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

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1.NOWPAP CEARAC

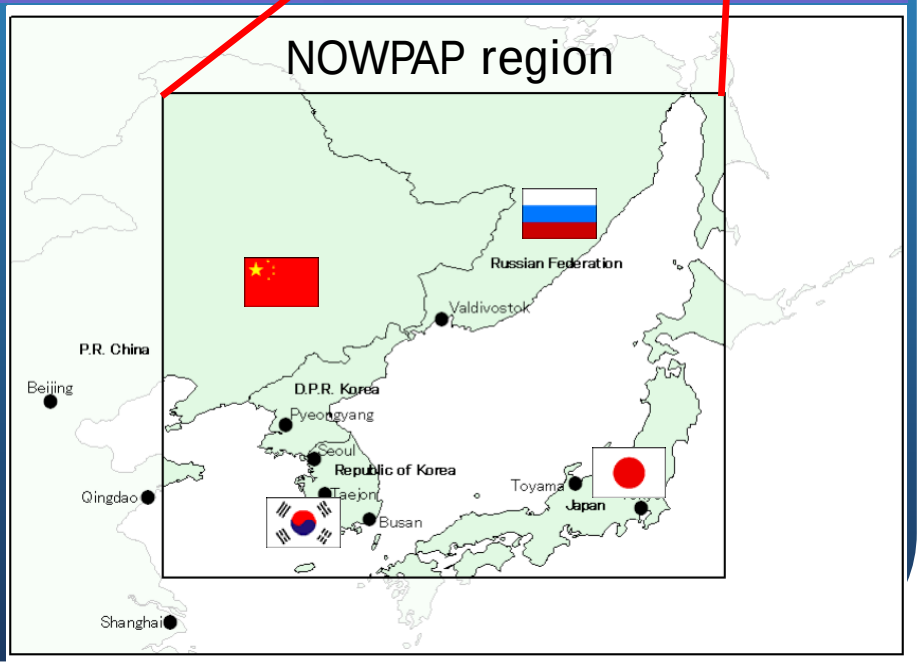
2.Nagoya University

Outline

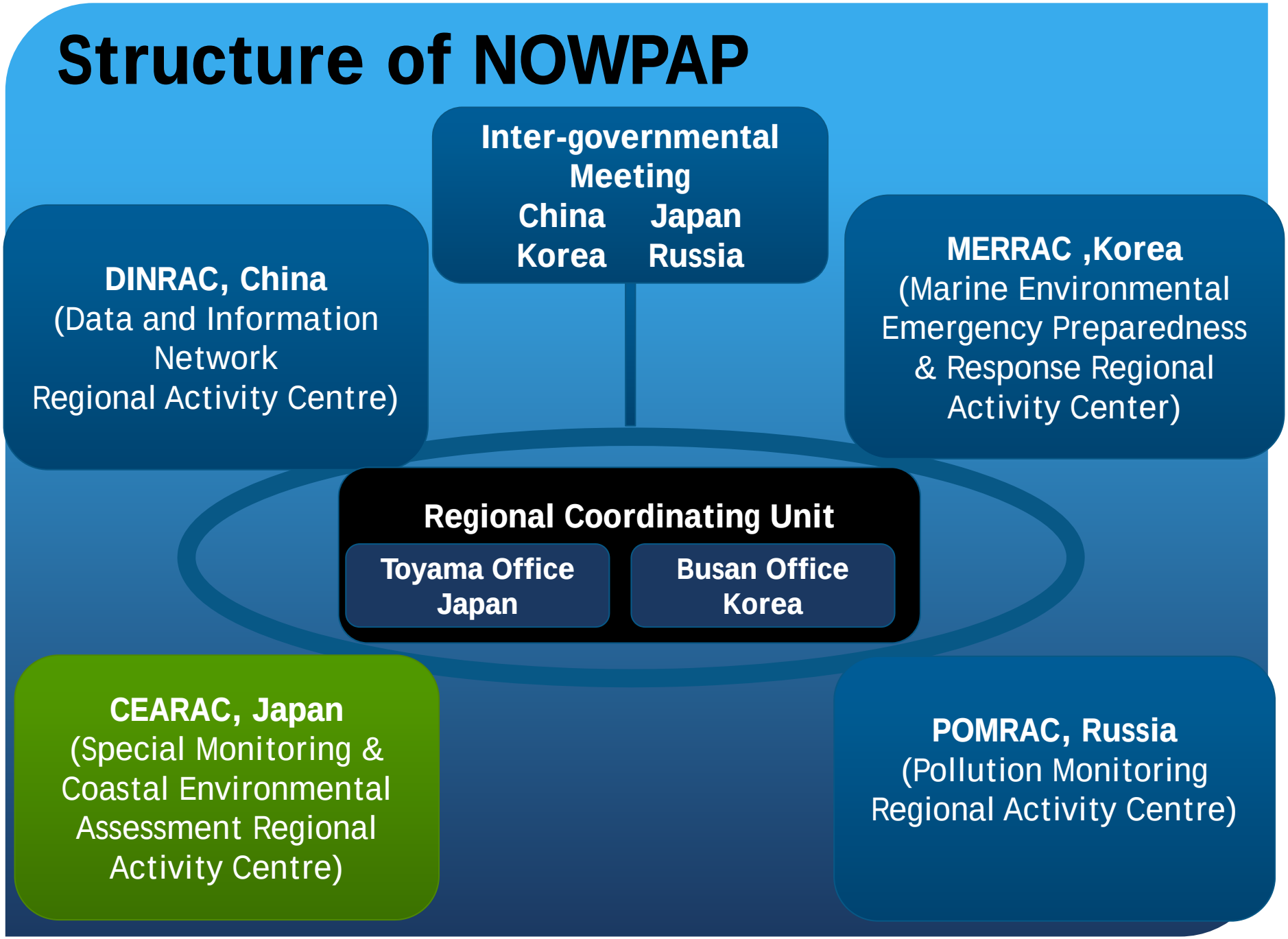
- 1. Regional Sea Program and NOWPAP
- 2. Mission of NOWPAP CEARAC
- 3. CEARAC activities related to satellite based monitoring of marine and coastal environment
- 4. Activities for 2012-2013

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



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.

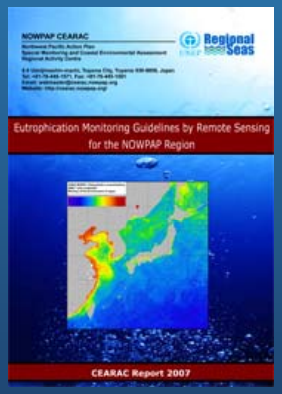
Publications

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

- National Reports on Ocean Remote Sensing of the NOWPAP Region (2005, 2011)
- Integrated Report on Ocean Remote Sensing of the NOWPAP Region (2005)
- Eutrophication Monitoring Guidelines by Remote Sensing for the NOWPAP Region (2007)
- Integrated Report on Eutrophication Assessment in Selected Sea Areas in the NOWPAP Region: Evaluation of the NOWPAP Common Procedure (2011)

