Ecosystem Production Potential

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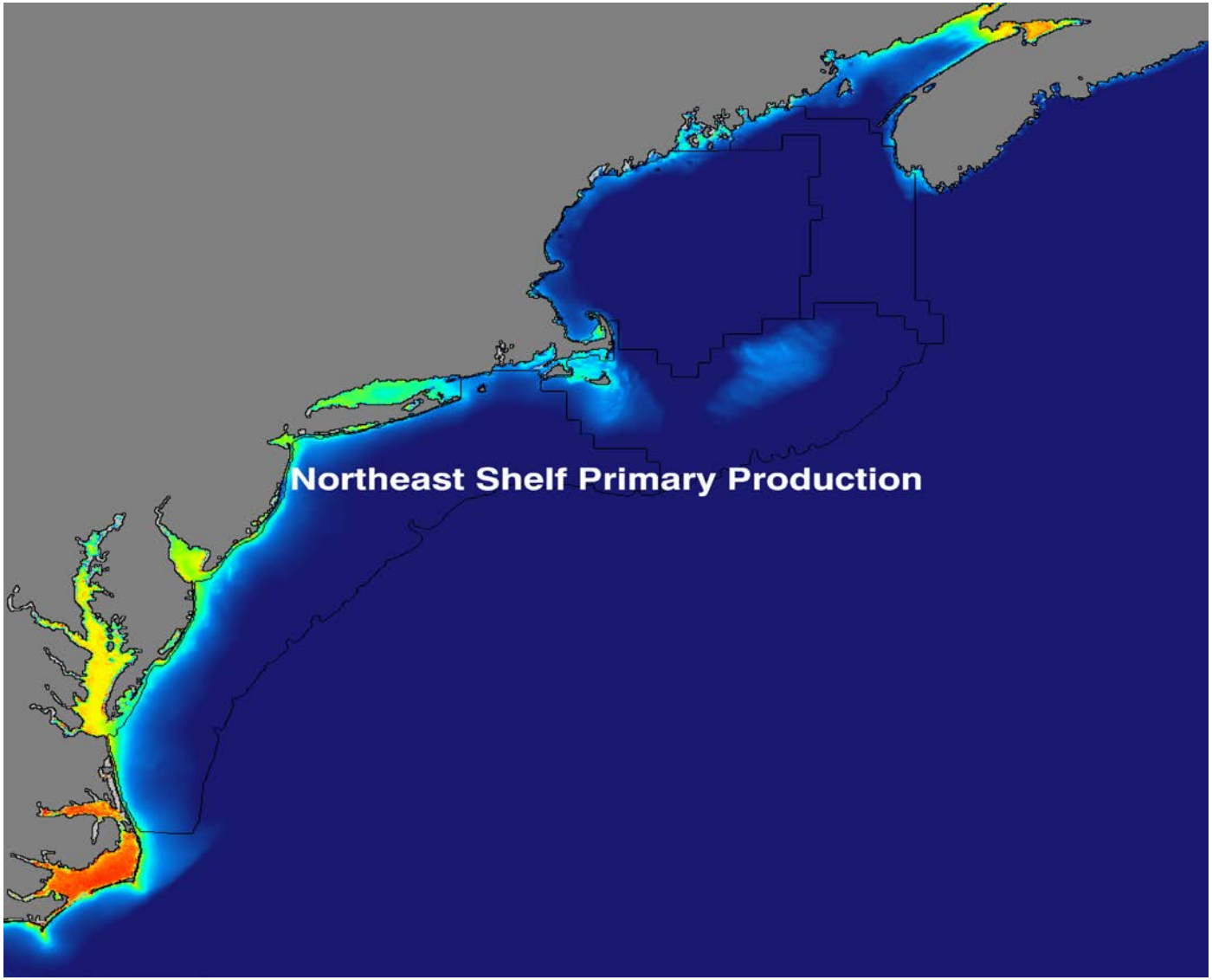
NOAA FISHERIES
Northeast Fisheries Science Center

NEFSC Ecosystem and Climate Science Program Review
Ecosystem Delineation and Production Session
June 8, 2016

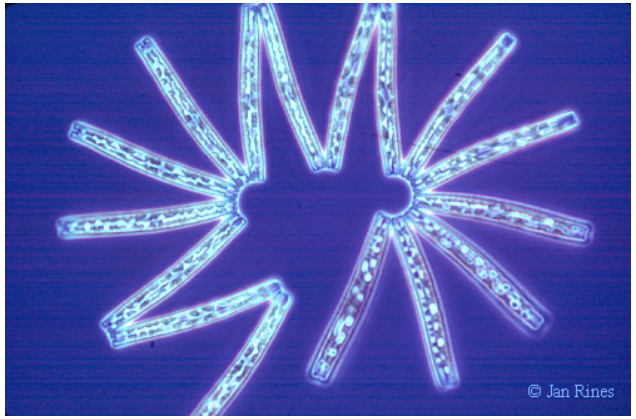
Phytoplankton Production

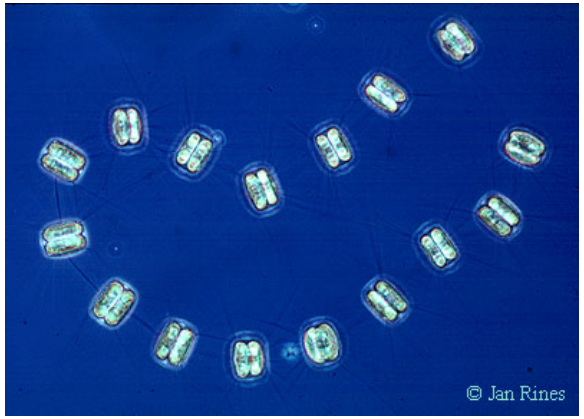


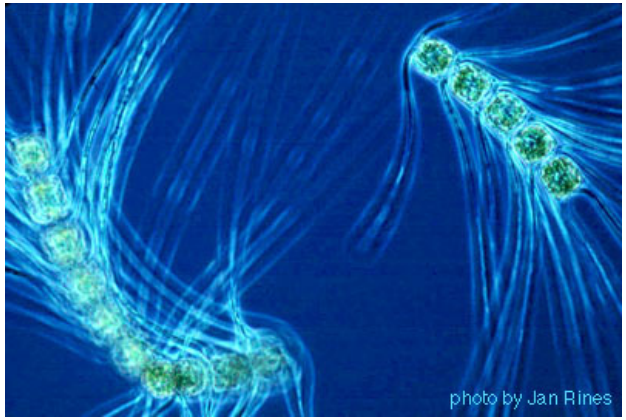
Fishery Production Potential

Goal: Use a bottom-up approach to determine fisheries production potential and exploitation for various ecosystem components.

Question: How efficiently is primary production transferred to higher trophic levels?



