Nooksack Salmon Enhancement Association

# Lower Nooksack River Basin 2003 Salmon Spawner Survey

Male Coho Carcass on Anderson Creek: 11/23/03 Photo By Shannon Moore

**By**

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# Introduction

The Nooksack Salmon Enhancement Association (NSEA), with substantial support from Bellingham Technical College's Fisheries Technology Program (FTP), conducted a spawning grounds survey program for late-run chinook salmon, coho salmon, and chum salmon. Surveys were done on ten creeks located in six lower Nooksack River sub-basins. Five sub-basins were downstream of the South Fork – North Fork confluence and one was located in the lower South Fork. One additional survey was done regularly on Terrell Creek, a tributary of Georges Strait. The Terrell Creek survey marks the initial phase of systematic spawner survey monitoring for this stream to establish baseline data while rehabilitation programs are being developed. Surveys were conducted between October 20th, 2003 and January 23rd, 2004.

Five stream reaches were surveyed in the Ten Mile Creek sub-basin, including two on Deer Creek and one each on Ten Mile Creek, Silver Springs Creek, and Starry Creek. Two stream reaches were surveyed on Fishtrap Creek, one in Lynden and one just south of the international border. Three stream reaches were surveyed in the Smith Creek sub-basin between Nugent's Corner and Deming; one each on Smith Creek, McCauley Creek, and Mitchell Creek. One stream reach each was surveyed on Bertrand Creek and Anderson Creek in the lower Nooksack basin and on Tinling Creek in the South Fork drainage. In addition to these and the Terrell Creek surveys, one-time supplemental surveys were done on Kinney Creek and Breckenridge Creek, tributaries of the Sumas River. NSEA surveyors and BTC students conducted all surveys, except for the Kinney Creek survey, which was done by an NSEA surveyor and volunteer, Binda Colebrook.

Surveys were conducted to provide data to augment those produced annually by Nooksack Basin fisheries co-managers and to provide year-to-year consistency with past NSEA survey efforts. Nooksack River basin fisheries co-managers are the Washington Department of Fish and Wildlife (WDFW), the Lummi Nation, and the Nooksack Indian Tribe. These surveys also provide post-rehabilitation monitoring data for stream reaches where riparian rehabilitation projects are located. Survey results also provide some insight into the health of Whatcom County chinook, coho, and chum salmon populations over time.

# Methods

Stream survey reaches were chosen from accessible spawning habitat on lower Nooksack River basin tributaries, with an emphasis on recovery of chinook salmon data. Reaches were targeted for survey every seven to ten days during chinook spawning and every seven to fourteen days during coho and chum spawning. Actual survey periodicity for each reach was determined by one or more considerations, including viewing conditions, crew availability, stream flow, and turbidity. Survey teams usually consisted of two people.

Standard salmon survey and biological sample collection techniques, consistent with Nooksack basin co-manager protocols, were maintained to maximize survey data utility for co-managing governments. Survey data categories included stream name, Water Resource Inventory Area (WRIA) basin and stream number (Williams et al, 1975), WRIA survey reach river mile locations for each redd and fish observation, live counts by species, dead counts by species, new redd counts by species, and percentage of the survey reach that was visible given visual obscuration by aquatic and streamside vegetation, water turbidity, flow conditions, weather, accessibility, and any number or combination of these and other factors. The start and finish times, viewing conditions, flow conditions, and other pertinent notes were taken for each survey. Streams were generally walked from the lower end to the upper end of the survey reach. The only exception to this was the upper Fishtrap Creek reach, which was walked downstream along one bank and then upstream along the opposing bank. This method was used here in the attempt to get more complete viewing in a reach where visibility was always limited (see page 13 below). Other instances when NSEA field techniques deviated from co-manager standard procedures will be noted in the following methodological discussions.

## Redd Documentation

Redds were counted and data about them recorded, in each instance, only after spawning and redd construction were complete. A 'redd date' was assigned to each completed redd on the day of the survey upon which each redd was first noted as completed. Completed redds were assigned a unique alphanumeric identifier and flagged to avoid trampling by those doing subsequent surveys. Redd data recorded in the field included redd date, WRIA river mile location, channel type, location in channel, GPS location, and number and species of live fish on the redd. Measurements of egg mound depth, stream flow velocity, and redd size are optional co-manager procedures and are utilized primarily in the documentation of early spawning Nooksack River chinook salmon in the mainstem and forks. These parameters were not routinely measured as part of this survey. When redd construction was not yet complete at the time of a survey, location and species were noted and live fish were counted.

## Carcass Documentation

Carcass documentation involved species identification, WRIA river mile location, fork-length measurement, sex identification, adipose fin presence/absence, and coded-wire tag presence/absence. Scales were collected on all chinook, and as many coho and chum as feasible on any given survey day/reach. Three scales were taken from just above the lateral line, just behind the dorsal fin, from each side of the selected carcasses. Scale data will be used for age composition analysis by the WDFW.

In addition, unmarked carcasses were assessed for the potential of tissue collections to yield DNA suitable for microsatellite analysis. A quick qualitative assessment of carcass condition, consisting of observations on gill color, eye condition, flesh firmness, presence/absence of rigor mortis, and presence or absence of fungal growth, was used to determine whether to collect tissues for DNA analysis. These data were recorded on carcass field forms. When carcass freshness was indicated by this assessment, four to six

holes were punched through opercle epithelial tissue using a standard paper hole punch. Tissues were stored in small vials with unique identifier labels and carcass condition information was recorded. These tissues are added to a growing Nooksack basin collection that can be used to help characterize wild spawner stocks.

A qualitative assessment of spawning completeness was undertaken to help determine rates of prespawn vs. post-spawning mortality. This was done by examining relative amounts of milt or eggs remaining in the body cavity and using rough descriptive categories of "0% spawned", "50% spawned", and "100% spawned" to approximate spawning status at the time of death. This technique is becoming standard in the Nooksack basin for early spawning chinook stocks in the forks to help in the assessment of impacts to these ESA listed populations due to low flows, elevated water temperatures, hatchery straying and other associated stressors. The simple technique of gutting each carcass and examining the contents of the body cavity is quickly done and the resulting information yield is cumulatively valuable for helping to understand the effectiveness of each spawning anadromous stock in each reach in a given year, regardless of its ESA status. For those reasons, NSEA chose to make this a standard procedure for this year's late chinook, coho, and chum spawners, even though it is not standard procedure for these populations. The use of this technique produced some interesting results as will be discussed below.

When sampling and measurement were finished, the tail was cut from the carcass to avoid re-counting and/or re-sampling. The carcass was then returned to the location where it was found.

## Live Counts

Live fish were identified to species, when possible, and counts recorded.

## Survey Reaches

Table 1 lists survey reaches by name, WRIA stream number, WRIA river miles surveyed, and the number of times each reach was surveyed; Figure 1 indicates the location in the Nooksack Basin of each survey reach.

# Results

Survey results are presented below in four parts titled as follows: survey conditions/effort, results by species, results by survey reach, and project archives. The first part is a general discussion of survey conditions and effort. The second is a general discussion of findings for each species spawning during the scheduled survey period.

**Table 1. Survey Stream Reaches and Surveys Completed**

| Stream/Reach Surveyed | WRIA # | River Miles Surveyed | # Surveys Completed |
|---|---|---|---|
| Ten Mile Creek | 01-0163 | 9.0 – 9.2 | 9 |
| Deer Creek, lower | 01-0165 | 0.5 - 1.0 | 8 |
| Deer Creek, upper | 01-0165 | 3.3 – 3.6 | 8 |
| Silver Springs Creek | 01-0184 | 0.5 – 1.4 | 9 |
| Starry Creek | 01-0189 | 0.0 – 0.8 | 7 |
| Bertrand Creek | 01-0201 | 7.5 – 9.7 | 8 |
| Fishtrap Creek, lower | 01-0210 | 4.7 – 5.8 | 5 |
| Fishtrap Creek, upper | 01-0210 | 8.5 – 10.1 | 7 |
| Anderson Creek | 01-0228 | 2.7 – 4.0 | 6 |
| Smith Creek | 01-0234 | 3.0 – 3.5 | 5 |
| McCauley Creek | 01-0235 | 1.0 – 1.5 | 5 |
| Mitchell Creek | 01-0236 | 0.3 – 1.0 | 5 |
| Tinling Creek | 01-0250 | 1.8 – 2.3 | 5 |
| Terrell Creek | 01-0089 | 4.3 - 5.3 | 5 |
| Kinney Creek, lower | 00-0012 | 0.8 – 0.9 | 1 |
| Kinney Creek, upper | 00-0012 | 1.6 – 1.8 | 1 |
| Breckenridge Creek | 00-0013 | 3.4 - 4.5 | 1 |

The third part consists of detailed results for each individual survey reach. The final section details the dispensation of, and access to, project paper and electronic records.

## Survey Conditions/Effort

Low water conditions prevailed through the summer and early fall 2003 early chinook and pink salmon spawning seasons. October brought heavy rainfall with widespread flooding occurring between October 17th and 23rd (Figure 2). As rainfall continued throughout October, high flows and turbidity in Nooksack River mainstem and forks precluded effective spawner surveys in many of the lower basin tributaries until the 27th

or 28th. The Ten Mile Creek sub-basin was an exception and surveys began on October 20th and 21st. Likewise, clear conditions in upper Fishtrap Creek made survey possible by October 23rd. Towards the end of October all tributary streams began dropping and cleared up enough for surveys to begin.

