Measuring Individuals' Knowledge, Attitude and Behaviour on Specific Ocean Related Topics

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Abstract: In order to measure the effectiveness of Ocean Literacy (OL) tools we can measure people's knowledge of, and attitude and behaviour towards, specific ocean-related topics, both before and after their use of the tool. The research described in this paper aims at development of more accurate, focused survey tools. In particular we are interested in ensuring that we can accurately assess knowledge on specific topics, rather than assessing broad ocean literacy levels. Surveys were created to measure the levels of knowledge, attitude, and behaviour of university students. The topics which the surveys focused on were micro-plastics, coastal tourism, and sustainable fisheries. The knowledge, attitude, and behaviour questions in the surveys are based on work carried out as part of the H2020 ResponSEAble project on Ocean Literacy. The results show that while the students have a high level of pro-ocean-environmental attitude, their existing behaviour is low to medium, and their future intended behaviour is at a higher level than their existing behaviour. The findings provide useful pointers on how to improve both the ocean literacy tools (no statistically significant correlation between knowledge and either attitude or behaviour) as well as the design of the survey and questions themselves.

1 INTRODUCTION

It seems that nearly every day we see news articles relating the urgency of addressing issues regarding the health of our oceans and the welfare of the species that inhabit them. In terms of the life span of the Earth, and the current ocean ecosystems, humanities impact has been relatively brief, but devastating. Phenomena such as ocean acidification, bleaching of corals, plastics, overfishing and warming can all be directly related to human activity. From deep ocean trenches to remote Antarctic seas, we can find evidence of our impact on the ocean environment (Ocean Plastic, 2017).

Rather than blindly addressing symptoms, it is vital to address causes of problems. Intelligent solutions require that we understand the complex systems involved in the interplay between humans and the oceans. The processes and activities involved must be understood in order to target interventions such that they have significant impact. Complex supply chains often involve multiple activities and human actors (Trienekens et al., 2012), each with different requirements in terms of knowledge, influence and ability to act. For example, individual tourists and planning officers will have very different perspectives, knowledge and potential impact in terms of addressing problems caused by mass coastal tourism. The recent efforts to prevent plastic microbeads from entering our oceans and ecosystems is a good example (Xanthos and Walker, 2017). Social media campaigns and awareness-raising helped to change individual consumer's attitude and behavior, while governments took notice of the problem and legislated to ban microbeads from cosmetics products (Girard et al., 2016). Meanwhile, cosmetics producers are removing microbeads from their products and replacing them with sustainable alternatives (Microbead Ban, 2018).

In this paper we examine the measurement of Ocean Literacy (OL) as a means of assessing the effectiveness of OL initiatives and tools. This research can also be applied to measurement in other areas e.g. Environmental Literacy. An approach to measure environmental knowledge, attitude, and behaviour would involve chosing specific topics related to environmental literacy and creating surveys on those topics. Examples of environmental

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literacy topics which could be chosen are air pollution and energy use. The Literature Review section of this paper looks at existing measurement approaches (typically surveys) in relation to OL and the data analysis procedures applied. We then describe our work in designing surveys to assess OL on specific topics, rather than large topics covering broad OL. The Methodology section describes the actions taken to create our surveys, and gather the data. The Data Analysis and Results section describes the analytical techniques applied to the data, such as Rasch analysis, comparison between current and future behavior, and distractor analysis. The Discussion section discusses the findings from the data analysis and the Conclusion section contains the conclusions drawn from this research.

2 LITERATURE REVIEW

2.1 Measurement of Ocean Literacy

Existing research typically derives the definition of Ocean Literacy (OL) or Ocean Environmental Awareness from the broader concept of environmental awareness (Umuhire and Fang, 2016). It includes a person's ability to realize an existing connection between human activities and the state of the ocean, and a person's attitude towards a safe and healthy marine environment. The understanding of the impact of human activities was the subject of a European-wide survey of societal awareness and perceptions about marine litter (MARLISCO project).

It is desirable for people to have a higher level of knowledge and understanding in relation to the ocean, as well as improvements in attitudes, behaviours, and how we communicate on ocean issues with other people. By improving knowledge, attitude, and behaviour in relation to the ocean, people are empowered to grasp complex issues and make informed decisions regarding their behaviour, while also communicating on them with other people and institutions.

