Stave River Project Water Use Plan

Seasonal Timing and Assemblages of Resident Fish

Implementation Year 3

Reference: SFLMON-08

Study Period: 2015

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October 2017

Report

Stave River Water Use Plan Technical Report SFLMON-8

Seasonal Timing and Assemblages of Resident Fish

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Seasonal Timing and Assemblages of Resident Fish

2495.03.02

Prepared for

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October 2017

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Executive Summary

The Stave River Water Use Plan (SFL WUP) was developed in 1999 to establish and ensure water use objectives for the Stave Lake watershed. In 2005, the SFL WUP's Monitoring Advisory Committee established a Terms of Reference to address data gaps identified in the original SFL WUP. The Monitoring Advisory Committee determined that a gap existed in the Terms of Reference such that it was not structured to confirm that flows downstream of the Ruskin Generating Station set for anadromous fish species were also sufficient to satisfy lifecycle requirements of resident fish species. Resident species of particular management concern were Rainbow Trout, Cutthroat Trout, Mountain Whitefish, and Brassy Minnow. A monitoring program was developed to confirm that the $100m^3/s$ base flow established for the Ruskin Dam to meet the needs of anadromous fish for spawning is also adequate for rearing resident fish species in the Lower Stave River. The monitoring program was contracted to Seyem' Qwantlen Business Group (SQBG), a business owned by Kwantlen First Nation. SQBG also provided field technicians to assist in the 2015 fish sampling program described in this report.

The key management question to be answered was as follows:

> *Do (Stave Falls Water Use Plan) operations based on anadromous salmonid rearing and spawning criteria conflict with the seasonal habitat use patterns of other resident fish species?*

The means to answer this question was to conduct fieldwork to determine:

a. *If the hydraulic and habitat capacities observed in the summer are suitable for resident rearing using habitat suitability collected during the study; and*
b. *If the attributes of winter flow regimes (average/peak flows, flow variation/consistency) represent limiting factors for overwintering survival using past reports from the SFL MON study and inferring the potential for any critical factors identified to impact overwintering survival; or*
c. *If there are other environmental or Fraser River (tidal/freshet) factors that may represent limiting factors for overall rearing in the Lower Stave River using existing literature, Lower Fraser flow records, and environmental data to infer any potential issues that may impact the productivity of rearing resident fish in the Lower Stave River.*

The present document contains the results and analysis of data collected in October 2015 that attempted to answer these questions. This report represents the final year of a three-year study (previous field program reports were prepared and submitted by LGL Limited on behalf of SQBG).

Real-world productivity was to be tested against two metrics of ideal habitat suitability and productivity:

- Fish Per Unit Area (FPU), or density, as described in work by Ptolemy (1993) which uses water chemistry as a means to determine the maximum carrying capacity of a body of water for fish. Numbers of fish captured during field surveys can be compared against a theoretical maximum (FPU) to determine if a body of water supports as many fish as theoretically possible.

- Weighted Useable Area (WUA), as described by Bovee and Cochnauer (1977), which uses measured physical parameters (water velocity, depth, and substrate type) to determine the suitability of habitat compared to a reference standard. Measurements of physical parameters taken in the field can identify how much suitable habitat is available in a given area.

With respect to question (a), above, it appears possible that summer flows established for anadromous fish are also suitable for resident species, but a number of confounding factors limit the confidence with which this statement can be made.

These confounding factors are as follows:

1. Backpack electrofishing, while stipulated as the method for fish sampling in 2015 because it is ideal for controlling fixed sampling areas, and other methods used in earlier seasons were ineffective, turned out to be poorly suited to use in the Lower Stave River for this type of study. As a result, low numbers of fish were captured, affecting the significance of results.

   Results suggest a much higher theoretical density as measured by FPU than the (extremely low, 0.0 to 8.5 FPU) number of resident fish collected in the main channel of the Lower Stave River. Lower than predicted densities suggest a limiting factor to productivity. It is not possible, however, to conclude with certainty that this lower-than-predicted productivity is related to the hydraulic regime. An alternate explanation may be that disturbances associated with setting up electrofishing pens, coupled with the absence of refuge features in the morphologically uniform Lower Stave River, caused fish to flee before they could be sampled.

   Further, the presence of Pink Salmon and Chum Salmon spawners, coupled with the presence of the public fishing for spawners, led to challenges in finding suitable sampling locations that could be safely electrofished, limiting sampling opportunities.

2. WUA is a meaningful metric only in the event that flow is constant between sites and set at the flow being queried for management purposes, in this case 100m^3/s.

   BC Hydro was not able to maintain a discharge rate from the Ruskin Dam of 100m^3/s during the sampling period. On three of the sampling days, discharges were upwards of 150% of targeted flow; on the final day of sampling, flows were less than 70% of the flow targeted for study. Nine of the 11 study sites were sampled during the first 3 days, while the remaining 2 sites were sampled on the last, lower flow, day.

   This is significant because velocity is a key determinant of WUA, and velocity in a watercourse is influenced by flow. It is possible to say that, at flows above the WUP-stipulated minimum, suitable habitat for resident species exists at the nine sites sampled on days of high discharge. It is also possible to say that, at flows below the same WUP-stipulated minimum, the two sites sampled on a day with lower flows have little suitable habitat present. It is not possible, however, in the absence of constant flow specific to the WUP-stipulated rate of 100m^3/s, to make a statement about the useable habitat associated with the WUP-stipulated rate. Furthermore, WUA was calculated for only a small portion of the Lower Stave River. While efforts were made to sample in a variety of habitat types, the available data do not permit a conclusion of habitat suitability for the entire Lower Stave River to be made.

3. Habitat requirements of each of the four target species (Rainbow Trout, Cutthroat Trout, Brassy Minnow, and Mountain Whitefish) vary, not only between species, but also between life stages. A broad determination of habitat suitability for rearing resident fish is not possible. While some species at a particular life stage may find suitable habitat conditions in the Mainstem Lower Stave River, other species and life stages may find the side channel is better suited to their

needs. The side channel appears to offer a range of habitat conditions that could meet the needs of many species.

With respect to questions (b) or (c), <u>It is less clear that existing winter regimes are suitable for overwintering</u>.

Field studies were not collected in the winter and literature on flow rates or other factors that may limit overwintering survival is scarce and inconclusive.

Management Recommendations

In order to increase confidence in these findings, a number of additional studies are suggested, as follows:

1. <u>Conducting additional fish sampling and habitat measurements to answer the same management question using different sampling methods at varying flows (to answer questions (b) or (c)).</u> Minnow trapping, beach seining, boat electrofishing and bottom-trawl jetboat sampling, are more appropriate to sampling in the morphologically uniform Lower Stave River where refugia are sparse. Several of these methods have also been recommended by Glova *et al*. (2011) and Glova and Robichaud (2014), and will provide information about relative abundance and presence/absence. Fish sampling relative abundance results can validate WUA calculations for resident species in the Lower Stave River for varying flows, as long as sampling sites remain consistent from season to season. This study should include the following additional recommendations:

    a. Additional Transects: Habitat assessment transects were useful in determining habitat suitability for some of the target species. These transects could be repeated at additional sites at varying flow conditions;

    b. No further Brassy Minnow study: It is likely that Brassy Minnow may not even exist below the Ruskin Dam on the Lower Stave River, and should not be included in further resident fish monitoring programs;

    c. Controlled flow conditions during study**:** Sampling should be conducted at constant flow conditions, and repetition of sites is encouraged within the same season. Additionally, repetition of sites used in the 2015 study is also recommended for ease of comparison;

    d. Scale sampling for age analysis: If ageing of fish is important (for FPU or WUA calculations), it is recommended that scale samples be taken from captured juvenile salmonids. Therefore, any discrepancy between size classes can be confirmed with ageing data;

    e. Even-numbered year sampling: Sampling should be conducted in an even-numbered year, to avoid the confounding presence of Pink Salmon spawners; and

    f. In-lab Alkalinity analysis: Lab analysis of alkalinity may be a good backup method to confirm *in situ* testing results, especially if using a drop titration method test kit.

    This study would show how habitat suitability for resident fish species changes based on water depth and velocity depending on flow in the Lower Stave River. This study could also help identify optimal flow for any one of the four target resident fish species, enabling more targeted management. Finally, data collected as part of this study could also usefully be compared to data collected from the study identified in recommendation #2, below.

2. Establishing a sampling program that compares Lower Stave River WUA with WUA in a similar system. The Pitt River is an ideal system for comparison and while reconnaissance to select appropriate sampling locations will require some time, a comparison will allow conclusions about flow rate suitability for resident species to be made with greater certainty. For a comparison study of this nature to yield meaningful results, flow from the Ruskin Dam will need to be maintained at or very near the WUP target flow of 100m^3/s. Fish sampling to compare relative abundance between systems may also be considered.

This Executive Summary is subject to the same standard limitations as contained in the report and must be read in conjunction with the entire report.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

In text

LIST OF APPENDICES

List of Acronyms

ALK	-	Alkalinity
BPU	-	biomass per unit
CPSF	-	Critical Period Stream Flow
EF	-	Electrofishing
FIDQ	-	Fish Inventory Data Query
FL	-	Fork Length
FPU	-	Measurement of fish density, calculated as fish numbers per $100m^2$ unit
HSI	-	Habitat Suitability Index
MAC	-	Monitoring Advisory Committee
MAD	-	mean annual discharge
MOE	-	BC Ministry of Environment
MT	-	Minnow Trapping
NPRF	-	non-power release flow
PGL	-	PGL Environmental Consultants
SE	-	standard error
SFL WUP	-	Stave River Water Use Plan
SQBG	-	Seyem' Qwantlen Business Group
TBF	-	turbine flow
TL	-	Total Length
TOR	-	terms of reference
WUA	-	Weighted Usable Area

1.0 INTRODUCTION

1.1 Background

The Lower Stave River is located in Mission, BC. BC Hydro, a Provincial Crown corporation and electric utility providing the majority of electrical power to BC residents, operates two hydroelectric dams on the Stave River: the Stave Falls Generating Station and the Ruskin Generating Station. These two generating stations provide 196MW of power combined. The Stave Falls Generating Station was built in 1911, with a replacement powerhouse constructed in 2000. The Ruskin Generating Station was built in 1930 and is currently undergoing seismic upgrades.

A Stave River Water Use Plan (SFL WUP) was developed in 1999 to ensure a water release regime favourable to anadromous salmon activity. That WUP established base flows from the Ruskin Dam for anadromous spawning at 100m^3/s.

In 2005, BC Hydro developed a Terms of Reference (TOR) for a monitoring program entitled "Seasonal Timing and Assemblage of Resident Fish" that was intended to determine if the flows established for anadromous fish species in 1999 were, in fact, also appropriate for resident fish species using the Lower Stave River.

Subsequent to the development of the TOR, the SFL WUP Monitoring Advisory Committee identified a data gap in the monitoring program: seasonal use of the Stave River by resident (non-anadromous) fish below Ruskin Dam had not been assessed, nor was there information on whether operational changes described in the SFL WUP had any potential impacts on resident fish. Monitoring Advisory Committee noted the importance of ensuring that conditions established for anadromous fish did not adversely impact resident fish species. Of specific concern were potential effects on four target species: Rainbow Trout (*Oncorhynchus mykiss*), Cutthroat Trout (*Oncorhynchus clarkii*), Mountain Whitefish (*Prosopium williamsoni*), and Brassy Minnow (*Hybognathus hankinsoni*). The Committee therefore issued TOR Addenda for studies that might address this gap.

Initial field programs and reports for these TOR Addenda were prepared and provided by LGL Limited on behalf of Kwantlen First Nation. In 2015, BC Hydro retained Seyem' Qwantlen Business Group (SQBG) to complete the final year of study. This report represents the final report of all three years of fieldwork.

1.2 Management Questions and Hypothesis

The key management question from the 2005 TOR was:

> *Do (Stave Falls Water Use Plan) operations based on anadromous salmonid rearing and spawning criteria conflict with the seasonal habitat use patterns of other resident fish species?*

In order to address this management question, Addendum 3 (BC Hydro, 2014) was developed, detailing a study design to address the management question for resident fish. The following impact hypothesis was developed:

> *H01: Releases downstream of Ruskin dam do not impact the seasonal habitat-use patterns of resident fish species, particularly non-salmonid species.*

To test this hypothesis, the Lower Stave River was to be compared to reference streams to determine:

a. *If the hydraulic and habitat capacities observed in the summer are suitable for resident rearing using habitat suitability collected during the study;*

b. *If the attributes of winter flow regimes (average/peak flows, flow variation/consistency) represent limiting factors for overwintering survival using past reports from the SFL MON study and inferring the potential for any critical factors identified to impact overwintering survival; or*

c. *If there are other environmental or Fraser River (tidal/freshet) factors that may represent limiting factors for overall rearing in the Lower Stave River using existing literature, Lower Fraser flow records, and environmental data to infer any potential issues that may impact the productivity of rearing resident fish in the Lower Stave River.*

2.0 METHODS

This section provides a summery of desktop work completed and describes the study area, field studies conducted, and data analysis methods used.

2.1 Literature Review

A literature review was conducted by searching available sources. These sources included:

- Previous WUP reports for the Lower Stave River (2011 and 2014, prepared by LGL);
- The Cross-Linked Information Resources database (Ministry of Environment [MOE]) which includes Ecological Reports Catalogue, BC Species and Ecosystems Explorer, Biodiversity/Environmental Information Resources e-Library, and others;
- Google ™ Scholar search;
- American Fisheries Society online journal search (available to members only); and
- University of British Columbia Alumni Online Journals Access (available to members only).

Key words and phrases used in searches included “weighted useable area”, “fish per unit”, “Fraser River”, “Stave River”, “Pitt River”, “habitat suitability”, in addition to species names.

2.2 Study Area

Fish sampling sites were selected in the same 1.5km section of the Lower Stave River as used in previous study years (2010/2011 LGL study [Glova *et al*., 2011]). Sites were selected to include various habitat types, including riffles, runs, and pools. Sampling occurred at 11 sites in 4 mainstem reaches (or River Segments, as described in previous studies) and 1 side channel, as per the LGL the "*Lower Stave River Resident Fish Monitor, 2014 Revised Field Approach 1*" designed by LGL for the 2014 field season. The study area, sampling sites and reaches are shown in Figure 1.

It was expected that flows from the Ruskin Dam could be maintained at 100m^3/s for the duration of the study; however, operational demands and weather forecasts prevented the Ruskin Dam operators from adhering to this request. Flows during the study ranged between 69m^3/s and 175m^3/s.

The Lower Stave River between Ruskin Dam and the Fraser River is tidally influenced, due to the tidal bore on the Fraser River that extends upstream to Mission. Daily tidal fluctuations in combination with varying flows from the Ruskin Dam had to be considered during site selection for sampling sites. Sites were positioned within the same four mainstem segment reaches and side channel as described in the previous studies (Glova *et al*., 2011; and Glova and Robichaud, 2014), thus were sufficiently similar to support meaningful inter-year comparison. Additional considerations for spawning salmon and public fisherpersons were also required. In addition, the mainstem channel of the Lower Stave River was found to be uniform in nature. These combined hazards and site characteristics limited the availability of sampling locations, resulting in field-fit modified sampling procedures, as described in the sub-sections below.

The Lower Stave River is a fifth-order (Strahler number) stream and has a gross drainage area, or watershed area, or 1,140km^2 at the Stave Falls dam. The mean annual discharge (MAD) of the Lower Stave River downstream and below the Ruskin Dam is 111m^3/s. The summer base flow of the Lower Stave River is >100% of the MAD, indicating high summer base flows.

2.3 Field Program

The field program took place between October 6 13, 2015. October 7, 2015 was used as a reconnaissance day, with field sampling taking place October 7 to 9 and 13, 2015. BC Hydro provided a boat and access to the Ruskin Dam boat launch, which was closed to the public at the time of sampling. The field program was led by PGL Environmental Consultants (PGL) biologist, Katharine Scotton. SQBG field technicians Joey Antone and Josh Antone assisted in the collection of fish and habitat data. Joey Antone, with Small Vessel Operator Proficiency training, operated the boat loaned by BC Hydro. Josh Antone, with field crew backpack electrofishing certification, assisted in electrofishing. Additional field assistance was provided by Candace Rose-Taylor of Cascade Environmental Resource Group Ltd.

2.3.1 Fish Sampling

LGL (Glova, *et al*,,2011) identified late-September as an ideal time for resident fish sampling for the following reasons:

- It avoids the Fraser River freshet period;
- The fry of several resident fish species have emerged by end of September; and
- Chum Salmon (*Oncorhynchus keta*) spawners will not yet be in the river.

Federal and provincial fish collection permits were obtained prior to sampling:

- Fisheries and Oceans Canada Permit: XR 343 2015 Valid October 5 to 14, 2015; and
- MOE Permit: SU15-177508 Valid August 11, 2015 to March 31, 2016.

DFO was also contacted and notified of the sampling works, per the directions of BC Hydro.

Fish sampling was delayed due to start-up logistics and early-October was identified by the BC Hydro team (Darin Nishi and Brent Wilson) as a reasonable alternative option for sampling.

Similarly, the project was originally scheduled to occur in 2014 but delays pushed sampling to 2015 – a Pink Salmon (*Oncorhynchus gorbuscha*) return year. As a result, a clear window between Pink and Chum spawning was unlikely.

Sampling occurred on October 7 to 9 and 13, 2015 (with October 6 used as a reconnaissance day); both Pink and Chum Salmon spawners were found to be present in and around the project site.

It was expected that only electrofishing (EF) sampling would be conducted for consistency. Due to the presence of spawning salmon, especially within the side channel, some sampling was conducted with Gee-type minnow traps (MT). Five sites were sampled by EF, four sites by MT, and two sites were sampled with both EF and MT. MT sampling was used in areas where EF was considered possibly harmful to spawning salmon, or conditions were not ideal for EF, such as water depth or flow. Using a combination of fish techniques allowed for sampling of a wider variety of habitat types.

EF sampling was conducted using a closed-site three-pass EF method (Anon, 1995), as recommended in the LGL *Field Approach* (2014). Sites were enclosed with ¼" mesh stop nets, anchored into the substrate using rebar and zip ties. Fish were collected during each pass, and were kept in recovery buckets until all sampling at the site was complete. MT sampling was carried out with eight traps at each site; each trap baited with salmon roe. Traps were left to soak overnight, between 19 and 25 hours to encompass crepuscular feeding activity and a full tidal cycle. Captured fish were placed in a recovery bucket until all traps were pulled and checked, at which point the captured fish were then processed.

Each captured fish was identified to the species level, where possible, using McPhail and Carveth (1993) *Field key to the freshwater fishes of British Columbia*. Fish were measured for fork length (or total length in the case of sculpin [*Cottidae* spp.] captures) in mm (in increments of 1mm) and weighed in g (in increments of 0.1g). All native captured species were released back to the site at the completion of electrofishing or minnow trapping. All non-native fish species captured (Pumpkinseed Sunfish [*Lempomis gibbosus*]) were humanely euthanized, as per the MOE fish collection permit requirements.

2.3.2 Water Quality

In situ water quality measurements were collected at each of the 11 sampling sites. Water quality parameters collected included: temperature (°C), pH, specific conductivity (μS/cm), dissolved oxygen (%), dissolved oxygen (mg) and alkalinity (mg/L $CaCO_3$). All measurements except for alkalinity were measured using a YSI Professional Plus multi-meter, rented from Hoskin Scientific. Hoskin Scientific maintains equipment and calibrates all rental units prior to delivery. Alkalinity was measured using a Hach AL-AP test kit that uses a drop count titration method to determine alkalinity.

2.3.3 Habitat Assessments

Water velocity and depth transects were conducted at each survey site. Measuring tape or rope with 0.5m markers was attached to rebar and arranged perpendicular to the shoreline. Transects extended into the water as far as was safely possible, with the goal of 10m in length where possible. One to three transects were conducted at each survey site depending on the complexity of the site. Due to time constraints, only one transect was conducted at sites where the habitat was found to be uniform.

At each transect, water velocity (at 0.6 depth), water depth, and substrates were recorded every 0.5m. Water velocity was measured using a Swoffer Model 2100. The dominant substrate type was classified as one of: clay; silt; sand; coarse sand; small gravel; large gravel; small cobble; large cobble; or, boulder. Mixed gravel and mixed cobble were also described when small and large gravel or cobble, respectively, were present together. One to three substrate classes were identified and recorded at each station.

Transects varied in total length, based on each site's conditions. Where possible, measurements spanned the entire channel, such as Sites 3 and 5 and transect 2 at Site 6. Depth, velocity and distance precluded the ability to measure across the entire channel for the remainder of the sites and transects safely.

Substrate classification was derived from the Wentworth Grain Size Class system, and modified for field use as follows:

Class	Diameter (mm)
Clay	<0.002
Silt	0.002 to 0.0625
Sand	0.0625 to 0.5
Coarse Sand	0.5 to 2.0
Small Gravel	2.0 to 15.0
Large Gravel	15.0 to 4.0
Small Cobble	4.0 to 64.0
Large Cobble	64.0 to 256.0
Boulder	>256.0

Habitat and channel types were categorized based on definitions provided in Rempel, 2004. Rempel's study aimed to identify physically distinct habitat types and channel types frequently found in rivers with large gravel bars and islands, such as the lower Fraser River. The habitat types may be characterized by velocity, depth and substrate characteristics based on 100m^2 units. Habitat types identified during the 2015 Stave River field work, using Rempel's definitions, were as follows in Table A.

Table A: Rempel, 2004 habitat and channel types for rivers with large gravel bars.

Habitat Type	Definition
Riffle	High-gradient area of shallow, fast water flowing over well-sorted substrate. The flow is rough. Common at bar heads.
Bar Edge	Any length of bar edge not occurring at the head or tail of a bar that is oriented parallel to the flow and subject to constant and consistent flow forces. Bank slope is variable and a range of velocities and substrate types is possible.
Bar Tail	Downstream end of a gravel bar, usually with moderate flow velocity. Surface substrate consists of gravels and occasionally sand.

Habitat Type	Definition
Open Nook	Shallow indentation along a bar edge of reduced velocity and variable substrate that is openly connected to the channel with no sedimentary barrier (unlike channel nook). An ephemeral habitat that may disappear with a relatively small change in water level.
Channel Nook	Dead-end channel or narrow embayment of standing water. Substrate is usually sand/silt and embedded gravel.
Cut Bank	Eroding bank of fine sediment that is steeply sloped or vertical. Dense riparian vegetation is often present. Large woody debris is common and flow is variable.
Channel Type	
Main	Channel conveys flow year-round and includes the thalweg. Bed material consists mostly of clean gravels with a low proportion of fine sediment.
Side	Channel conveys flow during freshet but may have little or no flow during winter. Wetted habitats at the lower end of the channel persist year-round. Bed material contains a low to moderate amount of fine sediment at the upstream end, and moderate to high amount at the downstream end.
Summer	Channel is seasonally inundated during freshet only and often intersects diagonally across bar tops. Bed material contains a high proportion of fine sediment.

Note: Summer channels, as described by Rempel, have been used in this study to represent tidal channels that are inundated during high tides, but can be dry during low tides.

2.4 Flow Data

Daily and hourly discharge data for Ruskin Dam was provided by BC Hydro. Hourly discharge was requested for the dates of October 6 to 13, 2015. Daily discharge was requested for all of 2015. MAD for Ruskin Dam was provided by Darin Nishi of BC Hydro.

Discharge for several locations on the Lower Fraser River were also obtained from the Government of Canada's Wateroffice (2016). Data for 2015 at Mission (station 08MH024), Whonnock (08MH044), and the Port Mann Pumping Station (08MH126) on the Fraser River, and the Pitt River near Port Coquitlam (08MH035) were compared.

2.5 Data Analysis

2.5.1 Fish Sampling

Zippin's method for estimating total population in a closed three-pass removal system (Zippin, 1958) was applied to Prickly Sculpin captures for EF sites. However, with low catch numbers, and catches that did not consistently decrease with each pass, Zippin's method did not return reliable numbers for total population in each enclosure. Sites with the most captures (Site 3 and Site 4) were populated with primarily very small, young-of-year sculpins, which were difficult to see and capture. Therefore, actual catch numbers were used to describe fish habitat and population conditions. Summary statistics were calculated for the Prickly Sculpin (*Cottus asper*) catch data, including standard error (SE), and mean, minimum, and maximum values.

2.5.2 Density

Relative fish density for each EF site was calculated using methods described in Ptolemy, 1993. Field measurements were compared with theoretical measurements of productive capacity using relationships between alkalinity and fish density/biomass.

Fish density measurements are specific to size classes for fish. This may be based on weight or length. The purpose of this is to separate age class cohorts using size (weight and length). The selected size classes are also specific to each species. Therefore, each species that was investigated for density, or Fish Per Unit (FPU), required a separate size class table. These tables are described and evidence is given for the classes in the following sections for Prickly Sculpin, Rainbow Trout, and Coastal Cutthroat Trout.

Estimates of observed fish density were calculated as fish numbers per 100m2 unit (FPU) for all EF sites using the following formula:

$$FPU_{site,size} = 100 \times \frac{n}{area\ of\ enclosure}$$

where *n* is the number of fish captured in each enclosure.

Ptolemy (1993) investigated the use of various models for estimating the maximum fish density of watercourses. The models suggested an inverse relationship between maximum fish density and fish size (by weight in g). Alkalinity (ALK) is used in the relationship to account for differences in nutrient availability. For the purposes of this report we have calculated theoretical fish density using the following formula from Ptolemy:

$$FPU_{general} = 36.3 \times ALK^{0.5} \times SIZE_g^{-1}$$

Additionally, fish density was also calculated using mean size by fork length (FL) in cm. This model assumes a nominal condition coefficient of k = 1.00. The equation is as follows:

$$FPU_{general} = 3300 \times ALK^{0.5} \times SIZE_{fl}^{-3}$$

Where size by weight or fork length was used in calculations, the mean weight or length of total captured fish in the study (for Prickly Sculpin) was used for size classes where fish were represented. If no captured fish were available for a size class, the median value of the size class was used in the calculation to show theoretical maximum density.

In addition to FPU, biomass per unit (BPU) can also be calculated, which is the amount of fish by weight (g) per unit ($100m^2$). BPU is calculated as follows:

$$BPU_{site,size} = Mean\ Weight_{site,g} \times FPU_{site,size}$$

BPU can be calculated for both observed FPU and theoretical maximum FPU. Mean weight for each size class by site is used to calculate the BPU.

In general, FPU calculations should be conducted during Critical Period Streamflow (CPSF), which is the month of lowest flow during the growing season, typically between August and September.

2.5.3 Weighted Useable Area and Habitat Assessments

Weighted usable area (WUA) was defined by Bovee and Cochnauer (1977) as follows:

> *"The weighted usable area is defined as the total surface area having a certain combination of hydraulic conditions, multiplied by the composite probability of use for that combination of conditions. This calculation is applied to each cell within the multidimensional matric. This procedure roughly equates to an area of marginal habitat to an equivalent area of optimal habitat."*

The collected velocity and depth data was used in the Bech *et al*. (1994) BC MOE Flow Master spreadsheet provided by BC Hydro (updated February 2010) to calculate the percent adjusted useable areas and Habitat Suitability Index (HSI) curves for Rainbow Trout and Coastal Cutthroat Trout. HSI calculators were not available for the other resident species of fish. The percent adjusted useable areas were then tabled with habitat length and mean width data for each site. Calculated theoretical FPU values, based on Ptolemy (1993) were then applied to determine rearing capacity for Rainbow Trout and Coastal Cutthroat Trout fry and parr, which is equivalent to WUA.

Mean habitat width was based on the measured length of the habitat (velocity and depth) transects, as this data was directly used in determining the percent adjusted useable area for each site. Where more than one transect was taken, the mean widths of the transects were used. Habitat lengths were determined by a combination of viewing each site in Google earth Pro™ and measuring the length of the site-specific habitat type (based on Rempel, 2004) in the field. The combination of methods was required because of the large distances between reaches and the feasibility of measuring the lengths in the field with a boat. The use of Google earth Pro™ to measure distances was not precise but the imprecision was measured in metres and was not sufficient over the length of the project to compromise statistical calculations.

The width of habitat assessment transects for depth and velocity were dependent on the site conditions. Transects could only be conducted where conditions were safe for field crew to work. As such, not all transects were conducted across the entire channel width at each site. Therefore, the measurements of useable area and rearing capacity are only for the portions of channel that were measured.

2.5.3.1 Habitat Suitability Curves

HSI curves (also referred to as habitat suitability criteria, or HSC) are relationships between habitat characteristics (water depth and velocity) and an independent variable (between 0.0 and 1.0), at a specific life history stage for a particular species. These relationships indicate the suitability of the habitat (0.0 being low suitability and 1.0 being high suitability) based on the measured habitat characteristics.

HSI curves for Rainbow Trout and Coastal Cutthroat trout (*Oncorhynchus clarkii clarkii*) fry and parr were graphed using the Bech *et al*. (1994) BC MOE Flow Master spreadsheet provided by BC Hydro (updated February 2010), including Ptolemy WUP HSI curves developed in February 2001. Stream depth and velocity measurements for each transect at each site were entered into the Bech spreadsheet and were plotted with the HSI curves for each species and life stage.

Additional HSI curves were obtained from Rempel *et al*. (2012) for juvenile Rainbow Trout and Mountain Whitefish. These curves are based on lower Fraser River habitat and channel types, which provide the most suitable models to compare Lower Stave River data to. These graphs are shown in the following sections. Additional habitat suitability models from other sources described below were used to compare Lower Stave River data where applicable. Some of the models were more qualitative than quantitative, but were suitable where calculable models did not exist.

2.5.4 Calculation of Uncertainty

Standard error for fish captures (Prickly Sculpin) was calculated for each age class (0+ and 2+). No other calculations of uncertainty were used, as the limited fish capture data meant that only Prickly Sculpin data was analysed. The standard error calculations are presented in Section 3.2 (Fish Captures).

3.0 RESULTS

This section describes study results. It is divided into two sections: results of work completed from 2010 to 2014 by previous consultants (Section 3.1), and by PGL and SQBG (Section 3.2).

3.1 Previous Studies

3.1.1 Lower Stave River Water Use Plan Fish Monitor Reports

Lower Stave River WUP resident fish monitoring was conducted in 2010/2011 and in 2013 (Glova *et al*., 2011; and Glova and Robichaud, 2014, respectively) by LGL and Kwantlen First Nation. The monitoring programs included a variety of fish sampling methods and flow monitoring in the Lower Stave River between Ruskin Dam and the Fraser River. Four mainstem segments were identified as target reaches, in addition to one side channel on river left.

3.1.1.1 2010/2011 Fish Monitor Report

Eight sampling sessions occurred between March 2010 and March 2011. A variety of fishing gear types were used, including beach seine, minnow trap, electrofishing, gill net and snorkelling. Ten different species (or species groups, as not all fish were identified to species) of fish (plus crayfish) were captured throughout the sampling program. These fish included *Cottidae* spp., *Catostomidae* spp., Peamouth Chub (*Mylocheilus caurinus*), Northern Pikeminnow (*Ptychocheilus oregonensis*), Leopard Dace (*Rhinichthys falcatus*), Redside Shiner, Three-spined Stickleback (*Gasterosteus aculeatus*), Rainbow Trout, Cutthroat Trout, and Mountain Whitefish. Only results from Cottidae, Peamouth Chub, Northern Pikeminnow, Three-spined Stickleback, and Rainbow Trout were included in beach seine analyses. For minnow trap analyses, only Cottidae, Peamouth Chub, Northern Pikeminnow, and Three-spined Stickleback were included. All other captures were excluded from analyses due to low catch-rate.

The 2010/2011 Fish Monitor report (Glova *et al*., 2011) concluded that river segment had no significant effect on beach seine results. However, the effect of month was found to be significant to the beach seine capture rates for several species, including Peamouth Chub fry and adults, Northern Pikeminnow adults, and Three-spined stickleback, dependent on what river segment the captures were made in. Minnow trapping was also significantly effected by month for Peamouth Chub in the side channel.

Flows during the survey ranged between 50-275m^3/s. However, the effect of flow could not be distinguished from the effect of month on fish presence. Specifically, August was found to have the lowest flows at 50m^3/s, which also resulted in the highest capture rates for Northern Pikeminnow adults (only captured in August), Three-spined stickleback, and Peamouth Chub fry. With limited data, it was not possible to determine whether the capture rates were related to seasonal movements, catchability or flow.

Overall, the 2010/2011 Fish Monitor Report (Glova *et al*., 2011), indicated that relative flow showed significant effects on two fish species, Northern Pikeminnow adults in River Segments 1-4 (mainstem), and Three-spine Stickleback in River Segment 5 (side channel). "Study-design artefacts" were considered as the source of uncertainty in the results. Additionally, beach seining in the mainstem and minnow trapping in the side channel were the only methods that provided enough data to analyze, or that could be used as baseline data for additional studies.

The recommendations made by Glova *et al*. (2011) for future sampling programs were:

- Use of a bottom-trawl jetboat in high flow conditions;
- Additional low flow sampling in months other than August;
- Sampling during controlled releases in September at 75, 100 and 125m^3/s; and
- Limiting sampling to beach seining in the main channel and minnow trapping in the side channel.

3.1.1.2 2013 Fish Monitor Report

LGL and Kwantlen First Nation conducted two fish sampling programs in September and October 2013 (Glova and Robichaud, 2014). The study area was consistent with sampling conducted in 2010/2011. Beach seining was the sampling method employed in the mainstem (River Segments 1-4), and minnow trapping was employed in the side channel (River Segment 5). Flows were regulated at 125m^3/s during the first survey, September 18-19, and at 175m^3/s during the second survey, October 3-4. While flow was maintained during the two weeks prior to the 125m^3/s survey in September, the flows had peaked as high as 275m^3/s in the days leading up to the 175m^3/s October survey. This peak in flow may have had an impact on the fish distributions that were sampled in October.

Eight fish species (or species groups) were captured during the 2013 study. These fish included *Catostomidae* spp., *Cottidae* spp., Peamouth Chub, Northern Pikeminnow, Leopard Dace, Redside Shiner, Three-spined Stickleback, Cutthroat Trout, Rainbow Trout, and Mountain Whitefish (Glova and Robichaud, 2014). Crayfish were also captured. Within the mainstem, Peamouth Chub fry, Three-spined Stickleback and cottid fry were the most frequently captured fish during the 125m^3/s flow rate. At 175m^3/s, total catch was significantly lower overall. Obvious decreases in catch between the high flow and low flow events in the mainstem were noted for Peamouth Chub fry, Rainbow Trout fry, and cottid fry and Three-spined Stickleback. Within the side channel, only cottid adults (and crayfish) were captured, with a marked increase in captures at the higher flow event (175m^3/s).

Similar to the 2010/2011 survey results, Peamouth Chub and Three-spined Stickleback both had significant decreases in catch rate during lower flows in the mainstem. Additionally, during the 2013 study, Rainbow trout fry and cottids were also caught more frequently during the low flow event (125m^3/s) in the mainstem. While a decrease in sampling gear efficiency at higher flows cannot be discounted, the difference in catch rate may also be the response of resident fish to changes in flow. Resident fish observed at higher frequencies at lower flows in the mainstem may have moved to lower velocity sites such as channel margins and interstitial spaces for shelter. The higher catch rate of cottids in the side channel supports this argument, as the water velocity in the side channel is more moderated than the mainstem.

The recommendations made by Glova and Robichaud (2014) for future sampling programs was:

- Including key habitat parameters in the data collection, such as water depth, water velocity and substrates.

3.2 2015 Study

This section describes the results of the research completed in 2015.

3.2.1 Desktop Research

This section describes the desktop research completed in support of the 2015 work program.

3.2.1.1 Captured Species and Target Species

Six groups of species captured or targeted in the 2015 study are discussed below.

3.2.1.1.1 Prickly Sculpin and Coastrange Sculpin

Coastrange Sculpin (*Cottus aleuticus*) spawning takes place upstream but young-of-year swim to the surface and are swept downstream to intertidal areas. Numerous young-of-year are found in intertidal areas until mid-summer when they reach about 20 to 30mm in length, at which point the young-of-year migrate back upstream.

Prickly Sculpin may spawn in freshwater or in brackish intertidal water. Those fish hatched in upstream freshwater streams are also swept downstream and maintain a similar upstream migration in mid-summer as the Coastrange Sculpin (McLarney, 1968).

Prickly Sculpin have been shown to reach a total length (TL) between 30 and 40mm over their first summer by September (McPhail, 2007). By the end of the second growing season Prickly Sculpin reach 50 to 60mm TL. Adults are typically larger than 200mm TL and reach maturity in two or three years (McPhail, 2007).

Coastrange Sculpin reach a TL an average of 25mm by September of their first year and 40 to 50mm TL by the end of their second growing season (Mason and Machidori, 1976 and Ringstad, 1974, as referenced in McPhail, 2007). Based on these findings, we have defined the size classes to represent Prickly Sculpin young-of-year (0+), yearlings (1+), and older individuals (2+ and greater) as this was the most frequently caught species in the EF sites. The split between Class 3 and Class 4 was chosen arbitrarily to separate the data to represent 2+ and mature adults, respectively. Weight class divisions were chosen based on the measured weights of captured fish, based on their length.

Four size classes were chosen for Prickly Sculpin fish density measurements. These size classes were:

Parameter	Class 1 (0+)	Class 2 (1+)	Class 3 (2+)	Class 4 (3+)
Length (cm)	0 - 4.0	4.1 – 6.0	6.1 - 10.0	10.1 - 14.0
Weight (g)	0 - 0.5	0.6 – 2.2	2.3 - 11.5	11.6 - 26.1

3.2.1.1.2 Peamouth and Northern Pikeminnow

Peamouth (formerly Peamouth Chub) reach between 35 and 60mm fork length (FL) by the end of the first growing season, reaching maturity at age 2+ and 3+ for males and females, respectively (McPhail, 2007). Northern Pikeminnow reach between 35 and 65mm FL in their first growing season. Northern Pikeminnow mature by age 4 or 5 for males, and by age 5 or 6 for females (McPhail, 2007). As captures of Peamouth and Northern Pikeminnow were rare, and on the small side representing young-of-year, separate size class tables were not created.

3.2.1.1.3 Rainbow Trout/Steelhead

Predictive models developed by Ptolemy (2013) have shown that Steelhead (*Oncorhynchus mykiss*) dominate third-order and higher-order streams. Coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*) dominate first- and second order streams, and are present at moderate levels in third-order streams. This information is relevant, as the Stave River is a fifth-order stream, therefore, it is expected that Steelhead would be dominate in the Stave River. Additional stream characteristics including long-term MAD, watershed area × runoff and stream width are even more accurate predictive models of dominance by either Steelhead or Coastal Cutthroat Trout.

The determination of size classes for rearing Rainbow Trout/Steelhead is challenging, as available data appears to be stream specific. McPhail (2007) indicates that Rainbow Trout in southern British Columbia streams may grow up to 100mm in length by the end of their first growing season, or greater than 120mm by late fall. Data gathered from the Fish Inventory Data Queries (FIDQ) BC MOE site for the Stave River from mid-September 2005 was analysed to determine size classes, however, fish scale information was not available. Fish captures from 2005 ranged in size from 3.1g to 41.8g (plus one fish at 125.6g) in weight and 68mm to 155mm (plus one fish at 223mm) in FL (n=73). Fish stocking information for the Stave River did not indicate any stocking of fry for either 2004 or 2005. The only stocking of Steelhead in the Stave River for 2004 and 2005 was for smolts, with average weights ranging between 76.3g and 100.1g. Release dates for both years were in the spring (April to June) (FIDQ, 2016). The captured fish were unlikely to be stocked Steelhead, however, since fin clips were not reported.

PGL possesses fish scale aging data from 2013 and 2014 for Rainbow Trout from the Clowhom River (Sunshine Coast). This data has been used to assist in defining age class sizes for Rainbow Trout.

Age 0+ (fry) ranged in weight between 1.9g and 6.8g with FLs of 57mm to 88mm (n=4). Age 1+ (parr) ranged in weight between 6.2g and 21.6g, with FLs of 84mm to 133mm (n=18). Age 2+ Rainbow Trout ranged from 7.7g to 18.6g in weight and 98mm to 118mm in FL (n=6). The Clowhom River is a steep, fast, cold river, and growth rates are slow. All Rainbow Trout are resident (i.e., no Steelhead present). A 5+ fish was captured with a weight of 90.8g and a FL of 214mm.

Rainbow Trout WUA calculations for the Salmon River in Salmon Arm, British Columbia, relied upon mean weight data from Bison (1991), which were collected in September and October. The mean weight reported for Rainbow Trout fry was 1.62g (n=260) and for parr was 9.68g (n=46).

Based on the available information, determining age class by size is unreliable. As growth rates may vary based on habitat conditions, local data is preferred and should be cross-referenced with scale ageing.

For the purposes of defining size classes for FPU calculations, Rainbow Trout/Steelhead have been assigned to two size classes based on FL. Data from 2005 (FDIQ) and sampling in October 2015 for this project have been sorted into the two classes to determine mean weights and lengths, as follows:

Parameter	Class 1 (0+)	Class 2 (1+)
Length (cm)	0 – 9.9	10.0 – 20.0
Mean Length (cm)	8.59	11.84
Mean Weight (g)	7.2	17.8
n	57	24

Most available literature for WUA was for Steelhead, therefore, comparisons in this report often include Steelhead data where Rainbow Trout data was not available.

3.2.1.1.3.1 HSI Curves

Updated HSI curves were developed by Rempel *et al*. (2012) for juvenile Rainbow Trout based on lower Fraser River habitat and channel types, specifically focusing on gravel bars. Fraser River gravel bars are morphologically similar to the gravel bars and habitat observed in the Lower Stave River; however, water clarity is quite different. The Fraser River tends to be a fairly turbid river, while water in the Stave River at the time of sampling was found to be quite clear. The following HSI curves are for the Fraser River (Figures A and B), but are based on the Ptolemy WUP HSI curves from the Bech *et al.* (1994) updated Flow Master, and features the availability and usage of the habitat in relation to the HSI curve.

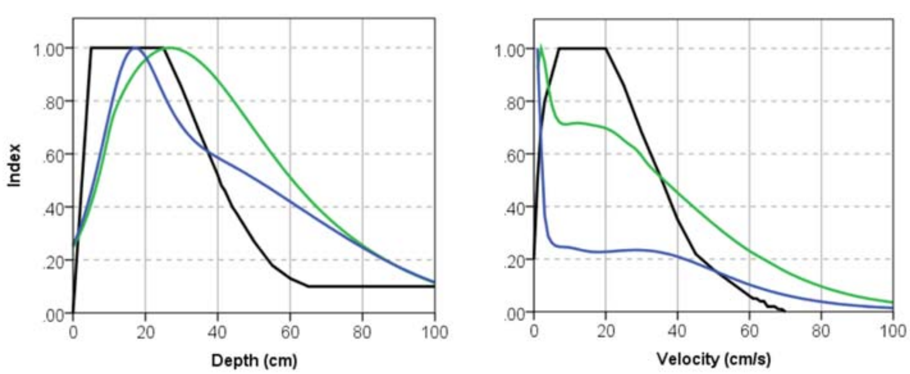

Figure A: Rainbow Trout 0+ HSI curves from Rempel *et al.*, 2012. Green lines represent availability, purple represents use in the Fraser River, and black is the Ptolemy WUP habitat suitability criteria.

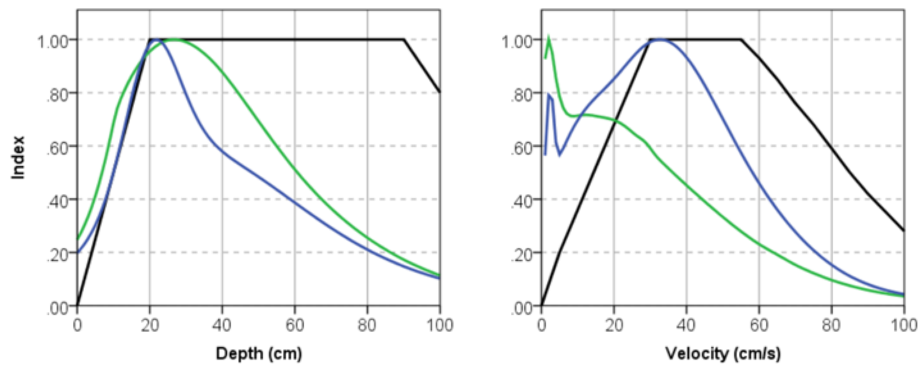

Figure B: Rainbow Trout 1+ HSI curves from Rempel *et al.*, 2012. Green lines represent availability, purple represents use in the Fraser River, and black is the Ptolemy WUP habitat suitability criteria.

From these curves we can determine that Rainbow Trout 0+ (fry) prefer shallow depth around 5 to 60cm, and slow water velocities of less than approximately 5cm/s (0.05m/s), despite the suitability curve suggesting habitat use up to approximately 40cm/s (0.4m/s) for 40% suitability. Rainbow Trout parr were found to use depths of 10 to 60cm, with use of deeper water less frequent than predicted by the model. Water velocity preference varied between 0 and 60cm/s (0.6m/s).

3.2.1.1.4 Cutthroat Trout

As discussed in a previous section, Ptolemy (2013) predicts Coastal Cutthroat Trout will not be the dominant species in the Stave River. Coastal Cutthroat Trout have been shown to dominate smaller streams, with mean wetted widths of less than 4.6m, long-term MAD less than $0.63m^3/s$ and watershed area x runoff less than $25,495km^2mm/year$. Based on these criteria, the Stave River, particularly in the reach below the Ruskin Dam, is not suited for Coastal Cutthroat Trout. In the 2010/2011 LGL survey of the Stave River (Glova *et al*., 2011), Coastal Cutthroat Trout were captured five times, and only in gill nets as adults. In comparison, 46 Rainbow Trout/Steelhead (of varying life stages) were captured using a variety of fishing gear during the same study.

Determining size classes by age for Coastal Cutthroat Trout is similarly challenging as it is for Rainbow Trout. Coastal Cutthroat Trout typically reach 40mm to 60mm at the end of the first growing season (0+), and 85mm to 107mm in length by the end of the second growing season (1+) (McPhail, 2007). A study on Vancouver Island (Narver, 1975) used extrapolated data from scales and length-weight relationships to show 0+ fish are an average weight of 44.6mm at the end of the first growing season, and 93.8mm at the end of the second growing season (1+) for Coastal Cutthroat Trout. The length-weight relationship from the report was as follows:

$$Weight_{kg} = 0.000053293 \times (Length_{cm})^{2.5852}$$

Using this equation, mean weights for the fish in the Narver report would be 2.5g for 0+ fish and 17.4g for 1+ fish.

Stocking of Cutthroat Trout in the Stave River (FIDQ, 2016) has historically been for anadromous, or sea-run, trout released as smolts. All releases have been of 1+ fish, with average weights ranging between 42.2g and 113.6g for spring releases, using a mix of wild and hatchery origin trout.

For the purposes of defining size classes for FPU calculations, Coastal Cutthroat Trout have been assigned to two size classes. Data is based on Narver's (1975) extrapolated data, which is consistent with average lengths reported in McPhail (2007). Using the length-weight relationship from Narver, our size classes are defined as follows:

Parameter	Class 1 (0+)	Class 2 (1+)
Length (cm)	4.0 – 6.0	8.5 – 10.7
Mean Length (cm)	4.46	9.38
Mean Weight (g)	2.5	17.4

In a streamflow study in Oregon by Nickelson *et al*. (1979), flow models were compared to determine habitat use by salmonids. Streamflow reductions were shown to impact Steelhead and Cutthroat Trout habitat more than Coho Salmon habitat. Based on modelling limitations, there is greater certainty in the Oregon study statement regarding Steelhead use. In the Oregon study, mean velocities of greater than 0.24m/s were expected to produce densities of Cutthroat Trout greater than 200g/100m^2.

3.2.1.1.5 Brassy Minnow

Brassy Minnow young-of-year (0+) average about 42mm in FL in the lower Fraser Valley by October (McPhail, 2007). Brassy Minnow are mature by the following spring and only live to a maximum of four years for females and three years for males.

Brassy Minnow were not captured in the 2010/2011 Lower Stave River survey (Glova, Robichaud and Kennedy, 2011). Brassy Minnow have also not been captured in the Lower Stave River based on FIDQ searches. A single Brassy Minnow was caught in Hayward Lake in 2009 (FIDQ, 2016)

HSI models are not available for Brassy Minnow. In 2008, Golder Associates Ltd. (Golder) developed habitat suitability models for 14 different species, including Brassy Minnow; however, the models relied on habitat characteristics such as substrate, cover, channel type, dissolved oxygen and pH, rather than water depth and velocity. The model was developed based on extensive literature reviews. The model Golder developed is as follows in Table B.

Table B: Golder Associates Ltd. habitat suitability model for Brassy Minnow in riverine habitat (Golder, 2008).

	Variable	Excellent (Suitability = 1.0)	Above Average (Suitability = 0.75)	Average (Suitability = 0.5)	Below Average (Suitability = 0.25)	None (Suitability = 0)
V1	Substrate	Gravel (>2 to 64mm), Sand (>0.06 to 2mm) and Clay/Silt (≤0.06mm)		Cobble (>64 to 256mm, rounded) and Rubble (>64 to 256mm, angular)	Bedrock and Boulder (>256mm)	
V2	Instream Cover	Submergent and emergent plants		Woody debris, rock		
V3	Spawning	Quiet, shallow, well vegetated areas	-	-	-	No suitable material
V4	Channel Unit	Pools, backwaters areas, flats	Runs		Riffles	Rapids, chutes and falls
V5	% Instream Cover	>50	>30 to 50	>20 to 30	>0 to 20	0
V6	Late winter dissolved oxygen (mg/L)	≥2		<2		
V7	pH	6 to 9		5.5 to <6		<5.5 or >9

While this model doesn't specifically fit the water depth and velocity measurements taken at each site, general assumptions for habitat suitability in the Lower Stave River can be made using Golder's model, specifically looking at substrate, instream cover, and channel unit type. These assumptions are discussed in the discussion section (Section 4.0).

3.2.1.1.6 Mountain Whitefish

Mountain Whitefish may reach a TL of 60mm to 100mm by the end of the first growing season (0+) (McPhail, 2007). Males and females mature by age 6 in the Fraser River and tributaries, with males maturing a year earlier than females, and as young as 2+. Mountain Whitefish typically live to a maximum of 12 years in British Columbia. In Rempel *et al*. (2012), separation between 0+ and 1+ Mountain Whitefish was chosen as 110mm, and 200mm for separation between 1+ and 2+ fish.

Mountain Whitefish were caught infrequently during sampling for the 2010/2011 Lower Stave River survey (Glova, *et. al*., 2011) and during the 2013 survey (Glova and Robichaud, 2014). The only captures of Mountain Whitefish in 2010/2011 were limited to one day in June 2010, with eleven fish captured by minnow trap and 18 captures by gill net. During the 2013 survey, only 20 total Mountain Whitefish were caught by beach seine within segments 1-4 during two days of sampling in September 2013.

3.2.1.1.6.1 HSI curves

HSI curves for juvenile Mountain Whitefish were compared by Rempel *et al*. (2012) to lower Fraser River habitat and channel types, specifically focusing on gravel bars. Fraser River gravel bars are morphologically similar to the gravel bars and habitat observed in the Lower Stave River, however water clarity is quite different. The Fraser River tends to be a fairly turbid river, while water in the Stave River at the time of sampling was found to be quite clear. The following HSI curves were developed by Bovee (1978), and feature Fraser River sampling data in relation to the curves (Figures C to E).

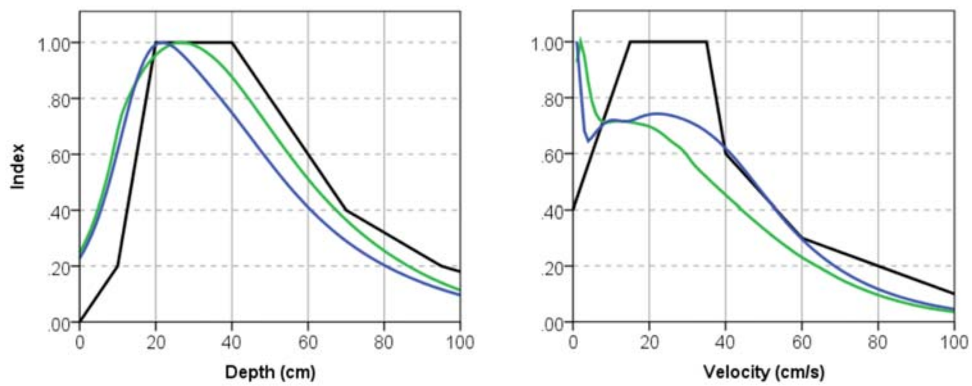

Figure C: Mountain Whitefish 0+ HSI curves from Rempel *et al*., 2012. Green lines represent availability, purple represents use in the Fraser River, and black is the Bovee habitat suitability criteria.

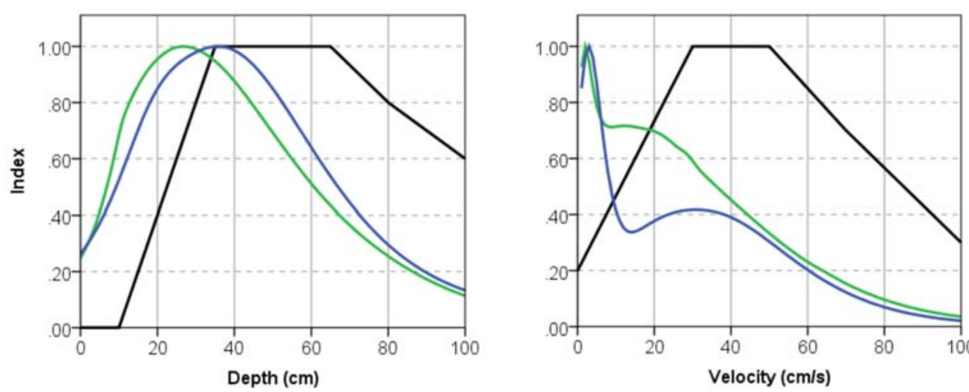

Figure D: Mountain Whitefish 1+ HSI curves from Rempel *et al*., 2012. Green lines represent availability, purple represents use in the Fraser River, and black is the Bovee habitat suitability criteria.

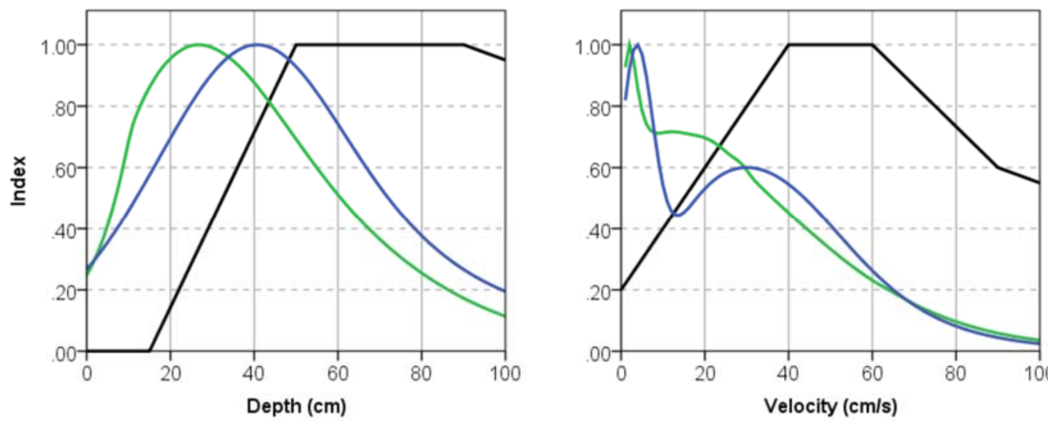

Figure E: Mountain Whitefish 2+ HSI curves from Rempel *et al*., 2012. Green lines represent availability, purple represents use in the Fraser River, and black is the Bovee habitat suitability criteria.

Based on the above graphs, actual use of habitat in the Fraser River trend towards shallower water and lower velocities than the Bovee model.

Addley *et al*. (2003) developed HSC models for the South Saskatchewan River Basin, for Alberta Sustainable Resource Development. These models were as follows for Mountain Whitefish (Table C and D.)

Table C: Addley *et al*. (2003) HSC depth model for Mountain Whitefish.

Adult		Juvenile		Fry		Spawning/Eggs	
Depth (m)	Suitability	Depth (m)	Suitability	Depth (m)	Suitability	Depth (m)	Suitability
0	0	0	0	0	0	0	0
0.15	0	0.06	0	0.01	0.01	0.15	0
0.55	1	0.45	1	0.3	0.3	0.5	1
4	1	1.4	1	1.15	1.15	4	1
		1.7	0.5	1.4	1.4		
		4	0.5	1.8	1.8		

Table D: Addley *et al*. (2003) HSC velocity model for Mountain Whitefish.

Adult		Juvenile		Fry		Spawning/Eggs	
Velocity (m/s)	Suitability	Velocity (m/s)	Suitability	Velocity (m/s)	Suitability	Velocity (m/s)	Suitability
0	0.2	0	0.2	0	1	0	0
0.4	1	0.35	1	0.7	1	0.15	0
1	1	1.1	1	1	0.15	0.4	1
1.2	0.4	1.8	0	1.25	0	1.1	1
1.8	0					1.8	0

These models were plotted in Microsoft Excel and are shown in Figure F and G.

