THE 2022 YOUNG MATHEMATICAL STORY AUTHOR (YMSA) COMPETITION

THE CINDY NEUSCHWANDER AWARD

(THE 12-15 YEARS OLD CATEGORY)

LONGLISTED

‘Nikao's Whale’ by Rebecca Kear (15 years old)

at Dulwich College Beijing (China)

You can read the author’s inspiration for the story and the judges’ comments on:

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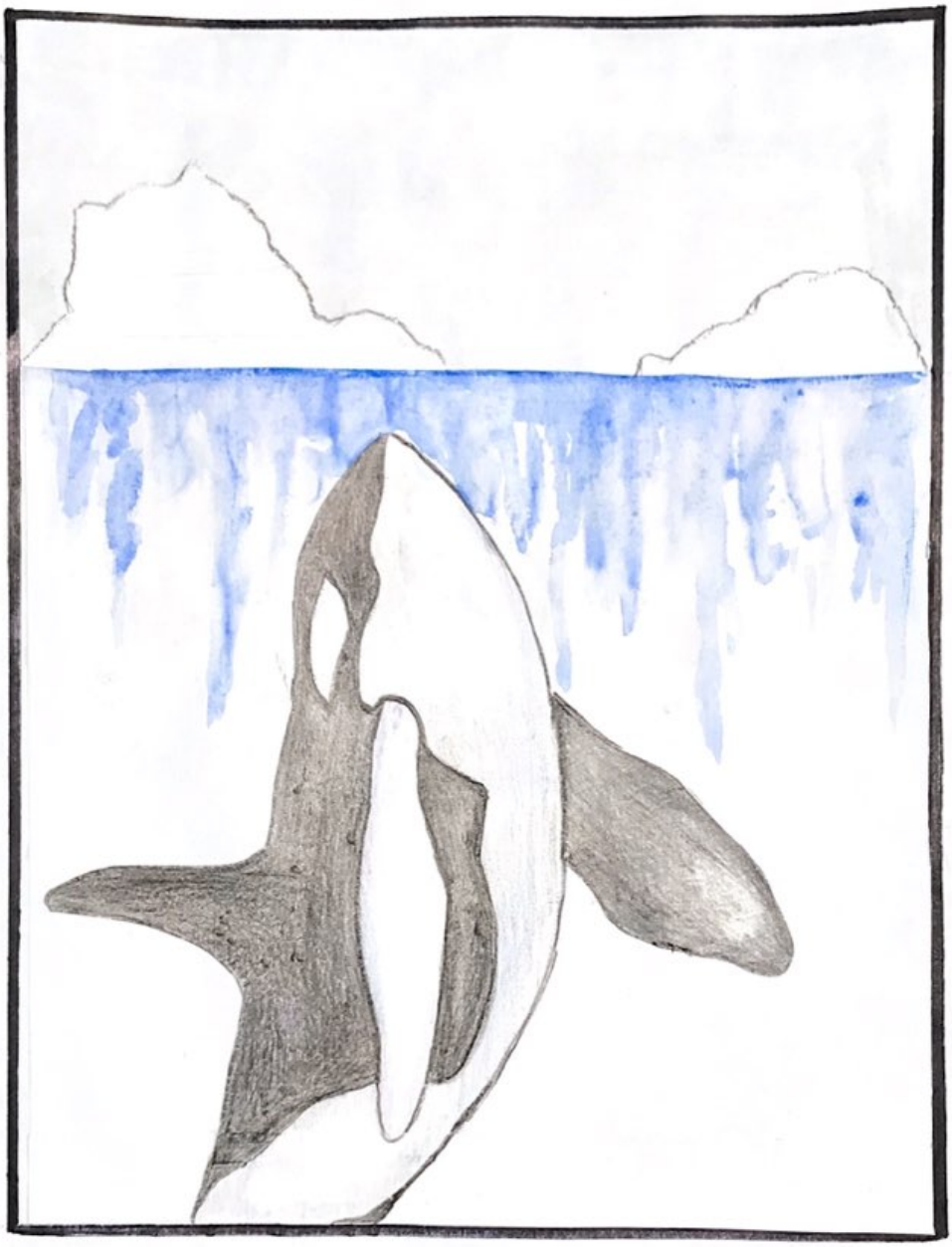
Nikao's Whale



