



## Center for Coastal Studies Provincetown

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**Report on Collection and Analysis of Tidal Data from Boston Harbor, Meetinghouse Pond,  
Chatham Fish Pier, Outermost Harbor and Stage Harbor:  
July 2018 – July 2019**

by

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for

**The Pleasant Bay Resource Management Alliance**

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## INTRODUCTION

### Background

The breaching of Nauset Beach during a severe northeasterly storm on January 2, 1987, ended a long period of growth of the barrier beach and initiated a new phase in the cyclic evolution of the Pleasant Bay/Chatham Harbor system. The pre-1987 barrier beach growth period is referred to as the “inlet migration” phase of the cycle in reference to the incremental southward migration of the system’s tidal inlet from its mid-19<sup>th</sup> C. initial location seaward of Minister’s Point. The January 1987 breach rapidly developed into a deep inlet (“South Inlet”) and thereby initiated the “inlet transition” phase of the cycle, during which old channels closed and new channels and shoals formed. The geomorphic and tidal changes that have occurred so far during the inlet transition phase of the system’s cyclic evolution can be sub-divided into three stages:

(1) 1987 – 2007 period. Following initiation and rapid deepening of South Inlet, “South Beach”, the detached south end of Nauset Beach, joined the mainland at its north end. As a result, a single tidal inlet, South Inlet, provided tidal flow to the Pleasant Bay/Chatham Harbor system.

(2) 2007 – 2013 period. “North Inlet” was initiated as a breach of the barrier beach opposite Minister’s Point. Unlike the behavior of South Inlet, this new opening initially remained shallow and, as a result, strongly flood-dominant. While it augmented the system’s tidal prism, it failed to capture the main ebb channel. Instead, by enhancing southward ebb flow through Chatham Harbor, it initially assured the dominance of South Inlet. North Beach Island (formed by the initiation of North Inlet) increasingly narrowed due to erosion on its eastward side, and grew southward and westward, reducing the breadth of South Inlet and the width of southern Chatham Harbor.

(3) 2013 – 2017 period. The continued southward and westward extension of North Beach Island and shoaling within Chatham Harbor combined to reduce flow from the north through South Inlet. Flow between the two inlets was further reduced by the breaching of South Beach’s connection to the mainland in April 2017 (“Fool’s Inlet”, see Figure 2). Within months the northern tip of North Beach Island was lost to erosion and the ebb channel from Pleasant Bay became established at North Inlet making it the system’s dominant tidal inlet.

The continuous change of the channels and inlets of the Pleasant Bay/Chatham Harbor system alter its tidal and wave patterns which in turn, affect the system's ecology and socio-economic health. The purpose of this study is to monitor, analyze and report sea level, tide level and tidal range patterns within the system in order to provide the information required to improve understanding and management of this dynamic system. The present document is the first of two reports - proposed and authorized in August, 2018 - presenting the results of observations following the 2017 shift in dominance to North Inlet. In this, the first of the two, we report observations made between July, 2018, and July, 2019. The second and more extensive report will report observations between July, 2019, and June, 2020. The second report will also review and discuss observations over the five year period from July, 2015, through June, 2020.

### Objectives

The initial objectives of the long-term study, which includes these two reports, were to compile and analyze tidal data acquired at Meetinghouse Pond, at the extreme head of the Chatham Harbor/Pleasant Bay system, and at Chatham Fish Pier which lies between the two tidal inlets at the mouth of the system. Additional gauges were added; the first at Outermost Harbor Marina in March, 2017 (in anticipation of the breaching of South Beach that occurred on April 1, 2017), and the second at Stage Harbor in April 2018. During the course of the study it was determined that some pronounced changes within Pleasant Bay/Chatham Harbor are direct responses to regional tidal characteristics. To help delineate these regional influences, limited tidal data from Boston Harbor have been included in this report.

Summarizing, here we report results of our study of tidal data recorded between the beginning of July, 2018, and the end of July, 2019, at five stations: two within the Chatham Harbor/Pleasant Bay estuary system, one in Outermost Harbor (adjacent to "Fools Inlet"), one in Stage Harbor, and one in Boston Harbor. The original tide readings at all four 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).

### METHODS

All available verified tide data from the recorders within the system were accessed: six-minute tide levels from tide recorders at Chatham Fish Pier, Meetinghouse Pond, Outermost Harbor and Stage

Harbor. In addition, as mentioned above, tide data from the NOAA/NOS tide recorder at Boston Harbor was accessed to define regional trends.

#### Meetinghouse Pond, Chatham Fish Pier, Outermost Harbor, and Stage Harbor

Tidal data collected during this reporting period (July 2018 – July 2019) were recorded by Onset HOBO pressure recorders installed at Nauset-East Marina on Meetinghouse Pond in Orleans, and at Chatham Fish Pier, in Chatham (Figure 1). We also report on tidal data recorded during this period by Onset HOBO pressure recorders installed in Chatham at the Outermost Harbor Marine Marina and by Onset HOBO pressure recorders installed at Stage Harbor (Figure 2).

#### Boston Harbor

The Boston Harbor data were recorded on a NOAA tide recorder and made available on the NOAA tides and water levels website ([www.tidesandcurrents.noaa.gov](http://www.tidesandcurrents.noaa.gov)).

#### Analysis

Initial tidal data from the stations within the estuary were corrected for the effects of atmospheric pressure using data from a HOBO atmospheric pressure recorder established at the Chatham Fish Pier and at Meetinghouse Pond to remove error due to the distance between the tidal and atmospheric pressure-recording instruments.

The sea level data were then adjusted to the vertical geodetic datum, NAVD88, by means of precision GPS (Global Positioning System) surveys. The instrument-provided tide levels are periodically checked against visual readings of a nearby tide staff and compared to the intermittently active NOAA tide gauge at Chatham Fish Pier. Times are reported as local standard time.

Statistics for each data set were calculated using MATLAB software. Using the six-minute data as input, mean sea level (MSL), mean high and low water (MHW and MLW), and mean tidal range (MTR) were derived for the individual time series.



Figure 1. Location of tide recorders at Meetinghouse Pond and Chatham Fish Pier. Image from April 2017.