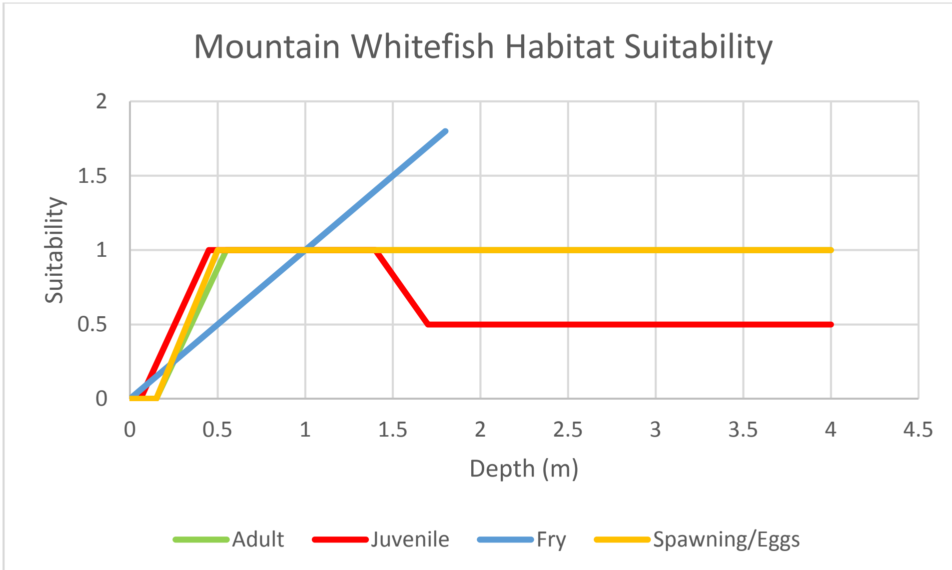

Figure F: Habitat suitability depth model for Mountain Whitefish from Addley *et al*. (2003). The adult line (green) follows the spawning/eggs line (yellow).

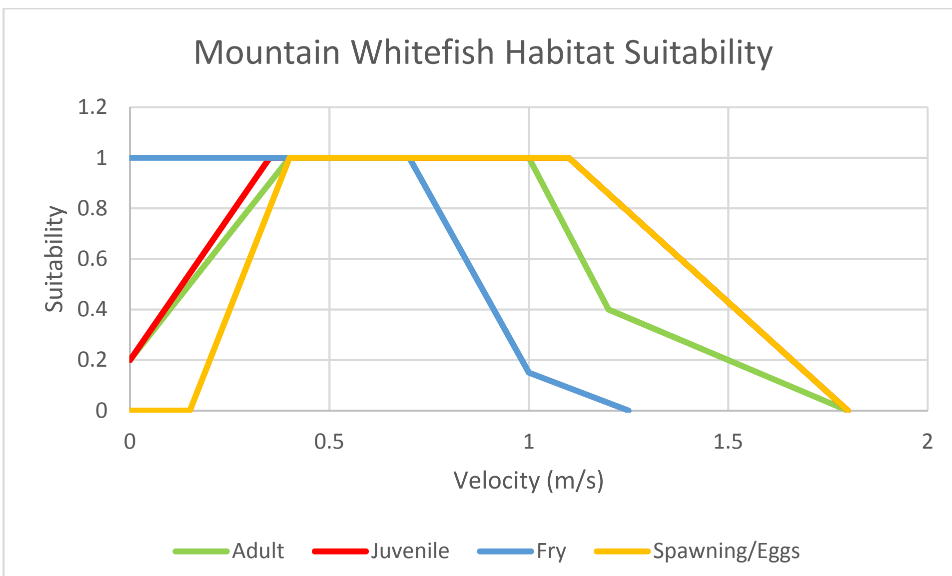

Figure G: Habitat suitability velocity model for Mountain Whitefish from Addley et al. (2003). The juvenile line (red) follows the spawning/eggs line (yellow).

Additional habitat suitability modelling for Mountain Whitefish was undertaken by Golder (2008), using descriptive models, as with Brassy Minnow, above. The models developed by Golder included rearing habitat, feeding habitat and spawning/incubation habitat. These models are presented in Tables E to G.

Table E: Golder Associates Ltd. habitat suitability model for Mountain Whitefish Rearing Habitat in riverine habitat (Golder, 2008).

	Variable	Excellent (Suitability = 1.0)	Above Average (Suitability = 0.75)	Average (Suitability = 0.5)	Below Average (Suitability = 0.25)	None (Suitability = 0)
V1	Substrate	Rubble (>64 to 256mm, angular), cobble (>64 to 256mm, rounded), gravel (>2 to 64mm)	Clay/Silt (≤0.06mm), Sand (>0.06mm to 2.0mm)	Boulder (>256mm)		Bedrock
V2	Channel Unit	Pools, flats		Runs, riffles	Rapids	Chutes, falls
V3	Late winter dissolved oxygen (mg/L)	≥7	≥5 to <7	≥4 to <5	≥3 to <4	<3
V4	Summer average maximum temperature (°C)	≤17			>17 to 25	>25
V5	% Instream cover	>30	>20 to 30	>10 to 20	>0 to 10	0

Table F: Golder Associates Ltd. habitat suitability model for Mountain Whitefish Feeding Habitat in riverine habitat (Golder, 2008).

	Variable	Excellent (Suitability = 1.0)	Above Average (Suitability = 0.75)	Average (Suitability = 0.5)	Below Average (Suitability = 0.25)	None (Suitability = 0)
V1	Substrate	Rubble (>64 to 256mm, angular), cobble (>64 to 256mm, rounded), gravel (>2 to 64mm)		Boulder (>256mm)	Clay/Silt (≤0.06mm), Sand (>0.06mm to 2.0mm)	Bedrock
V2	Channel Unit	Runs, riffles	Pools, flats	Rapids		Chutes, falls
V3	Late winter dissolved oxygen (mg/L)	≥7	≥5 to <7	≥4 to <5	≥3 to <4	<3
V4	Summer average maximum temperature (°C)	≤17			>17 to 25	>25
V5	% Instream cover	>20	>10 to 20		>0 to 10	0

Table G: Golder Associates Ltd. habitat suitability model for Mountain Whitefish Spawning/Incubating Habitat in riverine habitat (Golder, 2008).

	Variable	Excellent (Suitability = 1.0)	Above Average (Suitability = 0.75)	Average (Suitability = 0.5)	Below Average (Suitability = 0.25)	None (Suitability = 0)
V1	Substrate	Rubble (>64 to 256mm, angular), cobble (>64 to 256mm, rounded), gravel (>2 to 64mm)		Boulder (>256mm)	Clay/Silt (≤0.06mm), Sand (>0.06mm to 2.0mm)	Bedrock
V2	Channel Unit	Runs, riffles	Rapids		Pools, flats	Chutes, falls
V3	Late winter dissolved oxygen (mg/L)	≥7	≥5 to <7	≥4 to <5	≥3 to <4	<3

PGL
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3.2.1.2 Weighted Usable Area

Burt and Wallis (1997) calculated WUA calculations for the Salmon River in Salmon Arm, British Columbia. Their calculations included Rainbow Trout fry and parr, Chinook Salmon fry, and Coho Salmon fry. Their calculations relied on the Ptolemy (1993) alkalinity models for FPU, with Rainbow Trout calculated using the general fish calculation for each size class:

$$FPU_{general} = 36.3 \times ALK^{0.5} \times SIZE_g^{-1}$$

Alkalinity at CPSF was calculated using a double log regression analysis of measured alkalinity values on discharge. The alkalinity was calculated to be 172.6mg/L. This resulted in the following theoretical maximum FPU calculations for Rainbow trout (Burt and Wallis, 1997):

Size Class	Mean Weight (g)	Alkalinity (mg/L)	Maximum FPU (fish/100m^2)
Rainbow Trout fry	1.62	172.6	294.38
Rainbow Trout parr	9.68	172.6	49.27

The Puntledge River Steelhead Production Monitoring Study 2007 (Ecofish, 2008) also used alkalinity to determine Steelhead theoretical maximum FPU, and compared this data to fish captures for observed FPU, as follows:

Size Class	Mean Weight (g)	Alkalinity (mg/L)	Maximum FPU (fish/100m^2)	Observed FPU (fish/100m^2)
Steelhead fry	2.9 to 4.8	16.0 to 24.0	51.41 to 85.09	0.0 to 21.0
Steelhead parr	6.0 to 12.9	16.0 to 24.0	19.1 to 32.0	0.0 to 7.0

3.2.2 Fish Captures

Fish were captured at the 11 sites using either EF or MT techniques. Sites 1 and 2 were sampled using both EF and MT methods. Fish sampling effort and results are summarized in Table H. There were no fish caught at Site 2 during EF; however, fish were caught during MT. Site 10 was sampled by EF only, and no fish were caught. Across all sites, seven different species of fish were captured, in addition to crayfish. The fish species included Prickly Sculpin, Coastrange Sculpin, Pumpkinseed Sunfish (invasive), Threespine Stickleback, Northwestern Pikeminnow, Peamouth, and Rainbow Trout/Steelhead. All captures were of small or juvenile fish, less than or equal to 140mm in length.

Of the nine Rainbow Trout/Steelhead that were captured, eight had their adipose fin clipped, indicating they were of hatchery stock, with an average weight of 7.0g (range between 4.1g and 8.9g).

Upon investigation of the hatchery stocking information (FIDQ), Steelhead smolts were stocked in the spring of 2014 and 2015 (nearly yearly since 1985), as age 1+ fish with average weights of 71.1g and 76.5g in 2014 and 83.6g and 71g for releases in 2015. No young-of-year fry were released in 2015. In 2014, 11,500 Steelhead fry (2014 winter-run from the Vedder River) were released with adipose clips and an average weight of 4g on August 28. It seems unlikely that the Rainbow Trout/Steelhead captured in October 2015 would be from this 2014 fry release. The 2014 stock would have gone through a second growing season, and would likely be much larger than the average weight of 7.0g that were captured. Smolt releases in April and May are timed to coincide with natural migration times for Steelhead heading to the ocean, therefore, it is also unlikely that the captured fish in October 2015 were part of either of the 2015 smolt releases, which would have outmigrated already.

It is possibly that these 2015 captures were from another stocking program in a nearby river or tributary that may have migrated to the Stave River for over-winter rearing. Without ageing data (scale samples) or tagging, however, the age or origin of these clipped fish is unknown. It may also be important to note that sea-run Cutthroat Trout smolts were also released in May of 2015 and April of 2014, and no Cutthroat Trout were captured during the 2015 October sampling.

Table H: Summary of EF and MT effort and captures across all sites, October 2015

Site	Method	Soak Time	# traps	EF Effort (s)	Effort (traps x time)	Area (m2)	Prickly Sculpin	Coastrange Sculpin	Pumpkinseed Sunfish	Threespine Stickleback	Northern Pikeminnow	Peamouth	Rainbow Trout/ Steelhead	Crayfish
1	EF			668		100	2	-	-	-	-	-	-	-
1	MT	25.25	8		202		14	1	-	-	-	-	-	1
2	EF			719		100	-	-	-	-	-	-	-	-
2	MT	23	8		184		16	-	4	1	-	-	-	-
3	EF			909		153	15	-	-	-	-	-	-	-
4	EF			857		105	10	-	-	-	-	1	-	-
5	MT	19.25	8		154		27	-	-	-	1	3	6	-
6	MT	19.92	8		159		21	-	1	-	3	-	2	-
7	MT	16.33	8		131		19	-	-	-	-	-	1	-
8	MT	21.33	8		171		28	-	4	-	4	2	-	-
9	EF			2018		140	12	-	5	-	1	-	-	2
10	EF			931		100	-	-	-	-	-	-	-	-
11	EF			1099		100	1	-	-	-	-	1	-	-

Prickly Sculpin were the most frequently caught species during the study, and the only species that was reliably caught during EF sampling. As such, Prickly Sculpin were chosen as the resident fish species to focus on for FPU calculations. Prickly Sculpin are a valuable food source for resident Coastal Cutthroat Trout, Rainbow Trout and birds, such as Great Blue Heron. The summary statistics for Prickly Sculpin captures are shown in Table I.

Table I: Summary statistics for all captured Prickly Sculpin young-of-year and adults across all EF sites (Sites 1, 3, 4, 9 and 11).

Age	(n)	Percent of Catch	Length (mm)					Weight (g)				
			Mean	S.D.	S.E.	Min	Max	Mean	S.D.	S.E.	Min	Max
0+	21	65.6	30	4.27	0.93	21	40	0.3	0.11	0.02	0.1	0.5
1+	0	0.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2+	11	34.4	81	12.60	3.80	62	96	6.0	2.87	0.86	2.3	10.5
All Ages	**32**	**100**										

Based on the size classes described in Section 3.1.1.1, Prickly Sculpin captures were 0+ or 2+ aged fish, with mean lengths of 30mm (±0.93mm) and 81mm (±3.80mm), and mean weights 0.3g (±0.11g) and 6.0g (±0.86g), respectively.

One possible Coastrange Sculpin young-of-year (30mm TL, 0.3g) was captured while electrofishing at Site 3. This very small fish had the characteristic white patch at the top of the caudal peduncle, however, other identifying features were hard to determine due to the size of the fish.

Pumpkinseed Sunfish were captured at four of the sites. These fish are considered invasive species, and are frequently found in slow moving watercourses and throughout the Fraser Valley. The species is native to eastern North America, but has been introduced to BC and other western provinces and the states. All Pumpkinseed Sunfish captures were humanely euthanized onsite as per the requirements of the BC Ministry of Forests, Lands and Natural Resource Operations fish collection permit.

Of the four resident species of interest, only Rainbow Trout (potentially Steelhead) were captured during the October 2015 sampling.

3.2.3 Water Quality

In situ water quality measurements were taken at each site, including temperature, pH, specific conductivity, dissolved oxygen, and alkalinity. A summary of these results is provided in Table J.

Table J: *In situ* water quality measurements, and daily flow (provided by BC Hydro), for all sampling sites, October 2015.

Site	Date	Temp	pH	Specific Conductivity	Dissolved Oxygen	Dissolved Oxygen	Alkalinity $CaCO_3$	Daily total flow
		°C		µS/cm	mg/L	%	mg/L	m^3/s
1	7-Oct-15	15.3	6.09	12.3	9.83	97.6	13.6	174.6
2	7-Oct-15	15.2	6.29	12.4	9.84	97.8	13.6	174.6
3	8-Oct-15	15.5	6.54	13.1	9.03	90.5	13.6	173.6
4	8-Oct-15	15.8	6.33	13.7	8.75	88.2	13.6	173.6
5	9-Oct-15	15.2	6.51	15.1	9.31	92.6	20.4	173.2
6	9-Oct-15	15.2	6.52	15.1	9.35	92.8	13.6	173.2
7	9-Oct-15	15.1	6.41	12.9	9.3	92.4	13.6	173.2
8	9-Oct-15	15.1	6.47	15.3	8.2	82.9	13.6	173.2
9	9-Oct-15	15.1	6.45	14.0	9.32	91.6	13.6	173.2
10	13-Oct-15	14.8	6.89	42.3	9.76	95.8	13.6	69.53
11	13-Oct-15	16.3	7.03	28.1	10.16	104.2	13.6	69.53

Overall water quality in the Lower Stave River was found to be fairly constant between sites, with moderate temperatures (between 14.8 and 16.3 °C), suitable pH for fish (6.09 to 7.03 pH), generally low specific conductivity (between 12.3 and 42.3µS/cm), good dissolved oxygen 8.2mg/L and 82.9% to 10.16mg/L and 104.2%, and stable alkalinity (13.6mg/L $CaCO_3$ for all sites except Site 5 with 20.4 mg/L $CaCO_3$). The largest flux in water quality occurred when flows from the dam were reduced to 69.53m^3/s. For the majority of the study, flows were kept to just under 175m^3/s. All water quality parameters were within the range of suitable conditions for aquatic life, and for salmonids.

3.2.4 Flow Conditions

Flow conditions from the Ruskin Dam during the period of the study, and between January 1, 2015 and December 20, 2015, were provided by BC Hydro. Turbine flow (TBF) and non-power release flow (NPRF) measurements were supplied. Daily averages for 2015 (Figure H) and hourly flows during the period of the study (October 6 to 13, 2015) (Figure I) were included. TBF is the release of water from the Ruskin Generating Station, including all units, while NPRF is the release of water from the Ruskin Dam Spillway, including all spillway gates. The sum of both the TBF and NPRF is the roughly the total downstream flow in the Lower Stave River as there are only a few minor tributaries that intersect the Lower Stave River between Ruskin Dam and the Fraser River confluence. BC Hydro monitors the elevation of water in Hayward Lake Reservoir above the dam, which is used to determine TBF in relation to spillway rating curves for the NPRF.

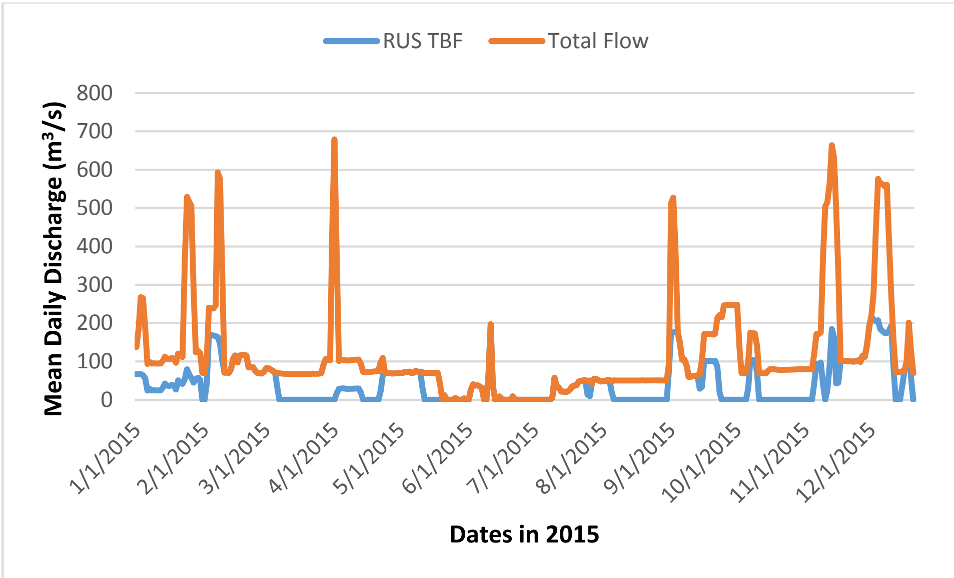

Figure H: Stave River at Ruskin Dam, January 1 to December 20, 2015. Turbine flow (TBF) and total flow (TBF and Non-Power Release Flow (NPRF) combined) are both shown.

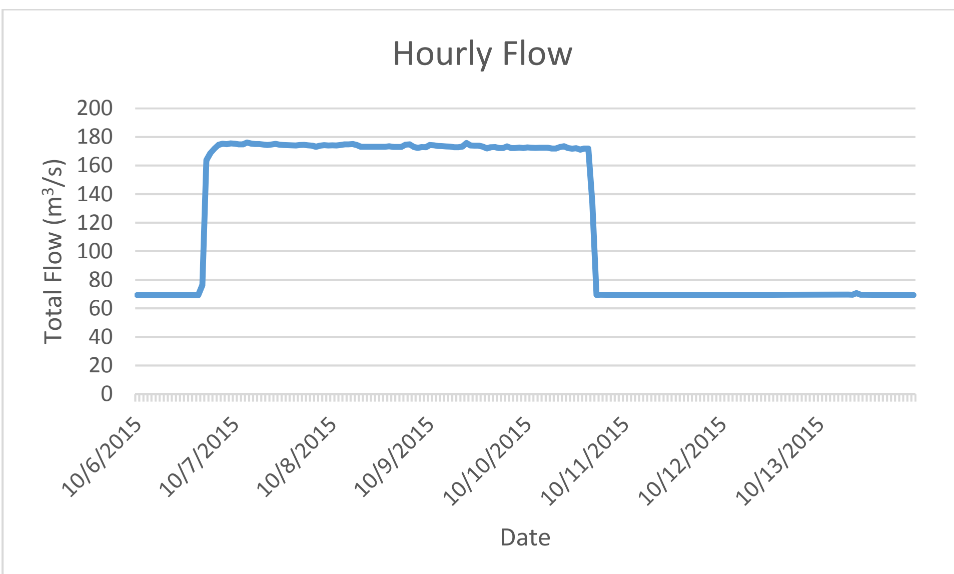

Figure I: Hourly flow for the Stave River at the Ruskin Dam, October 6 to October 13, 2016, for the length of the field study, showing total flow (TBF and NPRF combined).

Mean Daily Discharge (MDD) for the study period is shown in Figure J, including TBF, NPRF and total flow (m^3/s).

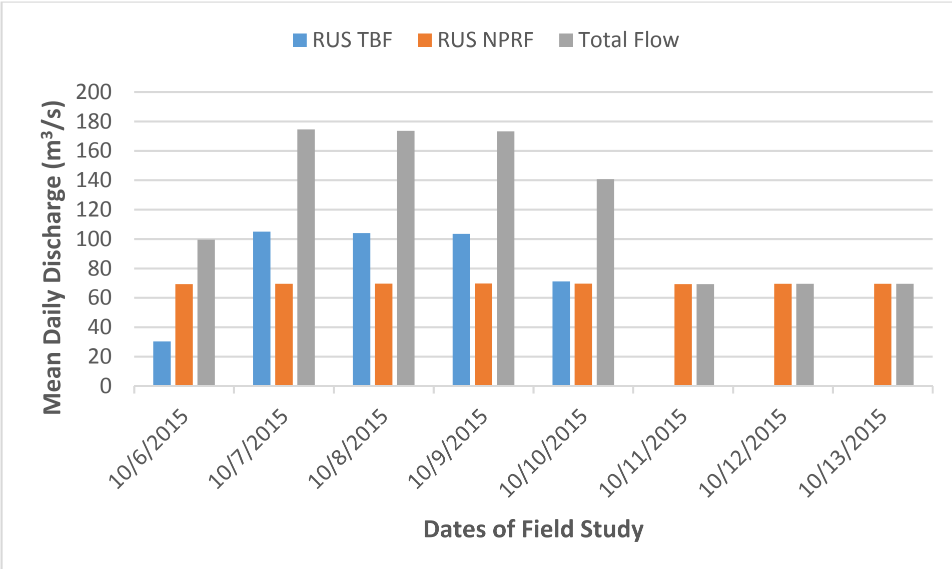

Figure J: Mean Daily Discharge for the Stave River at the Ruskin Dam, October 6 to October 13, 2015, for the length of the field study, showing TBF, NPRF and Total Flow.

Mean Monthly Discharge was calculated from the supplied BC Hydro data and is shown as total flow (TBF and NPRF combined) in Figure K.

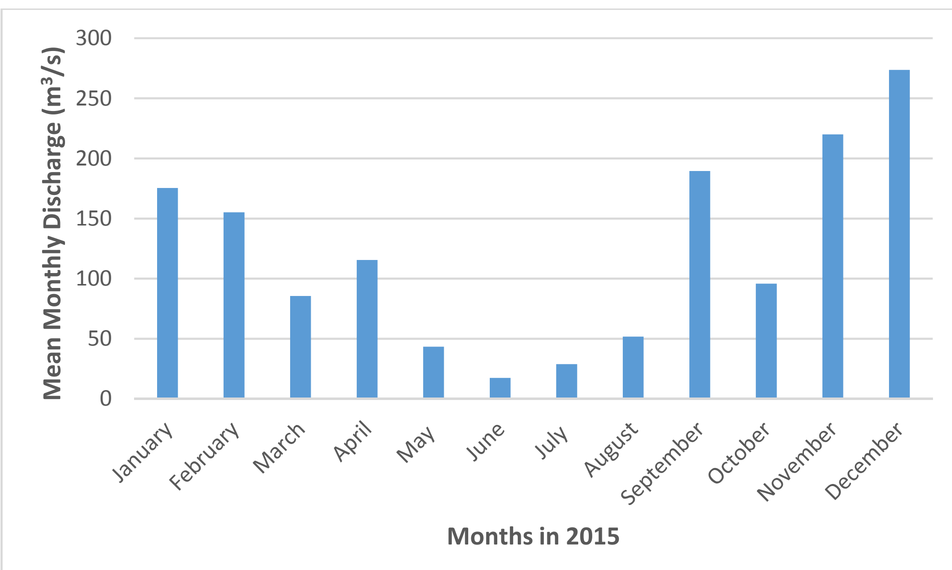

Figure K: Mean Monthly Discharge for the Lower Stave River below Ruskin Dam, January 1 to December 20, 2015, using total flow (TBF and NPRF combined).

Based on the above figures, it can be determined that in 2015 the CPSF was in June, with an average flow of 17.36m^3/s. October mean flow was 95.86m^3/s, which was less than the average daily flow during the sampling (sample days included October 7 to 9, and 13), at 147.73m^3/s for the four days.

MAD for the Lower Stave River is reported as 111m^3/s, with the mean discharge for 2015 (January 1 to December 20, 2015) calculated to 115.8m^3/s. With December flows being typically high, the annual discharge for 2015 including the additional data for December (not supplied as request for data was made in December) would likely be even higher, to around 120m^3/s. This is slightly higher than the reported value, but within an acceptable range (less than 10% variance) which is likely based off many years of data. Variance between years is not unexpected. The Lower Stave River is a controlled system (two dams in place upstream on the mainstem, in addition to two run-of-river projects on the Upper Stave River and a tributary); therefore, flows measured at the Ruskin Dam are not necessarily indicative of weather or climate regimes. Water level readings for the Lower Stave River are not available as there is no monitoring station in the Lower Stave River. A monitoring station at Stave Falls (current location of the Stave Falls Dam and Powerhouse) was in operation from 1901 to 1913, but water level was only recorded in 2012, seasonally (Wateroffice, Government of Canada, 2016). Stave Falls monitoring data is shown in Figure L for flow and Figure M for water level. This historical data shows a minor peak in water flow and a peak in water level during the typical freshet period of June to July.

Winter flows in the Lower Stave River can be quite high. BC Hydro recorded a high flow in 2015 of 678.9m^3/s on April 1st. Flows above 250m^3/s were not uncommon, with several instances of flows above 400m^3/s. Flows can also changes drastically from day to day by 400m^3/s on average. Such swift changes could leave fish stranded. In addition, spikes in flow may produce conditions that force fish out of the watercourse if velocities are too high and shelter is not available.

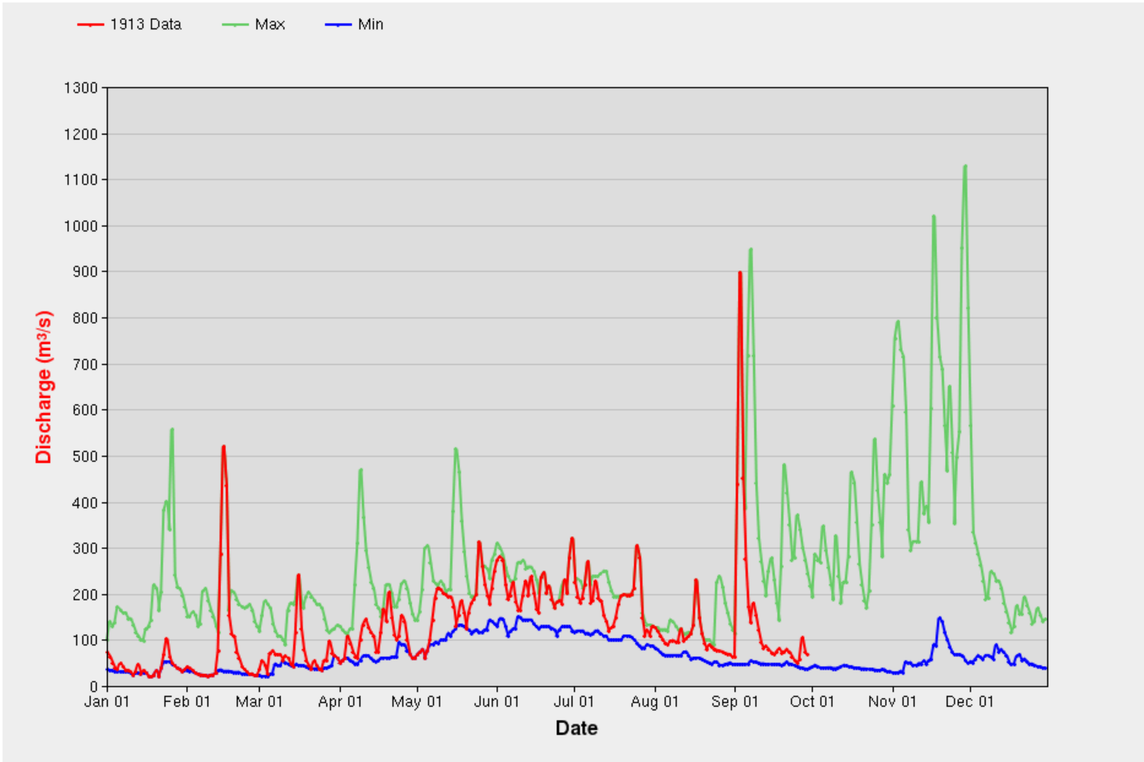

Figure L: Historical flow data (pre-dam, with unregulated flows) for the Stave River at Stave Falls (current location of the Stave Falls Dam and Powerhouse) (08MH011) from 1903 to 1913 showing minimum, maximum and 1913 daily flows (Wateroffice, Government of Canada, 2016).

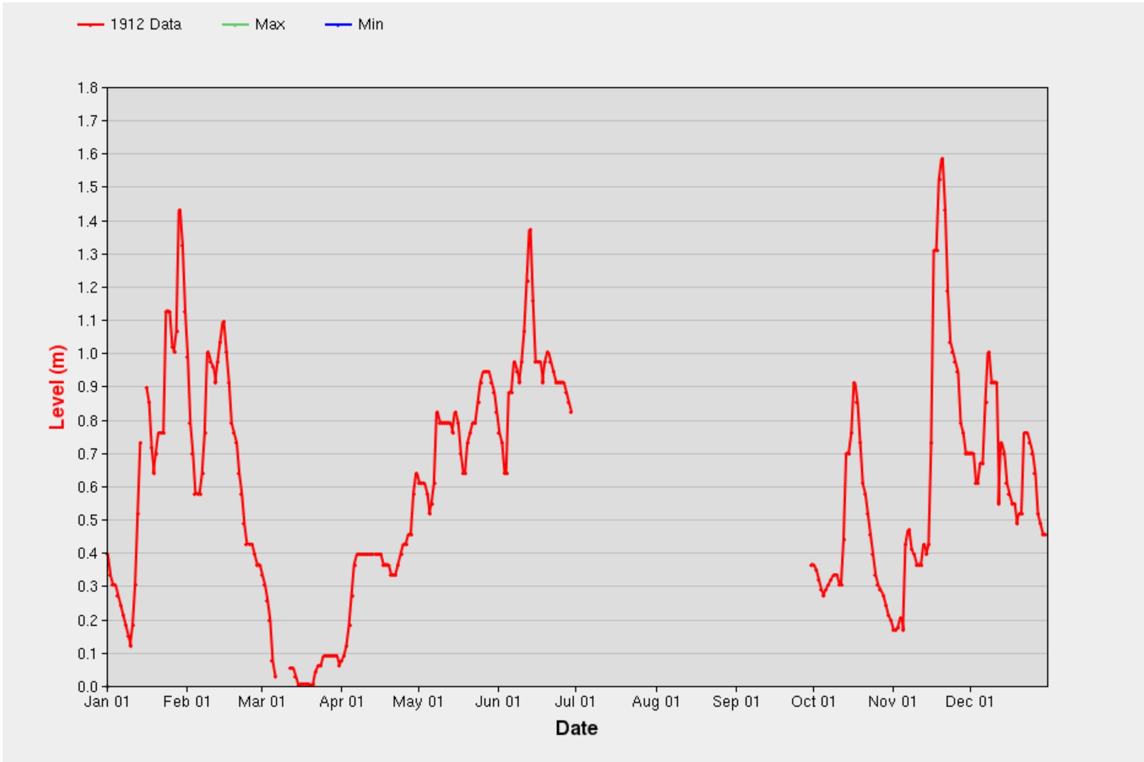

Figure M: Historical water level data (pre-dam with unregulated flows) for the Stave River at Stave Falls (current location of the Stave Falls Dam and Powerhouse) (08MH011) for 2012. Maximum and minimum water levels were not available, and only seasonal data was recorded (Wateroffice, Government of Canada, 2016).

In contrast to current Stave River data, the Fraser River water levels and water flow at Mission (Figure N) and water levels at Whonnock (Figure O) (upstream and downstream of the Stave River, respectively) peak in June, when freshet is occurring (Wateroffice, Government of Canada, 2016). Freshet affects the flow by adding additional water to the system from snow melt in the upper reaches of the watershed. The effects of freshet on water level at the Port Mann Pumping Station on the Fraser River appear to be dampened by the effects of the tide or other factors (such as width of the river at the sampling station) during the same freshet period, as the peak is far less pronounced (Figure P) (Wateroffice, Government of Canada, 2016). The Port Mann Pumping Station is located near the Port Mann Bridge, approximately 30km downstream of the Stave River.

Low release flows for the Stave River at Ruskin Dam during freshet are likely an operational decision, as the Lower Stave River between the Fraser River and the Ruskin Dam backs up considerably during freshet, due to the additional water in the Fraser River. By controlling the release of the flow at the Ruskin Dam, BC Hydro can avoid adding additional water to an already flooded system. As there are homes and businesses nearby, protecting property is a key concern. Therefore, flow data is not indicative of actual water level conditions on the Lower Stave River, particularly during freshet. Tidal influence of the Stave River is another daily concern, as the tide can change habitat conditions quite rapidly.

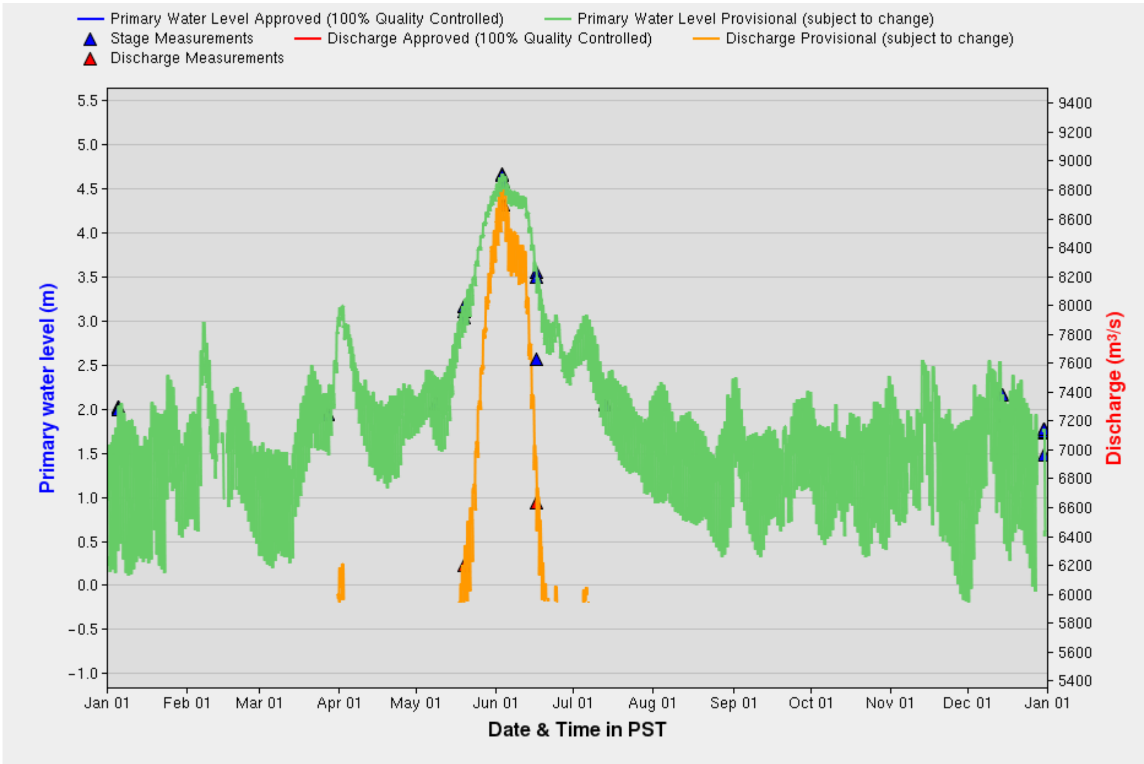

Figure N: Fraser River water level and flow at Mission (08MH024), January 1 to December 31, 2015 (Wateroffice, Government of Canada, 2016).

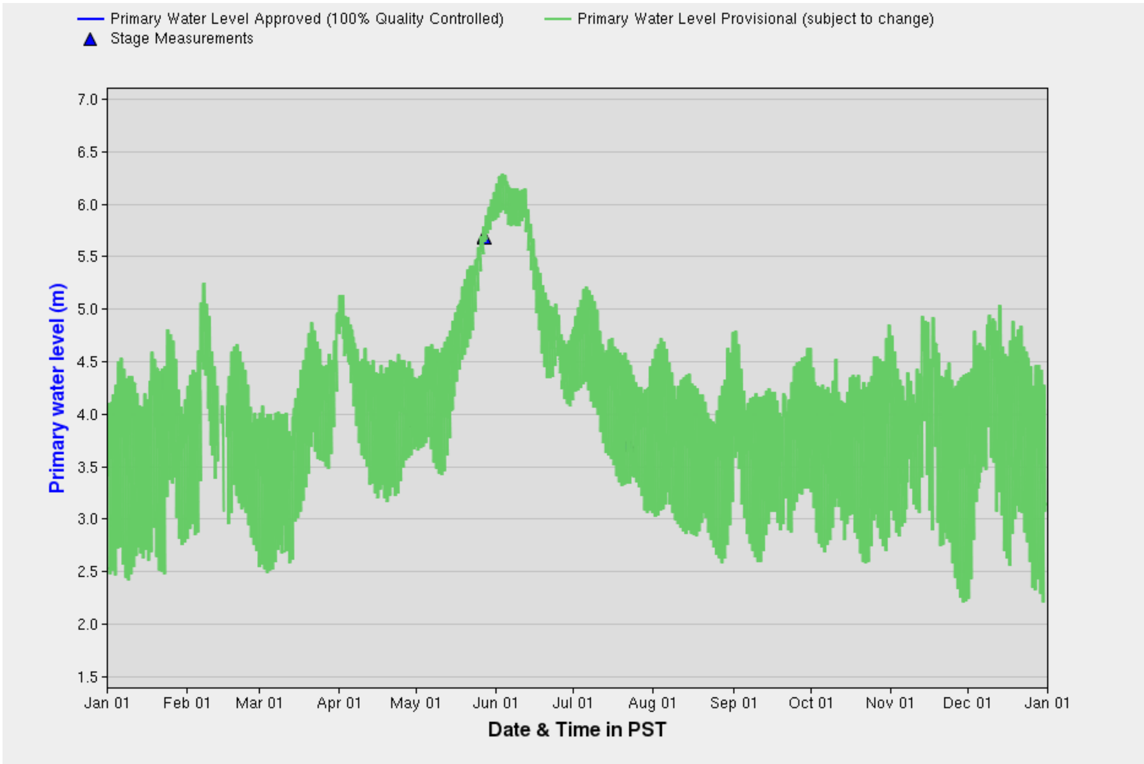

Figure O: Fraser River water level at Whonnock (08MH044), January 1 to December 31, 2015 (Wateroffice, Government of Canada, 2016).

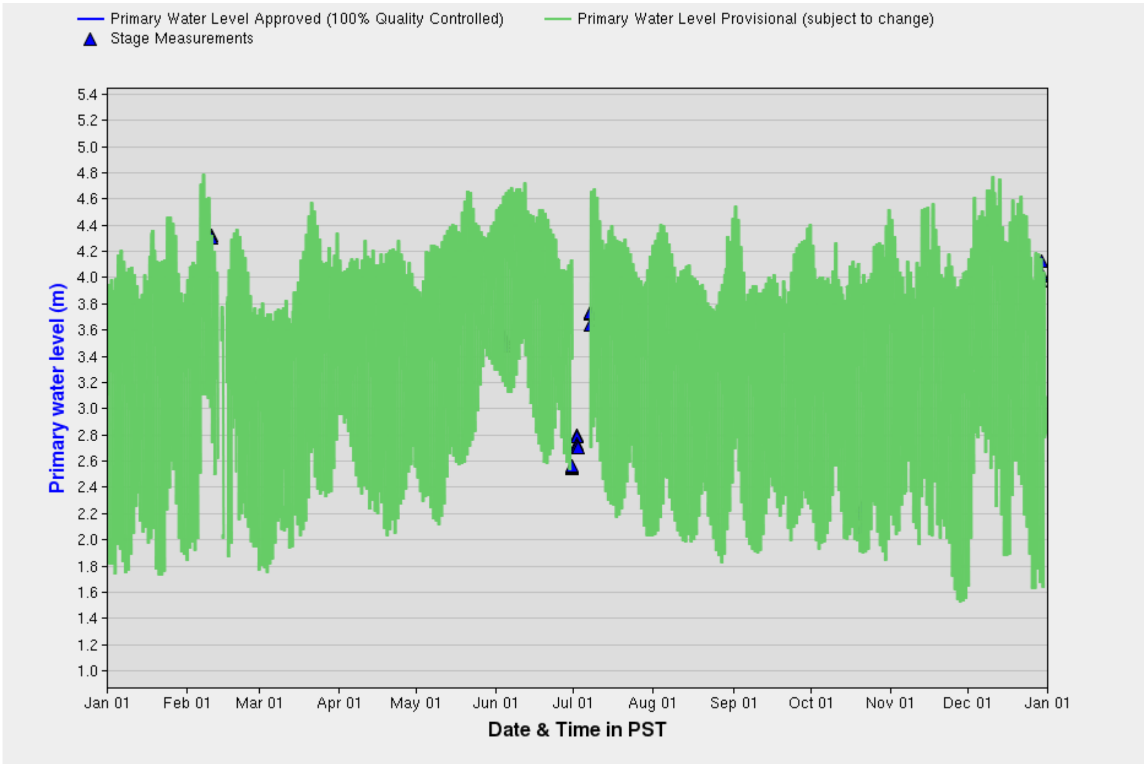

Figure P: Fraser River water level at the Port Mann Pumping Station (08MH126), January 1 to December 31, 2015 (Wateroffice, Government of Canada, 2016).

The Pitt River, in Coquitlam, BC, enters the Fraser River from the north, just upstream of the Port Mann Bridge. This river also shows a peak in water level around June, during freshet (Figure Q). The Pitt River is tidally influenced, and has a gross drainage area of 1640km^2. The Pitt River is unregulated (undammed); however, a tributary of the Lower Pitt River is the South Alouette River, which is regulated by flows from Alouette Dam which impounds Alouette Lake Reservoir.

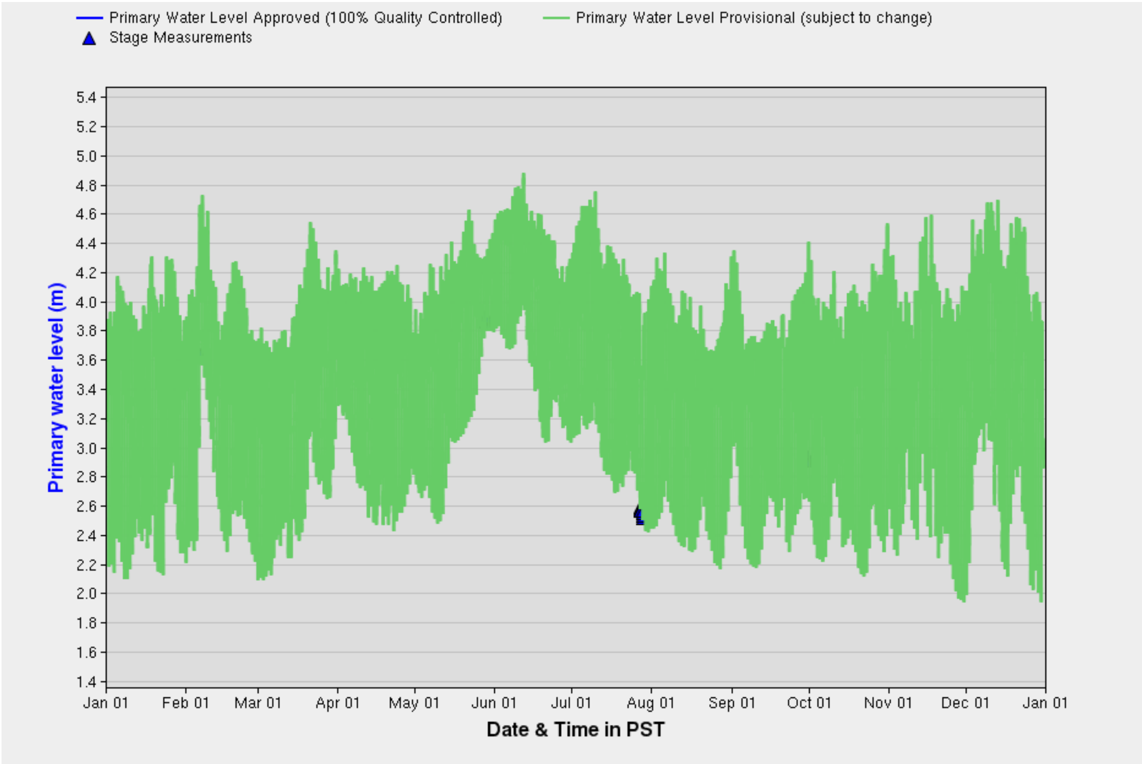

Figure Q: Pitt River water level near Port Coquitlam (08MH035), January 1 to December 31, 2015 (Wateroffice, Government of Canada, 2016).

Based on this information, CPSF for the Lower Stave River is in June; however, flow at this site is not congruent with water level. It can be assumed that August is likely a more appropriate month to assign as CPSF, as flows are still low, and freshet has completed, therefore, water levels in the Lower Stave would also be low.

3.2.5 Density

Density, or FPU, was calculated for Prickly Sculpin data from all EF sites, as this fish was the only species reliably caught during the study. FPU calculations for observed densities and maximum theoretical densities were based on Ptolemy, 1993. In addition to FPU, observed and maximum theoretical BPU was calculated to represent the amount of fish by weight per 100m^2 unit. A summary of these findings is shown in Table K for 0+ Prickly Sculpin and Table L for 2+ Sculpin. Weight in g was used as the parameter for calculating FPU, as this method, as opposed to using length is commonly used in the literature, as the calculations are not dependent on a condition factor (k) of 1.

Adjusted population per site was attempted by using Zippin's methods for estimating population size for a closed, three-pass removal procedure; however, without consistent decreases in catch per pass, this calculation was not appropriate. Therefore, total catch has been used to describe Prickly Sculpin data, rather than adjusted population size.

Table K: Summary of captures, mean weight, density (observed and maximum), and biomass (observed and maximum) for Prickly Sculpin (0+) with weights between 0g and 0.5g.

Site	Site Mean Weight (g)	Total Mean Weight (g)	Observed Densities		Maximum Densities	
			FPU_{obs} (#/100m^2)	BPU_{obs} (g/100m^2)	FPU_{max} (#/100m^2)	BPU_{max} (g/100m^2)
1 (n=0)	n/a	0.27	0.0	n/a	502.0	133.9
3 (n=13)	0.25	0.27	8.5	2.1	502.0	133.9
4 (n=8)	0.30	0.27	7.6	2.3	502.0	133.9
9 (n=0)	n/a	0.27	0.0	n/a	502.0	133.9
11 (n=0)	n/a	0.27	0.0	n/a	502.0	133.9

Notes:
FPU_{obs} = Observed fish per unit (100m^2) at each site, captured using three-pass electrofishing in a closed system.
FPU_{max} = Calculated maximum fish density per 100m^2, based on measured alkalinity and mean weight of the age class for all sites combined. Uses Ptolemy 1993 equation.
BPU_{obs} = Biomass per unit (100m^2) at each site, FPU_{obs} x mean weight of the age class per site.
BPU_{max} = Calculated maximum biomass per 100m^2, FPU_{max} x mean weight of the age class for all sites combined.

Table L: Summary of captures, mean weight, density (observed and maximum), and biomass (observed and maximum) for Prickly Sculpin (2+) with weights between 2.3g and 11.5g.

Site	Site Mean Weight (g)	Total Mean Weight (g)	Observed Densities		Maximum Densities	
			FPU_{obs} (#/100m^2)	BPU_{obs} (g/100m^2)	FPU_{max} (#/100m^2)	BPU_{max} (g/100m^2)
1 (n=2)	5.90	6.04	2.0	11.8	22.2	133.9
3 (n=1)	2.60	6.04	0.7	1.7	22.2	133.9
4 (n=1)	2.30	6.04	1.0	2.2	22.2	133.9
9 (n=6)	6.53	6.04	4.3	28.0	22.2	133.9
11 (n=1)	10.50	6.04	1.0	10.5	22.2	133.9

Notes:
FPU_{obs} = Observed fish per unit (100m^2) at each site, captured using three-pass electrofishing in a closed system.
FPU_{max} = Calculated maximum fish density per 100m^2, based on measured alkalinity and mean weight of the age class for all sites combined. Uses Ptolemy 1993 equation.
BPU_{obs} = Biomass per unit (100m^2) at each site, FPU_{obs} x mean weight of the age class per site.
BPU_{max} = Calculated maximum biomass per 100m^2, FPU_{max} x mean weight of the age class for all sites combined.

Site mean weight (g) was determined to calculate observed BPU for each site. Maximum theoretical BPU was calculated using the total mean weight for all captures in the weight class. Maximum theoretical FPU calculations across all sites in each age class were equal because alkalinity at all EF sites was the same at 13.6mg/L $CaCO_3$. As such, maximum theoretical BPU was also the same for all sites in each age class.

Observed vs. theoretical maximum FPUs were plotted for Prickly Sculpin at each EF site where Prickly Sculpin were captured (Sites 1, 3, 4, 9 and 11). FPUs for age class 0+ are shown in Figure R and age class 1+ FPUs are shown in Figure S.

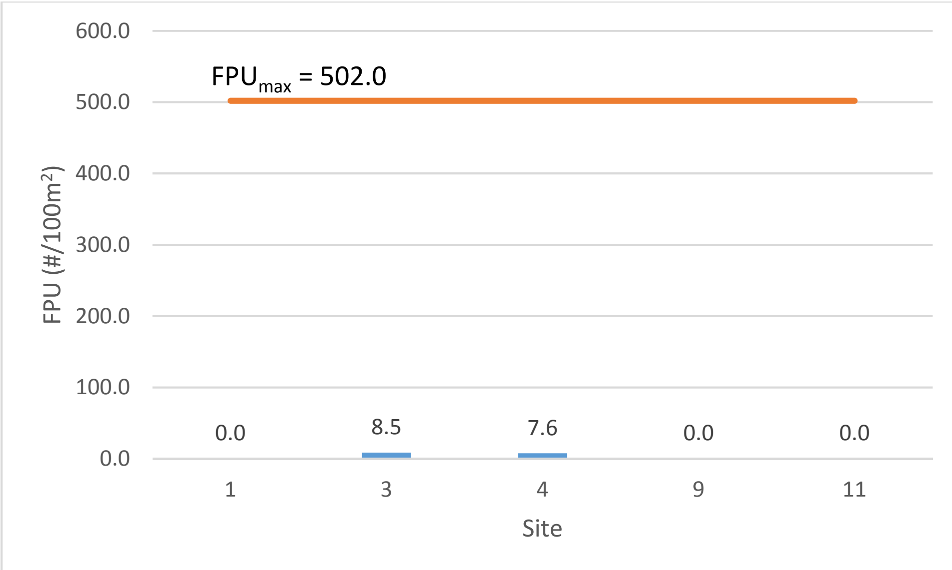

Figure R: Observed FPU for 0+ Prickly Sculpin across all electrofishing sites with captures, plotted with maximum available fish density based on measured alkalinity represented by the orange line.

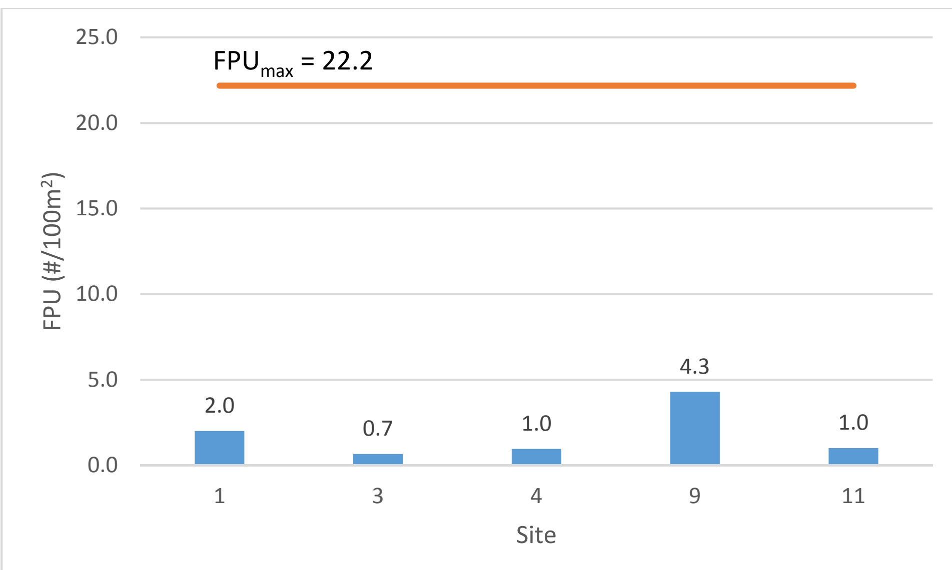

Figure S: Observed FPU for 2+ Prickly Sculpin across all electrofishing sites with captures, plotted with maximum available fish density based on measured alkalinity represented by the orange line.

As shown in the above tables and figures, observed FPUs for sites were much lower than the theoretical maximum FPUs, for both age classes. For 0+ Prickly Sculpin, the observed FPU at sites 3 and 4 were less than 2% of the theoretical maximum FPU, as predicted by the Ptolemy 1993 equation. For 2+ Prickly Sculpin, the observed FPUs for all sites were between 3% and less than 20% of the theoretical maximum FPU.

Compared to the Puntledge River WUP Project (Ecofish, 2008), observed densities for the Stave River were generally lower expressed as percentage of the theoretical maximum density. The adjusted densities for the Puntledge River ranged between 0.0% and 44.6% of the theoretical maximum for Steelhead. The summary of Puntledge River Steelhead FPU calculations are as follows:

Size Class	Mean Weight (g)	Alkalinity (mg/L)	Maximum FPU (fish/100m^2)	Observed FPU (fish/100m^2)
Steelhead fry	2.9 to 4.8	16.0 to 24.0	51.41 to 85.09	0.0 to 21.0
Steelhead parr	6.0 to 12.9	16.0 to 24.0	19.1 to 32.0	0.0 to 7.0

Management targets for Steelhead fry populations on Vancouver Island in several rivers were set at a minimum of 33% of the target density (range between 50 to 100 FPU), which were based on maximum theoretical FPUs (Wright, 2003) for each river. The target density was determined for each river, but could be adjusted based on more information about each system as it became available, and was not necessarily the maximum theoretical FPU. This study also used the Ptolemy 1993 alkalinity model and the HSI curves developed in February 2001. The Vancouver Island study only included wild Steelhead density. The minimum FPU target was considered the threshold for the Conservation Concern Zone (33 to 100%), set by the Greater Georgia Basin Steelhead Recovery Plan. Considering this target value, and the Puntledge River WUP Project, similar targets for the Stave River may be considered.

3.2.6 Habitat Assessments and Weighted Useable Area

Habitat assessments were key to determining the WUA for each site. Habitat characteristics such as width and length of habitat, substrates, alkalinity, and water depth and velocity were all used to determine the WUA for each species, where available. For Rainbow Trout and Coastal Cutthroat Trout, the HSI Flow Master worksheet (Bech *et al.*, 1994) using the updated models from 2001 was used to determine percent usable area for each transect. The summary of these results and WUA calculations is shown in Table M.

Table M: Habitat characteristics by site and calculated rearing capacity (WUA) for habitats at each site for Rainbow Trout parr and fry, and Cutthroat Trout parr and fry.

