Effectiveness Monitoring for LWD Placement in South Slough Tidal Wetlands

OWEB #205-111

Final Report Summary Submitted By:

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1. Description of the project including background on the problem which generated the project

Background

The Coos Watershed Association (CoosWA), South Slough National Estuarine Research Reserve (SSNERR) and Oregon Department of Fish and Wildlife (ODFW) collaborated on an OWEB-funded project to evaluate the effectiveness of placing large woody debris (LWD) in estuarine channels to provide improved habitat for juvenile salmonids. The project was designed to address the need for more and better information associated with the placement and function of LWD in estuaries. Supported by OWEB/USFWS Coastal Wetlands Conservation Program (grants 99-420 and 99-803) and FishAmerica funds, SSNERR partnered with CoosWA to coordinate a project in which 40 large (18-36" DBH) Sitka spruce trees with root wads attached into tidal reaches of Winchester Creek in South Slough's upper estuary. The trees, donated by Oregon Parks and Recreation Department (OPRD) as part of an Oregon Department of Transportation (ODOT) road realignment, were placed in specific locations and configurations designed to facilitate an effectiveness monitoring program to address a series of questions about juvenile salmon use and behavior as well as habitat development associated with LWD in tidal channels. CoosWA, SSNERR and ODFW staff were guided by SSNERR's Estuarine Wetland Restoration Advisory Group (Restoration Advisory Group) in finalizing tree placement locations and configurations as well as the development of effectiveness monitoring questions and protocols. The Restoration Advisory Group includes restoration specialists from academic research institutions, state and federal agencies, non-profit organizations, and private consulting firms.

Effectiveness monitoring for restoration projects targeting LWD recovery in estuaries is needed. Research and restoration monitoring projects from Pacific Northwest estuaries have clearly established the importance of estuaries in the life histories of Pacific salmon, increasing the priority of estuarine wetland restoration in Oregon. In 2001, Oregon's Independent Multidisciplinary Science Team (IMST) found lowland rivers and estuaries provide important foraging habitat for juvenile salmonids, but also documented significant reductions in salmonid habitat quality due to anthropogenic activity.

The importance of estuaries for salmon coupled with pervasive degradation of these areas across Oregon and the Pacific Northwest has increased efforts to re-establish important structural and functional attributes of tidal wetlands. We know juvenile salmon are continuing to use tidally-influenced areas throughout their over-wintering period; however, few projects seek to increase the quality and quantity of cover (large woody debris, LWD) in these areas even though LWD may be a major factor governing over-winter survival for coho in stream-channel environments. It is well known that LWD was an important physical characteristic to estuarine marshes before European settlement and was systematically removed from tidal systems to facilitate human activities.

The addition of LWD to estuaries is based on the current understanding of wood in streams and rivers as critical components of quality juvenile salmon foraging habitat that creates cover, produces beneficial hydrological changes, and increases prey resources. The importance of LWD in riverine systems has been documented, but only a few studies have targeted estuarine environments.

This project offered a unique opportunity to address urgent habitat recovery questions associated with LWD in estuarine habitats.

<u>Project Description</u>

Effectiveness monitoring of LWD placed in South Slough's upper estuary was designed to accomplish the following:

- Determine presence/absence and behavior of juvenile salmonids (i.e., coho and cutthroat trout) in and around LWD using underwater videography and acoustic tagging methods (a late addition to the project);
- Monitor abundance and species composition of juvenile salmonids in tidal creeks with (and without) LWD using fyke nets;
- Monitor fish use of other subtidal habitats with beach seines;
- Track changes in invertebrate abundance and composition;
- Detect wood movement with sub-meter GPS tracking;
- Record changes in channel profile around LWD with detailed elevation surveys; and,
- Track water temperature and flow in locations near and away from LWD.

Large woody debris was placed in 29 locations in South Slough's upper estuary. The effectiveness monitoring project focused on 12 sites, six pairs based on configuration and location (see Figures 1-7).

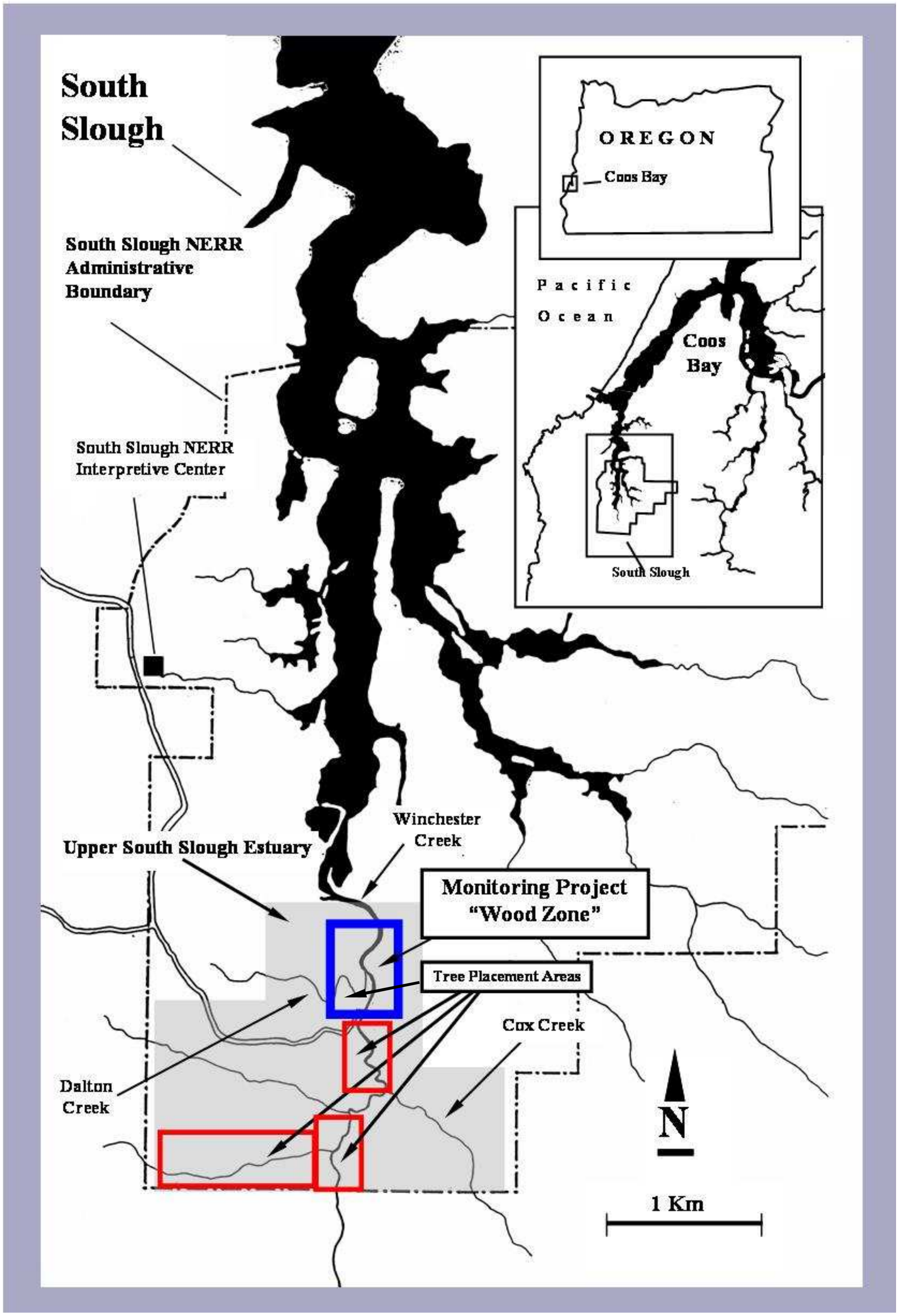

Figure 1. Location of the South Slough estuary, South Slough National Estuarine Research Reserve, the upper South Slough estuary, LWD placement areas and the project "Wood Zone".

South Slough NERR LWD Placement Project: "Wood Zone"

Six paired project monitoring sites are located in areas A1-A4 along Winchester Creek in South Slough's upper estuary, as shown at right. Pairs are located as follows:

1. Mouth of tributary tidal channel:
   Sites 1 and 2
2. Single tree in tributary tidal channel
   Sites 3 and 6
3. Single tree in tributary tidal channel
   Sites 4 and 5
4. Single tree in main tidal channel
   Sites 7 and 8
5. Double trees in main tidal channel:
   Sites 9 and 10
6. Double trees in main tidal channel:
   Site 11 and 12

N

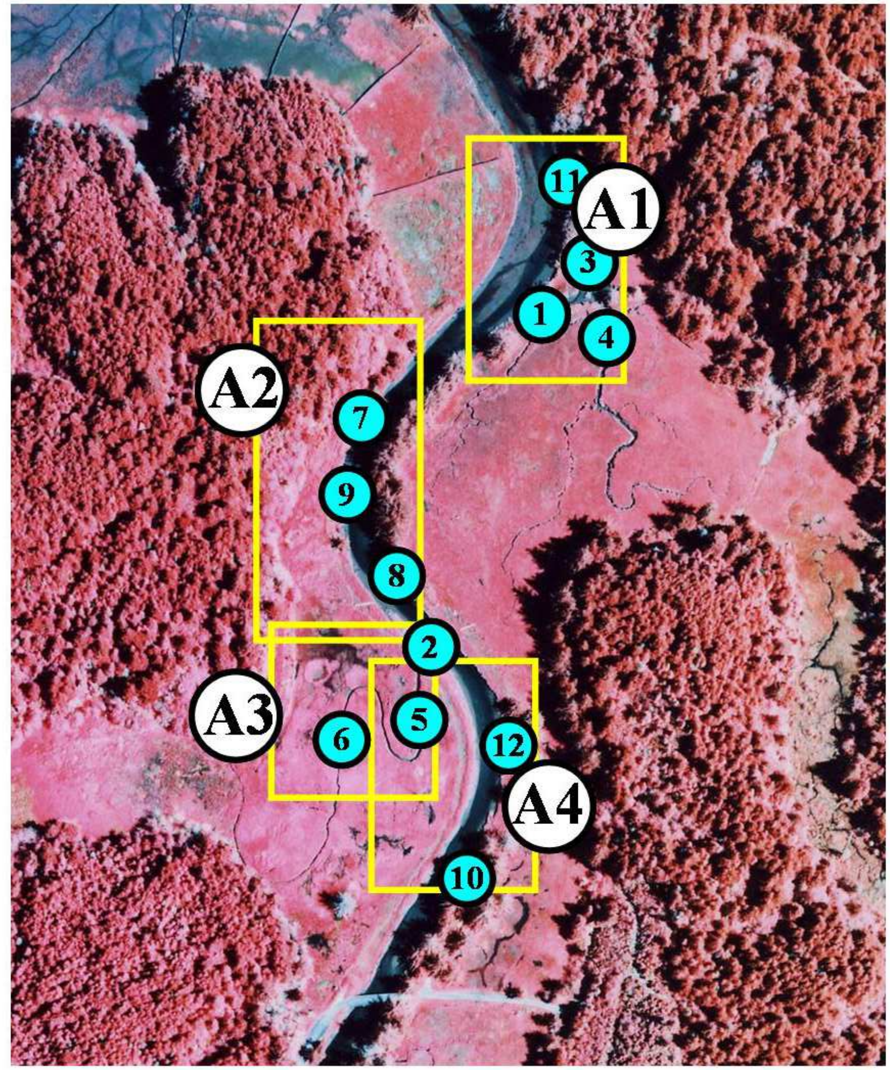

Figure 2. Location LWD monitoring sites in the project "Wood Zone".

The main questions addressed were the following:

1) Are there higher densities of fish near LWD compared with habitats lacking LWD?
2) Does placing LWD at the mouths of tidal creeks create a staging area for fish to hold before foraging up tributary tidal creeks during flood or ebb tide?
3) Is the presence of LWD increasing fish prey resources?
4) Does the presence of LWD change the percentage of fish using the tidal creeks over time?
5) Does placing LWD in tidal channels create changes in channel morphology (i.e., scour pools) which are associated with increased habitat quality for juvenile salmonids?
6) What significant changes in temperature or water flow occurs with the placement of LWD?
7) Does the LWD move?

2. Number of volunteers who participated in the project

Wood Project Volunteers	**Work Accomplished**	**Approximate Hours Worked**
Shannon Miller	invert sample processing/analysis, fish seining	40
Morgan Bell	invert sample processing/analysis, fish seining, GPS wood locations	120
Melanie Haggard	fish seining	20
Chris Zilka	fish seining	45
Oregon Youth Conservation Corps	fish seining	42
SSNERR Restoration Advisory Group	project planning	90
Nick Wilsman	GPS wood locations, invert sample collection	10
Beth Tanner	invert sample collection, fish seining, GPS wood locations	20
Pam Archer	Topo surveys	10
Total		397

3. List of other participants who assisted in the project

Wood Project Participants	Work Accomplished
Ayesha Gray (Cramer Fish Sciences- formerly with SSNERR)	project coordinator, invert sample collection, processing/analysis, estuarine wetland fish monitoring- seining, GPS wood locations (until 12/06)
Shannon Miller (as CoosWA employee)	invert sample collection, processing/analysis, fish seining
Morgan Bell (as CoosWA employee)	invert sample collection, processing/analysis, GPS wood locations
Stan van de Wetering- Siletz Tribes	Winchester Creek fish monitoring- videography
Ryan French- Siletz Tribes	Winchester Creek fish monitoring- videography
Michele Koehler- ABR Inc.	estuarine wetland fish monitoring- seining
Jenna Lemke- ABR Inc.	estuarine wetland fish monitoring- seining
Adam Harris- ABR Inc.	estuarine wetland fish monitoring- seining
Russ Faux- Watershed Sciences Inc.	data processing
German Whitley- Watershed Sciences Inc.	data processing
Mischa Hey- Watershed Sciences Inc.	RTK GPS data acquisition and data processing
David Alley- Watershed Sciences Inc.	RTK GPS data acquisition
Rochelle Buchser- Watershed Sciences Inc.	RTK GPS data acquisition
Ben Eilers- Watershed Sciences Inc.	RTK GPS data acquisition
Maggie Kirby (Shorebank Enterprises- formerly with CoosWA)	project grant administration
Jon Souder- CoosWA	project grant administration
Aimee Peters- CoosWA	project grant administration
Bruce Miller- ODFW	acoustic tag receiver deployment, tag surgery and data analysis
Craig Cornu- SSNERR	project coordinator, GPS wood locations, acoustic tag receiver deployment, tag surgery and data analysis, report compilation and writing
Alicia Helms- SSNERR	acoustic tag receiver deployment, and tag surgery
Adam Demarzo- SSNERR	acoustic tag receiver deployment, and tag surgery

4. Materials and Methods

This OWEB-supported project, *Effectiveness Monitoring for LWD Placement in South Slough Tidal Wetlands*, was implemented as six related tasks including, 1) Juvenile salmonid use/behavior near LWD; 2) Determining the use of LWD by juvenile salmonids using acoustic tagging methods; 3) Fish use monitoring of estuarine marshes associated with LWD; 4) Benthic invertebrate abundance and composition in wood and no-wood habitats; 5) Channel morphological change in “Wood Zone”; and 6) LWD movement. Tasks underlined were completed by project contractors. Reports completed by project contractors are appended to this final report and are reffered to in the report narrative, which does not include all the information contained in those reports.

This report is organized by task, presenting the task methods first and task results second.

Juvenile Salmonid Use/Behavior Near LWD

In spring of 2005 and 2006, fish biologists from the Confederated Tribes of the Siletz Indians were contracted to monitor juvenile salmonid presence and behavior near LWD structures in the project wood zone. The goal of the monitoring effort was to examine age-1+ coho use of LWD habitats within the Winchester Creek tidal channel and across tidal cycles. Fish abundance and behavior was monitored with underwater videography (due to difficulty sampling LWD areas with traditional methods). Years 2005 and 2006 were defined as the target work period. The project team defined April as the study season based on peak catch abundance at the ODFW rotary screw trap on Winchester Creek. The behavioral patterns of interest were those hypothesized by the team, in relation to the large wood structures that had been added to Winchester Creek channel in 2004.

Methods Summary

Traditional fisheries sampling equipment, such as seine and fyke nets, are of limited use around complex structures (LWD) in tidal environments, thus we used underwater videography to enumerate fish and track behavior. Additionally, we used traditional beach seine techniques to develop broader study zone density estimates that could be used for comparison of the camera counting results.

2005

In 2005, we focused on sampling fish presence around LWD. Using a grid cell type sampling design approach, we defined each discreet instream habitat cell with a visual estimate of stream attributes (e.g., velocity) and assigned the cell as *Good*, *Intermediate*, or *Poor* habitat. We based our classification of *Good, Intermediate* and *Poor* habitats on past research describing juvenile salmonid use of LWD structures in estuarine habitats. Cameras were operated in selected cells; the approach was not completely random. We evaluated abundance data to determine if fish preferentially choose optimal or *Good* habitats over sub-optimal or *Poor* habitats (*Intermediate* was also defined), thus estimating a preference for LWD habitats. Data were pooled for three mainstem and one tributary mouth site. In habitats without LWD, seine sampling was used to estimate overall study zone fish densities.

With prior underwater videography projects, we estimated fish densities by habitat type for a constant period of time (REF), a common means of reporting fish habitat associations. Fish encounters were limited during our sampling, so data are presented as fish per camera per minute to allow for appropriate comparisons. Values were generally of hundredths or thousandths of fish per camera per minute. For example, if 24 cameras during a 20 minute period recorded 2 fish, the estimate would be 2 fish / 24 cameras / 20 minutes, or 0.004 fish/camera/minute.

Analysis
In 2005, we analyzed the video to obtain a weighted average of fish per minute per camera for each 20-minute period throughout the tidal cycle. For each camera, we summarized the number of fish for a 20-minute sampling period and averaged across number of cameras operating within a site and habitat type. These averages were weighted by the number of 20-minute recording periods at each site. The variance of the average was estimated using a bootstrap resampling approach which assumes the variance in the population is equivalent to the variance in the sample (Manly 1997), and resampled data to get an estimate of the sample variance. We selected 1000 samples with the same number of observations as in the original dataset. The 2.5 and 97.5 percentiles of the 1000 estimates for each habitat and time period were taken as the 95% confidence interval for the calculated average.

2006
In 2006, we refined our approach based on the small population size and results for 2005. We defined habitat polygons rather than *Good*, *Intermediate* and *Poor* LWD habitats. The base of the LWD polygon was defined as that habitat (i.e., current direction, velocity, and depth) surrounding the LWD structures – similar to 2005. The polygons were then expanded in size by taking the inner channel polygon boundary to the opposite edge of the thalweg. The polygons were also expanded upstream and downstream to account for channel bed morphology that could influence fish migration patterns (pools and bars). Cameras were placed along the upper and lower sides of the polygons, and used to enumerate fish moving upstream and downstream across the tidal cycle. Fish observation numbers were analyzed for *Polygon Retention. Polygon retention* was defined as the sum of fish moving into and out of the polygon for a given time interval, across the tidal cycle. This method allows for a means to examine whether the LWD structures attract or hold fish during specific periods across a tidal cycle. The approach allowed us to determine if fish "hold" in LWD polygons, and evaluate what LWD polygon habitats may offer, in terms of depth, velocity, prey availability, etc., during specific periods of time. The Confederated Tribes of Siletz Indians (CTSI) has used this approach in other estuaries with useful results.

