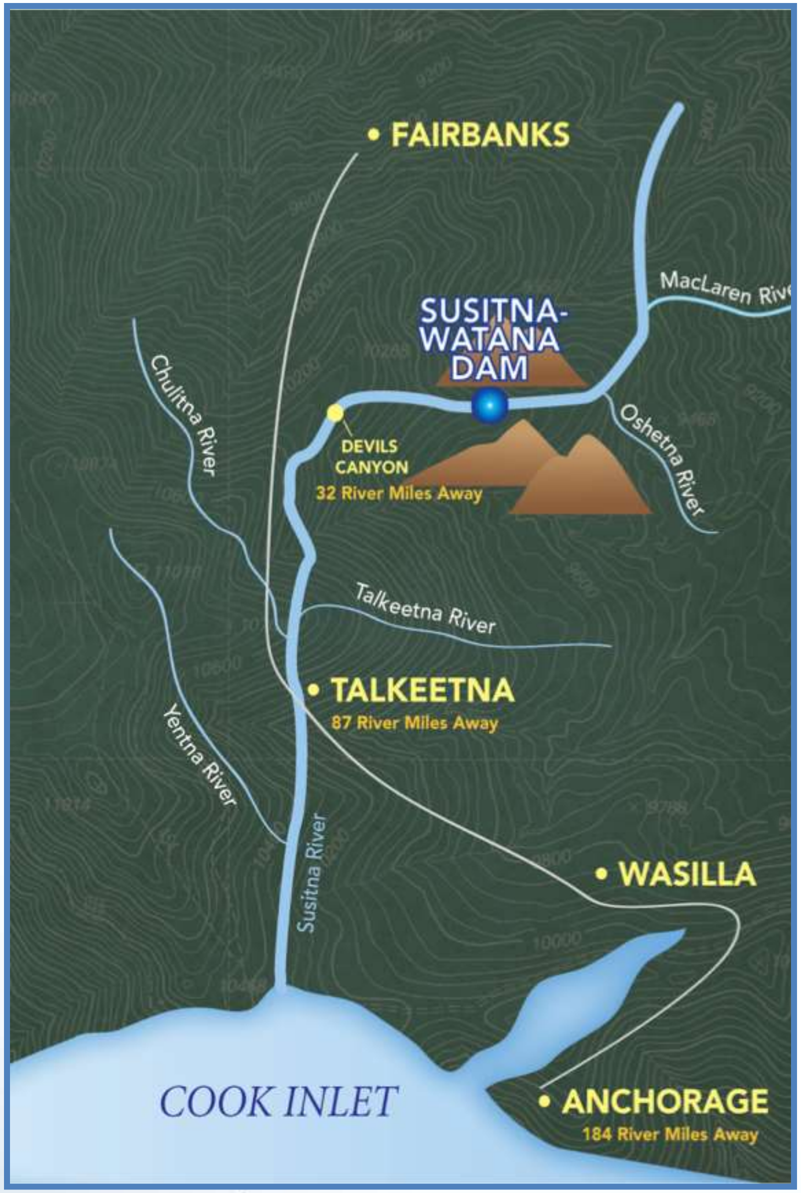

Technical Team Meeting

Study 8.5 IFS:

Update on HSC Curve Development

21 March 2014

Prepared by

R2 Resource Consultants

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Study 8.5 - HSC Curve Development

Presentation Outline

- **Goals for HSC curve development**
- **Types of HSC curves**
- **Summary of HSC *data collection and findings***
- ***Statistical methods for Preliminary HSC curve development***
- ***Update on relationship between fish abundance and water quality variables***
- ***Proposed 2014 Work***

Study 8.5 - HSC Curve Development

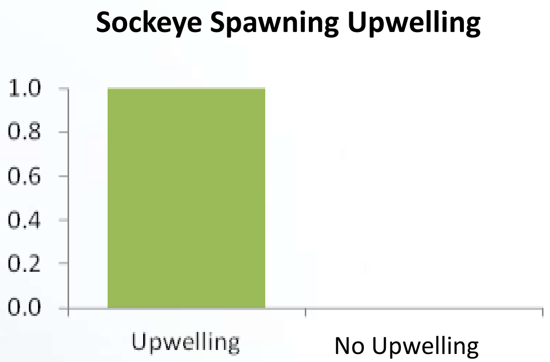
- **HSC Data Collection Goals**
  - Develop site-specific microhabitat preference curves for the target species and life stages.
    - Collect microhabitat use and availability data across a broad range of habitat conditions
  - Evaluate relationship between other variables (water quality & chemistry, groundwater upwelling) and fish presence where possible
  - Provide HSC curves for use in habitat modeling effort

Study 8.5 - HSC Curve Development

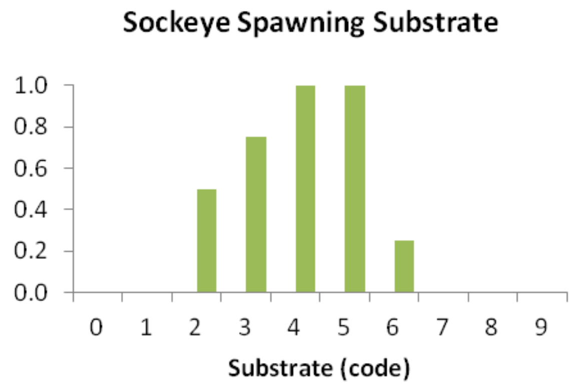
Habitat Suitability Criteria (HSC)

– HSC curves represent the functional relationship between independent variables such as depth, velocity, substrate, cover, etc., and the response of a species or life stage to a gradient of the independent variable (suitability).