November and December brought less intense rainfall events punctuated by several shorter high intensity storms that hampered survey efforts, but only for short periods.

Figure 1. 2003 NSEA Nooksack River tributary survey reach locations.

Figure 2. Nooksack River discharge in cubic feet per second (cfs) from September 2003 through January 2004 as recorded at the Deming and Ferndale U.S.G.S. gauging stations.

One of these led to the loss of a survey week between November 15th and 23rd, with lower basin peak flows not quite reaching flood stage this time. Again, flows in the Ten Mile Creek sub-basin had dropped and turbidity cleared earlier than other sub-basins. Surveys in that drainage restarted by November 21st. After November 23rd, survey conditions remained good for most of the rest of the fall and early winter in all sub-basins.

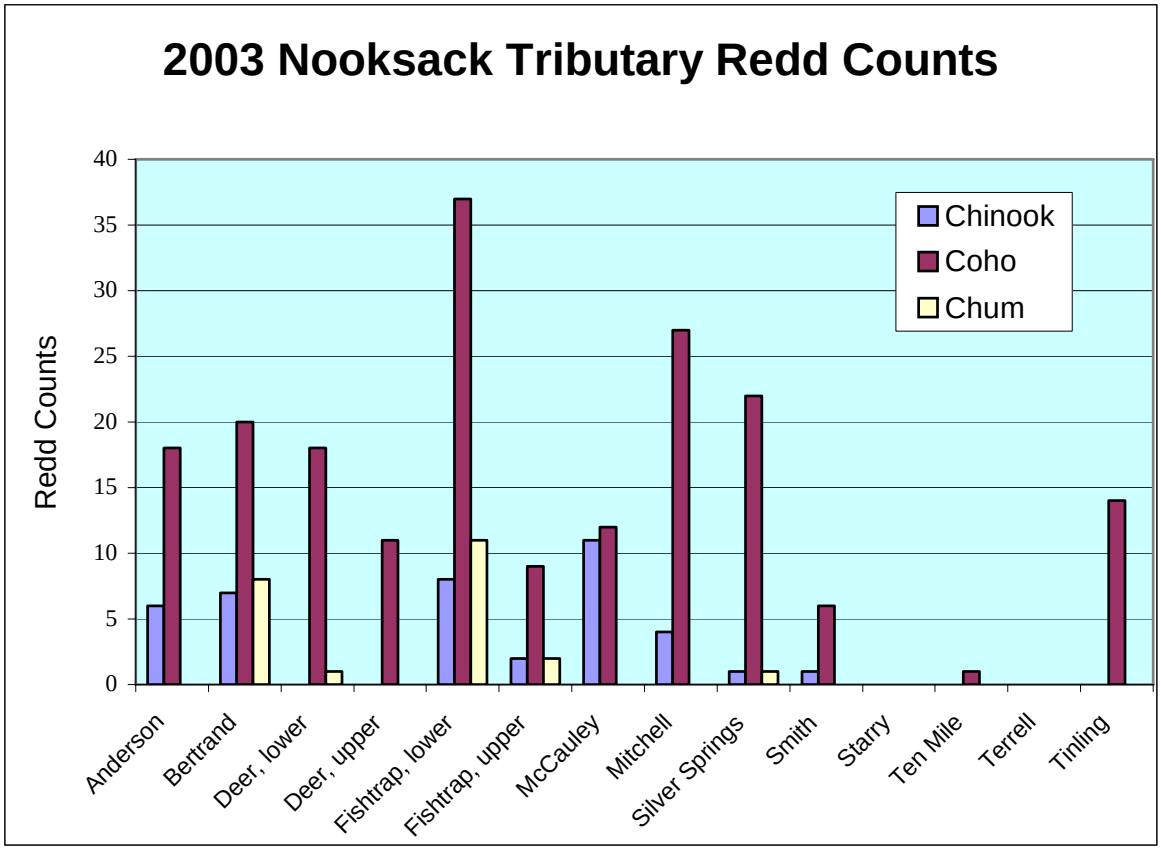
## Results by Species

**Chinook Salmon (Oncorhynchus tshawytscha)**. Forty chinook salmon redds (Table 2 and Figure 3) were documented from mid-October through mid-November (Table 3) in five lower Nooksack River sub-basins. Sixteen of those occurred in Smith Creek and its tributaries in the Nugent's Corner to Deming area, ten in Fishtrap Creek, seven in Bertrand Creek, six in Anderson Creek, and one in Silver Springs Creek, a small spring-fed tributary to Ten Mile Creek. All chinook redds recorded as part of these surveys were constructed within several weeks after the flood waters of mid-October receded.

### Table 2. 2003 Nooksack Tributary Spawner Survey Summary

| | ***Chinook*** | | | ***Coho*** | | | ***Chum*** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Creek Name** | Live Count | Dead Count | Redd Count | Live Count | Dead Count | Redd Count | Live Count | Dead Count | Redd Count |
| Anderson | 13 | 1 | 6 | 44 | 7 | 18 | 0 | 0 | 0 |
| Bertrand | 2 | 7 | 7 | 50 | 29 | 20 | 7 | 27 | 8 |
| Deer, lower | 0 | 0 | 0 | 45 | 6 | 18 | 3 | 3 | 1 |
| Deer, upper | 0 | 0 | 0 | 8 | 1 | 11 | 0 | 0 | 0 |
| Fishtrap, lower | 8 | 3 | 8 | 70 | 7 | 37 | 32 | 0 | 11 |
| Fishtrap, upper | 15 | 2 | 2 | 57 | 11 | 9 | 37 | 10 | 2 |
| McCauley | 2 | 12 | 11 | 8 | 1 | 12 | 0 | 0 | 0 |
| Mitchell | 1 | 2 | 4 | 22 | 7 | 27 | 0 | 0 | 0 |
| Silver Springs | 2 | 7 | 1 | 59 | 4 | 22 | 0 | 0 | 1 |
| Smith | 0 | 1 | 1 | 17 | 0 | 6 | 0 | 0 | 0 |
| Starry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ten Mile | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| Terrell | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tinling | 0 | 0 | 0 | 26 | 8 | 14 | 0 | 0 | 0 |
| | **43** | **35** | **40** | **407** | **82** | **195** | **80** | **41** | **23** |

Figure 3. 2003 Nooksack River tributary redd counts by species by survey reach




Thirty-five chinook carcasses were documented in survey reaches where chinook redds were recorded (Appendix A). Of these, thirty-two were retrieved and sampled. Two were not recoverable due to high water levels, a third due to scavenger/predator activity. Eleven of the thirty-two recovered were adipose fin-clipped; none had snouts containing a coded-wire tag. Four of those with intact adipose fins were fresh enough for DNA sample collection (Appendix B), all from the Smith Creek sub-basin. Scales were collected on all thirty-two recovered carcasses. Twenty-seven of the thirty-two recovered were females; only five males were documented.

Spawning completeness assessment dissections were done on thirty-one chinook carcasses. Twelve, or 38.7% of the total dissected were pre-spawn mortalities. Eight of these were females and four were males. Three of the eight female, and two of the four male, pre-spawn mortalities were adipose fin-clipped. Of the remaining carcasses investigated for spawning completeness, four, or 12.9% of the total dissected, had partially emptied egg skeins indicating some spawning may have occurred prior to time of death. Fifteen, or 48.4%, appeared to have completed spawning prior to death.

Table 3.  2003 spawn timing in lower Nooksack River tributaries

**Coho Salmon (*Oncorhynchus kisutch*)**.One hundred ninety-five coho salmon redds (Table 2 and Figure 3) were recorded from mid-October through mid-January in the lower Nooksack River tributaries (Table 3). Five were recorded on supplemental surveys in Sumas River tributaries. Coho spawned in all survey reaches except Starry Creek, which is a tributary of Ten Mile Creek, and Terrell Creek downstream of Terrell Lake. Only one redd and one carcass were counted for Ten Mile Creek itself. Otherwise, coho spawning was somewhat uniformly distributed throughout surveyed sub-basins.

Eighty-three coho salmon carcasses were recorded in lower Nooksack basin tributaries and twenty-eight in Sumas River tributaries (Appendix C). Five lower Nooksack tributary coho spawners had clipped adipose fins; none out of forty-five tested had coded-wire tags. Opercle epithelial tissues were collected from twenty-four fresh unmarked coho spawners for potential microsatellite DNA analysis. Scales were collected from thirty-one unmarked coho carcasses. Mortality assessment indicates a 20% prespawn mortality rate with 19% spawning partially and 61% being fully spawned.

**Chum Salmon (*Oncorhynchus keta*)**. Twenty–three chum salmon redds (Table 2 and Figure 3) were documented from early November through early December, primarily in Bertrand Creek and Fishtrap Creek (Table 3). Forty-one chum carcasses were recorded, again primarily in Bertrand Creek and Fishtrap Creek (Appendix D). Scales were collected from nine chum carcasses and tissues for potential microsatellite DNA study were collected from three fresh chum carcasses. Prespawn mortalities constituted 19% of spawners examined, with 8% partially spawned and 73% fully spawned at time of death.

