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Investigating the factors that affects the Ocean Literacy level of Hong Kong senior secondary students

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Abstract

This study was conducted to investigate the ocean literacy level of senior secondary Hong Kong school students. It aimed to find what factor influences the ocean literacy level. Factors such as gender, ethnicity, time spent learning about the ocean, exposure to the ocean and their attitude towards the ocean were investigated. the instrument used in this study was international ocean literacy survey and survey of ocean stewardship. This study found that high ocean literacy is positively correlated with time spent learning about the ocean and attitude towards the ocean. This study also conducts an analysis on formal school curriculum and recommends reforming the curriculum to include more ocean related topics as well as experiential learning.

Introduction

The ocean covers almost three quarters of the planet earth and holds 97% of its water. It is an abundant source of natural resources and plays an important role to regulate the health of the planet (Fauville, Strang, Cannady & Chen, 2019). It supplies most of the freshwater and atmospheric oxygen while storing food, providing jobs and medicine (Schoedinger, Cava & Jewell, 2006). The ocean also significantly affects earth's climate by storing, transporting and releasing carbon, energy and water (Schoedinger, Cava & Jewell, 2006). Every living thing on earth relies on the ocean for their livelihood either directly, by inhabiting it, or indirectly.

However, oceans around the world are under extreme anthropogenic pressure. Global climate change, natural disasters, overfishing, marine pollution, freshwater shortage, groundwater contamination and decreased biodiversity are only some of the issues that can be linked with ocean health (Greely, 2008). As a result of human activities, the average sea surface temperatures are rising, the chemistry of the ocean itself is changing and many commercially imported fish stocks are exploited and depleted (Fauville, Strang, Cannady & Chen, 2019). Unfortunately, more environmental, social and economic pressure is expected due to exploding human population whose effect will be evident in the health of our ocean.

This relationship and the negative impacts due to poor ocean health is more prominent in coastal cities like Hong Kong (HK), who relies on the ocean extensively and once was known as a "fishing village". Located in the tropics, HK has a diverse marine habitat which supports a rich marine biodiversity, such as coral and mangrove communities (Ng, Cheng, Ho, Lui, Leung & Williams, 2017). It hosts rich marine diversity of an estimated 6,500 known species. This accounts to 26% of

marine species, even though HK has marine area of only 0.03% in the whole of China (Ng et al., 2017). Many people in HK also relies on the busy harbor for their economic livelihood.

Since the impact on ocean can be attributed to lifestyle, decision-making and choices of an individual, the involvement of every person in understanding the importance of the ocean and the need to protect it, is essential. For individuals to become thoughtful participants in the debate about solutions to marine environmental issues, they need to be ocean literate (Fauville, Strang, Canandy & Chen, 2019).

The National Oceanic and Atmospheric Administration (NOAA) defines “Ocean Literacy” as “an understanding of the ocean's influence on you and your influence on the ocean” (Cava, Schoedinger, Strang & Tuddenham, 2005). It highlights seven principals every ocean literate person should know. They are:

1. *The Earth has one big ocean with many features.*
2. *The ocean and life in the ocean shape the features of the Earth.*
3. *The ocean is a major influence on weather and climate.*
4. *The ocean makes the Earth habitable.*
5. *The ocean supports a great diversity of life and ecosystems.*
6. *The ocean and humans are inextricably interconnected.*
7. *The ocean is largely unexplored.*

Ocean literacy goes beyond reading and writing in the classical sense but also requires an ocean literate person to (i) understand the essential principles and fundamental concepts about the functioning of the ocean, (ii) communicate about the ocean in meaningful ways, and (iii) make informed and responsible decisions regarding the ocean and its resources (Fauville, Strang, Cannady & Chen, 2019).

According to Dupont and Fauville (2017), being ocean literate and communicating about it helps foster:

1. *Our appreciation of the importance of the ocean.*
2. *Our understanding of our own responsibility in the destruction of ocean.*
3. *Our awareness of the relevance of its protection.*

The current literature shows low level of ocean literacy in countries such as Canada, The US, The UK, South Africa, New Zealand & The Netherlands (Guest & Wallace, 2015). No literature on ocean literacy among HK students could be found. This huge research gap is a hurdle to understanding the level of ocean literacy of HK students, which factors affect the ocean literacy and hence how to best foster ocean literacy.

Therefore, this study will investigate which factors affect the ocean literacy level of HK students. The factors investigated are: gender, ethnicity, time spent learning about the ocean, attitude towards ocean stewardship, source of information and exposure to ocean related activities.

Methodology

1. Instruments

The study was a quantitative study which used the "International Ocean Literacy Survey (IOLS)". The survey is proven to be psychometrically valid and reliable with a single factor across 17 languages and 24 countries. The survey was created in different versions to be used to test different populations and function as systematic review of the items. Creating an instrument that is valid and relevant across different culture and context is undoubtedly an extremely difficult task. Therefore, the IOLS has undergone two pilot study and modifications.

There are 3 versions of the questionnaire, version 1 and 2 has gone through pilot testing. It has been compiled, reviewed and culled for redundancy. After deleting or editing some questions, version 3 was created. Version 3 will be used in this study.

The version 1 underwent pilot testing in June 2016. It surveyed 417 US students aged 16 – 18. After the results were analysed, questions 6 and 45 were deleted after accounting for range of appropriate difficulty (too easy or too hard) and response that were driven by something other than Ocean Literacy. Based on this study, version 2 was created which better aligned with the concepts of ocean literacy.
The version 2 underwent same testing from August 2016 to October 2016. It surveyed 6971 students aged 16 – 18 from different countries, majority of them were from the US and Taiwan. From the result obtained, additional 4 questions were deleted, they are questions 5, 28, 29 and 31. This was done because these questions assessed only declarative knowledge or factual recall which wouldn't reflect their ocean literacy. It also had inconsistent construction of distractors, with spurious words, inconsistent distractor length, or contain words like "never" or "always" that often indicate that these are not the correct answer.

Some questions were modified to create version 3. The reasons were:

- To differentiate between low and high respondents. The concept that most of Earth's surface is covered by the ocean is a defining idea in Ocean Literacy, but respondents' ability to recall of the percentage does not indicate understanding of why this idea is so important to earth systems. Such questions were modified to be more conceptual.

- To reduce the reading demand and improve overall clarity of the questions and options.

- To minimize the effect of culture in the result. For instance, in the translated as well as the original English versions, distractors were used. However, some group, in this case Taiwanese respondents, were taught to ignore the distractors words like "always" and "never". This would give inaccurate result and askew the data.

Taking all these into consideration, the version 3 was created. It contains 44 questions covering all 7 principals and 45 concepts of ocean literacy.

The attitude of the participants was measured by using the “Survey of ocean Stewardship (SOS)”. The survey consists of 15 questions which participants rated in the five-point Likert scale.

2. Study design

The principles and concepts were defined by the Ocean Literacy community as what students should know by the end of high school, hence the target audience for the IOLS is 16–18 year old students.

Students completed an online survey that contained the IOLS, SOS, source of information, exposure to ocean related activities and number of hour spent learning about the ocean.

In the end, there were 344 form 5 and 6 students from 3 schools. The participant consisted of both male and female as well as Chinese and Non- Chinese ethnicity.

3. Data analysis

Not all questions in the IOLS is a ‘question’, some are fill in the blank. Therefore ‘item’ is used to refer to the ‘questions’. Some items needed respondents to select more than one response. In those cases, each response is scored separately and treated as a separate item. In every case, the response is scored as incorrect (0) or correct (1). Therefore, there were 74 unique items in the IOLS.
The response of each participant was checked using excel and an ocean literacy score was given. A histogram of the score was created to get the mean and standard deviation. Other descriptive statistics, such as gender and ethnicity, was presented in a pie chart. Source of information of the students and number of time being exposed to ocean related activities were presented using bar graph and table respectively.

Majority of the data was analysed using Statistical Package for Social Science (SPSS). Independent sample T- test was done to investigate the influence of gender and ethnicity on ocean literacy score. The SOS items were analyzed using Principal Component Analysis (PCA). Then Pearson correlation was performed on each component and ocean literacy score.

Pearson correlation was performed between time spent learning about the ocean and ocean literacy score. The same correlation analysis was done between exposure to ocean related activities and ocean literacy score. Finally, the factor with biggest effect on the ocean literacy was identified.

