Gulf of Mexico Primary Production Working Group

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Review of goals of Coastal Carbon Synthesis efforts

- The contribution of coastal margins to regional and global carbon budgets is not well understood, largely due to limited information about the magnitude, spatial distribution, and temporal variability of carbon sources and sinks in coastal waters
- Building on recommendations put forth during the 2005 North American Continental Margins (NACM) Synthesis and Planning Workshop, and progress made since then, the Ocean Carbon & Biogeochemistry (OCB) Program has been collaborating with the North American Carbon Program (NACP) to develop Coastal Synthesis Activity to stimulate the synthesis of observational and modeling results on carbon cycle fluxes and processes along the North American continental margins
- This activity has been divided geographically into five regions: East Coast, West Coast, Gulf of Mexico, Arctic, and Great Lakes.

Review of charge to Primary Production Working Group

- The Primary Production Working Group is charged with compiling relevant literature and databases related to primary production in the Gulf of Mexico in support of the development of a regional carbon budget
- In addition, the working group is encouraged to collaborate (including engaging other colleagues as appropriate) in developing a synthesis of the relevant information

Measurement Types

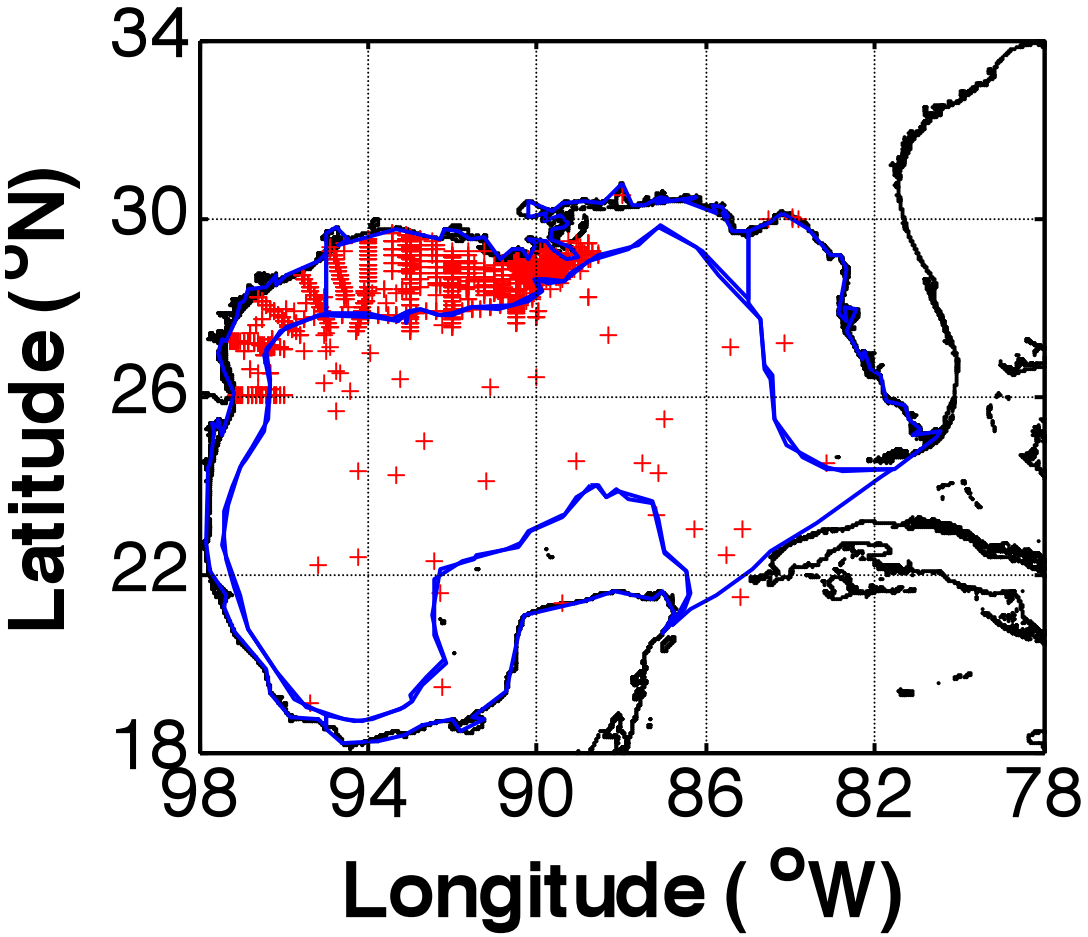
- ^{14}C-based primary production estimates - bottle incubations
  - P-E based measurements
  - In situ
  - Simulated In Situ
- Oxygen-based primary production estimates
- Other (^{13}C, ^{18}O, etc.) – few of these in the Gulf
- Satellite-derived primary production estimates
  - Vertically Generalized Production Model, VGPM;
  - Carbon-based Productivity Model, CbPM
  - Wavelength-resolved models
  - Other algorithms?
- Ecosystem models of primary production
- Benthic primary production
  - In situ Chamber
  - Benthic chl
- Other groups addressing net community production and particulate and dissolved organic carbon inputs

Approach

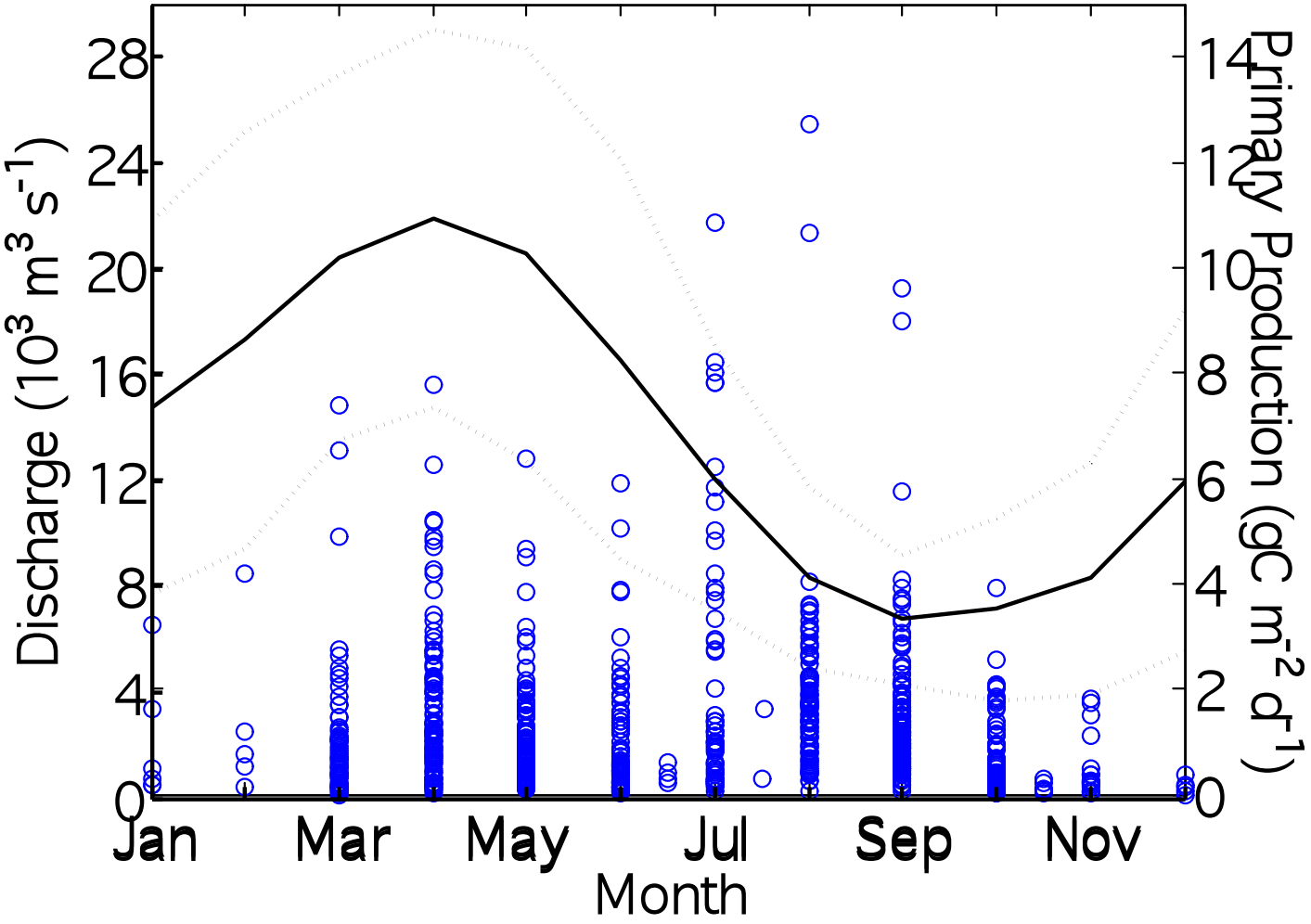
- Spatial and Temporal Distribution and Synthesis of Literature
- Group by area Gulf of Mexico be organized into different regions including:
  - Open Gulf
  - Texas
  - N Central
  - WFS
  - MX
- Errors and uncertainties

