Juvenile South Fork Nooksack River Chinook

Captive Brood Beach Seine Collection

& Life-history Observations

2008 Year End Report

by

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Executive Summary

The objective of the South Fork Nooksack River juvenile Chinook salmon captive brood program is to capture juvenile Chinook salmon to support a captive brood program to recover the ESA-listed South Fork Chinook population. A secondary objective of the program is to examine juvenile Chinook rearing and outmigration behavior using catch data, DNA results, and observed associations with habitat features where Chinook were caught.

Juvenile Chinook for the captive brood program were captured with small beach seines deployed by field crews from Lummi Natural Resources (LNR) and Nooksack Natural Resources (NNR). LNR and NNR coordinated field efforts, and together sampled more than 180 sites. All fish caught were identified, measured for fork lengths and examined for external marks. Crews identified in-stream conditions thought to be relevant habitat for juvenile Chinook salmon, including: cover structure, beach substrate, and velocity features such as back eddies and bubble curtains.

Stock identification of the juveniles was made possible by using DNA microsatellite analysis. The method matches juvenile tissue samples to one of three established baselines representing the three stocks found in the Nooksack Watershed: South Fork Chinook, North Fork Chinook, and Hatchery Fall Chinook (Green River Stock origin). South Fork and North Fork stocks are “spring” early-timed stocks that are native to the watershed. The WDFW DNA genetics laboratory in Olympia performed the DNA tissue analysis. A small group of South Fork Chinook was moved to NOAA’s Manchester research facility where they are acclimated and reared in saltwater.

As of 12/31/08, 400 confirmed South Fork Chinook juveniles have been collected with the beach seine and are on-station at the Kendall and Manchester Hatchery facilities. This represents juveniles collected from the period September 17, 2007 until December 11, 2008. Of this group, 25 individuals are from brood year 2006, and 375 from BY ’07. During this period, 1,661-beach seine sets were made at 197 sites. Most seine sites are located in the mainstem of the Nooksack South Fork. Total seine catch for this period was 3,911 Chinook. Three brood years (’06, ’07 & ’08) were represented in this group. The average catch per set was 2.3 Chinook during this period**.**

Most captured Chinook were DNA sampled. There were 3,271 DNA samples taken during this study period. The stock composition from this sample representing all brood years is 11.5% South Fork Chinook, 21.9% North Fork, and 66.6% Hatchery Fall Chinook.

Three environmental factors significantly affect our ability to catch Chinook: river discharge, river turbidity, and water temperature. The effects of these river conditions on catch appear to overshadow differences in catch between seine sites.

Table of Contents

EXECUTIVE SUMMARY 2

TABLE OF CONTENTS 3

LIST OF TABLES 5

LIST OF FIGURES 6

LIST OF FIGURES 6

INTRODUCTION 7

METHODS 8

STUDY AREA 8
BEACH SEINES 8

RESULTS 14

BEACH SEINE EFFORT 14
CHINOOK CATCH 15
CHINOOK ABUNDANCE 17
CHINOOK STOCK COMPOSITION 17
CHINOOK FORK-LENGTH DATA 23
NON-CHINOOK SPECIES 25

DISCUSSION 26

RIVER TURBIDITY AND CHINOOK ABUNDANCE 26
RIVER DISCHARGE AND CHINOOK ABUNDANCE 26
WATER TEMPERATURE AND CHINOOK ABUNDANCE 27
NOTES ON JUVENILE CHINOOK HABITAT UTILIZATION 29
JUVENILE CHINOOK MORTALITIES 29

CONCLUSIONS & RECOMMENDATIONS 32

CONCLUSIONS 32
RECOMMENDATIONS 33

ACKNOWLEDGEMENTS 34

REFERENCES OF IMPORTANCE 35

APPENDICES 36

Appendix A1. List of beach seine sites, page 1. 36
Appendix A2. List of beach seine sites, page 2 37
Appendix A3. List of beach seine sites, page 3 38
Appendix Figure B1. Map of seine sites coded by Chinook abundance (catch/set) for Lower South Fork reach "LS1". 39
Appendix Figure B2. Map of seine sites coded by Chinook abundance (catch/set) for Lower South Fork reach "LS2". 40
Appendix Figure B3. Map of seine sites coded by Chinook abundance (catch/set) for Lower South Fork reach "LS3". 41

Appendix Figure B4. Map of seine sites coded by Chinook abundance (catch/set) for Upper South Fork reach "US1". 42
Appendix Figure B5. Map of seine sites coded by Chinook abundance (catch/set) for Upper South Fork reach "US2". 43
Appendix Figure B6. Map of seine sites coded by Chinook abundance (catch/set) for Upper South Fork reach "US3". 44
Appendix C1. Table of Chinook catch by brood year and total catch per set at beach seine sites, page 1 45
Appendix C2. Table of Chinook catch by brood year and total catch per set at beach seine sites, page 2. 46
Appendix D. Table of juvenile Chinook mortalities. 48
Appendix E. Juvenile Chinook warm water transport protocols. 49
Appendix F. Table of juvenile Chinook behavior and habitat utilization model. 50

List of Tables

TABLE 1. SUB-REACH CODES, NAMES, RIVER MILE LOCATIONS, AND NUMBERS OF BEACH SEINE SITES IN EACH SUB REACH..10
TABLE 2. NUMBERS OF BEACH SEINE SETS COMPLETED BY THE LUMMI AND NOOKSACK TRIBES FROM SEPTEMBER 18, 2007 TO DECEMBER 31, 2008. 14
TABLE 4. TOTAL MONTHLY JUVENILE CHINOOK BEACH SEINE CATCH BY SUB-REACH IN THE NOOKSACK RIVER FROM SEPTEMBER 18, 2007 TO DECEMBER 31, 2008.....16
TABLE 5. MONTHLY TOTAL CATCH OF JUVENILE CHINOOK BY BROOD YEAR. 16
TABLE 6 . CATCH OF JUVENILE CHINOOK BY MONTH AND STOCK STATUS AND CALCULATED PERCENT FROM THE NATIVE SOUTH FORK CHINOOK STOCK. 19
TABLE 7. JUVENILE CHINOOK COMPOSITION BY CAPTURE MONTH AND BROOD YEAR IN 2007 AND 2008. 21

List of Figures

FIGURE 1. MAP OF SOUTH FORK NOOKSACK SHOWING BEACH SEINE SITE LOCATIONS AND BOUNDARIES OF SUB-REACHES IN 2007 / 2008. 9
FIGURE 2. BEACH SEINE TECHNIQUE SHOWING SAMPLING "FOOT-PRINT" RESULTING FROM DRIFTING DOWNSTREAM ON THE LOWER SECTION OF THE RIFFLE INTO A POOL AND ADJACENT TO COVER STRUCTURE (LOG AND ROOT-WAD)............................ 11
FIGURE 3. PLOT OF AVERAGE JUVENILE CHINOOK CATCH PER SEINE SET BY SUB-REACH 18
FIGURE 4. PLOT OF AVERAGE MONTHLY JUVENILE CHINOOK CATCH PER SEINE SET FROM SEPTEMBER 18, 2007 TO DECEMBER 31, 2008....................................... 18
FIGURE 5. PLOT OF AVERAGE MONTHLY JUVENILE CHINOOK CATCH PER SET IN UPPER AND LOWER SOUTH FORK STUDY REACHES IN 2007 & 2008............................. 19
FIGURE 6. PLOT OF MONTHLY JUVENILE CHINOOK CATCH BY STOCK COMPOSITION IN 2007 & 2008 FROM PRIMARILY THE NOOKSACK RIVER SOUTH FORK.................. 20
FIGURE 7. PLOT OF MONTHLY JUVENILE CHINOOK CATCH COMPOSITION FOR BROOD YEAR 2007 FROM SEPTEMBER 18, 2007 TO DECEMBER 31, 2008. 21
FIGURE 8. PLOT OF PERCENT S. FORK CHINOOK IN MONTHLY CATCH IN THE UPPER SOUTH FORK AND LOWER SOUTH FORK FROM SEPTEMBER 18, 2007 TO DECEMBER 31, 2008.. 22
FIGURE 9. PIE DIAGRAMS SHOWING STOCK COMPOSITION BY RIVER REACH IN 2008 AND 2009.. 22
FIGURE 10. BOX PLOT OF FORK LENGTHS FOR ALL JUVENILE CHINOOK SALMON LANDED DURING 2008 SEPARATED BY BROOD YEAR. DARK LINE REPRESENTS THE MEDIAN OF THE DISTRIBUTION, BOX REPRESENTS THE 25% TO 75% INTERQUARTILE RANGE OF THE DATA, WHISKERS REPRESENT THE 95% RANGE, AND OPEN CIRCLES ARE OUTLIERS. 23
FIGURE 11. BOX PLOT OF FORK LENGTHS FOR JUVENILE CHINOOK SALMON BROOD YEAR 2007 CAUGHT DURING 2008 SEPARATED BY STOCK. DARK LINE REPRESENTS THE MEDIAN OF THE DISTRIBUTION, BOX REPRESENTS THE 25% TO 75% INTERQUARTILE RANGE OF THE DATA, WHISKERS REPRESENT THE 95% RANGE, AND OPEN CIRCLES ARE OUTLIERS.. 24
FIGURE 12: BOX PLOT OF FORK LENGTHS FOR JUVENILE CHINOOK SALMON BROOD YEAR 2007 CAUGHT DURING 2008 SEPARATED BY LOCATION. DARK LINE REPRESENTS THE MEDIAN OF THE DISTRIBUTION, BOX REPRESENTS THE 25% TO 75% INTERQUARTILE RANGE OF THE DATA, WHISKERS REPRESENT THE 95% RANGE, AND OPEN CIRCLES ARE OUTLIERS. 24
FIGURE 13. AVERAGE CHINOOK CATCH PER SET FOR THREE WATER TURBIDITY CATEGORIES. 26
FIGURE 14. PLOT OF AVERAGE DAILY DISCHARGE DURING THE STUDY PERIOD TAKEN AT THE USGS STREAM GAUGE AT THE SAXON ROAD BRIDGE (RM 12.8) 27
FIGURE 15. AVERAGE CHINOOK CATCH PER SET FOR FOUR STREAMFLOW CATEGORIES. 27
FIGURE 16. AVERAGE DAILY WATER TEMPERATURE AT THE USGS GAGE AT THE SAXON BRIDGE AND FOUR DEFINED TEMPERATURE RANGES.. 28
FIGURE 17. AVERAGE CHINOOK CATCH PER SET FOR FOUR WATER TEMPERATURE CATEGORIES. 28

Introduction

The Juvenile Chinook Captive Brood Program began in September of 2007 with the primary objective to capture juvenile Chinook to support a captive brood program to recover the ESA-listed South Fork Nooksack River Chinook population. Secondarily, this project examines juvenile Chinook rearing and outmigration behavior using catch data, DNA results, and habitat features observed at sites where Chinook were caught. Ultimately, the objective is to restore Treaty Fishing Rights that are presently being impacted by this depressed stock.

Presently the target goal is to capture 500 juvenile South Fork Chinook for each brood year. Field efforts for the Juvenile Chinook Captive Brood Program are coordinated between LNR and NNR.

The primary capture method in this study uses a small beach seines, modified for riverine applications. As the target species is the South Fork Chinook juvenile, most seining occurs at sites in the mainstem of the South Fork Nooksack.

The first successful capture and retention of a juvenile belonging to the South Fork stock occurred on September 18, 2007. This document reports on progress made during the first fifteen months of this program, through the end of November 2008. Also included here in are contributions by the Nooksack Tribe who joined our field efforts to collect juveniles Chinook beginning in January 2008.

Brood collection work has continued year-around under various river flows and environmental conditions. All sampling has occurred during daylight hours. Catch success varies depending on the season. During the spring outmigration period, catches increase as juveniles actively move downstream. After this, catches decline reflecting only the sub-yearling fish that remain in the watershed. Three environmental factors significantly affect our ability to catch Chinook: river discharge, river turbidity, and water temperature. The effect of these river conditions on catch success appears to overshadow differences in catch between seine sites.

Efforts were made to isolate juveniles by capture week and capture reach at the Skookum Hatchery prior to collecting DNA tissues so as to develop an understanding of how the three stocks are distributed over the course of a season. We have defined three principle reaches (Mainstem Nooksack, Lower South Fork, & Upper South Fork). These are further divided into 10 sub-reaches. To avoid predation while holding in tanks at the hatchery, zero-age individuals are kept separate from the yearlings. Providing separation by year-class, capture week and stream reach requires many partitioned holding tanks. This can be a strain on the limited hatchery water supply in late summer.

Methods

Study Area

Beach seining occurred primarily in the South Fork Nooksack from the mouth to river mile 21.1 (Figure 1). Chinook spawning occurs up to river mile 30, however access to these locations would require longer transport times to the hatchery and risk a higher mortality rate. Additional beach seine locations were in the Mainstem, below the confluence of the North and South Forks. Generally these juveniles were not used for the captive brood program because of the high incidence of non-South Fork stocks originating from the North Fork.

Juveniles were most often collected along river margins and in pools in locations free of snags, but in proximity to cover features such as logjams, logs, stumps, and cut-banks providing habitat complexity. Most seine sites were located a short distance from road access, to facilitate transport of captured juveniles.

A single beach seine “set” is the standard unit of sampling effort. “Sets” were made with the beach seine at 197 different locations. We have defined three primary reaches, the Mainstem, Lower South Fork, and Upper South Fork. The dividing point between Upper and Lower South Fork reaches is Skookum Creek at river mile 14.2.

These primary reaches are further sub-divided into ten “sub-reaches” (Table 1). Break points between sub-reaches are typically bridge crossings or landmarks used for spawner surveys. Hutchinson Creek enters the South Fork at river mile 10.2 and is heavily utilized by spawning Chinook when suitable hydrological conditions exist. All other seine sites are located within the South Fork and Nooksack Mainstems. A list of all seine sites with name, access point, river mile, and sub-reach are in Appendix “A”. Locations of sites are shown on the 6 sub-reach maps in Appendix “B”.

Beach Seines

Chinook were captured with small rectangular beach seines measuring 9m long X 2m deep for all sets after October 10, 2007 (shown on report cover). Prior to this date an older net, 24’ long X 10’ deep was used. The Nooksack Tribe used a net that was 25’ long X 5’ deep. Mesh size of all nets was 3/16”.

Our 9m X 2m net was dyed green by the manufacture, Christensen Net Works in Everson, Washington. The netting is #8635 knotless web. The lead line is of 200/100 weight sewn into webbing on the bottom edge of the net. Corks are type BL-S attached on 16.5” centers. A unique feature of this net is a circular bag sewn into the center, which helped to retain fish after the net was drawn in. The center pocket is 4’ diameter opening tapering to a 3’ diameter end. The length of the ‘bag’ is 3’. The area encircled by this net is approximately 25.9 m^2.

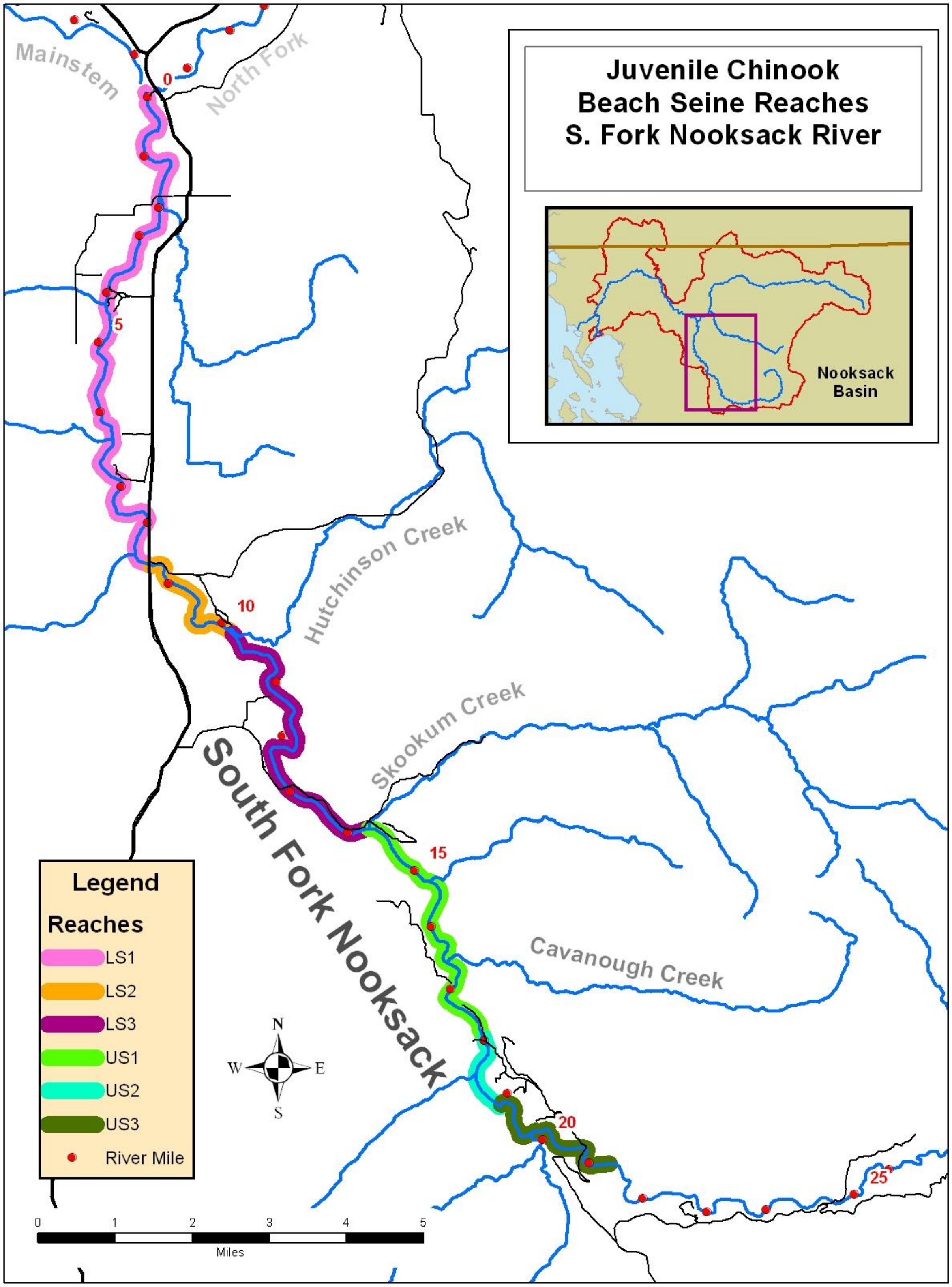

Figure 1. Map of South Fork Nooksack showing beach seine sub-reaches and river miles in 2007 / 2008.