Result

1. Gender and ethnicity

There were 344 participants in the study. 46.2% of them were males and 53.8% were females. Of the 344, 13.7% were of Chinese ethnicity and 86.3% were of Non-Chinese ethnicity.

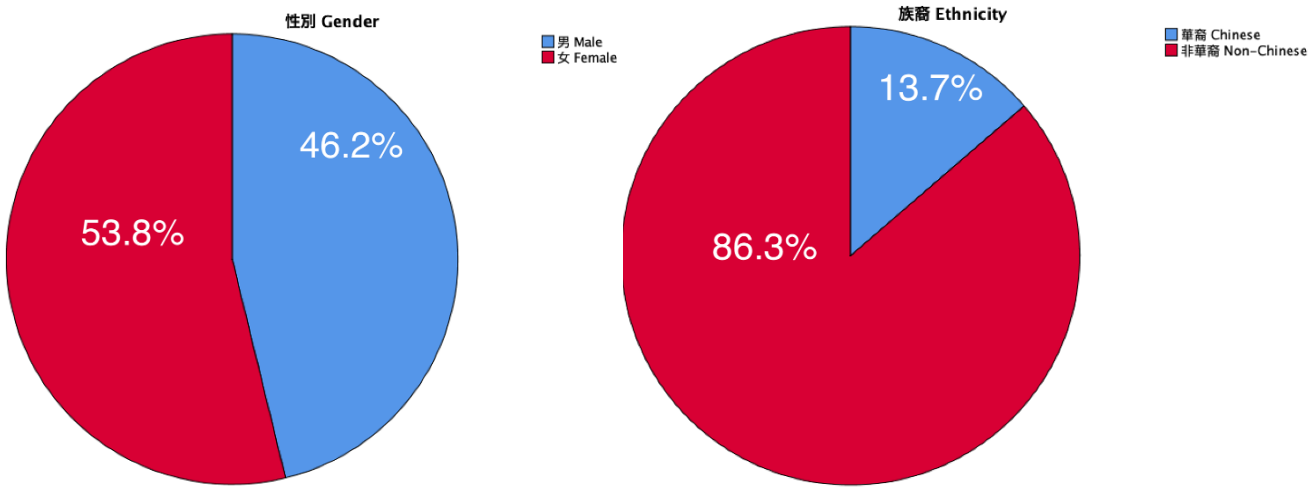
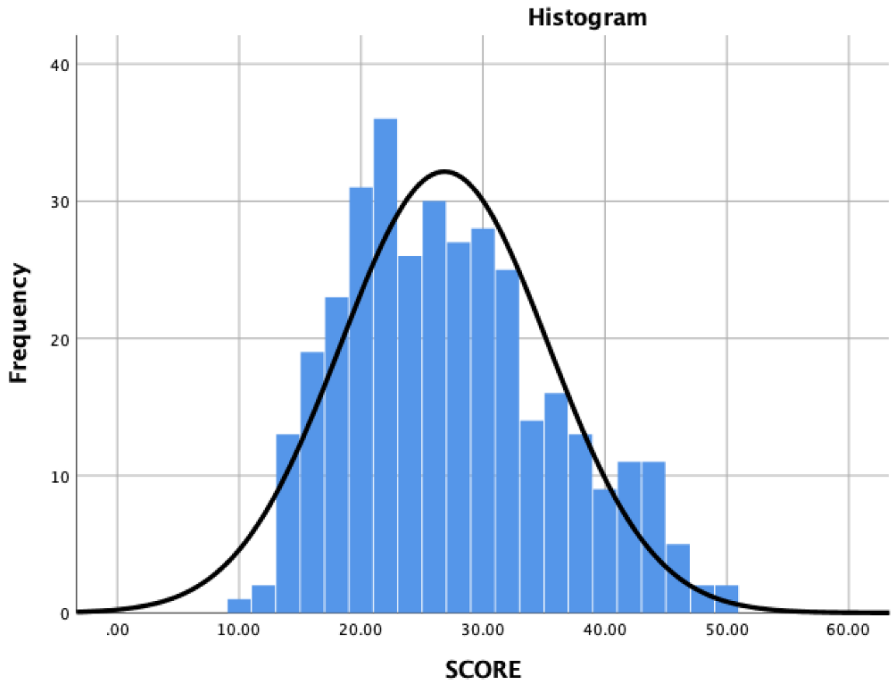


Fig 1) Gender and Ethnicity of the participants

2. Ocean literacy score

The ocean literacy score of the students were calculated and a score was given. The full mark was 74. A histogram was created using SSPS. The graph follows a normal distribution curve. The mean and standard deviation of the score was 26.8 and 8.5 respectively. The minimum score was 10, only one student had this score. The maximum score was 49, only two students had this score. Table 1 in the appendix shows details of the score and frequency of the score.



SCORE		
N	Valid	344
	Missing	0
Mean		26.8401
Std. Deviation		8.53533
Minimum		10.00
Maximum		49.00

Fig 2) Histogram of the ocean literacy score of the participants

3. Gender and ocean literacy score

The effect of gender on ocean literacy score was determined using independent sample T- test. The mean score of male and female was 27.1 and 26.7 respectively. The standard deviation was even closer at 8.69 for males and 8.34 for females. This result was not significant as shown by the P value of 0.656. Therefore, gender does not influence the ocean literacy of the participants.

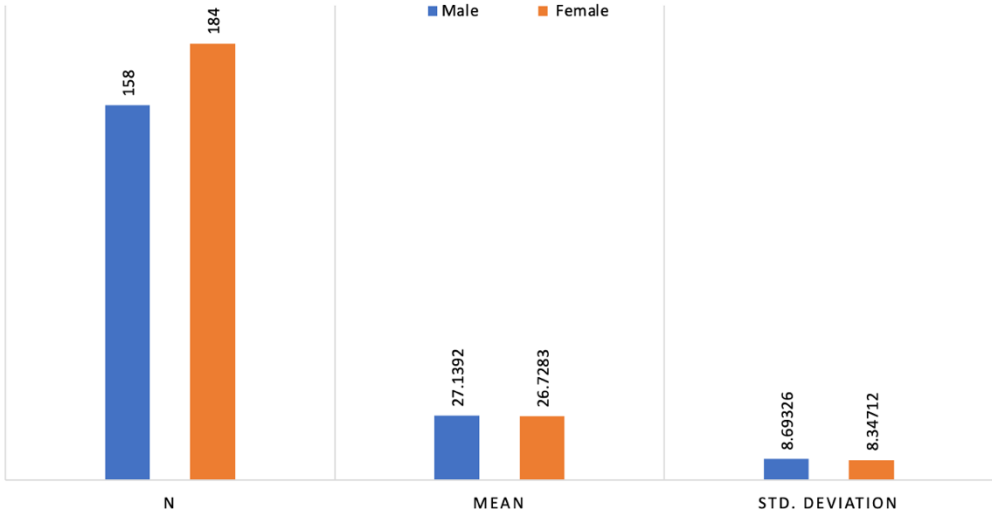


Fig 3) Bar graph showing the number of male & female participants with their score mean and standard deviation.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SCORE	Equal variances assumed	.088	.767	.445	340	.656	.41098	.92287	-1.40427	2.22623
	Equal variances not assumed			.444	327.752	.657	.41098	.92573	-1.41014	2.23210

Fig 4) Independent sample T- test of ocean literacy score and gender of the participants

4. Ethnicity and ocean literacy score

Similar to gender, the effect of ethnicity on ocean literacy score was determined using independent sample T- test. The mean score of Chinese and Non- Chinese were almost the same 26.9 and 26.8 respectively. The standard deviation was at 9.06 for Chinese and 8.4 for Non- Chinese. This result was not significant as shown by the P value of 0.919. Therefore, gender does not influence the ocean literacy of the participants.

