# MYTHS, REALITIES AND TRENDS OF COMPUTER MODELING OF OPEN-OCEAN FISH AQUACULTURE

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**Open Ocean Aquaculture Session**

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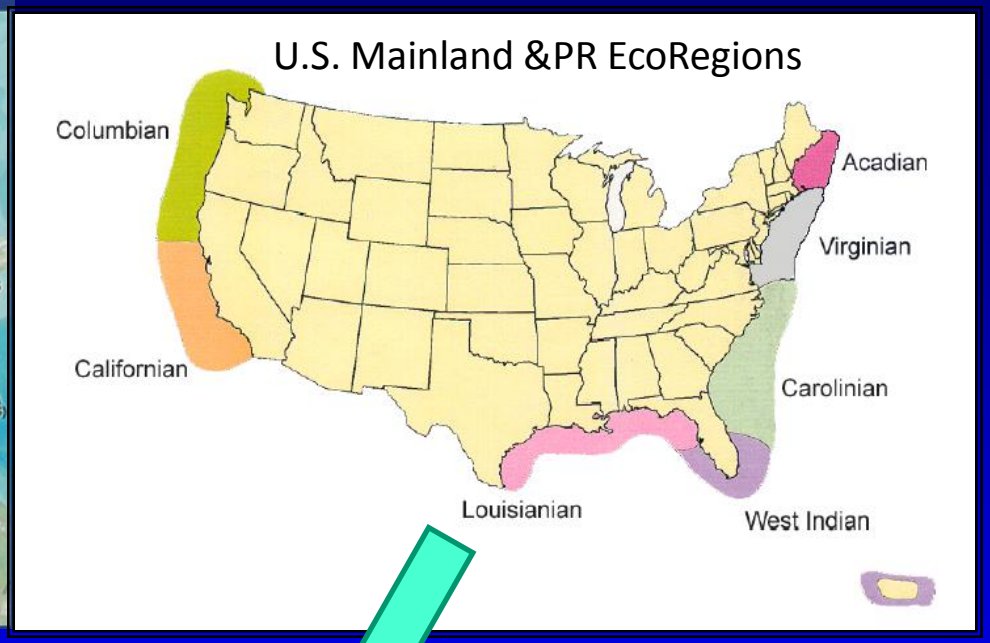
**System Science Applications & University of Southern California**


Disclaimer, we are not promoting net pens at shown locations. For demonstration purposes. Nor are any results other than tentative, subject to appropriate study.

# Myth No. 1 "Aquaculture *modeling is very expensive*"

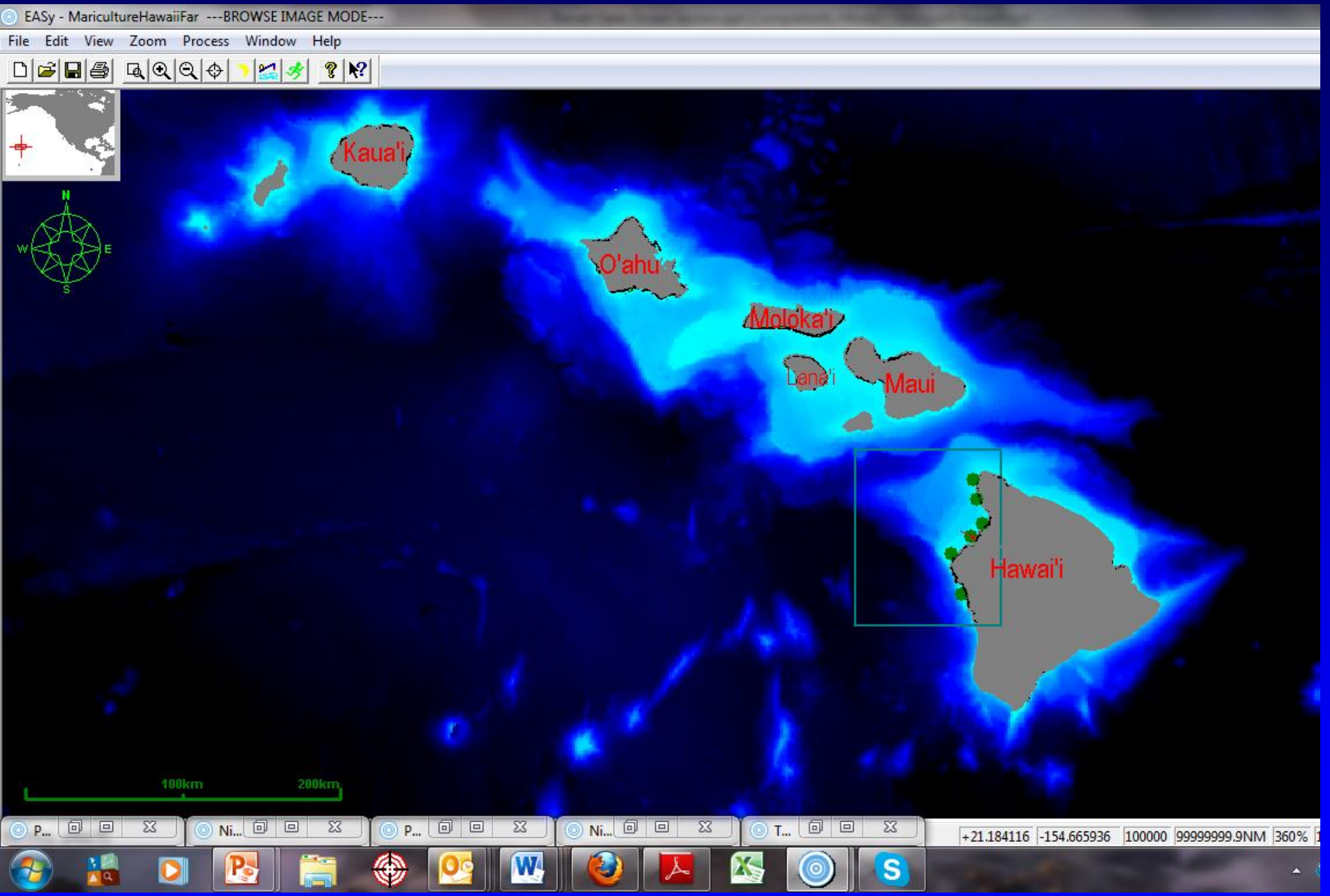
- Model development: Yes
  Model application: Not Necessarily, esp. for open ocean!
  Permitting costs: Yes, orders of magnitude more in U.S. & Canada
- Oceanic far-field circulation models: ↑ availability & reliability
  Inshore circulation models by definition more expensive
- Open Ocean: Ecoregion approach to minimize modeling costs
  - Cost savings of calibrating background conditions, fish species performance & waste production and foodweb response
- Costs of not using GIS and models for siting & permitting
  - Expensive compared to what? Permit litigation.
- Governments' role: performance standards & carrying capacity management as we take baby steps out to the true open ocean
- "Open Ocean" ≠ coastal shelf, not the 'wild blue yonder' yet!

