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 (https://www.italy-croatia.eu/web/innovamare), 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 sofija.stanic@mrezaznanja.hr.

* 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.

2. 1. Please indicate your gender: *

Mark only one oval.

- ◯ Male
- ◯ Female
- ◯ Other

3. 2. Please indicate your age: *

Mark only one oval.

- ◯ 25-34 years
- ◯ 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: _____

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

Mark only one oval.

- ◯ <5
- ◯ 5-9
- ◯ 10-14
- ◯ 15-20
- ◯ >20

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.

- Australia
- Austria
- Belgium
- Canada
- China
- Croatia
- Cyprus
- Denmark
- Estonia
- Finland
- France
- Germany
- Italy
- Ireland
- Japan
- Morroco
- Norway
- Poland
- Portugal
- Romania
- Slovenia
- South Korea
- Spain
- Sweden
- Turkey
- United Kingdom
- United States of America
- Other

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

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.

10. Statement 1. Underwater robotics and sensors will have significant impact in resolving challenge of pollution in Blue economy. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

11. Additional comments (optional)

12. Statement 2. Underwater robotics and sensors will have major role in cleaning seas and oceans from microplastics. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

13. Additional comments (optional)

14. Statement 3. Underwater robotics and sensors will have major role in cleaning seas and oceans from macroplastics. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

15. Additional comments (optional)

16. Statement 4. Underwater robotics and sensors will become the most important tools in prevention and detection of small-scale pollution events (small oil spills, chemical or nutrients pollution). *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

17. Additional comments (optional)

18. Statement 5. Remediation of marine pollution by marine (micro)organisms will be increased 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.

Mark only one oval.

	1	2	3	4	5	6	7	8	9	
Very strongly agree	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

19. Additional comments (optional)

20. Statement 6. Use of underwater robotics and sensors will play an important role in climate change mitigation. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

21. Additional comments (optional)

22. Statement 7. Underwater robotics and sensors will significantly contribute to development of sustainable fisheries and aquaculture. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

23. Additional comments (optional)

24. Statement 8. Underwater robotics and sensors will be used in different aspects of blue biotechnology. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

25. Additional comments (optional)

26. Statement 9. Underwater robotics and sensors will be used for stopping and preventing biodiversity loss. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

27. Additional comments (optional)

28. Statement 10. With the use of underwater robotics and sensors, negative environmental impacts of emerging “green” sectors will be prevented and detected (eg. disrupting seabed habitats for renewable energy production, or bycatch in the removal of marine litter and plastics). *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

29. Additional comments (optional)

30. Statement 11. Underwater robotics and sensors will improve efficiency of marine renewable energy technologies (eg. offshore wind, tidal and wave energy technologies, floating solar photovoltaic energy, hydrogen generation offshore). *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

31. Additional comments (optional)

32. Statement 12. Underwater robotics and sensors will significantly contribute to sustainable shipbuilding and sustainable maritime transport. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

33. Additional comments (optional)

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.

Mark only one oval.

	1	2	3	4	5	6	7	8	9	
Very strongly agree	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

35. Additional comments (optional)

36. Statement 14. Underwater robotics and sensors will significantly contribute to the sustainability of port activities. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

37. Additional comments (optional)

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.

	1	2	3	4	5	6	7	8	9	
Very strongly agree	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

39. Additional comments (optional)

Underwater robotics for detection, monitoring and prevention of marine pollution

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 high-quality 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.

40. 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.

	1	2	3	4	5	6	7	8	9	
Very strongly agree	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

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.

Mark only one oval.

	1	2	3	4	5	6	7	8	9	
Very strongly agree	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

43. Additional comments (optional)

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.

Mark only one oval.

	1	2	3	4	5	6	7	8	9	
Very strongly agree	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

45. Additional comments (optional)

46. Statement 4. Use of remotely operated robotic vehicles will decrease in favour of autonomous 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.

Mark only one oval.

