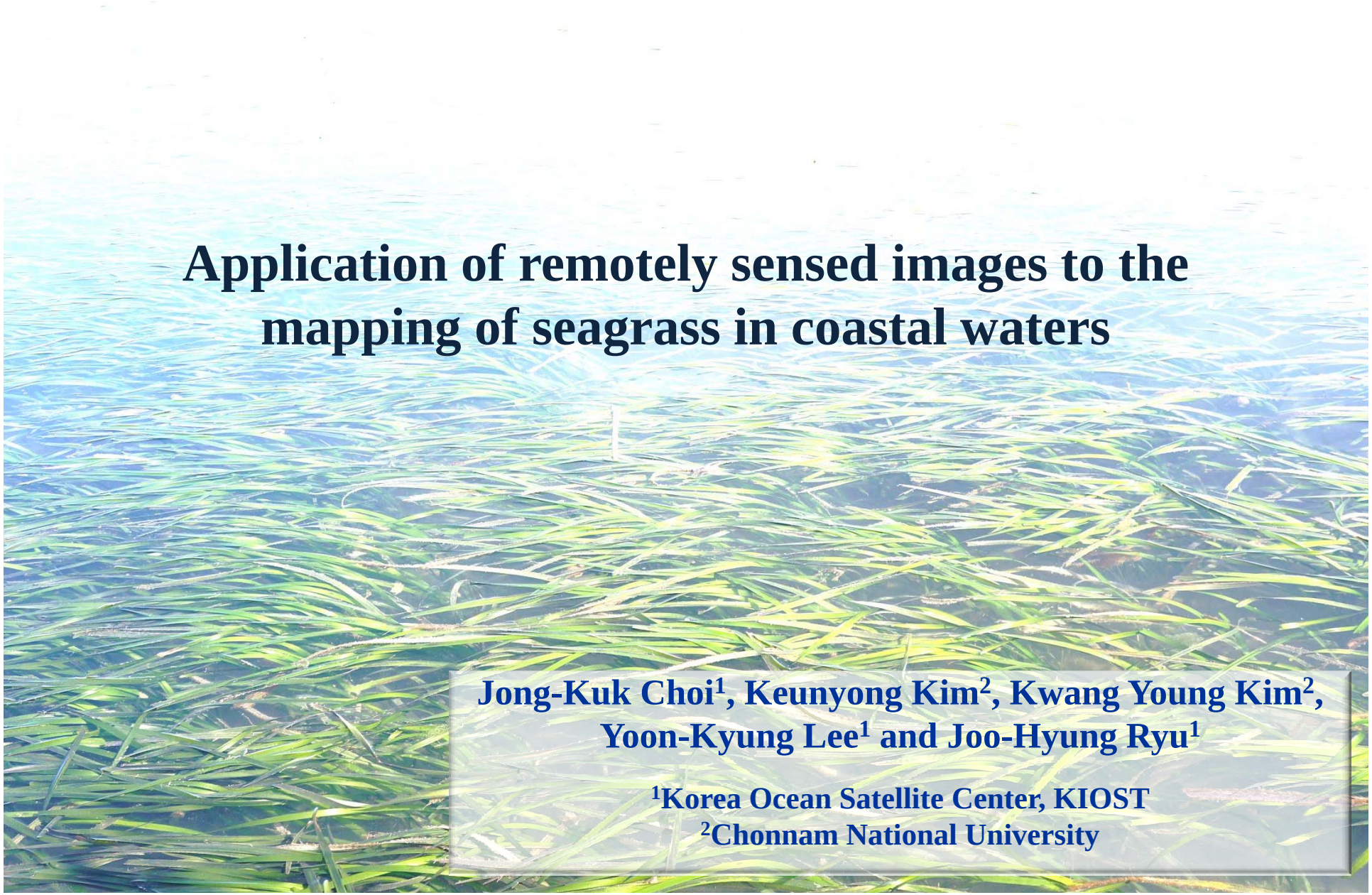
Expert Meeting on Marine Biodiversity and Eutrophication in the Northwest Pacific Region
(5-6 August 2013, Toyama, Japan)



Application of remotely sensed images to the mapping of seagrass in coastal waters

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- ❖ Seagrass mapping in the Korean coastal water
- ❖ Tidal flat application
- ❖ Coral reef habitat mapping
- ❖ Geostationary Ocean Color Imager (GOCI)

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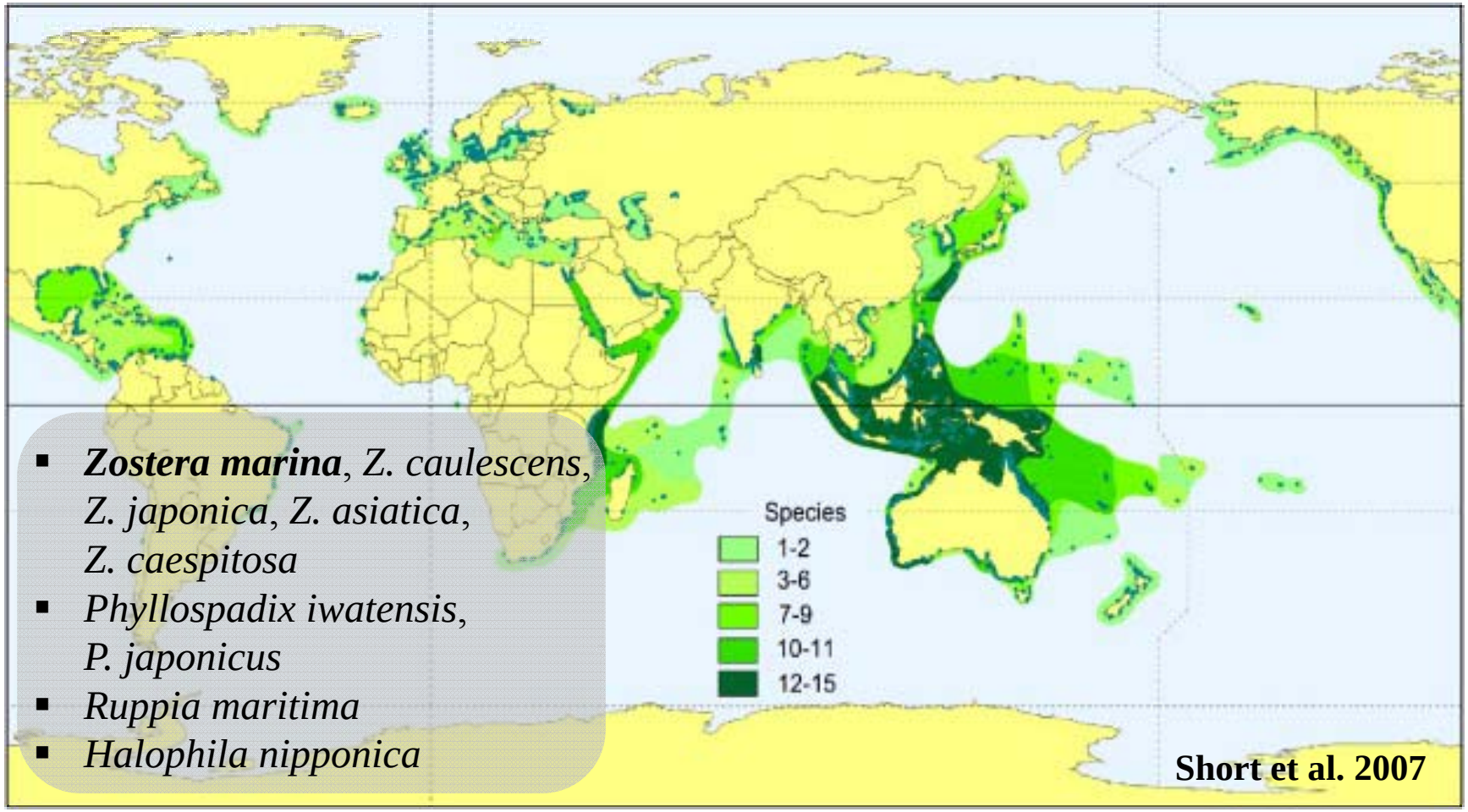
- ❖ **Seagrass mapping in the Korean coastal water**
- ❖ **Tidal flat application**
- ❖ **Coral reef habitat mapping**
- ❖ **Geostationary Ocean Color Imager (GOCI)**

Global seagrass diversity and distribution



- ***Zostera marina***, *Z. caulescens*, *Z. japonica*, *Z. asiatica*, *Z. caespitosa*
- *Phyllospadix iwatensis*, *P. japonicus*
- *Ruppia maritima*
- *Halophila nipponica*

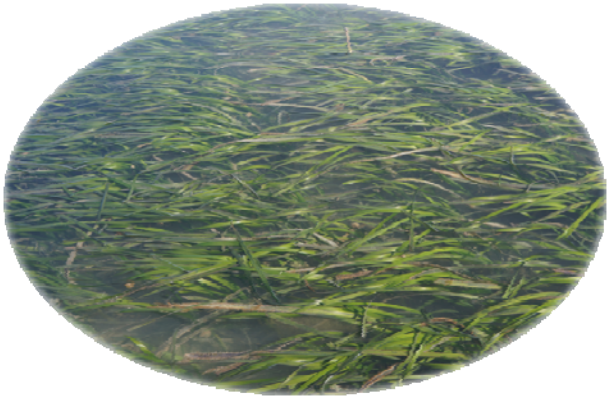
- **4 genus, 5 species inhabit in Korea**

Why seagrass beds are important?

- Provides habitats of a variety of coastal organisms
- Produces organic clasts through photosynthesis
- Dominates substances circulation in the coastal ecosystems by secreting dissolved organic matter
- Provides fields for spawning and growth of the fish of large economic value
- Stabilizes bottom sediment by controlling their movement and suspension

→ *very large ecological value in the coastal region*

Mapping seagrass



Seagrass beds

Physical Sampling

- Due to high ecological value of seagrass beds, studies on its distribution, production, etc. have been continuously carried out in Korea
- However, seagrass distribution and biomass research has been carried out in some limited areas and depth because it relies on the direct sampling method through scuba diving

Methods for mapping seagrass

Hydroacoustics

Aerial & Satellite image

Underwater Videography

- To overcome the difficulties in the research on the distribution and spatiotemporal changes of seagrass, diverse techniques like underwater photography, underwater acoustics and remote sensing are employed
- Underwater photography using video camera has an advantage in that it can identify species, density, and plant health status with relatively low cost. However, data collection is limited due to a narrow range of observation, and in particular, the accuracy is influenced by the turbidity of the water, which lead to difficulties in analyzing whole vegetated sites.

Methods for mapping seagrass

Hydroacoustics

Aerial & Satellite image

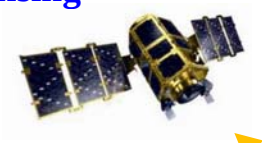
Underwater Videography

- Recently aerial photography is widely used. It can obtain images of wide area, but due to the large cost it is not suitable for repeated temporal analysis for a particular region
- Remote sensing technique is an effective way for the study on the temporal and spatial distribution of algae that live in the broadband

Aims of study

Satellite remote sensing method

- Mapping
- Wide area
- Time-series data

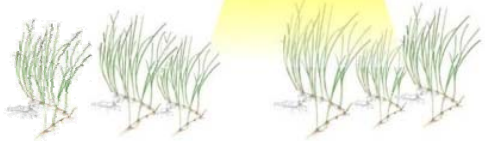


Hydroacoustic method

- Height
- Coverage
- Mapping

Direct sampling method

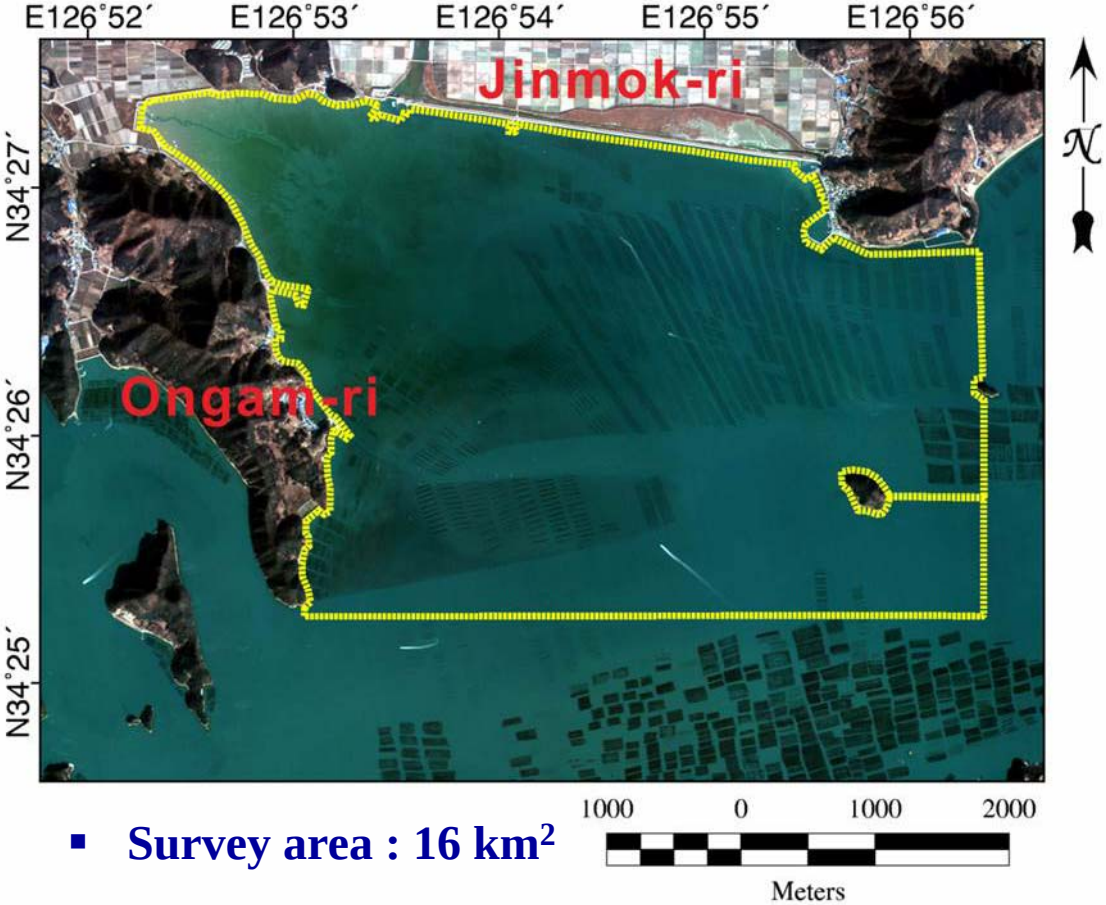
- Height
- Coverage
- Biomass



Application of a satellite image time-series to map changes of seagrass beds

Evaluate the accuracy of satellite image for mapping seagrass beds in turbid and shallow coastal waters

