

# FISH HABITAT ASSESSMENT AND SIMULATION TOOL

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# FHAST



U.S. ARMY



US Army Corps  
of Engineers



National Conference on Ecosystem Restoration

April 14-19, 2024

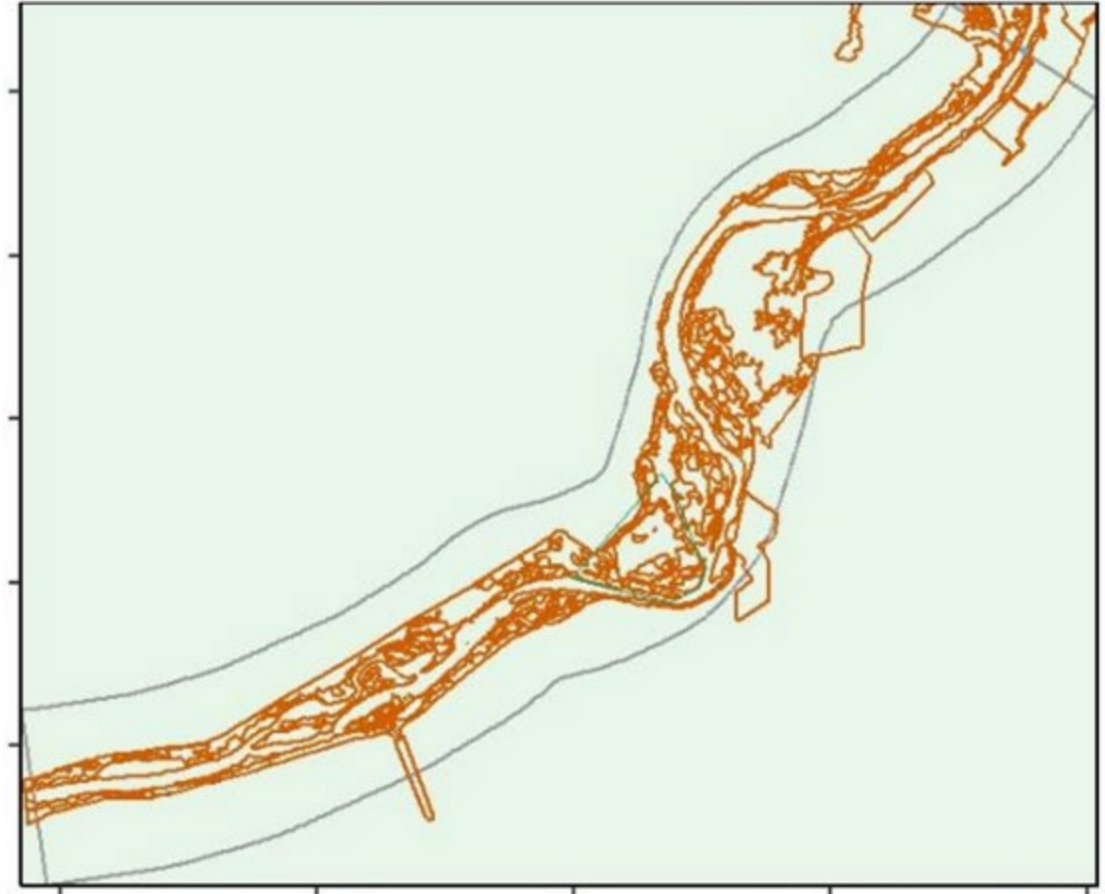
Albuquerque, New Mexico



# FHA<sup>ST</sup>

## FISH HABITAT ASSESSMENT AND SIMULATION TOOL

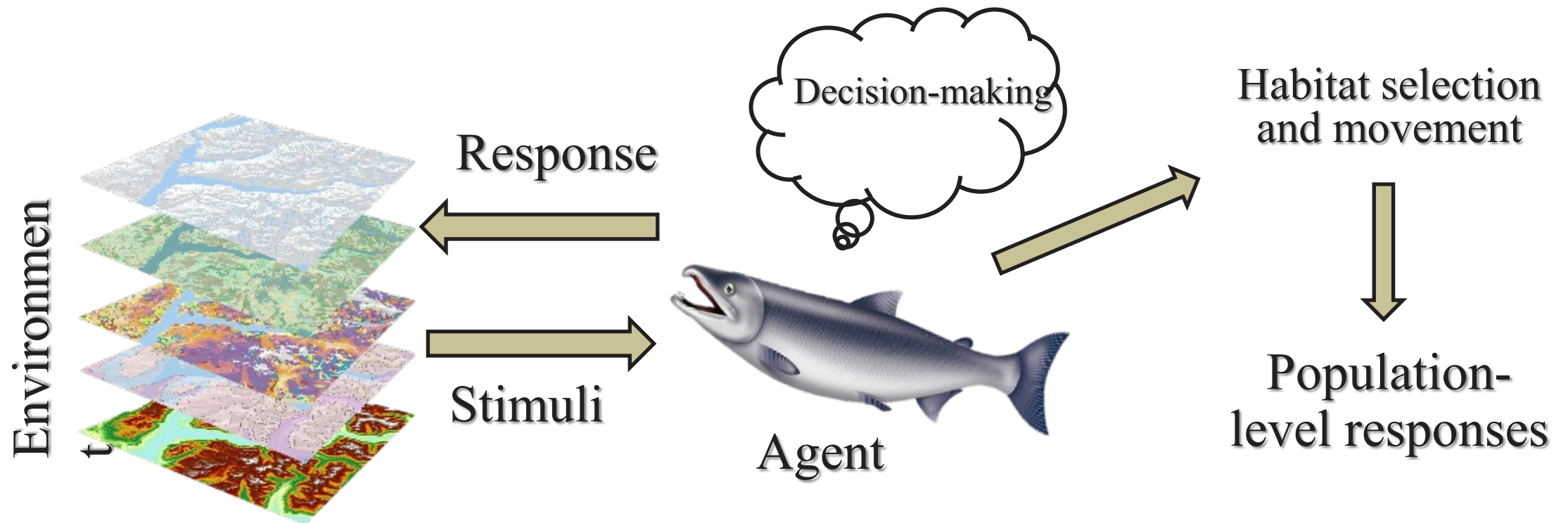
- National Marine Fishery Service
- Assess environmental effects
- Compare options
- Anadromous species
- Spatio-temporal data
- Agent-based model (ABM)