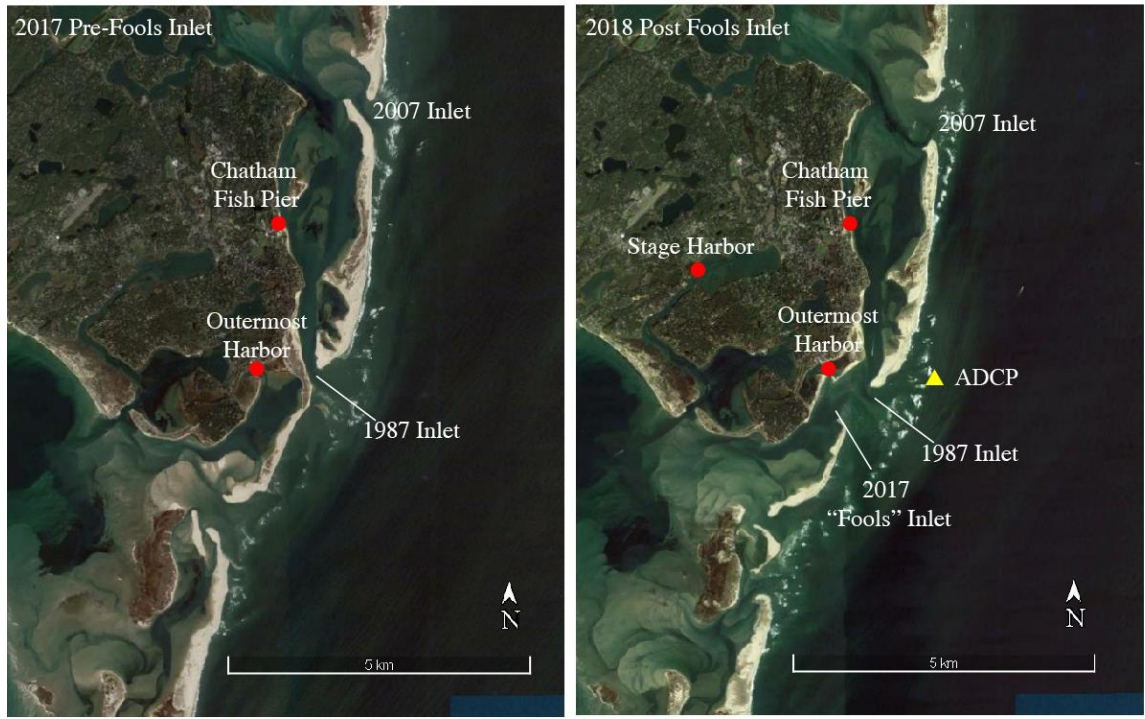


Figure 2. Location of tide recorders at Chatham Fish Pier and Outermost Harbor from March 2017 to present (Left: October 2016 aerial imagery). Location of Stage Harbor tide recorder from April 2018 to present, and location of offshore bottom-mounted tide recorder, designated ADCP, October-November 2018 (Right: October 2018 aerial imagery).

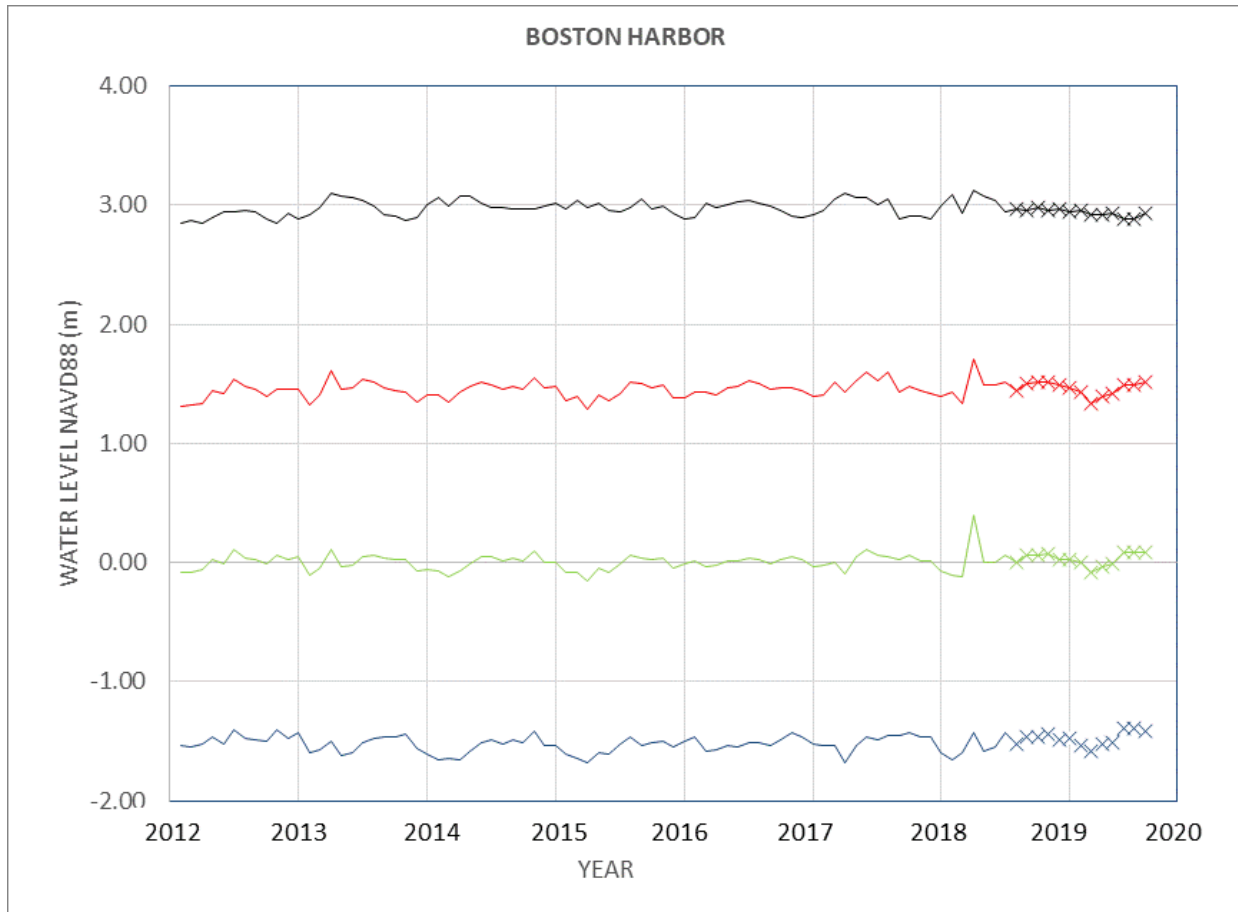


Figure 3. Summary data from Boston Harbor NOAA tide recorder from January 2012 to July 2019. Mean Sea Level (Green), Mean High Water (Red), and Mean Low Water (Blue) are given in NAVD88 (meters). Tide Range (Black) is also given in meters. Data collected during this reporting period indicated by marks (X).

Table 1. Summary data from Meetinghouse Pond tide recorder from June 2016 to July 2019. Mean Sea Level (MSL), Mean High Water (MHW), and Mean Low Water (MLW) are given in NAVD88 (meters). Tide Range (Range) is also given in meters. Uncertainty in December 2018 and January 2019 data (red numerals) due to construction at Nauset Marina. Data collected during this reporting period indicated by **bold** lettering.