The objectives of this research are to (i) investigate ocean environmental awareness related dimensions, (ii) find what approaches are taken to measure these dimensions, and the data analysis procedures that can be used to generate useful information from responses to questionnaires and surveys, (iii) create and administer surveys to measure the levels of knowledge, attitude, and behaviour of students, and (iv) use the survey response data to identify weaknesses in the questions with respect to the survey goals.

This last objective (iv) helps us to explore the difficulties involved in measuring the effectiveness of ocean literacy tools and interventions, especially where they relate to quite narrow and specific topics such as micro-plastics, coastal tourism, and sustainable fisheries.

The five essential components of environmental literacy outlined by the Environmental Literacy Ladder (ELL, 2007) are Awareness, Knowledge, Attitudes, Skills, and Collective Action. Each of the components are seen as steps on a ladder towards environmental literacy, as shown in Figure 1. However, rather than viewing the levels possessed by an individual as steps on a ladder, it is more realistic to view it as a combination of ocean related dimensions. Using the ocean related dimensions, the levels possessed by a person can be measured as a combination of their level of knowledge related to ocean, the extent to which their attitude is pro-ocean-environmental, and how environmentally friendly their behaviour is in relation to the ocean. In our framework, awareness is defined as the basic knowledge that a situation, problem or concept exists. Knowledge is what a person knows about an ocean related topic and the links between topics. Attitude is related to a level of agreement with or concern for a particular position. Communication is the extent to which a person communicates with others, such as family and peer groups, on ocean related topics. Behaviour relates to decisions, choices, actions, and habits with respect to ocean related issues.

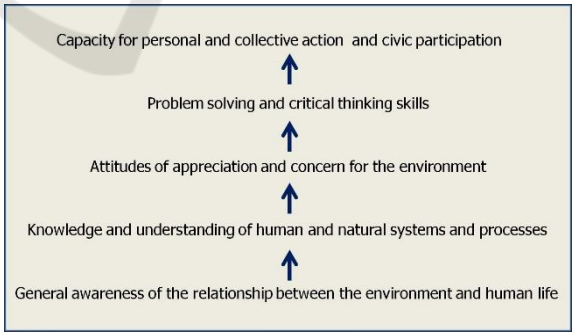

Figure 1: The Environmental Literacy Ladder.

Some of the existing approaches to measuring knowledge and awareness related to the ocean include the Survey of Ocean Literacy and Experience (SOLE) (Greely, 2008) and the International Ocean Literacy Survey (IOLS) (Fauville et al., 2018). Both surveys include similar

questions related to general knowledge about the ocean, e.g. how much of the earth is covered by the ocean, ocean circulation, the depth of the ocean, ocean resources, and the supply of salt to oceans by rivers. Having surveys on specific topics helps with the assessment of the impact of interventions which are targeted at specific topics. It is important to note that it is difficult to create a survey on specific topics because there may only be a small number of questions, on specific topics, that a person may know the correct answer to and it may also be difficult to establish a level of consistency of responses on a narrow range of questions.

2.2 Existing Data Analysis Approaches

Rasch analysis is an approach used to calculate a person's knowledge (called their "person ability"), item difficulties, error values, and fit values from responses to a set of questions. These values are then used to give an indication of how each respondent performed and the level of difficulty associated with each question. The level of error and fit associated with each question can be used to indicate questions which can be improved. The Rasch model is based on the idea that useful measurement involves examination of only one human attribute at a time and it provides a mathematical framework against which test developers can compare their data (Bond and Fox, 2007).

3 METHODOLOGY

The 3 surveys created as part of this research are based on 3 of the key story topics which are part of the ResponSEAble (2015) project. The key story topics are Micro-plastics (2018), Coastal Tourism (2018), and Sustainable Fisheries (2018). Each of the surveys contain the following 5 sections: (i) general respondent information e.g. country, city, age range, (ii) questions related to the knowledge possessed by the respondent regarding the topic, (iii) questions on the attitude of the respondent towards the topic, (iv) questions on the current behaviour of the respondent in relation to the topic, and (v) the future intended behaviour of the respondent in relation to the topic.

The surveys were created and administered online using Google Forms (2018). Google forms provide a way of creating and administering online surveys, and receiving and analysing the responses to the surveys. Bitly (2018) links were used to provide access to the surveys and all of the respondents to the surveys were undergraduate university students. The students surveyed were not involved in the ResponSEAble project and had not used any of the tools created as part of the project.

