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EVALUATING THE NEED FOR OCEAN LITERACY IN SOUTH AFRICA

By

EUGENE NYMAN
Republic of South Africa

A dissertation submitted to the World Maritime University in partial Fulfilment of the requirements for the award of the degree of

MASTER OF SCIENCE
In
MARITIME AFFAIRS
(OCEAN SUSTAINABILITY, GOVERNANCE AND MANAGEMENT)

2018

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DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me. The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): ..................................

(Date): 18 September 2018

Supervised by: Dr. Lawrence P. Hildebrand

Supervisor’s affiliation: Ocean Sustainability, Governance and Management
ACKNOWLEDGEMENTS

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Title of Dissertation: Evaluating the Need for Ocean Literacy in South Africa

Degree: Master of Science

Pressures on the ocean are increasing due to anthropogenic activities, which has caused decline in the health of the ocean. This has adversely affected the services and goods that populations are able to derive from the ocean. Various international agreements and partnerships, have been adopted to stem the human pressures on the ocean. However, the decline in the health of the ocean, has persisted.

Ocean literacy is summarised by UNESCO (2017) as an individual being able to understand the influence they have on the ocean, and the ocean’s influence on their life. The concept has been developed with the aim of educating society about the importance of the ocean, so that the individual will make decisions that do not adversely affect the ocean.

The marine and coastal habitats within South Africa’s EEZ are also under pressure, from activities such as over fishing and coastal development, despite the national laws and interventions in place to protect and conserve these habitats. In conjunction, South Africa’s blue ocean economy strategy, Operation Phakisa, has the objective of expanding the country’s economy, by sustainably harnessing the resources of the ocean.

The research presents the findings of the adapted International Ocean Literacy Survey, used to determine the level of ocean literacy in a South African high school population sample, as well as a review of ocean knowledge in the South African curriculum. Furthermore, the research looks at how ocean literacy has been adopted by other countries, and what is required for its further integration in South Africa as a tool to prevent further marine environmental degradation.

KEYWORDS: Ocean Literacy, Education, Sustainability, Behavior, Knowledge, Marine Environment
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<table>
<thead>
<tr>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>CAPS</td>
<td>Curriculum Assessment Policy Statements</td>
</tr>
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<td>EEZ</td>
<td>Exclusive Economic Zone</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agricultural Organization</td>
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<td>ICMA</td>
<td>Integrated Coastal Management Act</td>
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<td>IMO</td>
<td>International Maritime Organization</td>
</tr>
<tr>
<td>IPBES</td>
<td>Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services</td>
</tr>
<tr>
<td>UCN</td>
<td>International Union for Conservation of Nature</td>
</tr>
<tr>
<td>MLR</td>
<td>Marine Living Resources Act</td>
</tr>
<tr>
<td>RAS</td>
<td>Republic of South Africa</td>
</tr>
<tr>
<td>SA DAFF</td>
<td>South African Department Agriculture, Forestry and Fisheries</td>
</tr>
<tr>
<td>SA DEA</td>
<td>South African Department of Environmental Affairs</td>
</tr>
<tr>
<td>UNESCO</td>
<td>United Nations Educational, Scientific and Cultural Organization</td>
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CHAPTER ONE

1. Introduction

1.1. Background of Research

Over the past century there has been an exponential increase in the global population. Two hundred years ago there was less than one billion people on the planet, while the United Nations (UN) has estimated that in 2017, there was 7.6 billion people living on earth (United Nations, 2017b). The world population is expected to expand to 8.6 billion by 2030 and to 11.2 billion, by 2100. Comparatively, the world population has taken millennia to reach just under 1 billion people two hundred years ago, and the human population is now estimated to grow by a billion people in thirteen years (Roser & Ortiz-Ospina, 2017). Advancements in medicine and food production technology have meant that globally, on average, the infant mortality rate has declined and more people are living longer. The impact is that more people require resources to survive and to live in comfort. Food, clothing, shelter and transport are among the primary needs and consequently, drivers of human behavior (UN, 2016).

The question is whether nature can keep up with our demand for resources to satisfy our needs, let alone our wants. The mounting evidence points to an undesirable answer to the question, and an inconvenient resolution as the answer to the problem. We require nature to satisfy our needs, but at the same time, we are wearing the down capacity of nature to satisfy our needs (Sherbinin, Carr, Cassels, & Jiang, 2009). Secondly, the by-products and waste produced through the extraction of the resources required to satisfy our needs are also placing a strain on the environment’s capacity to satisfy our needs (UNESCO, 2015). We require energy to cook our food so that we can fill our bodies with the nourishment we require; and to move our vehicles so that we can get to the jobs that will provide us with the income to purchase energy, food and fuel for our vehicles. While the energy we use comes from nature, the extraction and use of it impede nature’s ability to provide other necessities to us. Our lives as modern human beings have become so inextricably connected to the extraction and the use of these resources and detached from the actual processes through modern technology; that we often do not spare a thought on the consequences of their use (Sherbinin et al., 2009).
Though more people around the globe are conscious of the effects of human activities on the environment, much more still needs to be done by governments, industries, and individuals in order to live sustainably. Many reports, journals, and research outputs have indicated the declining health of the environment as a result of global warming, threatened and endangered species, and the destruction of animal habitats (Holt & Miller, 2010; IPBES, 2018). Our attitudes and beliefs about the ocean have shaped our use of the ocean (Wiener, Manset, & Lemus, 2016). Pervading beliefs that the ocean is limitless and too vast for our actions to have an effect on it has resulted in the deterioration of marine ecosystems and the loss of marine life. Increased ocean acidification, rising sea temperatures, rising sea levels, declining fish stocks, and marine pollution are among the many pressures that humanity has placed on our ocean (UNESCO, 2010). If these pressures continue without austere abatement, it will have dire consequences for humanity, and life on the planet as a whole (UN, 2016).

Figure 1: Cumulative Human Impact by FAO Fishing Area

Figure 1 is a map depicting the extent of cumulative pressures on areas beyond national jurisdiction. These are areas of the ocean relatively far away from human development but are being adversely affected by human induced stressors such as ocean acidification, maritime traffic and fishing (Halpern, 2018). The adverse impacts of these pressures will continue to grow if not effectively managed (Halpern, et al., 2008). Continued overexploitation of fish stocks has caused collapses in fish populations and has affected the food security of communities, and jeopardized the economic livelihoods of families through the loss of work in the sector (UNESCO, 2010). The Canadian cod fishery Collapse and moratorium of 1992 resulted in approximately 20 000 jobs being lost (Mason, 2002). The collapse of commercial fish stock populations can disrupt the food chain and have significant effects for other species as well (FAO, 2011).

It is estimated that the ocean absorbs 26% of all anthropogenic carbon dioxide. Increasing carbon dioxide levels will mean that more will be dissolved into the ocean (Doney, Fabry, Feely, & Kleypas, 2009). Through chemical reactions, one of the chemicals released from the dissolution of carbon dioxide is carbonic acid, which decreases the pH level of the ocean. An acidic ocean will mean that organisms with a calcium-based shell, such as some types of plankton, will not be able to survive as their shells will be broken down by the acidic water (Orr et al., 2005). This is troubling on two levels. First, more than fifty percent of all the oxygen produced is produced by organisms such as plankton with their existence threatened, it means the world’s oxygen production capabilities are threatened (Doney et al., 2009). Secondly, plankton are among the primary producers in the ocean and form the base of the marine trophic level (D’Alelio et al., 2016). Their declining numbers or disappearance, will disrupt the food chain for animals higher in the trophic level that rely on plankton as their food source which will ultimately also affect the food security and economy of populations which rely on the ocean for food and work (Pinsky, Jensen, Ricard, & Palumbia, 2011). Research has indicated that if carbon dioxide levels continue on the same trajectory, the ocean could be acidic by the year 2100 (Orr et al., 2005; UN, 2016).
The collapse of fish stocks and an acidifying ocean, are just two elaborated examples of the anthropogenic pressures on the ocean and how they will inevitably adversely affect humanity as well. These pressures cannot be dealt with in an isolated manner or by one country at a time, because the ocean is one joint body of water, what occurs in one part of it will inevitably affect the other parts of it (UN, 2016). It is for this reason that a concerted global effort to mitigate adverse human impacts on the ocean is required. The 1982 United Nations Convention on Law of the Sea (UNCLOS) was the first piece of international law that bound countries to protect and conserve the ocean (IMO, 1982). Though it could be argued that UNCLOS has some limitations, such as it is only binding to countries who are party to it, the very existence of UNCLOS can create a legislative culture that can lobby other non-party States to observe the marine protection and conservation protocols of UNCLOS.

The UN in their adoption of the 2030 Agenda, has included the Sustainable Goal Number 14 (SDG 14), Life Below the Water, which is aimed at using the ocean in a sustainable manner (UN, 2016). SDG 14 was further galvanized through the appointment of the first-ever UN Special Envoy for the Oceans in 2017, which was aimed at specifically giving a diplomatic voice to the ocean (UN, 2017). In 2017, States agreed to recommend to the UN General Assembly an international treaty on the Conservation and Sustainable use of Marine Biological Biodiversity in Areas Beyond National Jurisdiction. The document was a culmination of negotiation between States that began in 2006 and although the framework is derived from UNCLOS, non-State parties to UNCLOS, such as the United States, have also been contributors to its ongoing development (Blasiak, Pittman, Yagi, & Sugino, 2016).

More research is required on the long-term and cumulative impacts of the anthropogenic activities on the marine environment. The scale and magnitude of these impacts require a mass change at all levels of society and not just governments and business (Ostrom, 2010). In South Africa, the government has taken the lead in the gradual shift towards a greener economy through the introduction of legislation and various initiatives that compel and encourage business and civil society to adopt behavior that is environmentally friendly (Pinto, Pedroso, Moraes, Pilatti, & Picinin, 2018).
The most recent focus of government has been on the maritime industry and harnessing the resources of the ocean to expand the economy of South Africa. The South African government aims to harness the economic potential of the ocean to help overcome the imbalances left by the legacy of Apartheid (Republic of South Africa, 2014). South Africa faced its first recession since 2009 in September of 2018, an unemployment rate of 26.7% in the first quarter of 2018, and the percentage of people living in poverty increased from 53.2% in 2011 to 55.5% in 2015, are some of the current challenges that are faced by the country (Statistics South Africa, 2018a; Statistics South Africa, 2018b; Statistics South Africa, 2018c). Though the government has made significant progress since the first democratic elections, the challenge remains in balancing the need for economic development, and the health of its marine and coastal habitats (Republic of South Africa, 2014).

1.2 Problem Statement

To determine whether there is a need for additional interventions to mitigate the adverse impacts of human activities on the South African marine and coastal environment, and if ocean literacy can be used as a tool in these interventions.

1.3 Research Objectives

The objectives of the dissertation are the following:

a. Outline how human activities have impacted the state of the marine environment in South Africa.

b. Determine what interventions are in place in South Africa to address the adverse impacts on the marine environment.

c. Demonstrate how ocean literacy can be used as a means to address the adverse human impacts on the marine environment in South Africa.

d. Determine the need for ocean literacy in South Africa.

e. Provide recommendations on the expansion of ocean literacy in South Africa, if required.
1.4. Research Questions

The following questions will be answered in order to achieve the objectives of the dissertation:

a. What are the human activities that have adversely impacted the marine environment in South Africa?

b. What is the state of the South African marine environment due to the adverse impacts of human activities.

c. What is the prognosis of the South African marine environment should the adverse human activities continue at their current rate?

d. What are the interventions to address these adverse impacts on the South African Marine Environment?

e. Are the interventions to address the adverse impacts on the South African marine environment sufficient on their own?

f. What is required to change human behavior and attitudes toward the marine environment in South Africa?

g. Is there a need for ocean literacy in South Africa?

h. How can ocean literacy be used to mitigate human behavior that has an adverse impact on the marine environment in South Africa?

i. How can the understanding and the appreciation for the ocean be increased in South Africa?

1.5. Relevance of research

At the time of conducting the research, no other evidence could be found evaluating the level of ocean literacy in South Africa through the administration of the International Ocean Literacy Survey (IOLS). Thus, it is hoped, that the research will aid the development of new and current initiatives that aim to mitigate and prevent the adverse effects of anthropogenic activities on the marine environment.
The identification of attitudes, and knowledge of how the ocean functions and how humans affect the ocean in South Africa, can assist in the formulation of marine environmental protection mechanisms and marine environmental education that targets these attitudes, and the knowledge that underlie behavior that adversely affects the ocean.

