Meeting minutes of CEARAC Expert Meeting
on Eutrophication Assessment in the NOWPAP Region
October 18, 2017 in Qingdao, China

1. Background and Objectives

As part of CEARAC activities for the 2014-2015 biennium: trial application of the screening procedure of the NOWPAP Common Procedure for eutrophication assessment was carried out for the assessment of eutrophication status in the NOWPAP region. As an outcome, a web-based map on potential eutrophic zone in the NOWPAP region was constructed in the website of the Marine Environmental Watch Project (http://ocean.nowpap3.go.jp/WebGIS/). The 14th CEARAC Focal Points Meeting recommended to continue of the activity of eutrophication assessment for a long-time scale (UNEP/NOWPAP/CEARAC/FPM 14/9).

Following this recommendation, CEARAC requested national experts to review the progress of CEARAC activity on eutrophication assessment as shown in Annex 1 and discuss future actions to be taken for updating information of the developed map of eutrophication assessment.

2. Date: October 18, 2017

3. Venue: HILTON QINGDAO GOLDEN BEACH

1 JIA LING JIANG EAST ROAD, ETDZ, QINGDAO, 266555, CHINA

4. List of participants: see Annex 2

5. Opening of the meeting

Dr. Genki Terauchi, CEARAC Secretariat, opened the meeting at 9:30. Dr. Fuchao Li and Dr. Yanwei Li from Institute of Oceanology, Chinese Academy of Sciences, gave their welcome addresses as local supporter of this meeting.

6. A brief introduction of the meeting and expert

Dr. Terauchi briefly introduced the background and objective of the meeting then introduced participant of the meeting.

7. Status report from national experts

7.1 Status report from China

Dr. Zhiming YU, Professor at Institute of Oceanology, Chinese Academy of Sciences, reported results of identification of eutrophic zones in the NOWPAP sea areas of China based on the screening procedure. He suggested use of nutrients data in the screening procedure, harmonizing reference values for DO and continuation of CEARAC activity on assessment of eutrophication. He also pointed out difference in water quality assessment result near Haizhou bay between CEARAC project and Chinse nutrient index method.

7.2 Status report from Japan

Dr. TERAUCHI reported results of identification of eutrophic zones in the NOWPAP sea areas of Japan based on the screening procedure. He showed the assessment result in Yamaguchi Prefecture and suggested revision of assessment criteria to identify potential eutrophic zones in case no satellite Chl-*a* data is available in coastal zone. He apologized that current WebGIS cannot be accessed from China and promised to modify the WebGIS to make it accessible from China by March 2018.

7.3 Status report from Korea

Dr. Juyun LEE, a senior researcher at Korean Marine Environment Management Corporation, reported results of identification of eutrophic zones in the NOWPAP sea areas of Korea. She suggested revision of assessment criteria becuase all Korean coast were identified as non-eutrophic zone although red tide and hypoxia keep occurring in Jinhae Bay and Yeosu area.

7.4 Status report from Russia

Dr. Vladimir SHULKIN Lee, Head of laboratory, Pacific Geographical Institute, Far Easter Branch of Russian Academy of Sciences, reported results of identification of eutrophic zones in the NOWPAP sea areas of Russia. He suggested use of nutrients data such as total nitrogen(TN) and total phosphate(TP) as there is no routine monitoring program of COD in Russian coastal zones.

8. Invited lectures

8.1 Eutrophication and HAB in the NOWPAP region

Dr. Yasuwo FUKUYO, a professor emeritus at the University of Tokyo currently belong to Tokai University, gave a talk on Eutrophication and HAB in the NOWPAP region. He then suggested several points to improve the web-based map on potential eutrophic zone in the NOWPAP region;

- Considering observation/occurrence ratio of red tide and hypoxia events,
- Unfirming threshold to define hypoxia and reconsidering symbol of hypoxia to avoid any misleading
- Adding explanation of observation method and frequency in each event,
- Adding explanation of the methodology and criteria for assessment.

8.2 Routine eutrophication monitoring by State Ocean Administration in China

Dr. Luo, an assistant researcher at National Marine & Environmental Monitoring Center, State Oceanic Administration of China, gave a talk on Eutrophication routine monitoring in China. He presented how Chinese government carry out eutrophication assessment by eutrophication index method using COD, inorganic nitrogen and active phosphate concentration data and explained advantage and disadvantages of this method. He then introduced a new approach of eutrophication assessment model using ecological response such as primary productivity and HAB, DO proposed by Dr. Zhiming YU and Dr. Zaixing WU of Institute of Oceanology, Chinese Academy of Sciences.

9. General discussion

Meeting participants discussed future actions to be taken for updating information of the developed map of eutrophication assessment, then acknowledge and agreed;

- Continuation of eutrophication assessment is necessary in the NOWPAP region,
- Organizing an expert meeting on a regular basis (every year) depending on funding,
- Clarifying DO level to determine hypoxia on the webGIS and adding explanation of observation method and frequency of monitoring,
- Updating satellite Chl-*a* information on annual basis by CEARAC,
- Submitting next CEARAC Focal Points a workplan to continuously organize expert meeting on eutrophication assessment.