Primary Production from Ship-based Studies

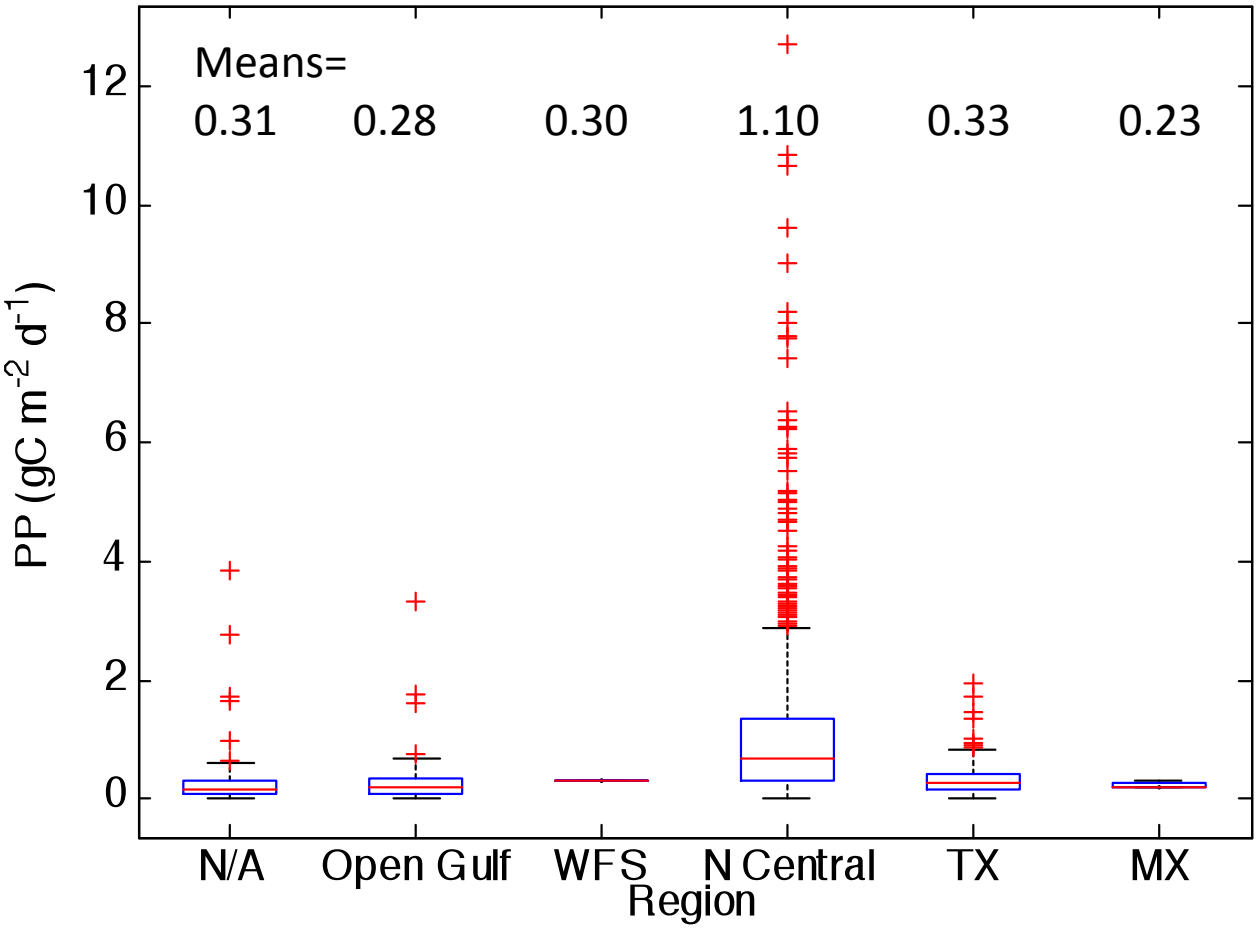
- Mainly concentrated in the north central Gulf
- More data available on the WFS?



Gulf Productivity by Month



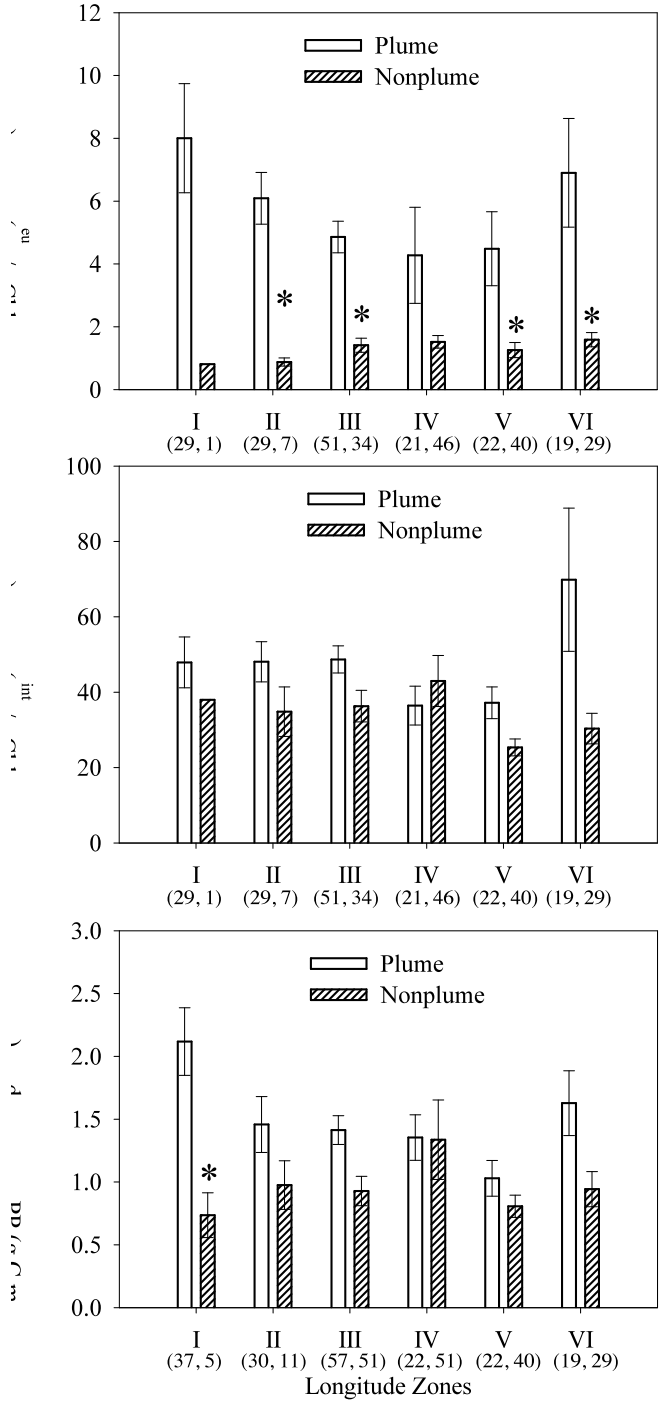
Gulf Productivity by Region



Louisiana Shelf Primary Production (Lehrter et al. 2009)

Plume: Sal < 31
Nonplume: Sal > 31

Region I: East of 89.5°W
Region II: 89.5°W to 90°W
Region III: 90°W to 91°W
Region IV: 91°W to 92°W
Region V: 92°W to 93°W
Region VI: West of 93°W

