Presence and Concentration of *Escherichia coli* (E. coli) Bacteria in the Waters of Five Humboldt County Beaches

Quinn Bunstock de Hinojosa, Kiara Cuerpo-Hadsall, Diego Padilla, Dustin Hixon

Abstract

There are several forms of bacteria located in Humboldt County's beaches. One of the ever growing and always consistent will be *Escherichia coli, otherwise known as E. coli.* Thanks to the Humboldt County Department of Health and Human Services, these *E. coli* levels must be monitored. This research shows the ever-growing problem that has been growing for over a decade now. By looking at data from the Humboldt County Department of Health and Human, it is clear to see that *E. coli* is a persistent problem at five locations: Clam Beach, Luffenholtz Beach, Moonstone Beach, North Mad River Mouth, and Trinidad State Beach.

By taking the excel spreadsheets available online from the Humboldt County Department of Health and Human Services, it was possible to create maps that display the levels of *E. coli* at the five locations over the past decade. In the end it is clear that Humboldt County's beaches have been exposed to high levels of *E. coli.* The interesting thing is that these high levels are always at one beach location. They tend to differ every time a new data set is collected. So the task is to analyze the spreadsheets and figure out if there is a pattern to the bacteria being present in the water or if it is something spontaneous that can't be predicted.

Introduction

Humboldt County is known for its beautiful beaches. Although cold, five beaches in particular are visited by a copious amount of beachgoers: Clam Beach, Luffenholtz Beach, Moonstone Beach, North Mad River Mouth, and Trinidad State Beach (see figure 2 for locations). Due to human exposure to these waters, under the U.S. Environmental Protection Agency Beach Environmental Assessment and Coastal Health Act (BEACH Act) the Humboldt County Department of Health and Human services must periodically test the beaches to monitor for the presence of numerous bacteria in ocean water areas. E. coli (*Escherichia coli*) is one of these bacteria monitored for under this act. The Humboldt County Department of Health and Human Services is monitoring the level of *E. coli* in order to prevent the spread of the bacterial infection. The bacterium that is being looked at is the fecal coliform. Feces of warm-blooded animals, including humans, usually bring up the coliform. In regards to that, it makes sense that there is *E. coli* present in beaches. It is also important to monitor the levels of *E. coli* because since it is being found at beaches and creeks, it poses

a problem to the swimmers in those areas. The people can develop illnesses such as skin rashes, ear infections, and diarrhea.

With this report, it crucial to see how the levels of *E. coli* have varied over the years. It also serves a purpose of trying to analyze a pattern and see if it is possible to predict *E. coli* growth in the future. If there is a pattern to this trend it will be important to pinpoint the main causes of the *E. coli* trends. Whether it is due to human causes or if they are related to other organisms contributing to the rise of the bacteria.

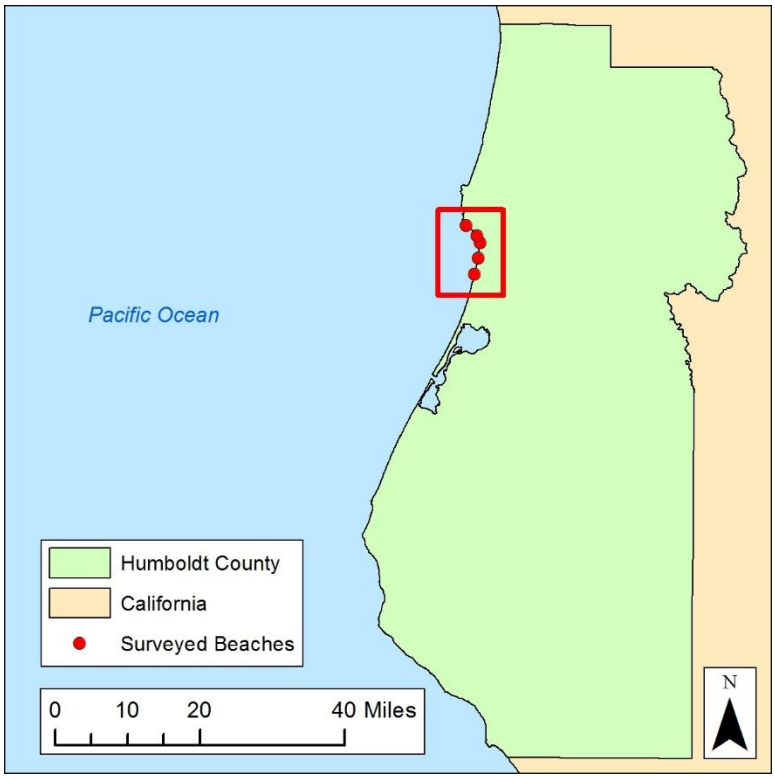

Figure 1 Location of the five test sites in relation to Humboldt County

Materials

First, the data set regarding the water quality test results the studied beaches (Clam Beach, Luffenholtz beach, Moonstone Beach, North Mad River Mouth, and Trinidad State Park) was sourced from the Humboldt County Department of Health & Human Services website. This data was downloaded as a Microsoft Excel spreadsheet and included the test results from 2/11/2003 through 10/25/2016. The data included the results (for the total coliform, E. coli, and Enterococcus tests) in MPN/100 ml (Most Probable Number per 100 mL). This data set will be used for the E. coli levels in each of the studied beach's waters.

Next, the raster imagery of the five test sites was located using the EarthExplorer website (http://earthexplorer.usgs.gov/) where raster imagery of Humboldt County was downloaded through the LandSat Archive. After locating the raster imagery of the area, the hydrography of Humboldt County was downloaded from the USDA NRCS Geospatial Data Gateway.

For the locator map a Humboldt County outline shapefile was downloaded from the Humboldt County GIS download website (https://humboldtgov.org/276/GIS-Data-Download) and a California outline shapefile was sourced from a previous GSP 270 lab data set. This California outline shapefile included the outlines for all U.S. states and was titled US_States.shp and is of an unknown author/creator.

