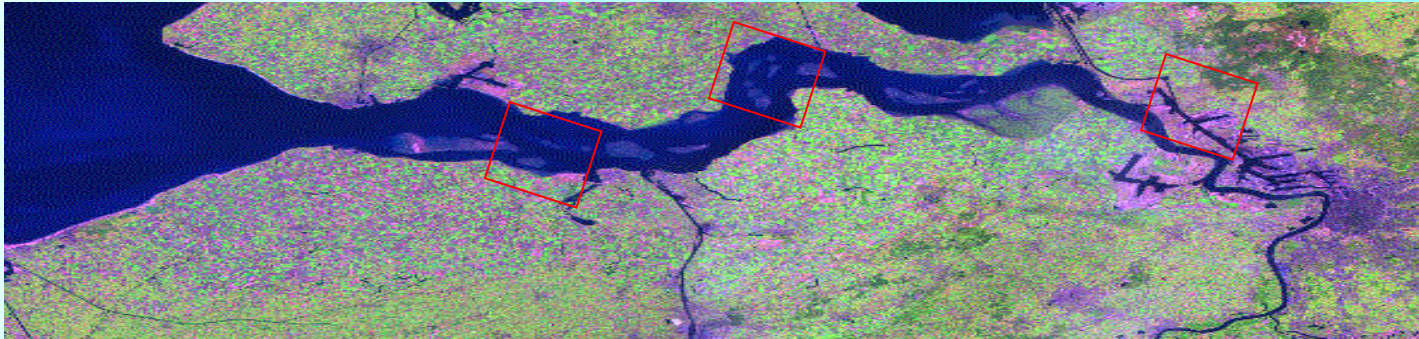


Hyperspectral remote sensing of the Western Schelde estuary - a summary of past and present UK-Netherlands operations

R.M. Forster, J.C. Kromkamp
Netherlands Institute of Ecology (NIOO-CEME)

A. Thomson, GM Smith,
NERC-CEH, England

GJ van den Berg, H. Hakvoort
RWS-MD, Netherlands

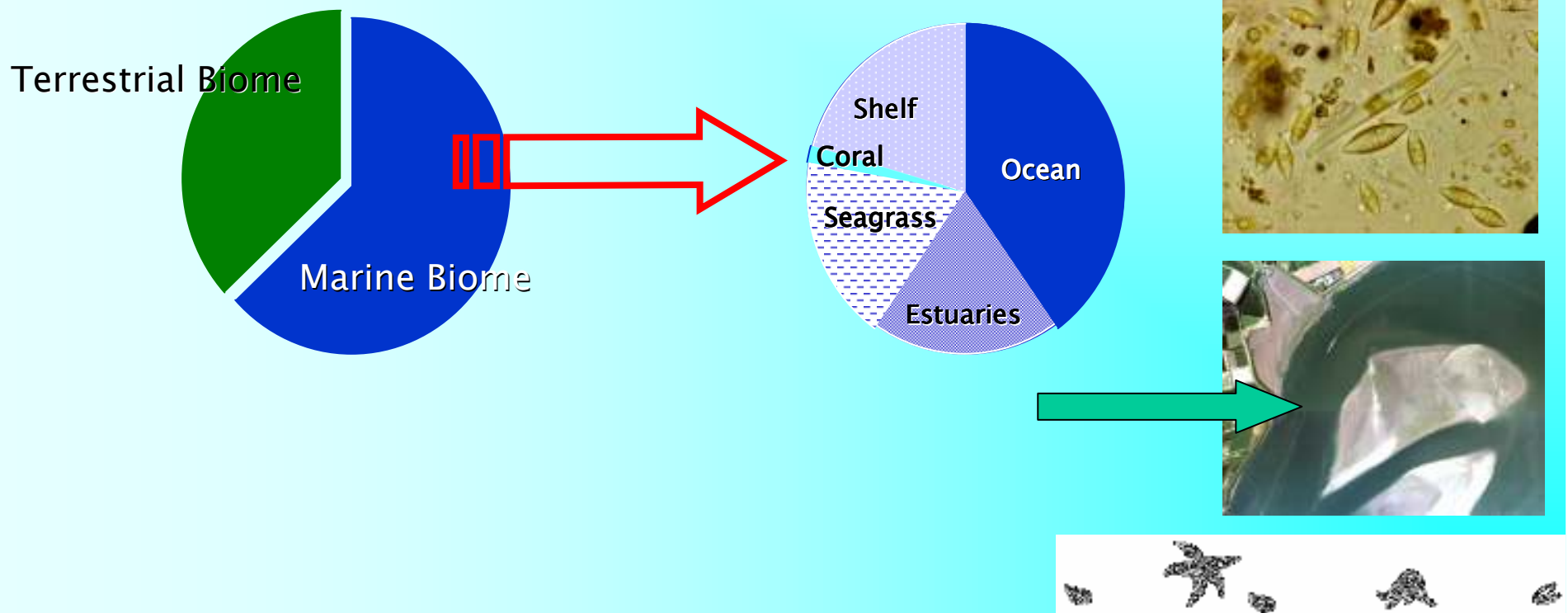


Importance of estuaries as providers of ecosystem services

Average global value of annual ecosystem services

Costanza et al., Nature 387, 1997

Total global flow value ($33\$ \times 10^9 \text{ yr}^{-1}$)




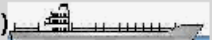




Current research at NIOO: environmental change in the western Schelde estuary

The Schelde estuary

- still has a full gradient from fresh to saltwater
- extends over more than 200 km
- tidal mud- and sandflats as well as marshes
- freshwater tidal areas are extremely rare in Europe
- birds – a crucial resting and foraging stop-over



Growth of ship traffic in the western Schelde

Generation Year	TEU	LOA (m)	Width(m)	Draught(m)
1. (1972) 	up to 1,500	225	24.5	9.00
2. (1980) 	up to 3,000	275	27.5	10.00
3. (1987) 	up to 4,500	300	32.2	11.50
4. (1997) 	up to 6,600	320	40.0	14.30
5. (1999) 	ca 8,000	347	42.6	14.50
Future 			???	

