WATER QUALITY OF FOUR ESTUARIES

IN COASTAL STONINGTON & MYSTIC, CT 2008–2013

CUSH, INC.

CLEAN UP SOUND & HARBORS 2014

WWW.CUSHINC.ORG

WATER QUALITY OF FOUR ESTUARIES

IN COASTAL STONINGTON & MYSTIC, CT 2008–2013

EXECUTIVE SUMMARY

CUSH ESTUARY MONITORING SITES

= GOOD = FAIR = POOR

This report, which covers the years 2008-2013, represents the most comprehensive set of publicly available water-quality data collected by a single organization in Stonington coastal waters. The purpose of our monitoring program is to assess the current and long-term health of local waters, to identify any ongoing trends, and to track identifiable sources of pollution. Our methods and quality control are those developed by the University of Rhode Island's Watershed Watch (URIWW) program (http://www.uri.edu/ce/wq/ww/).

EXECUTIVE SUMMARY

INTRODUCTION

CUSH has monitored water quality in Stonington Harbor and Wequetequock Cove since 2008 and in the Mystic River and Pequotsepos Cove since 2009. These four areas are estuaries; that is, they are open to ocean tides and also receive fresh water from a tributary river or stream. This mixing of fresh and salt water provides a complex, dynamic, and extraordinarily productive ecosystem, while the combination of fresh and tidal currents helps oxygenate the water and flush pollutants out to sea. Healthy estuaries feature clear waters and abundant oxygen, supporting diverse and viable communities of plants, fish, shellfish, and wildlife.

The benefits of mixing fresh and salt water come at a price: Estuaries are especially vulnerable to stormwater runoff, which carries pollutants not only from the surrounding land but from any point in the area drained by the tributary stream. When the amount of rainfall exceeds the capacity of the soil to absorb it, the excess water flows over the land surface, washing pollutants into the nearest ditch or storm drain and ultimately into the estuary itself. The pollutant of greatest concern in estuaries is nitrogen, a preferred fertilizer for saltwater plants, including algae. Fueled by excess nitrogen, algae blooms block sunlight from plants and animals in bottom habitats, while dead algae deplete oxygen and cover sediments with a thick layer of decomposing muck. **High levels of nitrogen and algae, accompanied by insufficient oxygen, result in poor estuary water quality that is harmful to aquatic life and unsuitable for recreation.**

Harmful levels of nitrogen result from human activity: chemical fertilizers from lawns, gardens, and farmland; poorly maintained septic systems; boat waste discharges; debris and pet waste washed from paved urban surfaces and smooth suburban lawns; the burning of fossil fuels; and waste from waterfowl fed by well-meaning people.

The quality of water in any estuary is largely the result of the interplay between nitrogen input from all these sources and removal (flushing) of the resulting algae by tidal and freshwater currents. Strong, unrestricted flows of well oxygenated water carry algae out to sea before harmful blooms can form, allowing aquatic life to thrive even when nitrogen is high. But incoming tides are often restricted by islands, sandbars, or narrow bridge openings, and freshwater flow in small tributary streams is minimal in dry summer months. In long, narrow coves, slow-moving waters and summer warmth provide ideal conditions for nitrogen accumulation followed by algae blooms and subsequent oxygen depletion. **In areas with restricted flow, good water quality can only be achieved by limiting the amount of nitrogen that enters the water.**

EVALUATING WATER QUALITY

Water-quality monitoring is a long-term effort. Some experts maintain that ten years of continuous monitoring are necessary before real trends can be distinguished from short-term effects due to weather and human activity. Meanwhile, interim reports such as this one provide a detailed look at the state of water quality in our monitored areas.

To describe and compare the water quality of each site, we use the Aquatic Health Index (AHI), developed for New England waters by the Buzzards Bay Coalition (MA) and the Salt Ponds Coalition (RI). The AHI is based on a site's summer levels of organic and inorganic nitrogen, microscopic algae, and dissolved oxygen; these indicators are used to calculate an overall aquatic-health score between zero and 100 (Callender, 2008). Zero represents severe degradation (very high nitrogen and algae, very low oxygen) that is harmful to aquatic life, while 100 represents excellent water quality fully supporting abundant and diverse aquatic life. An AHI score between zero and 35 indicates Poor water quality (red), a score between 65 and 100 indicates Good water quality (green), and a score between 35 and 65 is Fair (yellow). Fair water quality scores are further subdivided into Fair-plus (50-65) and Fair-minus (35-50). In addition to the AHI, we consult the water-quality standards for dissolved oxygen and fecal bacteria developed by the Connecticut Department of Energy and Environmental Protection (CT DEEP).

MAJOR FINDINGS

- A number of our monitored sites are located near marinas and the Mystic and Stonington sewage treatment plants, to assess their possible impacts on water quality. Our data reinforce those of regional studies concluding that nitrogen pollution primarily originates in multiple and widespread "nonpoint" sources rather than in specific businesses or facilities.

