The San Juan River Population Model: linking ecosystem components, management actions, and fish numbers to address uncertainty in new ways

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- NMGF
- UDWR
- ASIR
- UNM
- Other SJRIP participants

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Why an Ecosystem/population model?

- Uses a systems approach to endangered species recovery
- One method to address uncertainty associated with management actions for recovery of long lived endangered species
- Integrates data and expert opinion into a single explicit framework
- Integrates physical and biological data in one model
- Provides a means to simulate multiple management scenarios in a relatively short time frame.

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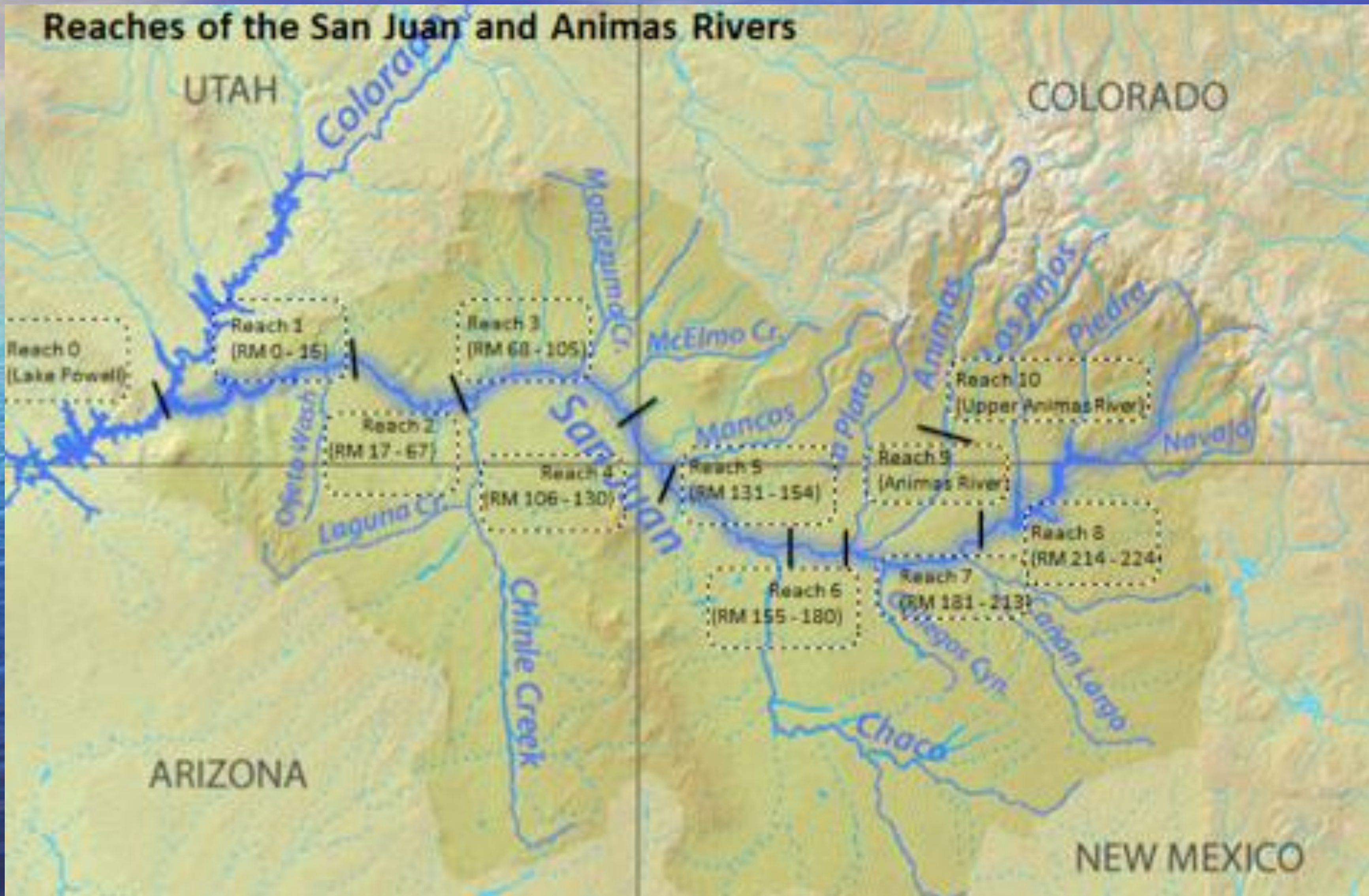
Model Background and Objectives

- Needed a method to estimate populations for long lived endangered species in response to management actions
- Management actions include flow manipulation, habitat modification, non-native removal and augmenting populations
- Develop carry capacity estimates for endangered fishes (To determine and validate recovery goals)
- Incorporate bioenergetics to represent food web dynamics and trophic interactions
- Provide a tool to critically evaluate management alternatives and population response over long time periods

Study Area



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San Juan Population Model Development Chronology

- 1998 Conceptual model
- 1998 – 2001 Population/productivity data collection
- 1999- 2001 Development of Mechanistic and Bioenergetic models
- 2000 Bioenergetic model used to calculate SJR recovery goals for Colorado pikeminnow
- 2001 – 2005 model calibration, testing, maintenance and initial evaluation of management actions
- Recommended for use in the San Juan Recovery Program when updated to newer model software
- 2012-2014- conversion from Stella 8 to Stella 9

