Fecal pathogen pollution: sources and patterns in water and sediment samples from the upper Cook Inlet, Alaska ecosystem


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Background

Concerns

- CI region - major urban center in Alaska, > 435,000 people (2/3 state’s pop), fastest growing region in the state

- Communities discharge treated wastes into upper CI (1 primary treatment, 2 secondary)

- Ecology and sources of fecal microbes in nearshore aquatic environments within CI

- By virtue of their habitat and dietary preferences, CIB may be exposed to potential pathogens

- Human and domestic animal health (??)
Background

- Asplund – primary thru EPA under auspices of Clean Water Act
- Eagle River & Girdwood – secondary treatment thru ADEC
- EPA evaluating AWWU application for reauthorization of the modified permit (CWA criteria)
- EPA consult with NMFS to reauthorize discharge into inlet from Asplund
- Effects of permit reauthorization on endangered species
- NOAA contract SAN to investigate presence of fecal pathogens in water/sed
- SAN developed into dissertation project (UC Davis and NOAA)
Background

- Water supplies vulnerable to:
  - Bacteria
  - Viruses
  - Volatile organic compounds
  - Heavy metals
  - Inorganic/synthetic organic compounds

- Potential sources:
  - Agriculture
  - Business
  - Industry/storage tanks
  - Transportation
  - Resource extraction
  - Wildlife
  - Recreation (Dog parks)
  - Campgrounds
  - Leaking septic tanks

Flyer from Anchorage park-wide clean-up (Sept. 2012)
Aim

- Investigate the presence and distribution of potentially pathogenic fecal organisms in environmental samples - 8 sites - upper CI

Hypotheses

- Environmental factors: late summer, urban location, sediment matrix, estuarine water, warmer water temperature (greater than 13°C), and recent precipitation (7 days prior)

- Wastewater effluent equal likelihood of having human and animal
Project design and methods
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- Matched water and sediment samples - 8 sites (1 marine, 1 fresh, 6 estuarine) (June and August 2011)

- Fresenius filtration of 20L water samples to ~180-250ml

Photo: S. Norman
Potential pathogens

- *Vibrio* spp.
- *Cryptosporidium* spp.
- *Giardia* spp.
- *Salmonella* spp.
- Norovirus

Fecal indicators

- *Enterococcus* spp.
- Fecal coliforms
- Microbial source tracking organisms
  - *Bacteroidales* spp.
  - *Catellicoccus* spp.
- Concentration of host source markers

Chester Creek, Anchorage
Photo: S. Norman
Project design and methods

Analyses

- **Descriptive**
  Overall pathogen prevalences for each sample
  Concentrations of fecal indicator counts (*Enterococcus* and fecal coliforms)

- **Modeling**
  Outcome = Presence of organism (yes/no) of each sample
  Predictors = Environmental factors (yes/no)
  Assessed association of each factor with organism presence

Results of *Enterococcus* testing.
Photo: S. Norman
Results

Potential pathogens

- *Vibrio* spp., *V. alginolyticus* *V. fluvialis*, detected most often (sediment > water - both months)
- *Giardia* prevalence > *Cryptosporidium* overall and matrix type
- *Cryptosporidium* not observed in sediment
- Norovirus – detected in water, but not sediment
- Water 10x > sediment to be + for protozoa

Fecal indicators

- Microbial source tracking (*Bacteroidales*) => human
- MST in water: human, canine; sediment: human, livestock
- 3 marker types each in effluent and Goose Creek
- *Enterococcus* counts – within water quality standards state of AK
- Fecal coliforms significantly higher in sediment than water
- Detection of + *Bacteroidales* marker was significantly associated with August and recent precipitation
Results

Fecal indicator counts

- **Sample month**
  - June
  - August

- **Sample matrix**
  - Water
  - Sediment

- **Sample location**
  - Rural
  - Urban

- **Recent precipitation**
  - No
  - Yes
Limitations

- Cross-sectional study – 2 points in time
- Dilution effect (detection limits of assay)
- Smaller sample size ($n = 41$)
- Logistical challenges – sample quality
Conclusions/Implications

- Documented organisms known to be potentially pathogenic
- Fecal pathogens appeared to derive most commonly from humans & dogs
- Exposure to terrestrial source pathogens should be considered potential threat for belugas, humans and other animals in CI region
- Exposure to fecal pathogens influenced by climatic & human factors
- Better refine critical habitat designation
- Inform public health agencies & state
- Incorporate epidemiological tools into conservation of endangered species
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Photo: S. Norman
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Fecal pathogens are transported from a variety of sources in multiscale ecosystems such as upper Cook Inlet (CI), Alaska, which includes the state’s urban center and is highly utilized by humans and animals. This study used a novel water quality testing approach to evaluate the presence and host sources of potential fecal pathogens in surface waters and sediments from aquatic ecosystems in upper CI. Matched water and sediment samples, along with effluent from a municipal wastewater treatment facility, were screened for Salmonella spp., Vibrio spp., Cryptosporidium spp., Giardia spp., and noroviruses. Additionally, Bacteroidales spp. for microbial source tracking, and the fecal indicator bacteria Enterococcus spp. as well as fecal coliforms were evaluated. Overall, Giardia and Vibrio were the most frequently detected potential pathogens, followed by Cryptosporidium and noroviruses, while Salmonella was not detected. Sample month, water type, and recent precipitation were found to be significant environmental factors for protozoa or host-associated Bacteroidales marker detection, whereas location and water temperature were not. The relative contribution of host-associated markers to total fecal marker concentrations was estimated using a Monte Carlo method, with the greatest relative contribution to the Bacteroidales marker concentration coming from human sources, while the remainder of the universal fecal host source signal was characterized by available host-associated assays, consistent with wildlife fecal sources. These findings show both fecal indicator and pathogen monitoring, along with identifying contributing host sources, can provide evidence of coastal pathogen pollution and guidance as to whether to target human and/or animal sources for management.

Introduction
The Cook Inlet (CI) watershed covers 47,000 square miles of southwestern Alaska that drains into Cook Inlet.* The CI region is the major urban center in Alaska, with over 435,000 people, or approximately 2.5% of the state’s population, residing in the watershed, and is the fastest growing region in the state.* With CI communities and the endangered CI beluga (Delphinapterus leucas) population dependent on a healthy watershed for sustainability, concern has grown among stakeholders regarding the inlet’s water quality as it pertains to human health and that of wildlife inhabiting this region. The presence of potential pathogens, introduced from terrestrial sources,