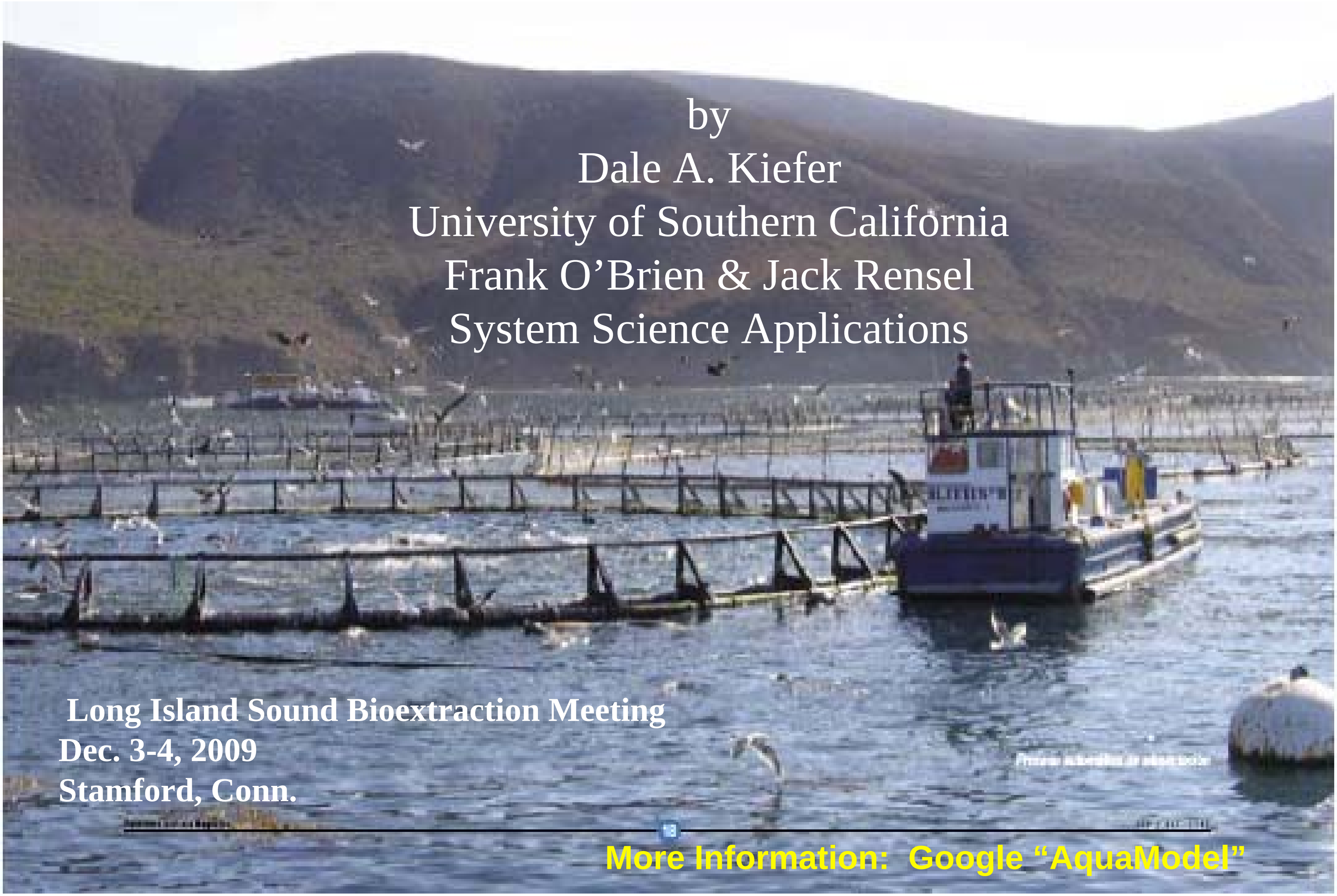
Modeling Fish Farm Operations and Impacts



by

Dale A. Kiefer

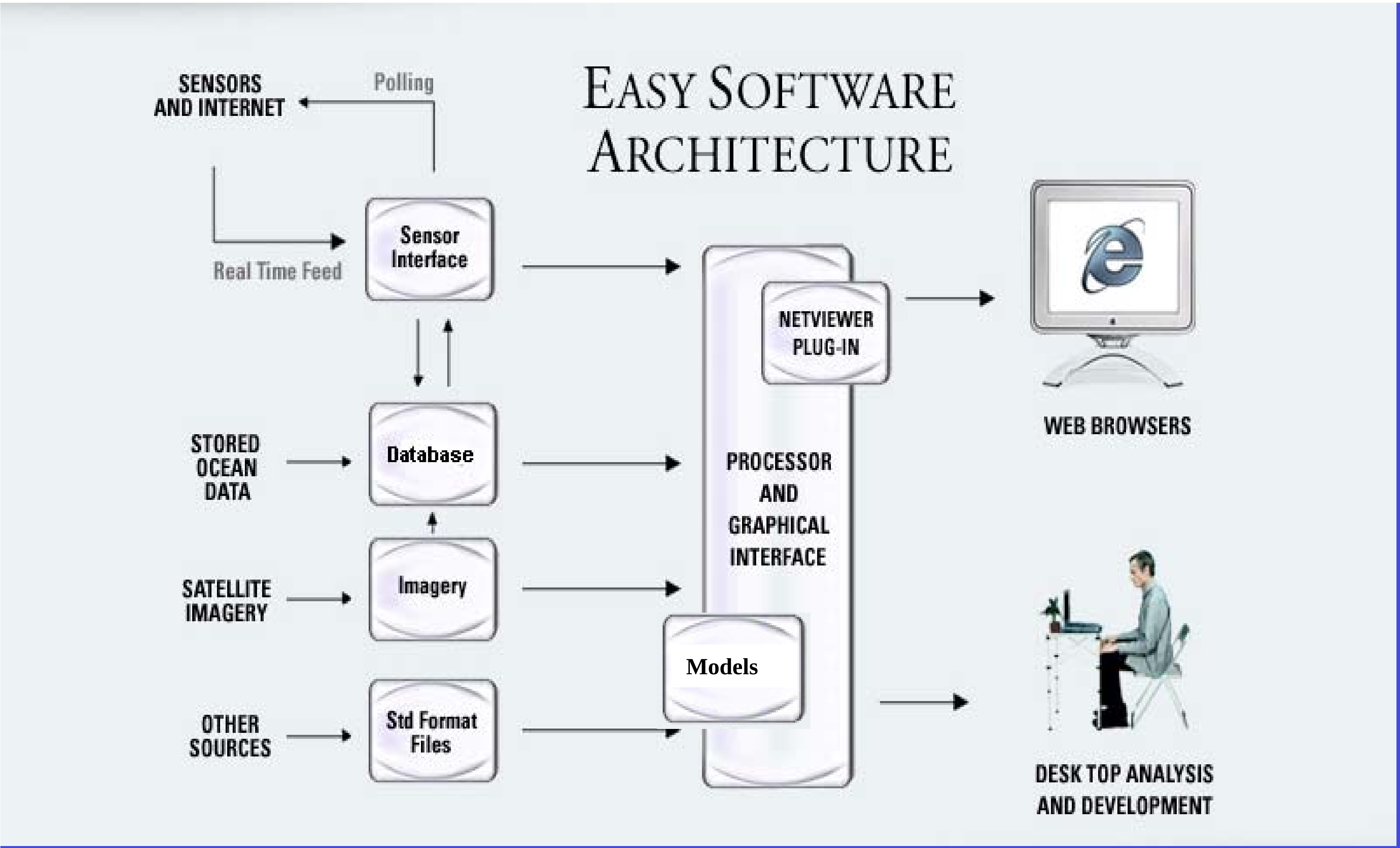
University of Southern California

Frank O’Brien & Jack Rensel

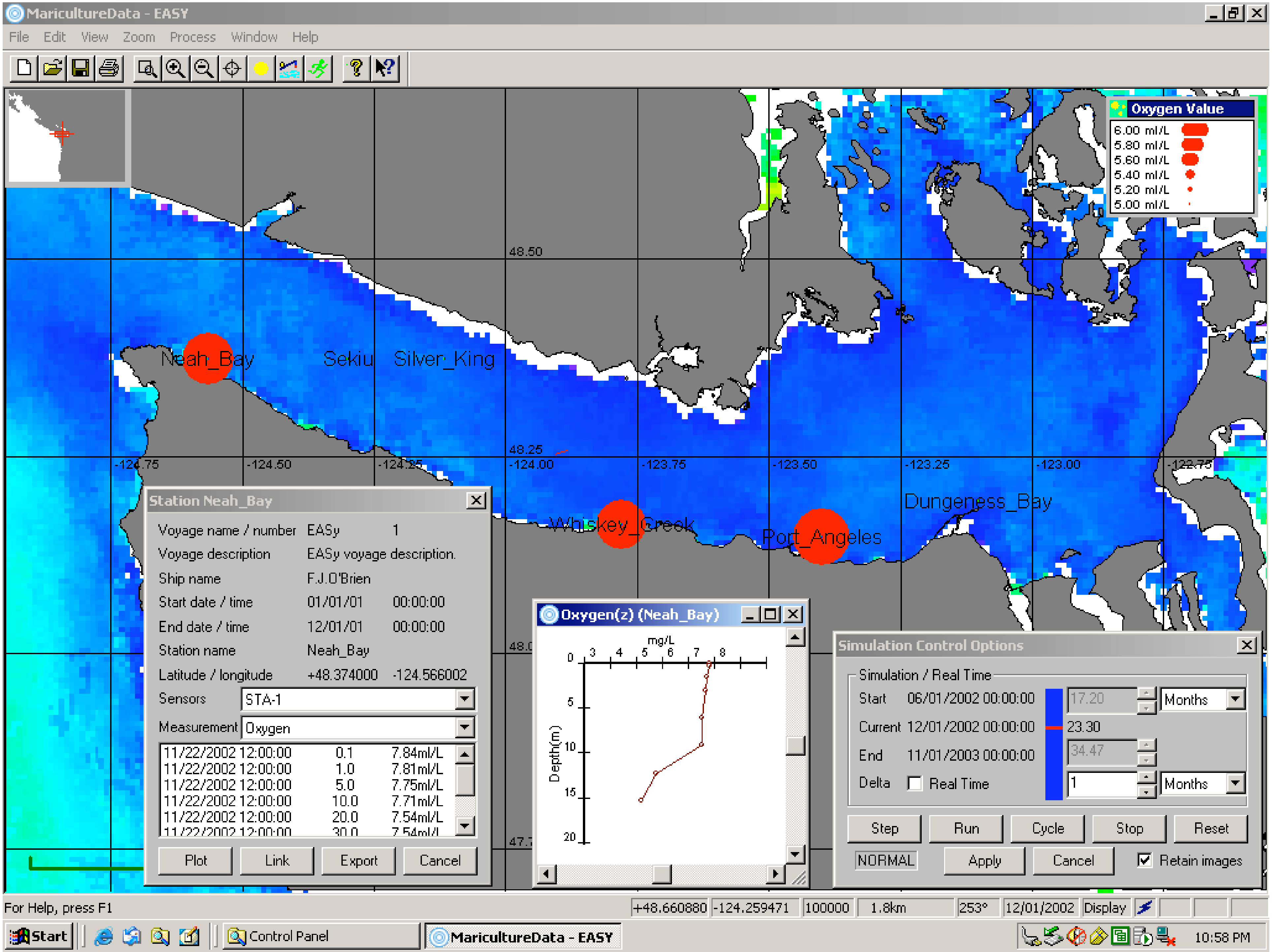
System Science Applications

Long Island Sound Bioextraction Meeting
Dec. 3-4, 2009
Stamford, Conn.