Methods 2005

LWD Sampling for Fish Presence and Activity Patterns
During spring 2005, the sampling was directed at describing age-1+ behavior around five unique LWD structures (Figure 3) placed in the Winchester Creek tidal channel, and at the mouths of Dalton and Tom's Creeks. Underwater cameras were placed on stationary poles and allowed to record fish movement. Recording began during the initiation of the morning flood tide, and continued through the completion of the afternoon ebb tide. Daily tidal cycle camera recording times averaged nine hours. Placement of individual cameras was based on a stratified design. A grid was developed in advance for each LWD structure

site. The grid covered the wood structure itself and the habitat immediately associated with the structure. The outer edges of the grid were visually defined by flow patterns. The outermost portion of the grid was that portion of the habitat where the influence of the LWD structure on tidal current patterns was not detectable, as defined by visual observation. Habitats cells were classified using multiple metrics, including total depth of water column, depth of camera placement, tidal velocity, flow direction (ebb vs. flood), and location of pole relative to LWD structure (down-flow vs. up-flow). Habitat cells were then recorded as *Good*, *Intermediate*, or *Poor* (Figure 4). *Good*, *Intermediate*, and *Poor* classifications were based on the author's past research examining preferred LWD microhabitats within estuarine environments (REF!). *Good* habitat can be summarized as: 1) cells where velocity has been reduced by the structure, but not eliminated; 2) cells where flow pattern has been shifted relative to the thalweg; 3) cells where eddy currents are present; and, 4) cells where cover is provided within a minimum distance of one meter. *Poor* habitat was defined as cells with higher or no velocity, and a uniform or no flow pattern. Poles with four cameras were stratified across habitat-type cells as the tide flooded and ebbed (Figures 5 and 6). Cameras were distributed evenly along poles with a distance of 0.6 m between lenses. Each camera recorded an image based on a conical field of view. Camera view fields were established to eliminate doubling of images. Cameras recorded images for 20 minutes. For those sites in Winchester and Tom's creeks, cameras were relocated every 30 minutes to new habitat cells to allow for a stratified sampling approach to occur across the full tidal cycle. The sampling at Dalton Creek mouth (Figure 7) involved all camera stations remaining constant, based on initial stratification (see full tidal cycle assessment above), across time. VHS video was used as the recording media for all sites.

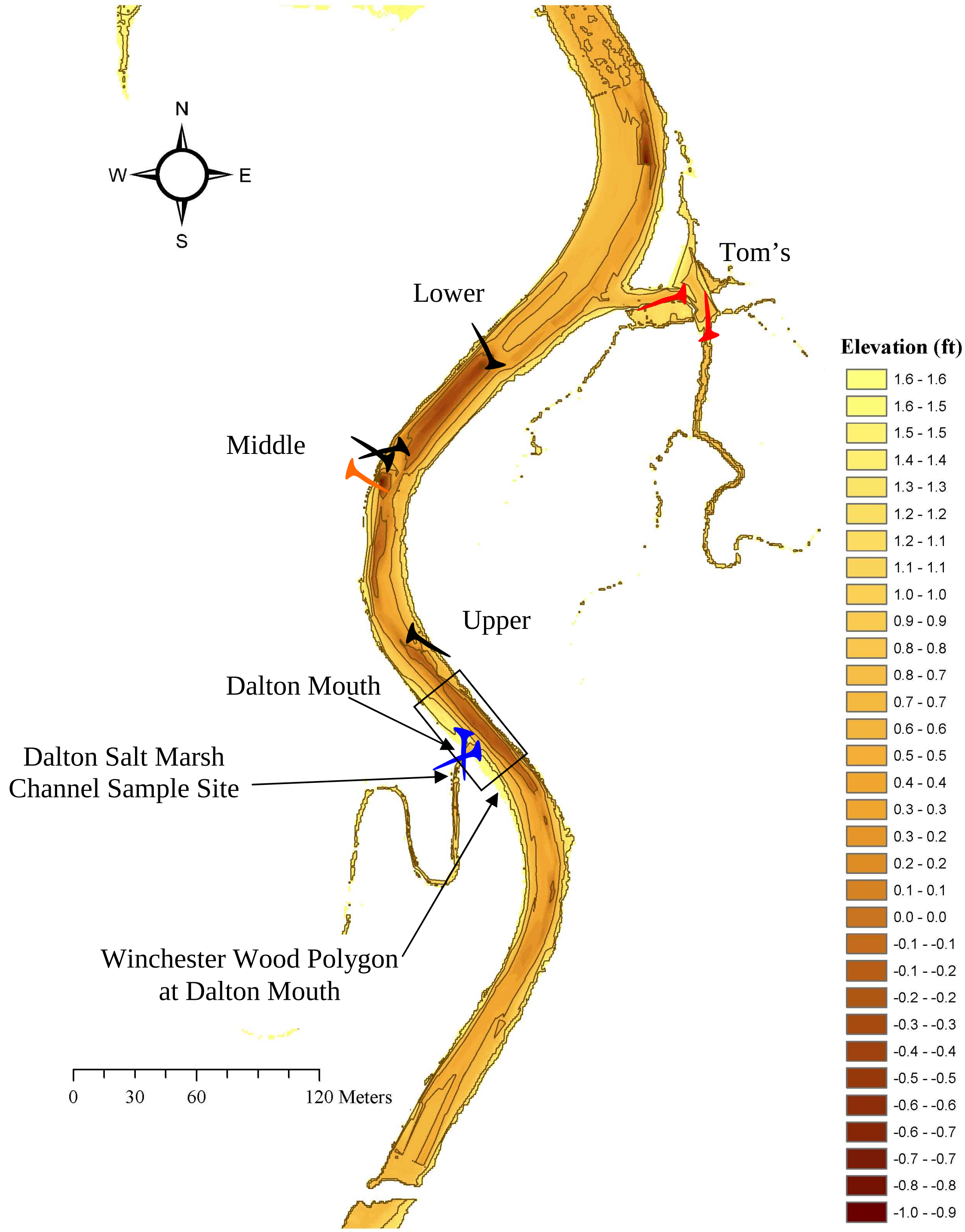

Figure 3. The 2005 LWD study sites examined for migration activity. Note, black cartoon logs are mainstem lower, middle and upper Winchester Creek sites; blue are Dalton Creek mouth site; red are Tom's Creek; and, orange are historic LWD. Background map is contour topography developed from the 2007 grid file created by Watershed Sciences, Inc.

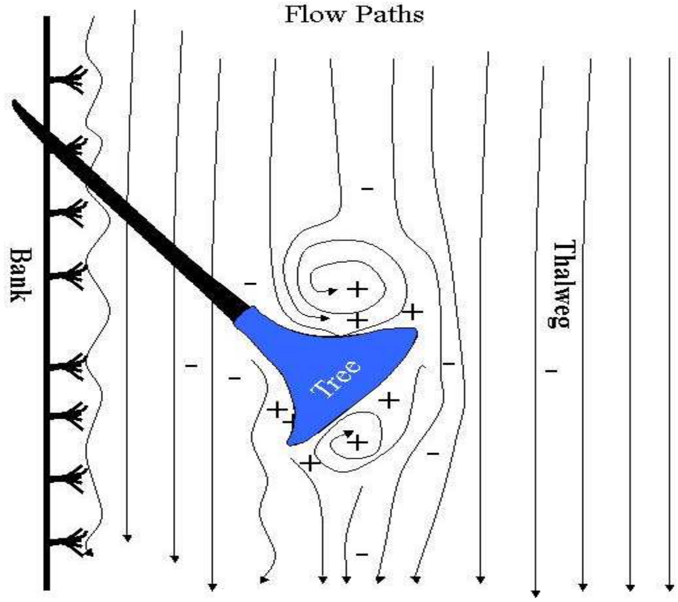

Figure 4. Example of typical flow path patterns around LWD positioned along a tidal channel bank. Plus (+) and minus (-) signs describe Good and Poor habitat classifications relative to flow paths and potential current velocities. The blue portion of the cartoon figure represents the submerged portion of the tree under tidal flows in comparison to the remainder which does not interact with the stream.

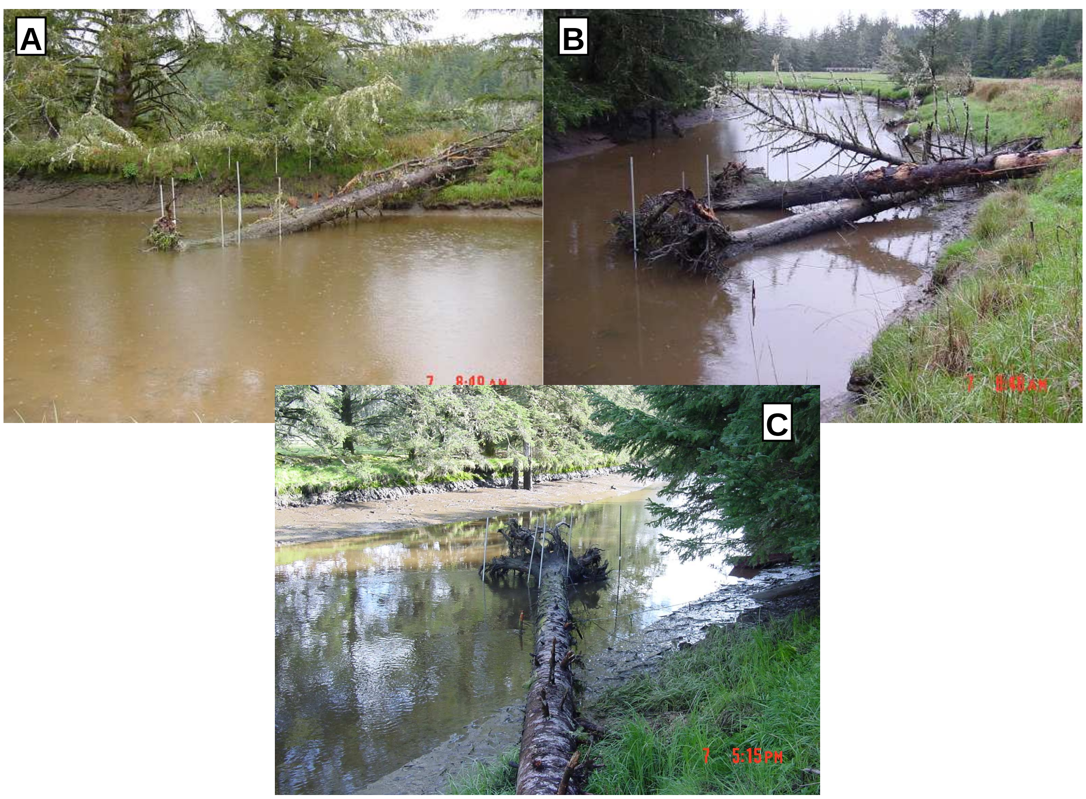

Figure 5. Photos show partial camera setup for LWD - Upper 2005 (A), Middle 2005 (B) and Lower 2005 (C)

Figure 6. Photos showing partial camera setup for Tom's Creek Mouth wood structure.

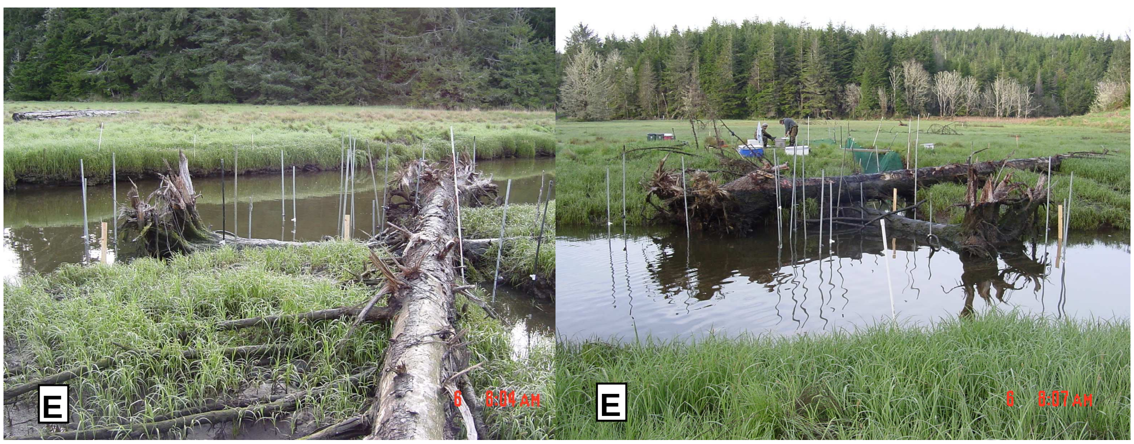

Figure 7. Photos showing partial camera setup for Dalton Creek Mouth wood structure.

<u>*Sampling for Fish Migration Into and Out of Dalton Creek Salt Marsh*</u>

During spring 2005, we also sampled in Dalton Creek tidal channel approximately six meters upstream of the mouth. Our objective was to define migration patterns into and out of Dalton Creek in association with the LWD located at the mouth. We placed four cameras in the tidal channel with a fyke net made of 0.635 centimeters (0.25 in.) mesh netting (Figure 8).

Figure 8. Photo showing fyke net and camera set up at mouth of Dalton Creek.

Methods 2006

Sampling for Wood Polygon Fish Retention in Winchester Creek Tidal Channel

During spring 2006, we directed sampling at describing age-1+ migration patterns within habitat polygons. These polygons included three LWD placements in the Winchester Creek tidal channel (Figure 9). We developed polygons for each LWD site. The base of the wood polygon was defined as that habitat (i.e., current direction, velocity, and depth) surrounding the LWD that was influenced by the wood structure. The polygons extended to the opposite edge of the Winchester Creek thalweg. The polygons also extended upstream and downstream to include channel bed morphology with potential to influence fish migration patterns (e.g., pools and bars). We placed cameras in transects along the upper and lower sides of the polygons, and enumerated fish moving upstream and downstream across the tidal cycle (see arrows in Figure 9). Three camera poles holding four cameras each were placed equal distance across the upstream and downstream ends of the polygon (Figure 10).

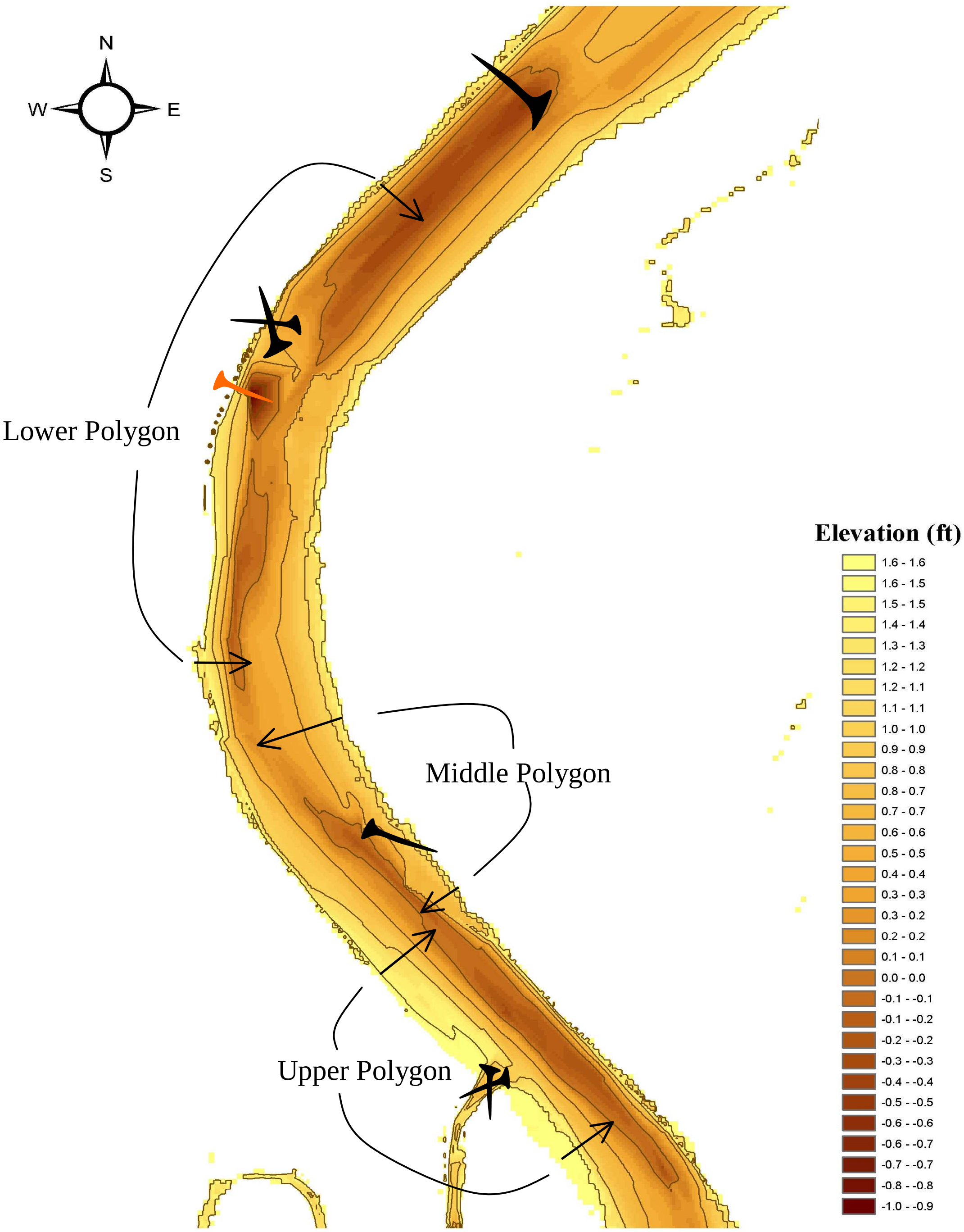

Figure 9. The 2006 habitat polygons examined for migration activity. Note, black tree symbols depict LWD placements, black arrows depict camera transect position and length, and arrow point denotes opposite bank edge of thalweg marking center most camera pole position. Orange tree symbol represents historical LWD structure. Background map is drawn from contour topography from the 2007 grid file created by Watershed Sciences, Inc.

Figure 10. Top photo shows cameras at upper transect for the lower wood structure polygon year 2006. Lower photo shows cameras at lower transect.

<u>Sampling Context 2005 and 2006</u>

Defining Fish Distribution Using Seining

We sampled fish in Winchester Creek with a 15.25 x 2.4 meter seine with 0.635 cm mesh netting during the low slack portion of the tide the day after camera observations were completed. We completed five seine sets across the study reach each year of the study. The study reach was 325 m in length, and encompassed six LWD complexes/structures. We spread the seine parallel to the channel, and pulled across the channel to standardize catch per unit effort (CPUE) at each site. We sampled three pools and two glides allowing for a bias toward overestimation of the total standing stock. All fish were identified to species, and salmonids were aged but not measured for length. For the purposes of this report, we present all CPUE data as fish per square meter of habitat to be comparable with other studies.

Camera Sampling Conditions

We present depth, velocity and migration data in English units (feet) because we find our regional audience understands these metrics best when presented these units. We recorded tidal height changes, water temperature, salinity, and current velocity values during the sampling period. Tidal height changes were measured hourly or more often by using a measuring stick secured in the tidal channel. Temperature and salinity samples were typically taken one hour prior to the beginning of filming (morning low slack), twice during the flood tide, at high slack, twice during the ebb tide, and at the termination of the filming period (afternoon low slack). Water temperatures were measured with a hand held thermometer at the surface only. Water samples were collected by syringe at the top and the bottom of the water column; salinity values were estimated using a hand-held refractometer. During the two day habitat cell classification period, current velocity was measured using a Rickly AA-1 current meter and an Aqua Calc velocity recorder. During the videography sampling period, velocity measurements were estimated with plankton drift and a submerged meter stick by camera. Drift speeds were measured against distance to calculate velocities per time interval.

General Video Review

In the laboratory, we analyzed video to enumerate fish and evaluate behavior. For 2005, we recorded fish migration and behavior for a 20-minute period nested within each 30-minute interval throughout the daylight tidal cycle. (Cameras were transferred among stations during the additional ten minute period.) However, at the Dalton Creek mouth site 30-minute intervals were recorded. In 2005, sampling for an equal ratio of habitat cell types was not possible due to the habitat available across the full tidal cycle. In 2006, we recorded video fish migration and behavior for each 30-minute interval throughout the full tidal cycle measured. We analyzed data for fish presence, direction of movement, and behavior.

Citations

Manly, B. F. J. 1997. Randomization, Bootstrap and Monte Carlo Methods in Biology, Chapman and Hall.

