MASTER THESIS

"The Impact of Education and Environmental Awareness on Mental Model Complexity: A Comparative Study of Dutch Young Adults' and Ocean Experts' Perceptions of Quality of Life in the Ocean."

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"The Impact of Education and Environmental Awareness on Mental Model Complexity: A Comparative Study of Dutch Young Adults' and Ocean Experts' Perceptions of Quality of Life in the Ocean."

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Abstract

This study examines the complexity of mental models (MMs) concerning the quality of life (QOL) in the ocean among young adults in the Netherlands and compares these with those of ocean experts. The research aims to understand how educational levels and environmental awareness influence the complexity of these MMs. Using the M-Tool for mapping and a follow-up survey, two primary sample groups were analysed: young adults and ocean experts. The study focuses on two research questions:

Question 1: What are the characteristics of the mental models of young adults and ocean experts concerning the quality of life in the ocean?

Question 2: What is the relationship between environmental awareness and educational level in the complexity of individuals' mental models?

Results indicate that both young adults and experts identify similar key drivers affecting ocean QOL, such as humanity and climate change. However, experts emphasise additional factors like marine habitats and biodiversity, which young adults tend to overlook. The complexity of MMs, measured by the number of interconnected concepts (nodes) and relationships (edges) per node, was notably higher among experts. This finding supports the hypothesis that experts possess a more nuanced understanding of the systemic interactions influencing ocean QOL.

Regarding educational levels, the study finds a positive relationship between higher education and MM complexity, primarily reflected in the increased number of relationships among concepts rather than the number of concepts themselves. This suggests that higher education enhances the ability to perceive and understand complex systems, corroborating previous research on the benefits of systems thinking in education. Conversely, the expected positive relationship between environmental awareness and MM complexity was not observed. Higher environmental awareness did not necessarily equate to a deeper understanding of the systemic relationships affecting ocean QOL, highlighting a gap between awareness and comprehensive systems knowledge.

These findings emphasise the importance of integrating systems thinking into all curricula for all educational levels to foster a more holistic understanding of environmental issues. The study suggests that while both young adults and experts recognise key drivers of ocean QOL, there is a significant disparity in their ability to understand the interconnected nature of these drivers. The results underline the need for enhanced educational frameworks and policies that promote systems thinking and ocean conservation across all educational levels to better address complex environmental challenges.

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1. List of Abbreviations

Term	Definition
GHG	Greenhouse Gases
MMs	Mental Models
SDB	Social Desirability Bias
QOL	Quality of Life

2. Glossary

Term	**Definition**
Environmental Awareness	Environmental awareness is a state of being aware, having knowledge about, and being conscious of the environment humanity lives in.
Trophic Cascades	Removal of higher trophic levels, shifting dominance and impacts of consumers to lower levels.
Mental Models	An individual's understanding of the causal dynamics within a system, drawing upon their personal experiences, knowledge, and values.
Marine Environment	Refers to the ocean and seas, including all life forms and physical features within them.
Quality of Life in the Ocean	Refers to the overall well-being and health of marine ecosystems, including the diverse flora and fauna that inhabit them.

3. Introduction

The majority of the earth's surface is covered by the ocean, accounting for more than 71% (Häder et al., 2020). Playing a pivotal role in climate stabilisation, the ocean regulates weather patterns, local climates, coastlines, and the well-being of both marine and terrestrial life (Liu et al., 2019). All organisms rely on their natural environment for sustenance, growth, nutrition, and development (Priya et al., 2023). Consequently, any alterations to the environment can profoundly impact the quality of life (QOL) for all living entities. The well-being of the ocean and its ecosystems is determined by the temperature, PH and oxygen level, and production (Frölicher et al., 2020). Despite its significance as a vital human resource, the ocean faces substantial threats with degraded marine ecosystems that are less resilient, productive, and diverse (Franke et al., 2020). Direct usage and upstream activities impact ecosystem well-being due to either natural or anthropogenic stressors (Levin & Lubchenco, 2008; Oesterwind et al., 2016). Certain anthropogenic activities pose direct threats to the ocean, such as overfishing (Brito-Morales et al., 2022), pollution (Kachel, 2008; Peng et al., 2020), invasive species (Kernan, 2015; Molnar et al., 2008), and sewage (Liu et al., 2019).

Studies have been investigating the impact of these threats on ocean well-being, noting that the scale of impact due to anthropogenic activities is growing (Christensen et al., 2007). Firstly, overfishing reduces marine diversity and triggers trophic cascades (Daskalov, 2002; Jackson et al., 2001; Steneck, 1998). Secondly, pollution, including oil spills and various discharges, damages ecosystems and creates dead zones in coastal areas (Macías-Zamora, 2011). Thirdly, plastic pollution threatens marine life and accumulates in mid-ocean gyres, while petroleum-based pollutants inhibit marine microorganism photosynthesis, impacting oxygen generation (Landrigan et al., 2020). Another prominent threat is ocean acidification, which affects marine ecosystems, such as algae and corals, moreover, poses risks to human health (Falkenberg et al., 2020; Leung et al., 2022).

Given humanity's heavy reliance on the ocean, understanding human-ocean interactions, and staying informed about changes in ocean ecosystems are crucial. Rock et al. (2019) highlight a growing awareness of this dependence, leading to increased concern over oceanic degradation caused by human activities. As scientific knowledge evolves, awareness of significant changes in the ocean increases (Roberts, 2003). Perceptions of these changes are influenced by factors such as the aesthetics, economic value, and cultural significance of the ocean (Allison & Bassett, 2015; Brito & Vieira, 2016). However, young adults' understanding of ocean issues remains limited (Ballantyne, 2004), even though they will face long-term consequences of current decisions (Wootton et al., 2024). Moreover, there is a notable gap between scientists' and the public's perceptions of marine environments (Eleiton et al., 2015; Lotze et al., 2018).

Recent environmental psychology studies have increasingly focused on public perceptions of the ocean (Giglio et al., 2022; Jefferson et al., 2014; Liu et al., 2023), but often overlook how well individuals can map and understand ocean systems. Mental models (MMs) —internal representations of the external environment shaped by personal experiences and knowledge (Van Den Broek et al., 2021a)—are useful for illustrating individuals' understanding of system causality. MMs help researchers visualize how people perceive and engage with ocean ecosystems through their internal maps of system components and their interrelations (Van Den Broek et al., 2023). While some studies have applied MMs to explore perceptions of marine pollution (Phelan et al., 2020), sea-level changes (Thomas et al., 2015), and children's views of marine environments (Atasoy et al., 2020), further research is crucial to deepen the understanding of how young adults perceive ocean well-being. Additionally, it is important to examine the disparity in perceptions of the ocean between young adults and scientists. Identifying gaps in public knowledge can guide the development of educational programs and resources (Lotze et al., 2018). Effective education can help bridge these gaps and foster a more knowledgeable and proactive public.

MMs vary among individuals, with some recognizing the holistic nature of systems, while others solely focus on individual components, neglecting the broader context (Arnold & Wade, 2015). MMs can vary among individuals in terms of complexity, by examining the interrelations between the components and their content (Van Den Broek et al., 2023). More complex MMs, as noted by Goldberg et al. (2020), enable a deeper understanding of the intricate relationships within systems.

MM complexity can be influenced by multiple factors (Van Den Broek et al., 2023). Research has demonstrated that higher education often correlates with greater MM complexity. Studies by

Flotemersch & Aho (2020), Hamilton (2010), and Yang et al. (2020) indicate that individuals with higher levels of education typically possess more extensive knowledge, which contributes to more intricate MMs. Conversely, those with lower education levels may exhibit illusory knowledge, a cognitive bias where individuals overestimate their understanding (Begg et al., 1996). Moreover, Driver & Streufert (1969) propose that acquiring more knowledge leads to the development of more complex cognitive systems. This suggests that increased education enhances knowledge, which in turn results in more intricate MMs. Studies have indicated that education may influence the complexity of MMs, however, there is a lack of research on whether this applies to MMs of environmental systems or, more specifically, marine systems. Studies have explored MMs related to the ocean (Atasoy et al., 2020; Liu et al., 2019; Uehara, 2020), but have not specifically examined how educational background impacts the complexity of these models. While research has addressed the effects of education on MMs of environmental issues (Atasoy et al., 2020; Shepardson et al., 2007) and ocean literacy (Lin et al., 2020), there is a gap in understanding how education influences MM complexity concerning marine environments. Addressing this gap is crucial for understanding how educational attainment may shape perceptions and system knowledge of marine QOL, which could inform targeted educational interventions and policy-making. As educational programs are known to be effective in enhancing scientific knowledge (Torres et al., 2019).

Furthermore, an individual's environmental awareness can influence the complexity of MMs related to environmental systems. Environmental awareness is closely connected to an individual's capacity to observe and reflect upon what they have learned (Hadzigeorgiou & Skoumios, 2013). With increased knowledge and conscious understanding of a system, individuals can develop a more nuanced and intricate comprehension of that system (Johnson, 2003). Goldberg et al. (2020) argue that more complex MMs reflect a deeper exploration of the intricate relationships within systems. Thus, heightened environmental awareness is likely to correlate with the development of more complex MMs. To date, research has not established a direct link between environmental awareness and the complexity of MMs, focusing instead on attitudes or general knowledge about the environment (Arcury, 1990; Safari et al., 2018; Sali et al., 2015). Understanding how environmental awareness influences the complexity of MMs concerning QOL in the ocean is crucial. This knowledge can inform policy-making and enhance communication strategies aimed at ocean well-being. Specifically, if increased environmental awareness leads to more complex and accurate MMs, it underscores the need to promote environmental awareness and effectively communicate these policies. By bridging this research gap, policymakers can tailor their approaches to foster better public understanding and engagement with ocean conservation efforts.

Recognising the ocean's critical role in providing essential ecosystem services (Sandifer & Sutton-Grier, 2014), it is vital to understand the knowledge and perceptions of the younger generation regarding its well-being. This study aimed to enhance the understanding of MMs that young adults hold concerning the QOL in the ocean. Additionally, compare young adults' MMs with those of scientists (ocean experts) to better understand the disparity in ocean perception. Given that young adults are pivotal for shaping future policies and contributing to ocean well-being (Ballantyne, 2004), it is essential to explore how their educational background and environmental awareness influence the complexity of these MMs. Investigating these factors will inform more effective communication strategies by tailoring messages to resonate with public values, enhance educational programs by integrating systems thinking to improve environmental literacy, and shape policies by emphasising the interconnectedness of economic, aesthetic, and cultural aspects of ocean conservation. This study addressed the following research questions:

Question 1: What are the characteristics of the mental models of young adults and ocean experts concerning the quality of life in the ocean?
Question 2: What is the relationship between environmental awareness and educational level in the complexity of individuals' mental models?

By addressing these questions, the study aimed to bridge the gap in research and offer valuable insights for policy-making and communication strategies aimed at enhancing ocean well-being. Additionally, it intended to inform educational programs designed to improve understanding of ocean systems.

4. Theoretical Background

This study has examined the impact of educational level and environmental awareness on the complexity of MMs related to the ocean. The theoretical background covers QOL, MMs, and how MM complexity is influenced by education or environmental awareness, along with the derived hypothesis. Lastly, it addresses potential confounding variables that may influence MM complexity.

4.1 Quality of Life in the Ocean

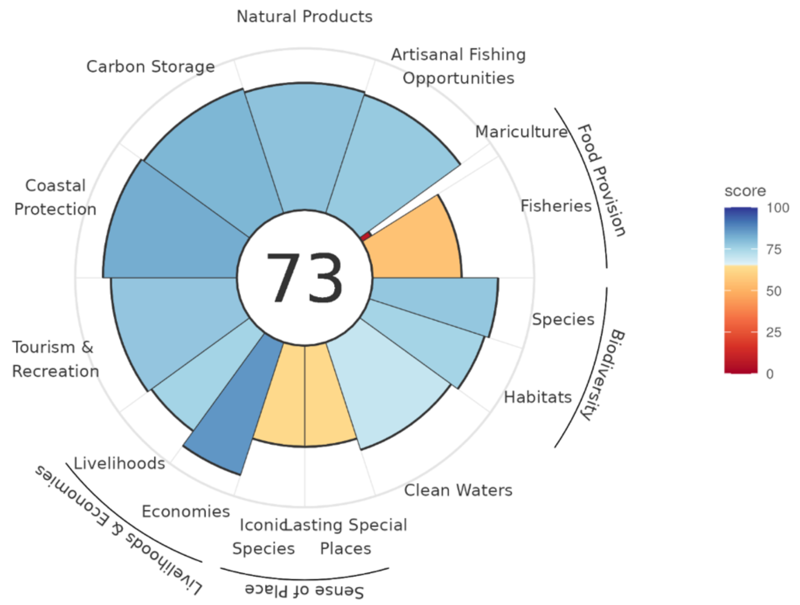
QOL is a concept used to evaluate the overall well-being and specific circumstances of individuals or groups, defined by life conditions and satisfaction of life (Felce & Perry, 1995). When applied to the ocean, it pertains to the state of ocean ecosystems and the well-being of marine life, specifically looking at the resilience, productivity, and diversity of the ocean (Franke et al., 2020). Jones (1984) describes the ocean as the sea area where oceanic currents are stronger than tidal currents. The ocean is a vast body of water that covers over 70% of the Earth's surface, with an average depth of 3,800 metres (Dempsey, 2023). All living organisms inhabiting these vast water bodies are considered as life in the ocean, further referred to as marine life.

The *diversity* and variety of marine life are fundamental for ocean well-being. Concerning diversity, one can rely on marine biodiversity, Palumbi (2008) defines this as "the variety of life in the sea, encompassing variation at levels of complexity from within species to across ecosystems." The biodiversity of marine life largely influences climate, water quality, many ocean state variables (temperature and nutrient, carbon, and oxygen concentration), and bottom structure, such as reefs (Estes et al., 2021). The concept of "*resilience"* is defined by Franke et al. (2020) as the ability of ecosystems to recover from disturbances, and to return to a previous course rather than to a specific state. Moreover, the *productivity* of marine environments plays a crucial role in the functioning of ecosystems (Franke et al., 2020). It serves as a fundamental support for biological diversity, contributes to economic productivity, and is vital for carbon sink. A productive marine ecosystem is essential for global conservation. The provision of ecosystem services including aspects like food security and climate regulation, relies on ocean productivity throughout the entire marine trophic web, referring to the complex network of feeding relationships and interactions among different organisms in a marine ecosystem (Fermepin et al., 2024).

Recently, changes have been marked in the physical and chemical structure of the ocean. Despite the human dependence on the ocean, humans have negatively impacted them through both direct and indirect means (Ban & Alder, 2007; Halpern et al., 2008). There are changes visible in sea level, temperature, surface winds, ocean circulation, oxygen concentration, and ocean pH. Many of these changes have important consequences for all marine life (Estes et al., 2021).

The global Ocean Health Index assesses the health of the ocean, assigning in 2023 a score of 73 out of 100. This score reflects the anticipated ecological, social, and economic benefits derived from a healthy ocean. Lower scores signify poor conditions or a deterioration in services (Ocean Health Index, 2023). See Figure 1 for the attributed score in 2023 and the scoring of each benefit.

Figure 1 Ocean Health Index Score & Conditions 2023 (Ocean Health Index, 2023)



Research on the challenges faced by marine environments and life has gained increased interest, alongside a growing awareness amongst the public (Rock et al. 2019). Researching people's perspectives on these topics fosters an understanding of the reasons behind their behaviours, as human expertise in ecological and biological processes is what fundamentally underlays their interaction with these environments (Boschetti & Andreotta, 2017). Eleiton et al. (2015) conducted a literature review on public perceptions of marine environments, uncovering a noteworthy disparity between scientists and the public. While the public prioritised pollution, litter, and large-scale industrialisation as major threats, scientists emphasised climate change, eutrophication, and overfishing. Participants, when asked about indicators of marine health, highlighted damaged habitats and low marine diversity as signs of an unhealthy sea. Notably, the review found that a significant portion of individuals considered marine health a relatively low priority, with only 46% recognising its importance.

