A SEAWEED SAFARI ALONG CONNECTICUT'S SHORE

Elevation Evidence of Natural Phenomena in the Supralittoral & Intralittoral

NEW LONDON HARBOR, CONNECTICUT

by
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This report was developed from a cooperative workshop presented on June 12, 2008 for the Connecticut Department of Transportation (CDOT), the Connecticut Department of Environmental Protection Office of Long Island Sound (DEP, OLIS) and the Connecticut Association of Land Surveyors (CALS). The assistance of the Connecticut Sea Grant Program was vital for the workshop to take place, and Peg Van Patten's editing for proper presentation of the seaweed for this report is greatly appreciated. Juliana Barrett and John Dirk Aurin from Connecticut Sea Grant provided additional research answers on the role of salinity in the growth limits of *Spartina* grass. Report pictures were taken by Jay Doody and Amanda Freitas from CDOT.

The workshop presenters were: Peg Van Patten, Communications Director Connecticut Sea Grant, author of Seaweeds of Long Island Sound, and Kevin Zawoy, Senior Environmental Analyst, Office of Long Island Sound, Connecticut Department of Environmental Protection

INTRODUCTION

Over the years, surveyors, engineers, environmental regulators, and shoreline homeowners along the Connecticut coast of Long Island Sound have made presumptions and judgments as to the location of the mean high water (ownership boundary) and other coastal regulatory lines based on the physical evidence that they have seen, such as seaweed lines, wrack lines, beach grass, and other vegetation. Do these natural phenomena represent an actual line of elevation in relation to important tidal boundary and regulatory lines? Do they represent the actual tidal boundary or regulatory line? When an opportunity arose to make use of the seaweed expertise of Peg Van Patten from the Connecticut Sea Grant program, and the tidal wetlands expertise of Kevin Zawoy from Connecticut DEP's Office of Long Island Sound, a cooperative workshop was developed with the Connecticut Department of Transportation (CDOT) surveyors, CDOT Office of Environmental Planning and The Connecticut Association of Land Surveyors. The purpose of the workshop was to properly identify and name natural phenomena above mean tide level and get elevations of their upper or lower elevation limits. The data was then analyzed to see whether each natural phenomenon followed elevations around the 6 sites established in New London Harbor, and if it did to what level of confidence it could be relied upon.

This report will attempt to answer the above question in regard to the area of New London harbor, on the east end of Long Island Sound. The conclusions of this article may apply from Niantic, Connecticut east to the Rhode Island border, due to this area having the same mean high water elevation and mean range of tide (see Table 1).

TOWN	NOAA ID #	Mean High Water (MHW) NAVD88	Mean Range (MR)
Watch Hill Point, RI	8455083	0.92'	2.58'
New London, CT	8461490	0.92'	2.58'
Niantic, CT	8461925	0.94'	2.58'

Table 1: NOAA tide determinations in eastern Long Island Sound.
http://tidesandcurrents.noaa.gov/ "benchmarks"

STUDY LOCATION AND BACKGROUND

New London harbor lies in eastern Connecticut on the north shore of Long Island Sound, at the mouth of the Thames River. It borders the City of New London on the west side, and the City of Groton on the east side. The harbor is approximately 0.63 miles wide at its opening to the sound. The harbor channel trends NNW at 355° to the I-95 bridge where the opening is reduced to 0.3 miles. From the shore of Long Island Sound north to I-95 is approximately 3.5 miles. The harbor channel has a depth of 40' throughout the harbor. The harbor is the home to a number of important maritime businesses and institutions, including Electric Boat, the State Pier, the Coast Guard Academy, a US submarine base, and a number of ferry companies (see Figure 1).

In September, 2004, New London harbor was the site for a field tidal determination workshop sponsored by the Connecticut Association of Land Surveyors (CALS) and the New England Section ACSM. This workshop, presented by Douglas Thompson, PLS, of Atlantic Professional Development, Tallahassee, Florida, successfully established mean high water (MHW) and mean range (MR) at six sites around new London harbor (see Table 2). Each site was accurately tied into the NAVD 88 vertical datum, and permanent bench marks were documented for future use (see Table 3).

