Mapping of Inland and Underwater Habitats with Satellite Images

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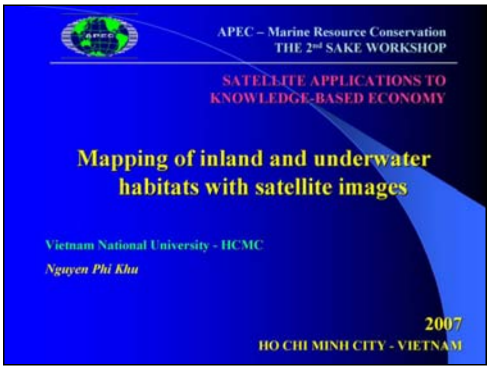
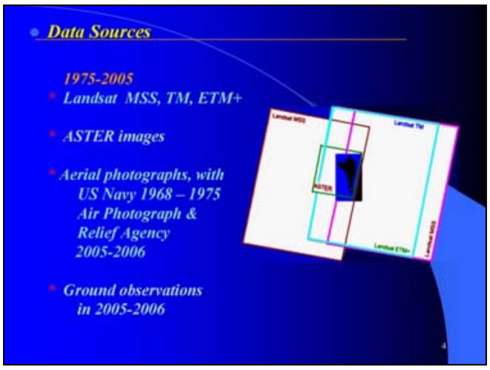
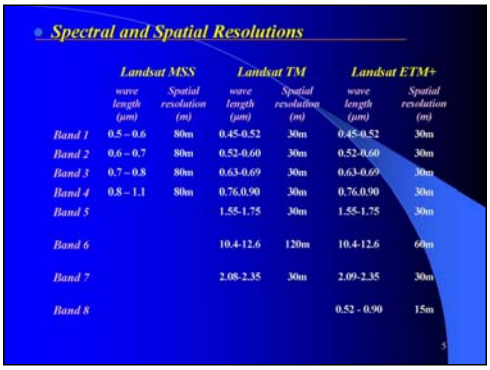
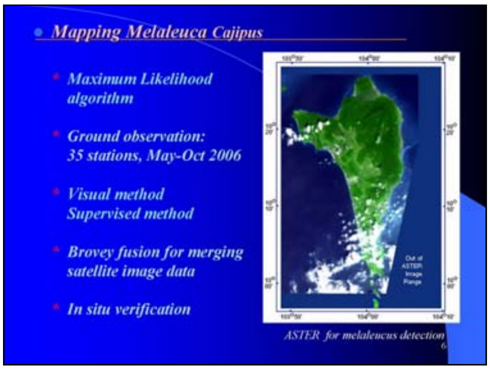


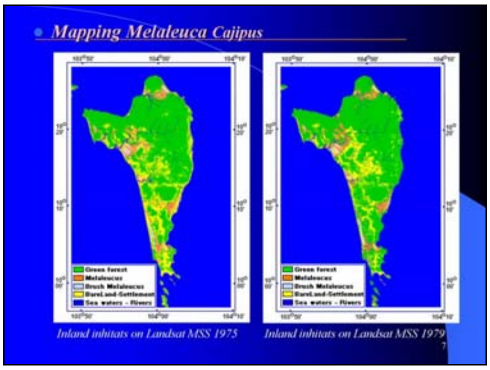


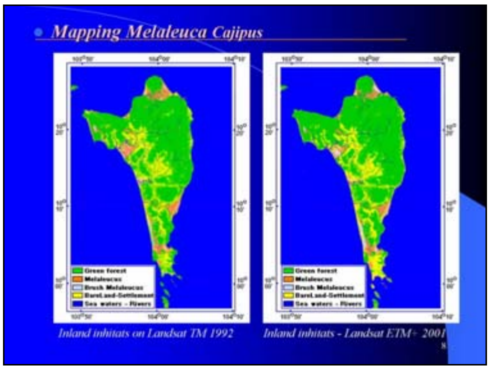

Spectral and Spatial Resolutions

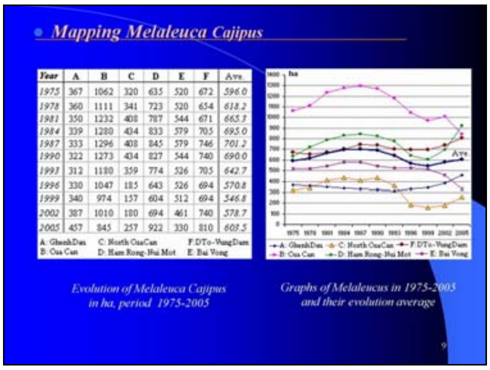
	Landsat MSS		Landsat TM		Landsat ETM+	
	wave length (μm)	Spatial resolution (m)	wave length (μm)	Spatial resolution (m)	wave length (μm)	Spatial resolution (m)
Band 1	0.5 – 0.6	80m	0.45-0.52	30m	0.45-0.52	30m
Band 2	0.6 – 0.7	80m	0.52-0.60	30m	0.52-0.60	30m
Band 3	0.7 – 0.8	80m	0.63-0.69	30m	0.63-0.69	30m
Band 4	0.8 – 1.1	80m	0.76.0.90	30m	0.76.0.90	30m
Band 5			1.55-1.75	30m	1.55-1.75	30m
Band 6			10.4-12.6	120m	10.4-12.6	60m
Band 7			2.08-2.35	30m	2.09-2.35	30m
Band 8					0.52 - 0.90	15m

5




Mapping Melaleuca Cajipus
Green forest
Melaleucus
Brush Melaleucus
BareLand-Settlement
Sea waters - Rivers
Inland inhitats on Landsat MSS 1975
Inland inhitats on Landsat MSS 1979
7


Mapping Melaleuca Cajipus
Green forest
Melaleucus
Brush Melaleucus
BareLand-Settlement
Sea waters - Rivers
Inland inhitats on Landsat TM 1992
Inland inhitats - Landsat ETM+ 2001
8


Mapping Melaleuca Cajipus

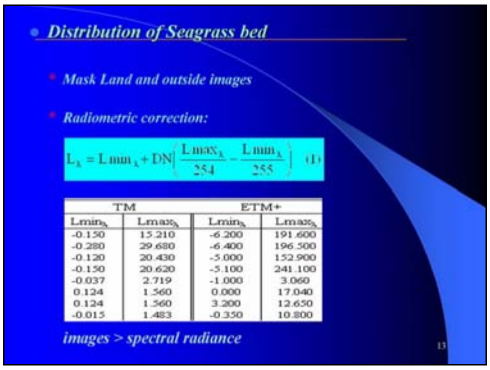
Year	A	B	C	D	E	F	Ave.
1975	367	1062	320	635	520	672	596.0
1978	360	1111	341	723	520	654	618.2
1981	350	1232	408	787	544	671	665.3
1984	339	1280	434	833	579	705	695.0
1987	333	1296	408	845	579	746	701.2
1990	322	1273	434	827	544	740	690.0
1993	312	1180	359	774	526	705	642.7
1996	330	1047	185	643	526	694	570.8
1999	340	974	157	604	512	694	546.8
2002	387	1010	180	694	461	740	578.7
2005	457	845	257	922	330	810	603.5

A: GhenhDau C: North CuaCan F:DTo-VungDam
B: Cua Can D: Ham Rong-Hui Mot E: Bai Vong
Evolution of Melaleuca Cajipus in ha, period 1975-2005
Graphs of Melaleucus in 1975-2005 and their evolution average
9


Mangrove forests
Mangrove patches:
Cua can, Tram stream,
Duong Dong town,
Ong doi Cap
Brovey fusion on
Landsat ETM+ 2005
Fusion-colour composite
image
10

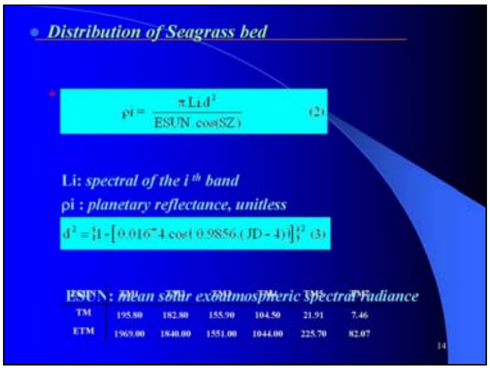

Mangrove forests
Mangrove patches in Cua Can, 22ha
Mangrove patches in Tram stream
Mangrove patches: ligth green, Melaleucus area: puple.
11


Mangrove forests
Mangrove patches in Duong dong, 22ha
Mangrove patches in Ong doi cap, 18 ha
Mangrove patches: ligth green, Melaleucus area: puple.
12


Distribution of Seagrass bed
Mask Land and outside images
Radiometric correction:
$$L_\lambda = L\min_\lambda + DN\left(\frac{L\max_\lambda}{254} - \frac{L\min_\lambda}{255}\right) \quad (1)$$

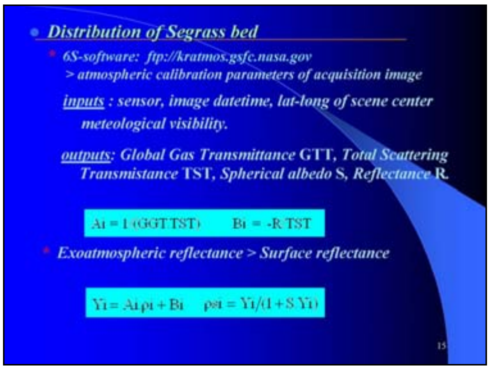
TM		ETM+	
$Lmin_\lambda$	$Lmax_\lambda$	$Lmin_\lambda$	$Lmax_\lambda$
-0.150	15.210	-6.200	191.600
-0.280	29.680	-6.400	196.500
-0.120	20.430	-5.000	152.900
-0.150	20.620	-5.100	241.100
-0.037	2.719	-1.000	3.060
0.124	1.560	0.000	17.040
0.124	1.560	3.200	12.650
-0.015	1.483	-0.350	10.800

