AquaModel software application to understand the regional effects of multiple marine fish farms in the Gulf of Maine, USA

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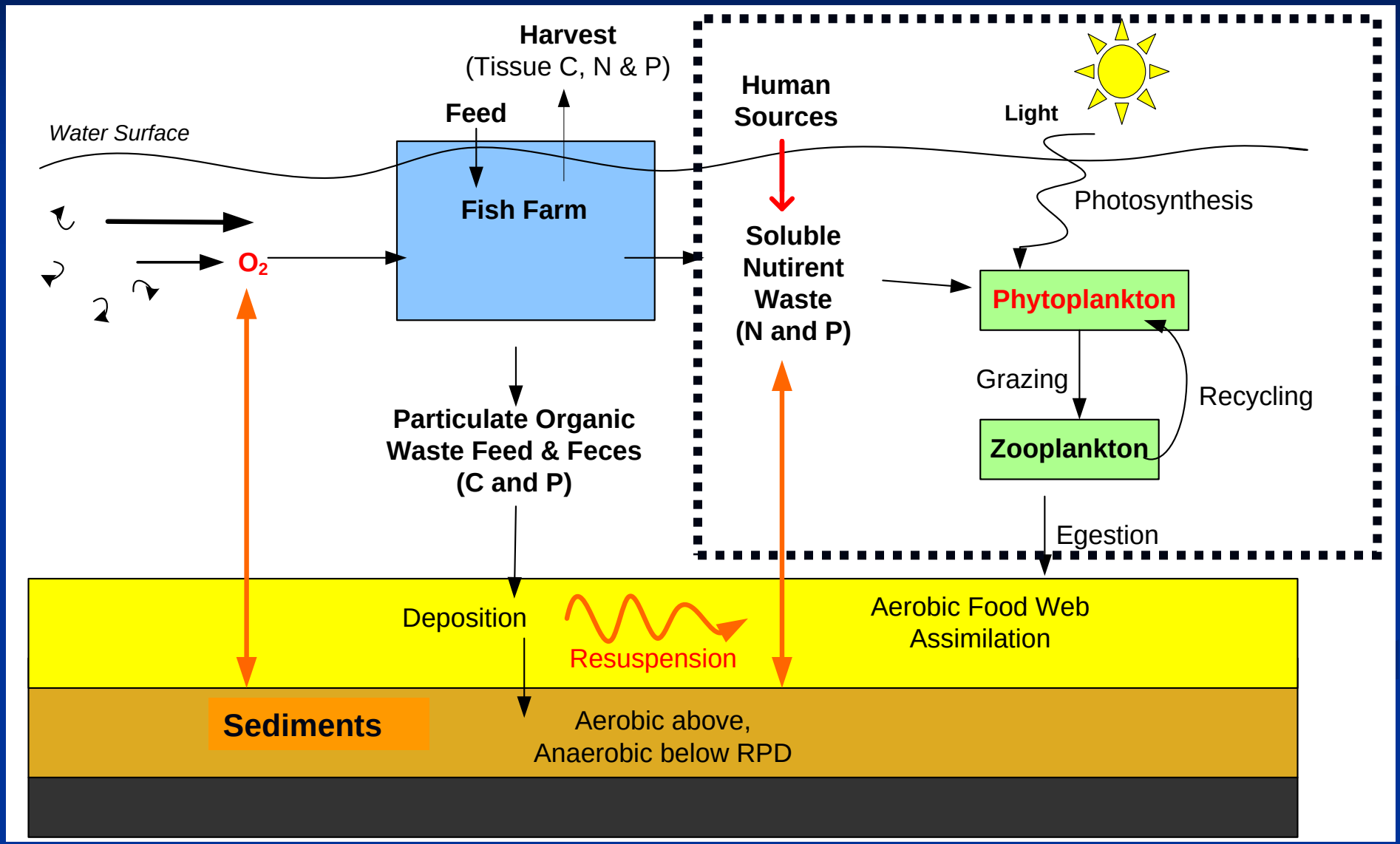
Think of all the complex interactions of the chemical, physical and biological processes

AquaModel (Conceptual)



So what was done that was new?

Well….we wanted to be able to run long term simulations (e.g. 18 months)…so we really needed a lot of long term data sets

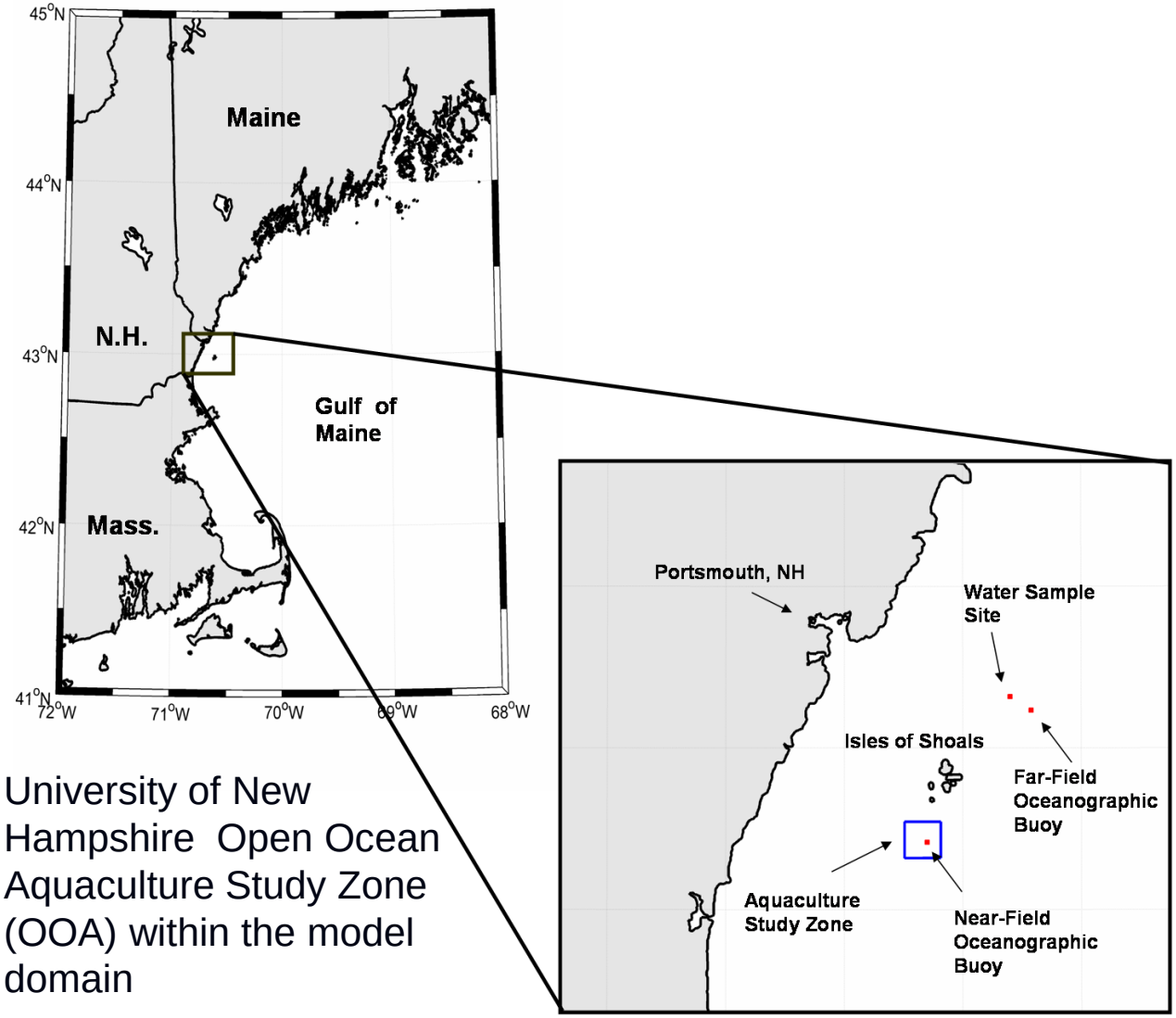
Objectives/Approach

1. Develop AquaModel to take environmental data sets characteristic of a region including:
    - Temperature, dissolved oxygen and inorganic nitrogen
    - Components of the nitrification process
    - Nitrogen from phyto- and zooplankton
    - Irradiance and wind speed

2. Develop regional circulation data sets
    - Validated circulation model for tides
    - Tides superimposed with depth dependent weather induced currents

