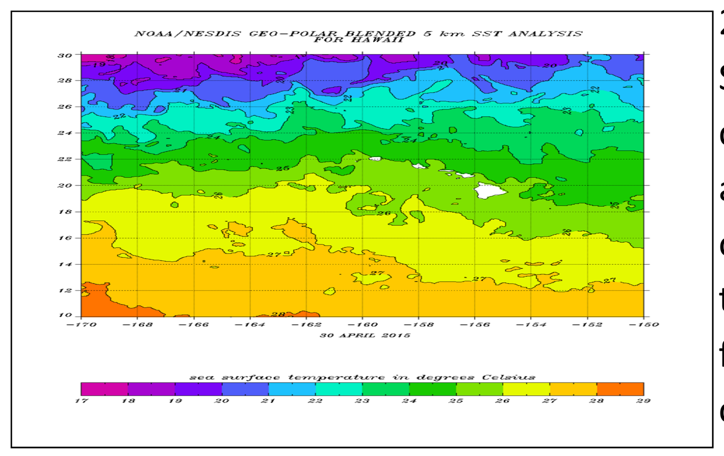
Rainforests of the Ocean:

The Effects of Inland Erosion on Coral Reefs in Oahu, Hawaii

Abstract

Coral reefs are the tropical rain forest of the ocean. The species' niche provides habitats for a variety of tropical fish and mammals. Only covering 2% of the ocean floor, corals host 25% of marine life (Wheeling Jesuit University). Towards the bottom of the food chain, these heterotrophs are the oldest living organisms on the planet (Kemp 2014). Single celled algae occupy the food chain's bottom. All corals have a symbiotic relationship with these algae. Zooxanthellae, a specific coral alga, produce glucose for both organisms. Corals safeguard zooxanthellae from predation. Zooxanthellae require visible light to photosynthesize.

