Results of Biological Assessment and Monitoring of Anadromous Fish at Summer Bay Lake, Unalaska Island, Alaska, 1998: Juvenile and Adult Fish Production the Summer Following the *M/V Kuroshima* Oil Spill

This document contains attachments pertinent to the study

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ABSTRACT

Fisheries studies began at Summer Bay Lake in 1998, to monitor those fishery production trends that may be influenced by the *M/V Kuroshima* oil spill. These studies included: 1) monitoring the abundance, size and age of emigrating juvenile sockeye *Oncorhynchus nerka*, pink *O. gorbuscha*, and coho *O. kisutch* salmon and abundance of Dolly Varden char *Salvelinus malma*, and 2) determining the adult salmon and Dolly Varden escapement into Summer Bay Lake. In addition, the salmon escapement age structure and size were assessed.

A total of 3,570 age 0. pink salmon fry emigrated from 9 May through 19 June and the peak emigration was on 28 May. Of 42,336 sockeye salmon smolt that emigrated, 39,515 (93.3%) were age 1., 2,619 (6.2%) were age 2., and 155 (0.3%) were age 3. fish. The majority (84%) of the sockeye smolt emigrated in July. Only 325 coho salmon smolt emigrated in 1998, of which ~50% were age 1. fish. Dolly Varden juveniles emigrated throughout the summer; however the majority of the emigration was in May and June. The average size of pink salmon fry was 0.2 grams (g) and 33 millimeters (mm). The sizes of age 1. (predominant age class) sockeye and coho salmon smolt were 8.9 g and 101 mm, and 10.5 g and 97 mm, respectively. Both sockeye and coho salmon juveniles appeared to feed primarily on dipteran insects.

Adult escapements into Summer Bay Lake were: 2,641 sockeye salmon from 12 June to 15 September, 7,290 pink salmon from 23 July to 26 September, 101 coho salmon from 17 August to 23 September, and 276 Dolly Varden from 5 July to 20 September. One adult female steelhead emigrated from Summer Bay Lake in 1998. Peak escapements occurred for sockeye salmon on 16 July (718), for pink salmon on 4 August (770), for coho salmon on 13 September (12), and for Dolly Varden on 9 August (53). The majority of the sockeye salmon were ages 1.2 (63.2%) and 1.3 (31.8%) fish, while coho salmon were about half age 1.1 (53.1%) and half age 2.1 (46.9%) fish. Average sizes of adult sockeye and coho salmon were 518 mm and 637 mm, respectively. Sockeye salmon sex ratios were 51.4% female: 48.6% male, and coho salmon sex ratios were 44.3% female: 55.6% male. Sockeye salmon distributed throughout the shoal areas of Summer Bay Lake in July, with some entering the main inlet tributary from mid August to mid September. The majority of sockeye salmon appear to spawn in shoal areas on the west side of the lake. Pink salmon entered the inlet tributary in mid August, with peak numbers observed on 25 August, and spawning activity observed shortly thereafter. The majority of the pink salmon spawned in the inlet tributary, and none were observed utilizing shoal areas of the lake.

Estimates of resident juveniles in Summer Bay Lake at the time of the *M/V Kuroshima* oil spill suggest that sockeye salmon smolt were least likely to have been impacted by oil. Conversely, pink and coho salmon juveniles were more likely to have been impacted by oil as implied by higher rearing estimates compared to actual emigrations. Estimates of remaining (post emigration) juveniles in the lake are substantial and along with the persistence of oil, may indicate future oil related implications for fish production.

The wide distribution and the characteristics of the fuel oil spilled in Summer Bay Lake and the early freshwater life histories of endemic fish suggest a high probability of direct exposure to hydrocarbons, as well as a potential for many indirect (to primary and secondary producers) impacts. There are sufficient similarities to the *Exxon Valdez* oil spill (EVOS) and other spills in

subarctic climates that relevant research should be considered when assessing damage to Summer Bay Lake.

The impacts of the *M/V Kuroshima* oil spill on Summer Bay Lake fish will not be known until several years of additional juvenile and adult production data are collected to provide brood year survival information. Lastly, poly-cyclic aromatic hydrocarbon (PAH) analyses from juvenile fish collected in 1998 will be important for oil impact assessment, especially if fish runs decline in the future.

INTRODUCTION

On November 26, 1997, the *M/V Kuroshima* went aground in Summer Bay just outside the city of Unalaska/Dutch Harbor (Figure 1), spilling approximately 39 thousand gallons of heavy bunker C fuel oil (Group V oil) into the water. Storm conditions, along with high tides, washed oil onto the coastline and eventually into Summer Bay Lake.

Identifying the source of the petroleum relies on special chemical characteristics of the spilled oil to distinguish it from other potential sources in the area of the spill and from background hydrocarbons (Stein et al. 1998). Determining the environmental fate of petroleum is dependent on a number of factors, such as the type of petroleum, weather and oceanographic conditions, and the geography of the spill site.

Group V oils (bunker C) have an API gravity less than 10° at 60°F, meaning that the specific gravity is less than or equal to 1.00 mg/l, the same as fresh water (NOAA 1994). Thus, Group V oils can float, be neutrally buoyant, or sink in water, depending on the properties of the specific oil and the salinity of the receiving waters. They are called Group V fuel oils to differentiate them from other types of Group V oils, such as asphalt, asphalt cutter stock, and very heavy crude oils. Group V fuel oils are likely to be chemically different than conventional crude oils, because of market-driven changes in source and production. Spilled fuel oil may separate into components that can float, suspend, and sink simultaneously, depending upon chemical properties. Group V fuel oil is much more likely to sink in freshwater due to the incorporation of sand. If only the water-soluble fraction is considered, bunker C is rated as toxic as diesel (Markarian et al. 1993). Thus, even though heavy residual oils are not usually considered to be acutely toxic to fish, spills that mix into the water column without first weathering (by evaporation) on the water surface may increase the amount of oil that dissolves and, therefore, promote acute toxicity to fish. Group V fuel oil poses significantly greater risks to natural resources, compared to floating oil spills, because it can float, sink, become neutrally buoyant, or separate and possess all three characteristics.

Several factors need to be considered to determine the deleterious effects on natural resources in the area of the spill. These include identification of which species are at risk of elevated exposure; which species present are reproductively active or present as sensitive larval or juvenile stages; and which species near the spill have populations that are depleted (Stein et al. 1998). The primary emphasis of the investigation of ecological effects is on determining the exposure of natural resources to and the toxic effects from the petroleum. The exposure of fish to aromatic hydrocarbons can result in a variety of adverse biological effects, many of which are associated with formation of reactive metabolites that exert their toxicity by binding to cellular macromolecules (Varanasi et al. 1989).

Crude oil contamination in Prince William Sound (PWS) from the EVOS resulted in sub lethal effects to herring and salmon stocks (Hose et al. 1996; Weidmer et al. 1996; Marty et al. 1997). Adults and juvenile pink salmon were vulnerable to oil exposure due to their extensive use of intertidal spawning areas and nearshore marine rearing areas, respectively (Bue et al. 1998). Pink salmon embryo mortality was significantly greater in oiled versus reference streams (Bue et al. 1996; 1998) and similar results were observed in laboratory tests (Heintz et al. 1995; Marty et al. 1997). Observations of PAH concentrations in sediments in pink salmon streams in PWS were consistent with the minimum concentrations required to impart both short and long-term damage in the laboratory (Heintz et al. 1995). Development of pink salmon incubating in gravel contaminated with weathered Prudhoe Bay crude oil was retarded at concentrations as low as 55.1 ug oil/g gravel, and several other oil-related changes were indicative of premature emergence (Marty et al. 1997). In addition, past research indicated that pink salmon embryos absorb PAHs (Moles et al. 1987) and that these compounds were capable of inducing chromosomal lesions (McBee and Bickham 1988) and influence endocrine function (Thomas and Budiantara 1995). Potentially, this genetic or physiological damage to one brood year would be expressed two years later in pink salmon since they have two genetically isolated lineages (odd and even years; Heard 1991).

There has been very little anadromous fish research on the Alaska Peninsula or Aleutian Islands, with the exception of escapement and harvest estimates. The earliest harvest records for the Alaska Peninsula date back to 1906, whereas commercial catches were first recorded in 1911 for the Aleutian Islands Management Area (Shaul and Dinnocenzo 1999). There are reportedly nearly 600 salmon systems in this region of which 70 support sockeye salmon runs and 105 have coho salmon runs (Murphy 1992). Nearly all of these systems have pink and/or chum *O.keta* salmon runs.

Several lakes on the Alaska Peninsula in the vicinity of Cold Bay were recently evaluated for potential sockeye salmon production or rearing capacity using limnological characteristics (Kyle et al. 1993). The limnology of these lakes as a group was unique in terms of sockeye salmon habitat in that some were very shallow, brackish or saline, and the zooplankton community was dominated by various marine taxa. This research was recently (1993-1995) expanded to other watersheds that support salmon on the Alaska Peninsula and Aleutian area, including Summer Bay Lake on Unalaska Island (Honnold et al. 1996).

Summer Bay Lake is located on the northwest side of Unalaska Island, approximately 6.8 km northeast of the city of Unalaska (Figure 1). The lake drains into Summer Bay (part of the larger Unalaska Bay) by way of Summer Bay Creek. Little was known about juvenile and adult fishery production limitations in Summer Bay Lake, other than the low sockeye salmon escapements (450 average from 1986-1995), prior to this recent research (Honnold et al. 1996). Recent research found the lake to be oligotrophic (nutrient poor) and indicated rearing habitat limitations. Modeling of the lake's surface area estimated potential sockeye salmon production to be 1,100 fish. Low zooplankton biomass suggested that the lake was a poor candidate for fry stocking; however, late fall stocking of presmolt was recommended as a suitable alternative stocking strategy. Although phosphorous and chlorophyll were somewhat deficient, levels were not within the established criteria for lake enrichment (Honnold et al. 1996). A suitable hatchery fry delivery system for sockeye and/or coho salmon did not exist; thus, initial recommendations for enhancement were not implemented. Further baseline limnology data were not collected after 1994 at Summer Bay Lake and baseline fishery data were limited to aerial survey indices of pink and sockeye salmon escapements.

Therefore, several fishery investigations were initiated in 1998 at the Summer Bay Lake system by the lead federal administrative trustee, the National Atmospheric and Oceanic Administration (NOAA). Various federal and state agencies and local native groups proposed investigations to determine the effects of the *M/V Kuroshima* oil spill on the surrounding environment. NOAA proposed that funding for these studies would come from the U.S. Coast Guard (USCG) Oil Spill Liability Trust Fund. The Alaska Department of Fish and Game (ADF&G) proposed juvenile and adult salmon enumeration projects to collect baseline data for assessing the status of Summer Bay Lake salmonid productivity (ADF&G 1998). Juvenile salmon migrations from the lake (to the ocean) have not been documented in the past. Juvenile migration and adult escapement data, as well as an improved understanding of the biological attributes of each stock, were considered essential to assist with any future restoration planning.

The goal of the project was to assess the abundance and biological attributes of juvenile and adult anadromous fish and to monitor the potential effects of the oil spill at Summer Bay Lake. Project objectives included: (1) estimating the number and timing of juvenile salmon and Dolly Varden emigrating from the lake, (2) estimating the average age composition, size, and condition factor of the sockeye and coho salmon smolt emigration and the average condition of the pink salmon fry emigration, (3) collecting juvenile salmon samples for use in additional analyses as determined by the resource trustees, (4) estimating adult salmon escapement, distribution, and age structure by species, and (5) summarizing all project activities in a written report.

The purpose of this report is to chronicle the initial data collection efforts conducted on the Summer Bay Lake system, and to discuss potential oil spill effects. This discussion will include production modeling to provide an indication of the number of juvenile salmon present in Summer Bay Lake in 1998 after the oil spill and what fish remained in the lake after the 1998 emigrations.

Description of Study Area

Summer Bay Lake (53° 53' N, 166° 24' W) is located on the Unalaska Island road system approximately 6.8 kilometers northeast of the City of Unalaska (Figure 1). The lake is considered oligotrophic (nutrient poor) and is 0.4 km long by 0.25 km wide with a surface area of 0.2 km^2 (Honnold et al. 1996). The mean depth and maximum depth of the lake is 5.8 m and 11.3 m, respectively. The Summer Bay Lake peak fish counts (live fish) from 1988-1997 aerial and/or foot surveys averaged 311 sockeye salmon, 1,248 pink salmon, and 9 coho salmon (ADF&G database). The pink salmon odd-year and even-year averages were 69 and 1,720 fish, respectively. Escapement estimates of salmon species have been difficult to ascertain on a consistent basis due to limitations associated with aerial survey techniques. Limnological investigations were conducted on the lake in 1994 (Honnold et al. 1996). The estimated production based on the lake's surface area is 1,100 adult sockeye salmon. Fish known to inhabit

Summer Bay Lake are sockeye salmon, pink salmon, coho salmon, Dolly Varden char, three spine stickleback *Gasterosteus aculeatus*, and freshwater sculpin *Cottus aleuticus*. In addition, starry flounder *Platichthys stellatus* have been observed in the lake.

METHODS

Juvenile Fish Assessment and Monitoring

Weir and Trap Description, Installation, and Operation

A juvenile fish trapping system, consisting of a diversion weir and one incline plane trap with attached collection tank, was installed in the Summer Bay Lake outlet stream just below the bridge on 9 May (Figure 2). The weir was placed in the river in a "V" shaped configuration with the two wings leading from adjacent stream banks to the incline plane smolt trap positioned mid channel.

Initially, fence posts were used to support the weir configuration; however, high water and strong winds (>50 mph gusts) washed out the east wing of the weir on 25 May. A pipe frame was placed behind this side of the weir for additional support and consisted of 1.5 m (legs), and 2.4 m (cross members), 5 cm diameter pipe and NU-RAIL fittings. Additionally, a system of fence posts and rope was placed around the smolt trap to adjust the trap height. The fence-post supported west wing was compromised due to high water on 6 June and was replaced with a pipe frame shortly thereafter. The face of the weir comprised 1.2 m by 2.4 m sheets of aluminum perforated plate ~ 3 mm thick with 3 mm diameter holes on 1.1 cm staggered centers. The base of each sheet of perforated plate was positioned on the stream bed substrate. Sandbags were installed where the weir met the stream banks and along the base of the weir. Sandbags were lined with polypropylene (lortex) material to prevent fish from escaping. Lortex was also used to line other areas of the weir to prevent potential injury to fish. Similarly, the inside of the trap was lined with lortex as needed. The incline plane trap comprised structural aluminum angle framing and cross-bracing of the following dimensions: 1.0 m wide by 2.4 m long by 0.8 m high. Thus, the entrance of the trap was 1.0 m by 0.8 m and the base of the inside of the trap (incline portion) tapered for approximately 2.0 m from a height of ~ 0 m to 0.8 m. A hinged aluminum plate (0.3 m by 1.0 m) was attached downstream of the incline for adjusting the flow through the trap and the attached fish collection box. The sides and base of the trap were covered with ~ 3 mm thick aluminum perforated plate with 1 cm diameter holes on 1.1 cm staggered centers.

The weir and trap were monitored at least every two hours from 2300 to 0600 hours and at least every four hours during daylight periods. Monitoring was increased during heavy emigrations. When monitoring the trapping system, the wings of the weir were cleaned of debris and the trap was adjusted to provide optimal flow (measured subjectively, based on the movement of fish) and to minimize mortality. The weir was also cleaned of all oil and oily debris when necessary. When significant oiling of the apparatus occurred, the time, location of oil, amount of oil, and any associated mortality were recorded. The trapping system was moved upstream of the bridge on 2 August to provide for installation of a separate adult weir, which was placed downstream of the bridge. The trapping system operated through the end of August at this site.

Emigration Counts

All salmonids were dip-netted from the holding box of the trap, counted individually and released. In addition, emigrating starry flounder, freshwater sculpin, and three-spined stickleback were tallied. A single counting day was the 24-hour period from noon to noon and identified by the calendar date corresponding to the first noon.

The trapping system was compromised and either did not fish or fished at less that 100% efficiency intermittently during the season because of high water or to pass migrating adult salmon. Missed juvenile emigrations were estimated in two ways. First, when the trapping system was at 0% efficiency, the mean passage rate (fish/hr) was calculated for the enumeration day (24-hour period from noon to noon) previous to and after the compromised period. This mean rate was multiplied by the number of hours the weir and trap were out of commission. Second, trap efficiency was estimated and the counts were adjusted proportionately when the trapping system was fishing > 0% but < 100% efficiency.

Salmon Age and Size

A portion of captured sockeye salmon smolt, coho salmon smolt, and pink salmon fry were sampled daily for age-weight-length (AWL) information. Fish were held for sampling in a live box (1.0 m by 1.0 m by 1.0 m) placed in the river. Approximately 40 sockeye salmon smolt were sampled daily for five days per week. AWLs were desired from 40 coho salmon smolt per day for three days per week when available; however, they had poor survival in the live box (especially after sampling) and most were released without sampling. Thus, fifteen baited (salmon roe) minnow traps were fished (Gray et al. 1984; Kyle 1990) on 11 and 20 August and 4 September at nearshore areas of the lake for 18 - 43 hour periods to collect salmon juveniles (Figure 3). All juvenile fish captured were enumerated by species and catch-per-unit-effort (hours; CPUE) calculated. Coho salmon over 80 mm (similar size to emigrating smolt) were sampled for AWL data. Length and weight was measured from 40-50 pink salmon fry nightly, when available.

Each AWL sample was taken from a single day's catch. A single sampling day was the 24-hour period from noon to noon, identified by the calendar date corresponding to the first noon. Smolt and fry were anesthetized in a tricaine methanesulfonate (MS-222) solution, measured to the nearest 1.0 millimeter (mm), and weighed to the nearest 0.1 gram (g). The ponderal index (condition coefficient K) was calculated (Bagenal 1978) using:

$$\hat{K} = \frac{W}{L^3} 10^5 \qquad (1)$$

where:
K=smolt condition factor
W=smolt weight in grams (g)
L=smolt length in millimeters (mm)

In addition, a scale smear was taken from the preferred area (INPFC 1963) of each sockeye and coho smolt, placed on a glass slide, and ages were determined using a microfiche projector (ADF&G 1998). The fish were revived in fresh water and then released downstream of the weir.

Salmon Stomach Content Analysis

Six sockeye salmon smolt and three coho salmon smolt were collected via the juvenile trapping system, and anesthetized with MS-222 to prevent regurgitation of stomach contents. Each fish was measured for length (nearest mm), weight (nearest 0.1 g), and scales collected for age analysis, and then frozen whole. Two of the sockeye salmon smolt were collected 5 June and the remainder on 18 June. The coho salmon smolt were collected on 18 June. The smolt were thawed on 5 January 1999 and their stomachs removed. Stomachs were visually determined to be either empty, partially full, full, or distended. Stomach contents were placed in a petri dish and examined under magnification with reflected light. All contents were identified to the lowest possible taxon (McCafferty 1983). The percentage by volume of each taxon per stomach was estimated and pooled by family.

Collection of Salmon for PAH Analysis

Fourteen sockeye salmon smolt, three coho salmon smolt, and six juvenile Dolly Varden were collected via the juvenile trapping system for future PAH analysis. In addition, ten coho salmon juveniles, of similar size to emigrating smolt, were collected by minnow trapping in Summer Bay Lake. Finally, one dead sockeye salmon smolt, two dead coho salmon smolt, and one dead juvenile Dolly Varden, all contaminated with oil, were collected from the weir. The live sockeye and coho salmon collected were anesthetized with MS-222, measured for length (nearest mm), weight (nearest 0.1 g), and scales collected for age analysis, and then frozen whole. The Dolly Varden and dead fish collected were frozen whole without sampling for AWL. One live sockeye salmon smolt was collected the 5 June and the remainder on the 5 August. The live coho salmon smolt were collected on 21 August (10 by minnow trapping) and on the 4 September (3 emigrating). The dead samples were collected on the 5 June. The samples were shipped under chain of custody protocol to the National Marine Fisheries Service, Auke Bay laboratory in late October 1998 for future PAH analysis.

Adult Fish Assessment and Monitoring

Weir Description and Installation

The original juvenile fish trapping configuration dually served as an adult counting weir from 9 May to 4 August. A gate, one-way trap, and holding pen were installed in the weir to pass returning adult salmon. A separate adult weir was placed downstream of the bridge on 4 August. This weir consisted of a pipe frame (as described for juvenile trapping system), and supporting panels consisting of 4 cm diameter aluminum pickets spaced approximately 4 cm apart. The one-way adult trap was configured into this weir. The weir washed out and was reinstalled 10 and 19 September, and was pulled and the project terminated 24 September.

Weir Operation and Escapement Counts

Immigrating salmonids were counted by species as they passed upstream through the weirs. Sockeye salmon would not approach the original juvenile/adult weir during daylight hours due to shallow water. It was undesirable to open the gate and pass adults at night, because opening the gate would compromise the trapping efficiency for juveniles. Therefore, sockeye salmon were dip-netted into the trap/holding pen at night, enumerated and sampled for size and age information the following day, and released upstream. Due to the run strength, this was acceptable for most of the run. On one occasion (16-17 July), sockeye salmon numbers made it necessary to open the gate at night. Adult pink salmon would not pass through the juvenile/adult weir during daylight hours or when approached by people (including weir personnel). The juvenile/adult weir was moved upstream of the bridge on 4 August to improve the movement of pink salmon. This weir site required frequent removal of panels to allow flushing of lake detritus and resulted in compromised juvenile and adult counts. Thus, a separate adult weir was installed downstream of the bridge to improve counting methods, and avoid compromising the enumeration, while still passing fish upstream. The downstream weir was used to enumerate adult salmon when it became necessary to pull a panel in the upstream weir. These modifications improved pink salmon passage, but still posed enumeration challenges. Pink salmon were passed by opening the downstream weir for a period of time and counting the fish between the two weirs after the downstream weir was closed. Then the upstream weir was opened to pass as many pink salmon as possible. Both weirs were then closed and the salmon between the two weirs were recounted. The difference between the two counts was the escapement. This method was improved by adding a one-way trap to the downstream weir on 26 August. Pink salmon were captured in the trap, counted, and released upstream of the lower weir. This provided an absolute count of fish upstream of the downstream weir, and negated the need to use the "difference" method. Estimates were made on site of adult salmon passage while the downstream weir was not 100% fish tight based on the numbers of fish in the stream.

Escapement Age, Size, and Sex Ratio

Age, length, and sex (ALS) data were collected from a portion of the sockeye and coho salmon escapement. Scales were collected from the preferred area (INPFC 1963) and mounted on gum cards. Impressions were made on cellulose acetate (Clutter and Whitesel 1956) and fish ages were classified by examining scales for annual growth using a microfiche reader (Mosher 1968). Ages were recorded on forms using European notation (Koo 1962). Fish lengths were measured from mid-eye to fork-of-tail to the nearest millimeter. Length composition data were summarized by age and sex representing the fish sampled (Nelson and Swanton 1996). Sex was determined by visually examination of morphological characteristics. Sampling was random and distributed throughout the escapement period for each species.

Escapement Distribution

Escapement distribution surveys in the Summer Bay Lake system were conducted from July through November at the primary tributary (inlet) creek, the outlet creek and lake shoals (Figure 3). Tributary and outlet surveys were conducted on foot, walking upstream until fish were not observed. Surveys were then replicated by walked back downstream. Lake shoals were surveyed by raft. All live and dead adult fish were enumerated by species.

Climatological Measurements

Water temperature (^{0}C), air temperature (^{0}C), stream depth (cm), wind direction (n-s) and velocity (mph), were measured twice daily from 9 May to 22 September at the Summer Bay Lake outlet stream. A standard Celsius thermometer was used to measure temperature, a meter rule was attached to a fence post and secured to the stream substrate to measure relative stream depth, and a wind sock was used to measure wind direction and velocity.

In addition, two Onset StowAwayTM thermographs capable of recording temperatures between –5°C and +37°C were used at the Summer Bay Lake outlet stream to record air and water temperatures. The thermograph loggers recorded data about every two hours. The thermographs were housed in plastic pipes with numerous holes to allow free passage of air and water. One pipe was attached in the shade under the bridge by means of a wire cable to collect air temperatures and the other pipe was attached underwater with cable to a bridge piling to collect water temperatures. Both were installed on 1 September 1998. Rocks were added to the interior of the latter pipe so that the entire unit would sink to the stream substrate surface. The thermographs that collected air and water temperatures were downloaded in the field with a small shuttle device on 30 May 1999.

