European Association of Remote Sensing Laboratories

White Sea Biological Station of Lomonosov Moscow State University

Faculty of Physics of Lomonosov Moscow State University

Carl von Ossietzky University of Oldenburg

International Laser Center of Lomonosov Moscow State University

International White Sea Student Workshop on Optics of Coastal Waters

30 August – 7 September, 2014

Nikolai Pertsov White Sea Biological Station of Lomonosov Moscow State University; Republic of Karelia, Russia

Book of abstracts

WSBS – Moscow

2014

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Details about the White Sea Student Workshop on Optics of Coastal Waters including presentations and some photos you can see also on the EARSeL website:
http://www.earsel.org/SIG/ET/1st-student-workshop/index.php
and on the WSBS website (in Russian):
http://wsbs-msu.ru/doc/index.php?ID=150

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Content

Introduction

More than 60% of humans live within 60 km from the coastline. Therefore coastal zones, including inland waters and land-ocean interfaces, are important environmental and economic resources, and their investigation with boats or ships has always been a challenge. Today hydrographic data are often collected from space or using airborne sensors, which is particularly relevant in regions with complex coastal waters influenced by freshwater and characterised by long coastlines. A particularly sensitive region is the Karelian coast of the White Sea, which is an inlet of the Barents Sea and one of the seas of the Arctic Ocean.

Optical methods in environmental sciences have reached a high precision in various marine and land surface applications: vegetation and phytoplankton diagnostics, quantification of suspended and dissolved matter in waters, composition of soils, and pollution analysis, to name but a few. Sunlight reflectance and thermal emission measurements make it possible to investigate parameters such as the penetration depth of light, the phytoplankton and coloured dissolved organic matter content in the ocean, land cover vegetation, and temperature of the Earth surface. Airborne remote sensing using lasers provides a tool for detecting pollutants such as oil spills at sea and discharges on land.

The White Sea Student Workshop on Optics of Coastal Waters was a one-week education and training event. It addressed the principles, methods and results of optical analysis of environmental parameters using modern instruments in tutorials and field excursions. Recent findings were evaluated in the context of hydrographic processes and ecosystem variables. The relevance of oceans and coastal zones for the daily weather and for the regional and global climate was outlined.

On behalf of organizers,

Alexander Tzetlin, Head of Nikolai Pertsov White Sea Biological Station, Lomonosov Moscow State University, Russia;
Rainer Reuter (Chairman), Institute of Physics, University of Oldenburg, Germany;
Svetlana Patsaeva (Chairman), Faculty of Physics, Lomonosov Moscow State University, Russia;
Elena Krasnova, Faculty of Biology, Lomonosov Moscow State University, Russia;
Tatiana Dolenko, Faculty of Physics, Lomonosov Moscow State University, Russia.

Workshop Programme

30 August 2014

08:00 Workshop Opening

Welcome Keynotes
Elena Krasnova
Opening Keynotes
Rainer Reuter

10:00 Plenary Session 1

Rainer Reuter. SEOS - EARSeL's e-learning tutorials for science education

11:30 Poster Session 1

Feodor Balabin, Semen Buvaly, Sanjima Garmaeva, Anastassia Grigorieva, Stella Ilchenko, Igor Izyurov, Viktor Karpychev, Alexey Kosenkov, Igor Kruchinin, Marina Krylova, Vladislav Kuznetsov, Ekaterina Malyshko, Alina Murtazina, Elena Nesmeyanova, Sergey Varlamov, Dmitry Vinogradov, Nadezhda Volovich, Larisa L. Menshenina, Maria V. Mardashova, Elena D. Krasnova. Investigation of separating sea bays: an integrated approach (bathymetry, structure of the water column, benthic communities, ecology of indicator benthic and terrestrial species) on the model Kislo-Sladkoye and Lower Ershovskoye lakes.

Anastasiia Kharcheva. Spectroscopic study of green sulfur bacteria in the separating reservoirs of the Kandalaksha Gulf of the White Sea.

Anna Voronova. Ice formation creates water stratification: experimental verification

Marianna Chebanova. Salt water intrusion in the tidal estuary of the river Kem.

Olesya Kalmatskaya, Anastasiia Kharcheva, Kirill Laptinskiy, Irina Medvetskaya, Andrew Meschankin, Kirill Nikolskiy, Anna Voronova. Complex study of water stratification in Kislo-Sladkoye lake.

Galina Losyuk, Natalia Kokryatskaya, Elena Krasnova. Distribution of hydrogen sulfide in the lake Trekhtsvetnoe and the lagoon (lake) on the Zelenyi Cape.

Natalia Kokryatskaya, Elena Krasnova, Galina Losyuk. Features of formation of hydrogen sulphide contamination in the separating lakes in the Kandalaksha Bay of the White Sea

14:00 Excursion and field experiments 1

Excursion to Kostian island

31 August 2014

09:00 Excursion and field experiments

Excursion to the brackish lake at the Green Cape (tour guided by *Dmitry Voronov*).

Preparation and organization of experiments; water sampling; testing of instruments, practical demonstrations.

19:00 Plenary Session 2

Natalia L. Frolova. Winter hydrological regime of the separating basins of the White Sea (according to the field research).

1 September 2014

08:00 Plenary Session 3

Anatoly N. Pantyulin. Hydrological system of the White Sea.

*Tatiana A. Dolenko.*Diagnostics of aqueous media by method of laser Raman spectroscopy using artificial neural networks.

Sergey A Dolenko. A brief introduction to artificial neural networks.

Sergey A Dolenko. Artificial neural networks as a method of solving inverse problems in laser spectroscopy.

14:00 Excursion and field experiments 2

Boat excursion on the separating lake called "Nizhnee Ershovskoe" (tour guided by *Nikolai A. Demidenko*); Water sampling and field work.

Laboratory work; processing of field data.

20:30 Keynote

Alexander B. Tzetlin, Director of WSBS. Long-established marine lab on the youngest sea on Earth.

2 September 2014

08:00 Plenary Session 4

Anatoly N. Pantyulin. Hydrological system of the White Sea and the separating lagoons.

Martin A Montes. A quick tutorial on optical remote sensing of aquatic systems based on passive systems (Part 1).

11:30 Poster Session 2

Alexey Vervald, Ernest Mazurin, Ivan Plastinin. Remote determination of temperature and salinity of natural waters of White Sea area by Raman spectra using artificial neural networks.

Andrew Meshchankin, Anastasiia Kharcheva. Chlorophyll distribution visualization based on digital pictures of plants.

Kirill Laptinskiy, Sergey Burikov, Tatiana A. Dolenko, Sergey A. Dolenko. Remote determination of saline composition of mineral waters using Raman spectroscopy.

Igor Lyalin, Anastasiia Kharcheva, Andrey Meshchankin, Elena D. Krasnova, Dmitry A. Voronov, Svetlana V. Patsaeva. Summer student work at the White Sea Biological Station devoted to study of meromictic water basins.

14:00 Excursion and field experiments 3

Demonstration of instruments and practical exercises.

21:30 Keynote

Rainer Reuter. The role of the oceans in climate change.

3 September 2014

08:00 Plenary Session 5

Daria Todorenko. Application of fluorescence methods to probe physiological state of microalgae.

Svetlana V. Patsaeva. Optical properties of humic substances and aquatic dissolved organic matter.

Rainer Reuter. Ocean remote sensing using lasers.

Elena D. Krasnova. Wonders of the lakes separating from the White Sea.

14:00 Excursion and field experiments 4

Boat excursion including walking tour to the Black River settlement

21:30 Keynote

Anatoly N. Pantyulin. Three admirals: Interlacing fate. S.O. Makarov (1849-1904), A.V. Kolchak (1874-1920), N.N. Zubov (1885-1960).

4 September 2014

08:00 Excursion and field experiments 5

Boat excursion to Lake Elovoe (water sampling and field work).

Laboratory work; processing of field data

21:30 Keynote

Alexander B. Tzetlin. Traditional fishery along the White Sea coast and recent state of the local recourses exploitation.