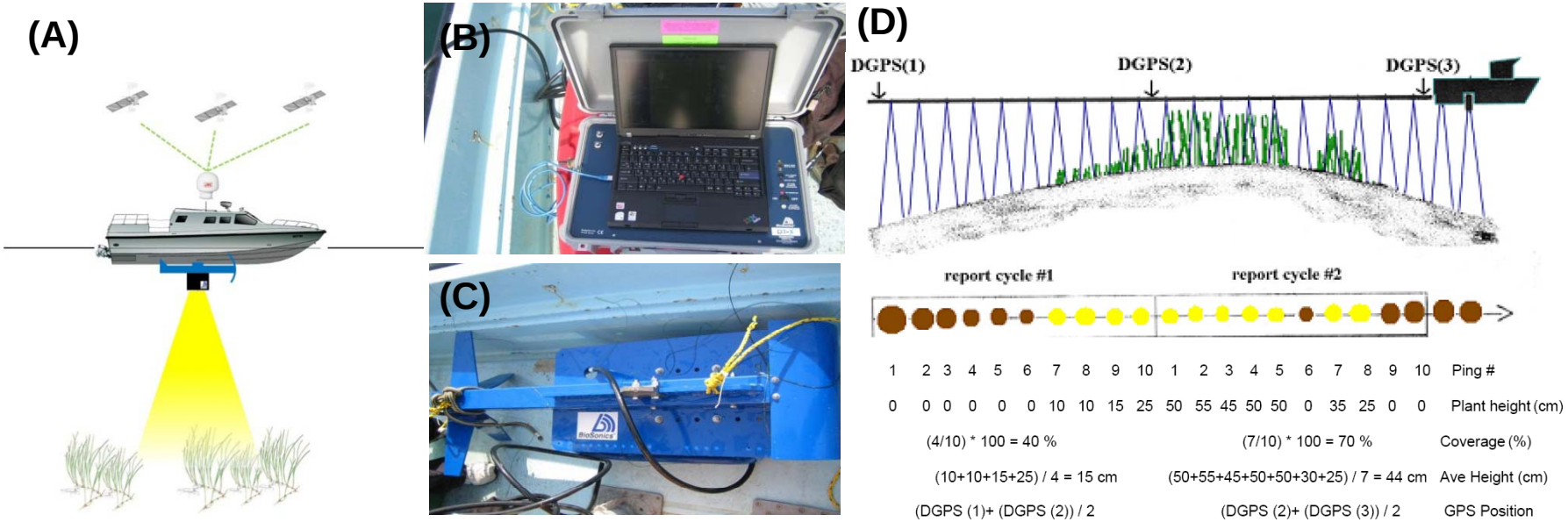
Study area



- **Survey area : 16 km^2**

Zostera marina, *Z. caulescens*, *Halophila nipponica*

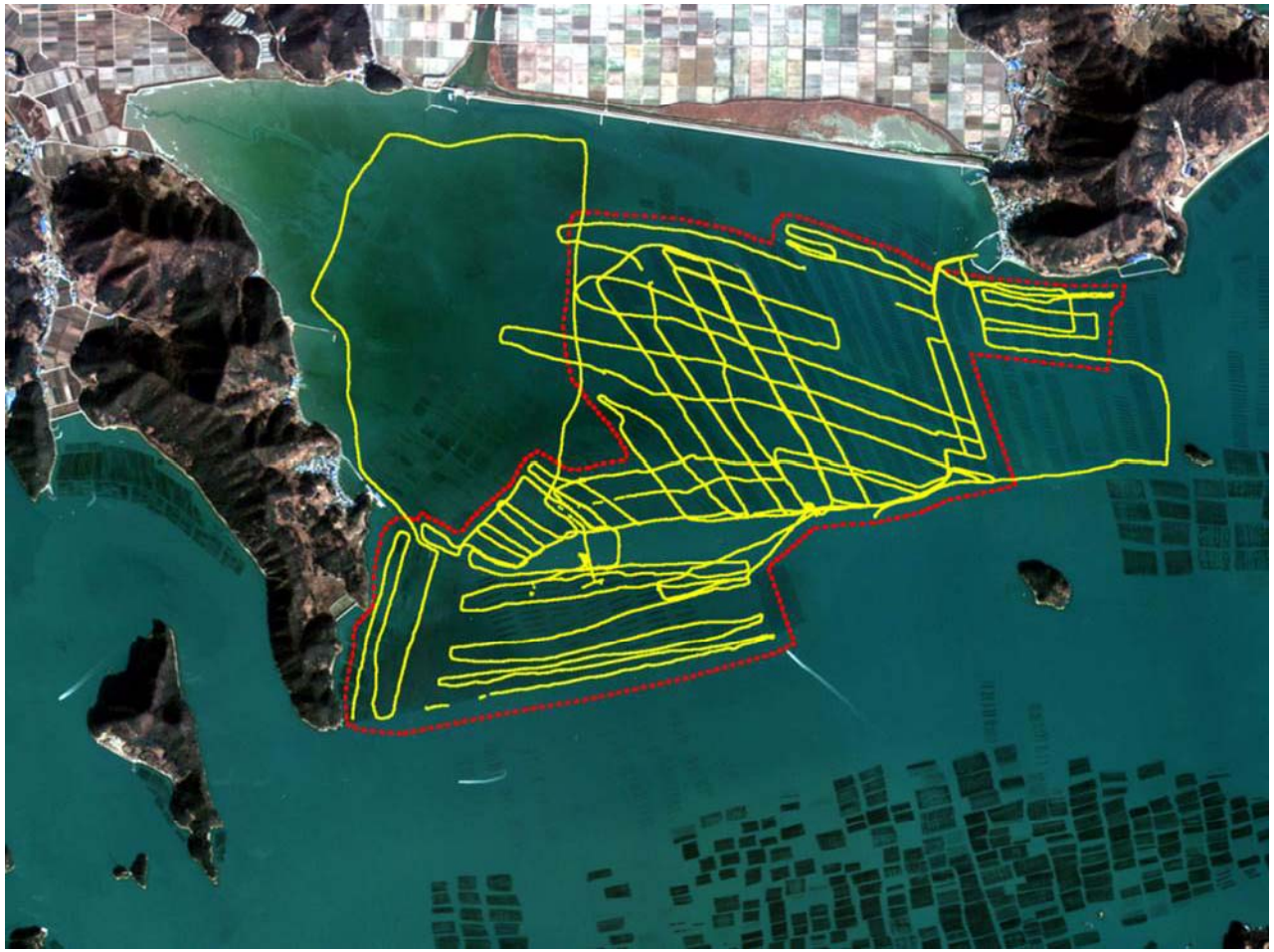
Hydroacoustic survey



- **Equipment**
  - Digital Echosounder (Biosonics, USA)
    > beam width : 6°(420KHz)
    > pulse width : 0.1 ms
    > pings rates : 5 pings s^{-1}
    > ship speed : 2 m s^{-1}

Accurate positioning of the surveyed location was secured
- DGPS (horizontal error : ± 5 m)

Hydroacoustic transect



Lines of hydroacoustic survey

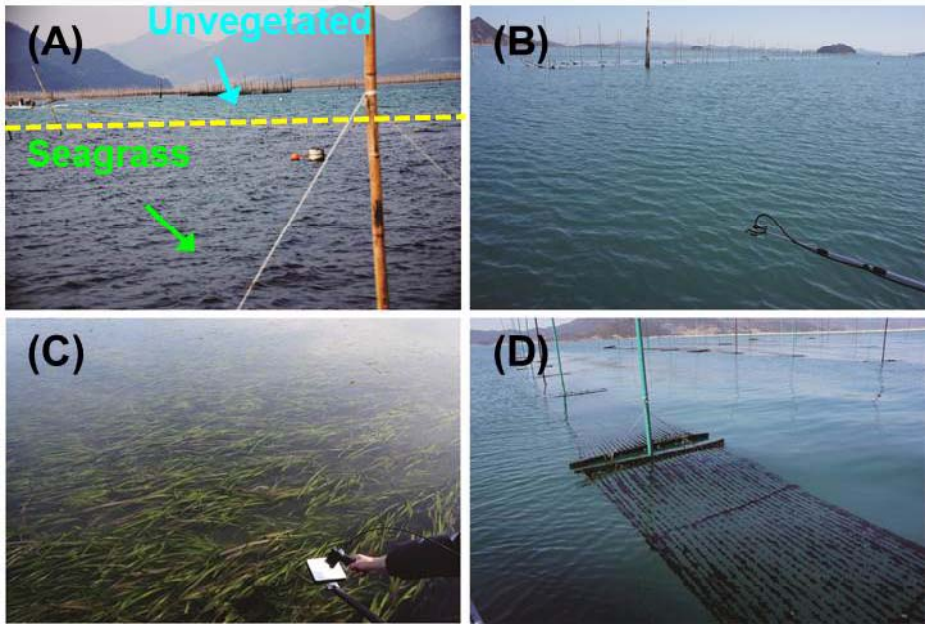
Specific area for satellite image analysis

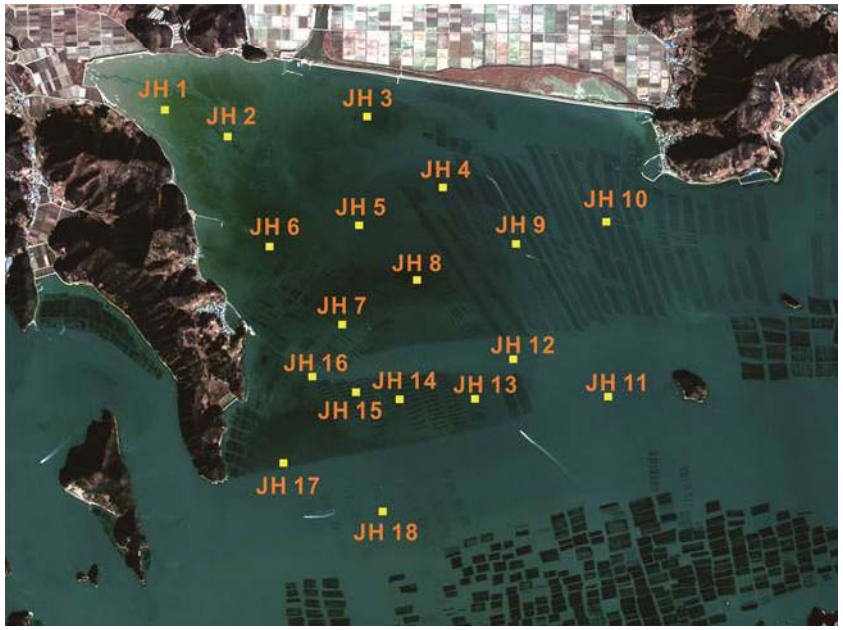
Analysis of satellite image

Satellite scene	Date	Time	Low tide	
Landsat 5TM	1995. 11. 27	10:05	07:00 (042)	13:00 (369)
Landsat 5TM	1999. 3. 11	10:44	05:00 (250)	11:00 (170)
Landsat 5TM	2000. 3. 13	10:39	09:00 (136)	15:00 (256)
Landsat 5TM	2001. 4. 1	10:45	09:00 (145)	14:00 (237)
Landsat 7ETM	2002. 2. 7	10:54	07:00 (275)	14:00 (146)
Spot-4	2004. 2. 27	11:38	09:00 (141)	14:00 (254)
Kompsat-2	2007. 12. 20	10:36	07:00 (301)	13:00 (129)
Aster	2011. 3. 27	11:24	11:41 (159)	16:46 (206)
Kompsat-2	2012. 1. 7	10:30	09:13 (321)	15:42 (108)

- **Image classification**
  - Mahalanobis distance classification (MDC) : one of the cluster analysis

Field observation & *in situ* spectral measurement





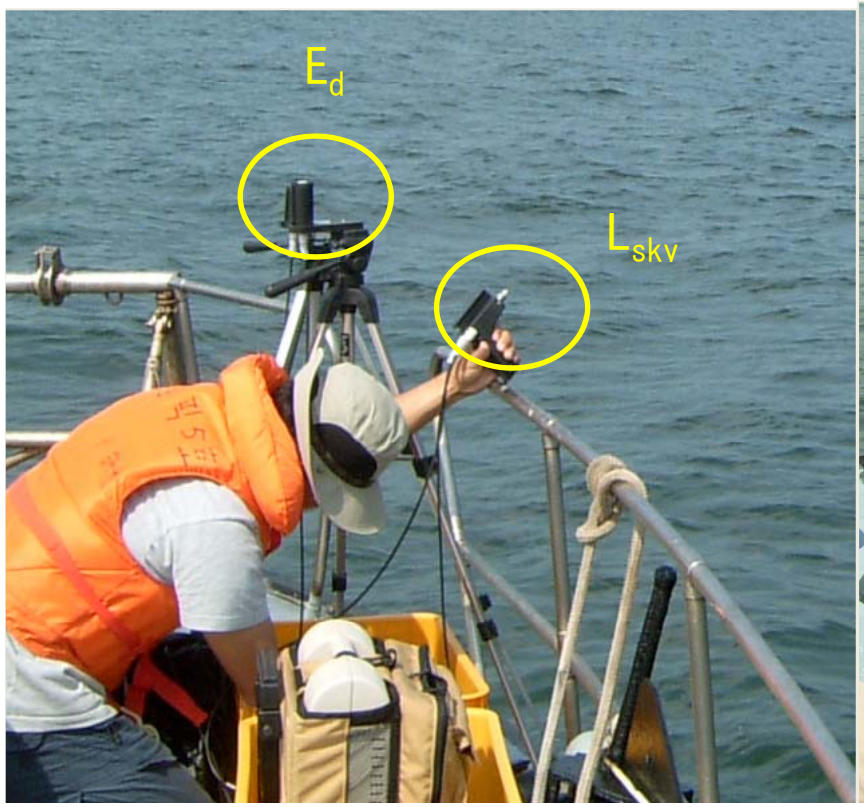
(A) Seagrass beds & unvegetated area
(B) Unvegetated seawater
(C) Seagrass beds
(D) Seaweed aquaculture