## Results by Survey Reach

Survey reach discussions are ordered by location in the Nooksack basin, beginning with the tributary closest to the river mouth and moving upstream. Nooksack basin tributary results are followed by brief result discussions for four Whatcom County survey reaches outside of the river basin.

**Ten Mile Creek** was surveyed nine times between October 20$^{th}$ and January 14$^{th}$. Water levels remained high enough for spawning during the entire survey season. Visibility was consistently limited, however, with surveyors estimating a seasonal average of just over 40%. The creek cross-section in this reach is deeply u-shaped and has a narrow and deep channel. This, in conjunction with high water conditions, restricted light penetration enough to limit visibility, even though turbidity was usually minimal.

Only a single completed coho redd was documented during Ten Mile Creek surveys, with sightings of one live coho, one dead coho, one live chum, and one dead chum for the season. No samples were taken due to the fragmentary nature of carcass remains. The redd was recorded on December 10$^{th}$.

**Lower Deer Creek** was surveyed eight times between October 21st and January 23rd. Visibility was not a problem in this reach with an estimated average exceeding 70%. This reach is amply shaded, contains abundant spawning gravels and some in-stream woody debris.

Coho were active for the entire duration of the survey period. Peak coho spawning occurred between late November and late December, with the most intense activity happening during the second week of December.

Eighteen completed coho redds total were recorded between October 21st and January 23rd. Six coho carcasses were noted between November 6th and December 25th. Of these, two were recovered for measurement and sampling. Neither of these were marked with an adipose fin-clip. Both were males, one completely spawned out and the other partially spawned. Scales were collected from both carcasses. No tissues for DNA analysis were collected. Forty-five live coho total were counted between October 21st and December 25th.
A small contingent of chum arrived in mid-November and finished spawning by early to mid-December. One completed chum redd and three carcasses were documented. A male and a female were identified among the carcasses. Scales were collected from the male. The female was completely spawned out. Three live chum total were counted between November 23rd and December 25th.

**Upper Deer Creek** was surveyed eight times between October 21st and January 19th. Water levels were generally low with little turbidity. Average estimated visibility for the season was just under 80%. In general, this reach is well-shaded and characterized by a moderate amount of spawning gravels and in-stream woody debris. Creek banks on the downstream end are overgrown with Himalayan Blackberry that limit access and visibility.

Eleven completed coho redds were recorded between December 10th and January 19th, with documentation of nine of those occurring after the first of the year. One coho carcass was recovered and scales were collected. Eight live coho were counted in this reach between December 10th and January 14th.

**Silver Springs Creek** was surveyed nine times between October 20th and January 19th. Both chinook and coho were very active in this small Ten Mile Creek tributary. Visibility remained very high for most of the survey season, averaging almost 90%. The lower portions of the survey area is partially shaded with a mixture of shrubs and mixed-age trees. The substrate in this subreach is sand and fine-gravels. The middle section is open pasture and riparian restoration planting. Adjacent to pasture, the creek is choked in places with dense stands of Reed Canary Grass, where no riparian work has been done. The upper part of the survey reach is heavily wooded with gravel substrate suitable for coho spawning.

Chinook spawning took place from mid- to late October in the lower section. Two live chinook were noted downstream of the reed canary grass choked subreach during the

October 21st survey. One completed chinook redd was recorded on October 30th. An even mix of three male and three female chinook carcasses were recovered, but not one of these was able to successfully spawn. All chinook that were observed exhibited an unusual white dorsal strip extending from nose to tail where epidermal tissues had been worn away, presumably from repeated attempts to swim through the dense thicket of grass. Five of these fish were adipose fin clipped. Though the unmarked carcass was too long dead to collect a tissue for DNA analysis, scales were collected from all six.

The upper section of Silver Springs Creek was very busy with coho spawning from mid-November until mid-December with a total of twenty-two completed redds recorded. Reed canary grass die-back allowed coho passage in the subreach where chinook passage was restricted earlier in the fall. Spawning was complete by December 10th. Tissue samples and scales were collected from two unmarked coho carcasses. Fifty-nine live coho were observed over the duration of the survey season.
One chum redd was recorded near the downstream end of the reach Silver Springs Creek Reach.

**Starry Creek**, a Ten Mile Creek tributary, was surveyed seven times between October 20th and December 18th with no fish or redd sightings to report. Average estimated visibility was good at 80%. This moderate-gradient creek is well shaded and contains moderate amounts of spawning gravel substrate.

**Bertrand Creek** was surveyed eight times between October 27th and January 11th. Estimated average visibility over the survey season was only 41% due to high water levels, turbidity, glare, and dense Himalayan blackberry thickets. The creek is partially shaded over most of the survey reach with abundant spawning gravels. The upper end is shaded and contains some woody debris.

Chinook spawning occurred between late October and mid-November. Seven completed redds were recorded, seven carcasses were documented, and two live fish were spotted. Redds were dispersed throughout the 2.2-mile long survey reach (Appendix E). Six of the seven carcasses were recovered and sampled. These were all females with adipose fins. All spawned prior to dying except for one, which had full egg skeins. Due to advanced decomposition, no tissues were collected for DNA analysis. Scales were collected from six chinook.

Twenty completed coho redds were recorded between mid-November and late December. As with chinook redds, these were distributed throughout the survey reach. Of the thirty carcasses recorded, only two had adipose fins clipped. Of the twenty-nine, upon which sex determinations could be made, twenty-two were male and eight were female. Of the twenty-one that mortality related to spawn could be determined, 14 were completely spawned out, six appeared to be about half-spawned out and one died prior to spawning. Tissues for microsatellite DNA samples were collected on six and scales were collected from five carcasses. Fifty live coho were counted over the course of the survey season.

Eight completed chum redds and 27 carcasses were recorded between mid-November and late December. Fourteen carcasses were males and eleven were females. Of the twenty-one upon which mortality related to spawn could be determined, eighteen were completely spawned, two were partially spawned and one was a prespawn mortality. Scales were collected from six carcasses and tissues for microsatellite DNA samples were collected from three. Seven live chum were counted over the duration of the survey season.

**Lower Fishtrap Creek** was surveyed five times between October 28th and December 17th. Average estimated visibility for the season was 80%, despite regular rainfall events. The creek has a high width to depth ratio in this reach that creates good viewing situations. The creek in this reach is well shaded and contains abundant spawning gravels.

Eight completed chinook redds were documented in the lower portion of this reach between late October and mid-November. Three Chinook carcasses were located and sampled. All three were females and each was totally spawned out. One of these was adipose fin-clipped. Scales were collected from all three. No tissues were collected for DNA analysis. Eight live chinook were noted over the course of the survey season.

Thirty-seven completed coho redds were recorded between late October and mid-December. Peak spawning occurred in early to mid-November. Redds were distributed over the entire reach, though redd density was higher near the lower end. Seven carcasses were located and five of these were measured and sampled. None were adipose fin-clipped. One female and 4 males were documented. Scales were collected from four and tissues for DNA samples were collected from two. Pre- vs. post spawning mortality assessments were not done. Seventy live coho were recorded during the course of surveys.

Eleven completed chum redds were recorded between mid-November and mid-December. Redds were distributed over the entire survey reach. No carcasses were noted during surveys. Thirty-two live chum were counted overall.

**Upper Fishtrap Creek** was surveyed eight times between October 23rd and January 14th. Average estimated visibility for this survey reach for the survey season was less than 12.0%, with a range of 5% to 15%. The creek here is a deep and narrow channel that cuts through soft sediments and is lined with dense stands of Reed Canary Grass and Himalayan Blackberry. Access to the stream for viewing is very limited for the entire reach. In places where access is available through the blackberries to the stream bank, dense stands of grass extend out partially over the water. This situation combined with poor light penetration into the narrow depths limited viewing. This situation is likely to have caused significant undercounts of both fish and redds.

Interestingly, fifteen live chinook were documented in this reach, two more than in any other 2003 survey reach (Table 2, above). These were observed between October 24th and November 11th. Only two completed chinook redds were identified in this reach,

however, compared to eight in lower Fishtrap. These were documented on October 31st. Only two chinook carcasses were located and identified in this reach, with one of these not recovered due to the depth and swiftness of the creek. The recovered chinook carcass was a fully spawned-out, adipose-clipped female. Scales were collected to contribute to spawner age-class studies.

Eleven carcasses were noted and nine completed redds were recorded over the entire survey season. Documented redds were all constructed between mid-October and mid-November. Of the eleven coho carcasses recorded, only four could be recovered for measurement and sampling. One of these was marked with an adipose fin-clip. All recovered coho carcasses were males. All were prespawn mortalities, except for one that was partially spawned out. One prespawn mortality had a fork-length measuring 85 cm. Scales were collected from this fish and two of the other three that were recovered. Tissue samples were collected from two of the freshest coho carcasses. Neither scales nor tissue for DNA analysis were collected from the one adipose fin-clipped recovery. Fifty-seven live Coho were counted between October 24th and December 22nd.

Ten chum carcasses were noted and two completed redds recorded over the duration of the survey season. Documented redds were recorded on two different surveys between mid-November and early December. Of the ten carcasses, only five could be recovered for measurement and sampling. All five were males and all died prior to spawning. Scales were collected from two of these. No tissues were collected for DNA anaylsis due to poor carcass condition. Thirty-seven live chum were counted in this reach with the earliest sighting on October 31st and the last sighting on December 22nd.

