Provincetown
Center for Coastal Studies

ANALYSIS OF TIDAL DATA FROM MEETINGHOUSE POND, CHATHAM FISH PIER AND BOSTON: JANUARY 2012 – JUNE 2015

by

Graham S. Giese and Cristina G. Kennedy
Department of Marine Geology

for

The Pleasant Bay Resource Management Alliance

November 2015

5 Holway Avenue
Provincetown, MA 02657
www.coastalstudies.org
(508) 487- 3623

INTRODUCTION

In the present document we report results of our analysis of tidal data recorded at two stations within the Chatham Harbor/Pleasant Bay estuary system and a single station in Boston Harbor between the beginning of January, 2012, and the end of June, 2015. The original tide readings at all three stations were recorded at 6-minute intervals, except for occasional periods of instrument malfunction. Details of the ongoing tidal study that includes this time period are presented in an earlier and more extensive report (Giese, 2012).

One of the two stations within the estuary is located at the Nauset Marine East marina in East Orleans at Meetinghouse Pond (Fig. 1). Tide heights are recorded on a non-vented Yellow Springs Instruments pressure, temperature and conductivity recorder owned and operated by the Cape Cod National Seashore (CCNS). The instrument was deployed in April, 2011, following completion of a new pier, and it has operated continually - with some data breaks due to instrument failure - to the present time.

The second tide station in the estuary is located at Chatham Fish Pier within Chatham Harbor (Fig. 1). Most of the Chatham Harbor data for the present report were obtained from a National Oceanic and Atmospheric Administration (NOAA) microprocessor-based acoustic tide recorder initially established at the Fish Pier in 2009. That instrument remained in operation until it was damaged by a storm in January, 2015. Subsequently, in March 2015, CCNS's Kelly Medeiros installed a HOBO pressure recorder – donated by the Orleans Pond Coalition – at the Fish Pier tide station.

Data from the two stations within the estuary were corrected for the effects of atmospheric pressure using data from a HOBO pressure recorder established at CCNS's North Atlantic Coastal Laboratory in North Truro. The tidal data presented in this report were corrected relative to the vertical geodetic datum, NAVD88, by means of precision GPS surveys. The instrument-provided tide levels are periodically checked against visual readings of a nearby tide staff.

The Boston Harbor data were recorded on a NOAA recorder and made available on the NOAA tidal website (www.tidesandcurrents.noaa.gov). The initial Chatham Fish Pier data are also available at that site, while the monthly averages of the recent Fish Pier data and all data from Meetinghouse Pond are available on the Center for Coastal Studies website (www.coastalstudies.org). Table 1 lists abbreviations frequently used in this report.

