WORKSHOP ON “DEVELOPING SMART AND GREEN PORTS”

Center for Research, Innovations and Entrepreneurship at the Faculty of Maritime studies

Prof. dr Danilo Nikolić

University of Montenegro, Faculty of maritime studies

27.04.2023 Kotor, Montenegro

”PrOmoting Resilient, Sustainable, and Smart Transport and logistic activities in the South Adriatic Area - PORTS PLUS/No. 552/SMALL/CAPITALIZATION restricted procedure”

Interreg - IPA CBC Italy - Albania - Montenegro

EUROPEAN UNION

ISTITUTO TECNICO SUPERIORE per la LOGISTICA

Programma Sviluppo lavoro • formazione • welfare

UCG Univerzitet Crne Gore

INSTITUTI TRANSPORTIT

Center for Research, Innovation and Entrepreneurship @UoM/PFK

Activities within Center:

- **Research and Innovation;**
- **Project activities;**
- **Provider of Life Long Learning;**
- **Supporting student start ups;**
- **Supporting activities between academia and industry, etc.**

Labs/equipment:

- **SMART BAY Lab;**
- **Marine fuels laboratory;**
- **3D Lab;**
- **Underwater ship archeology, etc**

Personnel:

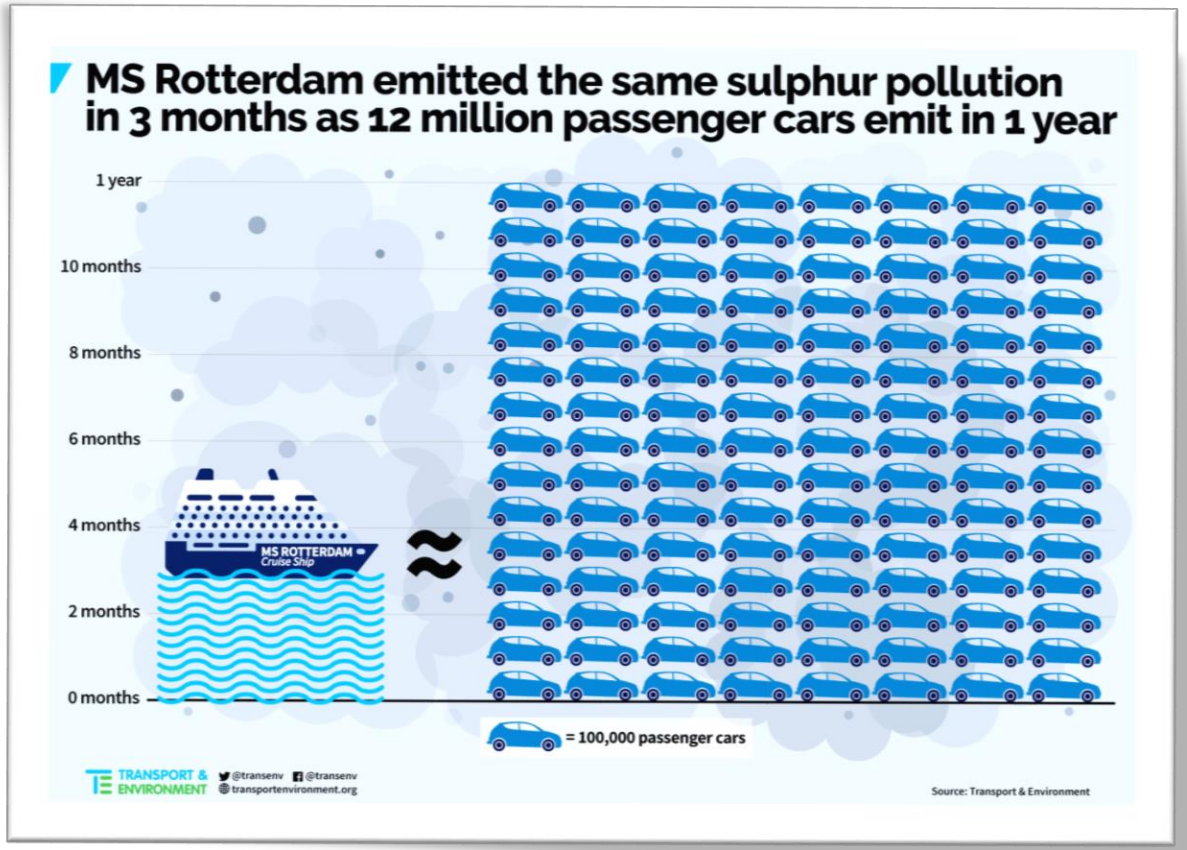
- **Prof. dr Danilo Nikolić, coordinator**
- **MSc Radmila Gagić**
- **PhD Maja Škurić**
- **MSc Darko Kovačević**

