Susitna-Watana Hydroelectric Project Document
ARLIS Uniform Cover Page

Title: Adult salmon distribution and habitat utilization study : final (4/30/12)	**SuWa 91**
Author(s) – Personal:	
Author(s) – Corporate: [by Alaska Energy Authority ?]	
AEA-identified category, if specified: 2012 Environmental Study Plans	
AEA-identified series, if specified:	
Series (ARLIS-assigned report number): Susitna-Watana Hydroelectric Project document number 91	Existing numbers on document:
Published by: [Anchorage, Alaska : Alaska Energy Authority, 2013]	Date published: April 30, 2012
Published for:	Date or date range of report:
Volume and/or Part numbers:	Final or Draft status, as indicated: Final
Document type:	Pagination: 27 pages
Related work(s): Revised under the same title as SuWa 7 and 28 (two distributions of the same draft version of January 2013) and SuWa 301 (February 2013).	Pages added/changed by ARLIS:
Notes:	

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Adult Salmon Distribution and Habitat Utilization Study – FINAL (4/30/12)

1. INTRODUCTION

The Alaska Energy Authority (AEA) is preparing a License Application that will be submitted to the Federal Energy Regulatory Commission (FERC) for the Susitna-Watana Hydroelectric Project (Project). The application will use the Integrated Licensing Process (ILP). The Project is located on the Susitna River, an approximately 300 mile long river in the Southcentral region of Alaska (Figure 1). The Project's dam site will be located at River Mile (RM) 184. The results of this study and of other proposed studies will provide information needed to support the FERC's National Environmental Policy Act (NEPA) analysis for the Project license.

Construction and operation of the Project as described in the Pre-application Document (PAD, AEA 2011a) will modify the flow, thermal, and sediment regimes of the Susitna River, which may alter the composition and distribution of fish habitat. This study plan outlines the goals, objectives, and methods for characterizing adult salmon habitat utilization in the Susitna River in order to provide data to evaluate potential Project-related effects to fish habitat. This study will initiate a multi-year effort, which will include data collection activities beginning in 2012. A comprehensive set of fisheries study plans (2013-2014 Fish Study Plans) will be developed during 2012 as part of the Project licensing process. The 2013-2014 Fish Studies will be used to describe the fisheries resources and their habitat within the Project area.

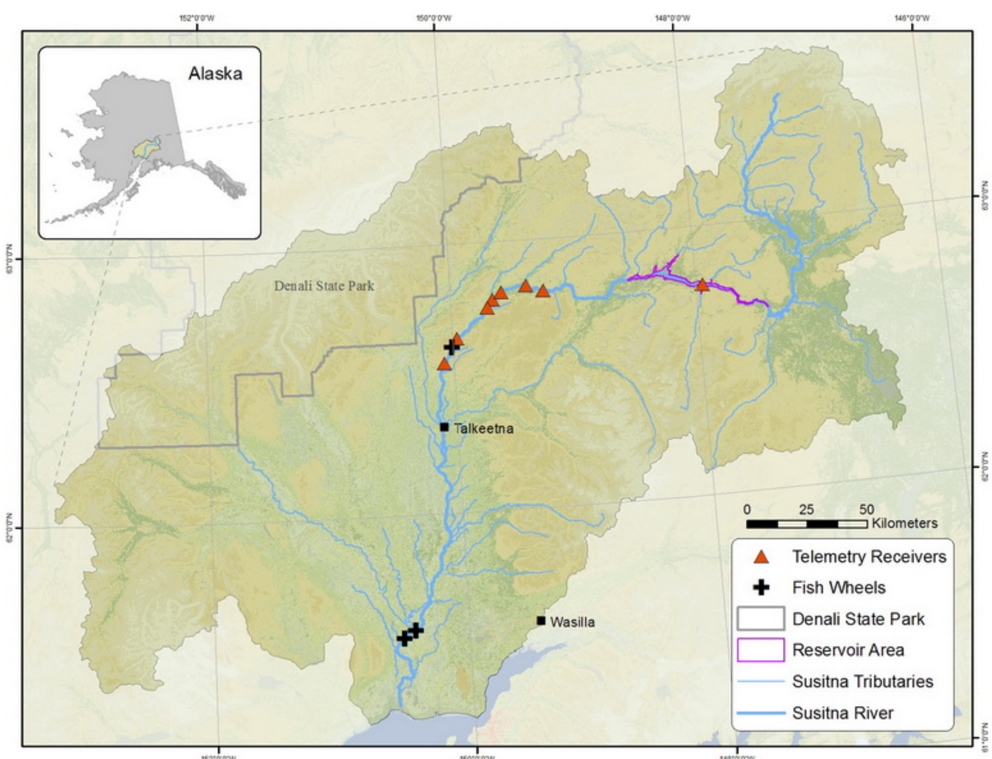

Figure 1. Susitna watershed showing fish capture sites (fishwheels) and the proposed locations of fixed-station telemetry receivers in the middle and upper Susitna River. The lower river ADF&G telemetry stations are not shown here. The middle river joins the Chulitna and Talkeetna rivers to form the lower river near the town of Talkeetna.

2. Study Goals and Objectives

Goals

- Characterize the distribution, migration behavior, and proportional abundance of adult anadromous salmon and determine their use of mainstem, side channel, and slough habitats in the lower, middle, and upper Susitna River in 2012.
- Determine whether historical study results and conclusions are consistent with the current distribution and relative abundance of spawning adult salmon in the mainstem Susitna River.
- Provide spawning habitat data to support the selection of sites for the instream flow study, develop site-specific habitat suitability criteria, and develop a habitat sampling protocol for 2013-14.
- Develop information to refine the scope, methods, and study sites for studying habitat use by adult salmon during the follow-on 2013-14 studies.

Objectives

1. Capture, radiotag, and track adults from five species of Pacific salmon in the middle Susitna River in proportion to their abundance.
2. Determine the migration behavior and spawning locations of radiotagged fish in the lower, middle, and upper Susitna River.
3. Assess the feasibility of using sonar to determine spawning locations in turbid water.
4. Characterize salmon migration behavior and timing above Devils Canyon.
5. Compare historical and current data on relative abundance, locations of spawning and holding salmon, and use of mainstem, side-channel, slough, and tributary habitat types by adult salmon.
6. Locate individual holding and spawning salmon in clear and turbid water and collect habitat data from holding and spawning salmon in the middle and lower river mainstem consistent with developing habitat suitability criteria for instream flow modeling.
7. Evaluate the effectiveness of methods used in 2012 to address study goals and objectives, and assess their suitability for future years' studies.

3. Existing Information

Existing information includes recent and historic aerial photography of the study area, fish spatial and temporal distribution, and relative abundance information from existing recent and early 1980s studies. The Aquatic Resources Data Gap Analysis (ARDGA; AEA 2011b) and PAD (AEA 2011a) summarized existing information and identified data gaps for adult salmon and resident and rearing fish. The adult salmon habitat utilization studies conducted by ADF&G during the 1980s are summarized by Woodward-Clyde Consultants and Entrix, Inc. (1985).

In recent years, ADF&G has been conducting adult salmon (sockeye, coho, and chum) spawning distribution and abundance studies in the Susitna River (e.g., Merizon et al. 2010; Yanusz et al. 2011). In addition to information contained in annual reports from these recent radio telemetry studies, telemetry re-sighting data are available in raw form and these can be used to inform the distribution of field effort in this study.

4. Study Area

The study area encompasses the Susitna River from Cook Inlet (RM 0) upstream to the Oshetna River (RM 234.4), with an emphasis on river reaches between its confluence with the Chulitna River (RM 98) and Devils Canyon (RM 150). The mainstem Susitna is divided into three generalized reaches for the purposes of this study plan: lower river (RM 0-98), middle river (RM 98-150), and upper river (150-234). Devils Canyon encompasses RM 150 to 154.

5. Methods

This study will be coordinated with basin-wide radiotelemetry studies that are being conducted by ADF&G. The goals of ADF&G studies include characterizing timing and distribution of the 2012 salmon escapement to the Susitna River among major and minor tributaries, and estimating the system-wide escapement of chum, sockeye, and coho salmon above Flathorn (RM 22). In 2012, AEA is supporting an additional radiotelemetry component by ADF&G to describe the distribution of adult Chinook and pink salmon in mainstem and tributary habitats. The 2012 AEA-supported ADF&G study will also examine the feasibility of estimating the system-wide escapement of Chinook salmon to the Susitna River. In 2012, ADF&G anticipates radiotagging 400 coho, 400 chum, 400 pink, 100 sockeye, and 500 Chinook salmon at capture sites at Flathorn and RM 30. An array of fixed stations located at mainstem sites and tributary mouths will be combined with fixed-wing aerial surveys to apportion the radiotagged fish to various waterbodies surveyed. ADF&G will track these radiotagged fish to the nearest river mile at intervals of approximately 14 days. The ADF&G studies will focus on apportioning the runs to various tributaries and, for coho, chum, and sockeye salmon, estimating escapement to the entire Susitna watershed.

This study differs from the ADF&G studies in that spatial data will be collected from radiotagged fish on a finer scale; the objective is to obtain locations of spawning and holding salmon at the microhabitat level. This contrasts with the tributary apportionment and the nearest river mile spatial resolution of the ADF&G studies. There is also a middle and upper river focus to this study, although the study includes assessment of habitat use in the lower river. This study will expand on the ADF&G effort by more frequent tracking of both AEA and ADF&G radiotagged fish in the lower, middle, and upper Susitna River. This study will use helicopter surveys to locate tagged fish and then boat and foot surveys to determine more precise locations of those fish that are holding and/or spawning.

Objective 1: Capture, radiotag, and track adults from five species of Pacific salmon in the middle Susitna River in proportion to their abundance.