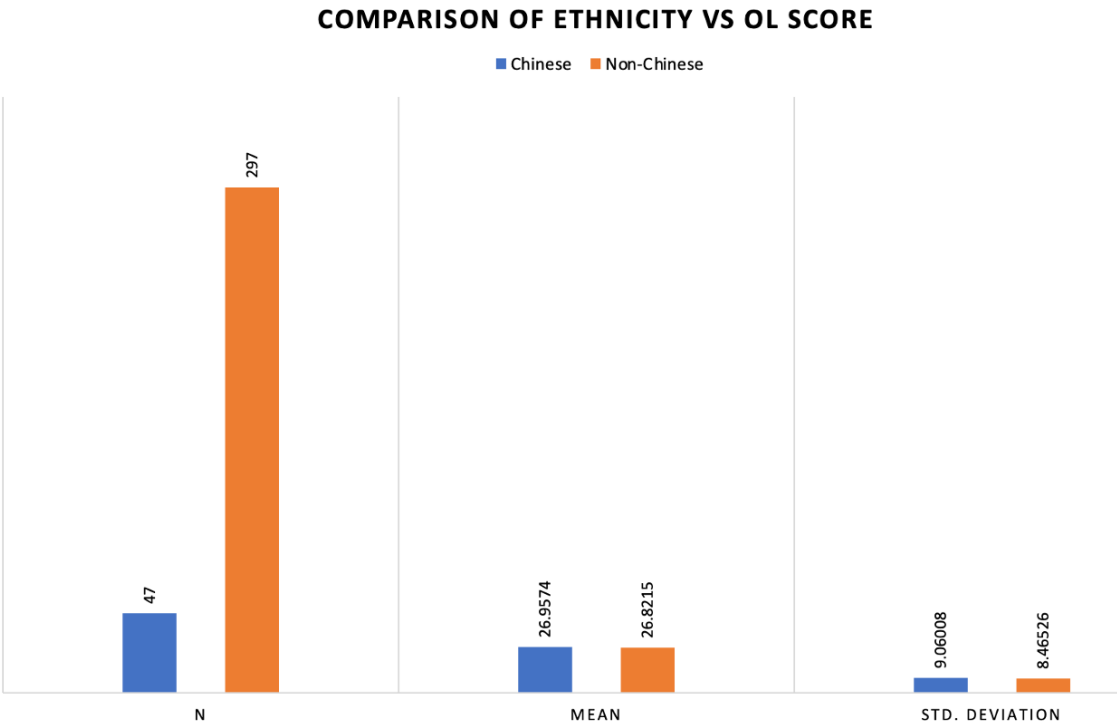


Fig 5) Bar graph showing the number of Chinese & Non- Chinese participants with their score mean and standard deviation.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SCORE	Equal variances assumed	.088	.767	.445	340	.656	.41098	.92287	-1.40427	2.22623
	Equal variances not assumed			.444	327.752	.657	.41098	.92573	-1.41014	2.23210

Fig 6) Independent sample T- test of ocean literacy score and ethnicity of the participants

5. Hours spent learning about the ocean per month in the past year

The students were asked “In the past year, how many hours per month did you spend learning about the ocean?”. Students had to select between six options (which were: 0, >1, 1-2, 3-5, 6-8, 8<). Pearson correlation analysis was performed to investigate the relationship between time spent learning about the ocean an ocean literacy. The analysis shows correlation coefficient of 0.143 and P value of 0.008. This shows that the correlation strength is small but positive and statistically very significant.

Correlations

		SCORE	1b. 近年，你每月會花多少時間獲取有關海洋資訊? In the past year, how many hours per month did you spend learning about the ocean?
SCORE	Pearson Correlation	1	.143**
	Sig. (2-tailed)		.008
	N	344	336
1b. 近年，你每月會花多少時間獲取有關海洋資訊? In the past year, how many hours per month did you spend learning about the ocean?	Pearson Correlation	.143**	1
	Sig. (2-tailed)	.008	
	N	336	336

**. Correlation is significant at the 0.01 level (2-tailed).

Fig 7) Correlation between time spent learning about the ocean and ocean literacy of the participants.

6. Source of information

A simple bar chart of the participants source of obtaining information about the ocean was created. The chart is in descending order.
The data collected on participant's source of information shows that school is the source of information for 262 participants. Technology and internet is also popular source of information with 221 choosing internet/ social media, 203 choosing documentary and 145 choosing movies. Only 24 chose conservation activities as their source of information.

Interestingly, although school is the most popular source of information, school extra-curricular activity was chosen by only 49 participants. Other source of information with frequency less than a hundred were: popular science/ ecological books (95), parents (81), water sport experience (73), storybooks/ novels (69) and magazine (47).

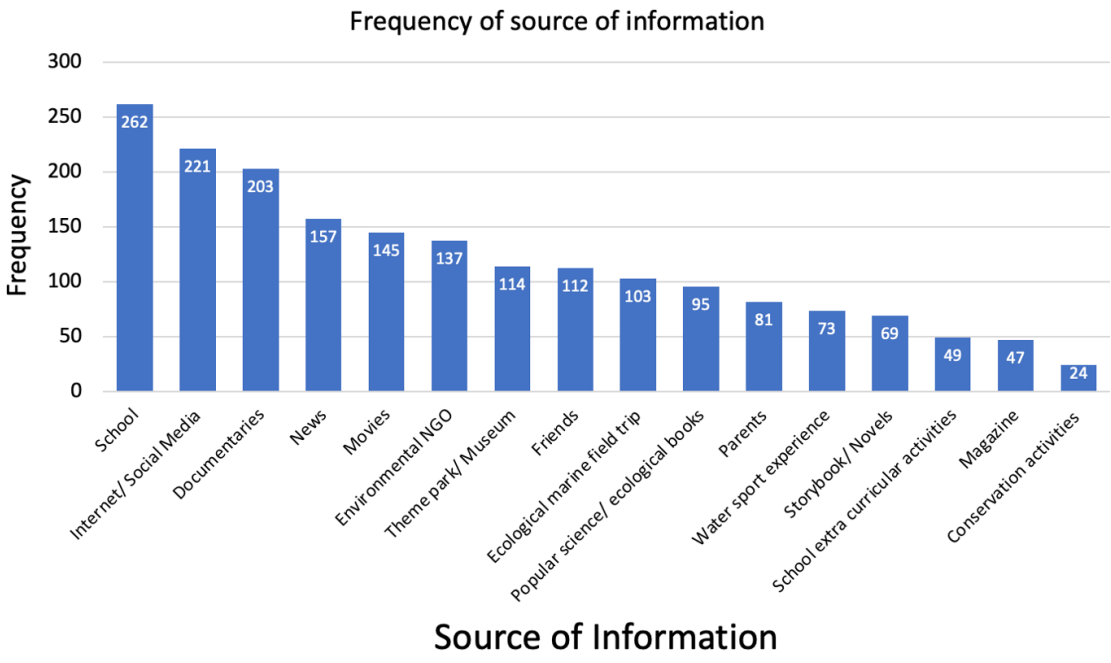


Fig 8) Source of information of the participants

7. Principal Component Analysis (PCA) of SOS items

Components of SOS items

PCA was performed on the SOS items. It consisted of 15 statements that participants had to rate in 5 point Likert scale. The PCA resulted in four components with percentage variance of 30.38, 16.44, 8.54 and 6.69. After further analysis, it was found that component 3 and 4 is insignificant and in fact all statements are under components 1 or 2.

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.558	30.384	30.384	4.558	30.384	30.384
2	2.467	16.447	46.830	2.467	16.447	46.830
3	1.281	8.540	55.370	1.281	8.540	55.370
4	1.005	6.699	62.069	1.005	6.699	62.069
5	.765	5.099	67.168			
6	.725	4.835	72.003			
7	.640	4.266	76.269			
8	.602	4.016	80.285			
9	.523	3.488	83.774			
10	.515	3.437	87.210			
11	.454	3.028	90.238			
12	.427	2.846	93.084			
13	.385	2.568	95.652			
14	.354	2.359	98.011			
15	.298	1.989	100.000			

Extraction Method: Principal Component Analysis.

Fig 9) Components of SOS items

Component 1

There were 10 statements under component 1. After analysis of these statements, it was found that component 1 refers to biocentric and eco-centric thoughts towards the ocean.

The relationship between the statements under component 1 and ocean literacy score was analyzed using Pearson correlation. The correlation analysis shows that component 1 and ocean literacy score are positively correlated. The correlation is of small to moderate strength but statistically significant.

