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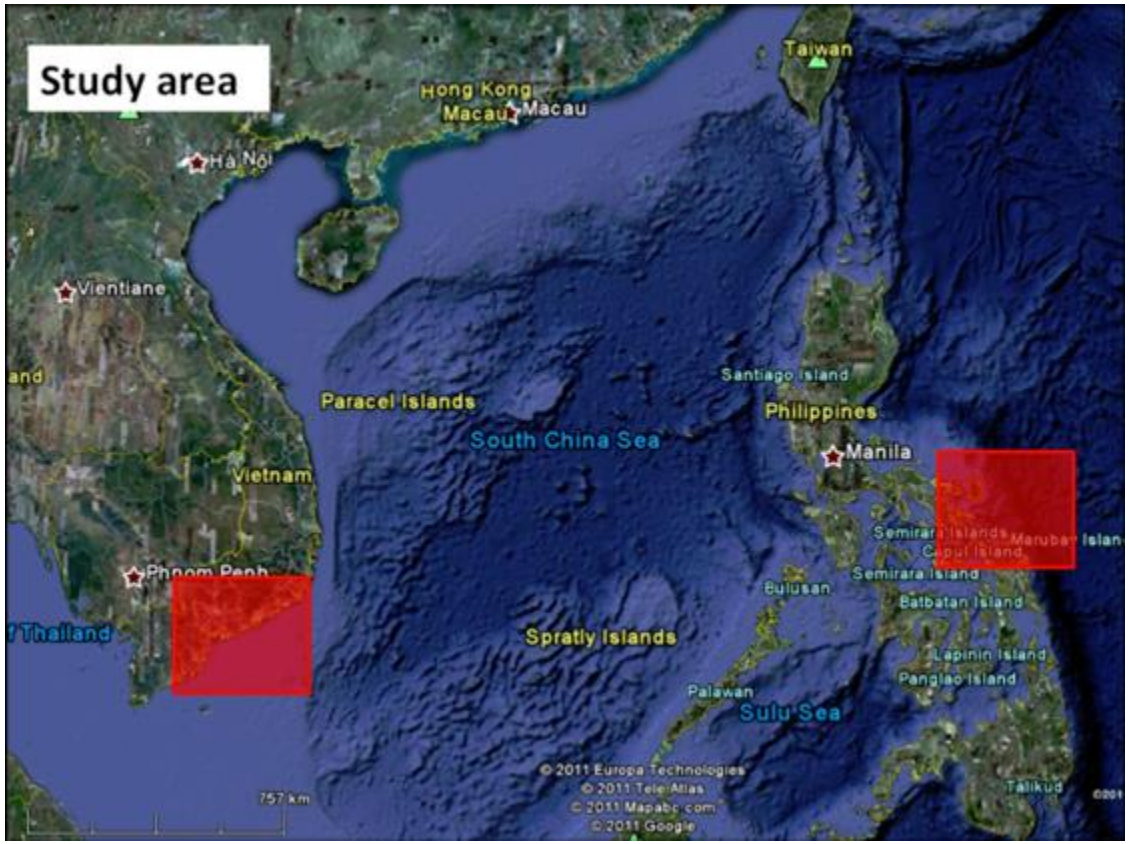
NF-POGO Alumni Network for Oceans

NANO SE Asia Regional Project
Eutrophication in the Coastal Waters of SE Asia: An Assessment

Dr. Vikki Cheung
Scientific Coordinator for POGO

NANO Coordination Meeting, 25 May 2015, Cairns, Australia

- **2012-13 : Harmful Algal Bloom Remote Sensing Model (RS-HAB) for the Southeast Asian Region**
  - Philippines: Marine Science Institute, UP
  - Vietnam: Hue University of Sciences/Institute of Oceanography
- Objectives: (a) Validate, refine and apply the RS-HAB model (b) Continuation of the Mekong Delta time-series.



Objectives:

(a) Validate, refine and apply the RS-HAB model (b) Continuation of the Mekong Delta time-series.

- **2014-15 : Eutrophication in the coastal waters of SE Asia: An assessment**
  - Joseph Palermo - Marine Science Institute, Philippines
  - Anukul Buranapratheprat - Burapha University, Thailand
  - Phan Minh Thu - Institute of Oceanography, Vietnam

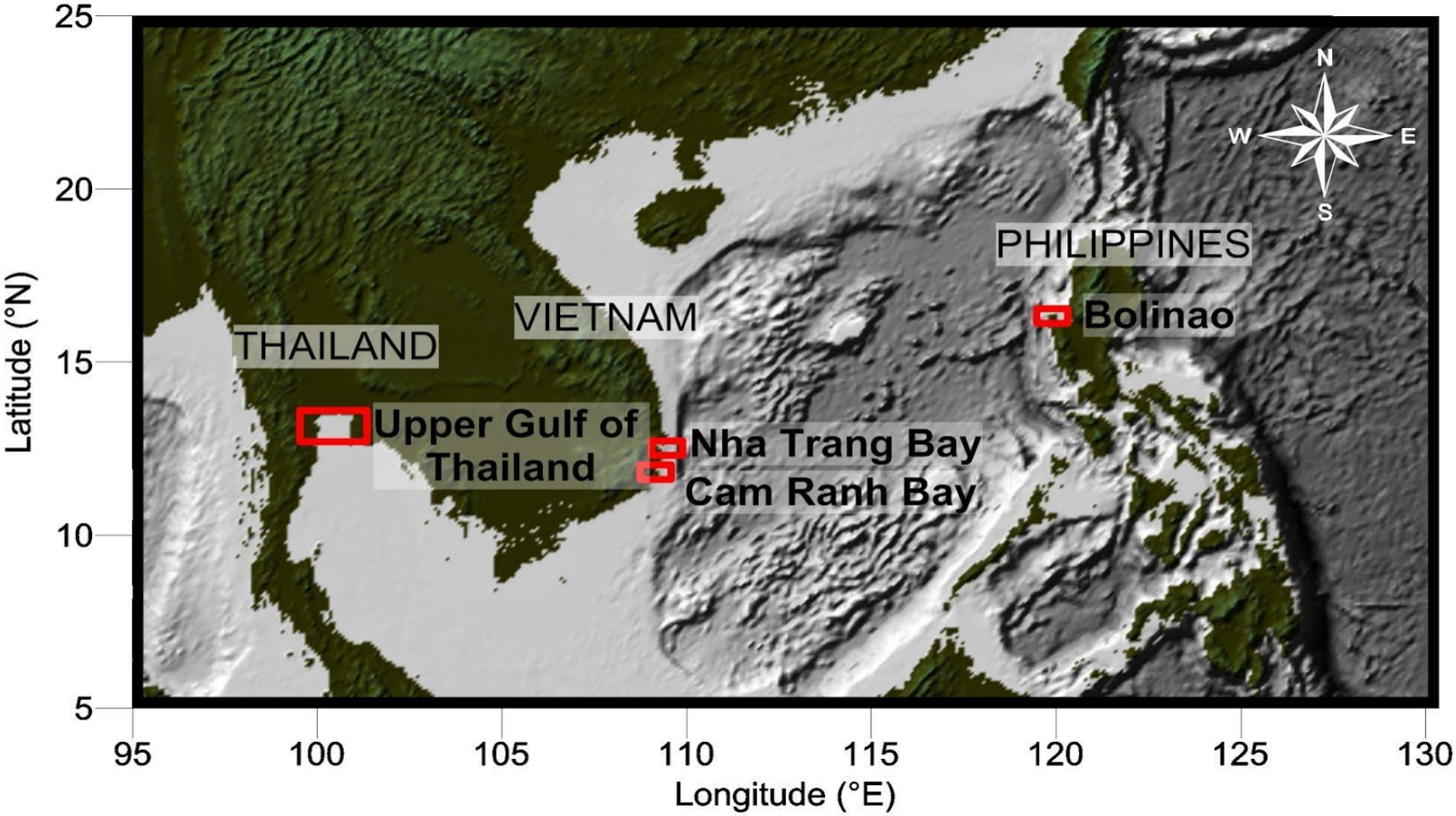
- Rationale:
  - Degrading water quality in the region as a result of unsustainable human activities and coastal development including aquaculture and agriculture, resulting in hypoxia, algal blooms and pollution in the coastal environments
  - Nutrient overload can lead to harmful algal blooms, fish kills, impacts upon tourism and ecosystems
  - ability to accumulate or exchange nutrients in a water body is influenced by the residence time. It exhibits seasonality and can also be modified by human activities e.g. the build-up of fish cages
  - To determine how impacted the systems are, the research will quantify residence time using the Land-Ocean Interactions in the Coastal Zone (LOICZ) methods and/or hydrodynamic models, assess eutrophication indices for dry and wet seasons in four monitoring sites: Bolinao, Nha Trang Bay, Cam Ranh Bay, and Upper Gulf of Thailand

