



Long Lake Weir Operations Protocol

Central Alaska Network, Wrangell-St. Elias National Park and Preserve

Natural Resource Technical Report NPS/CAKN/NRTR—2009/114



ON THE COVER

Long Lake weir, September, 2008. Sockeye salmon can be seen to the right of the weir
Photograph by: Trey Simmons

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Abstract

The National Park Service Inventory and Monitoring (I&M) Program measures long-term changes in the condition of natural resources throughout the National Park System. As part of this effort, the Central Alaska Network, which encompasses Denali National Park and Preserve, Wrangell-St. Elias National Park and Preserve, and Yukon-Charley Rivers National Preserve, has developed a comprehensive plan for monitoring status and trends in the return of spawning sockeye salmon (*Onchorynchus nerka*) to Long Lake in Wrangell-St. Elias National Park and Preserve. The plan consists of three sections: 1) a protocol narrative, 2) standard operating procedures (SOPs), and 3) supplementary materials. The protocol narrative summarizes the significance of sockeye salmon to Wrangell-St. Elias National Park and Preserve and discusses the history of the Long Lake weir. The narrative defines the network's monitoring questions and objectives with respect to the Long Lake sockeye salmon population and discusses the field and analytical methods that will be used to achieve these objectives. Finally, the narrative discusses the expected program budget and personnel qualifications. Specific SOPs prescribe personnel training and field season preparation, methods of protocol revision, field data collection, quality assurance/quality control, and data analysis and reporting. The protocol narrative and SOPs follow techniques outlined by the U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game. The comprehensive collection of information in the protocol narrative, SOPs, and supplementary materials is intended to standardize salmon monitoring at the Long Lake weir and ensure that methods and data are comparable and effective in the long-term.

Acknowledgements

A number of people made important contributions to the development of this Protocol, including Eric Veach, Molly McCormick, Dave Sarafin, Joshua Schmidt and Richard Brenner.

Background and Objectives

Introduction

The Central Alaska Network (CAKN) is part of the National Park Service (NPS) Inventory and Monitoring Program. It is composed of three national park units: Wrangell-St. Elias National Park and Preserve, Denali National Park and Preserve, and Yukon-Charley Rivers National Preserve.

The Inventory and Monitoring Program is a direct outgrowth of the National Parks Omnibus Management Act, which was passed by Congress in 1998. This act directs the National Park Service “to establish baseline [resource] information and to provide information on the long-term trends in the condition of National Park System resources.” To accomplish this formidable task, the NPS has grouped parks into 32 networks which are characterized by their ecological similarities. Four of these networks are in Alaska.

The Central Alaska Network is vast: its three parks together contain over 8.8 million hectares (21.7 million acres) and span an area that is 650 km from east to west and 650 km from north to south. Based on area, the Central Alaska Network represents 25% of all the land in the National Park Service system. Yet despite this immense coverage, these three parks contain natural resources — both physical and biological — that are similar in many respects. Perhaps the most significant shared feature is the integrity of their ecological systems. These parks provide the space and the time to see and understand natural processes that are occurring at great spatial and temporal scales.

The primary goal of the Central Alaska Network is to build a holistic database that will allow detection of change across the ecosystems of the network — specifically, to detect change in the ecological components of the Network parks, and in the relationships among those components. The Network has conducted baseline inventories of selected resources, and has developed a list of 36 Vital Signs that will provide the targets for the long-term monitoring program. Currently the Network is in the process of implementing monitoring protocols for 17 of the 36 identified Vital Signs.

Rationale for Selecting This Resource to Monitor

The distribution and abundance of freshwater fish has been identified as a Vital Sign for the Central Alaska Network (MacCluskie and Oakley 2005). CAKN streams, rivers and lakes support at least 28 species of fish, including all 5 species of anadromous salmon (Markis *et al.* 2004). Salmon are of particular importance, not only because of the commercial, subsistence and sport fisheries that depend on them, but also because of the critical roles they play in aquatic and terrestrial ecosystems, including the transport of vast quantities of marine-derived nutrients to nutrient-poor streams during their annual spawning runs (Cedarholm *et al.* 1999, Gende *et al.* 2002). These attributes are perhaps most clearly exhibited in Wrangell-St. Elias National Park and Preserve (WRST), which provides spawning and rearing habitat for large populations of sockeye (*Oncorhynchus nerka*), Chinook (*O. tshawytscha*), coho (*O. kisutch*) and pink (*O. gorbuscha*) salmon. The best-known of these is the Copper River sockeye population, which

supports a world-renowned commercial salmon fishery, as well as important subsistence and personal-use fisheries.

Accurate assessment of yearly run strength and migratory timing in tributaries to the Copper River is essential to the development of a management strategy that meets the mandates of the Alaska National Interest Lands Conservation Act (ANILCA). The Upper Copper River sockeye salmon populations are of particular importance to both federally qualified and state subsistence users. The WRST superintendent is the federal fisheries manager for the entire Copper River, and has the responsibility to ensure that adequate number of fish return to spawn in Copper River tributaries each year. The primary assessment of in-river abundance for Copper River sockeye salmon occurs at the Miles Lake sonar (see *e.g.*, Faulkner and Maxwell 2008). However, migratory timing of sockeye salmon into the Copper River is prolonged (May-August); and subsequent assessment of escapement into some drainages is needed to determine spawning distribution. A substantial portion of sockeye escapement into the Copper River consists of fish from the Gulkana River Hatchery; this proportion has increased over the last 30 years, and constitutes an unknown impact on naturally spawning populations like the Long Lake sockeye since commercial harvest limits are set based on mixed stock returns.

WRST visitors, stakeholders and users are interested in and concerned about fish populations in Long Lake. The Park has been approached by a variety of groups, interests, and individuals regarding obtaining private and state land surrounding portions of Long Lake to protect fish and water resources. At Federal Subsistence Board Regional Council meetings, Long Lake fish populations are raised as an issue that needs attention and protection. At Copper River Watershed Project meetings, Long Lake is regularly suggested as a site that should be monitored. The Wrangell Mountain Institute and the Copper River Watershed Project are partnering together to monitor water quality at this site. Clearly a monitoring project addressing salmon abundance at this site would be responsive to issues and concerns raised by park stakeholders. Furthermore, we know that changes in fish distribution, abundance and behavior due to climate change are likely in coming years (*e.g.*, Reist *et al.* 2006). A well-designed monitoring program at Long Lake could provide an “early warning system” of impending changes that could impact this important resource. For example, a recent analysis of existing weir data showed a trend in the timing of sockeye returns to Long Lake, with the peak of the run occurring increasingly later in the year since 1974 (Schmidt 2008).

Weirs have been used in Alaska since prehistoric times to catch and control salmon: first by Alaska Natives, then by the Russian explorers, and more recently by the early commercial fishermen. Since the first weir to enumerate salmon for estimating escapement was built in 1921 on the Karluk River on Kodiak Island, fish weirs have been increasingly used as a management tool by agencies throughout Alaska (Holmes 1992). Knowledge gained from the data provided by weirs has resulted in reducing over-escapement and enabling faster management decisions regarding the openings for commercial fisheries. This has made more salmon and longer fishing time periods available for the subsistence and sport fisheries. Weirs are typically more accurate measures of salmon abundance than most other methods of measuring adult salmon escapement.

The Chitina River drainage, approximately 5 million acres in size, is the largest anadromous drainage, contained in its entirety, within WRST. Long Lake (see Figure 1) is the only site

within the drainage where long term monitoring of salmon abundance has occurred. This site has the potential to complement the work occurring in Tanada Creek as an index site for abundance and spawning distribution of sockeye salmon within the Copper River Basin. If both sites are maintained in the future as index sites, they will provide a valuable tool for understanding the response of salmon returns to management or ecological changes at substantially different points in the Copper River Basin.

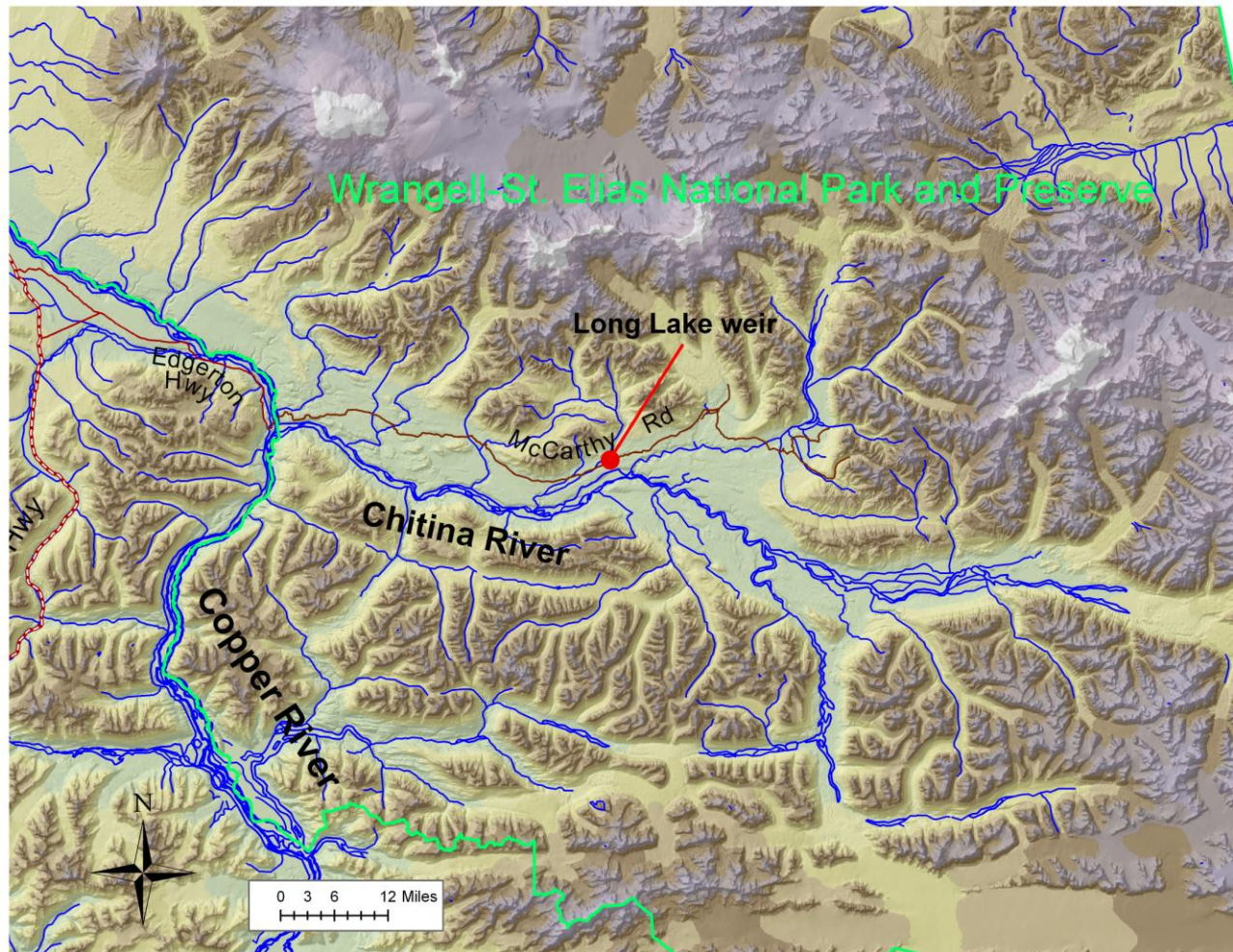


Figure 1. Overview of Chitina River drainage and Long Lake weir.