4.1.1 Drivers Influencing Quality of Life in the Ocean

To determine the well-being of the ocean, four primary factors are considered: (1) the temperature of water, (2) PH-level, (3) oxygen level, and (4) Net Primary Production (Frölicher et al., 2020; Oschlies et al., 2018). These factors are dynamic and influence the productivity, biodiversity, and resilience of marine ecosystems (Maxwell et al., 2015). Understanding the processes and relationships governing these aspects is crucial to comprehend the ocean's response to various perturbations (Murawski et al., 2009). The ecosystems can be impacted by direct usage and upstream activities (Levin & Lubchenco, 2008), either due to natural or anthropogenic factors (Oesterwind et al., 2016). These drivers have been categorised into two main groups: (1) natural factors and (2) anthropogenic factors. Table 1 presents a compilation of these drivers, organised into these categories.

Table 1 Drivers of QOL in the Ocean Identified in Academic Literature.

	Driver	***Definition***	***References***
Natural Factors	Abundance of animals and habitats	The extent to which animals or habitats are present in an ecosystem. It indicates how many individuals of a species or how many different habitats there are within a specific location.	Crowder & Norse, 2008; Murawski et al., 2009
	Diversity of animals and habitats	The variety of species (biodiversity) or different habitats within an ecosystem. It indicates how many different species there are and how many different habitat types are found within a specific location.	Borja et al., 2011; Crowder & Norse, 2008; Levin & Lubchenco, 2008; Murawski et al., 2009
	The ecological interaction between species	The relationships and interactions between different species in an ecosystem. These interactions can range from food relationships (e.g., predation, herbivory) to symbiotic relationships (e.g., mutualism, commensalism) and competition	Borja et al., 2011; Crowder & Norse, 2008; Murawski et al., 2009
	The change or loss of habitat	The decline or modification of a species' habitat.	Crowder & Norse, 2008; Levin & Lubchenco, 2008; Murawski et al., 2009
	Ocean resilience	The ability of the ocean to recover from disturbances or damage caused by human activities or natural events. A resilient ecosystem can adapt and recover from disturbances.	Borja et al., 2011; Levin & Lubchenco, 2008; Murawski et al., 2009
	Climate change	Climate change refers to the long-term changes in Earth's average weather patterns. Examples in the ocean include eutrophication (growing algae), ocean acidification, etc.	Borja et al., 2011; Levin & Lubchenco, 2008;

			Murawski et al., 2009
Anthropogenic Factors	Extraction of living resources	The activities in which living organisms are harvested from natural ecosystems. Such as aquaculture, recreational, and commercial fisheries.	Borja et al., 2011; Levin & Lubchenco, 2008; Murawski et al., 2009; Pletterbauer et al., 2017
	Shipping	The activity of vessels transporting goods or people along waterways, such as seas and rivers. It includes both commercial shipping and recreational vessels.	Borja et al., 2011; Levin & Lubchenco, 2008; Pletterbauer et al., 2017
	Human recreation	The activities people engage in for recreation, fun or leisure. Such as scuba diving, boating, swimming, etc.	Levin & Lubchenco, 2008; Pletterbauer et al., 2017
	Drilling and extraction of gas and oil	The process of extracting fossil fuels such as natural gas and crude oil from underground reservoirs.	Borja et al., 2011; Levin & Lubchenco, 2008; Pletterbauer et al., 2017
	Coastal developments	The construction of infrastructure and buildings along the coastline, such as ports, beach hotels, vacation homes and industrial areas.	Levin & Lubchenco, 2008; Pletterbauer et al., 2017
	Introduction of exotic species, parasites, and diseases	The introduction of non-native species (exotics) into an ecosystem, often as a result of human activities such as international trade and transportation.	Borja et al., 2011; Levin & Lubchenco, 2008; Murawski et al., 2009
	Pollution	The presence of harmful or undesirable substances in the environment, such as chemicals or plastics, among others.	Borja et al., 2011; Levin & Lubchenco, 2008; Pletterbauer et al., 2017

4.2 Mental Models

MMs represent an individual's understanding of the causal dynamics within a system, shaped by their personal experiences, knowledge, and values (LaMere et al., 2020). The significance of establishing MMs has grown in the realm of psychological research, serving as a framework for understanding human perception and thought processes. Researchers have increasingly relied on this concept to explore people's perceptions and cognitive patterns, constructing representations of their external world and assumptions about how systems operate (Carley & Palmquist, 1992; Van Den Broek et al., 2021a). MMs offer insight into specific system components and their causal relationships, shaped by individual experiences, cultural backgrounds, values, and beliefs. Individuals utilise their MMs to filter, process, and store information (Van Den Broek et al., 2023).

Research on MMs concerning marine environments is limited, with existing studies primarily focusing on children in Taiwan (Liu et al., 2019), Japan (Uehara, 2020), and Turkey (Atasoy et al., 2020). Both Atasoy et al. (2020) and Liu et al. (2019) utilised drawing activities to visualise MMs, discovering that students with more comprehensive MMs had a better perception of pollution issues in marine environments, as they were better able to connect the ecosystem with the problems affecting marine life. Uehara (2020) employed poster sessions and a questionnaire to explore children's MMs on marine plastic waste, highlighting a generally limited understanding among younger generations.

While Liu et al. (2019) and Uehara (2020) focused on MM discrepancies, Atasoy et al. (2020) suggested a parallelism between children's MMs and their grade levels.

Studies show that MMs are influenced by individual experiences, leading to different MMs for each stakeholder (Fazey et al., 2006). Distinctions identified in MMs are evident in terms of content or complexity. Regarding content, the use of different elements in an MM leads to distinctions, and complexity can be analysed by examining the number of concepts and the connectivity between these concepts (Gray, 2018; Van Den Broek et al., 2023). Individuals with more complex MMs are often better able to comprehend the interconnectedness of elements within a system. (Goldberg et al., 2020). This understanding provides insights into an individual's comprehension of a specific system.

4.2.1 Educational Level Influencing Mental Model Complexity

Similar to Atasoy et al (2020), Shepardson et al. (2007) identified increased MM complexity at higher grade levels, focusing on general environmental contexts rather than specifically marine environments. Both studies suggested that increasing the number of concepts used to map the MMs resulted in greater complexity. Lin et al. (2020) reached similar conclusions regarding ocean health, observing that students in higher grades possess greater ocean literacy compared to those in lower grades. Furthermore, Lin et al. (2020) highlighted that students with more ocean-related courses have a broader and deeper knowledge of ocean issues.

Research indicates that perceptions of individuals with higher education often align with scientifically established evidence, suggesting that education is crucial in understanding complex systems (Flotemersch & Aho, 2020). This alignment likely stems from the comprehensive knowledge base that shapes perceptions. Soares et al. (2021) found that individuals with higher education tend to rely on expert knowledge, supporting the idea that more complex information input influences system complexity, as suggested by Driver and Streufert (1969). This indicates that higher education results in a more nuanced understanding of a system and its drivers.

A notable gap exists between scientists and the public regarding ocean knowledge (Bailey et al., 2016). Eleiton et al. (2015) highlighted this disparity, noting that the public frequently prioritises different threats to ocean systems compared to scientists. Scientists generally possess a more holistic understanding of ocean systems, recognising both anthropogenic and natural factors affecting ocean health. In contrast, the public tends to focus primarily on anthropogenic factors. This perspective is supported by Brandstädter et al. (2012), who argue that scientists have a comprehensive grasp of ocean systems, enabling them to perceive complex details and interconnections that less experienced individuals might miss. These findings suggest a difference between scientists and young adults in terms of ocean knowledge and the ability to understand systems holistically. Currently, there is a lack of research examining the differences in MMs of QOL in the ocean between young adults and ocean experts, particularly in terms of their content and complexity. This study aimed to fill this gap by analysing the MMs content and complexity, assessing the number of nodes and edges per node, of young adults compared to ocean experts. The following hypothesis has been derived:

Hypothesis 1: *The Mental Models of Quality of Life in the Ocean among experts will exhibit greater complexity compared to those of young adults.*

Various studies have concluded that MM complexity is influenced by one's grade level, suggesting consistency with academic achievement. However, limited research specifically explores MMs related to marine environments across various academic levels. This study aimed to substantiate this hypothesis further.

Hypothesis 2: Positive Relationship between Educational Levels and Degree of Complexity of Mental Models of Quality of Life in the Ocean.

4.2.2 Environmental Awareness Influencing Mental Model Complexity

Environmental awareness significantly impacts the complexity of an individual's MM, particularly concerning marine environments. Gelcich et al. (2014) demonstrate that personal values, interests, and risk considerations, which are integral to one's environmental awareness, profoundly affect one's concern for marine environments. Despite the frequent use of the term, environmental awareness lacks a universally accepted definition and is often interpreted differently among scientists. Generally, environmental awareness involves being conscious of, knowledgeable about, and having a deep understanding of the environment in which humanity resides (Harju-Autti & Kokkinen, 2014). This awareness is a fundamental component of an individual's value system and contributes to broader social consciousness (Dabbous et al., 2023).

In academic settings, environmental awareness is a familiar and studied topic (Arshad et al., 2020; Jusoh et al., 2018; Sivamoorthy et al., 2013; Szeberenyi et al., 2022). Harju-Autti & Kokkinen (2014) argue that environmental awareness extends beyond mere knowledge to include a heightened consciousness of the implications of this knowledge. Research supports that individuals with higher levels of environmental awareness generally possess a more profound understanding of environmental systems, including marine environments (Steel et al., 2005).

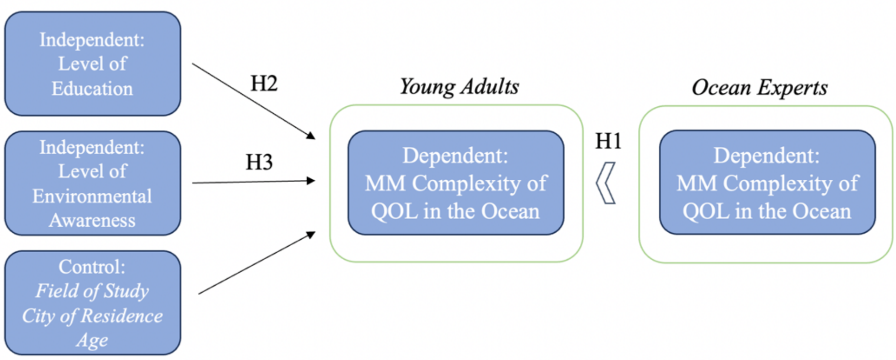
Linking this understanding to MM complexity, Goldberg et al. (2020) identify that the complexity of MM is influenced by one's ability to grasp the interconnectedness of system elements. It can be assumed, that higher environmental awareness is associated with a more intricate and nuanced understanding of these systems, leading to more complex MMs (Gelcich et al., 2014). This implies that individuals with greater environmental awareness tend to develop more sophisticated MMs due to their deeper and more detailed understanding of environmental systems.

When individuals are more environmentally aware, their interest intensifies, leading to a deeper understanding of the subject. Consequently, higher environmental awareness will likely result in increased knowledge, fostering more complex MMs concerning QOL in the ocean. This study assessed this relationship using the following hypothesis:

Hypothesis 3: Positive Relationship between Environmental Awareness and Degree of Complexity of Mental Models of Quality of Life in the Ocean.

Literature suggests that two predictors – educational level and environmental awareness – may influence the complexity of MMs related to QOL in the ocean. Additionally, it is crucial to account for any potential confounding variables that may impact MM complexity. Confounding variables arise when a third variable affects the observed relationship between the two primary variables under study (Bryman, 2021). To minimise the likelihood that factors other than awareness and education significantly impact MM complexity, the analysis included three additional variables: (1) field of study (Fauville et al., 2018; Lai, 2021; Mokos et al., 2020; Umuhire & Fang, 2016), (2) proximity to the ocean (Gkargkavouzi et al., 2020; Halkos & Matsiori, 2017), and (3) age (Hamilton & Safford, 2014; Van Liere & Dunlap, 1980; Xiao & McCright, 2007). Refer to Figure 2 for an overview of the variables influencing MM complexity in this study.

Figure 2 Overview of Predictors on MM Complexity.



5. Methodology

This study focused on three main variables derived from the research questions and the associated hypothesis: (1) MM complexity related to QOL in the ocean, (2) level of environmental awareness, and (3) educational level. The study aimed to examine how environmental awareness and educational level (independent variables) affect MM complexity (dependent variable) regarding ocean QOL. Moreover, comparing the content and complexity of MMs between young adults and ocean experts.

To measure MM complexity, the study employed the M-Tool, a specialised software designed for comparing MMs across various sample groups (van den Broek et al., 2021a). The M-Tool can be customised with self-made visual components and audio instructions tailored to the study's aims (M-Tool, 2023). Thus, to evaluate MMs related to QOL in the ocean, it was necessary first to identify the key drivers of QOL, as these drivers were used as elements for participants to incorporate into their MMs. To achieve this, an exploratory-sequential research design was employed (Edmonds & Kennedy, 2017). Phase 1 focused on determining the drivers of QOL in the ocean through a survey. In Phase 2, the study mapped and assessed MM complexities related to QOL in the ocean using the M-Tool. Additionally, Phase 2 addressed the independent variables by analysing environmental awareness and educational level and confounding variables through an online survey. For an operationalisation of the variables, see Table A1.

This study used a deductive approach by deriving hypotheses from existing theories on MM complexity and the effects of educational levels and environmental awareness (Clark et al., 2021). It aimed to test these hypotheses through empirical research, characteristic of deductive reasoning, focusing to validate or extend pre-existing theoretical constructs to new contexts.

The study targets young adults in the Netherlands and scientists referred to as ocean experts. The primary focus is on young adults, defined as Dutch citizens aged 18-30 with either vocational education (MBO), applied sciences (HBO), or university degrees. Before conducting the study, a power analysis (Nishat, 2021) determined that a sample size of 271 participants was needed for validity, as detailed in Table 2. The breakdown of the sample size calculation is as follows:

Table 2 Overview Values for Calculation Sample Size.

N	*Population size*	*4,132,373*
z	Z-score	2.576 (90%)
e	Margin of error	0.05 (5%)
p	Standard deviation	0.5

$$\text{Sample size} = \frac{\frac{2.576^2 \times 0.5(1-0.5)}{0.05^2}}{1+(\frac{2.576^2 \times 0.5(1-0.5)}{0.05^2 \times 4{,}132{,}373}} = 271 \text{ individuals}$$

In Phase One, 15% of the total sample size of Phase 2 will be included, amounting to 40 individuals (13 per educational level: MBO, HBO, and University) and 10 ocean experts. In Phase Two, 90 individuals per educational level (MBO, HBO, and University) will be contacted, along with an additional 10 ocean experts.

5.1 Phase 1: Determining the Drivers of Quality of Life in the Ocean

5.1.1 Participants and Procedure

As aforementioned, to determine the drivers of QOL in the ocean and create the elements necessary for the M-Tool, Phase 1 included a short survey conducted via Qualtrics to gather input from a small sample group, referred to as the pilot group.

The pilot group consisted of 63 participants, with data collected between the 20th of February and the 6th of March 2024. Participants were contacted online using a stratified random sampling strategy, selecting units from categorised populations (Clark et al., 2021). The group included young adults aged 18 to 30, categorised by Dutch educational levels MBO, HBO, and university. A snowball strategy was employed to gather data from young adults, starting with the researcher's network and subsequent referrals, resulting in 38 participants. Moreover, 25 ocean experts were surveyed during the

'Whose Oceans' project gathering (Utrecht University, n.d.), totalling 63 participants. Notably, the survey had a 100% completion rate by both young adults and ocean experts. The median age distribution among the young adults was 23.81 (SD = 2.067) and for ocean experts 38.96 (SD = 8.038). Among both the groups, 61.9% identified as female (SD = 0.936). For more descriptive statistics, see Appendix B. However, the sample distribution deviated from expectations, particularly with a lower representation of the MBO category compared to the other education categories. Refer to Table 3 for the distribution of educational levels among the pilot group.

Table 3 Descriptive Statistics Pilot Group Education.

	Young adults		*Experts*		
	Current Education	Finished Education	Current Education	Finished Education	%
MBO	3	3	-	-	9.5
HBO	5	11	-	-	25.4
University	15	1	-	25	65.1
Total	**23**	**15**	**-**	**25**	**100**

The short survey aimed to gain more insights into the sample group's perspectives, rather than relying solely on desk research to determine drivers. This approach increases data validity and ensures that the data includes the perspectives of all groups. The drivers mentioned in the survey were determined using desk research, *see Chapter 4.1.1.* The short survey included general questions about participants' demographics, age, gender, education, and current residence. It then explored the participants' understanding of QOL in the ocean, using an open-ended question to inquire about their perception of this concept and the drivers they believe impact it: "*What do you think are factors that influence the quality of life in the ocean?*" Subsequently, the survey featured a multiple-choice section using a Likert response scale, asking participants to rate the perceived influence of certain drivers on QOL in the ocean. The complete survey is detailed in Appendix C.