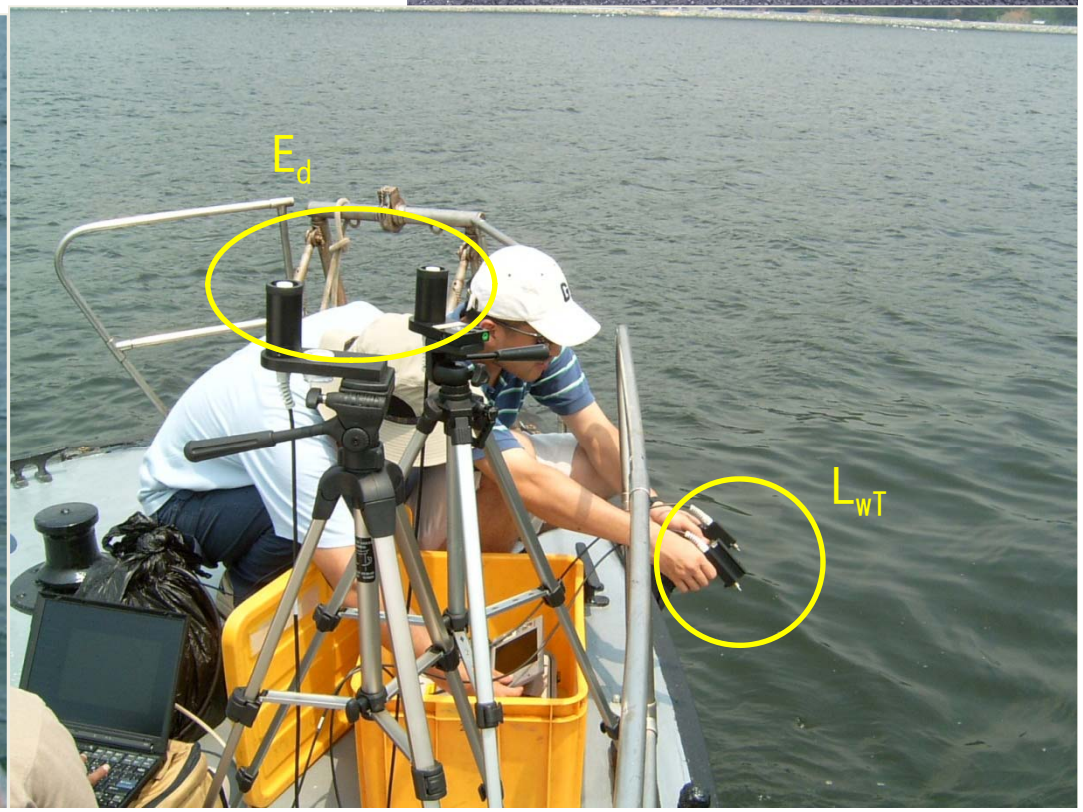
- Field observation
  - 2012. 1. 17-20
  - 2012. 2. 20

- Equipment
  - FieldSpec3 (ASD Inc., USA)

Optical data measurement

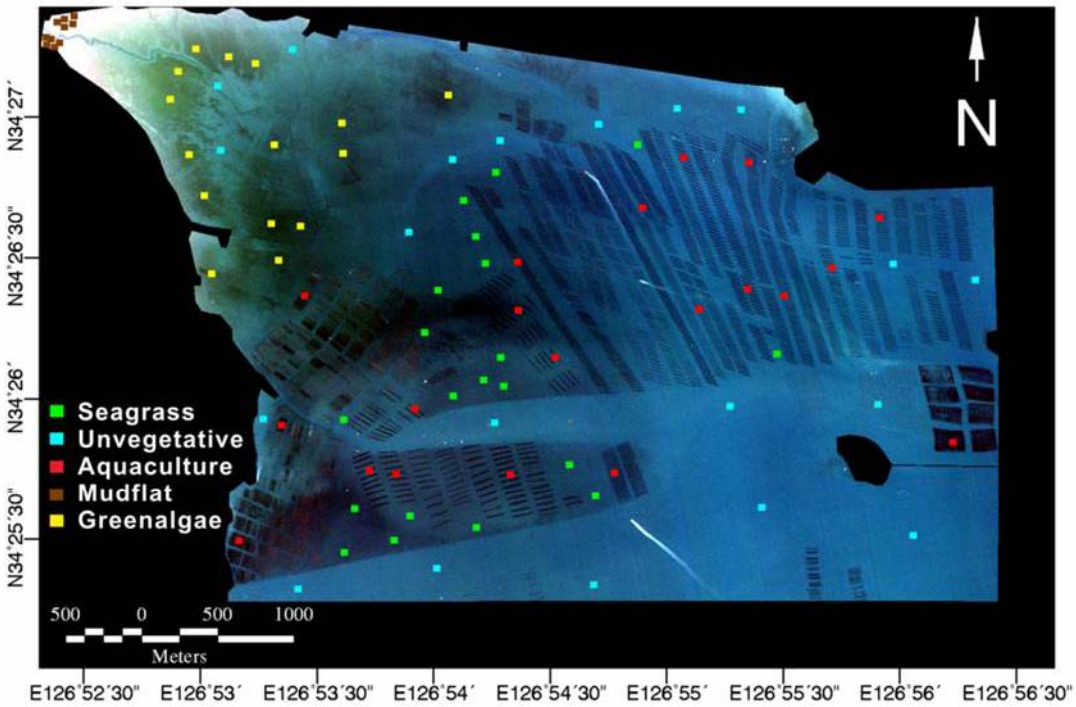
- Total water leaving radiance (LwT)
- Sky radiance (Lsky)
- Down-welling irradiance (Ed)
- Radiance from white reference plate (Lwhite) for data calibration
- Instrument : dual field spectroradiometer (ASD Inc.)





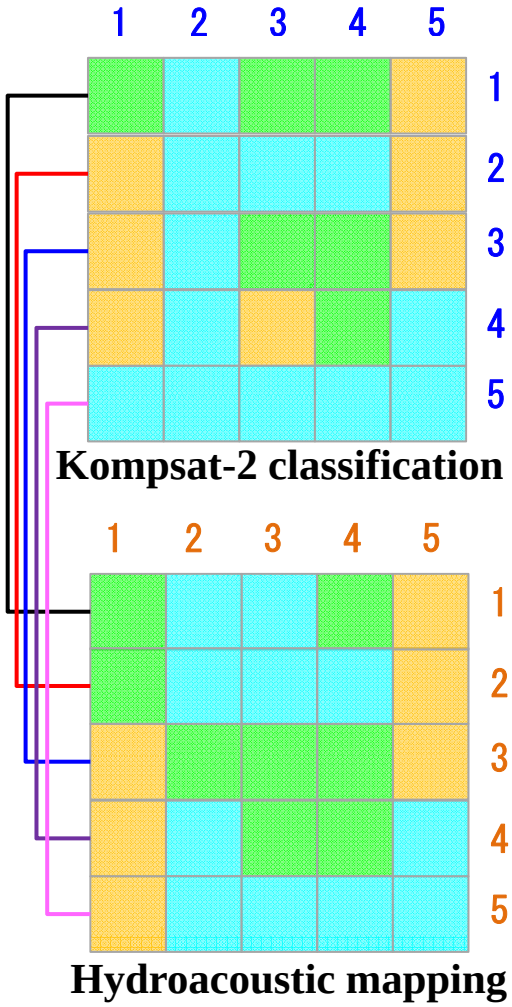
Accuracy evaluation of satellite image classification

1. Field observation for error matrix

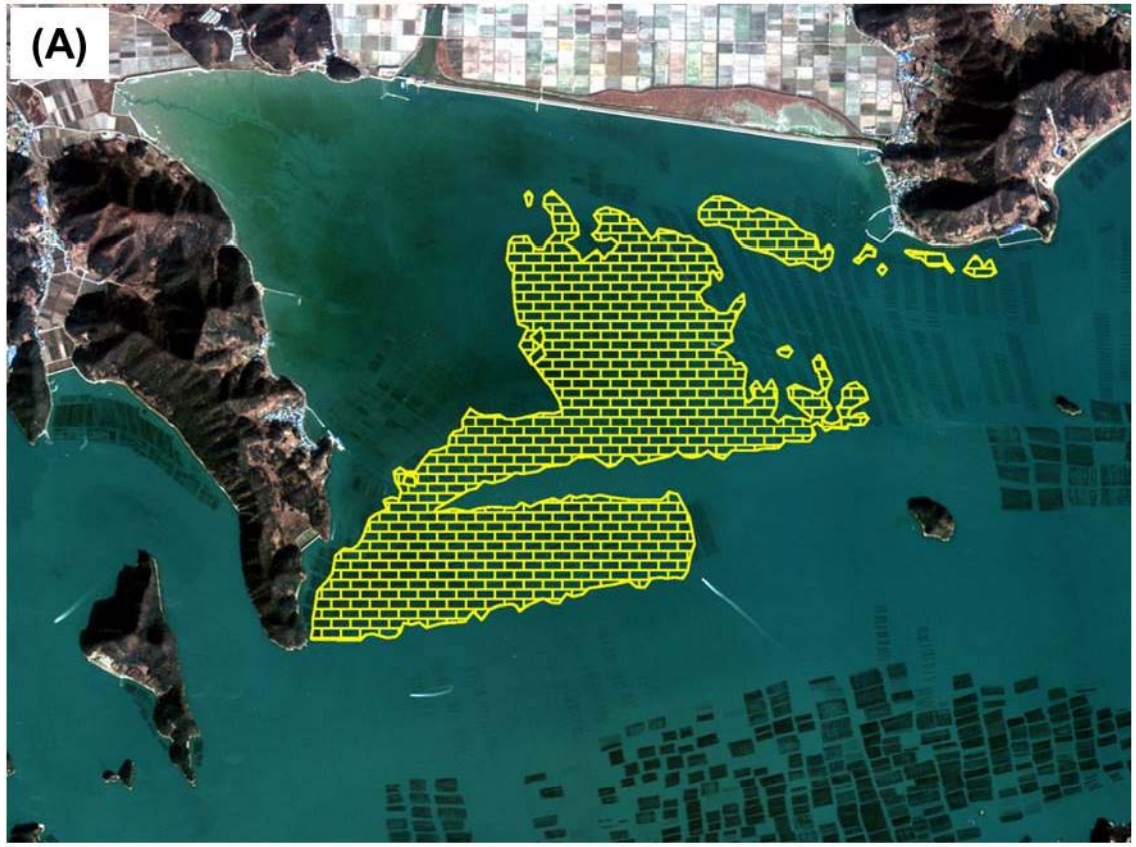


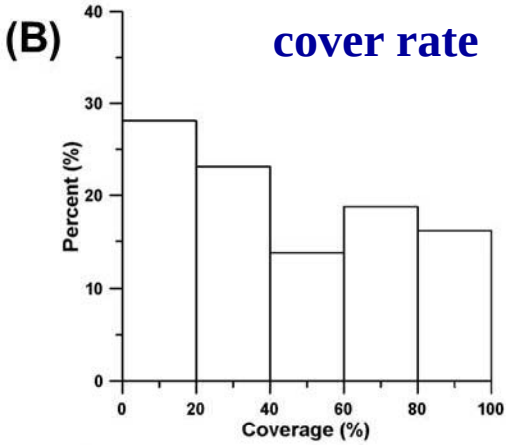
❖ 50% of in-situ measurement was used for the validation (error matrix)