1.6. Structure of Research

The dissertation has five key components. The first component investigates the effect of human impacts on the marine and coastal environment in South Africa (Chapter 2). Secondly, a review of literature concerning the concept of ocean literacy broadly, ocean literacy in South Africa and other countries specifically; and the connection between human behavior and ocean literacy is detailed (Chapter 3). The third component will be based on primary research through the administration of the IOLS in order to assess the level of ocean literacy within a sample population in South Africa (Chapter 4). The fourth component presents the findings and discussion of the survey results (Chapter 5). The last component (Chapter 6) is the provision of recommendations on how ocean literacy can be improved in South Africa and how it can be used as a primary intervention, or as a support tool, to mitigate the adverse impacts of human activities on the marine environment and further socio-economic development.

1.7. Scope and Limitations of Research

The primary focus of the research will be on the South African context. Other countries will be included in the research to determine how ocean literacy is used as a tool to mitigate the adverse effects on the environment in the respective countries. The survey administered was limited to the geographical area of the city of Cape Town, South Africa. This is due to the financial constraints of the researcher and the limited support he could enlist, if so required, with in the city.
CHAPTER TWO

2. Overview of South African Marine and Coastal Environmental Challenges

Marine and coastal habitats provide an array of goods and services to Humanity. Not enough people know about all the benefits that are derived from the ocean, or fully understand the value that these benefits add to our lives (Fauville & Dupont, 2017). This sentiment can be observed in how humanity has, over the years, placed increasing pressure on the marine and coastal habitats through the extraction of natural resources and through human activities, such as trawling and coastal development, that have adversely affected these habitats (Fischlin, et al., 2007; Duncan et al., 2016). As a maritime nation, South Africa is a country also facing the same challenge (SA DEA, 2012).

South Africa has an EEZ of more than 1,5 million square kilometers and a coastline that exceeds 2,700 km (Duncan et al., 2016). South African coastal and marine spaces are generally abundant with life and natural resources. The coasts of the country are bordered by two different ocean currents and are the key reason why the marine and coastal habitats of South Africa are so varied (SA DAFF, 2014).

A sub-tropical climate can be found along the East coast of South Africa, which is a result of the warm waters brought down from the equator by the Mozambique Current. A more temperate climate exists along the West Coast of South Africa, which is affected by the Benguela Current, which moves colder and nutrient-rich waters along the coast. Where the two currents converge, along the southwestern and southeastern coasts of South Africa, the climate is typical of the Mediterranean (Turpie & Katua, 2000).
According to the South African National Biodiversity Institute, 162 different types of marine and coastal habitats have been identified. These habitats provided an abundance of cultural, social, economic and natural benefits to the country. The habitats are increasingly under threat and much needs to be done to conserve these habitats for present and future generations (Skink et al., 2012).

2.1. Coastal Habitats

Figure 2 below, is an illustration of the different threat levels that are faced by the South African offshore (Marine) and coastal ecosystems. Coastal habitats are under more pressure than marine habitats, as approximately 62% of coastal habitats are threatened as opposed to 43% of marine habitats (Duncan et al., 2016; Department of Environmental Affairs, 2014). This can largely be attributed to the proximity and scale of human development along the South African coast (South African Department of Environmental Affairs, 2014).

Figure 2: South African Threatened Ecosystems

Source: Duncan J. et al., 2016.
Currently, around 30% of the South African population lives within 60km of the coast, and approximately 17% of the 2 798km coastline has some type sort of development within 100m of the shore (Duncan J. , et al., 2016). The effects of this widespread development along the coast have led to the damage and destruction of numerous habitats, and the loss of biodiversity in the area (South African National Biodiversity Institute, 2013). Development along the coast has also contributed to accelerated coastal erosion. This is demonstrated when harbors, buildings, and seawalls are built on sandy coastal habitats. Ultimately, both the physical structures and the lives of the occupants are at risk to the elements of nature (SA DEA, 2014; Skink et al., 2012).

Coastal squeeze, the loss of coastal habitats due to increasing coastal defence and rising sea levels, interrupts many biological processes (Doody, 2013). The destruction of habitats and the loss of biodiversity interrupt the natural ecological chain, and the goods and services derived from coastal habitats eventually are lost. Coastal squeeze will only be exacerbated by the rising sea levels due to global warming (Wigley, 2011).

A direct result of development, and a dense population living near the coast, is water pollution, in the form of wastewater discharge. This is a problem that threatens estuaries in particular as the energy of rivers decreases as it reaches the sea. This results in wastewater accumulating in estuaries, which leads to eutrophication and increased toxicity. Tourism is also affected in some areas as people are deterred from visiting estuaries where wastewater has accumulated (Skink, et al., 2012).

Sand mining on sandy beaches is uncommon in South Africa. However, sand mining from dunes is a growing sector and not enough has been done to understand and limit the adverse effects of this industry on the environment (SA DEA, 2014).

The outlook for the more common coastal habitats, such as sandy and rocky beaches is concerning. Two factors have contributed: the accelerating encroachment of the population towards the coast, and the size of these common habitats. In contrast, more unique South African coastal habitats such as mangroves and lagoons, are better protected as the area they cover is smaller and more attention is given to these unique habitats (Skink, et al., 2012; South African National Biodiversity Institute, 2013).
2.2. Marine Habitats

Marine habitats at large, are under pressure from global warming and overfishing (Duncan J., et al., 2016). Seawater temperatures along the west coast of South Africa are cooling due to the increase in the melting of ice in the Antarctic, and this colder water is being shifted along the west coast of South Africa by the Benguela current. Meanwhile, along the east coast of South Africa, water temperatures are rising. As a result that species along the east coast are shifting south to cooler waters and the species along the west coast are also shifting South, but for warmer waters. The impacts of this dual geographical migration of marine species have yet to be comprehensively researched (SA DEA, 2014).

Over forty percent of commercial fish species caught in South Africa are overexploited, while just under a third of stocks are optimally exploited, and nine percent are under-exploited (SA DEA, 2014). It is estimated that if current trends continue, species such as the abalone, will be extinct in the wild between 2025 and 2050. The knock-on effects of a collapsed fishery includes the loss of livelihoods for those employed, lost revenue for the State and the detrimental damage it could do to the ecology of marine habitats (Duncan J., et al., 2016).

Overfishing and Illegal, Unreported and Unregulated Fishing (IUU) have had the largest impact on the marine environment. Over exploited commercial fish stocks has resulted in the decline in catch tonnage and overall biomass of the caught species (SA DEA, 2012). This means that the overexploited species are not being given enough time to repopulate. Bycatch from commercial fishing also places a strain on non-catch species such as sharks and rays. These species have been listed as vulnerable by the IUCN's List for Threatened Species but in 2014, over 4 000 tonnes of sharks and rays became bycatch (Duncan J., et al., 2016; Fergusson, Compagno, & Marks, 2009).
According to the United States Energy Information Administration (2017), the South African coast has one of the highest concentration of oil tankers and bulk carriers passing through its waters. This is a benefit for the national economy and the livelihoods of many South Africans. However, the high concentration of these large vessels comes with adverse consequences for marine habitats (Chou, 2006). Damage to habitats through oils spills, noise pollution and alien species introduced through untreated ballast water discharge, add to the pressures that already exist on South Africa’s marine and coastal habitats (Skink, et al., 2012).

The cumulative effect of the pressures on the marine and coastal habitats adversely affect the goods and services that South Africa can derive from the ocean. The expansion of the offshore mining sector poses a new threat (SA DEA, 2012).

### 2.3 Interventions to Mitigate Human Impacts on the Marine and Coastal Environment

#### 2.3.1 Legislation

South Africa has an array of laws, policies, and regulations that provide the framework for the sustainable use of marine resources. One of the first critical pieces of legislation aimed at conserving the ocean’s resources was the Marine Living Resources Act 18 of 1998 (RAS) (SA DEA, 1998). The MLR Act primarily legislates the use of marine resources for commercial gain. However, this piece of legislation only sets boundaries concerning sustainable fisheries management but does not give guidance to fishing managers on how to manage catches sustainably (Republic of South Africa, 1998). In 2005, South Africa adopted an Ecosystems Approach to Fisheries (EAF) (Petersen, Duncan, Omardien, Betts, & Johnson, 2015). The EAF approach prescribes the conducting of environmental risk assessments for various marine ecosystems, redesigning management strategies in the fishing industry and conducting EAF workshops in order to educate members of the sector about the need and how-to of sustainable fishing (Duncan et al., 2016).
The introduction of the *Integrated Coastal Management Act 2008* (RSA), is legislation aimed at compelling all role players (municipalities, industry and local communities) to adopt environment-friendly practices (SA DEA, 2008). The ICMA prescribes regulations for sustainable coastal development and the need to mitigate coastal pollution as a result of development adjacent to the coast. Maritime pollution from the shipping industry has been dealt with in the *Merchant Shipping (Civil Liability Convention) Act of 2013* (RSA), which directly makes provision for the penalisation of shipping companies in the event of an oil spill and measures they have to implement in order to prevent oil spills (Republic of South Africa, 2014). The *Ballast Water Management Draft Bill of 2013* (RSA) has not been signed into effect. The Bill would compel ships to have their ballast water treated by an approved ballast water treatment system before being permitted to discharge it (Department of Transport, 2013).

### 2.3.2. Marine Protected Areas

South African Marine Protected Areas (MPA) are categorized into three types:

- **Restricted Areas:** In these areas no extraction activities may be conducted, and no marine life must be harvested.
- **Controlled Areas:** These are areas in which extraction and harvesting activities may be conducted, but which are controlled by the issuing of permits.
- **Restricted and Controlled Areas:** These are MPAs which have both of the aforementioned types of MPAs within the boundary of one MPA (SA DEA, 2016).
The above map (Figure 3) shows the contrast in the area covered by terrestrial protected areas as compared with marine protected areas (MPA). In 2016, MPAs covered only 0.5% of South Africa’s EEZ, as compared to the terrestrial protected areas which accounted for 8% of the land (SA DEA, 2016). The map also shows that all MPAs are situated along the coast and some close to highly developed and populated areas, and are therefore more susceptible to anthropogenic activities.
The shortage of resources available for enforcement and the lack of stakeholder participation, have been highlighted as key challenges in attaining the objectives of MPAs. Chadwick, Duncan and Tunley (2014), in the World Wildlife Fund’s State of the Management of South Africa’s Marine Protected Areas Report, found that crucial challenges included the lack of understanding by officials on a strategic level, for the need for MPAs, and clashes with local communities in the enforcement of MPAs. Further research has also cited that a lack of community participation in the enforcement of MPAs can be attributed to historical injustices, whereby local communities were not consulted in the establishment of MPAs (Charles & Wilson, 2009; Cormier-Salem, 2014). Communities which relied on the ocean for food and work were adversely impacted by the sudden limitation and prohibition on fishing and other activities, in the established MPAs (Snowman & Sunde, 2018).

2.3.3. National Strategy: Operation Phakisa

Operation Phakisa is a national blue economy strategy launched by the South African government in 2014. The primary aim of this strategy is to unlock the potential of the ocean, sustainably. Operation Phakisa has a number of targets that are linked to the sustainable use of South Africa’s marine resources which include creating 1 million employment opportunities in the maritime sector, the conservation and protection of marine resources, and the engagement of all relevant stakeholders (businesses, communities and local government) in the attainment of the operation’s objectives (Department of Planning, Monitoring and Evaluation, n.d.).

A crucial outcome, thus far, has been the introduction of the Marine Spatial Planning Bill in 2016, which will legislate the need for marine spatial planning to coordinate all maritime activities (SA DEA, 2017). In addition, the designation of 22 new MPAs by 2019 is part of the broader goal of having 15 percent MPA coverage by 2028. These activities demonstrate the will of government not only for the expansion of the economy, but also for the sustainable use of the ocean (SA DEA, 2016).
The conclusions that can be drawn from the interventions put in place by the South African government to combat the adverse effects on the marine and coastal environment demonstrate the will of government to balance economic development with the needs of the environment. The continued decline in fish stocks and biodiversity threats along the coast, are indicators that more is required. The South African government cannot conserve the marine and coastal environment alone. Stakeholders in the health of the ocean, such as industry and society, are not responding sufficiently to the interventions.
CHAPTER THREE

3. Ocean Literacy

3.1. History of Ocean Literacy

The concept of an ocean literacy campaign was developed by a team of United States (US)-based scientists and professional educators, which included the US National Marine Educators Association (NMEA), who recognized a need for ocean science to become a part of the US educational curriculum, (Fauville, Strang, Cannady, & Chen, 2018; UNESCO, 2017b). In 2002, the collaborative effort of the group as mentioned above, in conjunction with the National Geographic Society and The College of Exploration, crystallized into an online ocean conference. The focus of the conference was Oceans for Life, which later opened the doorway for the development of Ocean Literacy Essential Principles and Fundamental Concepts, which was the initial framework of what a person should know and understand in order to be considered ocean literate (UNESCO, 2017b).