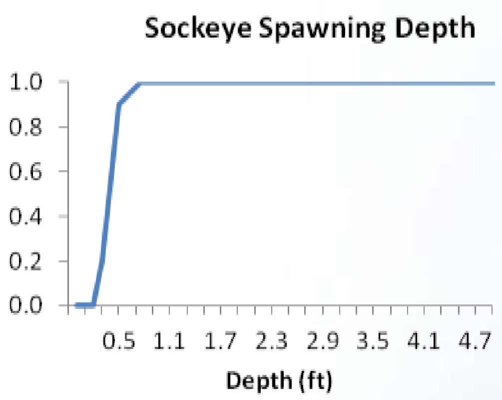
<u>Binary Curves</u>



<u>Categorical Curves</u>



<u>Continuous Curves</u>



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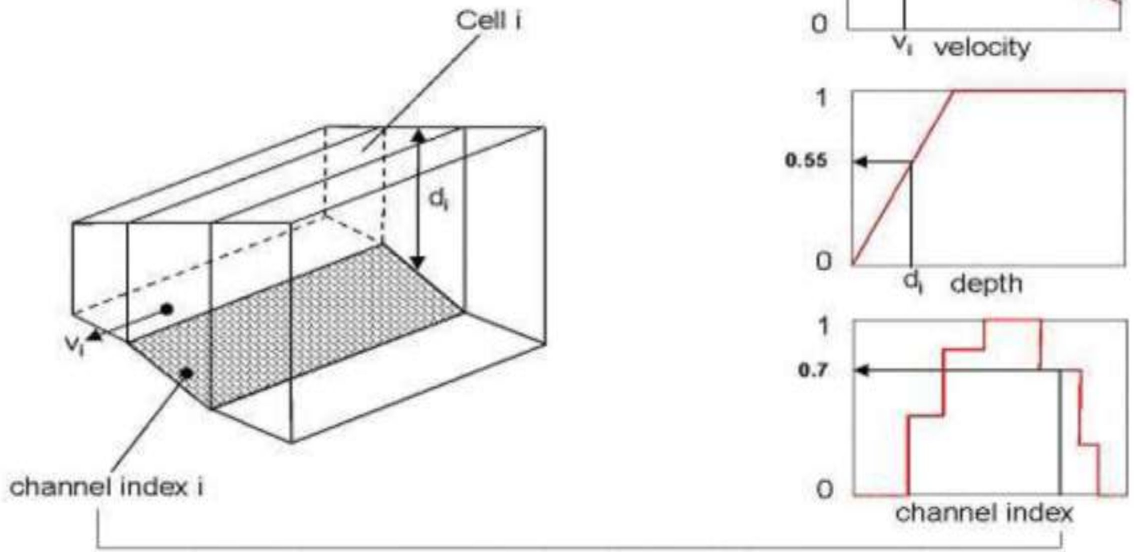
Study 8.5 - HSC Curve Development

Univariate HSC Curve

Composite Suitability for cell I =

$$HSCv * HSCd * HSCci = 0.9 * 0.55 * 0.7 = 0.3465$$



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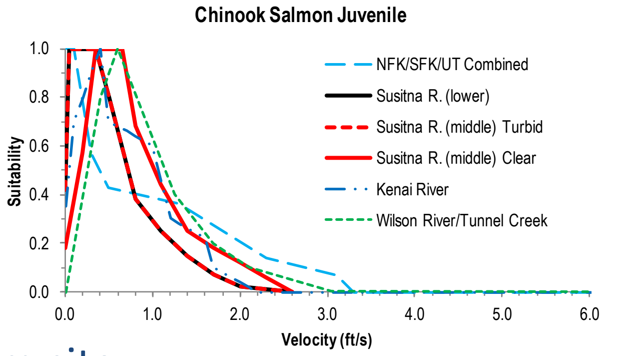
Study 8.5 - HSC Curve Development

- Multivariate Curves – present regression equation that predicts relative fish use/suitability using multiple predictor variables
  - Depth, velocity, substrate, cover, turbidity, water temperature, dissolved oxygen, conductivity, upwelling, distance to water's edge, etc.
  - Logistic regression model used to predict the effects of environmental factors on fish use/suitability
  - Believed to more accurately predict fish use when incorporated with 2-D hydrodynamic models

Study 8.5 - HSC Curve Development

– **The USGS classifies HSC curves into three categories (Categories 1, 2, and 3) based on the types of data used (Bovee 1986).**



Category 1 curves – derived from personal experience and professional opinion, from literature based curve sets, or from negotiated definitions.

Category 2 curves – developed from site-specific data that reflect microhabitat attributes measured at locations used by the target fish species.

Category 3 curves - rely on site-specific data and are designed to factor in the availability of certain habitat attributes into the curves thereby reducing bias.

Study 8.5 - 2013 HSC Sampling Update

- Collect microhabitat data for both occupied (utilization) and unoccupied (availability) areas:
  - ✓ Measurements collected at all FA sites d/s Portage Creek, expanded to outside FA
  - ✓ Sites selected based on stratified random sampling
    - Additional non-random spawning sites
  - ✓ 50m and 100m sampling reaches
  - ✓ Snorkel, seining, electrofishing, and pedestrian surveys
  - ✓ Collected depth, velocity, substrate, cover and water quality data (temp., D.O., conductivity, turbidity, groundwater upwelling)

Study 8.5 - 2013 HSC Sampling Update

Number of Individual Sampling Events by Focus Area, Habitat Type, and Sampling Session					
Focus Area	Number of Sampling Events	Habitat Type	Number of Sampling Events	Sample Session	Number of Sampling Events
104	47	Backwater	2	June 18-22	12
113	14	Clearwater Plume	4	July 10-17	44
115	11	Main Channel	30	July 23-30	26
128	36	Side Channel	66	August 6-13	58
138	32	Side Slough	44	August 20-23	18
141	22	Upland Slough	40	September 10-17	39
144	23	Tributary Mouth	9	September 24-29	10
Outside FA	25	Tributary	12		

