Adaptation of a Weighted Regression Approach to Evaluate Water Quality Trends in Tampa Bay, Florida

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May 1, 2014
Change over time is apparent – we have the data but often lack tools to unambiguously and quantitatively characterize
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Data without models are chaos, but models without data are fantasy.

– NWQMC 2014 plenary, R. Hirsch via [Nisbet et al., 2014]
Tampa Bay, Florida
A model system

Second largest estuary on the Gulf Coast

- Four bay segments
- Monthly wq data at 50 stations from 1974 to present

Data from [TBEP (Tampa Bay Estuary Program), 2011]
Figure: Annual trends in chlorophyll for each bay segment.
What affects our interpretation of chlorophyll response to nutrients?

Figure: Variation in chlorophyll by (a) salinity, (b) season, and (b) year in Hillsborough Bay. Panel (a) shows the relationship between salinity and chlorophyll before and after wastewater treatment in 1979.
Study objective

Adapt and apply nutrient response model for estuaries that leverages the descriptive capabilities of large datasets
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Questions of management concern – Can we...
- ...provide a natural history of water quality that is temporally consistent with drivers of change?
Analysis approach
Objectives and questions of management interest

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Questions of management concern – Can we...

- ...provide a natural history of water quality that is temporally consistent with drivers of change?
- ...characterize changes in extreme events in addition to describing the mean response?
- ...improve our understanding of the nutrient-response paradigm in estuaries?
The weighted regression (WRTDS) model is being developed by USGS for pollutant modelling in fluvial systems [Hirsch et al., 2010]

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**WRTDS functional form**

\[ \ln (c) = \beta_0 + \beta_1 t + \beta_2 \ln (Q) + \beta_3 \sin (2\pi t) + \beta_4 \cos (2\pi t) + \epsilon \]
Weighted regression approach
Adaptation to estuaries

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Logical extension to estuary eutrophication

Adapted functional form

$$\ln (Chl) = \beta_0 + \beta_1 t + \beta_2 Sal_{ff} + \beta_3 \sin (2\pi t) + \beta_4 \cos (2\pi t) + \epsilon$$
Weighted regression approach

Adaptation to estuaries

Flexibility through weighted parameterization - a moving window

January 1990, $Sal_{ff}$ 0.26

January

1990

Weights

$Sal_{ff}$ 0.26

All
Weighted regression approach
Adaptation to estuaries

Flexibility through weighted parameterization - a moving window

May 1992, $Sal_{ff} \ 0.21$

$Sal_{ff}$

Weights

$Sal_{ff} \ 0.21$

All

M. Beck (ORISE) Weighted regression for Tampa Bay  May 1, 2014
Weighted regression approach
Adaptation to estuaries

Flexibility through weighted parameterization - a moving window

September 1994, $Sal_{ff} 0.37$

Weights

$Sal_{ff} 0.37$

All
Weighted regression approach
Adaptation to estuaries

Flexibility through weighted parameterization - a moving window

January 1997, $Sal_{ff} \ 0.18$

Weights

$Sal_{ff} \ 0.18$

All

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Adaptation to estuaries

Flexibility through weighted parameterization - a moving window

August 2001, \( Sal_{ff} 0.35 \)

Weights

August

2001

\( Sal_{ff} 0.35 \)

All

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Weighted regression for Tampa Bay

May 1, 2014
Weighted regression approach

Adaptation to estuaries

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December 2003, $Sal_{ff} 0.24$

Weights

$Sal_{ff} 0.24$

All

December

2003

1990−01 2010−12

1990−01 2010−12
Weighted regression approach
Adaptation to estuaries

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April 2006, $Sal_{ff} 0.07$

Weights

$Sal_{ff} 0.07$

All

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Weighted regression approach

Adaptation to estuaries

Flexibility through weighted parameterization - a moving window
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December 2010, $Sal_{ff} 0.17$

Weights

$Sal_{ff} 0.17$

All
Weighted regression approach
Results for Tampa Bay

Provides internally consistent estimates of change independent of confounding variables – improved precision

Figure: Predicted and observed monthly chlorophyll by segment.
## Weighted regression approach

Results for Tampa Bay

**Table:** Fit statistics by bay segment comparing non-weighted and weighted regression.

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</tr>
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</table>
Weighted regression approach

Results for Tampa Bay

Results can also be normalized by predictors – salinity

Figure: Predicted and salinity-normalized annual chlorophyll by segment.
Weighted regression approach
Conclusions for Tampa Bay

What new information is obtained from the results?

- Trends generally followed observed chlorophyll – but increased clarity in the description

- Mean response does not show the whole picture – frequency of ‘high’ or ‘low’ chlorophyll events could be changing
Weighted regression approach

Conclusions for Tampa Bay

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- Trends generally followed observed chlorophyll – but increased clarity in the description
- Mean response does not show the whole picture – frequency of ‘high’ or ‘low’ chlorophyll events could be changing

How can this information be used?

- More detailed evaluation of trends allows greater insight into drivers of change
- The model parameters show us a picture...
Weighted regression approach

Conclusions for Tampa Bay

Changes in model parameters help generate hypotheses

Figure: Relationship between chlorophyll and salinity by decade and bay segment. Y-axis is expected changes in chlorophyll for a given salinity.
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