Questions !

Lessons From the North Delta Entrainment Model

- Combinations of simple linear systems can have complex, non-linear response
- Universal rates of predation change the impact of different management senarios
- Changing entrainment in a single junction can have large implications for survival throughout the system!

How do we determine junction entrainment?

The simple solution: Fish “go with the flow”

i.e., F1=Q1(Ftot/Qtot)

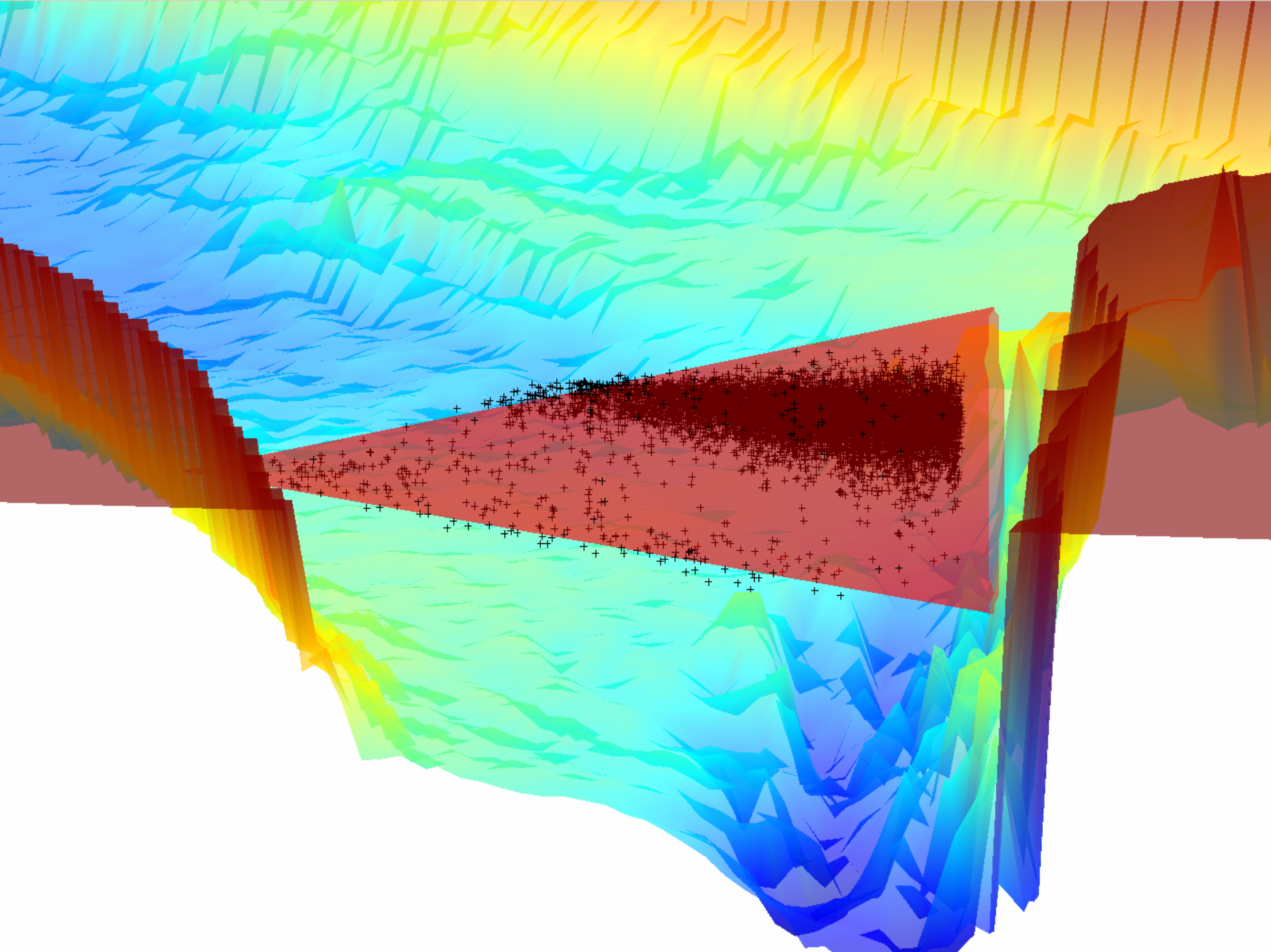
- Simply multiply the number of fish upstream by the percent of flow going into a given branch
- Our default solution in the North Delta model
- Assumes fish are uniformly distributed in the cross section

Convenient, but is this method valid?

Not particularly (but its going to take some time to show you why)

