BIO - OPTICAL CHARACTERIZATION OF THE BLACK SEA FOR REMOTE SENSING APPLICATIONS

(SfP Project Number 982678)

OCTOBER Progress Report - 2011

Progress Report prepared by:
Temel Oguz, Erdemli, Turkey, NPD
Atanas Palazov, Varna, Bulgaria, PPD

PROJECT CO-DIRECTORS:
Michael Lee, Sevastopol, Ukraine
Oleg Kopelevich, Moscow, Russia
Viorel Malciu, Contsanta, Romania

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1. LIST OF ABBREVIATIONS

Acronym	Extended name
EC	European Commission
IMS	Institute of Marine Sciences of the Middle East Technical University
IO	Institute of Oceanology of Bulgarian Academy of Sciences
JRC	Joint Research Centre
MHI	Marine Hydrophysical Institute
MODIS	Moderate Resolution Imaging Spectrometer
NIMRD	National Institute for Marine Research and Development
NPD	NATO country Partner Director
SeaWiFS	Sea-viewing Wide Field-of -view Sensor
SfP	Science for Peace
SIO	Shirshov Institute of Oceanology
NASA	National Aeronautics and Space Administration
ROSA	Romanian Space Agency
PPD	Partner country Project Director
IOP	Inherent optical properties
AOP	Apparent optical properties
CTD	Conductivity Temperature Depth system
HPLC	High Pressure Liquid Chromatography
Chl a	Chlorophyll a
CDOM	Colored Dissolved Organic Matter

2. PARTICIPANTS

(a) Project Director (NPD)

SURNAME/First name/Title	Job Title, Institute and Address	Phone, Fax and E-mail
Oguz /Temel/Prof.	Emeritus Prof. Institute of Marine Sciences, Middle East Technical University, 33731 Erdemli, Turkey	oguz@ims.metu.edu.tr

(b) Project Director (PPD)

SURNAME/First name/Title	Job Title, Institute and Address	Phone, Fax and E-mail
Palazov/Atanas/Dr.	Director of Institute of Oceanology P.O. Box 152, Varna 9000, Bulgaria	+359 52 370484 +359 52 370483 palazov@io-bas.bg

(c) Project Co-Director

SURNAME/First name/Title	Job Title, Institute and Address	Phone, Fax and E-mail
Lee/Michael/Dr.	Chief of Marine Optics Department at Marine Hydrophysical Institute Bldg. 2, Kapitanskaya Str., Sevastopol 99011, Ukraine.	+38 0692 540452 +38 0692 554253 lee@alpha.mhi.iuf.net

(d) Project Co-Director

SURNAME/First name/Title	Job Title, Institute and Address	Phone, Fax and E-mail
Kopelevich/Oleg/Dr.	Head of Ocean Optics Laboratory, P.P. Shirshov Institute of Oceanology, 36 Nakhimovsky prospect, Moscow 117997, Russia.	(499) 124 7583 (499) 124 5983 oleg@ocean.ru

(e) Project Co-Director

SURNAME/First name/Title	Job Title, Institute and Address	Phone, Fax and E-mail
Malciu/Viorel	Head Department Oceanography, Marine and Coastal Engineering, National Institute for Marine Research-Development “Grigore Antipa”, Bvd Mamaia, 300 Constanta, Romania	Tel: 000241543288 Fax: 000241831274 Email: incdmct@datanet.ro

(f) Participant / End-user

SURNAME/First name/Title	Job Title, Institute and Address	Phone, Fax and E-mail
Zibordi/Giuseppe/Dr.	Scientific Officier/ Joint Research Centre of the European Commission, I-21020 Ispra, Varese	+39 0332 785902 +39 0332 789177 giuseppe.zibordi@jrc.it

3. BACKGROUND AND OBJECTIVES

The Black Sea receives drainage from almost one-third of the continental Europe (five times its own surface) which includes significant portions of 17 countries, 13 capital cities and some 160 million people. The Black Sea is virtually isolated and hence a vulnerable water basin with 87% of its volume affected by anoxia. Of all the basins of the world ocean, the environmental degradation in the Black Sea is the most severe.

The monitoring of trophic and geochemical status of marine waters can rely on satellite ocean colour data. In fact such a technology allows for the determination at synoptic scale of water quality indicators like: chlorophyll a concentration (and potentially of accessory pigments) used as a proxy for phytoplankton biomass; concentration of total suspended matter and colored dissolved organic matter through its absorption properties.

Current limitation in the operational use of satellite ocean colour data in the Black Sea and in other marginal seas is the lack of regional bio-optical algorithms linking the satellite signal to the specific water quality indicators. In fact operational satellite products generally rely on algorithms developed for global applications which generally are the source of large uncertainties in coastal areas. This urges the development of specific regional bio-optical algorithms on the basis of comprehensive data sets of statistically representative in situ measurements.

The project, within the framework of the environmental security research topic, aims at the implementation of a tool to support remote sensing applications for operational environmental monitoring and climate studies in the Black Sea. Novel aspect of the project will be the comprehensive bio-optical characterization of the western-central ecological regions of the Black Sea (those exhibiting the highest environmental stress and range of variability in bio-optical features) using state of the art measurement methods and instrumentation during seasons exhibiting different trophic regimes. The in situ data collected within the framework of two oceanographic cruises will be the basis for the development of new bio-optical algorithms and models for Black Sea environmental monitoring through Earth observing systems (mostly the MODIS onboard the NASA AQUA polar platform). The sequential objectives defining the project flow are highlighted in Fig. 1

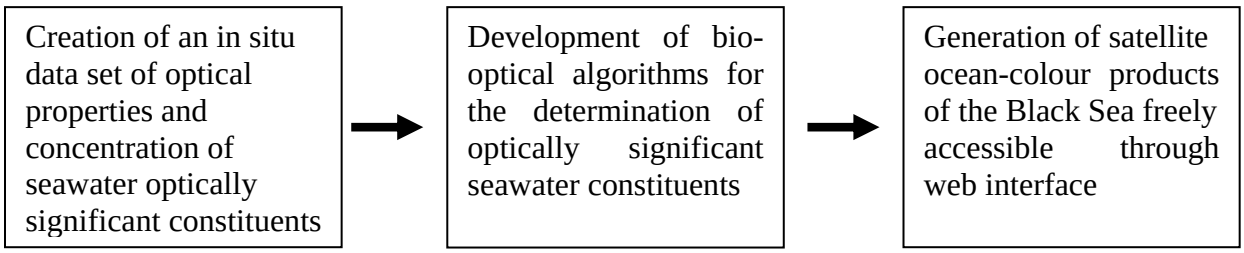

Figure 1: Major sequential objectives characterizing the project flow.

4. PROJECT STRUCTURE AND ACTIVITIES

MILESTONES, DELIVERABLES AND SCHEDULE: SfP-982678 REPORT DATE: 31.03.2011

Milestone/Year		1st Year				2nd Year				3rd Year			
Month №:			Planed				New plan				Done		
		1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12
	Month	XI-I	II-IV	V-VII	VII-X	XI-I	II-IV	V-VII	VII-X	XI-I	II-IV	V-VII	VII-X
1	**Instrument procurement & assessment of methods**												
1.1	Procurement of field instruments (profiler)												
1.2	Assessment of measurement method												
2	**Field measurements**												
2.1	First bio-optical cruise (within the selected period)												
2.2	Second Bio-optical Cruise												
3	**Data analysis and quality assurance**												
3.1	Analysis and assurance of data from first cruise												
3.2	Analysis and assurance of data from second cruise												
4	**Algorithms development**												
4.1	Development of bio-optical algorithms												
4.2	Cross-comparison of regional and global algorithms												
5	**Results implementation**												
5.1	Implementation of regional bio-optical algorithms												
5.2	Assessment of new products												
5.3	Distribution of new products through web interface												

Deliverables				Availability of equipment	Assessment of measuremen		Data from the first				Data from the second	Bio-optical algorithms	Ocean color products
Reporting			1st Progress		2nd Progress report		3rd Progress report		4th Progress		5th Progress report		Final Report

5. TECHNICAL PROGRESS

5.1. Major Accomplishments

Major accomplishments achieved in the previous six months of the project can be summarized as follows:

Task 1 Field measurements. First bio-optical cruise.