By Rebecca Kear
Dulwich College Beijing

Our people, left on the rugged island of Te Ika-a-Maui, once settled here long ago where the demigod Maui fished up the northern isle with the hook of his rod. His greatness was known throughout the islands of New Zealand for his ingenuity and power, becoming our forefather of the beautiful land of Aotearoa. In those days, our people spent weeks without end celebrating the feats of Maui, throwing massive hākari, feasts, and dancing in the moonlight of the warm summer night. Yet what the Maori people are most blessed with are the vast oceans of water and nature gifted through our god Tangaroa, the god of the oceans. His offspring of which conduct the life under the sea and are deemed sacred to the Maori people—the magnificent whales.

It was a bright, cold Sunday morning when I heard from my bedroom a faint whisper among the sound of crashing waves. We lived so close to the sea that if I leaned my ear against the frigid glass window, I could hear the hubbub of life stirring beneath the water's surface—the movement of a hermit crab, the cracking of turtle eggs, and the ever-so-quiet movement of sea anemone.

"Haere mai ki ahua" the ocean whispered. "Come to me."

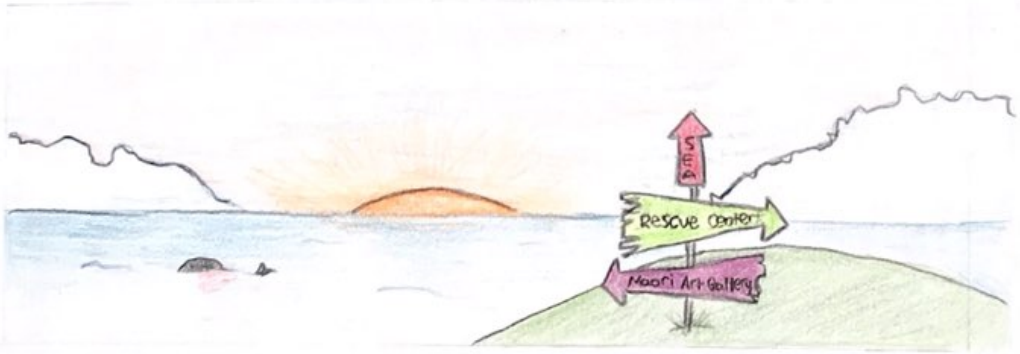
I heard this cry and before long, I was at the shore, barefoot, staring into the vast waters. I walked on the sand, trekking through a pile of small sharp stones, fragments of glass, and pieces of plastic prodding and poking the soles of my feet. As I came closer and closer to the water, I heard the voice again—only louder.

"Haere mai, haere mai ki ahau" it rang.

Right then, a baby orca appeared in my view—the majestic black and white creature that the Maori adore. The orca was bleeding with blood flowing from the right fin, tinting the blue waters crimson. It was not far from the shore, so I waddled out into the sea, and found myself not an inch away from the sacred being. I had to let everyone on the island know urgent help was needed. I bobbed my head into the water and there and behold was a white, stunning conch. I took the shelled beauty and blew into the end and sounded it like a horn. But it was early morning, no one would be awake to hear my cry, and if someone were awake no one would know what the sound meant, I thought to myself.