# AGENT-BASED MODELS (ABM)

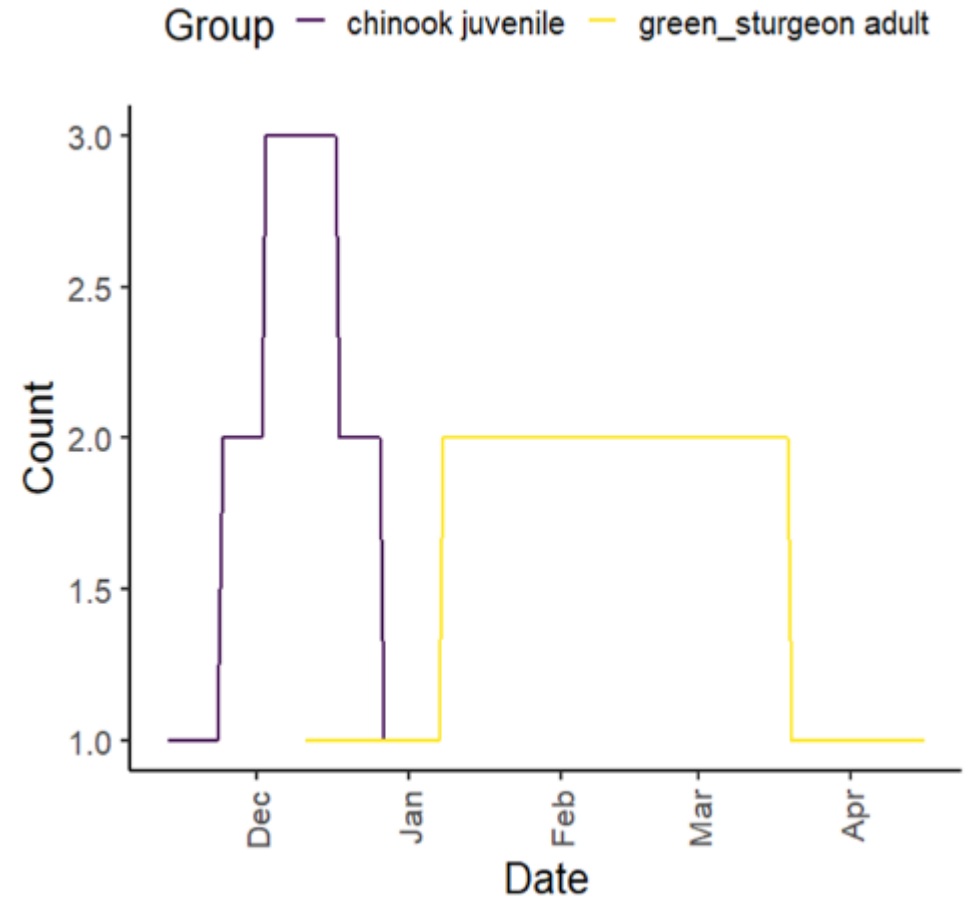
- Simulation model → virtual experimental systems
- “Bottom-up” modelling approach
- Agents can make fitness-related decisions resulting in life-like movement





# FISH HABITAT FUNCTIONS

- Hydrograph
- Hydraulics
- Fish metabolism
- Movement / migration
- Shade and cover
- Predation and survival



A time series graph of fish entering the system broken out by species and lifestage.