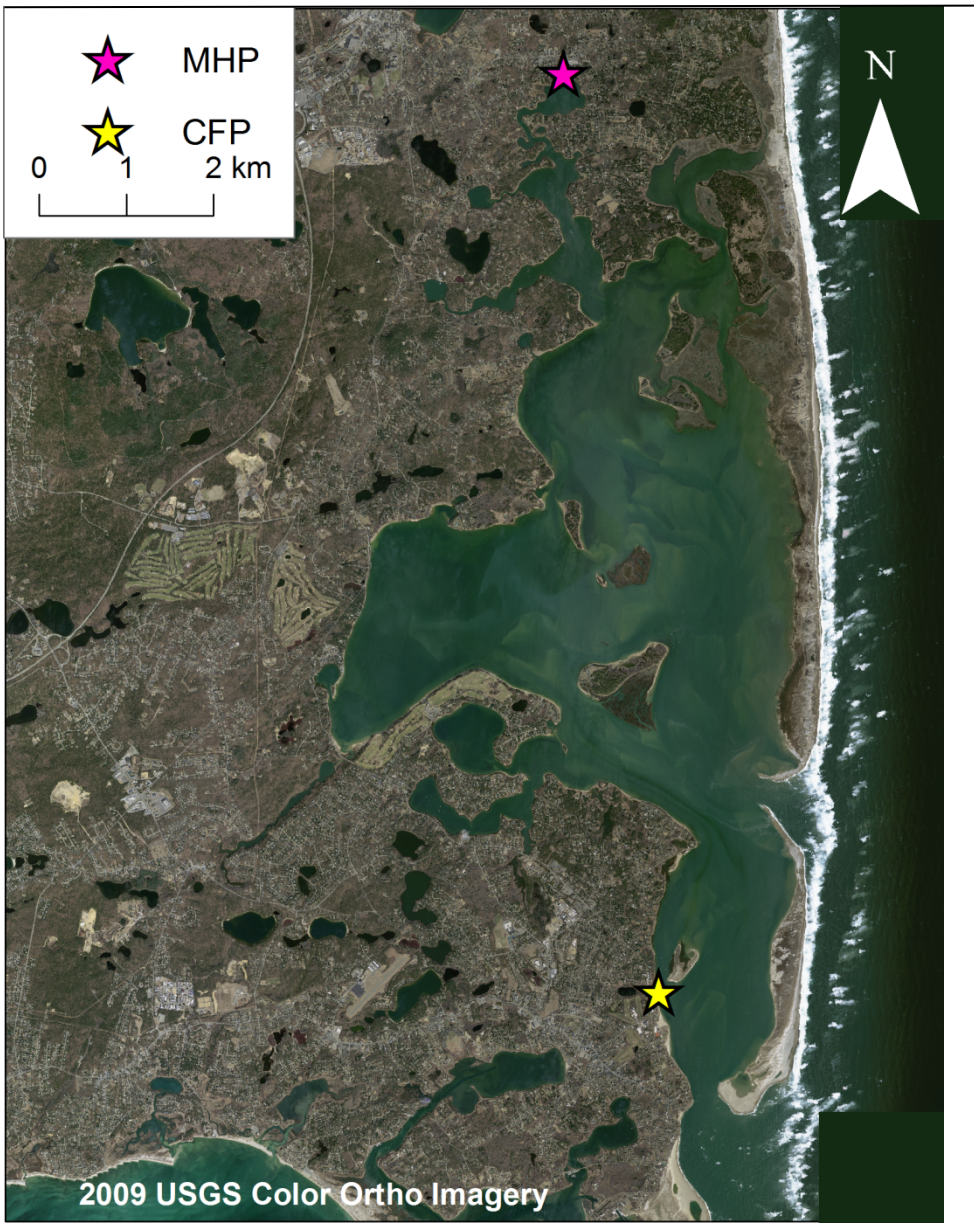

Fig. 1 : Locations of the Meetinghouse Pond (MHP) and Chatham Fish Pier (CFP) tide stations in the Pleasant Bay/Chatham Harbor Estuary. The two tidal inlets lying north and south of the Chatham Fish Pier station separate the barrier island, North Beach Island, from Nauset Beach to the north, and South Beach (not visible) to the south. Aerial imagery is from 2009.

CCNS	Cape Cod National Seashore
CCS	Center for Coastal Studies
GPS	Global Positioning System
MHW	Mean High Water
MLW	Mean Low Water
MSL	Mean Sea Level
MTR	Mean Tidal Range
NAVD88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration

Table 1 : Abbreviations used in the report

RESULTS

Figures 2-4 illustrate the full suite of monthly averaged data from the three tidal stations beginning with January 2012. We first show the Boston results (Fig. 2) since that station is the best representative of the open Gulf of Maine tides that "force" the Pleasant Bay/Chatham Harbor system. Each dot in this and subsequent figures represents the mean value of one of the levels (sea level, high water, low water) or the tidal range. The solid lines connecting the dots aid visualization but have no other significance; however breaks in the lines designate months for which the data were incomplete and monthly means could not be calculated.

Review of Boston data for the three-and-a-half year study period reveals an absence of any significant trend in overall monthly mean sea level. Tide range was similarly steady after mid-2013. Prior to mid-2013, tide range increased in elevation slightly, as did mean high water. The most extreme short-term variation in the record – clearest in the mean high water pattern – occurred between January (low) and March (high), 2013.

As seen in Figure 3, the Meetinghouse Pond tides show a similar increase in levels prior to mid-2013 and a similar short-term elevation change in early 2013. For the remainder of the record however, all Meetinghouse Pond tidal levels show a gradual overall decrease in elevation. Tidal range remained fairly constant throughout the study period.