Two further milestones cemented the need for ocean literacy in the US. The first was the Pew Commission’s report, which was started in 2000 and was tasked with reviewing over 30 years of US ocean policies, with the aim of determining what was needed to maintain the benefits the US derived from the ocean. In its report, the Pew Commission urged the National Oceans Agency to take the lead in building ocean literacy into the US conscience (PEW, 2003).
The second breakthrough for ocean literacy was the report, *An Ocean Blueprint for the 21st Century*, drafted by the Ocean Commission, which was tasked to document the need to conserve and sustainably use the ocean’s resources for the future prosperity of the US. One of the critical recommendations from the report to the President of the United States was to “Increase attention to ocean education through coordinated and effective formal and informal programs” (Justus, Buck, Zinn, & Morrissey, 2005, p. 10). Adoption of ocean literacy by the Intergovernmental Oceanographic Commission (IOC) of UNESCO, and the further development of the ocean literacy toolkit by the IOC and other leading organizations, galvanized the need for ocean literacy on an international level (Francesca, Selvaggia, Scowcroft, Fauville, & Tuddenham, 2017).

**3.2. Ocean Literacy Defined**

UNESCO (2017b) outlines three components of ocean literacy. The person has an understanding of the value the ocean has for humanity, the person can communicate about the value of the ocean in a meaningful way, and the person can make decisions that are sensitive to the effects their actions will have on the ocean. Essentially, it can be said that an ocean-literate person understands how their lives are affected by the ocean; and how their actions affect the ocean. The above components are also included in the NMEA’s definition of ocean literacy.
UNESCO and NMEA have each developed learning frameworks for the teaching of ocean literacy. Figure 4 and Figure 5 above show the seven principles that both organizations base their publications on. Both publications aim to achieve the objectives in line with their definitions of ocean literacy. The UNESCO publication focuses on teaching ocean literacy to people of all ages, in and out of formal schools, and provides guidance on practical demonstrations (UNESCO, 2017b). The NMEA’s publication is focused on implementing it in schools for learners from Grade K (preparatory school) to Grade 12. The NMEA has developed 45 *Fundamental Concepts* (Appendix A) that are each linked to understanding a specific principle (NMEA, 2013).
The UNESCO publication, because it has been developed from an international perspective, does not provide enough detailed guidance for the implementation of ocean literacy in schools. The NMEA’s publication has been specifically developed with US students in mind and adapted to US schools. Both publications have their merits, and should be used as a base for the implementation of ocean literacy in and outside the classroom, as each country has their own unique environmental and societal factors to consider.

3.3. Literature Overview

Studies have shown that one of the ways through which behavior can be changed is through the creation of awareness regarding the impact of human actions on the marine environment (Bronfman, Cisternas, López-Vázquez, de la Maza, & Oyanedel, 2015). There exists a positive correlation between the level of ocean literacy and the population’s concern for the adverse effects of anthropogenic activities on the marine environment (Guest, Lotze, & Wallace, 2015). The stressors on the marine environment can be mitigated, and in some instances prevented if populations understand the way the ocean works as an ecosystem (French, Santoro, Sousa Pinto, Borges, & McDonough, 2015).

One of the most common misconceptions is that people believe the ocean’s supply of resources is inexhaustible and that the ocean’s vastness can absorb the adverse effects of anthropogenic activities (Kaiser, Wolfing, & Fuhrer, 1999). Ocean literacy can be used as a tool in dispelling these myths and changing population behavior for the better (UNESCO, 2017b). Furthermore, ocean literacy helps the population to understand that their livelihood is inextricably connected to that of the ocean. It has also been suggested that people will be more likely to change their impacts on the marine environment when they experience the effects of anthropogenic activities on the marine environment, first hand (Steel, Smith, Opsommer, Curiel, & Warner-Steel, 2005).
It has been recognized that there is a need for a multi-pronged approach when it comes to the drive for marine environmental change (UNESCO, 2010). This entails both a top-down, bottom-up and individual approach; but essentially it all requires having a meaningful understanding of how the ocean works. This will mean that people in government can make informed decisions on how to best regulate human interaction with the ocean, that society can pressure government and industry to make decisions to contribute to a healthy ocean, and that individuals make sustainable choices in how they live (Guest et al., 2015).

One of the first ocean literacy surveys was conducted in the US in 2003, in which a random sample of 1233 citizens’ knowledge of the ocean was evaluated. The findings suggested that both coastal and non-coastal populations demonstrated a poor understanding of basic concepts relating to how the ocean works. However, the level of understanding an individual had concerning the aforementioned concepts could be linked to what was termed as trans-situational and situational-specific factors. Situational-specific factors relate to the individual’s interactions with the ocean, while trans-situational factors relate to the socio-economic status of the individual, such as their level of education and wealth. Individuals who demonstrated a high level of ocean literacy either had a high level of situational-specific factors, or a high level of trans-situational factors. The findings of the survey provide an indicator of how to structure effective ocean literacy programmes. (Steel et al, 2005).

A study was conducted by Guest, Lotze, and Wallace (2015), in order to evaluate the level of ocean literacy in Nova Scotia, Canada. The survey involved 723 students from 11 public schools, with ages ranging from 12 to 18 years of age. The survey results suggested a positive correlation between the level of ocean literacy of an individual and the value the individual places on the benefits derived from the ocean. Students with greater knowledge of the ocean also demonstrated greater awareness of ocean-related jobs, and this could imply a link between ocean literacy and the enhancement of a country’s blue economy (Guest et al., 2015).
More research is required on how individuals change their behavior once acquiring the first two components of ocean literacy. However, knowledge and understanding of the ocean is the first step to becoming ocean literate. The limited research, specifically on ocean literacy, indicates that knowledge can change attitudes, which can lead to the second part of being ocean literate; understanding the value the ocean has in sustaining their lives.

3.4. Ocean Literacy in South Africa

3.4.1. School Curriculum

The South African school system is divided into two parts, the first of which is primary school, which caters for Grade/Year R (preparatory school) until Grade/Year 7. High School/Secondary Schools, are composed of Grade/Year 8 to 12. Both primary and secondary schools are governed by the South African Department of Basic Education (SA DBE) which is responsible for the formulation of the national curriculum for all grades. It is compulsory for all public schools to follow the curriculum set out by the SA DBE. The curriculum is divided into four phases: Foundation Phase (Grade R to 3), Intermediate Phase (Grade 4 to 6), Senior Phase (Grade 7 to 9) and the Further Education and Training Phase (Grade 10 to 12). The school curriculum is such that from Grade 10, learners separate into their different chosen subject streams which are aimed at preparing learners for their chosen careers, or tertiary education after high school (SA DBE, nd).

The South African school curriculum currently does not have ocean literacy integrated into it. Subjects such as Life Sciences (Biology) and Social Science (Geography), together provide the closest link to the seven principles of ocean literacy. Life Sciences, includes the focus on the biological process such as photosynthesis, and Social Science, includes concepts relating to sustainability, of which the core is dealt with in high school (SA DBE, 2011a; SA DBE, 2011b).
The ocean and marine-related concepts are mentioned sporadically across Grades 4 to 12. Most of the basic understanding of the ocean is mentioned from Grade 10 to 12, which is significant as only students who choose Social Science and Life Science as a subject from Grade 10, will be exposed to these concepts. The ocean is discussed meaningfully and substantially during Grade 10, as can be seen in Figure 6 below. Some of the ocean goods and services are discussed, such as the production of oxygen. The adverse anthropogenic effects of the ocean are also included.

Figure 6: Grade 10 Geography Syllabus Excerpt

Source: South African Department of Basic Education, 2011.
Table 1: Specific aims of Geography CAPS for Intermediate and Senior Phases

<table>
<thead>
<tr>
<th>The Geography curriculum aims to develop learners who:</th>
<th>Examples of the skills involved. Learners will be able to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Are curious about the world they live in</td>
<td>• ask questions and identify issues</td>
</tr>
<tr>
<td></td>
<td>• discuss and listen with interest</td>
</tr>
<tr>
<td></td>
<td>• collect and refer to information (including newspapers, books and, where possible, websites)</td>
</tr>
<tr>
<td>2. Have a sound general knowledge of places and the natural forces at work on Earth</td>
<td>• read and use sources in order to obtain useful information</td>
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<tr>
<td></td>
<td>• use information to describe, explain and answer questions about people, places and the relationship between the two</td>
</tr>
<tr>
<td>3. Understand the interaction between society and the natural environment</td>
<td>• correlate, synthesise and organise information</td>
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<td></td>
<td>• make links between cause and effect, change and continuity</td>
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<tr>
<td></td>
<td>• acknowledge and appreciate diverse lifestyles and world views</td>
</tr>
<tr>
<td>4. Think independently and support their ideas with sound knowledge</td>
<td>• use geographical knowledge to solve problems</td>
</tr>
<tr>
<td></td>
<td>• discuss and debate issues</td>
</tr>
<tr>
<td></td>
<td>• recognise bias and different points of view</td>
</tr>
<tr>
<td></td>
<td>• develop own ideas based on new knowledge</td>
</tr>
<tr>
<td></td>
<td>• suggest solutions to problems</td>
</tr>
<tr>
<td>5. Care about their planet and the well-being of all who live on it</td>
<td>• engage with issues relating to the planet, its people and</td>
</tr>
<tr>
<td></td>
<td>• resources with knowledge and sensitivity</td>
</tr>
<tr>
<td></td>
<td>• act responsibly towards people and the environment</td>
</tr>
<tr>
<td>6. Understand and work with a range of sources – including maps, data and photographs</td>
<td>• use and draw maps</td>
</tr>
<tr>
<td></td>
<td>• identify and extract information from texts, atlases and other sources, including visual sources such as photographs</td>
</tr>
<tr>
<td></td>
<td>• work with data and statistics in the form of graphs, tables and diagrams</td>
</tr>
<tr>
<td></td>
<td>• cross-reference information using different sources</td>
</tr>
<tr>
<td>7. Observe and engage with phenomena in their own environment</td>
<td>• develop observation, interviewing and recording skills</td>
</tr>
<tr>
<td></td>
<td>• through fieldwork</td>
</tr>
<tr>
<td></td>
<td>• interview people and apply social skills</td>
</tr>
<tr>
<td></td>
<td>• process, interpret and evaluate data</td>
</tr>
<tr>
<td>8. Find out about places, people, events, and issues using different sources, e.g. books, people, photographs, the Internet</td>
<td>• devise and frame questions</td>
</tr>
<tr>
<td></td>
<td>• develop and apply research skills</td>
</tr>
<tr>
<td></td>
<td>• analyse, process and present information</td>
</tr>
<tr>
<td>9. Communicate ideas and information</td>
<td>• seek in a clear and informed way</td>
</tr>
<tr>
<td></td>
<td>• write in a structured and coherent way</td>
</tr>
<tr>
<td></td>
<td>• draw maps, sketches, simple illustrations, graphs, and flow charts</td>
</tr>
<tr>
<td></td>
<td>• provide reasoned explanations</td>
</tr>
<tr>
<td>10. Make informed decisions and take appropriate action</td>
<td>• work co-operatively and independently</td>
</tr>
<tr>
<td></td>
<td>• plan and evaluate actions systematically and critically</td>
</tr>
</tbody>
</table>

Source: South African Department of Basic Education, 2011.