**Anderson Creek** was surveyed six times between October 29th and December 31st. Visibility in this survey reach was excellent with an average estimated visibility of 82% for the season. The creek in this reach is heavily wooded with ample shade, relatively wide, with a high width-to-depth ratio, has abundant spawning gravels, and some in-stream woody debris. One problem encountered during surveys was our inability to beat the scavengers and predators to carcasses. Our carcass recovery and documentation rate was very low, as a result, compared with the abundance documented in live counts.

Thirteen live chinook were counted in Anderson Creek, more than any year recently surveyed. This count was also the second highest 2003 live count for any tributary reach other than upper Fishtrap Creek. Six completed redds were documented between October 29th and November 8th. Only one chinook carcass was recovered, a 70 cm fork-length, fully spawned out adipose-clipped female. Scales were collected.

Eighteen completed coho redds were documented between October 29th and December 18th, with spawning intensity tapering off after the fourth week of November. Forty-four live coho were counted during this period. One of these, the 44 cm fork-length unspawned and presumably exhausted male (title page photograph), was captured as he lay in the shallows. Scales and DNA tissues were collected and a photograph taken. This fish was released unharmed to finish his life-ending business.

Seven carcasses were noted between October 29th and December 31st. Five of these were recovered for sampling, two females and three males. Only two of the males had spawned, the other three were prespawn mortalities. Two were sampled for scales and tissues were collected from one for a DNA sample.

No chum were sighted.

**Smith Creek** was surveyed five times between October 26th and January 1st. Visibility was excellent with a seasonal estimated average of 94%. The creek in the survey reach is partially shaded, is wide and shallow with a high width to depth ratio, contains abundant spawning gravels, very little woody debris, and no pools of large enough dimensions to offer much protection.

One completed chinook redd and one carcass were documented on October 27th. The carcass was a spawned out 95 cm fork length unmarked female. Scales and tissues for DNA samples were collected.

Seventeen live coho, no carcasses, and 6 completed redds were recorded in this reach between October 26th and January 1st. Redds were constructed during the early to middle part of December.

No chum were sighted.

**McCauley Creek** was surveyed five times between October 26th and January 1st. Visibility was excellent with a seasonal estimated average of 96%. The creek in the survey reach is partially shaded, is wide and shallow with a high width to depth ratio, contains abundant spawning gravels, very little woody debris, and no pools of large enough dimensions to offer much protection.

Eleven completed chinook redds were documented on this reach between October 26th and November 12th. All were constructed as water levels in the nearby Nooksack River dropped from flood stage, but remained high and turbid.

Twelve chinook carcasses and a live pair were documented on October 27th. All those counted in the dead category had been pulled from the stream by predator/scavengers and, at least partially, consumed. The upper portion of jaws, snouts, and the front part of the head were removed on ten fish so that wanding for coded-wire tags was futile. The two with somewhat intact heads contained no tag. Two of the carcasses were male, nine female, and on one the sex could not be discerned due to its fragmentary nature.

Of the two McCauley Creek male chinook, one was a pre-spawn mortality due to predation. The remaining male spawned completely prior to being subject to scavenging/predation. Two McCauley Creek females were spawned out, three appeared to have skeins about half full, and two females were pre-spawn mortalities. The two spawned out females were marked with clipped adipose fins; none of the other males or females was clipped. The carcass of indeterminate sex was also indeterminate on adipose

fin clip status. Scales were collected on all eleven carcasses for which sex and adipose fin status could be determined; the remains of the other being two fragmentary to sample. Tissues were collected from two fresh female carcasses for DNA samples.

Twelve coho redds were documented during December. Four of these were flagged by a Nookack Tribal survey crew and eight were flagged by the NSEA crew. Eight live coho, and one carcass were documented in this reach of McCauley Creek. The carcass was too decomposed to determine tag or adipose fin status, spawn status, or collect tissues for a DNA sample. Scales were collected from this 41 cm fork length male. No chum were sighted.

**Mitchell Creek** was surveyed five times between October 26$^{th}$ and January 1$^{st}$. Visibility was excellent with a seasonal estimated average of 90%. The creek in the survey reach is well shaded and narrow, with a low width to depth ratio, and contains abundant small spawning gravels, a little woody debris, and only one pool large enough to offer much protection.

Four completed chinook redds and one live chinook were recorded on October 27$^{th}$ in Mitchell Creek. Two chinook carcasses were recovered at that time, both females. One was untagged with a clipped adipose fin and completely spawned out. The other was an unmarked, freshly killed, prespawn female 'predation' mortality. She was intact except for a slit open belly and missing egg skeins and lay in the shallows among abundant bear tracks. Tissues were collected from the second and scales from both.

Twenty-seven completed coho redds were recorded on Mitchell Creek from late November through December. Twenty-two live coho and seven carcasses were documented, mostly from the same time period. Seventeen live coho were noted on December 9$^{th}$. Of the seven carcasses, four were male and three female. One male was adipose fin-clipped. All females and two males were fully spawned; one male was partially spawned out and one was a prespawn mortality. Scales were collected from three and tissues for DNA samples from two.

**Tinling Creek**, a major tributary of Black Slough in the lower Nooksack River South Fork, was surveyed five times between November 13$^{th}$ and January 14$^{th}$. Visibility was excellent, with a seasonal estimated average of 96%. The creek in the survey reach is well shaded and diverse in character. It has a high width to depth ratio throughout, with most of the reach being wide and shallow. At its upstream end, the creek dissects a fan, presumably composed of alluvial and colluvial deposits, at the base of the Van Zandt Dike and has a moderate gradient. Here the substrate is primarily boulder-cobble, but several nice pockets of spawning gravels occur where the stream flattens out for a few meters. Riffles and small pools characterize the middle section. Abundant spawning gravels characterize the substrate there. At the lower end of the survey reach, the creek braids and separates into multiple channels as finer gravels accumulate to form an alluvial fan where the creek enters a flat, heavily forested wetland zone.

Fourteen completed coho redds were recorded from late November through late December. Twenty-six live coho were noted during this period with none seen in mid-November or in mid-January. Eight coho carcasses were documented, all on December 7th. Four were so fragmented from scavenger/predator activity that nothing could be determined about them. Of the other four, three were female and one was a male. None of the four were tagged. One female was adipose fin clipped. Scales were collected from all four and tissues for a DNA sample were collected from one.

**Terrell Creek**, a Georges Strait tributary, was surveyed five times between October 30th and January 19th. This survey was designed to provide baseline data for spawning activity for this stream as part of ongoing development of stewardship and restoration programs. Terrell Creek is a low-gradient stream with ample shade, pools and riffles, some woody debris, and a gravel substrate. The average visibility was estimated for the survey season to be 59%. This is due to a dark brownish tannin-like tint that characterizes creek water in the survey reach of Terrell Creek.

Terrell Creek, like Starry Creek in the Ten Mile Creek drainage, was devoid of spawning salmon during the fall and winter months. In fact, surveyors noticed no fish of any kind in Terrell Creek waters.

**Kinney Creek,** a tributary of the Sumas River, was surveyed one time on December 5th. Two short reaches were surveyed. The lower reach is WRIA river mile 0.8 to 0.9 and the upper reach is WRIA river mile 1.4 to 1.6. Results on the lower reach consisted of one completed Coho redd, three coho carcasses, and three live coho. Scales and tissues were collected. Results on the upper reach consisted or one completed Coho redd, one coho carcass, and three live coho. Scales and tissues were collected.

**Breckenridge Creek**, a tributary of the Sumas River, was surveyed one time on December 11th. A 1.1 mile reach was surveyed from WRIA river mile 3.4 to 4.5. Three coho redds, twenty-four coho carcasses, and thirteen live coho were noted. Scales and tissues for DNA samples were collected from two carcasses.

## Project Archives

NSEA 2003 spawner survey project field notes and forms are archived in paper files at NSEA. Scale cards, survey cards, and DNA samples are archived at WDFW in Olympia. Data spreadsheets and report can be accessed at each Nooksack Basin Co-Manager Office (Lummi Natural Resources; Nooksack Natural Resources; and Washington Department of Fish and Wildlife, La Conner Office) and at the Nooksack Salmon Enhancement Association Office in Bellingham.

Computer files include seventeen reach files, each of which consist of several worksheets for each species. These include general survey results, details about carcasses recovered, redd documentation, and redd timing. Redd GIS location plot data are included in the

redd documentation worksheet for each reach. Two summary files contain 1) summarized survey information and, 2) details about carcasses and DNA sampled fish.

# Discussion

Most 2003 Nooksack basin chinook spawning prior to October 12th took place in the river mainstem and forks, as was also the case in 2002. Salmonid spawners were unable to swim into tributaries before then due to extremely low flows in the basin. During and after the mid-October flood events, chinook and coho spawners entered tributaries to escape roiling, turbid conditions in the mainstem and to seek suitable spawning conditions. Lynden citizens reported chinook in lower Fishtrap creek during the October 12th-14th pre-flood discharge peak.