Annex 1

Construction of a web-based map on potential eutrophic zone in the NOWPAP region: progress and future updating plan

As part of one activity for the 2014-2015 biennium: trial application of the screening procedure of the NOWPAP Common Procedure for eutrophication assessment, CEARAC has been constructing a web-based map on potential eutrophic zones in the NOWPAP region, based on the data and information of chemical oxygen trend (COD) trend, red tides and hypoxia events, and satellite chlorophyll-a (Chl-*a*) data of each NOWPAP member state. The map is built on the webGIS in the website of Marine Environmental Watch System of CEARAC (http://ocean.nowpap3.go.jp/WebGIS/).

This document explains the progress of CEARAC activity on eutrophication assessment and suggestions for future update. CEARAC hopes to update the map on a regular basis in the future and expecting cooperation with national experts in the region.

1. Collection and analysis of in-situ observation data

Nominated experts by CEARAC Focal Points (FPs) and NPEC were responsible for collecting and analyzing in-situ observation data. The list of the nominated experts are shown in Table 1.

In case of COD in Japan, past annual mean values in the areas of the Northwest Pacific region was collected and analyzed from national databases of the Ministry of the Environment, Japan. Data on hypoxia events in the northwest pacific region was collected in the Japan's enclosed coastal sea areas which is defined by the Ministry of the Environment, Japan. Data on red tides events were found in the report of working group of red tide and toxic shellfish in the special committee on preserving the fishing ground environment and red tides in Kyushu sea area, and relevant data in the northwest Pacific region was collected.

The experts of China, Korea and Russia collected and analyzed relevant available information and data as much as possible from available data sources in respective countries.

Then, geographical information was added to each data, even by tracking down the location by address, so as to be registered with the WebGIS.

Table 1. List of nominated experts of the NOWPAP member states

country	organization	expert
China	Institute of Oceanology, Chinese Academy of Science	Dr. Zhiming YU Dr. Xupeng HU
Japan	NPEC	
Korea	National Fisheries Research & Development Institute	Dr. Changkyu Lee
Russia	Pacific Geographical Institute Far Eastern Branch of the Russian Academy of Sciences	Dr. Vladimir Shulkin

Table 2 shows the number of COD observation stations and the number of red tides and hypoxia events in the decided duration of time.

There are big differences between the number of data in Japan and that in other three countries: Japan has 333 COD water-sampling stations while Russia has only two. It is same in red tide events. The number of Japan stands out, and Korea and China follow with much less numbers. This happens because while the occurrence of hypoxia in Japan is calculated based on the observation data in the sea area for public use, that in China, Korea and Russia is counted from the data in literatures and/or reports.

Table 2. Number of observation points, occurrences of red tides and hypoxia and the period of information/data.

country	Type of info./data	period	Number of water-sampling station (COD) and occurrences (red tide and hypoxia)
China	COD	2005-2012	7
	Red tide	2009-2014	41
	Hypoxia	2003-2009	4
Japan	COD	1978-2013	333
	Red tide	2009-2013	453
	Hypoxia	1978-2012	1345
Korea	COD	1998-2013	10
	Red tide	2009-2014	99
	Hypoxia	1983-2014	33
Russia	COD	2010-2014	2
	Red tide	2004-2015	16

	Hypoxia	2005-2012	7

2. Development of a satellite chlorophyll-*a* map

Northwest Pacific Region Environmental Cooperation Center (NPEC), host organization of NOWPAP CEARAC, applied the screening procedure of the refined NOWPAP Common Procedure to the entire NOWPAP region and preliminary assessed the eutrophication status by long-term satellite derived Chl-a data set. First, the data of SeaWiFs (1998-2004) and MODIS on board Aqua (MODIS-A) Level 2 (2002-2015) were obtained from the NASA Ocean Color Website.

For the eastern part of the NOWPAP region (Sea of Japan) where the turbidity is rather low, daily composite of satellite Chl-*a* data of each sensor was first computed by the NASA standard algorithm. Next, SeaWiFS and MODIS-A data for July 2002 and December 2004, when data for both sensors exists, were averaged respecting the consistency of these 2 sensors validated by NASA. Monthly mean satellite Chl-*a* from 1998 to 2015 was then prepared from the daily composite data for eutrophication assessment.

However, in the western part with turbid water (Yellow Sea), a different algorithm, Yellow Sea Ocean Color (YOC), developed by Siswanto *et al. (*2011) that performs better in turbid waters was applied. For the overlapped period of the two sensors, remote sensing reflectance in the same pixel and the date were compared to estimate Chl-*a* of each sensor. Then, same as the eastern part of the region, monthly mean satellite Chl-*a* was prepared from the daily composite data. To estimate Chl-*a* in the coastal areas, images have 1km resolution in both algorithms.

High or low Chl-*a* areas, divided by 5*u*g/l as reference value (Bricker et al., 2003) were detected from three-year-mean satellite Chl-a from 2013 to 2015. The trends of the annual maximum Chl-*a* (increasing, decreasing or no trend) from 1998 to 2015 were estimated at pixel wise. Through the combination of Chl-*a* level and its trend, the sea areas were classified into one of six eutrophication status as shown in Figure 1 (HI: High-Increase, HN: High-No Trend, HD: High-Decrease, LI: Low-Increase, LN: Low-No trend and LD: Low-Decrease). HI and HN areas were then regarded as areas with symptoms of eutrophication.