- Summer algae levels were excessive in all monitored areas except Stonington Harbor, which is exceptionally well flushed by strong tidal flows from Block Island Sound. However, **all four estuaries had excessive summer levels of inorganic nitrogen.** At the mouth of Stonington Harbor, most of the high-nitrogen samples were collected on flood (incoming) tides.

- Overall water quality as indicated by AHI scores was Good throughout Stonington Harbor, Good to Fair-Plus at the mouth of the Mystic River, Fair-Minus in mid-town Mystic River, and Poor in Pequotsepos and Wequetequock Coves. Water quality was directly related to the extent of tidal flushing: Tidal currents were strong in unobstructed Stonington Harbor, moderately strong in the Mystic River, and weak in both coves, where flow is restricted by narrow bridge openings and other obstructions.

- In the tidal-flow-restricted coves, dissolved oxygen was low during extended periods of dry summer weather, when stream flow was minimal. After small rain events and their accompanying increases in stream flow, cove oxygen levels increased steadily; however, when rainfall exceeded 1.5 inches, surface runoff drove dissolved oxygen to its previous low level. In the Mystic River, tidal currents maintained abundant dissolved oxygen even in dry weather, but as in the coves, oxygen levels fell after rainfall over 1.5 inches.

- At the head of **Wequetequock Cove** (2009-2013), overall AHI scores remained at 8 or less (Very Poor water quality). Summer dissolved oxygen was consistently below 4.8 parts per million (ppm), the Connecticut standard for full support of aquatic life, and in 2012-2013, one in five ebb-tide samples was below 3 ppm, indicating acute oxygen insufficiency (CT DEEP 2011 Water Quality Standards, p. 16).

- At the **mouth of Wequetequock Cove** (2008-2013), on the edge of Little Narragansett Bay, water quality was variable, plunging from an average AHI score of 61 (Fair-Plus) in 2008-10 to 21 (Poor) in 2011-12 before rebounding to above 65 (Good) in 2013. This apparently positive change may be due to a rapidly proliferating infestation of macroalgae (seaweed) throughout the Bay. Dense mats of seaweed block sunlight from bottom-dwelling species and can destroy their habitat (Lambert, 2012) even as water-quality indicator scores remain deceptively high. Although both Bay and Cove are closed to recreational shellfishing due to bacterial contamination, the Cove mouth met safety standards for all other recreational uses.

- At the mouth of **Pequotsepos Cove** (2009-2013), ebb-tide samples reflect the water quality of the Cove itself, while flood-tide samples include waters from both Mystic Harbor and Fishers Island Sound. The average overall AHI score was 24 (Poor) in ebb-tide samples and 34 (just below the Fair-Minus threshold) in flood-tide samples. The modest improvement in water quality on flood tides was due to higher levels of oxygen; however, on both tides in 2013, biweekly dissolved oxygen samples remained below the 4.8 ppm aquatic life standard for two consecutive months. Pequotsepos Cove is closed to shellfishing due to bacterial contamination. Nearby Williams Beach, at the Mystic YMCA, is monitored weekly throughout the swimming season by the Town of Stonington.

- In the midtown section of the **Mystic River** (2009-2013), the average overall AHI score was 37 (Fair-Minus), lowered by generally high levels of algae and inorganic nitrogen and by occasional heavy rains producing runoff from the many paved surfaces. In 2012, coinciding with construction activity and bridge repairs, the overall AHI fell to 24 (Poor) before rebounding to 41 (Fair-Minus) in 2013. These abrupt changes highlight the fragility of a system highly vulnerable to runoff nitrogen and subject to intense development pressure.

WEATHER

Southern New England has experienced extreme weather in every year covered by this report: rain-induced flooding in 2009 and 2010, hurricanes in 2011 and 2012, and in 2013 a record-breaking rain event followed by record-breaking heat. These and other events suggest that water-quality results must be interpreted with caution; nonetheless, it seems clear that **either a further increase in nitrogen pollution or a decrease in flushing capacity could tip the balance toward poor water quality in even the healthiest estuary.**

WHAT HAVE WE LEARNED?

1. *When estuaries are well flushed with oxygen-rich water, as in Stonington Harbor and the Mystic River, aquatic life can be well supported even in the presence of nitrogen pollution—as long as nitrogen input does not overwhelm the flushing capacity.*

2. *When both fresh and saltwater flows are weak, as in our flow-restricted coves, poor flushing will allow pollutants to accumulate, and good water quality can only be achieved by limiting the amount of nitrogen that enters the water.*

WHAT WE CAN DO

Clearly, extreme weather is beyond our control, and restoring natural tidal flow is a long-term effort; however, it is well within our power to reduce nitrogen pollution. The following practices have been proven effective:

Manage lawns and gardens organically: Have your soil tested. Use only the amount of fertilizer you need, and use organic methods and organic slow release fertilizers. Eliminate the use of synthetic chemical fertilizers and pesticides. Do not dump lawn clippings and leaves near water bodies.