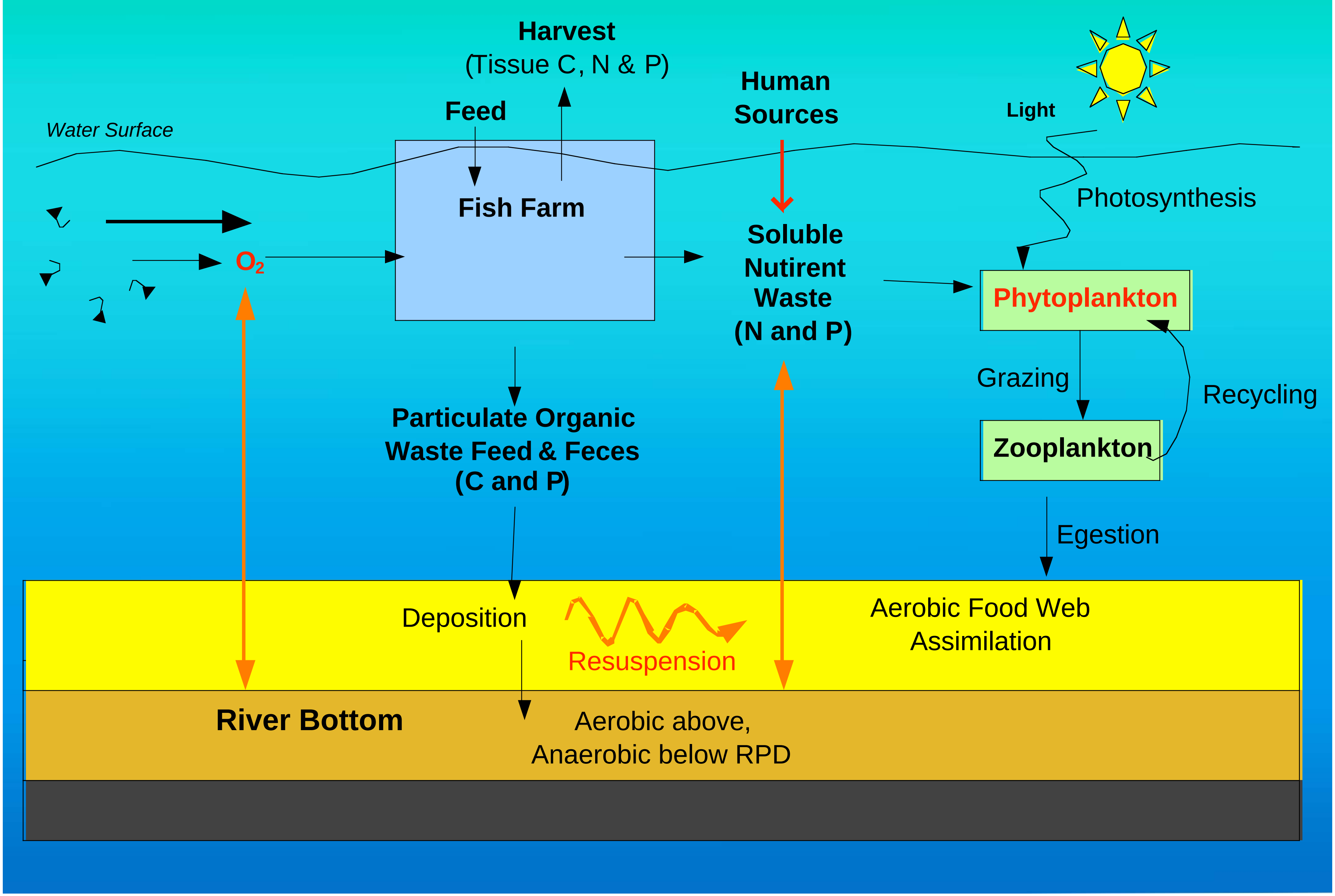
More Information: Google “AquaModel”



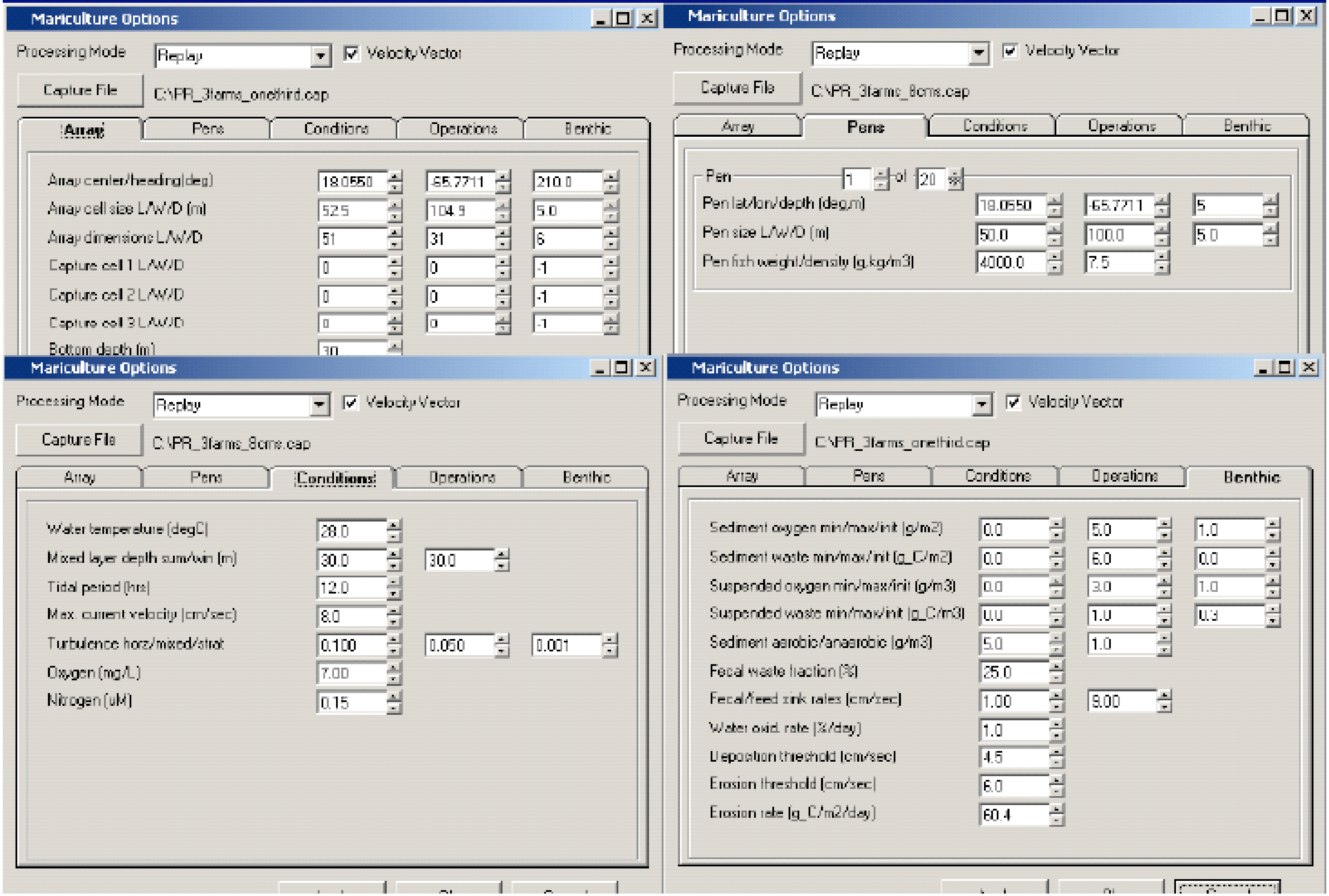
- Three dimensional system for marine applications
- Interfaces for models, spreadsheets, databases, and Internet
- PC Desktop & Web-enabled GIS applications
- Compatible with ESRI (arc-info) GIS


MaricultureData - EASY
File Edit View Zoom Process Window Help
Oxygen Value
6.00 ml/L
5.80 ml/L
5.60 ml/L
5.40 ml/L
5.20 ml/L
5.00 ml/L
48.50
48.25
-124.75
-124.50
-124.25
-124.00
-123.75
-123.50
-123.25
-123.00
-122.75
Neah_Bay
Sekiu
Silver_King
Whiskey_Creek
Port_Angeles
Dungeness_Bay
Station Neah_Bay
Voyage name / number EASy 1
Voyage description EASy voyage description.
Ship name F.J.O'Brien
Start date / time 01/01/01 00:00:00
End date / time 12/01/01 00:00:00
Station name Neah_Bay
Latitude / longitude +48.374000 -124.566002
Sensors STA-1
Measurement Oxygen
11/22/2002 12:00:00 0.1 7.84ml/L
11/22/2002 12:00:00 1.0 7.81ml/L
11/22/2002 12:00:00 5.0 7.75ml/L
11/22/2002 12:00:00 10.0 7.71ml/L
11/22/2002 12:00:00 20.0 7.54ml/L
11/22/2002 12:00:00 30.0 7.54ml/L
Plot
Link
Export
Cancel
Oxygen(z) (Neah_Bay)
mg/L
Depth(m)
Simulation Control Options
Simulation / Real Time
Start 06/01/2002 00:00:00 17.20 Months
Current 12/01/2002 00:00:00 23.30
End 11/01/2003 00:00:00 34.47
Delta Real Time 1 Months
Step
Run
Cycle
Stop
Reset
NORMAL
Apply
Cancel
Retain images
For Help, press F1
+48.660880 -124.259471 100000 1.8km 253° 12/01/2002 Display
Start
Control Panel
MaricultureData - EASY
10:58 PM