5 September 2014

08:00 Plenary Session 6

Vladimir M. Gorlenko, Alexander S. Savvichev. The role of light in depth distribution of phototropic organisms in planktonic and benthic communities in water reservoirs connected with the White Sea.

Maria A. Letarova, Andrey V. Letarov. Phage visualization. How to count phages in the natural source water.

Rainer Reuter. Ocean remote sensing using lasers (continued).

Martin A. Montes. A quick tutorial on optical remote sensing of aquatic systems based on passive systems (Part 2).

13:00 Poster session 2

Sergey Burikov, Kira Chevel, Tatiana A. Dolenko, Olga Gorshkova, Anastasia Kharcheva, Daria Khundzhua, Ivan Plastinin, Alexey Sabirov, Peter Borodin, Svetlana V. Patsaeva. Diagnostics of natural waters from various geographical locations using luminescence and Raman spectroscopy.

Habiba Bouakba, Martin Martin Montes-Hugo, Svetlana Patsaeva, Jean-Pierre Gagne. Spectrofluorometric examination of phytoplankton-derived organic detritus.

Marina Gladkova, Tatiana Poputnikova, Maria Pukalchik, Vera A. Terekhova, Dmitry N. Matorin, Anastasiia Kharcheva, Daria Khundzhua. Sensitivity of microalgae culture *Scenedesmus quadricauda* to model toxicant evaluated using different spectral characteristics.

Kirill Laptinskiy, Sergey Burikov, Tatiana A. Dolenko. Diagnostics of DNA nitrogenous bases using Raman scattering spectroscopy.

Daria Khundzhua, Anastasiia Kharcheva, Svetlana V. Patsaeva, Viktor I. Yuzhakov. Fluorescence quantum yield as a function of an excitation wavelength for CDOM in freshwater and brackish Karelian lakes.

Elena D. Krasnova, Tatiana A. Belevich, Dmitry A. Voronov, Dmitry N. Matorin, Daria Todorenko, Irina A. Milutina. Cryptophytic red layers in waterbodies separating from the White Sea.

Vera A. Terekhova, Marina Gladkova, Olga S. Yakimenko, Aleksandra Belik, Daria Khundzhua, Viktor I. Yuzhakov, Svetlana V. Patsaeva. Comparison of spectral properties of fungal melanins and natural humic substances in water.

15:00 Excursion and field experiments 6

Laboratory work; spectral measurements, data analysis

21:00 Workshop party

6 September 2014

08:00 Excursion and field experiments 7

Walking tour to Biofillters Bay

17:00 Concluding Sessions

Discussions and poster presentations by young researchers

Round table; **s**ummarizing the results of field work and laboratory analysis

Documentary films

1: Underwater White Sea.

2: The Eurasian Oystercatcher (*Haematopus ostralegus*)

7 September 2014

09:00 Departure day

Equipment and samples packing

Departure

ABSTRACTS

SEOS-EARSEL'S E-LEARNING TUTORIALS FOR SCIENCE EDUCATION

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SEOS is an initiative for using remote sensing in science education curricula in high schools funded under the 6th Framework Programme of the European Commission (EC). Eleven partners from several European countries, in cooperation with the European Space Agency (ESA) and teachers from European high schools, created e-learning tutorials for science students across Europe.

Based on real examples, the tutorials use remote sensing images and data to involve students in different aspects of current environmental research and monitoring. They cover a broad range of topics, from daily weather data to long-term climatic conditions, landcover changes, marine pollution and environmental hazards, ocean currents, coral reefs and coastal water quality, natural and cultural heritage and conservation, time series analysis, classification, and modelling, to name but a few. Connections between different topics are made clear, and links make it possible for users students to follow their own route through the tutorials according to their own interests. Teaching in high school is facilitated by Enquiry-based Learning, which is also supported by worksheets highlighting an interesting scenario in the environment followed by questions or tasks which can be solved when studying the web-based tutorials. Advanced information on a more complex level is available through links to supplementary pages, which is particularly relevant when used in physics and mathematics classes and at university.

A future initiative shall be related to subjects of actual concerns such as, e.g., energy production and use, and climate change in the context of remotely sensed information.

SPECTROFLUOROMETRIC EXAMINATION OF PHYTOPLANKTON-DERIVED ORGANIC DETRITUS

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Keywords: Spectrofluorometry, detritus, phytoplankton, bacteria

The aim of this study is to evaluate the use of spectrofluorometry for monitoring the production efficiency of organic detritus as derived from two phytoplankton species. A posteriori, this organic detritus is characterized in terms of inherent optical properties. Preliminary results show a minimum contribution of phytoplankton pigments to detritus spectra after disrupting cells using sonication and freeze-taw cycles. In general, organic detritus from *Thalasiossira pseudonana*, a diatom, and *Imantonia rotunda*, a haptophyte,

differed in terms of light absorption properties and within the green-red spectral range. We suggest spectrofluorometry as a tool for quick assessment of quality of detritus production.

DIAGNOSTICS OF NATURAL WATERS FROM VARIOUS GEOGRAPHICAL LOCATIONS USING LUMINESCENCE AND RAMAN SPECTROSCOPY

Burikov S.A.[1], Chevel K.A.[2], Dolenko T.A.[1], Gorshkova O.M.[2], Kharcheva A.V.[1], Khundzhua D.A.[1], Plastinin I.V.[1], Sabirov A.R.[3], Borodin P.A.[1], Patsaeva S.V.[1]

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Keywords: Raman spectroscopy, luminescence, natural water

Multiparametric characterization was performed for a large set of natural fresh and sea water samples using fluorescence, absorption and Raman scattering spectroscopy. The samples from the following sources were analyzed: the Baltic, Black, Dead, Mediterranean and White seas; the Indian Ocean (near Zanzibar and Sri Lanka); the rivers Don, Dnieper, Moscow, Mukhavets, Lena, Neva and Volga; the lakes Geneva, Onega and small bog lakes in the Karelian region. Fluorescence intensities describe content of dissolved organic matter naturally occurring in the water. The shift of emission maximum towards shorter wavelengths with variation of excitation wavelength in the UV range accompanied with fluorescence quantum yield characterize the nature of humic organic substances. Raman scattering spectra of water molecules analyzed with advanced mathematical algorithms provide rapid measurements of water temperature and salinity. The spectroscopic research on freshwater and marine samples from various geographical locations demonstrated good correlation of spectroscopic features with the origin of the sample.

SALT WATER INTRUSION IN THE TIDAL ESTUARY OF THE RIVER KEM

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Keywords: tidal mixing, salinity intrusion, estuarine circulation, highly stratified estuary, salt wedge, gradient-viscous flow regime

Recent work is devoted to the process of the salt water intrusion in the tidal estuary of Kem river, White sea basin. Mixing regime in estuaries and estuarine circulation are mainly determined by two factors: river freshwater inflow and the relative magnitude of tidal variations in water levels and currents. The estuary of river Kem is much influenced by the

semidiurnal tidal waves. Based on the calculations and the observation data the estuary of Kem can be classified as highly stratified, or salt-wedge, estuary with the stratification parameter higher than 1 (according to the Pritchard's classification). In the area of interaction of river and seawater within the estuary of Kem three zones can be clearly distinguished. The first sub-zone is an internal, or freshwater, zone where the degree of water mineralization varies insignificantly. The second sub-zone is an area of mixing, or transitional, zone with high horizontal and vertical salinity gradients. The third, or external, sub-zone is essentially marine area with insignificant influence of river inflow. Estimation of the salt wedge form and mixing length was based on the viscous theory approach, which is proved to give good results for the shallow waters of the coastal zone in a slightly mixed estuary. The approach is based on the assumption that for the tidal waves in the shallow waters the main terms in the momentum equation are the horizontal pressure gradient and the turbulent shear stress. That is so called gradient-viscous flow regime. The comparison of the measured and computed results shows good agreement for the river Kem. Salt wedge in the estuary of Kem is mobile with the noticeable moving of its frontal zone.