Component matrix of 1

1. My actions can have a significant effect on the health of oceans and coastal areas.	.560
2. I have a personal responsibility to work for the health of oceans and coastal areas.	.577
3. I know some specific things I could do to help the ocean.	.449
5. I am familiar with the issues facing the global ocean.	.539
8. Human-made stresses are endangering coastal regions and the ocean's ability to sustain itself and may well be leading to long-term damage and serious problems.	.665
9. The health of the ocean is important to human survival.	.688
12. Business and industry should be responsible for protecting marine environments.	.678
13. Government should be responsible for protecting marine environments.	.727
14. Individual citizens should be responsible for protecting marine environments.	.787
15. Agriculture and forestry should be responsible for protecting marine environments.	.689

Fig 10) Component matrix of 1

Correlations

	SCORE	1. 我的行動可對海洋和沿海地區的健康帶來重大影響。My actions can have a significant effect on the health of oceans and coastal areas.	2. 我有責任為海洋和沿海地區的健康付出。I have a personal responsibility to work for the health of oceans and coastal areas.	3. 我知道一些明確的事情，讓我可以做到，來幫助海洋。I know some specific things I could do to help the ocean.	5. 我熟悉全球海洋所面對的議題。I am familiar with the issues facing the global ocean.	8. 人類正威脅沿海地區和海洋的維持能力，這亦會導致長期損害和嚴重問題。Human-made stresses are endangering coastal regions and the ocean's ability to sustain itself and may well be leading to long-term damage and serious problems.	9. 海洋的健康對人類生存很重要。The health of the ocean is important to human survival.	12. 工商業應有責任地保護海洋環境。Business and industry should be responsible for protecting marine environments.	13. 政府應有責任地保護海洋環境。Government should be responsible for protecting marine environments.	14. 個人公民應有責任地保護海洋環境。Individual citizens should be responsible for protecting marine environments.	15. 農林業應有責任地保護海洋環境。Agriculture and forestry should be responsible for protecting marine environments.
Pearson Correlation	1	.149**	.136*	.087	.184**	.301**	.309**	.233**	.287**	.286**	.239**
Sig. (2-tailed)		.006	.013	.108	.001	.000	.000	.000	.000	.000	.000
N	344	338	337	338	336	334	336	337	339	338	340

Fig 11) Correlation between statements of component 1 and ocean literacy score

Component 2

There were 5 statements under component 2. After analysis of these statements, it was found that component 2 refers to anthropocentric thoughts towards the ocean.

The relationship between the statements under component 2 and ocean literacy score was analyzed using Pearson correlation. The correlation analysis shows that component 2 and ocean literacy score are negatively correlated. The correlation is of small to moderate strength but statistically significant.

Component matrix of 2

4. I am familiar with the environmental issues facing the coastal areas in my home state.	.506
6. I have enough background knowledge to write a substantive letter to my legislative / district council's representative about an issue affecting the ocean.	.754
7. The ocean and coastal regions overall are so vast and healthy that they can continue to absorb pollution and other kinds of man-made stresses for the foreseeable future.	.629
10. We do not need to worry about the health of the oceans, because we will develop new technologies to keep them clean.	.597
11. What I do in my life doesn't impact the ocean at all.	.483

Fig 12) Component matrix of 2

Correlations

		SCORE	4. 我熟悉我家鄉沿海地區所面對的環境議題。I am familiar with the environmental issues facing the coastal areas in my home state.	6. 我有足夠的背景知識，就影響海洋的議題寫一封實質性的信給我的立法會/區議會代表。I have enough background knowledge to write a substantive letter to my legislative / district council's representative about an issue affecting the ocean.	7. 整體而言，海洋和沿海地區是廣闊和健康。在可預見的未來，它們可繼續吸收污染和其他人為壓力。The ocean and coastal regions overall are so vast and healthy that they can continue to absorb pollution and other kinds of man-made stresses for the foreseeable future.	10. 我們不需要擔心海洋的健康，因為我們將發展新技術來潔淨海洋。We do not need to worry about the health of the oceans, because we will develop new technologies to keep them clean.	11. 我一生做的事情不會對海洋帶來影響。What I do in my life doesn't impact the ocean at all.
SCORE	Pearson Correlation	1	.129*	-.195**	-.244**	-.322**	-.323**
	Sig. (2-tailed)		.018	.000	.000	.000	.000
	N	344	337	338	335	336	336

Fig 13) Correlation between statements of component 2 and ocean literacy score

8. Exposure to ocean related activity

The students were asked how often they have been exposed to ocean related activity in the last year. More than half the participants had never been to ecological marine field trip or marine conservation activity. 51.0% of the participants had gone to the beach 1-3 times but 38.5% had never swam in the last year.

	Go to the beach	Visit ocean exhibition (eg: Ocean park)	Ecological marine field trip	Water sport (eg: swimming)	Participating in marine conservation activity (eg: beach clean-up)
Never	14.3%	27.6%	**60.2%**	**38.5%**	**68.5%**
1 – 3 times	**51.0%**	**54.9%**	29.8%	28.6%	20.6%
4 – 6 times	19.1%	13.8%	5.6%	17.7%	5.6%
7 – 9 times	**7.2%**	3.4%	3.4%	8.4%	4.4%
>10 times	8.4%	**0.3%**	**0.9%**	**6.8%**	**0.9%**

Fig 14) Table showing how often participants were exposed to ocean related activities.

Discussion

Ocean literacy score

This study revealed a mean ocean literacy score of 26.8 out of 74. This score gives an average of 36.2%. The lowest was 10 / 74 by a single participant which is only 13.5%. The highest score was by two participants with a score of 49 / 74, which is 66.2%.

There is currently no literature defining what score is considered a pass. Most of the study conducted only investigates the following:

- The level of difficulty of the items in IOLS
- Comparison between different age group
- Comparison between different countries/ regions
- Comparison between different principals of IOLS
- By using a different instrument than IOLS
  (*Mogias, et al.,2019, Guest, Lotze & Wallace 2015, Tsai & Tsang, 2019*)

So far, no study has defined which score is considered a “pass”. However, it is still worth reporting the scores of the participants in this study. If the general approach of 50% (in this case 37 / 74) being a pass is considered, then only 53 participants would have “passed” while 291 of them would “fail”. If the approach of 40% (29.6 / 74) being passing rate is considered, then 117 participants would “pass” while 227

would “fail”. Even in the best case scenario that was considered, only 34% of the participants would be considered to have pass.

Gender

The independent sample T- test done on gender and ocean literacy has a P value of 0.656, this is not a significant number. Therefore, it can be concluded that gender does not affect the ocean literacy score of the participants.

However current literature on gender an ocean literacy score has conflicting findings. For instance, Tsai (2019) and Kurtay (2018) found that females scored statistically higher than males. Whereas other studies found the opposite (Stelle et al., 2005, Guest et al., 2014). Meanwhile, Mogias et al., (2019) found no significant difference between the genders.

This difference may be due to different surveyed population. Tsai had surveyed senior secondary school students from different regions of Taiwan. Kurtay had surveyed high school students from an elite school in Turkey. Stelle et al had surveyed citizens of different age group and Guest et al surveyed students from public school in Canada. The age group, country, type of school etc were different. Hence this may be the reason for the difference in the result.

The difference in result may also be due to gender gap in math and science education opportunities in different countries and population group.

The reason for gender not affecting ocean literacy in this study may be because the students all went to schools with a local curriculum.

Ethnicity

This study only looked at Chinese and Non- Chinese population. Although the group of “Non- Chinese” consisted of different nationalities, it was generalised as one group called “Non- Chinese”. The independent sample T- test done on ethnicity and ocean literacy had a P value of 0.919, this is not a significant number. Therefore, it can be concluded that ethnicity does not affect the ocean literacy score of the participants

However, it should be noted that the percentage of Chinese participants in this study was only 13.7%. This result may not be representative of the whole population. For future study, there should be close to equal number of Chinese and Non- Chinese participants for a more accurate representation.

Some studies that were conducted with different nationalities aims to investigate the ocean literacy of participants when compared to distance they live away from the coastline (Mogias et al., 2019). Other studies uses a different instrument to measure ocean literacy (Leitão et al., 2018). However, these studies concludes that the most determining factor in participant’s ocean literacy is their access to education about the ocean and exposure to the ocean.

Source of information

The data collected on participant's source of information shows that school is the source of information for 262 participants. Technology and internet is also popular source of information. This may be due to interactive quality of internet and technology which allows participants to actively search for information (Leitão et al., 2018).

Interestingly, although school is the most popular source of information, school extra-curricular activity was chosen by only 49 participants. Conservation activities was the least popular source of information. Extra- curricular activity in school and conservation activities could potentially be merged together for a more holistic approach to increase ocean literacy.