Three consecutive bio-optical oceanographic cruises were carried out in the Western and Central Black Sea within EUROFLEETS BIO-OPT Project and Contract # 386675 between JRC of EC and Institute of Oceanology, BAS to support the activities of the NATO SfP 992678 Project. The EUROFLEETS BIO-OPT cruises were executed onboard the research vessels Mare Nigrum (Constanta, July 01-05, 2011) and Akademik (Varna, July 08-11). A specific JRC-IO BioMap cruise on the Bulgarian R/V Akademik was followed the EUROFLEETS cruises from 13 till 22 July. The three oceanographic cruises led to the completion of 112 measurement stations (Fig.1).

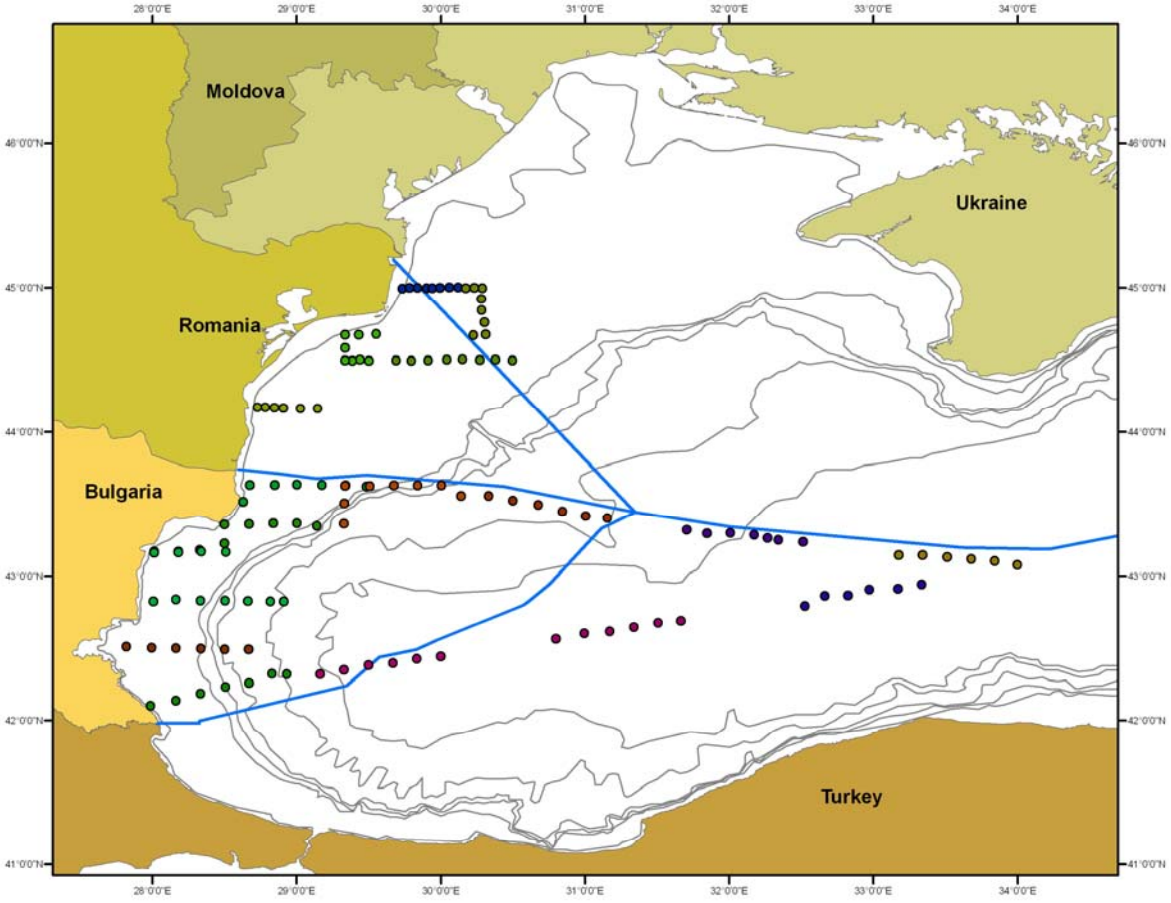

Figure 1. Working area and location of the measurement stations of the EUROFLEETS and BioMaP cruises

Objective of the bio-optical oceanographic cruises has been the production of state of the art measurements including comprehensive apparent and inherent optical properties

of the Black Sea seawater, in addition to the concentration of optically significant constituents (see Table 1).

Table 1: Bio-optical quantities that was determined during the bio-optical oceanographic cruises.

Quantity	*Symbol*	*Wavelengths range or center-wavelengths*	*Instrument/Method*
Remote sensing reflectance	R_{rs}	412,443,490,510,555,670,683 nm	JRC and NATO Satlantic micro-profiler
Diffuse attenuation coefficient	K_d	412,443,490,510,555,670,683 nm	JRC and NATO Satlantic micro-profiler
Total absorption coefficient	a	412,443,490,510,555, 630, 650, 676,715 nm	JRC WetLab AC-9
Absorption coefficient of pigmented particles	a_p	400-750 nm (with 1 nm resolution)	Spectrometry (JRC Perkin-Elmer Lambda 900)
Absorption coefficient of non-pigmented particles	a_{dt}	400-750 nm (with 1 nm resolution)	Spectrometry (JRC Perkin-Elmer Lambda 900)
Absorption coefficient of colored diss. organic matter	a_y	350-750 nm (with 1 nm resolution)	Spectrometry (JRC Perkin-Elmer Lambda 12)
Scattering coefficient	b	412,443,490,510,555, 630, 650, 676,715 nm	JRC WetLab AC-9
Backscattering coefficient	b_b	443,490,510,555,620, 670 nm	JRC HobiLabs Hydroscat-6
Volume scattering function	β	443,490,510, 532, 555,590, 620 nm	MHI VSF_Meter
Pigments concentration	Chl	Includes total chlorophyll-a	HPLC
Total suspended matter	TSM		Filtration and weighting
Salinity and temperature	S & T	Typically down to 25-35 m	JRC and Mare Nigrum CTDs
Aerosol optical thickness	τ_a	440, 490, 550, 670, 870 nm	JRC and NATO Sun-photometers
Fluorescence	Fl	Includes chlorophyll a and colored dissolved organic matter fluorescence	SIO Fluorometer

Apparent optical properties (AOPs) are the remote sensing reflectance and the diffuse attenuation coefficient (determined through in water radiometry). Inherent optical properties (IOPs) are the absorption, scattering, back-scattering coefficients and volume scattering function determined through in-water profiling and laboratory analysis of water samples. Concentrations of seawater suspended constituents include those of pigments and total suspended matter determined from laboratory analysis. The *in situ* data set will then be used to support the development and implementation of specific bio-optical algorithms and models for the determination of optically significant seawater constituents in the form of concentration or inherent optical properties, from remote sensing reflectance which is the primary satellite ocean color product determined from top-of-atmosphere radiances corrected for the atmospheric effects. First level of modelling will rely on the development of statistical relationships linking apparent (i.e.,ratios of remote sensing reflectance at different center-wavelengths) to the concentration of optically significant seawater constituents (i.e., chlorophyll a, total suspended matter) or additionally to the inherent optical properties (i.e., absorption).The completeness of the measured quantities will also provide the capability of implementing and assessing specific semi-analytical models (Lee et al. 2002).

Measurement stations have been chosen to represent seawaters likely characterized by different bio-optical regimes in the Western and Central Black Sea waters. The region selected during the Mare Nigrum EUROFLEETS cruise has been restricted to shelf waters which exhibit an appreciable variability in bio-optical properties (Fig.2).