A BRIEF INTRODUCTION TO ARTIFICIAL NEURAL NETWORKS

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Keywords: artificial neural networks, adaptive methods of data analysis, multi-layer perceptron

Artificial neural networks (ANN) are a family of computational algorithms capable to solve a wide range of problems of prediction, classification (pattern recognition), estimation, clusterization, inverse problems, and other data analysis problems. ANN are a subset of the so-called data driven methods, that do not require an a priori model of the studied object (as conventional methods do), but build an adaptive model themselves, learning by examples. The report presents a brief introduction into the concept, structure, history of invention, kinds of architecture, and training algorithms of the most popular ANN paradigm - a multi-layer perceptron (MLP). The properties, advantages and disadvantages of MLP and ANN in general are outlined and discussed, as well as most common areas of their application, including application for analysis of scientific data. The presentation is illustrated by visual examples provided by special demonstration software.

ARTIFICIAL NEURAL NETWORKS AS A METHOD OF SOLVING INVERSE PROBLEMS IN LASER SPECTROSCOPY

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Keywords: artificial neural networks, inverse problems, laser spectroscopy

Nearly all experiments in modern science provide results of indirect measurements. This means that extracting the information interesting for the researcher from the measured one is a

separate task, an inverse problem (IP). Solving such problems is an inherent necessity in spectroscopy, where a scientist always encounters the demand of conversion of the measured spectral intensities into physically interesting values. The report discusses methodological aspects of the solution of IP with the help of artificial neural networks (ANN). Different formulations of IP from the point of view of data processing methods are given. Various methodological approaches to the solution of IP using ANN techniques, their characteristics, differences and areas of application are discussed. The considered approaches are called "experiment-based", "model-based", and "quasi-model". The differences of ANN from other methods of solution of IP and the key areas where their use is justified are discussed. Different approaches to simultaneous determination of parameters when solving multi-parameter IP are considered. The material is illustrated by examples of IP from the area of optical spectroscopy: simultaneous determination of temperature and salinity of seawater by Raman spectra, identification and determination of concentrations of inorganic salts in multi-component solutions and others.

DIAGNOSTICS OF AQUEOUS MEDIA BY METHOD OF LASER RAMAN SPECTROSCOPY USING ARTIFICIAL NEURAL NETWORKS

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Keywords: laser Raman spectroscopy, artificial neural networks

Different types of diagnostics of natural waters - determination of saline composition of natural and mineral waters, monitoring of technical and waste waters, determination of temperature and salinity of natural water - are very topical now. To solve these problems, express non-contact methods of diagnostics of nature waters are required, that can be implemented in real time. One of such methods is laser Raman spectroscopy. The report presents the results of elaboration of the methods for solving the named problems by Raman spectra of water media. To solve these multi-parametrical inverse problems and pattern recognition problems, artificial neural networks were used.

WINTER HYDROLOGICAL REGIME OF THE SEPARATING BASINS OF THE WHITE SEA (ACCORDING TO THE FIELD RESEARCH)

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Keywords: field research, winter regime, lakes, snow cover

Results of 2014 winter student's expedition explored the lakes separating from White Sea are analyzed. Hydrological, hydrochemical and hydrobiological features of these lakes with different absolute marks of water levels during the winter period were investigated. Three

groups of lakes differed in temperature and salinity distribution and chemical composition were sorted out. By means of special sensors temporal variability of water level of some lakes was studied. Detailed snow surveys data enabled to evaluate the total water equivalent in the basin of each lake. Data of field measurements of snow cover are compared to data of remote sensing.

SENSITIVITY OF MICROALGAE CULTURE *SCENEDESMUS QUADRICAUDA* TO MODEL TOXICANT EVALUATED USING DIFFERENT SPECTRAL CHARACTERISTICS

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Keywords: bioassay, test-functions, fluorescence, absorption, *Scenedesmus quadricauda*, model toxicant

The bioassay techniques are widely applied to solve the problems of environmental assessment and to define a class of waste hazard production and consumption. The culture of cenobial freshwater green algae *Scenedesmus quadricauda* is often used as a standard test-organism in biotesting. Spectral express-methods are the most interest for bioassay techniques because of their efficiency, speed and convenience. However, there is not enough information on the comparability of the test-functions obtained using different instruments and methods. This work is devoted to comparing different methods of registration of the toxic action of the model toxicant potassium dichromate on microalgae *S. quadricaudia.* Viability of algae was evaluated in the following ways: (1) the population growth rate of algal cells counted under the microscope, (2) the optical density of the cell suspension measured by IPT-02 instrument (Energolab, Russia), (3) fluorescence test-functions: Fo — rapid background fluorescence of dark-adapted cells and Y — the yield of the photochemical conversion measured by ToxyPam (Walz, Germany), (4) chlorophyll absorbance Dchl calculated from absorption spectra of algal suspensions registered by spectrophotometer Unico (USA) with the subtraction of background caused by light scattering, and (5) the integrated intensity of chlorophyll fluorescence F475 excited with a wavelength of 475 nm and registered using luminescence spectrometer CM2203 (Solar, Belarus). Using different spectral parameters it was determined that potassium dichromate in a concentration range of 1.5–2.5 mg/l exerted inhibitory effect on the growth of microalgae *S. quadricauda.* Fluorescence test-functions F_o and F_{475}, the quantum yield of the photochemical conversion Y and chlorophyll absorption Dchl agree well with each other and with high reliability correlated with direct cell counts.

Acknowledgements. This work is supported by the ISTC grant (project KR-2092) and the Program of the RAS Presidium “Zhivaya priroda”.

THE ROLE OF LIGHT IN DEPTH DISTRIBUTION OF PHOTOTROPIC ORGANISMS IN PLANKTONIC AND BENTHIC COMMUNITIES: WATER RESERVOIRS CONNECTED WITH THE WHITE SEA

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Keywords: Phototrophic microorganisms, plankton, benthos, light irradiation

Physical factors such as ice cover, light irradiation and temperature, as well as nutrients availability, are of great importance in polar aquatic environments. Phototrophic microorganisms contain various pigments, and are divided into three functional groups according to their photosynthetic apparatus: oxygenic phototrophs containing PS_I and PS_{II}, green bacteria containing chlorosomes and purple bacteria containing LH_1. Vertical distribution of species composition of microbial communities in the water reservoirs connected with the White Sea depends on irradiance levels and light spectrum penetrating through the water column. Shallow lake ecosystems contain two separate microbial communities: plankton in the water column and the benthos attached to bottom substrata. The responses to environmental variation differ greatly between the plankton and the benthos.

COMPLEX STUDY OF WATER STRATIFICATION IN KISLO-SLADKOYE LAKE

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Keywords: water stratification, spectral measurements, cryptophytae algae, *Rhodomonas*

Kislo-Sladkoye lake is a waterbody separated from the White sea. It is located 2 km away from the White Sea Biological Station on the Rugozerskaya bay in Kandalaksha bay. Lake dimensions are 196×147 m, average depth is 1–1.5 m, maximum depth is 4.5 m. The main influx of fresh water comes with melted snow and rains. Salt water inflow takes place during the sizygy at high tides through the rapid between the lake and the White Sea. The main interest is in huge diversity of species of microorganisms inhabiting different depths. The most intriguing for the researchers is the red water layer at the depth from 2.2 to 2.4 m. Investigation was held during the summer student workshop in August 2014. Water samples were taken from the surface to maximum depth of 4.5 m with the 0.5 m step. In the range between 2 and 3 m step was 0.1 m. Fluorescence and absorption, H_2S concentration were measured in vitro. Also all the samples were studied with the fluorescent microscopy. Microscopy studies showed a huge amount of cryptophytae algae (genus *Rhodomonas*). The layer distribution is: 0–1.9m — organisms are virtually absent, 2.0 m — appearance of cryptophyte algae (*Rhodomonas*) and green cocci, 2.1–2.5 m — huge amount of cryptophyte algae (*Rhodomonas*) and infusorians of different species, 2.6–3.5 m —decrease of cocci concentration. This stratification corresponds the hydrological structure of the Kislo-Sladkoye lake. The maximum of the *Rhodomonas* concentration is on the depth of about 2.2 m.