Methods

Once all the data sets (EarthExplorer raster imagery and hydrography shapefile) were loaded into ArcMap, the test site locations for each beach needed to be digitized. The Humboldt County Department of Health & Human Services website from which the water quality results were sourced stated that the test site, "water samples [were] taken near creek mouths that deliver storm water into the ocean" (Water Quality Test Results, n.d.). The creeks/rivers that were used in the sampling were the mouths of Mill Creek, Strawberry Creek, Little River, Mad River, and Luffenholtz Creek. Using this information, the Humboldt County hydrography layer was limited down to just the creeks/rivers mentioned above. This query was completed by using "select by attribute" with the creek/river names in order to limit the data down to the necessary creeks/rivers. The resulting layer after this query consisted of only the creeks/rivers mentioned on the Humboldt County Department of Health & Human Services website and was made into its own separate shapefile. The test site locations were digitized at the creek/river mouths of Mill Creek (Trinidad State Beach), Strawberry Creek (Clam Beach), Little River (Moonstone Beach), Mad River (North Mad River Mouth), and Luffenholtz Creek (Luffenholtz Beach) (see figure 3).

An attribute table was then created for the 2004, 2006, 2008, 2010, 2012, 2014, and 2016 water quality test results. The E. coli test results were then loaded into the attribute table for each test date: 11/16/2004, 11/20/2006, 11/18/2008, 10/26/2010, 10/30/2012, 10/28/2014, and 10/20/2016. The results were then symbolized according to the E. coli test results in the beach waters.

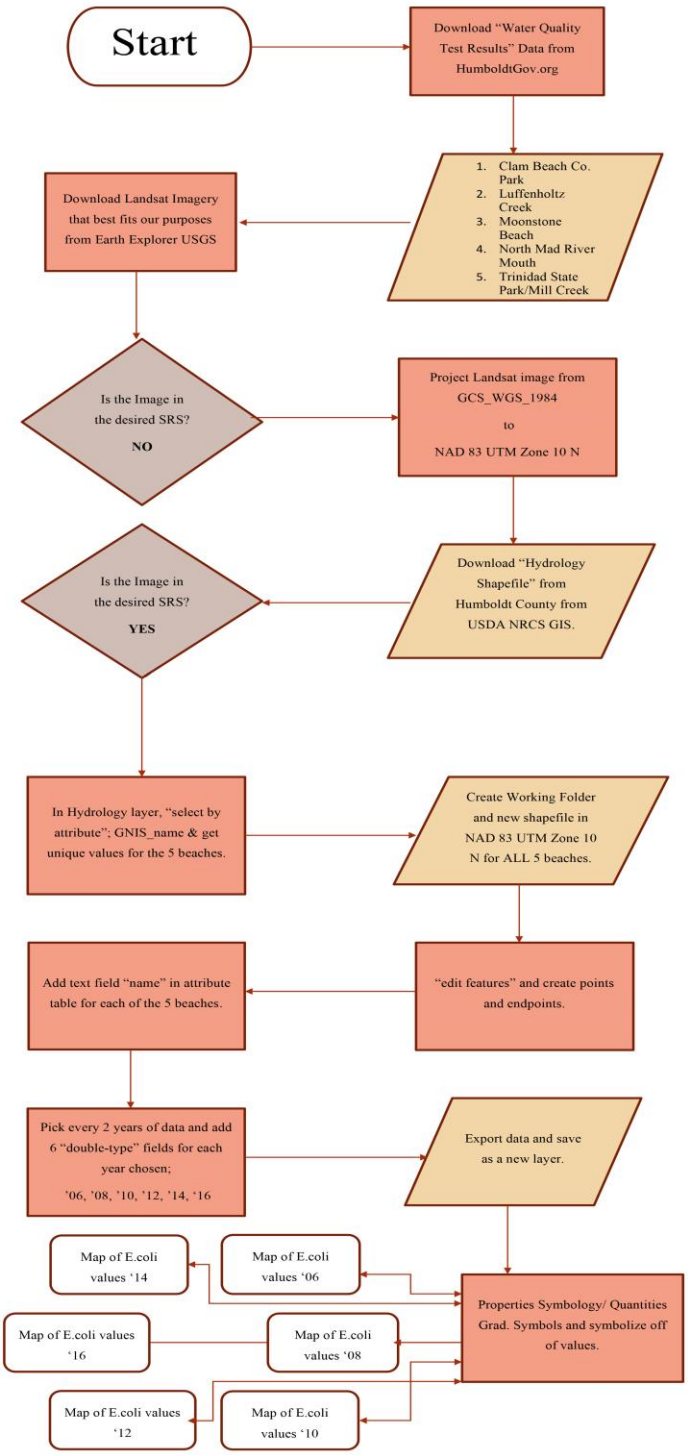

Figure 2 Steps taken during the analysis of data

Results

Using the maps made from the Humboldt Water Quality Data sets, we can see how much the data varies over time. From the 7 years picked, only in 2016 do we see one year and beach that exceeds the state water quality standards for E. coli; Clam Beach.

In the “Heal the Bay; Beach Report Card”, Clam beach was ranked the second dirtiest beach in California. High levels of E. coli are usually caused by animal feces but officials also believe potential upstream bacterial sources include onsite sewage treatment systems, wildlife, and domestic animals.

In the meantime, what procedures will the Humboldt County Health and Human Services use in order to make sure no humans or animals become sick from the water? Warning signs stating "Warning! Ocean Water Contact May Cause Illness! Bacteria Levels Exceed Health Standards" will be posted at the beach and swimmers should stay a minimum of 50 yards away from creek mouths. See figures 4 through 10 for the test results (all units are in MPN/100 ml. MPN = "most probable number").

