redd construction were observed in Doe Creek where fish were digging about 35 m upstream from the mean high water at the mouth.

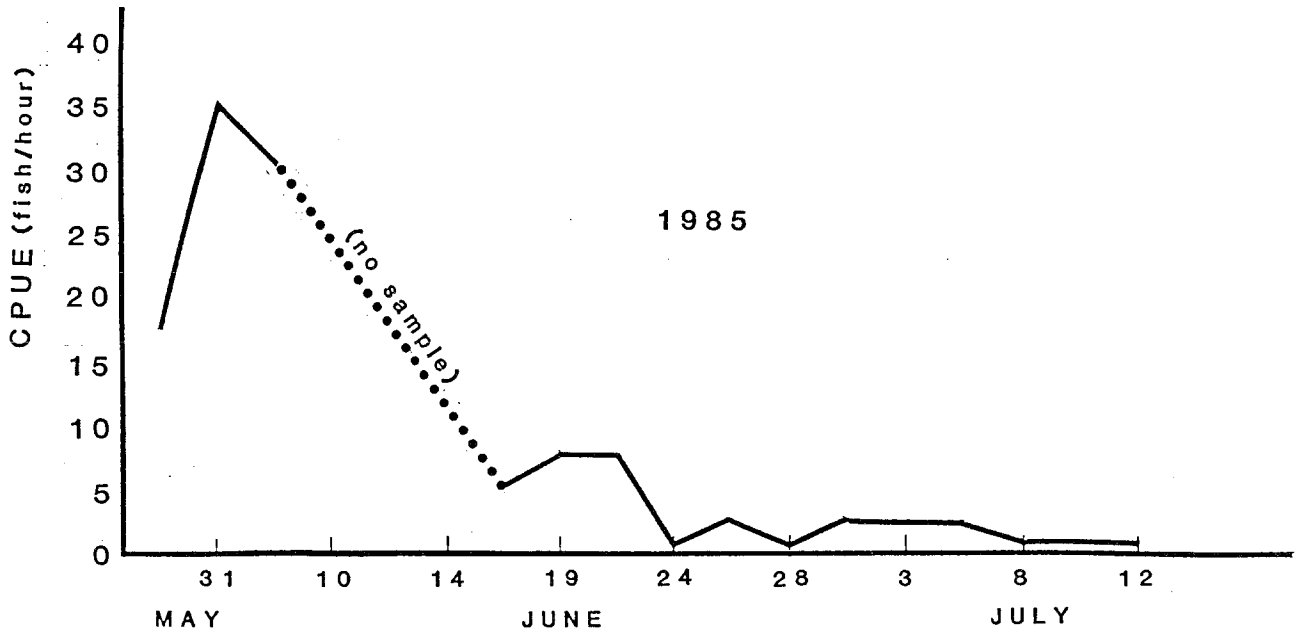


FIGURE 8. Catch-per-unit-effort (CPUE) from the Herendeen Bay Doe Creek fyke net sample, 1985-1986.

This spawning area exhibited no salt water intrusion but depth varied slightly with the tides and substrate consisted of medium to coarse gravels (0.6-6.4 cm). Redds were constructed in areas of moderate velocity and depth along the thalweg. Twenty-five redds were observed in a 91 m stretch of stream (up to 10 m wide).

Herendeen Bay streams were generally low in alkalinity, saturated with oxygen and had a neutral pH (Table 3). Streams are generally less than 16 km long with the greatest gradients (up to 171 m/km) occurring in the uppermost 3 km (mountain streams) and a moderate slope (9 m/km) as they traverse the valley floors. A comparison of selected physical characteristics of the sampled streams is illustrated in Figure 9.