# HYDROGRAPHS

## Pros

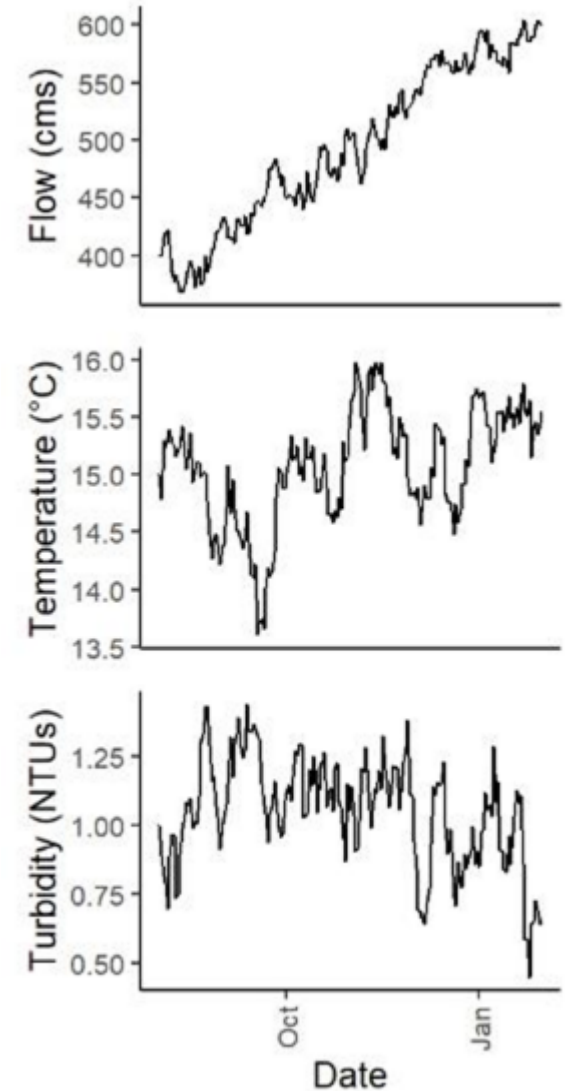
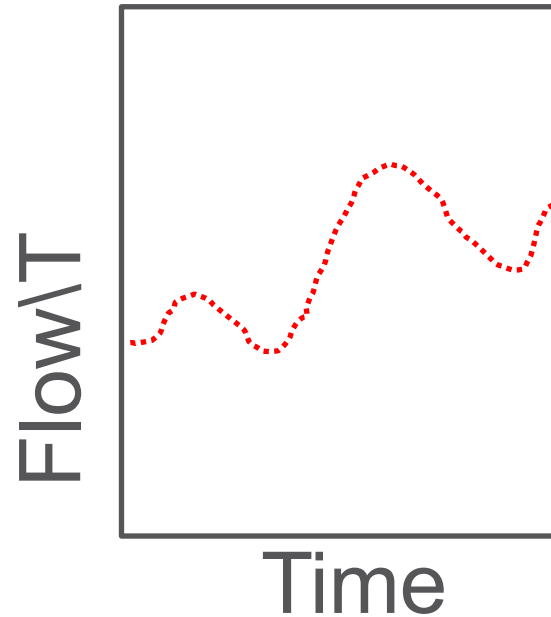
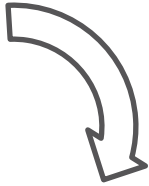
- Actual conditions
- No approximation work

## Cons

- Unrepresentative
- Multiple inputs likely necessary

## Provide sample tables

- Site specific
- Time of different
  - Water years
  - Characteristic conditions



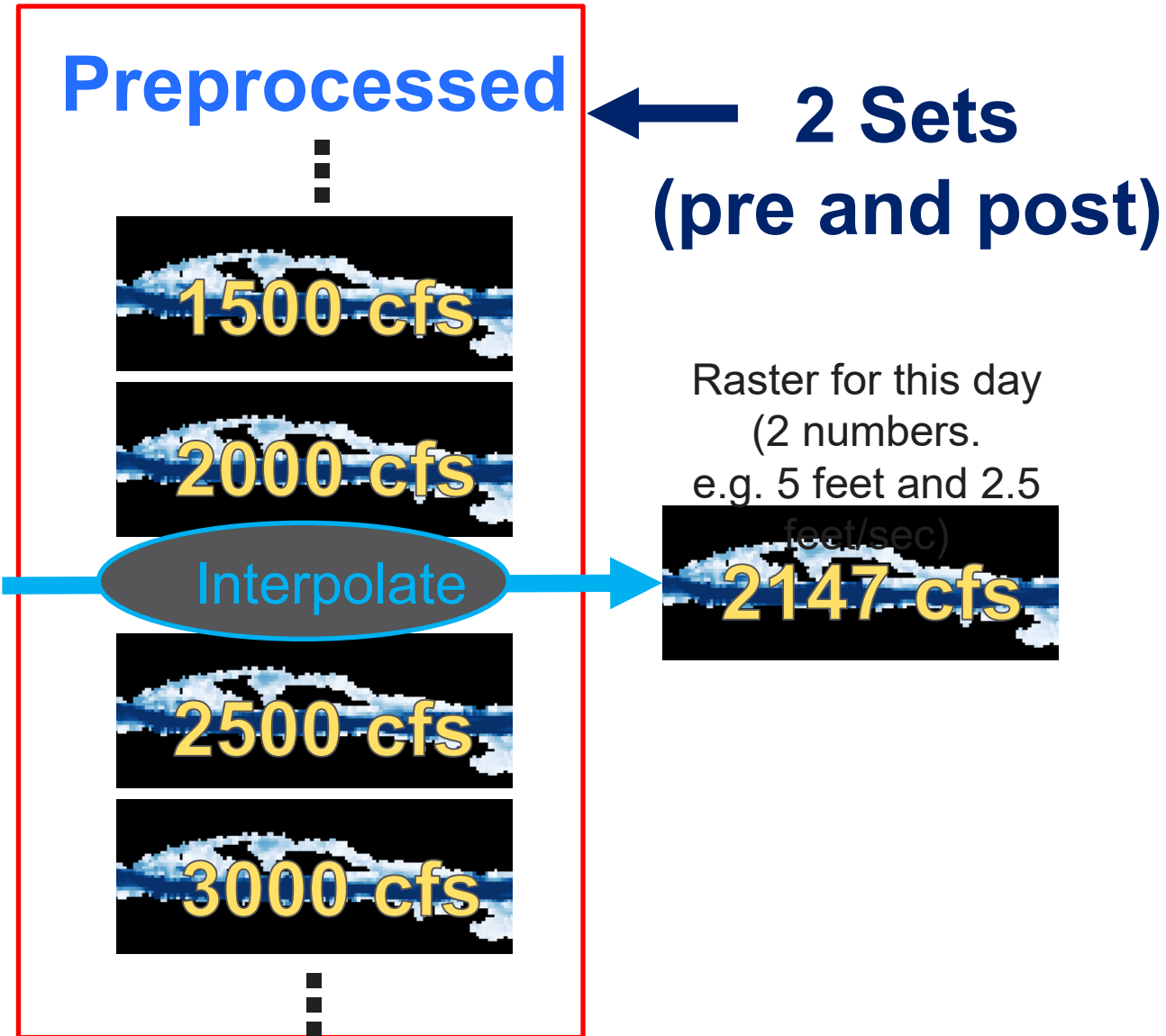
Three time series graph of the daily cor