Meeting several of the goals of this study requires that the radiotagged fish of each species are representative of each species' "population" in the middle river. Tagging particular stocks and/or sizes of fish at different rates than others will weaken inferences about habitat uses of the middle river such as the relative distribution of spawning fish, migratory behaviors, and any fish passage above Devils Canyon. For example, it is possible that mainstem spawning populations could be more vulnerable to capture in the fishwheels due to higher residence time and milling near the site. If this were to occur, the radiotagging would overestimate the contribution of mainstem fish and habitat use by the middle river population. Another example would be if the fishwheels are size selective, which they can be across species with a large range in body size (e.g., Chinook salmon); if larger fish are less vulnerable to being tagged, results will underestimate the contribution and extent of habitat use by large-fish stocks (e.g., mainstem or above Devils Canyon). Put differently, there is a need to examine whether all fish passing the tagging site are equally vulnerable to capture. If they are not, there are ways to stratify the data to mitigate or eliminate effects on results due to unequal vulnerability to capture.

There are multiple ways to assess whether fish passing Curry (RM 120) are equally vulnerable to being radiotagged. Of greatest importance is to survey spawning areas to determine the size composition of tagged and untagged fish (size distributions) and determine the proportion of fish in different areas that contain a tag (i.e., the mark rate). Statistically significant differences in mark rates among areas would suggest unequal vulnerability; differences in the size distributions of the marked and unmarked fractions of the fish would suggest size-selective capture and tagging.

Fish Capture

Fishwheels will be used to capture adult salmon for tagging. In late May 2012, a field camp for the fishwheel crew will be set up near Curry. Three fishwheels will be built and minimum of two will be operated at Curry from the first week of June through the first week of September 2012; if the sites are still favorable, these two fishwheels will be operated at the same sites used during the 1983 to 1985 studies (west bank at RM 120.6, east bank at RM 119.4). The other fishwheel will be used to test new sites in the same general area and to provide additional capacity to fish the primary sites continuously in the event of any damage to the primary fishwheels.

The fishwheels will be similar in design to those used by ADF&G (Yanusz et al. 2011) and consist of aluminum pontoons, two or three baskets, and two partially submerged live tanks for holding fish in river water. A tower and winch assembly will be used to adjust the height of the baskets and ensure the baskets are fishing within 30 cm of the river bottom. When necessary, picket weirs will be installed between fishwheels and the adjacent riverbank to direct fish away from the bank and into the path of the collection baskets. We will operate the fishwheels up to 18 hours per day. A 2-4 person crew will visit the fishwheels hourly whenever the fishwheels are fishing; when the crew is not on the river, the fishwheel baskets will stopped. The rotational speed (revolutions per minute, RPM) of each fishwheel will be recorded two to three times per day by measuring the number of axle revolutions in one minute.

Fishwheel effectiveness, expressed as a fraction of the passing salmon run they capture, often varies within and among seasons. Also known as the catchability coefficient, effectiveness changes with water depth under the fishwheel and water velocity around the fishwheel. The overall abundance of fish in the river at any one time may also affect effectiveness. Variable effectiveness within a season is most problematic for a study of this nature if it varies across the period of the annual run of a particular species and less problematic if it varies across species. Fish later or earlier within a run of a particular species can represent fish of different sizes, ages, and ultimately, fish bound for different habitats. Therefore, stable effectiveness across time, body size, and spawning destination are ideal, and these are assumptions that will need to be tested by appropriate data collection at the fishwheels and surveys of spawning areas. If sufficiently large numbers of fish can be tagged and later examined, any changes in effectiveness can be mitigated for by stratification of results.

A DIDSON sonar system will be used periodically and as changes in river conditions necessitate to guide fishwheel placement, characterize changes in fish behavior around the fishwheels over time, and help detect substantial changes in effectiveness over time. Study team members have recent experience doing this elsewhere, and the tool has been a cost-effective way to monitor fish behavior and fishwheel effectiveness that are otherwise difficult to assess (Smith et al. 2009). This method can help to interpret whether large increases or decreases in fishwheel catches are a result of changes in fishwheel effectiveness or the abundance of fish. This information can be used to guide changes in the position of the fishwheels to stabilize fishwheel effectiveness.

Radiotagging

The goal of this study is to deploy radio tags in approximately 400 Chinook salmon and 200 each of coho, sockeye, chum, and pink salmon captured at the Curry fishwheels. Only uninjured fish that meet or exceed a specific length threshold will be radiotagged. We anticipate tagging Chinook salmon with a mid-eye to fork length (METF) of ≥ 500 mm; coho, sockeye, and chum salmon ≥ 400 mm; and pink salmon ≥ 325 mm. These size thresholds proposed for coho, sockeye, and chum salmon are similar to those used by ADF&G (Yanusz 2011; Merizon 2010). The Chinook salmon length threshold will coincide with all ocean-age 3 fish and a to-be-determined portion of ocean-age 2 fish. All fish to be tagged will be placed in a water-filled, foam-lined, V-shaped trough. To minimize handling time (< 1 min per fish) and tagging-related effects on fish behavior, anesthetic will not be used. Radio tags will be inserted orally into the stomach of the fish using a piece of PVC tubing (1 cm diameter, 46 cm long) with a whip antenna left to protrude from the mouth. No external marks will be applied to radiotagged fish.

All radiotagged salmon will be measured for METF length (to the nearest mm), sexed from external morphological characteristics (coloration, body and fin shape, jaw morphology), and sampled for scales (age), with the exception of pink salmon (all are age 2). Every other radiotagged fish will be tagged with a spaghetti tag to assess tag loss, the effects of spaghetti tagging on post-handling behavior and final spawning destination, and, in the case of Chinook and coho salmon, provide an external mark for anglers to recognize a fish has a radio tag.

To minimize any effects from holding fish, only salmon held for 1 hour or less in the fishwheel live tanks will be radiotagged, and all fish will be released immediately after tagging. All fish will be inspected for radio and conventional (spaghetti) tags that were applied by ADF&G at the lower river fishwheels or at the Curry fishwheels. Catches and recaptures in the Curry fishwheels of ADF&G tagged fish can be used with recoveries from other sites to generate Susitna-wide escapement estimates (e.g., for coho and chum salmon).

Spaghetti Tagging

We expect the fishwheels will capture more fish than we have radio tags available for each species. More importantly, these additional fish will be useful to test assumptions about the representativeness of the fish captured to reflect the species-specific middle river populations. A portion of these additional fish captured will be spaghetti tagged and the portion will vary among the availability and abundance of the different species. At a minimum, testing of these assumptions in 2012 can guide the scope for 2013 and 2014.

All Chinook salmon above our daily goals will be spaghetti tagged, up to 400 additional fish over the season. Radiotagged Chinook salmon can be subsequently examined in Portage and Indian creeks (~90% of the middle river run) to verify study assumptions.

Sockeye and chum salmon spawn will be available for counting and sampling in clear-water side channels and sloughs, and tributaries. Given the number of radio tags deployed (200/species), some additional marking with spaghetti tags of sockeye and chum will enable a test of assumptions of marking in proportion to abundance and stocks passing Curry. Coho salmon are not likely to be very abundant and may provide few opportunities to subsequently examine fish, and therefore we do not expect that additional tagging effort is warranted. Pink salmon are expected to be abundant in 2012 (a "peak", even-year run) and therefore, a large tagging effort for pink salmon is not justified given spawning ground sampling may be difficult to achieve and conventional tagging will likely come at the expense of efforts to apply 1200 radio tags to all five species of salmon. Spaghetti tags will be applied systematically at a rate of some number fish per radio tag (to be determined).

Tagging Goals

Historical fishwheel catches, effectiveness, and salmon run timing will guide tag application rates over the season. In 1983, 1984, and 1985, respectively, totals of 1,064, 1,589, and 1,098 Chinook salmon, were captured at two fishwheels located at Curry. Based on mark-recapture estimates generated from collections at these fishwheels, these catches represented 8.8-11.7% of the total Chinook salmon run at that location. Across the five years from 1981 to 1985, Chinook salmon were caught at Curry from as early as 9 June (range 9-20 June) to as late as 20 August (range 29 July to 20 August), with midpoints ranging from 25 June to 9 July. During those studies, catches ranged from 201-379 (average 301) for sockeye salmon, 93-350 (average 215) for coho salmon, 861-4228 (average 2131) for chum salmon, and 17,394 for the 1984 even-year pink salmon run. Midpoints of the migrations at Curry ranged from approximately 4-5 August for sockeye, 12-13 August for coho, 3-15 August for chum, and 31 July to 7 August for pink salmon.

Early season tagging rates of fish captured in the fishwheels will be based on average historical run timing and expected daily fishwheel catches at Curry (Appendix A). These initial radio-tagging rates will be adjusted in-season using run timing information from the lower Susitna fishwheels (RM 22 and 30) and the ratio of 2012 daily catch at Curry to the expected daily fishwheel catch based on historical data.

Numbers and Size of Marked and Unmarked Fish at Selected Locations above Curry

To test if Chinook, sockeye, and chum salmon passing Curry are equally vulnerable to being captured and radiotagged we will count and examine fish on selected spawning grounds to develop two primary metrics. We will develop estimates of the proportion of fish tagged (mark rate) at two or more sites and characterize the size distributions of marked (i.e., tagged) and unmarked fish.

Foot surveys to count live and dead fish, combined with fixed-station and aerial survey data, will provide counts of marked and unmarked fish. Lengths of dead fish will be measured to the nearest mm (MEFT) and the sex and spawning success noted. For Chinook salmon, historical aerial survey data suggest as much as 90% of fish passing Curry are expected to return to Portage (70%) and Indian (20%) creeks. For sockeye and chum salmon, these two creeks combined with Sloughs 8A, 11, and 21 likely accounts for a similarly large portion of the middle river population. Fourth of July Creek, Indian River, and Portage Creek also have significant numbers of chum salmon.

Key Assumptions

Equal Probability of Capture across Fish from all Spawning Destinations

This assumption can be tested indirectly by examining several sources of information. If there are unequal probabilities of capture among spawning stocks it will be caused by, and manifest itself, in multiple ways.