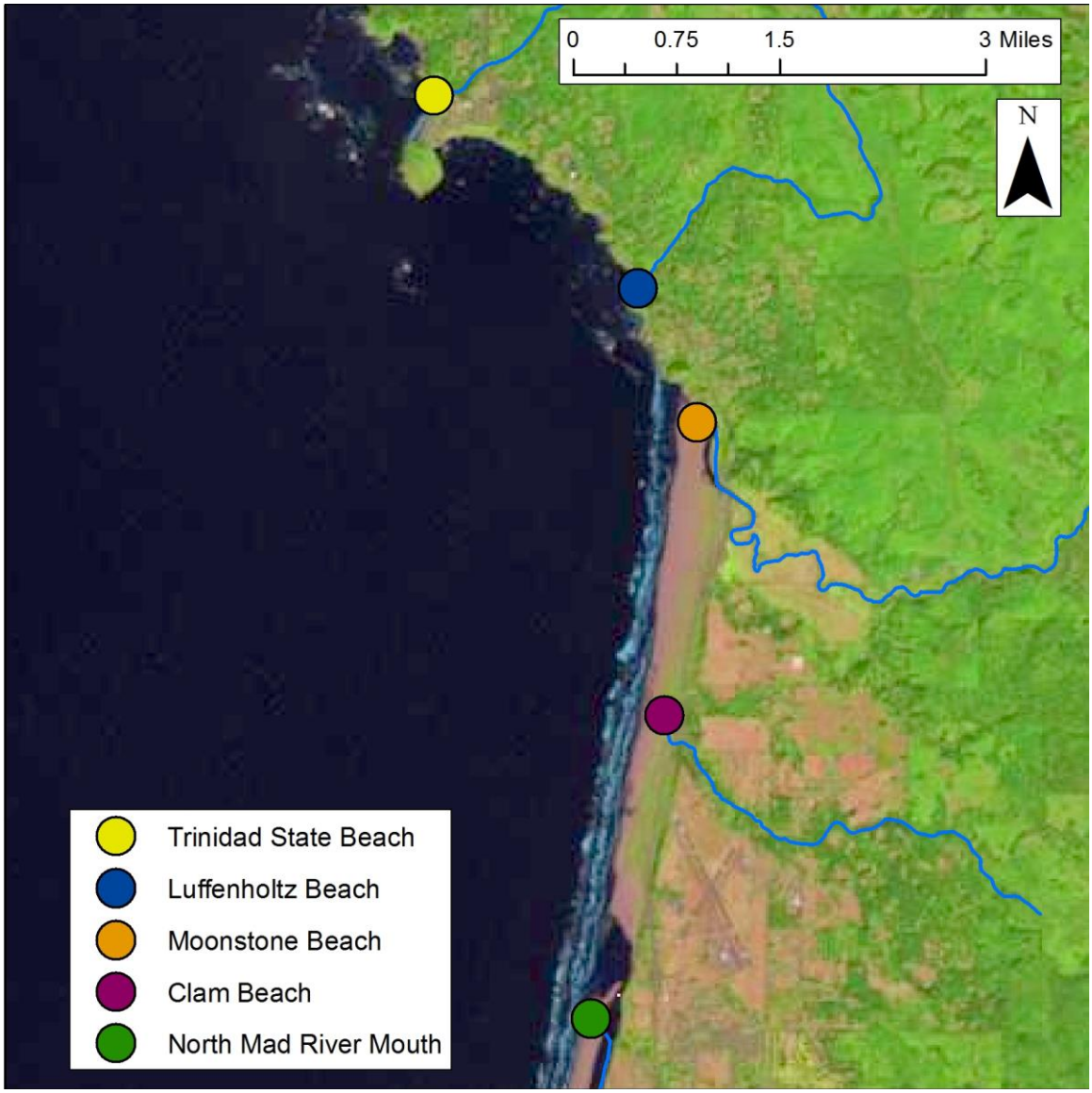

Figure 3 Locations of the 5 beach test sites

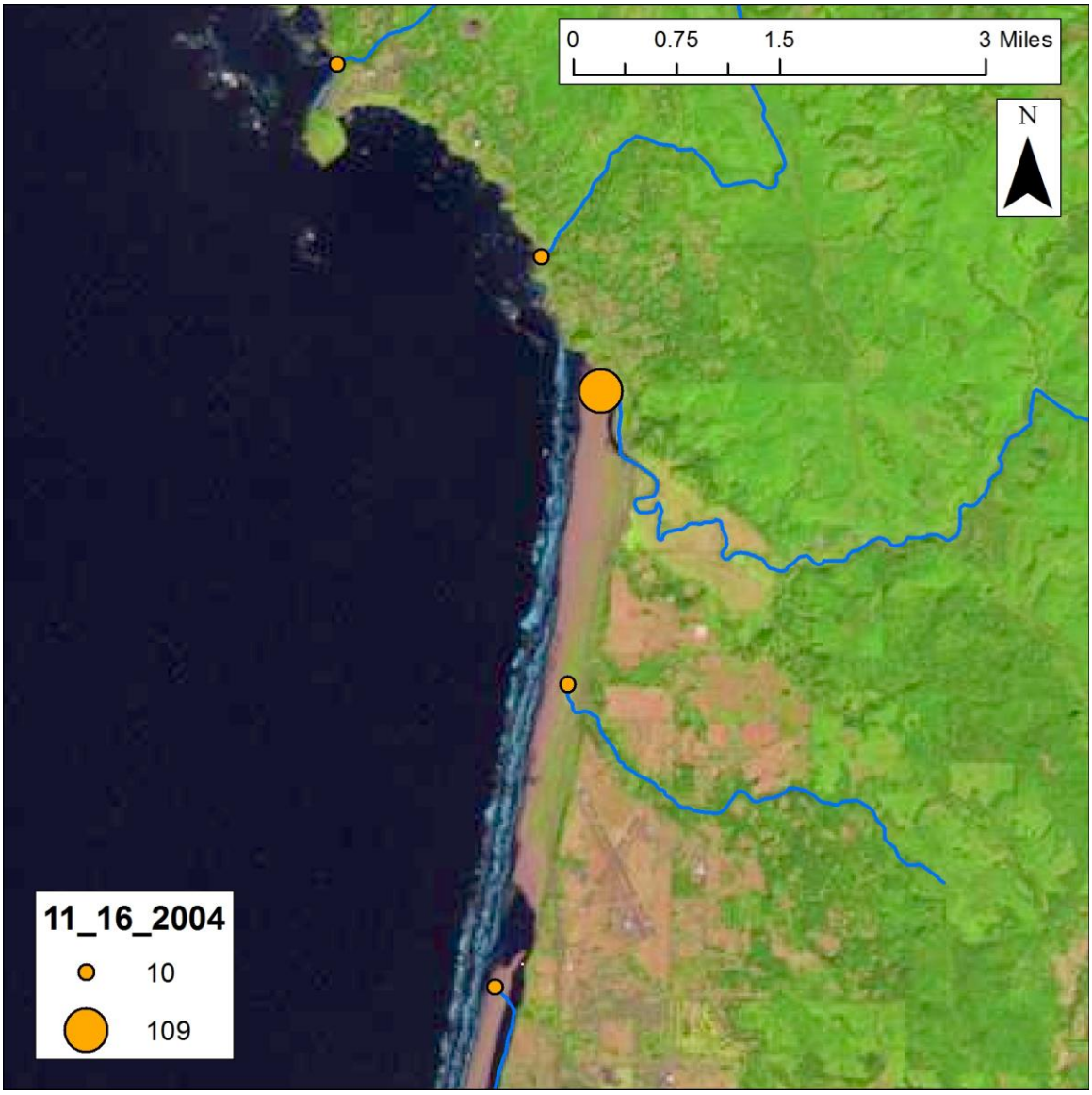