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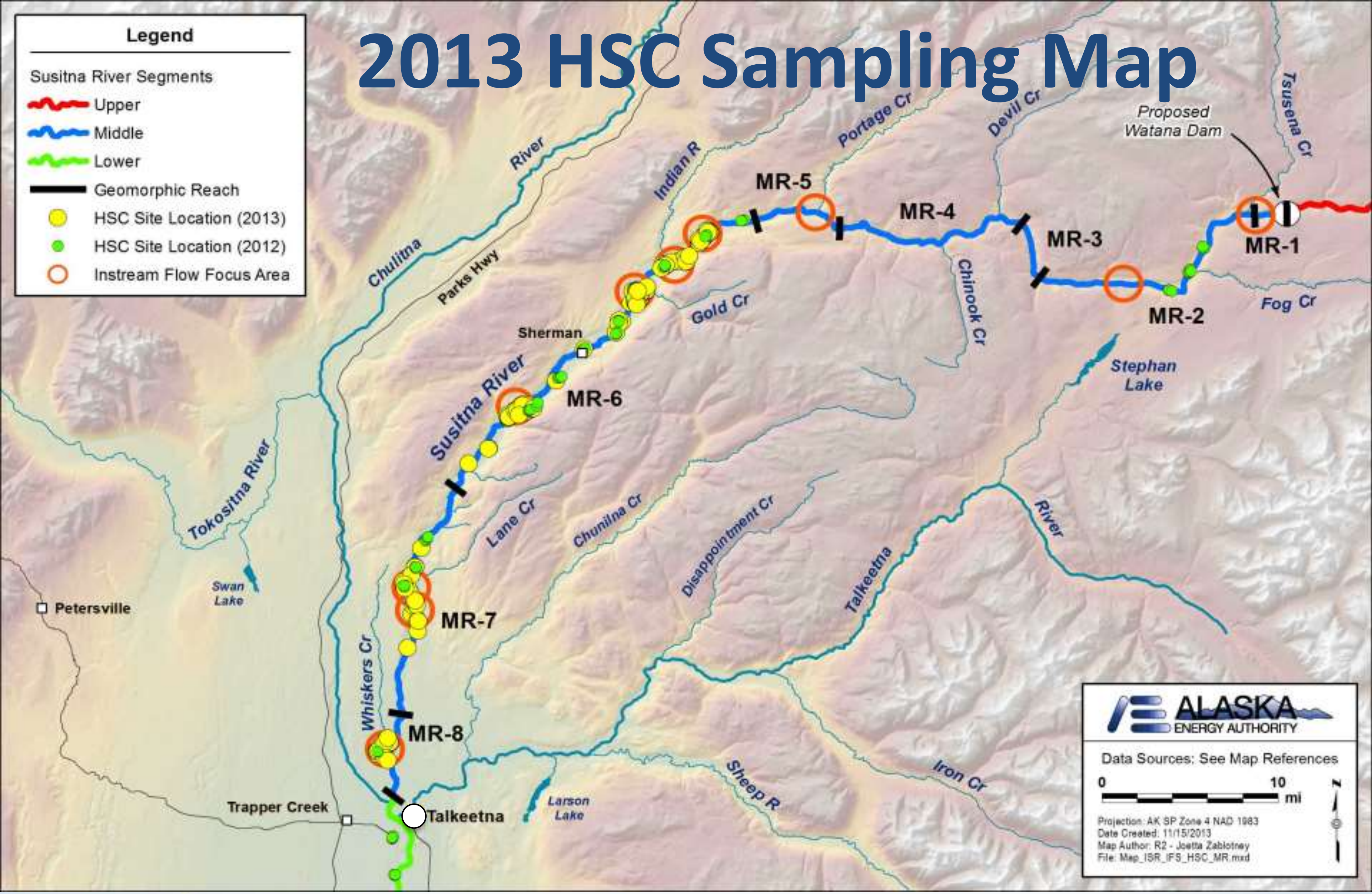
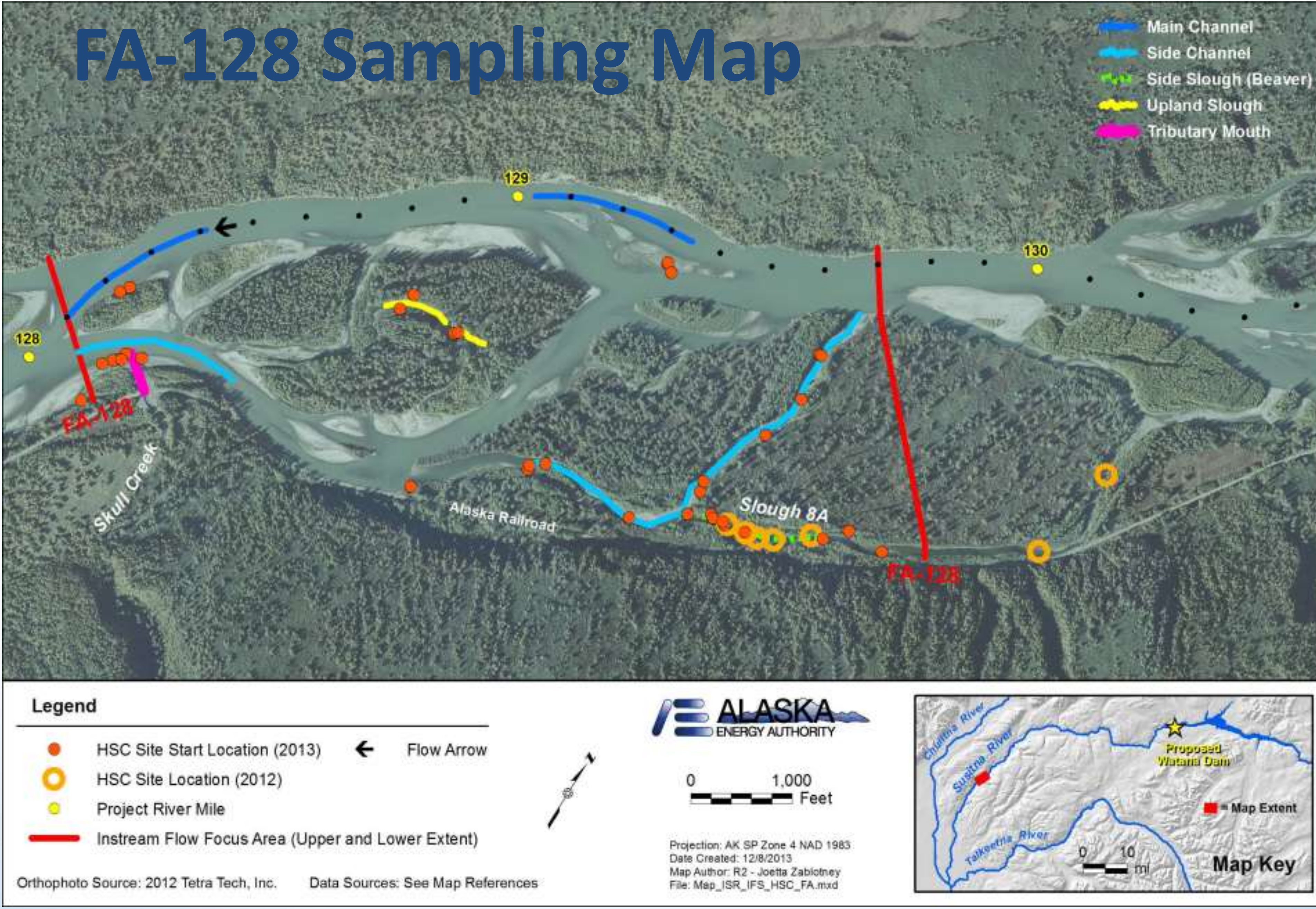
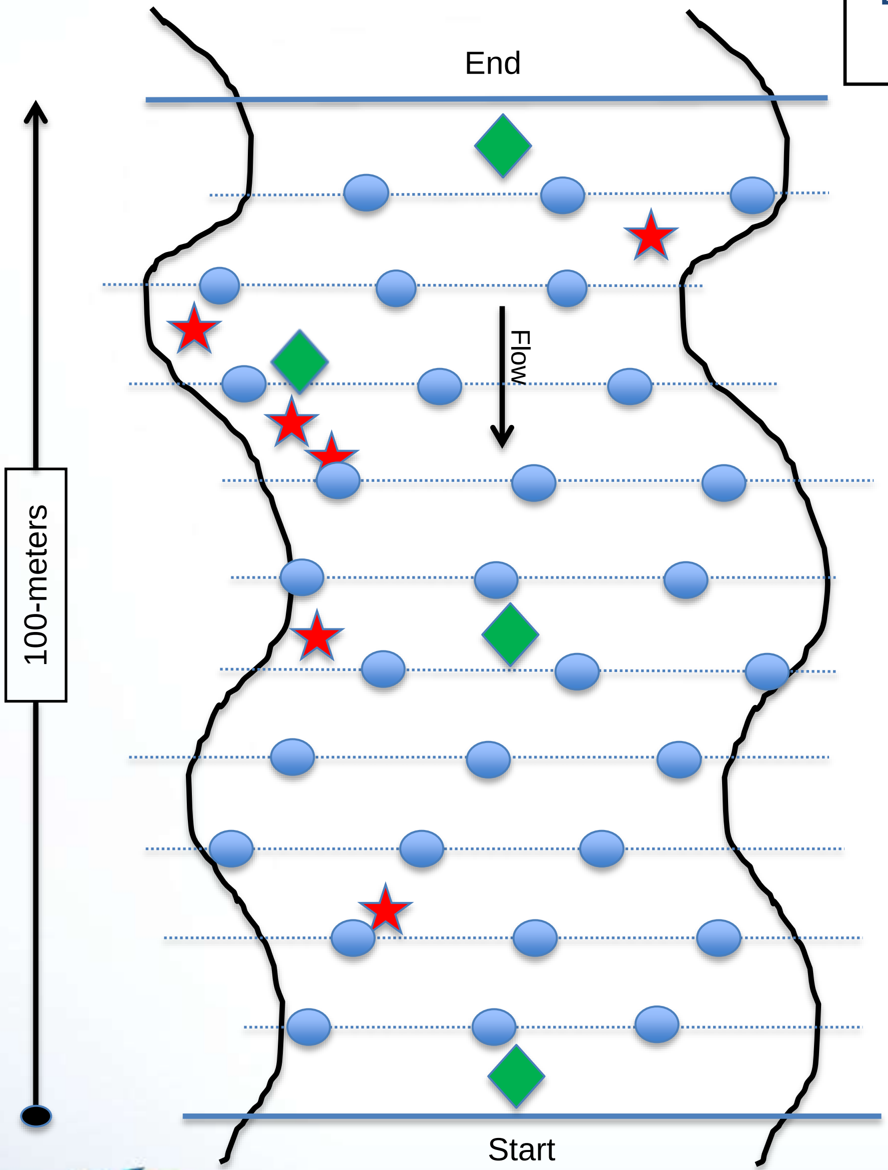
2013 HSC Sampling Map