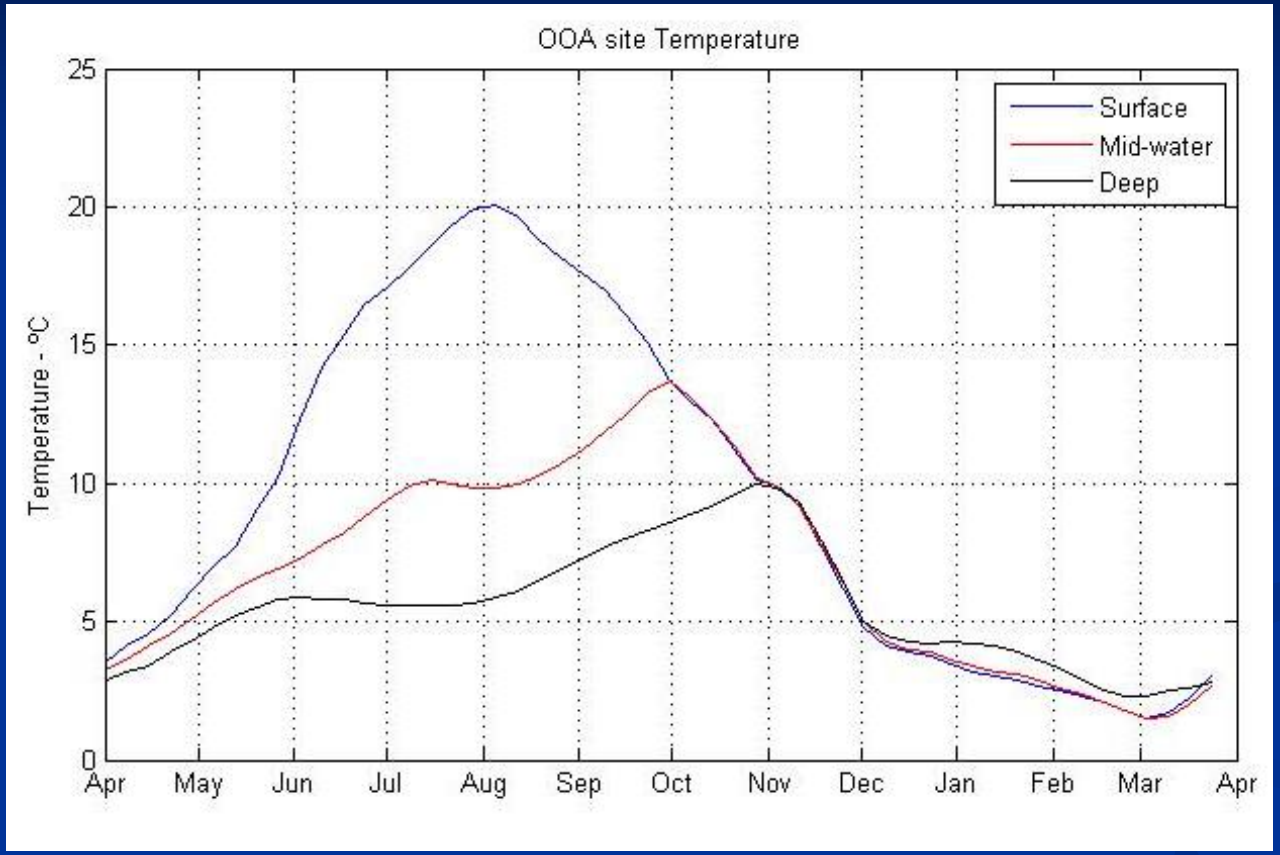
3. Perform regional fish farm waste modeling (AquaModel)
    - 8 “large” fish farms – 1.35 million fish each
    - Investigate growth and dissolved oxygen
    - Water column farm interactions using nitrogen concentrations?

Modeling and Data Collection Site



University of New Hampshire Open Ocean Aquaculture Study Zone (OOA) within the model domain

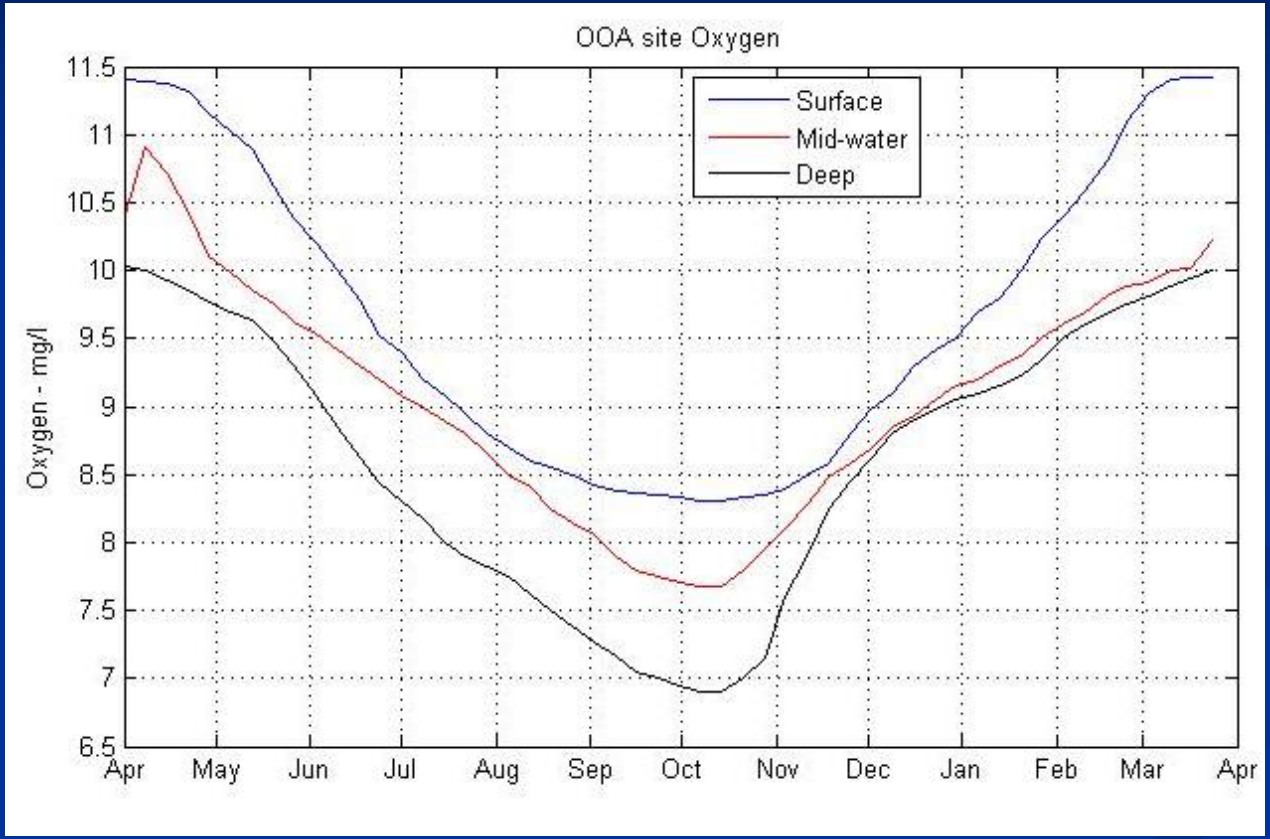
Temperature
Composite data set for 1-Year



Temperature is needed for the growth-rate calculations and therefore affects the loading rate (benthos and water column) – repeats after 1-year

Dissolved Oxygen

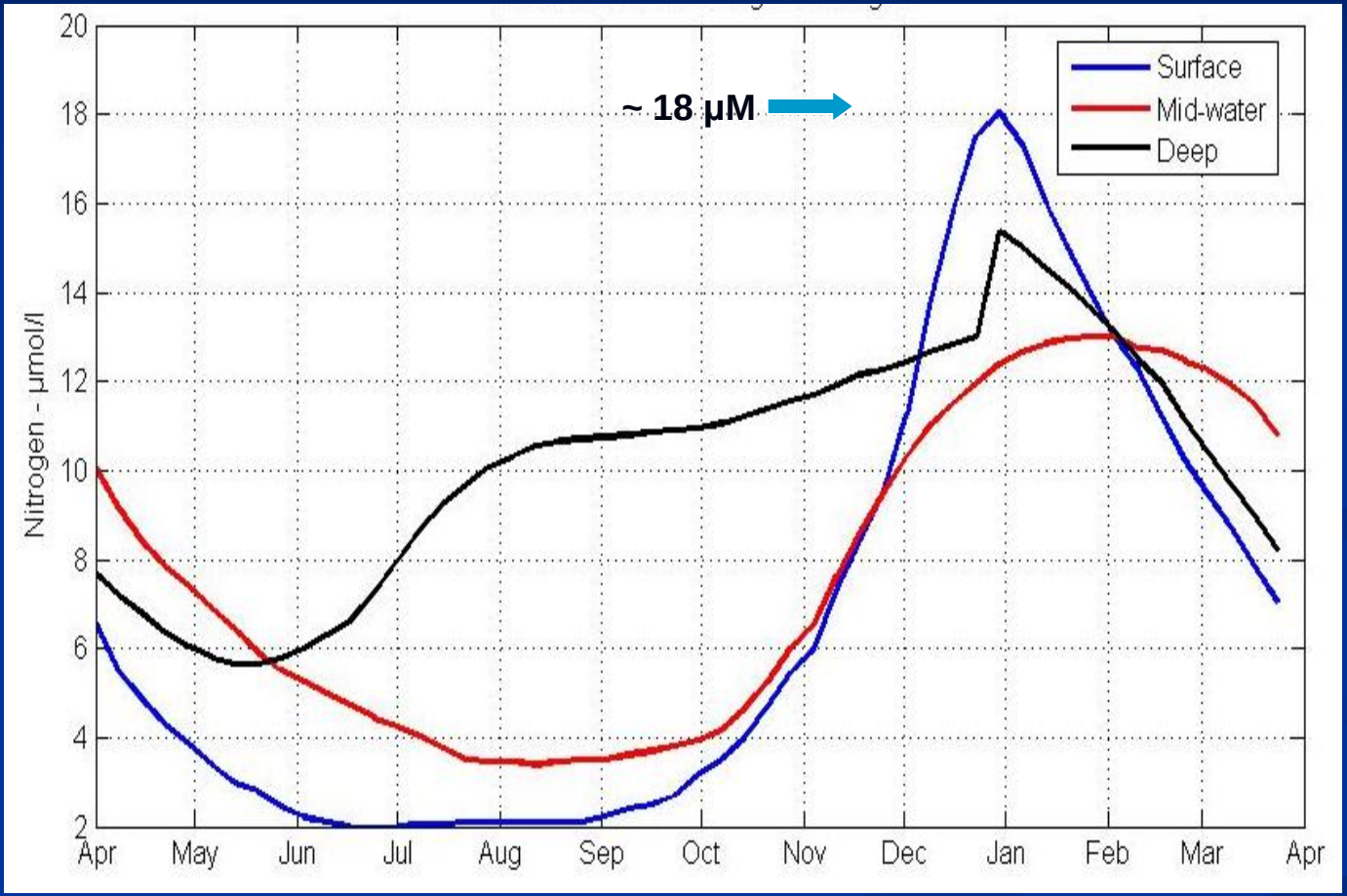
Composite data set for 1-Year



Ambient dissolved oxygen affects growth therefore production of wastes (solids and dissolved). Values are higher during the colder months, lower during the warmer months upon the location within the water column