5.1.2 Statistical Procedure

To determine key drivers, the Likert scale responses were assessed by calculating the mean score for each driver, with a scale from 1 (no influence) to 5 (a lot of influence). Drivers with a mean score higher than 4 were included (Table D1). Additionally, the responses to the open-ended questions were analysed by identifying the top 20 most frequently mentioned concepts (Figure D1) and generating word clouds to visualise the drivers mentioned by participants (Figures D2 and D3). The most frequently mentioned concepts were similar to the researched drivers. However, the open-ended responses provided more specific details on factors influencing QOL in the ocean, such as plastic, water temperature, oil disasters, and terms related to 'humanity.' To ensure representability, the pre-researched driver 'pollution' was divided into more specific categories: plastic pollution, oil disasters, and landfill in the sea. Additionally, the driver 'water temperature' and 'humanity' were added. Detailed data analysis is available in Appendix D. The determined drivers of QOL in the ocean are summarised in Table 4.

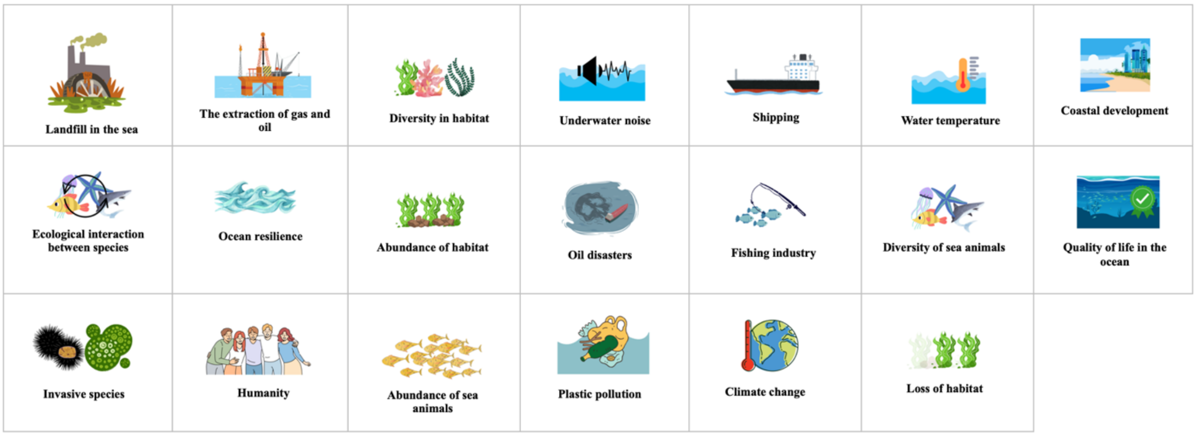
Table 4 Determined Drivers of QOL in the Ocean.

Natural	**Anthropogenic**
Abundance of animals and habitats	Fishing
Diversity of animals and habitats	Shipping
The ecological interaction between species	Coastal development
Loss of habitat	Drilling and extraction of gas and oil
Ocean resilience	Oil disasters
Climate change	Plastic pollution
Temperature of the water	Underwater noise
Invasive species	Landfill in the sea
	Humanity

5.1.3 M-Tool Setup

To utilise the findings in Phase 2, intuitive icons representing the drivers and the target variable (Quality of Life in the ocean) were created using Canva (see Figure 3). These icons were uploaded to the M-Tool, and a study was designed incorporating these icons. The study included only one mapping screen with neutral arrows and the target variable positioned on the right side to allow participants to direct their drivers toward it. To enhance the understandability of the tool, the participants were required to complete a practice task, for which visual and audio elements were created, explaining both the tool and the practice task. Additionally, a video explaining the topic of the MM was created, detailing each intuitive icon of the determined drivers and the significance of the arrow thickness. For the handout of all the created visuals and audio elements, see Appendix E. Since the study targeted Dutch young adults and ocean experts, the text below the icons is in English to ensure comprehension; the images with original text are available in Appendix F.

Figure 3 Intuitive Icons of the Determined Drivers.



5.2 Phase 2: Mapping and Assessing Mental Models and Their Complexity

5.2.1 Participants

To gather data for Phase 2 of the study, multiple methods were employed between March 25th and April 26th, 2024. Initially, participants were contacted through the researcher's network, leveraging various online platforms including Instagram, LinkedIn, and WhatsApp. Additionally, online survey exchange platforms such as Survey Circle and Survey Swap were utilised to expand participant reach. These platforms allow researchers to exchange surveys with students to increase participant numbers. Students at Deltion College Zwolle were also encouraged to participate during class sessions with the help of an MBO teacher. To further enhance participant recruitment efforts, visits were made to Utrecht University and Hogeschool Utrecht by approaching people in person with tablets to conduct the survey. Finally, ocean experts involved in the 'Whose Oceans' project were contacted via email through Prof. Dr. Erik van Sebille (Utrecht University, n.d.). These combined efforts resulted in a total of 207 participants.

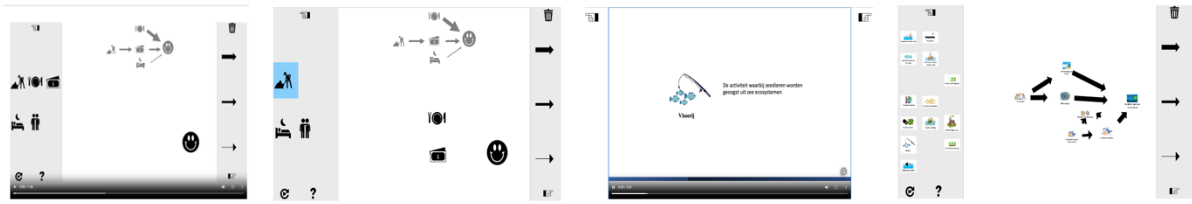
The survey had a completion rate of 94%, leading to a total of 194 participants. The majority of the study identified as female, with 68.3% of the young adults and 62.5% of the ocean experts identifying as female. Moreover, 80% of the participants were still students at the time of the study. In terms of current residence, the majority resided either in the provinces of Overijssel (23%) or Utrecht (28%). Furthermore, the largest demographic identified themselves as living far from the sea (68%). For a detailed distribution of educational levels among participants, see Tables G1 and G2.

5.2.2 M-Tool Procedure

As aforementioned, Phase 2 of the study involved mapping and assessing the MMs concerning QOL in the ocean and assessing the participant's level of environmental awareness and education. The MMs were mapped through the M-Tool, which can be accessed through web applications at the website www.m-tool.org (van den Broek et al., 2021a). Studies have demonstrated its success in mapping these models among diverse participants and have validated the usage of this tool (Van Den Broek et al., 2021b). This tool facilitates the aggregation of participants' MMs, with a pre-fixed set of components customised by the researcher, allowing comprehensive analysis of the different MMs of the chosen topic (Van Den Broek et al., 2021a). The components were determined and created in Phase 1 of this study.

Before the participants were able to map their MMs, the study's name, objectives, and expectations of the tasks were outlined, including a text asking for informed consent, see Appendix H. This text assured participants that all data would be treated confidentially and anonymously. Upon agreeing to participate, participants were instructed to create a practice MM. A tutorial video demonstrated how to use the tool and outlined expectations for the practice task along with an audio guiding the participants in the task. Only upon successful completion of the practice task were participants permitted to continue with the study. Following this, the participants viewed a description video of the study's topic and the elements. Participants were then tasked with mapping their own MM of QOL in the ocean. The procedure of MM mapping using the M-Tool is visualised in Figure 4.

Figure 4 Procedure Mapping Mental Models Using the M-Tool.



5.2.3 Survey Procedure

The survey covered participants' demographics, education, and environmental awareness. The confounding variables age, proximity to the ocean, and field of study were asked and measured. The variable 'age' was recorded numerically. For 'proximity to the ocean,' ("Do you live near the sea?") responses were coded as 0 = close proximity, 1 = average proximity, and 2 = far away, and set as a factor to analyse the influence of closer proximity on the responses. For the control variable 'field of study' ("What was/is your field of study?"), responses were translated, and 'natural sciences' was set as the reference category. This allowed for comparisons between other fields of study and the reference category.

Educational level was assessed through questions such as "Are you currently studying?" and "At what level did you study?" or "At what level are you studying?" Responses were categorized into three groups: vocational education (MBO), applied sciences (HBO), and university (Universitair), and coded for analysis as 1 = MBO, 2 = HBO, and 3 = Universitair.

Environmental awareness was measured using 29 statements adapted from Bozoglu et al. (2016) and Özden (2008), addressing various sustainability-related issues. Participants rated their agreement on a Likert scale from 1 (strongly disagree) to 5 (strongly agree) for favourable statements, with reverse scoring for unfavourable statements. The mean scores were used to classify participants' environmental awareness into three levels: Low (< 2.5), Moderate (2.5 – 3.5), and High (> 3.5), as detailed in Table 5. Appendix I provides a complete overview of the questionnaire (Table I1), including which statements were considered favourable or unfavourable (Table I2).

Table 5 Attributed Level of Environmental Awareness per Mean-score.

Level of Environmental Awareness	*Mean score*
Low	< 2.5
Moderate	2.5 – 3.5
High	>3.5

5.2.4 Data Cleaning Process

To clean the data retrieved from the M-Tool, a script developed by Boxtel & van den Broek (2021) was utilised. This script included steps such as excluding participants who did not complete their MM and listing their unique User_IDs. The script also measured the nodes (concepts) and weighted edges (arrows) that the respondents used to elicit their MMs. The script ensured that the data was ready for analysis. Additionally, since the data points were originally in Dutch, they were renamed to their English translations for easier reference.

Regarding the survey data, to ensure that all participants met the sample group requirements, the data was cleaned based on the variables 'Age' and 'Education'. Data points with age values below 18 were recoded to 'NA' and subsequently excluded from the dataset. For 'Education', if a participant responded with 'I did not study', those data points were also recoded to 'NA', indicating a missing value which was then removed from the dataset. Additionally, any respondents who did not complete their survey were removed from the dataset.

After cleaning both datasets, the MM data was merged with the survey data. Since there were no common User_IDs to facilitate the merge, an alternative approach was taken. The end time of eliciting the MMs was calculated based on the starting date and the duration of using the M-Tool. Before the end time was matched with the corresponding survey start time, the times were converted to the same date-time format. The merging process accounted for a potential delay of a few minutes between the end and start times. Any potential duplicate matches were excluded from the dataset. To ensure that experts were analysed separately, the survey included the question, "*How often are you involved in ocean-related matters?"* Data from respondents who answered "daily" were excluded from the main dataset and analysed separately to compare differences.

5.3 Statistical Procedure

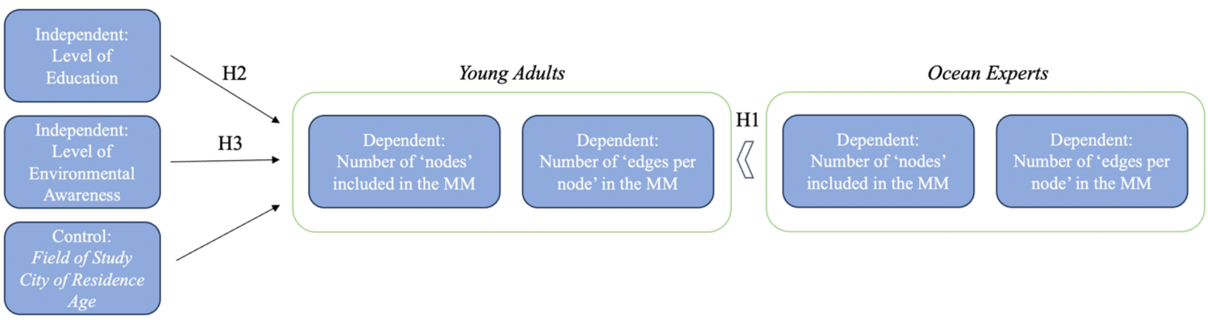
To analyse the data collected from both the M-Tool and Qualtrics, the software RStudio was utilised. The study' aimed to assess how the combination of two independent variables educational level and level of environmental awareness explain the dependent variable 'MM complexity of QOL in the ocean.' Moreover, comparing the MMs of young adults and ocean experts on their content and complexity. To analyse MM complexity, two parameters were created: the number of drivers (nodes) and the number of relations (edges) per driver. The MM parameters and content were analysed with a mean number of connections and the mean number of concepts. Table 6 details an overview of the dependent variables.

Table 6 Description of Dependent Variables (Krebs, 2000).

Dependent Variables	*Meaning*
Nodes selection (Number of drivers)	Participants indicate whether they include a driver ('node') in their MM. The number of used drivers was measured. If a driver is not selected, the corresponding variable was zero.
Edges per node (connectedness of drivers)	Participants used arrows ('edges') in their MM. The number of weighted arrows per concept indicated the connectedness.

The differences in MM complexity were examined through the main effects of the independent variables (environmental awareness and educational level) on the dependent variable. Refer to Figure 5 for the conceptual framework of this study.

Figure 5 Conceptual Framework.



5.3.1 Comparing Mental Models

To address H1, the MMs of young adults and ocean experts were analysed for both content and complexity. The content analysis involved visualising aggregated MMs using a script developed by Boxtel and van den Broek (2021). Each respondent's MM data was represented as a network, with nodes and edges depicting the structure (Newman, 2010). In this study, the nodes represented the drivers within the MMs, including the target variable, while the edges indicated the relationships between them (Chiesi, 2015; Hevey, 2018). The thickness of the arrows showed the strength of these connections: thin arrows weighed 1, medium arrows weighed 2, and thick arrows weighed 3. The target variable, quality of life (QOL) in the ocean, was present in every MM and thus was not measured separately.

To assess the complexity of the MMs, a descriptive analysis was conducted by calculating means, standard deviations, minimum and maximum values, and medians. The Mann-Whitney U-test was used to compare statistical differences between the two sample groups. This test is often employed to compare two independent groups and determine differences in the dependent variable (Karadimitriou et al., n.d.). In this study, MM complexity was the dependent variable, comprising two parameters: (1) the number of nodes and (2) the number of edges per node. Consequently, two tests were performed to analyse statistical significance—one focusing on the differences in the number of nodes, and the other on the number of edges per node.

5.3.2 Educational Level and Environmental Awareness

To address H2 and H3, the relationship between the independent variables (educational level and environmental awareness) and MM complexity of young adults was analysed using descriptive analysis and multiple linear regression. Both analyses were conducted on the two parameters of MM complexity: (1) number of included nodes and (2) number of edges per node.

The descriptive analysis consisted of the computation of means, standard deviations, minimum and maximum values, and medians. Prior to conducting the regression analysis, assumptions for multiple linear regression were tested to ensure the model's suitability, testing for linearity, normal distribution of residuals, and homoscedasticity (Ganesh, 2010), see Appendix J. A correlation matrix was used to test for multicollinearity. The statistical results for control variables (age, proximity to the ocean, and field of study) are also presented. The results confirmed that all assumptions were met, after which the regression analysis was conducted on the two parameters of MM complexity.

5.4 Ethical Issues

5.4.1 Reliability and Validity

Clark et al. (2021) emphasized the importance of reliability and validity in research. While reliability focuses on the consistency of measurements, validity ensures that a concept accurately reflects what it intends to measure. These concepts are crucial for indicating research quality and identifying limitations is important (Clark et al., 2021).

Environmental awareness is personally defined, and self-reported data may be subject to social desirability bias (SDB), where respondents might exaggerate their environmental consciousness or minimize their ecological footprint to appear more likeable. To mitigate SDB, the start of the M-tool and survey explicitly emphasised data anonymity and included a statement requesting honesty (Appendix H). Additionally, the environmental statements used to assess awareness (Bozoglu et al., 2016; Özden, 2008) incorporated Likert-scale responses, which have been proven to reduce SDB in studies (Larson, 2018).

To ensure research validity, the tool used to elicit the MMs was validated based on previous studies demonstrating their success in mapping MMs among diverse participants (Van Den Broek et al., 2021b). These studies showed that participants with varying literacy levels could understand the tool, ensuring clarity. Additionally, a test group completed the survey to confirm the clarity of the tool and questions.