Increasing levels prior to mid-2013 are also clearly present in the Chatham Fish Pier data (Fig. 4). Over the remainder of the record, however, these data reveal a different and distinctive pattern. Tide range, which was maximum in June, 2013, shows a gradual decrease after that time, while the mean low water data indicate a trend of increasing elevation throughout the entire 2012 through mid-2015 study period.

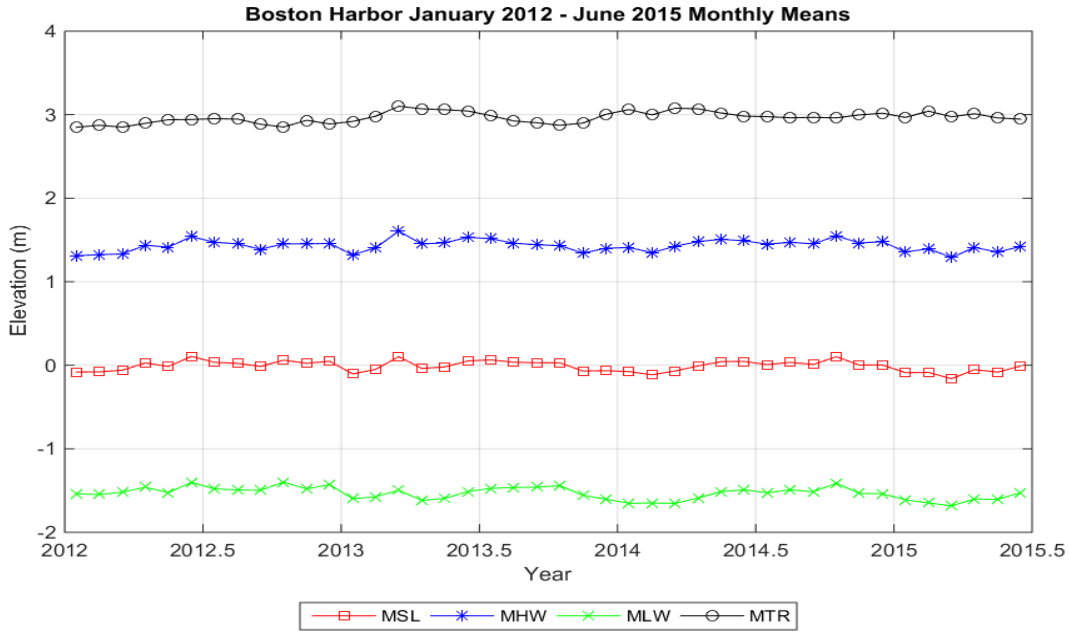

Fig. 2 : Monthly tide levels and range at Boston Harbor between January, 2012, and June, 2015. Note the difference in scale for elevation between this figure for Boston Harbor and the following two figures for the tide stations within the estuary.

