Incorporating Ocean Color Remote Sensing in Ecosystem Based Fisheries Management

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Ecosystem Based Management

- Within NOAA there is a strong focus on Integrated Ecosystem Assessments and Ecosystem-Based Approaches to Management, with an increasing emphasis on ecological forecasting.

- There is also an emphasis to monitor changes in the oceans and how climate changes impact phytoplankton species composition and the marine food web.

- In this context, there is a need for accurate, timely, consistent and fit for purpose ocean color data/products to support NOAA (NMFS, NOS, OAR) and related users with ongoing coastal, ocean and inland water applications, especially fisheries and broader living marine resource management.
Ocean color remote sensing

- Documenting, monitoring and forecasting the response of marine ecosystems to environmental variability and climate change
- Assessing biodiversity
- Biogeochemical cycling
- Connections between seasonal blooms (phenology) and recruitment
- Examining variations in functional groups/size class abundance and distribution patterns (temporally and spatially)
- Food-web structure and secondary/tertiary production
Ecosystem Production Potential

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

- Benthos
- Benthivores
- Planktivores
- Piscivores

Question: How efficiently is primary production transferred to higher trophic levels?
**Ecosystem Production Potential - Historical**

\[
EPP = PP \cdot T^{TL-1}
\]

Where **EPP** is Ecosystem Production Potential, **T** is the ecological transfer efficiency, **TL** is the mean trophic level of the catch.

Historically, an exploitation rate of 50% was assumed to be sustainable.

(Pauly, 1995 – Fisheries Research)
Ecosystem Production Potential - Model

\[ P_i = T \cdot P_j + A_i - F_i \]

Where \( P_i \) is Production at the \( i^{th} \) node, 
\( T \) is the matrix of ecological transfer efficiencies, 
\( A_i \) is a vector of external inputs to the \( i^{th} \) node, and 
\( F_i \) is a vector of losses from the \( i^{th} \) node.
Proposed Ecosystem Limit Reference Point:

The total Exploitation Rate should not exceed the fraction of Microplankton Production in the System.
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Use ocean color remote sensing to estimate the fraction of Microplankton Production.
Phytoplankton size classes

Pan et al. 2008 & 2010
Phytoplankton size classes

Pan et al. 2008 & 2010
Phytoplankton size classes
Size Fractionated Primary Production

![Graph showing the relationship between percent microplankton chlorophyll and percent microplankton production.](image)
Size Fractionated Primary Production

**TOTAL**

**MICROPLANKTON**

**NANO + PICOPLANKTON**

Chlorophyll $a$ (mg m$^{-3}$)

Percent Microplankton (%)

Percent Nano+Picoplankton (%)

(NOAA FISHERIES)
Size Fractionated Primary Production

TOTAL

MICROPLANKTON

NANO + PICOPLANKTON

Primary Production (gC m$^{-2}$ d$^{-1}$)

Percent Microplankton (%)

Percent Nano+Picoplankton (%)
Size Fractionated Primary Production
Ecosystem Production Potential - Model

- Upper Trophic Levels
  - Planktivores
    - MesoZooplankton
      - MicroZooplankton
        - Nano/picoplankton
    - Nanoflagellates
      - Bacteria
  - Benthivores
    - Deposit-Feeding Benthos
    - Suspension-Feeding Benthos
  - Microplankton
The proposed ecosystem limit reference point is that the exploitation rate should not exceed the fraction of microplankton production in the system (~20-30%), which equates to ~825,000 t of harvestable production.
Summary

- Fishery removals exceeded recommended levels (~825,000 t) in the past, but are now close to estimates of sustainable extraction rates for the ecosystem as a whole.
Directed targeting of some species means that some functional groups are still at risk.
A diversified catch will be necessary to create a more balanced harvesting policy.
Summary

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. Thus, there is an ongoing need for:

- Climatological quality (preferably hyper-spectral) ocean color remote sensing data (RRSs, PAR, CHL, IOPs, Kd) 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 pigments, primary production, and other related parameters.