SITE ID	DESCRIPTION	MHW NAVD88 (ft)	MR (ft)
1	New London, Pequot Ave.	0.85	2.44
2	New London, Fort Trumbull	0.89	2.57
3	New London, City Pier	0.91	2.57
4A	New London, I-95 Boat Launch Ramp	0.85	2.58
4B	Groton, I-95 Boat Launch Ramp	0.84	2.59
5	Groton, Univ. of CT, Avery Point	0.89	2.55
6	Groton, Bayberry Lane, Boat Launch Ramp	0.83	2.47
Average		**0.87**	**2.56**
Standard Deviation		**0.03**	**0.04**
8461490	New London Tide Station, State Pier	0.92	2.58
Accuracy		**-0.05'**	**0.02'**

Table 2. Field determinations of MHW and MR, September, 2004.
CDOT District 3 Surveys, site MHW determination spreadsheets.

SITE	SOURCE	BM ORDER	METHOD	CLOSURE
S1	TM 27	3	HI, 0.01'	0.06
S2	CGS BM X5	1	3 WIRE .003'	0.012
S3	CGS BM 138	1	3 WIRE .003'	0.014
S4A	BM 1490 N 1995	1	3 WIRE .003'	0.014
S4B	CTGS BM 1423X	2	3 WIRE .003'	0.012
S5	City of Groton	2	3 WIRE .003'	0.012
S6	City of Groton	2	3 WIRE .003'	0.012
8461490	NOAA 8461490	1	3 WIRE .003'	0.01

Table 3. Bench run methods and closures for vertical network. CDOT District 3 survey field book “Tidal A: pages 1-29” and Benchrun3wire.xls.

SITE CHARACTERISTICS

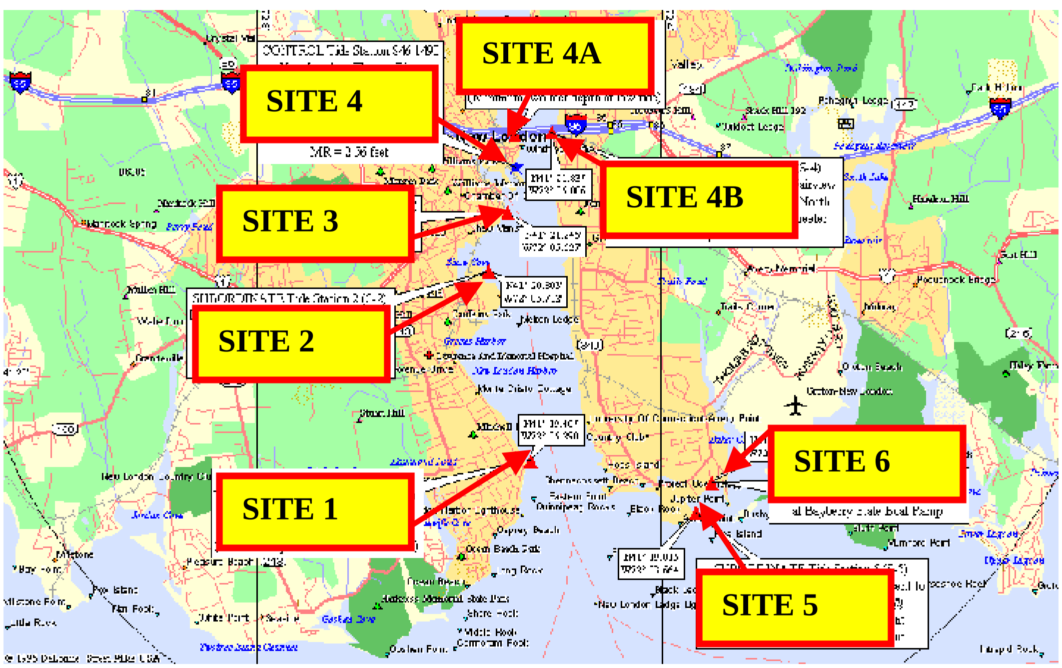

Figure 1. Observation Sites around New London harbor, 2004 & 2008

The six sites for the 2004 MHW determination workshop were chosen mainly for ease of access and the ability to set up a tide staff. The sites also possessed ample evidence of natural phenomena for this workshop.