Table 1. Sub-reach codes, names, river mile locations, and numbers of beach seine sites in each sub reach.

Sub-Reach Name List, River Mile Location and Numbers of Beach Seine Sites

Sub-Reach	Name	From RM		To RM	BS Sites
MS1	Lower Mainstem	4.8	-	15.3	3
MS2	Middle Mainstem	15.3	-	30.9	6
MS3	Upper Mainstem	30.9	-	36.6	11
LS1	Lower S. Fork, lower	0.0	-	8.7	27
LS2	Lower S. Fork, mid-reach	8.7	-	10.2	20
HC	Hutchinson Creek	10.2	-		6
LS3	Lower S. Fork, upper	10.2	-	14.2	60
US1	Upper S. Fork, downstream	14.2	-	18.0	6
US2	Upper S. Fork, mid-reach	18.0	-	19.0	29
US3	Upper S. Fork, upstream	19.0	-	21.1	29
				Total =	**197**

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We found that coarse cobble to be a favored type of environment for recently emerged fry and that many other types of areas may be used by more developed juveniles. River turbidity appears to also affect where at each site Chinook will be found. When the water is clear juveniles are often found in turbulent “bubble curtains” at the head of pools or underneath logs and undercut banks. More turbid conditions seem to promote greater movement as juveniles may be less vulnerable to predation.

We used various techniques with the beach seine to capture juvenile Chinook in a variety of habitat types. The beach seine is typically deployed by one individual who holds one end of the net while wading out downstream and back to the wetted perimeter in a semicircular arc. Both ends of the net are then drawn in so that the lead-line reaches the beach ahead of the cork-line. The net is drawn in further to isolate any fish to the center pocket in the net to keep some water in the net at all times

The standard seine set is deployed downstream while walking to the maximum depth or “wader depth” and then swept back to the shoreline in pool and riffle-type stream reaches. Occasionally a diver is used to reach greater depths offshore. When stream velocities were low we were successful in capturing juveniles sweeping the net in an upstream direction.

The “parallel” set is on variation from the standard seine set. This methods is used in areas adjacent to log jams or other structure thought to attract juveniles. The net is set out downstream adjacent to and parallel to the obstruction. It is then pulled across the channel to the opposite bank to complete the set. Another variation is the “riffle to pool” method where the net drifts from the bottom of a riffle into a pool (Figure 2). In this case the net drifts adjacent to a logjam. The "foot print" of the sampled area is shown. For all types of sets, the "foot-print" at each site varies with river discharge, extending outward at low flows and more inshore when the river rises.

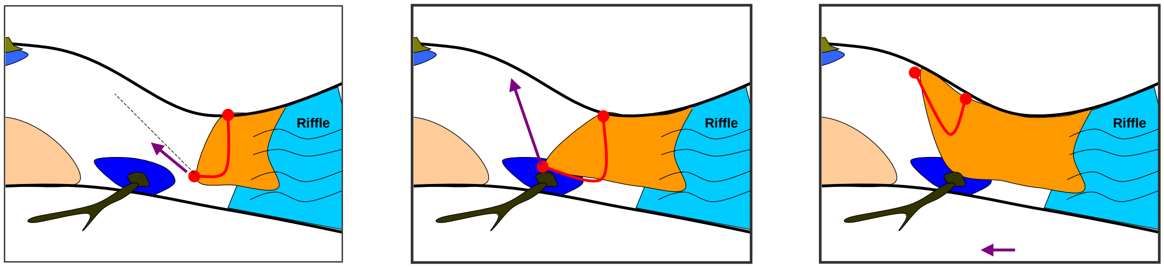

Figure 2. Beach seine technique showing sampling "foot-print" resulting from drifting downstream on the lower section of the riffle into a pool. Net sweeps downstream (right to left) next to a log and root-wad.

Catch Processing

At the completion of the seine set, all fish are removed by dip net to 5 gallon plastic buckets. All salmonids are identified to species. Other species are identified to genus. To avoid predation, care is taken not to place larger fish with smaller individuals.

Salmonid juveniles are sedated with a 100-mg/l concentration of MS222 and fork length measurements are taken to the nearest millimeter. Chinook, coho, and trout are examined for the presence of an adipose or caudle fin clip. Sedated specimens are transferred to a bucket containing fresh water until recovered.

Juvenile Chinook Transport

After capture Chinook were placed in 5 gallon plastic buckets with a lid containing many aeration holes, only after full recovery from sedation. Catch rates usually result in less that 10 fish per container. Higher numbers may occasionally require somewhat higher fish densities, but in all cases no more than 20 fish were transported in a 5-gallon container. A YSI dissolved oxygen meter is used to monitor oxygen levels during transport of densities higher than 10 fish / 5 gallons. During the warmer months when ambient air temperatures were higher than 16 C (60.8 F), in addition to monitoring DO, active aeration of the bucket is provided using a battery powered air pump and aeration stone.

Transport time by truck to the hatchery is generally less than 30 minutes. Temperature of the bucket water and the hatchery water is compared and adjusted slowly in 2 C increments prior to transfer of juveniles to the hatchery tanks.

Field Data Collected

The date and start time of each seine set is noted. The seine set is a standard unit of fishing effort. A total count by species is recorded for all salmonids. Other species are identified to genus and counted. Based on relative lengths, we indicate if Chinook individuals are zero-age or sub-yearlings. We note presence of external marks (adipose or caudle fin clips). For each salmonid, we record any abnormalities, injuries, or mortalities that may occur.

We collect data on river conditions including river discharge at time of set; “visibility depth”, which is a measure of turbidity similar to secchi depth; and water temperature using a YSI Model 30-10 field temperature / conductivity meter. The quality of the set is noted to record snags or any problems with the net.

Locating Seine Sites

Each site is located using a hand-held “Garman12” GPS receiver. River mile locations are determined after downloading site locations into a GIS map project and comparing these to a River Mile Index (RMI) shape-file. The RMI line feature follows the approximate thalweg as observed in the fall of 2007 and uses WDFW whole river miles that are re-located to this line and subdivided into tenths between whole River Mile marks.

Seine sites are numbered using a unique alpha/numeric code consisting of a two digit prefix indicating river basin and a three digit numeric code that increases moving upstream whenever possible. The two-letter pre-fix indicates the river reach. “MS-“ indicates the lower mainstem below the confluence of the North and South Forks. “SF-“ indicates South Fork Mainstem and “MF-“ indicates Middle Fork Mainstem.

Seine Site Descriptions

When a site is first located, habitat features associated with each site are recorded on the “Site Descriptions” form shown in Appendix “B”. Photos are taken of each site and are included in the Site Descriptions. The location of each set is captured using a handheld GPS receiver. As site conditions change, a new site description is recorded. Typically these changes include movement of the configuration of the river (location & depth of channel features) and movement of wood in and adjacent to the area seined. Due to the dynamic nature of river flows, it is not usually feasible to capture the exact footprint of the seined area at each site. The variable hydraulic regime can affect the depth of the set and occasionally the proximity to submerged features such as logs and boulders that could affect catch success. These changes are captured by recording the “maximum depth’ of each set and records of the river discharge at the time of the set.

Results

<u>Beach Seine Effort</u>

For the 15-month study period from September 18, 2007 until December 31, 2008, the combined Lummi and Nooksack Tribal effort completed **1,661 beach seine sets**. The Nooksack Tribe concentrated their effort in fewer reaches and at few sites, but their overall fishing efficiency (catch per set) was greater than the Lummi effort which included more seine sites over a wider range of the river.

Using both Lummi and Nooksack data, Table 2 lists numbers of seine sets by month for each of the 10 sub-reaches. Most fishing effort was in the Lower South Fork (920 sets) followed by the Upper South Fork (589 sets) with the fewest seine sets in the Mainstem (152 sets). Over half of the seine sets (55.4%) were conducted in the Lower South Fork. Monthly seine effort varies somewhat due to river conditions and other competing activities. Monthly effort increased significantly after December 2007 when the Nooksack Tribe joined the brood collection program. From this point forward we averaged approximately 127 seine sets per month.

Table 2. Numbers of beach seine sets completed by the Lummi and Nooksack Tribes from September 18, 2007 to December 31, 2008.

Total Seine Sets by Agency & Stream Reach

Reach	Name	LNR	NNR	Total
MS1	Lower Mainstem	26		26
MS2	Middle Mainstem	109		109
MS3	Upper Mainstem	17		17
LS1	Lower S. Fork, lower	55	213	268
LS2	Lower S. Fork, mid-reach	192	37	229
HC	Hutchinson Creek	6		6
LS3	Lower S. Fork, upper	352	65	417
US1	Upper S. Fork, downstream	20		20
US2	Upper S. Fork, mid-reach	167		167
US3	Upper S. Fork, upstream	307	95	402
	Total =	**1,251**	**410**	**1,661**

Seine effort by month and river reach is summarized in Table 3. Most effort (417 sets) was in reach “LS3”, followed by reach “US3” (402 sets), “LS1” (268 sets), and “LS2” (229 sets). Little effort (152 sets) occurred in Mainstem reaches.

Table 3. Numbers of beach seine sets completed in the Nooksack River by month and sub-reach from September 18, 2007 to December 31, 2008

Beach Seine Sets[1]
By Stream Reach

	Mainstem			**Lower S. Fork**				**Upper S. Fork**			
	Lower	Middle	Upper	Lower	Middle	H. Cr.	Upper	Lower	Middle	Upper	**All**
	MS1	**MS2**	**MS3**	**LS1**	**LS2**	**HC**	**LS3**	**US1**	**US2**	**US3**	**Reaches**
Sept '07							38				**38**
Oct '07		1		15	37		30	1		9	**93**
Nov '07	6	12	8	16	7		15				**64**
Dec '07	3	12	9	2	3		1				**30**
Jan '08	6	39		60	13		9		20	3	**150**
Feb '08	6	8		25	14		3		16	22	**94**
Mar '08	4	7		33	13		11		20	22	**110**
Apr '08	1	12		4	3		19		30	30	**99**
May '08		2		10	15		16		7	8	**58**
Jun '08		1		45	16	4	22			27	**115**
Jul '08		3		10			27		18	72	**130**
Aug '08					15	2	27	6	12	76	**138**
Sep '08					7		62		5	10	**84**
Oct '08		2		6	44		97	7	27	58	**241**
Nov '08				17	16		26		5	26	**90**
Dec '08		10		25	26		14	6	7	39	**127**
Total	**26**	**109**	**17**	**268**	**229**	**6**	**417**	**20**	**167**	**402**	**1,661**

[1]**Combined Lummi & Nooksack Tribe data**

Chinook Catch

We captured 3,911 juvenile Chinook during the 15-month study period. Table 4 lists monthly total catch for each of the sub-reaches. Most Chinook (2,868) were caught in the Lower South Fork. The Upper South Fork reaches yielded 809 Chinook, followed by the Mainstem where only 234 juveniles were captured. The months of highest catch generally corresponds to the spring / early summer outmigration period when fish are moving and river conditions are turbid due to snow melt.

During the study period we caught juveniles belonging to three brood years: 2006, 2007, and 2008. Table 5 shows monthly total catch by brood year data. When sampling began in September '07, juveniles with fork-lengths generally in the range 90-110 mm representing pre-yearlings were the only group captured. On November 30, 2007 we caught our first zero-age fry belonging to the 2007 brood year with a length of 37 mm. On April 30, 2008 we caught our last of the brood year '06 individuals. Brood year class can be determined because fork-lengths are much different between the two brood years with no overlap. On October 23, 2008 the first fry representing brood year '08 was caught.

Table 4. Total monthly juvenile Chinook beach seine catch by sub-reach in the Nooksack River from September 18, 2007 to December 31, 2008.

Juvenile Chinook Beach Seine Catch
By Stream Reach

	MS1	MS2	MS3	LS1	LS2	HC	LS3	US1	US2	US3	Total
Sept '07							57				**57**
Oct '07		2		1	21		17	0		1	**42**
Nov '07	0	2	1	4	0		0				**7**
Dec '07	0	8	3	0	0		0				**11**
Jan '08	10	31		11	0		1		0	0	**53**
Feb '08	0	8		30	3		0		6	17	**64**
Mar '08	22	11		180	161		1		6	24	**405**
Apr '08	0	37		380	64		67		20	36	**604**
May '08		1		290	172		26		5	8	**502**
Jun '08		3		223	362	2	70			49	**709**
Jul '08		19		50			230		27	192	**518**
Aug '08					20	16	99	34	5	186	**360**
Sep '08					5		65		5	28	**103**
Oct '08		30		2	52		70	4	34	32	**224**
Nov '08				28	25		5		1	56	**115**
Dec '08		46		9	49		0	5	0	28	**137**
Total	**32**	**198**	**4**	**1,208**	**934**	**18**	**708**	**43**	**109**	**657**	**3,911**

Table 5. Monthly total catch of juvenile Chinook by brood year.

Juvenile Chinook Catch
by Brood Year

Month	BY '06	BY '07	BY '08	Total
Sept '07	57			57
Oct '07	42			42
Nov '07	6	1		7
Dec '07	11			11
Jan '08	5	48		53
Feb '08	25	39		64
Mar '08	12	393		405
Apr '08	6	598		604
May '08		502		502
Jun '08		709		709
Jul '08		518		518
Aug '08		360		360
Sep '08		103		103
Oct '08		222	2	224
Nov '08		70	45	115
Dec '08		20	117	137
Total	**164**	**3,583**	**164**	**3,911**

Chinook Abundance

Chinook abundance can be expressed as average Chinook catch per standard seine set (i.e. CPUE or catch per unit of effort). Catch success is greatly affected by fish behavior that responds to various river conditions such as water turbidity, river stage, and water temperatures. Using CPUE to represent relative abundance requires the assumption that these and other factors affecting "catch-ability" are the same for all seine sets. For the purpose of this exercise, we must also assume that all nets, regardless of minor differences in overall dimensions, fish with the same effectiveness, and more importantly, that field crews use fishing techniques that are the same for all sets performed. Despite these obvious differences between seine sets, catch per set can provide an indication of relative abundance between sites.

The graph in Figure 3. shows average catch per set for each of the ten sub-reaches. The lowest most reach, "LS1" in the lower South Fork shows the highest abundance, which generally decreases as one goes upstream. This may be a result of higher numbers of Chinook in the lower reaches during downstream migration in the spring and early summer.

The months of highest abundance is during the period from April through July as shown in Figure 4. The peak month of abundance is May. October was the lowest month of abundance in 2008. We improved the average catch per set for the same month from 2007, however. This was based on finding suitable sites that fished well during this period of cooling water temperatures. Figure 5 shows monthly Chinook abundance for sites in the upper and lower South Fork. Sites in the lower South Fork have a higher overall abundance for Chinook. This may reflect the spring zero-age outmigration from upstream reaches "US2" and "US3" where most Chinook redds were found in 2008.

Chinook Stock Composition

Stock composition for the 3,454 juvenile Chinook that were examined in the DNA test are shown by capture month in Table 6. The South Fork Nooksack stock sought for the captive brood program represented 12.6% of the total Chinook tested. The native North Fork Nooksack stock made up 22.4% of the total catch tested. The highest percentage (65.1%) in the DNA group tested was from the hatchery Fall Chinook stock.

The lowest percentage of S. Fork Chinook in the catch occurred in the first two quarters of 2008 (4.3% & 4.1% respectively), while the highest percentage was in the last two quarters (27.7% & 25.2% respectively). Contributing to this was the high incidence of Fall Chinook in our catches in the during the spring outmigration period as shown in Figure 6. By far, the greatest catch of North Fork Chinook was in March '08.