Models of Juvenile Fish Production

Two models were used to project the numbers of each species of juvenile salmon residing in Summer Bay Lake at the time of the oil spill in 1997 and the numbers remaining after the 1998 juvenile migrations were complete. The peak count multiplier (PCM) model projected juvenile fish abundance using the following series of equations (production parameters and sources are listed in Appendix A):

$$\hat{b}_i = a_i c_i \qquad (2)$$

where :

$\hat{b}_i$ = estimated salmon escapment during brood year *i* for sockeye or pink or coho salmon;

a_i = peak salmon count during brood year *i* for sockeye or pink or coho salmon;

c_i = multiplier used to expand peak count for brood year *i* for sockeye (2.0) or pink (1.9) or coho (2.4) salmon;

$$\hat{d}_i = \hat{b}_i e \qquad (3)$$

where :

$\hat{d}_i$ = estimated number of females in escapement during brood year *i* for sockeye or pink or coho salmon;

e = proportion of females in escapement samples in 1998 for sockeye or pink or coho salmon;

(4)

$$\hat{f}_i = \hat{d}_i g$$

where :

$\hat{f}_i$ = potential egg deposition (PED) from brood year year i for sockeye or pink or coho salmon;

g = average fecundity for sockeye (2500) or pink (1858) or coho (4835) salmon from literature;

(5)

$$\hat{h}_i = \hat{f}_i i$$

where :

$\hat{h}_i$ = estimated number of emergent fry from brood year i for sockeye or pink or coho salmon;

i = average survival from PED to emergence for sockeye (7%) or pink (6.4%) salmon from literature;

(6)

$$\hat{j}_i = \hat{h}_i k$$

where :

$\hat{j}_i$ = estimated number of surviving juveniles from brood year i for
sockeye or pink or coho salmon;

k = average freshwater survival from emergence to emigration for sockeye (21%) or pink (85%; assumed) salmon and survival from PED to emigration for coho salmon (2%) from the literature;

(7)

$$\hat{l}_i = \hat{j}_i \hat{n}_i$$

where :

$\hat{l}_i$ = estimated number (potential) of emigrants in 1998 from brood year i for sockeye or pink or coho salmon;

$\hat{n}_i$ = proportion of 1998 actual emigrants from brood year i for sockeye or pink or coho salmon;

(8)

$$\hat{p} = \sum_{i=1} \hat{l}_i$$

where :

$\hat{p}$ = estimated (potential) total number of emigrants in 1998 from brood years n for sockeye or pink or coho salmon;

(9)

$$\hat{o}_i = \hat{j}_{i+1} n_i$$

where :

$\hat{o}_i$ = estimated number of remaining juveniles in lake after 1998 emigration s from brood year i for sockeye or pink or coho salmon;

$$\hat{q} = \hat{p} - m \quad (10)$$

where :

$\hat{q}$ = difference between estimated (potential) number of emigrants in1998 from brood years n and actual number of emigrants in 1998;

m_i = actual number of emigrants in 1998 for sockeye or pink or coho salmon;

The peak count divider (PCD) model projected juvenile fish abundance using the same series of equations as the PCM model; however, equation two is replaced by equation 11 described below (production parameters and sources are listed in Appendix A):

$$\hat{b}_i = \frac{a_i}{\frac{a_{1998}}{t_{1998}}} \quad (11)$$

where :

a_{1998} = the 1998 peak salmon counts for sockeye or pink or coho salmon;

t_{1998} = the 1998 weir counts for sockeye or pink or coho salmon;

Sockeye and coho salmon escapements were calculated for 1994-1997 brood years and pink salmon escapement for 1997 brood year. The selection of brood years was based on 1998 smolt age compositions.

RESULTS

Juvenile Fish Assessment and Monitoring

Salmon and Dolly Varden Emigrations and Timing

Pink salmon fry (age 0.) were the first juveniles to emigrate from Summer Bay Lake and were captured immediately when the weir and trap were installed on 9 May (Table 1; Figure 4; Appendix B). The pink salmon emigration peaked 28 May (1,065 fry), and none were captured after 19 June. A total of 3,570 pink salmon fry were counted, including an estimate of 646 when the trap was compromised (Appendix C), and 61% (2,172) of the emigration occurred the week of 30 May (Table 1).

Very few sockeye salmon smolt emigrated from Summer Bay Lake until mid June (Table 1; Figure 4; Appendix B). There was a substantial increase in the emigration during the last two weeks in June, another larger peak the last two weeks in July, and a rapid decline in the emigration in August. The last sockeye salmon smolt to emigrate was on 28 August. A total of 42,336 sockeye salmon smolt emigrated (129 were estimated while the trap was compromised; Appendix C) and 84% (~36,000) were enumerated in July (Table 1).

Approximately 93.3 % (39,515) of the overall sockeye salmon smolt emigration were age 1. fish compared to only 6.2% (2,619) age 2. fish, and 0.4% (155) age 3. fish (Table 1; Figure 5; Appendix B). Both the age 2. and 3. smolt emigrations peaked early, the week of 27 June, compared to the age 1. smolt emigration which peaked the week of 25 July (Table 1; Figure 5).

Only 325 coho salmon smolt emigrated from Summer Bay Lake in 1998 (Table 1; Appendix B), of which 30 were estimated (Appendix C). Approximately 3% (10) emigrated in May, 27% (88) in June, 14% (44) in July, and 56% (183) in August (Figure 4). The peak emigration was on 19 August (22 fish) and the last smolt emigrating were on 27 August (4).

The majority (50.3%) of emigrating coho salmon smolt were age 1. fish (163); however, 28% (91) were age 2. and 21.3% (69) were age 3. juveniles (Table 1; Figure 5; Appendix B). Emigration timing was similar for these three age class with the exception of a small number (10) of age 1. smolt that emigrated in May.

The emigration of juvenile Dolly Varden began similarly to pink salmon fry on 9 May, but peaked a week later (6 June), and a few fish continued to leave the lake all summer (Table 1; Figure 4 and 5; Appendix B). A total of 2,371 Dolly Varden were estimated to emigrate from Summer Bay Lake in 1998.

Salmon Age and Size

The age composition of the 1,592 sockeye salmon smolt sampled from the Summer Bay Lake emigration from weeks ending 9 May through 8 August was 0.1% age 0., 77.8% age 1., 19.8% age 2., and 2.3% age 3. fish (Table 2; Figure 6). There was a higher proportion of age 1. smolt during peak emigrations, which resulted in more overall (93.3%) fish of this age class in the total emigration (Table 1; Figure 5; Appendix B).

The average sizes of emigrating sockeye salmon were 1.5 g and 57 mm for age 0. smolt, 8.9 g and 101 mm for age 1. smolt, 24.5 g and 135 mm for age 2. smolt, and 40.9 g and 162 mm for age 3. smolt (Table 2; Figure 7). Condition factors (K) for sockeye salmon smolt were all over 0.80 and were highest for older smolt.

A total of 113 coho salmon were captured by minnow trapping (CPUE = 1.3/hour), of which 40 over 80 mm in length were sampled for AWL (Appendix D). The mean age composition of the coho salmon smolt sampled from the Summer Bay Lake emigration (N=35) and from minnow trapping (N=40 >80mm), combined, from weeks ending 16 May through 5 September was

49.3% age 1. fish, 40.0% age 2. fish, 9.3% age 3. fish, and 1.3% age 4. fish (Table 2; Figure 6). There was a higher proportion of age 1. smolt during peak emigrations, which resulted in more overall (50.3%) fish of this age class in the total emigration (Table 1; Figure 5; Appendix B).

The average sizes of emigrating coho salmon were 10.5 g and 97 mm for age 1. smolt, 18.5 g and 123 mm for age 2. smolt, 23.6 g and 137 mm for age 3. smolt, and 32.1 g and 154 mm for age 4. smolt (Table 2; Figure 7). Condition factors (K) for coho salmon smolt were all over 0.85 and, in contrast to sockeye salmon smolt, were highest for younger smolt. Most juvenile coho salmon captured in the minnow traps were larger than 70 mm FL (Figure 8).

Pink salmon fry were not aged; however, they were presumed to all be age 0. (Table 2). Their (N=368) average size was 0.2 g and 33 mm, which equates to a condition factor of 0.53 K (Table 2; Figure 7).

Sockeye and Coho Salmon Stomach Contents

Four of the six juvenile sockeye salmon stomachs were empty, while the remaining two stomachs were full (Table 3). Both fish were consuming primarily insects of the Order Diptera, which were in the aquatic life stage. Approximately 90% of the identifiable stomach content volume comprised the Family Chironomidae, of which the majority (70% of total volume) were in the larval stage, compared to few (20% of total volume) in the pupae stage. The remaining 10% of the sockeye stomachs with food contained insects of the Family Ceratopogonidae.

Two of the three juvenile coho salmon stomachs were partially full and the other was empty (Table 3). The two fish were also consuming insects of the Order Diptera, which were in the pupae (40% of the identifiable volume) and adult (60% of the identifiable volume) aquatic life stages. Approximately, 60% of the stomach content volume comprised the Family Chironomidae and the remaining stomach volume (40%) contained insects of the Family Ceratopogonidae.

AWL of Sockeye and Coho Juveniles Collected for PAH Analysis

Sockeye salmon smolt collected for PAH analysis were primarily (85.7%) age 1 (N=12). fish and had an average weight of 8.7 g and average length of 97 mm. One age 0. smolt was collected, which weighed 1.2 g and was 51 mm long. Also, one age 4. smolt was collected, weighing 310.4 g and was 442 mm long. This particular fish had all the characteristics of a smolt, but was of the size of a precocious (jack) adult sockeye salmon. It was, however, emigrating from, rather than immigrating to Summer Bay Lake.

Coho salmon juveniles collected for PAH analysis were 46% (N=6) and 54% (N=7) age 1. and age 2. fish, respectively. The age 1. fish averaged 16.5 g and 113 mm in size compared to the age 2. fish, which averaged 21.6 g and 125 mm in size.

None of the sockeye salmon, coho salmon, or Dolly Varden collected have been analyzed for PAH at the time of this writing.

Adult Fish Assessment and Monitoring

Escapements and Timing

The total sockeye salmon escapement into Summer Bay Lake in 1998 was 2,641 adults, primarily age 1.2 (63.2%) and age 1.3 (31.8%) fish (Table 4; Appendix E). There were also a small number of age 2.2 (0.9%) and age 2.3 (1.6%) sockeye salmon in the escapement. Few other age classes were represented (combined age 1.1, 0.3, and 0.2 fish was ~ 2%).

Sockeye salmon moved into the lake slowly, beginning on 12 June, with a mean passage rate of ~10-50 fish/day until the peak escapement of 718 fish on 16 July (Figure 9). After this peak, additional sockeye salmon moved into the lake at a low rate through 15 September. Similarly, the peak weekly escapement was 607 age 1.2 and 365 age 1.3 fish for a total of 972 sockeye salmon for the week ending 18 July (Table 4; Figure 10). This compares to an average of 175 fish of similar age ratios for all other weeks from 20 June through 15 August and ~ 14 fish (primarily age 1.2) for the remaining weeks.

The total pink salmon escapement into Summer Bay Lake in 1998 was 7,290 adults (Table 4; Appendix E). The pink salmon escapement began on 23 July, but very few fish returned until 2 August when 750 fish immigrated and on 4 August when the escapement was 770 fish (Figure 9). These were peak counts; however, several other smaller peaks occurred throughout August. Similarly, the peak weekly escapement was 2,419 pink salmon for the week ending 8 August (Table 4; Figure 10). Escapements were 1,465 and 1,321 pink salmon for the weeks ending 22 August and 29 August, respectively. The escapement in August accounted for 83.6% of the total pink salmon escapement for 1998.

Only 101 coho salmon were counted into Summer Bay Lake in 1998 (Table 4; Appendix E). The escapement comprised age 1.1 (53.1%) and age 2.1 (46.9%) fish, all of which immigrated into the lake from late August through late September (Figure 9). The peak weekly escapement was 32 coho salmon for the week ending 5 September (Figure 10).

A small number of Dolly Varden (276) also immigrated into the lake in 1998, beginning in early July and ending in early September (Table 4; Appendix E). The peak daily immigration was 53 Dolly Varden on 9 August and by the end of that week (15 August) a total of 153 or 55% had been passed into Summer Bay Lake (Figures 9 and 10). Dolly Varden counts are considered conservative, since the difference method was not applied to their enumeration and they were also able to pass through some sections of the weir without being enumerated.

In addition, one emigrating steelhead *Oncorhynchus mykiss* was captured June 27 in the smolt trap. She was extruding eggs, was thin, and was probably post-reproductive.

Escapement Age, Size, and Sex Ratio

Escapement age samples (N=705) indicate that the Summer Bay Lake sockeye salmon run is primarily composed of fish having spent one winter in freshwater as juveniles and two or three winters in the ocean as adults (Table 5; Figure 11). The dominant ages were 1.2 (58.3%) and 1.3 (35.9%) fish which, combined, equate to about 94% of the total run. The sample proportions by sex were 51.4% female and 48.6% male sockeye salmon.

Adult sockeye salmon averaged 518 mm in length (females 504 mm and males 532 mm) and size increased with ocean residence from 372 mm for age 1.1 fish to > 560 mm of age 0.3 and 2.3 fish (Table 5; Figure 11).

Only 18 adult coho salmon were sampled for age and size, due to the low escapement and potential mortality associated with handling of the fish (Table 5). These samples indicated that coho salmon spent one to two winters in freshwater as juveniles and one winter in the ocean as adults (Figure 11). Age 2.1 fish (61.1%) were most common, followed by age 1.1 (38.9%) fish. The sample proportions by sex were 44.4% female and 55.6% male coho salmon.

Adult coho salmon averaged 637 mm in length (females 641 mm and males 634 mm) and age 1.1 fish (644 mm) were slightly larger than age 2.1 fish (633 mm; Table 5; Figure 11).

The only steelhead emigrating from Summer Bay Lake in 1998 was a female, measuring 620 mm.

Escapement Distribution

Stream and lake surveys were conducted at the Summer Bay Lake system, as well as other area anadromous fish systems, in the summer and fall of 1998, to enumerate adult fish distributions over time (Table 6; Appendix F). The initial survey of the Summer Bay Lake system was conducted on 1 July; however, few salmon were observed in the lake and none in the inlet tributary. Approximately 173 sockeye salmon were observed in the shoal areas of the lake on 26 July, but few were observed in the vicinity of the inlet tributary or to enter the stream until 13 August. The peak observation of sockeye salmon in the system (563) was observed on this date, as well as the first observation of pink salmon (428). The peak observation of sockeye salmon in the inlet tributary was 256 on 17 September, while the peak number of pink salmon in the stream was 2,050 on 25 August. One coho salmon was observed on 17 September, and none were seen on the remaining survey dates. Dolly Varden were observed in the inlet stream beginning 6 August, and the most estimated was 100 on 13 August.

Most sockeye salmon spawned on the western side of Summer Bay Lake, where springs and runoff creeks enter the lake (Figure 3). Few sockeye salmon spawned in the inlet stream, although the gravel in the lower 200 m of the stream appeared to be excellent spawning substrate. The upper reaches of the stream consisted of ~ 50-60% good useable spawning gravel. Those sockeye salmon spawning in the inlet stream used the lower 100 m of habitat. Pink salmon used the inlet creek extensively for spawning, and none were observed to have spawned in the lake. A small number of pinks (< 200) spawned in the outlet stream.

Air and Water Temperature, Stream Height, and Wind Velocity

Water temperature was 5^{0}C in early May, warming to a maximum of 15^{0}C by mid-August and cooling in September to 9-11^{0}C (Figure 12A; Appendix G). Air and water temperatures were within a few degrees of each other throughout most of the field season. Air and water temperatures declined steadily from mid-September 1998 to mid-February 1999, then increasing slowly that spring (Figure 12B). In May 1999, air and water temperatures were similar to those in May 1998. Stream height fluctuated widely in early May and in late August, as well as in early September 1998, and appeared somewhat dependent on wind direction and velocity (Figure 12C,D).

Models of Juvenile Fish Production

The peak sockeye salmon counts for the 1994 – 1997 brood years were 174, 450, 400, and 800 fish, respectively (Table 7). Coho salmon peak counts for these brood years were 50, 8, 8, and 0 fish, respectively. The peak pink salmon count for brood year 1997 was 126 fish. The PCM model estimates a total escapement in 1994 of 348 sockeye salmon and 120 coho salmon (Table 7). The model estimated total escapements of 900 sockeye salmon and 19 coho salmon in 1995 and 800 sockeye salmon and 19 coho salmon in 1996. Approximately 1,600 sockeye salmon, 239 pink salmon, and 0 coho salmon were estimated to escape into Summer Bay Lake in 1997. Table 7 describes the PCM model estimates of the number of females comprised in the total escapement estimates and the resulting numbers of green eggs and emergent fry for each brood year. The model projected 6,522 sockeye salmon juveniles and 5,106 coho salmon juveniles surviving from brood year 1994 (Table 7). Juvenile survival from brood year 1995 was predicted to be 16,868 sockeye salmon and 817 coho salmon, which was similar to the 14,994 sockeye salmon and the 817 coho salmon predicted for brood year 1996. Lastly, 29,988 sockeye salmon, 12,099 pink salmon, and 0 coho salmon juveniles were projected to survive from brood year 1997. Approximately 26 sockeye salmon and 1,072 coho salmon smolt from brood year 1994 and 1,046 sockeye salmon and 229 coho salmon smolt from brood year 1995 were predicted to emigrate in 1998. An additional 13,944 sockeye salmon and 408 coho salmon smolt from brood year 1996, and 12,099 pink salmon from brood year 1997 were also predicted to emigrate in 1998. Thus, the PCM model predicts a total juvenile emigration from Summer Bay Lake in 1998 of 15,016 sockeye salmon, 12,099 pink salmon, and 1,709 coho salmon. Actual emigrations were 42,336 sockeye salmon, 3,570 pink salmon, and 325 coho salmon juveniles in 1998. Therefore, approximately 27,320 more sockeye salmon, 8,529 less pink salmon, and 1,384 less coho salmon juveniles actually emigrated than were predicted by the PCM model. Finally, 28,886 sockeye salmon, 0 pink salmon, and 400 coho salmon were predicted to remain in the lake after the 1998 emigrations.

Total escapements into Summer Bay Lake, estimated by the PCD model, were 796 sockeye salmon and 208 coho salmon in 1994 and 2,057 sockeye salmon and 33 coho salmon in 1995 (Table 8). Total escapement estimates were 1,829 sockeye salmon and 33 coho salmon in 1996, and 3,658 sockeye salmon, 487 pink salmon, and 0 coho salmon in 1997. The number of females comprised in the total escapement estimates and the resulting numbers of green eggs and emergent fry for each brood year predicted by the PCD model are described in Table 8. The model projected 14,910 sockeye salmon juveniles and 8,864 coho salmon juveniles surviving from brood year 1994 (Table 8). Juvenile survival from brood year 1995 was predicted to be

37,804 sockeye salmon and 1,612 coho salmon, which was similar to the 33,604 sockeye salmon and the 1,612 coho salmon predicted for brood year 1996. Lastly, 67,207 sockeye salmon, 24,601 pink salmon, and 0 coho salmon juveniles were projected to survive from brood year 1997. Approximately, 60 sockeye salmon, and 1,861 coho salmon smolt from brood year 1994 and 2,344 sockeye salmon and 451 coho salmon smolt from brood year 1995 were predicted to emigrate in 1998. An additional 31,251 sockeye salmon and 806 coho salmon smolt from brood year 1996, and 24,601 pink salmon from brood year 1997 were also predicted to emigrate in 1998. Thus, the PCD model predicts a total juvenile emigration in 1998 of 33,655 sockeye salmon, 24,601 pink salmon, and 3,119 coho salmon. Actual emigrations were 42,336 sockeye salmon, 3,570 pink salmon, and 325 coho salmon juveniles in 1998. Therefore, approximately 8,681 more sockeye salmon, 21,031 less pink salmon, and 2,794 less coho salmon actually emigrated than were predicted by the PCM model. Additionally, 64,738 sockeye salmon, 0 pink salmon, and 790 coho salmon were predicted to remain in the lake after the 1998 emigrations.

DISCUSSION

Quantity of Juvenile Fish in Summer Bay Lake at Risk for Exposure to Oil

The numbers of rearing fish in Summer Bay Lake were unknown at the time of the *M/V Kuroshima* oil spill and juvenile production data had not been collected previously at the system. Fishery professionals often extrapolate adult escapements to estimate juvenile recruitment, based upon system specific production parameters or production parameters gleaned from the literature. For example, knowing the average sex ratio, fecundity, potential egg deposition (PED), and survival to emergence would enable estimating juvenile recruitment from a known escapement. Recruitment estimates of this type are, however, predicated upon reliable escapement estimates.

Aerial surveys and limited foot surveys were the only methods employed to estimate Summer Bay Lake sockeye and pink salmon escapements in years prior to the spill (Honnold et al. 1996). Surveys of coho salmon abundance were sparse and typically conducted during poor survey conditions. Thus, previous escapement estimates of Summer Bay Lake salmon were considered indices of escapement, rather than the actual escapements. Peak counts were often used to index salmon escapements at Summer Bay Lake, as well as other area salmonid systems (Shaul and Dinnocenzo 1999). Peak counts generally represent only a portion of the estimated total escapement (Cousens et al. 1982), and are not comparable to other peak counts (Johnson and Barrett 1988). Counting biases have been widely documented and almost always result in surveys that underestimate total escapements (Symons and Waldichuk 1984; Tshaplinski and Hyatt 1991; Jones et al. 1998). As a result, many fishery mangers use multipliers to account for fish not present in the escapement at the time of the peak count and others not seen or counted (Barrett et al. 1990; Swanton and Nelson 1994; Jones et al. 1998). Peak counts of Summer Bay Lake salmon escapements have not been expanded to estimate total escapements (Shaul and Dinnocenzo 1999).

The juvenile age classes of each species must also be assessed when extrapolating from total escapements to estimate lake residence at a given time. The results of juvenile emigration estimates indicate three age classes of both sockeye and coho salmon rearing in Summer Bay Lake. Pink salmon do not rear in lakes for an extended periods (Heard 1991); however, in the Summer Bay

Lake, the majority of fry pass through the lake for short periods as they emigrate from where they emerge (primary spawning creek at south end of the lake) to the ocean.

Thus, brood years 1994-1997 must be included when expanding peak counts to model Summer Bay Lake sockeye and coho salmon escapements, and extrapolate juvenile production. Brood year 1997 peak count expansion is sufficient to model juvenile pink salmon present in the lake in 1998.

The intent of modeling juvenile salmon production is to provide an indication of the number of juvenile salmon present in Summer Bay Lake in 1998 after the oil spill until a portion of the fish emigrated and what fish remained in the lake until 1999. It appears that the PCD model may be more appropriate, since sockeye salmon smolt estimates for 1998 (~ 34,000) are much closer to the actual emigration (~ 42,000). Actual emigration counts were higher, however, indicating that survival at some stage of development was higher than assumed or the escapements are lower than estimated. Nevertheless, this analysis suggests that sockeye salmon juveniles did not experience a mortality event prior to emigration. Conversely, both the PCM and PCD models provide much higher estimates of pink and coho salmon than actually emigrated in 1998. This may indicate that these species exhibited an unusual rate of mortality prior to leaving the lake or that escapements were estimated too high. Lastly, the models illustrate that a substantial number of juvenile sockeye and coho salmon remained in the lake to rear through the winter of 1999 and beyond. Thus, the persistence of oil in the lake may have implications for future juvenile production.

Care must be taken when applying the conclusions from the EVOS, as well as other studies (Appendix J), to the *M/V Kuroshima* scenario since the type of oil, severity of oiling, and affected species differ in most cases. There are sufficient similarities, however, to suggest that the EVOS research is relevant and should be considered (D. Helton, NOAA, Anchorage, personal communication). For example, both spills occurred in subarctic climates, both spills involved persistent oils, both spills effected pink salmon, and both spills affected spawning and rearing habitat.

Juvenile and adult fishery data collected in 1998 and the timing and extent of the *M/V Kuroshima* oil spill at Summer Bay Lake provide information for supposition of potential damage to fish species residing in the lake at the time of the spill and in the interim. The full extent of the oil spill, however, will not be known until several years of juvenile and adult data are collected and some indication of brood year survivals can be established. Lastly, if fish survivals decline, PAH analyses of juvenile fish collected in 1998 will be essential to determine if oil contamination was the reason for reductions in production.