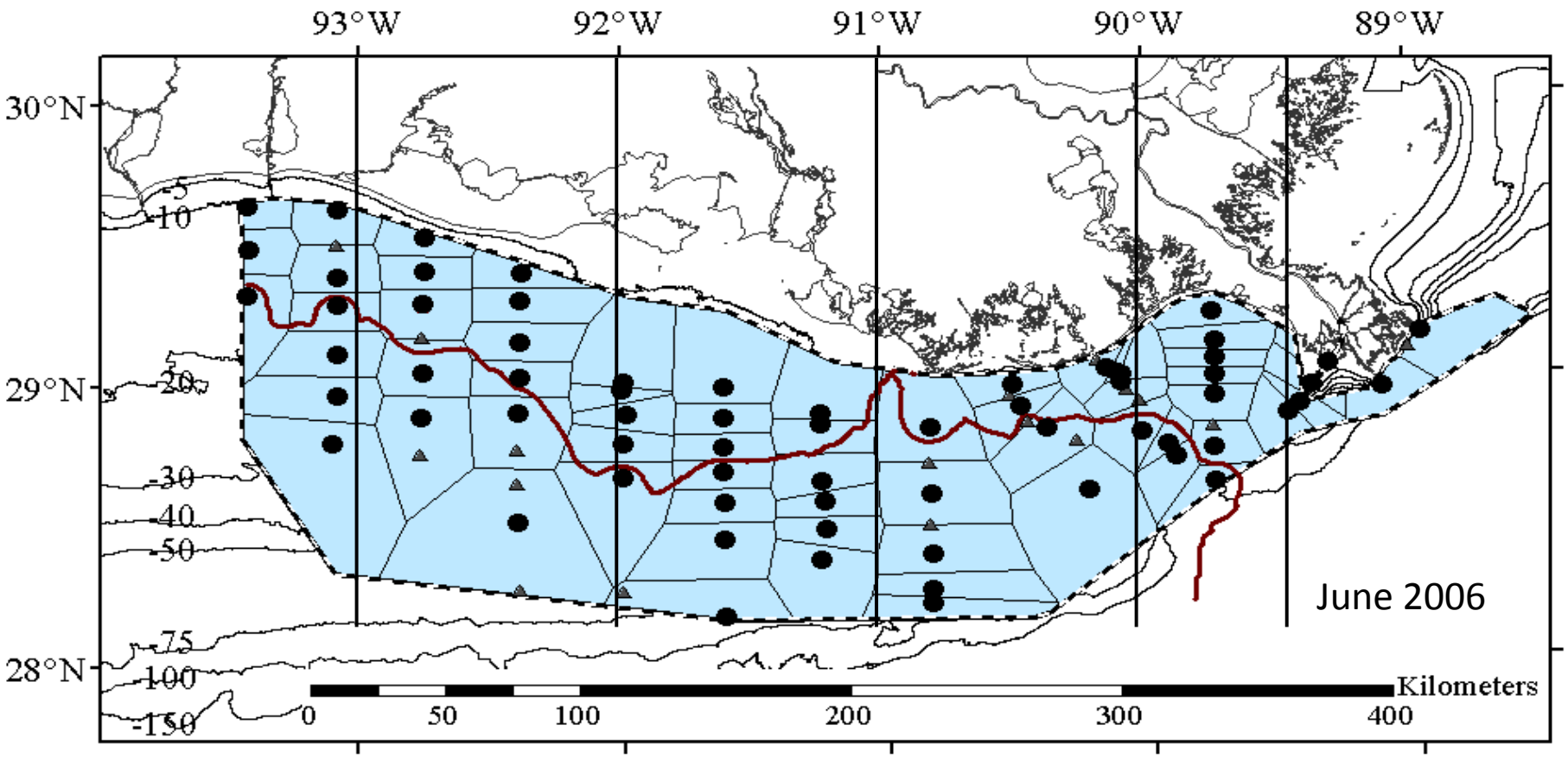


Annual Average = 381±58

Previous estimates

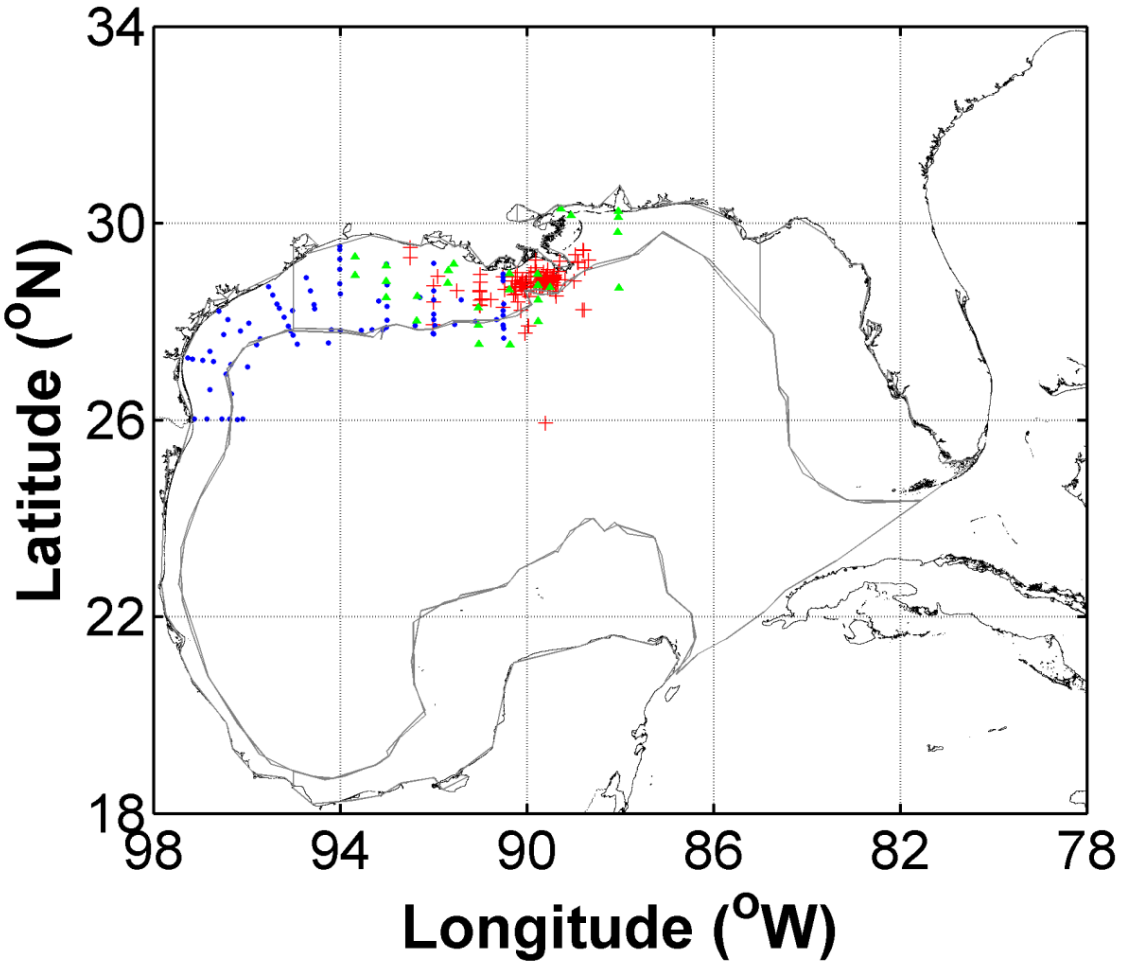
- 290 (Sklar and Turner 1981)
- 329 (Lohrenz et al. 1990)