Satellite Chl-*a* was verified by comparison with in-situ Chl-*a* reported from the national experts (Figure 3, 4, 5 and 6), and the estimation of Chl-*a* values by using YOC algorithm in the southern and the southwestern coastal areas of Korea has been improved (Figure 7).

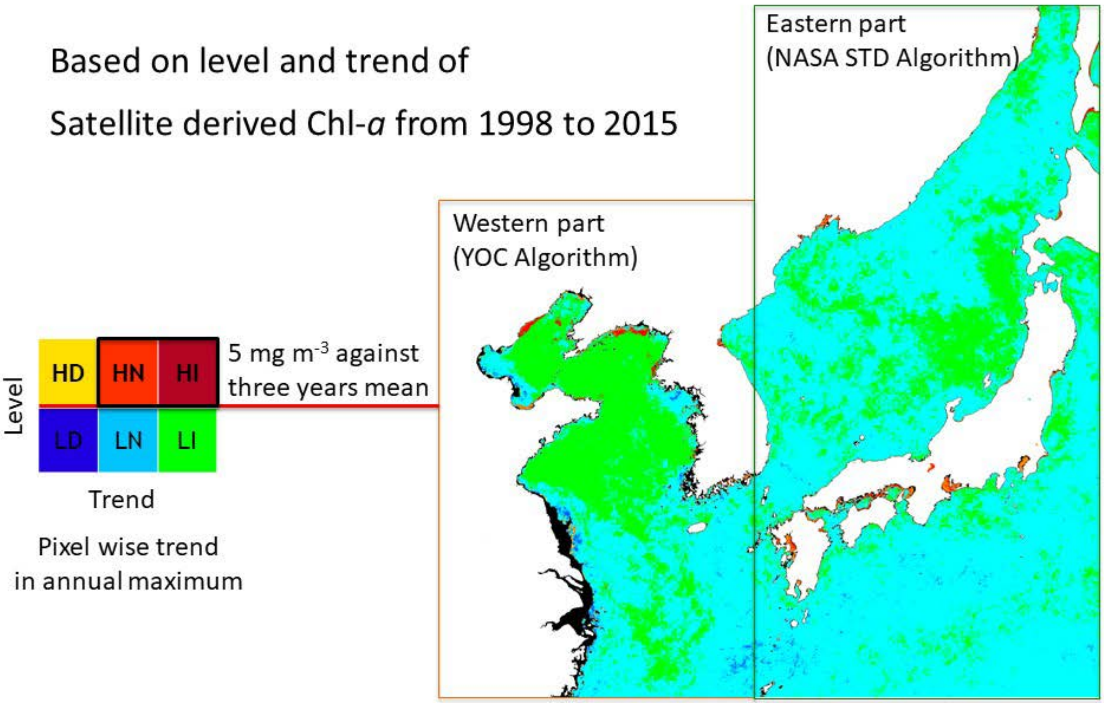

Figure 1. Results of preliminary assessment of the eutrophication status in the NOWPAP region based on satellite Chl-*a*

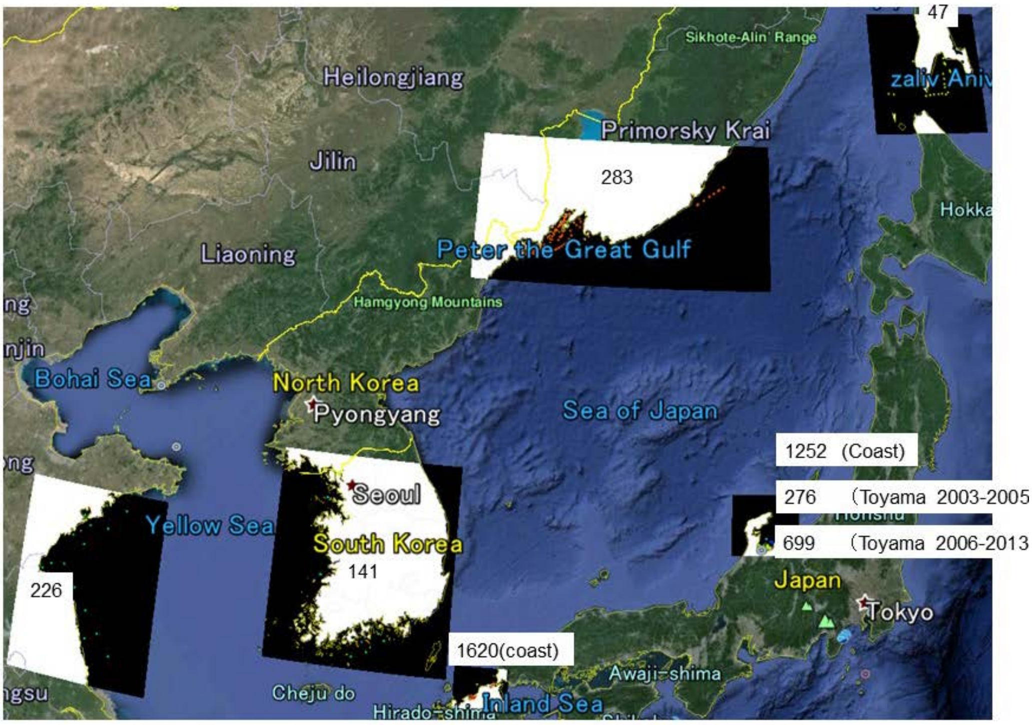

Figure 2. Number of in-situ Chl-a samplings and observation stations of the NOWPAP member states

