Observation of the Effects of Rainfall on the Santa Monica Beach and its Assorted Living and Non-Living Constituents

Student Example (7th Grade Student)
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Abstract:

The purpose of this investigation was to find out if rainfall and winter storms affect the state of the water, shore, and sky at Santa Monica Beach, and the living and non-living things there. This study was conducted on the beach in Santa Monica, California, at Lifeguard Station 26 near Ocean Park Boulevard. The study took place on seven data collection days, once each month from October 2006 to April 2007, from 08:50 to 09:20 on each data collection day. It was found that rainfall was very light during this seven month period, proven by the fact that February, the month with the highest amount of rainfall, had less than half an inch accumulate over the month, and both October and April were times of no rain at all. It was found that the beach sand took on its steepest slope during February, a drop of about 0.02082 meters for every 5 meters across, and its flattest in December, when the drop was only about 0.01411 meters for every 5 meters distanced. Lastly, it was also found that Western Gulls were the species of marine birds seen most, Pacific Bottlenose Dolphins the species of marine mammals, Surf/Eel Grass was seen the most of the marine plant debris, Bean Clams most of the marine animal debris, and lastly, Styrofoam most for non-ocean debris. From this observation, it was concluded that rainfall and winter storms affected the slope of the beach, for, as stated above, February had the most rain and the steepest slope. However, it was also concluded from the data, especially because each month had such insignificant rainfall, that it would be very hard to tell if any of the beach's different species or debris' presence was affected by the rainfall. Still, it did seem that very commonly, more beach plants, animals, and debris were seen in the fall and spring months.

Introduction:

A beach is a long area of sand, gravel, or other sediment that stretches from a cliff or area of permanent vegetation seaward to the low-water line. When winds blow across the ocean, transferring their energy into the water, a wave is formed. Waves cause both erosion, the process of breaking rock into sediment and then carrying the sediment away, and deposition, the process by which sediment settles out of the water or wind that is carrying it into a new location. A wave starts the erosion process when it strikes a rocky shoreline. Over time, the waves carve the shoreline into cliffs and arches, and grind rocks into sand and small pebbles, causing wide, sandy beaches to form. As waves continue to wash up on the shore, they wash away sand or bring new sand to the beach, which slowly and continually moves the shoreline inward. Waves affect the shore through erosion and deposition by creating, shaping, and daily changing the beaches. Different factors affect the amount of erosion and deposition, such as the size of a wave, the strength of a longshore current, the size of sediment, and the steepness of the slope. Waves with higher energy and a lower wavelength cause more erosion and deposition, and vice versa for smaller waves. The strength of a longshore current can affect how much sand it carries with it down a beach, and how far the sand travels. Strong longshore currents carry more sand greater distances. Also, large grains of sediment absorb more water into the gaps between each grain,

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preventing some of the waves' erosion, but small grains of sediment allow enough erosion that the amount of sediment eroded will be almost equal to the amount deposited, so the slope of the beach is flat. Conversely, when the slope is steep, gravity then helps pull more water and sediment down, causing the slope to erode until it flattens out, causing the amount of erosion and deposition to be the same once more, and the cycle repeats.

Marine animal debris, marine plant debris, and non-living debris, also called non-oceanic debris, can all be found on the beach in the Santa Monica Basin. The most debris is found after heavy rains, and at low tide. Marine plant and animal debris come from the deposition of uprush waves and rains, but non-ocean debris come from street gutters that feed to the ocean, visitors to the beach who litter, and boats or ships dumping their waste into the ocean. Non-ocean debris can have a lot of negative effects on marine and beach ecosystems. For example, fishing lines, soda can six-pack rings, and similar items can trap marine animals, preventing them from eating, breathing, or swimming. Secondly, marine animals can mistake debris for food, eat the debris, feel falsely full, and then die of starvation, and thirdly, broken pieces of glass, metal, or plastic left on the beach can injure any animal on the beach, including humans.

The most common species of marine birds found in the Santa Monica Basin are the sanderling (Califris alba), willets (Catoparophorus semipalmatus), and the western gull (Larus occidentalis). A sanderling's diet usually consists of insects, spiders, and vegetation, while willets will eat mollusks, crustaceans, insects, and small fish. Western gulls feed on clams, crabs, sea urchins, young birds, small vertebrates, and carrion. Sanderlings in North America are migratory; they spend their winters anywhere on the Pacific coast of the United States, and breed in the summer in northern Canada, west of Greenland. Willets in North America can be found year-round on the south Atlantic and Gulf coasts of the United States, but some spend their summers in an area that stretches from central Canada to northeast California, and their winters along Pacific coasts from Oregon moving south. Western gulls are not migratory; they live year-round along the west coasts of the United States and Baja California.

The most common species of marine mammals found in the Santa Monica Basin are the California Sea Lion (Zalophus californianus) and the Pacific Bottlenose Dolphin (Tursiops truncates gilli). The California Sea Lion feeds on fish and cephalopods, and do not migrate from where they live along North America's west coast. The Pacific Bottlenose Dolphin eats a variety of fish, squid, shrimp, and crabs, and lives year-round along the Pacific Coast from southern California to the tropics.

The purpose of this investigation was to find out if rainfall and winter storms affect the state of the water, shore, and sky at Santa Monica Beach, and the living and non-living things there. It was predicted that rainfall and winter storms would cause a decline in the number of marine birds and marine mammals seen during the winter months because of the cold and moisture at the beach. It was also predicted that fewer marine birds and marine mammals would be seen in the fall months and more marine birds and marine mammals would be seen in the spring months. It was predicted that rainfall and winter storms would cause an increase in the amount of marine plant and animal debris seen during the winter months because stronger waves would wash more debris onto the sand. It was also predicted that less marine plant and animal debris would be seen in the fall months and more marine plant and animal debris would be seen in the spring months. It was predicted that rainfall and winter storms would cause an increase in the amount of non-ocean debris seen during the winter months because stronger waves would wash more debris onto the sand and more debris would be washed down drains to the ocean by rains. It was also predicted that the same amount of non-ocean debris would be seen in the fall months as the spring months. It was predicted that rainfall and winter storms would cause the slope of the beach to get steeper because storms bring stronger, bigger waves to wash away the sand. It was also predicted that the beach slope would be flatter during the fall months and steeper during the spring months.