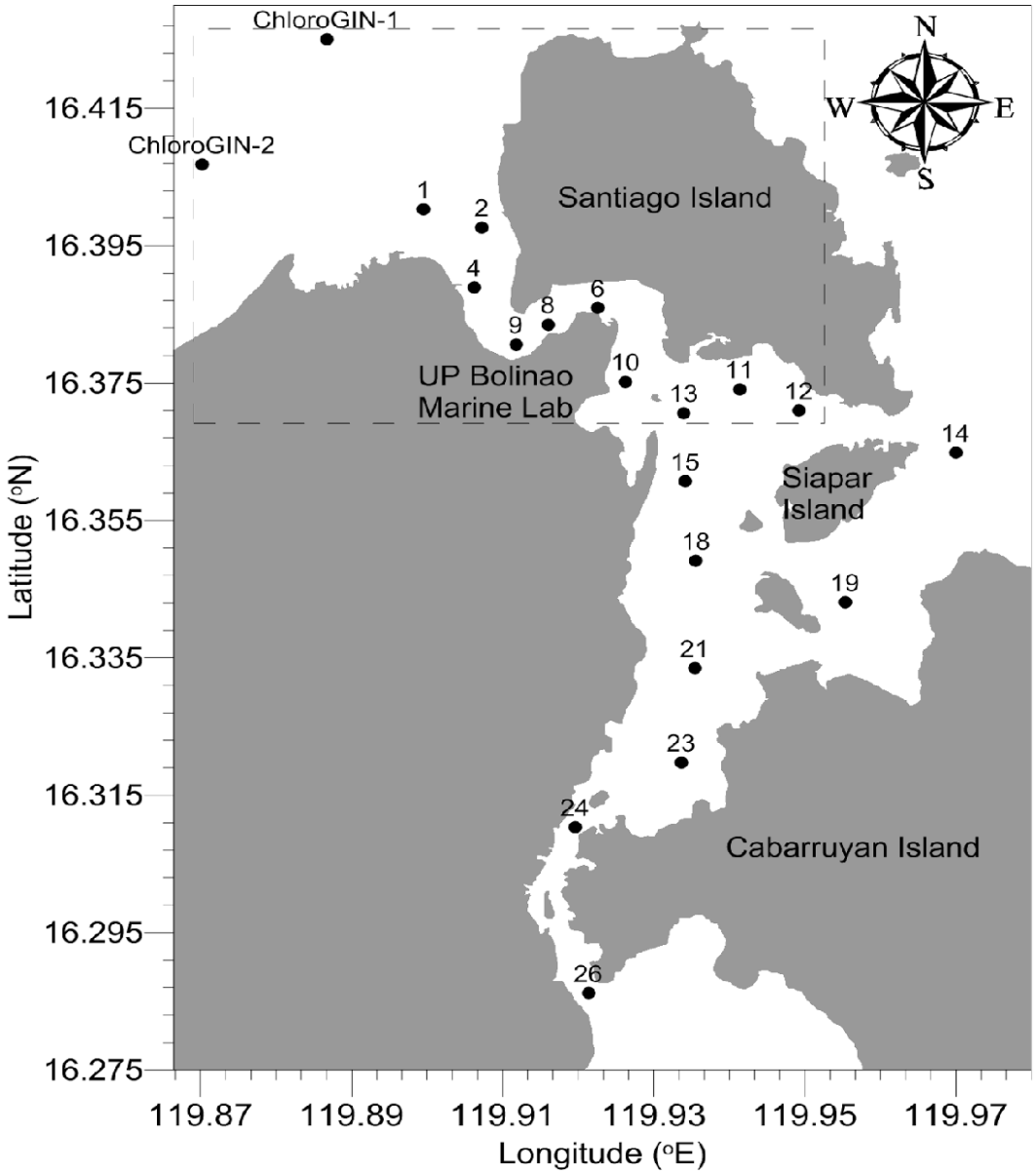
- Objectives:
  - Investigate eutrophication, possibly enhanced by nutrient load and modulated by residence time
  - Include fieldwork for in situ measurements, lab analysis and application of the LOICZ approach and/or hydrodynamic models and the TRIX eutrophication index.

Field Sampling Schedule

Season	Philippines	Thailand	Vietnam
Wet season	December 2013	August 2014	January 2014
Dry season	February 2014	February 2014	May 2014