Figure 4 E. coli results for 2004 (all units in MPN/100mL)

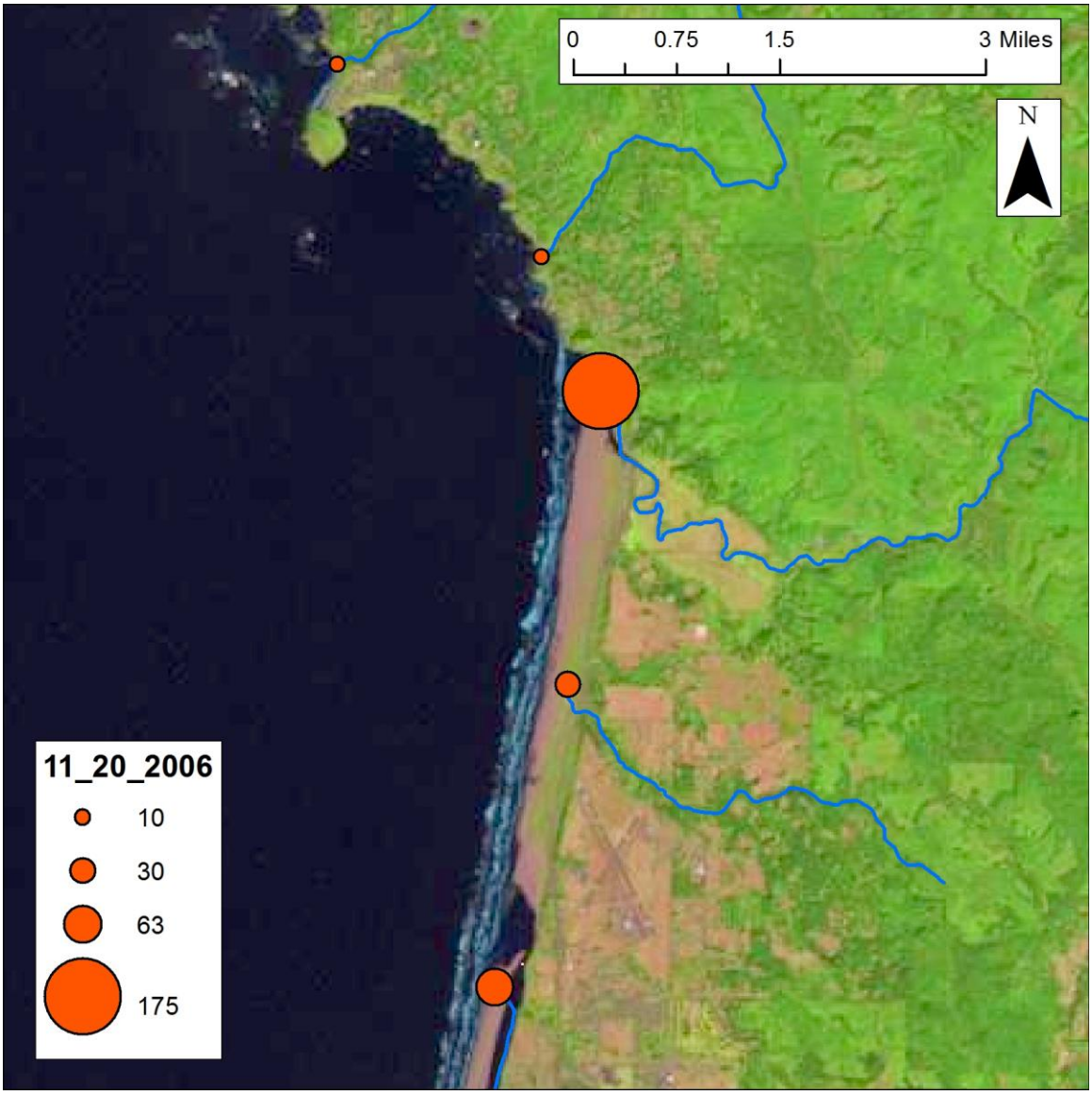

Figure 5 E. coli results for 2006 (all units in MPN/100mL)

