Mid-term presentation of the MSc thesis

Seagrass mapping and monitoring along the coast of Crete, Greece

By **Lemenkova P.**
CO9 – GEM – MSc - 09
November, 2010
Supervisors: V.Venus, B.Toxopeus

ITC

FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION, UNIVERSITY OF TWENTE
ENSCHEDE, THE NETHERLANDS

Research problem

The research problem of the current study focuses on the exploring of the spatial distribution of the seagrass meadows on the case study of *P. oceanica,* using aerial and satellite imagery over the 10-years period, to analyse its dynamics.

Spectral reflectance characteristics of the seagrass enables its discrimination from other seafloor types, therefore, raster images processing using RS methods is highly suitable for the seagrass mapping.

The current MSc research of the seagrass mapping is based on various sources of data: fieldwork in-situ measurements, satellite imagery, aerial imagery and GIS layers (maps of Crete), technically based on using GIS and RS methods (*ENVI* and *ArcGIS* software).

Fig. 1. Crete Island: general overview

Fieldwork research area: general overview

Seagrass sampling has been performed at two stations at a depth of 4 meters, in the following selected areas:

1. *Ligaria beach (Agia Pelagia district), 36°20′N 22°59′E*
2. *Xerokampos, 35°12′N 26°18′E*

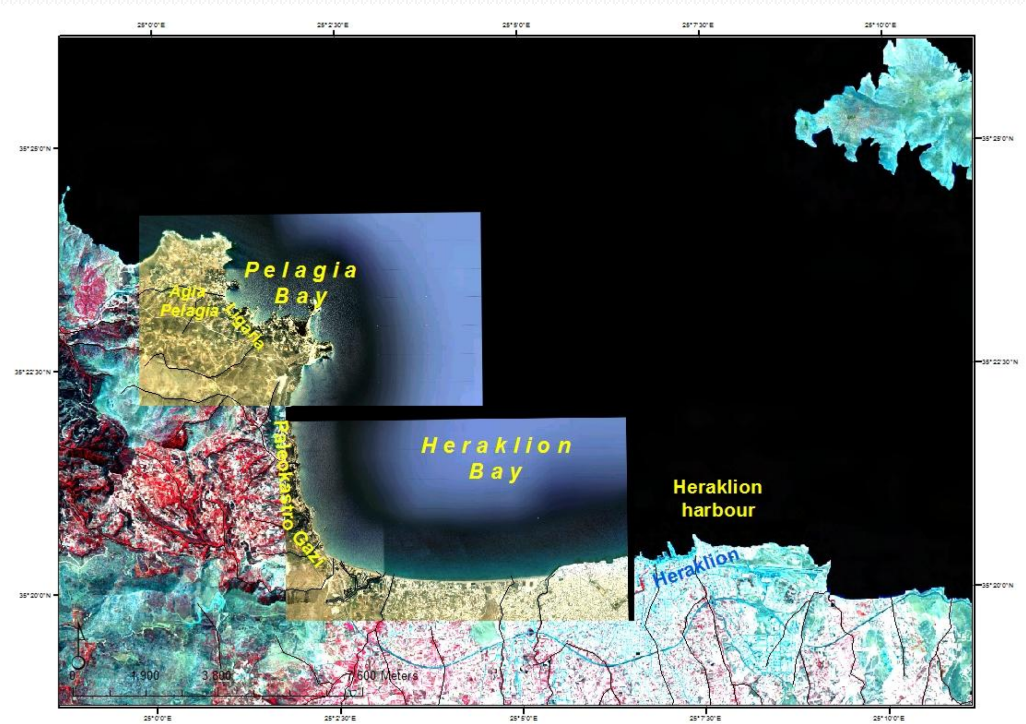


Fig. 2. Heraklion Bay: satellite imagery of the study area

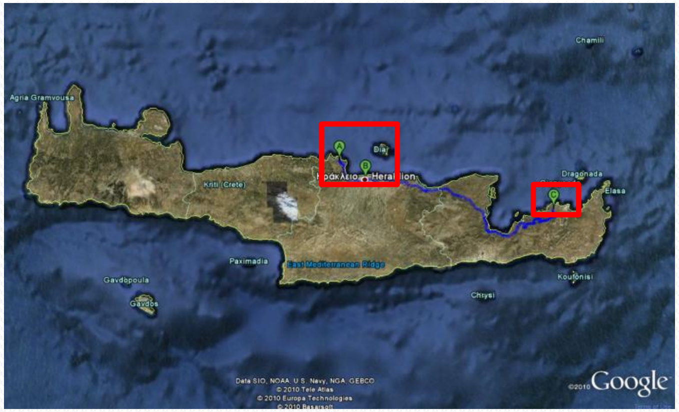


Fig. 3. Study area: locations of measurements. Source: Google Earth.

General research objectives

The general research objectives of the MSc research includes GIS and environmental analysis:

- ✓ **Mapping the extent of the spatial distribution of seagrass *P. oceanica* along the northern coast of Crete**

- ✓ **Monitoring environmental changes in seagrass meadows in the selected fieldwork sites** (Agia Pelagia, Xerokampos) over the 10-year period (2000-2010)

The research is based on three types of the data:
i) satellite, *ii)* aerial images and *iii)* fieldwork measurements, using methods of the remote sensing and GIS analysis.

Specific research objectives

- To apply aerial images from the Google Earth as well as broadband remote sensing imagery *Landsat TM* , *MSS, ETM+, Ikonos, SPOT* images for the seagrass monitoring along the Cretan coasts.

- To use supervised classification for the thematic mapping of the seagrass distribution
- Assessment of accuracy of seagrass mapping using GIS & RS

Fieldwork main research area: Ligaria beach

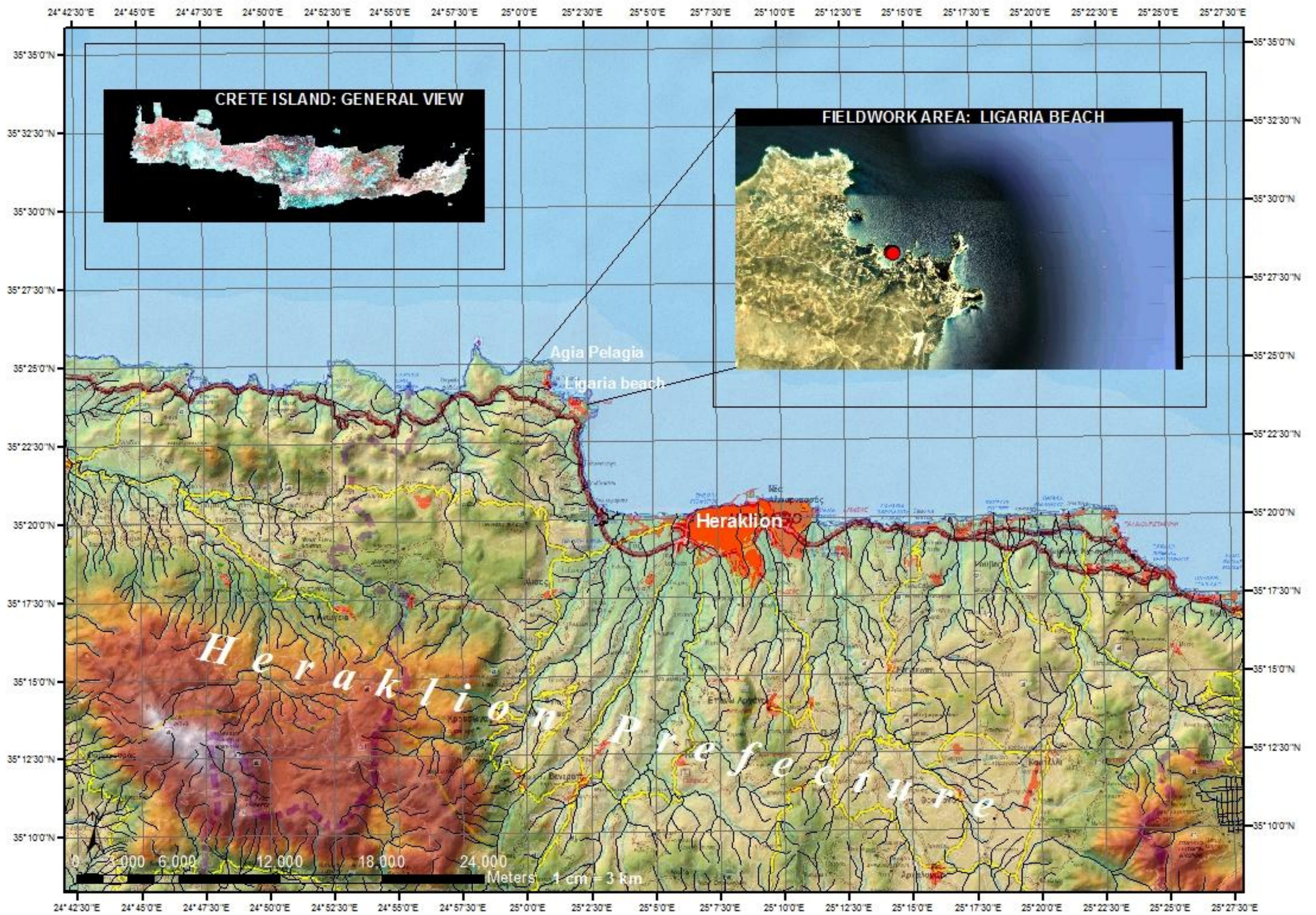


Fig. 4. General overview of the study area and its location within the Crete Island

Most important facts about seagrass…

Fig.5. Seagrasses. Source: Google

The endemic Mediterranean seagrass ***Posidonia oceanica*** is a main species in marine coastal environment of Greece:

- the largest,
- the most widespread,
- homogeneous,
- dense "mattes" forming meadows between 5 -40 m

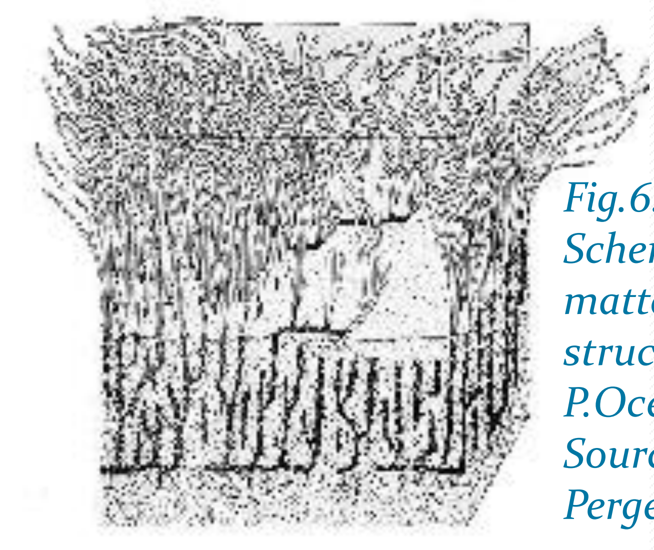


Fig.6. Scheme of matte structure of P.Oceanica. Source: Pergent, 1990

Fig.7. Seagrasses. Source: Google

Overview of Data – I
Sources of Data: primary and secondary

The research is based on the following types of data:

Primary source – data collected during the fieldwork :

- Underwater videometric measurements of the *Olympus* cameras made during the ship route: 9 total routes in the selected areas of the research places, resulting in series of consequent images, completely covering the area under the boat path.
- Underwater imagery received by the *Olympus* cameras

Secondary – source data:

i *Imagery*

Aerial imagery from the *Google Earth*

Satellite images from the open sources (mostly *Landsat*)

ii *Maps*

Detailed road map covering Crete island

Raster map consisted of satellite images (mosaic), whole Crete

Topographic detailed map of Crete island

iii *Results of measurements*

Data of the previous measurements received during the last year fieldwork, to analyse whether *P.Oceanica* is spectrally distinct from other sea floor types, using the differences in the spectral signatures on the graphs in a *WASI, the Water Colour Simulator* software.

Overview of data - II

Types of research data:

1. Satellite images from the open sources (*Landsat TM*)
2. Aerial images, Google Earth
3. *In-situ* observations of the seagrass in selected spots for the validation of the results, using measurement frame and underwater videographic measurements of 3 cameras *Olympus ST 8000* made during the boat route (9 total in the selected areas of the research places) resulting in series of consequent images, completely covering the area under the boat path
4. Arc GIS vector layers of Crete island and surroundings (.shp files)
5. Georeferenced raster maps covering the whole area of Crete island: road map, mosaic of satellite images and topographic map
6. Data of the previous measurements received during the last year fieldwork, to analyse whether *P.Oceanica* is spectrally distinct from other sea floor types, using the differences in the spectral signatures on the graphs in a *WASI*, the Water Colour Simulator software.