- **Manage or eliminate sources of bacteria and excess nitrogen** by monitoring septic systems, cleaning up after pets, and controlling surface runoff. For more information, visit (http://www.reducerunoff.org).
- **Practice clean boating** by using pumpout facilities and non-toxic cleaning materials, containing all washings and copper paint removed from boat bottoms, and properly disposing of boat trash in port.
- **Be an advocate!** Voice your water-quality concerns to your town and the CT Department of Energy and Environmental Protection (DEEP). Support Low Impact Development (LID) strategies to reduce stormwater runoff (http://www.nemo.uconn.edu/tools/publications.htm).

The full report (www.cushinc.org) contains additional information, recommendations, and helpful links. The website also contains links to detailed monitoring results.

MISSION STATEMENT

The mission of CUSH, Inc. (Clean Up Sound and Harbors) is to protect Fishers Island Sound and its coves, inlets, bays, rivers, and harbors, and thereby contribute to maintaining healthy water for future generations. We pursue our mission through sustained water-quality monitoring and by promoting good environmental stewardship through public education, demonstration projects, and coastal debris cleanups.

ACKNOWLEDGMENTS

We are grateful above all to our dedicated volunteers. We are also grateful for the generous help of CUSH members as well as Linda Green and Elizabeth Herron of URIWW, Jamie Vaudrey of the University of Connecticut, James T. Carlton of Williams College, Elise Torello and Edward Callender of the Salt Ponds Coalition, and many other environmental advocates and researchers in Connecticut and Rhode Island.

REFERENCES

Callender, Edward, "The Aquatic Health of Rhode Island's Salt Ponds." Salt Ponds Coalition Newsletter (Spring, 2008), pp. 4-7. www.saltpondscoalition.org. For further details, see www.buzzardsbay.org/eutroindex.htm.

CT DEEP Water Quality Standards, 2011. http://www.ct.gov/deep/lib/deep/water/ water_quality_standards/wqs_final_adopted_2_25_11.pdf.

Lambert, Lesley, "Water Quality Impacts on Macroalgae." Narragansett Bay Journal (Summer, 2012), pp. 1-3. Narragansett Bay Estuary Program, www.nbep.org.

TABLE OF CONTENTS

WATER QUALITY OF FOUR ESTUARIES

IN COASTAL STONINGTON & MYSTIC, CT 2008–2013

INTRODUCTION

WHAT WE MEASURE

- **Indicators of healthy aquatic life:** dissolved oxygen, temperature, pH, and salinity. Each form of aquatic life has its own preferred range of these indicators, but oxygen is the most important. If dissolved oxygen falls below 4.8 parts per million (ppm) for long enough, aquatic creatures begin to experience oxygen deprivation, a condition known as hypoxia. The EPA's Long Island Sound Study defines acute hypoxia as less than 3 ppm, and the State of Connecticut has issued detailed criteria for assessing chronic low-oxygen exposure (CT DEEP 2011 Water Quality Standards, p. 42). Faced with either acute or chronic hypoxia, creatures that can travel will leave, and those that can't leave will die.

- **Things that interfere with aquatic life:** In this area that means algae. Overgrowth blocks light from reaching eelgrass and other desirable vegetation, while dead algae deplete oxygen and cover sediments with a thick layer of decomposing muck.

- **Nutrients that fertilize algae and invasive plants:** various forms of nitrogen and phosphorus. Throughout Long Island Sound as well as in our local estuaries, the worst offender is excess nitrogen originating in diffuse and widespread "non-point" sources.

- **Fecal bacteria**, indicators of potential seafood contaminants and water-borne illnesses (CT DEEP 2011 Water Quality Standards, Appendix B). The State's safe limit for designated swimming beaches is a single sample containing 104 units of enterococci per 100 ml; for non-designated swimming beaches and other contact recreation, the limit is 500 units per 100 ml. The safe limit for direct shellfish consumption is an average (geometric mean) of 14 fecal coliform units per 100 ml.

For information on CUSH sampling protocols, schedules, and quality assurance, see URI Watershed Watch: http://www.uri.edu/ce/wq/ww.

INTERPRETING INDICATOR MEASUREMENTS

In addition to monitoring fecal bacteria and consulting Connecticut standards for dissolved oxygen, we employ a tool called the Aquatic Health Index (AHI), which was developed for New England waters by the Buzzards Bay Coalition (MA) and the Salt Ponds Coalition (RI). The AHI is based on four key water-quality indicators: average summer values of organic and inorganic nitrogen and chlorophyll-a (for microscopic algae), together with the lowest one-fifth of summer dissolved oxygen values. For each indicator, a level that does not support aquatic life is assigned a score of 0, and a level that fully supports aquatic life is assigned a score of 100. Each year at each monitoring site, the average summer level of each indicator is compared to the full range of values between 0 and 100, and a water-quality score is calculated for that indicator. A score of 0 to 35 is considered Poor, 35-50 Fair-Minus, 50-65 Fair-Plus, and 65-100 Good. Finally, the scores for all four indicators are averaged to obtain a single number representing the overall water-quality Aquatic Health Index for that site.