Determining the Use of LWD by Juvenile Salmonids using Acoustic Tagging Methods

As an augmentation to the complex LWD sampling for fish presence/activity patterns in Winchester Creek, a total of 25 juvenile cutthroat trout (average fork length: 158 mm; max/min: 254/134 mm) were surgically outfitted with OWEB-purchased Vemco acoustic transmitters (V7-4L-R64LK coded pingers) and released into Winchester Creek. We released fish at two separate locations and times. At release location 1 (see Figure 11), we implanted 20 tags and released fish between April 10 and May 9, 2007. At release location 2 (see Figure 9), we implanted five tags and released fish on May 30, 2007. Twelve Vemco receivers, purchased by the SSNERR as part of a 2001-03 OWEB-supported fish monitoring project (grant #200-032) were placed on March 6-7, 2007 in locations with and without LWD in Winchester Creek, including the project “wood zone” as well as other key locations (i.e., lower Anderson Creek pool; Cox beaver dam; Danger Point; Crown Point; and, Charleston Bridge) to detect fish presence (see Figure 9). Project was developed and implemented in partnership with Bruce Miller (ODFW).

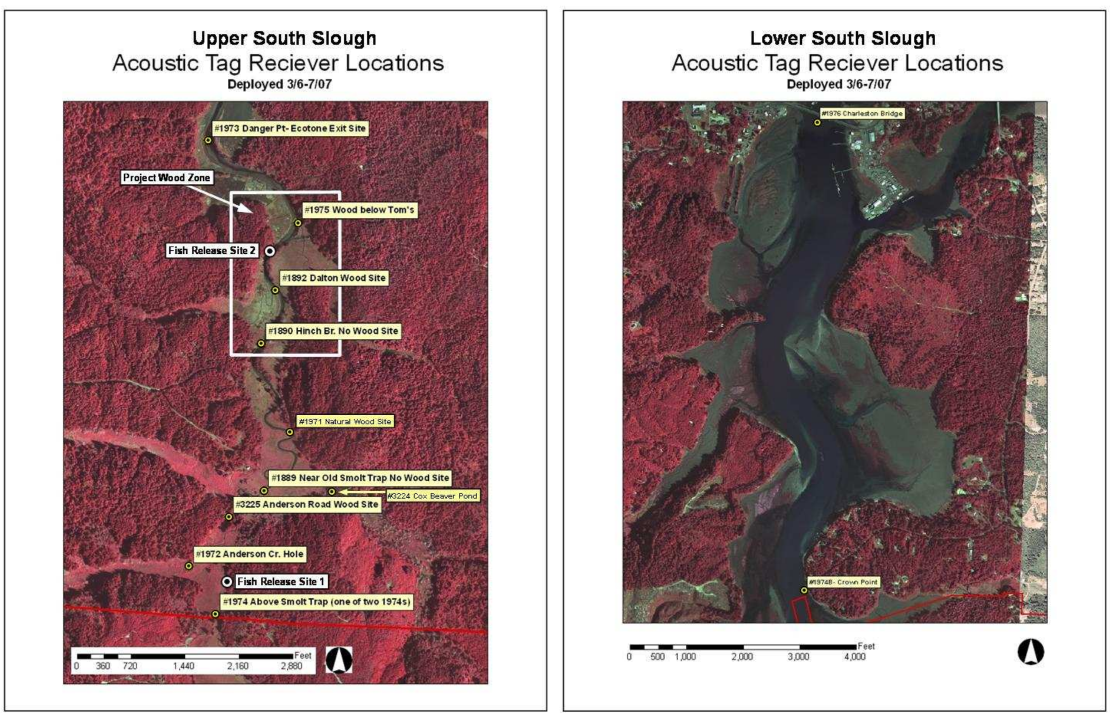

Figure 11- Acoustic tag receivers in upper (left) and lower (right) South Slough.

Table 1. Wood- no wood sampling status of the Vemco acoustic receivers:

Code	Location	Status
1974	Above juvenile trap	Wood
1972	Anderson Cr Reach	Wood
3225	Anderson Road	Wood
1889	Fredrickson Reach	No Wood
3224	Cox Beaver Dam	No Wood
1971	Cox Natural Wood Reach	Wood (natural)
1890	Hinch Bridge	No Wood
1892	Dalton Cr Reach	Wood
1975	Tom's Cr Reach	Wood
1973	Danger Point	No Wood
1974B	Crown Point	NA
1976	Charleston Bridge	NA

The bulk of the fish presence data from the acoustic receivers were downloaded May 25, 2007, and between August 22 and August 30, 2007.

To analyze the data for fish presence in wood vs. no wood reaches in Winchester Creek, percent detections of each fishes' total detections was established for each receiver. Percent detections at each receiver equals the number of each fishes' detections at a receiver divided by the total detections for each fish at all receivers. For the wood vs. no-wood comparison, three wood sites were selected: 1) Cox natural wood; 2) Dalton; and 3) Tom's. And, three no-wood sites were selected: 1) Fredrickson; 2) Hinch Bridge; and, 3) Danger Point. The receivers located in other wood/no-wood reaches either malfunctioned (no or limited data recorded), or were not applicable to this mainstem tidal channel comparison because they were not located in Winchester Creek. The fish included in the wood/no-wood analysis were those that were detected by any receiver 200 times or more.

<u>Fish Use Monitoring of Estuarine Marshes Associated with LWD</u>

Within the Winchester Creek study area, electrofishing passes were performed within a single reach of Dalton and Tom’s creeks, while beach seining was performed within two adjacent reaches of Winchester Creek. Beach-seined reaches were located between the confluences of Dalton and Tom’s creeks with Winchester Creek. Electrofishing and beach seine sampling occurred on two consecutive days in each of five sampling periods (February-June 2005 and 2006; Table 2).

In each of the reaches where electrofishing was performed, block nets were set up at the downstream and upstream end of the reach during high tide to prevent fish from leaving or entering the study area. Before the low slack tide, when the channel had sufficiently dewatered, a two-pass removal survey was performed with electrofishing equipment (Smith Root Model 12B Electrofisher) to estimate abundance of each species occurring within the surveyed reaches.

If salmonids were encountered, a second pass was conducted to ensure complete recovery. After each pass, captured fish were counted and length (fork length for salmonids and total length for other species; mm) of at least 25 individuals of each species was measured. After measurements were taken, counts of the remaining fish by species were recorded. In addition, the weights of all coho salmon were measured and recorded. After being processed, all fish were released downstream with the exception of a subsample of coho salmon and staghorn sculpin. When present, five coho and staghorn sculpin from each site were euthanized in MS222 and preserved for future stomach content and otolith analysis.

Table 2. Study reaches within the Winchester Creek Tidelands Restoration Area sampled in 2006.

Study Reach	Treatment Type	Sampling Method	Sampling Periods
Dalton Creek	Treatment with placed LWD	Electrofishing	February-June
Tom's Creek	Control without placed LWD	Electrofishing	February-June
Winchester Creek-Upstream	NA	Beach Seine	February-June
Winchester Creek-Downstream	NA	Beach Seine	February-June

Winchester Creek was sampled by beach seine in the upstream direction starting at the furthest downstream reach. During the initial sampling period, substantial difficulty in moving the seine against the flow was experienced likely allowing fish to avoid capture. During subsequent sampling periods, seining occurred in the downstream direction moving with the flow and started at the furthest upstream reach. Fish were brought to shore after each reach was seined and processed as described above.

Invertebrate Abundance and Composition Monitoring in Wood and No-Wood Habitats

Following the Estuarine Habitat Assessment Protocol (Simenstad *et al.* 1991), benthic invertebrates were sampled from 9 paired sites (with LWD placement and without) (Figure 12). One site (circled in red) was excluded from the analysis because LWD was pre-existing to placement due to this study.

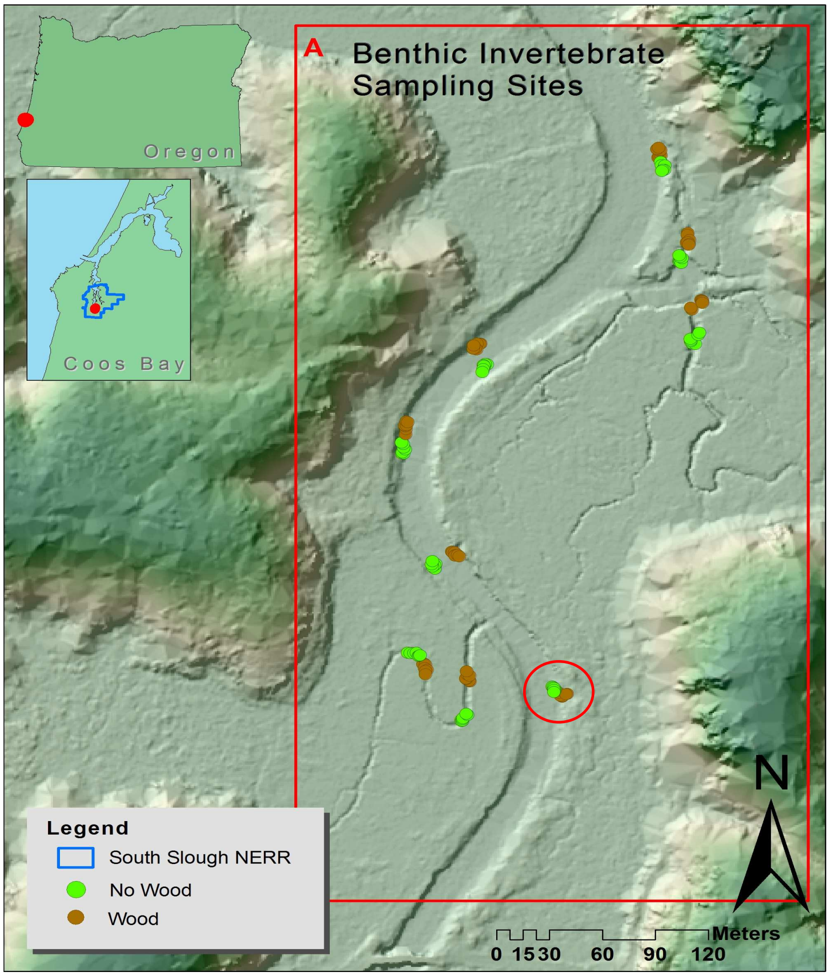

Figure 12. Map of invertebrate sampling locations (red circle indicates site excluded from analysis, see below).

Samples were taken at random from dewatered mudflats or channel sediments using a 2.5-cm diameter aluminum corer. Cores were taken to a depth of 5 cm for a volume of 160.8 cm^3. A pilot study was conducted in January 2005 to determine the appropriate number of samples necessary to capture the majority of the variation in invertebrate communities. We found no new species were added after the sixth sample in "no wood" (NW) sites and the seventh sample in sites with LWD. A replicate size of seven samples was chosen based on these analyses. Exact sampling location was randomized within the site (LWD/NW) boundaries using a random number table and 4 X 10 m grid. Sites were sampled in early May 2005, September 2005 and May 2006. Samples were retained in labeled sample jars and were fixed in the field with a 10% solution of buffered formalin. In the laboratory, sample contents were washed through a 0.5 mm sieve to remove fine particulates and retain macrofauna. Samples were then transferred to water or isopropanol (depending on length of time until identification), and stained with Rose Bengal. Using a light dissecting scope, all organisms were counted and identified to the finest taxonomic resolution possible without dissection, generally family or species identification for most common estuarine invertebrates. Total density was determined as the number of invertebrates per core volume and taxonomic richness was measured as the total number of taxonomic groups (separating life stages). Data were stored in a Microsoft Access database and Analysis of Variance (ANOVA) tests were performed in the statistical program, R (http://www.r-project.org, version 2.4.1). Total density and taxonomic richness was compared between 8 paired sites using a multi-factor ANOVA with site, year and wood/no wood as factors. We excluded one site with existing buried wood at time of sampling, not placed as part of project; the site was sampled to provide a possible comparison for established conditions. Community analyses were conducted using multivariate statistics: nonmetric multidimensional scaling (NMDS), analysis of similarity (ANOSIM), and similarity percentage analysis (SIMPER) using PRIMER 6.0 (Clarke and Gorley 2006). We log-transformed densities for multivariate analyses and discounted taxonomic groups accounting for less than 5% of any sample. NMDS graphically plotted differences in invertebrate assemblages in ordination space (axes with no scale) based on the Bray-Curtis similarity matrix. ANOSIM statistically tested for significant differences among groupings delivered by the NMDS with a p-value (similar to ANOVA) of < 0.05 to determine significance. An R value, scaled between -1 and +1, is also reported with 0 representing no difference and the closer the value is to 1 the greater the biological importance of the differences. SIMPER analysis was used to determine which taxonomic groups were primarily responsible for the observed ANOSIM differences.

Citations

Clarke, K.R., and Gorley, R.N., 2006, PRIMER v6: USers Manual/Tutorial PRIMER-E: Plymouth, England.

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Channel morphological change in "Wood Zone"

A team of surveyors from Watershed Sciences, Inc. used professional-grade RTK (real-time kinematic) GPS survey equipment to determine elevation changes in channel profiles in the Winchester Creek project reaches between Hinch Bridge and the northern most wood placement above Tom's Creek across from Kunz Marsh ("wood zone"). Surveys were conducted in summer 2006 and fall 2007.

2005 LiDAR Collection

Watershed Sciences, Inc. (WS) collected Light Detection and Ranging (LiDAR) data of the SSNERR on September 6, 2005 as part of a separate project. Near Infrared (NIR) imagery was collected coincidently with the LiDAR. The survey area encompassed the area between Coos Bay in the north and the confluence of Winchester Creek and the South Slough at the southern edge of the study area. RTK survey data were integrated into the LiDAR data to establish a seamless digital elevation model (DEM) of the project wood zone.

RTK Survey 2006

On July 27-28, 2006, WS performed an RTK transect survey on the wood zone of Winchester Creek in the SSNERR to be integrated with the LiDAR data. The survey covered a 620 m length of stream from the Hinch Road bridge north to the LWD placement above Tom's Creek (Figure 13).

Using RTK, the bathymetric surface was measured with cross-sections at approximately 15.25 meter (50 foot) intervals along the wetted stream channel. Data were collected for 54 main channel transects and 35 side channel transects. Five supplemental transects were collected by researchers at the SSNERR using traditional survey methods in the area of the GPS 'dead zone' (Figure 2). Once bathymetric surfaces were modeled, the terrestrial LiDAR was then merged, resulting in a seamless, comprehensive elevation data set for all surfaces.

RTK Survey 2007

On August 27-September 1, 2007, WS performed a follow-up RTK survey of Winchester Creek in order to perform a change detection analysis. The survey covered the same 620 m length of stream from the Hinch Road bridge north to the LWD placement above Tom's Creek.

Every effort was made to make measurements along the exact same transects used during the 2006 study. The 2006 transects were located by entering the bank coordinates into the GPS, and then navigating to and flagging the start of each transect.

As with the 2006 measurements, RTK was not possible in some areas of the stream due to canopy masking of the RTK receiver. The 2006 RTK survey was supplemented in these areas by additional cross sectional data collected by researchers at the SSNERR using traditional survey techniques.

GPS-based RTK Methods

A dual frequency DGPS base station collected static GPS data at 1–second epochs (1 Hz) for over 4-hours to compute a survey control point. The control was established in a location that had good visibility for GPS satellites and was proximate to the 'wood zone' of Winchester Creek (Table 1).

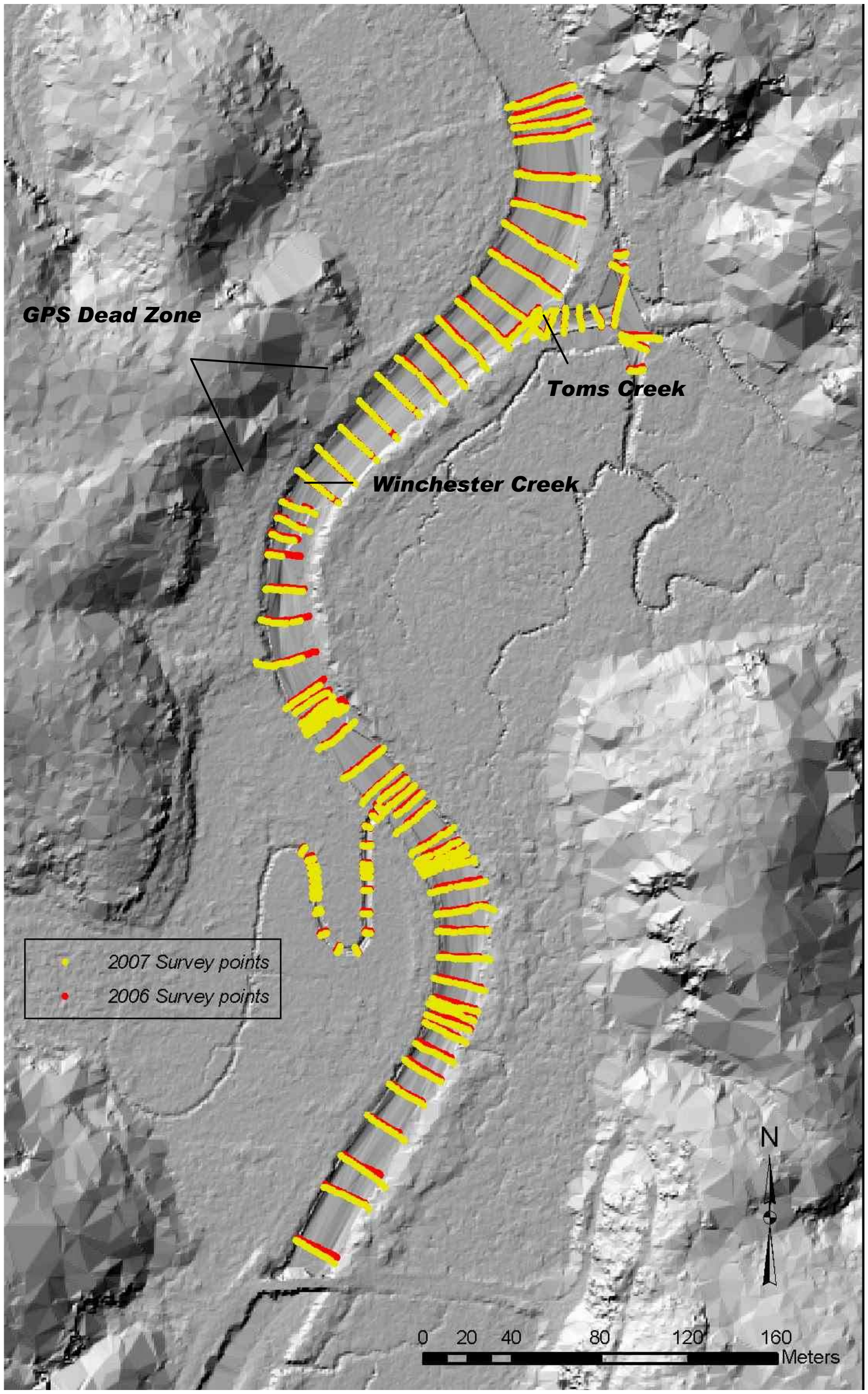


Figure 13 – Extent and location of the 2006 and 2007 RTK transects plotted over the LiDAR DEM hillshade. The five transects in the 'dead zone' were collected by traditional survey methods.

Table 3 – Control point location near Winchester Creek.

NAD83 NAVD88		
Latitude (North)	***Longitude (West)***	***Elevation (m)***
43°16’ 33.69	-124°19’ 08.315	2.342

The same survey control monument was used for both the 2006 and 2007 measurements. The control coordinates were computed for both years using the OPUS (Online Position User System) solution provided by the National Geodetic Survey. A comparison of the orthometric heights from the two solutions showed a difference of 0.4 cm.

Channel Cross Section Measurements

The hardware configuration consisted of a DGPS base station, a GPS Rover Unit, and a radio link (Figure 14). The rover unit receives real-time position corrections from the fast static base station allowing efficient collection of hundreds of points (RMSE of <2.0 cm). The survey was conducted by taking points at cross sections perpendicular to the stream aspect. Points were taken by leveling the rover unit and recording individual points at even spacing across the channel. The rover staff was modified with a flat base so that it would not sink into the soft mud of the channel bottom (Figure 15).