Materials/Methods:

This study was conducted on the beach in Santa Monica, California, at Lifeguard Station 26 near Ocean Park Boulevard. The study took place on seven data collection days, once each month from October 2006 to April 2007, from 08:50 to 09:20 on each data collection day. The survey area was located between Lifeguard Stations 25 and 26, and consisted of three observation stations for collecting data. The Beach Observation Station stretched over most of the study area. The Atmospheric Data Station was located close to Lifeguard Tower 26, a bit east of the Beach Observation Station, and the Beach Profile Station was located just south of Lifeguard Station 26, ten meters from a pole near the tower, and extended from this baseline to the waterline. These locations are shown in the figures below.

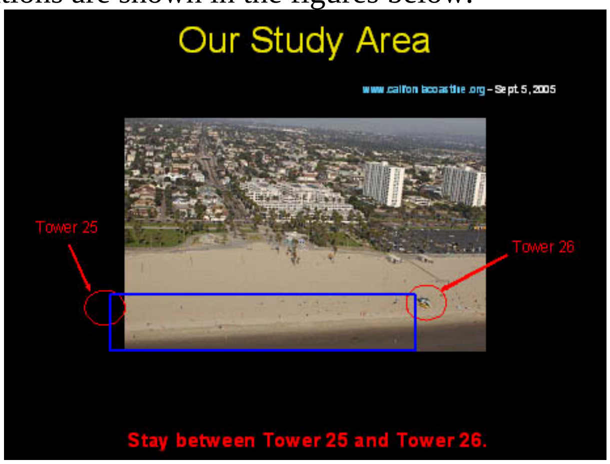

Figure 1: This is a photograph of Santa Monica Beach at Ocean Park Boulevard. Highlighted in red and blue are the lifeguard towers and area of observation for the students. (February 20, 2007/ <http://www.waterkid.net/projects/ocean_globe/OG_images.htm>)

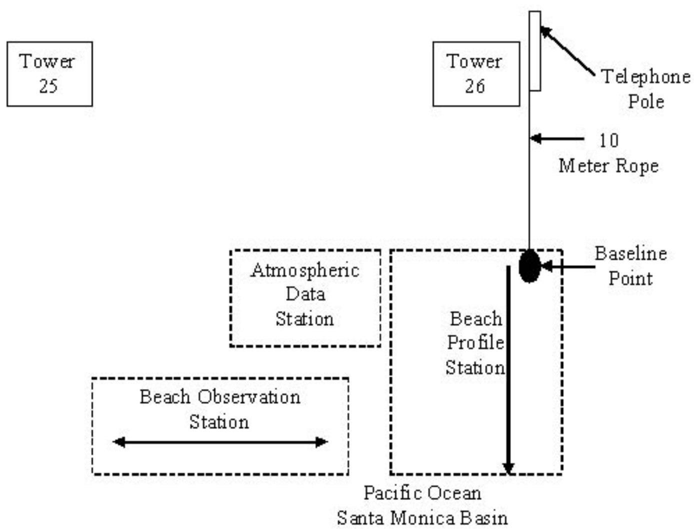

Figure 2: This is a diagram of the observation area along the beach. Sizes of stations and area between lifeguard towers are not drawn to scale.
(February 20, 2007/ <http://www.waterkid.net/projects/ocean_globe/OG_images.htm>)

At the Atmospheric Data Station, data for the air temperature, percentage of cloud covering, maximum wave height, sea state, wind speed, and wind direction were recorded. To find the air temperature in degrees Celsius, and the wind speed in knots, students used the Kestrel 3000 Anemometer. To find the cloud coverage percentage, the observer looked at the sky 360 degrees around him or her and estimated cloud cover to the nearest five percent. Students would also record the maximum wave height, which was found when the observer stood at the edge of the water with a meter stick and matched the line of their sight with the crest of a wave and the horizon, which would usually cause the observer to get into a crouching or even lying down position. The observer then measured the line of their sight with the meter stick and recorded the data in meters. The observer also recorded the sea state, which was found by looking at the surface of the water and comparing it to the "Ocean Globe Sea State Description Codes" provided by Robert Perry (UCLA OceanGLOBE & Malibu High School). The observer then recorded the number that matches the descriptions. To find the direction of the wind, the student used a wind vane to find the direction of where the wind was coming from, and then used a compass to find the magnetic degree of that direction. Lastly, the month's rainfall, in inches, was recorded. Rainfall data was not collected at the observation station, but was gathered from Weather Underground (http://wunderground.com) each month.

The second station was the Beach Observation Station. Here the student observed the marine mammals, birds, plant and animal debris, and non-ocean debris seen on or above (flying birds) the beach between Lifeguard Stations 25 and 26. The observer recorded the number of individuals seen in each species or type of things by adding a tally mark to their data sheet under the correct categories. In order to identify the species of each individual seen, the student used the three field guides written by Robert Perry (UCLA OceanGLOBE & Malibu High School): "Guide to the Plant and Animal Debris of Southern California Sand Beaches," "Guide to the Marine Birds of Southern California Sand Beaches," and "Guide to the Marine Mammals of Southern California Sand Beaches."