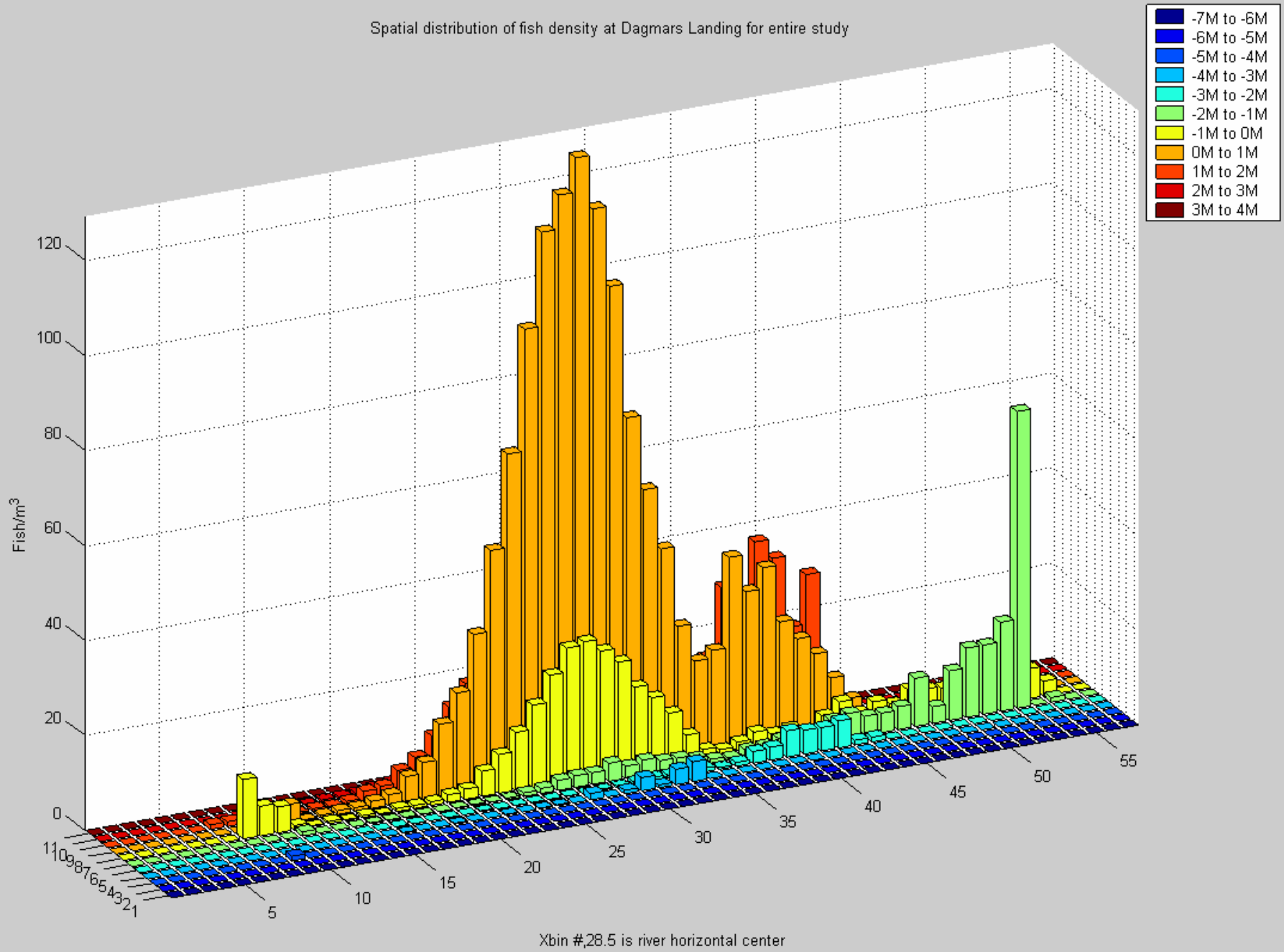
Tools for studying juvenile transport in junctions

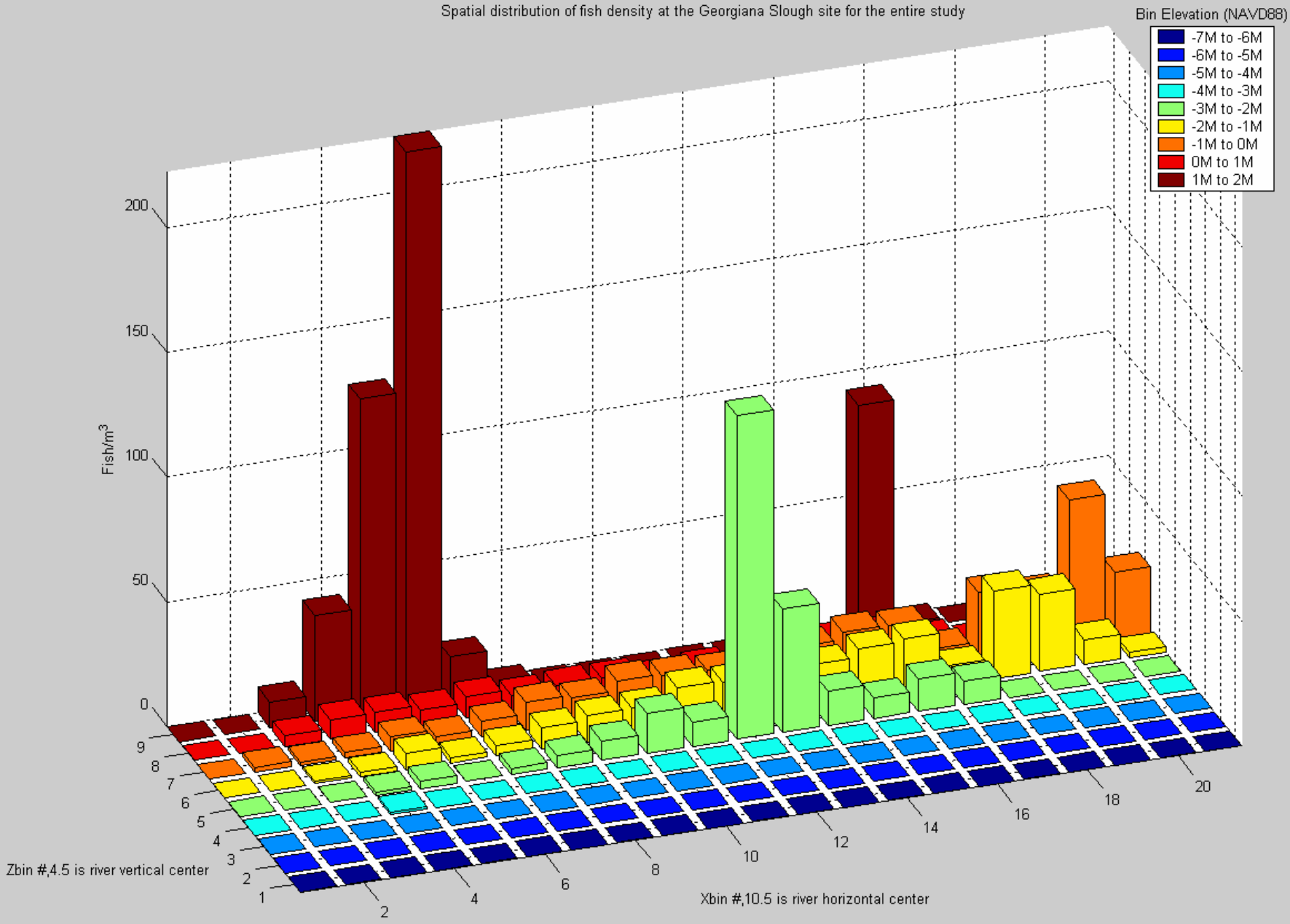
- Water velocity maps
- Passive drifters
- Passive acoustic data
  - Provides presence/absence and very accurate 4d fish tracks
- Active acoustic data
  - Provides fish location and velocity in a conical beam
  - Majority of analysis using Fish-Density Distribution Analysis (FDDA)