Site 1 lies on the west side of New London harbor, approximately 1 mile north of the harbor entrance. Since 2004, a private home has been built on the site and it was not accessible for the 2008 workshop. The author performed the original survey for this site at the 2004 workshop and collected evidence at that time which was utilized for the 2008 workshop report. The site contained a small beach with beach grass, assorted rocks and boulders, and a north-south retaining wall that received direct wave contact with spray.

Site 2 lies on the west side of New London harbor, approximate 2.5 miles north of the harbor entrance, just north of Fort Trumbull. The site contains a small beach, assorted rocks and boulders, and a north south retaining wall that received direct wave contact with spray. Location of blue green algae upper limit from 2004 was included in the report. This location was from rocks that were not receiving direct wave action.

Site 3 lies on the west side of the harbor about 3 miles north of the harbor entrance at the municipal pier. Due to the limited ability to observe natural evidence, and congested parking, this site was not utilized for observations in 2008. Observations on a pier from 2004 were incorporated into the report.

Site 4 lies at the state pier on the west side of the harbor just below I-95 and a railroad bridge. NOAA automated tide station 8461490 is located on the state pier. Security considerations at this site prevented its use in 2004 and 2008. All data from the tide station is available on the internet at http://tidesanddcurrents.noaa.gov.

Site 4A is located on the west side of the harbor underneath I-95 at a state boat launch ramp. This site had a wood dock, concrete boat ramp, boulders, a small beach, *Spartina* grass and Phragmites. This site is 3.5 miles north of the harbor entrance.

Site 4B is found on the east side of the harbor opposite site 4A. Its site characteristics are identical to those found at the previous site. Blue green algae lines were located in 2004 and incorporated into the report.

Site 5 is located at the dock for the University of Connecticut Avery Point campus, on the north shore of Long Island Sound, 0.3 miles east of the harbor entrance. It contains a beach, rocks and boulders, *Spartina* grass and Phragmites.

Site 6 is located at a state boat launch ramp on Bayberry Lane on the north shore of Long Island Sound, 0.6 miles east of the harbor entrance. It contained a stone retaining wall, wood dock, and concrete boat ramp, as well as *Spartina* grass.

SEAWEED IDENTIFICATION

On June 12, 2008, workshop participants gathered at each site from mid tide to low tide, learning about the types of seaweed found. Peg Van Patten, Communications Director of the Connecticut Sea Grant, and author of Seaweeds of Long Island Sound, pointed out a number of promising bacteria and seaweed types that occupied the upper intralittoral and supralittoral. The weather was mild; temperature around 80°F, with little wind, Barometric pressure was around 1022 mb, so the inverse barometer effect would lower sea levels in general by about 9 or 10 cm. The following items were located, from highest elevation to lowest.

Figure 2. Peg Van Patten (right) and Kevin Zawoy (left) explaining the characteristics of Spartina grass at Site 5.

Blue Green Algae, *Cyanobacteria.* These microalgae are well known to surveyors and environmental regulators by the distinctive "black" stain or line seen on rocks and retaining walls along the shore in the supralittoral (splash zone). Blue Green Algae lives above mean high water, existing in the supralittoral, an area that provides only splashes of salt water. See Figure 3.

Figure 3. Art Von Plachecki measuring elevation of blue green algae upper limit at Site 4A.

Stone Hair, *Blidingia minima.* Stone Hair was immediately noticeable to the workshop attendees due to its high elevation in the intralittoral zone, and its bright green color. This alga has very small tubular, bright yellowish green filaments that grow in carpet-like colonies. The alga is only around 2mm diameter at most, very hair-like and usually only up to 5 cm long. The literature indicates that Blidingia (stone hair) prefers low salinity. This alga formed distinct upper limits on the rocks and concrete walls.
See Figure 4.

Figure 4. Stone hair, *Blidingia minima,* at Site 5.

Barnacles. Barnacles were found at the two sites directly on Long Island Sound, attaching themselves to rocks up to the level of the Stone Hair seaweed. See Figure 5.

Figure 5. Barnacles and *Fucus vesiculosis* at Site 5.

Rockweed, *Fucus.* Rockweed is made up a number of different seaweed types that are of the same coloration and grow together in the upper intralittoral. They are olive green to brown, variable in color and shape, rubbery, some with floaters.

Fucus vesiculosus. This type of rockweed was the one most commonly observed by the workshop participants. Strap like branches generally fork into twos. Length may be 1 foot to 3 feet long. They have a midrib on flattened blades and paired float bladders filled with air along the midrib. See Figure 6.