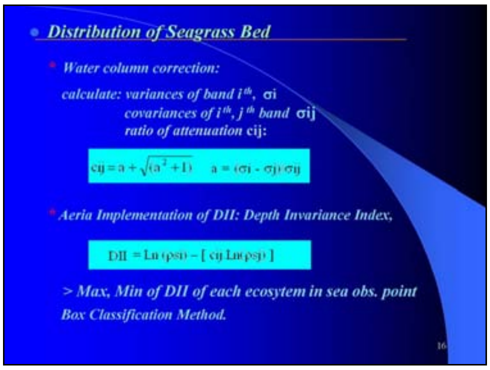
images > spectral radiance
13

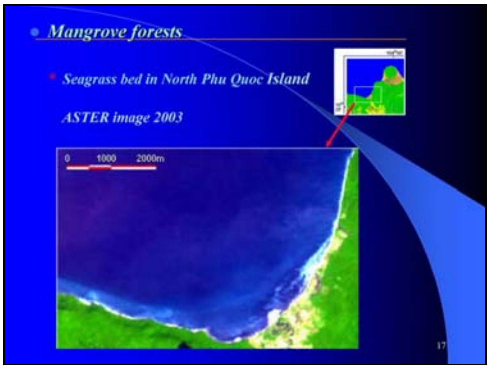

Distribution of Seagrass bed
$$\rho i = \frac{\pi Li\, d^2}{ESUN \cos(SZ)} \quad (2)$$
Li: spectral of the i th band
ρi : planetary reflectance, unitless
$$d^2 = \{1 - [0.01674 \cos(0.9856 (JD - 4))]\}^2 \quad (3)$$
ESUN: mean solar exoatmospheric spectral radiance

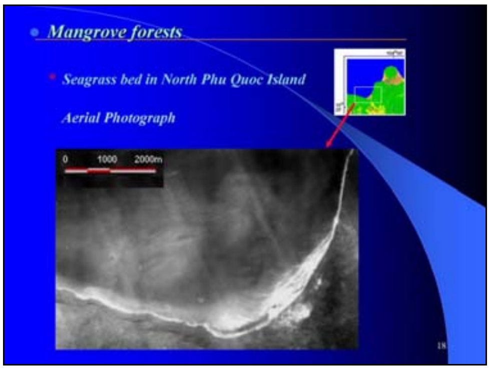
TM	195.80	182.80	155.90	104.50	21.91	7.46
ETM	1969.00	1840.00	1551.00	1044.00	225.70	82.07

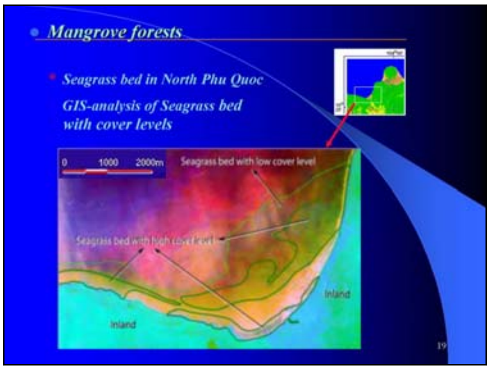
14



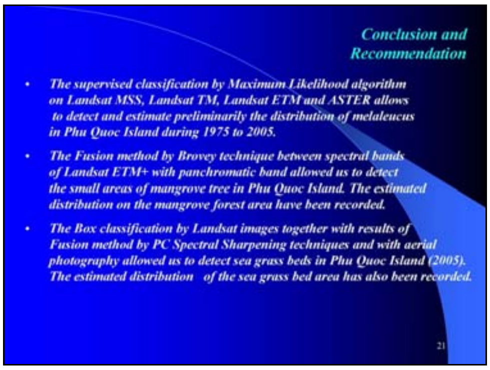








Regions	Distributed area (ha)
East of Ghenh dau	1120
North of Ham Rong	1045
Nui Mot	520
Ham Ninh	6010
Bai Vong	827
North of Ong Doi Cape	80
South of Ong Doi Cape	195
Total:	9797



Reef Connectivity: A Study of Larval Dispersal in Sulu Sea

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[1]*The Marine Science Institute, University of the Philippines, Diliman, Quezon City 1101*
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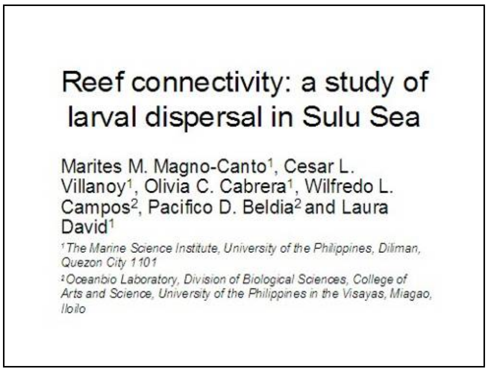
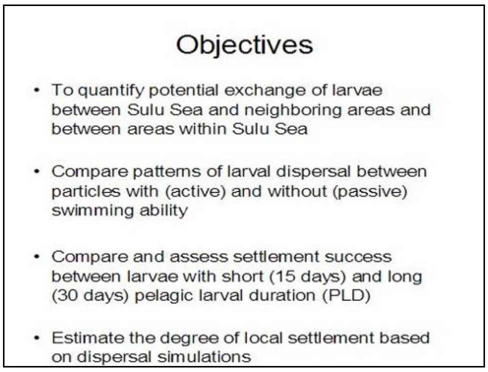
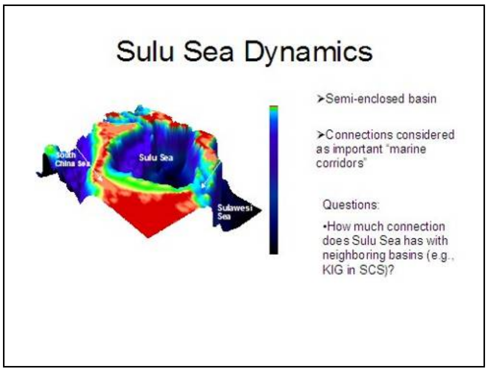
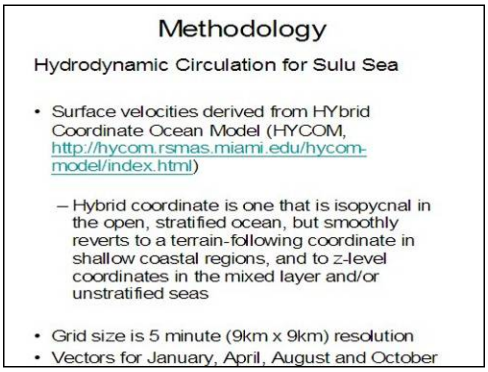
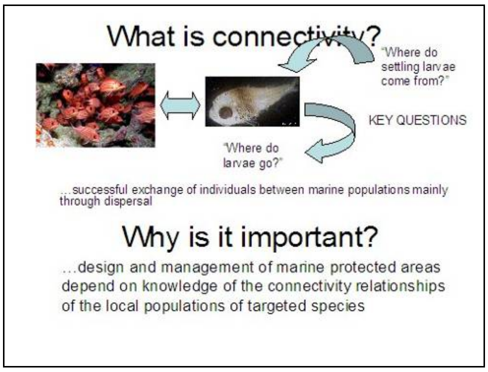
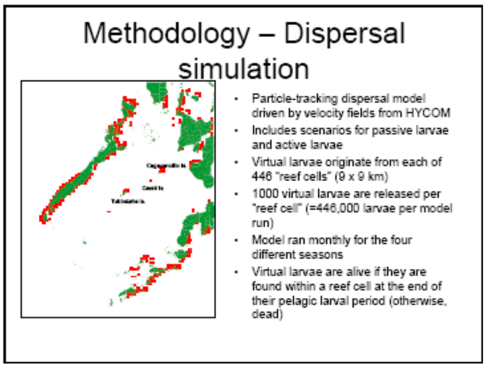












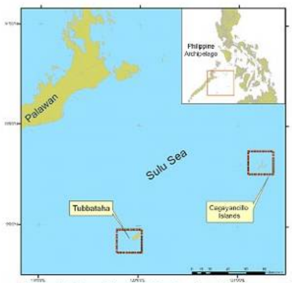
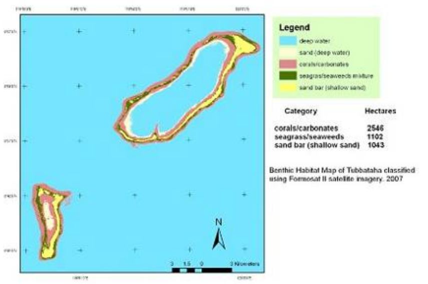


Figure 1. Map of the Sulu Sea showing the box areas of the satellite imagery

Methodology – Dispersal simulation

Parameter	Passive larvae	Active larvae
SHORT Pelagic larval duration (PLD)	15 days	15 days
Age when swimming ability is attained	Never	7.5 days
Age when competency to settle is attained	11.25 days	11.25 days
Swimming speed	0 m sec^{-1}	0.2 m sec^{-1}
Sensory range	N/A	18 km
LONG Pelagic larval duration (PLD)	30 days	30 days
Age when swimming ability is attained	Never	15 days
Age when competency to settle is attained	22.5 days	22.5 days
Swimming speed	0 m sec^{-1}	0.2 m sec^{-1}
Sensory range	N/A	18 km

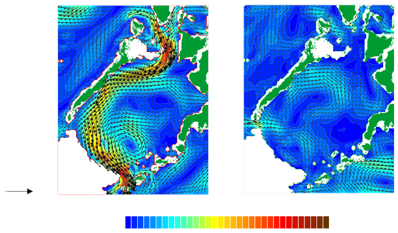
* based on the active larval simulation framework for MARINE RESERVES AND REEF CONNECTIVITY IN THE BOHOL SEA by Garry Russ, Angel Alcala, Rene Abesamis, Brian Stockwell,Cesar Villanoy, Charina Repollo

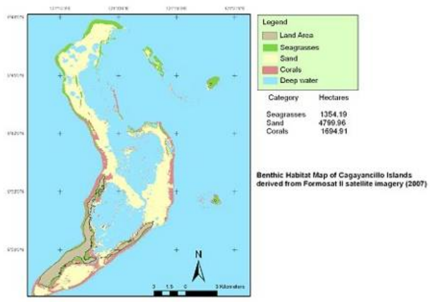


Benthic Habitat Map of Tubbataha classified using Formosat II satellite imagery. 2007