SPECTROSCOPIC STUDY OF GREEN SULFUR BACTERIA IN THE SEPARATING RESERVOIRS OF THE KANDALAKSHA GULF OF THE WHITE SEA

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Keywords: green sulfur bacteria, bacteriochlorophyll

Shores of the White Sea near the Kandalaksha Gulf rise at about 4 mm per year, resulting in some marine lagoon gradually transforming into lakes. Initial marine fauna and flora are gradually degrading and replacing by brackish or freshwater ones. Such separated lakes are interesting to explore stratified layers: water layers differ not only by temperature, salinity and other physico-chemical characteristics and optical properties, but also by microorganisms habituating there and by the quality of dissolved organic matter. Meromictic reservoirs in the Kandalaksha Gulf containing green sulfur bacteria are at different stages of their separation from the sea: lagoon on the Green Cape, lakes Kislo-Sladkoe, N.Ershovskoe, Elovoe and Trehtsvetnoe. The absorption spectra of natural water samples containing green sulfur bacteria were registered using a spectrophotometer Unico, fluorescence spectra — using spectrofluorimeter Solar CM2203. These data were compared with the physical and chemical characteristics of the water layer (temperature, salinity, pH, dissolved oxygen and sunlight intensity at certain depth). Identification of the main bands in the absorption and fluorescence spectra showed that the main photosynthetic organisms in the chemocline are green sulfur bacteria containing bacteriochlorophylls c, d, e. The maximum of the green sulfur bacteria concentration was achieved within the chemocline. Typical thickness of the layer with the highest concentration of microorganisms does not exceed 10–20 cm.

FLUORESCENCE QUANTUM YIELD AS A FUNCTION OF AN EXCITATION WAVELENGTH FOR CDOM IN FRESHWATER AND BRACKISH KARELIAN LAKES

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Keywords: CDOM, fluorescence quantum yield, separating basins, White Sea

Water basins separating from the White Sea are the unique natural objects with specific hydrological and physico-chemical conditions, characterized by the gradual turn of the marine into freshwater environment. Typically water in such lakes is brackish or fresh on surface due to rainfall, bog water and springs, while going down in few meters deep one observes salinity close to marine water. The objective of this work was to study fluorescence of chromophoric dissolved organic matter (CDOM) naturally occurring in the basins of the Karelian coast at different stages of isolation from the White Sea, and to compare it with that for small freshwater reservoirs in the same region and the Onego lake, the second largest lake in Europe. Fluorescence quantum yield and emission maximum wavelength were described as functions of excitation wavelength λ_{ex}. We found that humic-type CDOM fluorescence depends on water depth and salinity, and exhibit a continuous red-shift in emission maximum

with increasing excitation wavelength from 310 nm. So-called "blue shift" of fluorescence emission up to 20 nm with change in λ_{ex} from 270 to 310 nm was observed for all the samples. CDOM fluorescence quantum yield varied from 0.6% (surface water in summer-time) to almost 3% (the layer with maximum concentration of microorganisms). The behavior of the CDOM fluorescence quantum yield with excitation wavelength was found similar for different water basins and depths (increase from λ_{ex} =280 nm to a maximum at λ_{ex} ~370/380 nm and decrease monotonically thereafter). On the basis of spectroscopic findings we resume that CDOM in the studied lakes contains a substantial fraction of fulvic acids. Analysis of the spectral data obtained will help to characterize CDOM during aquatic ecosystems monitoring.

FEATURES OF FORMATION OF HYDROGEN SULPHIDE CONTAMINATION IN THE SEPARATING LAKES IN THE KANDALAKSHA BAY OF THE WHITE SEA

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Keywords: sulfate reduction, hydrogen sulfide, isolating lakes

On the Karelian coast of the White Sea after the last glacier retreats the part of the waterside zone rises rapidly. That's why some of the waters of the bays gradually lose their connection with the sea and turn into lakes. Unique hydrochemical and hydrobiological conditions are formed in these lakes. Therefore, the study of these reservoirs is interesting for studying biogeochemical processes which occurring in the reservoir during the transformation in the marine ecosystem. During the research expeditions which were started in March 2012, several water reservoir at different stages of separation from the sea and in the immediate vicinity of the N.A. Pertsov White Sea Biological Station of Lomonosov Moscow State University were examined. Development of hypoxia in stratified salt waters of these lakes creates favorable conditions for strengthening the process of sulfate reduction. Hydrogen sulfide appears after exhaustion of oxygen for the oxidation of organic compounds in water of these four study lakes (Kislo-Sladkoe, Trekhtsvetnoe, Nizhnee Ershovskoe, and the lagoon (lake) on the Zelenyi Cape). Its content in all cases increases in the direction from the surface to the bottom layer, where the highest concentrations H_2S were defined for each reservoir. While researching facts, it should be noted the stability in the vertical distribution and in the level of H_2S concentrations for anaerobic waters of the Lake Trekhtsvetnoe, which suggests it as a stacked meromictic lake. For the deep water of this lake the highest value of the content of hydrogen sulfide, stably exceeding in monimolimnione 200 mg l^{-1} (maximum 470–630 mg l^{-1}) is settled. Lake-lagoon on the Zelenyi Cape on the contrary, has not yet reached this status — fluctuations of the concentration of hydrogen sulfide in anoxic waters of this reservoir is still quite significant. There is a trend to a constant increase in the amount of H_2S in the bottom layers. Instability of anaerobic conditions is confirmed by the current (at the beginning of 2014) studies when the amount of H_2S in the bottom layer is 5 times higher than the facts which were obtained in winter 2013 (20.9 mg l^{-1}). In the bottom layer of the lake Kislo-Sladkoe concentration of hydrogen sulfide in the survey period were 4,8–6,5 mg l^{-1},that must be evidence of stabilization water reservoir after its "catastrophic washing" by the sea

waters in autumn 2011 (H_2S content in anaerobic waters was less than 30 mcg l^{-1}). The presence of seasonality in the distribution of H_2S — its concentration in September 2012 and October 2013 for this lake were significantly (for 20 times) higher than the values which has been obtained in the other seasons. Intensification of sulfate in this case is cause "volley" receipt labile organic matter in mass disappearing "summer productions". Concentration of hydrogen sulfide in the bottom of brackish water of the anaerobic layers in lakes explorations (2.5 m) — Nizhnee Ershovskoe, increased from 3.2 mg l^{-1} in March 2013 to 88.6 mg l^{-1} in January 2014. When it was taken during autumn 2013 was marked by its bright green color, which apparently as well as for the Lake Trekhtsvetnoe gives them a massive development of green sulfur bacteria. Saving the greenish color of the bottom waters in January 2014 in conjunction with a high level of hydrogen sulfide accumulation suggests the absence of seasonal mixing and speaks about the development of stable stratification in this reservoir.

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WONDERS OF THE LAKES SEPARATING FROM THE WHITE SEA. SALT LAKES SEPARATED FROM THE WHITE SEA: WHAT DO WE EXPLORE?

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Keywords: White Sea, sea bays separation, meromixis, redox zone, ecological sucsession

White Sea shore rises at about 4 mm per year, resulted in separation of some bays from the sea. The way from the initial marine to the final freshwater condition takes few centuries with the meromictic stage. The bottom layer contains sea salt, and the surface is freshened because of inflow from the catchment area. They do not mix due to the difference in density. These water bodies differ from the sea and freshwater lakes on hydrological features and ecological structure. In contrast to the sea, where the primary production appears by algal photosynthesis in the surface photic layer, in separated lakes in is provided mostly by anoxygenic phototrophic bacteria in deep maximum in the redox zone. Redox zone acts as biotope of specific ecological community consisted of bacteria, mycotrophic algae, protists and metazoans. This community we recognize by pronounced red or green color. As a result of isolation the salt lake becomes a kind bio-geo-chemical anomaly, and an analogue of an ancient ocean, which also consisted of anoxic and oxygenated layers. On the coastline of the White Sea there are many lakes at different stages of separation from the sea at the same time, so we can follow the patterns of change in ecological and hydrological system. Big team of researchers from various institutions, including oceanographers, hydrologists, biologists, microbiologists, sedimentologists, hydrochemists, physicists studying of optical and fluorescence properties of natural water explore the separated White Sea basins, every find some wonderful properties and surprises.