Overview of data collected during the fieldwork

Folder / Types of research data:

1. Video measurements:

folder "*28 Sep*":

Right camera

P9250114.MP4
P9250114.MP4
P9280616.MP4
P9260521.MP4
P9260507.MP4
P9260506.MP4
480 photos recorded

Middle Camera

P9280203.MP4
P9250019.MP4
P9250008.MP4
152 photos recorded

Left Camera

P9280074.MP4
73 photos recorded

folder "*29 Sep*":

PA060643.MP4
PA060624.MP4
PA060206.MP4

folder "*02 Oct*"

Camera 2 - PA020204.MP4
Left Camera - PA020107.MP4
Middle Camera - PA020204.MP4
Right camera - PA020618.MP4

folder "*ArcPadCrete*" (selected files w/o auxiliary ones)

29apr2004_Agia_Pelagia_Crete_googleearth_.ecw
gdal_enhhist_28may2002_GG.tif
gdal_enh_28may2002_Agia_Pelagia_Crete_googleearth_.ecw
gdal_28may2002_Agia_Pelagia_Crete_googleearth_.ecw
enhERDAS_28may2002_agia_pelagia_crete_googleearth_.ecw
Band1_APelagia_google_15juin2002.tif
Band2_APelagia_google_15juin2002.ti
Band3_APelagia_google_15juin2002.ti
APelagia_google_15jun2002.ecw
15june2002_composite.mpv

Stereobase.xls (the stereo base principles and calculation of the focus length)
Sand_characteristic_Data.xls (some meteorological data)

folder camera olympus 2 oct 2010_Ligaria

PA020204.MP4
PA020618.MP4

folder "*i-Paq-1*"

folder *Arc Pad*
folder *Greek Grid*
folder *UTM 35N*

Map of the locations of the video measurements and GPS tracklogs, Ligaria

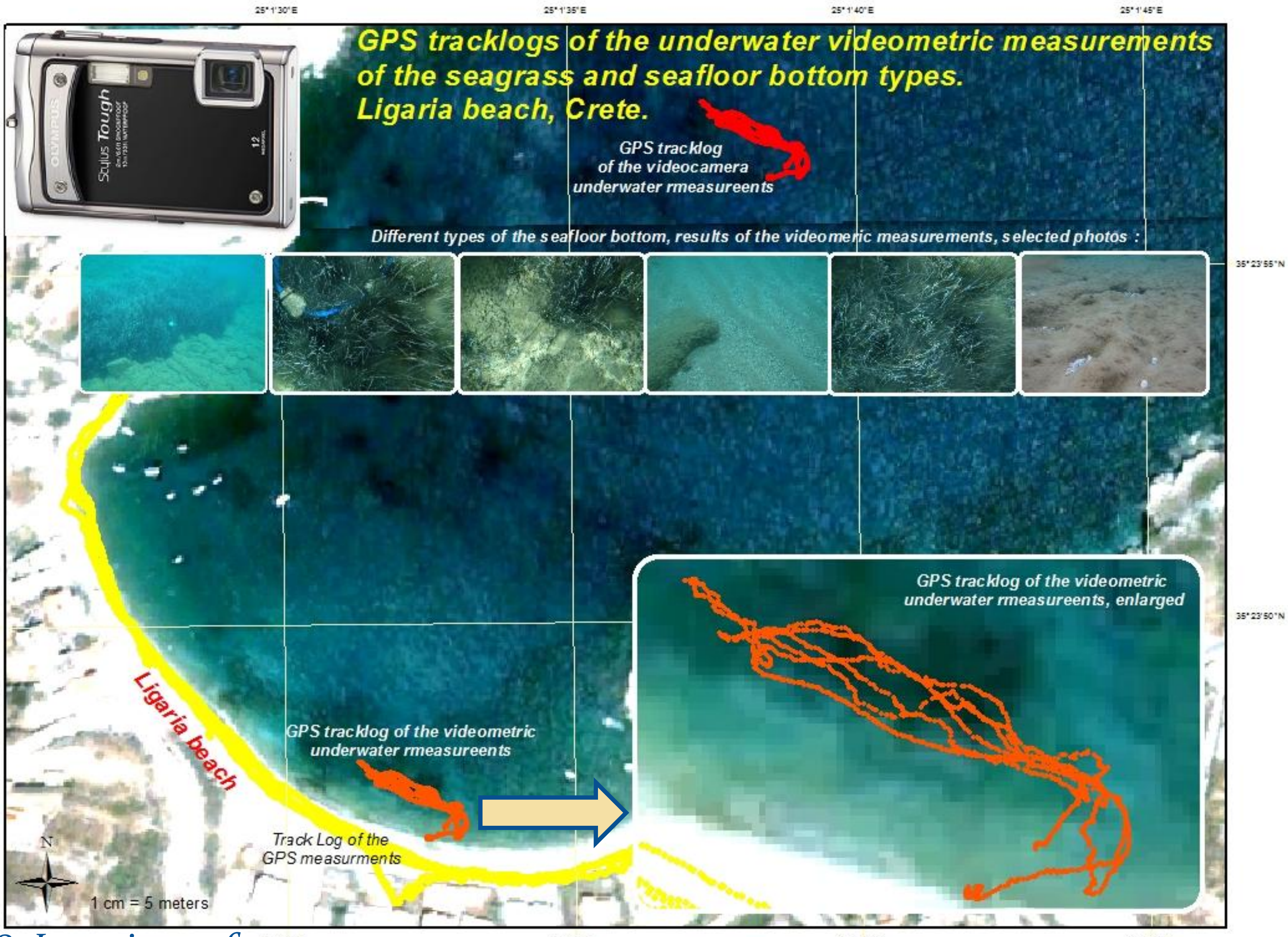
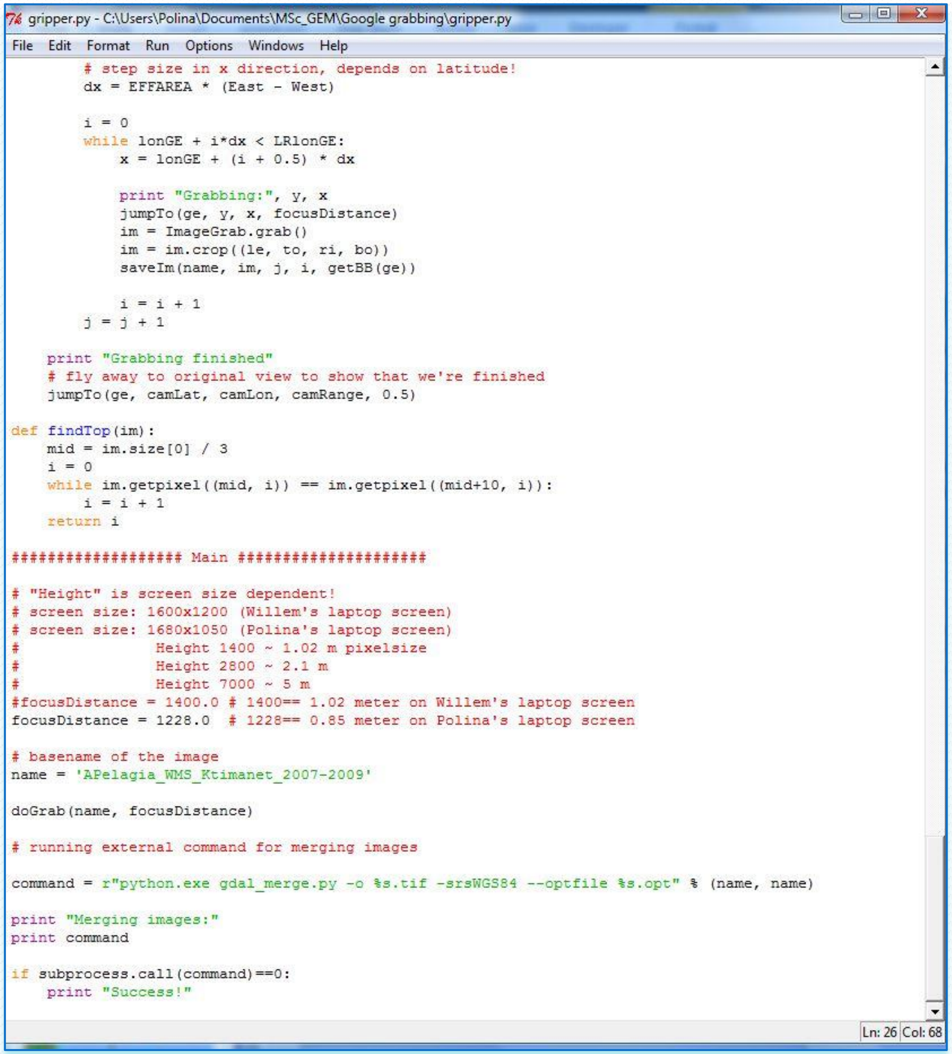


Fig. 8: Locations of measurements

Selected snapshots of the video recordings: different seafloor types, Ligaria beach, Crete.

Fig. 9. Seafloor types

Google Earth images grabbing and stitching - I



gripper.py - C:\Users\Polina\Documents\MSc_GEM\Google grabbing\gripper.py

File Edit Format Run Options Windows Help

```
        # step size in x direction, depends on latitude!
        dx = EFFAREA * (East - West)

        i = 0
        while lonGE + i*dx < LRlonGE:
            x = lonGE + (i + 0.5) * dx

            print "Grabbing:", y, x
            jumpTo(ge, y, x, focusDistance)
            im = ImageGrab.grab()
            im = im.crop((le, to, ri, bo))
            saveIm(name, im, j, i, getBB(ge))

            i = i + 1
        j = j + 1

    print "Grabbing finished"
    # fly away to original view to show that we're finished
    jumpTo(ge, camLat, camLon, camRange, 0.5)

def findTop(im):
    mid = im.size[0] / 3
    i = 0
    while im.getpixel((mid, i)) == im.getpixel((mid+10, i)):
        i = i + 1
    return i

################### Main ####################

# "Height" is screen size dependent!
# screen size: 1600x1200 (Willem's laptop screen)
# screen size: 1680x1050 (Polina's laptop screen)
#             Height 1400 ~ 1.02 m pixelsize
#             Height 2800 ~ 2.1 m
#             Height 7000 ~ 5 m
#focusDistance = 1400.0 # 1400== 1.02 meter on Willem's laptop screen
focusDistance = 1228.0  # 1228== 0.85 meter on Polina's laptop screen

# basename of the image
name = 'APelagia_WMS_Ktimanet_2007-2009'

doGrab(name, focusDistance)

# running external command for merging images

command = r"python.exe gdal_merge.py -o %s.tif -srsWGS84 --optfile %s.opt" % (name, name)

print "Merging images:"
print command

if subprocess.call(command)==0:
    print "Success!"
```

Ln: 26 Col: 68

I. The aerial imagery has been downloaded using the python scrip from the Google Earth webpage using the command (written on *Python* by Mr. W. Nieuwenhuis).

The script file ***gdal_merg.py*** tool has been used to stitch the tiles into one big image. (Fig. 11)

Fig. 10. Example of Google grabbing process.

Google Earth images grabbing and stitching - II

After the downloading the size of the images has been reduced to the lower one, from .tif to .ecw format, using the following script command of *FWTools2.4.7* (example of one of the files):

cd C:\Program Files\FWTools\bin

gdal_translate -of ECW -co "TARGET=0" -co "DATUM=WGS84" "C:\Users\Polina\Documents\MSc_GEM\Google grabbing\APelagia_WMS_Ktimanet_2007-2009.tif" "C:\Users\Polina\Documents\MSc_GEM\Google grabbing\APelagia_WMS_Ktimanet_2007-2009.ecw"

C:\Program Files\FWTools2.4.7\bin>gdal_translate -of GTiff -co "DATUM=WGS84" "C:\Users\Polina\Documents\MSc_GEM\HOLLAND\DISSER_MSc\Crete\ArcPad_crete\APelagia_google_15jun2002.ecw" "C:\Users\Polina\Documents\MSc_GEM\HOLLAND\DISSER_MSc\Crete\ArcPad_crete\APelagia_google_15juin2002.tif

Google Earth images grabbing and stitching - III

Some examples of the images downloaded from Google Earth using grabbing process (Crete, different areas) :

Fig. 11. Google Imagery

Google Earth images of the northern coast of Crete integrated into the ArcGIS as layers