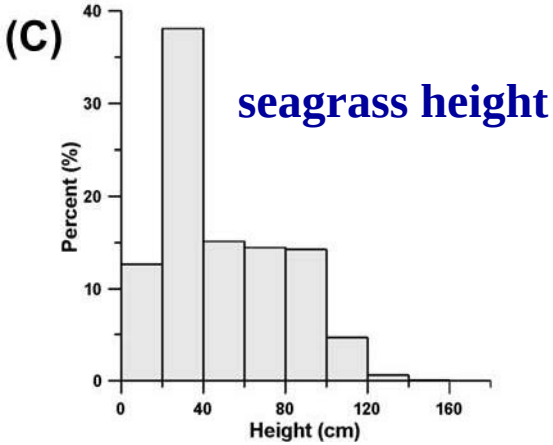
2. Correlation map



Results from hydroacoustic survey



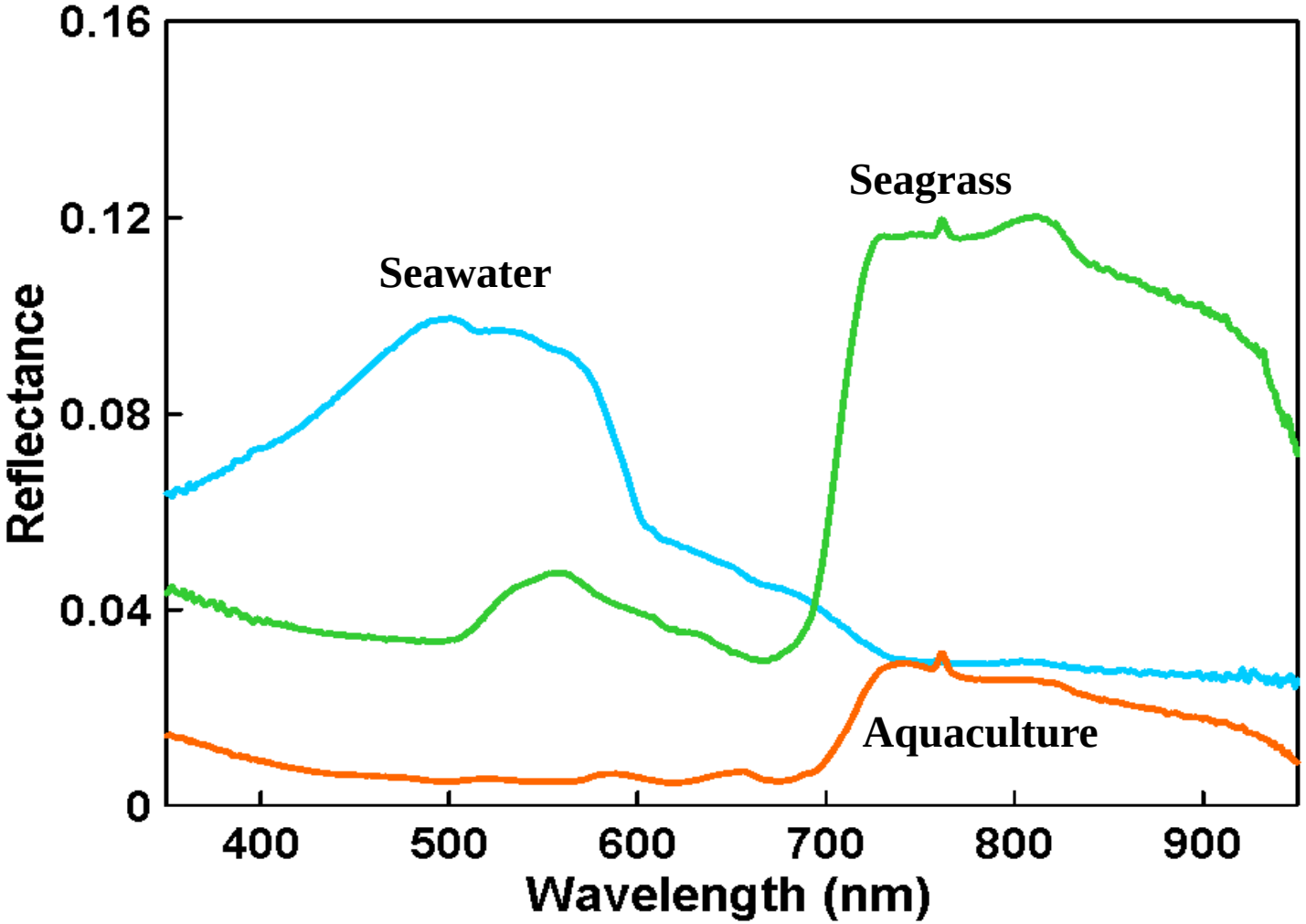




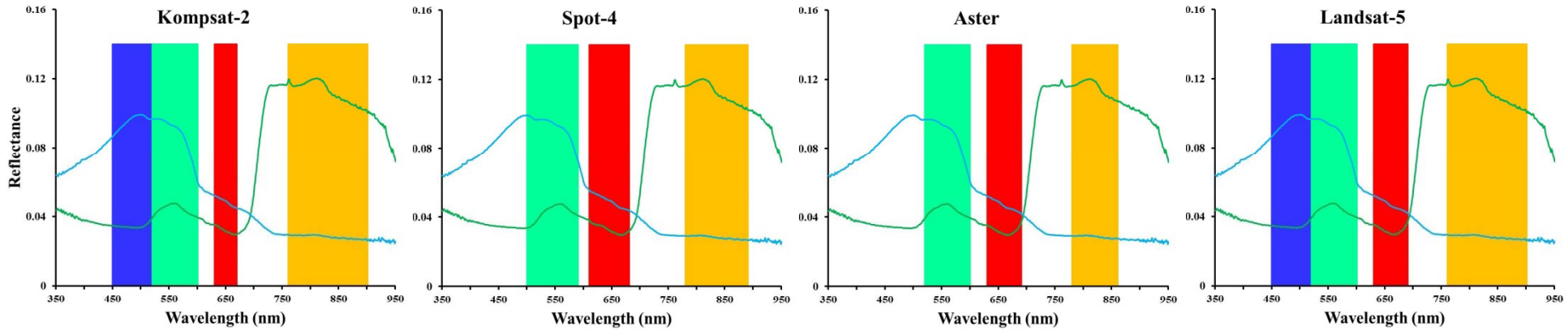
- **Seagrass area from hydroacoustic survey : 4.5 km^2**

- **Seagrass were mainly distributed within 0-2 m depth based on the lowest low water level**
- **No seagrass in the area of 7-9 m depth**

Field spectrum

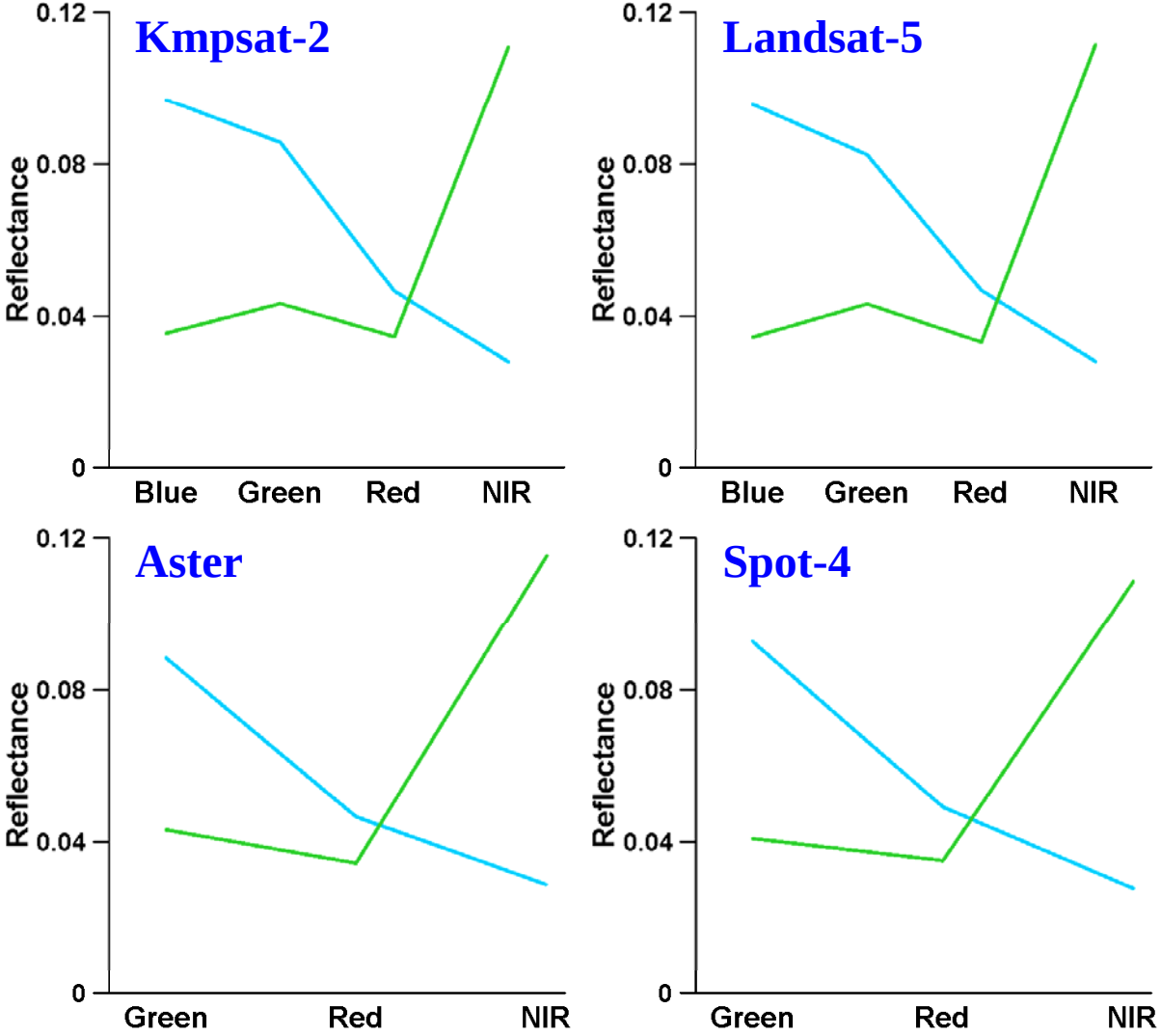


Spatial & spectral resolution



Band	Kompsat-2	Spot-4	Aster	Landsat-5
Blue	0.45-0.52	-	-	0.45-0.52
Green	0.52-0.60	0.50-0.59	0.52-0.60	0.52-0.60
Red	0.63-0.69	0.61-0.68	0.63-0.69	0.63-0.69
NIR	0.76-0.90	0.78-0.89	0.78-0.86	0.76-0.90
Spatial resolution	4 m	10 m	15 m	30 m

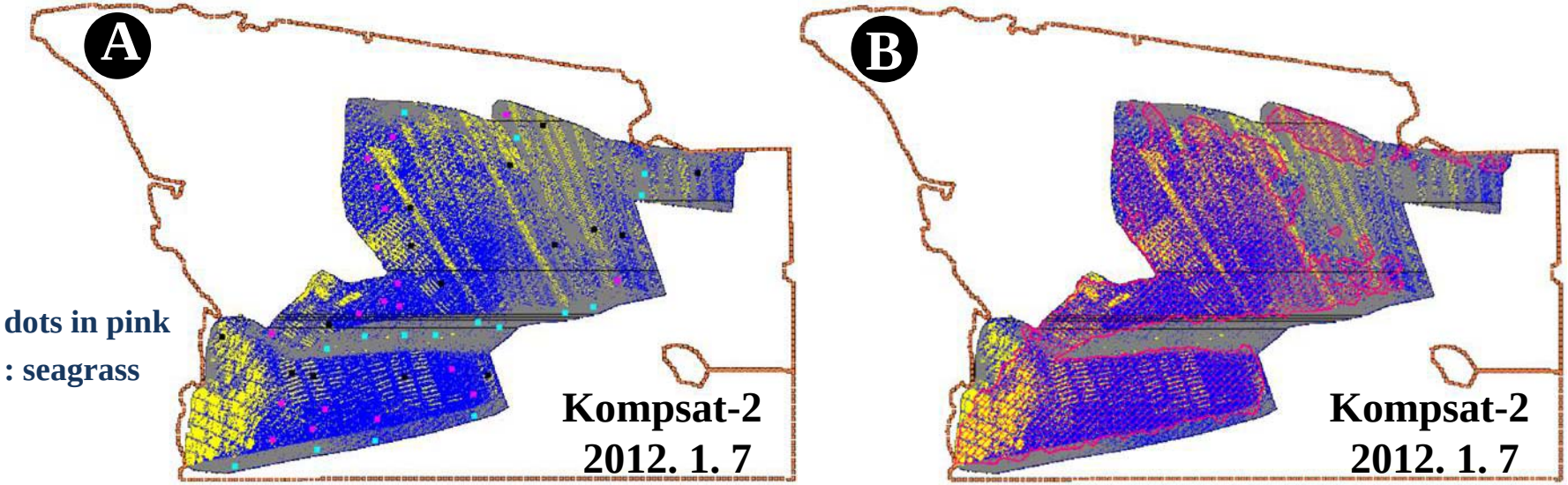
Reflectance correction using spectral response function



Seagrass

Seawater

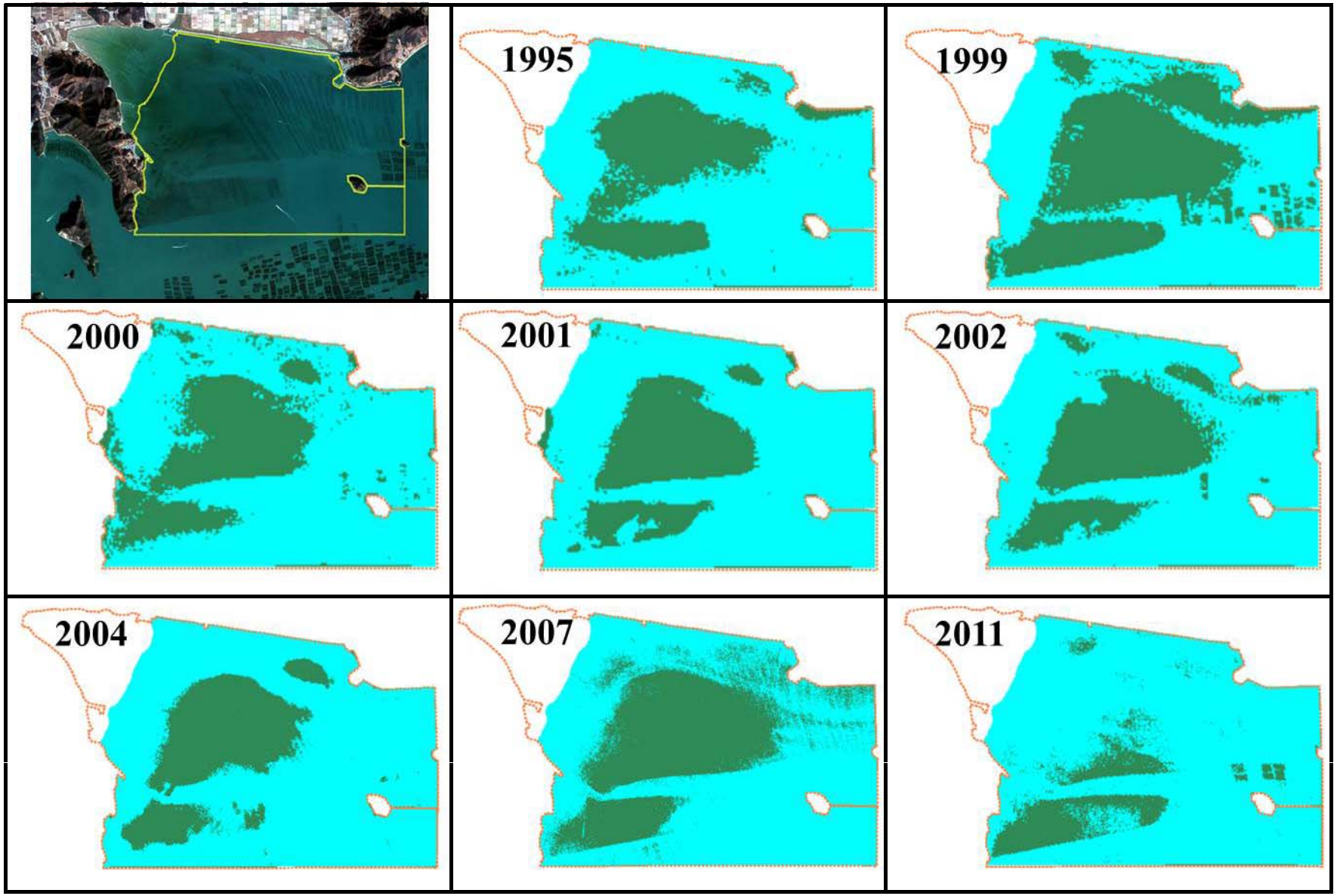
Accuracy assessment of satellite classification