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Conceptual Framework

- Physical Factors
- Bioenergetics
- Fish Populations

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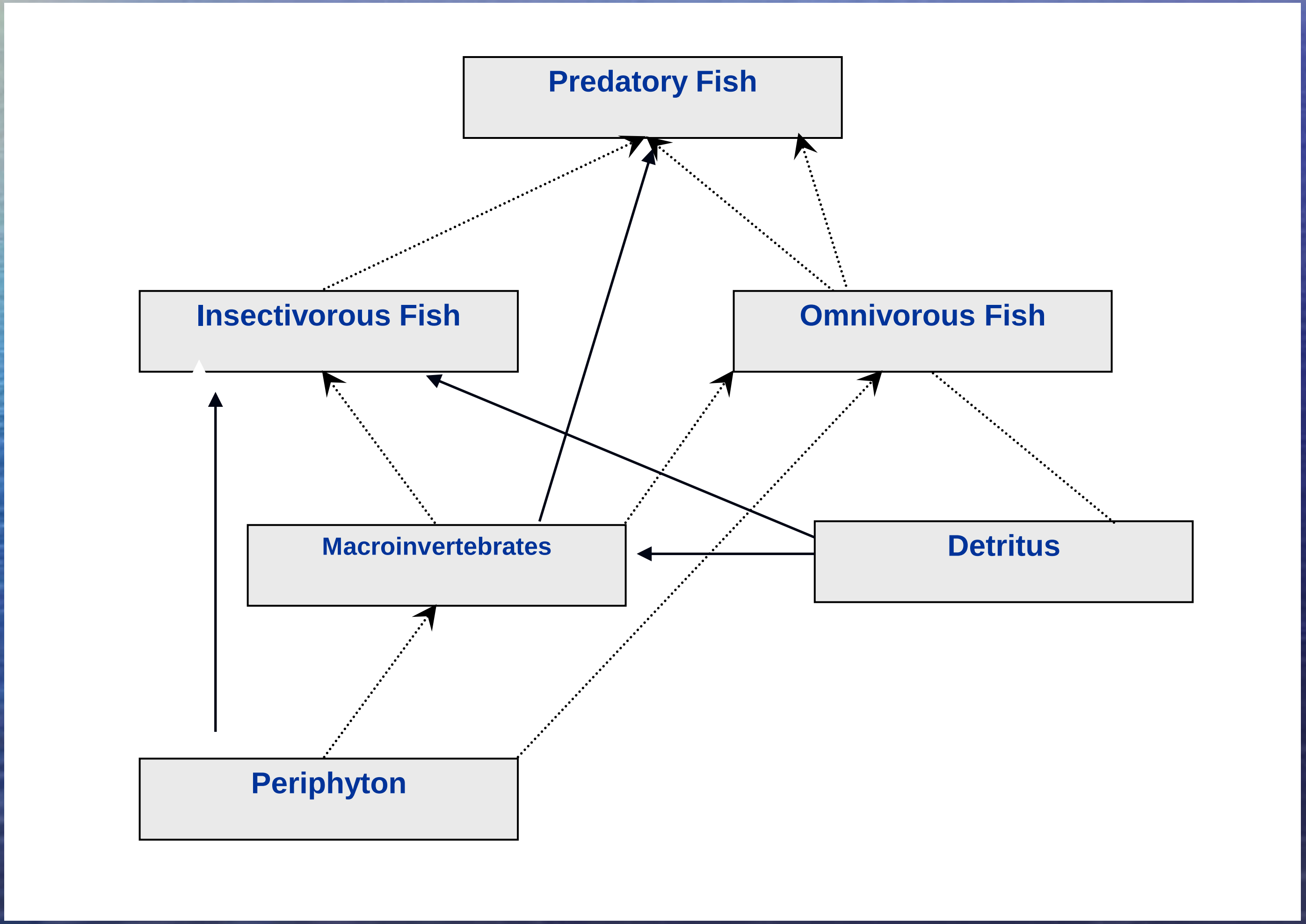
Physical Factors

- Habitat Area
  - Riffle and Run used for benthic invertebrate productivity
- Discharge
  - Habitat area
- Water Temperature
  - Growth Rates
- Turbidity/Storm Events
  - Benthic production reset

Bioenergetic trophic structure and data needs

- Producers
- Consumers
- Validated with stable isotope analysis
- Energetic demands for each species

Conceptual Model Development and Parameter Characterization



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Fish population data

- Needed for bioenergetic feedback
- Number per mile
- Length-Weight relationships
- Total biomass
- Prey availability
- Fecundity
- Survival rates

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Model Components

Fish

- Colorado Pikeminnow
- Razorback Sucker
- Bluehead Sucker
- Flannelmouth Sucker
- Speckled Dace
- Channel Catfish
- Common Carp
- Red Shiner
- Fathead minnow

Macroinvertebrates

Chironomids
Simulids
Hydropsychids
Baetids, Ephemerellids

Physical

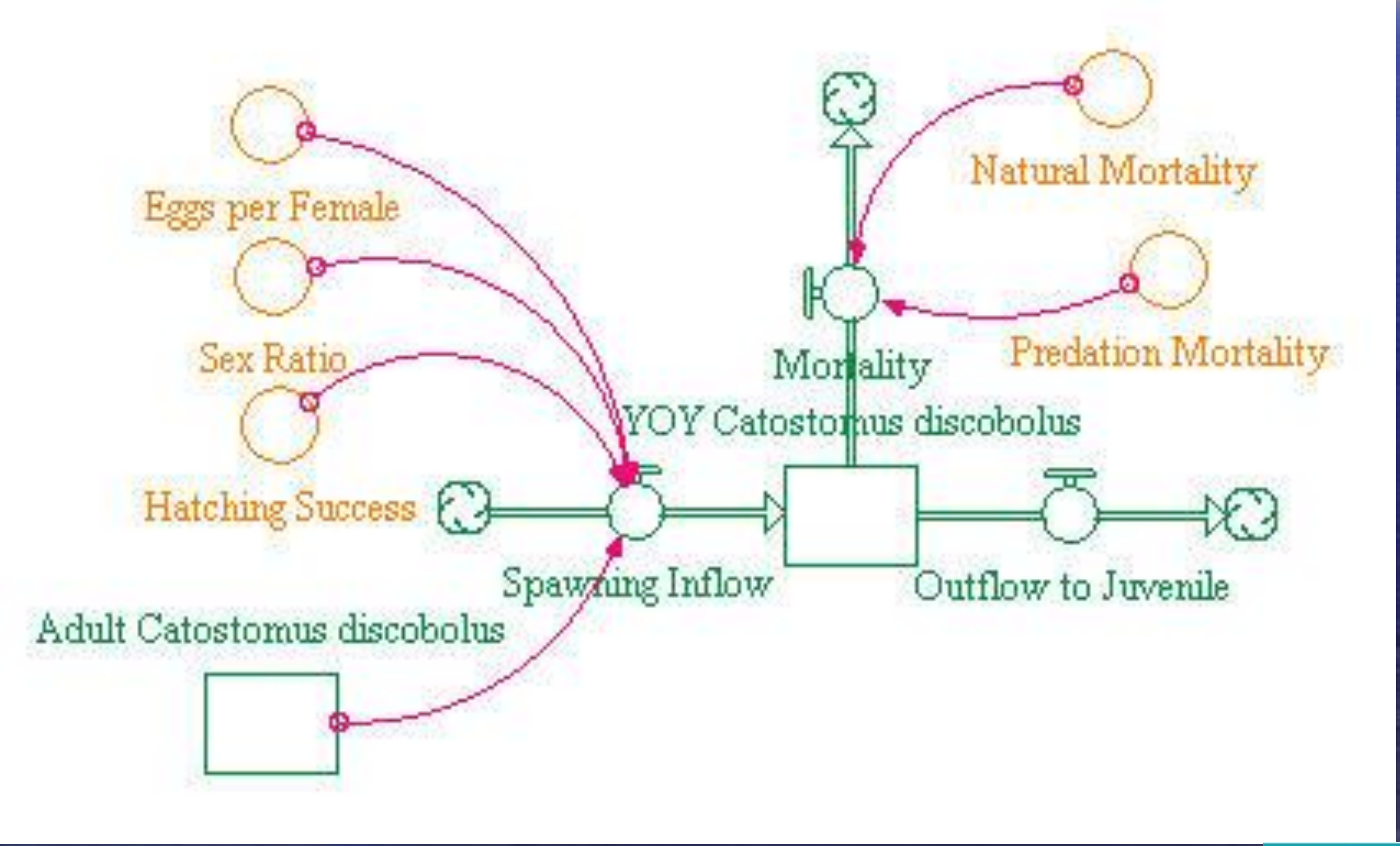
Discharge
Water Temp
Storm Events
Habitat

Bioenergetic sub model

Computational Platform for Mechanistic Model

- **STELLA modeling software**
  - **Combines graphical interface with mechanistic relationships**
- **MS Excel used for dynamic data link to exchange input/output data**