Results - Hydrodynamic Circulation

- HYCOM derived surface velocities

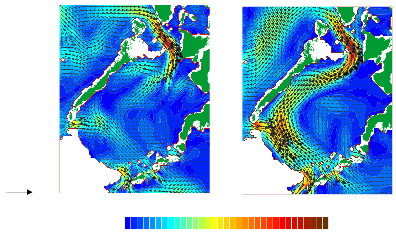




Benthic Habitat Map of Cagayancillo Islands derived from Formosat II satellite imagery (2007)

Hydrodynamic Circulation

- HYCOM derived surface velocities



Methodology – Dispersal simulation

position of passive larvae in two-dimensional space

$$x_{t+\Delta t} = x_t + (u_{x,y,t}\Delta t + \varepsilon\sqrt{D\Delta t})$$
$$y_{t+\Delta t} = y_t + (v_{x,y,t}\Delta t + \varepsilon\sqrt{D\Delta t})$$

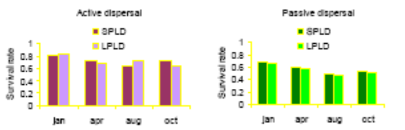
Where:
x, y = coordinates of a particle
u,v = components of velocities
t = the integration time step
ε = randomly generated number (–1 to 1)
D = the eddy diffusion rate ($m^2 s^{-1}$)

position of active larvae incorporating swimming and orienting ability

$$x_{t+\Delta t} = x_t + (u_{x,y,t}\Delta t + \varepsilon\sqrt{D\Delta t} + Sa)$$
$$y_{t+\Delta t} = y_t + (v_{x,y,t}\Delta t + \varepsilon\sqrt{D\Delta t} + Sa)$$

Sa = swimming ability
0m/s if age is < 50% PLD
0.2m/s if age is ≥ 50% PLD

Results: SHORT versus LONG PLD

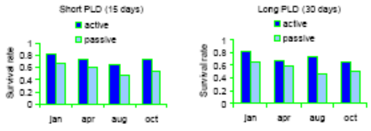


Comparison of the survival rates of active larvae for short and long PLD.

Comparison of survival rates of passive larvae for short and long PLD

- Survival rates (or settlement success) of virtual larvae did not vary significantly with the length of their PLD

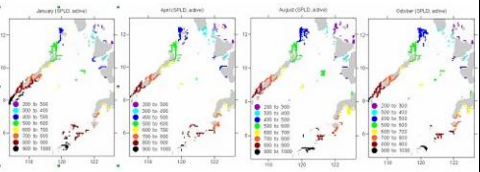
Results: ACTIVE versus PASSIVE



Survival rates between passive and active larvae

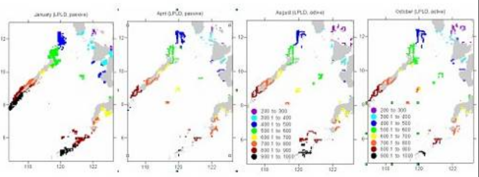
- Survival rates are relatively higher for larvae with swimming and orienting ability compared to passive larvae

Dispersal distance - Active

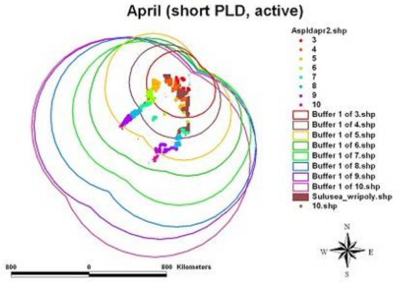


- Dots represents all the virtual larvae that settled to a reef successfully (in kilometers)
- Color of dots signify distance traveled relative to source grid

Dispersal distance - passive



Results: SETTLEMENT SCALE



Summary and conclusion

- Survival rates are relatively higher for larvae with swimming and orienting ability
- Survival rate does not differ significantly between PLDs except for August
- There is a net southward advection of larvae based on the computed distance traveled by the particles

Acknowledgements

- Conservation International
- Bohol Sea Connectivity Project
- Francis Friere
- SAKE Project

Thank you!!!

Mapping of Coastal Ecosystem Condition around Thousand Island of North Jakarta

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ABSTRACT

Kepulauan Seribu (Thousand Islands) is located north of Jakarta Bay. In addition to the threats of human activities and temperature rise, Kepulauan Seribu suffers from the sewage from city of Jakarta. The focus of this study is to map current condition of the land cover and bathymetry of 3 islands in the Kepulauan Seribu, namely the Pari, Pramuka and Harapan/Kelapa Islands.

Base on Lyzenga algorithm that classification of landcover and underwater substrate type of study area was classified into 5 classes. These classes are land and settlement, mangrove (inland area), mix substrate 1 (rubble and sand), mix substrate 2 (sand, dead coral reef, seagrass), mix substrate 3 (sand and seaweed/seagrass), coral reef condition, and deep water. The largest distribution of coral reef and mangrove ecosystem was found in the Pari Islands. This island is suitable place for conservation of coastal ecosystem such as mangrove, coral reef and seagrass or seaweeds farming. Mangrove species at Pari Islands dominated by *Rhizophora stylosa* dan *Rhizophora mucronata*. Other type can be found such as *Avicennia alba*, *Sonneratia alba*, *Hibiscus tilliaceus* and *Bruguiera gymnorrhiza*. However, according to early study of Fishery and Marine Science of Bogor Agriculture University at 1999 using Landsat ETM that coverage area for density class of mangrove was decreasing caused by growth local population and direct use on mangrove wood.

However, Pramuka and Kelapa/Harapan Islands are not suitable seaweed farming or conservation area caused by centre of economic and human activity in Thousand Islands. Coastal ecosystem around thousand islands is still under threatening by human activity and biophysics degradation.

The advantage of Lyzenga algorithm besides could be used to indentify sub bottom profile also to derive depth chart class. Based on algorithm was resulted 5 classes of depth chart range are (1) 0 -1 m; (2) 1 - 3 m; (3) 3 - 5 m; (4) 5 - 10 m and (1) > 10 m. Whereas, DOP method utilization resulted 4 depth classes range namely (1) 0 - 3 m; (2) 3 - 15 m; (3) 15 - 25 m; and (4) > 25 m.

Keyword: *coastal ecosystem, coral reef, mangrove, seaweed/seagrass, depth chart, shallow water mapping, depth of penetration.*

1. INTRODUCTION

The high biological diversity of coastal and marine ecosystem such as coral reef, seagrass, seaweed and mangrove forest make them valuable resources that sustain local and national economies through fisheries, coastal protection, and tourism. In spite of these important benefits, it has been estimated that 58% of coral reefs globally are threatened by human activities (Bryant et al., 1998). Lack of scientific data about the locations, spatial extent, and health of reefs has hindered responses to these threats. There have been a number of international calls from non-governmental organizations and groups of scientists to improve the mapping of coral reef environments (Center for Marine Conservation, 1999).

As one of the highest biological diversity of coral reef ecosystem in the world, Indonesia's coral reefs and mangrove forest ecosystem are currently undergoing rapid destruction from human activities including at Kepulauan Seribu (Thousand Islands, North of Jakarta Bay). These activities are such as the poison fishing; blast fishing; coral mining; sedimentation; pollution, overfishing, land utilization of mangrove forest for residences and brackish water aquaculture. These forces vary from high risk, high payoff poison fishing to poverty-trap activities such as coral mining.

Kepulauan Seribu (Thousand islands) is a group of small island part of administrative region of Jakarta province as a capital of Indonesia. Kepulauan Seribu is north of Jakarta Bay or Java

Sea. Recently, Kepulauan Seribu just has been new Municipal that separated to main city of North Jakarta Municipal. (Figure 1)

Figure 1: Situation of Thousand Island location at north of Jakarta Bay, Province of Jakarta

Kepulauan Seribu has the misfortune to lie immediately offshore from a society scum of 20 million people and the combined effects of land-based pollution and sedimentation are wreaking havoc in the fragile reef ecosystem of Jakarta Bay. Between 1996 – 2003, the research result of collaboration among UNESCO, Indonesian Institute for Sciences (LIPI) and many universities (University of Indonesia, Bogor Agricultural University, and Nasional University) had reported that the condition of the coral reefs in Kepuluan Seribu was continuing to decline, to the point that some islands have totally disappeared (Figure 2) (UNESCO electronic press released, 2003) .

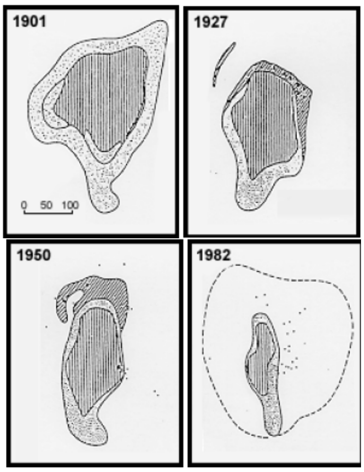

Figure 2: The vast evolution of Ubi Besar island map from 1901 – 1982 (Economic and Business Review Indonesia, 1997).

Part of the problem of coral reef degradation is the global warming and the El Nino effect have led to changed rainfall and runoff patterns and longer "dry-seasons" in Indonesia. Another part of the problem is 'anthropogenic perturbations' that affect the structure and health of the coral reef 'community'. They include archaic waste disposal systems and unsustainable resource management practices which lead to:

- Deposition of rubbish and sedimentation on the reefs,
- Physical destruction of reefs by fish bombing, cyanide fishing, coral mining, and dredging, and
- Decreasing water quality through industrial pollution and nutrient enrichment.

The worsening condition of coral reefs thus goes hand in hand with the unsustainable utilization of resources by local fishermen and specimen collectors and by the developers of private resorts, as well as the improper or inadequate disposal of waste by industry and local government authorities. The spiraling economic cost of reef degradation suggests that the improved management of coral reefs may be in Indonesia's best economic interest in the long term.