CRYPTOPHYTIC RED LAYERS IN WATERBODIES SEPARATING FROM THE WHITE SEA

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Keywords: White Sea, separating lagoons, cryptophytes, photoreactions efficiency

Colored water layers is an interesting phenomenon, observed in water bodies, separating from the White Sea. This work deals with red layer, which appears in some water bodies. The duration of its existence varies from one to five months. In all lagoons the red layer is always located in the salt layer (from 17.5‰ to 28.8‰, mean value 25‰ and standard deviation 4‰) with temperature usually close to +10°C. and located at the border of negative and positive redox values. Water from this layer has a little smell of hydrogen sulfide. Photosynthetic characteristics of phytoplankton inhabiting red water layers was studied with the use of a fluorometer with pulse amplitude modulation (Water-PAM, Walz, Germany) and Aqua-Pen (Photon Systems Instruments, Czech Republic) inductofluorometer. We recorded fluorescence intensity F_0, with open RC PSII, which, after calibration may be used for rapid estimation of the concentration of algal pigments. We estimated the maximum efficiency of photoreactions in photosystem II (PSII), which is equal to $F_V/F_M=(F_M–F_0)/F_M$, as well as parameters of the light intensity curves of fluorescence and the kinetics of light induction of fluorescence with a high time resolution. The content of chlorophyll, calculated from F_0 values in the surface water layer down to 1 m, was 5.6 g/l. The amount of algae and their photosynthetic activity, measured as Fv/Fm, were close to the values of these parameters in the open sea. These values of fluorescence in water samples increased with depth and attained the maximum values in the red layer. The content of chlorophyll a, as estimated from F_0, attained up to 281.3 pg/l in this layer. Photosynthetic activity was high, which is characteristic of algae during the period of an intense bloom. Accordingly, the probability of electron transfer from the primary to the secondary acceptor was markedly higher (Ψ_{ET2o}). The relative antenna size, parameter ABS/RC, was lower in phytoplankton from the red water layer due to a higher percentage of the active reaction centers of PSII. Light-dependence curves of fluorescence parameters indicated that phytoplankton from the red water layer was similar to a culture of algae grown in shaded conditions, which agrees with measurements of underwater irradiance (about 1% of PAR penetrates into this water layer). Large numbers of cells of red colored cryptophytic algae were found in the red layer. Ribosomal 18S rRNA gene shows 99% similarity with *Rhodomonas* sp. RCC2020 (GenBank – JN934672) from Beaufort Sea. These flagellates use phycoerithrine as photosynthetic pigment, allows them to photosynthesize at a depths, where only green range of the sunlight spectrum can penetrate. They are also able to mixotrophic nutrition, in addition to photosynthesis; they assimilate organic substances from water and can eat bacteria. It their turn, these flagellates may be used as food by larger organisms — infusorians, rotifers, and crustaceans. The red water layer seems to be a whole ecosystem near the

boundary of hydrogen sulfide layer, based on production of photoautotrophic organisms, which is associated with chemocline with its stable abiotic conditions.

DIAGNOSTICS OF DNA NITROGENOUS BASES USING RAMAN SCATTERING SPECTROSCOPY

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Keywords: DNA, nucleotide concentrations, Raman scattering spectroscopy

The urgency of diagnostics of content and state of DNA molecules in water is connected with the importance of study of biogeochemical processes in natural waters, vital functions of microorganisms, role of viruses in aqueous systems. The results of research of aqueous solutions of Lambda-DNA extracted from phage-lambda (this is the bacteriophage, which infects Escherichia coli) and of DNA chains extracted from salmon fish, using the Raman spectroscopy methods, are presented in this work. The method of identification of each DNA nitrogenous base by its spectral marker was elaborated by means of R-presentation. As the result of analysis of the dependence of Raman intensity of nucleotides spectral markers on their concentration, the method of determination of each nucleotide concentration was created. This method provides measurement of individual nucleotide concentrations with the average accuracy of 0.05 g/l.

REMOTE DETERMINATION OF SALINE COMPOSITION OF MINERAL WATERS USING RAMAN SPECTROSCOPY

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Keywords: Raman spectroscopy, remote sensing, mineral water

It is very important to be able to determine the saline composition of mineral waters (natural source waters with heightened mineralization of some ion, for example) and to control technical water and sewerage (salts of heavy metals, nitrates, nitrites, sulphates, sulfides etc. often exceed critical values of concentration). In order to solve these problems, express non-contact methods of diagnostics of natural waters, which can be implemented in real time, are required. High sensitivity of characteristics of Raman spectral bands to types and concentrations of substances dissolved in water allow using laser Raman spectroscopy for water media diagnostics.

This report presents results of determination of type and concentration of dissolved ions by Raman spectroscopy methods. Presence of complex anions or cations in water (for example NH_4^+, CO_3^{2-}, NO_3^-, PO_3^{2-}, SO_4^{2-}) is determined and their concentrations are measured using their proper Raman bands near 300–2000 cm^{-1}. Presence of such ions as Na^+, K^+, Rb^+, Ca^{2+}, Cu^{2+}, Cl^-, I^-, Br^- etc. is determined by their influence on position and shape of water Raman valence band (near 2700-4000 cm^{-1}). That means that using both high- and low-frequency regions of Raman spectra of water solutions (from 300 up to 4000 cm^{-1}) gives us the possibility of complete characterization of salt composition of mineral waters. Artificial neural networks provide a solution of this multi- parametrical inverse problem of laser Raman spectroscopy. It is demonstrated by the authors that the suggested method allows one to determine concentration of complex cations and anions with accuracy 10^{-4}–10^{-5}. The method was tested on natural mineral waters.

PHAGE VISUALIZATION. HOW TO COUNT PHAGES IN THE NATURAL SOURCE WATER

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Keywords: phage, bacteriophage, phage count, water ecosystem

Bacteriophages are viruses of microorganisms and they exist in every water ecosystems where bacterium lives appear. It is difficult to overestimate the bacteriophages role — they take part in lateral gene transfer, indicate specific groups of microorganisms, and control the strength of bacterium. And sometimes is impotent to understand is there any phage particles, how many virus particles per milliliter and what kind of viruses contains in the water ecosystem. There are many methods exist to solve of this categories of problems, but each of then requires non-trivial sample preparation and hence, gives big mistake. We will speak in general about filamentous phages and observe methods of phage visualization in application to problem for what is this visualization need.

DISTRIBUTION OF HYDROGEN SULFIDE IN THE LAKE TREKHTSVETNOE AND THE LAGOON (LAKE) ON THE ZELENYI CAPE

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Keywords: sulfate reduction, hydrogen sulfide, isolating lakes

The explorations of lakes which separate from the White Sea in the Kandalaksha Bay have been conducted since March 2012 to September 2013 on the basis of the N.A. Pertsov White Sea Biological Station of Lomonosov Moscow State University. In autumn in 2011 the

lakes have got sea water due to the strong surge. There are facts about two lakes, the lake Trekhtsvetnoe in the Pekkelinskaya Bay (maximum depth 7.5 m) and a lagoon on the Zelenyi Cape (maximum depth 6.5 m). The lake Trekhtsvetnoe has a distinct stratification for depth in all seasons, freshened top layer thickness of 1 m and a sharp increase in salinity to ~15 ‰ on 2 m. Then salinity increases smoothly to 23 ‰ at the bottom. Temperature changes depending on the season only in the upper layers in the lake, while the bottom layer remains constant between 4.8–6.0°C. The hydrogen sulfide content increases from the surface to the bottom where it reaches maximum concentration (250 mg/l in October 2012 and 470 mg/l in September 2013). There are meromictic signs in the lake. The lagoon (lake) on the Zelenyi Cape maintains a connection with the sea through a small threshold through the water is exchanged. There are seasonal variations in temperature. The lake water is salted throughout on the depth. Salinity changes in the upper layer, the maximum salinity of 28 ‰ in March 2012 and the minimum 12 ‰ in March 2013. Salinity remains at the bottom about 29 ‰. The hydrogen sulfide in the lake is defined in the bottom layers. The maximum content of H_2S was observed in September 2013 (117 mg/l) in the bottom layer. During the summer, the amount of hydrogen sulfide increased to 77 mg/l in June and 117 mg/l in September 2013. These waters have different amount of hydrogen sulfide content, because of different stages of isolation from the sea. The lake Trekhtsvetnoe has lost its connection with the sea and that's why it has more stable stratified structure. The lake on the Zelenyi Cape still retains this connection. The hydrochemical parameters in it are unstable and can change with the arrival of fresh portions of seawater. High concentrations of hydrogen sulfide is settled in the bottom layers in the both lakes.