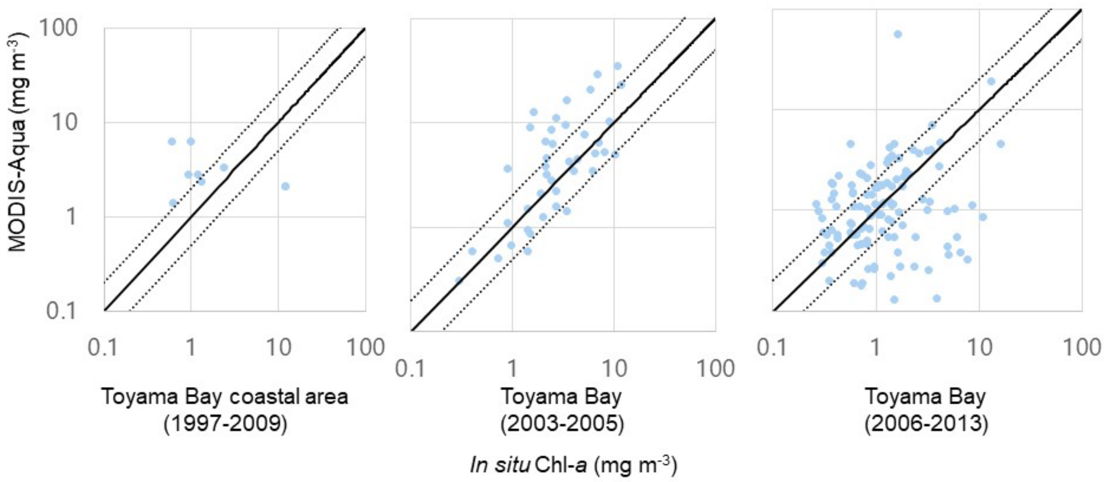

Figure 3. Comparison between in-situ Chl-*a* and satellite (MODIS-A) Chl-*a* in Toyama Bay

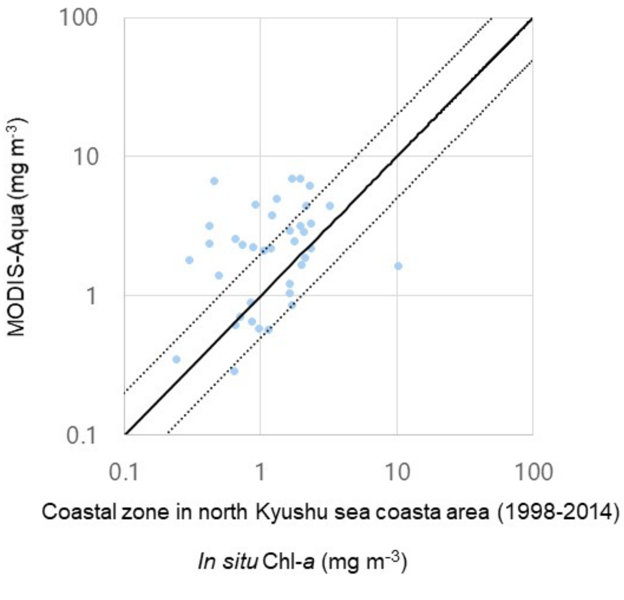

Figure 4. Comparison between in-situ Chl-*a* and satellite (MODIS-A) Chl-*a* in the north Kyushu sea area

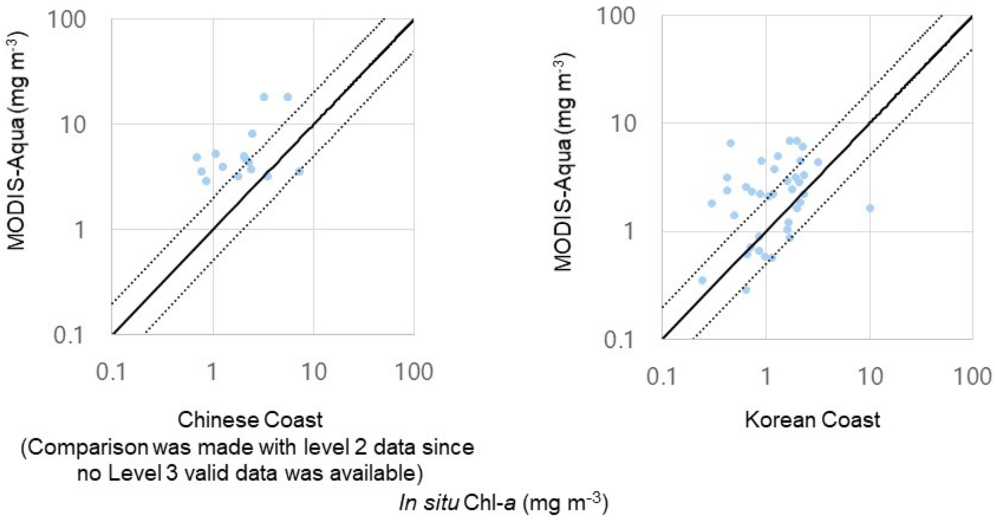

Figure 5. Comparison between in-situ Chl-*a* and satellite (MODIS-A) Chl-*a* in Chinese coast (left) and Korean coast (right)