Table 1 above details the aims to be achieved through the Geography Grade 10 syllabus. Aims 2 and 3, related to the first component of ocean literacy, knowledge. Aims 4 and 9, related to the second component, meaningful communication. While aims 5 and 10, can be linked to the third component of ocean literacy, change in behaviour.
Interviews with Ms C. C. Drury (personal communication, 12 September, 2018), Glenwood High School Subject Head for Life Sciences in Durban South Africa, and Mr W.C. Ross (personal communication, 10 June, 2018), Primary School Teacher at Hazendal Primary School in Cape Town, South Africa, indicated the following:

- The curricula for Life Science and Social Science, provides room for teachers to determine how they will achieve the aims set out. If a teacher has an interest in ocean related matters, they may use ocean specific examples to demonstrate a process, such as photosynthesis.

- Schools often integrate outings to the ocean that are focussed on coastal cleaning aka "beach clean-ups" with a small component dedicated to understanding the impacts of human activity on the ocean, this is primarily focused on marine litter.

- School excursions to the coast are not mandatory but are based on the time and resources available to the school, which is mainly dependent on the funding the school receives.

- The funding each school receives is a combination of state funds, school fees paid by parents, fees from school activities (fundraising) and sponsorships.

The conclusions that can be drawn from the curriculum review is that a significant amount of ocean literacy related concepts are present in the South African curriculum. The challenge is that not all students will be exposed to the same level of ocean knowledge. The interests of the teacher, their educational background and experience, will affect how teachers choose to educate, and how much they include regarding the ocean, when the syllabus permits.

The socioeconomic environment a school is situated in will significantly affect the additional resources it can amass to cover its operating costs and purchase teaching aids, such asmicroscopes, which affect how students learn. The effects of the availability of resources also extend to the interactions leaners have with the ocean, which are provided by the school.
3.4.2. **Ocean Literacy Beyond the Classroom**

Many organisations, both private and public, such as the South African Network for Coastal and Oceanic Research, and the Wildlife and Environment Society of South, offer environmental education to both students and local communities (Whitfield & Baliwe, 2013). The Two Oceans Aquarium in Cape Town is noted as being one of the first to formally integrate Ocean Literacy into its education programmes (UNESCO, 2017b). It has subsequently developed Marine Sciences Curriculum and Assessment Policy Statement for students from Grade 10 to 12 (UNESCO, 2017b; Stevens, 2018). If approved, it would mean that only students from the aforementioned grades would benefit from the curriculum amendment.

3.5. **Ocean Literacy in Other Countries**

The two countries discussed in this sub-chapter were included based on the following criteria:

- Sweden was chosen due to its progressive environmental policies, and to determine how it has included ocean knowledge into its national curriculum, without a formal ocean literacy program.
- Portugal was included because it has a formal ocean literacy program integrated into the national school curriculum.
- The availability of the required information as was made available by the respective organizations of both countries.
3.5.1. Sweden

Sweden’s history of implementing sustainable policies resulted in the country being ranked as number one on the Global Green Economy Index (GGEI) in 2016. The GGEI, which looks at 32 base datasets and indicators such as investment in renewable energy and management of fisheries, provides a gauge on how well a country is moving towards a green economy (Tamanini, 2016). Developments on a global level saw Sweden join the Clean Seas Campaign, a program initiated by the UN Environment which is aimed at reducing the amount of litter that ends up in the ocean (UN Environment, 2017). For instance, initiatives undertaken by the Swedish State placed a duty on retailers to inform customers of the adverse effects that plastic bags have on the environment. In February 2018, Sweden imposed a ban on micro-plastics that are rinsed off in cosmetic products (Government Offices of Sweden, 2017).

Though the Swedish Government has taken the lead in initiating and implementing interventions to protect the marine environment, ocean literacy, as referred to by UNESCO (2017) is not a part of the Swedish school curriculum. A certain number of NGOs promote marine environmental awareness, or provide ocean education, but do not align their learning outcomes with the seven principles of ocean literacy. The Marine Education Centre, situated in Malmö, is one institution that has focused on incorporating ocean literacy into its educational programs. The Centre combines practical demonstrations about how the ocean works and the human impacts on the ocean, based on the principles of ocean literacy. The center is open to all age groups, including non-students. Schools that require their services, and who want to incorporate practical demonstrations into their curriculum, contact the center in order to make arrangements for their students to visit (Marine Knowledge Center, 2018).
A review of the Swedish National Agency for Education (SNAE) *Curriculum for the Compulsory School, Preschool Class and the Recreation Centre 2011*, shows that ocean literacy is not explicitly addressed in the curriculum. Concepts such as the ecosystems, the food chain and human impacts on the environment are covered under the subject of Biology, and introduction to these concepts start from as early as year 1 (SNAE, 2011). An important pedagogical approach stipulated in the curriculum is found below:

> An environmental perspective provides opportunities not only to take responsibility for the environment in areas where they can exercise direct influence but also to form a personal position concerning overarching and global environmental issues. Teaching should illuminate how the functions of society and our ways of living and working can best be adapted to create sustainable development. (SNAE, 2011, p. 12)

The above approach can be linked to one component of the basic definition of ocean literacy, understanding the influence we have on the ocean. In years 7-9 *Nature and Society* is taught to learners under the subject of biology, which covers four concepts relating to the principles of ocean literacy:

- The impact society has on nature and how individuals can contribute to sustainable development.
- Recycling of materials, energy flow and ecosystem services such as photosynthesis.
- Biological diversity and the factors which favor and threaten it. (Specific mention is made of the relationship between forestry and hunting, as an example)
- The interaction between the resources available in the local ecosystem and the adjacent population (SNAE, 2011).

Throughout the curriculum, no mention is made of terms such as marine or coastal. The Social Studies subject for years 1-3, students are taught about the names and locations of oceans around the world. In Biology, years 4-6, students are taught similar concepts in *Nature and Society* as compared to years 7-9, and learners are specifically required to know the impacts of fishing (SNAE, 2011).
The Swedish curriculum demonstrates the need to understand and appreciate the impacts we have on the environment and how the environment sustains in our lives. However, how educators teach the concepts to their learners remains open to interpretation, if concepts relating to the ocean are not iterated explicitly in the curriculum. This could mean that a vital component of the environment, the ocean, could be left out in the classroom (SNAE, 2011).

3.5.2. Portugal

Portugal was one of the first European countries to include ocean literacy in the school teaching program. It was spearheaded by the *Conhecer o Oceano* (Knowing the Ocean), an NGO project aimed at increasing the level of knowledge Portuguese citizens had of the ocean. Integrating Ocean Literacy into the Portuguese curriculum was a challenging task because of the amount of time and bureaucracy it requires to change the school curriculum in Portugal. Thus *Conhecer o Oceano* modified its original goal and instead chose to demonstrate how ocean literacy can be implemented in the existing school curriculum, by including it in subjects such as History and Geography (Noronha, 2018).

Eventually, in 2011, Ocean Literacy become a part of the formal education that learners from Grade K to 12 received in Portugal. The NMEA’s Ocean Literacy: The Essential Principles of Ocean Sciences for All Learners of All Ages, was adapted to the Portuguese context and used as the framework for the teaching of ocean literacy in Portuguese schools. The NGO also provided a guidance table indicating which Ocean Literacy Principles could be introduced at the various levels and disciplines of the Portuguese school system. Training was provided to school teachers of all disciplines on what ocean literacy is, how it can be introduced to current subjects, and what practical demonstrations could be done in class to facilitate the learners understanding of how the ocean works (Noronha, 2018).
The Blue Schools initiative was subsequently launched by Portuguese Ministry of the Sea. The initiative was developed by the Portuguese Directorate General for Maritime Policy with assistance from the Ciência Viva (Living Science), a public institution created by the Portuguese Ministry of Science and Technology, to promote scientific culture in Portugal. The Blue Schools initiative aims to fortify ocean literacy within schools, and within the greater society of Portugal, through the involvement of schools and local communities in projects about the ocean, and fostering partnerships between various stakeholders in the maritime industry in supporting ocean projects and ocean literacy (Blue School, 2018).

The effectiveness of the ocean literacy program in Portuguese schools remains to be determined. However, the success in the implementation of the program was achieved through co-operation between government, NGOs, the community and the maritime industry.

3.6. The link between Ocean Literacy and Behavioural Change

As mentioned earlier in the section 3.2., the concept of ocean literacy comprised of three elements: knowledge, meaningful communication, and behavior. Ultimately, ocean literacy has the goal of changing how people interact with the ocean (UNESCO, 2015). One of the critiques of ocean literacy is that knowledge is not the only way in which to change behavior, and specifically environmental behavior (Greely, 2008). This is due to the reality that the drivers of behavior are not always linear because there are many facets as to why people act the way they do (Steg & Vlek, 2008). However, a universal concept in the literature about human behavior includes motivation and values. Consequently, there are many definitions for the constructs of values and motivation. According to Schwartz (1992), values are goals that apply across varying situations that provide a principle of guidance for a group of persons. Subba Roa (2010) outlined the three factors in the Basic Motivation Process (Figure 4) that illustrate how humans are motivated to act when there is a deficiency that they have to fulfill (need) and the need is then directed (drive) towards a specific outcome (goal).
What becomes apparent, is that both values and motivation are based on an outcome that an individual wants to actualize or that the person believes they can actualize. In the environmental context, if the individual believes that their action will cause harm or endanger the environment, they will stop or mitigate their behavior (Bronfman, Cisternas, López-Vázquez, de la Maza, & Oyanedel, 2015).

Though the explanation may be oversimplified, it provides a message that actions are based on outcomes, which are born through knowledge. The knowledge an individual has, either academically or through experience, shapes the goals they believe are possible and desirable (Kaiser, Wolfing, & Fuhrer, 1999). Thus, ocean literacy forms one core component in changing how individuals and society at large behave toward the ocean. Hence, whether an individual values self-worth, or are motivated by self-protection, understanding that their lives and their quality of life are inextricably linked to the health of the ocean will shape how an individual interacts with the ocean either directly or through secondary means (Francesca, Selvaggia, Scowcroft, Fauville, & Tuddenham, 2017).

Widely used existing interventions, such as legislation to prosecute environmental offenders, the imposition of fines and the introduction of national policies, are some of the mechanisms used to enforce behavior that is aimed at protecting the ocean (United Nations, 2016). However, these mechanisms offer a top-down solution whereby an individual’s behavior is reactive as opposed to the individual voluntarily acting sustainably towards the ocean (Bamberg & Moser, 2007; Bronfman, Cisternas, López-Vázquez, de la Maza, & Oyanedel, 2015).
Ocean literacy, as a concept, underlies a cultural shift whereby citizens act out on their own accord to protect and conserve the ocean. Ocean Literacy and the seven underlying concepts, provide a systematic approach that enables individuals to understand the profound range of existential benefits that the ocean provides to their daily lives and not just a set of abstract facts (Dupont, 2017). Ocean literacy, therefore, has a strong argument when it proposes that knowledge is the first step toward changing individual behavior towards the ocean. Thus, it is crucial that there is an assessment of the knowledge that is lacking, in order to determine what interventions are required to improve knowledge of the ocean; and subsequently an individual’s behavior towards it (Fauville & Dupont, 2017; Fauville, Strang, Cannady, & Chen, 2018).
CHAPTER FOUR

4. International Ocean Literacy Survey

The European Marine Science Educators Association (EMSEA) is a non-profit organization which was established in 2011. The EMSEA aims to increase ocean literacy in Europe through ocean education. The membership of the EMSEA is primarily composed of people from the scientific and educational sectors, though the organization recognizes the need for input from all disciplines in attaining the goal of an ocean literate society (EMSEA, n.d.). During the EMSEA 2015 conference, the need to develop an instrument to measure the first component of ocean literacy, that is knowledge, was highlighted (Fauville et al., 2018). Consequently, members of the EMSEA, in conjunction with the University of Gothenburg and the Lawrence Hall of Science at the University of California developed what has been named the International Ocean Literacy Survey (IOLS) (UNESCO, 2015; Tossey, 2016).

The objective in the development of the IOLS has been to create an instrument that could not only measure ocean knowledge but to specifically determine implicitly, an individual's understanding of the seven principles of ocean literacy which have been adopted by UNESCO. The ongoing development of the IOLS includes the translation of the survey into as many languages as possible, currently 16, so then it can be used as a tool for the measurement of ocean knowledge internationally. The first version of the IOLS was administered in 2016, and the fourth version is currently undergoing testing. Each successive version of the IOLS has been designed to measure the understanding of the 45 concepts related to the seven principles of ocean literacy and not merely to the individual’s ability to recall information (Fauville et al, 2018).
Because the IOLS consists of both questions and statements, the developers of the survey referred to both as "items" and therefore that term will also be adopted in this paper. Version 4 of the IOLS was used in this study, which initially consisted of 53 items. From 41 of the items the respondent was required to choose only one correct answer, while the last 12 items consisted of 45 options in total to choose from. Overall each respondent had a total of 86 options to answer, these excluded five biographical questions such as age and gender, and a question requesting consent (Fauville et al., 2018).