Tribal and state surveys in mainstem and forks provided managers with some late September through early October fall chinook counts. It is uncertain how many chinook may have attempted to spawn in mainstem and forks reaches after that time, however. This uncertainty was caused by poor viewing conditions and accessibility due to high flows and turbidity that severely restricted survey efforts in those reaches. As a result, tributary surveys provide a small, but important, view of late fall chinook spawning success.

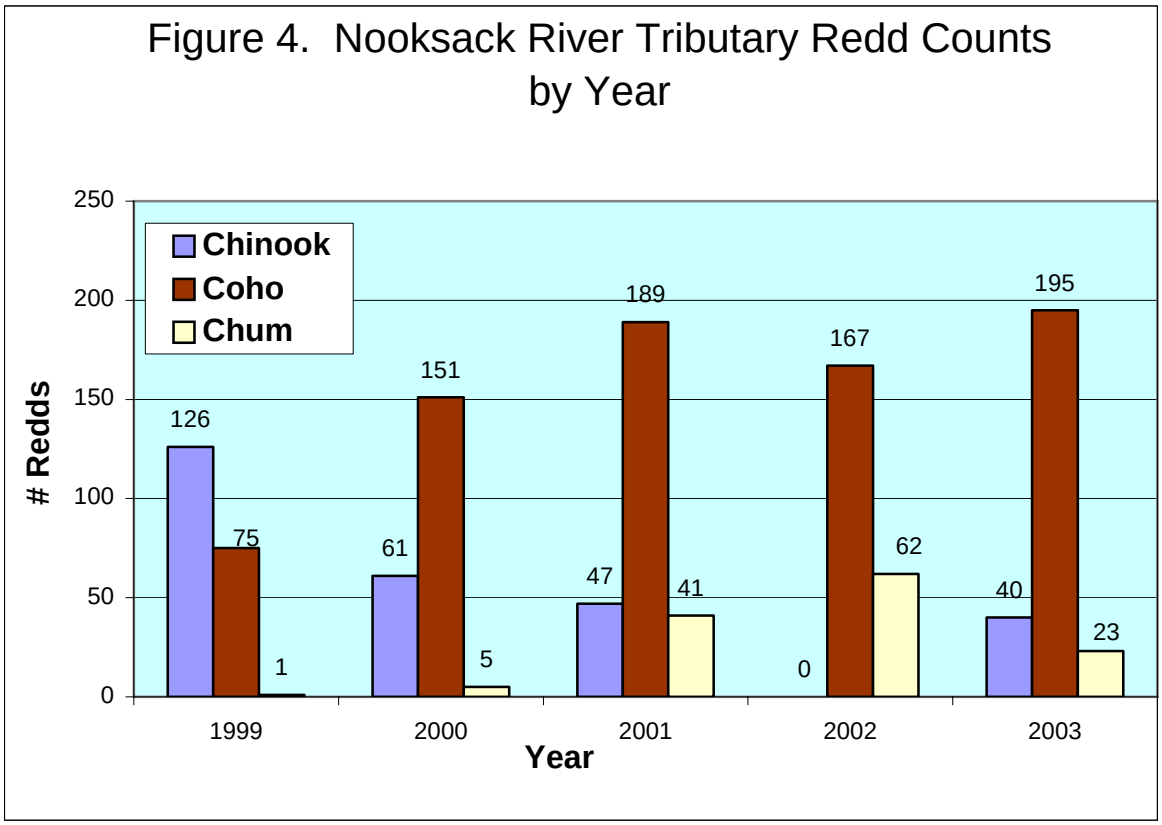
## Redd Counts as a Measure of Natality

Counts of completed redds are used in this study, not to produce *escapement estimates*, but more precisely, as a baseline for estimating the total number of ***effective spawners***. This distinction is seen as a necessary step in estimating *natality rates*, the number of hatchlings produced per female per unit time (Krebs 1994: 161), otherwise referred to as 'egg-to-fry survival rates'. By contrast, escapement estimates are useful for understanding fertility, or the number of individuals that are physiologically capable of breeding. Krebs (1994:160) emphasizes that an understanding of natality rates are needed to distinguish between potential and realized fecundity, fecundity being the number of offspring produced during a period of time. A measure of *realized fecundity* can, thereby, provide a more reliable basis for assessing egg-to-fry survival rates that escapement estimates population change.

As we have observed from body cavity examinations of all recovered carcasses, many adults returning to spawn are reproductive failures. We know from the unspent eggs and milt that these fish were at least physically capable of reproducing. more suitable than live or dead fish counts in providing consistent and reliable data that are accurate enough to base estimates of *effective spawner* counts and upon which to base annual comparisons. It is assumed that at least one pair spawned to produce each completed redd. Carcasses are also prone to loss by scavengers or remain unobserved. Likewise,

live fish counts are excluded from this discussion because of the extremely likely potential for miscount and/or recount errors (see Appendix F).

Although escapement estimates can be used to address issues concerned with anadromous species fertility, or the as well as offer insight on abundance and nutrient cycling, their utility for establishing a basis for estimating population change is limited. is not questioned their utility for assessing. The 2003 tributary chinook redd count (n=40) is somewhat lower than the annual average of 59, as calculated over the 1999-2002 period for the same streams. In addition this average is depressed by the 2002 count when chinook were excluded from surveyed tributaries by low flows for their entire spawning season (Krancus 2003). Nevertheless, an apparent downward trend in chinook redd frequency over the last five years, from 126 in 1999 to 40 in 2003 is illustrated in the Figure 4 graph.




The counts shown in Figure 4 reflect surveys that were repeated each year (Krancus 2003, Moore 2000, 2001; Timmer 2002) over the entire five-year period, but exclude data from streams not consistently and regularly surveyed each year. For example, results from Double Ditch are not included as part of this comparison since it was not surveyed each year.

Several other survey observations are worthy of mention in regard to 2003 Fall chinook spawning. First, many of the Fall chinook redds constructed prior to the mid-October high flow events were probably subjected to scouring of stream bed sediments with

significant loss of eggs likely. Second, male chinook did not all remain in the vicinity of spawning or were not available for sampling due to predation, scavenging or some other reason. Nevertheless, the occurance of completed chinook redds indicates that spawning did occur in at least forty instances in survey reaches, despite the relative dearth of male carcasses.

In Figure 4, we can also see that completed coho redds are more numerous than chinook and are holding steady or increasing slightly over the 1999-2003 period, with 195 redds documented in 2003. Annual average over the five years from 1999 through 2003 is 155 redds. Chum averaged 26 redds per year over the same period, with a peak of 62 in 2002.

Comparison of the geographic distribution of 2003 lowland Nooksack basin spawning activities with those in 2001 and 2002, offer insight into short-term sub-basin salmonid use trends. Spawning activity in the lower Ten Mile Creek sub-basin remains stable with all three species spawning in Silver Springs Creek and coho and chum spawning in Deer Creek. As in recent years, upper Ten Mile Creek and Starry Creek were almost devoid of spawning activity, with the exception of the healthy influx of Chum in 2002. All three species were very active in both Bertrand Creek and Fishtrap Creek with redd totals similar to those tallied during 2001 and 2002. Considerably smaller numbers of coho spawned in Anderson Creek in 2003 than in recent years. This was tempered somewhat, by an influx of chinook spawners, undocumented in this reach in recent years. Chinook spawners were also documented in Smith Creek, McCauley Creek, and Mitchell Creek for the first time since 1999 with the exception of one redd in Smith Creek in 2001. Coho spawning in these streams, and in Tinling Creek in the South Fork drainage, was of an intensity comparable to that in recent years. No salmonids, adults or juvenile, were observed in this first year of survey in the river mile 4.3-5.3 reach of Terrell Creek, a tributary of Georges Strait northwest of Ferndale.

## Future Studies

The following statements are made with humility at the risk of overstating the obvious. Repeat observations, important for elucidating in-season patterns as well as ensuring comparability among annual efforts that yield data of powerful interpretive potential, need to be maintained in terms of reaches surveyed each year, as well as the types of observations, measurements, and sampling done each time. At the same time, certain procedures will become obsolete or less useful and others will need to be adjusted as we learn more and new techniques are developed.

**Recommendations.** The following suggestions are offered, in view of the foregoing discussion:

1) Resurvey the same reaches each year at the 7-10 day periodicity for similar seasonal duration to maintain consistency and enhance data comparability year-to-year;

2) Continue with redd location and timing documentation; enter into GIS database;

3) Continue with collection of tissues from unmarked chinook and coho, and from chum for potential DNA analysis and associated carcass condition documentation; analyze salmon stocks from cross-boundary streams;

4) Continue with scale collections, especially on chinook; report on age structure of populations;

5) Continue with gut examinations and documentation to record spawning completeness or rough percentage.