To ensure data generalisability, it was crucial to represent all educational levels appropriately in the dataset. A stratified sampling strategy was used to prevent under- or overrepresentation, which will be discussed further in the discussion section. Moreover, to ensure diverse participation among young adults and not just those interested in marine environments, an incentive was offered. Participants had the chance to win a gift card, which simultaneously increased the response rate.

5.4.2 Ethical Considerations

Before starting the survey, participants reviewed an information sheet outlining the survey's procedures. The sheet clarified the survey's anonymous nature, assuring that no personal data or names were utilised. To continue the study, the participants had to consent to the use of data, both forms are shown in Appendix H.

6. Results

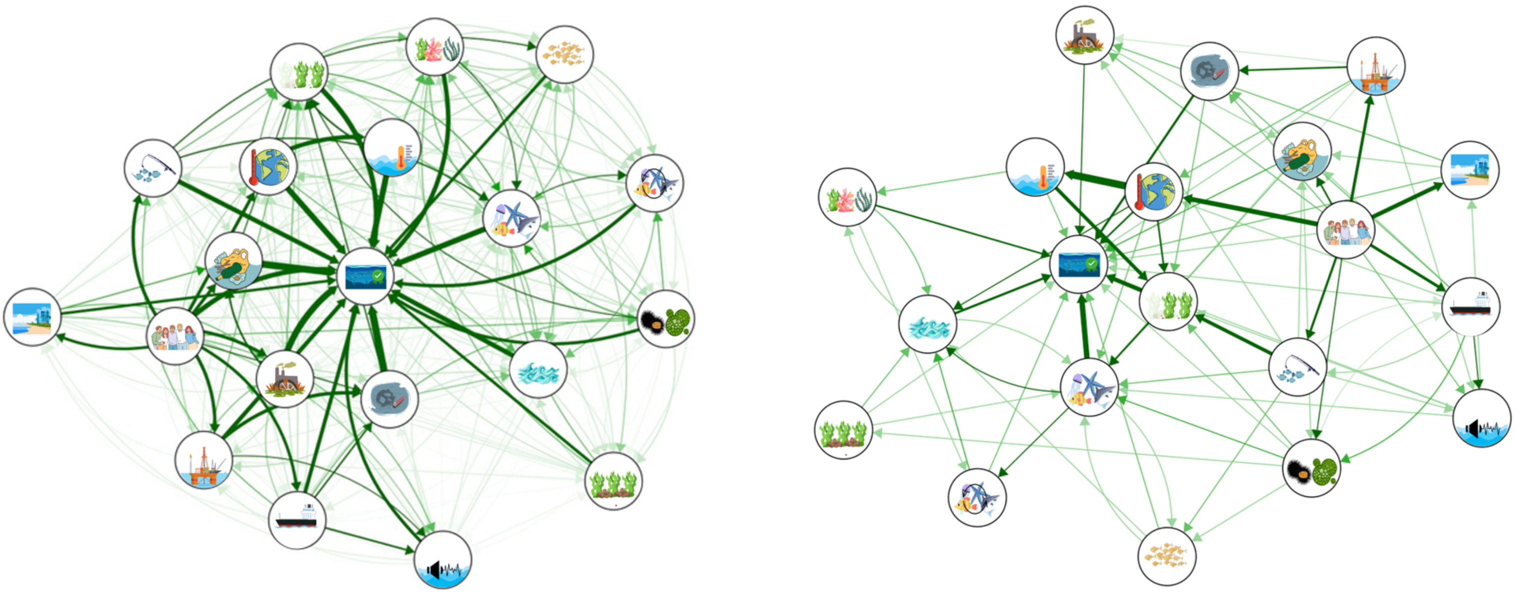
This chapter presents the findings on the mental models (MMs) of young adults and ocean experts in the Netherlands, including an analysis and comparison of their complexity. Moreover, it presents the results of analysing the relationship between MM complexity and environmental awareness as well as educational level. The results of the descriptive statistics on all the variables are detailed in Appendix K. The results section is organised around the three hypotheses: (1) a comparison of MMs between young adults and ocean experts, (2) the influence of education on MM complexity, and (3) the relationship between environmental awareness and MM complexity.

6.1 Mental Models of Quality of Life in the Ocean

When comparing the MMs of young adults and ocean experts, the content and complexity were assessed, as these are the factors that differentiate MMs among individuals (Van Den Broek et al., 2023). First, the content of the MMs was assessed through visualisation and examination of the most important drivers. The aggregated MMs were illustrated to depict the relationships identified by both sample groups. Figure 6 presents the aggregated MMs, showcasing all the relationships identified for each driver. These aggregated MMs utilise intuitive icons to represent the connections visually. For a detailed version of this figure with text, please refer to Figures L1 and L2.

Figure 6 Aggregate MM QOL in the Ocean.

Left: Mental Models Young Adults
Right: Mental Models Experts



To gain a better understanding of the MMs created by the two sample groups, the most connected concepts (drivers) were identified. These concepts, along with their relative percentages compared to other relationships, are presented in Table 7. Both young adults and experts identified humanity as the primary driver affecting QOL in the ocean, with young adults attributing 14.68% and experts attributing 21.3% of the total relationships to this concept. Climate change was recognized as the second most significant driver, with 6.30% attributed to young adults and 7.87% to experts. While both groups acknowledged shipping as a driver, experts considered it more significant, attributing 7.87% of the total relationships to it compared to 5.88% by young adults. Additionally, young adults highlighted gas and oil drilling and oil disasters among their most connected drivers, whereas experts ranked animal diversity and fishing higher.

Table 7 Top 5 Identified Drivers Impacting QOL in the Ocean.

	Young Adults	*Experts*
Top 5 identified Drivers Affecting QOL in the ocean	Humanity (14.68%)	Humanity (21.3%)
	Climate Change (6.30%)	Climate Change (7.87%)
	Drilling gas & oil (5.88%)	Shipping (7.87%)
	Shipping (5.88%)	Animal diversity (7.30%)
	Oil disaster (5.84%)	Fishing (6.74%)

6.1.1 Comparing Mental Model Complexity of Young Adults and Ocean Experts

To analyse the MMs created by young adults and experts concerning QOL in the ocean, a descriptive analysis was conducted on the average number of nodes (concepts) and edges (relations) per node. Table 8 provides an overview of these two parameters for both groups. The empirical findings indicate that the mean number of nodes used in the MMs by young adults was 13.62, with a range from 2 to 20 concepts. For experts, the mean number of nodes was 15.125, with a minimum of 10 and a maximum of 20 concepts. The number of edges per node also differed between the groups, with young adults averaging 15.09 and experts averaging 22.25 edges per node.

Table 8 The Average Number of Nodes and Edges in MM of QOL in the Ocean.

	Young Adults		***Experts***	
	Average number of nodes	Average number of edges per node	Average number of nodes	Average number of edges per node
Mean	13.62	15.09	15.125	22.25
Median	14	15	15	18
Standard Deviation	5.51	8.01	5.42	7.674
Minimum	2	1	10	12
Maximum	20	43	20	43

The Mann-Whitney U test revealed significant differences between the MMs of young adults and ocean experts regarding the QOL in the ocean. The analysis of MM complexity parameters (number of nodes and the number of included edges per node) showed that experts have more complex MMs than young adults. Specifically, the U-value for the number of nodes was 253,600 ($p = 0.001325$), and the U-value for edges per node was 189,200 ($p = 4.82e-15$), see Tables 9 and 10. With a significance level (α) of 0.05, these p-values indicate substantial disparities in MM complexity between the two groups. The results highlight a significant gap in understanding QOL in the ocean, with experts demonstrating a more intricate comprehension compared to young adults.

Table 9 Results Mann-Whitney U Test - Number of Nodes.

	N	*Mean*	*Standard Deviation*	*W*	*P*
Young Adults	186	13.62	5.51		
Oceanic Experts	8	15.125	5.42	253600	0.001325

Table 10 Results Mann-Whitney U Test - Number of Edges per Node.

	N	*Mean*	*Standard Deviation*	*W*	*P*
Young Adults	186	15.09	8.01		
Oceanic Experts	8	22.25	7.674	189200	4.82e-15

6.2 Predicting Differences in Mental Model Complexity of QOL in the Ocean

To analyse the influence of *environmental awareness and educational level* on MM complexity, two multiple regression analyses have been carried out; one analysis focused on the impact of the independent variables on the number of nodes and the second analysis focused on the number of edges per node. The model predicted 6.2% of the variance in the mean number of nodes in the young adult's MM complexity ($R^2 = 0.062$). In terms of the mean number of edges per node, the model accounted for 18.04% of the variance ($R^2 = 0.1804$).

Table 11 Results Multiple Linear Regression Analysis - MM Complexity.

		nr of. Nodes		*nr of. Edges per node*	
		β	Std. error	β	Std. error
	(Intercept)	17.849***	1.135	19.058***	1.503
	Educational Level	-0.177	0.165	1.054***	0.219
	Environmental Awareness	-0.712*	0.311	-1.493***	0.412
Field of Study	*Business Administration and Economics*	-3.37***	0.31	-6.974***	0.410
Field of Study	*Engineering Sciences*	-2.339***	0.454	-5.27***	0.601
Field of Study	*Arts and Humanities*	-3.454***	0.532	-8.856***	0.705
Field of Study	*Social Sciences*	-3.796***	0.293	-7.658***	0.389
Field of Study	*Other*	-0.549	0.584	-4.310***	0.773
	Age	0.107***	0.029	0.226***	0.039
Proximity to the ocean	Average distance to the sea 10-50km	-1.275**	0.431	-0.408	0.571
Proximity to the ocean	Far from the sea >50km	-0.825*	0.415	0.0448	0.550
	Adjusted R-squared	0.062		0.1804	

Note: *P<0.5 **P<0.01 ***P<-0.001
β = beta coefficient
Std. error = Standard Error
Field of study reference category: 'natural sciences'
Proximity to the ocean reference category: 'close to the sea <10km'

6.2.1 Educational Level and Mental Model Complexity

To analyse the relationship between the participant's educational level and MM complexity, the analysis assessed the number of nodes and edges per node. The results of the multiple linear regression model are presented in Table 11. For the independent variable educational level, there is no significant relationship (β = -0.177, p = 0.489) with the number of nodes in an MM. This indicates that educational level does not significantly predict the number of nodes in the MM. However, there was a significant positive relationship (β = 1.054, p =<0.001) with the number of edges per node in an MM, indicating that higher educational levels are associated with more edges. Thus, the hypothesis that there is a positive relationship between educational levels and the degree of complexity of MMs of QOL in the ocean can be considered true in the context of the number of edges per node but not in the context of the number of nodes. Therefore, H2 is partially supported by the data, indicating that higher educational levels are associated with more complex MMs in terms of the number of connections (edges) per concept.

6.2.2 Environmental Awareness and Mental Model Complexity

To explore the relationship between environmental awareness and the complexity of MM regarding QOL in the ocean, Hypothesis 3 (H3) posited a positive relationship, suggesting that higher environmental awareness would lead to more complex MMs. However, upon reviewing the results presented in Table 11, it is evident that as environmental awareness increases, the number of nodes decreases ($\beta = -0.712$, $p = 0.028$), as does the number of edges per node ($\beta = -1.493$, $p < 0.001$). These findings indicate that the hypothesised positive relationship cannot be supported. Instead, the relationship appears to be negative, suggesting that lower environmental awareness is associated with greater complexity in MMs.

7. Discussion

This study aimed to examine the MMs of QOL in the ocean and to assess their relative complexity. The analysis focused on two distinct groups: young adults and ocean experts. The objective was to identify differences in the MMs and complexity between these groups. Specifically, the study explored the hypothesis of whether ocean experts had more complex MMs compared to young adults. Additionally, the research investigated the relationship between environmental awareness, educational level, and the complexity of individuals' MMs. It assessed whether higher environmental awareness and higher educational levels were associated with more complex MMs. Complexity was evaluated based on the number of nodes and the number of edges per node within the MMs.

7.1 Mental Models of Quality of Life in the Ocean

To address the first hypothesis and research question on the characteristics of young adults and ocean experts' MM concerning QOL in the ocean, the study compared the content and complexity of their MMs. This analysis aimed to identify differences between ocean experts and young adults, focusing on the factors that distinguish their mental models (Van Den Broek et al., 2023).

7.1.1 Mental Model Content Differences

The results reveal that the content of the MMs of young adults and ocean experts are quite similar. Young adults identified humanity, climate change, extraction and drilling of gas and oil, shipping, and oil disasters as the most significant drivers for QOL in the ocean. In comparison, ocean experts highlighted humanity, climate change, shipping, animal diversity, and fishing as the most important drivers. The similarity in MMs between experts and young adults might be attributed to the extensive media coverage and environmental campaigns on long-standing marine issues (Lotze et al., 2018). Additionally, the public has shown a genuine interest in the marine environment and reasonable knowledge about specific marine issues (Fletcher et al., 2009). Both groups recognised humanity and climate change as the most significant drivers, contradicting Eleiton et al. (2015) and Lotze et al. (2018), who found a vast disparity between scientists and the public, with the latter prioritising different threats to ocean health. While both young adults and experts focus on human-induced drivers, young adults tend to overlook the influence of ocean habitats and marine animals, whereas scientists emphasise the importance of the marine environment. The different perceptions may arise from the specific areas of the ocean each group is familiar with, as visual perception significantly influences public awareness of environmental systems (Tran, 2006). While the public is more familiar with the nearshore coastal ocean, scientists tend to have a broader view of the ocean (Ressurreição et al., 2012).

7.1.2 Mental Model Complexity

The findings reveal that most participants demonstrate a substantial understanding of the drivers influencing QOL in the ocean. Young adults, on average, included 13.62 mean concepts, while oceanic experts included 15.125 mean concepts, indicating that young adults possess a good understanding of the factors shaping the marine environment. This observation is consistent with Rock et al. (2019), who noted an increasing interest in marine environments by the public amidst ongoing challenges. This aligns with the idea that more complex information input can influence the complexity of the system, as suggested by Driver and Streufert (1969).

However, a notable difference emerged between the MMs of young adults and experts concerning the number of relationships (edges) included in the MMs: experts perceive more connections among the factors influencing QOL in the ocean and can better understand this complex system (Goldberg et al., 2020). While many people recognise specific factors affecting QOL in the ocean, they often lack an understanding of the relationships between these factors. This supports the idea that not everyone can perceive systems holistically, people often are able to identify direct relations in a system. However, grasping a system holistically requires a subsequent understanding of indirect effects and cross-linked relations (Mambrey et al., 2020a). As ocean experts are more familiar with the system, they can identify more complex relations between the elements.

The findings of the study confirm H1, indicating that ocean experts exhibit more complex MMs compared to young adults. Despite the similarity in content between the MMs of young adults and experts, the MMs of experts were notably more complex in terms of the average number of nodes and edges per node included. The evidence aligns with Bailey et al. (2016) indicating there is a notable gap between ocean experts and the public. While the study's findings indicate similar content, there is a significant disparity in the overall understanding of the system's interrelationships between drivers.

The results of this study substantiate previous research, that to better comprehend a system, content knowledge is necessary, however, one must also grasp the interrelationship within a system (Goldberg et al., 2020). Current research indicates that lay individuals often focus on the individual elements grasping only direct relationships, whereas experts employ systems thinking, and identify the patterns of the system and structures influenced by system complexity as well as system specifics (Mambrey et al., 2020a).

This study reinforces existing findings by highlighting a significant gap in the holistic understanding of the drivers influencing QOL in the ocean between young adults and experts. While young adults recognise the importance of individual elements, they often fail to see the relationships between them. The study enhances our understanding of the differences in MM complexity between experts and the public, contributing to environmental psychology and systems thinking. The findings underscore the need to educate lay individuals, particularly young adults, about oceanic systems and the factors affecting QOL. Integrating systems thinking into educational and public awareness campaigns is essential to bridge the gap in understanding complex environmental systems. Individuals must comprehend these systems holistically to understand their role in influencing these drivers (Potts et al., 2016).

7.2 Educational Level and Mental Model Complexity

To address the first part of the research question regarding the relationship between the educational levels of young adults in the Netherlands and the complexity of their MM of QOL in the ocean, H2 hypothesised a positive relationship between educational level and MM complexity. The research partially supports this hypothesis: while the number of edges per node increased with higher educational levels, there was no significant relationship between educational level and the number of nodes (concepts) in an MM.