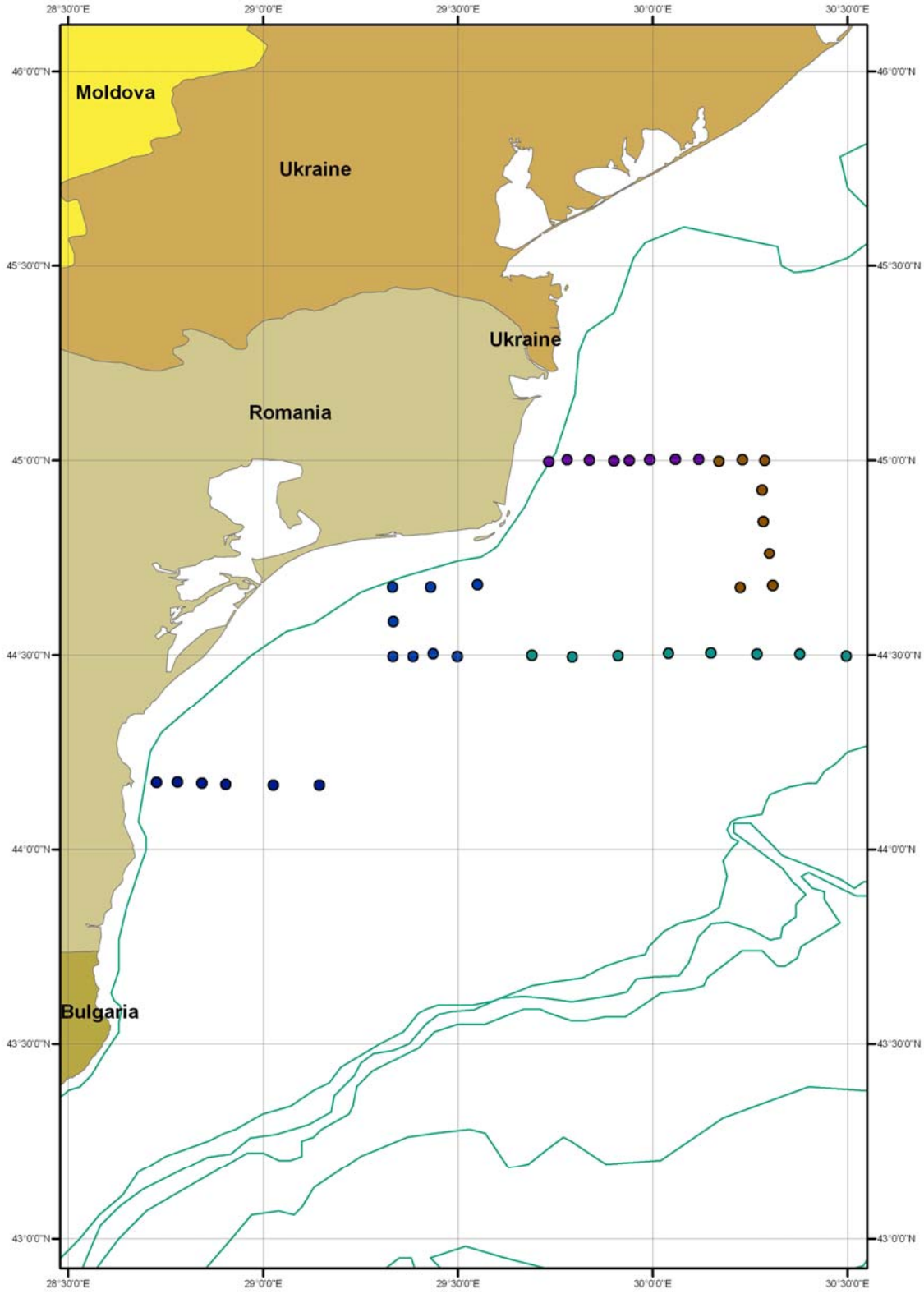

Figure 2. Working area and location of the measurement stations of the Mare Nigrum EUROFLEETS cruise

Regular girding is not a requirement for bio-optical modelling: variability and statistical representativeness of bio-optical regional regimes are the basic requirements. Because of this, actual measurement stations have been fixed on a daily basis to account for weather conditions or bio-optical features of the area. Station time has been approximately 40 minutes while travel time between stations has been kept between 1 and 1.5 hours. Recalling that bio-optical measurements are only possible on daylight conditions, transects of 6-8 stations per day were likely possible. Any transit required to reach relatively distant regions, which might provide better or alternative measurement conditions, has been made overnight.

Measurements were performed using the instruments and the methods listed in Table 1. Measurement sequence during each station comprised:

A. Deployment of free-fall optical radiometer systems (specifically two Satlantic optical profilers equipped with multispectral radiometers measuring upwelling radiance, downward and upward irradiance) to determine subsurface values of seawater apparent optical properties; and ii. atmospheric aerosol optical thickness (this latter quantity is only measured in view of future validation exercises for satellite derived products which generally require comprehensive characterizations of both marine and atmospheric optical quantities);

B. Deployment of the CTD and IOP instrumental packages (the latter includes a WetLabs AC-9 absorption and attenuation meter, and a HobyLabs Hydroscat-6 back-scattering meter) to characterize the near surface: salinity and temperature; spectral absorption, attenuation and back-scattering within the first 25-35 meters (which are those of interest for ocean color remote sensing);

C. Collection of surface seawater samples to determine: i. absorption coefficients of pigmented, non-pigmented and colored dissolved organic seawater components through spectrophotometric techniques; ii. seawater volume scattering function through the unique MHI VSF meter; and iii. total suspended matter concentration through dry-weighting and pigments concentrations through HPLC.

Measurements B and C were carried out in approximately 20 minutes by a team of five scientists (two handing the CTD and three the IOP packages). Equivalent time was required for measurements indicated at point A using two (NATO and JRC) free-fall profilers operated by a team of five/six scientists. Conditioning of water samples (i.e., seawater filtration) was generally started during stations and completed during travel time to next station by two scientists. Simultaneously to water filtration, volume scattering function measurements and additional ancillary measurements (i.e.,fluorescence) were performed during travel time to the following station by three/four scientists (this will specifically provide data suitable to investigate the spatial variability of colored dissolved organic matter and chlorophyll a). Additionally, measurements of the indirect sun irradiance were performed by two scientists during clear sky conditions between stations using two (NATO and JRC) hand held Microtops-II sun-photometers.

Measurements and Sampling

1. Apparent Optical Properties (AOP)

Apparent Optical Properties of seawater are determined from multispectral free-fall systems which simultaneously measure the upwelling radiance $L_u(z,\lambda)$, the downward irradiance $E_d(z,\lambda)$ and the upward irradiance $E_u(z,\lambda)$ as a function of depth z and wavelength λ, in addition to the above–water downward irradiance $E_d(0^+,\lambda)$. While

the in–water profile measurements are used to extrapolate to 0 − depth (i.e., just below the water surface) radiometric quantities which cannot be directly measured because of waves perturbation, the above–water downward irradiance measurements allow to minimize the effects of illumination variations on in–water data during profiling. All applied sensors(i.e., radiometers of the OCR-507) have equivalent spectral channels with 10 nm bandwidth centred at the nominal wavelengths 412, 443, 490, 510, 555, 665, and 683 nm, close to those of satellite ocean color sensors. With particular reference to optically complex waters like those encountered in the Black Sea, the determination of highly accurate in−water radiometric products often requires profiling near the surface to minimize the perturbing effects of non-homogeneities in the vertical distribution of optically significant constituents and to account for the rapid decrease of light signal with depth in highly attenuating waters. An additional requirement is the capability of producing a number of measurements per unit depth not significantly affected by the tilt of the roiling system to lessen the effects of wave perturbations. As a consequence, the accuracy of derived sub-surface radiometric products is a function of the sampling depth-interval and of the depth resolution as defined by the system acquisition rate and deployment speed (6Hz and 0.3-0.4 m s -1, respectively, for the considered free-fall radiometer systems). Bio-optical radiometric measurements used to determine sub-surface products have thus been performed by profiling in the near-surface layers and applying the multicast method that relies on the combination of measurements from successive and independent profiles to increase the number of samples per unit depth.