Other source of information with frequency less than a hundred were: popular science/ ecological books (95), parents (81), storybooks/ novels (69) and magazine (47). This may be due to passive nature of sources such as books and novels (Leitão et al., 2018).

Only 73 students chose water sport experience as their source of information. This may be due to having no opportunity to be involved in water sport. For instance, since late 2019 through early 2021, when this study was conducted, the schools in HK has periodically been suspended due to social movement and a global pandemic. Although, lessons were resumed via online means there has been significant disruption in the learning progress of students. Along with schools, public areas such as beaches, swimming pools and group activities were also suspended.

All these disruption in the participant's main source of information; school, and suspension of group field trips may also have contributed to the low ocean literacy of the participants.

Exposure to ocean related activities

The data collected on participant's exposure to ocean related activity showed going to the beach and ocean exhibition, like ocean park and water sport, such as swimming, is the most popular ocean related activity for the participants. Alarmingly, participating in marine conservation activity and ecological field trip is the least popular with more than 60% never attending it last year.

Once more, this may be due to the closure of public venues like swimming pool and beaches. The low level of participation in ecological field trip and conservation activities may be because of suspension of school and group activities and lack of opportunities.

Although in this study, no correlation analysis was performed between the participant's exposure to ocean related activity and their ocean literacy score, multiple studies have found that they're positively correlated. For instance, Steel et al. (2005) found that "frequent visits to the coast has positive effect on both subjective and objective form of knowledge". Other studies have found limited

interaction with marine environment showed “lower knowledge, greater pessimism and disinterest in sea areas” (Jefferson et al., 2014).

This may be because exposure to ocean related activities is an interactive and engaging way to learn about the ocean. Often, the participants is learning without even realizing it. A study conducted in 2000 found that 91% of surveyed students in coastal British Columbia, Canada, reported learning about the ocean or seashore by ‘doing things on or by the ocean’ (Cummings & Snively, 2000).

Therefore, it can be concluded that exposure to ocean related activity and ocean literacy is positively correlated.

Attitude and values

PCA on SOS items resulted in 2 valid components. These components were (i) biocentric and eco-centric views and (ii) anthropocentric views. Correlation between ocean literacy and the first component was positive while the one between second component was negative. The correlation coefficient was small to moderate but statistically significant.

This correlation corresponds well with theories on environmental stewardship (Hawthorne & Alabaster, 1999). Other research that was conducted also had similar findings (Guest et al., 2015, Mogias et al., 2015). Guest et al. (2015) found that 91% of the participants believed ocean is important for them. The study found that although the participants knew the economic value of the ocean, they value the ocean for recreational and environmental reasons more.

Students who scored higher in the “knowledge” of the ocean had higher “value score”. However, even if there were some misunderstandings about the factual and objective knowledge about the ocean, the students expressed “a passionate response” about their views towards the ocean (Guest et al., 2015).

Similarly, positive attitude towards the ocean is present regardless of the participant’s ocean literacy. A number of studies has explicitly reporting that increase in environmental knowledge leads to positive attitude towards the environment (Mogias et al., 2015). Therefore, educating the students about the ocean is important.

Recommendations

This study and countless others have found that ocean literacy is positively correlated with exposure to the ocean and positive attitude towards the ocean. Therefore, to improve ocean literacy marine education has to be the focus. Marine education includes both formal and informal education experiences.

Formal curriculum

This study found that more time spent learning about the ocean positively correlates with higher ocean literacy score. This study and other studies also found that high

ocean literacy is positively correlated with more positive attitude about the ocean. Since the main source of information for the participants was school, it is important to investigate the school curriculum.
The Education Department Bureau states there are eight key learning areas. The curriculum documents of three key learning areas will be analyzed. They are science education and personal, social and humanities education.

Science education
In HK education system, science subject is taught as "General studies" in primary school, "Integrated Science" in junior secondary and "Elective" in senior secondary. The formal science education technically ends by the end of junior secondary because the "elective" is an optional course for students who want to pursue science subject. This means that if ocean science was taught more in depth in senior secondary, not all students would be able to learn it.

The science education curriculum states that the aim is to:

"Recognise the social, ethical, economic, environmental and technological implications of science, and develop an attitude for responsible citizenship and a commitment to promote personal and community health".
(curriculum document 1 page 17)

To achieve this aim, there are 6 major learning elements that are equally important and interconnected. They are:

1. Scientific Investigation
2. Life and Living
3. The Material World
4. Energy and Change
5. The Earth and Beyond
6. Science, Technology, Society and Environment (STSE)

(curriculum document 1 page 18)

General studies curriculum *(curriculum document 7)*
According to the curriculum there are six strands in general studies curriculum. Strand 2 is about people and environment which includes some topics about environment and its importance. For instance, students are taught the interdependence nature of all living things, the effect of weather on people's lives and to conserve the environment.

Junior secondary science curriculum
The junior secondary science curriculum consists of 14 units.

Unit 2 is on water and upon close analysis of the curriculum, there are some concepts about the ocean (*curriculum document 2 page 22)*. They are:

- The process of water cycle
- Water purification
- Water conservation and pollution

Unit 3 is on living things and it included some topics on biodiversity and conservation (*curriculum document 2 page 28)* such as:

- Biodiversity
- Effects of human activities on biodiversity
- Conservation

These were the only topics related to ocean and environment that would be taught to the students before they have option to not continue science education. The unit 2 and 3 would also be taught in form 1 when the students are relatively young hence may not understand the implication of decreasing biodiversity or the importance of the ocean.

Senior secondary Biology curriculum *(Curriculum document 3)*
The biology curriculum consists of 6 units.

In unit 2 there is a subtopic about biodiversity and evolution. In unit 3 there is a subtopic about ecosystems. This subunit teaches a bit on different habitats like freshwater stream and rocky shore. Lastly, there's an optional elective on applied ecology.

The curriculum analysis shows that although the concepts of ecology and biodiversity is present, it is very superficial. Moreover, these content is not being taught to the students who choose not to pursue biology.

Senior secondary Chemistry curriculum *(Curriculum document 4)*
The biology curriculum consists of 14 units.

Unit 1 is about "planet earth" which has subtopic "the ocean". This topic is more about the composition of water, extracting materials from the ocean and testing for salts. Apart from this, there is no content taught about the ocean.

Personal, social and humanities education
The subjects under this key learning area are only for senior secondary students if they wish to pursue it. It is also not available in all schools in HK.

Ethnics and religious study
In the subject of ethnics and religious study, there is a topic called "environmental ethnics" *(Curriculum document 5 page 11).* Under this topic the students will be taught pollution and consumerism, exploitation of the environment, biodiversity and conservation and global village and sustainability. The curriculum document does not explicitly mention teaching about environmental ethics with regard to the ocean.

Geography *(Curriculum document 6)*
In terms of teaching about the earth, environmental problems and solutions, geography seems to be the most equipped. This subject includes topics such as

“living with our physical environment”, “facing change in the human environment” and “confronting global challenges”. There are subtopics like weather system and building sustainable cities. Moreover, there is also a field trip for students to put their knowledge to use.

However, it should be noted that geography is an elective like biology and chemistry which not all students would want to study. Hence, they will not learn about these topics.

After the analysis, it can be concluded that the formal education surely needs a reform to teach more about the ocean and the environment in general. The most alarming aspect of this result is that not enough content is taught when all students are required to study specific subjects.

Informal curriculum

Hands- on learning experiences such as field trip, being exposed to the ocean and experiential learning is equally important. Studies in environmental morality consistently reports the significant influence of direct personal experiences with nature in developing positive attitudes, values, and behaviours towards the environment (Greely, 2008).

A study found that teens participating in the Oceanography Camp for Girls had strong positive attitudes about ocean, stewardship, and the environment. They retained these positive attitudes up to 3 months after the camp and most were willing to act on their feelings to actively engage in ocean stewardship activities (Greely, 2008).

This study found that ecological field trip and conservation activity is the least popular way students learnt about the ocean. This surely needs to be improved for the participants to care about the ocean and environment. Making use of already popular method of learning, like internet and technology, is another effective way to increase ocean literacy. Schools can have activities such as “ocean awareness week” where the importance and risk faced by ocean is taught to the students.

As the decade (2021-2030) of United Nation’s decade of Ocean Science for Sustainable Development has commenced the environmental impact on marine environment and rest of the natural world is increasing. Therefore, it is perfect time to highlight the importance of marine environment through marine education. Marine education can invoke wonder and fascination with nature, in turn nurturing positive behaviours and attitudes toward the ocean (Winks et al., 2020).