4 DATA ANALYSIS AND RESULTS

4.1 Descriptive Analysis

There were a total of 184 responses: 70 to the micro-plastics survey, 69 to the coastal tourism survey, and 45 to the sustainable fisheries survey. The respondents to the surveys were Irish university students, and their age range was between 18 and 24 years. 17 of the 70 respondents to the micro-plastics survey used the link to view the micro-plastics correct answers, 9 of the 69 respondents to the coastal tourism survey used the associated correct answers link, and 13 of the 45 respondents to the sustainable fisheries survey used the associated correct answers links. So, the percentage of respondents who used the associated correct answers links for the micro-plastics, coastal tourism, and sustainable fisheries was 24.3%, 13%, and 28.9%, respectively.

4.2 Correlation Analysis

The correlation analysis of the relationship between attitude and behaviour in relation to the surveys shows that a correlation does exist. The Pearson correlation r-value for the correlation between attitude and behaviour for the micro-plastics responses was found to be 0.495 with the correlation significant at the 0.01 level (2-tailed). The r-value for the correlation between attitude and behaviour for the coastal tourism responses was found to be 0.442 with the correlation significant at the 0.01 level (2-tailed). The r-value for the correlation between attitude and behaviour for the sustainable fisheries responses was found to be 0.296 with the correlation significant at the 0.05 level (2-tailed). No statistically significant correlation was found between knowledge and attitude or knowledge and behaviour for each of the 3 surveys.

The internal consistency of the questions used to measure the attitudes and behaviour of respondents was measured by performing correlations between each of the questions measuring attitude and each of the questions measuring behaviour. A statistically significant correlation was found for all of the

pairings except for the pairing between micro-plastics behaviour questions 15 and 16, and the pairing between sustainable fisheries attitude questions 11 and 12.

4.3 Reliability Analysis

The Cronbach's alpha statistical test was used to check the internal consistency of the attitude and behaviour questions.

Table 1: Mean, standard deviation, and Cronbach's alpha if item deleted for micro-plastics attitude and behaviour questions.

Question number	Mean	Standard deviation	Cronbach's alpha if item deleted
Q 9	8.19	1.77	0.536
Q 10	8.07	1.82	0.565
Q 11	8.6	1.62	0.919
Q 12	5.63	2.74	0.741
Q 13	3.56	2.92	0.751
Q 14	4.79	3.09	0.724
Q 15	5.37	2.96	0.782
Q 16	8.13	2.24	0.834

Table 2: Mean, standard deviation, and Cronbach's alpha if item deleted for coastal tourism attitude and behaviour questions.

Question number	Mean	Standard deviation	Cronbach's alpha if item deleted
Q 6	7.25	2.11	0.655
Q 7	6.71	2.34	0.706
Q 8	8.64	1.79	0.800
Q 9	7.16	2.93	0.876
Q 10	3.94	3.19	0.837
Q 11	3.07	2.92	0.821
Q 12	3.61	3.17	0.810
Q 13	4.52	3.30	0.856

Table 3: Mean, Standard Deviation, and Cronbach's Alpha if Item Deleted for Sustainable Fisheries Attitude and Behaviour Questions.

Question number	Mean	Standard deviation	Cronbach's alpha if item deleted
Q 10	8.49	1.34	0.358
Q 11	7.78	1.99	0.427
Q 12	7.80	2.19	0.744
Q 13	3.11	3.14	0.818
Q 14	2.49	3.27	0.849
Q 15	4.76	3.40	0.842
Q 16	3.13	3.24	0.821
Q 17	4.87	3.35	0.892

The resulting Cronbach's alpha value for the attitude questions in the survey on micro-plastics was 0.783, coastal tourism was 0.8, and sustainable fisheries was 0.604. The Cronbach's alpha value for the behaviour questions in the survey on micro-plastics was 0.808, coastal tourism was 0.869, and sustainable fisheries was 0.873. Tables 1, 2, and 3 show the question number, mean, standard deviation, and the "Cronbach's alpha if item deleted" for each of the attitude and behaviour questions in the 3 surveys.