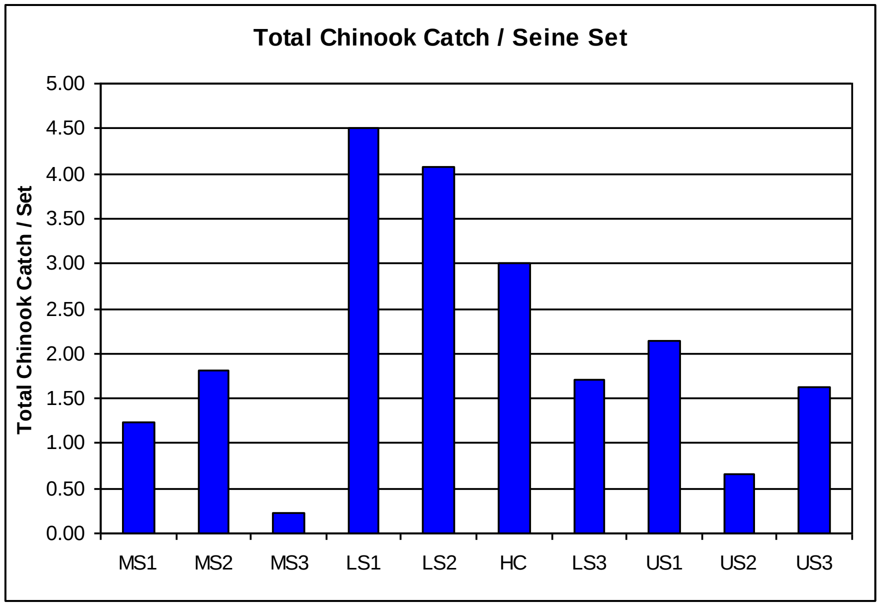

Figure 3. Plot of average juvenile Chinook catch per seine set by sub-reach

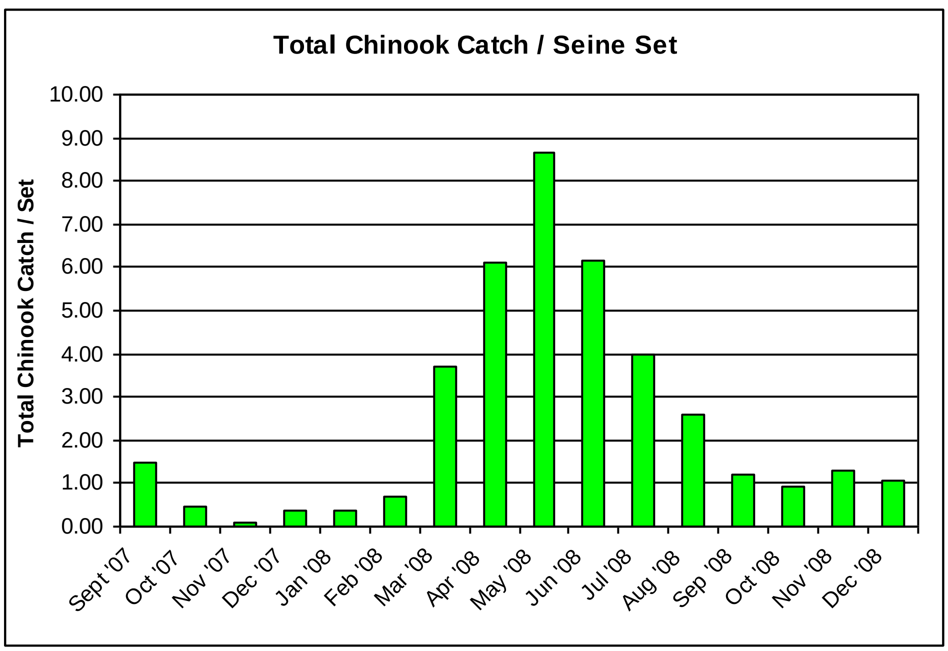

Figure 4. Plot of average monthly juvenile Chinook catch per seine set from September 18, 2007 to December 31, 2008.

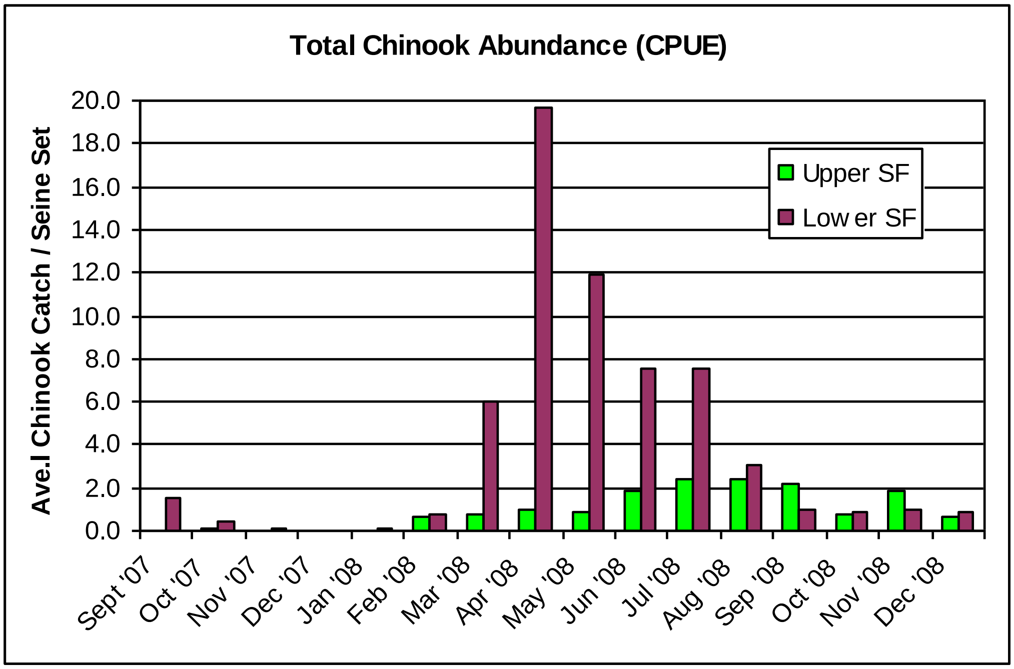

Figure 5. Plot of average monthly juvenile Chinook catch per set in Upper and Lower South Fork study reaches in 2007 & 2008.

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Table 6 . Catch of juvenile Chinook by month and stock status and calculated percent from the native South Fork Chinook stock.

Juvenile Chinook DNA Summary
Stock Composition by Month
(All Brood Years)

Month	Fall	NF	SF	Total	Percent SF
Sep '07	29	7	9	45	20.0%
Oct '07	24	2	8	34	23.5%
Nov '07	8	0	2	10	20.0%
Dec '07	6	2	1	9	11.1%
Jan '08	2	52	1	55	1.8%
Feb '08	13	59	3	75	4.0%
Mar '08	183	317	24	524	4.6%
Apr '08	739	80	18	837	2.2%
May '08	223	8	11	242	4.5%
Jun '08	353	31	33	417	7.9%
Jul '08	274	48	99	421	23.5%
Aug '08	148	43	93	284	32.7%
Sep '08	50	16	30	96	31.3%
Oct '08	127	52	43	222	19.4%
Nov '08	42	22	37	101	36.6%
Dec '08	26	34	22	82	26.8%
Total	**2,247**	**773**	**434**	**3,454**	**12.6%**
	65.1%	**22.4%**	**12.6%**		

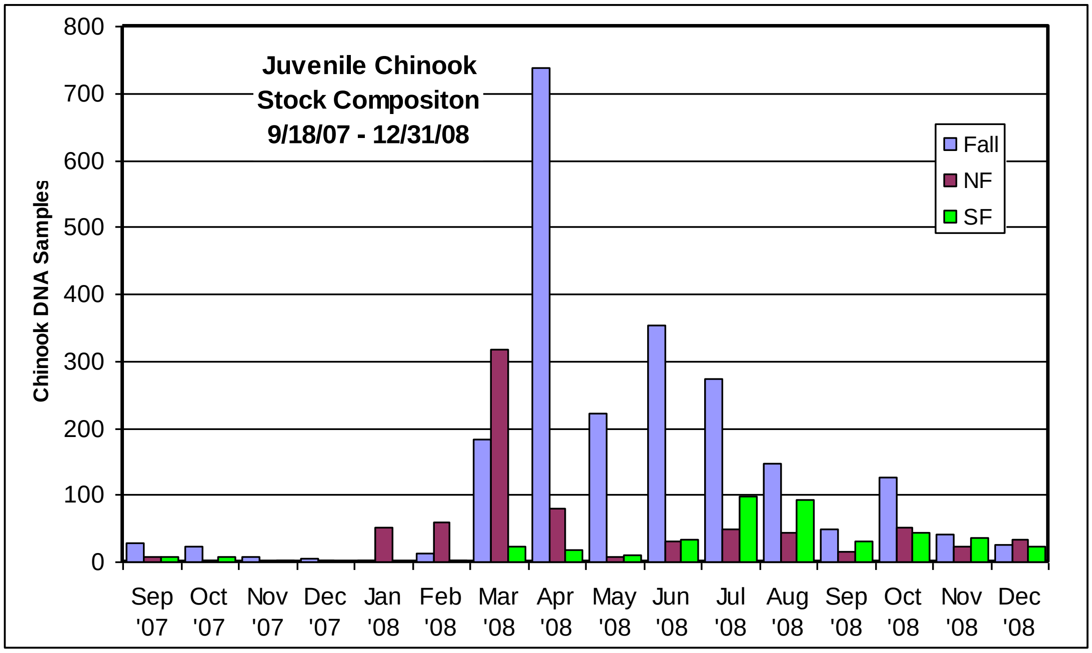

Figure 6. Plot of monthly juvenile Chinook catch by stock composition in 2007 & 2008 from primarily the Nooksack River South Fork.

Table 7 lists monthly stock composition by brood year. Most of the juveniles examined were from Brood Year 2007 (3,280 of 3,454 or 95.0%). The difference in the percentage of S. Fork Chinook for each brood year is very different, with 20.0% for BY '06 and 12.3% for BY'07, but does not represent the entire sampling period for each group. It appears, however that there is a higher incidence of S. Fork Chinook in the catches in the later months of the brood year cycle as discussed above.

Figure 7 is a plot for brood year 2007, the percentage of each of the three stocks in the monthly catch. The percentage of juveniles belonging to the S. Fork stock rises steadily throughout 2008 as crews focus effort on sites in the upper South Fork that produce more of these brood. This may also reflect a greater tendency for the spring populations to exhibit a yearling life-history strategy.

Shown on the plot in Figure 8 is the percentage of S. Fork Chinook in the catch for sites in the Upper and Lower South Fork. The incidence of S. Fork Chinook is much higher in the Upper South Fork, above Skookum Creek. Much of our seining effort was concentrated at these seine sites when flows were favorable. Generally flows greater than ~500 cfs prevented us from reaching seine sites on the opposite streambank in waders.

Figure 9 are pie diagrams showing stock composition for the upper South Fork, lower South Fork, and Mainstem sites for the study period in 2007 and 2008.

Table 7. Juvenile Chinook composition by capture month and brood year in 2007 and 2008.

Juvenile Chinook DNA Summary
Stock Composition by Month / Brood Year

Month	Fall	BY '06 NF	SF	BY '06 Total	Fall	BY '07 NF	SF	BY '07 Total	Fall	BY '08 NF	SF	BY '08 Total	Total
Sep '07	29	7	9	**45**									45
Oct '07	24	2	8	**34**									34
Nov '07	8		2	**10**									10
Dec '07	6	2	1	**9**									9
Jan '08	2	2	1	**5**		50		**50**					55
Feb '08	10	6	1	**17**	3	53	2	**58**					75
Mar '08	5	3	3	**11**	178	314	21	**513**					524
Apr '08	6	3	4	**13**	733	77	14	**824**					837
May '08					223	8	11	**242**					242
Jun '08	1			**1**	352	31	33	**416**					417
Jul '08					274	48	99	**421**					421
Aug '08					148	43	93	**284**					284
Sep '08					50	16	30	**96**					96
Oct '08					127	51	43	**221**		1		**1**	222
Nov '08					42	17	37	**96**		5		**5**	101
Dec '08					26	11	22	**59**		23		**23**	82
Total	**91**	**25**	**29**	**145**	**2,156**	**719**	**405**	**3,280**	**0**	**29**	**0**	**29**	**3,454**
	62.8%	**17.2%**	**20.0%**		**65.7%**	**21.9%**	**12.3%**			**100.0%**			

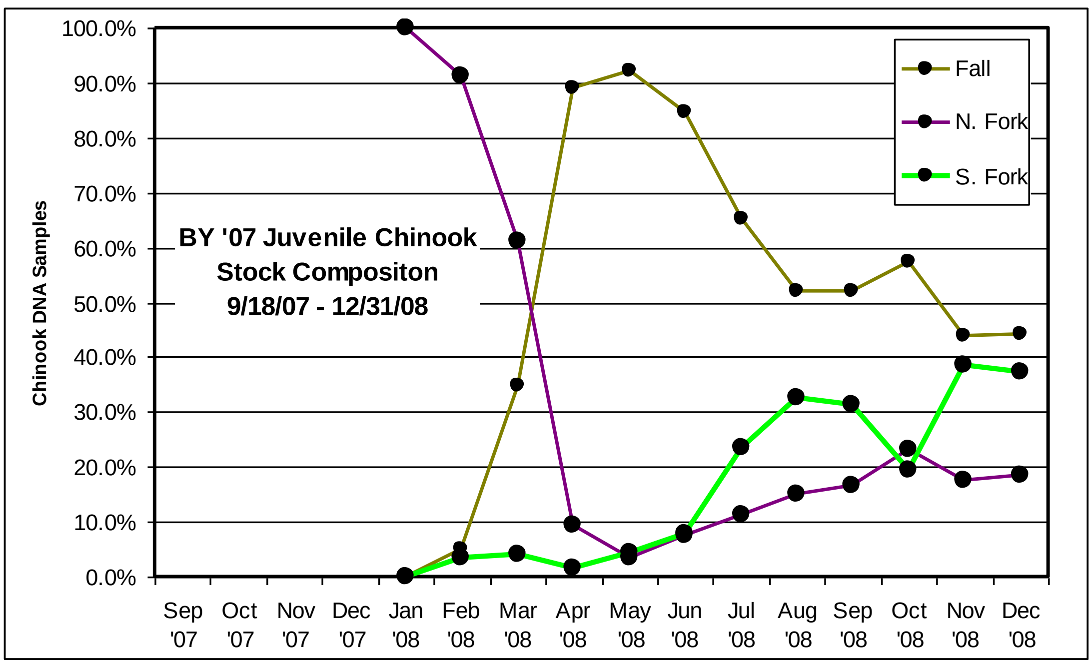

Figure 7. Plot of monthly juvenile Chinook catch composition for brood year 2007 from September 18, 2007 to December 31, 2008.

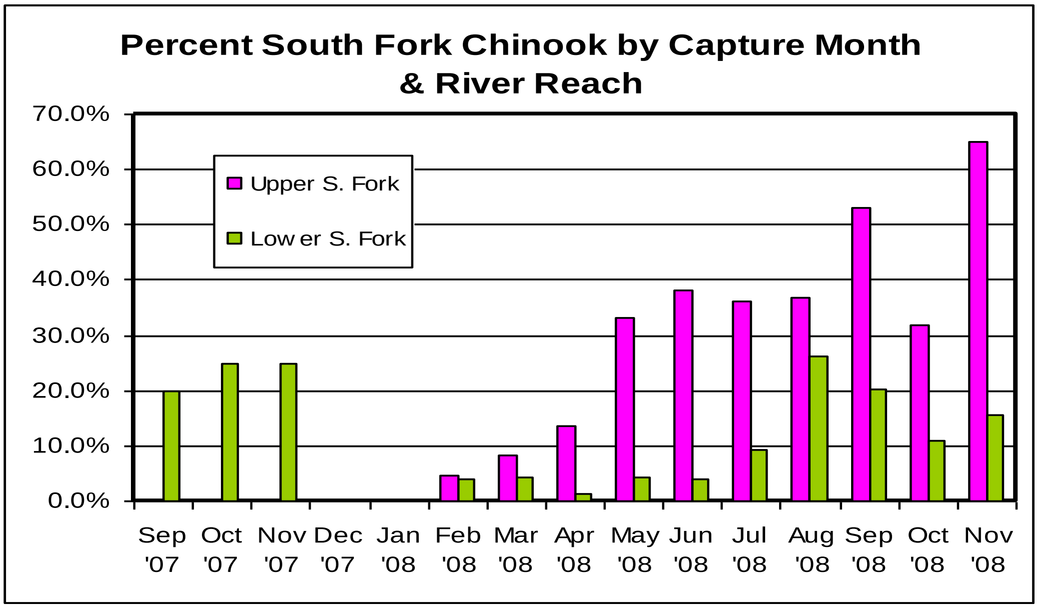

Figure 8. Plot of percent S. Fork Chinook in monthly catch in the Upper South Fork and Lower South Fork from September 18, 2007 to December 31, 2008.

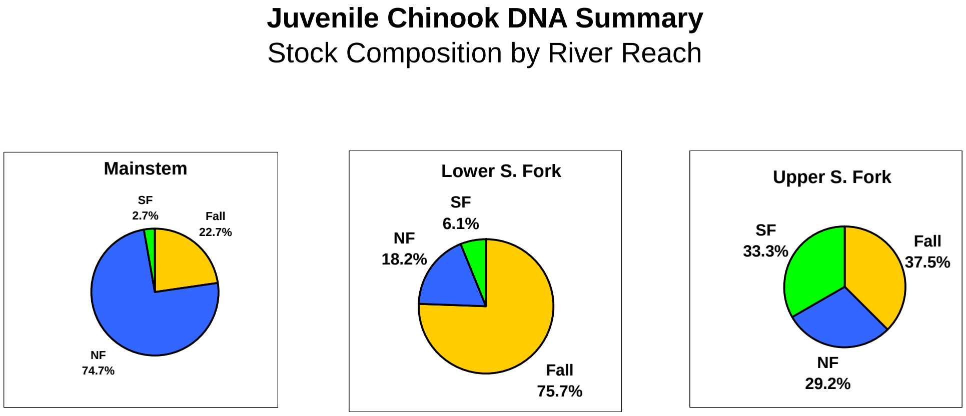

Figure 9. Pie diagrams showing stock composition by river reach in 2008 and 2009.