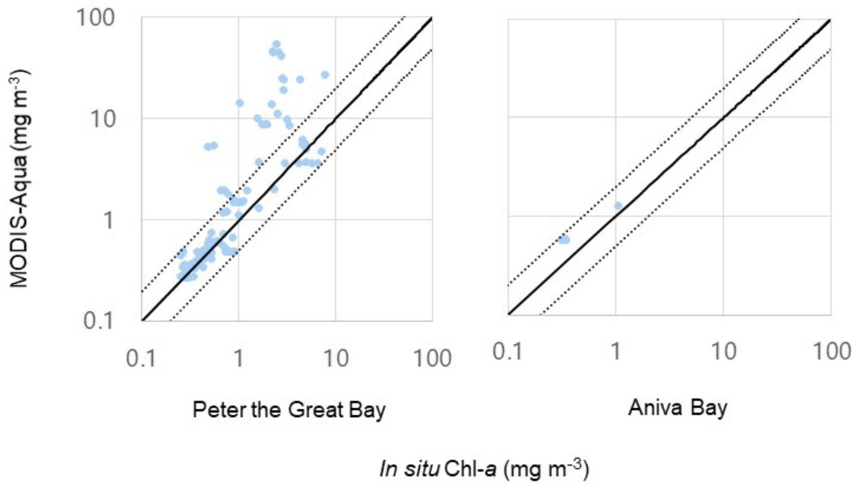

Figure 6. Comparison between in-situ Chl-*a* and satellite (MODIS-A) Chl-*a* in Peter the Great Bay (left) and in Aniva Bay (right).

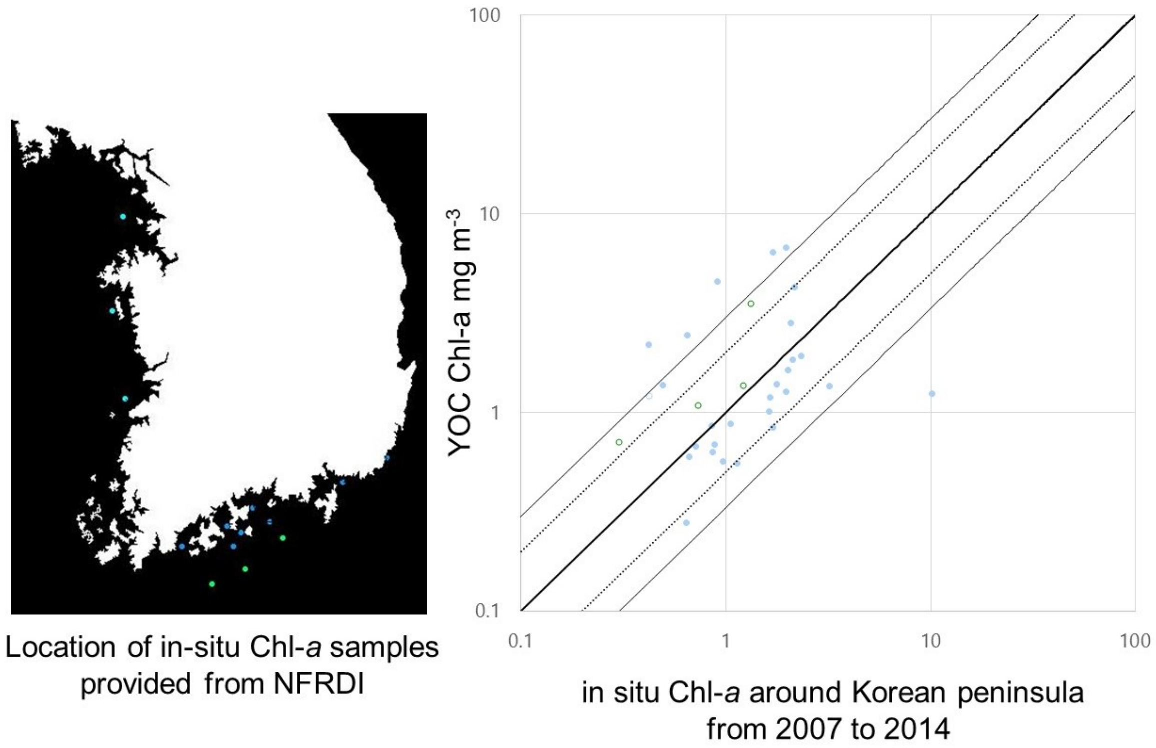

Figure 7. Comparison between in-situ Chl-*a* and YOC (MODIS-A) Chl-*a* in Korean coast (right). 50% (5 out of 10) of overestimated Chl-a by the NASA standard algorithm fitted within the range of 1:3/3:1 ratio.

3. Construction of a web-based map on potential eutrophic zone in the NOWPAP region

To assess the eutrophication status of the NOWPAP region, CEARAC used the collected and analyzed in-situ data and satellite Chl-*a* map by NPEC, following the judgement (Table 3) which was agreed at the 13th CEARAC FPM in April 2016. The assessment results are shown on the map of the NOWPAP region on the main tab of WebGIS, as well as detailed data of COD, red tide and hypoxia, and the satellite Chl-*a* map on the subtabs.