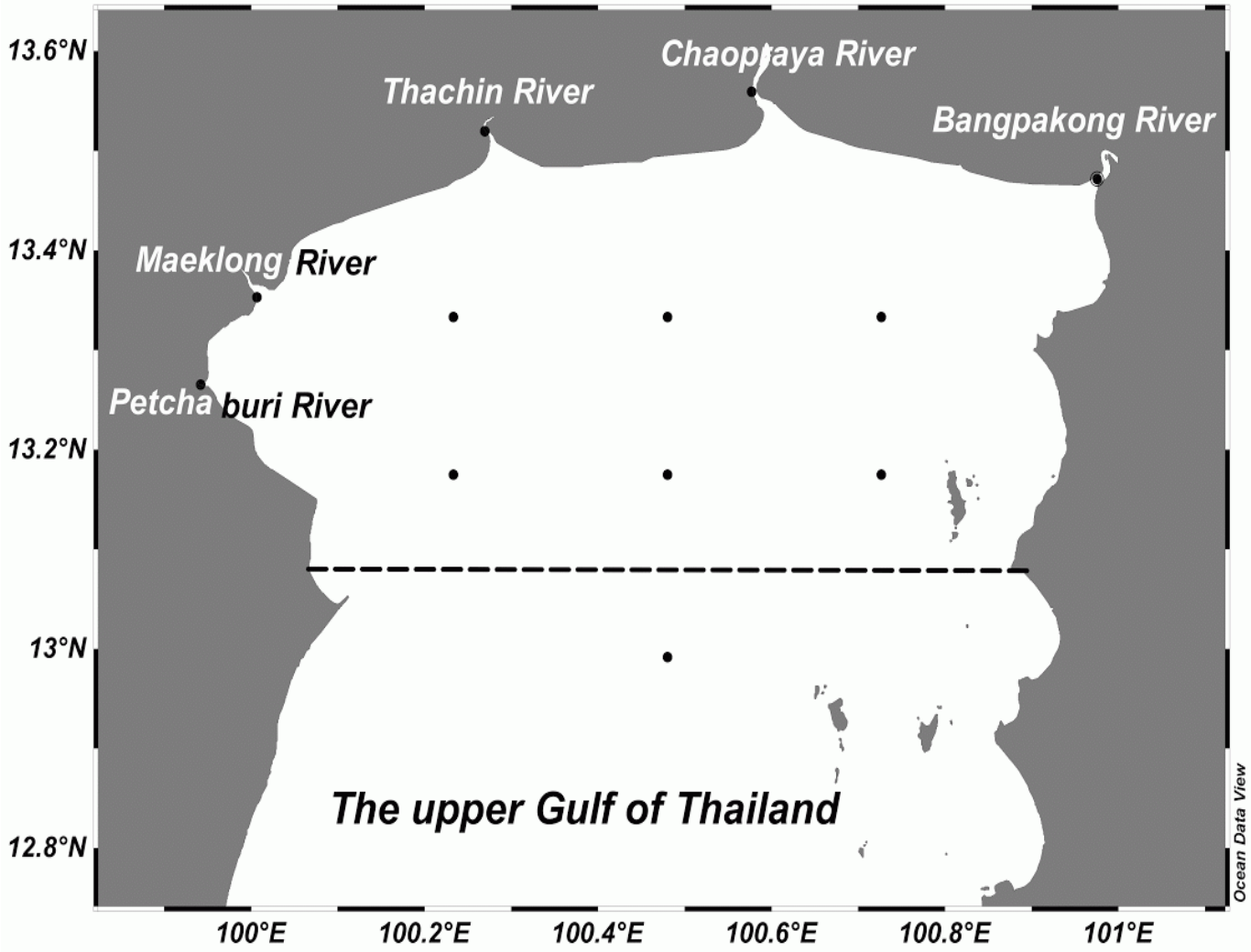
Sampling Sites



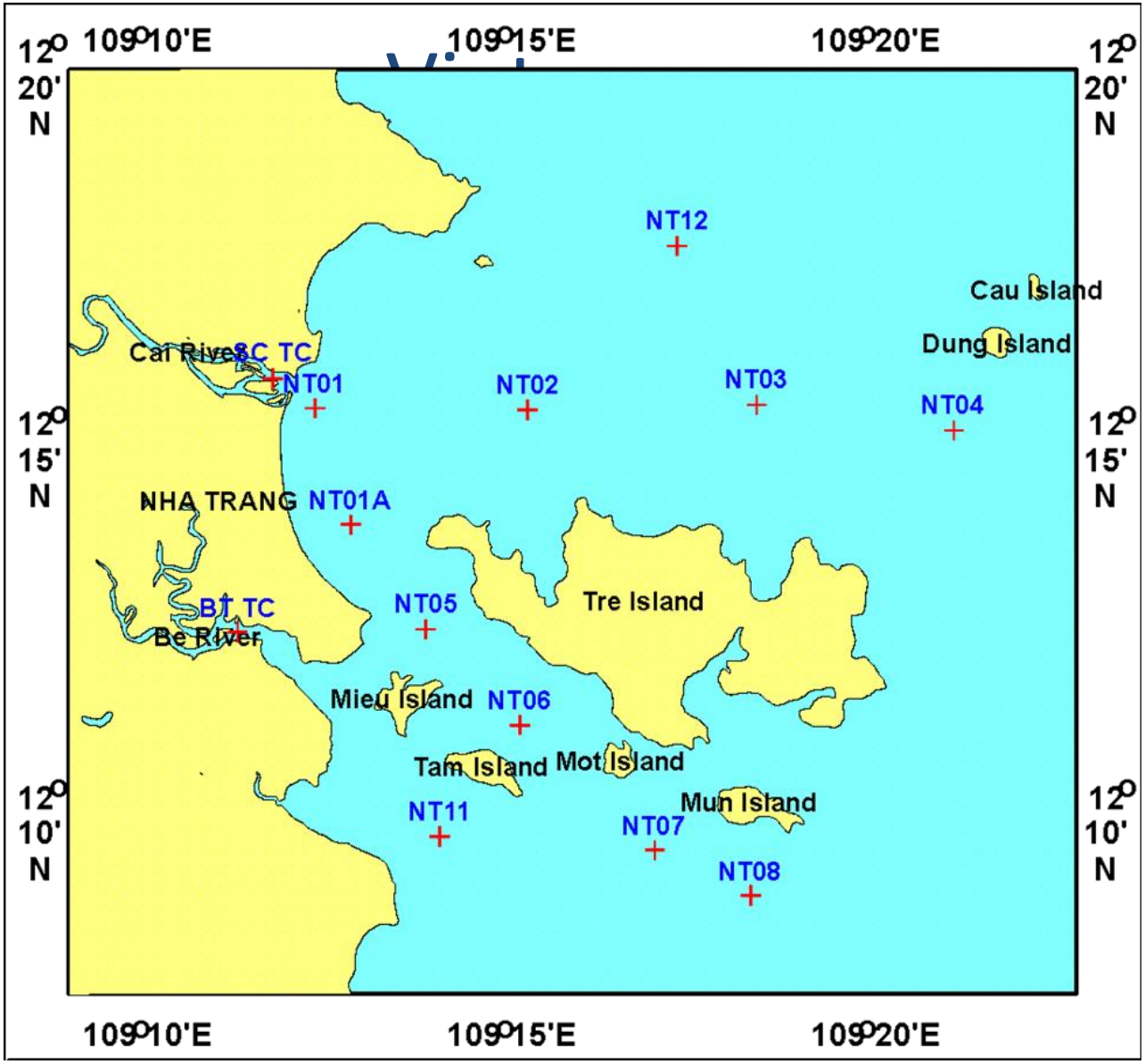

ChloroGIN-1
ChloroGIN-2
N
W
E
S
Santiago Island
UP Bolinao
Marine Lab
Siapar
Island
Cabarruyan Island
1
2
4
6
8
9
10
11
12
13
14
15
18
19
21
23
24
26
16.415
16.395
16.375
16.355
16.335
16.315
16.295
16.275
Latitude (°N)
119.87
119.89
119.91
119.93
119.95
119.97
Longitude (°E)

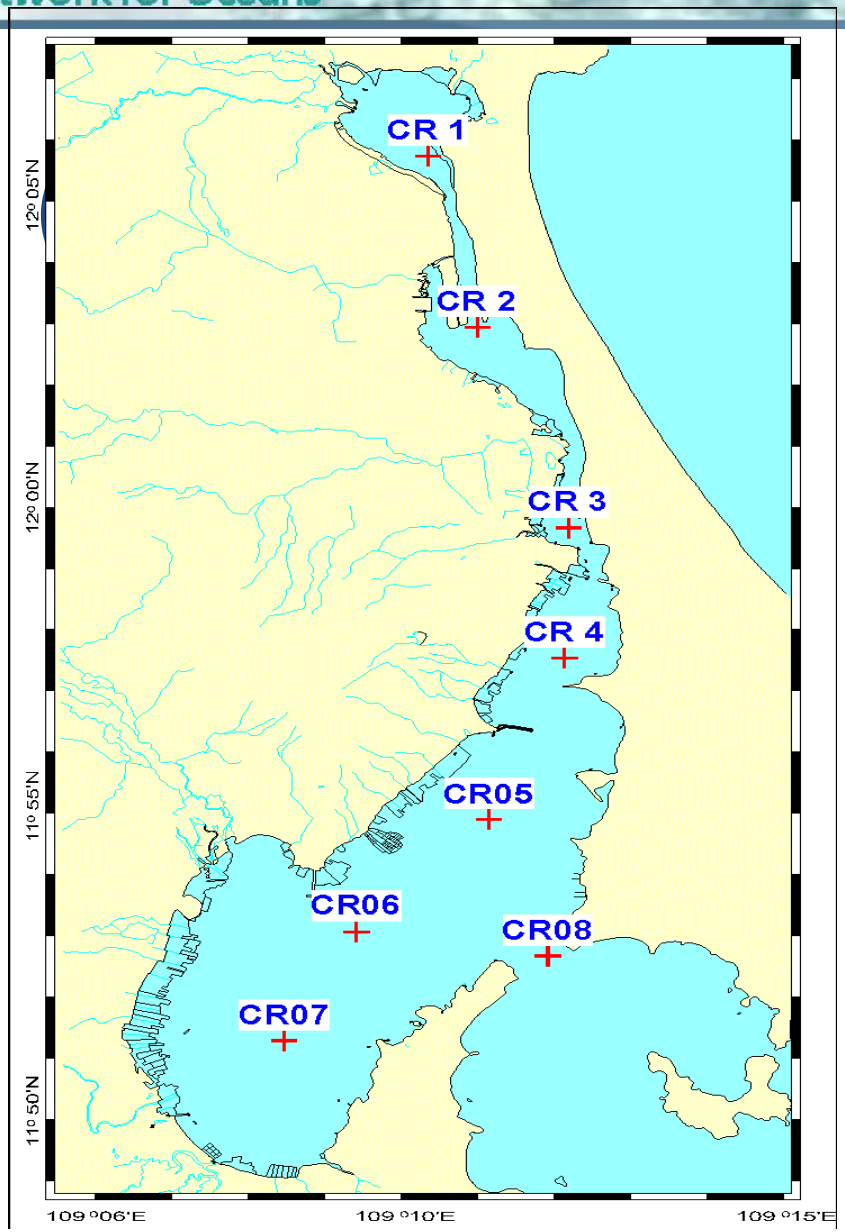
Field trips

- Highlights of the oceanographic monitoring activities in Bolinao, Philippines.
- **A)** On-site programming and calibration of ADCP.
- **B)** CTD deployment and real-time ADCP acquisition**.**
- **C)** Initialization of Infinity ME (Multi-exciter in-situ fluorometer) for deployment.
- **D)** Ship board pre-processing of nutrient, DO, pH, and chlorophyll-a samples.
- **E)** Deployment of Infinity ME and collection of plankton & discrete water samples using a Niskin Bottle on board a fiberglass boat. Photo credit: Joseph Dominic Palermo.

