Monitoring the Eastern Tropical Pacific Tuna Fishery from Space

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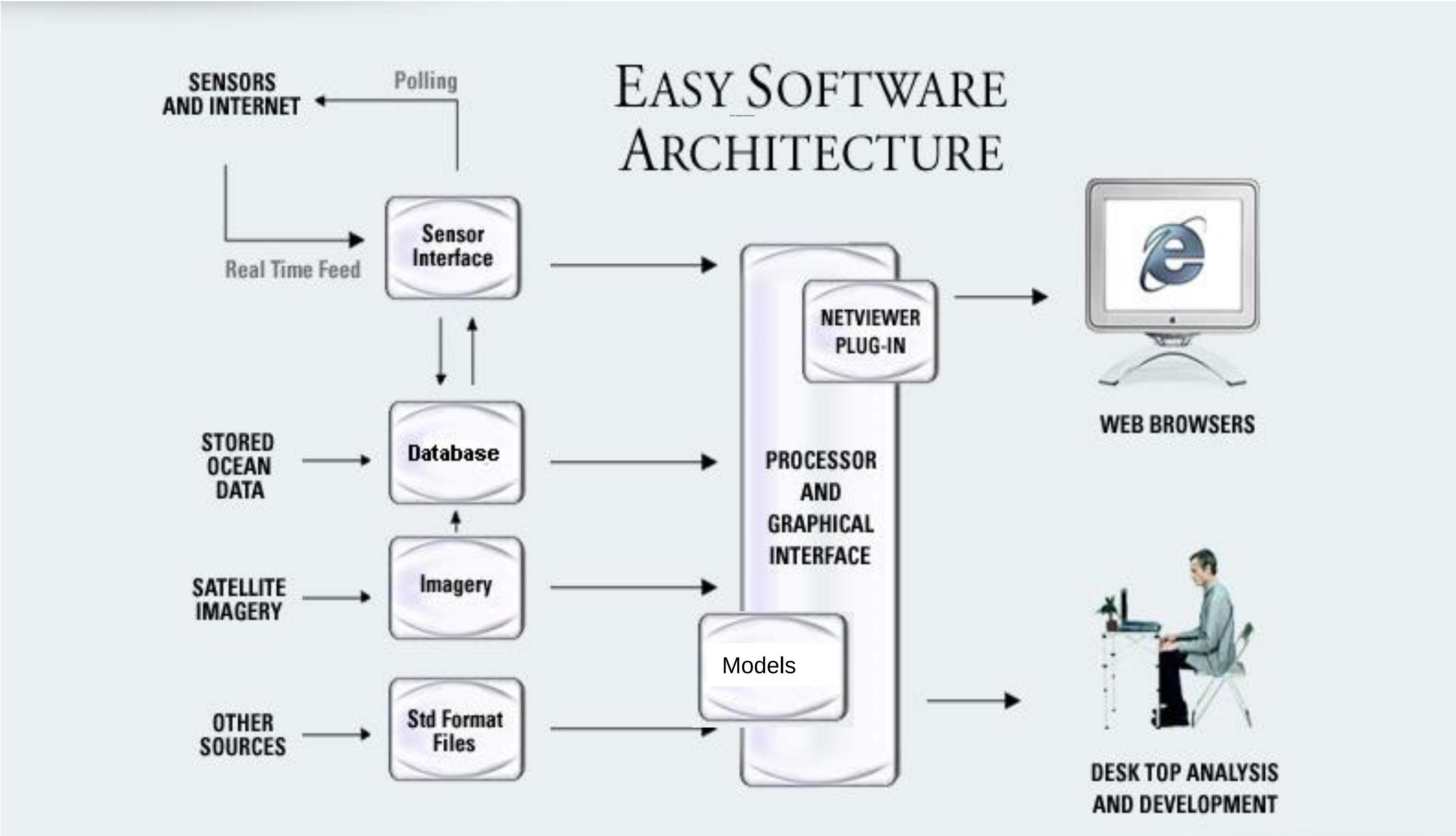
Fishscape Goal

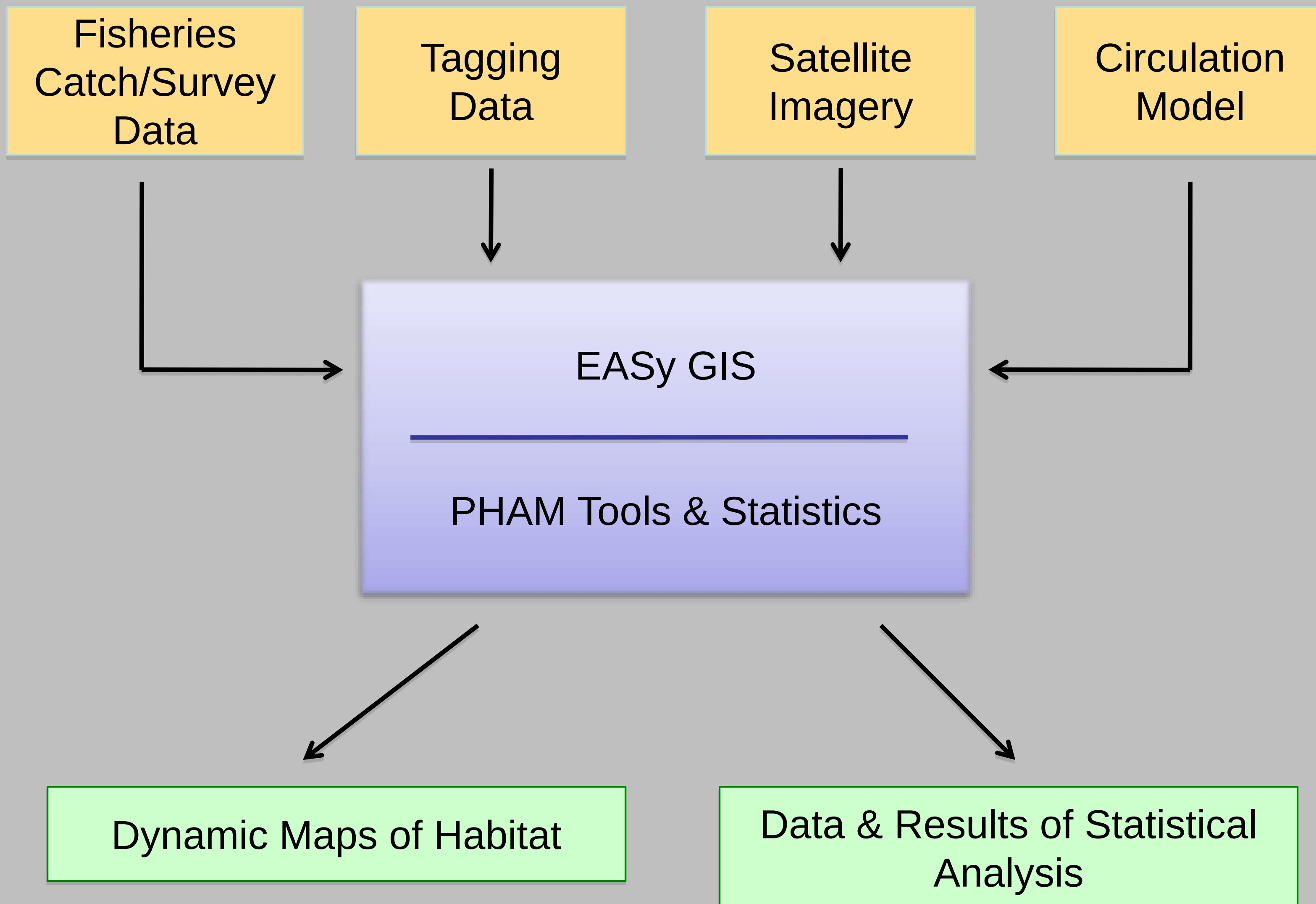
- Build an Eco-Socio-Economic Model of the Tuna Fishery of the Eastern Pacific Ocean that improves management of the resource: regional closures because of overfishing, by-catch, improved stock assessment models with improved definition of habitats.