The consistency in the number of concepts within MMs across different educational levels contradicts the findings of Atasay et al. (2020) and Shepherdson et al. (2007), who suggested that higher education levels lead to more complex MMs. Their research indicated that more elements were included in the MMs at higher educational levels. This discrepancy in findings may be due to the widespread media coverage and environmental campaigns on persistent marine issues (Lotze et al., 2018). Such campaigns are accessible to everyone, regardless of educational background, indicating that individuals at all levels can identify the drivers influencing QOL in the ocean.

While the similarities in the number of nodes were not hypothesised, the observed increase in the number of edges per node does support H2. This aligns with Flotemersch and Aho’s (2020) research, which found that higher education enhances understanding of complex systems. Higher education levels are associated with increased environmental concern (Hamilton, 2010), and concerned individuals often seek more information to better understand their environment (Milfont, 2012). This heightened concern can lead to a deeper understanding of the factors influencing ocean QOL, as indicated by Driver and Streufert (1969), resulting in more complex MMs.

This finding can also be understood through the concept of systems thinking, which involves viewing a system as an interconnected whole and understanding both its components and their relationships (Shaked & Schechter, 2013). System thinkers perceive systems as integrated wholes with interacting parts (Miller et al., 2023). While systems thinking is partly innate, it is often cultivated through education using tools like metaphors, case studies, and system modelling (Shaked & Schechter, 2013). A supportive learning environment and experiential learning play crucial roles in developing systems thinking skills (Nightingale, 2006). Research supports that understanding the relationships between concepts requires higher cognitive abilities such as intelligence, memory, and concentration (Brandstädter et al., 2012). Although many participants in this study could identify specific drivers affecting ocean QOL, not all were able to understand how these drivers interact holistically.

Examining the educational levels involved in this study—MBO (vocational education), HBO (applied sciences), and university—reveals distinctions in their educational approaches. MBO prioritises practical knowledge (De Bruijn et al., 2017), HBO emphasises the application of theories in projects, while university education sharpens abstract analytical skills and critical thinking (De Weert & Leijnse, 2010). These differences explain why MBO and HBO students may exhibit less familiarity with systems thinking compared to university students. At the MBO level, there is greater emphasis on practical information with less focus on methodologies like case studies or system modelling that promote systems thinking. Although this outcome was anticipated, the findings underscore a potential concern: understanding individual elements of a system without comprehending their interrelationships impedes holistic understanding. This underscores the necessity of integrating systems thinking education across all educational levels to enhance holistic comprehension.

7.3 Environmental Awareness and Mental Model Complexity

In addressing the second part of the research question—regarding the impact of environmental awareness on the complexity of MMs—H3 posited that higher environmental awareness would correspond with greater complexity in MMs. However, the findings did not support the hypothesis, the data revealed that participants with higher environmental awareness exhibited fewer concepts and connections per concept in their MMs than participants with lower awareness.

The results of this study are contradictory to the findings of Richardson (2023) who highlighted the importance of a person's personal experiences and values in acquiring knowledge on a specific topic. Similarly, Gelcich et al. (2014) inclined that individuals with heightened environmental awareness typically possess a more profound understanding of environmental systems and their intricacies. Contrary to the initial hypothesis, this study indicates that individuals with higher environmental awareness demonstrated less complex MMs in identifying drivers affecting QOL in the ocean and understanding their interrelationships.

This discrepancy can be attributed to the fact that environmental awareness does not inherently imply a deep understanding of environmental systems. True comprehension involves more than awareness—it necessitates an understanding of the system's complexities and dynamics (Mambrey et al., 2020b). For instance, while individuals might be aware that car usage increases CO2 emissions, they may lack a thorough understanding of greenhouse gas effects or climate change mechanisms. Environmental awareness is shaped by a blend of knowledge, behavioural constraints and opportunities, values, and motives (Bamberg & Möser, 2007).

The higher complexity of MMs observed in individuals with lower environmental awareness can be explained by their fewer preconceived notions or biases about environmental issues. According to the constructive perspective of knowledge, open-minded individuals—those who approach new information with flexibility and an exploratory mindset—are more likely to develop complex MMs. They are better positioned to integrate and understand a broader range of concepts and relationships. This contrasts with the deficit perspective, which often focuses on correcting errors rather than expanding on existing knowledge (Leonard et al., 2014). Thus, while environmental awareness is important, it does not necessarily reflect a high level of understanding of (marine) environmental systems. This study's findings highlight that environmental awareness does not automatically translate into a profound understanding of the underlying systems. Genuine comprehension requires a deeper grasp beyond recognising individual components and their interactions.

7.4 Practical Implications

The result of this study provides insights into the differences in individuals' understanding of QOL in the ocean, particularly concerning varying educational levels and levels of environmental awareness. These findings support the introduction of policies mandating the importance of integrating environmental education at all educational levels.

To improve people's ability to better understand the interrelationships and understand the system of QOL in the ocean, it may be necessary to develop the right policies that mandate the importance of providing environmental education at all educational levels. Individuals with a higher understanding of marine ecosystems may consider more relevant concepts and causal relationships between these concepts, indicating system-thinking capabilities necessary to enhance the ocean's QOL (Curseu, Schruijer & Boros, 2007). For example, a person with a better understanding of marine ecosystems may recognise that overfishing and pollution disrupt marine biodiversity, which subsequently affects the entire food web and ocean health. This understanding can influence people to support sustainable fishing practices and pollution reduction measures to preserve marine life and maintain the ocean's quality (Eleiton et al., 2015). Thus, supporting policies that integrate environmental education at all educational levels would lead to an increased understanding of individual responsibility towards the oceans and how certain drivers affect QOL in the ocean (Zsóka et al., 2013). The following sections provide an elaboration on the practical implications that arose from the observed content differences in MM, as evidenced by current research.

7.4.1 Mental Model Content Differences of Young Adults and Ocean Experts

The empirical findings of this study reveal that the main differences in the MMs of young adults and ocean experts lie in the importance placed on natural drivers affecting QOL in the ocean. These findings highlight the need for comprehensive educational and awareness strategies that address both widely recognized and overlooked factors influencing ocean QOL. Effective messaging should aim to bridge the gap between public and expert perceptions (Lotze et al., 2018), emphasising the importance of lesser-known factors. Focusing on these areas will foster a more informed and proactive generation, better equipped to tackle the multifaceted challenges facing the ocean. Future studies could explore why young adults overlook certain drivers, with longitudinal studies tracking changes in MMs over time and assessing the impact of enhanced educational initiatives on their understanding of ocean systems.

7.4.2 Educational Implications

The empirical findings of this study reveal that individuals at lower educational levels often lack a comprehensive understanding of the holistic nature of ocean systems, reflecting deficiencies in system thinking and understanding of system relationships. MBO (vocational education) and HBO (applied sciences) participants exhibited fewer interconnected elements in their MMs compared to university-level individuals. Addressing this gap requires integrating more system-thinking elements into educational curricula, such as metaphors, case studies, or system modelling (Behl & Ferreira, 2014). These approaches foster an analytical mindset across various fields of study, enhancing the ability to comprehend complex environmental systems holistically.

Young adults must grasp these systems, especially amidst environmental degradation and climate change, as understanding the interrelationships between drivers is essential for recognizing individual responsibility in marine environments (Mahmud, 2024). Moreover, the study's findings underscore a significant knowledge gap between young adults (novices) and ocean experts (scientists) concerning ocean systems. This disparity is concerning given current environmental challenges, as young adults often do not recognise the significance of natural drivers impacting ocean QOL. To address this, policies should prioritise comprehensive environmental education across all educational levels (Gough, 2017). Increasing young adults' knowledge of marine ecosystems and factors affecting QOL in the ocean can cultivate a more informed and responsible generation. This can be achieved through experiential learning opportunities, such as field trips and practical projects focused on marine systems (Behl & Ferreira, 2014).

Future research, specifically a longitudinal study, could track changes in MM complexity over time to determine if these interventions increase young adults' MM complexity regarding ocean QOL and their general ability to understand systems holistically. This study could target individuals with lower levels of education or encompass various educational backgrounds to distinguish effects across different educational levels, providing valuable insights into the long-term effectiveness of such programs.

7.4.3 Policy Implications

To combat the disparities in system thinking abilities and marine knowledge across educational levels, it is crucial to craft policies that support the integration of comprehensive environmental education programs into school curricula. This ensures that students at all levels receive the necessary knowledge to understand and address environmental issues, including marine-specific concerns. Additionally, it is necessary to have policies that enlist the opportunity for educators across disciplines to receive training in system thinking. Especially in non-natural sciences where such thinking is currently underutilised (Mambrey et al., 2020b).

7.4.4 Public Knowledge and Engagement

While the results of this study showed that knowledge of drivers influencing QOL in the ocean is adequate, understanding the holistic nature of this system remains limited among the public. Therefore, it is important that outside of changes within school curricula, it is necessary that generally system knowledge and understanding of marine environments is enhanced (McKinley & Fletcher, 2012). Enhancing public knowledge requires, workshops, seminars, and collaborations with NGOs to deliver community educational programs emphasising the importance of systems thinking in addressing (marine) environments. These initiatives can focus on marine conservation and other environmental issues, emphasising the interconnectedness of human activities and marine health (Guest et al., 2015).

By addressing these practical implications, the public's understanding of marine environments can be enhanced, promoting more informed decision-making, and fostering a generation better equipped to tackle environmental challenges holistically.

7.5 Limitations and Future Research Direction

This study provided valuable insights into the complexity of young adults MM concerning QOL in the oceans and the comparison with ocean experts, nevertheless, the limitations that could affect the results of the study should be addressed. Moreover, future possibilities for research are included.

7.5.1 Pre-determined Concepts

Although the selection of pre-determined concepts in the M-Tool enhances replicability and comparability across larger samples (van den Broek et al., 2021a), it restricts participants from adding their own perceived concepts to their MMs (van den Broek et al., 2021b). In this study, which aimed to explore MMs related to QOL in the ocean among young adults and ocean experts, the use of pre-determined concepts might have introduced bias. To mitigate this, a preliminary survey was conducted to gather insights into participants' knowledge of the topic. Nonetheless, since the survey respondents differed from those who created the MMs, it remains uncertain whether additional relevant concepts might have emerged. Using pre-determined concepts involves a trade-off between standardisation for comparability and the potential loss of unique, participant-driven insights. While standardisation facilitates data comparison, it may limit the capture of nuanced, individual perspectives, potentially impacting the depth and accuracy of the findings. Future studies could use a mixed-methods approach to acquire a richer and more nuanced understanding of individuals' MMs.

7.5.2 Direction of Perceived Causal Relationships

There could be a construct underrepresentation of young adults' MMs concerning QOL in the ocean, as the M-Tool did not capture all dimensions and aspects of the MMs (Hubley & Zumbo, 2011). The edges (arrows) that participants used were only differentiated by weight, indicating the extent of influence one element has on another. The study lacked insights into the type of relationships identified by participants since the arrows did not indicate whether relationships were positive or negative. Future studies could focus on the mechanisms that young adults perceive in QOL in the ocean by incorporating indicators for the nature of these relationships. This would provide a deeper, more holistic understanding of how young adults view the complex web of factors influencing QOL in the ocean. This could lead to more effective and inclusive strategies for managing and protecting ocean environments, ultimately enhancing QOL for current and future generations.

7.5.3 Bias in the Level of Environmental Awareness

The questionnaire provided valuable insights into the participants' level of environmental awareness. However, it is common for individuals to exaggerate their environmental consciousness or minimize their environmental footprint to appear more likeable or socially responsible (Larson, 2018). To mitigate this tendency, the survey was designed to be filled out anonymously, reducing the pressure to conform to social expectations. Additionally, the questions incorporated Likert-scale responses, as studies have shown that this reduces SDB by allowing for more nuanced and honest responses (Larson, 2018). Despite these measures, it is important to acknowledge that the results may not fully reflect the participants' true environmental awareness. There remains a possibility of residual bias, as self-reported data can never be entirely free from personal or social influences. Consequently, the results might not accurately reflect true levels of environmental awareness. Thus, while the survey provides a useful snapshot of environmental awareness among the participants, it should be interpreted with caution and understood as one of several tools needed to assess this multifaceted issue.

7.5.4 Minimum Response of Ocean Experts

The study primarily aimed to analyse the MM complexity of young adults, moreover, it included a comparative analysis with ocean experts. However, only a limited number of ocean experts participated. Consequently, the MMs provided by these experts may not be generalizable to the broader population of ocean experts due to the small sample size. This limitation raises concerns about the representativeness of the experts' MMs, as the insights derived from a limited response might not accurately reflect the diverse perspectives and expertise within the larger community of ocean experts. To address this issue in future research, it would be beneficial to increase the number of expert participants, ensuring a more comprehensive and representative analysis. Despite this limitation, the comparison provides initial insights and highlights the need for further investigation to fully understand the complexity of MMs among both young adults and ocean experts.

7.5.5 Generalisability

The current study specifically targeted young adults in the Netherlands, encompassing participants from MBO, HBO, and university educational levels. Since these educational distinctions are unique to the Netherlands, the findings of the study are limited to generalisability within this specific national context and may not apply universally outside of the Netherlands. Nonetheless, these findings could serve as valuable inputs for future research conducted in other countries where similar educational frameworks exist, allowing for comparative analyses across different educational levels. This approach could enrich understanding and provide insights into how educational backgrounds influence MM and perceptions across diverse cultural and educational settings globally.

8. Conclusion

The objective of this research was to explore the relationship between the complexity of mental models (MMs) of quality of life (QOL) in the ocean and individuals' educational levels or their level of environmental awareness. Two distinct sample groups were identified: young adults in the Netherlands formed the primary focus, with an additional group of experts included to compare their MMs and investigate differences in content and complexity. To elicit the MMs, both groups utilised the M-Tool for mapping and subsequently completed a survey detailing their educational background and environmental awareness. The research aimed to answer the following questions:

What are the characteristics of the mental models of young adults and ocean experts concerning the quality of life in the ocean? And what is the relationship between environmental awareness and educational level in the complexity of individuals' mental models?

To answer the first research question, the study focused on analysing and comparing the content and MM complexity of both young adults and ocean experts. Surprisingly, there was no significant variation in the content of MMs between young adults and experts concerning QOL in the ocean. Both groups identified humanity and climate change as primary drivers, although experts placed more emphasis on habitat and marine life, areas that were less prioritised by many young adults. As hypothesised, young adults generally demonstrated less complex MMs compared to experts, who showed a superior ability to perceive the system holistically and recognise interconnected relationships among the drivers. The findings showcase a vast disparity in understanding the systemic relationship between the drivers affecting QOL in the ocean among ocean experts and young adults.

The relationship between educational level and MM complexity in terms of QOL in the ocean can be characterised as positive. This suggests that individuals with higher education tend to exhibit more complex MMs concerning QOL in the ocean. This can be attributed to their enhanced capability in utilising systems thinking, enabling them to better understand and conceptualise complex systems. The number of edges was primarily the reason for variation in the MMs, as the number of nodes (drivers) utilised was similar across all educational levels. This showcases that someone’s educational level does not affect their ability to identify crucial drivers for QOL in the ocean, it primarily plays a role in the ability of an individual to understand the underlying interrelationships in a system. Thus, the relationship between educational levels and MM complexity shows a disparity in grasping systems holistically.

To answer the second part of the research question, the study investigated how environmental awareness could influence MM complexity concerning QOL in the ocean. Contrary to the anticipated hypothesis, the study did not establish a positive relation between an individual’s environmental awareness and the complexity of their MMs. The findings highlight that simply being aware of environmental issues does not necessarily correspond to a deep understanding of the intricate systemic relationships among drivers of QOL in the ocean. It reveals a distinction between knowing and wanting to do better for the environment and understanding all drivers and systems that affect (marine) environmental well-being. Thus, a high level of environmental awareness does not influence the complexity of MMs.

In conclusion, this research illuminates important insights into the complexity of MM models concerning QOL in the ocean among young adults and experts. It highlights that higher educational levels are positively associated with the complexity of MMs suggesting that advanced education promotes better systems thinking skills, however, more environmental awareness does not automatically improve one's understanding of systemic relationships. This study contributes to our understanding by emphasising the need for education in systems thinking to better address the complex environmental challenges facing our oceans globally and education on marine conservation. Moving forward, it is crucial to integrate robust educational frameworks and policies that promote a holistic understanding of environmental systems for fostering sustainable practices and policies in marine conservation efforts worldwide.

