



Invited feature

Whole truths vs. half truths – And a search for clarity in long-term water temperature records

R.W. Fulweiler^{a,*}, A.J. Oczkowski^b, K.M. Miller^c, C.A. Oviatt^d, M.E.Q. Pilson^d^a Department of Earth and Environment, Department of Biology, Boston University, 685 Commonwealth Ave. Boston, MA 02215, USA^b United States Environmental Protection Agency, USA^c CSC, Science, Engineering, and Mission Support, USA^d Graduate School of Oceanography, University of Rhode Island, USA

ARTICLE INFO

Article history:

Accepted 24 January 2015

Available online 10 February 2015

Keywords:

climate

long-term changes

water temperature

temporal variations

long-term records

ABSTRACT

There is widespread acceptance among the scientific community that human activities are the primary cause of present day climate change. But, how a changing climate impacts ecosystems is still a source of confusion to the public. Some of this confusion is associated with a lack of clear communication among journalists and scientists, particularly when it comes to addressing variability and uncertainty in ecological datasets. Here we use long-term surface water temperature data sets from Narragansett Bay and a recent misunderstanding of long-term temperature data that occurred on the national stage as a case study. Specifically, we re-evaluate and update the record and examine the variability inherent in long-term data sets. We found that despite high year to year variations the surface waters of Narragansett Bay have increased between 1.4 °C to 1.6 °C total rise over the last fifty years. Winter warming has been especially high over this time period, increasing between 1.6 °C to 2.0 °C. Finally, we identify the need for scientists, politicians, and journalists to appropriately address data variability and we argue for increased communication among these groups.

© 2015 Elsevier Ltd. All rights reserved.

Editor's note

As the public and decision-makers increasingly become aware of local and global environmental change, it is necessary for the environmental research and education community to communicate and transfer information as accurately and transparently as is possible. It is both a matter of clear initial exposition of the actual facts—including education of the various stakeholder sectors—, and prevention (and, unfortunately, too often) post-hoc correcting misunderstandings of what the facts are.

In the Invited Feature Article in this issue, Fulweiler and colleagues review high quality temperature records for a well-studied coastal bay, and furnish a clear instance of information transfer on an issue that had become garbled in the process of earlier communication: whether or not waters of Narragansett Bay had become warmer during recent decades.

1. Introduction

As the global population hits 7 billion there can be little doubt that our presence has had a lasting impact on the biosphere. Human activities have modified over 50% of Earth's land surface (Hooke et al., 2012), we appropriate 24% of the Earth's net primary production (Haberl et al., 2004), and we have doubled the amount of biologically reactive nitrogen circulating through the biosphere (Fowler et al., 2013). These activities and many more have convinced some scientists that we are now in a geologic epic known as the Anthropocene (Crutzen, 2002). One of the most profound changes has been an increase in atmospheric levels of greenhouse gases and the subsequent warming of the planet. Importantly, there is a strong consensus, with 97% of climate researchers agreeing, that the majority of Earth's warming is driven by anthropogenic greenhouse gas emissions (Anderegg et al., 2010).

Long-term trends in temperature are based on terrestrial and aquatic palaeoclimate data with time scales from decades to millions of years. According to the most recent Intergovernmental Panel on Climate Change (IPCC) report these proxy data show that temperature in the latter half of the 20th century are *very likely* higher than any period over the last 500 years and *likely* highest in the last 1300

* Corresponding author.

E-mail address: rwf@bu.edu (R.W. Fulweiler).

years (IPCC, 2013). Most recently, Marcott et al. (2013) reported that over the last decade global temperatures have yet to exceed peak interglacial values but that the last decade has been warmer than 75% of the Holocene temperature record. The instrumental record of air temperature is much shorter but exhibits a 0.76°C (0.57°C – 0.95°C) total increase between 1850–1899 and 2001–2005 (IPCC, 2013). Likewise, ocean water temperatures have increased. The ocean global volume mean temperature increase between the surface and 300 m depth was 0.31°C from the mid-1950s to the mid-1990s (Levitus et al., 2000). While more recent temperature trends have seen a “pause” in the rate of surface land and ocean temperature increase this apparent slowdown has been attributed to significant temperature increases in the deep ocean (Balmaseda et al., 2013; Cheng and Tung, 2014; Trenberth et al., 2014).

Like the open ocean, coastal waters have also warmed. A unique one hundred and seventeen year temperature record from Great Harbor, Woods Hole, Massachusetts revealed warming between 1970 and 2002 at a rate of 0.04°C per year or a 1.2°C total rise in mean annual temperature (Nixon et al., 2004). Unfortunately, such consistent long-term records are rare and as we try to document temperature changes in other coastal systems we must rely on more variable data sets. Additionally, and this is true of all field observations, natural variability as well as larger scale climatic cycles can add noise to temperature record trends. Such variability can lead to confusion and even unwarranted controversy as the public seeks finite truths and scientists struggle with assessing and effectively communicating uncertainty associated with ecological measurements.