DISCUSSION

The 1985-1986 fishery inventory of Herendeen Bay streams documented several new juvenile rearing areas utilized by coho salmon and Dolly Varden char. These findings expanded the known distributions of these species and were submitted to the Department for inclusion in the Catalog of Waters Important for Spawning, Rearing and Migration of Anadromous Fishes. Morrow (1980) reports the presence of threespine stickleback in the Herendeen Bay area but does not report ninespine stickleback, sharpnose sculpin or Alaska blackfish, all of which were documented during this study. The Atlas of North American Freshwater Fishes (1980) reports that no threespine stickleback or Alaska blackfish have been found in the Herendeen Bay area but states that the sharpnose sculpin is a rare visitor to fresh water in the area. These

Table 3.-Water quality and discharge statistics from Herendeen Bay, Alaska.

Site	Date	Staff gauge[a]	Temp. °C	Salinity ‰	Conductivity mhos	pH	Dissolved oxygen mg/l	Alkalinity mg/l $CaCO_3$	Turbidity NTU	Discharge m^3/sec
Herendeen Bay	5-30-85	2.16	6.5	24.5	25,000					
Doe Creek	5-29-85	2.04	5.5	.5	45	7.0	13.40	22.3	21.0	3.4
	7-01-85	2.34	9.0	.5	50	7.0	12.52	25.4	98.0	4.4
	7-29-85	1.70	8.0	.5	65	7.0	11.62	71.0	4.2	1.3
	5-08-86		4.5	0.0	50	7.0	17.90	41.0	3.0	1.3
Stickleback Pond	7-23-85	1.84	11.0	b	b	7.0	11.33	b	b	b
Portage Creek	7-25-85	1.82	6.0	b	b	6.7	11.41	8.1	b	6.4
Grass Creek	7-25-85	1.82	11.0	b	b	7.0	10.14	10.0	b	2.7
Range:		1.82-2.34	6.0-11.0	0.5-24.5	45-25,000	6.7-7.0	10.14-13.40	8.1-71.0	4.2-98.0	1.3-6.4