Site	Habitat Type	Channel Type	Mean Velocity (m/s)	Mean Depth (m)	Max Velocity (m/s)	No. of Transects	Habitat Length (m)	Mean Width (m)	Habitat Area (m^2)
1	Bar Edge	Main	0.32	0.32	0.71	3	52	12.8	665.6
2	Bar Tail	Main	0.14	0.28	0.38	3	88	15	1320
3	Riffle	Summer	0.22	0.23	0.57	1	50	17	850
4	Riffle	Summer	0.38	0.39	0.60	1	30	10.5	315
5	Cut Bank	Side	0.34	0.45	0.46	1	180	2	360
6	Bar Edge	Side	0.49	0.47	0.84	2	140	7	980
7	Bar Edge	Main	0.27	0.45	0.48	1	34	8.5	289
8	Open Nook	Side	0.02	0.53	0.04	1	105	6.5	682.5
9	Channel Nook	Main	0.00	0.15	0.00	1	23	8	184
10	Bar Edge	Main	0.00	0.30	0.00	1	140	13	1820
11	Bar Tail	Main	0.03	0.37	0.10	1	54	10	540

	Rainbow Trout Parr				Rainbow Trout Fry				Cutthroat Trout Parr				Cutthroat Trout Fry			
Site	Mean % Useable Area	Useable Area (m^2)	Calculated Density (FPU)	Rearing Capacity (#/site)	Mean % Useable Area	Useable Area (m^2)	Calculated Density (FPU)	Rearing Capacity (#/site)	Mean % Useable Area	Useable Area (m^2)	Calculated Density (FPU)	Rearing Capacity (#/site)	Mean % Useable Area	Useable Area (m^2)	Calculated Density (FPU)	Rearing Capacity (#/site)
1	69.7	463.9	7.5	34.9	39.7	264.2	18.6	49.1	49.3	328.1	7.7	25.2	45.0	299.5	53.5	160.4
2	55.0	726.0	7.5	54.6	69.0	910.8	18.6	169.3	83.7	1104.8	7.7	85.0	76.7	1012.4	53.5	542.1
3	64.0	544.0	7.5	40.9	75.0	637.5	18.6	118.5	77.0	654.5	7.7	50.4	70.0	595.0	53.5	318.6
4	89.0	280.4	7.5	21.1	23.0	72.5	18.6	13.5	61.0	192.2	7.7	14.8	18.0	56.7	53.5	30.4
5	92.0	331.2	9.2	30.5	26.0	93.6	22.8	21.3	72.0	259.2	9.4	24.4	22.0	79.2	65.6	51.9
6	63.0	617.4	7.5	46.4	40.0	392.0	18.6	72.9	56.0	548.8	7.7	42.2	44.5	436.1	53.5	233.5
7	86.0	248.5	7.5	18.7	40.0	115.6	18.6	21.5	90.0	260.1	7.7	20.0	41.0	118.5	53.5	63.4
8	10.0	68.3	7.5	5.1	11.0	75.1	18.6	14.0	97.0	662.0	7.7	50.9	38.0	259.4	53.5	138.9
9	0.0	0.0	7.5	0.0	19.0	35.0	18.6	6.5	57.0	104.9	7.7	8.1	99.0	182.2	53.5	97.5
10	0.0	0.0	7.5	0.0	14.0	254.8	18.6	47.4	85.0	1547.0	7.7	119.0	78.0	1419.6	53.5	760.2
11	17.0	91.8	7.5	6.9	18.0	97.2	18.6	18.1	93.0	502.2	7.7	38.6	66.0	356.4	53.5	190.8

Table N. Summary of substrates encountered at each site, October 2015.

Site	1	2	3	4	5	6	7	8	9	10	11
Substrate	%	%	%	%	%	%	%	%	%	%	%
Clay						18.8					
Silt	0.9				50.0	27.5					50.0
Sand	3.8		1.5	25.0	50.0	31.9	11.4	34.6		20.0	50.0
Coarse Sand			27.7				17.1			15.4	
Small Gravel	5.7	10.9	1.5	15.6		21.7	8.6	50.0	11.1	1.5	
Gravel Mix	10.4	5.0	24.6	43.8			2.9			9.2	
Large Gravel	19.8	18.5	18.5	3.1			34.3			18.5	
Small Cobble	47.2	55.5	21.5	12.5			25.7	15.4	55.6	30.8	
Cobble Mix	11.3	5.9	4.6						16.7	4.6	
Large Cobble	0.9	4.2							16.7		
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

It is important to remember that the WUA is based on calculations of habitat length and transect width at each site. The WUA does not represent the usable area for the entire Lower Stave River, just the habitat immediately around each site. However, information can be gathered from this data, such as the comparison of available habitat between Coastal Cutthroat Trout and Rainbow Trout, and fry *vs*. parr habitat. In addition, substrate summaries for each site are provided in Table N.

3.2.6.1 Rainbow Trout and Coastal Cutthroat Trout

For more information on the following site descriptions and usable area for Rainbow Trout and Coastal Cutthroat Trout, see Appendix 1 for site by site HSI curves plotted with depth and velocity data collected in the field.

Based on the HSI curves, ideal habitat requirements for Rainbow Trout parr are peak water velocity between 3.0 and 5.5 m/s, and depth greater than 0.3m (or greater than 0.2m for the Fraser River HSC curves from Rempel *et al*., 2012), and use of larger substrates (Rempel *et al*., 2012). For Rainbow Trout fry, peak water velocity of around 0.2m/s is ideal, with depths between 0.04m and 0.3m and gravel sized substrates (not included in WUA calculations) (Rempel *et al*., 2012). Coastal Cutthroat Trout parr ideal habitat is water velocity less than 0.4m/s and depth greater than 0.15m. For Coastal Cutthroat Trout fry, water velocity under 0.25m/s and depth of less than 0.3m is ideal.

Sites 1 and 2 were situated on gravel bars along the mainstem of the Lower Stave River. These sites were primarily gravel and cobble, with variable velocities, increasing with distance from the shoreline. Mean depth was similar between the sites, and increased with distance from the shoreline, as well. Usable area for Rainbow Trout parr was higher at Site 1 (69.7%) than Site 2 (55.0%), due to a higher proportion of swift water in Site 1. Rainbow Trout fry, on the other hand, had good usable area in Site 2 (69.0%) but only moderate usable area in Site 1 (39.7%), again due to water velocity which was too swift for fry in Site 1. Coastal Cutthroat Trout parr and fry had similar usable area, with Site 1 having moderate usable area (49.3% and 45.0%, respectively) and Site 3 having good to excellent usable areas (83.7% and 76.7%, respectively).

Sites 3 and 4 were adjacent to each other on a riffle cutting across the top end of a gravel bar. This habitat type is equivalent to what Rempel (2004) has described as a Summer Channel, however, in this circumstance, the riffle is inundated during high tide, but dry during low tide, rather than seasonally. Site 3 was upstream of Site 4 and had a small pool component with a piece of large woody debris. Neither site had any riparian cover associated with the channel. This channel was swift and shallow with mostly gravel and small cobble as substrates. Sites 3 and 4 were good to excellent for Rainbow Trout parr, but only Site 3 had good usable area for fry, whereas Site 4 had a low usable area of 23%. Coastal Cutthroat Trout usable area for Sites 3 and 4 were good for parr, but again, only Site 3 was good for fry, as Site 4 had a low usable area of 18% for fry. For both Rainbow Trout and Cutthroat Trout fry, Site 4 was too swift and too deep in sections to provide adequate usable area.

Sites 5, 6, and 7 had good riparian cover. Sites 5 and 6 were in the side channel towards the outflow to the Stave River. The channel at Sites 5 and 6 was fast flowing with very fine sediments and a steep profile, especially at site 5. Instream large woody debris was common in the channel at Sites 5 and 6, in addition to a few wooden pilings. Site 7 was on the channel edge of the mainstem Lower Stave River, on the far left bank. Water at Site 7 was swift, with a gradual slope out to the center of the channel. These three sites had good to excellent usable area for Rainbow Trout parr, but only low to moderate usable habitat for fry. Coastal Cutthroat Trout parr usable area for Sites 5, 6, and 7 was also good to excellent, and low to moderate for fry. Water velocity for fry of both species was considered too swift and limited usable habitat.

Low water velocities at Sites 8, 9, 10, and 11 led to very low usable area at these sites by Rainbow Trout parr in particular, but also fry. Usable area for Cutthroat Trout parr and fry, however, was moderate to excellent for these 4 sites (38% low at Site 8 and a high of 99% at Site 9 for Coastal Cutthroat Trout fry). Site 8 was in the side channel on river left, close to the boat launch. The site was a large open nook with very low velocities, or still water. Closer to the centre of the channel where the transect ended, water was moving upstream at the edge of a back eddy. Site 9 was in a channel nook with no flow. The channel nook was only flooded at high tides, but provided good shelter habitat for young sculpins. Site 10 was at the edge of a channel that cut between two gravel bars. Water flow was minimal along the channel edge, though the thalweg had moderate flow, it was too deep to measure and too far to reach. Site 11 was a sandy bar tail bench with slow water. The water profile dropped off drastically at the edge of the bench, closer to the center of the channel. Sites 8 and 9 had some riparian cover. Cover was more abundant at Site 8, which also had an undercut bank and trees that extended over the water. Sites 10 and 11 had minor instream cover around large woody debris and wooden pilings.

A summary of these habitat suitability descriptions is in Table O, below.

Table O: Summary of Rainbow Trout and Cutthroat Trout habitat suitability at all sites sampled on the Lower Stave River, October 2015. High suitability is equal to ≥70%, med suitability is <70% and ≥40% and low suitability is <40%.

Site	Habitat Type	Channel Type	Mean Velocity	Mean Depth	Max Velocity	Rb Parr Suitability	Rb Fry Suitability	Ct Parr Suitability	Ct Fry Suitability
1	Bar Edge	Main	0.32	0.32	0.71	High	Low	Med	Med
2	Bar Tail	Main	0.14	0.28	0.38	Med	Med	High	High
3	Riffle	Summer	0.22	0.23	0.57	Med	High	High	High
4	Riffle	Summer	0.38	0.39	0.60	High	Low	Med	Low
5	Cut Bank	Side	0.34	0.45	0.46	High	Low	High	Low
6	Bar Edge	Side	0.49	0.47	0.84	Med	Med	Med	Med
7	Bar Edge	Main	0.27	0.45	0.48	High	Med	High	Med
8	Open Nook	Side	0.02	0.53	0.04	Low	Low	High	Low
9	Channel Nook	Main	0.00	0.15	0.00	None	Low	Med	High
10	Bar Edge	Main	0.00	0.30	0.00	None	Low	High	High
11	Bar Tail	Main	0.03	0.37	0.10	Low	Low	High	Med

Investigations into biomass benchmarks for Coastal Cutthroat Trout (Ptolemy, 2005) by ecoregion were carried out to determine the use of the benchmarks by area. For the Fraser Lowlands ecoregion, the benchmark was determined to be 582g/100m^2, or BPU. Using the FPU calculations from above and the size classes determined for Coastal Cutthroat Trout, we can assume the Lower Stave River has the potential to support 133.8g/100m^3 to 930.9g/100m^3, depending on the size class and alkalinity of the water (Table P). The only site with elevated alkalinity, allowing a greater BPU, was in the side channel. The remainder of the sites were constant, producing a lower BPU. If we assume the lower BPU is more likely, then 133.8g/100m^3 and 134.0g/100m^3 are the potential BPUs for the Lower Stave River. This is only 23% of the benchmark for the bioregion, based on Ptolemy's findings. However, this is an upper limit benchmark and should be scaled according to the mesohabitat ratings, such as those determined during this study.

Table P: Coastal Cutthroat Trout BPU calculations for the Lower Stave River.

Parameter	Class 1 (0+)	Class 2 (1+)
Length (cm)	4.0 – 6.0	8.5 – 10.7
Mean Length (cm)	4.46	9.38
Mean Weight (g)	2.5	17.4
FPU (#/100m^3)	53.5 and 65.6	7.7 and 53.5
BPU (g/100m^3)	133.8 and 163.8	134.0 and 930.9

3.2.6.2 Brassy Minnow

As HSI spreadsheet models for Brassy Minnow do not exist, a comparison of habitat characteristics to the Golder, 2008 model has been used and is the reference for the following description. For riverine habitat, rearing Brassy Minnow use pools, backwaters and flats, with lesser use of runs and only minnow use of riffles. Ideal substrates are gravel, sand and clays/silts, with some minnow use of cobble and rubble and minnow use of bedrock and boulders. Instream cover from submergent and emergent plants is highly used, while woody debris and rock cover is sometimes used. Total instream cover of greater than 50% is ideal, with less instream cover equating less useable habitat. Additionally, water pH of 6 to 9 is also ideal.

Upon review of the Lower Stave River October 2015 data, Brassy Minnow habitat is considered very limited in the Lower Stave River. Well vegetated pools and backwaters are not available with the exception of the side channel (Sites 5, 6, and 8). The upper end of the side channel near Site 8 may offer some Brassy Minnow habitat, but further down the water is too swift by Sites 5 and 6. It is possible that some of the channel offshoots and nooks towards the middle of the side channel would offer some above average habitat. The mainstem Lower Stave River does not offer any Brassy Minnow habitat better than a suitability index of 0.25 (below average). This lack of habitat is mainly due to a lack of instream cover. Most of the habitat in the mainstem Lower Stave River can be classified as run habitat, which is considered above average (suitability index of 0.75), but without the instream cover, it seems unlikely that this habitat would be used. Water quality (pH) was within the excellent range for Mountain Whitefish at all sampling sites.

To summarize, the side channel on river left of the Lower Stave River could be considered above average habitat (suitability index of 0.75), while the mainstem Lower Stave River is likely below average habitat (suitability index of 0.25) for Brassy Minnow.

3.2.6.3 Mountain Whitefish

HSI spreadsheet models do not exist for Mountain Whitefish as they do for Coastal Cutthroat Trout and Rainbow Trout, however, a several manual models have been provided by Addley *et al*. (2003), Bovee (1978), Rempel *et al*. (2012) and Golder (2008). Fraser River comparisons by Rempel *et al*. are likely the most suitable descriptions of habitat suitability for the Lower Stave River. The following descriptions of Stave River habitat for Mountain Whitefish are based on the Rempel *et al.* (2012) habitat suitability descriptions for the Fraser River, which is the reference for the following section.

Mountain Whitefish fry (0+) in the Fraser River utilize water depths of 0.2m to 0.3m and 0.2m/s to 0.6m/s water velocities, with substrates of gravel, and some sand and cobble. Based on this Fraser River description, Sites 1, 2, and 3 would likely provide good to excellent Mountain Whitefish fry habitat, with some habitat use in Sites 4 and 7. Mountain Whitefish yearlings (1+) in the Fraser River utilize depths between 0.3m and 0.65m, and water velocities of 0.3m/s to 0.5m/s, with gravel substrates dominant and some use of cobbles. Therefore, Sites 1, 4, 5, 6, and 7 would likely provide good to excellent Mountain Whitefish yearling habitat, with some use in Sites 2 and 3. Mountain Whitefish aged 2+ in the Fraser River utilize water depth of 0.5m or greater, with minimal use of water less than 0.2m in depth. Peak water velocity for 2+ Mountain Whitefish is 0.4m/s to 0.6m/s, with gravel as the predominant substrate. Lower Stave River 2+ Mountain Whitefish suitability is likely to be best in Sites 5 and 6 at the end of the side channel where water is deep and swift, while Sites 1, 4 and 7 in the mainstem may offer some average habitat use. A summary of these Fraser River based habitat suitability assumptions are shown in Table Q.

Table Q: Summary of Fraser River based habitat suitability of Mountain Whitefish in the Lower Stave River, based on criteria from Rempel *et al*., 2012.

Site	Habitat Type	Channel Type	Mean Velocity	Mean Depth	Max Velocity	0+ Suitability	1+ Suitability	2+ Suitability
1	Bar Edge	Main	0.32	0.32	0.71	High	High	Med
2	Bar Tail	Main	0.14	0.28	0.38	High	Med	Low
3	Riffle	Summer	0.22	0.23	0.57	High	Med	Low
4	Riffle	Summer	0.38	0.39	0.60	Med	High	Med
5	Cut Bank	Side	0.34	0.45	0.46	Low	High	High
6	Bar Edge	Side	0.49	0.47	0.84	Low	Med	High
7	Bar Edge	Main	0.27	0.45	0.48	Med	High	Med
8	Open Nook	Side	0.02	0.53	0.04	Low	Low	Low
9	Channel Nook	Main	0.00	0.15	0.00	Low	Low	Low
10	Bar Edge	Main	0.00	0.30	0.00	Low	Low	Low
11	Bar Tail	Main	0.03	0.37	0.10	Low	Low	Low

For comparison, the Golder (2008) report describes Mountain Whitefish rearing habitat as excellent (suitability index of 1.0) for pools and flats with rubble, cobble and gravel substrates, and instream cover greater than 30%. Clay, silt and sand substrates with instream cover of 20-30% is above average habitat (suitability index of 0.75) for rearing Mountain Whitefish, while boulders with runs, riffles and only 10-20% instream cover are average habitat (suitability index of 0.5). Rapids, chutes and falls with less than 10% instream cover are below average habitat (suitability index of 0.25), or not suitable. Based on these descriptions, the only suitable habitat in the Lower Stave River is within the side channel on river left, where some flat water, eddies and off-channel habitat exist where instream cover is greatest. While runs and riffles may exist in the mainstem Lower Stave River, there is a lack of instream cover, and likely brings the suitability, based on this model, down to below average (suitability of 0.25).

4.0 DISCUSSION

Fish captures in the Lower Stave River during the October 2015 sampling exercise were very low. The most consistently caught species was Prickly Sculpin. Captures of the four target species -- Rainbow Trout, Coastal Cutthroat Trout, Brassy Minnow and Mountain Whitefish -- were limited to nine Rainbow Trout/Steelhead parr that were captured in minnow traps. Eight fish were classed as fry, and one fish was classed as parr, based on weight and length, but without age verification by scale sample, this method is assumptive. These fish were captured in Sites 5, 6, and 7, where water depths and flows are generally greater than the other sites. All fish except one had adipose fin clips, indicating that these fish were of hatchery stock, and likely Steelhead rather than Rainbow Trout. The origin of the clipped fish has not been confirmed, as local stocking records do not show any fry releases for 2015. It is possible that the clipped fish were fry released in 2014 and were 1+ in age, but based on size, this was considered unlikely.

In the absence of EF captures of any of the four target species, Prickly Sculpin were chosen for density calculations. Density, or FPU, was calculated based on fish captured (observed) and as a theoretical maximum using site-specific alkalinity measurements. Observed Prickly Sculpin density ranged between 0.0% and 19.4% of the theoretical maximum density. However, theoretical maximum densities for 0+ fish were 502 per $100m^2$. This is based on the size of the sculpins being very small in their first year. While densities such as these may be possible just as hatchlings are emerging, such large densities seem unrealistic. It is possible that this model for calculating maximum FPU is better suited to larger 0+ fish, such as the sizes seen in Rainbow Trout fry. Estimates for maximum density in the 2+ Prickly Sculpin did not seem unattainable in ideal situations. Another consideration for this model is that the total maximum density and biomass is based on one species. Where multiple species exist, total density and biomass must account for all living things in that unit area that are using resources and occupying space.

WUA calculations were based on HSI curves and the BC MOE Flow Master spreadsheet. Percent usable area was provided for each transect at each site for Rainbow Trout and Coastal Cutthroat Trout. WUA could not be calculated for either Brassy Minnow or Mountain Whitefish. Nonetheless, assumptions on usability based on available literature were made for these species.

WUA calculations were site specific and based on the availability of the habitat in the direct vicinity of each site. The calculations also used width measurements based on the length of each transect, which didn't always include the entire channel width. Therefore, the WUA calculations are not as useful as the percent usable area for each site. In order to determine the WUA for the entire Lower Stave River many more habitat measurements would be required. Sampling conducted in this study covered less than 10% of the Lower Stave River. However, by comparing habitat types, assumptions can be made about the usability of the Lower Stave River in general. The side channel provides useful habitat for parr of both Rainbow Trout and Coastal Cutthroat Trout in the lowest reaches. Slower water in the upper reaches of the side channel and at main channel sites 10 and 11 may also provide habitat for Coastal Cutthroat Trout parr and fry. The tidal channel (Sites 3 and 4) could provide good habitat for both species, but is a temporary feature and fish would be displaced upon each tidal cycle. Mainstem sites along bar edges (Sites 1, 2, and 7) provide potential habitat use for both species and life stages, where water depth and velocity are typically proportional to the distance from the shore. Limits to these assumptions include the lack of instream complexity, cover, and vegetation at most sites on the mainstem Lower Stave River.

Rainbow Trout usability was typically greatest in moderately fast and deep water for parr, and shallow and slow for fry. For Coastal Cutthroat Trout usability was greatest in slow and deep water for parr and slow and shallow water for fry. There is some overlap in habitat suitability between the two species and life stages where more than one to all four may exist, however, some sites are better suited to some species than others. For example, the side channel at Sites 5 and 6 had high usability for parr of both species but not fry, and Sites 9, 10, and 11 had low usability by Rainbow Trout, but medium or high usability by Coastal Cutthroat Trout.

Brassy Minnow usable area in the Lower Stave River is likely limited to the side channel on river left, which could be considered above average habitat (suitability index of 0.75). The mainstem Lower Stave River is likely below average habitat (suitability index of 0.25) for Brassy Minnow. WUA measurements were not available for this species.

Several models for determining Mountain Whitefish suitable habitat exist. The Fraser River model has been chosen as the most appropriate model. The slow waters sites were considered unsuitable habitat for all life stages of Mountain Whitefish, while habitat in the lower reaches of the side channel where water was swift was considered suitable for 1+ fish or older, but not suitable for young-of-year fish (0+). The remaining mainstem Stave River sites offered a good balance of depth and velocity for medium to high quality habitat for Mountain Whitefish, based on the Fraser River data.

Flows from the Ruskin Dam for the Lower Stave River for the duration of the project period were 175m^3/s during the first three days of sampling and the reconnaissance day, and 69m^3/s on the final day of sampling. The management target baseflow of 100m^3/s during spawning and incubation periods for anadromous salmon could not be supplied by BC Hydro as weather conditions required the release of excess flows prior to a heavy rain event. Despite requests to moderate flows at a specific level, sampling had to be conducted in the conditions that were available. Important to note that water flow on the last day of sampling (Sites 10 and 11) was more than 100m^3/s lower than the other sampling days, thereby possibly affecting water velocity at these sites. Water velocities measured during the final day of sampling were very low, or nil. It was difficult to determine in the field whether these low velocities were a result of low flows, or a product of each individual site. Compared to other sites that were similar, it seems reasonable that the flow at Site 10 was reduced enough to cause a change in water velocity at this site. Site 11 had very fine substrates and was situated on a shallow ledge, and therefore is likely always sheltered from heavy velocities which are limited to the much deeper channel. It can be assumed that Site 10 was affected by the low flow, but Site 11 was not.

Flow data from the Ruskin Dam for 2015 showed a low flow period in June, followed by July. Historically, the Lower Stave River had a peak discharge in June and July when freshet was strongest. This is comparable to the Fraser River and the Pitt River. However, with the Ruskin Dam in place, and the Stave Falls dam upstream, water flow to the Lower Stave River can be controlled. Backup into the Lower Stave River from the Fraser River during freshet provides water depth, but not flow. The CPSF for most systems is in August or September, which is the month of lowest flow during the growing season, as it is in the Fraser River and the Pitt River. Winter flow regimes in the Lower Stave River can be very high, at times well above 250m^3/s, and spiking to greater than 650m^3/s. These high flows and sudden jumps or drops in flows can be problematic for fish, either forcing fish out of watercourses when velocities are too high and shelter is not available, or by causing stranding when flows suddenly drop.

Previous WUP Fish Monitor reports (Glova *et al*., 2011; and Glova and Robichaud, 2014) concluded that lower flows in the mainstem, particularly flows between 50-125m^3/s, were potentially more suitable for resident fish species, particularly Peamouth fry and Three-spined Stickleback. Additionally, Rainbow Trout fry, cottid fry, and Northern Pikeminnow may also be more abundant in the mainstem during lower flows. While results from the earlier studies were not conclusive, these results are based on beach seine surveys as opposed to EF methods used in 2015. Fish sampling in the side channel during the previous studies was conducted using MT, comparable to the 2015 methods. Cottids were abundant in the side channel in all studies. Three-spined Stickleback were oddly absent in the 2015 study (only one individual captured in the mainstem by MT). The high flow conditions of 175m^3/s in the 2013 study (Glova and Robichaud, 2014) were comparable to most of the 2015 sampling survey, with the exception of the last day of 2015 sampling when flows were reduced to 69m^3/s. However, with a lack of site characteristic data, such as depth, velocity and substrates, the 2013 data could not be incorporated into the 2015 data.

5.0 CONCLUSION

The key management question from the original terms of reference was:

> *Do (Stave Falls Water Use Plan) operations based on anadromous salmonid rearing and spawning criteria conflict with the seasonal habitat use patterns of other resident fish species?*

In order to address this management question, Addendum 3 (BC Hydro, 2014) was developed, detailing a study design to address the management question for resident fish. The following impact hypothesis was developed for the original terms of reference:

> *H01: Releases downstream of Ruskin dam do not impact the seasonal habitat-use patterns of resident fish species, particularly non-salmonid species.*

To test the hypothesis and answer the management question the aim of the project was to test the following:

a. *If the hydraulic and habitat capacities observed in the summer are suitable for resident rearing using habitat suitability collected during the study;*

b. *If the attributes of winter flow regimes (average/peak flows, flow variation/consistency) represent limiting factors for overwintering survival using past reports from the SFL MON study and inferring the potential for any critical factors identified to impact overwintering survival; or*

c. *If there are other environmental or Fraser River (tidal/freshet) factors that may represent limiting factors for overall rearing in the Lower Stave River using existing literature, Lower Fraser flow records, and environmental data to infer any potential issues that may impact the productivity of rearing resident fish in the Lower Stave River.*

This question is difficult to answer. Each of the four target resident species, including Rainbow Trout, Coastal Cutthroat Trout, Brassy Minnow, and Mountain Whitefish, have different habitat suitability requirements. In addition, flows during the study were not constant, and were not at the 100m^3/s minimum flow. Flows on the Lower Stave River during the study were either well above the spawning salmon target flow of 100m^3/s at 175m^3/s, or below at 69m^3/s. This has led to uncertainty in the data, as to whether 100m^3/s flows create suitable habitat conditions for resident fish.

A number of initial conclusions may be made:

- Rearing habitat for Coastal Cutthroat Trout was found to be suitable at most sites sampled for either fry, parr, or both lifeforms.
- Habitat for Rainbow Trout was not suitable at many of the low velocity sites, especially for parr.
- low velocity habitats are not suitable for Mountain Whitefish
- Brassy Minnow habitat is strongly linked to instream cover, and slower pool type habitat, therefore the only adequate habitat for Brassy Minnow in the Lower Stave River is in the side channel.
- All of the target species should be able to find habitat that suits their individual habitat requirements within the side channel, whether it is in the slow, upper reaches, or in the fast lower reaches. Accessibility to the side channel was not assessed but, from observations on site, the flow where the side channel enters back into the Stave River is very swift and may be a hindrance to upstream migration.

Several confounding issues remain:

Limits to extrapolation of findings: The Lower Stave River is a dynamic system that is constantly in flux. In general, the Lower Stave River is fairly uniform in habitat (excluding the side channel) from a broad perspective. Gravel bars have little to no vegetation, large woody debris is minimal or limited to wooden pilings, substrates are mostly gravels and cobbles, and there is a lack of pool habitat. Furthermore, many habitat features are small and disappear with rising tides, or dry out at low tides. Most sites that were selected for sampling could be considered temporary features produced by tides and water flow conditions. While the side channel is a fairly constant feature, the gravel bars with tidal channels, channel nooks, and channel edges all can change from hour to hour, or season to season. Habitat suitability calculations may only be realistic for a site at a particular tide level and flow. Once the tide changes, depth and velocity change, too, as is true for change in flow.

Extreme-year events: During 2015, very low flows were reported in June (average 17.36m^3/s) and July (average 28.80m^3/s), well below the target 100m^3/s. While water depth was likely not affected due to the effect of the Fraser River freshet, water velocity likely was. This could impact available habitat for the rearing resident fish and the Lower Stave River becomes more lake-like than riverine. Winter and spring flows may also cause challenges with rapidly changing flows and high peaks in flows.

Small data sets: Catchability of fish was an issue, and based on past sampling, it may be fair to conclude that some resident species are not common in the Lower Stave River; therefore, modelling for habitat suitability is moot. Based on the lack of fish data, it was impossible to compare the WUA and habitat suitability data to fish catch. Observed FPU for Prickly Sculpin compared to theoretical maximum FPU was poor, however, only EF captures were included in the calculations. Using EF methods to compare sites is a good practice as fixed areas are easily defined and it ensures only fish from the fixed area are captured. However, in a system like the Lower Stave River where instream cover is limited or non-existent, and habitat is constant and open, establishing fishing enclosures for electrofishing may have the effect of scaring fish away before they can be enclosed.

In conclusion, the Lower Stave River may provide some adequate habitat for rearing resident fish species during flow conditions of 175m^3/s, with the most valuable habitat being in the side channel where multiple habitat types exist, and protection from higher mainstem velocities is available. Based on the 2013 survey, lower flows around $125m^3/s$ in the mainstem may provide more suitable rearing habitat than the $175m^3/s$ flows experienced in 2013 and 2015. Additionally, very low flows of less than $100m^3/s$ may limit rearing opportunities in the mainstem Lower Stave River, based on the 2015 sampling data. Flows during freshet, which are reduced due to the influence of the Fraser River, and flows during the winter and spring may limit rearing capabilities by decreasing or increasing water velocities, respectively. Furthermore, changing tide conditions create or eliminate channel features in the Lower Stave River mainstem on a twice daily basis. In the end, it is challenging to definitively state whether flow conditions set for spawning salmon and incubation affect the rearing capacity of resident fish species.

5.1 Challenges

There were several challenges during the field program and research for this project including changing tides levels, changing flows, the presence of spawning salmon and the people that were fishing for them, the limits of the study area, the efficiency of electrofishing in a system like the Lower Stave River, the availability of suitable EF sites, and the availability of WUA and HSI models.

Changing daily tides were a challenge, as EF sites could change drastically in water level and extent from the start to finish. By the time EF work was complete and habitat assessment transects were started, the site could be completely different from the start of EF work. Some habitat features that looked suitable for EF could only be fished at particular tide levels.

Flows from the dam were constant during the first three days of sampling, but were more than $100m^3/s$ lower on the final day of sampling. In addition, the flow level that was required for the study was not attainable. In the absence of constant flow at the desired flow level, firm conclusions are difficult to make.

In addition to changing tides and flows, EF sampling was challenging due to the lack of complexity in the mainstem Stave River. Sites that were suitable in depth and velocity to safely EF did not provide adequate shelter for fish, so it is likely that the process of setting up EF enclosures scattered fish, which were then never captured. The use of MT was good for comparing fish species presence, but could not be used for determining FPU.

The presence of spawning Chum and Pink Salmon on the Lower Stave River caused several problems. Spawning fish had to be avoided for EF work, and therefore the side channel was only sampled using minnow traps. Finding suitable EF sites was further limited by the presence of spawning salmon. Furthermore, many members of the public were out fishing on the river, taking advantage of the salmon return. This became and health and safety concern, as electric current from the EF unit could seriously harm someone who was not protected properly. Signage was erected around work sites, and members of the public were spoken to about the work that was being conducted.

Determining WUA for the Lower Stave River was a challenge as the habitat that was sampled represented less than 10% of the available habitat in the area. To fully assess the WUA of the entire Lower Stave River complete cross sections across the entire river would be required, and at frequent intervals. This would be very labour intensive, and again would be influenced by any changes in tides and flows.

Finally, the availability of WUA and HSI models was a challenge during the reporting phase of the project. Models were not available for all four of the target resident species, and models that did exist were not always appropriate for a large river such as the Lower Stave River.

5.2 Recommendations

If further sampling for rearing resident fish habitat is planned, the following recommendations are suggested:

1. **Additional Transects**: Habitat assessment transects were useful in determining habitat suitability for some of the target species. These transects could be repeated at additional sites at varying flow conditions;
2. **Fish presences/absence studies**: Using fishing methods other than backpack EF is advised to determine presence/absence and relative abundance in order to ascertain whether resident fish actually exist in the Lower Stave River in numbers sufficient to support a rearing population. MT and beach seining are useful methods for this River, as recommended by the 2011 LGL Report (Glova *et al*., 2011). However, the 2014 LGL report (Glova and Robichaud, 2014) suggested that differences in beach seining efficiency at higher flows could not be accounted for or determined, and may affect the results. The 2011 Glova *et al*. report also suggested the use of a bottom-trawl jetboat to conduct sampling in high flow conditions. This can be particularly useful for maintaining efficiency between high and low flow conditions. Boat electrofishing may also provide useful data for fish presence/absence and relative abundance;
3. **No further Brassy Minnow study**: It is likely that Brassy Minnow may not even exist below the Ruskin Dam on the Lower Stave River, and should not be included in further resident fish monitoring programs;
4. **Controlled flow conditions during study:** Sampling should be conducted at constant flow conditions, and repetition of sites is encouraged within the same season. Additionally, repetition of sites used in the 2015 study is also recommended for ease of comparison;
5. **Scale sampling for age analysis:** If ageing of fish is important (for FPU or WUA calculations), it is recommended that scale samples be taken from captured juvenile salmonids. Therefore, any discrepancy between size classes can be confirmed with ageing data;
6. **Even-numbered year sampling:** Sampling should be conducted in an even-numbered year, to avoid the confounding presence of Pink Salmon spawners;
7. **In-lab Alkalinity analysis:** Lab analysis of alkalinity may be a good backup method to confirm *in situ* testing results, especially if using a drop titration method test kit. Alkalinity is an important component in the calculation of potential habitat density (FPU); therefore, imprecision may over- or under estimate potential habitat density; and
8. **Parallel Study**: Establishing a sampling program that compares Lower Stave River WUA with WUA in a similar system. The Pitt River is an ideal system for comparison and while reconnaissance to select appropriate sampling locations will require some time, a comparison will allow conclusions about flow rate suitability for resident species to be made with greater certainty. For a comparison study of this nature to yield meaningful results, flow from the Ruskin Dam will need to be maintained at or very near the WUP target flow of 100m^3/s. Fish sampling to compare relative abundance between systems may also be considered.

6.0 ACKNOWLEDGEMENTS

The successful completion of this project was the result of the coordination of many people and businesses. Appreciation and thanks are recognized for the following: Darin Nishi and Brent Wilson of BC Hydro for funding this project and assisting with the planning process, coordination and logistics. BC Hydro also provided the use of their boat and access to the boat ramp at the Ruskin Generating Station. Additional thanks to Jeff Greenbank of Greenbank Environmental Inc. for providing advice and onsite assistance. Seyem' Qwantlen Business Group provided administrative assistance and field technicians, Joey and Josh Antone. Special thanks to Joey Antone for operating the boat, without whom this project would not have been possible. Candace Rose-Taylor assisted in the field from Cascade Environmental Resource Group Ltd. Rose Spicker of Spicker GIS Services provided mapping and GIS services. From PGL, thanks go to Tyler Gray and Matt Hammond for providing technical and scientific advice, and Susan Wilkins and Leslie Beckmann for providing support and reviewing the final draft.

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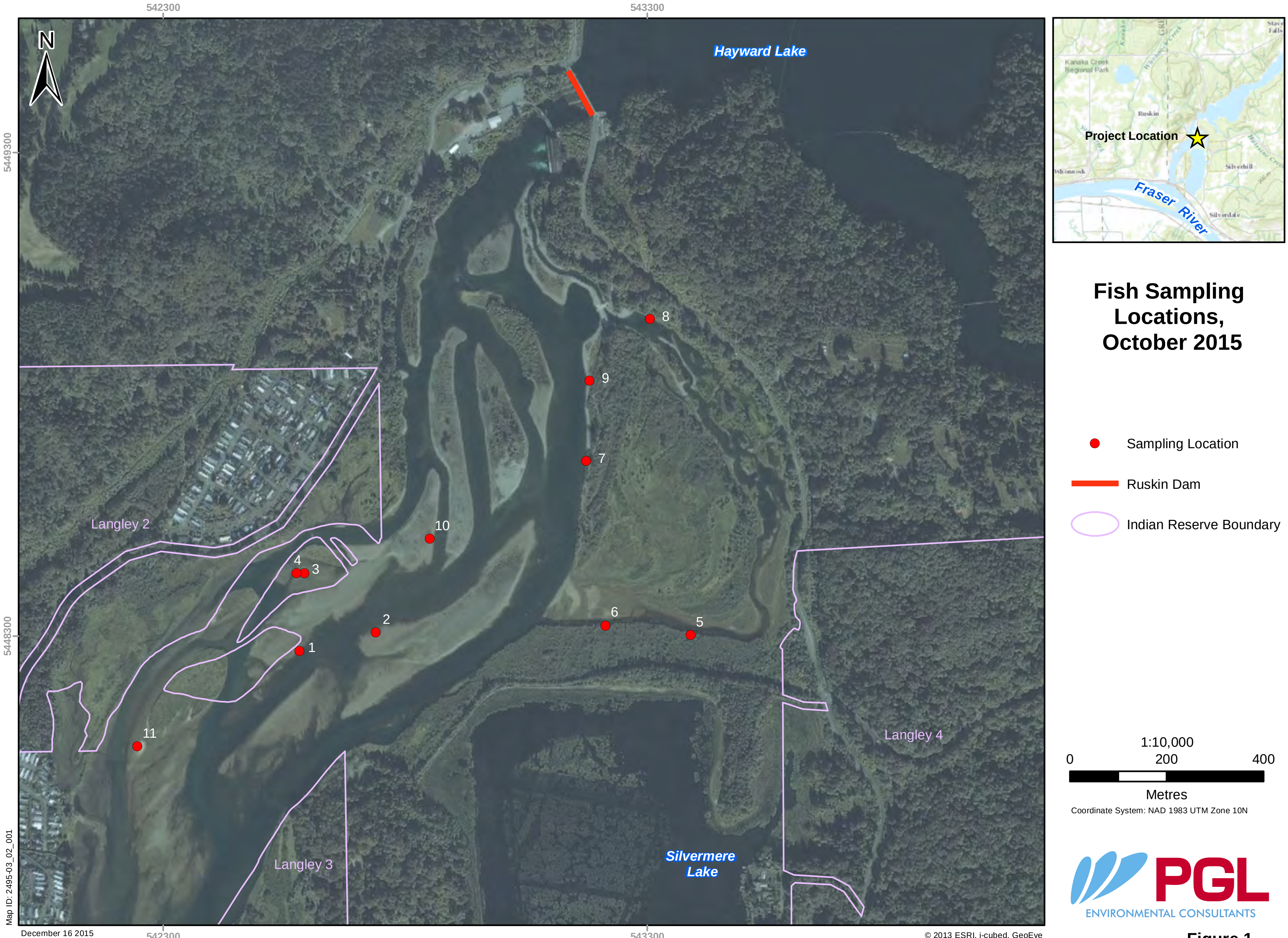
Figure



Fish Sampling Locations, October 2015

Sampling Location
Ruskin Dam
Indian Reserve Boundary

1:10,000
0 200 400
Metres
Coordinate System: NAD 1983 UTM Zone 10N

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Figure 1

Appendix 1

HSI Curves for Rainbow Trout and Coastal Cutthroat Trout

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Appendix 1

Site-by-site HSI graphs were created for both Rainbow Trout and Cutthroat Trout, as these were the two models available. The following HSI graphs and tables in this section were created using the BC MOE Flow Master Spreadsheet (Bech *et al*., 1994, revised 2010). Tables are outputs from the model that summarize percent usable area for each transect. Each figure represents the habitat suitability for the site by species and age class.

SITE 1

Table S1-A. Site 1, Transect 1 percent usable area.

ADJUSTED USABLE AREAS

% USABLE BY RBT FRY	43	%
% USABLE BY RBT PARR	68	%
% USABLE BY CT FRY	51	%
% USABLE BY CT PARR	50	%
% USABLE BY CHINOOK	62	%
% USABLE BY COHO	34	%
Generic Insect suitability	41	%

Table S1-B. Site 1, Transect 2 percent usable area.

ADJUSTED USABLE AREAS

% USABLE BY RBT FRY	33	%
% USABLE BY RBT PARR	59	%
% USABLE BY CT FRY	40	%
% USABLE BY CT PARR	29	%
% USABLE BY CHINOOK	47	%
% USABLE BY COHO	21	%
Generic Insect suitability	47	%

Table S1-C. Site 1, Transect 3 percent usable area.

ADJUSTED USABLE AREAS

% USABLE BY RBT FRY	43	%
% USABLE BY RBT PARR	82	%
% USABLE BY CT FRY	44	%
% USABLE BY CT PARR	69	%
% USABLE BY CHINOOK	78	%
% USABLE BY COHO	37	%
Generic Insect suitability	43	%

Rainbow Trout

Figure S1-A. Site 1 Rainbow Trout parr HSI model for velocity.

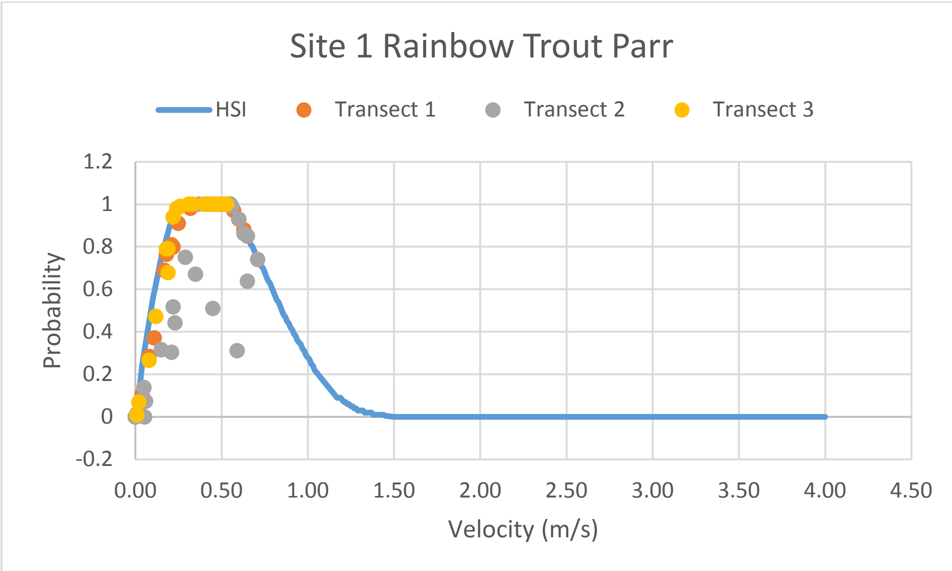


Figure S1-B. Site 1 Rainbow Trout parr HSI model for depth.

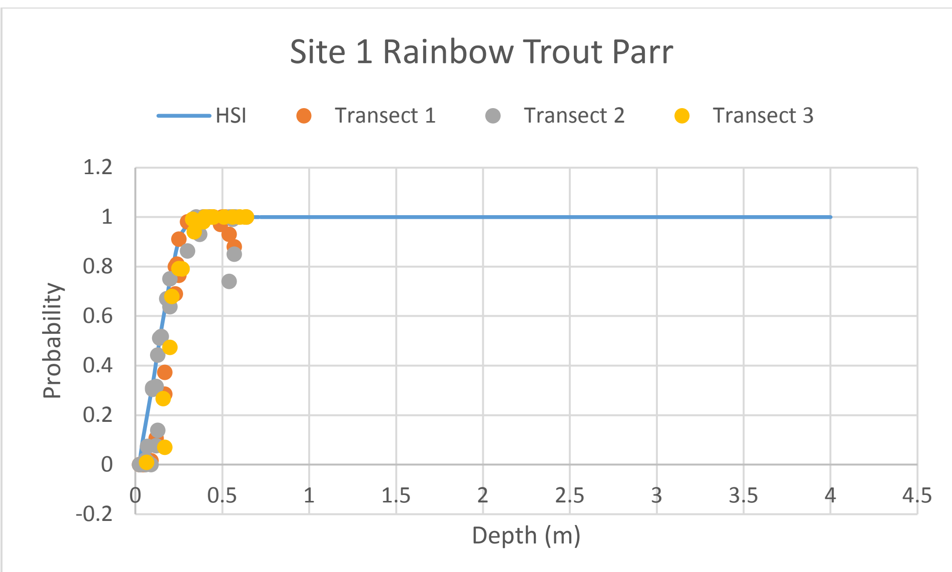


Figure S1-C. Site 1 Rainbow Trout fry HSI model for velocity.

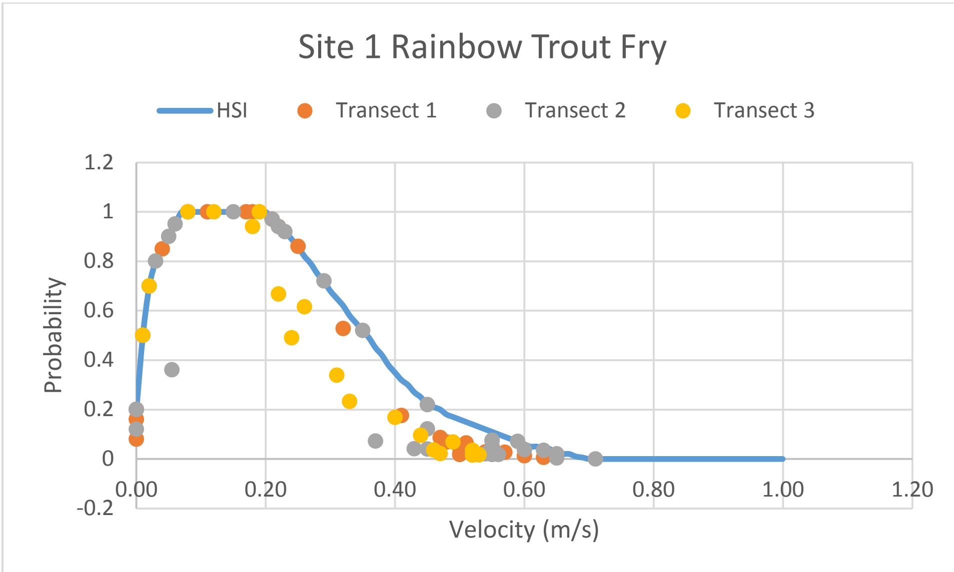
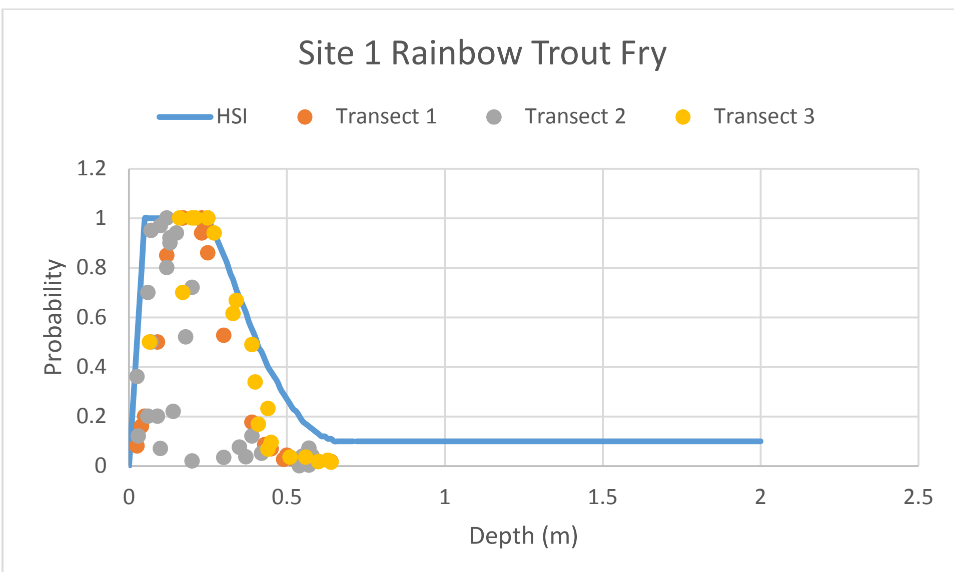


Figure S1-D. Site 1 Rainbow Trout fry HSI model for depth.



Cutthroat Trout

Figure S1-E. Site 1 Coastal Cutthroat Trout parr HSI model for velocity.

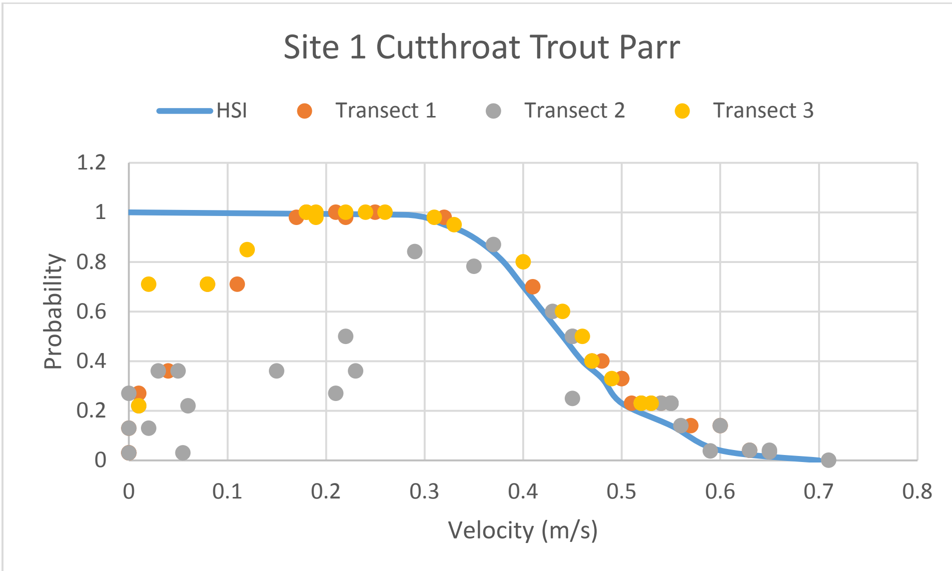


Figure S1-F. Site 1 Coastal Cutthroat Trout parr HSI model for depth.

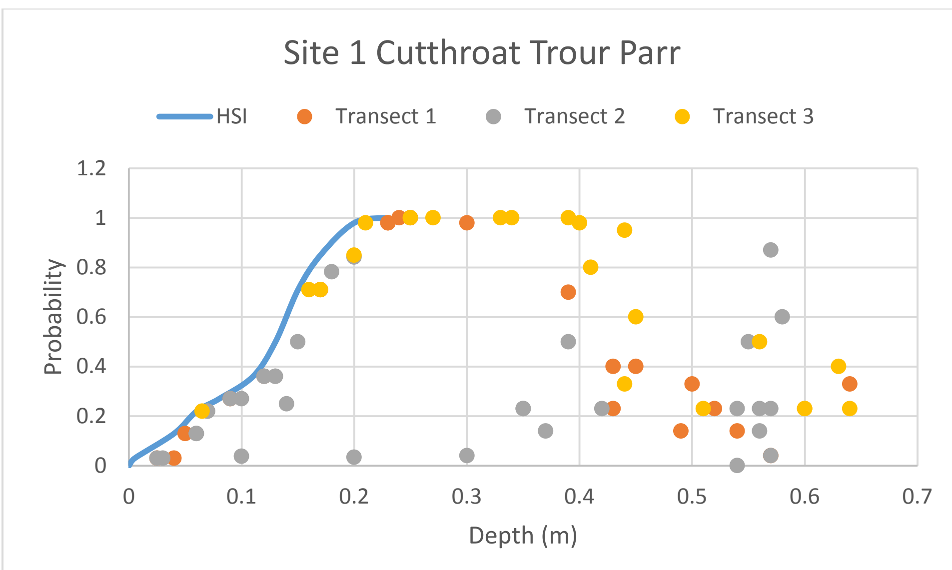


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Figure S1-G. Site 1 Coastal Cutthroat Trout fry HSI model for velocity.

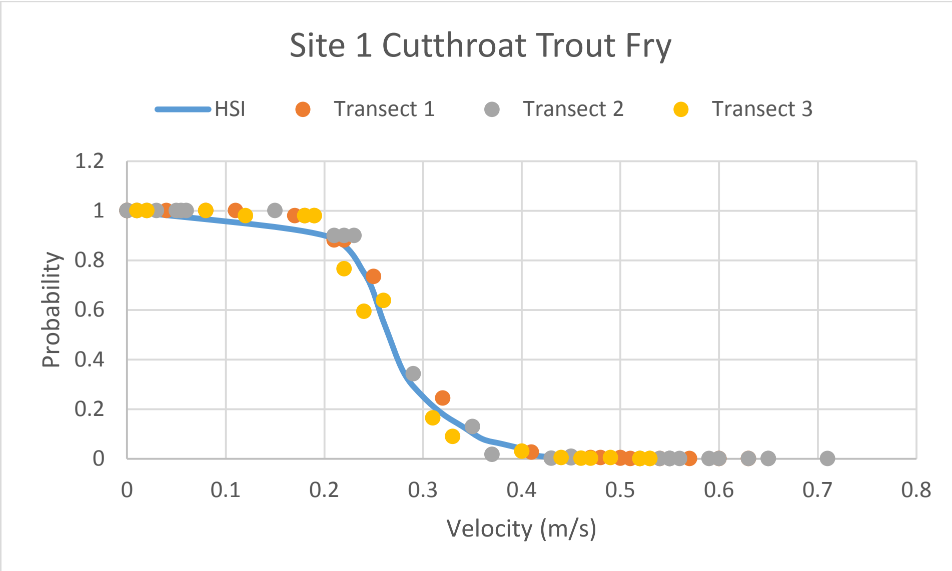
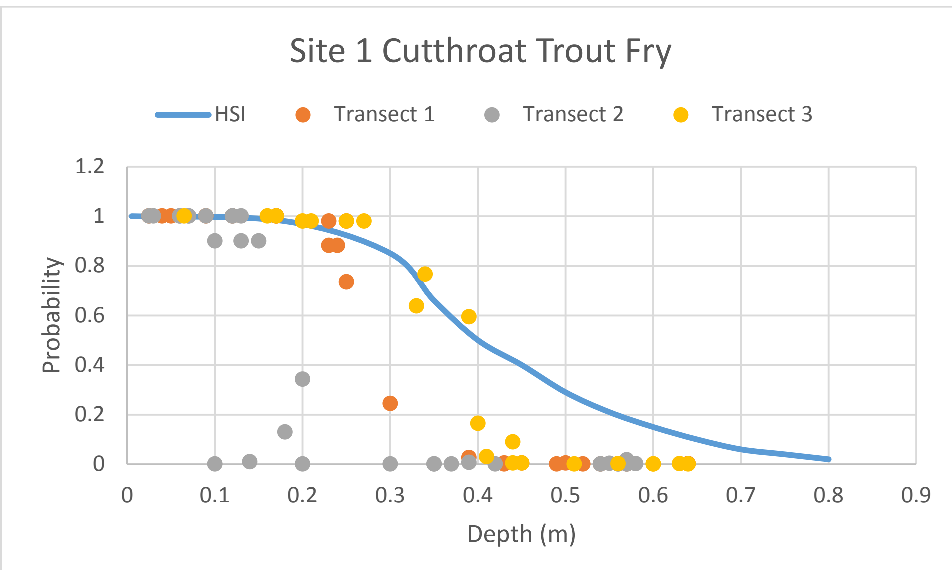


Figure S1-H. Site 1 Coastal Cutthroat Trout fry HSI model for depth.



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SITE 2

Table S2-A. Site 2, Transect 1 percent usable area.

% USABLE BY RBT FRY	44	%
% USABLE BY RBT PARR	62	%
% USABLE BY CT FRY	52	%
% USABLE BY CT PARR	93	%
% USABLE BY CHINOOK	66	%
% USABLE BY COHO	73	%
Generic Insect suitability	19	%

Table S2-B. Site 2, Transect 2 percent usable area.

ADJUSTED USABLE AREAS

% USABLE BY RBT FRY	80	%
% USABLE BY RBT PARR	39	%
% USABLE BY CT FRY	96	%
% USABLE BY CT PARR	75	%
% USABLE BY CHINOOK	47	%
% USABLE BY COHO	80	%
Generic Insect suitability	8	%

Table S2-C. Site 2, Transect 3 percent usable area.

ADJUSTED USABLE AREAS

% USABLE BY RBT FRY	83	%
% USABLE BY RBT PARR	64	%
% USABLE BY CT FRY	82	%
% USABLE BY CT PARR	83	%
% USABLE BY CHINOOK	71	%
% USABLE BY COHO	67	%
Generic Insect suitability	20	%

Rainbow Trout

Figure S2-A. Site 2 Rainbow Trout parr HSI model for velocity.