Dissolved Inorganic Nitrogen

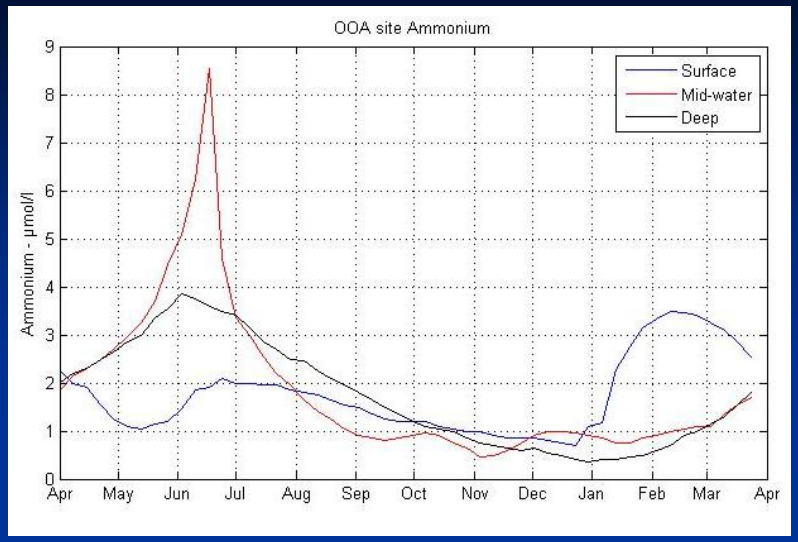
Composite data set for 1-Year



Note the levels and fluctuations of the ambient data throughout the year

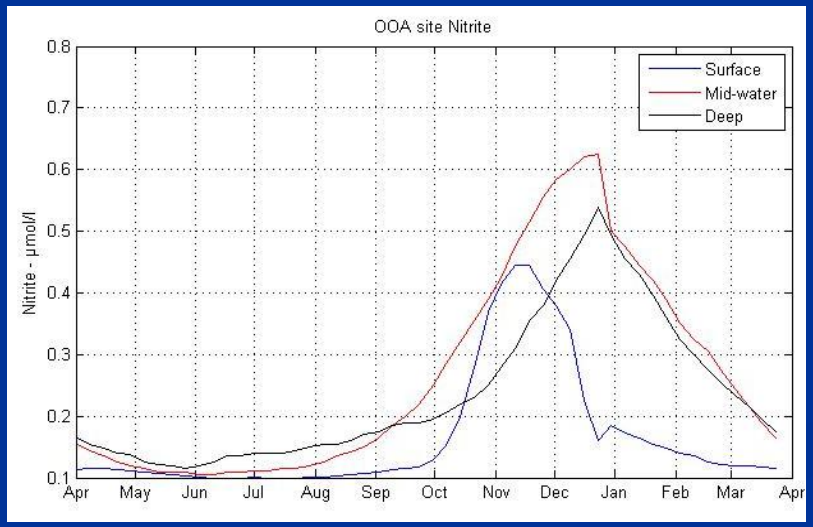
Composite data sets for 1-Year

Ammonium and Ammonia

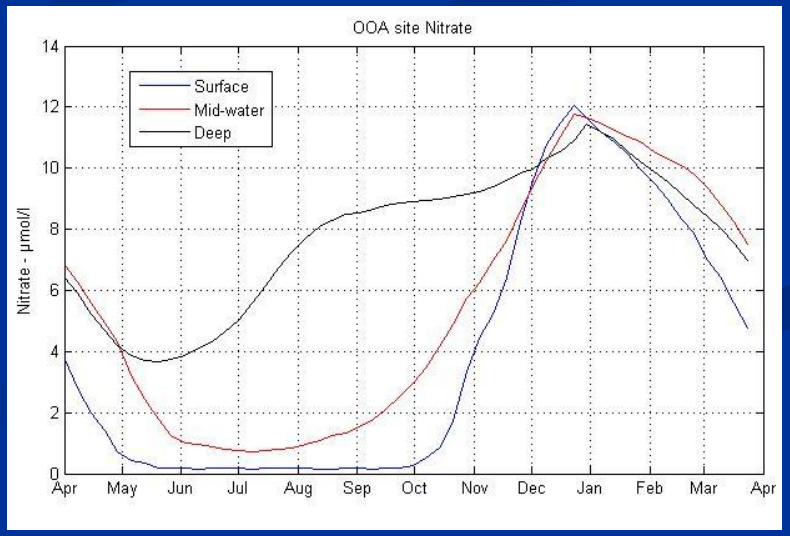


Information is included in the water column NPZ dynamic model

Nitrite



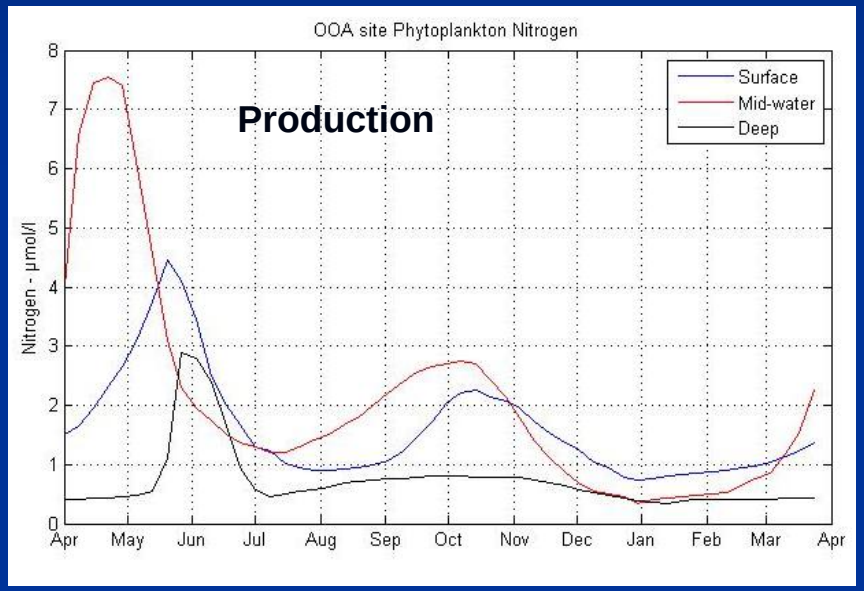
Nitrate



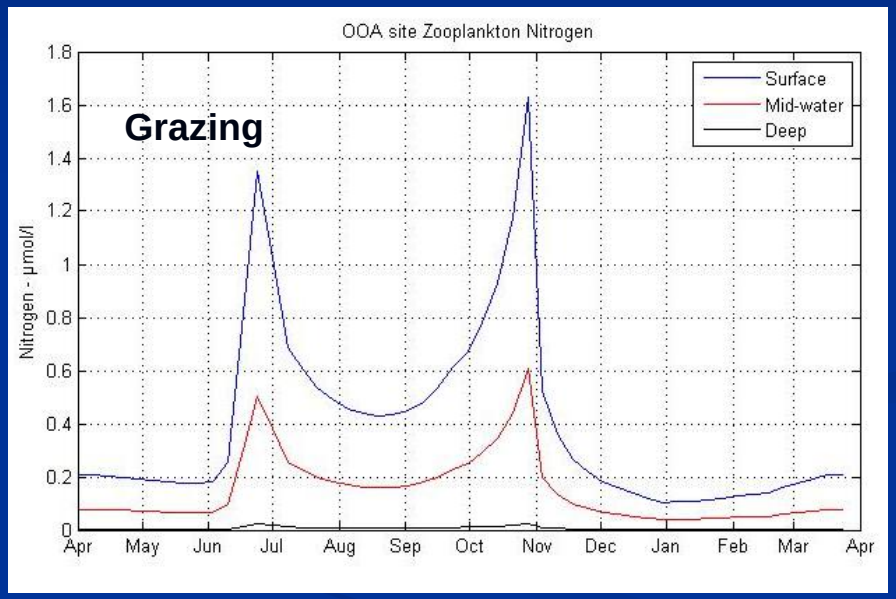
Nitrogen, Phytoplankton and Zooplankton

Composite data set for 1-Year

Phytoplankton Nitrogen



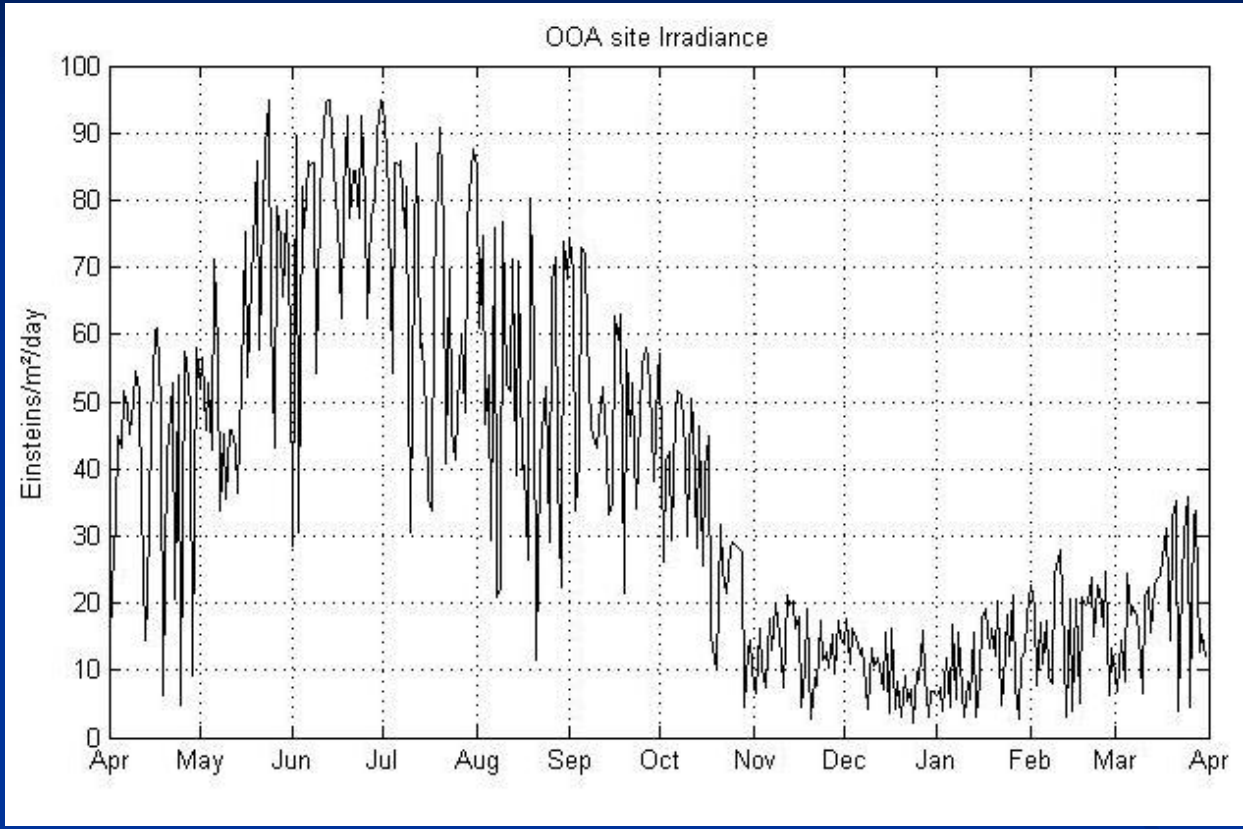