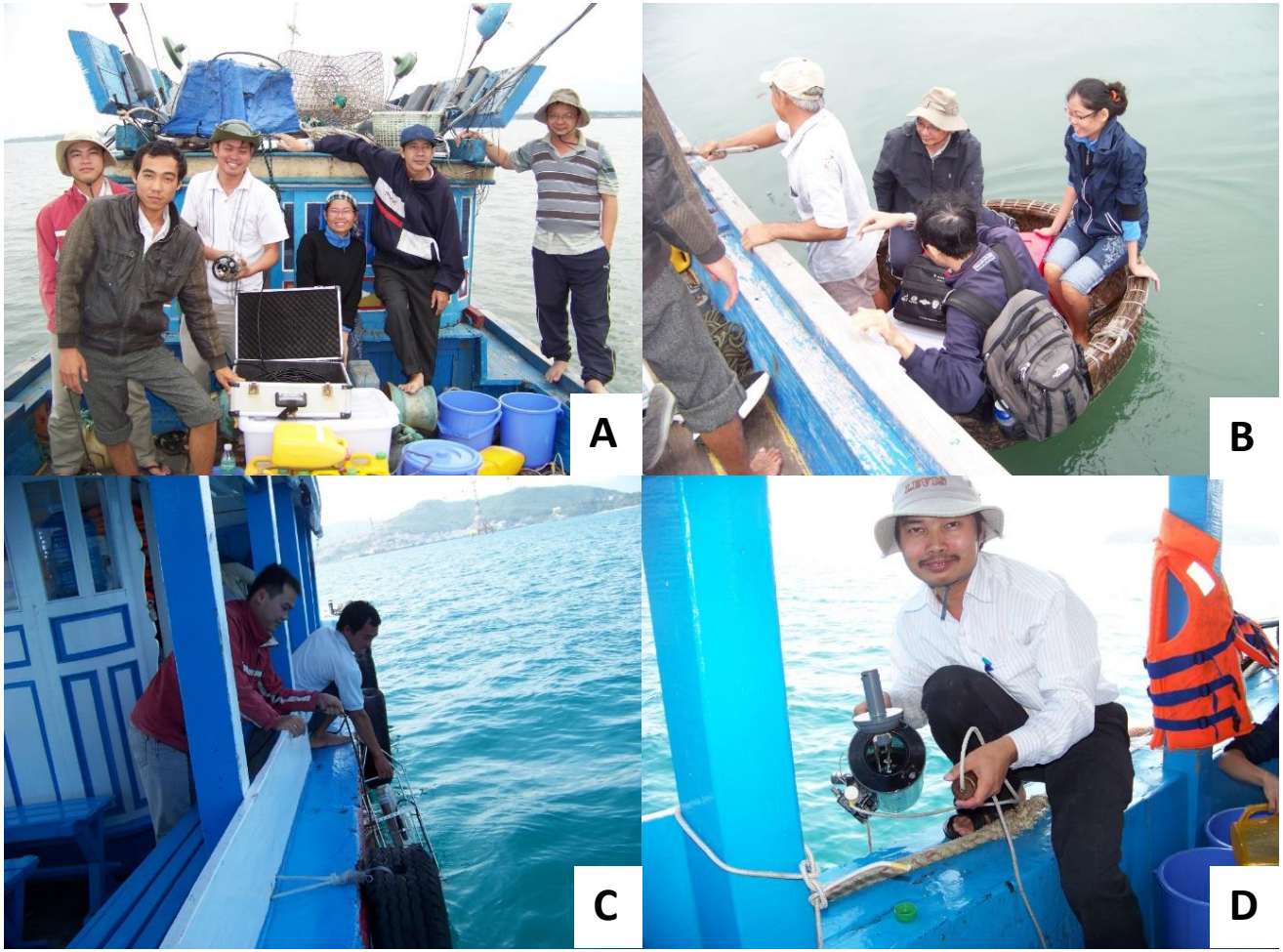

13.6°N
13.4°N
13.2°N
13°N
12.8°N
100°E
100.2°E
100.4°E
100.6°E
100.8°E
101°E
Chaopraya River
Thachin River
Bangpakong River
Maeklong River
Petchaburi River
The upper Gulf of Thailand
Ocean Data View

- Highlights of the oceanographic monitoring activities in the Upper Gulf of Thailand.
- **A)** Pre-processing of water samples on board.
- **B)** Discrete sample collection.
- **C)** RV Kasetsart 1 for UGoT observation.
- **D)** Sampling at a river mouth


109°10'E
109°15'E
109°20'E
12° 20' N
12° 15' N
12° 10' N
NT12
Cau Island
Dung Island
Cai River
SC TC
NT01
NT02
NT03
NT04
NHA TRANG
NT01A
BT TC
Be River
NT05
Tre Island
Mieu Island
NT06
Tam Island
Mot Island
Mun Island
NT11
NT07
NT08


CR 1
CR 2
CR 3
CR 4
CR05
CR06
CR08
CR07
12º 05'N
12º 00'N
11º 55'N
11º 50'N
109 º06'E
109 º10'E
109 º15'E

- Highlights of activities of the field trips in Nha Trang and Cam Ranh Bay, Vietnam.
- **A)** Team on board in the beginning.
- **B)** Moving samples and equipment from fishing boat to coracle.
- **C)** Collected CTD profiles.
- **D)** Water collection



Methods: Water residence time

- Philippines
  - Salinity gradient between sites <2.0 psu (as is required for the application of the LOICZ model)
  - Delft 3D therefore applied to determine water residence time
- Thailand
  - Single box method applied and LOICZ model used
- Vietnam
  (a) Nha Trang – Single box method applied and LOICZ model used
  (b) Cam Ranh – Four-box LOICZ model applied

Physico-chemical parameters

BIOLOGICAL PARAMETERS	Philippines		Thailand		Vietnam	
	12/11/2013	2/26/2014	22-23 Feb 14	31 Jul - 9 Aug 14	5-10 Jan 14	13-18 May 14
Chl-a (ug/l)	Turner Fluorometer/Ocean Optics Spectrophotometer	Turner Fluorometer/Ocean Optics Spectrophotometer	Spectrophotometry (Stickland & Parsons, 1972)	Spectrophotometry (Stickland & Parsons, 1972)	90% acetone & Spectrophotometer (Jeffrey & Welschmeyer, 1997)	90% acetone & Spectrophotometer (Jeffrey & Welschmeyer, 1997)
Multispectral Florescence (nm)	Infinity ME	Infinity ME			Infinity Alex	Infinity Alex
Biological Oxygen Demand (BOD)			(Stickland & Parsons, 1972)	(Stickland & Parsons, 1972)	DO chemical (APHA, 2005)	DO chemical (APHA, 2005)

PHYSICAL PARAMETERS	Philippines		Thailand		Vietnam	
Temperature	SBE 19 CTD	SBE 19 CTD	mini CTD SD204	mini CTD SD204	SBE 19 CTD	SBE 19 CTD
Salinity (PSU)	SBE 19 CTD	SBE 19 CTD	mini CTD SD204	mini CTD SD204	SBE 19 CTD	SBE 19 CTD
Turbidity (NTU)	SBE 19 CTD	SBE 19 CTD	YSI model 600 XLM	YSI model 600 XLM	SBE 19 CTD	SBE 19 CTD
Density	SBE 19 CTD	SBE 19 CTD	mini CTD SD204	mini CTD SD204	SBE 19 CTD	SBE 19 CTD

CHEMICAL PARAMETERS	Philippines		Thailand		Vietnam	
Nitrate + Nitrite (NO3 + NO2)	Nutrient Autoanalyzer	Nutrient Autoanalyzer	APHA 2005	APHA 2005	APHA 2005	APHA 2005
Phosphate (PO4)	Nutrient Autoanalyzer	Nutrient Autoanalyzer	APHA 2005	APHA 2005	APHA 2005	APHA 2005
Ammonia (NH4)	Nutrient Autoanalyzer	Nutrient Autoanalyzer	APHA 2005	APHA 2005	APHA 2005	APHA 2005
TSS	APHA 2005	APHA 2005	APHA 2005	APHA 2005	APHA 2005	APHA 2005
Dissolved oxygen (DO)	SBE 19 CTD	SBE 19 CTD	APHA 2005	APHA 2005	APHA 2005	APHA 2005
Dissolved Organic Carbon (DOC)	Flash 2000 elemental analyser	Flash 2000 elemental analyser			APHA 2005	APHA 2005
pH	CTD Seabird	CTD Seabird	YSI model 600 XLM	YSI model 600 XLM	YSI	YSI

