Fecal Coliforms in Antarctica

Part I - "McMurdo Station"

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Sally Freeley bounced in her seat as the C-130's powerful turboprops screamed to life, pulling the cargo plane down the runway. After months of planning, she checked her mental lists, knowing it was too late to go back. She took comfort in knowing her scientific equipment was secure in the hold. Sally was heading to Antarctica for the 2002 field season. Re-supply was impossible, so she needed everything in perfect order for the next three months of field work.

The brief austral summer is October through January. Only then does the midnight sun warm the coast to -15ºC (5ºF), balmy enough for a dedicated group of scientists to study the coldest continent on Earth. Scientists like Sally have alerted us to the growing hole in the ozone layer, discovered cold-loving life forms, and demonstrated the importance of polar oceans in global carbon and oxygen cycles.

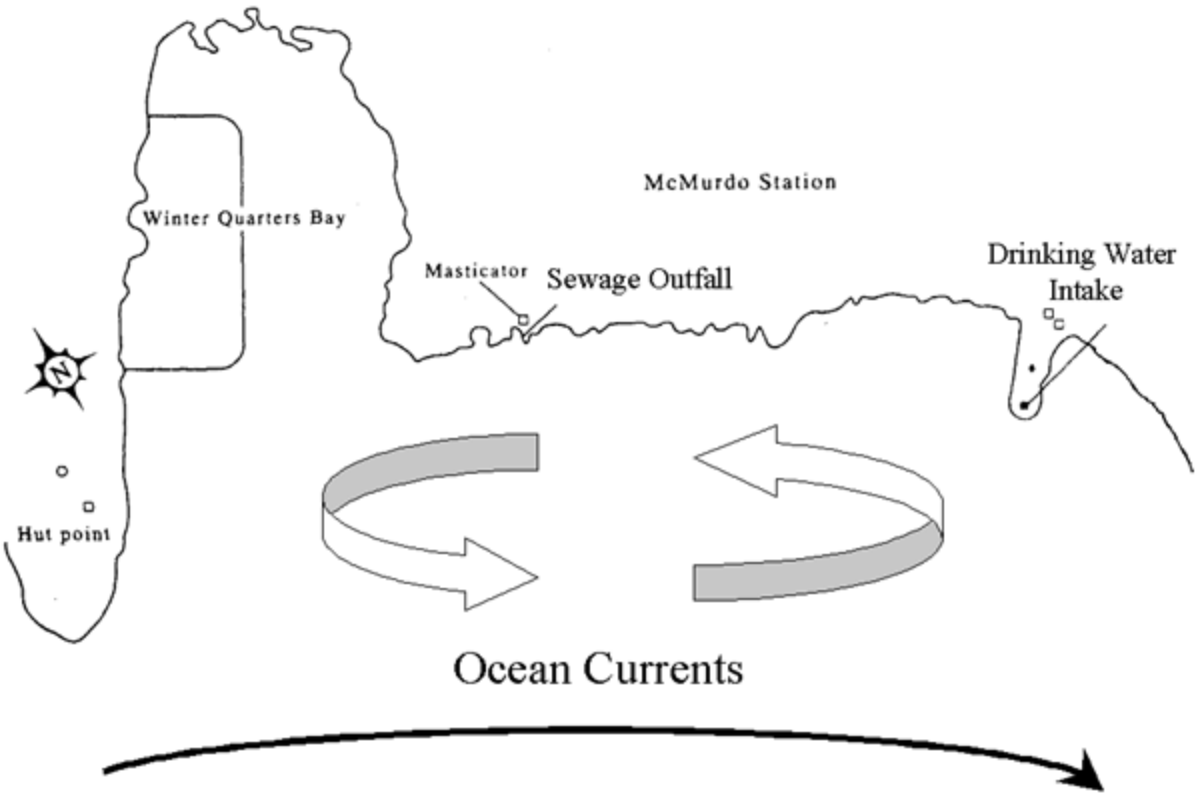
Sally would spend her next three months at McMurdo Station. This facility offers 1,100 seasonal scientists warm meals, a place to sleep, logistical support such as air and surface transportation, and laboratory space. Funded by the U.S. government, the National Science Foundation (NSF) oversees the management of McMurdo's daily operations.[1]

Several months before, Sally's boss had stopped outside her office. "Sally, I just got a call from NSF. The polar programs office is concerned about how McMurdo Station is managing its waste. It turns out that Greenpeace has been poking around the facility. Those environmentalists raised a big stink over McMurdo's sewage. They collected samples at the sewage outfall and claim that the U.S. is polluting the International waters of McMurdo Sound!"

