Satellite based monitoring of marine and coastal environment of the Northwest Pacific

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Outline

- 1. Regional Sea Program and NOWPAP
- 2. Mission of NOWPAP CEARAC
- 3. CEARAC activities related to satellite based monitoring of marine and coastal environment
- 4. Activities for 2012-2013
1. Regional Sea Program and NOWPAP

- **Regional Sea Program (RSP)**
  - Launched in 1974 by UNEP to address the accelerating degradation of the world’s oceans and coastal areas.
  - RSP covers 18 regions across the world today

- **NOWPAP**
  - Adopted in 1994
  - China, Japan Korea and Russia
  - Latitude 33 - 52°N
  - Longitude 121 - 143E
Structure of NOWPAP

Inter-governmental Meeting
- China
- Korea
- Japan
- Russia

Regional Coordinating Unit
- Toyama Office, Japan
- Busan Office, Korea

DINRAC, China
(Data and Information Network Regional Activity Centre)

MERRAC, Korea
(Marine Environmental Emergency Preparedness & Response Regional Activity Centre)

CEARAC, Japan
(Special Monitoring & Coastal Environmental Assessment Regional Activity Centre)

POMRAC, Russia
(Pollution Monitoring Regional Activity Centre)
2. Mission of NOWPAP CEARAC

- **Mission**
  - Assessment of the state of the marine, coastal and associated fresh water environment
  - Development of tool for environmental monitoring and assessment by satellite remote sensing

- **Activities**
  - Harmful Algal Blooms
  - Remote Sensing of Marine Environment
  - Assessment of eutrophication
  - Marine Litters
  - Marine biodiversity
3. CEARAC activities related to satellite based monitoring of marine and coastal environment

- Publication of reports
- Provision of satellite data through websites
- Capacity building activities for utilization of satellite data
- Development of methodology for monitoring and assessment of marine and coastal environment by satellite remote sensing

The above activities are carried out by CEARAC under the support of NOWPAP Working Group 4, comprised of experts from each NOWPAP member countries.
Publications

http://cearac.nowpap.org/publications/index.html

Provision of satellite data
NPEC Marine Environmental Watch

http://ocean.nowpap3.go.jp/

- Sea surface temperature
- Chlorophyll-a concentration
NPEC Marine Environmental Watch

Marine Calendar - daily satellite images

- Ariake Bay, Japan
- South Sea in Korea
- North sea area of Shandong peninsula, China
- Peter the Great Bay
NOWPAP Ocean Remote Sensing Portal

http://www.cearac-project.org/wg4/portalsite/
providing links to website and publications on ocean remote sensing
NOWPAP Ocean Remote Sensing Portal

Geo referenced satellite images for various applications are available.
Website on oil spill monitoring by remote sensing

http://cearac.poi.dvo.ru/en/

Providing information on techniques and satellite images on oil spill detection by remote sensing

Satellite instruments are well adapted to monitor and therefore to detect oil pollution since they produce regularly images of the sea surface including the remote areas. Several kinds of measurements have been tested: optical, infrared, radars with different frequencies. Below the main attention will be given to Consideration of oil spills on Synthetic Aperture Radar (SAR) images. SAR seems to be one of the most suitable instruments to the detection of slicks since slicks damp strong short waves measured by SAR and oil spills appear as a dark patch on the SAR image. SAR observations do not depend on weather (cloudy) and sunshine, which allows showing illegal discharges that most frequently appear during night. SAR can also survey storms areas, where accident risks are increased.

The constraints related to SAR measurements are of several kinds. First, wind speed value has to be between 2-3 to 10-14 m/s. Secondly, it is rather hard to distinguish oil spill from other phenomena which analogously to oil spills have negative radar contrast (look dark on SAR images) relative the surrounding waters and commonly referred to as "look-slicks". Among such "look-slicks", are films of surface active substances (mainly, natural) observable particularly at wind speed < 5-6 m/s, wind shadow areas near the coast, heavy rains damping small scale roughness, upwelling zones and grease ice (Figure 2). Thirdly, the SAR image allows detecting oil on the seawater surface only, before it goes down in sub-surface layer as a result of dispersion (see: Behaviour of oil at sea).

Figure 1. Subsides of ERS-2 SAR image for 20 May 1994 at 14:20 UTC (a) and for 23 March 1999 at 13:27 UTC (b) showing illegal discharge of oil polluted waters by ships. Ships are clearly visible as white dots at the beginning of dark bands.

(a) Fresh discharge from a moving ship: dark band broaden as a function of the distance from the ship. Surface currents deform shape of oil band.

(b) Oil discharge ship on anchor. Width of the oil slick does not change.