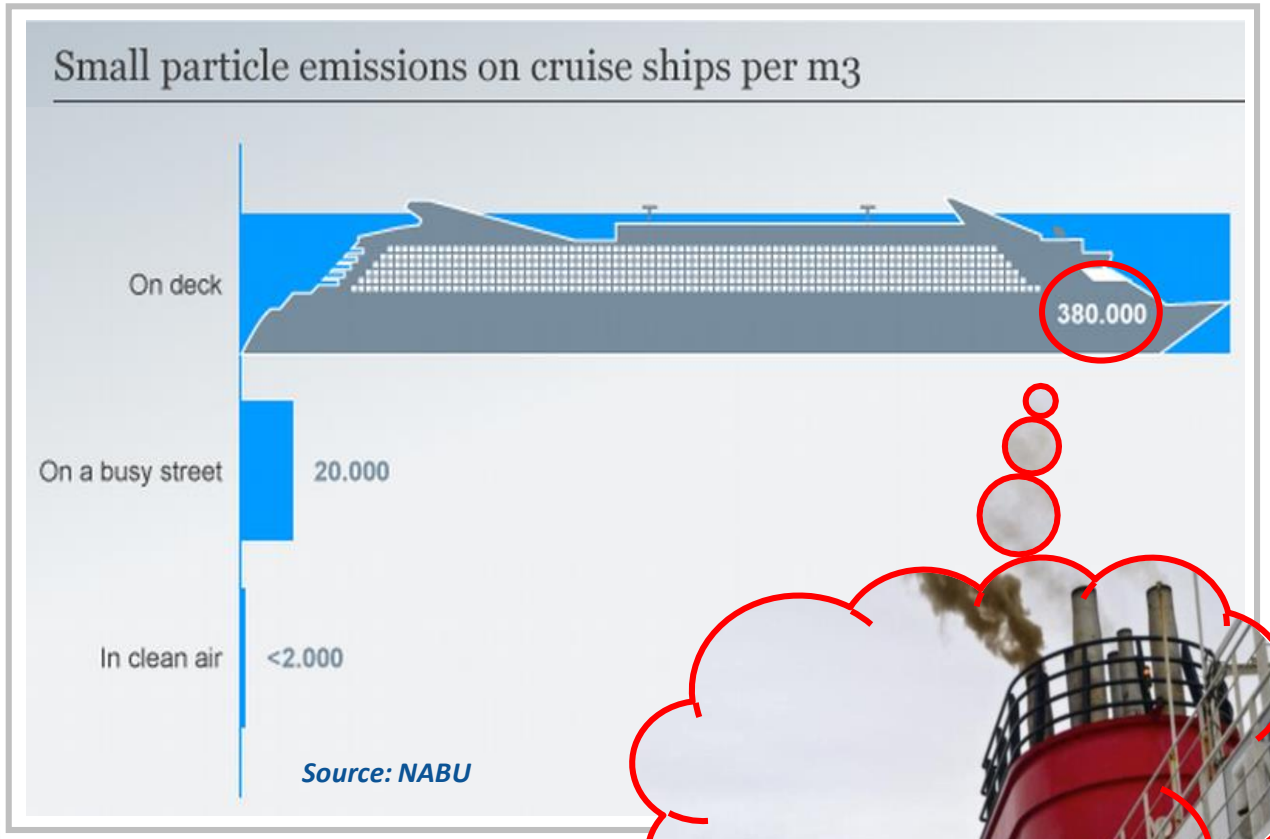
Managing International Projects

PROGRAM	PROJECT TITLE	ROLE	YEAR	TOTAL BUDGET	PFK BUDGET
Erasmus + CBHE	Development of Regional Joint Master Program in Maritime Environmental Protection and Management (MEP&M)	C	2021 -2024	845,188.00 €	216,000.00 €
Interreg IPA	Protecting underwater heritage through its digitalization and valorisation as a novel touristic offer (WRECKS4ALL)	C	2020 - 2022	1,016,778.32 €	334,737.17 €
Tempus	Modernizing and Harmonizing Maritime Education in Montenegro and Albania (MArED)	C	2013 - 2017	1,154,776.80 €	316,181.47 €
Erasmus + CBHE	Sustainable development of BLUE economies through higher education and innovation in Western Balkan Countries (BLUEWBC)	P	2020 - 2023	985,755.00 €	207,766.00 €
Interreg IPA	Innovative Systems to enhance Antifraud Customs Controls (ISACC)	P	2020 - 2022	996,997.04 €	148,356.00 €
Interreg IPA	Partnership for the Observation and study of new Routes and Transnational Sea-highways (PORTS)	P	2018 - 2020	109,1053.08	136,755.00 €
Interreg IPA	Partnership for the prOmotion of a maRiTime cross-border Strategy (PORTS 4.0)	P	2020 – 2021	94,000.00 €	24,000.00 €
Interreg IPA	PrOmoting Resilient, Sustainable, and Smart Transport and logistic activities in the South Adriatic Area (PORTS PLUS)	P	2022 - 2023	94,000.00 €	11,000.00 €
Tempus	Development of Sustainable Interrelations between Education, Research and Innovation at WBC Universities in Nanotechnologies and Advanced Materials where Innovation Means Business (WIMB)	P	2013 - 2017	1,200,000.00 €	152,000.00 €
HERD	Montenegro Sustainable Maritime Competence Initiative	P	2013 – 2016	1,400,000.00€	900,000.00 €
HERIC	Knowledge transfer for increased maritime competences in Montenegro (EDUMAR)	P	2016 – 2017	55,000.00 €	55,000.00 €
TOTAL:				**8,933,548.24 €**	**2,501,795.64 €**

SMART BAY LAB

FOCUS ON CRUISE SHIPS IN KOTOR BAY





Interreg – IPA CBC
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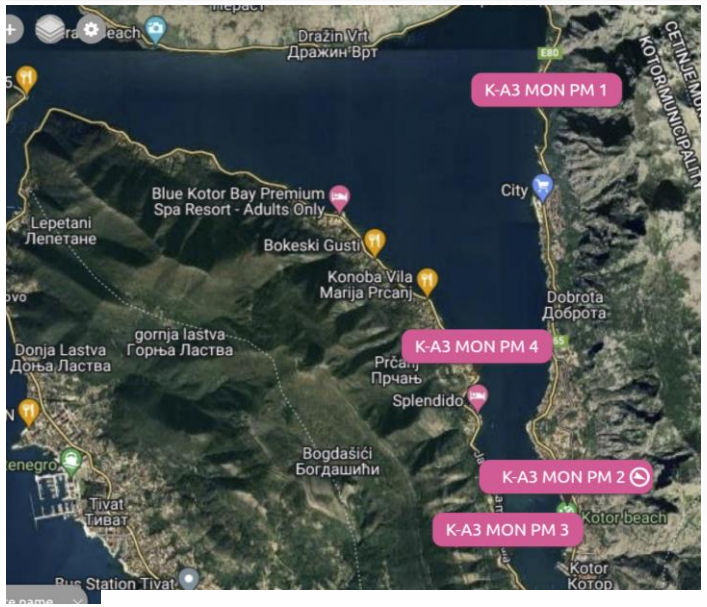
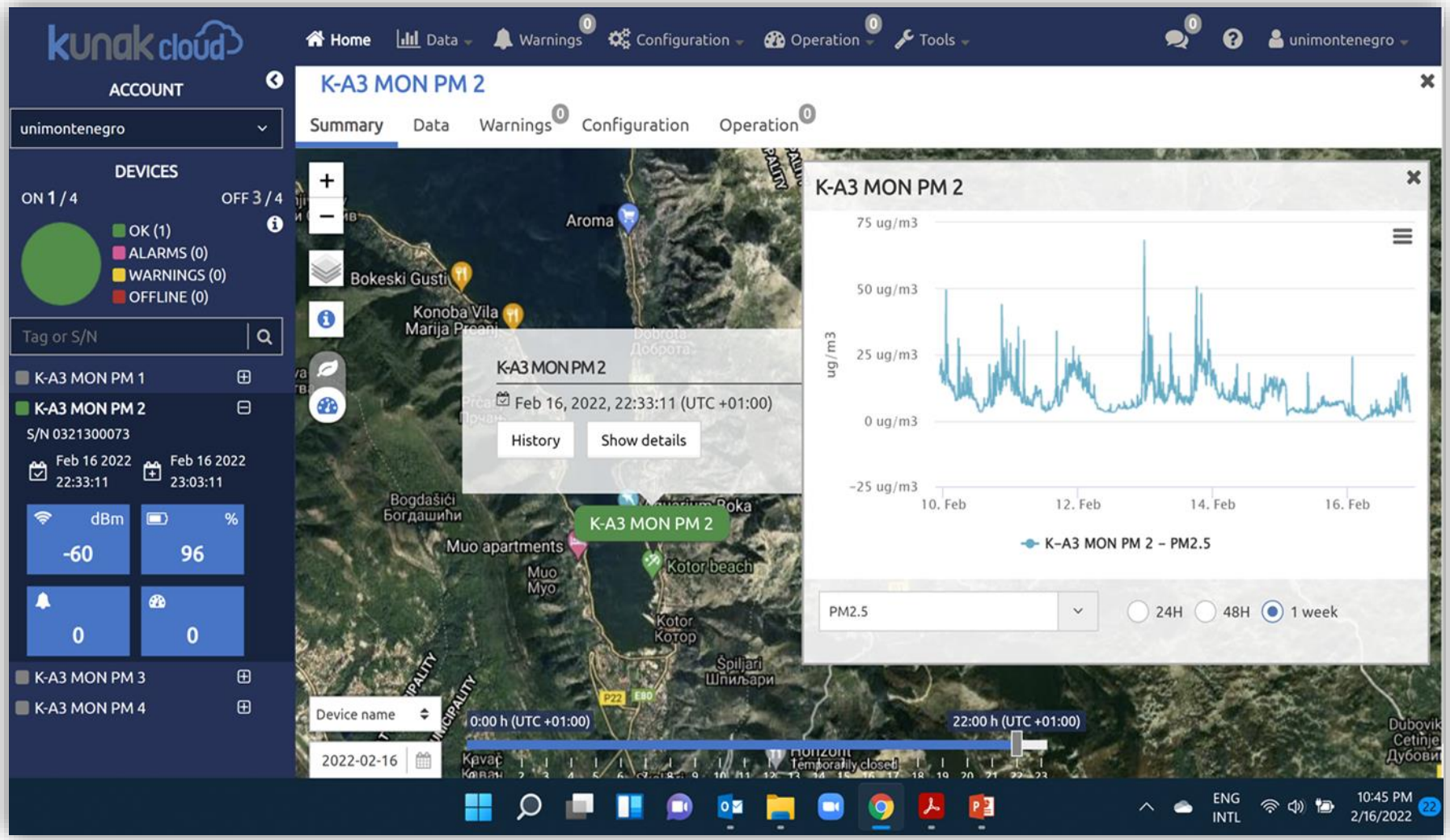
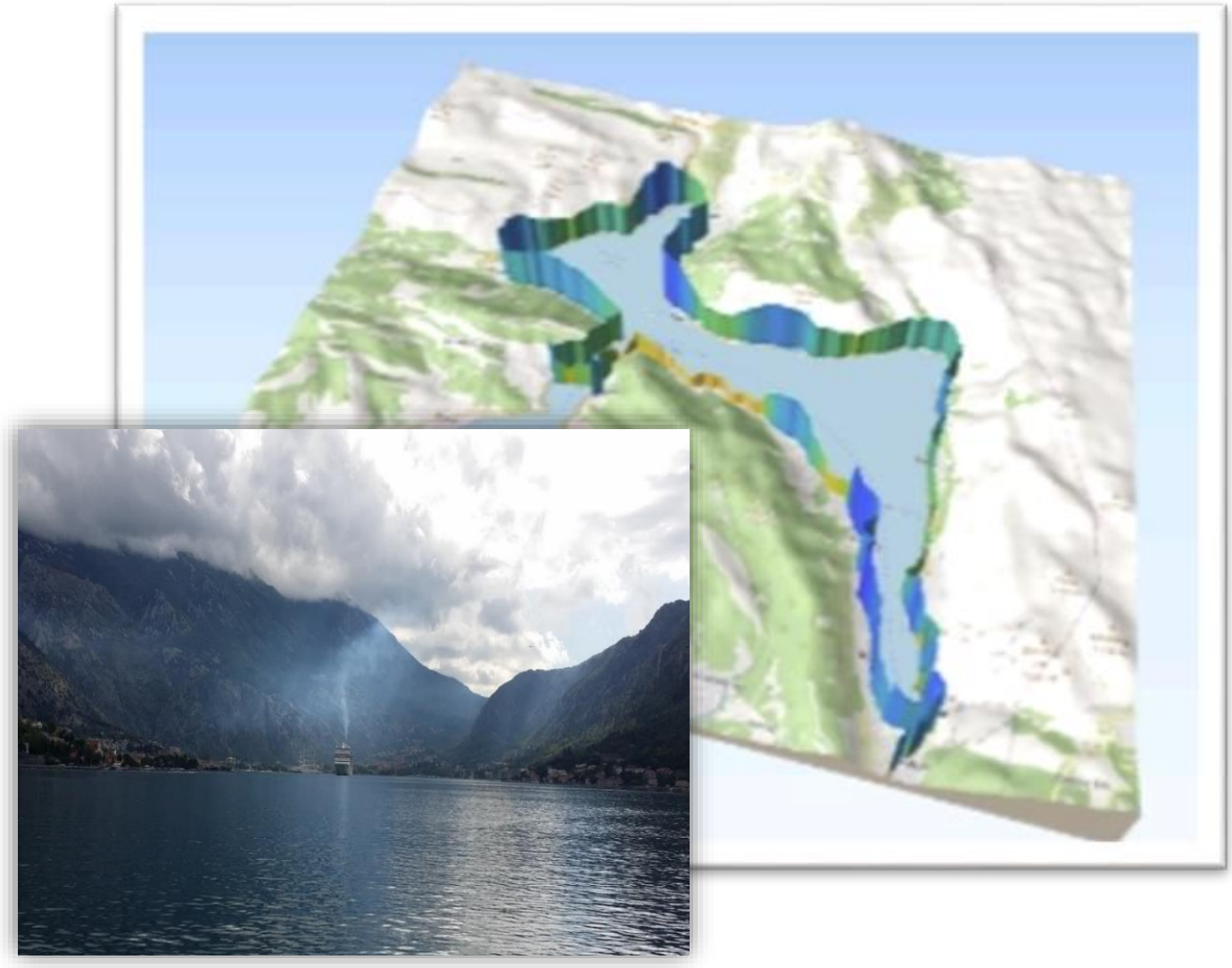
SMART BAY LAB – KUNAK PM, O_3, CO, NOx, SO_2 sensors