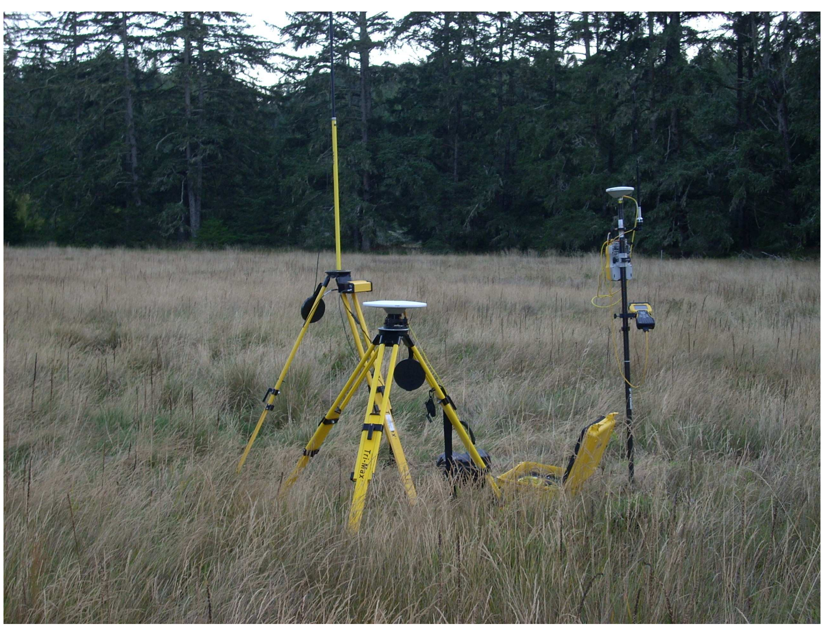


Figure 14 - DGPS Base Station, Radio Link, and GPS rover used for data collection in the South Slough.

At some locations, the rover did not have sufficient satellite coverage to compute an accurate solution or a radio link could not be established between the base station and the rover. In these areas, the survey crew moved along the channel until a GPS solution could be calculated. This resulted in some inconsistencies between the spacing of channel cross sections.   This is a limitation of a GPS RTK survey in areas with significant vegetation or terrain masking.

High tide hours were avoided since some areas of the stream became too deep to wade with the RTK pole (Figure 16). The RTK survey consisted of 54 main-channel transects, 35 side-channel transects, as well as control points and check points, totaling 2015 point locations with elevation data.

Figure 15 – The foot of the 2-meter RTK pool was modified with a flat base to prevent the tip from sinking into the channel mud.

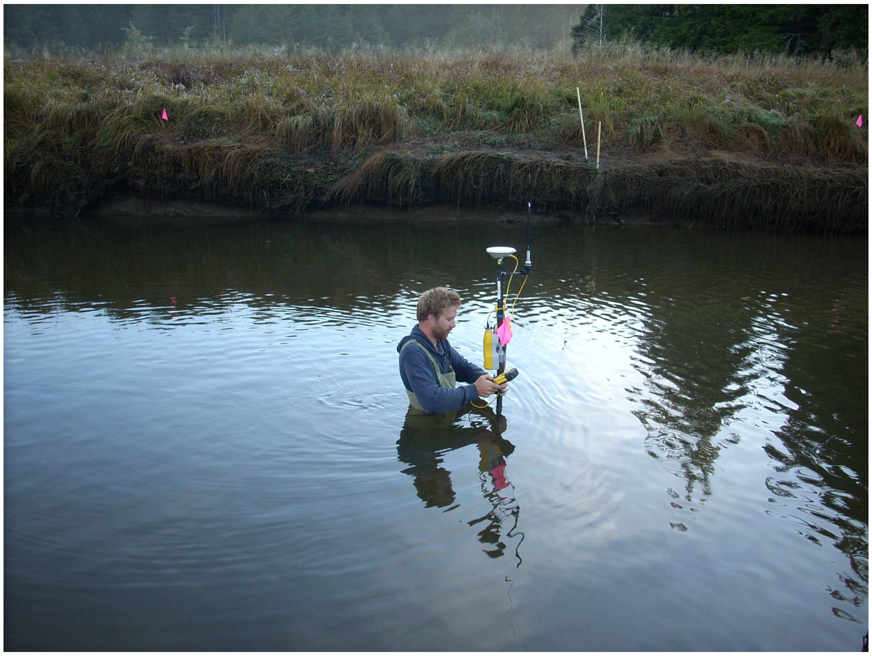


Figure 16 – Wading Winchester Creek with the GPS Rover (RTK pole). Lower tides were required to wade some sections of the study area.

Change Detection

Once the digital elevation models (DEMs) for the 2006/2007 dates were created, it was possible to compare the resulting bathymetry models. A quantitative change detection analysis was done by subtracting the DEMs. Because the two surveys did not cover exactly the same locations, the TIN (Triangulated Irregular Network) for each survey was clipped to only the overlapping areas, so as not to detect false change. The channel could have shifted in those areas, but that change cannot be adequately quantified by the data alone.

Additional Information

Additional information concerning ellipsoid to geoid elevation correction methods, determining LiDAR ground model accuracy, methods for the supplemental transects, and bathymetric interpolation are included in the Watershed Sciences report entitled, *2007 RTK Data Collection and LiDAR Integration, South Slough Estuarine Reserve, OR* (November 5, 2007), submitted with this final report.

LWD Movement

We tracked movement of the LWD by tagging with coded aluminum tags, and geo-locating with a Trimble GPS unit with sub-meter accuracy. Multiple tags were nailed into the extremes of each LWD piece (root wad and tree top) in the project “wood zone”. During various stages of the tidal cycle, LWD has the potential to shift position and/or roll, so multiple tag placement helps ensure consistent identification over time. The extremes of each LWD piece were located spatially using the Trimble DGPS, and data points were mapped using ESRI ArcGIS software (Version 9.2). We located LWD and mapped positions in September 2004, June 2005, May 2006, October 2006, and January 2007. [Note: A condition of the project permit requires Winchester Creek to remain open for canoe and kayak use. Two LWD pieces were staked in place (at the mouth of Dalton Creek), and eight other pieces were loosely tethered to established trees on the banks to limit the distance LWD tops could swing into the waterway.]

4. Results

Juvenile Salmonid Use/Behavior Near LWD

Results Summary

2005

The seine sampling showed that very few fish were available during the study period. The camera results were similar to the seine data in that few fish were encountered. These low fish counts eliminated our ability to examine fish behavior (i.e., swimming and feeding patterns, etc.) around LWD. We observed trends suggesting that juvenile fish preferred *Good* LWD habitat over *Poor* and *Intermediate* habitat, but the results were not statistically significant.

2006

Fish numbers were low again during the 2006 sampling period. Wood polygon fish observations were relatively high with respect to available fish densities. We recorded 631 observations relative to a study zone population estimate of 21 age-1+ salmonids. However, overall the observation numbers were low enough that error values were too great to make for conclusive analyses. We found significant retention late in the tidal cycle (ebb) in the lower polygon and no retention in the middle and upper polygons. We suggest the broader habitat characteristics of the study zone were the likely drivers resulting in low or no retention values in the three polygons. We suggest these broader habitat characteristics were dominated by channel morphologies which in turn were driven by historic diking and historic wood presence. We also suggest that although the initial morphology data shows limited shifts in channel bed form associated with the new wood, that over time shifts will occur and we predict, based on results from other estuaries, juvenile fish will react to those shifts with increased retention in wood habitats.

Results 2005

2005 Video Analysis for Fish Activity Across Wood Structure Grids

No age-1+ salmonids were observed during the full tidal cycle. Very few age-0+ salmonids were observed. Table 1 shows the mean age-0+ salmonid count per minute per camera by habitat type. There were positive values for seven of the time intervals (all habitats) across the four sites. The *Good* habitat resulted in the greatest number (5) of observations. Of those, one value was in the one fish per hundred minute range, and four values were in the one fish per thousand minute range. The error associated with the age-0+ results was great enough that no significant (α=0.05) differences were found between habitat types.

Table 4. Year 2005 age-0+ salmonid observations per minute per camera across the complete tidal cycle for Good, Intermediate, and Poor habitat types, for Winchester and Tom's creek sites. Non-zero values highlighted in yellow. The 2.5 and 97.5 percentiles are labeled as P2.75 and P97.5. n = sample size.

Time Interval	Good Habitat	P2.75	P97.5	n	Intermediate Habitat	P2.75	P97.5	n	Poor Habitat	P2.75	P97.5	n
30	0.000	0.000	0.000	2					0.000	0.000	0.000	2
60	0.000	0.000	0.000	4					0.000	0.000	0.000	6
90	0.000	0.000	0.000	11	0	0.000	0.000	2	0.000	0.000	0.000	6
120	0.000	0.000	0.000	12	0	0.000	0.000	2	0.000	0.000	0.000	8
150	0.000	0.000	0.000	13	0	0.000	0.000	2	0.000	0.000	0.000	9
180	0.000	0.000	0.000	18	0	0.000	0.000	2	0.000	0.000	0.000	11
210	0.000	0.000	0.000	22	0	0.000	0.000	2	0.000	0.000	0.000	13
240	0.000	0.000	0.000	22	0	0.000	0.000	2	0.000	0.000	0.000	16
270	0.000	0.000	0.000	22	0	0.000	0.000	2	0.000	0.000	0.000	16
300	0.000	0.000	0.000	12	0.002	0.000	0.008	22	0.000	0.000	0.000	6
330	0.002	0.000	0.007	24					0.000	0.000	0.000	16
360	0.020	0.000	0.068	26					0.000	0.000	0.000	14
390	0.003	0.000	0.010	32					0.000	0.000	0.000	8
420	0.007	0.000	0.019	31					0.000	0.000	0.000	8
450	0.000	0.000	0.000	29	0	0.000	0.000	2	0.000	0.000	0.000	8
480	0.003	0.000	0.009	30	0	0.000	0.000	2	0.006	0.000	0.021	8
510	0.000	0.000	0.000	29	0	0.000	0.000	2	0.000	0.000	0.000	8

2005 Wood Structure Sampling for Fish Activity at the Mouth of Dalton Creek

Age-1+ and age-0+ salmonid activity occurred throughout the full tidal cycle (Figure 17). Three surges in age-0+ activity occurred during the early flood, early ebb and late ebb tide.

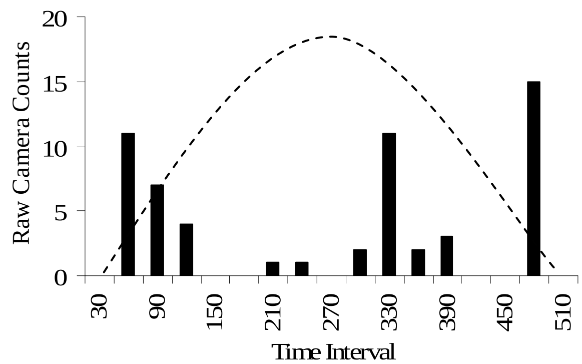


Figure 17. Age 0+ activity patterns (all stations and cameras pooled) within the wood structure at Dalton Mouth. Relative tide elevation shown as dashed line.

The age-0+ fish per minute per camera values for the series of time intervals were greater overall (Table 5) than that observed for the four sites monitored in Winchester Creek during the same week (Table 4.). There were positive age-0+ values for 12 of the time intervals at Dalton Mouth. Five of the ten values for Good habitat at the Dalton Creek Mouth site were in the fish per hundred minute range. We examined the Dalton Creek Mouth results using a two sample t-test. The error associated with the estimates at Dalton Creek Mouth was great enough that there were no significant differences (α=0.05) within that site when comparing Good and Poor habitat types. No intermediate habitat types were measured at the Dalton Creek mouth sites. No statistical comparisons were made between Dalton's Mouth and the other four combined sites because the camera sampling methods were different. (These data were analyzed for the average number of fish per minute per camera. The method of analysis was different than that used for the three main wood sites in Winchester Creek described above. We report the average number of fish per minute per camera for a given time interval by habitat type. We did not weight any cameras based on time in the water because only two were not in the water for two of the 17 intervals.)

Table 5. Year 2005 Dalton Creek Mouth age 0+ salmonid observations per minute per camera across the complete tidal cycle for Good and Poor habitat types. Non-zero values are highlighted in yellow. n = sample size.

Time Interval	Good Habitat	1 SEM	n	Poor Habitat	1 SEM	n
30	0.000	0.000	60	0.000	0.000	40
60	0.031	0.027	60	0.000	0.000	40
90	0.019	0.015	60	0.000	0.000	40
120	0.011	0.008	60	0.008	0.008	40
150	0.000	0.000	60	0.000	0.000	40
180	0.000	0.000	60	0.000	0.000	40
210	0.003	0.003	60	0.000	0.000	40
240	0.003	0.003	60	0.000	0.000	40
270	0.000	0.000	60	0.000	0.000	40
300	0.006	0.006	60	0.000	0.000	40
330	0.031	0.025	60	0.000	0.000	40
360	0.006	0.004	60	0.000	0.000	40
390	0.008	0.008	60	0.000	0.000	40
420	0.000	0.000	60	0.0003	0.0003	40
450	0.000	0.000	60	0.000	0.000	40
480	0.042	0.023	60	0.000	0.000	40
510	0.000	0.000	60	0.000	0.000	40

For the age 1+ fish at Dalton Mouth three surges in activity occurred during the early flood, late flood and early ebb tide (Figure 11). The age 1+ fish per minute per camera values for the Dalton Mouth series of time intervals were greater overall (Table 6.) than those observed for the four sites monitored in Winchester Creek during the same week (Table 4.). There were positive age 1+ values for eight of the time intervals (Good and Poor habitats) at Dalton Mouth. One of the eight values was in the fish-per-hundred-minute range while the other seven were in the fish-per-thousand-minute range. We examined the Dalton Creek Mouth results using a two sample t-test. The error associated with the estimates at Dalton Creek Mouth was great enough that there were no significant differences (α=0.05) within that site when comparing Good and Poor habitat types.

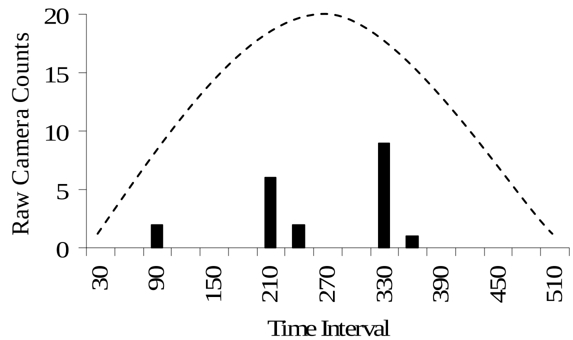


Figure 18. Age 1+ activity patterns (all stations and cameras pooled) within the wood structure at Dalton Mouth. Relative tide elevation shown as dashed line.

Table 6. Year 2005 Dalton Creek Mouth age 1+ salmonid observations per minute per camera across the complete tidal cycle (30 minute intervals). n = sample size.

Time Interval	Good Habitat	1 SEM	n	Poor Habitat	1 SEM	n
30	0.000	0.000	60			40
60	0.000	0.000	60	0.003	0.003	40
90	0.006	0.006	60	0.006	0.008	40
120	0.000	0.000	60			40
150	0.000	0.000	60			40
180	0.000	0.000	60			40
210	0.017	0.014	60			40
240	0.006	0.006	60			40
270	0.000	0.000	60			40
300	0.000	0.000	60			40
330	0.003	0.003	60	0.003	0.003	40
360	0.003	0.003	60			40
390	0.000	0.000	60			40
420	0.000	0.000	60			40
450	0.000	0.000	60			40
480	0.000	0.000	60			40
510	0.000	0.000	60			40

<u>2005 Dalton Creek Salt Marsh Fish Migration Sampling</u>

We measured one Dalton Creek salt marsh polygon for fish migration during April 2005 as an additional product. Our intent was to provide a better understanding of movement between mainstem Winchester Creek, the complex wood at the mouth of Dalton, and the marsh. The polygon was measured using a single transect of cameras because the marsh channel was a closed system. Eight hours of video were recorded. The video was summarized for movement using 30 minute intervals. Fifty-seven 30 minute samples were reviewed. No age 1+ fish were observed. Age 0+ fish showed a surge in activity early in the flood tide and late in the ebb tide (Figure 12). Movement *into* or *out of* was similar for the complete cycle. No retention model was applied to these data.

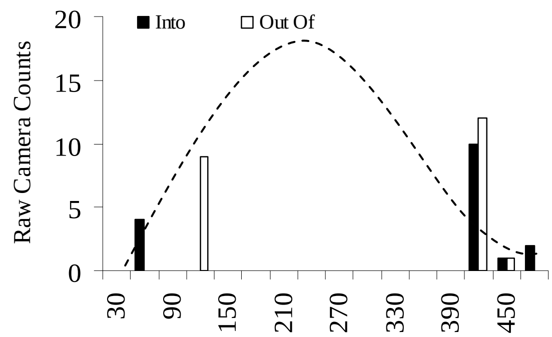


Figure 19. Age 0+ migration patterns (all stations and cameras pooled) for Dalton Salt Marsh channel 2005. Relative tide elevation shown as dashed line.

<u>Results 2006</u>

2006 Wood Polygon Fish Retention Raw and Modeled Responses

Movement of both 1+ and 0+ age salmonids within the Lower Wood Polygon occurred across the full tidal cycle with the greatest numbers observed late in the ebb tide (Figure 20). The inside cameras observed 35 of the 36 fish counted. During the flood tide, migration into and out of the polygon occurred mainly through the upper transect (transect data not shown – refer to into/out of summary (Figure 21) and transect position description (Figure 9)). During the ebb tide all the movement occurred through the lower transect. The surge of migration into the polygon occurred late in the ebb tide (Figure 21). The cumulative retention values for the lower wood polygon resulted in no significant shift until the 420 min interval was completed (Figure 22). At that time immigration was greater than prior outmigration and retention increased. This retention resulted from fish migrating against the current through the lower transect and into the polygon. Fish remained in the polygon at the completion of the afternoon ebb.

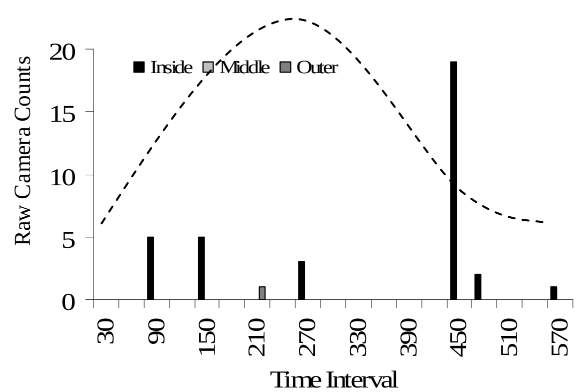


Figure 20. 2006 Lower Wood Polygon fish migration patterns relative to camera station position (raw camera counts used) and tide height (dashed line).

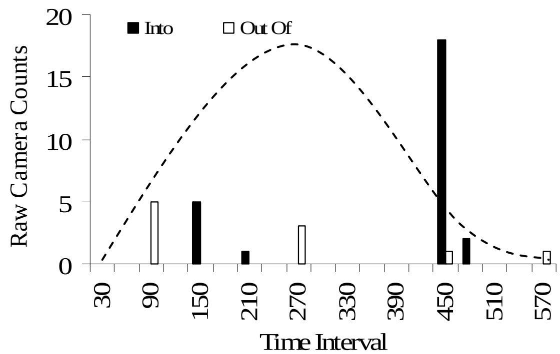


Figure 21. 2006 Lower Wood Polygon fish migration patterns relative to movement into and out of the polygon (raw camera counts used) and tide height (dashed line).

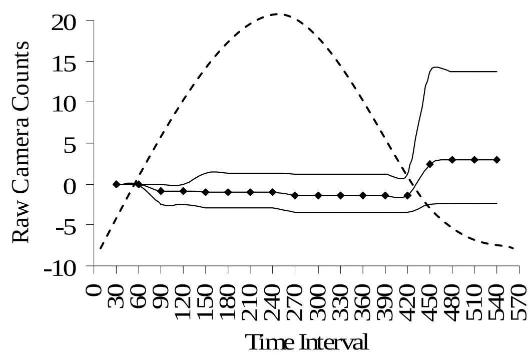


Figure 22. Observed cumulative retention and 95% confidence intervals for age 1+ for the 2006 Lower Wood polygon. Tide height shown as dashed line.