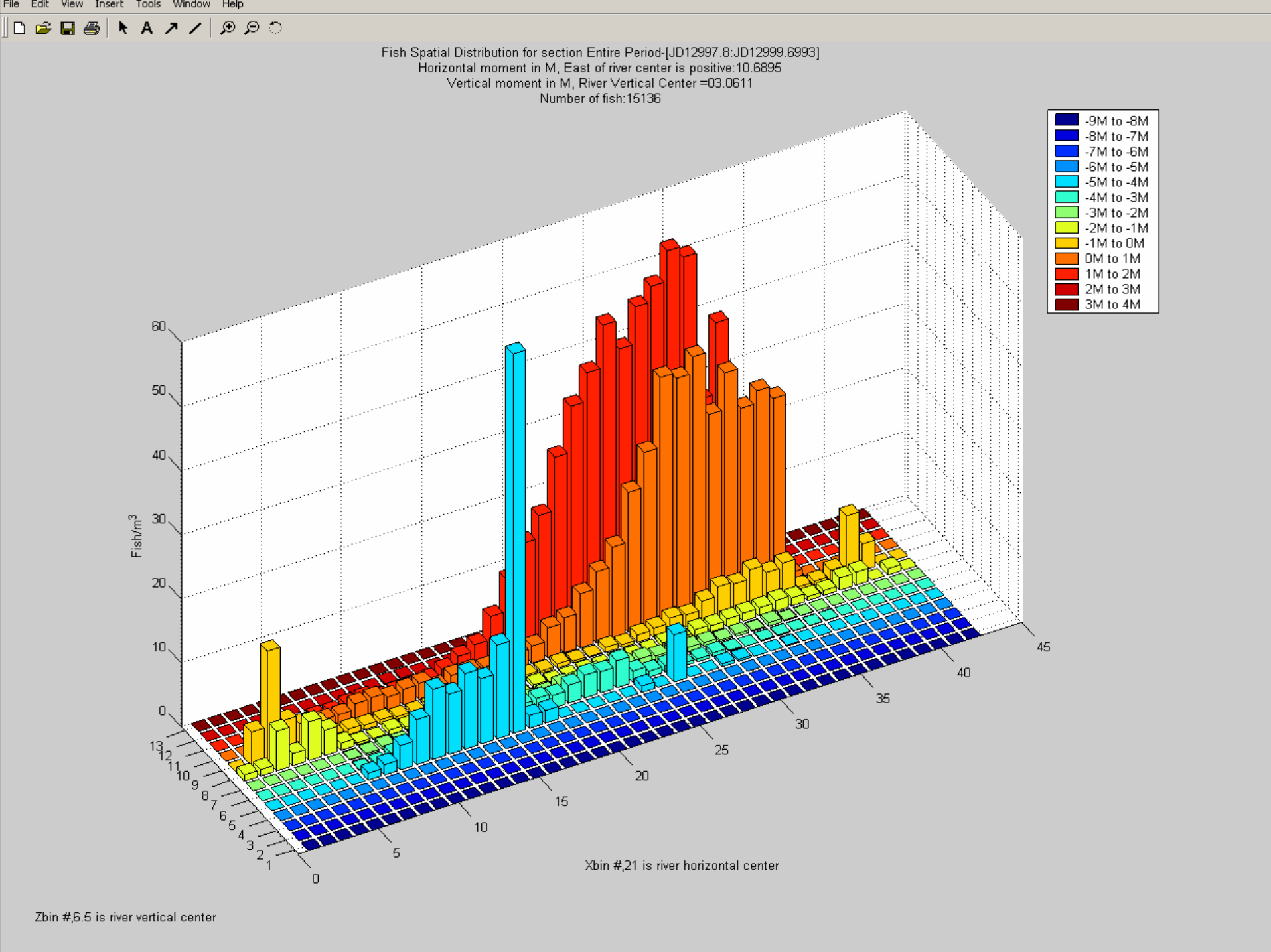
So…Why Don’t fish go with the flow?