SMART BAY LAB – Mobile PM sizer



TSI Optical particle sizer (OPS) 3330

SMART BAY LAB - PM Concentration in Kotor bay related to cruise ships

atmosphere

MDPI

Article

Establishing Correlation between Cruise Ship Activities and Ambient PM Concentrations in the Kotor Bay Area Using a Low-Cost Sensor Network

Radmila Gagic [1,*], Maja Skuric [1], Gordana Djukanovic [2] and Danilo Nikolic [1]

[1] Center for Research, Innovation and Entrepreneurship, Faculty of Maritime Studies Kotor, University of Montenegro, 85330 Kotor, Montenegro
[2] Environmental Protection Agency of Montenegro, 81000 Podgorica, Montenegro
* Correspondence: radmilag@ucg.ac.me

Abstract: The analysis of cruise ships is focusing on port areas where they may represent a significant source of anthropogenic emissions. In order to determine the correlation between cruise ship activities (hoteling and maneuvering) in ports with the ambient concentration of pollutants associated with marine diesel fuel combustion, the low-cost sensors are finding their market share due to lower prices compared to the referent ones. In this study, a network of four low-cost PM sensors was used to determine the correlation between ambient $PM_{2.5}$ and PM_{10} mass concentrations with cruise ship activities in the Kotor Bay area during 27 days in the peak summer season, with a 10-min resolution. Recorded data and the Openair model were used to investigate the potential relationship between cruise ship operations and temporal fluctuations in PM concentrations in the ambient air. Additionally, an Tier 3 methodology developed through the European Monitoring and Evaluation Programme of the European Environmental Agency (EMEP/EEA) was applied in order to estimate the total cruise ship PM emissions. The study has shown that weather conditions play a significant role in local PM concentrations, so that, with predominant ENE wind directions, the west side of the Bay experienced on average higher concentrations of both $PM_{2.5}$ and PM_{10}. Rain precipitation and higher winds tend to decrease rapidly ambient PM concentrations. Higher PM levels are associated mainly with lower wind speeds and the inflows from neighboring berths/anchorages. During the maneuvering (arrival and departure) of cruise ships, higher spikes in PM values were detected, being more visible for PM_{10} than $PM_{2.5}$. A significant correlation between daily average PM concentrations and cruise ships' daily estimated PM emission was not found. As a result, higher temporal resolution demonstrated a stronger correlation.

Keywords: cruise ship emission; port air pollution; $PM_{2.5}$; PM_{10}; low-cost sensors; sensor network

Citation: Gagic, R.; Skuric, M.; Djukanovic, G.; Nikolic, D. Establishing Correlation between Cruise Ship Activities and Ambient PM Concentrations in the Kotor Bay Area Using a Low-Cost Sensor Network. *Atmosphere* **2022**, *13*, 1819. https://doi.org/10.3390/atmos13111819

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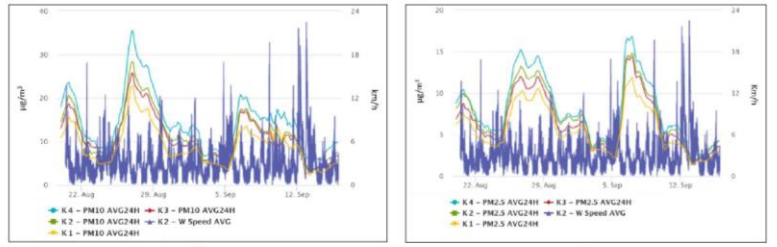
1. Introduction

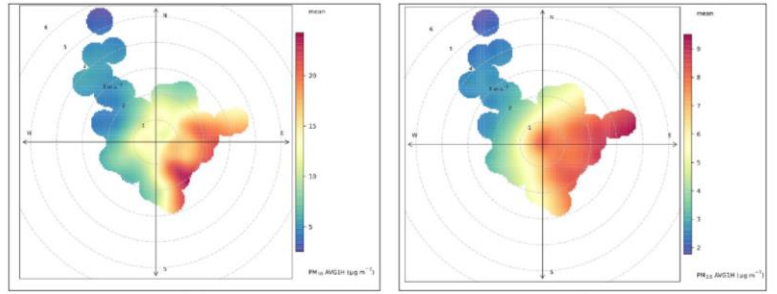
The environmental effect of shipping should be assessed in the context of port sites, since air quality in the surrounding area is significantly impacted, resulting in serious repercussions for human health for people living in coastal areas [1]. Ships produce considerable amounts of pollutants into the neighboring environment while berthed, even three to five times more than when underway [2]. In some cases, ships in ports can account for up to 77% of total emissions [3,4].

Particulate matter (PM) generated by ships' diesel engines has a range of adverse health and environmental-related consequences. It is estimated that shipping-related $PM_{2.5}$ emissions cause about 60,000 premature cardiac and lung cancer deaths worldwide each year [5]. Another study has shown that ships account for over 6 million childhood asthma cases and 250,000 deaths annually [6].



(a) (b)

Figure 8. Average wind speed vs. PM_{10} (**a**) and $PM_{2.5}$; (**b**) 24 h average over the experimental period 20 August–15 September 2022.



(a) (b)

Figure 9. Bivariate polar plot of $PM_{2.5}$ (**a**) and PM_{10} (**b**) concentrations at the K4 measuring location during experimental period from 20 August to 15 September 2022. Each plot's center indicates a wind speed of zero, which rises radially outward. The color scale indicates the concentration of PM.

Figure 10 shows both the estimated total cruise ship PM emission and $PM_{10}/PM_{2.5}$ ambient concentrations for the observed period of time. For better visibility, a 7-day period was selected, from 29 August to 4 September 2022. When evaluating the data, it is worth noting that the cruise ship activities, linked to the realization of the ship's operational phases (arrival/hoteling/departure), as described in Section 2.3, and estimated PM emissions (Table 2), affect the height of the PM ambient concentration spikes. This is more evident for PM_{10} than $PM_{2.5}$.

When observing the whole experimental period, the daily average values of both $PM_{2.5}$ and PM_{10} did not significantly correlate with the daily cruise ship's estimated total PM emission (Figure 11).

As also previously suggested by [33], a cruise ship's direct impact on PM concentration is best assessed using a higher temporal resolution.