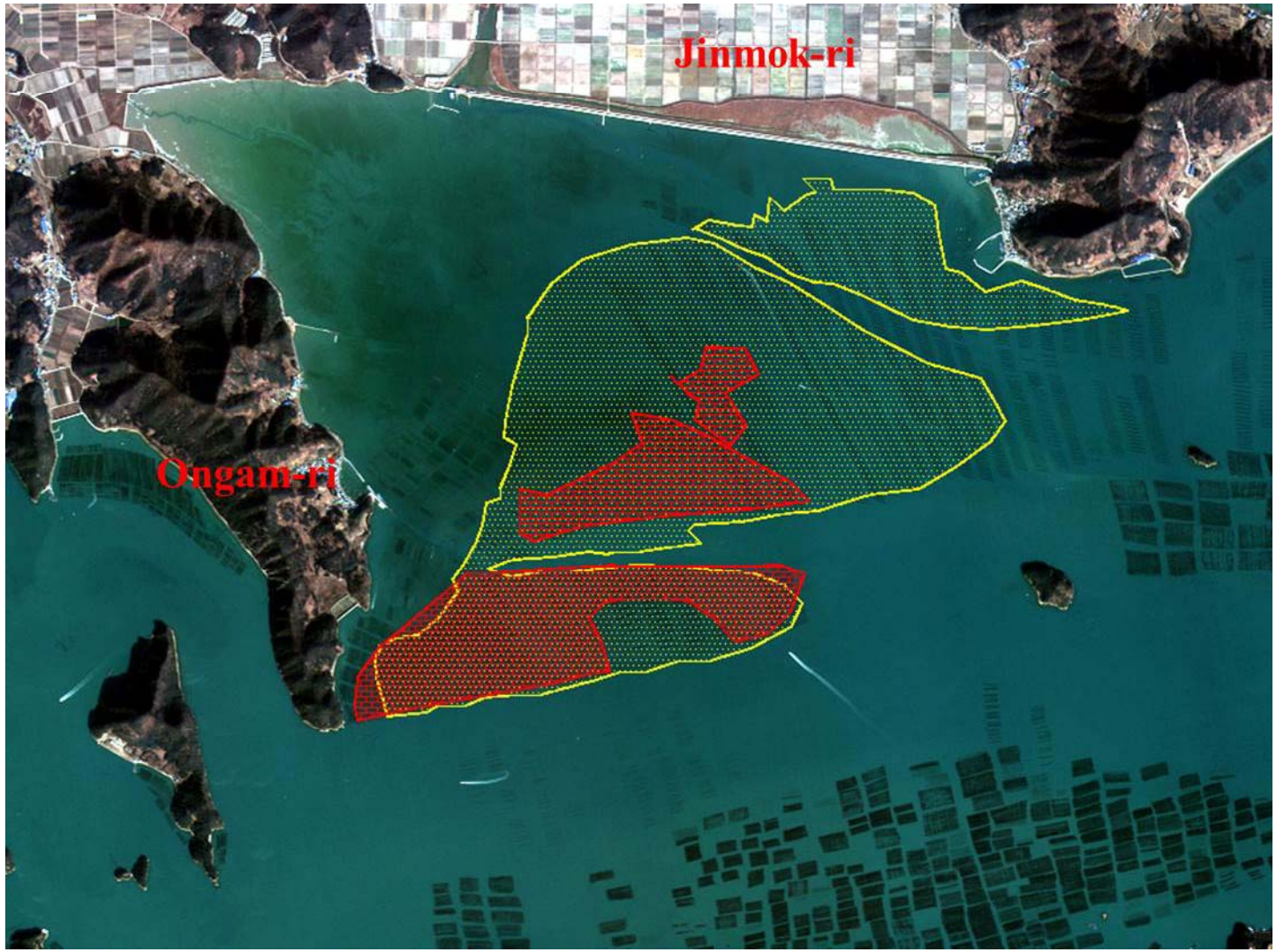
	In situ data				User's accuracy
Classification	Seagrass	Seawater	Aquaculture	Total	
Seagrass	10	2	2	14	71.4%
Seawater	4	13	1	18	72.2%
Aquaculture	4	0	12	16	75.0%
Total	18	15	15	48	
Producer's accuracy	55.5%	86.6%	80%		**72.9%**

Seagrass (satellite) **Aquaculture (satellite)** **Seagrass (echosounder)**

Spatial distribution of seagrass beds



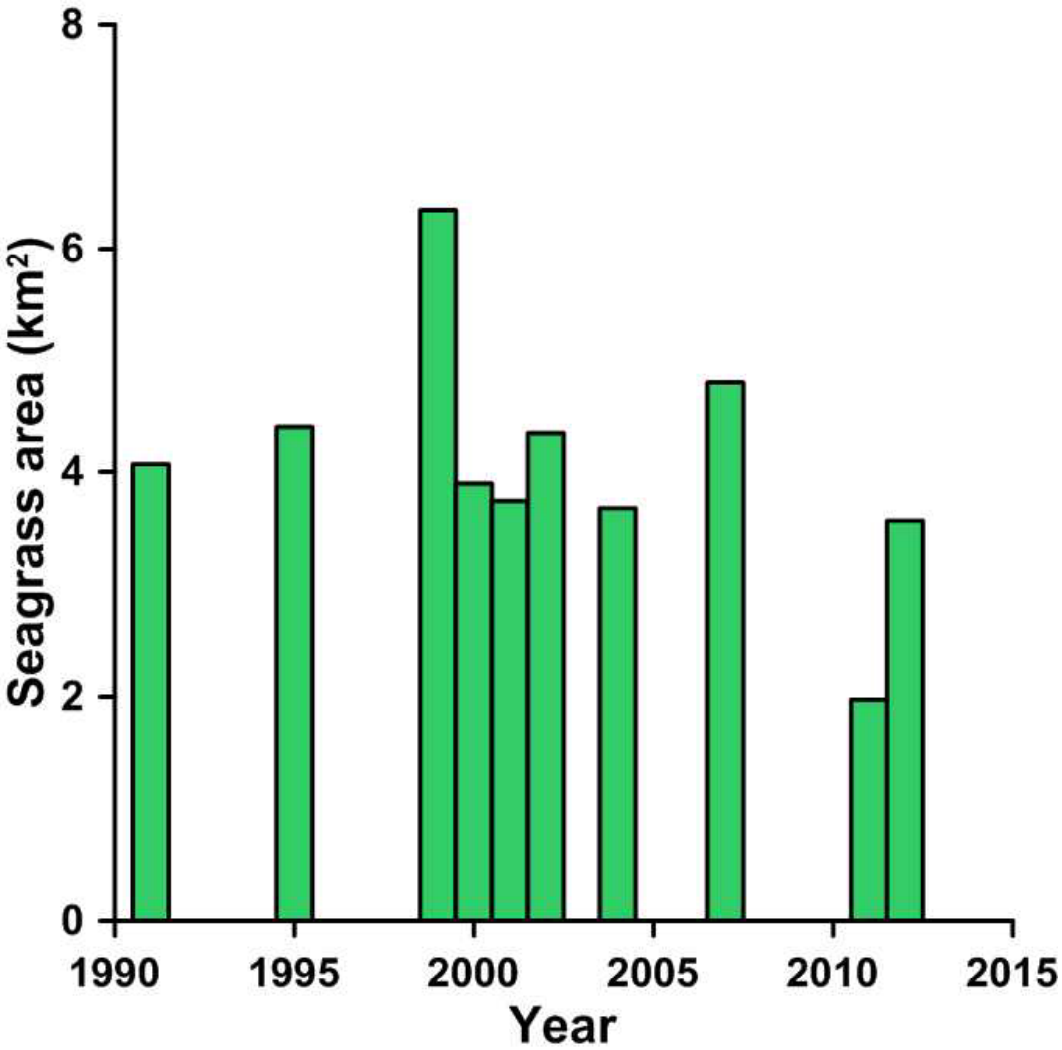
Spatial distribution of seagrass beds



1999 (Maximum)

2011 (Minimum)

Long term changes of seagrass distribution



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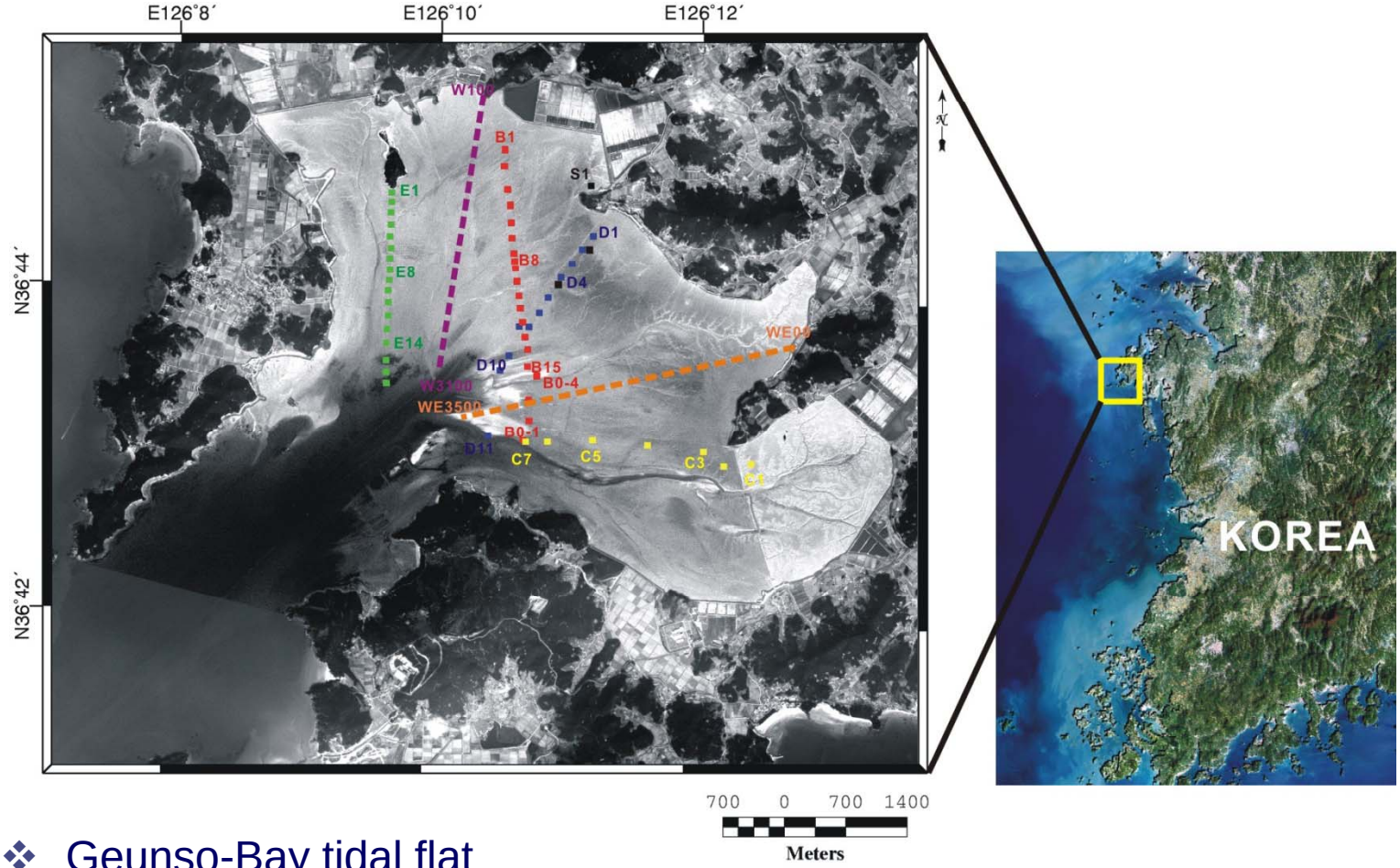
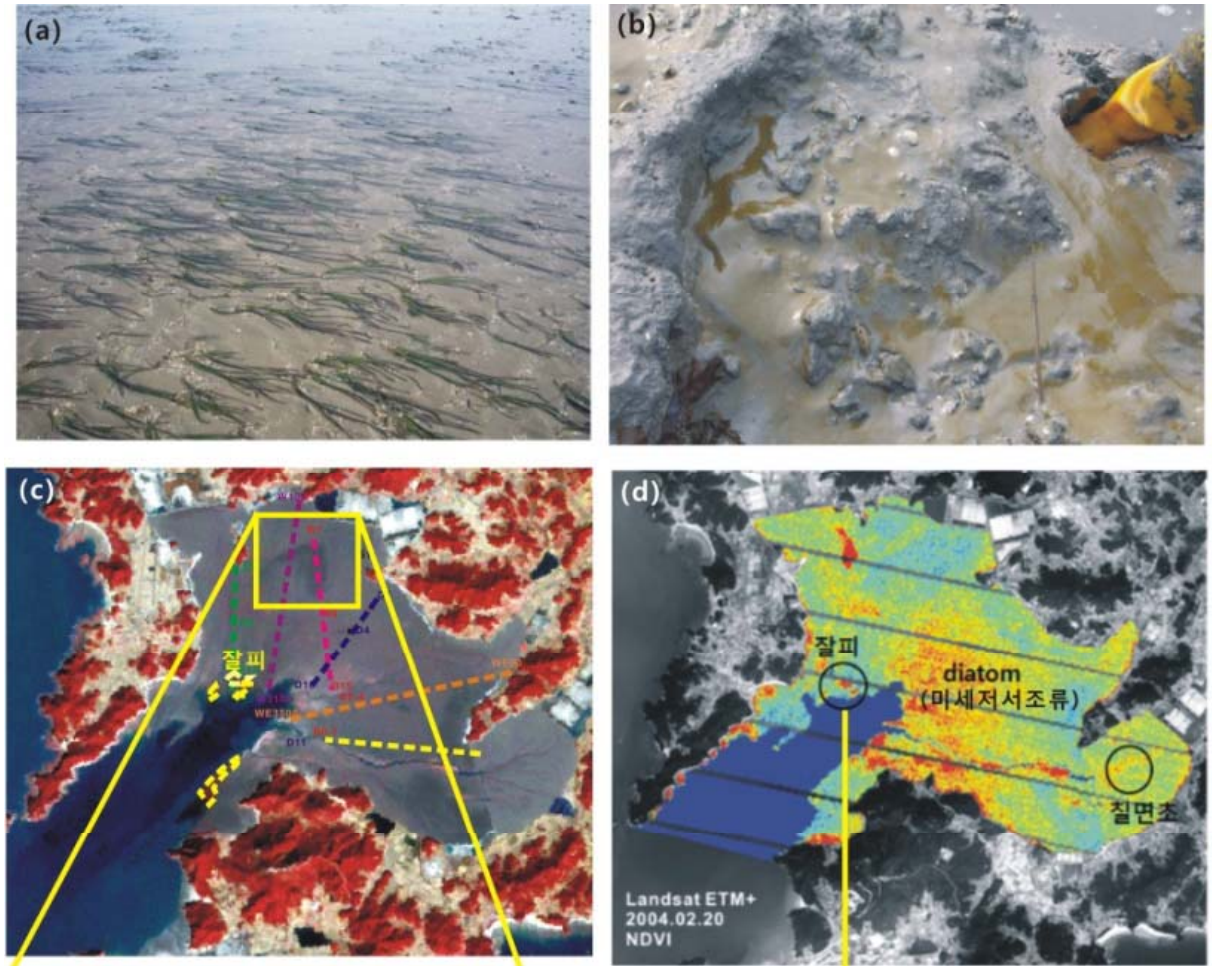
Seagrass in tidal flats