Chinook Fork-Length Data

Fork lengths are plotted by capture month in Figure 10. None of the brood years are complete for an entire freshwater life-history, but BY2007 is the most complete. The July – August slope indicates the period of greatest growth. The greatest fork-length measurements were approximately 120 mm, indicating maximum freshwater growth. Figure 11 is a box-plot showing fork-length data by month for each of the three identified Chinook stocks. No obvious differences are apparent between the stocks. There is a slight reduction in forklength from November to December for all stocks. Fork-lengths are plotted for each stock by month in Figure 12.

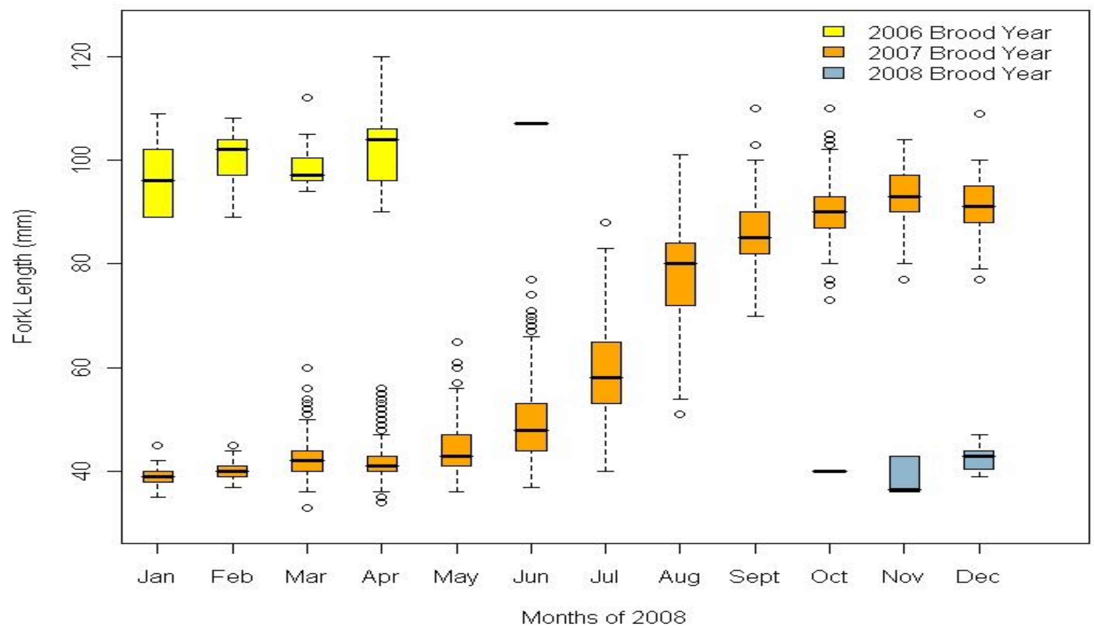

Figure 10. Box plot of fork lengths for all juvenile Chinook salmon caught during 2008 separated by brood year. The dark lines represent the median of the distribution, the box represents the 25% to 75% interquartile range of the data, the whiskers represent the 95% range, and open circles are outliers.

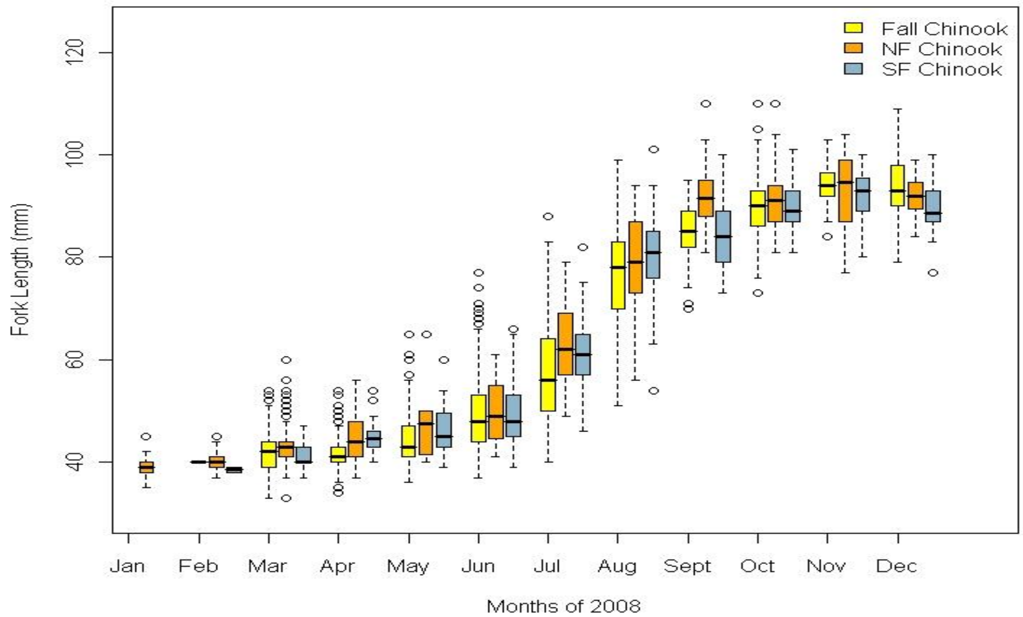

Figure 11. Box plot of fork lengths for juvenile Chinook salmon brood year 2007 caught during 2008 separated by stock. The dark line represents the median of the distribution, and the boxes represents the 25% to 75% interquartile range of the data, the whiskers represent the 95% range, and open circles are outliers.

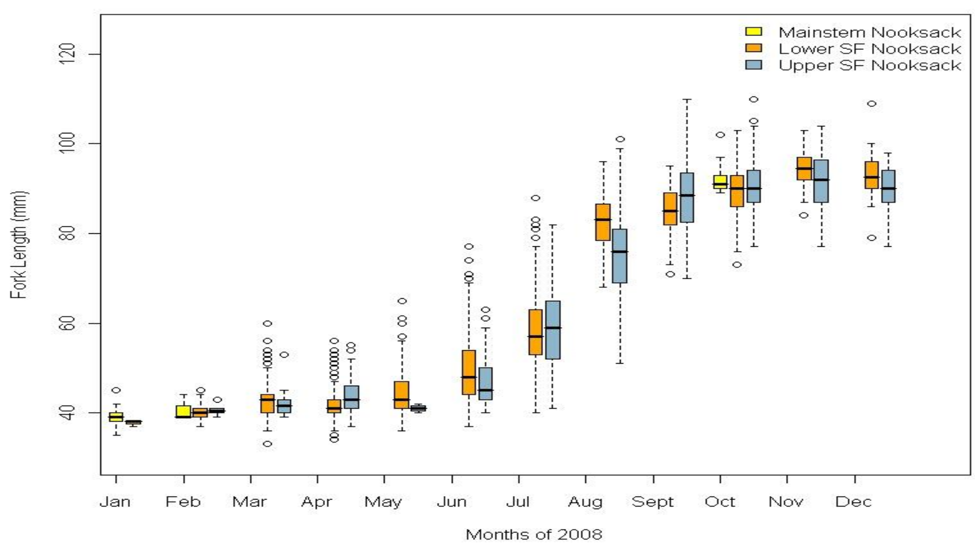

Figure 12: Box plot of fork lengths for juvenile Chinook salmon from brood year 2007 caught during 2008 separated by location. Dark lines represents the median of the distribution, the boxes represents the 25% to 75% interquartile range of the data, the whiskers represent the 95% range, and open circles are outliers.

Non-Chinook Species

Following Chinook, juvenile trout (*Salmo sp*.) were the second most numerous group in our seine catch. During this 15-month period both Tribes caught 3,597 trout. No attempt was made to distinguish steelhead (*Oncorhynchus mykiss*).from cutthroat (*Oncorhynchus clarki*). in smaller individuals with a fork-length less than 70 mm. Fourteen cutthroat trout were identified from larger individuals.

Other salmonids in our seine catch included 1,445 juvenile Coho (*Oncorhynchus kisutch*) of which 80 were hatchery origin with an adipose fin clip. Ninety one sockeye (*Oncorhynchus nerka*) and 18 Chum (*Oncorhynchus keta*) were also captured.

We caught 34 char**,** (*Salvelinus sp*). DNA tissues were taken from many of these individuals to identify those that may be Bull Trout (*Salvelinus confluentus)*

Most numerous non-salmonid species (582 caught) was the Mountain Whitefish (*Prosopium williamsoni*) followed by 73 Longnose Dace (*Rhinichthys cataractae*), 35 sculpins, Family *Cottidae* (various species), and 24 Large-scale Sucker, (*Catostomus sp.*).

Discussion

River Turbidity and Chinook Abundance

River turbidity is estimated during each seine set by noting the maximum water depth in centimeters where the bottom substrate is still visible. This is referred to as “visibility depth”. Early on, it was noted that our catch increased with turbidity. This is likely a combination of reduced “gear avoidance” afforded by more turbid conditions and a more active fish behavior that is less restricted due to reduced predation when the water is cloudy. Three turbidity categories were based on the “visibility depth” during the seine set. The “Turbid” category is for visibility depths less than 30 cm. “Moderate” turbidity is for readings from 30 – 70 cm and “Clear” conditions are those with visibility depths exceeding 70 cm.

The average catch per set of juvenile Chinook was calculated and plotted for each of the turbidity categories in Figure 13. It can be seen that Chinook abundance is over twice as high (4.5 vs. 1.8 Chinook / set) under turbid conditions than in moderate or clear conditions.

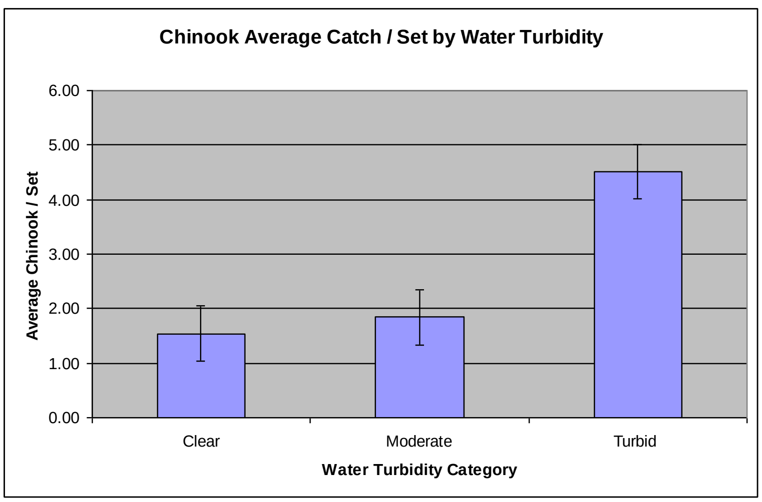

Figure 13. Average Chinook catch per set for three water turbidity categories.

River Discharge and Chinook Abundance

South Fork mainstem stream flows for the study period are shown in Figure 14. This was taken from the USGS gauge on the Saxon Bridge at RM 12.8. Four flow categories are shown. Very High are flows unfishable at nearly all sites where the discharge exceeds 3,000 cubic feet per second (cfs). High Flows are those above bank-full, 1,000-3,000 cfs. Medium flows are 500 – 1,000 cfs and Low Flows are less than 500 cfs, which allows stream crossing at most sites.

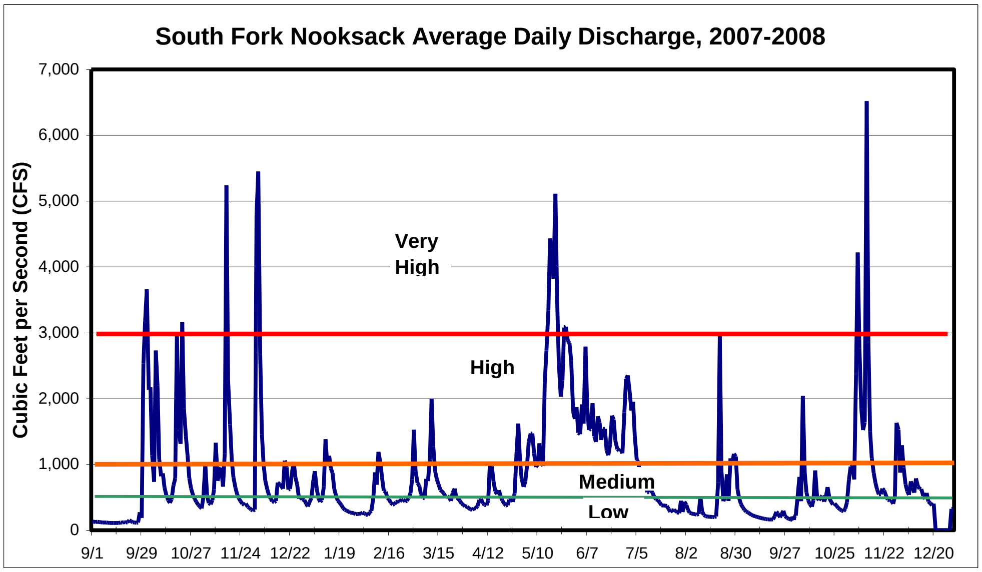

Figure 14. Plot of average daily discharge during the study period taken at the USGS stream gauge at the Saxon Road Bridge (RM 12.8)

Chinook abundance as represented by catch per set was calculated and plotted for sets completed during each of these flow categories in Figure 15. The "high" flow category resulted in the highest average catch per set (7.5) followed by "very high" flows (4.0). Another factor that contributes to the lower abundance during lower flows has to do with the timing of low flow periods. Many Chinook leave the South Fork during the spring outmigration and actual Chinook abundance is less during the summer months when flows are typically lower.

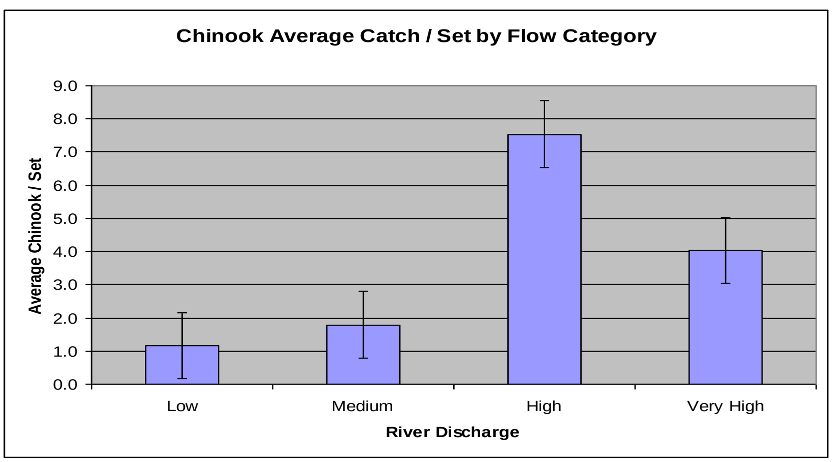

Figure 15. Average Chinook catch per set for four streamflow categories.

<u>Water Temperature and Chinook Abundance</u>

Average daily water temperature as taken from the Saxon Bridge gage at river mile 12.9 is shown in Figure 16. This plot groups temperatures into four categories, "hot" where average daily temperatures exceed 15 C, "warm" with temperatures from 12-15C, "cool" 4-12 C, and "cold" below 4C.

Average Chinook CPUE was calculated for each of the temperature categories. These are shown in Figure 17. In the winter when water temperatures fall below 4C, catches drop off, indicating that perhaps juveniles are located out of reach of the beach seine in deeper areas or underneath cover structure. They are also less likely to be mobile to conserve energy reserves when the water is cold which might also reduce the swimming range if this is outside the area fished by the seine. Smaller individuals might also burrow into cobble substrate where they cannot be captured by the seine.

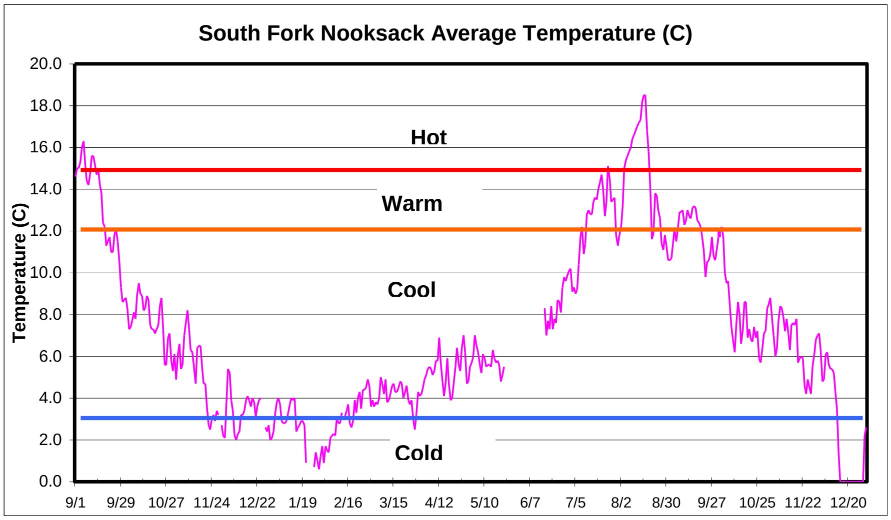

Figure 16. Average daily water temperature at the USGS gage at the Saxon Bridge and four defined temperature ranges.

