Delphi survey on future trends and technologies in the field of maritime technologies for detection, monitoring and prevention of marine pollution

Dear expert,

thank you for participating in this survey!

This modified Delphi survey is a part of a larger Technology foresight study within the InnovaMare project (<u>https://www.italy-croatia.eu/web/innovamare</u>), and it aims to identify the key challenges and opportunities in Blue economy, as well as future trends and innovative technologies in the field of maritime technologies, with the emphasis on underwater robotics and sensors.

The survey will be conducted in two rounds in order to build consensus on a set of statements generated through an extensive analysis of the sustainable Blue economy trends and innovative maritime technologies. Participation in the survey won't take much of your time, approximately 30 minutes per round. Once we have received responses from all participants in the first round, we will collate and summarize the findings and formulate a second questionnaire.

As an expert on maritime technologies, you will be asked for your personal opinion on the statements listed below regarding emerging technologies for detection, monitoring and prevention of marine pollution within the 10-20 years time horizon. Feel free to provide your honest opinions; there are no "right or wrong" answers. All data provided will be accessed only by the team conducting the survey and will be treated with full confidentiality and anonymity of the participants. However, email addresses of respondents are needed for sending you the inputs for the second round and the overall survey results afterwards.

Please fill in the questionnaire at your earliest convenience and not later than Wednesday, April 6. The second round of survey starts immediately afterwards.

If you have any questions regarding this study, please contact Sofija Stanić at <u>sofija.stanic@mrezaznanja.hr</u>.

* Required

1. Email *

General information Participant information collected by the research team within this survey will be kept strictly confidential and will not be divulged to any outside party, including other survey participants. Please answer all questions that are listed as mandatory. Delphi survey on future trends and technologies in the field of maritime technologies for detection, monitoring and preventio...

2. 1. Please indicate your gender: *

Mark only one oval.

\square	\supset	Male

Female

- Other
- 3. 2. Please indicate your age: *

Mark only one oval.

\bigcirc	25-34	years
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- 35-44 years
- _____ 45-54 years
- 55-64 years
- 65 years or older
- 4. 3. Please indicate the highest degree or level of school you have completed? *

Mark only one oval.

- Bachelor's degree
- Master's degree
- Doctoral degree
- 5. 4. Please indicate the area of your expertise: *

Mark only one oval.

- Maritime technologies
 Underwater robotics
 Sensors
- Other:

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Delphi survey on future trends and technologies in the field of maritime technologies for detection, monitoring and preventio...

6. 5. Please indicate the years of your professional experience: *

Mark only one oval.

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7. 6. Please indicate your employment sector: *

Mark only one oval.

Academic/research sector	
Industry/private sector	

Other:

8. 7. Please indicate which organization or institution you are currently affiliated * with.

9. 8. Please indicate your country of employment: *

Mark only one oval.

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- China
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- United States of America
- Other

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The concept of Blue Economy is recognized as central for sustainable development since it incorporates socio-economic benefits and ecological conservation.

Nonetheless, the traditional Blue economy industries and activities (fisheries, shipbuilding and repair, maritime transport, coastal tourism) have a cumulative impact on the marine environment, from visible pollution such as plastic litter and oil spills to invisible pollution such as microplastics, underwater noise, chemicals and nutrients. In addition, a major threat posed by biodiversity loss, which is driven by climate change, pollution, over-exploitation of resources and the destruction of natural habitats, is challenging the resilience of the Blue economy and society as a whole.

In those circumstance, making traditional Blue economy sectors sustainable together with the emerging ones, that are innovative and sustainable in their nature (offshore renewable energy, blue biotechnology, marine minerals, desalination, maritime security), can offer a valuable solutions for the prevention of marine pollution. Innovative technologies such as Big Data, AI, advanced modelling, sophisticated sensors and autonomous systems are likely to transform the Blue economy sector in the immediate future.

On the basis of a conducted analysis of current trends and technologies on EU and global levels regarding maritime technologies for detection, monitoring and prevention of marine pollution, key challenges and opportunities in the Blue economy sector were identified, with the main focus being on the underwater robotics and sensors as part of the innovative technologies.