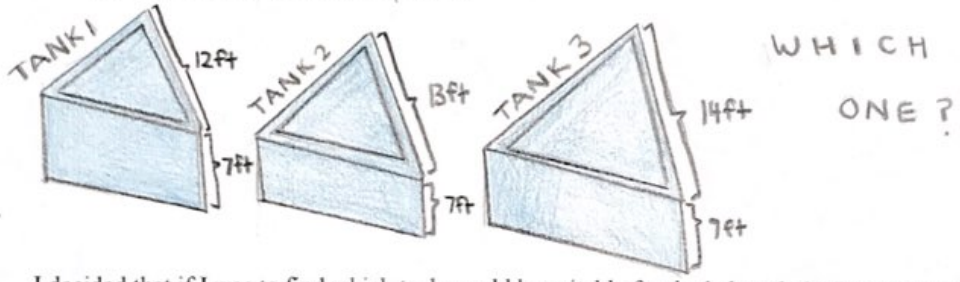
Sitting on the beach, I waited for what it seemed like over an hour, waiting. Waiting for anything to happen. I knew I could not save the animal—that sad reality struck me hard. The sun's ray kissed my falling tears as they plopped onto the sandy shore and was taken by the crashing waves. As I turned my back from the sea and slouched my way back home, a huge truck pulled itself onto the beach right in front of me, blocking my path. Two young lifeguards jumped out of the sides of the vehicle, one wearing a red vest and the other a blue vest.

They discussed amongst themselves and then came forward to ask me, "Aue taku, what's wrong child? We heard the signal from your conch." I told them about all I saw and about the orca whale bleeding in the water. Before long we were hauling the baby whale out of the ocean and were driving away to the nearest animal rescue center.

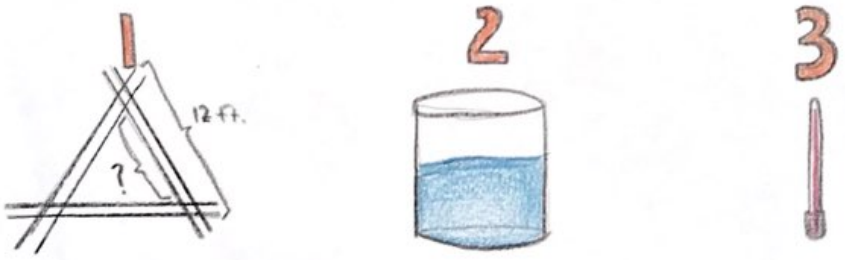


When we arrived at the rescue center, a dozen workers met us out at the parking lot and helped take the baby orca out of the trunk of the truck. They moved her onto a trolley with a dampened cloth over her. One worker said, "She's a beauty. The poor thing must feel horrible. Better get her bandaged to stop the bleeding and get her into one of our tanks." There was a full medical team that strolled the huge trolley into the rescue center through a door similar to a garage door and started working fast on her fin as soon as she was in the clinic.

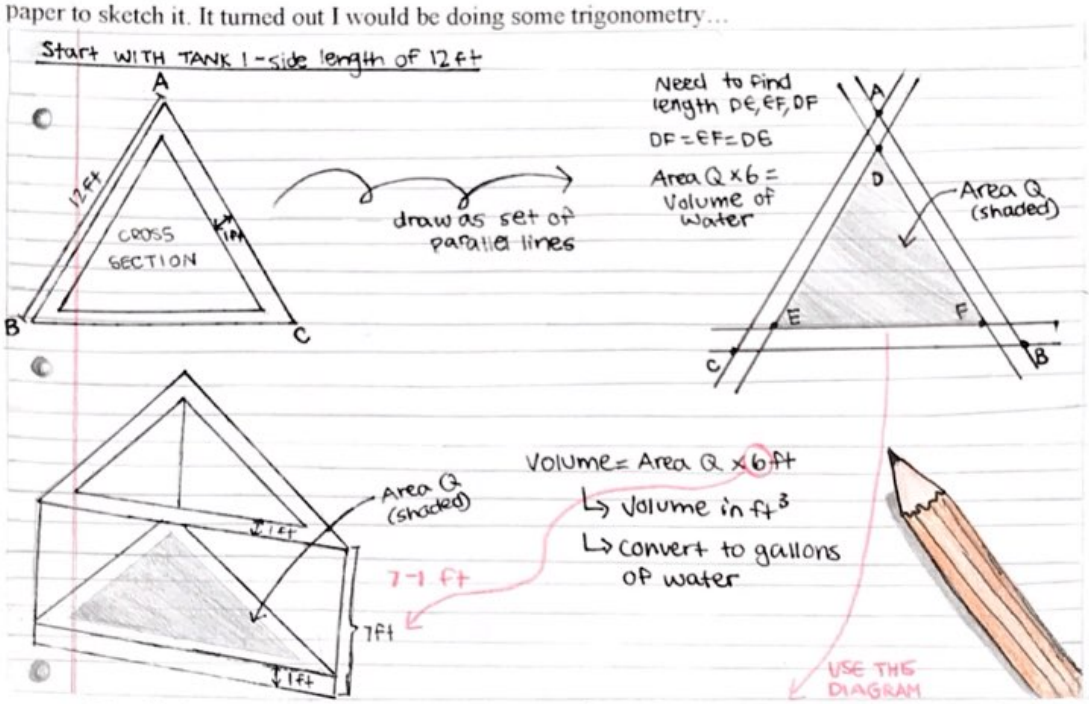
After a quick fifteen minutes of bandaging, the team needed to put her into a tank that would fit her in. But since she was one of the biggest animals the team had worked with, the largest three tanks might not be able to fit even a baby orca. I asked one worker if I could see the tanks. They led me to it, and gathering primary measurements from the workers there, I found the tanks were triangular prisms with the equal sides of the cross-section of 12, 13 and 14 feet with the glass being 1 foot in width and 7 feet deep. The whale herself was 8.5 feet in length. I found a pencil and paper and sketched the tanks out—it turned out I would need to do a bit of math.