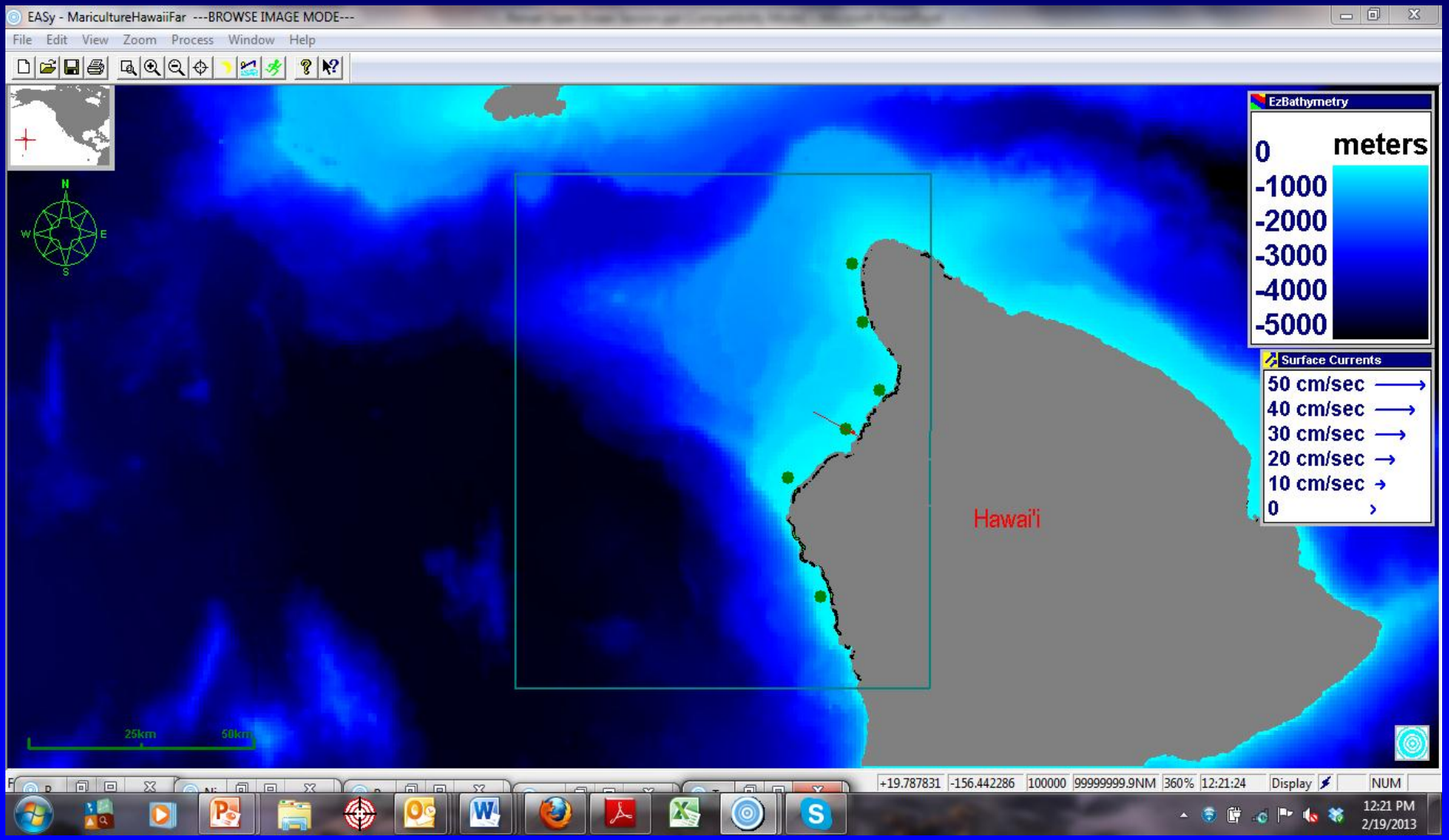
# U.S. Integrated Ocean Observation System (IOOS) + EcoRegion Biological Models


Aquaculture Models
(Biophysical Coupling)

But every regions uses different models or construction !


EASy - MaricultureHawaiiFar ---BROWSE IMAGE MODE---
File Edit View Zoom Process Window Help
Kaua'i
O'ahu
Moloka'i
Lana'i
Maui
Hawai'i
N
W
E
S
100km
200km
+21.184116 -154.665936 100000 99999999.9NM 360%


EASy - MaricultureHawaiiFar ---BROWSE IMAGE MODE---
File Edit View Zoom Process Window Help
EzBathymetry
0 meters
-1000
-2000
-3000
-4000
-5000
Surface Currents
50 cm/sec
40 cm/sec
30 cm/sec
20 cm/sec
10 cm/sec
0
Hawai'i
N
W
E
S
25km
50km
+19.787831 -156.442286 100000 99999999.9NM 360% 12:21:24 Display NUM
12:21 PM
2/19/2013

EASy - MaricultureHawaiiFar ---BROWSE IMAGE MODE---

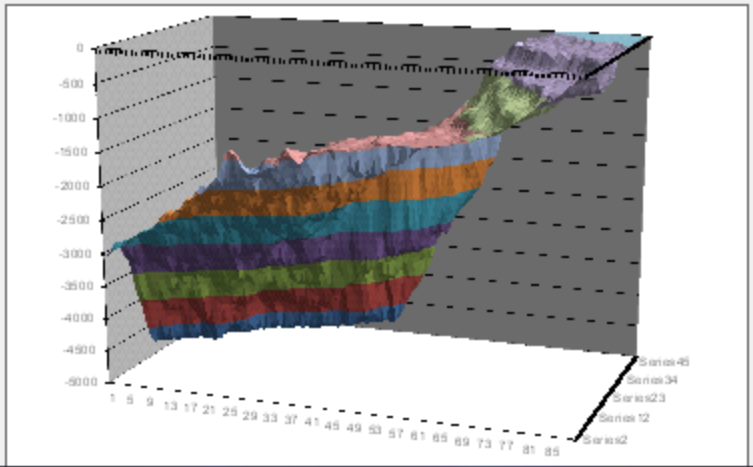
File Edit View Zoom Process Window Help

EzBathymetry Statistics

| | Minimum | Maximum | |
|---|---|---|---|
| Latitude | +19.760418 | +20.158481 | Screen Res ☐ |
| Longitude | -156.629387 | -155.907710 | Enable Filters ☐ |
| | | | Image View ☐ |
| | | | Perspective ☑ |

Window | Filters | Apply | OK | Cancel

| | | | | | |
|---|---|---|---|---|---|
| Mean | -2292.2689 | St dev | 1616.7742 | Pixels | 4135 |
| Width (km) | 75.5403 | Height (km) | 44.0667 | Area (km^2) | 3327.2209 |
| Minimum | -4851.0638 | Maximum | -21.2766 | Vol (km^3) | 2325.1513 |



25km 50km

Haw

EASy - MaricultureHawaiiFar ---BROWSE IMAGE MODE---

EzBathymetry Statistics

| | Minimum | Maximum | |
|---|---|---|---|
| Latitude | +19.760418 | +20.158481 | Screen Res ☐ |
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| | | | Image View ☐ |
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Window | Filters | Apply | OK | Cancel