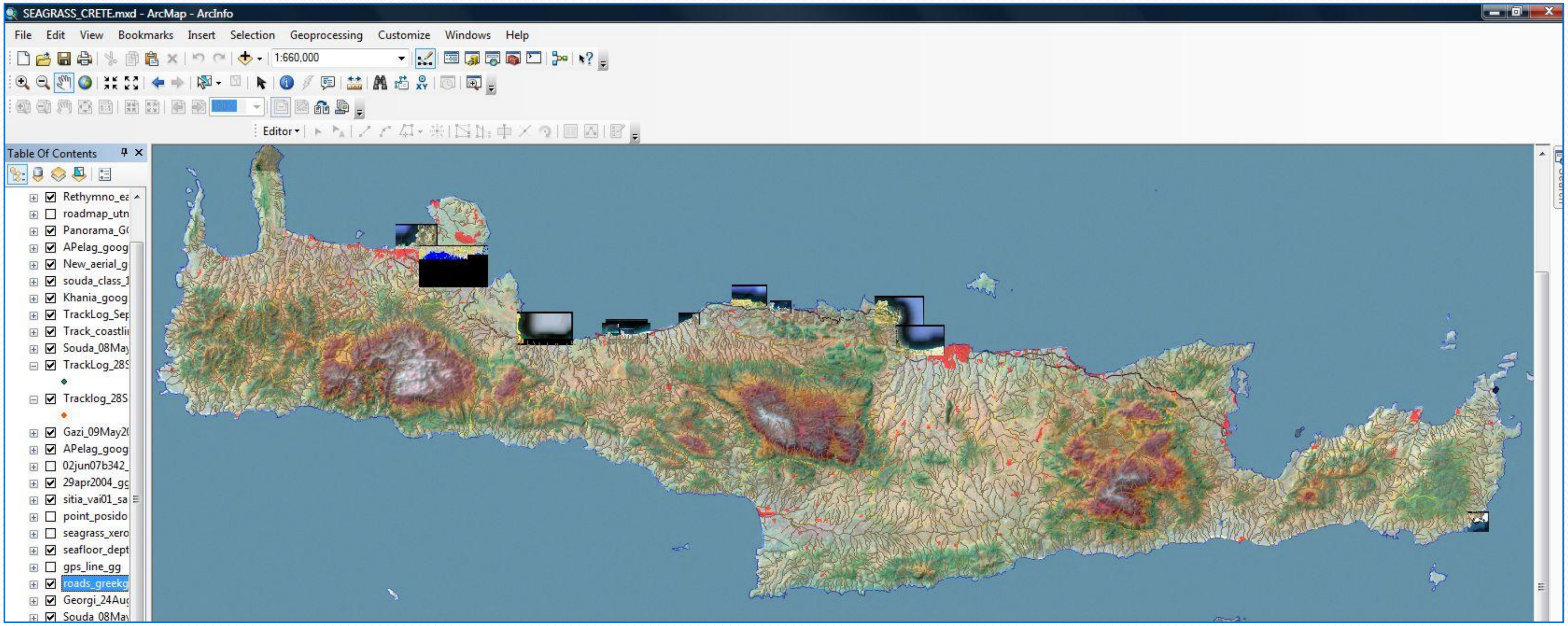


Fig. 12. Google images read into GIS project of Crete Island

Results of the unsupervised classification, Agia Pelagia, raster layer read into the ArcGIS project

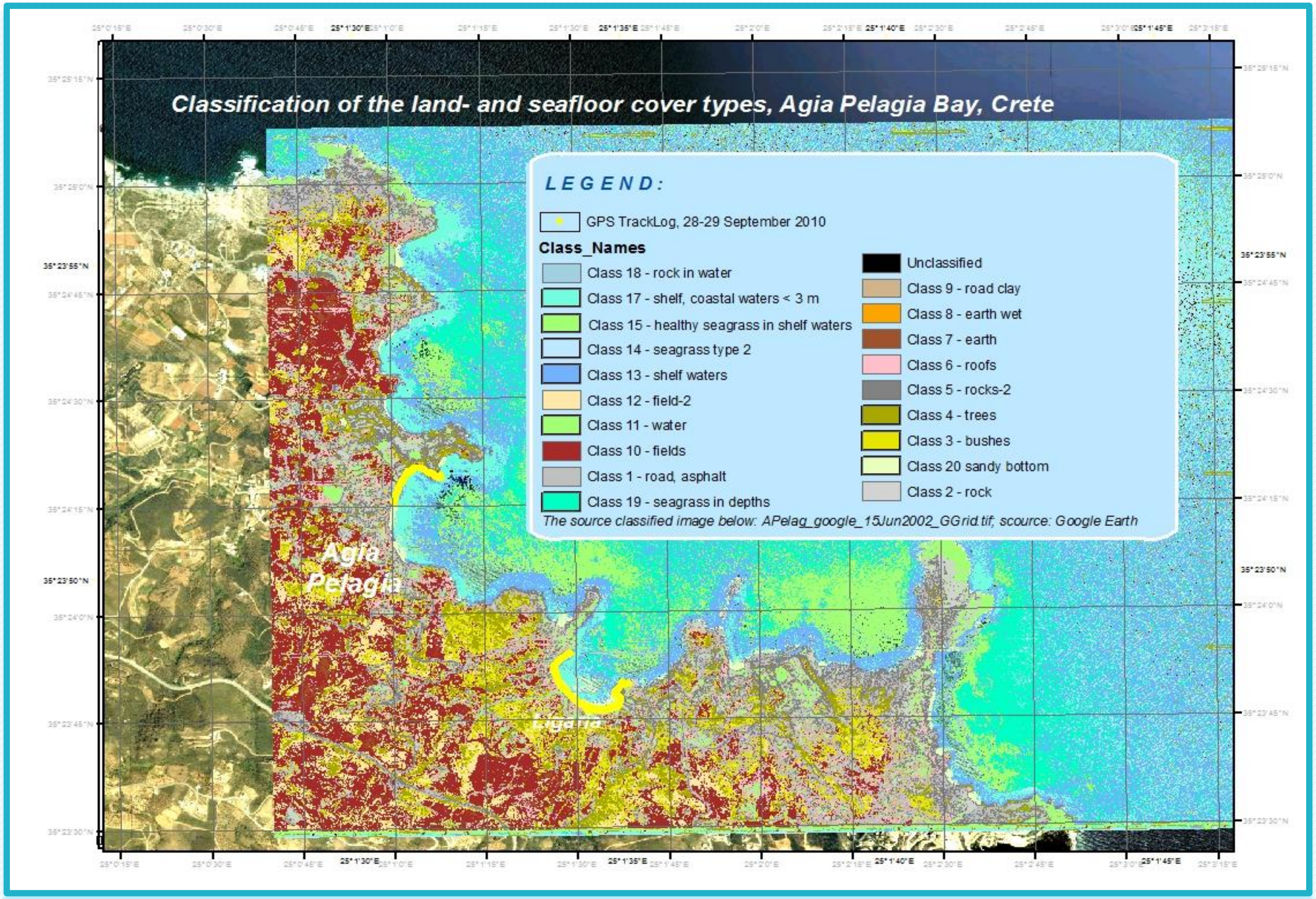
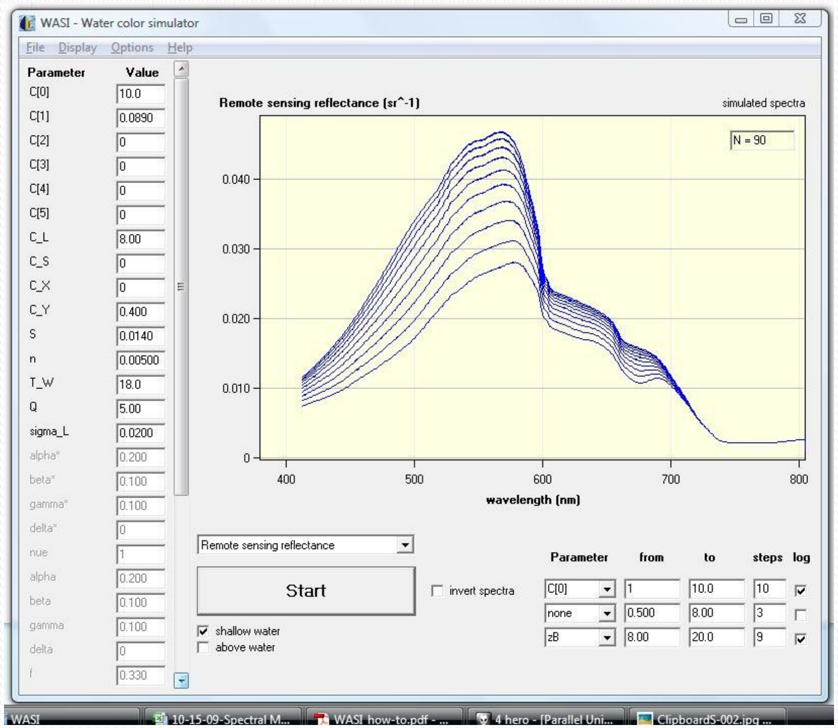


Fig. 13. unsupervised classification

WASI water colour simulator software - I

WASI software is used to simulate situations with different water colour, coloured by presence of *P.Oceanica* and other factors (see below).

WASI helps to perform <u>colour discrimination and spectral reflectance of water under various environmental conditions</u> which influence its colour, namely :



- ✓ Different bottom depths,
- ✓ Concentration of suspended particles in water column
- ✓ Water temperature,
- ✓ Sun angle
- ✓ Concentration of Gelbstoff (coloured dissolved organic matter)
- ✓ Concentration of phytoplankton
- ✓ Aerosol scattering
- ✓ Exponent of backscattering by small particles

Fig. 14. WASI: RS reflectance; concentration of phytoplankton at depths 0.5 – 8.0 m

WASI water colour simulator software - II

From all different parameters for the simulation of the *P.oceanica* spectrum, the most valuable and important are the following three:

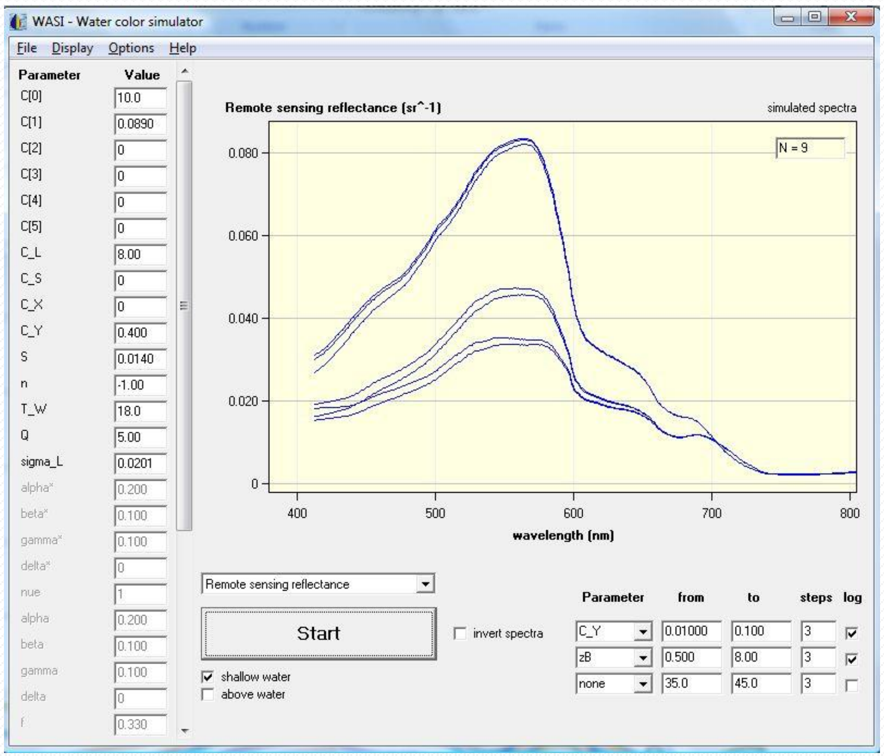


Fig. 15. WASI water colour simulator; Concentration of Gelbstoff at depths 0.5 – 8.0 m

- bottom depths,
- sun angle at zenith
- concentration of Gelbstoff (coloured dissolved organic matter)

The concentration of Gelbstoff is a primary factor affecting the absorption on incident sunlight in coastal and estuarine waters.

Changes in these parameters affects the accuracy of the seagrass mapping

Plots of bottom reflectance (right) and remote sensing reflectance (left)

The calculations are done for the spectrum *400-800 nm* (Fig. 15 - 16), covering the most important part of the RS spectrum:

1) Blue-green 0.45 - 0.5 µm

2) Green 0.5 - 0.6 µm

3) Red 0.6 - 0.7 µm

4) Red-NIR 0.7 - 0.8 µm

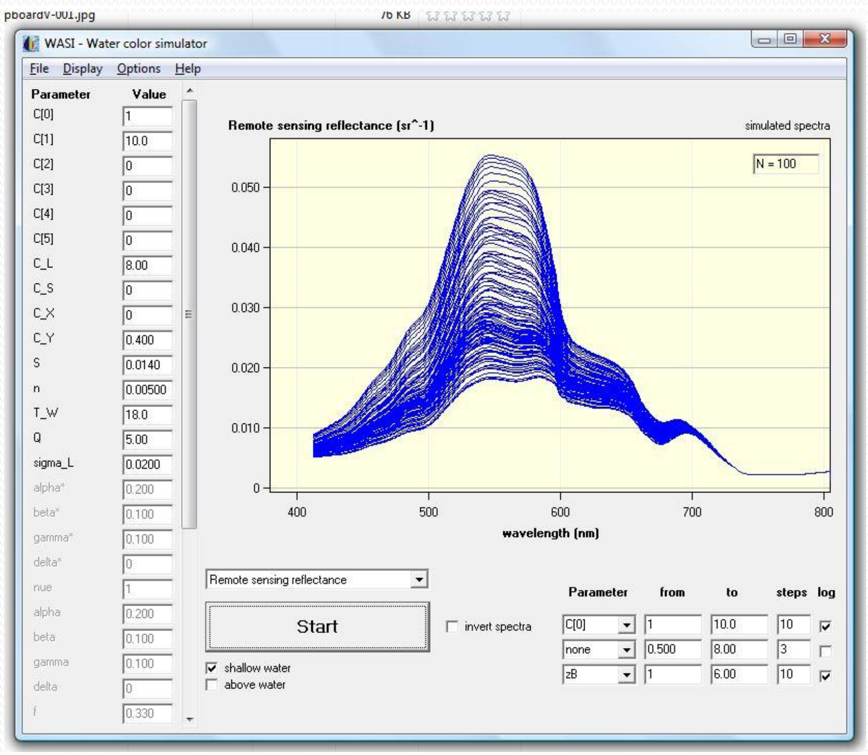


Fig. 16. Remote sensing reflectance, depth 0.5-8.0 meters

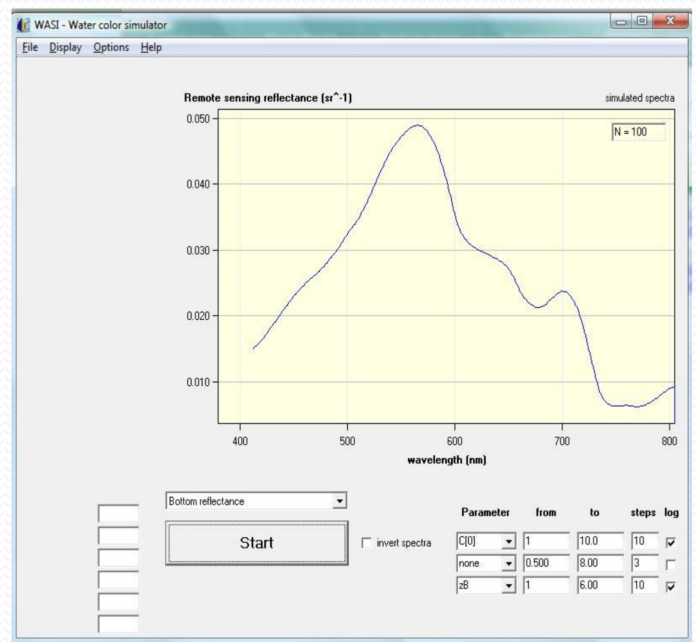


Fig. 17. Bottom reflectance depth 0.5-8.0 meters

Bottom reflectance of P.oceanica

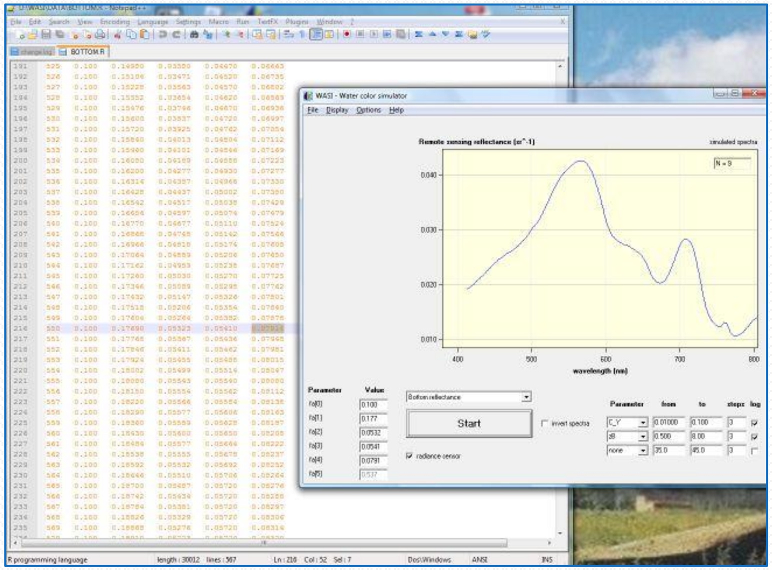
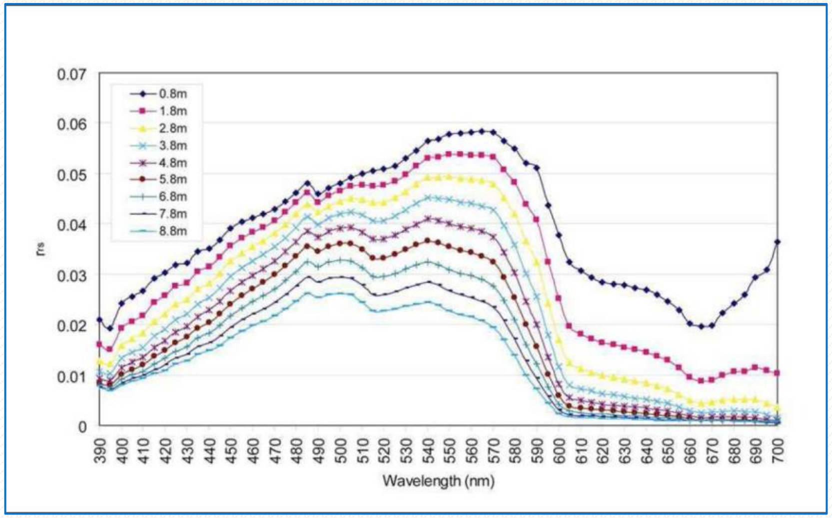


Fig. 18. Bottom reflectance of P.oceanica, 550 nm; depth 0.5-8.0 meters

The WASI models of bottom reflectance are used to calculate reflectance and radiance spectra in shallow waters.
The data of reflectance of P.oceanica, silt and green algae macrophyte, are read from the specific file (*bottom.r*) of the WASI documentation (Fig.16).



The data of reflectance has been measured by N.Pinnel in 2005 using a submersible RAMSES spectroradiometer.

RS of seagrass underwater measurement at various depths measured by a remote operated vehicle (ROV), equipped with a SPECTRIX sensors.

Fig.19. Figure taken from: Farmer (2005). Bottom Albedo Derivations Using Hyperspectral Spectrometry and Multispectral Video.

Satellite images of the Crete island

№	Image source	Data	Name
1	Landsat ETM+	2005/May/04	WRS2p181r035L71181035_035_20050504_ETM-GLS2005
2	Landsat TM	2006/Nov/07	WRS2p181r036L5181036_036_20061107_TM-GLS2005
3	Landsat ETM+	2005/Apr/25	WRS2p182r035L71182035_035_20050425_ETM-GLS2005
4	Landsat ETM+	2000/Jul/09	WRS2p181r036_7dx_20000709_ETM-GLS2000
5	Landsat TM	1987/Jun/10	LandsatWRS2p183r035p183r035_5dx_19870610_TM-GLS1990
6	Landsat ETM+/ Earth Sat	1999/Aug/08	071-261Mosaic_LandsatN-35N-35-35ETM-EarthSat-MrSID_19990808-20020624
7	Landsat ETM+/ Earth Sat	1999/Aug/08	071-260Mosaic_LandsatN-35N-35-30ETM-EarthSat-MrSID_19990808-20020617
8	Landsat ETM+	2000/Jun/30	WRS2p182r036_7x_20000630_ETM-EarthSat
9	Landsat MSS / Earth Sat	1975/Jul/26	LandsatWRS1p196r35_2m_19750726_MSS-EarthSat
10	Landsat TM / Earth Sat	1987/Jun/10	012-807LandsatWRS2p183r35_5t_19870610_TM-EarthSat
11	Landsat ETM+	2000/Jun/30	LandsatWRS2p182r036_7dx_20000630_ETM-GLS2000
12	Landsat ETM+	2005/Apr/09	LandsatWRS2p182r036L71182036_036_20050409_ETM-GLS2005

Fig.20. Table of the available satellite images.

Previews of some of the selected Landsat satellite images...

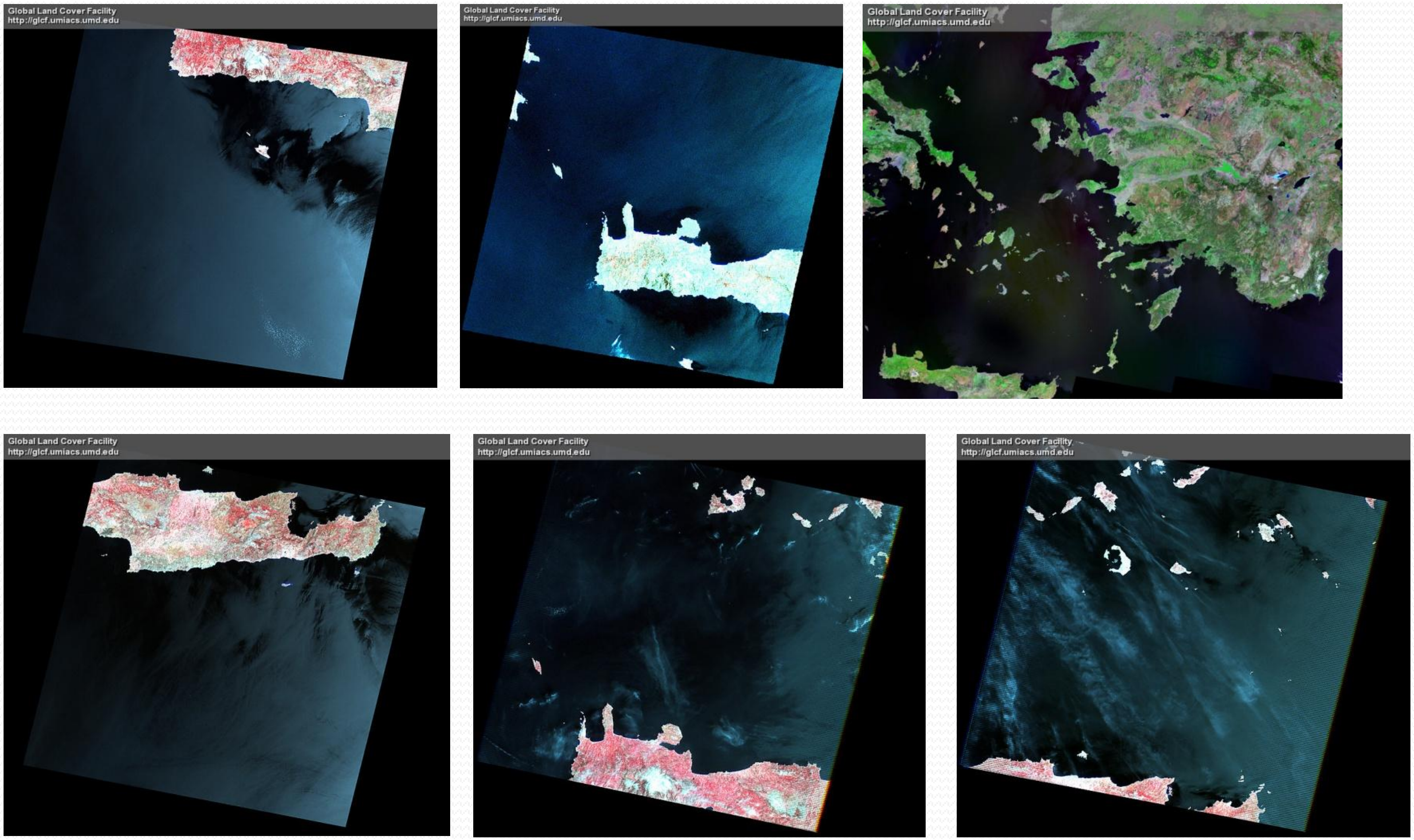


Fig. 21. Satellite images of Crete Island

Supervised classification in Erdas Imagine

Areas of seagrass mattes within the image, various in colour and form of mattes were classified as types of the seagrass (below, screenshot of the classification of areas): Example of Bali area, northern Crete