Figure 6. Site 4B boat ramp. *Fucus vesiculosis*

Bladder Wrack, *Ascophyllum nodosum.* Very large, coarse algae that drape down from rocks between the low and high tide lines. Olive-green color, sometimes ranging to yellow or to quite dark brown-green; main axis is flattened. Size: up to about 39 inches. Single, large, firm, oval float bladders are conspicuous along the branches. Tips of branches are often forked. This seaweed was found mixed in with the rockweed at the sites observed. It did not form a distinctive upper limit. See Figures 6 & 7.

Figure 7. Bladder wrack, *Ascophyllum nodosum*

BEACH AND TIDAL WETLAND FLORA

Once the seaweed was described, workshop participants learned about the types of beach and tidal wetlands vegetation found. Kevin Zawoy, Senior Environmental Analyst with the Office of Long Island Sound, Connecticut Department of Environmental Protection described a number of vegetation types that are important for protecting and regulating. Below are listed some of the vegetation described.

Beach grass. Beach grass grows at an elevation above regulatory lines. No beach grass was observed on the sites visited. Site 1 elevations on a number of beach grass lower limits was collected in 2004. See Figure 8.

Figure 8. Beach grass at Site 1, 2004.

Wrack lines. Wrack lines are created from debris washed onto the shore. They can be recent or weeks or months old. Surveyors have located these lines in the past as an indication of DEP regulatory High Tide Line (HTL). Wrack lines were located in their middle, if they were wide as in the case of site 5. Elevation measurements of wrack lines from 2004 and 2008 were recorded for this report, as well as multiple wrack lines for site 4A. See Figures 9, 10, and 11. There was no consensus of either surveyors or regulators as to where a wrack line should be located.