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Table 1. Summer Bay Lake weekly juvenile emigration estimates by age class, 1998. [a]

Week Ending	Number of Sockeye Salmon Smolt by Age				Number of Coho Salmon Smolt by Age				Pink Salmon	Dolly Varden
Date	1.	2.	3.	Total	1.	2.	3.	Total	Age 0.	(not aged)
9-May	3	0	0	3	2	0	0	2	22	23
16-May	3	0	0	3	8	0	0	8	611	250
23-May	0	0	0	0	0	0	0	0	364	231
30-May	0	0	8	8	0	2	0	2	2,172	428
6-May [b]	19	53	6	80	10	9	3	23	366	538
13-Jun	46	115	29	190	9	7	7	22	23	288
20-Jun	269	413	36	718	9	3	6	17	12	214
27-Jun	3,678	1,251	75	5,004	13	4	9	26	0	176
4-Jul	5,823	345	0	6,168	10	3	7	20	0	38
11-Jul	3,868	136	0	4,004	4	1	3	8	0	13
18-Jul	6,882	133	0	7,015	4	1	2	7	0	4
25-Jul	13,116	173	0	13,289	2	1	1	4	0	15
1-Aug	5,268	0	0	5,268	3	1	2	5	0	2
8-Aug [b]	281	0	0	304	26	9	17	52	0	21
15-Aug [b]	83	0	0	90	20	7	13	40	0	50
22-Aug [b]	146	0	0	158	30	30	0	60	0	43
30-Aug [b]	31	0	0	34	15	14	0	29	0	37
Total:	39,515	2,619	155	42,336	163	91	69	325	3,570	2,371
Percent	93.3	6.2	0.4	100.0	50.3	28.0	21.3	100.0	100	100

[a] Includes fish that were estimated when trap was fishing at < 100% efficiency.

[b] Age 0. smolt were present in AWL samples for week ending 6 June (2.6%) and 8 August (7.7%); a total of ~ 47 age 0. smolt emigrated.

Table 2. Age composition, mean size at age, and mean condition of Summer Bay Lake juvenile salmon sampled in 1998.

Species	Sample Size	Age	Age (%)	Weight (g)	Length (mm)	Condition (K)
Sockeye	2	0	0.1	1.5	57	0.81
	1238	1	77.8	8.9	101	0.86
	315	2	19.8	24.5	135	0.89
	37	3	2.3	40.9	162	0.91
Coho	37	1	49.3	10.5	97	1.01
	30	2	40.0	18.5	123	0.98
	7	3	9.3	23.6	137	0.91
	1	4	1.3	32.1	154	0.88
Pink	368	0	100.0	0.2	33	0.53

Table 3. Summer Bay Lake sockeye and coho salmon smolt collection for stomach contents and results of stomach content analysis, 1998.

	Collection		Stomach Content Analysis			
Species	Dates	Number	No. with Contents	Condition	Taxa Present	Percent of Volume
Sockeye	5 ,18-June	6	2	Full	Chironomidae larva	70
					Chironomidae pupae	20
					Ceratopogonidae pupae	10
Coho	18-Jun	3	2	Partially Full	Chironomidae adults	30
					Chironomidae pupae	30
					Ceratopogonidae adults	30
					Ceratopogonidae pupae	10

Table 4. Summer Bay Lake weekly adult escapement estimates by age class, 1998.

Week Ending	Number of Sockeye Salmon Adults by Age					Number of Coho Salmon Adults by Age			Pink Salmon	Dolly Varden
Date	1.2	1.3	2.2	2.3	Total [a]	1.1	2.1	Total	Age 0.1	(not aged)
13-Jun	1	0	0	0	1					
20-Jun	67	45	0	0	112					
27-Jun	77	59	0	4	139					
4-Jul	154	118	8	11	291					
11-Jul	116	63	3	19	202					14
18-Jul	607	365	0	0	972					20
25-Jul	180	73	9	7	269				10	2
1-Aug	89	25	2	1	118				2	1
8-Aug	187	44	0	0	231				2,419	11
15-Aug	125	30	0	0	155				890	153
22-Aug	46	11	0	0	56	1	0	1	1,465	61
29-Aug	9	2	0	0	11	13	8	21	1,321	13
5-Sep	6	1	0	0	8	24	8	32	702	0
12-Sep	6	1	0	0	8	10	10	20	467	1
19-Sep	2	0	0	0	2	6	17	23	8	0
26-Sep	0	0	0	0	0	0	4	4	6	0
3-Oct	0	0	0	0	0	0	0	0	0	0
Total:	1,670	839	23	42	2,574	54	47	101	7,290	276
Percent	63.2	31.8	0.9	1.6	97.5	53.1	46.9	100.0	100	100

[a] Age 1.1, 0.3, and 0.2 adults (0.2% for each age class) were present in age samples; a total of ~ 67 (2%) total 'other' age sockeye were estimated.

Table 5. Age composition and mean length at age of Summer Bay Lake sockeye and coho salmon adults sampled in 1998.

Species	Sample Size	Age	Age (%)	Length (mm)		
				Female	Male	All
Sockeye	2	0.2	0.2	420	460	440
	2	0.3	0.2		560	560
	2	1.1	0.2		372	372
	411	1.2	58.3	487	509	497
	253	1.3	35.9	537	561	550
	16	2.2	2.3	507	527	513
	19	2.3	2.7	547	571	564
	705	total	100.0	504	532	518
Coho	7	1.1	38.9	650	642	644
	11	2.1	61.1	638	627	633
	18	total	100.0	641	634	637

Table 6. Summer Bay Lake and inlet stream escapement distribution by date and species, 1998.

		Live Counts by Species			
Date	Section/area	Sockeye	Pink	Coho	Dolly Varden
1-Jul	Lake	2	0	0	0
26-Jul	Lake (North)	15	0	0	0
	Lake (West)	~100	0	0	0
	Lake (South)	~50	0	0	0
	Lake (East)	~8	0	0	0
	Total	173	0	0	0
28-Jul	Inlet Stream	1	0	0	0
6-Aug	Inlet Stream	4	0	0	20-30
13-Aug	Inlet Stream	68	118	0	~100
	Mouth of Inlet	~150	~300	0	0
	Lake (East)	15	10	0	0
	Lake (West)	~300	0	0	0
	Total	563	428	0	100
25-Aug	Inlet Stream	191	2,050	0	0
17-Sep	Lake (East)	100	0	0	0
	Lake (West)	150	0	0	0
	Inlet Stream	256	634	1	40
	Total	506	634	1	40
23-Nov	Inlet Stream	0	0	0	0
25-Nov	Inlet Stream	0	0	0	0

Table 7. Summer Bay Lake resident salmon estimates, by species, based on peak count multiplier (PCM) model.

Brood Year	*Variable*	1994	1995 [a]	1996	1997				
Peak Survey	*a*								
sockeye		174	450	400	800				
pink		NA	NA	NA	126				
coho		50	8	8	0				
Escapement Estimate	*b*								
sockeye		348	900	800	1,600				
pink		NA	NA	NA	239				
coho		120	19	19	0				
Number Females	*d*								
sockeye		177	459	408	816				
pink		NA	NA	NA	120				
coho		53	8	8	0				
Number Green Eggs	*f*								
sockeye		443,700	1,147,500	1,020,000	2,040,000				
pink		NA	NA	NA	222,403				
coho		255,288	40,846	40,846	0				
Number Emergent Fry	*h*								
Year		1995	1996	1997	1998				
sockeye		31,059	80,325	71,400	142,800				
pink		NA	NA	NA	14,234				
coho		[b]	[b]	[b]	[b]				
Number of Surviving Juveniles	*j*								
sockeye		6,522	16,868	14,994	29,988				
pink		NA	NA	NA	12,099				
coho		5,106	817	817	0				
Number Emigrants 1998	*l*					*Variable*	*p*	*m*	*q*
(May-Aug.)							Total	Actual	**Difference**
sockeye		26	1,046	13,944	0		15,016	42,336	**-27,320**
pink		0	0	0	12,099		12,099	3,570	**8,529**
coho		1,072	229	408	0		1,709	325	**1,384**
Number Remaining Juveniles	*o*								
sockeye		0	67	930	27,889		**28,886**		
pink		NA	NA	NA	0		**0**		
coho		0	172	229	0		**400**		

[a] 1995 sockeye salmon peak count is 10 year average.

[b] Number of emergent coho salmon fry not included - survival estimate is from egg to smolt.

Table 8. Summer Bay Lake resident salmon estimates, by species, based on peak count divider (PCD) model.

Brood Year	*Variable*	1994	1995 [a]	1996	1997	1998			
Peak Survey	*a*								
sockeye		174	450	400	800	563			
pink					126	2050			
coho		50	8	8	0	1			
1998 Weir Count	a_{1998}								
sockeye		2,574	2,574	2,574	2,574	2,574			
pink		7,920	7,920	7,920	7,920	7,920			
coho		101	101	101	101	101			
Proportion Peak of Weir	t_{1998}								
sockeye						0.22			
pink						0.26			
coho						0.24			
Escapement Estimate	*b*								
sockeye		796	2,057	1,829	3,658				
pink		0	0	0	487				
coho		208	33	33	0				
Number Females	*d*								
sockeye		406	1,029	914	1,829				
pink		0	0	0	243				
coho		92	17	17	0				
Number Green Eggs	*f*								
sockeye		1,014,284	2,571,714	2,285,968	4,571,936				
pink		0	0	0	452,228				
coho		443,208	80,583	80,583	0				
Number Emergent Fry	*h*								
Year		1995	1996	1997	1998				
sockeye		71,000	180,020	160,018	320,036				
pink		0	0	0	28,943				
coho		[b]	[b]	[b]	[b]				
Number of Surviving Juveniles	*j*								
sockeye		14,910	37,804	33,604	67,207				
pink		0	0	0	24,601				
coho		8,864	1,612	1,612	0				
Number Emigrants 1998	*l*					*Variable*	*p*	*m*	*q*
(May-Aug.)							Total	Actual	Difference
sockeye		60	2,344	31,251	0		33,655	42,336	**-8,681**
pink		0	0	0	24,601		24,601	3,570	**21,031**
coho		1,861	451	806	0		3,119	325	**2,794**
Number Remaining Juveniles	*o*								
sockeye		0	151	2,083	62,503	**64,738**			
pink		0	0	0	0	**0**			
coho		0	338	451	0	**790**			

[a] 1995 sockeye salmon peak count is 10 year average.

[b] Number of emergent coho salmon fry not included - survival estimate is from egg to smolt.

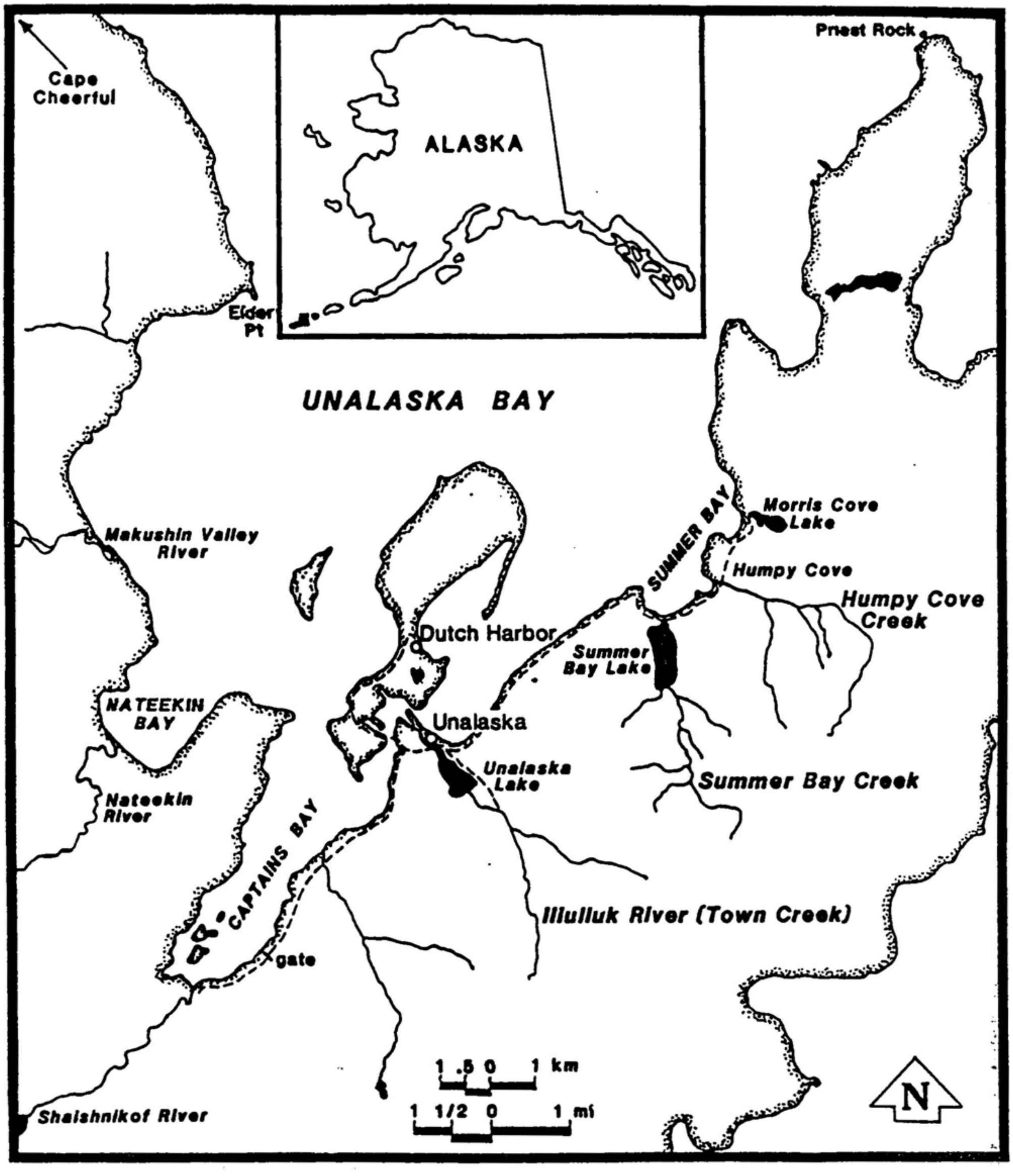

Figure 1. Map of Unalaska Bay and surrounding coastal area showing the relative location of Summer Bay Lake.

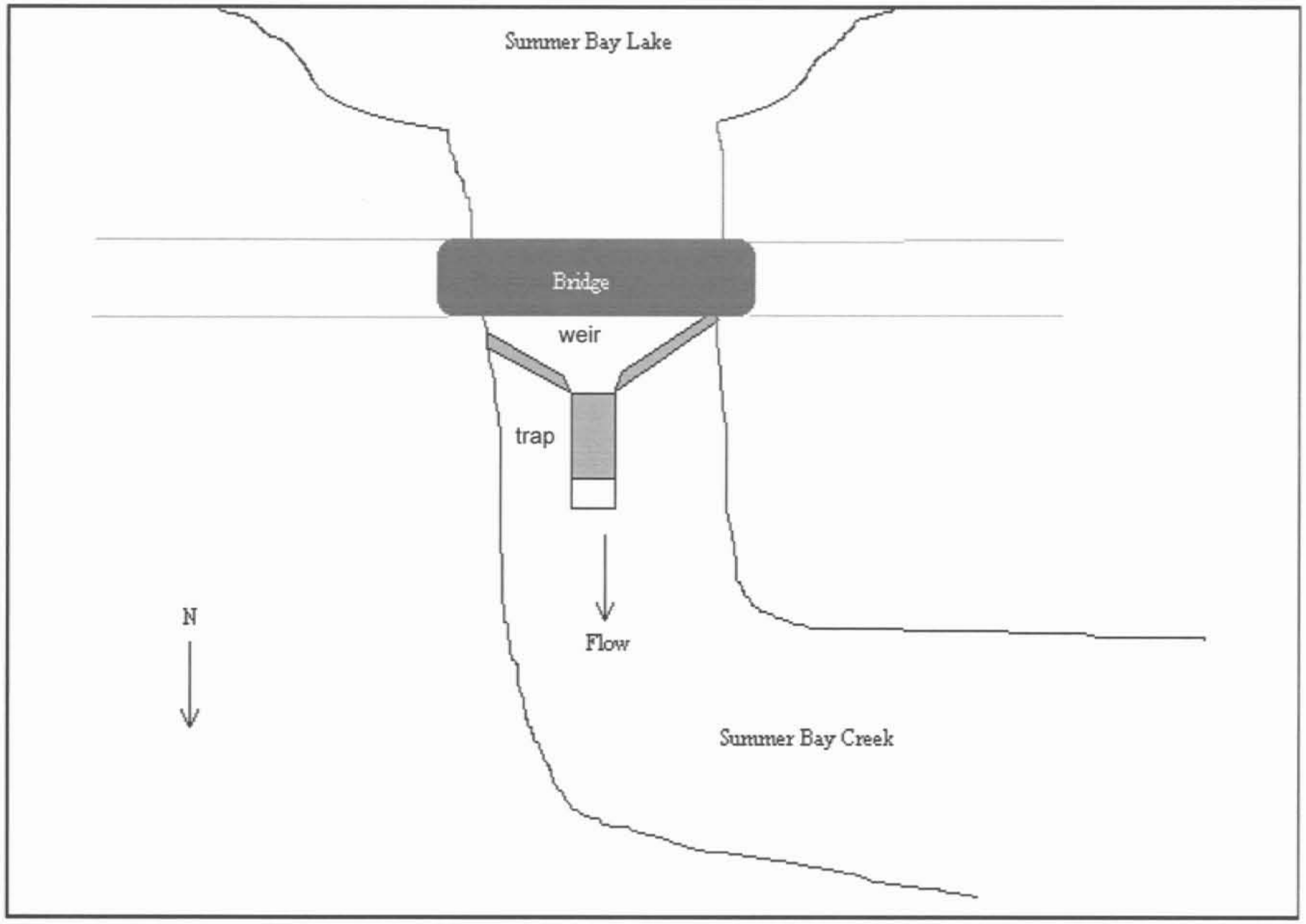

Figure 2. Diagrammatic representation of Summer Bay Creek and the relative locations of the bridge[a], weir, and lake.

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[a] The bridge is located at 53.897439/-166.457789 decimal degrees.

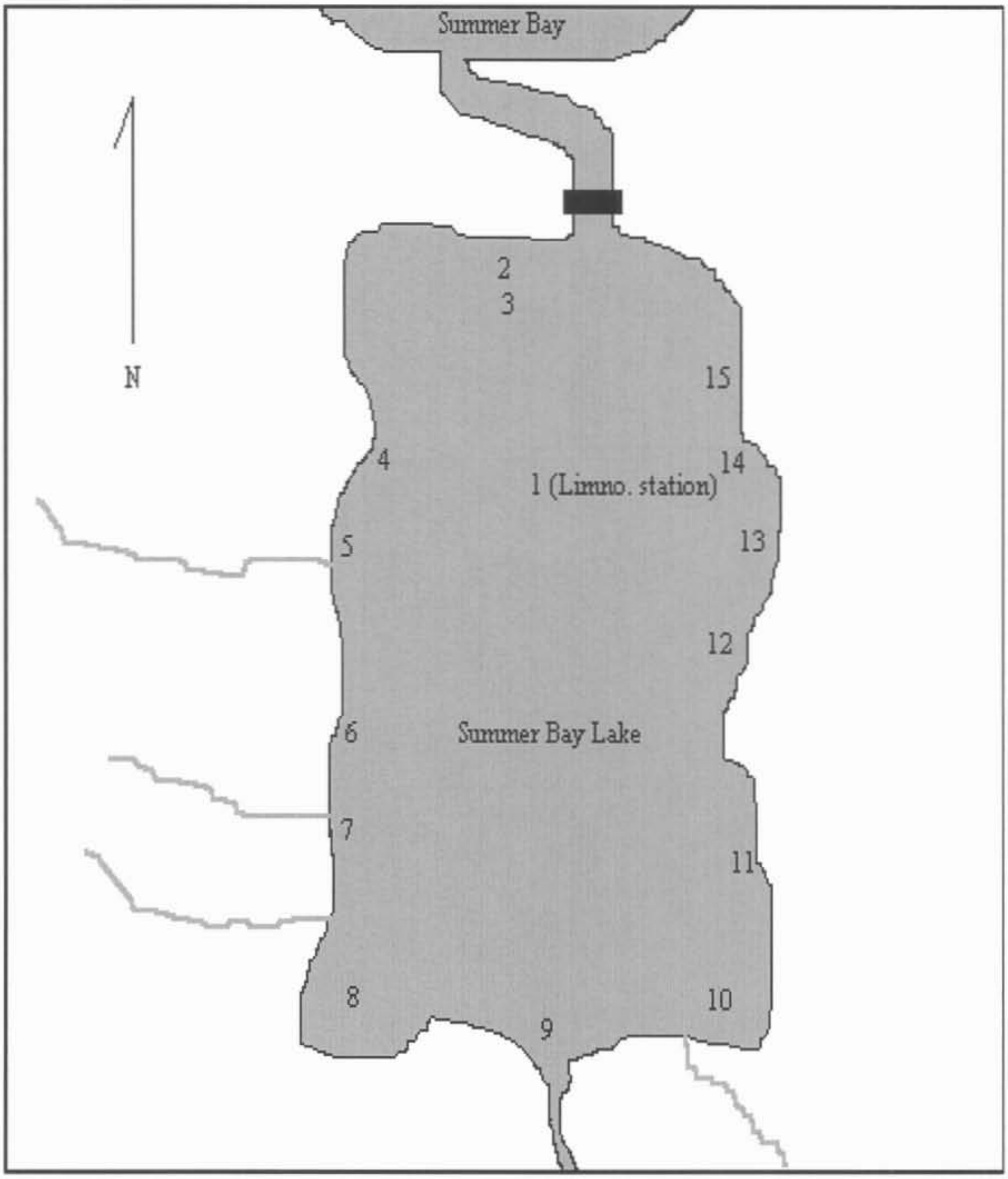


Figure 3. View of Summer Bay Lake showing bridge (black rectangle), and numbered minnow trap locations, and primary inlet stream surveyed in 1998.

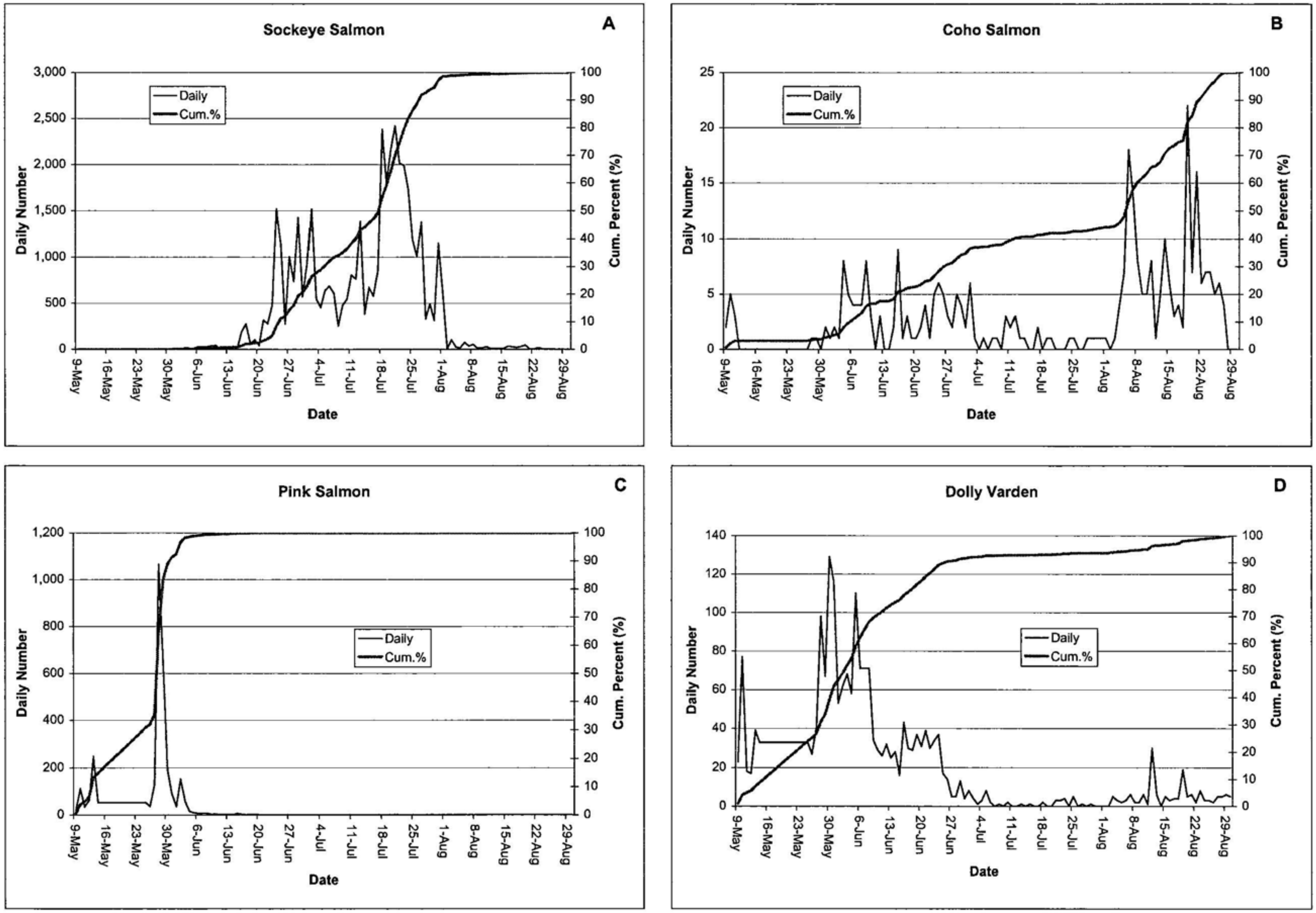


Figure 4. Daily and cumulative (%) juvenile sockeye salmon (A), coho salmon (B), pink salmon (C), and Dolly Varden (D) emigrations from Summer Bay Lake, 1998.