The Wrangell-St.Elias National Park/Preserve Superintendent considers the information collected at this weir to be important to both her role as the in-season Federal subsistence fisheries manager and her duties to manage fish and wildlife populations within the Park in a natural and healthy state. Therefore the Park is committed to providing resources to support this project as well, as demonstrated by finding funding to support the operation of the weir in 2008. The Park intends to hire a local rural resident from the McCarthy area to provide additional support to the operation of the weir as needed.

History of the Long Lake Weir

ADFG initially operated the Long Lake weir in 1974 and 1975. Cliff Collins, a private citizen, voluntarily took over operation of the weir in 1976 when ADFG was no longer able to fund the operation of the weir and has operated the weir continuously since 1976 (Table 1). In 2003 a cooperative agreement was drawn up between Mr. Collins (then aged 93), Wrangell-St.Elias National Park/Preserve and the Copper River Watershed Project to operate the weir at Long Lake in order to continue the long running uninterrupted data set.

Table 1. Long Lake weir fish counts and Miles Lake sonar fish estimates. The Miles Lake sonar is operated by the Alaska Department of Fish and Game to provide estimates of overall escapement into the Copper River. The sonar was first operated in 1978.

Year	Miles Lake sonar estimates	Long Lake weir counts
1974		4501
1975		6786
1976		24689
1977		8772
1978	107,011	15458
1979	237,173	46110
1980	276,538	38978
1981	535,263	12687
1982	467,306	28064
1983	545,724	28003
1984	536,806	10729
1985	436,313	21431
1986	509,275	16947
1987	483,478	13323
1988	488,398	7065
1989	607,797	17760
1990	581,895	21399
1991	579,435	11501
1992	601,952	10141
1993	797,902	16101
1994	715,181	18289
1995	599,265	17933
1996	906,867	6209
1997	1,148,079	4433
1998	866,957	8531
1999	848,921	12922
2000	587,592	8665
2001	833,569	26939
2002	819000	50000
2003	695233	4604
2004	669,646	19,215
2005	854,268	7,770
2006	959,731	9,239
2007	926,438	7,846

Twenty-nine years of weir data show annual variations in abundance of Long Lake runs ranging from 4400 to over 50,000 sockeye. This is the longest running data set of weir counts of salmon in the Copper River drainage. The sockeye salmon stock that spawns within Long Lake is the largest salmon stock within the Chitina River drainage. The percentage of the total estimated Copper River sockeye run composed of Long Lake fish has varied from 0.4% (1997) to over 19% (1979), with a 30 year average of just under 4% (Table 1). This demonstrates the need for stock specific monitoring sites in addition to broad scale sonar sites estimating mixed stock returns. This system is an excellent candidate to use for insight into the status of Chitina River salmon stocks. Weir counts of salmon are a simple and basic data set and therefore likely to provide valuable data far beyond the foreseeable future.

Measurable Objectives

1. Enumerate sockeye salmon entering Long Lake on an annual basis. Sample individual fish to estimate age and sex structure and physical condition of returning spawners.
2. Detect long-term trends in the timing of the Long Lake sockeye salmon run.
3. Detect long-term trends in the magnitude of the Long Lake sockeye salmon run.
4. Detect long-term trends in age, life history and sex structure of the Long Lake sockeye salmon run.
5. Use modeling techniques to identify potential factors (hatchery releases, lake conditions, climate, etc.) that could explain variation in run timing, run strength, sex, life history and age composition.

Sampling Design

Study Area

Long Lake is located at 61.3838° North latitude and 143.2877° West longitude in Wrangell-St. Elias National Park and Preserve (Figure 1). The lake is situated at 480 meters above sea level, and is approximately 0.5 kilometers wide and 8.5 kilometers long. Long Lake is directly adjacent to the McCarthy Road, providing for easy access to both the lake and the weir (Figure 2, Figure 3). The lake outflow stream, Long Lake Creek, is 3 kilometers long and empties into the Lakina River, a tributary of the Chitina River (Figure 2). Long Lake is a relatively deep lake for its small size, with a maximum depth of over 30 meters (M. McCormick, Wrangell-St. Elias National Park and Preserve, personal communication). Warm springs located along the north shore of the lake provide the majority of the spawning beds for the Long Lake sockeye. In addition to providing critical spawning and rearing habitat for sockeye salmon, Long Lake is also host to a variety of other fish species, including Dolly Varden, coho salmon, Arctic grayling, longnose sucker and slimy sculpin. Rainbow trout, Dolly Varden, slimy sculpin and Arctic grayling are among the species known to inhabit Long Lake Creek (Markis *et al.* 2004).

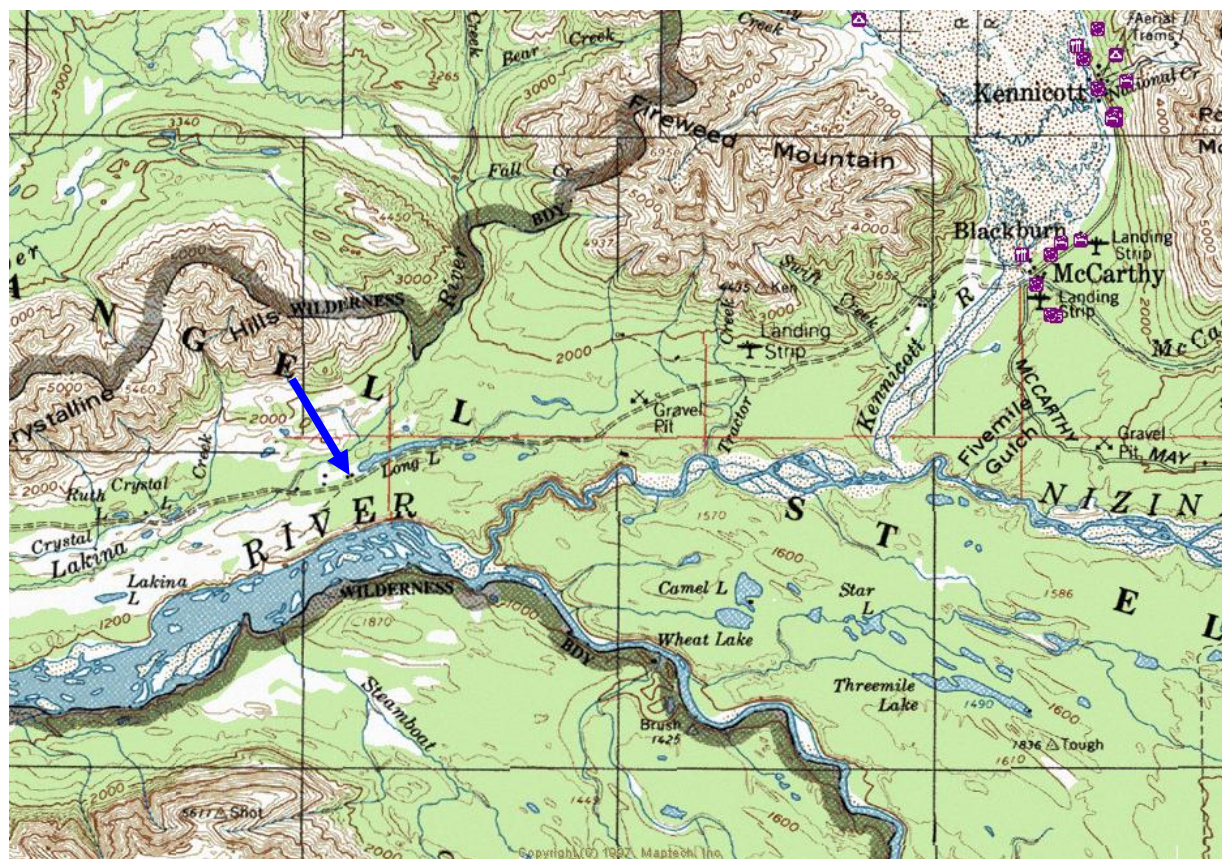


Figure 2. Map of the vicinity of the Long Lake weir. 1:63,360 scale map of the east end of the McCarthy Road (dotted double line) in Wrangell-St. Elias National Park and Preserve, showing the approximate location of the Long Lake weir (blue arrow). The black arrow indicates north.

The weir itself is located approximately 150 meters downstream of the lake outlet at 61.37811° North, 143.31204° West (Figure 3). It is a rigid picket weir (Baxter 1981); the framework remains in place year-round, while the pickets are inserted during active weir operation. The site is extremely conducive to the operation of a rigid picket weir. Flows fluctuate only slightly, water velocity is always low, and Long Lake Creek is shallow and easily waded. A boardwalk immediately upstream of the weir allows the weir operator to stand and count migrating salmon simply by removing 3-4 pickets from the weir. The weir has been in operation for nearly 30 years so most of the needed equipment is already in place and additional equipment needs will be minimal. The weir can be safely operated by one individual.