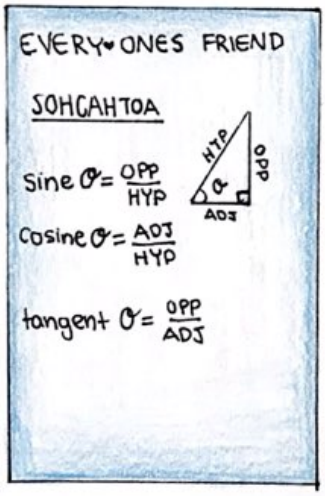
I decided that if I was to find which tank would be suitable for the baby whale, I would need to find out three things: the inner side lengths of the tank, the volume of the water and the temperature of the water. The tank which satisfies the three requirements the best—having the largest inner side lengths and volume for the most suitable water temperature—would be the one tank I would choose.

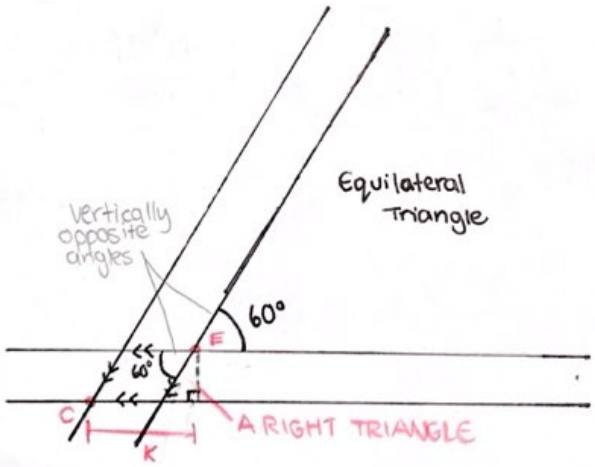


I drew the cross section of the tank. To solve for the volume of the water in each tank, I would need to know the inner area of the cross section, then multiply that by 6 ft to get the volume as there is one feet of glass for the base, ultimately converting cubed feet to gallons. To get the area of the cross section, I would first need to find the side lengths of the inner triangle as the glass itself was one foot in width. The triangle being equilateral meant only one side length needed to be found. I used my entire paper to sketch it. It turned out I would be doing some trigonometry…