### 4.1. Research Design

IOLS was used in this study because there is currently no other ocean literacy survey that covers as many of the ocean literacy concepts as the IOLS does and that the IOLS is being developed by an international group of researchers and educators. Cognisance has been made of the reality that the IOLS is not without its flaws as it attempts to balance a comprehensive survey of ocean literacy knowledge without making the survey cumbersome. Furthermore, the IOLS was used as a means to further its development and refinement.

<table>
<thead>
<tr>
<th>Table 2: Biographical Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. What is the name of the school you attend?</td>
</tr>
<tr>
<td>c. Which gender do you identify as?</td>
</tr>
<tr>
<td>d. How old are you?</td>
</tr>
<tr>
<td>e. How close do you live to the ocean?</td>
</tr>
<tr>
<td>f. How often do you visit the beach?</td>
</tr>
<tr>
<td>g. Can you swim?</td>
</tr>
<tr>
<td>h. What type of work would you like to do after graduating from high school or university?</td>
</tr>
</tbody>
</table>

Source: Adapted from Fauville, Strang, Cannady and Chen, 2018.
The IOLS used in this study was slightly modified to include more biographical detail of the respondents (Table 1). Question D was included to differentiate between respondents attending schools situated close to the coast and one situated further inland. Questions E, F, and G were included to determine if there was any correlation between proximity and use of the ocean to their levels of ocean literacy knowledge. While Question H aims to determine if there is a link between the ocean literacy and knowledge of or involvement of an individual in the blue economy, as highlighted in the Nova Scotia study (Guest et al., 2015. In total, the modified survey had a total of 84 options which the respondent could select from, with each option weighing one point. The total available points the respondent could achieve was therefore 84.

High schools in the city of Cape Town were contacted with a request to administer the IOLS, with the covering letter explaining the purpose of the IOLS and the need for ocean literacy. Only schools in Cape Town were contacted as the researcher had limited time and resources available to assist the schools in the administration of the survey. Of the 12 schools contacted, three replied, of which only two schools had Wi-Fi available for the students to complete the survey online. A request was made to the school without Wi-Fi to determine if the survey could be printed out, however the school stated that it did not have the resources to print the survey in such large quantity and the consequent issue would be sending the hard copy survey results to Sweden (where the researcher was based) and digitalizing the responses for analysis. Ultimately, only one of the two schools responded to the survey, Simon’s Town High School, situated within 5km of the coast. Students were chosen based upon availability and completed the survey either via smartphone in class or through the desktop computers at school. Google Forms was used as the electronic medium for the students to complete the form. It was chosen because of its simplicity in use, both for the researcher and for the respondents.
The modified IOLS survey was tested by peers (test respondents) of the researcher who were students at the World Maritime University in Malmo, Sweden. This was done to highlight any errors found in the transcribing of the IOLS into a Google form. In a verbal debrief with the test respondents the two main critiques highlighted were that the survey was too long and that the questions were too technical. It should be born in mind that the seven respondents had varying educational and occupational backgrounds. However, the critique that the survey was too technical could be an indication that not enough ocean literacy was present in their school curricula.

A further review of the IOLS found that some answer choices to the questions were too similar. For example, the Question 27 in table 3 below:

Table 3: Question 27 of the modified IOLS

<table>
<thead>
<tr>
<th>Answer No</th>
<th>What is the best explanation of ocean acidification?</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td><strong>Burning fossil fuels (coal, oil, etc.) adds carbon dioxide to the atmosphere, which is absorbed by the ocean and increases its acidity.</strong></td>
</tr>
<tr>
<td>ii</td>
<td>Pollution adds toxic chemicals to the ocean that increases its acidity.</td>
</tr>
<tr>
<td>iii</td>
<td>Fertilizers from agriculture are washed into the ocean, and this increases the acidity of the ocean.</td>
</tr>
<tr>
<td>iv</td>
<td>Upwelling of naturally acidic seawater from deep in the ocean increases the acidity at the surface.</td>
</tr>
</tbody>
</table>

** Correct answer


According to the UNESCO (2017) definition, ocean acidification occurs when carbon dioxide dissolves in seawater, and carbonic acid is formed. Carbon dioxide occurs naturally in the environment, such as when animals and humans exhale. However, the concern lies with the excess carbon dioxide that is produced through human activities such as the combustion of fossil fuels. Carbon dioxide produced by the burning of fossil fuels through human activities can be classified as pollution. Therefore, the question should be rephrased to make the options more distinct.
Table 4: Question 46 of the modified IOLS

<table>
<thead>
<tr>
<th>Answer No</th>
<th>Industrial development by humans has lead to ______.</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>ocean pollution (FALSE/**TRUE)</td>
</tr>
<tr>
<td>ii</td>
<td>changing the shape of the coastline (FALSE/**TRUE)</td>
</tr>
<tr>
<td>iii</td>
<td>increasing ocean acidity (FALSE/**TRUE)</td>
</tr>
<tr>
<td>iv</td>
<td>Increasing the frequency of tsunamis. (**FALSE/TRUE)</td>
</tr>
<tr>
<td>v</td>
<td>improving conditions for indigenous people (**FALSE/TRUE)</td>
</tr>
</tbody>
</table>


Question 46 in Table 5 above, answer v cannot be classified as false. Industrial development and the effects thereof has not been the same for all indigenous people around the world though they may have been disproportionately adversely affected by industrial development. Further ambiguity is that the definition of indigenous people changes across different countries (Stavenhagen, 2004).

4.2. Survey Sample Rationale

As stated previously in Section 3.4.1, the South African school curriculum requires high school students from grade 10 to study subjects based on their intended career or tertiary study direction. Each student is required to choose a minimum of six subjects, of which two language subjects are compulsory for all students. Thus from grade 10, students do not receive the same subject-orientated education. It was for this reason that the sample group for the IOLS from both schools was focussed on grade 10, grade 11 and grade 12 students. Thus, the objective of the sample populations is to determine whether the formal education learners receive in primary school and the first two years of high school are enough to equip students with the necessary understanding of ocean literacy.
4.3. Limitations of the Study

Due to the researcher’s distance from South Africa and the confines of resources, the sample population was not as broad as was anticipated and could only focus on schools in the Cape Town region. Thus, the survey had to be completed online and necessitated that schools with internet-enabled computer laboratories or with Wi-Fi on their premises, were targeted for the completion of the IOLS. Schools that did not have Wi-Fi or internet-enabled computers were willing to have their learners complete the survey on hardcopy. However, the survey could not be completed by hard copy as schools had restrictions on paper usage and printing facilities for non-academic work. If the high school learners had completed the IOLS, the practical issue would be transporting the completed surveys to Sweden and capturing the information digitally.

The schools that were able to have their students complete the IOLS online had limitations on the availability of computer access. This resulted in only a certain number of students being able to complete the survey at a time. As a result of the aforementioned factors, the final number of respondents (37), limits the generalizations that can be made about ocean literacy in South Africa.
CHAPTER FIVE

5. Discussion of Results

In total, 37 respondents completed the IOLS survey. All of the respondents were from Simon's Town High School (STHS), situated in the southern part of the city of Cape Town in South Africa. STHS is situated less than five kilometers from the coast and offers maritime-related subjects such as nautical science, and the generically termed subject, maritime studies. It is a public school, which means that it is subject to the authority of the South African Department of Basic Education. The medium of instruction at the STHS is English. Although a significant percentage of the students do not speak English as their first language, this, however, is a common practice within schools of South Africa.

Figure 8: Scoring Summary

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>38.05 / 84 points</td>
<td>40 / 84 points</td>
<td>2 - 58 points</td>
</tr>
</tbody>
</table>

Source: Produced with Google Forms
Figure 8 (above) is a summary of the 37 respondents scores. The number of bars does not correspond with the total number of respondents, as respondents who scored the same are plotted on the same bar. The average score achieved out of a total of 84 points was 38.05. The median score achieved was 40 points; while the range of scoring was between a low of 2 points and the highest score of 58 points. The aim of the biographical detail was to determine if there was a correlation between biographical factors (such as being able to swim) and the respondents score in the survey. A positive correlations means that the increase in one variable (being able to swim) will lead to an increase in the other variable (ocean literacy knowledge).

5.1. Biographical Detail

The gender distribution of respondents amounted to 59.5% who identified as male and 40.5% who identified as female. On average, respondents who identified as male scored higher than their female counterparts, males scored an average of 40 out of 84 points and females scored 35 out of 84 points.

Figure 9: Age Distribution of Respondents

Source: Produced by Google Forms
The largest group of respondents was made up of those aged 16 years old at 44.4%. Respondents aged 19 years, and 20 years and older, equally formed the smallest percentage of students at 2.8% each of the total percentage of respondents (Figure 9). Respondents aged 15 years scored an average of 32.5 out of 84, respondents aged 16 years scored an average of 38 out of 84, respondents aged 17 years scored an average of 41 out of 84, respondents aged 18 years scored an average of 36 out of 84, the only respondent aged 19 years scored 49 out of 84; and respondents aged 20 years and older scored an average of 20 out of 84 points. The results indicate that there is no positive correlation between the respondent’s age and knowledge of ocean literacy.

There was an equal percentage of students who live less than five kilometers from the ocean (40.5%) and respondents who live five to ten kilometers from the ocean (40.5%). 13.5% of respondents live ten to twenty kilometers from the ocean and 5.4% of respondents live more than twenty kilometers from the ocean. The average score from respondents who live less than five kilometers from the beach was 38 out of 84. Respondents who live five to ten kilometers from the ocean scored an average of 39 points out of a total of 84. Respondents who live ten to twenty kilometers from the ocean scored an average of 38 out of 84 points. Finally, respondents who live more than twenty kilometers from the ocean scored an average of 33 out 84 points. This indicated that there was no positive correlation between a respondent’s level of ocean literacy and their domicile proximity to the ocean.

Almost sixty percent (59.5) of respondents indicated that they visit the beach at least once a month. The most frequent visitor to the beach, respondents who indicated they visit the beach at least once a day, made up 5.4% of the total percentage of respondents. Respondents who indicated they visited the beach at least once a day had the highest average score with 48 points out of 84, while respondents that indicated they visited the beach at least once a week scored an average of 42 points. Respondents who visited the beach at least once a year scored an average of 40 points out of 84 and respondents who visited the beach at least once a month had the lowest average score of 36 points out of 84.
Over three-quarters of respondents indicated that they could swim (75.7%), while just under one quarter indicated they could not swim (24.3%). Respondents who indicated that they could not swim scored an average of 34 out of 84 points. Respondents who stated that they could swim scored an average of 39 out of 84 points. There is a positive correlation between the respondent’s ability to swim and their knowledge of the ocean. The limited sample could be indicative of how be able to swim changes how an individual interacts with the ocean and how they view and understand it.

In total, 6 of the 37 respondents indicated that they would like to take up a career in a field related to the maritime industry. This represented a 16.21% of the total number of respondents and scored an average of 39 points out of 84. Respondents who did not indicate an interest in the maritime industry scored an average of 38 points out of a total of 84. The results indicate that there is a correlation between a respondent’s knowledge of the ocean and their interest in work in the maritime industry.