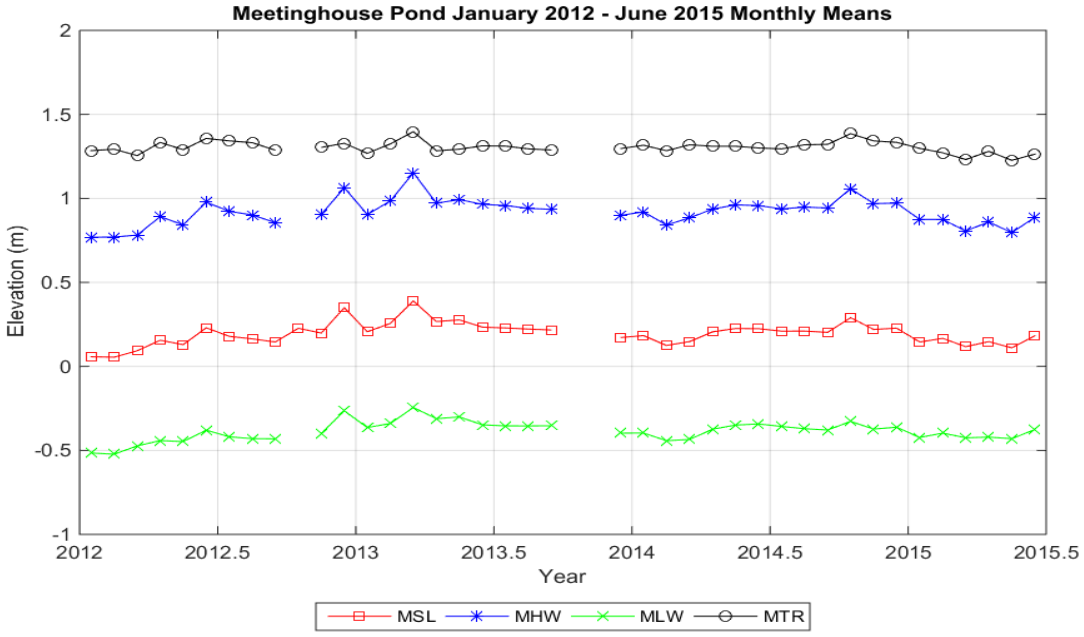

Fig. 3 : Monthly tide levels and range at Meetinghouse Pond between January, 2012, and June, 2015.

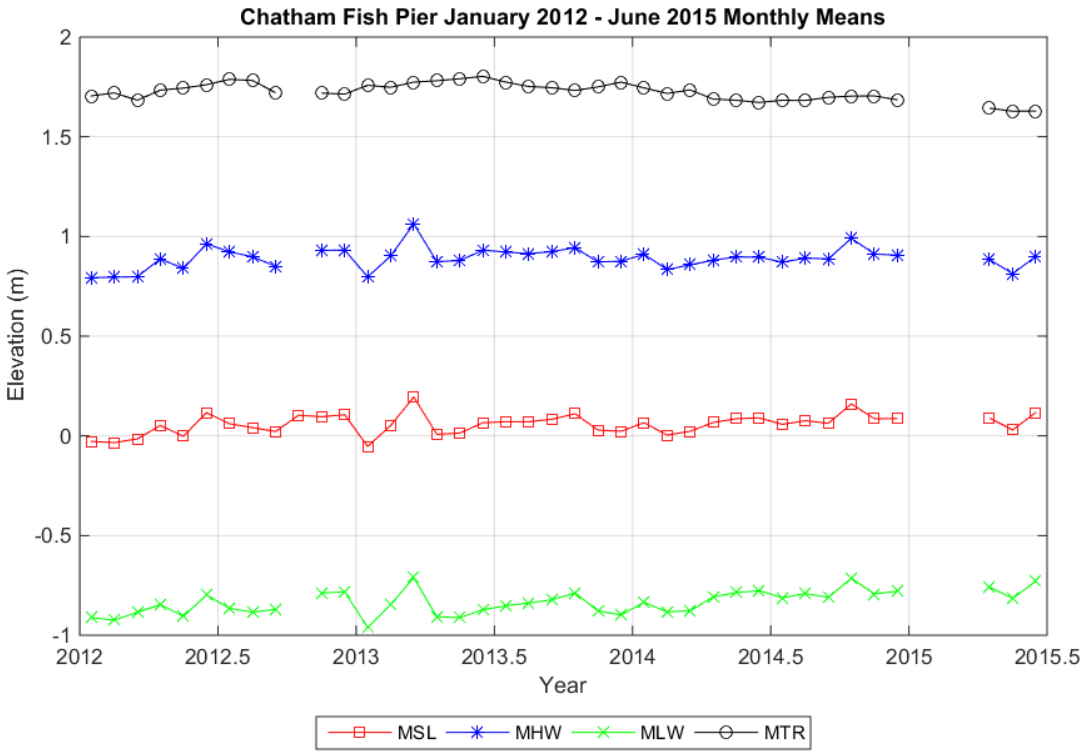

Fig. 4 : Monthly tide levels and range at Chatham Fish Pier between January, 2012, and June, 2015.

DISCUSSION

Meetinghouse Pond. Our 2012 report noted a trend of both decreasing MHW levels and decreasing MTR at Meetinghouse Pond between early 2010 and early 2012, and noted that "decreasing tidal range and decreasing high water levels reduce the volume of the Pleasant Bay tidal prism, which in the absence of other factors, acts to reduce water quality."