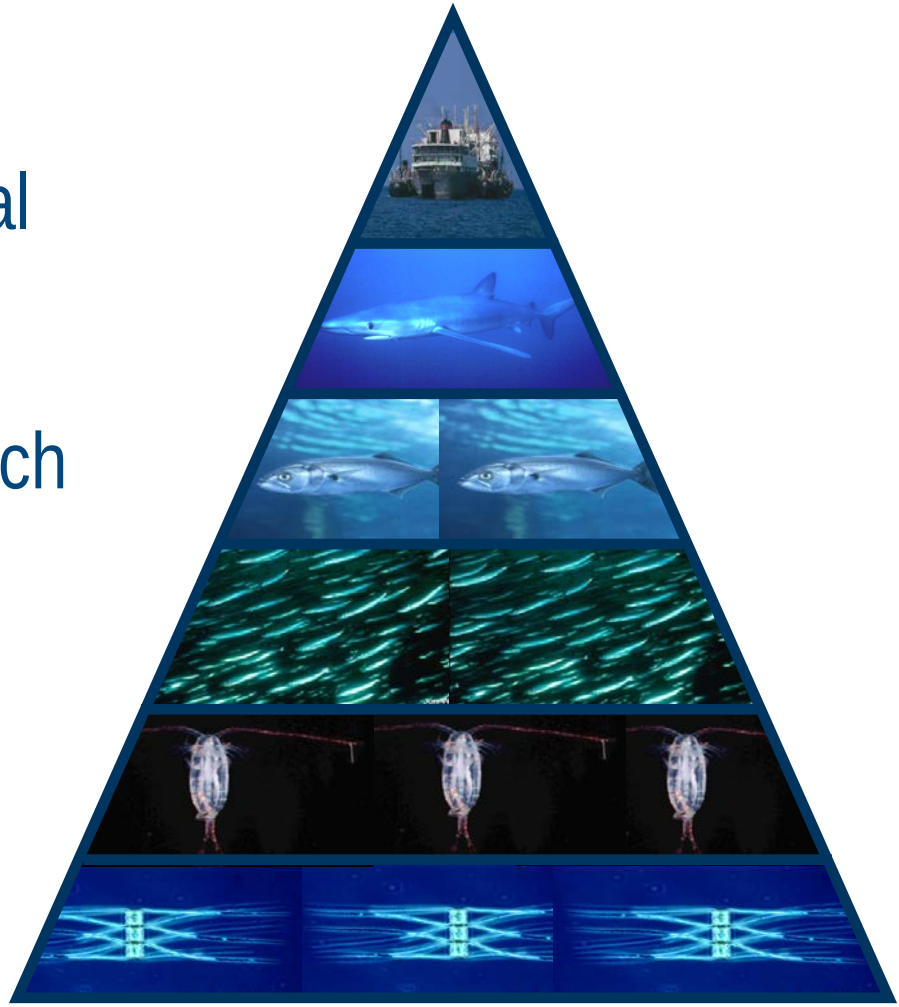




Fishery Production Potential
Ryther (1969)

$$FPP = PP \cdot T^{TL-1}$$

- *FPP:* Fishery production potential
- *PP:* Primary production
- ***T***: Ecological transfer efficiency
- TL: Mean trophic level of the catch



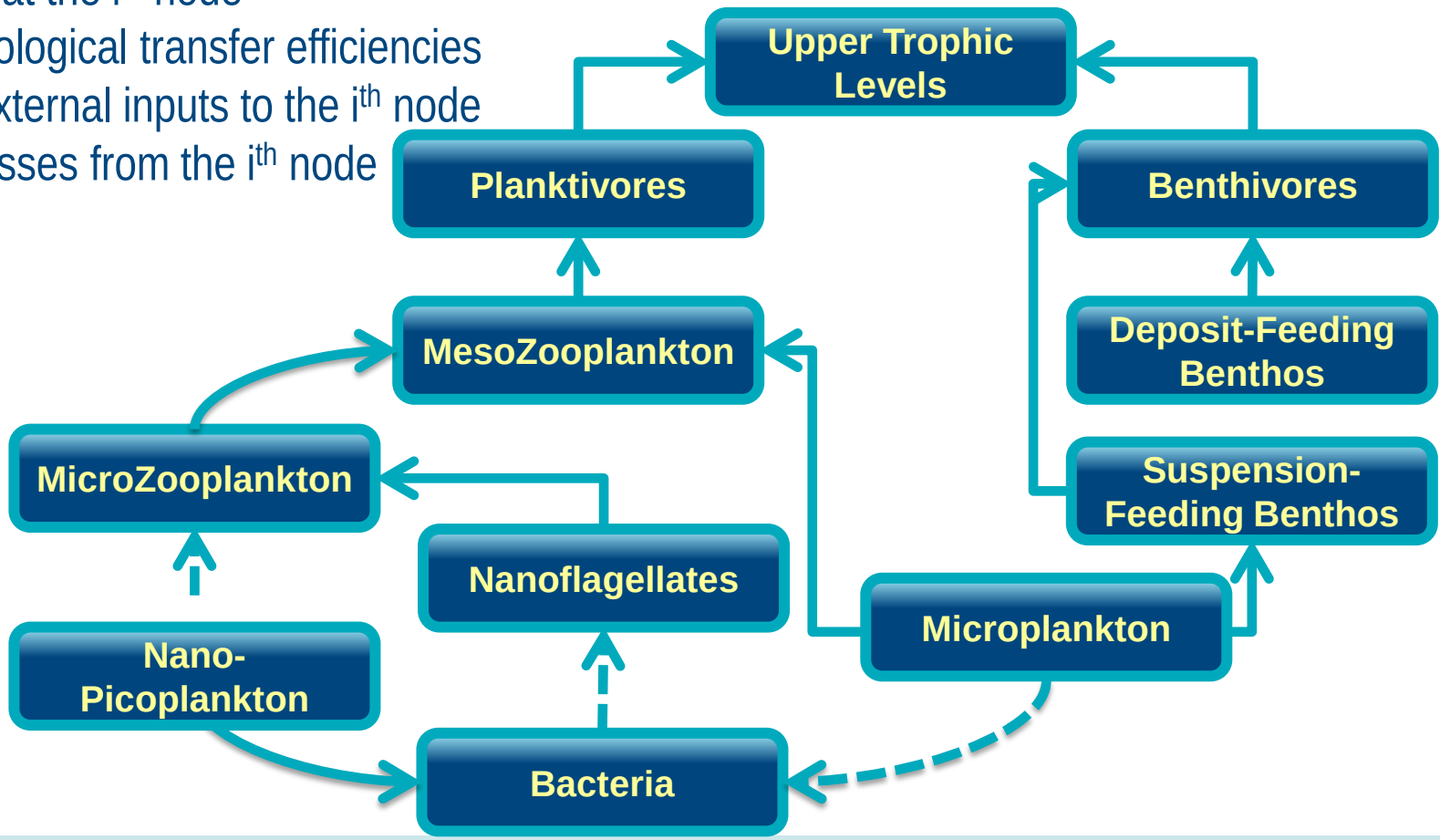
* Typically an exploitation rate of 50% of the total primary production was assumed to be sustainable.

Fishery Production Potential

Ryther Revisted

$$P_i = \mathbf{T} \cdot \mathbf{P}_j + A_i - F_i$$

- P_i: Production at the ith node
- T: Matrix of ecological transfer efficiencies
- A_i: Vector of external inputs to the ith node
- F_i: Vector of losses from the ith node