The third and last station was the Beach Profile Station, which was also where data for the tide level distance was collected. The baseline point was ten meters from the telephone pole located just south of Lifeguard Station 26, measured using a ten-meter long rope which was stretched from the pole seaward. The baseline point was marked and the baseline extended from the point parallel to the ocean. (see Figure 2 above) The beach profiler used to measure the slope of the beach was created by connecting two 1-meter PVC poles with a 5-meter long rope. This rope created a 5 meter interval between each measurement of the slope, and data was recorded as such. Students measured the slope of the beach using the beach profiler and a meter stick. One student would stand with one of the PVC poles at the baseline while another student stretched the 5 meter rope toward the ocean as far as it would go, and placed the other PVC pole in this location, holding the meter stick at their side. The student at the baseline would then crouch down so his/her eye was level with the top of the PVC pole and the horizon. This student then directed the seaward student to raise or lower the meter stick so that it too lined up with the horizon from the shoreward student's line of sight, and from the meter stick a measurement was found for the slope of the beach in that 5 meter interval and recorded in meters. The shoreward observer then moved the PVC pole in his/her hands seaward to the next 5 meter location while the other student stayed in place, now becoming the shoreward person as this process continued. When one of the researchers reached the tide line, he or she stopped and recorded the distance between the baseline and tide line as the tide level distance. See illustration below.

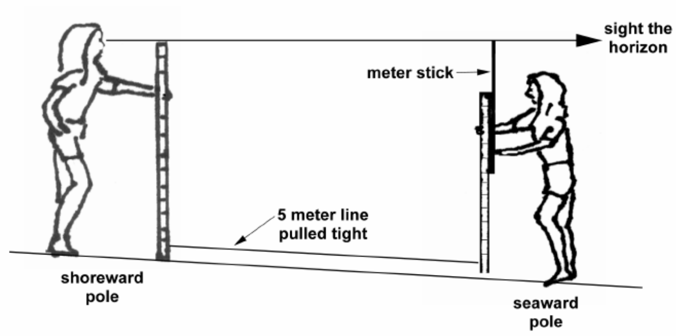

Figure 3: This illustration shows two students using the beach profiler and a meter stick to perform the process to measure the slope of the beach.
(February 21, 2007/<http://www.waterkid.net/projects/ocean_globe/OG_images.htm>)

Results:

Over this data collection period of seven months, the rainfall was very scarce. From the data collected, February had the most rainfall: 0.43 inches, and October and April tied for least rainfall, both standing at zero inches. The monthly rainfall totals first rose through the fall and winter months, but once it became March, the totals dropped dramatically. From October to February, the rainfall increased 0.43 inches, starting at zero, but then the total dropped to zero again by April. The average monthly rainfall total for fall months during this data collection period was 0.015 inches, the winter months had an average of 0.3233…, and the spring months 0.005 inches. On the graph below, October and April may look as though they're missing data. However, no bars appear because there had been no rainfall during those months. Also, notice that, because rainfall was so scarce, the top of the graph does not even reach half an inch.

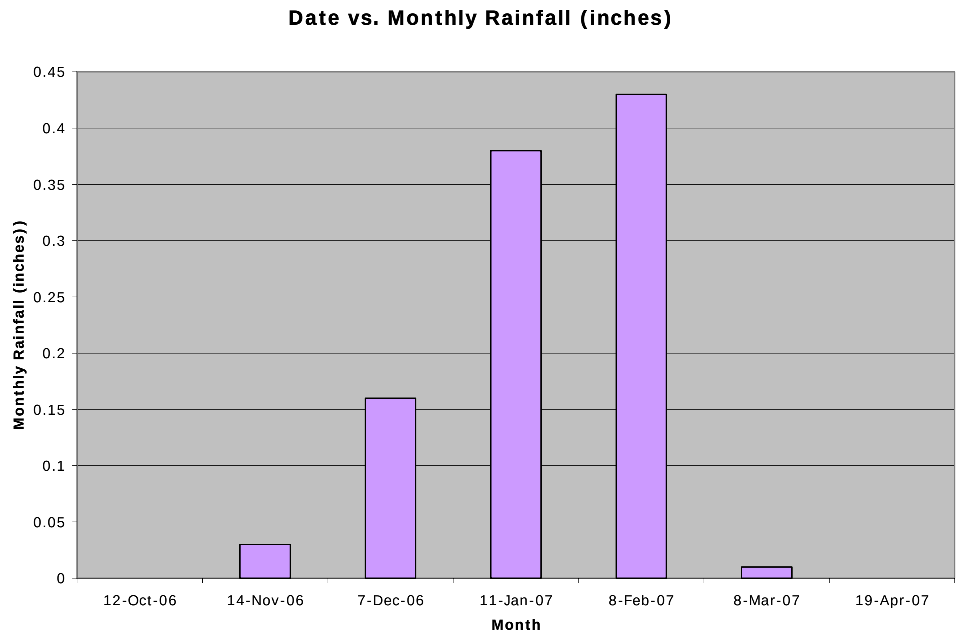

Figure 4: This graph represents the monthly rainfall totals during this data collection period. October and April may look as though they're missing data, but there was no rainfall in those months so no bars appear.

During the seven months of this data collection period, beach profiling was done by every student, and the slope was recorded for each month. February had the steepest slope seen during this investigation, with an average drop of about 0.2082 meters for every 5 meters distanced. December, in contrast, had the flattest slope recorded, with an average drop of about 0.1411 meters for every 5 meters distanced. A trend found between each month's average slope was that starting in January and going through April, the average drop never fell less than 20 centimeters to a 5 meter run. Also, in this data collection period, the average slope always fell at least 14 centimeters for every five meter run. In October, the average drop was about 17 centimeters, and in November, it was about 20. In December, the average drop fell to about 14 centimeters, which set the flattest slope record, but January had a drop of about 20 centimeters again. The average drop then became about 20.8 centimeters in February, which set the steepest slope record, very little was lost in March: the average stayed around a drop of 20 centimeters, and April finished off the trend with a drop of 0.2031 meters for every 5 meters distanced, just five tenths of a centimeter off of February's record. On average, the fall months' and winter months' slopes were relatively flat, and the spring months were relatively steep, as March and April's average slopes together were the only season whose average was more than a drop of 0.02 meters for every 5 meters across.