Basic Study Design

The project will use a rigid picket weir to completely enumerate the number of salmon migrating into Long Lake and to sample age, sex and length of a portion of the salmon migrating through the weir. The weir will be operational from July 15 – October 15 each year to capture the entire sockeye run. The weir will be staffed and fish counted, and sampled if appropriate, each day at the same time. A stratified random sample design is often used to select individual fish for determination of sex, age and length (*e.g.*, Zimmerman and Zabkar 2007, Maschmann 2008),

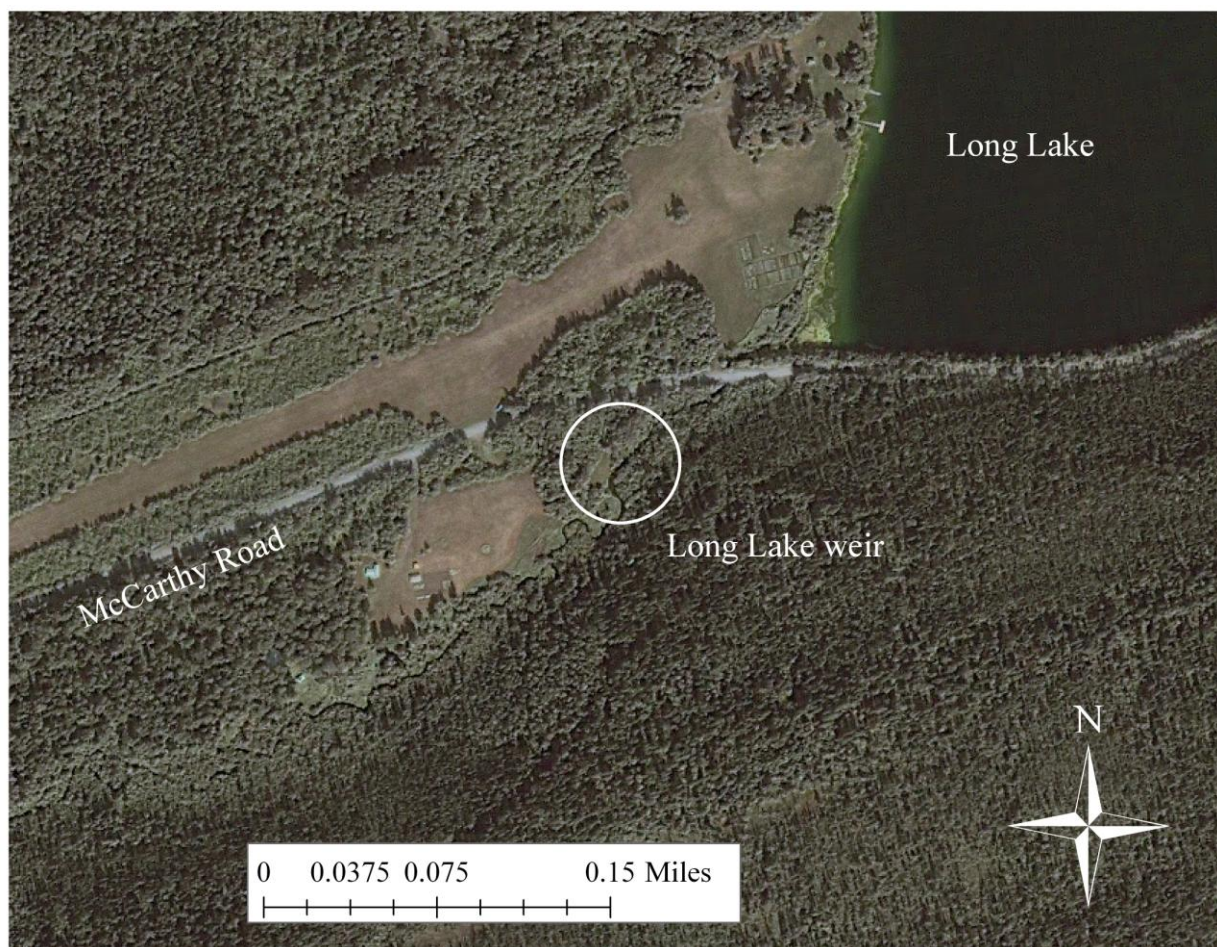


Figure 3. IKONOS image of the vicinity of the Long Lake weir. Long Lake is in the upper right of the image. The McCarthy Road appears gray and runs along the south shore of the lake and then southwest (traveling right to left). Long Lake Creek can be seen emerging from the southwest corner of Long Lake, passing under the McCarthy Road, and meandering southwest. The weir itself is located approximately in the center of the labeled circle.

where the strata are time periods. The Alaska Department of Fish and Game Commercial Fisheries Division in Cordova, Alaska uses a modified version of this approach, where the emphasis is on the absolute numbers of fish sampled during each time period (R. Brenner, ADF&G, personal communication). The basic methodology is to collect data from a minimum number of fish during each of three time periods – the beginning of the spawning run, the peak of the run, and the tail of the run. The minimum number of fish required to generate a sufficient sample (for a given desired accuracy and precision) of each age and sex class is calculated using a statistical model (see Thompson 1992), based on the projected total size of each year's run (R. Brenner, ADF&G, personal communication). These data can be used to determine the age and sex structure of the run, including freshwater versus marine age, which provides critical insight into the ongoing status of the Copper River sockeye population. The best approach to reconstructing the age and sex structure of the population is a combination of data from 2 sources. Given sufficient length/sex data from otolith-aged fish, the age structure of the remaining fish can be accurately estimated from length and sex data alone. Therefore, our approach will be to obtain length, sex and otoliths from carcasses in Long Lake as well as obtaining sex and length data from a substantial number of fish at the weir.

We will sample fish at the weir during each of the 3 time windows, as determined by long-term running averages of the timing of the Long Lake sockeye return. Although fish will be sampled opportunistically as a rule, the goal should be to obtain the target sample size over a period of 6-8 days. The number of fish to be sampled during each time window will be determined in consultation with ADF&G Commercial Fisheries personnel in Cordova. However, in general the target for each sampling window should be 600 fish (Given the uncertainties inherent in projecting the actual size of the Long Lake return, the goal should be to collect data from enough fish to provide a statistically valid sample no matter how large the run actually turns out to be). We will also sample sockeye carcasses from Long Lake in early to mid September (spawning rarely begins before early September). The goal will be to obtain sex and length data and otoliths from 100 carcasses/year. Otoliths will be collected and sent to ADF&G Commercial Fisheries Division for age and life history determination. Age-length correlations developed from the carcass data will allow us to reconstruct the age structure of the run without relying on age estimates from scales, which are unreliable for this population due to substantial scale resorption during migration (Richard Brenner, Alaska Dept. of Fish and Game, personal communication).

Field and Laboratory Methods

Standard operating procedures (SOP) will cover field season preparations and equipment, sequence of events in the field, details of taking measurements (including example field forms), post-collection handling of samples (*e.g.*, lab analysis), end-of-season procedures, data management and analysis, quality assurance/quality control (QA/QC), and all other details of weir operation and data collection. The bulk of information related to field methods is included in SOP 2 and SOP 3. SOP 4 covers most of the details related to data analysis and QA/QC.

Standard Operating Procedures

All aspects related to field and laboratory methods are included in Standard Operating Procedures. Methods follow existing national programs (EPA and USGS). Quality assurance and quality control methods follow California Water Resources Control Board EPA-approved guidelines for Quality Assurance Project Plans. Details of field methods and implementation are outlined in the SOP documents including:

SOP 1: Revising the Protocol

SOP 2: Field Season Preparation

SOP 3: Field Methods

SOP 4: Data Management, Analysis and Reporting

SOP 1: Revising the Protocol

This SOP refers to revisions to be made after the operations plan has been implemented in July 2009. Data analysis after the first year or two of monitoring will help determine whether the monitoring data collected adequately answer the stated questions and meet objectives. Revising the protocol to thoroughly answer the monitoring questions will be a top priority. Practical issues to be considered include: sampling frequencies and sample size, method of enumeration at the weir (*e.g.*, installation of digital video), live sampling versus carcass sampling and methods of data analysis. It is essential to make these critical changes earlier in the implementation of the monitoring plan to ensure long-term effectiveness of the protocol. Therefore, it is expected that the majority of major changes (*i.e.*, those having the most effect on sampling design and statistical analysis) to the protocol would be made in the first few years. Any changes to the protocol or SOPs will be documented in a revision history log. In addition, the SOP emphasizes the importance of overlap in equipment, methods, and staff when changes occur.

SOP 2: Field Season Preparation

Crewmembers need to be hired and trained in advance of the installation of the weir. Crewmember(s) should read all sections of the protocol upon hiring to know what is expected of them during the season and to know the purpose of the work at the Long Lake weir. They should pay special attention to the SOP#3 and familiarize themselves with the field procedures, including species identification, sex determination and sampling design and methodology. All of the equipment and supplies listed in SOP #2 should be organized and made ready for the field season, and copies of the field data forms in Appendix C should be made on Rite-in-the-Rain paper. Training should ensure that each crewmember is comfortable with making rapid visual determinations of species identity and sex among related salmonids. At least one crewmember or

park technician needs to be trained in the proper technique for otolith removal from salmon carcasses.

SOP 3: Field Methods

This SOP covers all aspects of field methods, including installation of the weir and sampling chamber, enumeration of fish at the weir, sampling schedules and methods, data management in the field and end-of-season procedures. The weir will be installed each year by July 15 and operate until the end of the run in mid-October. Because the basic framework for the weir remains in place year-round, weir installation consists largely of replacing the weir pickets, conducting minor repairs and setting up the electric bear fence. During weir operation, the weir will be monitored each day at approximately the same time, during which time all fish present will be allowed to pass the weir and be enumerated, identified to species and sexed based on visual characteristics. Maintaining consistency in the weir monitoring schedule is critical, as it will minimize variability in fish counts and improve the strength of statistical analyses. The weir will be closed when it is not monitored; hence weir counts for a given monitoring event represent all fish that have arrived at the weir in the previous 24 hours.