Shelf Segmentation Scheme



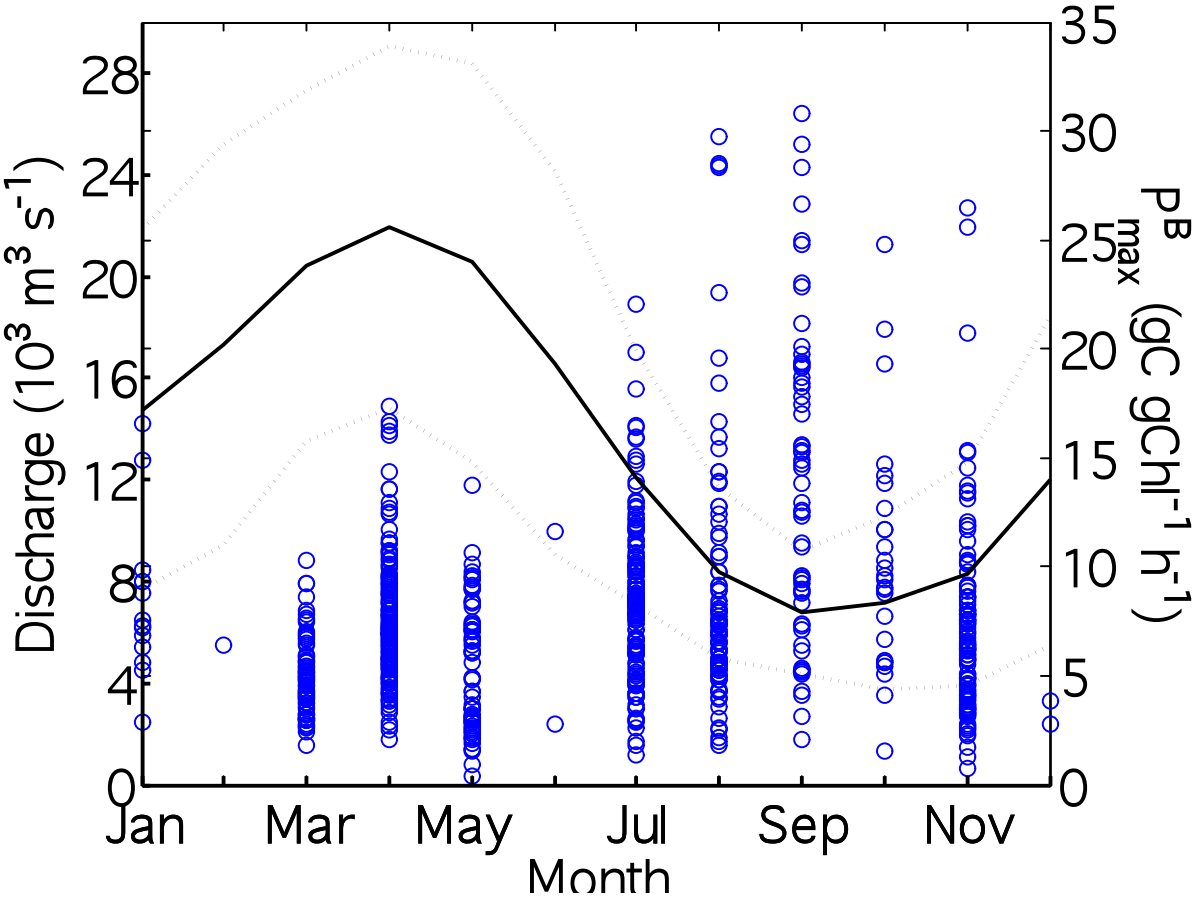
Photosynthesis-Irradiance

- PBmax observations mainly in N and NW



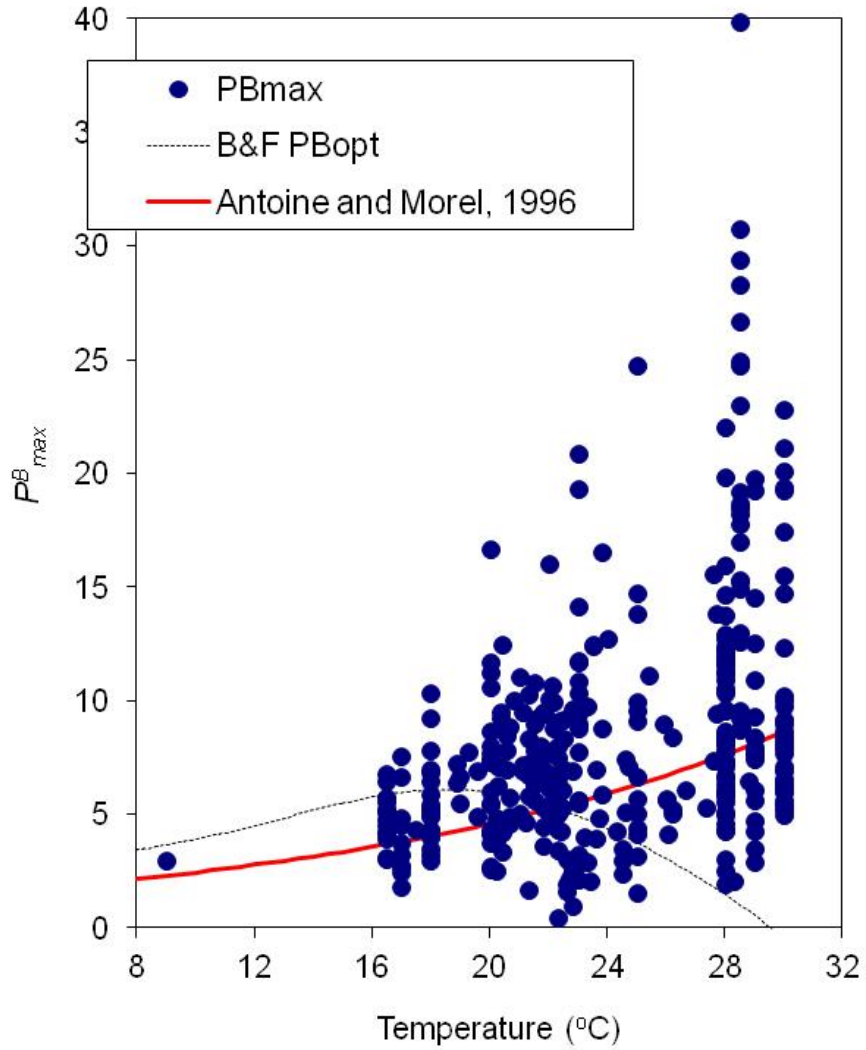
Photosynthesis-Irradiance

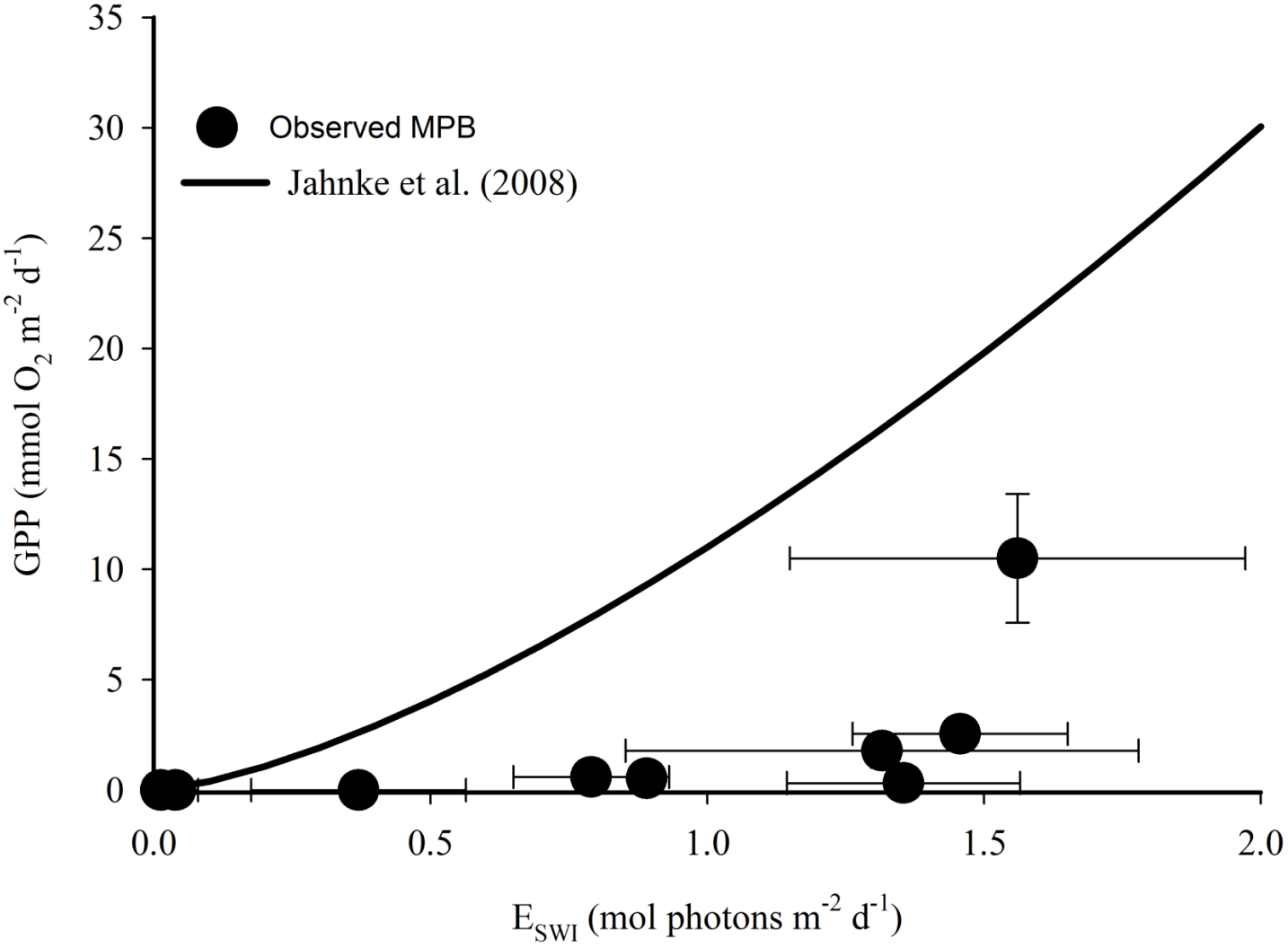
- Variation in relation to time of year



Photosynthesis-Irradiance

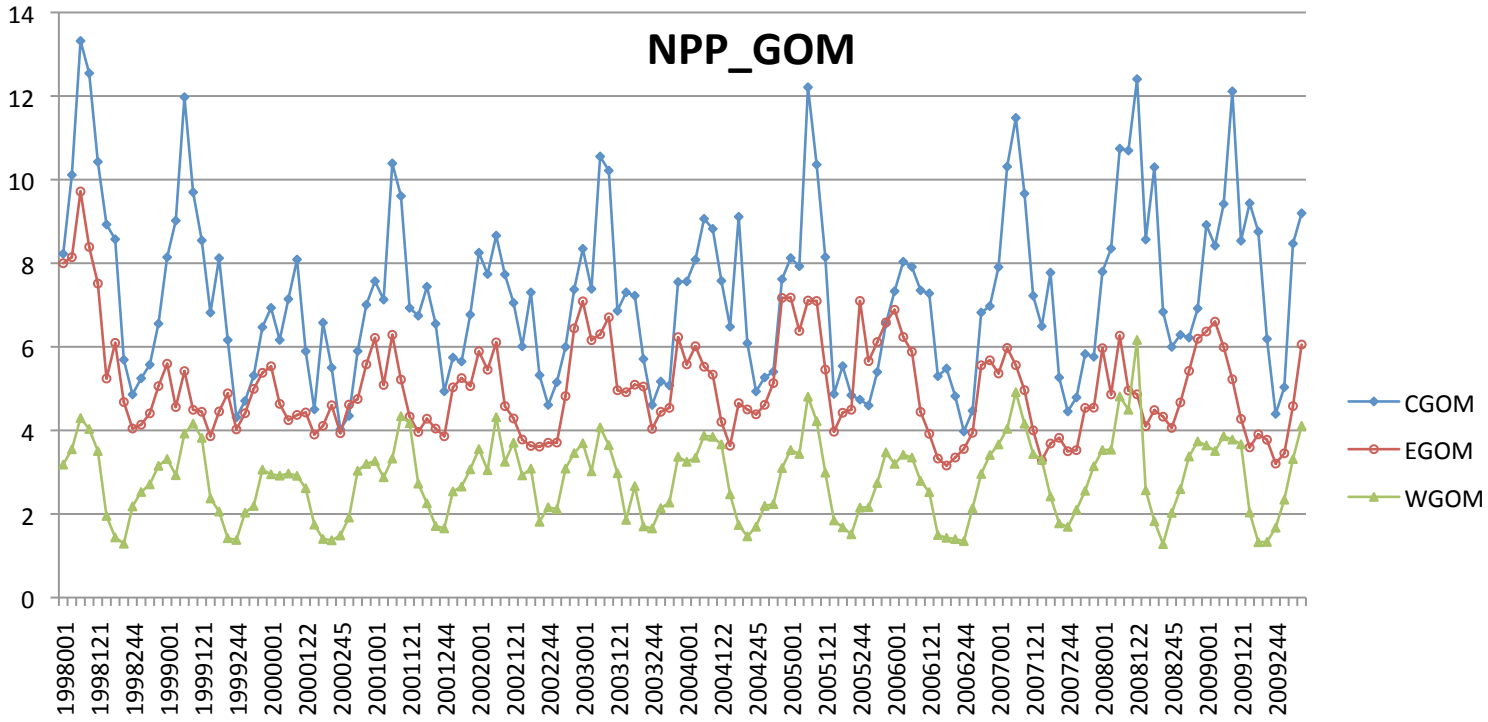
- PBmax in relation to temperature





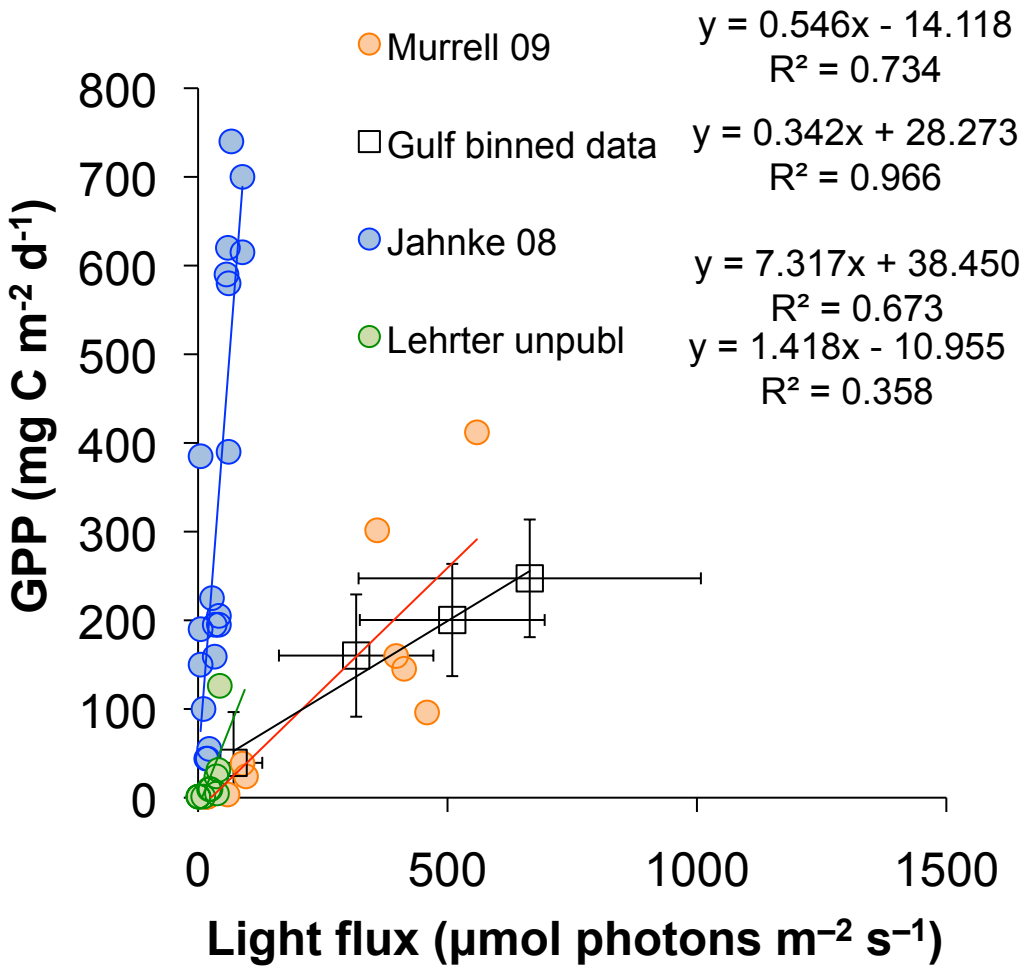
