CHaMP – ISEMP Habitat Models

ISEMP-CHaMP Work Session

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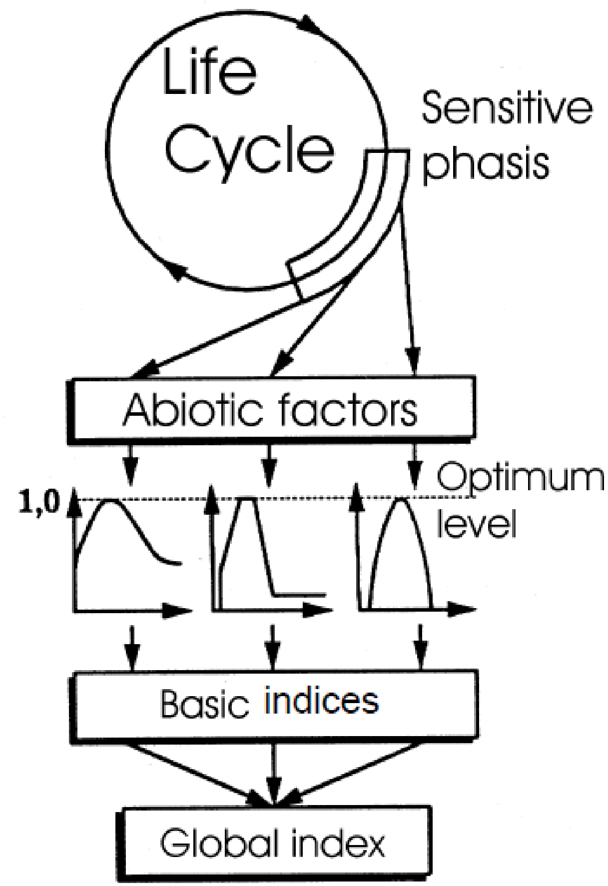
Contributors: Philip Bailey, Nick Bouwes, James Hensleigh, Claire McGrath, Matt Nahorniak, Joe Wheaton, Kelly Whitehead

Habitat Suitability Models

- Describes combined interactions of key habitat variables on survival and carrying capacity for given area
- Combines suitability assessments for individual variables into a combined assessment that predicts ability of a habitat to support a species
- Extent to which habitat requirements are met can be mapped and compared for alternative management actions