Fishwheel effectiveness across time: The main assumption of this study component is that the radio tags are deployed at the Curry fishwheels in proportion to abundance for each species. To help evaluate this assumption, we will compare the relative effectiveness of each fishwheel, as determined from the ratio of fish caught by a fishwheel and the number of fish observed with DIDSON across different time periods, fishwheel rotational speeds (RPM), and river discharge (all three are expected to co-vary). DIDSON will also be used to qualitatively assess fish approach behavior at the fishwheel relative to discharge and fish abundance. We will also compare the catch per unit effort (CPUE; fish per fishwheel hour) over time and across a range of discharges. Additionally, we will compare the cumulative run-timing profiles for each species to historic run-timing profiles at the Curry fishwheels and to those generated from fish radiotagged at ADF&G's lower river sites (RM 22 and 30) that are subsequently detected in the middle river.

For all species, radio tags will be deployed in proportion to catch on the east and west bank fishwheels as long as there is no sign that individual fishwheel effectiveness is dramatically different (from other fishwheels) and/or has not changed substantially within the season. If individual fishwheel effectiveness appears to have changed, the proportion of the catch to tag may be altered in-season.

Differences among stocks: To assess whether fish from a particular spawning area were right or left bank-oriented with respect to capture at Curry, we will compare the proportion of fish migrating into specific areas with the collection bank at Curry. Assuming data are suited to statistical analysis, we will also use contingency table analysis to compare mark rates over time and area at locations upstream of Curry. If tags are deployed in proportion to abundance, then we would expect mark rates to be constant across both temporal and spatial strata in these spawning ground areas. For example, mark rates by period for Chinook salmon in Portage Creek can be obtained from regular aerial/foot surveys (total number of live and dead fish) in combination with mobile-tracking surveys (number of tagged live and dead fish). Assessing the mark rate in any groups of fish spawning in mainstem habitats will be more challenging. One concern is that mainstem fish could be more vulnerable to the fishwheels because they linger or mill upstream and downstream of Curry. We expect that the fishwheels will recapture some of our radiotagged fish; assuming capture efficiencies of 5-10% and no significant "trap avoidance," we could recapture as many as 10-40 fish of each species. In addition to quantitative and qualitative assessment of subsequent behavior of these recaptured fish, we will compare the final destinations (mainstem/tributary) of recaptured fish to other tagged fish to determine whether fish that spawn in the mainstem are recaptured at a higher rate.

Size-selective capture: Size-related (and age-related) bias will be tested using Kolmogorov-Smirnov (K-S) two-sample tests. For each species, we will compare the cumulative length-frequency distributions of: 1) radiotagged and spaghetti-tagged fish and those fish randomly sampled on the spawning grounds; 2) radiotagged and spaghetti-tagged fish and all other fish sampled for length at the Curry fishwheels; and 3) radiotagged and spaghetti-tagged fish captured in individual fishwheels. Using data from similar sources, contingency table analyses and Chi-square tests will be used to compare the sex and age composition of fish radiotagged by species. Size-related bias can usually be eliminated by size stratification of results.

Handling-Induced Changes in Behavior: An assumption of this study component is that the behavior of radiotagged fish is not materially affected by the capture and handling process. By materially affected, we mean that the capture and tagging does not affect the final spawning destination of a fish and/or its migration behavior once it has recovered from the tagging event and resumed its upstream migration. These assumptions cannot be tested directly but there are several indirect ways to assess its potential magnitude.

The post-release survival and travel time (days) to first detection at upstream fixed-station receivers will provide an indication of the level of handling-induced changes in behavior. Long delays to resume upstream migration and high mortality rates would be indicative of significant changes in behavior; little delay and low mortality rates would be indicative of little effect. Second, we will compare the upstream movement (delays and rates of travel) of tagged fish that were subjected to different holding densities and holding times in the fishwheels. Third, although potentially confounded with different stock-specific vulnerabilities to capture, tag mark rates at spawning locations based on visual observations and telemetry detections (number of tags) can provide an indication of possible handling-induced changes in behavior. Stratification of results by spawning destination based on mark rates can help to mitigate any effects of differences that this source of post-release changes in spawning destination might have on our conclusions. Finally, we expect that the fishwheels will recapture some of our radiotagged fish and the post-release migratory behavior of these already tagged fish will provide additional data on the effects of the fish capture process, including any potential cumulative handling effects.

Objective 2: Determine the migration behavior and spawning locations of radiotagged fish in the lower, middle, and upper Susitna River.

Adult Chinook, coho, chum, pink, and sockeye salmon will be radiotagged and released in the lower (RM 22 and 30) and middle (Curry, RM 120) Susitna River during their upstream migration (Figure 1). ADF&G is conducting the tagging in the lower river and LGL is tagging fish at Curry. The two studies will be tightly coordinated and analysis will be done in a collaborative manner. All mobile (aerial, boat, and foot) and fixed-station receiver data will be handled together for relevant analyses and analysis products will be characterized in a consistent manner.

The primary function of the telemetry component is to track these tagged fish spatially and temporally with a combination of fixed and mobile receivers. Time/date stamped, coded radio signals from tags implanted in fish will be recorded by fixed station or mobile positioning. All telemetry gear (tags and receivers) across both studies will be provided by ATS, Inc. (Advanced Telemetry Systems, www.atstrack.com)

The types of behavior to be characterized include:

- arrival and departure timing at specific locations/positions;
- direction of travel;
- residence time at specific locations/positions;
- travel time between locations/positions;
- identification of migratory, holding, and spawning time and locations/positions; and
- movement patterns in and between habitats in relation to water conditions (e.g., discharge, temperature, turbidity).

These data, in conjunction with habitat descriptions, will allow the characterization of migratory behavior and final destinations for salmon in mainstem habitats (main channel, slough, side channel) and tributaries. In addition, observed spawning locations will be characterized at a microhabitat level (e.g., depth, velocity, substrate). Spawning or final locations of tagged fish will be used to determine the number and proportion of the tagged fish of each species using mainstem habitats.

Radio Tags

ATS pulse-coded, extended-range tags will be applied to a subset of salmon captured in the lower and middle river fishwheels. There are 18 and 12 frequencies allocated to the lower (ADF&G) and middle river (F-S3) tags, respectively (Table 1). There are 100 unique codes on each frequency, except for the reference tag, which will use a single code. In total, these frequency/code combinations will provide unique tags for ~3,000 radiotagged fish in 2012. Model F1835B transmitters will be used for pink salmon (16 g, 30 cm long antenna, 96 d battery life), Model F1840B tags for sockeye, coho, and chum salmon (22 g, 30 cm antenna, 127 d battery life), and Model F1845B tags for Chinook salmon (26 g, 41 cm antenna, 162 d battery life). All transmitters will be equipped with a mortality sensor that changes the signal pattern to an “inactive” mode for the remainder of the season once the tag becomes stationary for 24 h. All of the radio tags will be labeled with return contact information. Each tag will be tested immediately prior to deployment to ensure it is functioning properly upon release. The fishwheel field team will regularly provide the telemetry team with the records of tags released to inform them of the specific tags at large.

Table 1. Expected radio frequencies (MHz) for tags applied to salmon in the lower and middle Susitna River in 2012. Middle river frequencies (Curry) will be apportioned among species as noted.

Tagging Sites/Frequencies		
Flathorn and RM 30	Curry	
Frequencies (all species)	Frequencies	Species
151.033	151.710	Chinook
151.204	151.760	Chinook
151.264	151.780	Chinook
151.324	151.910	Chinook
151.343	151.920	Chum, Coho, Sockeye
151.363	151.930	Chum, Coho, Sockeye
151.384	151.940	Chum, Coho, Sockeye
151.404	151.950	Chum, Coho, Sockeye
151.423	151.960	Chum, Coho, Sockeye
151.500	151.970	Chum, Coho, Sockeye
151.510	151.980	Pink
151.520	151.990	Pink
151.530	152.000	Reference tags
151.540		
151.560		
151.570		
151.580		
151.633		

Fixed-Station Monitoring

Stand-alone operating telemetry arrays will be deployed at strategic locations on the middle and upper river to provide migration checkpoints and spawning ground inventories. Each station will include a radio receiver, power supply, antenna switcher, and two or three aerial antennas. Antennas may be mounted in trees or on tripod-mounted poles, and orientated to distinguish upstream/downstream movements by fish (i.e., direction of travel). Receivers will be programmed to scan all middle river tag frequencies (Curry released) and record coded tags. Initial station installation will include range testing to define the expected detection range (approximately 900 linear feet at 10 foot water depth, configuration dependent) of each antenna. Standard reference or "beacon" tags will be deployed at most fixed stations to provide a continuous record of known signal detections. Fixed stations will be manually downloaded (i.e., by the field crew) on a weekly basis unless a remote communication protocol is established. Raw telemetry files will be archived and then imported into the Telemetry Manager database software for processing and summarizing throughout the season.

Proposed locations for radio-telemetry fixed stations in the middle river of the Susitna (Figure 2):

1. Gateway - mainstem of middle river about 4.2 miles below Curry (~ RM 116.5);
2. Confluence of Fifth of July Creek (RM 123.7);
3. Slough 11 (~ RM 135.3);
4. Confluence of Indian River (RM 138.6);
5. Slough 21 (~ RM 141.1);

6. Confluence of Portage Creek (RM 148.8);
7. Devils Canyon impasse (~ RM154);
8. Confluence of Kosina Creek (RM 206.8)

These sites were chosen based on: 1) the need to provide basic geographic separation of the Middle River area to describe migration and spawning behaviors, 2) monitoring at the appropriate resolution through the upper river area to quantify passage through Devils Canyon, and 3) the need to focus mobile survey effort over an expansive area. At the Gateway station, a second receiver (provided by ADF&G) will be dedicated to monitoring the 18 frequencies for fish tagged in the lower river. When tagged fish are detected at this station, the individual tag frequencies of these fish will be scanned during mobile aerial surveys of the middle river to document their migration and final destination. See Objective 4 (below) for additional details about the telemetric monitoring in Devils Canyon.

