Toward the Management of Eutrophication of NOWPAP Sea Area: Monitoring by New Satellites and Modeling

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2019 March 22
Outline

- Time Series of Satellite Ocean Color
- Possibility of Phytoplankton Community Monitoring
- Possibility of Use of Modelling for Management of NOWPAP area
## Major Ocean Color Sensors Available for Eutrophication Monitoring

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Satellite</th>
<th>Agency</th>
<th>Spatial Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>SeaWiFS</td>
<td>SeaSTAR</td>
<td>NASA</td>
<td>1100</td>
</tr>
<tr>
<td>MODIS</td>
<td>AQUA</td>
<td>NASA</td>
<td>1000</td>
</tr>
<tr>
<td>GOCI</td>
<td>COMS</td>
<td>KARI/KOSC</td>
<td>500</td>
</tr>
<tr>
<td>VIIRS</td>
<td>SuomiNPP</td>
<td>NASA</td>
<td>750</td>
</tr>
<tr>
<td>VIIRS</td>
<td>JPSS-1/NOAA-2</td>
<td>NOAA/NASA</td>
<td>740</td>
</tr>
<tr>
<td>OLCS</td>
<td>Sentinel-3A</td>
<td>ESA/EUMETSAT</td>
<td>300</td>
</tr>
<tr>
<td>OLCS</td>
<td>Sentinel-3B</td>
<td>ESA/EUMETSAT</td>
<td>300</td>
</tr>
<tr>
<td>SGLI</td>
<td>GCOM-C</td>
<td>JAXA</td>
<td>250</td>
</tr>
</tbody>
</table>

- Long time series
- Geostationary
- High resolution
MODIS NPP JPSS SGLI

Need Inter-calibration
Influence of Changjiang to East China Sea

Changjiang Diluted Water

Shelf Water

Kuroshio
High P, Low Excess N – High Chl-a (Xu et al. JO-2019)
2009/2013
High Diatom Phosphate

2010/2011
Low Diatom Phosphate

CDW

Prochlorophytes
Cyanobacteria
Prasinophytes
Cryptophytes
Dinoflagellates
Diatoms
Chlorophytes
Chrysophytes
Prymnesiophytes

KSW

CHL
Difference of N:P ratio ↓

difference of phytoplankton groups

(Xu et al., JO-2019
Gomes et al., FMS-2019)
Phytoplankton Size in the East China Sea (Zhang et al., JGRO-18)
Noctiluca bloom ⇒ in Japan Sea
April 20, 2018

Macro-algae bloom (Brown Algae) in East China Sea
In March 14, 2018
Environmnet Agency R&D Project

*High freshwater and nutrient input*

*Kuroshio Current*

*Global Warming*

*Environmental Change in ECS*

*Winter cooling*

*Tsushima Current*

*High freshwater and nutrient input*

*ECS* (East China Sea)

*Taiwan Warm Current*

*Japan Sea*

*JAPAN*

*CHINA*

*KOREA*

*Russia*
Research Method: Ecosystem Models

Low trophic

Prof. Morimoto
Ehime University

【Characteristic】
Detailed classification of phytozooplankton

【Objective】
Understanding response of low trophic species to change of nutrient condition

Impact from the ECS

High trophic

Prof. Hirose
Kyushu University

【Characteristic】
Simplification of phyto-zooplankton
Data assimilation by DO

【Objective】
Forecasting long-term trend

Impact of Global warming

Prof. Guo
Ehime University

Japanese common squid
(Todarodes pacificus)

【Characteristic】
Transportation of egg and larvae and its survival under environmental and feed condition

【Objective】
Effective/efficient setting of MPAs

Impact of Global warming

Snow crab
(Chionoecetes opilio)
Impact from the East China Sea?

Where is the main source of water and nutrient in coastal area of Japan?

- **Water**
  - Deep water: 56%
  - East China Sea: 44%
  - River discharge: 9%

- **Nutrient (N)**
  - Deep water: 89%
  - East China Sea: 11%
  - River discharge: 2%

Ratio of three different sources of waters in the surface of Japan Sea

Ratio for utilization of three different sources of nutrient (N)

Environment of Japanese coastal area is controlled by the ECS
Where is origin of nutrient?

Direct impact of river discharge on environment of Japan Sea: small?
Impact of global warming on SST?

Surface Temperature Increase

Main reason: Strengthen and change of Tsushima Current

August

JMA

1917-2017

2000-2100

RCP8.5, RCP2.6

JMA

Surface Temperature Increase

August
Impacts on ecosystems in the JS

Nutrient input from the ECS

<table>
<thead>
<tr>
<th>Year</th>
<th>2005</th>
<th>2010</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIN transport [kmol/sec]</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>

Change of primary production in JS

<table>
<thead>
<tr>
<th>Month</th>
<th>Jun</th>
<th>Aug</th>
<th>Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Impacts from GW

Nutrient condition in 2000, 2050 and 2100

<table>
<thead>
<tr>
<th>Year</th>
<th>1960</th>
<th>2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature [°C]</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>DIN transport [kmol/sec]</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

(Continued)
Impacts on ecosystems in the JS

Global warming

Survival of Japanese Common Squid Larva

Survival of Larva of Snow Crab

Spawning ground

Settlement number of Crab Larva
Management in the NOWPAP area

“Three Layer Management”

- Wide scale management
  International cooperation

- Middle scale management
  Domestic cooperation

- Local scale management
  Local land-sea integrated management
EXAMPLE of wide-scale management: International surveillance network
### EXAMPLE of wide-scale management: International surveillance network

<table>
<thead>
<tr>
<th>Surveillance network</th>
<th>Monitoring items</th>
<th>Monitoring methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Global warming</strong></td>
<td>Water temp. (surface, bottom), Ocean Current (direction, velocity), DO, Nutrients (N, P)</td>
<td>Ship survey, Remote sensing, Argo float</td>
</tr>
<tr>
<td><strong>Nutrients</strong></td>
<td>Nutrients (N, P), Phytoplankton, Chlorophyll a</td>
<td>Ship survey, Remote sensing</td>
</tr>
<tr>
<td><strong>Low salinity water</strong></td>
<td>Salinity, PAHs, POPs</td>
<td>Ship survey</td>
</tr>
</tbody>
</table>

**Collaboration with International Organizations**

- IOC/WESTPAC
- NEAR-GOOS
- North Pacific Marine Science Organization（PICES）AP-CREAMS
- NOWPAP
Middle scale management · Domestic cooperation
Conservation of marine biodiversity/ecosystem

Dynamic Marine Protected Area
Existing MPA for snow crab (No fishing area, period)

Joint management of the ECS

Phyto/zooplankton

High trophic

Ecological and biological significant sea area

Catch of Japanese common squid

To protect main spawning ground where is changed by ocean environment
EXAMPLE of local-scale management: Land-sea Integrated management

Change of natural and social environment

Snowfall (cm)


Snowfall (cm)
EXAMPLE of local-scale management: Land-sea Integrated management

Effect of river input

Without river discharge

With river discharge

Effect of SGD

DIN Flux

Horizontal
Vertical
River+SDG
Total
EXAMPLE of local-scale management: Land-sea Integrated management

Ministry of the Environment, Japan

Forest-Village (Sato)-River-Ocean
Conclusions

• More than 20 years of time series of satellite ocean color is available to use eutrophication monitoring (Need inter-calibration)
• High resolution satellite available recently
• Change of N/P ratio in East China Sea changes phytoplankton community
• Ocean color satellite is becoming possible to monitor phytoplankton community
• Prediction by numerical modelling is useful for management in near future