SMART BAY LAB – Prediction of pollutant and GHG emission from ships in Kotor bay

Table 7 Total annual exhaust emission from cruise ships in the Boka Kotorska Bay in 2015 (tons/year)

Month	NOx	CO	CO_2	VOC	PM	SOx[a]	SOx[b]
January	1.017	3.374	12.097	0.772	0.045	0.0378	2.021
February	1.54	5.122	183.622	1.172	0.069	0.0574	3.064
March	1.23	4.04	145.643	0.923	0.055	0.0455	2.43
April	13.469	32.13	1,348.232	7.101	0.506	0.4213	22.499
May	34.074	74.088	3,264.452	16.175	1.224	1.0201	54.476
June	40.071	92.154	3,941.245	20.272	1.478	1.2316	65.77
July	34.48	75.709	3,318.375	16.552	1.244	1.037	55.375
August	37.082	82.632	3,593.37	18.102	1.348	1.1229	59.964
September	42.686	94.137	4,116.418	20.593	1.544	1.2863	68.693
October	32.982	71.155	3,148.458	15.518	1.181	0.9839	52.54
November	17.127	36.393	1,623.624	7.92	0.609	0.5074	27.094
December	2.74	7.86	301.208	1.774	0.113	0.0941	5.026
Total (tons/year)	258.498	578.794	24,996.744	126.874	9.416	7.8453	418.952

[a]Estimation for average sulphur content in fuel of 0.0457% m/m
[b]Estimation for average sulphur content in fuel of 2.67% m/m

Nikolic et al, DOI 10.1007/698_2016_34,

Estimation of Air Pollution from Ships in the Boka Kotorska Bay

Danilo Nikolić, Radmila Gagić, and Spiro Ivošević

Abstract The Boka Kotorska Bay, with the Port of Kotor, has become one of the most attractive cruising destinations at the Adriatic Sea. It shows not only great potential in terms of economy, but also great danger if environmental issues are taken into consideration. Emission from cruise ships represents majority of anthropogenic emissions of pollutants in this area, since there are no merchant ports and industrial plants in the bay.

In this paper exhaust emission from ships in the Boka Kotorska Bay in 2015 was calculated by using emission estimation methodology. Only cruise ships were taken for research since that is the only shipping activity in the bay, besides yachting. Cruise ship's gross tonnage, marine engine types, marine fuel types, navigation modes and retention times of the ship in the Bay were taken into consideration in the study. Total emissions from cruise ships in the Boka Kotorska Bay area in 2015 were estimated as follows: 258.50 t y^{-1} of NOx, 578.80 t y^{-1} of CO, 24,996.74 t y^{-1} of CO_2, 126.87 t y^{-1} of VOC, 9.42 t y^{-1} of PM and 7.84 t y^{-1} of SOx in the case when assumed that cruise ships burn low sulphur fuels and 418.95 t y^{-1} of SOx in the case of high sulphur fuels.

Keywords Air pollution, Boka Kotorska Bay, Cruise ships, Exhaust emission estimation

Contents

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A. Joksimović et al. (eds.), *The Boka Kotorska Bay Environment*,
Hdb Env Chem, DOI 10.1007/698_2016_34,

Some Results of Air Pollution from Passenger Ferries in the Boka Kotorska Bay

Maja Škurić, Vladislav [illegible], Radmila Gagić, and Danilo Nikolić

Contents

Abstract Emission from passenger ships represents a threat especially for a population in the coastal area that is exposed to air pollution due to the port traffic throughput and other frequent activities at the seaside. Passenger ferries are one of the marine small vessels that have a primary role in connecting domicile inhabitants and serves as a favorite mode of transport for short tourist visits. In this chapter, the

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Danijela Joksimović, Mirko Đurović, Igor S. Zonn, Andrey G. Kostianoy, and Aleksander V. Semenov (eds.), *The Montenegrin Adriatic Coast: Marine Chemistry Pollution*, Hdb Env Chem, DOI 10.1007/698_2020_702,

SMART BAY LAB – Exhaust emission analyser & smoke tester

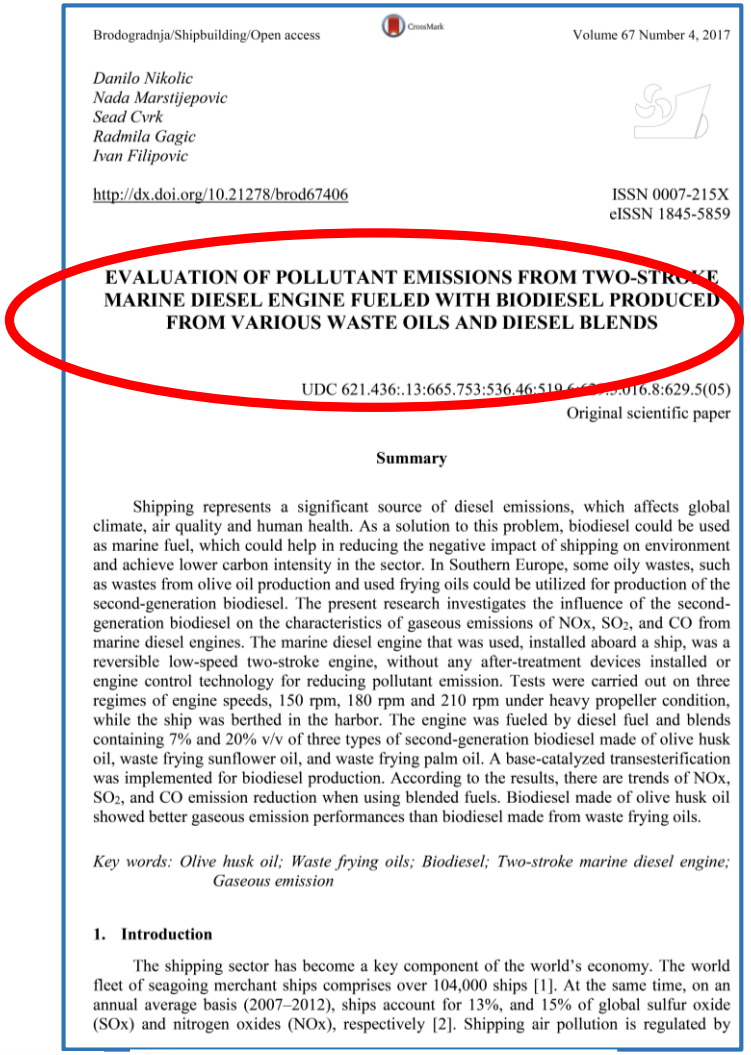
TESTO 350 MARITIME

SMART BAY LAB – Renewable fuels

Research on three types of second-generation biodiesel made from:

- Olive husk oil;
- Waste sunflower, and
- Waste palm oil from frying.

Biodiesel blends (7%, 20% and 25%) show better emission performance in regard to NOx, SO_2, CO, and CO_2 than pure low sulfur diesel.



Brodogradnja/Shipbuilding/Open access

Volume 67 Number 4, 2017

Danilo Nikolic
Nada Marstijepovic
Sead Cvrk
Radmila Gagic
Ivan Filipovic

http://dx.doi.org/10.21278/brod67406

ISSN 0007-215X
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EVALUATION OF POLLUTANT EMISSIONS FROM TWO-STROKE MARINE DIESEL ENGINE FUELED WITH BIODIESEL PRODUCED FROM VARIOUS WASTE OILS AND DIESEL BLENDS

UDC 621.436:.13:665.753:536.46:519.6[illegible].016.8:629.5(05)
Original scientific paper