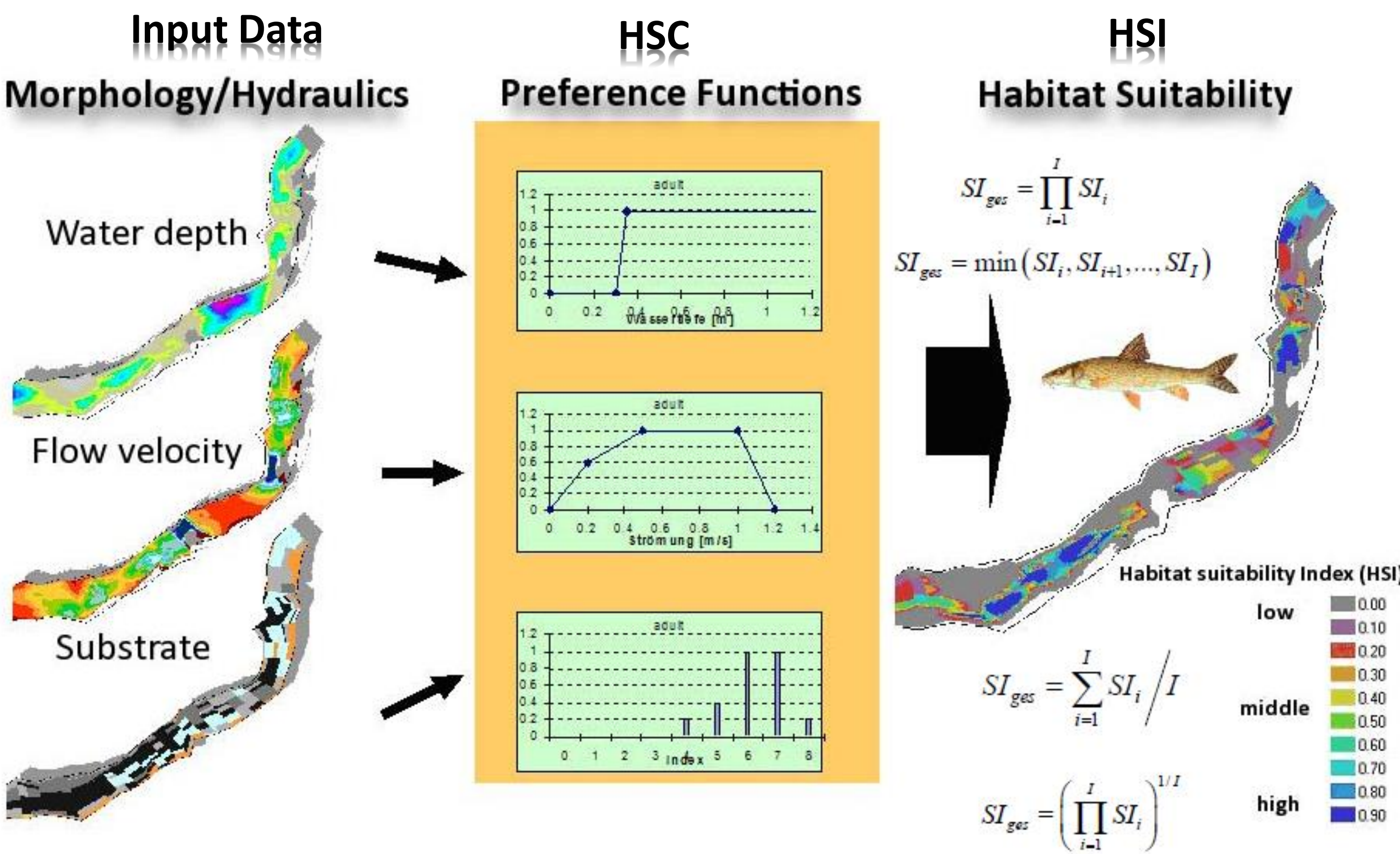
Habitat Suitability Curves (Criteria)

- Describe fish-habitat relationships
- Life stage specific
- Typical variables: depth, velocity, substrate, cover, temperature, fines.
- Develop using literature, expert opinion, laboratory and/or field studies.
- Site specific criteria are ideal