Beach Profile: Distance from Baseline (meters) vs. Total Change (meters)

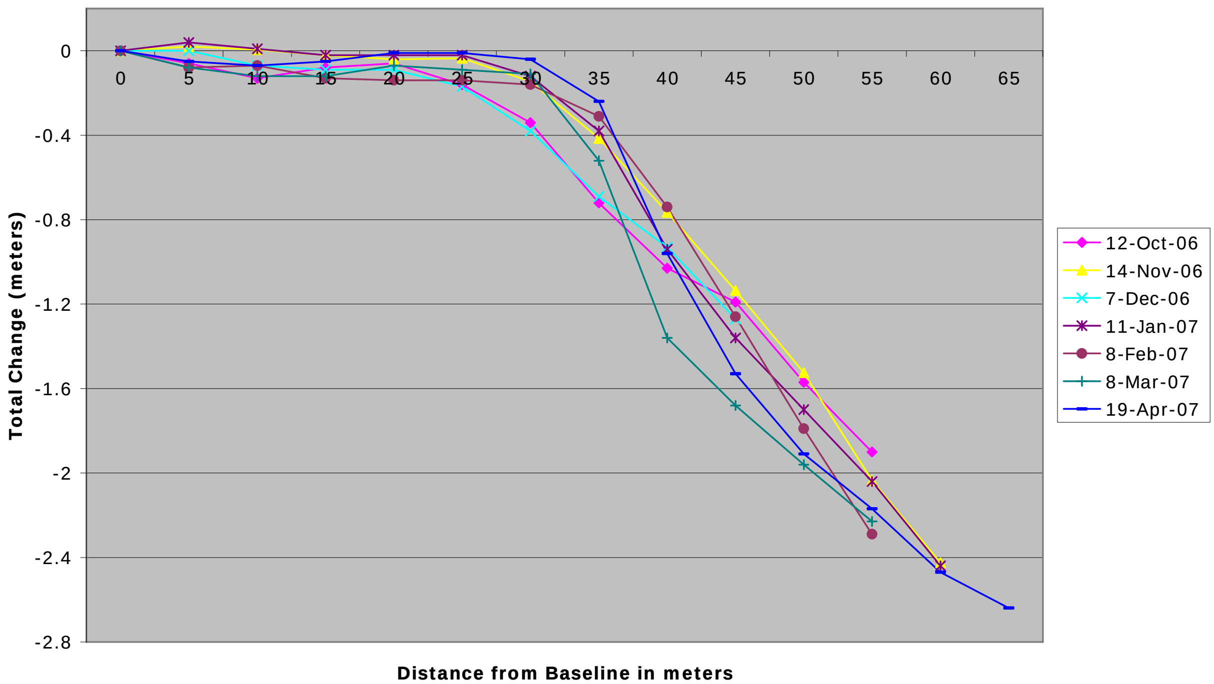

Figure 5: This line graph shows the comparison between the dropping slopes of each month's beach. Each symbol marks a 5 meter line, and another measurement. Some lines are longer than others based on how far out the tide was on that day.

Many different marine birds were seen during this data collection. Between October and April, Western Gulls were the most common, and the Ring-Billed Gull, Black Bellied Polver, Brandt's Cormorant, Surf Scooter, and Common Loon were the least common, because none of them were seen at all. An average of nine Western Gulls were observed each month, and only two Herman's Gulls and two Sanderling were seen each month, on average. Brown Pelicans and Willets were each seen an average of once in a month. Foster's Terns, Marbled Godwits, and Western Greebes were all seen at least once in the data collection period, but so infrequently that their averages did not amount to even one per month. There were many trends seen in the marine birds' appearances and disappearances. The Western Gull first appeared in November, but was not seen again until January, where it stayed through March, when an average of twenty per month were observed. No Western Gulls were sighted in April. The Herman's Gulls first appeared in December, and an average of four Herman's Gulls were sighted each month from December through February, and then none were seen in March or April. The Foster's Tern was only seen once in November, and never again, whereas three Brown Pelicans were seen in November, two in February, and none in any other month. Sanderlings were seen from October to January, with an average of two per month observed during that period, then it disappeared for a month, three were observed in March, and none in April. A small number of Willets were seen on a more regular basis. One Willet per month was seen from October to December, one in February, and two in April, with none seen in January or March. All in all, more birds were seen in late winter or early spring, in March and April, than all the other months, although the greatest variety of birds was seen in November.