FA-128 Sampling Map



Example Plot Depicting HSC and Water Quality Locations and Sampling Grid



Red Stars - Utilization Measurements

- Depth
- Velocity
- Substrate
- % Embeddedness
- Cover
- Distance from Start
- Distance from water's edge

Blue Dots - Availability Measurements

- Depth
- Velocity
- Substrate
- % Embeddedness
- Cover

Green Diamond - Water Qual. & VHG

- Temperature
- Dissolved Oxygen
- Conductivity
- Turbidity
- Vertical Hydraulic Gradient

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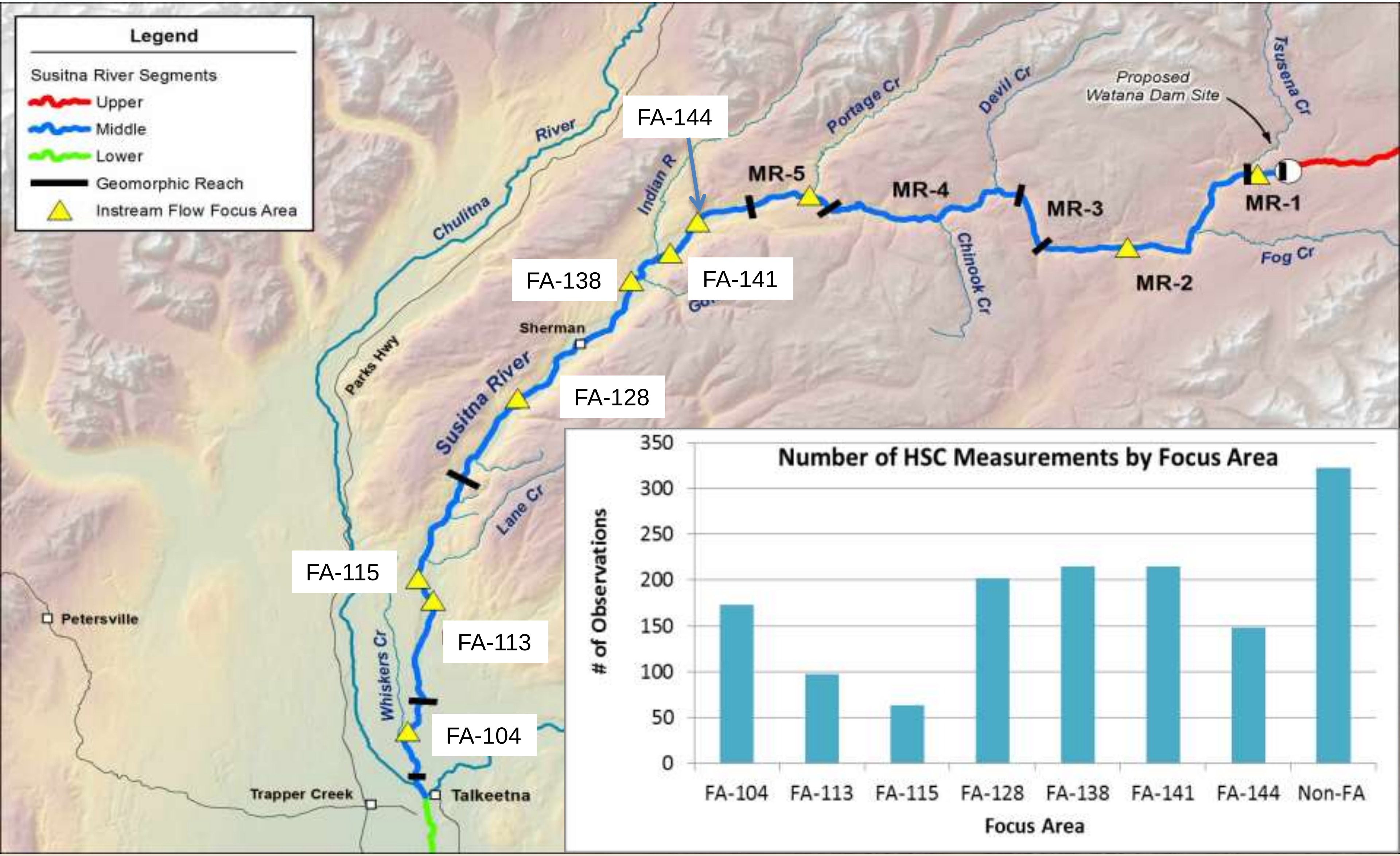
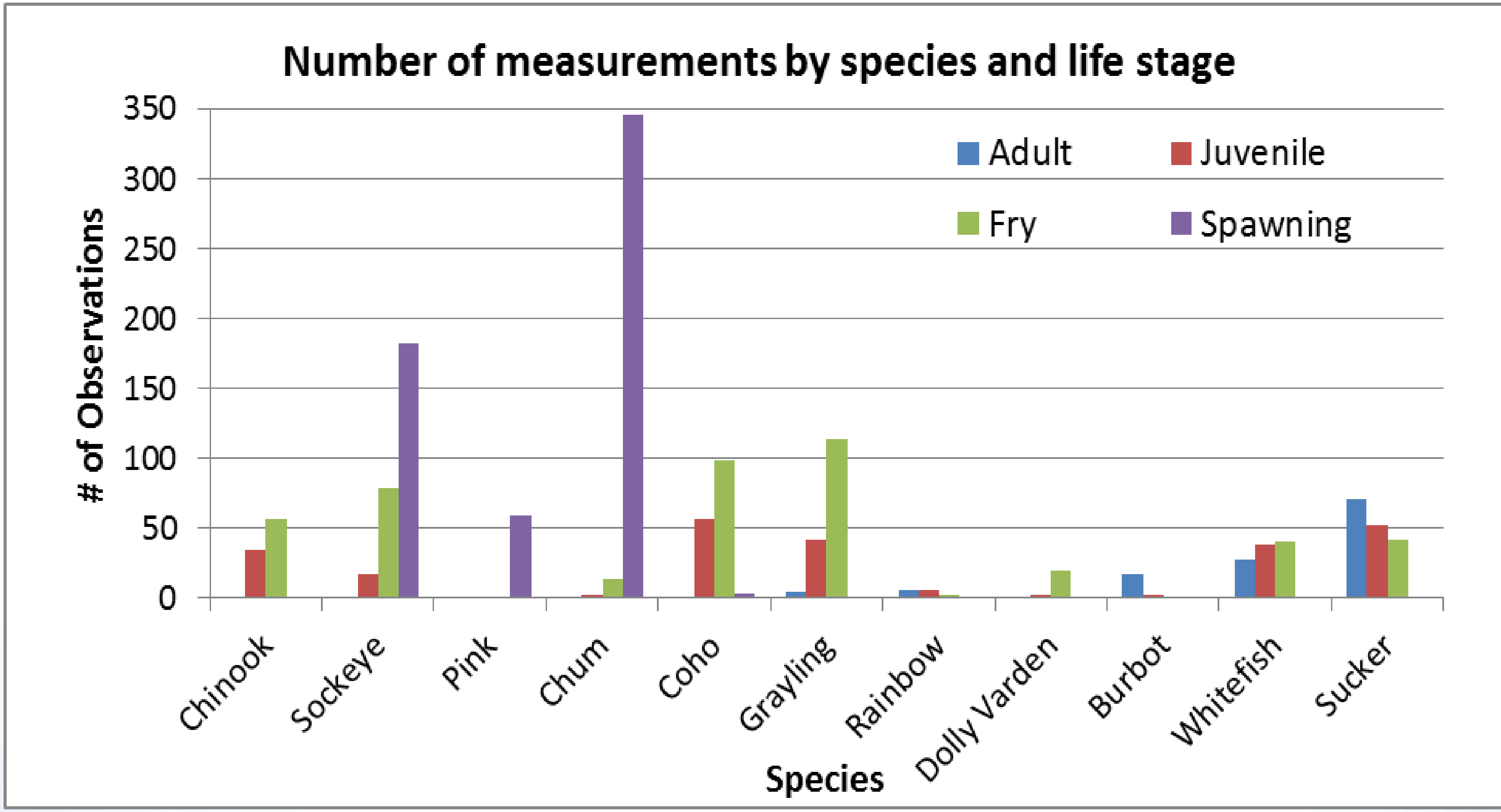
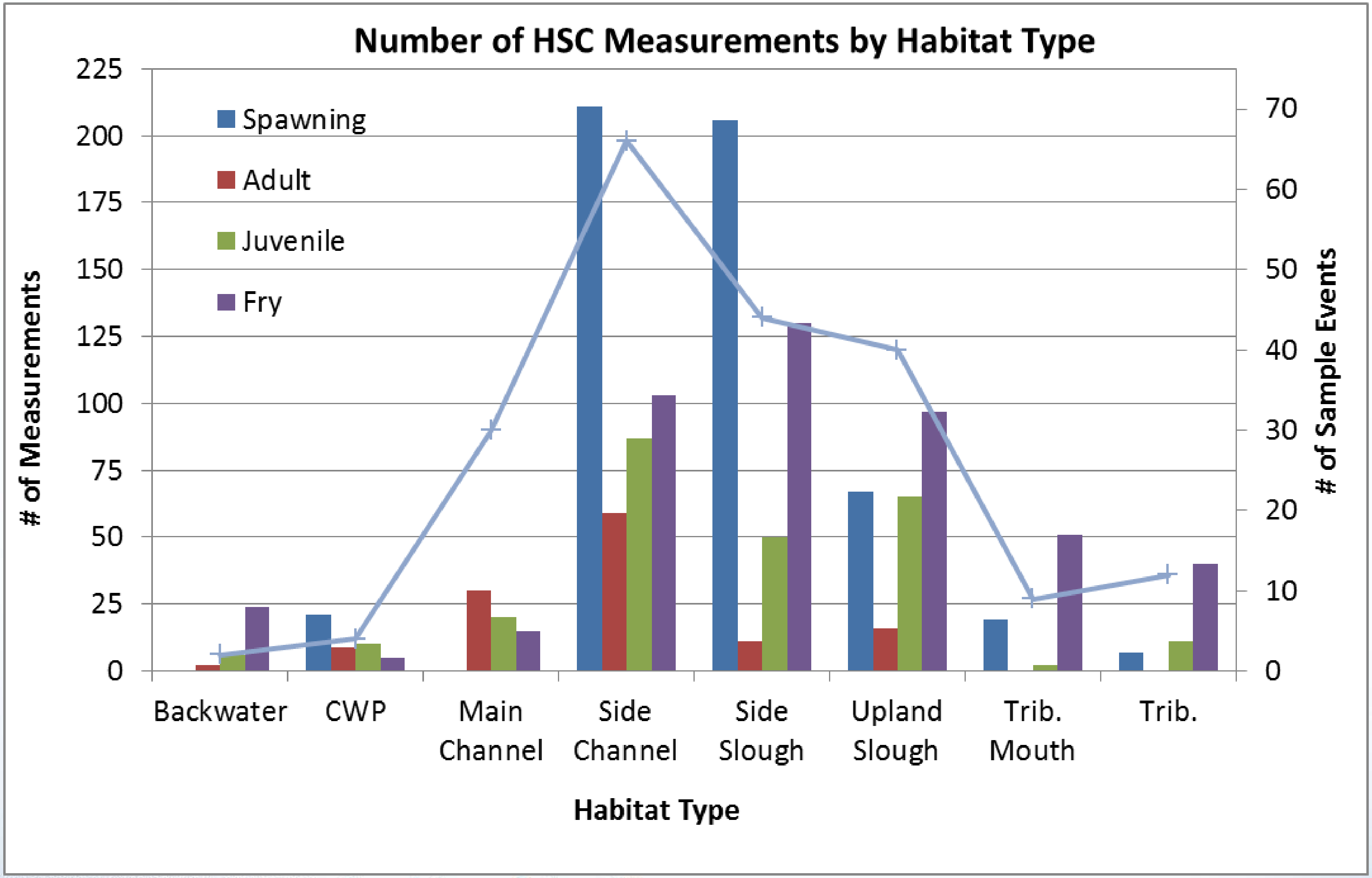
Study 8.5 - 2013 HSC Sampling Update