| | | | | | |
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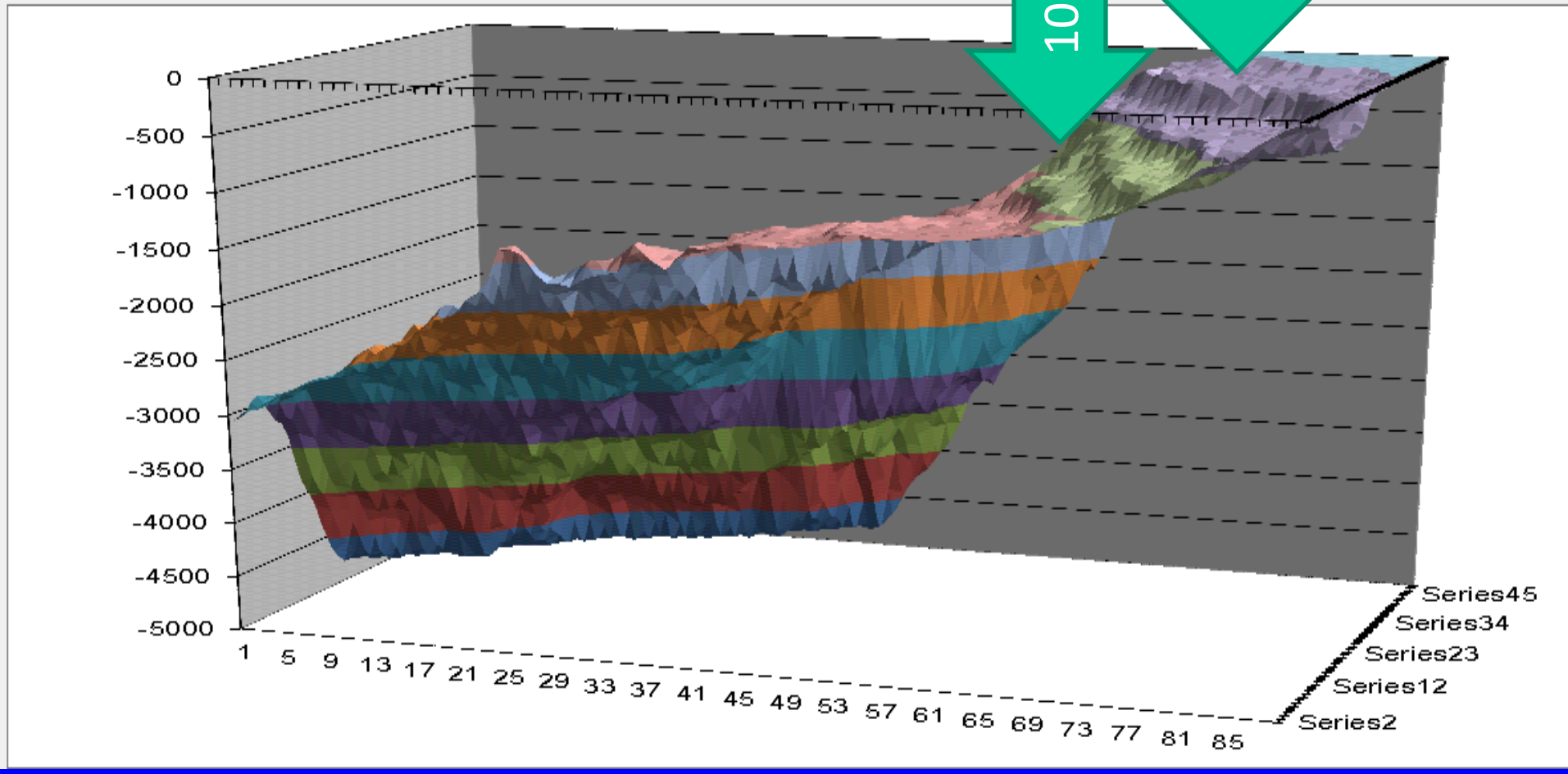