There are 15 statements on the influence of underwater robotics and sensors on key challenges and opportunities in sustainable Blue economy, on which we are keen to hear your honest point of view. Please answer all the questions to the best of your knowledge. There are no "right or wrong" answers, nor your rankings will be shared with anyone outside the research team that is conducting this survey. Your rankings and comments will provide valuable feedback on the impact, opportunities and challenges of the sustainable Blue economy sector which is immediately correlated with the development of the maritime technologies over the next 10 to 20 years.

Please rate the degree to which you agree or disagree with the following statements, on a rating scale of 1-9 listed below, where 1 is 'very strongly agree' and 9 is 'very strongly disagree'. After every statement, there is an option for comments if you wish to further elaborate your opinion and provide additional information

or explanation.

Sustainable Blue economy & underwater robotics and sensors for detection, monitoring and prevention of marine pollution

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10.	Statement 1. Underwater robotics and sensors will have significant impact in * resolving challenge of pollution in Blue economy.											
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22.	Statemer developm	Statement 7. Underwater robotics and sensors will significantly contribute to * development of sustainable fisheries and aquaculture.											
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26.	Statement 9. Unde preventing biodiver	rwater r sity los	obotic s.	s and s	sensors	s will be	e used f	for stop	oping a	ind	*
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34.	 Statement 13. Development of sustainable coastal tourism will be significantly * influenced by underwater robotics and sensors. 1-Very strongly agree, 2-Strongly agree, 3-Agree, 4-Slightly agree, 5-Neither agree nor disagree, 6-Slightly disagree, 7-Disagree, 8-Strongly disagree, 9-Very strongly disagree. 											
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36.	Statement 14. Under the sustainability o	erwater f port a	r roboti ictivitie:	cs and s.	senso	rs will s	signific	antly c	ontribu	te to	*	
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Very strongly agree

Very strongly disagree

*

38. Statement 15. Underwater robotics and sensors will play a crucial role in the field of sustainable maritime defence, security and surveillance.

1-Very strongly agree, 2-Strongly agree, 3-Agree, 4-Slightly agree, 5-Neither agree nor disagree, 6-Slightly disagree, 7-Disagree, 8-Strongly disagree, 9-Very strongly disagree.

 Mark only one oval.

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 Very strongly agree
 Image: Imag

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Delphi survey on future trends and technologies in the field of maritime technologies for detection, monitoring and preventio...

Underwater robotics has been continuously expanding researchers' possibilities to study, monitor and prevent the marine pollution. Robots' capability of operating and exploring challenging and hazardous scenarios has made these innovative technologies key tools for experts, especially for collecting highquality data to analyze and understand complex underwater environments.

Intensive research and development in this field have led to major advances and shown the effectiveness and reliability of marine robotics solutions in several domains. Increasingly intelligent control and trajectory planning systems, high manoeuvrability, sophisticated anti-collision systems, as well as high data collection and processing capabilities have made robotic vehicles particularly well suited for industrial and scientific uses, including detection, monitoring and prevention of various types of pollution.

This section provides 17 statements on which we would be interested to hear your opinion. Please answer all the questions to the best of your knowledge. There are no "right or wrong" answers, nor your rankings will be shared with anyone outside the research team that is conducting this survey. Your rankings and comments will provide valuable feedback on the range of potential underwater robotics development over the next 10 to 20 years.

Please rate the degree to which you agree or disagree with the following statements, on a rating scale of 1-9 listed below, where 1 is 'very strongly agree' and 9 is 'very strongly disagree'. After every statement, there is an option for comments if you wish to further elaborate your opinion and provide additional information or explanation.

 Statement 1. Human input in operation of robotic vehicles will decrease. *
 1-Very strongly agree, 2-Strongly agree, 3-Agree, 4-Slightly agree, 5-Neither agree nor disagree, 6-Slightly disagree, 7-Disagree, 8-Strongly disagree, 9-Very strongly disagree.

Mark only one oval.