National Report

Integrated Report

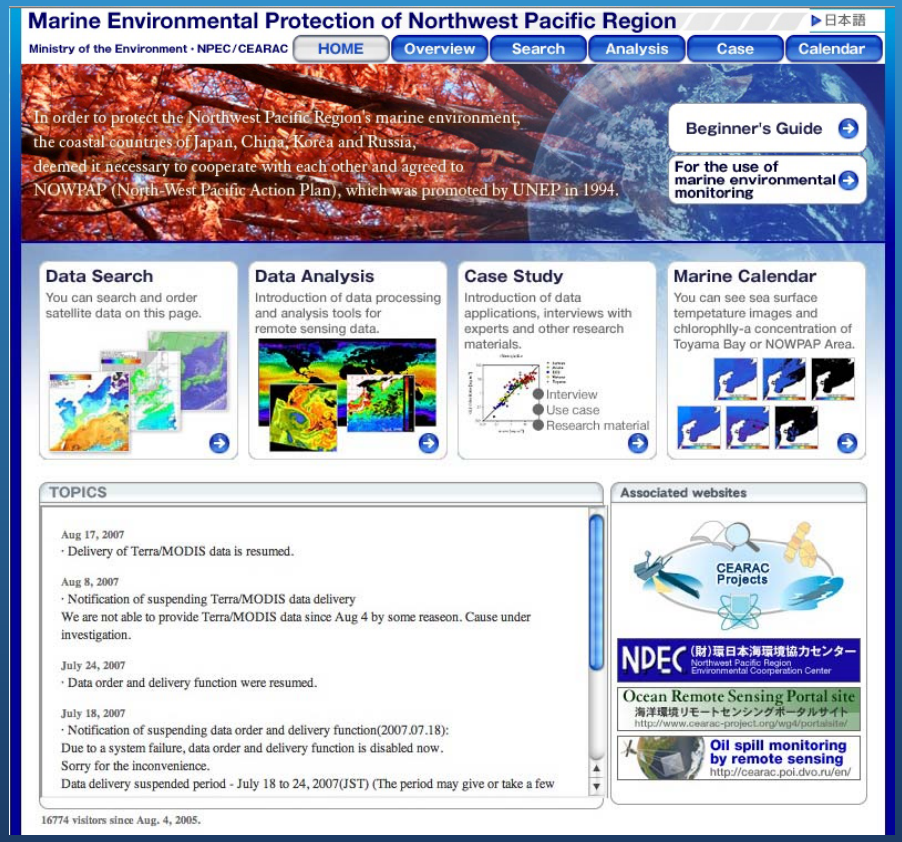


Eutrophication Monitoring Guidelines

Provision of satellite data
NPEC Marine Environmental Watch

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

- Sea surface temperature
- Chlorophyll-a concentration



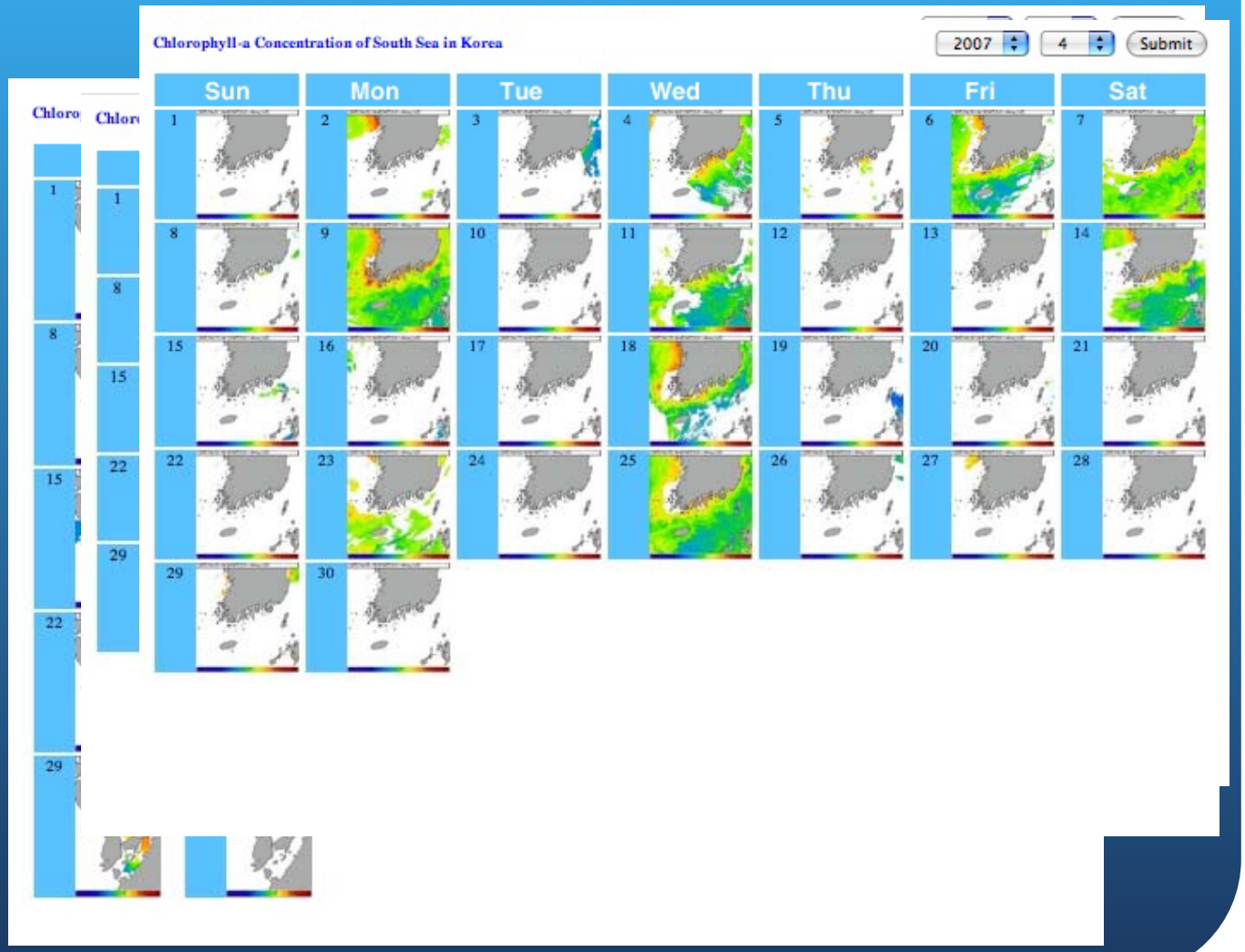
NPEC Marine Environmental Watch Marine Calendar – daily satellite images