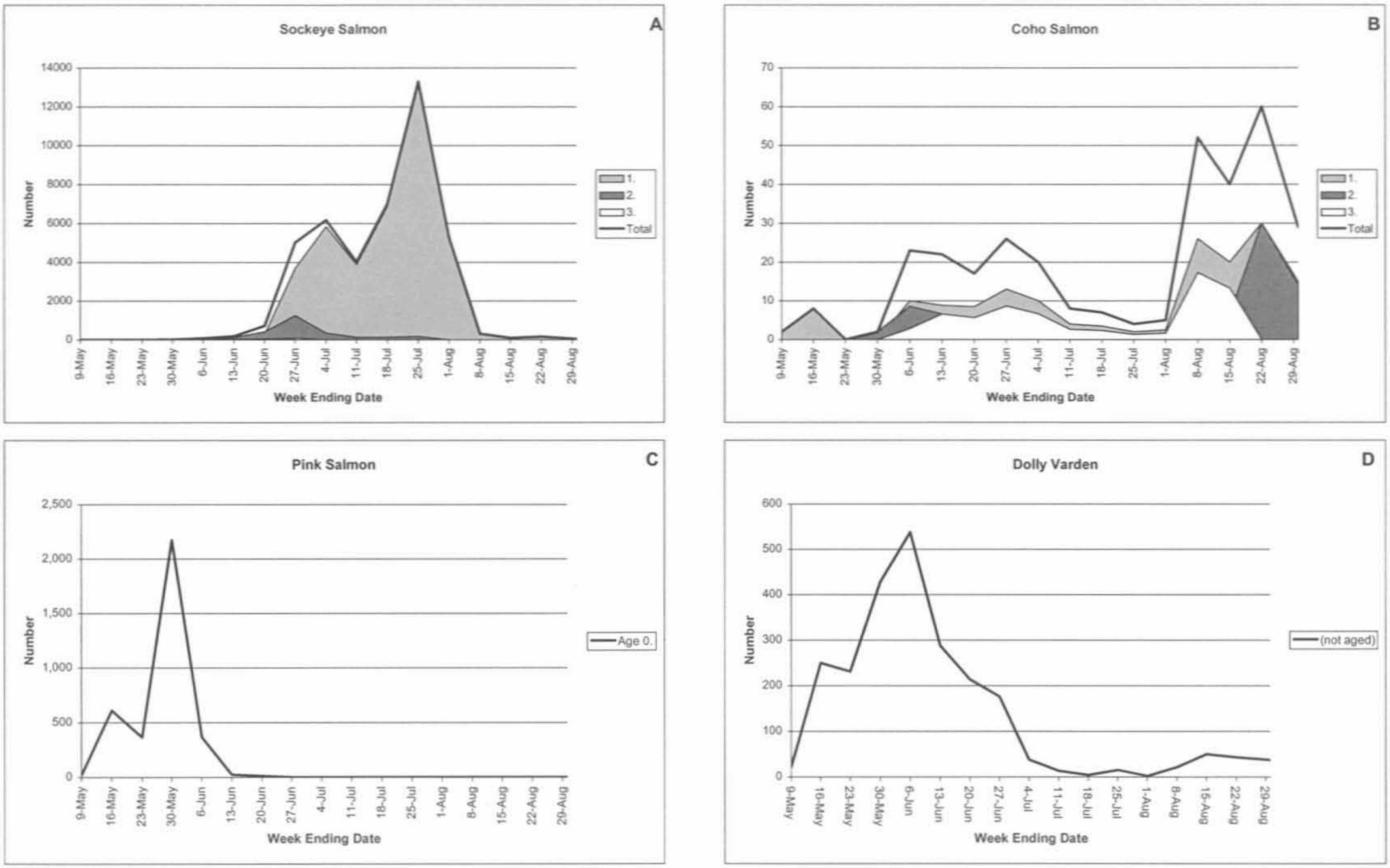
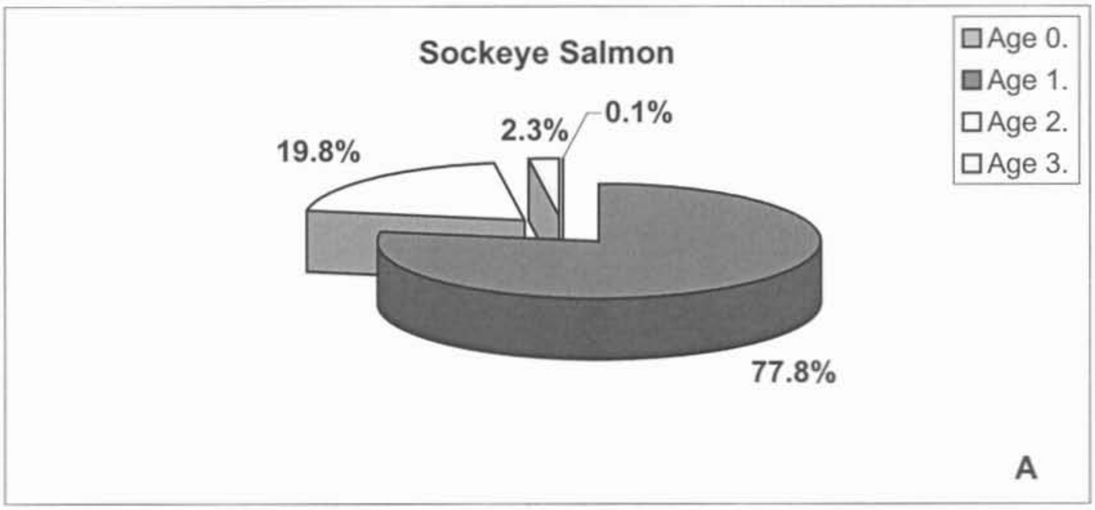


Figure 5. Summer Bay Lake weekly juvenile sockeye salmon (A), coho salmon (B), pink salmon (C), and Dolly Varden (D) emigrations by age, 1998.



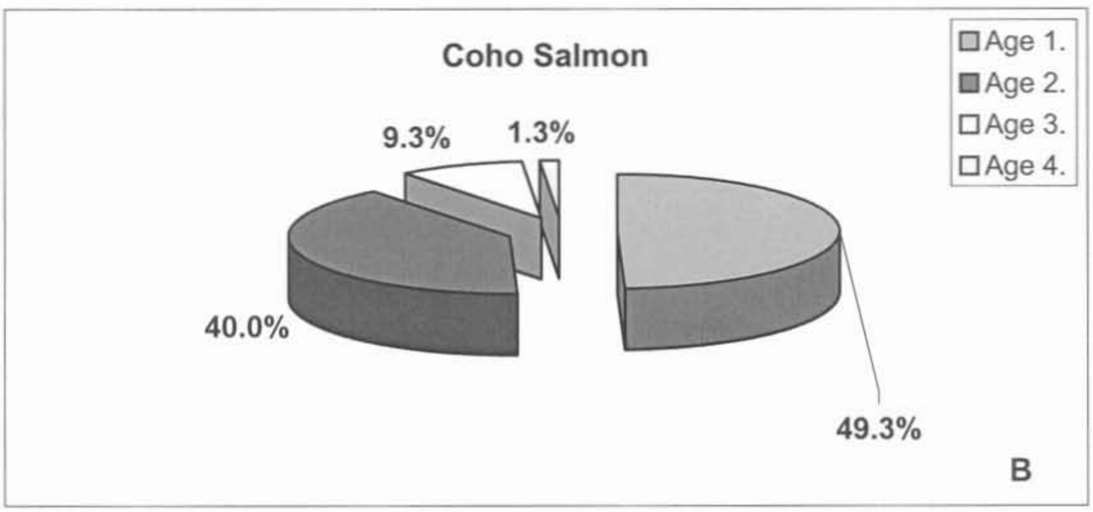


Figure 6. Age composition of sockeye (A) and coho (B) salmon smolt sampled from the emigration from Summer Bay Lake in 1998.

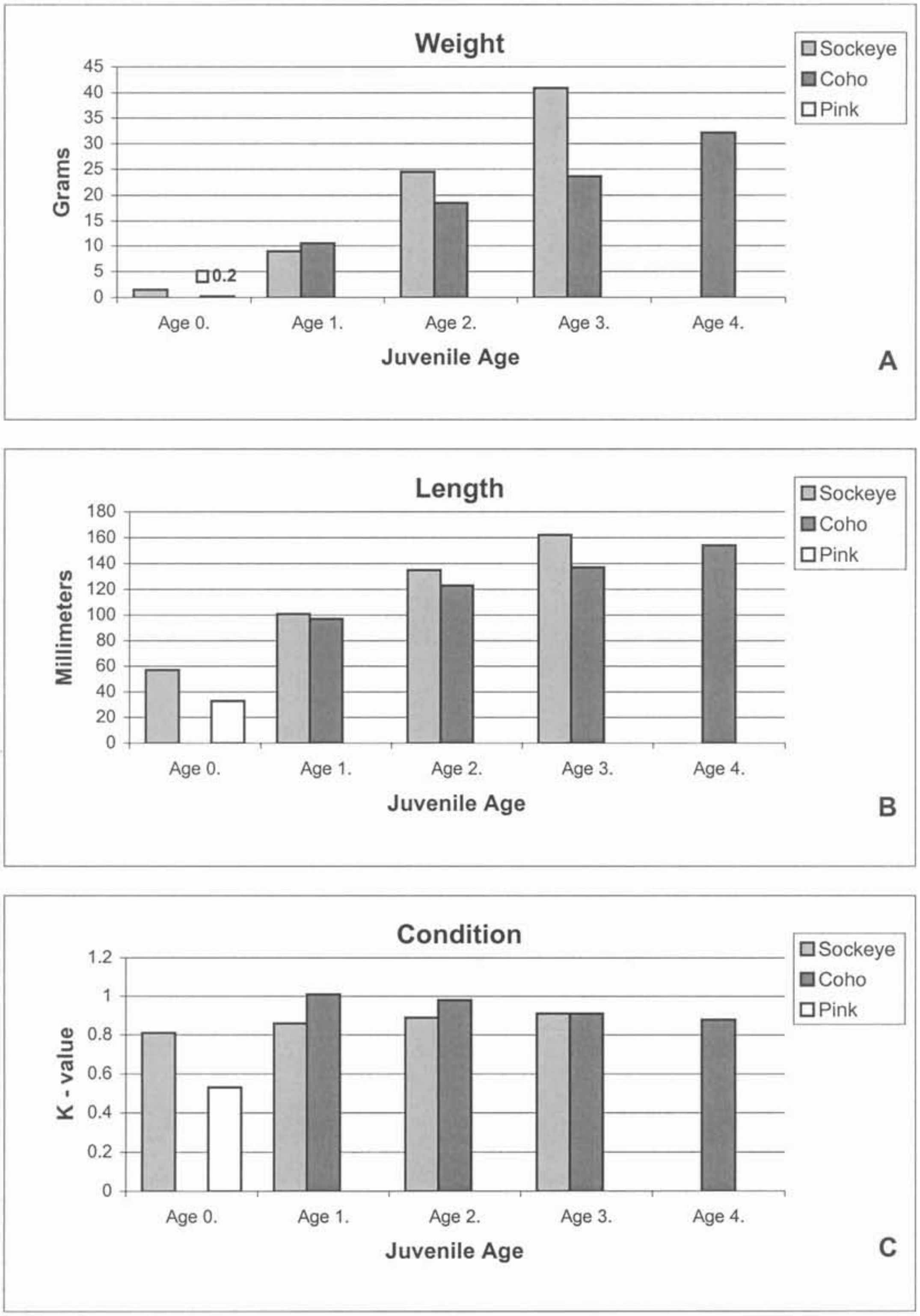


Figure 7. Weight (A), length (B), and condition (C) of sockeye, coho, and pink salmon juveniles sampled from the emigration from Summer Bay Lake in 1998.

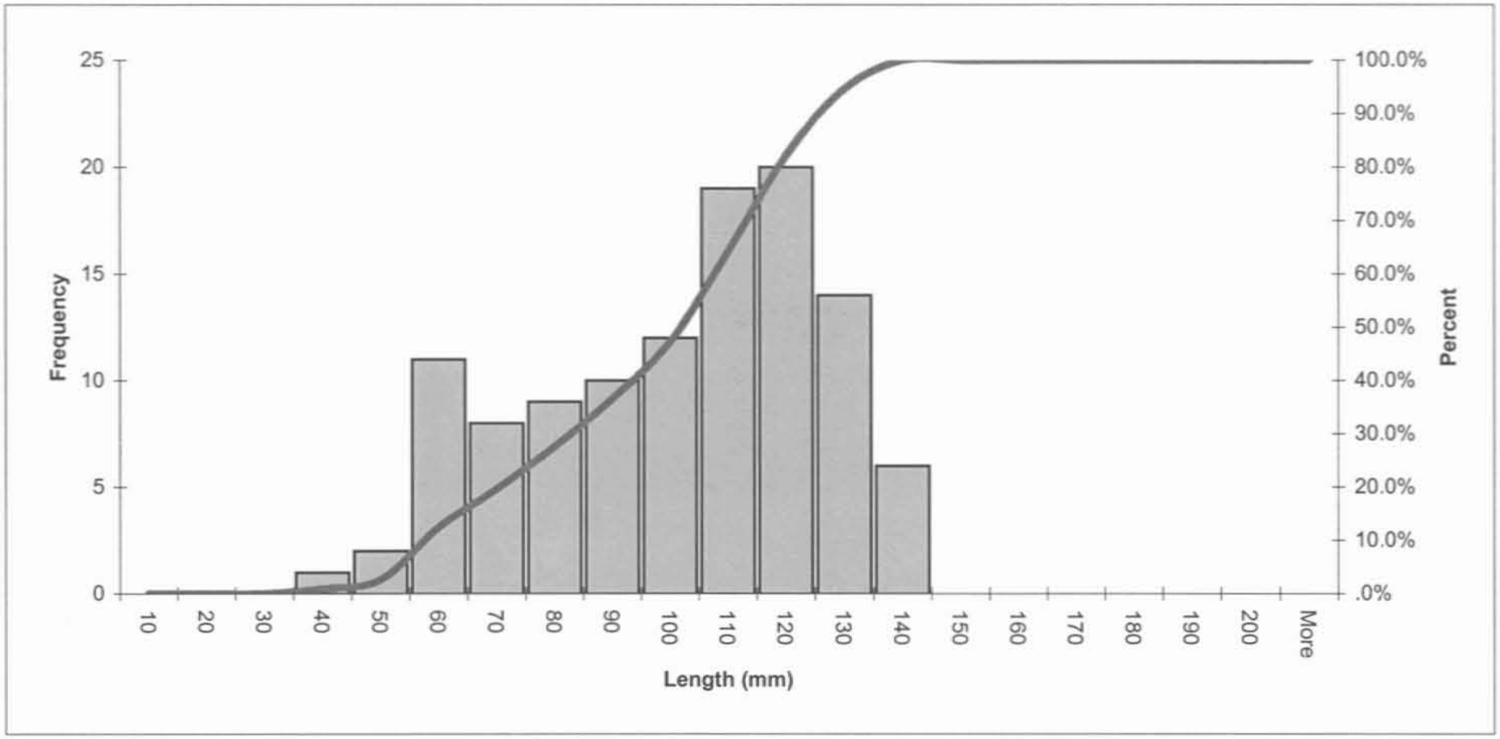


Figure 8. Length frequency of juvenile coho salmon captured in minnow traps in Summer Bay Lake, 1998.

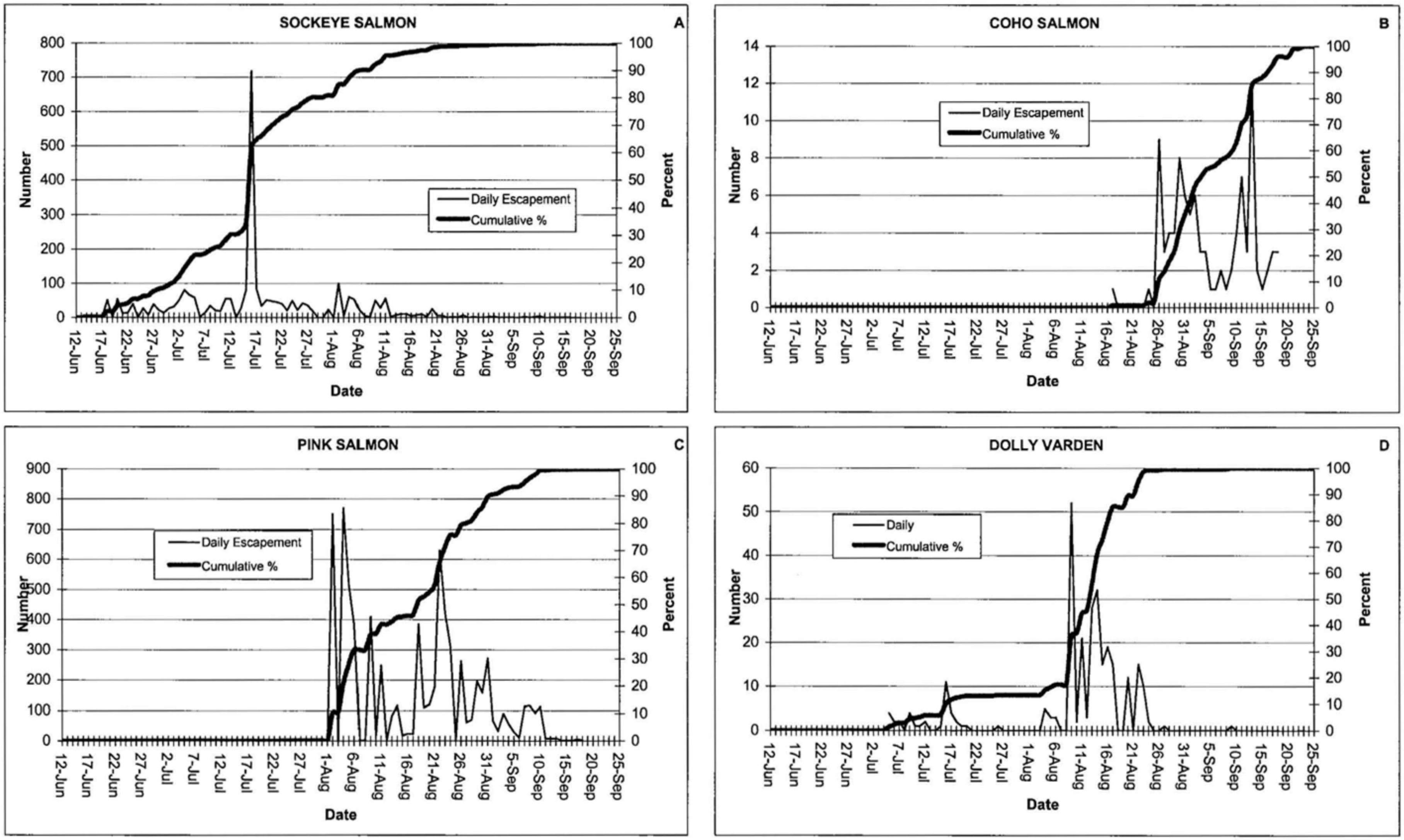


Figure 9. Summer Bay Lake daily adult escapements and cumulative % by date for sockeye salmon (A), coho salmon (B), pink salmon (C), and Dolly Varden (D), 1998.

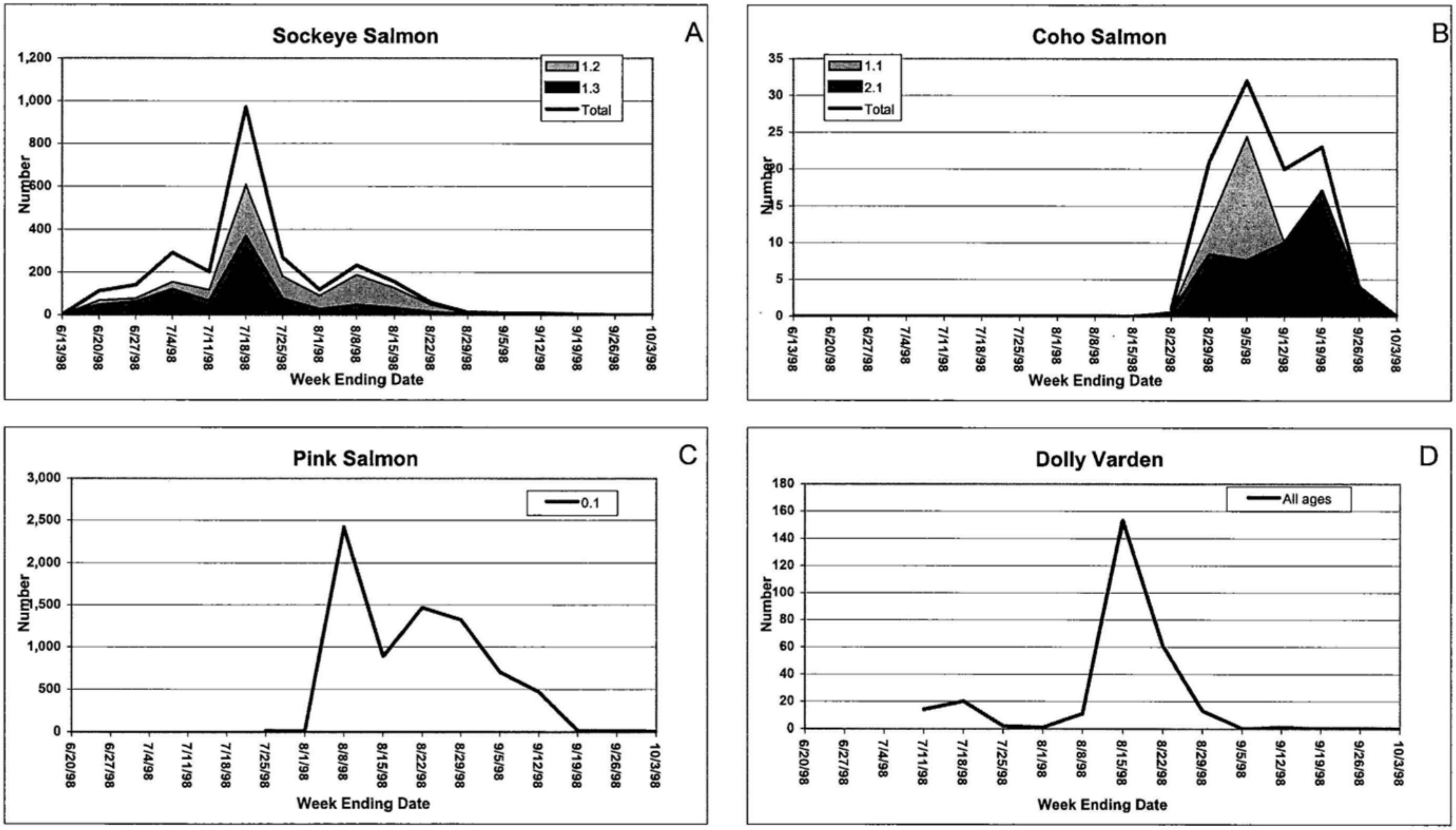


Figure 10. Summer Bay Lake weekly adult escapement timing by age for sockeye salmon (A), coho salmon (B), pink salmon (C), and Dolly Varden (D), 1998.