The contrast between a spill and the surrounding water, and thus the probability of detecting pollution slicks, depends on the amount and type of split oil as well as on environmental factors such as wind speed, wave height, SST, currents and current shift zones (Figure 3).
Development of procedures for holistic eutrophication assessment

Procedures for assessment of eutrophication status including evaluation of land-based sources for nutrients for the NOWPAP region (June, 2009)

Developed with experts of HAB and Ocean Remote sensing, referring to experiences in European countries such as HELCOM and OSPAR

Available on CEARAC Website at http://cearac.nowpap.org/
Past training courses on remote sensing in the Northwest Pacific

2009

2007

2008

2011

October 2013

Ocean University of China
Chinese National Environmental Monitoring Center

IOC/WESTPAC

NOWPAP
CEARAC

PICES

NOWPAP
CEARAC

KORDI

NOWPAP
CEARAC

UNEP
Ongoing activities for 2012-2013

- Regular update of existing websites related remote sensing
  - Recent publications
  - Links to newly established websites
- Development of methodology to preliminary assess marine eutrophication by satellite
- 4th NOWPAP remote sensing training course

For further information, please visit http://cearac.nowpap.org/
Preliminary assessment of coastal marine eutrophication by remote sensing

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Outline

1. Background
   - Procedures for assessment of eutrophication status including evaluation of land-based sources for nutrients for the NOWPAP region (June, 2009)

2. Ideas behind the preliminary eutrophication assessment by remote sensing

3. Data and method

4. Result of preliminary assessment in Toyama Bay

5. Application of the preliminary assessment approach in other part of Northwest Pacific region

6. Conclusion
1. Background

Procedures for assessment of eutrophication status including evaluation of land-based sources for nutrients for the NOWPAP region (June, 2009)

Developed with experts of HAB and Ocean Remote sensing, referring to experiences in European countries such as HELCOM and OSPAR

Available on CEARAC Website at http://cearac.nowpap.org/
2. Ideas behind - Strength and weakness in satellite and in situ based monitoring

<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>
</tr>
<tr>
<td>Preliminary Assessment for screening</td>
<td>• Free data access over the Internet</td>
<td>• No data obtained under cloud</td>
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<td></td>
<td>• Objectively detect relative change</td>
<td>• Data is available only at sea surface</td>
</tr>
<tr>
<td>Ship board measurement</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 accurate measured value</td>
<td>• Analysis of Chl-a need expertise</td>
</tr>
<tr>
<td></td>
<td>• Can obtain many parameters</td>
<td>• Costly</td>
</tr>
<tr>
<td></td>
<td>• Long time series</td>
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</table>
2. Ideas behind Concept of methodology

- **Objective**
  - To detect potential eutrophic area only with satellite derived Chlorophyll-a concentration (satellite Chl-a)

**Preliminary Assessment**
- Detection of potential eutrophic areas by satellite Chl-a

**Holistic Assessment**
- Detailed assessment in the detected potential eutrophic areas with the Common Procedures
2. Ideas behind
Simplifying environmental signals
2. Ideas-behind Classification of Eutrophication

Classification base on the Common Procedures (NOWPAP CEARAC, 2009)
3. Data used: satellite data

Sensor: NASDA (JAXA) OCTS on ADEOS
  NASA SeaWiFS on Orbview 2
  NASA MODIS on Aqua

Algorithm: R2009 NASA standard datasets

Duration: 13 Years from Jan 1997 to Dec 2009

Data: Monthly composite

Area: Toyama Bay (36.5 to 38°N, 136.5 to 138.5°E)
3. Data used: *in situ* data

<table>
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<tr>
<th>Data Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>River discharge</td>
<td>Daily river discharge in the Oyabe and Jinzu Rivers</td>
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<tr>
<td>Total Nitrogen and Phosphate</td>
<td>TN and TP in the Oyabe and Jinzu Rivers (monthly observed from 1986 to 2005 and quarterly from 2006 to 2008)</td>
</tr>
<tr>
<td><em>In situ</em> Chl-a</td>
<td>Ship observed data at 2km offshore from Apr 1997 to Dec 2009</td>
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</tbody>
</table>

Location of study area:

- Toyama Bay
- Oyabe River
- Jinzu River

Water sampling stations of *in situ* Chl-a

Map showing locations and water sampling stations.
3. Methods -
High and Low Chl-a area

(a) 13-years overall mean of satellite Chl-a. (b) High and Low Chl-a area determined by the Chl-a level more than 5 \( \mu g \text{ l}^{-1} \) referring to the Medium Chl-a condition (>5, <20 \( \mu g \text{ l}^{-1} \)) of Bricker et al. (2003).
3. Methods

Detecting interannual Chl-a trend

13-years of satellite Chl-a trend.
(a) The trend of annual Chl-a max in monthly mean Chl-a and its significance were estimated at pixel wise by the Sen Slope test at 90% confidence level. (b) Increase Trend, No Trend and Decrease Trend area were then detected.
4. Results- Preliminary assessment of eutrophication in Toyama Bay

Potential eutrophic area?
4. Results - Validation of satellite Chl-a with in situ Chl-a

Comparison of satellite and in situ Chl-a during the studied period in Toyama Bay coastal area.
4. Results - Interannual change of annual riverine input of TN and TP

- **Jinzu TN**
- **Oyabe TN**
- **Jinzu TP**
- **Oyabe TP**
5. Application of the preliminary assessment in Northwest Pacific region

Tunings required

#1. Reference condition to determine High and Low Chl-a

What is appropriate Chl-a amount to maintain balance food web?

#2. Reliability of satellite Chl-a

Is the standard satellite data accurate enough?
5. Application of the preliminary assessment in Northwest Pacific region

Why the result so different?

Standard algorithm

YSLME Case 2 algorithm
6. Conclusion

- Preliminary assessment of eutrophication by satellite
  - Usefulness was validated in Toyama Bay
- Application to the suggested methodology to the other areas
  - Things to be tuned
    - Reference Chl-α condition
    - Algorithms for case II water
      - Collaboration with YSLME
    - Consistency between sensors
Thank you very much!