1. Fish are not evenly distributed within the river cross section

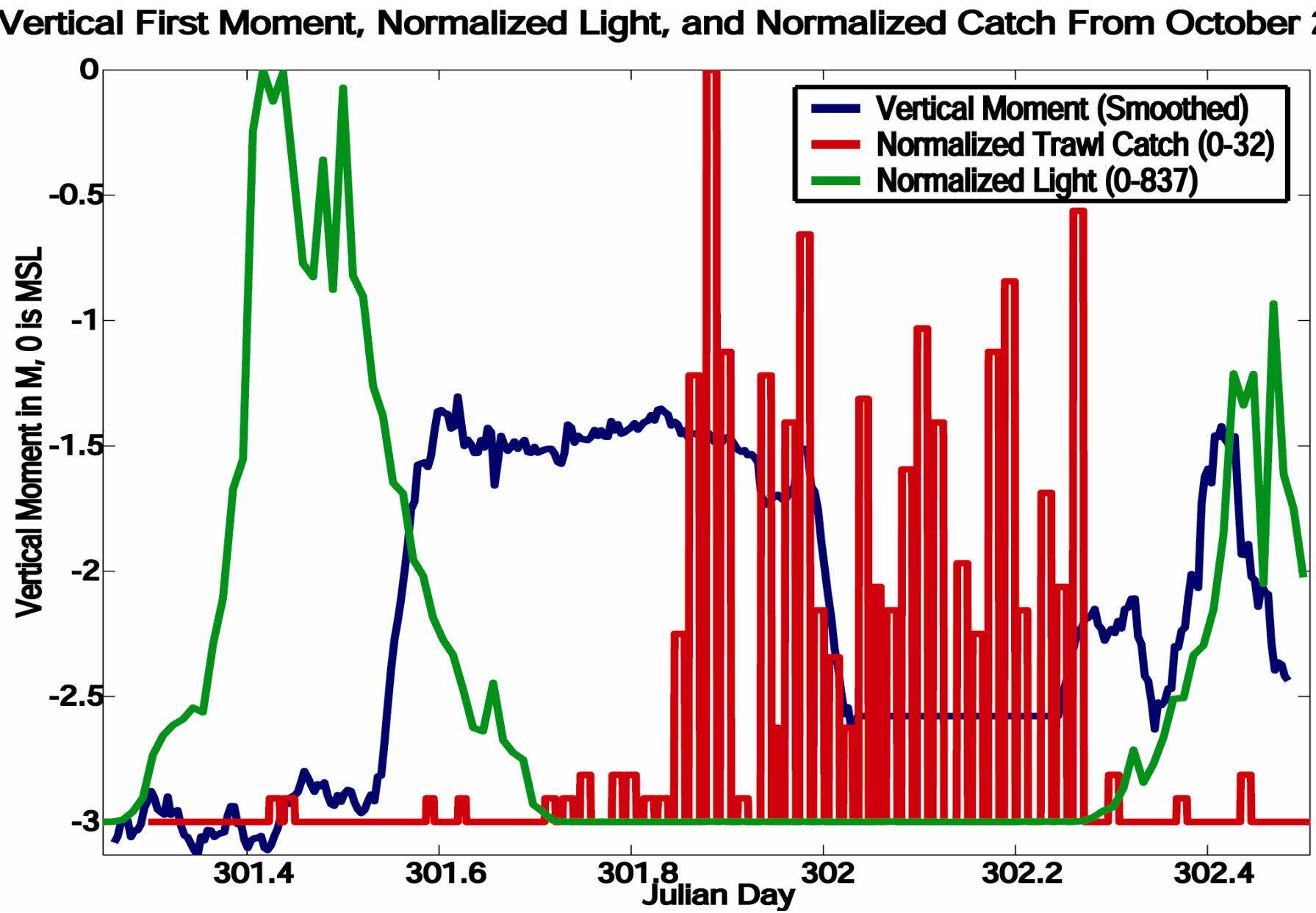

Spatial distribution of fish density at Dagmars Landing for entire study
-7M to -6M
-6M to -5M
-5M to -4M
-4M to -3M
-3M to -2M
-2M to -1M
-1M to 0M
0M to 1M
1M to 2M
2M to 3M
3M to 4M
Fish/m3
120
100
80
60
40
20
0
11
10
9
8
7
6
5
4
3
2
1
5
10
15
20
25
30
35
40
45
50
55
Xbin #,28.5 is river horizontal center


Spatial distribution of fish density at the Georgiana Slough site for the entire study
Bin Elevation (NAVD88)
-7M to -6M
-6M to -5M
-5M to -4M
-4M to -3M
-3M to -2M
-2M to -1M
-1M to 0M
0M to 1M
1M to 2M
Fish/m3
200
150
100
50
0
Zbin #,4.5 is river vertical center
9
8
7
6
5
4
3
2
1
Xbin #,10.5 is river horizontal center
2
4
6
8
10
12
14
16
18
20

File Edit View Insert Tools Window Help



Diel Changes in Vertical Signal



So…Why Don’t fish go with the flow?

1. Fish are not evenly distributed within the river cross section
2. Water velocities are not evenly distributed within the river cross section

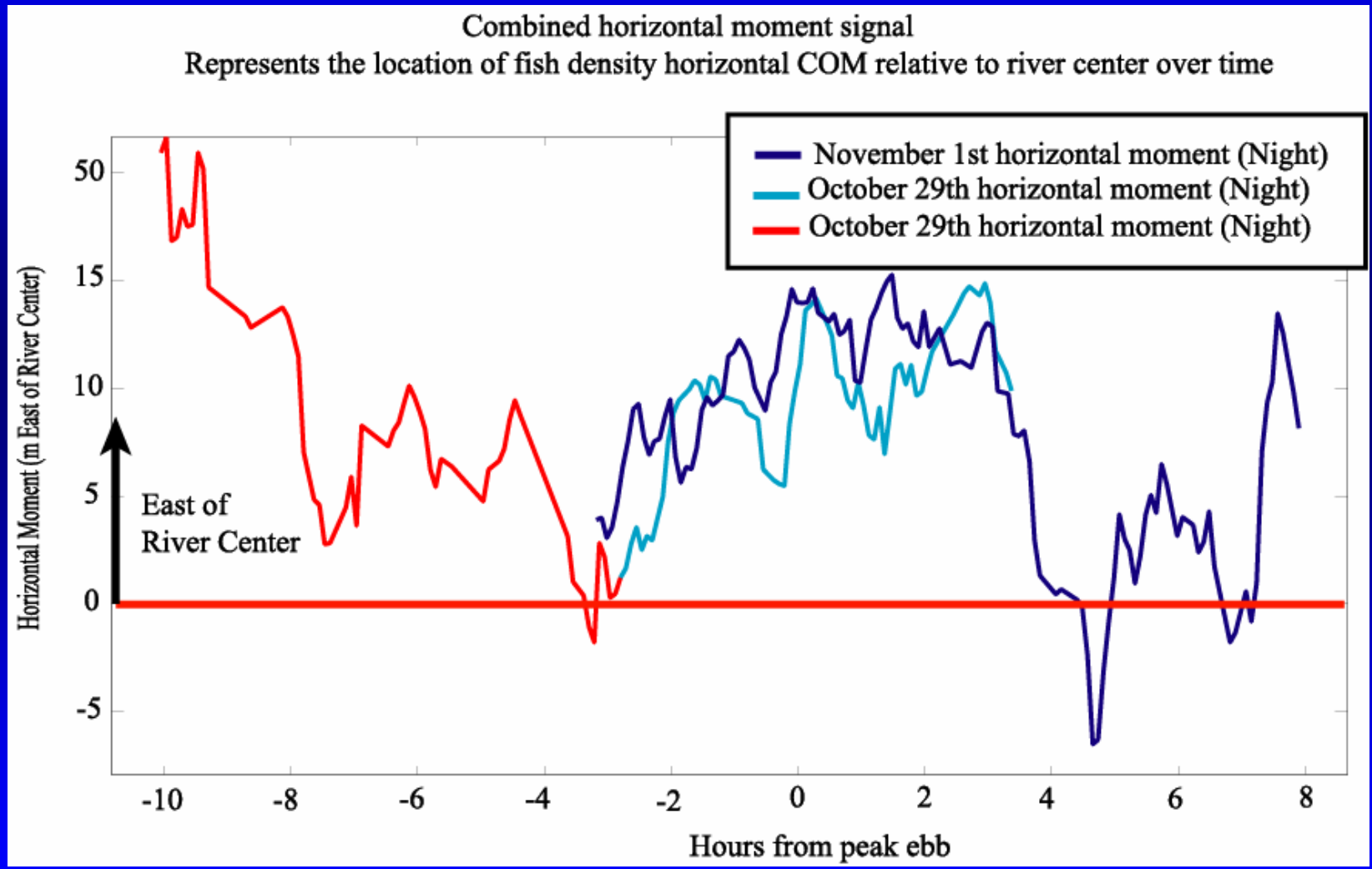
So…Why Don’t fish go with the flow?