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10. Appendix

Appendix A: Operationalisation Table

Table A1 Operationalisation Table All Variables

Type of Variable	***Variable***	***Conceptual Definition***	***Operational Definition***	***Dimensions & Indicators***	***Measuring Scale***
Independ-ent Variable (qualitative)	Educational Levels	An individual's formal learning achievements, that reflect their acquired knowledge, skills, and competencies.	The highest academic degree attained by an individual.	**High school diploma** **Bachelor's degree** A. MBO B. HBO C. University **Master's degree**	Ordinal
Depend-ent Variable (quantitative)	Degree of Complexity of Mental Models (Quality of Life in the Ocean)	Intricacy and sophistication of an individual's cognitive frameworks, beliefs, and perceptions regarding marine ecosystems.	A composite score based on the elicitation of MM, by considering number of drivers and arrows used in the MM.	**The complexity of MM** (using the M-Tool) A. Number of drivers (nodes) used B. Number of mean weighted arrows per node (edges)	Ratio-scale
Independ-ent Variable (quantitative)	Level of Environmental Awareness	A state of being aware, having knowledge about, and being conscious of the environment humanity lives in.	A score derived from responses to a questionnaire measuring awareness and responsibility to environmental issues.	**Awareness of environmental problems** Adopted statements (Bozoglu et al., 2016) **Awareness of individual responsibility** Adopted statements (Özden, 2008)	Likert-scale (1= no threat, 5= threat) (1=very unlikely, 5= very likely)
Control Variable	Field of Study	An area of academic concentration	Providing a list of predefined categories that declares the field of studies	**What is your field of study?** "Natural Sciences, Social Sciences, Engineering, Arts and Humanities, Business and Economics, Other (Specify).	Nominal
Control Variable	Proximity to the Ocean	The geographical nearness of something to the ocean	Provide option for respondents to fill in the province they reside in and the proximity to the ocean	**Province (of the Netherlands)** List all provinces in the Netherlands **Proximity of Residence to the Ocean** Near the Ocean, Moderate Proximity, Far from the Ocean.	Nominal Scale Ordinal scale
Control Variable	Gender	Socially constructed roles, that identities girls, women, boys, men, and gender diverse people.	Provide option for respondents to fill in their gender	**What is your gender?** Male, Female, Non-Binary, Prefer not to say.	Nominal

Appendix B: Descriptive Statistics Short Survey

B.1: Gender

Table B1 Percentage Gender

	NUMBER	%
FEMALE	39	61.9
MALE	19	30.2
NON-BINARY	2	3.2
PREFER NOT TO SAY	3	4.8

Table B2 Descriptive Statistics Gender

	MEDIAN	MEAN	SD
EXPERTS	1	1.72	0.936
YOUNG ADULTS	1	1.3684	0.633

Female = 1, Male = 2, Non-Binary = 3, and 4= I'd rather not say

B.2: Age

Figure B1 Distribution of Age Pilot Group (Short Survey)

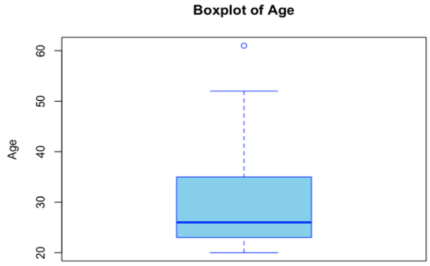
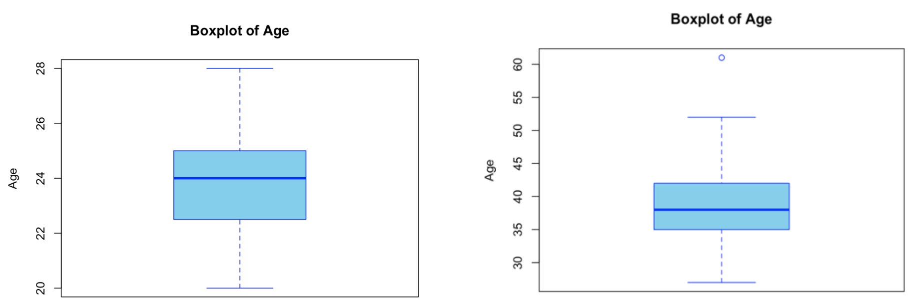


Table B3 Descriptive Statistics Age

	MEAN	SD
EXPERTS	38.96	8.038864
YOUNG ADULTS	23.80556	2.067703

Figure B2 Boxplot of Age per Sample group.

Note: Left figure: Young adults, Right figure: Experts



Appendix C: Short Survey

Table C1 Short Survey in Dutch.

	Question	*Answers*
1	Ga je akkoord met deelname?	Ja, Nee
2	Wat is je geslacht?	Man, Vrouw, Non-binair, Zeg ik liever niet
3	Hoe oud ben je?	*Open-ended*
4	Volg je op dit moment een opleiding?	Ja, Nee
(4= Ja) 5a	Welk onderwijsniveau volg je momenteel?	MBO, HBO, Universiteit
(4 = Nee) 5b	Wat is je hoogst behaalde diploma?	Ik heb geen diploma, middelbare school, Bachelor's, Master's
6 (only after 5b)	Op welk onderwijsniveau heb je dit diploma behaald?	MBO, HBO, Universiteit
7	Wat is je studierichting?	Taal en communicatie, Gedrag en Maatschappij, Informatica, Aarde en Milieu, Onderwijs en Opvoeding, Kunst en Cultuur, Zorg en Welzijn, Bedrijfsleven en Economie, Anders
8	In welke provincie woon je?	Groningen, Friesland, Drenthe, Overijssel, Gelderland, Flevoland, Utrecht, Noord-Brabant, Noord-Holland, Zuid-Holland, Limburg, Zeeland
9	Hoe dicht woon je bij zee?	Dichtbij de zee (binnen 10km), Gematigde dichtbijheid (tussen 10 en 50km), Ver van de zee (meer dan 50km)
10	Hoe bekend ben je met de kwaliteit van leven in de oceaan?	Niet mee bekend, Enigszins mee bekend, Neutraal, Heel bekend, Heel erg bekend
11	Hoe zou jij kwaliteit van het leven in de oceaan definiëren?	*Open-ended*
In deze studie wordt de kwaliteit van leven in de oceaan gedefinieerd als: "De algemene toestand van marine ecosystemen en het welzijn van alle organismen die hierin leven."		
12	Wat zijn volgens jou factoren die de kwaliteit van leven in de oceaan beïnvloeden? *Noem er minstens drie.*	*Open-ended*
Geef aan hoeveel invloed je denkt dat de volgende factoren hebben op de kwaliteit van leven in de oceaan. Als je niet bekend bent met sommige termen, hieronder vind je een overzicht van de definities van de benoemde factoren.		
D1	Overvloed van dieren en habitats	Helemaal geen invloed, Weinig invloed, Neutraal, Wel invloed, Heel veel invloed
D2	Diversiteit van dieren en habitats	
D3	De ecologische interacties tussen soorten	
D4	De verandering of het verlies van habitat	
D5	De veerkracht van de oceaan	
D6	Klimaatverandering	
D7	Het winnen van levende middelen	
D8	De scheepvaart	
D9	Recreatie	
D10	Het boren en winnen van gas en olie	
D11	Ontwikkelingen aan de kust	
D12	Introductie van exotische soorten, parasieten en ziekten	
D13	Vervuiling	

Table C2 Terms Definitions utilised in Short Survey.

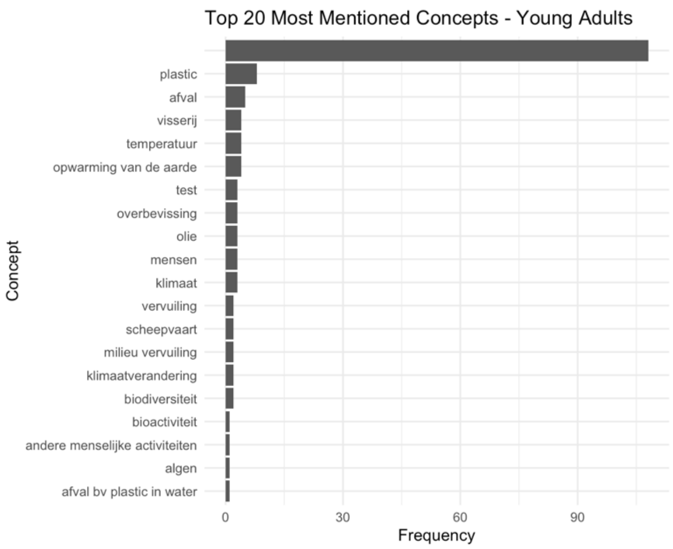
Number	Term (translated to English	Definition (translated to English)
D1	Abundance of Animals and Habitats	Abundance refers to the extent to which animals or habitats are present in a given ecosystem. It indicates how many individuals of a species or how many different habitats there are within a specific location.
D2	Diversity of Animals and Habitats	The variety of species (biodiversity) or different habitats within an ecosystem. It indicates how many different species there are and how many different habitat types can be found within a specific location.
D3	The Ecological Interactions between Species	The relationships and interactions between different species in an ecosystem. These interactions can range from feeding relationships (e.g., predation, herbivory) to symbiotic relationships (e.g., mutualism, commensalism) and competition.
D4	The Alteration or Loss of Habitat	The decline or modification of a species' habitat.
D5	Ocean Resilience	The ability of the ocean to recover from disturbances or damage caused by human activities or natural events. A resilient ecosystem can adapt and recover from disturbances.
D6	Climate Change	The long-term changes in Earth's average weather patterns. Examples in the ocean include eutrophication (growing algae), ocean acidification, etc.
D7	The Extraction of Living Resources	The activities in which living organisms are harvested from natural ecosystems. Such as aquaculture, recreational and commercial fisheries
D8	The shipping industry	The activity of ships transporting goods or people along waterways, such as seas and rivers. It includes both commercial shipping and recreational vessels.
D9	Recreation	The activities people engage in for relaxation, pleasure, or leisure. Such as scuba diving, boating, swimming, etc.
D10	Drilling and Extracting Gas and Oil	The process of extracting fossil fuels such as natural gas and crude oil from underground reservoirs.
D11	Coastal Developments	The construction of infrastructure and buildings along the coastline, such as ports, beach hotels, holiday homes and industrial areas.
D12	Introduction of Exotic Species, Parasites, and Diseases	The introduction of non-native species (exotic species) into an ecosystem, often as a result of human activities such as international trade and transport.
D13	Pollution	The presence of harmful or unwanted substances in the environment, such as chemicals or plastics, among others.

Appendix D: Data Analysis Short Survey

Table D1 Driver Influence QOL in the Ocean (Mean Score).

	YOUNG ADULTS	OCEAN EXPERTS	*COMBINED AVERAGE*
ABUNDANCE OF ANIMALS AND HABITATS	4.033333	4.304348	*4.169*
DIVERSITY OF ANIMALS AND HABITAT	3.965517	4.826087	*4.396*
ECOLOGICAL INTERACTION	3.566667	4.782609	*4.175*
ALTERATION/ LOSS OF HABITAT	4.500000	4.869565	*4.685*
OCEAN RESILIENCE	4.000000	4.409091	*4.205*
CLIMATE CHANGE	4.551724	4.826087	*4.689*
THE EXTRACTION OF LIVING RESOURCES	4.166667	4.695652	*4.431*
SHIPPING INDUSTRY	4.100000	4.608696	*4.354*
RECREATION	3.666667	3.869565	*3.768*
DRILLING AND EXTRACTING GAS AND OIL	4.366667	4.608696	*4.488*
DEVELOPMENTS	3.482759	4.608696	*4.046*
EXOTIC SPECIES	4.033333	4.391304	*4.212*
POLLUTION	4.800000	4.826087	*4.813*

Figure D1 Top 20 Most-mentioned Drivers.



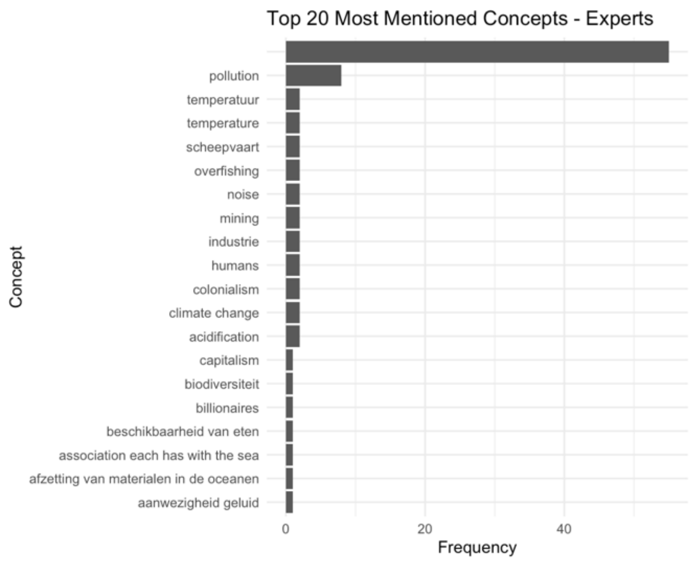


Figure D2 Wordcloud - Drivers Opted by Young Adults.

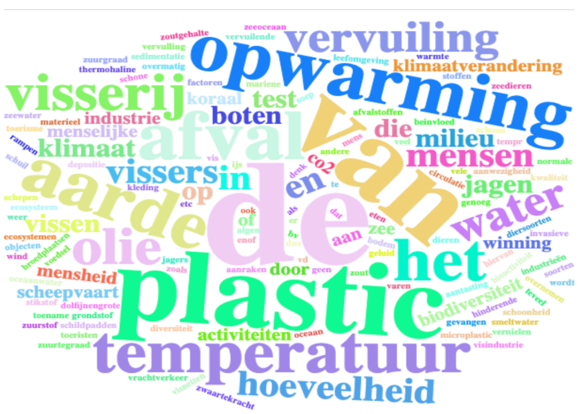


Figure D3 Wordcloud - Drivers opted by Ocean Experts.

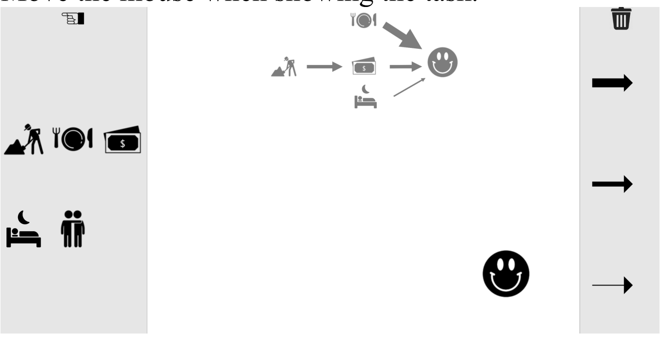
Appendix E: Handout Audio and Visual Elements

E1. Audio Handout

Welcome audio:
"Probeer nu het model uit de instructie video na te maken. Let op de diktes van de pijlen en klik op de hand rechtsonder als je klaar bent."
Practice fail audio:
"*Het model is nog niet compleet. Kijk goed naar het voorbeeld model.*"
Mapping screen 1 audio:
"Creëer nu jouw model voor kwaliteit van leven de oceaan. De factoren aan del linkerkant kan je gebruiken om jouw model te weergeven. Dit zijn de factoren waarbij jij denkt dat ze de kwaliteit van leven in de oceaan beïnvloeden. Gebruik enkel de factoren waarbij jij denkt dat ze belangrijk zijn
Aan de rechterkant staan de verschillende soorten pijlen
Waarbij de grote pijl heel veel invloed betekent, de middelmatige pijl gemiddelde invloed en de kleine pijl weinig invloed
Als je een element of een pijl wilt verwijderen klik dan eerst op het element of de pijl, dan op het prullenbakje rechtsboven.
Vergeet niet na het maken van je model op het handje rechtsonder te klikken om verder te gaan."
Thank you audio:
"Bedankt voor het maken van jouw model over de kwaliteit van leven in de oceaan."