Zooplankton Nitrogen



Nitrogen concentration is related to the phytoplankton blooms that occur in April and Sept. Ambient values affect the NPZ model results

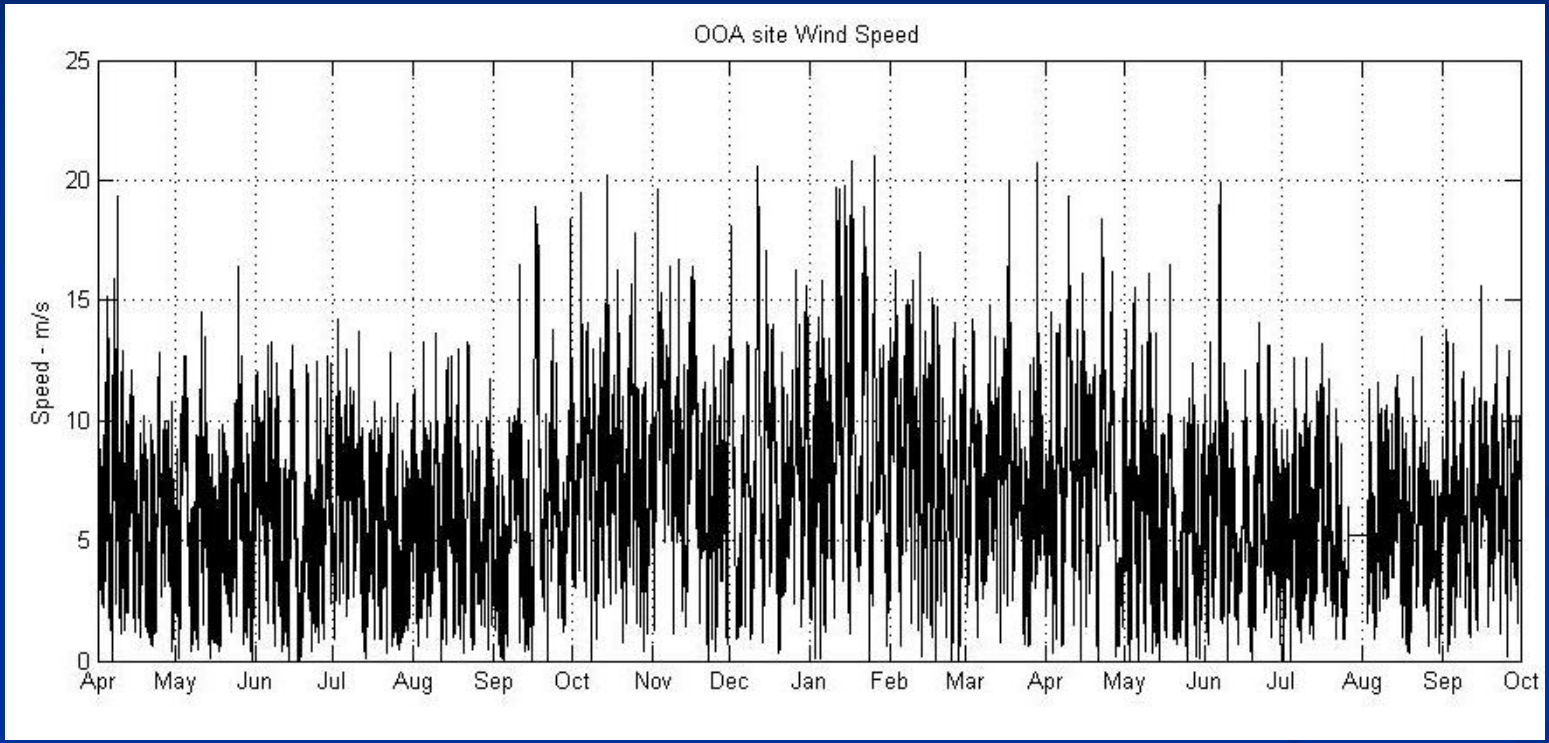
Irradiance

Composite data set for 1-Year



Daily average amount of sunlight (irradiance) affects phytoplankton production - enhances in the summer and limits in the winter

Wind Speed Data



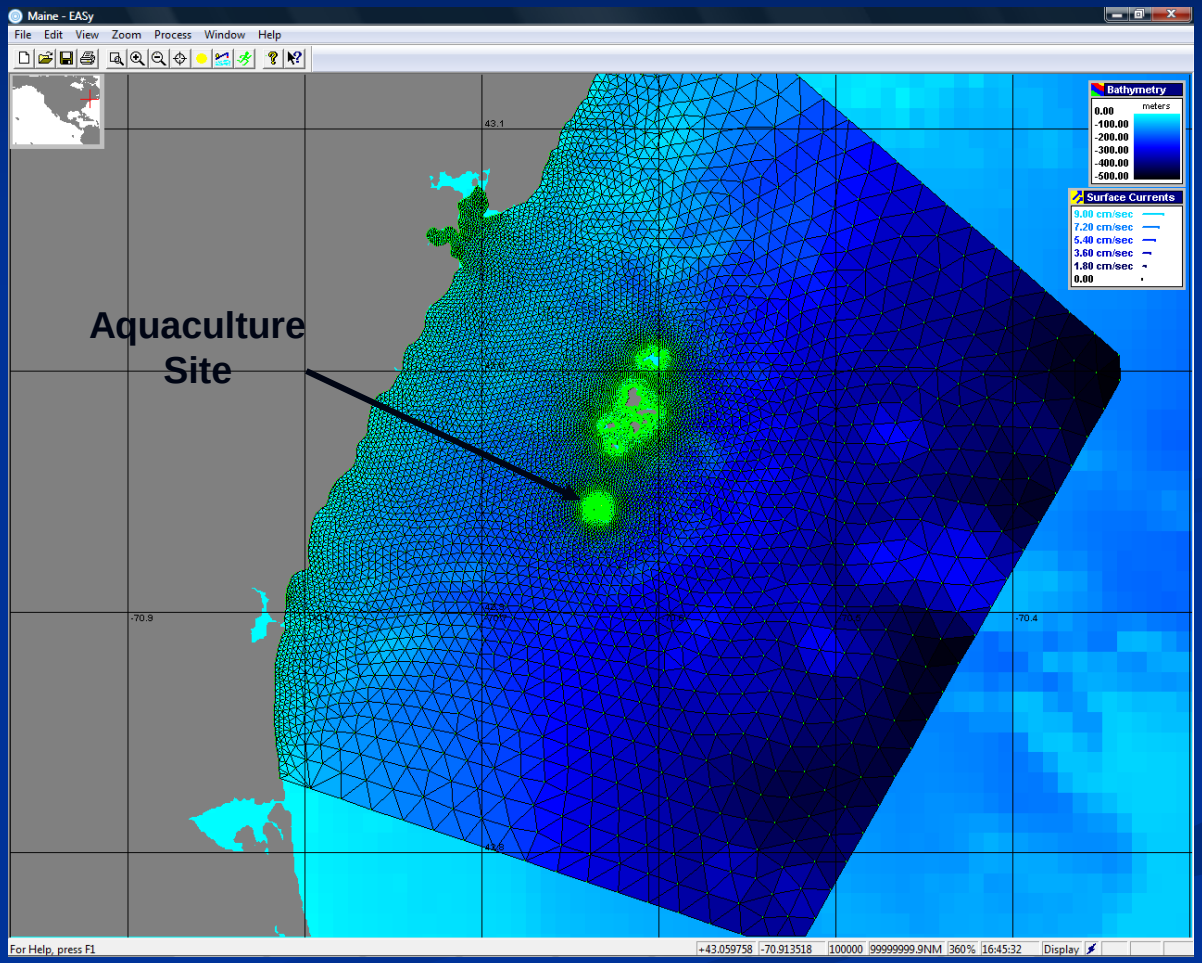
Data set for 18 months. Affects the surface dissolved oxygen concentration affecting growth and loading rates - Higher in the winter and lower in the summer