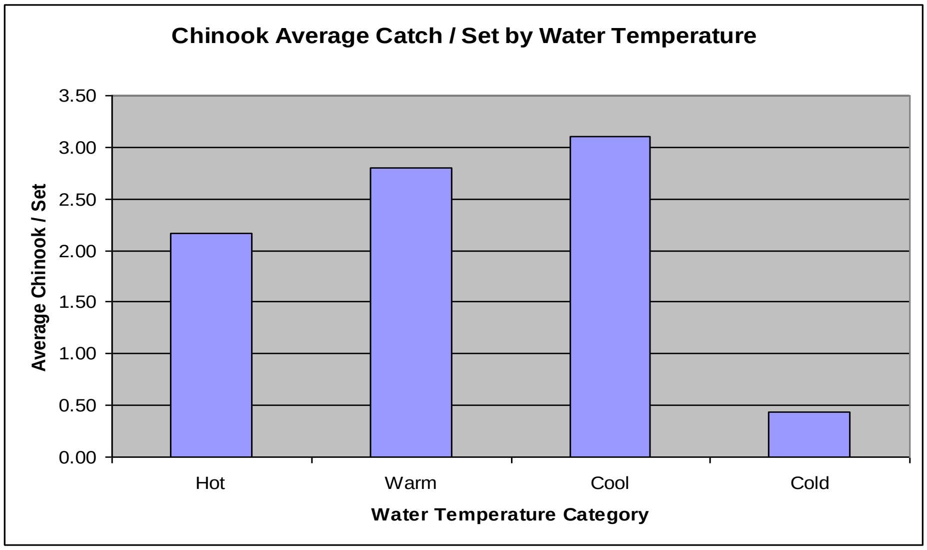

Figure 17. Average Chinook catch per set for four water temperature categories.

Juvenile Chinook Mortalities

Appendix D lists our mortality data. Catch and hatchery records indicate that 125 juvenile Chinook died during this 15-month brood collection period. Most losses occurred at the Skookum Hatchery. Fourteen Chinook died during field operations (Lummi data only) as a result of seining and transport to the hatchery.

Most mortalities (53) were discovered during the holding period, either in holding tanks or in the isolation trays at the hatchery. In all cases these were found by DNA sampling crews. No daily monitoring of these tanks/trays occurred at the hatchery, and so it is not known if these mortalities appeared soon after transfer to the tanks / trays or if there were causes not related to moving these fish.

We believe some of these mortalities may have resulted from stress associated with prior field collection and transport during the “warm water” period (7/1/08 – 9/30/08). These were dates when average daily water temperatures exceeded 10 C (USGS gage data). Eight Chinook were lost in transport on 7/7/08 at the start of this warm water period., Fish loading and low dissolved oxygen levels in transport containers may be a related to this incident.

As a result of these losses, we developed “warm water” transport protocols which are found in Appendix E. These focus on temperature and DO monitoring during transport and the use of ice to cool buckets during transport from the river to the truck and during the ride to the hatchery.

In the early weeks of this project significant losses (20) occurred at the Skookum Hatchery, possibly as a result of the quality of hatchery water supplies or changes to the water supply during the holding period.

There were 5 mortalities as a result of net capture. On at least one occasion a mortality was the result of mechanical injury after a large rock was found in the net. The non-reported Nooksack Tribe’s field losses from capture may be similar to our mortalities. If we assume this to be the case, there would be a total of 130 mortalities. Compared to our total juvenile Chinook catch of 3,911, our approximate overall mortality rate would be 3.3%.

If we can avoid “warm-water” mortalities, perhaps our mortalities could have been reduced by 50 individuals, resulting in a rate of 2.0%.

<u>Notes on Juvenile Chinook Habitat Utilization</u>

Appendix F is a table suggesting a simplified model of juvenile Chinook behavior and habitat utilization. We theorize that behavior of juvenile Chinook depends on the development life-stage and is highly influenced by three principal stream conditions: river discharge, turbidity, and temperature. These life-stages and environmental factors in-turn influence the nature of the habitat sought by individuals. This is, of course, a very simplistic model that ignores many other factors such as presence and abundance of predators, diel responses, and inter- and intra- specific competition for limited food and selected habitats.

This model predicts that when river conditions are cold (less than 4 C) and clear, both post-emergent fry and yearlings restrict swimming to conserve energy reserves. Under these conditions, we believe they seek cover within or under large woody debris (LWD) so as to avoid the need to escape from predators when the water is clear. This behavior seems to be consistent with our difficulty in catching juveniles during these periods, because we cannot sample these habitats effectively with the beach seine. Also, smaller post-emergent individuals may also be in the cobble and not easily captured with the beach seine.

As water temperatures warm gradually, movement becomes greater which might explain why our catch per set improves slightly. As the swimming range expands to include areas within our sampling area we are more able to catch juvenile Chinook, especially when the river is more turbid. Turbidity may have the dual effect of increasing swimming activity (more cover to avoid predation) and reducing gear avoidance, both of which contributes to better catches.

With warmer water temperatures, as the river becomes less turbid when flows decline, some feeding may start to occur as prey items become more visible for capture beyond the range where olfactory detections are possible. When flows increase and the water again becomes turbid, larger individuals may locate pockets of clearer water at the mouths of tributaries that provide “opportunistic” feeding, but also allow for avoidance of predators if turbid mainstem water is available to hide in nearby. Some of our highest seine catches have been under these conditions at these locations.

The urge to out-migrate is a shift from stationary feeding territories to active movement downstream, usually along channel margins in zero-age individualsin less turbid conditions. Yearlings may take a deeper route closer to the thalweg. Zero-age individuals in turbid condtions, are also likely to taking advantage of the downstream currents in deeper portions of the channel. Active movement make capture by the beach seine more likely, especially when the river is turbid because the need to seek cover in LWD and in deeper environments is lessened. During the months of active outmigration (April – June), when the river is turbid we have our highest average monthly catch/set, especially at sites in the lower South Fork (see figure 5). At one site (site #SF312 at river mile 13.96), when the velocity is not too great and the water depth is “wade-able”, we have been successful in catching sub-yearlings using a mid-channel technique to sweep the net upstream.

Our catch success remains high during the summer after the spring outmigration of zeros and yearlings which leaves only the sub-yearlings behind. These are undergoing their greatest growth rate, based on observed changes in fork-length (see Chinook Fork-Length Data section, above). We have found some seining techniques to be particularly effective during this period. One involves starting on the riffle immediately above the pool and allowing the net to sweep downstream through turbulent water on the riffle, past bubble curtains at the head of the pool, and sweeping along LWD in the pool before closing the net on the sandy bank opposite the log or logjam structure (see Figure 2). We accomplish a high catch per set at sites that allow this technique (e.g. Site SF290 at river mile 12.5) during the active feeding period that can extend into the early fall. At these time, snorkel observations, indicate Chinook are maintaining feeding stations at the head of the pool, near LWD. They sometimes also using turbulence for cover when the water is clear. In late summer as temperatures rise and DO lowers, being in the more oxygenated water at these locations becomes a necessity, especially if energy is going to be expended to capture prey.

In the fall, after the first freshet, the water again becomes more turbid and flows increase. Some of our sites cannot be reached due to the need to cross the river. As the number of available sites are reduced, we have observed a gradual reduction in catch success if a site if visited often, indicating that perhaps there is some residency at these locations and that repeated fishing gradually “fishes out” a site. With moderate stream-flows, most sites tend to be pools.

On occasion, usually in November, will have a major flow event, sometimes exceeding bank-full levels. Under these conditions, the number of fishable seine sites are very limited but not absent altogether. Fishable sites tend to be in overflow channels where the meander zone of the river is wide or in confined areas that have a steep, but clear stream banks free of snags where lower water velocities allow setting the net in waders. Our highest catches have been under these high flow / turbid conditions at these sites. In both the overflow channels and in the confined mainstem sites, Chinook appear to be seeking the less swift margins, but are probably being swept downstream to some degree. This movement downstream is indicated by multiple sets with high catches at a single site when flows are very high.

As flows diminish, the water becomes less turbid. More sites become fishable but catches decline as the weather becomes cooler. When the water temperature drops below about 4 C, we seldom catch Chinook or other salmonids. Under these conditions they appear “hunkered down’ in substrate, not moving and in LWD not within the grasp of the beach seine.

Future work includes improving our catch under these “clear & cold” conditions. We will to attempt to locate new sites that include features creating temperature refugia, such as groundwater seeps or sites influenced by warmer tributaries.

Conclusions & Recommendations

We have demonstrated that Chinook belonging to the South Fork Stock can be collected for the Captive Brood Program. To accomplish this techniques have been developed to transport, hold, and collect tissues for DNA micro-satellite analysis. We have also insight into life-history patterns and habitat requirements of juvenile Chinook. Our Conclusions and Recommendations are listed below:

<u>Conclusions</u>

1. Small beach seines are effective at collecting juvenile Chinook for the captive brood program. To facilitate reaching remote sites, backpacks can be used to carry transport buckets and the seine net.
2. Transport time to the hatchery exceeding 1 hour can be achieved without mortalities when proper aeration cool water temperatures are maintained .
3. The incidence of South Fork Chinook in the catch is highest at seine sites in the upper South Fork, above Skookum Creek (RM12).
4. The percentage of South Fork Chinook in our catch increased from July to December, following the spring juvenile out-migration period.
5. In 2008, a high percentage of hatchery Fall Chinook were in our seine catch in April. Numbers of Falls in our catch declined gradually through July. During periods like this where Fall (or North Fork) Chinook are abundant, sub-sampling could reduce overall DNA costs.
6. Important environmental factors affecting catch success with the beach seine include: water turbidity, water temperature, and river discharge. Catch success for Chinook is high when the river is turbid and high. Only some sites can be sampled under high flows due to the profile of the streambank or because the need to cross the river to reach sites on the opposite bank.
7. Catch success is lowest when water temperature falls below approximately 4 C, and when the river is low and clear.
8. Importance and function of LWD to Chinook juveniles appears to be greatly influenced by river conditions. Under clear (less turbid) and cold conditions, juveniles appear to seek cover and are observed to be strongly associated with LWD. Conversely, when discharge is high and the river is turbid, juveniles are not strongly associated with LWD and may seek out shallower areas having lower velocities. The need for cover is replaced with the need to remain in non-moving water. Under these conditions the importance of LWD changes from habitat providing cover to a structure that in some locations, forms pockets of water having low velocities.
9. As warm water temperatures exceed approximately 12 C, special “warm water protocols” are needed to minimize transport mortalities. These may include aeration and chilling of transport buckets and regular monitoring of water temperature and dissolved oxygen levels.
10. The most rapid growth of juvenile Chinook, based on a comparison of fork-length measurements, appears to be in July and August. In 2008, Chinook belonging to the South Fork stock were smaller than other stocks after September.

Recommendations

1. Sub-sample large catches where a low percentages of South Fork individuals may be present to minimize DNA analysis costs.
2. Target areas and periods where prior sampling has yielded a high percentage confirmed S F Chinook juveniles (e.g.- upper South Fork sites in the Fall).
3. Secondarily, select sites and sampling periods to best represent the entire population of South Fork Chinook.
4. Employ "Warm Water Transport" protocols (chilled water containers, more frequent monitoring during transport) when water temperatures exceed 12 C and/or when air temperatures are forecast to exceed 20 C.
5. Set up a systematic sampling approach for productive seine sites to provide an index of juvenile abundance in selective reaches of the South Fork.
6. Examine juvenile fitness seasonally and in upper / lower sections of the South Fork by, in addition to fork length measurements, collecting body width and weight data to provide insight into growth and food availabitly.
7. Conduct daily monitoring of juveniles in tanks and trays at the hatchery, especially during warm water conditions. Preserve and label any juvenile mortalities for possible pathological examinations.
8. Examine juvenile Chinook weight / length relationships and correlate to observed body types ("deep-bodied", "normal", "slender"). Look for temporal or spatial relationships. Explore measurements of body depth to define body types.
9. Re-evaluate habitat features at sites and provide a comparative analysis with catch success (catch per set).
10. Exercise extreme care to avoid walking in cobble areas during the early emergence period to avoid crushing juveniles.
11. When conditions reduce catch (low water temperatures / clear water) explore alternate capture techniques:
    - Use swimmer in dry suit to make sets in deeper water
    - Use diver to locate presence of juveniles prior to setting net
    - Sample during twilight or dark periods
    - Set net around removable artificial cover structures
    - Use baited traps

Acknowledgements

The following dedicated field technicians from the Lummi Nation collected most of the field data included in this project: Hank Hoskins, David James Jr., Kyle Finkbonner, Ben LaClair, and Tom Morris Jr. Thanks also to Adam Pfundt, Biologist, who on many occasions provided crew oversight, logistical planning, and field assistance for this project.

I would like to recognize the Nooksack Tribe's field crew for contributing efforts towards collecting juvenile Chinook brood and providing beach seine data. They include Jim Bura, Lauren Roberts, and Russ Roberts. Thanks also to Ned Currence and Treva Coe for arraigning exchanges of field data.

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I'm especially appreciative to the following individuals who took the time to provide a critical review of this report: Ned Currence with Nooksack Natural Resources, Ryan Vasak, Michael LeMoine, and Adam Pfundt with Lummi Natural Resources.

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Appendices

Appendix A1. List of beach seine sites, page 1.

Site	Reach	RM	Bank	SiteName	Access
MS102	MS1	4.80	LB	Screwtrap Site	Hovander Park
MS280	MS1	13.20	RB	Fishtrap Cr. Mouth	River Road
MS298	MS1	15.30	LB	Guide Meridian Bridge	Guide Turnout
MS360	MS2	21.00	LB	Abbot Road Bar	Abbot Road
MS390	MS2	23.03	LB	Nultie Road Bar	Nultie Road
MS397	MS2	23.66	RB	Everson Park Side Channel	Everson Park
MS398	MS2	23.66	RB	Everson Park Bar	Everson Park
MS399	MS2	23.74	RB	Everson Park Bar, upstr	Everson Park
MS499	MS2	30.86	LB	Below Nugents Br., LB	Nugents Bridge, W.
MS502	MS3	30.88	RB	Above Nugents RB, lower	Nugents Bridge, E.
MS503	MS3	30.88	RB	Above Nugents RB, upper	Nugents Bridge, E.
MS514	MS3	31.70	LB	Shallow sand inside LWD	Jet boat - Nugents ramp
MS515	MS3	31.71	LB	Cobble backeddy	Jet boat - Nugents ramp
MS530	MS3	32.24	LB	LB Slough w/ LWD	Jet boat - Nugents ramp
MS540	MS3	32.67	LB	High bank cobble	Jet boat - Nugents ramp
MS560	MS3	33.72	LB	Swift steep cobble	Jet boat - Nugents ramp
MS569	MS3	35.00	LB	Coarse cobble	Jet boat - Nugents ramp
MS570	MS3	35.10	LB	Upper backeddy - 1st set	Jet boat - Nugents ramp
MS572	MS3	35.12	RB	Demming Slough	NNR Boneyard
MS573	MS3	35.12	RB	Demming MS	NNR Boneyard
SF001	LS1	0.00	RB	Confluence w/ N. Fork	Road to bar near bridge
SF105	LS1	3.60	RB	Todd Creek Logjam Site (Teneska)	Teneska Property
SF110	LS1	3.73	RB	Tree Farm, lower bar, dwnstr	Alpine Tree Farm,lower
SF111	LS1	3.75	RB	Tree Farm, lower bar, mid	Alpine Tree Farm,lower
SF112	LS1	3.79	RB	Tree Farm, lower bar, upstr	Alpine Tree Farm,lower
SF113	LS1	4.13	RB	TF upper Bar, lower slough TF04D	Alpine Tree Farm
SF114	LS1	4.13	RB	TF upper Bar, below LWD TF04C	Alpine Tree Farm
SF115	LS1	4.14	RB	TF upper Bar, above LWD TF04B	Alpine Tree Farm
SF121	LS1	4.15	RB	TF upper Bar, above LWD TF04A	Alpine Tree Farm
SF122	LS1	4.15	RB	TF upper Bar, truck site TF03B	Alpine Tree Farm
SF117	LS1	4.20	RB	TF upper Bar, opposite Cr. TF03A	Alpine Tree Farm
SF118	LS1	4.24	RB	TF upper Bar TF02B	Alpine Tree Farm
SF119	LS1	4.29	RB	TF upper Bar, Outside Jam TF02A	Alpine Tree Farm
SF120	LS1	4.31	RB	TF upper Bar, Inside Jam TF01	Alpine Tree Farm
SF168	LS1	6.43	RB	Kalsbeck,#5 (WP04)	Kalsbeek Property
SF169	LS1	6.44	RB	Kalsbeck,#4B (WP04)	Kalsbeek Property
SF170	LS1	6.45	RB	Kalsbeck,#4A (WP04)	Kalsbeek Property
SF172	LS1	6.60	MC	Kalsbeck Lower Channel	Kalsbeek Property
SF173	LS1	6.61	MC	Kalsbeck Mid-Channel	Kalsbeek Property
SF174	LS1	6.66	MC	Kalsbeck Upper-Channel	Kalsbeek Property
SF175	LS1	6.89	RB	Kalsbeck #2 (WP02)	Kalsbeek Property
SF176	LS1	6.91	RB	Kalsbeck #1 (WP01)	Kalsbeek Property
SF177	LS1	6.95	LB	Kalsbeck #3 (WP03)	Kalsbeek Property
SF180	LS1	8.10	RB	Old Hutch. Outlet	Hwy 9 Turnout
SF184	LS1	8.20	RB	Below Jam	Hwy 9 Turnout
SF185	LS1	8.24	RB	Small Jam dwnstr	Hwy 9 Turnout
SF186	LS1	8.26	RB	Small Jam upstr	Hwy 9 Turnout
SF210	LS2	8.67	RB	Bar above Acme Br.	MLR Turnout
SF211	LS2	8.68	RB	Upstr.bar above Br.	MLR Turnout
SF212	LS2	8.72	LB	Betty Lu's Bar dwnstr	Betty Lu's Park
SF213	LS2	8.76	LB	Betty Lu's Sandbar	Betty Lu's Park
SF214	LS2	8.80	LB	Betty Lu's Sandbar mid	Betty Lu's Park
SF215	LS2	8.81	LB	Betty Lu's Bar upstr	Betty Lu's Park
SF248	LS2	9.80	LB	Below Backeddy	E. Acme Farm Park
SF250	LS2	9.84	RB	Backeddy below Hutchinson	E. Acme Farm Park
SF251	LS2	9.85	RB	Slough below Hutchinson	E. Acme Farm Park
SF259	LS2	9.87	RB	Lower Overflow Channel	E. Acme Farm Park
SF252	LS2	9.88	LB	Lower High Flow Channel	E. Acme Farm Park
SF253	LS2	9.89	RB	Lower High Flow Braid	E. Acme Farm Park
SF254	LS2	9.90	RB	Mid High Flow Braid	E. Acme Farm Park
SF257	LS2	9.91	LB	Mid High Flow Channel	E. Acme Farm Park
SF256	LS2	9.93	RB	Upper High Flow Braid	E. Acme Farm Park
SF258	LS2	9.93	RB	Upper High Flow Channel	E. Acme Farm Park
SF201	LS2	10.19	RB	Hutchinson Mouth, upstream	E. Acme Farm Park
SF244	LS2	10.19	RB	Below Hutchinson Cr. Mouth, B	E. Acme Farm Park
SF245	LS2	10.19	RB	Below Hutchinson Cr. Mouth, A	E. Acme Farm Park
SF200	LS2	10.20	RB	Above Hutchinson Creek	E. Acme Farm Park