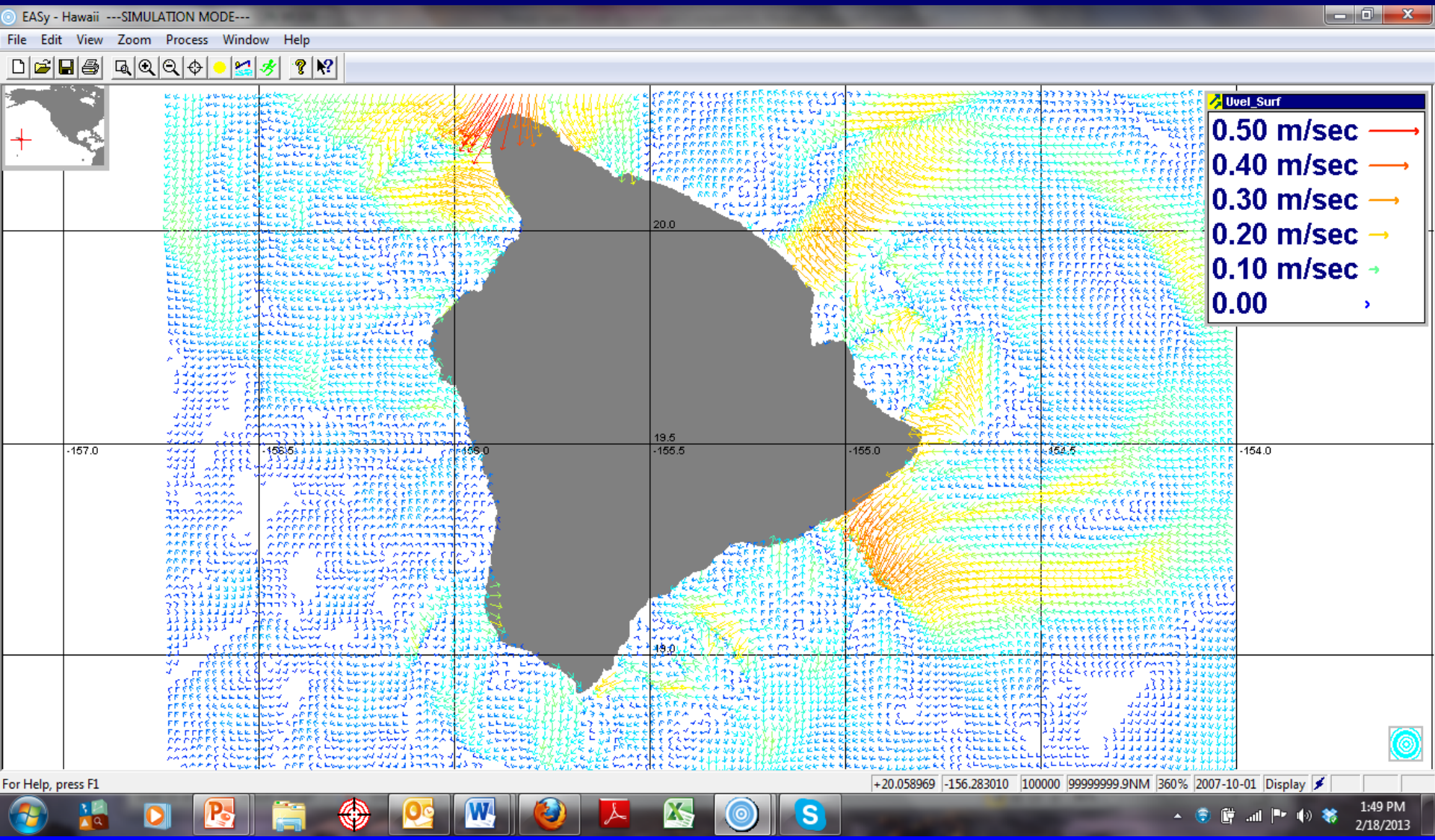
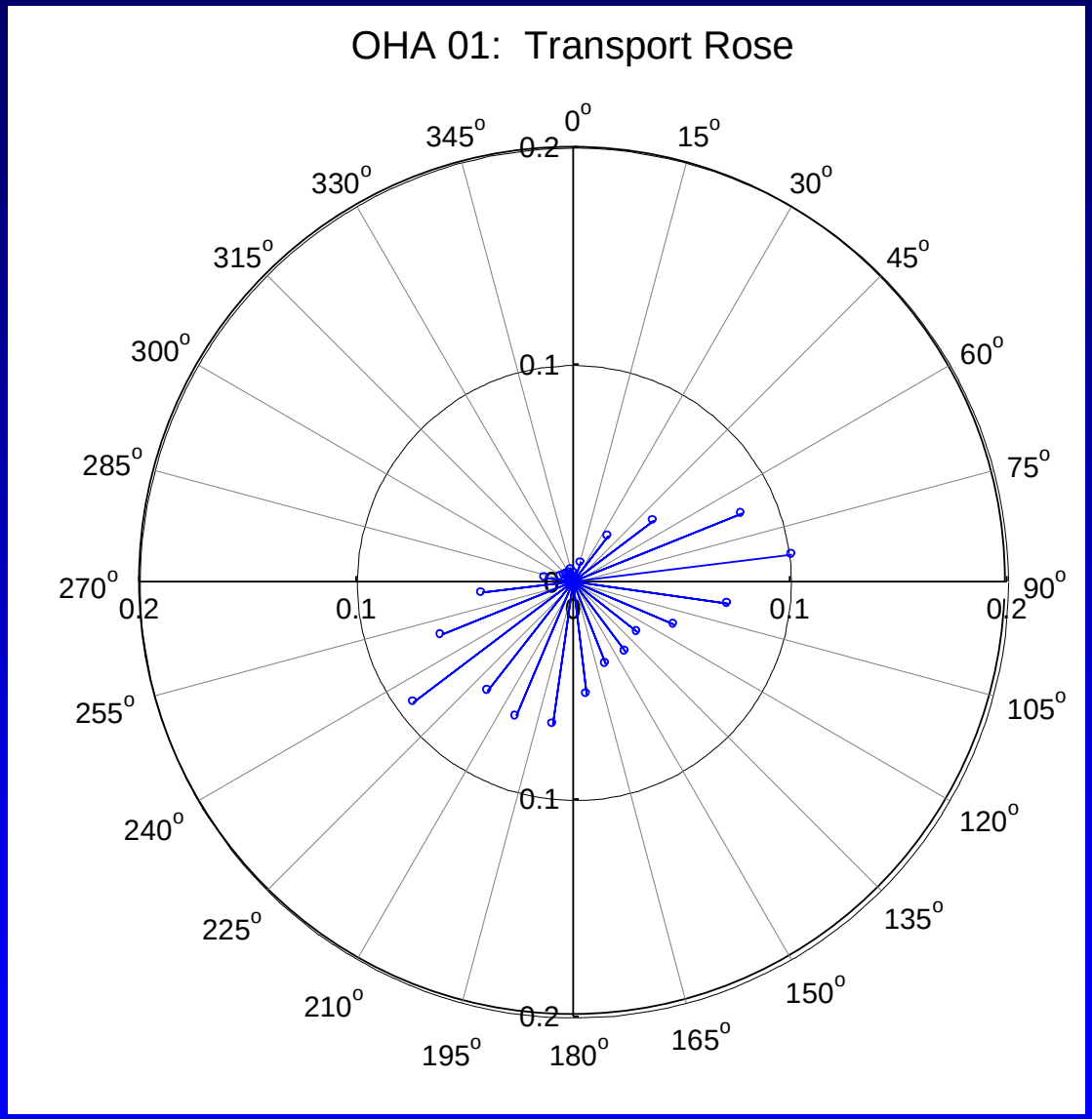


