The effects of precipitation, river discharge, land use and coastal circulation on water quality in coastal Maine

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Review History
RSOS-140429.R0 (Original submission)

Review form: Reviewer 1

Is the manuscript scientifically sound in its present form?
Yes

Are the interpretations and conclusions justified by the results?
Yes

Is the language acceptable?
Yes

Is it clear how to access all supporting data?
Yes

Do you have any ethical concerns with this paper?
No

Have you any concerns about statistical analyses in this paper?
No

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Recommendation?
Accept with minor revision (please list in comments)

Comments to the Author(s)
RSOS-140429
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Specific comments:

In a few instances, correlation and causation are intermingled. For example, in the abstract, it is stated that several parameters “have significant effects on water quality.” Also, in the introduction, it is stated that physical mechanisms “may be responsible for reduced water quality.” The ultimate cause of reduced water quality is the sewage input; coastal processes merely concentrate or disperse the contaminant.

There are a few instances of questionable language. In the introduction (line 90-91), the language “resulting in unsafe water conditions” might be changed instead to “resulting in exposure to contaminated water”. ‘Unsafe’ doesn’t fully describe the condition here.

The introduction paragraph starting on line 87 is quite a mishmash of information; consider reorganizing or splitting.

The description of the statistical models needs some clarity. In the decision model, were only high discharge/high fecal coliforms selected?

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‘model skill’ (line 570) should be changed to ‘model outcome’

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The figures that include water quality stations for the Kennebec and Androscoggin are difficult to interpret, given the complex landform. Is there a way to improve these, visually?

Review form: Reviewer 2

Is the manuscript scientifically sound in its present form?
Yes

Are the interpretations and conclusions justified by the results?
Yes

Is the language acceptable?
Yes

Is it clear how to access all supporting data?
NA

Do you have any ethical concerns with this paper?
No

Have you any concerns about statistical analyses in this paper?
No

Recommendation?
Accept as is

Comments to the Author(s)
The manuscript is well written, and the data/statistical analyses were soundly presented. Suggest please fix a few editorial problems, e.g. L45 "similar that of..." and the y-axis for Figure 9.

Decision letter (RSOS-140429)

11-May-2015

Dear Dr Tilburg,

The Subject Editor assigned to your paper ("The effects of precipitation, river discharge, land use and coastal circulation on water quality in coastal Maine") has now received comments from reviewers. We would like you to revise your paper in accordance with the referee and Subject
Editor suggestions which can be found below (not including confidential reports to the Editor). Please note this decision does not guarantee eventual acceptance.

Please submit a copy of your revised paper within three weeks (i.e. by the 03-Jun-2015). If we do not hear from you within this time then it will be assumed that the paper has been withdrawn. In exceptional circumstances, extensions may be possible if agreed with the Editorial Office in advance. We do not allow multiple rounds of revision so we urge you to make every effort to fully address all of the comments at this stage. If deemed necessary by the Editors, your manuscript will be sent back to one or more of the original reviewers for assessment. If the original reviewers are not available we may invite new reviewers.

To revise your manuscript, log into http://mc.manuscriptcentral.com/rsos and enter your Author Centre, where you will find your manuscript title listed under "Manuscripts with Decisions." Under "Actions," click on "Create a Revision." Your manuscript number has been appended to denote a revision. Revise your manuscript and upload a new version through your Author Centre.

When submitting your revised manuscript, you must respond to the comments made by the referees and upload a file "Response to Referees" in "Section 6 - File Upload". Please use this to document how you have responded to the comments, and the adjustments you have made. In order to expedite the processing of the revised manuscript, please be as specific as possible in your response.

In addition to addressing all of the reviewers' and editor's comments please also ensure that your revised manuscript contains the following sections before the reference list:

- **Ethics statement**
  If your study uses humans or animals please include details of the ethical approval received, including the name of the committee that granted approval. For human studies please also detail whether informed consent was obtained. For field studies on animals please include details of all permissions, licences and/or approvals granted to carry out the fieldwork.