Eutrophication Index

- Vollenweider et al. (1998) established the formulation of TRIX in the linear function as:

  $$TRIX = [Log_{10}(Chl\text{-}a * aD\%O * DIN * DIP) - a]/b$$

- Chl-a: Chlorophyll-a concentration in mg m^{-3}; DIN: Dissolved inorganic nitrogen concentration in mg N m^{-3}; DIP: Dissolved inorganic phosphorus concentration in mg P m^{-3}; aD%O: the absolute percentage deviation from oxygen saturation; a and b: scale factors based on extended data set in study areas.
- Due to strong changes of a and b coefficients of different study areas, Pettine et al. (2007) suggested using UNTRIX to understanding eutrophic level of marine regions. UNTRIX was calculated as:
- $UNTRIX = Log_{10}(Chl\text{-}a * aD\%O * DIN * DIP)$

- Methods to combine the environmental status for intercomparison between study sites among the countries.

$$TQR_{UNTRIX} = 50^{th}\ UNTRIX_{reference} / 75^{th}\ UNTRIX_{site}$$

$$TQR = TQR_{UNTRIX} \times (1/\tau + 1)$$

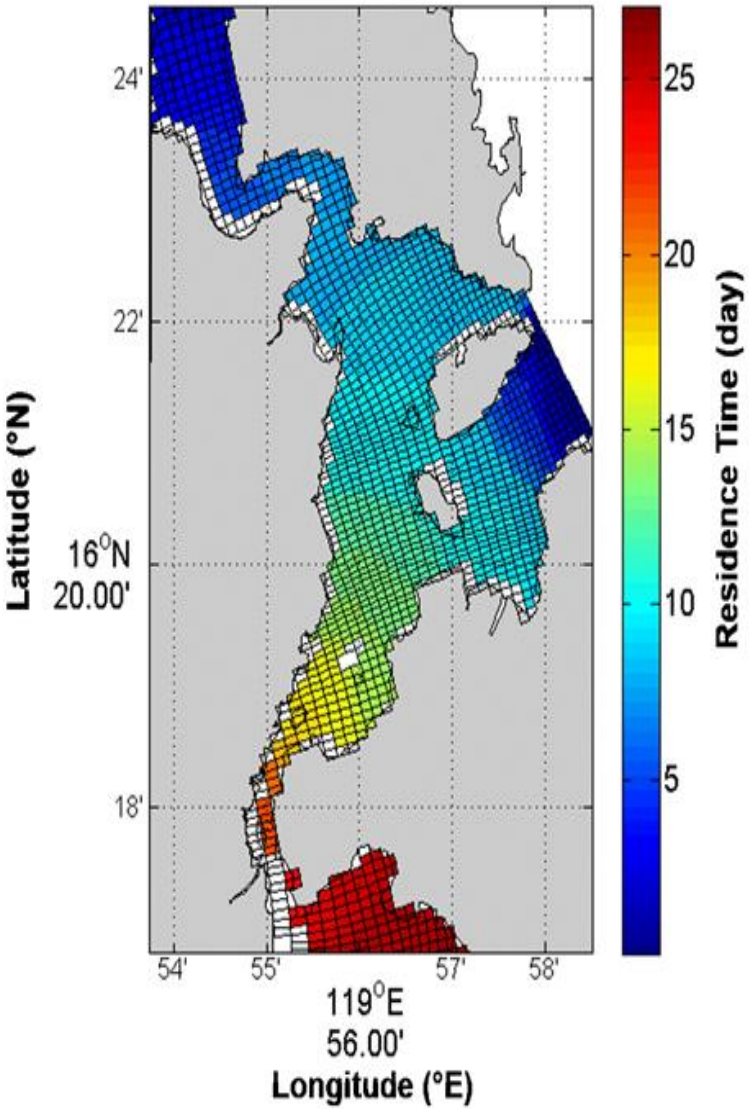
- Reference sites were determined among the 4 study sites by cluster analysis of chl*a*, DIN, DIP, %DO and UNTRIX.

Results: Philippines

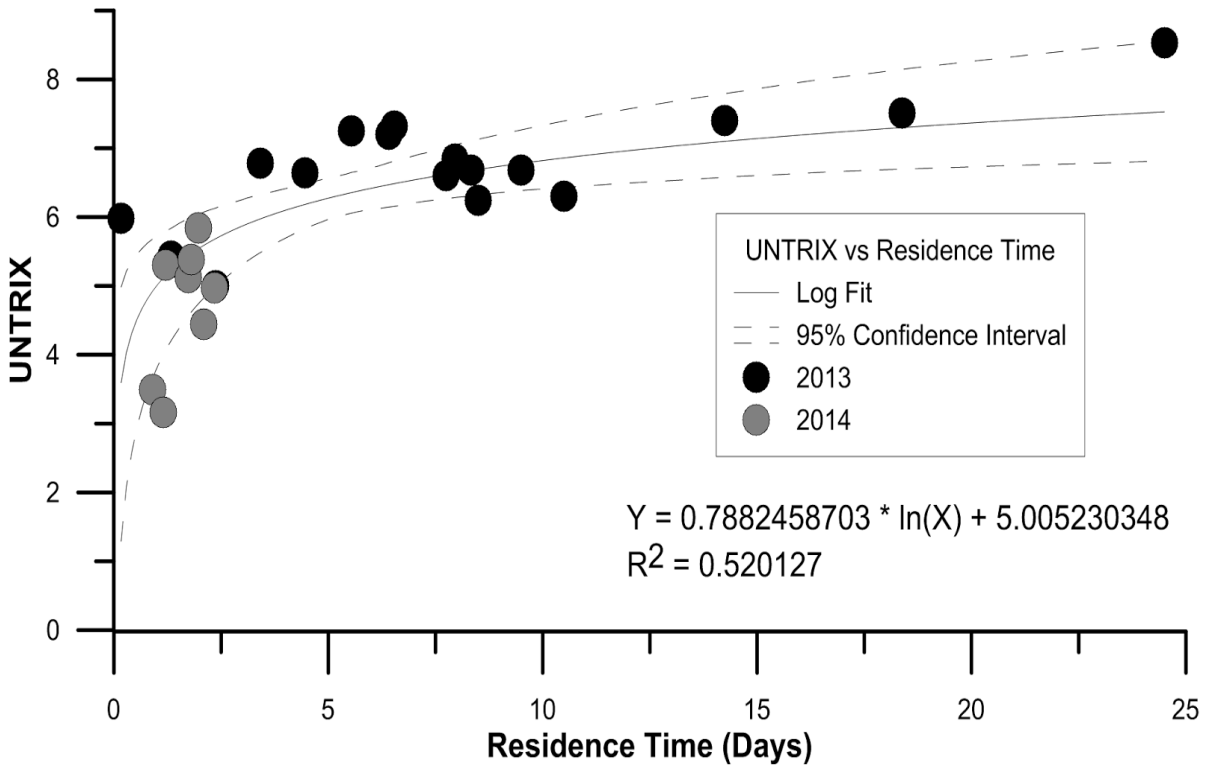
- Water quality in Bolinao varied spatially from off shore through the inner channel.
- Offshore stations were relatively low in nutrients while the inner channel were characterized with high levels of nutrients.
- There was no stratification observed between the sampled water layers- subsurface, middle, and near bottom.
- A marked difference in the water quality was observed between wet and dry seasons

Philippines: Bolinao

- The residence time in the water channel of Bolinao averaged 7.38 ± 5.95 $^{-days}$.
- The north and east boundaries were comparatively low in residence time (respectively 0.75 ± 0.82 $^{-day}$ and 0.15 ± 0.089 $^{-days}$) and generally progressed to 5.76 ± 3.07 $^{-days}$ in the central portion.
- The south, the residence time exhibited 21 ± 4.33 $^{-days}$.