As presented above (RESULTS), the present data show that both trends reversed between early 2012 and early 2013. Mean high water increased in elevation markedly, reaching a maximum in March, 2013, that exceeded all MHW levels recorded since the beginning of Meetinghouse Pond tide measurements in 2005. The upward trend in MTR was more moderate since MLW, as well as MHW, increased in elevation to a maximum in March, 2013. The results also indicated that after mid-2013 all levels were relatively stable, with very slowly decreasing elevation trends.

Chatham Fish Pier. In some respects, the 2012 to mid-2015 Chatham Fish Pier results were similar to those for Meetinghouse Pond. Specifically, all levels trended upward until mid-2013, and following mid-2013, MSL and MHW were relatively stable. With regard to MLW and MTR, however, the Chatham Fish Pier tidal patterns were found to be distinctive between mid-2013 and the end of the series in mid-2015. During that period the trend of MLW increased in elevation (upward trend, Fig. 5C) while MTR decreased (downward trend, Fig. 6C).

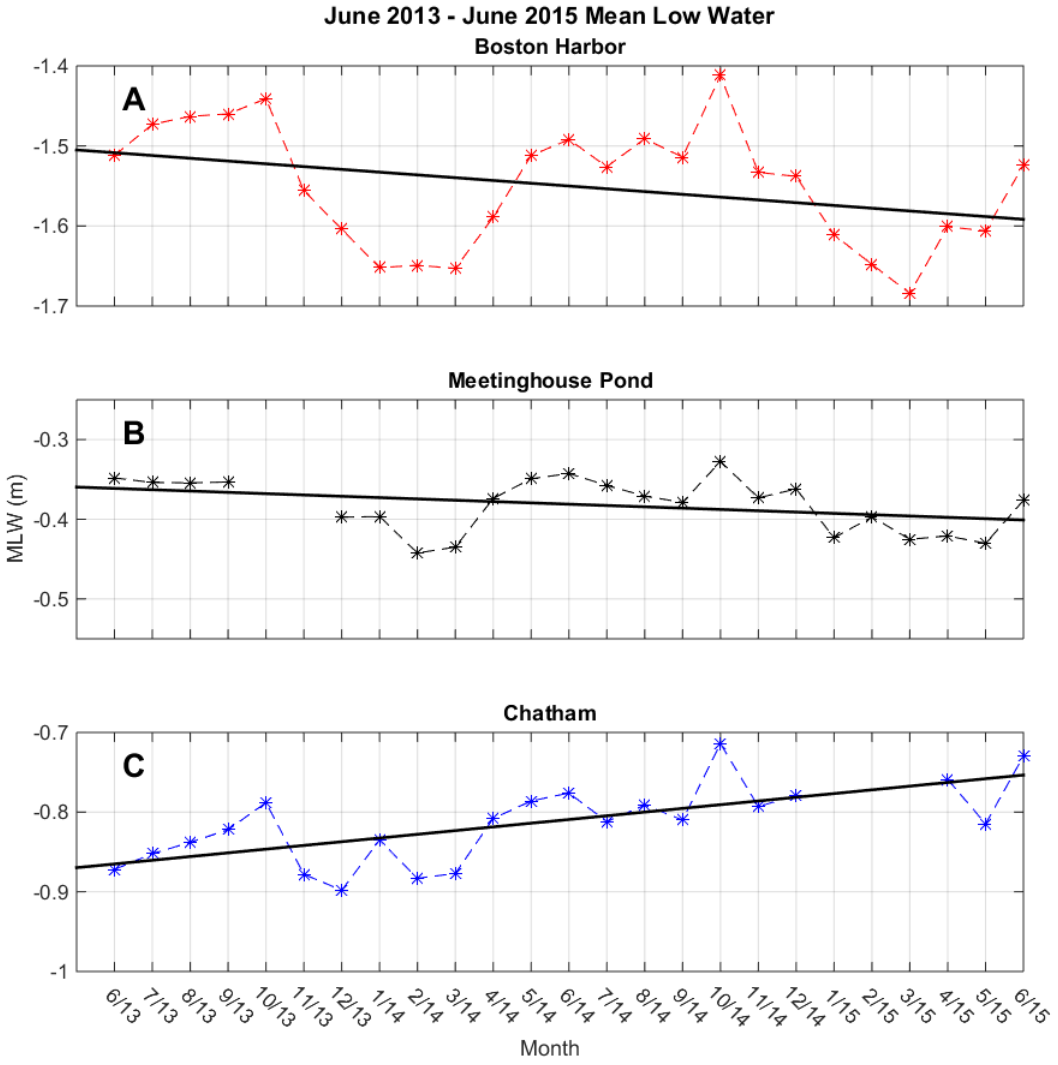

Fig. 5 : Monthly MLW at (A) Boston Harbor, (B) Meetinghouse Pond and (C) Chatham Fish Pier between June, 2013, and June, 2015.