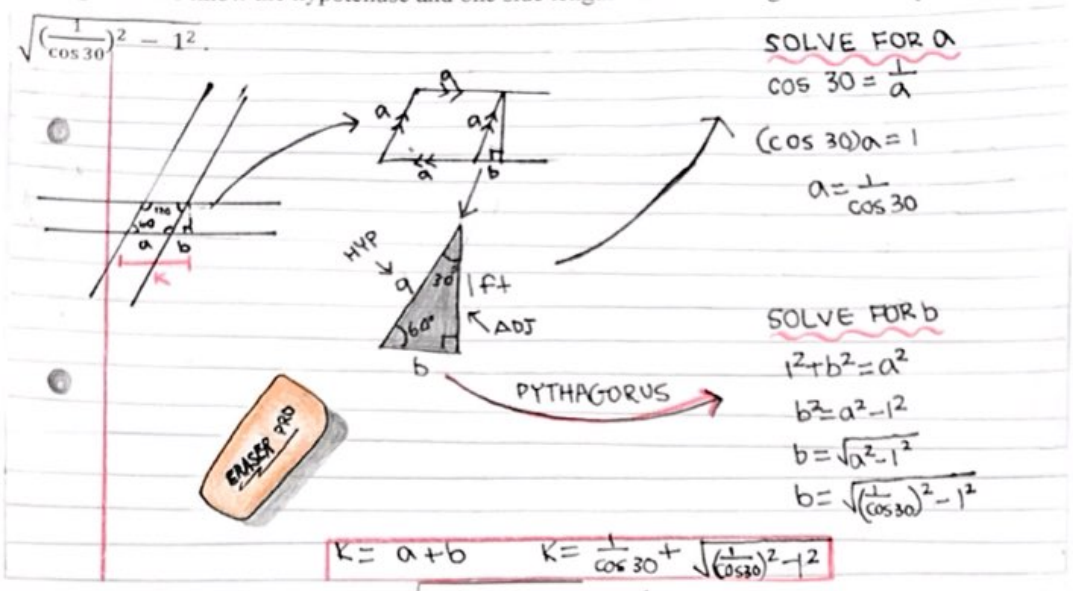


I decided to zoom up at the area near the points C and E. It seemed that to find the length of EF I just needed to subtract CB with two times the length labelled k. The angles of an equilateral triangle makes three sets of 60° which is useful for solving with trigonometry. Using my trigonometry knowledge of sine, cosine, and tangent, I could solve for the length of k as shown below.

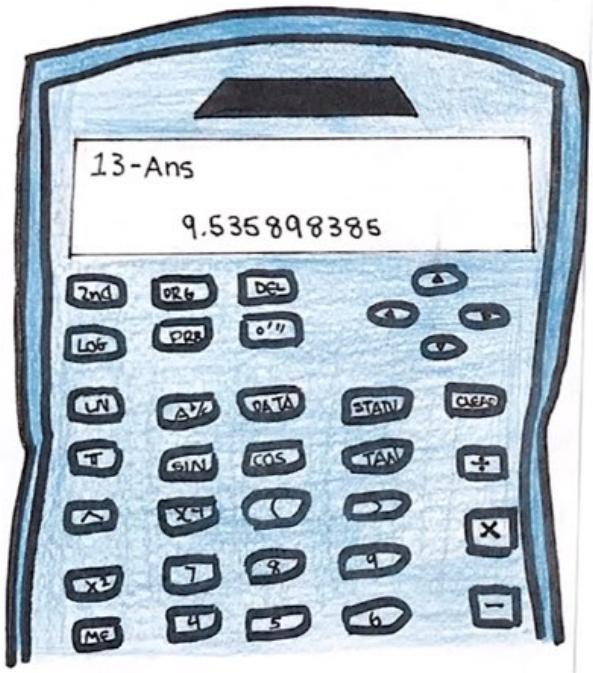




To solve for length k, I would need to find the lengths a and b by trigonometry. Using cosine, length a can be solved as the adjacent side of the triangle from the 30° angle is 1 ft and the hypotenuse (x) needs to be found. This gives the equation $\cos 30 = \frac{1}{x}$ so $x = \frac{1}{\cos 30}$. Solving for length b, simply uses Pythagoras. We know the hypotenuse and one side length—thus side length b would equal