COMPONENTS OF THE AQUATIC HEALTH INDEX (AHI)

Oxygen saturation: Dissolved oxygen measurements, as described above, are a key indicator of water quality. However, because warmer and saltier water holds less dissolved oxygen than cold, fresh water, the measured oxygen concentration is expressed as a percentage of the maximum amount the sample could hold at its temperature and salinity. The result, called the percent oxygen saturation, permits direct comparison of oxygen levels in water samples as different as cold, fast-flowing rivers and warm, shallow coves. The oxygen saturation score is based on the lowest 20% of summer samples.

Dissolved Inorganic Nitrogen (Inorganic N): The main forms of dissolved inorganic N are nitrate and ammonium, simple molecules that plants can take up rapidly and easily. What fertilizes lawns and gardens also fertilizes aquatic plants, and excessive amounts of inorganic N can trigger noxious algae blooms. In our waters, important sources of inorganic N include poorly maintained septic systems, boat waste discharges, waste from congregating geese and swans, the burning of fossil fuels, and stormwater runoff from farms, lawns, gardens, and impervious surfaces such as parking lots, roadways, and roofs.

Total Organic Nitrogen (Organic N) is nitrogen that is, or once was, part of a plant or animal; in the garden store it is a component of "organic fertilizer." Organic N is broken down by bacteria into successively simpler compounds that ultimately include nitrate and ammonium. Major sources of organic N in coastal waters and their tributaries are decomposing plants and animals—large, small, and microscopic—as well as human and animal wastes.

Chlorophyll-a reveals the presence of **microscopic algae**, single-celled plants that multiply rapidly in response to excess nutrients, turning clear water into a thick green soup that smells bad.

WEATHER MATTERS

Water-quality indicators in estuaries and their tributaries are influenced by weather changes—a major reason why regular, long-term monitoring is essential. Extreme weather has occurred in Connecticut every year since 2009: storm-related floods in July, 2009 and March, 2010; more flooding from storm surges in 2011 (Hurricane Irene) and 2012 (Superstorm Sandy). 2011 was the wettest year in the 116-year State record. 2013 featured record-breaking rainfall in June followed by record-breaking heat in July. Moreover, throughout the Northeast rainfall totals are increasingly concentrated in a few large storms interrupting prolonged dry spells: In Connecticut alone, a single month accounted for a quarter to a third of the entire year's rainfall in 2009, 2010, and 2013. In addition to causing damaging surface runoff, heavy rain raises groundwater levels, threatening to overwhelm even fully functional septic systems and release nitrogen-laden wastewater. **One of the best means of protecting fragile shorelines is to nurture healthy coastal ecosystems by protecting them from nitrogen pollution.**

MONITORING RESULTS

STONINGTON HARBOR SITES
2008–2013

= GOOD = FAIR = POOR

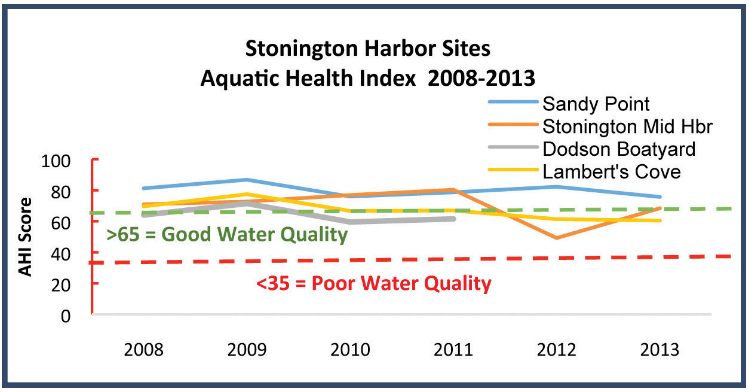


FIGURE 1

Average 6-year AHI scores for all four Stonington Harbor sites were the area's best, ranging from 65 (Good) to 80, as seen in Figure 1. Incoming currents from Block Island Sound are funneled directly into the Harbor through Watch Hill Passage, between Napatree Point and the east end of Fishers Island. At these tide-dominated sites, water-quality indicators showed little or no response to rainfall up to six inches, and fecal bacteria were low.