4.4 Rasch Analysis

Person abilities are calculated by performing a log odds (logit) transformation on the percentage of questions a respondent has answered correctly (Bond and Fox, 2007). For example, to calculate the logit value for a percentage correct score of 64%, we calculate the odds of 64 to 36 by dividing 64/36, and then get the natural log of the result, which is +0.58 logits. The item difficulties are calculated similarly and are based on the percentage of times a question is answered correctly. The error value is an indication of the accuracy of the Rasch measure for a person ability or item difficulty and the error values are related to how many items or persons are positioned in the same area on the Rasch logit scale. The fit value for items is an indication of the extent to which a question appears to be measuring the unidimensional topic and the fit for a person can give an indication of unusual sequences of responses e.g. a person guessing the answers to questions. The "Outfit Zstd" values reported in tables 4, 5, and 6 are standardized fit statistics which are the result of t-tests of the hypothesis "Does the data fit the model (perfectly)?" (Outfit, 2018).

Tables 4, 5, and 6 show the Rasch estimates for the knowledge questions in the surveys. The tables are ordered by question difficulty with the most difficult question at the top. The "Question number" column shows the number of the question used in the survey. The "Total score" column contains the number of respondents who answered the question correctly. The "Measure" column contains the logit value which gives an indication of the difficulty of the question. The "Standard Error" column shows the error related to the Rasch measurement and the "Outfit Zstd" is the level of fit associated with the Rasch measurement.

5 DISCUSSION

The results of the descriptive analysis shows that the survey respondents have a slightly higher level of knowledge about sustainable fisheries (mean 51.85%) when compared to knowledge of micro-plastics (mean 48.93%). The level of knowledge possessed by the respondents with regard to coastal tourism is the lowest at 39.71%. The respondents to the sustainable fisheries survey have the highest percentage (28.9%) for viewing the correct answers to the knowledge questions, followed by the percentage (24.3%) of respondents who viewed the correct answers to the micro-plastics knowledge questions, and the percentage who viewed the correct answers to the coastal tourism knowledge questions is the lowest at 13%.

The mean scores for the attitude questions in the 3 surveys are similar with the attitude score for micro-plastics the highest at 8.29, followed by sustainable fisheries at 8, and coastal tourism with the lowest at 7.53. The mean scores for the current behaviour responses were highest for micro-plastics (5.49), followed by coastal tourism (4.46), and sustainable fisheries had the lowest (3.67). The mean scores for future behaviour are all higher than the scores for current behaviour with the score for micro-plastics (6.9) the overall highest, and similar mean scores for sustainable fisheries and coastal tourism at 5.78 and 5.71, respectively. A comparison of the results of the current and future behaviour questions shows that, in general, respondents intend to improve their behaviour in the future.

5.1 Correlations

A medium correlation was found between attitude and behaviour for the responses to the surveys. The Pearson correlation r-value of 0.224 found by Yoon Fah and Sirisena (2014) for the relationship between environmental attitudes and environmental behaviours is slightly lower than the r-value of 0.296 found in this research for the relationship between attitude and behaviour with regard to sustainable fisheries. The r-values for attitude and behaviour for the micro-plastics and coastal tourism surveys are higher at 0.495 and 0.442, respectively. Michalos et al. (2017) found an r-value of 0.35 for attitudes and behaviour towards sustainable development which is slightly higher than the r-value found in this research for the same relationship related to sustainable fisheries. One of the behaviour questions in our sustainable fisheries survey relates to supporting campaigns that tell people to eat seafood that is sustainably sourced. There is no attitude question in the sustainable fisheries survey which relates to attitude towards supporting campaigns. This could be an indication of why the r-value for the correlation between the attitude and behaviour questions, in the sustainable fisheries survey, is the lowest.

The reason why no significant correlation was found between knowledge and attitude or knowledge and behaviour could be related to the quality of the questions. If the knowledge questions were more aligned with measuring knowledge related to the specific topics being measured in the attitude and behaviour questions, a significant correlation may exist. One of the coastal tourism attitude questions measures how worried respondents are about the effects of coastal tourism activities on the marine environment. Adding a knowledge question to the survey which tests knowledge related to coastal tourism activities may help to identify the knowledge which relates to a high level of pro-ocean-environmental concern in relation to coastal tourism activities. An example of such a question would be "How does the activity of cleaning seaweed from a beach impact the coastal environment?" Care should be taken to ensure that aligning the knowledge questions with the attitude and behaviour questions will not constrain the measurement too much and will not create questions that are too difficult.