Fish movement within the Middle Wood polygon occurred a few intervals prior to and after the high slack period (Figure 23). The inside cameras observed 19 of the 24 fish counted (Figure 23). All movement out of the polygon occurred through the lower transect, just prior to and just after high slack. All movement into the polygon occurred through the upper transect during the early ebb tide (transect data not shown refer to Figure 24). A shift toward retention within the polygon occurred during this early ebb tide period but the cumulative retention values resulted in non-significance during the full tidal cycle (Figure 25).

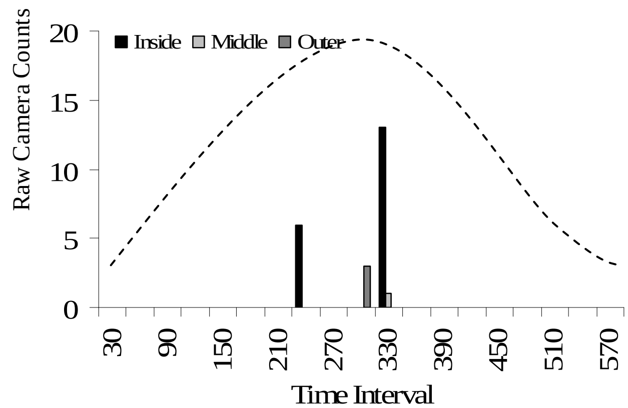


Figure 23. 2006 Middle Wood Polygon fish migration patterns relative to camera station position (raw camera counts used) and tide height (dashed line).

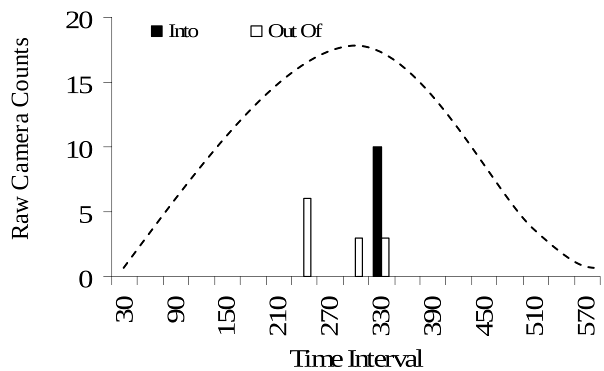


Figure 24. 2006 Middle Wood Polygon fish migration patterns relative to movement into and out of the polygon (raw camera counts used) and tide height (dashed line).

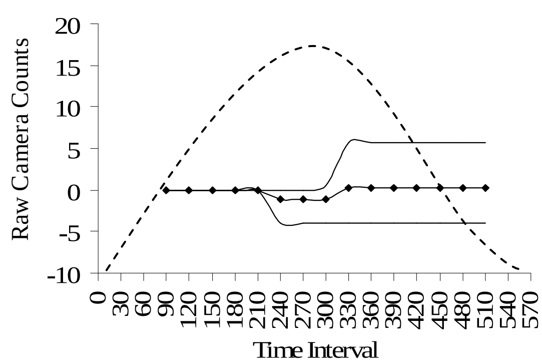


Figure 25. Observed cumulative retention and 95% confidence intervals for age 1+ salmonids for the 2006 Middle Wood polygon. Tide height shown as dashed line.

Within the Upper Wood Polygon a small amount of fish movement occurred during the early flood and near high slack tide (Figure 26). Each station type observed one of the three total fish counted. Overall the results were very similar to those for 2005 in that very few fish were observed. There was very little movement into our out of the polygon (Figure 27). The cumulative retention values for the upper wood polygon resulted in no significant shifts during the complete tidal cycle (Figure 28.).

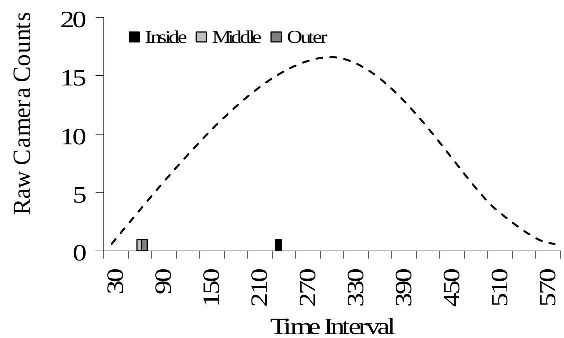


Figure 26. 2006 Upper Wood Polygon fish migration patterns relative to camera station position (raw camera counts used) and water elevation.

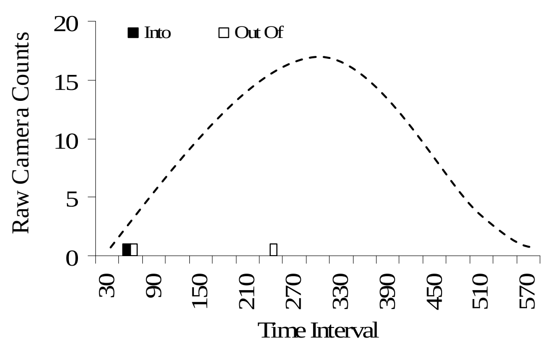


Figure 27. 2006 Upper Wood Polygon fish migration patterns relative to movement into and out of the polygon (raw camera counts used) and tide height (dashed line).

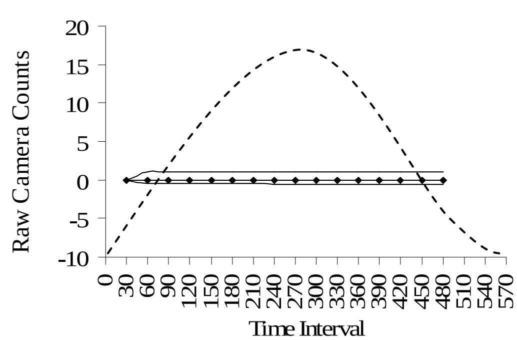


Figure 28. Observed cumulative retention (dotted line) and 95% confidence intervals for the 2006 Upper Wood Polygon. Tide height shown as dashed line.

2005 Seine Sampling in Winchester Creek at Low Tide

We report only the salmonid catch results as they are specific to the project goals and the video results. The mean catch per unit effort (CPUE) for age 0+ was 8.4 (1 SEM = 5.1). For age 1+ the mean CPUE was 0.60 (1 SEM = 0.40). The surface area sampled per seine set during both years was 150 m^2. The CPUE data were expanded to account for surface area sampled. The resultant age 0+ mean density was 0.056 fish/m^2 or less than six fish per 100 m^2 of study site habitat. Age 1+ were estimated to be 0.005 fish/m^2 or five fish per 1000 m^2. The age 1+ values were lower than those observed in other estuaries where the authors have completed similar work examining use of woody structures by juvenile salmonids. The total habitat available during seine sampling was conservatively estimated (using GIS) at 2600 m^2. Using CPUE derived densities and available habitat we estimated the low tide population of age 0+ for the complete study reach to be 145. The estimate for the age 1+ population was 14. The data were useful in determining the species seen in the camera observations. When visibility is high (>3.0 ft) and fish move across the camera screen at slower speeds, or hold, we can differentiate between salmonid species. Otherwise we differentiate fish by size using seine data to validate size/age classifications. Identifying fish as salmonids vs perch, stickle back, and cottids is not an error prone task when reviewing video.

2006 Seine Sampling in Winchester Creek at Low Tide

The mean CPUE for age 0+ was zero. For age 1+ the mean CPUE was 1.2 (1SEM = 0.37). The surface area sampled per seine set was 150 m^2. The catch per unit effort data were expanded to account for surface area sampled. The resultant age 1+ mean density was 0.008 (SEM 0.033) fish * m^{-2} or eight age 1+ in every 1000 m^2 of habitat. The total habitat available during seine sampling was conservatively estimated (using GIS) at 2600 m^2. Using CPUE derived densities and available habitat we estimated the total population of age 1+ for the complete study reach to be 21. These values were much lower than those observed in other estuaries where the authors have completed similar work examining use of woody structures by juvenile salmonids.

Additional Information

Additional information concerning camera sampling conditions, specifics of the behavior model used to generate the 2006 cumulative retention results, and general fish behavior within wood structures, tributary junctions and other study reaches is found in the Confederated Tribes of Siletz Indian's report entitled, *Tidal Fish Migration Patterns In Winchester Creek- Final Report* (2007), submitted with this report.

Determining the Use of LWD by Juvenile Salmonids Using Acoustic Tagging Methods

Of the 25 fish tagged, three fish were never detected by any receivers. The other 22 fish were detected by one or more receivers, displaying widely varying patterns of movement- mainly moving against the tidal currents, and in at least one case, moving great distances.

In the wood/no-wood analysis based on 15 fish each detected a minimum of 200 times combined for all sites (maximum detections was 7,970 for an individual fish, (Table 7) most average percent fish detections were recorded at the Cox natural wood site (30.5%) and at the Fredrickson no-wood site (27.0%). The next highest average percent detections were at the Dalton and Tom's wood sites (18.3% and 12.5%, respectively). The lowest average percent detections were at Hinch Bridge and Danger Point no-wood sites (10.4% and 1.2%, respectively). Overall average percent detections of fish with >200 detections at all wood sites was 20.5% (Table 9); for fish with >200 detections at all no-wood sites it was 12.9%. Overall average percent detections of fish with >1000 detections at all wood sites was 25.2% (Table 9); for fish with >1000 detections at all no-wood sites it was 9.5%.

The data were also analyzed using the six fish who displayed the most residence time in the upper South Slough estuary (each with 1,000 or more detections). These fish were detected an average of 25.2% of the time at wood sites and 8.1% at no-wood sites. (Table 8)

Table 7. Average Percent Detections for Each Reach. (SE = Standard Error)

	Wood Reaches			n
	Cox (SE)	Dalton (SE)	Tom's (SE)	
>200 Detections	30.48 (8.69)	18.33 (7.31)	12.54 (6.61)	15
>1000 Detections	47.88 (13.19)	19.23 (12.57)	8.44 (4.29)	6

	No-Wood Reaches			n
	Fredrickson (SE)	Hinch (SE)	Danger (SE)	
>200 Detections	27.01 (9.20)	10.43 (5.35)	1.15 (0.66)	15
>1000 Detections	18.28 (8.21)	5.43 (3.36)	0.72 (0.33)	6

These 6 fish were further analyzed based on their behavior determined by movement between sites. Four of the six fish exhibited fidelity to one or two sites- we called these fish "stayers". The other two fish moved frequently from site to site- we called these fish "movers". The typical movement patterns for the stayers and movers are shown in Figures 30 and 31.

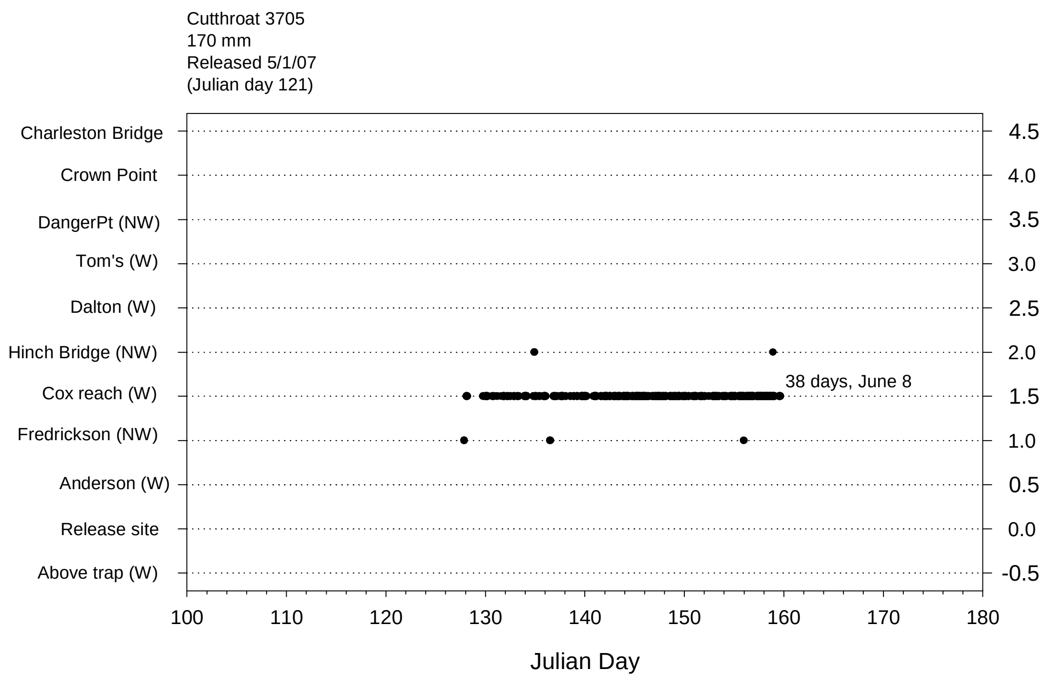


Figure 30. Typical pattern of acoustic tag detections for a "stayer" (NW = no wood site; W = wood site). Each black dot represents one detection. (Figure courtesy of Bruce Miller, ODFW)

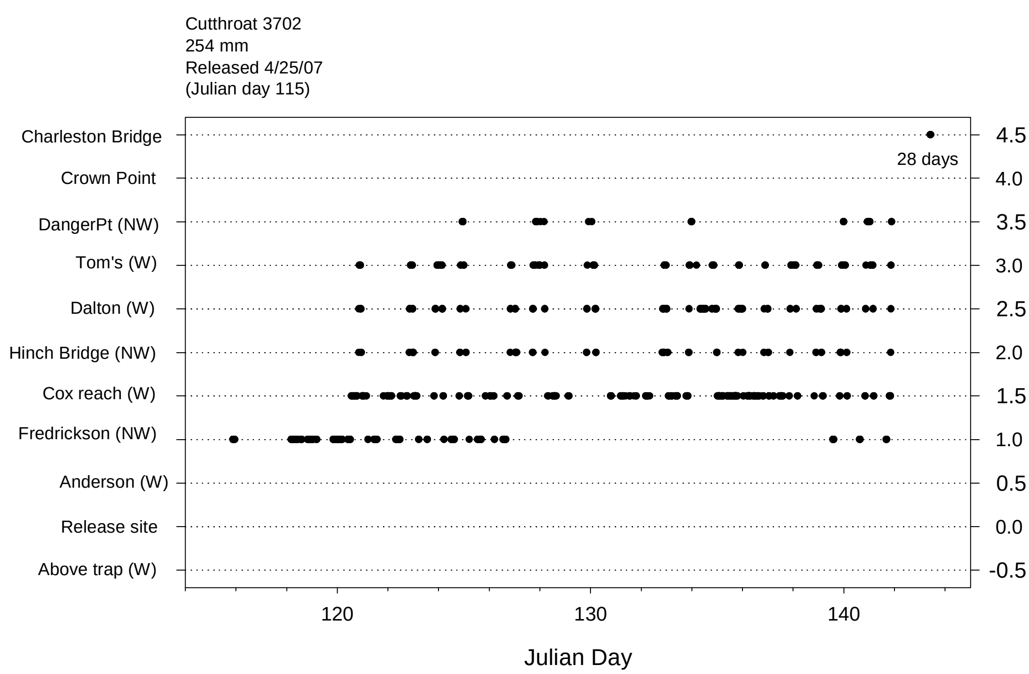


Figure 31. Typical pattern of acoustic tag detections for a "mover" fish (NW = no wood site; W = wood site) Each black dot represents one detection. (Figure courtesy of Bruce Miller, ODFW)

Of the four “stayer” fish, most average percent fish detections were recorded in the Cox wood reach (63.6%)(Table 8). The highest percent detection in the no-wood reaches was 16.4% in the Fredrickson reach. Of the 2 “mover” fish, most average percent fish detections for "stayers" were recorded in the Dalton wood reach (43.0%). The next highest detection was in the Fredrickson no-wood reach (22.0%). Overall average percent detections of “stayer” fish at all wood sites was 25.9% (Table 9). For “stayers” at all no-wood sites, the average percent detections was 7.5%. Overall average percent detections of “mover” fish at all wood sites was 23.8%; for “movers” at all no-wood sites average percent detections was 9.5%.

Table 8 Average Percent Detections for “stayer” and “mover” fish at each reach. (SE = Standard Error)

		Wood Reaches		n
	Cox (SE)	Dalton (SE)	Tom's (SE)	
"Stayers"	63.61 (12.01)	7.33 (6.40)	6.66 (6.54)	4
"Movers"	16.42 (15.21)	43.03 (35.71)	12.01 (0.84)	2
		No-Wood Reaches		n
	Fredrickson (SE)	Hinch (SE)	Danger (SE)	
"Stayers"	16.38 (9.61)	5.73 (5.37)	0.29 (0.29)	4
"Movers"	22.07 (20.89)	4.82 (1.38)	1.59 (0.68)	2

Table 9. Average Percent Detections for All Wood/No-Wood Reaches. (SE = Standard Error)

	Wood Reaches (SE)	No-Wood Reaches (SE)	n
>200 Detections	20.45 (4.42)	12.87 (3.83)	45
>1000 Detections	25.18 (7.10)	8.14 (3.31)	18
"Stayers"	25.87 (9.25)	7.47 (3.87)	12
"Movers"	23.82 (11.75)	9.49 (6.74)	6

Of all 25 tagged fish, only one was determined most likely to have left the South Slough estuary (meaning that its last detected location was at the Charleston Bridge). Of the fate of all tagged fish is described in Table 10.

Table 10. Fate of all tagged fish.

Summary of probable fates:	n	Average size (mm)	Ave. Weight (g)
No detections (possible short term mortalities)	3		
Moved upstream of release site (and all receivers) within 20 days of release	6	166.17	53
Tag expired in live fish, last detection site (area) known	6	141.33	27
Mortality, last detection site (area) known	9	159.22	41
Exited South Slough	1	161.00	41

<u>Fish use monitoring of estuarine marshes associated with LWD</u>

A total of 2,363 fish were caught in the Winchester Creek study area, representing eight species from six families: Pacific staghorn sculpin (*Leptocottus armatus*), shiner perch (*Cymatogaster aggregata*), threespine stickleback, (*Gasterosteus aculeatus*), prickly sculpin (*Cottus asper*), starry flounder (*Platichthys stellatus*), coho salmon (*Oncorhynchus kisutch*), cutthroat trout (*Oncorhynchus clarkia*), and Pacific herring (*Clupea pallasii pallasii*; Table 11). Starry flounder and Pacific herring were only found in the mainstem of Winchester Creek, while all other species were observed in either one or both of the sampled tidal channel tributaries.

Table 11. Total number and percent of fish species sampled by electrofishing and beach seine in the Winchester Creek study area in February-June, 2006.

Common name	Scientific Name	Family	Total Number	Percent of Catch
Pacific staghorn sculpin	*Leptocottus armatus*	Cottidae	2354	78.68
Shiner perch	*Cymatogaster aggregata*	Embiotocidae	293	9.79
Three-spine stickleback	*Gasterosteus aculeatus*	Gasterosteidae	256	8.56
Prickly sculpin	*Cottus asper*	Cottidae	41	1.37
Starry flounder	*Platichthys stellatus*	Pleuronectidae	30	1.00
Coho salmon	*Oncorhynchus kisutch*	Salmonidae	15	0.50
Cuttroat trout	*Oncorhynchus clarkii*	Salmonidae	2	0.07
Pacific herring	*Clupea pallasii pallasii*	Clupeidae	1	0.03

Of the fish sampled in the tributaries of Winchester Creek, Dalton and Tom's Creeks contained 60.2 and 39.8 percent of the total catch respectively. The majority of the fish sampled in the two tributaries were Pacific staghorn sculpin, comprising 86.6 percent of the total catch for both creeks. Of the subsample of staghorn sculpin that were measured, average total length was 53.9 and 44.7 mm respectively for Dalton and Tom's Creeks (Figure 32). Staghorn sculpin were more abundant in Dalton Creek in comparison to Tom's Creek, however, the second most abundant species, threespine stickleback, was observed in nearly equal numbers between the two creeks (Table 12). Most notably, a small number of salmonids were observed in Dalton Creek, while salmonids were absent from Tom's Creek. In the mainstem of Winchester Creek, 63.3 percent of the fish sampled were collected in the upstream reach while 36.7 percent were collected in the adjacent downstream reach. Similar to the Winchester Creek tributaries, the most abundant species sampled was staghorn sculpin, comprising 63.0 percent of the total catch. The second most abundant species found in Winchester Creek, shiner perch, comprised 29.3 percent of the total catch (Table 13).