Regional Hydrodynamics

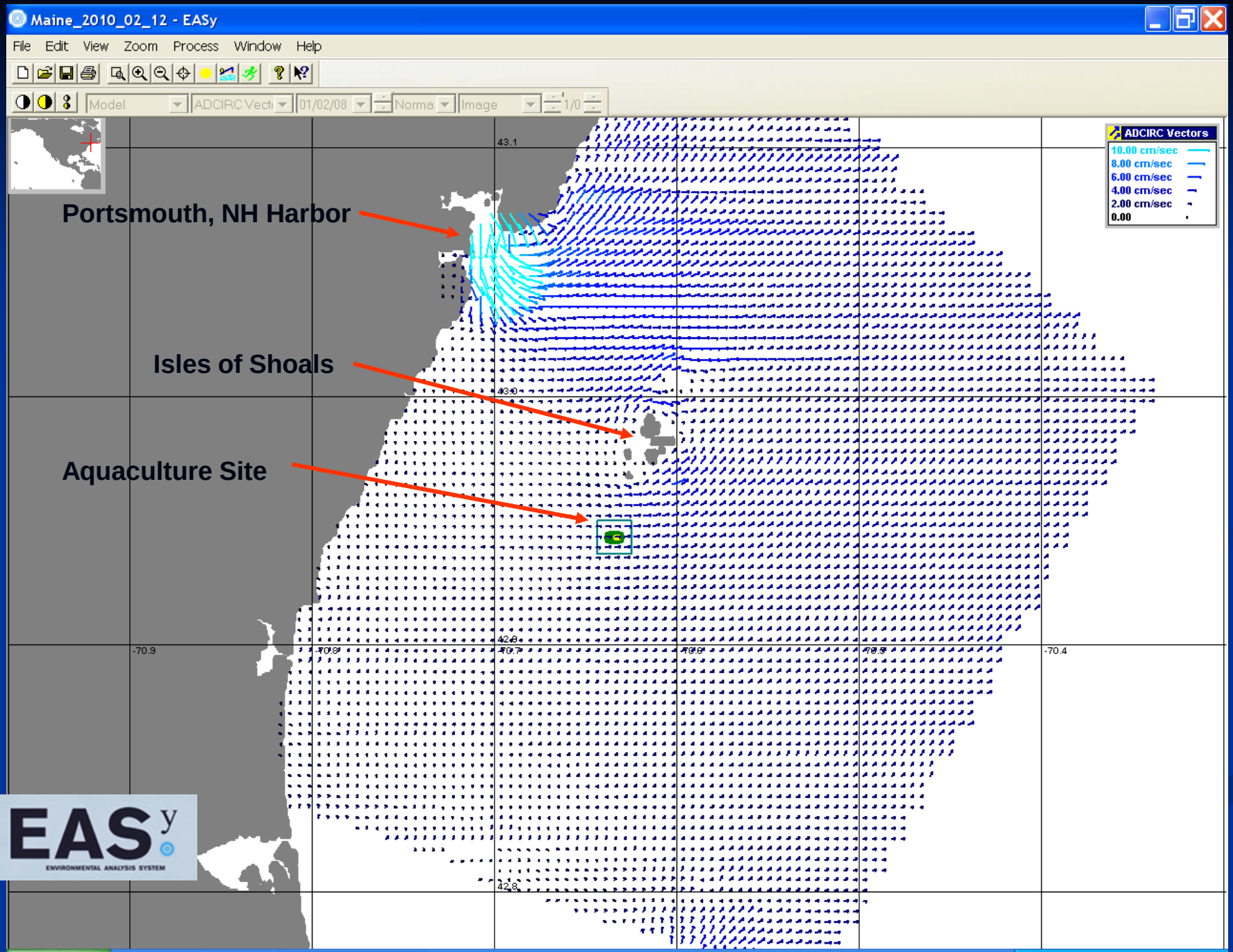
Single point measurements do not represent the large scale

Circulation Tidal Model

1. ADCIRC Model
2. Unstructured Mesh (triangular elements)
3. Interpolated Bathymetry
4. High Resolution at aquaculture site (~50 m)
5. Depth averaged results



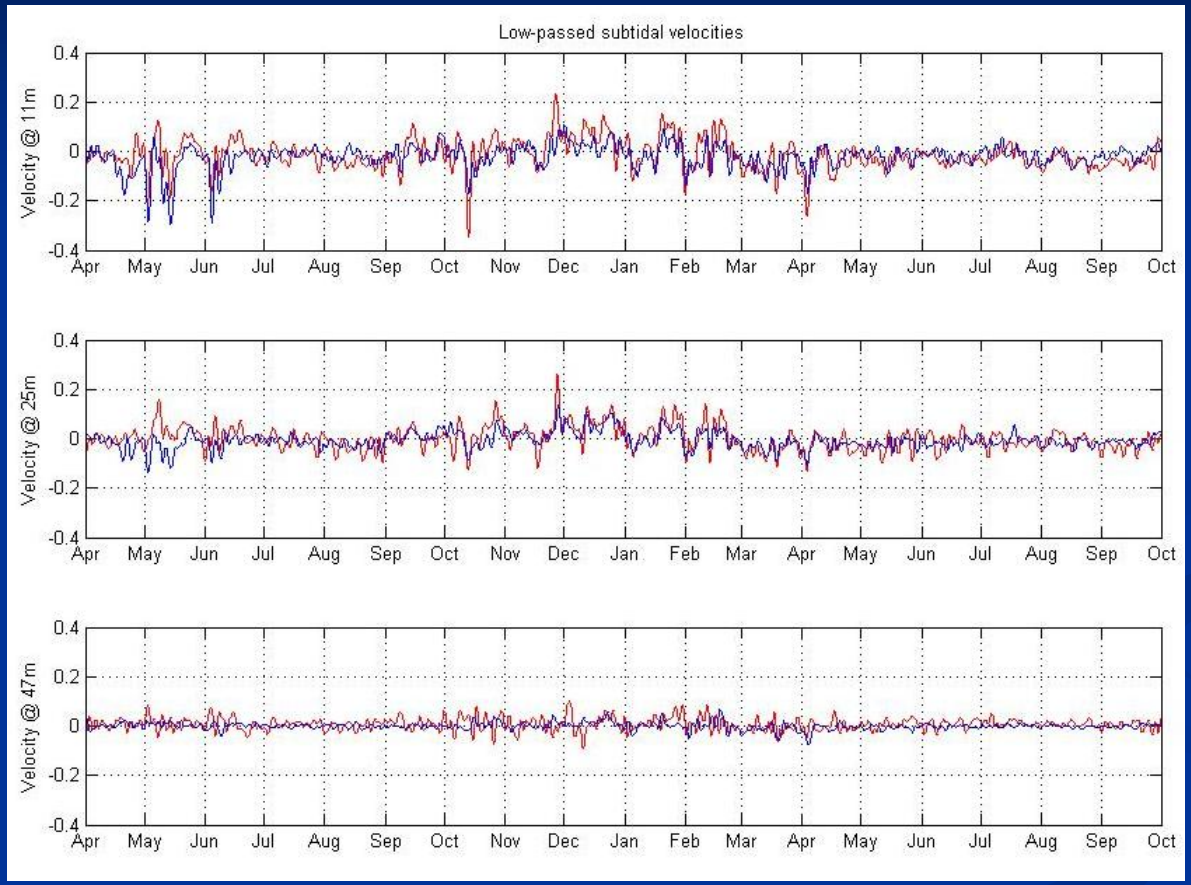
Apply dominant tide elevations and phases at open boundaries


Maine_2010_02_12 - EASy
File Edit View Zoom Process Window Help
Model
ADCIRC Vecti
01/02/08
Norma
Image
ADCIRC Vectors
10.00 cm/sec
8.00 cm/sec
6.00 cm/sec
4.00 cm/sec
2.00 cm/sec
0.00
Portsmouth, NH Harbor
Isles of Shoals
Aquaculture Site
43.1
43.0
42.9
42.8
-70.9
-70.8
-70.7
-70.6
-70.5
-70.4
EASy
ENVIRONMENTAL ANALYSIS SYSTEM
start
EasyMaine
Maine_2010_02...
9:15 AM

Hydrodynamic model results of the tidal velocities compared well to observations

(see World Aquaculture Society 2010 presentation)

Hydrodynamic Input to AquaModel



Model generated spatial and temporal tidal currents, AquaModel input combined tidal velocities with weather induced effects at three depths from measurements – not perfect…..