Protection of coral reefs is often presumed to conflict with economic development. However an economic study by the World Bank on the economic value of Indonesian Coral Reefs (1996) clearly indicates that the unsustainable exploitation and management of coral reef leads directly to considerable economic losses in the longer term. The divergence between short-term profits to private individuals and long-term costs to society can reach a ratio of 50:1 (The World Bank Report, *in* H. Cesar 1996).

Base on the vary problem ongoing in Kepuluan Seribu and Jakarta Bay, this research would be focused on 2 topics interest that are:

- Identification of mangrove, seaweeds and coral reef ecosystem condition.
- Shallow water mapping in Pari Islands

Kepuluan Seribu consist more than 100 islands, and due to the limitation of time and cost so the more detail study of coastal ecosystem will be carried out only on 2 islands as sample that represent problem and condition interest namely Pramuka as a municipal city of Thousands Islands and Pari islands as research island (Figure 3).

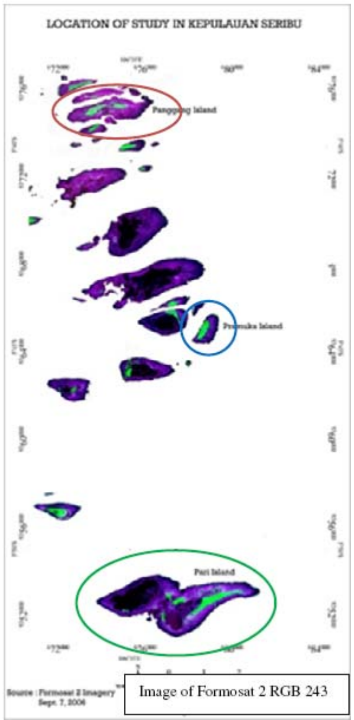

Figure 3: Harapan (red circle), Pramuka (blue circle) and Pari Islands (green circle) as Study area on Kepulauan Seribu, Province of Jakarta

2. DATASETS AND METHODS

2.1Identification Coastal And Marine

Since there are 2 datasets covering the area of study, the first step is to do a mosaic and balance of the histograms of the images. Classification for land cover of the three islands (Pari, Pramuka and Kelapa/Harapan) started with calculation principal component of the 4 bands and then calculates the classification. The classification method used was isodata unsupervised (before field survey) and supervised (after field survey).

A 3x3 majority filter was applied twice to the classified images to reduce speckle appearance. Field survey was done on both terrestrial landcover (vegetation and settlement) and underwater substrate using snorkeling, Line Transect (LIT) and square meter method.

2.2 Shallow Water Mapping

Using the algorithms of Lyzenga (1978) and Depth of Penetration (DOP) by Jupp (1988) to identify the Shallow Water Mapping can identify both a benthic form and water bathymetry. Navigation map and Field survey of water depth was carried out around Pari Island using echosounder (Garmin GPSMAP 178c) to compare between depth classification using Lyzenga and Jupp method and real depth of shallow water.

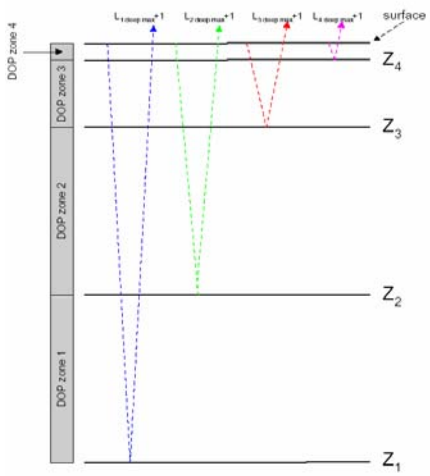

Figure 4: Illustration of Depth of Penetration (DOP) of wavelength characteristics for InfraRed, Red, Green and Blue channel in water column, Jupp (1988) and GPSMAP Garmin 178c.

Figure 5: Small Boat for survey depth and under water substrate type

3. RESULT AND DISCUSSION

3.1 Identification of Coastal Ecosystem

Classification result is presented in the following figures (Figures 6). Landcover and underwater substrate type of study area was classified into 5 classes. These classes are land and settlement, mangrove (inland area), mix substrate 1 (rubble and sand), mix substrate 2 (sand, dead coral reef, seagrass), mix substrate 3 (sand and seaweed/seagrass), coral reef condition, and deep water.

According to data on Table 1 showed that coral reef area and mangrove is found largest in the Pari Island. It is a good place as conservation for coastal ecosystem such as mangrove, coral reef and seagrass or seaweeds farming. Pari Island was dominated by mangrove species such as *Rhizophora stylosa* dan *Rhizophora mucronata*. Other type can be found such as *Avicennia alba*, *Sonneratia alba*, *Hibiscus tilliaceus* and *Bruguiera gymnorrhiza*.

Table 1. Area of class in 3 islands of study area (Pari, Pramuka and Kelapa)

	Percentage of Coverage		
Class	Pari	Pramuka	Kelapa
Coral reef (good & poor)	12	9	15
Sand and Seagrass	40	7	5
Sand, coral, and seagrass	30	33	20
Rubble and Sand	8	24	36
Mangrove	3	1	1
Land & settlement	7	23	23
	100	100	100

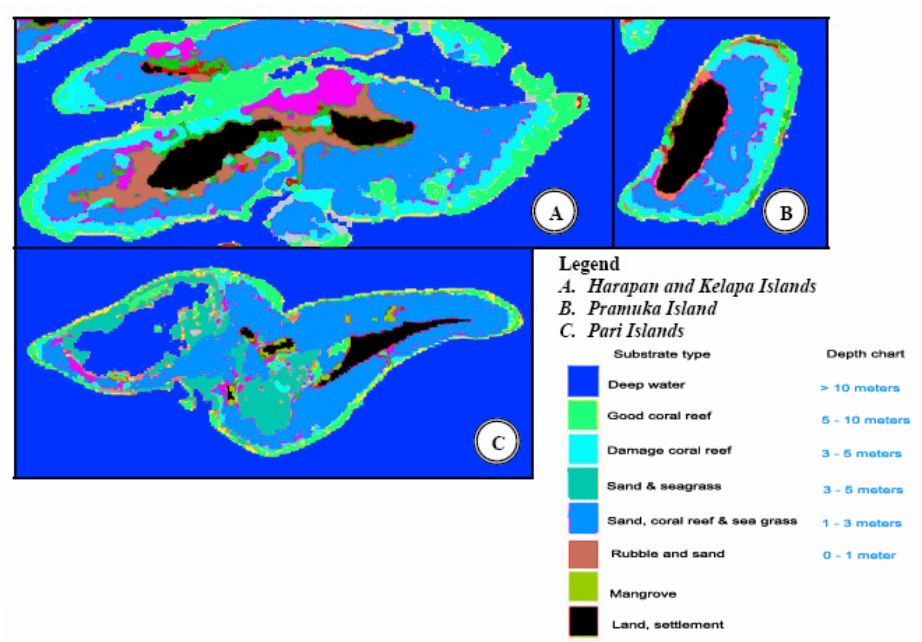

Figure 6: Result of landcover and underwater substrate type of three location study sample area at Kelapa/Harapan Islands, Pramuka Island and Pari Islands and compared to the Depth chart (Using Lyzenga Algorithm).

Harapan/kelapa and Pramuka Island are very dense population and centre of activity than Pari islands. According to the information from the local government, Pramuka island is the location for turtle conservation and one of place for Mangrove seedling. There are only 200 m2 classified as mangrove ecosystem that dominated by *Rhizhopora stylosa*. More detail about distribution and coverage of mangrove and seaweeds farming at Pari Islands as showed at table 2 and figure 7.

Table 2. Mangrove coverage at Pari Islands (in hectare)

Mangrove Class	ETM 1999	F2 2006	LC change	+/-
Rare	7.65	0.15	7.50	Decrease
Moderate	13.96	8.17	5.79	Decrease
Dense	8.32	6.08	2.24	Decrease
Land/Settlement	67.77	83.30	24.47	Increase
	97.7	97.7		

IPB survey in Ganjar (2007)

Mangrove Seedling at Pramuka Island

Mangrove ecosystem at Kongsi Island of Pari Islands

Seaweeds Farming near Kongsi Island of Pari Islands

Figure 7: Condition and Distribution of Mangrove Ecosystem and seaweeds farming around Study Location (Pramuka and Pari Islands)

According to early study of Fisheries Faculty of Bogor of Agriculture University using Landsat ETM at 1999, there are a difference of wide area of mangrove ecosystem at Pari Islands between Landsat ETM 1999 with survey and Formosat 2 2006 classification result. During 5 years, mangrove coverage in all class using (rare, moderate and dense) in decreasing condition, and the other side the land and settlement was increasing. This condition correlated to population growth and mangrove product direct using was increasing as socio-economic activity at Pari Islands.

Generally, Pari Peoples used mangrove wood as boat anchor pole, firewood, and pole of seaweeds farming. Existence of ecosystem mangrove very supported on nutrient supply and suitable habitat for fish and crab economical that gave beneficiary for socio-economic activity in this island. For instant, grouper fish has economic value ranging from 80.000 ~ 120.000 rupiah per kilo, crab has value ranging from 20.000 ~ 25.000 rupiah per kilo, and for seaweeds has value ranging from 5.000 ~ 15.000 rupiah per kilo.

To support mangrove conservation area at Penjaliran Island north of Kelapa/Harapan Islands, the forest local official has collaborate with local people to make seedling location at Pramuka and Pari Island (Figure 7). The institution gave a price about 1.500 rupiah per seed of mangrove tree. Other than, this island is managed by is LIPI (Indonesian Scientific Institute) as a research island since 1980's. This island will also become the location for seaweed mariculture research. But considering the location of this island to be nearest to Jakarta, the water and environment may not be conducive for healthy coral growth. Pari Island is a good study area for bathymetry because of the size of shallow water area.