- Apply this new spatially and temporally detailed model to future challenges of increased fuel costs, climate change, and technological development- e.g. expanded use and sophistication of fish aggregation devices.

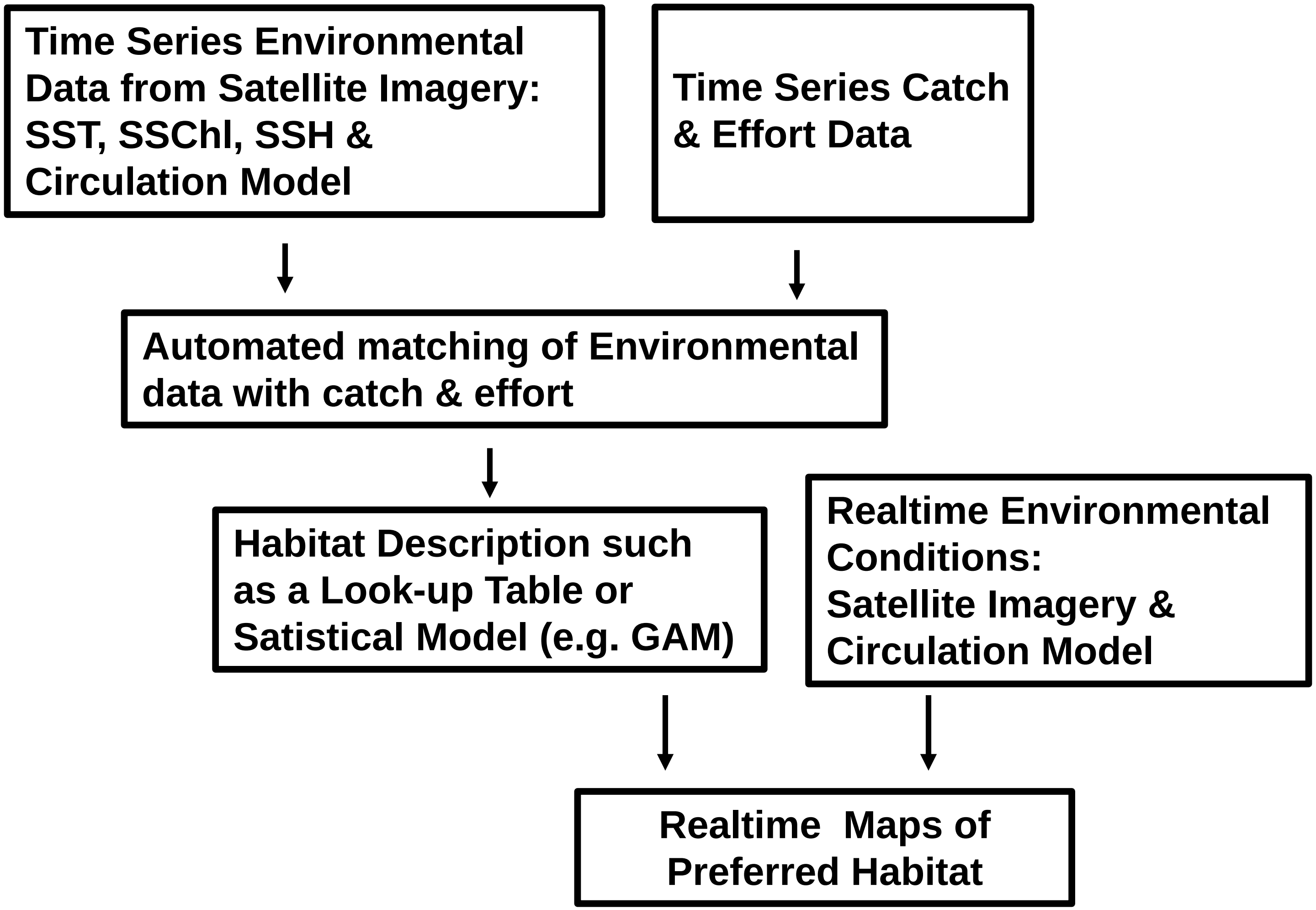


- 4 dimensional system for marine applications WGS 84/geodetic representation
- interfaces for models, spreadsheets, databases, and Internet
- PC Desktop & Web-enabled GIS applications