Example of individual life stage population flow



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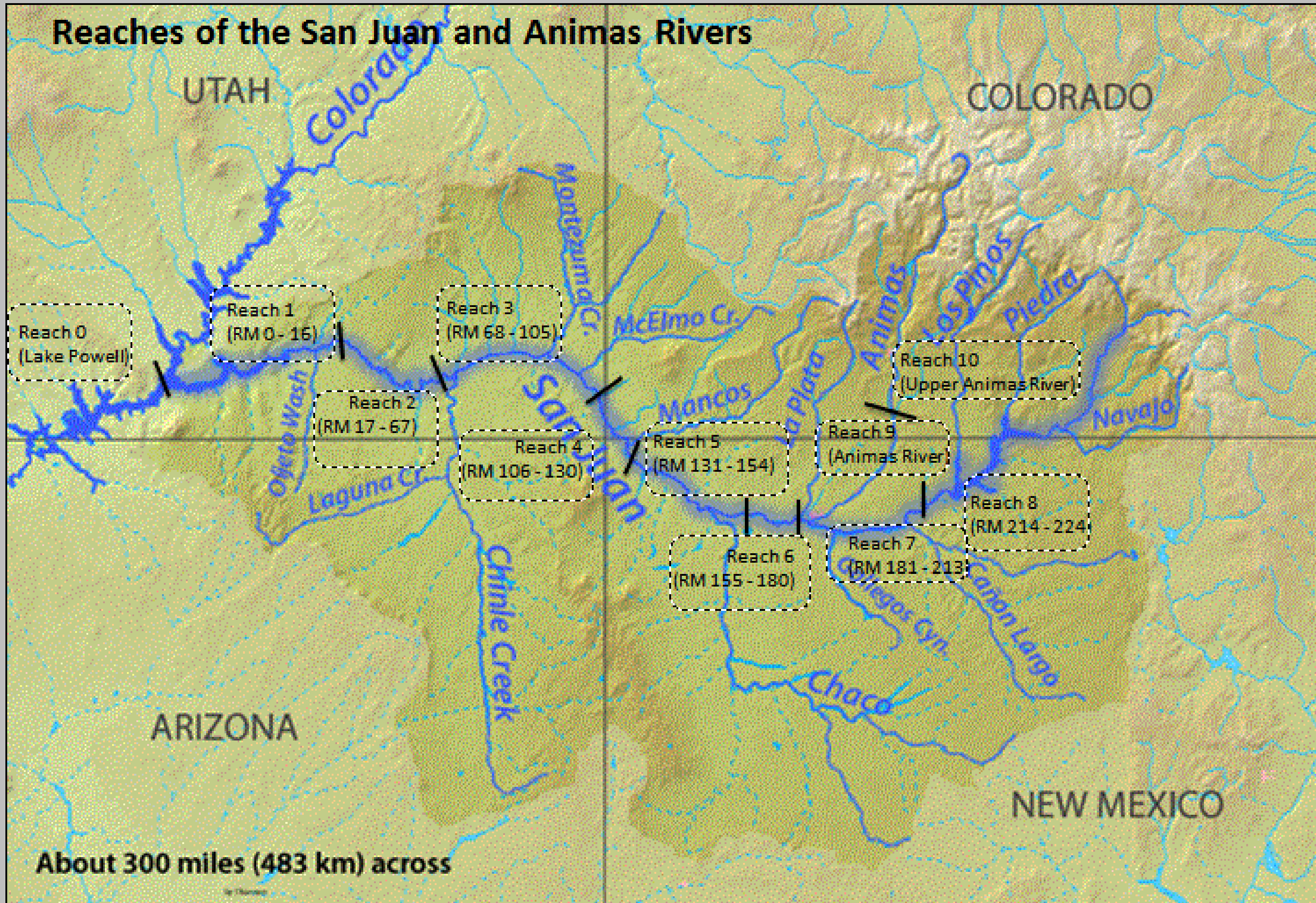
San Juan River Fish/Invertebrate Simulation

Choose Modules to Simulate

Set Length of Simulation

Save As...

Exit



See Outputs for Specific Reaches

See Outputs Summed Across All Reaches

Import Data from Excel

Export Data to Excel

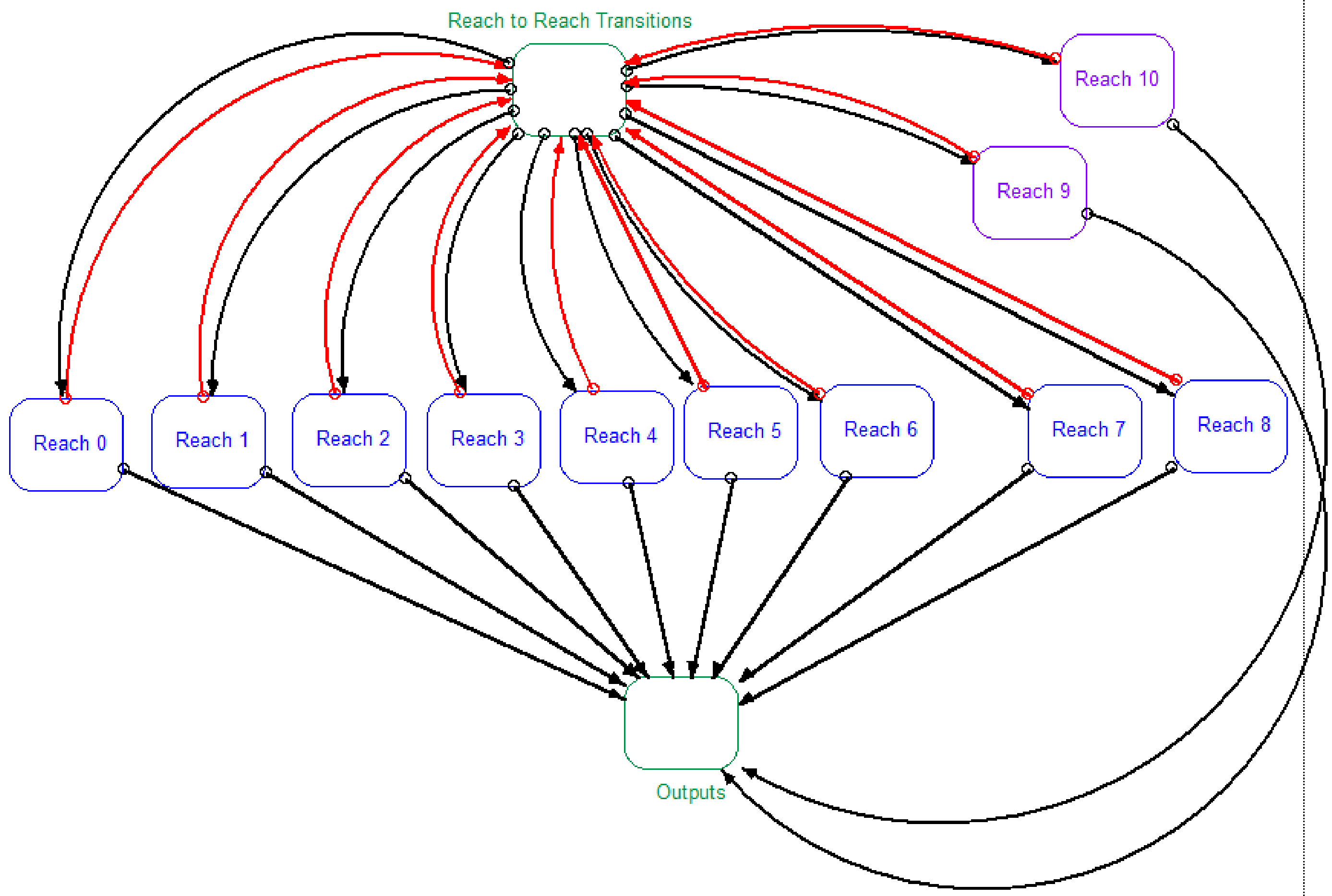
Click on the name of the reach on the map above to access management inputs for that reach.