# HYDRAULICS

**Depth  
Velocity**

Flow for this day  
(a number. e.g.  
2147 cfs)





# FHA<sup>ST</sup> - FISH HABITAT

- Depth and Velocity (RAS hydraulic model)





# FHAST – FISH PARAMETERS

- Migratory species:
  - Chinook Salmon
  - Steelhead
  - Green Sturgeon
- Critical swimming speed
- Size for out-migrating
  - Fork length
  - Mass
  - Condition
  - Metabolic rate

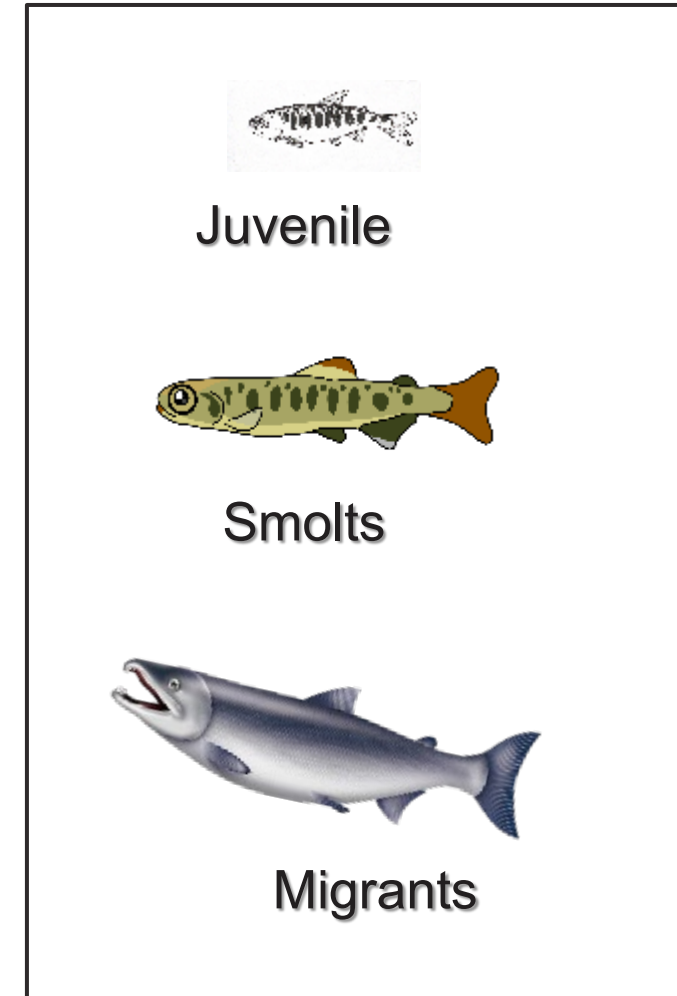


Photo By/Credit  
Hannah Ferwerda, USFWS intern/USFWS





## Environment



- Velocity
- Depth
- Turbidity
- Food
- Velocity shelters
- Predator presence



## Agent

- Fork length
- Mass
- Condition
- Metabolic rate
- Energy intake
- Daily growth



Juvenile



Smolts



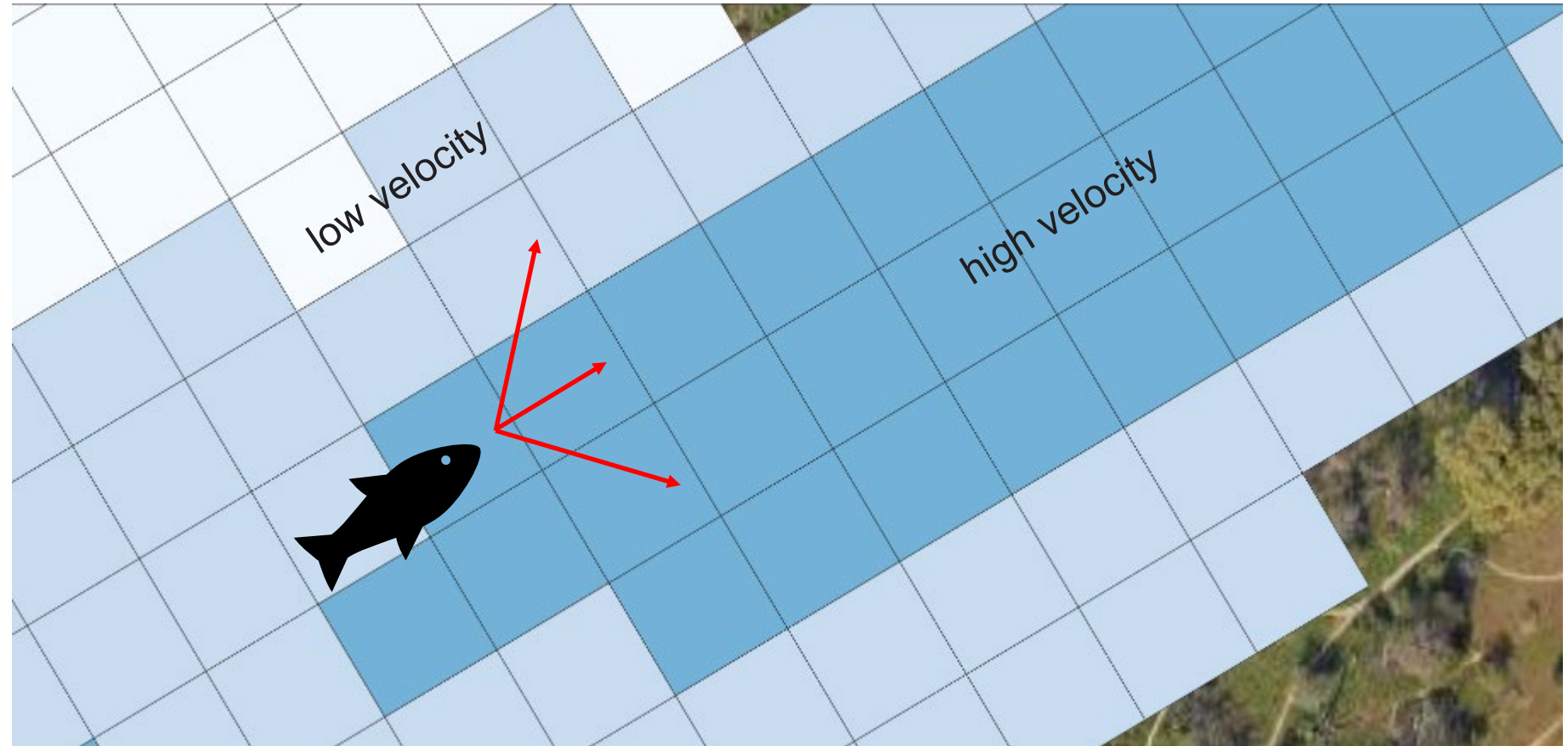
Migrants

## Movement rules

- Fish move once a day
- Fitness-based habitat selection strategy
- Condition vs probability of starvation
- Maximize energy intake or consider both energy intake and predation risks
- Respond to changes in their physiological state and environment by shifting their strategy



