International Baccalaureate

Exploring The Effects That Harbors Have On Water Pollution

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Environmental Issue

As we continue to advance our technology further, we must consider the environmental impacts we make. Water pollution is one of these significant impacts that relate directly to our technology. Water pollution can be seen globally as most bodies of water have anthropogenic pollutants. Globally, we lose more human lives to water pollution than to war[1]. The most prevalent areas containing water pollution are generally ocean coastlines near heavily populated areas. These pollutants include but are not limited to nitrogen and phosphorus, heavy metals, persistent organic pollutants, microplastics, and oil and other petroleum products. They can come from all kinds of anthropogenic sources, including agriculture, sewage, radioactivity, etc. One way to measure the health of the water is by measuring the amount of phosphate, as phosphate is a leading factor in the harm to sea life. As someone who lives on the coast, I was interested in seeing our impact on ocean water quality.

Question

Do harbors contribute to the levels of phosphate on ocean coastlines?

Harbors are relatively common where I live, allowing me further to understand their implications on water health. By studying the harbors around me, I can infer that most harbors have similar impacts. Water pollution is a huge factor in destroying the habitats of many oceanic animals and plants. Studying our effects on the ocean up close will allow me to understand our impact on the environment further.

Since harbors have one of the largest amounts of human traffic on the coast, I decided to look at pollution levels there. Excessive phosphate levels can lead to an extreme increase in algae

[1] January 11, 2023 Melissa Denchak. “Water Pollution: Everything You Need to Know.” *NRDC*, 8 Feb. 2023, https://www.nrdc.org/stories/water-pollution-everything-you-need-know.

growth[2], which can be extremely harmful to sea life. While the boats don't produce the phosphates themselves, the increase in human activity does. Some examples of how these harbors may be impacted by the boats include extra agricultural runoff (due to an excess in waves from the boats), sewage dumping (likely from onboard bathroom systems), and cleaning products for the boats themselves[3].

Background Information

I chose to use phosphate testing kits made by Hanna Instruments[4]. They check for phosphates by using technology to scan water samples using an adaptation of the Standard Methods for the Examination of Water and Wastewater. Marine water is healthy as long as it stays below 0.1 ppm phosphate[5], and is known to be unacceptable at levels above 0.25 ppm[6].

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[2] "Phosphorous: Nutrients: Algal Blooms: Cynobacteria." *Mystic River Watershed Association*, https://mysticriver.org/phosphorus#:~:text=One%20of%20the%20primary%20impacts,cyanobacteria%20can%20cause%20additional%20problems.

[3] "What Is Phosphate?" *OCP Group*, https://www.ocpgroup.ma/what-is-phosphate#:~:text=How%20is%20phosphate%20formed%3F,matter%20on%20the%20ocean%20floor.

[4] "Phosphate Ultra Low Range Colorimeter – Checker® HC HI774." *Phosphate Ultra Low Range Colorimeter – Checker® HC HI774*, https://www.hannainst.com/phosphate-ultra-low-range-colorimeter-checkerr-hc-hi774.html.

[5] Hauter, Stan & Debbie. "How Do Phosphates Affect My Saltwater Aquarium?" *The Spruce Pets*, The Spruce Pets, 14 Jan. 2022, https://www.thesprucepets.com/phosphates-in-your-saltwater-aquarium-2924576.

[6] Professional Coral Solutions. "Why Reduce Phosphate?" *Professional Coral Solutions*, https://professionalcoralsolutions.com.au/pages/why-reduce-phosphate.

Hypothesis:

I hypothesize that phosphate levels are higher in harbors, proportionally related to the number of boats in the port. I can assume that the greater number of boats, the more phosphates there would be produced from human activity.

Safety & Ethics:

Throughout the course of my data collection, I ran into numerous safety and ethical considerations. While collecting data from certain harbors, I had to climb down rocks and other obstacles. In doing so, I was aware that that my actions could harm sea life, particularly in areas where there were plants and animals living on or under the rocks. To mitigate this risk, I was careful when climbing down to the ocean in order to not step on any organisms. Despite my careful efforts, I understand that I could have harmed certain organisms, and I take full responsibility for my actions.