Table 3. Four categories of the assessment results of the eutrophication status

	Eutrophic area All parameters among COD, frequencies of red tides and hypoxia events and satellite chlorophyll-*a* indicate symptoms of eutrophication.
	Potential eutrophic area More than two parameters among COD, frequencies of red tides and hypoxia events and satellite chlorophyll-*a* indicate symptoms of eutrophication.

	Non eutrophic area Only one parameter among COD, frequencies of red tides and hypoxia events or satellite chlorophyll-*a* indicates symptoms of eutrophication. Or, neither of these parameters indicates symptoms of eutrophication.
	Improved area COD or frequencies of red tide and hypoxia events indicate the eutrophic status has improved.

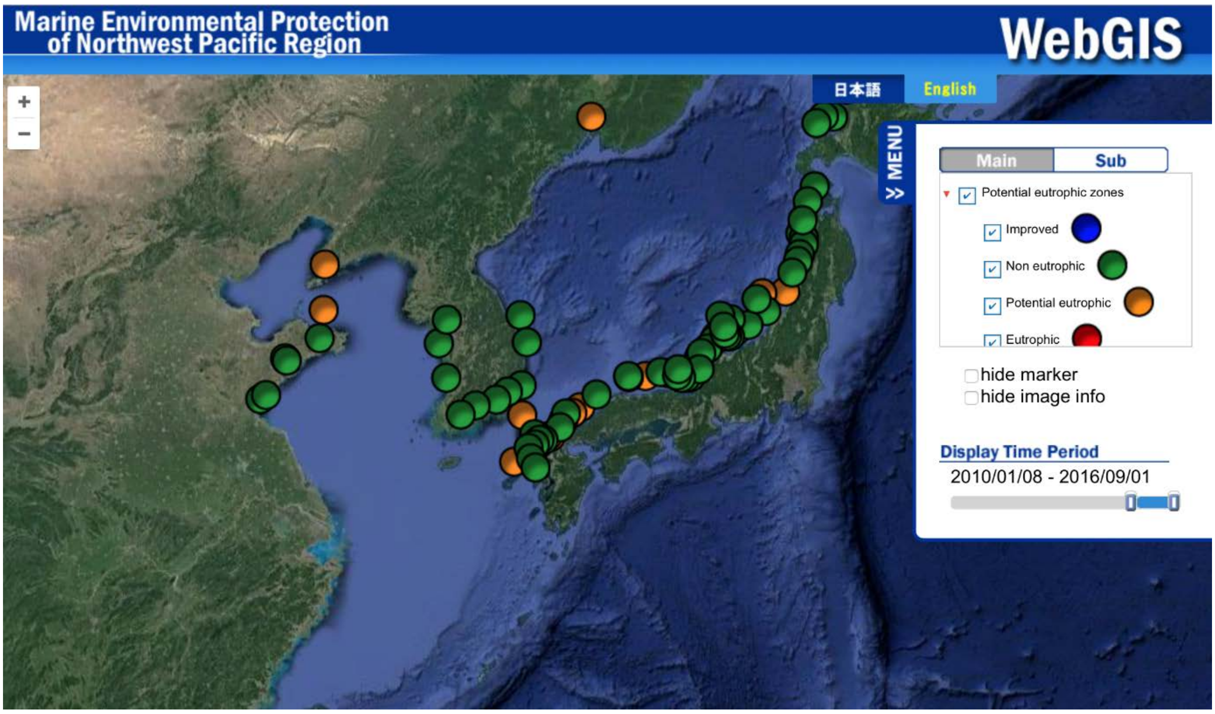

Figure 8. Assessment results of the eutrophication status (Main tab)