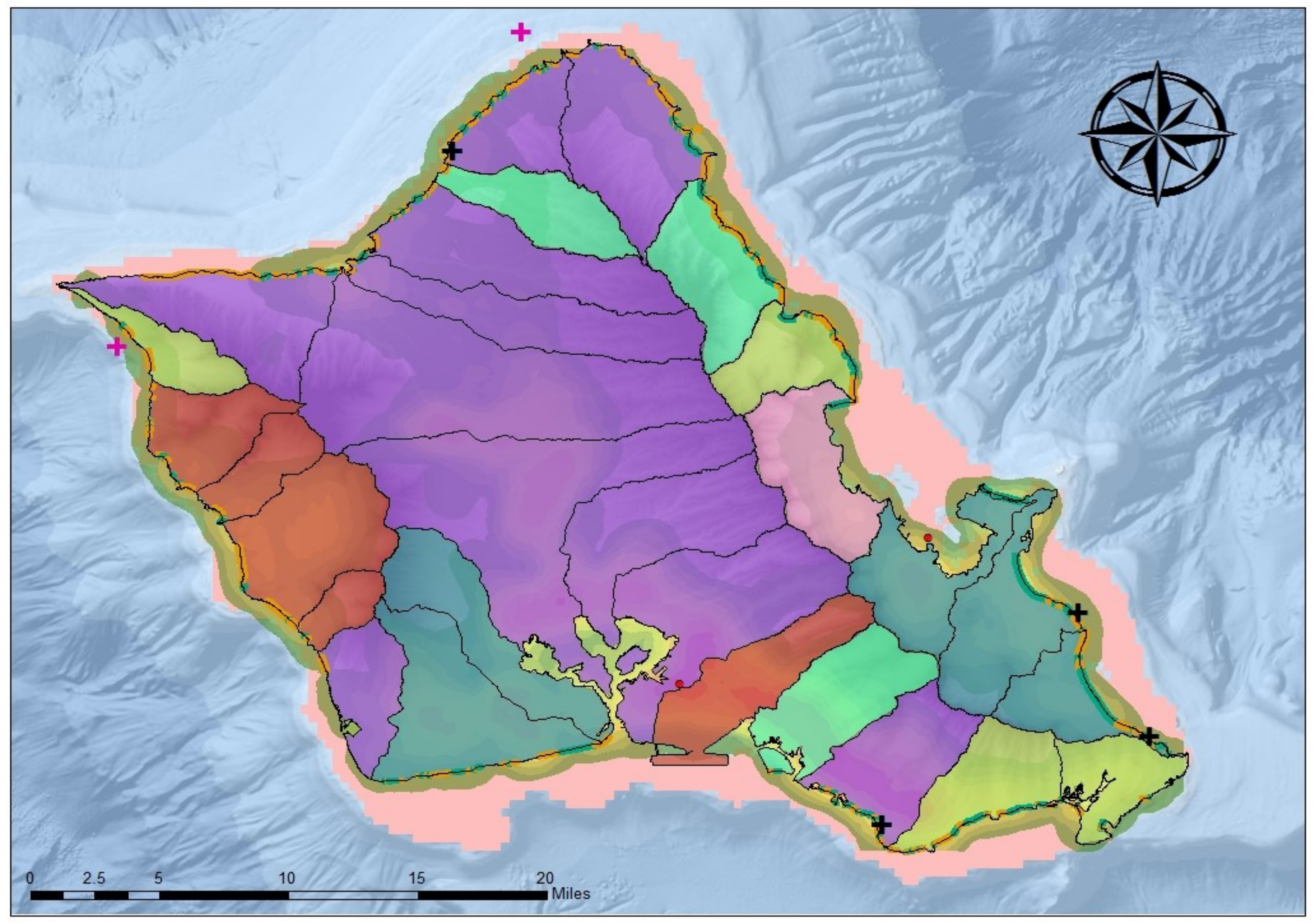


Map 1. Contour average ocean surface temperature (°C) in April 2015 around the Hawaiian Islands (OSPO).

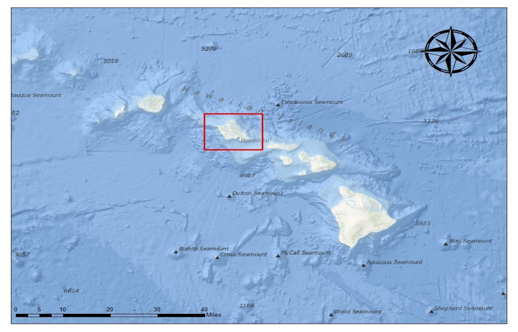
The reefs' optimal depth is less than 70 meters (NOAA), any deeper and visible light cannot breach deeper bathymetry. Like any terrestrial environment, reefs have specific temperature range of 21-29 °C (NOAA.). Corals habitat salt water, and most need salinity higher than 32ppm (Kemp 2014). Corals specialized in certain environments are more affected from outside influences. The influences can be global including ocean acidification from rise in CO_2; however, determinants can also be specific to the corals' global location.

In Oahu, Hawaii, the island possesses inland and coastal erosion. The erosion is mostly dependent on water runoff (Ridge 2015). Runoff rates differ based on bedrock, land use, and road coverage (Ridge 2015). The bedrock consists of volcanic and sedimentary rock layers. The different layers means there will be different rates of erosion. Increasing erosion in the area will increase the local turbidity. Turbidity determines the amount of available sunlight in the Neritic Province. Changing the turbidity can affect the amount of zooxanthellae photosynthesis. The purpose of this exercise is to demonstrate the relationship between erosion and the threat it has towards coral reefs.

Results



Map 10. Result map displaying the relation between erosion from erosion and coral reefs in Oahu, HI.



Map 11. Inset map of Oahu relative to other Hawaiian Islands.

The relation between bedrock, annual rainfall, and ground permeability varies throughout Oahu, Hawaii. Eleven watersheds contained igneous rocks with high permeability and little rainfall (Map 10). The high permeability means more water will infiltrate the water table and not affect surface erosion. These areas will have lower levels of erosion because of decreased permeability and igneous rock type (higher resistance). Road coverage shows a higher density towards the south and central part of the island (Map 10). The ground being overlain with a higher road density means there will be more runoff. The man-made roads will increase run off, but will not change erosion rates of predominant rock type. Absences of coral reefs occur around the eastern bay and southern tip (Map 10). These areas contain different rock types (Map 10). Having the same permeability and annual rainfall means there could be a positive correlation between the infiltration of groundwater and amount of rain fall.