In addition to the ethical considerations, there were also a few safety concerns. As mentioned above, some of the harbors required that I climb down some rocks or other barriers. This created a risk of injury, particularly because I was carrying water samples and other testing materials with me. Throughout the data collection process, I attempted to minimize these risks by being aware of my surroundings and as cautious as possible, but of course, there was still a chance of an accident occurring.

Justification of method:

To get samples that accurately reflect the phosphate levels in harbors, I needed to get as close to the actual boat docking area as possible. In some cases, I had to climb over rocks or walls to collect samples, but for the integrity of my research, it was necessary. I used trustworthy testing kits developed by the scientific brand, Hanna Instruments. The best (and potentially only) way to figure out the amount of boats the individual harbors held was to use satellite imaging taken by Google. Utilizing these images, I was able to compare the number of boats to the level of phosphates in the water. In doing so, I could see the direct impact the human activity had on phosphate pollution. All of this information helped me determine the overall impact our harbors have on the ocean.

Materials

- 1 Phosphate Ultra Low Range PPM Colorimeter HI774 Hanna Checker (including an AAA battery, 10 HI774-25 reagent refills, and 2 sample cuvettes)
- 25 Additional HI774-25 reagent refills
- 1 Plastic Cup
- 1 Plastic refilling pipette
- 1 Microfiber cloth

Procedure:

1. Place the AAA battery into the Hanna Checker device.
2. Travel to an ocean coastline that has as little run-off and human traffic as possible.
3. Use the plastic cup to gather as much water as possible.
4. Refer to the Hanna Checker tutorial or direction booklet for instructions on how to test the water[7].
5. Record the value displayed on the checker into the data table.
6. Repeat steps 3 through 5, 4 additional times.
7. Once you have 5 total values recorded in the data table for the testing location, calculate the average phosphate/ppm and record that value in the data table.
8. Use satellite imagery provided by Google Maps to estimate the amount of boats in the area of data collection. Record this value.
9. Travel to 4 different harbors, preferably as far away from each other as possible. For each harbor, repeat steps 3 through 8.

[7] HannaInc, director. *YouTube*, YouTube, 20 Nov. 2018, https://www.youtube.com/watch?v=Gt8UOr-0wxE. Accessed 4 Feb. 2023.

Raw Data:

The amount of Phosphate in PPM in different marine bodies of water.

	Test #1 (Phosphate /ppm)	Test #2 (Phosphate /ppm)	Test #3 (Phosphate /ppm)	Test #4 (Phosphate /ppm)	Test #5 (Phosphate /ppm)	Average (Phosphate /ppm)
Beacons (not a harbor)	0.08	0.05	0.05	0.07	0.07	0.064
Oceanside Harbor	0.18	0.21	0.20	0.23	0.22	0.208
Point Loma Harbor	0.28	0.24	0.22	0.26	0.25	0.25
San Diego Habor	0.16	0.18	0.22	0.21	0.23	0.20
Chula Vista Harbor	0.25	0.22	0.21	0.24	0.21	0.226

Processed Data:

Utilizing aerial images for each harbor, I was able to estimate how many boats each harbor holds:

Chula Vista[8] - 850

San Diego[9] - 448

Point Loma[10] - 2,115

Oceanside[11] - 916

Beacons[12] - 0

Boat to Average Phosphate (PPM) Ratio:

Chula Vista: 850/0.226 = 3761:1

San Diego: 448/0.20 = 2,240:1

Point Loma: 2,115/0.25 = 8,460:1

Oceanside: 916/0.208 = 4,403:1

Beacons: 0/0.064 = 0

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[8] https://www.google.com/maps/place/Chula+Vista+Harbor/@32.6225507,-117.1047479,821m/data=!3m1!1e3!4m5!3m4!1s0x80d94dc1e9a96183:0x3fc5b42400c64af5!8m2!3d32.6239433!4d-117.0983626