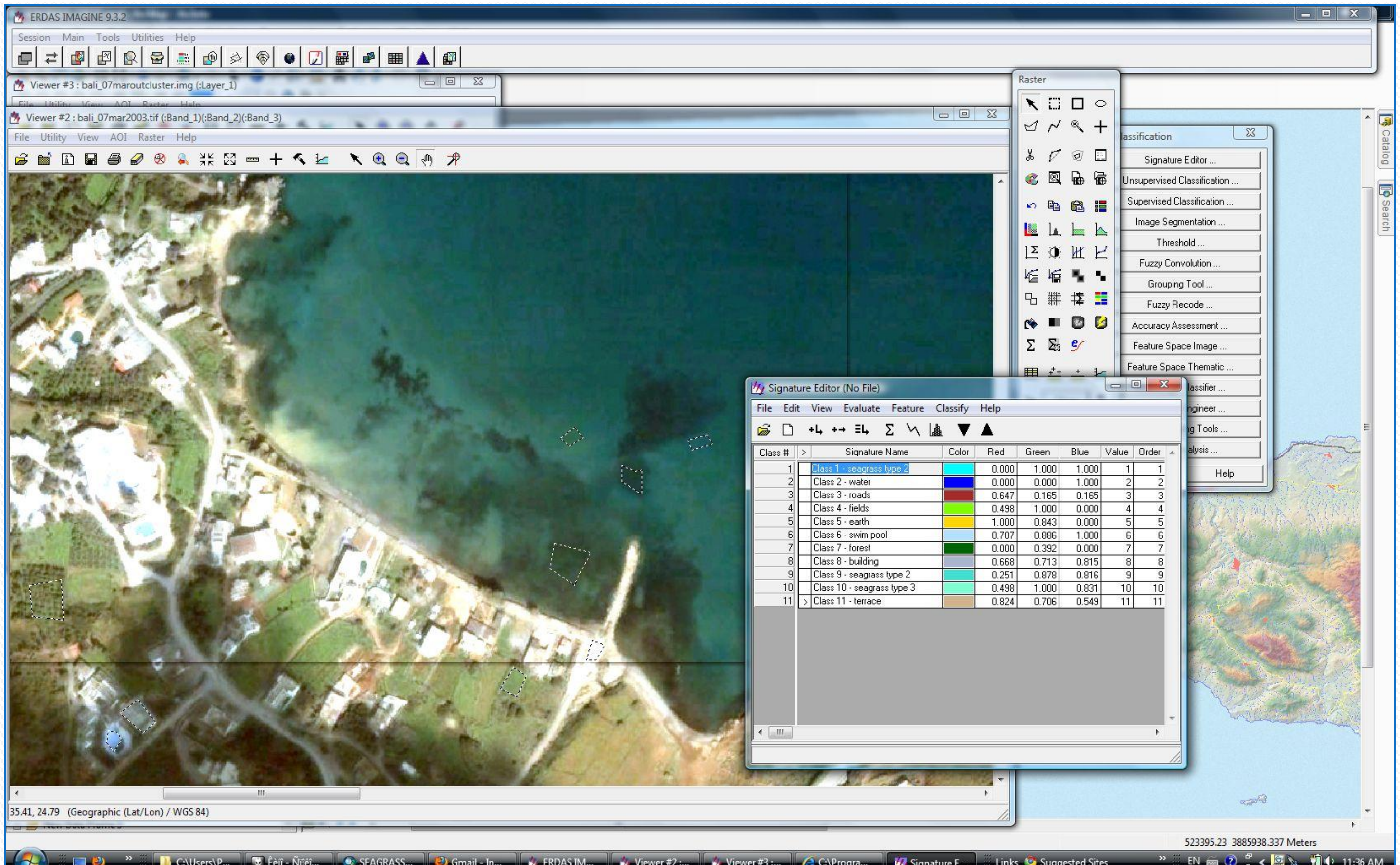
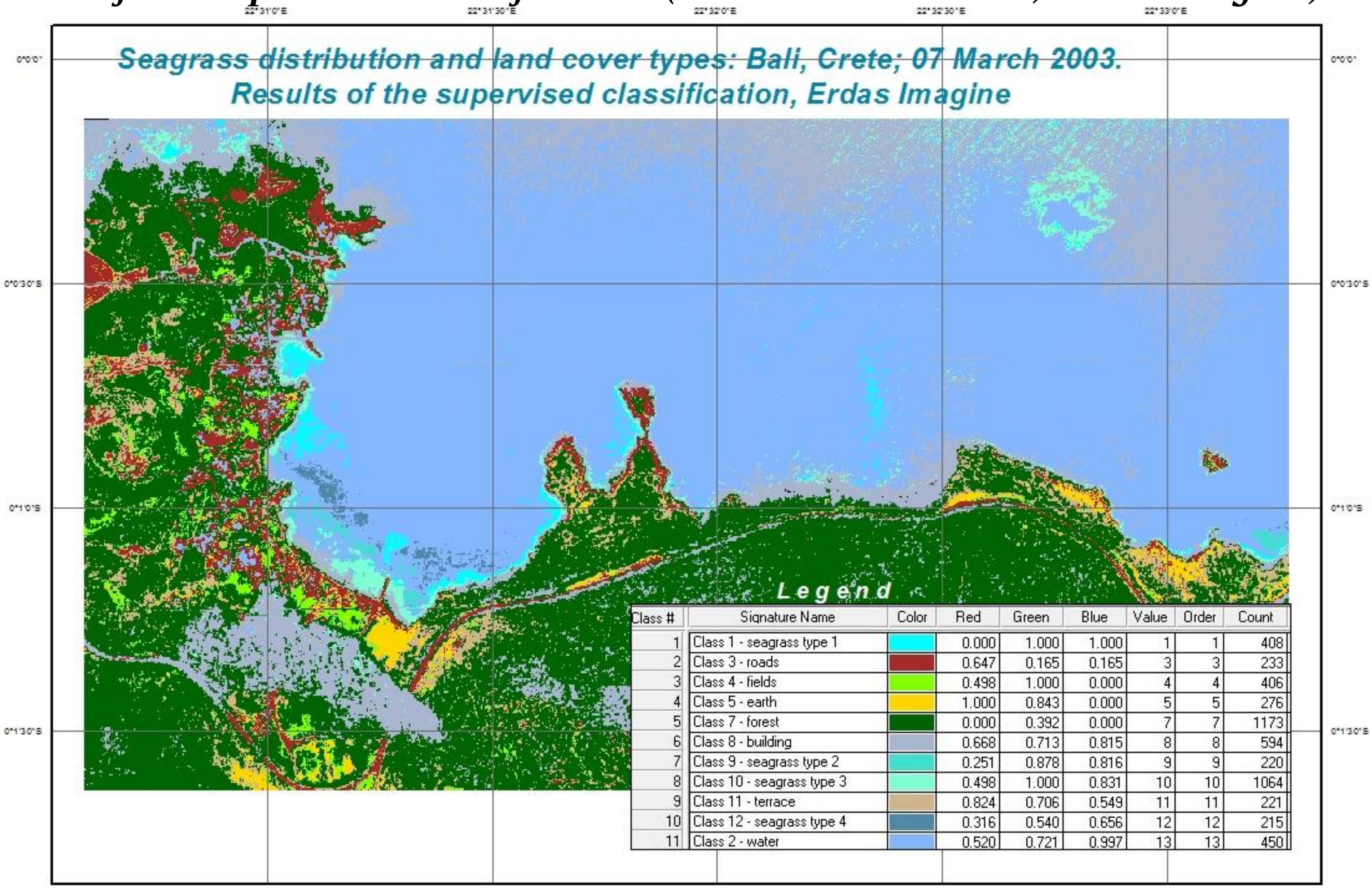


Fig.22. Images classification in Erdas Imagine: selection of training sites

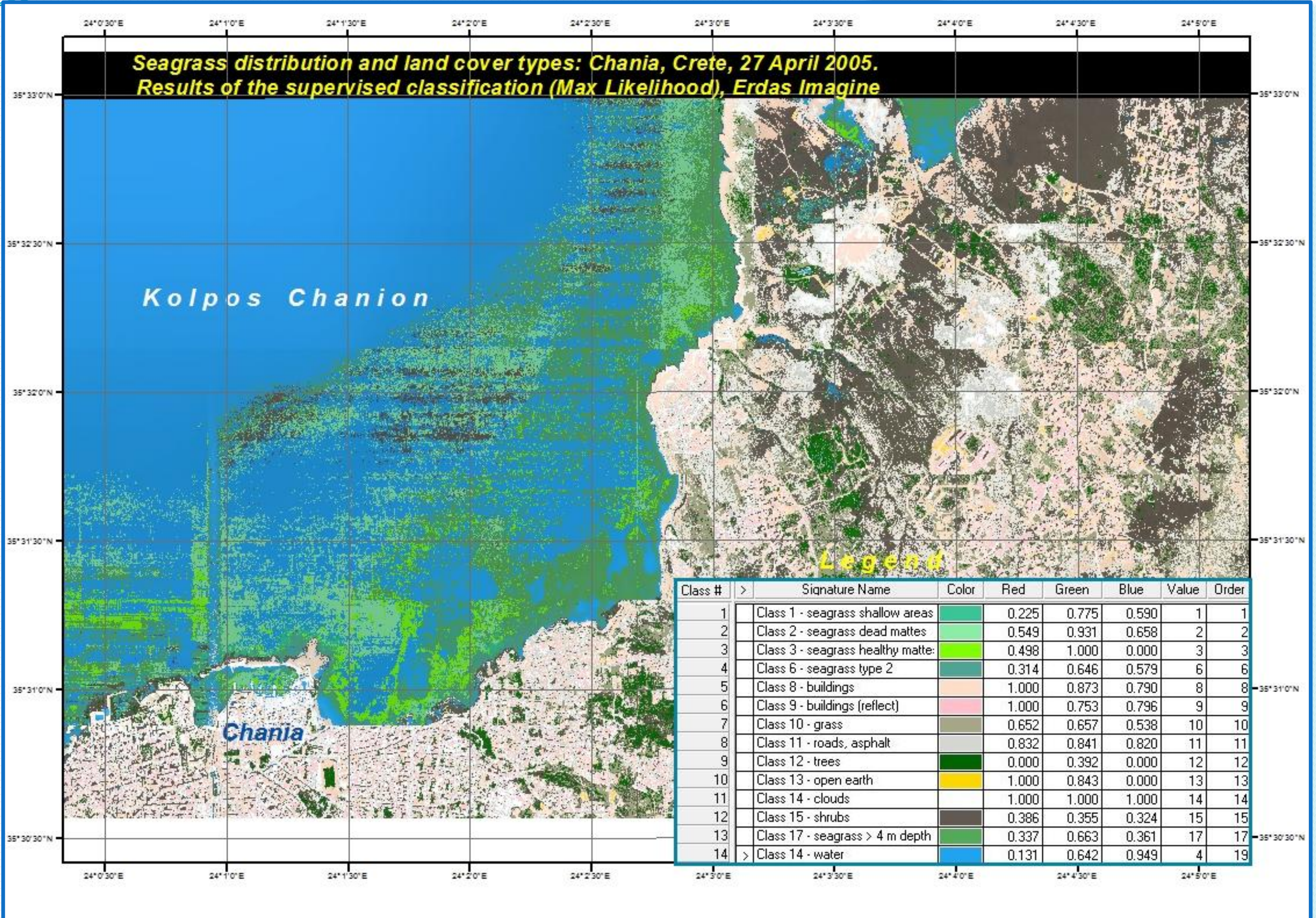
Results of the Supervised Classification (Maximal Likelihood, Erdas Imagine)



Class #	Signature Name	Color	Red	Green	Blue	Value	Order	Count
1	Class 1 - seagrass type 1		0.000	1.000	1.000	1	1	408
2	Class 3 - roads		0.647	0.165	0.165	3	3	233
3	Class 4 - fields		0.498	1.000	0.000	4	4	406
4	Class 5 - earth		1.000	0.843	0.000	5	5	276
5	Class 7 - forest		0.000	0.392	0.000	7	7	1173
6	Class 8 - building		0.668	0.713	0.815	8	8	594
7	Class 9 - seagrass type 2		0.251	0.878	0.816	9	9	220
8	Class 10 - seagrass type 3		0.498	1.000	0.831	10	10	1064
9	Class 11 - terrace		0.824	0.706	0.549	11	11	221
10	Class 12 - seagrass type 4		0.316	0.540	0.656	12	12	215
11	Class 2 - water		0.520	0.721	0.997	13	13	450

Fig.23. Map of seagrass distribution in Bali area: results of the image classification in Erdas Imagine.

Results of the Supervised Classification (Maximal Likelihood, Erdas Imagine)



Class #	>	Signature Name	Color	Red	Green	Blue	Value	Order
1		Class 1 - seagrass shallow areas		0.225	0.775	0.590	1	1
2		Class 2 - seagrass dead mattes		0.549	0.931	0.658	2	2
3		Class 3 - seagrass healthy matte:		0.498	1.000	0.000	3	3
4		Class 6 - seagrass type 2		0.314	0.646	0.579	6	6
5		Class 8 - buildings		1.000	0.873	0.790	8	8
6		Class 9 - buildings (reflect)		1.000	0.753	0.796	9	9
7		Class 10 - grass		0.652	0.657	0.538	10	10
8		Class 11 - roads, asphalt		0.832	0.841	0.820	11	11
9		Class 12 - trees		0.000	0.392	0.000	12	12
10		Class 13 - open earth		1.000	0.843	0.000	13	13
11		Class 14 - clouds		1.000	1.000	1.000	14	14
12		Class 15 - shrubs		0.386	0.355	0.324	15	15
13		Class 17 - seagrass > 4 m depth		0.337	0.663	0.361	17	17
14	>	Class 14 - water		0.131	0.642	0.949	4	19

Fig.24. Map of seagrass distribution in Chania area: results of the supervised classification, Erdas.