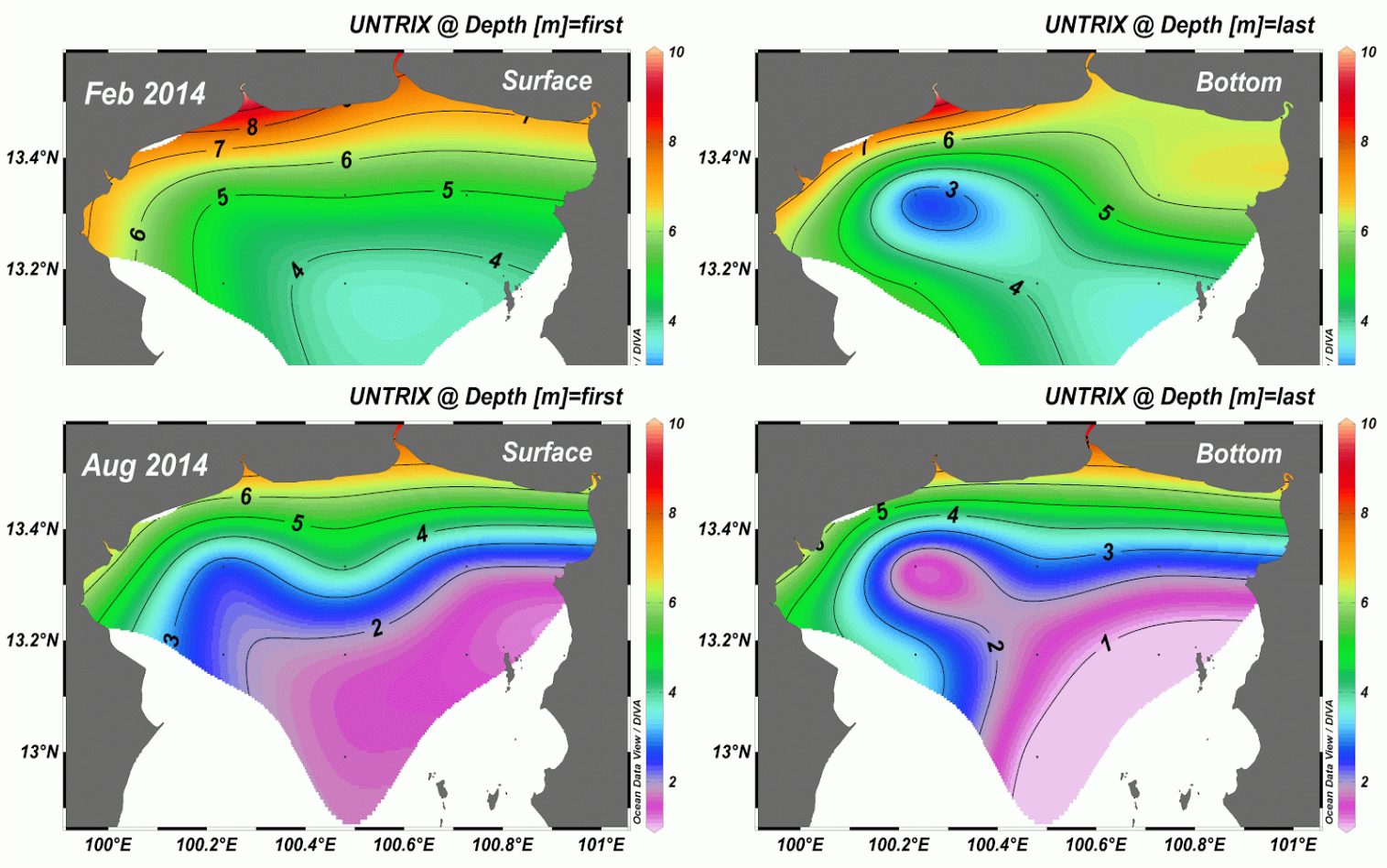


Philippines: Bolinao

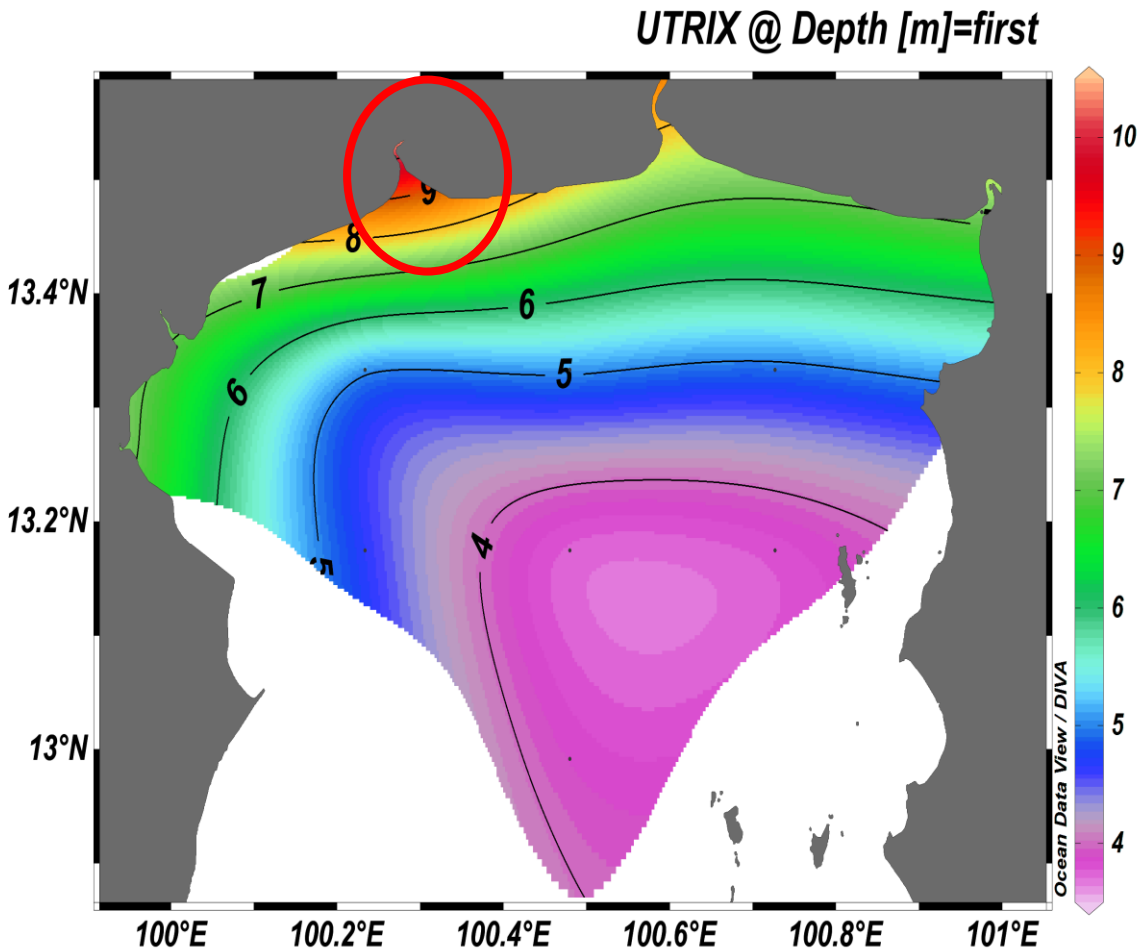


- Eutrophication in Bolinao was generally modulated by the residence time.
- The empirically derived UNTRIX values were logarithmically proportional to the increase in residence time in the channel

Thailand : UGofT



Thailand: UNTRIX in dry season (22 - 27 Feb 2014)



- High values occurs in the western coast in vicinity of the Thachin River
- An unscaled TRIX eutrophication index (UNTRIX) is applied to assess the conditions of water quality in UGoT.
- The distributions of UNTRIX at the sea surface suggests that water quality near the Thachin river mouth is quite poor with the highest UNTRIX of over 10 while the averaged value is 5.57 in February 2014

Thailand: LOICZ assessments

- Uncertainty in freshwater inputs mostly from river discharges make residence time of freshwater in dry season vary greatly around from 10 to 40 days.
- Freshwater inputs need to be clarified.
- Different approaches may be used to confirm LOICZ assessments.