1. Fish are not evenly distributed within the river cross section
2. Water velocities are not evenly distributed within the river cross section

1+2 =

3. Fish distribution should change as water velocities change, and/or behavior changes

Tidal Changes in Horizontal Signal



Verification that fish don't go with the flow – the Georgiana Slough Control volume

- Created a control volume around the Georgiana Slough Junction with active acoustics
- Measured the distribution and numbers of fish coming in upstream of the junction, and in the two junction branches downstream
- Entrainment wasn't dependent on flow!

Entrainment Zone Concept

- Its just grouping forces/processes
  - Approach path processes are generally Lagrangian and weaker
  - Entrainment zone processes are generally Eulerian and stronger

(Weak forces)x(Long time scales) ~ (Strong forces)x(Short time scales)

The Question…

How can we use the entrainment zone conceptual model to predict juvenile movement through junctions?

- Juveniles as swimming particles in 4d velocity fields

Juvenile Movement in Junctions

The juvenile particle model

- Juveniles as particles that can choose to swim

$$P_{t+1} = P_t + \vec{U}_t(\Delta t) + \vec{S}_t(\Delta t)$$

- Both water velocity and swimming velocity are important !

$$SN = \frac{\vec{U}}{2bl / s}$$

- What happens when SN<<1 or SN>>1?

Juvenile Movement in Junctions

Vertical Swim Velocity

- Consider horizontal and vertical swim choices separately
- Strongest behavioral signal in vertical swim velocity
- Trying to maintain a specific vertical location
- Light!
  - Balance between predation risk and feeding efficiency?
  - Also smoltification and buoyancy
  - Turbidity

Juvenile Movement in Junctions

Horizontal Swim Velocity

- Weak positive rheotaxis motion model
- Weaker behavioral signals superimposed
  - Shear?
  - Maximum velocity?
  - Bank Avoidance?
  - Treat this as noise for now!

Juvenile Movement in Junctions

Temporal Patterns

- Short term temporal variance
  - Resting
  - Feeding
- Long term temporal variance - migratory spiral model
  - Life history strategy (Ocean type Vs. Stream type)
  - Degree of smoltification

Why are temporal patterns important?

Changes in outflow

Tidal influence

Solar/Lunar cycles

Juvenile Movement in Junctions

Current juvenile particle model

$$P_{t+1} = P_t + \vec{U}_t(\Delta t) + n(bl)\frac{\vec{U}_t}{\|\vec{U}\|}(\Delta t) + m(bl/s)(z_t - z_{o_t})\hat{K}(\Delta t) + E$$

$n = -.5 \text{ to } 1$

positive rheotaxis motion

$m = -3 \text{ to } +3$

Vertical positioning

Other behaviors

How do we test our swimming particles?

Passive Acoustic Data

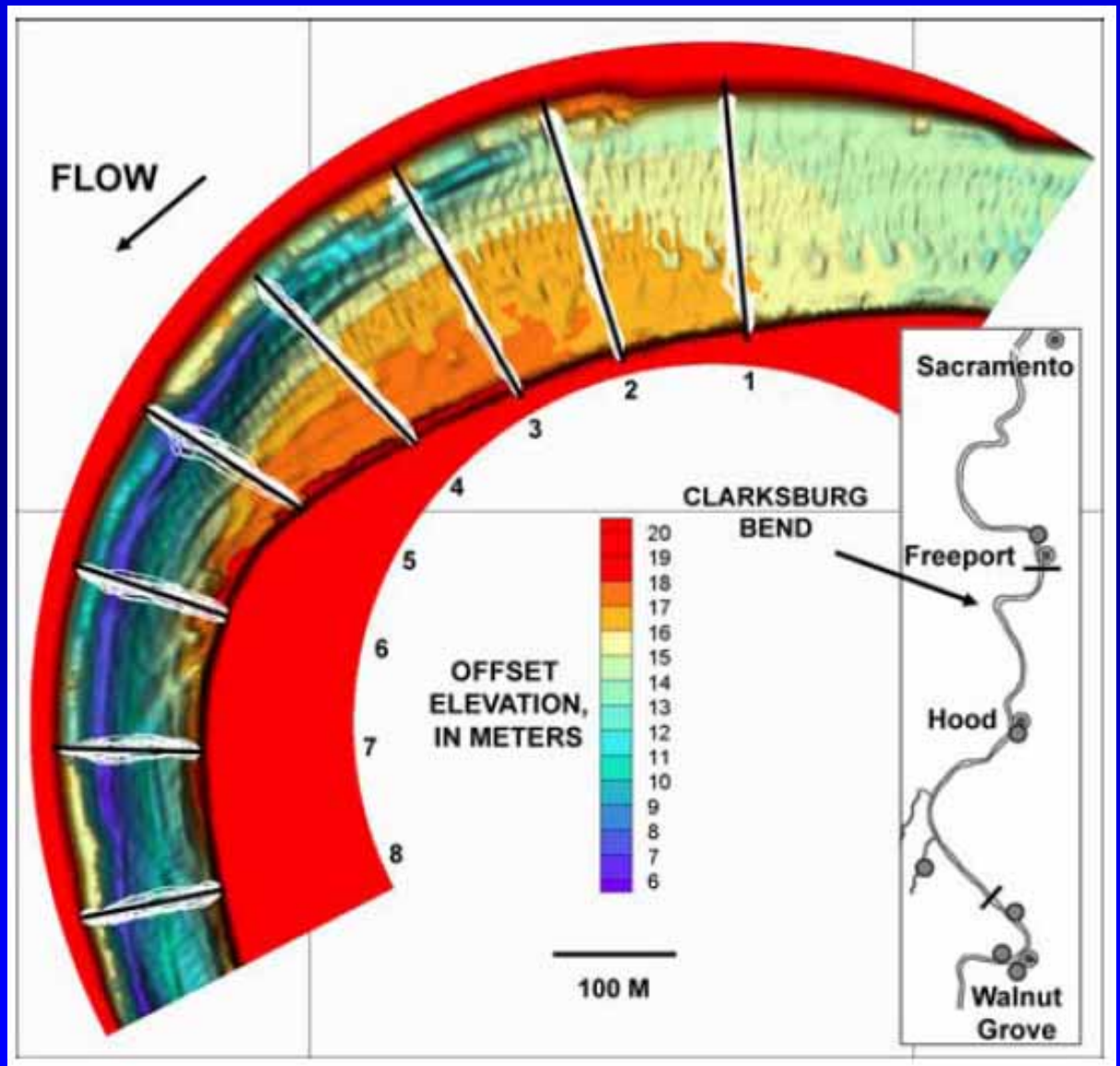
- Analysis Techniques
  - Compare paths with multiple numeric fish from the same starting point
  - Calculate lagrangian difference velocities for a discrete time period