- **Data accessibility**
  It is a condition of publication that all supporting data are made available either as supplementary information or preferably in a suitable permanent repository. The data accessibility section should state where the article's supporting data can be accessed. This section should also include details, where possible of where to access other relevant research materials such as statistical tools, protocols, software etc can be accessed. If the data has been deposited in an external repository this section should list the database, accession number and link to the DOI for all data from the article that has been made publicly available. Data sets that have been deposited in an external repository and have a DOI should also be appropriately cited in the manuscript and included in the reference list.

- **Competing interests**
  Please declare any financial or non-financial competing interests, or state that you have no competing interests.

- **Authors’ contributions**
  All submissions, other than those with a single author, must include an Authors’ Contributions section which individually lists the specific contribution of each author. The list of Authors should meet all of the following criteria; 1) substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data; 2) drafting the article or revising it critically for important intellectual content; and 3) final approval of the version to be published.

All contributors who do not meet all of these criteria should be included in the acknowledgements.
We suggest the following format:
AB carried out the molecular lab work, participated in data analysis, carried out sequence alignments, participated in the design of the study and drafted the manuscript; CD carried out the statistical analyses; EF collected field data; GH conceived of the study, designed the study, coordinated the study and helped draft the manuscript. All authors gave final approval for publication.

• Acknowledgements
Please acknowledge anyone who contributed to the study but did not meet the authorship criteria.

• Funding statement
Please list the source of funding for each author.

Once again, thank you for submitting your manuscript to Royal Society Open Science and I look forward to receiving your revision. If you have any questions at all, please do not hesitate to get in touch.

Yours sincerely,
Emilie Aime
Senior Publishing Editor, Royal Society Open Science
openscience@royalsociety.org

Comments to Author:

Associate Editor's comments:
Associate Editor: 1
Comments to the Author:
Both referees are supportive of publication. Referee 1 makes an important point about clarifying causation and correlation in different parts of the MS that the authors need to deal and raises a few other editorial suggestions that need addressing.

Reviewers' Comments to Author:
Reviewer: 1

Comments to the Author(s)
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Reviewer: 2

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Author's Response to Decision Letter for (RSOS-140429)

See Appendix A.
Appendix A

Response to Reviewers:

Reviewer #1

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We have modified the text to reflect that the physical mechanisms are transporting the water containing the contaminants and the parameters examined in our study are correlated with variations in water quality.

“Analysis of a higher frequency, two-year study using multiple linear regression models revealed that precipitation, salinity, river discharge, winds, seasonality, and coastal circulation correlate with variations in water quality.” – lines 40-42

“In addition to precipitation and river discharge, other physical mechanisms may be responsible for the concentration or dispersal of pathogens in estuaries and the coastal ocean [20, 21].” – lines 77-79

There are a few instances of questionable language. In the introduction (line 90-91), the language “resulting in unsafe water conditions” might be changed instead to “resulting in exposure to contaminated water”. ‘Unsafe’ doesn’t fully describe the condition here.
We have modified the text to remove the questionable language and more accurately describe water quality and water conditions.

“Water quality may change during that time period [33], which could lead to inaccurate water quality advisories resulting in exposure to pathogens in the water or unnecessary closures.” – lines 96-98

The introduction paragraph starting on line 87 is quite a mishmash of information; consider reorganizing or splitting.

We have split the paragraph into three separate paragraphs and reorganized the information to be clearer to the reader.

“The threats to human health from pathogens have increased [10, 34]. Reductions in water quality after high precipitation events and the subsequent increases in river discharge have led local authorities to close beaches and shellfish beds after large events in coastal Maine [e.g. 35, 36] and other locations throughout north America [37, 38, 39]. The inability of local authorities to accurately predict these events or to immediately assess the water quality exacerbates the losses to fishing and tourist economies in these regions [37, 38, 39].

The need for accurate and timely predictions of water quality in the United States has become acute [11]. However, the testing for the presence of fecal bacteria is labor intensive and generally requires an 18-24 hr. period for sample incubation. Water quality may change during that time period [33], which could lead to inaccurate water quality advisories resulting in exposure to pathogens in the water or unnecessary closures.