Ariake Bay, Japan

South Sea in Korea

North sea area of Shandong peninsula, China

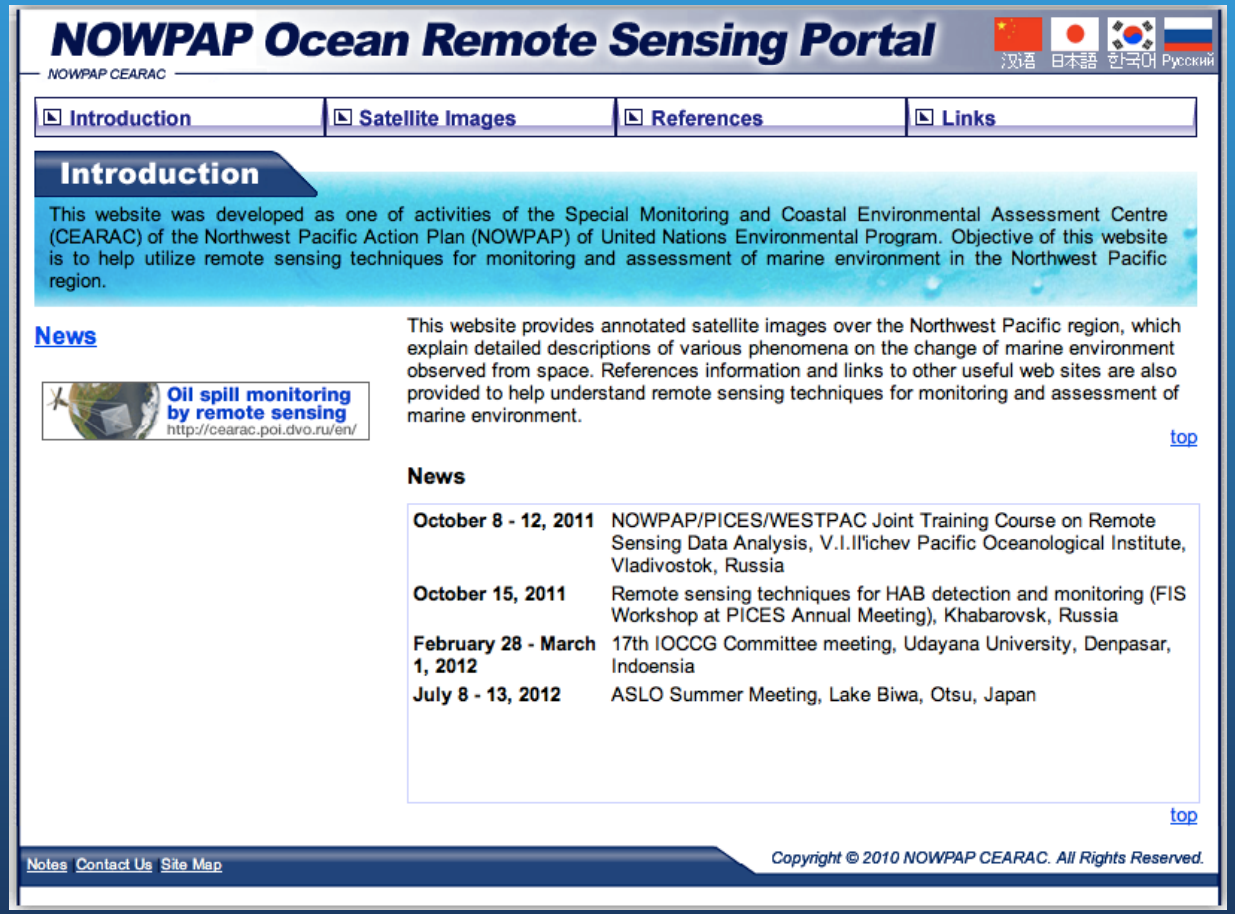
Peter the Great Bay



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

NOWPAP CEARAC

汉语 日本語 한국어 Русский

Introduction | Satellite Images | References | Links

Introduction

This website was developed as one of activities of the Special Monitoring and Coastal Environmental Assessment Centre (CEARAC) of the Northwest Pacific Action Plan (NOWPAP) of United Nations Environmental Program. Objective of this website is to help utilize remote sensing techniques for monitoring and assessment of marine environment in the Northwest Pacific region.

News

Oil spill monitoring by remote sensing
http://cearac.poi.dvo.ru/en/

This website provides annotated satellite images over the Northwest Pacific region, which explain detailed descriptions of various phenomena on the change of marine environment observed from space. References information and links to other useful web sites are also provided to help understand remote sensing techniques for monitoring and assessment of marine environment.

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News

October 8 - 12, 2011	NOWPAP/PICES/WESTPAC Joint Training Course on Remote Sensing Data Analysis, V.I.Il'ichev Pacific Oceanological Institute, Vladivostok, Russia
October 15, 2011	Remote sensing techniques for HAB detection and monitoring (FIS Workshop at PICES Annual Meeting), Khabarovsk, Russia
February 28 - March 1, 2012	17th IOCCG Committee meeting, Udayana University, Denpasar, Indoensia
July 8 - 13, 2012	ASLO Summer Meeting, Lake Biwa, Otsu, Japan

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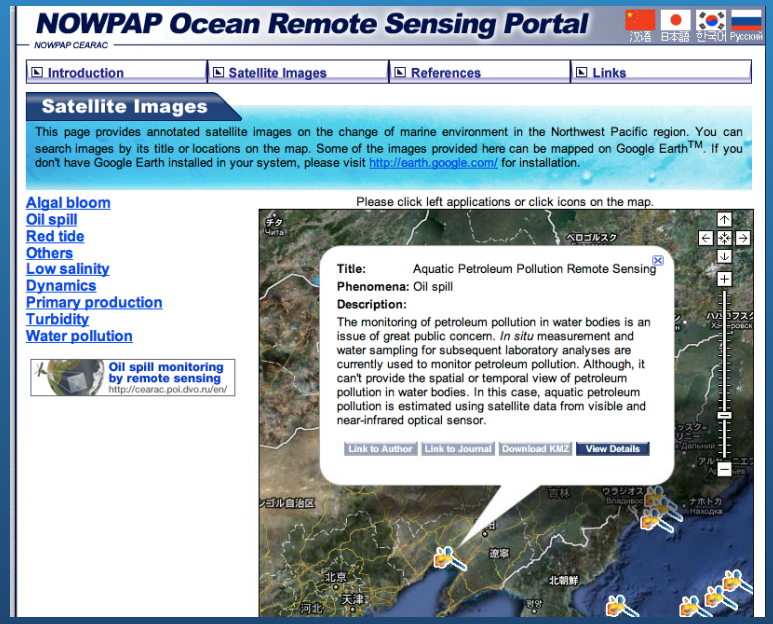
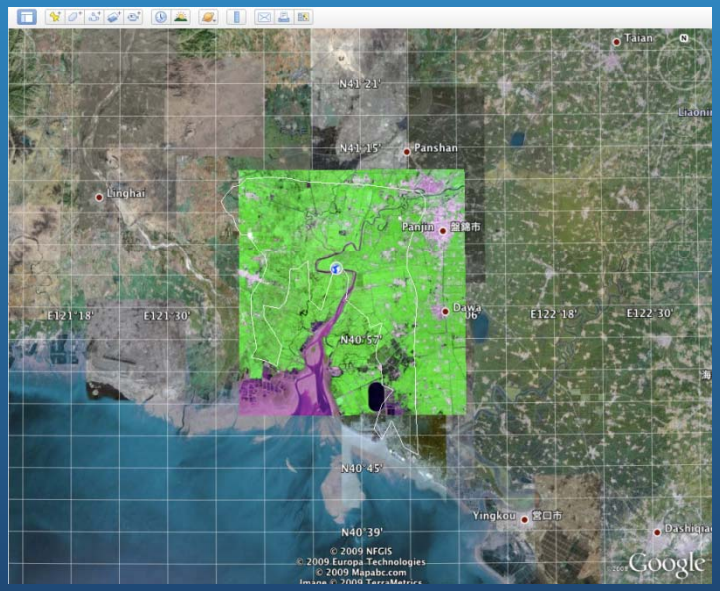
NOWPAP Ocean Remote Sensing Portal

Geo referenced satellite images for various applications are available.