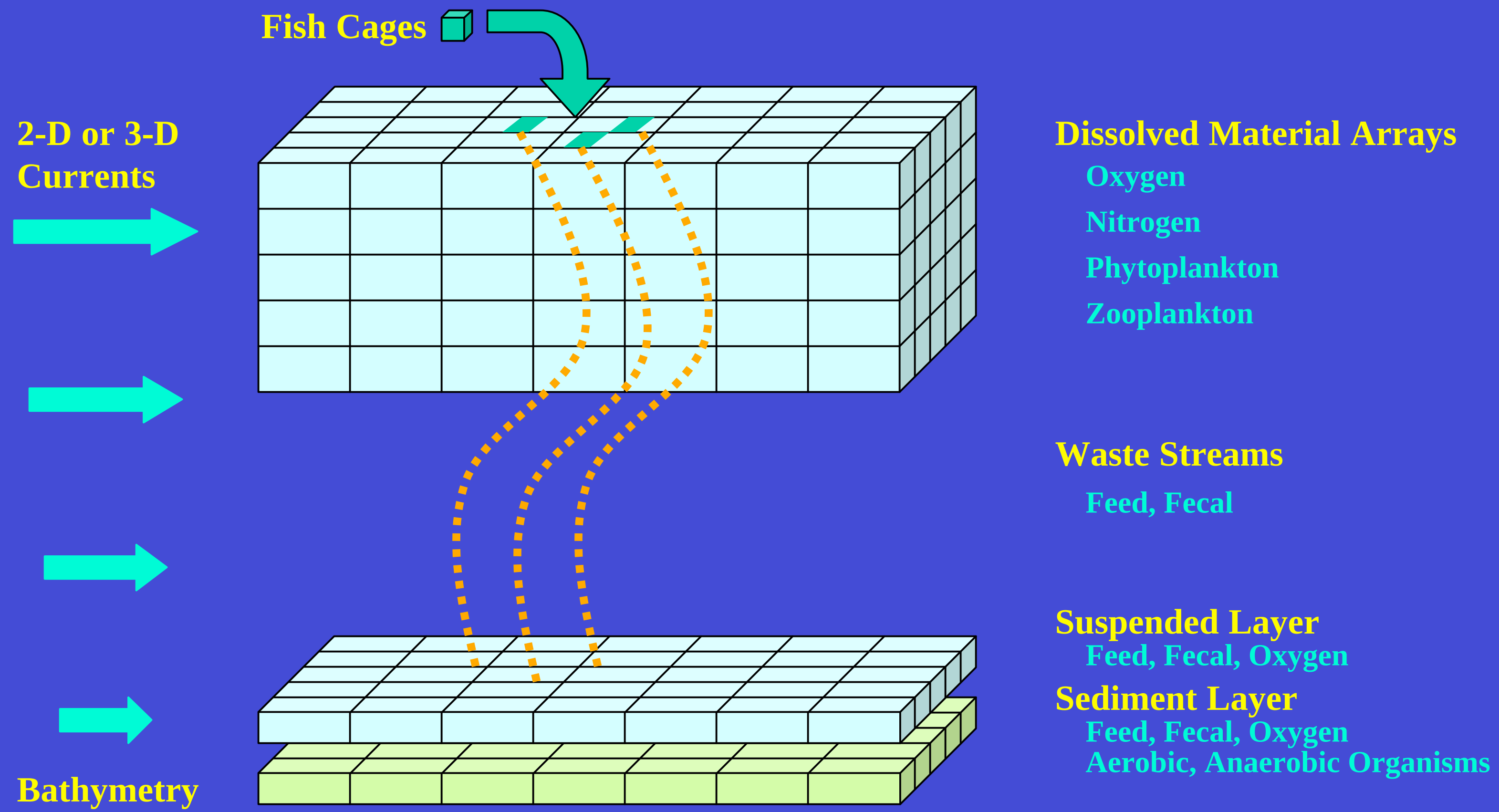
Model Overview



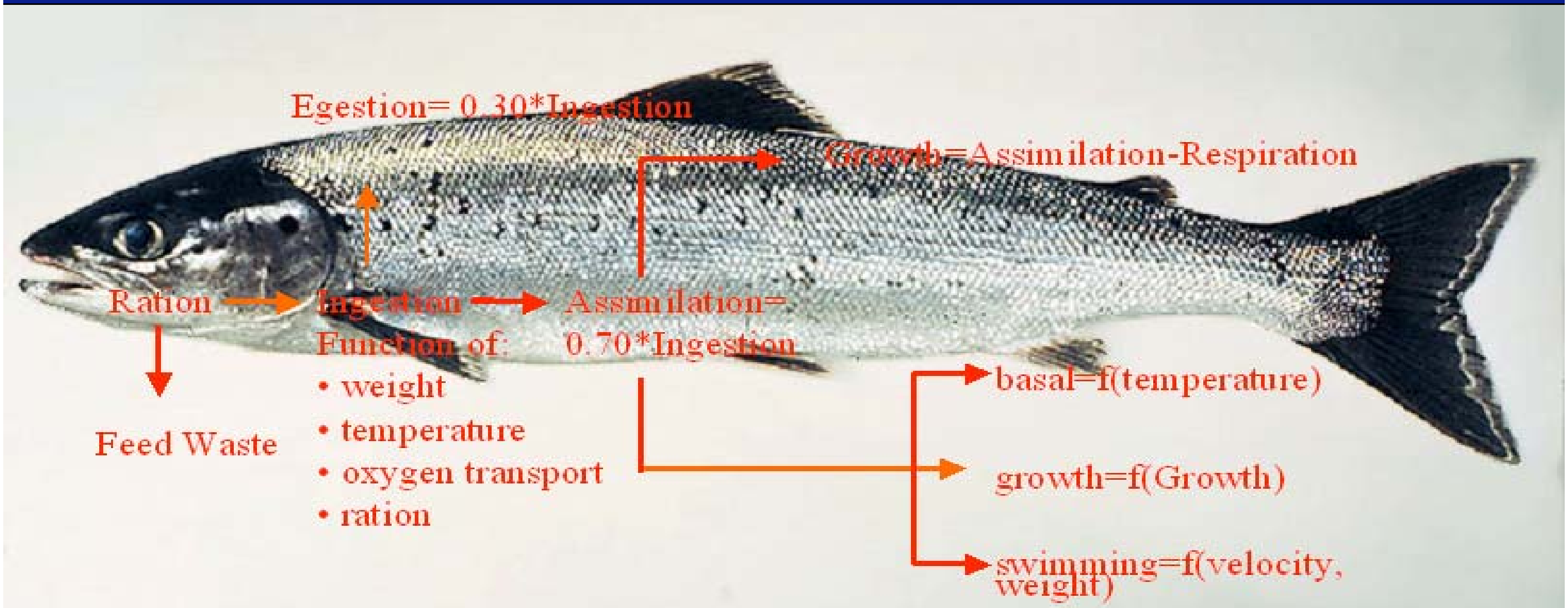
Examples of Some User Controls



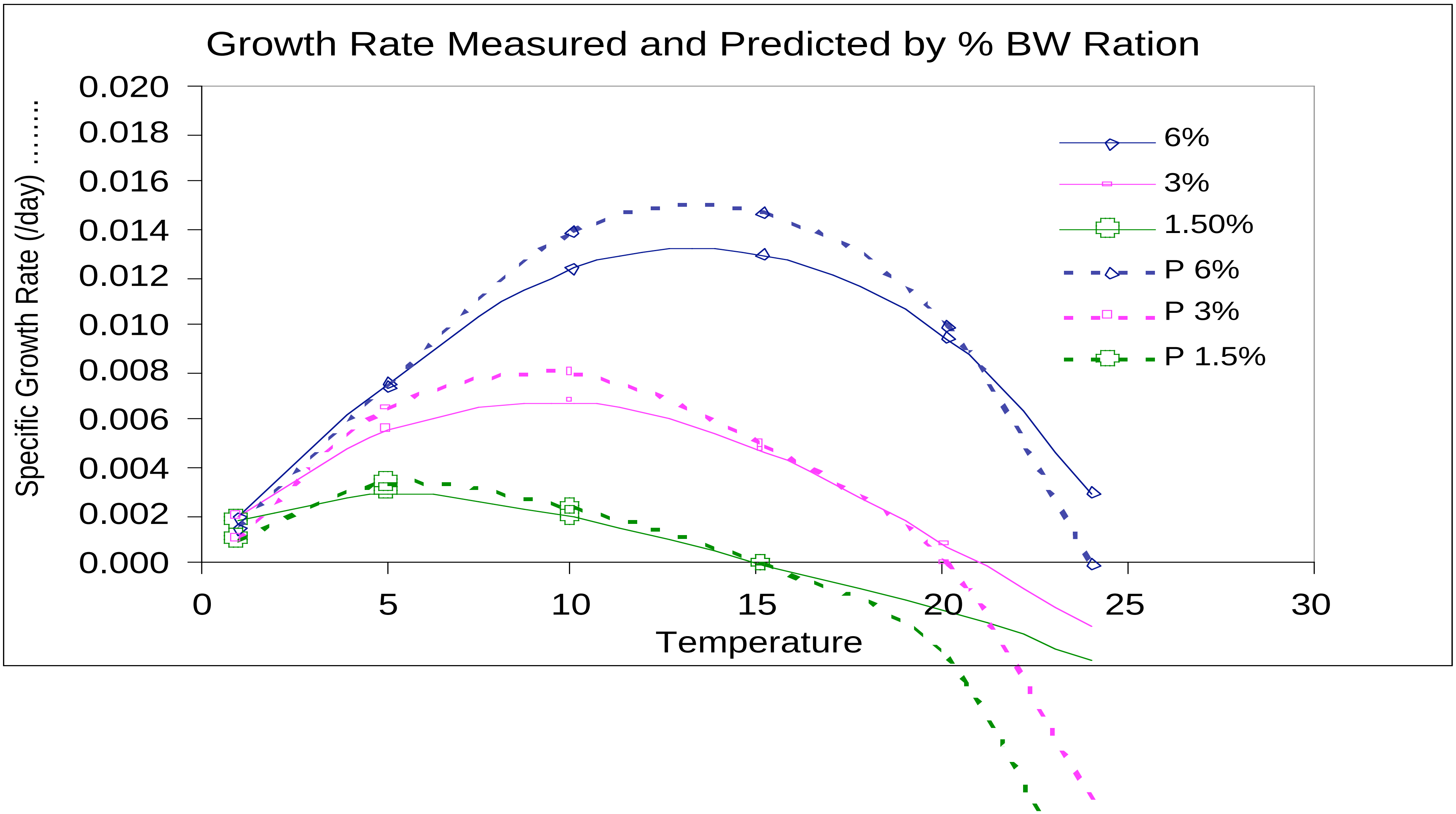
AquaModel 3-D Features



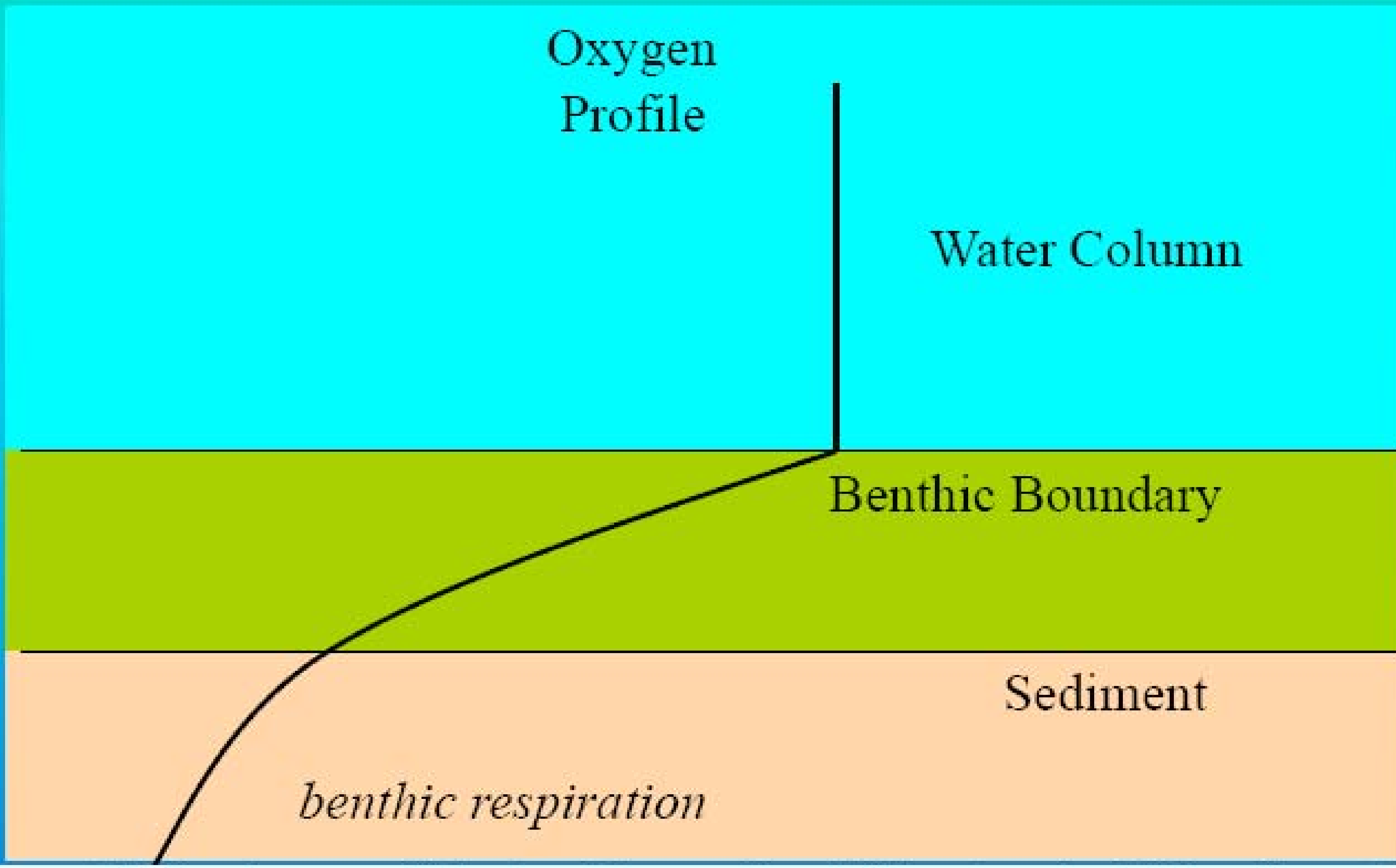
Bioenergetics Model



Atlantic Salmon measurements and AquaModel calculations

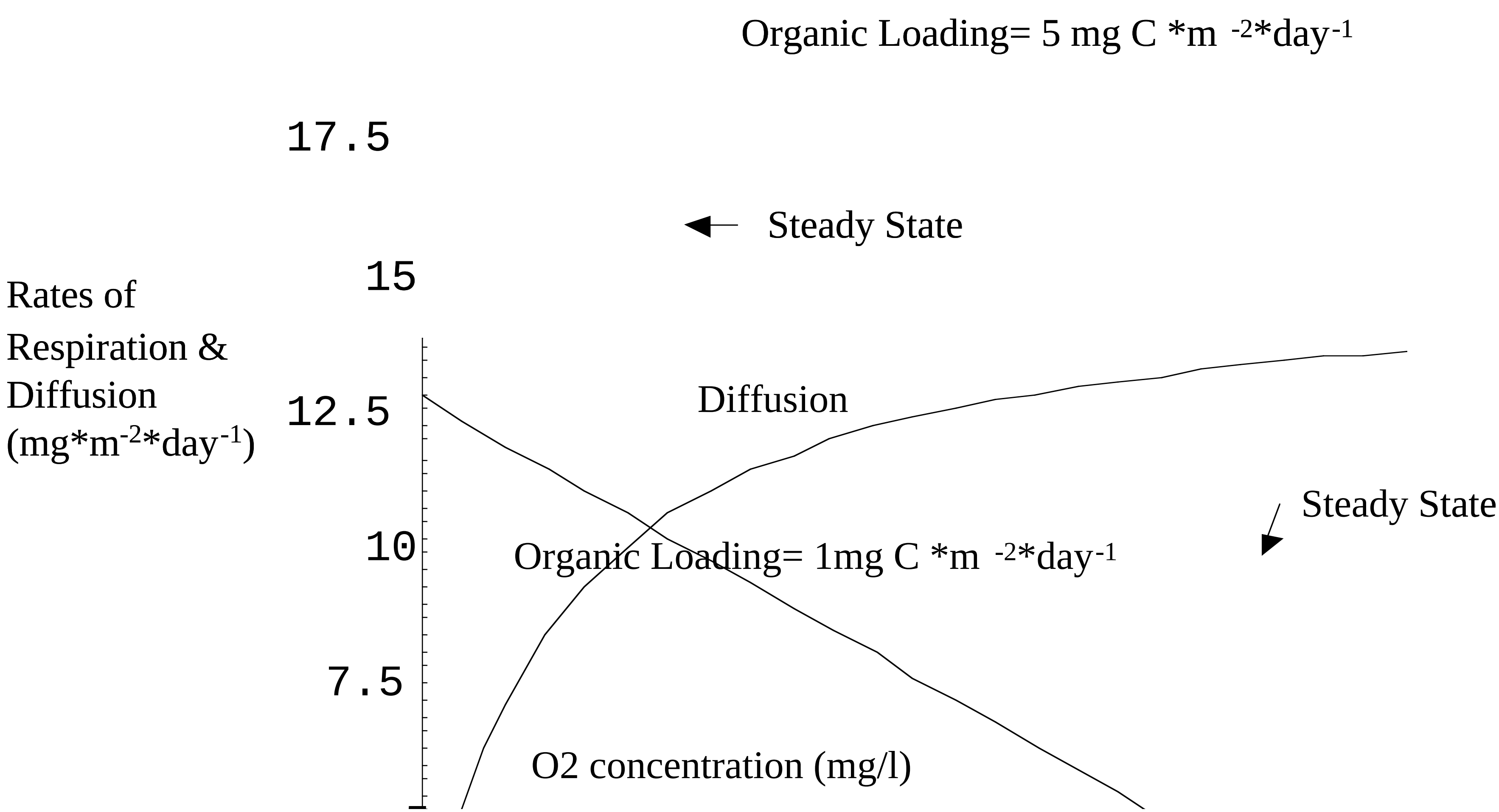