From LeClerc 2005

Habitat Suitability Index



$$SI_{ges} = \prod_{i=1}^{I} SI_i$$ Product

$$SI_{ges} = \min\left(SI_i, SI_{i+1}, \ldots, SI_I\right)$$ Minimum

$$SI_{ges} = \sum_{i=1}^{I} SI_i \Big/ I$$ Arithmetic Mean

$$SI_{ges} = \left(\prod_{i=1}^{I} SI_i\right)^{1/I}$$ Geometric Mean

*can weight individual variables

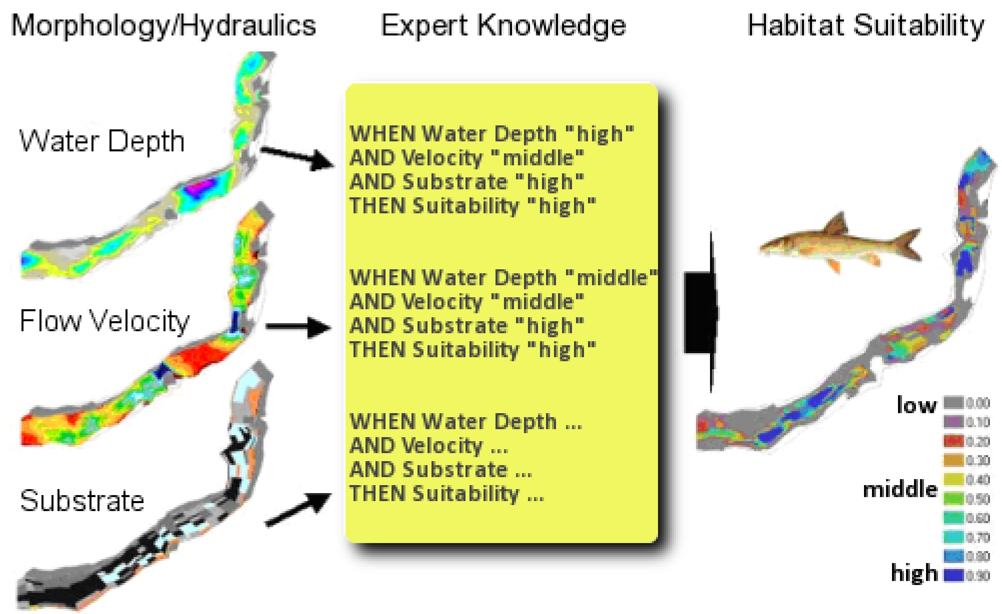
http://www.casimir-software.de/data/CASiMiR_Fish_Handb_EN_pdf

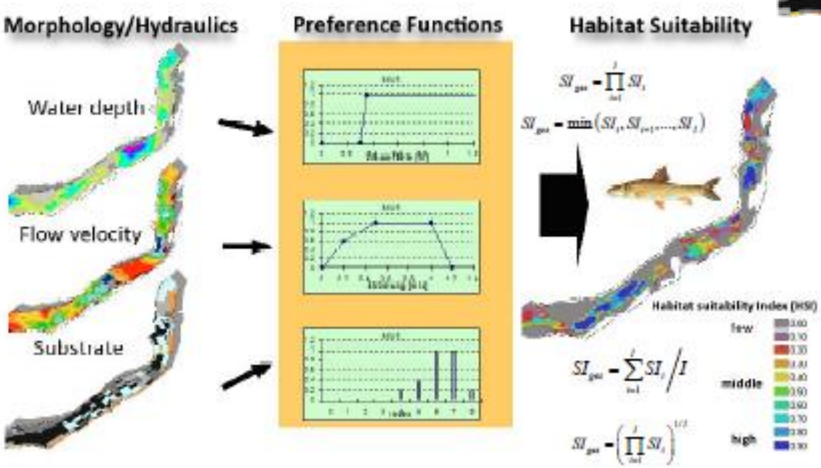
Weaknesses of Traditional HSIs

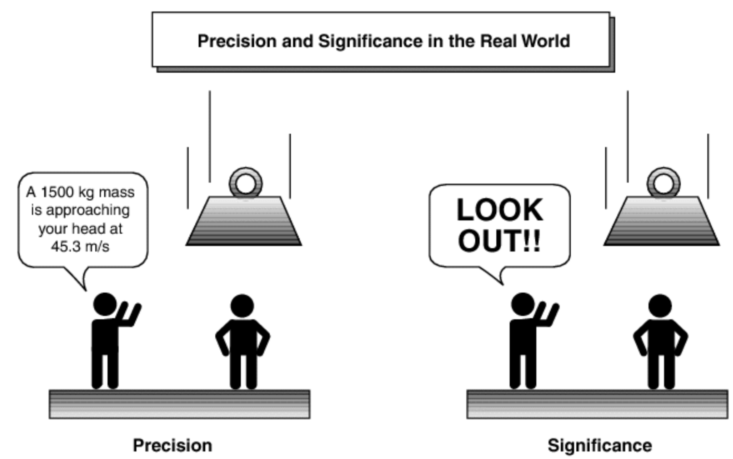
- Habitat requirements described by precise functions (even though observations are imprecise)
- Independence of habitat parameters is assumed
- New parameters difficult to incorporate (i.e. other then velocity, depth, substrate)
- Limitations associated with HSCs: intensive field data needed for site-specific HSCs, assumptions in using generic HSCs