	1	2	3	4	5	6	7	8	9	
Very strongly agree	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

47. Additional comments (optional)

48. Statement 5. Development of AI will enable detecting and removing plastic waste and debris. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

49. Additional comments (optional)

50. Statement 6. Development of underwater communication technologies for autonomous robotic vehicles will enable reliable navigation and data transmission, regardless of the depth. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

51. Additional comments (optional)

52. Statement 7. Development of underwater communication technologies will enable groups of coordinated robotic vehicles to cover large areas. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

53. Additional comments (optional)

54. Statement 8. Autonomous robotic vehicles will be able to find oil, chemical and nutrient pollution source in sea water by following increase in pollutant concentration. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

55. Additional comments (optional)

56. Statement 9. Development of advanced materials and micro- and nanoelectronics will improve sensors needed for 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.

Mark only one oval.

	1	2	3	4	5	6	7	8	9	
Very strongly agree	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

57. Additional comments (optional)

58. Statement 10. Use of robotic vehicles will eliminate the need for use of human operated research ships. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

59. Additional comments (optional)

60. Statement 11. Development of advanced materials and micro- and nanoelectronics will enable miniaturisation of robotic vehicles and sensor payloads. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

61. Additional comments (optional)

62. Statement 12. Advancements in battery technology, alternative power supply systems and energy efficient propulsion systems will at least double the operation time of untethered 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.

Mark only one oval.

	1	2	3	4	5	6	7	8	9	
Very strongly agree	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

63. Additional comments (optional)

64. Statement 13. In design and engineering will be applied solutions which imitate nature, i.e. features of some marine organisms. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

65. Additional comments (optional)

66. Statement 14. Development of renewable energy will decrease the number of offshore oil and gas platforms, reducing the need for monitoring and detection of pollution from these sources. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

67. Additional comments (optional)

68. Statement 15. Docking and deployment of robotic vehicles from ships or fixed stations will be completely automated with the need for human assistance only in case of malfunctions. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

69. Additional comments (optional)

70. Statement 16. Ships for deployment of robotic vehicles in open sea will be fully autonomous, without human crew. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

71. Additional comments (optional)

72. Statement 17. Some robotic vehicles will be widely available as “off the shelf” products, similar to current situation with air drones. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

73. Additional comments (optional)

Sensors for detection, monitoring and prevention of marine pollution

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.

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.

74. Statement 1. Development of advanced materials will decrease maintenance and replacement costs (e.g. increased durability to environmental conditions and resistance to fouling). *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

75. Additional comments (optional)

76. Statement 2. Development of advanced materials and micro- and nanoelectronics will increase research and development cost of sensor instruments. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

77. Additional comments (optional)

78. Statement 3. Research and development in advanced materials and micro- and nanoelectronics will significantly increase use of Lab-on-a-chip solutions. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

79. Additional comments (optional)

80. Statement 4. Production cost of sensor instruments will decrease due to demand for monitoring and larger volume of production. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

81. Additional comments (optional)

82. Statement 5. Number of deployed autonomous sensor instruments and sensor arrays will significantly increase. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

83. Additional comments (optional)

84. Statement 6. Cabled observatories will steadily 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.

	1	2	3	4	5	6	7	8	9	
Very strongly agree	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

85. Additional comments (optional)

86. Statement 7. Development of satellite technology for remote sensing will decrease the need for in situ 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.

Mark only one oval.

	1	2	3	4	5	6	7	8	9	
Very strongly agree	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

87. Additional comments (optional)

88. Statement 8. Autonomous sensors and arrays will decrease the need for use of human operated research ships. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

89. Additional comments (optional)

90. Statement 9. Remote sensor management will be based on IoT technologies. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

91. Additional comments (optional)

92. Statement 10. Integration of IoT technologies in sensors will become prevalent * solution for collection and transmission of pollution data.

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

93. Additional comments (optional)

94. Statement 11. Use of Big Data technologies will become standard in interpretation of collected data. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

95. Additional comments (optional)

96. Statement 12. Energy harvesting technologies (e.g. solar power, thermal and wind energy and salinity gradients) will become main power supply source for autonomous sensor instruments. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

97. Additional comments (optional)

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

99. Additional comments (optional)

100. Statement 14. Increase in offshore renewable energy facilities will create demand for monitoring and detection of small-scale pollution. *

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	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very strongly disagree

101. Additional comments (optional)

Thank your for taking the time to complete this survey!

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. If you have any queries regarding the survey, please do get in touch with Sofija Stanić via e-mail sofija.stanic@mrezaznanja.hr.