SANDY POINT

The Sandy Point site, off Stonington Point, is directly in the path of incoming tides from Block Island Sound. This is our control site—that is, its water quality was expected to be the gold standard for the region, and so it is, for the most part. Sandy Point's 6-year average AHI score is 80, with annual scores near 100 for oxygen, chlorophyll-a, and organic N; however, inorganic N was not only unacceptably high (see Figure 3), but most of the highest levels were seen in flood-tide samples.

MID HARBOR

The Stonington Mid Harbor site is located off the Town Dock at the outfall pipe of the Stonington sewage treatment plant. Its 6-year average AHI score is 70 (Good). Figure 2 shows that Mid Harbor's oxygen saturation scores increased from 80 (Good) in 2008-09 to an average of 98 in 2010-13, the largest sustained improvement among all our sites.

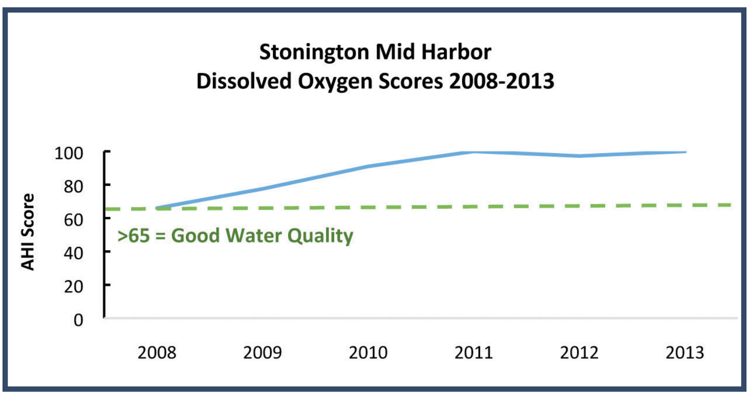


FIGURE 2

DODSON BOATYARD

Dodson Boatyard, on the Harbor's northeast side, was sampled off its longest dock from 2008-2011. This site maintained a 4-year average AHI of 65 (Good), with scores near 90 for chlorophyll-a and organic N. In 2012-2013, we moved the site close to shore near the outfall of a stormwater pipe carrying runoff from approximately 55 acres of Stonington Borough. In this sheltered spot, overall Harbor water quality was Fair, chiefly due to increased chlorophyll-a, while nitrogen levels were roughly comparable to those measured previously from the outer dock. Summer flows in the stormwater pipe were minimal, and its true impact on the Harbor will only become clear after a sustained period of winter and other wet-weather sampling.

LAMBERT'S COVE

Lambert's Cove at Don's Dock, separated from the main Harbor by the railroad, has the distinction of being the only CUSH cove site with consistently high overall water quality—perhaps because it has not one but two bridge openings. Its western end is home to the Harbor's only eelgrass bed. The Cove's 6-year average AHI score is 67 (Good), decreasing somewhat to 60 (Fair-Plus) during extensive bridge construction and repair in 2012-2013.

STONINGTON HARBOR INORGANIC NITROGEN

The average overall AHI scores seen in Figure 1 are the highest among all our sites. But while annual scores of oxygen, chlorophyll-a, and organic nitrogen remained high, Figure 3 shows that inorganic nitrogen scores were generally Poor in all Harbor sites, including Sandy Point, where most high-nitrogen samples were collected on flood tides. This finding was unexpected and prompts the following conclusions:

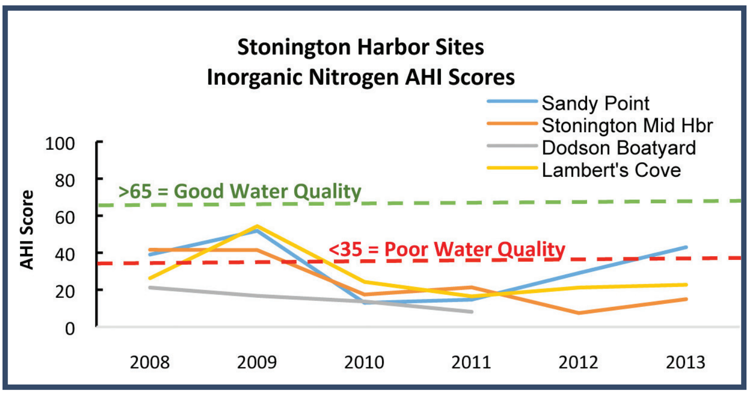


FIGURE 3

1. Throughout Stonington Harbor, the threat from high inorganic N appears to be kept in check by tidal flushing with strong, well oxygenated currents that remove algae before they can grow into destructive blooms.

2. If nitrogen pollution from any source should increase to levels that overwhelm flushing capacity, water quality in the Harbor would certainly suffer.