Sally knew how to measure fecal coliforms, indicator bacteria that suggest the presence of pathogenic organisms from human waste. After researching the subject, she learned that raw sewage is collected from the housing and laboratory buildings and pumped to a masticator (literally, "chewer") that purees the sewage before a pipe carries it to the waters of McMurdo Sound. She also learned that ocean currents rarely mix water in the bay, so if they survived the ice-cold salt water (-1.8ºC)[2], fecal contaminants could accumulate, posing health risks to Antarctic researchers and polluting pristine waters.

"What can we do to help?" Sally asked.

"We need to get down there pronto. I'd like to provide background data so we can make some informed decisions," was the reply.



Questions

1. Why is Greenpeace concerned that McMurdo Station is releasing raw sewage into McMurdo Sound?
2. What type of sampling scheme would you design to see how much of McMurdo Sound is contaminated by fecal bacteria?
3. What are the potential outcomes of the sampling scheme you designed?
4. What experimental controls did you include? Why?

References

1. "McMurdo Station," http://www.nsf.gov/od/opp/support/mcmurdo.htm. [A National Science Foundation publication that describes McMurdo Station operations.]

2. McFeters, G.A., Barry, J.P., and J.P. Howington. Distribution of enteric bacteria in Antarctic seawater surrounding a sewage outfall. 1993. *Water Research* 27:645-650. [The original citation from which this case grew.]

Image Credit: The National Science Foundation's main office in McMurdo, known as the Chalet. NSF photo by Peter West.
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Part II - "Counting Environmental Bacteria"

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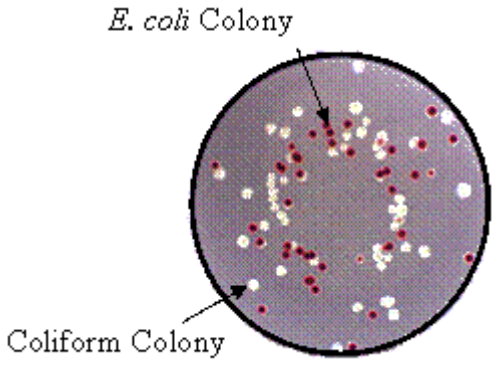
Bacteria are everywhere—on our skin, in our food, suspended in our drinking water. Although the microbial majority is benign, a few bacterial species can make us sick. To safeguard against food- and water-borne disease, microbiologists routinely screen our drinking water for bacterial pathogens.

Animal feces contain **coliform bacteria**, microorganisms that inhabit the intestines of warm-blooded animals. Many coliform bacteria are also found on plants and in soil and water. Coliform bacteria are not pathogens themselves, but their presence indicates the possibility of finding pathogens. In contrast, **fecal coliform bacteria** such as *Escherichia coli* are found in feces, and their presence in drinking water indicates fecal contamination. *E. coli* can also be a pathogen itself, so if *E. coli* is found in drinking water there is a good chance that other pathogens are present, too.[1]

To detect *E. coli* and other coliform bacteria, microbiologists filter water samples and place the filter in a Petri dish containing growth medium such as Endo agar. Microorganisms from the water grow and form colonies, giving an estimate of the number of bacteria in each milliliter of water.

While *E. coli* forms colored, shiny colonies on Endo agar, other coliforms grow as white or clear colonies.



Dark colonies = *E. coli*
White/clear colonies = coliform bacteria
White + Dark colonies = total coliform bacteria

The guidelines of maximum allowable limits for total coliforms in drinking and recreational waters vary by state. Representative limits appear in the table below.[2, 3, 4]

Table 1. Maximum allowable limits of fecal coliform bacteria (cells/100 ml)

	Total Coliforms	*E. coli*
Drinking Water	0	0
Recreational Waters	400	235

Questions

1. Why would we want to count the number of fecal coliforms in a water sample?
2. Do 400 coliforms per 100 milliliters strike you as very many?
3. How many other types of bacteria might be present in a normal water sample?
4. What problems might Sally encounter when she uses these techniques in Antarctica?