Pelagic Habitat Analysis Module (PHAM) Data Flow

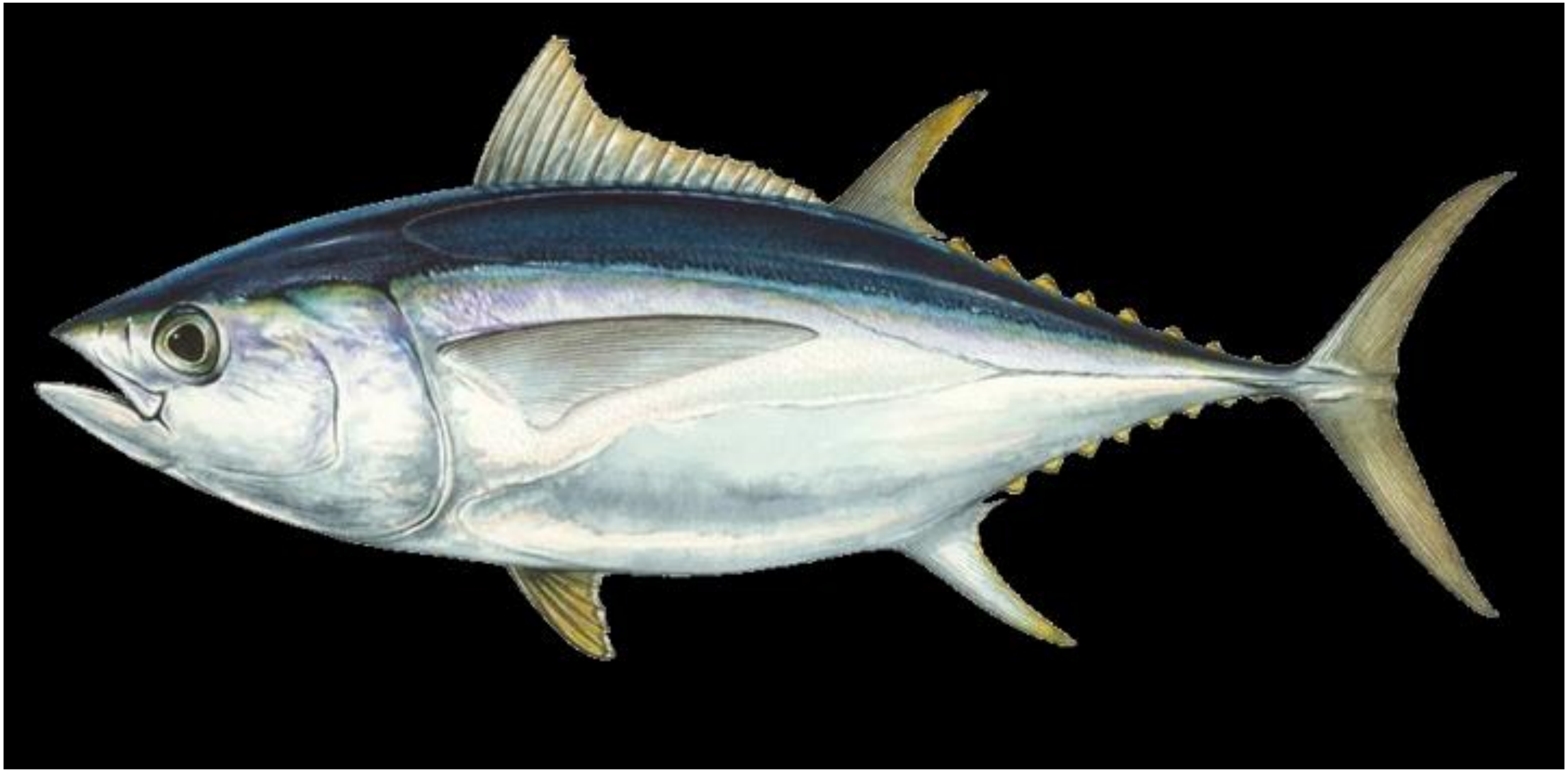


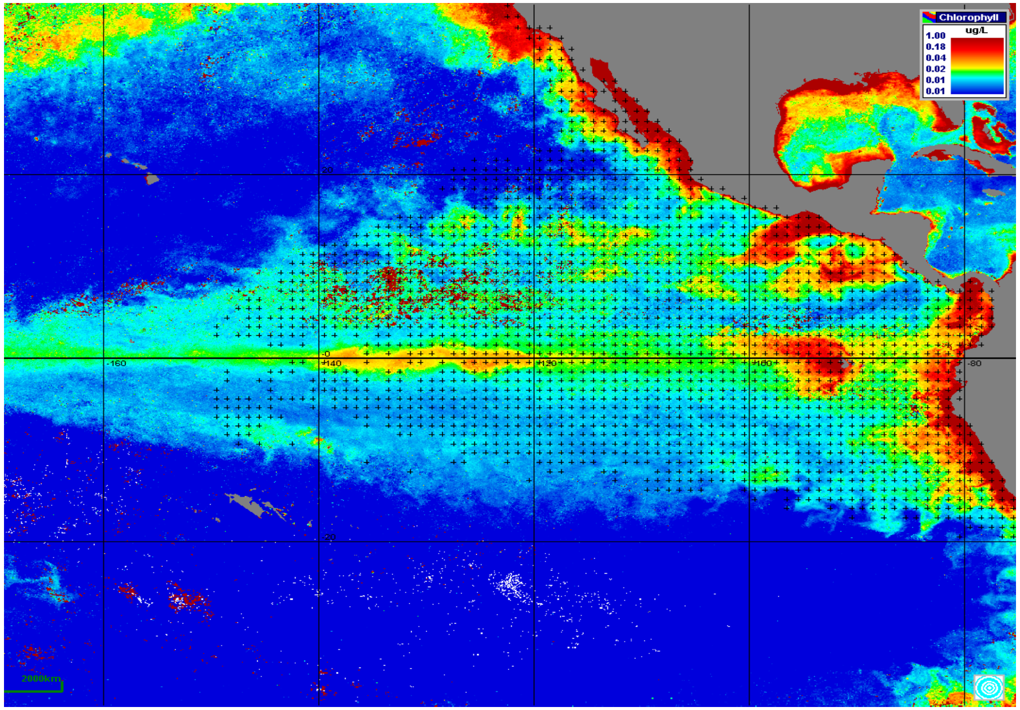
Pelagic Habitat Analysis Module (PHAM) Software Processing