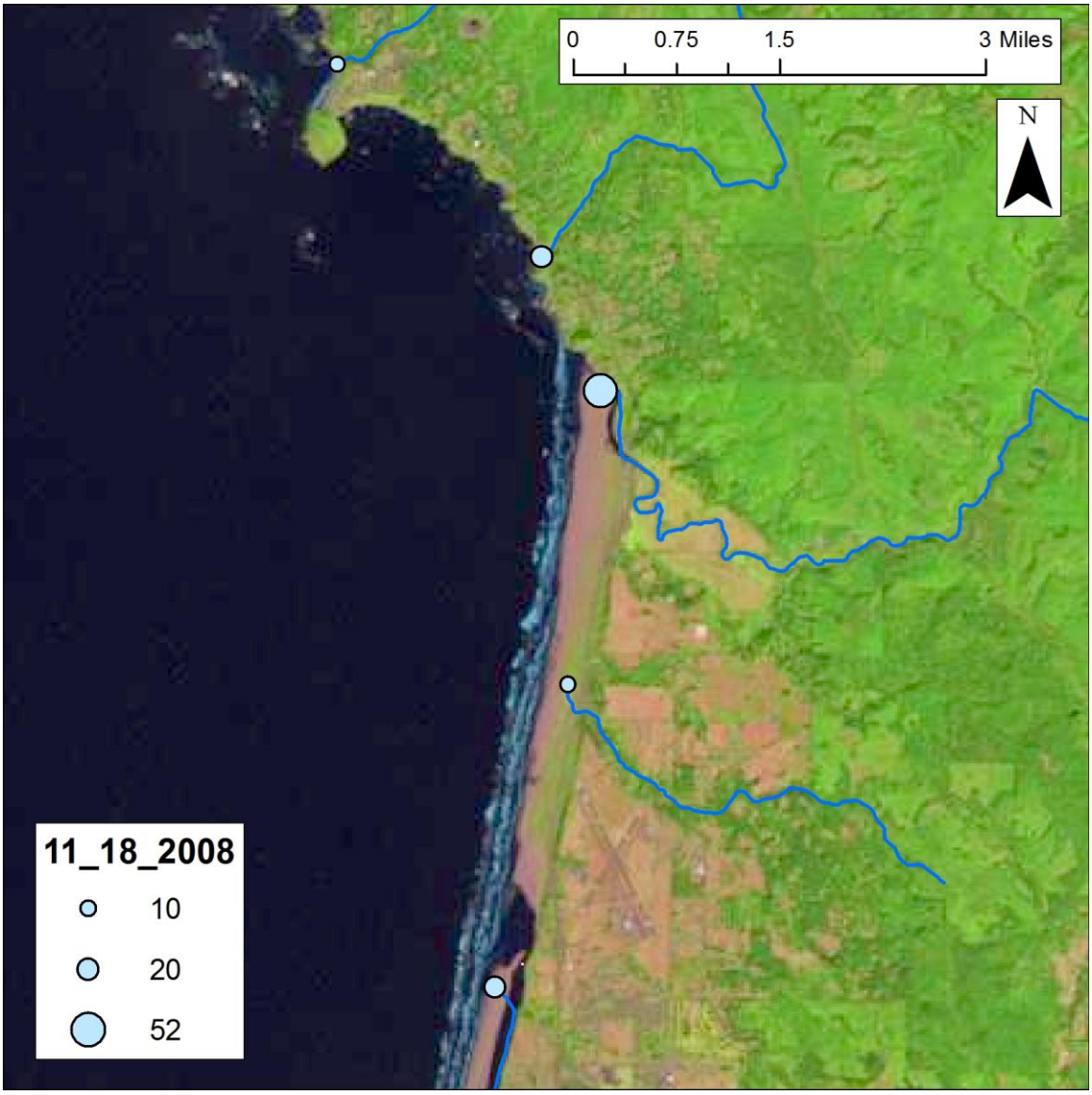

Figure 6 E. coli results for 2008 (all units in MPN/100mL)