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SUMMER STUDENT WORK AT THE WHITE SEA BIOLOGICAL STATION DEVOTED TO STUDY OF MEROMICTIC WATER BASINS

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Keywords: bacteriochlorophyll, meromictic water basins

In the research practice of students of Lomonosov Moscow State University great attention is paid to interdisciplinary research. Summer practice of students of Faculty of Physics was performed at the White Sea Biological Station belonging to the Faculty of Biology of Moscow State University and was devoted to the study of physico-chemical and spectral-optical characteristics of natural water with habituating photosynthetic microorganisms. In environmental studies spectral techniques play an important role because

of high sensitivity, rapidity and ability to use them in non-contact or remote mode to examine living organisms in vivo or in situ. During the summer field practice performed in July–August 2013 spectral methods were used to estimate the concentration of photosynthetic microorganisms at different depths in the water bodies separating from the White Sea, and these spectroscopic data were compared with the depth profiles of temperature, salinity, pH, and dissolved oxygen concentration. In several water reservoirs located close to the White Sea Biological Station of Moscow State University a submersible pump was used to get water samples from different depth from the surface to the maximum depth with an increment of 0.5 m. Absorption and fluorescence spectra of water were measured in laboratory using Unico 2804 spectrophotometer and fluorescence spectrometer Solar CM2203. In the absorption spectra of water samples we found the bands of light absorption by typical pigments of photosynthetic microorganisms; fluorescence emission spectra manifested bands of chlorophyll a and bacteriochlorophylls *c*, *d*, *e*. Depth distribution profiles of algae and sulphur bacteria calculated from absorption and fluorescence spectra were compared with profiles of temperature, salinity, pH, dissolved oxygen concentration.

INVESTIGATION OF SEPARATING SEA BAYS: AN INTEGRATED APPROACH (BATHYMETRY, STRUCTURE OF THE WATER COLUMN, BENTHIC COMMUNITIES, ECOLOGY OF INDICATOR BENTHIC AND TERRESTRIAL SPECIES) ON THE MODEL KISLO-SLADKOYE AND LOWER ERSHOVSKOYE LAKES

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Keywords: Kislo-Sladkoye, Lower Ershovskoye, separating water bodies, meromictic lakes, benthos, marine ecology, bathymetry, hydrology, spectrophotometry, *Ophioglossum*

In August 2014 a group of students from Biophysics Department, Faculty of Physics, Lomonosov Moscow State University, conducted comprehensive study of lakes separating from the White Sea during field practice on White Sea Biological Station of Moscow State University. Kislo-Sladkoye lake and Lower Ershovskoye lake estuary were taken as model objects. The aim was to study the bathymetry, hydrological characteristics, absorption spectra of at different depths, benthic communities, and ecological features of macrobenthic and terrestrial organisms. Kislo-Sladkoye lake is in 196 m length, 147 m in width and has the area of 16100 m^2. The maximum depth is 4.2 m. The Sonar study of the lake bottom showed that the depth of 0.5 m reaches 38% (6000 m^2) of the lake area, 0,5–1m — 19%, 2.1 m — 18%, 2–3 m — 12%, 3–4 m — 12% and 3% of the area is taken by depths of more than 4 m. Based on the vertical profiles of light, temperature, salinity, redox potential, pH and oxygen content in the lake allocated 5 areas: (1) 0–0 5m — wind mixing zone; (2) 0.5–1.5 m — halocline; (3) at the bottom of the halocline at a depth of 1–1.5 m an area with a high oxygen content is located; (4) 1.5–3.0 m - thermocline; (5) from 2.5 m to the bottom — hydrogen sulfide unlit

area. In the colored layers spectrophotometry detected following pigments: chlorophyll a, chlorophyll b, and bacteriochlorophyll, bacteriochlorophyll c or g, and phycoerythrin. Therefore the presence of cryptophytae algae (genus *Rhodomonas*), blue-green algae and green sulfur bacteria is shown. The distribution of the layers: 0–1.7m — organisms are virtually absent; 1.7–2.2m — cyanobacteria; 2,2–2,4 m — light absorption peaks corresponding to phycoerythrin and chlorophyll *a* and *b* appear, a large number of cryptophytae algal (genus *Rhodomonas*); 2.4–2.7 m — concentration of pigments decline, a small amount of green cocci and cryptophytae algae; 2.7–4m — green sulfur bacteria. 15 taxa of macrobenthic organisms were found in the lake, including the first note on the beetle Enochrus halophilus, both adults and larvae, for the Russian seas. Marine organisms (*Mydius edulis, Semibalanus balanoides, Littorina saxatilis*) distribution boundaries are determined. Those are limited to the zone of contact with sea water. Brackish water species (*Chironomus salinarius, Hydrobia ulvae, Enochrus halophilus*) were found around the lake excluding the rapid. An increased diversity of species is observed in the muddy shallows. The most popular species are *Hydrobia ulvae* and *Chironomus salinarius*, which are most commonly found at depths of 0.5 and 1 m. Number of organisms ranges from 0 to 11767 per 1 m^2; average — 240 ind/m^2. Biomass varies from 0.59 g/m^2 to 202.62 g/m^2; the average biomass is 44.98 g/m^2. The largest number is noted at a depth of 0.5 m, the lowest is at 4 m. Biomass is the largest at a depth of 1 m, the lowest at 3–4 m. In Lower Ershovsky lake estuary species composition of the benthos is observed. 22 marine, brackish and freshwater species were found. The species adapted to marine and freshwaters distribution boundaries were defined. The groups of organisms, successive over the creek were allocated. Also we conducted experimental studies of 8 benthic species survival under different salinity and temperature. The optimal conditions for the survival of these species in the laboratory were determined. *Ophioglossum vulgatum* L., a potential indicator of separating reservoirs, growth conditions under Kindo peninsula and adjacent areas were specified. Three new settlement spots were found.

CHLOROPHYLL DISTRIBUTION VISUALIZATION BASED ON DIGITAL PICTURES OF PLANTS

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Keywords: chlorophyll

The tasks of ecological monitoring demand robust and simple techniques of environmental characteristics quantification. For vegetation diagnostics the concentration and distribution of major photosynthetic pigments in plants is one of the main characteristics. Method of visualization of chlorophyll in plants we present in this work is based on the registration of the green light reflected from the plant tissue and includes the computer analysis of photographic or scanned digital image. The algorithm of chlorophyll visualization requires special software and consists of several steps:

1) preparation and analysis of control samples for calibration purposes:

• photographing of the sample plant tissues and storage of digital RGB images;

- determining the concentration of pigments in the ethanol or acetone extractions prepared from the same samples by standard methods using a laboratory spectrophotometer;
- calculating the calibration curve for a particular type of plant;

2) photographing the samples of interest;
3) computer image processing;
4) data analysis;
5) creating a database of all the samples studied.

The program has been tested for the first time in the analysis of fungal diseases of maple leaves (*Acer platanoides* L.) during autumn senescence and degradation of chlorophyll in leaves of different color. To confirm the successful implementation of the method we investigated same series of samples using standard optical methods (absorption spectrometry, reflection, fluorescence). Data obtained by different methods are in a good agreement, which confirms the correct operation of the program. Proposed method makes possible fast and noninvasive determination of concentration of major plant pigments, which allows diagnostics and identification of sick leaves, fruits and plants in general.