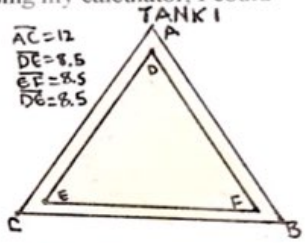


This means the length of k is $\sqrt{(\frac{1}{\cos 30})^2 - 1^2} + \frac{1}{\cos 30}$. We subtract the original side length of tank 1 which is 2k from 12. This gives the inner side length of the tank. However, we can use the length of k for all three tanks by simply subtracting 2k from 13 and 2k from 14. Using my calculator, I could solve for these and add them to my success table.



$K \approx 1.73$

$2K \approx 2.46$



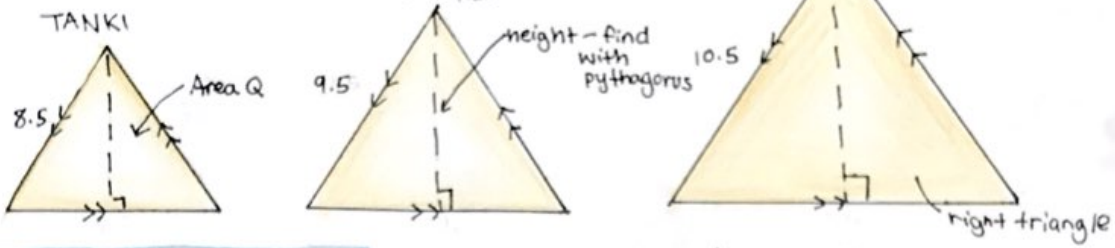
$12 - 2K = 8.5\text{ft} \rightarrow$ TANK 1

$13 - 2K = 9.5\text{ft} \rightarrow$ TANK 2

$14 - 2K = 10.5\text{ft} \rightarrow$ TANK 3

SUCCESS TABLE			
CRITERIA	TANK 1	TANK 2	TANK 3
INNER SIDE LENGTH	8.5 ft	9.5 ft	10.5 ft
Water Volume			
Water Temperature			

I took a five-minute break, almost forgetting there was a baby orca that needed to be placed in water—and quick. The workers were trying to haul the baby whale onto a crane to place her into one of the tanks, so I had to choose the best tank quick. Now that I had solved for test #1, I had to solve for test #2—Volume of water. Now that I knew the inner side lengths of each of the inner cross sections of the tank, I just had to find Area Q and multiply by 6 ft to get the volume. This would give an answer of ft^3 which I would convert to gallons.



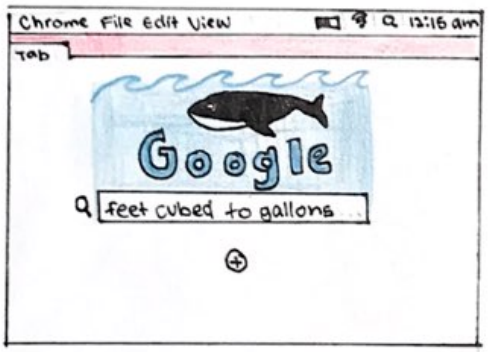
Area of Triangle = $\frac{base \times height}{2}$

base = 8.5
height = $\sqrt{8.5^2 - 4.25^2}$
Area = 31.3 ft^2
Volume = Area × 6 = 187.7 ft^3