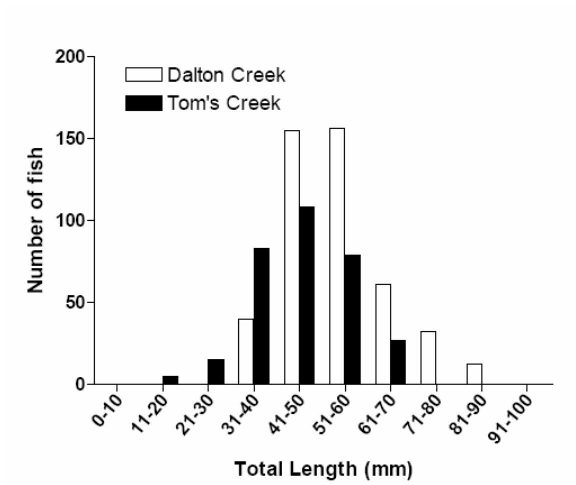


Figure 32. Length distribution of subsampled Pacific staghorn sculpin (Leptocottus armatus) captured by electrofishing in the tidal channel tributaries for all sampling periods.

Table 12. Number, total number, and percent of fish species sampled by electrofishing in the Winchester Creek tributary study reaches in February-June, 2006 (Pacific staghorn sculpin, LEAR; threespine stickleback, GAAC; Prickly sculpin, COAS; coho salmon, ONKI; cutthroat trout, ONCL; and shiner perch, CYAG).

	Species					
Study Area	LEAR	GAAC	COAS	ONKI	ONCL	CYAG
Dalton Creek	1059	111	23	6	1	0
Tom's Creek	667	118	8	0	0	1
Total	1726	229	31	6	1	1
Percent	86.56	11.48	1.55	0.30	0.05	0.05

Table 13. Number, total number, and percent of fish species sampled by beach seine in the Winchester Creek study reaches in February-June, 2006 (Pacific staghorn sculpin, LEAR; shiner perch, CYAG; starry flounder, PLST; threespine stickleback, GAAC; Prickly sculpin, COAS; coho salmon, ONKI; cutthroat trout, ONCL; and Pacific herring, CLPA).

	Species							
Study Area	LEAR	CYAG	PLST	GAAC	COAS	ONKI	ONCL	CLPA
Upstream	342	243	19	19	3	4	0	1
Downstream	286	49	11	8	6	5	1	0
Total	628	292	30	27	9	9	1	1
Percent	62.99	29.29	3.01	2.71	0.90	0.90	0.10	0.10

Shiner perch were sampled in the Winchester Creek study area only during the May and June sampling sessions and were predominately observed in the mainstem of Winchester Creek. A single perch was sampled from Tom's Creek in June. A small percentage of shiner perch were observed in May (35.8 percent of the total catch), while the majority were observed in June (64.2 percent of the total catch). Interestingly, the majority of the shiner perch were sampled from the upstream reach of Winchester Creek (83.2 percent) in comparison to the downstream reach (16.8 percent).

Of the 17 total salmonids sampled in the Winchester Creek Study area over the course of the study, 58.8 percent were sampled in the mainstem of Winchester Creek by beach seine, and 41.2 percent were captured in the Dalton Creek tributary by electrofishing. Two juvenile coho were observed in March while 13 juvenile coho were observed in April. In March, these coho were only sampled from the upstream reach of Winchester Creek, while in April a nearly even split was observed between the Winchester Creek reaches (Upstream: 2 coho, Downstream: 5 coho) and the Dalton Creek tributary reach (6 coho). One cutthroat trout was sampled in April in the downstream reach of Winchester Creek while one cutthroat trout was sampled from Dalton Creek in May.

A peak in the number of fish present in the tributaries was observed in May; a trend driven by the fluctuating presence of the abundant staghorn sculpin (Figure 33). The pattern of abundance was similar between Dalton and Tom's Creeks throughout the sampling periods. In mainstem Winchester Creek a peak in the number of fish present was observed in June. While the number of individuals in the downstream reach remained fairly constant (mean when individuals observed= 91.5, SE= 7.0), the number of individuals in the upstream reach increased as the year progressed (mean when individuals observed= 157.8, SE= 36.6; Figure 4). This difference can be attributed to the presence and increase of shiner perch within the system during May and June which was predominately observed in the upstream reach, and the nearly constant presence of the staghorn sculpin, the dominant species in both reaches (Figure 35).

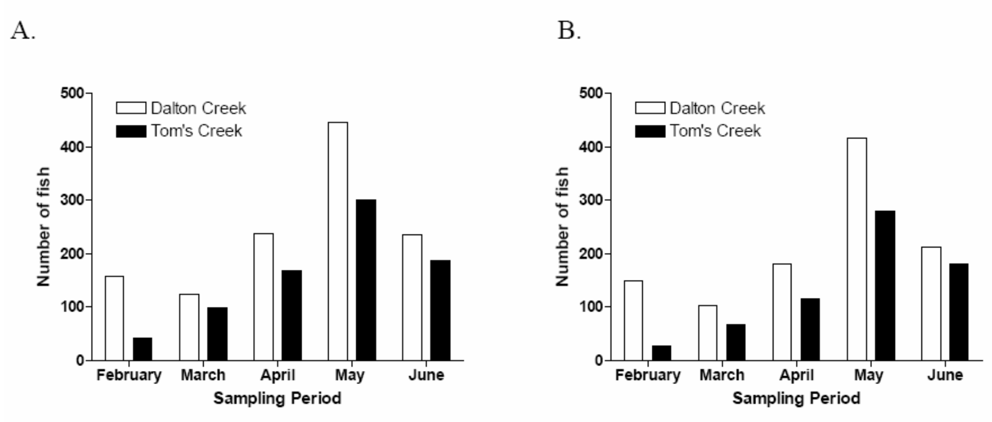


Figure 33. Total number of fish (A) and total number of Pacific staghorn sculpin (Leptocottus armatus (B) caught in study reaches of Dalton and Tom's Creeks during each of five sampling periods in 2006.

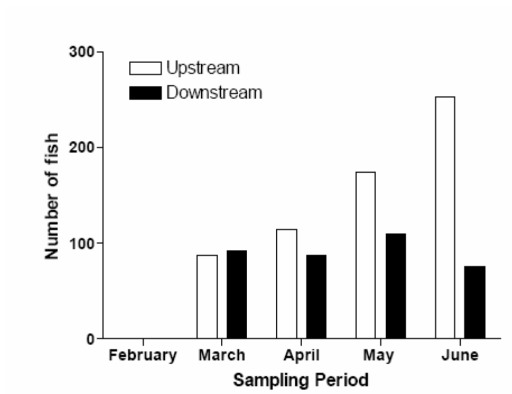


Figure 34. Total number of fish caught in study reaches of Winchester Creek during each of five sampling periods in 2006. Note: Sampling methods were changed after the first sampling period.

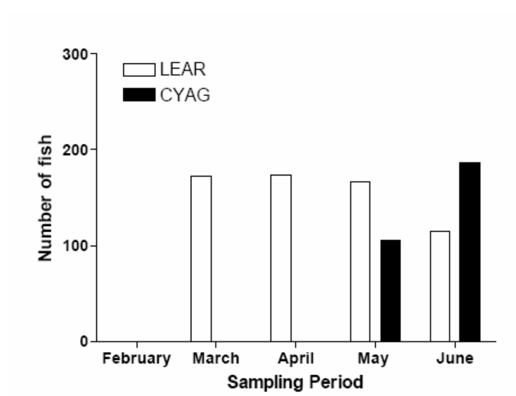


Figure 35. Total number of Pacific staghorn sculpin (Leptocottus armatus, LEAR) and shiner perch (Cymatogaster aggregata, CYAG) caught in both study reaches of Winchester Creek during each of five sampling periods in 2006. Note: Sampling methods were changed after the first sampling period.

Water quality parameters including water temperature, salinity, and conductivity were measured before the commencement of electrofishing in the afternoon (Table 14). On average, among all sampling periods, the Dalton Creek study reach had warmer water temperatures and higher conductivity in comparison to the Tom's Creek study reach. Salinity, on average among all sampling periods was the same for both study reaches. While differences in the water quality parameters measured in the two study reaches were observed, none of these differences were significant.

Table 14. Water chemistry parameters measured in the afternoon before commencement of electrofishing surveys.

Temperature (^{o}C)			Salinity (ppt)		Conductivity (µs/cm)	
Month	Dalton	Tom's	Dalton	Tom's	Dalton	Tom's
February	10.1	8.6	0.3	0.2	444.3	391.5
March	11.0	12.4	0.2	0.2	450.4	246.7
April	15.6	12.6	0.1	0.1	258.2	187.0
May	15.9	16.0	0.4	0.9	1360.5	1447.0
June	18.3	15.1	0.5	0.3	807.1	561.3
Mean	14.2	12.9	0.3	0.3	664.1	566.7

While only a small number of salmonids were observed in the Winchester Creek study area, all of the salmonids observed in the tidal tributaries were found in the Dalton treatment reach which has been enhanced with the placement of large wood debris. No salmonids were observed in the Tom's Creek control reach. All of the coho sampled in Dalton Creek were found under an old wood weir structure, not associated with the placed LWD. This may be due in part to the difficulty of sampling under the placed LWD, where branches and deep water limit the effectiveness of electrofishing techniques. Young-of-the-year coho were observed in Dalton Creek, while primarily coho smolts were observed in Winchester Creek.

Overall, fish were more abundant in the treatment reach in comparison to the control reach. Pacific staghorn sculpin, the most abundant fish species sampled in the Winchester Creek study area, were similarly more abundant in the treatment reach and observed to be larger on average than those in the control reach. These differences in fish communities are possibly influenced by the presence of LWD, or other factors. It is unlikely that water temperature, salinity, or conductivity influenced fish community composition as no significant differences in these parameters were observed between the two reaches.

These results differ from those observed during the sampling conducted in May and June 2005. In this study, coho salmon fry as well as cutthroat trout fingerlings were observed at both sites in May. In June, juvenile coho were once again observed at both sites, while cutthroat trout were only observed in Dalton Creek. More than seven times as many salmonids were observed utilizing the tidal channel habitats in 2005 during two sampling periods in comparison to 2006 with five sampling periods. In 2005, sampling was conducted using a combination of fyke nets and electrofishing. It was noted however, that juvenile coho, were not being caught in large numbers by the fyke nets although they were observed in both creeks. Therefore, sampling by electrofishing was conducted in 2006. As this a more active sampling method, it is unlikely that the change in sampling methodology influenced the differences in salmonid abundance noted between the two years. It is more likely that 2006 had poorer returns of coho in comparison to 2005.

Benthic Invertebrate Abundance and Composition in Wood and No-Wood Habitats

Results from a multi-factor ANOVA with site number, month, year and wood/no wood as factors revealed total density of benthic invertebrates to be significantly greater at LWD sites ($p = 0.00$). Significant differences were also found among month and year factors ($p = 0.00$, both), indicating strength of differences in total density was due to season and year; however, no significant differences were found among site numbers ($p = 0.08$). Based on these differences, data were partitioned and ANOVA was applied for each sampling period (May 2005, September 2005 and May 2006). No significant difference was found in May 2005 ($p = 0.199$), but differences were detected in September 2005 and May 2006 ($p = 0.007$, $p = 0.011$, respectively). Boxplots were used to compare distribution of data and results of ANOVA are noted (Figure 36).

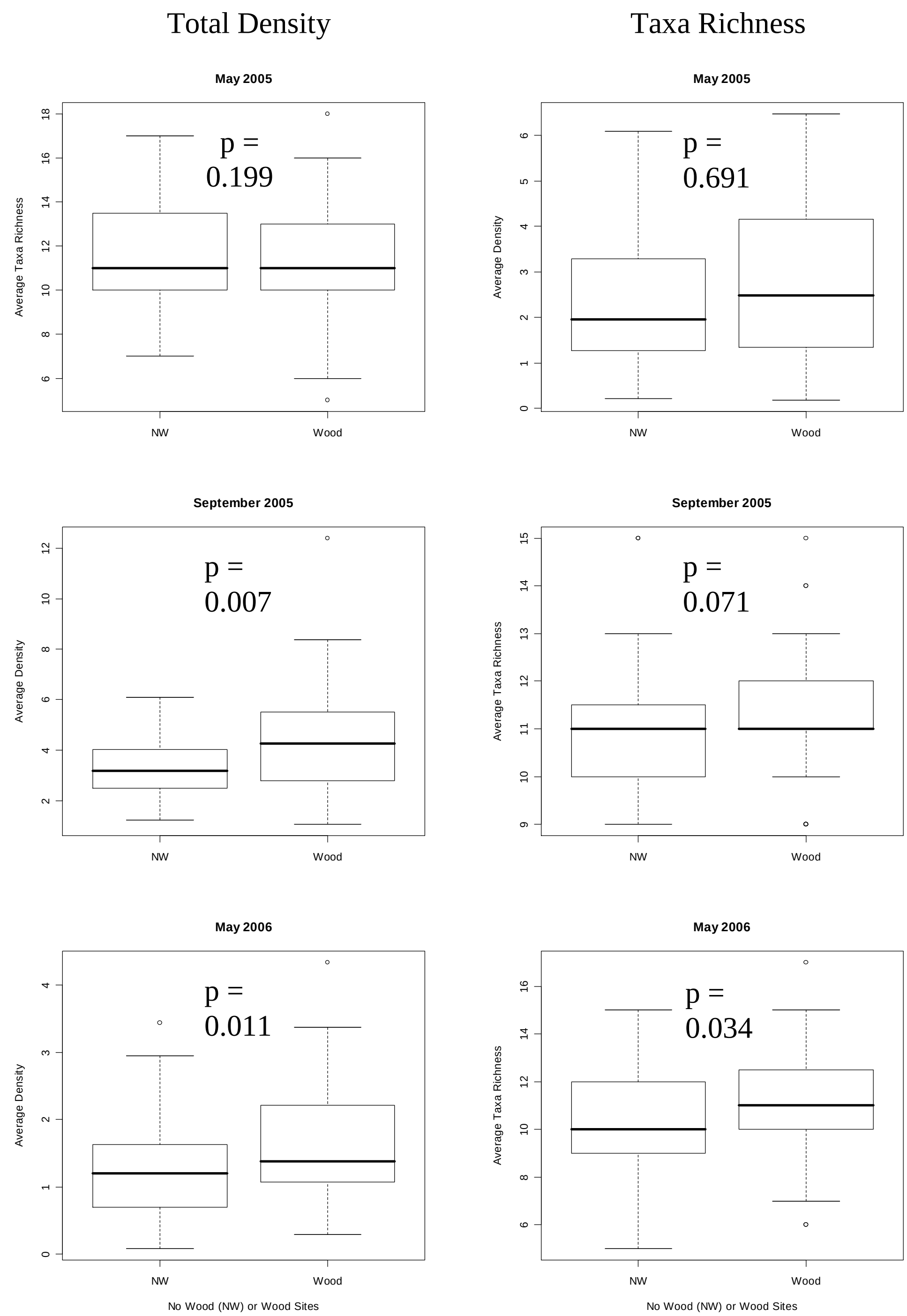


Figure 36. Comparison of total abundance and taxonomic richness by sampling period. Note, NW and Wood refer to paired sampling sites with no wood and LWD placements, respectively.

A One-way ANOVA was similarly applied to taxonomic richness data (partitioned by sampling period). No significant difference in taxonomic richness was detected during May and September 2005 ($p = 0.691$, $p = 0.077$, respectively), but significantly more taxonomic groups were found in LWD sites in May 2006 ($p = 0.034$) (Figure 36).

Generally, oligochaetes, nematodes, the two polychaetes, *Hobsonia florida* and *Manayunkia aestuarina* were found to dominate benthic samples in May 2005 and 2006, but samples from September 2005 showed overall higher densities (after growing season) and notably higher densities of the amphipod, *Corophium spp.*(Figure 37).

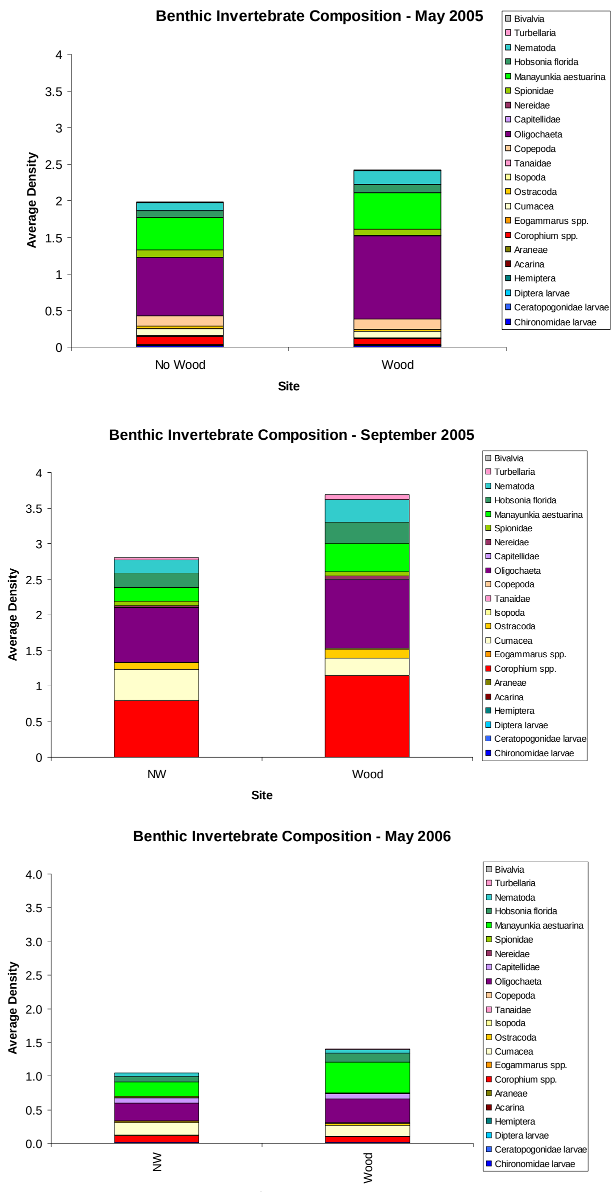


Figure 37. Comparison of benthic invertebrate abundance and composition by sampling period. Note, NW and W refer to paired sites with no wood and LWD placement.

NMDS was used to explore invertebrate community differences between LWD and NW (no wood) samples. NMDS plots the relative differences among samples on two axes (Figure 38), and ANOSIM is applied to determine statistical differences between groups (Table 15). No significant differences were found between LWD and NW samples during our sampling periods. SIMPER analysis was used to determine how much of difference (or lack of difference) among groups was due to juvenile salmonid prey items to test for impact of LWD placement on prey resource community. Some difference among paired sites was due to densities of the amphipod, *Corophium spp.* (see Table 15).