# ROMS Model Circulation




Ocean Circulation Data: PACIOOS




# Puerto Rico Open Ocean Current Variability

Year One

Year Two

Capella 2004

# Myth No. 2 "*Models for open ocean fish farm are not needed*"

> Will water currents be suitable for optimum growth?

- Optimum range of current velocity issues:
- Predictable inshore, less so coastal & open oceans (calm/gyres)
- D.O. delivery to pens normally sufficient for commercial densities?

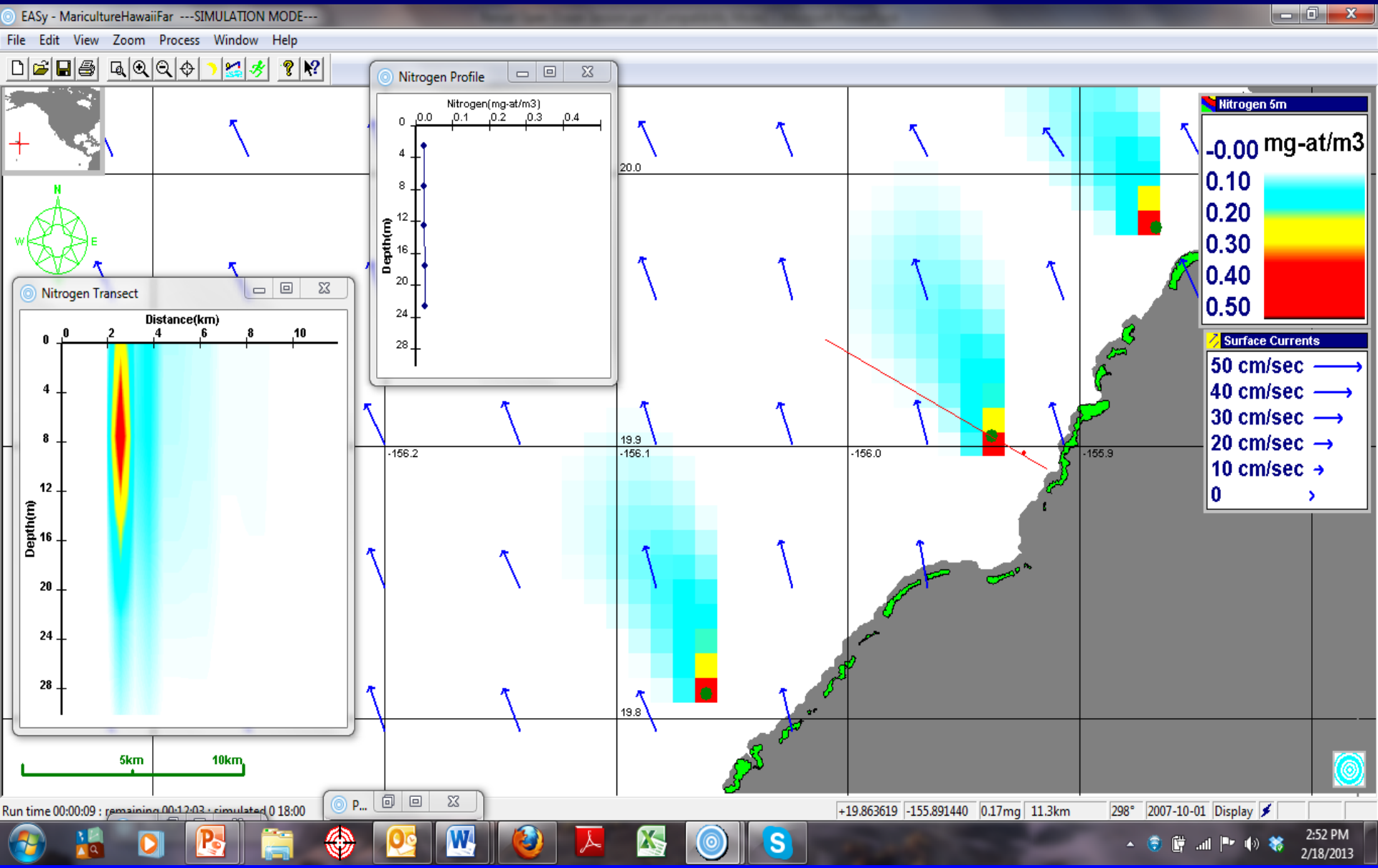
➢ Regulators' uncertainty & accountability:

Benthic effect over deep: minimal, more likely beneficial !