During designated sampling windows, fish will be diverted into a live box and captured for data collection. Diverted fish will be trapped in a live box attached to the weir, removed from the box using a dipnet, and will be released immediately following sampling. These fish will be identified to species and sexed, but will also be measured for mid-eye to fork length, and a scale sample will be removed (after DuBois and Molyneaux 2000). Ideally 600 fish will be sampled over a 6-8 day period; however, the actual number of fish captured and the duration of the sampling window will be determined opportunistically. In mid to late September, carcasses will be recovered from Long Lake and sampled. Carcasses will be sexed and mid-eye to fork length determined if possible; otoliths will be removed by dissection and retained. If possible, 100 carcasses/year will be sampled. A submersible data logger (HoboTemp or equivalent) will be installed at the weir to collect water temperature data throughout the summer. A staff gage located at the weir will also be read daily to provide a record of water depth in Long Lake Creek.

SOP 4: Data Management, Analysis, and Reporting

An overview of data management, analysis methods and reporting is covered in Section IV.

Data Management, Analysis, and Reporting

Roles and responsibilities for data managers, project managers, and the Network Coordinator in relation to data management are outlined in the CAKN Data Management Plan (Wilder 2005). The Data Management Plan also provides guidance on dealing with legacy data and non-programmatic data from internal (NPS) and external sources. Details regarding data management, analysis and reporting are covered in SOP 4.

Data Entry and Management

Fish species count and sex data will be entered in Rite-in-the-rain field notebooks and later transferred to Rite-in-the-rain data sheets. Fish sample data will be entered directly into AWL data sheets. Completed data sheets will be returned to the weir operator's place of residence daily. Each week these data sheets will be sent to the Wrangell-St. Elias National Park and Preserve Headquarters office in Copper Center where they will be photocopied and the photocopies stored separately. Salmon counts and sample data will be entered into an Excel spreadsheet weekly through the season. At the end of the season, the data will be compiled and forwarded to the CAKN Data Manager in Fairbanks and to the Alaska Department of Fish and Game Commercial Fisheries Division in Cordova (current contact is Richard Brenner). The accuracy of digitized records should be verified with field data sheets. Once data are entered into the database, a different individual verifies the datasheet information against the database. Field staff will verify each of the field sheets that are entered into the database. As a QA/QC measure, the project manager will verify approximately 10% of the data entered. Thermographs will be downloaded from temperature data recorders at the end of the season and both temperature and staff gage depth data will be compiled, transferred to Excel spreadsheets, and forwarded to the CAKN Data Manager.

Data Analysis

Escapement estimates collected using weir counts will be analyzed using standard procedures and techniques similar to the analysis presented by Veach and Scotton (2001), and follow methods similar to those used by Unwin and Glova (1997) and Merritt and Roberson (1986). Once a historic range is determined, this information can be used to establish an escapement objective. Standard statistics and analyses generated either annually, or as often as deemed appropriate by CAKN or WRST staff, will include the following:

Average Run Timing

- Calculate the date when 50% of salmon observed in a given year passed the weir.
- Convert date to the number of days since July 14 (i.e. July 15 = 1, July 16 = 2, etc)
- Use program R to construct linear fixed-effects models explaining variation in the date that 50% of the run has passed.
- Include covariates in the model set that are thought to potentially influence salmon return timing (*e.g.* PDO, el Nino, stream flow, spring conditions, *etc.*)
- Use Akaike's Information Criterion (AIC) to select among competing models.
- Use WinBUGS software to fit the best fixed-effects model plus any random effects, probably year at least. Use Deviance Information Criterion (DIC) to assess whether the random effects are appropriate.

- Use the final mixed-effects model for inference unless DIC indicates the random effects are unnecessary.

Population

- Standardizing the counting timing to the same dates (July 15 through Oct 31) and the same time each day will help reduce the amount of variation in the daily count data. This will make any trends in the population easier to identify.
- Collect relevant covariate values *annually* to help explain variation due to conditions at Long Lake (e.g. nutrient levels, stream flow, etc.). These could help identify factors specific to the lake that might be affecting spawning success or the survival of juvenile salmon.
- Use Bayesian models to help explain variation in the daily number of salmon counted. This will be necessary to produce reasonable estimates because of missing data for some days in early years. If dates of observation are consistent in later years, more standard approaches might become possible.
- Use WinBUGS to fit generalized linear mixed-effects models containing covariates of interest to help explain variation in the number salmon returning.
- Use DIC to select among competing models (analogous to AIC).

These analyses, and others that may be deemed necessary to answer specific questions, will follow standard statistical procedures, and will be performed using Program R. Analytical methods will likely follow Neter *et al.* (1996).

Reporting

An annual report will be prepared each year summarizing the results of that year's data collection, and including analyses forwarded by the Alaska Department of Fish and Game. Every 5 years a synthesis report will be prepared that includes trend and covariate analyses.

Personnel and Operational Requirements and Training

Roles and Responsibilities

Molly McCormick, Fishery Biologist at Wrangell-St. Elias National Park/Preserve, and Nancy Bird, President and CEO of Prince William Sound Science Center, are the principal investigators of the project. All questions regarding methodology, data collection and analysis should be addressed to them. Phil Collins, land owner, is the coordinator of the project. All decisions regarding the physical placement of the weir in the creek or the weir itself should be addressed to him. Crewmembers will be responsible for the daily running of the weir: counting and sampling fish, recording data, faxing data to park headquarters. Data entry will be performed at the end of the season by crewmembers if they are still available; otherwise it will be performed by NPS staff. Data analysis will be performed by qualified NPS staff, either from Wrangell-St. Elias National Park and Preserve or from the Central Alaska Network Inventory and Monitoring Program. The scale and otolith samples will be analyzed by the Alaska Department of Fish & Game in Cordova, Alaska. All questions regarding these should be addressed to them.

Training Requirements

Crewmembers need to be proficient in visually recognizing fish species occurring in this area and in collecting scale samples, measurements and sex information. At least one crewmember needs to be proficient in collecting otolith samples from carcasses by dissection. Other training may be required in some years, depending on opportunities for ancillary data collection (*e.g.*, limnological data collection from Long Lake). A Fishery Biologist from Wrangell- St. Elias National Park will be available to assist in training each crewmember.

Operational Requirements

Field Schedule

The Long Lake weir will be installed no later than July 15 of each year and will operate through mid-October. It will be monitored daily at the same time of day, each day between July 15 and October 15. The weir will be actively operated until all fish have been enumerated each day. The monitoring time (window of active weir operation) will be extended accordingly during periods of peak passage. The weir will be closed when it is not being monitored. During normal operations, only one crewmember is necessary for monitoring the weir. During times of peak passage up to three crewmembers may be necessary to monitor and sample fish.

Equipment and Facility Requirements

The equipment list for the crew is listed in SOP#2. There are no facility needs at the weir, although housing for crewmembers may be required in some years. Electronic data entry will occur at WRST headquarters in Copper Center. Laboratory work will occur at the Alaska Department of Fish and Game Commercial Fisheries Division laboratory in Cordova.

Budget

Budget funding for this project is based on grant monies from the U.S. Fish and Wildlife Service and will come from both of the agencies in the partnership: Prince William Sound Science Center (PWSSC) and Wrangell-St. Elias National Park and Preserve (Table 2).

Table 2. Estimated Long Lake weir operations budget for 2007.

Source	Amount
PWSCC	\$12,500
Personnel	\$6,452
Travel	\$100
Materials & Supplies	\$200
Total Budget	\$19,252

Literature Cited

- Baxter, R. 1981. Ignatti weir construction manual. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim Salmon Escapement Report No. 28, Anchorage, Alaska.
- Cedarholm, C.J., M.D. Kunze, T. Murota and A. Sibatani. 1999. Pacific salmon carcasses: essential contributions of nutrients and energy for aquatic and terrestrial systems. *Fisheries* 24:6-15.
- DuBois, L. and D. B. Molyneaux. 2000. Salmon age, sex, and length catalog for the Kuskokwim area, 1999 Progress Report. Regional Information Report 3A00-18. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage, Alaska.
- Faulkner, A.V. and S.L. Maxwell. 2008. Copper River Hydroacoustic Salmon Enumeration Studies, Miles Lake Sonar Project, 2005-2006. Fishery Data Series No. 08-37, Alaska Department of Fish and Game, Anchorage, Alaska.
- Gende, S.M., R.T Edwards, M.F. Wilson and M.S. Wipfli. 2002. Pacific salmon in aquatic and terrestrial ecosystems. *BioScience* 52:917-928.
- Holmes, P. 1992. A fence across the creek. *Alaska Wildlife* 24:2 36-37.
- Linderman, J. C. Jr., D. B. Molyneaux, L. DuBois, and W. Morgan. 2002. Tatlawiksuk River weir salmon studies, 1998-2001. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A02-11, Anchorage, Alaska.
- MacCluskie, M. and K. Oakley. 2005. Central Alaska Network Vital Signs Monitoring Plan. National Park Service, Fort Collins, Colorado. 307 pages.
- Markis, J., E. Veach, M. McCormick and R. Hander. 2004. Freshwater Fish Inventory of Denali National Park and Preserve, Wrangell-St. Elias National Park and Preserve and Yukon-Charley Rivers National Park and Preserve, Central Alaska Inventory and Monitoring Network. Natural Resource Technical Report NPS/AKRC/KN/NRTR-2004/006. National Park Service, Fort Collins, Colorado
- Maschmann, G.F. 2008. Abundance and Run Timing of Adult Pacific Salmon in the East Fork Andreafsky River, Yukon Delta National Wildlife Refuge, Alaska, 2007. Alaska Fisheries Data Series Number 2008-6. U.S. Fish and Wildlife Service, Fairbanks, Alaska.
- Merritt, M.F. and K. Roberson. 1986. Migratory timing of Upper Copper River sockeye salmon stocks and its implications for the regulation of the commercial fishery. *North American Journal of Fisheries Management* 6: 216-225.
- Neter, J., M.H. Kutner, C.J. Nachtsheim and W. Wasserman. 1996. Applied Linear Statistical Models. McGraw-Hill, Boston.