Description Google Map

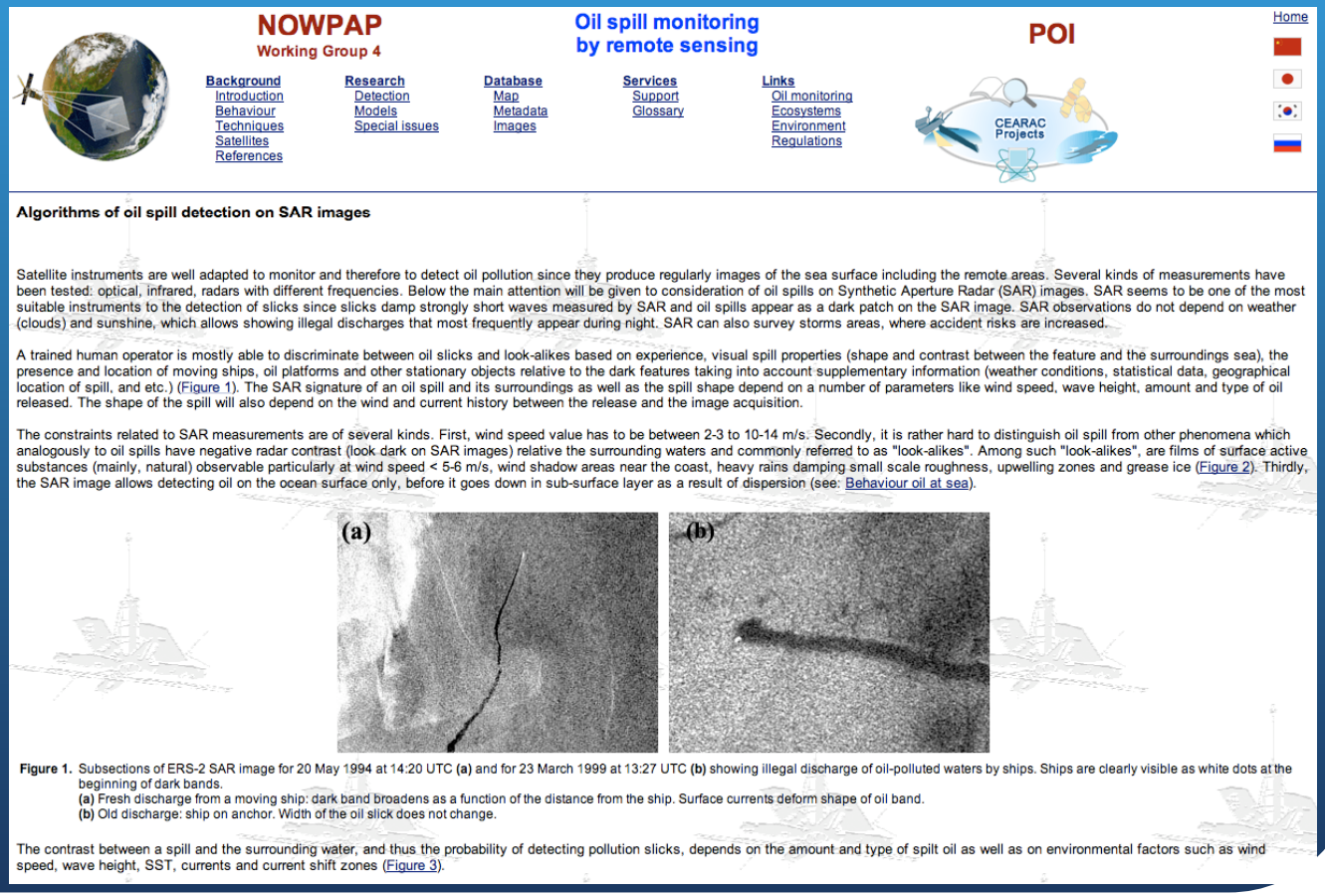


Mapping on Google Earth

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



NOWPAP
Working Group 4

Oil spill monitoring by remote sensing

POI

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CEARAC Projects

Algorithms of oil spill detection on SAR images

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 strongly short waves measured by SAR and oil spills appear as a dark patch on the SAR image. SAR observations do not depend on weather (clouds) and sunshine, which allows showing illegal discharges that most frequently appear during night. SAR can also survey storms areas, where accident risks are increased.

A trained human operator is mostly able to discriminate between oil slicks and look-alikes based on experience, visual spill properties (shape and contrast between the feature and the surroundings sea), the presence and location of moving ships, oil platforms and other stationary objects relative to the dark features taking into account supplementary information (weather conditions, statistical data, geographical location of spill, and etc.) (Figure 1). The SAR signature of an oil spill and its surroundings as well as the spill shape depend on a number of parameters like wind speed, wave height, amount and type of oil released. The shape of the spill will also depend on the wind and current history between the release and the image acquisition.

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-alikes". Among such "look-alikes", 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 ocean surface only, before it goes down in sub-surface layer as a result of dispersion (see: Behaviour oil at sea).

(a) (b)

Figure 1. Subsections 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 broadens as a function of the distance from the ship. Surface currents deform shape of oil band.
(b) Old 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 spilt 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/

The Common Procedures

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

—Contents—

Past training courses on remote sensing in the Northwest Pacific

2009

NOWPAP CEARAC UNEP

support

RIO

PICES

2011

V.I. Il'ichev Pacific Ocean

NOWPAP CEARAC UNEP

PICES

October 2013

Ocean University of China
Chinese National Environmental Monitoring Center

NOWPAP CEARAC UNEP

2008

KORDI Korea Ocean Research & Development Institute

NOWPAP CEARAC UNEP

2007

NOWPAP CEARAC UNEP

UNESCO

IOC/WESTPAC

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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2. Graduate School of Science and Technology, Nagasaki University
3. Hydrospheric Atmospheric Research Center, Nagoya University

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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

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The Common Procedures

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

—Contents—

2. Ideas behind - Strength and weakness in satellite and in situ based monitoring

Means of observation	Strength	Weaknesses
Satellite Remote Sensing **Preliminary Assessment for screening**	•Wider area and higher temporal coverage •Free data access over the Internet •Objectively detect relative change	•Low accuracy in estimation of Chl-a in coastal area •No data obtained under cloud •Data is available only at sea surface
Ship board measurement **Holistic Assessment**	•Obtain data under sea surface •Can obtain accurate measured value •Can obtain many parameters •Long time series	•Data represent only point of information •Analysis of Chl-a need expertise •Costly

2. Ideas behind Concept of methodology

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

Preliminary Assessment

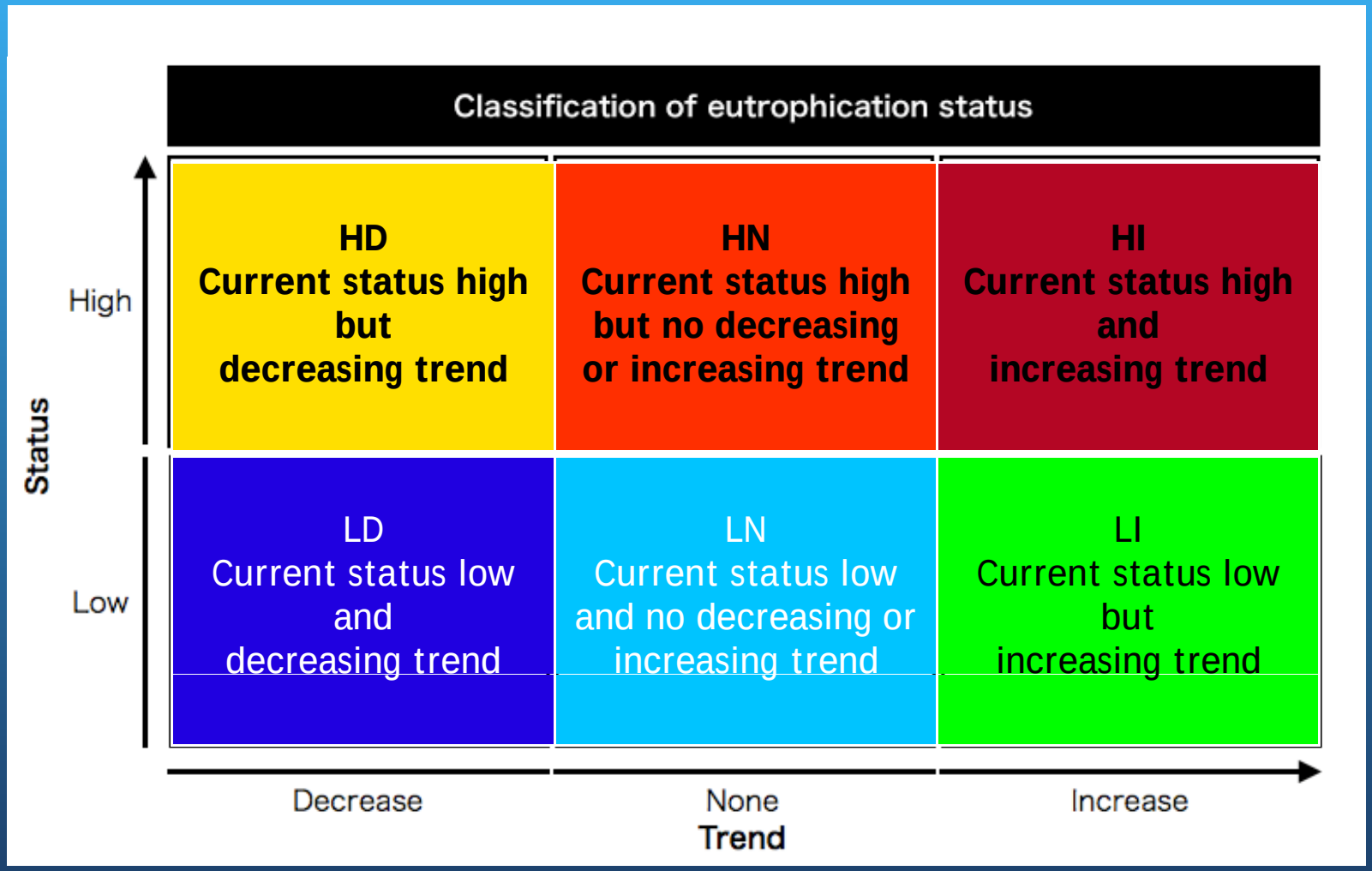
Detection of potential eutrophic areas by satellite Chl-a

