

OVERARCHING QUESTION: Why should we be concerned about ocean acidification?													
	INVESTIGATION 1	INVESTIGATION 2	INVESTIGATION 3										
LITTLE QUESTION	Are the oceans around NZ becoming more acidic?	What is causing our oceans to become more acidic?	What does ocean acidification mean for the future of our kai moana?										
TYPE OF INVESTIGATION	Pattern Seeking	Observing & Exploring	Modelling										
EVIDENCE GATHERED (CONCLUSION)	From 1995 to 2021, pCO2 levels were increasing from 35-390. During this same time period, pH levels were lowering and becoming more acidic going from 8.18.05. This shows us that pCO2 levels rise while pH levels drop.	When vinegar (acid) was added to baking soda (alkali), it released carbon dioxide. When this carbon dioxide settled in the solution (water), it created carbonic acid. This gives us the formula: Carbon dioxide + water → carbonic acid (CO2 + H2O → H2CO3)	Oysters build their shells using aragonite (a form of calcium carbonate) which dissolves quickly as the oceans become more acidic. Scientists predicted what NZ's aragonite saturation state would be in the future. Oyster larvae struggle to grow when aragonite levels drop under 2. Using this, we found out that after 2075 oyster larvae will struggle to grow in NZ waters.										
WHY WAS THIS INVESTIGATION TYPE USED TO ANSWER THE QUESTION?	Pattern seeking is an investigation used by scientists to identify patterns and relationships between different variables over time. It can be used to gather information for other investigation methods such as exploring & observing and to see the relationship between variables that are hard to control. Since the ocean is a variable that is almost impossible to control as there is so much variation, we used this approach by analysing data collected by the natural Institute of Water and Atmospheric Research that had been put into a graph. This way we were able to draw trend lines indicating what happened to both the pCO2 levels and acidification levels over time. After analysing these graphs, I found out that as the amount of carbon dioxide entering our water was increasing, our oceans pH levels were decreasing and becoming more acidic.	Scientists use exploring and observing to gain a general understanding of a topic and to discover new information. Tools are usually used to aid this investigation to extend the scientists senses so they can gather more data. We used this approach to observe what happened to water after being mixed with CO2 to see how the oceans are becoming more acidic. To do this, we used the set up below:	Scientists use modelling to represent and test ideas so they can predict possible future outcomes, it can be especially helpful to test things that are too expensive in real life. We used this approach by analysing a model created by the NOAA which predicts future aragonite levels in sea water. It was based on historic data and projected carbon dioxide emissions so they could predict the aragonite saturation state in the future due to carbon dioxide which causes ocean acidification. The model showed aragonite levels in the ocean from 1861-2000 so we were able to observe the saturation state in future years and recorded it in a table.										
			<table><tr><td>Year</td><td>Aragonite saturation state</td></tr><tr><td>2000</td><td>3.1</td></tr><tr><td>2025</td><td>2.5</td></tr><tr><td>2075</td><td>1.9</td></tr><tr><td>2100</td><td>1.7</td></tr></table>	Year	Aragonite saturation state	2000	3.1	2025	2.5	2075	1.9	2100	1.7
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	pH and Dissolved CO₂ Concentrations off the Otago Coast (Munida Transect) (Source: National Institute of Water and Atmospheric Research) Since the pH scale is logarithmic, this range represents approximately a 30% increase in acidity.	We put baking soda in a boiling tube that was inside a jar of water mixed with bromothymol blue solution. We then added vinegar and covered the top with glass to observe what happened. We saw the vinegar and baking soda fizz and bubble up which showed them releasing carbon dioxide. A while later, we found out that the bromothymol blue solution had turned yellow meaning that once the carbon dioxide had mixed with it, it turned acidic (yellow). This left us with the final solution of carbonic acid and gave us the formula: $\text{Carbon dioxide} + \text{water} \rightarrow \text{carbonic acid}$	Using this information, we found out that in 2075 NZ oyster larvae will struggle to grow because of ocean acidification. And, if things keep going at this rate, after 2100 oyster larvae might start dying instantaneously.