- Peitz, D. G., S. G. Fancy, L. P. Thomas, and B. Witcher. 2002. Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Prairie Cluster Prototype Monitoring Program, National Park Service.
- Reist, J.D., F.J. Wrona, T.D. Prowse, M. Power, J.B. Dempson, J.R. King and R.J. Beamish. 2006. An overview of effects of climate change on selected Arctic freshwater and anadromous fishes. *Ambio* 35:381-387.
- Schmidt, J. 2008. Changes in Sockeye Salmon Population Size and Run Timing at Long Lake in Wrangell-St. Elias National Park and Preserve. Unpublished draft report. Central Alaska Network, Fairbanks, Alaska.
- Thompson, S. K. 1992. Sampling. John Wiley & Sons, Hoboken, N.J. 343 pages.
- Unwin, M. J. and G. J. Glova. 1997. Changes in life history parameters in a naturally spawning population of Chinook salmon (*Oncorhynchus tshawytscha*) associated with natural releases of hatchery-reared fish. *Canadian Journal of Fisheries and Aquatic Sciences* 54:1235-1245.
- Veach, E.R. and S. Scotton. 2001. Abundance and Run Timing of Adult Salmon in Tanada Creek, Wrangell-St. Elias National Park and Preserve. Wrangell - St. Elias National Park and Preserve, Annual Report No. FIS00-01-3, Copper Center, Alaska.
- Wilder, D. 2005. Data Management Plan, Central Alaska Network. National Park Service, Inventory and Monitoring Program, Fairbanks, Alaska. 86 pp. plus appendices.
- Zimmerman, C.E. and L.M. Zabkar. 2007. Weirs. Pages 385 – 398 in Johnson, D.H., B.M. Shrier, J.S. O’Neal, J.A. Knutzen, X. Augerot, T.A. O’Neil and T.N. Parson, editors. *Salmonid Field Protocols Handbook: Techniques for Assessing Status and Trends in Salmon and Trout Populations*. American Fisheries Society, Bethesda, Maryland.

Appendix I. ADF&G Sample Size Spreadsheet

Sample size, n, from population, N, to simultaneously estimate age proportions, p_i , of age categories, k, within a specified distance, d, of the true population age proportion, π_i , $(1 - \alpha) \times 100\%$ of the time. The number of age Categories, k, at which the largest sample size is required is m.

Assumptions:

- 1.) Random sampling
- 2.) Sample size large enough for normal approximation (30).

Reference = Thompson (1987; 1992)

$\alpha=0.10$ $(1 - \alpha) \times 100=90\%$ (Specified accuracy) $d=0.05$ $(\pm 5\%)$ (Specified precision) The "worst case" (n = 403) occurs when m=3 and $p_i=1/m$ (three age groups in equal proportions) without finite population correction.					$\alpha=0.05$ $(1 - \alpha) \times 100=95\%$ (Specified accuracy) $d=0.05$ $(\pm 5\%)$ (Specified precision) The "worst case" (n = 510) occurs when m=3 and $p_i=1/m$ (three age groups in equal proportions) without finite population correction.				
Finite Population Size N	Finite Pop. Correction Sample Size n'	Sample size with correction for Regenerated scales			Finite Population Size N	Finite Pop. Correction Sample Size n'	Sample size with correction for Regenerated scales		
		10%	15%	20%			10%	15%	20%
1,000	287	316	330	345	1,000	338	372	388	405
2,000	335	369	386	402	2,000	406	447	467	488
3,000	355	391	409	426	3,000	436	479	501	523
4,000	366	403	421	439	4,000	452	498	520	543
5,000	373	410	429	448	5,000	463	509	532	555
6,000	378	415	434	453	6,000	470	517	541	564
7,000	381	419	438	457	7,000	475	523	547	570
8,000	384	422	441	460	8,000	479	527	551	575
9,000	386	424	444	463	9,000	483	531	555	579
10,000	387	426	445	465	10,000	485	534	558	582
11,000	389	428	447	467	11,000	487	536	561	585
12,000	390	429	448	468	12,000	489	538	563	587
13,000	391	430	450	469	13,000	491	540	564	589
14,000	392	431	450	470	14,000	492	541	566	590
15,000	392	432	451	471	15,000	493	543	567	592
16,000	393	432	452	472	16,000	494	544	568	593
17,000	394	433	453	472	17,000	495	545	569	594
18,000	394	434	453	473	18,000	496	546	570	595
19,000	395	434	454	474	19,000	497	546	571	596
20,000	395	435	454	474	20,000	497	547	572	597
40,000	399	439	459	479	40,000	504	554	579	604
60,000	400	440	460	480	60,000	506	556	582	607
80,000	401	441	461	481	80,000	507	557	583	608
100,000	401	442	462	482	100,000	507	558	584	609
120,000	402	442	462	482	120,000	508	559	584	609
140,000	402	442	462	482	140,000	508	559	584	610
160,000	402	442	462	482	160,000	508	559	585	610
180,000	402	442	462	483	180,000	509	559	585	610
200,000	402	442	463	483	200,000	509	560	585	610
220,000	402	442	463	483	220,000	509	560	585	611
240,000	402	443	463	483	240,000	509	560	585	611
260,000	402	443	463	483	260,000	509	560	585	611
400,000	403	443	463	483	400,000	509	560	586	611

Appendix II. Standard Operating Procedures

Standard Operating Procedure (SOP) #1: Revising the Protocol

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Only changes in this SOP will be logged. “Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number” (Peitz *et al.*, 2002).

Introduction

This Standard Operating Procedure (SOP) explains how to make changes to the Long Lake Weir Operations Protocol Narrative and accompanying SOPs, and explains procedures for tracking these changes. CAKN or park staff editing the Protocol Narrative or any SOP need to follow this procedure to eliminate confusion in data collection and analysis methods. All CAKN aquatic resources staff should be familiar with this SOP in order to identify and use the most current methodologies. This SOP is adapted from the Bird Monitoring Protocol SOP #11 for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas (Peitz *et al.*, 2002). Their protocol can be accessed at <http://science.nature.nps.gov/im/monitor/protocols/birds.htm>

Procedures

1. The Long Lake Weir Operations Protocol Narrative and accompanying SOPs have made every effort to incorporate the most sound methodologies for collecting and analyzing sockeye salmon spawning run data. However, all protocols require editing as new and different sample collection, analysis, and data management information becomes available. Required edits should be made as soon as they are deemed necessary and appropriate reviews should be conducted.
2. All edits will be reviewed for grammatical and technical accuracy and overall clarity. Minor changes or additions to existing methods will be reviewed “in-house” by the CAKN aquatic

ecologist and other appropriate network staff. However, if a complete change in methods is anticipated, then an outside review is required. Regional (Alaska Region) and National staff of the National Park Service familiar with the collection of salmon monitoring data and data analysis will be utilized as reviewers. Also, local and state experts in salmon monitoring and statistical methodologies outside of the Park Service will be utilized in the review process as needed.

3. Edits and protocol revisions will be documented in the Revision History Log that accompanies the Protocol Narrative and each SOP. Only changes in the Protocol Narrative or specific SOP that has been edited will be logged. "Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number" (Peitz *et al.*, 2002).
4. Notify the CAKN Data Manager of any changes to the Protocol Narrative or SOP.
5. Post new versions on the internet and forward copies to all individuals with a previous version of the Protocol Narrative or SOP.
6. When any significant changes in the sampling protocol occur such as changes in sample collection techniques or equipment, a change in analytical laboratory, or changes in staff, there should be an "overlap" of methods and personnel (Oakley *et al.*, 2003). This requires using both the old and new techniques on a given sample as well as having both the outgoing and new staff sample concurrently. While this approach is likely not feasible for the Long Lake weir, it should be the goal of the weir program to conform to these guidelines to the extent possible.

Literature cited

- Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher. 2002. Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002.
- Oakley, K.L., L.P. Thomas, and S.G. Fancy. 2003. Monitoring Protocol Guidelines. Wildlife Society Bulletin 31: 1000-1003.

Standard Operating Procedure (SOP) #2: Field Season Preparation

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Only changes in this SOP will be logged. “Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number” (Peitz *et al.*, 2002).

Introduction

This Standard Operating Procedure (SOP) provides the step-by-step instructions for preparing for the field season. These exercises should be completed before each field season. The procedures outlined here are essential for successful implementation and program maintenance. Outlined in this SOP are training requirements, scheduling requirements, logistical organization as well as general organization and preparedness. Each crewmember needs to carefully review this entire protocol including all the related SOPs, data sheets, and instructions.

General Preparation and Training Requirements

1. Each crewmember should meet with the project lead to discuss the general project implementation plan.
2. It is imperative that each observer carefully review all background information including the project narrative and all related SOPs and supplementary materials.
3. Each crewmember should review field notes from previous surveys (if available) to identify any unique events that may be encountered and to familiarize new crewmembers with the procedures. Park fisheries staff should be available to facilitate this process.
4. The crew must prepare a new field notebook for the survey year with pages for entry of sampling schedules, observer names, field hours and unique happenings that may influence how the data are reported. Data sheets and spreadsheets are based on information recorded in field notebooks, so it is imperative that they are clearly organized for ease of field note entry.

5. A collection permit from the Alaska Department of Fish and Game is required for fish capture, handling and sampling. At present, sampling activities at the weir are covered under the permit issued each year to the Prince William Sound Science Center. The weir crew should be provided with a laminated copy of this permit, which should be kept in the sampling box at all times.
6. Crewmembers must be able to accurately identify, by visual observation, the two salmon species most likely to be encountered at the weir. These are sockeye salmon (*Oncorhynchus nerka*) and coho salmon (*Oncorhynchus kisutch*). Keys to salmon identification are available for the crew. This should be verified by park fisheries staff prior to beginning weir operation.
7. Crewmembers must be able to determine the sex of captured fish by visual observation. This should be verified by park fisheries staff prior to beginning weir operation.
8. At least one crewmember should be trained in removing otoliths from salmon carcasses.
9. Crewmembers should be trained in bear safety and be familiar with the use of bear spray canisters.
10. Crewmembers should be trained in safe operation of the weir, and in weir construction and repair.
11. Ideally, Crewmembers should be certified in First Aid and CPR.
12. Crewmembers and fisheries staff that will be conducting carcass sampling in Long Lake should be trained in boat safety and be properly certified for the operation of NPS watercraft.
13. Staff from the fisheries department at WRST will be available to train new crewmembers.