Holistic Assessment

Detailed assessment in the detected potential eutrophic areas with the Common Procedures

2. Ideas behind
Simplifying environmental signals

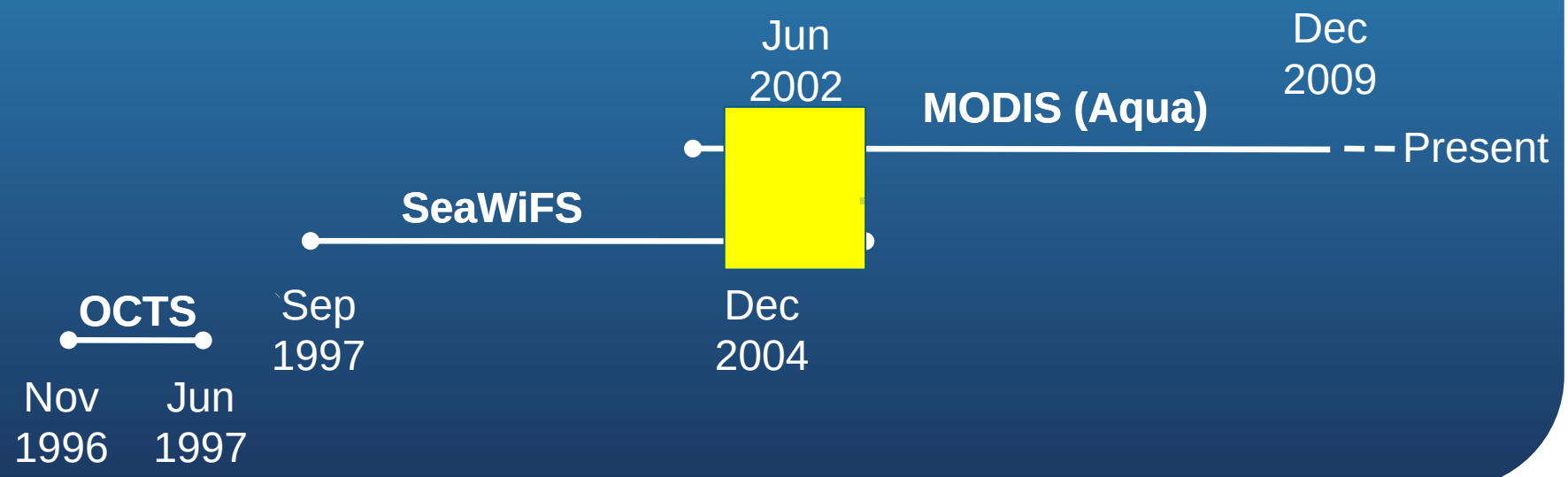
2. Ideas-behind Classification of Eutrophication



Classification base on the Common Procedures (NOWPAP CEARAC, 2009)

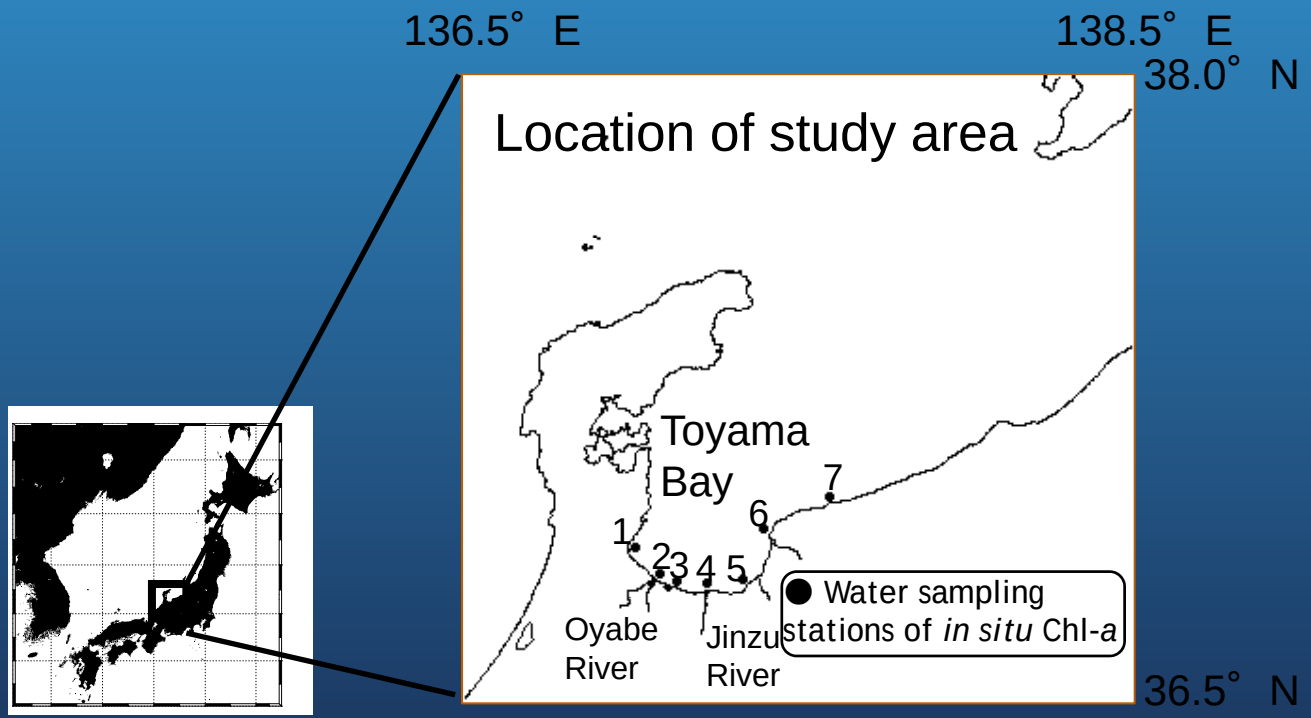
3. Data used : satellite data

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^{o}E)