Restore Management Inputs to Defaults

Model Configuration

- Weekly time step- capable of 100 year simulation
- Sub model for bioenergetics
- Individual based model for population parameters expanded to total population
- Biomass used for prey consumption, availability and growth
- Growth feedback loop for fish and macroinvertebrates from prey density and consumption
- Dynamic upstream and downstream movement for all species and life stages

Stella 9 model linkages - function



PURPLE: Animas River Reaches

BLUE: San Juan River Reaches

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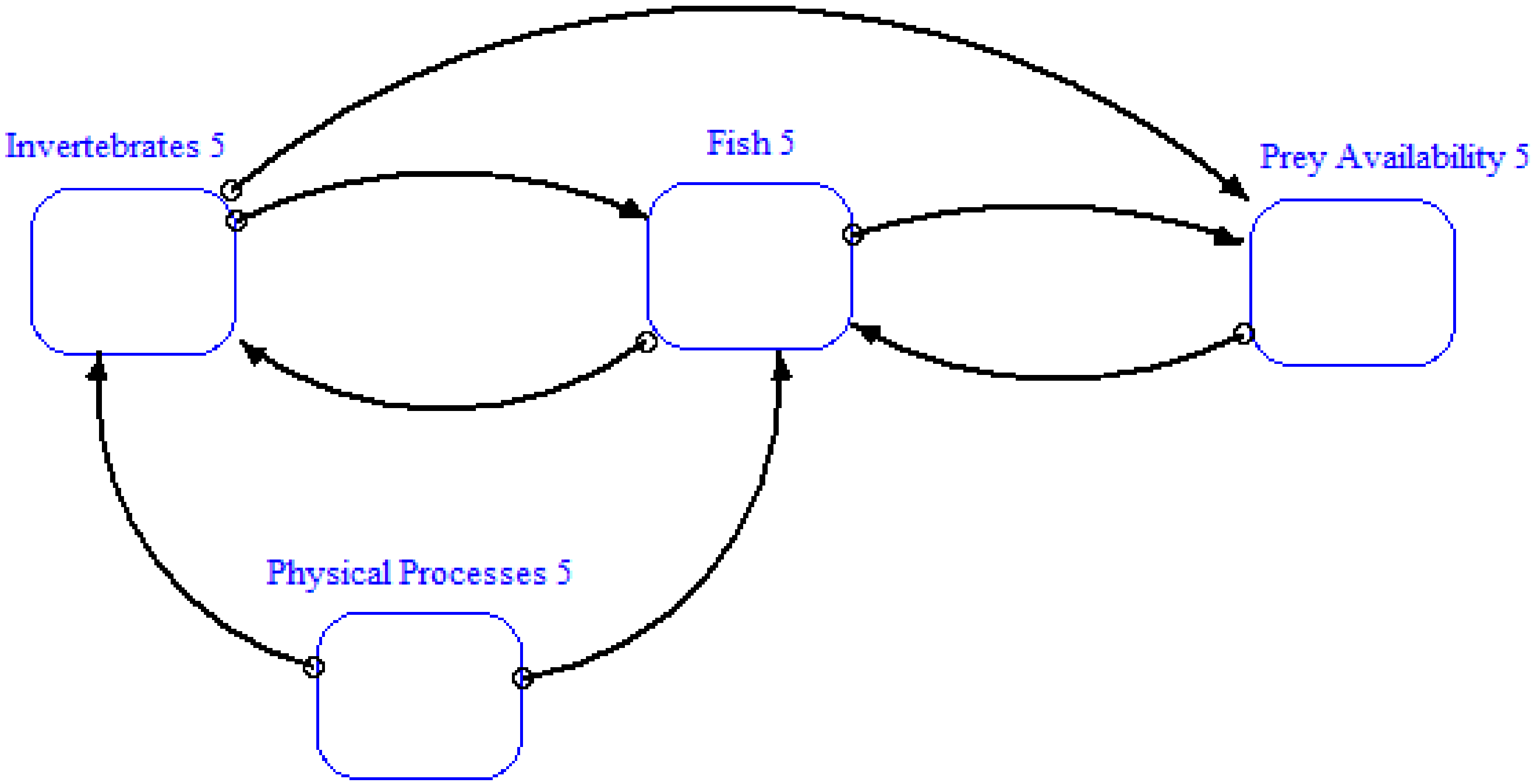
Stella 9 updates – module function



Stella 9 updates - function

[natural mortality after 1 year]

Nmort Juv annual	Juvenile Class 1	Juvenile Class 2	Juvenile Class 3	Juvenile Class 4	Juvenile Class 5	Juvenile Class 6	Juvenile Class 7
FH	0	0	0	0	0	0	0
RS	0	0	0	0	0	0	0
BH	0.6	0.5	0.4	0.3	0	0	0
FS	0.2	0.2	0.2	0.2	0	0	0
CC	0.6	0.3	0.15	0	0	0	0
RB	0.05	0.01	0.01	0	0	0	0
Ch	0.8	0.6	0.4	0	0	0	0
SD	0	0	0	0	0	0	0
CP	0.5	0.4	0.35	0.35	0.3	0.2	0.2
N1	0	0	0	0	0	0	0
N2	0	0	0	0	0	0	0
N3	0	0	0	0	0	0	0

[Initial stock value]

Init Adult Avg Bio	Adult Class 1	Adult Class 2	Adult Class 3	Adult Class 4
FH	5.87	0.001	0.001	0.001
RS	4.5	0.001	0.001	0.001
BH	489.03	884.38	0.001	0.001
FS	975.28	1811.15	0.001	0.001
CC	2101.47	4026.24	0.001	0.001
RB	1146.1	1593	0.001	0.001
Ch	778.76	2022.63	0.001	0.001
SD	1.32	4.18	8.3	16.47
CP	1727.47	2596.9	0.001	0.001
N1	0.001	0.001	0.001	0.001
N2	0.001	0.001	0.001	0.001

Adult grow fract parameter a	Adult Class 1	Adult Class 2	Adult Cla
FH	0.083730388	0	0
RS	0.102557535	0	0
BH	0.003176452	0.003080168	0
FS	0.003067365	0.002973787	0
CC	0.024986274	0.024721555	0
RB	0.003861385	0.003746491	0
Ch	0.023567565	0.019957435	0
SD	0.042453772	0.028569817	0.021561
CP	-0.0076115	-0.011527722	0
N1	0	0	0
N2	0	0	0

Control Panel | Notations | Invertebrates Inputs 5 | Physical Processes Inputs 5 | Bioenergetics Inputs 5 | Fish Inputs 5 | Reach Transition Inputs 5 | STELLA Inputs 5 | RS Adult 1 Prey Inputs | Ch

Model Calibration

- Iterative process of multiple model runs
- Initial conditions from 2002 data set
- Adjusted the following to match SJR monitoring data from 2002 to 2013:
  - Mortality rates
  - Hatching success
  - Downstream and upstream migration
  - Input yearly values for augmentation and mechanical removal.