Skipjack *Katsuwonus pelamis*

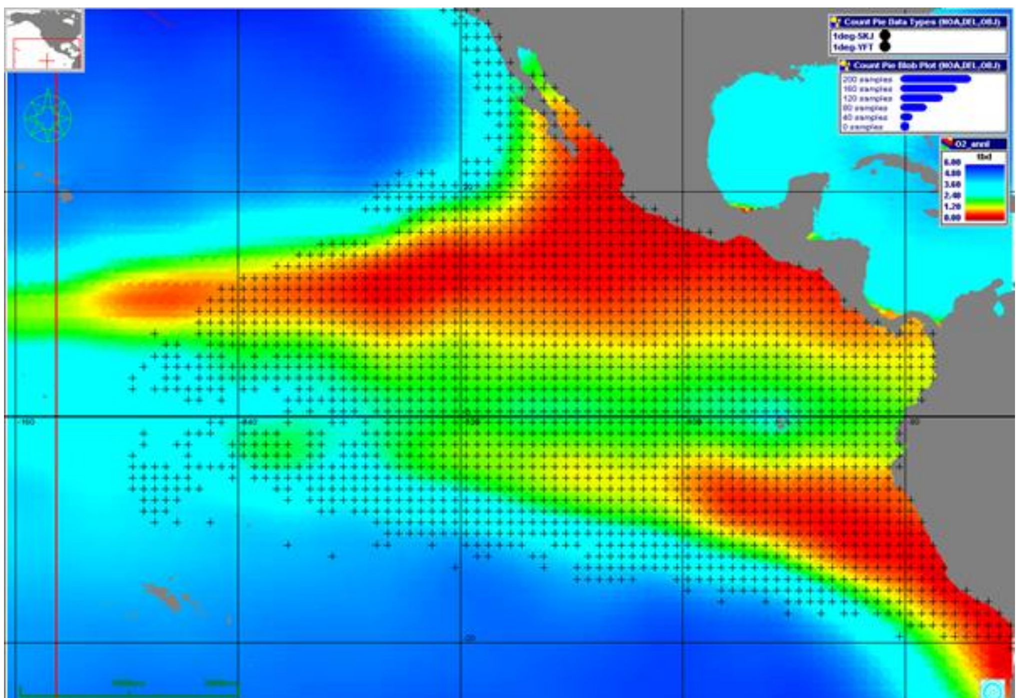
Yellowfin *Thunnus albacares*



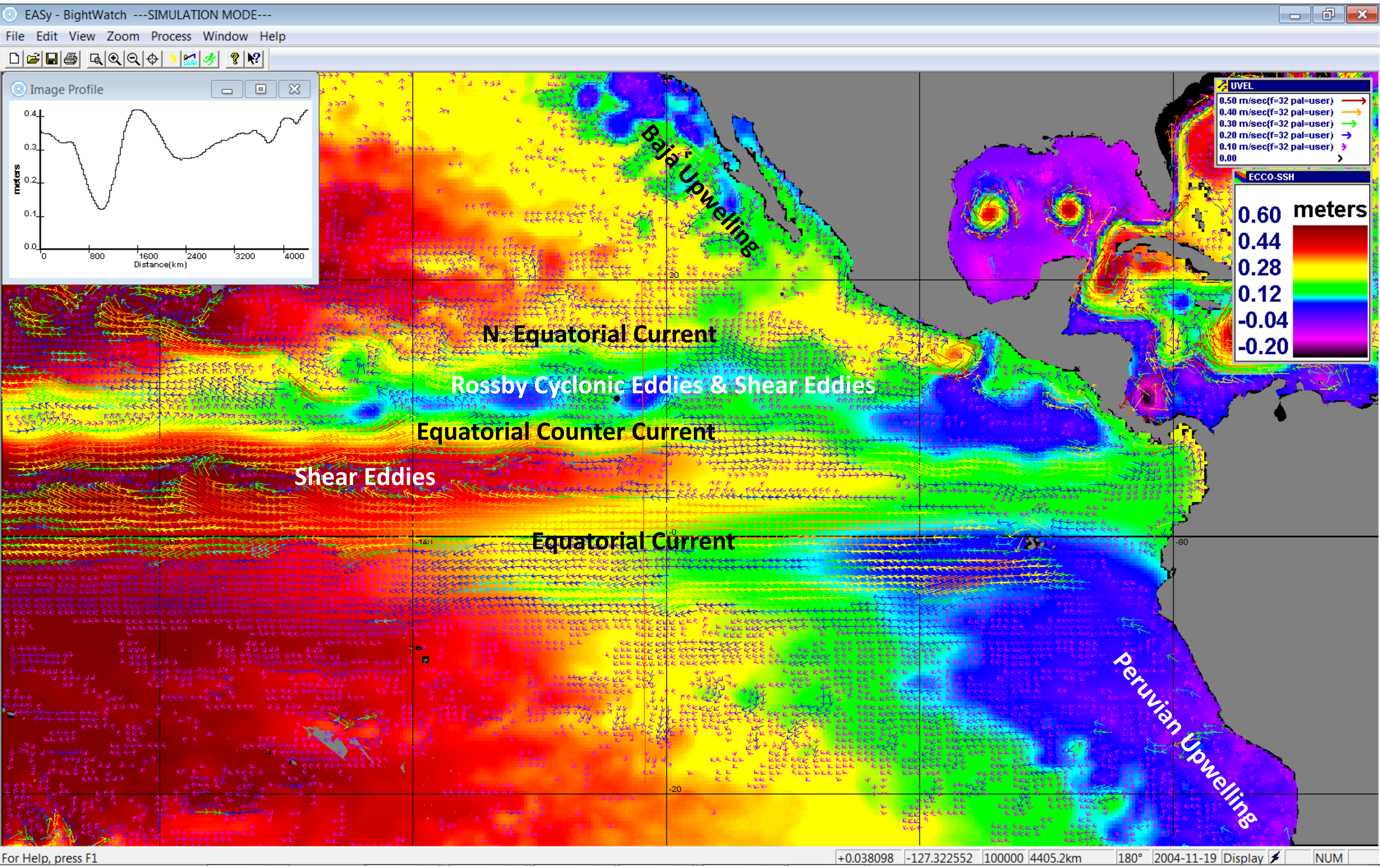


PHAM screen shots.
The purse seine fishing ground (indicated by +) matches well surface waters where chlorophyll concentration exceeds 1 mg/m3 (upper panel) & overlies the hypoxic layer (lower panel).

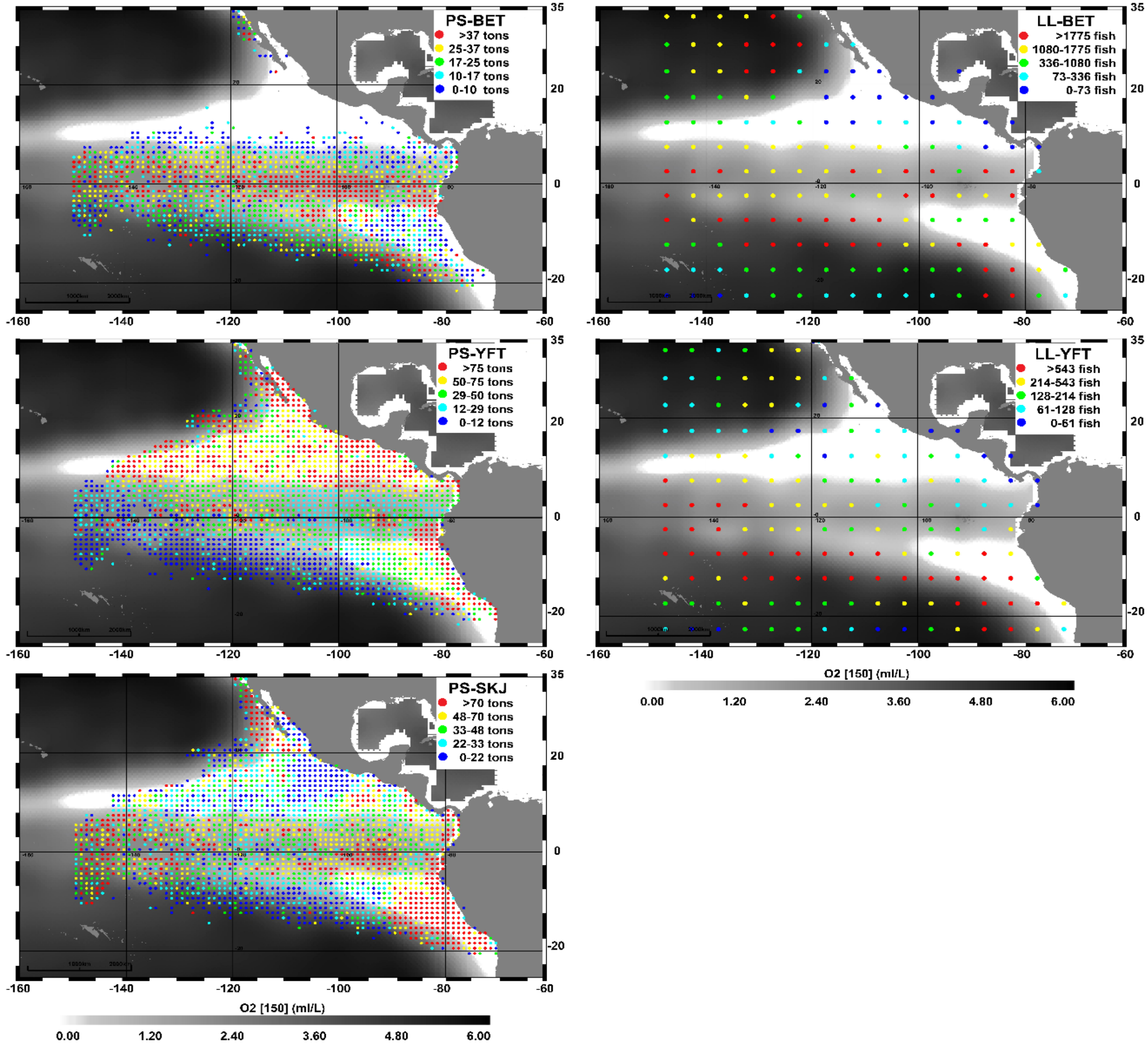
Purse seine recording stations superimposed upon a MODIS satellite image of surface chlorophyll concentration.



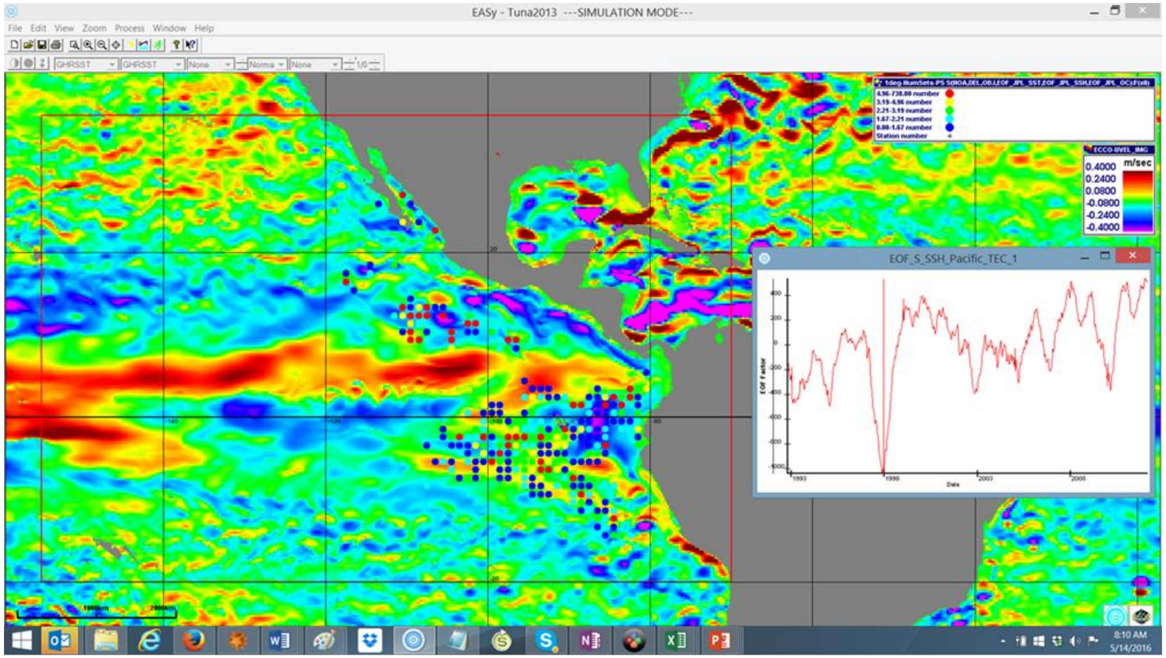
Purse seine recording stations superimposed upon a climatological image of annual average oxygen concentration at 150 m depth.