Pre- and post-campaign absolute calibration data were determined at the JRC using NIST traceable irradiance standards to verify the stability with time of each radiometer. Data products from the free-fall optical profilers include spectral values of: irradiance reflectance, remote sensing reflectance, normalized water–leaving radiance, diffuse attenuation coefficient and the so called Q-factor.

Figure 3 Free-fall optical profilers (NATO and JRC) deployed during the cruises.

2 Inherent Optical Properties (IOP)

Measurements of the seawater inherent optical properties include vertical profiles of:

i. total (except water) beam attenuation and absorption coefficients c(λ) and a(λ), performed with a WET Labs (Philomath, USA) “AC-9” at the nominal wavelengths (λ) 412, 440, 488, 510, 555, 630, 650, 676 and 715 nm (where the particulate scattering coefficient b(λ) is determined as c(λ)-a(λ));
ii. back-scattering coefficient b b (λ) at the nominal wavelengths 442, 488, 510, 555, 620, and 665 nm made with a HobiLabs (Bellevue, USA) “HydroScat-6” (HYD-6). Measurements and processing of AC-9 and HYD-6 data were performed as described in Berthon et al. (2007).

Additional measurement of inherent optical properties is the Volume Scattering Function (VSF) on discrete water samples (generally collected at the same time of IOP profiling) performed with the MVSM (Lee and Lewis, 2003) developed at the Marine Hydrophysical Institute in Sevastopol, Ukraine. The system allows for light scattering measurements at angles 0.5° to 179° with a resolution 0.25°, at twelve wavelengths 380, 400, 412, 435, 456, 490, 532, 60, 590, 625, 683 and 780 nm. Single scanning on one filter requires about one minute. During the cruise the measurements were performed at seven wavelengths 380, 412, 435, 456, 532, 560, 590 and 780 nm.). Details on the data processing are available in Berthon et al. (2007).

Despite of essential progress in VSF measurements technique, some lack of instrument performance still exist. Before this campaign mechanical stability of photomultiplier slit stepper motor setting has been essentially increased. The housing of the light source was also modified allowing decreasing the magnitude of glint at small angles. VSF measurements were performed using the laboratory configuration of MVSM. Water samples were taken from the surface layer at 0.5-1.5 m depth. Additional water samples were taken at the Chlorophyll maximum using the onboard rosette during deep CTD casts.

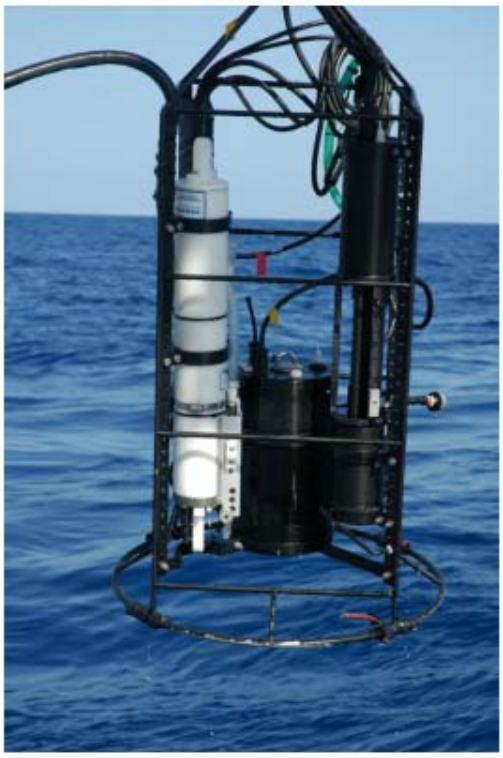

Figure 4 IOP package deployed during the bio-optical cruises.

3 Water Sampling (WS)

Subsurface water samples (at approximately 1 m depth) were collected at each station at the same time of IOP profiling using a sampling bottle. These discrete water samples were conditioned between stations for successive laboratory analysis of:

i. Pigments concentration (specifically total Chlorophyll a, Chla) through High Performance Liquid Chromatography according to the methodology described in Canuti and Berthon (2011);
ii. Total suspended matter (TSM) through dry-weighting (see Zibordi et al 2002);
iii. Absorption coefficients of pigmented, a ph (λ), and non-pigmented, a dp (λ), particulate matter between 400 and 750 nm through filter-pads and spectro-photometric techniques (see Berthon et al. 2007, and references therein);
iv. Absorption coefficient of colored dissolved organic matter, a ys (λ), between 350 and 750 nm of filtrated (0.22 mm) seawater (see Berthon et al. 2007, and references there in).

4 Station and Underway Fluorescence (FL)

Data on seawater fluorescence were measured by a SIO Flow-Through Fluorometer (FTF). The intensity of seawater fluorescence in relative units is determined at two spectral intervals with center-wavelength of 480 nm and 68 5 nm: the first is consistent with the spectral maximum of the CDOM fluorescence; the second corresponds to the maximum of Chl-fluorescence. To induce fluorescence, two super flux LEDs with maximum of intensity at 373 nm and 522.5 nm (10nm bandwidth) were used for CDOM and Chl-A, respectively. The fluorescence parameters and, additionally, seawater temperature are measured by the water intake at about 1.5 m depth underway every 30 sec. The spatial resolution depends on the vessel speed and it is equal to 150 m at a speed of 10 knots. The fluorescence measurement is accompanied by recording of the GPS data (GlobalSat MR-350) providing the actual ship position, speed and direction of motion. The FTF and GPS data are recorded in the same file using the PLF-4 software developed at SIO. The data processing includes the following procedures: data averaging over the preset time interval (usually 30 sec) to decrease influence of water perturbation; calibration for pure water (subtraction some constant signal which is an inherent characteristic of equipment) and removal of CDOM fluorescence from the fluorescence intensity in Chl A channel. The FTF measurements provide information on CDOM spatial changeability and phytoplankton abundance between the stations and, additionally, on the vertical distribution of the same constituents at drift stations where the measurements were performed singe water samples from different depths.

Figure 5 Fluorometer system operated during the bio-optical cruises

5 CTD Profiling and Rosette Sampling (CTD and ROS)

Conductibility, temperature and depth (CTD) measurements were performed during each IOP cast using a CTD operated in conjunction with the IOP package. These profiles were restricted to the near-surface layer (i.e.,generally 25-35 meters). Additional deep casts were performed with the CTD system operated on the ship together with a rosette (ROS). In conjunction with these deep casts, water samples were also collected at different water depths for VSF and FL measurements.

Figure 6 CTD SBE 911 plus system deployed during the R/V Akademik cruises.

6. Sun-Photometry (SUN)

Sun-photometric measurements were performed at stations and between stations during clear sky conditions. Measurements of the direct sun-irradiance were carried out with hand held Microtops II sun-photometers equipped with five spectral channels within the spectral range 340–1020 nm. Instruments calibration and data processing procedures comply with requirements of the international Maritime Aerosol Network (MAN) traceable to the Aerosol Robotic Network (AERONET). Instruments and data analysis details are described in Smirnov et al. (2011).

7. PSICAM (Point-Source Integrating-cavity Absorption Meter)

Sea water and CDOM absorption coefficients has measured by PSICAM, where no scattering error might occur. The method has used according to Röttgers and Doerffer 2007. Seawater samples were measured immediately after collecting from the Rosette sampler for avoiding temperature effect on phytoplankton assemblages. CDOM samples were prepared by filtering the pre-filtered (G/FF) sea water through 0.22 nucleopore filters. Both measurement have repeated 3 times and corrected by blank measurements by milliq water. The temperature and salinity corrections have done by post processing. PSICAM setup has combined by PSICAM sphere, light source, detector and fibber optic cables. Data collection program has developed by Wolfgang Schoenfeld and Rüdiger Röttgers from Helmholtz Zentrum Geesthacht.