<b>Meeting House Pond</b>				
<b>Month</b>	<b>MSL</b>	<b>MHW</b>	<b>MLW</b>	<b>Range</b>
Jun-2016	0.19	0.86	-0.35	1.21
Jul-2016	0.20	0.86	-0.34	1.19
Aug-2016	0.19	0.85	-0.34	1.18
Sep-2016	0.22	0.86	-0.31	1.17
Oct-2016	0.24	0.86	-0.29	1.15
Nov-2016	0.16	0.78	-0.35	1.14
Dec-2016	0.14	0.74	-0.37	1.12
Jan-2017	0.23	0.84	-0.26	1.11
Feb-2017	0.25	0.85	-0.26	1.11
Mar-2017	0.16	0.75	-0.32	1.06
Apr-2017	0.31	0.89	-0.18	1.07
May-2017	0.36	0.95	-0.14	1.09
Jun-2017	0.32	0.91	-0.16	1.07
Jul-2017	0.18	0.80	-0.32	1.12
Aug-2017	0.16	0.77	-0.34	1.10
Sep-2017	0.15	0.77	-0.36	1.13
Oct-2017	0.20	0.80	-0.30	1.10
Nov-2017	0.18	0.79	-0.32	1.11
Dec-2017	0.11	0.72	-0.38	1.10
Jan-2018	0.09	0.75	-0.42	1.17
Feb-2018	0.06	0.68	-0.43	1.11
Mar-2018	0.32	1.04	-0.27	1.31
Apr-2018	0.18	0.82	-0.34	1.16
May-2018	0.16	0.79	-0.36	1.15
Jun-2018	0.23	0.88	-0.30	1.18
<b>Jul-2018</b>	<b>0.18</b>	<b>0.80</b>	<b>-0.33</b>	<b>1.13</b>
<b>Aug-2018</b>	<b>0.21</b>	<b>0.86</b>	<b>-0.31</b>	<b>1.18</b>
<b>Sep-2018</b>	<b>0.22</b>	<b>0.85</b>	<b>-0.30</b>	<b>1.15</b>
<b>Oct-2018</b>	<b>0.23</b>	<b>0.88</b>	<b>-0.30</b>	<b>1.18</b>
<b>Nov-2018</b>	<b>0.20</b>	<b>0.84</b>	<b>-0.32</b>	<b>1.15</b>
<b>Dec-2018</b>	<b>0.16</b>	<b>0.77</b>	<b>-0.34</b>	<b>1.11</b>
<b>Jan-2019</b>	<b>0.17</b>	<b>0.80</b>	<b>-0.34</b>	<b>1.14</b>
<b>Feb-2019</b>	<b>0.10</b>	<b>0.71</b>	<b>-0.39</b>	<b>1.10</b>
<b>Mar-2019</b>	<b>0.14</b>	<b>0.76</b>	<b>-0.36</b>	<b>1.13</b>
<b>Apr-2019</b>	<b>0.16</b>	<b>0.78</b>	<b>-0.35</b>	<b>1.13</b>
<b>May-2019</b>	<b>0.21</b>	<b>0.85</b>	<b>-0.31</b>	<b>1.16</b>
<b>Jun-2019</b>	<b>0.22</b>	<b>0.88</b>	<b>-0.30</b>	<b>1.18</b>
<b>Jul-2019</b>	<b>0.23</b>	<b>0.92</b>	<b>-0.29</b>	<b>1.21</b>



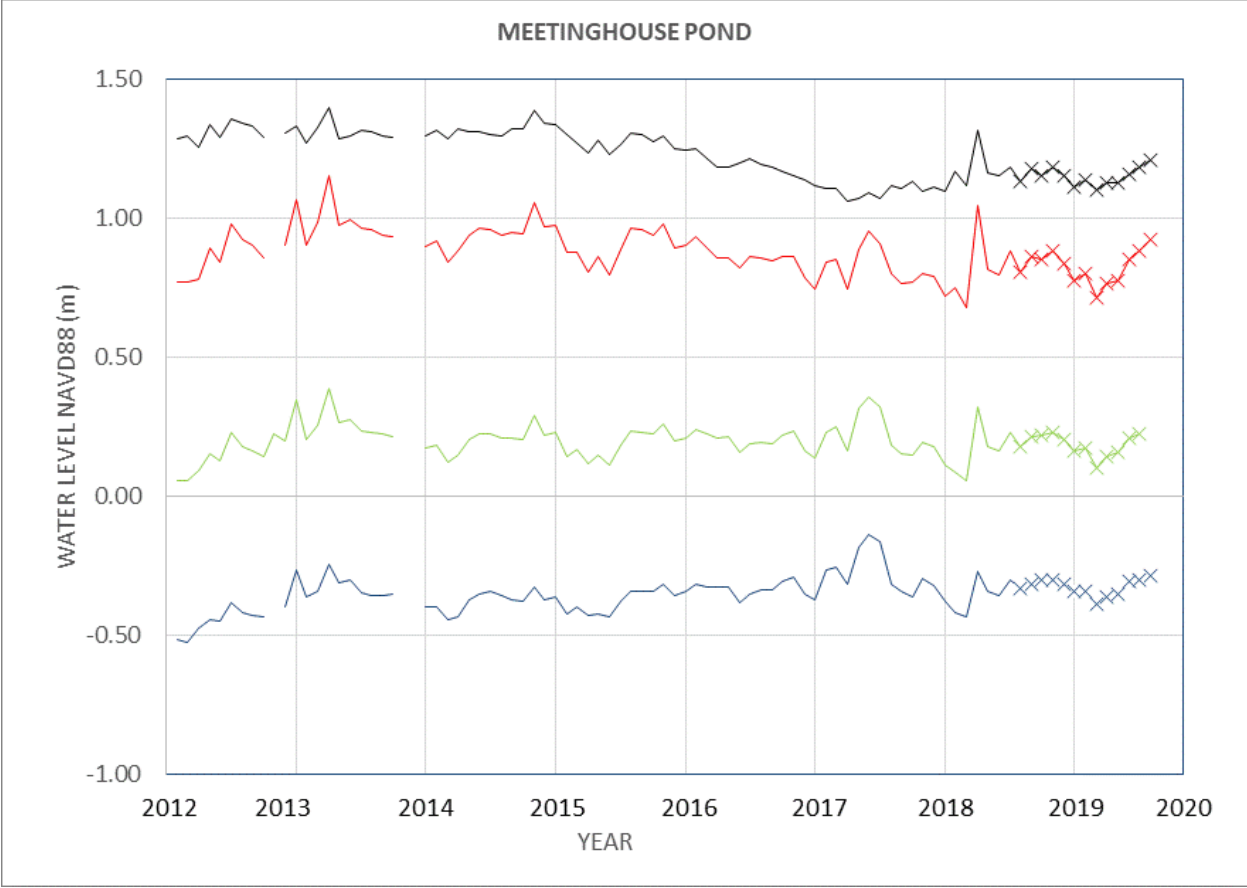


Figure 4. Summary data from Meetinghouse Pond tide recorder from January 2012 to July 2019. Mean Sea Level (Green), Mean High Water (Red), and Mean Low Water (Blue) are given in NAVD88 (meters). Tide Range (Black) is also given in meters. Uncertainty in December 2018 and January 2019 due to construction at Nauset Marina. Data collected during this reporting period indicated by marks (X).