Scheduling Field Work

1. According to historical records fish generally start migrating up Long Lake Creek on or about July 26. Accordingly, it is imperative that the weir be installed and operative no later than July 15.
2. Field staff should be trained and ready to begin observations at the weir by no later than July 20.

3. Sampling efforts at Long Lake weir require one person to count the salmon migrating through the weir. When sampling fish a 2 person crew is preferable. At peak times extra effort from the crew might be needed. Sampling carcasses and otolith removal can be accomplished by a single crewmember.
4. Sampling will begin when salmon first move through the weir.

The weir site is on Collins Family Trust land and is located within a few hundred meters of the Collins family residence. The Prince William Sound Science Center intends to hire members of the Collins family so the weir operator will already be living in close proximity to the weir site and travel will not be required. If this is not possible, then arrangements for housing for the crewmembers, and travel to and from the weir site if local accommodations cannot be secured, need to be arranged well in advance of the start of weir operation.

Organizing Supplies and Equipment

Gummed scale cards and AWL data sheets should be prepared and numbered before the run begins. An equipment list should be compiled, and equipment organized and made ready for the field season prior to the start of the field season. This allows time to make needed repairs and order equipment.

The following is a list of necessary field equipment:

Number Required	Description
1	Identification key for salmon and trout species
1	Copy of SOP#2 printed on Rite-in-the-Paper
1	Electric bear fence with solar charger and batteries
2	Dipnets, short handles, round rim, deep net
1	Sampling cradle
1	Metal clipboard and cover
1	Large toolbox or similar for transporting and storing gear
1	Rite-in-the-Rain field notebook
2	Hand counters
1	Flexible measuring tape, metric
2 pairs	Tweezers suitable for removing scales
Numerous	Rite-in-the-Rain AWL data sheets
Numerous	Gummed scale cards w/tissue paper
1	Scale card holder

1	Roll of waxed paper for gum cards
1	Waterproof box to hold the equipment
Numerous	Mosquito repellent
2	Hobo temperature recorder, set and with new battery
2	White plastic cases for Hobo recorders
Numerous	Mechanical pencils
1	Extra lead for pencils
1	NIST-traceable thermometer in plastic case (°C)
1	1 st aid kit
2	Bear spray canisters
1 small spool	Stainless steel 20 gauge wire
1 each	Neoprene or Gore-Tex waders and wading boots for each crew member or
1 pair	Hipboots

Literature cited

Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher. 2002. Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002.

Standard Operating Procedure (SOP) #3: Field Operations and Procedures

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Only changes in this SOP will be logged. “Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number” (Peitz *et al.*, 2002).

Introduction

This Standard Operating Procedure (SOP) provides step-by-step instructions for all procedures that will occur at the Long Lake weir or at Long Lake itself. The procedures outlined here are essential for successful implementation and program maintenance. Outlined in this SOP are instructions for initial installation of the weir, sampling box and electric bear fence, enumeration of salmon at the weir, capture and sampling of salmon at the weir, including the sampling design, collection of water level data, carcass sampling and otolith removal, and end-of-season demobilization of the weir. Each crewmember needs to carefully review this entire protocol including all the related SOPs, data sheets, and instructions.

Weir installation

The weir, sampling box and electric bear fence should be installed by July 15 each year, to allow repairs to be made if necessary and equipment to be organized. The basic structure of the weir stays in place throughout the year (Figure 1). Each July the framework and banks need to be checked for structural problems before the weir is set up, the pickets need to be put in place, and the sampling box behind the weir needs to be constructed. An electric bear fence is then installed around the weir and sampling box.

In October, the pickets are pulled from the framework, the sampling box is removed and stored and the bear fence is taken down. General guidance for weir construction can be found in Baxter (1981) and Lindemann, *et al.* (2002), among other sources.



Figure A 1. View of weir framework during winter.

The basic weir framework consists of 2 steel bars mounted across the width of Long Lake Creek (Figure 1). The bars are bolted to 4 steel posts; 2 located on either bank and 2 in the center of the stream. The lower bar is approximately 1 foot above the streambed and the upper bar is approximately 2 feet above the streambed. A 2 by 6 wooden plank mounted to either bank immediately upstream of the weir framework, and reinforced with lumber, serves as a working platform. An aluminum pole mounted to the top of the structure, and spanning the stream, serves as a railing. The weir pickets themselves are constructed out of 1 ¼ inch diameter aluminum tubing, cut into ~36 inch sections. The pickets are stored on the Collins family property near the weir when not in use. The weir is reconstructed each summer by sliding the weir pickets through aligned holes in the upper and lower bars so that the pickets rest directly on the streambed. The finished weir has a picket spacing of 3.75 cm. Typically, some maintenance work must be completed each season before the weir is made operational. This includes straightening and/or reinforcing the weir structure, stabilizing the streambanks, and mowing the grass in the vicinity of the weir. WRST fisheries personnel have experience with these and other aspects of weir construction and maintenance and will be available to assist crewmembers as needed. Figure 2 shows what the completed weir structure looks like.

Bears are attracted to the weir because of the presence of salmon, especially when the weir is closed (because fish “pile up” downstream). Therefore, electric bear fencing is installed around



Figure A 2. Overview of the weir when operational. Stream flow is from left to right. Note placement of electric bear fence (strung on white poles). The bear fence completely surrounds the weir. The weir itself stretches straight across the stream. Additional framing and pickets are used to construct the sampling area seen on the left.

the weir on both sides of the stream to protect the weir from damage by curious bears (see Figure 2). The fence should be capable of generating 5,000 to 7,000 volts at all points along the wires. The fence should be tested regularly with an appropriate voltmeter to ensure that this level of performance is obtained. The energizer for the fence should have a Joule rating of between 0.025 and 0.70. The fence should be constructed of at least 3 strands of polywire. At least one strand (the top strand if only one is used) should be high-visibility $\frac{1}{2}$ inch polytape. The lowest strand should be 10-12 inches above ground level, and the top wire should be around 40 inches above ground level. The fence must be properly grounded in order to operate correctly. The fence is powered by 12 -volt wet cell batteries that are charged using a solar panel. A voltmeter manufactured for testing electric bear fences should be kept with the sampling gear and used to test the bear fence regularly to ensure it is operating properly (maintaining 5,000-7,000 volts at all points). WRST fisheries staff are familiar with the set up and maintenance of the electric bear fence, batteries and solar panels, and will be available for assistance as needed.



Figure A 3. Overview of the sampling box that is attached to the weir. Fish are allowed into the sampling box by removing appropriately located pickets in the weir. Note the work area to the left, where sampling occurs after fish are captured. After sampling, fish are returned directly to the water upstream of the weir structure.

Basic weir operation

The essential purpose of a weir is enumerating fish as they pass through it. The Long Lake weir is constructed of removable pickets which allow the crew to make a gap in the weir at any place along it. To count the salmon passing through the weir a crewmember stands on the walkway over the weir, lifts 2-3 pickets out of the weir, and counts salmon with hand counters as they swim through it. Separate counters should be maintained for sockeye versus coho so that daily counts for each species can easily be determined. It is important that the opening in the weir be large enough for fish to easily swim through it, but not be so large as to allow more than one fish at a time to pass through the weir. The total number of salmon counted should be entered into the field notebook each day, at the end of each counting session, or entered directly into the Weir Count Datasheet (Appendix 1, see below for explanation). The number of sockeye and coho counted should be entered separately. Detailed field notes should be recorded each day, documenting any relevant aspects of weir operation, fish behavior, etc. For example, were most fish already at the weir upon arrival, or did they “trickle in” over the counting operation? Was fish behavior typical? What was the general condition of the fish? Weather should be recorded as well. This type of information often proves valuable in later interpretation of data.

To minimize variability in daily salmon counts that is associated with sampling error, it is very important that the weir be staffed every day during the operating season. Missed days generate “artificial” zeros and may inflate counts on the first sampling day following the missing period. Ideally, the weir will be staffed at approximately the same time each day; this ensures that each

day's count accurately reflects the number of fish that have arrived at the weir in the previous 24-hour period. Large variations in the elapsed time between weir counts introduces unnecessary variability in the data and may complicate analysis and interpretation. To ensure that the enumeration data collected are correctly interpreted, it is important to keep an accurate record of exactly when the fish counts occur. Accordingly, crewmembers will fill out the attached Weir Count Datasheet each day that the weir is staffed (See Appendix 1 for example datasheet). This data sheet requires the entry of the date, start and stop times, and the number of fish enumerated during the counting session. If sampling does not occur on a given day, this should be clearly noted on the data sheet. Do not enter '0' if the weir was not staffed. There should be a record entered on the data sheet for every day of the season.

Sampling salmon at the weir

Sampling design: Age, sex and size information from salmon catches and escapements is used to aid in forecasting run strength, evaluating run strength in-season, setting escapement goals, examining spawning system productivity, evaluating growth characteristics of salmon populations, and estimating stock contributions based on age composition and growth patterns on scales. Accordingly, sampling returning sockeye to determine the sex and age structure of the run and related population statistics (mean length, etc.) will constitute an important part of the Long Lake weir data collection effort.

A stratified random sample design is often used to select individual fish for determination of sex, age and length (*e.g.*, Zimmerman and Zabkar 2007, Maschmann 2008), where the strata are generally time periods. The Alaska Department of Fish and Game Commercial Fisheries Division in Cordova, Alaska uses a modified version of this approach, where the emphasis is on the absolute numbers of fish sampled during each time period (R. Brenner, ADF&G, personal communication). The basic methodology is to collect data from a minimum number of fish during each of three time periods – the beginning of the spawning run, the peak of the run, and the tail of the run. The minimum number of fish required to generate a sufficient sample (for a given desired accuracy and precision) of each age and sex class is calculated using a statistical model, based on the projected total size of each year's run (R. Brenner, ADF&G, personal communication). This model adjusts the multinomial sampling guidelines for infinite populations from Thompson (1992) using corrections for finite populations.