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Task 2 Training on Optical Profile Measurements and Data handling.

Training activities were carried out during the EUROFLEETS cruises between stations. During the Mare Nigrum Cruise training included tutorials on:

i. Optical Radiometric Profile Measurements by G.Zibordi;
ii. Inherent Optical Measurements of Seawater (a, b, c, bb) by J.F.Berthon;
iii. Water Sampling and Conditioning for Bio-Optical Analysis by E.Canuti.

During the Akademik Cruise training included tutorials on:

i. Optical Radiometric Profile Data Handling and Processing by G.Zibordi:
ii. Analysis of Seawater Inherent Optical Properties (a, b, c, bb) by J.-F.Berthon;
iii. Determination of Seawater VSF by Y.Shibanov;
iv. Pigments Quantification through HPLC by E.Canuti;
v. Underway Fluorometry using a Flow-Through System by V.Levchenko.

Task 3 Analysis and assurance of data from first cruise

The processing and quality assurance of free-fall optical profiler's data products are made using the Optical Processor developed at the JRC. The various processing steps, defined in agreement with consolidated protocols are fully documented in Zibordi et al. (2011).
The implementation of Task 3 will continue during the first half of the next project semester. The main results of the bio- optical data analysis and data quality assurance will be reported in the April progress report 2012.

References:

G.Zibordi, J.-F.Berthon, F.Mélin and D. D'Alimonte . Cross-site consistent in situ measurements for satellite ocean color applications: the BiOMaP radiometric dataset. Remote Sensing of Environment,115, 2104–2115, 2011.

5.2. Milestones for the next six months

- Analysis and assurance of data from first cruise;
- Project Annual review meeting will be held in Istanbul, Turkey in November 2011
- Development of bio-optical algorithms
- Training on Optical Profile Data Analysis and Applications

5.3. Involvement of young scientists

Currently the number of scientists less than 40 years old involved in the project activities is as follows:

- 3 from METU-IMS, Turkey:

In addition to one post doc (Dr. Heather Cannaby), and Msc Student (Mr. Akif Korkmaz), and Anıl Akpınar (Phd Student) is involving the project. All are working on Black Sea ecosystem modelling, by using remote sensing, Argo float data and field optical measurements. They will partly involve to campaigns and data processing issues. Also they will be potential end users of the resulting products of the project

- 3 from IO – BAS, Bulgaria:

Ms. Violeta Slabakova (Associate Researcher), has prepared the Web presentation for the Project, and maintains it as the permanent task. She was involved in the bio-optical oceanographic campaigns, AOP measurements and data processing.
Mrs. Elitsa Stefanova (PhD student) was involved in water samples collection and seawater filtration during the EUROFLEETS bio-optical oceanographic campaigns.
Mr. Yavor Vekov (technician) was involved in the AOP and Sunphotometry measurements during the bio-optical oceanographic campaigns.

- 3 from MHI NASU,Ukraine:

Mrs. Elena Korchomkina, Junior Scientist is developing and testing two algorithms: for remote chlorophyll-retrieval in Case 2 waters and for improvement of standard atmospheric correction of remote sensed reflectance. Also, she is ready to present her PhD Thesis: "DETERMINATION OF PHYTOPLANKTON PIGMENTS CONCENTRATIONS IN SEAWATER USING REMOTE SENSING AND CONTACT OPTICAL MEASUREMENTS".
Mrs. Daria Kalinskaya, Junior Scientist is concerned with aerosol optical properties spatial distribution and its analyses.
Mr. Alexander Latushkin, engineer, is studying spectral features of phytoplankton spectral attenuation coefficient and also taking part in design of spectral transparency meter.

- 1 from SIO RAS, Russia

Mr. Vladimir Levchenko, MSc Student (Moscow Institute of Physics and Technology). He is preparing a new flow-through fluorometer for studying spatial changeability of CDOM and phytoplankton fluorescence during the oceanographic campaigns.

- 2 from NIMRD, Romania

Dr. Razvan Mateescu, hydrotechnical engineer, was involved in the oceanographic campaign for ocean colour determination
Alina Spanu, geographer, involved in spatial distribution of the physical parameters and data processing.

5.4. Major travel

IMS –METU. Erdemly, Tukey
Names: Dr. Hasan Örek and Anil Akpinar (2 persons)
Travelling to: Varna, Bulgaria (8-23 July 2011- Akpinar, 12-23 July 2011-Örek)
Purpose: Participation to EUROFLEETS Akademik BIO OPT and Akademik BioMap cruises.

IO-BAS, Varna, Bulgaria
Names: Ms: Violeta Slabakova, Mrs Elitsa Stefanova and Mr. Yavor Vekov (3 persons)
Travelling to: Constanta, Romania (29 - 30.06.2011)
Purpose: Participation to EUROFLEETS Mare Nigrum BIO OPT Cruise

Name: Ms. Violeta Slabakova
Travelling to: Istanbul, Turkey (08-11.06.2011)
Purpose: Participation to 5 th International Conference on Recent Advances in Space Technologies, RAST 2011, 09-11 June 2011

MHI, Sevastopol, Ukraine
Names: Dr. Yevgen Shybanov and Oleg Martynov (2 persons)

Travelling to: Constanta, Romania (29.06 - 08.07.2011) and Varna, Bulgaria (08-14.07.2011 Martynov; 08-24.07.2011 Shybanov)
Purpose: Participation to EUROFLEETS Mare Nigrum and Akademik BIO OPT and Akademik BioMap Cruises

Name: Dr. Michael Lee, Dr. Elena Korchomkina, Mrs. Daria Kalinskaya and Mr. Alexander Latushkin (4 persons)
Travelling to: St.Petersburg, Russia (04-11.09.2011) and Dr. Lee also to Tartu, Estonia (11-17.09.2011 Lee)
Purpose: Participation to VI International Conference Current Problems in Optics of Natural Waters (ONW'2011), 06-10 September 2011

SIO, Moskow, Russia
Name: Mr: Vladimir Levchenko and Mr. Yuly Venskut (2 persons)
Travelling to: Constanta, Romania (28.06-05.07.2011) and to Varna, Bulgaria (06-12.07.2011)
Purpose: Participation to EUROFLEETS Mare Nigrum and Akademik BIO OPT Cruises

Name: Mr: Vladimir Levchenko
Travelling to: Varna, Bulgaria (13-24.07.2011)
Purpose: Participation in JRC-IO BioMap cruise on R/V Akademik

NIMRD, Contsanta, Romania
Names: Mr. Razvan Mateescu, Mr. Dan Vasiliu (2 persons)
Travelling to: Gloria Platform, Romania (25-26.09 2010)
Purpose: Installation of the radiometer

Names: Ms. Luminita Buga (1 person)
Travelling to: Constanta, Romania (01-05.07.2011)
Purpose: Participation to EUROFLEETS Mare Nigrum BIO OPT Cruise

Names: Mr. Razvan Mateescu (1 person)
Travelling to: Varna, Bulgaria (08-12.07.2011)
Purpose: Participation to EUROFLEETS Akademik BIO OPT Cruise

Names: Mr. Razvan Mateescu (1 person)
Travelling to: Yantai, China, (11-16.09.2011)
Purpose: Participation to International *conference LOICZ "Coastal Systems, Global Change and Sustainability"* (12-15.09.2011)

5.5. Visit by experts/advisors and NATO consultant

No advisor and consultants are foreseen in the project.

5.6. Visibility of SfP project

Presentation of the results of preliminary analysis of data obtained in the Black Sea was made at the "Oceans from Space" Symposium, Venice 2010 (Burenkov V., Kopelevich O., Sheberstov S., Vazyulya S. Bio-optical characteristics of the Black Sea from satellite data.

For the purpose of visibility of the project, the Web site: www.natosps.io-bas.bg was dedicated to the Project following the NATO existing recommendations. Besides ongoing and planned activities related to the Project, important document on outcomes, all necessary links to participating institutions, as well as to NATO SfP Programme are available.