A QUICK TUTORIAL ON OPTICAL REMOTE SENSING OF AQUATIC SYSTEMS BASED ON PASSIVE SYSTEMS

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Keywords: remote sensing, inherent optical properties, biogeochemistry, passive optical sensors

Important ecological processes and biogeochemical cycles in aquatic systems can be studied based on hydrological optics and remote sensing techniques. The proposed tutorial includes 3 sessions and is expected to provide basic training in applying optical remote sensing methods for studying aquatic environments. The first session will be devoted to teach fundamental concepts related to the radiation transfer theory, inherent and apparent optical properties, and light propagation models including forward and backward techniques. During the second session, the student will learn how to use optical instruments for developing and validating in-water biogeo-optical algorithms in optically-shallow or deep waters. Lastly, a third session will provide the basic knowledge for processing satellite images and implementing radiance-based remote sensing models for estimating biogeo-chemical properties of different water bodies. Field work will include time series and spatial surveys of optical properties in the White Sea. A portable radiometer in the visible-NIR spectral range will be provided by the instructor during each experiment.

HYDROLOGICAL SYSTEM OF THE WHITE SEA

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Keywords: White Sea, Hydrological system

The talk contains a description of the new model of the structural organization of the White Sea as a hierarchic estuary system. The description is preceded by a characterization of the main factors forming the sea regime and a description of the classical conception of the hydrological regime of the White Sea.

THREE ADMIRALS: INTERLACING FATES. S.O. MAKAROV (1849–1904), A.V. KOLCHAK (1874–1920), N.N. ZUBOV (1885–1960)

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Keywords: Polar research, Navy, Russian admirals

Stepan Osipovich Makarov (1849–1904) was a Russian vice-admiral, a highly accomplished and decorated commander of the Imperial Russian Navy, an oceanographer, awarded by the Russian Academy of Sciences, and an author of several books. He was born in Nikolaev. In 1863, he joined the Imperial Russian Navy where he served as a cadet aboard a clipper of the Russian Pacific Fleet. In 1866 he took part in the voyage of the corvette "Askold" from Vladivostok to Kronstadt via the Cape of Good Hope. In 1870, Makarov invented a design for a collision mat, to seal holes in a ship's hull. He was one of the first to adopt the idea of using flotillas of torpedo boats and had combat experience as a torpedo boats commander. Over the next two decades, Makarov specialized in naval research, publishing over fifty papers on oceanography and naval tactics. In 1886–1989 Makarov directed a round-the-world oceanographic expedition. He became a vice admiral in 1896, and began to concentrate on the design for new warships, especially icebreakers needed to establish a northern sea route between Europe and East Asia. He proposed the world's first icebreaker, the "Yermak", and commanded the ship on an Arctic expedition to survey the coasts of Novaya Zemlya and Franz Josef Land. Alexander Vasilyevich Kolchak (1874–1920) was a polar explorer and commander in the Imperial Russian Navy, who fought in the Russo-Japanese War and the First World War. Kolchak was a son of a naval artillery officer and graduated from the Naval College (1894). During the Russian-Japanese War of 1904–1905 he commanded a destroyer and a battery in Port Arthur. He participated as a hydrologist in polar expeditions in 1900–1903 and 1908–1911. He took part in World War I (1914–1918) as chief of the operations department of the Baltic Fleet, commander of a mine division, and, from July 1916, commander of the Black Sea Fleet. After the February Revolution of 1917 he took a sharply counterrevolutionary position and, under pressure from the masses of seamen, he was recalled to Petrograd by the Provisional Government. During the Russian Civil War, he

established a reactionary government in Siberia and was recognised as the "Supreme Ruler and Commander-in-Chief of All Russian Land and Sea Forces" by the other leaders of the White movement (1918–1920). He tried to defeat Bolshevism by ruling as a dictator but his government proved weak and confused. For example, he lost track of the imperial gold reserves and much of it disappeared. As his White forces fell apart, he was captured by independents who handed him to the Bolsheviks, who executed him. Nikolai Nikolaevich Zubov (1885–1960) was a naval officer, hydrographer, oceanologist, Arctic explorer. He participated in the Russian-Japanese War and the Battle of Tsushima in 1905. In 1932, he headed the expedition on sailing-motor boat "Nikolai Knipovich" and for the first time in the history of Arctic navigation rounded from the north the Franz Josef Land archipelago. In 1935 he led the scientific part of the first Soviet high-altitude expedition on the icebreaker "Sadko". Nikolai Zubov made the great contribution to the development of the native oceanography: he was among the first to put forward and develop the problem of ice forecasting in the Arctic seas, he also founded the Department of Oceanology in Moscow Hydrometeorological Institute and Moscow State University. Gulf in Antarctica, cape of the Novaya Zemlya archipelago and two research ships: "Nikolay Zubov" and "Professor Zubov" were named in his honor.

OPTICAL PROPERTIES OF HUMIC SUBSTANCES AND AQUATIC DISSOLVED ORGANIC MATTER

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Keywords: fluorescence, absorption spectroscopy, CDOM, humic substances

Humic substances (HS) of natural terrestrial and water sources are thought to be among main environmental protectors on our planet. HS provide many ecosystem functions by binding and inactivating the pesticides, herbicides, heavy metals, polycyclic hydrocarbons and other pollutants. Because of their high absorbance of the ultraviolet light they protect aquatic organisms from damaging UV radiation. Aquatic chromophoric dissolved organic matter (CDOM) absorbs UV and visible light and is a major determinant of optical properties for both fresh and marine waters, directly affecting the spectral quality of the underwater light field. The CDOM is present in all types of natural water in concentration varying from 0.5 to 50 mg/l, and represents a significant reservoir of organic carbon on Earth, which exceeds the reserves of organic substances of all living organisms. Its photo-reactivity plays a significant role in the biogeochemistry of natural waters through the formation of biologically available compounds affecting the growth of aquatic organisms and reactive oxygen species influencing the bioavailability of trace metals and nutrients.

The CDOM fluorescence spectra are applied in aquatic ecosystems monitoring. Fluorescence spectra of various HS, including commercially available preparations and aquatic CDOM, may vary in wavelengths of emission maximum, fluorescence quantum yields and their dependence upon excitation wavelength. HS and CDOM have been investigated for decades; however, their molecular-level composition and sources are still under debates. By this reason it is very difficult to describe the exact mechanisms of HS fluorescence and identify certain fluorophores. To date, there are two basic models explaining

the nature of the humic substances fluorescence: superposition model describing broad spectrum as an additive sum of independently emitting fluorophores and a model involving energy transfer. We discuss absorption and fluorescence spectra for HS and CDOM of various origin, their similarity and differences for the samples from various sources, and the models describing experimental spectroscopic data.

OCEAN REMOTE SENSING USING LASERS

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Keywords: laser spectroscopy

Methods of airborne laser remote sensing (lidar) of hydrographic parameters are presented with a focus on several goals: bottom depth measurements and detection of submerged objects; measuring seawater turbidity, dissolved coloured substances and suspended particles; quantifying phytoplankton biomass; depth profiling of temperature and salinity. Each subject is presented starting with the basic physical principles, the relevance in specific applications is outlined, and typical results are illustrated with sample data demonstrating the potential and limitations of laser remote sensing.

THE ROLE OF THE OCEANS IN CLIMATE CHANGE

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Keywords: Climate change

The relevance of the oceans for the dynamics of climate change during the last century is discussed with a focus on the following questions: atmospheric temperatures increase, but is there much evidence for ocean warming? If so, how much excess heat is absorbed by the oceans compared with atmosphere and land surface? Land vegetation exceeds biomass in the oceans, but play the oceans a minor role in atmospheric carbon dioxide capture and storage? How much regenerative energy is produced today in coastal waters and where are the limits? In which way is remote sensing useful to deal with these questions?