Telemetry Aerial Surveys

Aerial surveys of the mainstem Susitna from Flathorn up to Kosina Creek and/or the Oshetna River will be conducted by helicopter to allow relatively accurate positioning of tagged fish as compared to fixed-wing surveys, to locate spawning areas, and to make visual counts of fish in clear water areas, all with respect to mainstem habitat type. Aerial surveys will begin in July and end in early October (≈14 weeks). Survey timing may be adjusted depending on the observed fishwheel catches in the lower and middle river. Surveys will be scheduled at 5-day intervals with the intent to ensure a maximum of 7 days between surveys with weather contingencies. In the event that fixed stations indicate that no tagged fish have migrated upstream of Devils Canyon, aerial surveys to at least Kosina Creek will be conducted at least three times to confirm these results. If radiotagged fish are detected moving upstream in the mainstem at the Kosina Creek telemetry station, aerial surveys will be extended to locate those radiotagged fish and visually survey for untagged fish.

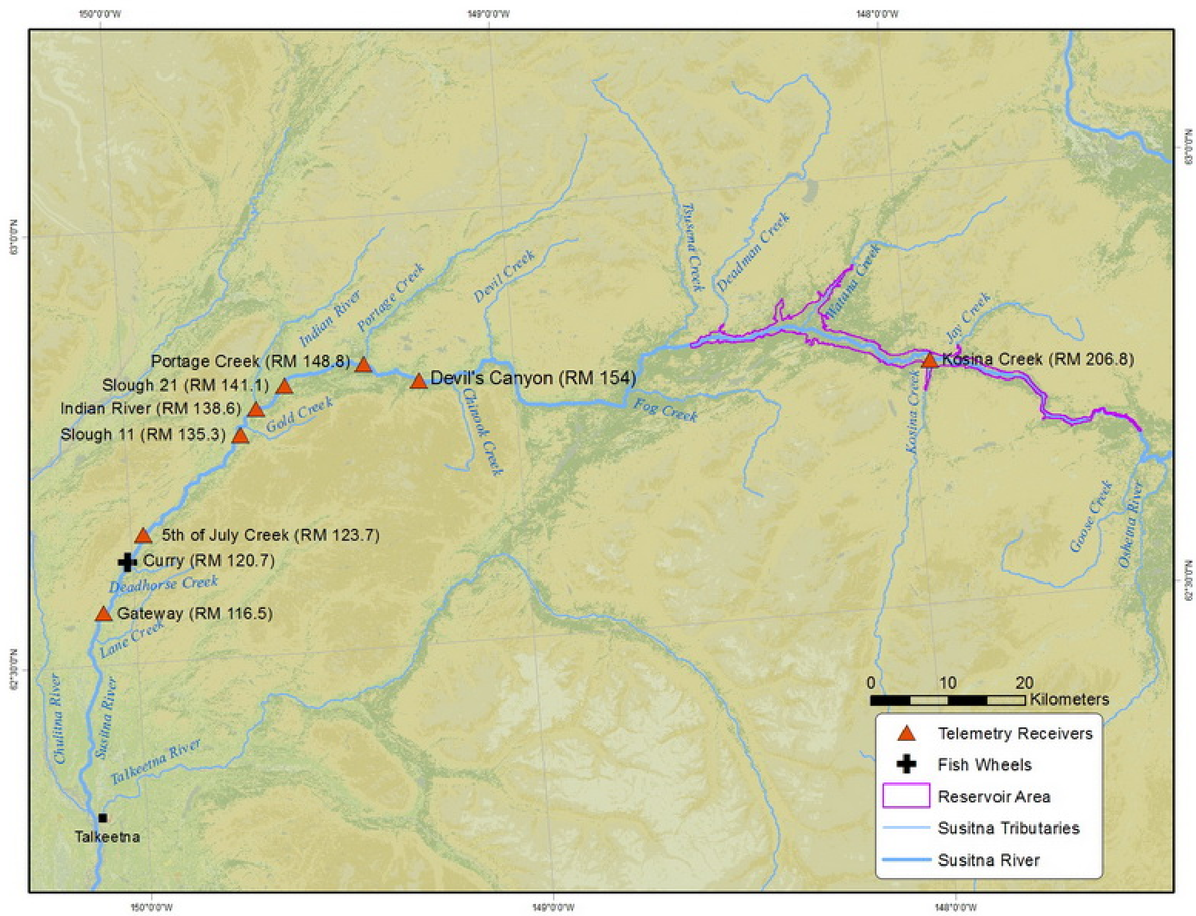

Figure 2. Proposed fixed-station telemetry locations in the middle and upper reaches of the Susitna River.

Surveys via helicopter can be conducted at lower elevations and at slower speeds than can be achieved using fixed wing, and therefore will allow more time for signal acquisition, higher spatial resolution, and fish/habitat observations. Fixed-wing surveys are most appropriate when the study goal is a spatial resolution of tagged fish locations to be within ≈800 m (to the nearest 0.5 river mile), as is the case for ADF&G's fish apportionment study (i.e., the lower river radiotagging). The goal for helicopter-based surveys is to be within ≈300 m, as well as to determine whether the fish is in off-channel or the river mainstem habitat. Higher precision will be achievable in reaches where conditions are most favorable. Geographic coordinates will be recorded for each detected signal using an integrated communication link between the telemetry receiver and a Global Positioning System (GPS). The position of the fish will be determined as that position of the aircraft at the time of the highest signal power. Range testing of the mobile aerial setup will be conducted in the lower river to confirm detection ranges for typical flying heights, receiver gains, and antenna orientation, as well as to work with the helicopter pilot to refine our methods for achieving highest spatial resolution.

The mainstem aerial surveys will need to cover over 200 river miles (RM 22 to RM 230), and multiples of that total when side channels and braids of the lower river are included. To allocate survey effort efficiently and to the highest priority needs, resolution will be a function of fish behavior. The highest priority and highest resolution needs will be for fish that appear to be holding or spawning. For migrating fish, resolution to the nearest 300 m of river will generally be sufficient. The proposed frequent surveys will provide a means of focusing a higher-resolution and time-intensive tracking effort on identifying exact locations of spawning and holding fish. To do this, the aerial survey team will have available the most recent observed river locations (to the nearest 1 km) of all mainstem fish "at large" (i.e., tagged and not tracked in a tributary). During the survey, the "river km" of all detected fish will be compared to the last seen location from previous surveys to ascertain whether its position has changed by more than 2 km. When tagged fish are within 2 km of their last seen location, the helicopter will circle at a lower altitude to pinpoint the fish location to mainstem, side channel, or slough habitats.

As well, when aggregations of two or more tagged fish are found "stationary" (i.e., within 2 km on one or more surveys) and/or when visual observations of spawning fish are made from the helicopter, ground- and boat-based surveys will pinpoint spawning locations to within 5-10 m. This protocol will be particularly important for ensuring coverage of any suspected lower river habitats with the appropriate level of spatial resolution.

The channel location (mainstem, side channel, slough) and relative water turbidity at the location of the fish will be classified for each tag detected (time stamp, frequency, code, power level) during aerial surveys. If other fish can be seen in the area of the tag position, their relative abundance will be estimated to provide context for the tag observation.

Tag identification, coordinates, and habitat type data will be archived and systematically processed after each survey. A data handling script will be used to extract unique tag records with the highest power level from the receiver files generated during the survey. These records will be imported into a custom database software application (Telemetry Manager) and incorporated into a GIS-based mapping database. Geographically and temporally stratified data of radiotagged fish will be provided to the habitat sampling team and Instream Flow Study to inform their field sampling efforts.

Lower River Surveys

Mobile aerial surveys of the lower river will cover mainstem areas from Flathorn (RM 22) to the confluence of the Chulitna River (RM 98). This reach is highly braided with side channels and sloughs, so complete coverage will require considerable effort and in-flight route tracking. With the survey protocol outlined above and the number of tags anticipated to be at-large on any one survey, this area will require up to two survey days to complete.

Middle River Surveys

Mobile aerial surveys of the middle river will cover mainstem areas from the confluence of the Chulitna River (RM 98) to the Devils Canyon impasse (≈ RM 150-154). This reach (52 miles) will require approximately one day to complete, and as much as two days late in the season when all tags are deployed.

Upper River Surveys

Mobile aerial surveys of the upper river will regularly cover the mainstem areas from Devils Canyon (≈ RM 150-154) to the confluence of the Kosina Creek (RM 206.8). This reach will include approximately 57 relatively confined river miles, and we predict we will see less than 50 tags at-large. This survey will require approximately one survey day; less when done in conjunction with middle river surveys (i.e., when less conveyance time involved). Radiotagged fish above Devils Canyon will be located to similar spatial resolution and habitat types as in the middle and lower river surveys. The F-S4 study team will be informed of all radiotagged fish movement above Devils Canyon and will be provided the locations of all spawning radiotagged fish for measurements of microhabitat features.

Boat and Ground Surveys

Telemetry surveys also will be conducted by boat and on foot to obtain the most accurate and highest resolution positions of spawning fish. Using the guidance of fixed-station and aerial survey data on the known positions of tagged fish, specific locations of any concentration of tagged fish that are suspected to be spawning will be visited to obtain individual fish positions. We expect resolution to be within 5-10 m in turbid water and within 2-3 meters in clear water (dependent on density and highest resolution at low densities). Underwater stripped-coax antennas and judicious use of signal gain control will allow locating tagged fish and recording their geographic position with a GPS. These data will be collected in concert with the field activities and provided to the habitat suitability sampling team to inform their sampling efforts. These surveys will be conducted approximately weekly during the July through September mobile tracking period.

Objective 3: Assess the feasibility of using sonar to determine spawning locations in turbid water.