History of maritime cargo traffic(in tonnes)

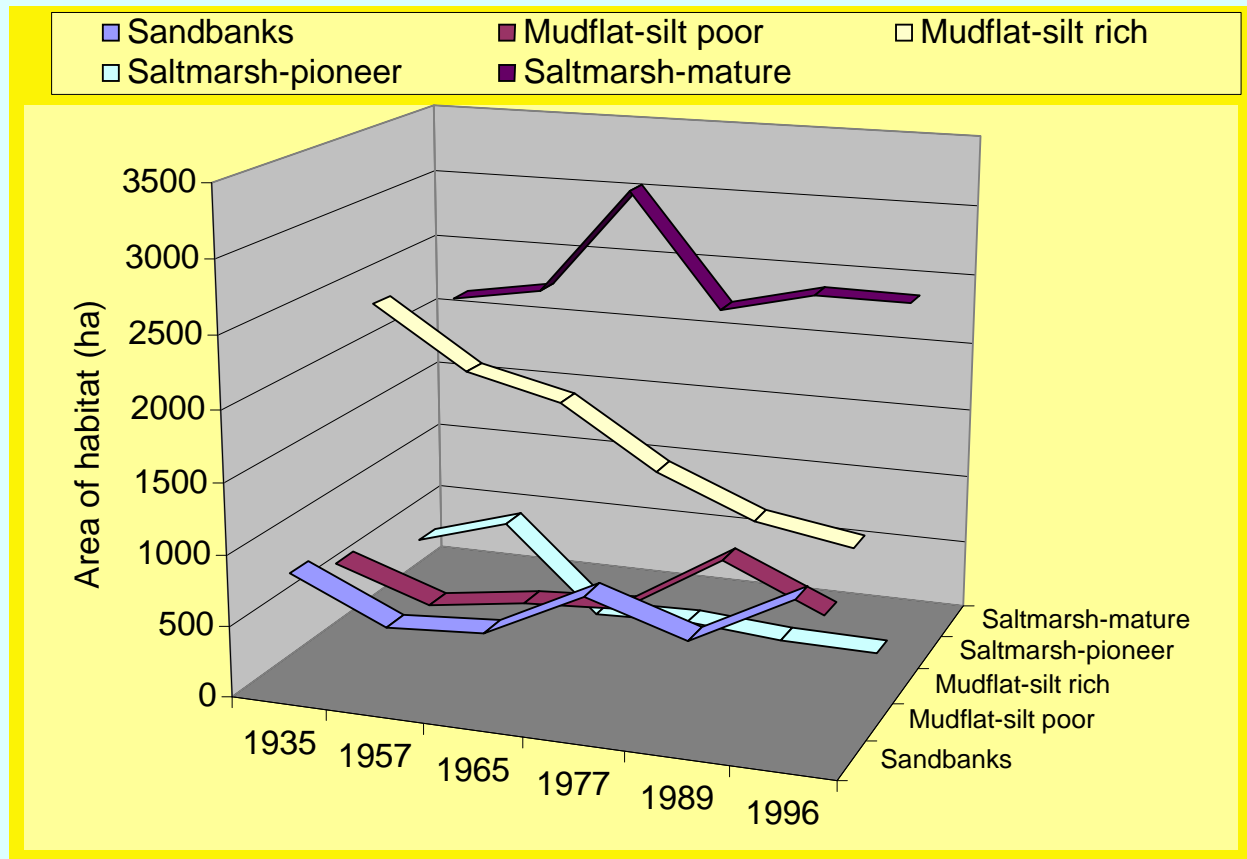
Year	Total
1975	60,395,241
1980	81,935,340
1985	86,246,065
1990	102,009,165
1995	108,073,400
1996	106,526,343
1997	111,894,783
1998	119,788,549
1999	115,654,020
2000	130,530,626

Source: Antwerp Port Authority

1997- 3rd round of dredging agreed between Vlanders and Netherlands



Change of habitat ecotypes in the western Schelde



Orthophotography since 1940s
 Landsat since 1972
 Multi/hyper spectral RS since 1993



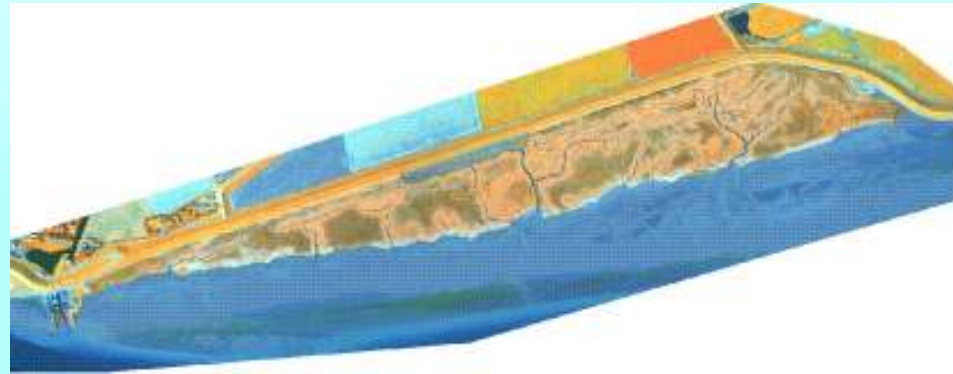
Airborne spectral datasets for the Westerschelde estuary

<i>Project</i>	<i>Target</i>	<i>Date</i>	<i>Tide</i>	<i>Sensor</i>	<i>Wavebands</i>	<i>No. of flightlines</i>	<i>Spatial resolution</i>	<i>Processing</i>
UK/NL + ISLED	Saltmarsh	20-Sep-93		CASI	12 (vis/nir) DELFT	18	4	Thomson et al. (2003, IJRS (in press))
ISLED	Saltmarsh	24-Sep-98		CASI	14 (vis/nir) BIOTA	10+1	2	Thomson et al. (2003, IJRS (in press))



Isled campaigns 1993-98-2000

<http://www.nmt.ac.uk/isled/>



Thomson et al. (2003) IJRS, in press



Airborne spectral datasets for the Westerschelde estuary

<i>Project</i>	<i>Target</i>	<i>Date</i>	<i>Tide</i>	<i>Sensor</i>	<i>Wavebands</i>	<i>No. of flightlines</i>	<i>Spatial resolution</i>	<i>Processing</i>
UK/NL + ISLED	Saltmarsh	20-Sep-93		CASI	12 (vis/nir) DELFT	18	4	Thomson et al. (2003, IJRS (in press))
ISLED	Saltmarsh	24-Sep-98		CASI	14 (vis/nir) BIOTA	10+1	2	Thomson et al. (2003, IJRS (in press))
BIOPTIS	Intertidal flat	27-Jun-00	LW	CASI	17 (vis/nir)	2	3	Level 1g
				ATM	8 (vis/nir)	2	3	Level 1g
HYSENS	Intertidal flat	20-Jul-00	LW	DAIS	79 (vis/nir/mir/tir)	2	4	Smith et al (2003, JCR, sub)
ISLED	Saltmarsh	24-Sep-00		CASI	14 (vis/nir) BIOTA	11+1	2	Thomson et al. (2003, IJRS (in press))
				ATM	11 (vis/nir/mir/tir)			