Fuzzy vs. HSI Models

- In contrast to HSI based approach, here we use expert knowledge



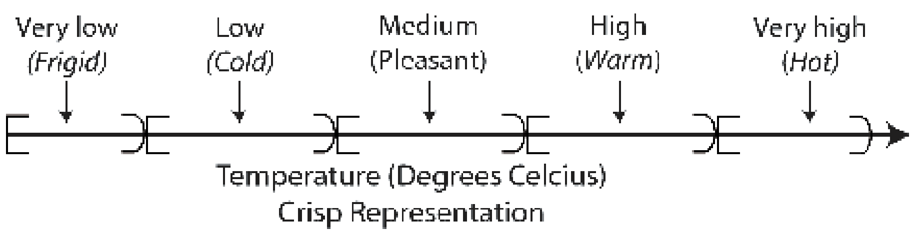


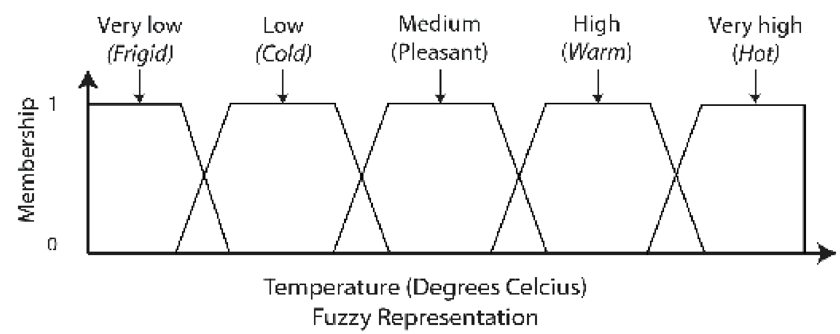


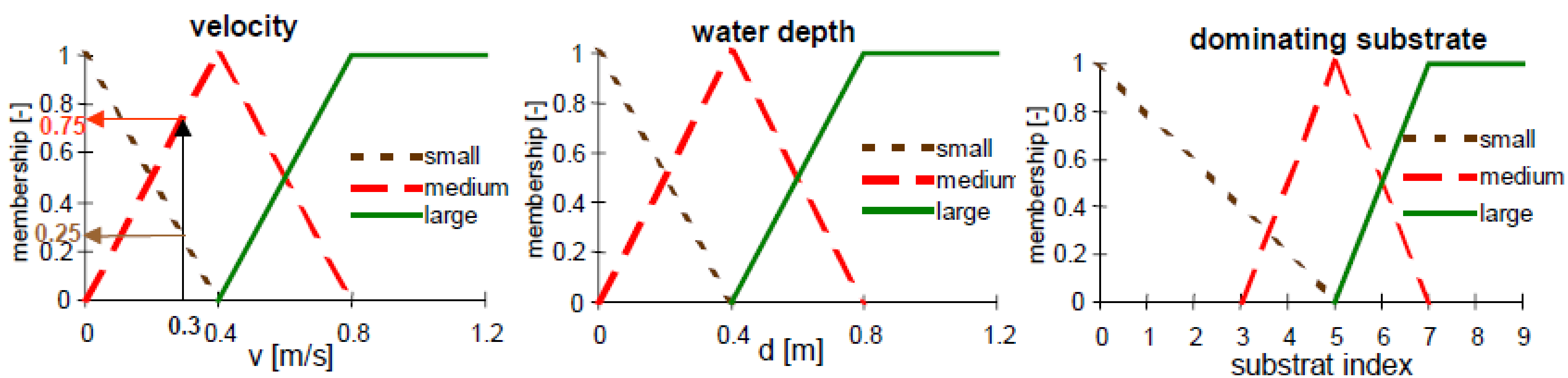
http://www.casimir-software.de/data/CASiMiR_Fish_Handb_EN_2010_10.pdf