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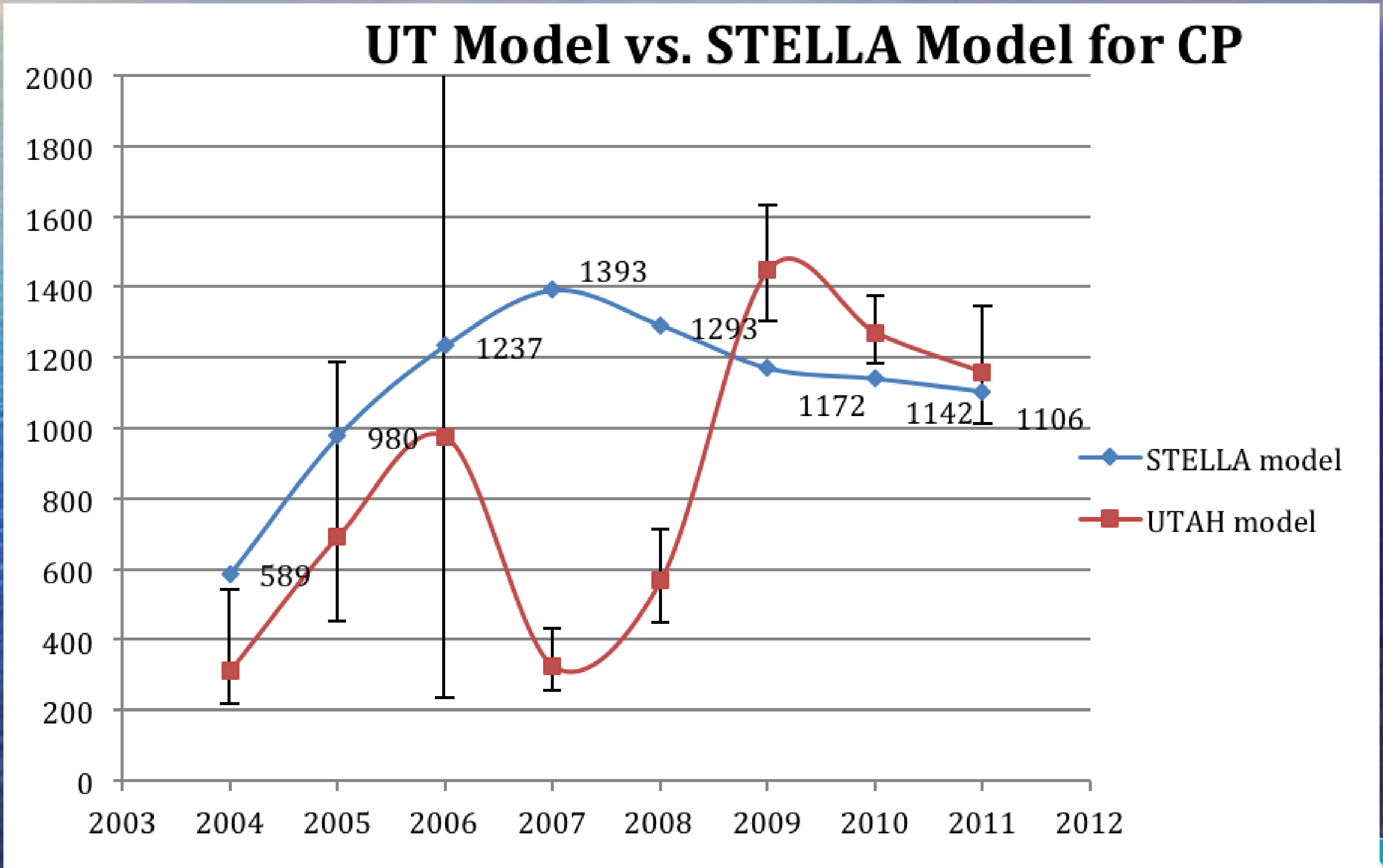
Comparison to UDWR data



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Model Validation

- Initial conditions 2002 data
- Calibrated model parameters
- Compared to population estimates from UDWR, Franssen et al. and mechanical removal
- Iterative runs to fine tune to population estimates

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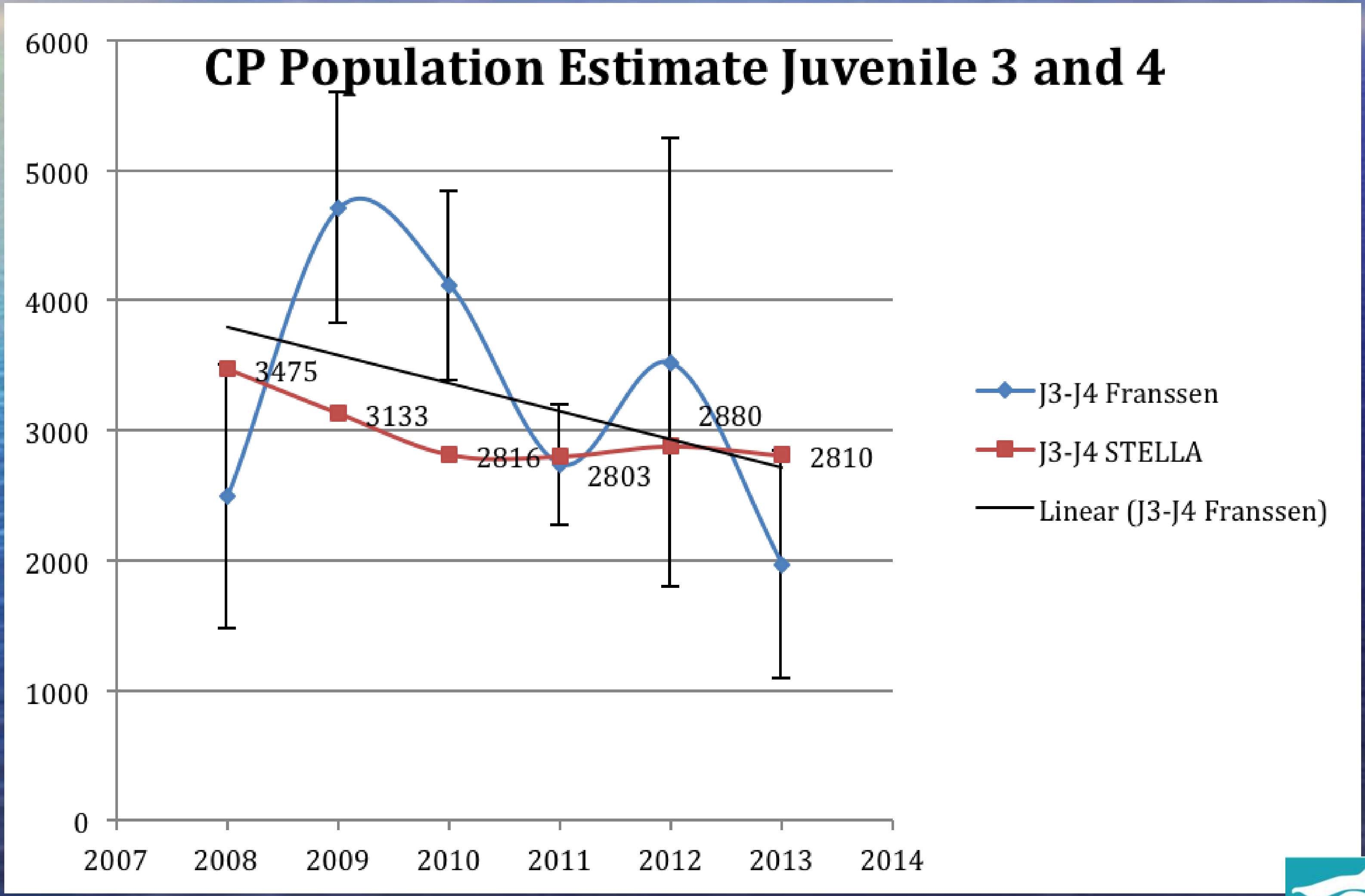
Comparison of model to monitoring data set