# ADULT MIGRATION PATHFINDING



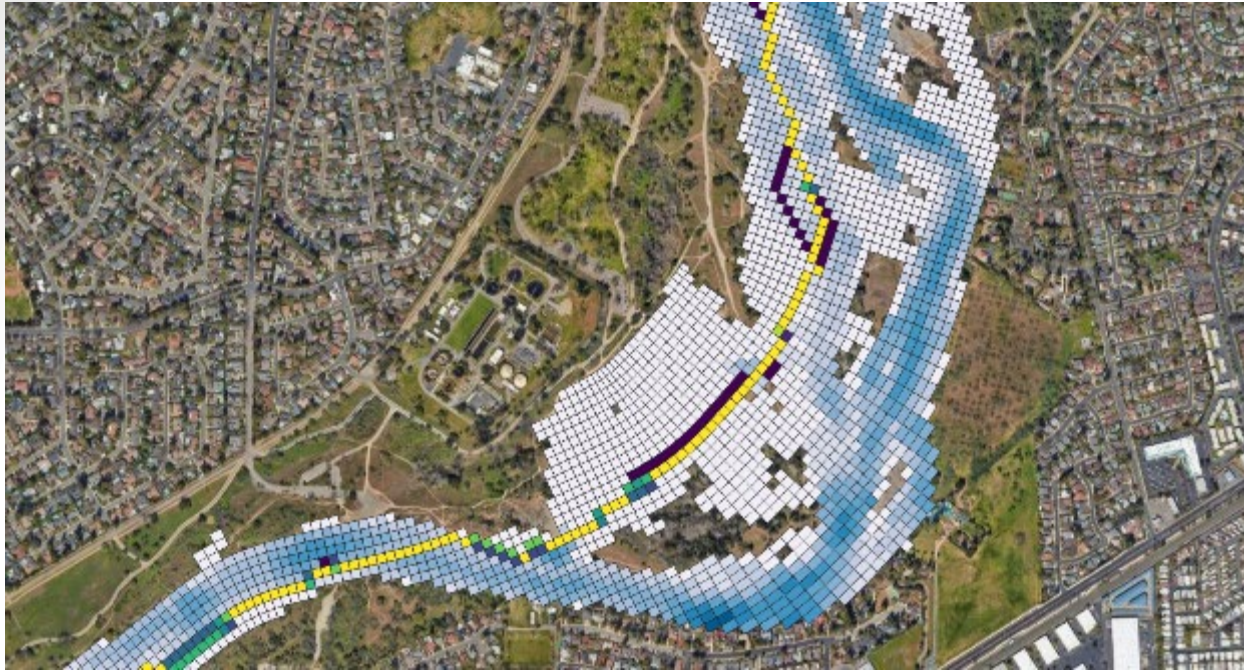
- Fish moving upstream, and can choose cells either straight ahead or diagonally
- Diagonal moves are more expensive, all else equal, due to the longer distance