[a] staff gauge reading from Doe Creek
b not measured

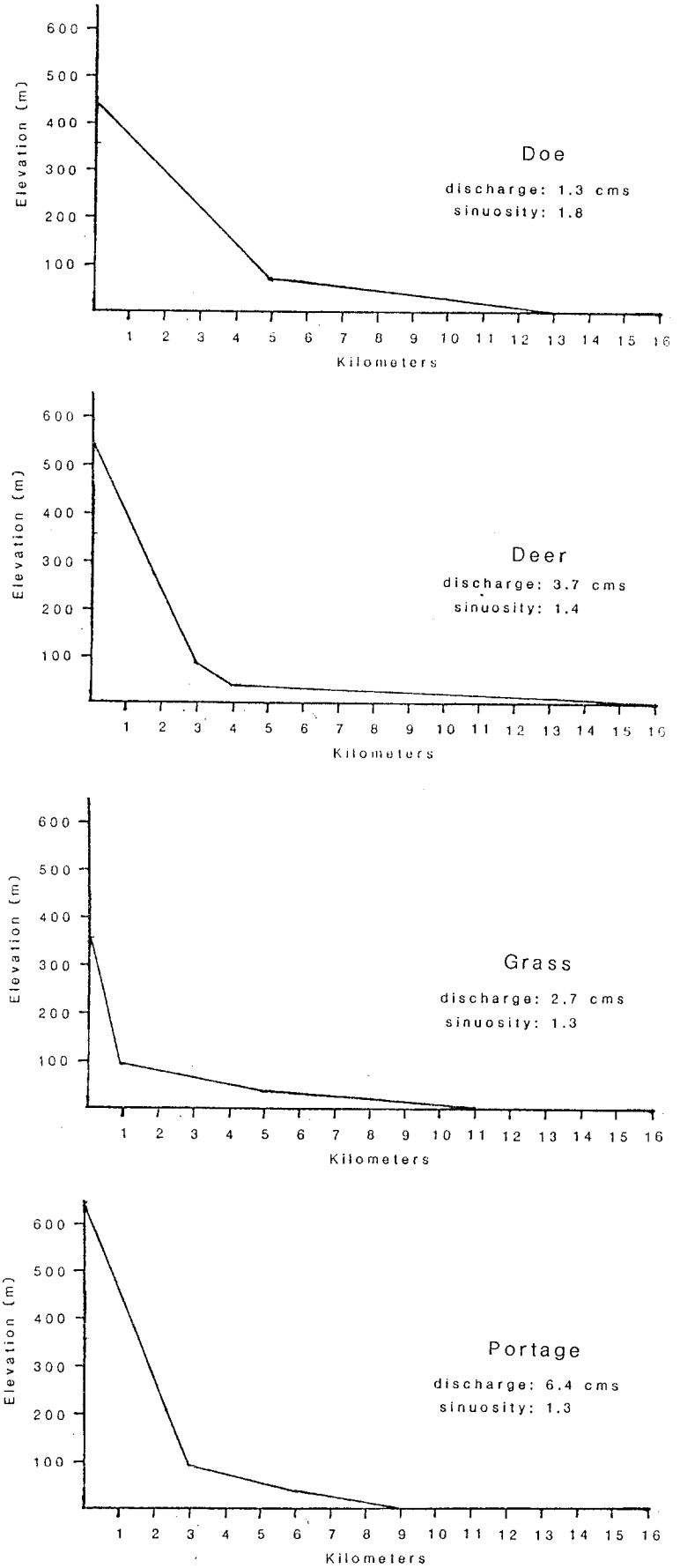


FIGURE 9. Stream elevation, length, discharge, and sinuosity (stream km/vally km) of selected streams in Herendeen Bay, Alaska. Discharge measured 25-29 June, 1985

conflicting reports point out the lack of definitive distribution information for many resident stream fishes of the Alaska Peninsula.

Young-of-the year sockeye salmon were found in the small lake systems in Grass Valley but we were unable to document sockeye in Deer Valley where Department personnel previously reported a spawning population (Anonymous 1986). A number of factors could explain this: 1) sockeye seaward migration was completed prior to our sampling dates; 2) poor fyke net placement; 3) very low numbers of sockeye outmigrants; or 4) misidentification of fry. Sockeye spawners were not observed in 1985 or 1986 (Anonymous 1985, 1986) so low numbers are suspected. Juvenile salmon overwintering areas are still unknown but the many small spring-fed tributaries and ponds appear to play an important role. Coho salmon juveniles of three age classes were found in spring-fed tributaries and ponds in all of the sampled watersheds. The lack of extensive lake systems in the area and short streams may be factors limiting production of overwintering species (e.g., juvenile coho and sockeye salmon, Dolly Varden char).

Temporal and spatial rearing area partitioning among juvenile coho was apparent as young of the year fry were found in the smaller tributaries and backwater pools whereas the larger juveniles (one and two year olds) were concentrated in the larger ponds and pools. Some of these spring-fed pools showed extreme water level fluctuations in response to precipitation. One pool was totally cut off from the stream during low water periods and inundated at high flows. During high water flows at the end of June, the larger coho juveniles apparently migrated out of the pools. It is not known whether these fish smolted and went to sea or moved to other areas of the stream. Young-of-the-year coho remained in the pools during this time. The extent of juvenile coho salmon movement between pools is also unknown, but the importance

of these areas for rearing and possibly overwintering is reflected by the population structure and size. Very few age 0 coho salmon were observed during the 1986 sampling in habitat areas that were heavily occupied in 1985. This could indicate that the fry migrate to rearing areas from main stem spawning areas in early summer (e.g., June), after we had completed the 1986 sampling. No adult coho were sampled so the percentages of zero, one and two year freshwater rearing periods is unknown.