2000 – HySENS DAIS campaign

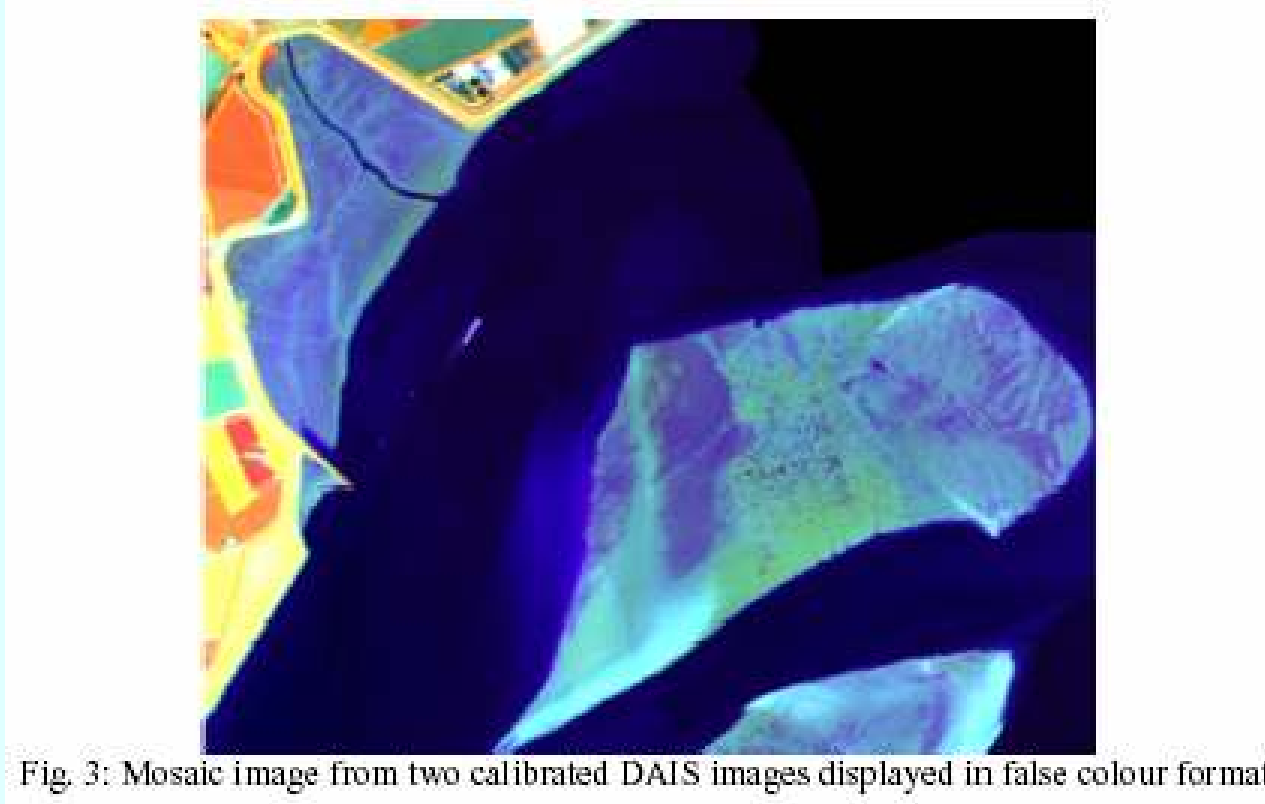
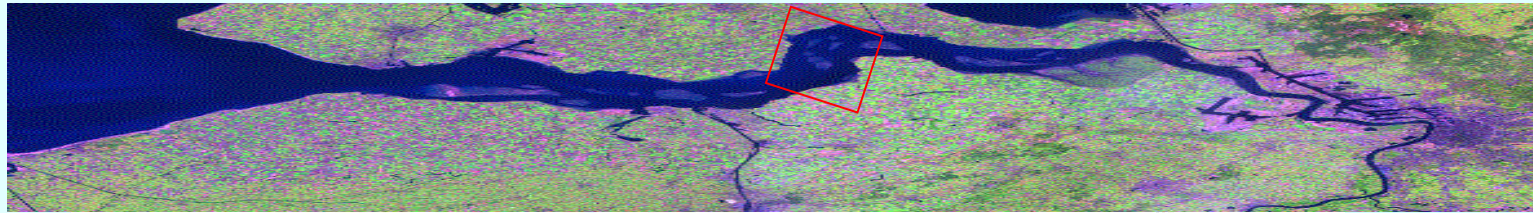
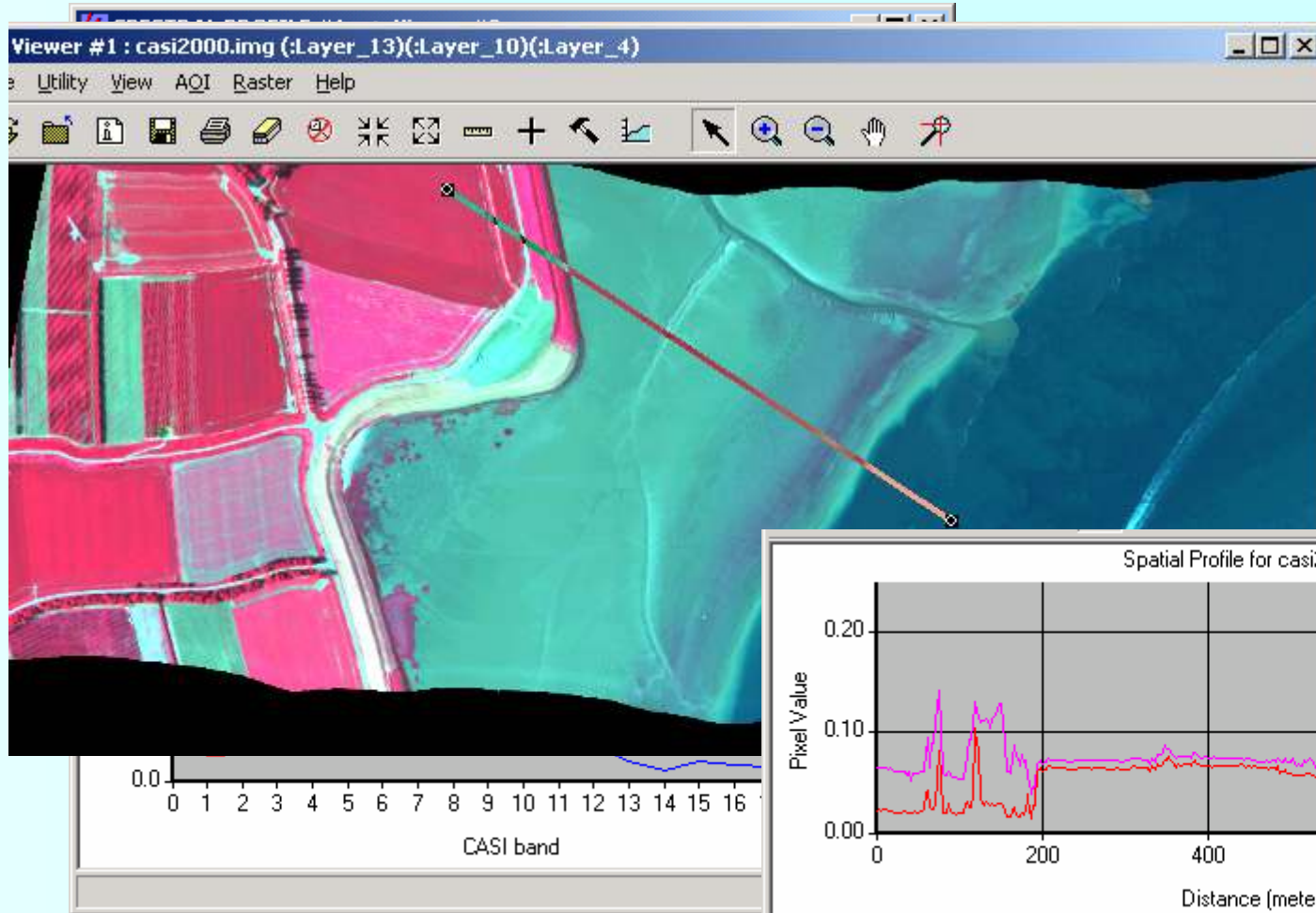
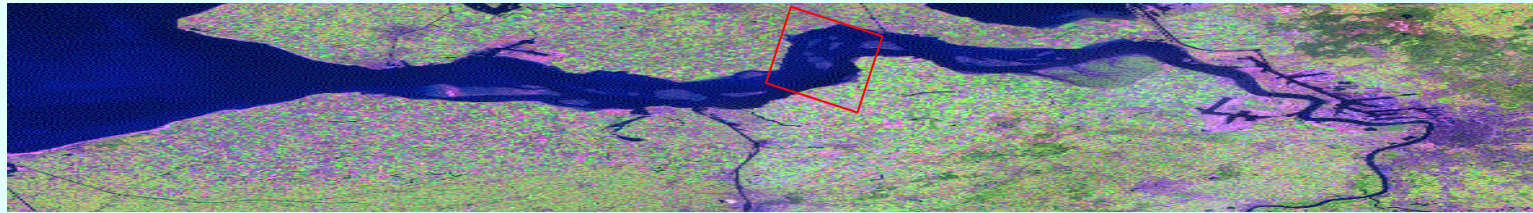


