How Local Pollutants Affect Coral Reefs in Kaneohe Bay, Oahu

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Abstract:
Coral reef ecosystems are responsible for absorbing one third of the carbon dioxide in our atmosphere as well as releasing 50% of our oxygen. Coral reefs provide nursery habitats for marine fishes, create income for coastal communities, and even protect our coastlines from erosion and hazardous weather. What actually is a coral reef? Corals are colonial animals. There are two types of corals, hard and soft corals. Hard corals separate calcium ions from the seawater and move them into a calcifying space between the polyp and its calcareous skeleton, and this is how reefs are formed. These calcareous skeletons build massive reefs that provide habitat for a large number of species. Soft corals do not create a calcareous skeleton and therefore cannot form a reef, however they are still present in reef ecosystems. Sadly, our reefs are in danger because of human activities along the coast ("What are Corals?"). In particular, the coral reefs in Kaneohe Bay, Oahu are suffering immensely from local pollutants that are creating harmful algal blooms and wiping out species from the bay. Kaneohe Bay is on the northeastern shore of Oahu. The bay is about 12.8 km long and has an area of 56.7 km^2. Kaneohe Bay reefs are important because they help protect the Oahu coastline, support local economies, and create an ecosystem with a high biodiversity. Since the 1900s, Kaneohe Bays' reefs have experienced dredging, bleaching, sewage spills, invasive species and more that are destroying the ecosystem. Each of these issues is caused by humans living along the coastline, and can easily be prevented to create a safer environment in the bay for the reef to be able to thrive. This paper looks at the local pollution in Kaneohe Bay that causes detrimental impacts on the coral reef ecosystem such as species extinctions, harmful algae blooms, coral bleaching, and much more.

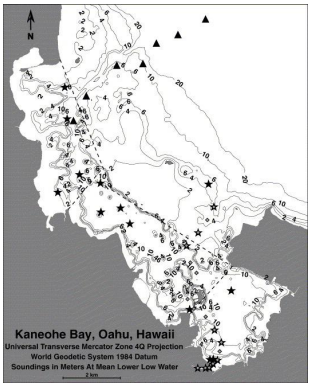
Introduction:
Coral reef ecosystems go way beyond what we can see. The species you are familiar with, the corals and fish, are the basis of the ecosystem, but there are many more factors that contribute to the well-being of the reef. Corals are animals in the phylum Cnidaria. Corals are unique because they don't have internal organs. Most corals are colonial organisms meaning they are composed of hundreds of individual polyps that are mounted on a calcareous skeleton. There are two types of corals, hard and soft corals. Hard corals separate calcium ions from the seawater and move them into a calcifying space between the polyp and its calcareous skeleton, and this is how reefs are formed. Soft corals do not create a calcareous skeleton and therefore cannot create a reef, however they are still present in reef ecosystems. ("What are Corals?"). The biology of a polyp is simple, there is a stomach that has only one opening to eat and expel waste, as well as tentacles that surround this opening. On the tentacles there are stinging cells called nematocysts that are used to paralyze their prey, which can be microscopic plankton to small fish. These tentacles can also be used to defend themselves from predators. (Turner, Joseph)
Corals form a variety of relationships with organisms in their ecosystem, such as a mutualistic relationship. A mutualistic relationship is when two organisms in an ecosystem benefit from their relationship. Corals form a mutualistic relationship with an algae called zooxanthellae. The zooxanthellae live inside the coral and gain protection from predators while still having access to the sunlight and elements needed for photosynthesis. In return for giving the zooxanthellae habitat, the corals receive 90% of the nutrients produced from the algae's photosynthesis. The corals use these nutrients to build their own proteins, fats, and carbohydrates to survive. This

type of relationship is obligate mutualism, which means that the organisms wouldn't be able to survive without each other. (citation needed about zooxanthellae) Coral reef ecosystems are home to many different species and host a wide variety of biodiversity which allows for more relationships to form.

Another example of a mutualistic relationship occurs between sea anemones and clownfish. Sea anemones are another organism in the phylum Cnidaria and share similar traits with the corals such as their stinging cells. Clownfish have a layer of mucus to protect themselves from the sting of the anemone, and so they are able to live within their tentacles and have full protection from any other species. The anemone gains easier hunting by either eating the leftovers from the clownfish or eating fish that are lured to them by the clownfish.

A different kind of relationship in coral reefs is mimicry. A species will evolve to look like a larger or poisonous species to avoid predation. The four-eye butterflyfish is a fish that can be found in the Pacific Ocean on Hawaiian reefs. This fish evolved to have a large eye spot on its tail to appear larger to predators ("Symbiotic Relationships in Coral Reef Ecosystems"). Many other fish and eels have adapted to protect themselves through mimicry as well.

Coral reefs' impact goes beyond just their relationships. Corals provide many fundamental aspects of life for marine species, including habitat for 25 percent of fish. The coral reefs on the Northwest Hawaiian islands give shelter, nursery habitats, food sources, and breeding grounds to over 7,000 species. Not only do coral reefs protect thousands of marine species, the reefs also protect our coastlines and provide food or income for half a billion people. The reefs are part of cultures and drive tourism to support small businesses and teach people more about how to help the reefs. However, these important reefs are in extreme danger from human activities, especially Kaneohe bay in Oahu.