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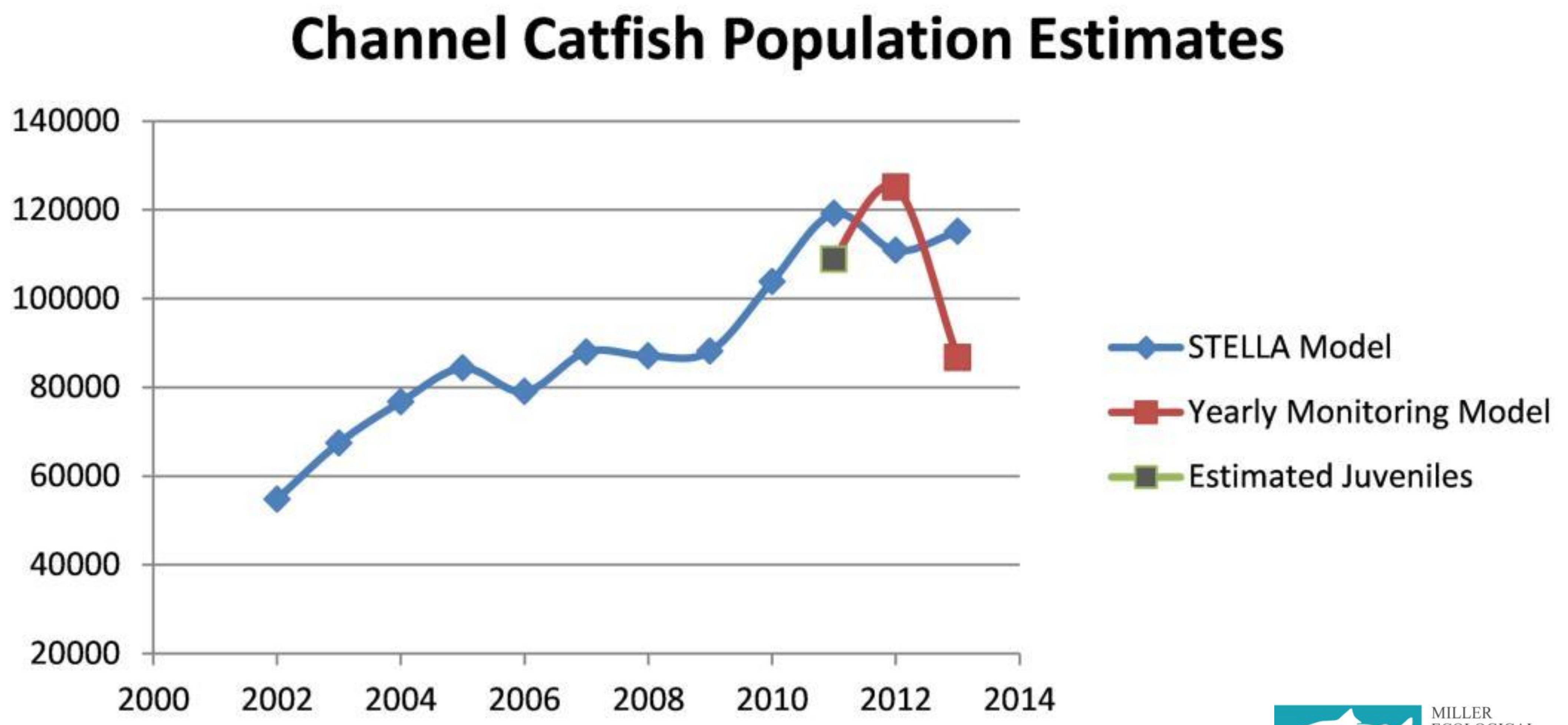
Validation against channel catfish population estimates



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Stella Model Preliminary Management Scenarios

- Mechanical removal – hypothesis that non-natives limited endangered species
- Augmentation – How many and what age? Used to evaluate the long term population resulting from stocking
- River reaches allow testing of longitudinal connectivity