5.7. Technical and administrative difficulties

No problems encountered with NATO administration, which provided help and assistance whenever requested.

5.8. Changes in personnel

As far it was no changes in personnel, but we are creating additional possibilities for involvement of new personnel and young researchers in the Project.

6. FINANCIAL STATUS

6.1 Annexes 4a: SfP NATO BUDGET TABLES

A) INSTITUTE OF MARINE SCIENCES, ERDEMLY, TURKEY

SfP NATO BUDGET TABLE

Project number: SfP - 982678		Project short title:	SfP - Black Sea Characterization
Report date: 30.09.2011		Duration of the Project [1]:	November 2009 – October 2012
Project Co-Director: *(Temel Oguz, Erdemly, Turkey)*			

	ACTUAL EXPENDITURES	**FORECAST EXPENDITURES**		
Detailed Budget Breakdown *(to be completed in EUR[3])*	*(1)* from start until 31.09.2011	*(2)* for the following six months	*(3)* for the following period until project's end	**Comments on changes, if any, in the financial planning compared to the approved Project Plan**
(a) Equipment				
Subtotal "Equipment"				
(c) Training				
Subtotal "Training "				
(f) Travel		5 000	6 345	
(F1). Kick-off meeting Istanbul, Turkey 09-10 November 2009 - 2 person	680			
(F2) Eurofleets and IOBAS-JRC R/V Akademik cruises. 08-23.July 2011 -2 persons	2475			
Subtotal "Travel"	**3 155**	**5 000**	**6 345**	
(g) Consumables - Spare parts:	0	2 000	4 000	
Subtotal "Consumables - Spare parts"	**0**	**2 000**	**4 000**	
(h) Other costs and (i) stipends *(specify)*	0	1 500	3 000	
Subtotal "Other costs"	**0**	**1500**	**3000**	
TOTAL *(1), (2), (3)* **:**	**3 155**	**8 500**	**13 345**	
CURRENT COST OUTLOOK *=(1)+(2)+(3)*			***25 000***	

B) INSTITUTE OF OCEANOLOGY-BAS, VARNA, BULGARIA

SfP NATO BUDGET TABLE

Project number: SfP - 982678		Project short title:	SfP - Black Sea Characterization
Report date: 30.09.2011		Duration of the Project [1]:	November 2009 – October 2012
Project Co-Director: *(Atanas Palazov, Varna, Bulgaria)*			

Detailed Budget Breakdown *(to be completed in EUR[3])*	**ACTUAL EXPENDITURES** *(1)* from start until 30.09.2011	**FORECAST EXPENDITURES** *(2)* for the following six months	*(3)* for the following period until project's end	**Comments on changes, if any, in the financial planning compared to the approved Project Plan**
(a) Equipment		0	0	
(A1) MicroPRO-II profiler system	70 493			
Subtotal "Equipment"	**70 493**	**0**	**0**	
(c) Training	0	2 500	2 000	
Subtotal "Training "	**0**	**2 500**	**2 000**	
(f) Travel		5000	5 085	
(F1). Kick-off meeting Istanbul, Turkay 09-10 November 2009 - 2 person	980			
(F2). Rresent Advances in Space Technology- RAST conference, Istanbul, Turkey, 08-11.06.2011 - 1person	517			
(F3) Eurofleets R/V Mare Nigrum cruise,Constanta, Romania, , 29-30.06.2011 -4 persons	525			
Subtotal "Travel"	**2022**	**5 000**	**5 085**	
(g) Consumables - Spare parts:		4500	641	
(G1) Laboratory materials and consumables	380			
(G2) Spare parts	79			
Subtotal "Consumables - Spare parts"	**459**	**4 500**	**641**	
(h) Other costs and (i) stipends *(specify)*		**1 200**	**780**	
(H1)Project specific mailing	317			
(H2) Stationary	10			
(H2) Other expenses	493			
(I1) Stipendies for Mrs.Violeta Salabakova	2400			
(I2) Stipendies for Ms.Elitsa Stefanova	100			
(I3) Stipendies for Mr. Yavor Vekov	300			

Subtotal "Other costs"	**3 620**	**1 200**	**780**	
TOTAL *(1), (2), (3)* **:**	**76 594**	**13 200**	**8 506**	
CURRENT COST OUTLOOK *=(1)+(2)+(3)*			***98 300***	

C) MARINE HYDROPHYSICAL INSTITUTE, SEVASTOPOL, UKRAINE

SfP NATO BUDGET TABLE

Project number: SfP - 982678		Project short title:	SfP - Black Sea Characterization
Report date: 30.09.2011		Duration of the Project [1] :	November 2009 – October 2012
Project Co-Director: *(Michael Lee, Sevastopol, Ukraine)*			

Detailed Budget Breakdown *(to be completed in EUR[3])*	**ACTUAL EXPENDITURES** *(1)* from start until 31.09.2011	**FORECAST EXPENDITURES** *(2)* for the following six months	*(3)* for the following period until project's end	**Comments on changes, if any, in the financial planning compared to the approved Project Plan**
(a) Equipment				
Subtotal "Equipment"				
(c) Training	0	1 000	1 000	
Subtotal "Training "	**0**	**1 000**	**1 000**	
(f) Travel		2 000	2 000	
Kick-off Project meeting, Istanbul, 09.11.2009	714			
CASRE meeting, Kiev, 12.10.2010	133			
Eurofleets Bio-Opt Campaign - one person for period 27.06-15.07.2011and second person for period 27.06-15.07.2011	3 544			
The VI International Conference Current Problems in Optics of Natural Waters (ONW'2011) in St.Petersburg - 3 persons for period 04-11.09.2011 and one person for period 04 – 17.09.2011	2 958			
Subtotal "Travel"	**7 349**	**2 000**	**2 000**	
(g) Consumables - Spare parts:				
Component parts	913	1 000	1 000	
Subtotal "Consumables - Spare parts"	**913**	**1 000**	**1 000**	
(h) Other costs and (i) stipends *(specify)*		300	259	
(H1)Post services	102			
(H2)Bank services	28			
(H3)Customs services	75			
(H4)Expedition service expenses	649			
(I1) Stipends for Mrs. Elena Korchomkina	2 300	600	700	
(I2)Stipends for Mrs. Daria Kalinskaya	525			
(I3)Stipends for Mr. Alexander Latushkin	1 150	300	350	
Subtotal "Other costs"	**4 829**	**1 200**	**1 309**	

TOTAL *(1), (2), (3)* **:**	**13 091**	**5 200**	**5 309**	
CURRENT COST OUTLOOK *=(1)+(2)+(3)*			***23 600***	

D) P.P SHIRSHOV INSTITUTE OF OCEANOLOGY, MOSCOW, RUSSIA

SfP NATO BUDGET TABLE

Project number: SfP - 982678		Project short title:	SfP - Black Sea Characterization
Report date: 30.09.2011		Duration of the Project [1]:	November 2009 – October 2012
Project Co-Director: *(Oleg Kopelevich, Moscow, Russia)*			

Detailed Budget Breakdown *(to be completed in EUR[3])*	**ACTUAL EXPENDITURES** *(1)* from start until 30.09.2011	**FORECAST EXPENDITURES** *(2)* for the following six months	*(3)* for the following period until project's end	**Comments on changes, if any, in the financial planning compared to the approved Project Plan**
(a) Equipment				
Subtotal "Equipment"				
(c) Training				
Subtotal "Training "				
(f) Travel		600	4 000	
(F1) Kick-off meeting Istanbul, Turkey 09-10 November 2009 – 1 person	600			
(F2)"Ocean form Space" symposium, Venice, Italy, 25-30 Apr, 2010, 1person	2 070			
(F3) EUROFLEETS BIO-OPT cruises, 28 Jun-24 Jul – 2 persons	3 330			
Subtotal "Travel"	**6 000**	**600**	**4 000**	
(g) Consumables - Spare parts:	100	1 000	2 000	
Subtotal "Consumables - Spare parts"	**100**	**1 000**	**2 000**	
(h) Other costs and (i) stipends *(specify)*				
(H1)Other cost			200	
(I1) Stipendies for Mr.Vladimir Levchenko (or the other student)	2 100	800	900	
Subtotal "Other costs"	**2 100**	**800**	**1 100**	
TOTAL *(1), (2), (3)* **:**	**8 200**	**2 400**	**7 100**	
CURRENT COST OUTLOOK *=(1)+(2)+(3)*			***17 700***	