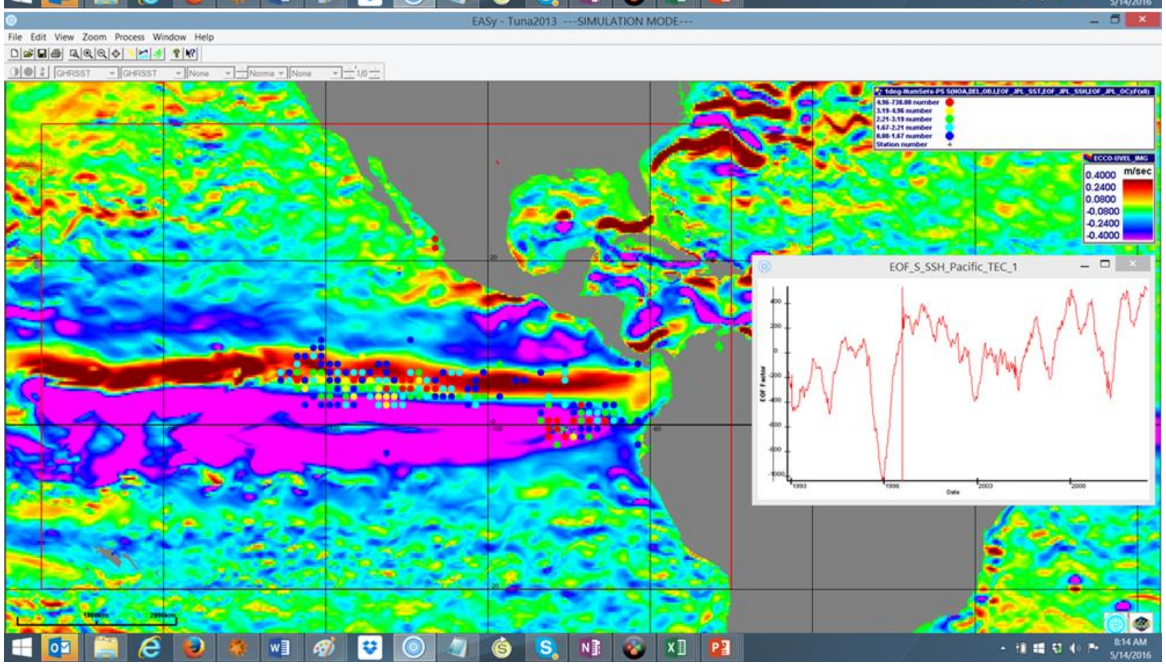
ECCO Sea Surface Height & Flow fields Nov. 19, 2004



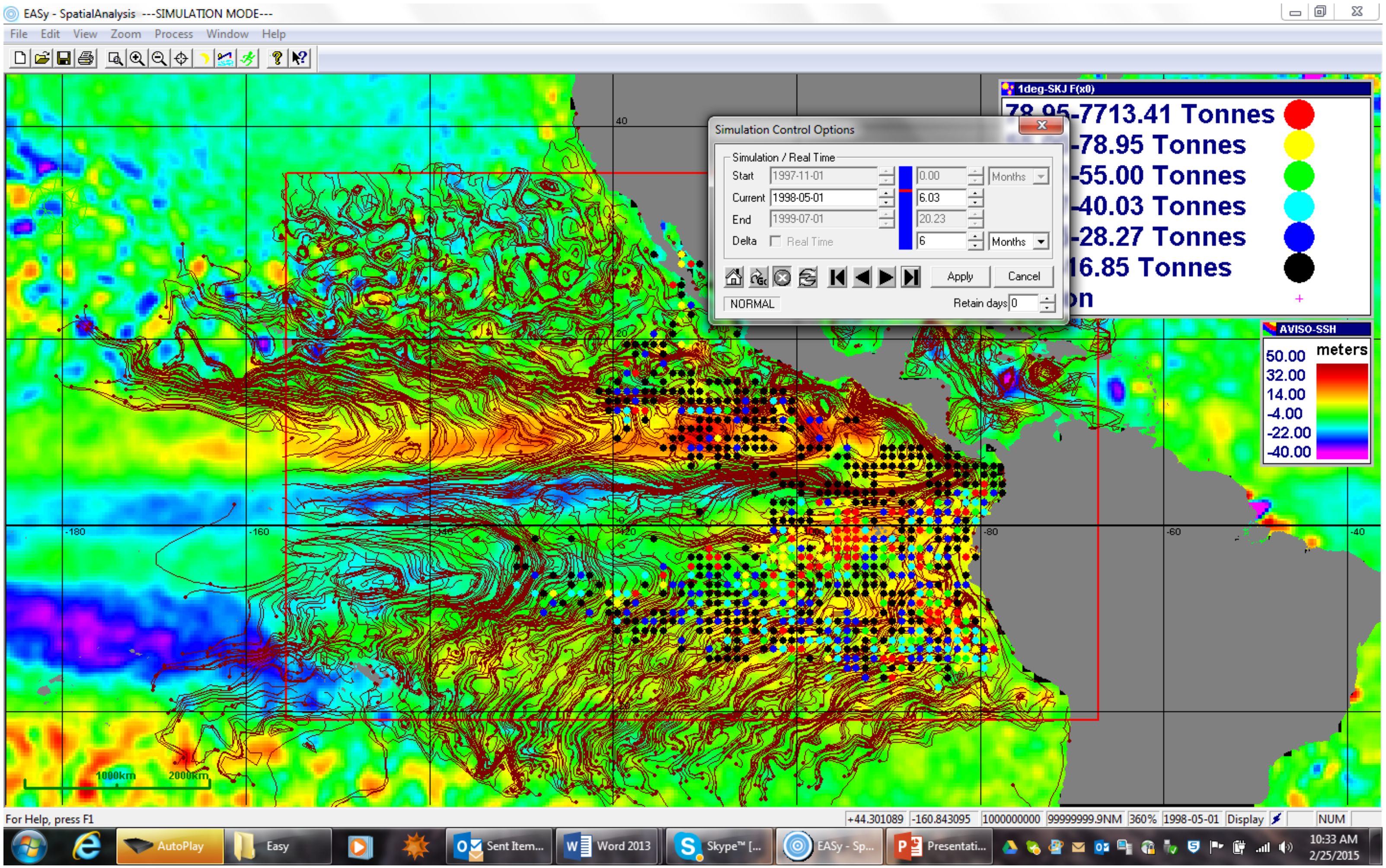
The left panels show the distribution of the average monthly biomass catch from 1975 to 2008 of bigeye (top), yellowfin (middle) and skipjack (bottom) tuna caught by the purse seine fleet superimposed on an image of the average annual concentration of oxygen at 150 m, O2 [150]. The right panels show the distribution of the catch of bigeye (top) and yellowfin (bottom) caught by longline fleet, respectively for the same time period.