References

1. "Membrane Filter Method for the Simultaneous Detection of Total Coliforma and *E. coli* in Drinking Water," EPA 600-R00-013, http://www.epa.gov/nerlcwww/MI_emmc.pdf. [An EPA publication that describes the background and experimental protocol for a membrane filter fecal coliform detection method.]

2. "The Subcommittee on Water Resources and Environment Hearing on H.R. 3673, The Recreational Waters Protection Act," http://www.house.gov/transportation/water/05-01-02/05-01-02memo.html. [One resource suggesting a federal law governing minimum acceptable limits for fecal coliform contamination.]

3. "The Estimation of Bacterial Biomass in Mediterranean Seawater," http://www.cetiis.fr/mtp/qaps/BACFINL.html. [An estimate of total bacterial counts in Mediterranean seawater.]

4. "Public Health Tests Available to Wisconsin Citizens," http://www.slh.wisc.edu/ehd/citizens.html. [The fecal coliform and *E. coli* acceptable limits for swimming beaches from the State of Wisconsin.]

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Part III - "Data Prediction"

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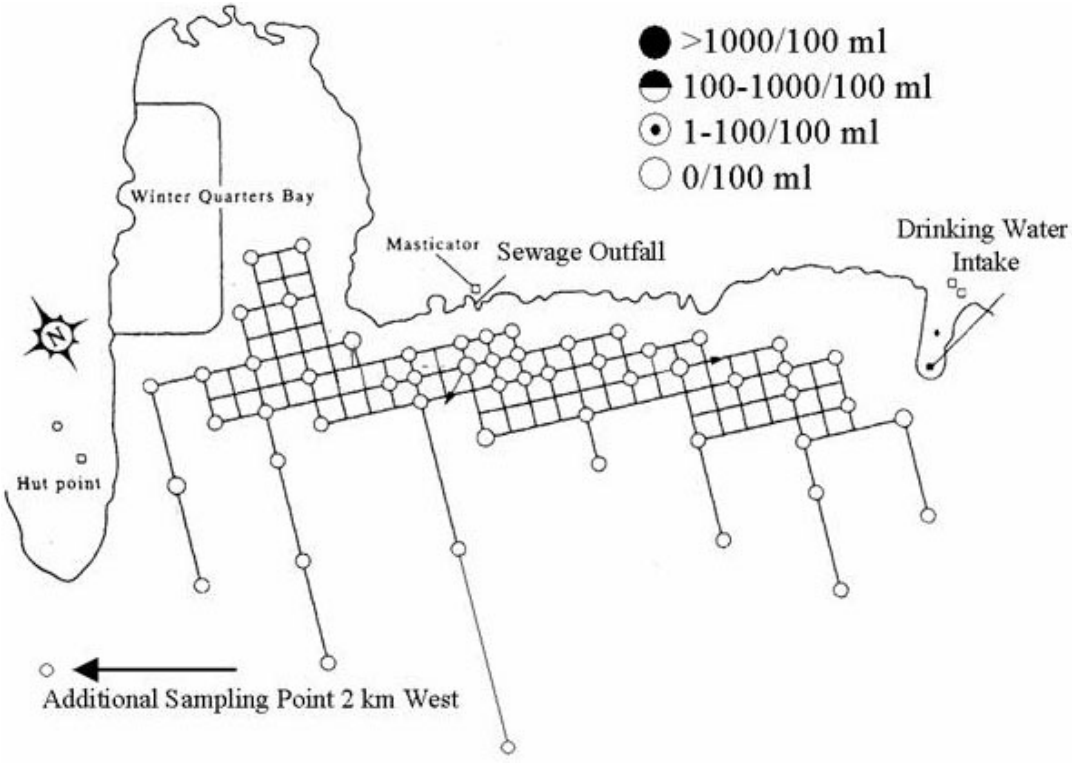
Sally had spent the day drilling 56 holes through two meters of sea ice to collect her water samples (see her sampling scheme below). Sally needed to quickly return to the station before her samples froze so she could filter the water, place the filters on Petri dishes, and incubate them. Right now, though, she needed help. The snow machine, her only transportation, wouldn't start in the bitter cold. She was three kilometers out and the temperature was quickly dropping. Luckily, the two-way was working when she called for helicopter support to bring her and her valuable samples to the lab. Two days later, Sally counted the colonies growing on her Petri dishes.