3. **The way to protect Stonington Harbor in the long term is not only to reduce surface runoff, but also to ensure the health of Block Island Sound, because the Harbor is only as good as the water that enters it twice a day.**

MYSTIC RIVER & PEQUOTSEPOS COVE SITES 2009–2013

= GOOD = FAIR = POOR

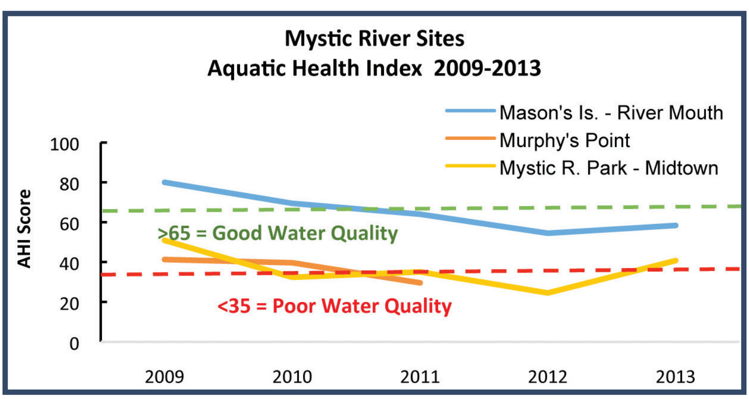


FIGURE 4

MYSTIC RIVER SITES

Five-year Aquatic Health Index (AHI) scores for the three Mystic River sites shown in Figure 4 averaged 65 (Good) at Mason's Island and 37 (Fair-Minus) for the midtown sites of Murphy's Point and Mystic River Park. The River is fed by Whitford and Haley Brooks, but in summer brook flows are minimal and the River is flushed primarily by tides from Fishers Island Sound. In midtown, it is an urban waterway surrounded by roads, sidewalks, roofs, docks, and parking lots. In ebb-tide samples, oxygen saturation fell with each increase in rainfall over 1.5 inches, as a result of runoff from the paved surfaces. Based on fecal bacteria test results, the entire River is approved for all recreational uses as well as for commercial but not recreational shellfishing.

MASON'S ISLAND / RAM POINT

Mason's Island – Ram Point (2009-2013) is the westernmost point on the Island at the mouth of the River, outside the channel and open to Fishers Island Sound. The negative trend seen in Figure 4 is chiefly due to steadily declining AHI scores for both chlorophyll-a and inorganic N (Figure 5). The great majority of high-nitrogen samples were collected on outgoing (ebb) tides, suggesting land-based sources entering the river via stormwater runoff.

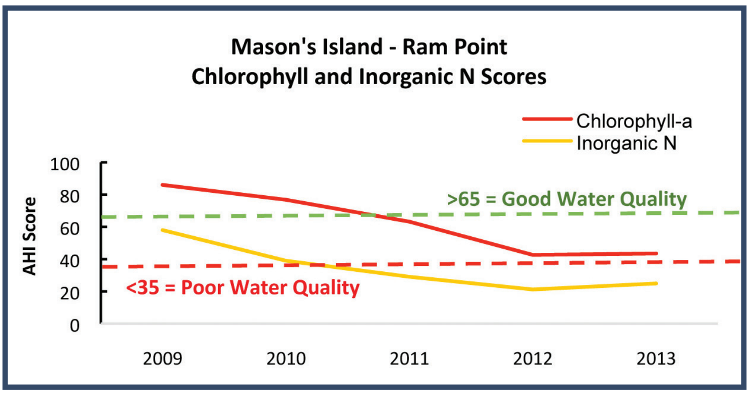


FIGURE 5

MYSTIC RIVER PARK & MURPHY'S POINT

Mystic River Park (2009-2013) is midtown Mystic's green space near the Rte 1 drawbridge. Overall AHI scores were 37 (Fair-Minus; Figure 4) based on individual component scores below 35 for both inorganic N and chlorophyll-a (Figure 6), around 65 for oxygen (Figure 7), and 44 (Fair-Minus) for organic N (not shown). High inorganic nitrogen was found in both ebb and flood-tide samples.

Murphy's Point at Brewer's Yacht Yard, F Dock (2009-2011) is nearly a half mile south of Mystic River Park. This site monitored the outfall of the Mystic sewage treatment plant just south of the railroad bridge and just outside the river channel. Overall AHI scores for Murphy's Point were nearly identical to those of Mystic River Park.

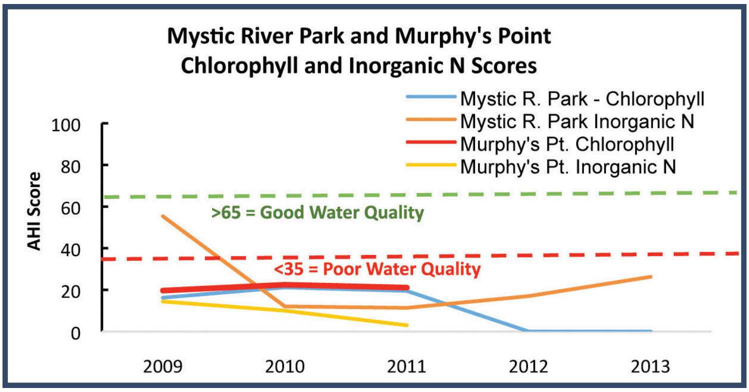


FIGURE 6

MYSTIC RIVER DISSOLVED OXYGEN

Despite differences in overall water quality between the River mouth at Ram Point and mid-town, all three sites had very similar annual oxygen scores (Figure 7). Average summer dissolved oxygen concentrations at all three sites were well above the 4.8 ppm standard for aquatic life.