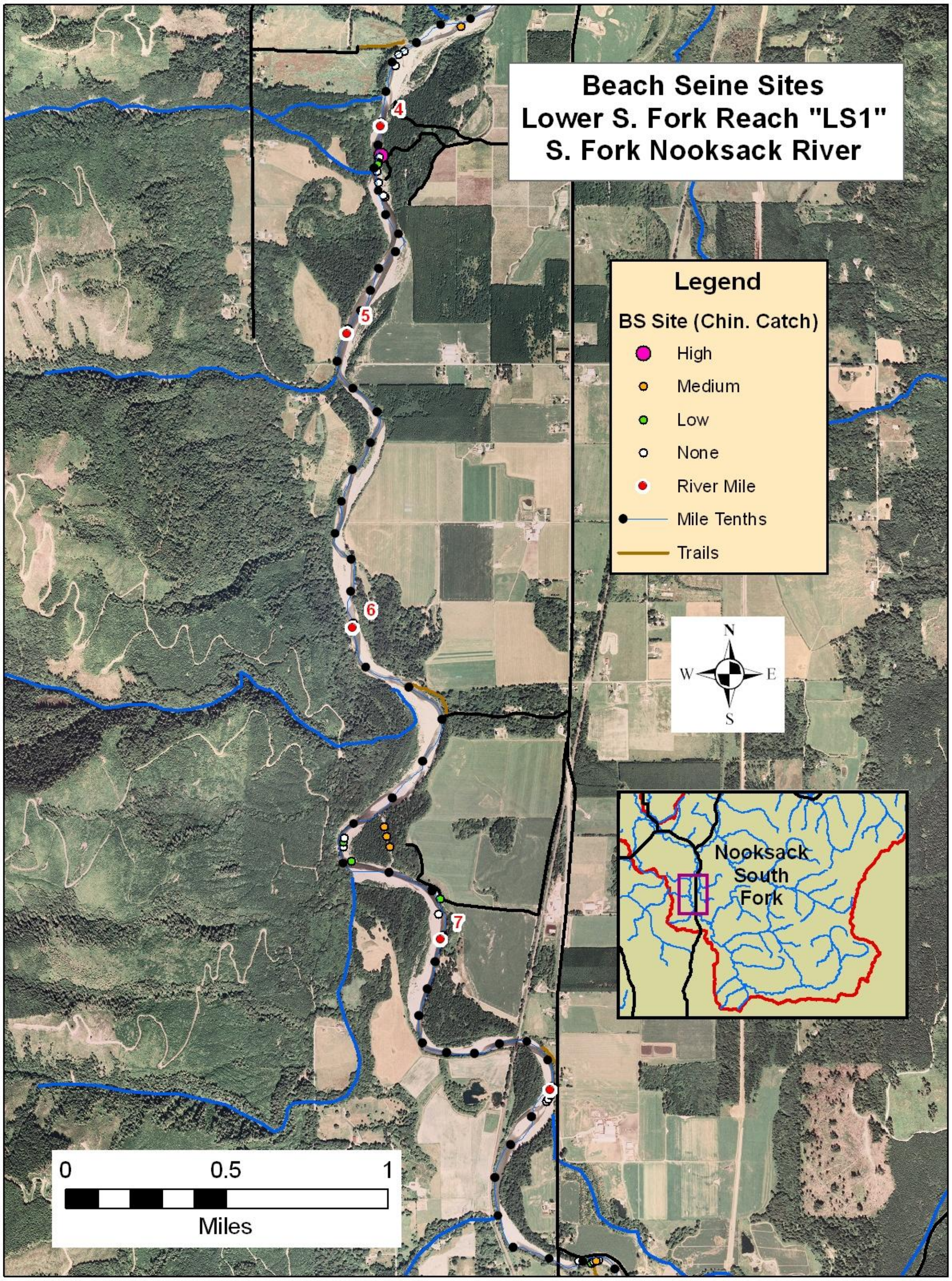
Appendix A2. List of beach seine sites, page 2

Site	Reach	RM	Bank	SiteName	Access
SF204	HC	10.20	LB	Hutchinson Creek lower pool	E. Acme Farm Park
SF205	HC	10.20	RB	Hutchinson Creek swift bar	E. Acme Farm Park
SF206	HC	10.20	RB	Hutchinson Cr. WPB 296	E. Acme Farm Park
SF207	HC	10.20	RB	Hutchinson Cr. WPB 297	E. Acme Farm Park
SF208	HC	10.20	RB	Hutchinson Cr. WPB 298	E. Acme Farm Park
SF209	HC	10.20	RB	Hutchinson Cr. WPB 299	E. Acme Farm Park
SF218	LS3	10.23	RB	Hutchinson Cr Mouth WPB 295	E. Acme Farm Park
SF234	LS3	11.12	RB	Downstream of trail WP104	WLT Curtis Property
SF235	LS3	11.13	RB	Downstream of trail WP101	WLT Curtis Property
SF236	LS3	11.19	RB	Downstream of trail WP103	WLT Curtis Property
SF237	LS3	11.20	RB	Downstream of trail WP102	WLT Curtis Property
SF238	LS3	11.21	LB	Downstream of trail WP100	WLT Curtis Property
SF239	LS3	11.22	RB	Downstream of trail WP99	WLT Curtis Property
SF240	LS3	11.26	RB	Downstream of trail WP98	WLT Curtis Property
SF270	LS3	11.30	LB	WLT Oveflow Bank	WLT Curtis Property
SF272	LS3	11.38	RB	Below Riffle C WP 97	WLT Curtis Property
SF273	LS3	11.39	RB	Below Riffle B WP 96	WLT Curtis Property
SF274	LS3	11.41	RB	Below Riffle A WP 95	WLT Curtis Property
SF275	LS3	11.44	RB	Riffle/Pool	WLT Curtis Property
SF277	LS3	11.50	LB	LB Sandbar, lowest site	WLT Curtis Property
SF260	LS3	11.51	LB	LB Sandbar lower	WLT Curtis Property
SF276	LS3	11.52	RB	Bever Den	WLT Curtis Property
SF261	LS3	11.53	LB	LB Sandbar lower	WLT Curtis Property
SF262	LS3	11.53	LB	LB Sandbar lower	WLT Curtis Property
SF263	LS3	11.54	LB	LB Sandbar, mid reach	WLT Curtis Property
SF264	LS3	11.55	LB	LB Sandbar, mid reach	WLT Curtis Property
SF265	LS3	11.56	LB	LB Sandbar, mid reach	WLT Curtis Property
SF266	LS3	11.56	LB	LB Sandbar, mid reach	WLT Curtis Property
SF267	LS3	11.56	LB	LB Sandbar, mid reach	WLT Curtis Property
SF278	LS3	11.56	RB	Alder glide	WLT Curtis Property
SF268	LS3	11.68	LB	LB Sandbar, uppermost site	WLT Curtis Property
SF279	LS3	11.72	LB	Willow & logs,below	WLT Curtis Property
SF280	LS3	11.73	LB	Willow & logs	WLT Curtis Property
SF283	LS3	12.26	LB	Below Saxon Br. - WP 279	Property Below Saxon Br
SF284	LS3	12.27	LB	Below Saxon Br. - WP 281	Property Below Saxon Br
SF285	LS3	12.28	LB	Below Saxon Br. - WP 280	Property Below Saxon Br
SF296	LS3	12.29	RB	Below Saxon Br. - WP 275	Property Below Saxon Br
SF297	LS3	12.30	RB	Below Saxon Br. - WP 274	Property Below Saxon Br
SF298	LS3	12.31	RB	Below Saxon Br. - WP 272	Property Below Saxon Br
SF291	LS3	12.34	RB	Below Saxon Br. - WP 273	Property Below Saxon Br
SF292	LS3	12.37	RB	Below Saxon Br. - WP 276	Property Below Saxon Br
SF281	LS3	12.41	RB	Left Channel - WPA 005	Property Below Saxon Br
SF293	LS3	12.44	RB	Below Saxon Br. - WP 278	Property Below Saxon Br
SF294	LS3	12.45	RB	Below Saxon Br. - WP 277	Property Below Saxon Br
SF286	LS3	12.46	RB	Lower sandbar	Property Below Saxon Br
SF287	LS3	12.47	RB	Bend in bar	Property Below Saxon Br
SF288	LS3	12.48	RB	Below stump	Property Below Saxon Br
SF289	LS3	12.49	RB	Glide below pool	Property Below Saxon Br
SF290	LS3	12.50	RB	Logjam Pool	Property Below Saxon Br
SF299	LS3	12.51	LB	Below Saxon Br. - WP 282	Property Below Saxon Br
SF295	LS3	12.78	LB	Logs & Riprap	Below Saxon Br
SF300	LS3	12.90	RB	Above Saxon Bridge	Saxon Road Turnout
SF303	LS3	13.38	LB	Riprap Glide "C"	Saxon Road Turnout
SF304	LS3	13.39	LB	Riprap Glide "B"	Saxon Road Turnout
SF305	LS3	13.40	LB	Riprap Glide "A"	Saxon Road Turnout
SF306	LS3	13.84	RB	Forever Fishing Site, below	Saxon Road Turnout
SF307	LS3	13.85	RB	Forever Fishing Site	Saxon Road Turnout
SF301	LS3	13.86	RB	Forever Fishing Site, above	Saxon Road Turnout
SF308	LS3	13.94	RB	Below Skookum Id., lower	Saxon Road Turnout
SF309	LS3	13.96	RB	Below Skookum Id. Pool	Saxon Road Turnout
SF312	LS3	13.96	MC	Below Skookum Id., upstr set	Saxon Road Turnout
SF310	LS3	13.98	LB	Below Skookum Id. LB,lower	Saxon Road Turnout
SF311	LS3	13.99	LB	Below Skookum Id. Pool, LB	Saxon Road Turnout
SF314	LS3	14.02	LB	Skookum Id. L Chan., lower	Skookum Hatchery outlet
SF313	LS3	14.03	LB	Skookum Id. L Chan., upper	Skookum Hatchery outlet
SF316	LS3	14.20	RB	Below Skookum Creek Mouth	Saxon Road

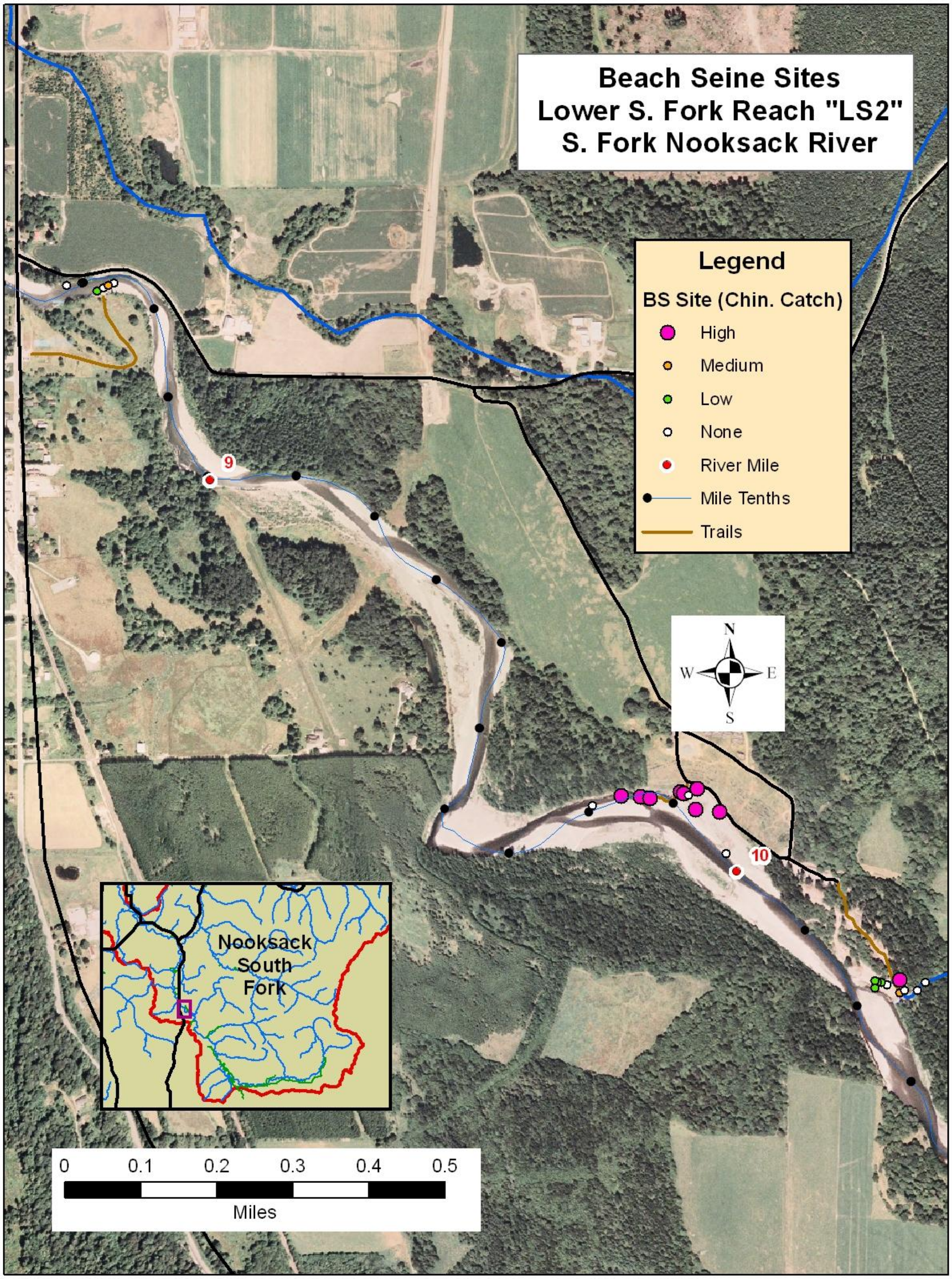
Appendix A3. List of beach seine sites, page 3