Oxygen Diffusion at Benthic Boundary Layer

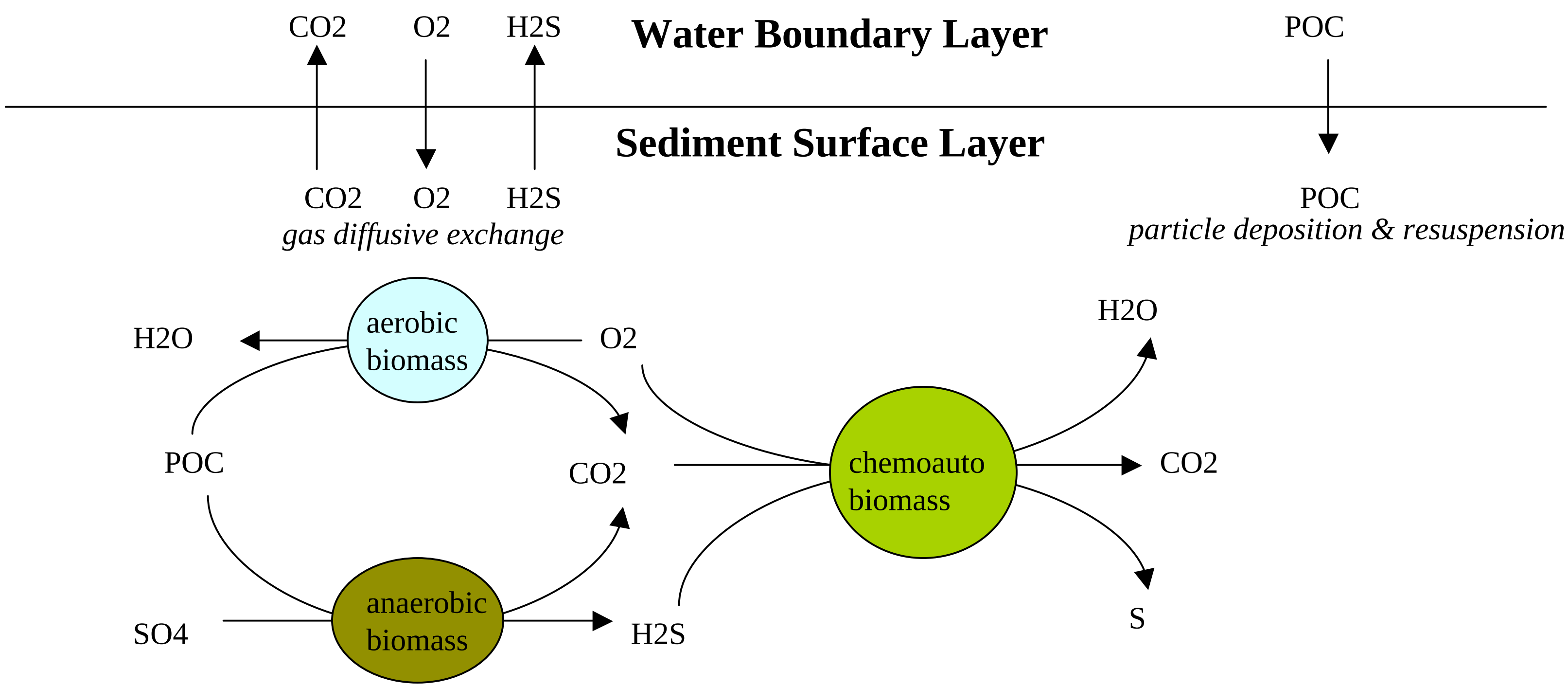


$$JO2 = \frac{\text{Diffusion coefficient Porosity } (O2[\text{water}] - O2[\text{sediment}])}{\sqrt{\frac{C1}{\text{Velocity}}} + C2}$$

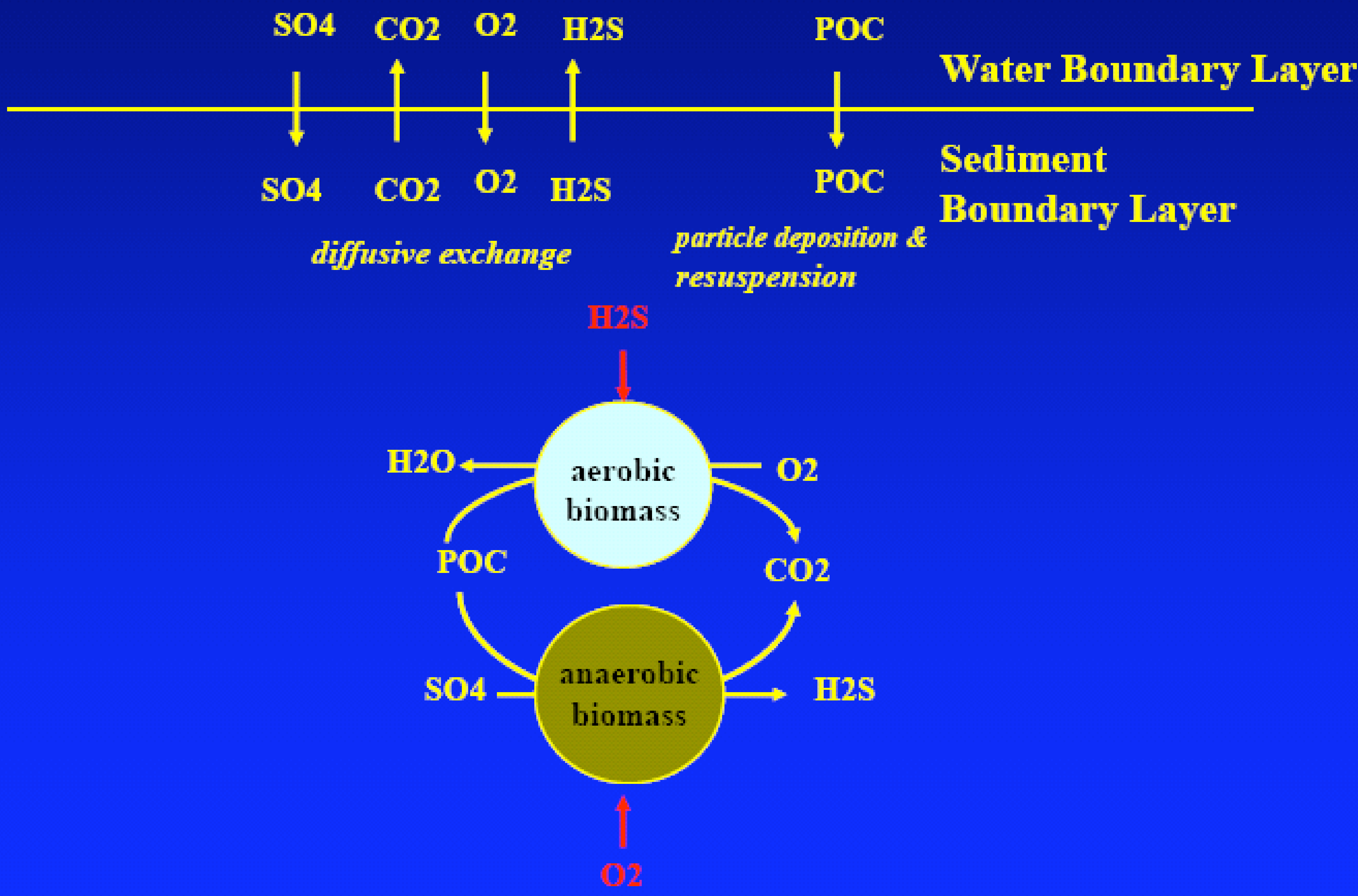
Behavior of benthic subroutine: steady state conditions defined for low and high rates of loading.

