The effect of tropical cyclone on the primary production enhancement - Some results from the W-PASS (Western Pacific Air-Sea interaction Study) project

Eko Siswanto, Joji Ishizaka, Mitsuhiro Toratani, Toru Hirawake and Sei-Ichi Saitoh
W-PASS (Western Pacific Air-Sea interaction Study) project
Solas-Japan Chair: Mitsuo Uematsu

Linkages in Biogeochemical Cycles Between Surface Ocean and Lower Atmosphere
Background

The facts have been known:

• Typhoon passage can enhance ocean phytoplankton chlorophyll-a and primary production,
• The northwest Pacific typhoon activities have been known to be related to El Nino/La Nina events, but

Some information have not been documented yet, such as:

• How El Nino/La Nina events influence ocean primary production in the East China Sea through typhoon activity,
• Complete interannual and interdecadal variations in typhoon-enhanced ocean primary production,
• Estimation of typhoon contribution to summer-fall new production in the East China Sea.
Number of Typhoons per year

![Chart showing the number of typhoons per year from 1950 to 2010. The mean number is 26.6.](chart_image)

台風経路データ（気象業務支援センター）より
Life Time of Typhoon

mean
4.8 days
Spatial Pattern of Frequency of Typhoon Passage (1951-2005)

Number of Typhoon
Interannual and Interdecadal Variations of Typhoon-Induced Primary Production: A Case Study for The Outer Shelf of The East China Sea

Siswanto, E., J. Ishizaka, K. Yokouchi, K. Tanaka, C.K. Tan
**Materials and Methods**

**Study Area:**
- Area delineated with blue polygonal
- The west border of the area (green contour) is 0.37 mg m\(^{-3}\) chlorophyll-a (Chl-a) isopleth derived from summer mean SeaWiFS Chl-a

**Study Period:**
- Summer-fall period (June – October)

**Satellite Data (1998 ~ 2004):**
- SeaWiFS Chl-a
- SeaWiFS photosynthetically available radiation (PAR)
- TRMM/TMI sea surface temperature (SST)

**Typhoon Data:**
- 13 typhoons (red curves and circles) before and after which clear SeaWiFS Chl-a data are available (from Japan Meteorological Agency)
- Typhoon variables: typhoon transit speed (TS) and maximum sustained wind (MSW)

**Primary Production Model:**
- VGPM (Behrenfeld and Falkowski, 1997)

\[
PP = 0.66125 \times P_{\text{opt}}^B \times \left[ \frac{\text{PAR}}{\text{PAR} + 4.1} \right] \times Z_{\text{eu}} \times \text{Chl}_0 \times D_{\text{irr}}
\]

Combined with specific \(P_{\text{opt}}^B\) model for the ECS (Siswanto et al., 2006)

\[
P_{\text{opt}}^B = 9.06 e^{0.08 \text{SST}}
\]
Pre- and post-typhoon SeaWiFS Chl-a images

Pre- and post-typhoon primary production images
Chl-a, PP Enhancements Vs. Typhoon Variables, Bottom Depth (BD)

PP enhancement = -28.14 + 2.57 Mean MSW – 0.98 Mean TS – 0.04 Mean BD

TS: Transit Speed
MSW: Maximum Sustained Wind
BD: Bottom Depth

Empirical relationship

R² = 0.65, p < 0.001
In general, PP enhancements inversely oscillated with SOI.

PP enhancements were higher during El Nino years associated with higher MSW.

Total PP enhancements were not related to number of typhoons.
Trend Observed:

- **During the past 25 years, the number of typhoons has tended to increase** ($R = 0.48$, $p < 0.05$),
- **The mean number of typhoons (red lines) during 1991-2004 period** (mean $\sim 3.9$ typhoon yr$^{-1}$) > **during 1980-1990 period** (mean $\sim 2.5$ typhoons yr$^{-1}$),
- **As a consequence, mean total PP enhancement (black lines) during 1991-2004 period** (133 Gg C d$^{-1}$) > **during 1980-1990 period** (82 Gg C d$^{-1}$).
Estimates of typhoon contribution on the summer-fall new production in the study region

Estimates of summer-fall new production


  - f-ratio = 0.15 (Chen et al., 2003)
  - f-ratio = 0.1 (Eppley, 1989)

Mean summer-fall new production (1998 – 2004)

Typhoon-induced new production

- Typhoon-enhanced primary production
  - Pre-typhoon
  - Post-typhoon

  - Meari

  - f-ratio = 0.6

Typhoon-induced new production

- Typhoon contribution to summer-fall new production was lowest in 1988 (0.4%) and highest in 2004 (39.7%) (mean 13.7%),

- Typhoon contribution to summer-fall new production was also higher during El Nino years (16.7%) than during La Nina years (7.2%).
Study Area

East-China Sea

Western North Pacific
Number of Typhoon in 2003 = 21

- Trajectory of Typhoon in 2003
Typhoon No.0317 (2003)

Minimum Pressure  940hPa
Maximum Wind Speed  46.3m/s
Mean Speed  4.67m/s

SeaWiFS 8days Mean Chl-a
October 24-31, 2003
Using typhoon variables and bottom depth, PP enhancements due to typhoon passage are possible to be estimated even without satellite ocean color data,

In general, because typhoons tended to be more (less) intense during El Nino (La Nina) years, typhoon-enhanced PP was also higher (lower) during El Nino (La Nina) years,

Typhoon-enhanced PP has also shown a tendency to be higher during 1991-2004 period than that during 1980-1990 period,

Typhoon crossing the ECS might contribute within 0.4% - 39.7% of the summer-fall new production in the study region of ECS.
Thank you