❖ Geunso-Bay tidal flat

- semi-diurnal tides (mean tidal range = 6 m)
- 70% of the flat is exposed during low tide and water depth is 2-4 m at high tide

Seagrass in tidal flats



d) NDVI (NIR-R / NIR+R)

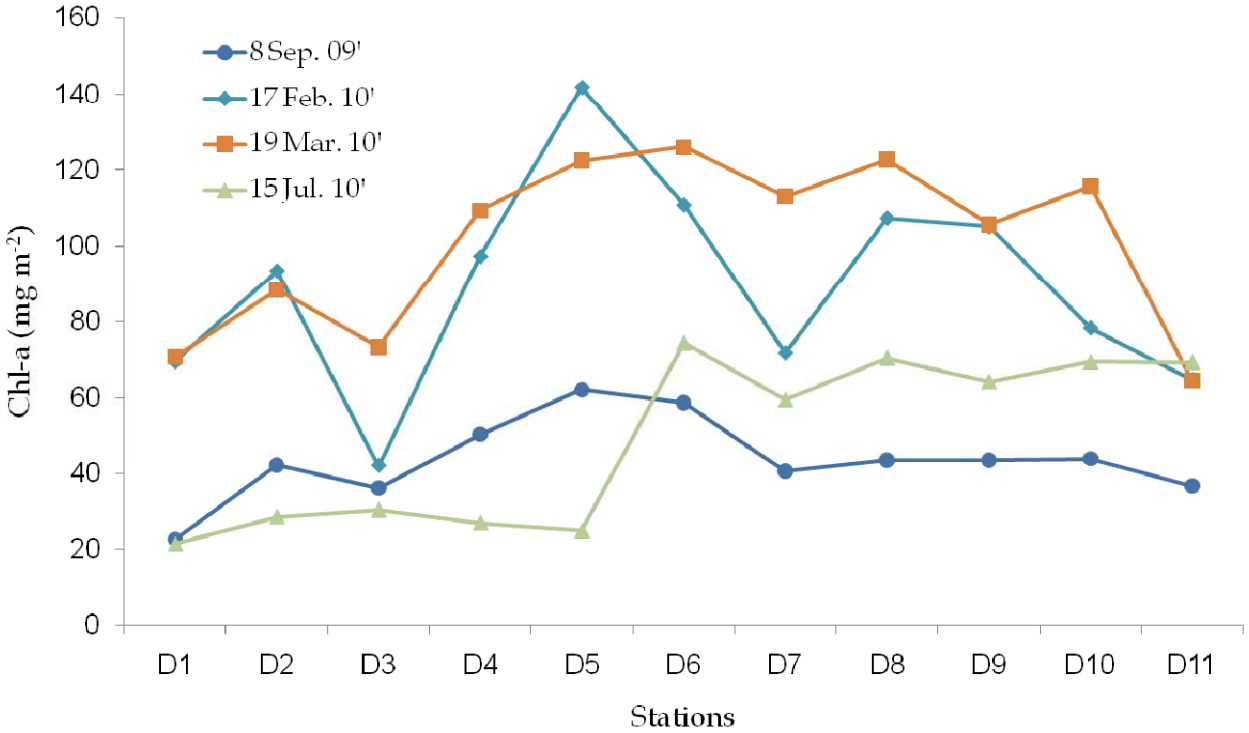
: clear pattern of seagrass, diatom

c) NIR+Red+Green of Landsat ETM+ (February 20, 2004)

→ red area : chlorophyll dominant (seagrass at the bay mouth, Fig. a)

→ widely reddish area : algal mat (Fig. b)

Diatom blooming in tidal flat surface



- Overall concentration of Chlorophyll a
  - 88.0 ~ 222.1 mg·m-2 (February, 2007)
  - 43.2 ~ 115.9 mg·m-2 (May, 2007)
- Algal mat, which has been formed by diatom blooming, is well developed at some sampling locations in February

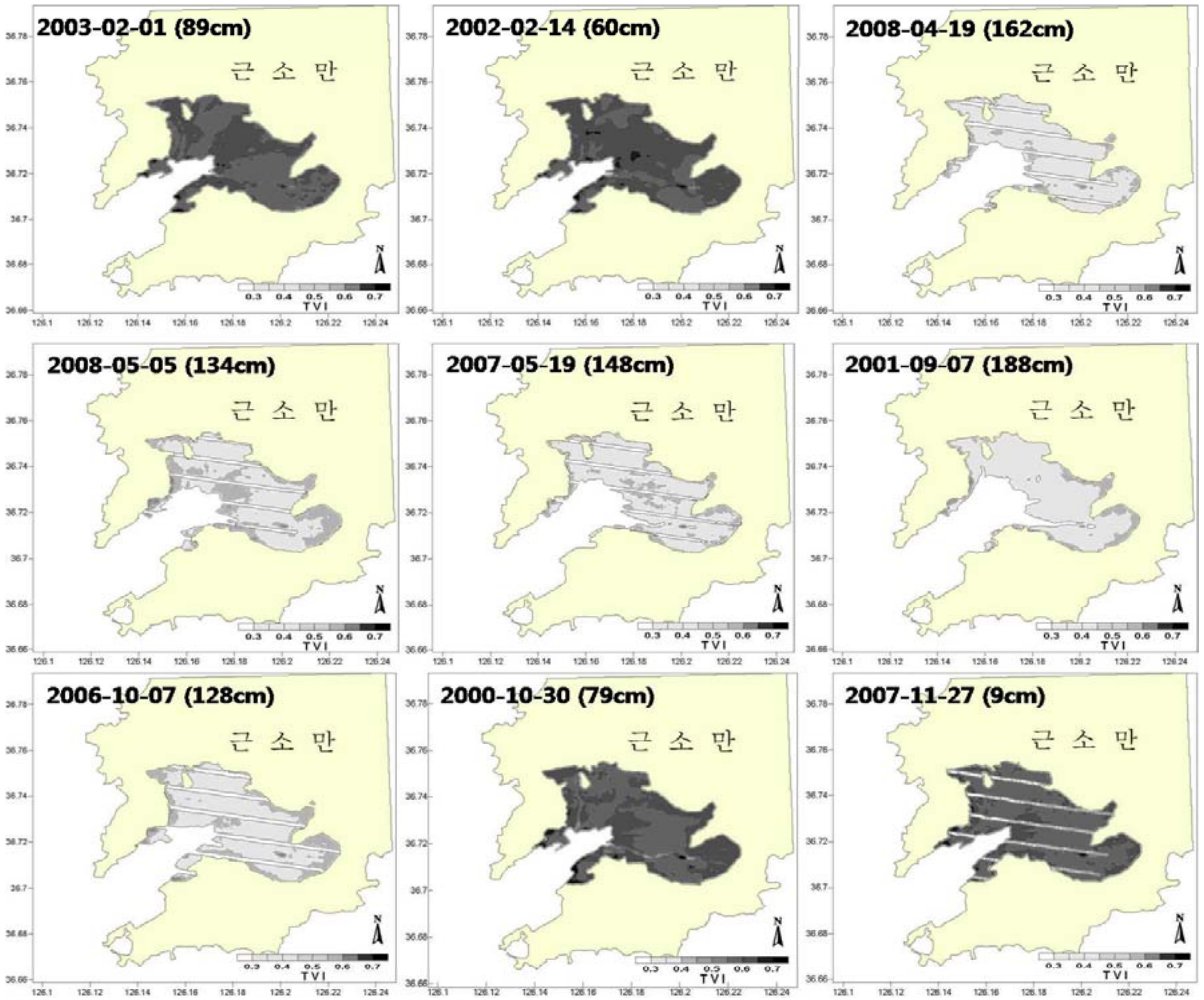
Diatom blooming in tidal flat surface

❖ Seasonal variations in diatom distribution Landsat ETM+

- clear pattern of diatom blooming in tidal surface was identified in the image from October to February

- decrease until September and increase again

- specific blooming in the center part of study area from the image of February



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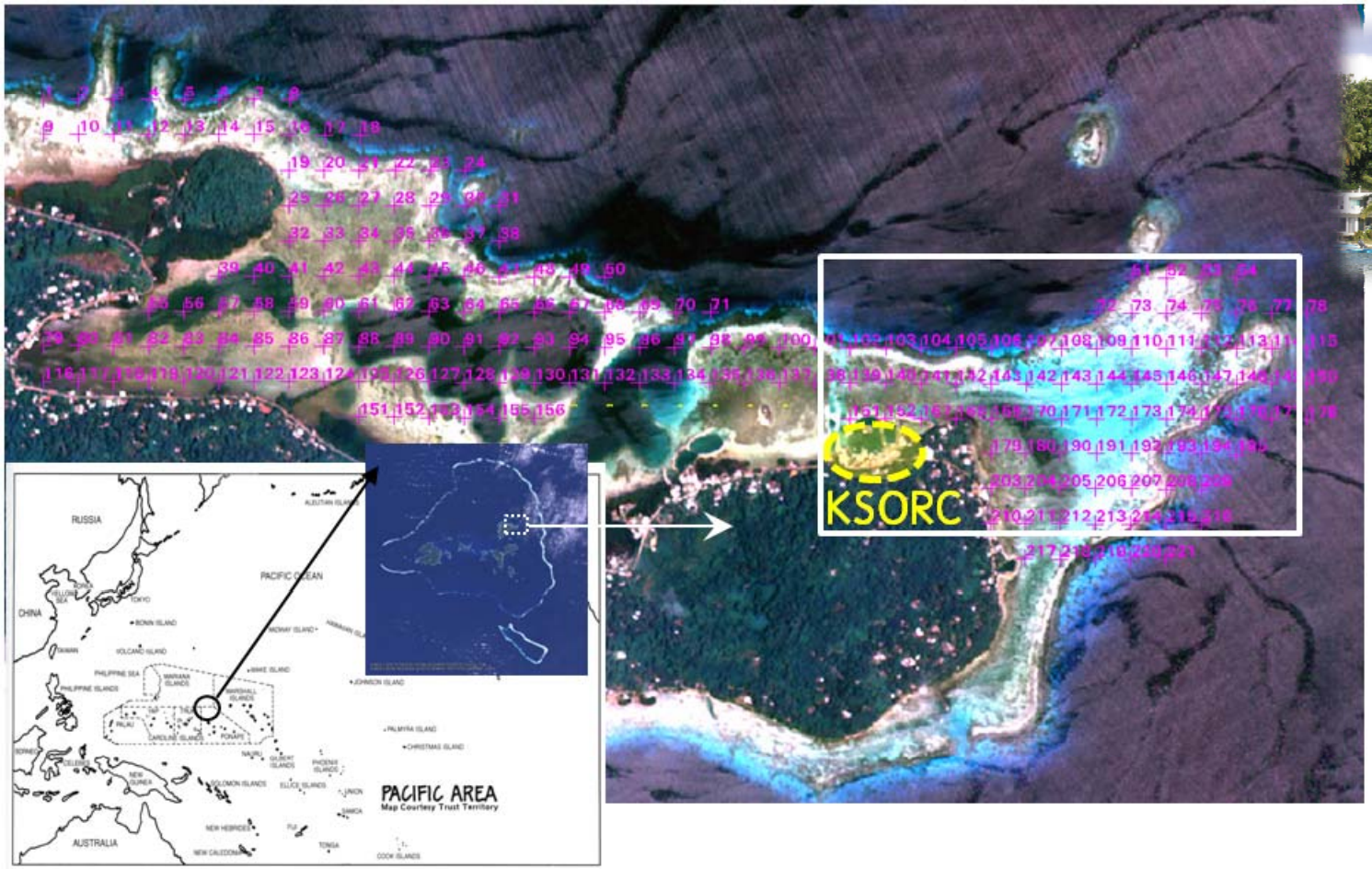
Coral reef habitat in Weno Island, FSM