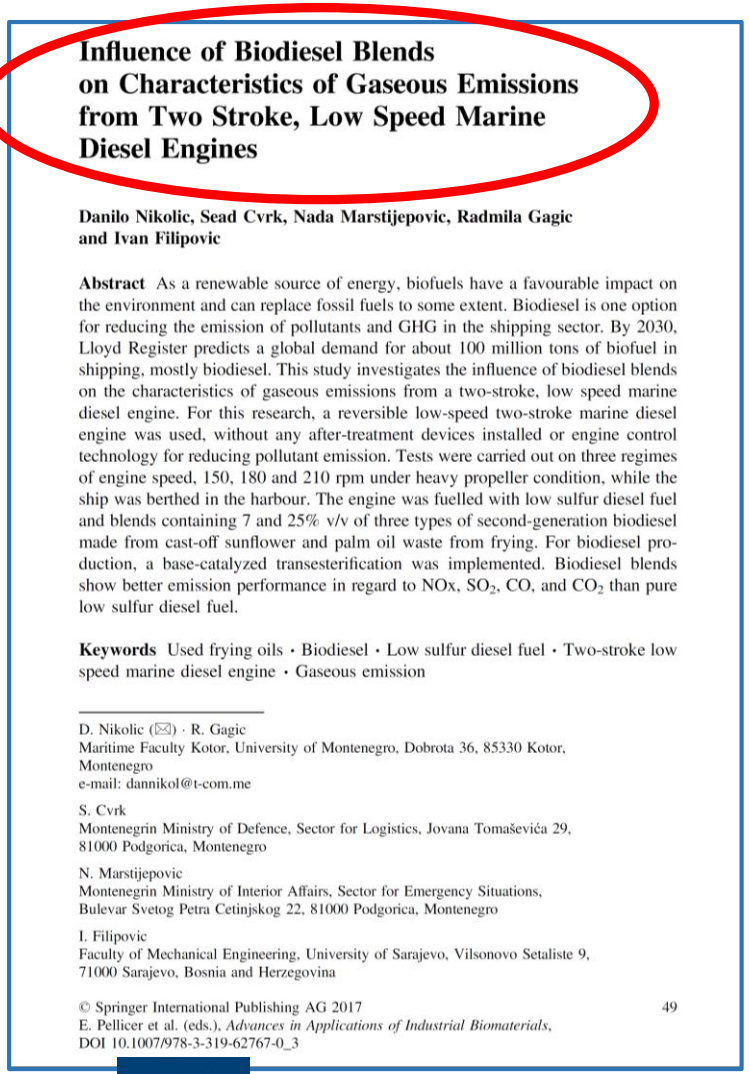
Summary

Shipping represents a significant source of diesel emissions, which affects global climate, air quality and human health. As a solution to this problem, biodiesel could be used as marine fuel, which could help in reducing the negative impact of shipping on environment and achieve lower carbon intensity in the sector. In Southern Europe, some oily wastes, such as wastes from olive oil production and used frying oils could be utilized for production of the second-generation biodiesel. The present research investigates the influence of the second-generation biodiesel on the characteristics of gaseous emissions of NOx, SO_2, and CO from marine diesel engines. The marine diesel engine that was used, installed aboard a ship, was a reversible low-speed two-stroke engine, without any after-treatment devices installed or engine control technology for reducing pollutant emission. Tests were carried out on three regimes of engine speeds, 150 rpm, 180 rpm and 210 rpm under heavy propeller condition, while the ship was berthed in the harbor. The engine was fueled by diesel fuel and blends containing 7% and 20% v/v of three types of second-generation biodiesel made of olive husk oil, waste frying sunflower oil, and waste frying palm oil. A base-catalyzed transesterification was implemented for biodiesel production. According to the results, there are trends of NOx, SO_2, and CO emission reduction when using blended fuels. Biodiesel made of olive husk oil showed better gaseous emission performances than biodiesel made from waste frying oils.

Key words: Olive husk oil; Waste frying oils; Biodiesel; Two-stroke marine diesel engine; Gaseous emission

1. Introduction

The shipping sector has become a key component of the world's economy. The world fleet of seagoing merchant ships comprises over 104,000 ships [1]. At the same time, on an annual average basis (2007–2012), ships account for 13%, and 15% of global sulfur oxide (SOx) and nitrogen oxides (NOx), respectively [2]. Shipping air pollution is regulated by



Influence of Biodiesel Blends on Characteristics of Gaseous Emissions from Two Stroke, Low Speed Marine Diesel Engines

Danilo Nikolic, Sead Cvrk, Nada Marstijepovic, Radmila Gagic and Ivan Filipovic

Abstract As a renewable source of energy, biofuels have a favourable impact on the environment and can replace fossil fuels to some extent. Biodiesel is one option for reducing the emission of pollutants and GHG in the shipping sector. By 2030, Lloyd Register predicts a global demand for about 100 million tons of biofuel in shipping, mostly biodiesel. This study investigates the influence of biodiesel blends on the characteristics of gaseous emissions from a two-stroke, low speed marine diesel engine. For this research, a reversible low-speed two-stroke marine diesel engine was used, without any after-treatment devices installed or engine control technology for reducing pollutant emission. Tests were carried out on three regimes of engine speed, 150, 180 and 210 rpm under heavy propeller condition, while the ship was berthed in the harbour. The engine was fuelled with low sulfur diesel fuel and blends containing 7 and 25% v/v of three types of second-generation biodiesel made from cast-off sunflower and palm oil waste from frying. For biodiesel production, a base-catalyzed transesterification was implemented. Biodiesel blends show better emission performance in regard to NOx, SO_2, CO, and CO_2 than pure low sulfur diesel fuel.

Keywords Used frying oils · Biodiesel · Low sulfur diesel fuel · Two-stroke low speed marine diesel engine · Gaseous emission

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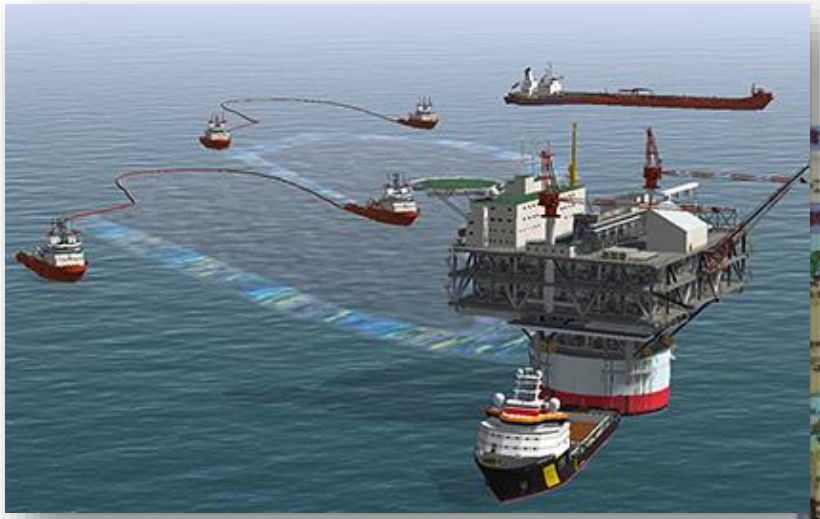
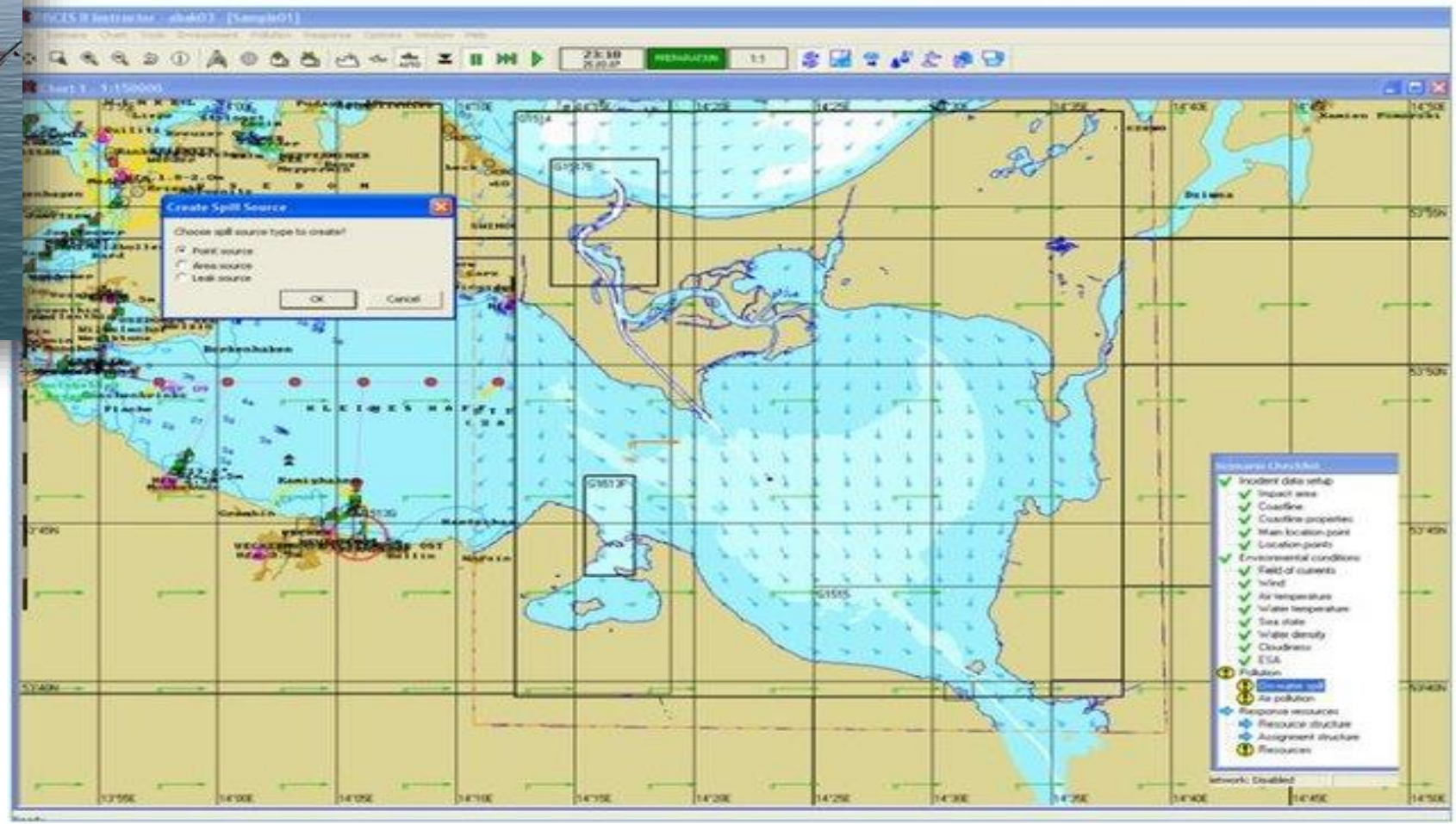
E. Pellicer et al. (eds.), *Advances in Applications of Industrial Biomaterials*,
DOI 10.1007/978-3-319-62767-0_3