FIS Models

- Use imprecise info about fish preferences to specify whether a particular combination of physical criteria = high, medium, or low quality habitat
- Useful for classifying continuous variables







Advantages of Fuzzy Models

- Knowledge about ecological linkages is **imprecise**
- Fuzzy logic calculations consider **multivariate effects** (no assumption of independence)
- **New parameters** incorporated easily
- **Few observations** needed
- Calculation is **understandable** (no black box effect)
- High **flexibility** and adaptability
- Results often validate better then traditional HSI*

**Jorde et al. 2001. Fuzzy based models for the evaluation for fish habitat quality and instream flow assessment. Proceedings of the 3rd Intl. Symposium on Environmental Hydraulics, Dec 5-8, Tempe, AZ.*

Benefits of Habitat Models

- Habitat suitability maps and simulations
  - Before/after habitat restoration
  - Alternative climate / flow scenarios
- Translate results to input capacity parameter for life cycle models
- Identify limiting factors for restoration planning
- Evaluate spatio-temporal relationships; e.g., proximity of rearing to spawning habitat

Objective

- Describe aquatic habitat suitability for species and life stages, using suite of novel tools
- Chinook and steelhead for multiple life stages:
  - Adult passage
  - Spawning and embryo
  - Juvenile rearing
- Build flexible processes and user interface
- Generate comprehensive output reports with results and metadata

Data Inputs

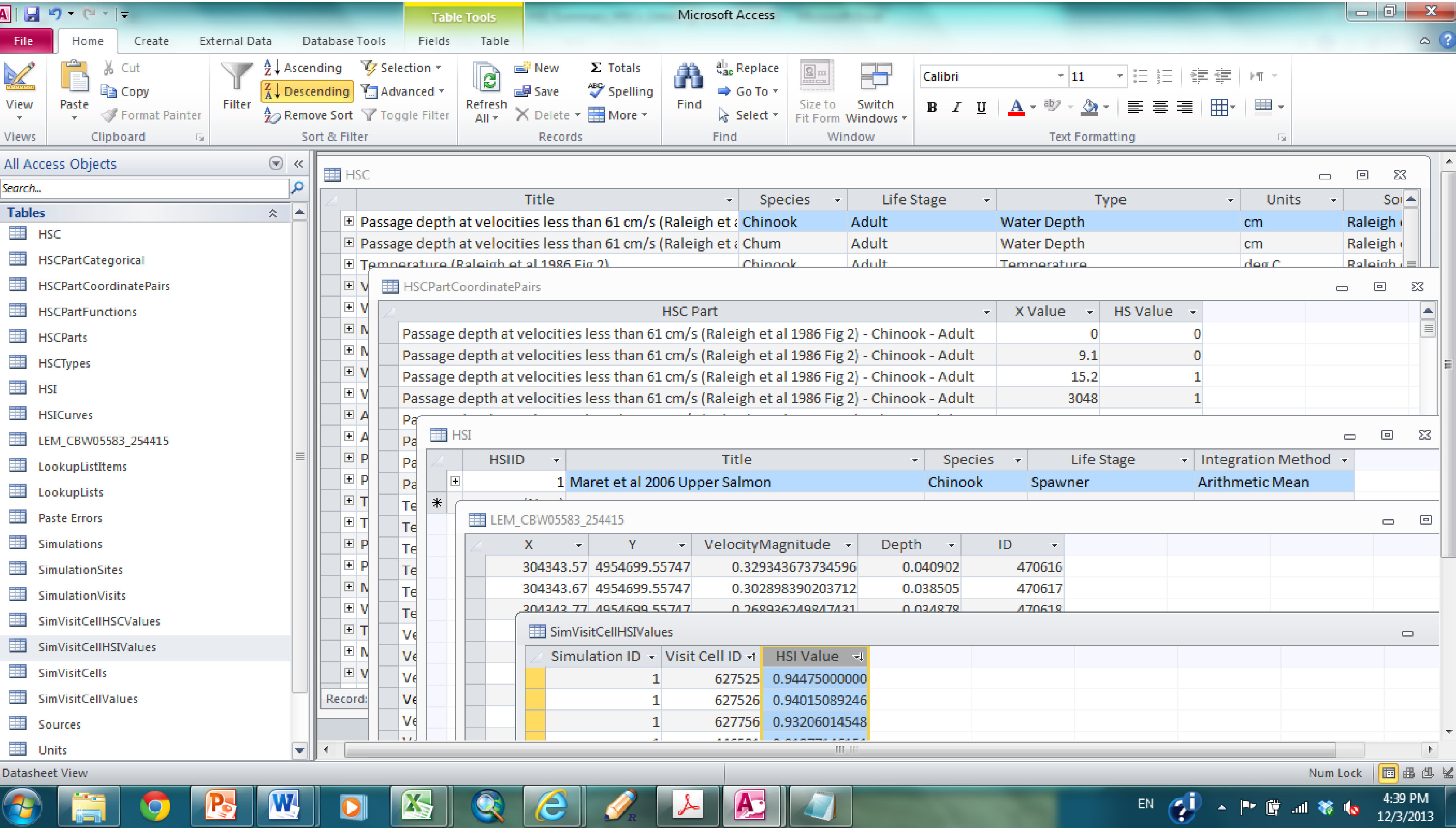
Habitat Variable	Spatial Resolution	Spatial Data Source	Primary CHaMP Survey Data	Life Stage
Velocity, Depth	10-cm cell	Delft3D hydraulic model	Topographic data, substrate/roughness, flow data	All
Substrate	Channel Unit	Derived	Areal % substrate categories	Spawner-Embryo
Cover	Channel Unit	Derived	Cover, Undercut Banks, Areal % Substrate	Juvenile Rearing
Water Temperature	Site	Derived	Mean, Min., Max at daily, 8-day, or monthly scales	All
Fines	Channel Unit	Derived	Areal % substrate, pebble counts	Spawner - Embryo

