Introduction to NEAT:
NOWPAP Eutrophication Assessment Tool

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Marine and coastal eutrophication

Increasing Eutrophication
Excessive growth of marine plant life, is seriously Disrupting ecosystems and threatening health throughout the worlds: coral reefs, seagrass beds and other vital habitats are suffering.

Eutrophication can trigger explosive blooms of toxic algae which can blight tourism, contaminate seafood and poison people.

GESAMP (2001)
Marine eutrophication as a global concern

Experts meeting about methodology on eutrophication and plastic debris assessment under SDG 14.1.1. convened by UN Environment and IOC UNESCO

12-13 September 2018, UNESCO HQ, Room XV, Paris, France

Participants: Scientific experts in regional seas programmes and earth observation specialists working on the science of marine pollution indicators, data capture and dissemination.
Potential of remotely sensed Chlorophyll-a for assessment of eutrophication

Strength and weakness of satellite and shipboard measurements

<table>
<thead>
<tr>
<th>Means of observation</th>
<th>Strength</th>
<th>Weaknesses</th>
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<tbody>
<tr>
<td>Satellite Remote Sensing</td>
<td>• Wider area and higher temporal coverage</td>
<td>• Low accuracy in estimation of Chl-a in coastal area</td>
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<tr>
<td></td>
<td>• Objectively detect relative change</td>
<td>• No data obtained under cloud</td>
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<td></td>
<td>• Free data access over the Internet</td>
<td>• Data is available only at sea surface</td>
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<td>Preliminary Assessment for screening</td>
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<tr>
<td>Ship board measurements</td>
<td>• Obtain data under sea surface</td>
<td>• Data represent only point of information</td>
</tr>
<tr>
<td>Holistic Assessment</td>
<td>• Can obtain actual measured value</td>
<td>• Analysis of Chl-a need expertise</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Costly</td>
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Refinement of the common procedure for eutrophication assessment

- Procedures for assessment of eutrophication status including evaluation of land-based sources for nutrients for the NOWPAP region (refined in 2013)

Use of selected parameters including the remotely sense data is proposed as a screening tool.

The Common Procedures
Procedures for assessment of eutrophication status including evaluation of land-based sources of nutrients for the NOWPAP region
(as of Aug 2013)

- Screening procedure: Detection of eutrophication symptoms
- Comprehensive procedure:
  - Setting of assessment objectives
  - Selection of assessment areas
  - Collection of relevant information
  - Collection of eutrophication related information/data
  - Categorization and selection of assessment parameters
  - Preparation of assessment data sets
  - Division of assessment area into sub-areas
  - Setting of assessment period
  - Setting of assessment criteria
  - Setting of criteria for classifying the eutrophication status of the assessment areas/sub-areas

Results and discussion:
- Classifying eutrophication status of the assessment areas/sub-areas
- Review of the obtained assessment results by literatures

Conclusion/Recommendation:
- Eutrophication status of assessment areas
- Recommendation for future actions
Assessment of eutrophication using remotely sensed chlorophyll-a concentration in the Northwest Pacific region (NOWPAP Eutrophication Assessment Tool: NEAT)

Assessment of eutrophication using remotely sensed chlorophyll-a in the Northwest Pacific region


Event: SPIE Asia-Pacific Remote Sensing, 2018, Honolulu, Hawaii, United States
Satellite Chl-a used to assess eutrophication in the NOWPAP region

- **Satellite Sensors**

- **OC Data Processing version**
  - Reprocessing 2014
Assessment of eutrophication by the NOWPAP Common Procedure (NEAT: NOWPAP Eutrophication Assessment Tool)

Classification of eutrophication status

- HD: Current status: high, Trend: decreasing
- HN: Current status: high, Trend: no trend
- HI: Current status: high, Trend: increasing
- LD: Current status: low, Trend: decreasing
- LN: Current status: low, Trend: no trend
- LI: Current status: low, Trend: increasing

Threshold = 5 ug/L

More eutrophic
High
Level
Low
Oligotrophic (Less eutrophic)

Decreasing
Becoming oligotrophic (less eutrophic)

No Trend
Terauchi et.al, 2014

Increasing
Becoming eutrophic
Assessment of eutrophication with the NASA STD Chl-\(\alpha\)


Sensors: SeaWiFS and MODIS (Aqua)

Algorithm: NASA Standard (Hu et al., 2012)
Assessment of eutrophication in the Northwest Pacific Region with the NEAT