Fig. 3: Mosaic image from two calibrated DAIS images displayed in false colour format.

Smith et al. (2003) JCR



2000 – BIOPTIS CASI campaign



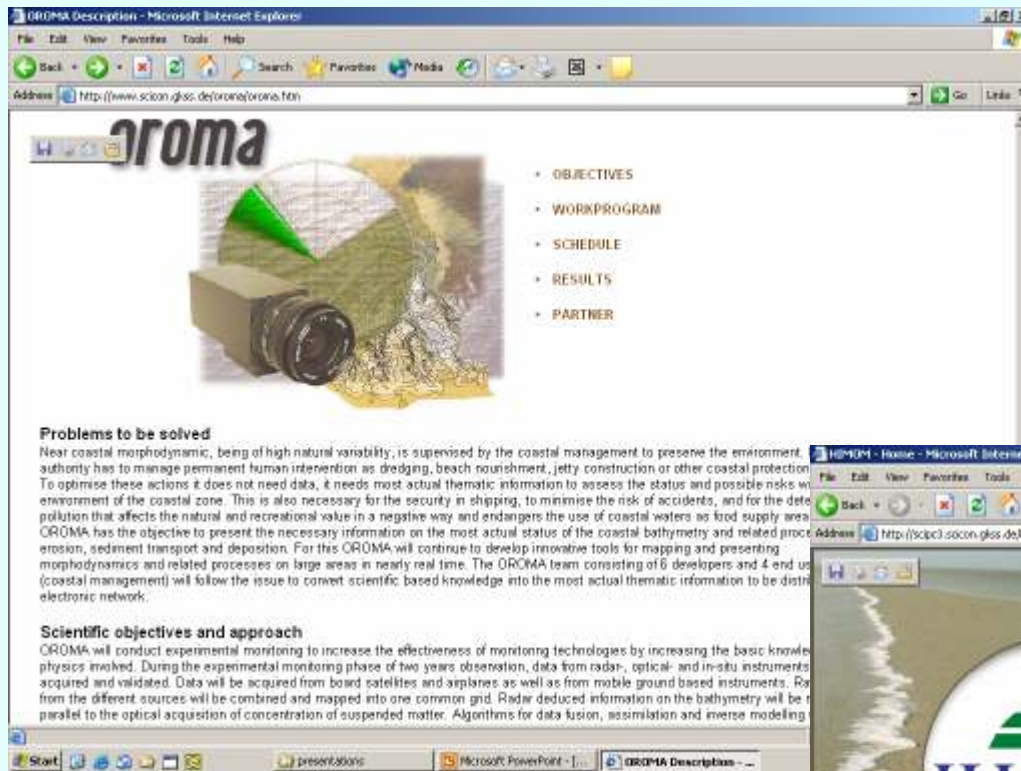
Airborne spectral datasets for the Westerschelde estuary

<i>Project</i>	<i>Target</i>	<i>Date</i>	<i>Tide</i>	<i>Sensor</i>	<i>Wavebands</i>	<i>No. of flightlines</i>	<i>Spatial resolution</i>	<i>Processing</i>
UK/NL + ISLED	Saltmarsh	20-Sep-93		CASI	12 (vis/nir) DELFT	18	4	Thomson et al. (2003, IJRS (in press))
ISLED	Saltmarsh	24-Sep-98		CASI	14 (vis/nir) BIOTA	10+1	2	Thomson et al. (2003, IJRS (in press))

BIOPTIS	Intertidal flat	27-Jun-00	LW	CASI	17 (vis/nir)	2	3	Level 1g
				ATM	8 (vis/nir)	2	3	Level 1g
HYSENS	Intertidal flat	20-Jul-00	LW	DAIS	79 (vis/nir/mir/tir)	2	4	Smith et al (2003, JCR, sub)
ISLED	Saltmarsh	24-Sep-00		CASI	14 (vis/nir) BIOTA	11+1	2	Thomson et al. (2003, IJRS (in press))
				ATM	11 (vis/nir/mir/tir)			