Site	Reach	RM	Bank	SiteName	Access
SF325	US1	15.15	RB	Below Edfro - RB, lower	Edfro Trail
SF326	US1	15.19	RB	Below Edfro - RB	Edfro Trail
SF327	US1	15.21	LB	Below Edfro - LB	Edfro Trail
SF328	US1	15.21	LB	Above Overflow Channel	Edfro Trail
SF329	US1	15.42	LB	Edfro Island RB Channel, upper	Edfro Trail
SF330	US1	15.44	RB	Above Edfro Island	Edfro Trail
SF444	US2	18.00	LB	LB Trib mouth above Cable Xing	Cable Xing Trail
SF445	US2	18.01	LB	Upstr of LB Trib above Cable Xing	Cable Xing Trail
SF446	US2	18.01	LB	Slough above Cable Xing	Cable Xing Trail
SF447	US2	18.05	LB	LB Sidechannel Log below	Cable Xing Trail
SF448	US2	18.05	LB	LB Sidechannel Log above	Cable Xing Trail
SF443	US2	18.06	RB	At Trailhead	Cable Xing Trail
SF449	US2	18.06	LB	LB Sidechannel, lower	Cable Xing Trail
SF450	US2	18.06	LB	LB Sidechannel, upper	Cable Xing Trail
SF451	US2	18.10	LB	Pool Below Big Jam, lower	Cable Xing Trail
SF452	US2	18.11	LB	Pool Below Big Jam	Cable Xing Trail
SF453	US2	18.12	RB	Cable Xing LJ, pool above	Cable Xing Trail
SF454	US2	18.12	RB	Cable Xing LJ boulder set	Cable Xing Trail
SF455	US2	18.12	RB	RB Chan. upstr. of LJ, lower	Cable Xing Trail
SF456	US2	18.13	RB	RB Chan. upstr. of LJ, upper	Cable Xing Trail
SF457	US2	18.13	RB	LB Chan. Below lateral chan.	Cable Xing Trail
SF470	US2	18.13	RB	Cable Xing LJ, pool above, upstr.	Cable Xing Trail
SF467	US2	18.17	LB	RB Channel	Cable Xing Trail
SF468	US2	18.20	LB	RB Channel	Cable Xing Trail
SF458	US2	18.22	RB	LB Channel	Cable Xing Trail
SF469	US2	18.22	RB	LB Channel	Cable Xing Trail
SF459	US2	18.26	RB	RB Glide below Island	Cable Xing Trail
SF460	US2	18.27	LB	LB Glide, lower	Cable Xing Trail
SF461	US2	18.29	LB	LB Glide, upper	Cable Xing Trail
SF462	US2	18.33	LB	Wooded Island Pool, LB	Cable Xing Trail
SF463	US2	18.33	MC	Wooded Id Pool, parallel set	Cable Xing Trail
SF464	US2	18.34	RB	Wooded Island Pool, lower	Cable Xing Trail
SF465	US2	18.34	RB	Wooded Island Pool, upper	Cable Xing Trail
SF466	US2	18.34	RB	Wooded Island above Pool	Cable Xing Trail
SF471	US2	18.34	MC	Wooded Id overflow channel	Cable Xing Trail
SF473	US2	18.37	RB	Wooded Id Kyles Site	Cable Xing Trail
SF475	US3	19.73	LB	Opp. LWD at sidechan.	Dunphy Delight Trail
SF476	US3	19.76	LB	Middle Channel WP 001	Dunphy Delight Trail
SF477	US3	19.78	LB	Right Channel WP 002	Dunphy Delight Trail
SF484	US3	19.81	LB	RB Side Channel & DD Cr.	Dunphy Delight Trail
SF483	US3	19.82	LB	RB Side Channel, lower	Dunphy Delight Trail
SF481	US3	19.87	RB	LB chan. Glide	Dunphy Delight Trail
SF478	US3	19.89	LB	Opposite ELJ #6 site "C"	Dunphy Delight Trail
SF479	US3	19.89	LB	Opposite ELJ #6 site "B"	Dunphy Delight Trail
SF480	US3	19.89	LB	Opposite ELJ #6 site "A"	Dunphy Delight Trail
SF482	US3	19.89	RB	LB chan. below Stump	Dunphy Delight Trail
SF485	US3	20.02	LB	Below Plumbago Cr	Dunphy Delight Trail
SF486	US3	20.04	LB	Below Roaring Cr.	Dunphy Delight Trail
SF499	US3	20.59	LB	Below Larson's Br.	Below Larson's Bridge
SF501	US3	20.61	LB	Just above Larsons	Larson's Bridge Turnout
SF502	US3	20.62	LB	Above Larson's Br.	Larson's Bridge Turnout
SF503	US3	20.66	LB	Below Claybank	Larson's Bridge Turnout
SF504	US3	20.67	LB	Claybank Eddy	Larson's Bridge Turnout
SF510	US3	20.88	RB	Larsons NNR#2	Trail Above Larson's Br.
SF511	US3	20.89	LB	Mouth of Unnamed Tributary	Trail Above Larson's Br.
SF509	US3	20.90	LB	Above Mouth of Tributary	Trail Above Larson's Br.
SF512	US3	21.00	LB	Backeddy at trail end	Trail Above Larson's Br.
SF514	US3	21.03	RB	Below Claybank	Trail Above Larson's Br.
SF515	US3	21.05	LB	Larsons NNR#1 C	Trail Above Larson's Br.
SF516	US3	21.06	LB	Larsons NNR#1 B	Trail Above Larson's Br.
SF517	US3	21.07	LB	Larsons NNR#1 A	Trail Above Larson's Br.
SF518	US3	21.08	LB	Below LB Channel riffle	Trail Above Larson's Br.
SF519	US3	21.09	RB	Upper RB Channel - RB	Trail Above Larson's Br.
SF520	US3	21.10	LB	Upper RB Channel - LB	Trail Above Larson's Br.

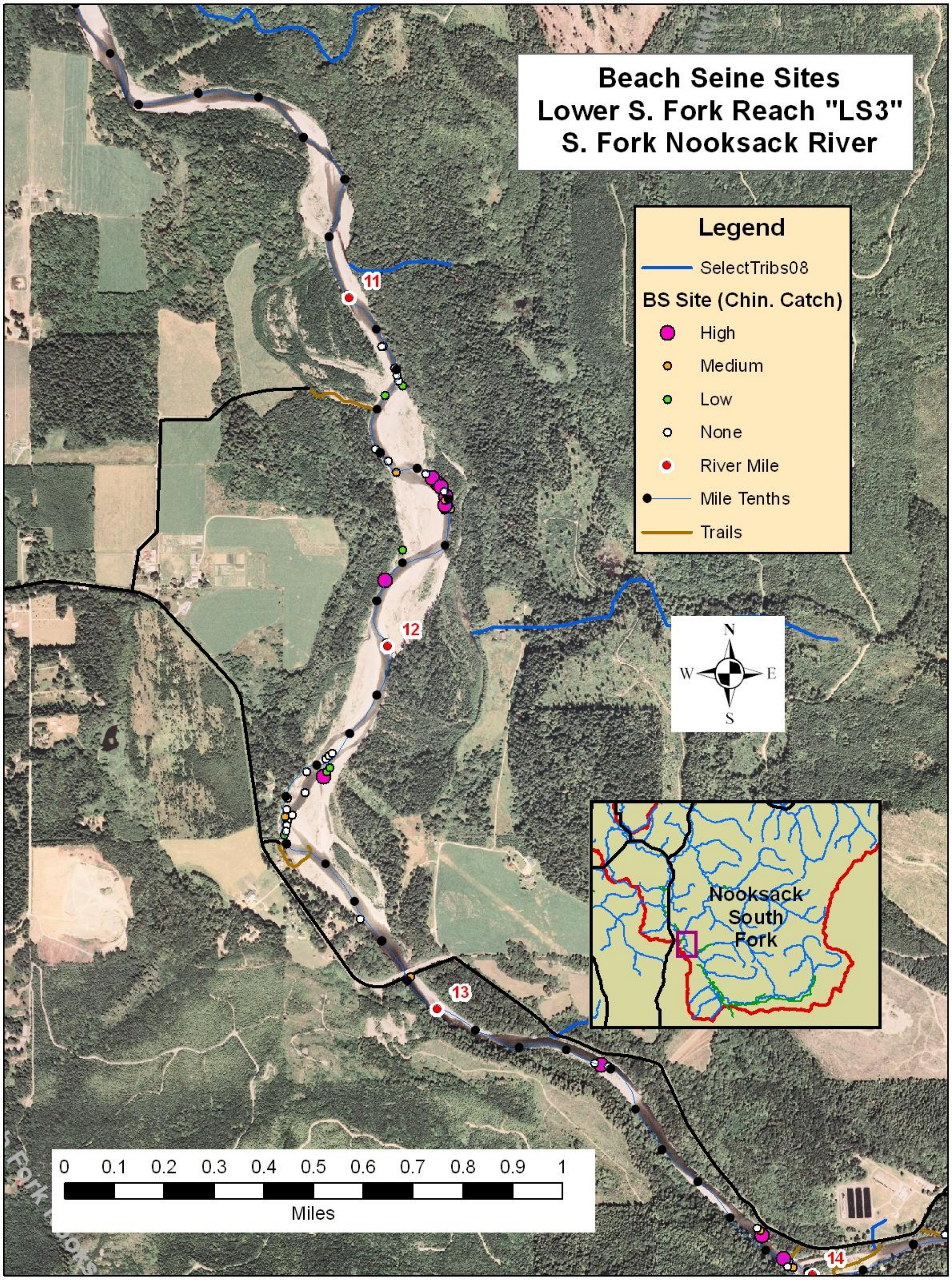
Appendix Figure B1. Map of seine sites coded by Chinook abundance (catch/set) for Lower South Fork reach “LS1”.



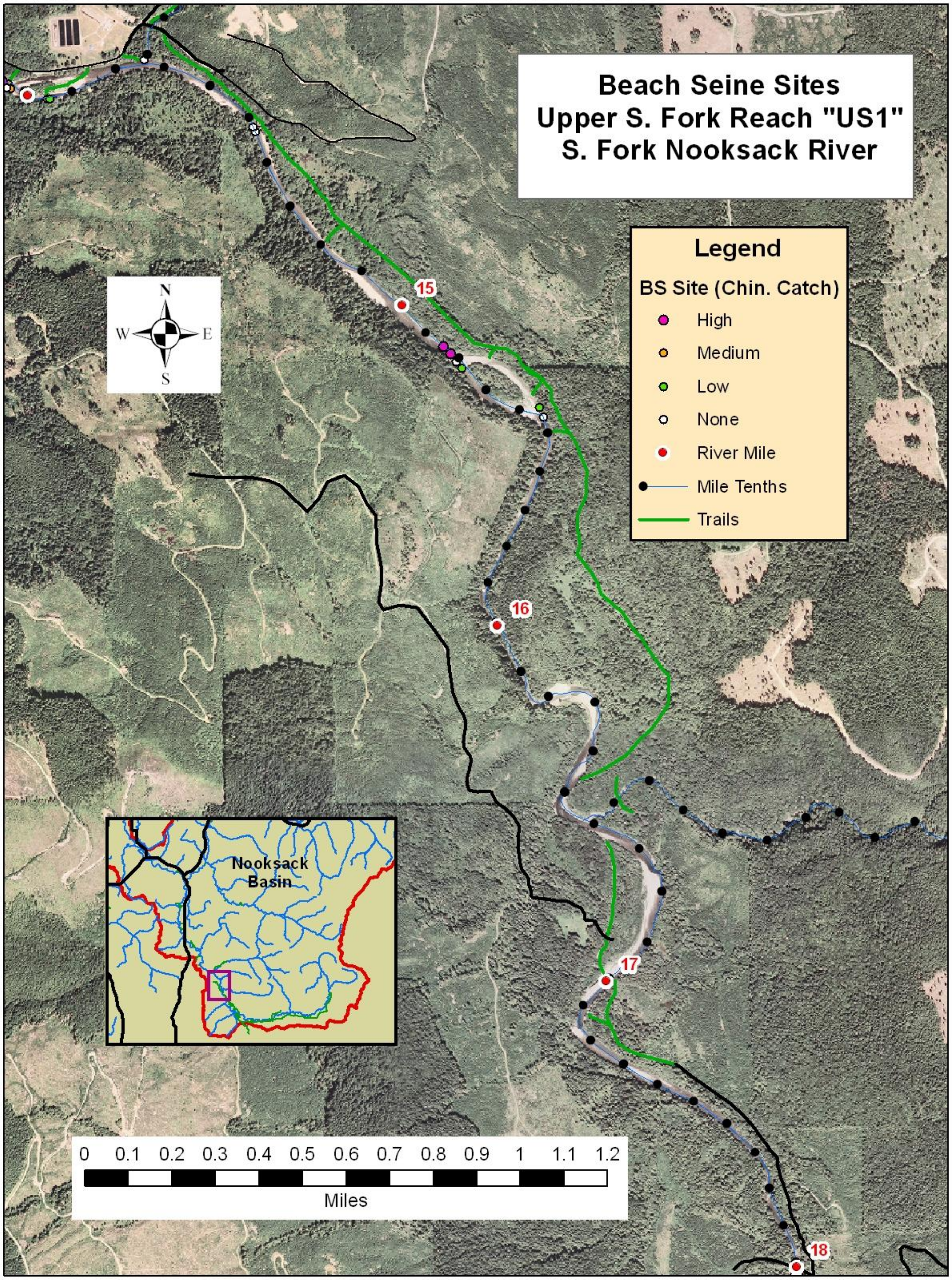
Appendix Figure B2. Map of seine sites coded by Chinook abundance (catch/set) for Lower South Fork reach “LS2”.



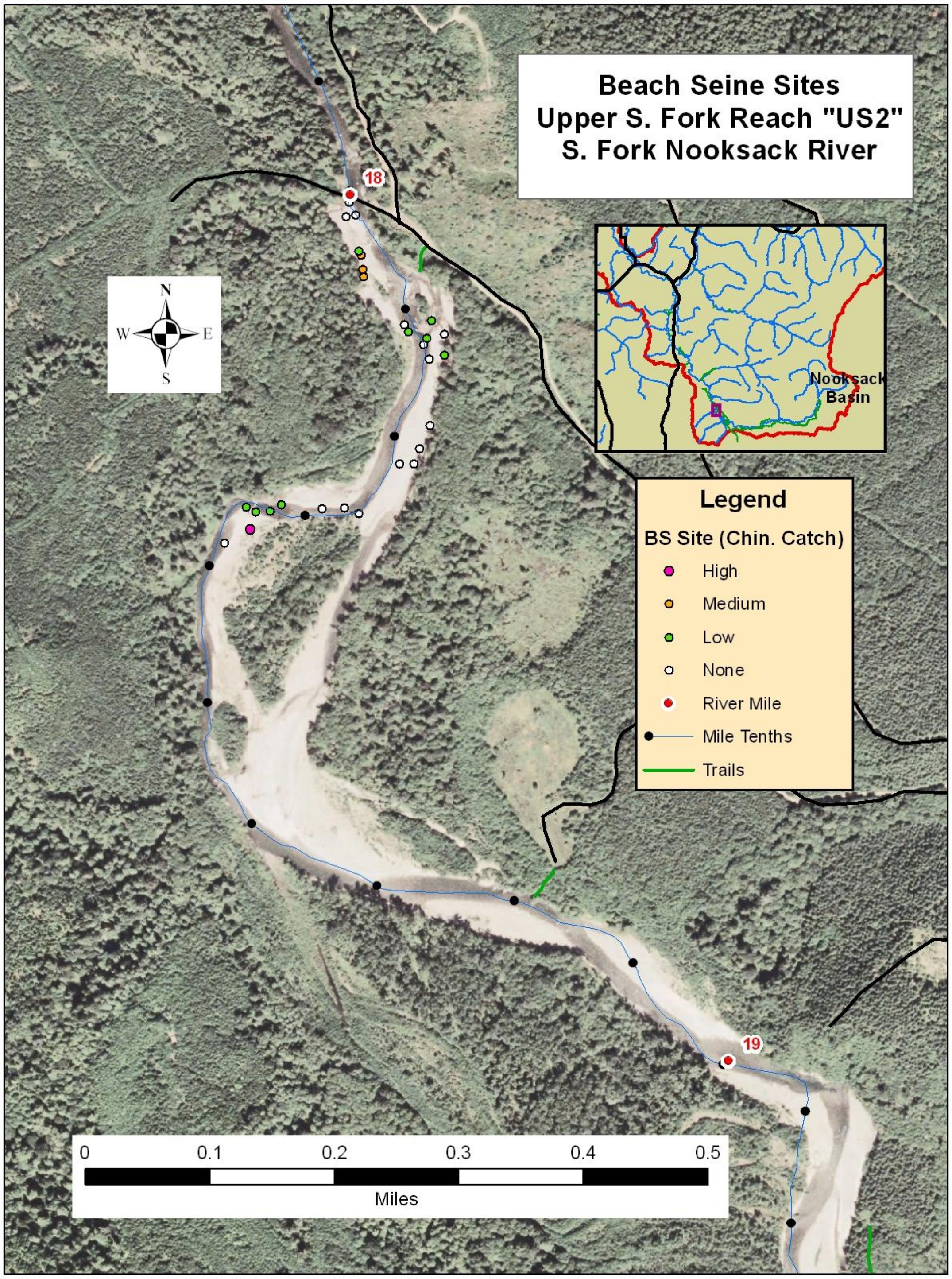
Appendix Figure B3. Map of seine sites coded by Chinook abundance (catch/set) for Lower South Fork reach "LS3".



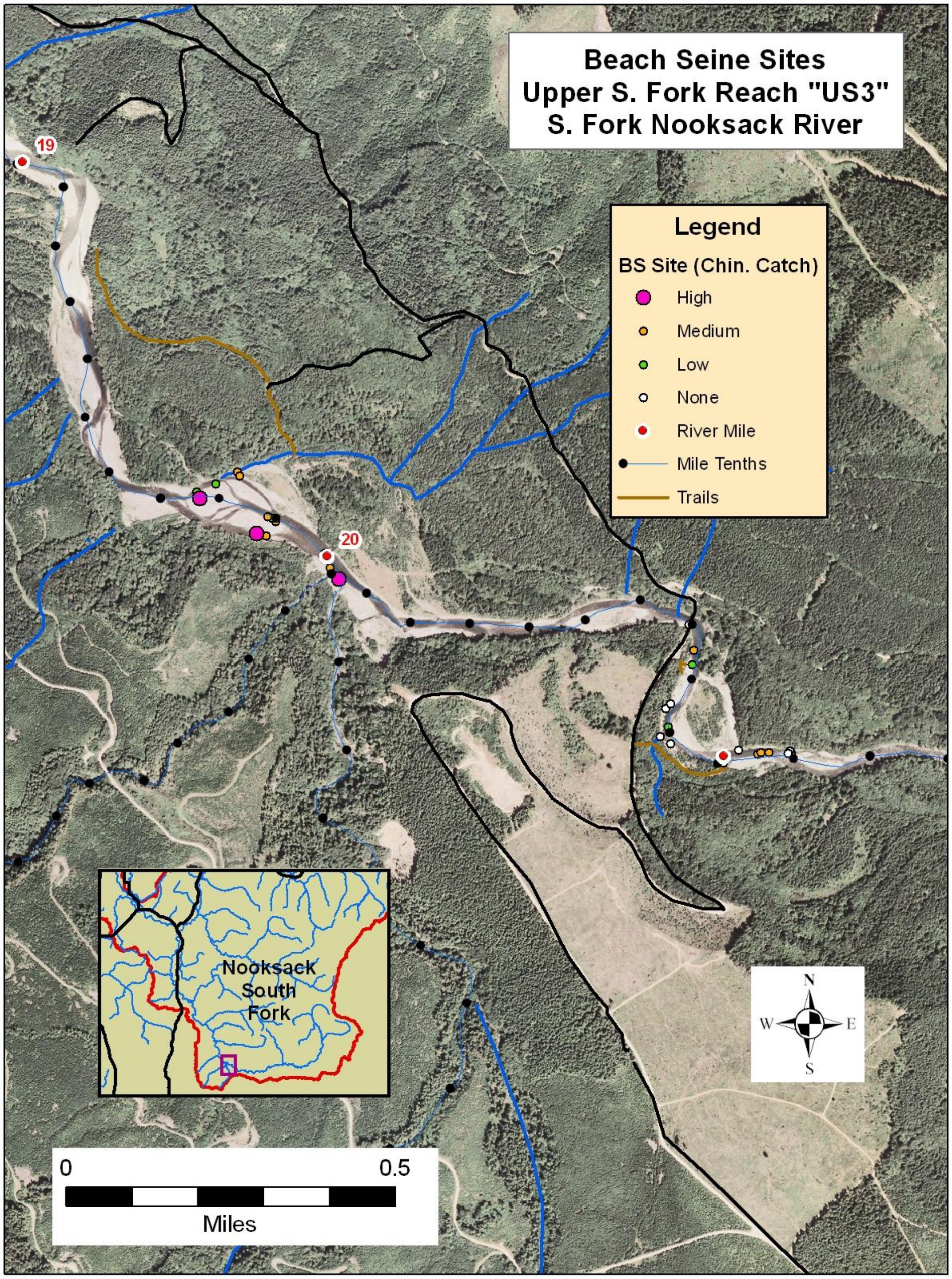
Appendix Figure B4. Map of seine sites coded by Chinook abundance (catch/set) for Upper South Fork reach "US1".