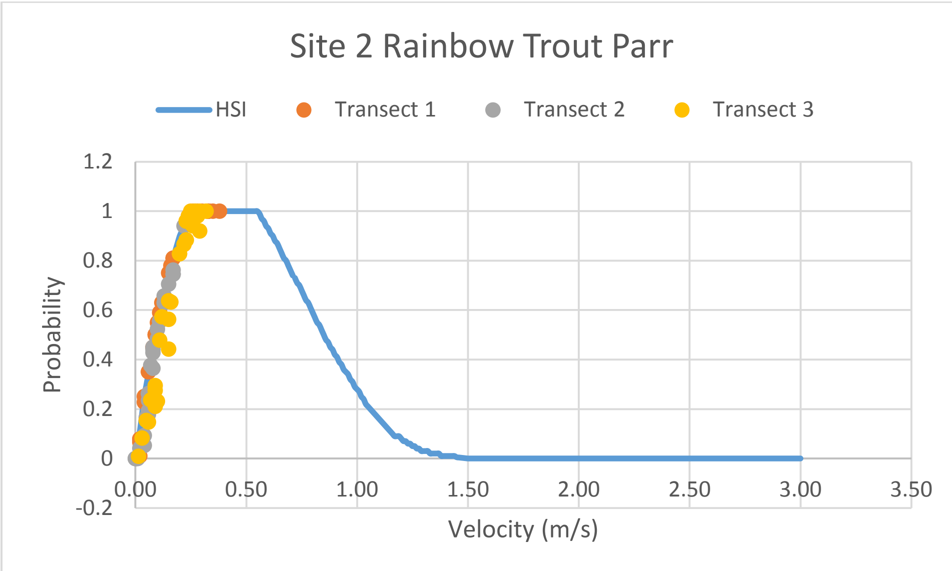


Figure S2-B. Site 2 Rainbow Trout parr HSI model for depth.

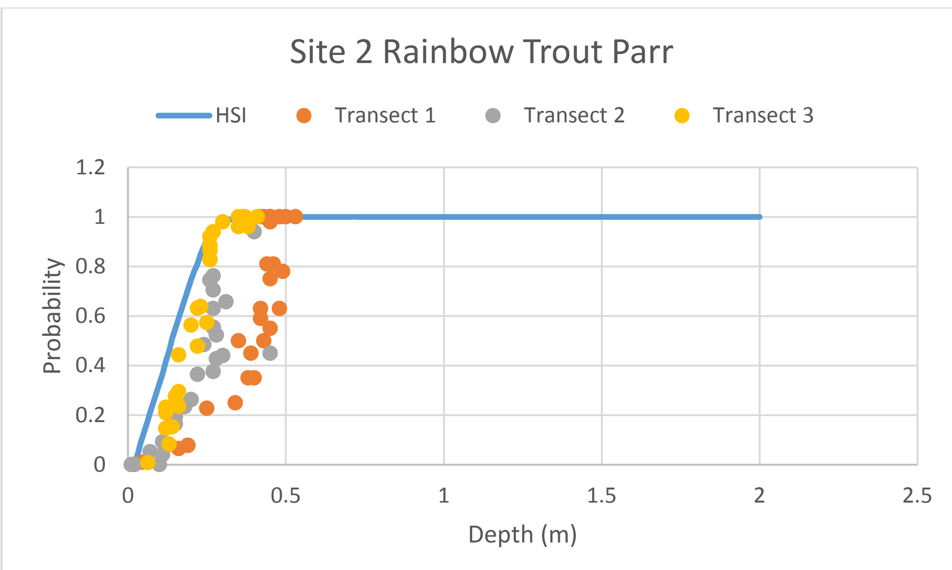


Figure S2-C. Site 2 Rainbow Trout fry HSI model for velocity.

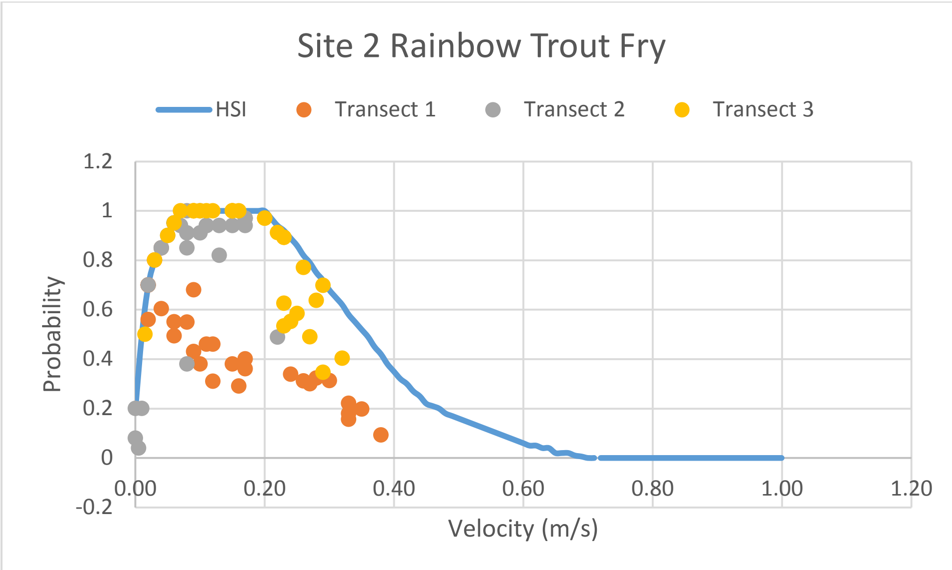
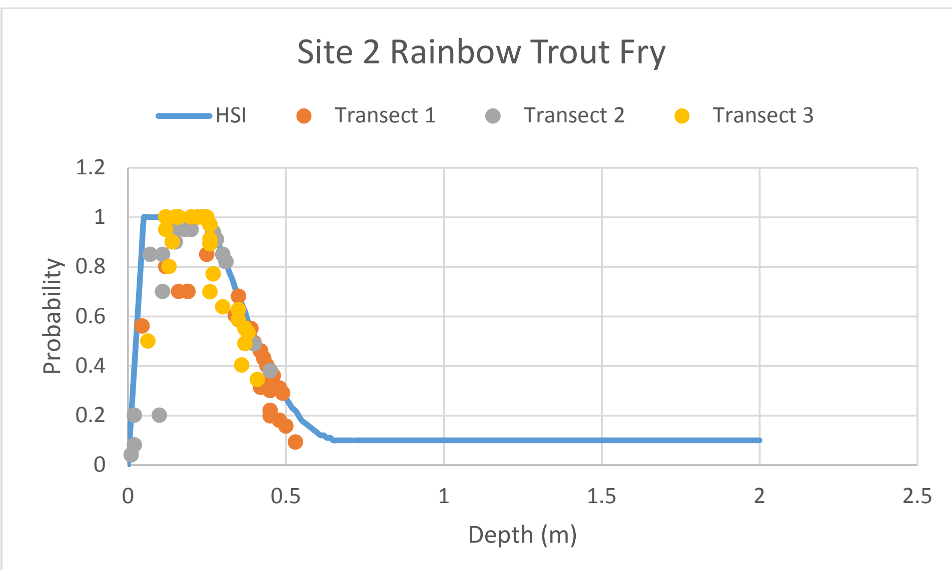


Figure S2-D. Site 2 Rainbow Trout fry HSI model for depth.



Cutthroat Trout

Figure S2-E. Site 2 Coastal Cutthroat Trout parr HSI model for velocity.

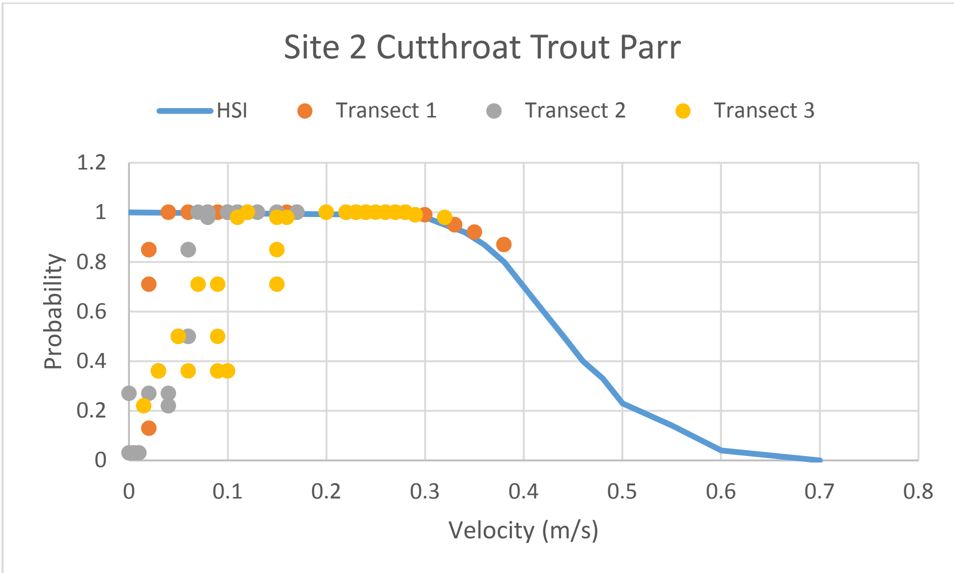


Figure S2-F. Site 2 Coastal Cutthroat Trout parr HSI model for depth.

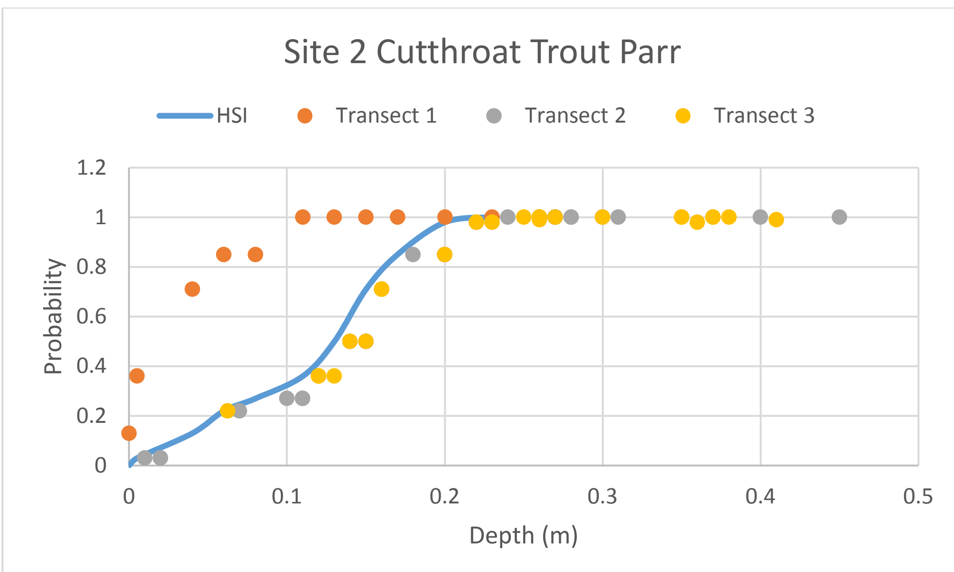


Figure S2-G. Site 2 Coastal Cutthroat Trout fry HSI model for velocity.

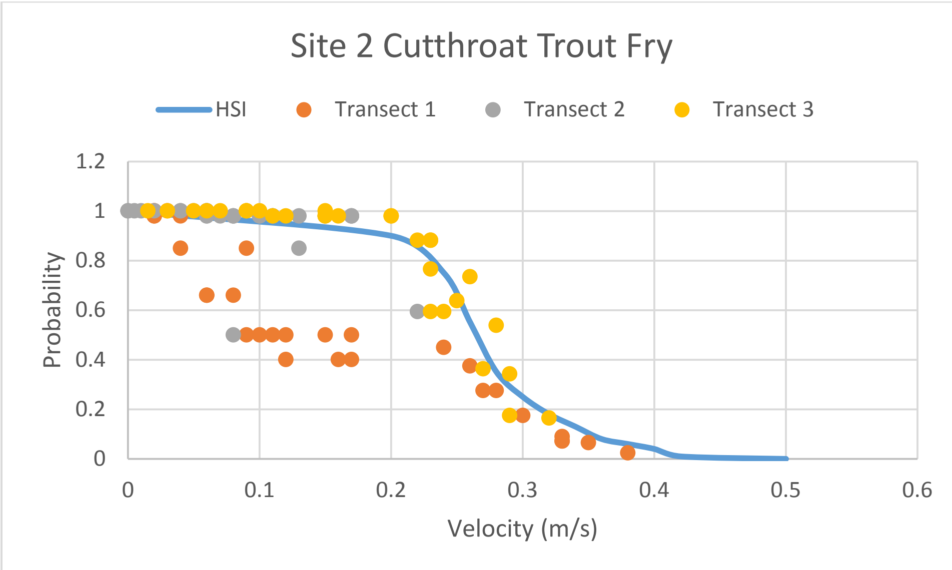
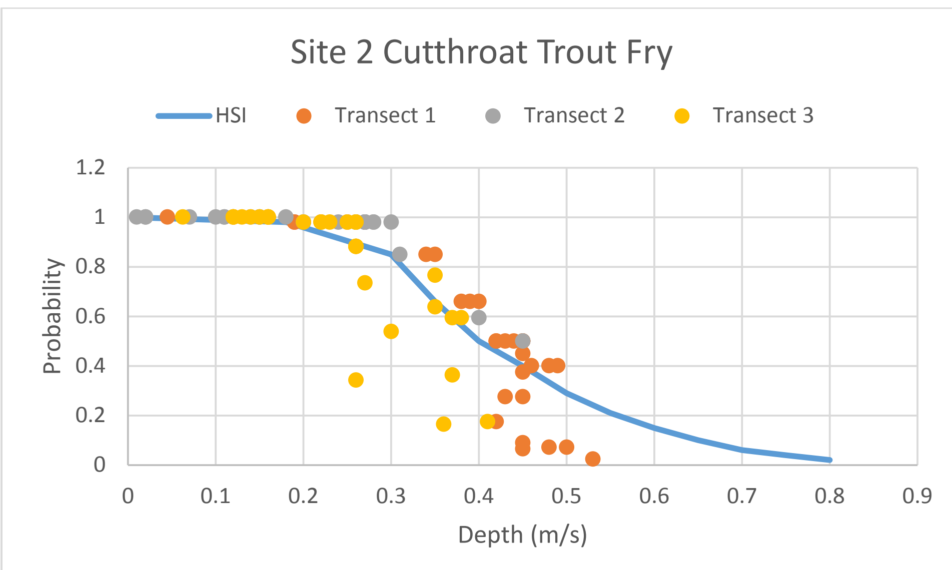


Figure S2-H. Site 2 Coastal Cutthroat Trout fry HSI model for depth.



SITE 3

Table S3-A. Site 3, Transect 1 percent usable area.

ADJUSTED USABLE AREAS

% USABLE BY RBT FRY	75	%
% USABLE BY RBT PARR	64	%
% USABLE BY CT FRY	70	%
% USABLE BY CT PARR	77	%
% USABLE BY CHINOOK	73	%
% USABLE BY COHO	54	%
Generic Insect suitability	25	%

Rainbow Trout

Figure S3-A. Site 3 Rainbow Trout parr HSI model for velocity.

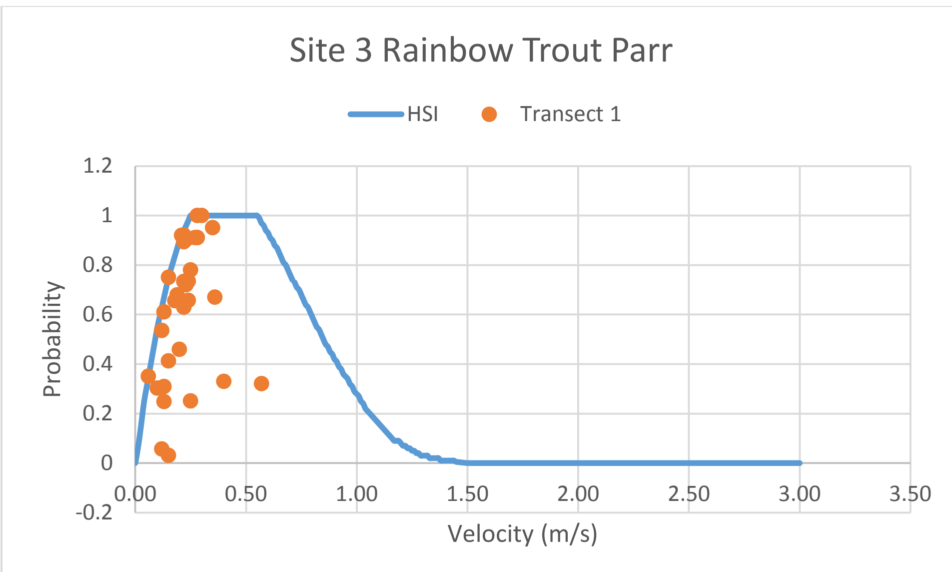


Figure S3-B. Site 3 Rainbow Trout parr HSI model for depth.

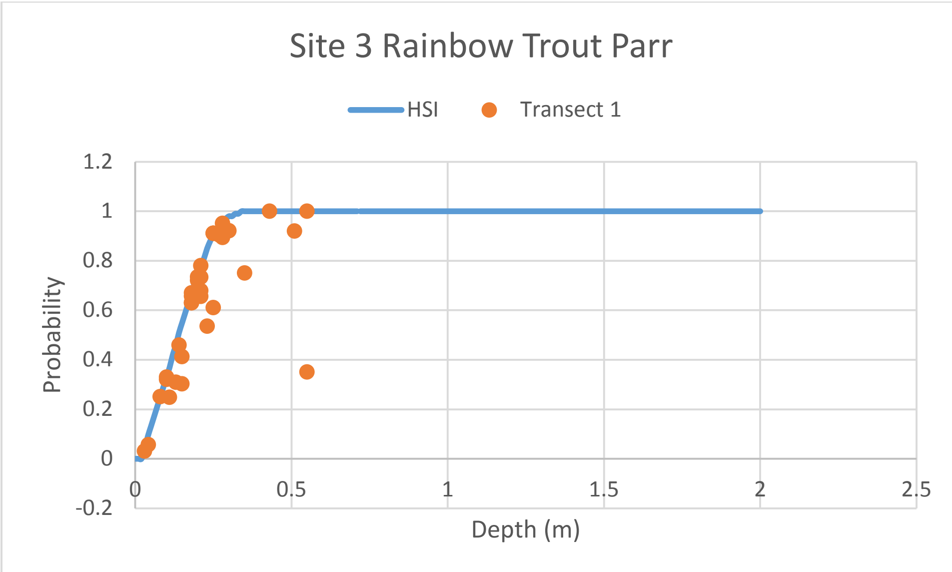


Figure S3-C. Site 3 Rainbow Trout fry HSI model for velocity.

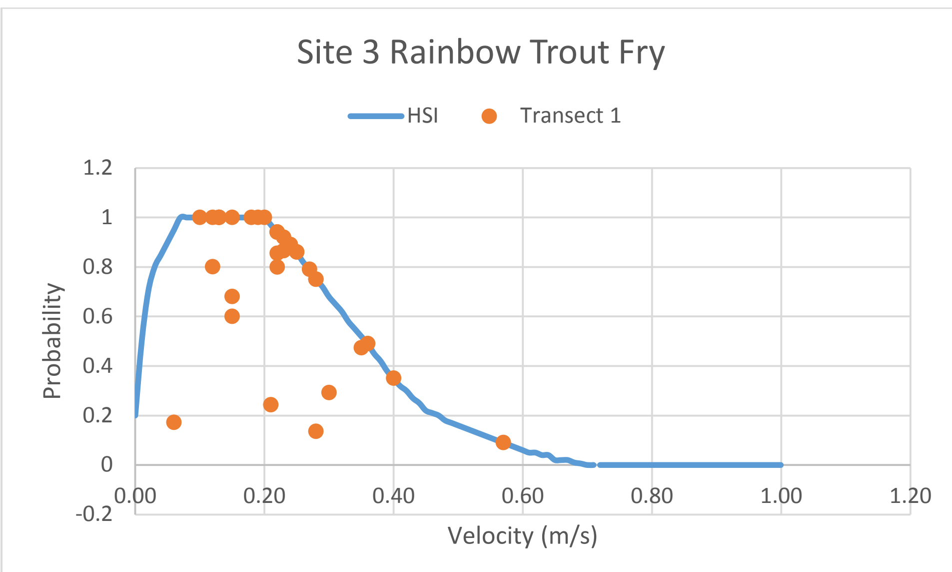
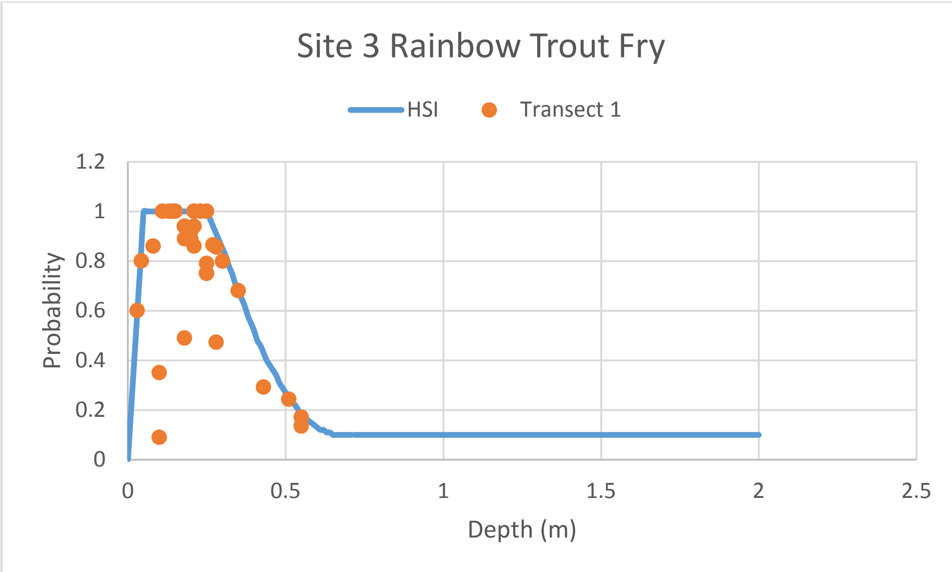


Figure S3-D. Site 3 Rainbow Trout fry HSI model for depth.



Cutthroat Trout

Figure S3-E. Site 3 Coastal Cutthroat Trout parr HSI model for velocity.

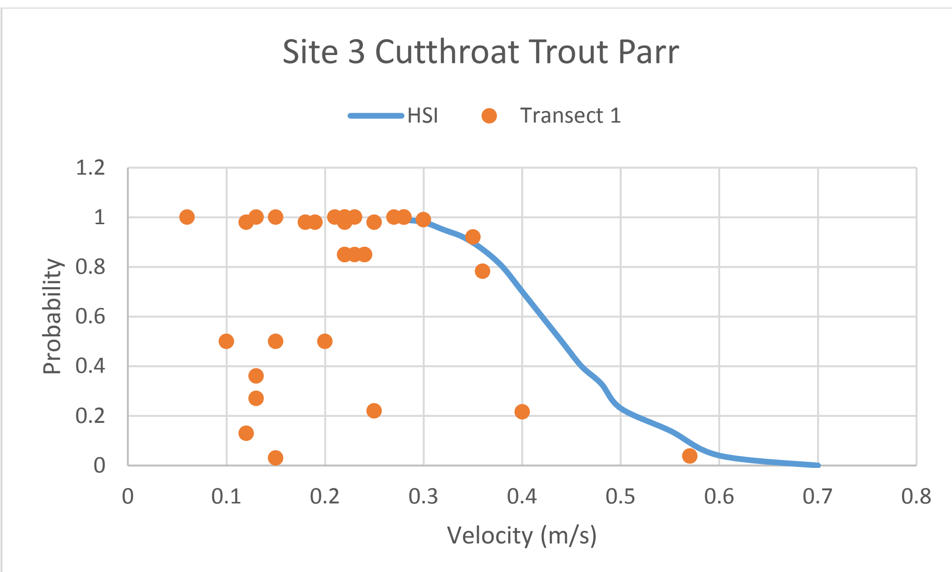


Figure S3-F. Site 3 Coastal Cutthroat Trout parr HSI model for depth.

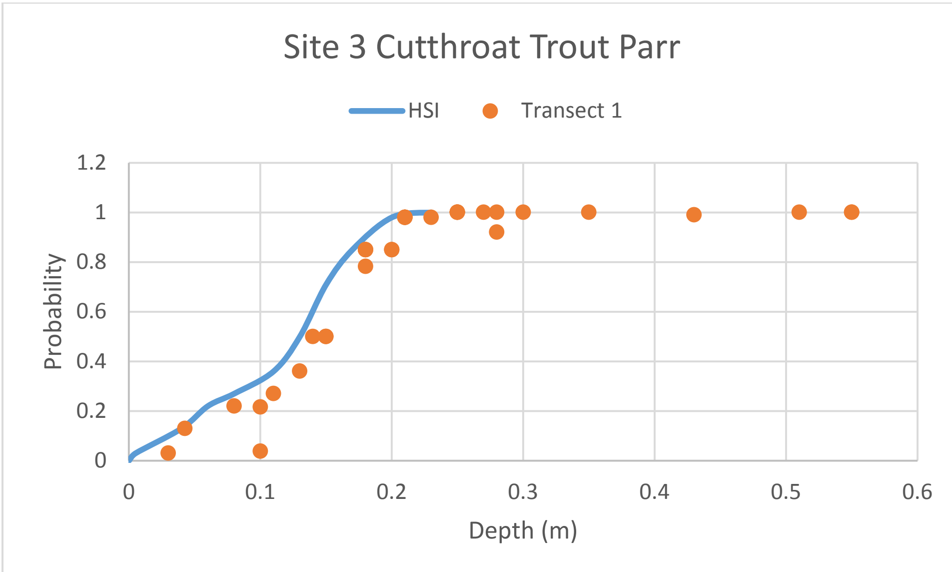


Figure S3-G. Site 3 Coastal Cutthroat Trout fry HSI model for velocity.

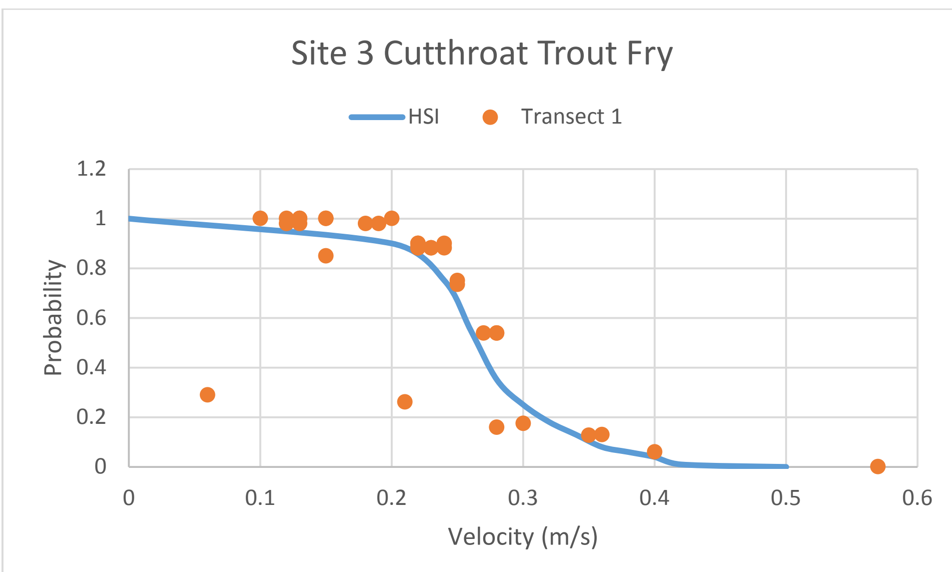
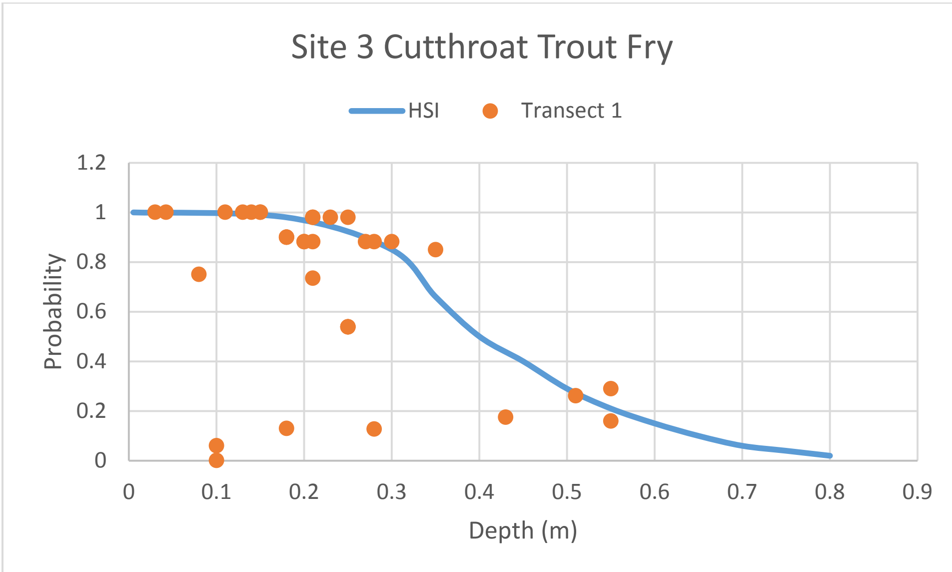


Figure S3-H. Site 3 Coastal Cutthroat Trout fry HSI model for depth.



SITE 4

Table S4-A. Site 4, Transect 1 percent usable area.

ADJUSTED USABLE AREAS

% USABLE BY RBT FRY	23	%
% USABLE BY RBT PARR	89	%
% USABLE BY CT FRY	18	%
% USABLE BY CT PARR	61	%
% USABLE BY CHINOOK	75	%
% USABLE BY COHO	23	%
Generic Insect suitability	55	%

Rainbow Trout

Figure S4-A. Site 4 Rainbow Trout parr HSI model for velocity.

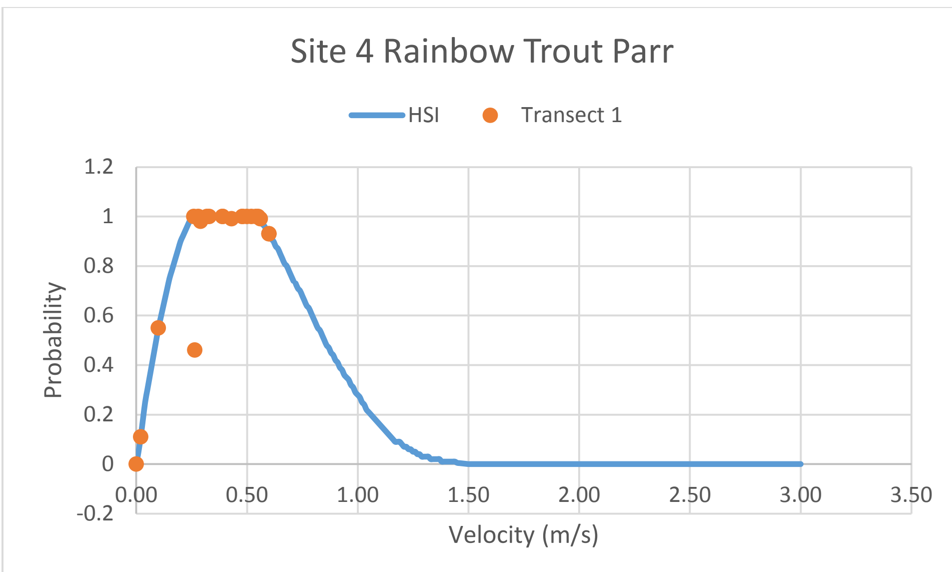


Figure S4-B. Site 4 Rainbow Trout parr HSI model for depth.

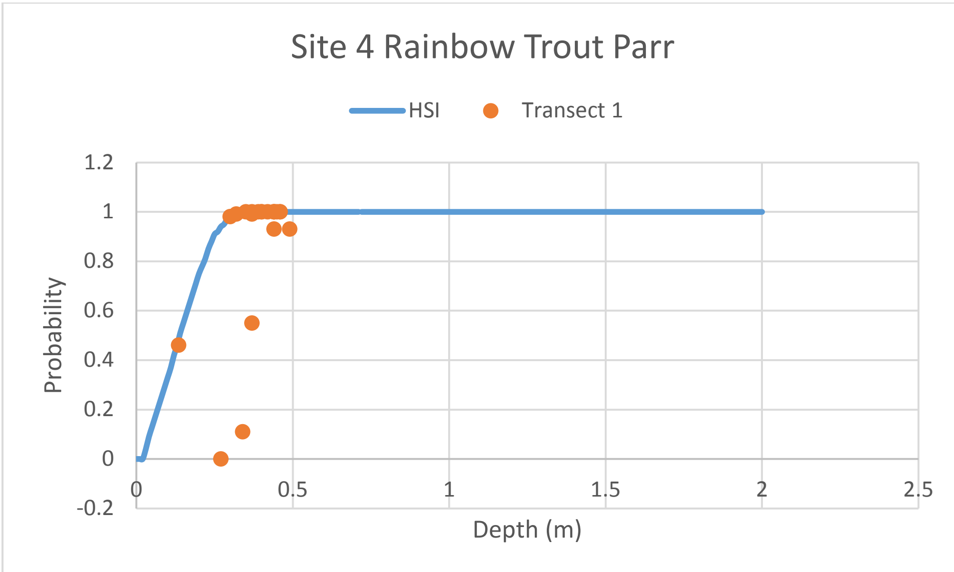


Figure S4-C. Site 4 Rainbow Trout fry HSI model for velocity.

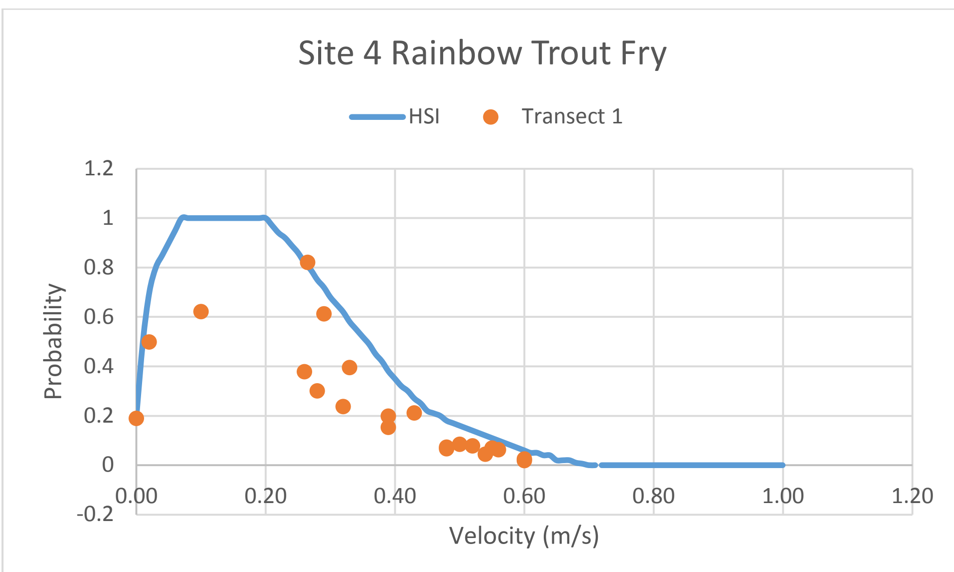
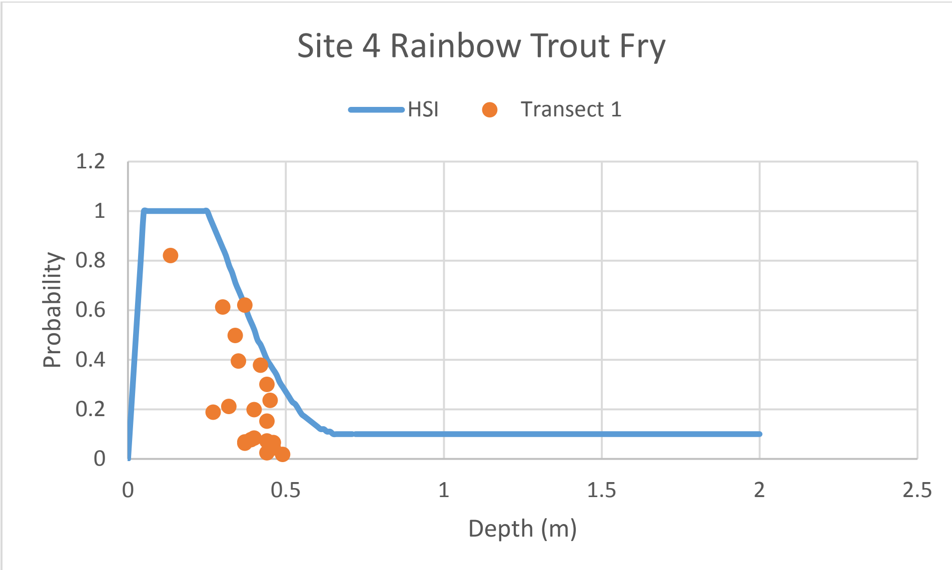


Figure S4-D. Site 4 Rainbow Trout fry HSI model for depth.



Cutthroat Trout

Figure S4-E. Site 4 Coastal Cutthroat Trout parr HSI model for velocity.

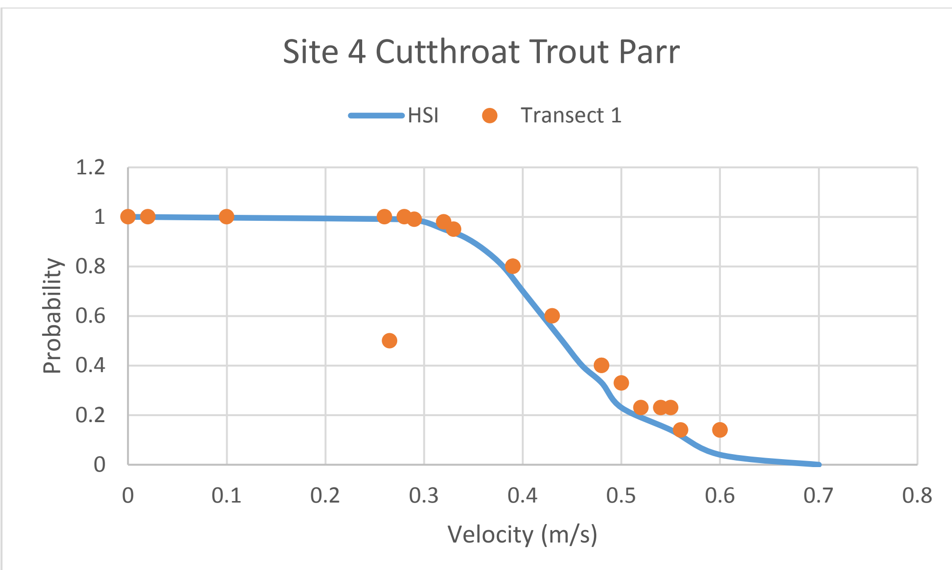


Figure S4-F. Site 4 Coastal Cutthroat Trout parr HSI model for depth.

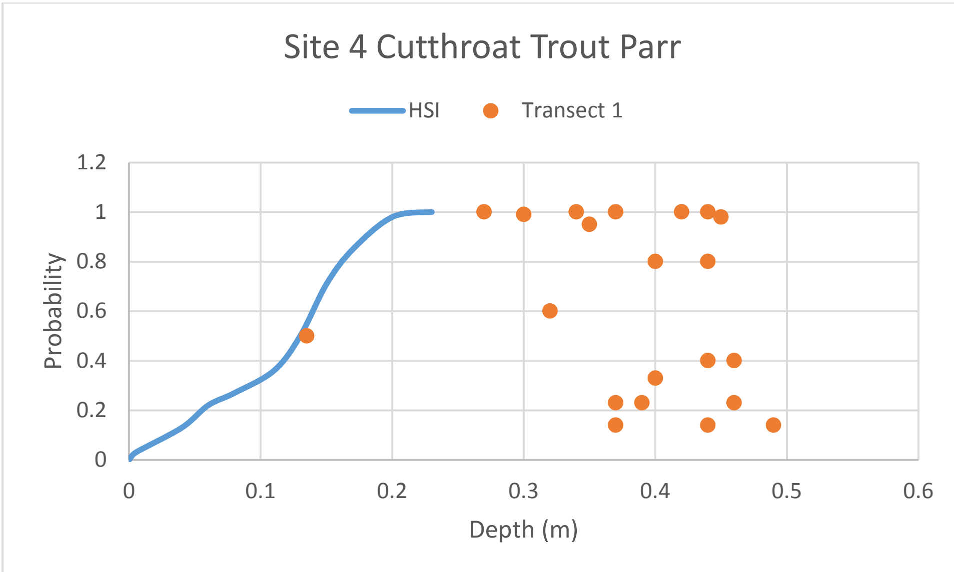


Figure S4-G. Site 4 Coastal Cutthroat Trout fry HSI model for velocity.

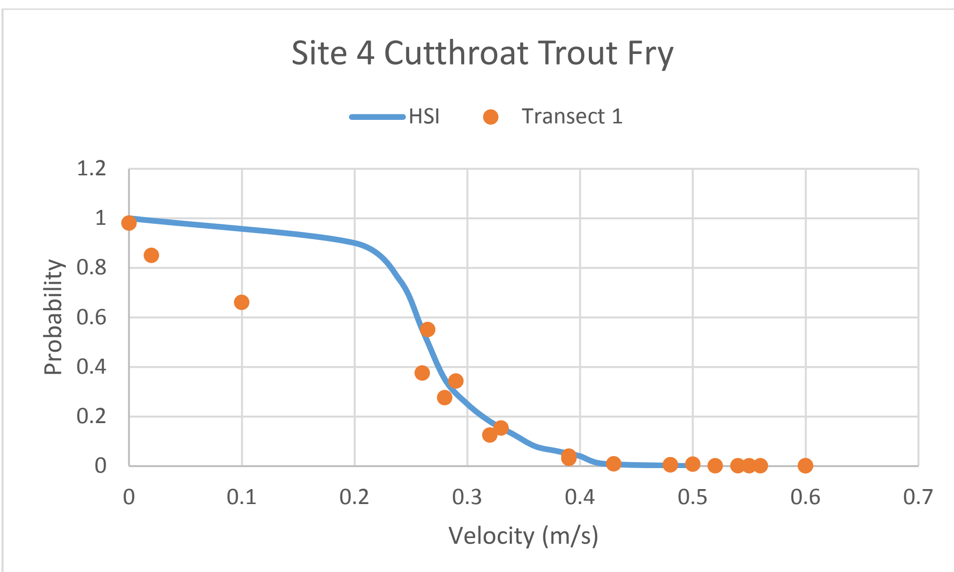
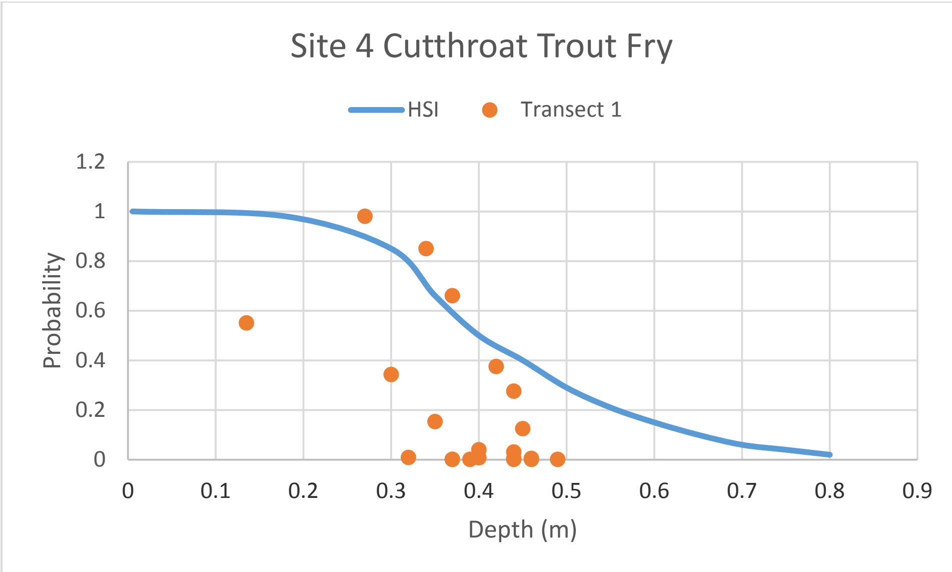


Figure S4-H. Site 4 Coastal Cutthroat Trout fry HSI model for depth.



SITE 5

Table S5-A. Site 5, Transect 1 percent usable area.

ADJUSTED USABLE AREAS

% USABLE BY RBT FRY	26	%
% USABLE BY RBT PARR	92	%
% USABLE BY CT FRY	22	%
% USABLE BY CT PARR	72	%
% USABLE BY CHINOOK	86	%
% USABLE BY COHO	23	%
Generic Insect suitability	51	%

Rainbow Trout

Figure S5-A. Site 5 Rainbow Trout parr HSI model for velocity.

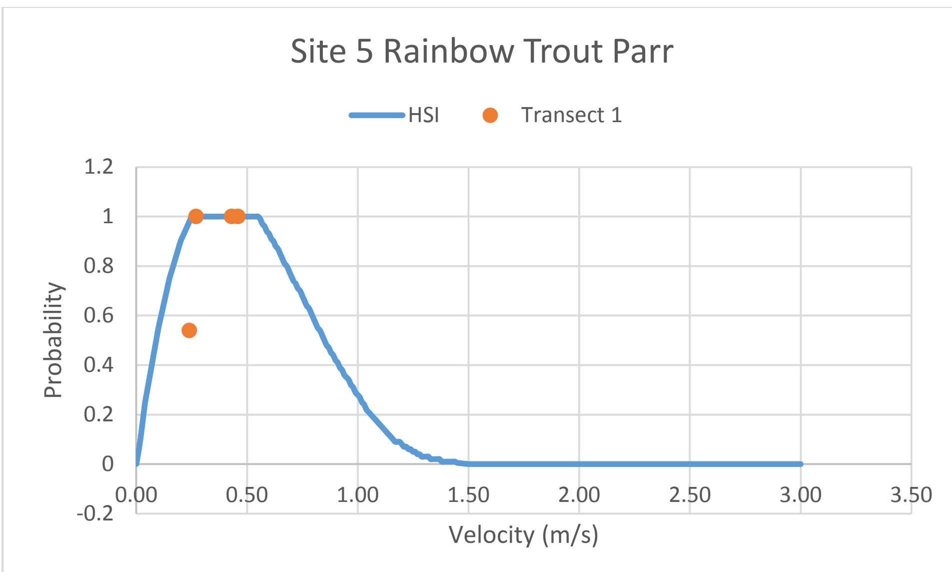


Figure S5-B. Site 5 Rainbow Trout parr HSI model for depth.

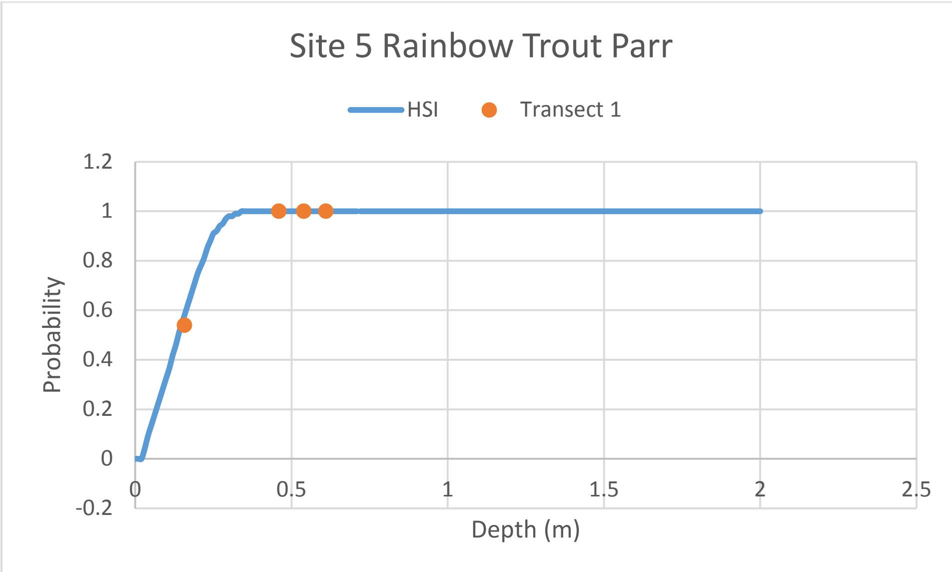


Figure S5-C. Site 5 Rainbow Trout fry HSI model for velocity.

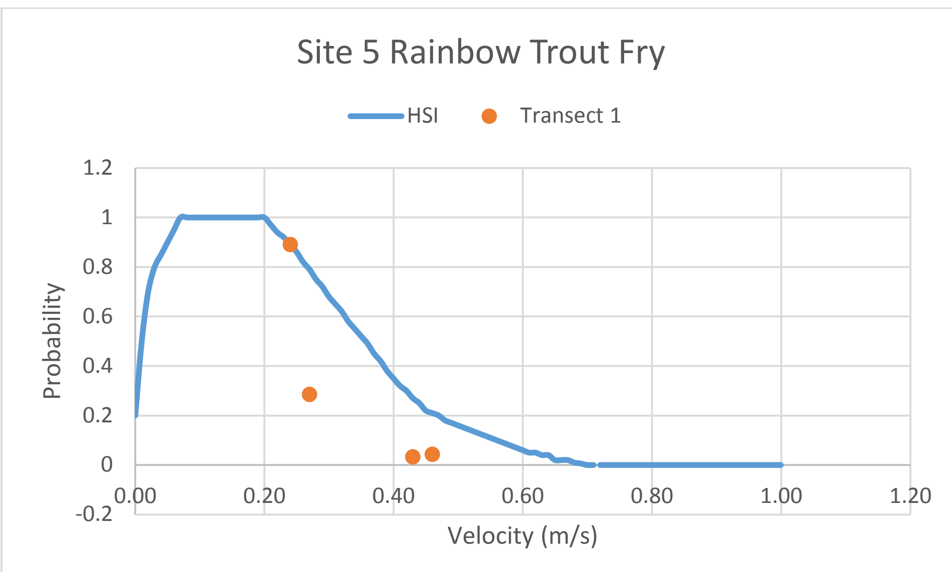
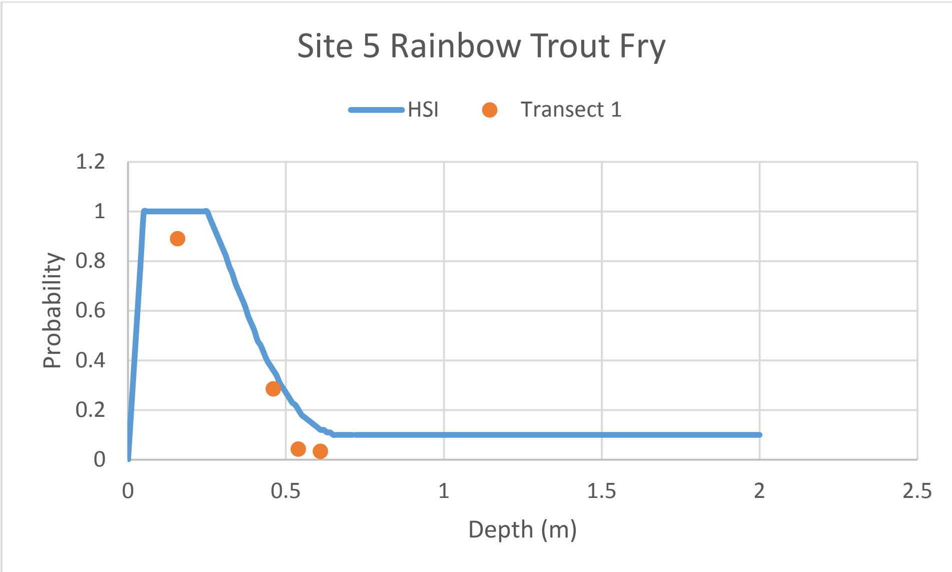


Figure S5-D. Site 5 Rainbow Trout fry HSI model for depth.



Cutthroat Trout

Figure S5-E. Site 5 Coastal Cutthroat Trout parr HSI model for velocity.

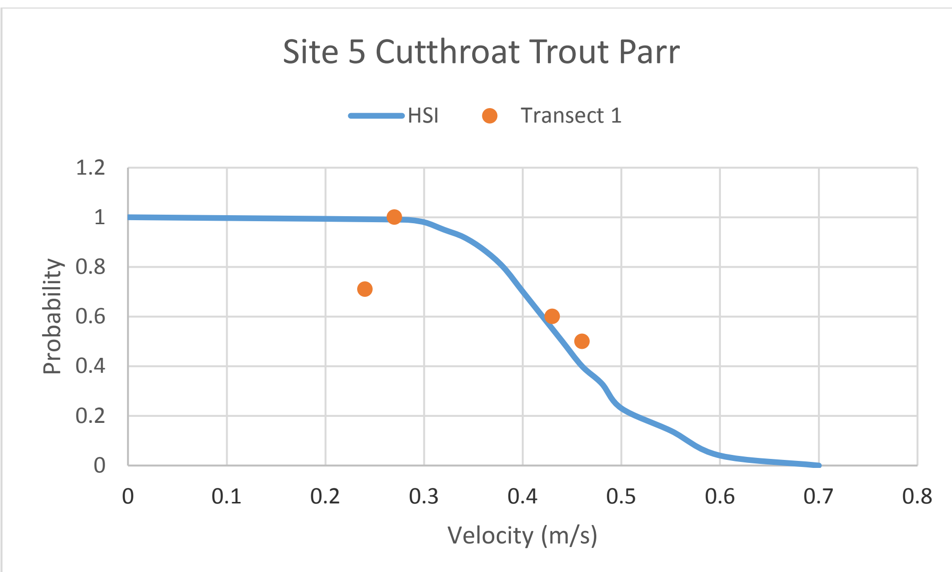


Figure S5-F. Site 5 Coastal Cutthroat Trout parr HSI model for depth.

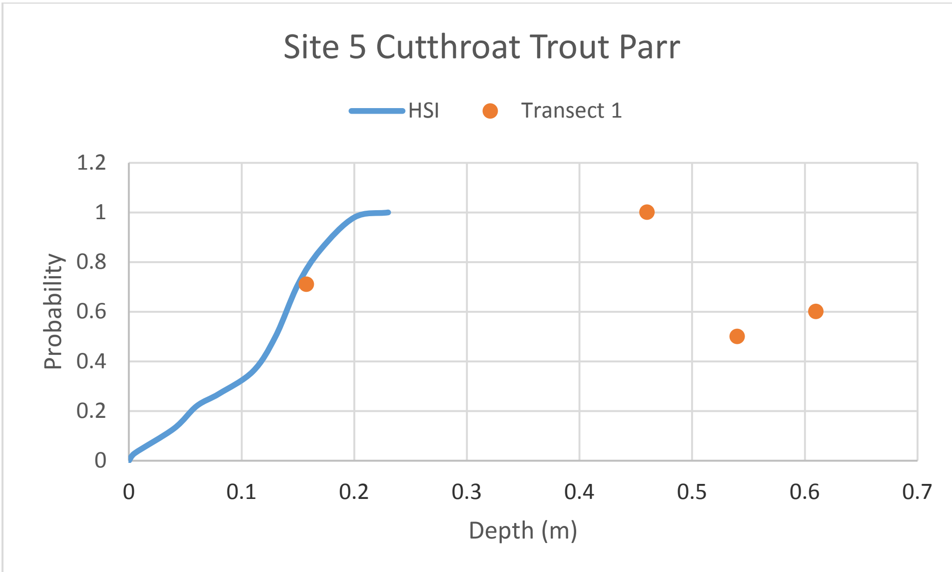


Figure S5-G. Site 5 Coastal Cutthroat Trout fry HSI model for velocity.

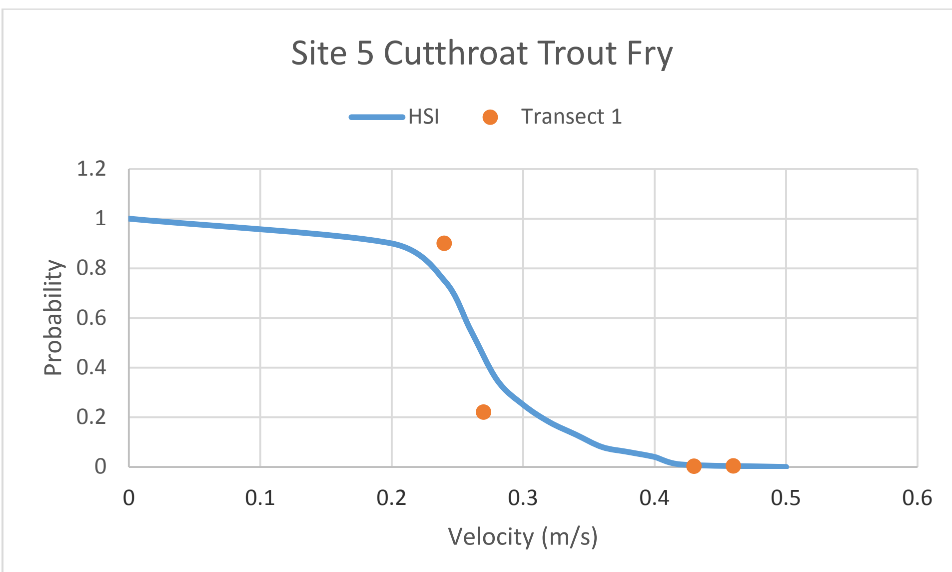
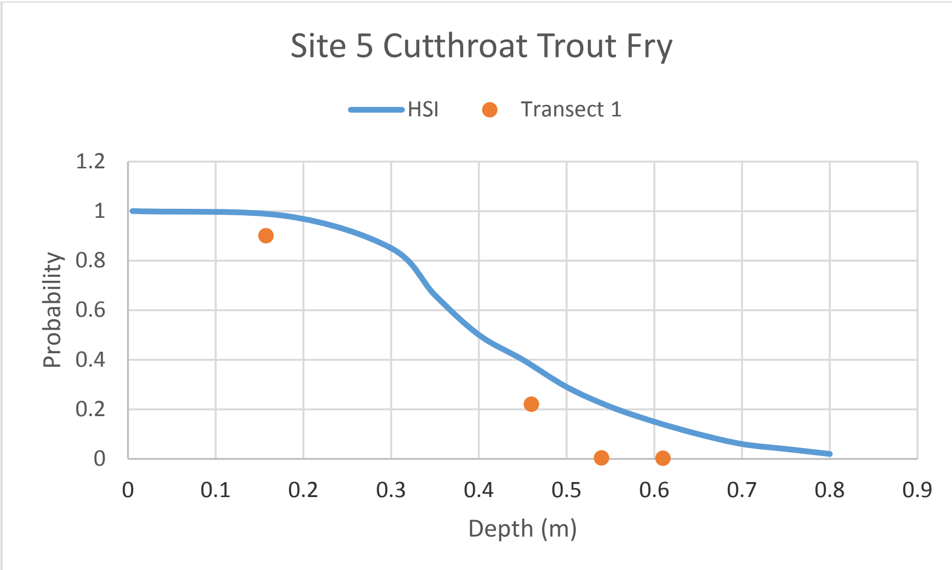


Figure S5-H. Site 5 Coastal Cutthroat Trout fry HSI model for depth.