Limitations of seagrass mapping - I

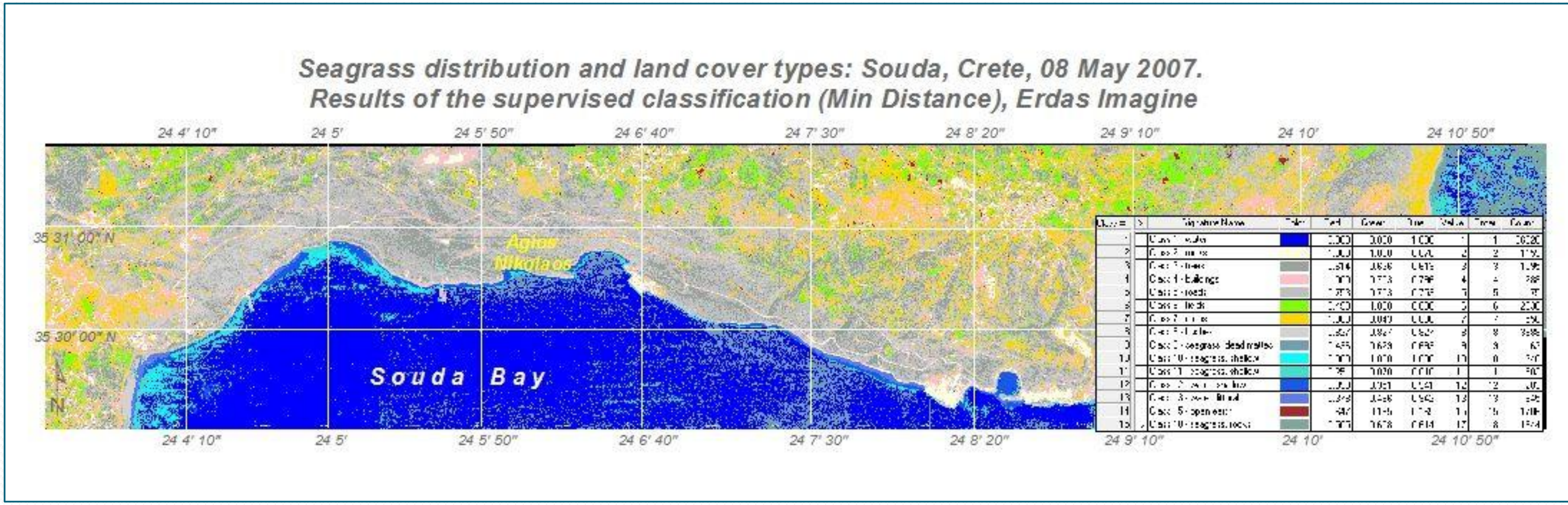


Fig.25. Map of seagrass distribution in Souda area, northern Crete: results of the image classification.

Seagrass mapping has certain difficulties and some limitations:

- uncertainties of the spectral signature of the seagrass
- Uncertainties during the process of the classification : noises, errors, misclassified pixels (see Fig.10)
- technical difficulties of the underwater measurements comparing to the terrestrial ones
- availability of necessary data, including up-to-date imagery
- uncertainties & errors can be caused by techniques used in data capture

Limitations of seagrass mapping - II

- Bad resolution (Fig.27)
- Different reflectance of the seagrasses due to the form, position and health of separate leaves (Fig. 28)
- Spots & noises on the images

Fig.28. Image of the seafloor

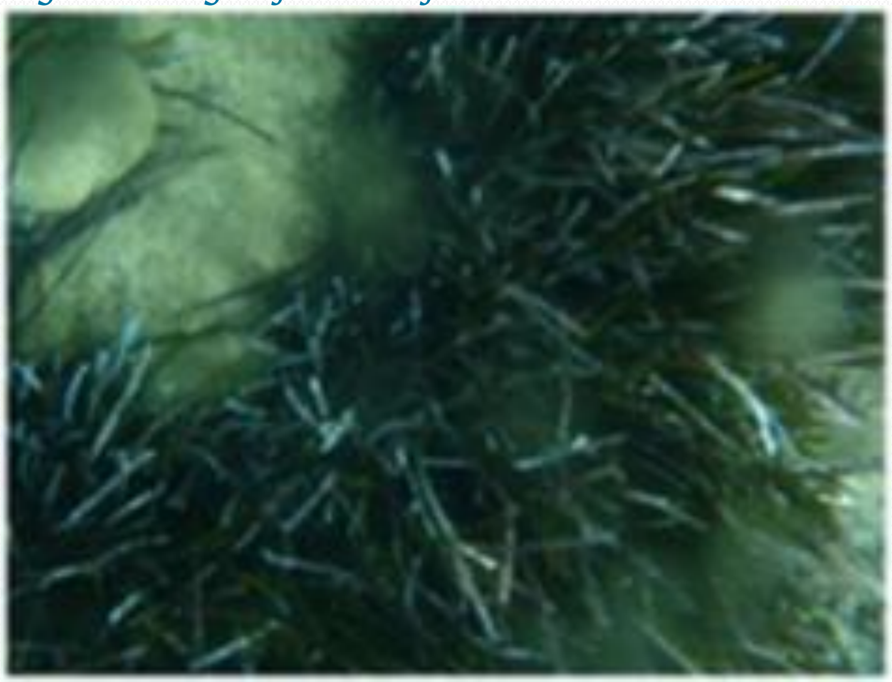


Fig. 26. Spots on the image caused by the imperfect process of photographing

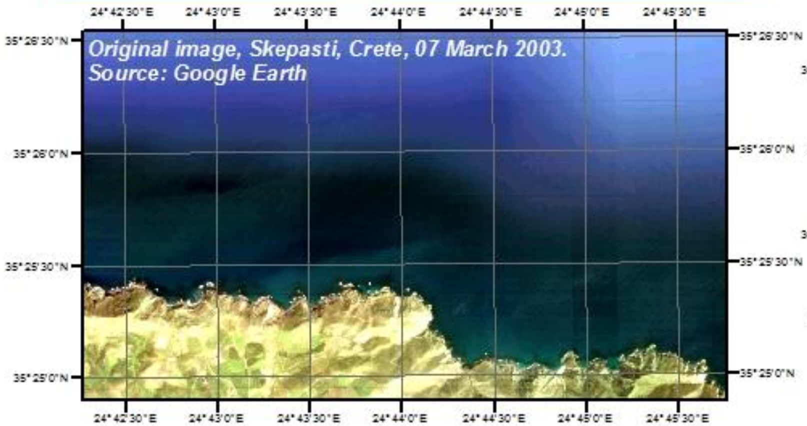
Fig. 27. Some images are not suitable due to the bad resolution caused by the trembling camera

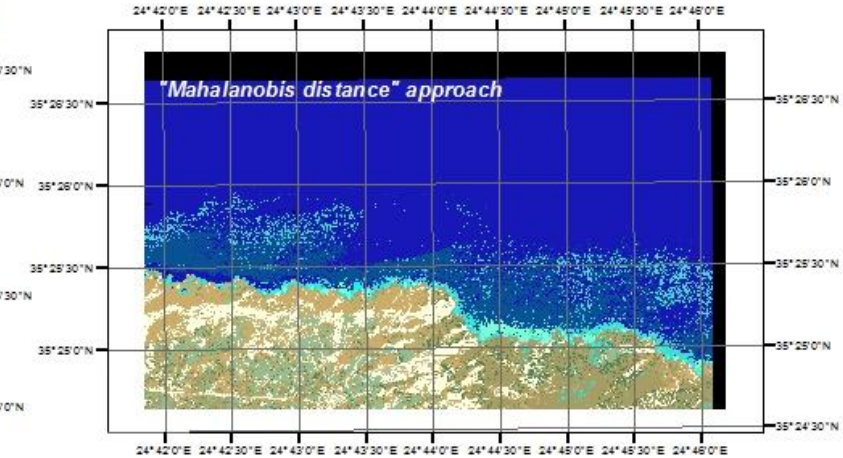
Supervised Classification

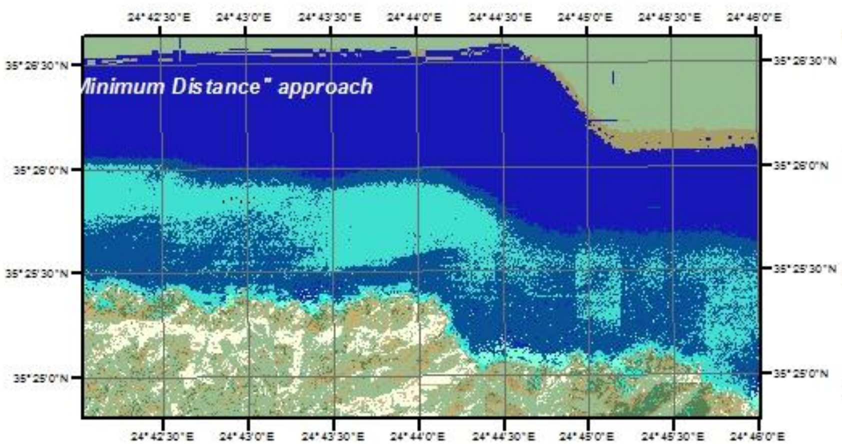
Legend of classification, common

Class #	>	Signature Name	Color	Red	Green	Blue	Value	Order	Count
1	>	Class 1 - wet earth		[illegible]	0.616	0.384	1	1	[illegible]
2		Class 2 - dry earth		0.324	[illegible]	0.549	2	2	[illegible]
3		Class 3 - fields		0.591	0.743	0.577	3	3	5189
4		Class 4 - trees		0.332	0.506	0.342	4	4	22
5		Class 5 - roads		1.000	1.000	0.833	5	5	320
6		Class 6 - rocks		0.303	0.679	0.413	6	6	11713
7		Class 7 - water		0.037	0.322	0.555	7	7	29482
8		Class 8 - deep waters		0.046	0.046	0.724	8	8	[illegible]
9		Class 9 - seagrass, type 1		0.000	1.000	1.000	9	9	1159
10		Class 10 - seagrass, type 2		0.400	1.000	0.031	10	10	521
11		Class 11 - seagrass, type 3 - coa		0.251	0.070	0.010	11	11	[illegible]

Example of results of different approaches of the supervised classification of the images, Erdas Imagine







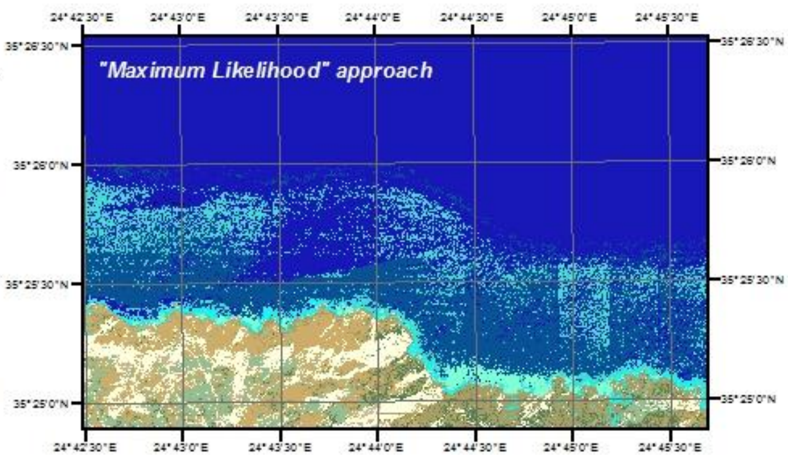


Fig.29. Supervised classification, different approaches.

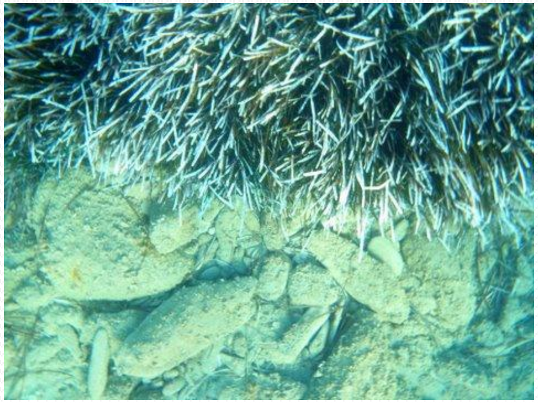
Research questions – I

Mapping of spatial distribution of the seagrass using broadband RS data:

- ✓ to study properties of spectral reflectance *P.oceanica* and detect exact areas of its location along the Cretan coast
- ✓ to detect dynamic in changes of *P.oceanica* seagrass distribution along Crete during the past 10 years using series of *Landsat TM, MSS* satellite images for 2000-2010
- ✓ to study the heterogeneity of the seafloor
- ✓ is there any difference between the spectral reflectance in diverse species of seagrasses (*P.oceanica*, *Zostera*, *Cymodecea, Halophila, Ruppia, etc*)?