Lehrter in prep.

Satellite Derived NPP



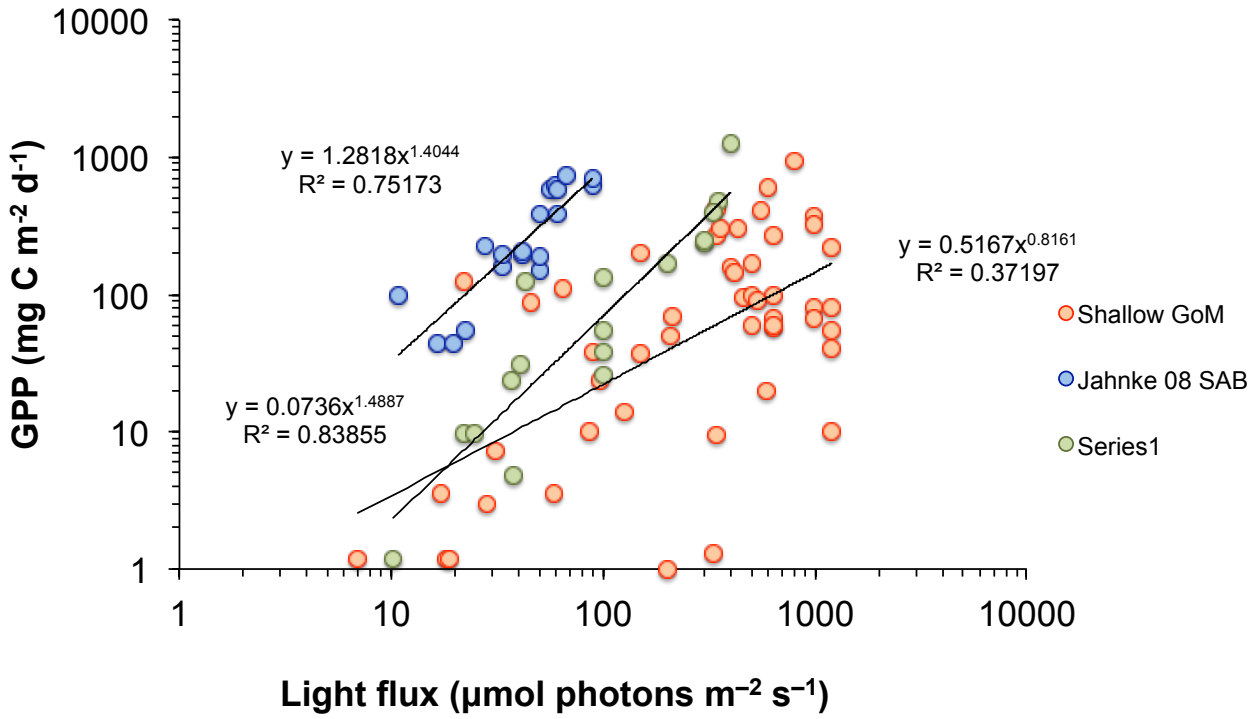
Benthic Primary Production

Production of Microphytobenthos vs. Light



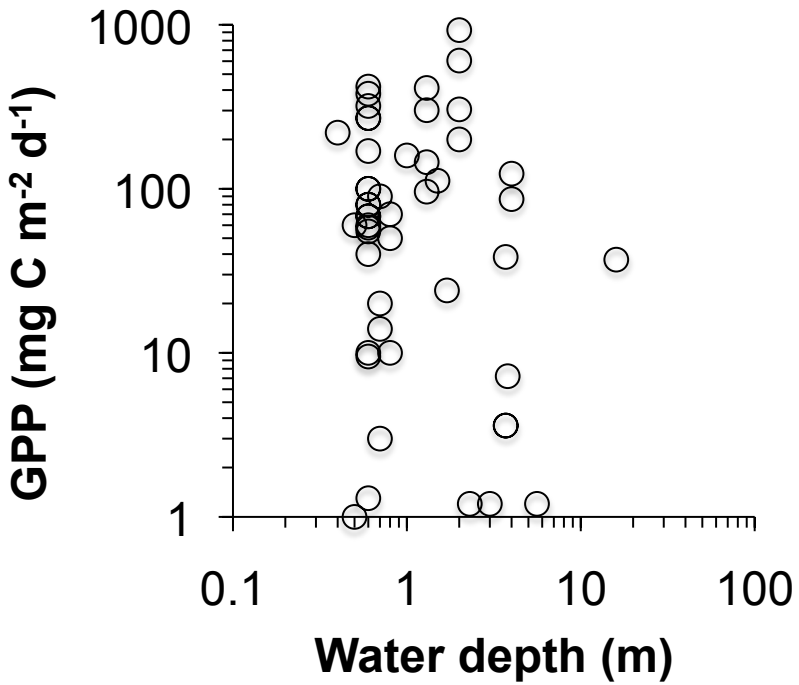
Comparison of microphytobenthos production data from the shallow (<10 m) Gulf of Mexico with those of the deeper Louisiana shelf (Lehrter) and SAB shelf (Jahnke 08, <40 m) suggest that the deeper communities are low light adapted.