SITE 6

Table S6-A. Site 6, Transect 1 percent usable area.

ADJUSTED USABLE AREAS

% USABLE BY RBT FRY	67	%
% USABLE BY RBT PARR	50	%
% USABLE BY CT FRY	78	%
% USABLE BY CT PARR	93	%
% USABLE BY CHINOOK	58	%
% USABLE BY COHO	94	%
Generic Insect suitability	10	%

Table S6-B. Site 6, Transect 2 percent usable area.

% USABLE BY RBT FRY	13	%
% USABLE BY RBT PARR	76	%
% USABLE BY CT FRY	11	%
% USABLE BY CT PARR	19	%
% USABLE BY CHINOOK	49	%
% USABLE BY COHO	7	%
Generic Insect suitability	79	%

Rainbow Trout

Figure S6-A. Site 6 Rainbow Trout parr HSI model for velocity.

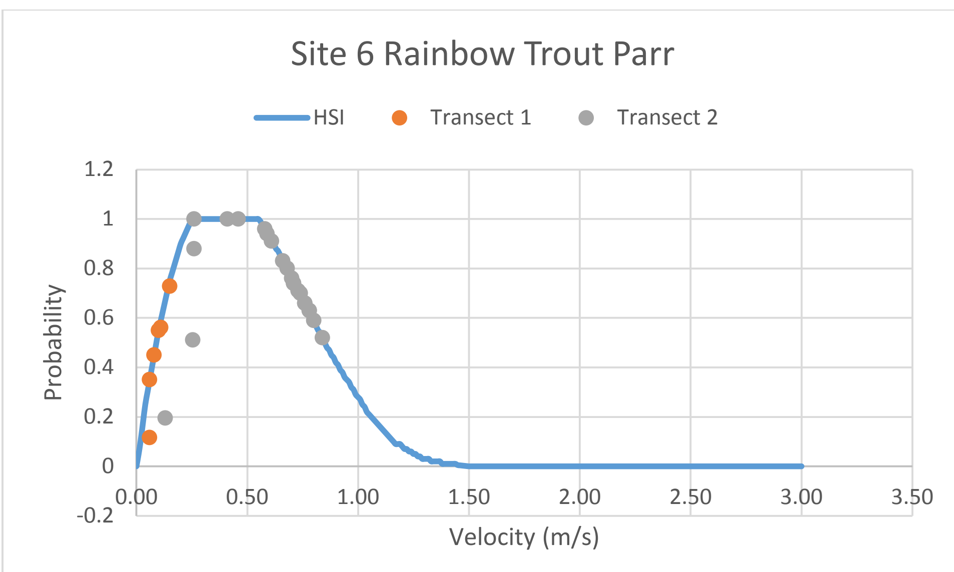


Figure S6-B. Site 6 Rainbow Trout parr HSI model for depth.

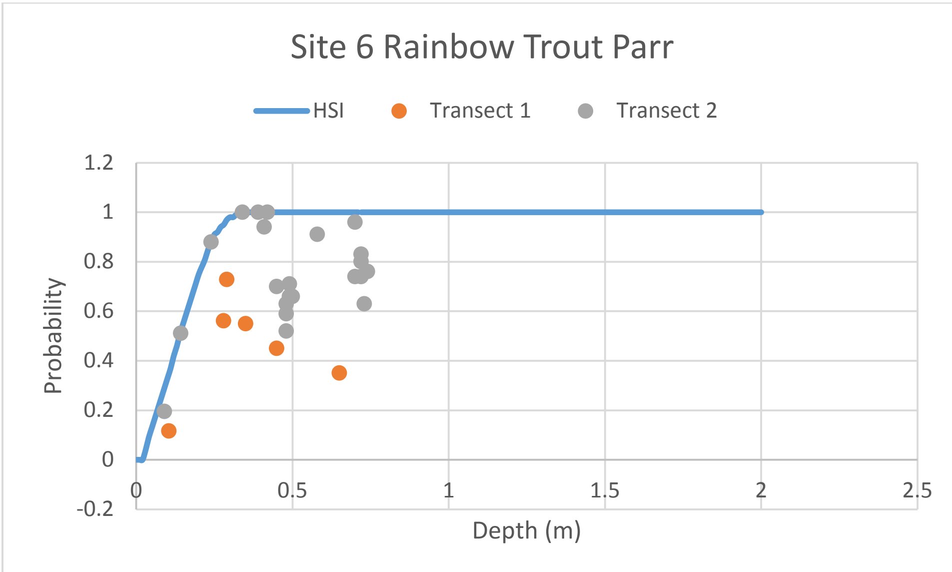


Figure S6-C. Site 6 Rainbow Trout fry HSI model for velocity.

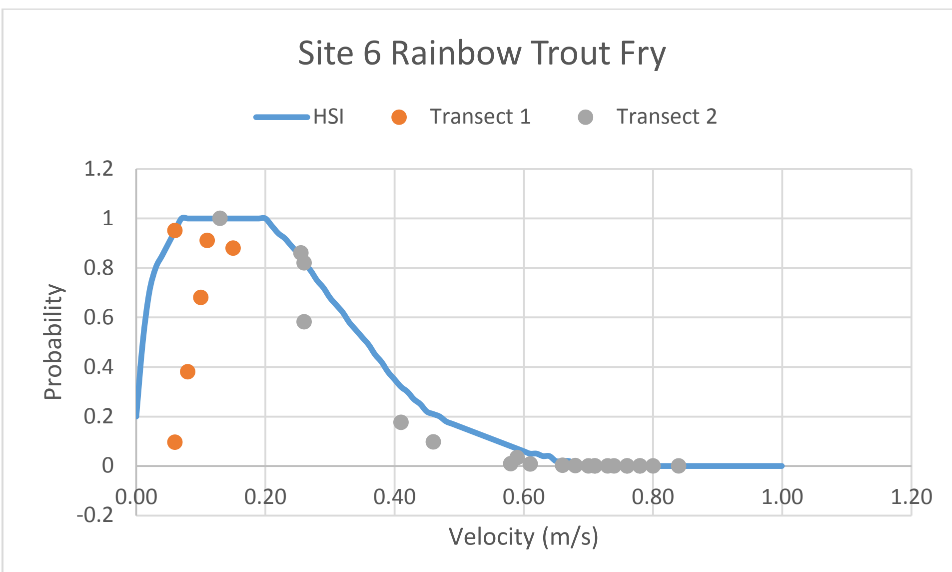
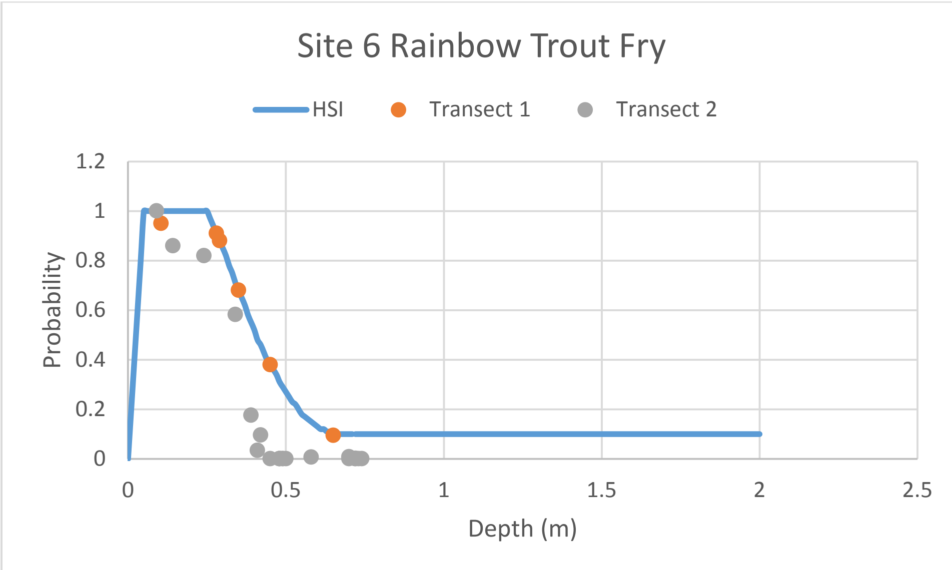


Figure S6-D. Site 6 Rainbow Trout fry HSI model for depth.



Cutthroat Trout

Figure S6-E. Site 6 Coastal Cutthroat Trout parr HSI model for velocity.

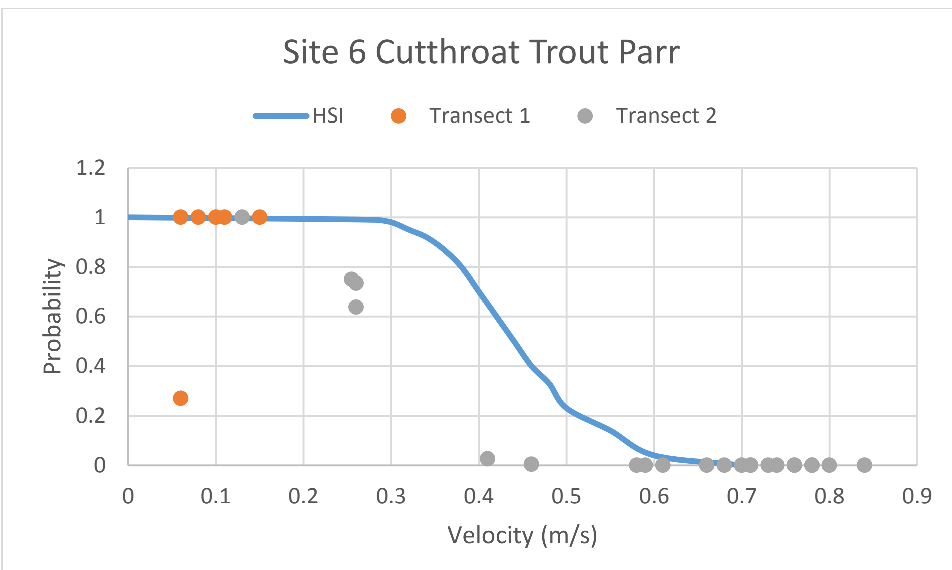


Figure S6-F. Site 6 Coastal Cutthroat Trout parr HSI model for depth.

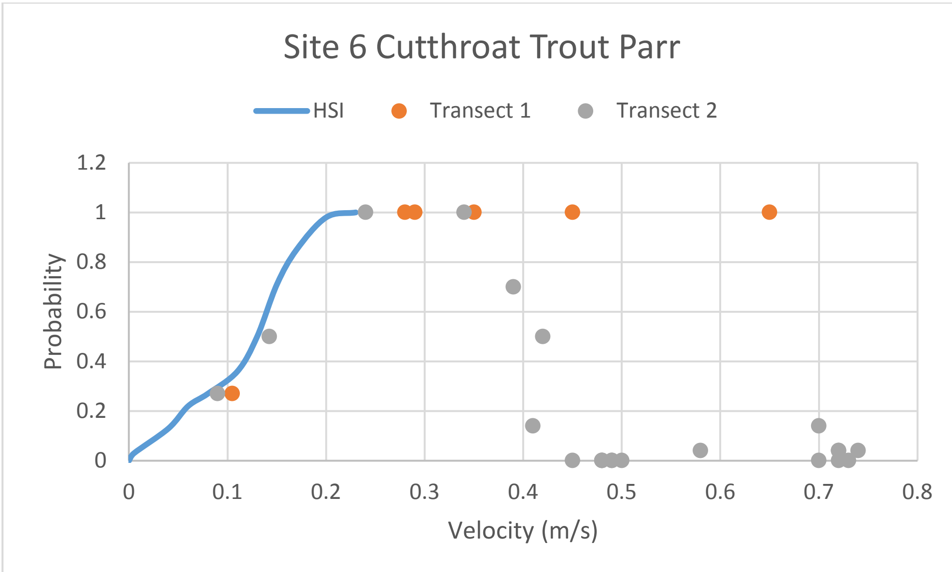


Figure S6-G. Site 6 Coastal Cutthroat Trout fry HSI model for velocity.

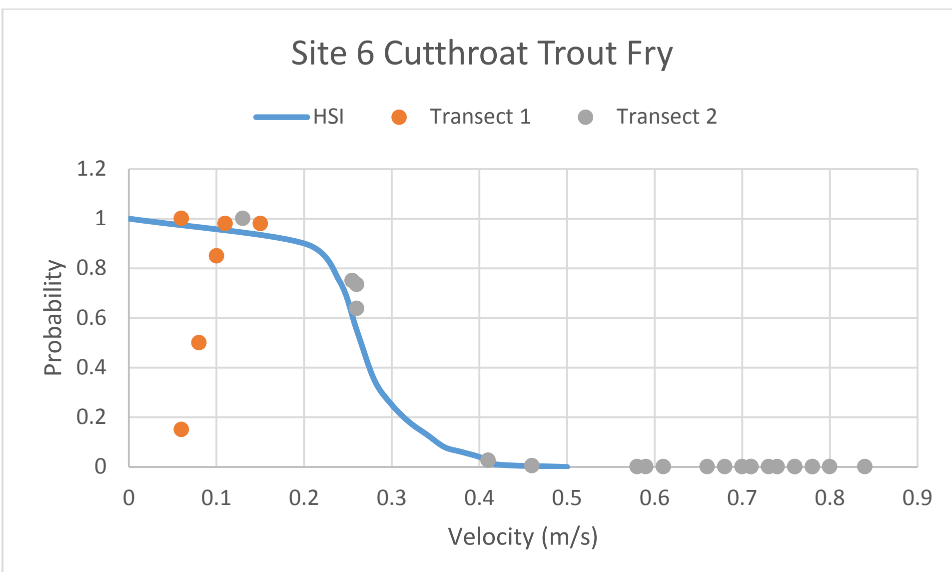


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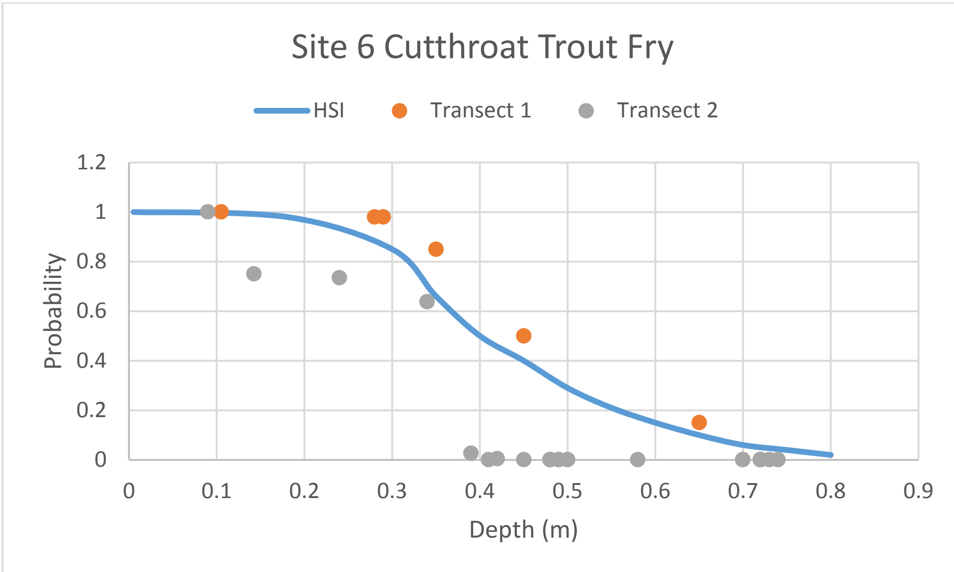
Figure S6-H. Site 6 Coastal Cutthroat Trout fry HSI model for depth.



SITE 7

Table S7-A. Site 7, Transect 1 percent usable area.

ADJUSTED USABLE AREAS

% USABLE BY RBT FRY	40	%
% USABLE BY RBT PARR	86	%
% USABLE BY CT FRY	41	%
% USABLE BY CT PARR	90	%
% USABLE BY CHINOOK	86	%
% USABLE BY COHO	44	%
Generic Insect suitability	36	%

Rainbow Trout

Figure S7-A. Site 7 Rainbow Trout parr HSI model for velocity.

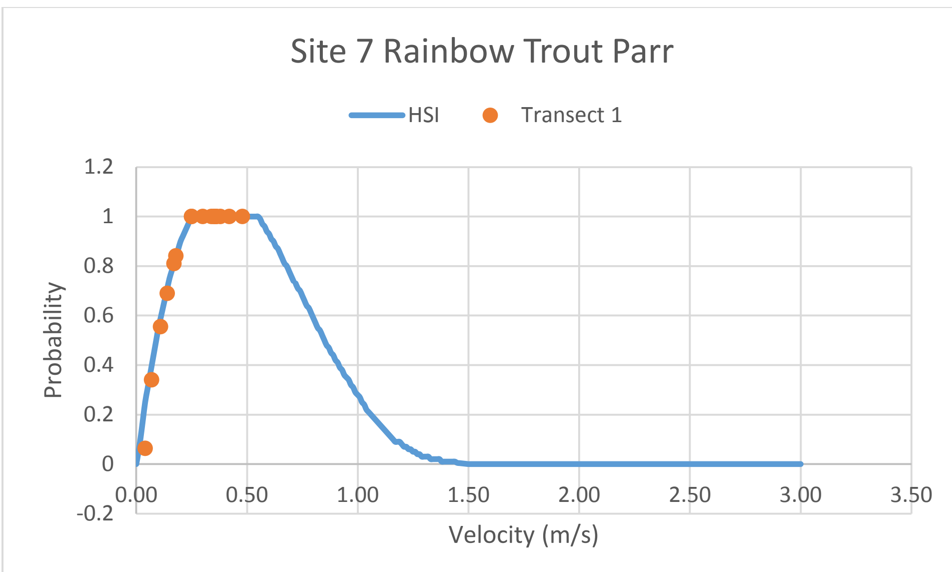


Figure S7-B. Site 7 Rainbow Trout parr HSI model for depth.

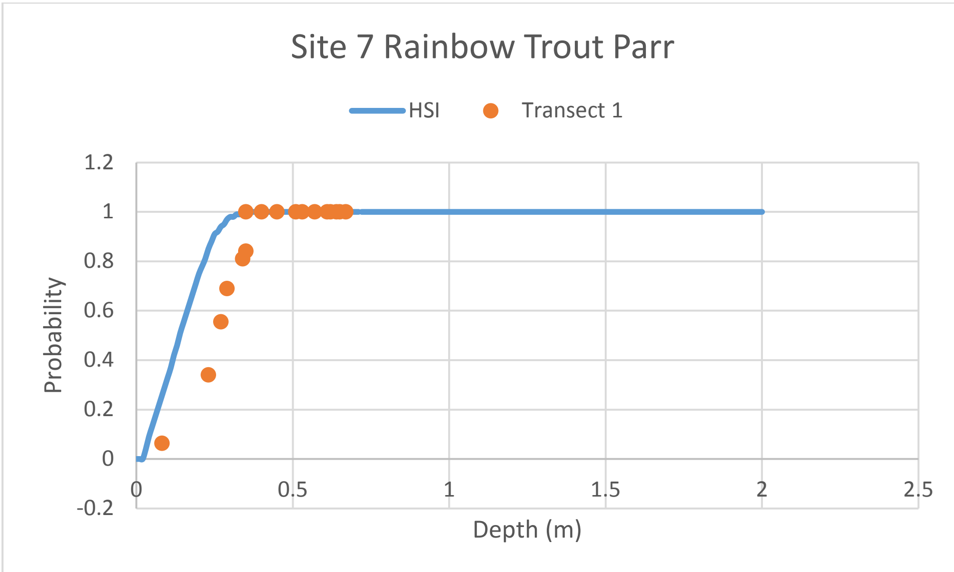


Figure S7-C. Site 7 Rainbow Trout fry HSI model for velocity.

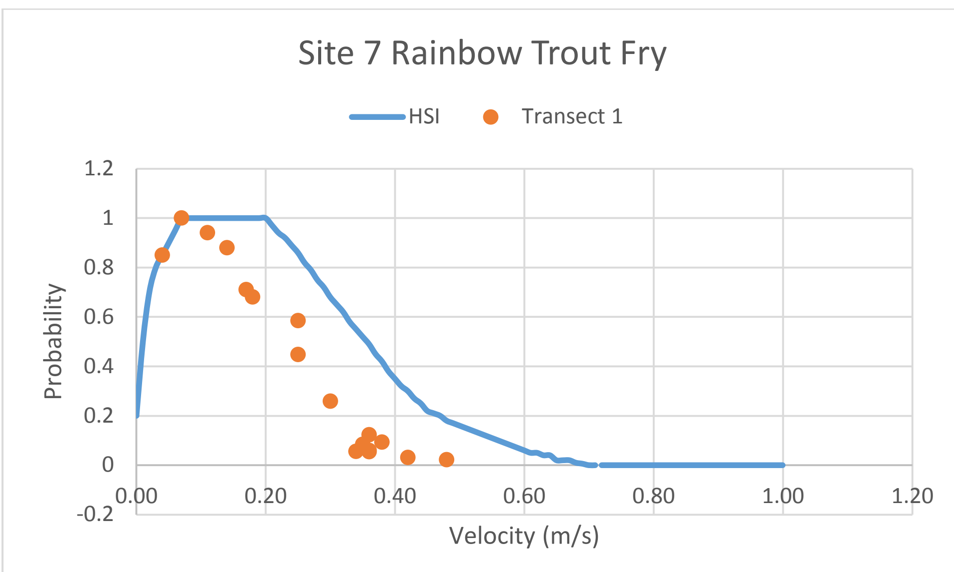
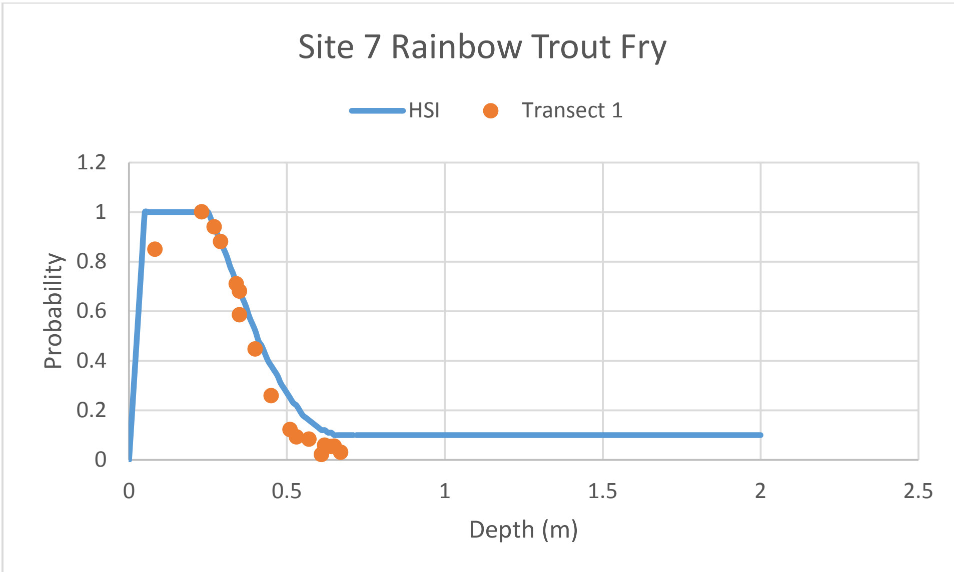


Figure S7-D. Site 7 Rainbow Trout fry HSI model for depth.



Cutthroat Trout

Figure S7-E. Site 7 Coastal Cutthroat Trout parr HSI model for velocity.

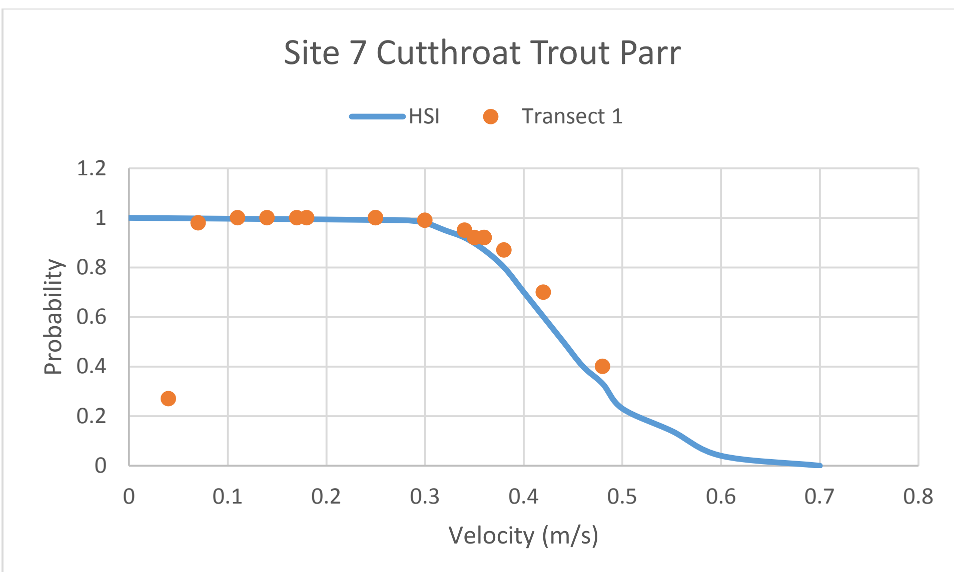


Figure S7-F. Site 7 Coastal Cutthroat Trout parr HSI model for depth.

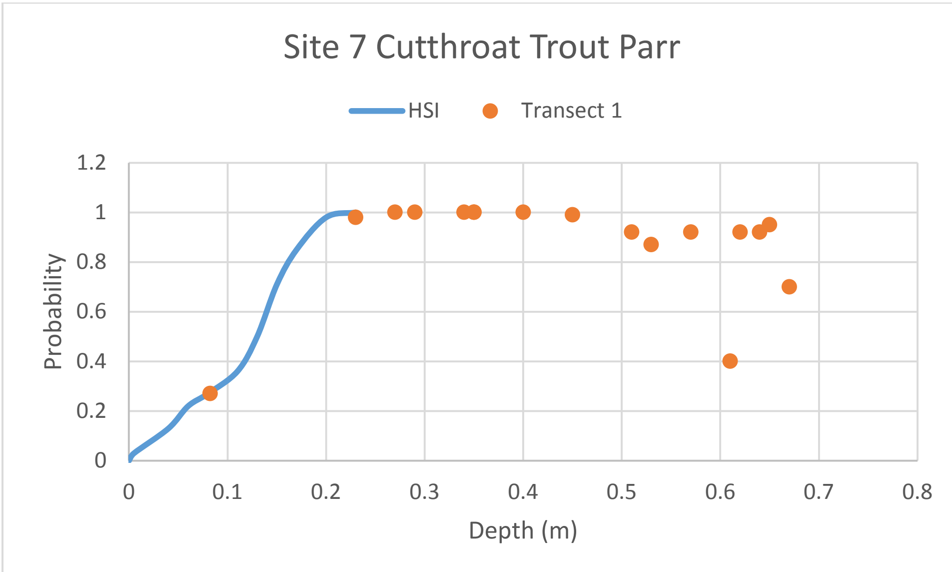


Figure S7-G. Site 7 Coastal Cutthroat Trout fry HSI model for velocity.

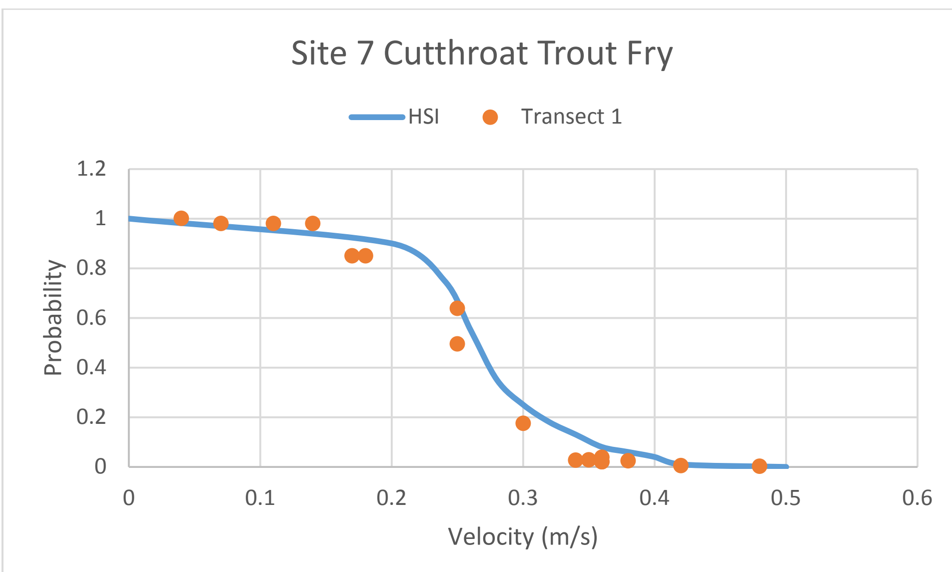
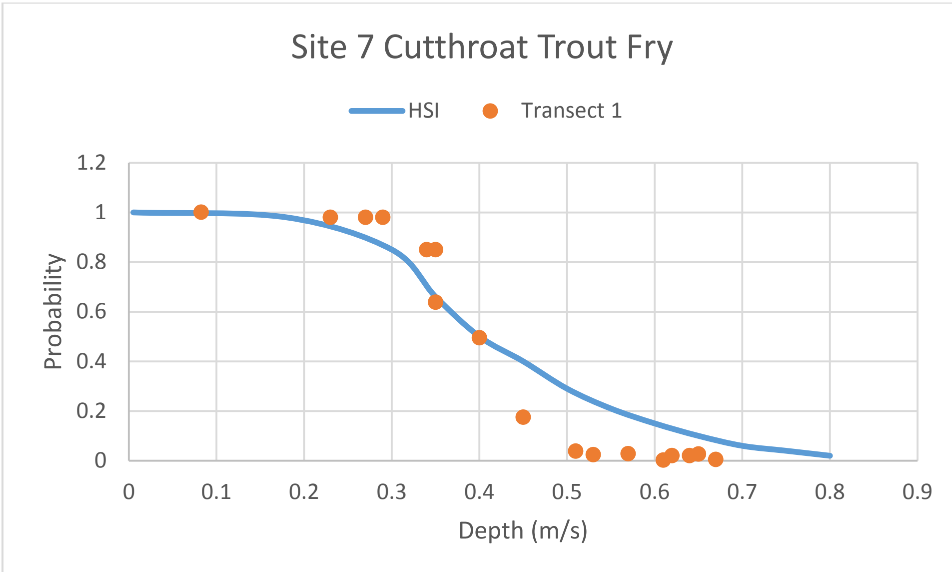


Figure S7-H. Site 7 Coastal Cutthroat Trout fry HSI model for depth.



SITE 8

Table S8-A. Site 8, Transect 1 percent usable area.

ADJUSTED USABLE AREAS

% USABLE BY RBT FRY	11	%
% USABLE BY RBT PARR	10	%
% USABLE BY CT FRY	38	%
% USABLE BY CT PARR	97	%
% USABLE BY CHINOOK	11	%
% USABLE BY COHO	99	%
Generic Insect suitability	2	%

Rainbow Trout

Figure S8-A. Site 8 Rainbow Trout parr HSI model for velocity.

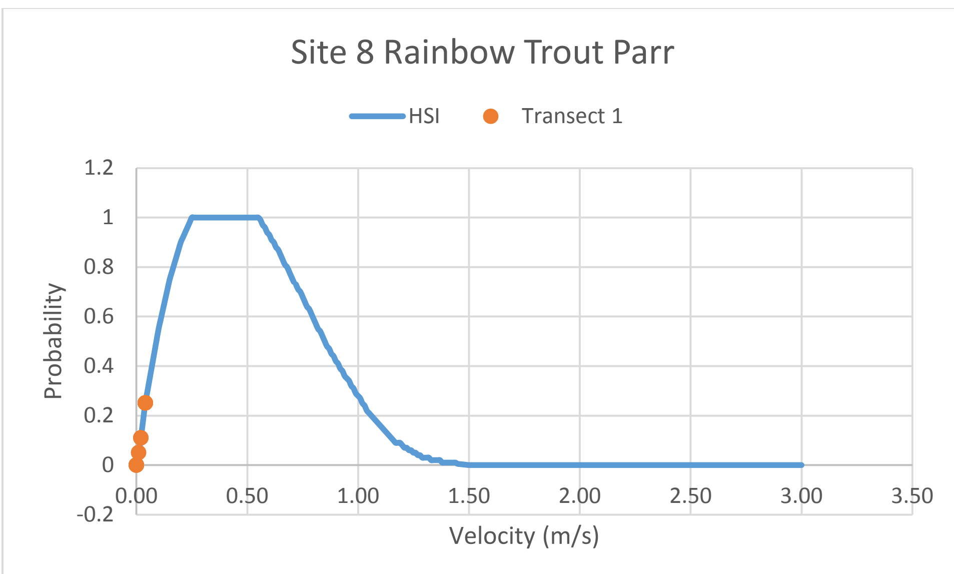


Figure S8-B. Site 8 Rainbow Trout parr HSI model for depth.

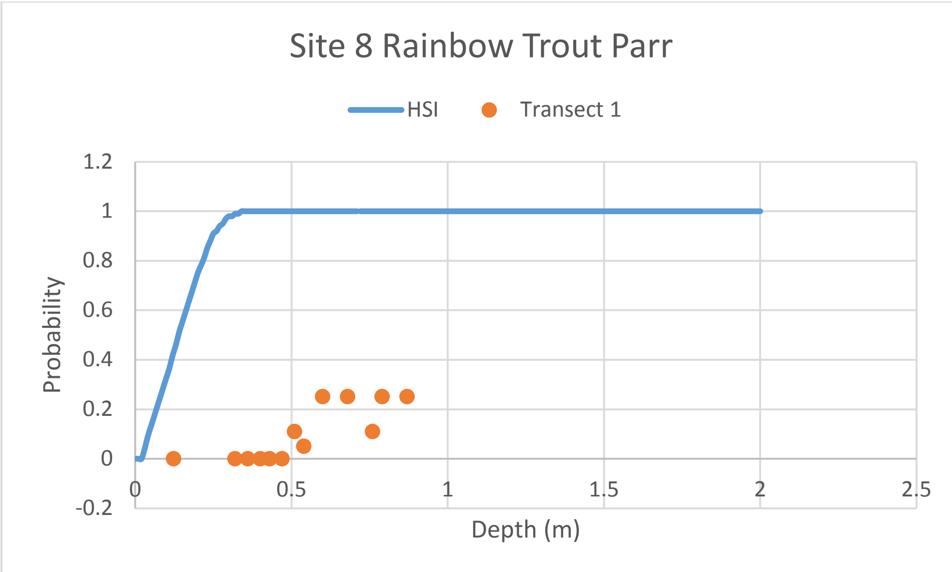


Figure S8-C. Site 8 Rainbow Trout fry HSI model for velocity.

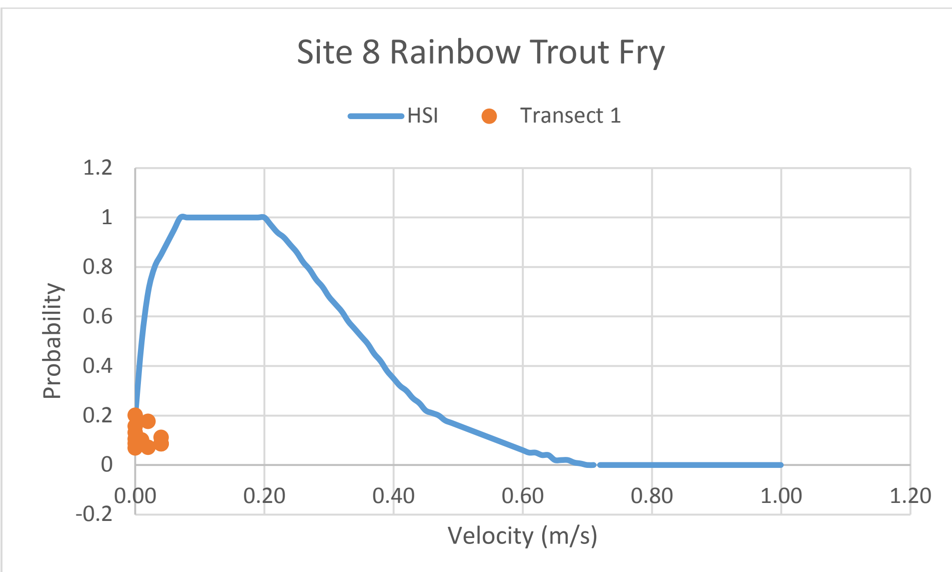
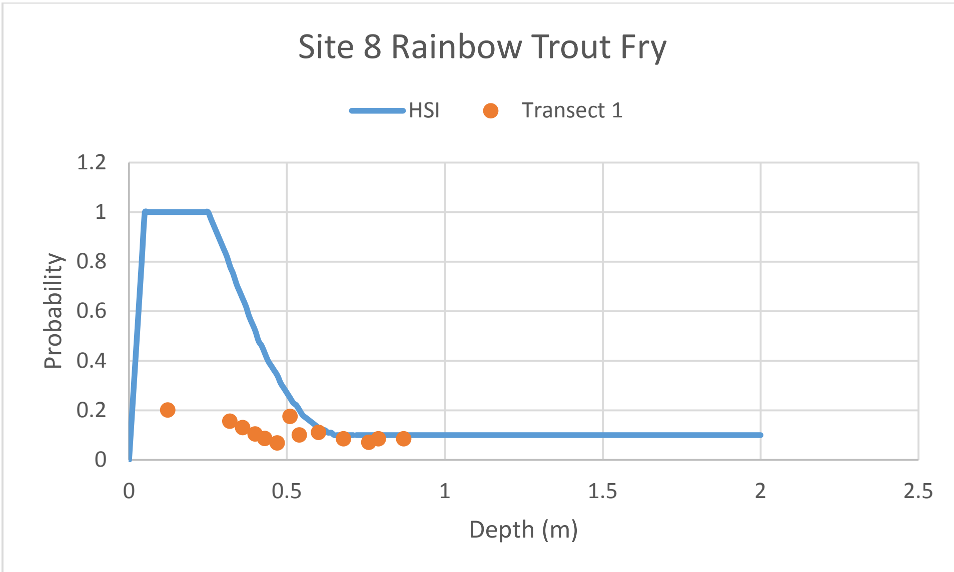


Figure S8-D. Site 8 Rainbow Trout fry HSI model for depth.



Cutthroat Trout

Figure S8-E. Site 8 Coastal Cutthroat Trout parr HSI model for velocity.

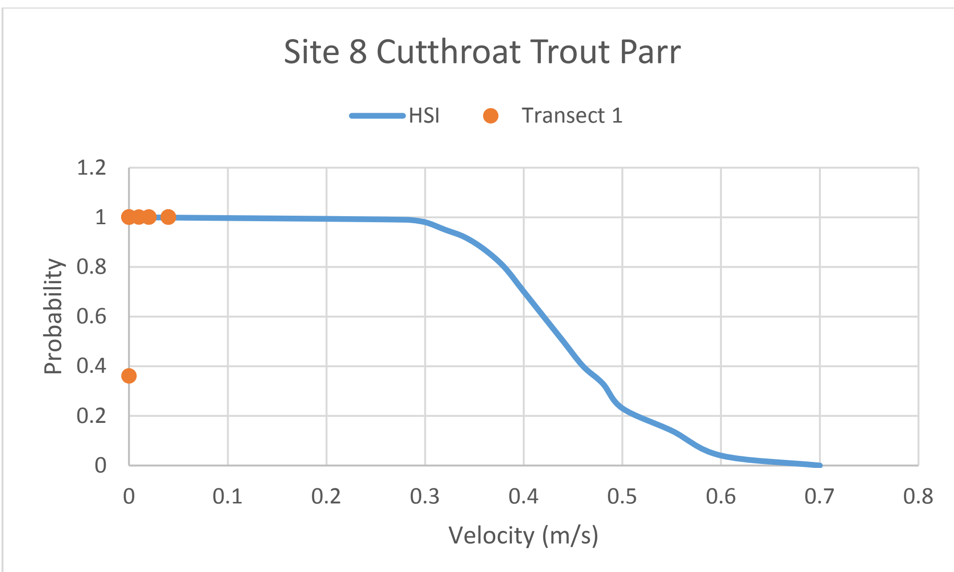


Figure S8-F. Site 8 Coastal Cutthroat Trout parr HSI model for depth.

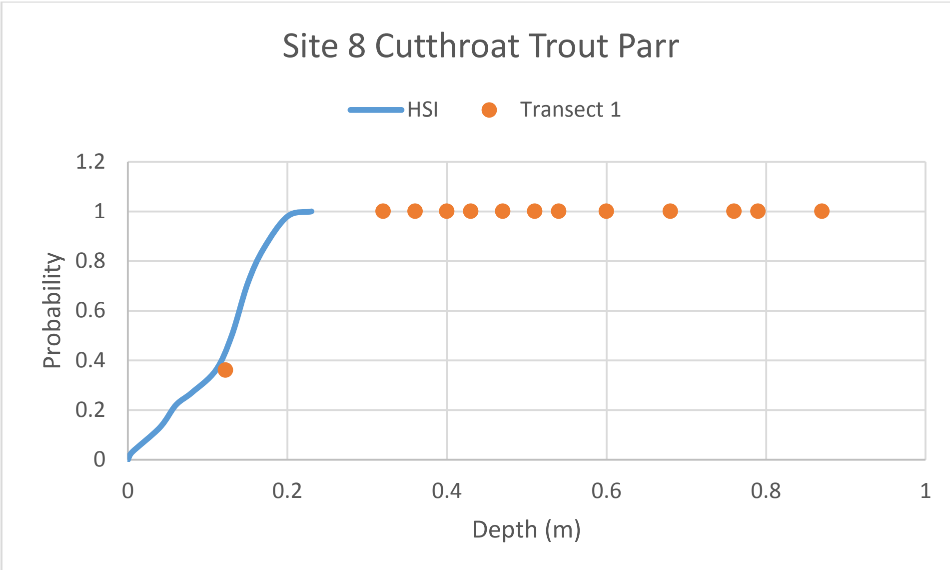


Figure S8-G. Site 8 Coastal Cutthroat Trout fry HSI model for velocity.

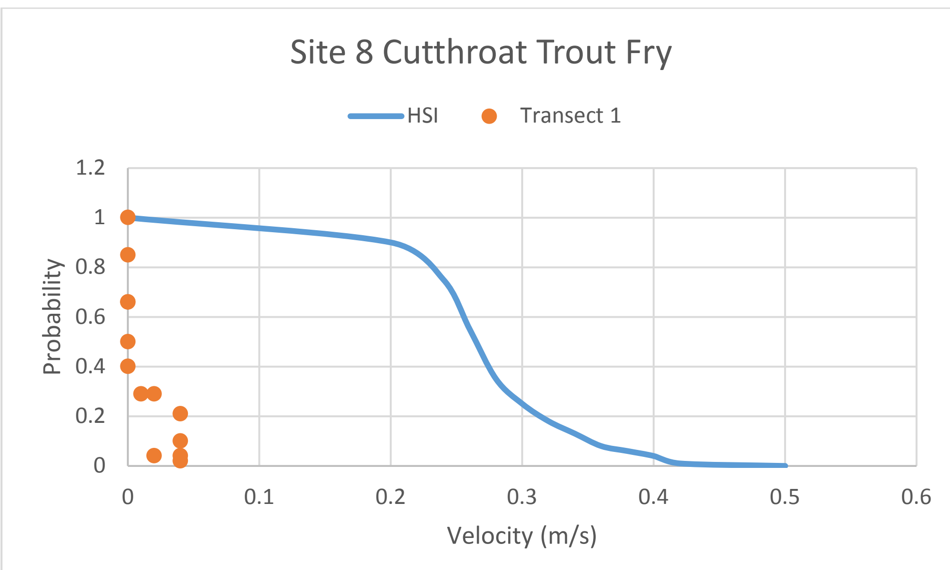
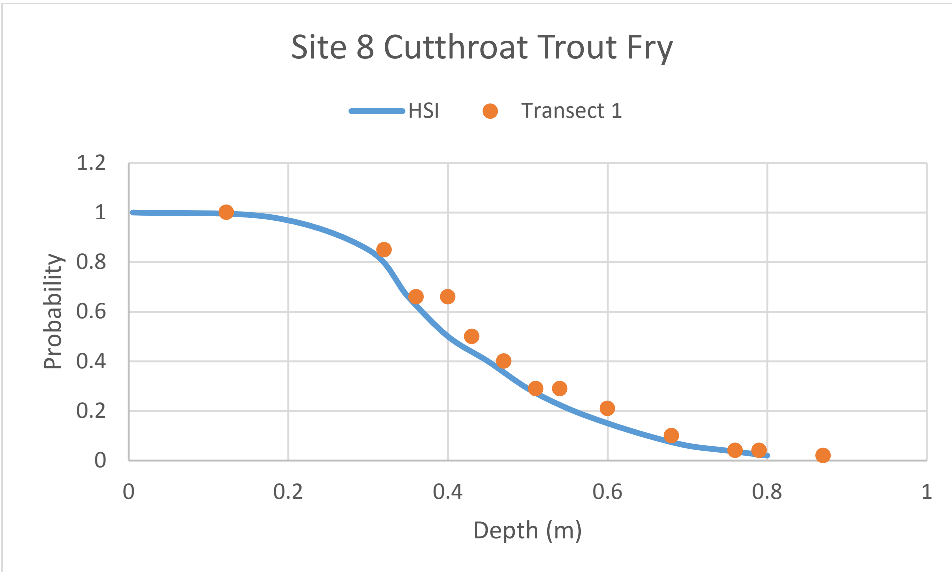


Figure S8-H. Site 8 Coastal Cutthroat Trout fry HSI model for depth.



SITE 9

Table S9-A. Site 9, Transect 1 percent usable area.

ADJUSTED USABLE AREAS

% USABLE BY RBT FRY	19	%
% USABLE BY RBT PARR	0	%
% USABLE BY CT FRY	99	%
% USABLE BY CT PARR	57	%
% USABLE BY CHINOOK	0	%
% USABLE BY COHO	76	%
Generic Insect suitability	0	%

Rainbow Trout

Figure S9-A. Site 9 Rainbow Trout parr HSI model for velocity.

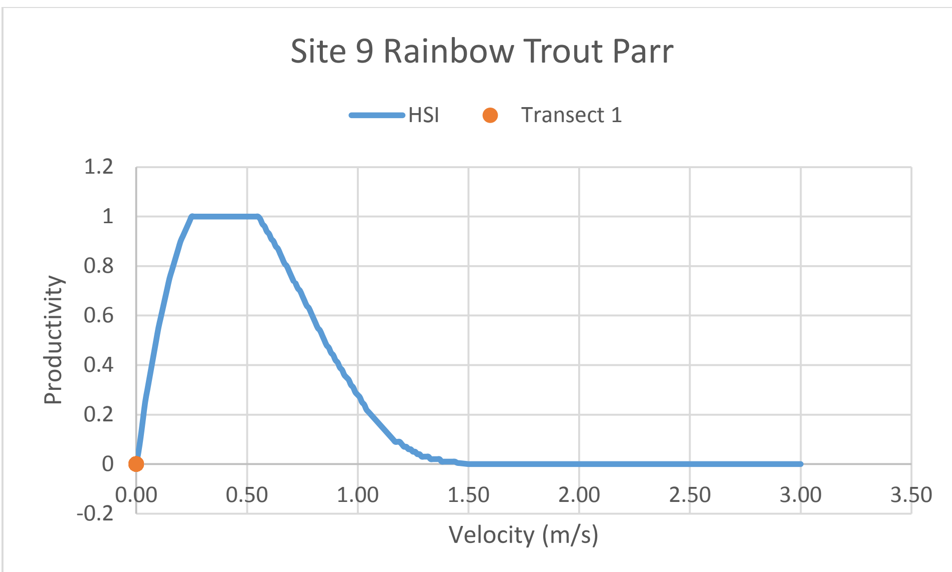


Figure S9-B. Site 9 Rainbow Trout parr HSI model for depth.

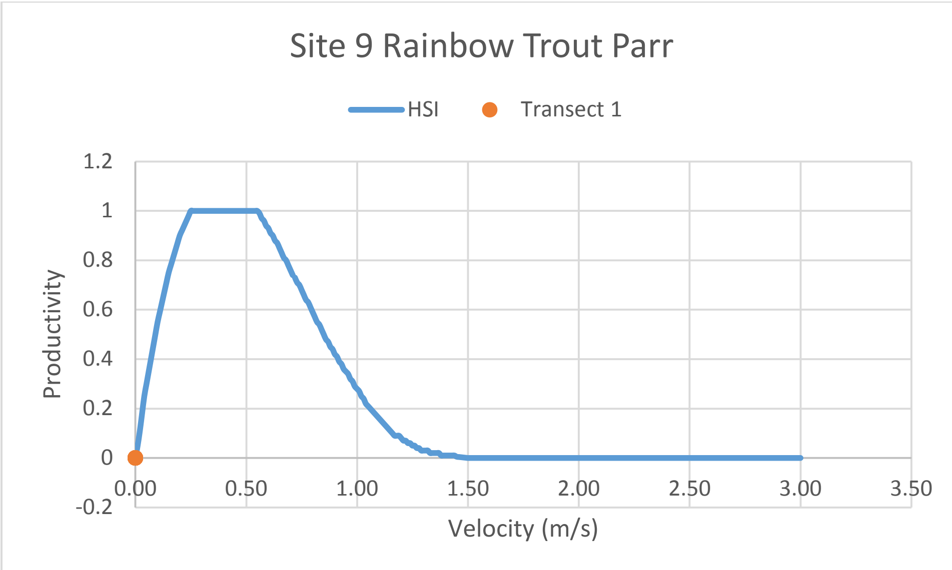


Figure S9-C. Site 9 Rainbow Trout fry HSI model for velocity.

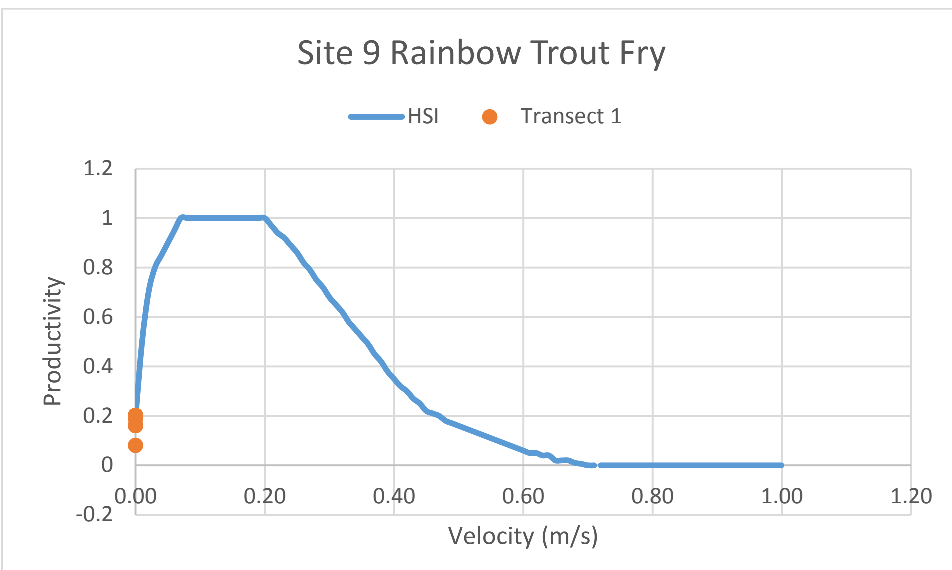
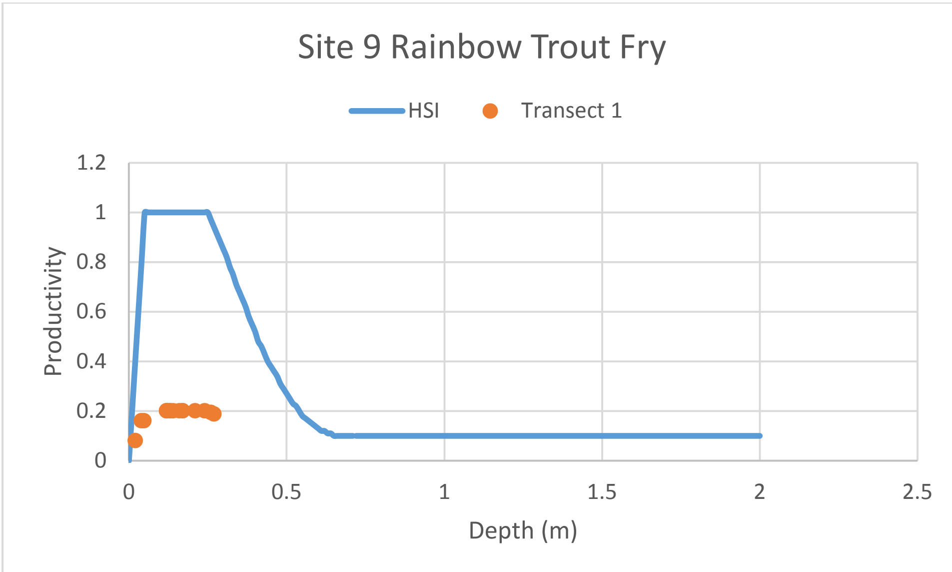


Figure S9-D. Site 9 Rainbow Trout fry HSI model for depth.



Cutthroat Trout

Figure S9-E. Site 9 Coastal Cutthroat Trout parr HSI model for velocity.

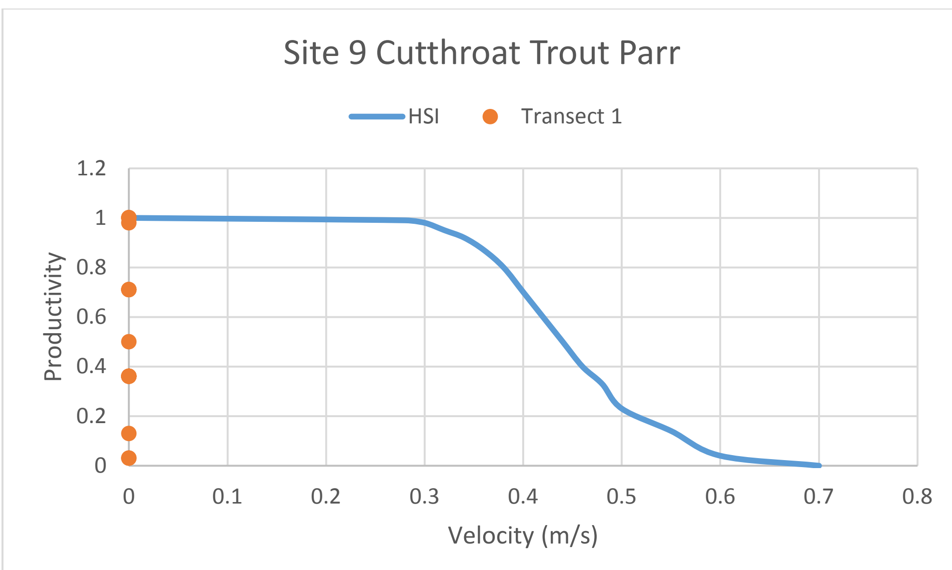


Figure S9-F. Site 9 Coastal Cutthroat Trout parr HSI model for depth.