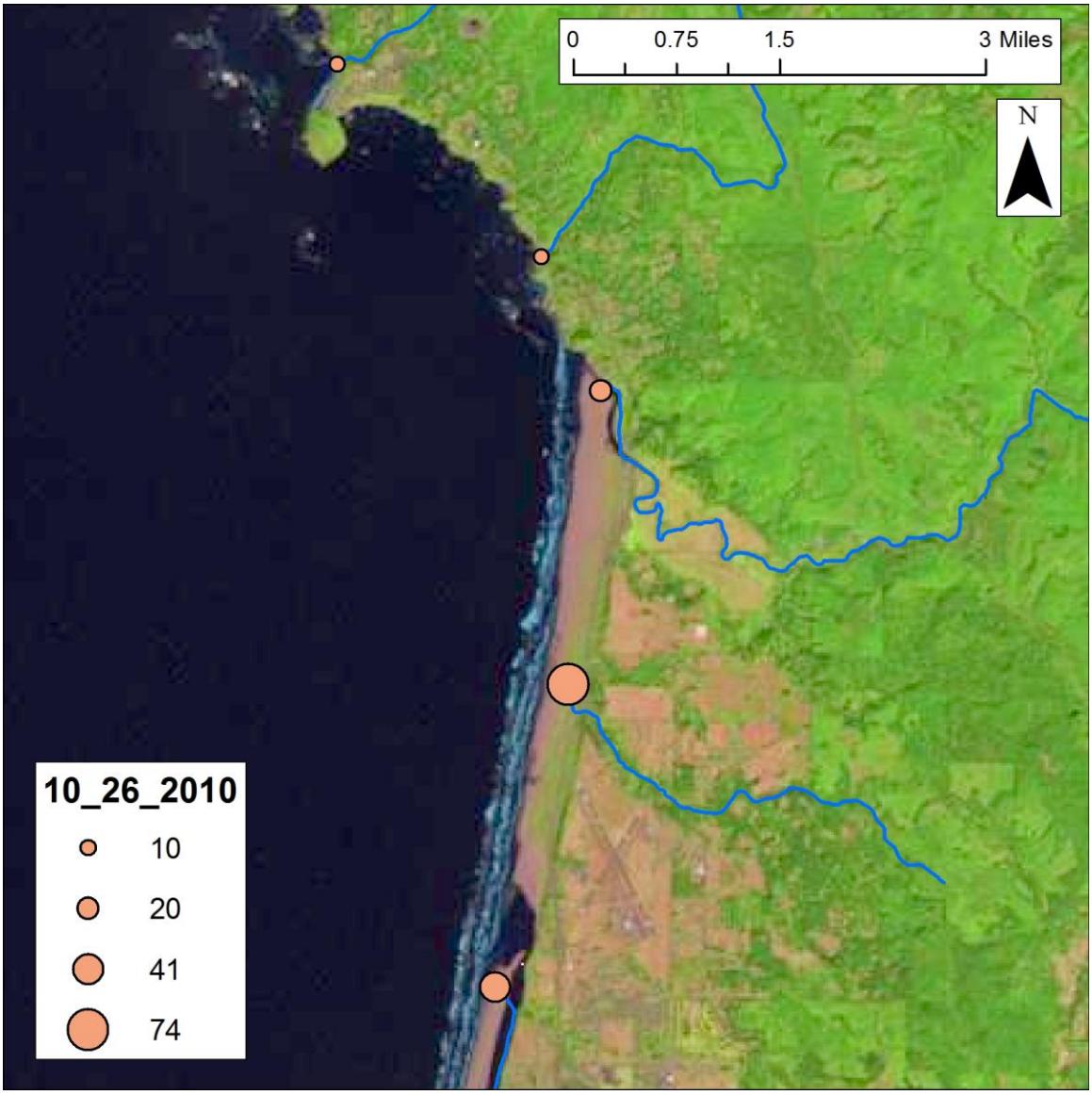

Figure 7 E. coli results for 2010 (all units in MPN/100mL)

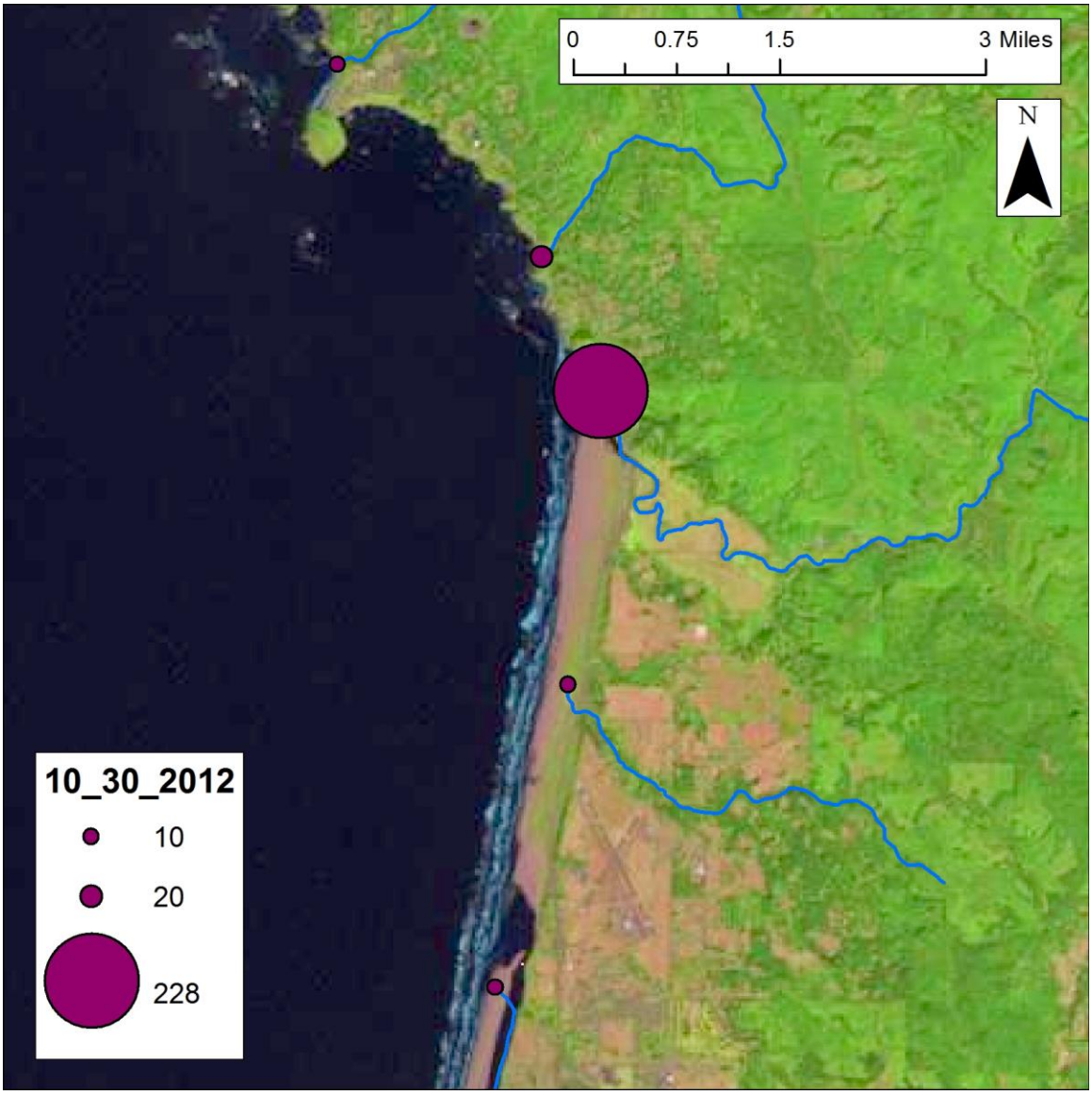

Figure 8 E. coli results for 2012 (all units in MPN/100mL)