While the aim of the informal curriculum would be to create individuals who are concerned about marine environmental issue, the larger question is how can we create individuals who are concerned about the environment in general? Surely, the answers lies in robust formal and informal education curriculum.

Limitation and further studies

The biggest limitation of this study is the small sample size which may not represent the entire population. The number of Chinese participants were limited and did not contain other population group such as parents, teachers and civil servants.

To bridge this gap and have a better understanding of ocean literacy in general public and hence how to improve it, some further studies are suggested. A study with participants of different age group to get general idea of ocean literacy. Ocean literacy of current and preservice teachers to assess their ability to teach about the ocean. And Lastly a comparative study before and after students have received some intervention.

Conclusion

Ocean is a dominating feature of our planet and it encompasses every life on earth. One cannot understand plate tectonics without seafloor spreading, the climate system without the ocean's role in it, productivity without marine photosynthesis and chemosynthesis and biodiversity without marine ecosystem. Therefore, understanding the ocean is essential to understanding and, thereby, protecting our planet (Mogias et al., 2015)

However, this study found an average score of less than 50% in the IOLS. This finding adds to a growing list of studies that discovered low level of OL in countries such as Canada, The US, The UK, South Africa, New Zealand & The Netherlands (Guest & Wallace, 2015).

Exposure to marine environment and positive ocean stewardship was found to be positively correlated with student's ocean literacy. Since, school was the most popular source of information for the students, it is important to teach about it in school. However, it should be noted that learning does not happen in vacuum and an individual's environmental literacy is result of many attributes: formal education, ecological knowledge, socio-economic knowledge, knowledge of environmental issues, skills and environmentally responsible behaviour (Mogias et al., 2015).

Therefore, apart from modifying the school curriculum, a wider community outreach and awareness should be established. It is difficult and a long process. But it can be achieved by continuous cooperation between formal and informal education facilities as well as commitment of research institutes, authorities, decision makers and stakeholders (Niedoszytko et al., 2019).

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Appendix 1: Ocean literacy score

SCORE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	10.00	1	.3	.3	.3
	12.00	2	.6	.6	.9
	13.00	6	1.7	1.7	2.6
	14.00	7	2.0	2.0	4.7
	15.00	6	1.7	1.7	6.4
	16.00	13	3.8	3.8	10.2
	17.00	9	2.6	2.6	12.8
	18.00	14	4.1	4.1	16.9
	19.00	17	4.9	4.9	21.8
	20.00	14	4.1	4.1	25.9
	21.00	23	6.7	6.7	32.6
	22.00	13	3.8	3.8	36.3
	23.00	16	4.7	4.7	41.0
	24.00	10	2.9	2.9	43.9
	25.00	17	4.9	4.9	48.8
	26.00	13	3.8	3.8	52.6
	27.00	19	5.5	5.5	58.1
	28.00	8	2.3	2.3	60.5
	29.00	19	5.5	5.5	66.0
	30.00	9	2.6	2.6	68.6
	31.00	15	4.4	4.4	73.0
	32.00	10	2.9	2.9	75.9
	33.00	8	2.3	2.3	78.2
	34.00	6	1.7	1.7	79.9
	35.00	10	2.9	2.9	82.8
	36.00	6	1.7	1.7	84.6
	37.00	5	1.5	1.5	86.0
	38.00	8	2.3	2.3	88.4
	39.00	5	1.5	1.5	89.8
	40.00	4	1.2	1.2	91.0
	41.00	4	1.2	1.2	92.2
	42.00	7	2.0	2.0	94.2
	43.00	7	2.0	2.0	96.2
	44.00	4	1.2	1.2	97.4
	45.00	2	.6	.6	98.0

	46.00	3	.9	.9	98.8
	47.00	1	.3	.3	99.1
	48.00	1	.3	.3	99.4
	49.00	2	.6	.6	100.0
	Total	344	100.0	100.0	

Appendix 2: SOS

Here are a number of statements that may or may not describe your belie
ocean (Cudaback, 2006). You are asked to rate each statement by selecti
and 5 where the numbers mean the following:

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

Choose one of the above five choices that best expresses your feelings about the
understand a statement, leave it blank. If you have no strong opinion, choose 3.

15._____ My actions can have a significant effect on the health of oceans and c

16._____ I have a personal responsibility to work for the health of oceans and c

17._____ I know some specific things I could do to help the ocean. [3]

18._____ I am familiar with the environmental issues facing the coastal areas in

19._____ I am familiar with the issues facing the global ocean. [3]

20._____ I have enough background knowledge to write a substantive letter to r
representative about an issue affecting the ocean. [3]

21._____ The ocean and coastal regions overall are so vast and healthy that they
absorb pollution and other kinds of man-made stresses for the

22._____ Human-made stresses are endangering coastal regions and the ocean's
itself and may well be leading to long-term damage and seriou

23._____ The health of the ocean is important to human survival. [5]

24._____ We do not need to worry about the health of the oceans, because we v
technologies to keep them clean. [5]

25._____ What I do in my life doesn't impact the ocean at all? [3]

26._____ Business and industry should be responsible for protecting marine env

27._____ Government should be responsible for protecting marine environment

28._____ Individual citizens should be responsible for protecting marine enviro

29._____ Agriculture and forestry should be responsible for protecting marine e

[4]AAAS Public Opinion Survey
[5]Ocean Project Public Opinion Survey
[6]Based on questions used for Minnesota Environmental Literacy Report Card

Appendix 3: IOLS

Table A1. List of the questions from Version 2 and their modification in V3. Note there is no Q16 and 45 as they were deleted after V1 and the numbers were kept unchanged in order to make it easier to track the questions from one version to the next. Column C. corresponds to the specific 'fundamental concept' from the Ocean Literacy Framework that is addressed by each specific question. The items in bold are the correct answers. The symbol 'Ψ' represent distractors that were not sufficiently attractive to respondents. The items are placed in numerical order.

Q.	C.	V2	V3
Q1	1a	Which statement is the most accurate:	Which statement best explains how ocean water moves?
Q1_1		The water in the Pacific Ocean will never reach the Indian Ocean	Water in each ocean basin (e.g. Atlantic, Pacific, Indian) circulates only within that basin
Q1_2		Water in Pacific Ocean will eventually reach all other parts of the world ocean	Water in the Pacific ocean basin will eventually circulate to all other ocean basins
Q1_3		The water in the North Atlantic Ocean will eventually move throughout the Northern Hemisphere, but cannot move to the Southern Hemisphere	Ocean water circulates throughout the northern hemisphere but will not cross over to the southern hemisphere
Q1_4		The water in the Gulf of Mexico can never reach the Pacific Ocean	Water in the Gulf of Mexico stays there, and does not reach other ocean basins.
Q2	3a	Which statement is true:	Because the ocean covers most of the Earth (select the best answer):
Q2_1		The ocean covers 70% of the Earth's surface	It controls our weather, climate, and oxygen production
Q2_2		The land covers 70% of the Earth's surface	Most living things are concentrated on the continents
Q2_3		The ocean and the land each cover 50% of the Earth's surface	Lots of the Earth is not very useful for humans
Q2_4 Ψ		The ocean covers 10% of the Earth's surface	It generates most of the Earth's greenhouse gases
Q3	1b	How deep is the deepest part of the ocean?	Which statement best describes the ocean floor compared to the land?
Q3_1 Ψ		500 meters	The land has mountains, valleys and plains, but the ocean floor only has trenches
Q3_2 Ψ		1000 meters	The ocean floor has small hills but no mountains
Q3_3		6000 meters	The ocean floor has mountains and valleys that are larger than those on land
Q3_4		11,000 meters	The land has mountains and valleys, but the ocean floor is mostly flat
Q4	1c	Ocean circulation is influenced by (select all that apply):	SAME
Q4_1		Satellites	Global ship traffic
Q4_2		The shapes of ocean basins	SAME
Q4_3		Adjacent land masses	SAME
Q4_4		Acidity of the ocean	SAME
Q5		By which process does the ocean lose heat that it absorbs from solar radiation?	DELETED
Q5_1		Precipitation	DELETED
Q5_2		Condensation	DELETED
Q5_3		Evaporation	DELETED
Q5_4		Sublimation	DELETED
Q6	1d	How is sea level measured?	SAME
Q6_1		Average depth of the ocean	SAME
Q6_2		Average height of the ocean relative to the land	SAME
Q6_3		Level of the ocean at the lowest tide	SAME
Q6_4		Level of the ocean at the highest tide	SAME
Q7	1e	Which of these statements is TRUE?	SAME
Q7_1		Seawater freezes at a lower temperature than freshwater	SAME
Q7_2		Seawater freezes at the same temperature as freshwater	SAME
Q7_3		Seawater freezes at a higher temperature than freshwater	SAME
Q7_4		Seawater cannot freeze	SAME

(*Continued*)

Table A1. (*Continued*).