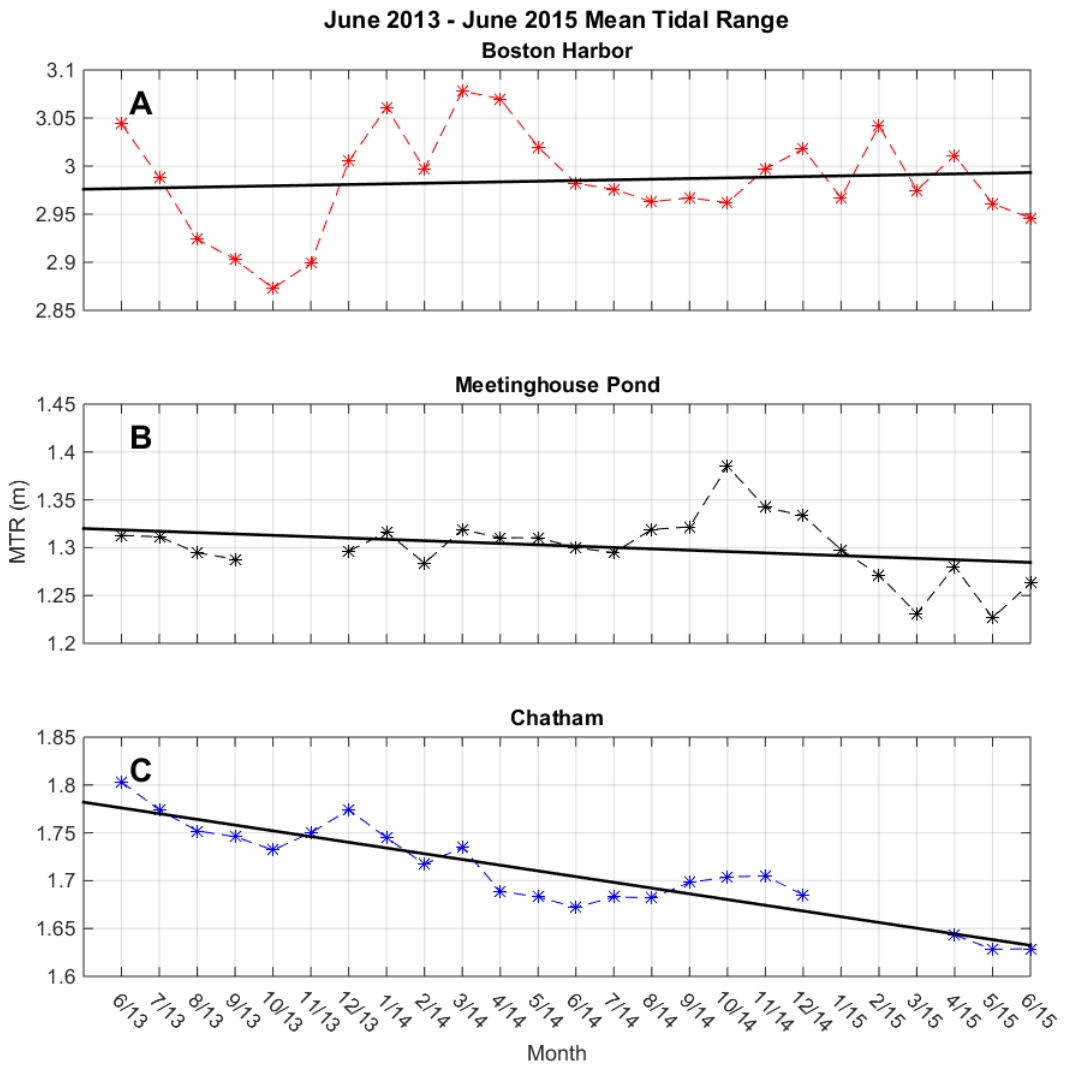

Fig. 6 : Monthly MTR at (A) Boston Harbor, (B) Meetinghouse Pond and (C) Chatham Fish Pier between June, 2013, and June, 2015.