- Fish swim either at an optimal swim speed or a burst swim speed so that the upstream component of their velocity exceeds the water velocity



# PATHFINDING RESULTS

Mean flow: 200 m<sup>3</sup>/s

Mean flow: 600 m<sup>3</sup>/s

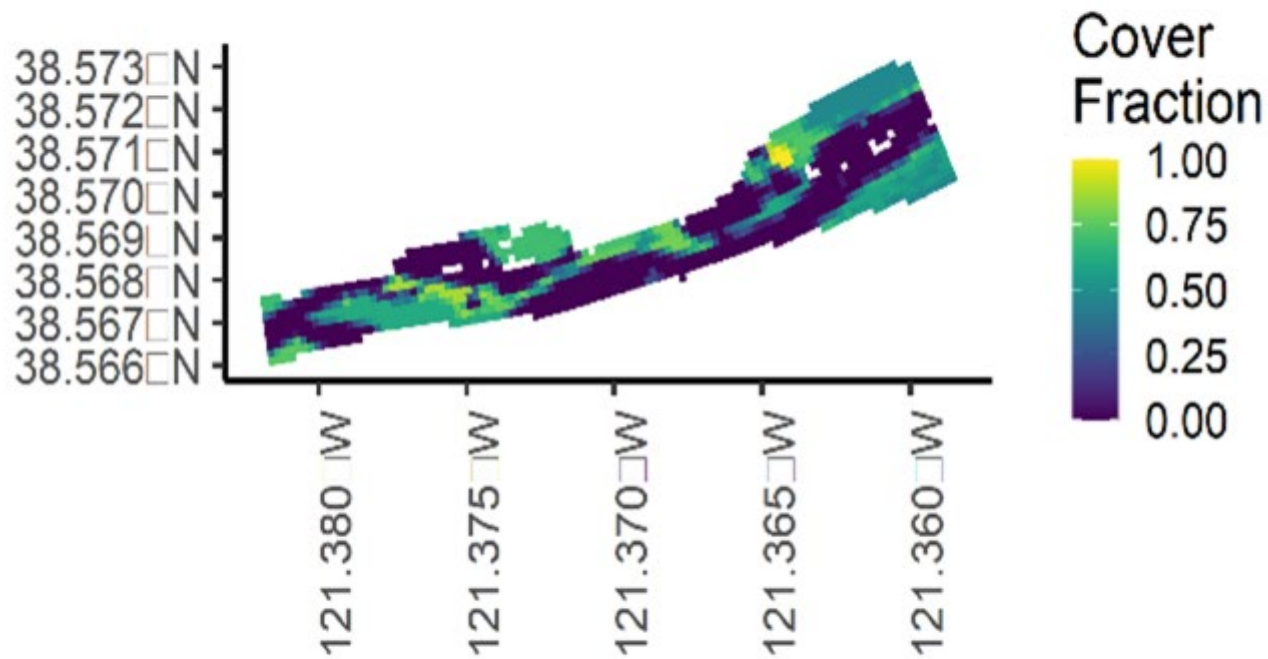
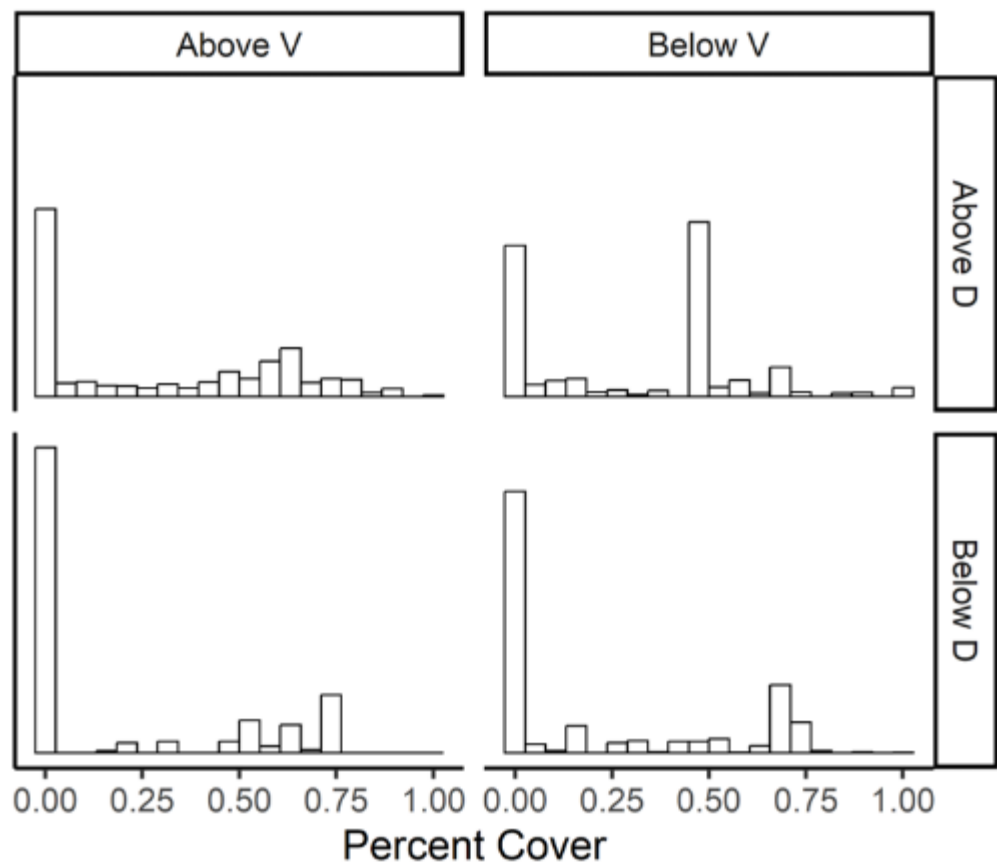