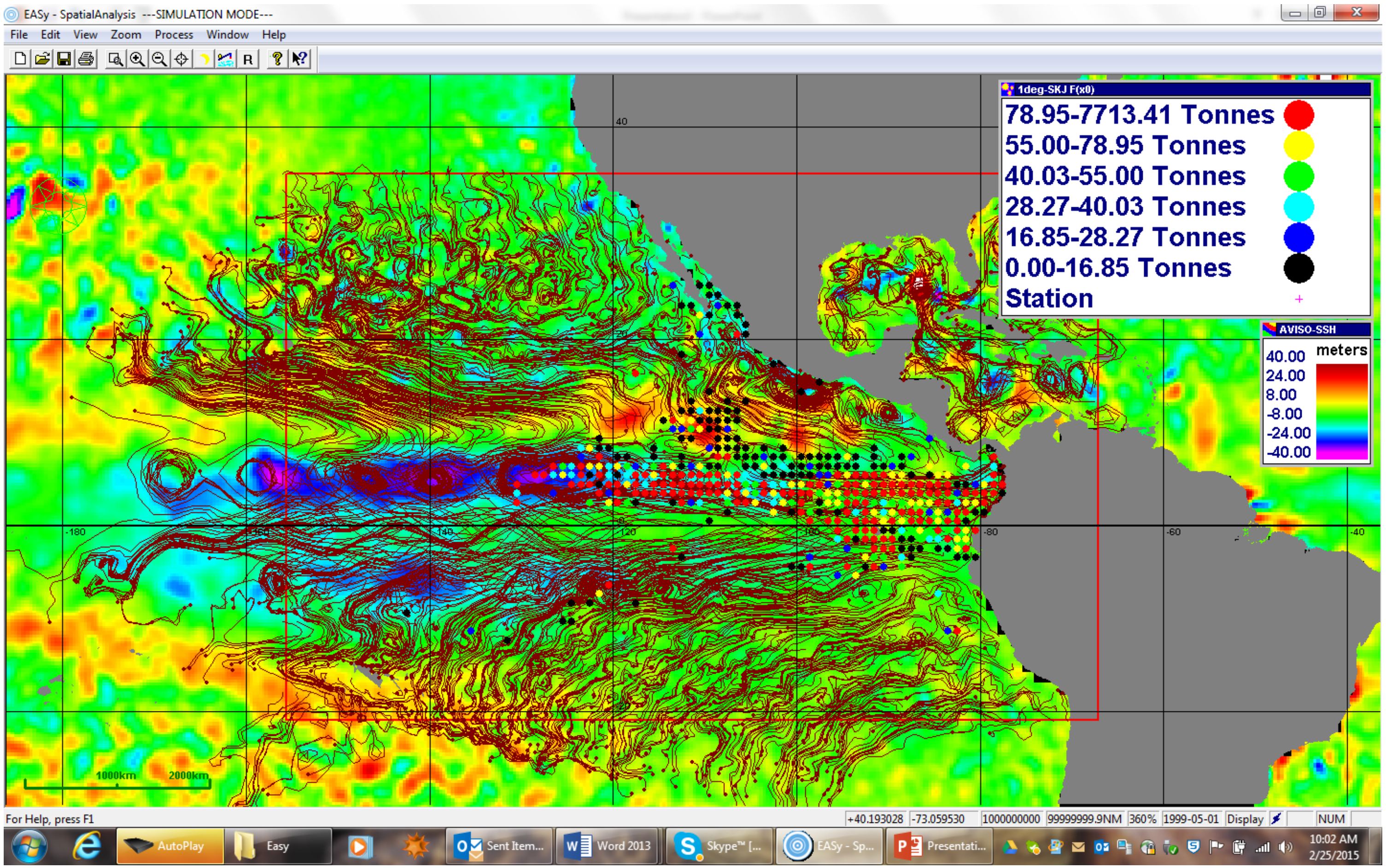
El Nino Number of Sets plotted on ECCO 2 zonal velocity 12/15/1997



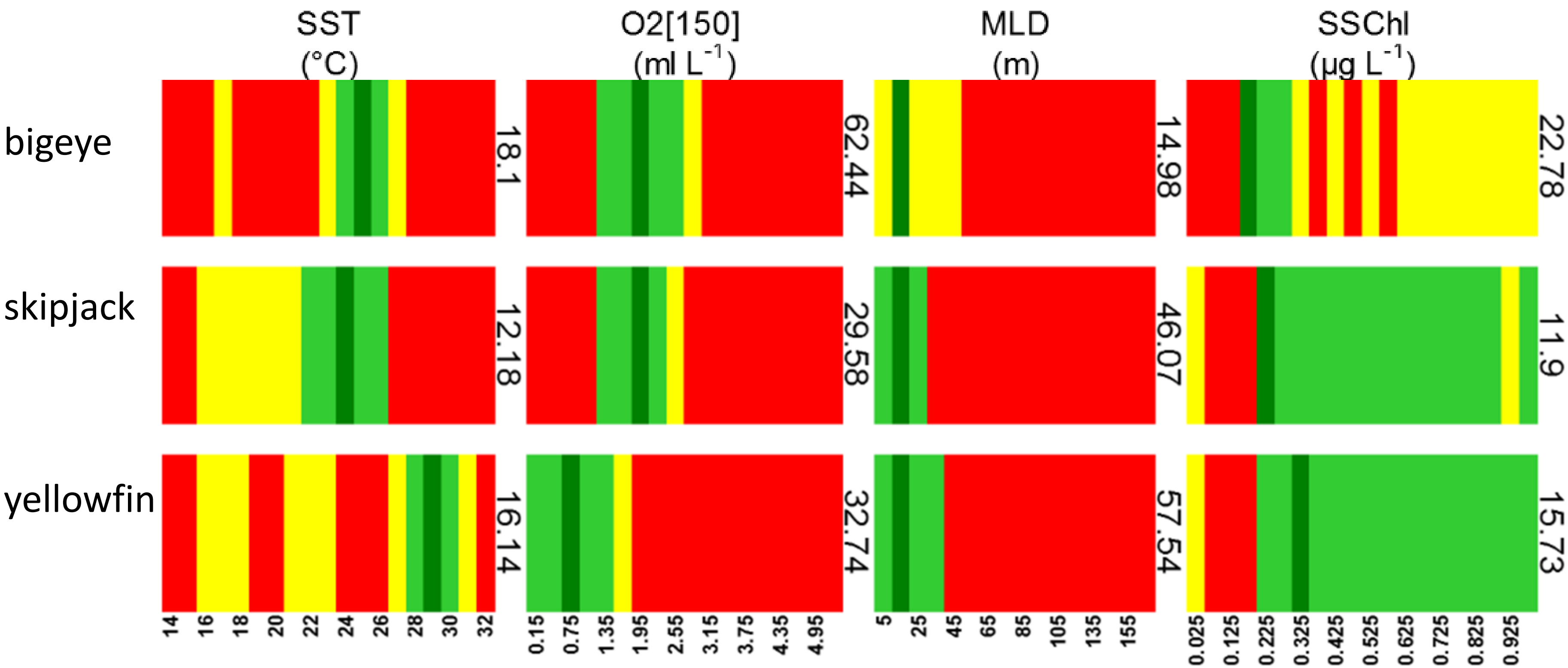
La Nina Number of Sets plotted on ECCO 2 zonal velocity 12/15/1998