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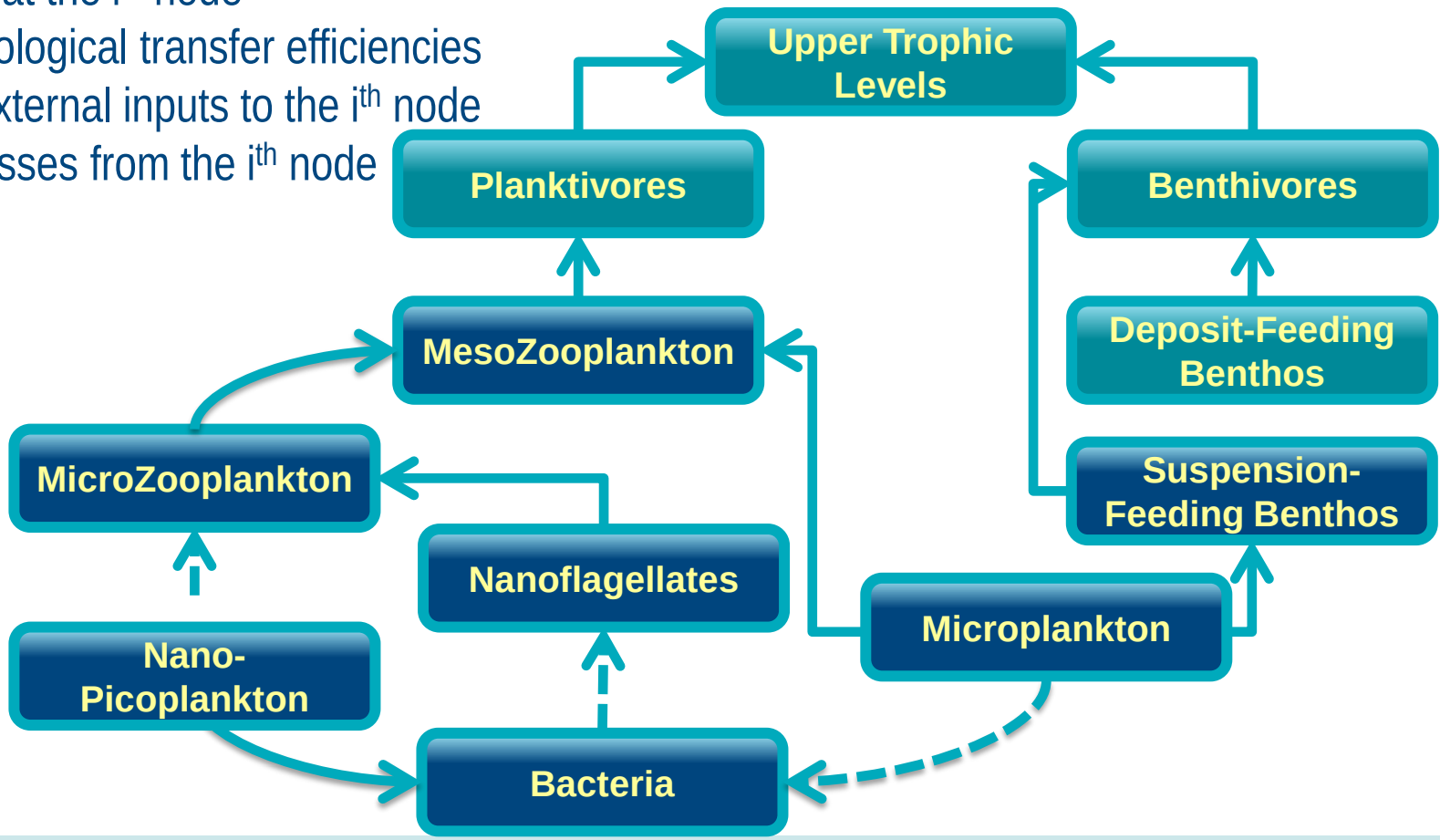
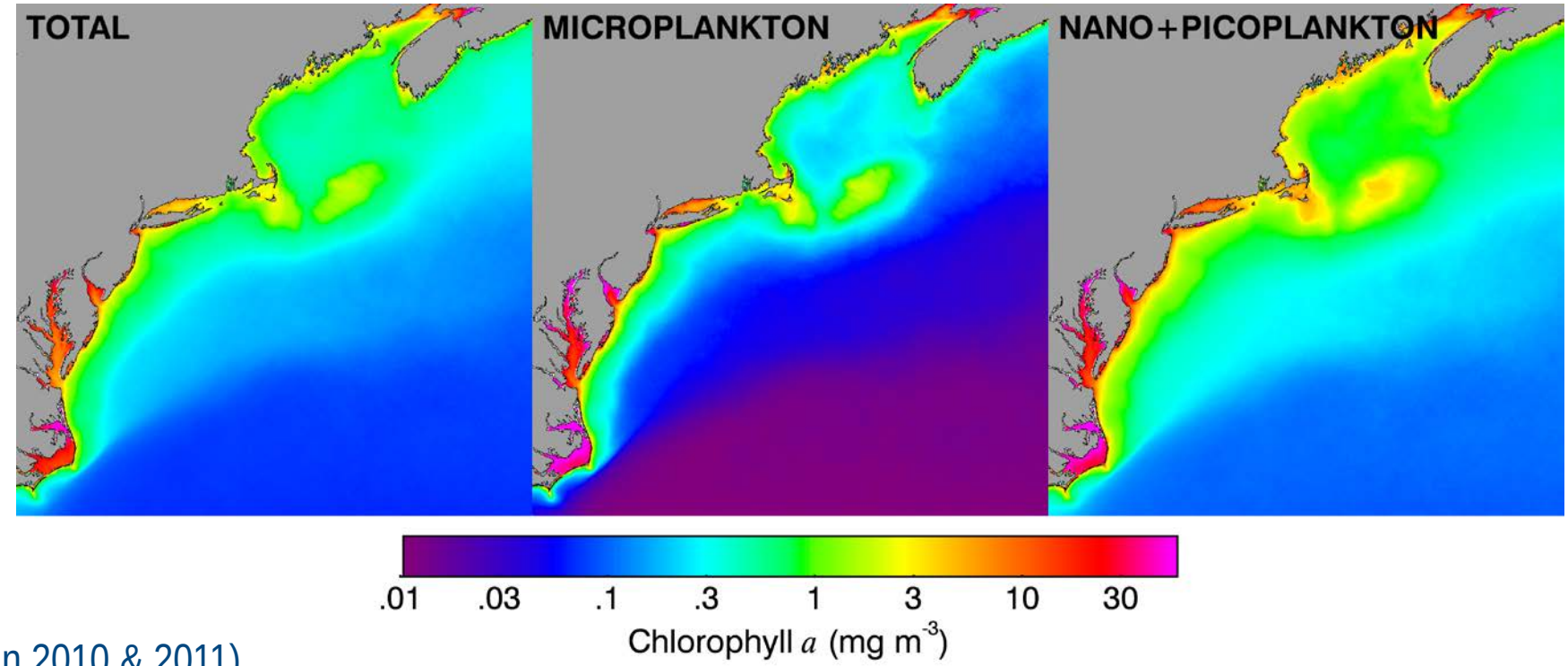


Phytoplankton Composition

Satellite ocean color data is used to derived phytoplankton functional groups a series of Remote Sensing Reflectance (R_{RS}) band ratio algorithms at 490, 555 and 670 nm.

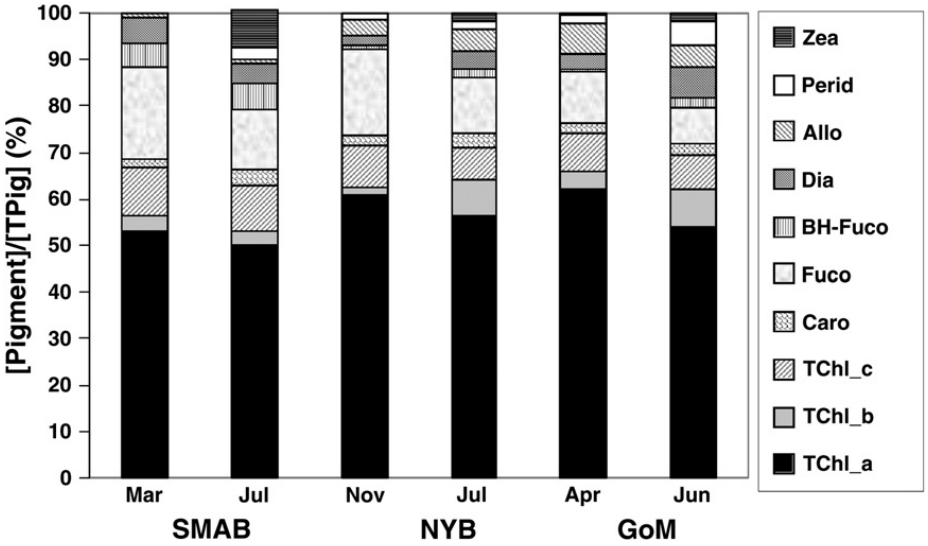


(Pan 2010 & 2011)

Phytoplankton Composition

$$\log[\text{Pigment}] = A_0 + A_1X + A_2X^2 + A_3X^3$$

$$X = \log[R_{RS}(\lambda_1)/R_{RS}(\lambda_2)]$$



Total chlorophyll *a*
Total chlorophyll *c*
Carotene
Fucoxanthin
Diadinoxanthin + Diatoxanthin

Peridinin
Zeanthin
Total chlorophyll *b*
Lutein
Alloxanthin
Neoxanthin
Violaxanthin

(Pan 2010 & 2011)