OROMA	Water quality	2-Sep-02	HW	CASI	10 (MERIS)	10	3	Level 1g
HIMOM	Intertidal flat	3-Sep-02	LW	CASI	10 (MERIS)	3	3	Level 1g
OROMA/HIMOM	Water /intertidal	7-May-03	LW	CASI	10 (MERIS)	13	3	data in preparation
OROMA/HIMOM	Water /intertidal	17-Aug-03	LW	CASI	10 (MERIS)	13	3	mission failed
OROMA/HIMOM	Water /intertidal	1-Sep-03	LW/HW	CASI	10 (MERIS)	13	3	in planning





Coastal Water Quality

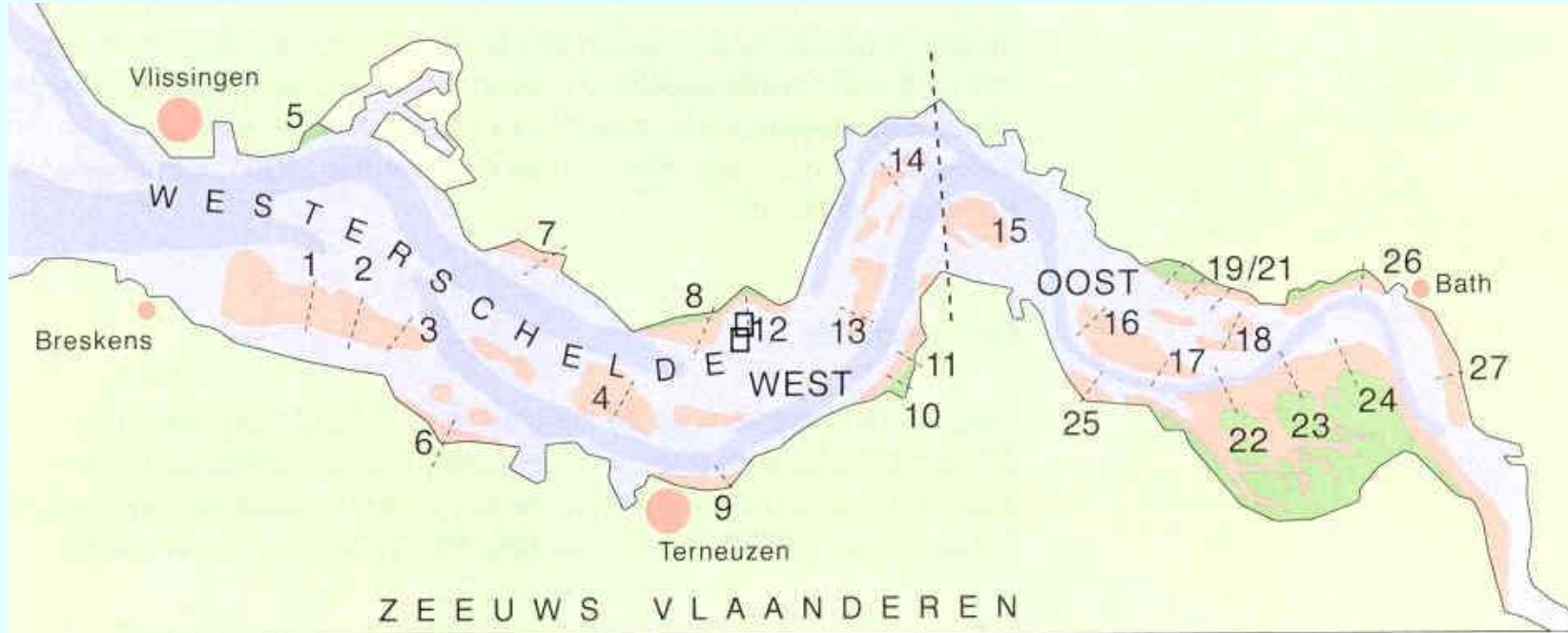
<http://www.scicon.gkss.de/oroma/oroma.htm>



Intertidal sediments

<http://scipc3.scicon.gkss.de/himom/>

Can RS be used as a cost-effective alternative to traditional coastal zone monitoring?