Conclusion

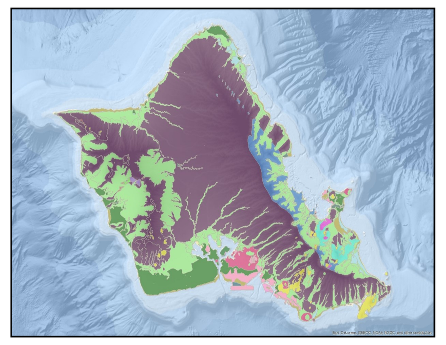
The relationship between turbidity and erosion is positive because to decrease visibility, solutes need to come from preexisting rock material. Having sedimentary rock and igneous rocks in Oahu means there are different rates of erosion. Igneous rocks formed from volcanic activity have high bond energies. Sedimentary rocks are caused by preexisting rock compressing and compacting. Sedimentary rocks are more prone to weathering and erosion based on their chemical composition and atomic bond strength. This means the watershed with sedimentary rock will have higher erosion rates.

The moderate permeability means the water is not completely infiltrating the groundwater. The less permeable the bedrock, the more runoff will occur. More runoff means higher erosion rates. Runoff is determined by amount of precipitation in each watershed. Low precipitation amounts in Oahu, Hawaii are still substantial (~20 inches). However the higher rainfall amount means more ability to runoff. In the Oahu rainforest preservation annual rainfall equals ~278 inches. Only 1 watershed fits into the model of sedimentary rock and moderate permeability. The location of the watershed is within preservation limits; thus, the rainfall will be more than the zonal statistic. The statistic was wrong because it does not include that water from higher elevations (the preservation) will flow to lower elevations.

The eastern bay could be affected from turbidity factors based on the erosion determinants. The watershed will have high rates of erosion which will cause higher turbidity to the bay. Turbidity, the ability for light to penetrate the upper ocean zone, is a factor to the quality of life for corals and algae. Coral bleaching has been observed as a high severity in the bay. Bleaching is caused by algae no longer able to survive within the environment and leaving their host coral. No longer able to photosynthesize the algae abandon the coral. The corals can no longer survive and slowly perish from lack of glucose.

At the south-eastern point of the island, no corals live within a range of about 5 miles. The preexisting rock consists of igneous rock which has a low erosion rate, moderate permeability, and little rainfall. Even though this area does not fit with the model, there are some hypotheses as to why no corals live in this area. One hypothesis is an igneous event overlaid the coral habitat. To test this hypothesis, a core sample could be taken to view the cross section layering. If there is a coral layer, then a correlation between an increase inland erosion and a decline in coral reefs. To validate the correlation, other factors of coral reduction should be tested.

Experimental Methods



Map 2. Underlying bedrock based upon specific rock type in Oahu, HI.

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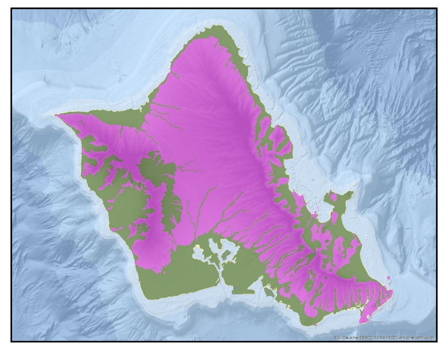
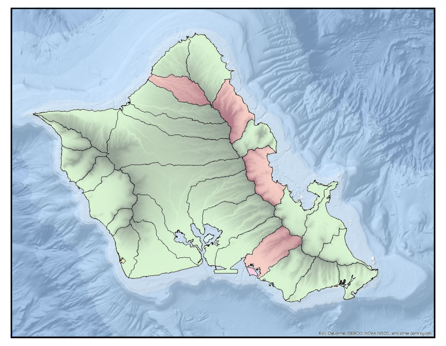


Map 3. Bedrock simplified into general rock types in Oahu, HI.



Map 3. Annual rainfall intensity in each watershed in Oahu, HI.