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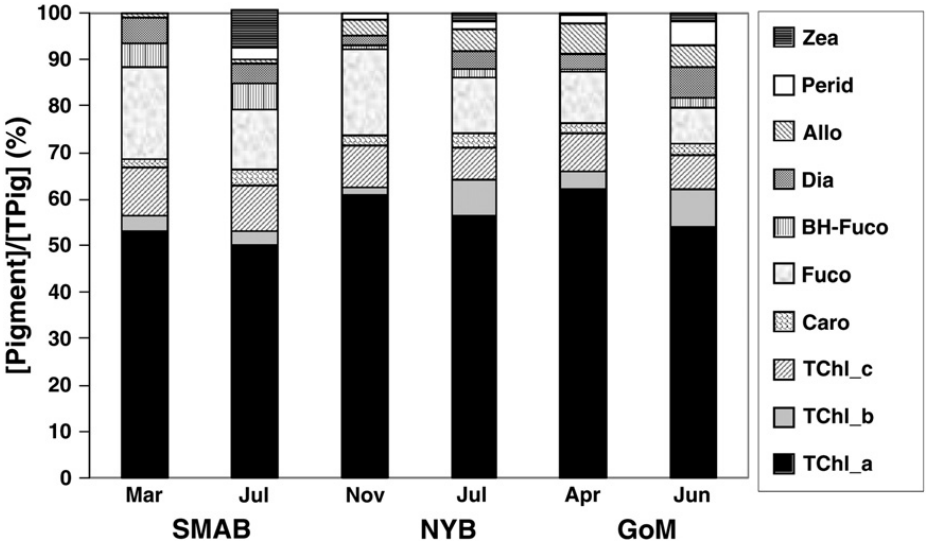
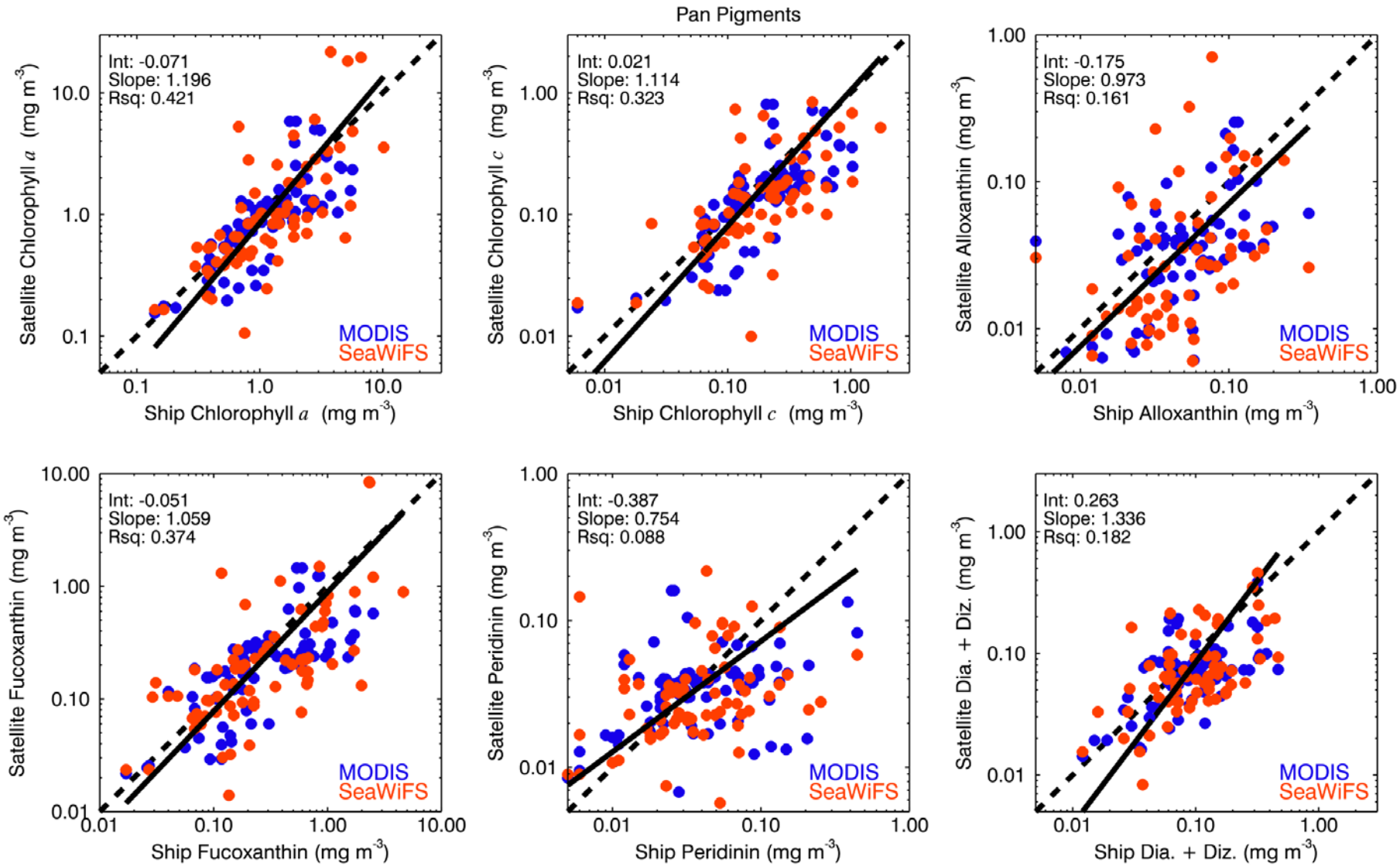


Total chlorophyll *a* - Diatoms
Total chlorophyll *c*
Carotene
Fucoxanthin
Diadinoxanthin + Diatoxanthin

Peridinin - Dinoflagellates
Zeanthin - Cyanobacteria
Total chlorophyll *b*
Lutein
Alloxanthin
Neoxanthin
Violaxanthin
Chlorophytes & Prasinophytes

(Pan 2010 & 2011)