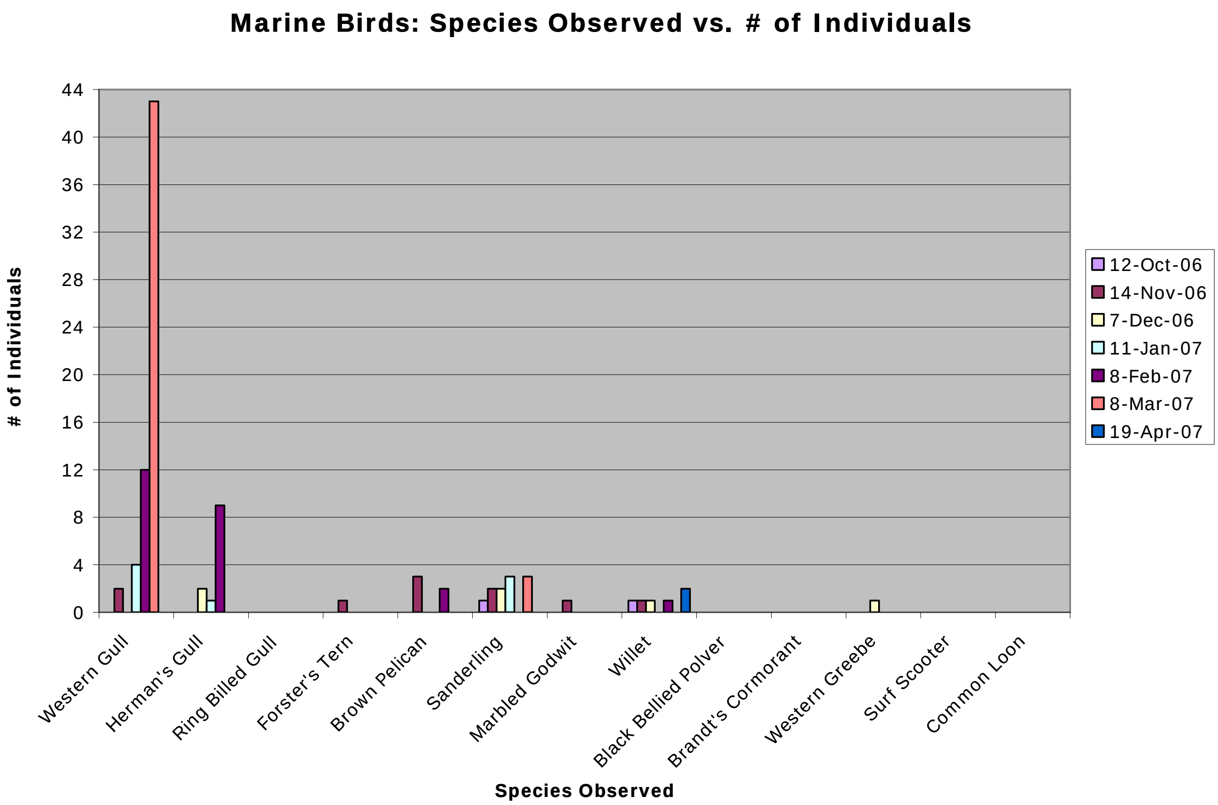

Figure 6: This graph shows each type of marine bird, and how many of each were seen each month. Where bars seem to be missing, none were seen.

Marine mammals were very scarce during this observation period. The Pacific Bottlenose Dolphin was the only mammal seen during these seven months, which also made it the species most seen. Therefore, the California Sea Lion, Pacific Harbor Seal, Pacific Grey Whale, and the Common Dolphin were all seen the least, as they were all not seen at all by this student observer. When calculating the average monthly sightings of the Pacific Bottlenose Dolphin, it is concluded that about one was seen per month. However, in reality, six dolphins were all seen in one day, in December, and never in preceding or following months. There were no visible trends in the appearances of the Pacific Bottlenose Dolphins.

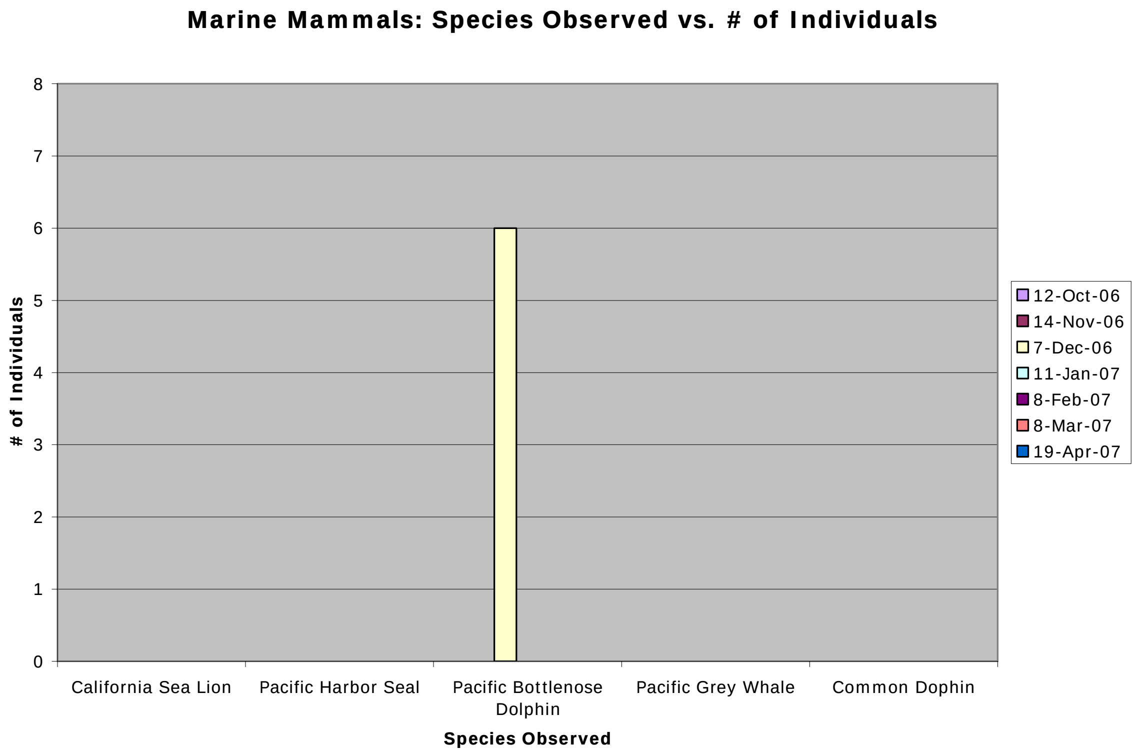

Figure 7: This graph shows each type of marine mammal, and how many of each were seen each month. Where bars seem to be missing, none were seen.

Tallies for the amount of marine plant debris were also taken during this data collection period. The species seen most in this period was Surf/Eel Grass, and least was Turtle/Eel Grass. Surf/Eel Grass was seen an average of eleven times per month, two Giant Kelp strands and two Ribbon Kelp strands were seen per month, and only one each for Bladder Chain Kelp and Turtle/Eel Grass were seen. Giant Kelp was seen in October and November, an average of eight per month. Then, it was not seen again until February and March, with an average of one seen per month. An average of six Ribbon Kelp strands were observed each month in October and November, and one was observed in February, but none were seen after that. Bladder Chain Kelp was first seen in December, but only one was seen that month and none was seen in January. An average of two Bladder Chain Kelp strands per month were seen between February and April. Lastly, Surf/Eel Grass was present from October to December, with an average of twelve examples per month during that time; none was seen in January or April; and an average of four per month was seen in February and March.