Progress: HSC Library

Species	In Database?	Factor	Referenced By	Primary Source	Study Location
Chinook	Yes	Velocity	Raleigh et al 1986	Burger et al 1982	Kenai R, Alaska
Chinook	Yes	Substrate	Raleigh et al 1986	Burger et al 1982	Kenai R, Alaska
Chinook	Yes	Velocity	Raleigh et al 1986	USFWS 1985	American River, CA
Chinook	Yes	Depth	Raleigh et al 1986	USFWS 1985	American River, CA

Notes	HSC	Pg	Table / Fig	Quantitative	adult migration	spawning	embryo	fry	juvenile	juvenile migration
Category 2 HSC for juveniles, mean column velocity and nose velocity curves reported.	1	49	18	1					1	
Category 2 HSC for juveniles, n=880	1	49	18	1					1	
Juvenile (5.1-10.2 cm, n=948); Category 1 HSC. Derived from two years of American River field studies, professional judgement, Bovee (1978), and a Sacremento River habitat preference study. Developed for lower American R, CA	1	50	19	1					1	
Juvenile (5.1-10.2 cm, n=948); Category 1 HSC. Derived from two years of American River field studies, professional judgement, Bovee (1978), and a Sacremento River habitat preference study. Developed for lower American R, CA	1	50	19	1					1	
Most fry associated with silt, sand, and rock. Not enough quantitative info for HSC development.								1		
Concensus on HSCs in formal meetings among fishery experts. Data taken from original HSC spreadsheets provided by Terry Maret, USGS (Sept 2013). Curves provided for Spawning, Adult (holding), Juvenile.	1					1	1	1	1	
Concensus on HSCs in formal meetings among fishery experts. Data taken	1					1	1	1	1	