Condition factor is often used to describe the condition or well-being of a fish (Carlander 1969). The coefficient of condition, K, was calculated for juvenile coho salmon to enable a comparison of rearing area richness and population characteristics among the proposed corridors. Condition has been calculated for age 0, 1 and 2 coho salmon from the Meshik River, Alaska, and for ages 1 and 2 for Herendeen Bay salmon. Fork length condition factors for Herendeen Bay coho are slightly smaller than for Meshik River coho, but statistical significance is unknown. A more rigorous study design is needed to ensure that condition factor variations produced by season, sex and genetics can be accounted for when comparing these populations and habitats.

Only three juvenile and one adult pink salmon were captured. The low number of juveniles captured could be due to one or more of the following: 1) the seaward migration was completed prior to the sampled dates; 2) low numbers of pink spawners in 1984 (150 were counted by Department biologists during aerial surveys); or 3) the fyke net was fished only during daylight hours in 1985. It is generally agreed that downstream migration of pink and sockeye fry is initially nocturnal and regulated by light intensity, especially for shorter distances (McDonald 1960). No pinks were reported by Department biologists during 1985 or 1986 Herendeen Bay aerial surveys (Anonymous 1985, 1986). It is

evident that Bristol Bay side streams are not important pink salmon producers on the Alaska Peninsula.

No chinook salmon (O. tshawytscha) were reported or observed in the study area during this survey. The short and relatively shallow streams in the area may limit the distribution of this species (Chambers et al. 1955). Only one adult Dolly Varden was captured and it was assumed to be anadromous. Juvenile Dolly Varden (n~20) were captured in Doe and Portage Valley pools and streams, but abundance appears to be low.

Adult chum salmon scales showed a freshwater rearing structure common among Alaska Peninsula chum populations (D. Bill, Alaska Department of Fish and Game, personal communication). These scales show a zone of closely spaced circuli numbering for 8 to 12 out from the focus, followed by 15 to 24 widely spaced circuli ending with the first annulus. This could be a result of a stream rearing period (indicated by the late migration timing) or a period of rearing in the nearshore estuarine areas before they move offshore to feed. Mason (1974) reports that entry into salt water is usually complete by June but that chum juveniles will come in with the tides to feed. Amur River fry have been reported to spend up to a month feeding in the spawning grounds (Levanidov 1954). Chum salmon fry were observed feeding in an upwelling pool in Doe Creek. This behavior may account for the capture of chum juveniles through July, although late spring conditions during 1985 (with resultant low water temperatures) may have contributed to this phenomenon. Juvenile chum salmon were found in high densities in upland sloughs and side channels through July 1983 in the Susitna River and 1982 catches confirmed that juvenile chums use these upland sloughs for rearing (Schmidt et al. 1984).

It is still difficult to say with any certainty when the peak outmigration of chum salmon occurs in Herendeen Bay streams. There was a general decline of

out-migrant numbers after mid-May but catches continued to be highly variable. The increased mean number of fish caught in 1986 may indicate the majority of chum salmon smolt in May. The last juvenile chum salmon was captured 20 August 1983 in the Susitna River, with peak outmigrations during late May and early June (Schmidt et al. 1984). The majority of fish in this river system (Susitna) had outmigrated by 15 July. These findings are very similar to the Herendeen Bay chum stocks; however, the duration of the outmigration is unknown. The Susitna River is a much longer system than the short Herendeen Bay streams, and probably has greater discharge fluctuations during the spring migration season. There was no statistically significant correlation between CPUE and stream discharge; however, on several occasions high CPUE's occurred with high flows, and the Susitna chum salmon outmigration rate showed a higher correlation with discharge than other species (Schmidt et al. 1984).

Chum salmon are the most abundant and widespread salmonid species in Herendeen Bay streams. Department catch statistics report a commercial chum catch of 258,842 fish and an estimated total escapement of 64,800 for a 1985 total run size in excess of 323,000 fish for Herendeen Bay streams (Anonymous 1985). Catch statistics from 1986 report a commercial catch of 20,420 and an estimated escapement of 44,500 for a total run of 64,920 (Anonymous 1986). Chum salmon utilize most of the Herendeen Bay spring-fed tributaries and the main stem streams for spawning. Pairing up and redd building activities began in early July but the duration of the run is unknown. The latest survey flown in the 1985 season was on 27 August and over 7,000 chums were reported in Deer Valley. The prolonged juvenile chum out-migration may indicate a late spawning population in Herendeen Bay.