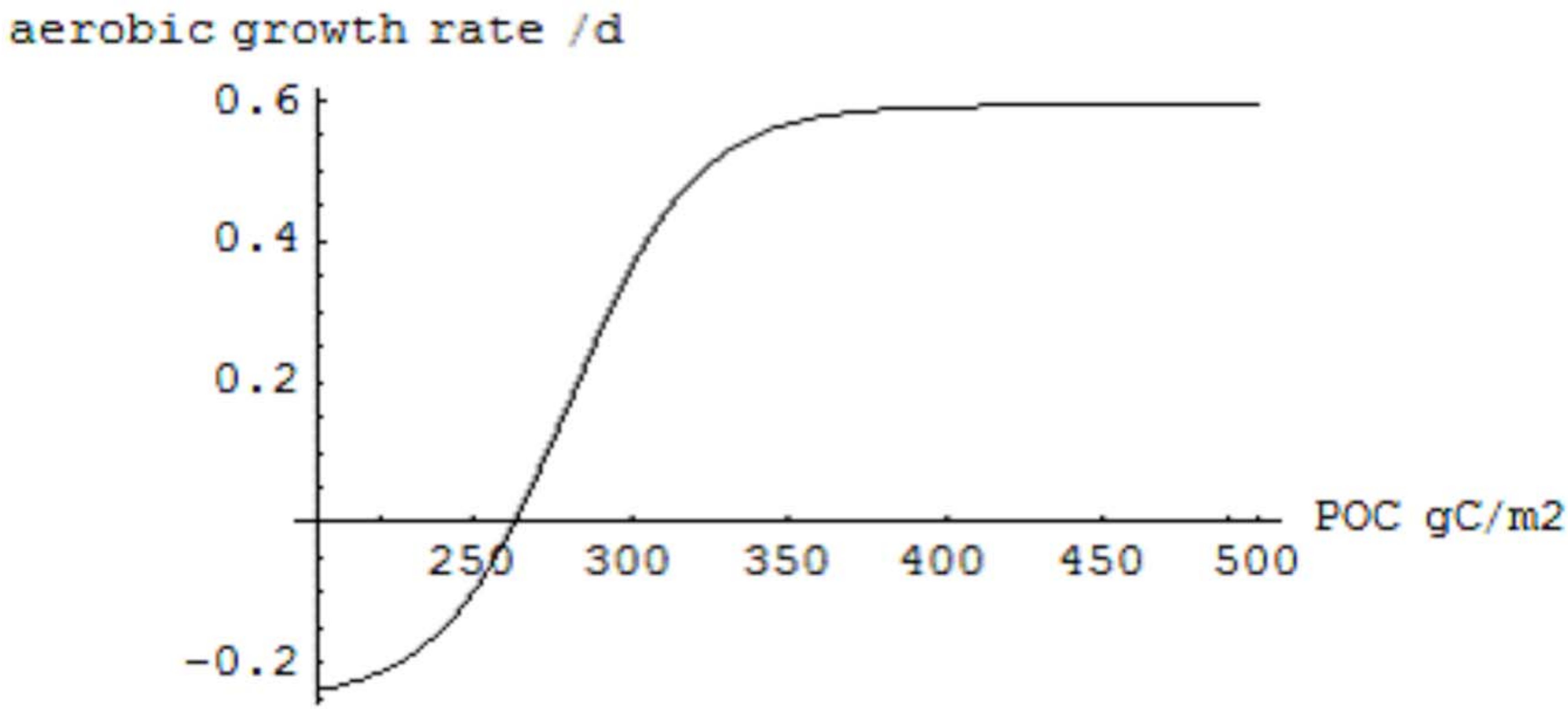


Benthic Dynamics

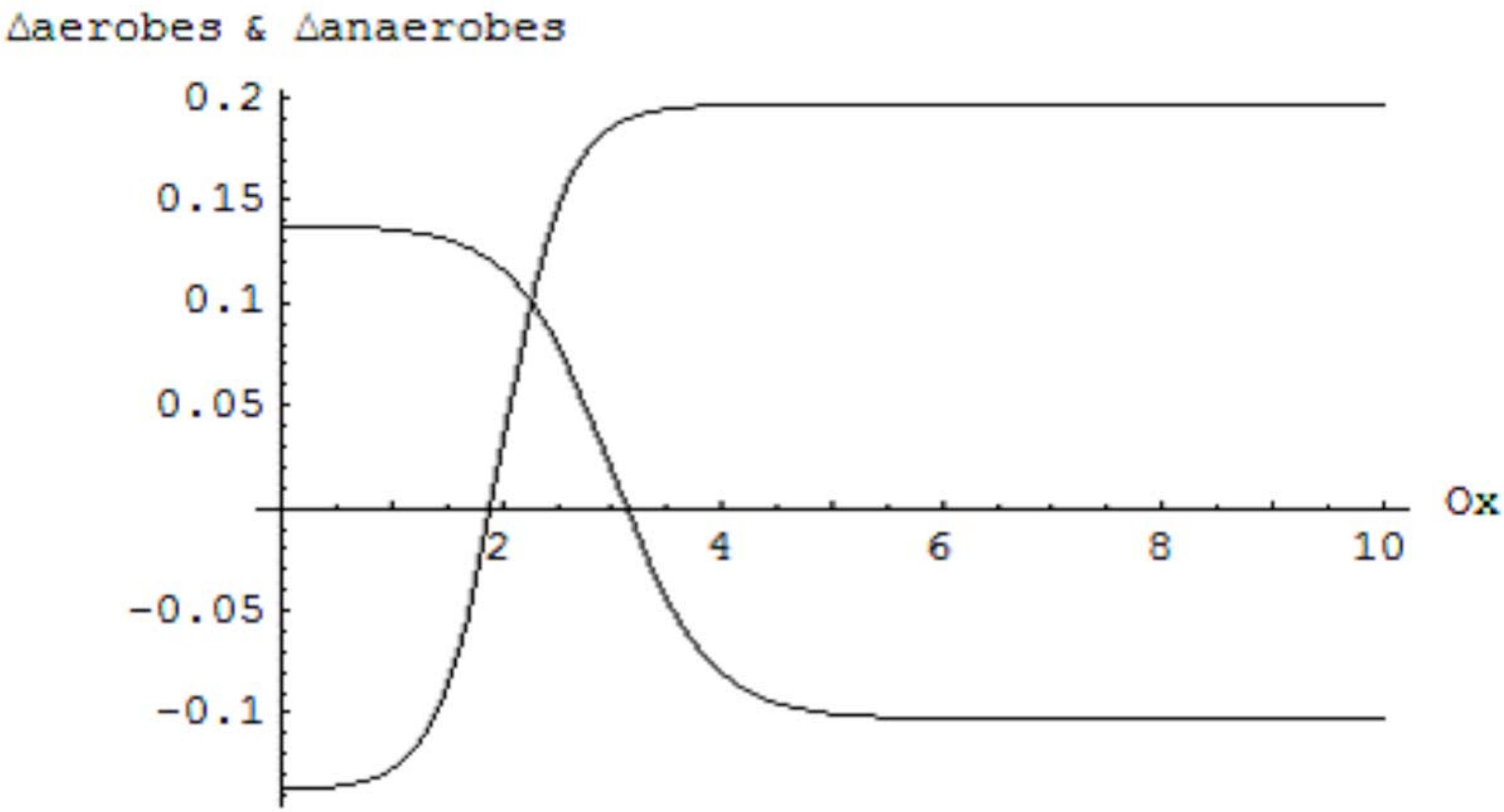


Benthic Dynamics

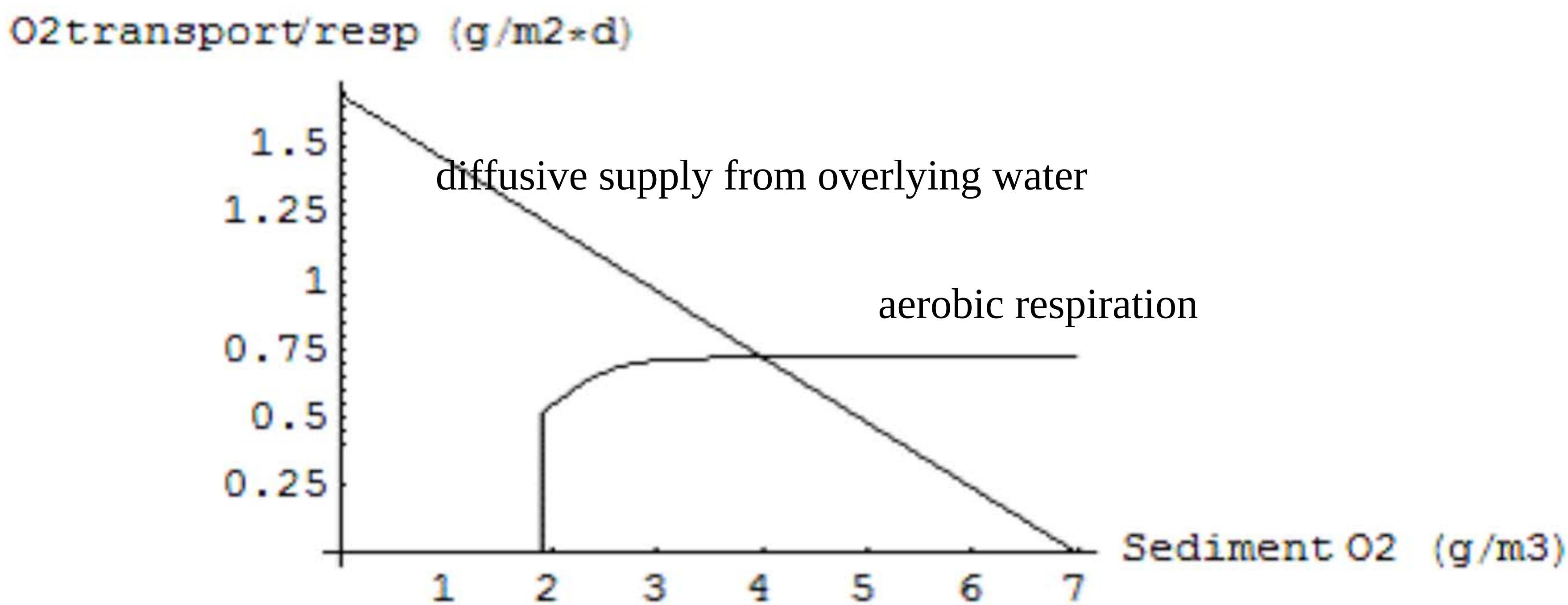




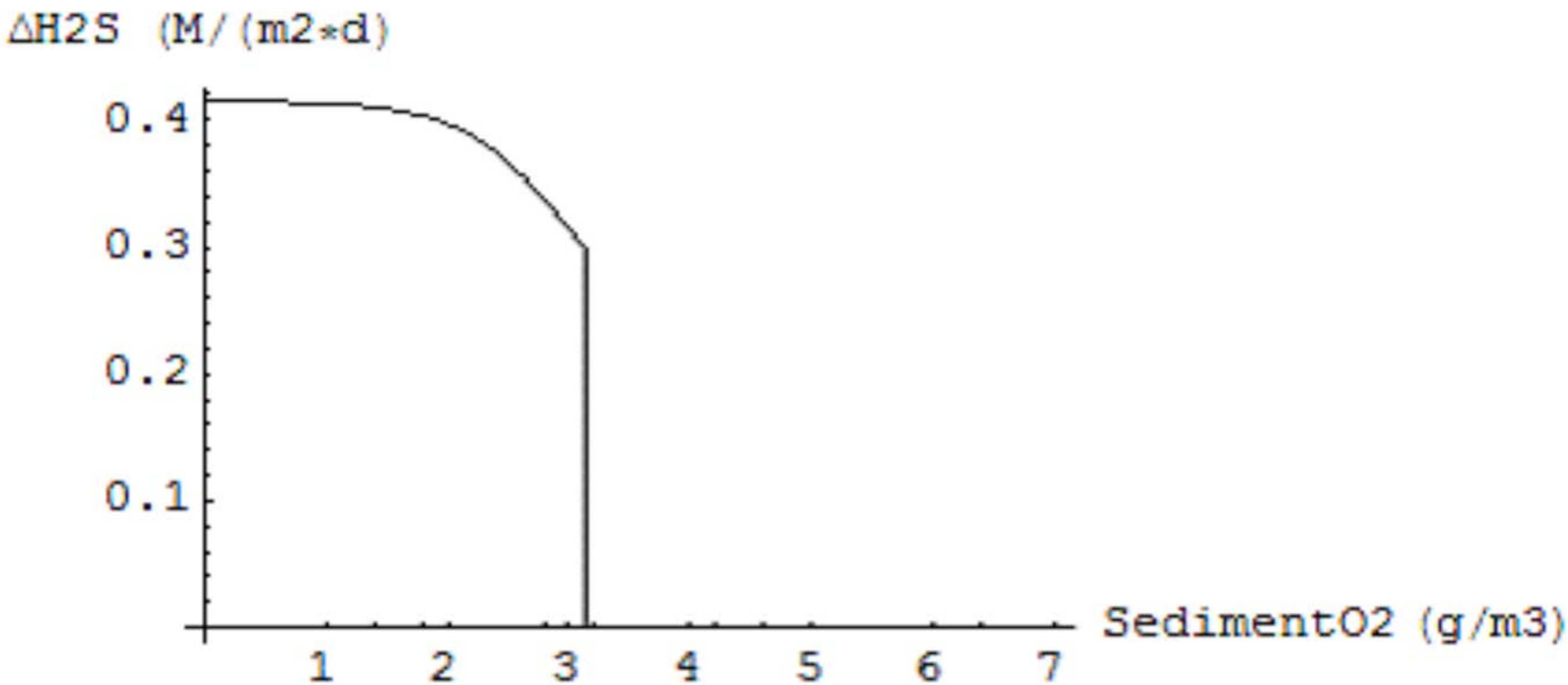
Specific growth rate of aerobic microbial community as a function of reactive carbon concentration (temperature, oxygen saturating)



Change in specific growth rate of aerobic and anaerobic communities as a function of O2 concentration. Temperature and concentration of particulate organic carbon are saturating.

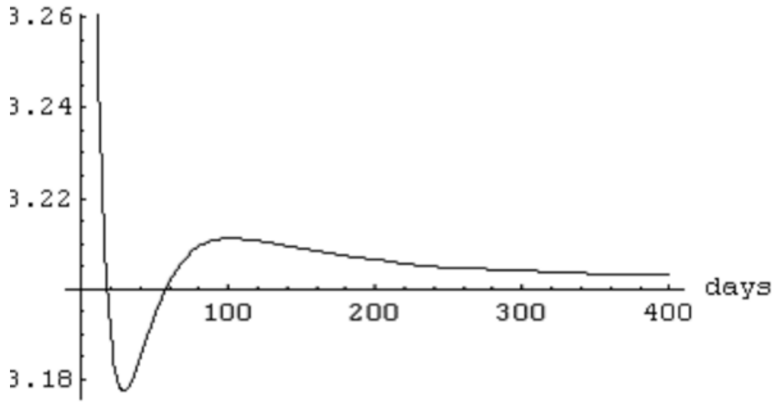


Respiration rate of aerobic microbial community and rate of diffusion of oxygen into the sediments as a function sediment 02 concentration. Oxygen concentration in the overlying water is 7 g/m3, and nominal bottom flow.

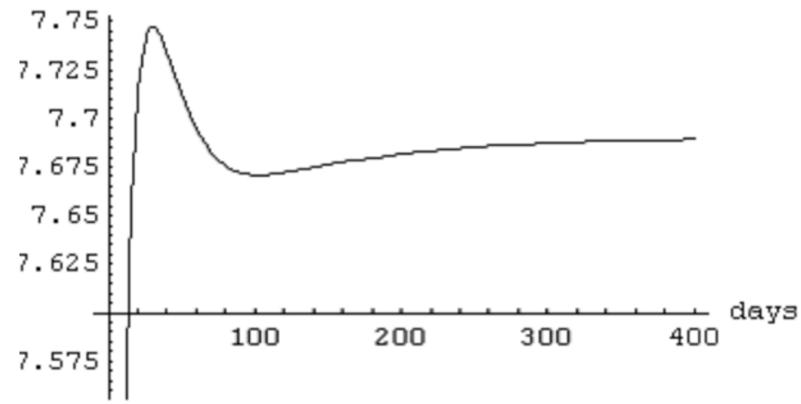


Rate of H2S production by anaerobic community as a function of the sediment O2 concentration.   Calculations are for nominal temperature and concentrations of anaerobic microbes and concentration of reactive, particulate organic carbon.