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# Appendix A. Chinook Carcasses (n=33) - 2003 NSEA Nooksack River Tributaries Spawner Survey

| Stream Name | WRIA | River Mile | Date | Field DNA#* | Lab DNA # | Sex (M/F) | FKL (cm) | Adipose Clip? (y/n) | cwt? (y/n) | Scales Collected? (y/n) | % spawn (approx) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Silver Springs Cr | 01-0184 | 0.7 | 10/21 | none | none | M | 87 | y | n | y | 0 | |
| Silver Springs Cr | 01-0184 | 0.5 | 10/30 | none | none | F | 75 | y | n | y | 0 | |
| Silver Springs Cr | 01-0184 | 0.5 | 10/30 | none | none | F | 95 | y | n | y | 0 | |
| Silver Springs Cr | 01-0184 | 0.6 | 10/30 | none | none | M | 75 | n | n | y | 0 | |
| Silver Springs Cr | 01-0184 | 0.6 | 10/30 | none | none | F | 74 | y | n | y | 0 | |
| Silver Springs Cr | 01-0184 | 0.7 | 10/30 | none | none | M | 74 | y | n | y | 0 | |
| Bertrand Creek | 01-0201 | 8.5 | 10/28 | none | none | F | 65 | n | n | y | 0 | |
| Bertrand Creek | 01-0201 | 8.3 | 11/4 | none | none | F | 64 | n | n | y | 100 | |
| Bertrand Creek | 01-0201 | 8.5 | 11/4 | none | none | F | 77 | n | n | y | 100 | |
| Bertrand Creek | 01-0201 | 9.3 | 11/4 | none | none | F | 93 | n | n | y | 100 | |
| Bertrand Creek | 01-0201 | 9.2 | 11/4 | none | none | unk | unk | unk | n | n | unk | c |
| Bertrand Creek | 01-0201 | 9.0 | 11/14 | none | none | F | 81 | n | n | y | 100 | |
| Bertrand Creek | 01-0201 | 9.2 | 11/14 | none | none | F | 89 | n | n | y | 100 | |
| Fishtrap Creek, upper | 01-0210 | 9.3 | 11/13 | none | none | F | 59 | y | n | y | 100 | |
| Fishtrap Creek, upper | 01-0210 | 9.2 | 11/13 | none | none | unk | unk | unk | n | n | unk | c |
| Fishtrap Creek, lower | 01-0210 | 4.9 | 11/14 | none | none | F | 78 | y | n | y | 100 | |
| Fishtrap Creek, lower | 01-0210 | 5.1 | 11/14 | none | none | F | 87 | n | n | y | 100 | |
| Fishtrap Creek, lower | 01-0210 | 5.2 | 11/14 | none | none | F | 72 | n | n | y | 100 | |
| Anderson Creek | 01-0228 | 4.0 | 10/30 | none | none | F | 70 | y | n | y | 100 | |
| Smith Creek | 01-0234 | 2.9 | 10/27 | nc03rss1 | 03GD4 | F | 95 | n | n | y | 100 | |
| McCauley Creek | 01-0235 | 1.1 | 10/27 | none | none | F | ? | unk | unk | y | 0 | |
| McCauley Creek | 01-0235 | 1.2 | 10/27 | none | none | M | 84 | n | n | y | 100 | |
| McCauley Creek | 01-0235 | 1.2 | 10/27 | none | none | M | 91 | n | unk | y | 0 | |
| McCauley Creek | 01-0235 | 1.2 | 10/27 | nc03rss2 | 03GD2 | F | 93 | n | unk | y | 0 | |
| McCauley Creek | 01-0235 | 1.2 | 10/27 | none | none | F | 89 | y | unk | y | 100 | |
| McCauley Creek | 01-0235 | 1.2 | 10/27 | none | none | F | 94 | y | unk | y | 100 | |
| McCauley Creek | 01-0235 | 1.2 | 10/27 | nc03rss3 | 03GD1 | F | 90 | n | n | y | 50 | |
| McCauley Creek | 01-0235 | 1.4 | 10/27 | none | none | F | 82 | n | unk | y | 50 | |
| McCauley Creek | 01-0235 | 1.5 | 10/27 | none | none | F | 85 | n | unk | y | 50 | |
| McCauley Creek | 01-0235 | 1.5 | 10/27 | none | none | F | 79 | n | unk | y | 50 | |
| McCauley Creek | 01-0235 | 1.5 | 10/27 | none | none | F | 95 | n | unk | y | 0 | |
| Mitchell Creek | 01-0236 | 0.5 | 10/27 | none | none | F | 82 | y | n | y | 100 | fr |
| Mitchell Creek | 01-0236 | 0.6 | 10/27 | nc03rss4 | 03GD3 | F | 87 | n | n | y | 0 | b |

*DNA collected on fresh carcasses only; carcass freshness scoring data available on DNA inventory.

# Appendix B. 2003 Chinook Spawner DNA Sample Inventory/Carcass Condition

| Lab ID# | Field ID# | Date Collected | Stream Name | WRIA # 01- | River Mile | Collector's ID | CARCASS CONDITION Gills | Eye | Flesh | Rigor Mortis | Fungus on Opercle? | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 03GD1 | NC03RSS3 | 10/27/03 | McCauley Creek | 235 | | | red | clear | firm | yes | no | very fresh |
| 03GD2 | NC03RSS2 | 10/27/03 | McCauley Creek | 235 | 1.2 | SR | white | gone | soft | no | no | |
| 03GD3 | NC03RSS4 | 10/27/03 | Mitchell Creek | 236 | | | red | gone | firm | no | no | fresh |
| 03GD4 | NC03RSS1 | 10/27/03 | Smith Creek | 234 | | | red | clear | firm | yes | no | very fresh |