Phytoplankton Composition



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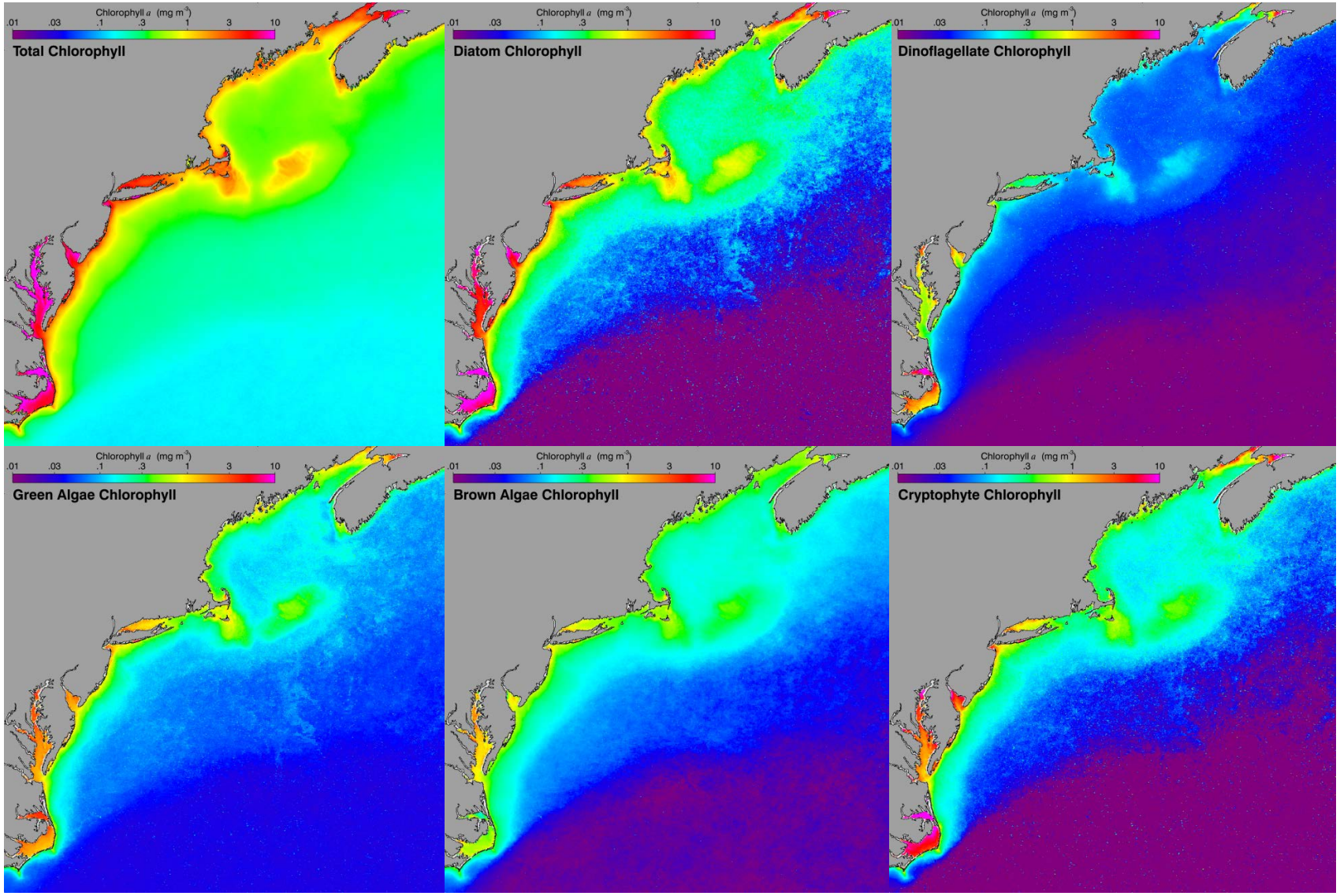
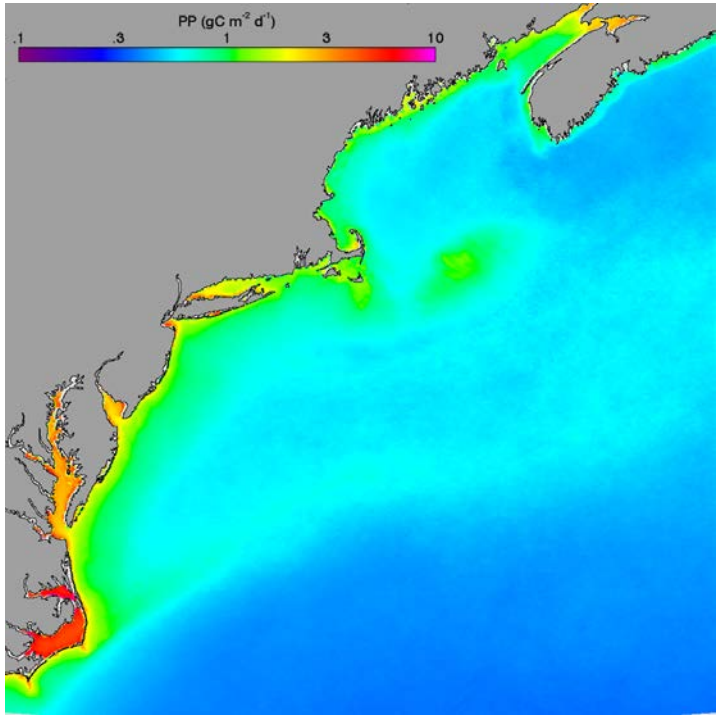
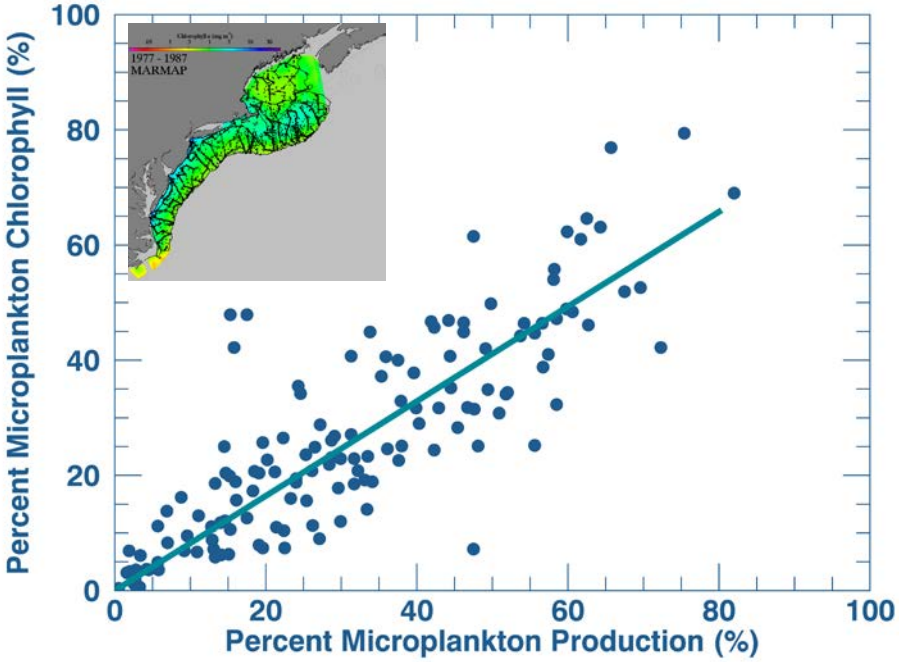
Phytoplankton Composition