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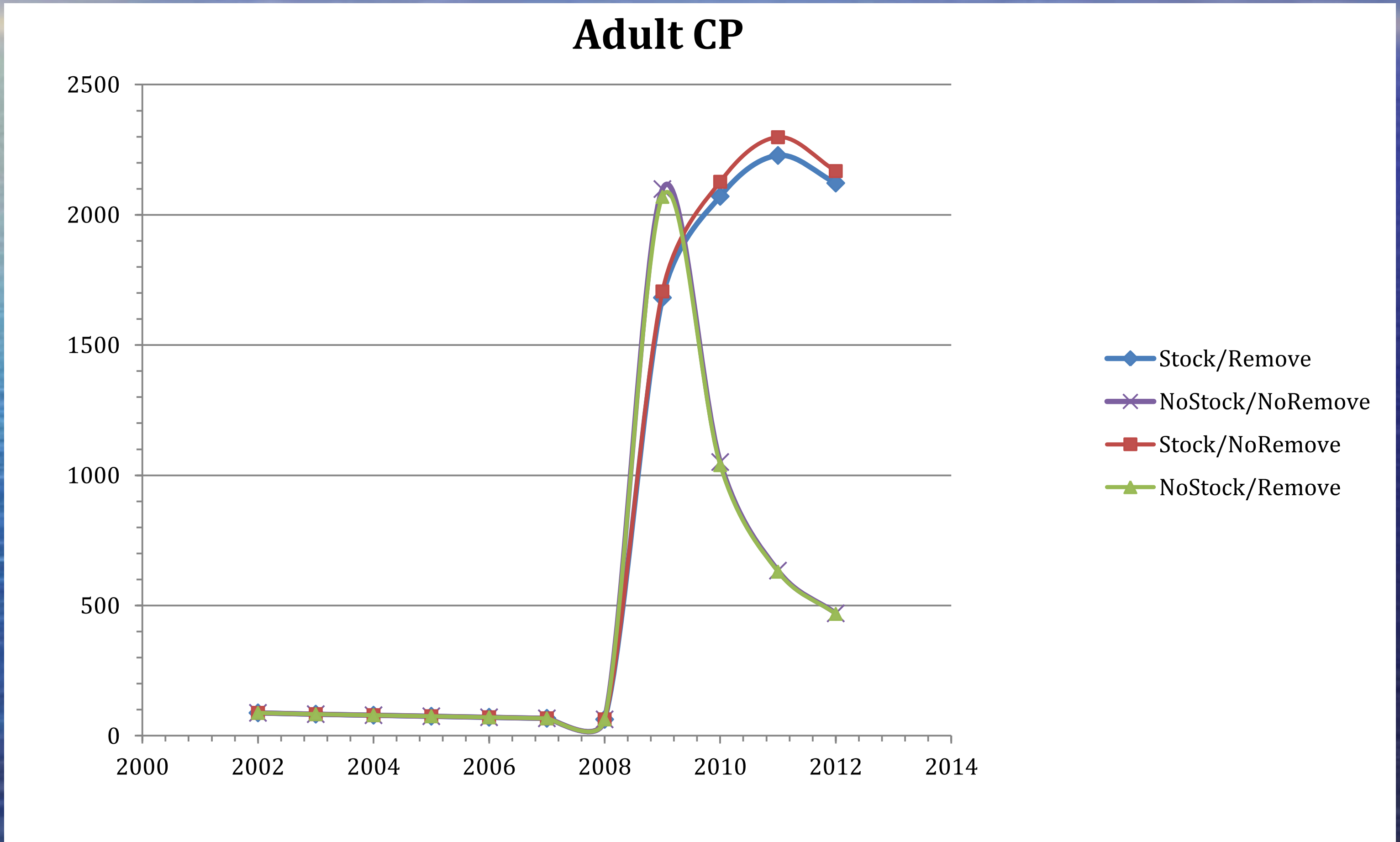
Colorado pikeminnow



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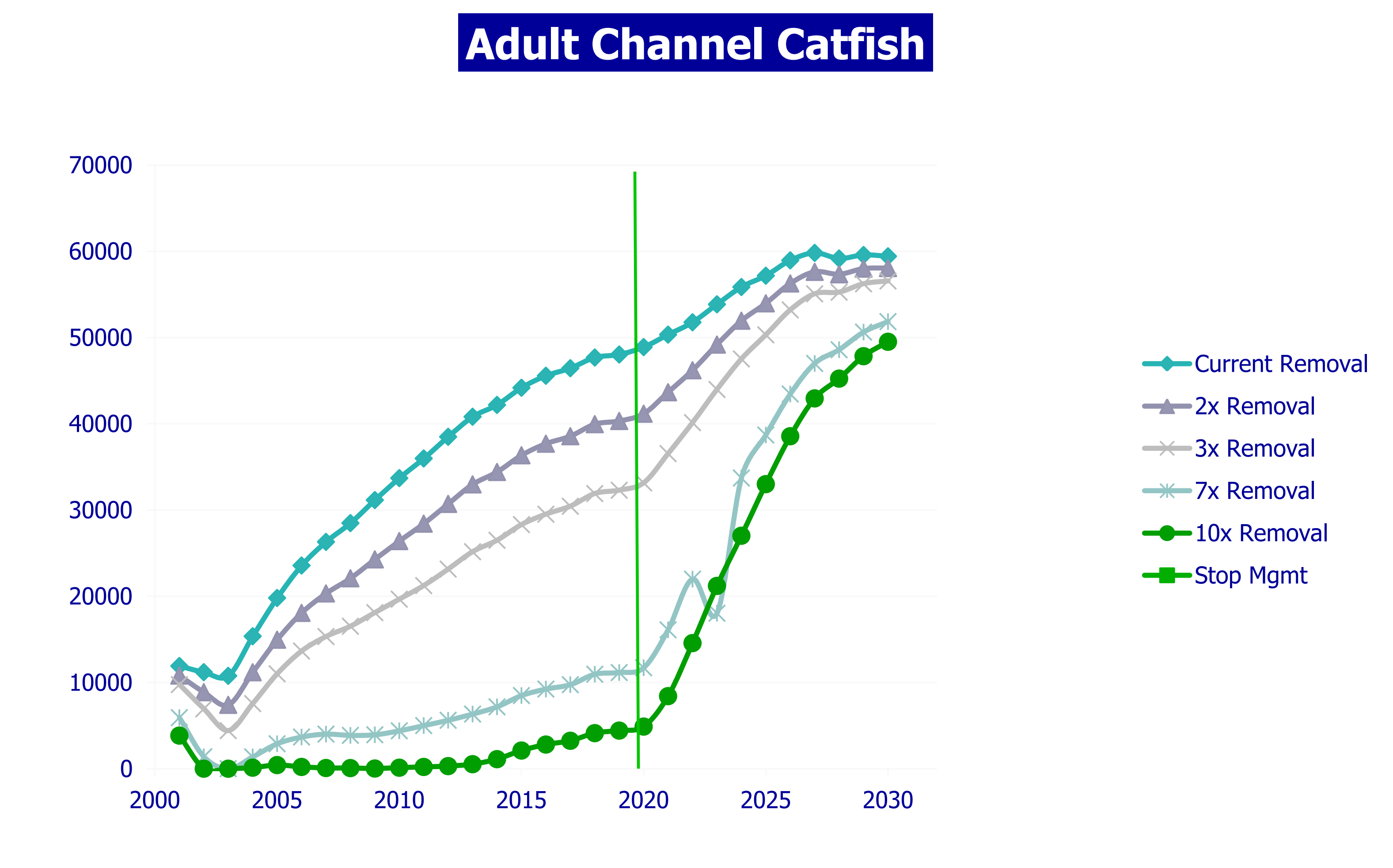
Mechanical removal