Underwater

robotics

detection, monitoring

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pollution

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41.	Additional comments (optional)	
42.	Statement 2. Development of AI will enable fully autonomous operation of * robotic vehicles.	:
	1-Very strongly agree, 2-Strongly agree, 3-Agree, 4-Slightly agree, 5-Neither agree nor disagree, 6-Slightly disagree, 7-Disagree, 8-Strongly disagree, 9-Very strongly disagree.	
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43.	Additional comments (optional)	
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44.	Statement 3. AI will be used in mission planning. *	
	1-Very strongly agree, 2-Strongly agree, 3-Agree, 4-Slightly agree, 5-Neither agree nor disagree, 6-Slightly disagree, 7-Disagree, 8-Strongly disagree, 9-Very strongly disagree.	
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The development of sensor technologies provides an excellent opportunity to improve the efficiency and safety of marine structures and environments. Real-time monitoring and analysis strategies are vital to improving commercial automation in shipping, logistics, marine and offshore activities. IoT devices and machine learning algorithms will contribute a certain level of intelligence for industrial control systems and answer problems that may arise in relation to the marine pollution.

The use of innovative sensor technologies is likely to overcome the problems of the under-sampling (in both space and time) of coastal waters and the ocean. Many engineering platforms are available on which sensors can be deployed in the environment and include buoys, floats, AUVs, gliders, benthic landers and moorings. By collecting high-quality data with reliable sensor technologies, the possibility of extending the life cycle of marine structures can be improved according to the highest standards of operation and maintenance. The development of a new generation of sensors and robust networking architectures will lead to revolutionary changes in environmental monitoring and data collection in the field of maritime technologies.

Sensors for detection, monitoring and prevention of marine pollution

This section consists of 14 statements on which we would appreciate to have your honest perspective. Please answer all the questions to the best of your knowledge. There are no "right or wrong" answers, nor your rankings will be shared with anyone outside the research team that is conducting this survey. Your rankings and comments will provide valuable feedback on the range of potential sensors development over the next 10 to 20 years.

Please rate the degree to which you agree or disagree with the following statements, on a rating scale of 1-9 listed below, where 1 is 'very strongly agree' and 9 is 'very strongly disagree'. After every statement, there is an option for comments if you wish to further elaborate your opinion and provide additional information or explanation.

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80.	Statement 4. Product of the statement of	oduc nitori	tion c ng an	ost of d large	sensoi er volur	r instrui me of p	ments roduct	will dec ion.	rease	due to		*
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82.	Statement 5. Num arrays will significa	ber of d antly ind	leploye crease.	d autor	nomou	s senso	or instru	uments	s and s	ensor '	k
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84.	Statement 6. Cable	ed obse	ervatori	es will	steadil	y decre	ase. *				
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11/07/2022, 15:04	Delp	hi survey or	n future tr	ends an	d techno	logies in	the field o	of maritim	ne techno	logies fo	r detectio	on, monitoring and preventio…
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90.	Statement 9. Remote sensor management will be based on IoT technologies. *											
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91.	Additional comr	nents (op	tional)									
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92.	Statement 10. Ir	ntegration	of loT	techno	ologies	in sens	ors wil	l becor	ne prev	/alent	*	
	solution for collection and transmission of pollution data.											
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94.	Statement 11. Use of Big Data technologies will become standard in * * interpretation of collected data.											
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96.	Statement 12. Ene	ergy har	vesting	techno	ologies	(e.g. s	olar po	wer, th	ermal a	and	*	
	autonomous sensor instruments.											
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98. Statement 13. Increase in offshore renewable energy facilities (wind and solar * farms) will create favourable opportunities for sensor instruments installation. 1-Very strongly agree, 2-Strongly agree, 3-Agree, 4-Slightly agree, 5-Neither agree nor disagree, 6-Slightly disagree, 7-Disagree, 8-Strongly disagree, 9-Very strongly disagree. Mark only one oval. 1 2 3 4 5 6 7 8 9 Very strongly agree	
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1 2 3 4 5 6 7 8 9 Very strongly agree Image: Im	
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99. Additional comments (optional)	
100. Statement 14. Increase in offshore renewable energy facilities will create * demand for monitoring and detection of small-scale pollution.	
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Delphi survey on future trends and technologies in the field of maritime technologies for detection, monitoring and preventio...

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