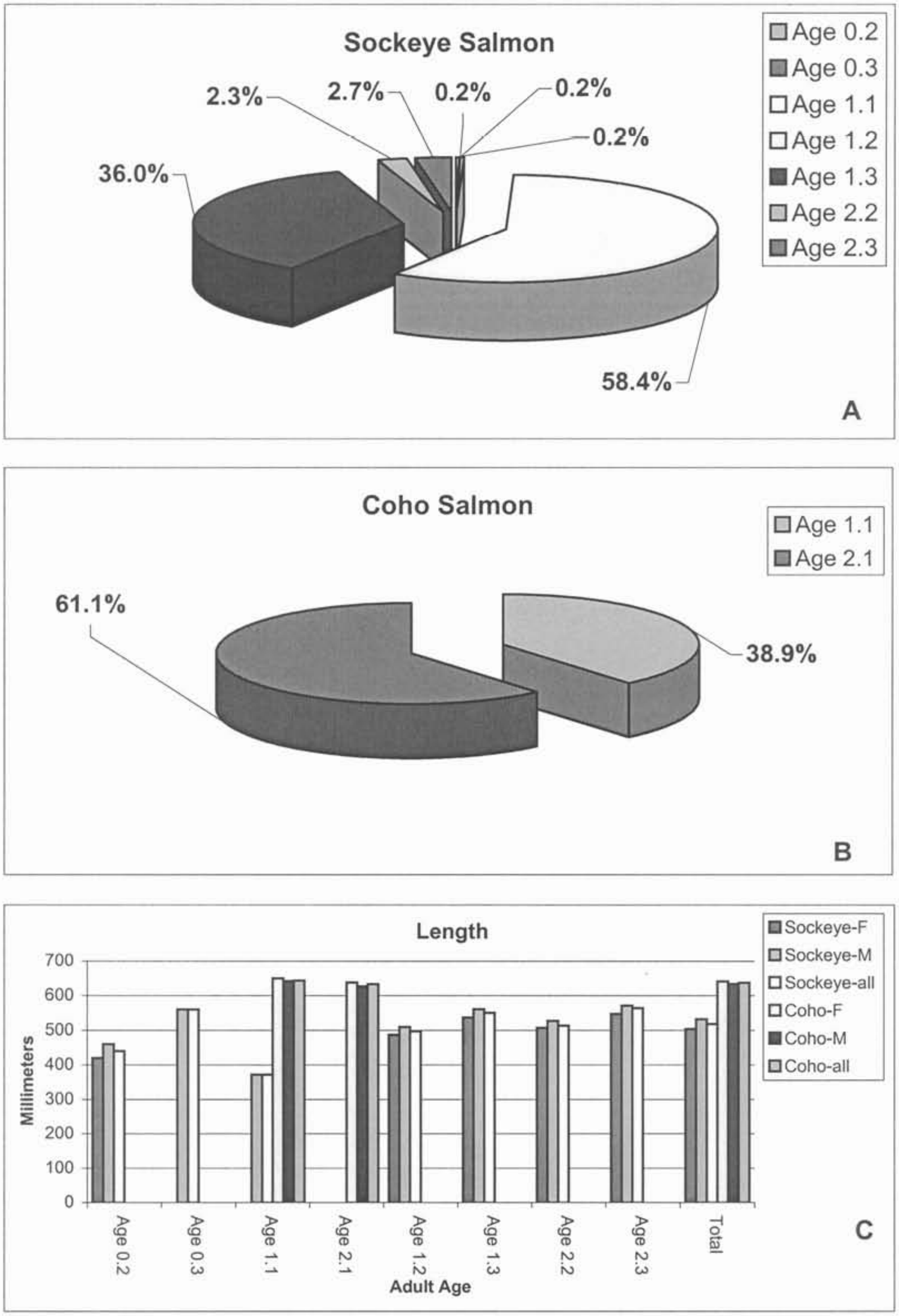


Figure 11. Age composition (sockeye - A and coho - B) and length (sockeye and coho - C) of adults sampled from the escapement into Summer Bay Lake in 1998.

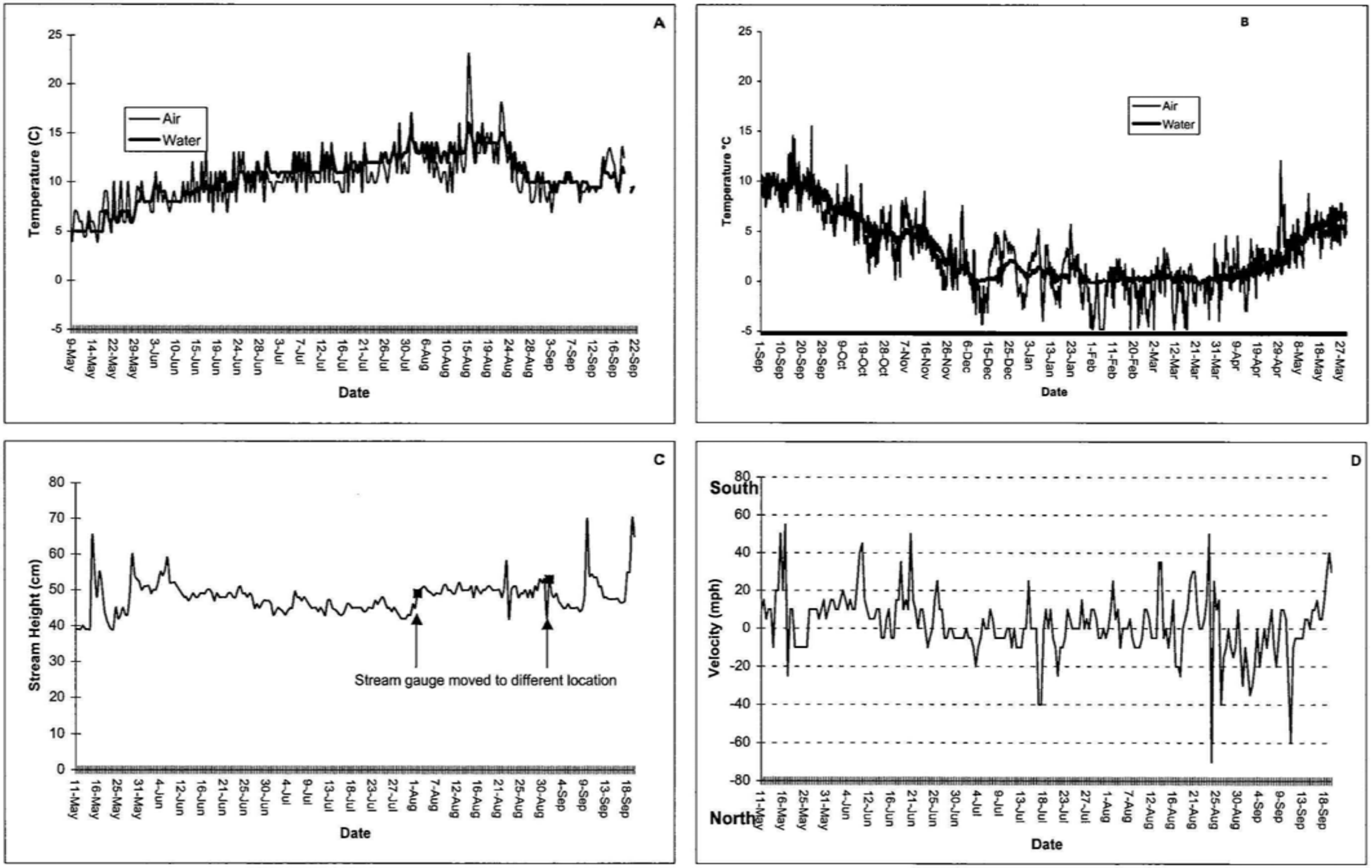


Figure 12. Summer Bay Lake study area air and water temperature for May-Sept. 1998 (A), and Sept. 1998-May 1999 (B), stream height for May-Sept. 1998 (C), and wind velocity for May-Sept. 1998 (D).

APPENDIX

Appendix A. Production parameters used to calculate Summer Bay Lake resident juvenile salmon at the time of oil spill and after 1998 emigrations.

Parameter	*Variable*	Value Used			Source		
		Sockeye	Pink	Coho	Sockeye	Pink	Coho
Peak Count (PC)	*a*	actual	actual	actual	ADF&G data base	ADF&G data base	ADF&G data base
PCM Model (Escapement estimate)	*c*	2	1.9	2.4	Barrett et al. 1990	Swanton and Nelson 1994	Minard 1986
PCD Model (Escapement estimate)	t_{1998}	0.22	0.26	0.24	PC/weir count	PC/weir count	Average for sockeye and pink
No. Females	*e*	51%	50%	44%	1998 Sex ratio	Assumed	1998 Sex ratio
No. Green Eggs (PED) (fecundity)	*g*	2500	1858	4835	Roelofs 1964 Honnold and Edmundson 1993	Willette et al. 1995 Honnold 1999	Willette et al. 1995 Honnold 1999
No. Emerg. Fry (PED to emergence)	*i*	7%	6.40%		Average of Drucker 1970 (4%) Koenings and Kyle 1997 (10%)	Willette et al. 1995 Honnold 1999	
No. of Emigrants (freshwater survival)	*k*	21%	85%	2% from PED	Koenings and Kyle 1997	Assumed	Bradford 1994
No. of Emigrants 1998 (by brood year)	*n*				Based on 1998 age composition	same as above	Based on 1998 age compostion
No. Future Emigrants (by brood year)	*n*				Based on 1998 age composition and emigration by age	Based on 1998 emigration	Based on 1998 age composition and emigration by age

Appendix B. Daily and cumulative juvenile fish emigrations, cumulative %, and daily emigations by age class, by species, Summer Bay Lake, 1998.

Date	Sockeye			Daily Sockeye By Age Class			Coho			Daily Coho By Age Class			Pink			Dolly Varden		
	Daily [a]	Cumulative	Cumulative %	1	2	3	Daily [a]	Cumulative	Cumulative %	1	2	3	Daily [a]	Cumulative	Cumulative %	Daily	Cumulative	Cumulative %
9-May	3	3	0	3	0	0	2	2	1	2	0	0	22	22	1	23	23	1
10-May	1	4	0	1	0	0	5	7	2	5	0	0	111	133	4	77	100	4
11-May	2	6	0	2	0	0	3	10	3	3	0	0	34	167	5	18	118	5
12-May	0	6	0	0	0	0	0	10	3	0	0	0	62	229	6	17	135	6
13-May	0	6	0	0	0	0	0	10	3	0	0	0	248	477	13	39	174	7
14-May	0	6	0	0	0	0	0	10	3	0	0	0	52	529	15	33	207	9
15-May	0	6	0	0	0	0	0	10	3	0	0	0	52	581	16	33	240	10
16-May	0	6	0	0	0	0	0	10	3	0	0	0	52	633	18	33	273	12
17-May	0	6	0	0	0	0	0	10	3	0	0	0	52	685	19	33	306	13
18-May	0	6	0	0	0	0	0	10	3	0	0	0	52	737	21	33	339	14
19-May	0	6	0	0	0	0	0	10	3	0	0	0	52	789	22	33	372	16
20-May	0	6	0	0	0	0	0	10	3	0	0	0	52	841	24	33	405	17
21-May	0	6	0	0	0	0	0	10	3	0	0	0	52	893	25	33	438	18
22-May	0	6	0	0	0	0	0	10	3	0	0	0	52	945	26	33	471	20
23-May	0	6	0	0	0	0	0	10	3	0	0	0	52	997	28	33	504	21
24-May	0	6	0	0	0	0	0	10	3	0	0	0	52	1,049	29	33	537	23
25-May	0	6	0	0	0	0	0	10	3	0	0	0	52	1,101	31	33	570	24
26-May	0	6	0	0	0	0	0	10	3	0	0	0	36	1,137	32	27	597	25
27-May	0	6	0	0	0	0	0	10	3	0	0	0	130	1,267	35	41	638	27
28-May	0	6	0	0	0	0	1	11	3	0	1	0	1,065	2,332	65	98	736	31
29-May	2	8	0	0	0	2	1	12	4	0	1	0	644	2,976	83	67	803	34
30-May	6	14	0	0	0	6	0	12	4	0	0	0	193	3,169	89	129	932	39
31-May	3	17	0	1	2	0	2	14	4	1	1	0	90	3,259	91	116	1,048	44
1-Jun	5	22	0	1	3	0	1	15	5	0	0	0	36	3,295	92	53	1,101	46
2-Jun	6	28	0	1	4	0	2	17	5	1	1	0	153	3,448	97	62	1,163	49
3-Jun	14	42	0	3	9	1	1	18	6	0	0	0	57	3,505	98	68	1,231	52
4-Jun	12	54	0	3	8	1	8	26	8	3	3	1	15	3,520	99	58	1,289	54
5-Jun	12	66	0	3	8	1	5	31	10	2	2	1	9	3,529	99	110	1,399	59
6-Jun	28	94	0	7	18	2	4	35	11	2	2	1	6	3,535	99	71	1,470	62
7-Jun	28	122	0	7	17	4	4	39	12	2	1	1	6	3,541	99	71	1,541	65
8-Jun	28	150	0	7	17	4	4	43	13	2	1	1	6	3,547	99	71	1,612	68
9-Jun	37	187	0	9	22	6	8	51	16	3	2	2	2	3,549	99	34	1,646	69
10-Jun	41	228	1	10	25	6	3	54	17	1	1	1	3	3,552	99	29	1,675	71
11-Jun	6	234	1	1	4	1	0	54	17	0	0	0	2	3,554	100	26	1,701	72
12-Jun	27	261	1	7	16	4	3	57	18	1	1	1	2	3,556	100	32	1,733	73
13-Jun	23	284	1	6	14	4	0	57	18	0	0	0	2	3,558	100	25	1,758	74
14-Jun	30	314	1	11	17	2	0	57	18	0	0	0	1	3,559	100	28	1,786	75
15-Jun	18	332	1	7	10	1	2	59	18	1	0	1	5	3,564	100	16	1,802	76
16-Jun	196	528	1	73	113	10	9	68	21	5	2	3	2	3,566	100	43	1,845	78
17-Jun	274	802	2	102	158	14	1	69	21	1	0	0	0	3,566	100	30	1,875	79
18-Jun	58	860	2	22	33	3	3	72	22	2	1	1	2	3,568	100	29	1,904	80
19-Jun	102	962	2	38	59	5	1	73	22	1	0	0	2	3,570	100	37	1,941	82
20-Jun	40	1,002	2	15	23	2	1	74	23	1	0	0	0	3,570	100	31	1,972	83
21-Jun	317	1,319	3	233	79	5	2	76	23	1	0	1	0	3,570	100	39	2,011	85
22-Jun	277	1,596	4	204	69	4	4	80	25	2	1	1	0	3,570	100	30	2,041	86
23-Jun	477	2,073	5	351	119	7	1	81	25	1	0	0	0	3,570	100	34	2,075	88
24-Jun	1,514	3,587	8	1,113	379	23	5	86	26	3	1	2	0	3,570	100	37	2,112	89
25-Jun	1,137	4,724	11	836	284	17	6	92	28	3	1	2	0	3,570	100	17	2,129	90

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Appendix B. (page 2 of 3)

Date	Sockeye			Daily Sockeye By Age Class			Coho			Daily Coho By Age Class			Pink			Dolly Varden		
	Daily [a]	Cumulative	Cumulative %	1	2	3	Daily [a]	Cumulative	Cumulative %	1	2	3	Daily [a]	Cumulative	Cumulative %	Daily	Cumulative	Cumulative %
26-Jun	279	5,003	12	205	70	4	5	97	30	3	1	2	0	3,570	100	14	2,143	90
27-Jun	1,003	6,006	14	737	251	15	3	100	31	2	1	1	0	3,570	100	5	2,148	91
28-Jun	738	6,744	16	697	41	0	2	102	31	1	0	1	0	3,570	100	5	2,153	91
29-Jun	1,428	8,172	19	1,348	80	0	5	107	33	3	1	2	0	3,570	100	13	2,166	91
30-Jun	573	8,745	21	541	32	0	4	111	34	2	1	1	0	3,570	100	4	2,170	92
1-Jul	915	9,660	23	864	51	0	2	113	35	1	0	1	0	3,570	100	8	2,178	92
2-Jul	1,511	11,171	26	1,426	85	0	6	119	37	3	1	2	0	3,570	100	4	2,182	92
3-Jul	548	11,719	28	517	31	0	1	120	37	1	0	0	0	3,570	100	1	2,183	92
4-Jul	455	12,174	29	430	25	0	0	120	37	0	0	0	0	3,570	100	3	2,186	92
5-Jul	637	12,811	30	615	22	0	1	121	37	1	0	0	0	3,570	100	8	2,194	93
6-Jul	684	13,495	32	661	23	0	0	121	37	0	0	0	0	3,570	100	2	2,196	93
7-Jul	604	14,099	33	583	21	0	1	122	38	1	0	0	0	3,570	100	0	2,196	93
8-Jul	252	14,351	34	243	9	0	1	123	38	1	0	0	0	3,570	100	1	2,197	93
9-Jul	479	14,830	35	463	16	0	0	123	38	0	0	0	0	3,570	100	0	2,197	93
10-Jul	542	15,372	36	524	18	0	3	126	39	2	1	1	0	3,570	100	2	2,199	93
11-Jul	806	16,178	38	779	27	0	2	128	39	1	0	1	0	3,570	100	0	2,199	93
12-Jul	762	16,940	40	748	14	0	3	131	40	2	1	1	0	3,570	100	0	2,199	93
13-Jul	1,387	18,327	43	1,361	26	0	1	132	41	1	0	0	0	3,570	100	1	2,200	93
14-Jul	382	18,709	44	375	7	0	1	133	41	1	0	0	0	3,570	100	0	2,200	93
15-Jul	672	19,381	46	659	13	0	0	133	41	0	0	0	0	3,570	100	1	2,201	93
16-Jul	578	19,959	47	567	11	0	0	133	41	0	0	0	0	3,570	100	0	2,201	93
17-Jul	854	20,813	49	838	16	0	2	135	42	1	0	1	0	3,570	100	0	2,201	93
18-Jul	2,380	23,193	55	2,335	45	0	0	135	42	0	0	0	0	3,570	100	2	2,203	93
19-Jul	1,798	24,991	59	1,775	23	0	1	136	42	1	0	0	0	3,570	100	0	2,203	93
20-Jul	2,157	27,148	64	2,129	28	0	1	137	42	1	0	0	0	3,570	100	0	2,203	93
21-Jul	2,417	29,565	70	2,386	31	0	0	137	42	0	0	0	0	3,570	100	3	2,206	93
22-Jul	2,010	31,575	75	1,984	26	0	0	137	42	0	0	0	0	3,570	100	3	2,209	93
23-Jul	1,990	33,565	79	1,964	26	0	0	137	42	0	0	0	0	3,570	100	4	2,213	93
24-Jul	1,727	35,292	83	1,705	22	0	1	138	42	1	0	0	0	3,570	100	0	2,213	93
25-Jul	1,190	36,482	86	1,175	15	0	1	139	43	1	0	0	0	3,570	100	5	2,218	94
26-Jul	1,008	37,490	89	1,008	0	0	0	139	43	0	0	0	0	3,570	100	0	2,218	94
27-Jul	1,380	38,870	92	1,380	0	0	0	139	43	0	0	0	0	3,570	100	1	2,219	94
28-Jul	329	39,199	93	329	0	0	1	140	43	1	0	0	0	3,570	100	0	2,219	94
29-Jul	496	39,695	94	496	0	0	1	141	43	1	0	0	0	3,570	100	1	2,220	94
30-Jul	313	40,008	95	313	0	0	1	142	44	1	0	0	0	3,570	100	0	2,220	94
31-Jul	1,150	41,158	97	1,150	0	0	1	143	44	1	0	0	0	3,570	100	0	2,220	94
1-Aug	592	41,750	99	592	0	0	1	144	44	1	0	0	0	3,570	100	0	2,220	94
2-Aug	5	41,755	99	5	0	0	0	144	44	0	0	0	0	3,570	100	0	2,220	94
3-Aug	101	41,856	99	93	0	0	1	145	45	1	0	0	0	3,570	100	5	2,225	94
4-Aug	24	41,880	99	22	0	0	4	149	46	2	1	1	0	3,570	100	3	2,228	94
5-Aug	13	41,893	99	12	0	0	7	156	48	4	1	2	0	3,570	100	2	2,230	94
6-Aug	73	41,966	99	67	0	0	18	174	54	9	3	6	0	3,570	100	3	2,233	94
7-Aug	35	42,001	99	32	0	0	14	188	58	7	2	5	0	3,570	100	6	2,239	94
8-Aug	53	42,054	99	49	0	0	8	196	60	4	1	3	0	3,570	100	2	2,241	95
9-Aug	13	42,067	99	12	0	0	5	201	62	3	1	2	0	3,570	100	2	2,243	95
10-Aug	15	42,082	99	14	0	0	5	206	63	3	1	2	0	3,570	100	6	2,249	95
11-Aug	28	42,110	99	26	0	0	8	214	66	4	1	3	0	3,570	100	1	2,250	95
12-Aug	8	42,118	99	7	0	0	1	215	66	1	0	0	0	3,570	100	30	2,280	96

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Appendix B. (page 3 of 3)

Date	Sockeye			Daily Sockeye By Age Class			Coho			Daily Coho By Age Class			Pink			Dolly Varden		
	Daily [a]	Cumulative	Cumulative %	1	2	3	Daily [a]	Cumulative	Cumulative %	1	2	3	Daily [a]	Cumulative	Cumulative %	Daily	Cumulative	Cumulative %
13-Aug	9	42,127	100	8	0	0	5	220	68	3	1	2	0	3,570	100	6	2,286	96
14-Aug	9	42,136	100	8	0	0	10	230	71	5	2	3	0	3,570	100	0	2,286	96
15-Aug	8	42,144	100	7	0	0	6	236	73	3	1	2	0	3,570	100	5	2,291	97
16-Aug	32	42,176	100	30	0	0	3	239	74	2	2	0	0	3,570	100	3	2,294	97
17-Aug	28	42,204	100	26	0	0	4	243	75	2	2	0	0	3,570	100	4	2,298	97
18-Aug	19	42,223	100	18	0	0	2	245	75	1	1	0	0	3,570	100	4	2,302	97
19-Aug	30	42,253	100	28	0	0	22	267	82	11	11	0	0	3,570	100	19	2,321	98
20-Aug	43	42,296	100	40	0	0	7	274	84	4	4	0	0	3,570	100	5	2,326	98
21-Aug	4	42,300	100	4	0	0	16	290	89	8	8	0	0	3,570	100	6	2,332	98
22-Aug	2	42,302	100	2	0	0	6	296	91	3	3	0	0	3,570	100	2	2,334	98
23-Aug	16	42,318	100	15	0	0	7	303	93	4	3	0	0	3,570	100	8	2,342	99
24-Aug	6	42,324	100	6	0	0	7	310	95	4	3	0	0	3,570	100	3	2,345	99
25-Aug	5	42,329	100	5	0	0	5	315	97	3	2	0	0	3,570	100	3	2,348	99
26-Aug	5	42,334	100	5	0	0	6	321	99	3	3	0	0	3,570	100	2	2,350	99
27-Aug	1	42,335	100	1	0	0	4	325	100	2	2	0	0	3,570	100	5	2,355	99
28-Aug	1	42,336	100	1	0	0	0	325	100	0	0	0	0	3,570	100	5	2,360	100
29-Aug	0	42,336	100	0	0	0	0	325	100	0	0	0	0	3,570	100	6	2,366	100
30-Aug	0	42,336	100	0	0	0	0	325	100	0	0	0	0	3,570	100	5	2,371	100
Totals	42,336			39,517	2,623	161	325			165	95	75	3,570			2,371		
Percent				93.3	6.2	0.4				50.9	29.3	23.1						

[a] Daily counts in bold are estimates of fish emigrating when trap efficiency was < 100% (Appendix C).

Appendix C. Estimated numbers of juvenile fish that emigrated from Summer Bay Lake in 1998 while weir/trap was fishing at less than 100% efficiency.