Vietnam - Water exchange

Nha Trang Bay

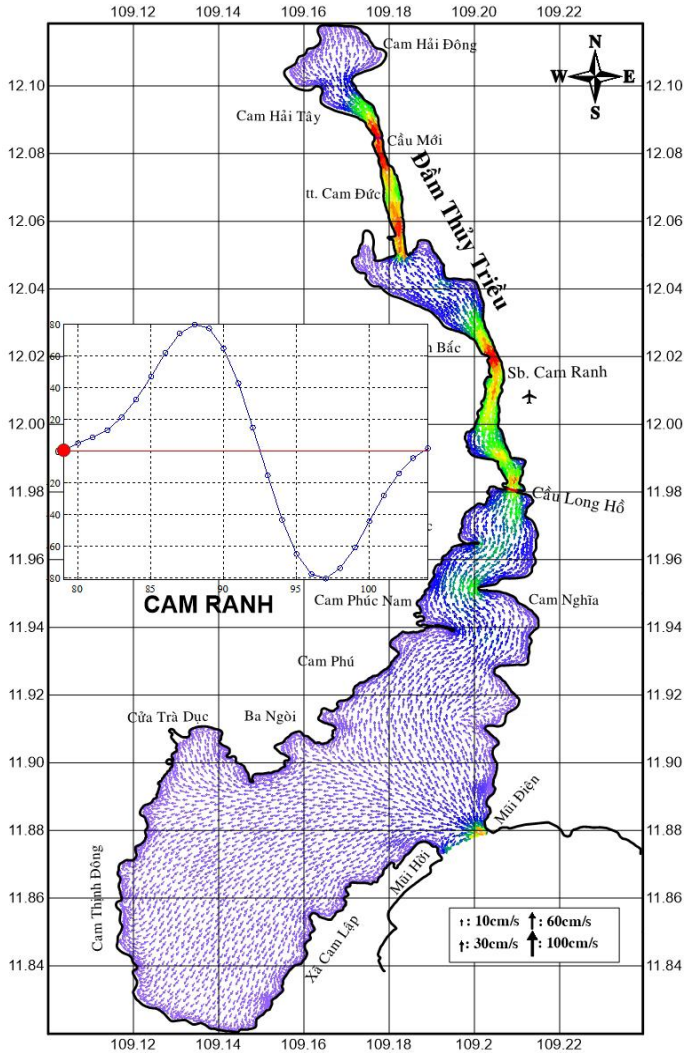
- Rainy season: 37 day^{-1}
- Dry season: 67 day^{-1}
- This did not apply the current and tide.

Cam Ranh Bay

- Rainy season: 19.80 day^{-1}
- Dry season: 16.20 day^{-1}

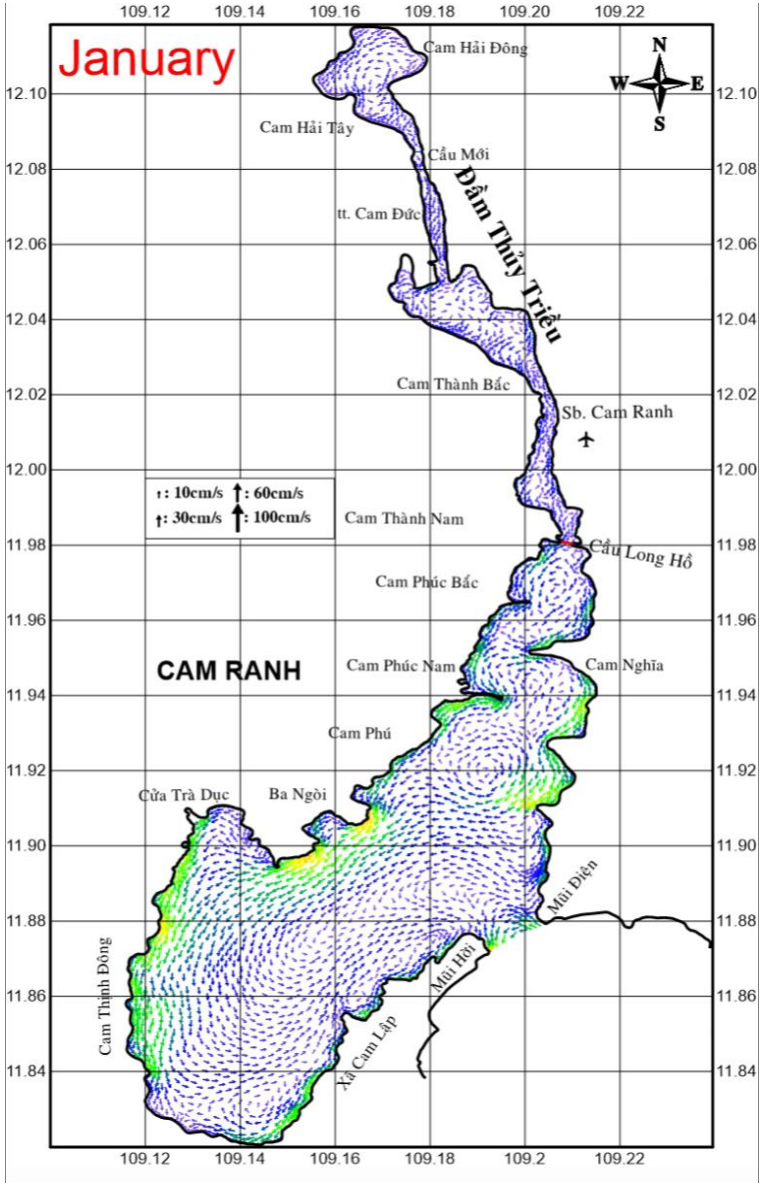
Tidal cycle in Cam Ranh

- ***Tidal currents at flood tide***
  - maximum current speed was 57.9 cm/s, and direction of 299.0°
  - weak current was about 88%, and moderate current: 10.5%,
- ***Tidal currents at ebb tide***
  - maximum vertical velocity was reached to 81.6 cm/s with direction of 99.4°
  - 73.3% weak current, 15.7% moderate current, 7.6% quite strong current and 3.7% strong current.