The reliance on a single parameter for the prediction of water quality can be problematic, requiring more complex, predictive models. Sampson et al. [40] found no relation between rainfall events and fecal bacteria at Lake Superior recreational beaches. Studies have examined various inputs on water quality using partial least squares regression models [42], artificial neural networks [4], and multiple linear regression models [3, 43]. Although there has been extensive development of predictive models for freshwater [e.g. 3, 43, 44], applications to marine waters have been limited [e.g. 4, 42, 45]. “ – lines 87-106
The description of the statistical models needs some clarity. In the decision model, were only high discharge/high fecal coliforms selected?

We examined the effect of both high discharge and high precipitation events on high fecal coliforms. We have modified the text to make this clearer to the reader.

“The relationships between water quality and the hydrometeorological parameters of the region were examined by (1) a decision model that linked high river discharge events with Reduced Water Quality Events (RWQEs) during Study I, (2) a decision model that linked high precipitation events with RWQEs during Study I...” – lines 227-230

“The decision models allowed us to test the hypotheses that a RWQE (defined as the time when fecal coliforms within a sample exceeded 14 colonies /100mL, which is the maximum allowable value for shellfish growing areas for the state of Maine [52]) occurs within a set period of time after a high discharge event or after a high precipitation event within the watershed.” – lines 242-246

On line 255, the wording ‘resulting in no unnecessary exposure to waterborne diseases’ is not quite accurate. First, the presence of fecal coliform bacteria does not guarantee that there is a sewage source because fecal coliform bacteria are present in a variety of natural environments. Second, the presence of fecal coliforms does not guarantee the presence of pathogens or waterborne disease. The authors may want to change the language to indicate an increased potential for pathogens.

We have modified the text to remove the inaccurate language and more accurately describe the use of the model to examine the presence of fecal coliform bacteria and the potential presence of waterborne pathogens.

“A perfect model would predict all RWQEs, resulting in no exposure to fecal coliforms and potential pathogens (or Type II errors [53]), and produce no false alarms or unnecessary closures of the region.” – lines 255-257
The model results are surprisingly good! Some models had an R2 of 0.76, which is much higher than I would anticipate.

*The model results are good! However, the high correlations are not unprecedented. We have compared these values to other studies and found that they are consistent with previous examinations of other mechanistic water quality models.*

“Several studies of beaches on Lake Michigan [3, 20, 43] found correlation values between their various models and *E. coli* concentrations that ranged from 0.56 to 0.84.” – lines 587-589

The input of EC from another location (see lines 423-424) increased the explanation of variation in the model, but this does not improve timeliness of results because it still requires bacteria culturing. This should be noted.

*Agreed. We have added text to reflect the limitations of the model.*

“Although the inclusion of total coliform and *E. coli* concentrations from upstream increased the ability of the model to explain the variance of downstream stations, it would not improve the immediate utility of this particular model since acquiring this information still requires culturing bacteria. However, because the ultimate source of fecal contamination at Saco is largely point-source discharge from combined sewer overflows, empirical measurement of indicator bacteria at this location might be replaced with another regression model that predicted discharges as a function of recent and historical precipitation.” – lines 606-613

The influence of season on the Saco River watershed is notable. Do the authors have any comments on the overwhelming importance of this in the model?
We have added text to better describe possible reasons for the strong influence of season on the water quality in the region.

“The strong seasonal signals of the *E. coli* and total coliform concentrations within the Saco River and near the mouth of the Scarborough River are consistent with temporal variations in the population of the area. The lag times for the seasonal signal (Eqn. 2) range from 171 to 269 days (Tables 4 & 5), resulting in peak values for the seasonal signal that range from June 21 to September 27, which encompass the summer season when the population of southern Maine increases due to an influx of tourists (and the associated sewage outflow is greatest).” – lines 523-529

‘model skill’ (line 570) should be changed to ‘model outcome’

Done.

The figures that include water quality stations for the Kennebec and Androscoggin are difficult to interpret, given the complex landform. Is there a way to improve these, visually?

*Unfortunately, our attempts at modifying the figures have not resulted in clarity. We are confident that the figures are able to represent the information required [although we do agree that the figures can be somewhat difficult to interpret].*

**Reviewer #2**

The manuscript is well written, and the data/statistical analyses were soundly presented. Suggest please fix a few editorial problems, e.g. L45 "similar that of..." and the y-axis for Figure 9.

*Done.*