Higher low water levels at Chatham Fish Pier have been reported by local observers. The Chatham MLW data displayed in Figure 5C confirm and quantify the trend of increasing low water elevations since June 2013, while, interestingly, Boston (Fig. 5A) and Meetinghouse Pond (Fig. 5B) data show an opposite trend of decreasing low water elevations over the same time period.

It is clear from Figure 5 that while the 25-month trends differ in direction, many of the shorter term (month-to-month) variations in all three plots are similar. Many of these shorter term variations in tide levels are produced by seasonally-varying conditions such as water temperature and salinity, which in general lead to higher levels in the summer and lower levels in the winter. Tide range (Fig. 6) is calculated by subtracting MLW from MHW, which does away

with much of the seasonal variation (common to both MLW and MHW) and isolates the longer-term trends in tide range at the three sites. Figure 6 indicates that while the 25-month trends of MTR at Boston and Meetinghouse Pond show little change over time, the trend at Chatham shows a clear decrease in tide range of about 15 centimeters (0.5 feet) over the approximately two year period, i.e., a rate of decrease of 0.25 feet per year.

Such a regular, multiyear trend of decreasing tide range suggests that some change in the physical characteristics of the estuary's hydraulic system - such as the extension and narrowing of the tidal channel at the south inlet - may be responsible. Figure 7 shows the inlet as it appeared in May, 2015, while its change in form since 2006 (one year prior to the formation of the north inlet) can be seen in Figure 8. Hydraulic friction at channels is a major element in determining basin response to tidal forcing, so it is reasonable to ask whether the ongoing sedimentation at the southern extremity of North Beach Island, including the south inlet, could be reducing tide range at Chatham Fish Pier.

Continuation of the MTR trend that began in June 2013 at Chatham Fish Pier would result in a tide range decrease of a foot (0.3 meters) by June 2017, a magnitude of change that could well arouse community concern for the future of the south inlet as a secure navigational channel. Therefore, we recommend that the ongoing tidal observations described in this report be continued, and that interim reports be issued at 6-month intervals beginning in January, 2016, primarily to provide updates concerning the tidal behavior at Chatham Fish Pier.

ACKNOWLEDGEMENTS

Kelly Medeiros (CCNS) provided all the data used in this study for Meetinghouse Pond, and the more recent data for Chatham Fish Pier. The tide recorder at Chatham Fish Pier was donated by the Orleans Pond Coalition. Nauset Marine East marina made available facilities for mounting the Meetinghouse Pond tide recorder, while Cathrine Macort and Oharra Deschamps provided visual readings of a nearby tide staff. The National Oceanographic and Atmospheric Administration provided the processed tide data for Boston Harbor and the initial data for Chatham Fish Pier. Mark Adams (CCNS) provided the surveying required to adjust the Chatham Fish Pier data to the contemporary national vertical datum.

This study was supported by the Pleasant Bay Resource Management Alliance, and benefitted greatly from the guidance of its director, Carole Ridley, the members of its Coastal Resource Work Group, and the Director of Coastal Resources for the Town of Chatham, Ted Keon.

Fig. 7 : May 2015 imagery of the south inlet. The Chatham Fish Pier (CFP) tide station is shown for reference. Image from Google Earth.

Fig. 8 : Composite of seven sequential aerial photographs showing the progressive southward extension and growth of North Beach Island since 2006, one year prior to the formation of the north inlet, and the resulting extension and narrowing of the tidal channel at the south inlet. Image courtesy of T. Keon, Town of Chatham.

REFERENCES

Giese, G.S., 2012. Analysis of tidal data from Meetinghouse Pond, Chatham Fish Pier and Boston: with application to management. Technical Report to the Pleasant Bay Resource Management Alliance, Center for Coastal Studies, Provincetown, MA, 17p.