Previous studies in the mainstem Susitna River have relied on late-season visual surveys of redds to identify and characterize salmon spawning that occurs in turbid water after temperatures have fallen and the river water has cleared. The efficacy of this technique in the Susitna mainstem habitats has not been evaluated and may underestimate the extent of spawning activity in turbid waters. Late-season visual surveys of redds may fall below 100% as detection may vary with discharge, suspended sediment levels, etc. This study will explore the feasibility of using sonar to sample turbid water to quantify spawning activity. Sonar has the potential to detect redds in turbid water and confirm spawning activity by directly monitoring fish behavior. Radio telemetry provides a powerful tool to identify suspected spawning activity but subsequent sampling of fish with sonar may be needed to help determine whether spawning has actually occurred. Net sampling may help to determine the degree of sexual maturation and reduce confusion between holding and spawning areas in some instances.

To examine the feasibility of using sonar for this purpose, a combination of DIDSON and high resolution side-scan sonar will be used in known clear-water spawning areas, in known turbid-water spawning areas, and the results compared to visual surveys of spawning fish (in clear water) and counts of redds (in clear but previously turbid water).

Sonar Equipment and Methods

The EdgeTech 4125 600/1600 kHz side-scan sonar can generate high-resolution images with an across-track resolution of 0.6 cm, independent of the range sampled. The system is therefore well suited for collecting data over large areas. Depending on the water depth, the high frequency side-scan sonar can sample a swath of up to 50 m. As a rule of thumb, if the transducer is 1 m above the bottom, one can "see" a ~10 m wide swath on each side of the survey boat (port and starboard). The minimum water depth required for the deployment of the transducer is approximately 0.5 m. The draft of the boat and boat motor may require deeper water. The survey will be conducted at a boat speed of approximately 1 m/s, slower in shallow water if there is a danger of hitting obstacles. Where the side-scan sonar encounters aggregations of redds, the survey will periodically be paused to supplement the data with stationary spot checks with a DIDSON.

DIDSON is a high-resolution imaging sonar that provides video-type images over a 29° field of view and can thus be used to observe fish behavior associated with spawning, i.e., dynamic behavior that cannot be identified on the static side-scan images. To obtain high-quality images of adult salmon the maximum range will be limited to 15 m. Within this field of view, evidence of spawning behavior, e.g., redd digging, chasing, spawning, will be clearly identifiable. Furthermore, on DIDSON images fish can be classified by size category, e.g., < 40 cm, 40 – 70 cm, > 70 cm. While this is not sufficient for a direct species ID, it will give some separation of smaller resident fish, medium-sized adult salmon, and large Chinook salmon. DIDSON sonar has successfully been used to survey salmon redds in the Columbia River.

The feasibility study will focus on selected areas for which visual estimates with sufficient spatial accuracy and resolution can be obtained. Approximately one third of the sampling effort will be in clear-water sloughs where we expect to see spawning fish based on historical data. Another third of the sampling effort will be directed toward areas where redds were historically observed after the water had cleared up. The remaining third of the survey we would reserve for areas that had been difficult to survey in the 1980s, or where no redds had been observed previously, but where current information (radio telemetry, recent aerial photography, etc.) indicates potential spawning sites. The selection of survey sites may be modified after the first survey based on accessibility and telemetry data. The number of sites that can be covered in one survey depends on their size as well as the travel time required to move between sites. Three days for each survey should provide sufficient data to examine the feasibility of the technique.

At a minimum, we will conduct three surveys from early August through September. The goal is to have the surveys coincide with the times when sockeye, chum, Chinook, and pink salmon are actively spawning, and for the last survey, to wait until the water has cleared up to maximize the chances of obtaining good visual comparison data. Additional surveys may be conducted in the event that the radiotelemetry component of this study identifies suspected new spawning areas in turbid water.

Data Analysis and Reporting

All sonar data will be collected along with a differential GPS with 10 Hz positioning rate. The GPS coordinates together with heading, pitch and roll information will allow us to match side-scan and DIDSON data with the visual ground-truthed data. The visual data will be collected by an independent crew. The side-scan analysis will provide locations for individual redds or redd fields. The DIDSON data analysis will provide the coordinates, coverage and duration of each station surveyed, together with the mean number of fish observed in the field of view, their size category (< 40 cm, 40 – 70 cm, > 70 cm) and a qualitative description of their behavior.

The results will be compared to those obtained with aerial and/or ground-based visual observations and radio telemetry. Visual observations made under good conditions will represent the expected value. When visual conditions are less than ideal (e.g., poor visibility, redds covered with silt) sonar may detect redds that may be missed in the visual surveys. The results will be assessed in terms of the number and location of redds (or redd fields) and associated fish detected, the ability to observe actively spawning fish, the correspondence of areas surveyed where no sign of spawning activity was seen, and the conditions under which it was possible to make observations. The results will also include screen shots of selected side-scan images and DIDSON video clips and a map overlay. A cost-benefit analysis will summarize the trade-offs involved in the different methods.

The final report will present the methods, the results and their discussion, and provide recommendations whether or not to use side-scan in conjunction with DIDSON sonar for future spawning habitat surveys. This report will be included as an appendix in the study report.

Objective 4: Characterize salmon migration behavior and timing above Devils Canyon.

A combination of fixed-station receivers below (middle river at the Portage Creek confluence), and above Devils Canyon (≈ RM 154) will be used to determine the migration timing and behavior of any radiotagged salmon that pass into the Upper river area (Figure 2). Fixed station receivers will be deployed at locations where they will have the highest probability of detecting radiotagged salmon. The fixed station deployed at the confluence with Kosina Creek will provide additional information that can be used to assess the detection efficiencies for all mainstem fixed-station receivers downstream from this site. The data from these receivers will also be used to identify the broad reaches where radio-tagged fish are located to guide the aerial and ground based survey efforts needed to identify spawning areas.

The mobile survey data will aid in confirming the presence of radio-tagged fish, and locating any fish not detected at downstream fixed-station receiver sites. These additional detections will be combined with the fixed-station data to estimate detection efficiencies for each fixed-station receiver as done in other studies (e.g., English et al. 2005; Robichaud and English 2007). Aerial surveys will be conducted in the mainstem Susitna to at least Kosina Creek; they will begin when fish are first detected at the Devils Canyon station and continue through late September. The timing and proportion of tagged salmon to pass Devils Canyon will be calculated, and their final spawning locations will be identified.

Objective 5: Compare historical and recent data on relative abundance, locations of spawning and holding salmon, and use of mainstem habitat types by adult salmon.

Research effort in the early 1980s provided information relevant to this study. Annual abundance estimates relevant to at least four fishwheel sites along the Susitna River mainstem were developed in each of three years (1983-85). These abundance estimates were apportioned to mainstem, sloughs, and tributaries, and the results will be useful for assessing the potential impacts of the Susitna-Watana Hydroelectric Project. One weakness of these studies was that they relied heavily on visual observations of fish (and abandoned late-season redds). These methods and results may underestimate the use and relative importance of mainstem habitats, many of which are covered in turbid water during a substantial portion of the spawning period. Another more general concern is that data collected approximately 30 years ago may not characterize the current habitat use in the mainstem Susitna River.

This study will address both of these concerns by deploying a similarly scaled study of the spawning runs to the Susitna in 2012-14 and using radio telemetry and sonar technology not available and/or used in the 1980s. Both methods will provide a more rigorous characterization of the use of mainstem habitats than methods used in the 1980s. To the extent spawning distribution and habitat use in the current study are similar to earlier studies, it will greatly increase the sample size and confidence in the conclusions from studies in both periods. Therefore, it will be important to explicitly compare and contrast the distribution and habitat use of salmon in the lower, middle, and upper river habitats of the Susitna River.

In addition, new instream flow studies (F-S5) are proposed for 2013-14, and results from this study will help guide the site selection for that study. Similarities and differences in habitat use between the 1980s and now will influence the selection of IFIM study sites.

Objective 6: Locate individual holding and spawning salmon in clear and turbid water and collect habitat data from spawning salmon in the middle and lower river mainstem consistent with developing habitat suitability criteria for instream flow modeling.

Beginning in early August and continuing into October 2012, we will locate clear and turbid water locations in the mainstem middle and lower Susitna River that are representative of different habitats (side-channels, sloughs, and tributary mouths) used by spawning salmon. From these habitats, 10 to 20 redds for each salmon species will be sampled for microhabitat data (water depth, water velocity, turbidity, substrate size and composition, surface and intergravel water temperature, and vertical hydraulic gradient). These data will be used to develop habitat suitability criteria (HSC) for spawning salmon. Spawning habitats located, but not sampled for microhabitat in 2012, will be sampled as part of the 2013-2014 study. This field effort will be coordinated with the Instream Flow Program (ISF) staff to ensure data are collected consistent with requirements for developing habitat suitability criteria. As part of the integration of this study with ISF study (F-S5), we will provide the ISF team with spawning habitat locations and microhabitat data to be used in the development of their ISF model. The compilation of site locations will also be supplied to the aquatic habitat and geomorphic mapping team as part of integration with the G-S2 study; this will ensure that the necessary sections of river are digitized.

To locate turbid and clear water mainstem spawning locations in the lower and middle Susitna River, we will use existing data (concurrent radio telemetry studies, recent ADF&G radio telemetry studies, and 1980s data) to identify known and potential spawning locations to include as study sites. Spawning locations in turbid water areas will be identified with the use of radio telemetry tracking and/or sonar (combination of DIDSON and side scan sonar) technologies.

Some pre-selected sites, based on historic data, will be sampled in 2012. These sites will include 2 to 4 documented sloughs above river mile 98.6 where the percent distribution of visual counts of spawning fish was greater than 10% of the total annual counts in the middle Susitna River for a given species. This will be done for each species documented to spawn in mainstem habitats (chum, sockeye, and pink salmon) from 1981-1983 (Table 2). These sites selections will allow us to begin to characterize the microhabitats for salmon spawning in the middle Susitna River. Additional sites will be determined in-season from telemetry tracking and aerial visual surveys.

Table 2. Distribution of visual counts of sockeye, chum, and pink salmon in mainstem habitats in the middle Susitna River based on the average percent of the annual counts by slough name and river mile. Shaded values represent the locations with greater than 5% of the annual counts.