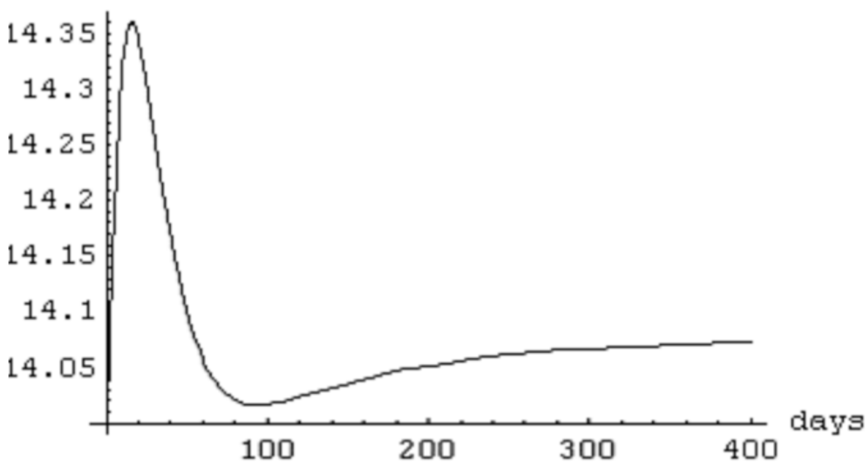
sediment O_2



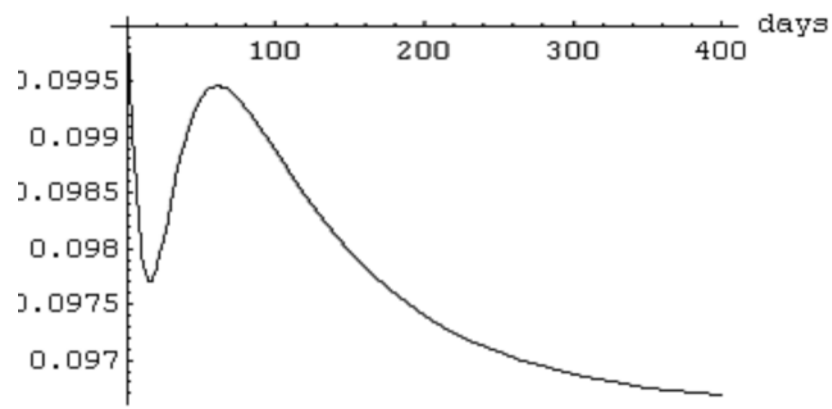
aerobic biomass



sediment POC

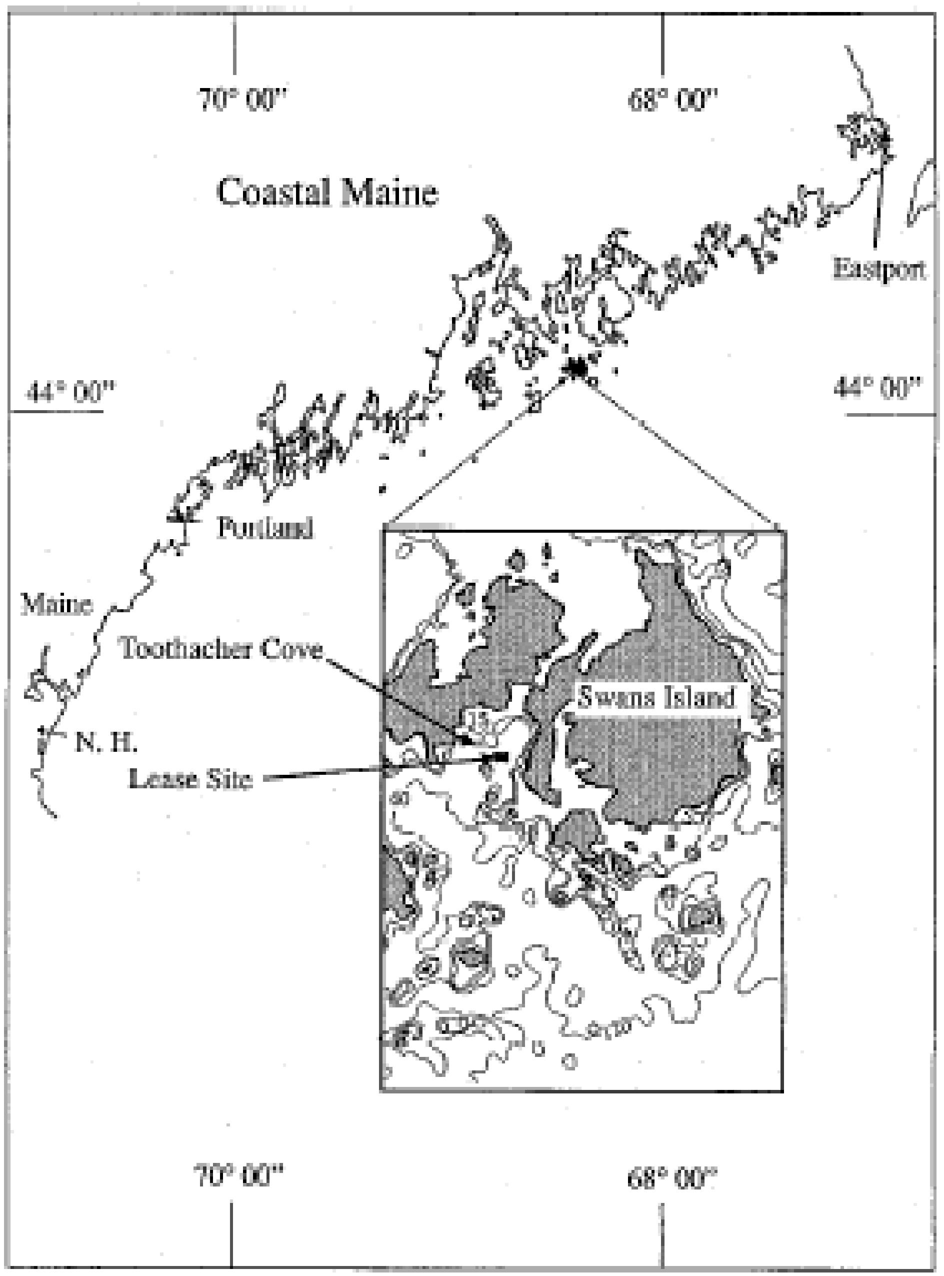


anaerobic biomass



Simulation under constant, nominal conditions of temperature, water column O2, bottom currents, and organic loading of the sediments. **Steady state conditions** are established in about three months.

Findlay & Watling (94, 95, 97)



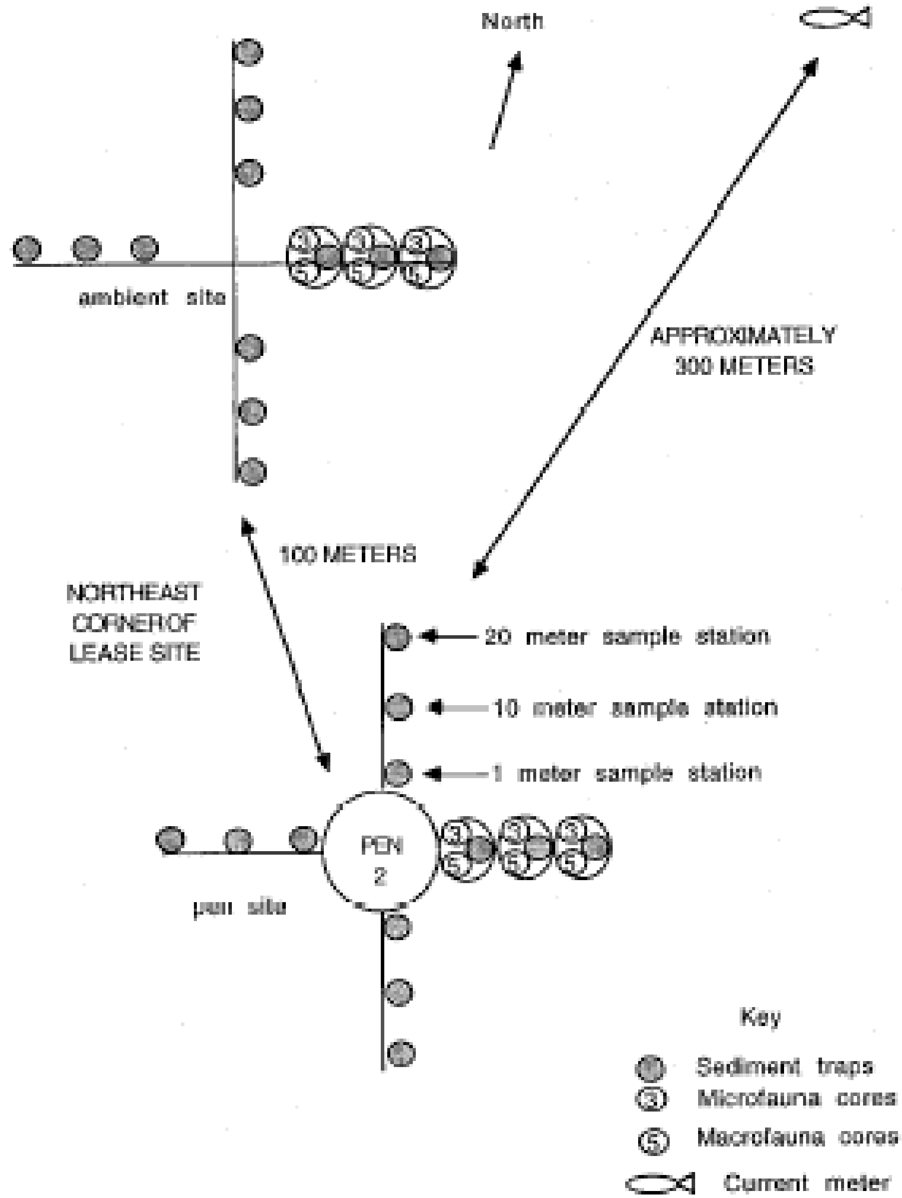
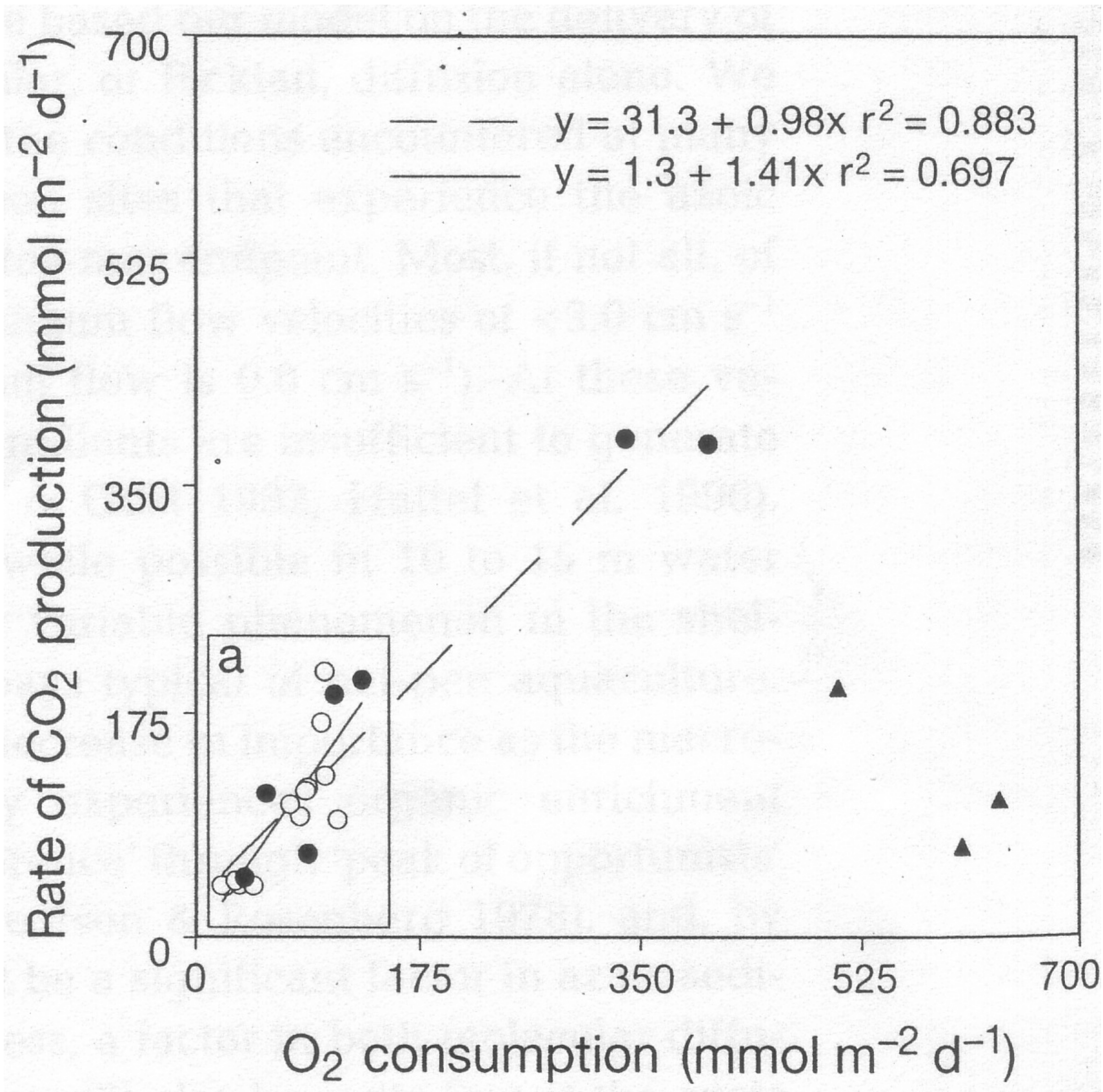
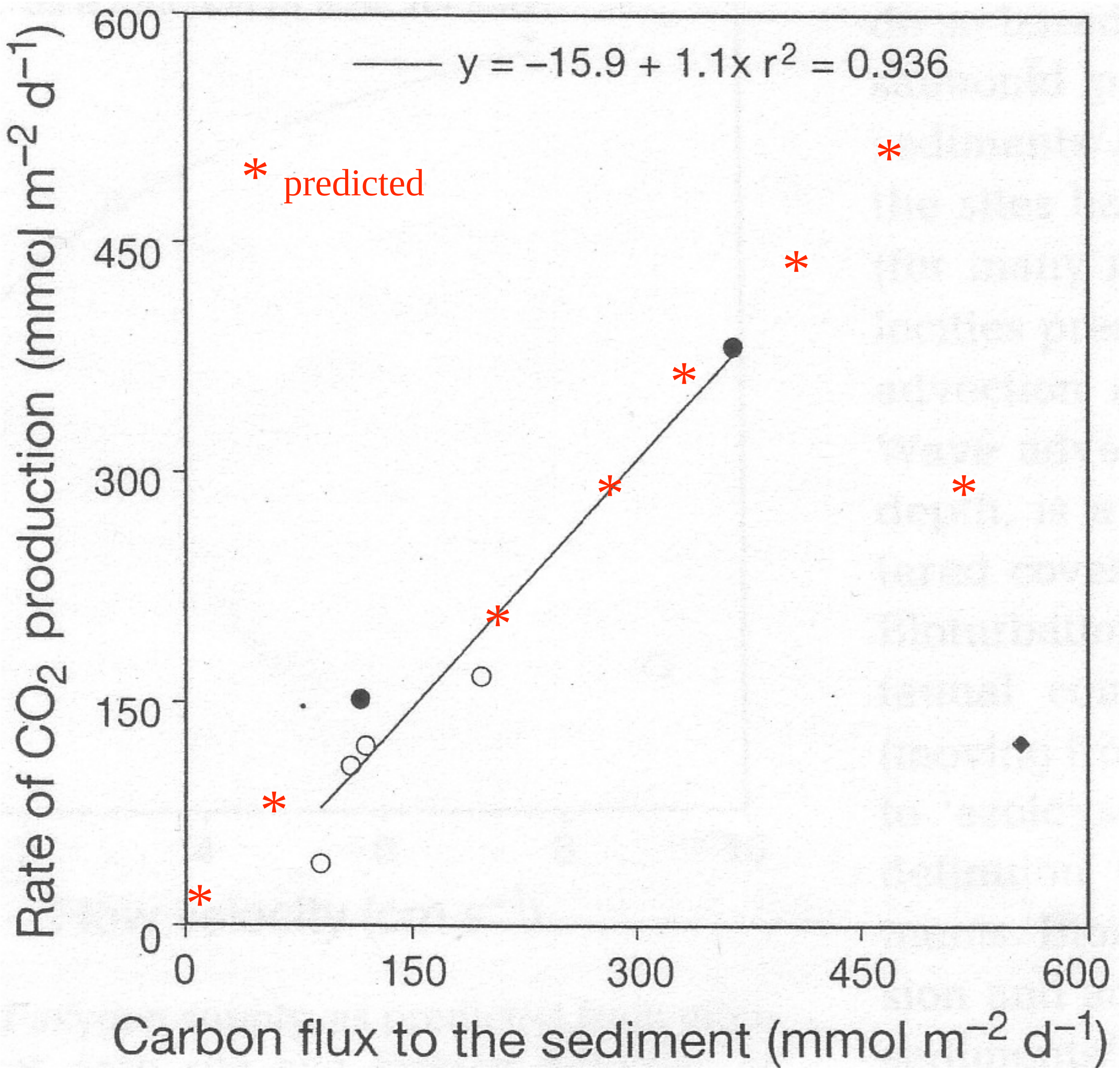