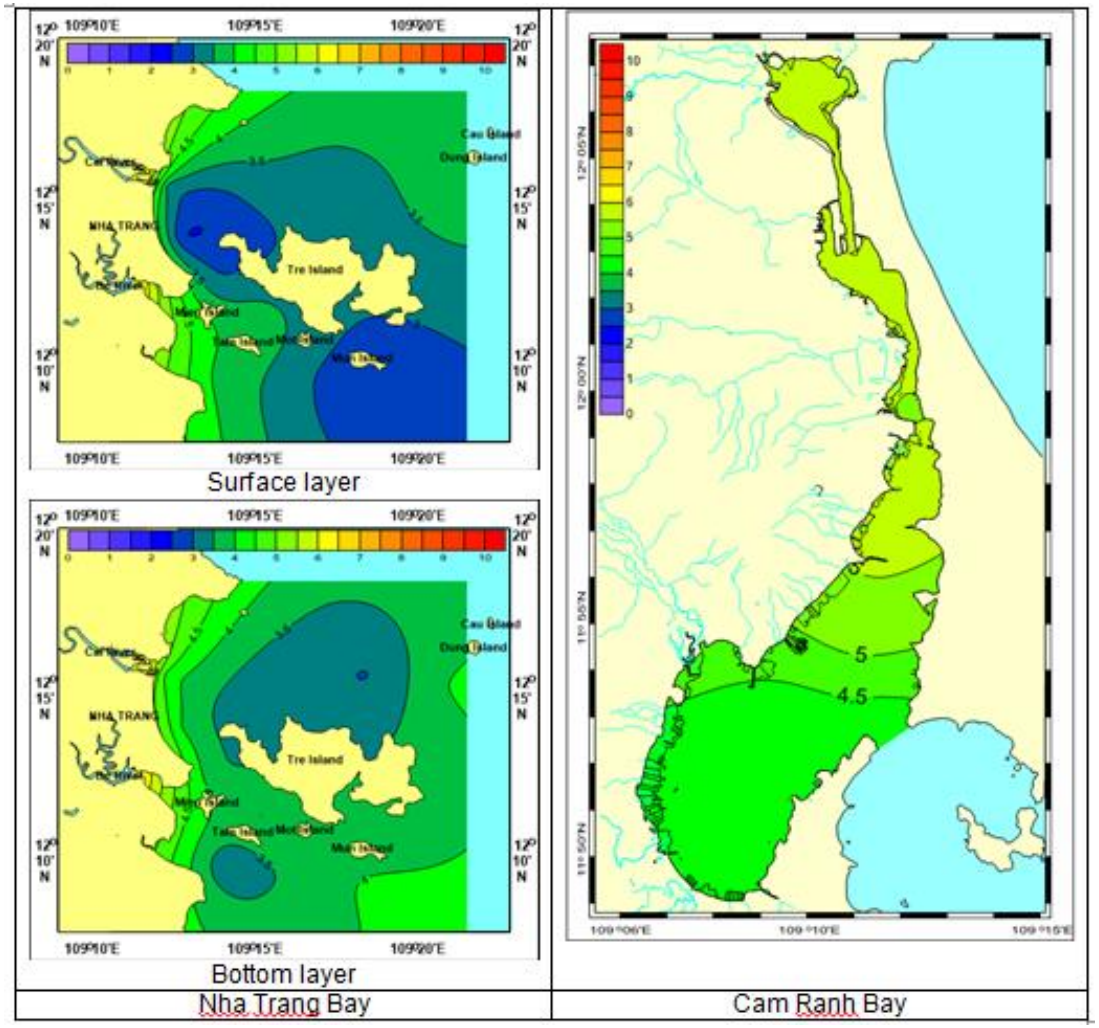


Seasonal changes

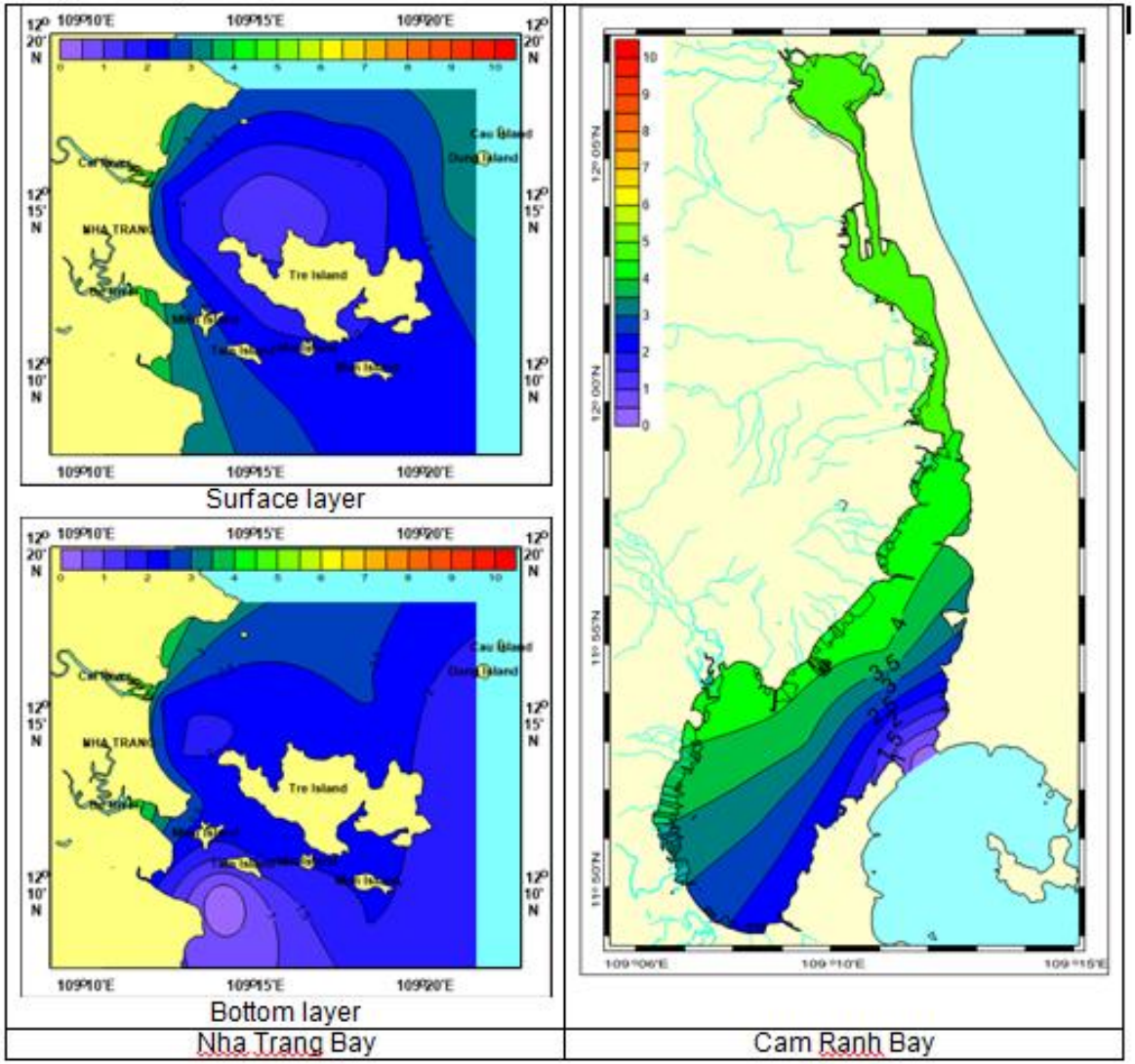
- in northeast monsoon,
  - 70.4% weak current,
  - 27.8% moderate current
  - 1.8% quite strong current
  - without strong current.
- in southwest monsoon,
  - 85.9% weak current,
  - 12.5 % moderate current,
  - 0.8 % quite strong current and
  - 0.8% strong current



UNTRIX in Vietnam: Dry season



UNTRIX in Vietnam: Wet season



Vietnam

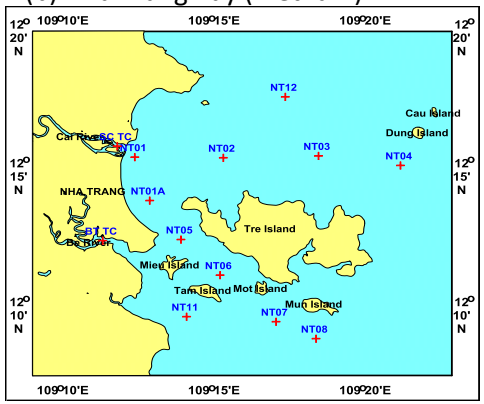
- In Nha Trang Bay, the UNTRIX value in dry and rainy seasons were averaged in 3.74±0.97 and 0.47 ± 0.13, respectively; whereas these values in Cam Ranh Bay were 4.56 ± 1.78 and 3.65 ± 1.54
- The results indicated that the water quality in Nha Trang was better than that in Cam Ranh Bay.
- In general, the water quality in dry season was worse than that in wet season, because of the higher flow through of water residence time (thus reducing water residence time).

- **2015-16 : Eutrophication in the Coastal Waters of SE Asia: Monitoring and Capacity Building**
  - Joseph Palermo - Marine Science Institute, Philippines
  - Anukul Buranapratheprat - Burapha University, Thailand
  - Phan Minh Thu - Institute of Oceanography, Vietnam
  - Umi Zakiyah – Brawijaya University, Indonesia
  - Nurul Aini Kamaruddin - University Sultan Zainal Abidin, Malaysia

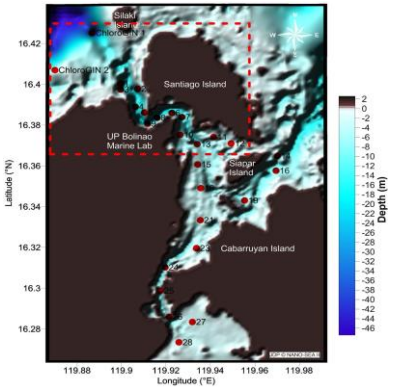
- Rationale:
  - NANO members from 5 countries will further investigate eutrophication enhanced by nutrient load and modulated by water residence time.
  - Expand upon the methods applied by the NANO SEA research group in 2014 and share the knowledge obtained by this group to NANO alumni and associates from the additional two participating countries.
  - To include remote sensing data to quantify chlorophyll-a from satellite derived information, where applicable.

(a) Upper Gulf of Thailand (Thailand)

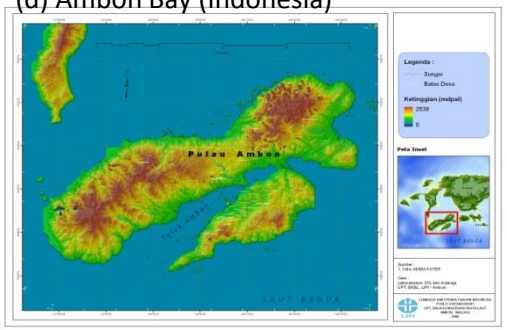
(b) Nha Trang Bay (Vietnam)



(c) Bolinao (Philippines)



(d) Ambon Bay (Indonesia)



(e) Bachok (Malaysia)