AquaModel Simulations

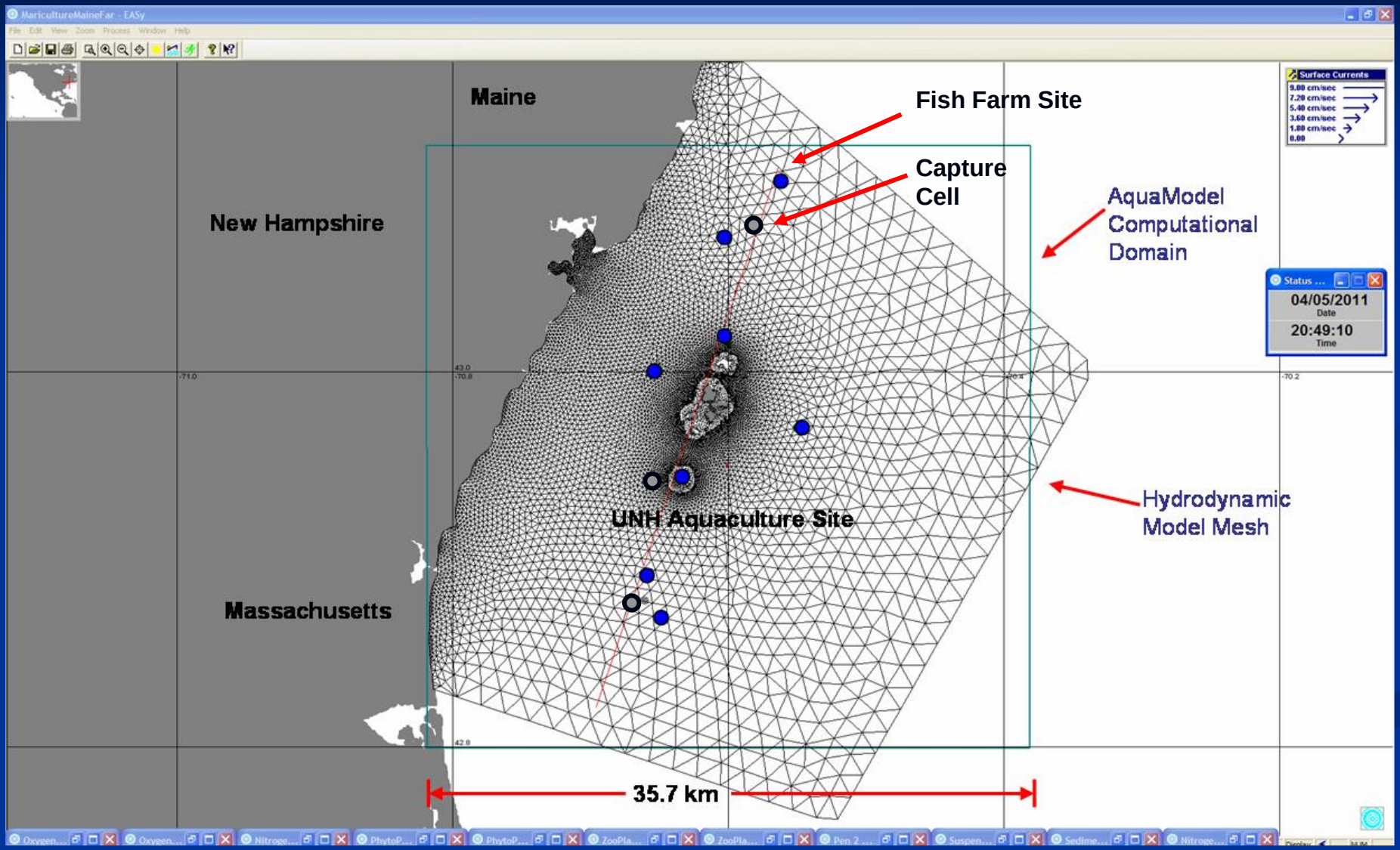
Farm Setup:

1. 8 farm sites in the Gulf of Maine Region
2. 1.35 million fish per farm (bioenergetics based on salmon)
3. Initial stocking size and density: 200 grams and 0.6 kg/m^3
4. Fish fed at rate based on temp and size of fish

Objectives:

1. To estimate biomass during the growth process
2. Calculate farm dissolved oxygen and nitrogen
3. Determine if interactions occur between farms

AquaModel – Gulf of Maine example

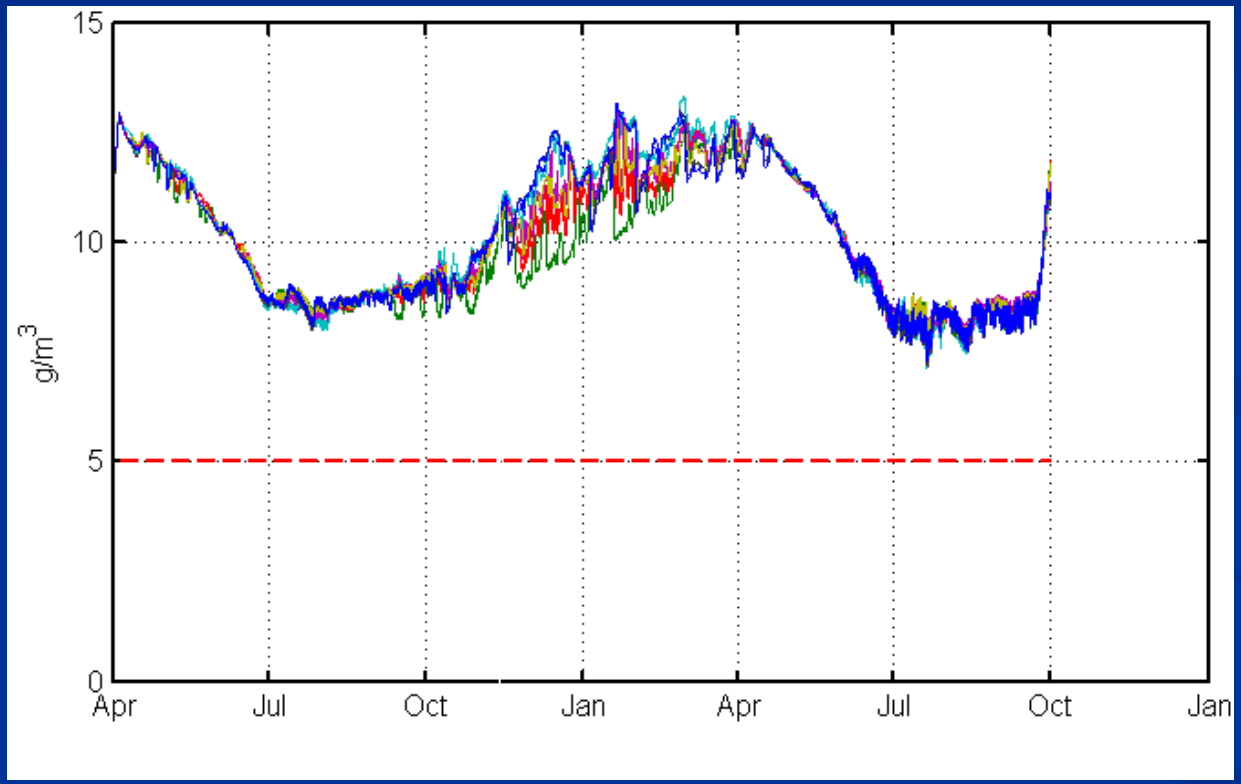


Simulations were run for an 18-month grow out from April to October of the following year!