E2. Visual Handout

Introduction video mental model practice task
Text:
"*Hierboven zie je een Plaatje dat je na afloop van deze video gaat maken. Het is een oefenopdracht waarbij je een model maakt van geluk. Welke factoren ervoor zorgen dat iemand gelukkig is. Aan de linkerkant van je scherm kan je plaatjes vinden betreft dingen die te maken hebben met geluk: werk, eten, geld, slapen en vriendschap.*
We zullen in deze oefenopdracht het bovenstaande model gaan namaken. Hiervoor moet je de plaatjes van de linkerkant naar het scherm verplaatsen. Klik hiervoor eerst op het plaatje aan de linkerkant, klik dan op de plek waar in het scherm dit geplaatst moet worden. Let op dat je de plaatjes niet kan slepen. Doe dit voor alle plaatjes die je wilt gebruiken.
Aan de rechterkant van het scherm staan verschillende pijlen om de verbanden tussen de verschillende plaatjes te weergeven. Hoe ze zich onderling verhouden en hoe ze geluk beïnvloeden. De brede pijl staat voor een sterke invloed, een middelgrote pijl voor gemiddelde invloed en een zwakke pijl voor weinig invloed. Om de pijl in het scherm te plaatsen klik je eerst op de pijl tot dat deze blauw oplicht. Klik dan op de plaatjes die je met elkaar wil verbinden. Doe dit dan voor alle plaatjes waar jij ziet dat ze zich onderling met elkaar verhouden. Voor het verwijderen van een geplaatst plaatje of een pijl, klik dan op dit element en dan op het prullenbakje rechtsboven in je scherm. Probeer nu het model uit de instructie video na te maken."
Imagary:
Move the mouse when showing the task.



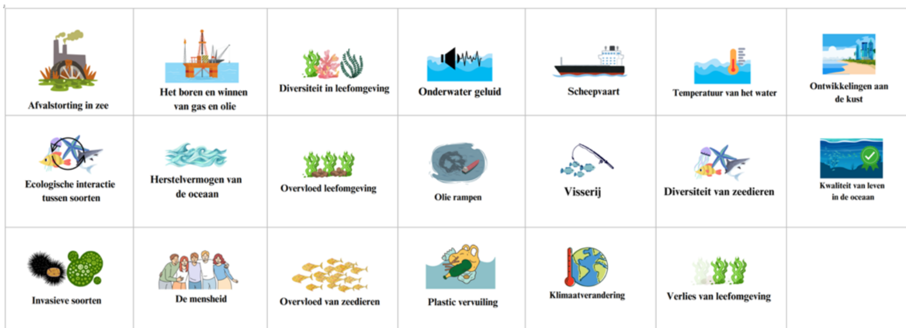
Icon explanation video

Text:

"*Nu vragen we aan jou om een model te maken over dingen die volgens jou de kwaliteit van leven in de oceaan beïnvloeden. Dit houdt in, factoren die de toestand van de oceaan zowel negatief als positief beïnvloeden.*
De factoren die je kan gebruiken worden nu uitgelegd:
Verlies van leefomgeving: De afname van de leefomgeving van een soort
Klimaatverandering: De langdurige veranderingen in de gemiddelde weerpatronen van de aarde. Voorbeelden in de oceaan zijn: Eutrofiëring (groeien van algen), verzuring van de oceaan, etc.
Visserij: De activiteit waarbij zeedieren worden geoogst uit zee-ecosystemen
Het boren en winnen van gas en olie: Het proces van het winnen van fossiele brandstoffen zoals aardgas en ruwe olie uit ondergrondse reservoirs.
Temperatuur van het water: De warmte toestand van het water
Scheepvaart: De activiteit van schepen die goederen of personen vervoeren over waterwegen, zoals zeeën en rivieren. Het omvat zowel commerciële scheepvaart als recreatieve vaartuigen
Overvloed van leefomgeving: Overvloed verwijst naar de mate waarin habitats aanwezig zijn in een bepaald ecosysteem.
Diversiteit in leefomgeving: De variatie aan habitats binnen een ecosysteem. Het geeft aan hoeveel verschillende typen habitats er binnen een specifieke locatie te vinden zijn.
Ecologische interactie tussen soorten: De relaties en interacties tussen verschillende soorten in een ecosysteem.
Onderwater geluid: Het aanwezig zijn van geluid onder water door menselijke activiteiten, zoals recreatie en scheepvaart.
Plastic vervuiling: De aanwezigheid van schadelijke of ongewenste stoffen in het milieu, zoals onder andere plastic
Afvalstorting in zee: Het storten van afval op zee, vanaf schepen of op zeebodem gerichte werken
Herstelvermogen van de oceaan: Het vermogen van de oceaan om te herstellen van verstoringen of schade veroorzaakt door menselijke activiteiten of natuurlijke gebeurtenissen
Diversiteit van zeedieren: De variatie aan soorten (biodiversiteit) binnen een ecosysteem. Het geeft aan hoeveel verschillende soorten er binnen een specifieke locatie te vinden zijn
Ontwikkelingen aan de kust: De bouw van infrastructuur en gebouwen langs de kustlijn, zoals havens, strandhotels, vakantiehuizen en industriegebieden
Overvloed van zeedieren: Overvloed verwijst naar de mate waarin dieren aanwezig zijn in een bepaald ecosysteem. Het geeft aan hoeveel individuen van een soort er zijn binnen een specifieke locatie
Invasieve soorten: Het inbrengen van niet-inheemse soorten (exoten) in een ecosysteem, vaak als gevolg van menselijke activiteiten zoals internationale handel en transport
De mensheid: Een verzamelnaam voor alle mensen ter wereld
Olierampen: Een ramp veroorzaakt door het al dan niet opzettelijk vrijkomen van een grote hoeveelheid olie in het milieu
Zodra je jouw model hebt gecreëerd vergeet dan niet om op het handje rechtsonder te klikken om verder te gaan met het onderzoek en de enquête in te vullen."

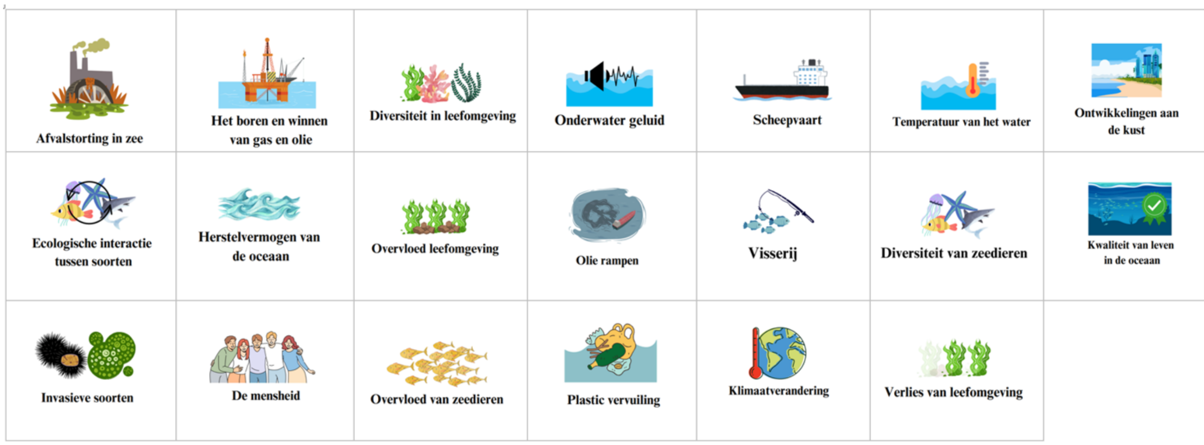
Imagery:

Show individual element that is being explained in the text.



Appendix F: Translated Intuitive Icons

Figure F1 Original Intuitive Icons Drivers of QOL in the Ocean (Dutch).



Appendix G: General Information of Sample Group

Table G1 Gender Distribution Sample Group.

Gender	*% of people*		*Nr. of people*
	Young Adults	Experts	Both
Female	68.28	62.50	131
Male	29.57	37.50	57
Non-Binary	1.08	-	2
Rather not say	1.08	-	2

Table G2 Provinces Distribution of the Sample Group.

Province	*% of people*		*Nr. of people*
	Young Adults	Experts	Both
Drenthe	6.45		12
Flevoland	1.08		2
Friesland	6.99		13
Gelderland	7.58		14
Groningen	0.54		1
Limburg	1.08		2
Noord-Brabant	7.53		14
Noord-Holland	11.83	12.50	23
Overijssel	23.12		43
Utrecht	25.81	87.50	54
Zeeland	0.54		1
Zuid-Holland	7.53		14

Appendix H: Consent Form & Information Sheet

H.1: Consent form:

In this study, we want to learn about different perceptions of marine environments. Participation in this survey is voluntary and you can quit the M-Tool and survey at any time without giving a reason and without penalty. Your answers to the questions will be shared with the research team. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act). Please respond to the questions honestly and feel free to say or write anything you like.

Everything you say or write will be confidential, and anonymous. This means that we do not ask for your name, and no one will know which respondent said what.

I confirm that:
I am satisfied with the received information about the research;
I have no further questions about the research at this moment;
I had the opportunity to think carefully about participating in the study;
I will give an honest answer to the questions asked.

I agree that:
the data to be collected will be obtained and stored for scientific purposes;
the collected, completely anonymous, research data can be shared and re-used by scientists to answer other research questions;

I understand that:
I have the right to withdraw my consent to use the data as long as they can be identified;
I have the right to see the research report afterwards.

Do you agree to participate**?** o Yes o No

H.2: Information sheet:

Introduction

You are invited to take part in this study on various perceptions concerning marine environments. The purpose of the study is to learn specifically about your perceptions of these environments. The study is conducted by Floor van der Kolk who is a student in the MSc programme Sustainable Business and Innovation at the Department of Sustainable Development, Utrecht University. The study is supervised by Dr. Karlijn van den Broek.

Participation

Your participation in this survey is completely voluntary. You can quit at any time without providing any reason and without any penalty. Your contribution to the study is very valuable to us and we greatly appreciate your time taken to complete this survey. We estimate that it will take approximately 10-15 minutes to complete the M-Tool and survey. Some of the questions require little time to complete, while other questions might need more careful consideration. Please feel free to skip questions you do not feel comfortable answering. The data you provide will be used for writing a Master thesis report and may be used for other scientific purposes such as a publication in a scientific journal or presentation at academic conferences. Only patterns in the data will be reported through these outlets. Your individual responses will not be presented or published.

Data protection

All answers in this survey will be confidential and completely anonymous. This means that we will not ask for your name, date of birth, or other personal information that can be traced to you by us or a third party. We will process your data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act).

Appendix I: Survey

Table 11 Questionnaire Mapping Mental Models

	QUESTION	ANSWERS
1	Ga je akkoord met deelname?	Ja, Nee
2	Wat is je geslacht?	Man, Vrouw, Non-binair, Zeg ik liever niet
3	Wat is je leeftijd?	*Open-ended*
4	Studeer je momenteel?	Ja, Nee
(4= JA) 5A	Op welk niveau studeer je?	MBO, HBO, Universiteit
4 =NEE) 5B	Op welk onderwijsniveau heb je dit diploma behaald?	MBO, HBO, Universiteit
6	Wat was/is je studierichting?	Sociale Wetenschappen (zoals Sociologie, Psychologie, Rechten, Pedagogiek, en Communicatie), Natuurwetenschappen (zoals, fysica, chemie, biologie en andere gerelateerde opleidingen), Ingenieurswetenschappen (zoals, techniek, mechanica, scheikunde, informatica en andere gerelateerde opleidingen), Kunsten en Geesteswetenschappen (zoals, geschiedenis, taal, theologie en andere gerelateerde opleidingen), Bedrijfskunde en Economie (zoals, bedrijfskunde, accountancy, andere economie gerelateerde opleidingen), Anders
7	In welke provincie woon je?	Groningen, Friesland, Drenthe, Overijssel, Gelderland, Flevoland, Utrecht, Noord-Brabant, Noord-Holland, Zuid-Holland, Limburg, Zeeland
8	Woon je dichtbij zee?	Dichtbij de zee (binnen 10km), Gematigde dichtbijheid (tussen 10 en 50km), Ver van de zee (meer dan 50km)
9	Hoe vaak ben je betrokken bij zaken die verband houden met de oceaan?	Nooit, Zelden, Maandelijks, Wekelijks, Dagelijks
DE VOLGENDE VRAGEN ZIJN VERSCHILLENDE STELLINGEN DIE TE MAKEN HEBBEN MET KLIMAATVERANDERING EN DE VERANTWOORDING VAN DE MENS. GRAAG BIJ IEDERE STELLING AANGEVEN IN HOEVERRE JE HET ER WEL OF NIET MEE EENS BENT. ER ZIJN GEEN GOEDE OF FOUTE ANTWOORDEN.		
PART 1:	De volgende stellingen gaan over verschillende problemen die zich in de natuur voor doen.	Mee oneens, Een beetje mee oneens, Neutraal, Een beetje mee eens, Helemaal mee eens
PART 2:	De volgende stellingen gaan over de menselijke verantwoording betreft natuurproblemen. Graag aangeven in hoeverre je het eens bent met de stelling. Ook bij deze vraag zijn er geen goede of foute antwoorden.	

For the statements utilised during the survey (Part 1 and 2) see Table 18 below, including their favourability which was not indicated during the survey.

Table I2 Environmental Statements Questionnaire including Favourability.

	Statement Nr	*Statement*	*Statement Favourability*
Environmental problems	1	We overbelasten het natuurlijke vermogen van de aarde om het leven op aarde te ondersteunen	Favourable
	2	Mensen mishandelen het milieu	Favourable
	3	Een te snelle bevolkingsgroei is een ernstig milieuprobleem	Favourable
	4	Lucht, water en bodem zijn onuitputtelijke bronnen	Favourable
	5	Milieubewustzijn belemmert niet de ontwikkeling van een land	Favourable
	6	De voordelen van technologie zijn groter dan de schadelijke gevolgen	Unfavourable
	7	De oplossing voor milieuproblemen in Nederland is het vergroten van het milieubewustzijn	Favourable
	8	Milieuvervuiling is een tijdelijk probleem	Unfavourable
	9	Milieuvervuiling is niet overal ter wereld op een gevaarlijk niveau	Unfavourable
	10	Vervuiling van de zee is een natuurlijke gebeurtenis	Unfavourable
	11	Milieuvervuiling heeft schadelijke gevolgen voor de menselijke gezondheid	Favourable
	12	Bescherming van het milieu is belangrijker dan economische groei	Favourable
	13	Milieuvervuiling heeft altijd bestaan en is opgelost. Er is geen reden om je zorgen te maken over de toekomst	Unfavourable
	14	De komende tien jaar zullen de milieuproblemen afnemen	Unfavourable
	15	Consumptiepatronen zijn niet gerelateerd aan uitputting van natuurlijke hulpbronnen	Unfavourable
	16	Er zijn veel planten en dieren in ons land die op de rand van uitsterven staan	Favourable
	17	Iedereen heeft een aandeel in de achteruitgang van het milieu	Favourable
	18	De bescherming van het milieu is een plicht van de staat, niet van mensen	Unfavourable
Individual responsibility	19	Ik vind dat milieuproblemen worden overdreven	Unfavourable
	20	Ik verdiep me vaak over de effecten van onze activiteiten op het milieu	Favourable
	21	Het geven van milieueducatie helpt niet bij het oplossen van milieuproblemen	Unfavourable
	22	Geen enkele internationale instelling of organisatie mag zich bemoeien met het gebruik van natuurlijke hulpbronnen.	Favourable
	23	Ik kan veranderingen in levensstijl accepteren om natuurlijke bronnen te beschermen	Favourable
	24	Individuele verantwoordelijkheden zijn erg belangrijk bij het voorkomen van milieuvervuiling	Favourable
	25	Ik doe (actief) mee aan activiteiten op het gebied van milieukwesties	Favourable

26	We moeten gebruiken van de huidige grondstoffen voor onze generatie	Unfavourable
27	De mensheid zou in harmonie met de natuur moeten leven	Favourable
28	De samenleving zou het behoud van de natuur moeten aanmoedigen	Favourable

Appendix J: Assumptions

J.1 Assumptions Multiple Linear Regression Analysis - Nodes

Figure J1 Assumptions of Linearity (nodes).