[9] https://www.google.com/maps/place/Seaport+Village/@32.7071594,-117.1679027,563m/data=!3m1!1e3!4m5!3m4!1s0x80d95354fd94ac8f:0x3e4c5c4163d7af44!8m2!3d32.7090645!4d-117.1709366

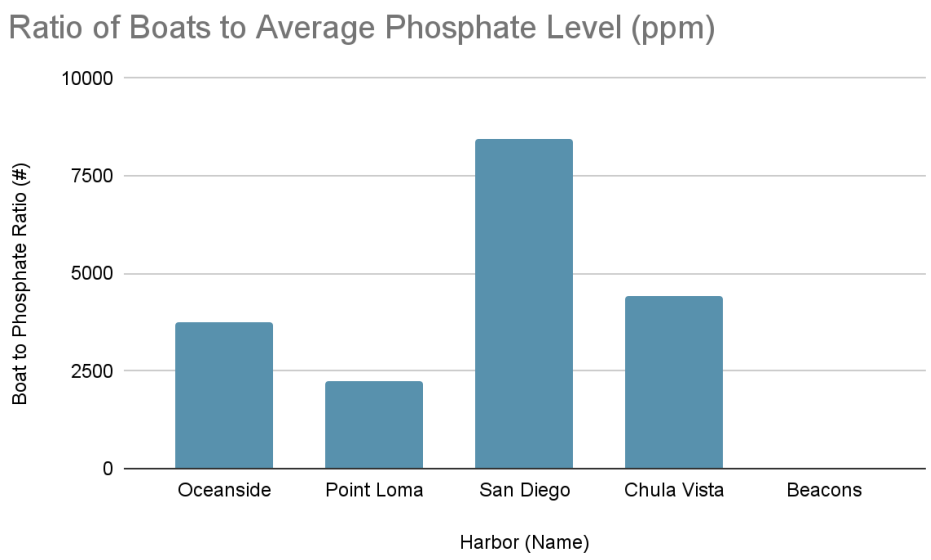
[10] https://www.google.com/maps/@32.7148536,-117.2373998,1238m/data=!3m1!1e3

[11] https://www.google.com/maps/place/Oceanside+Harbor/@33.2087588,-117.3971904,990m/data=!3m1!1e3!4m5!3m4!1s0x80dc6fb19686aa05:0x7050f08bd7351d4f!8m2!3d33.2078136!4d-117.3950394

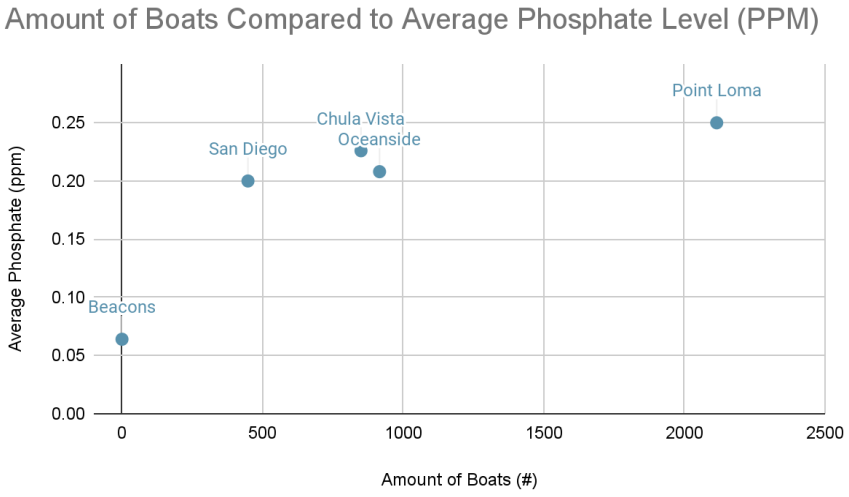
[12] https://www.google.com/maps/place/Leucadia+State+Beach+(Beacon's)/@33.0650681,-117.3068285,379m/data=!3m1!1e3!4m6!3m5!1s0x80dc0cfaee9df7b1:0x793cdc13b9fd3dd0!8m2!3d33.0651901!4d-117.3047175!16zL20vMDdfYzB5

Presented Data:

Graph 1:



Graph 2:



Conclusion:

As seen in graph 2, the number of boats almost had an exact correlation to the number of phosphates in the water. Although Chula Vista had less boats than Oceanside, but more phosphates, the overall trend seems to be that the more boats in the harbor, the more phosphates.