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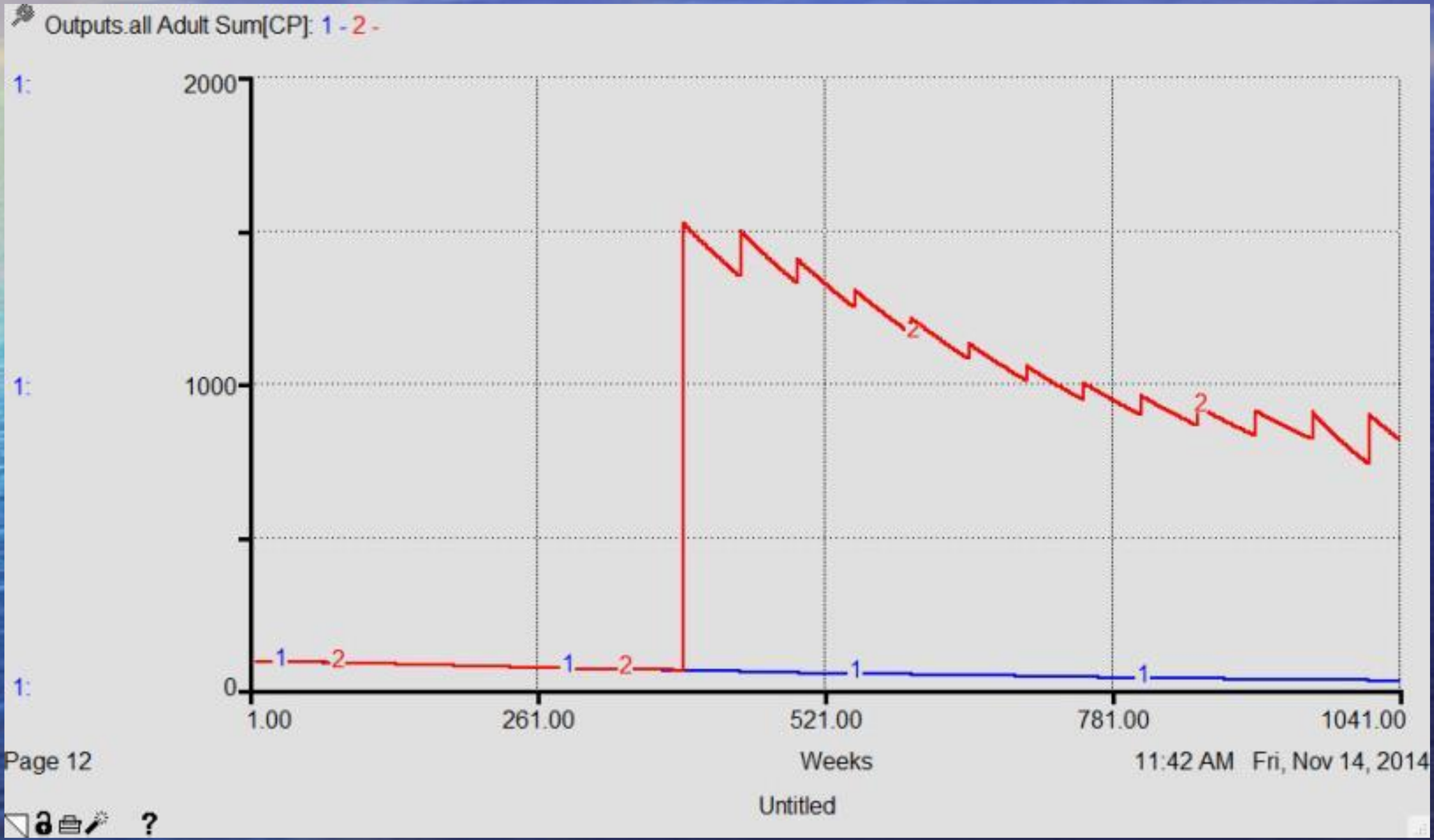
Colorado pikeminnow recruitment –no stocking, no return from Lake Powell



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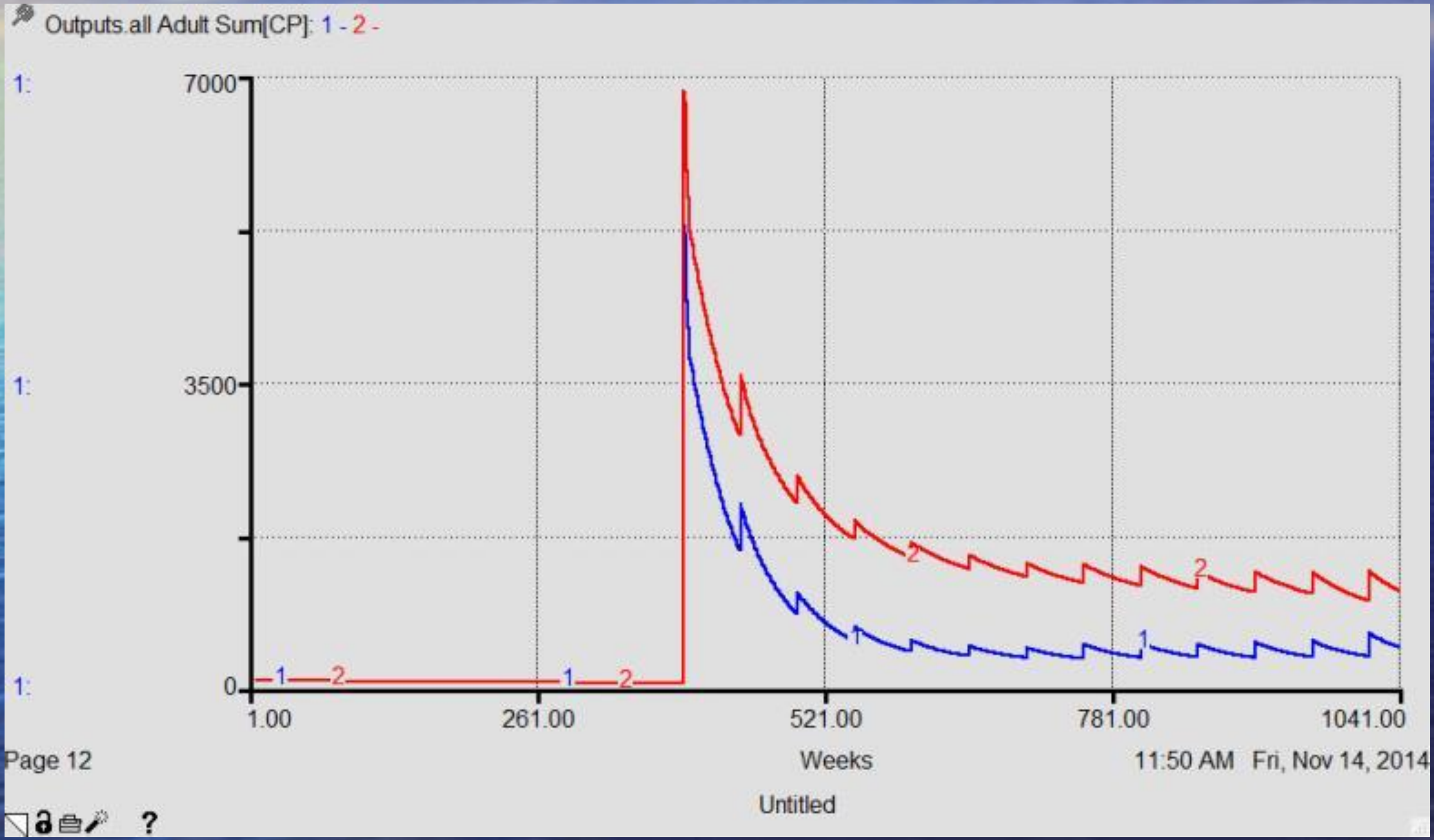
Colorado pikeminnow recruitment –no stocking, with return from Lake Powell



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Lessons Learned

- Selection of existing software packages may limit model flexibility
- Data intensive
- Requires multiple year data sets to reduce model uncertainty
- Model can be used as a tool to assist in evaluation of management actions
- Lower confidence in input data or inter-relationships increases the uncertainty of accuracy of the long term population projections.

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Lessons Learned

- Refined input data sets for fish populations would provide higher confidence in model output
- Data needs/ model limitations:
  - Large complex systems with endangered species require cooperation from multiple groups for data collection
  - River-wide population estimates
  - Data for retention of larvae by reach
  - Data for juvenile and adult movement
  - Population numbers as a function of habitat for key life stages

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