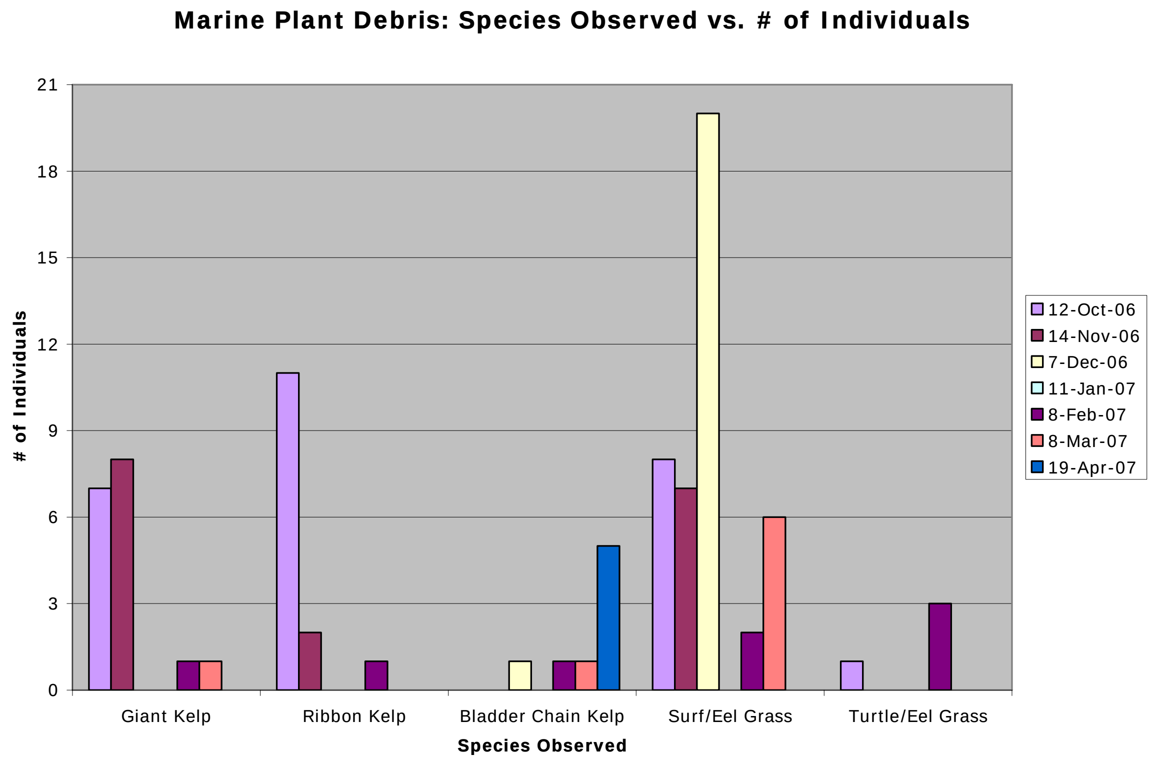

Figure 8: This graph shows each type of marine plant debris, and how many of each were seen each month. Where bars seem to be missing, none were seen.

Another type of debris whose amounts were recorded is marine animal debris. Over the seven months of this observation, more Bean Clams were seen than anything else, and Sand Dollars, Rock Oysters, Giant Rock Scallops, and Little Necked Clams were all seen the least, as none of them were seen at all. An average of 117 Bean Clams, 43 Pismo Clams, 4 Mussels, and 1 White Sand Clam were seen per month. The Grey Sand Crab and Spiny Sand Crab were both seen so few times that they averaged less than one per month, but they were each at least seen once during the data collection period. January had the most animal debris total over all the months, and this may have been related to the fact that January also had more rain that most of the other months. March also brought the most Bean Clams seen in one observation day on the beach, but no other type of animal debris was seen that month.