Table 2. Summary data from Chatham Fish Pier tide recorder from June 2016 to July 2019. Mean Sea Level (MSL), Mean High Water (MHW), and Mean Low Water (MLW) are given in NAVD88 (meters). Tide Range (Range) is also given in meters. Data collected during this reporting period indicated by **bold** lettering.

Month	Chatham			
	MSL	MHW	MLW	Range
Jun-2016	0.13	0.89	-0.67	1.55
Jul-2016	0.10	0.85	-0.72	1.57
Aug-2016	0.07	0.81	-0.72	1.52
Sep-2016	0.12	0.83	-0.63	1.46
Oct-2016	0.17	0.83	-0.54	1.37
Nov-2016	0.15	0.80	-0.55	1.35
Dec-2016	0.11	0.76	-0.58	1.34
Jan-2017	0.14	0.80	-0.53	1.33
Feb-2017	0.17	0.81	-0.49	1.30
Mar-2017	0.10	0.78	-0.57	1.35
Apr-2017	0.19	0.85	-0.46	1.31
May-2017	0.23	0.88	-0.42	1.30
Jun-2017	0.20	0.84	-0.44	1.28
Jul-2017	0.15	0.89	-0.57	1.46
Aug-2017	0.12	0.87	-0.62	1.49
Sep-2017	0.19	0.93	-0.55	1.48
Oct-2017	0.13	0.88	-0.61	1.49
Nov-2017	0.14	0.89	-0.59	1.48
Dec-2017	0.06	0.84	-0.68	1.52
Jan-2018	0.07	0.90	-0.70	1.59
Feb-2018	0.02	0.84	-0.71	1.55
Mar-2018	0.35	1.21	-0.44	1.66
Apr-2018	0.12	0.98	-0.62	1.60
May-2018	0.10	0.94	-0.67	1.61
Jun-2018	0.17	0.97	-0.61	1.58
<b>Jul-2018</b>	<b>0.10</b>	<b>0.90</b>	<b>-0.69</b>	<b>1.59</b>
<b>Aug-2018</b>	<b>0.18</b>	<b>0.98</b>	<b>-0.62</b>	<b>1.60</b>
<b>Sep-2018</b>	<b>0.21</b>	<b>1.01</b>	<b>-0.58</b>	<b>1.58</b>
<b>Oct-2018</b>	<b>0.22</b>	<b>1.01</b>	<b>-0.56</b>	<b>1.58</b>
<b>Nov-2018</b>	<b>0.19</b>	<b>0.96</b>	<b>-0.57</b>	<b>1.54</b>
<b>Dec-2018</b>	<b>0.17</b>	<b>0.96</b>	<b>-0.59</b>	<b>1.55</b>
<b>Jan-2019</b>	<b>0.19</b>	<b>0.97</b>	<b>-0.57</b>	<b>1.54</b>
<b>Feb-2019</b>	<b>0.11</b>	<b>0.89</b>	<b>-0.66</b>	<b>1.55</b>
<b>Mar-2019</b>	<b>0.15</b>	<b>0.93</b>	<b>-0.61</b>	<b>1.54</b>
<b>Apr-2019</b>	<b>0.19</b>	<b>0.97</b>	<b>-0.58</b>	<b>1.54</b>
<b>May-2019</b>	<b>0.24</b>	<b>1.02</b>	<b>-0.52</b>	<b>1.54</b>
<b>Jun-2019</b>	<b>0.22</b>	<b>1.01</b>	<b>-0.57</b>	<b>1.58</b>
<b>Jul-2019</b>	<b>0.22</b>	<b>1.04</b>	<b>-0.59</b>	<b>1.63</b>