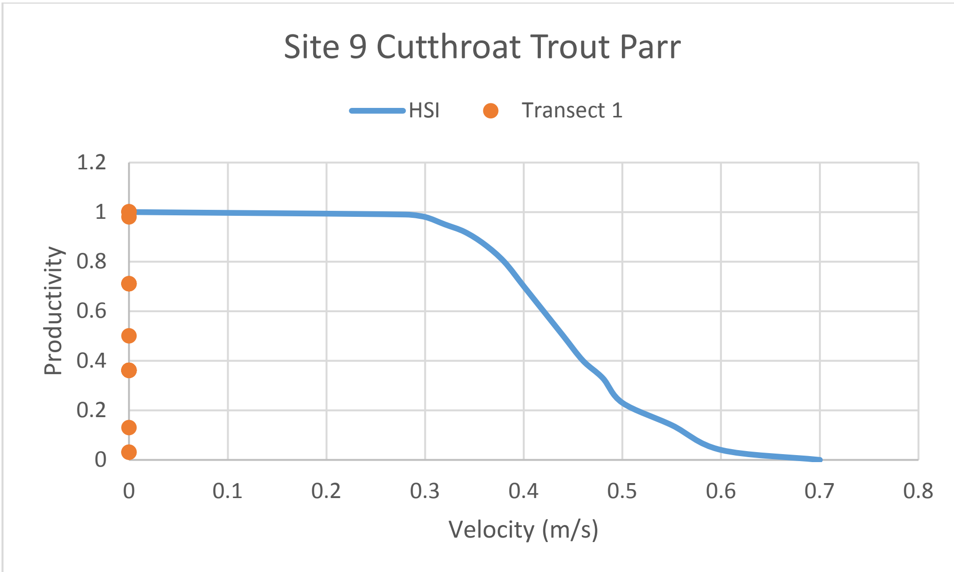


Figure S9-G. Site 9 Coastal Cutthroat Trout fry HSI model for velocity.

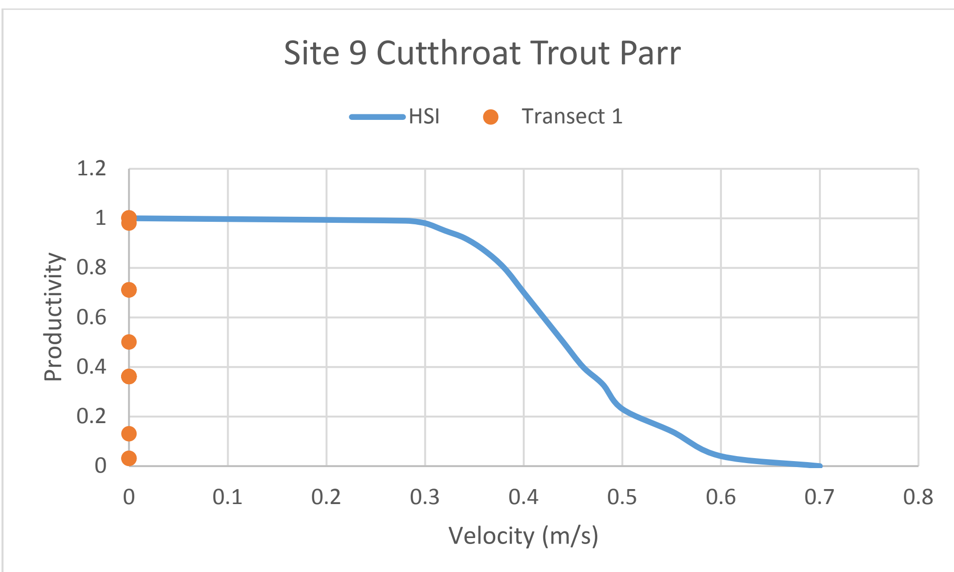
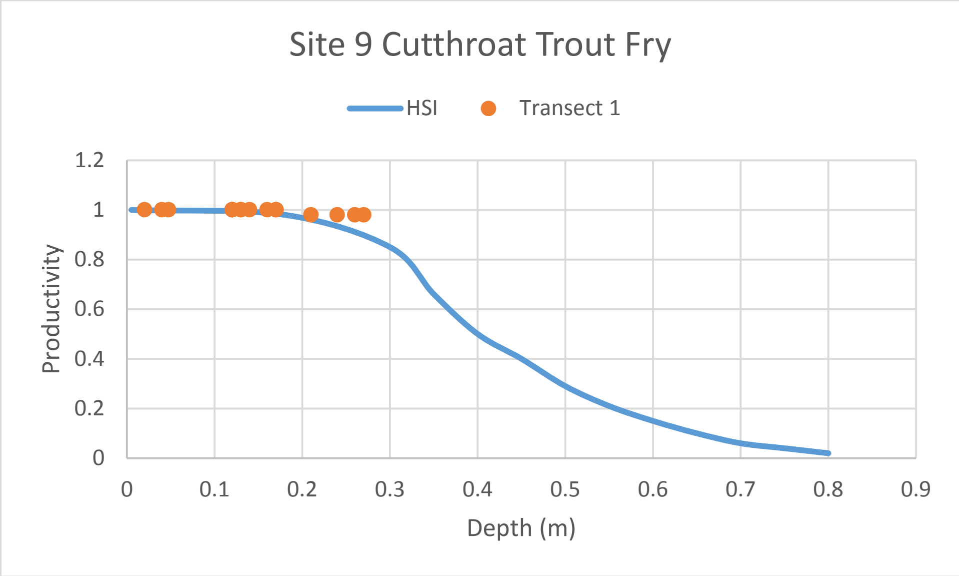


Figure S9-H. Site 9 Coastal Cutthroat Trout fry HSI model for depth.



SITE 10

Table S10-A. Site 10, Transect 1 percent usable area.

ADJUSTED USABLE AREAS

% USABLE BY RBT FRY	14	%
% USABLE BY RBT PARR	0	%
% USABLE BY CT FRY	78	%
% USABLE BY CT PARR	85	%
% USABLE BY CHINOOK	0	%
% USABLE BY COHO	90	%
Generic Insect suitability	0	%

Rainbow Trout

Figure S10-A. Site 10 Rainbow Trout parr HSI model for velocity.

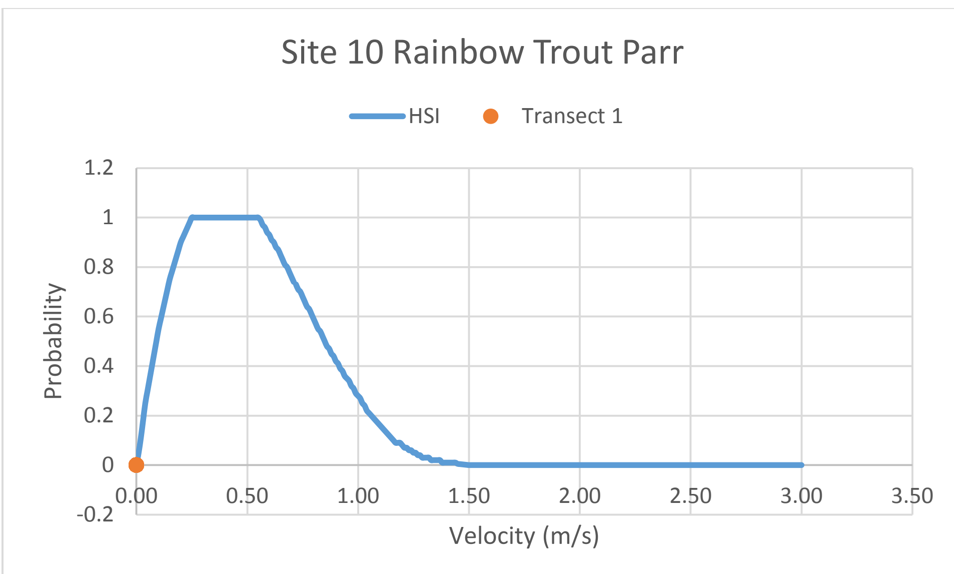


Figure S10-B. Site 10 Rainbow Trout parr HSI model for depth.

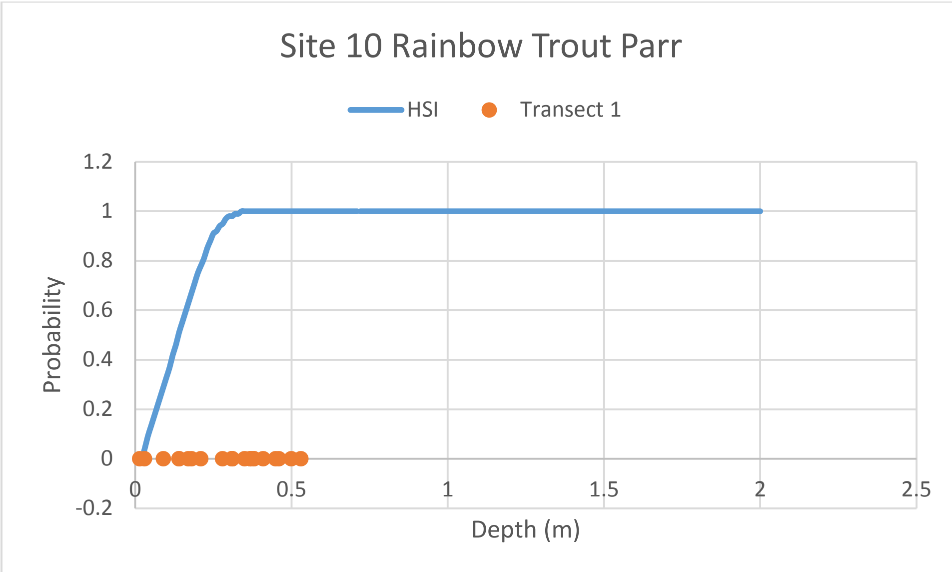


Figure S10-C. Site 10 Rainbow Trout fry HSI model for velocity.

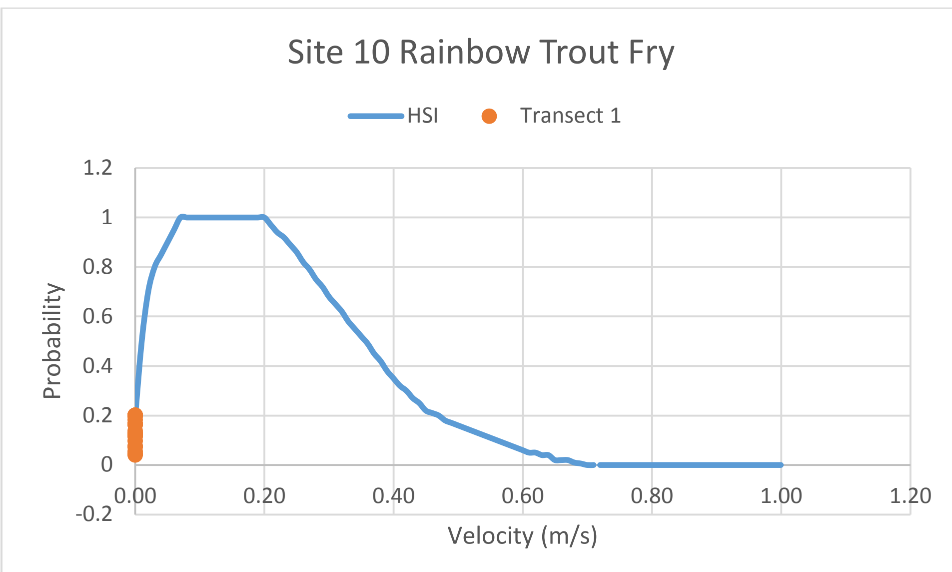
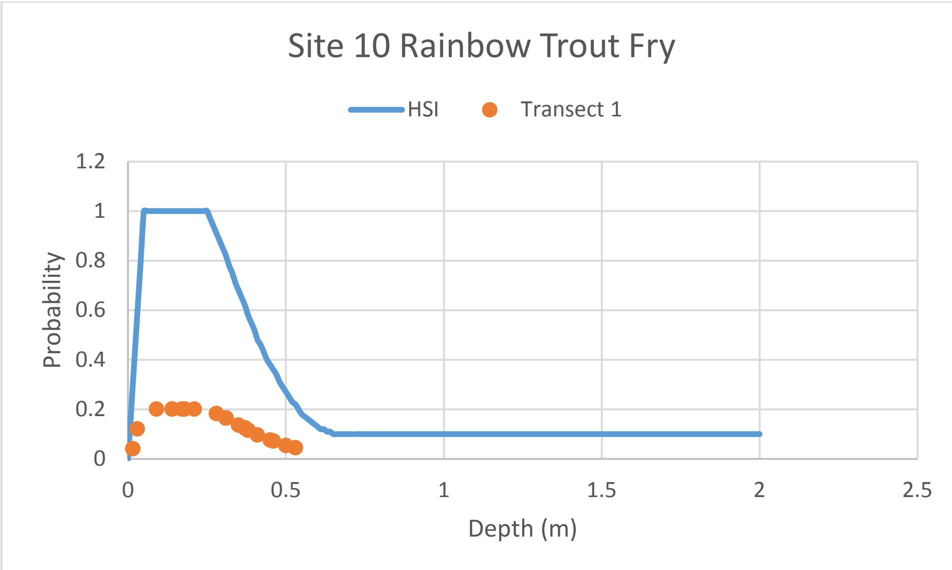


Figure S10-D. Site 10 Rainbow Trout fry HSI model for depth.



Cutthroat Trout

Figure S10-E. Site 10 Coastal Cutthroat Trout parr HSI model for velocity.

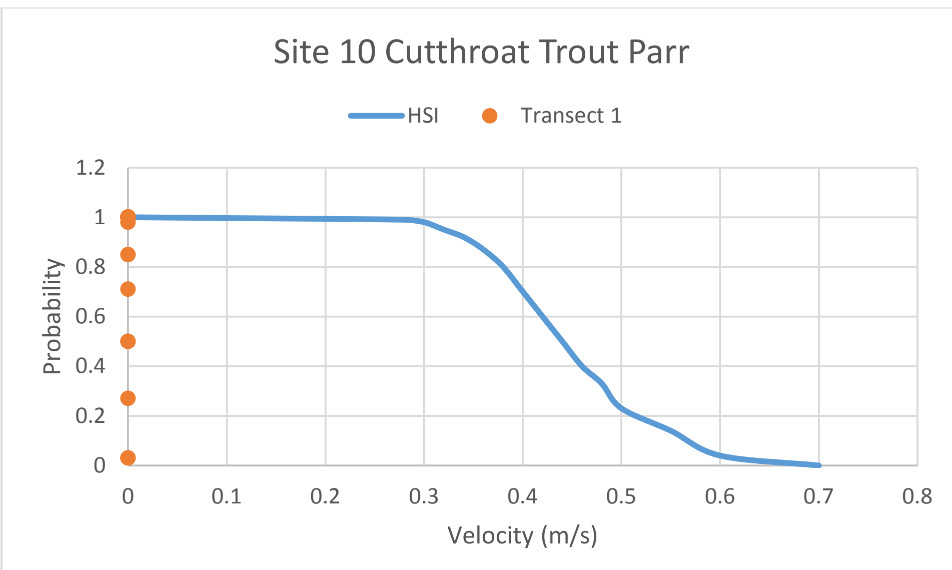


Figure S10-F. Site 10 Coastal Cutthroat Trout parr HSI model for depth.

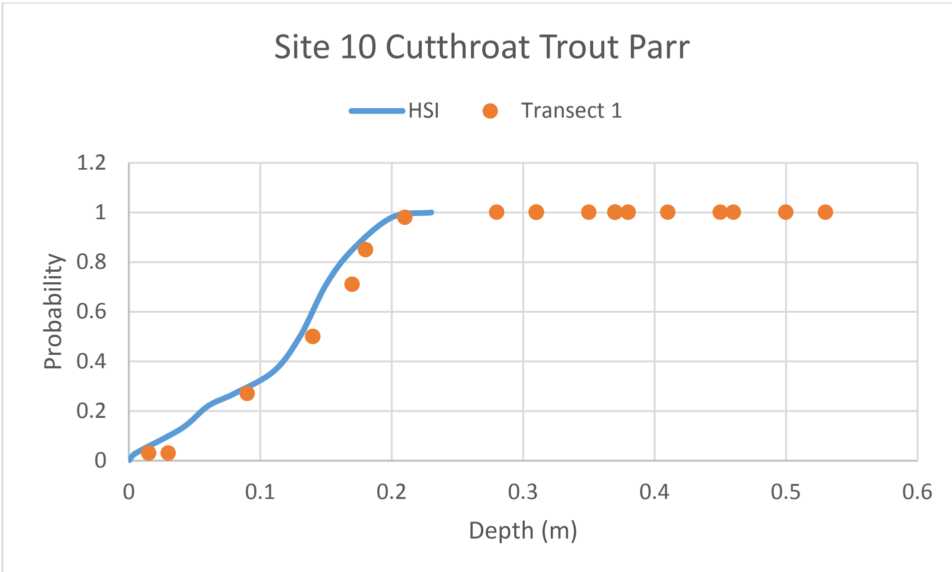


Figure S10-F. Site 10 Coastal Cutthroat Trout parr HSI model for depth.

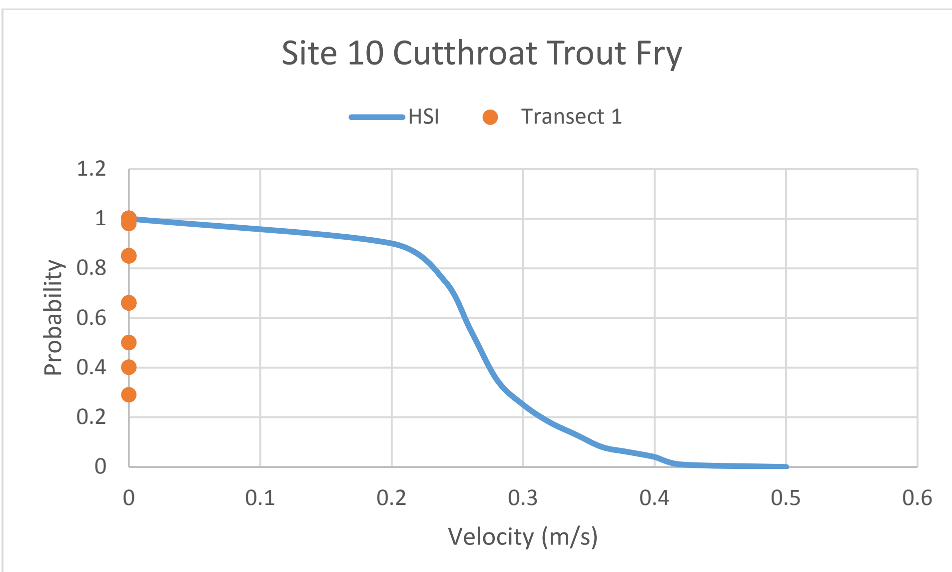
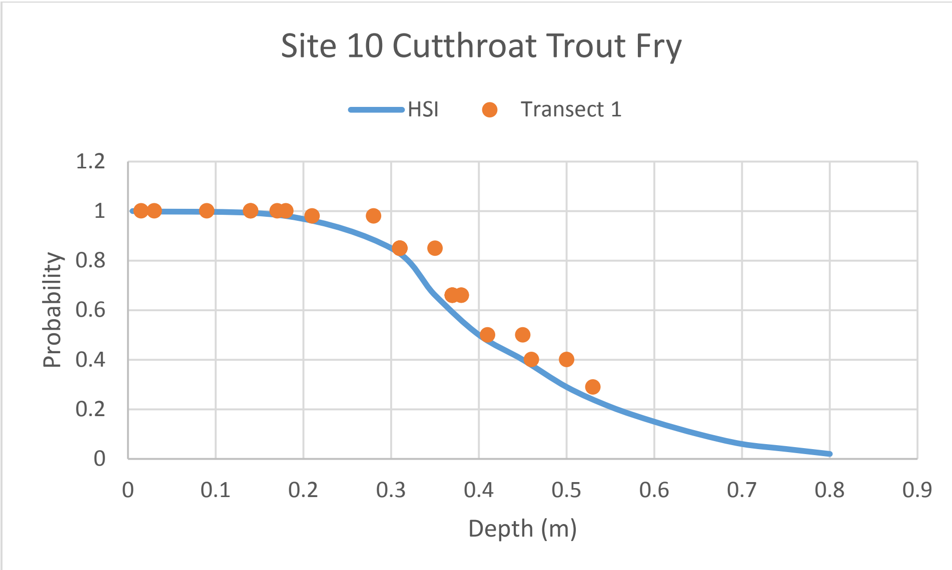


Figure S10-H. Site 10 Coastal Cutthroat Trout fry HSI model for depth.



SITE 11

Table S11-A. Site 11, Transect 1 percent usable area.

ADJUSTED USABLE AREAS

% USABLE BY RBT FRY	18	%
% USABLE BY RBT PARR	17	%
% USABLE BY CT FRY	66	%
% USABLE BY CT PARR	93	%
% USABLE BY CHINOOK	19	%
% USABLE BY COHO	96	%
Generic Insect suitability	3	%

Rainbow Trout

Figure S11-A. Site 11 Rainbow Trout parr HSI model for velocity.

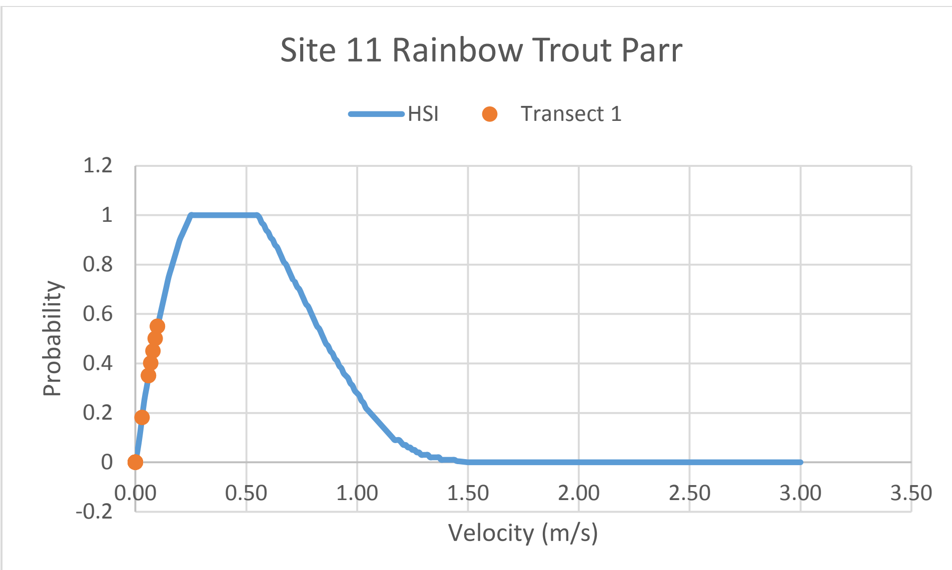


Figure S11-B. Site 11 Rainbow Trout parr HSI model for depth.

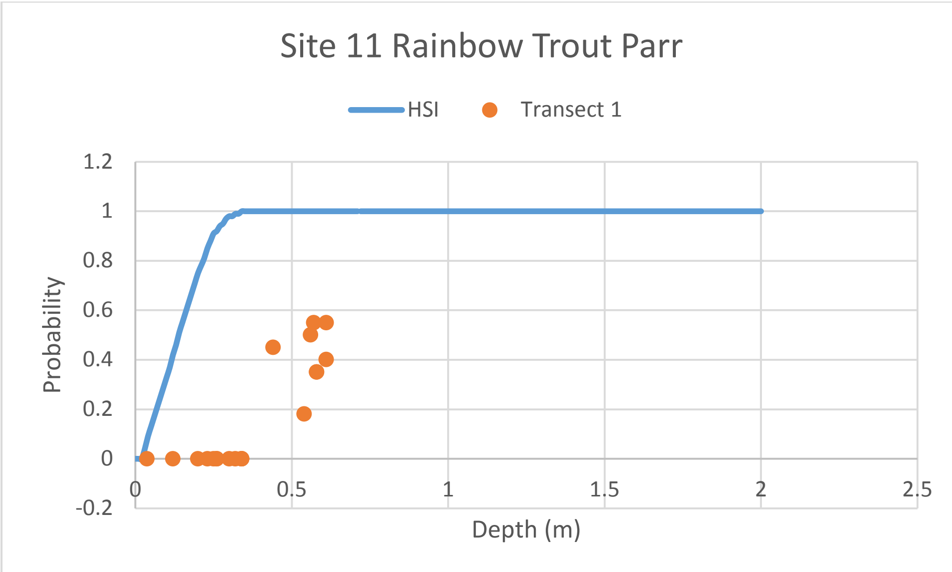


Figure S11-C. Site 11 Rainbow Trout fry HSI model for velocity.

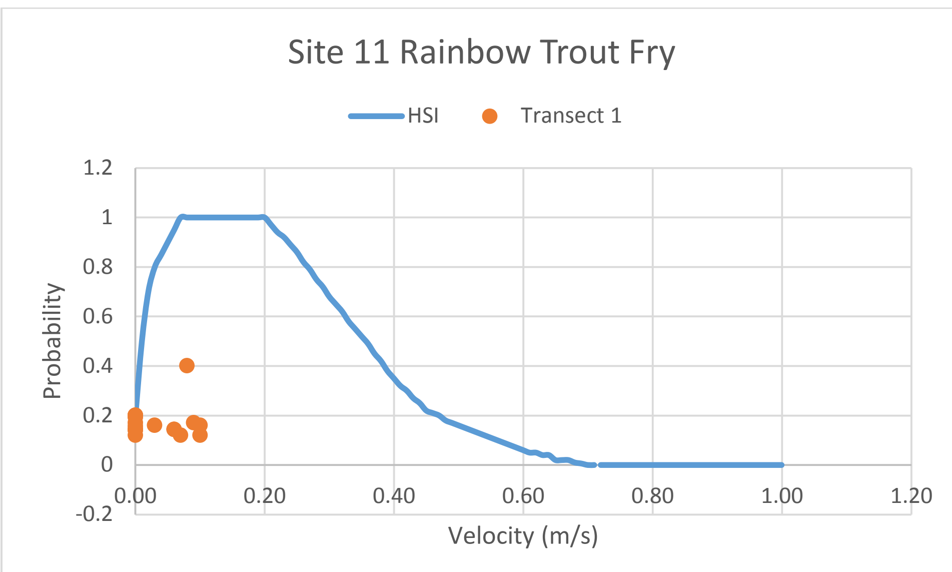
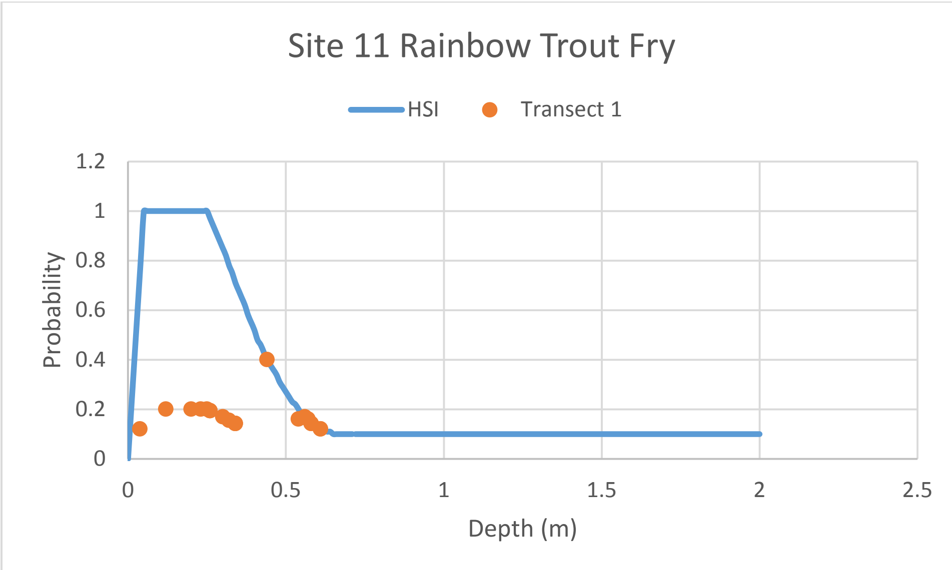


Figure S11-D. Site 11 Rainbow Trout fry HSI model for depth.



Cutthroat Trout

Figure S11-E. Site 11 Coastal Cutthroat Trout parr HSI model for velocity.

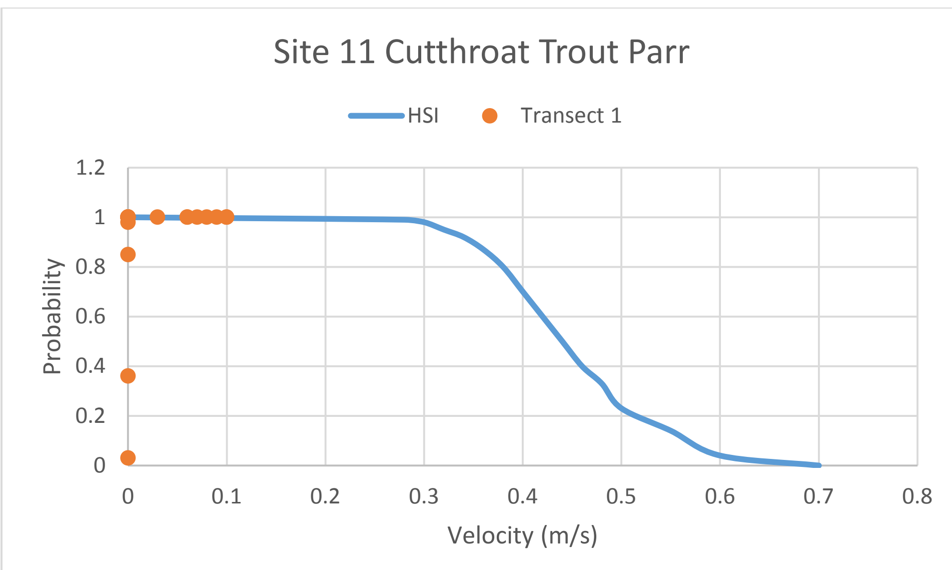


Figure S11-F. Site 11 Coastal Cutthroat Trout parr HSI model for depth.

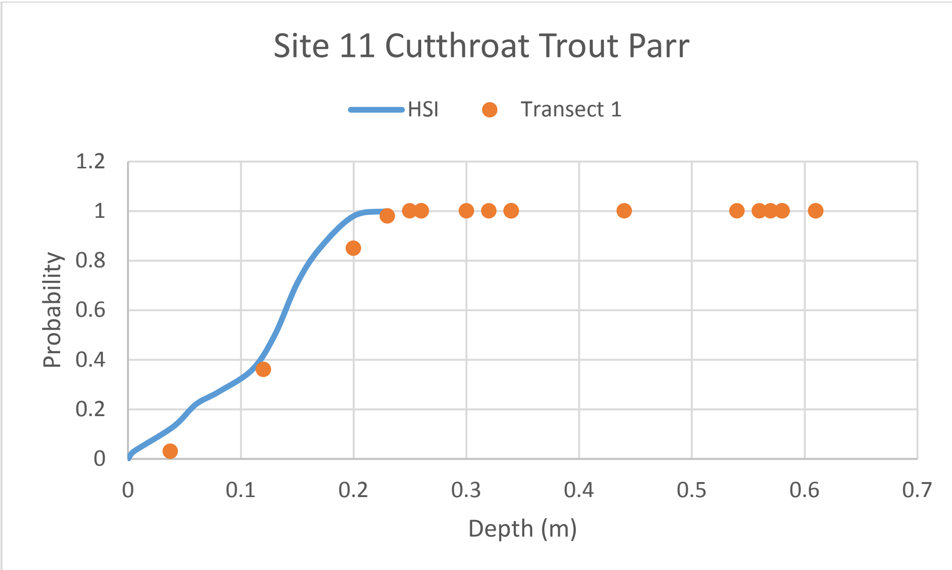
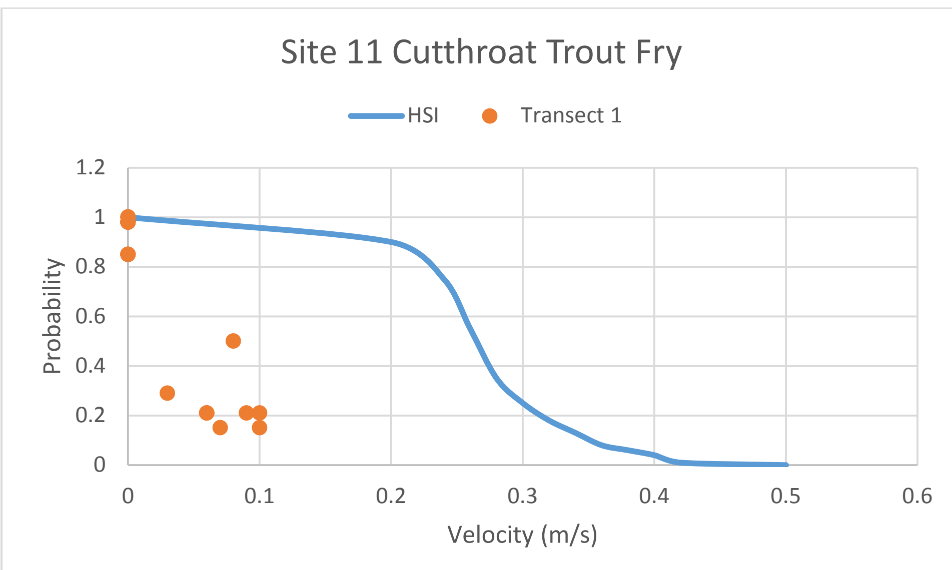
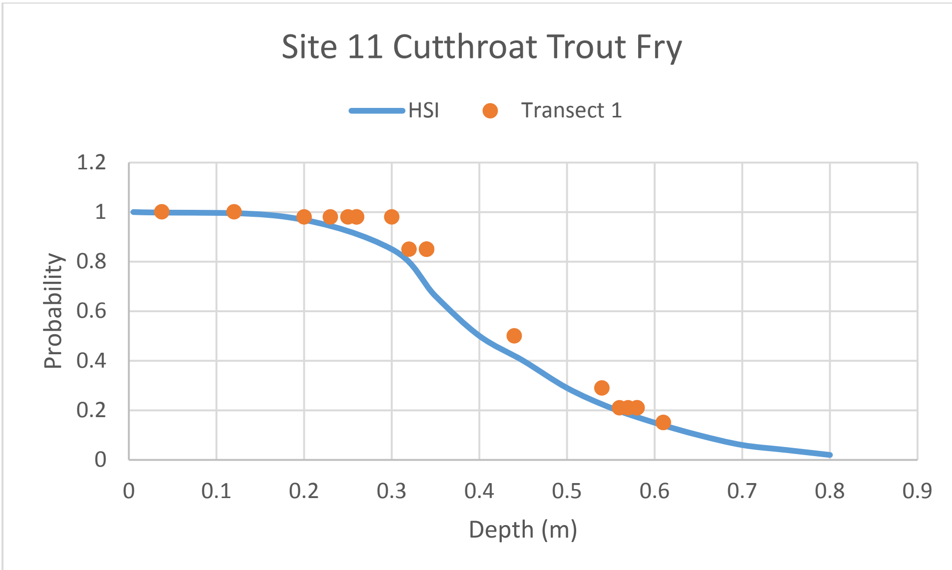


Figure S11-G. Site 11 Coastal Cutthroat Trout fry HSI model for velocity.



PGL ENVIRONMENTAL CONSULTANTS

Figure S11-H. Site 11 Coastal Cutthroat Trout fry HSI model for depth.



Appendix 2

Site 7 Sample HSI Data

ENVIRONMENTAL CONSULTANTS

DEPTH/VELOCITY TRANSECT DATA ANALYSIS SPREADSHEET
(CALCULATES W.U.A. & DISCHARGE)
Modified Feb 2010*

STREAM:	Stave River
DATE:	7-Oct-15
SAMPLE TYPE:	
SITE NAME:	Site 1

UTM CODE:	
STREAM CODE:	
SITE REFERENCE:	
TRANSECT #:	

MAIN/SIDE CHANNEL:	M
METERED/EST.:	M
MEAN/SURFACE:	M
TRANSECT WIDTH:	10.0 m
METER TYPE:	Swoffer
SENSOR DEPTH (from bottom):	60 %
METERED DISCHARGE:	175.0000 m^3s^{-1}

HYDRAULIC TYPE:	
WIDTH : DEPTH RATIO :	27.86
TRANSECT TYPE:	
STREAM WIDTH:	9.5 m
NO. OF STATIONS:	20

ADJUSTED USABLE AREAS

% USABLE BY RBT FRY	18 %
% USABLE BY RBT PARR	17 %
% USABLE BY CT FRY	66 %
% USABLE BY CT PARR	93 %
% USABLE BY CHINOOK	19 %
% USABLE BY COHO	96 %
Generic Insect suitability	3 %

SITE WEIGHTED MEANS

MEAN DEPTH:	0.359 m
MEAN VELOCITY:	48.755 ms^{-1}
CROSS-SECT. AREA:	3.589 m^2

Sum usable width Kokanee 0.39 **Sum usable width Insects 0.28**
Sum usable width Rb parr 1.58
Sum usable width Rb fry 1.67

DEPTH/ VELOCITY DATA FOR WEIGHTED USABLE AREA (WUA) CALCULATIONS

Transect Data																								
station length (m)	depth (m)	velocity (m/s)	substrate	cell width (m)	cell mean depth (m)	cell mean velocity (m/s)	cell prob. RBT	usable width Fry (m)	cell prob. RBT Parr	usable width RBT Parr	cell prob. CT fry	usable width CT fry	cell prob CT parr	usable width CT parr	cell prob. CH	usable width CH (m)	cell prob. CO	usable width CO (m)	cell prob. Ins.	usable width Ins. (m)	cell area (sq. m)	cell discharge (cu. m/se	cell prob Kokanee Spawn	usable width Kokanee Spawn
0.5	0.03	0		0.3	0.0	0.00	0.1	0.0	0.0	0.0	1.0	0.3	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.00	0.0
1	0.12	0		0.5	0.1	0.00	0.2	0.1	0.0	0.0	1.0	0.5	0.4	0.2	0.0	0.0	0.7	0.4	0.0	0.0	0.1	0.0	0.00	0.0
1.5	0.2	0		0.5	0.2	0.00	0.2	0.1	0.0	0.0	1.0	0.5	0.9	0.4	0.0	0.0	0.9	0.5	0.0	0.0	0.1	0.0	0.00	0.0
2	0.3	0		0.5	0.3	0.00	0.2	0.1	0.0	0.0	1.0	0.5	1.0	0.5	0.0	0.0	1.0	0.5	0.0	0.0	0.2	0.0	0.00	0.0
2.5	0.32	0		0.5	0.3	0.00	0.2	0.1	0.0	0.0	0.9	0.4	1.0	0.5	0.0	0.0	1.0	0.5	0.0	0.0	0.2	0.0	0.00	0.0
3	0.34	0		0.5	0.3	0.00	0.1	0.1	0.0	0.0	0.9	0.4	1.0	0.5	0.0	0.0	1.0	0.5	0.0	0.0	0.2	0.0	0.00	0.0
3.5	0.34	0		0.5	0.3	0.00	0.1	0.1	0.0	0.0	0.9	0.4	1.0	0.5	0.0	0.0	1.0	0.5	0.0	0.0	0.2	0.0	0.00	0.0
4	0.26	0		0.5	0.3	0.00	0.2	0.1	0.0	0.0	1.0	0.5	1.0	0.5	0.0	0.0	1.0	0.5	0.0	0.0	0.1	0.0	0.00	0.0
4.5	0.26	0		0.5	0.3	0.00	0.2	0.1	0.0	0.0	1.0	0.5	1.0	0.5	0.0	0.0	1.0	0.5	0.0	0.0	0.1	0.0	0.00	0.0
5	0.23	0		0.5	0.2	0.00	0.2	0.1	0.0	0.0	1.0	0.5	1.0	0.5	0.0	0.0	1.0	0.5	0.0	0.0	0.1	0.0	0.00	0.0
5.5	0.25	0		0.5	0.3	0.00	0.2	0.1	0.0	0.0	1.0	0.5	1.0	0.5	0.0	0.0	1.0	0.5	0.0	0.0	0.1	0.0	0.00	0.0
6	0.34	0		0.5	0.3	0.00	0.1	0.1	0.0	0.0	0.9	0.4	1.0	0.5	0.0	0.0	1.0	0.5	0.0	0.0	0.2	0.0	0.00	0.0
6.5	0.44	0.08		0.5	0.4	0.08	0.4	0.2	0.5	0.2	0.5	0.3	1.0	0.5	0.5	0.3	1.0	0.5	0.1	0.0	0.2	0.0	0.22	0.1
7	0.54	0.03		0.5	0.5	0.03	0.2	0.1	0.2	0.1	0.3	0.1	1.0	0.5	0.2	0.1	1.0	0.5	0.0	0.0	0.3	0.0	0.05	0.0
7.5	0.58	0.06		0.5	0.6	0.06	0.1	0.1	0.4	0.2	0.2	0.1	1.0	0.5	0.4	0.2	1.0	0.5	0.1	0.0	0.3	0.0	0.07	0.0
8	0.56	0.09		0.5	0.6	0.09	0.2	0.1	0.5	0.3	0.2	0.1	1.0	0.5	0.6	0.3	1.0	0.5	0.1	0.0	0.3	0.0	0.13	0.1
8.5	0.57	0.1		0.5	0.6	0.10	0.2	0.1	0.6	0.3	0.2	0.1	1.0	0.5	0.6	0.3	1.0	0.5	0.1	0.1	0.3	0.0	0.13	0.1
9	0.61	0.1		0.5	0.6	0.10	0.1	0.1	0.6	0.3	0.2	0.1	1.0	0.5	0.6	0.3	1.0	0.5	0.1	0.1	0.3	0.0	0.08	0.0
9.5	0.61	0.07		0.5	0.6	0.07	0.1	0.1	0.4	0.2	0.2	0.1	1.0	0.5	0.5	0.2	1.0	0.5	0.1	0.0	0.3	0.0	0.06	0.0
10	0.58	0.06		0.3	0.6	0.06	0.1	0.0	0.4	0.1	0.2	0.1	1.0	0.3	0.4	0.1	1.0	0.3	0.1	0.0	0.1	0.0	0.07	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

This spread sheet is brought to you by Poul Bech, Ron Ptolemy, and Rob Knight, B.C. Environment, Fisheries Section, May 1994.
(Modified by Harlan Wright, British Columbia Conservation Foundation, January 2003, using Febuary 2001 WUP HSI curves and Generic Insect curves from Stalnaker and Arnette, 1976).
* Modified by James Craig, BCCF, February 2010, to correct deficiency in RB parr lookup table data (cells AH110 to AH158).
10
0.5
9.5

Ptolemy WUP HSI curves (Febuary 12, 2001)

Rainbow fry (summer)				Rainbow parr (summer)				Coho (summer)			
depth (m)	probability of use	velocity (m/s)	probability of use	depth (m)	probability of use	velocity (m/s)	probability of use	depth (m)	probability of use	velocity (m/s)	probability of use
0	0	0.00	0.2	0	0	0.00	0	0	0	0	1
0.01	0.2	0.01	0.5	0.01	0	0.01	0.05	0.01	0.05	0.01	1
0.02	0.4	0.02	0.7	0.02	0	0.02	0.11	0.02	0.12	0.02	1
0.03	0.6	0.03	0.8	0.03	0.04	0.03	0.18	0.03	0.2	0.03	1
0.04	0.8	0.04	0.85	0.04	0.09	0.04	0.25	0.04	0.27	0.04	1
0.05	1	0.05	0.9	0.05	0.13	0.05	0.3	0.05	0.34	0.05	1
0.06	1	0.06	0.95	0.06	0.17	0.06	0.35	0.06	0.4	0.06	1
0.07	1	0.07	1	0.07	0.21	0.07	0.4	0.07	0.45	0.07	1
0.08	1	0.08	1	0.08	0.25	0.08	0.45	0.08	0.51	0.08	1
0.09	1	0.09	1	0.09	0.29	0.09	0.5	0.09	0.56	0.09	1
0.1	1	0.10	1	0.1	0.33	0.10	0.55	0.1	0.61	0.1	1
0.11	1	0.11	1	0.11	0.37	0.11	0.59	0.11	0.66	0.11	1
0.12	1	0.12	1	0.12	0.42	0.12	0.63	0.12	0.7	0.12	1
0.13	1	0.13	1	0.13	0.46	0.13	0.67	0.13	0.74	0.13	0.96
0.14	1	0.14	1	0.14	0.51	0.14	0.71	0.14	0.78	0.14	0.94
0.15	1	0.15	1	0.15	0.55	0.15	0.75	0.15	0.81	0.15	0.91
0.16	1	0.16	1	0.16	0.59	0.16	0.78	0.16	0.84	0.16	0.88
0.17	1	0.17	1	0.17	0.63	0.17	0.81	0.17	0.87	0.17	0.84
0.18	1	0.18	1	0.18	0.67	0.18	0.84	0.18	0.89	0.18	0.8
0.19	1	0.19	1	0.19	0.71	0.19	0.87	0.19	0.92	0.19	0.76
0.2	1	0.20	1	0.2	0.75	0.20	0.9	0.2	0.94	0.2	0.72
0.21	1	0.21	0.97	0.21	0.78	0.21	0.92	0.21	0.95	0.21	0.68
0.22	1	0.22	0.94	0.22	0.81	0.22	0.94	0.22	0.97	0.22	0.64
0.23	1	0.23	0.92	0.23	0.85	0.23	0.96	0.23	0.98	0.23	0.6
0.24	1	0.24	0.89	0.24	0.88	0.24	0.98	0.24	0.99	0.24	0.56
0.25	1	0.25	0.86	0.25	0.91	0.25	1	0.25	1	0.25	0.52
0.26	0.97	0.26	0.82	0.26	0.92	0.26	1	0.26	1	0.26	0.48
0.27	0.94	0.27	0.79	0.27	0.94	0.27	1	0.27	1	0.27	0.44
0.28	0.91	0.28	0.75	0.28	0.95	0.28	1	0.28	1	0.28	0.4
0.29	0.88	0.29	0.72	0.29	0.97	0.29	1	0.29	1	0.29	0.36
0.3	0.85	0.30	0.68	0.3	0.98	0.30	1	0.3	1	0.3	0.33
0.31	0.82	0.31	0.65	0.31	0.98	0.31	1	0.31	1	0.31	0.3
0.32	0.78	0.32	0.62	0.32	0.99	0.32	1	0.32	1	0.32	0.26
0.33	0.75	0.33	0.58	0.33	0.99	0.33	1	0.33	1	0.33	0.23
0.34	0.71	0.34	0.55	0.34	1	0.34	1	0.34	1	0.34	0.2
0.35	0.68	0.35	0.52	0.35	1	0.35	1	0.35	1	0.35	0.18
0.36	0.65	0.36	0.49	0.36	1	0.36	1	0.36	1	0.36	0.14
0.37	0.62	0.37	0.45	0.37	1	0.37	1	0.37	1	0.37	0.12
0.38	0.58	0.38	0.42	0.38	1	0.38	1	0.38	1	0.38	0.1
0.39	0.55	0.39	0.38	0.39	1	0.39	1	0.39	1	0.39	0.08
0.4	0.52	0.40	0.35	0.4	1	0.40	1	0.4	1	0.4	0.06
0.41	0.48	0.41	0.32	0.41	1	0.41	1	0.41	1	0.41	0.04
0.42	0.46	0.42	0.3	0.42	1	0.42	1	0.42	1	0.42	0.03
0.43	0.43	0.43	0.27	0.43	1	0.43	1	0.43	1	0.43	0.02
0.44	0.4	0.44	0.25	0.44	1	0.44	1	0.44	1	0.44	0.01
0.45	0.38	0.45	0.22	0.45	1	0.45	1	0.45	1	0.45	0
0.46	0.36	0.46	0.21	0.46	1	0.46	1	0.46	1	0.46	0
0.47	0.34	0.47	0.2	0.47	1	0.47	1	0.47	1	0.47	0
0.48	0.31	0.48	0.18	0.48	1	0.48	1	0.48	1	0.48	0
0.49	0.29	0.49	0.17	0.49	1	0.49	1	0.49	1	0.49	0
0.5	0.27	0.50	0.16	0.5	1	0.50	1	0.5	1	0.5	0
0.51	0.25	0.51	0.15	0.51	1	0.51	1	0.51	1	0.51	0
0.52	0.23	0.52	0.14	0.52	1	0.52	1	0.52	1	0.52	0
0.53	0.22	0.53	0.13	0.53	1	0.53	1	0.53	1	0.53	0
0.54	0.2	0.54	0.12	0.54	1	0.54	1	0.54	1	0.54	0
0.55	0.18	0.55	0.11	0.55	1	0.55	1	0.55	1	0.55	0
0.56	0.17	0.56	0.1	0.56	1	0.56	0.99	0.56	1	0.56	0
0.57	0.16	0.57	0.09	0.57	1	0.57	0.97	0.57	1	0.57	0
0.58	0.15	0.58	0.08	0.58	1	0.58	0.96	0.58	1	0.58	0
0.59	0.14	0.59	0.07	0.59	1	0.59	0.94	0.59	1	0.59	0
0.6	0.13	0.60	0.06	0.6	1	0.60	0.93	0.6	1	0.6	0
0.61	0.12	0.61	0.05	0.61	1	0.61	0.91	0.61	1	0.61	0
0.62	0.12	0.62	0.05	0.62	1	0.62	0.9	0.62	1	0.62	0
0.63	0.11	0.63	0.04	0.63	1	0.63	0.88	0.63	1	0.63	0
0.64	0.11	0.64	0.04	0.64	1	0.64	0.87	0.64	1	0.64	0
0.65	0.1	0.65	0.02	0.65	1	0.65	0.85	0.65	1	0.65	0
0.66	0.1	0.66	0.02	0.66	1	0.66	0.83	0.66	1	0.66	0
0.67	0.1	0.67	0.02	0.67	1	0.67	0.81	0.67	1	0.67	0
0.68	0.1	0.68	0.01	0.68	1	0.68	0.8	0.68	1	0.68	0
0.69	0.1	0.69	0.006	0.69	1	0.69	0.78	0.69	1	0.69	0
0.7	0.1	0.70	0	0.7	1	0.70	0.76	0.7	1	0.7	0
0.71	0.1	0.71	0	0.71	1	0.71	0.74	0.71	1	0.71	0
0.72	0.1	0.72	0	0.72	1	0.72	0.73	0.72	1	0.72	0
0.73	0.1	0.73	0	0.73	1	0.73	0.71	0.73	1	0.73	0
0.74	0.1	0.74	0	0.74	1	0.74	0.7	0.74	1	0.74	0

0.75	0.1	0.75	0	0.75	1	0.75	0.68	0.75	1	0.75	0
0.76	0.1	0.76	0	0.76	1	0.76	0.66	0.76	1	0.76	0
0.77	0.1	0.77	0	0.77	1	0.77	0.64	0.77	1	0.77	0
0.78	0.1	0.78	0	0.78	1	0.78	0.63	0.78	1	0.78	0
0.79	0.1	0.79	0	0.79	1	0.79	0.61	0.79	1	0.79	0
0.8	0.1	0.80	0	0.8	1	0.80	0.59	0.8	1	0.8	0
0.81	0.1	0.81	0	0.81	1	0.81	0.57	0.81	1	0.81	0
0.82	0.1	0.82	0	0.82	1	0.82	0.55	0.82	1	0.82	0
0.83	0.1	0.83	0	0.83	1	0.83	0.54	0.83	1	0.83	0
0.84	0.1	0.84	0	0.84	1	0.84	0.52	0.84	1	0.84	0
0.85	0.1	0.85	0	0.85	1	0.85	0.5	0.85	1	0.85	0
0.86	0.1	0.86	0	0.86	1	0.86	0.48	0.86	1	0.86	0
0.87	0.1	0.87	0	0.87	1	0.87	0.47	0.87	1	0.87	0
0.88	0.1	0.88	0	0.88	1	0.88	0.45	0.88	1	0.88	0
0.89	0.1	0.89	0	0.89	1	0.89	0.44	0.89	1	0.89	0
0.9	0.1	0.90	0	0.9	1	0.90	0.42	0.9	1	0.9	0
0.91	0.1	0.91	0	0.91	1	0.91	0.41	0.91	1	0.91	0
0.92	0.1	0.92	0	0.92	1	0.92	0.39	0.92	1	0.92	0
0.93	0.1	0.93	0	0.93	1	0.93	0.38	0.93	1	0.93	0
0.94	0.1	0.94	0	0.94	1	0.94	0.36	0.94	1	0.94	0
0.95	0.1	0.95	0	0.95	1	0.95	0.35	0.95	1	0.95	0
0.96	0.1	0.96	0	0.96	1	0.96	0.34	0.96	1	0.96	0
0.97	0.1	0.97	0	0.97	1	0.97	0.32	0.97	1	0.97	0
0.98	0.1	0.98	0	0.98	1	0.98	0.31	0.98	1	0.98	0
0.99	0.1	0.99	0	0.99	1	0.99	0.29	0.99	1	0.99	0
1	0.1	1.00	0	1	1	1.00	0.28	1	1	1	0
1.01	0.1	1.00	0	1.01	1	1.01	0.27	1.01	1	1.01	0
1.02	0.1	1.00	0	1.02	1	1.02	0.25	1.02	1	1.02	0
1.03	0.1	1.00	0	1.03	1	1.03	0.24	1.03	1	1.03	0
1.04	0.1	1.00	0	1.04	1	1.04	0.22	1.04	1	1.04	0
1.05	0.1	1.00	0	1.05	1	1.05	0.21	1.05	1	1.05	0
1.06	0.1	1.00	0	1.06	1	1.06	0.2	1.06	1	1.06	0
1.07	0.1	1.00	0	1.07	1	1.07	0.19	1.07	1	1.07	0
1.08	0.1	1.00	0	1.08	1	1.08	0.18	1.08	1	1.08	0
1.09	0.1	1.00	0	1.09	1	1.09	0.17	1.09	1	1.09	0
1.1	0.1	1.00	0	1.1	1	1.10	0.16	1.1	1	1.1	0
1.11	0.1	1.00	0	1.11	1	1.11	0.15	1.11	1	1.11	0
1.12	0.1	1.00	0	1.12	1	1.12	0.14	1.12	1	1.12	0
1.13	0.1	1.00	0	1.13	1	1.13	0.13	1.13	1	1.13	0
1.14	0.1	1.00	0	1.14	1	1.14	0.12	1.14	1	1.14	0
1.15	0.1	1.00	0	1.15	1	1.15	0.11	1.15	1	1.15	0
1.16	0.1	1.00	0	1.16	1	1.16	0.1	1.16	1	1.16	0
1.17	0.1	1.00	0	1.17	1	1.17	0.09	1.17	1	1.17	0
1.18	0.1	1.00	0	1.18	1	1.18	0.09	1.18	1	1.18	0
1.19	0.1	1.00	0	1.19	1	1.19	0.09	1.19	1	1.19	0
1.2	0.1	1.00	0	1.2	1	1.20	0.08	1.2	1	1.2	0
1.21	0.1	1.00	0	1.21	1	1.21	0.07	1.21	1	1.21	0
1.22	0.1	1.00	0	1.22	1	1.22	0.07	1.22	1	1.22	0
1.23	0.1	1.00	0	1.23	1	1.23	0.06	1.23	1	1.23	0
1.24	0.1	1.00	0	1.24	1	1.24	0.06	1.24	1	1.24	0
1.25	0.1	1.00	0	1.25	1	1.25	0.05	1.25	1	1.25	0
1.26	0.1	1.00	0	1.26	1	1.26	0.05	1.26	1	1.26	0
1.27	0.1	1.00	0	1.27	1	1.27	0.04	1.27	1	1.27	0
1.28	0.1	1.00	0	1.28	1	1.28	0.04	1.28	1	1.28	0
1.29	0.1	1.00	0	1.29	1	1.29	0.03	1.29	1	1.29	0
1.3	0.1	1.00	0	1.3	1	1.30	0.03	1.3	1	1.3	0
1.31	0.1	1.00	0	1.31	1	1.31	0.03	1.31	1	1.31	0
1.32	0.1	1.00	0	1.32	1	1.32	0.03	1.32	1	1.32	0
1.33	0.1	1.00	0	1.33	1	1.33	0.02	1.33	1	1.33	0
1.34	0.1	1.00	0	1.34	1	1.34	0.02	1.34	1	1.34	0
1.35	0.1	1.00	0	1.35	1	1.35	0.02	1.35	1	1.35	0
1.36	0.1	1.00	0	1.36	1	1.36	0.02	1.36	1	1.36	0
1.37	0.1	1.00	0	1.37	1	1.37	0.02	1.37	1	1.37	0
1.38	0.1	1.00	0	1.38	1	1.38	0.01	1.38	1	1.38	0
1.39	0.1	1.00	0	1.39	1	1.39	0.01	1.39	1	1.39	0
1.4	0.1	1.00	0	1.4	1	1.40	0.01	1.4	1	1.4	0
1.41	0.1	1.00	0	1.41	1	1.41	0.01	1.41	1	1.41	0
1.42	0.1	1.00	0	1.42	1	1.42	0.01	1.42	1	1.42	0
1.43	0.1	1.00	0	1.43	1	1.43	0.01	1.43	1	1.43	0
1.44	0.1	1.00	0	1.44	1	1.44	0.01	1.44	1	1.44	0
1.45	0.1	1.00	0	1.45	1	1.45	0.005	1.45	1	1.45	0
1.46	0.1	1.00	0	1.46	1	1.46	0.004	1.46	1	1.46	0
1.47	0.1	1.00	0	1.47	1	1.47	0.003	1.47	1	1.47	0
1.48	0.1	1.00	0	1.48	1	1.48	0.002	1.48	1	1.48	0
1.49	0.1	1.00	0	1.49	1	1.49	0.001	1.49	1	1.49	0
1.5	0.1	1.00	0	1.5	1	1.50	0	1.5	1	1.5	0
1.51	0.1	1.00	0	1.51	1	1.51	0	1.51	1	1.51	0
1.52	0.1	1.00	0	1.52	1	1.52	0	1.52	1	1.52	0
1.53	0.1	1.00	0	1.53	1	1.53	0	1.53	1	1.53	0
1.54	0.1	1.00	0	1.54	1	1.54	0	1.54	1	1.54	0
1.55	0.1	1.00	0	1.55	1	1.55	0	1.55	1	1.55	0
1.56	0.1	1.00	0	1.56	1	1.56	0	1.56	1	1.56	0
1.57	0.1	1.00	0	1.57	1	1.57	0	1.57	1	1.57	0
1.58	0.1	1.00	0	1.58	1	1.58	0	1.58	1	1.58	0
1.59	0.1	1.00	0	1.59	1	1.59	0	1.59	1	1.59	0