Fig. 3. Graphic representation of experimental design utilized for Toothacher Cove net-pen study.

O2 Consumption to Carbon Flux



CO2 Production vs Carbon Deposition



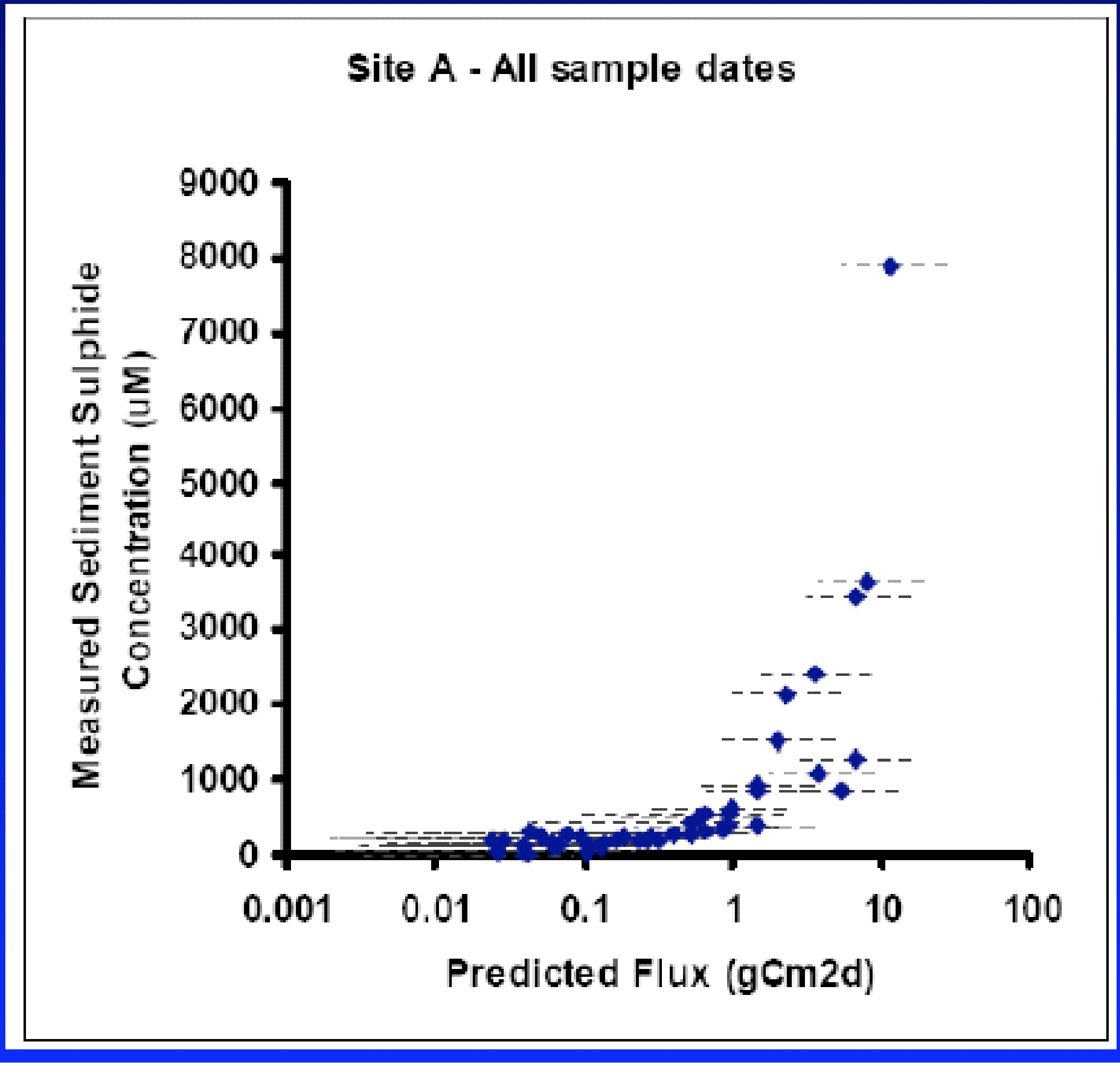


Figure 8 – Relationship between predicted carbon flux and measured sediment sulphide concentration (µM). Solid (♦) represents median parameter estimates with dashed horizontal line representing best- and worse- case parameter estimates.

