Bacterial and Protozoal Contamination of Nearshore Marine Environments

Rob Atwill, Veterinary Medicine, UC Davis
Patricia Conrad, Veterinary Medicine, UC Davis

SUMMARY

In this project, scientists show that coastal dairies can reduce pathogen pollution in runoff through a combination of inexpensive, adaptable management practices, such as by planting barley and rye grasses around lots holding young calves. The grasses help filter and trap pathogens and are called "vegetative buffer strips."

The project also demonstrates the utility of mussels in concentrating and hence detecting the fecal parasite *Cryptosporidium*. Sentinel mussels were used to show the sporadic yet widespread presence of the parasite in coastal Central California, irrespective of proximity to livestock runoff and/or human sewage.

M. Lennox/UC Davis

A dairy lot covered with straw and seeds to reduce pathogen pollution in storm runoff.

PROJECT

Water quality was monitored at 35 high-density lots at five dairies above Tomales Bay for two years. Cattle densities at these lots ranged from 5 to 309 animals per hectare, the average being 104.

About 350 water samples were collected on-site and in runoff generated by 13 winter storms. All samples were tested for the parasites *Giardia duodenalis* and *Cryptosporidium* spp., known to cause diarrhea in mammals, including humans, and for fecal coliform bacteria. The goal was to identify factors that might contribute to, alleviate, or have no bearing on pathogen pollution in runoff.

Farming characteristics examined for the study included lot size, cattle density, lot slope, and ages of cattle on a lot, among other things. Farm practices hypothesized to be able to trap and filter pathogens in runoff under normal precipitation patterns included: planting buffer strips; mulching with straw; applying seeds to the ground; removing manure prior to rainfall; and bringing animals indoors during part of the winter.

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A vegetative buffer strip below a dairy reduces pathogen pollution in runoff.

The project also sought to provide a broad overview of the scope of *Cryptosporidium* contamination along Central California. To do this, scientists planted 150 batches of mussels (each batch contained 30 animals) around Tomales, Monterey and Estero bays, at sites where researchers expected coastal water quality to be affected by either cattle waste, human sewage or neither of these. Mussels were analyzed for *Cryptosporidium* using immunomagnetic separation, fluorescent assays and DNA methods.

FINDINGS

Giardia

Giardia cysts were detected in runoff from all five dairy farms. The factor most predictive of *Giaridia* contamination was proximity to very young calves. Specifically, cysts were detected in 41 percent of samples collected near calves less than 2 months old and in only 10 percent of samples near calves older than 6 months. Planting barley and rye grasses in buffer strips to prevent flows into tributaries greatly diminished pathogen pollution. A 10 meter-wide buffer strip was shown to decrease *Giardia* loads by a factor of 10 (i.e., from almost 10,000 cysts per second to less than 1,000 cysts per second in runoff from areas holding calves). Interestingly, other low-cost farm practices (e.g., mulching with straw, sprinkling seeds on the ground and/or removing manure before rainstorms) were less effective at reducing *Giardia* contamination.

Cryptosporidium

Cryptosporidium cysts were detected in runoff at four of the five farms but in only 21 percent of the stormwater samples. As observed with *Giardia*, calves less than 2 months old were a source of *Cryptosporidium*. The pathogen was detected in 59 percent of water samples collected near these calves, compared with only 10 percent for calves older than 6 months. The size of the dairy

lot and the number of animals on it did not influence the presence or intensity of *Cryptosporidium* contamination. Perhaps surprisingly, planting buffer strips and mulching with straw prior to rain reduced pathogen pollution more than moving cattle indoors and removing manure before a storm.

Fecal Coliform

Reductions in fecal coliform bacteria were achieved by moving cattle indoors during the rainy season; locating high-use areas on level ground (to reduce flows into tributaries); mulching with straw and applying seeds, and planting buffer strips around lots. Similar to results for the protozoal study, wider and longer buffer strips led to increased reductions in coliform bacteria in runoff.

Mussels

Experiments with mussels show that the bivalves concentrate and purge parasites over a period of days and weeks. A variety of *Cryptosporidium* genotypes were found in mussels, especially those exposed to high freshwater outflows (i.e., rivers and storm drains). Genotypes detected include: *Cryptosporidium parvum*, shed by mammals (including people); *C. felis*, primarily shed by cats; *C. andersoni*, primarily shed by cattle, and two novel *Cryptosporidium* spp. with unknown hosts. Notably, the protozoan was detected at sites believed to be at both low and high risk of fecal contamination — a pattern underscoring the widespread distribution of fecal pollution along the coast.

OUTREACH

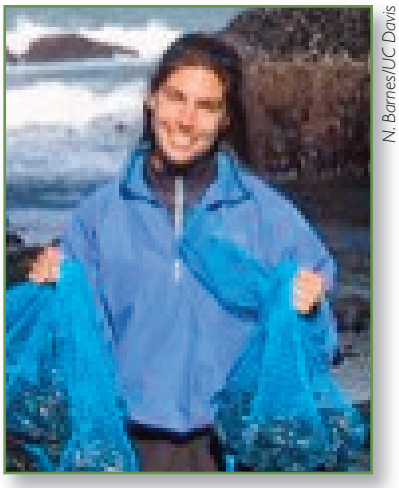
Stakeholders' meetings to discuss the studies were held in Morro Bay and Tomales Bay. Attendees included extension personnel, farmers, shellfish growers, California Department of Fish and Game staff, Central Coast Regional Water Quality Board members and sewage plant operators. Project updates were provided to the Tomales Bay Agricultural Producers Group, Watershed Council, and Shellfish Technical Advisory Committee. Study results also have been presented at national and international meetings, and published in peer-reviewed journals.

IMPACTS

A dozen coastal dairies have implemented some of the best management practices developed during this project. Findings also have relevance to the Tomales Bay Pathogen Total Maximum Daily Load and subsequent Conditional Waiver for Grazing Lands in the Tomales Bay Watershed, which establishes ambient water-quality standards for fecal coliform bacteria to protect public health. The regulations call for implementing management practices, including those at dairies for reducing pathogen pollution into the bay, which is a regional center of shellfish aquaculture.

STUDENT

Woutrina Miller, Ph.D.



N. Barnes/UC Davis

Former Sea Grant Trainee Woutrina Miller holds batches of mussels placed in the field to collect pathogens.

PUBLICATIONS

Lewis, D.J., E.R Atwill, M.S. Lennox, M.D.G. Pereira, W.A. Miller, P.A. Conrad, and K.W. Tate. Management of microbial contamination in storm runoff from California coastal dairy pastures. 2010. J. Environ. Qual. In press.

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CONTACT:

Rob Atwill
Environmental Animal Health and Medical Ecology
Veterinary Medicine
UC Davis
530 754-2154
ratwill@ucdavis.edu

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California Sea Grant, University of California, San Diego, 9500 Gilman Drive, Dept. 0232, La Jolla, CA 92093-0232
Communications Phone: 858-534-4440