When looking at graph 1, we can see that the boats seem to really affect the phosphate level. San Diego Harbor recorded the least amount of phosphates, but since they also had a significantly lower amount of boats, they have by far the worst ratio.

After looking at the data in graph form, it appears my hypothesis was correct; phosphate levels are higher in harbors, proportionally related to the number of boats in the harbor. Again, this is due to the heavy increase in human activity, likely in relation to agricultural run-off and sewage dumping.

The amount of phosphates found in harbors is significantly greater than those found at a public beach and tends to be higher depending on the number of boats it holds.

It is generally observed that the concentration of phosphates rises with an increase in human activity in a given area, therefore providing an explanation for the elevated levels found in harbors.

Conclusion & Environmental Context:

While my data came out as expected, proving that harbors do harm the environment by indirectly producing excessive amounts of phosphate, it is important to note that I was using a very small sample size. I was only able to go to the harbors that were closest to me to test the water. To fully support my hypotheses, I would have to check a substantially larger number of harbors, but with time and cost constraints, it would be completely impossible. It can be assumed that these harbors represent harbors overall, but it can not be said for certain.

Evaluation

The main strength of my research included my accurate, first-hand data as I was able to not only collect it myself but also collect it numerous times to find an average. Rather than just finding data online, I was able to come up with trustworthy and accurate data that reflects my local area. Some weaknesses included my inability to attend more harbors and count the number of boats at the harbor at the time of testing. My sample size ended up being pretty small, and this was due mainly to time and cost restraints. If I were to support my research further, I would have visited more harbors, in different parts of the world. Another improvement that I would have made would have been flying a drone over the harbor to get a more accurate count of the boats, but again, due to time and cost constraints, this was not possible. In conclusion, my data is extremely accurate locally, but it is impossible to say if it would hold up at a more global level.

Application

One of the most significant reasons for an excess amount of phosphates in or near harbor water is due to the waves created by incoming and outgoing boats pulling more agricultural run-off into the area. Regulations of agricultural run-off vary state by state in the United States, and by country worldwide. My state has a program called Irrigated Lands Regulatory Program (ILRP)[13]. The ILRP seems to be extremely helpful for mainland farming, preventing pesticides and other toxic byproducts of agriculture from entering the ocean. Although to improve upon the program, I would suggest the solution of closely monitoring the agricultural chemicals used within a close radius to the ocean coastlines, especially harbors. If we were to ban the usage of

[13] Central Valley Regional Qater Quality Control Board. “Irrigated Lands Regulatory Program (ILRP).” *Irrigated Lands Regulatory Program | Central Valley Regional Water Quality Control Board*, https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/.

pesticides and other chemicals near harbors, we would see a large decrease in phosphate levels as the waves would end up pulling less toxic substances into the water. Some strengths of this solution include that the implementation of the policy would likely be swift as it would not drastically change preexisting land practices, it would boost the overall health of the water, and would also likely benefit air quality and the exposure to toxic chemicals for nearby workers and animals. Some weaknesses of the solution include that there may be public pushback from certain companies who rely on the use of pesticides, it may increase the use of other toxic chemical substitutions, and it would likely be hard to monitor. Some limitations may include that there would be no cost-effective alternatives to the toxic chemicals and it would likely require collaboration to maintain between different cities/states/countries.

In conclusion, the use of this solution would help to mitigate the harmful effects of agricultural run-off to sea life. While there are some weaknesses and limitations, the end goal of having significantly healthier water near the ocean coastlines would heavily outweigh them. The weaknesses and limitations mainly rely on public change, so it really is entirely possible for the solution to succeed, if enough people worked together to implement it.

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117.1679027,563m/data=!3m1!1e3!4m5!3m4!1s0x80d95354fd94ac8f:0x3e4c5c4163d7af44!8m2!3d32.7090645!4d-117.1709366.

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