5.2 Reliability

The Cronbach's alpha values for the attitude and behaviour question in the surveys show an acceptable to good reliability except for the attitude questions in the sustainable fisheries survey. The Cronbach's alpha value for the attitude questions in the sustainable fisheries survey was 0.604. This value could be increased to 0.744 if attitude question 12 was removed from the survey, as shown in table 3. Question 12 in the sustainable fisheries survey is related to both the benefit to the marine environment and the fishing industry of buying and eating seafood that is labelled sustainable. This question could be improved by dividing it into 2 questions, one which relates to the benefit to the marine environment and another which relates to the fishing industry.

5.3 Rasch Estimates

The Rasch analysis of the knowledge questions (table 4) in the micro-plastics survey shows that the

most difficult question was question 5 “Select products which might have contained micro-beads in the past” and the least difficult question was question 7 “Where does the majority of our plastic waste end up?”. The respondents and questions are grouped towards the centre of the logit scale in the Rasch person-item map which indicates that the questions are not measuring the upper and lower respondent abilities. The Rasch person-item map provides a visual representation of the positioning of person abilities and item difficulties in relation to each other along a vertical logit scale (Bond and Fox, 2007).

Table 4: Rasch estimates for micro-plastic survey knowledge questions.

Question number	Total score	Measure	Standard Error	Outfit Zstd
Q 5	17	1.34	0.31	-1.0
Q 4	31	0.23	0.27	-0.3
Q 3	32	0.15	0.27	-0.5
Q 1	33	0.08	0.27	-1.4
Q 8	34	0.01	0.26	1.7
Q 2	37	-0.20	0.26	4.0
Q 6	38	-0.27	0.27	-1.3
Q 7	52	-1.35	0.30	-0.5

The error associated with each of the questions is low due to the fact that there are a lot of respondents grouped at the same logit level as the questions. The Oufit Zstd value for question 2 is 4.0 which is well outside the acceptable range of -2 to 2. This means that question 2 does not fit with the unidimensionality of the micro-plastics survey. Question 2 is “Which of the face wash ingredients shown might be micro-plastics?” An image and a list of options to choose from are provided to the respondent. The correct answer to the question is a single option but the format of the question allowed the respondent to choose multiple options. This may explain why question 2 had poor fit in the Rasch analysis. To improve the fit of this question the format of the question could be changed to only allow the respondent to choose one option. The rest of the knowledge questions in the micro-plastics survey have Oufit Zstd values which are within the acceptable range. Improving the set of micro-plastic knowledge questions, with a view to making them a more effective scale to measure the levels possessed by respondents, would involve creating more knowledge questions that are more difficult and less difficult. These new questions could be combined with the existing questions, the survey could then be administered to another cohort, and Rasch analysis could be used to check the improvement of the questions as a scale to measure micro-plastic knowledge.

The Rasch analysis of the coastal tourism knowledge questions (table 5) shows that the most difficult question is question 3 “Please choose the main effects of coastal development from the list below” and the least difficult question is question 1 “The picture below shows a paradise beach in the middle of summer. There is an artificial rock barrier in front of the beach. What is the function of the artificial rock barrier?” The person-item map shows that the questions are spread out along the logit scale with questions 2, 5, and 1 measuring ability below the zero logit point and questions 3 and 4 measuring abilities above the zero logit point. The zero logit point on the logit scale is the mean point of the item difficulty estimates (Bond and Fox, 2007).

Table 5: Rasch estimates for coastal tourism survey knowledge questions.

Question number	Total score	Measure	Standard Error	Outfit Zstd
Q 3	3	3.01	0.62	-0.4
Q 4	18	0.59	0.31	0.7
Q 2	32	-0.60	0.28	-0.1
Q 5	32	-0.60	0.28	-1.6
Q 1	52	-2.40	0.35	2.9

The error associated with the Rasch measure for each of the respondents is larger than the error associated with the items which is due to the fact that there are only 5 coastal tourism knowledge questions and they are spread out along the logit scale. To increase the effectiveness of the coastal tourism knowledge questions, more knowledge questions could be created to measure the levels of knowledge in between the existing knowledge questions. As well as being the least difficult question, question 1 is also the question with an Outfit Zstd value of 2.9 which is outside the acceptable range of -2 to 2. The reason question 1 does not appear to fit with the measurement of respondents’ knowledge related to coastal tourism may be due to the fact that question 1 is a question more related to coastal erosion than coastal tourism. To improve the fit of this question, it would need to be changed to focus more on coastal tourism.