Date/time compromised	Date/time repaired	Hrs:Min trap compromised	Estimated efficiency	Sockeye	Pink	Coho	Dolly Varden
05/14 14:00	05/26 17:00	291:00	0%	0	626	0	399
06/06 12:00	06/09 20:30	80:30	0%	94	20	13	241
07/11 02:00	07/11 03:00	01:00	50%	2	0	0	0
08/02 17:30	08/03 17:00	23:30	50%	5	0	0	0
08/12 16:00	08/13 10:00	18:00	25%	4	0	0	24
08/17 23:00	08/18 12:00	13:00	50%	11	0	1	2
08/19 01:00	08/19 08:00	07:00	50%	3	0	1	4
08/21 12:00	08/22 08:00	20:00	50%	2	0	8	3
08/22 22:00	08/23 07:00	09:00	50%	1	0	2	1
08/23 12:00	08/23 18:00	06:00	50%	0	0	1	0
08/23 23:00	08/24 10:00	11:00	50%	6	0	2	3
08/27 18:00	08/30 12:00	66:00	50%	1	0	2	8
		546:00	Total:	**129**	**646**	**30**	**685**

Appendix D. Results of minnow trapping in Summer Bay Lake, 1998.

			Catch by Species and Catch Per Unit Effort (CPUE)							
Date Set	Number Traps	Soak Time (hrs.)	Coho Salmon	CPUE (hrs.)	Sockeye Salmon	CPUE (hrs.)	Dolly Varden	CPUE (hrs.)	Other [a]	CPUE (hrs.)
11-Aug	15	43	18	0.42	1	0.02	5	0.12	59	1.37
20-Aug	15	18	54	3.00	0	0.00	0	0.00	353	19.61
4-Sep	15	26	41	1.58	0	0.00	0	0.00	153	5.88
Totals:	45	87	113	1.30	1	0.01	5	0.06	565	6.49

[a] Included stickleback, and sculpin.

Appendix E. Daily and cumulative adult fish escapements, cumulative %, and daily escapements by age class, by species, Summer Bay Lake, 1998.

Date	Sockeye			Sockeye By Age Class					Coho			Coho By Age Class		Pink			Dolly Varden		
	Daily	Cumulative	Cumulative %	1.2	1.3	2.2	2.3	Other	Daily [a]	Cumulative	Cumulative %	1.1	2.1	Daily [a]	Cumulative	Cumulative %	Daily	Cumulative	Cumulative %
12-Jun	1	1	0	1	0	0	0				0					0			0
13-Jun	0	1	0	0	0	0	0				0					0			0
14-Jun	6	7	0	4	2	0	0				0					0			0
15-Jun	0	7	0	0	0	0	0				0					0			0
16-Jun	0	7	0	0	0	0	0				0					0			0
17-Jun	1	8	0	1	0	0	0				0					0			0
18-Jun	51	59	2	31	20	0	0				0					0			0
19-Jun	0	59	2	0	0	0	0				0					0			0
20-Jun	54	113	4	32	22	0	0				0					0			0
21-Jun	12	125	5	7	5	0	0				0					0			0
22-Jun	14	139	5	8	6	0	0				0					0			0
23-Jun	40	179	7	24	16	0	0				0					0			0
24-Jun	0	179	7	0	0	0	0				0					0			0
25-Jun	27	206	8	16	11	0	0				0					0			0
26-Jun	7	213	8	3	3	0	1				0					0			0
27-Jun	39	252	10	18	18	0	3				0					0			0
28-Jun	22	274	10	12	9	0	1				0					0			0
29-Jun	14	288	11	8	5	1	0				0					0			0
30-Jun	27	315	12	11	14	1	0				0					0			0
1-Jul	32	347	13	19	12	0	1				0					0			0
2-Jul	51	398	15	32	13	3	3				0					0			0
3-Jul	80	478	18	38	36	2	4				0					0			0
4-Jul	66	544	21	33	30	1	1				0					0			0
5-Jul	58	602	23	35	12	0	12				0					0	4	4	1
6-Jul	2	604	23	1	1	0	0				0					0	2	6	2
7-Jul	14	618	23	11	3	0	0				0					0	2	8	3
8-Jul	35	653	25	18	14	0	1	1			0					0	0	8	3
9-Jul	21	674	26	16	5	0	0				0					0	4	12	4
10-Jul	19	693	26	7	7	0	5				0					0	1	13	5
11-Jul	55	748	28	28	21	3	1	1			0					0	1	14	5
12-Jul	55	803	30	29	26	0	0				0					0	2	16	6
13-Jul	0	803	30	0	0	0	0				0					0	0	16	6
14-Jul	26	829	31	16	10	0	0				0					0	0	16	6
15-Jul	81	910	34	50	28	0	0	2			0					0	1	17	6
16-Jul	718	1,628	62	445	251	0	0	14			0					0	11	28	10
17-Jul	84	1,712	65	52	29	0	0	2			0					0	4	32	12
18-Jul	34	1,746	66	15	19	0	0	1			0					0	2	34	12
19-Jul	51	1,797	68	29	15	1	0	2			0					0	1	35	13
20-Jul	48	1,845	70	31	14	1	1				0					0	1	36	13
21-Jul	45	1,890	72	31	14	0	0				0					0	0	36	13
22-Jul	40	1,930	73	24	14	1	0				0			3	3	0	0	36	13
23-Jul	20	1,950	74	13	3	2	2				0			0	3	0	0	36	13
24-Jul	49	1,999	76	33	8	4	4				0			5	8	0	0	36	13
25-Jul	22	2,021	77	18	4	0	0				0			2	10	0	0	36	13
26-Jul	42	2,063	78	31	10	1	0				0			1	11	0	1	37	13
27-Jul	35	2,098	79	26	8	1	0				0			0	11	0	0	37	13
28-Jul	19	2,117	80	15	3	0	1				0			0	11	0	0	37	13
29-Jul	0	2,117	80	0	0	0	0				0			0	11	0	0	37	13

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Appendix E. (page 2 of 3)

Date	Sockeye			Sockeye By Age Class					Coho			Coho By Age Class		Pink			Dolly Varden		
	Daily	Cumulative	Cumulative %	1.2	1.3	2.2	2.3	Other	Daily[a]	Cumulative	Cumulative %	1.1	2.1	Daily[a]	Cumulative	Cumulative %	Daily	Cumulative	Cumulative %
30-Jul	0	2,117	80	0	0	0	0				0			0	11	0	0	37	13
31-Jul	23	2,140	81	17	4	0	0	1			0			1	12	0	0	37	13
1-Aug	0	2,140	81	0	0	0	0	0			0			0	12	0	0	37	13
2-Aug	100	2,240	85	76	18	0	0	6			0			750	762	10	0	37	13
3-Aug	4	2,244	85	3	1	0	0	0			0			0	762	10	0	37	13
4-Aug	60	2,304	87	46	11	0	0	4			0			770	1,532	21	5	42	15
5-Aug	53	2,357	89	40	10	0	0	3			0			515	2,047	28	3	45	16
6-Aug	22	2,379	90	17	4	0	0	1			0			383	2,430	33	3	48	17
7-Aug	5	2,384	90	4	1	0	0	0			0			1	2,431	33	0	48	17
8-Aug	2	2,386	90	2	0	0	0	0			0			0	2,431	33	0	48	17
9-Aug	50	2,436	92	38	9	0	0	3			0			409	2,840	39	52	100	36
10-Aug	28	2,464	93	21	5	0	0	2			0			18	2,858	39	2	102	37
11-Aug	56	2,520	95	43	10	0	0	3			0			248	3,106	43	21	123	45
12-Aug	2	2,522	95	2	0	0	0	0			0			0	3,106	43	3	126	46
13-Aug	7	2,529	96	5	1	0	0	0			0			82	3,188	44	28	154	56
14-Aug	11	2,540	96	8	2	0	0	1			0			116	3,304	45	32	186	67
15-Aug	11	2,551	97	8	2	0	0	1			0			17	3,321	46	15	201	73
16-Aug	4	2,555	97	3	1	0	0	0			0			24	3,345	46	19	220	80
17-Aug	7	2,562	97	5	1	0	0	0	1	1	1	1	0	23	3,368	46	15	235	85
18-Aug	10	2,572	97	8	2	0	0	1	0	1	1	0	0	385	3,753	51	0	235	85
19-Aug	2	2,574	97	2	0	0	0	0	0	1	1	0	0	110	3,863	53	0	235	85
20-Aug	25	2,599	98	19	5	0	0	2	0	1	1	0	0	118	3,981	55	12	247	89
21-Aug	6	2,605	99	5	1	0	0	0	0	1	1	0	0	175	4,156	57	0	247	89
22-Aug	6	2,611	99	5	1	0	0	0	0	1	1	0	0	630	4,786	66	15	262	95
23-Aug	0	2,611	99	0	0	0	0	0	0	1	1	0	0	420	5,206	71	10	272	99
24-Aug	2	2,613	99	2	0	0	0	0	1	2	2	1	0	313	5,519	76	2	274	99
25-Aug	0	2,613	99	0	0	0	0	0	0	2	2	0	0	0	5,519	76	0	274	99
26-Aug	7	2,620	99	5	1	0	0	0	9	11	11	5	4	263	5,782	79	0	274	99
27-Aug	0	2,620	99	0	0	0	0	0	3	14	14	2	1	61	5,843	80	1	275	100
28-Aug	2	2,622	99	2	0	0	0	0	4	18	18	2	2	69	5,912	81	0	275	100
29-Aug	1	2,623	99	1	0	0	0	0	4	22	22	2	2	195	6,107	84	0	275	100
30-Aug	0	2,623	99	0	0	0	0	0	8	30	30	5	3	158	6,265	86	0	275	100
31-Aug	2	2,625	99	2	0	0	0	0	6	36	36	4	2	272	6,537	90	0	275	100
1-Sep	3	2,628	100	2	1	0	0	0	5	41	41	3	2	66	6,603	91	0	275	100
2-Sep	1	2,629	100	1	0	0	0	0	6	47	47	6	0	32	6,635	91	0	275	100
3-Sep	1	2,630	100	1	0	0	0	0	3	50	50	3	0	90	6,725	92	0	275	100
4-Sep	1	2,631	100	1	0	0	0	0	3	53	52	3	0	55	6,780	93	0	275	100
5-Sep	0	2,631	100	0	0	0	0	0	1	54	53	1	0	29	6,809	100	0	275	100
6-Sep	0	2,631	100	0	0	0	0	0	1	55	54	1	0	10	6,819	94	0	275	100
7-Sep	2	2,633	100	2	0	0	0	0	2	57	56	2	0	113	6,932	95	0	275	100
8-Sep	0	2,633	100	0	0	0	0	0	1	58	57	1	0	116	7,048	97	0	275	100
9-Sep	2	2,635	100	2	0	0	0	0	2	60	59	2	0	91	7,139	98	1	276	100
10-Sep	4	2,639	100	3	1	0	0	0	4	64	63	4	0	112	7,251	99	0	276	100
11-Sep	0	2,639	100	0	0	0	0	0	7	71	70	0	7	7	7,258	100	0	276	100
12-Sep	0	2,639	100	0	0	0	0	0	3	74	73	0	3	7	7,265	100	0	276	100
13-Sep	1	2,640	100	1	0	0	0	0	12	86	85	6	6	7	7,272	100	0	276	100
14-Sep	0	2,640	100	0	0	0	0	0	2	88	87	0	2	2	7,274	100	0	276	100
15-Sep	1	2,641	100	1	0	0	0	0	1	89	88	0	1	2	7,276	100	0	276	100

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Appendix E. (page 3 of 3)

Date	Sockeye			Sockeye By Age Class					Coho			Coho By Age Class		Pink			Dolly Varden		
	Daily	Cumulative	Cumulative %	1.2	1.3	2.2	2.3	Other	Daily [a]	Cumulative	Cumulative %	1.1	2.1	Daily [a]	Cumulative	Cumulative %	Daily	Cumulative	Cumulative %
16-Sep	0	2,641	100	0	0	0	0	0	2	91	90	0	2	1	7,277	100	0	276	100
17-Sep	0	2,641	100	0	0	0	0	0	3	94	93	0	3	5	7,282	100	0	276	100
18-Sep	0	2,641	100	0	0	0	0	0	3	97	96	0	3	2	7,284	100	0	276	100
19-Sep		2,641	100							97	96				7,284	100		276	100
20-Sep		2,641	100							97	96				7,284	100		276	100
21-Sep		2,641	100						3	100	99	0	3	5	7,289	100		276	100
22-Sep		2,641	100							100	99				7,289	100	0	276	100
23-Sep	0	2,641	100	0	0	0	0	0	1	101	100	0	1	1	7,290	100	0	276	100
24-Sep		2,641	100							101	100				7,290	100		276	100
25-Sep		2,641	100							101	100				7,290	100		276	100
26-Sep		2,641	100							101	100				7,290	100		276	100
27-Sep		2,641	100							101	100				7,290	100		276	100
28-Sep		2,641	100							101	100				7,290	100		276	100
29-Sep		2,641	100							101	100				7,290	100		276	100
30-Sep		2,641	100							101	100				7,290	100		276	100
1-Oct		2,641	100							101	100				7,290	100		276	100
2-Oct		2,641	100							101	100				7,290	100		276	100
3-Oct		2,641	100							101	100				7,290	100		276	100
Totals	2,641			1,670	839	23	42	54	101			54	47	7,290			276		
Percent				63.2	31.8	0.9	1.6	2.0				53.1	46.9						

Appendix F. Summer Bay Lake, Unalaska Lake, Humpy Cove Creek, and Morris Cove Creek escapement distribution surveys, 1998.

			Live Counts by Species				
System	Date	Section/area	Sockeye	Pink	Coho	Dolly Varden	Comments
Summer Bay Lake	1-Jul	Lake	2	0	0		No spawning activity
	26-Jul	Lake (N)	15	0	0		Fish cruising
		Lake (W)	~100	0	0		Some spawning activity
		Lake (S)	~50	0	0		Schooling off mouth of inlet creek
		Lake (E)	~8	0	0		No spawning activity
	28-Jul	Inlet Stream	1	0	0		Lower 100 yds
	6-Aug	Inlet Stream	4	0	0	20-30	Not spawning
	13-Aug	Inlet Stream	68	118	0	~100	Most fish lower 100 yds
		Mouth of Inlet	~150	~300	0		Buildup at mouth
		Lake (E)	15	10	0		Little activity
		Lake (W)	~300	0	0		Shoal spawners
	25-Aug	Inlet Stream	191	2,050	0		
	17-Sep	Lake (E)	100	0	0		25 sockeye morts
		Lake (W)	150	0	0		Spawning activity
		Inlet Stream	256	634	1	40	987 pink morts; 20 coho fry
	23-Nov	Inlet Stream	0	0	0	0	Surveyor-Pappas
	25-Nov	Inlet Stream	0	0	0	0	Surveyor-Pappas
Unalaska Lake	17-Aug	Inlet Stream	0	491	0	~350	Fish pass to lake; 5 pink morts
		Mouth of creek	2	100	0		
	7-Sep	Inlet Stream	4	3,032	0	~1500	517 pink morts
	21-Nov	Outlet Stream	0	0	355	0	
Humpy Cove Cr.	25-Jun	Lower creek*	0	0	0	0	* From bridge down
		Mouth	0	**	0		** Jumpers every 5 seconds
	18-Aug	Upper creek	0	997	0	~40	
		Lower creek	0	4,094	0	100-150	24 pink morts
	4-Sep	Upper creek	0	1,665	0	0	297 pink morts
		Lower creek	0	6,360	0	100	1933 pink morts
Morris Cove Cr.	10-Aug	Creek	0	0	0	0	Pulled weir
		Bay	0	**	0	0	**Couple of Jumpers
	17-Aug	Creek	0	7	0	0	Good Visibility
		Bay	0	0	0	0	
	4-Sep	Creek	1	3	0	0	Good vis.; Sockeye spawned
		Bay	0	0	0	0	
	12-Sep	Creek	2	0	2	0	4 fishers, no fish caught
		Bay	0	0	0	0	Good Visibility

Appendix G. Climatological observations at the Summer Bay Lake juvenile and adult fishery monitoring project in 1998.

		Temperature (C)		Cloud	Wind		Stream	
Date	Time (hrs)	Air	Water	%	Direction	Vel (kts)	Height (cm)	Comments
9-May	2000	4	5	25	S	5-10		
10-May	1100	7	5	50	S	15+		
10-May	2300	7	5	100	S	1-5		
11-May	1200	6	5		S	5-10	39	Drizzle, 100'solid, fog
11-May	2300	6	5		S	5-10	39	
12-May	1100	4.5	5		N	5-10	39	
12-May	2300	4.5	5		S	10-20	40	
13-May	1200	7	6		S	10-20	39	2500' overcast
13-May	2300	6	5		S	50+	39	"
14-May	1100	6	5		S	10-20+	39	rain
14-May	2300	5	5		SW	10-55+	65	Mixed rain and snow, blowing hard, approx. 50+winds
15-May	1100	4	5		N	10-25	55	Gusts to 20+, rain and snow, water dropping
16-May	1200	7	5		S	5-10	48	Rain and snow mixed
17-May	1100	7	5		S	5-10	55	Rain, slight wind
18-May	1100	9	7		N	5-10	52	Some sun today! Wind gusting to 25 from north
19-May	1100	9	7		N	5-10	45	Sunny most of day. Evening rain.
20-May	1100	6	6		N	5-10	42	Gusting to 20-25+
21-May	1100	5	6		N	5-10	40	
22-May	1100	10	7		N	5-10	39	
23-May	1200	6	6		N	5-10	39	
24-May	1200	7	6		S	5-10	45	
25-May	1200	10	7		S	5-10	42	
26-May	1200	6	7		S	5-10	43	
26-May	2300	6	7		S	5-10	45	
27-May	1200	10	7		S	1-5	43	
27-May	2300	7	6		S	5-10	43	
28-May	1100	6	6		S	10-15	50	Creek rising, wind increasing out of north
29-May	2300	7	7		S	0-5	60	
30-May	1100	9.5	8		SW	5-10	54	
30-May	2300	9	8		SW	10-15	53	
31-May	1200	10	9		SE	15	52	
31-May	2300	8	8		SE	10	50	
1-Jun	1100	8	8		S	5-10	51	
1-Jun	2300	8	8		S	10-15	51	
2-Jun	1100	7	8		S	15-20	51	
2-Jun	2300	7	9		S	10-15	49	
3-Jun	1130	11	10	75	S	10	50	
3-Jun	2300	8	9	100	S	15	50	Sun today, sprinkling now
4-Jun	1200	10	9	100	S	10	52	High wind last night, rain now
4-Jun	2300	8	9	85	S	10	55	
5-Jun	1200	9	9	90	S	25	54	
5-Jun	2300	8	8	100	S	30-40	56	Int. Rain
6-Jun	1200	7	8	100	S	45	59	rain, wind, nasty
9-Jun	2300	8	8	80	S	15	52	Sun most of the day
10-Jun	1200	9	8	100	S	10	52	
10-Jun	2300	8	8	100	S	5	52	Nice Day!
11-Jun	1200	8	8	75	S	0-5	51	No wind!
11-Jun	2300	8	8	50	S	0-5	50	Nice!
12-Jun	1200	10	9	100	S	5-10	49	
12-Jun	2300	8	9	100	S	5-10	48	Int Rain
13-Jun	1200	10	9	100	N	0-5	48	
13-Jun	2300	8	8.5	75	N	0-5	47	Nice Day!
14-Jun	1200	12	9	75	S	0-5	48	Sun!
14-Jun	2300	8	9	100	S	5-10	49	
15-Jun	1200	10	9	100	NE	5	48	
15-Jun	2300	8	9	100	NE	0-5	48	Sun part of the day
16-Jun	1200	12	10	50	S	15	49	
16-Jun	2300	9	9	80	S	15	49	

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		Temperature (C)		Cloud	Wind		Stream	
Date	Time (hrs)	Air	Water	%	Direction	Vel (kts)	Height (cm)	Comments
17-Jun	1200	13	10	60	S	35	49	
17-Jun	2300	8	9	100	S	10	50	
18-Jun	1200	11	9	100	S	15	50	
18-Jun	2300	7	9	100	S	5-10	49	
19-Jun	1200	11	10	75	S	10-50	47	Very heavy gusts of wind
19-Jun	2300	8	9	100	S	10-15	49	
20-Jun	1200	10	11	100	S	10	48	
20-Jun	2300	8	10	100	VAR	0-5	48	
21-Jun	1200	10	11	100	S	10	48	
21-Jun	2400	7	9	100	SE	5-10	48	Rain
22-Jun	1200	9	10	100	VAR	5-10	49	Fog, rain, etc.
22-Jun	2300	9	9	100	NW	10	49	
23-Jun	1200	13	10	5	NW	5	48	
23-Jun	2300	8	9	40	0	0	48	Beautiful evening
24-Jun	1200	13	11	100	S	10-15	50	Rain early today
24-Jun	2300	11	11	5	S	25	51	
25-Jun	1200	13	11	100	S	10	49	
25-Jun	2300	9	10	75	S	5-10	49	
26-Jun	1200	11	11	100	N	5	48	Int Drizzle
26-Jun	2300	9	10	100	N	5	49	
27-Jun	1200	10	11	100	VAR	2	48	
27-Jun	2300	9	10	100	0	0	45	
28-Jun	1200	12	12	70	N	5	46	
28-Jun	2300	10	11	75	N	0-5	45	Nice Day!
29-Jun	1030	11	11	100	N	5	46	
29-Jun	2300	8	10	100	N	5	47	Drizzle
30-Jun	1200	11	13	100	N	5	47	
30-Jun	2300	10	11.5	100	VAR	0-5	47	Fog at times
1-Jul	1200	10	11	100	N	5	46	Foggy
1-Jul	2300	9	11	100	N	5	43	Rain, fog, yuck
2-Jul	1200	10	11	100	N	10	44	Rain, fog, wind
2-Jul	2300	10	10.5	100	N	20	45	
3-Jul	1200	10	11	100	NW	10	44.5	Nice Day!
3-Jul	2300	10	11	90	N	5	44	
4-Jul	1200	11	11	100	S	0-5	43	
4-Jul	2300	10	11	100	VAR	5-10	44	
5-Jul	1200	11	11	100	VAR	0-5	45	
5-Jul	2300	10	11	90	S	5-10	45	
6-Jul	1200	11	13	100	S	5	49.5	
6-Jul	2300	9	11	100	N	0-5	48	
7-Jul	1200	12	13	90	N	0-5	48	
7-Jul	2300	10	11	100	N	0-5	47	
8-Jul	1200	13	12	100	W	0-5	48	
8-Jul	2300	9	11	100	N	0-5	47	
9-Jul	1200	12	13	85	VAR	0-5	46	
9-Jul	2300	10	11	75	VAR	0-5	45	
10-Jul	1200	11	11	100	N	10	45	
10-Jul	2300	10	11	97	VAR	10-15	45	
11-Jul	1200	10	11	100	N	5-10	44	
11-Jul	2300	10	11	100	N	5-10	45	
12-Jul	1200	14	13	25	N	5-10	44	
12-Jul	2300	10	11	90	0	0	43	Patchy fog
13-Jul	1200	13	13	100	VAR	5-10	47	
13-Jul	2300	10	11	100	S	25	47	Rain
14-Jul	1200	14	13	100	VAR	0-5	45	Fog
14-Jul	2300	10	12	100	VAR	0-5	44.5	Fog, Drizzle
15-Jul	1200	10	11	100	VAR	0-5	44	Rain, Fog
15-Jul	2300	10	11	100	NE	35-40	43	Rain
16-Jul	1200	9	11	100	NE	40+	43	Int. Rain