# Appendix C. Coho Carcasses (n=80) - 2003 Nooksack Lowlands Spawner Survey

| Stream Name | WRIA | River Mile | Date | NSEA Field DNA#* | Lab DNA # | Sex (M/F) | FKL (cm) | Adipose Clip? (y/n) | cwt? (y/n) | Scales Collected? (y/n) | % spawn | Field Tech. | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kinney Creek,lower | 00-0012 | 0.8 | 12/5 | NC03RSS15 | none | F | 58 | n | unk | y | 100 | MH BC | |
| Kinney Creek,lower | 00-0012 | 0.8 | 12/5 | NC03RSS16 | none | M | 72 | n | unk | y | 100 | MH BC | |
| Kinney Creek,lower | 00-0012 | 0.9 | 12/5 | NC03RSS18 | none | F | 66 | n | unk | y | 100 | MH BC | |
| Kinney Creek, upper | 00-0012 | 1.8 | 12/5 | NC03RSS19 | none | F | 56 | n | unk | y | unk | MH BC | |
| Breckenridge Creek | 00-0013 | 3.4-4.5 | 12/11 | NC03RSS24 | none | M | 50 | n | unk | y | 100 | JG WR | |
| Breckenridge Creek | 00-0013 | 3.4-4.5 | 12/11 | none | none | F | 60 | n | unk | n | 100 | JG WR | |
| Breckenridge Creek | 00-0013 | 3.4-4.5 | 12/11 | none | none | F | 53 | n | unk | n | unk | JG WR | |
| Breckenridge Creek | 00-0013 | 3.4-4.5 | 12/11 | none | none | F | 58 | unk | unk | n | unk | JG WR | |
| Breckenridge Creek | 00-0013 | 3.4-4.5 | 12/11 | none | none | M | 62 | n | unk | n | unk | JG WR | |
| Breckenridge Creek | 00-0013 | 3.4-4.5 | 12/11 | none | none | M | 49 | n | unk | n | 0 | JG WR | |
| Breckenridge Creek | 00-0013 | 3.4-4.5 | 12/11 | none | none | M | 53 | n | unk | n | 100 | JG WR | |
| Breckenridge Creek | 00-0013 | 3.4-4.5 | 12/11 | NC03RSS25 | none | F | 57 | n | unk | y | 100 | JG WR | |
| Breckenridge Creek | 00-0013 | 3.4-4.5 | 12/11 | none | none | M | 56 | n | unk | n | 100 | JG WR | |
| Breckenridge Creek | 00-0013 | 3.4-4.5 | 12/11 | none | none | F | 55 | n | unk | n | 100 | JG WR | 12 additional dead coho |
| Breckenridge Creek | 00-0013 | 3.4-4.5 | 12/11 | none | none | M | 68 | n | unk | n | 50 | JG WR | were not sampled |
| Breckenridge Creek | 00-0013 | 3.4-4.5 | 12/11 | none | none | F | 65 | n | unk | n | 100 | JG WR | |
| Ten Mile Creek | 01-0163 | 0.9 | 12/10 | none | none | unk | unk | unk | unk | n | unk | BG JG | tail and gills only |
| Deer Creek | 01-0165 | 0.9 | 12/11 | none | none | unk | unk | unk | unk | n | unk | RC TR | |
| Deer Creek | 01-0165 | unk | 12/11 | none | none | unk | unk | unk | unk | n | unk | TR | |
| Deer Creek | 01-0165 | unk | 12/11 | none | none | unk | unk | unk | unk | n | unk | TR | |
| Deer Creek | 01-0165 | 1.0 | 12/11 | none | none | unk | unk | unk | unk | n | unk | TR | |
| Deer Creek | 01-0165 | 0.6 | 12/24 | none | none | M | 51 | N | N | Y | 50 | MH | |
| Deer Creek | 01-0165 | 0.6 | 12/24 | none | none | M | 57 | N | N | Y | 100 | MH | |
| Deer Creek | 01-0165 | 3.3 | 12/24 | none | none | F | 49 | N | N | N | unk | MH | |
| Silver Springs Cr | 01-0184 | 1.3 | 11/11 | NC03RSS5 | 03KL1 | M | 45 | N | n | Y | 0 | BG CS | |
| Silver Springs Cr | 01-0184 | 1.0 | 12/10 | n/a | none | F | unk | N | N | N | unk | BG | fish not recoverable |
| Silver Springs Cr | 01-0184 | 1.0 | 12/10 | n/a | none | F | unk | N | N | N | unk | BG | fish not recoverable |
| Silver Springs Cr | 01-0184 | 1.3 | 12/10 | NC03RSS49 | 03KL2 | F | 41 | N | N | Y | 100 | BG | |
| Bertrand Creek | 01-0201 | 9.5 | 11/4 | none | none | M | unk | n | unk | n | unk | BG | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bertrand Creek | 01-0201 | 8.2 | 11/14 | none | none | M | 41 | y | unk | n | 50 | BG | |
| Bertrand Creek | 01-0201 | 8.3 | 11/14 | none | none | M | 55 | y | unk | n | 0 | BG | |
| Bertrand Creek | 01-0201 | 8.9 | 11/14 | NC03RSS6 | 03KL3 | M | 39 | n | n | Y | 50 | BG | |
| Bertrand Creek | 01-0201 | 9.0 | 11/14 | NC03RSS7 | 03KL4 | F | 53 | n | n | Y | 100 | BG | |
| Bertrand Creek | 01-0201 | 9.2 | 11/14 | none | none | M | 50 | unk | unk | n | unk | BG | |
| Bertrand Creek | 01-0201 | 9.5 | 11/14 | none | none | M | 57 | n | n | y | 50 | BG | |
| Bertrand Creek | 01-0201 | 9.5 | 11/14 | none | none | M | 41 | n | n | y | 50 | BG | |
| Bertrand Creek | 01-0201 | 9.6 | 11/14 | none | none | M | 55 | n | n | n | 50 | BG | |
| Bertrand Creek | 01-0201 | 9.6 | 11/14 | none | none | F | 51 | n | n | n | 100 | BG | |
| Bertrand Creek | 01-0201 | 9.6 | 11/14 | none | none | F | 53 | n | n | n | 100 | BG | |
| Bertrand Creek | 01-0201 | 9.6 | 11/14 | none | none | M | 58 | n | n | n | 100 | BG | |
| Bertrand Creek | 01-0201 | 9.7 | 11/14 | none | none | F | 57 | n | n | n | 100 | BG | |
| Bertrand Creek | 01-0201 | 8.1 | 12/9 | none | none | M | 47 | n | n | n | 100 | BG | |
| Bertrand Creek | 01-0201 | 8.5 | 12/9 | none | none | M | unk | n | n | n | unk | BG | |
| Bertrand Creek | 01-0201 | 8.8 | 12/9 | none | none | M | 57 | n | n | n | 100 | BG | |
| Bertrand Creek | 01-0201 | 9.1 | 12/9 | NC03RSS35 | 03KL5 | M | 36 | n | n | y | 100 | BG | |
| Bertrand Creek | 01-0201 | 9.3 | 12/9 | none | none | M | unk | n | n | n | unk | BG | |
| Bertrand Creek | 01-0201 | 9.4 | 12/9 | none | none | F | 48 | n | n | n | 100 | BG | |
| Bertrand Creek | 01-0201 | 9.5 | 12/9 | none | none | M | unk | n | n | n | unk | BG | |
| Bertrand Creek | 01-0201 | 9.6 | 12/9 | NC03RSS36 | 03KL6 | F | 49 | n | n | n | 100 | BG | |
| Bertrand Creek | 01-0201 | 9.6 | 12/9 | none | none | M | unk | n | n | n | unk | BG | |
| Bertrand Creek | 01-0201 | 9.7 | 12/9 | none | none | M | unk | n | n | n | unk | BG | |
| Bertrand Creek | 01-0201 | 7.7 | 12/23 | none | none | M | unk | n | unk | n | unk | BG | |
| Bertrand Creek | 01-0201 | 7.9 | 12/23 | none | none | M | 39 | n | n | n | 100 | BG | |
| Bertrand Creek | 01-0201 | 9.3 | 12/23 | NC03RSS39 | 03KL7 | F | 55 | n | n | n | 100 | BG | |
| Bertrand Creek | 01-0201 | 9.4 | 12/23 | none | none | M | 45 | n | n | n | 100 | BG | |
| Bertrand Creek | 01-0201 | 9.5 | 12/23 | NC03RSS37 | 03KL8 | M | 47 | n | n | n | 50 | BG | |
| Bertrand Creek | 01-0201 | 9.5 | 12/23 | none | none | unk | unk | n | unk | n | unk | BG | |
| Bertrand Creek | 01-0201 | 9.6 | 12/23 | none | none | F | 45 | n | n | n | 100 | BG | |
| Fishtrap Creek, upper | 01-0210 | unk | 10/31 | none | none | unk | unk | unk | unk | n | unk | NN DY | |
| Fishtrap Creek, upper | 01-0210 | unk | 10/31 | none | none | unk | unk | unk | unk | n | unk | NN DY | |
| Fishtrap Creek, upper | 01-0210 | 9.5 | 11/13 | none | none | unk | unk | unk | unk | n | unk | NN DY | |
| Fishtrap Creek, upper | 01-0210 | 9.5 | 11/13 | none | none | unk | unk | unk | unk | n | unk | NN DY | |
| Fishtrap Creek, upper | 01-0210 | 9.0 | 11/26 | NC03RSS22 | 03KL10 | M | 55 | n | n | y | 50 | NN DY | |
| Fishtrap Creek, upper | 01-0210 | 9.2 | 11/26 | NC03RSS20 | 03KL9 | M | 45 | n | n | y | 0 | NN DY | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fishtrap Creek, upper | 01-0210 | 9.7 | 12/9 | none | none | unk | unk | unk | unk | n | unk | NN DY | |
| Fishtrap Creek, upper | 01-0210 | 9.1 | 12/22 | none | none | unk | unk | unk | unk | n | unk | NN DY | |
| Fishtrap Creek, upper | 01-0210 | 9.1 | 12/22 | none | none | M | 85 | n | n | y | 0 | NN DY | |
| Fishtrap Creek, upper | 01-0210 | 9.4 | 12/22 | none | none | M | 65 | y | n | n | 0 | NN DY | |
| Fishtrap Creek, upper | 01-0210 | 9.8 | 12/22 | none | none | unk | unk | unk | unk | n | unk | NN DY | |
| Fishtrap Creek, lower | 01-0210 | 4.9 | 12/16 | NC03RSS40 | 03KL11 | M | 49 | N | unk | Y | unk | RC TR | |
| Fishtrap Creek, lower | 01-0210 | 5.0 | 12/16 | NC03RSS38 | 03KL12 | M | 55 | N | unk | Y | unk | RC TR | |
| Fishtrap Creek, lower | 01-0210 | 5.0 | 12/16 | none | none | M | 54 | N | unk | N | unk | RC TR | |
| Anderson Creek | 01-0228 | 3.4 | 10/30 | none | none | unk | unk | unk | unk | n | unk | NN DY | Fragmentary remains |
| Anderson Creek | 01-0228 | 3.9 | 11/7 | none | none | unk | unk | unk | unk | n | unk | NN DY | |
| Anderson Creek | 01-0228 | 3.6 | 11/23 | NC03RSS8 | 03KL13 | M | 44 | n | n | Y | 0 | NN DY | |
| Anderson Creek | 01-0228 | 3.7 | 12/9 | NC03RSS46 | 03KL14 | M | 45 | n | n | Y | 0 | MH SM | |
| Anderson Creek | 01-0228 | 3.7 | 12/9 | NC03RSS47 | 03KL15 | M | 43 | N | n | Y | 100 | MH SM | |
| Anderson Creek | 01-0228 | 3.9 | 12/17 | none | none | M | 60 | N | n | N | 100 | NN DY | |
| Anderson Creek | 01-0228 | 4.0 | 12/17 | none | none | F | 50 | N | n | N | 0 | NN DY | |
| Anderson Creek | 01-0228 | 3.6 | 12/30 | none | none | F | unk | unk | n | n | 0 | NN DY | pre-spawn dog predation |
| McCauley Creek | 01-0235 | 1.2 | 11/24 | none | none | M | 41 | n | unk | Y | unk | SR CS MK | |
| Mitchell Creek | 01-0236 | 0.6 | 11/24 | NC03RSS23 | 03KL16 | M | 45 | n | unk | Y | 0 | SR MK | |
| Mitchell Creek | 01-0236 | 0.8 | 11/24 | none | none | M | 42 | n | unk | Y | 50 | SR MK | |
| Mitchell Creek | 01-0236 | 0.3 | 12/9 | NC03RSS17 | 03KL17 | F | 50 | n | unk | Y | 100 | SR MK WR | |
| Mitchell Creek | 01-0236 | unk | 12/9 | none | none | M | 45 | y | unk | N | 100 | SR MK WR | |
| Mitchell Creek | 01-0236 | unk | 12/9 | none | none | M | 55 | n | unk | N | 100 | SR MK WR | |
| Mitchell Creek | 01-0236 | unk | 12/9 | none | none | F | 52 | n | unk | N | 100 | SR MK WR | |
| Mitchell Creek | 01-0236 | unk | 12/9 | none | none | F | 56 | n | unk | N | 100 | SR MK WR | |
| Tinling Creek | 01-0250 | 1.9 | 12/7 | none | none | unk | unk | unk | unk | N | unk | SM MH | fragmentary |
| Tinling Creek | 01-0250 | 2.0 | 12/7 | none | none | unk | unk | unk | unk | N | unk | SM MH | fragmentary |
| Tinling Creek | 01-0250 | 2.0 | 12/7 | none | none | unk | unk | unk | unk | N | unk | SM MH | fragmentary |
| Tinling Creek | 01-0250 | 2.0 | 12/7 | none | none | F | 52 | n | n | Y | unk | SM MH | |
| Tinling Creek | 01-0250 | 2.0 | 12/7 | none | none | M | 56 | n | n | Y | unk | SM MH | |
| Tinling Creek | 01-0250 | 2.0 | 12/7 | NC03RSS32 | 03KJ1 | F | 61 | n | n | Y | unk | SM MH | |
| Tinling Creek | 01-0250 | 2.1 | 12/7 | none | none | F | 51 | y | n | Y | unk | SM MH | |
| Tinling Creek | 01-0250 | 2.1 | 12/7 | none | none | unk | unk | unk | unk | N | unk | SM MH | fragmentary |