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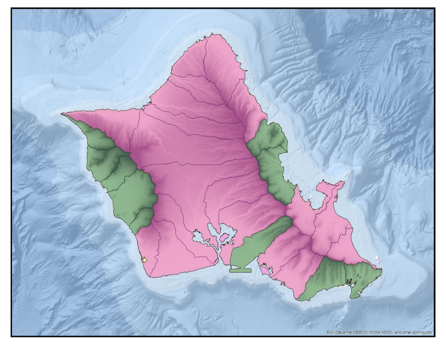

Map 4. Level of permeability in individual watersheds in Oahu, HI.

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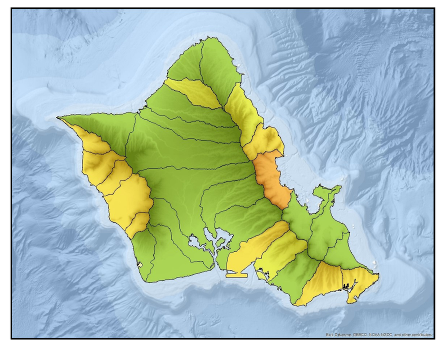
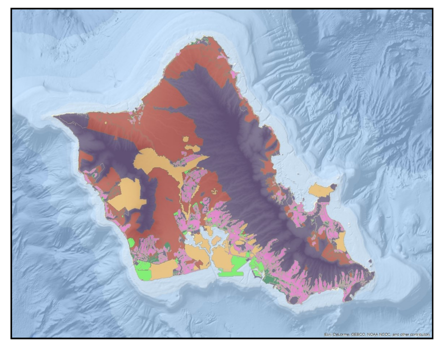


Map 6. Different permeability and rainfall by watersheds in Oahu, HI.



Map 7. Generalized zoning map of Oahu, HI.

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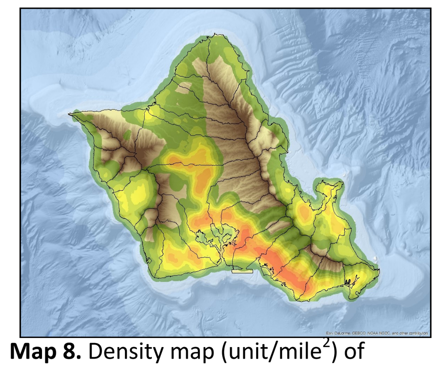

Map 8. Density map (unit/mile^2) of roads in Oahu, HI.

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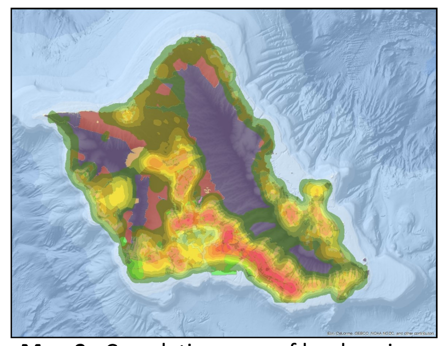

Map 9. Correlation map of land zoning and road density in Oahu, HI.

World Ocean's bathymetry map was clipped to only the island of Oahu, Hawaii. Clipped geology shape file of Oahu had generalized rock types to display sedimentary and igneous (Map 3). New class developed from igneous or sedimentary quality. The bedrock rastered as igneous rock equaling 1 and sedimentary rock equal 2 (Map 3). Zonal statistics used with rastered, generalized bedrock with input feature as the watersheds. The precipitation polygon reclassified into 5 equal interval classes. The units then underwent zonal statistics with watersheds as the input feature (Map 4). The clipped permeability shape file converted to a raster. Permeability raster reclassified into 5 equal interval classes. Zonal statistics underwent with the permeability raster, continuing to use the watershed as the input feature (Map 5). Both raster converted back to polygon shape files. The zonal maps merged to display watersheds of different annual rainfall and different levels of permeability (Map 6). Line density tool used on Oahu roads (Map 8). The zoning map of Oahu generalized to preservation, agriculture, residential, business, federal, and industrial (Map 7). The maps were overlain to show the positive correlation between land zoning and road density (Map 9). The coastal erosion classified with 2 breaks (positive and negative) to indicate erosion and accumulation.

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