E) NATIONAL INSTITUTE FOR MARINE RESEARCH AND DEVELOPMENT, CONSTANTA, ROMANIA

SfP NATO BUDGET TABLE

Project number: SfP - 982678		Project short title:	SfP- Black Sea Characterization
Report date: 30.09.2011		Duration of the Project [1]:	November 2009 – October 2012
Project Co-Director: *(Viorel Malciu, Contanta, Romania)*			

	ACTUAL EXPENDITURES	**FORECAST EXPENDITURES**		
Detailed Budget Breakdown *(to be completed in EUR[3])*	*(1)* from start until 30.09.2011	*(2)* for the following six months	*(3)* for the following period until project's end	**Comments on changes, if any, in the financial planning compared to the approved Project Plan**
(a) Equipment				
Subtotal "Equipment"				
(c) Training	0	2 250	2 000	
Subtotal "Training "	0	**2 250**	**2 000**	
(f) Travel		3 000	2 698	
(F1) Kick-off meeting Istanbul, Turkey 09-10 November 2009 – 1 person	497			
(F2) Gloria Platform, Constanta, Romania 25-26.09 2010 – 2 persons	17			
(F3) Eurofleets R/V Mare Nigrum cruise, Constanta, Romania, , 01-05.07.2011 - 1 person	250			
(F3) Eurofleets R/V Akademik cruise, Varna, Bulgaria, 08-12.07.2011 - 1 person	338			
(F4) International conference LOICZ "Coastal Systems, Global Change and Sustainability",Yantai, China, 12-15.09.2011 - 1 person	750			
Subtotal "Travel"	**1 852**	**3 000**	**2 698**	
(g) Consumables - Spare parts:		0	0	
(G1) Laboratory spare parts	624			
(G2) Laboratory materials and consumables	2028			
(G4) Office spare parts	270			
(G3) Office consumables	310			
Subtotal "Consumables - Spare parts"	**3 232**	0	0	
(h) Other costs and (i) stipends (specify)		600	771	
(H1) Fuel research vessel	749			
(H2)Protection equipment	137			
(H3) Other costs	611			
(I1)Stipends	1 000			
Subtotal "Other costs"	**2 497**	**600**	**771**	
TOTAL (1), (2), (3) :	**7 581**	**5 850**	**5 469**	
CURRENT COST OUTLOOK =*(1)+(2)+(3)*				***18 900***

6.2 Annexes 4b: SfP NATO SUMMARY BUDGET TABLES

SFP NATO BUDGET SUMMARY TABLE

Project number: SfP - 982678 Report date: 30.09.2011 The Project is in the year *(please indicate)*: *1 – 2- 3*	Project short title: SfP - Black Sea Characterization Duration of the Project[1]: November 2009 – October 2012

Breakdown per Project Co-Director *(to be completed in EUR [3])*

Project Co-Director's name, city, country	APPROVED BUDGET: Total year1- 3	CURRENT COST OUTLOOK: Total year1- 3	ACTUAL EXPENDITURES since start until 30.09.2011	FORECAST EXPENDITURES for the following 6 months	FORECAST EXPENDITURES for the following period until project's end	Comments on changes, if any, in financial planning compared to the approved Project Plan
Prof.Temel Oguz,, Erdemli, Turkey	*25 000*	*25 000*	*3 155*	*8 500*	*13 345*	
Dr. Atanas Palazov, Varna, Bulgaria	*98 300*	*98 300*	*76 594*	*13 200*	*8 506*	
Dr. Michael Lee, Sevastopol, Ukraine	*23 600*	*23 600*	*13 091*	*5 200*	*5 309*	
Dr. Oleg Kopelevich, Moscow, Russia	*17 700*	*17 700*	*8 200*	*2 400*	*7 100*	
Dr. Viorel Malciu, Constanta, Romania	*18 900*	*18 900*	*7 581*	*5 850*	*5 469*	
TOTAL *(must be identical with TOTALs given in 'Breakdown per item')*:	**183 500**	**183 500**	**108 621**	**35 150**	**39 729**	

Breakdown per item *(to be completed in EUR [3])*

Item	APPROVED BUDGET: Total year 3	CURRENT COST OUTLOOK: Total year 3	ACTUAL EXPENDITURES since start until 30.09.2011	FORECAST EXPENDITURES for the following 6 months	FORECAST EXPENDITURES for the following period until project's end	Comments on changes, if any, in financial planning compared to the approved Project Plan
(a) Equipment	*68 000*	*70 493*	*70 493*	*0*	*0*	
(b) Computers - Software						
(c) Training	*13 000*	*10 750*	*0*	*5 750*	*5 000*	
(d) Books - Publications						
(e) Experts - Advisors						
(f) Travel	*52 000*	*56 106*	*20 378*	*15 600*	*20 128*	
(g) Consumables - Spare parts	*23 000*	*20 845*	*4 704*	*8 500*	*7 641*	
(h) Other costs and (i) stipends	*27 500*	*25 306*	*13 046*	*5 300*	*6 960*	
TOTAL :	**183 500**	**183 500**	**108 621**	**35 150**	**39 729**	

6.3 Annexes 4c: SfP NATO NATIONAL CONTRIBUTION TABLES

B) INSTITUTE OF OCEANOLOGY-BAS, BULGARIA

SFP NATIONAL CONTRIBUTION TABLE

Project number: SfP -982678 Project Co-Director: *(Atanas Palazov,Varna, Bulgaria)* Report date: 30.09.2011	Project short title: SfP - Black Sea Characterization

A. TYPE of EXPENDITURE

Budget breakdown	**Year of expenditure 1st year**	**2nd year**	**3rd year**
(a) Salaries *(Name and qualification of research and support personnel)*			
(A1) Dr Atanas Palazov, director	2 500	2 500	2 500
(A2) Violeta Slabakova, associated researcher	2 000	2 000	2 000
(A3) Mr. Hirsto Stanchev, associated researcher	500	500	500
Subtotal "Salaries"	**5 000**	**5 000**	**5 000**
(b) Overhead Costs *(specify: consumables, energy, local transportation)*			
(B1) Energy	500	500	500
(B2) Consumables	500	500	500
Subtotal "Overhead"	**1 000**	**1 000**	**1 000**
(c) Equipment - Computers			
Subtotal "Equipment"			
(d) Other costs			
(D1) Ship crew	10 000		
Subtotal "Other costs"	**10 000**		
TOTAL :	**16 000**	**6 000**	**6 000**
GRAND TOTAL = (1) + (2) + (3) + (4) + (5)	**28 000**		

B. SPONSORING INSTITUTIONS

Name of sponsoring institution	**Year of expenditure 1st year**	**2nd year**	**3rd year**
TOTAL :	(1)	(2)	(3)
GRAND TOTAL = (1) + (2) + (3) + (4) + (5)			

E) NATIONAL INSTITUTE FOR MARINE RESEARCH AND DEVELOPMENT, CONSTANTA, ROMANIA

SFP NATIONAL CONTRIBUTION TABLE

Project number: SfP -982678 Project Co-Director: *(Viorel Malciu,Constanta, Romania)* Report date: 30.09.2011	Project short title: SfP- Black Sea Characterization