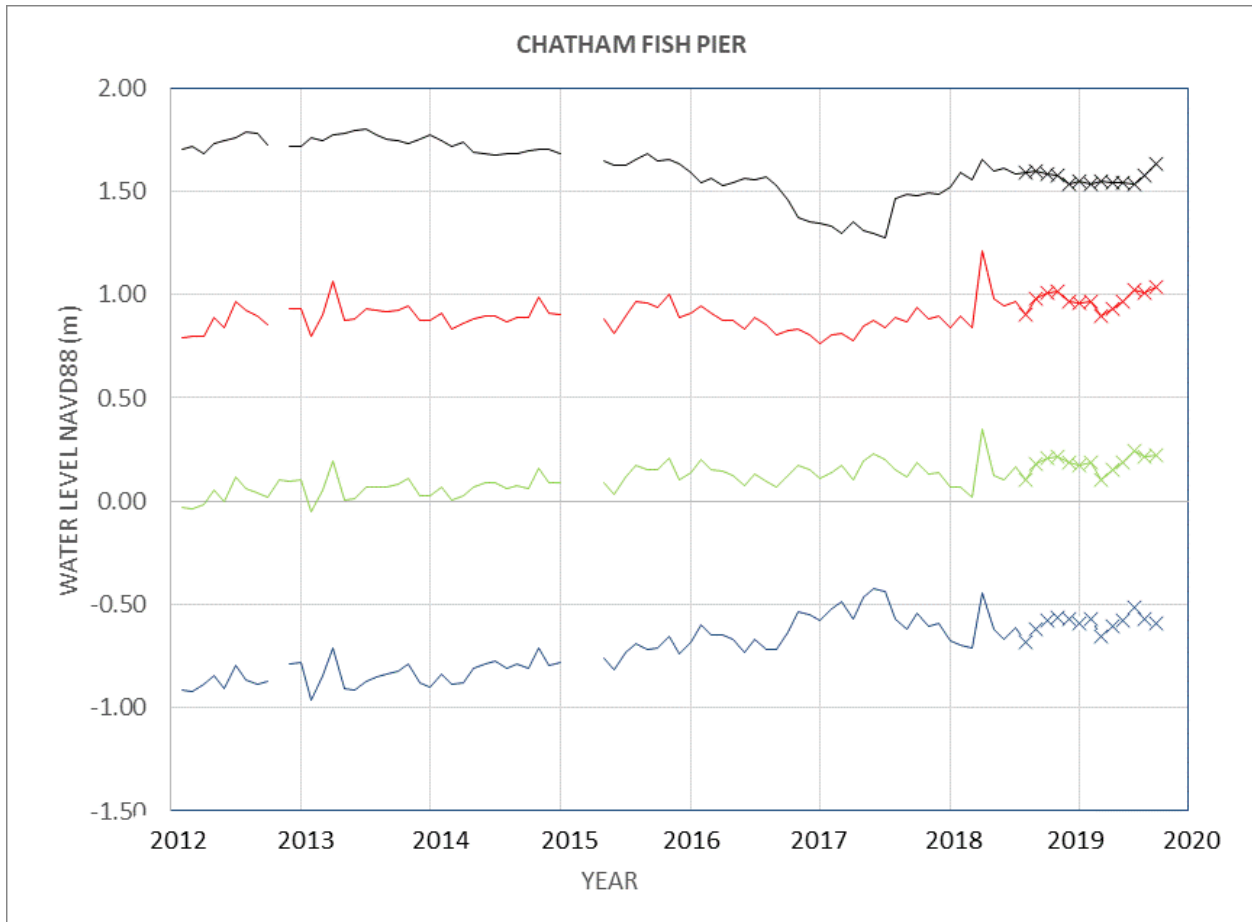


Figure 5. Summary data from Chatham Fish Pier tide recorder from January 2012 to July 2019. Mean Sea Level (Green), Mean High Water (Red), and Mean Low Water (Blue) are given in NAVD88 (meters). Tide Range (Black) is also given in meters. Data collected during this reporting period indicated by marks (X).

Table 3. Summary data from Outermost Harbor tide recorder from March 2017 to July 2019. Mean Sea Level (MSL), Mean High Water (MHW), and Mean Low Water (MLW) are given in NAVD88 (meters). Tide Range (Range) is also given in meters. Data collected during this reporting period indicated by **bold** lettering.

Outer Most Harbor				
Month	MSL	MHW	MLW	Range
Mar-2017	-0.15	0.55	-0.81	1.36
Apr-2017	-0.01	0.77	-0.71	1.48
May-2017	0.06	0.84	-0.65	1.50
Jun-2017	0.04	0.81	-0.67	1.48
Jul-2017	0.01	0.79	-0.74	1.53
Aug-2017	-0.01	0.78	-0.75	1.53
Sep-2017	0.05	0.82	-0.68	1.50
Oct-2017	0.00	0.79	-0.75	1.54
Nov-2017	0.01	0.79	-0.73	1.51
Dec-2017	-0.07	0.73	-0.82	1.55
Jan-2018	-0.07	0.78	-0.83	1.61
Feb-2018	-0.11	0.72	-0.85	1.57
Mar-2018	0.20	1.10	-0.59	1.69
Apr-2018	-0.01	0.91	-0.77	1.67
May-2018	-0.01	0.90	-0.81	1.71
Jun-2018	0.06	0.92	-0.74	1.67
<b>Jul-2018</b>	<b>-0.02</b>	<b>0.85</b>	<b>-0.85</b>	<b>1.70</b>
<b>Aug-2018</b>	<b>0.04</b>	<b>0.92</b>	<b>-0.80</b>	<b>1.73</b>
<b>Sep-2018</b>	<b>0.05</b>	<b>0.94</b>	<b>-0.78</b>	<b>1.73</b>
<b>Oct-2018</b>	<b>0.05</b>	<b>0.94</b>	<b>-0.79</b>	<b>1.73</b>
<b>Nov-2018</b>	<b>0.02</b>	<b>0.89</b>	<b>-0.79</b>	<b>1.68</b>
<b>Dec-2018</b>	<b>0.13</b>	<b>0.99</b>	<b>-0.59</b>	<b>1.58</b>
<b>Jan-2019</b>	<b>0.12</b>	<b>0.98</b>	<b>-0.64</b>	<b>1.62</b>
<b>Feb-2019</b>	<b>0.03</b>	<b>0.89</b>	<b>-0.71</b>	<b>1.60</b>
<b>Mar-2019</b>	<b>0.10</b>	<b>0.93</b>	<b>-0.56</b>	<b>1.49</b>
<b>Apr-2019</b>	<b>0.08</b>	<b>0.96</b>	<b>-0.73</b>	<b>1.69</b>
<b>May-2019</b>	<b>0.16</b>	<b>1.02</b>	<b>-0.62</b>	<b>1.65</b>
<b>Jun-2019</b>	<b>0.21</b>	<b>1.03</b>	<b>-0.42</b>	<b>1.45</b>
<b>Jul-2019</b>	<b>0.27</b>	<b>1.05</b>	<b>-0.26</b>	<b>1.31</b>