Study 8.5 - 2013 HSC Sampling Update



Study 8.5 - 2013 HSC Sampling Update



Summary of Water Quality and VHG Characteristics Within Select Macrohabitat Types

Statistic	Main Channel	Side Channel	Backwater	Clearwater Plume	Side Slough	Upland Slough	Tributary	Tributary Mouth
	Temperature (°C)							
Max	17.3	16.7	13.2	14.9	17.9	26.7	17.1	16.4
Mean	12.5	10.4	10.3	11.2	9.4	10.4	13.1	10.4
Min	7.7	3.2	7.5	7.1	4.6	3.6	7.8	5.4
	Conductivity (uS)							
Max	173	258	126	95	328	381	78	253
Mean	143	159	96	69	179	136	44	128
Min	100	43	28	19	28	23	24	66
	Dissolved Oxygen (mg/L)							
Max	12.5	13.0	10.5	11.8	12.4	12.8	11.8	12.7
Mean	11.0	10.7	9.5	10.8	10.0	8.1	10.3	10.8
Min	10.1	6.7	8.6	8.8	5.3	3.4	8.2	7.9
	Turbidity (NTU)							
Max	962	528	89	21	95	312	3	10
Mean	209	73	49	8	7	28	1	3
Min	1	1	10	2	1	1	0	1
	VHG (mm)							
Max	40	80	70	10	200	190	62	75
Mean	-8	14	24	4	20	31	6	-20
Min	-95	-60	0	-5	-75	-32	-35	-120

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HSC Model

- Preference rather than utilization
  - They are the same if all habitat types are equally available
- Multivariate regression rather than multiplying univariate HSC
  - Weighting and selection of predictor variables based on well-established statistical methods

HSC Model

- Objective is to build a multivariate preference model that predicts the *relative* probability of fish use in a habitat cell based on measurable predictable habitat characteristics

Generalized Regression Model

- Modeling probability of use is a "generalized" regression model because
  - Data consist of 0s and 1s
    - 1s are utilization data
    - 0s are systematic random samples collected at HSC sites (availability)
  - data are discrete, not normal
  - logistic transformation is used for regression
- Polynomial regression up to order 4 (non-linear)

Variables Considered for HSC

- Depth
- Velocity
- Substrate
- Cover
- Upwelling
- Water Temperature
- DO
- Conductivity
- Turbidity

HSC Spawning Model - Substrate

- We include substrate as a 3 level factor
  - Gravel dominant or subdominant
  - No gravel, but cobble dominant or subdominant
  - Other (suitability = 0)

HSC Spawning Model - Upwelling

- Relationship does not appear continuous
- We include upwelling as a 2 level factor based on HSC “VHG” measurements
  - Upwelling present if >5mm
  - Downwelling (< -5mm) also considered, but small sample size and no obvious difference from neutral for chum spawning

HSC Modeling Process

- Fit univariate polynomial models for each variable to determine individual relationships
  - Important because predictors may not be independent
- Use Akaike Information Criteria (AIC) to evaluate weight of evidence for each possible model
- If there is strong evidence of predictive relationship, include variable in multivariate analysis
  - Stong evidence is AIC 2 units better than null model

HSC Modeling Process

- Multivariate model using best polynomial relationships for each variable, and all subset models
- Included models with each single 2-way interaction
  - Interactions would be evaluated for ecological relevance prior to including in any final models
- Best model selected using AIC

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HSC Site Effects

- "Site" is a blocking/grouping factor
- Prob(use) varies considerably among sampled sites, even after we correct for all fixed variables
  - Option 1: Ignore this
  - Option 2: Use a fixed effect for site (or use other defining covariates)
  - **Option 3: Use a "random effect" for site**

HSC Site Effects

- Option 1 – ignoring differences among sites
  - This is usually done (e.g., combine all utilization data into one histogram).
  - But: sites with the most data (availability + use) drive the model
  - Combination of sites with different mean level can mask underlying relationship