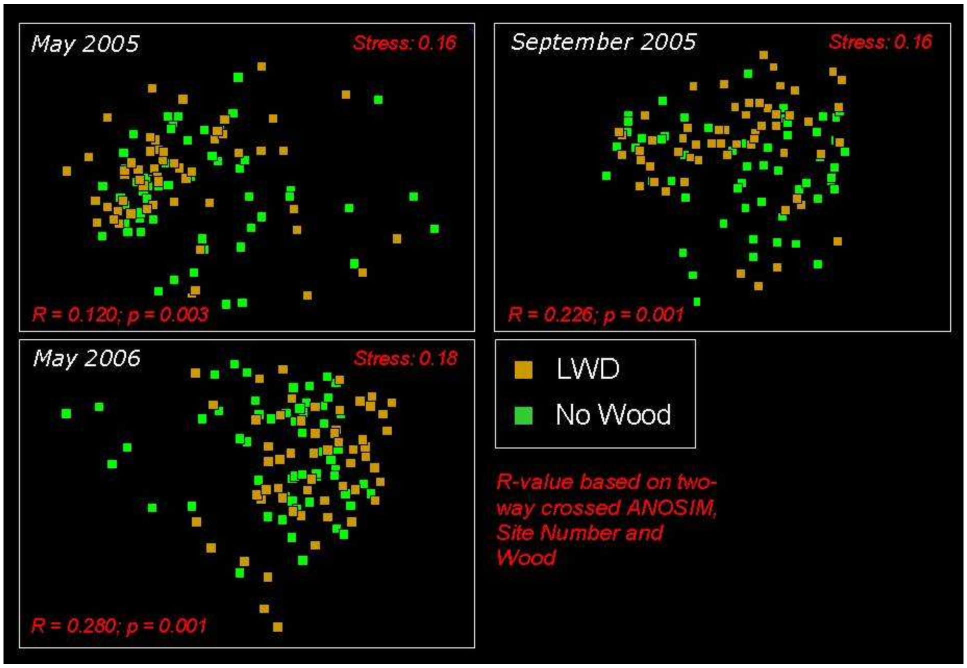


Figure 38. NMDS plot of eight paired sites each sampling period. No significant differences are indicated by plots.

Table 15. Results from multivariate statistical tests to assess invertebrate assemblages at eight paired sites.

Multivariate Statistics		Sampling Periods		
Tests	Values	May 2005	Sept 2005	May 2006
ANOSIM	R (significant at > 0.4)	0.120	0.226	0.280
	p-value (significant at < 0.05)	0.003	0.001	0.001
SIMPER	% Dissimilarity	35.57	33.45	39.04
	Corophium spp.	8.59	17.82	7.99

Channel morphological change in "Wood Zone"

The final change grid indicates several areas of significant change (Figure 39). The sources of error in the modeled surfaces need to be considered when analyzing change. The RTK measurement error is typically less than 2-cm vertical; however, the distance between cross sections and uneven spacing between measurements can introduce interpolation errors into the bathymetry models. While the LiDAR ground model does not directly influence the accuracy of the bathymetric model, it does provide a quantified assessment of model accuracy and a good metric for change detection. Circled areas are discussed further in Figures 40, 41, and 42.

Change Without Locations of LWD Indicated **Change With Locations of LWD Indicated**

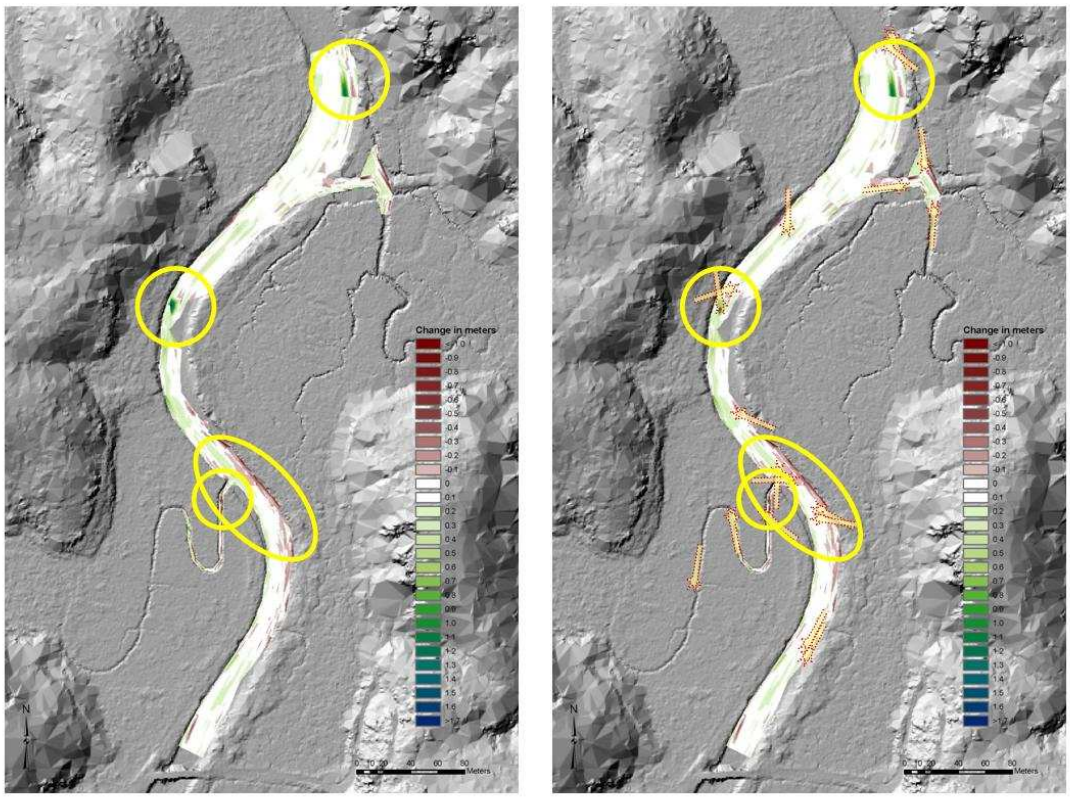


Figure 39. Bathymetric changes detected from 2006 to 2007 along Winchester Creek. Areas shown in deep green to blue indicate areas of aggradation. Areas seen in red are areas of erosion and degradation.

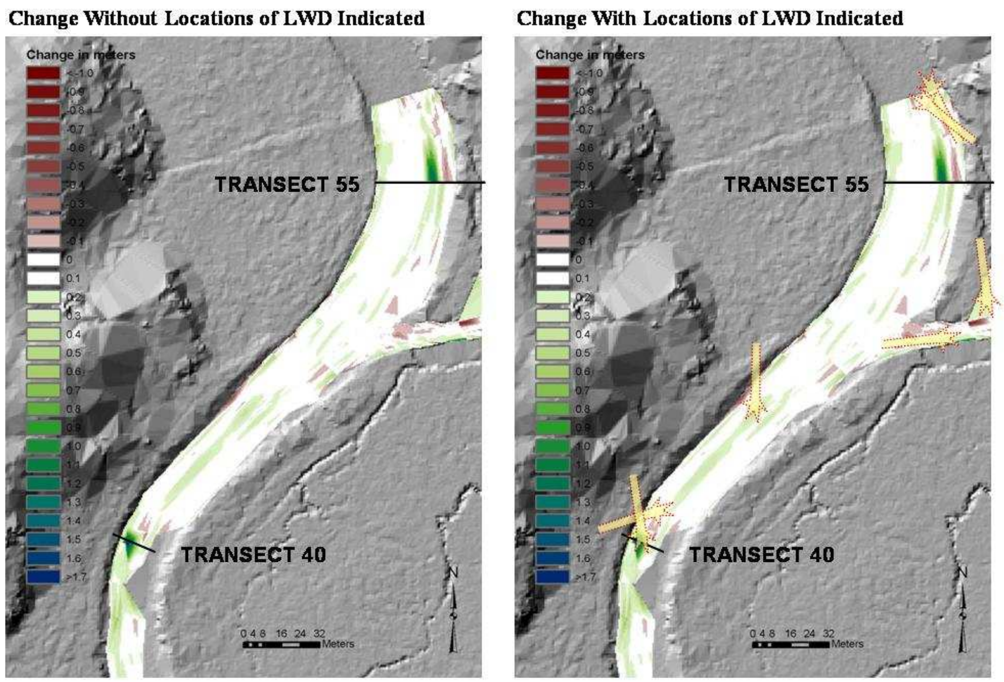
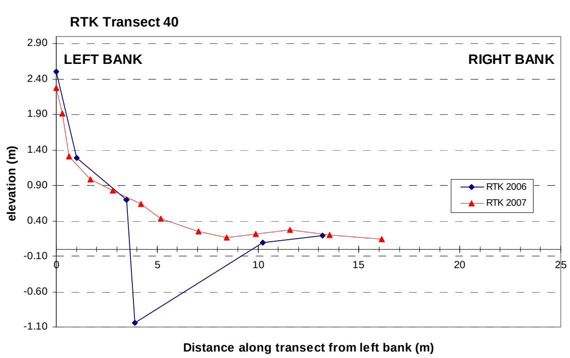
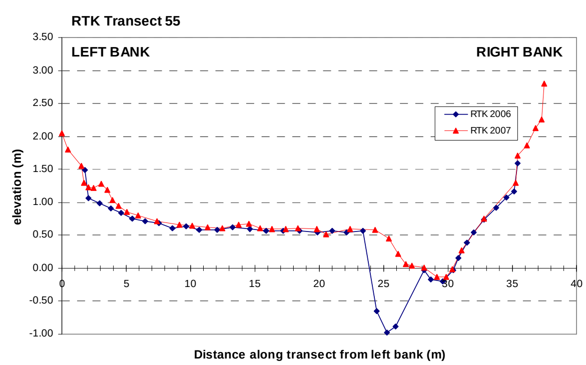


Figure 40. In the northern half of the survey area, at transects 40 and 55, two significant areas of deposition have occurred. In both cases, large holes seen in the 2006 surveys were no longer there. Transect 40 occurred on the edge of the GPS dead zone, but the magnitude of the 1.5 meter change far exceeds the uncertainty in the survey. The magnitude of the change seen at transect 55 is similar at 1.2 meters.





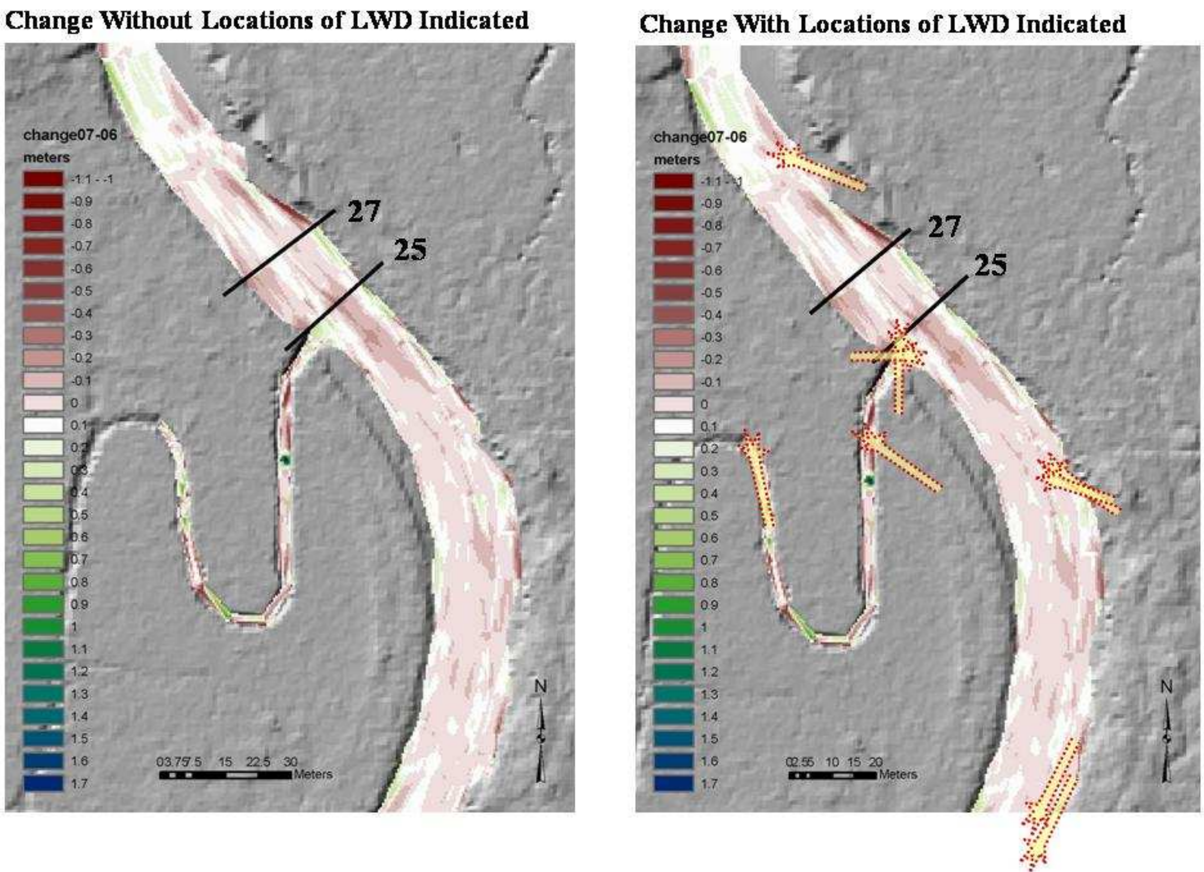
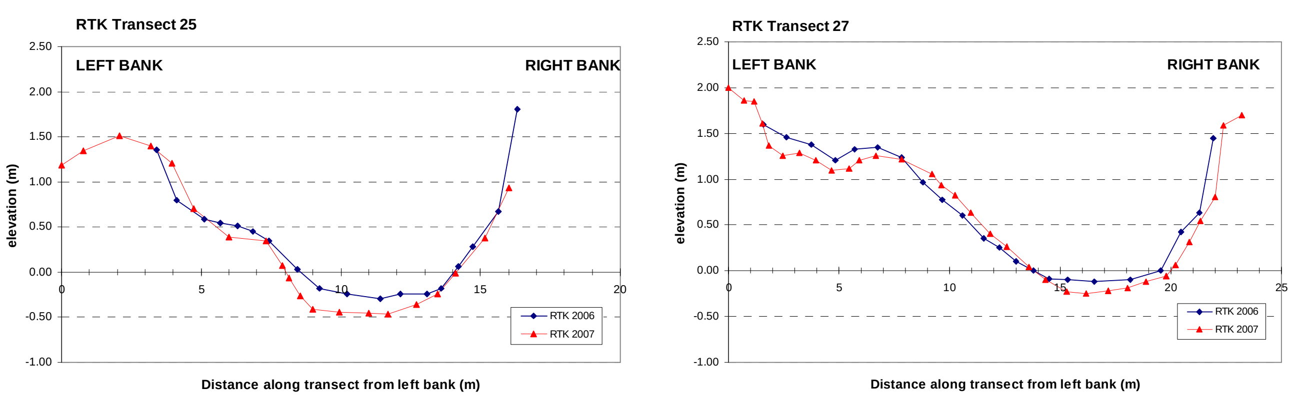


Figure 41. The change detection analysis shows an area of degradation where the side channel flows into Winchester Creek. The thalweg of Winchester Creek seems to have deepened and shifted to the east slightly. The deepening can be seen clearly in the cross-section of Transect 25, and the slight shift to the east can be seen in Transect 27.



Change Without Locations of LWD Indicated **Change With Locations of LWD Indicated**

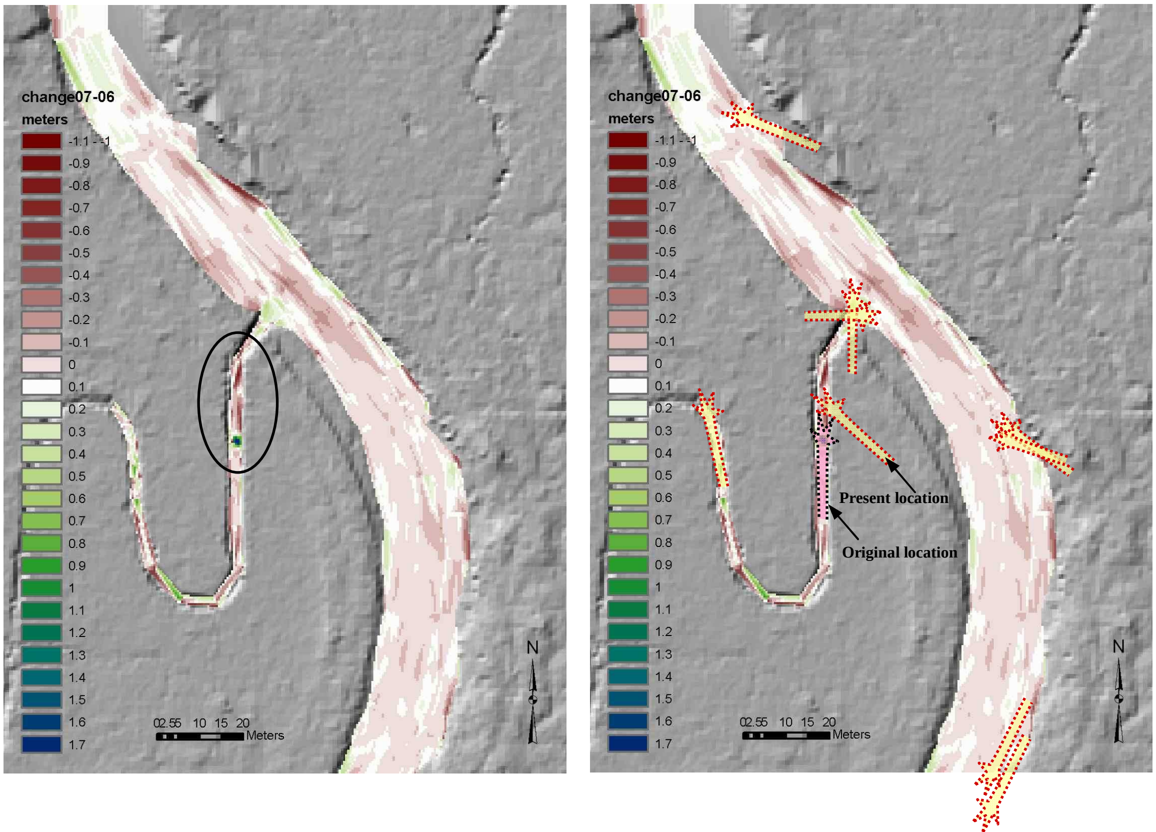
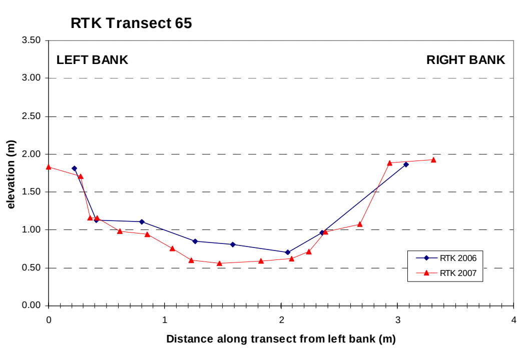
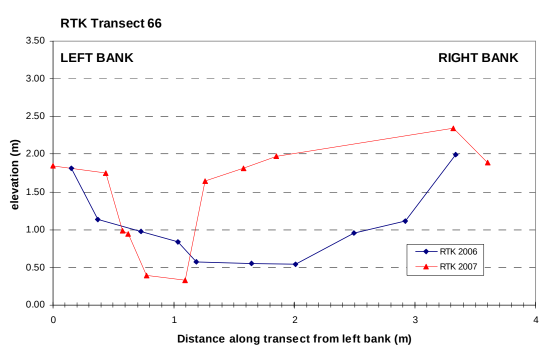


Figure 42. On the western side channel, an area of change is seen at transect 64-66. In the area of transect 66, a large hole was surveyed in the channel. The hole was the result of the tree and root wad present in the channel. In winter 2006-07 the tree moved slightly enabling the survey crew to freely survey the full extent of the hole. The channel had significantly deepened on the west side of the root wad.

Downstream of the root wad, the channel also appears to have deepened as seen in the cross-section for transect 65.





LWD Movement

As of January 2007, all of the LWD pieces variously shifted or rolled and five of the LWD pieces moved away from the location they were initially placed. All of the tree tethers were removed by vandals but the stakes and lines keeping the LWD in place at the mouth of Dalton Creek were left untouched. So except for the LWD at the at the mouth of Dalton Creek, all LWD in the project wood zone was free to be floated and moved by tidal action.