Production of Microphytobenthos vs. Light



The data for microphytobenthos production from the shallow (<10 m) Gulf of Mexico suggest that the increase of growth rate with increasing light is less effective than in the deeper Louisiana shelf (Lehrter, Huettel <20m) and SAB shelf (Jahnke 08, <40 m), which may be caused by nutrient limitation or enhanced grazing.

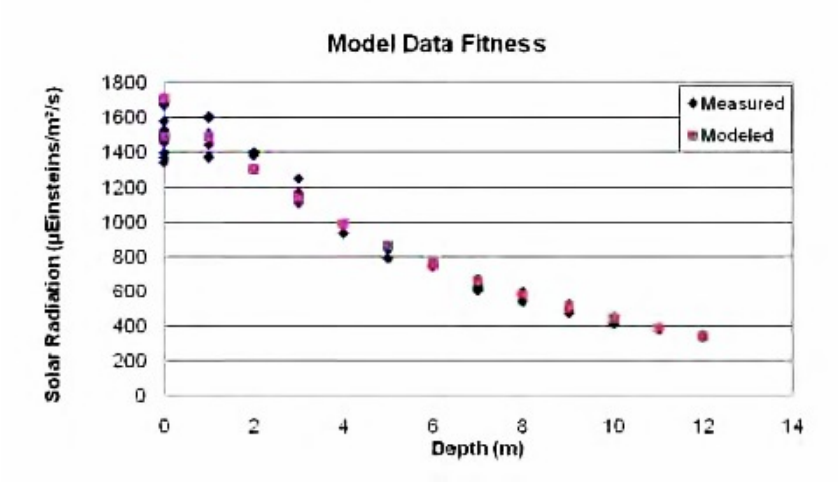
Shallow GOM microphytobenthos gross production vs. water depth

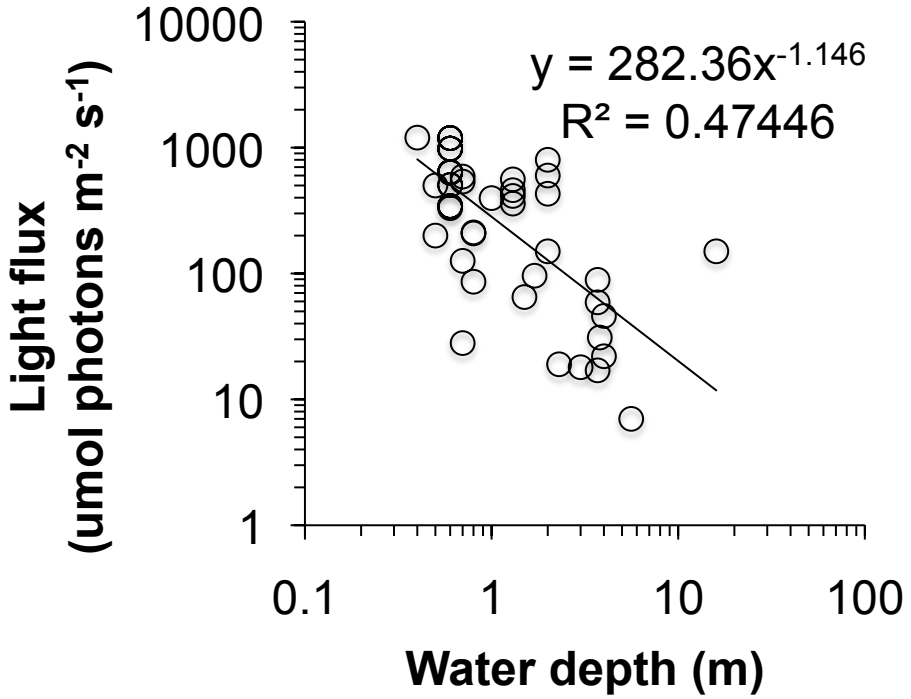


Similar to the findings of Jahnke08 for microphytobenthos production from the SAB shelf, the data from the shallow Gulf of Mexico did not show a clear correlation with water depth. This is likely due to the high and variable turbidity of the shallow areas and the large fluctuations in nutrient concentrations

Light vs. depth for West Florida Shelf and other shallow Gulf areas

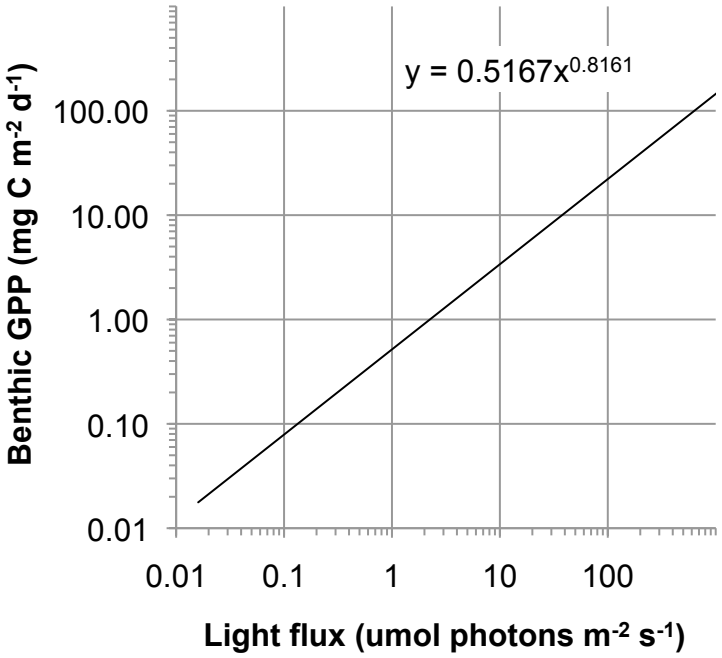
From:
Hallock, Pamela, and others, 2010, West Florida Shelf: A natural laboratory for the study of ocean acidificiation: U.S. Geological Survey Open-File Report 2010-1134, 95 p.

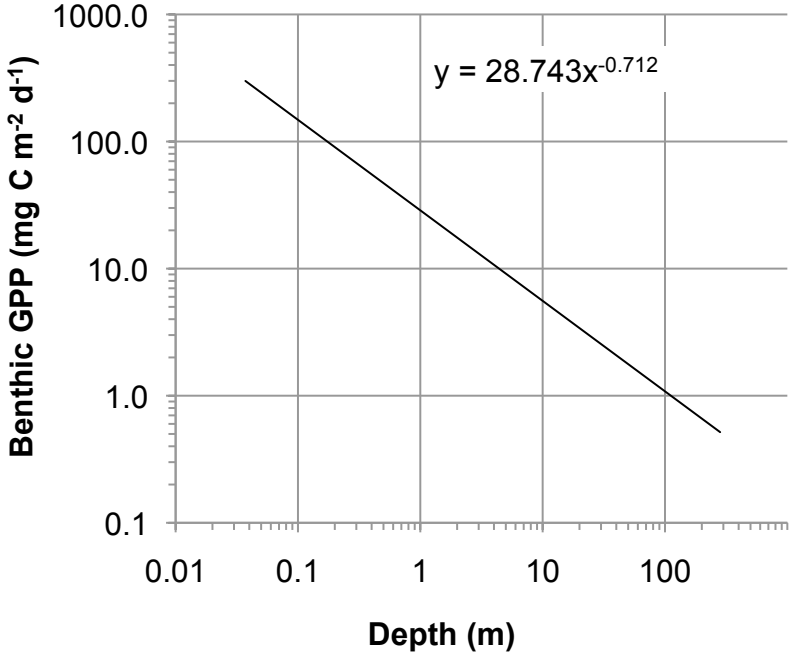




Hallock's data suggest that in the WFS about 400 µmol photons m^{-2} s^{-1} (April 2008) reach 10 m water depth, while in the shallow coastal Gulf, only about 20 µmol photons m^{-2} s^{-1} reach that depth.

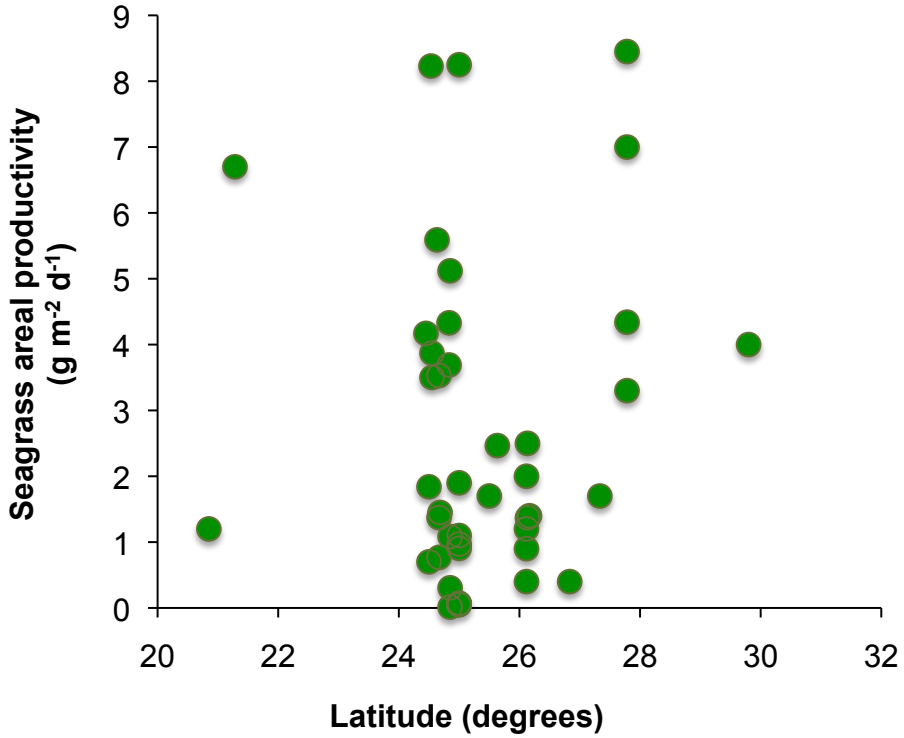
Fitted functions for shallow water microphytobenthos production





Based on the literature data on shallow Gulf microphytobenthos production, above graphs can be used to make rough approximations based on light and water depth.