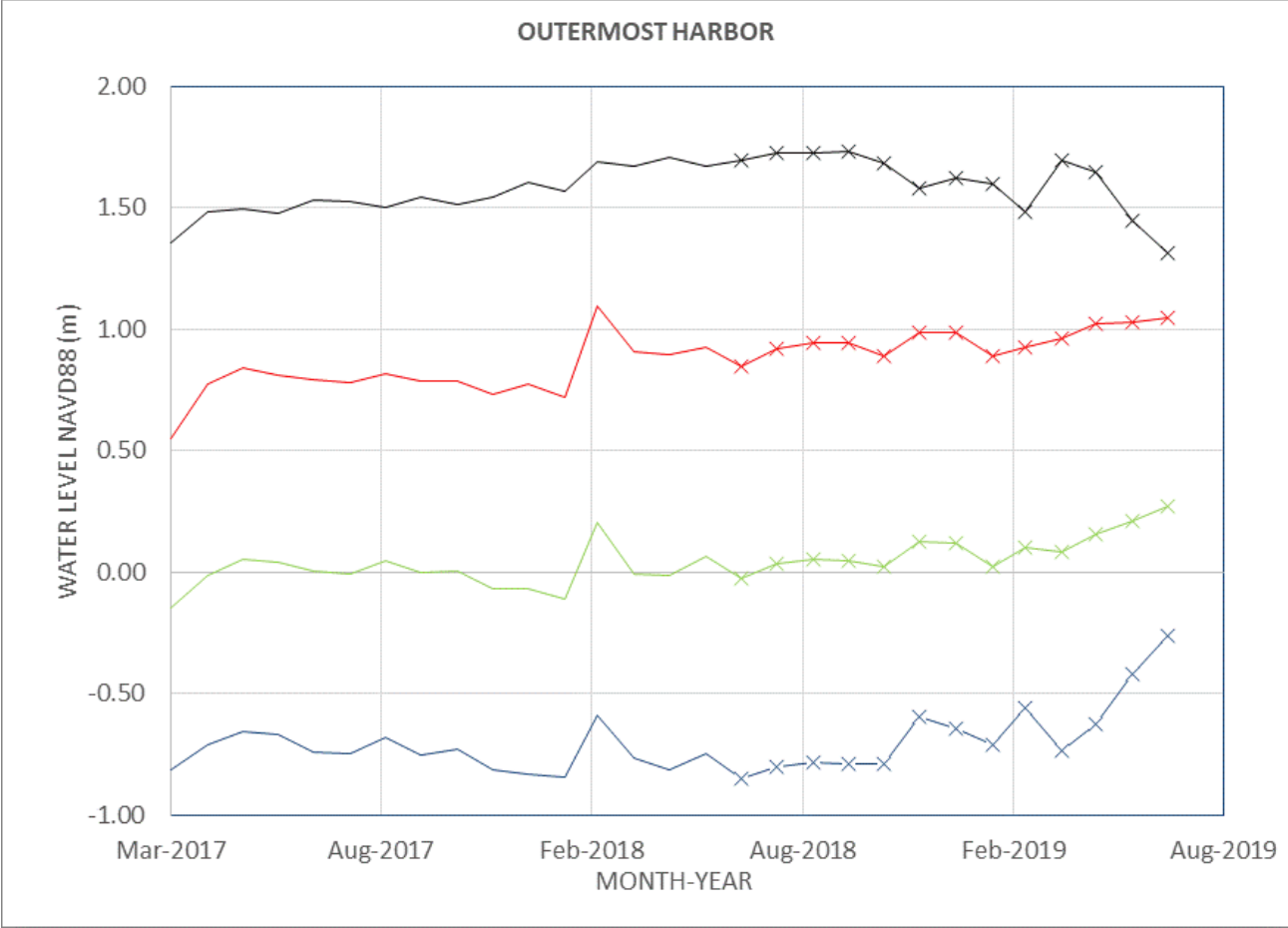


Figure 6. Summary data from Outermost Harbor tide recorder from March 2017 to July 2019. Mean Sea Level (Green), Mean High Water (Red), and Mean Low Water (Blue) are given in NAVD88 (meters). Tide Range (Black) is also given in meters. Data collected during this reporting period indicated by marks (X).

Table 4. Summary data from Stage Harbor tide recorder from April 2018 to July 2019. Mean Sea Level (MSL), Mean High Water (MHW), and Mean Low Water (MLW) are given in NAVD88 (meters). Tide Range (Range) is also given in meters. Data collected during this reporting period indicated by **bold** lettering.

Stage Harbor				
Month	MSL	MHW	MLW	Range
Apr-2018	-0.06	0.54	-0.72	1.26
May-2018	-0.06	0.57	-0.73	1.29
Jun-2018	0.03	0.61	-0.62	1.22
<b>Jul-2018</b>	<b>-0.03</b>	<b>0.55</b>	<b>-0.68</b>	<b>1.23</b>
<b>Aug-2018</b>	<b>0.03</b>	<b>0.60</b>	<b>-0.62</b>	<b>1.22</b>
<b>Sep-2018</b>	<b>0.03</b>	<b>0.60</b>	<b>-0.62</b>	<b>1.23</b>
<b>Oct-2018</b>	<b>0.03</b>	<b>0.62</b>	<b>-0.64</b>	<b>1.25</b>
<b>Nov-2018</b>	<b>-0.02</b>	<b>0.60</b>	<b>-0.72</b>	<b>1.32</b>
<b>Dec-2018</b>	<b>-0.04</b>	<b>0.55</b>	<b>-0.71</b>	<b>1.25</b>
<b>Jan-2019</b>	<b>-0.02</b>	<b>0.56</b>	<b>-0.67</b>	<b>1.23</b>
<b>Feb-2019</b>	<b>-0.11</b>	<b>0.48</b>	<b>-0.75</b>	<b>1.23</b>
<b>Mar-2019</b>	<b>-0.06</b>	<b>0.52</b>	<b>-0.70</b>	<b>1.22</b>
<b>Apr-2019</b>	<b>-0.03</b>	<b>0.56</b>	<b>-0.67</b>	<b>1.23</b>
<b>May-2019</b>	<b>0.03</b>	<b>0.60</b>	<b>-0.59</b>	<b>1.19</b>
<b>Jun-2019</b>	<b>0.06</b>	<b>0.64</b>	<b>-0.56</b>	<b>1.20</b>
<b>Jul-2019</b>	<b>0.07</b>	<b>0.67</b>	<b>-0.56</b>	<b>1.22</b>