Due to the limitation of time and seawater transportation support, detail coverage and distribution of coral reef ecosystem survey only carried out at Pari Islands. The percentage of coral reef coverage at Pari Islands showed at the following table 3. Line transect 1 and 2 was done at south of Pari Island (Figure 8) with 10 sample square plot where is in the LIT 2 that coral reef condition relative good that LIT 1. Refer to the TERANGI foundation (NGO of coral reef conservation activity) suggestion this location is quiet good for coral reef conservation area at Pari Islands.

Table 3. Percentage of Coral coverage at Pari Island

Station No		Hard Coral (%)	Dead Coral (%)
LIT 1	1	8.92	0
	2	40.07	26.04
	3	87.68	0
	4	24.19	0
	5	71.08	9.18
	6	13.32	5.77
Average		40.88	6.83
LIT 2	1	89.87	1.04
	2	83.51	11.07
	3	100	0
	4	46.74	26.30
Average		80.03	9.6

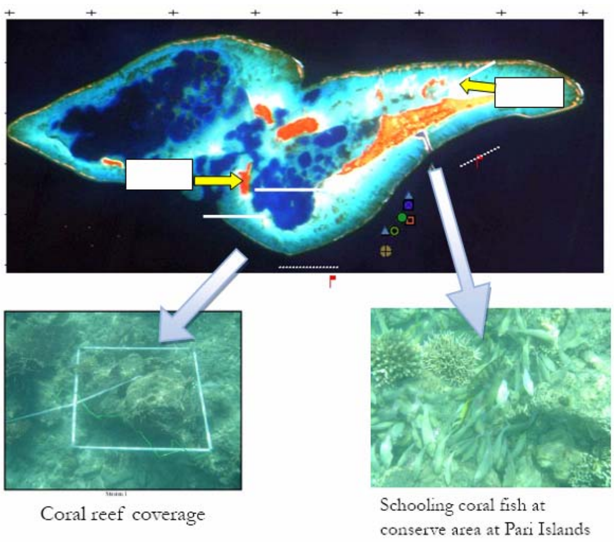

Figure 8: Line Transect (LIT 1 and LIT2) of coral reef coverage location at Pari Islands and sample of coral reef coverage using square meter transect.

4. SHALLOW WATER MAPPING

The Shallow Water Mapping Analysis derived from Formosat 2 images was carried out at Pari Islands. In this study algorithm of Lyzenga and DOP method of Jupp used to indicate depth chart in shallow water area mapping. Refer to Lyzenga analysis (Figure 9) was resulted 5 classes of depth chart range are (1) 0 -1 m; (2) 1 - 3 m; (3) 3 - 5 m; (4) 5 - 10 m and (1) > 10 m. And the other side, the depth chart of DOP method resulted 4 depth classes range namely (1) 0 - 3 m; (2) 3 - 15 m; (3) 15 - 25 m; and (4) > 25 m (Figure 10). The difference both

Lyzenga and DOP method based on initial approach. Lyzenga algorithm used green and blue channel in his linier interpolation formula to classify not only underwater substrate identification but also can used for shallow water mapping.

Whereas, DOP method was only focused on depth penetration based on the wave length characteristic of each channel using. For instants, blue is the far penetration in underwater column, than green, red and infrared channel. So we can

describe that the composition of depth penetration of 4 differences channel are blue (0 – 25 m) > green (0 – 15 m) > red (0 – 3 m) > infrared (0 – 1 m).

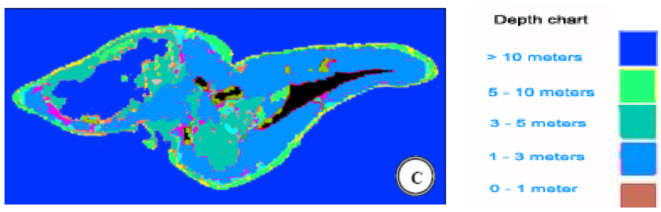

Figure 9: Result of depth chart using lyzenga Algorithm (1978) has resulted 5 depth classes.

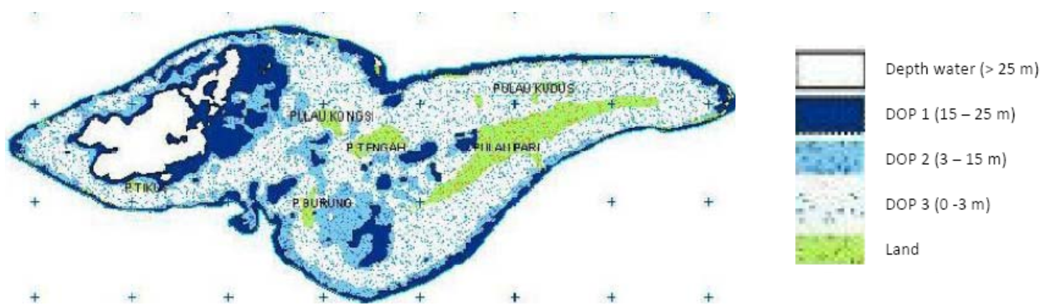

Figure 10: Result of depth chart using DOP of Jupp (1988) has resulted 4 depth classes.

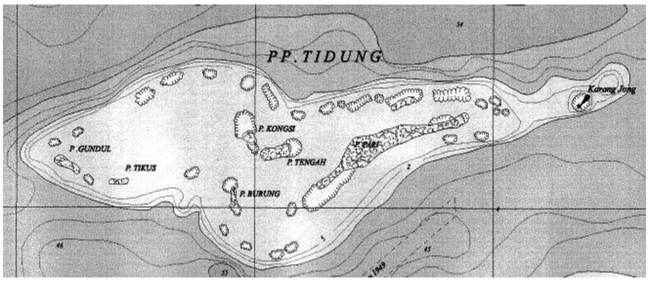

Figure 11: Bathymetry Map of Indonesia Seawater at Pari Islands at 1999, Bakosurtanal scale map 1 : 50.000.

Table 4. Zone of DOP division based on Pixel Digital Number.

Formosat 2 band	1	2	3	Zone DOP
DN of Maximum Depth	136	121	12	
If DN value (L) of pixel	≤136	≤121	≤12	then depth > 25.02 m
If DN value (L) of pixel	>136	≤121	≤12	then depth = 15.64-25.02 m (zone 1)
If DN value (L) of pixel	>136	>121	≤12	then depth = 3.32-15.64 m (zone 2)
If DN value (L) of pixel	>136	>121	>12	then depth = 0-3.32 m (zone 3)

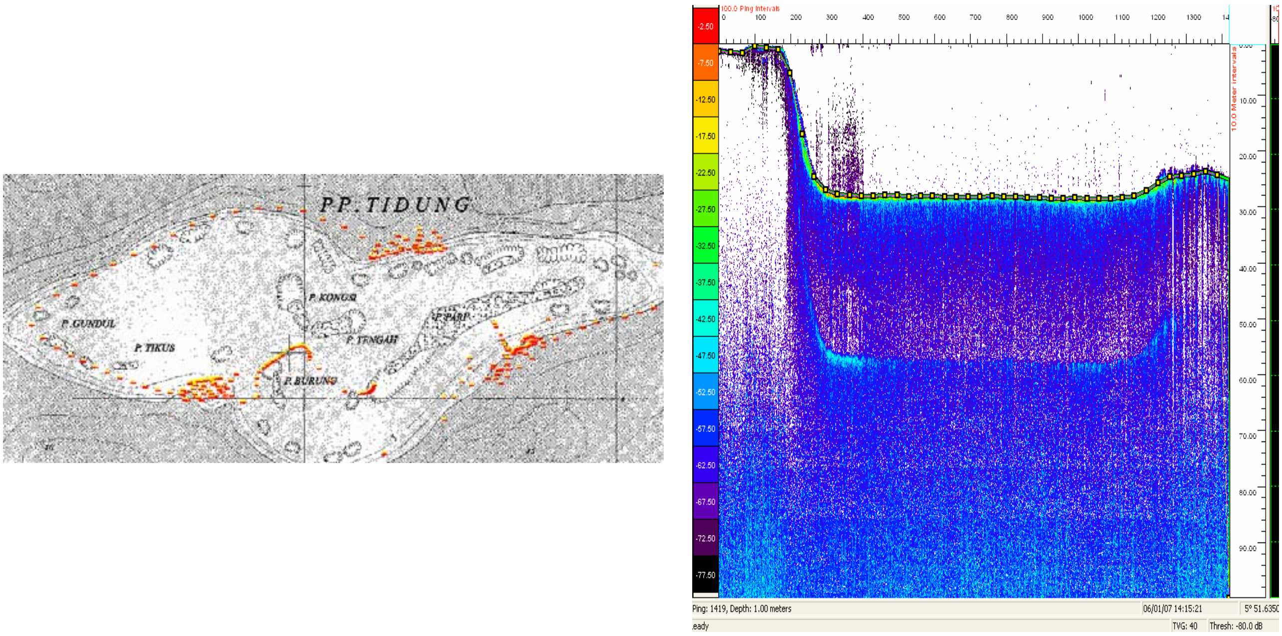

Figure 12: 293 points sample data and depth echogram data around Pari Islands.

Using confusion matrix to test the truth level between DOP zone range class and ground truth data from 293 points of depth sample data (Figure 12) indicated that the overall accuracy value is 99,87% (Table 5).

Table 5. Matrix Confusion to test the truth level of depth classification based on ground truth data.

Classification	Depth Reference					Total Row	UA (%)
	Land	Zona DOP 3	Zona DOP 2	Zona DOP 1	Depth Water		
Land	448	0	0	1	0	449	99.777
Zona DOP 3	0	1400	0	0	0	1400	100
Zona DOP 2	0	0	623	2	0	625	99.680
Zona DOP 1	1	0	2	683	3	689	99.129
Depth Water	0	0	0	3	6618	6621	99.455
Total Column	449	1400	625	689	6621	9784	
PA (%)	99.777	100	99.680	99.129	99.455		
Overall Accuracy (%)	99.877%						
Kappa coeff.	0.998						

5.CONCLUSION AND SUGGESTION

According to the study and final result about mapping of coastal ecosystem condition around thousands island at north Jakarta could be concluded that:

- Utilization FORMOSAT 2 satellite image data in this study very useful especially to identify coastal ecosystem condition in remote and small islands likes Thousand Islands Municipal at the North of Jakarta.
- Coral reef ecosystem condition at surrounding area of Pramuka and Harapan/Kelapa Islands has been threatening not only by local people activity such as coral mining and illegal fish but also by water quality degradation.
- Coverage area of mangrove and coral reef at Pari Islands is 3% and 12% of total coverage area. This condition is quiet good compare to mangrove and Coral reef ecosystem coverage at Pramuka and Harapan/Kelapa Islands.
- Mangrove coverage in Pari Islands was decreasing in all class (rare, moderate, and dense) due to the local population growth and direct use of mangrove wood by local people.
- Both Lyzenga Algorithm and DOP of Jupp method can use to indentify
- depth chart in shallow water mapping is very worthwhile.