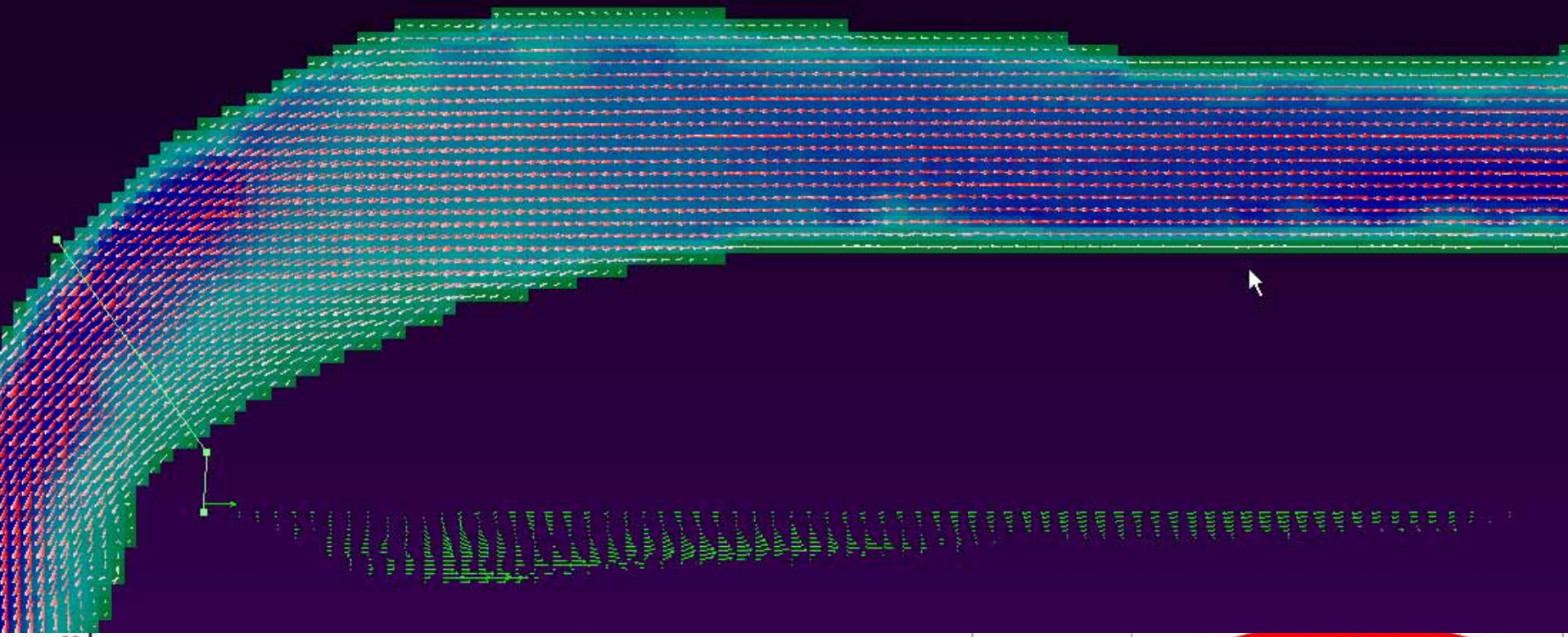
- Requires SI3D, Flow Mapper, and particle based fish tracking models

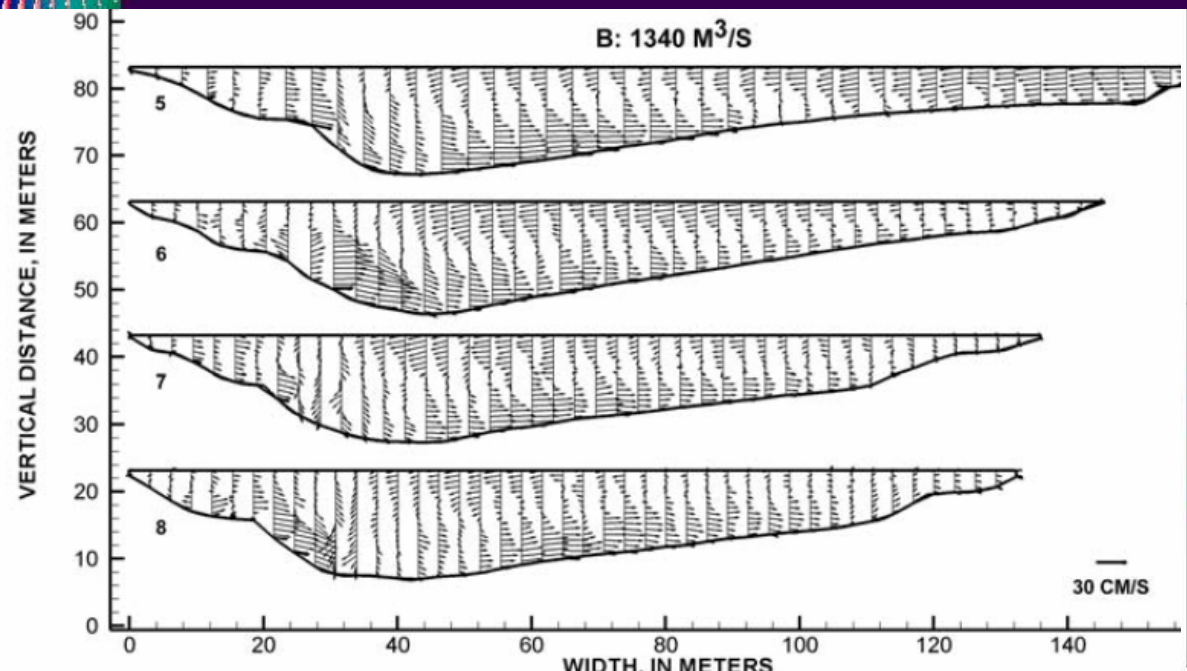
SI3D:
Numeric accuracy for better predictions of high-order processes