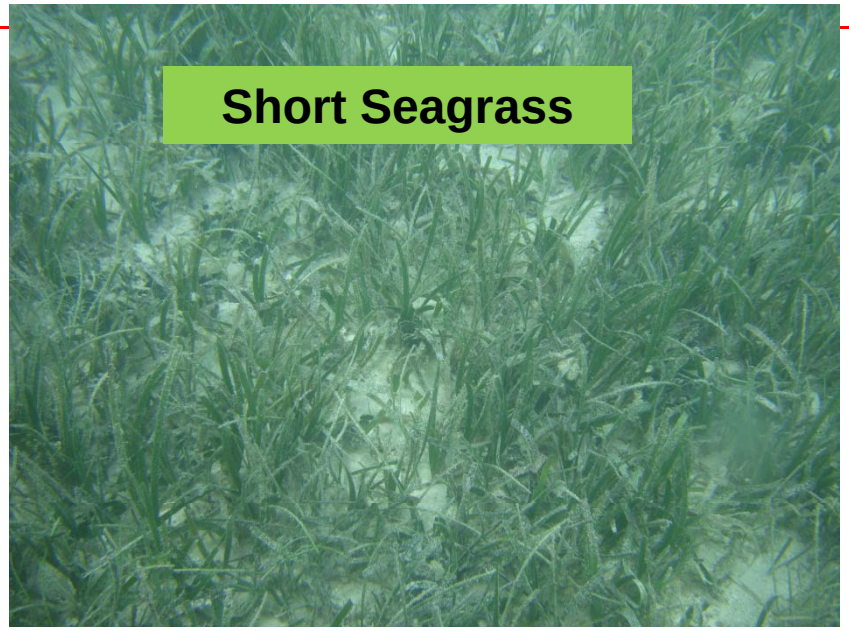


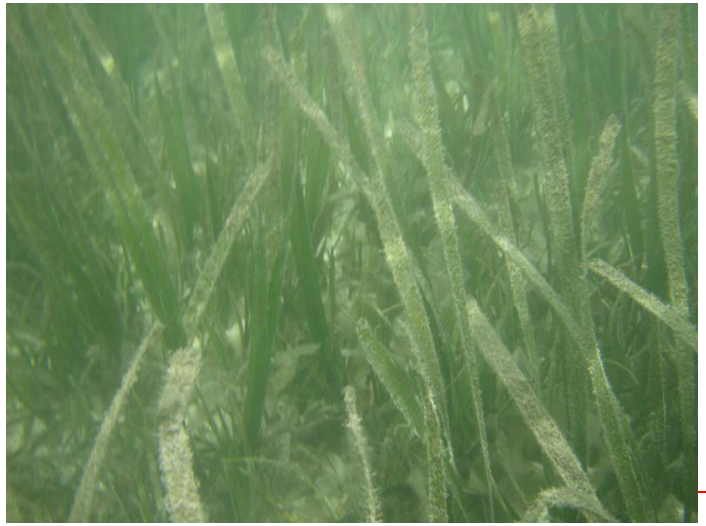
Korea-South pacific Ocean Research Center, KSORC

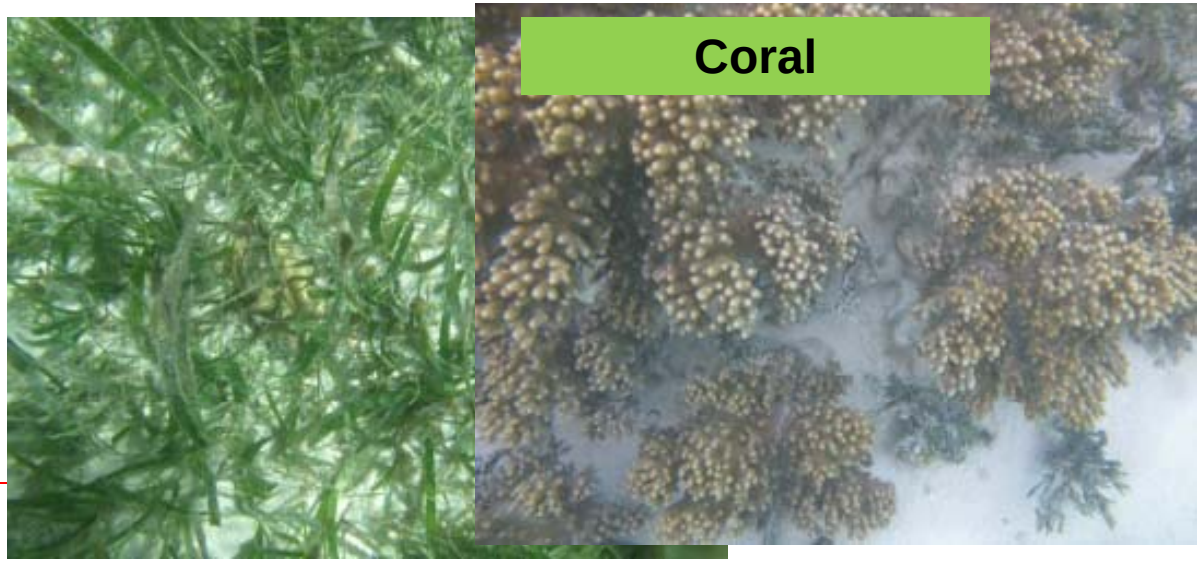
Weno island in the Chuuk lagoon of Federated States of Micronesia

- biodiversity : Mangrove forest, Seagrass, Coral reef comunities

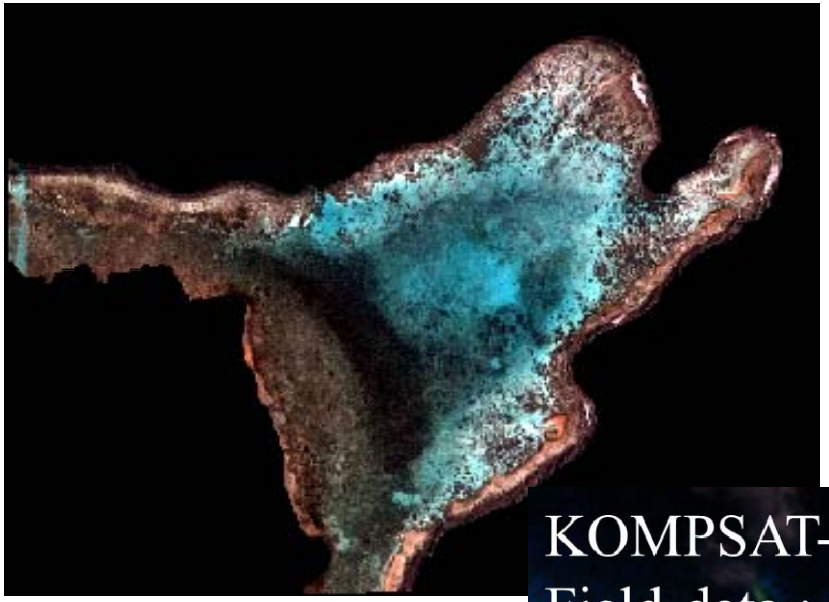
Seagrass in Weno Island, FSM



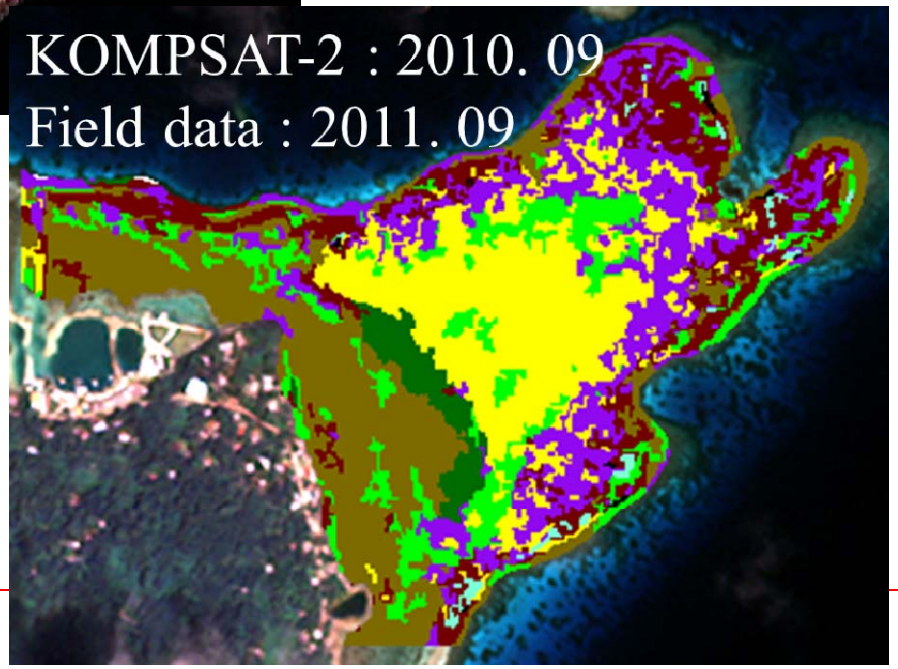




Coral reef habitat mapping

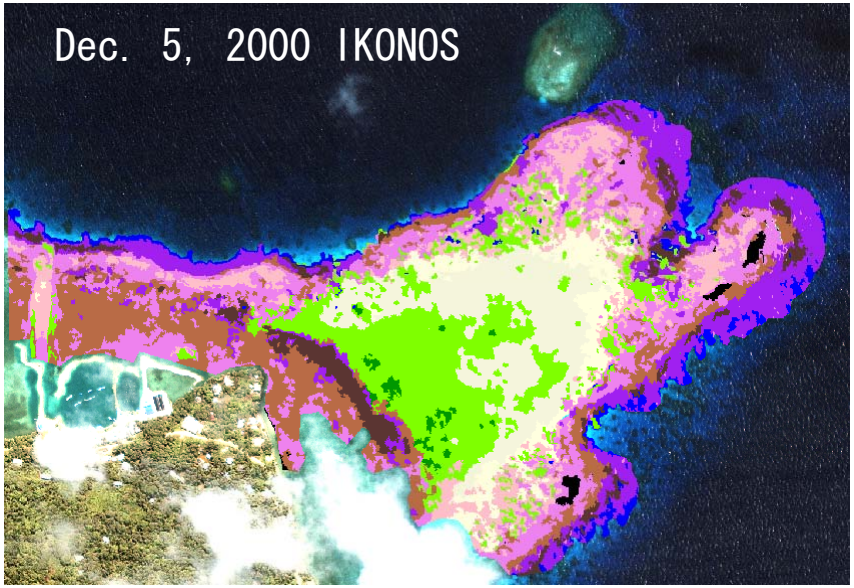


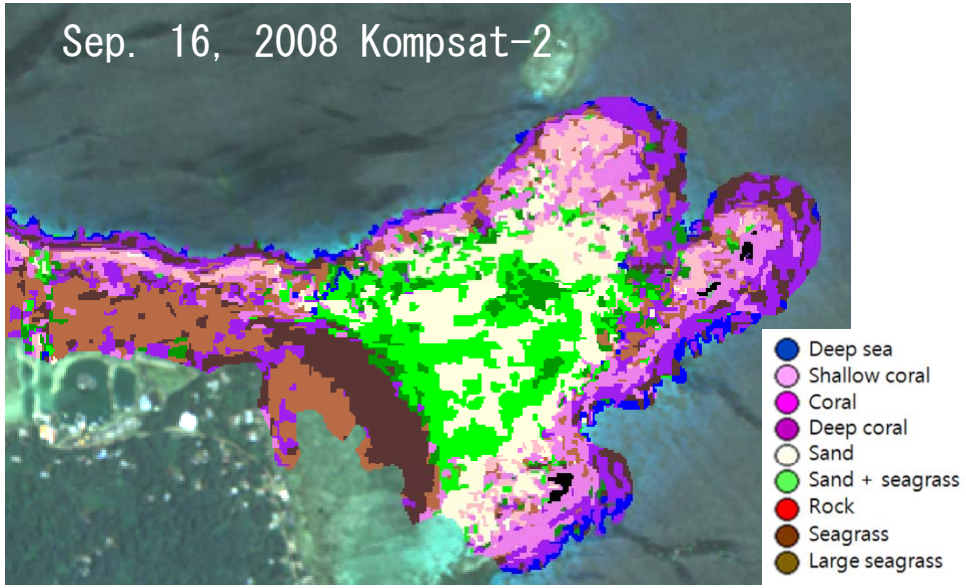
← WorldView-2 image at Feb, 3rd, 2010



- Large Seagrass
- Short Seagrass
- Sand+Seagrass
- Sand
- Coral
- Rubble
- Rock

Habitat mapping & Change monitoring





	Class Names	Color	Pixels	Area (m^2)	%
1	seagrass (1)		78557	78557	15.26
2	seagrass (2)		24794	24794	4.82
3	Sand		85416	85416	16.60
4	sand + short grass		86134	86134	16.74
5	sand + long grass		16286	16286	3.16
6	coral (1)		51790	51790	10.06
7	coral (2)		70603	70603	13.72
8	coral (3)		94248	94248	18.31
9	rock		3261	3261	0.63
10	deep sea		3570	3570	0.69
		Total	514659	514659	100

	Pixels	Area (m^2)	%
1	5969	95504	15.05
2	5019	80304	12.65
3	5799	92784	14.62
4	5375	86000	13.55
5	2054	32864	5.18
6	2366	37856	5.96
7	5560	88960	14.02
8	6282	100512	15.84
9	166	2656	0.42
10	1079	17264	2.72
	39669	634704	100

- area of seagrass
  : increased 8%
- Total area of coral reef habitat : decreased 6.28%
  from 42.09 % to 35.82%

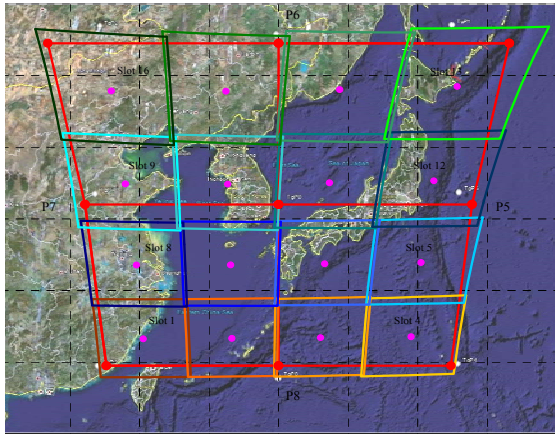
Contents

- ❖Seagrass mapping in the Korean coastal water
- ❖ Tidal flat application
- ❖ Coral reef habitat mapping
- ❖ **Geostationary Ocean Color Imager (GOCI)**