Adult chum salmon sampled were predominantly age 0.4 with 0.3 fish second most represented. Age statistics for Herendeen Bay commercial catches are not

available for the 1985 season; however, age 0.3 fish were dominant in 1984 and 1986 (Anonymous 1984, 1986) and Bakkala (1970) stated that age 0.3 chum salmon are the dominant age class throughout the stocks of the world. The predominance of age 0.4 fish in this sample may be due to sampling only the early half of the run. Bricker (1982) reported that older fish returned earlier to the streams than the younger fish.

Coho salmon spawning areas have not been delineated in Herendeen Bay because Department aerial surveys are usually completed prior to the fall runs. Coho salmon entry timing into nearby Nelson (Sapsuk) River occurs in September (Anonymous 1985), and since 1976, coho have only been observed once in Doe Creek in September by the base camp cabin owner (C. Konigsberg, personal communication). The largest 1985 and 1986 commercial catches of coho in Port Moller occurred during the last weeks of August and early September (Anonymous 1985, 1986). Additional aerial surveys in late September and October will be necessary to estimate coho salmon escapement and document spawning habitat. The 16 October aerial survey covered Deer and Grass Valley Creeks. No salmon were observed; however, wind conditions prevented surveying of smaller streams and Deer Creek was highly turbid from recent rains. Very few carcasses were observed, but three bears were still on the stream and may have been feeding on salmon.

Sockeye spawners have been documented in Grass and Deer Valleys but their numbers are relatively low. The 19 July 1985 survey flown by Department personnel reported 700 sockeye in Grass Creek with 300 of these in the small lake system that it contains. The 1986 sockeye salmon escapement estimate in Grass Valley was 300 fish. No sockeye were observed in Deer Valley in 1985 (Anonymous 1985) or in 1986 (A. Shaul, Alaska Department of Fish and Game, personal communication). Local commercial fishermen reported catching only

seven sockeye in 1985 and 341 in the 1986 Herendeen Bay fishery (Anonymous 1985, 1986), which also suggests low sockeye numbers.

Main stem streams appear to provide good spawning habitat and the smaller tributaries provide rearing and possibly the overwintering habitat for resident and rearing species. Portage Valley is the narrowest corridor route while Grass and Deer Valleys have more extensive flood plains. A major habitat feature present in Grass and Deer Valleys but lacking in Portage Valley is small lake systems that support very small sockeye populations. Sockeye young-of-the-year were collected (N=25) in Grass Valley at one of these small lakes. We were unable to capture any sockeye salmon in Deer Valley, probably due to minimal sampling effort and small run size.

Portage Valley was surveyed up to the headwaters at the pass and habitats were characterized by elevation. The upper three km offers limited spawning and rearing habitat because of steep slopes (170 m/km), large boulder and bedrock substrate and few pools and slow water areas to provide velocity shelters. There were no fish observed in this area; however, downstream migration of rearing juveniles may have occurred previously. Limited sampling techniques may have failed to capture fish in this area. The middle reaches (approximately the 90 to 30 km elevation level) show an increase in the frequency of pools, side sloughs and backwaters and suitable spawning gravels. Sources of cover become more diverse (e.g., undercut banks, overhanging and instream vegetation) and rearing coho salmon, Dolly Varden and coastrange sculpins, were observed in this section. The lower reaches (30 km to sea level) offer both spawning and rearing habitats characterized by extensive backwater areas (e.g., spring fed tributaries, sloughs). Juvenile chum and coho salmon were abundant and widespread in these lower reaches.