- Less reliance on hugging the shoreline
- Fewer paths

- Greater reliance on shoreline
- More paths overall



# COVER HABITAT





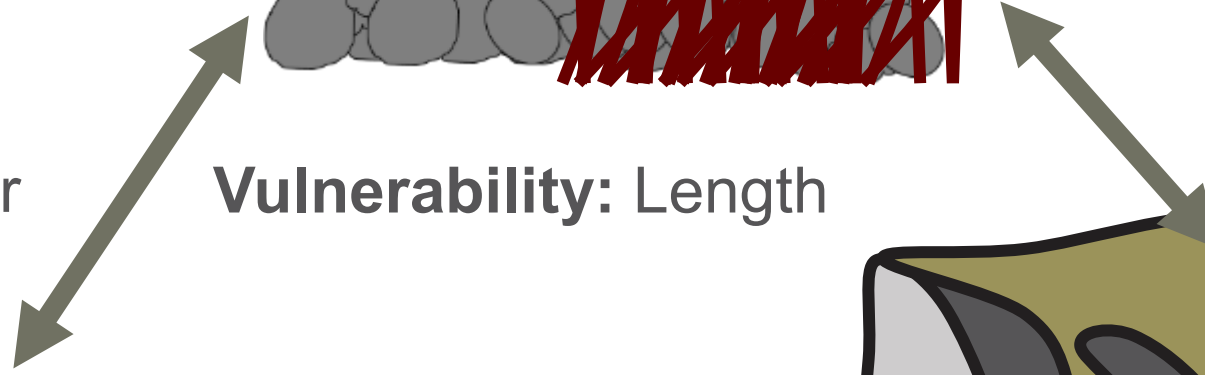
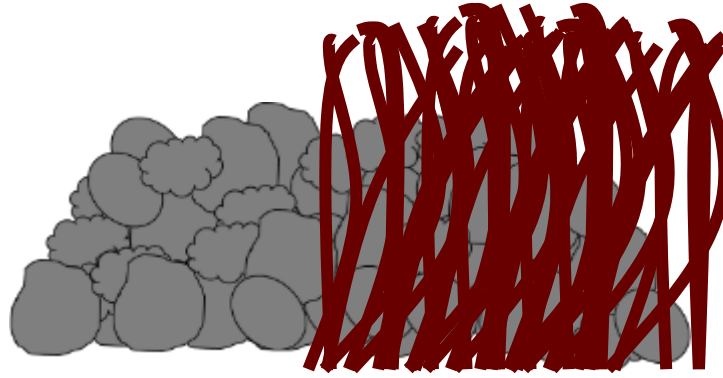
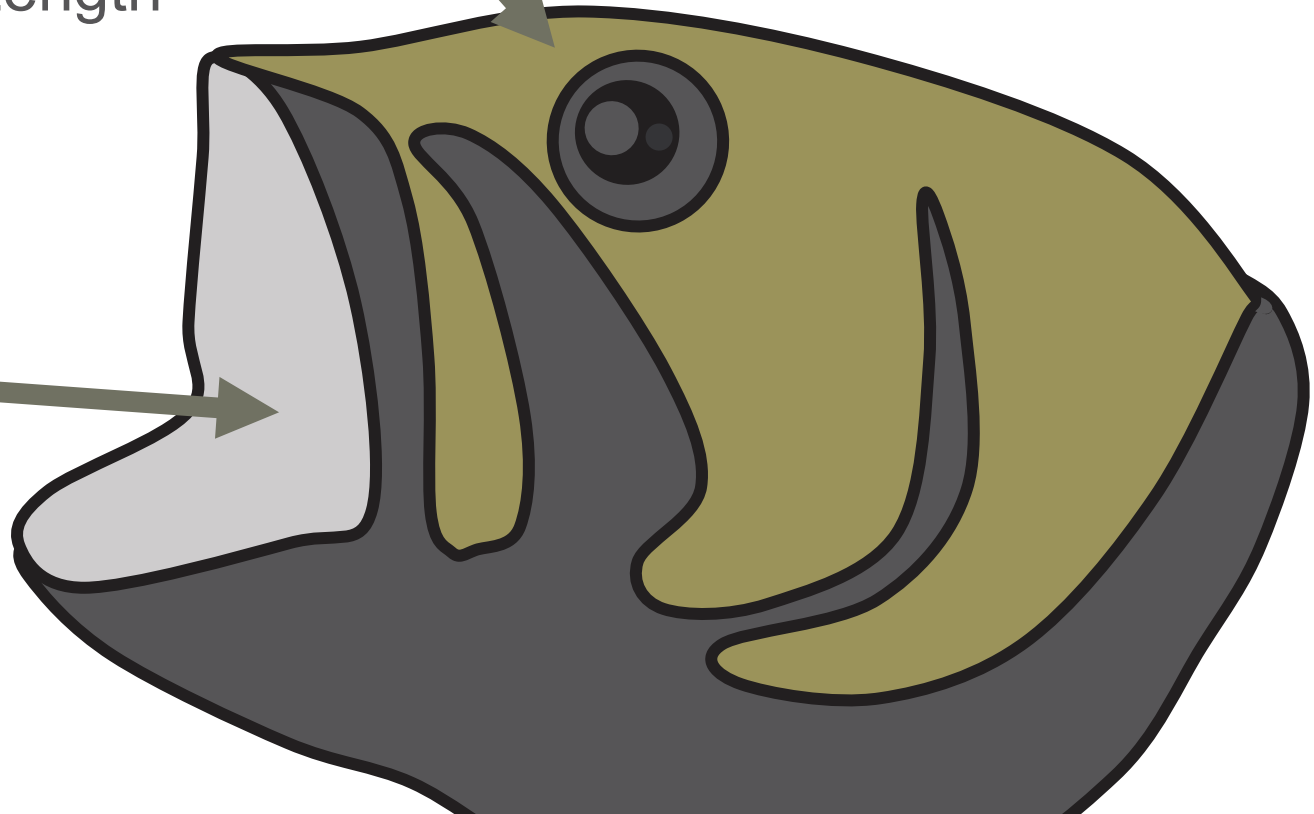
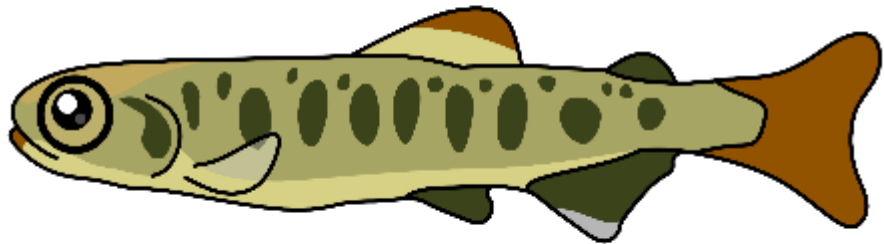
# PREDATION MODEL

#: Shade, substrate, Depth, Wood, Veg, Velocity (logistic)

Activity: Temperature

**Vulnerability:**  
Distance to cover

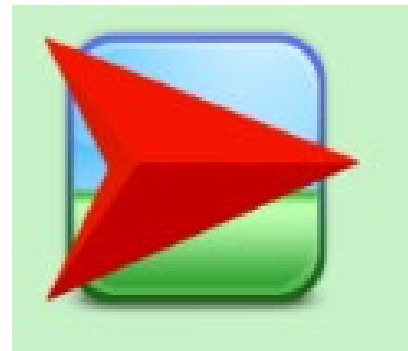
**Vulnerability:** Length





# SOFTWARE REQUIREMENTS

- Open source – public license, continual refinement
- HEC-RAS – project area depth and velocity tiff files
- R / RStudio –scripts for data management and analysis
- NetLogo – agent-based simulations
- QGIS – open-source GIS tools based on GRASS
- FHAST-P repository ([github.com/pndphd/FHAST-P](https://github.com/pndphd/FHAST-P))





# OTHER AGENT-BASED MODELS

## YOLO BYPASS SALMON BENEFITS MODEL: MODELING THE BENEFITS OF YOLO BYPASS RESTORATION ACTIONS ON CHINOOK SALMON

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Model Documentation, Alternatives Analysis, and Effects Analysis





# QUESTIONS