Q.	C.	V2	V3
Q8	1e	Approximately how much of the Earth's water is in the ocean?	Where is most of the water on Earth?
Q8_1 Ψ		Very little	In the ocean
Q8_2 Ψ		A small amount	Frozen in the polar ice caps
Q8_3		About half of it	Trapped in underground aquifers
Q8_4		Almost all of it	Circulating in the atmosphere
Q9	1f	Which is the most accurate statement about the water in the Earth's water cycle?	SAME
Q9_1		Much of the same water has been traveling through the water cycle for millions of years	SAME
Q9_2		Water joins the water cycle when new water is made through condensation	SAME
Q9_3		Water leaves the water cycle through evaporation	SAME
Q9_4 Ψ		All of the water in the water cycle is liquid	Water leaves the water cycle when humans drink it
Q10	1f	Water moves from the ocean to the atmosphere to the land and back again to the ocean by a process called:	Because of the global water cycle:
Q10_1 Ψ		Watershed	When water evaporates from the ocean the rain that forms is a little bit salty
Q10_2 Ψ		Hurricane	Water goes from the ocean to the atmosphere to the land
Q10_3 Ψ		Cyclone	Climate change could cause more tsunamis
Q10_4 Ψ		Tsunami	Water that evaporates from the ocean will never return to the ocean
Q10_5		Water cycle	DELETED
Q11	1f	What connects the ocean to all of Earth's water reservoirs? Select all that apply	SAME
Q11_1		Sublimation	Ionization
Q11_2		Precipitation	SAME
Q11_3		Evaporation	SAME
Q11_4		Deposition	SAME
Q12	1 g	Rivers supply most of the salt to the ocean. The salt comes from:	SAME
Q12_1		Seafloor reactions	SAME
Q12_2		Eroding land	SAME
Q12_3		Volcanic emissions	SAME
Q12_4		The atmosphere	SAME
Q13	1 g	Which of the following are transported by rivers from watersheds to estuaries and to the ocean? Select all that apply	SAME
Q13_1		Nutrients	SAME
Q13_2		Salts	SAME
Q13_3		Sediments	SAME
Q13_4		Pollutants	SAME
Q14	1 h	Which statement is the most accurate?	Which is the most accurate description of the ocean?
Q14_1		There is one ocean, it is large, and it has enough resources to support the growing human population	SAME
Q14_2		When resources are depleted from one ocean, we can always find them in another ocean	SAME
Q14_3		There are many oceans and they can each replenish themselves	SAME
Q14_4		There is one ocean, it is large, it is finite, and the resources are limited	SAME

Q15	1 h	What is one example of an ocean resource at risk of being depleted?	SAME
Q15_1		Fishes and invertebrates.	Seafood
Q15_2		Wave energy	SAME
Q15_3		Sand	SAME
Q15_4 [ψ]		Salt	Carbon dioxide
Q17	2c	Which statement is the most accurate?	SAME
Q17_1		The sand present on most beaches has probably been there for 100 years	Sand on the shoreline is mostly stable and is likely to stay on the same beach for about 100 years
Q17_2		Sand on the shoreline is constantly moving and being redistributed by waves and currents	SAME
Q17_3		Sand on the shoreline is constantly moving and being redistributed by animals that live there	Sand on the shoreline is constantly moving and being redistributed mostly by activities of animals that live there
Q17_4		The sand present on most beaches has probably been there for 10,000 years	Sand on the shoreline is mostly stable and is likely to stay on the same beach for several 100 years
Q18	1d	What processes cause changes to sea level? Select all that apply	SAME
Q18_1		Movement of Earth's crust	SAME
Q18_2		Ice caps melt and grow	Melting and growing of ice caps on land
Q18_3		Seawater expands and contracts when it warms and cools.	Warming and cooling of ocean water
Q18_4		Coastal erosion	SAME
Q19	2e	What naturally influences the physical structure and landforms of the coast? Select all that apply	Which of the following can lead to changes in the physical structure and landforms of the coast? Select all that apply
Q19_1		Sea level changes	SAME
Q19_2		Changing salinity of the seawater	SAME
Q19_3		Tectonic activity	SAME
Q19_4		Forces of waves	SAME
Q20	3a,b	Imagine there are two cities of the same size that are at the same latitude (same distance north or south of the equator). One is on the coast, and the other is 200 km inland. On average, which of the following conditions would you expect? Choose the best answer	Look at the image. If both cities are at the same elevation, which is the best explanation of the average temperature in cities A and B:
Q20_1		The coastal city will have hotter summer temperatures and cooler winters	City A will have warmer summers and cooler winters than city B
Q20_2		The inland city will have cooler summer temperatures and warmer winters	City B will have cooler summers and warmer winters than city A
Q20_3		The coastal city will have cooler summer temperatures and warmer winters	City A will have cooler summers and warmer winters than city B
Q20_4		Temperature is not affected by distance from the ocean.	SAME
Q21	3a,b	What is the difference between weather and climate? Choose the best answer	SAME
Q21_1 [ψ]		Weather and climate are the same	Weather is what is happening right now, and climate is what happened last year
Q21_2		Weather is what is happening right now, and climate is what happens over many years	Weather is what is happening now, and climate is what happens over many years
Q21_3		Climate is what is happening right now, and weather is what happens over many years	SAME
Q21_4		Weather is everywhere while climate is local	SAME

(*Continued*)

Table A1. (*Continued*).

Q.	C.	V2	V3
Q22	3b	If Earth did not have an ocean, what would the surface temperatures on Earth be like? Would surface temperatures be:	If Earth did not have an ocean, what would the surface temperatures on Earth be like?
Q22_1		More extreme than they are now	There would be more extreme high and low temperatures than there are now
Q22_2		More uniform around the globe	Temperatures would be more uniform around the globe
Q22_3 [Ψ]		About the same as today	There would be cooler temperatures in the summer and warmer temperatures in the winter
Q22_4		We don't have enough information to know what would happen	Scientisits don't have enough information to know what would happen
Q23	3c	What is the most common impact of an El Niño year?	SAME
Q23_1		The salinity of the ocean water changes	The salinity of the global ocean water changes.
Q23_2		The temperature of the ocean gets colder	The temperature of the global ocean gets colder
Q23_3		There are significant temporary changes in global weather.	SAME
Q23_4		There are significant permanent changes in global weather.	SAME
Q24	3c	El Niño originates from which ocean basin?	El Nino is a complex weather pattern associated with changes in water temperature in which ocean basin?
Q24_1		Atlantic	SAME
Q24_2		Indian	SAME
Q24_3		Arctic	SAME
Q24_4		Pacific	SAME
Q24_5 [Ψ]		Southern	DELETED
Q25	3d	Most rain that falls on land originally evaporated from:	SAME
Q25_1		The tropical ocean	The tropical region of the ocean
Q25_2 [Ψ]		The polar ocean	DELETED
Q25_3		The temperate ocean	The temperate region of the ocean.
Q25_4		The Great Lakes	The nearby lakes and rivers
Q25_5		The ocean nearest the land where it fell	SAME
Q26	3f	The ocean has a significant influence on climate change by absorbing, storing, and moving what? Select all that apply	SAME
Q26_1		Salts	SAME
Q26_2		Carbon	SAME
Q26_3		Heat	SAME
Q26_4		Fresh water	Trash
Q27	3 g	In what way is global warming impacting the Arctic?	SAME
Q27_1 [Ψ]		Humpback whales populations are decreasing	The impact on the Arctic is the same as on the rest of the planet
Q27_2		Polar ice is decreasing	The Arctic is warming faster than the rest of the planet
Q27_3 [Ψ]		Mountain glaciers are growing larger	Glaciers are melting in some parts of the Arctic and growing in other parts
Q27_4 [Ψ]		Arctic fish populations are increasing	Populations of warm water fishes are migrating to the Arctic