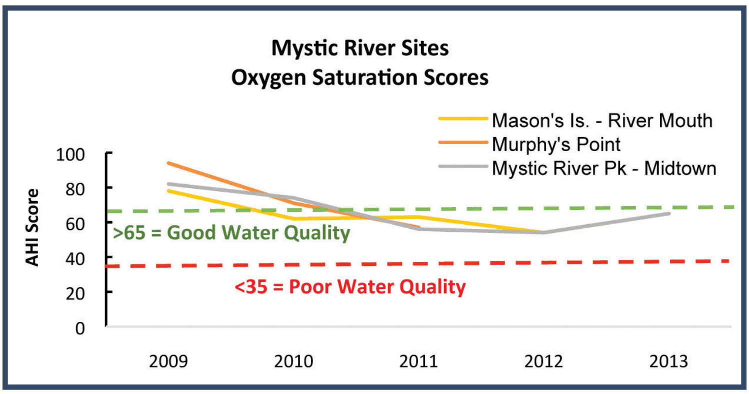


FIGURE 7

We conclude that strong, well oxygenated flows are capable of maintaining water quality that fully supports aquatic life, even when both algae and nitrogen are unacceptably high. Such water bodies are vulnerable to changes, such as waterfront development, that further increase nutrient runoff; the River is therefore at risk and should be considered a valuable resource in need of protection.

PEQUOTSEPOS COVE SITES

For clarification of the following discussion of Pequotsepos Cove, please refer to the map on Page 12. The shoreline map on Page 3 may also be helpful.

Pequotsepos Cove (2009-2013) is a narrow cove less than a mile long, fed by Pequotsepos Brook. Samples collected from the Brook since 2012 met EPA nutrient criteria for streams with no human impact; however, its flow slows to a trickle during dry summer months, contributing very little fresh water to the Cove. In ebb-tide Cove samples, oxygen saturation increased with increasing rainfall up to about 1.5 inches, illustrating the beneficial flushing effect of increased stream flow; with each further increase in rainfall oxygen saturation decreased, illustrating the harmful effect of surface runoff.

Saltwater flows into and out of the Cove are restricted by the narrow openings of the railroad bridge, the Route 1 bridge, and the Mason's Island causeway. Incoming tides enter the Cove partly from Mystic Harbor north of Mason's Island and partly from Fishers Island Sound by way of the causeway east of the Island. In the future, proper study of the Harbor must include an examination of flow patterns as well as water-quality indicators. Since 2010, we have monitored the mouth of the Cove on both ebb and flood tides.

EBB TIDE AND FLOOD TIDE

Pequotsepos Cove ebb-tide samples reflect the overall water quality of the Cove itself. Figure 8A shows that ebb-tide AHI scores at the Cove mouth were generally below 35 (Poor). The 5-year average AHI was 24, chiefly because of very low scores for chlorophyll-a and inorganic N (not shown).

Pequotsepos Cove flood-tide samples reflect the quality of the water entering the Cove from Fishers Island Sound and Mystic Harbor. Chlorophyll-a and inorganic N scores were as low as those in ebb-tide samples; however, overall AHI scores were somewhat higher in 2011-2013, averaging 34 due to higher levels of oxygen (Figures 8A and 8B).