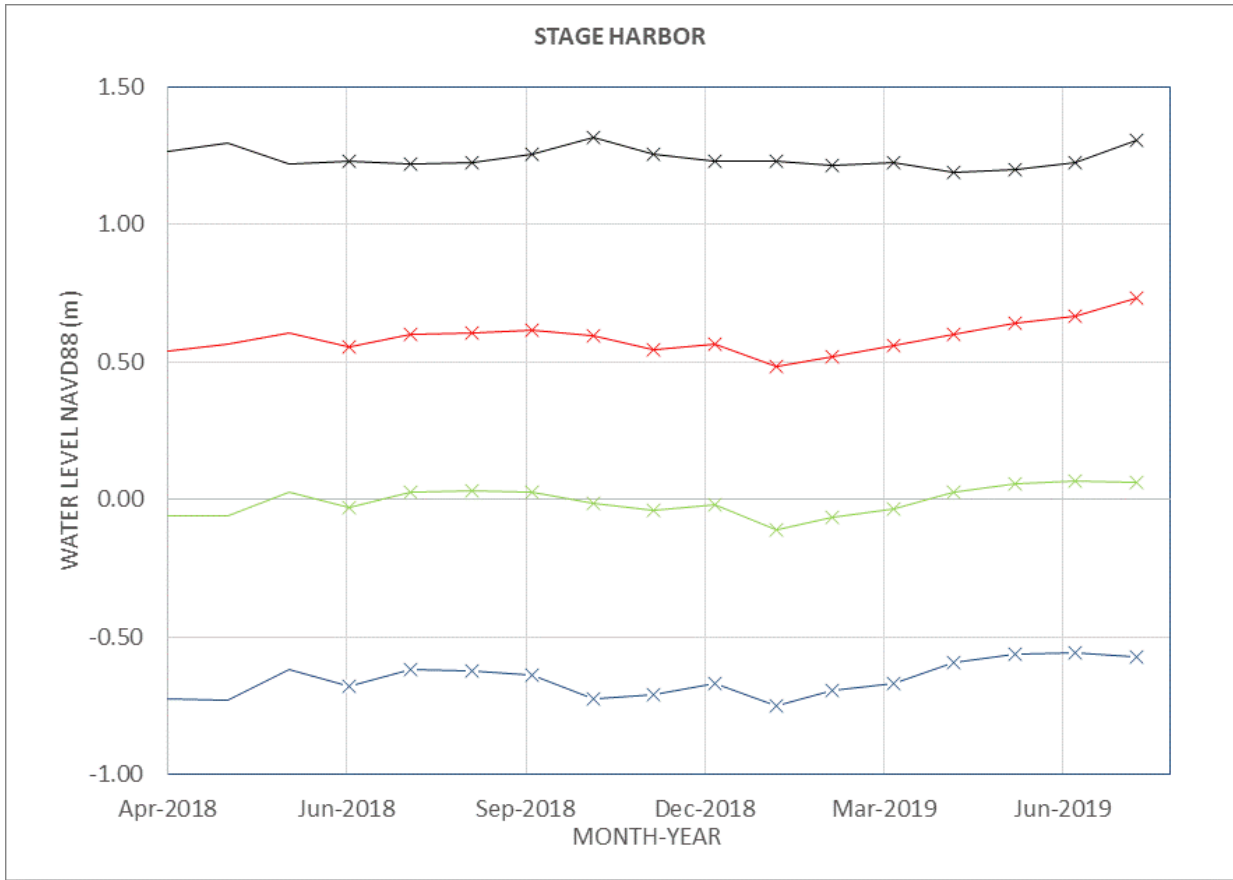


Figure 7. Summary data from Stage Harbor tide recorder from April 2018 to July 2019. Mean Sea Level (Green), Mean High Water (Red), and Mean Low Water (Blue) are given in NAVD88 (meters). Tide Range (Black) is also given in meters. Data collected during this reporting period indicated by marks (X).

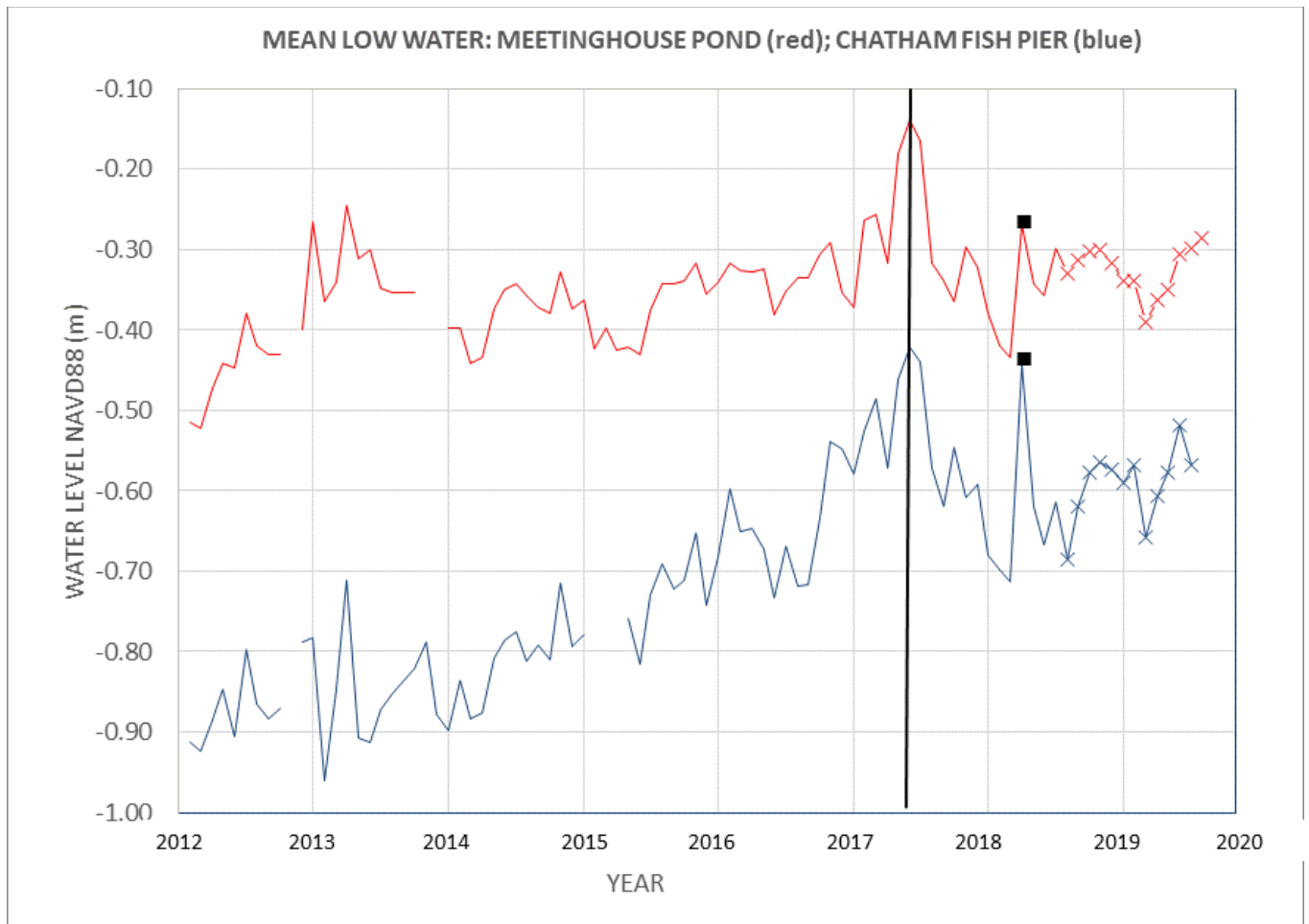


Figure 8. Mean Low Water from Meetinghouse Pond (Red) and Chatham Fish Pier (Blue) from tide recordings from January 2012 to July 2019. Values are given in NAVD88 (meters). Data collected during this reporting period indicated by marks (X). June 2017 is denoted by the black bar and the March 2018 water level anomaly is denoted (■).