Q28		What is one possible impact of a warming Arctic?	DELETED
Q28_1		Less snow and ice, causing more solar energy to be absorbed by the Earth's surface	DELETED
Q28_2		Less snow and ice, causing less solar energy to be absorbed by the Earth's surface	DELETED
Q28_3		Decrease in sea level	DELETED
Q28_4		Less fresh water available to coastal communities	DELETED
Q29		The uneven heating of Earth's surface causes the temperature of the ocean to vary with latitude. Which of the following maps is correct if 1 represents the warmest ocean water and 3 the coldest ocean water?	DELETED
Q29_1		Image 1	DELETED
Q29_2		Image 2	DELETED
Q29_3		Image 3	DELETED
Q29_4		Image 4	DELETED
Q30	4a	The accumulation of oxygen in Earth's atmosphere was necessary for life to develop and be sustained on land. Where did this oxygen originate?	Where did most of the oxygen in the atmosphere originally come from?
Q30_1		Oxygen was already there when the Earth was formed	The same processes that formed the Earth
Q30_2		All oxygen originated from photosynthetic organisms on land	Photosynthesis by plants on land
Q30_3		All oxygen originated from photosynthetic organisms both on land and in the ocean	Respiration of animals
Q30_4		All oxygen originated from photosynthetic organisms in the ocean	Photosynthesis by organisms in the ocean
Q31		What produces most of Earth's oxygen?	DELETED
Q31_1		Tropical Rain Forests	DELETED
Q31_2		Photosynthetic organisms in the ocean	DELETED
Q31_3 Ψ		Respiration from marine animals	DELETED
Q31_4 Ψ		Decomposition of dead plants and animals	DELETED
Q32	4b	Where did the first life on Earth evolve?	SAME
Q32_1 Ψ		In the desert	On land
Q32_2		In the ocean	In the ocean
Q32_3		Under rocks on high mountains	Deep under the surface of Earth
Q32_4 Ψ		In the atmosphere	In fresh water
Q33	5a	What is the largest animal ever to live on Earth?	SAME
Q33_1		Giant squid	SAME
Q33_2 Ψ		Elephant	Orca (killer whale)
Q33_3		Blue whale	SAME
Q33_4		Tyrannasaurus rex	SAME
Q34	5b	Which types of living things are there the most of in the ocean?	Most of the biomass in the ocean resides in:
Q34_1		Fish	Fishes
Q34_2		Plankton	SAME
Q34_3 Ψ		Animals with shells	Mammals
Q34_4 Ψ		Whales and seals	Molluscs
Q34_5 Ψ		Sharks	DELETED

(*Continued*)

Table A1. (*Continued*).

Q.	C.	V2	V3
Q35	5c	How large is the variety of living things in the ocean compared to other environments?	There are 35 major groups of organisms (vertebrates, arthropods, molluscs, etc.) Where are most of the major groups found?
Q35_1		More in the ocean than in forests	Almost all are found exclusively in the ocean.
Q35_2		Equally in the ocean and in the jungle	Most are found equally on land and in the ocean
Q35_3		Less in the ocean than in the forests	Slightly more than half are found exclusively in the ocean
Q35_4 Ψ		Equally in the ocean and in the desert	Most are found exclusively in the tropical rainforests
Q36	5e	Both land and ocean provide space for animals and other organisms to live. How much of Earth's living space is found in the ocean?	SAME
Q36_1		Only a little bit	SAME
Q36_2		About half	SAME
Q36_3		A little more than half	SAME
Q36_4		Nearly all	SAME
Q37	5e	In the ocean living organisms are found (select all that apply):	SAME
Q37_1		At the surface	SAME
Q37_2		In the water column	SAME
Q37_3		On the seafloor	SAME
Q37_4		In the tidal zone	SAME
Q38	5f	Which of the following influences the vertical distribution of organisms in the open ocean?	SAME
Q38_1		Amount of time exposed to air	SAME
Q38_2		Crashing waves	SAME
Q38_3		Light levels	SAME
Q38_4		Human activity	SAME
Q39	5 g	What is the source of energy for primary productivity in ocean ecosystems where there is no sunlight?	SAME
Q39_1		Chemical energy	SAME
Q39_2		Wave energy	SAME
Q39_3		Nuclear energy	SAME
Q39_4		Cold fusion	SAME
Q40	5 h	What is the main cause of vertical zonation patterns along the shore that influence the distribution and diversity of organisms?	All of the options below have an influence on the vertical distribution of living organisims along the shoreline. Select the option that has the largest influence on shorelines around the world
Q40_1		Sunlight	SAME
Q40_2		Salinity	SAME
Q40_3		Tides	SAME
Q40_4		Trampling by people	SAME

Q41	5i	The marine habitat that provides the most important and productive nursery areas for many marine and aquatic species are:	SAME
Q41_1		Regional seas	SAME
Q41_2		The deep sea	SAME
Q41_3		Rivers	DELETED
Q41_4		Open ocean	SAME
Q41_5		Estuaries	SAME
Q42	6b	Which of the following statements are true about how humans depend on the ocean? Select all that apply	SAME
Q42_1		It provides us with food and medicine	SAME
Q42_2		It provides us with mineral and energy resources	SAME
Q42_3		It provides us with transportation and jobs	SAME
Q42_4		It benefits our economy	SAME
Q42_5		It is important to our national security	DELETED
Q43	6b	Which statement about eating animals from the ocean is true?	SAME
Q43_1		All kinds of ocean animals are endangered, so no one should eat any ocean animals	SAME
Q43_2		Some populations of ocean animals are declining, so people should choose carefully what to eat	SAME
Q43_3		In the ocean, only whales and dolphins are declining so it is OK to eat fish	SAME
Q43_4		There are plenty of all the kinds of ocean animals that people normally eat	SAME
Q44	6d	What statement about ocean acidification is the most accurate?	Which statement is the best explanation of ocean acidification?
Q44_1		Burning fossil fuels adds carbon dioxide to the atmosphere, which is then absorbed by the ocean and increases its acidity	SAME
Q44_2		Human caused pollution adds toxic chemicals to the ocean that increases its acidity	SAME
Q44_3		Fertilizers used in agriculture are washed into the ocean by rainfall and this increases the acidity of seawater	SAME
Q44_4		Ocean currents and other natural cycles are constantly changing the acidity of the ocean around the world	SAME
Q46	6d	Humans affect the ocean in a variety of ways. What does human development and activity often lead to? Select all that apply	SAME
Q46_1		Pollution.	SAME
Q46_2		Physical changes to beaches	SAME
Q46_3		Changes to ocean chemistry	SAME
Q46_4		Increased frequency of tsunamis	SAME
Q47	6e	What will be the most immediate effects of climate change on the ocean? Select all that apply	Recent human activities have changed ocean temperatures and pH. Which of the following have happened because of these changes? Select all that apply
Q47_1		Changes to ocean chemistry	Ocean salinity is increasing
Q47_2		Changes to sea level	Many corals reefs are dying
Q47_3		More oil spills	The frequency of oil spills is increasing
Q47_4		Changes in sea surface temperatures	Biodiversity in the ocean is decreasing

(*Continued*)

Table A1. (*Continued*).

Q.	C.	V2	V3
Q48	6f	Most humans live:	SAME
Q48_1		Near rivers	SAME
Q48_2		In rural areas	SAME
Q48_3		In coastal areas	SAME
Q48_4 Ψ		In inland areas	SAME
Q49	7a	About what percentage of the ocean has been explored to date?	SAME
Q49_1		5%	SAME
Q49_2		25%	SAME
Q49_3		50%	SAME
Q49_4		75%	SAME
Q49_5		90%	DELETED
Q50	7d	Fewer ocean scientists go to sea to conduct their research than in the last century. They rely more on satellites, buoys and unmanned submersibles. What impact is that having on our understanding of the ocean: Select the best answer	Ocean scientists increasingly rely on satellites, buoys and remote-operated submersibles. What impact is that having on our understanding of the ocean: Select the best answer
Q50_1		It improves our understanding because the new technology can collect vastly more data than scientists on ships can	It improves our understanding because the new technology can collect much more data than scientists on ships can
Q50_2		It decreases our understanding because scientists don't collect data with their own hands	SAME
Q50_3		It decreases our understanding because the technology isn't very reliable	SAME
Q50_4		It improves our understanding because it eliminates human error	SAME