- Second order accurate numerics
- Leapfrog trapezoidal algorithm
- Mass and momentum conserving numeric scheme
- Public domain code

Measured Secondary Circulation






B: 1340 M3/S
VERTICAL DISTANCE, IN METERS
WIDTH, IN METERS
5
6
7
8
30 CM/S
0
10
20
30
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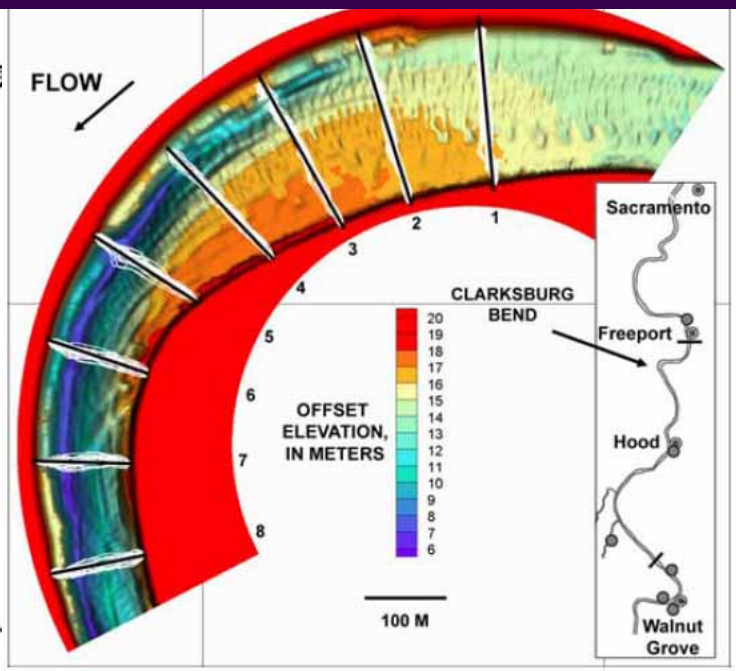
50
60
70
80
90
0
20
40
60
80
100
120
140


FLOW
CLARKSBURG
BEND
OFFSET
ELEVATION,
IN METERS
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
100 M
Sacramento
Freeport
Hood
Walnut
Grove
1
2
3
4
5
6
7
8

Improving SI3D Flow Fields

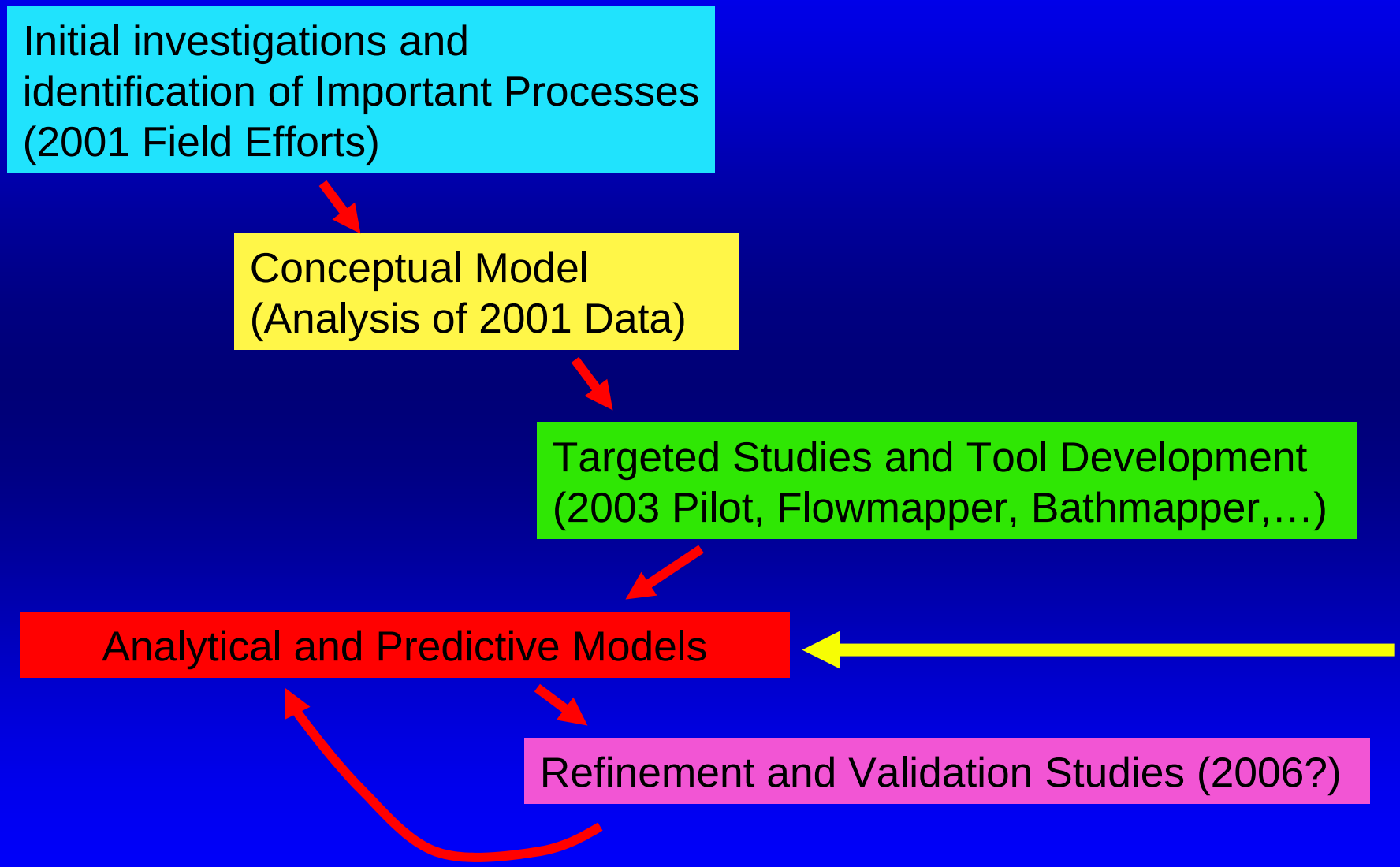
- BathMapper used to acquire up to date bathymetry for study junctions
- Automated SI3D interface tools to make stable runs easier
- Flowmapper data for validation and data assimilation
  - Improve the accuracy of both flowmapper data and SI3D estimates