COMPARISON OF SPECTRAL PROPERTIES OF FUNGAL MELANINS AND NATURAL HUMIC SUBSTANCES IN WATER

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Keywords: fluorescence, absorption spectra, fungal melanins, humic substances

Melanins play important role in physiological and ecological functions of fungi. Their most commonly significance is linked with increased virulence of melanized forms, their contribution to the survival and reproduction of fungi in adverse environmental conditions, high ability of dark-pigmented fungal mycelium to the accumulation of toxicants. Fungal melanins (FM) are amorphous polymers, which detailed structure is poorly understood. Dark-pigmented fungi and especially soil melanized micromycetes are essential in hypotheses of humification of organic matter in natural environment. The similarity of humic substances (HS) and melanins on several chemical and physical properties stimulated discussion about their mutual transformation. Our work is aimed to compare spectral properties of aqueous solutions of fungal melanins and humic substances using fluorescence and absorption spectroscopy. Fungal mycelium of melanized culture *Cladosporium cladosporioides* was grown for 14 days in liquid Czapek medium under stationary conditions in the darkness. Biomass accumulation and spectral properties of melanin synthesized by *C. cladosporioides* were different for the cultures grown in the medium without additives and with the addition of HS and nanodiamond particles. The FM was extracted from the fungi mycelium by alkaline hydrolysis followed by precipitation with concentrated HCl and represented dark-colored powder. For spectral measurements FM preparations were diluted in water. Fluorescence spectra were recorded with a luminescence spectrometer Solar CM2203. Electronic absorption spectra were measured by spectrophotometer. Both HS and FM in water highly absorb UV light and absorbencies in the visible spectral range decrease along with rising wavelength. Absorption spectra for HS typically show monotonic decrease of absorbance values towards longer wavelengths, except of spectra of HS originating from peat and lignosulphonate. This is due to various sorts of chemical conformations and numerous molecular fragments found in the structure of HS. In contrast to featureless HS spectra, in the absorption spectra of the FM samples the peaks at 260, 280 and 350–420 nm were found. Fluorescence emission spectra excited by the UV light for both HS and FM are very broad. For HS the maximum of the emission band typically is located within 420–460 nm depending on the origin of the sample and excitation wavelength (so-called “blue shift” of fluorescence emission upon changing excitation). The biggest “blue shift” effect usually appears under excitation at 310 nm demonstrating the shortest emission wavelength for fluorescence spectrum within range of excitation from 270 nm to 400 nm and more. For the FM solutions there are two broad overlapping bands with maxima at 415 and 505 nm, the intensity ratio of those bands depends on the sample. The first band the most clearly is observed upon excitation at 310 nm. This is an apparent manifestation of the two types of fluorophores with different excitation/emission wavelengths. We resume that absorption and fluorescence spectra of FM in contrast to the spectra of HS have more features and individual peaks.

Despite the great variety of chemical structures there are analogous molecular fragments in the melanins of fungal cultures grown in different conditions.

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APPLICATION OF FLUORESCENCE METHODS TO PROBE PHYSIOLOGICAL STATE OF MICROALGAE

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Keywords: chlorophyll fluorescence, phytoplankton, ecology

Fluorescence methods are widely used approach to probe physiological state of photosynthetic organisms in vivo and in situ under different conditions. Due to emission of fluorescence quanta, chlorophyll of the photosynthetic organisms may act as a natural indicator of photosynthetic activity. In the resent time a large number instruments are based on recording and analysis of chlorophyll fluorescence emissions from photosynthetic organisms have been designed. Such instruments allow analyzing photosynthetic organisms under various environmental conditions. There are different principles of measure chlorophyll fluorescence applied in instruments such as pulse-amplitude-modulated (PAM) excitation and a strong continuous actinic excitation. Measurement chlorophyll fluorescence intensity under the photosynthesis saturating illumination (F_M) and under conditions inducing no changes in the state of the photosynthetic apparatus (F_0) (low light intensity) makes possible to determine the maximum efficiency of the PSII processes, which is equal to $(F_M–F_0)/F_M=F_V/F_M$. The F_V/F_M parameter presents a dimensionless energetic characteristic of photosynthesis, similar to the coefficient of efficiency and independent of the species specific features of organisms. Accordingly, many fluorescence parameters extracted from the recorded fluorescence rise may be used as indicators of photosynthetic organism state to different stress. In the resent time a newly instrument $(Multi)^{-2}$ was designed to gain a comprehensive picture of primary photosynthetic events. This instrument allows to measure simultaneously light-induced kinetics of prompt and delayed fluorescence, as well as light-induced absorbance changes of the P700 of PSI at 820 nm (redox transitions of P700). In our investigations we used fluorescence methods to study the effect of copper and silver nanoparticles on primary photosynthetic process in green microalgae. Moreover these methods were applied for investigation phytoplankton of basins separating from the White Sea.

REMOTE DETERMINATION OF TEMPERATURE AND SALINITY OF NATURAL WATERS OF WHITE SEA AREA BY RAMAN SPECTRA USING ARTIFICIAL NEURAL NETWORKS

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Keywords: laser Raman spectroscopy, artificial neural network

Necessity of global monitoring of salinity and temperature arises from tendency observed during recent years — decrease of icecap in polar latitudes because of global warming. Melting of ice leads to desalination of the surface layer of ocean. This can give impulse to reconstruction of system of oceanic currents and it can be the reason of considerable climate changes not only in polar areas but in planetary scale. In previous research, a method of simultaneous determination of temperature and salinity of seawater by Raman spectra was suggested and elaborated [1-3]. To solve this multi-parametrical inverse problem and pattern recognition problem, modern methods — artificial neural networks (ANN) — were used. Approbation of the presented method was carried out on natural waters of White Sea area from seven meromictic lakes: Kislo-sladkoye, Lower and Upper Ershovsky, lake in the Cape Verde, Vodoprovodnoye, Verkhneye and Tryokhtsvetnoye. Accuracy of determination of natural waters parameters is 0.1°C for temperature and 0.2 p.s.u. for salinity. Thus, approbation on the natural waters of White Sea area fully demonstrated the efficiency of this method and once again demonstrated high resistance of ANN to noise.

1. Bekkiev, A., T. Gogolinskaya (Dolenko), V. Fadeev. Simultaneous determination of temperature and salinity of seawater by the method of laser Raman spectroscopy // Soviet Physics Doklady, 1983, v.271 (4), pp. 849–853.

2. Burikov, S.A., I.V. Churina, S.A. Dolenko, T.A. Dolenko, V.V. Fadeev. New approaches to determination of temperature and salinity of seawater by laser Raman spectroscopy // EARSeL Workshope “Remote sensing of the coastal zone”, 5-7 June 2003, Ghent, Belgium, Abstract book, p.5. EARSeL eProceedings 3, 2004, #3, pp.298–305.

3. Dolenko, S.A., S.A. Burikov, T.A. Dolenko, I.G. Persiantsev, A.R. Sabirov, V.V. Fadeev. Neural network solution of the inverse problem of laser spectroscopy for remote determination of the temperature and salinity of natural waters, taking into account the influence of dissolved organic matter // Informatsionnye tekhnologii, 2013, #1, pp.60–64.

ICE FORMATION CREATES WATER STRATIFICATION: EXPERIMENTAL VERIFICATION

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Keywords: stratification of water, separating sea lagoons, salinity, ice formation

One of the possible factors that determine the stratification of water of separating sea lagoons is ice formation. When seawater is freezing the salt from it remains in solution that

fills the pores in ice. The aim of this research is to proof experimentally if ice formation can cause stratification and if so, how sustainable it is. Water from the White Sea was frozen in plastic bottles of 1.5 to 2 litres, and then slowly thawed. Water was sampled with a long pipette dropwise starting from the surface at every five centimeters. Salinity was measured with a refractometer. The hypothesis that the water stratification can result from the formation of ice is proved. In all bottles a desalted upper layer with salinity between 3 and 15 ‰ (average 7 ‰) was formed, most of the samples had salinity 3-5 ‰. At the lower edge of the ice we observed a salinity change at 6 - 14 %. And at the bottom a very thin layer with salinity 40-50 % was created, which salinity is higher than marine. After a day in the same bottles the measurement were repeated. It turned out that the stratification remained the same. In real meromictic lakes salinity of the freezing layer is usually lower than in the sea. The following experiments were made with seawater with different dilutions: 27%, 24%, 20%, 15%, 10%, 6% and1%. The stratification appeared in every bottle no matter how salty was the water. One of the observed effects was unexpected. The lens of concentrated brine at the bottom has probably the same origin as brinicles discovered in late 2011 in the Antarctic. The supercooled salty water from the cavities in the ice breaks out and without mixing with sea water because of differences in their density sinks to the bottom.

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