SMART BAY LAB – Simulations of oil spills



Wärtsilä Oil Spill Response Simulator



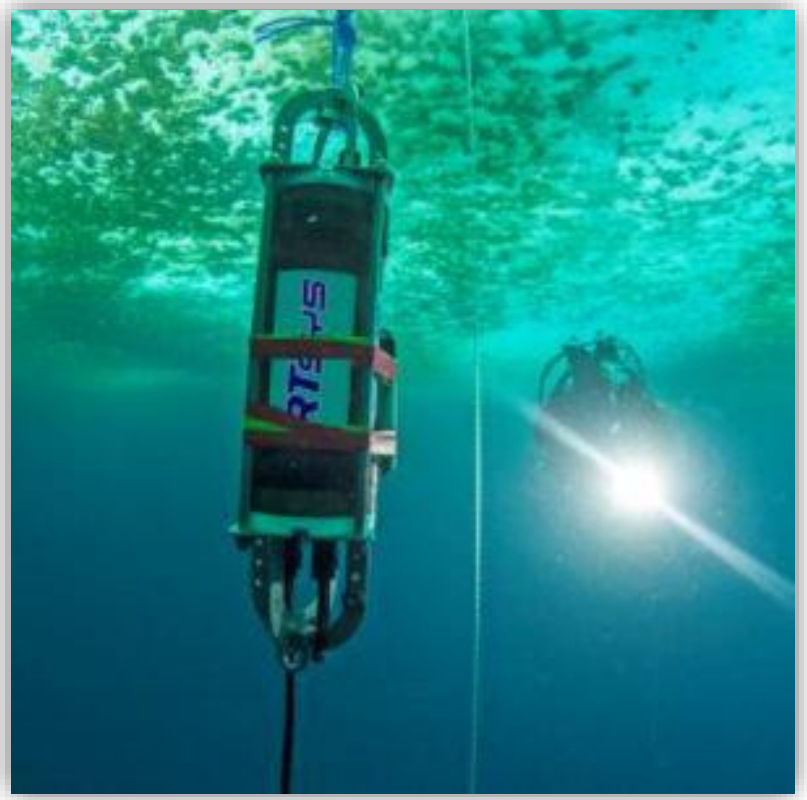
SMART BAY LAB – Equipment for underwater research

SMART BAY LAB – Equipment for underwater research

Multi-parameter Water Quality Checker

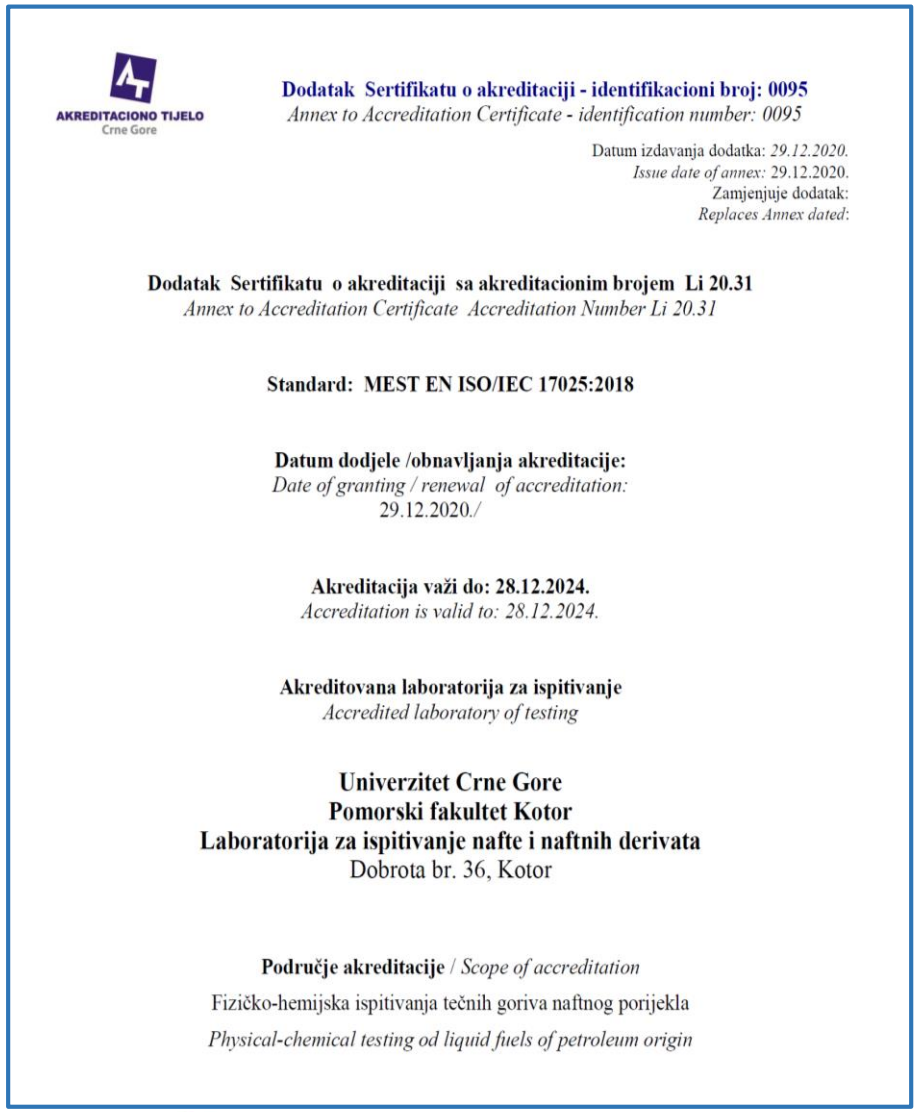
Horiba U-50 series Multi-parameter water quality checker

Underwater acoustic recorder & Hydrophone



LAB FOR LIQUID FUELS

Equipment for fuel and oil quality testing - **Accredited**



AKREDITACIONO TIJELO
Crne Gore

Dodatak Sertifikatu o akreditaciji - identifikacioni broj: 0095
Annex to Accreditation Certificate - identification number: 0095

Datum izdavanja dodatka: *29.12.2020.*
Issue date of annex: 29.12.2020.
Zamjenjuje dodatak:
Replaces Annex dated:

Dodatak Sertifikatu o akreditaciji sa akreditacionim brojem Li 20.31
Annex to Accreditation Certificate Accreditation Number Li 20.31

Standard: MEST EN ISO/IEC 17025:2018

Datum dodjele /obnavljanja akreditacije:
Date of granting / renewal of accreditation:
29.12.2020./

Akreditacija važi do: 28.12.2024.
Accreditation is valid to: 28.12.2024.