A. TYPE of EXPENDITURE

Budget breakdown	Year of expenditure 1st year	2nd year	3rd year
(a) Salaries *(Name and qualification of research and support personnel)*			
Dr. Viorel Malciu	400	400	300
Dr. Razvan Mateescu	300	300	300
Dan Vasiliu	300	300	300
Subtotal "Salaries"	**1 000**	**1 000**	**900**
(b) Overhead Costs *(specify: consumables, energy, local transportation)*	500	500	500
Subtotal "Overhead"	**500**	**500**	**500**
(c) Equipment - Computers	1 000	700	1 000
Subtotal "Equipment"	**1 000**	**700**	**1 000**
(d) Other costs			
Subtotal "Other costs"			
TOTAL :	**2 500**	**2 200**	**2 400**
GRAND TOTAL = (1) + (2) + (3) + (4) + (5)	**7 100**		

B. SPONSORING INSTITUTIONS

Name of sponsoring institution	Year of expenditure 1st year	2nd year	3rd year
TOTAL :	(1)	(2)	(3)
GRAND TOTAL = (1) + (2) + (3) + (4) + (5)			

7. EQUIPMENT INVENTORY RECORDS

Inventory Label №	Property Item	Manufacturer	Model Number	Serial Number	Date of Purchase	Cost (EUR[1])	Location
1776	7 channel free fall optical profiler	Satlantic	MPRO II	141	07.12.2010	27 725.4	Institute of oceanology, Bulgaria
1777	In water profiling package reference sensor multispectral Irradiance cosine Air (E_s) sensor	Satlantic	Micro II Ref 7 Channel	214,215	07.12.2010	6 226.9	Institute of oceanology, Bulgaria
1778	7 channel Irradiance cosine water (E_d, E_u) sensor	Satlantic	OCR-507I	216	07.12.2010	5 913.00	Institute of oceanology, Bulgaria
1779	Combination chlorophyll fluorometer and 2 channel backscattering	Wet labs	Triplet puck		07.12.2010	7 219.7	Institute of oceanology, Bulgaria
1780	Advanced pich/roll compensated compass/ magnetometer system	Satlantic	SAT-THS	025	07.12.2010	2 847.00	Institute of oceanology, Bulgaria
1781	Sunphotometer	Solar Light Company Inc.	Model 540 Microtops II		07.12.2010	7 628.5	Institute of oceanology, Bulgaria
1782	GPS	Trimble	Geo XT	5002508893	07.12.2010	9 022.8	Institute of oceanology, Bulgaria

8. CRITERIA FOR SUCCESS TABLE

Project number:	SfP -982678	Project short title: SfP - Black Sea Characterization
Report date:	30.09.2011	Duration of the Project [1] : 10.11.2009 - 10. 11. 2012
The Project is in the year [2] : *1 – 2 - 3*		

Criteria for Success as approved with the first Grant Letter on: *12.12.2008*	%	**Criteria for Success: Achievements as at** *10.11.2009. / 31.03 2011*	%
1) Procurement and test of new in situ instrumentation (bio-optical profiler)	20	Bio-optical equipment was purchased and assessment of the measurement method was performed.	20
2) Execution of the first bio-optical cruise	20	The first bio-optical cruise was carry out	20
3) Analysis and quality assurance of the bio-otical data from the first cruise	10	1) Processing and quality assurance of free-fall optical profiler's data	5
4)Execution of the second bio-optical cruise	10		0
5)Analysis and quality assurance of the bio-optical data from the second cruise	10		0
6)Development of regional bio-optical algorithms	10		0
7)Implementation of the new bio-optical algorithms in the JRC processing chain for ocean color satellite data	10		0
8)All countries involved in the project continue the bio-optical sampling program in the Black Sea to future improve bio-optical algorithms of available ocean color products	10		0
TOTAL :	**100%**	**TOTAL [4] :**	**45 %**

SUMMARY REPORT

SfP – Black Sea Characterization

SfP – 982678
Bio - Optical Characterization of the Black Sea for Remote Sensing Applications

Project Co-Directors:
Prof. Temel Oguz, IMS, Erdemli, Turkey (NPD)
Dr. Atanas Palazov, IO, Varna, Bulgaria (PPD)
Dr. Michael Lee, MHI, Sevastopol, Ukraine
Dr. Oleg Kopelevich, SIO, Moscow, Russia
Dr. Viorel Malciu, NIMRD, Constanta, Romania

Approval Date: *12 th December 2008* Effective Date: 10 th November 2009
Duration: 3 years till 10 th November 2009
NATO Budget: 183 500 EUR

Information about the SfP Project through Internet: www.natosps.io-bas.bg

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Abstract of Research

The project, within the framework of the environmental security research topic, aims at the implementation of a tool to support remote sensing applications for operational environmental monitoring and climate studies in the Black Sea. This final objective is expected to be achieved through the implementation of new models and algorithms in a processing chain for ocean colour imagery. The new models and algorithms for the quantification of the concentration of seawater optically significant constituents (mostly chlorophyll a, total suspended matter and yellow substance), will result from the analysis and application of comprehensive *in situ* bio-optical measurements of optical properties (inherent and apparent) and concentration of seawater optically significant constituents performed during two major oceanographic campaigns.

Major Objectives:

- to create an *in situ* data set of optical properties (inherent and apparent) and concentration of seawater optically significant constituents for the Black sea.
- to develop a new bio-optical algorithms for the determination of optically significant seawater constituents for Black Sea environmental monitoring through Earth observing systems (mostly the Medium Resolution Imaging Spectrometer (MODIS) onboard the NASA AQUA polar platform).
- to validate a new regional bio-optical algorithm.
- to cross - compare of regional and global bio- optical algorithms
- to generate satellite ocean-colour products of the Black Sea freely accessible thought web interface

Overview of Achievements since the Start of the Project until 30 September of current year

- Organisation of the first kick-off meeting in November 2009, in Istanbul, Turkey.
- Purchase request/ delivery of the free- fall radiometric profiler.
- Assessment of measurement method was carried out through the cross-site comparison of early bio-optical data collected by the JRC scientific team in the Black Sea in 2006 and 2009.
- Joint research proposal was submitted to obtain funding for ship-time through the EUROFLEETS program. The project was granted in the late Fall 2010.
- Three consecutive bio-optical oceanographic cruises were carried out in the Western and Central Black Sea (01-23.07.2011) within EUROFLEETS BIO-OPT Project and Contract # 386675 between JRC of EC and Institute of Oceanology, BAS to support the activities of the NATO SfP 992678 Project.
- 112 bio-optical measurements were carried out in the Western and Central Black Sea waters during the cruises.
- Training on Optical Profile Measurements and Data handling was carried out onboard Mare Nigrum and Akademik.
- A new spectral transparency meter was made, for future use in calibration of Volume Scattering Function meter during the both planning bio-optical expeditions.
- Presentation of the results of preliminary analysis of data obtained in the Black Sea was made at three International Conferences
- Project Internet web site was prepared and is now available under Institute of Oceanology, BAS web server: www.natosps.io-bas.bg

Payments through NATO Funds: 108 621 EUR

Milestones for the Next Six Months

- Analysis and assurance of data from first cruise;
- Project Annual review meeting will be held Istanbul, Turkey in November 2011
- Development of bio-optical algorithms
- Training on Optical Profile Data Analysis and Applications

Implementation of Results

The Institute for Environment and Sustainability of the Joint Research Centre is a major civil entity that will make use the outcomes of the scientific activities of this project in its processing chain for satellite ocean colour data in view of generating more accurate remote sensing products for the Black Sea.

Other Collaborating Institutions

- Maritime Hydrographic Directorate, Romania
- Research Center of the Navy, Romania

Abbreviations: *(give full expression for all abbreviations which occur in this summary)*
IMS – Institute of Marine Science
IO- Institute of Oceanology
MHI – Marine Hydrophysical Institute
SIO – Shirshov Institute of Oceanology
NMRD – National Institute for Marine Reaseach and Development
JRC- Joint Research Centre
NASA – National Aeronautics and Space Administration
ROSA – Romanian Space Agency
ESA – European Space Agency