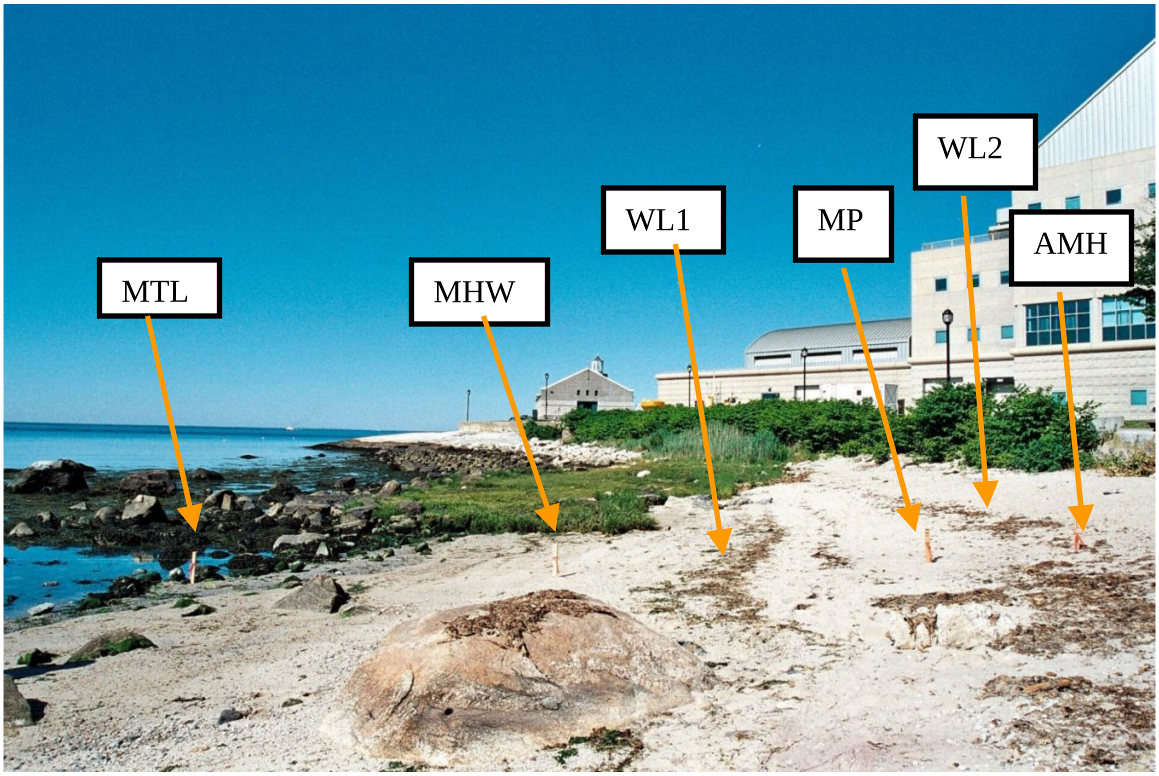

Figure 9. Site 5 with two wrack lines (WL1, WL2). Stakes on the beach represent (from left to right) Mean Tide Level (MTL), Mean High Water (MHW), Highest Predicted Tide (MP), and Average Monthly High Tide 2002-2007 (AMH).

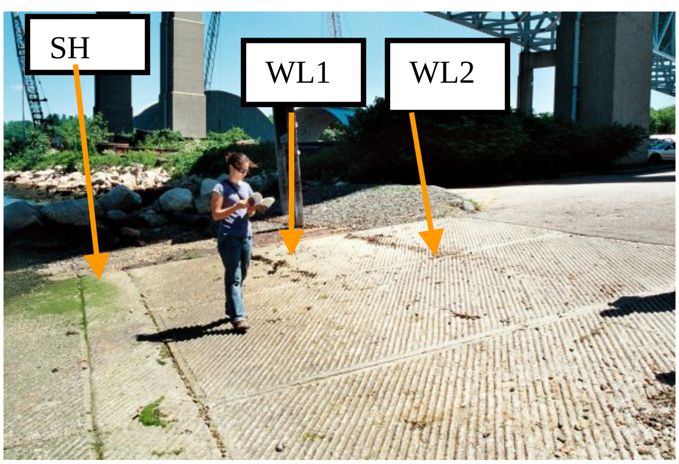

Figure 10. Site 4B, 2 wrack lines (WL1 & WL2) and stone hair upper limit (SH)

Figure 11. Site 4A with three wrack lines

Common reed, *Phragmites australis.* This invasive species crowds out other plants where it grows. Its lower limit is reached when the salt in the soil is too great for it to grow and reproduce. See Figure 12.

High tide bush, *Iva frustescens*, “Jesuit’s bark” or “Marsh elder”. This 2-3 foot tall green bush was found growing at the lower limits of *Phragmites.* It has a high salinity tolerance. See Figure 12.

Figure 12. *Iva frustescens* with *Phragmites australis.* Site 5.

Salt cord grass or smooth cord grass, *Spartina.* Salt cord grass is extremely valuable as the only plant that can tolerate the full salt environment of the upper intralittoral. It grows in a marsh peat base that can be hundreds of years old, and anchors the shoreline as well as providing a home for small fish to grow.

Spartina patens is the shorter flexible grass and grows higher up in elevation. See Figure 13.

Figure 13. *Spartina patens*. Site 5.

Spartina alterniflora, is the taller or stiffer grass and grows lower in elevation. See Figure 10.

Figure 10. *Spartina alterniflora* Site 4A

ELEVATIONS AND ACCURACIES OF OBSERVATIONS

The intent of this workshop was to identify and get elevations of natural phenomena around New London harbor and reach some conclusions as to their suitability in predicting the location of mean high water or any other tidal or regulatory elevation. The data contained in Table 4 is commented upon in this section, starting from the highest natural indicator and continuing down in elevation. All elevations are in the NAVD 88 datum and based on the 83-01 tidal epoch established by NOAA. The standard deviation of the readings is reported to assess usefulness and accuracy of the item reported for determining mean high water or other regulatory lines.

<u>Beach grass.</u> Evidence was found only at Site 1. 4 elevations were taken. The average elevation was 3.0'±0.6'.

<u>Average monthly high tide 2002-2007</u>. This elevation includes all weather effects, for the NOAA tide station 8461490 in New London harbor. It is the average of the actual monthly highest high tide readings in the years from January 2002 to December 2007. The average elevation was 2.50'±0.6'.

