Comparative Productivity and Biomass Yields of the Yellow Sea, East China Sea, and the East Sea LMEs

Sinjae Yoo and Young Baek Son
Korea Institute of Ocean Science and Technology
Ansan, South Korea 426-744
sjyoo@kiost.ac

3rd Global LME Conference
2014.10.08
Are the seas in the northwestern Pacific more productive than other seas in NP, or are they?

Figure 5A. Positive correlation of 5-yr. mean annual fisheries biomass yield with 9-yr. mean annual primary production in fast warming (red), moderately warming (yellow) and slower warming (green) LMEs. The two blue circles represent cooling LMEs. P<0.001.

(PICES NPESR, 2004)

UNEP LME Report, Sherman and Hempel (2009)
# Physical setting

## Yellow Sea
- Shallow (mean depth = 44m)
- Strong tides (max range = 11m)
- Tidally-mixed nearshore and seasonally stratified offshore
- High turbidity
- Huge river drainage (14 rivers with discharge $\geq 10^9$ m$^3$ yr$^{-1}$)
- Slow water exchange (residence time = 5~6 years)

## East Sea
- Little Shelf area (max depth $>2,000$m)
- Weak tides (max range = 0.5m)
- Seasonal stratification
- Case 1 water
- Negligible river drainage
- Miniature ocean
  - Thermo-haline circ.
  - Gyres
  - Subpolar front
  - Boundary currents
  - Coastal upwelling
  - Meso-scale Eddies
PP estimates from the previous studies

- Point measurements vary in the range of $11.78 \sim 3,175 \, \text{mg C m}^{-2} \, \text{d}^{-1}$ depending on time and space.
- Some of in-situ estimates on annual production are $135 \sim 265 \, \text{gC m}^{-2} \, \text{y}^{-1}$, which is much smaller than satellite estimates.
- Park and Yoo (2010) compared 4 chlorophyll X 2 PP algorithm combinations: 96.5 to 610.2 gC m$^{-2}$ yr$^{-1}$.
  - Bohai Sea: $564.4 \, \text{gC m}^{-2} \, \text{y}^{-1}$
  - Northern Yellow Sea: $363.1 \, \text{gC m}^{-2} \, \text{y}^{-1}$
  - southern YS: $536.5 \, \text{gC m}^{-2} \, \text{y}^{-1}$
  - northern East China Sea (ECS): $413.9 \, \text{gC m}^{-2} \, \text{y}^{-1}$
  - southern ECS: $195.8 \, \text{gC m}^{-2} \, \text{y}^{-1}$
Key variables in PP estimation

- **Chl-a**: Chlorophyll-a
- **Vertical profile**
- **$K_{\text{PAR}}$**: attenuation coefficient of water body
- **Zeu**: euphotic depth
- **$P_{b\text{, opt}}$**: production rate per chlorophyll
- **SST**: sea surface temperature
- **$E_o$**: surface new production

**PP algorithm**

- **Attainable from satellites**

- **PP**: new production

- **$K_{\text{PAR}}$: Attenuation coefficient of water body**
- **Zeu**: euphotic depth
- **$P_{b\text{, opt}}$: Production rate per chlorophyll**
Depth-integrated NPP Model

\[ \Sigma PP = ab \times bd \]

\[ = \{ C_{surf} \times P_{opt}^B \times DL \} \times \{ Z_{eu} \times f(E_0) \} \]

Behrenfeld and Falkowski (1997)
Comparison of CHL by OC4 (standard) algorithm and in-situ CHL

Park and Yoo (2010)

Figure 7. *In situ* Chl-a versus derived Chl-a. Fil
Yellow Sea Ocean Color Database
(Bio-optical measurements)

- In-situ bio-optical data from 5 institutions in China, Japan and Korea
- Data points > 700
- A new regional algorithm was developed:
  - Specifically tuned to the turbid waters in the Yellow Sea and east China Sea
  - Uses 4 spectral bands
- Supported by YSLME Project
Comparison of regional PP algorithms

Yoon et al. (2012)

\[
IPP = 0.66125 \times P^B_{opt} \times \frac{E_0}{E_0 + 4.1} \times Z_{eu} \times \text{SCHL} \times D_{irr}
\]

Behrenfeld and Falkowski (1997)

\[
P^B_{opt} = -3.27 \times 10^{-8} \times \text{SST}^7 + 3.4132 \times 10^{-6} \times \text{SST}^6 \\
- 1.348 \times 10^{-4} \times \text{SST}^5 + 2.465 \times 10^{-3} \times \text{SST}^4 - 0.0205 \\
\times \text{SST}^3 + 0.0617 \times \text{SST}^2 + 0.2749 \times \text{SST} + 1.2956
\]

Kameda and Ishizaka (2005)

\[
P^B_{opt} = \frac{0.071 \times \text{SST} - 3.2 \times 10^{-3} \times \text{SST}^2 + 3.0 \times 10^{-5} \times \text{SST}^3}{\text{SCHL}} \\
+ (1.0 + 0.17 \times \text{SST} - 2.5 \times 10^{-3} \times \text{SST}^2 - 8.0 \times 10^{-5} \times \text{SST}^3)
\]
Data

- **Satellite data**
  - SeaWiFS and MODIS/Aqua (1998–2013)
    - CHL-a:
      - Ocean Color Chlorophyll (OC4 v4, NASA)
      - OC4 v6 (NASA, 2010)
      - YOC (Siswanto et al., 2011)
  - SST
  - PAR
  - Eupohic depth
    - K490
    - ZP Lee (2005, 2007)

- **Fish catch**
Comparison of Chlorophyll-a

OC4_V6 / OC4_V4
Comparison of Chlorophyll-a

YOC_OC4_V6 / OC4_V6

[Map and scatter plots showing data comparison]
Comparison of Euphotic depth

Zeu(Lee) – Zeu(Kd490)
Comparison of PBopt

KI_PBopt(YOC_OC_4_V6) – VGPM_PBopt
Comparison of NPP
VGPM - NewNPP

VGPM: chlor:OC4_V4
  Zeu: Kd(490)
  PBopt: VGPMPBopt

NewNPP: chlor:YOC, OC4_V6
  Zeu: Lee
  PBopt: KI-PBopt
Comparison of NPP climatology (1998-2013) by two methods

CHL-a: OC4v4
$P^B_{\text{opt}}$: BF–VGPM
$Z_{\text{eu}}$: K490

CHL-a: YOC algorithm
$P^B_{\text{opt}}$: KI algorithm
$Z_{\text{eu}}$: Lee IOP algorithm
NPP vs Fish Catch
(1998-2006)
Figure 5A. Positive correlation of 5-yr. mean annual fisheries biomass yield with 9-yr. mean annual primary production in fast warming (red), moderately warming (yellow) and slower warming (green) LMEs. The two blue circles represent cooling LMEs. P<0.001.

UNEP LME Report, Sherman and Hempel (2009)
Conclusion

• The primary productivity of the Yellow Sea and East China Sea seems to have been overestimated.

• The new estimates using the most recent parameterization of the three major variables (CHL–a, $Z_{eu}$ and $P_{opt}^B$) are about half of the estimates by standard methods.

• Accurate parameterization in turbid and CDOM–rich area is needed to further reduce the error.
THANK YOU!