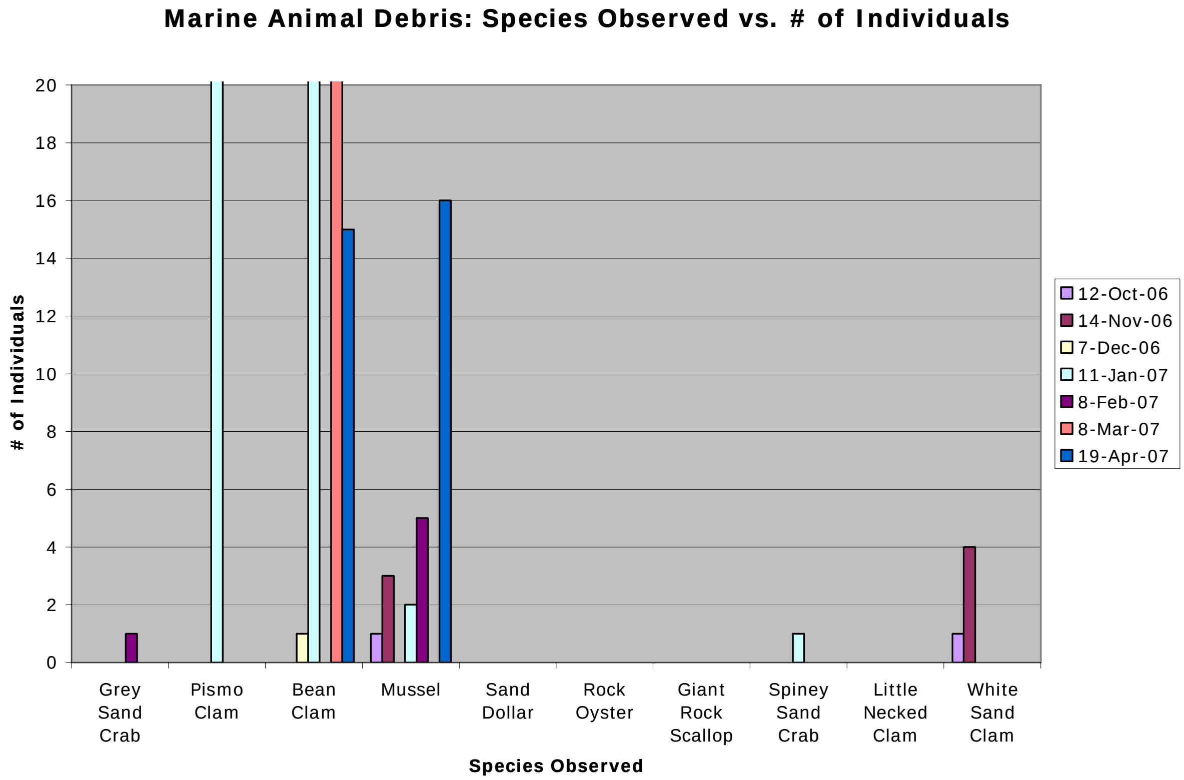

Figure 9: This graph shows each type of marine animal debris, and how many of each were seen each month. Where bars seem to be missing, none were seen. Notice that January's bars for Pismo Clams and Bean Clams go off the chart because their values are both 300, which does not fit. March's bar for Bean Clams also goes off the chart; its value is 500.

The last type of observation data recorded is for Non-Ocean Debris. Styrofoam pieces were the most common type of Non-Ocean Debris seen between October and April; tar was the least common. An average of nine Styrofoam pieces, eight plastic pieces, three wood pieces, two cigarettes, one piece of paper, one piece of rubber, and one feather were seen per month. Socks, dog waste, glass pieces, and tile pieces were all seen at least once, but so rarely that their averages were too insignificant to amount to one seen per month. Tar was not observed at all. Plastic was the only type of debris seen every month. Also, the amount of debris seen on the beach started increasing as spring approached. Monthly totals and individual type tallies, such as Styrofoam, cigarettes, wood, and rubber, rose steadily from January to April.

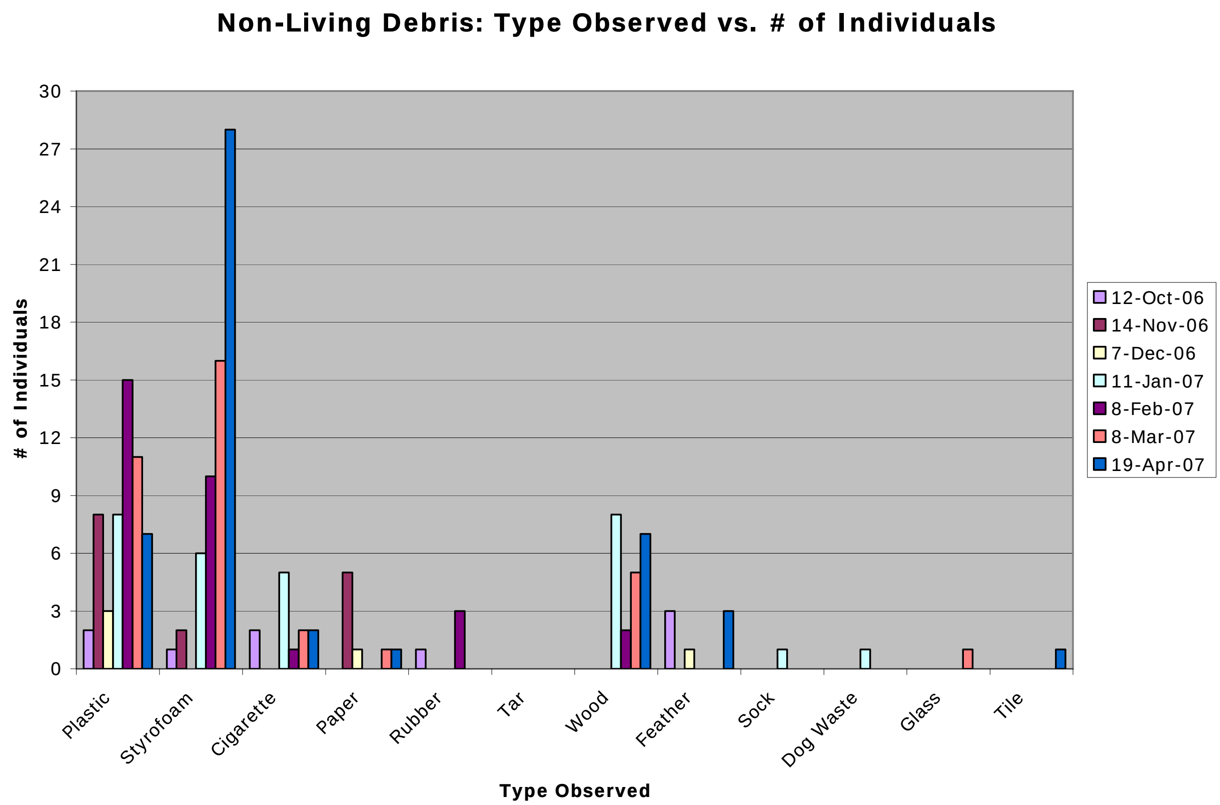

Figure 10: This graph shows each type of non-ocean debris, and how many of each were seen each month. Where bars seem to be missing, none were seen.