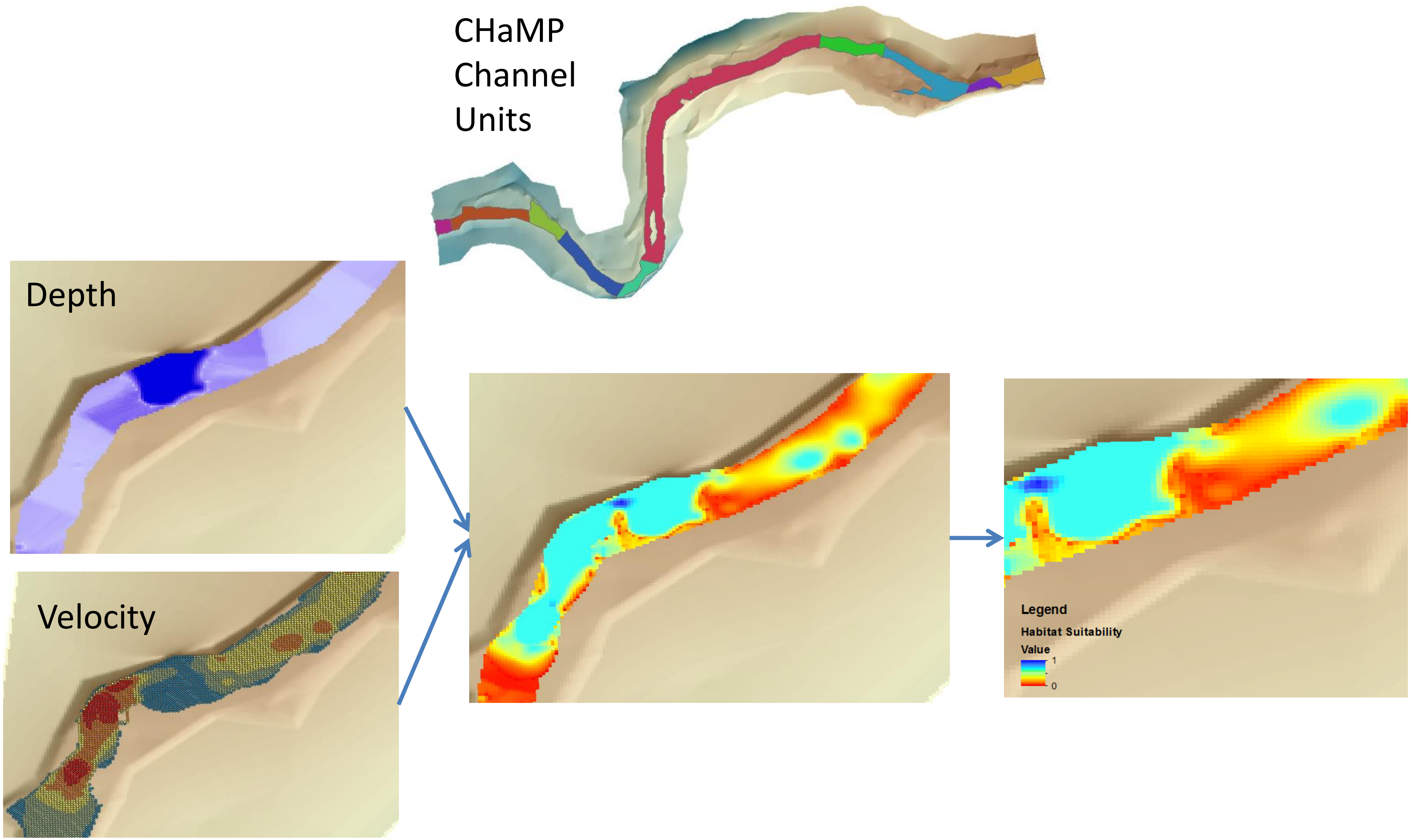
Progress: HSI Database



Progress: HSI Software

- Software (vb.net) http://northarrowresearch.com/tools/habitat-suitability-model/
- Video demonstration http://www.youtube.com/watch?v=yomfsk4Q_2Y&hd=1
- Email claire@qcinc.org to get status updates/links