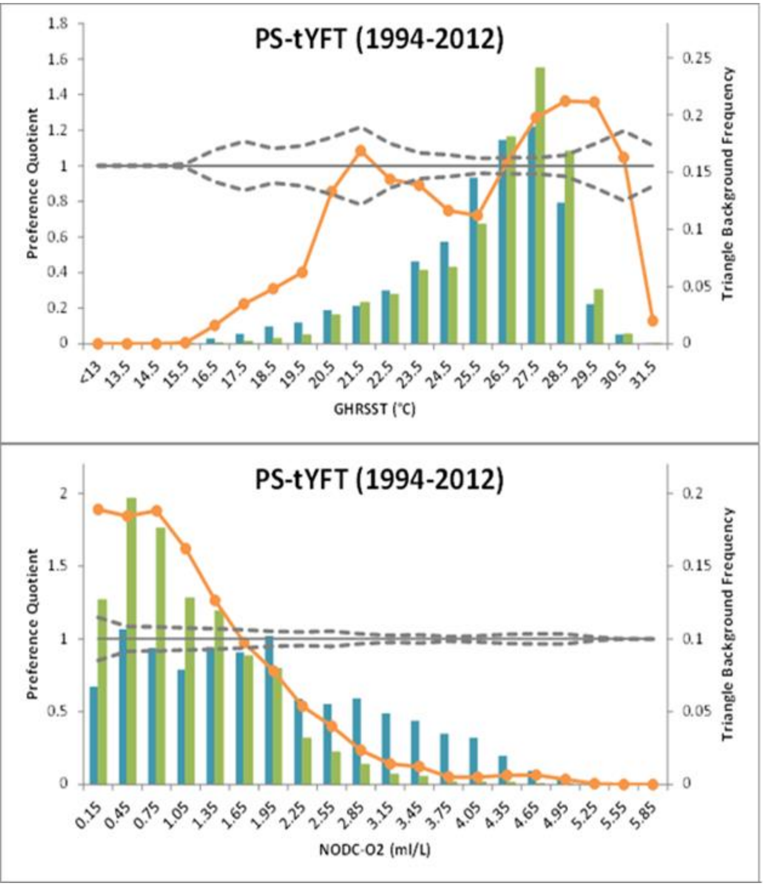
El Nino 11/1/97-5/1/98 SKJ PS Catch, ECCO-2 Drifts, AVISO SSH (5/1/98)



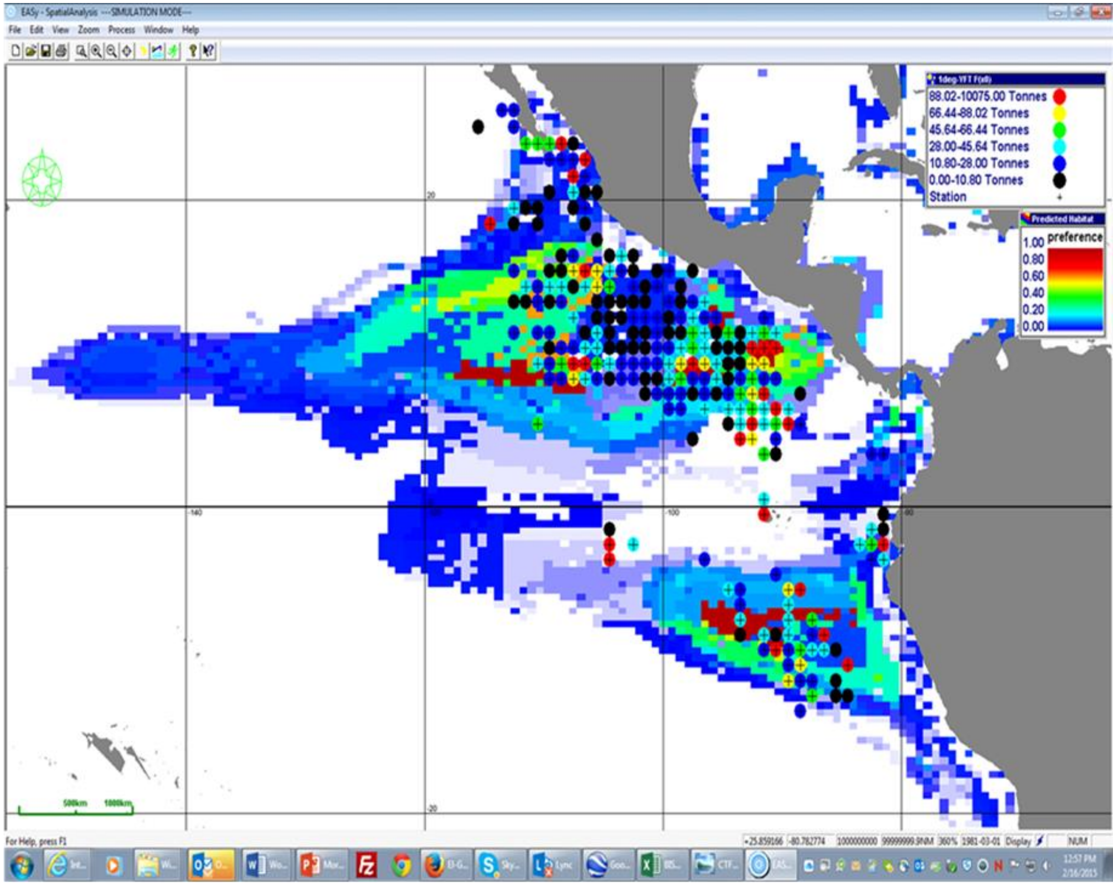
La Nina11/1/98-5/1/99 SKJ PS Catch, ECCO-2 Drifts, AVISO SSH (5/1/99)



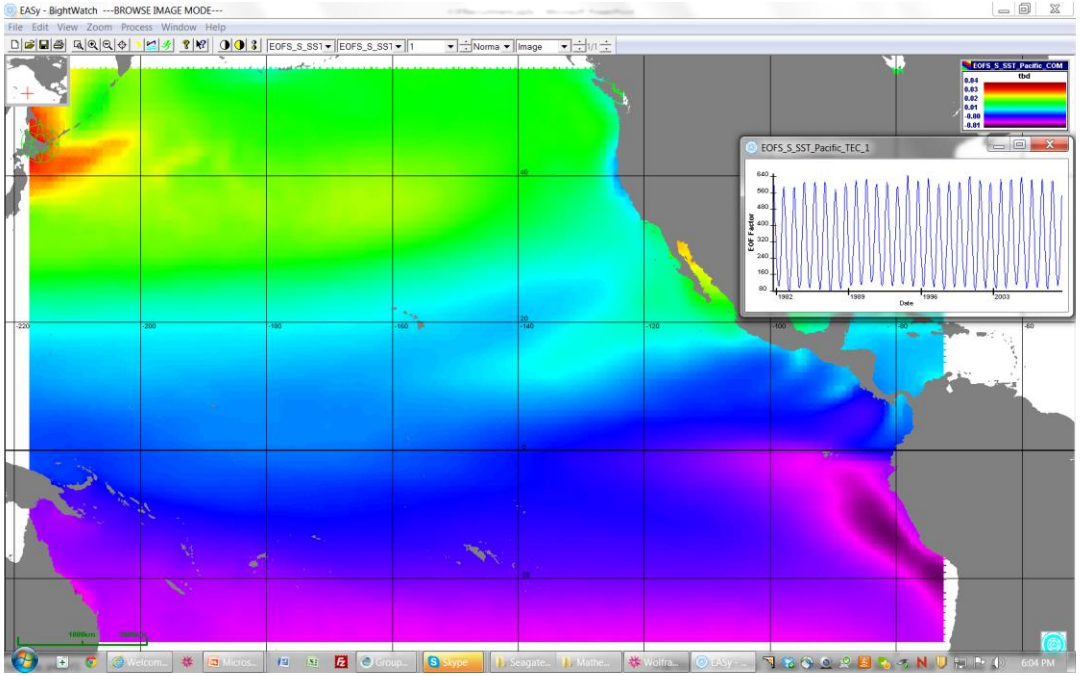
SST
(°C)
O2[150]
(ml L^{-1})
MLD
(m)
SSChl
(µg L^{-1})
bigeye
skipjack
yellowfin
18.1
62.44
14.98
22.78
12.18
29.58
46.07
11.9
16.14
32.74
57.54
15.73
14
16
18
20
22
24
26
28
30
32
0.15
0.75
1.35
1.95
2.55
3.15
3.75
4.35
4.95
5
25
45
65
85
105
135
155
0.025
0.125
0.225
0.325
0.425
0.525
0.625
0.725
0.825
0.925



Quotient Analysis: Preference/Avoidance of Juvenile Yellowfin for SST and depth of hypoxic layer