The age of a fish can be determined using length-frequency analysis, or by examining hard structures such as otoliths or scales (*e.g.*, DeVries and Frie 1996). Because collecting otoliths requires sacrificing fish, scales have generally been used to age fish passing through the Long Lake weir. However, resorption of scales, which can complicate interpretation of scale patterns, is generally substantial among sockeye returning to Long Lake (Richard Brenner, Alaska Dept. of Fish and Game, personal communication). For this reason, it is important that otoliths and length data be collected from as many spawned-out carcasses in Long Lake as is feasible. Given sufficient length/sex data from otolith-aged fish, the ages of other fish in the population can be accurately estimated from length and sex data alone. Furthermore, otoliths can provide life history information as well (freshwater age versus marine age). Therefore, our approach will be to obtain length, sex and otoliths from carcasses in Long Lake in early to mid September (spawning rarely begins before early September), as well as obtaining sex and length data from a substantial number of fish at the weir. The goal will be to obtain sex and length data and otoliths

from 100 carcasses/year. Otoliths will be collected and sent to ADF&G Commercial Fisheries Division in Cordova for age and life history determination. Scales will also be collected at the weir and sent to ADF&G Commercial Fisheries Division as a backup source of age data for the population. These data can be used to determine the age and sex structure of the run, including freshwater versus marine age, which provides critical insight into the ongoing status of the Copper River sockeye population.

We will sample fish at the weir during each of the 3 time windows. The goal, based on consultation with ADF&G fisheries staff, is to collect fish from the beginning of the run, the peak of the run and the tail of the run. Ideally, the timing of the run would be known in advance to allow efficient sampling of each of these phases. In the absence of such knowledge, however, set sampling windows will be determined. Currently, based on ADF&G analysis of past runs, the recommended sampling windows are:

1. July 15 – August 20
2. August 21 – September 5
3. September 6 – October 15

These sampling windows may be adjusted in the future depending on changes in average run timing or other circumstances. Although fish will be sampled opportunistically as a rule, the goal should be to obtain the target sample size over a period of 6-8 days. The number of fish to be sampled during each time window will be determined in consultation with ADF&G Commercial Fisheries personnel in Cordova. However, in general the target for each sampling window should be 600 fish (Given the uncertainties inherent in projecting the actual size of the Long Lake return, the goal should be to collect data from enough fish to provide a statistically valid sample no matter how large the run actually turns out to be). At the beginning of each time window, the objective is to sample every fish that passes through the weir until the target sample size has been reached. To avoid oversampling on a particular day, no more than 100 fish will be sampled on any given day. This ensures that each sample will be collected over a minimum of 6 days. On peak sampling days, at least one person from the WRST fisheries staff will be available to assist the crew.

We will also sample sockeye carcasses from Long Lake in early to mid September, or later in the season if necessary. The goal will be to obtain otoliths, sex information and length measurements from as many carcasses as possible, but no fewer than 100 each year. Carcasses will be retrieved opportunistically from the lake wherever they occur. At least 2 field trips per year should be dedicated to carcass sampling. Crewmembers and/or park staff involved in carcass sampling should have boat safety training and all necessary National Park Service certifications for operating watercraft. Section VI provides detailed instructions for carcass sampling.



Figure A 4. Overview of sampling at the weir.

Sampling Procedures Overview: To be useful, sex and size data must be recorded accurately and neatly on data sheets, and scales (used for age determination) must be mounted neatly and cleanly on gummed paper scale cards. Rite-in-the-rain notebooks, AWL data sheets (Table A 1), and gum cards are used for sampling. Each gum card must correspond with information on the AWL data sheets. Although it may be more convenient to initially record data in “Rite in the rain” field notebooks and later transfer the data to the AWL data sheet, the preferred procedure is to record data directly in the AWL datasheet. Begin the sampling season with gum card #1 and a corresponding AWL data sheet #1 and continue in sequence through the season. New AWL data sheets and gum cards should be started each day, even if those from the previous day were not totally filled. It is imperative that the gum card numbers and the AWL data sheet numbers match. Record the following information on each AWL data sheet and gum card:

- Project name (Long Lake Weir)
- Date (MM/DD/YYYY format)
- Start time
- End time
- Crew names
- Species sampled (separate AWL data sheets and gum cards should be prepared for coho if they are to be sampled)

If using Rite-in-the-rain notebooks for initial data recording, label each notebook with the following information:

Project name (Long Lake Weir)
Start Date
End Date
Crew names

In addition, record the date, start time, end time, species sampled, and crewmembers involved on the appropriate page of the notebook, before beginning to record data (except end time, which should be recorded last).

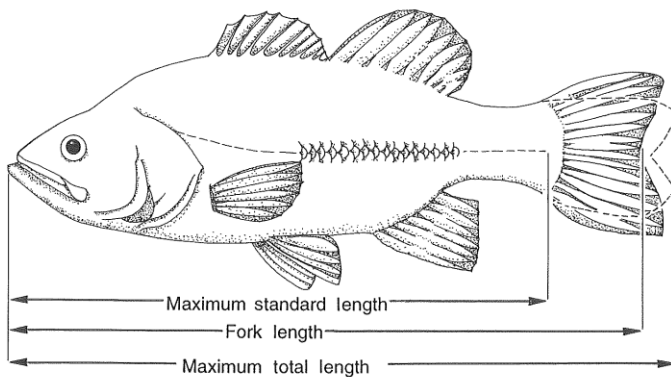
Once data sheets, gum cards and necessary equipment are prepared, fish are isolated for sampling by removing appropriate pickets to allow them to enter the sampling box. Individual fish are then captured using the short-handled dipnet, and transferred to the sampling cradle on the sampling table, where identification of sex, length measurement and scale removal will occur (Figure 4). After data collection, each fish should be returned directly into Long Lake Creek. All data collection and recording for a given fish should be completed before the next fish is captured.

Detailed Sampling Procedures:

1. After capturing it using the dipnet, place fish to be sampled in the sampling cradle with its left side facing up. It is easiest to complete the sampling procedure with the fish still in the dipnet (Figure A 4). Sex the fish using external characteristics. Record the sex of the fish in the field notebook or directly into the “Sex” column of the AWL data sheet.
2. Measure the fish to the nearest millimeter using the flexible meter tape. Both mid-eye to tail fork length and fork length (snout to tail fork) measurements should be recorded for each sampled fish. See Figure A 5 for illustrations of these measurements. Record both lengths in the field notebook or directly into the “Length” column of the AWL data sheet. Record mid-eye to tail fork first, then fork length, both in the “Length” box corresponding to the fish being measured.
3. Pluck the preferred scale from the left side of the fish using a pair of forceps to grasp the exposed, posterior edge and pulling the scale free. Remove all slime, grit and skin from the scale using thumb, forefinger, spit and/or tweezers, but be sure not to change orientation of the scale. It needs to be placed on the gum card in the same orientation that it is removed from the fish. See Figure A 6 for an illustration of the procedure. References for scale removal and use of scales to age fish include Clutter and Whitesel (1956), and International North Pacific Fisheries Commission (1963).
4. The preferred scale is located on the left side of the fish, two rows above the lateral line. Draw a diagonal line from the back (posterior) of the dorsal fin to the front (anterior) of the anal fin. Follow that line up two rows of scales from the lateral line. That scale is the preferred scale (Figure A 6). If that scale is missing, select a scale to the right or left, still

in the preferred area. If no scales are present in the preferred area on either side of the fish and there are plenty of fish available for sampling, disregard the fish and select another one. If there are a limited number of fish available for sampling, and scales are absent in the preferred area on both sides, sample a scale as close to the preferred area as possible and write “not preferred scale” on the data form. This is important because the scales may be used for scale pattern analysis, and non-preferred scales produce erroneous results.

a.



b.

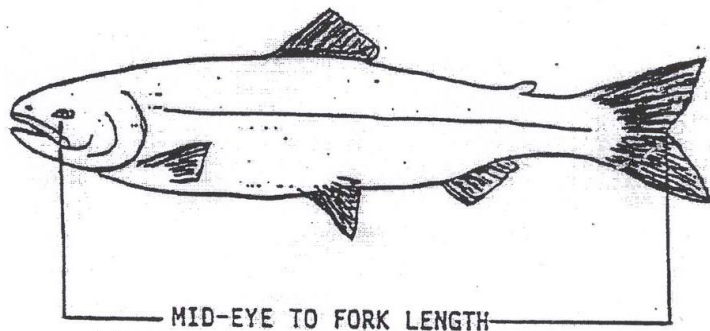


Figure A 5. Common measurements of fish length. a) Illustration of Fork Length. b) Illustration of Mid-eye to Fork Length

5. Examine the cleaned scale for regeneration (Figure A 6). A regenerated scale is one that has replaced a lost scale. Regenerated scales **CANNOT** be aged and should also be discarded. They will usually have a clear area near the focus that will be visible if held up to the sky or a light. Regenerated scales are usually obvious on the fish's side because of their irregular margin outline and shape. If the preferred scale is regenerated, choose another one for sampling purposes.
6. Moisten the clean scale and, holding it with the forceps, mount it on the gum card directly on top of the appropriate scale number on the card. The anterior end of the scale should

be oriented toward the top of the card, and the exterior of the scale should be oriented outwards away from the card. The side of the scale facing outward from the card **MUST BE** the same as the side facing outward when attached to the fish. This outward facing side is referred to as the sculptured side of the scale, and the ridges on this side can be felt with a fingernail or tweezers. This is very important.

7. Repeat the sampling procedures on subsequent fish until the gum card is full (40 samples), being sure to match the number of the scale with the corresponding number for the length measurement and sex of that fish on the AWL form.