Rearing areas appear to be limited to the lowest reaches of streams in backwater sloughs and tundra streams on valley floors. Juvenile coho salmon and Dolly Varden were found to the 30 km elevation in Portage Valley and in Grass Valley at the level of the lakes. Small tundra tributaries may play an important role for rearing where streams are of limited value. Coho and chum salmon juveniles were found in these tributaries in Deer, Doe, Portage and Grass Valleys.

Spawning and redd construction were directly observed in Doe Creek (chums only). The upstream limit of spawning activity is undetermined, but probably extends to the upstream limit of suitable gravels. The lower limit is very near the outlets (approximately 200 m from the mean high tide mark). Spawning surveys indicate chum spawning areas reaching the 30 km elevation in Grass and Portage Creeks, and to approximately the 90 km elevation in Deer Valley. Sockeye spawning areas include the small lakes in Grass and Deer Valleys (Anonymous 1982). Pink salmon spawning areas have been documented for many small streams on the Gulf of Alaska side of the peninsula. The extent and magnitude of the coho salmon spawning areas are unknown. More aerial surveys are planned to increase the data base for this species.

CONCLUSION AND RECOMMENDATIONS

The only apparent limiting factors to fish production are the size of the streams and the lack of extensive lake systems. Some species may have a very narrow window for spawning activities (e.g., coho salmon and smelts) and more information needs to be gathered to understand this life cycle requirement. Further documentation of species distributions, spawning and rearing area utilization, and important life cycle data (migration timing) are recommended to ensure that fishery resources are protected.

Specific studies to determine the effects of pipeline construction as well as increased human use should focus on the delicate nature of the habitats in this area. Although the numbers of fish in the Port Moller/Balboa Bay corridor are small compared to other Bristol Bay salmon producers, they still play an important role in both the commercial and subsistence fisheries, as well as being an intricate part of the refuge ecosystem. There are large populations of brown bears, marine mammals, bald eagles and other birds that depend on the fish resource.

Recommended studies include: 1) spawning area delineation for coho salmon; 2) juvenile chum salmon residence time in fresh water; 3) overwintering habitat availability, quality and utilization; and 4) migration timing and spawning characteristics of non-salmon species (i.e., Dolly Varden and smelts). This information could be used to help protect the limited spawning and rearing areas on these short peninsula streams. The small populations of sockeye and coho salmon may need additional protection if increased human use occurs. The small size of the streams would make both spawners and rearing juveniles very vulnerable to human disturbance.

ACKNOWLEDGMENTS

I thank Charles Konigsberg of Anchorage, Alaska, for allowing us the use of his cabin at Herendeen Bay. I also extend my appreciation to volunteers Mark Baker and John Peters and to Barbara Mahoney for their hard work and enthusiasm during the field season.

REFERENCES

Anonymous. 1982. An atlas to the catalog of waters important for spawning, rearing and migration of anadromous fishes, South Central Region 2. Alaska Department of Fish and Game, Habitat Division Resource Assessment Report, Anchorage.

Anonymous. 1985. Alaska Peninsula National Wildlife Refuge Final comprehensive conservation plan, environmental impact statement and wilderness review. U.S. Fish and Wildlife Service, Anchorage.

Anonymous. 1986. Aerial survey data of the Port Moller area. Alaska Department of Fish and Game, unpublished data, Kodiak.

Bakkala, R.G. 1970. Synopsis of biological data on the chum salmon Oncorhynchus keta (Walbaum) 1792. U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries. FAO Species Synopsis No. 41, Circular 315. Washington D.C.

Bricker, M.J. 1982. Biological and physical data taken at Russell Creek, Alaska Peninsula, 1981. Alaska Department of Fish and Game, Technical Report no. 62, Cold Bay, Alaska.

Bristol Bay Coastal Resource Service Area Board. 1984. Bristol Bay Coastal management program. Volume 1: Resource inventory. Bristol Bay Coastal Resource Area Board, Dillingham, Alaska.