Technical Specification of GOCI

- GOCI
  - GSD(Ground Sampling Distance) : 500m * 500m
  - Target Area : 2,500km * 2,500km (Center : 130˚E 36˚N)
  - Included Nations : Korea, China, Japan, Russia, etc.
  - Temporal Resolution : 1hour (8 times at 1 day)

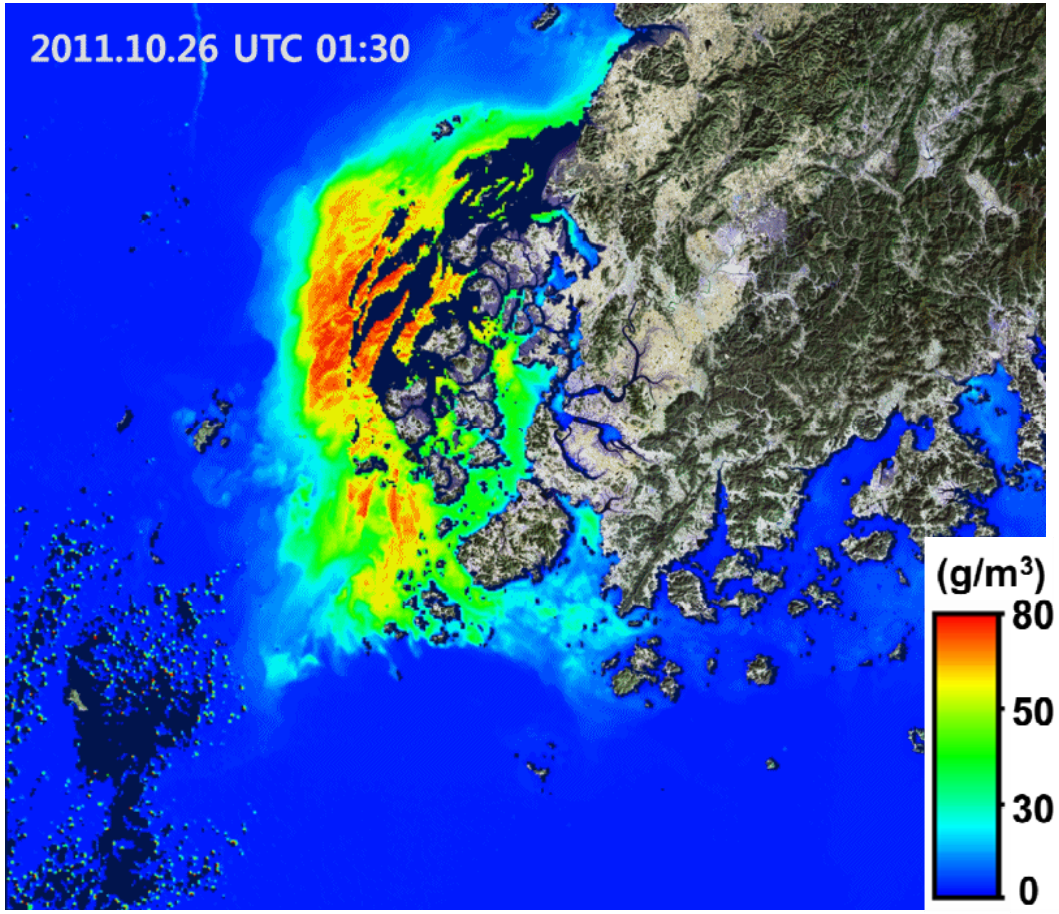
Target Area

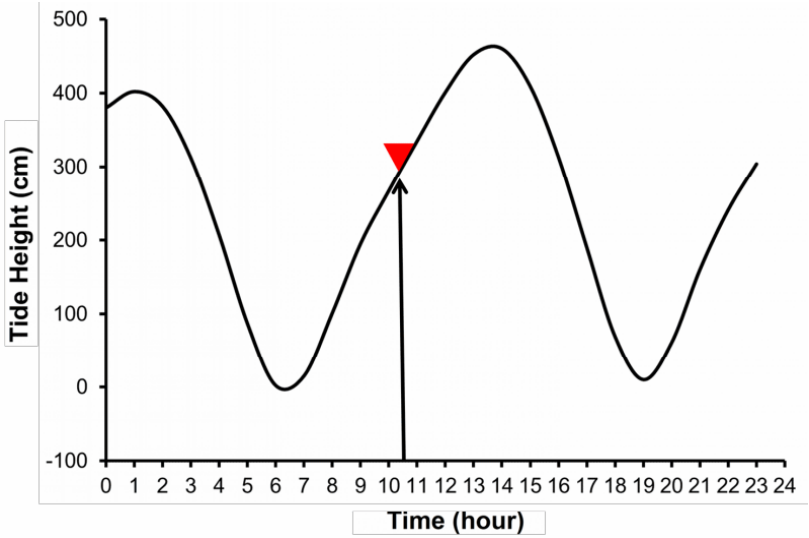


Spectral Bands Characteristic and Requirements of GOCI

Band	*Central wavelengths*	*Band Width*	*SNR*	*Type*	*Primary Application*
B1	412 nm	20 nm	1,000	Visible	Yellow substance and turbidity
B2	443 nm	20 nm	1,090	Visible	Chlorophyll absorption maximum
B3	490 nm	20 nm	1,170	Visible	Chlorophyll and other pigments
B4	555 nm	20 nm	1,070	Visible	Turbidity, suspended sediment
B5	660 nm	20 nm	1,010	Visible	Baseline of fluorescence signal, Chlorophyll, suspended sediment
B6	680 nm	10 nm	870	Visible	Atmospheric correction and fluorescence signal
B7	745 nm	20 nm	860	NIR	Atmospheric correction and baseline of fluorescence signal
B8	865 nm	40 nm	750	NIR	Aerosol optical thickness, vegetation, water vapor reference over the ocean

Time-series variations in GOCI-derived turbidity



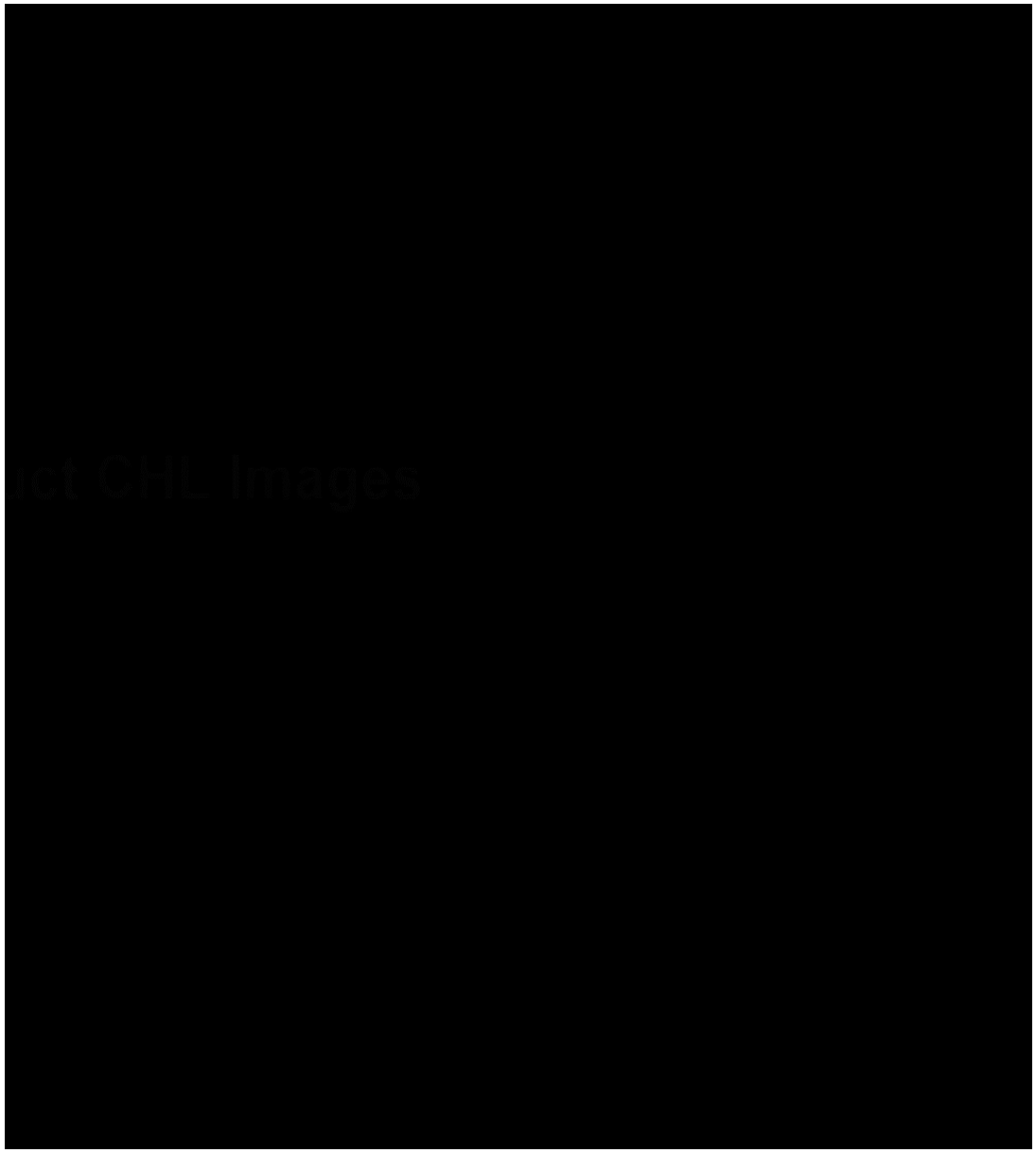


areas of relatively high turbidity (in red) gradually decreased over time

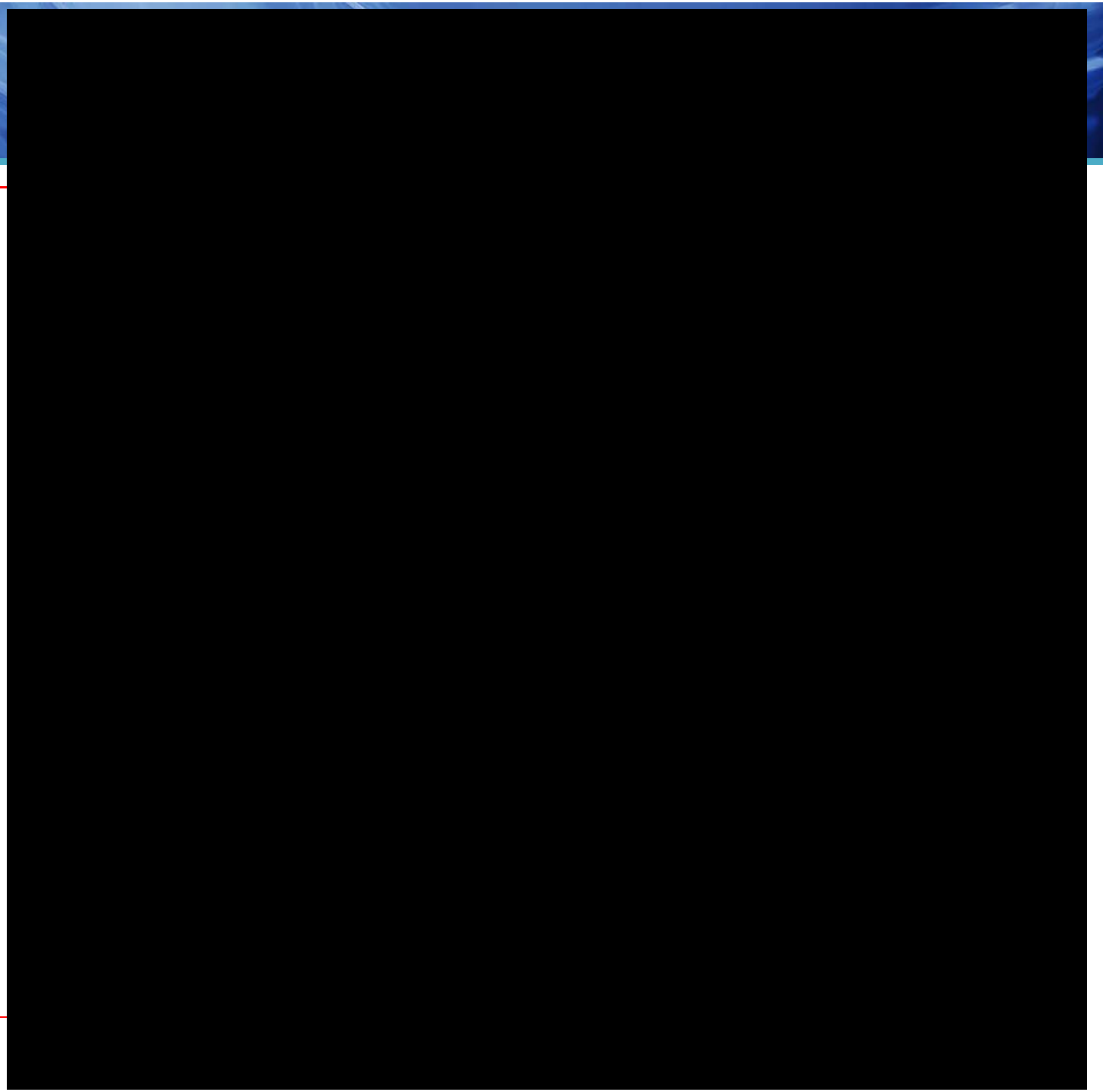
- clear water from open sea suppressed turbidity during flood tide

around the time of high tide, turbidity was remarkably lower

- settlement of suspended particulates during the transition from flood to ebb tide and resulting lull in the tidal current



GOCI-based CHL-a
1-h interval image
(2012.4.17)



GOCI-based TSM daily composite (2011.9.1-2013.12.31)

Summary

- **Seagrass beds was spectrally distinct from unvegetated seawater and aquaculture in the high spatial resolution satellite images**
- **Remotely sensed images can be applied to the mapping of seagrass distribution with relatively high accuracy (73%)**
- **Annual variability in spatial change of seagrass distribution was observed between 1995 and 2012**

→ Remote sensing technique is effective for long-term monitoring of seagrass beds distribution combined with in-situ observation

Thank you

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http://www.divephotoguide.com/user/stevedeneef/gallery/gallery/photo/12361/