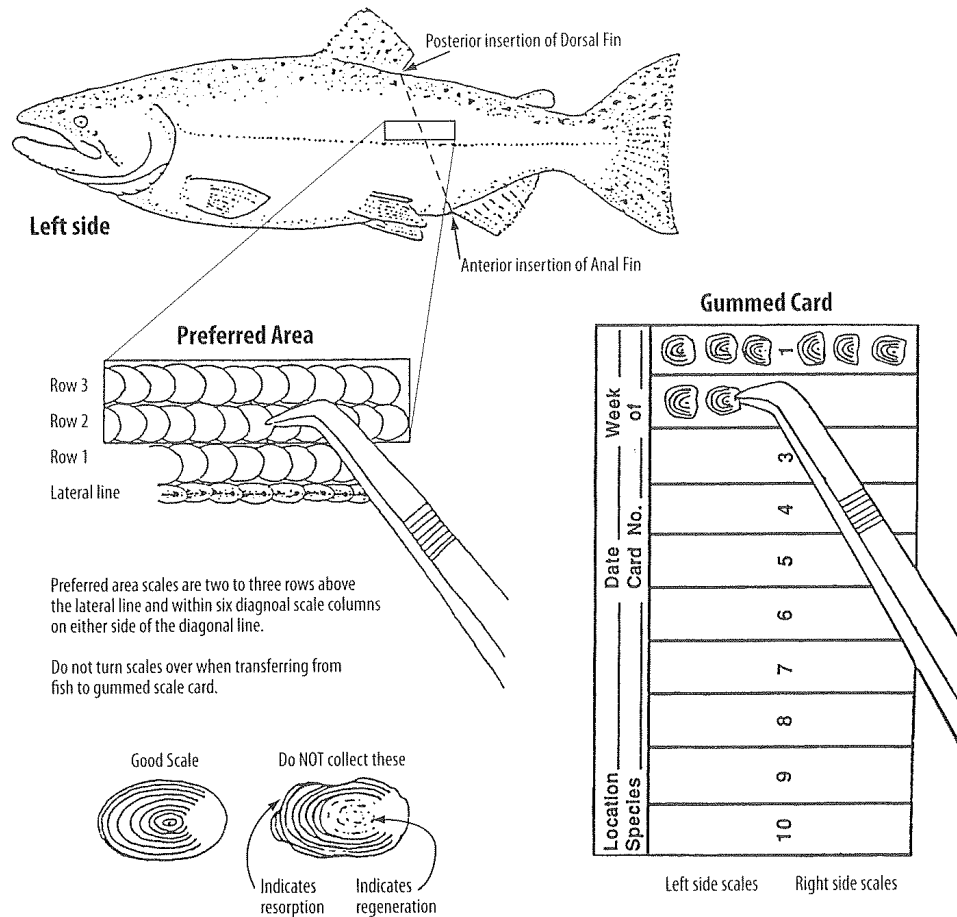


Figure A 6. Scale sampling procedure (from Crawford *et al.* 2007). Forceps are shown grasping the preferred scale.

8. Cover the completed gum card with wax paper. If the card is very wet, let it dry out before placing the wax paper directly over it or the scales will stick to the paper when it is removed. If the card gets too wet, the scales will not stick to it.
9. Put the gum card with wax paper between the two pieces of plastic and close them together so the card is flattened. Make sure not to leave wet gum cards pressed together. If the cards are wet, be sure to dry them out.

10. Be sure to check your data at the end of each day for neatness and accuracy; make sure all data are complete (card numbers, dates, times, sampler's names). Remount any scales that appear to be curling on the edges. Data completeness and accuracy are essential to the success of the project. It is much easier for the field crewmembers who are actually doing the sampling to complete the required information and correct mistakes than it is for someone else to attempt to do it months later when data are being analyzed.

Collection of water level data

Each day, the water level should be read from the staff gage located just downstream of the weir and recorded in the Rite-in-the-rain field notebook along with the date and time, and any relevant notes.

Carcass Sampling

Salmon carcasses will be measured for length (mid-eye to fork) if whole, and dissected to remove otoliths and determine sex and spawning status if possible. Often, only heads will be recovered due to scavenging of carcasses. In these cases, an otolith will be removed and sex determined if possible (using external characteristics). Fish sex and length should be entered into an AWL data sheet that is clearly labeled as containing carcass data. Small envelopes (*e.g.*, coin envelopes) for preserving otoliths should be labeled and numbered to match the AWL data sheets. Each envelope should be labeled with the following information:

Name of Project (Long Lake Weir)
Date (MM/DD/YYYY)
Fish number
Fish species
Crew name(s)

AWL data sheets should be labeled with the same information (with the exception of fish number, since each numbered row will correspond to a fish). All fish sampled should be recorded on the AWL data sheet, whether or not the carcass was intact. For non-intact carcasses, a note to that effect should be entered in lieu of a length measurement.

All teleost fishes, including sockeye salmon, have 3 pairs of otoliths: the sagittae, lapilli, and asterisci (Figure A 7). Because the sagittae are the largest, they are generally used for microstructure analysis (aging). In salmonids, otolith analysis generally focuses on the left sagitta, because it is often much larger than the right sagitta (Neilson and Geen 1982).

Accordingly, if possible, the left sagitta is the otolith that should be removed. There are a variety of techniques for removal of otoliths, some of which may be more suitable than others for use in the field, where speed and efficiency are paramount (*e.g.*, Secor *et al.* 1992,). It is not important which of these or other techniques for otolith removal is used. It is, however, vitally important that the crewmember(s) responsible for carcass sampling be well trained in the procedure to ensure the collection of high-quality otoliths. WRST fisheries staff will be responsible for training crewmembers as needed. The otolith should be treated gently so as to avoid breakage, especially along the anterior end. Otoliths should be cleaned gently to remove excess tissue and placed in small labeled envelopes.

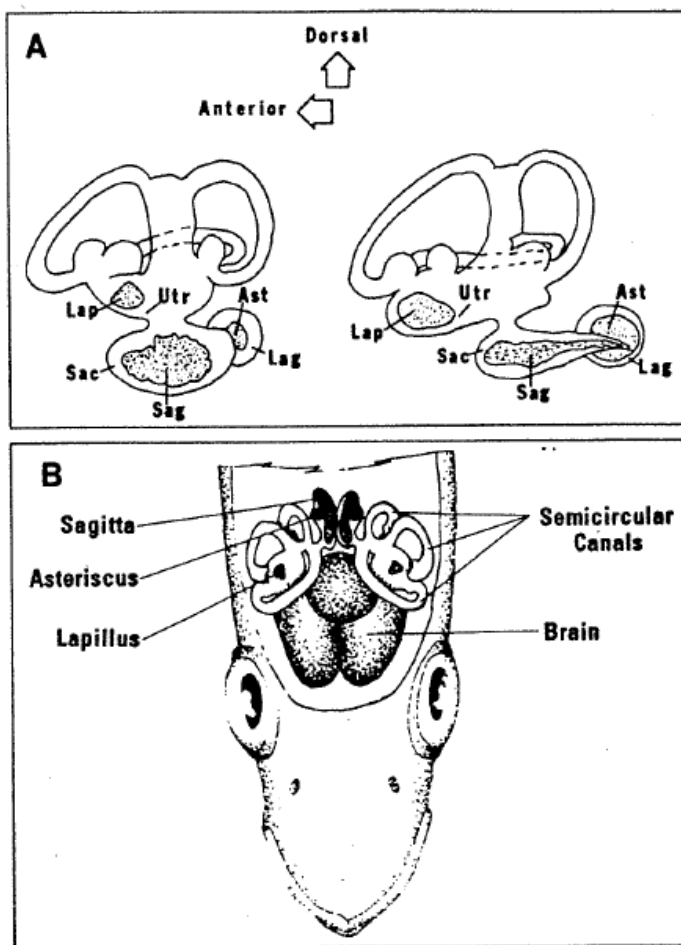


Figure A 7. Location of otolith pairs in a representative teleost fish.

Weir breakdown

In general, the weir should be decommissioned for the season on October 15 each year. However, if spawning fish are still arriving at that time, the weir should remain operational as long as is feasible, or until no fish are sighted for 3 consecutive days. Weir removal is simply the reverse of weir installation. WRST fisheries staff should assist the weir crew in breaking down the weir and ensuring that equipment and parts are properly stored over the winter.

Literature cited

- Baxter, R. 1981. Ignatti weir construction manual. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim Salmon Escapement Report No. 28, Anchorage.
- Crawford, B., T. R. Mosey and D. H. Johnson. 2007. Carcass counts. Pages 59-85 in D. H. Johnson, *et al.*, editors. Salmonid Field Protocols Handbook: Techniques for Assessing Status and Trends in Salmon and Trout Populations. American Fisheries Society, Bethesda, Maryland.

- Clutter, R. and L. Whitesel. 1956. Collection and Interpretation of Sockeye Salmon Scales. Bulletin of the International Pacific Salmon Fisheries Commission 9, New Westminster, British Columbia.
- DeVries, D. R. and R. V. Fries. 1996. Determination of age and growth. Pages 483-512 in B. R. Murphy and D. W. Willis, editors. *Fisheries Techniques*. American Fisheries Society, Bethesda, Maryland.
- International North Pacific Fisheries Commission. 1963. *Annual Report – 1961*. Vancouver, British Columbia
- Linderman, J. C. Jr., D. B. Molyneaux, L. DuBois, and W. Morgan. 2002. Tatlawiksuk River weir salmon studies, 1998-2001. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A02-11, Anchorage.
- Neilson, J. D. and G. H. Geen. 1982. Otoliths of chinook salmon: Daily growth increments and factors influencing their production. *Canadian Journal of Fisheries and Aquatic Sciences* 39:1340-1347.
- Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher. 2002. Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002.
- Secor, D. H., J. M. Dean and E. H. Laban. 1992. Otolith removal and preparation for microstructural examination. Pages 19-57 in D. K. Stevenson and S. E. Campana, editors. *Otolith Microstructure Examination and Analysis*. Canadian Special Publication in Fisheries and Aquatic Sciences 117, Department of Fisheries and Oceans, Ottawa, Canada.

Table A 1. Weir Count Data Sheet example

LONG LAKE WEIR FISH COUNT DATASHEET

[illegible]

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