base = 9.5
height = $\sqrt{9.5^2 - 4.75^2}$
Area = 39.1 ft^2
Volume = 234.5 ft^3

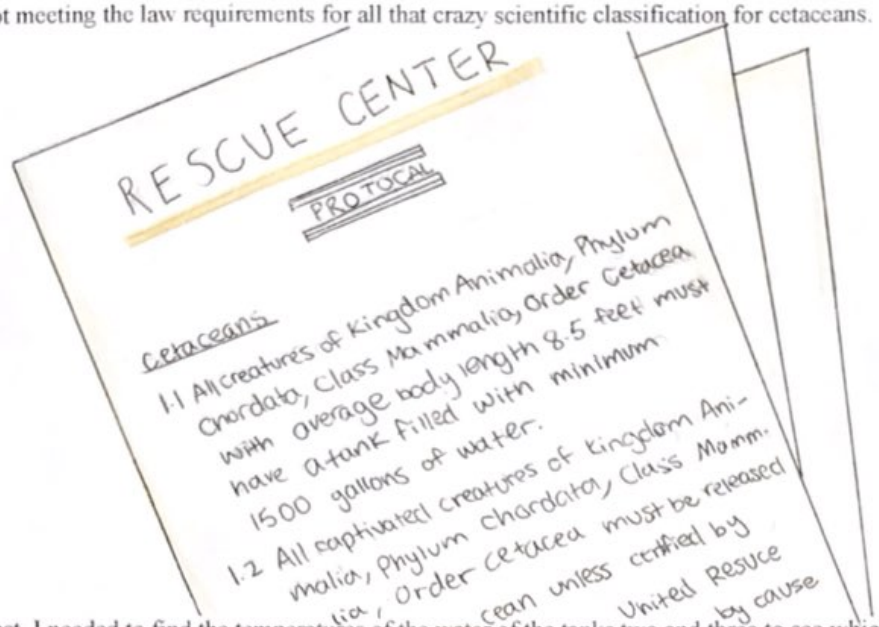
base = 10.5
height = $\sqrt{10.5^2 - 5.25^2}$
Area = 47.7 ft^2
Volume = 286.4 ft^3

Searching on the web for a unit converter, I searched feet cubed to gallons and got all of my results. I placed them into my success table. I only needed to find the temperature of the water and I would know which tank to put the orca in.

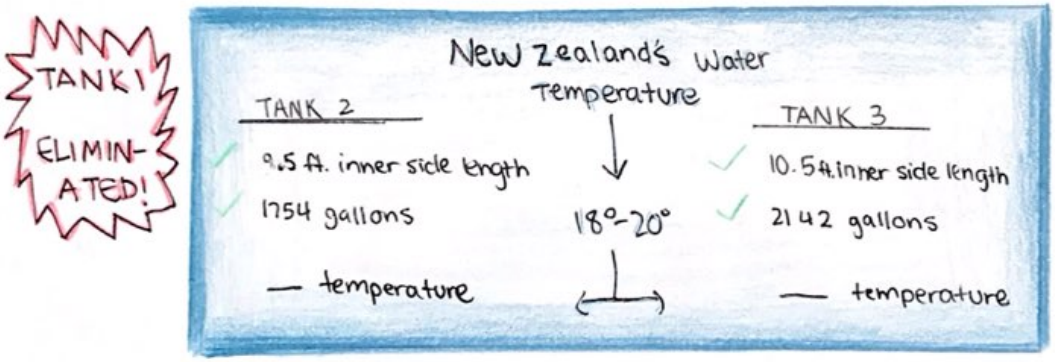


SUCCESS TABLE			
CRITERIA	TANK 1	TANK 2	TANK 3
Inner side length	8.5 ft	9.5 ft.	10.5 ft
Volume of Water	1404 gallons	1754 gallons	2142 gallons
Water Temperature			