-Continued-

		Temperature (C)		Cloud	Wind		Stream	
Date	Time (hrs)	Air	Water	%	Direction	Vel (kts)	Height (cm)	Comments
16-Jul	2300	9	11	50	0	0	44	
17-Jul	1200	13	12	100	S	10	46	
17-Jul	2300	9	11	100	VAR	5	46	Rain, fog
18-Jul	1200	13	12	100	S	5-10	45	Int. Rain
18-Jul	2300	10	12	100	N	0-5	45	Mist, light rain
19-Jul	1200	12	12	100	N	5-10	45	
19-Jul	2300	11	11	100	N	25	45	Int. Fog
20-Jul	1200	12	12	75	N	5-10	45	
20-Jul	2300	9	11	100	N	5-10	44	High fog, Mist
21-Jul	1200	14	13	5	N	5	44	Sun!
21-Jul	2300	10	12	65	S	5-10	45	
22-Jul	2300	10	12	85	S	0-5	45	Cloudy, fog
23-Jul	1200	11	12	100	0	0	45	Rain
23-Jul	2300	10	12	100	VAR	0-5	47	Drizzle
24-Jul	1200	10	12	100	0	0	46	
24-Jul	2300	11	12	100	0	0	47	Rain
25-Jul	1200	13	12	100	S	0-15	48	
25-Jul	2300	12	12.5	100	0	0	47	
26-Jul	1200	11	13	100	S	0-5	45	
26-Jul	2300	10	12	100	0	0	45	
27-Jul	1000	12	12	85	S	5-10	44	
27-Jul	2300	13	13	100	S	5-10	45	
28-Jul	1200	14	13	100	S	5	44	
28-Jul	2300	11	12	100	N	5	43	
29-Jul	1200	16	13	100	N	5	42	
29-Jul	2300	11	12.5	100	0	0	42	Calm, buggy
30-Jul	1200	12	13	100	N	5	42	
30-Jul	2300	11	13	85	0	0	43	
31-Jul	1200	11	14	85	S	5-10	43	Wind increasing from south. Wind blew 40-50 last night.
31-Jul	2300	17	15	100	S	25	46	
1-Aug	1200	14	14	100	S	5	45	
3-Aug	2300	13	14	100	S	10	49*	*Moved gauge. Rain
4-Aug	1200	13	13	100	N	10	50	Blew south 35 before turning north this AM.
4-Aug	2300	13	13	85	VAR	0-5	50.5	
5-Aug	1200	13	14	100	VAR	0-5	51	
5-Aug	2300	12	13	100	VAR	0-5	50	
6-Aug	1200	13	14	100	S	0-5	49.5	
6-Aug	2300	11	12	40	N	5	49	Foggy today, nice now
7-Aug	1200	13	14	25	N	5-10	48.5	
7-Aug	2300	10.5	12	65	N	5-10	49	
8-Aug	1200	12	14	90	N	5-10	49	Nice Day!
8-Aug	2300	11	13	10	N	5	49	Sun!!!
9-Aug	1000	10	12	100	S	5-10	51	Rain
9-Aug	2300	11	13	100	S	5-10	51.5	Drizzle
10-Aug	1200	11	13	100	S	5	50	
10-Aug	2300	9	12	10	N	5	50	Calm, nice evening
11-Aug	1200	12	14	50	N	0-5	49	Sun!!!
11-Aug	2300	9	13	100	N	0-5	49	fog
12-Aug	1200	14	13	100	S	25-35	51	
12-Aug	2300	11	12	100	S	35	52	Gusts to 60mph
13-Aug	1200	16	14	99	N	5	50	
13-Aug	2300	12	13	100	0	0	50	Calm
14-Aug	1200	11	13	100	N	5-10	50	Patchy fog
14-Aug	2300	13	14	100	0	0	50	Calm
15-Aug	1200	23	16	80	S	10-15	51	Sun, high wind
15-Aug	2300	19	15	50	N	15-20	48	Blew S 60 today
16-Aug	1200	14	14	75	N	20	51	Gusts 90+ from south last night
16-Aug	2300	12	12	90	N	20-25	50	Water level fluctuating
17-Aug	1200	13	15	10	0	0	49	

-Continued-

		Temperature (C)		Cloud	Wind		Stream	
Date	Time (hrs)	Air	Water	%	Direction	Vel (kts)	Height (cm)	Comments
17-Aug	2300	13	14	50	S	5	50	
18-Aug	1200	16	15	20	S	5-10	50	
18-Aug	2300	14	13	100	S	25	51	Beginning to rain
19-Aug	1200	15	14	100	S	25-30	51	Rain
19-Aug	2300	14	14	100	S	25-30	50	
20-Aug	1200	15	14	95	S	5-10	50	
20-Aug	2300	12	14	100	VAR	0-5	50	
21-Aug	1200	14	14	100	VAR	0-5	50	
21-Aug	2300	12	14	100	S	5	48	
22-Aug	1200	18	15	50	S	10-15	51	
22-Aug	2300	17	15	25	S	50	58	
23-Aug	1200	14	14	35	N	50-70	42	
23-Aug	2300	12	13	50	S	20-25	50	Wind!
24-Aug	1200	13	14	100	S	10	51	
24-Aug	2300	10	11	40	S	10-15	51	Gusts 40-45 mph
25-Aug	1200	13	13	30	N	10-40	48	
25-Aug	2300	10	11	80	N	10-15	49	
26-Aug	1200	9	12	20	N	5-10	49	
26-Aug	2300	9	11	90	VAR	5	50	
27-Aug	1200	11	12	100	N	5-10	48	Rain
27-Aug	2300	10	11	50	N	15	50	
28-Aug	1200	11	10	100	N	5-10	48	Rain
28-Aug	2300	8	10	100	S	10	51	Rain
29-Aug	1200	8	10	100	N	10	50	Rain
29-Aug	2300	9	10	100	N	20-30	53	Rain
30-Aug	1200	11	11	80	N	5-10	52	
30-Aug	2300	8	10	100	N	15-20	53	Rain
31-Aug	2000	11	10	100	N	35	42	Rain/pulled smolt weir
1-Sep	0800	9	10	100	N	30	53*	*moved gauge
1-Sep	2000	8	10	100	N	20	49	Rain
2-Sep	1000	9	10	100	VAR	10	48	Rain
3-Sep	1000	7	9	100	N	15-20	49	Rain
3-Sep	2000	9	10	100	N	5-10	47	
4-Sep	1000	9	9	50	VAR	5	46	
4-Sep	2000	10	10	100	NW	10	45	
5-Sep	1000	10	10	100	0	0	45	
5-Sep	2000	10	10	100	S	10	46	
6-Sep	1000	11	10	100	N	10	45	
6-Sep	2000	11	11	100	S	10-20	45	
7-Sep	1000	11	10	100	N	5	45	
7-Sep	2000	10	10	100	S	5-10	45	Rain
8-Sep	1000	10	10	100	S	10	44	Rain
8-Sep	2000	10	10	100	S	0-5	45	Rain
9-Sep	1000	8	9	100	N	25	49	Rain
9-Sep	2000	9	10	100	N	60+	70	Extreme wind, heavy waves, rain
10-Sep	1000	9	10	100	N	10	54	
10-Sep	1830	9.5	10	100	n	5	54.5	
11-Sep	1000	9	9.5	85	N	5	53.5	
11-Sep	2000	9.5	9.5	80	NE	5	53.5	
12-Sep	1000	9.5	9.5	60	N	5	51	Some blue sky
12-Sep	2000	9	9.5	50	SW	5	51	
13-Sep	1000	9.5	9.5	35	SW	5	48	
13-Sep	2000	9.5	9.5	30	0	0	48	Calm
14-Sep	0830	12.5	12	40	SW	5-10	47.5	Wind switching from N to S throughout day
14-Sep	2115	11.5	11	80	SW	5-10	47.5	
15-Sep	0945	13	11	95	SW	15	47.5	Wind started at 0800-SW15 w/ higher gusts
15-Sep	2030	13.5	10.5	85	SW	5	47.5	
16-Sep	0900	12.5	10.5	80	SW	5	47.5	
16-Sep	2030	11.5	11	85	SW	15	46.5	

-Continued-

Appendix G. (page 5 of 5)

		Temperature (C)		Cloud	Wind		Stream	
Date	Time (hrs)	Air	Water	%	Direction	Vel (kts)	Height (cm)	Comments
17-Sep	1030	9.5	9.5	30	SW	30+	46.5	High winds blowing all night. Started at 1030pm. Rain
17-Sep	2000	9	9.5	60	SW	40	47	
18-Sep	0900	13.5	11.5	80	SW	30	55	River up due to heavy rain.
18-Sep	1900	12.5	11	100	SW	20	55	
19-Sep								River mouth blown shut, water over panels
19-Sep								"
20-Sep	2000	9.5	9	100	SW	40	70	River busted through @1100 am
21-Sep	1000	9.5	9.5	80	SW	25	65	River slowly going down
22-Sep								Pulled weir

SITUATION REPORT

INCIDENT NAME: M/V Kuroshima **NUMBER:** 26

LOCATION: Second Priest Rock, Summer Bay, Dutch Harbor/Unalaska, Alaska

SPILL NUMBER: 97259933001 **LEDGER CODE #:** 14620770

TIME AND DATE OF REPORT: 4:00 PM Tuesday, May 5,1998

TIME AND DATE OF NEXT REPORT: 4:00 PM, May 12, 1998

The Unified Command web site for M/V Kuroshima incident is: www.state.ak.us/local/akpages/ENV.CONSERV/dspar/perp/krshm.htm and can be accessed through the ADEC Homepage. The site contains photos, maps, sitreps, and press releases.

TYPE AND AMOUNT OF PRODUCT SPILLED: 39,000 gallons of bunker fuel is estimated to have spilled from the M/V Kuroshima.

CAUSE OF SPILL: The M/V Kuroshima, attempting to move to safer anchorage, ran aground near Second Priest Rock in Summer Bay in extremely heavy weather.

TIME AND DATE OF SPILL: 3:05 PM, November 26, 1997

POTENTIAL RESPONSIBLE PARTY (PRP): Kuroshima, Inc., Tokyo, Japan

CURRENT SITUATION: This sitrep covers the period April 28 - May 5, 1998.

ERST/O'Brien, the Kuroshima cleanup contractor directed crews to work the east, west, and north ends of Summer Lake, the east and west sides of Summer Bay and the north side of Morris Cove. Approximately 55 laborers manually removed bunker fuel patties, oiled mats, oiled grass, and oiled rock from the shorelines and beaches at these areas. Crews have completed their cleanup on the west and south sides of Summer Lake. Only minor clean up work remains on the north shore beach following removal of an oil mat from the beach. On the east side of the lake, workers continued to use pressure washers to clean the remaining oiled areas of the rock covered shoreline.

Tar balls occasionally wash ashore on the north and south ends of Summer Lake following high winds. Crews are monitoring the lake shore and are collecting any tar balls that do wash in.

Nineteen full rolloffs left the Samson Yard in Dutch Harbor by barge on May 2, 1998 for an Oregon disposal site. Because all the rolloffs available to the responsible party have been used,

-Continued-

contaminated materials are now being stored on site in super sacks in a lined pit until more rolloffs arrive on May 8. In addition, approximately 600 cubic yard of sand, small rocks and tar mix have been transferred by dump trucks to the FUD site in Unalaska for disposal.

Workers are using chain saws to cut oiled logs along the lake shore and Summer Bay beaches for burning at pre-approved burn sites. They continue to use smart ash burners to dispose of oiled personal protective equipment (PPE).

Workers completed the cleaning of the wooden bridge over the Summer Lake Outlet Creek using high pressure hot water washers. A scaffolding that was built under the bridge to provide a platform to clean the bridge has been removed. Wading in the anadromous stream during the bridge cleaning was minimized. Snare boom that was placed downstream of the bridge to collect tarballs and sheen also has been removed.

Divers, contracted to remove oil from the bottom of Summer Lake, have begun recovery operations. The divers are removing tar balls, patties, and several oil mats from the bottom of the lake. They are working in the area of the highest oil concentration at the north end of the lake and recovered three super sacs of almost pure bunker oil in the first afternoon. Oil is collected in bags by the divers and then raised to the surface where it is placed into super sacks inside a fish tote. From there it is taken by boat to an off loading area on the east side of the lake where it is transported by road to the temporary storage area.

A teleconference was held today to discuss results of the recent subsistence harvest sampling program. The meeting included staff from State, Local, and Federal Governments, the University of Alaska (Fairbanks), the Responsible Party, and the Qawalangin Tribal Council. The objective of the meeting was to bring everyone up to date on the subsistence sampling project and to exchange thoughts on interpretation of the analytical data that had come back from the lab. The group expects to provide a public statement on the interpretation of the results by the time the clean up is completed (late May or early June). Until the clean-up is complete, we will be recommending that subsistence users do not harvest organisms from the area impacted by the spill.

There are approximately 110 responders in Dutch Harbor working on the spill of which 55 are laborers in the field. The remaining staff are supervisors, technical specialists, and support personnel. There are four State and four Coast Guard personnel on site. The State and Coast Guard are working together to share oversight duties of the cleanup. The cooperation has reduced duplication of effort between the agencies and personnel requirements.

FUTURE PLANS AND RECOMMENDATIONS:

Maintain an "on site" staff of 4 to 6 persons in Dutch Harbor to work with the Responsible Parties' contractors and the USCG in oversight of the cleanup efforts.
Review work orders for cleanup of submerged oil in Summer Lake.

Coordinate with the resource agencies and the local subsistence users on impacts to subsistence resources.

-Continued-

Coordinate with the Responsible Party, NOAA, and the resource agencies regarding Natural Resource Damage Assessment issues.

WEATHER: Generally, the temperatures have been 35-45 degrees with winds from 20-40 knots with scattered rain showers, rain and snow.

COMMAND POST LOCATION: The Unified Command is operating out of offices Located at Walashek Shipyard in Dutch Harbor (907) 581-6192. The phone numbers for the ADEC office in Dutch Harbor are (907) 581-1822, FAX (907) 581-1795. The office is located in Room 210 in the FTS building, 2315 Airport Beach Road, Dutch Harbor 99692.

MEDIA INTEREST: __ Radio __Television _x_Newspaper

FOR ADDITIONAL INFORMATION CONTACT: Bob Flint at or Dick McKean at (907) 581-1822 (Dutch Harbor).

AGENCY/STAKEHOLDER NOTIFICATION LIST

Organization/Name	Sitrep sent	Sitrep phone#Fax #	Sitrep
AGENCY			
ADEC - Sitrep Distribution	email	465-5233	465-5244
ADEC- Webmaster (Camille Stephens)	email		
ADNR - Mike Bennett	email	269-8548	269-8913
ADF&G - Mark Fink	email	267-2338	267-2464
EPA - Carl Lautenberger	email	271-4306	272-0690
USCG MSO Anchorage	email	271-6700	271-6751
USCG MSD Dutch Harbor	email	581-3466	581-3468
DEC Field Office, Dutch Harbor	email	581-1822	581-1795
Port Director, Dutch Harbor	email	581-1254	581-2519
Governors Office, Juneau	email		465-3532
Governors Office, Anchorage	email		269-7461
Attorney Generals - Kay Rawlings	email	269-5274	278-7022
Marti Early, ADEC	email		
Jim McCullough, ADF&G Kodiak	email		486-1841
OTHER			
Legislator (Senate) - Lyman Hoffman	email	465-4453	465-4523
Legislator (Senate) - Randy Phillips		694-4949	465-4979
Legislator (House) - Carl Moses		581-1607	465-3445
Legislator (House) - Mark Hodgins	email		465-2833
Mayor, Unalaska - Frank Kelty	email	581-1251,7526	581-1695
Anchorage Daily News	email	257-4300	258-2157
Alaska Public Radio Network			263-7425
Aleut Corporation	email		563-4328
Alaska Newspapers	email		272-9512
Associated Press - Jim Clark			274-2189
Anchorage Channel 2 News	email		563-3318
Unalaska Police Dept., Glenn Herbst	none	581-1233	581-5024
Unalaska City Mgr., Gene Green	email	581-1251	581-3664
Ounalashka Corp., Dick Davis	email	581-1276	581-1496
Unalaska Public Utilities, Bill Bradshaw	email	581-1260	581-2187
Qawalangin Tribal Council	email	581-2920	581-3644

Appendix I. Photographs of the Summer Bay Lake juvenile and adult fishery monitoring project.

Plate 1: Fisheye view of weir, Summer Bay Creek below bridge and Summer Bay.

Plate 2: Public on bridge viewing weir operation.

Plate 3: View of Summer Bay Lake from the bridge.

Plate 4: View of smolt trap, live box, and Summer Bay Creek below bridge.

Plate 5: Summer Bay Lake bridge, weir, adult trap, smolt trap, live box, and van in the background.

Plate 6: Smolt weir showing rack master supports, smolt trap and live box.

Plate 7: Smolt trap and live box.

Plate 8: Smolt trap.

Plate 9: Summer Bay Lake housing.

Plate 1

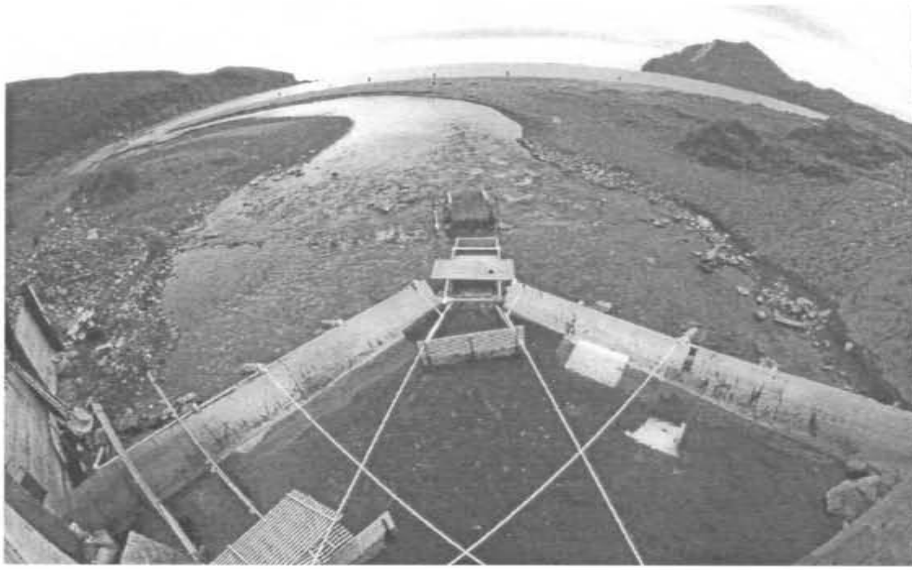


Plate 2

Plate 3

Plate 4

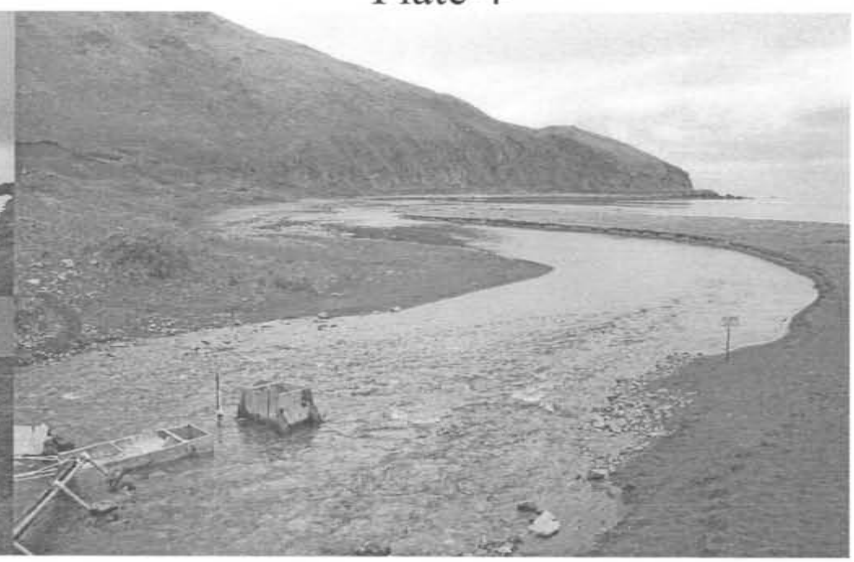


Plate 5

Plate 6

Plate 7

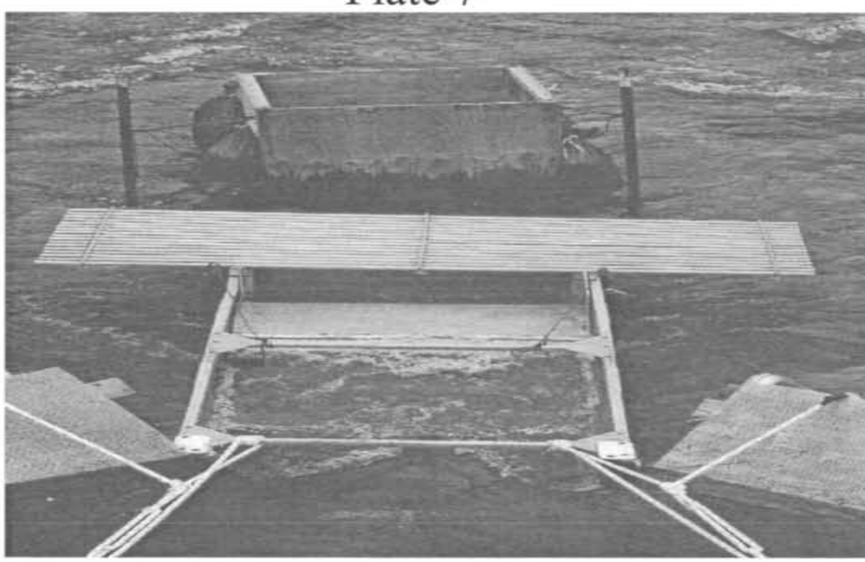


Plate 8

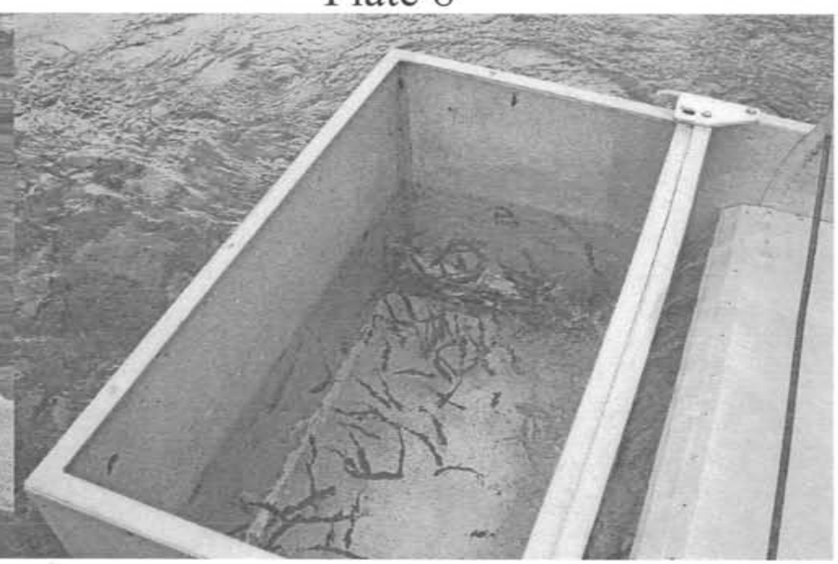
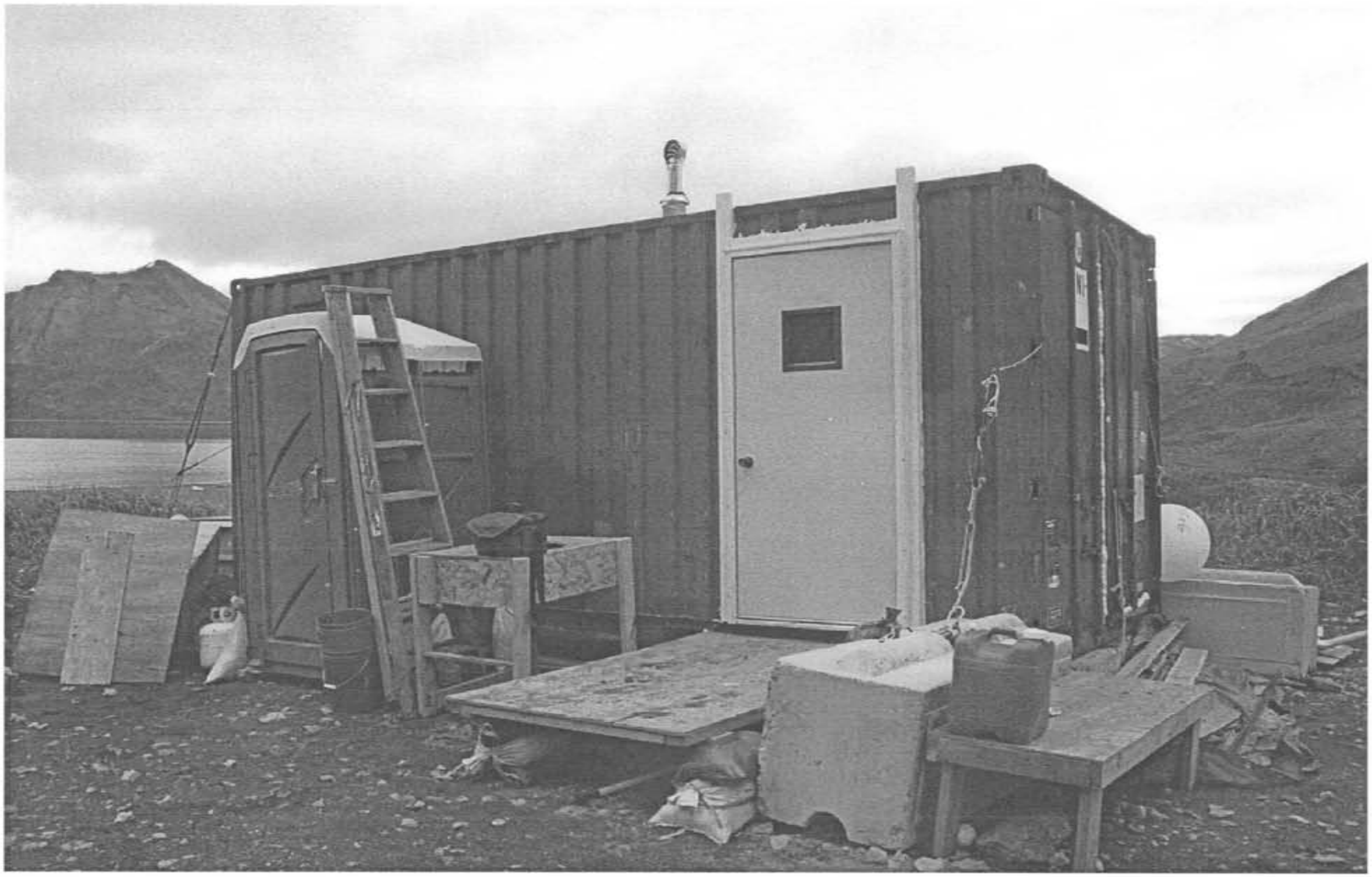


Plate 9



Appendix J. Characteristics of salmonids and previous oil spills that suggest that oil spilled by the *M/V Kuroshima* posed substantial risks to Summer Bay Lake salmonids.