		Distribution (% of annual observations)		
Slough	River Mile	Sockeye	Chum	Pink
1	99.6	0.0	0.1	0.0
2	100.2	0.0	1.2	0.0
3B	101.4	0.3	*	0.0
3A	101.9	0.3	0.0	*
4	105.2	0.0	0.0	0.0
5	107.6	0.0	*	0.0
6	108.2	0.0	0.0	0.0
6A	112.3	0.0	0.3	6.3
7	113.2	0.0	0.0	0.0
8	113.7	0.0	4.6	4.2
8D	121.8	0.0	0.4	0.0
8C	121.9	0.1	0.8	0.0
8B	122.2	0.3	2.8	0.0
Moose	123.5	1.2	3.9	1.6
A'	124.6	0.0	3.3	0.0
A'	124.7	0.0	0.6	0.5
8A	125.4	13.0	15.1	5.2
B	126.3	0.6	1.5	8.4
9	128.3	0.7	11.1	2.1
9B	129.2	3.4	1.5	0.0
9A	133.8	0.1	6.2	0.0
10	133.8	0.0	*	0.0
11	135.3	66.3	16.9	24.1
12	135.4	0.0	0.0	0.0
13	135.9	0.0	0.1	0.0
14	135.9	0.0	0.0	0.0
15	137.2	0.0	*	23.0
16	137.3	0.0	*	0.0
17	138.9	0.5	2.3	0.0
18	139.1	0.0	0.0	0.0
19	139.7	1.1	0.1	0.5
20	140.0	0.1	1.7	12.6
21	141.1	12.0	20.2	11.5
22	144.5	0.0	5.2	0.0
21A	145.3	0.0	0.1	0.0

*Indicates a location were a trace of fish were observed

Data for developing HSC will be collected following close collaboration and direction from the ISF team. Species-specific microhabitat data will be collected at the time of spawning. Data will include measurements of redd area, water depth, water velocity, turbidity, substrate size and composition, surface and intergravel water temperature, and vertical hydraulic gradient. Each of these measurements will be made at redds. At each site up to 5 redds will be systematically sampled. Coordinates will be recorded for the upper and lower extent of each spawning patch (grouping of redds) that has been sampled.

Habitat surveys will be conducted by walking the habitat reach or sub-plot in an upstream direction and identifying the location of newly constructed redds. For each redd sampled, the following measurements will be made:

1. Redd dimensions, length and width, to nearest 1.0 cm, to allow computation of area;

2. Water depth to the nearest 1.0 cm at the upstream end of each redd measured using a top setting wading rod;

3. Mean water column velocity (m/s) at the upstream end of each redd to the nearest 0.01 m/s using a Swoffer Model 2100 or Marsh McBirney Flow Mate 2000 current meter;

4. Turbidity to the nearest 1.0 NTU;

5. Substrate size (dominant, sub-dominant, and percent dominant);

6. Surface and intergravel water temperature to the nearest 0.1 ^{o}C. Intergravel temperature measurements will be taken at a depth representative of the average egg burial depth from literature for each salmon species;

    a. Chinook salmon = 30.0 cm (Healey 1991).
    b. Chum salmon = 35.0 cm (Salo 1991).
    c. Coho and pink salmon = 25.0 cm (Sandercock 1991; Heard 1991).
    d. Sockeye salmon = 20.0 cm (Burgner 1991).

7. Vertical hydraulic gradient (upwelling or downwelling) will be measured using mini-standpipe piezometers. Piezometer installation depth will follow the same, previously mentioned, criteria as measurements of intergravel temperature. Measurements will be made to the nearest 1.0 mm.

In addition, representative digital photographs of selected redds will be taken. Collected data will be checked for errors and supplied to the ISF team to be used as HSC for ISF.

Objective 7: Examine the effectiveness of methods used in 2012 to address study goals and objectives, and assess their suitability for future years' studies.

As part of the study report, we will examine the study's overall success toward meeting its objectives and goals. A critical evaluation will be required to make improvements to the 2013-14 studies and make any improvements to the usefulness of this study to guide the instream flow study. The ultimate use of results of this study is as input to the instream flow model, which will assess potential Project-related impacts.

6. NEXUS BETWEEN PROJECT AND RESOURCES TO BE STUDIED AND HOW THE RESULTS WILL BE USED

Project facilities and operations will modify the flow, thermal, and sediment regimes of the Susitna River, which may alter the composition and distribution of fish habitat. Knowing the seasonal use of different riverine habitat types by fish species and life-stage is essential to evaluating the impact of potential Project-induced changes on habitat and in turn on fish species composition, distribution and abundance. Information from this habitat utilization study will also be used in combination with other studies, including the geomorphology studies, Instream Flow Study, and Production Study.

Existing fish and aquatic resource information appears insufficient to address the following issues that were identified in the PAD (AEA 2011):

F4: Effect of Project operations on flow regimes, sediment transport, temperature, and water quality that would result in changes to seasonal availability and quality of aquatic habitats, including primary and secondary productivity. The effect of Project-induced changes include stream flow, stream ice processes, and channel morphology (streambed coarsening) on anadromous fish spawning and incubation habitat availability and suitability in the mainstem and side channels and sloughs in the Middle River above and below Devils Canyon.

F5: Potential effect of Project flow regime on anadromous fish migration above Devils Canyon. Devils Canyon is a velocity barrier to most fish movement and changes in flows could result in changes in potential fish movement through this area (approximately RM 150-154).

F6: Potential influence of the proposed Project flow regime and the associated response of tributary mouths on fish movement between the mainstem and tributaries within the Middle River reach.

F7: Influence of Project-induced changes to mainstem water surface elevations from July through September on adult salmon access to upland sloughs, side sloughs, and side channels.

F8: Potential effect of Project-induced changes to stream temperatures, particularly in winter, changing the distribution of fish communities, particularly invasive northern pike.

7. STUDY PRODUCTS

Data

All original data collected in the field in 2012 will be entered into the relational database described below, QA/QC'd, and delivered to AEA.

Geospatially-Referenced Relational Database

All data generated during this study will be incorporated into the Susitna Fish Program geospatially-referenced relational database. This database will form the basis for additional data collection in 2013-2014. All new field data will be associated with location information collected using a GPS receiver in unprojected geographic coordinates (latitude/longitude) and the WGS84 datum. Naming conventions of files and data fields, spatial resolution, and metadata descriptions will meet the ADNR standards established for the Susitna-Watana Hydroelectric Project.

Spatial Products in ArcGIS Software

The geospatial products will include geodatabases and maps indicating survey area, radiotagged fish locations by survey, habitat types used by spawning fish, habitat data, and locations of significant features such as barriers and springs. Naming conventions of files, data fields, and metadata descriptions will meet the ADNR standards established for the Susitna-Watana Hydroelectric Project. All map and spatial data products will be delivered in the two-dimensional Alaska Albers Conical Equal Area projection and North American Datum of 1983 (NAD 83) horizontal datum consistent with ADNR standards.

Summary of Interim Results

A brief interim report will be prepared and presented to the licensing participants to document the progress of the study, identify any issues that have occurred, and allow for further refinement of the 2013-2014 studies.

Technical Memorandum

A technical memo summarizing the 2012 results will be presented to resource agency personnel and other licensing participants, along with spatial data products.

Project Report

A report will be prepared that documents the methods, field effort, results, conclusions, and recommendations from the 2012 study.

8. SCHEDULE

This is a multi-year study and includes an ongoing study planning component. The schedule for the 2013-2014 components will be developed in coordination with the AEA during the 2013-2014 study planning process.

- Final Draft 2013-2014 Study Plan – March 23, 2012.
- Summary of Interim Results – September 10, 2012.
- Original QC'd 2012 Data - December 1, 2012.
- QC'd geospatially-referenced relational database – December 1, 2012.
- Technical Memorandum on 2012 Activity – December 1, 2012.
- Draft report, December 7, 2012.
- Final report, December 31, 2012.

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APPENDIX A: Anticipated daily catches at Curry based on historical catches and run timing and preliminary radiotagging goals for each of five species of salmon at Curry in 2012, based on fitting a normal curve to the average annual catches and run duration in two fishwheels 1983-85 (1984 for an even-year pink salmon run). The second set of figures show the daily catches by species from two fishwheels at Curry, 1983-85.

Figure A-1. Anticipated daily catch rates by species in two fishwheels at Curry, based on fitting a normal curve to the historical catch data from 1983-85.