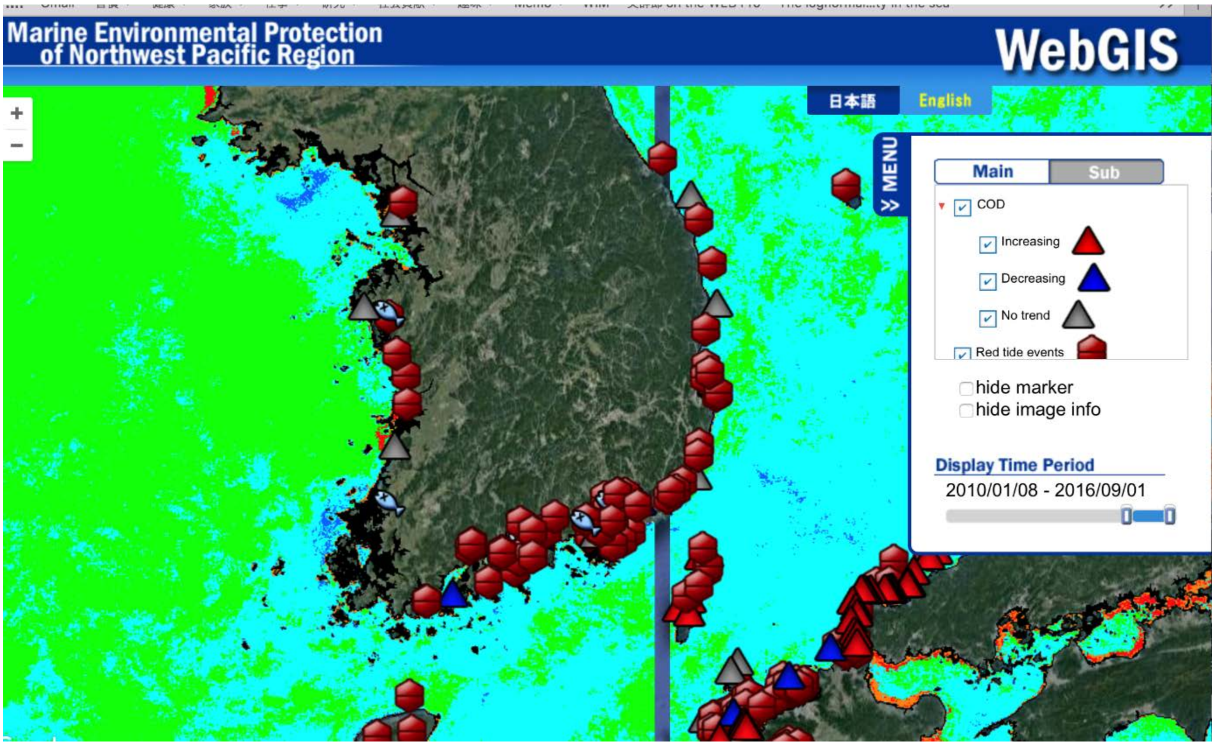

Figure 9. Detailed data used for eutrophication assessment (Sub tab)

4. Problems of the developed map and suggestions for improvement

Based on the criteria in Table 3, the eutrophication status of the NOWPAP region was assessed by applying the screening procedure of the refined NOWPAP Common Procedure. However, the result map on the WebGIS does not include some areas with the red circle, where all the symptoms of eutrophication are shown (Table 3). Especially in the closed sea areas where hypoxia often occur, for example the coastal area of Nagato City, Yamaguchi Prefecture (Figure 10), the assessment result is potentially eutrophic. This happens because the area does not have satellite Chl-*a* data while COD is increasing yearly and there were four red tide events in 2010-2012. It means that the data shows only two symptoms of eutrophication so that the area is judged as potential eutrophic (orange), not eutrophic (red). Similar judgement occur in other areas, therefore, the criteria in Table 3 need to be re-considered.

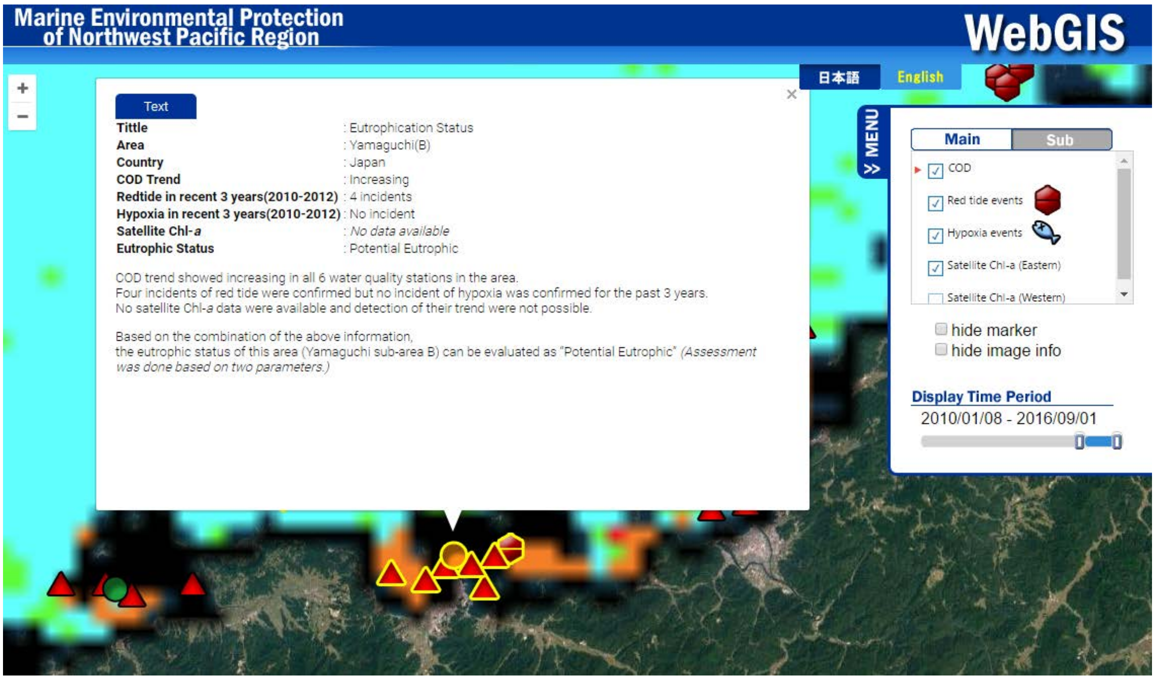

Figure 10. Result of the preliminary assessment of the eutrophication status in the coastal area of Nagato City, Yamaguchi Prefecture

Table 4 is a draft of revised criteria of the current preliminary assessment of the eutrophication status. When there is no satellite Chl-*a* data, the judgement is done only with COD and red tide and hypoxia events: when COD is increasing and red tide or hypoxia events occur, the area is judged as 'eutrophic', and when there is no increasing trend in COD but red tide or hypoxia events occur, the area is judged as 'potential eutrophic area.'