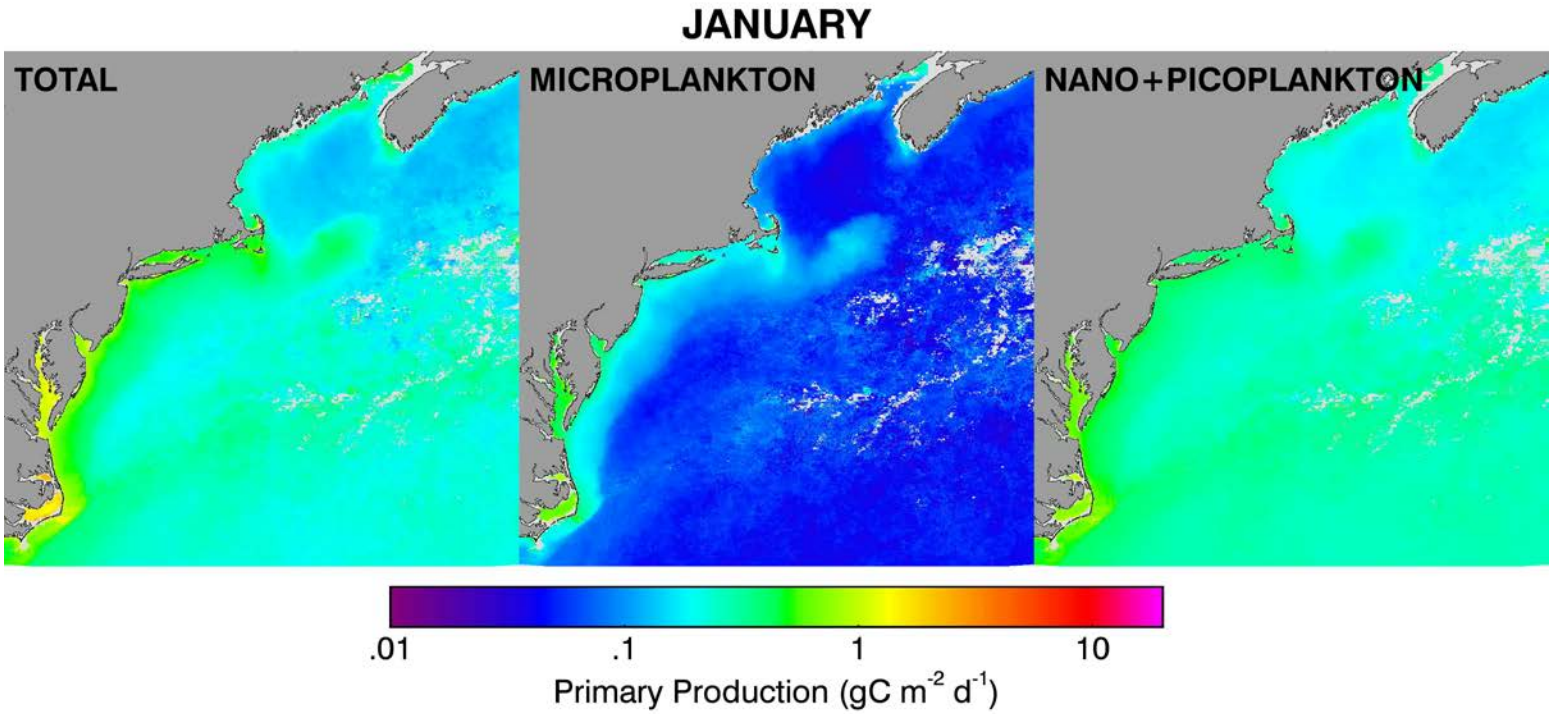


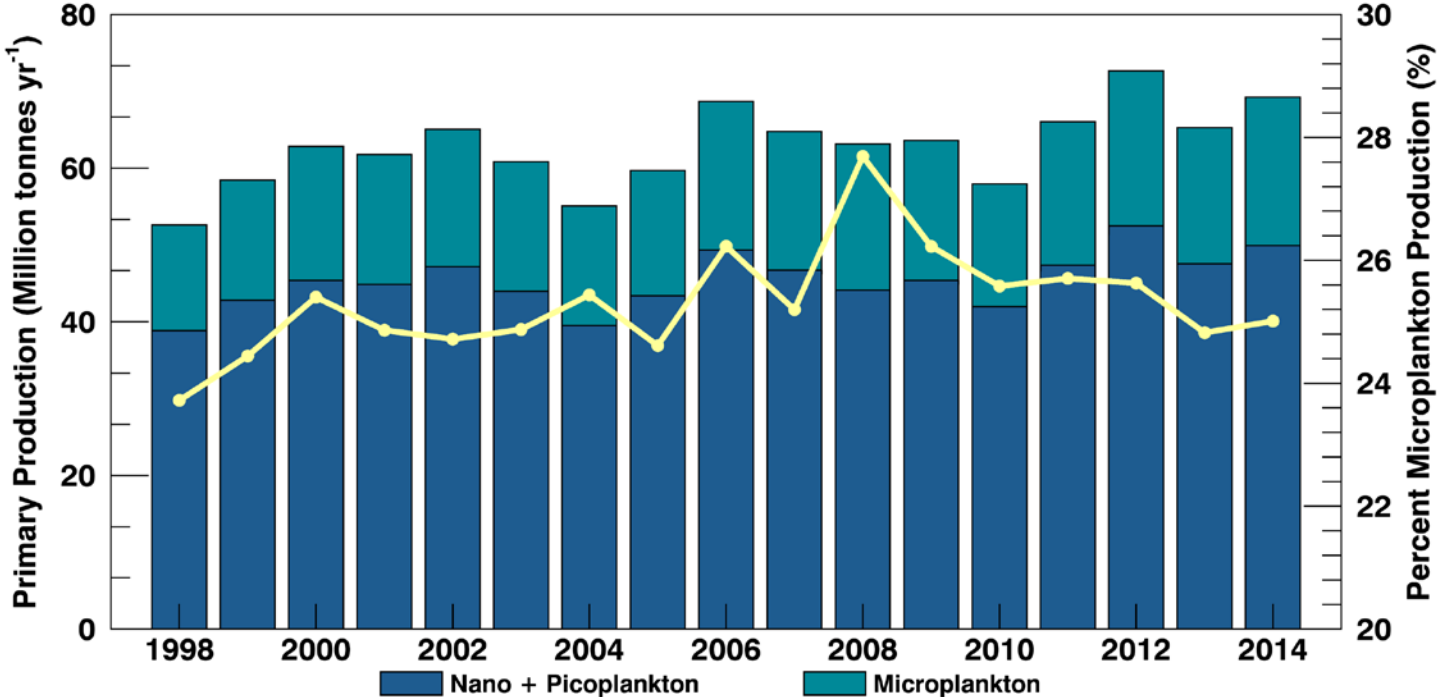
Primary Production

Modeled primary production and the percent microplankton chlorophyll is used to estimate microplankton primary production based on an empirical relationship derived from *in situ* measurements collected during MARMAP.





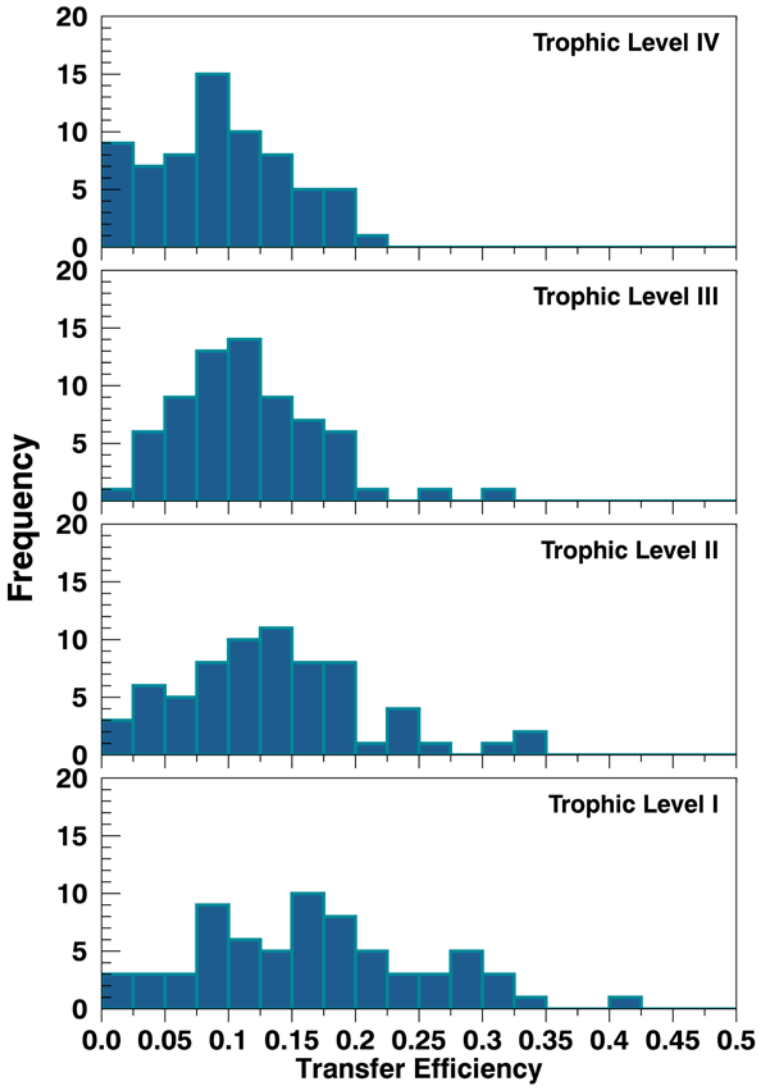

JANUARY
TOTAL
MICROPLANKTON
NANO+PICOPLANKTON
.01
.1
1
10
Primary Production (gC m-2 d-1)


Primary Production (Million tonnes yr-1)
Percent Microplankton Production (%)
0
20
40
60
80
20
22
24
26
28
30
1998
2000
2002
2004
2006
2008
2010
2012
2014
Nano + Picoplankton
Microplankton

Ecological Transfer Efficiencies

Meta-analysis of network models to determine ecological transfer efficiencies.

Observations drawn from temperate boreal ecosystems.