Cederholm, C.J. and E.O. Salo. 1979. The effects of logging road landslide siltation on the salmon and trout spawning gravels of Stequaalero Creek and the Clearwater River basin, Jefferson County, Washington, 1972-1978. Final report Fisheries Research Institute. University of Washington. Seattle.

Carlander, K.D. 1969. Handbook of freshwater fishery biology, Volume 1. Iowa State University Press, Ames.

Chambers, J.S., Allen, G.H., and R.T. Pressey. 1955. Research relating to study of spawning grounds in natural areas. Washington Department of Fisheries. Annual report, 1955. Seattle.

Conwell, C.N. and D.M. Triplehorn. 1978. Herendeen Bay-Chignik coals, Southern Alaska Peninsula. Special Report 8. Division of Geological and Geophysical Surveys, College, Alaska.

Hanley, P.T., et al. 1981. Natural resource protection and petroleum development in Alaska. FWS/OBS-80/22. U.S. Fish and Wildlife Service, Biological Services Program. Washington, D.C.

Everhart, W.H. and W. D. Youngs. 1981. Principles of fishery science, second edition. Cornell University Press, Ithica, New York.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer. 1980. Atlas of North American freshwater fishes. Publication #1980-12 of the North Carolina Biological Survey, North Carolina State Museum of Natural History, Raleigh, North Carolina.

Levanidov, V.Y. 1954. Ways of increasing the reproduction of Amur chum salmon. (Transl. from Russian). Akademiya. Nauk SSSR. Ikhtiologicheskaya Komissya, Trudy Soveshanii, No. 4;120-128. Israel Program for Scientific Translations. Cat. No. 8. Office of Technical Services, U.S. Department of Commerce, Washington, D.C.

Mason, J.C. 1974. Behavioral ecology of chum salmon fry (Oncorhynchus keta) in a small estuary. Journal of Fishery Research Board of Canada. 31:83-92

McDonald, J. 1960. The behavior of Pacific salmon fry during their downstream migration to freshwater and saltwater nursery areas. Journal of Fisheries Research Board of Canada. 17(5):655-676.

Morrow, J.E. 1980. The freshwater fishes of Alaska. Alaska Northwest Publishing Co., Anchorage.

Koo, T.S.Y. 1962. Studies of Alaska red salmon. University of Washington Press. Seattle.

Schmidt, D. C., Hale, S. S., Crawford, D. L., and P. M. Suchanek. 1984. Resident and juvenile anadromous fish investigations (May-October 1983). Alaska Department of Fish and Game. Alaska Department of Fish and Game Susitna Hydro Aquatic Studies, Report No. 2. Anchorage.

Selkregg, L.L. (ed). 1976. Alaska regional profiles - Southwest region. Arctic Environmental Learning Center, University of Alaska, Anchorage.

Shaul, A.R., Schwarz, L.J., McCullough, J.N., and L.M. Malloy. 1985. Alaska Peninsula-Aleutian Islands area annual finfish management report. Alaska Department of Fish and Game, Finfish Data Report No. 1-86, Anchorage.

Shaul, A.R., Schwarz, L.J., McCullough, J.N., Malloy, L.M., and S.J. Theis. 1987. Alaska Peninsula-Aleutian Islands area annual finfish management report. Alaska Department of Fish and Game, Finfish Data Report no. 3-87, Anchorage.

Strahler, A.N. 1957. Quantitative analysis of watershed geomorphology. American Geophysical Union Transactions 38:913-920.

Trihey, E.W., and D.L. Wegner. 1983. Field Data Collection Procedures for Use with the physical habitat simulation system of the instream flow group. Cooperative Instream Flow Service Group, U.S. Fish and Wildlife Service, Fort Collins, Colorado.

Zar, Jerrold H. 1984. Biostatistical analysis. Second edition. Prentice-Hall Inc., Englewood Cliffs, New Jersey.

Appendix A.-Mean length and weight for sampled fishes of Herendeen Bay, Alaska.