For the next study to get a good reason which the main factor that caused coastal ecosystem degradation whether human socio-economic condition, biophysics factor or both, we suggest that economic valuation and socio-economic must be carried out. Whereas, to get the sub bottom profile, we could be used hyperspectral data (imagery or radiometer data) and high resolution image data such Quick bird (0,6 m) or IKONOS (1 m) to derive sub bottom substrate characteristic profile or spectral profile.

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A Remote Sensing Investigation on River Discharges and Their Influences to Marine Environmental Changes over Jakarta Bay

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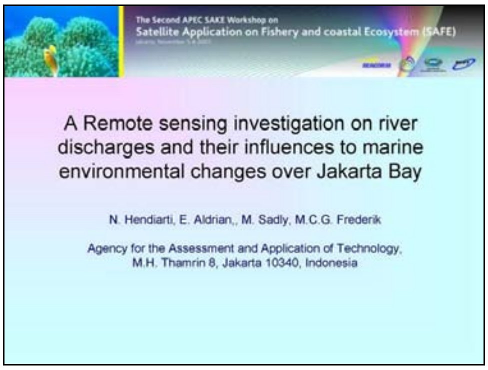
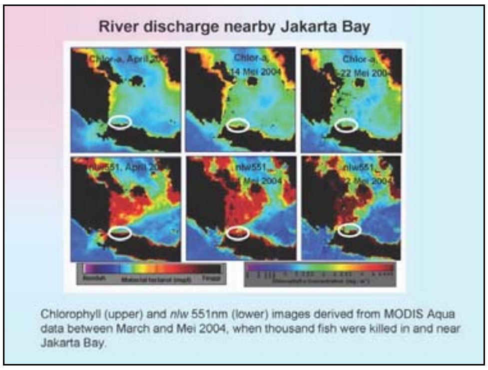
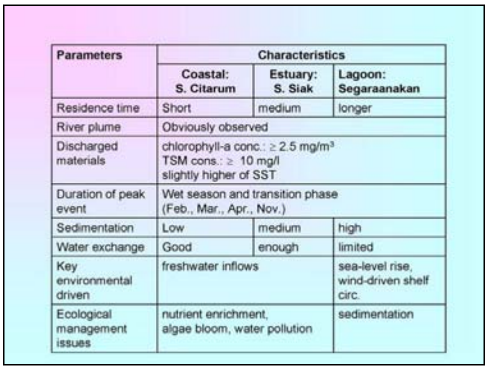
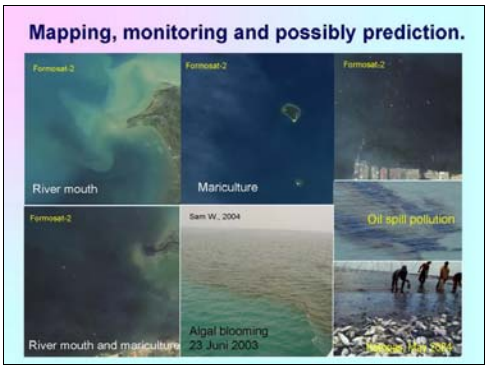
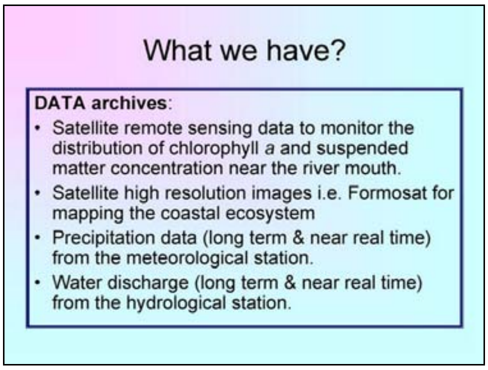




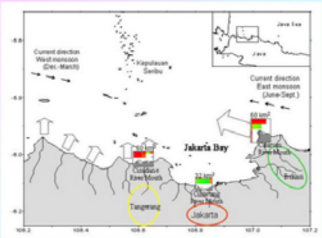


Parameters	Characteristics		
	Coastal: S. Citarum	Estuary: S. Siak	Lagoon: Segaraanakan
Residence time	Short	medium	longer
River plume	Obviously observed		
Discharged materials	chlorophyll-a conc.: ≥ 2.5 mg/m^3 TSM cons.: ≥ 10 mg/l slightly higher of SST		
Duration of peak event	Wet season and transition phase (Feb., Mar., Apr., Nov.)		
Sedimentation	Low	medium	high
Water exchange	Good	enough	limited
Key environmental driven	freshwater inflows		sea-level rise, wind-driven shelf circ.
Ecological management issues	nutrient enrichment, algae bloom, water pollution		sedimentation

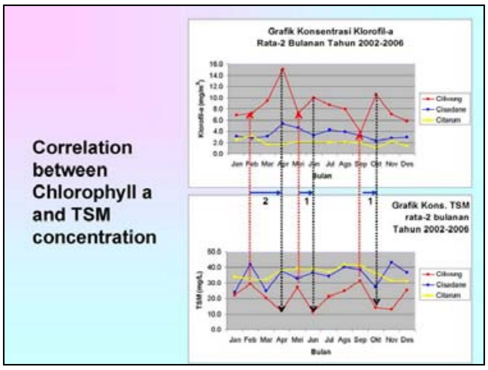


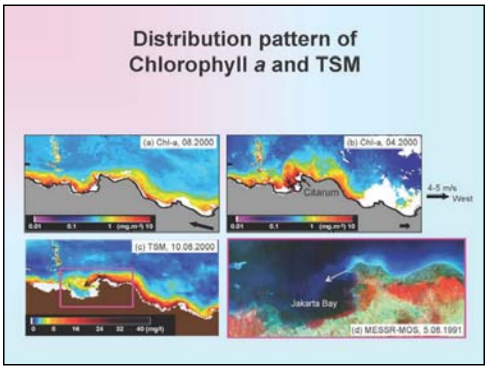


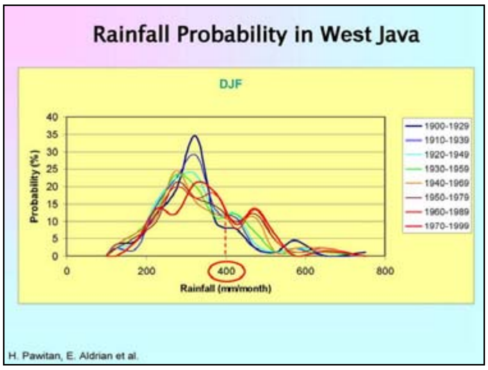
→ Subset areas for satellite images analysis

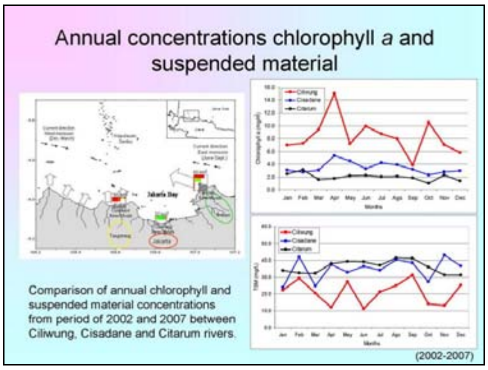


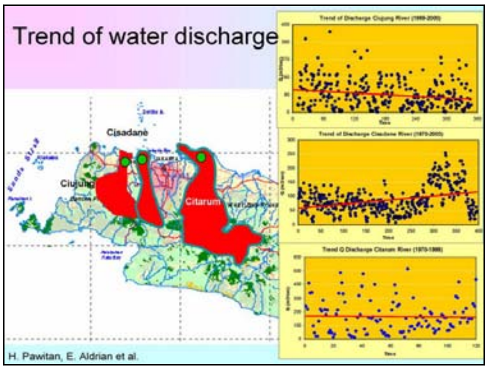
River Mouth - City	Coverage (km²)	Geographic Location
Cisadane - Tangerang	54 - 80	5.92 - 6.06° S ; 106.50 - 106.70° E
Ciliwung - Jakarta	36 - 48	6.02 - 6.12° S ; 106.76 - 106.90°E
Citarum - Bekasi	108 - 120	5.82 - 6.00° S ; 106.95 - 107.12° E