Questions

1. Why did Sally sample the sites you see on the map in the figure?
2. Using the scheme, fill in the sampling sites with the number of fecal coliforms you think Sally found.
3. What would you consider to be the "Action Level" of fecal coliform contamination in McMurdo Sound? At what levels would you like to see the National Science Foundation take remedial action?

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Part IV - "Decision Time"

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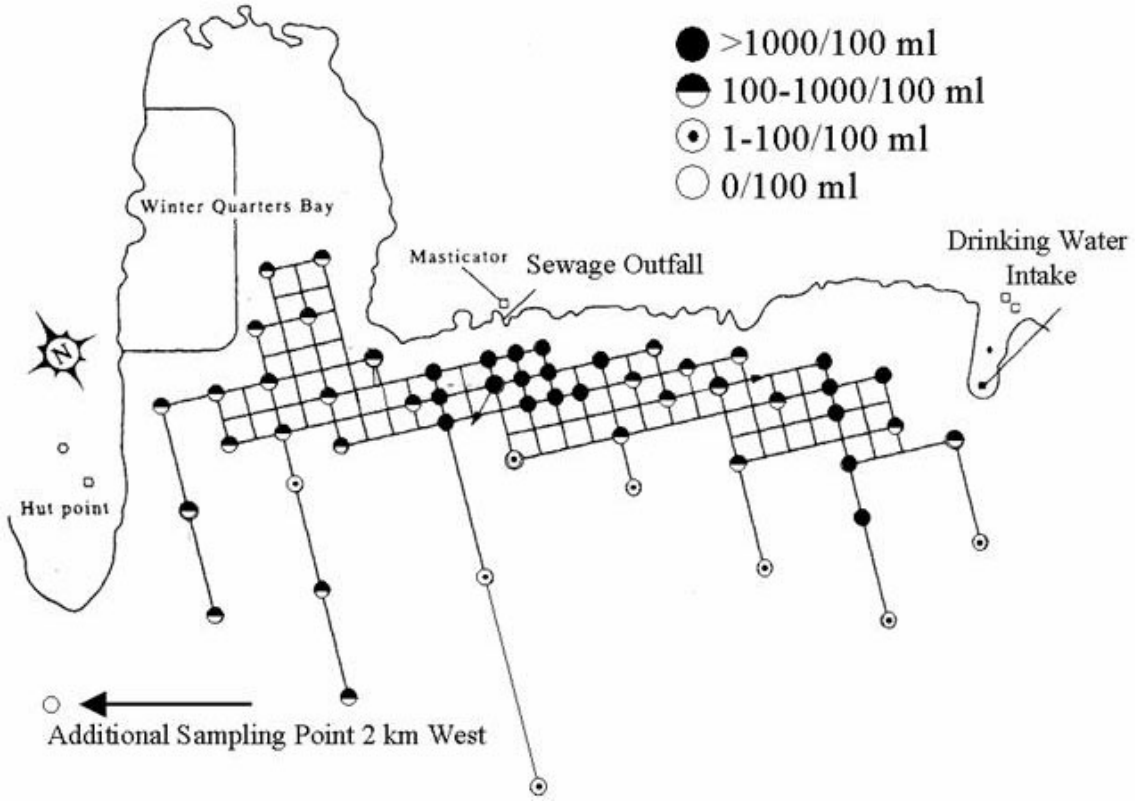
Sally's results appear below. From these she had to prepare her report in order to make a recommendation to the National Science Foundation. (These are actual results obtained from McMurdo Sound waters.[1])



Questions

1. What do you think Sally should recommend to the National Science Foundation?
2. What roles should scientists play in forming environmental policy?

References

1. McFeters, G.A., Barry, J.P., and J.P. Howington. Distribution of enteric bacteria in Antarctic seawater surrounding a sewage outfall. 1993. *Water Research* 27:645-650. [Maps were modified from original work from this citation.]