HSC Site Effects

- Option 2 – Fixed effect for site
  - This doesn’t work because our predictive model has to apply to all sites in the river – mostly unsampled sites
  - Including macrohabitat type or other covariates to the model is possible, but
    - presumes relationships hold under project operations
    - categorical variables greatly increase sample size requirements

HSC Site Effects

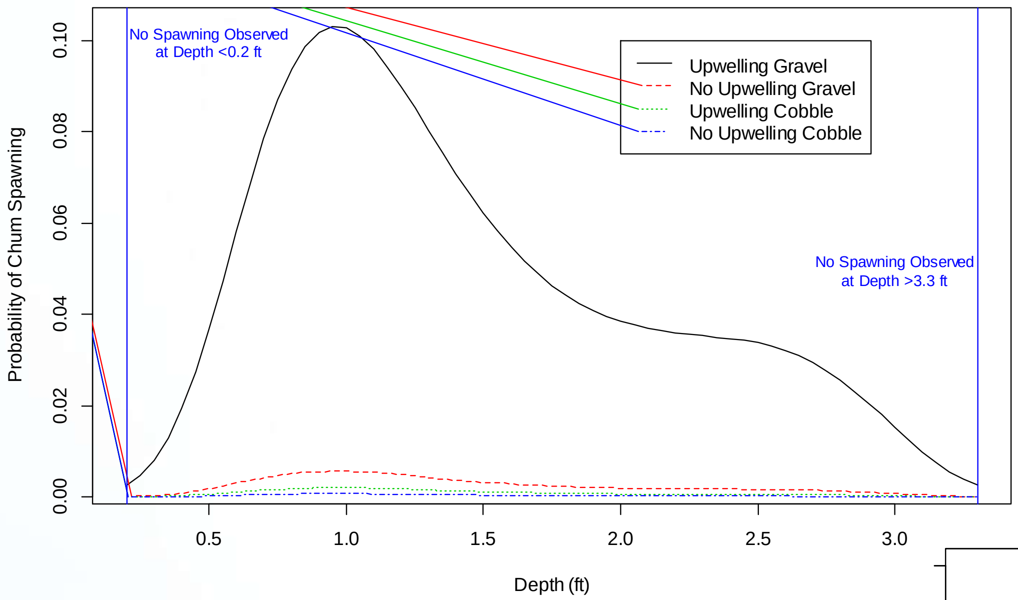
- Option 3 – Random effect for site
  - This is a "Generalized Mixed Model" with a random "intercept" or overall mean level of use for each site
  - Regression relationship is averaged over sites
  - Model does not predict the probability of use of any particular site (e.g., macrohabitat unit)
  - Rather, it predicts the ***relative*** suitability of individual prediction locations (modeled cells) based on predictors

HSC Chum Spawning Model – Best Fit

$$\log\left(\frac{p}{1-p}\right) = C_k + 19depth - 18depth^2 + 6.8depth^3 - 0.91depth^4 + 3.9vel - 1.9vel^2 + \gamma_{site} + \varepsilon,$$

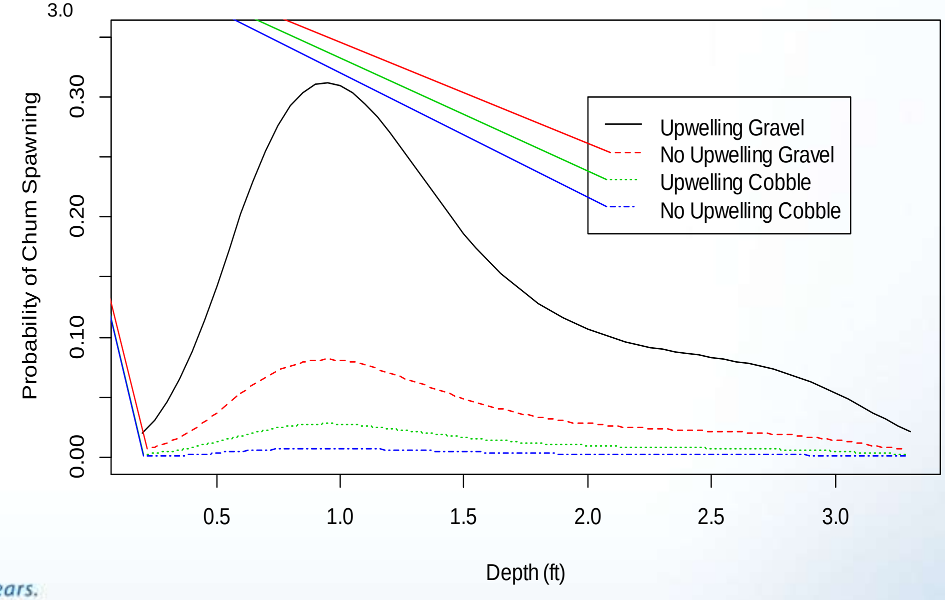
where

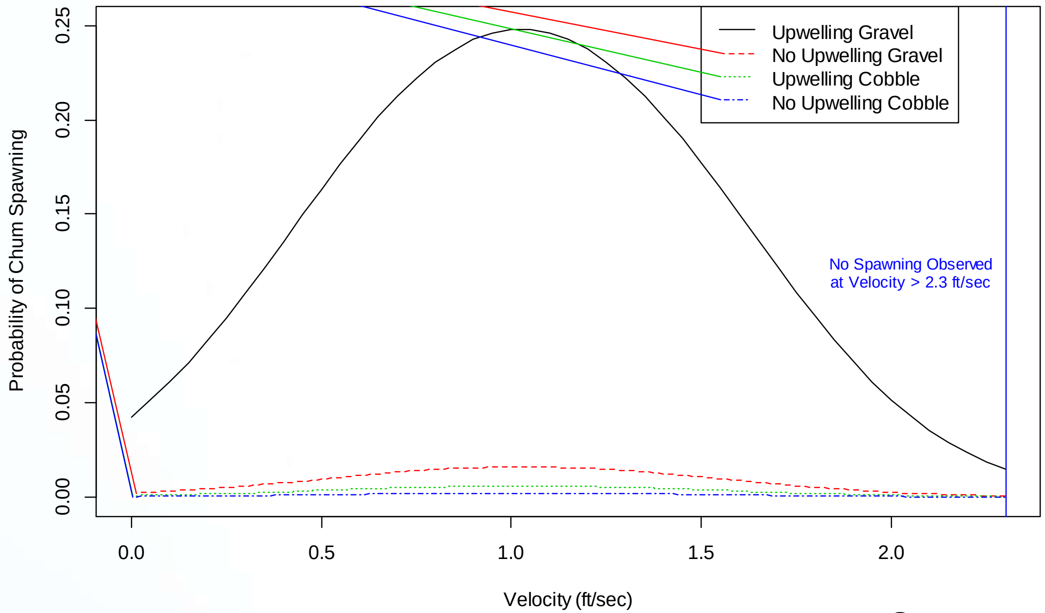
$$C_{UPGR} = -10$$
$$C_{UPCO} = -14$$
$$C_{NOGR} = -13$$
$$C_{NOCO} = -15$$