Species		Mean length (mm)	Mean weight (g)	N
Alaska Blackfish		56	1.5	2
	range	50-62	1.0-2.0	
Threespine stickleback		61	2.5	34
	range	40-92	0.5-8.5	
Ninespine stickleback		39	--	7
	range	31-41		
Coastrange sculpin		55	--	2
	range	24-86		
Eulachon smelt		228	--	2
	range	225-230		
Dolly Varden char		121	24.1	9
	range	60-168		
Chum salmon		46	~.25 (est)	143
	range	34-60		
Sockeye salmon		30	~.25 (est)	7
		29-33		

Appendix B.-Fyke net catches from Herendeen Bay, Alaska.

1985 Date	Effort (hrs)	Catch CS	PS	SS	Other	Total	Mean catch/hour
29 May	1.5	27	1	0	0	28	18.6
31 May	3.0	107	0	0	0	107	35.6
7 June	7.0	214	0	2	0	216	30.8
17 June	7.0	36	1	0	0	37	5.2
19 June	7.0	59	0	3	1(CR)	63	9.0
21 June	7.0	56	0	1	0	57	8.1
24 June	7.0	11	0	0	0	11	1.5
26 June	7.0	25	0	2	2(EU)	29	4.1
28 June	7.0	7	0	0	3(EU)	10	1.4
1 July	7.0	19	0	0	2(EU)	21	3.0
3 July	7.0	28	0	1	0	29	4.1
5 July	7.0	33	0	0	1(EU)	34	4.8
8 July	7.0	11	0	1	0	12	1.7
10 July	7.0	11	0	0	1(CR)	12	1.7
12 July	7.0	10	0	0	1(CR)	11	1.5

Key

CS=chum salmon

PS=pink salmon

SS=coho salmon

RB=rainbow smelt

*=fyke data from Deer Creek

EU=eulachon smelt

SN=sharpnose sculpin

CR=coastrange sculpin

~=estimated catch from night fishing

Appendix B.-Continued

1986 Date	Effort (hrs)	Catch CS	PS	SS	Other	Total	Mean catch/hour
1 May	2.5	46	0	0	0	46	30.6
2 May	7.0	159	0	1	2(CR) 1(SN)	163	23.2
2 May	3.0	~800	0	~20	0	~820	
5 May	7.0	107	0	2	3(DV)	112	15.5
7 May	7.0	112	1	0	0	113	16.0
9 May	7.0	289	0	4	0	293	41.8
12 May	7.0	140	0	0	0	140	20.0
14 May	7.0	101	0	0	0	101	14.4
16 May	7.0	236	0	0	0	236	33.7
17 May	3.0	~800	0	5	3(DV)	~808	
19 May	7.0	138	0	1	1(DV)	140	20.0
21 May	7.0	65	0	1	0	66	9.4
23 May	7.0	65	0	0	2(DV)	67	9.5
24 May	3.0	~400	0	0	0	~400	
26 May	7.0	75	0	2	0	77	11.0
28 May	7.0	101	0	1	0	102	14.5
30 May	7.0	49	0	1	0	50	7.14
31 May	3.0	~800	0	0	0	~800	
2 June	7.0	34	0	1	0	35	5.0
4 June	7.0	116	0	3	1(RB)	120	17.0
6 June	7.0	125	0	0	0	125	17.8
9 June	7.0	215	0	1	0	216	30.8

Appendix B.-Continued

1986 Date	Effort (hrs)	Catch CS	PS	SS	Other	Total	Mean catch/hour
11 June	7.0	63	0	0	0	63	9.0
16 June	7.0	160	0	1	0	161	23.0
18 June	7.0	50	0	3	1(DV)	54	7.7
6 May*	4.0	43	0	0	0	43	10.7
16 May*	4.0	69	0	0	0	69	17.2
20 May*	5.0	98	1	1	0	100	20.0
26 May*	5.0	172	2	0	0	174	34.8