Akreditovana laboratorija za ispitivanje
Accredited laboratory of testing

Univerzitet Crne Gore
Pomorski fakultet Kotor
Laboratorija za ispitivanje nafte i naftnih derivata
Dobrota br. 36, Kotor

Područje akreditacije / *Scope of accreditation*
Fizičko-hemijska ispitivanja tečnih goriva naftnog porijekla
Physical-chemical testing od liquid fuels of petroleum origin

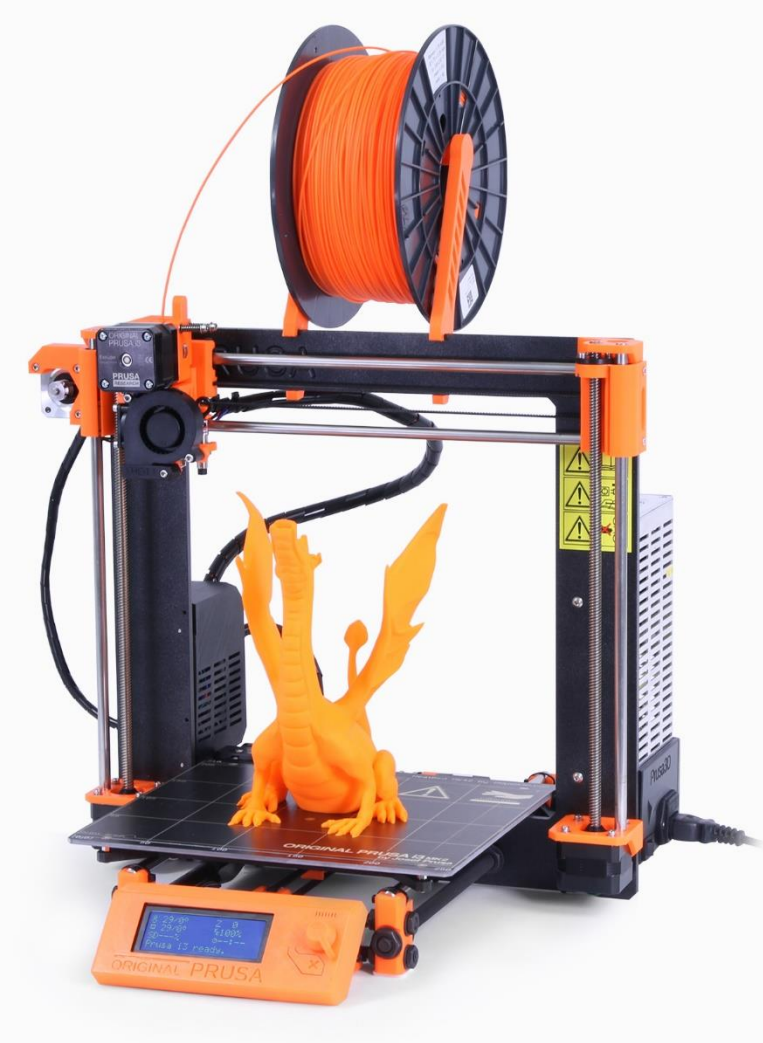
LAB FOR SHIP UNDERWATER ARCHEOLOGY

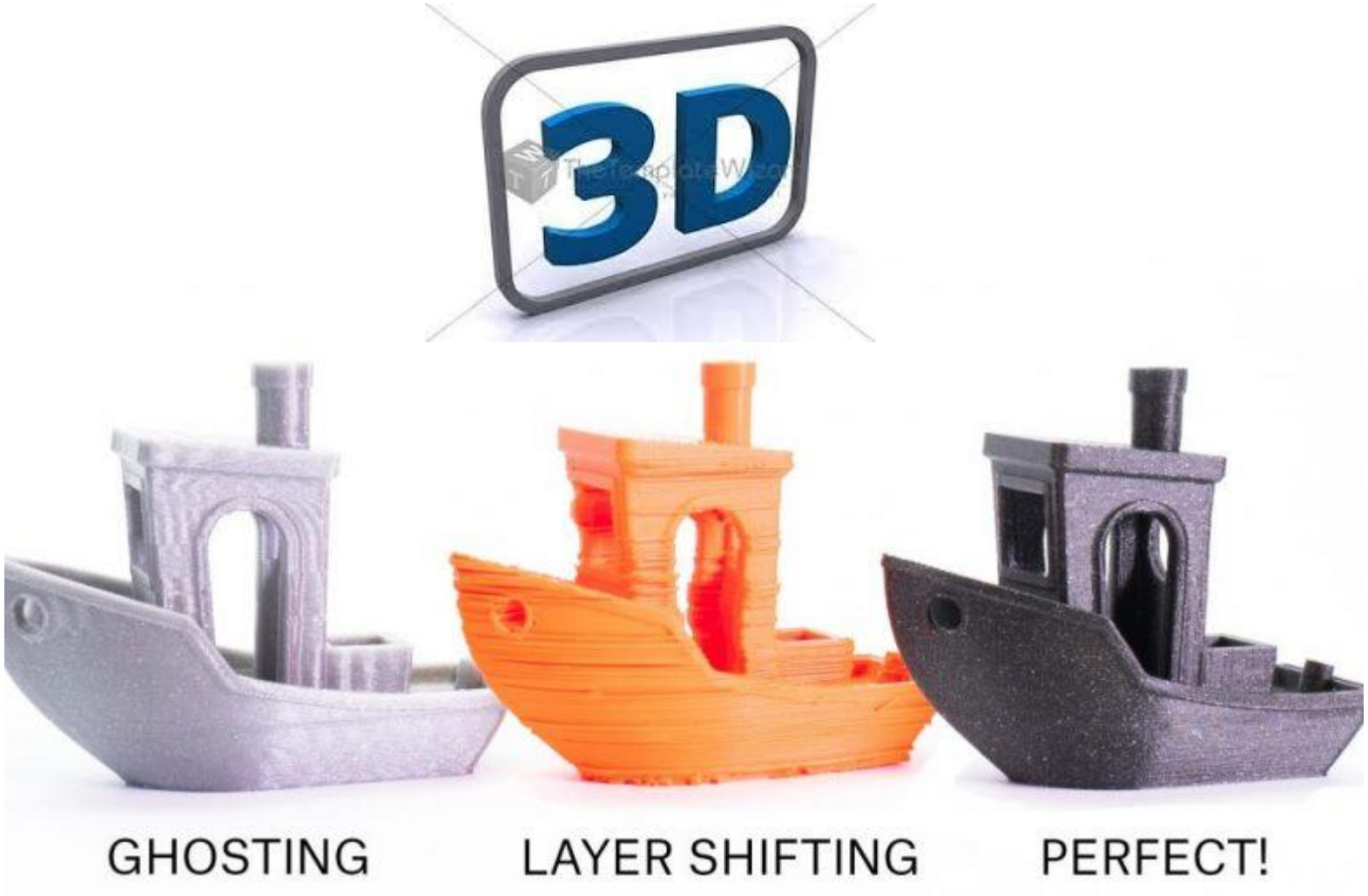
Ship underwater archeology

3D LAB

3D LAB - Artec Spider 3D Scanner (BLUEWBC)

3D LAB - 3D printer Prusa i3 (BLUEWBC)