Multivariate Curve

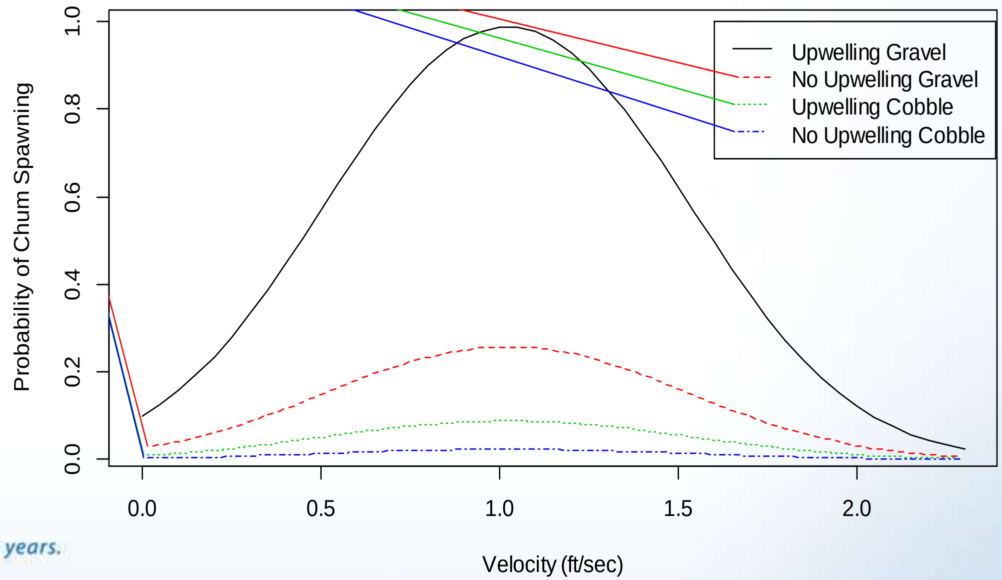
Multiplied Univariate Curves





Multivariate Curve

Multiplied Univariate Curves



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HSC Chum Spawning Competing Models

- Velocity is not a strong predictor
  - Model without velocity has similar likelihood
- Some indications that the importance of substrate and upwelling varies with velocity
- More data will help verify the best model

HSC Chum Spawning Refinements

- Is the use of random effects for sites the best approach?
- Non-random spawning HSC sites appear to have different relationships
  - Upwelling and substrate seem to have less impact in these selected sites
    - Some high-use sites with upwelling available, but VHG at used site is neutral
    - Is this a scale issue?

Study 8.5 - HSC Next Steps

- Juvenile salmonid HSC curves have been created
- Focus on species/lifestages that REQUIRE HSC relationships because they will be used as evaluation endpoints
- Collect more data in 2014, but we will not have enough data on all species to build these types of curves

HSC for Other Species/Life stages: Sample Size

- Sample size is total # of observations including availability, but obviously can't be all zeros
- Most important thing = multiple sites with both fish observations and availability observations
- Low sample size impacts precision and reliability of model

HSC for Other Species/Life stages

- Stick with preference models, but when sample size is “too small”:
  - Combine species/life stages based on ecological theory
  - Univariate models
  - Assume shape of relationship, and just get “best” parameters
- Fall back to utilization curves because we can combine historic data

HSC Curve Development

Common Name	High	Moderate	Low
Chinook salmon	X		
Chum salmon	X		
Coho salmon	X		
Pink salmon	X		
Sockeye salmon	X		
Arctic grayling	X		
Arctic lamprey			X
Bering cisco			X
Burbot		X	
Dolly Varden		X	
Eulachon		X	
Humpback whitefish		X	
Lake trout			X
Longnose sucker		X	
Northern pike			X
Rainbow trout	X		
Round whitefish			X
Sculpin			X
Threespine stickleback			X

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Study 8.5 - HSC Curve Development

Life Stage	High	Moderate	Low
	Multivariate Preference Curve	Univariate Utilization/1980's Data	Literature Based/ Prof. Opinion
Spawning	Chum		
	Sockeye		
	Pink		
Fry	Coho	Arctic Grayling	
	Sockeye	Whitefish	
	Chinook	Longnose Sucker	
Adult	Whitefish	Rainbow	Bering Cisco
	Arctic Grayling	Burbot	Eulachon
	Longnose Sucker	Dolly Varden	
Juvenile	Coho	Arctic Grayling	
	Chinook		
	Longnose Sucker		

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Study 8.5 - HSC Curve Development

Variable	Source/Study	Availability (QC 3 data sets)
Fish Distribution/Abundance	FDA	Q1 2014
Water Temperature	Water Quality, River Productivity, Groundwater, FDA, HSC	Q1 2014
Dissolved Oxygen	Water Quality, River Productivity, FDA, HSC	Q2 2014
Conductivity	Water Quality, River Productivity, FDA, HSC	Q2 2014
pH	Water Quality	Q2 2014
Surface flow and groundwater exchange flux	Groundwater	Q3/Q4 2014
Intragravel water temp.	Groundwater	Q2 2014
Macronutrients	Water Quality	Q2 2014
Dissolved Organic Carbon	Water Quality	Q2 2014
Alkalinity	Water Quality	Q2 2014
Chlorophyll-a	Water Quality	Q2 2014

Study 8.5 - HSC Curve Development

Proposed 2014 Data Collection

June 2014

- Lower River Segment:
  - ✓ Trapper, Sheep, Birch, Caswell creeks
- Middle River Segment:
  - ✓ known juvenile and fry use

July-September 2014

- Lower River Segment:
  - ✓ Trapper, Sheep, Birch, Caswell creeks
- Middle River Segment:
  - ✓ FA-151 (Portage Cr.), FA-173 (SLC), FA-184 (Watana Dam)