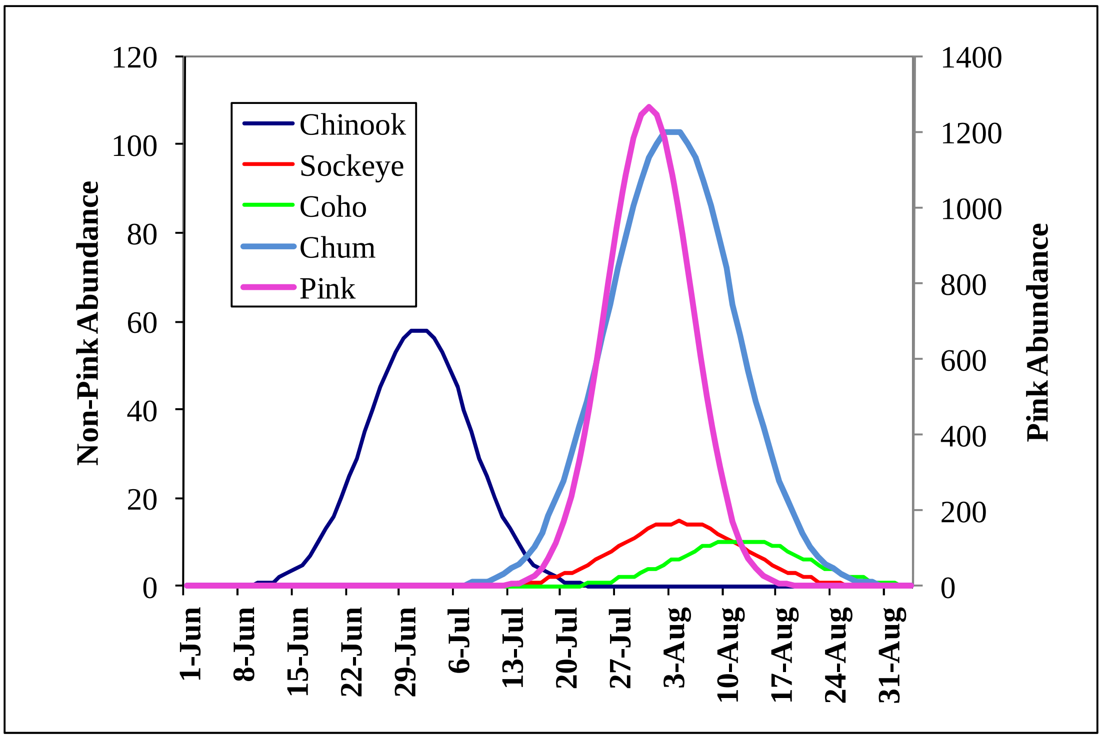
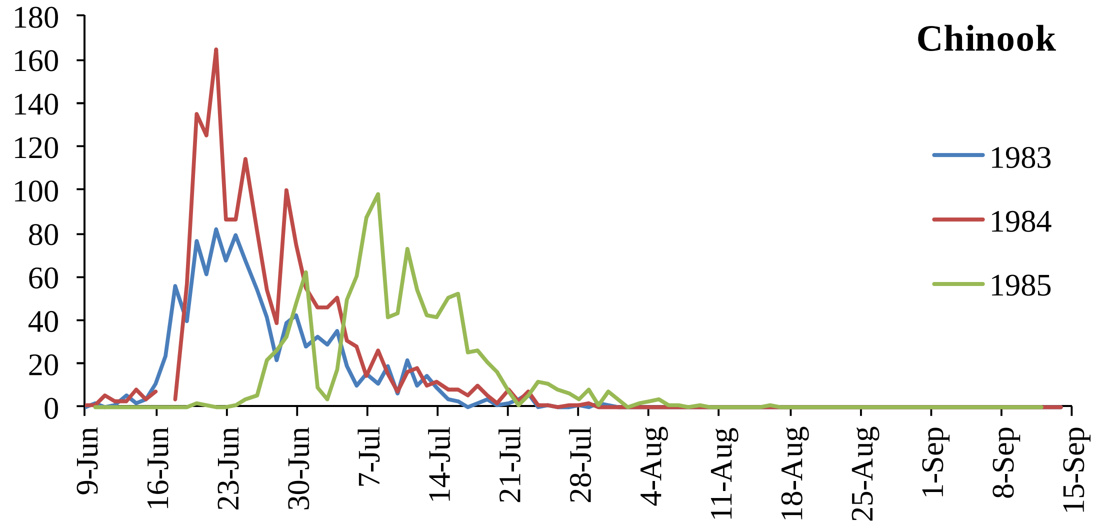


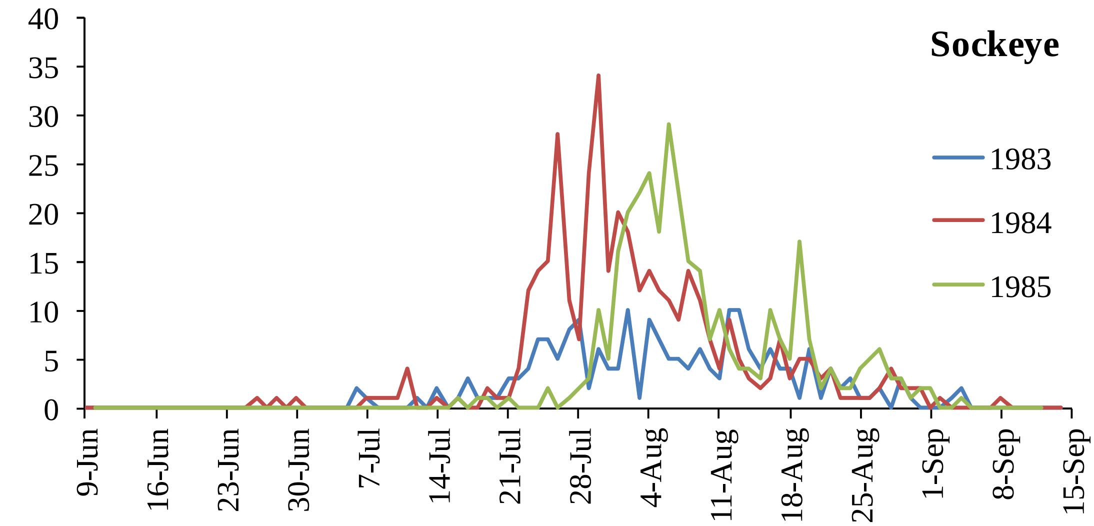
Table A-1. Anticipated catches and tagging goals by species for salmon to be captured at Curry.

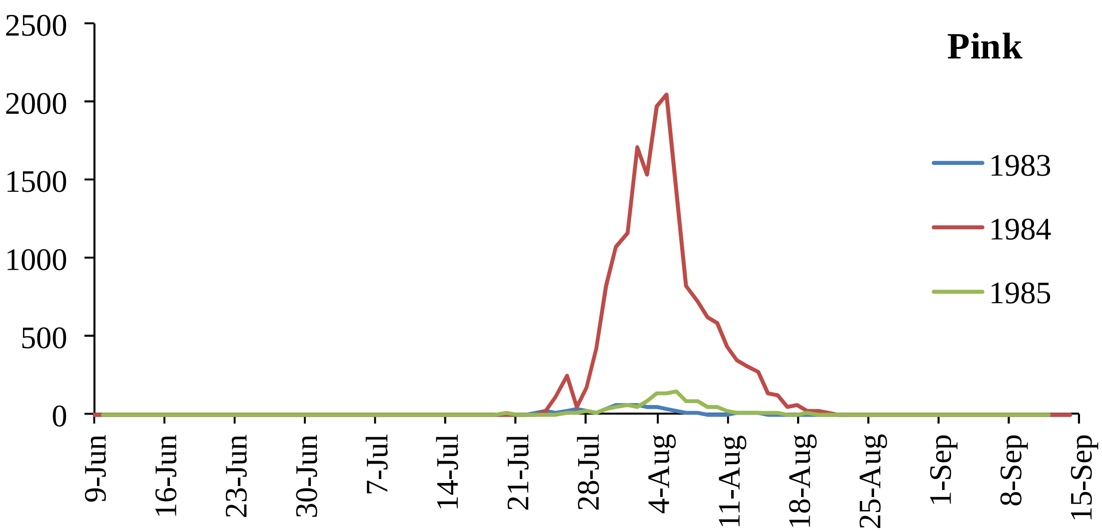
	Fishwheel Catch based Historical Average					Total	Tagging Goal					
	Chinook	Sockeye	Coho	Chum	Pink	Catch	Chinook	Sockeye	Coho	Chum	Pink	Total
Calibration Parameters												
Abundance	1000	300	215	2131	17394		400	200	200	200	200	
50% Date	1-Jul	4-Aug	12-Aug	3-Aug	31-Jul		1-Jul	4-Aug	12-Aug	3-Aug	31-Jul	
Spread	**25**	**30**	**30**	**30**	**20**		**25**	**30**	**30**	**30**	**20**	
% Tagged	40%	67%	93%	9%	1%							
Predicted catch and tag daily deployment												
1-Jun	0	0	0	0	0	0	0	0	0	0	0	0
2-Jun	0	0	0	0	0	0	0	0	0	0	0	0
3-Jun	0	0	0	0	0	0	0	0	0	0	0	0
4-Jun	0	0	0	0	0	0	0	0	0	0	0	0
5-Jun	0	0	0	0	0	0	0	0	0	0	0	0
6-Jun	0	0	0	0	0	0	0	0	0	0	0	0
7-Jun	0	0	0	0	0	0	0	0	0	0	0	0
8-Jun	0	0	0	0	0	0	0	0	0	0	0	0
9-Jun	0	0	0	0	0	0	0	0	0	0	0	0
10-Jun	1	0	0	0	0	1	0	0	0	0	0	0
11-Jun	1	0	0	0	0	1	0	0	0	0	0	0
12-Jun	1	0	0	0	0	1	1	0	0	0	0	1
13-Jun	2	0	0	0	0	2	1	0	0	0	0	1
14-Jun	3	0	0	0	0	3	1	0	0	0	0	1
15-Jun	4	0	0	0	0	4	2	0	0	0	0	2
16-Jun	5	0	0	0	0	5	2	0	0	0	0	2
17-Jun	7	0	0	0	0	7	3	0	0	0	0	3
18-Jun	10	0	0	0	0	10	4	0	0	0	0	4
19-Jun	13	0	0	0	0	13	5	0	0	0	0	5
20-Jun	16	0	0	0	0	16	6	0	0	0	0	6
21-Jun	20	0	0	0	0	20	8	0	0	0	0	8
22-Jun	25	0	0	0	0	25	10	0	0	0	0	10
23-Jun	29	0	0	0	0	29	12	0	0	0	0	12
24-Jun	35	0	0	0	0	35	14	0	0	0	0	14
25-Jun	40	0	0	0	0	40	16	0	0	0	0	16
26-Jun	45	0	0	0	0	45	18	0	0	0	0	18
27-Jun	49	0	0	0	0	49	20	0	0	0	0	20
28-Jun	53	0	0	0	0	53	21	0	0	0	0	21
29-Jun	56	0	0	0	0	56	22	0	0	0	0	22
30-Jun	58	0	0	0	0	58	23	0	0	0	0	23
1-Jul	58	0	0	0	0	58	23	0	0	0	0	23
2-Jul	58	0	0	0	0	58	23	0	0	0	0	23
3-Jul	56	0	0	0	0	56	22	0	0	0	0	22
4-Jul	53	0	0	0	0	53	21	0	0	0	0	21
5-Jul	49	0	0	0	0	49	20	0	0	0	0	20
6-Jul	45	0	0	0	0	45	18	0	0	0	0	18
7-Jul	40	0	0	0	0	40	16	0	0	0	0	16
8-Jul	35	0	0	1	0	36	14	0	0	0	0	14
9-Jul	29	0	0	1	0	30	12	0	0	0	0	12
10-Jul	25	0	0	1	1	27	10	0	0	0	0	10
11-Jul	20	0	0	2	2	24	8	0	0	0	0	8
12-Jul	16	0	0	3	3	22	6	0	0	0	0	6
13-Jul	13	0	0	4	6	23	5	0	0	0	0	5
14-Jul	10	1	0	5	10	26	4	0	0	1	0	5
15-Jul	7	1	0	7	18	33	3	1	0	1	0	5
16-Jul	5	1	0	9	30	45	2	1	0	1	0	4
17-Jul	4	1	0	12	49	66	2	1	0	1	1	5
18-Jul	3	2	0	16	76	97	1	1	0	1	1	4
19-Jul	2	2	0	20	116	140	1	1	0	2	1	5
20-Jul	1	3	0	24	170	198	1	2	0	2	2	7
21-Jul	1	3	0	30	240	274	0	2	0	3	3	8