5.2. Weighted Questions

Table 5: Questions with a less than a fifty percent correct response rate

<table>
<thead>
<tr>
<th>I</th>
<th>li</th>
<th>iii</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question Number</td>
<td>Score</td>
<td>Principle linked to the question</td>
</tr>
<tr>
<td>1</td>
<td>14/37</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>11/36</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>17/35</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>11/36</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>12/33</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>5/34</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>10/36</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>10/35</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>2/36</td>
<td>2</td>
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<tr>
<td>17</td>
<td>9 / 36</td>
<td>2</td>
</tr>
<tr>
<td>19</td>
<td>7 / 36</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>3 / 36</td>
<td>3</td>
</tr>
<tr>
<td>21</td>
<td>3 / 36</td>
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<tr>
<td>22</td>
<td>17 / 36</td>
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<td>23</td>
<td>6 / 36</td>
<td>3</td>
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<tr>
<td>24</td>
<td>12 / 34</td>
<td>3</td>
</tr>
<tr>
<td>26</td>
<td>1 / 36</td>
<td>3</td>
</tr>
<tr>
<td>27</td>
<td>11 / 35</td>
<td>3</td>
</tr>
<tr>
<td>28</td>
<td>11 / 35</td>
<td>UD</td>
</tr>
<tr>
<td>29</td>
<td>17 / 36</td>
<td>UD</td>
</tr>
<tr>
<td>30</td>
<td>9 / 36</td>
<td>4</td>
</tr>
<tr>
<td>31</td>
<td>9 / 36</td>
<td>4</td>
</tr>
<tr>
<td>32</td>
<td>2 / 36</td>
<td>4</td>
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<tr>
<td>33</td>
<td>12 / 36</td>
<td>5</td>
</tr>
<tr>
<td>35</td>
<td>16 / 36</td>
<td>5</td>
</tr>
<tr>
<td>36</td>
<td>8 / 36</td>
<td>5</td>
</tr>
<tr>
<td>37</td>
<td>8 / 35</td>
<td>5</td>
</tr>
<tr>
<td>38</td>
<td>10 / 35</td>
<td>5</td>
</tr>
<tr>
<td>39</td>
<td>10 / 34</td>
<td>5</td>
</tr>
<tr>
<td>41</td>
<td>17 / 36</td>
<td>5</td>
</tr>
<tr>
<td>43</td>
<td>11 / 32</td>
<td>6</td>
</tr>
<tr>
<td>46*</td>
<td>14 / 29</td>
<td>6</td>
</tr>
</tbody>
</table>
Table 5 (above) is a presentation of questions in which less than fifty percent of the respondents answered correctly. Column i is the number of the question (a list of the complete survey administered can be found in Appendix B). In Column ii, the red number shows the number of respondents who answered the question correctly; and the grey number shows the number of respondents who answered the question. Column iii indicates the specific ocean literacy principle which the question was designed to assess. Where “UD” is marked in the column indicates that the question is not linked to one specific ocean literacy principle. Questions 46 and 47 (multiple choice questions) had the least amount of respondents. Question 26 (Which of the following marine ecosystems is the most important nursery areas for many marine species?) had only one correct respondent. While questions 32 (Which of the following is the best way for scientists to make predictions about complex ocean and atmospheric interactions, like hurricanes and climate change?) and Question 16 (Where did most of the oxygen in the atmosphere originally come from?) had only two correct respondents each. The significantly low correct responses to question 16 could be indicative of how the school curriculum is concentrated on the services provided by terrestrial ecosystems and shows the disconnect that the sample population has with understanding the services the ocean provides and their dependence on it.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>46*</td>
<td>12 / 29</td>
<td>6</td>
</tr>
<tr>
<td>47*</td>
<td>14 / 29</td>
<td>6</td>
</tr>
<tr>
<td>47*</td>
<td>12 / 29</td>
<td>6</td>
</tr>
<tr>
<td>49*</td>
<td>6 / 31</td>
<td>7</td>
</tr>
<tr>
<td>50*</td>
<td>12 / 30</td>
<td>7</td>
</tr>
<tr>
<td>50*</td>
<td>14 / 31</td>
<td>7</td>
</tr>
<tr>
<td>51*</td>
<td>13 / 30</td>
<td>UD</td>
</tr>
</tbody>
</table>

* Questions that have more than one selection or that have a true or false selection

Source: Produced by Google Forms based on the IOLS.
On average, less than one-third of the respondents were able to answer the 39 questions listed in table 1 correctly. There exists no meaningful correlation between less than fifty percent of the respondents’ answering the questions listed in Table 1 correctly and the principle which the questions are linked to. This means that all principles lacked sufficient understanding by the respondents that failed to answer them correctly.

No contrast can be made to the results of the respondents from STHS and a school that was situated further from the coast. This could have shown insight into whether a school situated close to the ocean and a school further from the ocean knowledge had different significantly different scores, thus making determining if there is a correlation between understanding of ocean literacy principles and proximity to the ocean. It should also be acknowledged that many other factors affect the respondents’ knowledge of the ocean. These include, but are not limited to, the level of formal education of their parents, the occupation of their parents; and their parents own understanding and communication of ocean literacy concepts at home. As mentioned earlier, the average score achieved by the respondents was 38, which is an average score of 45%. The question thus posed is what is a satisfactory score for a respondent to achieve in order to deem them as having sufficient knowledge of ocean literacy principles? Based on the curriculum standards of South Africa, respondents who scored less than fifty percent (42 points out of 84), would have failed. Only fifteen of the respondents achieved a result of 50% or more, which means that only 40,45% percent of respondents passed the survey.
6. Conclusion

Human pressures are mounting on the ocean. The marine and coastal ecosystems, including the habitats that they exist in, are under threat. It is peculiar given that most evidence points to the fact that life came from the ocean, the ocean continues to support our lives and our very existence, but we are killing the ocean and because of this: we are killing ourselves. Our behavior towards the ocean requires meaningful and lasting change. Various international agreements and corporate interventions have been developed and implemented in order to conserve and protect the ocean. However, the global need for development and economic progress outweighs the need to conserve and protect the ocean. Therefore, the global health of the ocean has continued to deteriorate. We do not value it because we do not fully comprehend the meaning it has to our very existence.

The South African marine and coastal environment are also increasingly under pressure. Overfishing and coastal development are some of the significant pressures on the marine and coastal environment in South Africa. The expansion of offshore mining and increased seaborne trade pose new threats to the marine and coastal habitats as the country seeks to capitalize on maritime opportunities. Although South Africa has relevant legislation to protect the health of the ocean within it is EEZ, more still needs to be done if South Africa wants to correct the equilibrium between economic development and a healthy ocean.

Ocean Literacy provides a structured means of comprehending what the ocean is doing for us and how we are affecting it. Hence, through the meaningful understanding of the ocean, we are motivated to change how we interact with the ocean. South Africa has an opportunity to fortify national marine conservation efforts and to aid its
development through the implementation of an ocean literacy programme. South Africa has identified the need to increase its economic development through the sustainable use of the ocean, which is a task not easily achieved. Ocean literacy can expand the responsibility for a healthy ocean so that it is not only the task of the government but society at large as well.

The IOLS was administered to a population sample of South African high school students. The small number of respondents, limits the generalisations that can be made about the results of the survey. However, only 40% of the 37 respondents achieved a score of 50%, or more. A review of the South African high school curriculum, found that only students who choose life sciences and social sciences from Grade 10, are taught substantive concepts relating to ocean science. The survey results and the review of the current curriculum, indicate that there is a need for the inclusion of ocean literacy knowledge in the South African curriculum.
CHAPTER SEVEN

7. Recommendations and Opportunities

7.1. Recommendations

7.1.1. Ocean Literacy Research

Determining the need for ocean literacy will require more extensive research that is inclusive of a sample population that is large enough to be representative of the South African high school population. This would be a logical point to start at before the implementation of an ocean literacy program. The primary goal of the research will be to determine if ocean literacy is required in the national educational system of South Africa. A secondary outcome would be that it will provide insight into what is currently lacking from the South African school curriculum and supplement the current curriculum with the necessary modules so that it encompasses the seven principles of ocean literacy and the associated concepts.

7.1.2. Formalised Ocean Literacy

The current South African curricula do not incorporate enough ocean-related concepts to enable learners to become ocean literate. The curricula should be amended to give knowledge of the ocean as much importance as knowledge of the terrestrial environment. The Ocean Literacy framework by UNESCO and the NMEA, could be adapted to make it suitable to the South African context and incorporated into the South African curricula. The curricula may then be pilot tested in various schools around South Africa so that educators and learner inputs can be included before the final implementation. The goal should be that by the time learners reach the end of Grade 9 (when learners choose specific subjects based on career and study options), all learners should’ve been equipped with sufficient understanding of the ocean to be deemed ocean literate.
An essential factor to take into consideration is that South Africa is a country that is in the process of redressing the legacy of a previously oppressive dispensation. One of the remnants remains socio-economic inequality, which is still patterned along the racial demographics of the country. Integrating ocean literacy into the formal education system of South Africa ensures that all students will receive the same potential to learn about how the ocean affects them and how they affect the ocean. An argument may be made that the level of educational instruction and the capacities of schools across South Africa is not equal, and will affect how learners grasp the concepts of ocean literacy.

However, this is the same for all subjects that South African students are taught, across all schools in South Africa. Just because it is not perfect does not mean that having nothing is better. Having ocean literacy in the school curriculum will help to create a culture of ocean citizens, whereby individuals take responsibility for their actions regarding the ocean and drive changes that will help to safeguard the ocean. This development of a bottom-up approach will help to redress government interventions that are not sufficient and place pressure on industry to make changes that are congruent with the principles of sustainability.

7.1.3. Marine Environmental Organisations

The implementation of ocean literacy will require interventions that provide students with the practical demonstrations on how the ocean works and show first-hand accounts on which anthropogenic activities adversely affect the ocean. There are many NGOs and public institutions that provide marine environmental awareness programme to local communities. However, these organizations have different ideologies regarding what they expose students to. The government should foster collaboration between the schools and organizations so that there is a concerted effort on building ocean literacy into these environmental initiatives.
A practical concern would be that schools situated inland and schools situated close to the coast would not receive the same practical demonstrations and first-hand experience. This is a constraint, but it is not insurmountable. The anthropogenic effects can be simulated in class or offsite in places with large bodies of water. Though the experience would not be the same, they would provide students with better insight than just in situ learning.

7.2. Opportunities

7.2.1. Social Responsibility

Population growth and increased development of the coast will expound the pressures currently impacting the marine environment. In addition to this is Operation Phakisa. The expansion of maritime activities will expand the footprint of human threats posed to the marine environment. The introduction of ocean literacy into the school curriculum provides an opportunity for South Africa to mitigate the impacts on the environment through formalized education. Current students will eventually become the leaders and managers of the public and private sector. Ocean literacy will provide these future leaders with an understanding of how the ocean works, an appreciation for the goods and services provided by the ocean, and ultimately a drive to incorporate the protection of the ocean into planning and decision making.
7.2.2. Sustainable Maritime Development

Ocean literacy can, in the long run, aid the effectiveness of marine protection interventions by providing the public as a whole with the necessary education to make informed decisions that impact the marine environment, and consequently, less money can be spent on curtailing individual actions that contribute to marine degradation. Formalised ocean literacy can also help to alleviate socio-economic inequalities by introducing students from disadvantaged backgrounds to careers in the maritime industry that they may not be exposed to, such as aquaculture and marine spatial planning. Thus, it can also aid the expansion of the maritime industry and support the goals of Operation Phakisa by attracting more people to careers in the maritime industry.
8. Bibliography


9. References


Cormier-Salem, M.-C. (2014). Participatory governance of Marine Protected Areas: a political challenge, an ethical imperative, different trajectories: Senegal Case Studies. *Surveys and Perspectives Integrating Environment and*


Association:
http://www.coexploration.org/oceanliteracy/documents/OceanLitChart.pdf


Republic of South Africa. (2014, August 15). Retrieved May 18, 2018, from Operation Phakisa:
https://www.operationphakisa.gov.za/operations/oel/pmpg/Marine%20Protec


South African Department of Agriculture, Forestry and Fisheries. (2012). *Status of the South African Marine Fishery Resources*. Department of Agriculture, Forestry and Fisheries. Pretoria: Department of Agriculture, Forestry and

South African Department of Basic Education. (2011a). *Curriculum and Assessment Policy Statement Grades 10-12- Geography*. Retrieved September 5, 2018, from Department of Basic Education:

South African Department of Basic Education. (2011b). *CURRICULUM AND ASSESSMENT POLICY: SOCIAL SCIENCES*. Retrieved August 21, 2018, from Department of Basic Education:


South African Department of Environmental Affairs and Tourism. (1998, September 2). *MARINE LIVING RESOURCES ACT, 1998 (ACT No. 18 OF 1998)*. Retrieved from South African Department of Agriculture, Forestry and Fisheries:


http://unesdoc.unesco.org/images/0018/001865/186559e.pdf


http://unesdoc.unesco.org/images/0026/002607/260721e.pdf


Appendix A

NMEA Ocean Literacy Principles and Fundamental Concepts

<table>
<thead>
<tr>
<th>Principal 1: The Earth has one big ocean with many features.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ocean is the defining physical feature on our planet Earth—covering approximately 70% of the planet’s surface. There is one ocean with many ocean basins, such as the North Pacific, South Pacific, North Atlantic, South Atlantic, Indian, Southern, and Arctic.</td>
</tr>
<tr>
<td>Ocean basins are composed of the seafloor and all of its geological features (such as islands, trenches, mid-ocean ridges, and rift valleys) and vary in size, shape and features due to the movement of Earth’s crust (lithosphere). Earth’s highest peaks, deepest valleys and flattest plains are all in the ocean.</td>
</tr>
<tr>
<td>Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of Earth’s rotation (Coriolis effect), the Sun and water density differences. The shape of ocean basins and adjacent land masses influence the path of circulation. This “global ocean conveyor belt” moves water throughout all of the ocean basins, transporting energy (heat), matter, and organisms around the ocean. Changes in ocean circulation have a large impact on the climate and cause changes in ecosystems.</td>
</tr>
<tr>
<td>Sea level is the average height of the ocean relative to the land, taking into account the differences caused by tides. Sea level changes as plate tectonics cause the volume of ocean basins and the height of the land to change. It changes as ice caps on land melt or grow. It also changes as sea water expands and contracts when ocean water warms and cools.</td>
</tr>
<tr>
<td>Most of Earth’s water (97%) is in the ocean. Seawater has unique properties. It is salty, its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is slightly basic. Balance of pH is vital for the health of marine ecosystems, and important in controlling the rate at which the ocean will absorb and buffer changes in atmospheric carbon dioxide.</td>
</tr>
<tr>
<td>The ocean is an integral part of the water cycle and is connected to all of Earth’s water reservoirs via evaporation and precipitation processes.</td>
</tr>
<tr>
<td>The ocean is connected to major lakes, watersheds, and waterways because all major watersheds on Earth drain to the ocean. Rivers and streams transport nutrients, salts, sediments, and pollutants from watersheds to coastal estuaries and to the ocean.</td>
</tr>
<tr>
<td>Although the ocean is large, it is finite, and resources are limited.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The ocean and life in the ocean shape the features of Earth.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Many earth materials and biogeochemical cycles originate in the ocean. Many of the sedimentary rocks now exposed on land were formed in the ocean. Ocean life laid down the vast volume of siliceous and carbonate rocks.</td>
</tr>
<tr>
<td>Sea level changes over time have expanded and contracted continental shelves, created and destroyed inland seas, and shaped the surface of land.</td>
</tr>
<tr>
<td>Erosion—the wearing away of rock, soil and other biotic and abiotic earth materials—occurs in coastal areas as wind, waves, and currents in rivers and the ocean, and the processes associated with plate tectonics move sediments. Most beach sand (tiny bits of animals, plants, rocks, and minerals) is eroded from land sources and carried to the coast by rivers; sand is also eroded from coastal sources by surf. Sand is redistributed seasonally by waves and coastal currents.</td>
</tr>
<tr>
<td>The ocean is the largest reservoir of rapidly cycling carbon on Earth. Many organisms use carbon dissolved in the ocean to form shells, other skeletal parts, and coral reefs.</td>
</tr>
<tr>
<td>Tectonic activity, sea level changes, and the force of waves influence the physical structure and landforms of the coast.</td>
</tr>
</tbody>
</table>
The ocean is a major influence on weather and climate.

The interaction of oceanic and atmospheric processes controls weather and climate by dominating the Earth’s energy, water, and carbon systems. The ocean moderates global weather and climate by absorbing most of the solar radiation reaching Earth. Heat exchange between the ocean and atmosphere drives the water cycle and oceanic and atmospheric circulation. Heat exchange between the ocean and atmosphere can result in dramatic global and regional weather phenomena, impacting patterns of rain and drought. Significant examples include the El Niño Southern Oscillation and La Niña, which cause important changes in global weather patterns because they alter the sea surface temperature patterns in the Pacific.

Condensation of water that evaporated from warm seas provides the energy for hurricanes and cyclones. Most rain that falls on land originally evaporated from the tropical ocean. The ocean dominates Earth’s carbon cycle. Half of the primary productivity on Earth takes place in the sunlit layers of the ocean. The ocean absorbs roughly half of all carbon dioxide and methane that are added to the atmosphere.

The ocean has had, and will continue to have, a significant influence on climate change by absorbing, storing, and moving heat, carbon, and water. Changes in the ocean’s circulation have produced large, abrupt changes in climate during the last 50,000 years. Changes in the ocean-atmosphere system can result in changes to the climate that in turn, cause further changes to the ocean and atmosphere. These interactions have dramatic physical, chemical, biological, economic, and social consequences.

The ocean made Earth habitable.

Most of the oxygen in the atmosphere originally came from the activities of photosynthetic organisms in the ocean. This accumulation of oxygen in Earth’s atmosphere was necessary for life to develop and be sustained on land. The ocean is the cradle of life; the earliest evidence of life is found in the ocean. The millions of different species of organisms on Earth today are related by descent from common ancestors that evolved in the ocean and continue to evolve today.

The ocean provided and continues to provide water, oxygen, and nutrients, and moderates the climate needed for life to exist on Earth (Essential Principles 1, 3, and 5).

The ocean supports a great diversity of life and ecosystems.

Ocean life ranges in size from the smallest living things, microbes, to the largest animal on Earth, blue whales. Most of the organisms and biomass in the ocean are microbes, which are the basis of all ocean food webs. Microbes are the most important primary producers in the ocean. They have extremely fast growth rates and life cycles, and produce a huge amount of the carbon and oxygen on Earth.

Most of the major groups that exist on Earth are found exclusively in the ocean and the diversity of major groups of organisms is much greater in the ocean than on land. Ocean biology provides many unique examples of life cycles, adaptations, and important relationships among organisms (symbiosis, predator-prey dynamics, and energy transfer) that do not occur on land.

The ocean provides a vast living space with diverse and unique ecosystems from the surface through the water column and down to, and below, the seafloor. Most of the living space on Earth is in the ocean. Ocean ecosystems are defined by environmental factors and the community of organisms living there. Ocean life is not evenly distributed through time or space due to differences in abiotic factors such as oxygen, salinity, temperature, pH, light, nutrients, pressure, substrate, and circulation. A few regions of the ocean support the most abundant life on Earth, while most of the ocean does not support much life.

There are deep ocean ecosystems that are independent of energy from sunlight and photosynthetic organisms. Hydrothermal vents, submarine hot springs, and methane cold seeps, rely only on chemical energy and chemosynthetic organisms to support life. Tides, waves, predation, substrate, and/or other factors cause vertical zonation patterns along the coast; density, pressure, and light levels cause vertical zonation patterns in the open ocean. Zonation patterns influence organisms’ distribution and diversity.

Estuaries provide important and productive nursery areas for many marine and aquatic species.
The ocean and humans are inextricably interconnected.

<table>
<thead>
<tr>
<th>The ocean affects every human life. It supplies freshwater (most rain comes from the ocean) and nearly all Earth’s oxygen. The ocean moderates the Earth’s climate, influences our weather, and affects human health.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ocean provides food, medicines, and mineral and energy resources. It supports jobs and national economies, serves as a highway for transportation of goods and people, and plays a role in national security.</td>
</tr>
<tr>
<td>The ocean is a source of inspiration, recreation, rejuvenation, and discovery. It is also an important element in the heritage of many cultures.</td>
</tr>
<tr>
<td>Humans affect the ocean in a variety of ways. Laws, regulations, and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, nonpoint source, and noise pollution), changes to ocean chemistry (ocean acidification), and physical modifications (changes to beaches, shores, and rivers). In addition, humans have removed most of the large vertebrates from the ocean.</td>
</tr>
<tr>
<td>Changes in ocean temperature and pH due to human activities can affect the survival of some organisms and impact biological diversity (coral bleaching due to increased temperature and inhibition of shell formation due to ocean acidification).</td>
</tr>
<tr>
<td>Much of the world’s population lives in coastal areas. Coastal regions are susceptible to natural hazards (tsunamis, hurricanes, cyclones, sea level change, and storm surges).</td>
</tr>
<tr>
<td>Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.</td>
</tr>
</tbody>
</table>

The ocean is largely unexplored.

<table>
<thead>
<tr>
<th>The ocean is the largest unexplored place on Earth—less than 5% of it has been explored. The next generation of explorers and researchers will find great opportunities for discovery, innovation, and investigation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding the ocean is more than a matter of curiosity. Exploration, experimentation, and discovery are required to better understand ocean systems and processes. Our very survival hinges upon it.</td>
</tr>
<tr>
<td>Over the last 50 years, use of ocean resources has increased significantly; the future sustainability of ocean resources depends on our understanding of those resources and their potential.</td>
</tr>
<tr>
<td>New technologies, sensors, and tools are expanding our ability to explore the ocean. Scientists are relying more and more on satellites, drifters, buoys, subsea observatories, and unmanned submersibles.</td>
</tr>
<tr>
<td>Use of mathematical models is an essential part of understanding the ocean system. Models help us understand the complexity of the ocean and its interactions with Earth’s interior, atmosphere, climate, and land masses.</td>
</tr>
<tr>
<td>Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, physicists, animators, and illustrators. And these interactions foster new ideas and new perspectives for inquiries.</td>
</tr>
</tbody>
</table>
Appendix B:  Modified IOLS

International Ocean Literacy Survey
Greetings!
Our research team is interested in your understanding of the ocean. Please answer the questions below as best as you can. We will not share your responses with your teacher or school, we just want to know what you know about the ocean. Do your best to answer them correctly, but we are interested in what you know now, so please don’t try to find the answers online.

Your participation is completely voluntary, if you don’t want to answer a question you may skip it and you are free to stop taking the survey at any time. All personal information will be treated with the strictest of confidentiality practices.

Thanks for your contribution to our work.

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a. Do you agree to participate in the International Ocean Literacy Survey?  
Mark only one oval.  
• Yes  
• No

b. What is the name of the school you attend?

c. Which gender do you identify as?  
Mark only one oval.  
• Female  
• Male  
• Non binary  
• Prefer not to disclose

d. How old are you?  
Mark only one oval.  
• 15 years and younger  
• 16 Years old  
• 17 years old  
• 18 years old  
• 19 years old  
• 20 years and older

e. How close do you live to the ocean?  
Mark only one oval.  
• less than 5km  
• 5km-10km  
• 10km-20km  
• more than 20km

f. How often do you visit the beach?  
Mark only one oval.  
• At least once a day  
• At least once a week
• At least once a month
• At least once a year
• I have never been to the beach

g. Can you swim?  
*Mark only one oval.*
• Yes
• No

h. What type of work would you like to do after graduating high school or university?

1. Which statement best explains how ocean water moves?  
*Mark only one oval.*
• Water in each ocean basin (e.g. Atlantic, Pacific, Indian) circulates only within that basin
• Water in the Pacific ocean basin will eventually circulate to all other ocean basins
• Ocean water moves throughout either the northern hemisphere or the southern hemisphere. Water does not cross the equator.
• Water in smaller basins, like the Mediterranean Sea, remains there and does not move to other basins.

2. Because the ocean covers most of the Earth (select the best answer):  
*Mark only one oval.*
• It has the most dominant influence on Earth’s weather and climate.
• Most living things are concentrated on land
• Most of earth is not useful for humans
• It generates most of the Earth’s greenhouse gases

3. Which statement describes the main process that shapes the features of the land and the ocean floor?  
*Mark only one oval.*
• Both the land and the ocean floor are shaped by movement of the Earth’s crust.
• Erosion caused by rivers brings material from the land to the ocean which shapes the ocean floor.
• Both land and ocean features are shaped by the wind.
• Both the land and the ocean floor are shaped by changes to climate.

4. Ocean currents are influenced by both:  
*Mark only one oval.*
• Global ship traffic and Earth’s rotation.
• The position of land masses and Earth’s rotation.
• Global ship traffic and the acidity of the ocean.
• Adjacent land masses and the acidity of the ocean.

5. How is sea level measured?  
*Mark only one oval.*
• Average depth of the ocean
• Average height of the ocean relative to the land
• Height of the ocean at the lowest tide
• Height of the ocean at the highest tide
6. Which of these statements is TRUE about seawater and freshwater?
*Mark only one oval.*
- Seawater freezes at a lower temperature than freshwater, and seawater conducts electricity better than freshwater.
- Seawater freezes at a higher temperature than freshwater, and seawater conducts electricity better than freshwater.
- Seawater freezes at a lower temperature than freshwater, and freshwater conducts electricity better than seawater.
- Seawater cannot freeze and seawater conducts electricity better than freshwater.