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Kaneohe Bay is on the northeastern shore of Oahu and has survived multiple forms of local pollution. The bay is about 12.8 km long and has an area of 56.7 km^2. Since the 1900s, Kaneohe Bay reefs have experienced dredging, bleaching, sewage spills, invasive species, and more. So, how do local pollutants affect coral reef ecosystems in Kaneohe Bay?

Dredging:

An example of local pollution in the Kaneohe Bay is dredging. Dredging is the excavation of sediments from the bottom of a body of water. In Kaneohe Bay, dredging was limited to boat landings and piers until 1939 when the Kaneohe Bay naval air station was built and needed dredging to clear space. Another example of dredging in Kaneohe Bay is building ship channels. There were multiple channels present, however, a deeper channel was dredged across the entire bay and another was dug all the way to the ocean. As well as creating new channels,

companies used dredging to deepen already existing channels like the Sampan channel that became 2.4 m deep and the Mokoli'i passage at 7.6 m. During the time from 1939 when dredging was permitted to 1991, 5% of the coral reefs were killed. Corals in the South Bay still haven't been able to recover (Bahr, Keisha D).

Sedimentation:

Dredging isn't the only pollution affecting Kaneohe Bay; the seafloor that is being removed is then left in other parts of the bay to create sedimentation. From 1940-1950 the human population in Kaneohe Bay increased by 130 percent, and in 1950-60 the population increased by 190 percent. The increase in population lead to an increase in human activity. Dredging alone accounts for 70 percent of the sedimentation in Kaneohe Bay. The other 30 percent is due to terrestrial runoff and because of farming near the coastline, the soil is especially nutrient rich. Terrestrial runoff provides the ecosystem with excess nutrients which causes harmful algae to bloom and create anoxic conditions. Anoxic conditions are when the water no longer has a sufficient amount of oxygen which kills off coral and fish species (Bahr, Keisha D).

Sewage Outfalls:

Excess nutrients can also enter Kaneohe Bay through sewage outfalls which became a major problem in the 1960s. Before 1963 minimal sewage waste was found in Kaneohe Bay which originated from private septic tanks along the coast. However, in the fall of 1963, a treatment plant was built with an outfall 8 m deep in Kaneohe Bay. Another outfall was put in after the construction of the marine corps air station and another was put in the North Bay in 1970. With all of the waste in the water, excess nitrogen and phosphorus were introduced to the ecosystem which created eutrophic conditions. These conditions gave opportunity for phytoplankton and benthos to thrive off of the inorganic material which created an increase of detritivorous, heterotrophic biomass. The biomass limited light penetration in the bay and prevented photosynthesis which killed corals and healthy algae (Smith, Stephen V). A native algae to Kaneohe Bay called *Dictyosphaeria* also began to grow rapidly during this time and was abundant until the 1990s. The reason for the algae's decline in 2006 was due to 42 days of rain and no sun to promote growth via photosynthesis. Finally after 20 years of sewage discharge into the Kaneohe Bay, the outfalls were removed. Although the reefs have not fully recovered, removing this pollutant has improved reef growth significantly (Bahr, Keisha D).

Fishing:

Humans can also directly affect the reef ecosystem through fishing. Kaneohe Bay is home to many multi-species fisheries that have significantly lower yields compared to other bays around Oahu. One study compared Kaneohe Bay and a similar bay in size called Hanalei on the island of Kauai. In 1991 in Kaneohe Bay, active fishing was measured to be 2.5 times more popular than active fishing in Hanalei. Line and hook fishing contributed to 55% of active fishing methods in Kaneohe Bay, while gill nets accounted for the majority of passive methods. These two methods add to 36,000 hours worth of fishing each year, which shows how common fishing was in Kaneohe Bay. The catch per unit of effort (CPUE) measurements were taken in the bay for each passive method in which surround nets had the highest rates of 155 kg/effort-hour in 1992, which were significantly higher than those of Hanalei. In total, Kaneohe Bay had over 300% more annual harvest than Hanalei: the bay produced 63,958 kg of fish for the local fisheries (Friedlander, Alan M). These large statistics show how many kilograms of fish were removed from the ecosystem each year; this can disrupt the ecosystem severely. Due to the extreme fishing, Kaneohe Bay lost all fish in 1992 from a 1500 m^2 reef. The scarce amount of young fish that remained here took 2 years to repopulate and restore the trophic structure on the

reef. Similar events occurred across the bay and continue to happen because fishing conditions still have not changed (Bahr, Keisha D).

Conclusion:

With all of the unique organisms and important relationships that contribute to the wellbeing of a reef, it is a sensitive ecosystem. In coral reefs like Kaneohe Bay, human activities are killing the ecosystem, and although the reefs are resilient, some areas of the bay have not recovered. As the human population continues to grow specifically in Oahu, pollution continues to be on the rise. As a community it is vital to stop using toxic chemicals on farms, creating new outfalls, and limiting human activity in Kaneohe Bay. For the sake of our planet, and for the sake of our oceans, stop pollution.

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