<u>Wrack lines</u>. This elevation is the average of 9 elevations at 6 sites. Three of the elevations were from 2004. The average elevation was 2.2'±0.4'. Sites close to each other in location and observed at the same date could be close to each other in elevation. Sites 5 and 6 have elevations of 2.60' and 2.49' respectively. The same site can have two different elevations at two different parts of the site. Site 4A has one wrack line at 2.60' and one at 2.14' within 50' of each other. One was on the beach and one on the boat ramp. The highest wrack lines were found at Site 1 from 2004, with elevations of 2.87' and 2.42'. Variations of place and time will affect the elevation. The highest wrack line (if there was more than one) appeared to be the most useful in terms of recording a maximum tide over a time period of less than one month.

<u>Maximum predicted tide</u>. This elevation is the maximum predicted tide (all weather effects removed) for the NOAA tide station 8461490 in New London harbor from 1983 to 2007. This elevation is 2.1'. This elevation was developed by William Giel, PLS as part for a proposal to utilize this highest predicted tide as the best statewide tidal line to be used for the DEP High Tide Line (HTL). See "Using Highest Predicted Tide Levels to Determine the Connecticut DEP High Tide Line, Kings Point, NY to Newport, RI – 1983-2007".

<u>Blue green algae, *Cyanoacteria*.</u> This bacteria lives in the supralittoral (splash zone) and leaves a very distinctive black line on the rocks and retaining walls in the New London harbor area. 13 elevations were taken at 6 sites, 5 from 2004. Blue green algae showed a consistency of elevation over the entire study area. It did not appear to be affected by salinity levels. The one situation where readings can be misleading is for retaining walls facing direct wave impact, as in Sites 1 and 2. These sites were on the west side of the harbor, where large ships might generate waves perpendicular to the walls. These sites

may also be more vulnerable to storm events (called "northeasters" in New England). These areas recorded higher elevations on the retaining wall than on the rocks that were rounded and did not face direct wave impact. This elevation averaged 1.65'±0.25'.   It would be reasonable to assume in the study area that MHW was 0.7' below the Blue green algae upper limit within ±0.25' standard deviation. This is an indicator but should not be misused to authoritatively determine MHW if elevations can be utilized.

Common reed, *Phragmites australis.* The lower limit of this plant might be dependent on the salinity in the environment. Only three elevations were recorded. Sites 5 and 6 had elevations of 1.92' and 1.86' respectively, and Site 4A, 3.5 miles north in the harbor had an elevation of 0.79', possibly due to less salinity. This plant does not appear to be a reliable indicator of tidal elevation. The average elevation was 1.6'±0.5'

High tide bush or Jesuit's bark, *Iva frustescens*. This bush has a tolerance for salinity in the environment and it appears that its lower limit is about the same as the common reed, and for the same reasons. There were only two recordings for this bush, 1.92' at Site 5 and -0.03' at Site 4A. The average elevation was 1.0'±1.4'. This plant does not appear to be a reliable candidate for predicting elevations.

Mean High Water (MHW) measured. If mean high water is measured by the accepted range reduction (RR), amplitude reduction (AR) or direct height (HD)methods, an accuracy of 0.1' and precision of 0.04' can be expected for 3 tidal readings. 3 readings were taken at each of 7 sites around New London harbor in 2004 and the average results were 0.87', compared with the published MHW elevation of 0.92' from NOAA tide station 8461490 at the state pier in the harbor. *The most certain way to find MHW is to measure it using established and proven surveying methodology.*

Stone hair, *Blidingia minima*. Stone hair is immediately recognizable as the seaweed that has the highest upper limit in the intralittoral zone. It is bright green due to the chlorophyll in its structure, standing out on the rocks in the harbor area. 8 readings were taken at 7 sites, three from 2004. The average elevation was 0.6'±0.4'. This upper limit could be used to estimate approximately the elevation of MHW as 0.3' above the upper limit. The same caveat applies as Blue green algae; there is uncertainty in using this for authoritative purposes. Stone hair has significantly more uncertainty than Blue green algae.

Salt cord grass, *Spartina alterniflora.* This plant has the same characteristics as the previous two plants in terms of its elevation in high or low salinity environments. Site 5 has an elevation of 0.67', site 4A's elevation was 0.05' and -0.03' respectively. The average elevation was 0.2'±0.4'. This plant does not appear to be a reliable candidate for predicting tidal elevations. Studies show that although this species is primarily confined to the intertidal zone, its elevation limits of occurrence do not correspond to a consistent elevation relative to a tidal datum in all marsh locations. The variation in the vertical distribution of this species reported among marsh studies was attributed primarily to differences in mean tide range (MR). Salt cord grass is part of tidal wetlands identification, so its location will be regulated based on its location at whatever elevation it is found.