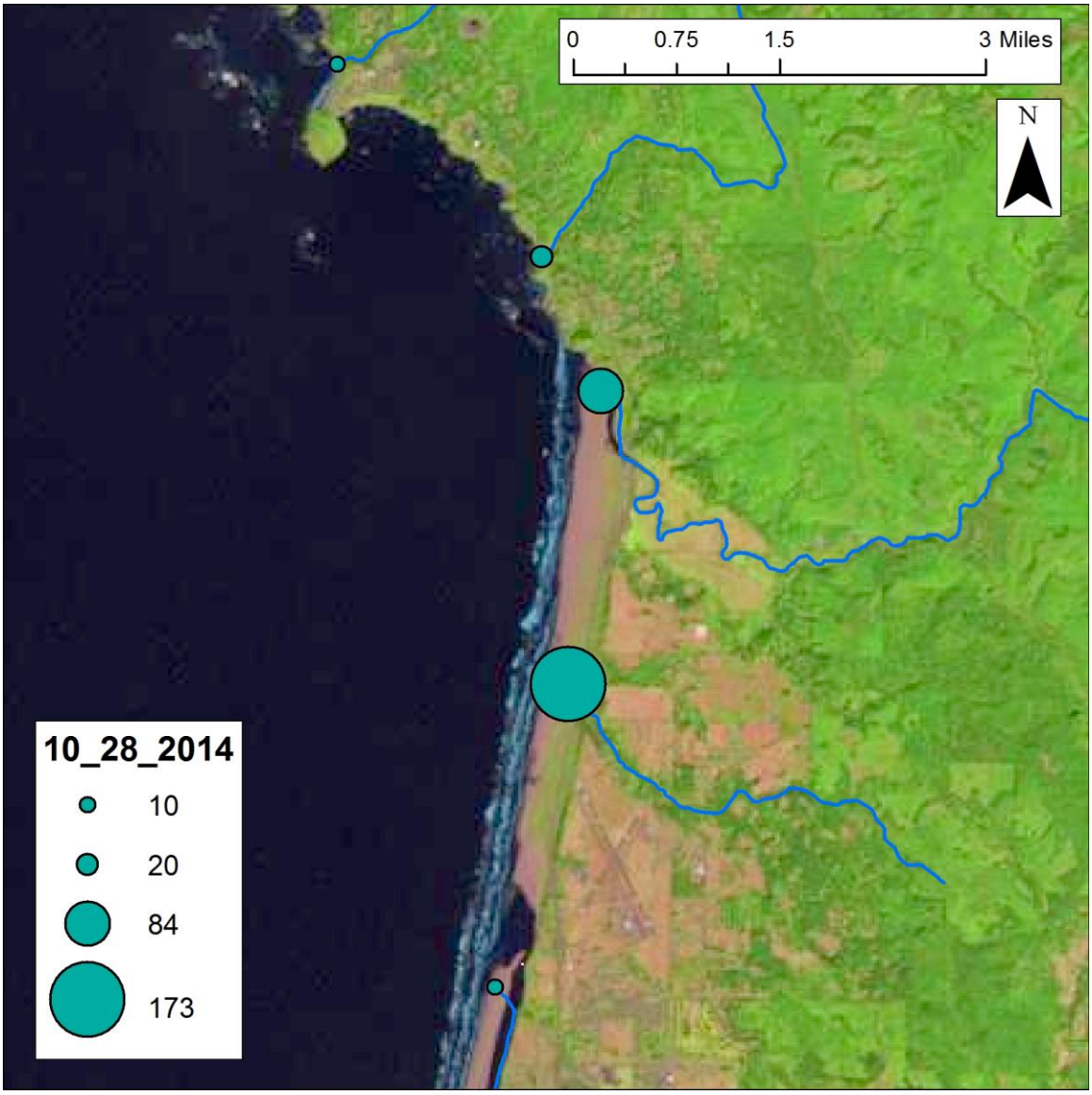

Figure 9 E. coli results for 2014 (all units in MPN/100mL)