The Rasch analysis of the sustainable fisheries knowledge questions (table 6) shows that the most difficult question is question 1 “What is the kind of fishing shown in the image below?” and the least difficult question is question 5 “The picture below shows a Cod (Gadus morhua) fish. Where does the

Cod species live?" It would be interesting to establish why the respondents scored so highly on this question; perhaps due to their proximity to the North Atlantic. As such it might highlight the importance of location-specific surveys based on what is considered common knowledge. It also highlights its relative lack of usefulness as a discriminator.

Table 6: Rasch estimates for sustainable fisheries survey knowledge questions.

Question number	Total score	Measure	Standard Error	Outfit Zstd
Q 1	2	3.59	0.76	-0.2
Q 8	14	0.91	0.36	0.7
Q 7	23	-0.11	0.33	1.0
Q 2	25	-0.33	0.33	-0.2
Q 9	25	-0.33	0.33	2.1
Q 4	27	-0.55	0.33	-0.6
Q 6	29	-0.77	0.34	-0.7
Q 3	31	-1.01	0.35	0.3
Q 5	34	-1.40	0.37	-0.3

The person-item map for the sustainable fisheries knowledge questions shows that most of the questions are grouped below the zero logit point which means that they are providing measurements of respondents with medium to low knowledge levels. Questions 1 and 8 are the only questions above the zero logit point. Improving the set of sustainable fisheries knowledge questions as a scale to measure knowledge related to sustainable fisheries would involve creating more knowledge questions to measure those respondents with medium to high knowledge related to sustainable fisheries. The positioning of the respondents with medium to high knowledge of sustainable fisheries has a larger error than the positioning of those with medium to low knowledge. This is due to the fact that there are less questions in the medium to high knowledge section. The "Outfit Zstd" value for question 9 is 2.1 which is just outside the acceptable range for fit. Question 9 relates to the percentage of the global population that depends on the ocean for food. A way of attempting to improve this question could involve adding more specific information to the wording of the question.

5.4 Question Distractors

The distractor analysis of the micro-plastics knowledge questions indicated that questions 4 and 7 could be improved. Question 4 is "Sunlight can degrade plastics in the ocean: true or false?" More respondents chose the incorrect (false) answer than the correct answer. This question could be improved by adding a third option to allow the respondent to indicate if they are unsure about the answer. Question 7 is "Where does the majority of our plastic waste end up?" and less than 5% of respondents chose the options "Burned for energy" and "Recycled". This question could be improved by removing these answer options and possibly adding in an option which would successfully attract respondents who are unsure about the correct answer.

6 CONCLUSIONS

A person's level of knowledge on an ocean related topic, and their attitude and behaviour towards that topic are important dimensions to measure and can be used to measure the effectiveness of ocean literacy and general ocean environmental awareness related tools and initiatives. An effective approach to measuring these dimensions involves asking people to respond to questionnaires or surveys on topics related to the ocean. There were 3 surveys created in this research which measure respondent's knowledge, attitude, and behaviour related to the topics of micro-plastics, coastal tourism, and sustainable fisheries. The data from responses to the surveys was used to measure the level of knowledge, attitude, and behaviour possessed by the respondents in relation to the topics and it was also used to indicate how the contents of the surveys might be improved. In this research, the level of knowledge possessed by the students on micro-plastics, coastal tourism, and sustainable fisheries was found to be slightly below medium. A statistically significant correlation was found between attitude and behaviour for the 3 topics, but no significant correlation was found for the relationship between knowledge and attitude or behaviour. The use of Cronbach's alpha analysis, Rasch analysis, and distractors analysis has provided results which can be used to improve the effectiveness of the questions contained in the surveys. This research has highlighted the difficulty in creating reliable and consistent survey instruments for relatively narrow topics.

In future research, it would be useful to apply the results of the data analysis to a review of the contents of the surveys with a view to improving the questions, so that the knowledge which correlates with a pro-ocean-environmental attitude and behaviour can be identified. The improved questions

could then be used as a scale to measure the respondent's levels of knowledge, attitude, and behaviour in relation to the topics. The contents of the surveys could be used to inform the measurable objectives of the Theory of Change framework (ToC, 2019). The information required by a respondent to answer the questions on the knowledge scale could then be incorporated into the existing tools created as part of the ResponSEAble project. Structural Equation Modelling and Confirmatory Factor Analysis could be used as part of the process of improving the survey questions by creating a model of which types of knowledge related to a topic are factors in the level of pro-ocean-environmental attitude and behaviour possessed by respondents.

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