So, how fish tracking inform our management model

- 2 Test cases, with alternate geometries for a diversion, such as a peripheral canal
- Based on the modified geometry of Clarksburg bend
- Randomly released particles and fish in an upstream cross section
- Tracked 10,000 of each, and evaluated the difference in entrainment

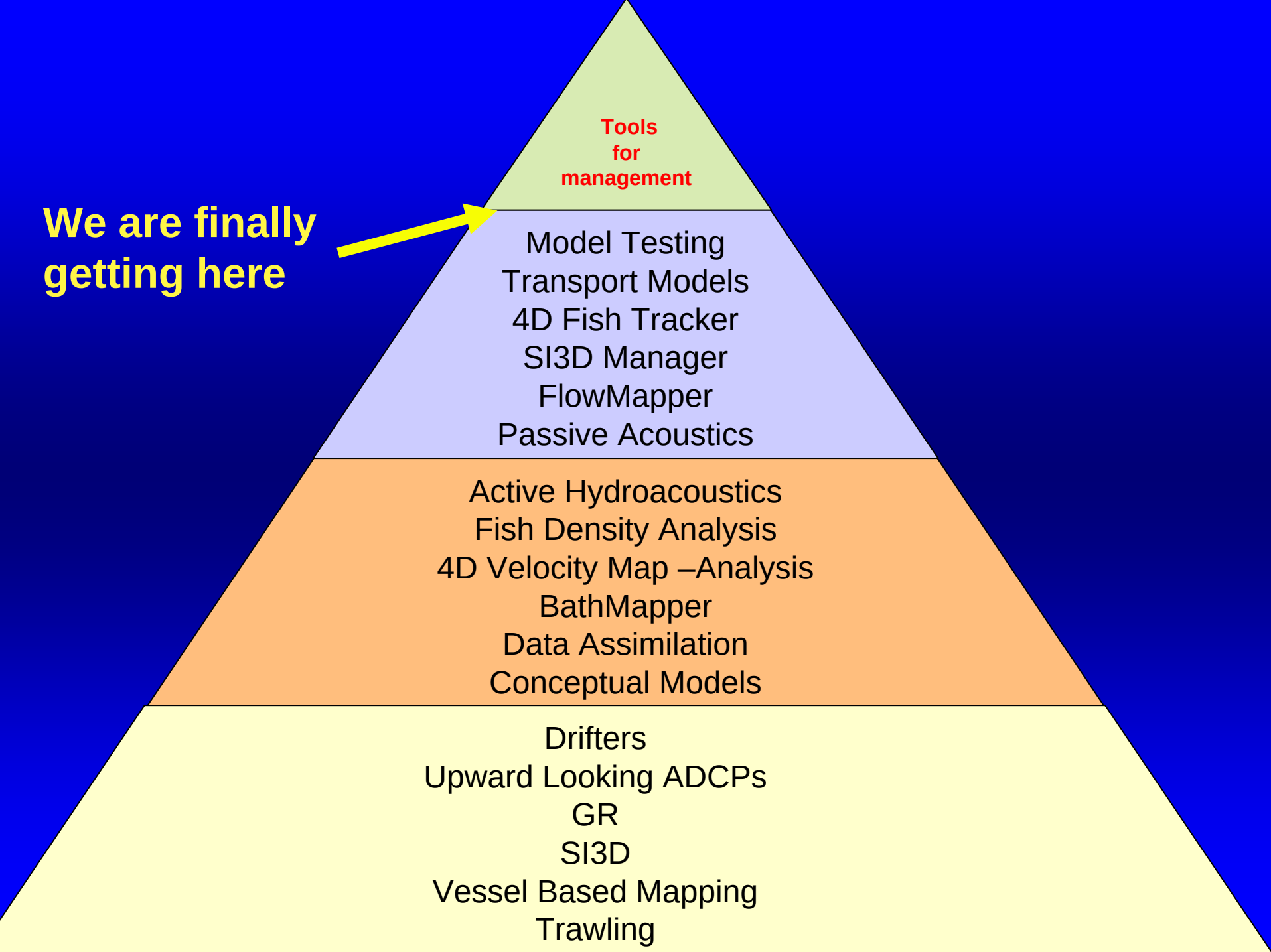
What is the potential North Delta impact of these differences?

Path to the Present….



Taking a step back
Field time versus analysis time

- Previously, fieldwork/analysis ratio was high
- Each level of our analysis requires custom processing software
- In the past month, I have written and modified codes in c++, Java, Matlab, LabView, and Fortran
- Accuracy Vs effort curve is exponential!


We are finally getting here
Tools for management
Model Testing
Transport Models
4D Fish Tracker
SI3D Manager
FlowMapper
Passive Acoustics
Active Hydroacoustics
Fish Density Analysis
4D Velocity Map –Analysis
BathMapper
Data Assimilation
Conceptual Models
Drifters
Upward Looking ADCPs
GR
SI3D
Vessel Based Mapping
Trawling