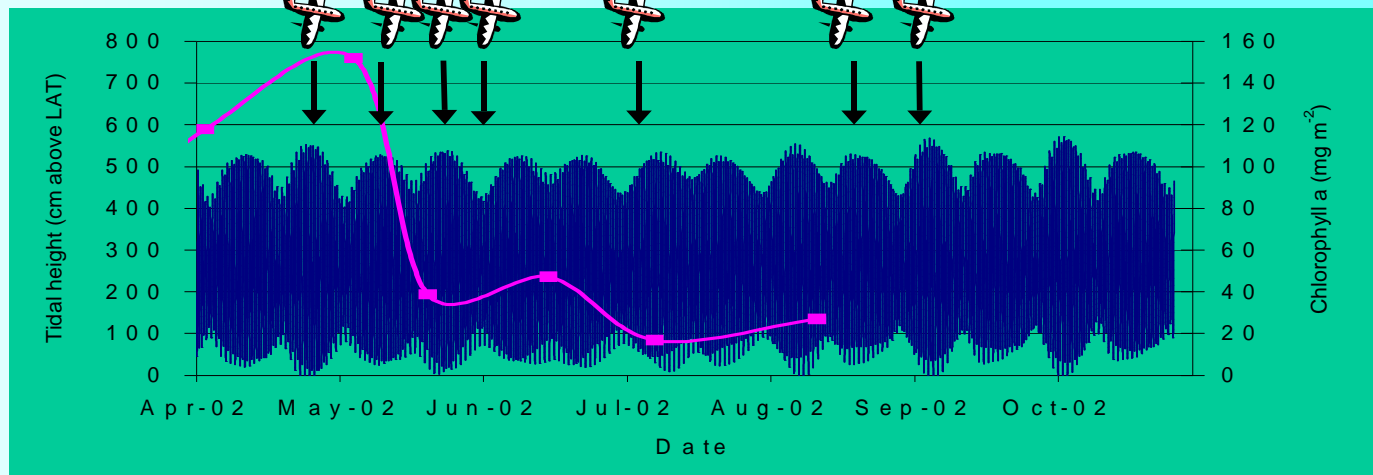


RIKZ sampling stations

27 transects, 115 stations, from 1989



HiMOM/MD-RWS planned EPS-A remote sensing campaigns 2002



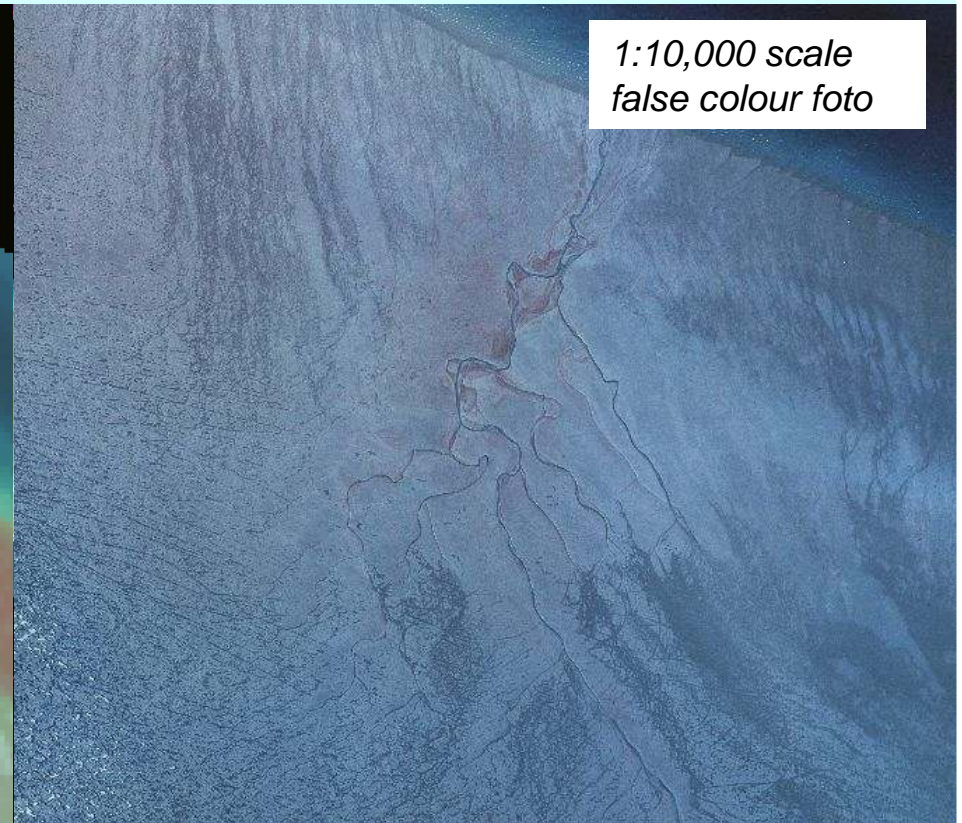
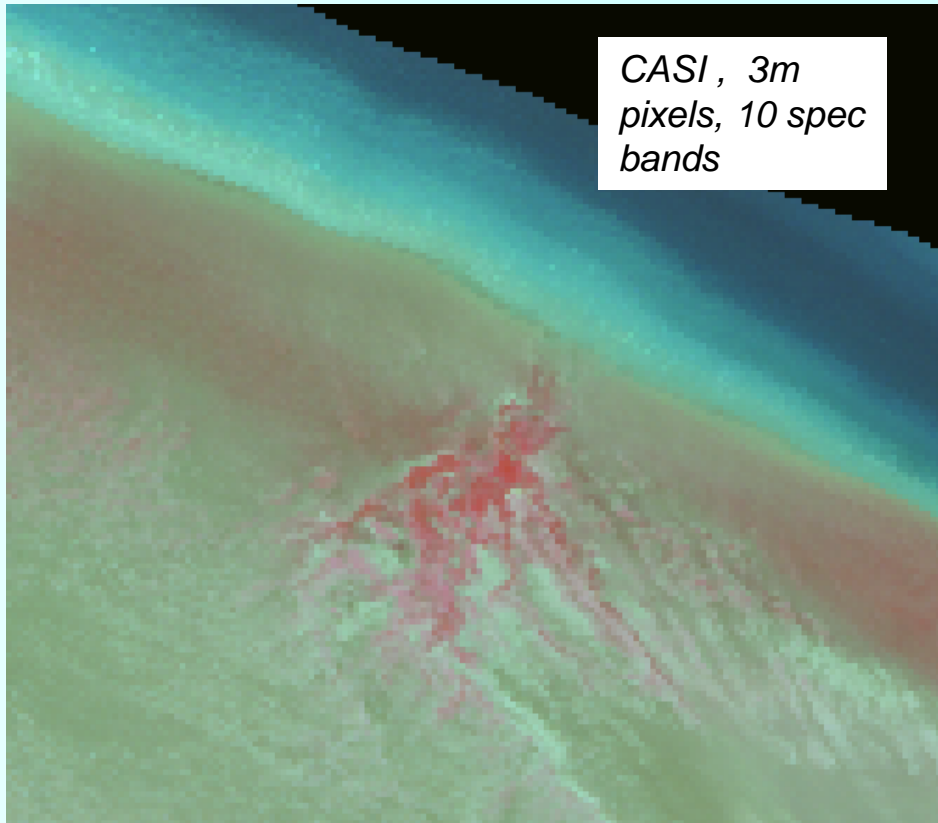
CASI HIMOM / OROMA flight 03/09/02



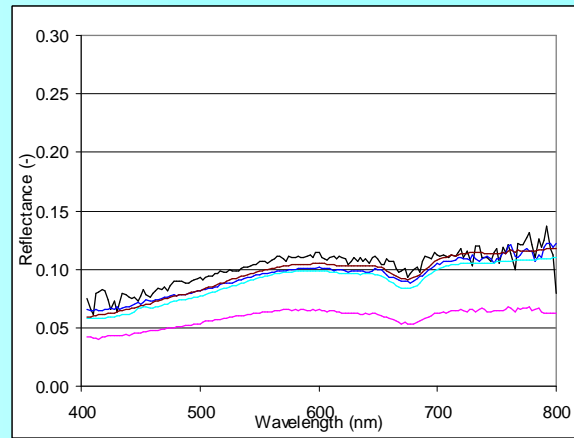
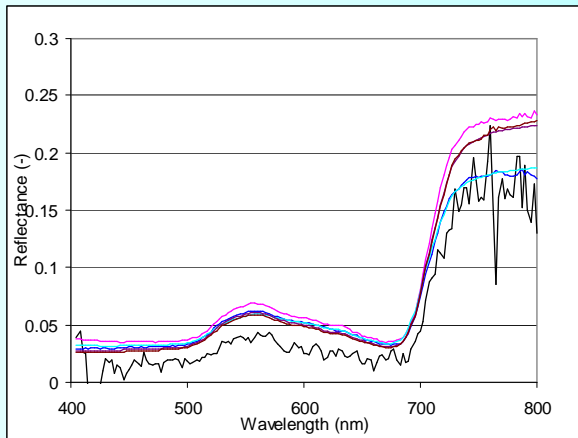
Height	3000 m
Strip width	1915 m
Pixel size	3,7 x 3,7 m
Number Bands	10
Wavelengths (appr.)	1
cal information	
2	437-447 nm
3	485-495 nm
4	505-515 nm
5	555-565 nm
6	615-625 nm
7	660-670 nm
8	676-686 nm
9	700-710 nm
10	748-757 nm
11	770-780 nm



Airborne photography and spectral scanning (CASI)