1.6	0.1	1.00	0	1.6	1	1.60	0	1.6	1	1.6	0
1.61	0.1	1.00	0	1.61	1	1.61	0	1.61	1	1.61	0
1.62	0.1	1.00	0	1.62	1	1.62	0	1.62	1	1.62	0
1.63	0.1	1.00	0	1.63	1	1.63	0	1.63	1	1.63	0
1.64	0.1	1.00	0	1.64	1	1.64	0	1.64	1	1.64	0
1.65	0.1	1.00	0	1.65	1	1.65	0	1.65	1	1.65	0
1.66	0.1	1.00	0	1.66	1	1.66	0	1.66	1	1.66	0
1.67	0.1	1.00	0	1.67	1	1.67	0	1.67	1	1.67	0
1.68	0.1	1.00	0	1.68	1	1.68	0	1.68	1	1.68	0
1.69	0.1	1.00	0	1.69	1	1.69	0	1.69	1	1.69	0
1.7	0.1	1.00	0	1.7	1	1.70	0	1.7	1	1.7	0
1.71	0.1	1.00	0	1.71	1	1.71	0	1.71	1	1.71	0
1.72	0.1	1.00	0	1.72	1	1.72	0	1.72	1	1.72	0
1.73	0.1	1.00	0	1.73	1	1.73	0	1.73	1	1.73	0
1.74	0.1	1.00	0	1.74	1	1.74	0	1.74	1	1.74	0
1.75	0.1	1.00	0	1.75	1	1.75	0	1.75	1	1.75	0
1.76	0.1	1.00	0	1.76	1	1.76	0	1.76	1	1.76	0
1.77	0.1	1.00	0	1.77	1	1.77	0	1.77	1	1.77	0
1.78	0.1	1.00	0	1.78	1	1.78	0	1.78	1	1.78	0
1.79	0.1	1.00	0	1.79	1	1.79	0	1.79	1	1.79	0
1.8	0.1	1.00	0	1.8	1	1.80	0	1.8	1	1.8	0
1.81	0.1	1.00	0	1.81	1	1.81	0	1.81	1	1.81	0
1.82	0.1	1.00	0	1.82	1	1.82	0	1.82	1	1.82	0
1.83	0.1	1.00	0	1.83	1	1.83	0	1.83	1	1.83	0
1.84	0.1	1.00	0	1.84	1	1.84	0	1.84	1	1.84	0
1.85	0.1	1.00	0	1.85	1	1.85	0	1.85	1	1.85	0
1.86	0.1	1.00	0	1.86	1	1.86	0	1.86	1	1.86	0
1.87	0.1	1.00	0	1.87	1	1.87	0	1.87	1	1.87	0
1.88	0.1	1.00	0	1.88	1	1.88	0	1.88	1	1.88	0
1.89	0.1	1.00	0	1.89	1	1.89	0	1.89	1	1.89	0
1.9	0.1	1.00	0	1.9	1	1.90	0	1.9	1	1.9	0
1.91	0.1	1.00	0	1.91	1	1.91	0	1.91	1	1.91	0
1.92	0.1	1.00	0	1.92	1	1.92	0	1.92	1	1.92	0
1.93	0.1	1.00	0	1.93	1	1.93	0	1.93	1	1.93	0
1.94	0.1	1.00	0	1.94	1	1.94	0	1.94	1	1.94	0
1.95	0.1	1.00	0	1.95	1	1.95	0	1.95	1	1.95	0
1.96	0.1	1.00	0	1.96	1	1.96	0	1.96	1	1.96	0
1.97	0.1	1.00	0	1.97	1	1.97	0	1.97	1	1.97	0
1.98	0.1	1.00	0	1.98	1	1.98	0	1.98	1	1.98	0
1.99	0.1	1.00	0	1.99	1	1.99	0	1.99	1	1.99	0
2	0.1	1.00	0	2	1	2.00	0	2	1	2	0
2.01	0.1	1.00	0	2.01	1	2.01	0	2.01	1	2.01	0
2.02	0.1	1.00	0	2.02	1	2.02	0	2.02	1	2.02	0
2.03	0.1	1.00	0	2.03	1	2.03	0	2.03	1	2.03	0
2.04	0.1	1.00	0	2.04	1	2.04	0	2.04	1	2.04	0
2.05	0.1	1.00	0	2.05	1	2.05	0	2.05	1	2.05	0
2.06	0.1	1.00	0	2.06	1	2.06	0	2.06	1	2.06	0
2.07	0.1	1.00	0	2.07	1	2.07	0	2.07	1	2.07	0
2.08	0.1	1.00	0	2.08	1	2.08	0	2.08	1	2.08	0
2.09	0.1	1.00	0	2.09	1	2.09	0	2.09	1	2.09	0
2.1	0.1	1.00	0	2.1	1	2.10	0	2.1	1	2.1	0
2.11	0.1	1.00	0	2.11	1	2.11	0	2.11	1	2.11	0
2.12	0.1	1.00	0	2.12	1	2.12	0	2.12	1	2.12	0
2.13	0.1	1.00	0	2.13	1	2.13	0	2.13	1	2.13	0
2.14	0.1	1.00	0	2.14	1	2.14	0	2.14	1	2.14	0
2.15	0.1	1.00	0	2.15	1	2.15	0	2.15	1	2.15	0
2.16	0.1	1.00	0	2.16	1	2.16	0	2.16	1	2.16	0
2.17	0.1	1.00	0	2.17	1	2.17	0	2.17	1	2.17	0
2.18	0.1	1.00	0	2.18	1	2.18	0	2.18	1	2.18	0
2.19	0.1	1.00	0	2.19	1	2.19	0	2.19	1	2.19	0
2.2	0.1	1.00	0	2.2	1	2.20	0	2.2	1	2.2	0
2.21	0.1	1.00	0	2.21	1	2.21	0	2.21	1	2.21	0
2.22	0.1	1.00	0	2.22	1	2.22	0	2.22	1	2.22	0
2.23	0.1	1.00	0	2.23	1	2.23	0	2.23	1	2.23	0
2.24	0.1	1.00	0	2.24	1	2.24	0	2.24	1	2.24	0
2.25	0.1	1.00	0	2.25	1	2.25	0	2.25	1	2.25	0
2.26	0.1	1.00	0	2.26	1	2.26	0	2.26	1	2.26	0
2.27	0.1	1.00	0	2.27	1	2.27	0	2.27	1	2.27	0
2.28	0.1	1.00	0	2.28	1	2.28	0	2.28	1	2.28	0
2.29	0.1	1.00	0	2.29	1	2.29	0	2.29	1	2.29	0
2.3	0.1	1.00	0	2.3	1	2.30	0	2.3	1	2.3	0
2.31	0.1	1.00	0	2.31	1	2.31	0	2.31	1	2.31	0
2.32	0.1	1.00	0	2.32	1	2.32	0	2.32	1	2.32	0
2.33	0.1	1.00	0	2.33	1	2.33	0	2.33	1	2.33	0
2.34	0.1	1.00	0	2.34	1	2.34	0	2.34	1	2.34	0
2.35	0.1	1.00	0	2.35	1	2.35	0	2.35	1	2.35	0
2.36	0.1	1.00	0	2.36	1	2.36	0	2.36	1	2.36	0
2.37	0.1	1.00	0	2.37	1	2.37	0	2.37	1	2.37	0
2.38	0.1	1.00	0	2.38	1	2.38	0	2.38	1	2.38	0
2.39	0.1	1.00	0	2.39	1	2.39	0	2.39	1	2.39	0
2.4	0.1	1.00	0	2.4	1	2.40	0	2.4	1	2.4	0
2.41	0.1	1.00	0	2.41	1	2.41	0	2.41	1	2.41	0
2.42	0.1	1.00	0	2.42	1	2.42	0	2.42	1	2.42	0
2.43	0.1	1.00	0	2.43	1	2.43	0	2.43	1	2.43	0
2.44	0.1	1.00	0	2.44	1	2.44	0	2.44	1	2.44	0

2.45	0.1	1.00	0	2.45	1	2.45	0	2.45	1	2.45	0
2.46	0.1	1.00	0	2.46	1	2.46	0	2.46	1	2.46	0
2.47	0.1	1.00	0	2.47	1	2.47	0	2.47	1	2.47	0
2.48	0.1	1.00	0	2.48	1	2.48	0	2.48	1	2.48	0
2.49	0.1	1.00	0	2.49	1	2.49	0	2.49	1	2.49	0
2.5	0.1	1.00	0	2.5	1	2.50	0	2.5	1	2.5	0
2.51	0.1	1.00	0	2.51	1	2.51	0	2.51	1	2.51	0
2.52	0.1	1.00	0	2.52	1	2.52	0	2.52	1	2.52	0
2.53	0.1	1.00	0	2.53	1	2.53	0	2.53	1	2.53	0
2.54	0.1	1.00	0	2.54	1	2.54	0	2.54	1	2.54	0
2.55	0.1	1.00	0	2.55	1	2.55	0	2.55	1	2.55	0
2.56	0.1	1.00	0	2.56	1	2.56	0	2.56	1	2.56	0
2.57	0.1	1.00	0	2.57	1	2.57	0	2.57	1	2.57	0
2.58	0.1	1.00	0	2.58	1	2.58	0	2.58	1	2.58	0
2.59	0.1	1.00	0	2.59	1	2.59	0	2.59	1	2.59	0
2.6	0.1	1.00	0	2.6	1	2.60	0	2.6	1	2.6	0
2.61	0.1	1.00	0	2.61	1	2.61	0	2.61	1	2.61	0
2.62	0.1	1.00	0	2.62	1	2.62	0	2.62	1	2.62	0
2.63	0.1	1.00	0	2.63	1	2.63	0	2.63	1	2.63	0
2.64	0.1	1.00	0	2.64	1	2.64	0	2.64	1	2.64	0
2.65	0.1	1.00	0	2.65	1	2.65	0	2.65	1	2.65	0
2.66	0.1	1.00	0	2.66	1	2.66	0	2.66	1	2.66	0
2.67	0.1	1.00	0	2.67	1	2.67	0	2.67	1	2.67	0
2.68	0.1	1.00	0	2.68	1	2.68	0	2.68	1	2.68	0
2.69	0.1	1.00	0	2.69	1	2.69	0	2.69	1	2.69	0
2.7	0.1	1.00	0	2.7	1	2.70	0	2.7	1	2.7	0
2.71	0.1	1.00	0	2.71	1	2.71	0	2.71	1	2.71	0
2.72	0.1	1.00	0	2.72	1	2.72	0	2.72	1	2.72	0
2.73	0.1	1.00	0	2.73	1	2.73	0	2.73	1	2.73	0
2.74	0.1	1.00	0	2.74	1	2.74	0	2.74	1	2.74	0
2.75	0.1	1.00	0	2.75	1	2.75	0	2.75	1	2.75	0
2.76	0.1	1.00	0	2.76	1	2.76	0	2.76	1	2.76	0
2.77	0.1	1.00	0	2.77	1	2.77	0	2.77	1	2.77	0
2.78	0.1	1.00	0	2.78	1	2.78	0	2.78	1	2.78	0
2.79	0.1	1.00	0	2.79	1	2.79	0	2.79	1	2.79	0
2.8	0.1	1.00	0	2.8	1	2.80	0	2.8	1	2.8	0
2.81	0.1	1.00	0	2.81	1	2.81	0	2.81	1	2.81	0
2.82	0.1	1.00	0	2.82	1	2.82	0	2.82	1	2.82	0
2.83	0.1	1.00	0	2.83	1	2.83	0	2.83	1	2.83	0
2.84	0.1	1.00	0	2.84	1	2.84	0	2.84	1	2.84	0
2.85	0.1	1.00	0	2.85	1	2.85	0	2.85	1	2.85	0
2.86	0.1	1.00	0	2.86	1	2.86	0	2.86	1	2.86	0
2.87	0.1	1.00	0	2.87	1	2.87	0	2.87	1	2.87	0
2.88	0.1	1.00	0	2.88	1	2.88	0	2.88	1	2.88	0
2.89	0.1	1.00	0	2.89	1	2.89	0	2.89	1	2.89	0
2.9	0.1	1.00	0	2.9	1	2.90	0	2.9	1	2.9	0
2.91	0.1	1.00	0	2.91	1	2.91	0	2.91	1	2.91	0
2.92	0.1	1.00	0	2.92	1	2.92	0	2.92	1	2.92	0
2.93	0.1	1.00	0	2.93	1	2.93	0	2.93	1	2.93	0
2.94	0.1	1.00	0	2.94	1	2.94	0	2.94	1	2.94	0
2.95	0.1	1.00	0	2.95	1	2.95	0	2.95	1	2.95	0
2.96	0.1	1.00	0	2.96	1	2.96	0	2.96	1	2.96	0
2.97	0.1	1.00	0	2.97	1	2.97	0	2.97	1	2.97	0
2.98	0.1	1.00	0	2.98	1	2.98	0	2.98	1	2.98	0
2.99	0.1	1.00	0	2.99	1	2.99	0	2.99	1	2.99	0
3	0.1	1.00	0	3	1	3.00	0	3	1	3	0
3.01	0.1	1.00	0	3.01	1	3.01	0	3.01	1	3.01	0
3.02	0.1	1.00	0	3.02	1	3.02	0	3.02	1	3.02	0
3.03	0.1	1.00	0	3.03	1	3.03	0	3.03	1	3.03	0
3.04	0.1	1.00	0	3.04	1	3.04	0	3.04	1	3.04	0
3.05	0.1	1.00	0	3.05	1	3.05	0	3.05	1	3.05	0
3.06	0.1	1.00	0	3.06	1	3.06	0	3.06	1	3.06	0
3.07	0.1	1.00	0	3.07	1	3.07	0	3.07	1	3.07	0
3.08	0.1	1.00	0	3.08	1	3.08	0	3.08	1	3.08	0
3.09	0.1	1.00	0	3.09	1	3.09	0	3.09	1	3.09	0
3.1	0.1	1.00	0	3.1	1	3.10	0	3.1	1	3.1	0
3.11	0.1	1.00	0	3.11	1	3.11	0	3.11	1	3.11	0
3.12	0.1	1.00	0	3.12	1	3.12	0	3.12	1	3.12	0
3.13	0.1	1.00	0	3.13	1	3.13	0	3.13	1	3.13	0
3.14	0.1	1.00	0	3.14	1	3.14	0	3.14	1	3.14	0
3.15	0.1	1.00	0	3.15	1	3.15	0	3.15	1	3.15	0
3.16	0.1	1.00	0	3.16	1	3.16	0	3.16	1	3.16	0
3.17	0.1	1.00	0	3.17	1	3.17	0	3.17	1	3.17	0
3.18	0.1	1.00	0	3.18	1	3.18	0	3.18	1	3.18	0
3.19	0.1	1.00	0	3.19	1	3.19	0	3.19	1	3.19	0
3.2	0.1	1.00	0	3.2	1	3.20	0	3.2	1	3.2	0
3.21	0.1	1.00	0	3.21	1	3.21	0	3.21	1	3.21	0
3.22	0.1	1.00	0	3.22	1	3.22	0	3.22	1	3.22	0
3.23	0.1	1.00	0	3.23	1	3.23	0	3.23	1	3.23	0
3.24	0.1	1.00	0	3.24	1	3.24	0	3.24	1	3.24	0
3.25	0.1	1.00	0	3.25	1	3.25	0	3.25	1	3.25	0
3.26	0.1	1.00	0	3.26	1	3.26	0	3.26	1	3.26	0
3.27	0.1	1.00	0	3.27	1	3.27	0	3.27	1	3.27	0
3.28	0.1	1.00	0	3.28	1	3.28	0	3.28	1	3.28	0
3.29	0.1	1.00	0	3.29	1	3.29	0	3.29	1	3.29	0

3.3	0.1	1.00	0	3.3	1	3.30	0	3.3	1	3.3	0
3.31	0.1	1.00	0	3.31	1	3.31	0	3.31	1	3.31	0
3.32	0.1	1.00	0	3.32	1	3.32	0	3.32	1	3.32	0
3.33	0.1	1.00	0	3.33	1	3.33	0	3.33	1	3.33	0
3.34	0.1	1.00	0	3.34	1	3.34	0	3.34	1	3.34	0
3.35	0.1	1.00	0	3.35	1	3.35	0	3.35	1	3.35	0
3.36	0.1	1.00	0	3.36	1	3.36	0	3.36	1	3.36	0
3.37	0.1	1.00	0	3.37	1	3.37	0	3.37	1	3.37	0
3.38	0.1	1.00	0	3.38	1	3.38	0	3.38	1	3.38	0
3.39	0.1	1.00	0	3.39	1	3.39	0	3.39	1	3.39	0
3.4	0.1	1.00	0	3.4	1	3.40	0	3.4	1	3.4	0
3.41	0.1	1.00	0	3.41	1	3.41	0	3.41	1	3.41	0
3.42	0.1	1.00	0	3.42	1	3.42	0	3.42	1	3.42	0
3.43	0.1	1.00	0	3.43	1	3.43	0	3.43	1	3.43	0
3.44	0.1	1.00	0	3.44	1	3.44	0	3.44	1	3.44	0
3.45	0.1	1.00	0	3.45	1	3.45	0	3.45	1	3.45	0
3.46	0.1	1.00	0	3.46	1	3.46	0	3.46	1	3.46	0
3.47	0.1	1.00	0	3.47	1	3.47	0	3.47	1	3.47	0
3.48	0.1	1.00	0	3.48	1	3.48	0	3.48	1	3.48	0
3.49	0.1	1.00	0	3.49	1	3.49	0	3.49	1	3.49	0
3.5	0.1	1.00	0	3.5	1	3.50	0	3.5	1	3.5	0
3.51	0.1	1.00	0	3.51	1	3.51	0	3.51	1	3.51	0
3.52	0.1	1.00	0	3.52	1	3.52	0	3.52	1	3.52	0
3.53	0.1	1.00	0	3.53	1	3.53	0	3.53	1	3.53	0
3.54	0.1	1.00	0	3.54	1	3.54	0	3.54	1	3.54	0
3.55	0.1	1.00	0	3.55	1	3.55	0	3.55	1	3.55	0
3.56	0.1	1.00	0	3.56	1	3.56	0	3.56	1	3.56	0
3.57	0.1	1.00	0	3.57	1	3.57	0	3.57	1	3.57	0
3.58	0.1	1.00	0	3.58	1	3.58	0	3.58	1	3.58	0
3.59	0.1	1.00	0	3.59	1	3.59	0	3.59	1	3.59	0
3.6	0.1	1.00	0	3.6	1	3.60	0	3.6	1	3.6	0
3.61	0.1	1.00	0	3.61	1	3.61	0	3.61	1	3.61	0
3.62	0.1	1.00	0	3.62	1	3.62	0	3.62	1	3.62	0
3.63	0.1	1.00	0	3.63	1	3.63	0	3.63	1	3.63	0
3.64	0.1	1.00	0	3.64	1	3.64	0	3.64	1	3.64	0
3.65	0.1	1.00	0	3.65	1	3.65	0	3.65	1	3.65	0
3.66	0.1	1.00	0	3.66	1	3.66	0	3.66	1	3.66	0
3.67	0.1	1.00	0	3.67	1	3.67	0	3.67	1	3.67	0
3.68	0.1	1.00	0	3.68	1	3.68	0	3.68	1	3.68	0
3.69	0.1	1.00	0	3.69	1	3.69	0	3.69	1	3.69	0
3.7	0.1	1.00	0	3.7	1	3.70	0	3.7	1	3.7	0
3.71	0.1	1.00	0	3.71	1	3.71	0	3.71	1	3.71	0
3.72	0.1	1.00	0	3.72	1	3.72	0	3.72	1	3.72	0
3.73	0.1	1.00	0	3.73	1	3.73	0	3.73	1	3.73	0
3.74	0.1	1.00	0	3.74	1	3.74	0	3.74	1	3.74	0
3.75	0.1	1.00	0	3.75	1	3.75	0	3.75	1	3.75	0
3.76	0.1	1.00	0	3.76	1	3.76	0	3.76	1	3.76	0
3.77	0.1	1.00	0	3.77	1	3.77	0	3.77	1	3.77	0
3.78	0.1	1.00	0	3.78	1	3.78	0	3.78	1	3.78	0
3.79	0.1	1.00	0	3.79	1	3.79	0	3.79	1	3.79	0
3.8	0.1	1.00	0	3.8	1	3.80	0	3.8	1	3.8	0
3.81	0.1	1.00	0	3.81	1	3.81	0	3.81	1	3.81	0
3.82	0.1	1.00	0	3.82	1	3.82	0	3.82	1	3.82	0
3.83	0.1	1.00	0	3.83	1	3.83	0	3.83	1	3.83	0
3.84	0.1	1.00	0	3.84	1	3.84	0	3.84	1	3.84	0
3.85	0.1	1.00	0	3.85	1	3.85	0	3.85	1	3.85	0
3.86	0.1	1.00	0	3.86	1	3.86	0	3.86	1	3.86	0
3.87	0.1	1.00	0	3.87	1	3.87	0	3.87	1	3.87	0
3.88	0.1	1.00	0	3.88	1	3.88	0	3.88	1	3.88	0
3.89	0.1	1.00	0	3.89	1	3.89	0	3.89	1	3.89	0
3.9	0.1	1.00	0	3.9	1	3.90	0	3.9	1	3.9	0
3.91	0.1	1.00	0	3.91	1	3.91	0	3.91	1	3.91	0
3.92	0.1	1.00	0	3.92	1	3.92	0	3.92	1	3.92	0
3.93	0.1	1.00	0	3.93	1	3.93	0	3.93	1	3.93	0
3.94	0.1	1.00	0	3.94	1	3.94	0	3.94	1	3.94	0
3.95	0.1	1.00	0	3.95	1	3.95	0	3.95	1	3.95	0
3.96	0.1	1.00	0	3.96	1	3.96	0	3.96	1	3.96	0
3.97	0.1	1.00	0	3.97	1	3.97	0	3.97	1	3.97	0
3.98	0.1	1.00	0	3.98	1	3.98	0	3.98	1	3.98	0
3.99	0.1	1.00	0	3.99	1	3.99	0	3.99	1	3.99	0
4	0.1	1.00	0	4	1	4.00	0	4	1	4	0

Chinook (summer)

depth (m)	probability of use	velocity (m/s)	probability of use
0	0	0	0
0.01	0.03	0.01	0.08
0.02	0.05	0.02	0.15
0.03	0.08	0.03	0.22
0.04	0.1	0.04	0.28
0.05	0.12	0.05	0.35
0.06	0.15	0.06	0.41
0.07	0.18	0.07	0.46
0.08	0.22	0.08	0.52
0.09	0.26	0.09	0.57
0.1	0.3	0.1	0.63
0.11	0.37	0.11	0.67
0.12	0.42	0.12	0.71
0.13	0.5	0.13	0.74
0.14	0.58	0.14	0.78
0.15	0.63	0.15	0.82
0.16	0.72	0.16	0.84
0.17	0.78	0.17	0.87
0.18	0.85	0.18	0.89
0.19	0.91	0.19	0.92
0.2	0.96	0.2	0.94
0.21	0.99	0.21	0.95
0.22	1	0.22	0.96
0.23	1	0.23	0.97
0.24	1	0.24	0.98
0.25	1	0.25	0.99
0.26	1	0.26	1
0.27	1	0.27	1
0.28	1	0.28	1
0.29	1	0.29	1
0.3	1	0.3	1
0.31	1	0.31	1
0.32	1	0.32	1
0.33	1	0.33	1
0.34	1	0.34	0.99
0.35	1	0.35	0.98
0.36	1	0.36	0.97
0.37	1	0.37	0.96
0.38	1	0.38	0.95
0.39	1	0.39	0.94
0.4	1	0.4	0.93
0.41	1	0.41	0.91
0.42	1	0.42	0.9
0.43	1	0.43	0.88
0.44	1	0.44	0.87
0.45	1	0.45	0.85
0.46	1	0.46	0.83
0.47	1	0.47	0.82
0.48	1	0.48	0.8
0.49	1	0.49	0.79
0.5	1	0.5	0.77
0.51	1	0.51	0.75
0.52	1	0.52	0.73
0.53	1	0.53	0.71
0.54	1	0.54	0.69
0.55	1	0.55	0.68
0.56	1	0.56	0.66
0.57	1	0.57	0.64
0.58	1	0.58	0.62
0.59	1	0.59	0.6
0.6	1	0.6	0.58
0.61	1	0.61	0.56
0.62	1	0.62	0.54
0.63	1	0.63	0.52
0.64	1	0.64	0.5
0.65	1	0.65	0.48
0.66	1	0.66	0.47
0.67	1	0.67	0.45
0.68	1	0.68	0.43
0.69	1	0.69	0.41
0.7	1	0.7	0.39
0.71	1	0.71	0.38
0.72	1	0.72	0.36
0.73	1	0.73	0.35
0.74	1	0.74	0.33

Fisheries Branch CT hydraulic suitability curves (1994)

depth range	fry probability	velocity range	fry probability	depth range	parr probability	velocity range	parr probability
0	0	0	1	0	0	0	1
0.0051	1	0.2001	0.9	0.0051	0.03	0.2801	0.99
0.1801	0.98	0.2401	0.75	0.0401	0.13	0.3001	0.98
0.3001	0.85	0.2601	0.55	0.0601	0.22	0.3201	0.95
0.3501	0.66	0.2801	0.35	0.0801	0.27	0.3401	0.92
0.4001	0.5	0.3001	0.25	0.1101	0.36	0.3601	0.87
0.4501	0.4	0.3201	0.18	0.1301	0.5	0.3801	0.8
0.5001	0.29	0.3401	0.13	0.1501	0.71	0.4001	0.7
0.5501	0.21	0.3601	0.08	0.1701	0.85	0.4201	0.6
0.6001	0.15	0.3801	0.06	0.2001	0.98	0.4401	0.5
0.6501	0.1	0.4001	0.04	0.2301	1	0.4601	0.4
0.7001	0.06	0.4201	0.01	##	##	0.4801	0.33
0.7501	0.04	0.5001	0	##	##	0.5001	0.23
0.8001	0.02	10	0	##	##	0.5501	0.14
##	##	##	##	##	##	0.6001	0.04
##	##	##	##	##	##	0.7001	0

Generic Insect Curves - Stalnaker and Arnette (1976)

depth (m)	AD	velocity (m/s)	AV
0	0.00	0.00	0.00
0.01	0.02	0.01	0.01
0.02	0.05	0.02	0.02
0.03	0.11	0.03	0.03
0.04	0.18	0.04	0.04
0.05	0.25	0.05	0.05
0.06	0.30	0.06	0.06
0.07	0.42	0.07	0.07
0.08	0.52	0.08	0.08
0.09	0.65	0.09	0.09
0.1	0.73	0.10	0.10
0.11	0.85	0.11	0.11
0.12	0.90	0.12	0.12
0.13	0.95	0.13	0.13
0.14	0.98	0.14	0.14
0.15	1.00	0.15	0.15
0.16	1.00	0.16	0.16
0.17	1.00	0.17	0.17
0.18	1.00	0.18	0.18
0.19	1.00	0.19	0.19
0.2	1.00	0.20	0.20
0.21	1.00	0.21	0.22
0.22	1.00	0.22	0.24
0.23	1.00	0.23	0.26
0.24	1.00	0.24	0.28
0.25	1.00	0.25	0.30
0.26	1.00	0.26	0.32
0.27	1.00	0.27	0.34
0.28	1.00	0.28	0.36
0.29	1.00	0.29	0.38
0.3	1.00	0.30	0.40
0.31	1.00	0.31	0.42
0.32	1.00	0.32	0.44
0.33	1.00	0.33	0.46
0.34	1.00	0.34	0.48
0.35	1.00	0.35	0.50
0.36	1.00	0.36	0.52
0.37	1.00	0.37	0.54
0.38	1.00	0.38	0.56
0.39	1.00	0.39	0.58
0.4	1.00	0.40	0.60
0.41	1.00	0.41	0.62
0.42	1.00	0.42	0.64
0.43	1.00	0.43	0.66
0.44	1.00	0.44	0.68
0.45	1.00	0.45	0.70
0.46	1.00	0.46	0.71
0.47	1.00	0.47	0.72
0.48	1.00	0.48	0.73
0.49	1.00	0.49	0.74
0.5	1.00	0.50	0.75
0.51	1.00	0.51	0.76
0.52	1.00	0.52	0.77
0.53	1.00	0.53	0.78
0.54	1.00	0.54	0.79

Kokanee spawning curves

depth (m)	UI-depth	velocity (m/s)	SI-velocity
0	0.00	0.00	0.00
0.01	0.00	0.01	0.03
0.02	0.00	0.02	0.06
0.03	0.01	0.03	0.10
0.04	0.09	0.04	0.13
0.05	0.18	0.05	0.16
0.06	0.26	0.06	0.20
0.07	0.34	0.07	0.25
0.08	0.42	0.08	0.27
0.09	0.51	0.09	0.30
0.1	0.59	0.10	0.33
0.11	0.67	0.11	0.36
0.12	0.75	0.12	0.40
0.13	0.84	0.13	0.43
0.14	0.92	0.14	0.47
0.15	1.00	0.15	0.50
0.16	1.00	0.16	0.53
0.17	1.00	0.17	0.57
0.18	1.00	0.18	0.60
0.19	1.00	0.19	0.63
0.2	1.00	0.20	0.67
0.21	1.00	0.21	0.70
0.22	1.00	0.22	0.73
0.23	1.00	0.23	0.77
0.24	1.00	0.24	0.80
0.25	1.00	0.25	0.83
0.26	1.00	0.26	0.87
0.27	1.00	0.27	0.90
0.28	1.00	0.28	0.93
0.29	1.00	0.29	0.97
0.3	1.00	0.30	1.00
0.31	0.99	0.31	1.00
0.32	0.98	0.32	1.00
0.33	0.97	0.33	1.00
0.34	0.96	0.34	1.00
0.35	0.95	0.35	1.00
0.36	0.94	0.36	1.00
0.37	0.93	0.37	1.00
0.38	0.92	0.38	1.00
0.39	0.91	0.39	1.00
0.4	0.90	0.40	1.00
0.41	0.88	0.41	1.00
0.42	0.86	0.42	1.00
0.43	0.84	0.43	1.00
0.44	0.82	0.44	1.00
0.45	0.80	0.45	1.00
0.46	0.77	0.46	1.00
0.47	0.74	0.47	1.00
0.48	0.71	0.48	1.00
0.49	0.68	0.49	1.00
0.5	0.65	0.50	1.00
0.51	0.62	0.51	1.00
0.52	0.59	0.52	1.00
0.53	0.56	0.53	1.00
0.54	0.52	0.54	1.00

0.75	1	0.75	0.32		0.55	1.00	0.55	0.80		0.55	0.48	0.55	1.00
0.76	1	0.76	0.31		0.56	1.00	0.56	0.81		0.56	0.44	0.56	1.00
0.77	1	0.77	0.29		0.57	1.00	0.57	0.81		0.57	0.40	0.57	1.00
0.78	1	0.78	0.28		0.58	1.00	0.58	0.82		0.58	0.36	0.58	1.00
0.79	1	0.79	0.26		0.59	1.00	0.59	0.83		0.59	0.32	0.59	1.00
0.8	1	0.8	0.25		0.6	1.00	0.60	0.83		0.6	0.28	0.60	1.00
0.81	1	0.81	0.24		0.61	1.00	0.61	0.84		0.61	0.24	0.61	1.00
0.82	1	0.82	0.23		0.62	1.00	0.62	0.85		0.62	0.20	0.62	0.97
0.83	1	0.83	0.22		0.63	1.00	0.63	0.85		0.63	0.18	0.63	0.93
0.84	1	0.84	0.21		0.64	1.00	0.64	0.86		0.64	0.16	0.64	0.90
0.85	1	0.85	0.2		0.65	1.00	0.65	0.87		0.65	0.14	0.65	0.87
0.86	1	0.86	0.19		0.66	1.00	0.66	0.87		0.66	0.12	0.66	0.83
0.87	1	0.87	0.18		0.67	1.00	0.67	0.88		0.67	0.10	0.67	0.80
0.88	1	0.88	0.17		0.68	1.00	0.68	0.89		0.68	0.08	0.68	0.77
0.89	1	0.89	0.16		0.69	1.00	0.69	0.89		0.69	0.06	0.69	0.73
0.9	1	0.9	0.15		0.7	1.00	0.70	0.90		0.7	0.05	0.70	0.70
0.91	1	0.91	0.14		0.71	0.99	0.71	0.90		0.71	0.05	0.71	0.67
0.92	1	0.92	0.14		0.72	0.99	0.72	0.91		0.72	0.04	0.72	0.63
0.93	1	0.93	0.14		0.73	0.99	0.73	0.92		0.73	0.04	0.73	0.60
0.94	1	0.94	0.13		0.74	0.98	0.74	0.92		0.74	0.03	0.74	0.57
0.95	1	0.95	0.12		0.75	0.98	0.75	0.92		0.75	0.03	0.75	0.53
0.96	1	0.96	0.12		0.76	0.98	0.76	0.93		0.76	0.02	0.76	0.50
0.97	1	0.97	0.12		0.77	0.98	0.77	0.94		0.77	0.02	0.77	0.49
0.98	1	0.98	0.11		0.78	0.98	0.78	0.94		0.78	0.01	0.78	0.47
0.99	1	0.99	0.1		0.79	0.97	0.79	0.95		0.79	0.01	0.79	0.46
1	1	1	0.1		0.8	0.97	0.80	0.95		0.8	0.00	0.80	0.45
1.01	1	1.01	0.1		0.81	0.97	0.81	0.96		0.81	0.00	0.81	0.44
1.02	1	1.02	0.1		0.82	0.97	0.82	0.96		0.82	0.00	0.82	0.42
1.03	1	1.03	0.09		0.83	0.97	0.83	0.97		0.83	0.00	0.83	0.41
1.04	1	1.04	0.09		0.84	0.96	0.84	0.97		0.84	0.00	0.84	0.40
1.05	1	1.05	0.09		0.85	0.96	0.85	0.98		0.85	0.00	0.85	0.39
1.06	1	1.06	0.09		0.86	0.96	0.86	0.98		0.86	0.00	0.86	0.37
1.07	1	1.07	0.09		0.87	0.96	0.87	0.99		0.87	0.00	0.87	0.36
1.08	1	1.08	0.08		0.88	0.96	0.88	0.99		0.88	0.00	0.88	0.35
1.09	1	1.09	0.08		0.89	0.95	0.89	1.00		0.89	0.00	0.89	0.34
1.1	1	1.1	0.08		0.9	0.95	0.90	1.00		0.9	0.00	0.90	0.32
1.11	1	1.11	0.08		0.91	0.95	0.91	1.00		0.91	0.00	0.91	0.31
1.12	1	1.12	0.08		0.92	0.94	0.92	1.00		0.92	0.00	0.92	0.29
1.13	1	1.13	0.07		0.93	0.94	0.93	1.00		0.93	0.00	0.93	0.28
1.14	1	1.14	0.07		0.94	0.94	0.94	1.00		0.94	0.00	0.94	0.27
1.15	1	1.15	0.07		0.95	0.94	0.95	1.00		0.95	0.00	0.95	0.26
1.16	1	1.16	0.07		0.96	0.94	0.96	1.00		0.96	0.00	0.96	0.24
1.17	1	1.17	0.07		0.97	0.93	0.97	1.00		0.97	0.00	0.97	0.23
1.18	1	1.18	0.06		0.98	0.93	0.98	1.00		0.98	0.00	0.98	0.22
1.19	1	1.19	0.06		0.99	0.93	0.99	1.00		0.99	0.00	0.99	0.20
1.2	1	1.2	0.06		1	0.92	1.00	1.00		1	0.00	1.00	0.19
1.21	1	1.21	0.06		1.01	0.92	1.01	1.00		1.01	0.00	1.01	0.18
1.22	1	1.22	0.05		1.02	0.92	1.02	1.00		1.02	0.00	1.02	0.16
1.23	1	1.23	0.05		1.03	0.92	1.03	1.00		1.03	0.00	1.03	0.15
1.24	1	1.24	0.05		1.04	0.92	1.04	1.00		1.04	0.00	1.04	0.14
1.25	1	1.25	0.04		1.05	0.91	1.05	1.00		1.05	0.00	1.05	0.13
1.26	1	1.26	0.04		1.06	0.91	1.06	1.00		1.06	0.00	1.06	0.11
1.27	1	1.27	0.04		1.07	0.91	1.07	1.00		1.07	0.00	1.07	0.10
1.28	1	1.28	0.04		1.08	0.90	1.08	0.99		1.08	0.00	1.08	0.09
1.29	1	1.29	0.03		1.09	0.90	1.09	0.99		1.09	0.00	1.09	0.09
1.3	1	1.3	0.01		1.1	0.90	1.10	0.98		1.1	0.00	1.10	0.09
1.31	1	1.31	0.008		1.11	0.89	1.11	0.98		1.11	0.00	1.11	0.09
1.32	1	1.32	0.006		1.12	0.88	1.12	0.97		1.12	0.00	1.12	0.09
1.33	1	1.33	0.004		1.13	0.87	1.13	0.97		1.13	0.00	1.13	0.09
1.34	1	1.34	0.002		1.14	0.86	1.14	0.96		1.14	0.00	1.14	0.08
1.35	1	1.35	0		1.15	0.85	1.15	0.96		1.15	0.00	1.15	0.08
1.36	1	1.36	0		1.16	0.84	1.16	0.95		1.16	0.00	1.16	0.08
1.37	1	1.37	0		1.17	0.83	1.17	0.95		1.17	0.00	1.17	0.08
1.38	1	1.38	0		1.18	0.82	1.18	0.94		1.18	0.00	1.18	0.08
1.39	1	1.39	0		1.19	0.81	1.19	0.94		1.19	0.00	1.19	0.07
1.4	1	1.4	0		1.2	0.80	1.20	0.93		1.2	0.00	1.20	0.07
1.41	1	1.41	0		1.21	0.79	1.21	0.93		1.21	0.00	1.21	0.07
1.42	1	1.42	0		1.22	0.79	1.22	0.92		1.22	0.00	1.22	0.07
1.43	1	1.43	0		1.23	0.78	1.23	0.92		1.23	0.00	1.23	0.07
1.44	1	1.44	0		1.24	0.78	1.24	0.91		1.24	0.00	1.24	0.06
1.45	1	1.45	0		1.25	0.77	1.25	0.89		1.25	0.00	1.25	0.06
1.46	1	1.46	0		1.26	0.76	1.26	0.89		1.26	0.00	1.26	0.06
1.47	1	1.47	0		1.27	0.75	1.27	0.88		1.27	0.00	1.27	0.06
1.48	1	1.48	0		1.28	0.74	1.28	0.87		1.28	0.00	1.28	0.05
1.49	1	1.49	0		1.29	0.74	1.29	0.86		1.29	0.00	1.29	0.05
1.5	1	1.5	0		1.3	0.73	1.30	0.85		1.3	0.00	1.30	0.05
1.51	1	1.51	0		1.31	0.72	1.31	0.84		1.31	0.00	1.31	0.05
1.52	1	1.52	0		1.32	0.71	1.32	0.83		1.32	0.00	1.32	0.04
1.53	1	1.53	0		1.33	0.71	1.33	0.82		1.33	0.00	1.33	0.04
1.54	1	1.54	0		1.34	0.70	1.34	0.81		1.34	0.00	1.34	0.04
1.55	1	1.55	0		1.35	0.69	1.35	0.80		1.35	0.00	1.35	0.04
1.56	1	1.56	0		1.36	0.68	1.36	0.79		1.36	0.00	1.36	0.04
1.57	1	1.57	0		1.37	0.66	1.37	0.77		1.37	0.00	1.37	0.03
1.58	1	1.58	0		1.38	0.65	1.38	0.76		1.38	0.00	1.38	0.03
1.59	1	1.59	0		1.39	0.64	1.39	0.74		1.39	0.00	1.39	0.03

1.6	1	1.6	0	1.4	0.63	1.40	0.73	1.4	0.00	1.40	0.03
1.61	1	1.61	0	1.41	0.62	1.41	0.71	1.41	0.00	1.41	0.02
1.62	1	1.62	0	1.42	0.61	1.42	0.70	1.42	0.00	1.42	0.02
1.63	1	1.63	0	1.43	0.60	1.43	0.68	1.43	0.00	1.43	0.02
1.64	1	1.64	0	1.44	0.58	1.44	0.67	1.44	0.00	1.44	0.02
1.65	1	1.65	0	1.45	0.56	1.45	0.65	1.45	0.00	1.45	0.02
1.66	1	1.66	0	1.46	0.55	1.46	0.63	1.46	0.00	1.46	0.01
1.67	1	1.67	0	1.47	0.54	1.47	0.62	1.47	0.00	1.47	0.01
1.68	1	1.68	0	1.48	0.52	1.48	0.58	1.48	0.00	1.48	0.01
1.69	1	1.69	0	1.49	0.51	1.49	0.58	1.49	0.00	1.49	0.01
1.7	1	1.7	0	1.5	0.50	1.50	0.55	1.5	0.00	1.50	0.01
1.71	1	1.71	0	1.51	0.50	1.51	0.52	1.51	0.00	1.51	0.01
1.72	1	1.72	0	1.52	0.49	1.52	0.50	1.52	0.00	1.52	0.00
1.73	1	1.73	0	1.53	0.49	1.53	0.48	1.53	0.00	1.53	0.00
1.74	1	1.74	0	1.54	0.49	1.54	0.45	1.54	0.00	1.54	0.00
1.75	1	1.75	0	1.55	0.48	1.55	0.42	1.55	0.00	1.55	0.00
1.76	1	1.76	0	1.56	0.48	1.56	0.40	1.56	0.00	1.56	0.00
1.77	1	1.77	0	1.57	0.48	1.57	0.38	1.57	0.00	1.57	0.00
1.78	1	1.78	0	1.58	0.47	1.58	0.36	1.58	0.00	1.58	0.00
1.79	1	1.79	0	1.59	0.47	1.59	0.34	1.59	0.00	1.59	0.00
1.8	1	1.8	0	1.6	0.47	1.60	0.32	1.6	0.00	1.60	0.00
1.81	1	1.81	0	1.61	0.46	1.61	0.30	1.61	0.00	1.61	0.00
1.82	1	1.82	0	1.62	0.46	1.62	0.29	1.62	0.00	1.62	0.00
1.83	1	1.83	0	1.63	0.46	1.63	0.28	1.63	0.00	1.63	0.00
1.84	1	1.84	0	1.64	0.45	1.64	0.27	1.64	0.00	1.64	0.00
1.85	1	1.85	0	1.65	0.45	1.65	0.26	1.65	0.00	1.65	0.00
1.86	1	1.86	0	1.66	0.45	1.66	0.25	1.66	0.00	1.66	0.00
1.87	1	1.87	0	1.67	0.44	1.67	0.24	1.67	0.00	1.67	0.00
1.88	1	1.88	0	1.68	0.44	1.68	0.23	1.68	0.00	1.68	0.00
1.89	1	1.89	0	1.69	0.44	1.69	0.22	1.69	0.00	1.69	0.00
1.9	1	1.9	0	1.7	0.43	1.70	0.21	1.7	0.00	1.70	0.00
1.91	1	1.91	0	1.71	0.43	1.71	0.20	1.71	0.00	1.71	0.00
1.92	1	1.92	0	1.72	0.43	1.72	0.19	1.72	0.00	1.72	0.00
1.93	1	1.93	0	1.73	0.42	1.73	0.17	1.73	0.00	1.73	0.00
1.94	1	1.94	0	1.74	0.42	1.74	0.16	1.74	0.00	1.74	0.00
1.95	1	1.95	0	1.75	0.42	1.75	0.14	1.75	0.00	1.75	0.00
1.96	1	1.96	0	1.76	0.41	1.76	0.13	1.76	0.00	1.76	0.00
1.97	1	1.97	0	1.77	0.41	1.77	0.11	1.77	0.00	1.77	0.00
1.98	1	1.98	0	1.78	0.41	1.78	0.10	1.78	0.00	1.78	0.00
1.99	1	1.99	0	1.79	0.40	1.79	0.09	1.79	0.00	1.79	0.00
2	1	2	0	1.8	0.40	1.80	0.08	1.8	0.00	1.80	0.00
2.01	1	2.01	0	1.81	0.40	1.81	0.07	1.81	0.00	1.81	0.00
2.02	1	2.02	0	1.82	0.40	1.82	0.06	1.82	0.00	1.82	0.00
2.03	1	2.03	0	1.83	0.39	1.83	0.05	1.83	0.00	1.83	0.00
2.04	1	2.04	0	1.84	0.39	1.84	0.05	1.84	0.00	1.84	0.00
2.05	1	2.05	0	1.85	0.39	1.85	0.05	1.85	0.00	1.85	0.00
2.06	1	2.06	0	1.86	0.38	1.86	0.04	1.86	0.00	1.86	0.00
2.07	1	2.07	0	1.87	0.38	1.87	0.04	1.87	0.00	1.87	0.00
2.08	1	2.08	0	1.88	0.38	1.88	0.04	1.88	0.00	1.88	0.00
2.09	1	2.09	0	1.89	0.38	1.89	0.03	1.89	0.00	1.89	0.00
2.1	1	2.1	0	1.9	0.37	1.90	0.03	1.9	0.00	1.90	0.00
2.11	1	2.11	0	1.91	0.37	1.91	0.03	1.91	0.00	1.91	0.00
2.12	1	2.12	0	1.92	0.37	1.92	0.03	1.92	0.00	1.92	0.00
2.13	1	2.13	0	1.93	0.37	1.93	0.02	1.93	0.00	1.93	0.00
2.14	1	2.14	0	1.94	0.36	1.94	0.02	1.94	0.00	1.94	0.00
2.15	1	2.15	0	1.95	0.36	1.95	0.02	1.95	0.00	1.95	0.00
2.16	1	2.16	0	1.96	0.36	1.96	0.01	1.96	0.00	1.96	0.00
2.17	1	2.17	0	1.97	0.36	1.97	0.01	1.97	0.00	1.97	0.00
2.18	1	2.18	0	1.98	0.36	1.98	0.01	1.98	0.00	1.98	0.00
2.19	1	2.19	0	1.99	0.35	1.99	0.01	1.99	0.00	1.99	0.00
2.2	1	2.2	0	2	0.35	2.00	0.00	2	0.00	2.00	0.00
2.21	1	2.21	0	2.01	0.35	2.01	0.00	2.01	0.00	2.01	0.00
2.22	1	2.22	0	2.02	0.34	2.02	0.00	2.02	0.00	2.02	0.00
2.23	1	2.23	0	2.03	0.34	2.03	0.00	2.03	0.00	2.03	0.00
2.24	1	2.24	0	2.04	0.34	2.04	0.00	2.04	0.00	2.04	0.00
2.25	1	2.25	0	2.05	0.34	2.05	0.00	2.05	0.00	2.05	0.00
2.26	1	2.26	0	2.06	0.34	2.06	0.00	2.06	0.00	2.06	0.00
2.27	1	2.27	0	2.07	0.33	2.07	0.00	2.07	0.00	2.07	0.00
2.28	1	2.28	0	2.08	0.33	2.08	0.00	2.08	0.00	2.08	0.00
2.29	1	2.29	0	2.09	0.33	2.09	0.00	2.09	0.00	2.09	0.00
2.3	1	2.3	0	2.1	0.32	2.10	0.00	2.1	0.00	2.10	0.00
2.31	1	2.31	0	2.11	0.32	2.11	0.00	2.11	0.00	2.11	0.00
2.32	1	2.32	0	2.12	0.32	2.12	0.00	2.12	0.00	2.12	0.00
2.33	1	2.33	0	2.13	0.32	2.13	0.00	2.13	0.00	2.13	0.00
2.34	1	2.34	0	2.14	0.32	2.14	0.00	2.14	0.00	2.14	0.00
2.35	1	2.35	0	2.15	0.31	2.15	0.00	2.15	0.00	2.15	0.00
2.36	1	2.36	0	2.16	0.31	2.16	0.00	2.16	0.00	2.16	0.00
2.37	1	2.37	0	2.17	0.31	2.17	0.00	2.17	0.00	2.17	0.00
2.38	1	2.38	0	2.18	0.30	2.18	0.00	2.18	0.00	2.18	0.00
2.39	1	2.39	0	2.19	0.30	2.19	0.00	2.19	0.00	2.19	0.00
2.4	1	2.4	0	2.2	0.30	2.20	0.00	2.2	0.00	2.20	0.00
2.41	1	2.41	0	2.21	0.30	2.21	0.00	2.21	0.00	2.21	0.00
2.42	1	2.42	0	2.22	0.30	2.22	0.00	2.22	0.00	2.22	0.00
2.43	1	2.43	0	2.23	0.30	2.23	0.00	2.23	0.00	2.23	0.00
2.44	1	2.44	0	2.24	0.30	2.24	0.00	2.24	0.00	2.24	0.00

2.45	1	2.45	0		2.25	0.30	2.25	0.00		2.25	0.00	2.25	0.00
2.46	1	2.46	0		2.26	0.30	2.26	0.00		2.26	0.00	2.26	0.00
2.47	1	2.47	0		2.27	0.30	2.27	0.00		2.27	0.00	2.27	0.00
2.48	1	2.48	0		2.28	0.30	2.28	0.00		2.28	0.00	2.28	0.00
2.49	1	2.49	0		2.29	0.30	2.29	0.00		2.29	0.00	2.29	0.00
2.5	1	2.5	0		2.3	0.30	2.30	0.00		2.3	0.00	2.30	0.00
2.51	1	2.51	0		2.31	0.30	2.31	0.00		2.31	0.00	2.31	0.00
2.52	1	2.52	0		2.32	0.30	2.32	0.00		2.32	0.00	2.32	0.00
2.53	1	2.53	0		2.33	0.30	2.33	0.00		2.33	0.00	2.33	0.00
2.54	1	2.54	0		2.34	0.30	2.34	0.00		2.34	0.00	2.34	0.00
2.55	1	2.55	0		2.35	0.30	2.35	0.00		2.35	0.00	2.35	0.00
2.56	1	2.56	0		2.36	0.30	2.36	0.00		2.36	0.00	2.36	0.00
2.57	1	2.57	0		2.37	0.30	2.37	0.00		2.37	0.00	2.37	0.00
2.58	1	2.58	0		2.38	0.30	2.38	0.00		2.38	0.00	2.38	0.00
2.59	1	2.59	0		2.39	0.30	2.39	0.00		2.39	0.00	2.39	0.00
2.6	1	2.6	0		2.4	0.30	2.40	0.00		2.4	0.00	2.40	0.00
2.61	1	2.61	0		2.41	0.30	2.41	0.00		2.41	0.00	2.41	0.00
2.62	1	2.62	0		2.42	0.30	2.42	0.00		2.42	0.00	2.42	0.00
2.63	1	2.63	0		2.43	0.30	2.43	0.00		2.43	0.00	2.43	0.00
2.64	1	2.64	0		2.44	0.30	2.44	0.00		2.44	0.00	2.44	0.00
2.65	1	2.65	0		2.45	0.29	2.45	0.00		2.45	0.00	2.45	0.00
2.66	1	2.66	0		2.46	0.29	2.46	0.00		2.46	0.00	2.46	0.00
2.67	1	2.67	0		2.47	0.29	2.47	0.00		2.47	0.00	2.47	0.00
2.68	1	2.68	0		2.48	0.29	2.48	0.00		2.48	0.00	2.48	0.00
2.69	1	2.69	0		2.49	0.29	2.49	0.00		2.49	0.00	2.49	0.00
2.7	1	2.7	0		2.5	0.29	2.50	0.00		2.5	0.00	2.50	0.00
2.71	1	2.71	0		2.51	0.29	2.51	0.00		2.51	0.00	2.51	0.00
2.72	1	2.72	0		2.52	0.29	2.52	0.00		2.52	0.00	2.52	0.00
2.73	1	2.73	0		2.53	0.29	2.53	0.00		2.53	0.00	2.53	0.00
2.74	1	2.74	0		2.54	0.29	2.54	0.00		2.54	0.00	2.54	0.00
2.75	1	2.75	0		2.55	0.29	2.55	0.00		2.55	0.00	2.55	0.00
2.76	1	2.76	0		2.56	0.28	2.56	0.00		2.56	0.00	2.56	0.00
2.77	1	2.77	0		2.57	0.28	2.57	0.00		2.57	0.00	2.57	0.00
2.78	1	2.78	0		2.58	0.28	2.58	0.00		2.58	0.00	2.58	0.00
2.79	1	2.79	0		2.59	0.28	2.59	0.00		2.59	0.00	2.59	0.00
2.8	1	2.8	0		2.6	0.28	2.60	0.00		2.6	0.00	2.60	0.00
2.81	1	2.81	0		2.61	0.28	2.61	0.00		2.61	0.00	2.61	0.00
2.82	1	2.82	0		2.62	0.28	2.62	0.00		2.62	0.00	2.62	0.00
2.83	1	2.83	0		2.63	0.28	2.63	0.00		2.63	0.00	2.63	0.00
2.84	1	2.84	0		2.64	0.28	2.64	0.00		2.64	0.00	2.64	0.00
2.85	1	2.85	0		2.65	0.28	2.65	0.00		2.65	0.00	2.65	0.00
2.86	1	2.86	0		2.66	0.28	2.66	0.00		2.66	0.00	2.66	0.00
2.87	1	2.87	0		2.67	0.27	2.67	0.00		2.67	0.00	2.67	0.00
2.88	1	2.88	0		2.68	0.27	2.68	0.00		2.68	0.00	2.68	0.00
2.89	1	2.89	0		2.69	0.27	2.69	0.00		2.69	0.00	2.69	0.00
2.9	1	2.9	0		2.7	0.27	2.70	0.00		2.7	0.00	2.70	0.00
2.91	1	2.91	0		2.71	0.27	2.71	0.00		2.71	0.00	2.71	0.00
2.92	1	2.92	0		2.72	0.27	2.72	0.00		2.72	0.00	2.72	0.00
2.93	1	2.93	0		2.73	0.27	2.73	0.00		2.73	0.00	2.73	0.00
2.94	1	2.94	0		2.74	0.27	2.74	0.00		2.74	0.00	2.74	0.00
2.95	1	2.95	0		2.75	0.27	2.75	0.00		2.75	0.00	2.75	0.00
2.96	1	2.96	0		2.76	0.27	2.76	0.00		2.76	0.00	2.76	0.00
2.97	1	2.97	0		2.77	0.26	2.77	0.00		2.77	0.00	2.77	0.00
2.98	1	2.98	0		2.78	0.26	2.78	0.00		2.78	0.00	2.78	0.00
2.99	1	2.99	0		2.79	0.26	2.79	0.00		2.79	0.00	2.79	0.00
3	1	3	0		2.8	0.26	2.80	0.00		2.8	0.00	2.80	0.00
3.01	1	3.01	0		2.81	0.26	2.81	0.00		2.81	0.00	2.81	0.00
3.02	1	3.02	0		2.82	0.26	2.82	0.00		2.82	0.00	2.82	0.00
3.03	1	3.03	0		2.83	0.26	2.83	0.00		2.83	0.00	2.83	0.00
3.04	1	3.04	0		2.84	0.26	2.84	0.00		2.84	0.00	2.84	0.00
3.05	1	3.05	0		2.85	0.26	2.85	0.00		2.85	0.00	2.85	0.00
3.06	1	3.06	0		2.86	0.26	2.86	0.00		2.86	0.00	2.86	0.00
3.07	1	3.07	0		2.87	0.26	2.87	0.00		2.87	0.00	2.87	0.00
3.08	1	3.08	0		2.88	0.25	2.88	0.00		2.88	0.00	2.88	0.00
3.09	1	3.09	0		2.89	0.25	2.89	0.00		2.89	0.00	2.89	0.00
3.1	1	3.1	0		2.9	0.25	2.90	0.00		2.9	0.00	2.90	0.00
3.11	1	3.11	0		2.91	0.25	2.91	0.00		2.91	0.00	2.91	0.00
3.12	1	3.12	0		2.92	0.25	2.92	0.00		2.92	0.00	2.92	0.00
3.13	1	3.13	0		2.93	0.25	2.93	0.00		2.93	0.00	2.93	0.00
3.14	1	3.14	0		2.94	0.25	2.94	0.00		2.94	0.00	2.94	0.00
3.15	1	3.15	0		2.95	0.25	2.95	0.00		2.95	0.00	2.95	0.00
3.16	1	3.16	0		2.96	0.25	2.96	0.00		2.96	0.00	2.96	0.00
3.17	1	3.17	0		2.97	0.25	2.97	0.00		2.97	0.00	2.97	0.00
3.18	1	3.18	0		2.98	0.25	2.98	0.00		2.98	0.00	2.98	0.00
3.19	1	3.19	0		2.99	0.24	2.99	0.00		2.99	0.00	2.99	0.00
3.2	1	3.2	0		3	0.24	3.00	0.00		3	0.00	3.00	0.00
3.21	1	3.21	0		3.01	0.24	3.01	0.00		3.01	0.00	3.01	0.00
3.22	1	3.22	0		3.02	0.24	3.02	0.00		3.02	0.00	3.02	0.00
3.23	1	3.23	0		3.03	0.24	3.03	0.00		3.03	0.00	3.03	0.00
3.24	1	3.24	0		3.04	0.24	3.04	0.00		3.04	0.00	3.04	0.00
3.25	1	3.25	0		3.05	0.24	3.05	0.00		3.05	0.00	3.05	0.00
3.26	1	3.26	0		3.06	0.24	3.06	0.00		3.06	0.00	3.06	0.00
3.27	1	3.27	0		3.07	0.24	3.07	0.00		3.07	0.00	3.07	0.00
3.28	1	3.28	0		3.08	0.24	3.08	0.00		3.08	0.00	3.08	0.00
3.29	1	3.29	0		3.09	0.24	3.09	0.00		3.09	0.00	3.09	0.00