LWD that moved beyond shifting and rolling in place moved as little as 18 m and as much as 490 m. Average movement was 215 m. All net LWD movement was downstream (towards the mouth of South Slough), however two of the five pieces that moved initially moved to locations 30 m and 185 m upstream before moving back downstream to where they were located in January 2007. Movement upstream lasted between 3 and 8 months which included fall and winter high precipitation seasons.

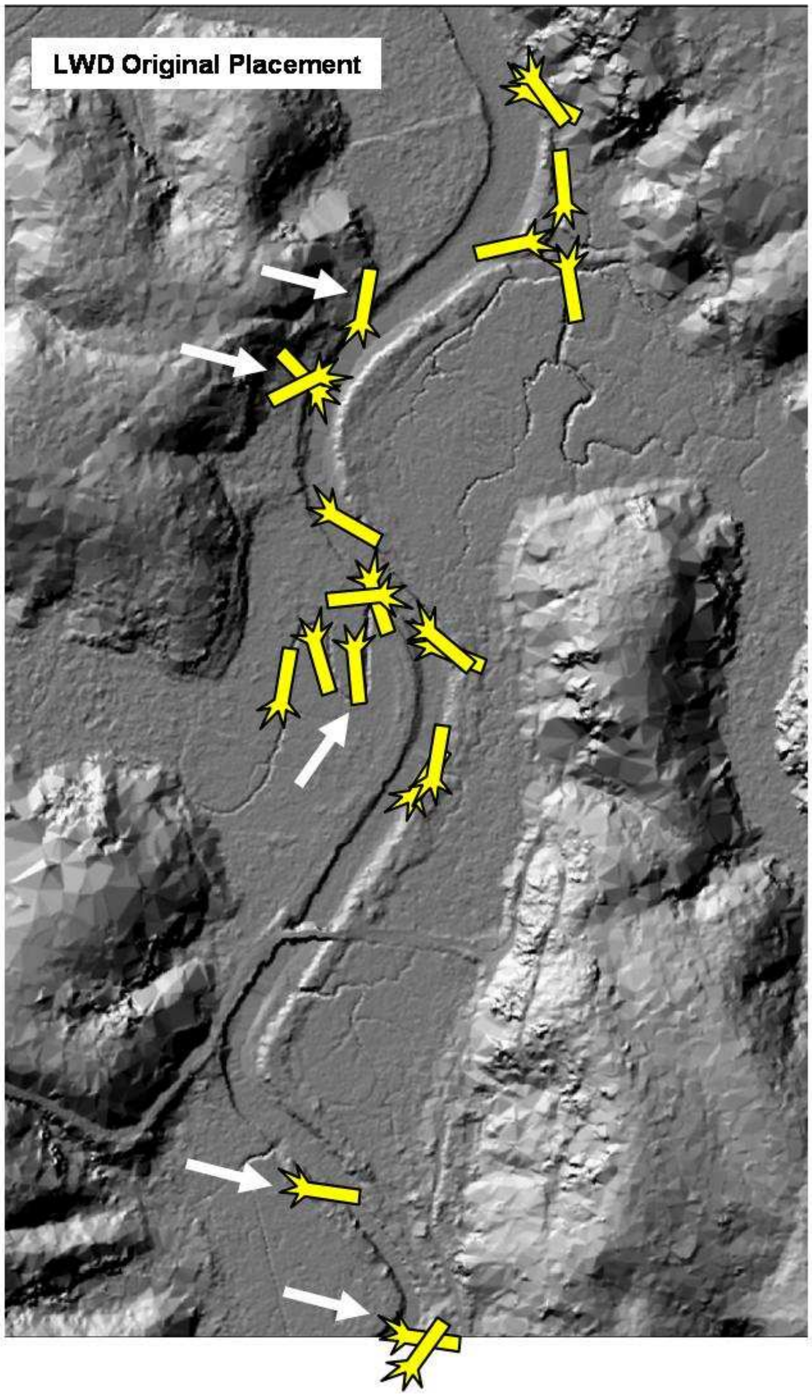


Figure 43. Approximate original placement of LWD in the project wood zone indicated by yellow LWD graphics. Orientation of root wad and tree top is indicated by the orientation of the graphics. White arrows indicated LWD that moved beyond shifting and rolling in place.

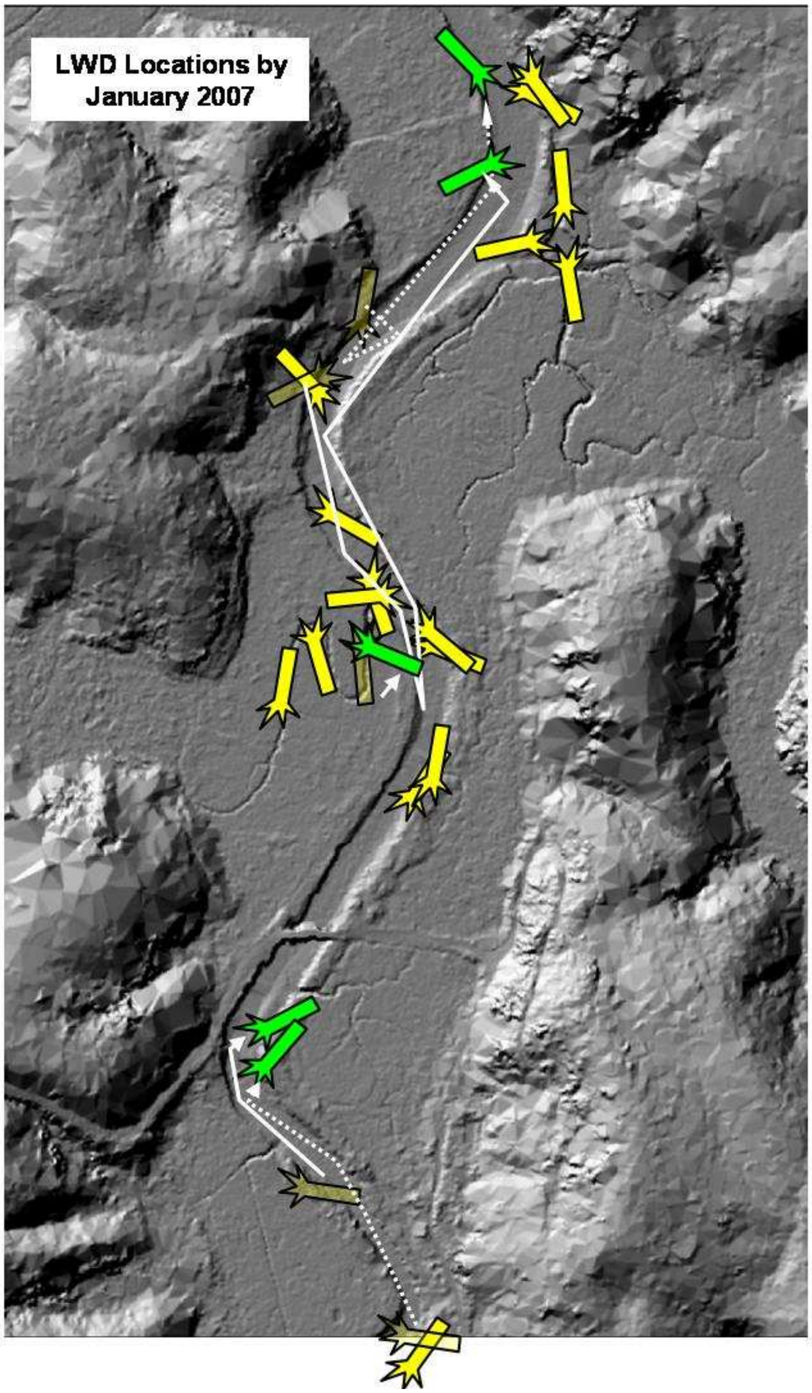


Figure 44. LWD locations as of January 2007 in the project wood zone indicated by yellow and green LWD graphics. Orientation of root wad and tree top is indicated by the orientation of the graphics. Green graphics indicated new location of LWD that moved beyond shifting and rolling in place. White solid and dotted lines indicated approximate movement path (both upstream and downstream for two pieces).

Project Conclusions

This project was designed to address a series of questions focused on determining the effects of large woody debris placements in tidal channels on the development of instream habitat for juvenile salmonids. The study duration was two years. Since many ecological processes occur over much longer time frames, additional project monitoring will be needed to fully understand the processes associated with LWD placement and the development of productive fish habitat.

<u>Are there higher densities of juvenile salmonids near LWD compared with habitats lacking LWD?</u>
Answer: A qualified "Yes"

This monitoring project used two methods to determine whether estuarine fishes, juvenile salmonids in particular, would actually use the LWD placed in the Winchester Creek tidal channel. Despite the frustratingly low numbers of salmonids observed in the channel, the underwater video monitoring suggested some interesting patterns indicating some fish use of LWD structures. Some additional observations shed light on the results and set the stage for further LWD monitoring in tidal channels:

- The absence of age-1+ fish at the Lower, Middle and Upper Winchester Creek wood sites in 2005 may have been explained by the 2006 analysis showing the majority of juveniles were not using the flow paths in which the Winchester Creek complex wood structures were located. The majority of the 2006 migrants moved along the inside/bank camera stations and near the channel bottom and would have been out of sight of the cameras placed around the LWD structures in 2005.
- The 2006 results also suggest habitat attributes other than the new Winchester Creek LWD structures could have been influencing the 2006 age-1+ presence/absence patterns. For example, the lower wood polygon monitored in 2006 was shown to have significant retention of age-1+ salmonids across portions of the full tidal cycle, while the other polygons did not. The channel morphology in the lower polygon appears to have been affected by historically-placed pilings and revetments (west bank), and a dike (east bank). These elements appear to have created scour and fill patterns not seen in the other polygons. The new LWD, placed two years prior to the 2006 monitoring, has not yet exerted significant influence on channel morphology, creating one scour hole 0.5 m deep and areas of sediment accumulation near LWD structures (likely due to reduced velocity during seasonal peak flow periods with high suspended sediments loads). We suggest that the migration retention observed for the lower wood polygon reflects more of an attraction to the historic pool habitat in the lower polygon (as well as the overall increased bed complexity) than an attraction to the newly placed LWD in that polygon.
- Observations made in other estuaries indicate that when LWD has created stream current velocity refugia and cover in the form of larger scour pools and bars, juvenile salmonids that migrate into the sampling polygon are more likely to be

retained longer than in polygons without this complex habitat. For this project, we suggest the observed channel velocities in Winchester Creek (1-3 ft $^{-sec}$) were not great enough to require current velocity refugia like that observed in the lower Siletz Estuary (4-5 ft $^{-sec}$). We also suggest that if the newly placed LWD were to create a grid of significant scour and fill in future years (likely to take some time due to low current velocities), the retention would increase at that time.

- We have hypothesized that fish migration lanes are determined by fish finding the right balance between optimizing feeding opportunities and limiting their energy expenditure. The presence and drift of available prey may be an additional factor influencing our Winchester Creek flow path and migration path observations.

Observations of fish movement patterns were consistent with observations from previous studies. At the lower polygon, fish movement during flood tide occurred at the upper transect indicating fish were leaving the deeper pool area and moving upstream with the current into shallower water then returning downstream to the polygon again. This return movement was against the flood current and was repeated (but to a lesser degree) near the high slack period. The final pulse of movement seen late in the ebb tide occurred through the lower transect as fish moved upstream into the polygon from below the lower transect**.** Observations made in the Siletz River Estuary (van de Wetering 2003) suggest tidal migration of juvenile salmonids in larger non-complex channels includes two components: 1) small scale (0.5 m distance) upstream-downstream milling behavior exhibited by a limited number of individuals; and, 2) fish migrating greater distances upstream or downstream, exhibiting similar larger-scale milling behavior influenced by current direction.

We treated the Winchester Creek wood polygons, Dalton mouth, and Dalton marsh channel observations, as separate analyses. The results for Dalton mouth when compared to the results for the Winchester Creek wood polygons showed some interesting patterns. Although the Winchester data were not modeled for retention rates one can see from the raw data that very little migration occurred in either the upstream or downstream direction. When comparing that to the activity measured within the wood complex at Dalton mouth, one can see the comparatively higher level of activity at the Dalton mouth LWD structure. Taking that one step further and comparing the into/out-of results for the Dalton salt marsh estimates, one can see that the Dalton mouth LWD structures also had comparatively more activity than the Dalton salt marsh channel. We suggest the wood located at the mouth of Dalton Creek was providing the most optimal habitat for both age-0+ and age-1+ salmonids during 2005. We suggest this increased activity is a response to increased complexity of hard structures, flow paths, current velocities and feeding opportunities. These are a result of a salt marsh tributary that experiences significant tidal exchange (~ 4.5 ft) interacting with hard structures at the junction where the mainstem and tributary currents join. To expand on this ideal habitat hypothesis, we highlight the age-0+ raw counts for Dalton Creek mouth which showed increased activity at the beginning of the flood, the beginning of the ebb and the end of the ebb. Results from other salt marsh research sites (van de Wetering, S. 2005, unpublished results) suggest marsh channels with complex habitats near the mouths result in juvenile migration patterns into tidal currents during the early period of both the flood and the ebb tides. We think this upstream movement may be feeding activity. This more common pattern was not quite as obvious in the age-1+ results. Considering the present age-0+ results, these early and late activity peaks might be occurring at times during which age-1+ predators are not as likely to be in or near the LWD habitat. Considering the present age-1+ results, the late flood and early ebb activity peaks might be occurring at times during which optimal prey resource drift occurs, and the age-1+ are not as susceptible to predation themselves mainly because there is more cover habitat. When comparing the peaks in activity around the Dalton Creek mouth LWD and the Dalton salt marsh migration, our results suggest the velocities were a limiting factor. That is to say, age-0+ fish were observed migrating into and out of the salt marsh only during those periods when the velocities were at a minimum. This corresponds, to some extent, with our anecdotal observations of very high velocities in the Dalton salt marsh channel during both the flood and ebb tides. Although high slack typically offers a few minutes of limited velocity flows, we suggest in this case the time was too limiting to allow for age-0+ migration.

In summary, we suggest the most preferred juvenile salmonid habitat was that of the Dalton Creek mouth LWD, due to its complexity and position within a tributary junction with strong tidal fluctuations. We hypothesize this habitat allowed for optimal cover, prey availability, feeding lanes, and velocity refugia. Looking at the full study zone, as well as habitat upstream and downstream of it, one can see that fish have to migrate more than ten channel widths upstream, and six downstream (van de Wetering, S., unpublished results) before they encounter similar pool-bar-complex wood habitats. We suggest the study zone-wide composition of habitat has a greater likelihood of retaining fish on that scale than any one polygon nested within the study zone.

For the fish presence monitoring using acoustic tagging methods, there was a clear overall trend showing juvenile cutthroat trout presence in zones with LWD present. Like the findings discussed above, the preference for the juvenile trout was the Cox natural wood reach, which contained old, naturally-occurring LWD. While channel morphology was not measured in this reach, anecdotal evidence (observations during low tide receiver deployment, removal, and data retrieval) strongly suggests that, like the historically-placed structures in the lower polygon described above, the natural LWD has formed much more complex scour pool and bar habitat for fish than the newly placed LWD structures have so far- simply due to the difference in time necessary for these habitat elements to develop.

Citations

Van de Wetering, S. 2003. American Fisheries Society Meeting, Oregon Chapter. Large Wood and Juvenile Salmonid Migration Patterns in the Siletz River Estuary.

Watershed Sciences, Inc. 2007. RTK Data Collection and LiDAR Integration, South Slough Estuarine Reserve, OR. Watershed Sciences, Inc. 111 NW Second St Unit One, Corvallis OR 97330.

Does placing LWD at the mouths of tidal creeks create a staging area for fish to hold before foraging up tributary tidal creeks during flood or ebb tide?
Answer: A qualified "Yes"

See discussion above...

Is the presence of wood increasing fish prey resources?
Answer: A qualified "Yes"

Investigations into changes in invertebrate communities associated with LWD placement were targeted at the infaunal benthic community. Replicate samples were taken from eight paired sites throughout the wood zone. Data were analyzed to compare total density, taxonomic richness, and changes in composition. Total density of benthic invertebrates was found to be significantly greater at LWD sites compared with paired sites lacking LWD. In addition, taxonomic richness was found to be significantly higher in May 2006. No differences in community composition were detected. Estuarine processes that translate LWD placement into increased invertebrate abundance likely occur over longer time frames. Potential mechanisms include increased edge-water interface, source of organic matter, collection of wrack and other potential food sources, etc. Additional sampling is necessary to fully determine the increase to fish prey resources due to LWD placements. Anecdotal field reports suggest active invertebrate communities exist on the LWD surface (SSNERR, unpublished notes), as well as epifauna in the scour pools near LWD. Additional sampling efforts for invertebrates should use an epibenthic pump, or similar sampling device, to obtain a fully view of the estuarine invertebrate community in complex LWD environments.

Does the presence of wood change the percentage of fish using the tidal creeks over time?
Answer: “Inconclusive”

In 2006 sampling, the presence of LWD appeared to influence the presence of both salmonid and non-salmonid estuarine fishes in the study area: all the juvenile salmonids observed in the tidal tributaries were found in the Dalton Creek treatment reach enhanced with LWD, and no salmonids were observed in the Tom’s Creek control reach (LWD placed only at its mouth); Pacific staghorn sculpin were more abundant in the Dalton Creek treatment reach and were larger than those in the Tom’s Creek control reach. However, in 2005 sampling, juvenile coho salmon and cutthroat trout were present at both sites in May, and in June sampling, juvenile coho were found at both sites, but cutthroat trout were found only in Dalton Creek. More than the presence of LWD, it is likely that the sites relative position in the estuarine gradient, in addition to some adjustments in sampling methods, and the natural year-to-year variation of salmonid populations had more to do with where fish were found than LWD during the study period. The study was further complicated by overall low abundances of juveniles salmonids. Our results are inconclusive on whether the presence of LWD is having on fish presence in tributary, tidal streams.

<u>Does placing LWD in tidal channels create changes in channel morphology (i.e., scour pools) which are associated with increased habitat quality for juvenile salmonids?</u>
Answer: "Inconclusive"

We detected significant changes in channel morphology between channel profile surveys conducted in 2006 and 2007 that were mainly due to sediment deposition and some channel bottom scour, likely due to hydraulic changes of the LWD. However, site conditions are highly dynamic. Three relatively large scour holes detected in 2006 were filled by the time of the 2007 the survey. In two cases (Dalton Creek and Winchester Creek at transect 40), the filling of the scour hole was due to LWD movement- the cause of channel scour shifted away from the site. It is less clear what was involved with the third scour hole fill (Winchester Creek at transect 55). Channel scour detected in Winchester Creek just downstream from the mouth of Dalton Creek LWD structures was also likely related to the presence of LWD structures. So, while the presence or absence the LWD structures was notably influencing channel morphology, how these changes "increase habitat quality" for salmonids is far from clear. We can say that the LWD structures cause changes in channel morphology, but since, stable subtidal and intertidal channel habitat around LWD will take years to develop (wherever the LWD structures remain in place- see below), it is too soon to make judgments about the quality of the habitat.

<u>What significant changes in temperature or water flow occurs with the placement of LWD?</u>
No change in water temperatures; detectable changes in flow.

Water temperature data was collected using Onset TidBit temperature data loggers deployed around various LWD structures. Data collection for this part of the project was not completed, in part because many of the TidBit loggers were buried under shifting LWD logs. What little data was retrieved indicated that water temperature was no different near or under LWD structures than water temperature in areas with no LWD. Rapid exchange of tides through the study area may act to mix waters and keep temperatures similar across microhabitats. However, the potential seasonality of water temperature fluctuations in wood and no-wood areas was not determined.

Water velocity measurements were taken by CTSI contractors as part of their underwater videography fish monitoring (see CTSI reported submitted with this document). Current velocities in Winchester Creek were found to vary between LWD structures and between habitats around the LWD structures. Winchester Creek stream velocities are lower than the measured by the CTSI contractors in other coastal Oregon mainstem channels. Higher velocities were recorded during ebb tide flows.

Does the wood move?
Answer: “Yes”

Several LWD structures moved, as expected, during extreme winter high tides and moved both upstream and downstream, with the net direction of movement being downstream.