Rock weed, *Fucus vesiculosis*. This common seaweed with paired float bladders is found with other types of Rockweed and also Bladder wrack *Ascophyllum nodosum*. It also appeared to be at a uniform upper limit throughout the study area. 6 readings were taken at 5 sites, all in 2008. The average elevation was 0.1'±0.3'. The same caveat applies as Blue green algae; there is uncertainty in using this for authoritative purposes. Rockweed has slightly more uncertainty than Blue green algae.

Barnacles. Barnacles were recorded 4 times at three sites. The data was limited and variable, and may also be affected by salinity levels. No examples of barnacles were found 3.5 miles into the harbor at Sites 4A and 4B. Average elevation 0.2'±0.4'

Mean Tide Level (MTL). MTL elevation was determined to be -0.39'±0.04'. The NOAA tide station determination was -0.37'. See comments for MHW.

SUMMARY TABLE ELEVATIONS OF OBSERVATIONS NAVD 88			
ELEVATION	**STANDARD DEVIATION**	**DESCRIPTION**	**COMMENTS**
3.0'	±0.6'	Beach grass	
2.5'	±0.6'	Average monthly highest high tide, 2002-2007	From NOAA tide station 8461490
2.2'	±0.4'	Wrack line	
2.1'	n/a	Maximum predicted tide, 1983-2007	From NOAA tide station 8461490
1.65'	±0.25'	Blue green algae	Best natural indicator of elevation
1.6'	±0.5	Common reed	
1.0'	±1.4'	Jesuit's bark	
0.92	n/a	Mean High Water (MHW)	From NOAA tide station 8461490
0.6'	±0.4'	Stone hair	
0.2'	±0.4'	Salt cord grass	
0.1'	±0.3'	Rock weed	2nd best natural indicator of elevation
-0.37'	n/a	Mid Tide Level (MTL)	From NOAA tide station 8461490

Table 4. Summary of Observations and Accuracy for New London Harbor.

CONCLUSIONS

Through the measurement of natural phenomena and direct tidal measurements in a fairly large area of stable mean high water, conclusions can reached as to the suitability of natural phenomena in determining tidal boundary and regulatory lines.

The best overall indicator for long term tidal elevations, rather than wave and weather action appears to be Blue green algae. It was found at all locations and was clearly visible on the granite rocks found in the harbor area. With an average elevation of 1.65' and standard deviation (1 sigma mean square error) of ±0.25', it could be used as an indicator that MHW is 0.7' below the upper limit of Blue green algae with ¼ foot uncertainty 2 out of every 3 measurements. If the surveying standard was held that all survey data be evaluated to 2 sigma mean square error, then the deviation becomes ± 0.5' in 95 out of 100 measurements.

In comparison, field measurement of mean high water using accepted practices and 3 sets of readings returned an average MHW of 0.87' ±0.03' 1 sigma mse, as well as the mean range (MR) of 2.56' ±0.04'. With MHW and MR computed, Mean Tide Level (MTL= MHW-MR/2) and Mean Low Water (MLW=MHW-MR) can be computed. With 2 sigma mse these values can be determined within 0.1'. The surveying profession needs to apply accepted surveying practices to make the authoritative MHW determinations for purposes of boundary determination and shoreline regulatory purposes. Regulators and environmental scientists can use the natural phenomena for guides as to where MHW is, but should rely on the surveyed determination for regulatory purposes.

This report applies to an area of stable tidal characteristics with measurements taken in summer, where seaweed and other algae that are living at the upper extreme of their environment, the sea, under high temperatures. In Peterson et al, it is reported that changes in environmental conditions such as air and seawater temperature, salinity, as well as more storms and waves in the fall and winter, might cause the upper limits of the seaweed and algae studied to rise to higher elevations than we measured them in the summer. This indicates more uncertainty in relying on natural phenomena for indicating over the long term where mean high water is.

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www.tidesandcurrents.noaa.gov. This is the home page for tidal benchmarks and tidal data in the US and its territories maintained by NOAA.