WAS THIS INVESTIGATION TYPE APPROPRIATE (OR NOT)?	It was appropriate to use pattern seeking to answer our little question of “Are the oceans around NZ becoming more acidic?” This approach allowed us to analyse real data with variables we would be unable to control ourselves as the ocean is too wide a variable for us to manage. The NIWAR scientists had gathered lots of data from the years 1995-2021 so we could observe the trends in graphs to tell	It was not appropriate to use exploring and observing to answer our little question of “What is causing our ocean to become more acidic? While this investigation did show us what effect carbon dioxide had on water, it was very inaccurate. Since we used tap water rather than ocean water, we were unable to see how the carbon dioxide might have affected our ocean differently. By not using sea water, the time it took for the	It was appropriate to use modelling to answer our little question of “What does ocean acidification mean for the future of our kai moana? By using modelling, we were able to get an idea of how our oceans would be affected by acidification by observing the aragonite levels in New Zealand. We wouldn’t be able to predict these future levels with a different approach as modelling helped us to predict a possible future outcome which

	us more about ocean acidification. The graph showing pCO₂ levels overtime doesn't help answer our little question as much, however, it does contribute to our broader question of "Should we be concerned about ocean acidification?" as it shows the effects of our carbon usage in the water and how our actions are leading to ocean acidification. It also helped to generate questions such as "How does ocean acidity change over time?" or "What happens to the oceans pH levels when pCO₂ levels increase?"	carbon to affect the water and the effect that it had was inaccurate. Alongside this, carbon dioxide is not trapped with ocean in real life so having a glass lid trapping the CO₂ was unrealistic. A better approach would have been modelling so we were able to accurately scale down the experiment and see what would happen when the factor of carbon dioxide was introduced to ocean water. This way the experiment would give us more accurate information and clearly answer our question by showing that it was carbon dioxide making our oceans more acidic. It could also generate questions like 'what happens when carbon dioxide and ocean water interact?'	cannot be done with something like fair testing. We learned through this investigation that after 2075 oyster larva will begin to die in NZ due to insufficient aragonite levels which could greatly affect NZ's kai moana therefore helping to answer our question about the effects of ocean acidification to the future NZ ecosystem. This helped us generate questions like 'what could happen in the future if ocean acidification levels continue to rise?' and we are able to explore the effects of this future through a model when the scale is too big for us to control.
Analyse how using three different types of investigative approaches together enabled you to answer your overarching question or not? Why should we be concerned about ocean acidification? To answer this question, we were required to split it into three smaller question to answer the two main aspects of the question. We used two investigative approaches to analyse the effects of acidification on NZ currently and then 1 investigation to observe future effects which are reason for concern. Using all these, I was able to answer our main question. The first little question that was generated by our overarching question was "Are the oceans around NZ becoming more acidic?" It was important to start our investigation here and we used pattern seeking to analyse the effect of ocean acidity to answer this question. We needed lots of data to answer this question but, instead of exploring and observing, we used pattern seeking for this question. Since we already had data provided by Natural Institute of Water and Atmospheric Research, we didn't need to collect it ourself in order to answer the question as we provided scientific evidence to use instead of what is actually happening in the world. We would not have been able to collect this data ourself as the ocean is too unpredictable and we cannot control it. By using pattern seeking with the information provided through the exploring and observing done by the scientists, we were able to establish trends on the rising levels of ocean acidification. We discovered that as pCO₂ levels were rising, the oceans pH was lowering meaning it was getting more acidic with carbon dioxide. This gave us the knowledge we needed to answer our big question as we can see a reason for concern in the fact that it is on the rise. We needed the other investigations to truly answer the why part of the question. Pattern seeking helped us generate our next little question of "What is the effect of carbon dioxide on water?" so we could look deeper into the reason our oceans were becoming more acidic now that we know that acidification levels are rising. What is causing our ocean to become more acidic? We chose to use exploring and observing to answer this question, as we were focused on gathering new information that can be used to give us a general understand9ng about the cause of ocean acidification. Modelling might have been a better method to use instead of this because we could accurately see the cause with sea water compared to tap water, however we did not have access to sea water so exploring and observing still worked well to answer the question. When carrying out this investigation we used tools such as dye so we could clearly see what happened to the water when it was mixed with carbon dioxide. By using tap water compared to sea water we were limiting the information we gathered so modelling would have been much more helpful to gather the information we needed. With the information we did receive of observing the acidification of water when mixed with carbon dioxide, we generated our next question looking into what future carbon dioxide levels might do to ocean acidification, which gave us the question of "What does ocean acidification mean for the future of our kai moana?" It helped answer our big question by giving us information on the cause of ocean acidification so we know what we are doing to cause the concern for ocean acidification.			