Terauchi et al. (2018)
Satellite data used for assessment:

| Sensor        | NASA SeaWiFS on Orbview 2  
<table>
<thead>
<tr>
<th></th>
<th>NASA MODIS on Aqua</th>
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</table>
| Algorithm     | R2014 NASA standard for the eastern part  
|               | R2014 NASA standard and YOC algorithm for the western part (Siswanto et al. 2011) |
| Duration      | Jan 1998 to Dec 2016        |
| Data          | Level 2                     |
| Area          | Northwest Pacific           |

- SeaWiFS: Jan 1998 – Jun 2002
Comparison of assessment results

(a) 1998-2015

(b) 1998-2016
1998-2015

Qinhuangdao City

Dandong City

Innermost part of the Bohai Bay

Razdolnaya River

Peter the Great Bay

Vladivostok

1998-2016

HD
HN
HI
LD
LN
LI
Preprocessing of ocean color data

Level 2

• Screening by level 2 flags
  ATMFAIL, LAND, HIGLINT, HILT, HISATZEN, STRAYLIGHT, CLDICE, HISOLZEN, LOWLW, CHLFAIL, NAVWARN, CHLWARN, NAVFAIL

Level 3 data will be masked if above flags are on.

Level 3

Eastern part

• Chl-a was estimated by the NASA standard algorithm (Reprocessing version 2014)

Western part

#Case 1
• Chl-a was estimated the NASA standard algorithm (Reprocessing version 2014)

#Case 2
• Chl-a was estimated from the YOC algorithms from SeaWiFS and MODIS Rrs
Comparison of band ratios between SeaWiFS and MODIS Rrs

$\text{CHL}_{\text{oS}} = 10^{(-0.166 - 2.158 \log_{10}(R_{\text{oS}}) + 9.345 \log_{10}^2(R_{\text{oS}}))}$

$R_{\text{oS}} = \left[ \begin{array}{cc} \frac{\text{Rrs}(443)}{\text{Rrs}(555)} & \frac{\text{Rrs}(412)}{\text{Rrs}(490)} \\ \end{array} \right]^{-0.463}$

$A = \left[ \begin{array}{c} \text{Rrs}(443) \\ \text{Rrs}(555) \end{array} \right]$

$B = \left[ \begin{array}{c} \text{Rrs}(412) \\ \text{Rrs}(490) \end{array} \right]$

Siswanto et al. (2011)

SeaWiFS
Rrs(443)/Rrs(555) = A
Rrs(412)/Rrs(490) = B

MODIS (Aqua)
Rrs(443)/Rrs(547) = A'
Rrs(412)/Rrs(488) = B'

Pixel to pixel Comparison

Jan 1998
MODIS (Aqua)
Dec 2016

Jun 2002

Dec 2004
Comparison of Rrs ratios and Rrs between SeaWiFS and MODIS-A

SeaWiFS Rrs(443/555) vs MODIS-A Rrs(443/547)

SeaWiFS Rrs(412/490) vs MODIS-A Rrs(412/488)

SeaWiFS Rrs(555) vs MODIS-A Rrs(547)
Switching OC algorithms

Rrs555

0.013605

YOC 100%

NASA STD 100%

0.008163
Validation of satellite Chl-a with in situ Chl-a
Comparison of satellite and in situ Chl-a with the two different algorithms

(a) NASA STD

(b) YOC

In situ Chl-a in southern and western coastal area around Korean Peninsula
Exploring potential of Google Earth Engine, a planetary geo-spatial analysis tool, for assessing eutrophication in a global scale

- Eutrophication assessment based on Google Earth Engine
  - Easy to update by non-expert
  - Always provides the most recent information
  - Only focus on the interpretation of results
Global assessment of marine and coastal eutrophication by the NEAT

G. Terauchi and E. R. Maúre (2018)

- Satellite Sensors and OC Data processing version
  Reprocessing version 2018
Use of SGLI of the GCOM-Mission will enhance the applicability of satellite Chl-a in eutrophication assessment in coastal zone

Chlorophyll-a concentration on May 23, 2018 observed by SGLI on board GCOM-C mission. Image provided by Dr. Hiroshi Murakami, JAXA
Conclusion

• Regionally tuned Chl-a algorithms is helpful and necessary to improve accuracy in turbid water

• Merging satellite Chl-a from different ocean color sensors are necessary to carry out a long-term assessment

• Increase in resolution of recent ocean color sensors will give better picture in coastal zones

• Use of cloud computing will enhance applicability of the NEAT in wider spatial scale