Focus on AquaModel results for the first 7-8 months

AquaModel – Bio-Mass and DO Results

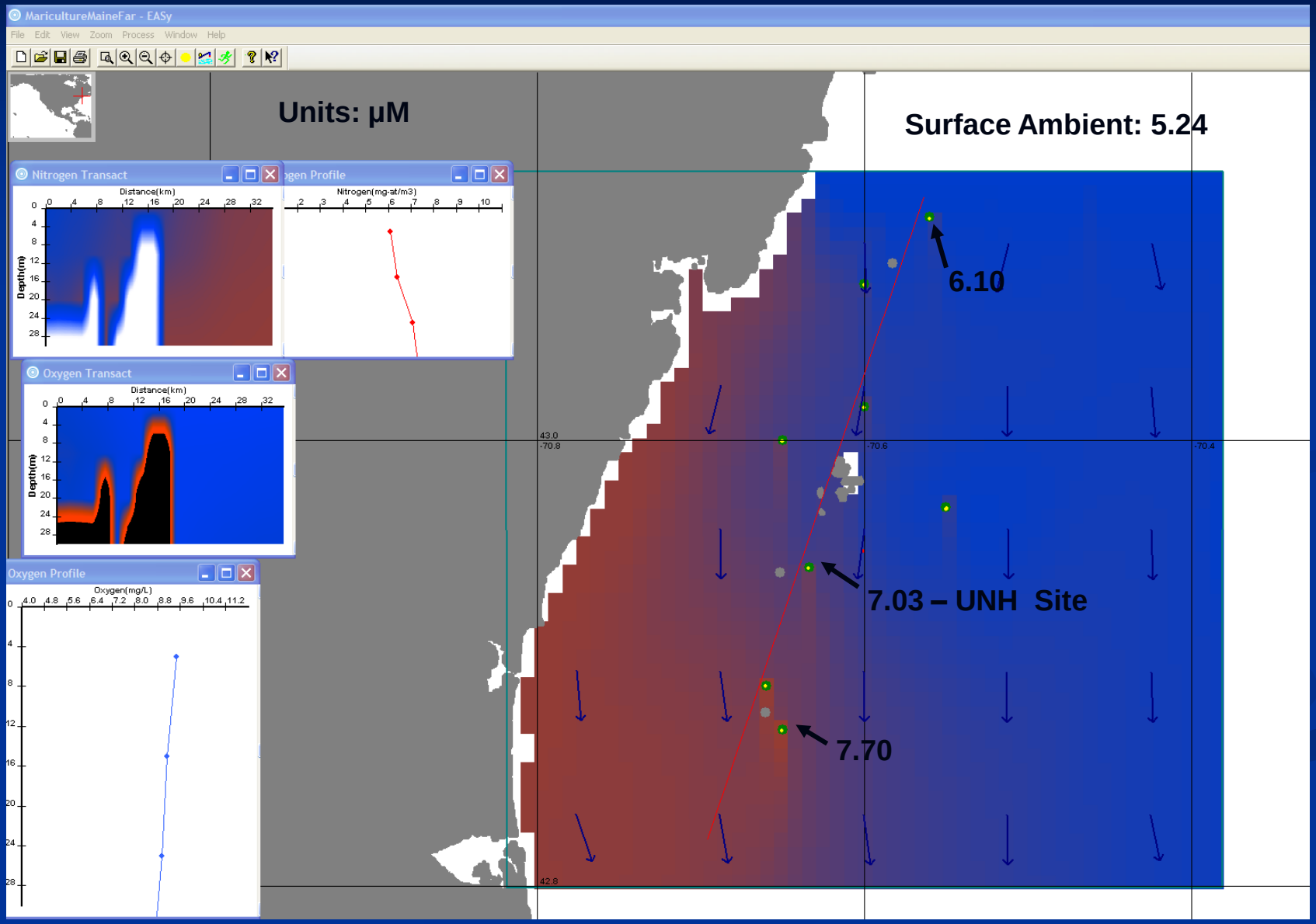
Dissolved Oxygen: Values above 5 g/m^3 (5 mg/l)



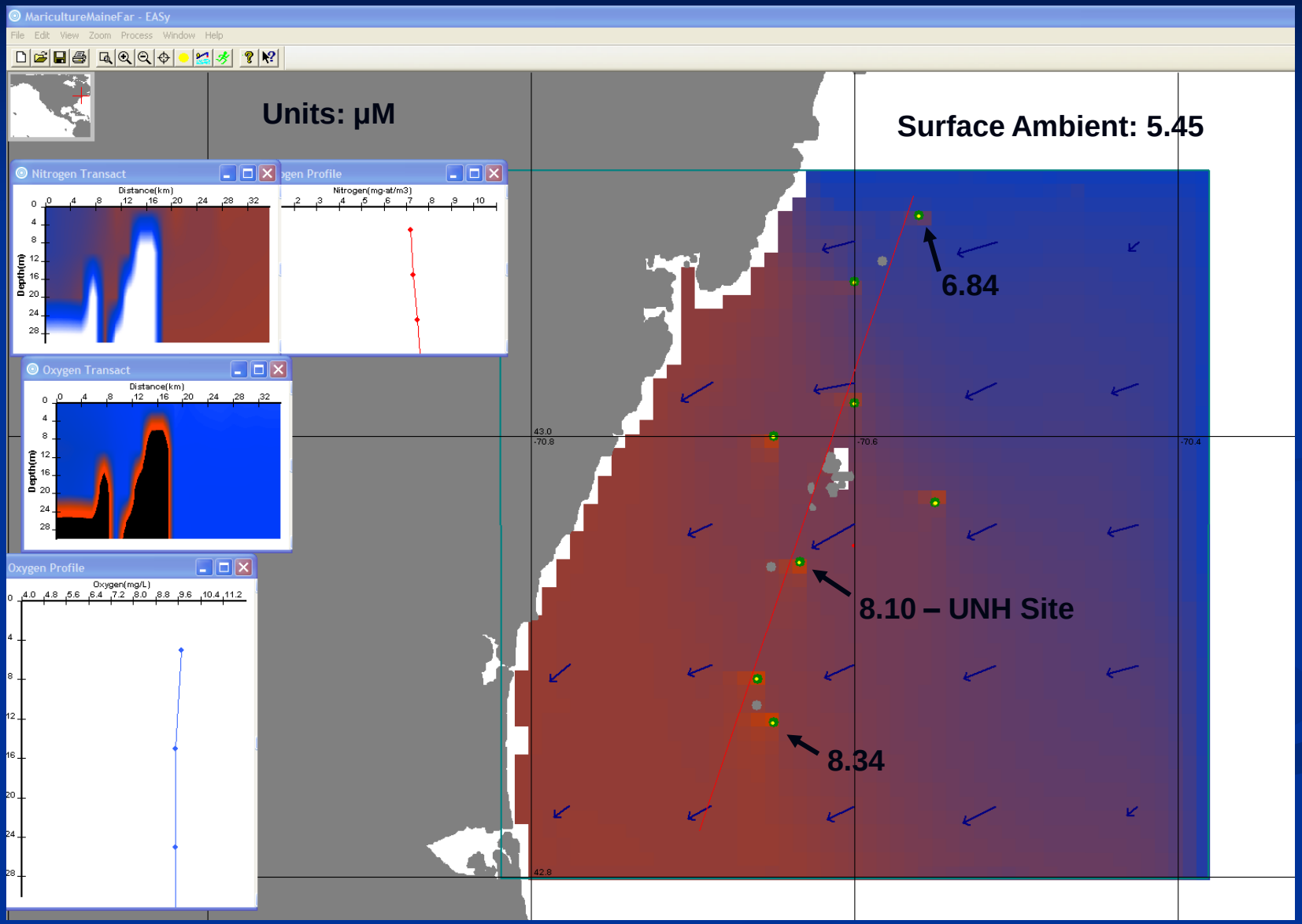
Values for each of the 8 cages

Biomass results: From April to October (first 7 months) the fish grew from 0.2 to 3 Kg (~4000 MT per farm)