What does ocean acidification mean for the future of our kai moana? This is the question we generated from our exploring and observing. This required us to use information from the NOAA website. This website used data from pattern seeking to establish trends that helped determine what acidity levels might be in the future. They did this by using historical data and projected carbon dioxide emissions and used aragonite as the substance they measured as it used by many sea creatures, particularly oysters, to build their shells. Using a computer program to simulate and see these trends was appropriate when looking into the future so we can see trends because the data is so complex. This information collected from pattern seeking was essential to create a model of what the aragonite levels might be for NZ in the future. With this approach we were able to see how oyster larvae would be effected in NZ in the future as it would become hard for them to grow after 2075. This is because of the predicted aragonite levels we observed at this time for NZ which was the right information to answer our little question as we can see what will, happen to some of NZ marine life in the future. This helped answer our overarching question as we were able to see why we should be concerned about ocean acidification. Learning that marine life would struggle to grow in the future is a huge reason for concern if ocean acidity keeps on rising like the model suggested.

By breaking our overarching question of Why should we be concerned about ocean acidification? Into three parts, we were able to see scientific reasoning as to why we should be concerned about ocean acidification. These three investigations all involved collecting data to help do things like establish trends and generate questions. They all used each other to help answer each little questions, as scientists used exploring and observing to get the data we used for pattern seeking, and the model we used was based on pattern seeking data and evidence to predict the future. Some differences between these approaches was that in exploring and observing we collected the data ourself and just recorded the results of what we saw. With pattern seeking, we were just presented the information and had to find the relationships and trends ourself. Meanwhile modelling did the pattern seeking for us while we used it to record the different levels over years in a table. Some advantages of pattern seeking is that it shows us accurate data that allows us to see trends we need to answer questions especially when the variables are difficult to control in an investigation. A disadvantage is that it doesn't give us an accurate full picture as some graphs only show short period of times and trends may be different in the long run. An advantage of exploring and observing is that it is good to give us a general understanding and give us the big picture that pattern seeking leaves out. A disadvantage is that it is not 100% accurate as in our case where we didn't have access to sea water so observed tap water instead. Finally, an advantage of modelling is that we were able to predict outcomes which is impossible with other investigations. This way we can see how things change overtime as certain factors (like carbon dioxide) increase. A disadvantage is that there is no way to ensure that this will actually happen in the future as factors in the environment might change overtime as new technology is introduced. Overall, these three different approaches and little questions helped us answer our big question by first discovering how it was an issue by seeing acidification levels rise. Then we got to the root of the issue which is carbon dioxide, something present in everyday life causing reason for concern. And finally, the why we should care part demonstrated through modelling as we see the possible effects that acidification will have on NZ by analysing its sea life. This shows us why ocean acidification is big reason for concern as it is on the rise due to a product that is all over our atmosphere (carbon dioxide) and its proved to have a large impact on sea creatures and life meaning we should be concerned to act on it and stop it from getting this bad.