3D LAB - Tobii 3 Eye-tracking glasses

MARINE SIMULATORS

Wärtsilä/Transas Navigation simulator

Wärtsilä/Transas Engine room simulators

Rolls Royce DP Dynamic positioning sim

OSC Offshore simulator

CREATIVITY SPACE

Interreg – IPA CBC
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Programma Sviluppo
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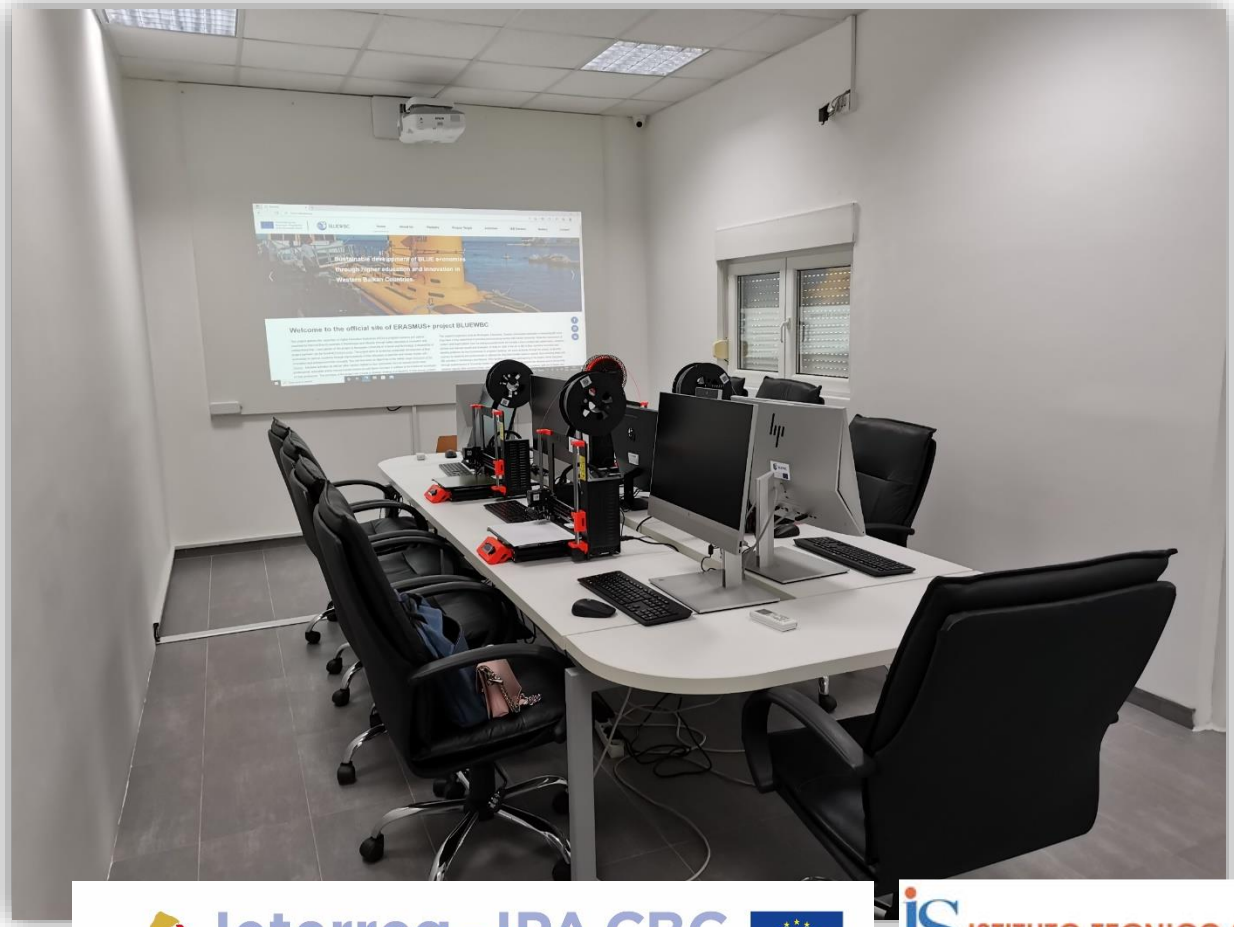
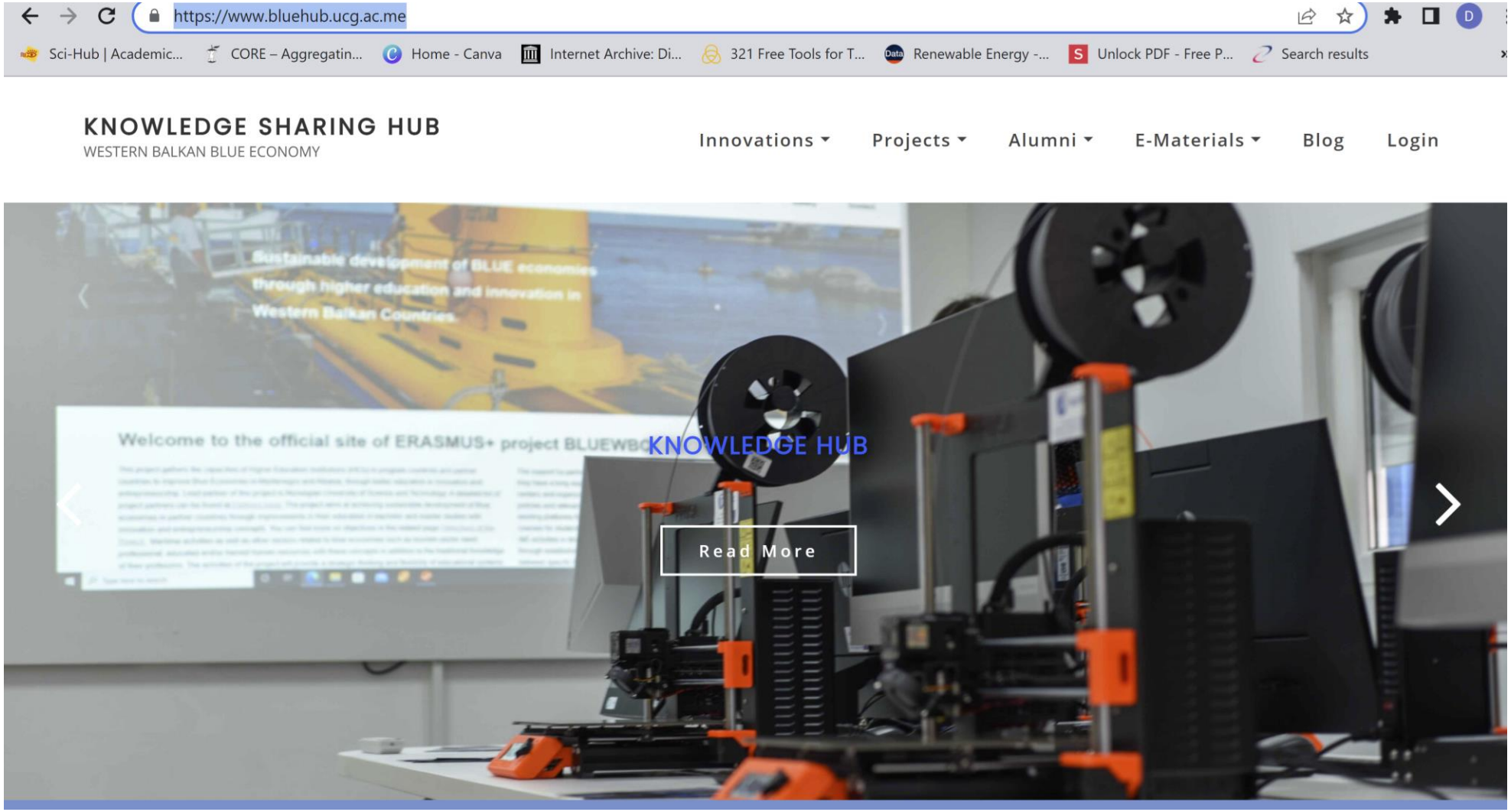
CREATIVITY SPACE



Knowledge hub



Interreg - IPA CBC
Italy - Albania - Montenegro
EUROPEAN UNION
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Distance learning equipment – Hardware and software for lecture production

A Week of BLUE Challenge

Svrha:

- stvaranje čvršće studentske zajednice;
- kreativni proces;
- sticanje novih znanja;
- pokazivanje talenta;
- implementacija novih ideja;
- start-up projekti.

LIFE LONG LEARNING PROGRAMS
Summer schools

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Summer school

6-day accredited summer school providing 2 ECTS

SUSTAINABLE DEVELOPMENT OF YACHTING AND CRUISE INDUSTRY

Date: July 3rd – July 8th, 2023
Place: University of Montenegro, Faculty of Maritime Studies Kotor
Address: Put I Bokeljske brigade 44, 85330 KOTOR, MONTENEGRO

BACKGROUND

The summer school (Lifelong Learning Program) on "Sustainable development of yachting and cruise industry" started in 2022 as a part of the Erasmus+ CBHE project "Fostering Internationalization at Montenegrin HEIs through Efficient Strategic Planning (IESP)", project No. 609675-EPP-1-2019-1-ME-EPPKA2-CBHE-SP.

It is Montenegrin first accredited lifelong learning program, as determined by Decision No. 02-607/22 – 51/74P of the national Agency for Control and Quality Assurance of Higher Education on 21.4.2022.

The summer school provides students with 2 ECTS and is conducted in English.

It is organized by the Center for Research, Innovation, and Entrepreneurship at the University of Montenegro, Faculty of Maritime Studies in Kotor.

The lecturers are eminent professors and professionals from Montenegro, Albania, and the European Union.

JOINT MASTER PROGRAM

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Joint MSc in Maritime Environmental Protection and Management

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Joint MSc in Maritime Environmental Protection and Management

#	Sem.	Course title	# of hours	ECTS	O/E
I	I	**Research Skills, Methods and Tools**	2+2+0	10	O
2	I	**Fundamentals of Environmental Science and Sustainability**	2+2+0	10	O
3	I	**Introduction to the Blue Economy**	2+2+0	10	O
4	II	**Marine Ecology and Conservation**	2+1+1	10	O
5	II	**Marine Environmental Pollution and Prevention**	2+1+1	10	O
6	II	**GHG Emission and Climate Change Mitigation Policies**	2+1+1	10	O
7	III	**Environmental Management Standards and Impact Assessment**	2+2+0	10	O
8	III	**Elective Course #1**	2+1+1	10	E
9	III	**Elective Course #2**	2+1+1	10	E
		Sustainable Development of Maritime Transport and Ports			
		Sustainable Development of Coastal Tourism			
		Management of Offshore Energy and Mineral Resources			
		Fisheries Management			
		Integrated Coastal Management			
		Management of Protected Marine Areas And Species			
		Maritime Safety and Security			
		Entrepreneurship and Innovation			
13	IV	Professional Practice/Research		12	
14	IV	Master Degree Thesis		18	

Thank you for your attention!

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