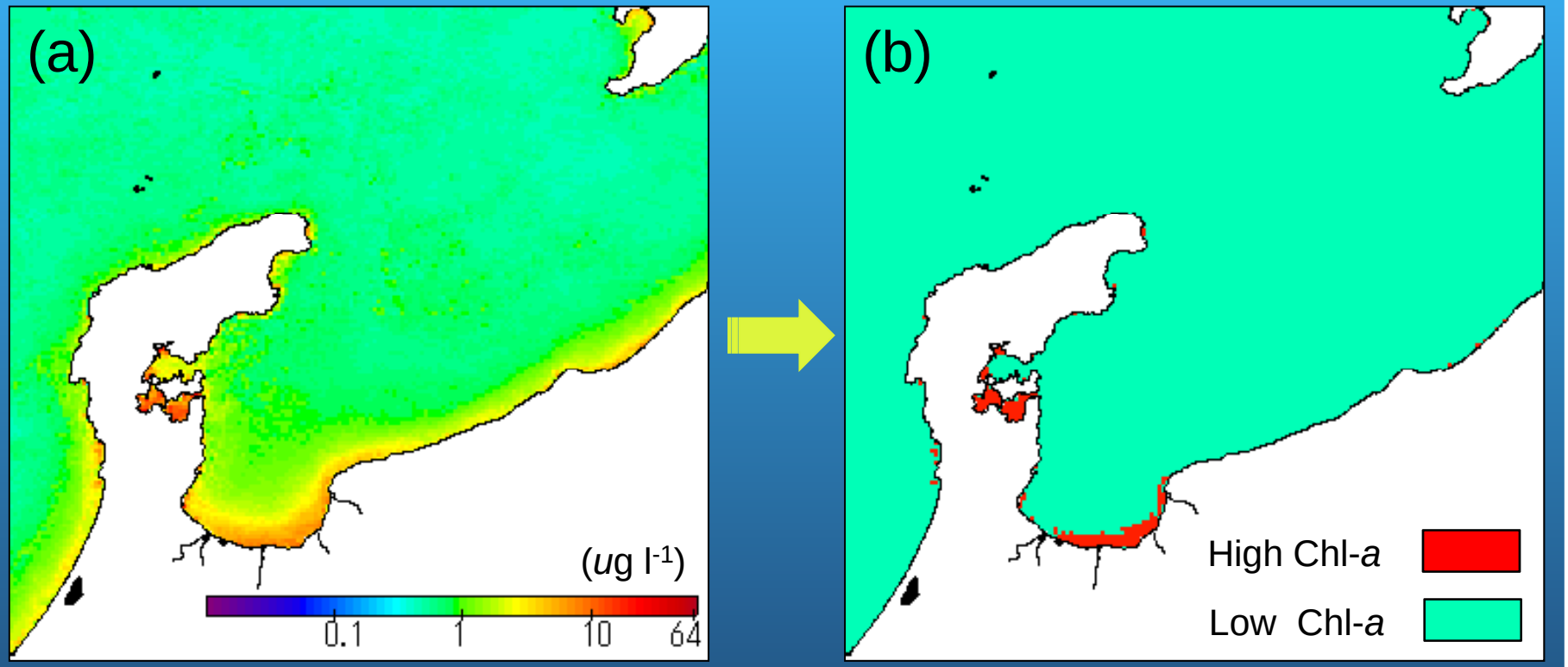


3. Data used : *in situ* data

River discharge	Daily river discharge in the Oyabe and Jinzu Rivers
Total Nitrogen and Phosphate	TN and TP in the Oyabe and Jinzu Rivers (monthly observed from 1986 to 2005 and quarterly from 2006 to 2008)
In situ Chl-a	Ship observed data at 2km offshore from Apri1997 to Dec 2009



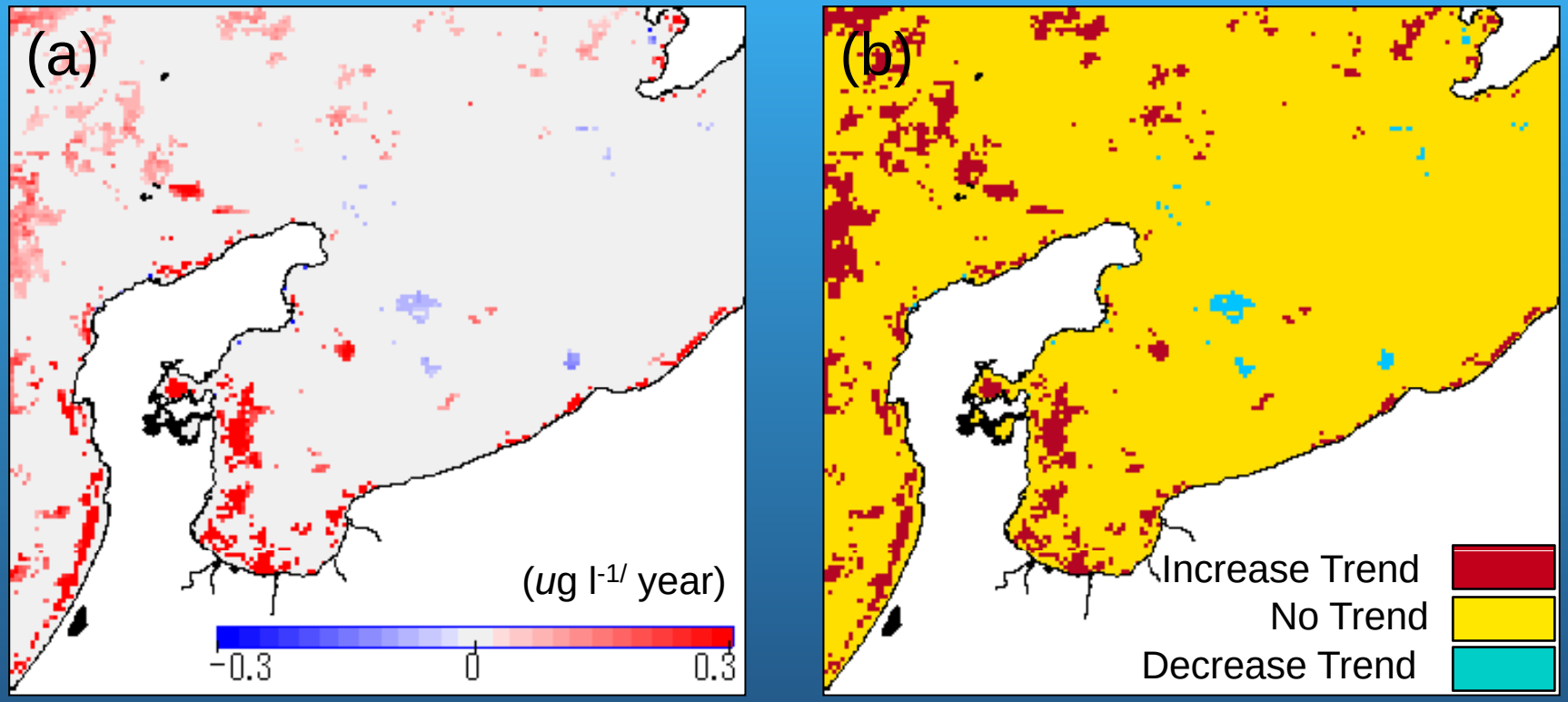
3. Methods - High and Low Chl-*a* area



Detection of High and Low Chl-*a* area in Toyama Bay. (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 *ug* l^{-1} referring to the Medium Chl-*a* condition (>5, <20 *ug* l^{-1}) of Bricker *et al*. (2003).

3. Methods

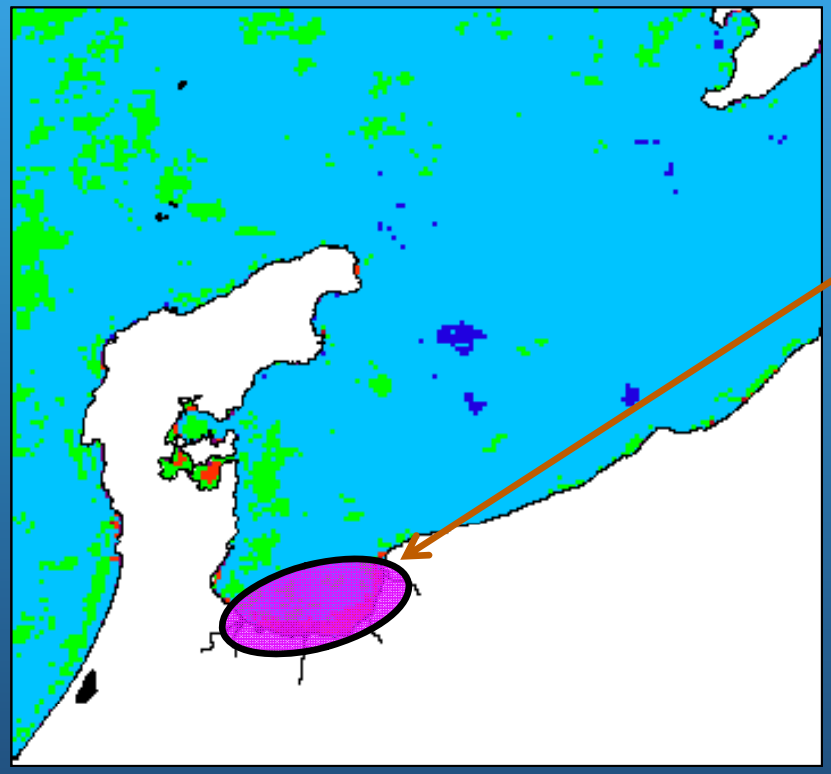
Detecting interannual Chl-*a* trend



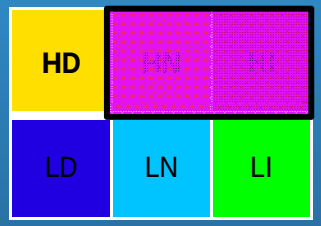
13-years of satellite Chl-*a* trend.

(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.