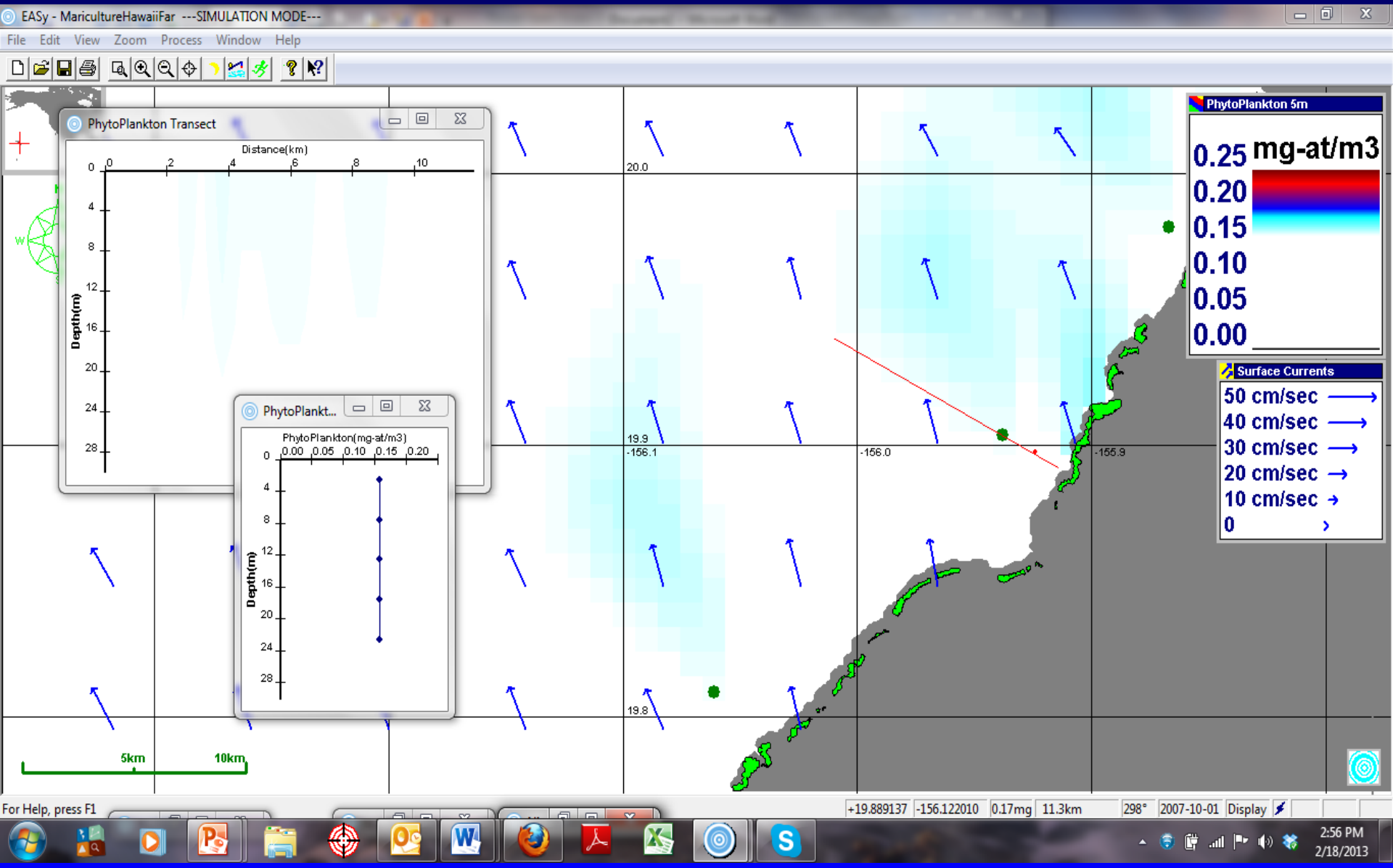
But……

- multiple fish farms …… pelagic to nearshore cumulative effects?
- not truly "open ocean", in oceanography "coastal shelf"
- eutrophication, HABs, habitat degradation common worldwide
- Choice to enhance pelagic OO productivity or have cumulative effect nearshore and littoral
- Hawaii and Pacific Islands: potential for optimum citing ……

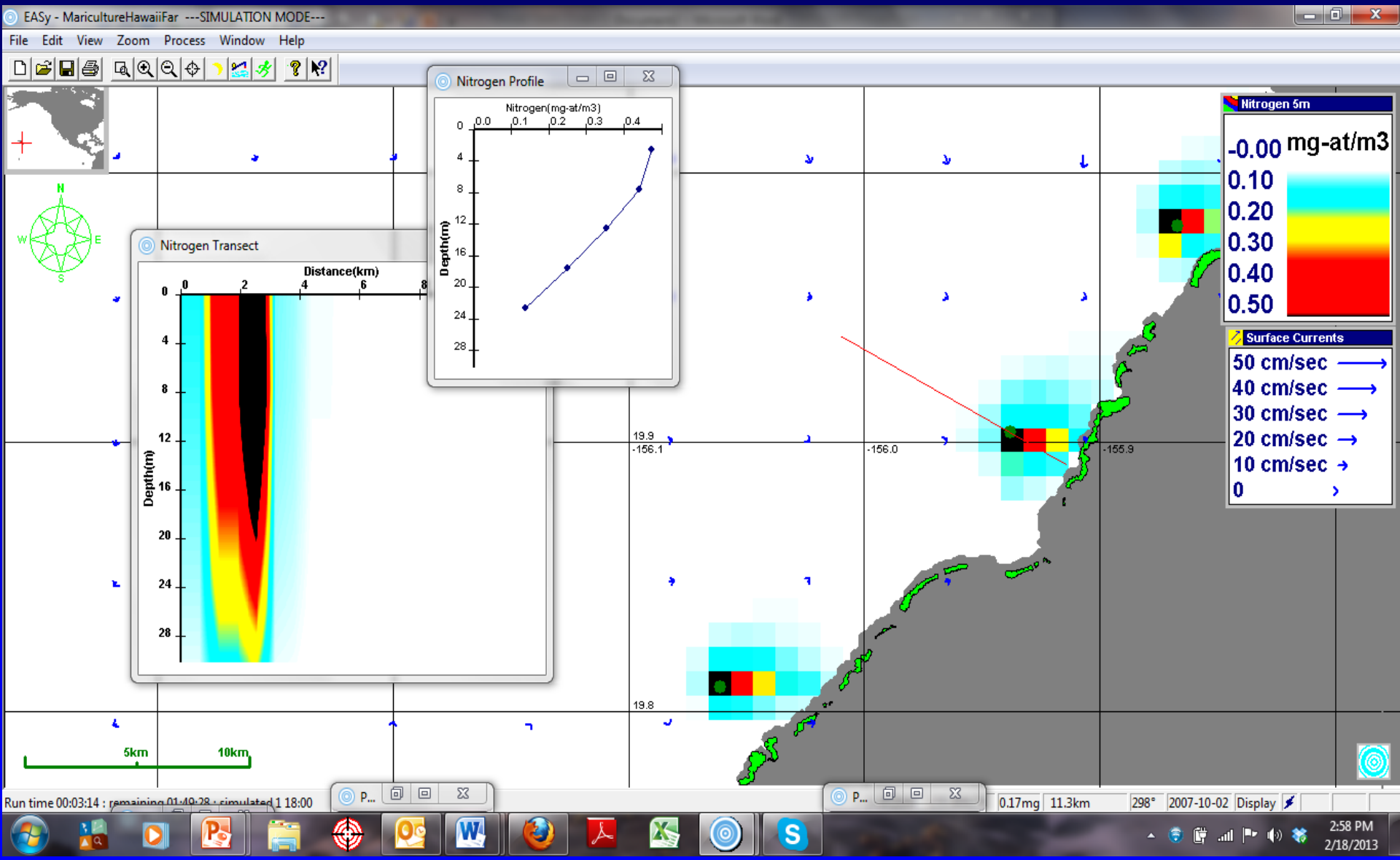
# Offshore Flow: Nitrogen (DIN+). AquaModel Snapshot