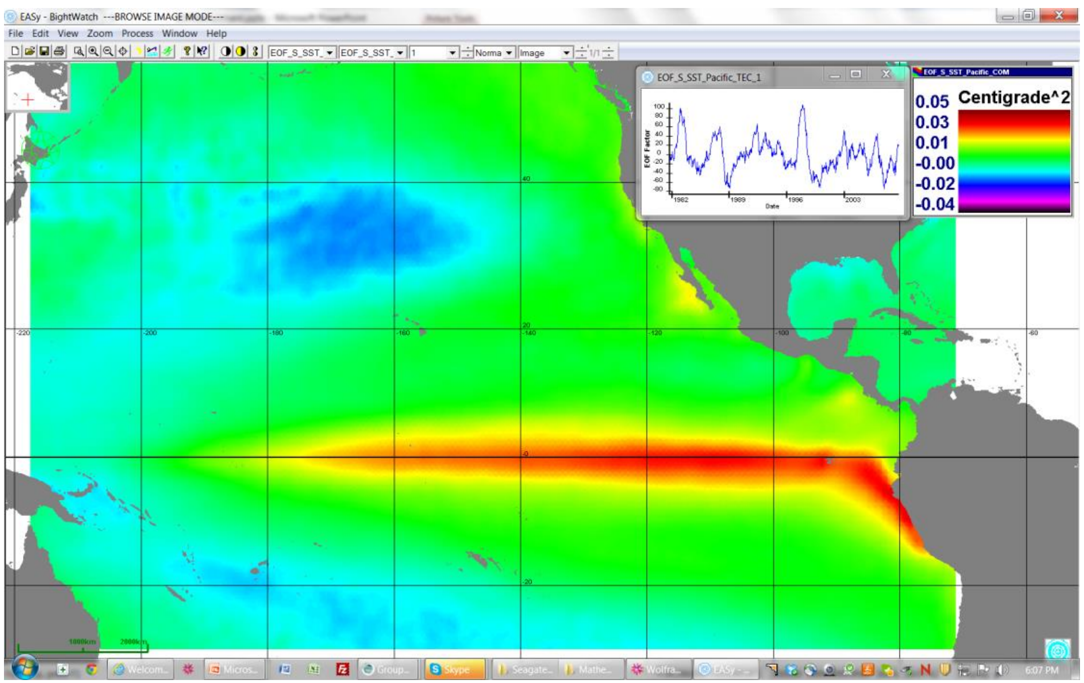


PHAM Realtime Mapping of Preferred Habitat of Yellowfin from Look-up Table and Catch



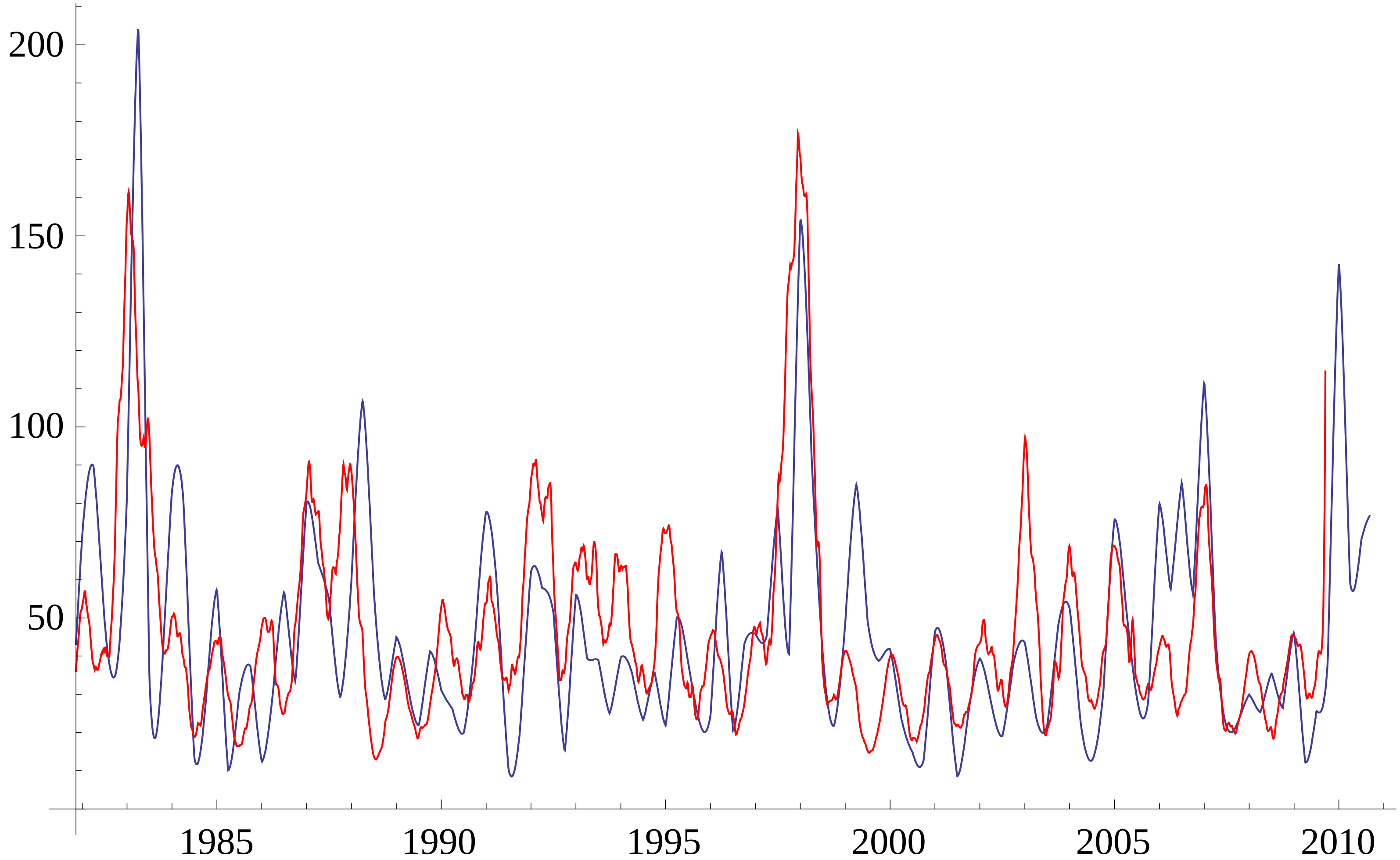
We have developed an algorithm to predict the recruitment of yellowfin tuna based upon EOF extraction of patterns from time series of satellite imagery.

EOF 1st Seasonal spatial component & temporal expansion coefficient (right hand corner)



EOF 1st nonseasonal spatial component & temporal expansion coefficient

Yellowfin Tuna Recruits Per Spawner Biomass from Stock Assessment (blue) and EOF Algorithm Applied to Satellite SST



Correlation between temporal expansion coefficients and yellowfin recruitment lead to hypothesis of temporal evolution.

Technical and Scientific Conclusions

The PHAM software provided us with the tools to automate the process of defining and mapping the preferred habitat of tuna of the Eastern Tropical Pacific. These tools include:

- automated downloading and spatial- temporal integration of diverse formats of satellite imagery and model output with catch and effort data
- automated matching in space and time environmental variables with catch and effort data
- built-in statistical analyses to define preferred habitat
- automated real time mapping of species habitat from satellite imagery and circulation models.

The distribution of tuna in equatorial waters is driven by the strengths of the equatorial and coastal currents. In turn these currents drive changes in mesoscale and submesoscale features. It is also driven by the strength of coastal upwelling. This most clearly illustrated with changes in distribution and catch with ENSO signals.

The depth of the hypoxic layer also shapes the vertical and horizontal distribution of the three commercial species. We propose that the hypoxic layer of the eastern tropical Pacific vertically compresses the planktonic and pelagic ecosystem leading to a more efficient cycling of nitrogen. It also limits the vertical migration of tuna prey making them more vulnerable to the tuna as well as making the tuna more vulnerable to fishers.