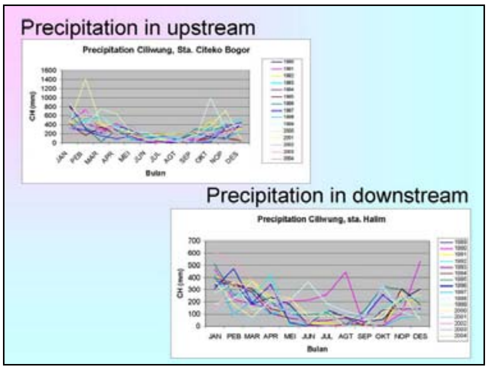


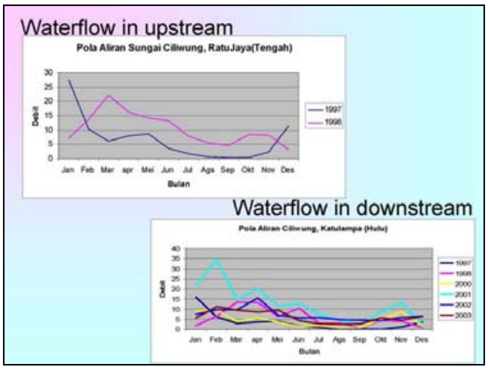


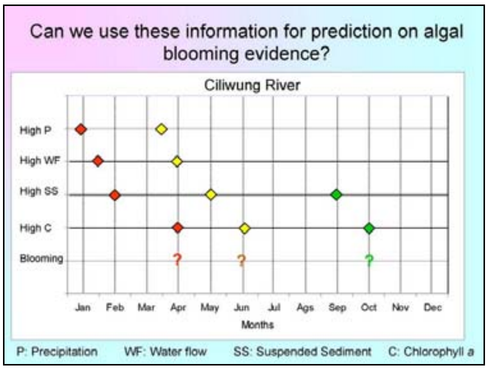


General characteristics of discharged waters near the river mouth from images

River Name	Suspended Material: Range Conc. (mg/L)	Suspended Material: Peak months	Chlorophyll *a*: Range Conc. (mg/ m³)	Chlorophyll *a*: Peak months	Distribution Pattern	Land use cover	Water Classification	Potential problem
Citarum (Eastern)	30 – 40	Slightly Apr. – Sept.	1 – 3	Slightly in Feb.	**No seasonal influence**	Bekasi city	Very turbid	Accretion
Ciliwung (Middle)	10 - 30	Feb., May, Sept.	4 - 15	Apr., Jun., Oct.	**Seasonal influence**	Jakarta city	turbid	**Algae blooming**
Cisadane (Western)	25 - 45	Feb., Apr.- Sept., Nov.	2 – 5,5	Apr., Jul.	**Small seasonal influence**	Tangerang city	Very turbid	Accretion




Waterflow in upstream
Pola Aliran Sungai Ciliwung, RatuJaya(Tengah)
Bulan
Waterflow in downstream
Pola Aliran Ciliwung, Katulampa (Hulu)
Bulan


Can we use these information for prediction on algal blooming evidence?
Ciliwung River
High P
High WF
High SS
High C
Blooming
Jan Feb Mar Apr May Jun Jul Ags Sep Oct Nov Dec
Months
P: Precipitation
WF: Water flow
SS: Suspended Sediment
C: Chlorophyll a


Thank you

Application of Ocean Color Remote Sensing for Monitoring and Mapping Total Suspended Matter: A Case Study in East China Sea

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ABSTRACT

In situ total suspended matter concentration (TSM) and the Sea-viewing Wide Field-of-view Sensor (SeaWiFS)-derived normalized water leaving radiance (nlw) data were used to examine to what degree the current SeaWiFS ocean color data in conjunction with TSM algorithms can be used to assess TSM in the East China Sea (ECS). In general, current SeaWiFS ocean color data combined with local TSM algorithms could explain the variability of in situ TSM by < 80% with a single band algorithm at 555 nm seemed to be an optimal algorithm for retrieving TSM from the SeaWiFS ocean color sensor. Estimated TSM showed a clear seasonal variation in the ECS. A remarkable high TSM was observed over the shallow region during the prevailing strong wind in winter and disappeared during the calm condition in summer, suggesting that the seasonal variation of TSM in the ECS was modulated by the East Asian monsoon wind systems and bottom topographic feature. Flow pattern of the Yangtze River diluted water during the severe summer flood in 1998 could also be traced from the summer TSM image. This study showed the potency of using SeaWiFS ocean color data to monitor both spatial and temporal variations of TSM in the ECS, the variability of which seemed to be largely influenced by monsoon system, bottom topography, and the Yangtze River discharge.

1. BACKGROUND

The Asia's longest Yangtze River is the main source of freshwater discharge, by which nutrients and sediment are transported into the East China Sea (ECS), one of the most productive waters in the world's ocean. The Yangtze River has been undergoing long-term ecosystem modifications due to anthropogenic perturbations such as the increase in nitrogen fertilizer application and the long-term dam constructions in the Yangtze River basin. More than 50,000 dams, including the world's largest hydroelectric dam, Three Gorges Dam, have been built since 1950 in the Yangtze River basin.

It has been reported that due to the dam constructions since 1950s in the Yangtze River basin, sediment discharged into the ECS has decreased more than 40% compared to that in the 1950s – 1960s period despite an increase in the Yangtze River discharge (e.g., Yang et al., 2006;Xu et al., 2006). The transport of sediment from river into the marine ecosystem is of critical important because of its co-occurrence with nutrients, carbon materials, and pollutants. Suspended sediment also influences light availability in the water column that in turn will influence biological production. This may have a further impact on the biogeochemical processes in the ECS (e.g., Jiao et al., 2007).

It is thus crucial to routinely monitor temporal variation and map spatial extent of biogeochemical variable than can be directly influenced by changes in sediment load, such as total suspended matter concentration (TSM). Ship-borne TSM observation however is not feasible especially when deals with the high spatial and temporal resolutions.

Satellite remote sensing with its synoptic observation capability is the only reasonable tool for monitoring TSM variation with the high spatial and temporal resolutions. The long-wavelength bands (e.g., 555 nm and 670 nm) in the visible spectrum from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) ocean color sensor are commonly used as an index of TSM and thus to map its spatial extent, as well as its temporal variation (e.g., Salisbury et al., 2004; Thomas and Weatherbee, 2006). This is because water reflectance from the long-wavelength bands can be obviously enhanced from the water with high TSM.

With the use of bio-optical datasets shared under the research collaboration between Korea, China and Japan, and supported by UNDP/GEF Yellow Sea Large Marine Ecosystem (YSLME) Project, this preliminary study is therefore to investigate the relationship between TSM and the SeaWiFS normalized water leaving radiance bands 555 nm and 670 nm (hereinafter referred to as nlw 555 and nlw 670, respectively). The study merely aims at investigating to what degree current SeaWiFS ocean color data in conjunction with TSM algorithms can be used to monitor spatial and temporal variations of TSM in the ECS.

2. MATERIALS AND METHODS

2.1. In situ and satellite data

In situ TSM data from the bio-optical data sharing used in this study were collected within the period from 1998 through 2006 covering all seasons. Despite more than 750 in situ TSM data are available from the shared bio-optical datasets, we only analyzed 160 pairs of in situ TSM and satellite data for match-up due to the cloud coverage. The region where the 160 in situ TSM data were collected encompassing both deep clear open ocean and shallow turbid coastal water and thus optically encompassing both Case 1 and Case 2 waters (Fig.1). In situ TSM used in this study were within the range of 0.04 – 22.86 mg l^{-1}.

With the use of SeaWiFS Data Analysis System (SeaDAS) version 5, nlw 555 and nlw 670 were derived from the SeaWiFS level 2 products. For the periods of 1997 – 2004 and 2005 – 2006 we used respectively, SeaWiFS daily merged local area coverage (MLAC) with 1 km resolution and daily global area coverage (GAC) with 4 km resolution.

2.2. Data match-up

SeaWiFS-derived nlw 555 and nlw 670 to be compared with the in situ TSM are defined as the median values from 3 x 3 boxes the center of which is the in situ TSM sampling point. Rather than the mean value, the use of median value has an advantage as it is less sensitive to the outlier value than the mean one.

The relations between nlw 555, nlw 670 versus in situ TSM are then plotted. The least squares fittings are applied to obtain the equation that best fits to the emerged relationships. TSM is then computed to be compared with in situ TSM. The capabilities of previous local and SeaWiFS standard TSM algorithms in assessing TSM in the ECS are also investigated.

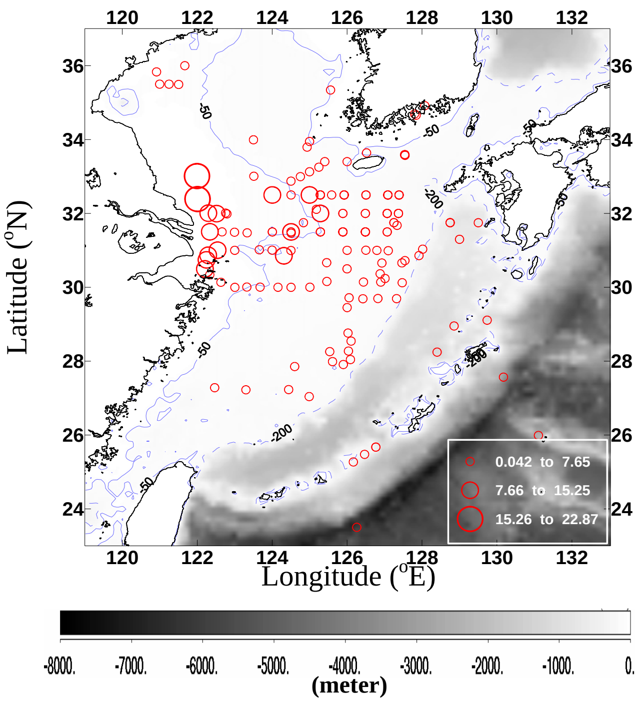

Fig. 1: Bathymetric map of the ECS over which the sampling points (red circles) for TSM are overlaid. The size of the red circles represents the magnitude of TSM as indicated in the legend. Solid and dashed blue contours indicate 50 m and 100 m isobaths, respectively. The bottom depth is shown as negative values (see the scale bar).

3. RESULTS AND DISCUSSION

3.1. Relationship between SeaWiFS nlw 555, nlw 670 and in situ total suspended matter

With the in situ TSM within the range of 0.04 – 22.86 mg l^{-1}, remarkable increases of both nlw 555 and nlw 670 could be observed with the increase of in situ TSM (Fig. 2). Applying a linear function, the variation of in situ TSM could significantly be explained better by nlw 670 (75%) than that by nlw 555 (68%). But by applying an exponential function, nlw 555 could assess in situ TSM variation better (79%) than nlw 670 (51%).

Applying a multiple linear regression relation expressing TSM as a function of both nlw 555 and nlw 670 (TSM = 0.48 + 0.29 nlw555 + 5.91 nlw670, $R^2 = 0.76$, $p < 0.0001$) could not improve the accuracy in assessing TSM. Ahn et al. (2001) also showed that TSM algorithm using a single band at long-wavelength band provided a better result than that using multiband.