Uncertainties

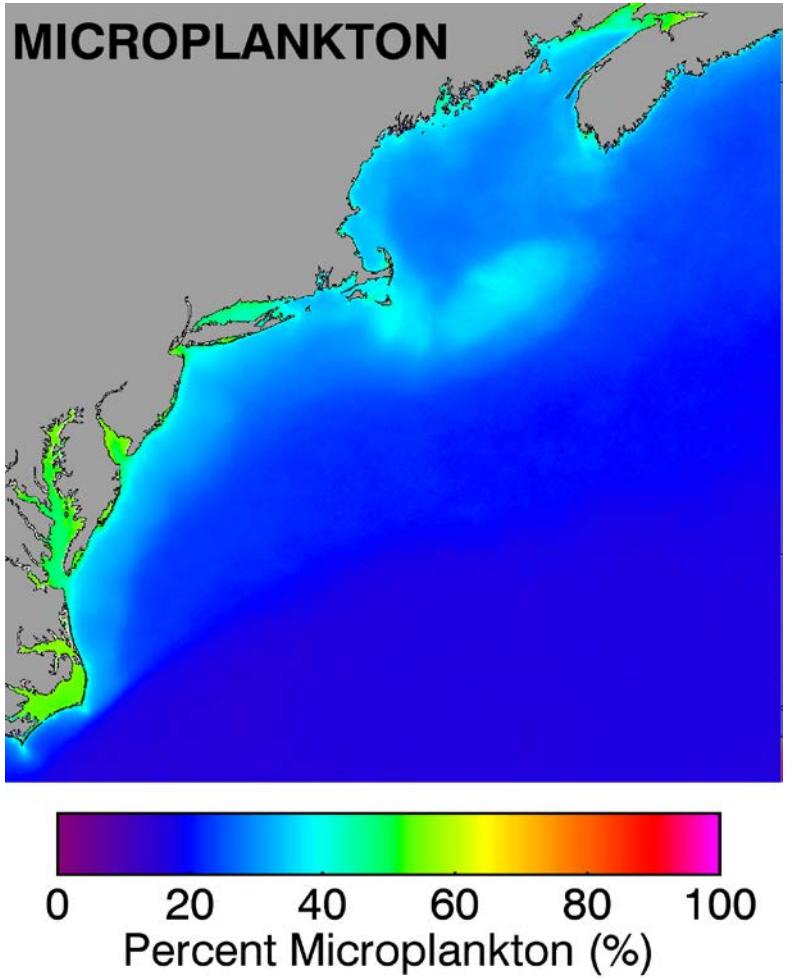
Probability distributions of input parameters to account for uncertainty.

- Primary production: Truncated normal distribution
- Microplankton “split”: Uniform distribution
  (Range: Upper and lower quartiles)
- Transfer efficiencies: Beta distribution
- Proportion suitable for harvest: Uniform distribution
  (Benthos and planktivores)

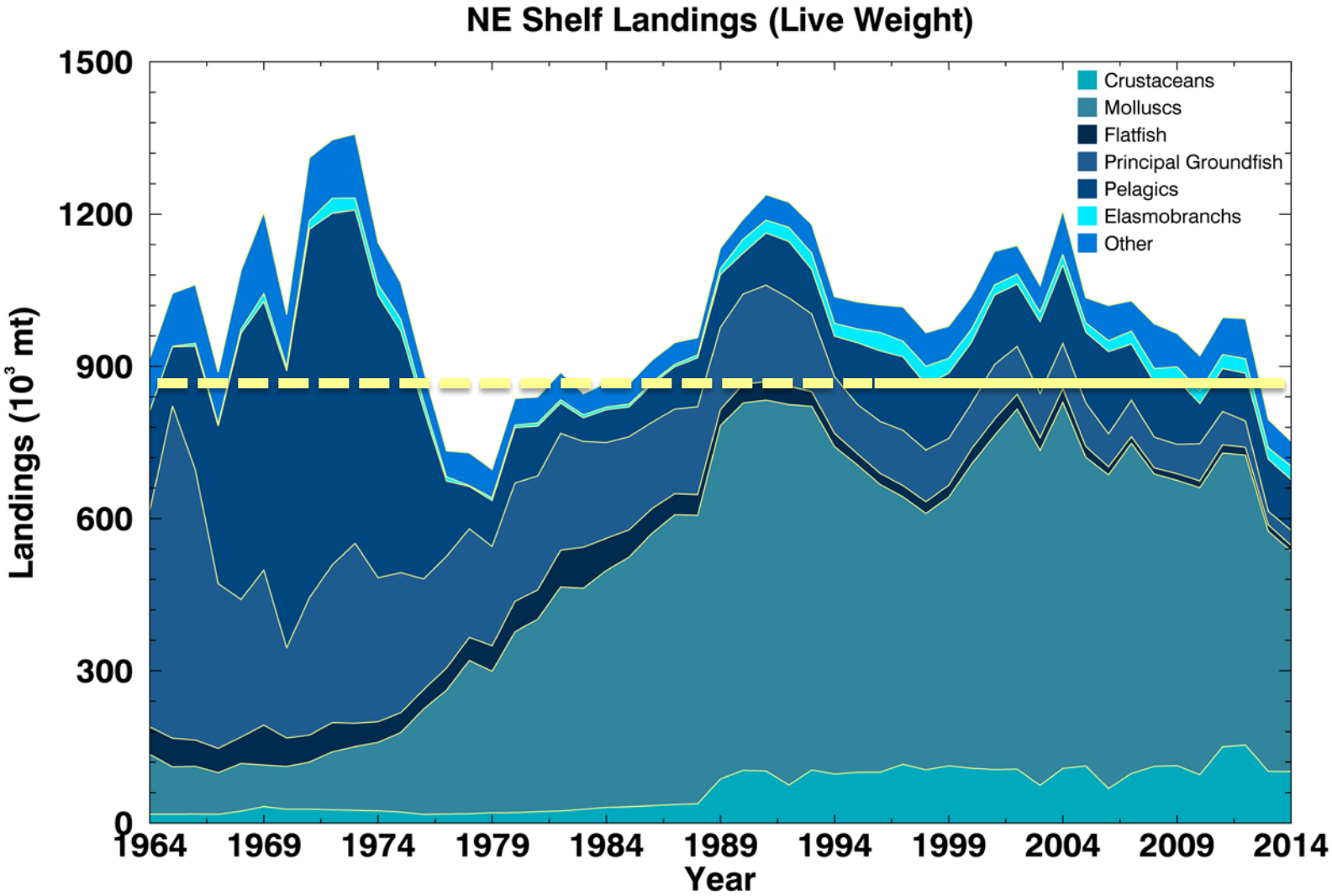
Proposed Ecosystem Limit Reference Point

Exploitation rate should not exceed the fraction of *microplankton production* in the system.

~ 895,000 tonnes of harvestable production based on a proportional harvest strategy.