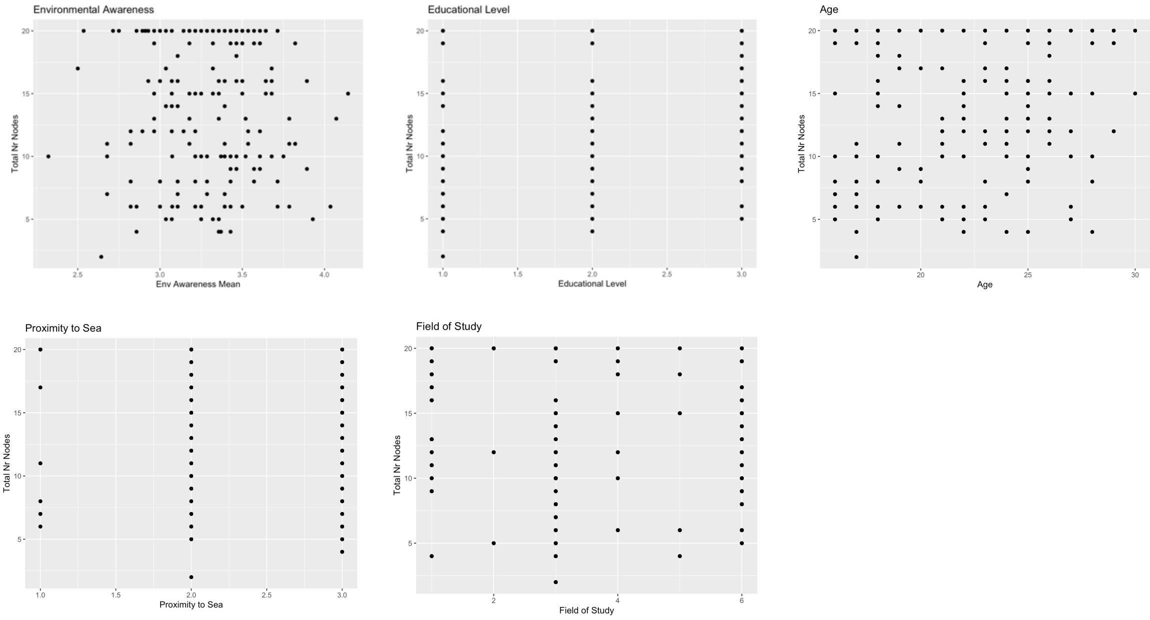


Figure J2 Assumptions of Normal Distribution & Homoscedasticity.

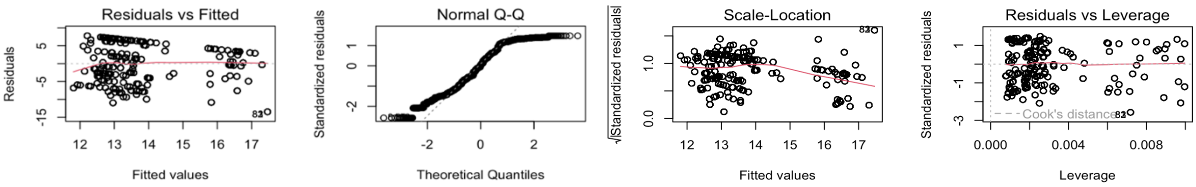


Table J1 No Multicollinearity (Correlation Matrix).

	Nr of nodes	*Env. Awareness*	*Educational Level*	*Age*	*Proximity to sea*	*Field of Study*
Nr of nodes	1	-0.0087	0.061	0.062	0.021	-0.178
Env. Awareness	-0.0087	1	0.218	0.32	0.15	0.143
Educational level	0.061	0.217	1	0.58	-0.1	0.131
Age	0.062	0.32	0.579	1	0.076	0.175
Proximity to sea	0.021	0.15	-0.099	0.076	1	-0.133
Field of study	-0.18	0.143	0.131	0.175	-0.134	1

The correlations between environmental awareness, educational level, and total number of nodes are all weak or moderate. This suggests that *multicollinearity is not a major concern* with these predictors.

Table J2 Assumptions Multiple Linear Regression Model (Nodes).

Assumptions Multiple Linear Regression model 'Nodes'	
Linearity	Met
Normality	Met
Homoscedasticity	Met
No multicollinearity	Met

J.2 Assumptions Multiple Linear Regression Analysis – Edges

Figure J4 Assumptions of Linearity (Edges per Node).

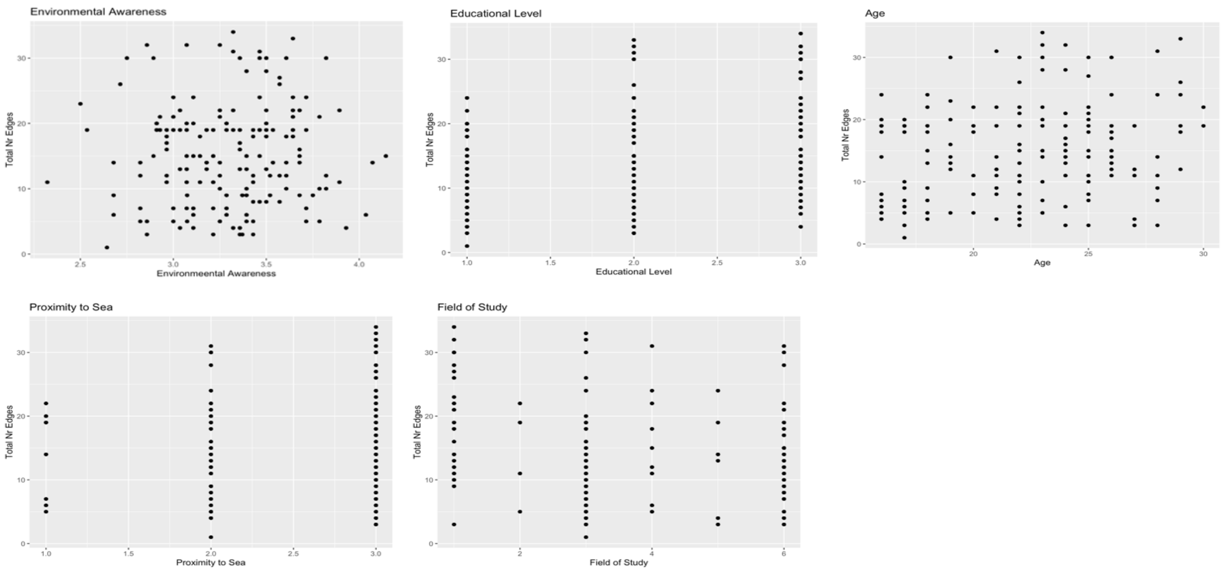


Figure J3 Assumptions of Normal Distribution & Homoscedasticity.

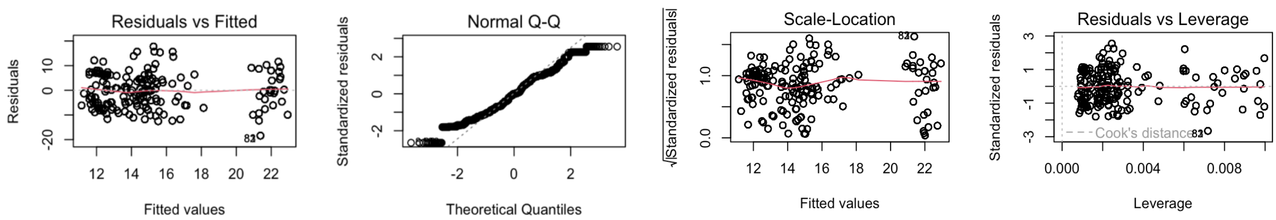


Table J3 No Multicollinearity (Correlation Matrix).

	Nr of edges	*Env. Awareness*	*Educational Level*	*Age*	*Proximity to sea*	*Field of Study*
Nr of edges	1	0.027	0.268	0.191	0.014	-0.226
Env. Awareness	0.027	1	0.218	0.319	0.15	0.143
Educational level	0.268	0.218	1	0.576	-0.095	0.131
Age	0.191	0.319	0.576	1	0.079	0.175
Proximity to sea	0.014	0.15	-0.096	0.079	1	-0.134
Field of study	-0.226	0.143	0.131	0.175	-0.134	1

The correlations between environmental awareness, educational level, and total number of nodes are all weak or moderate. This suggests that *multicollinearity is not a major concern* with these predictors.

Table J4 Assumptions Multiple Linear Regression Model (Edges per Node).

Assumptions Multiple Linear Regression model 'Edges per Node'	
Linearity	Met
Normality	Met
Homoscedasticity	Met
No multicollinearity	Met

Appendix K: Descriptive Statistics

K.1. Dependent Variables

Table K1 Descriptive Statistics - Mental Model Complexity (Nodes and Edges per Node).

	Young Adults		*Experts*	
	Average number of nodes	Average number of edges per node	Average number of nodes	Average number of edges per node
Mean	13.62	15.09	15.125	22.25
Median	14	15	15	18
Standard Deviation	5.51	8.01	5.42	7.674
Minimum	2	1	10	12
Maximum	20	43	20	43

K.2: Descriptive Statistics Independent variables

Table K2 Descriptive Statistics - Level of Environmental Awareness per Sample Group.

	MEAN	MEDIAN	STANDARD DEVIATION	MINIMUM	MAXIMUM
YOUNG ADULTS	3.295	3.295	0.32	2.32	4.14
EXPERTS	3.51	3.508	0.26	2.93	3.75

Table K3 Descriptive Statistics - Level of Environmental Awareness per Educational Level.

	MEAN	MEDIAN	STANDARD DEVIATION	MINIMUM	MAXIMUM
MBO	3.15	3.18	0.24	2.54	3.79
HBO	3.39	3.42	0.32	2.68	4.14
UNIVERSITY	3.33	3.38	0.34	2.32	4.04

Table K4 Descriptive Statistics - Educational Levels.

	Young adults		*Experts*	
	%	Number	%	Number
MBO	32	59	-	-
HBO	32	60	12.50	1
University	36	66	87.50	7
	100%	184	100%	8
Median	2		3	
Standard Deviation	0.88		0.33	
Mean	2.03		2.88	

K.3: Descriptive Statistics Control Variables

Table K5 Descriptive Statistics – Age.

	Young Adults	*Experts*
Mean	21.68	28
Median	22	26.5
Standard Deviation	4	6.09
Minimum	16	23
Maximum	30	42

Figure K1 Boxplot - Age.

Left: young adults
Right: experts

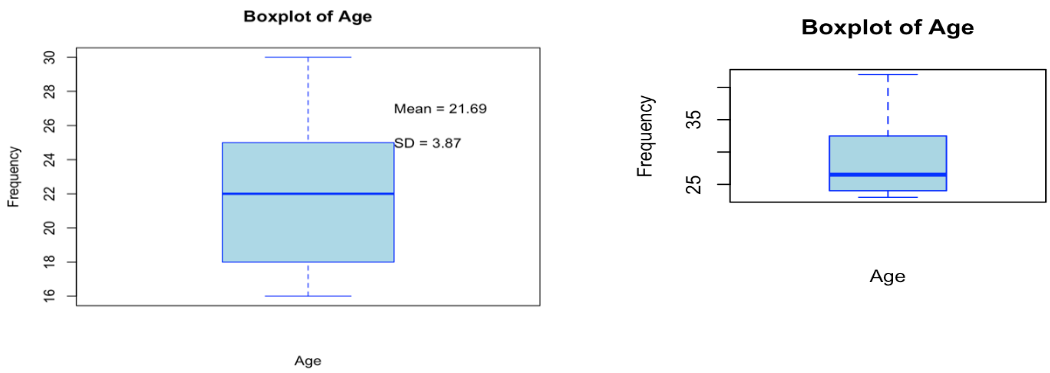


Table K6 Descriptive Statistics - Proximity to the Ocean.

	Young Adults	*Experts*
Mean	2.63	3
Median	3	3
Standard Deviation	0.57	0.66

Table K7 Distribution - Proximity to the Ocean.

	Young Adults		*Experts*	
	%	Number	%	Number
1 – Close to sea (<10km)	4.84	9	12.50	1
2 – Average closeness (10-50km)	27.42	50	-	-
3 – Far from sea (>50km)	67.74	125	87.50	7

Table K8 Distribution - Field of Study.

	Young Adults		*Experts*	
	%	**Number**	**%**	**Number**
Business and economics	51.1	94	25	2
Engineering sciences	4.84	9	-	-
Arts and humanities	3.23	6	-	-
Natural sciences	16.1	30	50	4
Social sciences	21.5	40	-	-
Other	3.23	6	25	2

Appendix L: Aggregated Mental Models

Figure L1 Aggregated Mental Model Text - Young Adults.

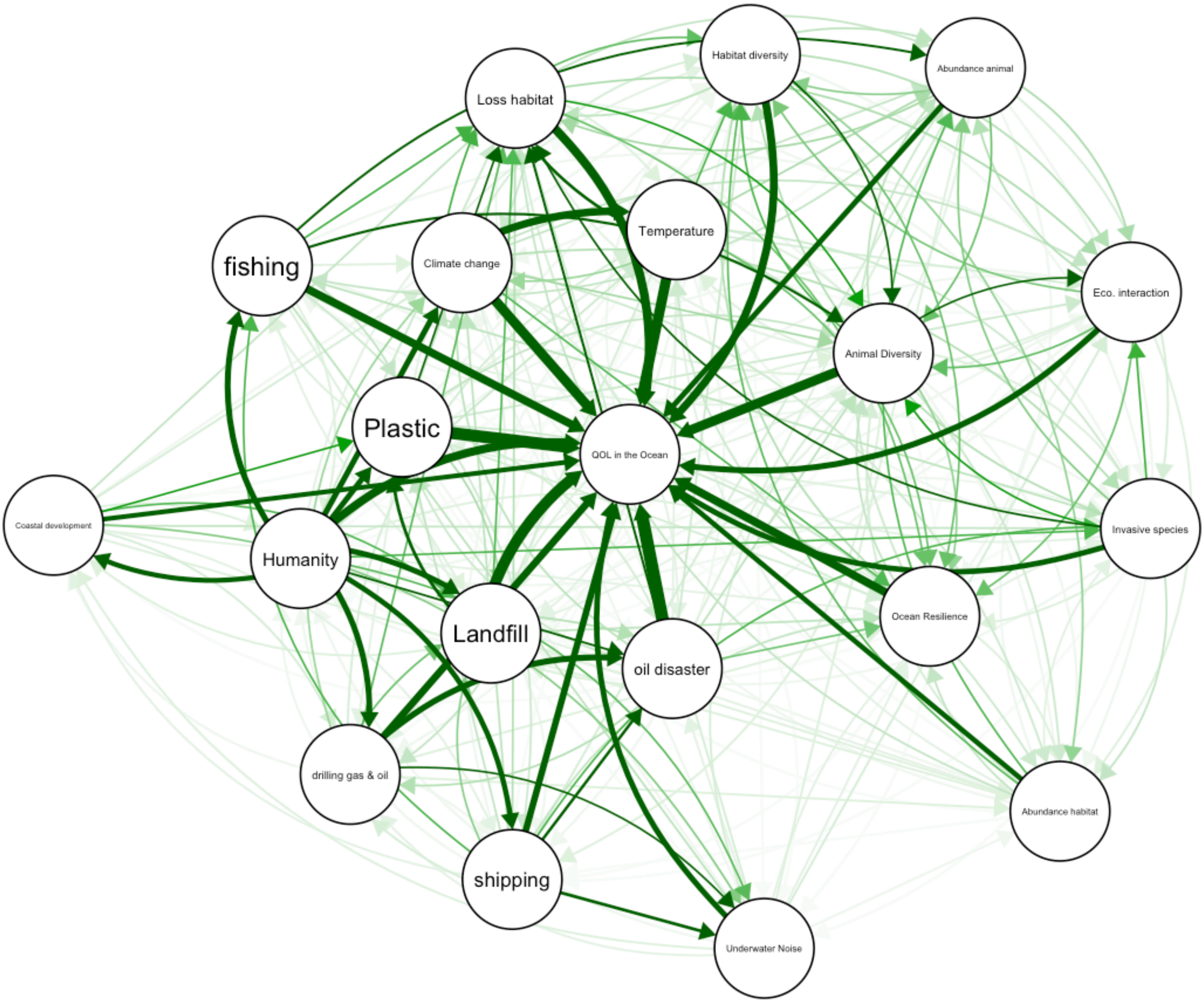


Figure L2 Aggregated Mental Model Text - Ocean Experts.