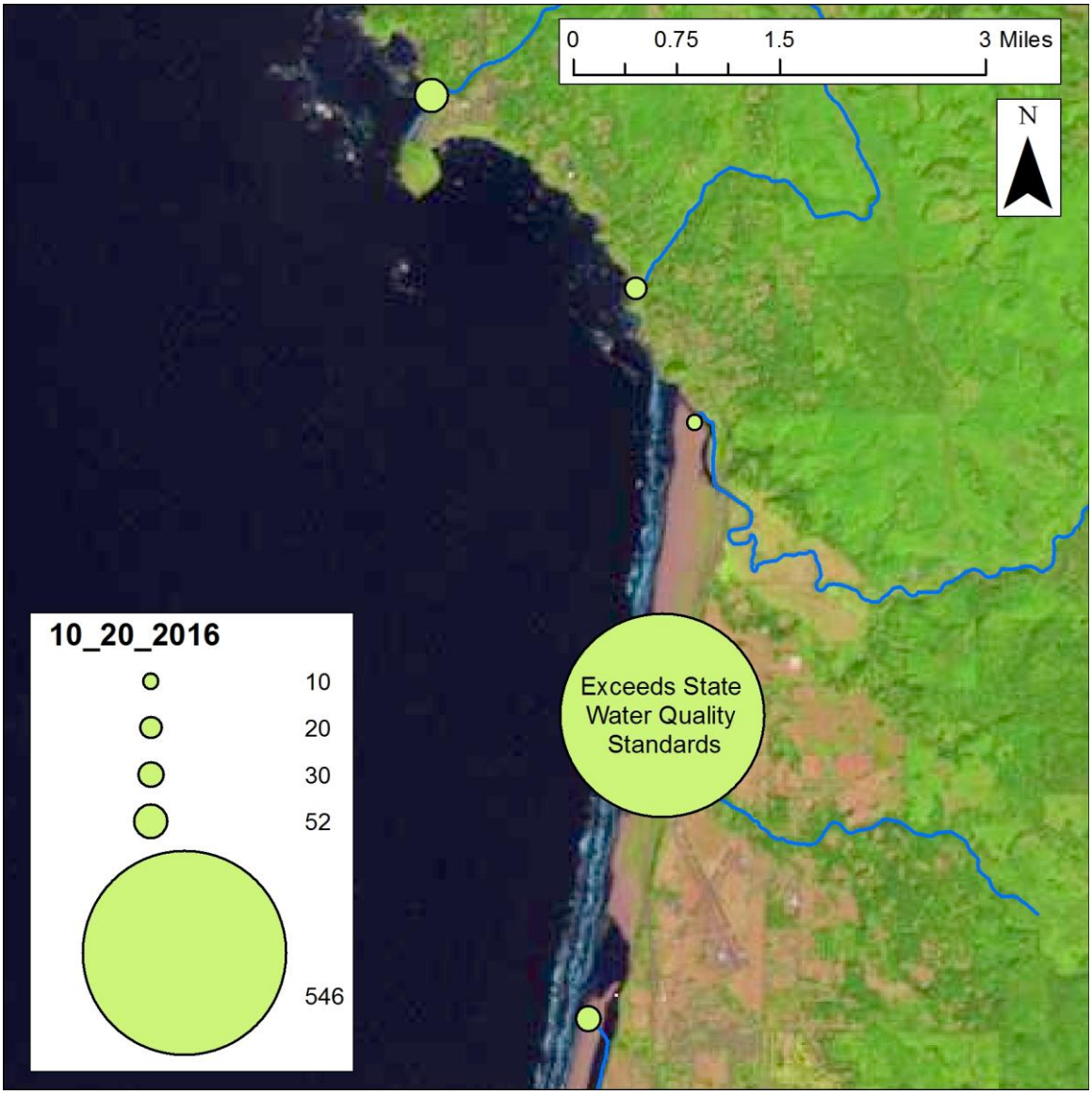

Figure 10 E. coli results for 2016 (all units in MPN/100mL). Clam beach exceeded the state water quality standard of <400 MPN/100mL

Discussion

The finding that Moonstone and Clam Beach are consistently dirty beaches is similar to those in other published reports. According to one report, Clam Beach was ranked as the second dirtiest beach in California (Healthebay, n.d.). Additionally, the EPA graded each of these beaches. Clam Beach was given a grade of "F", while the other four beaches in our study were given a grade of "A", although it was noted that some were "impaired by pathogenic bacteria". These findings have many possible explanations but no definitive explanations due to private landowners denying access to Humboldt County representatives seeking test sites upstream in order to find the bacterial sources. However, some possible causes include: changes in creek

composition due to the recent removal of a beaver dam that was believed to capture many of these bacteria, private and communal sewer system leakage, feces from cattle infecting streams, and waste from transient camps. Yet, without the proper testing of these waters the actual source will not be definitively identified.

However, there is a current push for a possible testing method that will be able to detect the source of the bacteria without having to be granted access to the private lands: the use of genetic markers. By testing these local waterways for genetic markers the test would indicate which animals the bacteria originated from as well as the proportion of the total bacteria originated from these sources. These tests are crucial in finding a solution to the E. coli problems in these waterways. Sources must be identified before the possibility of stopping or minimizing bacterial infections in these waterways is feasible.

Conclusion

While each of the five beaches showed presence of E. coli, levels remained well under the threshold for concern for all but Clam Beach. Over the time period of this study, E. coli presence fluctuated variably between years tested and the beaches themselves. There did not seem to be a common trend over the course of years we observed. Some E. coli levels rose in one beach, while fell in others, suggesting that the E. coli levels between the beaches are not connected to one another. It is likely that the presence of E. coli in these beaches is affected by varying sources and conditions. A common source of E. coli is found in the waste products of animals such as livestock. Due to the heavy agricultural land presence surrounding the areas of concern, it is likely that this has an effect on the E. coli level at the beaches due to runoff of bacteria from pasture to streams to beach. While the changes in cattle grazing rotation surrounding the stream watersheds may affect some of the beaches, it is likely that there are other sources of E. coli contributing to the presence at the beach considering that Clam Beach, with a 2016 E. coli presence that exceeds the State Water Quality Standards, is fed from Strawberry Creek which runs through an urbanized area, rather than agricultural land near the beach. Perhaps the source is infecting the creek more inland, or there is a source reaching the creek from the urbanized area such as via the sewer system. According to the Heal the Beach initiative that ranks beaches according to their cleanliness, a possible cause for the spike in bacterial level may be linked to the now absent beaver dam in Strawberry Creek which may have altered the flow of water (BRRC 2016). An additional note to consider is the popularity of Clam Beach and the high use of the beach by people and their animals. High densities of people could be the reason for the spread of the bacteria. All in all, with the exception of Clam Beach, each of the other beaches maintain levels of E. coli that are well below the amount that would cause concern. While they fluctuate greatly throughout the years, there does not seem to be a trend of continual increase. For the case of Clam Beach, follow up testing of the E. coli level would be helpful to

determine whether it is a cause for concern, or if this was a rare scenario. Currently, work is being done to trace back direct sources of E. coli through the use of genetic markers which will show which type of animal the bacteria originated from (Mann 2015). It is important for future studies to assess the direct sources of E. coli in these beaches so that in the case of rising levels, action can immediately be implemented in order to correct and stop the sites of infection within the streams as well as the beaches.

Bibliography

BRRC. Beach River Report Card. *Heal the Bay*. 2016. Web. 04 Dec. 2016. https://healthebay.org/

"GIS Data Download | Humboldt County, CA - Official Website." GIS Data Download | Humboldt County, CA - Official Website. N.p., n.d. Web. 03 Dec. 2016. <https://humboldtgov.org/276/GIS-Data-Download>.

Healthebay. "Home -Heal the Bay." Heal the Bay. N.p., n.d. Web. 03 Dec. 2016. <https://healthebay.org/>.

Mann, Paul. “Bacterial barrage washes ashore – test imminent for E. coli sources”. *Mad River Union.* 27 Aug. 2015. Web. 04 Dec. 2016. http://madriverunion.com/bacterial-barrage-wahses-ashore-tests-imminent-for-e-coli-sources/

Survey, USGS - U.S. Geological. "EarthExplorer." EarthExplorer. N.p., n.d. Web. 03 Dec. 2016. <http://earthexplorer.usgs.gov/>.

"Water Quality Test Results." Humboldt County Department of Health & Human Services. N.p., n.d. Web. 22 Oct. 2016. <https://humboldtgov.org/1696/Water-Quality-Test-Results>.