# Offshore Flow: Phytoplankton (chl *a*)



# Onshore/weak Flow: Nitrogen (DIN+)



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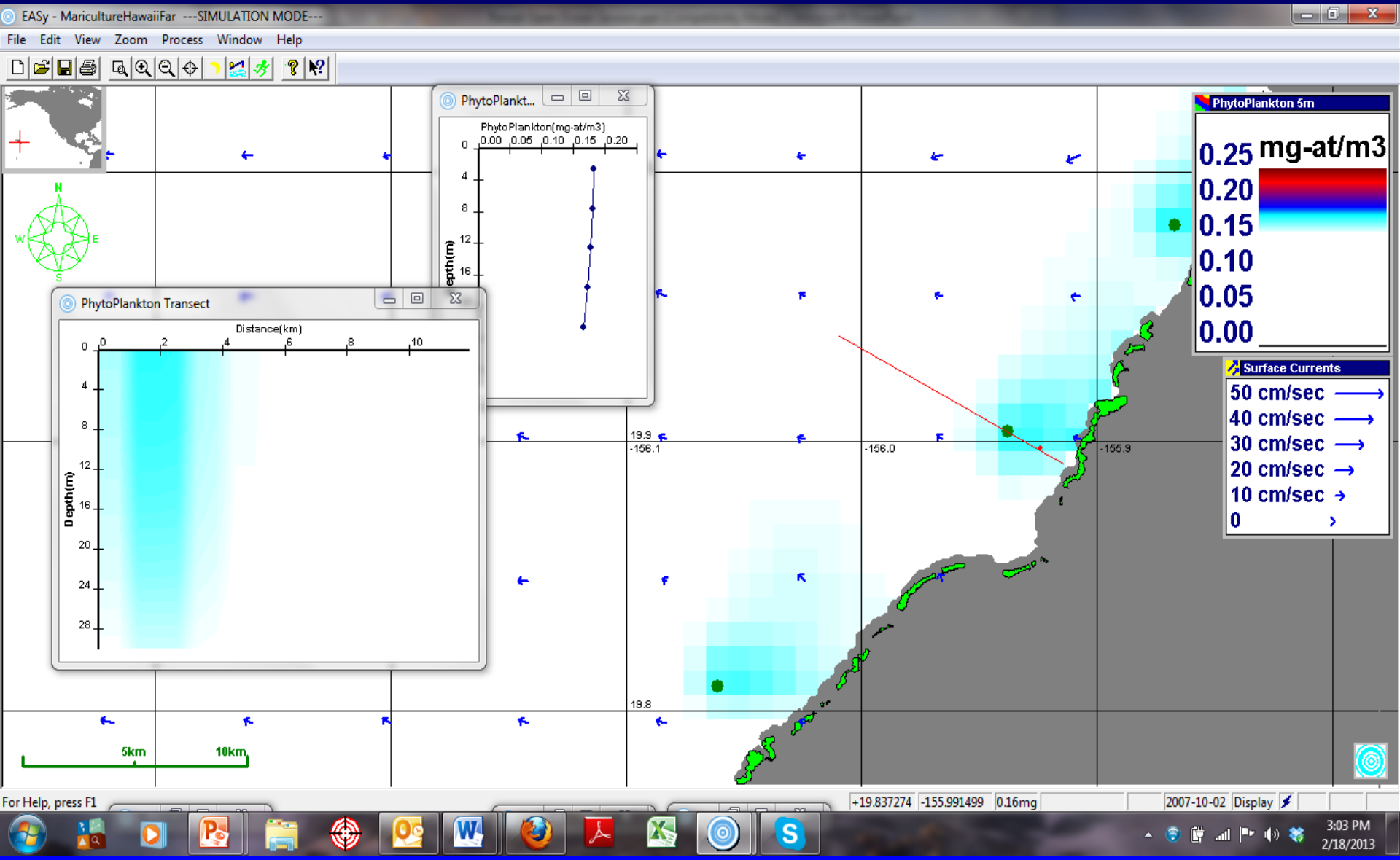
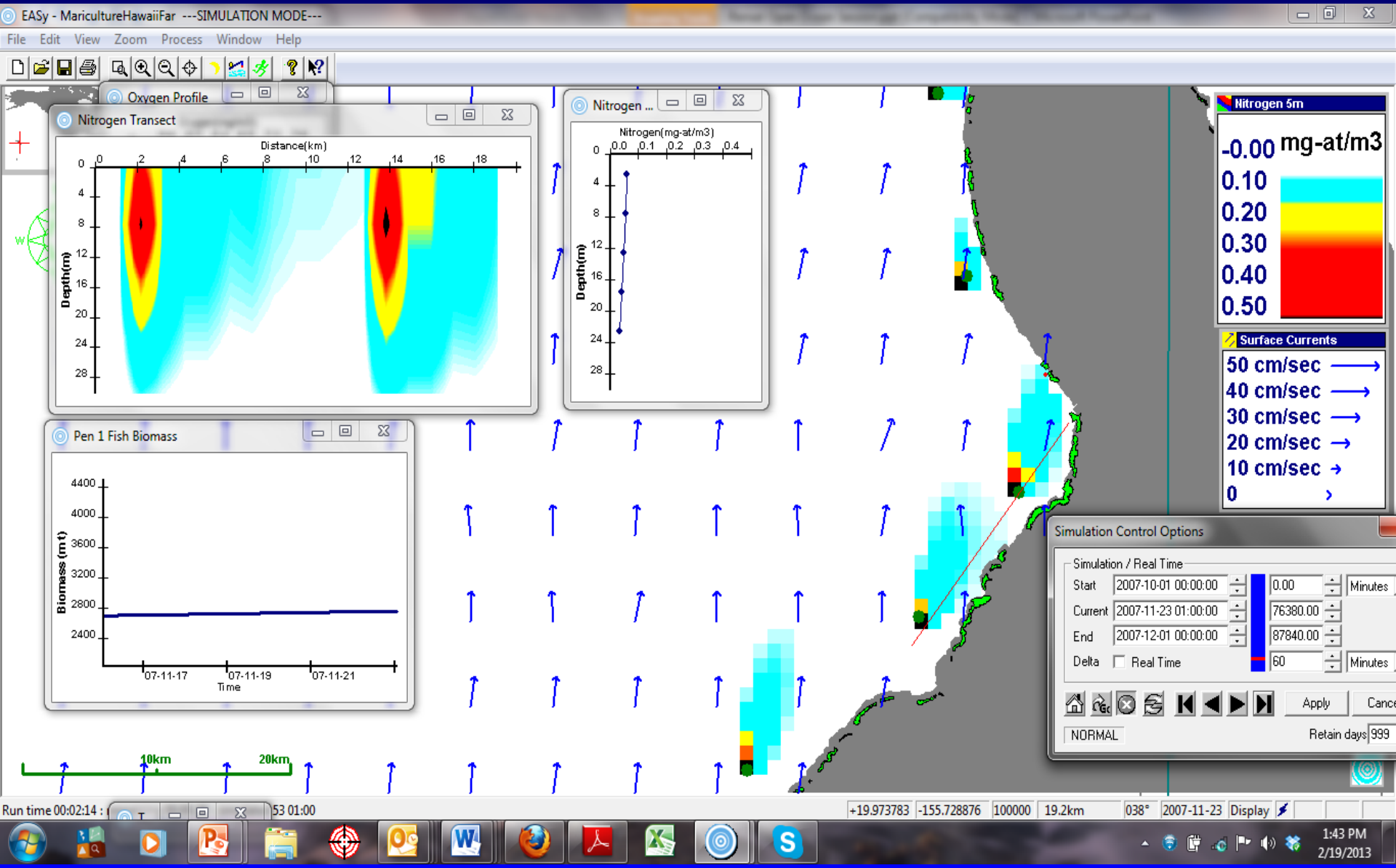
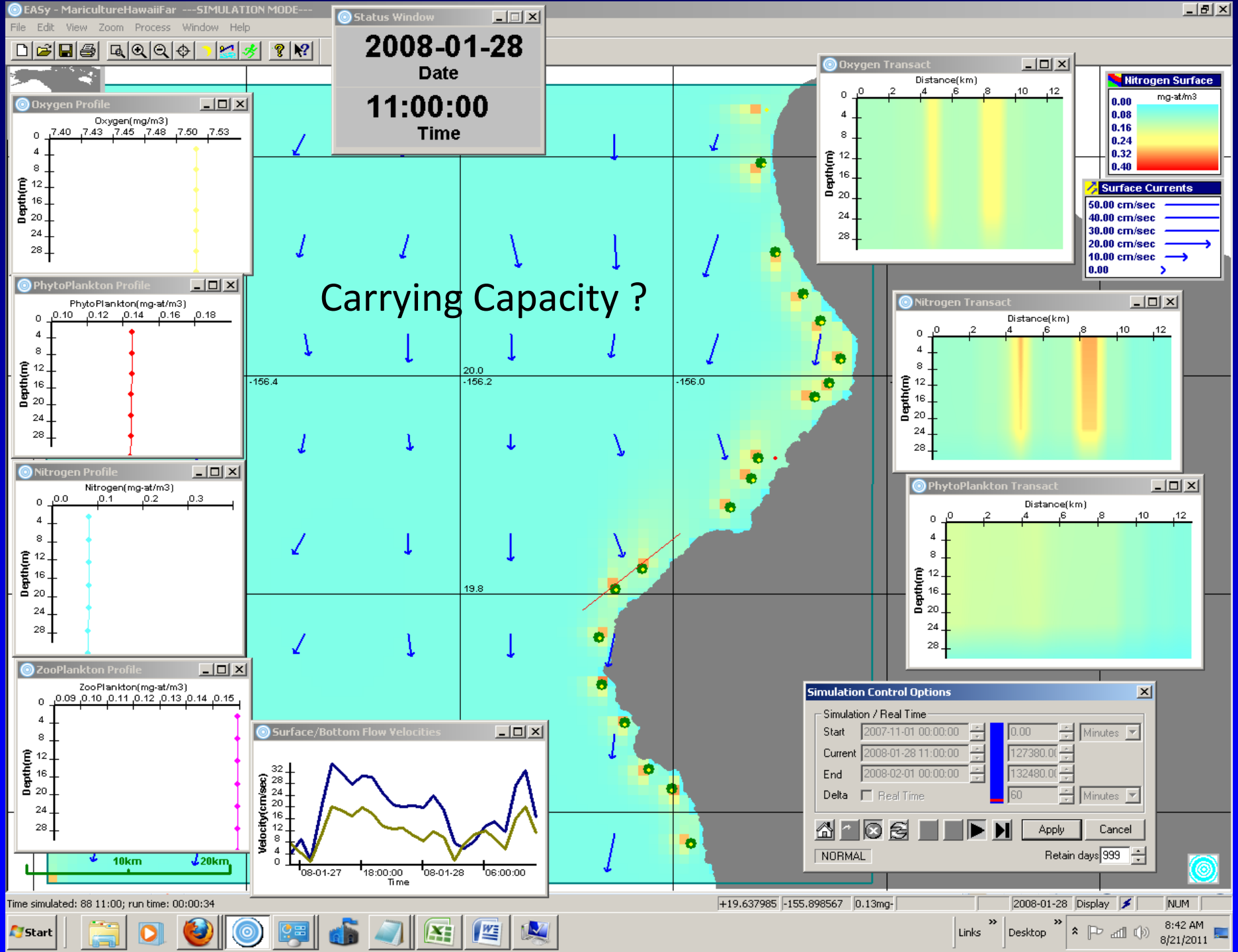