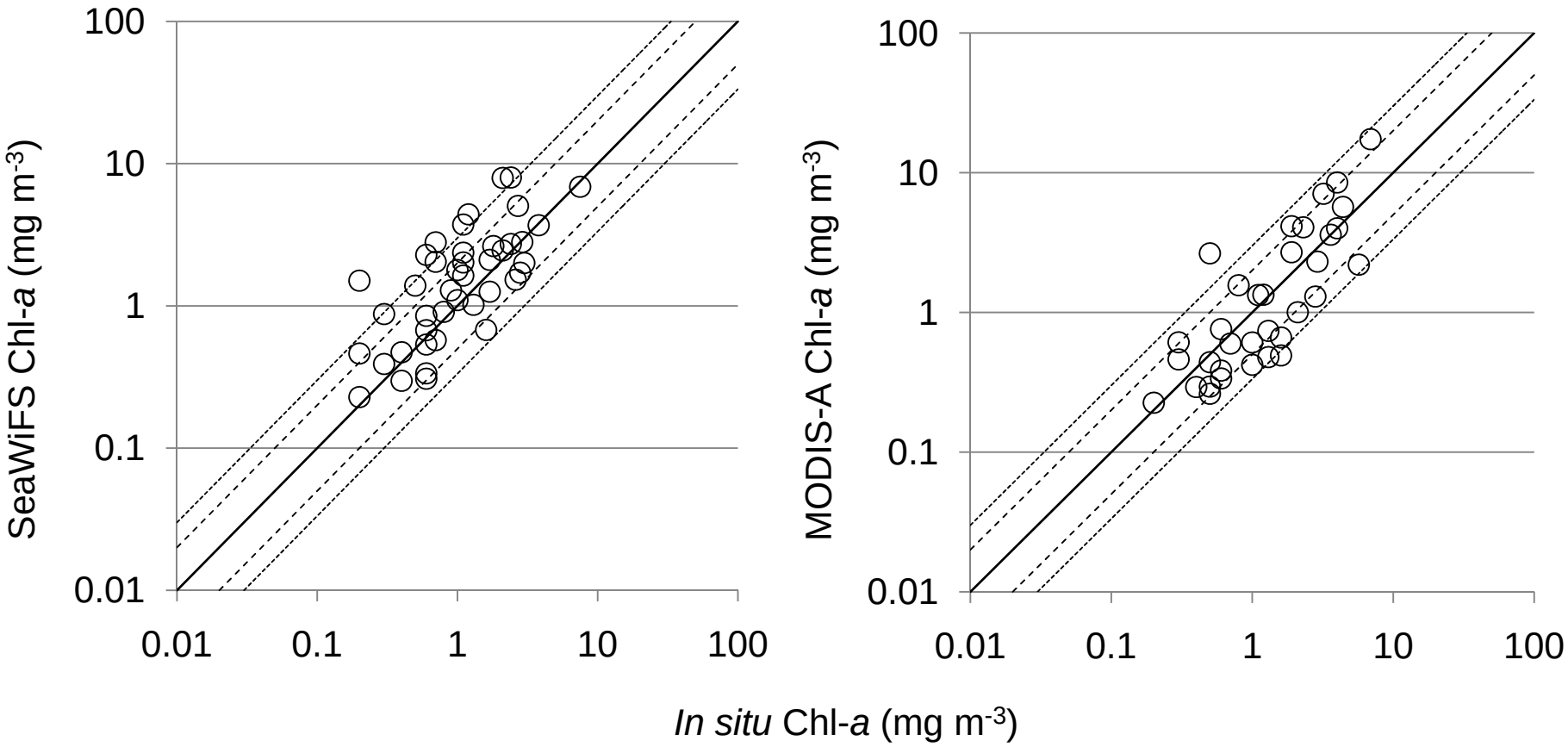
4. Results- Preliminary assessment of eutrophication in Toyama Bay



Potential eutrophic area?