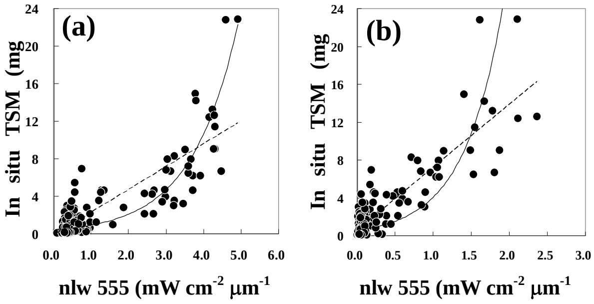

Fig. 2: (a), Scatter plot of nlw 555 versus in situ TSM. The dashed line indicates linear least squares fit to the data (TSM = 2.44 nlw555 - 0.18, $R^2 = 0.68$, $p < 0.0001$). The solid curve indicates the exponential least squares fits to the data (TSM = 0.41 $e^{0.81\ nlw555}$, $R^2 = 0.79$, $p < 0.0001$). (b), The same as (a), except for nlw 670. Linear least squares and exponential least squares fits to the data are respectively, TSM = 6.62 nlw670 + 0.60 ($R^2 = 0.75$, $p < 0.0001$) and TSM = 0.57 $e^{1.95\ nlw670}$, $R^2 = 0.51$, $p < 0.0001$).

It has been commonly reported that the water reflectance of long-wavelength band is non-linearly or exponentially correlated to TSM (e.g., Nechad et al., 2003; Salisbury et al., 2004). It is therefore in the present state, the exponential function and nlw 555 respectively, seemed to be the effective model and band to be used for estimating TSM in the ECS from the SeaWiFS sensor, at least within the observed TSM range (0.04 – 22.86 mg l^{-1}). Ahn et al. (2001) also suggested the 555 nm band as an alternative band for retrieving TSM from SeaWiFS, as the optimal band (625 nm) he suggested is not available in the SeaWiFS channels.

3.2. Comparison of present study, local and SeaWiFS standard total suspended matter algorithms

In order to know the capability of current SeaWiFS ocean color data in conjunction with TSM algorithms for retrieving TSM in the ECS, we also analyzed several established local TSM algorithms which were also constructed for the ECS region, to be compared with the single band (555 nm) algorithm resulted from the present study.

Among the local algorithms is the multiband ratio proposed by Tang et al. (2004) with the equation of log(TSM) = 0.58 + 23.84 (nlw555 + nlw670) – 0.48 (nlw490/nlw555). The other algorithms to be verified are Ahn et al.'s (2001) single band algorithms from SeaWiFS bands (555 nm and 670 nm) with the formulations of TSM = 3.18 $(nlw555)^{0.95}$ and TSM = 6.38 $(nlw670)^{0.69}$. Standard SeaWiFS TSM algorithm embedded in the SeaDAS msl12 code was also verified.

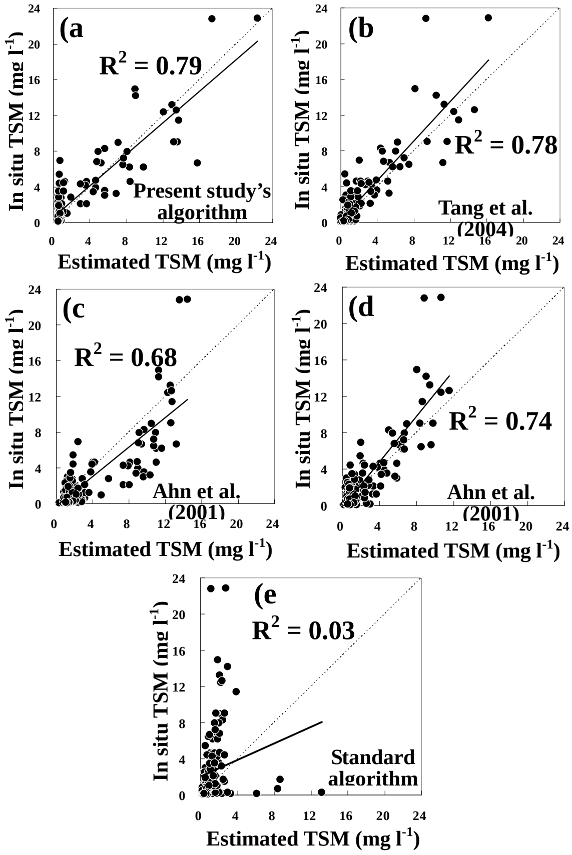

Fig. 3: Scatter plot of estimated versus in situ TSM. The estimated TSM in (a), (b), (c), (d) and (e) were computed based on the present study-derived exponential function of single band algorithm, Tang et al.'s (2004), Ahn et al.'s (2001) nlw555 single band, Ahn et al.'s (2001) nlw670 single band and SeaWiFS standard algorithms, respectively. The variability of the in situ TSM explained by each algorithm is represented by R^2 values. Dashed and solid lines are respectively, the unity and linear regression lines, respectively.

In general, TSM in the ECS could be predicted by the current SeaWiFS ocean color data in conjunction with TSM algorithms both yielded from the present study and previously established ones by less than 80% (Figs.3a - 3d). SeaWiFS standard TSM algorithm however did not work well in the ECS region (Fig. 3e). Such inaccuracy of standard algorithm might be due to the optical property differences between the ECS and the region from which the data were collected to develop standard algorithm (mostly Case 1 waters).

3.3. Seasonal variation of total suspended matter

The ecosystem of the ECS is largely influenced by the East Asian monsoon system with the strong northeasterly wind prevails during winter and weak southwesterly wind prevails during summer. In addition, the feature of bottom topography may also modulate the seasonal variations of physical and biogeochemical variable in the ECS (e.g., Tseng et al., 2000).

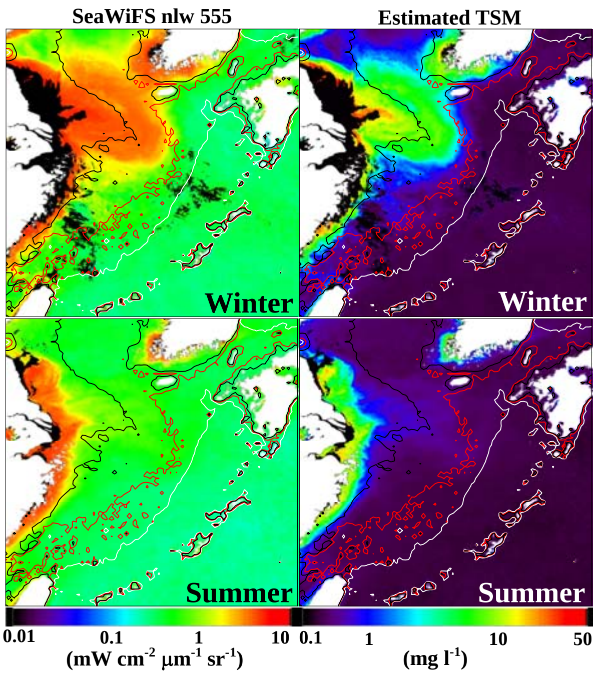

Fig. 4: Images of SeaWiFS-retrieved nlw 555 (left) and TSM estimated using present study's algorithm (right) during winter (upper) and summer (lower) in the ECS. Black, red and white contours are 50 m, 100 m and 200 m isobaths, respectively. The nlw 555 and TSM images are based on the 1998 SeaWiFS data.

The East Asian monsoon wind systems and bottom topographic feature seemed also to influence the seasonal variation of TSM in the ECS. During winter, high nlw 555 and thus TSM were clearly observed in the shallow region of the ECS. The pattern distribution of this high TSM during winter seemed to follow the tongue-like shallow bathymetric feature indicating that the prevailing strong winter wind re-suspended shallow bottom sediment, resulting in high TSM during winter (Fig. 4). The tongue-like high TSM pattern disappeared in summer associated with the less sediment re-suspension due to the weak southwesterly wind during summer.

Summer is flood season in the Yangtze River valley, particularly during the summer 1998 when the catastrophic flood occurred. Based on the ship-borne observations, Wang et al. (2003) showed that during this catastrophic flood period (August 1998) the Yangtze River diluted water flowed to the northeast toward the Cheju Island in a tongue-like shape, and then it diffused southeastward in the area east of 125.5^{o}E, and eastward continually. Such a flow of Yangtze River diluted water could also be traced from the summer TSM image (Fig. 4).

Despite using SeaWiFS standard or dark pixel atmospheric correction which usually fails to retrieve water leaving radiance in the Case 2 waters, this preliminary study indicated that the ocean color data in conjunction with TSM algorithms can be used to assess TSM in the ECS. Conducting atmospheric correction scheme for turbid water (e.g., Lavender et al., 2005) and validating TSM algorithm with more datasets are expected to improve TSM retrieval from SeaWiFS ocean color sensor, and thus allowing us to better understand the spatial and not only the seasonal, but also the interannual variations of TSM, as well as the future scenario of TSM variation related to the completion of the Three Gorges Dam in the middle stream of the Yangtze River in 2009.

4. SUMMARY

Analyzing 160 pairs of in situ TSM and SeaWiFS ocean color data, significant relationships between nlw 555, nlw 670 and in situ TSM emerged. In general, current SeaWiFS data combined with present study's and previously established TSM algorithms could explain the variability of in situ TSM by < 80%, whereas SeaWiFS standard algorithm could not work well in the ECS. A single band algorithm at 555 nm, rather than at 670 nm, seemed to be the effective algorithm for retrieving TSM from the SeaWiFS ocean color sensor.

Applying the present study's single band equation with the SeaWiFS-derived nlw 555, a seasonal variation of TSM was clearly observed. The magnitude and spatial extent of TSM variation seemed to be influenced by the East Asian monsoon wind systems, bottom topographic feature, and the Yangtze River discharge.

Despite using standard atmospheric correction, this preliminary study showed the potency of using ocean color data to monitor both spatial and temporal variations of TSM in the ECS. Improving atmospheric correction and TSM algorithm are expected to obtain a better accuracy in retrieving TSM from the SeaWiFS ocean color sensor.

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