Discussion:

The purpose of this investigation was to find out if rainfall and winter storms affect the state of the water, shore, and sky at Santa Monica Beach, and the living and non-living things there. It was predicted that rainfall and winter storms would cause the slope of the beach to get steeper because storms bring stronger, bigger waves to wash away the sand. It was also predicted that the beach slope would be flatter during the fall months and steeper during the spring months. From the results of this investigation, it seems that no conclusion can be drawn as to whether the first prediction was correct or not, as there was such insignificant rainfall during the seven month period. However, if a conclusion must be drawn, it would seem that rainfall and winter storms *did* affect the slope of the beach, for February had the most rainfall and the steepest slope. References said that stronger waves, caused by more rain, would erode more sand and make beach slopes steeper, and this data agrees.

It was predicted that rainfall and winter storms would cause a decline in the number of marine birds seen during the winter months because of the cold and moisture at the beach. It was also predicted that fewer marine birds would be seen in the fall months and more marine birds would be seen in the spring months. From this data, it was unclear as to whether the number of birds seen in a month was influenced by the amount of rain that month. In October and April, both months with no rainfall at all, only two birds were seen in each month, and in February, the month with the most rain, 24 birds were seen. However, in March, with only a hundredth of an inch of rain, the most birds were seen. It is also possible that the number of birds seen in one month was influenced by the amount of rain in the previous month, which could explain February's record rainfall leading into March's record number of birds. However, both explanations counter the first prediction: that more rain would mean fewer birds. Still, final data proves the second prediction true. An average of six birds were seen per month in the fall, and an average of 24 birds were seen per month in the spring. References said that Sanderlings were migratory, and not seen on the Pacific Coast in the summers, but that Willets were only found on the Pacific Coast in the winter, which didn't completely agree with the data, in which Willets were seen almost every month. The sources also said that Western gulls are not migratory, but live year-round along the west coasts of the United States and Baja California. This also agrees with the observer's results: Western Gulls were also seen almost every month.

It was predicted that rainfall and winter storms would cause a decline in the number of marine mammals seen during the winter months because of the cold and moisture at the beach. It was also predicted that fewer marine mammals would be seen in the fall months and more marine mammals would be seen in the spring months. From the results, only the Pacific Bottlenose Dolphin was seen at all during this data collection period, and the sighting was in January, a winter month of relatively high amounts of rain. However, it is unclear to the student observer whether the January sighting of dolphins was influenced by rain. This investigation partially agrees with the information sources used. The references stated that both the California Sea Lion *and* the Pacific Bottlenose Dolphin were common to the Santa Monica coast, but only the Pacific Bottlenose was seen. Also, Pacific Bottlenose Dolphins were said to live year-round on the Pacific Coast, but were only seen during one month.

It was predicted that rainfall and winter storms would cause an increase in the amount of marine plant and animal debris seen during the winter months because stronger waves would wash more debris onto the sand. It was also predicted that less marine plant and animal debris would be seen in the fall months and more marine plant and animal debris would be seen in the spring months. It was predicted that rainfall and winter storms would cause an increase in the amount of non-ocean debris seen during the winter months because stronger waves would wash more debris onto the sand and more debris would be washed down drains to the ocean by rains. It was also predicted that the same amount of non-ocean debris would be seen in the fall months as the spring months. From the results of this investigation, there does not appear to be much of a correlation between the amount of rainfall in a certain month, and the amount of debris found that same month. The most rainfall happened in February and January, but the most plant debris was seen in October and December. The most animal debris was seen in January and March, and the most non-ocean debris was seen in March and April. These statistics do not seem to show any strong relationships to the amount of rainfall. The sources of information said that the most debris was found after heavy rains and at low tide, which this data partially agrees with. During this data collection period, there was never enough precipitation to qualify as "heavy rains," but with the rainfall that did take place, there did not seem to be a connection to the amount of debris. However, this data does agree with the statement that more debris would be found at low tide, because April and January, months with lower tides than others, both had record sightings of debris.

During this investigation there were sources of error. First, data collection was not done exactly every four weeks. This could have changed the amount of rainfall data, because rainfall might have fallen after the end of a four week period, but after the next data collection trip, and so monthly rainfall might have counted for the wrong month. It also could have changed tide level data, as tides change every day, and it could have changed all beach observations, as well as atmospheric data. This could have been avoided by scheduling data trips every four weeks exactly, no matter the day of the week. A second source of error was the beach maintenance tractor, which drove along the beach every morning. As it drives over the sand, it shifts sand around, covering some items, and sometimes changing the slope slightly. This could change both observation data and beach profiling data. This could have been avoided if John Adams Middle School roped off the observation area for a full year, not allowing the tractor to come through, which would allow debris and sand to accumulate naturally in the area, even though it might make the beach less appealing to tourists.

There are also different studies that could be done by students that would add to their beach investigation experiences and lessons. One example is similar to this investigation, but instead of visiting the beach once monthly, to do a daily study. The purpose of this investigation would be to see how drastically the Santa Monica Beach environmental, atmospheric, and profiling data changed from day to day, and to compare if certain days brought certain trends, such as weekends bringing more non-ocean debris or something of the sort. The study would also be carried out on the Santa Monica Beach, at Ocean Park Boulevard, between Lifeguard Stations 25 and 26. Researchers would visit the beach every day for six months to perform the same investigations performed in this investigation: beach profiling, tallying of different species and items seen, and finding wind direction, wind speed, air temperature, maximum wave height, sea state, and percentage of cloud covering. This would add on to knowledge gained in this investigation by revealing the constant changes the beach undertakes every day, and by showing correlation between the beach and specific days of the week. A second possible future study would be a population vs. beach observations investigation. The purpose of this investigation would be to see whether the number of people who visit the beach in a day influences the number of debris, marine birds, and marine mammals seen on the beach that day. This investigation would, again, take place on the Santa Monica Beach, at Ocean Park Boulevard, between Lifeguard Stations 25 and 26. Researchers would, again, come to the beach daily for six months, recording the number of humans seen, and the numbers of birds, mammals, plant debris, animal debris, and non-ocean debris seen. From the results, the observers would look for trends, which would enhance previous knowledge from this investigation by showing just how much people influence their beaches.

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