Research questions – II

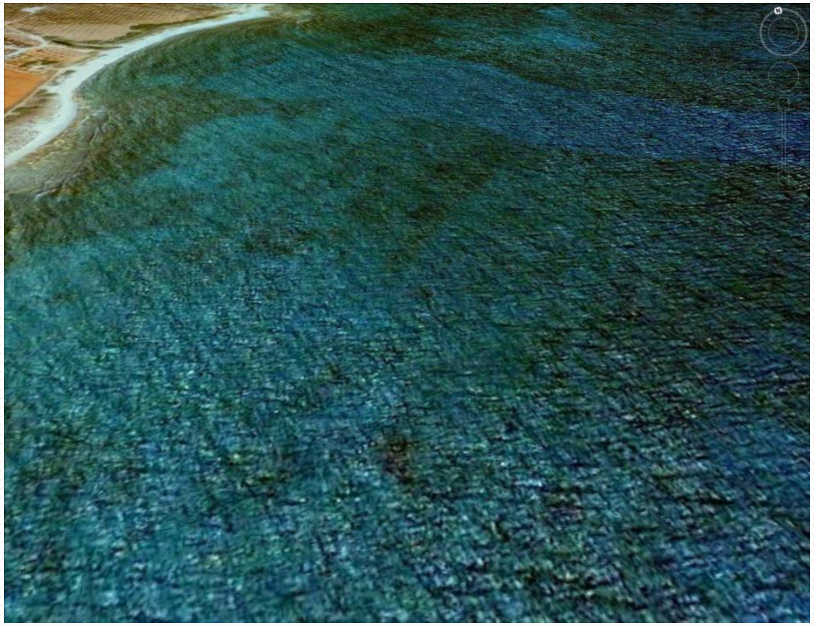
Underwater videometric measurements (UVM) for the up-scaling mapping of meadows and mattes



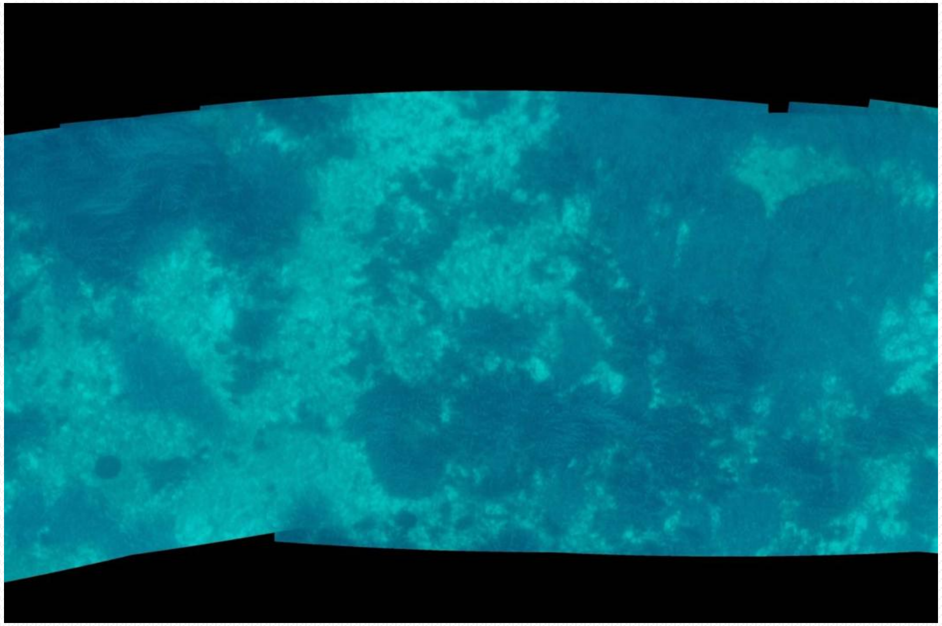
- ✓ mapping *P.oceanica* at different scales:
  - small-scaled mapping (ca *1: 30 000*) of seagrass meadows, based on satellite imagery and aerial photographs
  - large-scaled mattes mapping (ca *1: 1 000* or *1: 2 000*) of seagrass mattes, based on the UVM (more detailed)
- ✓ using the RS UVM for the mapping of *P.oceanica* on the mattes scale level and compare the results of the images classifications on the meadows scale level

Up-scaling: matte *vs* meadows

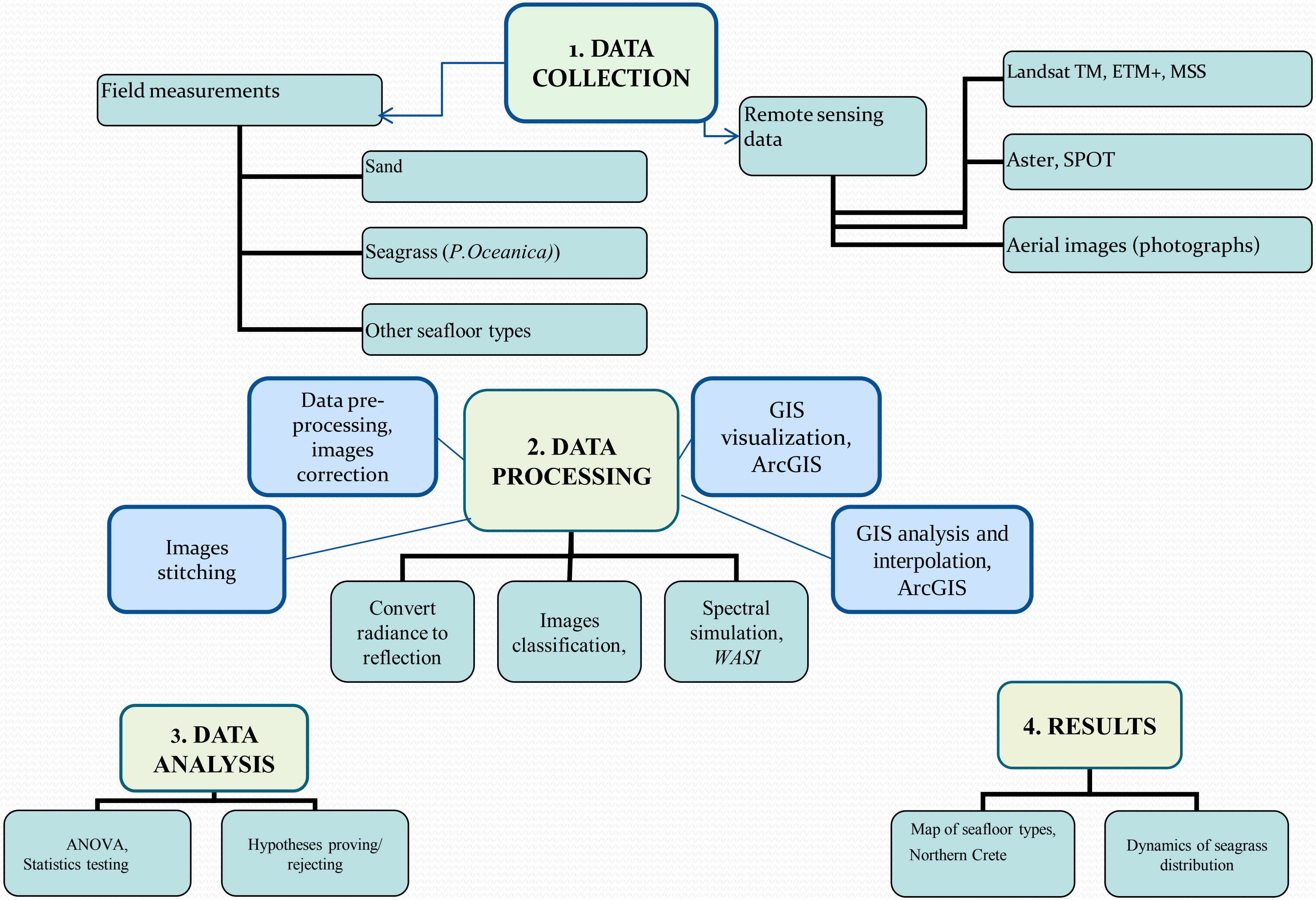
Seagrass meadows…



and seagrass mattes



Research scheme

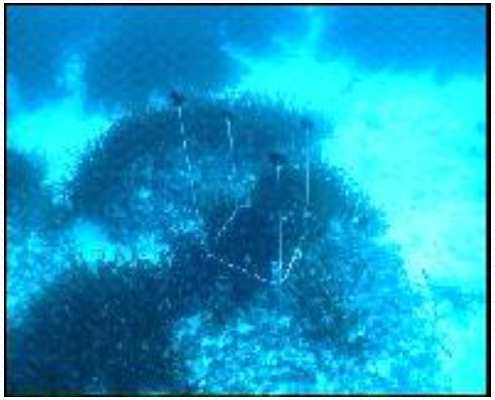


Fieldwork sampling design

The series of images of the underwater videographic measurements (footage) for further analysis and classification according to differences in the structure, colour, texture and shapes of the depicted objects, in order to receive information about the seafloor cover types.

Several boat routes, in a direction parallel to the coast with videometric measurements and photographs taken along the path.
Spot measurements in the selected locations - measurements frame,
(data about the density, amount of leaves per shoot and other health indicators)

Measurement frame
Source: Google



Olympus ST 8000 camera. Source: Google

SAMPLING DESIGN

DEPTHS MEASUREMENTS FOR THE SEAGRASS MONITORING

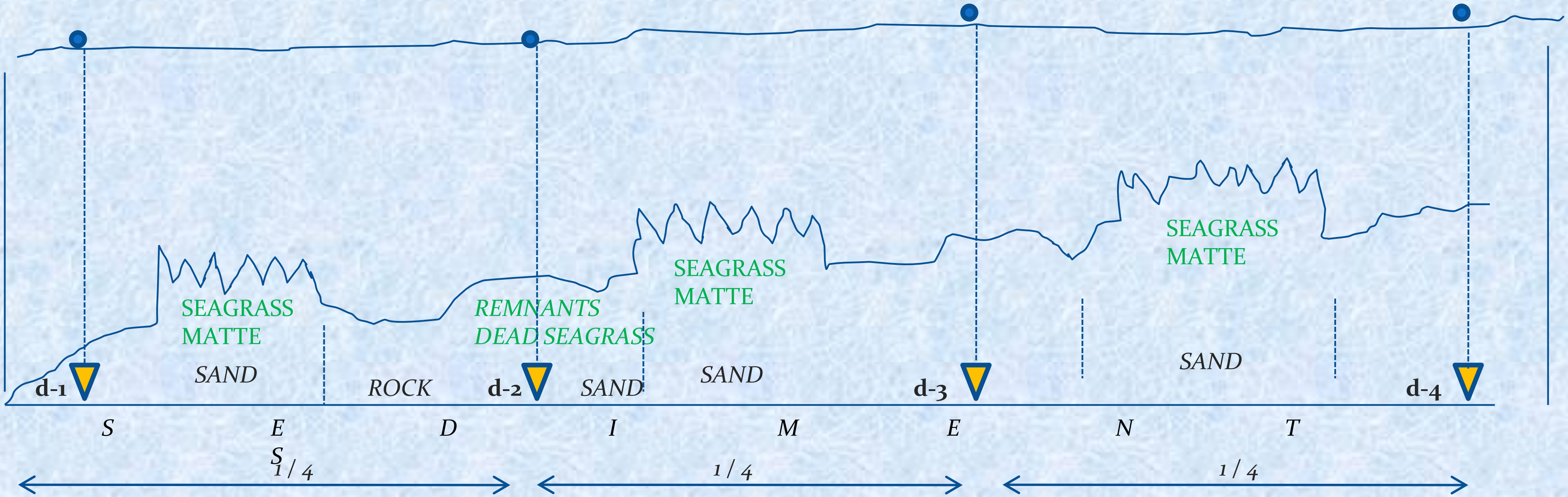


Fig.11. Scheme of the sampling design during the fieldwork.

- TRANSECT MARKER (d): 5 cm depth, 30 cm height

Using of markers:

1) Position of transect line
2) Depth of the sea floor
3) Depth of the marker (d)

Measurement important points:

1. Photos of the seagrass meadow
2. Type of the sediment sand: coarse, fine vs middle-sized
3. Name of species (mostly *Posidonia*)
4. % cover of the seagrass

Fieldwork sampling design (continue)

The transect sampling method.

Advantages:

✓ Simplicity, objectivity and ease of comparison.

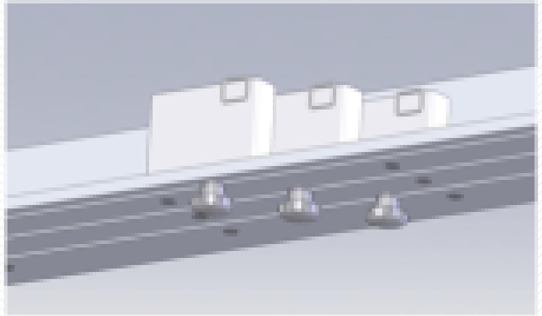
✓ Boat path covers the research area in most complete way

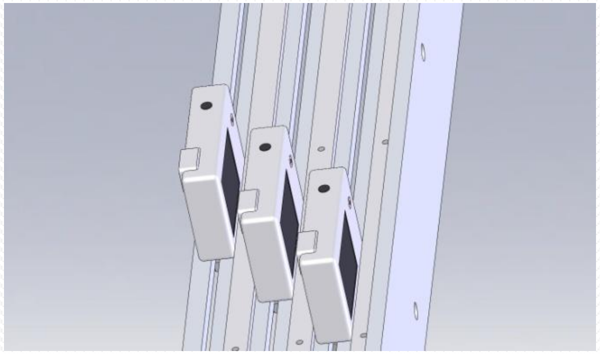
- Several (5-7) routes of the boat in each sampling site perpendicular to the coast line, 150-200 m long each,
- 1-2 routes parallel the coastline
- 9 measurements total

Underwater video cameras:

the underwater videographic measurements of the seafloor:

a series of consequent overlapping images of the seafloor under the boat path.