# Farms Interacting or influencing littoral corals ? Or Not !

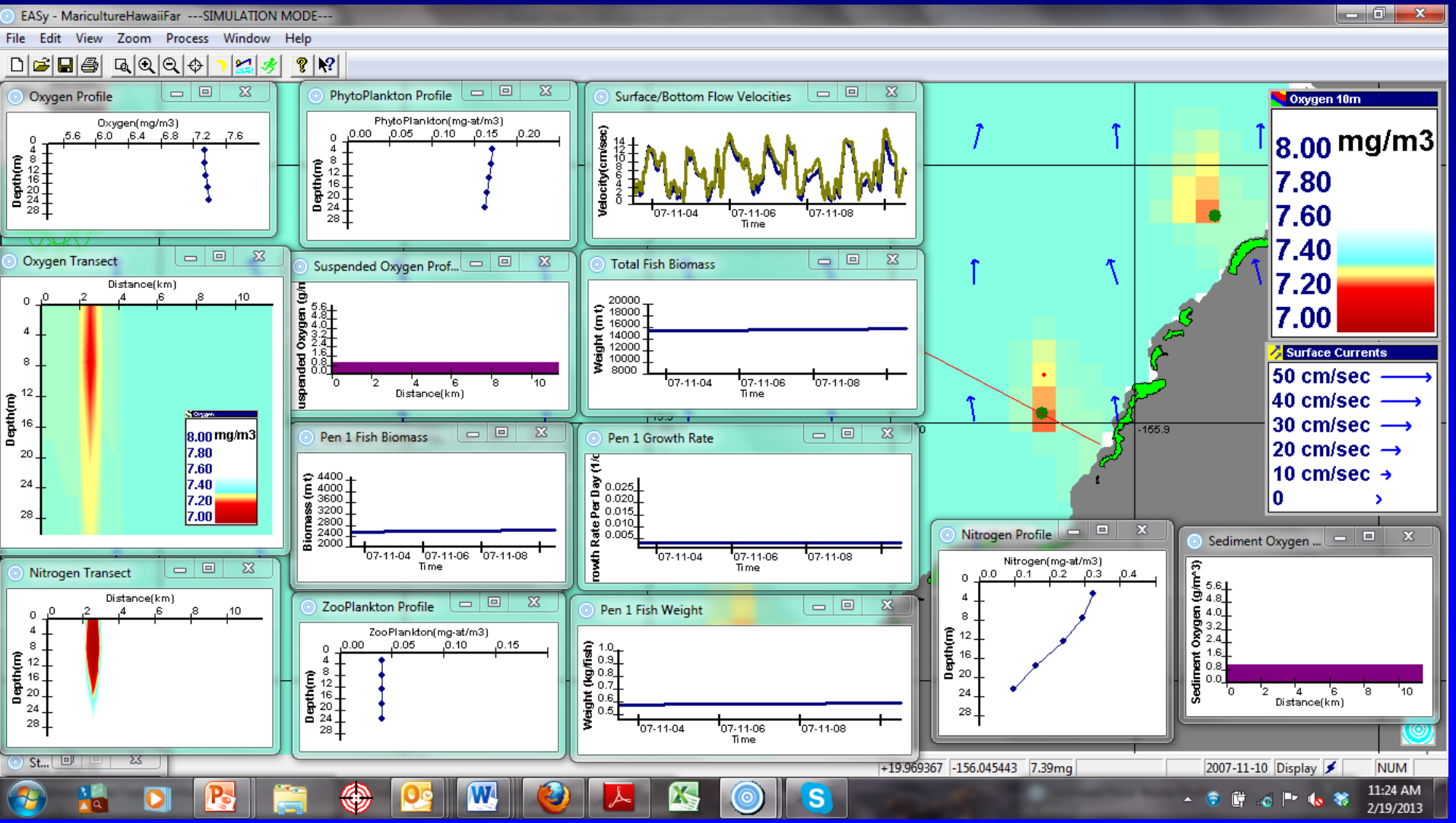


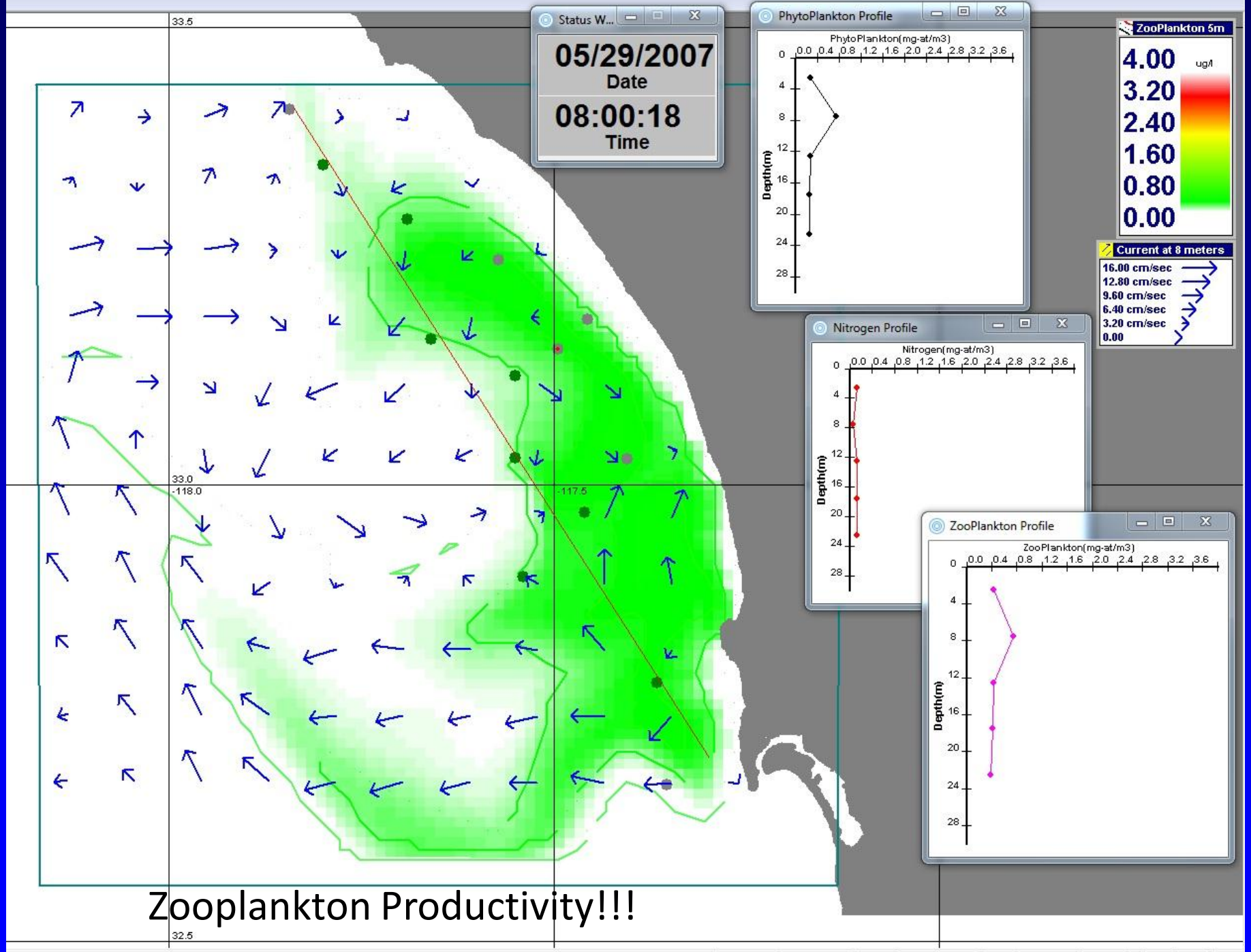

EASy - MaricultureHawaiiFar ---SIMULATION MODE---
File Edit View Zoom Process Window Help
Status Window
2008-01-28
Date
11:00:00
Time
Oxygen Profile
Oxygen(mg/m3)
Depth(m)
PhytoPlankton Profile
PhytoPlankton(mg-at/m3)
Nitrogen Profile
Nitrogen(mg-at/m3)
ZooPlankton Profile
ZooPlankton(mg-at/m3)
10km
20km
Surface/Bottom Flow Velocities
Velocity(cm/sec)
08-01-27
18:00:00
08-01-28
06:00:00
Time
Carrying Capacity ?
20.0
19.8
-156.4
-156.2
-156.0
Oxygen Transact
Distance(km)
Nitrogen Transact
PhytoPlankton Transact
Nitrogen Surface
mg-at/m3
0.00
0.08
0.16
0.24
0.32
0.40
Surface Currents
50.00 cm/sec
40.00 cm/sec
30.00 cm/sec
20.00 cm/sec
10.00 cm/sec
0.00
Simulation Control Options
Simulation / Real Time
Start 2007-11-01 00:00:00
Current 2008-01-28 11:00:00
End 2008-02-01 00:00:00
Delta Real Time
Minutes
Apply
Cancel
NORMAL
Retain days 999
Time simulated: 88 11:00; run time: 00:00:34
+19.637985 -155.898567 0.13mg-
2008-01-28 Display NUM
Start
Links
Desktop
8:42 AM
8/21/2011

# Quantitative Analysis

## 50+ parameters, 20+ tools.

## 300+ types of satellite imagery






Zooplankton Productivity!!!

# One More Popular Myth

- *"Circulation Models of Ocean Currents are inaccurate":*
  - For near field, single farm- benthic effects: Often YES
    One solution: nest high resolution ROMS in normal ROMS
    AquaModel can test far field vs. current meter results within the grid at one farm location
  - For far field & multiple farms open ocean simulations:
    Degree of accuracy not as critical due to large distances, less bathymetric forcing vs. nearshore.
    More important to have long period of simulation to capture extremes of conditions than to be 100% spot on at all times.

But for now, before and if into the wild blue yonder,
← this is what we want to avoid!

What we can protect with proper tools & planning while enhancing the true offshore & oligotrophic pelagic zone!!

Photos: Hawaii DAR

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NOAA National Ocean Service Beaufort N.C.
Hukilau Foods, Hawai'i
Hubbs Seaworld Research Institute, San Diego
American Gold Seafoods / Icicle Seafoods Seattle
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University of Washington, School of Oceanography
United Arab Emirates, Ministry of Environment & Water

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