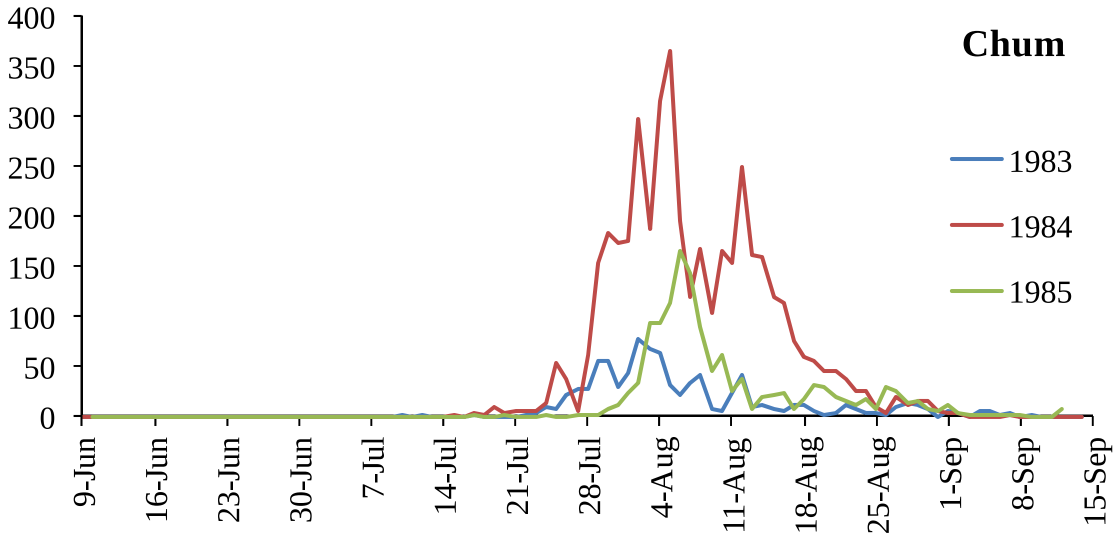
	Fishwheel Catch based Historical Average					Total	Tagging Goal					
	Chinook	Sockeye	Coho	Chum	Pink	Catch	Chinook	Sockeye	Coho	Chum	Pink	Total
Calibration Parameters												
Abundance	1000	300	215	2131	17394		400	200	200	200	200	
50% Date	1-Jul	4-Aug	12-Aug	3-Aug	31-Jul		1-Jul	4-Aug	12-Aug	3-Aug	31-Jul	
Spread	**25**	**30**	**30**	**30**	**20**		**25**	**30**	**30**	**30**	**20**	
% Tagged	40%	67%	93%	9%	1%							
Predicted catch and tag daily deployment												
22-Jul	1	4	0	36	330	371	0	3	0	3	4	10
23-Jul	0	5	1	42	437	485	0	3	1	4	5	13
24-Jul	0	6	1	49	561	617	0	4	1	5	6	16
25-Jul	0	7	1	57	696	761	0	5	1	5	8	19
26-Jul	0	8	1	64	835	908	0	5	1	6	10	22
27-Jul	0	9	2	72	969	1052	0	6	1	7	11	25
28-Jul	0	10	2	79	1089	1180	0	7	2	7	13	29
29-Jul	0	11	2	86	1183	1282	0	7	2	8	14	31
30-Jul	0	12	3	92	1244	1351	0	8	3	9	14	34
31-Jul	0	13	4	97	1264	1378	0	9	3	9	15	36
1-Aug	0	14	4	100	1244	1362	0	9	4	9	14	36
2-Aug	0	14	5	103	1183	1305	0	9	5	10	14	38
3-Aug	0	14	6	103	1089	1212	0	10	5	10	13	38
4-Aug	0	15	6	103	969	1093	0	10	6	10	11	37
5-Aug	0	14	7	100	835	956	0	10	7	9	10	36
6-Aug	0	14	8	97	696	815	0	9	7	9	8	33
7-Aug	0	14	9	92	561	676	0	9	8	9	6	32
8-Aug	0	13	9	86	437	545	0	9	9	8	5	31
9-Aug	0	12	10	79	330	431	0	8	9	7	4	28
10-Aug	0	11	10	72	240	333	0	7	9	7	3	26
11-Aug	0	10	10	64	170	254	0	7	10	6	2	25
12-Aug	0	9	10	57	116	192	0	6	10	5	1	22
13-Aug	0	8	10	49	76	143	0	5	10	5	1	21
14-Aug	0	7	10	42	49	108	0	5	9	4	1	19
15-Aug	0	6	10	36	30	82	0	4	9	3	0	16
16-Aug	0	5	9	30	18	62	0	3	9	3	0	15
17-Aug	0	4	9	24	10	47	0	3	8	2	0	13
18-Aug	0	3	8	20	6	37	0	2	7	2	0	11
19-Aug	0	3	7	16	3	29	0	2	7	1	0	10
20-Aug	0	2	6	12	2	22	0	1	6	1	0	8
21-Aug	0	2	6	9	1	18	0	1	5	1	0	7
22-Aug	0	1	5	7	0	13	0	1	5	1	0	7
23-Aug	0	1	4	5	0	10	0	1	4	1	0	6
24-Aug	0	1	4	4	0	9	0	1	3	0	0	4
25-Aug	0	1	3	3	0	7	0	0	3	0	0	3
26-Aug	0	0	2	2	0	4	0	0	2	0	0	2
27-Aug	0	0	2	1	0	3	0	0	2	0	0	2
28-Aug	0	0	2	1	0	3	0	0	1	0	0	1
29-Aug	0	0	1	1	0	2	0	0	1	0	0	1
30-Aug	0	0	1	0	0	1	0	0	1	0	0	1
31-Aug	0	0	1	0	0	1	0	0	1	0	0	1
1-Sep	0	0	1	0	0	1	0	0	1	0	0	1
2-Sep	0	0	0	0	0	0	0	0	0	0	0	0
3-Sep	0	0	0	0	0	0	0	0	0	0	0	0
	1004	297	212	2127	17394		401	198	198	198	201	

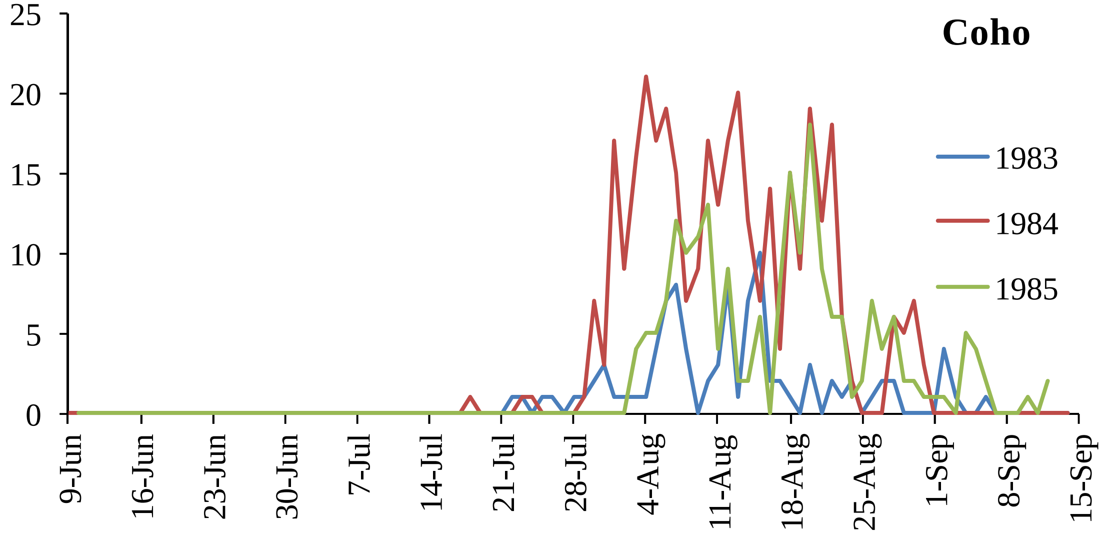
Figures A-2 to A-6. Daily catches by species in two fishwheels at Curry, 1983-85.








Chum
400
350
300
250
200
150
100
50
0
9-Jun
16-Jun
23-Jun
30-Jun
7-Jul
14-Jul
21-Jul
28-Jul
4-Aug
11-Aug
18-Aug
25-Aug
1-Sep
8-Sep
15-Sep
1983
1984
1985


Coho
25
20
15
10
5
0
9-Jun
16-Jun
23-Jun
30-Jun
7-Jul
14-Jul
21-Jul
28-Jul
4-Aug
11-Aug
18-Aug
25-Aug
1-Sep
8-Sep
15-Sep
1983
1984
1985