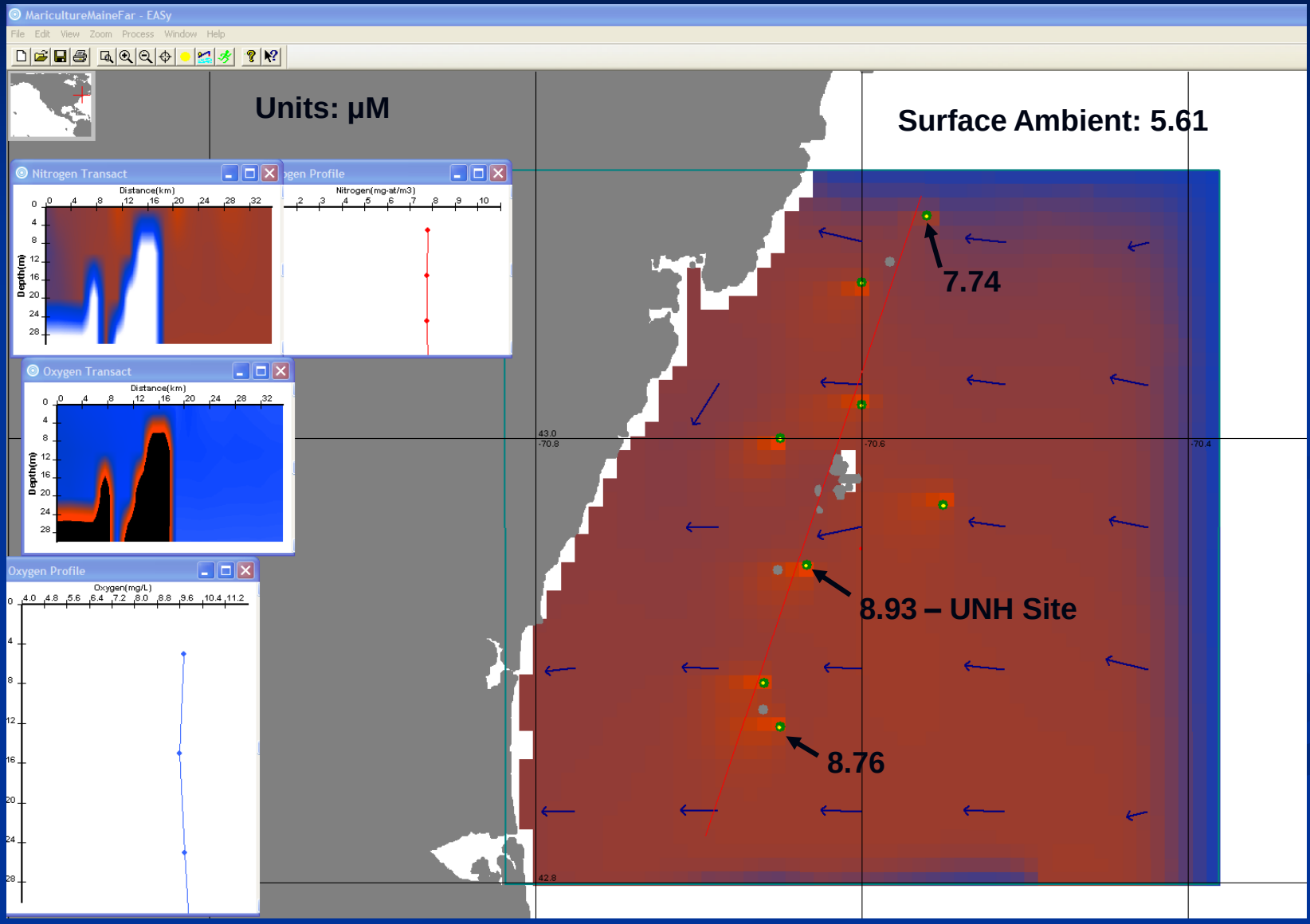
Nitrogen: 10/26/2009



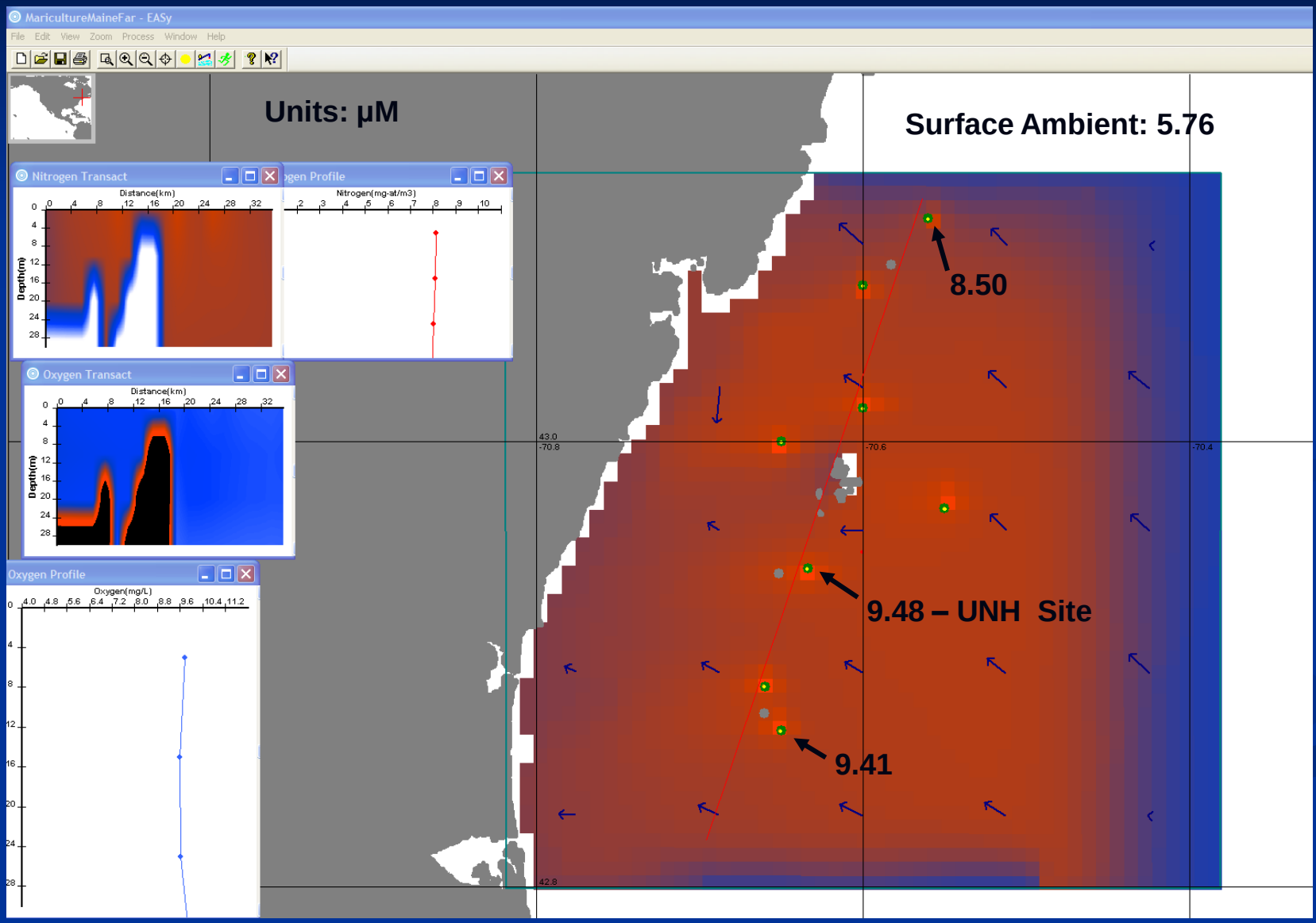
Nitrogen: 10/28/2009



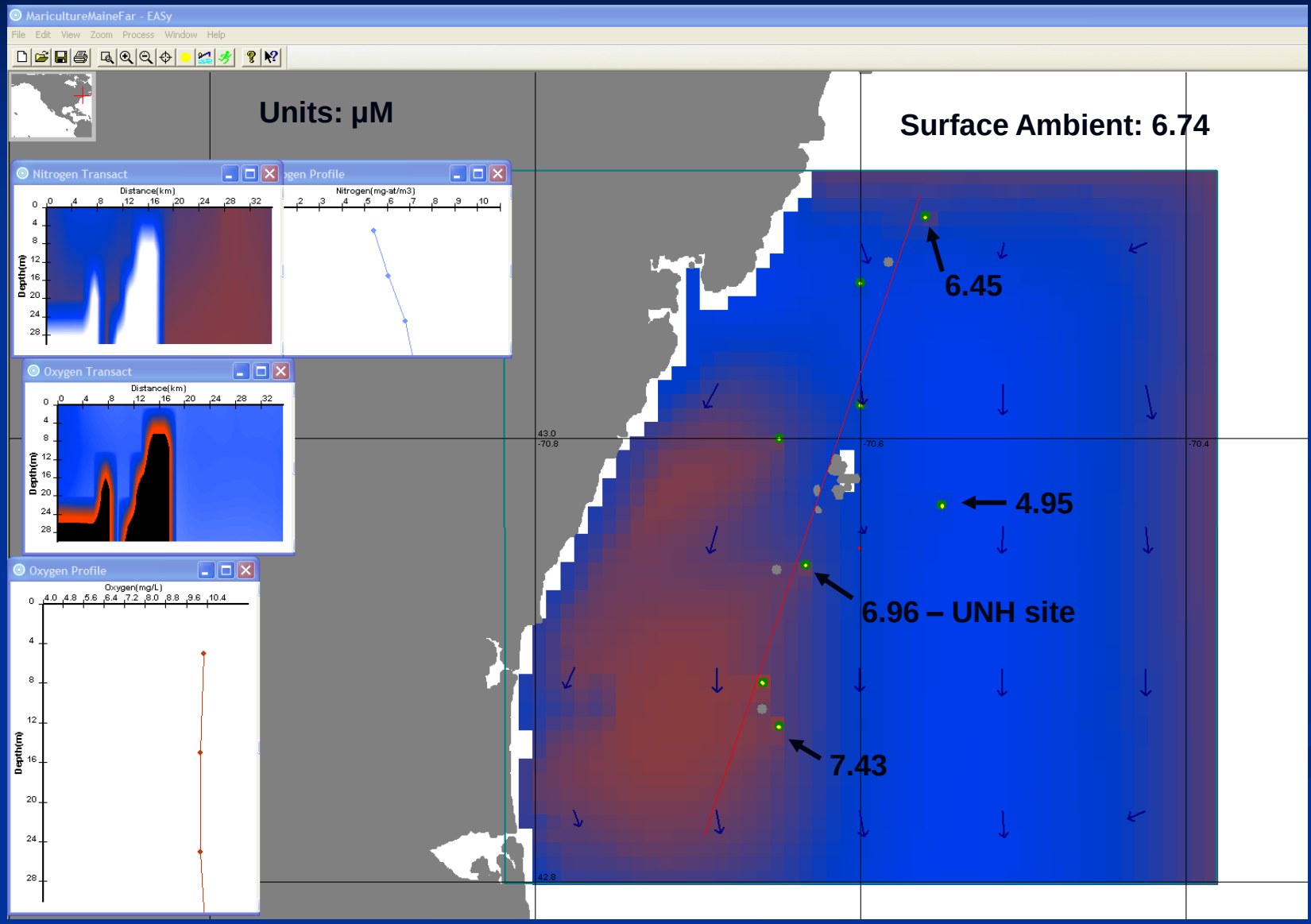
Nitrogen: 10/30/2009



Nitrogen: 11/01/2009



Nitrogen: 11/08/2009



What else can AquaModel estimate?

1. Oxygen (throughout water column)
2. Phytoplankton (throughout water column)
3. Zooplankton (throughout water column)
4. Oxygen (sediment)
5. Aerobic activity (sediment)
6. Anaerobic activity (sediment)
7. CO2 (sediment)
8. Sulfide (sediment)
9. Fecal waste (sediment and suspended)
10. Feed waste (sediment and suspended)
11. Consolidated waste

Is there anything else?

What have we done?

1. Enabled the input of long-term data sets for entire production cycles
2. Able to simulate 3-D circulation pattern for an entire region with multiple fish farms
3. Useful diagnostic tool attempting to simultaneously represent physical, chemical, biological interactions of the dominant processes associated with fish farming

What are our next steps?

1. Continue Validation
2. Validation is the hard part of modeling

Thanks!