Appendix Figure B5. Map of seine sites coded by Chinook abundance (catch/set) for Upper South Fork reach “US2”.



Appendix Figure B6. Map of seine sites coded by Chinook abundance (catch/set) for Upper South Fork reach “US3”.



Appendix C1. Table of Chinook catch by brood year and total catch per set at beach seine sites, page 1

Site	Total Sets	BY '06 Chinook	BY '07 Chinook	BY '08 Chinook	Total Chinook	Total Chin per Set
MS102	5	0	5		**5**	1.00
MS280	11	0	2		**2**	0.18
MS298	10	0	25		**25**	2.50
MS360	12	1	7	13	**21**	1.75
MS390	24		36	19	**55**	2.29
MS397	2		1	5	**6**	3.00
MS398	12	1	2		**3**	0.25
MS399	6		13	0	**13**	2.17
MS499	53	12	80	8	**100**	1.89
MS502	2	0			**0**	0.00
MS503	4	3			**3**	0.75
MS514	1	0			**0**	0.00
MS515	1	0			**0**	0.00
MS530	2	0	1		**1**	0.50
MS540	1	0			**0**	0.00
MS560	1	0			**0**	0.00
MS569	1	0			**0**	0.00
MS570	1	0			**0**	0.00
MS572	2	0			**0**	0.00
MS573	1	0			**0**	0.00
SF001	1	0			**0**	0.00
SF105	5		2		**2**	0.40
SF110	2	0			**0**	0.00
SF111	3	0			**0**	0.00
SF112	4	0			**0**	0.00
SF113	6	0	38		**38**	6.33
SF114	10	0	38	1	**39**	3.90
SF115	15	3	45	0	**48**	3.20
SF121	24	4	101	3	**108**	4.50
SF122	4	0	1	1	**2**	0.50
SF117	32	1	126	0	**127**	3.97
SF118	15	2	167		**169**	11.27
SF119	18	0	275		**275**	15.28
SF120	10	1	6	1	**8**	0.80
SF168	8	0	6		**6**	0.75
SF169	4	1	0		**1**	0.25
SF170	15	0	11	1	**12**	0.80
SF172	7		20		**20**	2.86
SF173	7		60		**60**	8.57
SF174	10		250		**250**	25.00
SF175	28	10	19		**29**	1.04
SF176	12	2	1		**3**	0.25
SF177	6		0		**0**	0.00
SF180	6	0	1		**1**	0.17
SF184	3	0	0		**0**	0.00
SF185	2	0			**0**	0.00
SF186	2	0			**0**	0.00
SF210	2	0	0		**0**	0.00
SF211	20	6	0		**6**	0.30
SF212	22	3	0	0	**3**	0.14
SF213	3		0	1	**1**	0.33
SF214	23	0	33	11	**44**	1.91
SF215	7	0	0	1	**1**	0.14
SF248	2		0		**0**	0.00
SF250	72	12	367	24	**403**	5.60
SF251	7		84	1	**85**	12.14
SF259	6		108	1	**109**	18.17
SF252	4		25		**25**	6.25
SF253	6		28		**28**	4.67
SF254	2		0		**0**	0.00
SF257	4		65		**65**	16.25
SF256	1		3		**3**	3.00
SF258	2		12		**12**	6.00
SF201	1		0		**0**	0.00
SF244	9	1	86	2	**89**	9.89
SF245	8		31		**31**	3.88
SF200	13		26		**26**	2.00

Appendix C2. Table of Chinook catch by brood year and total catch per set at beach seine sites, page 2.

Site	Total Sets	BY '06 Chinook	BY '07 Chinook	BY '08 Chinook	Total Chinook	Total Chin per Set
SF204	4		18		**18**	4.50
SF205	2		0		**0**	0.00
SF206	2				**0**	0.00
SF207	1				**0**	0.00
SF208	1				**0**	0.00
SF209	1				**0**	0.00
SF218	1				**0**	0.00
SF234	1				**0**	0.00
SF235	1				**0**	0.00
SF236	1				**0**	0.00
SF237	1				**0**	0.00
SF238	1				**0**	0.00
SF239	2			1	**1**	0.50
SF240	1		1		**1**	1.00
SF270	4	0	2		**2**	0.50
SF272	3				**0**	0.00
SF273	2				**0**	0.00
SF274	3		4		**4**	1.33
SF275	3	0	7		**7**	2.33
SF277	2		0		**0**	0.00
SF260	3		13		**13**	4.33
SF276	7	6			**6**	0.86
SF261	3		8		**8**	2.67
SF262	3		11		**11**	3.67
SF263	2		0		**0**	0.00
SF264	2		9		**9**	4.50
SF265	3		4		**4**	1.33
SF266	2		15		**15**	7.50
SF267	3		5		**5**	1.67
SF278	2	4			**4**	2.00
SF268	2		1		**1**	0.50
SF279	1	0			**0**	0.00
SF280	9	23	0		**23**	2.56
SF283	1				**0**	0.00
SF284	2				**0**	0.00
SF285	2				**0**	0.00
SF296	10		3		**3**	0.30
SF297	8		1		**1**	0.13
SF298	1		0		**0**	0.00
SF291	12		24		**24**	2.00
SF292	5		5		**5**	1.00
SF281	1				**0**	0.00
SF293	2		0		**0**	0.00
SF294	3		1		**1**	0.33
SF286	2	0			**0**	0.00
SF287	1	0			**0**	0.00
SF288	1	0			**0**	0.00
SF289	2	0			**0**	0.00
SF290	27	24			**24**	0.89
SF299	2				**0**	0.00
SF295	2	0			**0**	0.00
SF300	6		3		**3**	0.50
SF303	1		0		**0**	0.00
SF304	2		5		**5**	2.50
SF305	2		0		**0**	0.00
SF306	1		0		**0**	0.00
SF307	14		6	0	**6**	0.43
SF301	1		3		**3**	3.00
SF308	25		68		**68**	2.72
SF309	131	18	162	1	**181**	1.38
SF312	4		4	0	**4**	1.00
SF310	15	0	11		**11**	0.73
SF311	18		36		**36**	2.00
SF314	4		13		**13**	3.25
SF313	2				**0**	0.00
SF316	25		2	0	**2**	0.08

Appendix C3. Table of Chinook catch by brood year and total catch per set at beach seine sites, page 3.

Site	Total Sets	BY '06 Chinook	BY '07 Chinook	BY '08 Chinook	Total Chinook	Total Chin per Set
SF325	6		18	3	**21**	3.50
SF326	3		10	0	**10**	3.33
SF327	3		7		**7**	2.33
SF328	3		3		**3**	1.00
SF329	1			1	**1**	1.00
SF330	3		0	1	**1**	0.33
SF444	4		0		**0**	0.00
SF445	2		0		**0**	0.00
SF446	3		0		**0**	0.00
SF447	16		14		**14**	0.88
SF448	1		2		**2**	2.00
SF443	1				**0**	0.00
SF449	4		4		**4**	1.00
SF450	13		17		**17**	1.31
SF451	4		0		**0**	0.00
SF452	41	1	36		**37**	0.90
SF453	13		1	1	**2**	0.15
SF454	10		6		**6**	0.60
SF455	1		0		**0**	0.00
SF456	8		6		**6**	0.75
SF457	1		0		**0**	0.00
SF470	2				**0**	0.00
SF467	1				**0**	0.00
SF468	1				**0**	0.00
SF458	1				**0**	0.00
SF469	1				**0**	0.00
SF459	2		0		**0**	0.00
SF460	1		0		**0**	0.00
SF461	1		0		**0**	0.00
SF462	9		4		**4**	0.44
SF463	7	1	4		**5**	0.71
SF464	5	1	0		**1**	0.20
SF465	8		4		**4**	0.50
SF466	1		0		**0**	0.00
SF471	1		7		**7**	7.00
SF473	2		0		**0**	0.00
SF475	5		2		**2**	0.40
SF476	3			8	**8**	2.67
SF477	4		4	1	**5**	1.25
SF484	1		1		**1**	1.00
SF483	1		1		**1**	1.00
SF481	13		25		**25**	1.92
SF478	14	1	9	1	**11**	0.79
SF479	20	4	29	2	**35**	1.75
SF480	36	1	68	10	**79**	2.19
SF482	15	1	26		**27**	1.80
SF485	29		36	0	**36**	1.24
SF486	25		76	0	**76**	3.04
SF499	3	0			**0**	0.00
SF501	23	0	25	7	**32**	1.39
SF502	35	1	71	0	**72**	2.06
SF503	1	0			**0**	0.00
SF504	4	0	0		**0**	0.00
SF510	8		7		**7**	0.88
SF511	5		0	0	**0**	0.00
SF509	1				**0**	0.00
SF512	3		0		**0**	0.00
SF514	4		0		**0**	0.00
SF515	39	1	56	2	**59**	1.51
SF516	42	2	47	10	**59**	1.40
SF517	57	12	81	21	**114**	2.00
SF518	1		0		**0**	0.00
SF519	1		0		**0**	0.00
SF520	1		1		**1**	1.00
	1,612	**164**	**3,355**	**163**	**3,682**	**2.28**

Appendix D. Table of juvenile Chinook mortalities.

Juvenile Chinook Capture & Skookum Hatchery Holding Mortalities, 9/18/07 - 12/31/08[1]
South Fork Nooksack Chinook Captive Brood Project

Date	Total Morts	Notes:	Field Capture Morts	Field Trasport Morts	DNA Processing Morts	Tank Morts "warm water" Period	Tank Morts "cool water" Period	Unknown Cause[2]
9/24/07	10	Escaped from tank to floor grate.						10
10/15/07	14	Found dead in trays. WQ problem?						14
10/26/07	10	Fround in tray by hatchery crew.						10
9/19/07	1	Lost through floor grate.			1			
1/14/08	1	Net Mort in field	1					
1/28/08	1	found in tank during DNA - Seaponds					1	
1/30/08	2	found in tank during DNA - Seaponds					2	
2/18/08	3	found in tank during DNA - Seaponds					3	
2/22/08	4	found in tank during DNA - Seaponds					4	
2/25/08	1	found in tank during DNA - Seaponds					1	
3/13/08	1	Net Mort in field (rock in net)					1	
4/2/08	1	Net Mort in field	1					
4/14/08	1	found in tank during DNA - Skookum					1	
4/23/08	1	Net Mort in field	1					
5/13/08	1	Net Mort in field	1					
5/19/08	1	found in tank during DNA - Skookum					1	
5/29/08	2	found in tank during DNA - Skookum					2	
6/9/08	3	found in tank during DNA - Skookum					3	
6/16/08	1	hit with net while removing from tank?			1			
6/23/08	1	found in tank during DNA - Skookum					1	
7/7/08	8	Morts during transport		8				
7/14/08	3	found in tank during DNA - Skookum				3		
7/17/08	1	found in tank during DNA - Skookum				1		
7/21/08	2	found in tank during DNA - Skookum				2		
7/28/08	8	found in tank during DNA - Skookum				8		
7/31/08	5	found by Ryan during DNA - Skookum				5		
7/31/08	10	found by Ryan during DNA - Skookum				10		
8/4/08	1	Lost through floor grate.			1			
8/7/08	9	found 8/11 during DNA, heavy fungus				9		
8/11/08	1	found caudle fin "chewed" during DNA				1		
8/14/08	3	found in tank during DNA - Skookum				3		
8/18/08	3	found in tank during DNA - Skookum				3		
8/25/08	1	found in tray during DNA - Skookum				1		
8/25/08	1	found in tank during DNA - Skookum				1		
9/2/08	3	found in tank during DNA - Skookum				3		
9/2/08	1	found in tank during DNA - Skookum				1		
9/17/08	1	Net Mort in field	1					
9/22/08	2	"DOA" during DNA - Skookum (Ryan)				2		
10/13/08	1	found in tank during DNA - Skookum					1	
11/10/08	1	found by Bill in tray						1
Totals =	**125**		**5**	**8**	**3**	**53**	**21**	**35**

3,911 **= Total Chinook captured (Lummi & Nooksack Tribes)**

3.2% **= Mortality Rate**

Bold = Indicates "warm water" period (Ave.temperatures exceeding 10 C).

[1] Lummi Natural Resources data only.
[2]Unknown cause, may be related to water supply

Appendix E. Juvenile Chinook warm water transport protocols.

Warm Water Transport Protocols
Juvenile Chinook River Brood Collection

To avoid mortality incidents during transport during "warm weather" operations (air temperatures expected to be higher than 20 C / 68 F) the following protocols will be followed:

1. Cooler in truck to be pre-chilled with ice. River water to be collected in two 5 gallon buckets placed in cooler and surrounded with crushed ice **prior to** seining.
2. Transport from the river to the truck to be made in insulated 5 gallon "field buckets" with aeration provided from battery-powered aerators when water temperatures exceed 12 C. "Field buckets" to be chilled by suspending a water bottle with frozen water in the bucket and secured with twine.
3. When arriving at the truck, Chinook are transferred from the "field buckets" to pre-chilled buckets with river water in the cooler on the truck (**water not transferred to buckets in cooler**). Truck cooler will be aeriated during transport to hatchery.
4. Monitor and record water temperature in the "field buckets" when arriving at the truck and during truck transport to the hatchery. Immediate action to return fish to cooler water if at any time "field bucket" water temperature exceeds 16 C (60.8 F).

Appendix F. Juvenile Chinook behavior and habitat utilization model.

Juvenile Chinook Behavior & Habitat Utilization Model

	Lifestage	Season	Activity	River Conditions: River Discharge	River Turbidity	River Temperature	Habitat Category	Key Habitat Feature(s)	Habitat Types
1	Post emergent fry	Winter / early spring	Hiding / not moving	Low	**Clear**	**Cold**	Cold-water Rufugia	Cover / low velocity Groundwater upwelling Warmer water "seeps"	Cobble margin interstitial spaces Under / within LWD Below / next to undercut banks Still-water "bays" Low velocity areas in pools
2	Post emergent fry	Winter / early spring	Hiding / not moving	**High**	**Turbid**	**Cold**	High Flow Refugia	Low velocity Groundwater upwelling Warmer water "seeps"	Overflow channels Sloughs LWD back eddies Tributaries,lower
3	Zero-age fingerlings	Spring	Feeding	Low	**Clear**	Cool	Feeding Stations	Cover with higher velocity Warmer water "seeps"	Gravel bar margins, upstream Below / within riffles Adjacent to LWD Adjacent to spring seeps
4	Zero-age fingerlings	Spring	Opportunitstic Feeding	Medium	**Turbid**	Cool	"Feeding" Refugia	Pockets of "clear water"	Tributary mouths Still-water "bays" Sloughs
5	Zero-age fingerlings	Mid spring / early summer	Outmigration	Medium	**Turbid**	Cool	Migration Corridor	High velocity with cover	Riffles Mid-channel pools Glides
6	Sub-yearlings	Summer	Feeding / high level	Low	**Clear**	Cool	Feeding Stations		
7	Sub-yearlings	Late summer	Feeding / lower level	Low	**Clear**	**Hot**	Warm-water Refugia	Turbulent / cool water Pockets of high DO Groundwater upwelling	Deep pools under LWD Head of pools below riffles Tributary mouths
8	Sub-yearlings	Fall	Opportunitstic Feeding	Medium	**Turbid**	Cool	"Feeding" Refugia	Pockets of "clear water"	Tributary mouths Still-water "bays" Low velocity areas in pools
9	Sub-yearlings	Fall	**Outmigration (unknown)**	**High**	**Turbid**	Cool	Migration Corridor	High velocity with cover	Riffles Mid-channel pools Glides
10	Yearlings	Winter / early spring	Feeding	Low	**Clear**	**Cold**	Cold-water Rufugia	Cover / low velocity Groundwater upwelling	Under / within LWD Below / next to undercut banks Low velocity areas in pools
11	Yearlings	Winter / early spring	Feeding	Low	**Clear**	Cool	Feeding Stations	Cover with higher velocity	Riffles Mid-channel pools Glides
12	Yearlings	Late winter / spring	Feeding / Outmigration	Medium	**Turbid**	Cool	Migration Corridor	High velocity with cover	Riffles Mid-channel pools Glides