Ground truthing using hyperspectral field spectrometry



Forster et al. (in prep) IJRS



Vertical distribution of photosynthetically-active biomass in the sediment

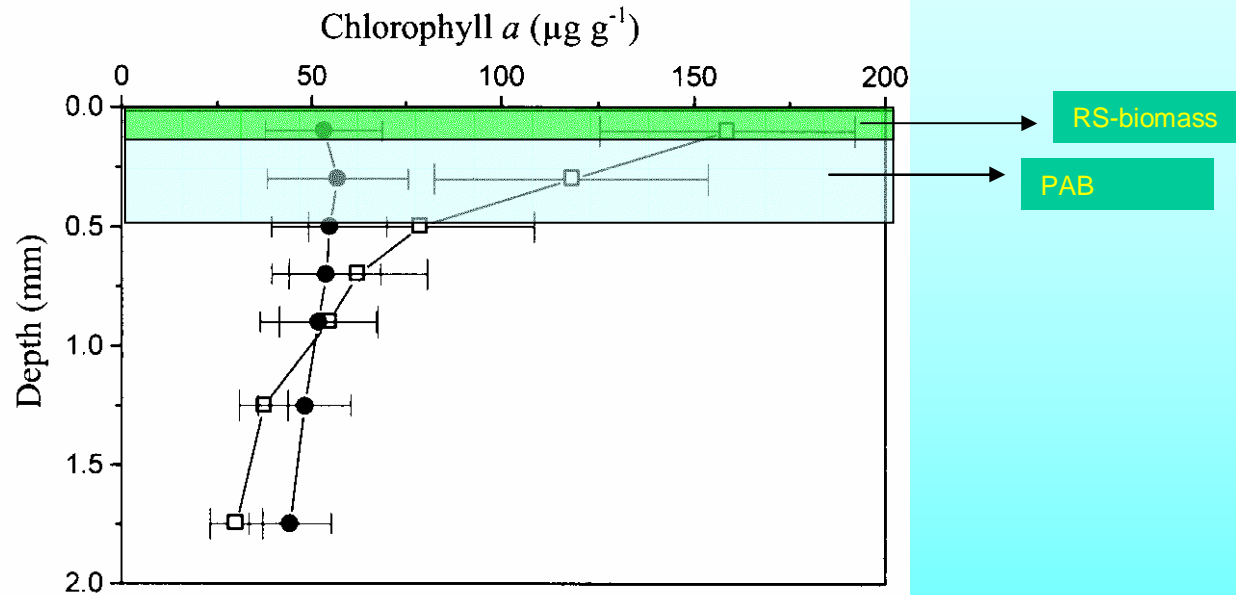


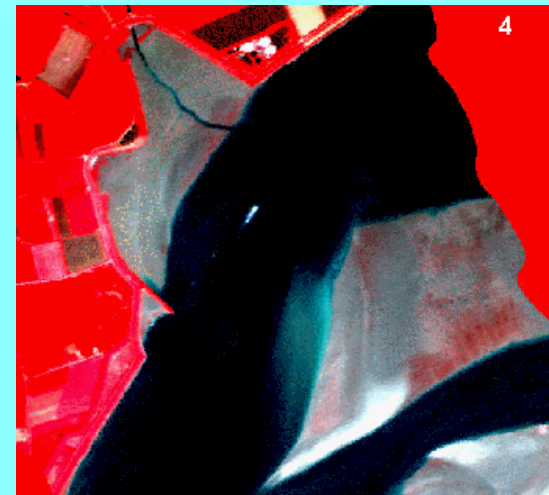
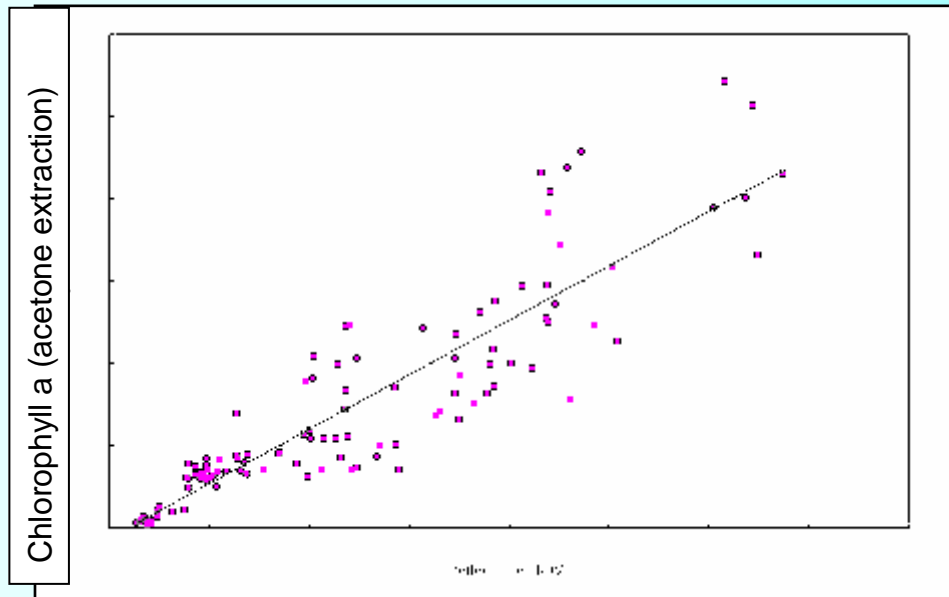
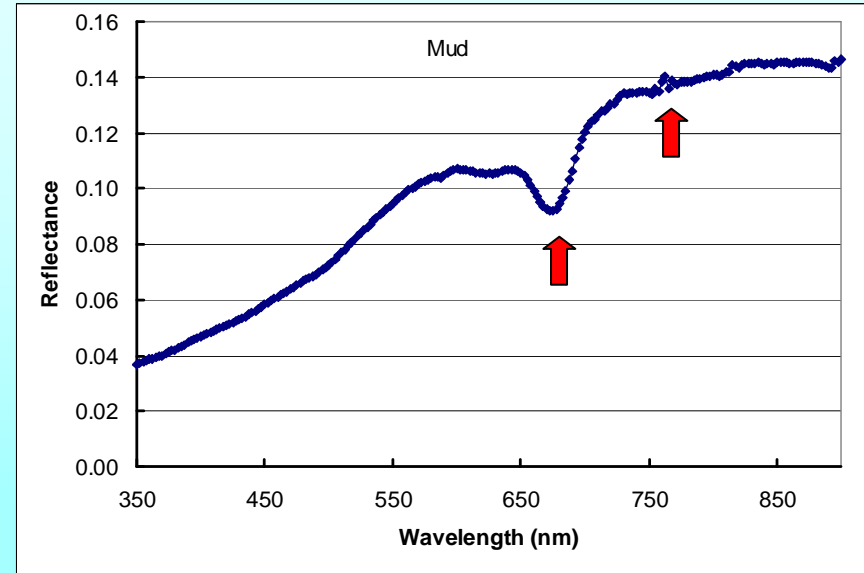
Fig. 5. Vertical profiles of average (± 1 SD) chl *a* contents on 20 May 1999 during daytime (□) and nighttime (●) emersion periods