Seagrass areal productivity



Literature data suggest that the areal productivity of seagrass in the Gulf of Mexico is approximately 2.65 ± 2.38(SD) g m^{-2} d^{-1}. The majority of the data is based on measurements of *Thalassia testudinum* production and thus may overestimate areas colonized by smaller species or less dense seagrass meadows.

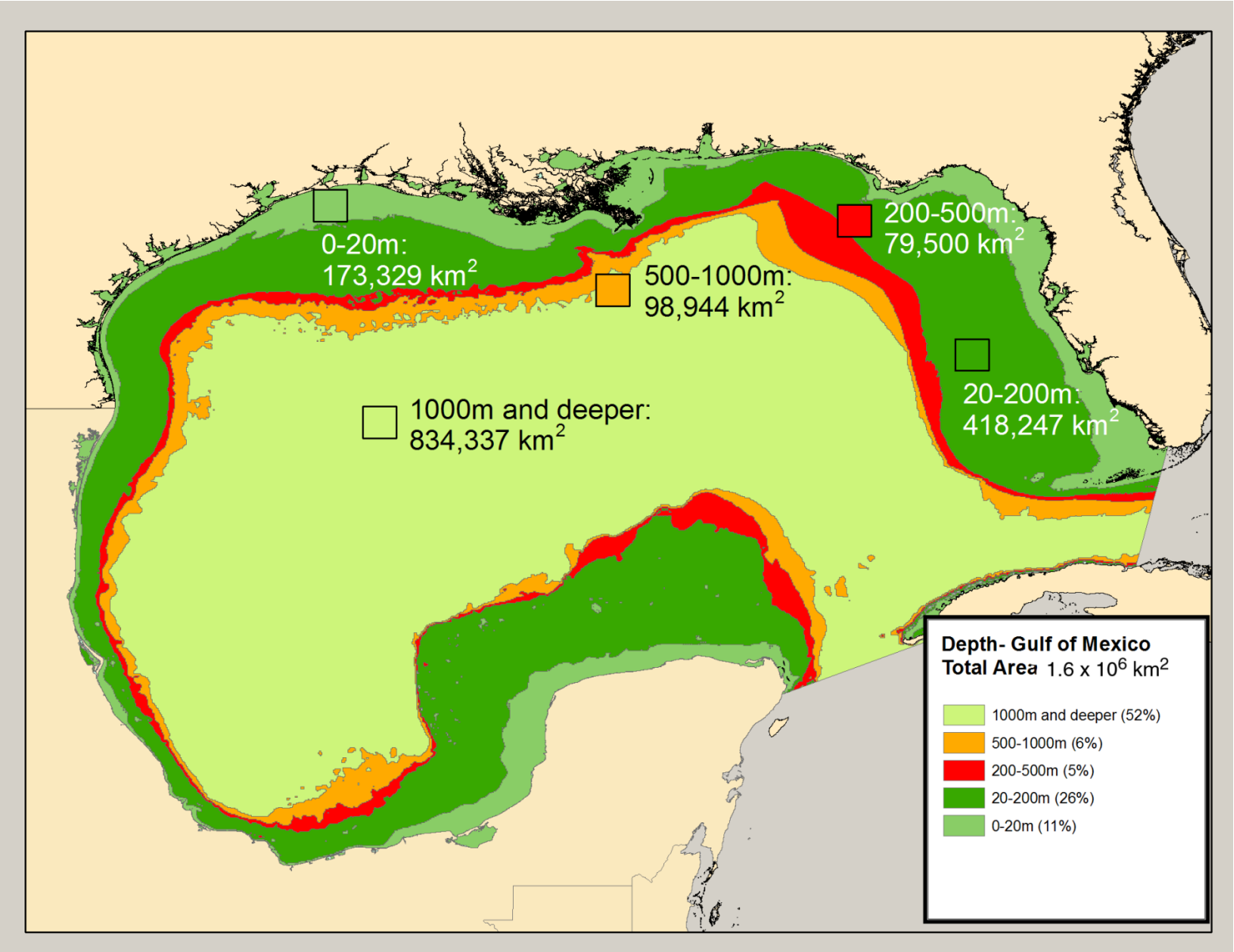
Coral primary productivity

Long, M.H., Berg, P., de Beer, D. and Zieman, J.C. (2013)
In Situ Coral Reef Oxygen Metabolism: An Eddy Correlation Study.
PLoS ONE, **8,** e58581.

Florida Keys reef
Jun-Aug 2009, 2010.

	GPP		Resp		NEM	
	Av	Stdev	Av	Stdev	Av	Stdev
	(mg C m^{-2} d^{-1})	(mg C m^{-2} d^{-1})	(mg C m^{-2} d^{-1})	(mg C m^{-2} d^{-1})	(mg C m^{-2} d^{-1})	(mg C m^{-2} d^{-1})
Reef crest	11338	1441	6798	937	4540	913
Reef slope	2318	300	2390	468	-72	252

Gulf depth zones from first report



Gulf of Mexico Primary Productivity

- Estimates of NPP based on NASA Satellite data

Products Available

- NPP estimates are obtained from www.science.oregonstate.edu/ocean.productivity/ as referenced by NASA Ocean Color Web
- Estimates available include SeaWiFS and MODIS-Aqua based estimates

Sensor	Date Range	Spatial Resolution	Temporal Resolution	Model	Format
SeaWiFS	Oct. 1997- 2009	9 km	8-day and Monthly	VGPM, VGPM-e, CbPM	hdf or xyz
MODIS-A	July 2002- Nov. 2012	4 and 9 km	8-day and Monthly	VGPM, VGPM-e, CbPM	hdf or xyz

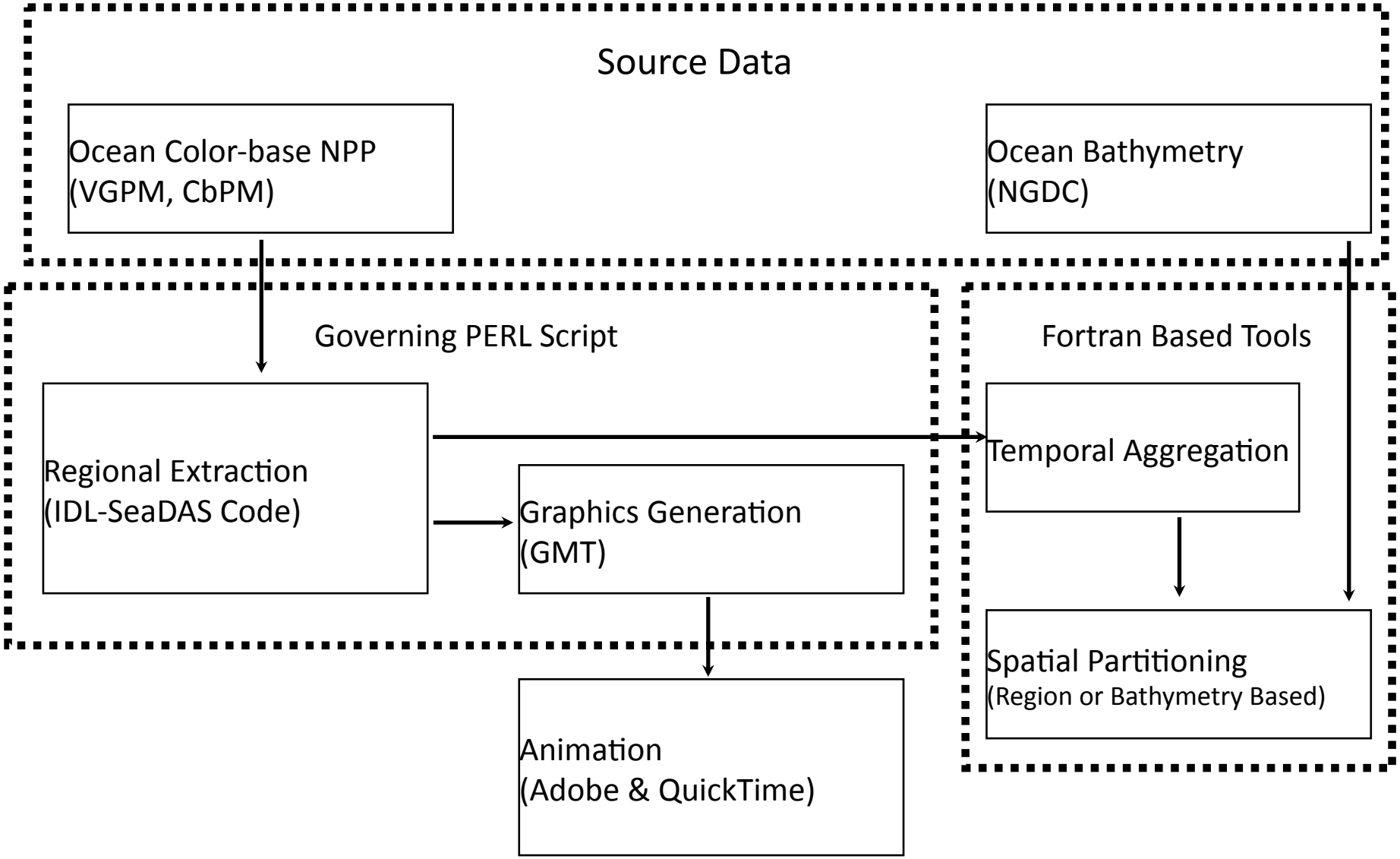
Data Inventory

- Currently obtained estimates include:

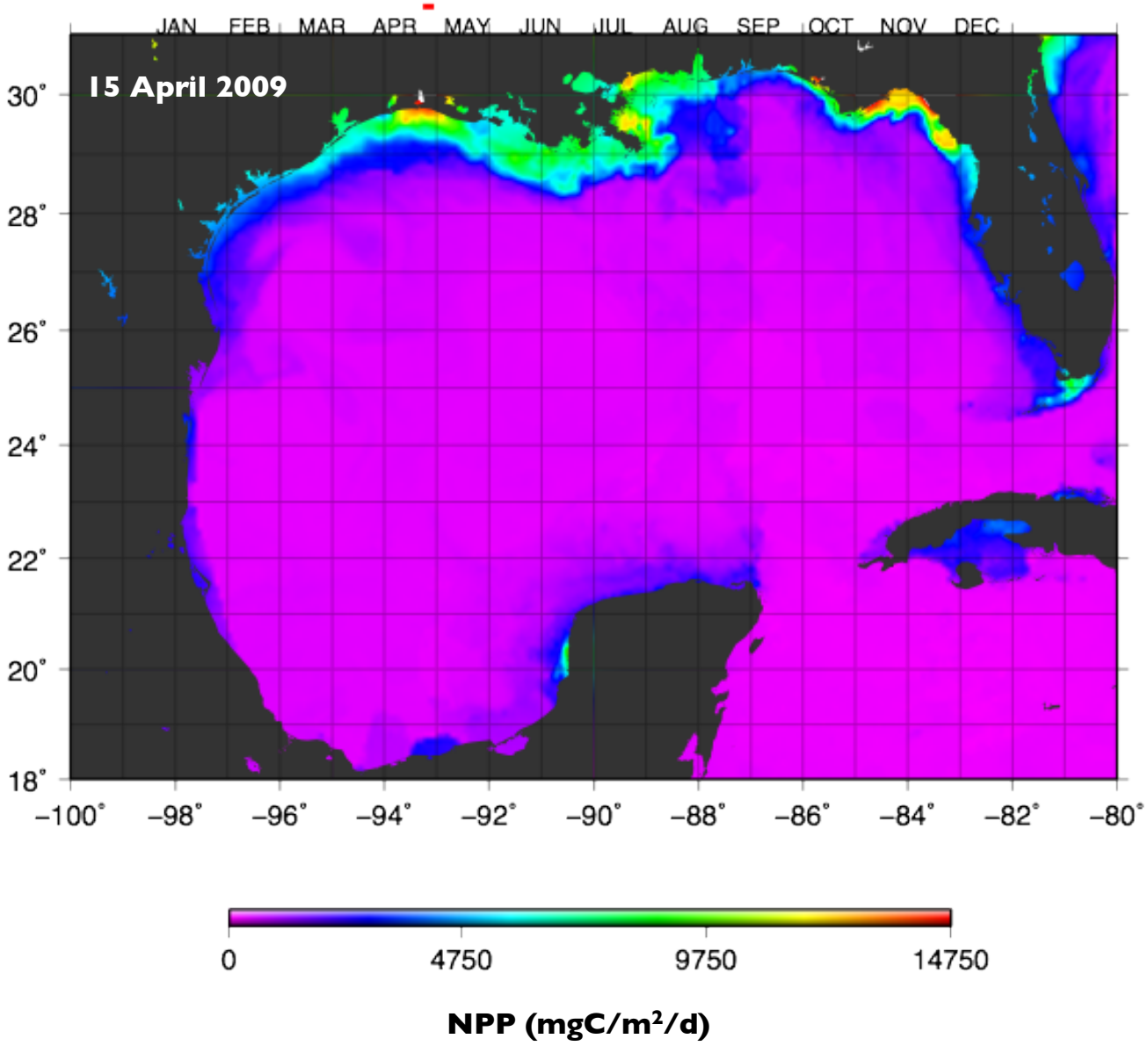
Sensor	Date Range	Spatial Resolution	Temporal Resolution	Model	Format
SeaWiFS	1998-2007	9 km	8-day	VGPM	xyz
MODIS-A	2003-2011	4 km	8-day	VGPM	xyz
MODIS-A	2002-2012	4 km	8-day	CbPM/VGPM	hdf

- Scripts and programs created to process current estimates are transferable to all available products
- VGPM is the Vertically Generalized Production Model (Behrenfeld and Falkowski,1997)
- CbPM is the Carbon-based Production Model (Westberry et al., 2008)
- All estimates use MODIS-A or SeaWiFS Chl and PAR along with AVHRR SST
- Clouds are filled using Oregon State's proprietary gap-filling software

Work flow

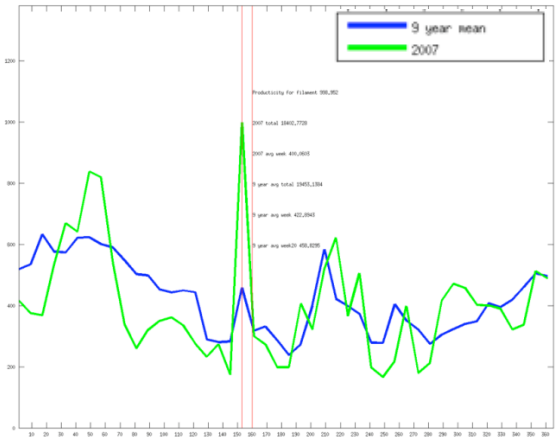

Source Data
Ocean Color-base NPP
(VGPM, CbPM)
Ocean Bathymetry
(NGDC)
Governing PERL Script
Fortran Based Tools
Regional Extraction
(IDL-SeaDAS Code)
Graphics Generation
(GMT)
Temporal Aggregation
Spatial Partitioning
(Region or Bathymetry Based)
Animation
(Adobe & QuickTime)

NPP (VGPM-MODISA) Example

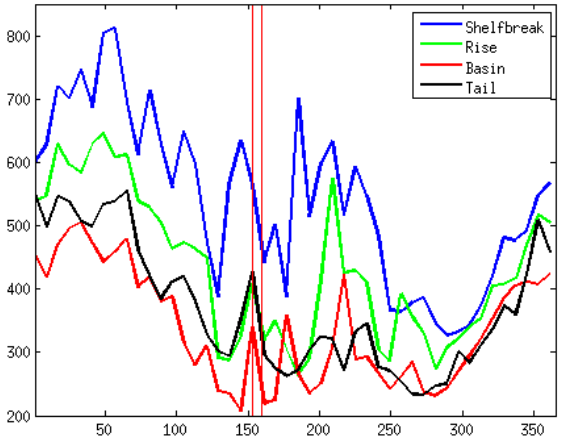


NPP regional extractions
climatology, Interannual Variability & Spatial Variability

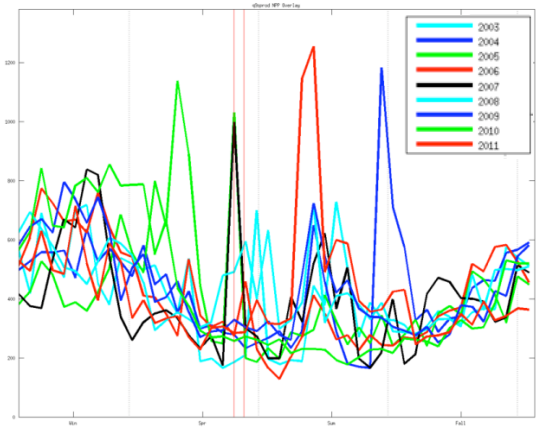
Regional Extraction:
Climatology vs. 2007



Regional Extraction:
Spatial Comparison in 2007



Regional Extraction:
Interannual Variability



Group Synthesis Questions

- How do we develop updated PP estimates on a regional and Gulf-wide basis?
- How do we reconcile different types of measurements (ship-based, satellite, etc.)?
- How do we compare and incorporate model-based estimates with other sources?
- Where are the gaps in our estimation of primary production and how can we improve?
- Other?