7. Where is most of the water on Earth?
*Mark only one oval.*
- In the atmosphere
- In polar ice caps
- In rivers and lakes.
- In the ocean

8. Which is the most accurate statement about the water in the Earth’s water cycle?
*Mark only one oval.*
- Much of the same water has been traveling through the water cycle for millions of years
- Water joins the water cycle when new water is made through condensation
- Water leaves the water cycle when it evaporates from the ocean
- Water leaves the water cycle when humans and other organisms drink it

9. What connects the ocean to all water on Earth?
*Mark only one oval.*
- Transpiration and precipitation.
- Precipitation and evaporation.
- Deposition and evaporation.
- Deposition and transpiration.

10. Rivers supply most of the salt to the ocean. The salt in the rivers comes from:
*Mark only one oval.*
- Mountain ice melting
- Erosion of land.
- Rainfall in the rivers.
- Human caused pollution

11. Sand on the shoreline is:
*Mark only one oval.*
- likely to stay on the same beach for hundreds of years.
- continually transported by waves and currents.
- continually transported by activities of animals that live there.
- likely to be transported inland by wind and rivers.

12. What occurs during an El Nino year?
*Mark only one oval.*
- There are large but temporary changes in the salinity of the ocean.
- The temperature of the ocean gets colder.
- There are large but temporary changes in global weather patterns.
- There are large permanent changes in global weather patterns.
13. Most rain that falls on land originally evaporated from:
Mark only one oval.
- the ocean near the equator.
- the middle of each ocean basin.
- nearby lakes and rivers.
- the nearest ocean basin.

14. The ocean affects climate change by absorbing, storing, and moving:
Mark only one oval.
- carbon and salt.
- carbon and heat.
- phytoplankton and heat.
- phytoplankton and salt.

15. How is climate change impacting the Arctic?
Mark only one oval.
- The impact on the Arctic is the same as on the rest of the planet.
- The Arctic is warming faster than the rest of the planet.
- Glaciers are melting in some parts of the Arctic and growing in other parts.
- Tropical ocean fishes are migrating to the Arctic.

16. Where did most of the oxygen in the atmosphere originally come from?
Mark only one oval.
- Released into the atmosphere by volcanos erupting.
- From interstellar gases when the Earth was first formed.
- Released during photosynthesis by land plants.
- Released during photosynthesis by marine organisms.

17. Fossil evidence shows that life most likely first evolved:
Mark only one oval.
- on land.
- in the ocean.
- under Earth's surface.
- in outer space.

18. What is the largest animal ever to live on Earth?
Mark only one oval.
- Giant squid.
- Woolly mammoth.
- Blue whale.
- Giganotosaurus

19. Most living material (biomass) in the ocean is found in:
Mark only one oval.
- fishes (sharks, salmon, cod, etc.).
- plankton (jellyfish, krill, diatoms, etc.).
- marine mammals (whales, dolphins, walruses, etc.).
- molluscs (snails, clams, squid, etc.).
20. There are over 30 major groups of organisms (vertebrates, arthropods, molluscs, etc.) on Earth. Where are most of these major groups found?

*Mark only one oval.*

- Most are found exclusively in the tropical rainforests.
- Most are found on both land and in the ocean.
- About half are found exclusively in the ocean.
- Almost all are found exclusively in the ocean.

21. Both land and ocean provide space for organisms to live. How much of Earth’s living space is found in the ocean?

*Mark only one oval.*

- Only a little bit (less than 10%).
- About half (40–60%).
- More than half (60–80%).
- Nearly all (more than 90%).

22. In the ocean, organisms are found:

*Mark only one oval.*

- at the surface, in the water column, on the sea floor, and on the seashore.
- at the surface, on the sea floor, and on the seashore but not in the water column.
- on the sea floor and in the water column, but not on the surface or on the seashore.
- mostly in the water column and on the sea floor but not at the surface or on the seashore.

23. Which of the following most influences the depth at which organisms live in the open ocean (away from the shoreline)?

*Mark only one oval.*

- Salinity levels.
- Crashing waves.
- Light levels.
- Human activity.

24. What is the source of energy for ocean ecosystems where there is no sunlight?

*Mark only one oval.*

- Chemical energy from hydrothermal vents.
- Wave energy from the wind.
- Nuclear energy from underwater radioactive material.
- Thermal energy from volcanoes.

25. Which of the following has the largest influence on the vertical distribution of organisms on the seashore?

*Mark only one oval.*

- Sunlight.
- Salinity.
- Tides.
- Trampling by people.

26. Which of the following marine ecosystems is the most important nursery areas for many marine species?

*Mark only one oval.*

- Coral reefs (reefs formed by living corals).
- The deep sea (more than 100m below the ocean surface).
- The open ocean (away from the shoreline).
- Estuaries (where rivers meet the ocean).
27. What is the best explanation of ocean acidification?
   Mark only one oval.
   - Burning fossil fuels (coal, oil, etc.) adds carbon dioxide to the atmosphere, which is absorbed by the ocean and increases its acidity.
   - Pollution adds toxic chemicals to the ocean that increases its acidity.
   - Fertilizers from agriculture are washed into the ocean and this increases the acidity of the ocean.
   - Upwelling of naturally acidic sea water from deep in the ocean increases the acidity at the surface.

28. Which of the following are happening because of human-caused changes to ocean temperatures and pH levels?
   Mark only one oval.
   - Ocean salinity is increasing and the frequency of oil spills is increasing.
   - The frequency of oil spills is increasing and many coral reefs are degraded or dying.
   - Many coral reefs are degraded or dying and the diversity of life in the ocean is decreasing.
   - The diversity of life in the ocean is decreasing and ocean salinity is increasing.

29. The use of satellites, buoys, and remotely-operated vehicles improve our understanding of the ocean because the new technologies:
   Mark only one oval.
   - reduce errors from human measurements of the ocean.
   - cause less disturbance to the marine environment.
   - are cheaper than previous tools.
   - collect much more data than scientists on ships can.

30. Sea level changes have:
   Mark only one oval.
   - reversed the direction that some rivers flow.
   - changed global temperatures.
   - changed the shape of the coastline.
   - increased fish populations.

31. Scientists are discovering that more species than they expected live in the deep sea. These discoveries are only being made now because:
   Mark only one oval.
   - environmental conditions are causing species to migrate to the deep sea.
   - deep sea species evolve more rapidly than shallow water species.
   - shallow water species have been overfished.
   - scientists are just beginning to explore the deep sea.

32. Which of the following is the best way for scientists to make predictions about complex ocean and atmospheric interactions, like hurricanes and climate change?
   Mark only one oval.
   - Simulations in aquariums
   - Detailed long term monitoring of ocean and atmosphere.
   - Observations of coastlines.
   - Mathematical modeling.

33. Making new discoveries about the complexity of the ocean requires:
   Mark only one oval.
   - a degree in marine biology.
   - living near the ocean.
   - collaboration among people with different expertise.
   - use of SCUBA gear for diving.
34. Over the last 50 years humans have:
Mark only one oval.
- increased their use of ocean resources.
- explored most of the ocean.
- reduced total emissions from ships into the ocean.
- reduced unsustainable use of ocean resources.

35. Absorption of carbon dioxide (CO2) by the ocean has a direct influence on which of the following?
Mark only one oval.
- The greenhouse effect and dead zones in the ocean.
- Acid rain and harmful algal blooms.
- Acid rain and ocean acidification.
- The greenhouse effect and ocean acidification.

36. Clams, oysters, and other marine organisms use the carbon dissolved in the ocean to:
Mark only one oval.
- breathe underwater.
- regulate body temperature.
- build shells.
- assist in reproduction.

37. Which of the following is true about ecological relationships in the ocean?
Mark only one oval.
- They are very similar to those on land, including similar food web, life cycle, and symbiotic relationships.
- They are mostly unknown since so much of the ocean has not been explored.
- They are mostly very simple compared to those on land.
- There are unique features of food webs, life cycles, and symbiotic relationships in the ocean that are not found on land.

38. Which of the following is true concerning the exploration of the ocean?
Mark only one oval.
- People have been exploring the ocean for thousands of years and most of it has been explored.
- Almost all of the ocean has been explored in the last 50 years because of new technology.
- Most of the ocean is still unexplored despite improvements in technology in the last 50 years.
- Most of the ocean is still unexplored because scientists focus on the areas where most organisms live.

39. City A is at the coast and city B is inland. City A and city B are also at the same elevation, it is likely that:
Mark only one oval.
- city A will have warmer summers and cooler winters than city B.
- city A will have warmer summers and warmer winters than city B.
- city A will have cooler summers and warmer winters than city B.
- city A will have similar temperatures as City B in each season.

40. If there was no ocean, the Earth’s surface temperatures would be:
Mark only one oval.
- more extreme around the world.
- less extreme around the world.
- cooler in the summer and warmer in the winter.
- about the same as they are now.
39. Which statement about eating animals from the ocean is true?
Mark only one oval.
- All kinds of ocean animals are endangered, so no one should eat any ocean animals
- Some populations of ocean animals are declining, so people should choose carefully what to eat
- In the ocean, only whales and dolphins are declining so it is OK to eat fish
- There are plenty of all the kinds of ocean animals that people normally eat

40. If there was no ocean, the Earth’s surface temperatures would be:
Mark only one oval.
- more extreme around the world.
- less extreme around the world.
- cooler in the summer and warmer in the winter.
- about the same as they are now.

41. Ocean resources:
Mark only one oval.
- are sufficient to support today’s fishing practices into the future.
- can always be replaced with resources from another part of the ocean.
- replenish themselves quickly.
- are limited and in rapid decline around the world.

Complete each of the following sentences with the statements below them, and mark each one true or false.

42. Rivers can transport _____ to the ocean.
Mark only one oval per row.
- nutrients
- sand
- rocks
- pollutants

43. Changes to sea level are caused by _____.
Mark only one oval per row.
- movement of the continental plates
- melting and growing of ice caps on land
- warming and cooling of ocean water
- movement of sediments from coastal erosion

44. Changes to the shape of coastlines are caused by _____.
Mark only one oval per row.
- sea level changes
- seawater salinity changes
- movement of the continental plates
- forces of waves
45. Humans depend on the ocean for ______.
Mark only one oval per row.
True False
- food and medicine
- minerals and energy resources
- transportation and jobs
- benefits to the economy
- nuclear fusion

46. Industrial development by humans has lead to ______.
Mark only one oval per row.
True False
- ocean pollution
- changing the shape of the coastline
- increasing ocean acidity
- Increasing the frequency of tsunamis.
- improving conditions for indigenous people

47. Humans use the ocean for ______.
Mark only one oval per row.
True False
- transportation
- recreation
- food and medicine
- earthquake and tsunami prediction
- art and cultural heritage

48. Caring for and protecting the ocean is the responsibility of ______.
Mark only one oval per row.
True False
- leaders of each country because they set national policies
- individuals because everyone benefits from the ocean regardless of where they live
- highly intelligent ocean animals like whales and dolphins

49. Mark each geology statement below TRUE or FALSE
Mark only one oval per row.
True False
- Many rocks on land were formed in the ocean.
- Rocks on land are formed differently from rocks in the ocean.
- Geological processes (e.g., volcanoes and earthquakes) can push rocks formed in the ocean above the surface of the ocean.

50. Mark each statement below about human impacts to the ocean TRUE or FALSE
Mark only one oval per row.
True False
- People who live far from the ocean do not cause pollution in the ocean.
- Airplanes increase the rate of ocean acidification more than other forms of transportation.
- All people, regardless of where they live, cause pollution in the ocean.
- People who live near the ocean contribute more to ocean acidification that people who live far from the ocean.
51. Mark each of the statements below about the ocean and atmosphere

Mark only one oval per row.
True False

- Interactions between the ocean and the atmosphere strongly influence weather and climate.
- There are different seasons throughout the year because the ocean absorbs much of the heat from the sun.
- Transfer of heat between the ocean and the atmosphere drives global circulation of water and air and can cause storms around the world.
- The water cycle is powered by the transfer of heat between the ocean and the atmosphere.