3.3	1	3.3	0	3.1	0.23	3.10	0.00	3.1	0.00	3.10	0.00
3.31	1	3.31	0	3.11	0.23	3.11	0.00	3.11	0.00	3.11	0.00
3.32	1	3.32	0	3.12	0.23	3.12	0.00	3.12	0.00	3.12	0.00
3.33	1	3.33	0	3.13	0.23	3.13	0.00	3.13	0.00	3.13	0.00
3.34	1	3.34	0	3.14	0.23	3.14	0.00	3.14	0.00	3.14	0.00
3.35	1	3.35	0	3.15	0.23	3.15	0.00	3.15	0.00	3.15	0.00
3.36	1	3.36	0	3.16	0.23	3.16	0.00	3.16	0.00	3.16	0.00
3.37	1	3.37	0	3.17	0.23	3.17	0.00	3.17	0.00	3.17	0.00
3.38	1	3.38	0	3.18	0.23	3.18	0.00	3.18	0.00	3.18	0.00
3.39	1	3.39	0	3.19	0.23	3.19	0.00	3.19	0.00	3.19	0.00
3.4	1	3.4	0	3.2	0.23	3.20	0.00	3.2	0.00	3.20	0.00
3.41	1	3.41	0	3.21	0.22	3.21	0.00	3.21	0.00	3.21	0.00
3.42	1	3.42	0	3.22	0.22	3.22	0.00	3.22	0.00	3.22	0.00
3.43	1	3.43	0	3.23	0.22	3.23	0.00	3.23	0.00	3.23	0.00
3.44	1	3.44	0	3.24	0.22	3.24	0.00	3.24	0.00	3.24	0.00
3.45	1	3.45	0	3.25	0.22	3.25	0.00	3.25	0.00	3.25	0.00
3.46	1	3.46	0	3.26	0.22	3.26	0.00	3.26	0.00	3.26	0.00
3.47	1	3.47	0	3.27	0.22	3.27	0.00	3.27	0.00	3.27	0.00
3.48	1	3.48	0	3.28	0.22	3.28	0.00	3.28	0.00	3.28	0.00
3.49	1	3.49	0	3.29	0.22	3.29	0.00	3.29	0.00	3.29	0.00
3.5	1	3.5	0	3.3	0.22	3.30	0.00	3.3	0.00	3.30	0.00
3.51	1	3.51	0	3.31	0.22	3.31	0.00	3.31	0.00	3.31	0.00
3.52	1	3.52	0	3.32	0.21	3.32	0.00	3.32	0.00	3.32	0.00
3.53	1	3.53	0	3.33	0.21	3.33	0.00	3.33	0.00	3.33	0.00
3.54	1	3.54	0	3.34	0.21	3.34	0.00	3.34	0.00	3.34	0.00
3.55	1	3.55	0	3.35	0.21	3.35	0.00	3.35	0.00	3.35	0.00
3.56	1	3.56	0	3.36	0.21	3.36	0.00	3.36	0.00	3.36	0.00
3.57	1	3.57	0	3.37	0.21	3.37	0.00	3.37	0.00	3.37	0.00
3.58	1	3.58	0	3.38	0.21	3.38	0.00	3.38	0.00	3.38	0.00
3.59	1	3.59	0	3.39	0.21	3.39	0.00	3.39	0.00	3.39	0.00
3.6	1	3.6	0	3.4	0.21	3.40	0.00	3.4	0.00	3.40	0.00
3.61	1	3.61	0	3.41	0.21	3.41	0.00	3.41	0.00	3.41	0.00
3.62	1	3.62	0	3.42	0.21	3.42	0.00	3.42	0.00	3.42	0.00
3.63	1	3.63	0	3.43	0.20	3.43	0.00	3.43	0.00	3.43	0.00
3.64	1	3.64	0	3.44	0.20	3.44	0.00	3.44	0.00	3.44	0.00
3.65	1	3.65	0	3.45	0.20	3.45	0.00	3.45	0.00	3.45	0.00
3.66	1	3.66	0	3.46	0.20	3.46	0.00	3.46	0.00	3.46	0.00
3.67	1	3.67	0	3.47	0.20	3.47	0.00	3.47	0.00	3.47	0.00
3.68	1	3.68	0	3.48	0.20	3.48	0.00	3.48	0.00	3.48	0.00
3.69	1	3.69	0	3.49	0.20	3.49	0.00	3.49	0.00	3.49	0.00
3.7	1	3.7	0	3.5	0.20	3.50	0.00	3.5	0.00	3.50	0.00
3.71	1	3.71	0	3.51	0.20	3.51	0.00	3.51	0.00	3.51	0.00
3.72	1	3.72	0	3.52	0.20	3.52	0.00	3.52	0.00	3.52	0.00
3.73	1	3.73	0	3.53	0.20	3.53	0.00	3.53	0.00	3.53	0.00
3.74	1	3.74	0	3.54	0.20	3.54	0.00	3.54	0.00	3.54	0.00
3.75	1	3.75	0	3.55	0.20	3.55	0.00	3.55	0.00	3.55	0.00
3.76	1	3.76	0	3.56	0.20	3.56	0.00	3.56	0.00	3.56	0.00
3.77	1	3.77	0	3.57	0.20	3.57	0.00	3.57	0.00	3.57	0.00
3.78	1	3.78	0	3.58	0.20	3.58	0.00	3.58	0.00	3.58	0.00
3.79	1	3.79	0	3.59	0.20	3.59	0.00	3.59	0.00	3.59	0.00
3.8	1	3.8	0	3.6	0.20	3.60	0.00	3.6	0.00	3.60	0.00
3.81	1	3.81	0	3.61	0.20	3.61	0.00	3.61	0.00	3.61	0.00
3.82	1	3.82	0	3.62	0.20	3.62	0.00	3.62	0.00	3.62	0.00
3.83	1	3.83	0	3.63	0.20	3.63	0.00	3.63	0.00	3.63	0.00
3.84	1	3.84	0	3.64	0.20	3.64	0.00	3.64	0.00	3.64	0.00
3.85	1	3.85	0	3.65	0.20	3.65	0.00	3.65	0.00	3.65	0.00
3.86	1	3.86	0	3.66	0.20	3.66	0.00	3.66	0.00	3.66	0.00
3.87	1	3.87	0	3.67	0.20	3.67	0.00	3.67	0.00	3.67	0.00
3.88	1	3.88	0	3.68	0.20	3.68	0.00	3.68	0.00	3.68	0.00
3.89	1	3.89	0	3.69	0.20	3.69	0.00	3.69	0.00	3.69	0.00
3.9	1	3.9	0	3.7	0.20	3.70	0.00	3.7	0.00	3.70	0.00
3.91	1	3.91	0	3.71	0.20	3.71	0.00	3.71	0.00	3.71	0.00
3.92	1	3.92	0	3.72	0.20	3.72	0.00	3.72	0.00	3.72	0.00
3.93	1	3.93	0	3.73	0.20	3.73	0.00	3.73	0.00	3.73	0.00
3.94	1	3.94	0	3.74	0.20	3.74	0.00	3.74	0.00	3.74	0.00
3.95	1	3.95	0	3.75	0.20	3.75	0.00	3.75	0.00	3.75	0.00
3.96	1	3.96	0	3.76	0.20	3.76	0.00	3.76	0.00	3.76	0.00
3.97	1	3.97	0	3.77	0.20	3.77	0.00	3.77	0.00	3.77	0.00
3.98	1	3.98	0	3.78	0.20	3.78	0.00	3.78	0.00	3.78	0.00
3.99	1	3.99	0	3.79	0.20	3.79	0.00	3.79	0.00	3.79	0.00
4	1	4	0	3.8	0.20	3.80	0.00	3.8	0.00	3.80	0.00

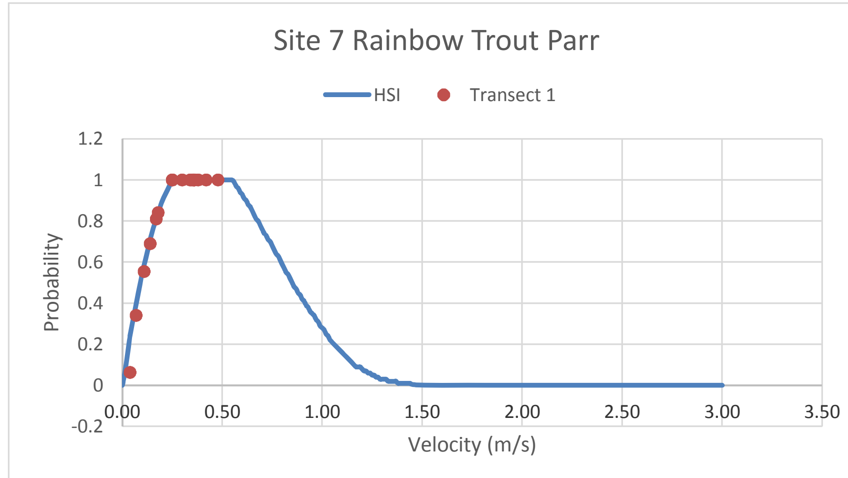
3.81	0.20	3.81	0.00	3.81	0.00	3.81	0.00
3.82	0.20	3.82	0.00	3.82	0.00	3.82	0.00
3.83	0.20	3.83	0.00	3.83	0.00	3.83	0.00
3.84	0.20	3.84	0.00	3.84	0.00	3.84	0.00
3.85	0.20	3.85	0.00	3.85	0.00	3.85	0.00
3.86	0.20	3.86	0.00	3.86	0.00	3.86	0.00
3.87	0.20	3.87	0.00	3.87	0.00	3.87	0.00
3.88	0.20	3.88	0.00	3.88	0.00	3.88	0.00
3.89	0.20	3.89	0.00	3.89	0.00	3.89	0.00
3.9	0.20	3.90	0.00	3.9	0.00	3.90	0.00
3.91	0.20	3.91	0.00	3.91	0.00	3.91	0.00
3.92	0.20	3.92	0.00	3.92	0.00	3.92	0.00
3.93	0.20	3.93	0.00	3.93	0.00	3.93	0.00
3.94	0.20	3.94	0.00	3.94	0.00	3.94	0.00
3.95	0.20	3.95	0.00	3.95	0.00	3.95	0.00
3.96	0.20	3.96	0.00	3.96	0.00	3.96	0.00
3.97	0.20	3.97	0.00	3.97	0.00	3.97	0.00
3.98	0.20	3.98	0.00	3.98	0.00	3.98	0.00
3.99	0.20	3.99	0.00	3.99	0.00	3.99	0.00
4	0.20	4.00	0.00	4	0.00	4.00	0.00

Site 7

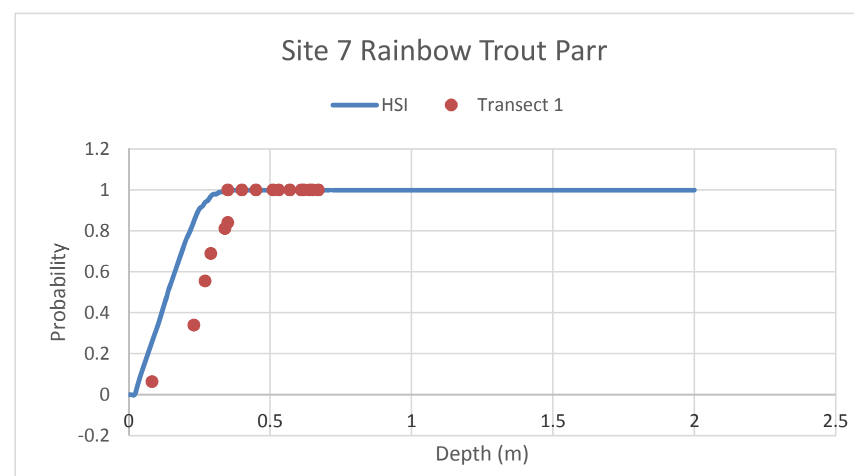
station leng (m)	Transect Data depth (m)	velocity (m/s)	substrate	cell width (m)	cell mean depth (m)	cell mean velocity (m/s)	cell prob. RBT	usable width Fry (m)	cell prob. RBT Parr	usable width RBT Parr	cell prob. CT fry	usable width CT fry	cell prob CT parr	usable width CT parr
0.5	0.1	0.01		0.25	0.0825	0.04	0.85	0.2125	0.0625	0.015625	1	0.25	0.27	0.0675
1	0.23	0.07		0.5	0.23	0.07	1	0.5	0.34	0.17	0.98	0.49	0.98	0.49
1.5	0.27	0.11		0.5	0.27	0.11	0.94	0.47	0.5546	0.2773	0.98	0.49	1	0.5
2	0.29	0.14		0.5	0.29	0.14	0.88	0.44	0.6887	0.34435	0.98	0.49	1	0.5
2.5	0.35	0.18		0.5	0.35	0.18	0.68	0.34	0.84	0.42	0.85	0.425	1	0.5
3	0.34	0.17		0.5	0.34	0.17	0.71	0.355	0.81	0.405	0.85	0.425	1	0.5
3.5	0.35	0.25		0.5	0.35	0.25	0.5848	0.2924	1	0.5	0.6375	0.31875	1	0.5
4	0.4	0.25		0.5	0.4	0.25	0.4472	0.2236	1	0.5	0.495	0.2475	1	0.5
4.5	0.45	0.3		0.5	0.45	0.3	0.2584	0.1292	1	0.5	0.175	0.0875	0.99	0.495
5	0.51	0.36		0.5	0.51	0.36	0.1225	0.06125	1	0.5	0.0377	0.01885	0.92	0.46
5.5	0.53	0.38		0.5	0.53	0.38	0.0924	0.0462	1	0.5	0.0232	0.0116	0.87	0.435
6	0.57	0.35		0.5	0.57	0.35	0.0832	0.0416	1	0.5	0.0273	0.01365	0.92	0.46
6.5	0.62	0.36		0.5	0.62	0.36	0.0588	0.0294	1	0.5	0.0195	0.00975	0.92	0.46
7	0.64	0.36		0.5	0.64	0.36	0.0539	0.02695	1	0.5	0.0195	0.00975	0.92	0.46
7.5	0.61	0.48		0.5	0.61	0.48	0.0216	0.0108	1	0.5	0.0015	0.00075	0.4	0.2
8	0.65	0.34		0.5	0.65	0.34	0.055	0.0275	1	0.5	0.027	0.0135	0.95	0.475
8.5	0.67	0.42		0.25	0.67	0.42	0.03	0.0075	1	0.25	0.004	0.001	0.7	0.175

Rainbow Trout Parr

HSI		Transect 1	
Velocity	HSI Score	Velocity	HSI Score
0.00	0	0.04	0.0625
0.01	0.05	0.07	0.34
0.02	0.11	0.11	0.5546
0.03	0.18	0.14	0.6887
0.04	0.25	0.18	0.84
0.05	0.3	0.17	0.81
0.06	0.35	0.25	1
0.07	0.4	0.25	1
0.08	0.45	0.3	1
0.09	0.5	0.36	1
0.10	0.55	0.38	1
0.11	0.59	0.35	1
0.12	0.63	0.36	1
0.13	0.67	0.36	1
0.14	0.71	0.48	1
0.15	0.75	0.34	1
0.16	0.78	0.42	1
0.17	0.81		
0.18	0.84		
0.19	0.87		
0.20	0.9		
0.21	0.92		
0.22	0.94		
0.23	0.96		
0.24	0.98		
0.25	1		
0.26	1		
0.27	1		
0.28	1		
0.29	1		
0.30	1		
0.31	1		
0.32	1		
0.33	1		
0.34	1		
0.35	1		
0.36	1		
0.37	1		
0.38	1		
0.39	1		
0.40	1		
0.41	1		
0.42	1		
0.43	1		
0.44	1		
0.45	1		
0.46	1		
0.47	1		
0.48	1		
0.49	1		
0.50	1		
0.51	1		
0.52	1		



HSI		Transect 1	
Depth	HSI Score	Depth	HSI Score
0	0	0.0825	0.0625
0.01	0	0.23	0.34
0.02	0	0.27	0.5546
0.03	0.04	0.29	0.6887
0.04	0.09	0.35	0.84
0.05	0.13	0.34	0.81
0.06	0.17	0.35	1
0.07	0.21	0.4	1
0.08	0.25	0.45	1
0.09	0.29	0.51	1
0.1	0.33	0.53	1
0.11	0.37	0.57	1
0.12	0.42	0.62	1
0.13	0.46	0.64	1
0.14	0.51	0.61	1
0.15	0.55	0.65	1
0.16	0.59	0.67	1
0.17	0.63		
0.18	0.67		
0.19	0.71		
0.2	0.75		
0.21	0.78		
0.22	0.81		
0.23	0.85		
0.24	0.88		
0.25	0.91		
0.26	0.92		
0.27	0.94		
0.28	0.95		
0.29	0.97		
0.3	0.98		
0.31	0.98		
0.32	0.99		
0.33	0.99		
0.34	1		



0.53	1
0.54	1
0.55	1
0.56	0.99
0.57	0.97
0.58	0.96
0.59	0.94
0.60	0.93
0.61	0.91
0.62	0.9
0.63	0.88
0.64	0.87
0.65	0.85
0.66	0.83
0.67	0.81
0.68	0.8
0.69	0.78
0.70	0.76
0.71	0.74
0.72	0.73
0.73	0.71
0.74	0.7
0.75	0.68
0.76	0.66
0.77	0.64
0.78	0.63
0.79	0.61
0.80	0.59
0.81	0.57
0.82	0.55
0.83	0.54
0.84	0.52
0.85	0.5
0.86	0.48
0.87	0.47
0.88	0.45
0.89	0.44
0.90	0.42
0.91	0.41
0.92	0.39
0.93	0.38
0.94	0.36
0.95	0.35
0.96	0.34
0.97	0.32
0.98	0.31
0.99	0.29
1.00	0.28
1.01	0.27
1.02	0.25
1.03	0.24
1.04	0.22
1.05	0.21
1.06	0.2
1.07	0.19
1.08	0.18
1.09	0.17
1.10	0.16
1.11	0.15
1.12	0.14
1.13	0.13
1.14	0.12

0.35	1
0.36	1
0.37	1
0.38	1
0.39	1
0.4	1
0.41	1
0.42	1
0.43	1
0.44	1
0.45	1
0.46	1
0.47	1
0.48	1
0.49	1
0.5	1
0.51	1
0.52	1
0.53	1
0.54	1
0.55	1
0.56	1
0.57	1
0.58	1
0.59	1
0.6	1
0.61	1
0.62	1
0.63	1
0.64	1
0.65	1
0.66	1
0.67	1
0.68	1
0.69	1
0.7	1
0.71	1
0.72	1
0.73	1
0.74	1
0.75	1
0.76	1
0.77	1
0.78	1
0.79	1
0.8	1
0.81	1
0.82	1
0.83	1
0.84	1
0.85	1
0.86	1
0.87	1
0.88	1
0.89	1
0.9	1
0.91	1
0.92	1
0.93	1
0.94	1
0.95	1
0.96	1

Rainbow Trout Fry HSI

Velocity	HSI Score
0.00	0.2
0.01	0.5
0.02	0.7
0.03	0.8
0.04	0.85
0.05	0.9
0.06	0.95
0.07	1
0.08	1
0.09	1
0.10	1
0.11	1
0.12	1
0.13	1
0.14	1
0.15	1
0.16	1
0.17	1
0.18	1
0.19	1
0.20	1
0.21	0.97
0.22	0.94
0.23	0.92
0.24	0.89
0.25	0.86
0.26	0.82
0.27	0.79
0.28	0.75
0.29	0.72
0.30	0.68
0.31	0.65
0.32	0.62
0.33	0.58
0.34	0.55
0.35	0.52
0.36	0.49
0.37	0.45
0.38	0.42
0.39	0.38
0.40	0.35
0.41	0.32
0.42	0.3
0.43	0.27
0.44	0.25
0.45	0.22
0.46	0.21
0.47	0.2
0.48	0.18
0.49	0.17
0.50	0.16
0.51	0.15
0.52	0.14
0.53	0.13
0.54	0.12
0.55	0.11
0.56	0.1
0.57	0.09
0.58	0.08

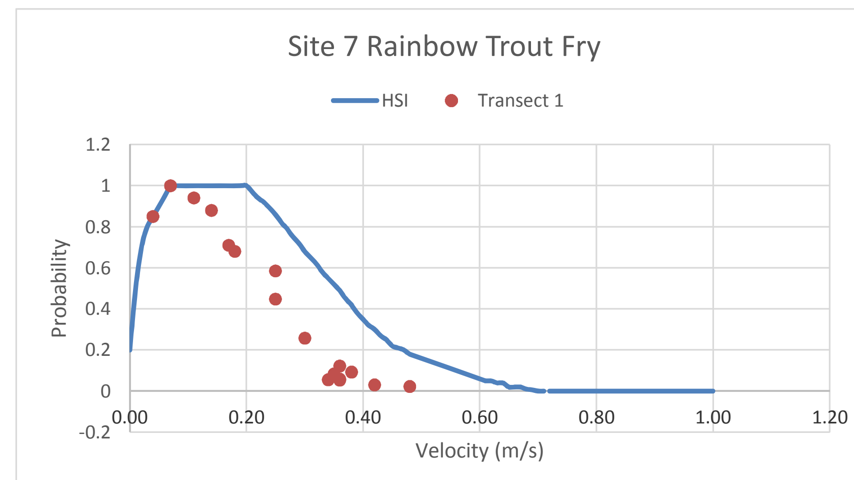
Transect 1

Velocity	HSI Score
0.04	0.85
0.07	1
0.11	0.94
0.14	0.88
0.18	0.68
0.17	0.71
0.25	0.5848
0.25	0.4472
0.3	0.2584
0.36	0.1225
0.38	0.0924
0.35	0.0832
0.36	0.0588
0.36	0.0539
0.48	0.0216
0.34	0.055
0.42	0.03

1.15	0.11
1.16	0.1
1.17	0.09
1.18	0.09
1.19	0.09
1.20	0.08
1.21	0.07
1.22	0.07
1.23	0.06
1.24	0.06
1.25	0.05
1.26	0.05
1.27	0.04
1.28	0.04
1.29	0.03
1.30	0.03
1.31	0.03
1.32	0.03
1.33	0.02
1.34	0.02
1.35	0.02
1.36	0.02
1.37	0.02
1.38	0.01
1.39	0.01
1.40	0.01
1.41	0.01
1.42	0.01
1.43	0.01
1.44	0.01
1.45	0.005
1.46	0.004
1.47	0.003
1.48	0.002
1.49	0.001
1.50	0
1.51	0
1.52	0
1.53	0
1.54	0
1.55	0
1.56	0
1.57	0
1.58	0
1.59	0
1.60	0

0.97	1
0.98	1
0.99	1
1	1
1.01	1
1.02	1
1.03	1
1.04	1
1.05	1
1.06	1
1.07	1
1.08	1
1.09	1
1.1	1
1.11	1
1.12	1
1.13	1
1.14	1
1.15	1
1.16	1
1.17	1
1.18	1
1.19	1
1.2	1
1.21	1
1.22	1
1.23	1
1.24	1
1.25	1
1.26	1
1.27	1
1.28	1
1.29	1
1.3	1
1.31	1
1.32	1
1.33	1
1.34	1
1.35	1
1.36	1
1.37	1
1.38	1
1.39	1
1.4	1
1.41	1
1.42	1

0.59	0.07
0.60	0.06
0.61	0.05
0.62	0.05
0.63	0.04
0.64	0.04
0.65	0.02
0.66	0.02
0.67	0.02
0.68	0.01
0.69	0.006
0.70	0
0.71	0
0.72	0
0.73	0
0.74	0
0.75	0
0.76	0
0.77	0
0.78	0
0.79	0
0.80	0
0.81	0
0.82	0
0.83	0
0.84	0
0.85	0
0.86	0
0.87	0
0.88	0
0.89	0
0.90	0
0.91	0
0.92	0
0.93	0
0.94	0
0.95	0
0.96	0
0.97	0
0.98	0
0.99	0
1.00	0



1.61	0
1.62	0
1.63	0
1.64	0
1.65	0
1.66	0
1.67	0
1.68	0
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1.70	0
1.71	0
1.72	0
1.73	0
1.74	0
1.75	0
1.76	0
1.77	0
1.78	0
1.79	0
1.80	0
1.81	0
1.82	0
1.83	0
1.84	0
1.85	0
1.86	0
1.87	0
1.88	0
1.89	0
1.90	0
1.91	0
1.92	0
1.93	0
1.94	0
1.95	0
1.96	0
1.97	0
1.98	0
1.99	0
2.00	0
2.01	0
2.02	0
2.03	0
2.04	0
2.05	0
2.06	0
2.07	0
2.08	0
2.09	0
2.10	0
2.11	0
2.12	0
2.13	0
2.14	0
2.15	0
2.16	0
2.17	0
2.18	0

1.43	1
1.44	1
1.45	1
1.46	1
1.47	1
1.48	1
1.49	1
1.5	1
1.51	1
1.52	1
1.53	1
1.54	1
1.55	1
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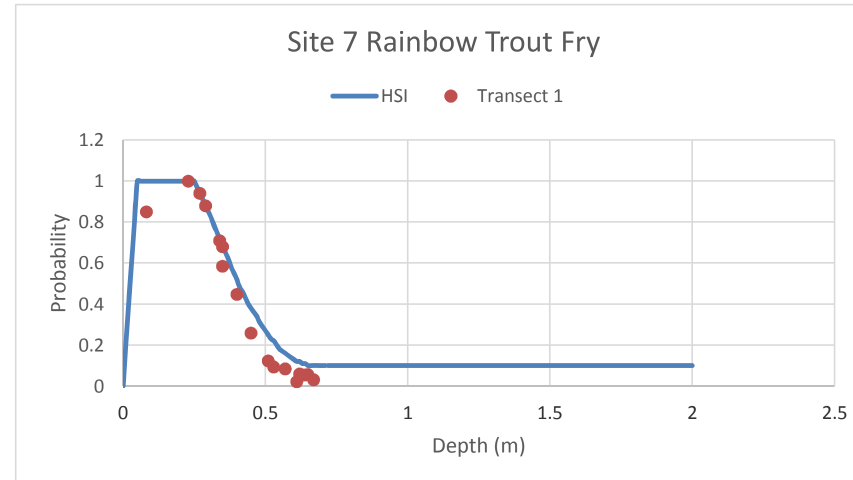
1.57	1
1.58	1
1.59	1
1.6	1
1.61	1
1.62	1
1.63	1
1.64	1
1.65	1
1.66	1
1.67	1
1.68	1
1.69	1
1.7	1
1.71	1
1.72	1
1.73	1
1.74	1
1.75	1
1.76	1
1.77	1
1.78	1
1.79	1
1.8	1
1.81	1
1.82	1
1.83	1
1.84	1
1.85	1
1.86	1
1.87	1
1.88	1
1.89	1
1.9	1
1.91	1
1.92	1
1.93	1
1.94	1
1.95	1
1.96	1
1.97	1
1.98	1
1.99	1
2	1

HSI	
Depth	**HSI Score**
0	0
0.01	0.2
0.02	0.4
0.03	0.6
0.04	0.8
0.05	1
0.06	1
0.07	1
0.08	1
0.09	1
0.1	1
0.11	1
0.12	1
0.13	1
0.14	1
0.15	1
0.16	1
0.17	1
0.18	1
0.19	1
0.2	1
0.21	1
0.22	1
0.23	1
0.24	1
0.25	1
0.26	0.97
0.27	0.94
0.28	0.91
0.29	0.88
0.3	0.85
0.31	0.82
0.32	0.78
0.33	0.75
0.34	0.71
0.35	0.68
0.36	0.65
0.37	0.62
0.38	0.58
0.39	0.55
0.4	0.52
0.41	0.48
0.42	0.46
0.43	0.43
0.44	0.4
0.45	0.38
0.46	0.36
0.47	0.34
0.48	0.31
0.49	0.29
0.5	0.27
0.51	0.25
0.52	0.23
0.53	0.22
0.54	0.2
0.55	0.18

Transect 1	
Depth	**HSI Score**
0.0825	0.85
0.23	1
0.27	0.94
0.29	0.88
0.35	0.68
0.34	0.71
0.35	0.5848
0.4	0.4472
0.45	0.2584
0.51	0.1225
0.53	0.0924
0.57	0.0832
0.62	0.0588
0.64	0.0539
0.61	0.0216
0.65	0.055
0.67	0.03

2.19	0
2.20	0
2.21	0
2.22	0
2.23	0
2.24	0
2.25	0
2.26	0
2.27	0
2.28	0
2.29	0
2.30	0
2.31	0
2.32	0
2.33	0
2.34	0
2.35	0
2.36	0
2.37	0
2.38	0
2.39	0
2.40	0
2.41	0
2.42	0
2.43	0
2.44	0
2.45	0
2.46	0
2.47	0
2.48	0
2.49	0
2.50	0
2.51	0
2.52	0
2.53	0
2.54	0
2.55	0
2.56	0
2.57	0
2.58	0
2.59	0
2.60	0
2.61	0
2.62	0
2.63	0
2.64	0
2.65	0
2.66	0
2.67	0
2.68	0
2.69	0
2.70	0
2.71	0
2.72	0
2.73	0
2.74	0
2.75	0
2.76	0
2.77	0
2.78	0
2.79	0
2.80	0
2.81	0

0.56	0.17
0.57	0.16
0.58	0.15
0.59	0.14
0.6	0.13
0.61	0.12
0.62	0.12
0.63	0.11
0.64	0.11
0.65	0.1
0.66	0.1
0.67	0.1
0.68	0.1
0.69	0.1
0.7	0.1
0.71	0.1
0.72	0.1
0.73	0.1
0.74	0.1
0.75	0.1
0.76	0.1
0.77	0.1
0.78	0.1
0.79	0.1
0.8	0.1
0.81	0.1
0.82	0.1
0.83	0.1
0.84	0.1
0.85	0.1
0.86	0.1
0.87	0.1
0.88	0.1
0.89	0.1
0.9	0.1
0.91	0.1
0.92	0.1
0.93	0.1
0.94	0.1
0.95	0.1
0.96	0.1
0.97	0.1
0.98	0.1
0.99	0.1
1	0.1
1.01	0.1
1.02	0.1
1.03	0.1
1.04	0.1
1.05	0.1
1.06	0.1
1.07	0.1
1.08	0.1
1.09	0.1
1.1	0.1
1.11	0.1
1.12	0.1
1.13	0.1
1.14	0.1
1.15	0.1
1.16	0.1
1.17	0.1

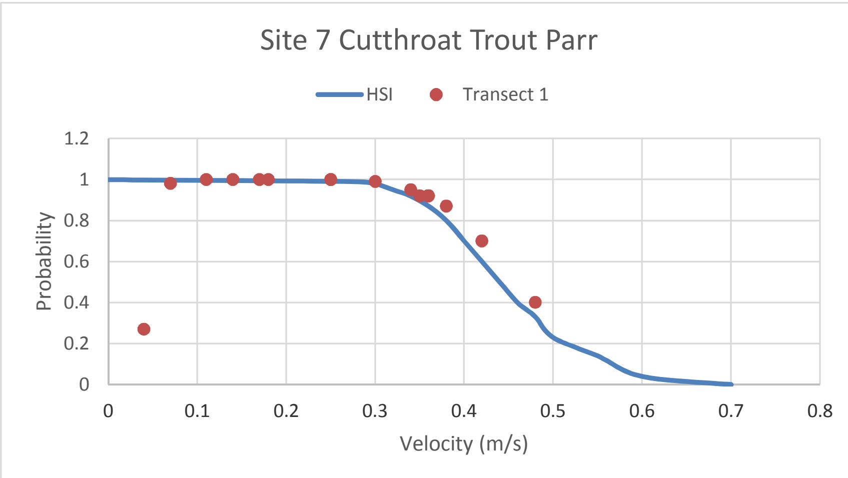


2.82	0
2.83	0
2.84	0
2.85	0
2.86	0
2.87	0
2.88	0
2.89	0
2.90	0
2.91	0
2.92	0
2.93	0
2.94	0
2.95	0
2.96	0
2.97	0
2.98	0
2.99	0
3.00	0

Cutthroat Trout Parr

HSI		Transect 1	
Velocity	**HSI Score**	**Velocity**	**HSI Score**
0	1	0.04	0.27
0.2801	0.99	0.07	0.98
0.3001	0.98	0.11	1
0.3201	0.95	0.14	1
0.3401	0.92	0.18	1
0.3601	0.87	0.17	1
0.3801	0.8	0.25	1
0.4001	0.7	0.25	1
0.4201	0.6	0.3	0.99
0.4401	0.5	0.36	0.92
0.4601	0.4	0.38	0.87
0.4801	0.33	0.35	0.92
0.5001	0.23	0.36	0.92
0.5501	0.14	0.36	0.92
0.6001	0.04	0.48	0.4
0.7001	0	0.34	0.95
		0.42	0.7

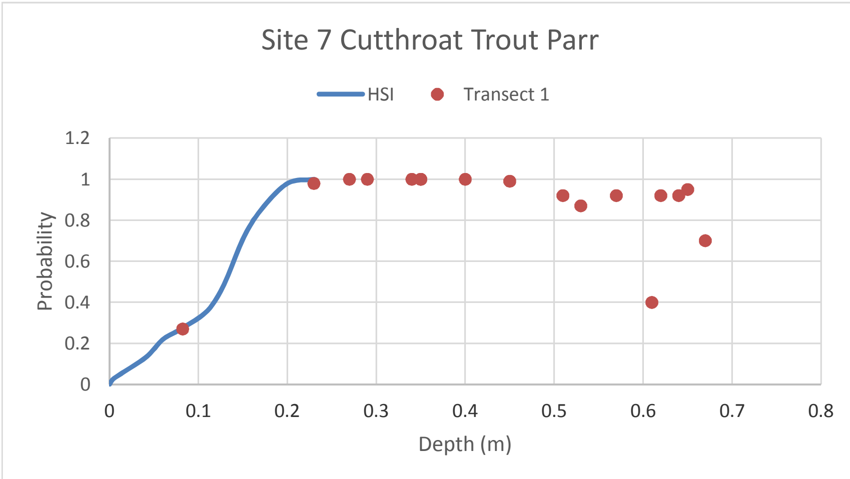
1.18	0.1
1.19	0.1
1.2	0.1
1.21	0.1
1.22	0.1
1.23	0.1
1.24	0.1
1.25	0.1
1.26	0.1
1.27	0.1
1.28	0.1
1.29	0.1
1.3	0.1
1.31	0.1
1.32	0.1
1.33	0.1
1.34	0.1
1.35	0.1
1.36	0.1
1.37	0.1
1.38	0.1
1.39	0.1
1.4	0.1
1.41	0.1
1.42	0.1
1.43	0.1
1.44	0.1
1.45	0.1
1.46	0.1
1.47	0.1
1.48	0.1
1.49	0.1
1.5	0.1
1.51	0.1
1.52	0.1
1.53	0.1
1.54	0.1
1.55	0.1
1.56	0.1
1.57	0.1
1.58	0.1
1.59	0.1



HSI		Transect 1	
Depth	HSI Score	Depth	HSI Score
0	0	0.0825	0.27
0.0051	0.03	0.23	0.98
0.0401	0.13	0.27	1
0.0601	0.22	0.29	1
0.0801	0.27	0.35	1
0.1101	0.36	0.34	1
0.1301	0.5	0.35	1
0.1501	0.71	0.4	1
0.1701	0.85	0.45	0.99
0.2001	0.98	0.51	0.92
0.2301	1	0.53	0.87
		0.57	0.92
		0.62	0.92
		0.64	0.92
		0.61	0.4
		0.65	0.95
		0.67	0.7

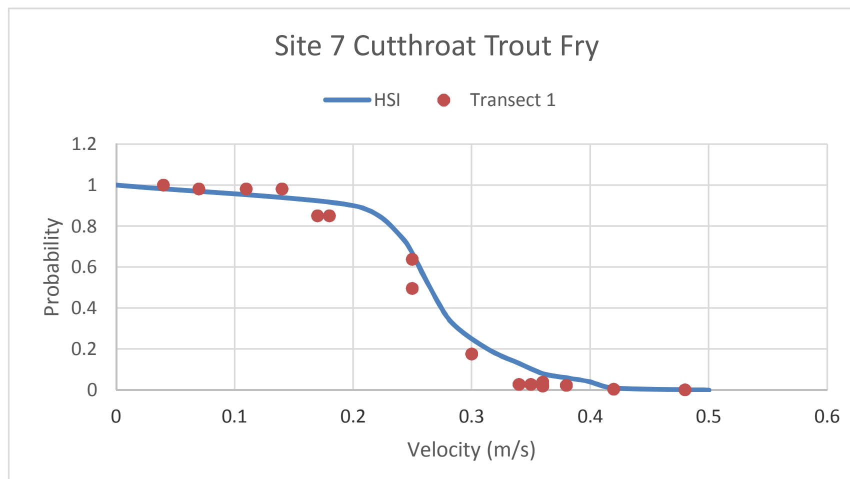
1.6	0.1
1.61	0.1
1.62	0.1
1.63	0.1
1.64	0.1
1.65	0.1
1.66	0.1
1.67	0.1
1.68	0.1
1.69	0.1
1.7	0.1
1.71	0.1
1.72	0.1
1.73	0.1
1.74	0.1
1.75	0.1
1.76	0.1
1.77	0.1
1.78	0.1
1.79	0.1
1.8	0.1
1.81	0.1
1.82	0.1
1.83	0.1
1.84	0.1
1.85	0.1
1.86	0.1
1.87	0.1
1.88	0.1
1.89	0.1
1.9	0.1
1.91	0.1
1.92	0.1
1.93	0.1
1.94	0.1
1.95	0.1
1.96	0.1
1.97	0.1
1.98	0.1

1.99	0.1
2	0.1

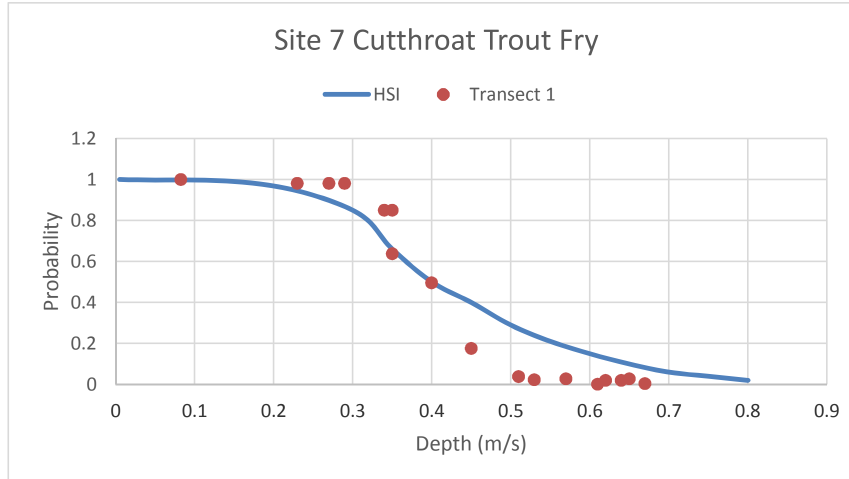


Cutthroat Trout Fry

HSI		Transect 1	
Velocity	**HSI Score**	**Velocity**	**HSI Score**
0	1	0.04	1
0.2001	0.9	0.07	0.98
0.2401	0.75	0.11	0.98
0.2601	0.55	0.14	0.98
0.2801	0.35	0.18	0.85
0.3001	0.25	0.17	0.85
0.3201	0.18	0.25	0.6375
0.3401	0.13	0.25	0.495
0.3601	0.08	0.3	0.175
0.3801	0.06	0.36	0.0377
0.4001	0.04	0.38	0.0232
0.4201	0.01	0.35	0.0273
0.5001	0	0.36	0.0195
		0.36	0.0195
		0.48	0.0015
		0.34	0.027
		0.42	0.004



HSI		Transect 1	
Depth	HSI Score	Depth	HSI Score
0.0051	1	0.0825	1
0.1801	0.98	0.23	0.98
0.3001	0.85	0.27	0.98
0.3501	0.66	0.29	0.98
0.4001	0.5	0.35	0.85
0.4501	0.4	0.34	0.85
0.5001	0.29	0.35	0.6375
0.5501	0.21	0.4	0.495
0.6001	0.15	0.45	0.175
0.6501	0.1	0.51	0.0377
0.7001	0.06	0.53	0.0232
0.7501	0.04	0.57	0.0273
0.8001	0.02	0.62	0.0195
		0.64	0.0195
		0.61	0.0015
		0.65	0.027
		0.67	0.004



Appendix 3

Raw Data – Fish Collection

ENVIRONMENTAL CONSULTANTS

Total Fish Captures

Date	Site	Method	ID	Species	Length (mm)	Weight (g)	Condition Factor (k)	Comments
7-Oct-15	1	EF	1-01	CAS	95	8.5	0.991398163	
7-Oct-15	1	EF	1-02	CAS	70	3.3	0.962099125	
7-Oct-15	2	EF		NFC				
8-Oct-15	3	EF	3-01	CAS	31	0.3	1.007015542	
8-Oct-15	3	EF	3-02	CAS	29	0.2	0.820041822	
8-Oct-15	3	EF	3-03	CAS	28	0.2	0.911078717	
8-Oct-15	3	EF	3-04	CAS	30	0.3	1.111111111	
8-Oct-15	3	EF	3-05	CAL	30	0.3	1.111111111	
8-Oct-15	3	EF	3-06	CAS	30	0.3	1.111111111	
8-Oct-15	3	EF	3-07	CAS	36	0.4	0.85733882	
8-Oct-15	3	EF	3-08	CAS	30	0.3	1.111111111	
8-Oct-15	3	EF	3-09	CAS	30	0.2	0.740740741	
8-Oct-15	3	EF	3-10	CAS	30	0.2	0.740740741	
8-Oct-15	3	EF	3-11	CAS	65	2.6	0.946745562	
8-Oct-15	3	EF	3-12	CAS	30	0.2	0.740740741	
8-Oct-15	3	EF	3-13	CAS	34	0.2	0.508854061	
8-Oct-15	3	EF	3-14	CAS	30	0.2	0.740740741	
8-Oct-15	3	EF	3-15	CAS	24	0.2	1.446759259	
8-Oct-15	4	EF	4-01	CAS	35	0.4	0.932944606	
8-Oct-15	4	EF	4-02	CAS	40	0.5	0.78125	
8-Oct-15	4	EF	4-03	CAS	62	2.3	0.965056561	
8-Oct-15	4	EF	4-04	CAS	34	0.5	1.272135152	
8-Oct-15	4	EF	4-05	CAS	32	0.2	0.610351563	
8-Oct-15	4	EF	4-06	CAS	21	0.1	1.079796998	
8-Oct-15	4	EF	4-07	CAS	27	0.2	1.016105269	
8-Oct-15	4	EF	4-08	CAS	34	0.3	0.763281091	
8-Oct-15	4	EF	4-09	CAS	25	0.2	1.28	
8-Oct-15	4	EF	4-10	PCC	21	0.1	1.079796998	Mortality
8-Oct-15	2	MT	2-01	PMB	65	5.3	1.929904415	
8-Oct-15	2	MT	2-02	PMB	67	5.6	1.861931155	
8-Oct-15	2	MT	2-03	TSB	40	0.4	0.625	
8-Oct-15	2	MT	2-04	PMB	33	0.5	1.391323705	
8-Oct-15	2	MT	2-05	CAS	96	8.7	0.983344184	
8-Oct-15	2	MT	2-06	CAS	105	11.5	0.993413238	
8-Oct-15	2	MT	2-07	CAS	100	11.3	1.13	
8-Oct-15	2	MT	2-08	CAS	114	17.4	1.174450438	
8-Oct-15	2	MT	2-09	CAS	93	7.9	0.98215096	
8-Oct-15	2	MT	2-10	CAS	94	8.5	1.023376323	
8-Oct-15	2	MT	2-11	CAS	100	12.3	1.23	
8-Oct-15	2	MT	2-12	CAS	89	7.1	1.007136484	
8-Oct-15	2	MT	2-13	CAS	90	9.2	1.262002743	
8-Oct-15	2	MT	2-14	CAS	82	6.7	1.215159385	
8-Oct-15	2	MT	2-15	CAS	81	7	1.317173496	
8-Oct-15	2	MT	2-16	PMB	32	0.5	1.525878906	
9-Oct-15	9	EF	9-01	CAS	80	9.5	1.85546875	
9-Oct-15	9	EF	9-02	CAS	90	6.7	0.919067215	
9-Oct-15	9	EF	9-03	CAS	96	7.4	0.836407697	
9-Oct-15	9	EF	9-04	CAS	80	7	1.3671875	
9-Oct-15	9	EF	9-05	CAS	70	3.4	0.991253644	
9-Oct-15	9	EF	9-06	NSC	36	0.4	0.85733882	

Total Fish Captures

Date	Site	Method	ID	Species	Length (mm)	Weight (g)	Condition Factor (k)	Comments
9-Oct-15	9	EF	9-07	PMB	45	1.4	1.536351166	
9-Oct-15	9	EF	9-08	PMB	44	1.5	1.760894065	
9-Oct-15	9	EF	9-09	PMB	41	1	1.45093658	
9-Oct-15	9	EF	9-10	PMB	37	0.9	1.776795057	
9-Oct-15	9	EF	9-11	Crayfish	65	8.7		
9-Oct-15	9	EF	9-12	Crayfish	65	8.7		
9-Oct-15	9	EF	9-13	PMB	36	1.2	2.572016461	
9-Oct-15	9	EF	9-14	CAS	82	5.2	0.943108777	
9-Oct-15	7	MT	7-01	CAS	84	5	0.843591405	
9-Oct-15	7	MT	7-02	CAS	105	12.2	1.05388187	
9-Oct-15	7	MT	7-03	CAS	125	23.9	1.22368	
9-Oct-15	7	MT	7-04	ST/RB	72	4.1	1.098465364	Adipose clipped
9-Oct-15	7	MT	7-05	CAS	110	14	1.051840721	
9-Oct-15	7	MT	7-06	CAS	116	13.3	0.852074706	
9-Oct-15	7	MT	7-07	CAS	89	8.7	1.234096818	
9-Oct-15	7	MT	7-08	CAS	94	10.5	1.264170752	
9-Oct-15	7	MT	7-09	CAS	106	14.7	1.234240346	
9-Oct-15	7	MT	7-10	CAS	90	7.3	1.001371742	
9-Oct-15	7	MT	7-11	CAS	90	9.2	1.262002743	
9-Oct-15	7	MT	7-12	CAS	70	3.3	0.962099125	
9-Oct-15	7	MT	7-13	CAS	105	10.6	0.915667854	
9-Oct-15	7	MT	7-14	CAS	95	9.4	1.096369733	
9-Oct-15	7	MT	7-15	CAS	90	5	0.685871056	
9-Oct-15	7	MT	7-16	CAS	90	6.6	0.905349794	
9-Oct-15	7	MT	7-17	CAS	70	2.8	0.816326531	
9-Oct-15	7	MT	7-18	CAS	80	4.2	0.8203125	
9-Oct-15	7	MT	7-19	CAS	76	4	0.911211547	
9-Oct-15	5	MT	5-01	PCC	67	3.2	1.06396066	
9-Oct-15	5	MT	5-02	NSC	130	20.5	0.933090578	
9-Oct-15	5	MT	5-03	ST/RB	91	8.7	1.154503026	Adipose clipped
9-Oct-15	5	MT	5-04	PCC	61	3.1	1.365753081	Mortality
9-Oct-15	5	MT	5-05	ST/RB	101	8.9	0.863825232	Adipose clipped
9-Oct-15	5	MT	5-06	ST/RB	84	6.4	1.079796998	Adipose clipped
9-Oct-15	5	MT	5-07	CAS	80	6.1	1.19140625	
9-Oct-15	5	MT	5-08	CAS	116	14.5	0.928953627	
9-Oct-15	5	MT	5-09	CAS	120	21.2	1.226851852	
9-Oct-15	5	MT	5-10	ST/RB	78	4.7	0.990407795	Not clipped
9-Oct-15	5	MT	5-11	CAS	108	12.2	0.968475334	
9-Oct-15	5	MT	5-12	ST/RB	87	6.8	1.032645258	Adipose clipped
9-Oct-15	5	MT	5-13	CAS	105	13.2	1.14026563	
9-Oct-15	5	MT	5-14	CAS	110	13.1	0.984222389	
9-Oct-15	5	MT	5-15	PCC	61	2.3	1.013300673	
9-Oct-15	5	MT	5-16	CAS	105	12.5	1.079796998	
9-Oct-15	5	MT	5-17	CAS	102	10.5	0.989438451	
9-Oct-15	5	MT	5-18	CAS	90	8.2	1.124828532	
9-Oct-15	5	MT	5-19	CAS	82	5.8	1.05192902	
9-Oct-15	5	MT	5-20	ST/RB	90	8.5	1.165980796	Adipose clipped
9-Oct-15	5	MT	5-21	CAS	96	11.4	1.288519965	
9-Oct-15	5	MT	5-22	CAS	114	18.4	1.24194759	
9-Oct-15	5	MT	5-23	CAS	80	4.3	0.83984375	

Total Fish Captures

Date	Site	Method	ID	Species	Length (mm)	Weight (g)	Condition Factor (k)	Comments
9-Oct-15	5	MT	5-24	CAS	100	12.2	1.22	
9-Oct-15	5	MT	5-25	CAS	84	6	1.012309686	
9-Oct-15	5	MT	5-26	CAS	78	4.9	1.032552808	
9-Oct-15	5	MT	5-27	CAS	71	3.1	0.866137112	
9-Oct-15	6	MT	6-01	NSC	140	26.1	0.951166181	
9-Oct-15	6	MT	6-02	CAS	110	15	1.126972201	
9-Oct-15	6	MT	6-03	CAS	108	14.1	1.11930346	
9-Oct-15	6	MT	6-04	CAS	117	19.3	1.205035174	
9-Oct-15	6	MT	6-05	CAS	105	14.5	1.252564518	
9-Oct-15	6	MT	6-06	PMB	69	6.5	1.978636811	
9-Oct-15	6	MT	6-07	NSC	96	9.5	1.073766638	
9-Oct-15	6	MT	6-08	CAS	85	5.9	0.960716467	
9-Oct-15	6	MT	6-09	CAS	94	9.4	1.131733816	
9-Oct-15	6	MT	6-10	ST/RB	87	6.7	1.017459298	Adipose clipped
9-Oct-15	6	MT	6-11	CAS	110	18	1.352366642	
9-Oct-15	6	MT	6-12	ST/RB	83	6.2	1.08431986	Adipose clipped
9-Oct-15	6	MT	6-13	CAS	94	8.8	1.059495488	
9-Oct-15	6	MT	6-14	CAS	90	7.2	0.987654321	
9-Oct-15	6	MT	6-15	NSC	100	11	1.1	
9-Oct-15	6	MT	6-16	CAS	76	4.2	0.956772124	
9-Oct-15	6	MT	6-17	CAS	80	6.2	1.2109375	
9-Oct-15	6	MT	6-18	CAS	95	10.4	1.213004811	
9-Oct-15	6	MT	6-19	CAS	69	2.5	0.761014158	
9-Oct-15	6	MT	6-20	CAS	70	3.3	0.962099125	
9-Oct-15	6	MT	6-21	CAS	86	5.4	0.848981851	
9-Oct-15	8	MT	8-01	PCC	65	2.3	0.83750569	
9-Oct-15	8	MT	8-02	CAS	100	13.8	1.38	
9-Oct-15	8	MT	8-03	PMB	33	0.7	1.947853188	
9-Oct-15	8	MT	8-04	NSC	81	6.4	1.204272911	Mortality
9-Oct-15	8	MT	8-05	CAS	120	25.9	1.498842593	
9-Oct-15	8	MT	8-06	CAS	109	25.9	1.999955213	
9-Oct-15	8	MT	8-07	CAS	109	16.1	1.243215403	
9-Oct-15	8	MT	8-08	CAS	90	9	1.234567901	
9-Oct-15	8	MT	8-09	CAS	95	10	1.16635078	
9-Oct-15	8	MT	8-10	CAS	95	10.1	1.178014288	
9-Oct-15	8	MT	8-11	PCC	64	2.7	1.029968262	
9-Oct-15	8	MT	8-12	NSC	87	6.5	0.987087378	
9-Oct-15	8	MT	8-13	CAS	100	13.9	1.39	
9-Oct-15	8	MT	8-14	CAS	80	4	0.78125	
9-Oct-15	8	MT	8-15	CAS	104	13.9	1.235704939	
9-Oct-15	8	MT	8-16	CAS	106	15.4	1.293013696	
9-Oct-15	8	MT	8-17	CAS	106	15.7	1.318202274	
9-Oct-15	8	MT	8-18	CAS	90	9.3	1.275720165	
9-Oct-15	8	MT	8-19	PMB	44	1.7	1.99567994	
9-Oct-15	8	MT	8-20	CAS	93	10.4	1.292958226	
9-Oct-15	8	MT	8-21	CAS	90	8.7	1.193415638	
9-Oct-15	8	MT	8-22	PMB	36	1.2	2.572016461	
9-Oct-15	8	MT	8-23	CAS	85	6.8	1.107266436	
9-Oct-15	8	MT	8-24	PMB	46	2.5	2.568422783	
9-Oct-15	8	MT	8-25	PMB	30	0.4	1.481481481	

Total Fish Captures

Date	Site	Method	ID	Species	Length (mm)	Weight (g)	Condition Factor (k)	Comments
9-Oct-15	8	MT	8-26	CAS	70	3.2	0.932944606	
9-Oct-15	8	MT	8-27	NSC	74	4.1	1.011786074	
9-Oct-15	8	MT	8-28	NSC	48	1.4	1.265914352	
13-Oct-15	10	EF		NFC	-	-		
13-Oct-15	11	EF	11-01	PCC	15	0.1	2.962962963	
13-Oct-15	11	EF	11-02	CAS	96	10.5	1.186794705	
8-Oct-15	1	MT	2-01	CAS	100	13.7	1.37	
8-Oct-15	1	MT	2-02	CAS	122	20.1	1.106920844	
8-Oct-15	1	MT	2-03	CAS	80	5.2	1.015625	
8-Oct-15	1	MT	2-04	CAS	115	19.4	1.275581491	
8-Oct-15	1	MT	2-05	CAS	90	7.7	1.056241427	
8-Oct-15	1	MT	2-06	CAS	126	22.3	1.114790419	
8-Oct-15	1	MT	2-07	CAS	99	10.2	1.051222355	
8-Oct-15	1	MT	2-08	CAS	101	12.3	1.193825882	
8-Oct-15	1	MT	2-09	CAS	99	11.6	1.195507776	
8-Oct-15	1	MT	2-10	CAS	78	4.6	0.969335289	
8-Oct-15	1	MT	2-11	CAS	95	11.8	1.37629392	
8-Oct-15	1	MT	2-12	CAS	77	4.3	0.941881529	
8-Oct-15	1	MT	2-13	CAS	80	5.8	1.1328125	
8-Oct-15	1	MT	2-14	CAS	103	13.1	1.198835574	
8-Oct-15	1	MT	2-15	Crayfish	63	7.7		