When a discussion of the magnitude of warming of our local Narragansett Bay (Rhode Island) waters recently reached a national stage, we were motivated to take a closer look at the evidence for warming in the bay and to address the complexities associated with quantifying trends in long-term temperature datasets (Nixon et al., 2004; Emery, 2013). Briefly, in a speech to the Senate, Senator Whitehouse said, “*Narragansett Bay waters are getting warmer – 4 degrees Fahrenheit warmer in the winter since the 1960s (4/9/2013).*” He was referring to work we (RWF) published reporting a surface winter (December, January, February) warming of 2.2°C between 1960 and 2006 (Nixon et al., 2009). The temperature data referenced in Nixon et al. (2009) were collected as part of a long-term monitoring program designed to survey Phytoplankton populations in Narragansett Bay. At the time the Senator was referencing the most recently published study reporting the warming waters in the bay. However, seven years later there were more data available and the journalist running the “Truth-O-Meter” for PolitiFact accessed a different although similar temperature dataset collected as part of a complementary long-term monitoring program designed to survey fish. In plotting the temperature data from the Fish Survey, but not those from the Phytoplankton Survey, and running their own regression, PolitiFact ruled “*The trend is certainly correct, but Whitehouse is too far off for the Truth-O-Meter to register True. It is, to pardon the pun, a matter of degree. Because the temperature rise is a little more than half of what he said, we rate his statement Half True (Emery, 2013).*” Given the different datasets and different timescales used to make this determination, we felt that a more synthetic assessment was warranted.

Here we use Narragansett Bay as a case study for discussing the complexities of ecological datasets and of communicating analytical results to broader audiences. First, we provide the most complete and up-to-date data on temperature increases in the bay and we discuss the perceived discrepancies that inspired us to compare three distinct, yet complementary, temperature datasets. We then touch on the wider implications of three decades of warming for the ecology of Narragansett Bay and other temperate marine systems.

2. Methods

We analyzed and compared temperature data from Narragansett Bay, RI that were collected from three different sources. To our knowledge, these are the three longest temperature records for the bay. In two cases, water temperature was collected as part of the long-term weekly Phytoplankton and Fish Surveys conducted by graduate assistants from the Graduate School of Oceanography (GSO) at the University of Rhode Island in Narragansett, RI. The third temperature dataset was from a National Oceanic and Atmospheric Administration (NOAA) monitoring station in Newport, RI. We compiled each of these data sets to analyze for long-term temperature changes in this manuscript.

2.1. Temperature data collected during the Phytoplankton and Fish Surveys

Through GSO assistantships, graduate students were responsible for gathering data in the morning Phytoplankton Survey and in the subsequent afternoon Fish Survey conducted from the same boat. While temperature measurements were made as part of both of these excursions, the temperature measurements were not the primary objective of the surveys. Two stations were monitored during these surveys: a station internal to the estuary and another at the opening of the bay. Because the latter is influenced by shelf waters and our focus here is on estuarine water temperatures we only used data from the internal estuary station (Fox Island, $41^{\circ}34.2'\text{N}$, $71^{\circ}23.4'\text{W}$).

During the Phytoplankton Survey temperature was measured at surface and bottom depths first using a bucket and thermometer and then, after 2008, a YSI sonde (Model 6920 V2). Temperature measured with the YSI had a precision of within 0.15°C . Phytoplankton Survey data from 1999 to 2014 are available for download from <http://www.gso.uri.edu/phytoplankton/> (accessed June 2014). Earlier data from 1959 to 2007 were collected by Professor T. Smayda and are available at http://www.narrbay.org/d_projects/plankton-tsv/plankton-tsv.htm (accessed June 2014). There were also years where some (1963, 1998, 2011) or all (1997, 2012) of the data were missing.

Surface and bottom temperatures were measured at the same stations in the Fish Survey as in the Phytoplankton Survey. Fish Survey temperature data are available from 1959 to 2012 at <http://www.gso.uri.edu/fishtrawl/data.htm> (accessed June 2014). More recent data are available upon request. Temperature measurements were made using a thermometer until 2006, after which a YSI sonde of the same model as that used in the Phytoplankton Survey.

For both surveys, monthly average temperatures were calculated using the individual measurements, and overall winter means were calculated as the average of all individual measurements taken within the three winter months (December, January, February). Years for which some or all of the measurements were missing were excluded from the mean calculations and analyses.

Due to the paucity of bottom temperature data, likely attributable to difficult field conditions, we only addressed surface temperature data. We were particularly concerned that the availability of bottom data might be skewed towards calmer seas associated with milder weather, thus biasing our results.

2.2. NOAA temperature data

While the Phytoplankton and Fish Surveys are two of the longest temperature records for Narragansett Bay, measurements are made at a relatively low frequency (weekly). To add context, here we also analyzed additional estuarine temperature data from nearby

Download English Version:

<https://daneshyari.com/en/article/4539480>

Download Persian Version:

<https://daneshyari.com/article/4539480>

[Daneshyari.com](https://daneshyari.com)