Chamberlain and Stucci in press

Gokasho Bay data

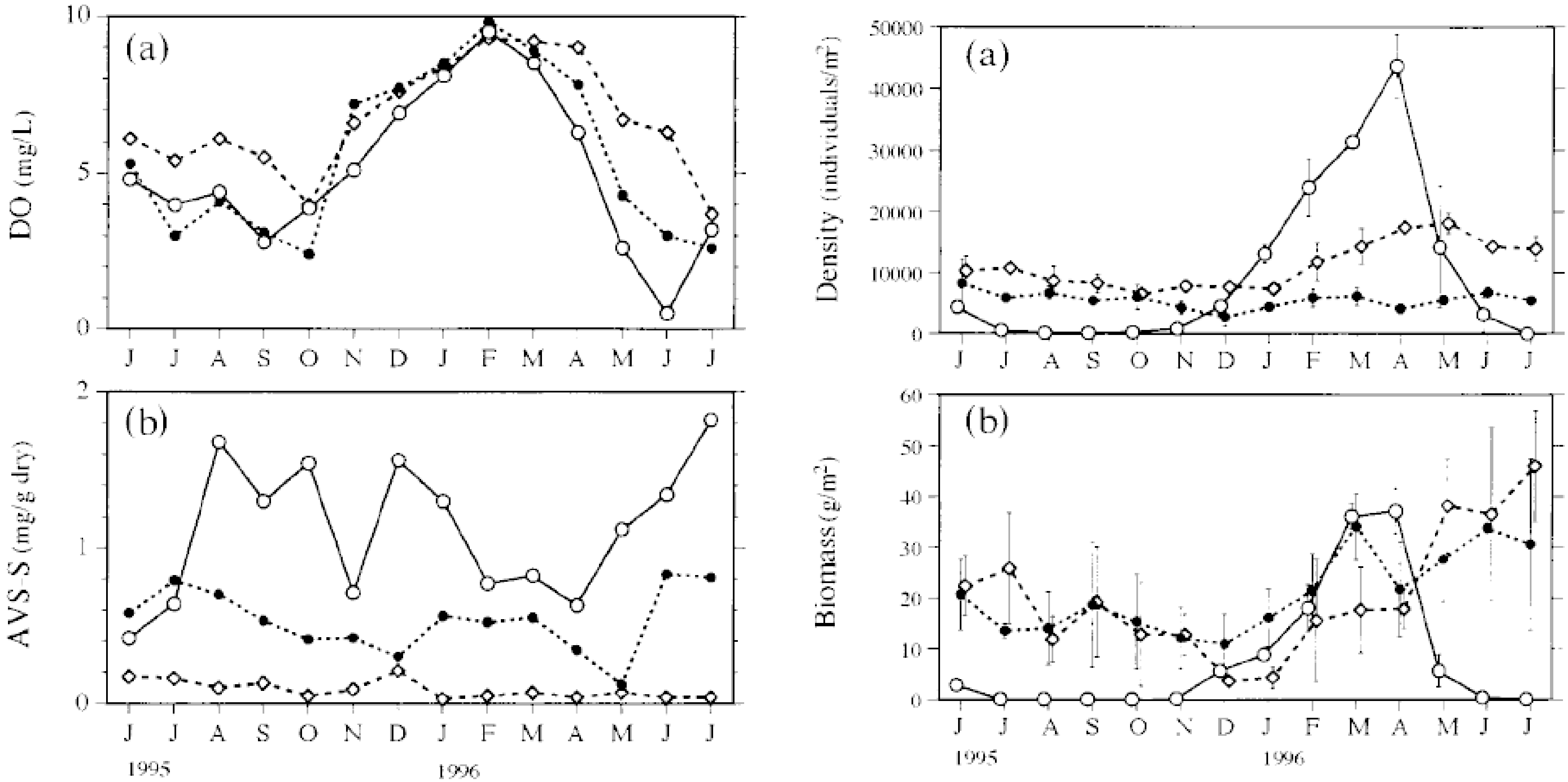
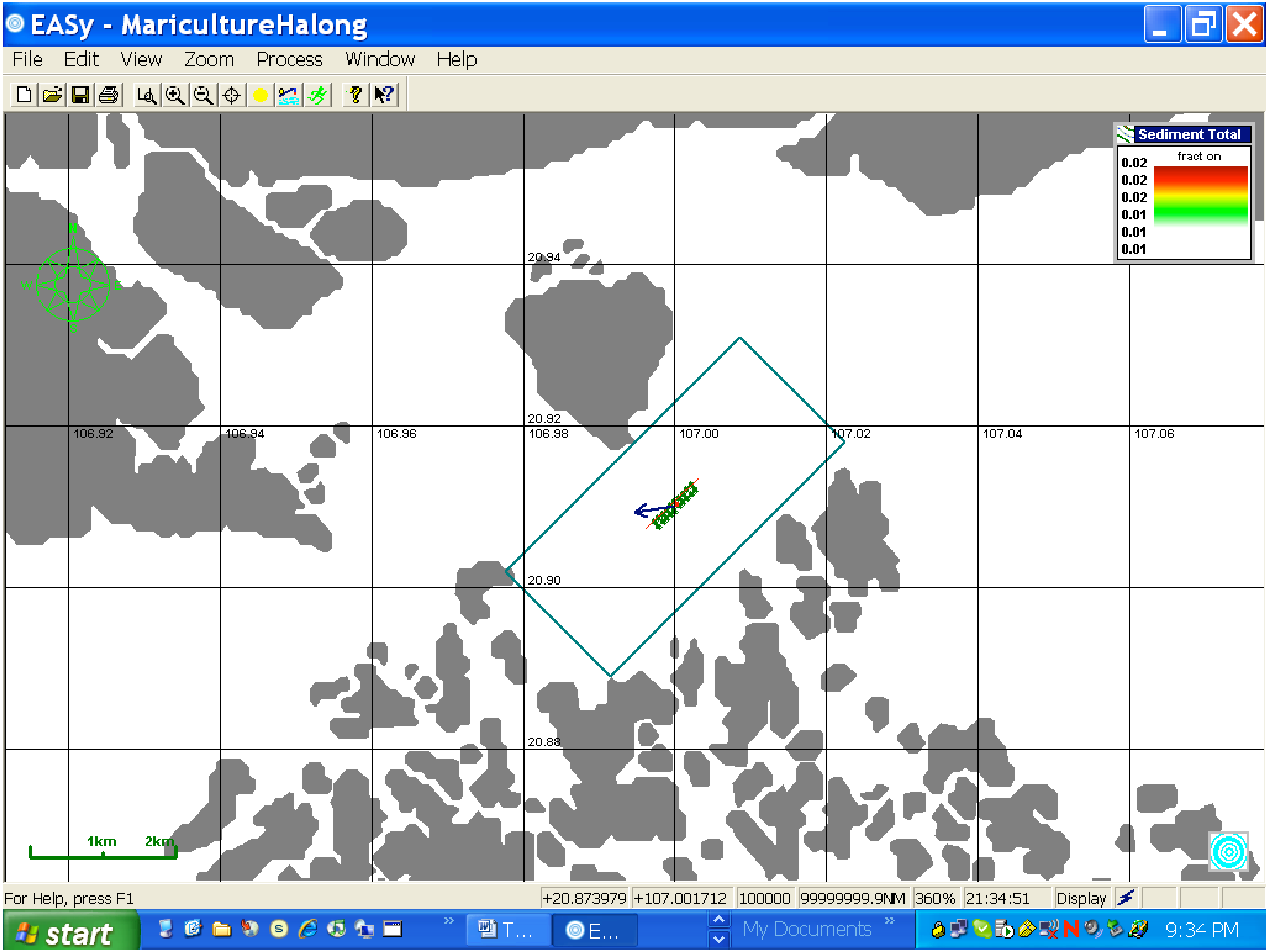
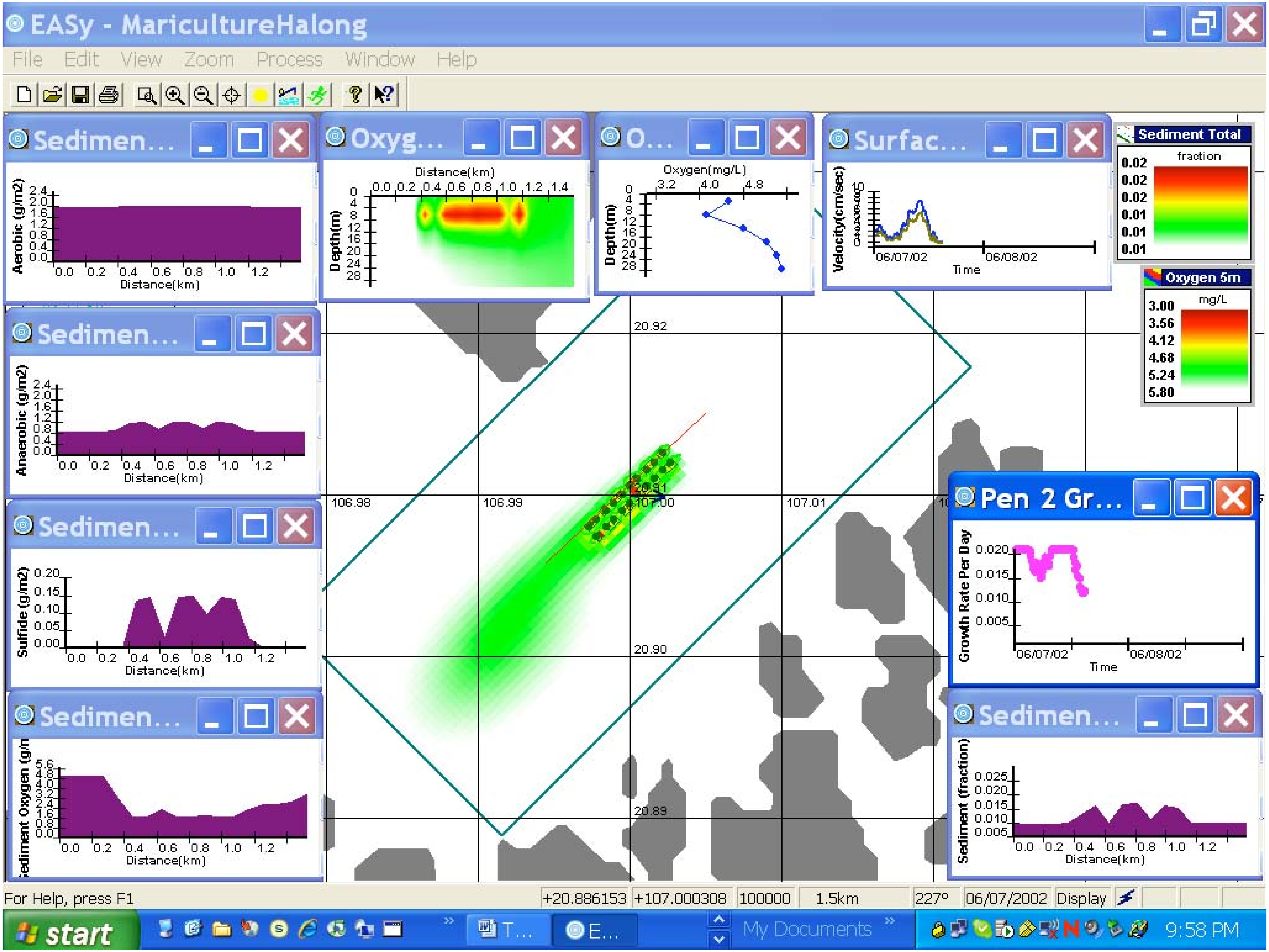
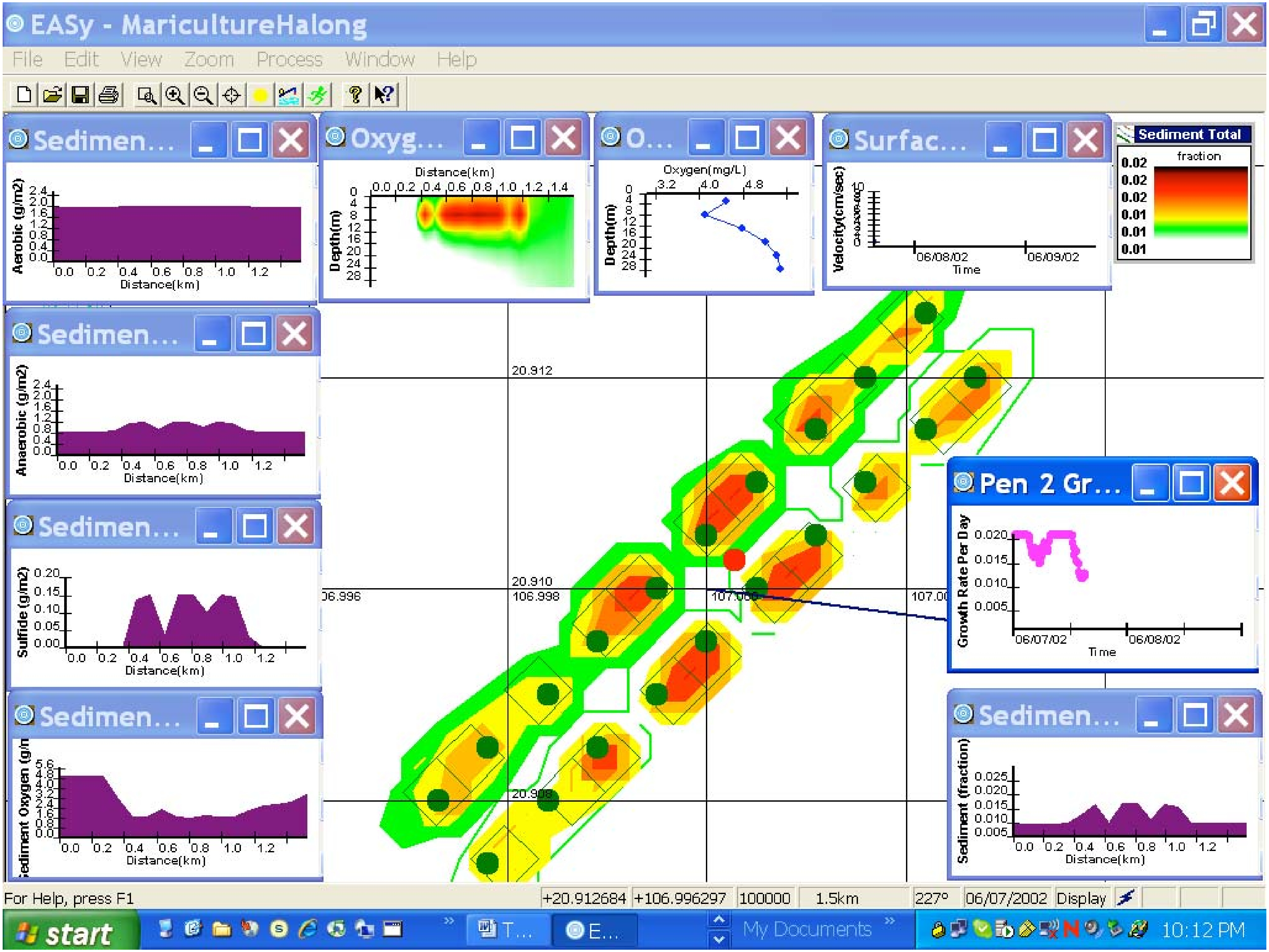


Figure 6.7. Monthly values at the sediment boundary for the concentration of dissolved oxygen (upper left), acid volatile sulfides (lower left), and numerical density (upper right) and biomass (lower right) of the macrobenthos. The three plots are values for the farm site (o), a nearby pearl farm (.), and control station (o).


EASy - MaricultureHalong
File Edit View Zoom Process Window Help
Sediment Total
fraction
0.02
0.02
0.02
0.01
0.01
0.01
N
W
E
S
20.94
20.92
20.90
20.88
106.92
106.94
106.96
106.98
107.00
107.02
107.04
107.06
1km
2km
For Help, press F1
+20.873979
+107.001712
100000
99999999.9NM
360%
21:34:51
Display
start
My Documents
9:34 PM


EASy - MaricultureHalong
File Edit View Zoom Process Window Help
Sedimen...
Aerobic (g/m2)
Distance(km)
Oxyg...
Distance(km)
Depth(m)
O...
Oxygen(mg/L)
Depth(m)
Surfac...
Velocity(cm/sec)
06/07/02
06/08/02
Time
Sediment Total
fraction
Oxygen 5m
mg/L
Sedimen...
Anaerobic (g/m2)
Distance(km)
Sedimen...
Sulfide (g/m2)
Distance(km)
Sedimen...
Sediment Oxygen (g/m
Distance(km)
Pen 2 Gr...
Growth Rate Per Day
Time
Sedimen...
Sediment (fraction)
Distance(km)
For Help, press F1
+20.886153 +107.000308 100000 1.5km 227° 06/07/2002 Display
start
My Documents
9:58 PM



EASy - MaricultureHalong
File Edit View Zoom Process Window Help
Sedimen...
Aerobic (g/m2)
Distance(km)
Oxyg...
Distance(km)
Depth(m)
O...
Oxygen(mg/L)
Depth(m)
Surfac...
Velocity(cm/sec)
06/08/02
06/09/02
Time
Sediment Total
fraction
Sedimen...
Anaerobic (g/m2)
Distance(km)
Sedimen...
Sulfide (g/m2)
Distance(km)
Sedimen...
Sediment Oxygen (g/m
Distance(km)
20.912
20.910
106.998
107.000
20.908
Pen 2 Gr...
Growth Rate Per Day
06/07/02
06/08/02
Time
Sedimen...
Sediment (fraction)
Distance(km)
For Help, press F1
+20.912684 +106.996297 100000 1.5km 227° 06/07/2002 Display
start
My Documents
10:12 PM

Conclusions

• While the biological dynamics of benthic cycling of nutrients is complicated, I propose that we have sufficient scientific knowledge to successfully employ generalized models that are tuned to local field measurements.

• These models will be used to find optimal sites for restoration and intervention and define the parameters of sustainable operations.

• The software that I have discussed is devoted to research on managing marine resources. If you are interested in using either AquaModel or our EASy geographical information system for your research, please contact me or introduce yourself to me during our meeting.