Table 4. Current judgement of the eutrophication status

COD	Red tide and Hypoxia		Satellite Chl-a	Current result	Refined result
1	1	1	1	Eutrophic	Eutrophic
1	1	0	1	Eutrophic	Eutrophic
1	0	1	1	Eutrophic	Eutrophic
1	0	0	1	Potentially Eutrophic	Potentially Eutrophic
1	1	1	0	Potentially Eutrophic	*Eutrophic*
1	1	0	0	Potentially Eutrophic	Potentially Eutrophic
1	0	1	0	Potentially Eutrophic	Potentially Eutrophic
1	0	0	0	Non Eutrophic	Non Eutrophic
1	1	1	n/a	*Potentially Eutrophic*	*Eutrophic*
1	1	0	n/a	*Potentially Eutrophic*	*Eutrophic*
1	0	1	n/a	*Potentially Eutrophic*	*Eutrophic*
1	0	0	n/a	*Non Eutrophic*	*Non Eutrophic*
0	1	1	n/a	*Non Eutrophic*	*Non Eutrophic*
0	1	0	n/a	*Non Eutrophic*	*Non Eutrophic*
0	0	1	n/a	*Non Eutrophic*	*Non Eutrophic*
0	0	0	n/a	*Non Eutrophic*	*Non Eutrophic*
0	1	1	1	Potentially Eutrophic	Potentially eutrophic
0	1	0	1	Potentially Eutrophic	Potentially eutrophic
0	0	1	1	Potentially Eutrophic	Potentially eutrophic
0	0	0	1	Potentially Eutrophic	Potentially eutrophic
0	1	1	0	Non Eutrophic	Non Eutrophic
0	1	0	0	Non Eutrophic	Non Eutrophic
0	0	1	0	Non Eutrophic	Non Eutrophic
0	0	0	0	Non Eutrophic	Non Eutrophic

1. Increasing COD, more than 1 event of red tide or hypoxia, and HN or HI of satellite Chl-a

0. Decreasing COD or No trend, no red tide or hypoxia event, and HN or HI satellite Chl-a, or

n/a. No satellite Chl-a data

Another consideration is big gaps among the four member states in their sample numbers and spatiotemporal ranges of in-situ data. To make the gap smaller, it is necessary to consider reducing the sampling stations in Japan and increasing those in other member states as well. Or, if it is difficult to increase in-situ data, the preliminary assessment is conducted only with satellite Chl-*a* data, and later experts or each user will assess the eutrophication status with the results of the preliminary assessment and *in situ* observation data on the map.

5. Conclusion and next steps

CEARAC implemented the preliminary assessment of the eutrophication status for the entire NOWPAP region by applying the screening procedure of the refined NOWPAP Common Procedure. Through this activity, the overview of COD trend, frequency of red tide and hypoxia events, satellite Chl-*a* of each NOWPAP member state were collected and used for assessment of the eutrophication status of the NOWPAP region. Assessment result are uploaded on a WebGIS interactive map at http://ocean.nowpap3.go.jp/WebGIS/.

In the western part of the NOWPAP region where application of ocean color remote sensing is difficult due to turbidity, CEARAC used a different algorithm to suit to the condition to develop the long-term satellite Chl-*a* data. Then, that data was merged with the eastern part to make satellite Chl-*a* of the whole NOWPA region.

However, there are still some uncertainty in the eutrophication assessment result as mentioned in the early chapter. CEARAC hopes to cooperation with national experts of the member states to further updating the developed webGIS map of eutrophication assessment.

Annex 2

List of participants

Name	Position	Affiliation
Genki Terauchi	Senior Researcher	NOWPAP CEARAC
Yasuwo FUKUYO	Emeritus Professor	Tokai University
Mihoko Nagamori	Staff member	NOWPAP CEARAC
Juyun Lee	Senior Researcher	Korea Marine Enviornment Management Corporation (KOEM)
Vladimir SHULKIN	Chief Researcher	Pacific Geographical Institute, Russian Academy of Sciences
Zhiming Yu	Professor	Institute of Oceanology Chinese Academy of Sciences
Fuchao Li	Chief of scientific research office	Institute of Oceanology Chinese Academy of Sciences
Yanwei Li	Chief of abroad affair office	Institute of Oceanology Chinese Academy of Sciences
Yingzhong Tang	Professor	Institute of Oceanology Chinese Academy of Sciences
Caiwen Li	Professor	Institute of Oceanology Chinese Academy of Sciences
Humin Zong	Associate Professor	National Marine& Environmental Monitoring Center
Hao Luo	Assistant Researcher	National Marine & Environmental Monitoring Center

Xihua Cao	Professor	Institute of Oceanology Chinese Academy of Sciences
Yongquan Yuan	Associate Professor	Institute of Oceanology Chinese Academy of Sciences
Zaixing Wu	Assistant Researcher	Institute of Oceanology Chinese Academy of Sciences
Wentao Wang	Post Doctor	Institute of Oceanology Chinese Academy of Sciences
Man Ding	Staff	Institute of Oceanology Chinese Academy of Sciences
Yingze Xu	Staff	Institute of Oceanology Chinese Academy of Sciences