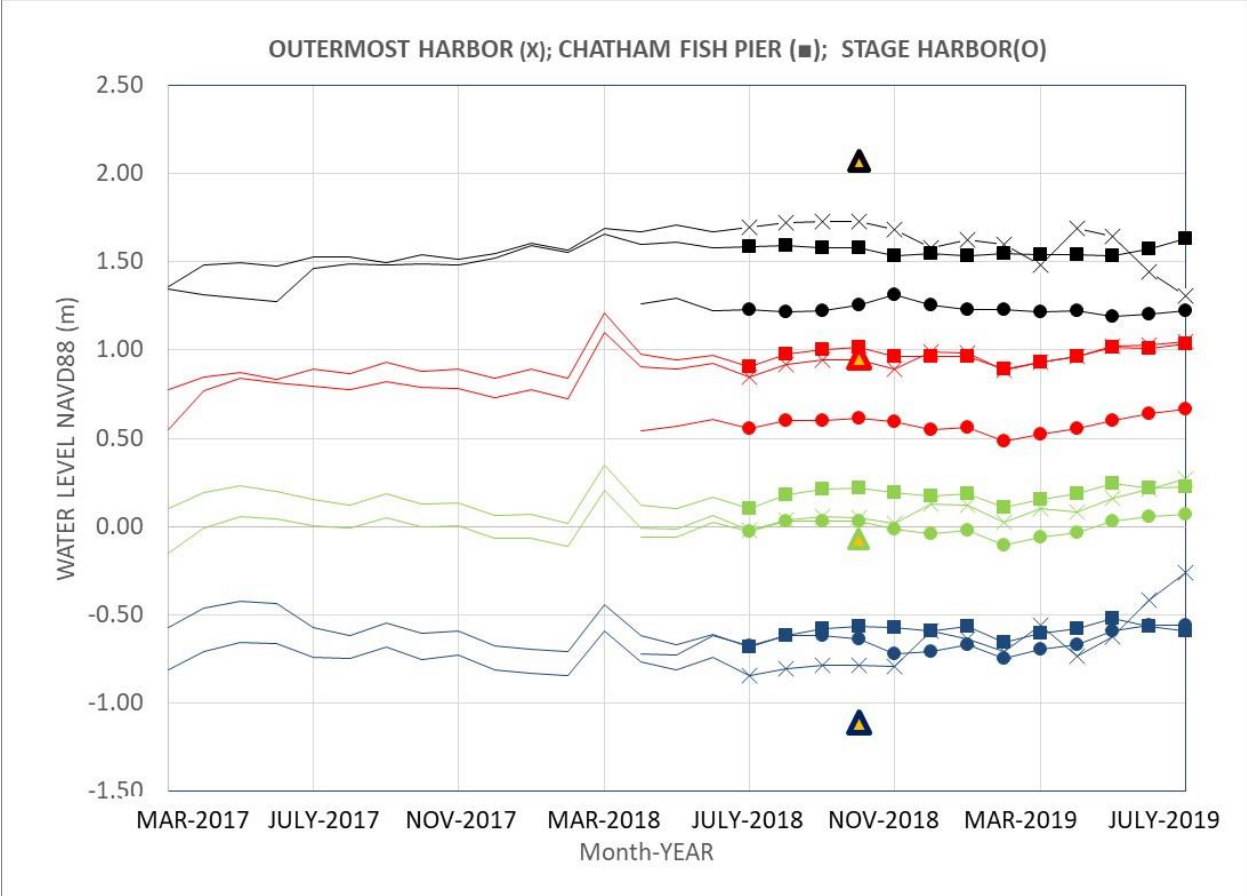


Figure 9. Summary data from Outermost Harbor (X), Chatham Fish Pier (■), Stage Harbor (O) from March 2017 to July 2019. Also a month-long data set from Outside of South Inlet (▲); see “Discussion”. Mean Sea Level (Green), Mean High Water (Red), and Mean Low Water (Blue) are given in NAVD88 (meters). Tide Range (Black) is also given in meters. Data collected during this reporting period indicated by the symbols identified above.

## DISCUSSION

Our previous (2019) report suggested that by Spring, 2018, the “final major element” of the transition phase of the Pleasant Bay – Nauset Beach barrier system’s century-and-a-half long cycle was in place. The statement was in reference to the connection of Pleasant Bay’s major ebb channel with North Inlet. Indeed, as discussed below, the data presented in the present report support that assessment. However, unlike the abrupt *initiation* of the transition phase with the breaching of Nauset Beach in January, 1987, the timing and form of the shift from inlet transition phase to inlet migration phase of the system evolution remains uncertain.

In its most fundamental depiction, the system’s “cycle” results from a competition between its two basic functions: (1) providing for tidal flow into and out of Pleasant Bay and (2) providing for wave-driven sediment flow along the outer coast from sediment sources in the north to sediment sinks in the south. An inlet located east of Ministers Point is optimal for the first function, providing hydraulically efficient tidal flow; southward migration of that inlet is optimal for the second function, enhancing net longshore sediment transport. That southward migration, however, increasingly lessens the inlet’s hydraulic efficiency, i.e., it increasingly counteracts the system’s first function. At the same time, however, the southward inlet migration sets in play processes that will eventually lead the system to transition from decreasing to increasing inlet tidal flow efficiency. That transition was initiated abruptly with the January 1987 inlet formation, and it has continued until the present time with the gain of dominance by North Inlet. However, the expected migration phase will not be initiated abruptly (as the present transition phase was). Southward migration of the inlet is hindered by the relic barrier, North Beach Island (Figure 2, right), and tidal flows to and from Pleasant Bay are presently restricted at Ministers Point.

### *Boston Harbor, Meetinghouse Pond and Chatham Fish Pier Tides*

Boston Harbor tidal patterns continue to provide this study with a useful proxy to the patterns of the Gulf of Maine tides forcing the Pleasant Bay/Chatham Harbor system. A comparison of Figures 3, 4 and 5 indicates that over this report’s 13-month study period, both Meetinghouse Pond and Chatham Fish Pier monthly MHW and MLW tide patterns are striking similar to those of the “outside” forcing

tides, adding support to earlier evidence of the decreased hydraulic coupling between North and South Inlets that took place between 2013 and 2017.

As part of a coastal management study (Applied Coastal Research and Engineering, 2019), a month-long tidal data set was recorded in October-November, 2018, from offshore of South Inlet (Figure 2). The resulting tidal datums for that offshore location are shown on Figure 9 together with the monthly mean tidal results for Chatham Fish Pier, the nearest onshore station. Interestingly, MHW levels at the two stations (onshore and offshore) were very similar during that time period, while MLW levels were approximately one-half meter lower offshore than onshore at Chatham Fish Pier.

#### *Outermost Harbor and Stage Harbor Tides*

Figure 9 also shows that MHW levels at Outermost Harbor are very similar to those at Chatham Fish Pier. Since the flood-prone Little Beach area is adjacent to Outermost Harbor, we must expect that future regional “outside” sea level increases – both those due to short-term anomalies and to predicted long-term sea level rise – will produce similar flood level increases at Little Beach. The MLW levels (and MTR magnitudes) at Outermost Harbor (Figure 6) tell an entirely different story. The rapid increase in low water since Spring, 2019, is due to shoaling of the channel to the harbor, and only by dredging of that waterway is it kept navigable. That difficulty must be expected to continue/increase into the near future due to sedimentation resulting from the continual reworking of relic coastal forms.

Stage Harbor tides (Figure 7) changed little over the reporting period, with MLW levels approximating those of Chatham Fish Pier (Figure 9). On the other hand, results presented on Figure 9 indicate that MHW levels at Stage Harbor were a little less than one-half meter lower than those at Chatham Fish Pier. That difference in levels between the two stations is consistent with the observed net flows westward through Morris Island Cut. Continued monitoring at Stage Harbor can be expected to provide significant insights as tides there respond to ongoing shoaling in the vicinity of Morris Island Cut.

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