The period of incubation (3.2^0-5^0C) for sockeye salmon eggs ranges from 175-225 days (Burgner 1991). Summer Bay Lake sockeye salmon spawn during August and September on lake shoals and in the primary inlet tributary; thus, emergence likely occurs in March and April. In most stream situations, fry migrate downstream without delay to nursery areas (Burgner 1991), and in many Alaskan lakes, feed in littoral (nearshore) areas for a month or more before entering pelagic (offshore) zones (Burgner 1991; Coggins 1997). Generally, sockeye salmon shift from a dependence on dipteran insects to pelagic entomostracan zooplankton when making the transition from littoral to pelagic zones in a lake; however, variations in feeding strategies have been observed in Alaska Peninsula lakes (Honnold et al. 1996). That is, in non-typical nursery lakes (shallow with little zooplankton), sockeye salmon feed almost exclusively on insects. Data from stomach content analysis of Summer Bay Lake sockeye salmon suggest a similar feeding strategy. Sockeye salmon spend one or more years in nursery lakes, as indicated by the 1998 emigration by age from Summer Bay Lake. Sockeye salmon smolt emigrate in schools and travel in both nearshore and offshore areas before congregating at outlet areas, prior to leaving the lake.

Pink salmon eggs incubate for approximately the same period as sockeye salmon (Burgner 1991), depending on water temperatures. Migrant pink salmon fry can be found from late February to mid-August, throughout the range of the species (Heard 1991). Peak emigrations generally occur from mid-April to mid-May in Alaska, but have been reported in some areas to occur until late June (K.Brennan, ADF&G, Kodiak, personal communication). In addition, emigrations for smaller streams tend to be more compressed over time (shorter emigration curves with steeper slopes); the number of emigration days positively correlated with stream length (Heard 1991). Summer Bay Lake pink salmon fry appeared to have this type of compressed emigration in 1998. Pink salmon fry emigrate in schools, tend to orient in areas of increased flow, and commonly move from the spawning grounds to the ocean in one night (Heard 1991). Due to their rapid emigration to the ocean, pink salmon fry feed little in fresh water and exogenous feeding often begins in salt water.

Coho salmon usually spawn from November to January; however, spawning timing is highly variable (Sandercock 1991). Summer Bay Lake coho salmon have been reported to return as late as mid-November (D.Tracy, ADF&G, Kodiak, personal communication), indicating that they may be a late spawning stock. Coho salmon eggs incubate in the gravel for approximately 115-125 days, depending on water temperature, and fry typically emerge from early March to as late as the end of July (Sandercock 1991). Spring freshets may sweep coho fry downstream; however, if emerging late, they may avoid this risk at the expense of higher growth rates. Newly emergent fry often remain in small creeks, sloughs, and other slow moving waters that provide adequate cover and feed. As they increase in size, coho salmon fry will move into larger bodies of water, stream margins, and generally, to areas of greater velocity. In lakes, coho fry will occupy the littoral (nearshore) zones. Typically, the majority of coho salmon fry rear in streams rather than lakes. Minnow trapping in Summer Bay Lake indicated few coho salmon fry; however, larger coho salmon juveniles (>70 mm) were common. This suggests that as coho salmon juveniles grow over time, the Summer Bay Lake littoral zone is utilized for rearing. This also suggests that coho salmon

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fry were not present in typical nearshore rearing areas and may have been displaced or did not survive well, due to oiling. Juvenile coho salmon juveniles feed primarily on stream and terrestrial insects (Sandercock 1991); however, lake rearing juveniles have been reported to consume zooplankton (Mason 1974; Crone 1981; Kyle 1990; Honnold et al. 1996). Stomach contents of juvenile coho salmon from Summer Bay Lake were comprised exclusively of dipteran insects. Coho salmon spend one or more years in fresh water, as indicated by the 1998 emigration by age from Summer Bay Lake. Coho salmon smolt emigrate in schools and travel primarily in streams near the surface and in lake nearshore areas (Sandercock 1991).

Dolly Varden usually spawn from September to early November (Scott and Crossman 1979). Anadromous fish enter freshwater after 60 to 160 days of ocean residence, usually from August to September and lake populations move into inlet rivers at about the same time. Eggs hatch in March or April and juveniles emerge in late April to early May. Anadromous stocks often spend three to four years in fresh water prior to going to sea in late May, early June, while non-anadromous stocks may spend from several months to several years in streams and then move into lakes (Scott and Crossman 1979). Stream and lake resident young consume insects, snails, and leeches in the spring and salmon eggs and insects in the fall. Larger freshwater resident Dolly Varden consume salmon fry and smolt during their lake emigrations (Coggins *in press*).

Oil spilled in Summer Bay Lake was widely dispersed throughout the lake and nearshore areas from the time of the spill (November 1997) through May 1998 (Appendix H). Residual oil was observed in all areas of the lake and outlet stream (on weirs-see Appendix I, Plate 1) throughout the summer and fall of 1998. The spilled oil likely degraded over time; however, the rate of weathering is determined mainly by the ratio of surface area to volume of petroleum in the environment and a variety of environmental conditions (Short and Heintz 1997). Thus, the rate of weathering of the *M/V Kuroshima* oil is difficult to predict and high concentrations of oil were observed in nearshore areas six months or more after the spill. Divers also reported substantial amounts of oil on the lake bottom during several surveys in the spring of 1998.

The temporal and spatial distribution of juvenile anadromous and resident fish, their feeding ecology, and other aspects of their early freshwater life history, plus the wide distribution of oil suggest both direct exposure and other indirect impacts as a result of the spilled fuel oil in Summer Bay Lake. Furthermore, juvenile fish do not necessarily avoid petroleum-contaminated waters (Maynard and Weber 1981). Coho salmon juveniles actually swam in a film of oil in one study (Morrow 1973) and in another study coho salmon smolt only avoided concentrations of oil greater than 2 mg/L, whereas coho salmon presmolt avoided concentrations of 3-4 mg/L (Maynard and Weber 1981). Rice (1973) found that avoidance of the water-soluble fraction of Prudoe Bay crude oil by pink salmon fry varied with stage of fish development, temperature, and salinity.

Sinking oil can smother and kill fish and their food, though impacts are likely to be localized (Vincente 1994). During a Group V fuel spill in Puerto Rico, diving scientists observed dead

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fish, living fish with lesions and tumors, and many lethargic territorial fish in nearshore waters adjacent to the point of oil release. Fish and other marine vertebrates can efficiently metabolize aromatic compounds present in oil and the metabolites are excreted (Stein et al. 1998); however, the formation of reactive metabolites can potentially lead to toxic effects (Statham et al. 1976).

Non-floating Group V fuel oils are also likely to readily adhere to aquatic vegetation, affecting the associated animals (NOAA 1994). Submerged aquatic vegetation beds are important primary producers and nursery habitats for juvenile fish (DeMort 1991). In contrast to vertebrates, aromatic compounds can accumulate in invertebrates, because these animals do not efficiently metabolize aromatic compounds (Statham et al. 1976). Thus, partent aromatic compounds can be transferred to higher trophic levels such as fish. In addition, oils that quickly sink or suspend in the water column could have greater impacts to water-column organisms because more of the water-soluble fraction of the oil could actually dissolve rather than be lost by evaporation, which usually is the dominant process for floating slicks (Vincente 1994).

Planktonic larvae are among the most vulnerable organisms after an oil spill because they are sensitive to oil, are affected immediately, and cannot avoid spilled oil (Rice et al. 1984). Planktonic copepods exposed to a high concentration of water soluble fraction of aromatic heating oil showed significant reduction in subsequent length of life, total fecundity, mean brood size, and rate of egg production (Berdugo et al. 1977). Cyclopoid copepods were the only common zooplankters able to survive a pond oil spill in Barrow, while other species died rapidly (O'Brien 1978). This study suggested that zooplankton may be the most susceptible of all arctic freshwater organisms to oil contamination.

Oil toxicity appeared to inhibit algal production and biomass accumulation during the study of contained oil spills in several Alaskan lakes and ponds (Miller et al. 1978). Toxicity by prolonged exposure to weathered oil was not known because the data were ambiguous. Many of the effects observed in the study of ponds appeared to be adequately explained by the elimination of zooplankton at fairly low doses of oil. The dominant zooplankton grazers were eliminated within five days in all of the spills, which predicated an eventual increase in algal biomass, but of a different species composition. It appeared that the algal biomass increase observed when oil was spilled in grazing-dominated systems was more a function of reduced grazing pressure on phytoplankton than upon release of nutrients from oil mineralizaiton. The recovery of the phytoplankton to prespill species composition did not occur after six years and authors concluded that it would probably not happen until the zooplankton were capable of developing to their prespill density. Oil spill effects on the marine benthos have also been recognized, in which species such as amphipods experience a brief period of mortality following oil exposure, followed by a full recovery over time (Spies 1987). Benthos impacts in lakes, however, are largely unknown.

Damage to PWS pink salmon from the 1988 brood, following the EVOS in the spring of 1989, included reduced growth during emigration (Wertheimer and Celewycz 1996; Willette 1996) and

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reduced survival when adults returned in 1990 (Geiger et al. 1996). The 1989 brood incubated in oiled intertidal environments, which put them at risk of exposure for up to eight months during the sensitive egg and larval stages (Brannon et al. 1995). Pre-emergent pink salmon larvae from oiled streams were exposed to oil for up to two years after the spill (Weidmer et al. 1996). In the first years following the EVOS, oiled streams exhibited an 7% to 21% higher pink salmon embryo mortality than unoiled streams and a continued reduction in survival four to five years after the spill (Bue et al. 1998). The impacts from oil exposure on juvenile pink salmon on subsequent total PWS adult returns were estimated to be a 28% reduction in the first brood year and a 6% reduction in each of the following two brood years (Geiger et al. 1996). The latter level of reduction was projected to occur for at least two more brood years. This analysis was based on the entire productivity of wild stocks in the southwestern portion of PWS, where about 31% of the streams were oiled. The oiled streams were smaller than the unoiled streams in the area, accounting for ~ 20% of the spawning habitat in the region. The primary pink salmon spawning habitat contaminated was the intertidal and supratidal areas, which represents ~ 75% of habitat utilized. The remaining 25% of utilized spawning habitat was in upstream sections of PWS streams. Therefore, to have a 6% reduction in adult returns, an 18% to 30% reduction would have to occur in oiled streams.

There is a paucity of literature describing oiling effects on sockeye and coho salmon with the exception of several laboratory studies. These studies indicate that both juvenile sockeye and coho salmon experience significantly increased mortality rates at all oil concentrations and at all temperatures (Morrow 1973; Morrow 1974). Coho salmon adults exposed to oil, however, do not appear to lose their homing capabilities (Nakatani et al. 1985), unless concentrations of oil reach 3.2 mg/L (Weber et al. 1981). Actual reductions in sockeye and coho adult returns, as a result of exposure to oil contamination, have not been reported; however, a simulation model of the effects of a tanker accident (34,000 tons of diesel fuel) in Bristol Bay resulted in predictions of sockeye salmon mortality ranging from 1% to 5% of adult returns and 1% to 2% of the fish being tainted with oil (Bax 1987).

Subject: **FW: FW: Summer Bay Lake weir site and smolt enumeration data**
Date: Mon, 6 Mar 2000 11:48:44 -0900
From: "Mark Fink" <mark_fink@fishgame.state.ak.us>
To: <steve_honnold@fishgame.state.ak.us>
CC: "McCullough, Jim" <jim_mccullough@fishgame.state.ak.us> ,
"'Swiderski, Alex'" <alex_swiderski@law.state.ak.us>

The legal reps had a meeting this morning. We have the o.k. to release the 1999 report (1998 field data).

-----Original Message-----
From: Mark Fink [mailto:mark_fink@fishgame.state.ak.us]
Sent: Monday, March 06, 2000 9:02 AM
To: 'steve_honnold@fishgame.state.ak.us'
Subject: RE: FW: Summer Bay Lake weir site and smolt enumeration data

Not yet. DOL has to doublecheck with the feds (Dept of Justice, NOAA). Shouldn't take but a few days.

-----Original Message-----
From: Steven Honnold [mailto:steve_honnold@fishgame.state.ak.us]
Sent: Monday, March 06, 2000 7:56 AM
To: mark_fink@fishgame.state.ak.us
Subject: Re: FW: Summer Bay Lake weir site and smolt enumeration data

So does this mean distribution of the 1998 data (RIR) is ok?

Mark Fink wrote:
>
> FYI.
>
> -----Original Message-----
> From: Alex Swiderski [**mailto:Alex_Swiderski@law.state.ak.us**]
> Sent: Thursday, March 02, 2000 4:31 PM
> To: Mark_Fink@fishgame.state.ak.us
> Cc: kirsten.l.erickson@NOAA.gov
> Subject: Summer Bay Lake weir site and smolt enumeration data
>
> The purpose of this memo is to request that you reaffirm to
> appropriate Department of Fish and Game staff that weir site
> counts and smolt enumeration data from the 1999 operations at
> Summer Bay Lake in Dutch Harbor, Alaska are confidential, and
> data that cannot be released to the public without approval from
> the Department of Law. The restriction includes any report that
> the Department prepares summarizing and interpreting the data.
> This data was collected using federal funds and for purposes
> relating to litigation, and the State of Alaska and the United
> States have executed a letter of confidentiality concerning data
> collected for pursuit of claims against the owners of the MV
> Kuroshima
>
> I understand that the Department will be
> preparing a report similar to the report on the 1998 data. Prior
> to publication, please circulate it to me for review by the NOAA,
> DOI, and the Department of Justice.
>
> Alex Swiderski
> Assistant Attorney General
> Office of the Attorney General

> 1031 West Fourth Av. Suite 200
> Anchorage, AK 99501
> (907) 269-5274
> alex_swiderski@law.state.ak.us

STATE OF ALASKA

TONY KNOWLES, GOVERNOR

333 Raspberry Rd.
Anchorage, AK 99518
PHONE: (907) 267-2342
FAX: (907) 267-2464

DEPARTMENT OF FISH AND GAME

Habitat and Restoration Division

MEMORANDUM

TO: Alex Swiderski
Assistant Attorney General
Environmental Section
Department of Law

FROM: Mark Fink
Habitat Biologist
Region II
Habitat and Restoration Division

DATE: March 3, 2000

SUBJECT: Summer Bay Lake Salmon Report (Revised)

Attached is a copy of the Alaska Department of Fish and Game (ADF&G) report, "Results of Biological Assessment and Monitoring of Anadromous Fish at Summer Bay Lake, Unalaska, Alaska, 1998: Juvenile and Adult Fish Production the Summer Following the *M/V Kuroshima* Oil Spill." The project was conducted in support of the *M/V Kuroshima* Natural Resource Damage Assessment. ADF&G has revised the Introduction in this report to incorporate comments made by the U.S. Department of Justice.

ADF&G staff in Kodiak have received requests for copies of this report. Please advise as to when we may release this report.

Attachment

Cc w/attachment: Doug Helton, NOAA
Regina Belt, DOJ
Deborah Heebner, DNR
Catherine Berg, FWS
Dan Duame, Attorney for the Qawalangin Tribe

Cc w/o attachment: Steve Honnold, ADF&G
Jim McCullough, ADF&G

ALASKA DEPARTMENT OF FISH AND GAME

DIVISION OF COMMERCIAL FISHERIES

MEMORANDUM

TO:	Mark Fink Habitat Biologist Division of Habitat Anchorage	DATE:	January 10, 2000
		PHONE:	(907) 486-1873
		FAX:	(907) 486-1841
FROM:	Steven G. Honnold Kodiak Finfish Research Biologist Commercial Fisheries Division Region IV - Kodiak	SUBJECT:	Summer Bay RIR Jeep Rice's Comments

The following are my thoughts/response to Jeep Rice's (NOAA Auke Bay Lab) specific comments (as numbered below in italics) regarding the ADF&G 1998 Summer Bay Project report (RIR 4K99-62).

3. Pickyuny details:

a. The diet data is insignificant. It was not a seasonal sampling, and it ended up being two sockeye stomachs with insects and two coho stomachs with insects. This result is not worthy of mention anywhere, and especially not in the abstract.

Granted, the diet data are limited as far as sample size; however, the reader is given specific methods and sample sizes are clearly stated. The presentation of these data was not intended to imply definitively that all juvenile sockeye and coho salmon in Summer Bay Lake eat similarly. These fish ate primarily Dipteran insects and, since populations of fish of the same species and age class often consume the same food items, it would appear (as stated in the ABSTRACT) that Summer Bay juvenile sockeye and coho consume Dipteran insects.

b. There are no conclusions labeled. Some are alluded to in the discussion, but the authors are not pinned down. If you take all of the statements in the discussion, and make them a conclusion, then they go to far, and by default, that is what you are left with at the present time.

The CONCLUSION section typically consists of fairly definitive statements supported by the data. Conclusions were not specifically included because the data from 1998 (only one year) do not provide for strong findings (see last paragraph of DISCUSSION page 18).

c. There is no objective for the modeling work listed in the objectives area of the introduction, and there is NO topic sentence for the modeling results given in the results section (page 16). This section is a very important section, and the writing needs to be upgraded, verified, and more communicative with the reader. Lots of numbers in these two paragraphs, and not much of a road map of where it is going.

Modeling production was not one of the original objectives of the Summer Bay Lake project (see Operational Plan; ADF&G 1998); therefore, it was not listed as an objective in the report. However, the last paragraph, prior to the *Description of Study Area* (page 4), states the reason for inclusion of modeling in the report.

According to *Reporting Policies and Procedures for the Division of Commercial Fisheries, Special Publication No. 3* (ADF&G 1994), "the RESULTS should present the results of your work without interpretation and analysis. It should present the findings through a combination of text, tables, figures, and appendices." Tables 7 and 8 (pages 32 and 33) are described succinctly almost line for line in the RESULTS of the report. The reader is lead through the life history of specific brood years, chronologically to the number of juveniles produced, juveniles emigrating from the lake, and projected remaining lake residents. In my opinion, this is a fair road map for the reader.

4. Big heart burn:
The modeling effort is interesting and suggestive, but is it premature or in error? I am not sure I know the answer to that, but I am sure it needs a critical review, both from a scientific perspective, but also in a word smithing/editing perspective.

ADF&G regional reviewers (see ACKNOWLEDGMENTS) critically reviewed the modeling effort.

There is little or no mention that the models may be in error. We at ABL ran the PCM model against our Auke Creek Sockeye data, where we have much more precise numbers of smolts emigrating and adults returning, for a 31 year period of time (our logistics base is much better). The error estimates range from plus 73% to minus 56%. About 1/3 of the time, the model is withing 15%, and 2/3 of the time it is off by more than 15%- or wrong.

As stated on page 18, third paragraph, the intent of the modeling effort was to provide <u>an indication</u> of the number of juvenile salmon present in Summer Bay Lake in 1998 after the oil spill until a portion emigrated and then what fish remained in the lake. Granted, 'the models may be in error' is a fair statement; however, the DISCUSSION (same page as above) describes the difference between the actual and projected smolt estimates and states the likely reasons for the discrepancies. I concur that additional discussion of potential error may have been helpful to the reader.

The adult data prior to the spill is particularly shaky, and we wonder about the value of using it in a modeling effort. To give the data, to demonstrate the lack of information, and the range of data is one thing, and it is another to use it in a model.

I also agree that adult data prior to the oil spill are 'shaky,' as suggested by the second paragraph of the DISCUSSION (page 17). These were, however, the only data available with which to indicate to the reader, through the modeling effort, that a portion of juvenile fish remained in the lake and were potentially exposed to oil.

In the discussion paragraphs at the end, there is no mention or caveats that the models may be in error. The estimates of fish remaining in the lake are not very believable, although the main point of this would appear to be for the support of the potential problem- fish are still there and potentially still exposed to oil in their life history.

A detailed discussion of the caveats regarding modeling error were not presented in the report; however, the second and third paragraphs of the DISCUSSION (page 17) were intended to provide the reader with potential sources of error (poor survey conditions, survival assumptions in error, escapements lower than estimated, etc.). Lastly, the final paragraph of the DISCUSSION explains that one year of data does not provide for conclusive results.

My conclusion about the modeling is that it is a good effort- but the theme needs to be qualified more- "If the models are correct, then coho suffered greater than expected mortalities prior to emigration, or adult escapement estimates were in error. There is cause for concern, but we can't definitively state there is a pre-emigration problem. " something like that. The report needs to cut off criticism from the outside first.

5. The modeling efforts and theme should have critical review, along with the conclusions BEFORE the next report is released in the future. Litigative biology, whether it be subsistence-marine mammal takes- spill effects, etc- is the future for state and federal agency biology, unfortunately, and relatively obscure regional reports such as this may have the potential for more impact than in the past. Having been the subject of and subjected to 3 FOIA requests in the last 2 years, I am sensitized to requirements and stress that litigation causes, and sympathize with all authors so impacted. But review of the conclusions before release is needed and is necessary.

In conclusion, I appreciate Mr. Rice's comments and agree in concept with their intent. However, given the caveats stated in the report, I see no reason to make revisions at this time. Mr. Rice's comments will be considered in the future when reporting continuing work at Summer Bay Lake.

Cc: Denby S. Lloyd
Jim McCullough
Ken Bouwens
Steven Schrof

Subject: **FW: Kuroshima : ADFG 98 report, some comments**
Date: Mon, 20 Dec 1999 10:56:24 -0900
From: "Mark Fink" <mark_fink@fishgame.state.ak.us>
To: "'Honnold, Steve'" <steve_honnold@fishgame.state.ak.us> , "McCullough, Jim" <jim_mccullough@fishgame.state.ak.us>
CC: "Denby Lloyd" <denby_lloyd@fishgame.state.ak.us>

Here are some comments from Jeep Rice (NOAA Auk Bay Lab) on the Summer Bay Report. Thoughts?

-----Original Message-----
From: Jeep Rice [mailto:Jeep.Rice@noaa.gov]
Sent: Friday, December 17, 1999 2:48 PM
To: Doug Helton; JeepRice; Mark_Fink@fishgame.state.ak.us
Subject: Re: Kuroshima : ADFG 98 report, some comments

To: Doug Helton and Mark Fink

From: Jeep Rice 17 DEC 99

Subject: Review of the Nov.99 report on 1998 Summer Lake assessments by Honnold et al. (Report #4K99-62)

I have several comments on the report. The volume of data and effort are impressive, and to be commended.

1. First, operating a weir from smolt emigration through adult escapement is a difficult task, and the field crew is to be commended for their efforts. Most people, including supervisors, often forget the continuous effort that is needed, especially at times when the environment is not very forgiving.

2. The authors have pushed this data as far as it can go at this time. I am impressed with the collection of data and presentation, including the past pre-spill data.

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b. There are no conclusions labeled. Some are alluded to in the discussion, but the authors are not pinned down. If you take all of the statements in the discussion, and make them a conclusion, then they go to far, and by default, that is what you are left with at the present time.
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