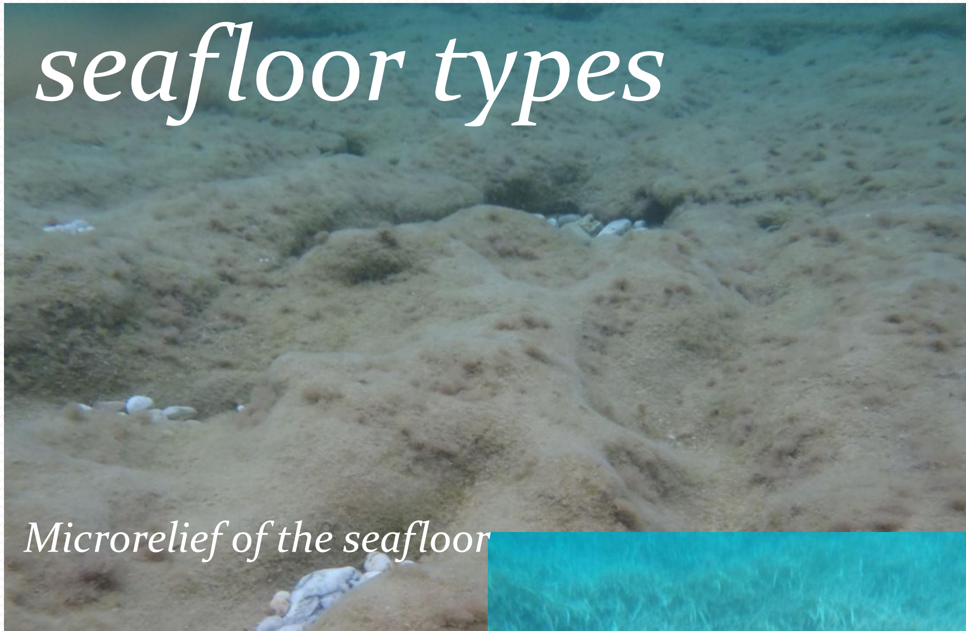




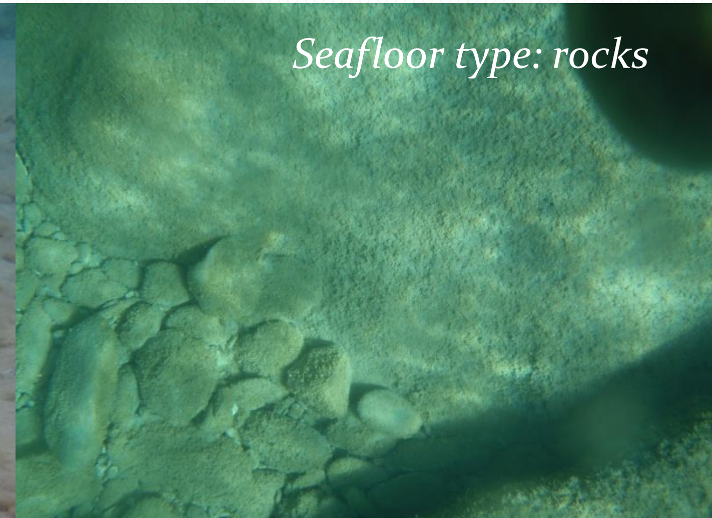
Adjustment of three cameras for the measurements of depths
Source: courtesy of V.Venus

Some examples of the results of the underwater measurements:

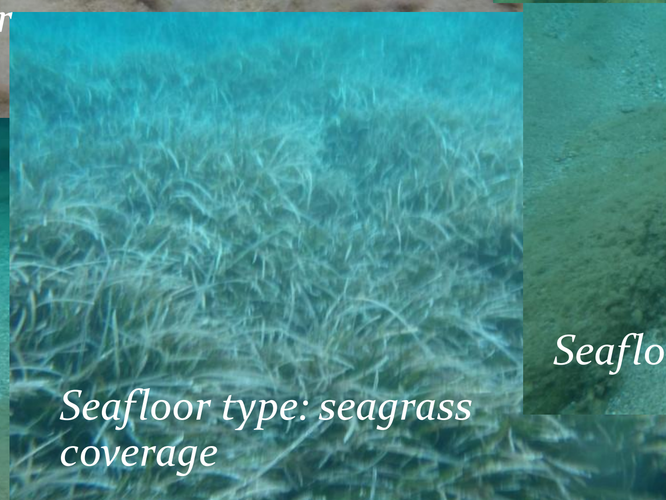
seafloor types



Microrelief of the seafloor

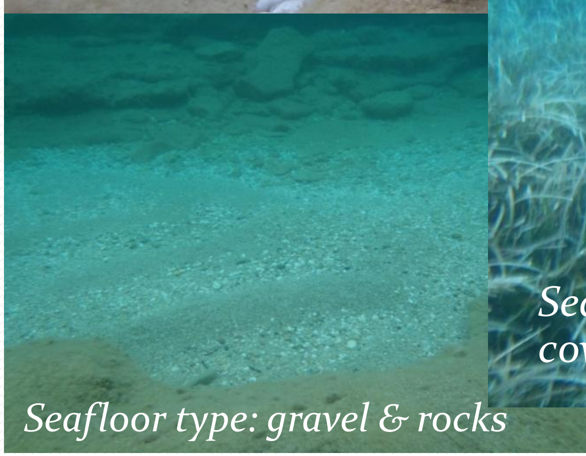


Seafloor type: rocks



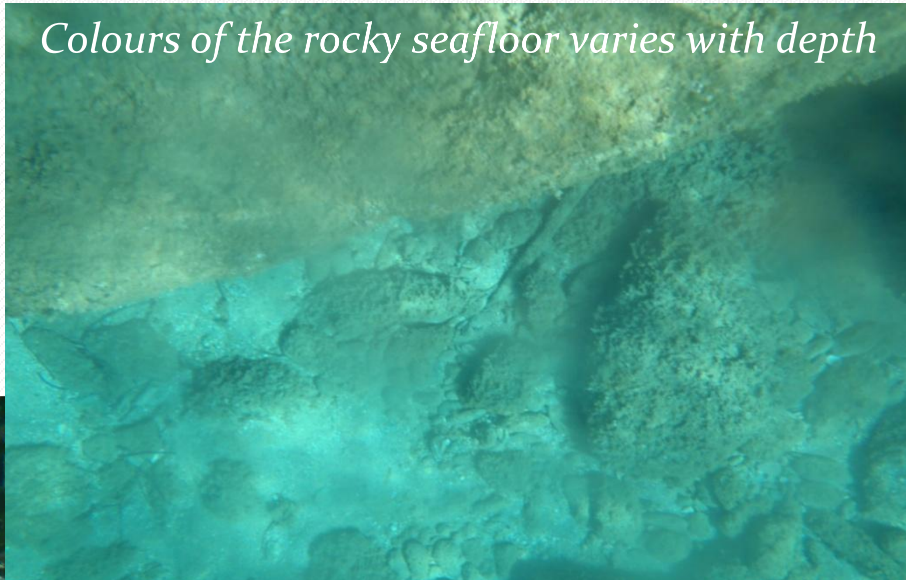
Seafloor type: seagrass coverage

Seafloor type: sand & gravel



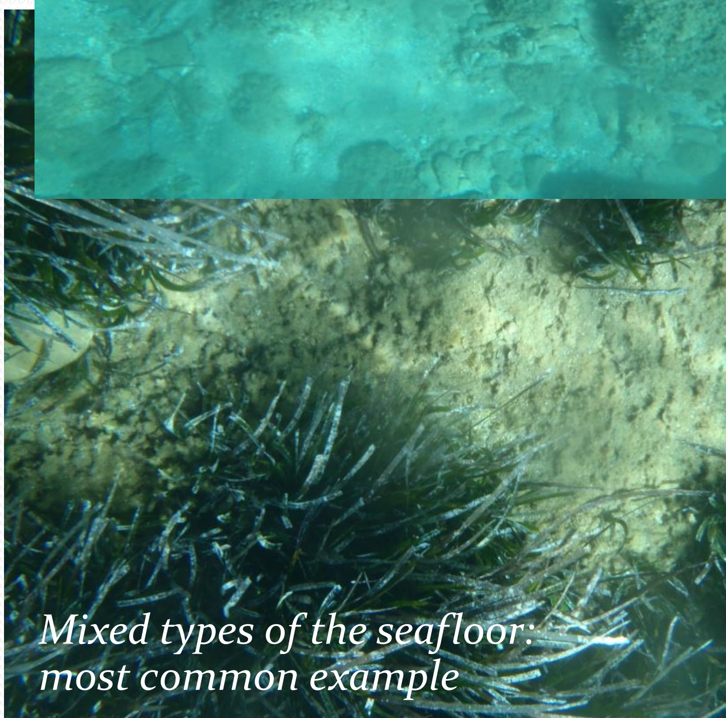
Seafloor type: gravel & rocks

Some examples of the results of the underwater measurements (continue)



Colours of the rocky seafloor varies with depth

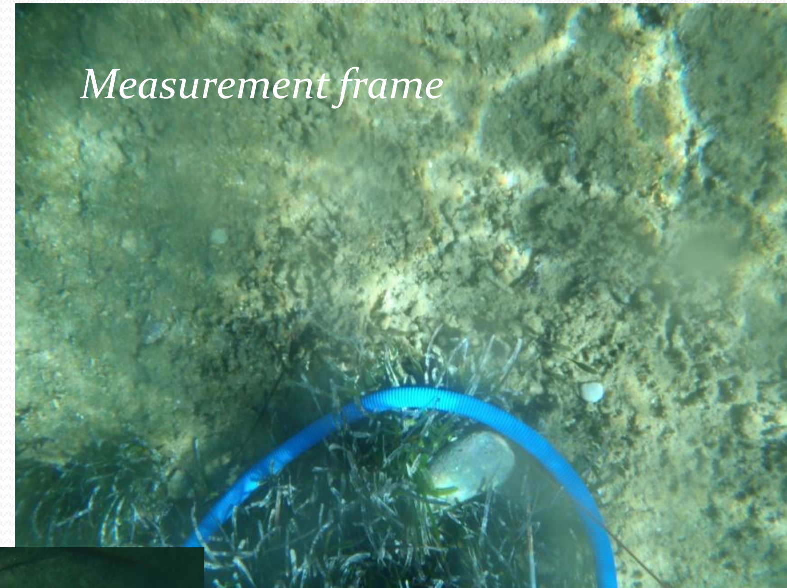
Seagrass pur: vertical photo of a matte



Mixed types of the seafloor: most common example

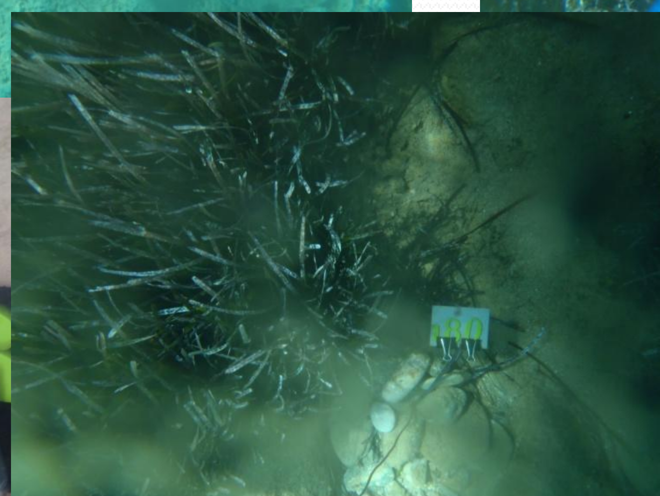
Measurement devices

Measurement marker located in the bottom



Measurement frame

Measurement marker



Measurement marker

Hypothesis testing

I. A statistical testing will be used to compare between the spectral responses of the different seagrass types, whether it is spectrally distinct and at least one pair is statistically different at every spectral band.

Hypothesis Ho: seagrass aquatic vegetation types are not spectrally distinct, which means

Ho: $\mu_1 = \mu_2 = \mu_3 = \ldots = \mu_n$.

The alternative *Hypothesis Ha* claims the opposite statement: seagrass aquatic vegetation types are spectrally distinct, i.e. *Ho:* $\mu_1 \neq \mu_2 \neq \mu_3 \neq \ldots \neq \mu_n$.

II. Another research question is to find out, whether there are any changes in the spatial distribution of the seagrass within the research area. Therefore, the statements will be the followings: *Hypothesis Ho:* there are no changes between its spatial distributions. *Hypothesis Ha:* the areas have reduced their area, i.e. how has the seagrass distribution changed during the research period of 10 years?

The hypothesis testing is suggested to be carried out using the ANOVA statistical test. The purpose of ANOVA test is to visualize in an effective and quick way the spectral differences between seagrass species and their spatial distribution. The key hypotheses of the research thus will be tested to prove whether the results of the research are meaningful and correct.

The distribution of the spectral responses at every spectral band is assumed to be normal as well as the equality of the statistical variances.

Significance and justification

Precise, correct and up-to-date information about the seagrass distribution over the coasts is necessary for the sustainable conservation of marine environment.

Accurate mapping of the seagrasses meadows enables…

- evaluating the seagrass current distribution
- analysing the effects of environmental characteristics and geographic locations on seagrass distribution
- analysis of its dynamics and changes over time
- estimations of the degree of
  deterioration for the purpose of
  coastal management

Expected results

The research work is expected to have following results :

- Over the northern coasts of Crete: thematic maps showing sea floor types and seagrass *P.oceanica* spatial distribution along the coasts of Crete
- Within the fieldwork locations, Ligaria beach: monitoring of the environmental changes , based on classification of satellite & aerial imagery and fieldwork video camera footage
- Within the fieldwork locations : maps of the sea floor cover types, based on the fieldwork measurements and UVM
- Results of the WASI spectra analysis illustrating graphs of the spectral reflectance of different sea floor types (sand, *P.oceanica,* rocky, etc) at various depths (0.5-4 m), based on the results of 20.