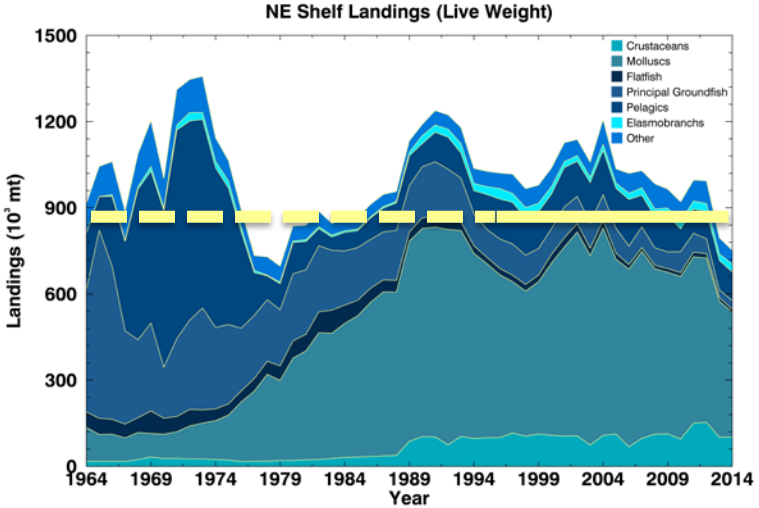


Harvest Strategies



Harvest Strategies

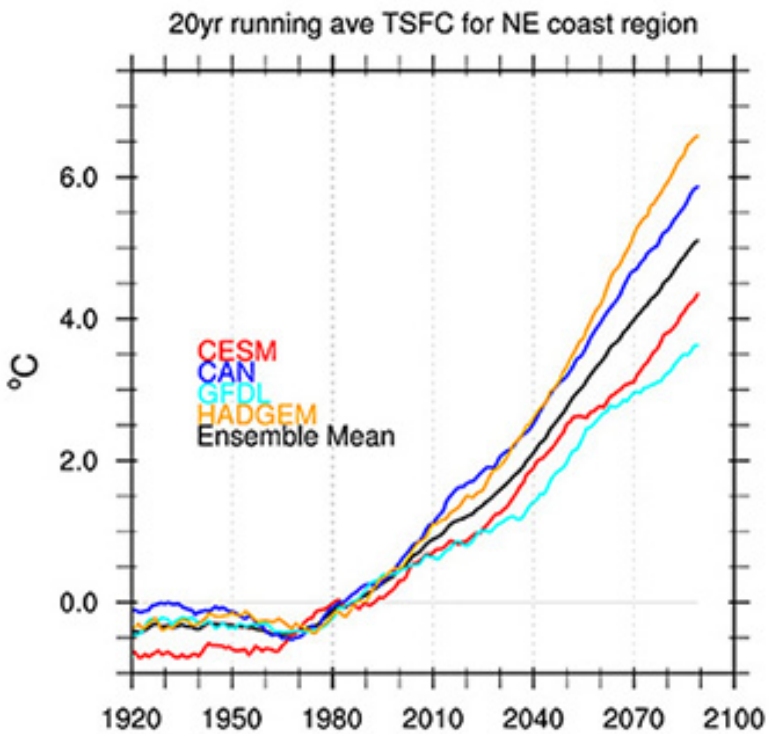
Changing the proportions extracted at each trophic level will alter the total allowable catch.

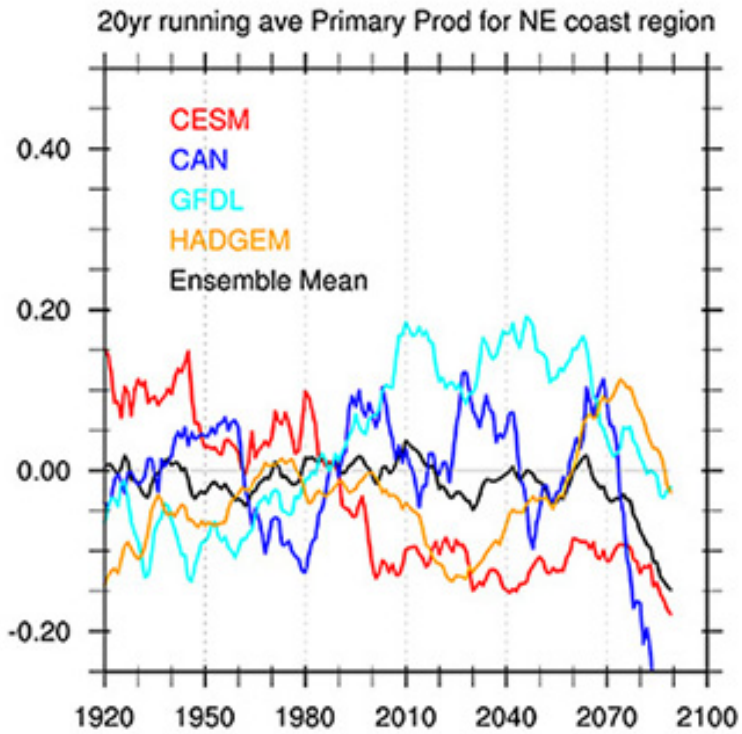


A harvest strategy that permits higher removals at lower trophic levels would increase the total yield.

Future Projections

Changes in the phytoplankton community composition and/or rates of primary production will affect the community production and the overall fisheries yield of the system.





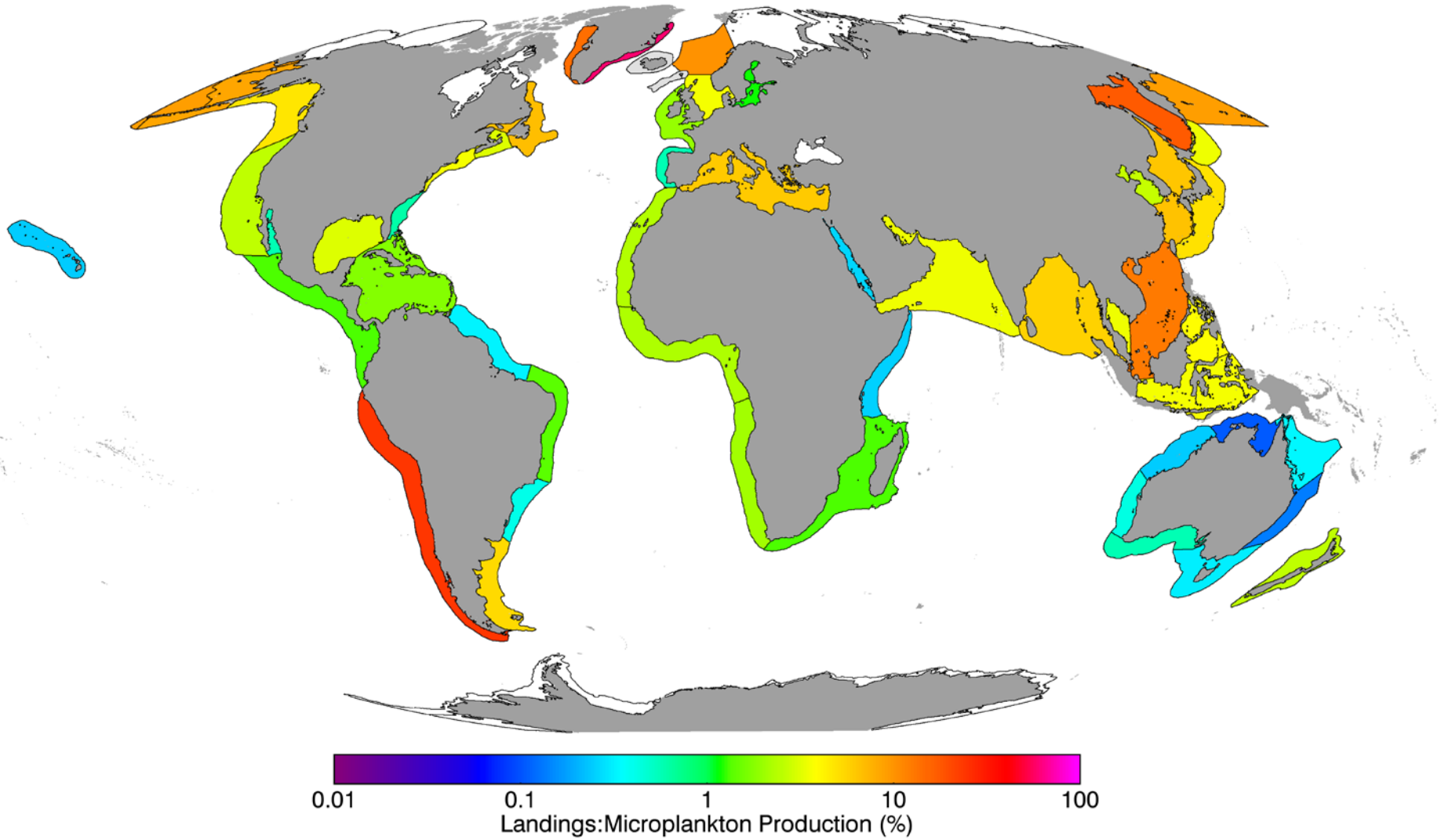
nefsc.noaa.gov/ecosys/climate-change

Successes and Challenges

From a remote sensing perspective, there is an ongoing need for:

- Climatological quality (preferably hyper-spectral) ocean color remote sensing data to monitor changes in the phytoplankton community.
- Improved algorithms for measuring phytoplankton functional groups/size classes on the continental shelf.
- *In situ* validation data of phytoplankton composition/pigments, size-fractionated primary production, and other related parameters.

Successes and Challenges



Questions