De Brouwer & Stal (2001)



Remote sensing of sediment surface chlorophyll

Indices derived from hyperspectral reflectance at ground level provide an excellent prediction of microalgal chlorophyll in the upper 2 mm layer of the sediment



Tidal flat primary production model

Classification of ecotypes using expert knowledge

(P_{max}, α, K_d)

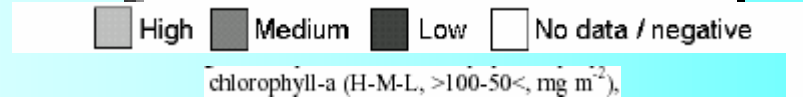
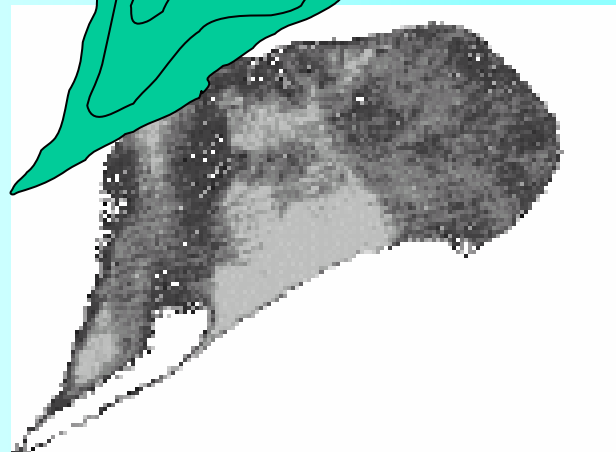
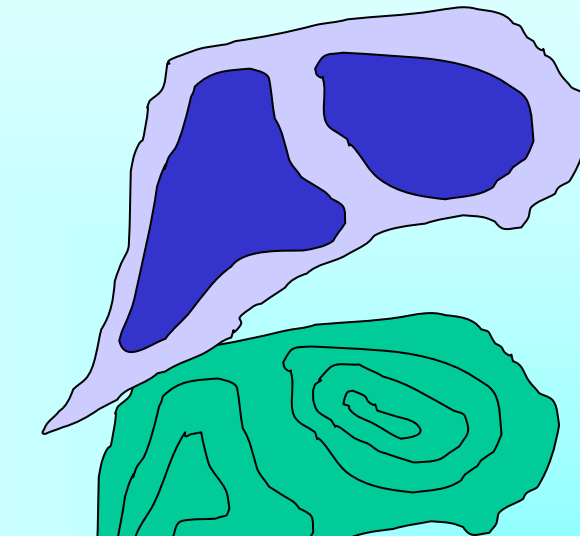
2 classes for ecophysiology

Digital elevation model for calculation of E and SST

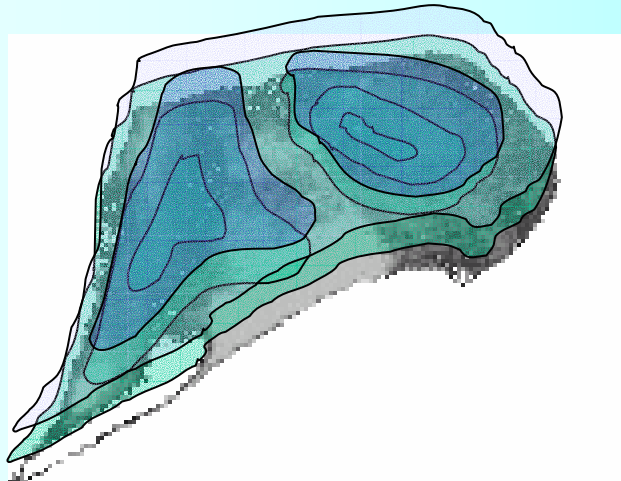
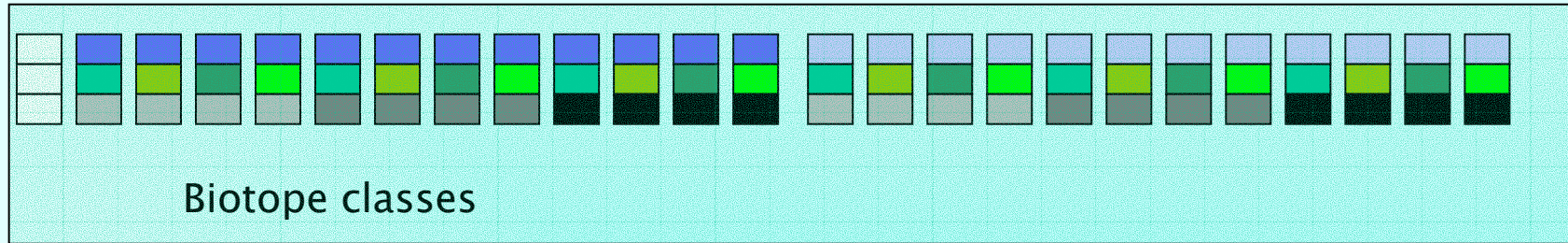
4 classes for depth (0.5 m)

Classification of biomass using spectral reflectance

4 classes for B

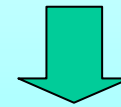


Combination of feature layers in a GIS

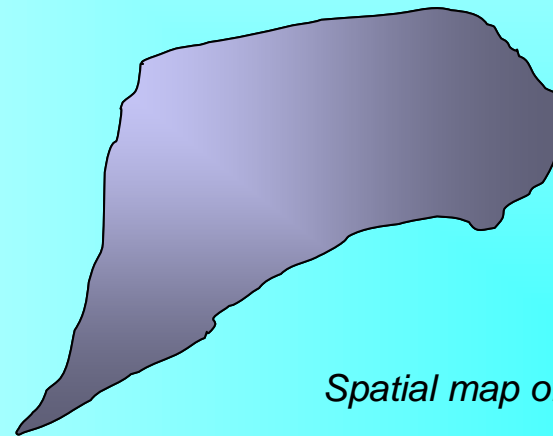


High Medium Low No data / negative

chlorophyll-a (H-M-L, >100-50<, mg m⁻²),



PP for each class



Spatial map of production



Summary

Airborne RS with CASI can be used successfully in estuarine ecology for:

- quantifying changes in land cover
- classification of intertidal habitat types
- prediction of microalgal biomass (primary production)

But, a higher frequency of overflights (at lower price!) is required before recommendation for use in coastal zone management / monitoring programs