# Appendix D. Chum Carcasses (n=42), 2003 Nooksack R. Tributaries Spawner Survey

| Stream Name | WRIA | River Mile | Date | Field DNA#* | Lab DNA # | Sex (M/F) | FKL (cm) | Scales Collected? (y/n) | % spawn | Field Tech. | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ten Mile Creek | 01-0163 | 0.9 | 10-Dec | none | none | unk | unk | n | unk | BG JG | skin only |
| Deer Creek | 01-0165 | 0.7 | 12/11 | none | none | M | 81 | y | unk | TR | |
| Deer Creek | 01-0165 | 1.0 | 12/11 | none | none | unk | unk | n | unk | TR | |
| Deer Creek | 01-0165 | 0.6 | 12/24 | none | none | F | 65 | n | 100 | MH | |
| Bertrand Creek | 01-0201 | 8.8 | 11/14 | none | none | F | 76 | n | 100 | BG JG | |
| Bertrand Creek | 01-0201 | 9.3 | 11/14 | none | none | M | 79 | n | 50 | BG JG | |
| Bertrand Creek | 01-0201 | 9.6 | 11/14 | none | none | F | 67 | n | 100 | BG JG | |
| Bertrand Creek | 01-0201 | 9.6 | 11/14 | none | none | F | 71 | n | 100 | BG JG | |
| Bertrand Creek | 01-0201 | 9.7 | 11/14 | none | none | M | 70 | n | 100 | BG JG | |
| Bertrand Creek | 01-0201 | 7.6 | 12/9 | NC03RSS33 | none | M | 58 | y | 100 | BG JG | |
| Bertrand Creek | 01-0201 | 7.7 | 12/9 | none | none | F | unk | n | unk | BG JG | |
| Bertrand Creek | 01-0201 | 8.0 | 12/9 | NC03RSS34 | none | M | 68 | y | 100 | BG JG | |
| Bertrand Creek | 01-0201 | 8.5 | 12/9 | none | none | unk | unk | n | unk | BG JG | |
| Bertrand Creek | 01-0201 | 8.8 | 12/9 | none | none | M | unk65 | n | 100 | BG JG | |
| Bertrand Creek | 01-0201 | 8.8 | 12/9 | none | none | M | 72 | n | 100 | BG JG | |
| Bertrand Creek | 01-0201 | 8.8 | 12/9 | none | none | F | 59 | n | 100 | BG JG | |
| Bertrand Creek | 01-0201 | 9.1 | 12/9 | none | none | F | 60 | n | 100 | BG JG | |
| Bertrand Creek | 01-0201 | 9.1 | 12/9 | none | none | M | 84 | n | 100 | BG JG | |
| Bertrand Creek | 01-0201 | 9.2 | 12/9 | none | none | M | unk | n | unk | BG JG | |
| Bertrand Creek | 01-0201 | 9.2 | 12/9 | none | none | F | unk | n | unk | BG JG | |
| Bertrand Creek | 01-0201 | 9.2 | 12/9 | none | none | M | 63 | n | 100 | BG JG | |
| Bertrand Creek | 01-0201 | 9.3 | 12/9 | none | none | unk | unk | n | unk | BG JG | |
| Bertrand Creek | 01-0201 | 9.5 | 12/9 | none | none | F | 57 | n | 0 | BG JG | |
| Bertrand Creek | 01-0201 | 9.5 | 12/9 | none | none | M | 62 | n | 50 | BG JG | |
| Bertrand Creek | 01-0201 | 9.6 | 12/9 | none | none | M | unk | n | unk | BG JG | deep in pool, unsampleable |
| Bertrand Creek | 01-0201 | 9.6 | 12/9 | none | none | F | unk | n | unk | BG JG | deep in poo, unsampleable |
| Bertrand Creek | 01-0201 | 7.9 | 12/23 | none | none | M | 75 | y | 100 | BG | |
| Bertrand Creek | 01-0201 | 8.0 | 12/23 | none | none | M | 64 | y | 100 | BG | |
| Bertrand Creek | 01-0201 | 8.0 | 12/23 | NC03RSS41 | none | F | 63 | y | 100 | BG | |
| Bertrand Creek | 01-0201 | 8.9 | 12/23 | none | none | M | 67 | n | 100 | BG | |
| Bertrand Creek | 01-0201 | 9.1 | 12/23 | none | none | M | 80 | y | 100 | BG | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Bertrand Creek | 01-0201 | 9.4 | 12/23 | none | none | F | 65 | n | 100 | BG |
| Fishtrap Creek, Upper | 01-0210 | 8.7 | 10/31 | none | none | M | 73 | n | 0 | NN DY |
| Fishtrap Creek, Upper | 01-0210 | 8.5 | 11/13 | none | none | unk | unk | n | unk | NN DY |
| Fishtrap Creek, Upper | 01-0210 | 9.4 | 11/13 | none | none | unk | unk | n | unk | NN DY |
| Fishtrap Creek, Upper | 01-0210 | 9 | 12/9 | none | none | M | 75 | y | 0 | NN DY CS |
| Fishtrap Creek, Upper | 01-0210 | 9.4 | 12/9 | none | none | M | 77 | n | 0 | NN DY CS |
| Fishtrap Creek, Upper | 01-0210 | 9.4 | 12/9 | none | none | unk | unk | n | unk | NN DY CS |
| Fishtrap Creek, Upper | 01-0210 | 9.6 | 12/9 | none | none | M | 79 | y | 0 | NN DY CS |
| Fishtrap Creek, Upper | 01-0210 | 9.1 | 12/16 | none | none | M | 75 | n | 0 | NN DY CS |
| Fishtrap Creek, Upper | 01-0210 | 8.9 | 12/16 | none | none | unk | unk | n | unk | NN DY CS |
| Fishtrap Creek, Upper | 01-0210 | 8.7 | 12/22 | none | none | unk | unk | n | unk | NN DY |

## Appendix E. 2003 Bertrand Creek redd distribution maps (produced by Brett

**Gaddis, BTC)**

## Appendix F. Cautions on the use of fish count data

**Chinook fish counts vs. redd counts.** If a spawning pair is assumed unique to each redd, then eighty chinook were responsible for the creation of the forty documented 2003 redds. Males are not always faithful to one redd, however (Neilson and

Geen, 1981, in Healey, 1991:324), and females have been known to dig more than one redd on occasion (Scott and Crossman, 1973:175). One or more such occurrences would cause an assumed *effective spawner* count to be slightly high if we use redd counts as the basis. Conversely, the presence of two-year jacks in the run would cause the assumed count, based on redd count, to be slightly low. Perhaps these factors balance out, perhaps not. It can be fairly safely assumed, however, that at least one female has spawned when a completed redd is documented, and that that female had a mate.

**A conservative estimate of *effective spawners* in 2003 tributary survey reaches, therefore, equals the redd count times a pair of spawners, or 80+ chinook, 390+ coho, and 46+ chum (see Table 2).**

Estimated percent spawn data, recovered through systematic examination of carcass body cavities, corroborates the need to go beyond fish counts to develop estimates of *effective spawner* counts. Conversely, as we can see from carcass body cavity examinations, many of the live fish we so diligently count, often fail to spawn despite their best efforts.

Fish counts can be suspect data for characterizing the health of a run because of the potential for miscount and recount errors. Such errors are related to pre- and post-mortality removal from spawning locations by predators and scavengers, the variability in details various field personnel have recorded in relation to fish counts over the years, and the possibility for recounting error due to fish movement and repeat surveys. Also see Krancus (2002), page 7 and Appendix A.

**Visibility Variability.** It is noteworthy to be aware that viewing conditions vary considerably from stream to stream. Average conditions for two streams in close proximity, Bertrand Creek and Fishtrap Creek, offer a good illustration. Seasonal average viewing conditions, or the approximate percentage of the creek bed observable over the course of the survey season, in Bertrand Creek was 41% and that in Upper Fishtrap Creek nearby was 15% for the same survey period. Care should be taken, therefore, in any comparison of redd and fish count data between or among reaches. This situation is due to extremely different stream characteristics.