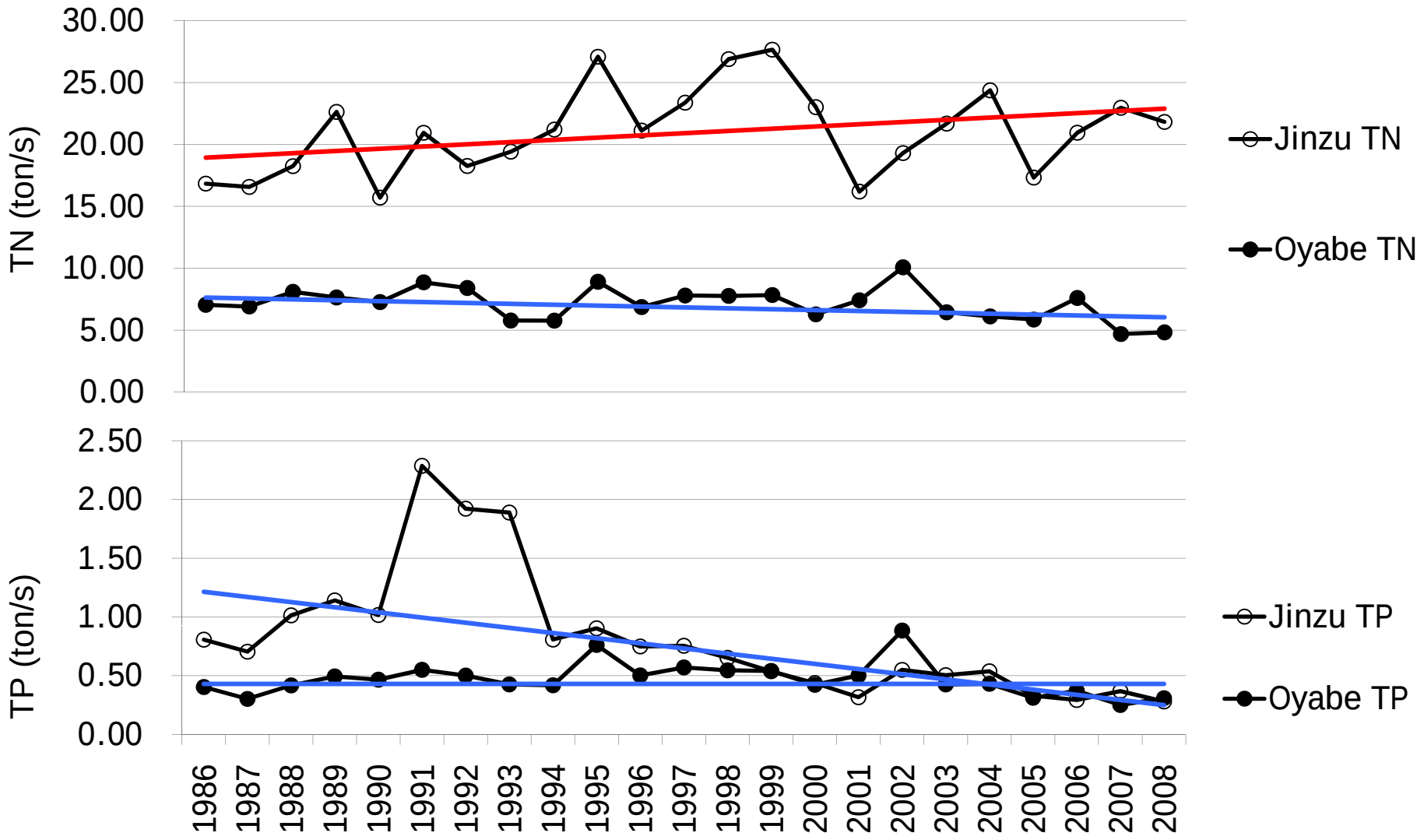


4. Results -Validation of satellite Chl-*a* with in situ Chl-*a*



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



5. Application of the preliminary assessment in Northwest Pacific region

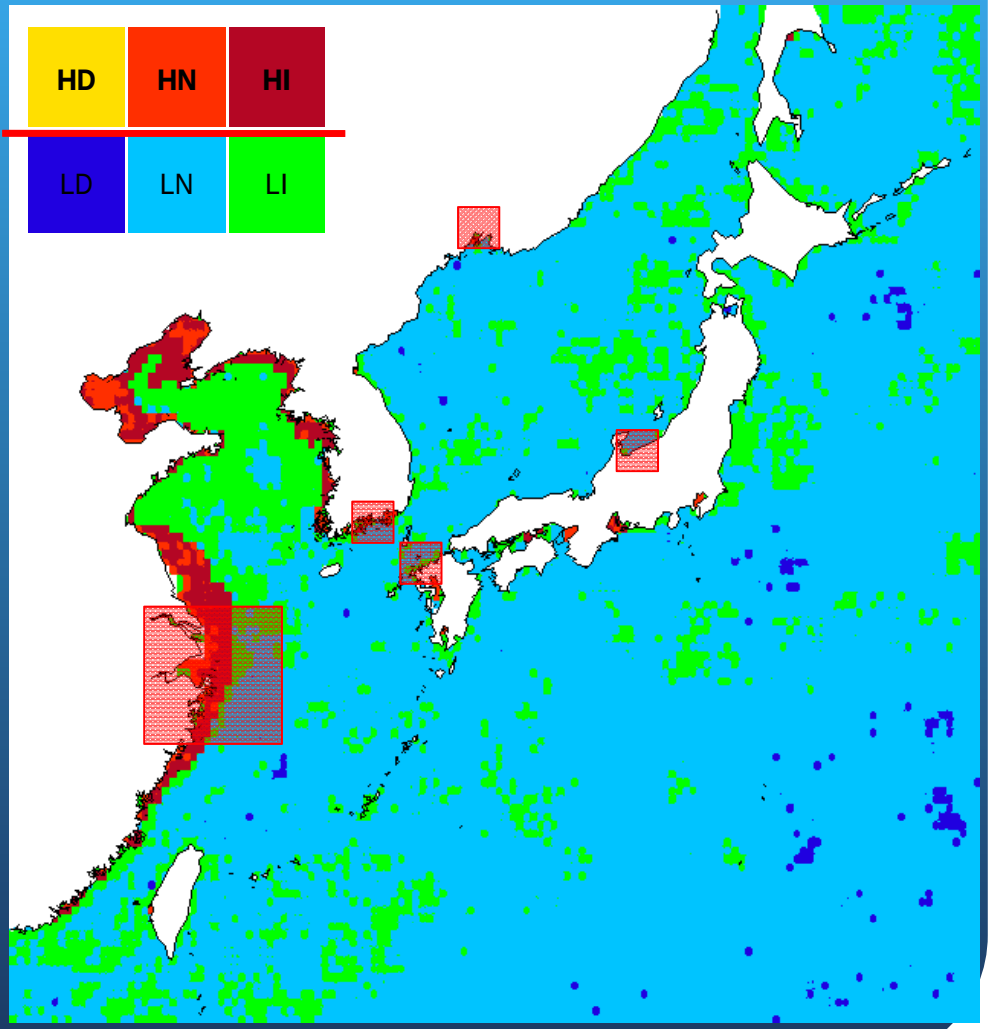
Tunings required

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

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

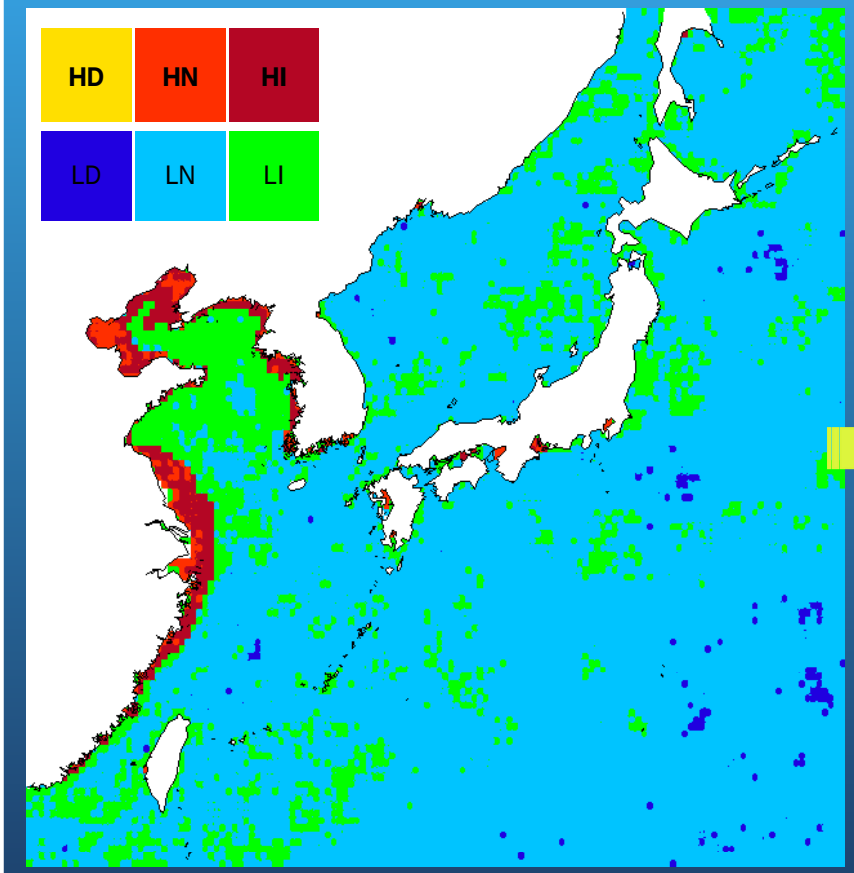
#2. Reliability of satellite Chl-a

Is the standard satellite data accurate enough?

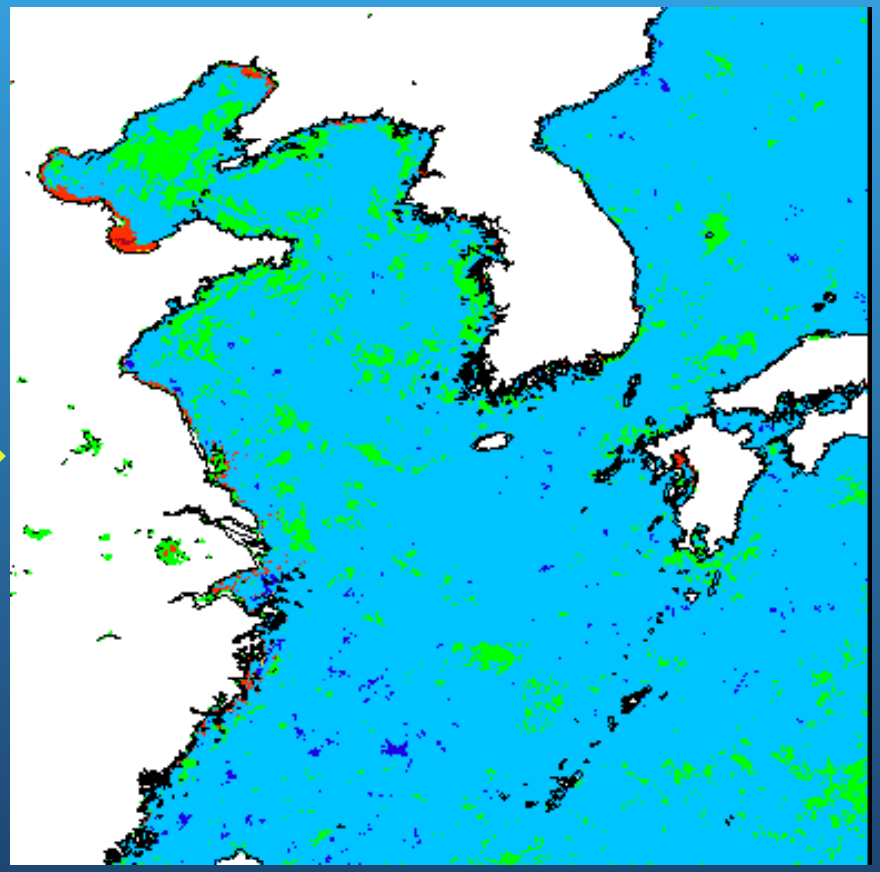


5. Application of the preliminary assessment in Northwest Pacific region

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-*a* condition
    - Algorithms for case II water
      - Collaboration with YSLME
    - Consistency between sensors


Thank you very
much!