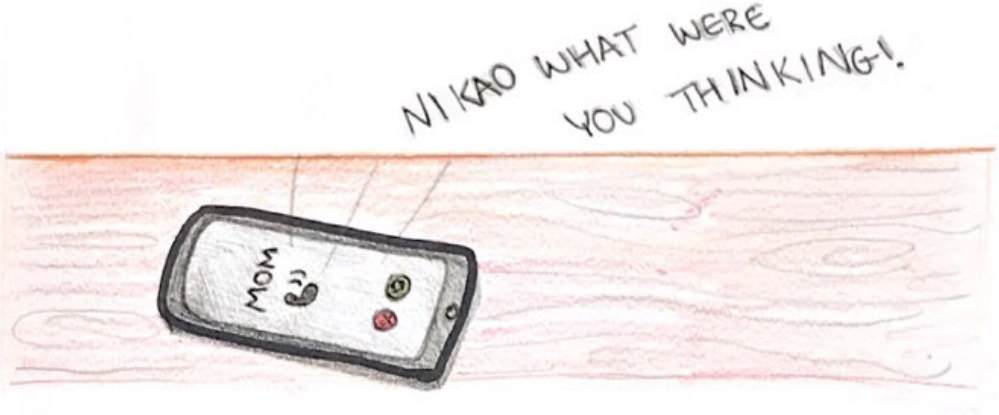
One worker, wearing a black suit, oversized safety goggles and holding a clipboard in his hand, paced towards me. He licked his finger as he turned a page on the clipboard and spoke, "According to this official document I have here, all creatures of Kingdom Animalia, Phylum Chordata, Class Mammalia, Order Cetacea with average body length of 8.5 feet must have a tank filled with minimum 1500 gallons of water." I smiled as this information had already eliminated tank number one, which contains 1404 gallons of water—not meeting the law requirements for all that crazy scientific classification for cetaceans.



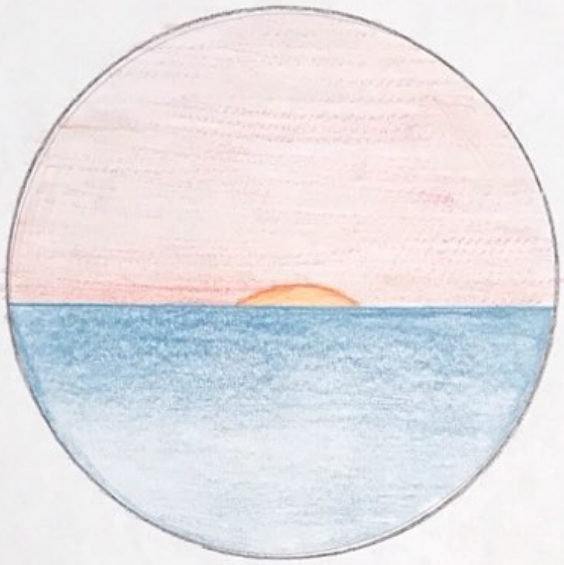
At last, I needed to find the temperatures of the water of the tanks two and three to see which tank best would match the temperature of that her previous water environment. That way we wouldn't shock the orca with cold temperatures or hot temperatures of water. The temperatures of New Zealand's waters range from 12 to 20° C and especially in this time of summer they range from 18° to 20° C. However, since orca blubber reaches almost 10 cm thick, they can withstand very cold temperatures. I grabbed a huge ladder and reached my way up to tank 2 and 3, using a thermometer to measure the temperature. I was shocked how hugely different the water temperature was.



The temperature of tank 2 was roughly 9° C while the temperature of tank 3 was 19° C—a whole ten degrees in difference. It was quite obvious to me now that tank 3 was the right tank to place her in as it was larger, had a closer water temperature to New Zealand's water, and did not violate the official document from the Rescue Center. I hollered out to the rescue team, "I've got it! Place her into Tank 3!" I was so exhausted from such an amount of math but also proud that I was able to find hidden math in a real-life situation using both Pythagoras and trigonometry to solve for it. It was then I got a phone call from my parents, saying "Where are you? Come back home this instant! Nikao, what were you thinking?"



When I got home, I found an entire party set up for me with thousands of balloons shaped as whales and a huge cake shaped as an orca. It was that day that I was claimed as the "whale hero" and I even was invited to work at the Rescue Center, training whales and bringing them back to health. The same time the following year, I heard a call from the ocean again saying, "Haere mai ki ahua." But this time when I strode out to the ocean's shore, I saw my whale, Nikao's whale, sailing out in the ocean and truthfully I had a couple tears rolling across my face as I whispered, "E te Atua Tangaroa, te atua o nga moana, kia ora", "God Tangaroa, god of the oceans, keep her safe."



Haere mai, Haere mai ki ahua