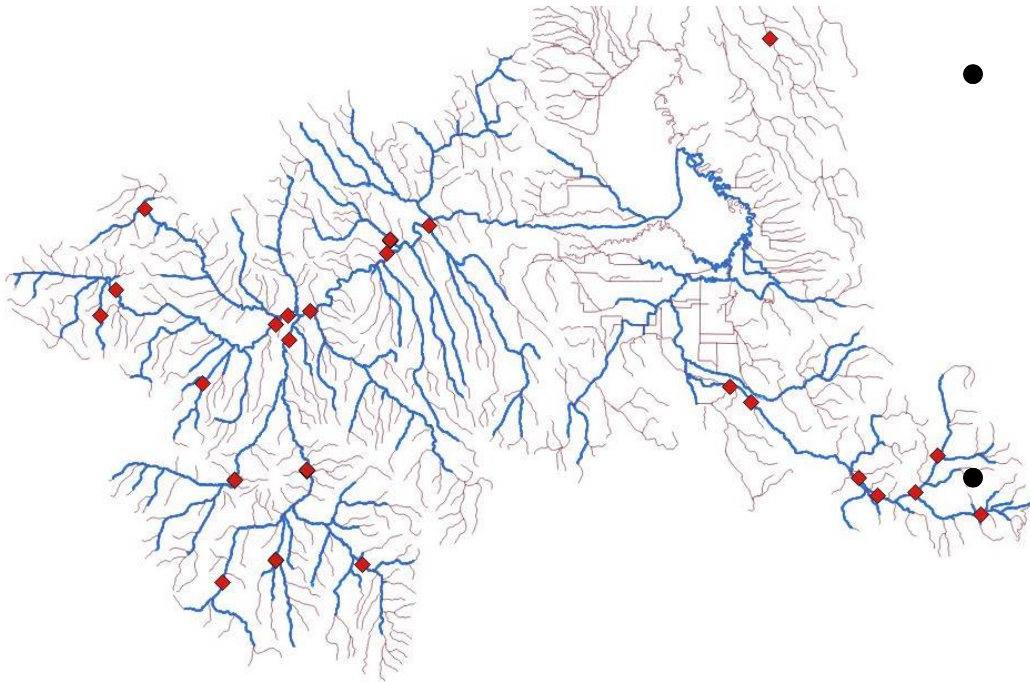
Demonstration Results



Moving Forward - Issues/Needs

- Develop and automate data inputs, model capabilities, outputs
- Validate, compare to fish observations
- Methods for extrapolating site assessments to watershed scale (e.g., GRTS, Riverstyles)

Validation – Grande Ronde



- 25 annual sites for Chinook and steelhead
- Juvenile data: ODFW/CRITFC snorkel and electrofishing surveys at channel unit scale, matched to CHaMP data
- Spawner data: ODFW redd surveys
  - Chinook index reaches with GPS locations of redds
  - steelhead surveys use a GRTS design

Moving Forward - Technical Priorities

- *Data in – hydro model and Aux. Streamlining this process.
- Ways to visualize data in (e.g., maps of individual input variables)
- Way to visualize model (plots of HSCs or Fuzzy inference membership functions, description of algorithms used)
- *Model output data tables and maps – for individual variables and combined suitability assessment
- Boilerplate report that gets populated for every simulation –
  - Description - metadata (site, date, flow)
  - Model inputs (velocity, depth, etc maps and histograms)
  - Model structure: describes specific HSC curves or fuzzy membership functions, and model algorithm – likely more than one model run per project
  - Output maps, figures, and tables

Habitat Modeling With CHaMP Data