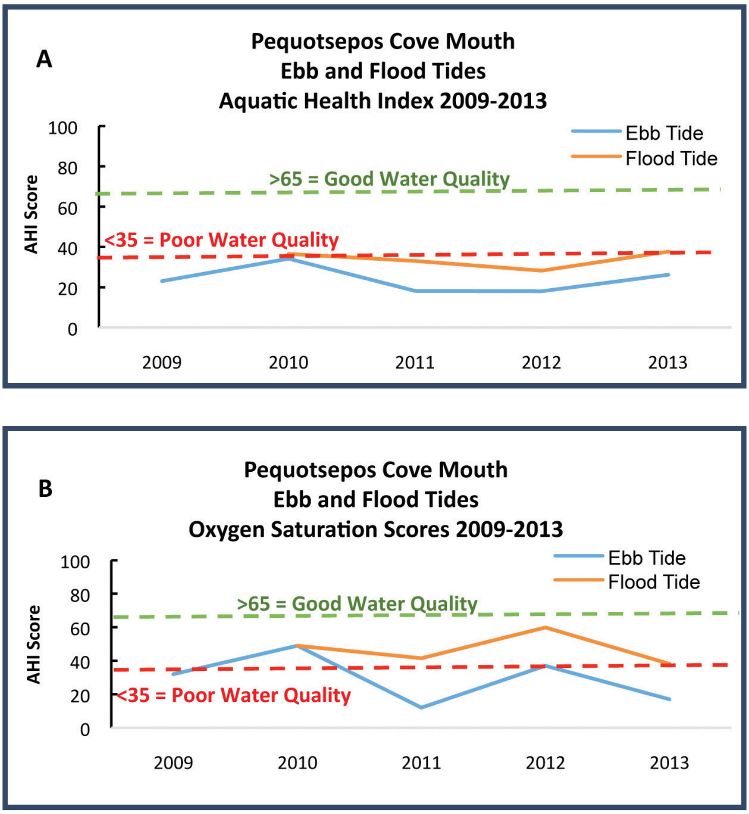


FIGURE 8

PEQUOTSEPOS COVE DISSOLVED OXYGEN

Although flood-tide AHI scores at the mouth of the Cove were similar to those of the midtown River sites, average oxygen scores were 30% lower: 47 (Fair-Minus) in waters entering the Cove versus 70 (Good) at the River sites (see figures 4, 7, and 8). In ebb-tide samples, Cove oxygen scores were much lower, averaging 29 (Poor). In every year except 2010, summer average dissolved oxygen was below the 4.8 ppm standard for aquatic life. In general, dissolved oxygen was higher on flood tides; however, in the summer of 2013, four consecutive biweekly samples on both ebb and flood tides failed to meet the aquatic-life standard.

Pequotsepos Cove is closed to shellfishing due to fecal bacteria, and the recreational limit was exceeded in one CUSH sample per year in 2009-2011. Note that waters at Williams Beach, a public beach east of Pequotsepos Cove, are monitored weekly by the Town of Stonington and originate in Fishers Island Sound, where fecal bacteria are low.

WEQUETEQUOCK COVE SITES
2008–2013

= GOOD = FAIR = POOR

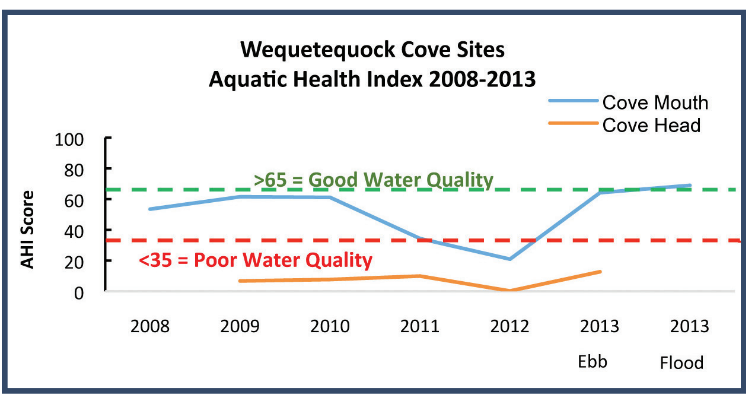


FIGURE 9

A narrow, wedge-shaped water body nearly two miles long, Wequetequock Cove is fed at its shallow head by Anguilla Brook and empties at its mouth into Little Narragansett Bay. Like Pequotsepos Brook, Anguilla Brook has minimal flow in dry summer weather, and in both coves oxygen saturation responds similarly to differing amounts of summer rainfall, with increased oxygen after modest rainfall followed by decreases above 1.5 inches. Saltwater flows within the Cove are weakened by its length and funnel shape, its narrow railroad bridge opening, Sandy Point island, and masses of macroalgae (seaweed) in the Bay. The Cove is closed to recreational shellfishing due to bacterial contamination.

Anguilla Brook is known as a high-quality trout stream in a lightly developed watershed. Samples collected since 2012 show that the average total-nitrogen level exceeds EPA water-quality standards for rivers and streams (US EPA, 2002). However, because of the relatively small volume flow, its nitrogen contribution to the Cove during the summer months appears to be small except after heavy rainfall or sustained wet weather. Perhaps more significantly, a comparison of ebb- and flood-tide samples (see below) suggests that poor flushing at the head of the Cove may lead to accumulation of nitrogen, even from relatively small additions over time.

WEQUETEQUOCK COVE HEAD & INLET

The Head of Wequetequock Cove (2009-2013) is near the intersection of Route 1 and Greenhaven Rd. and is monitored from Stonington (formerly King Cove) Marina. The Cove has consistently had the lowest water quality of any CUSH site (Figure 9), with exceptionally low scores for all individual components except inorganic N (Figure 10). In all years, dissolved oxygen in 7-12 biweekly summer samples averaged less than the aquatic-life standard of 4.8 ppm. In 2012 and 2013, one out of five ebb-tide samples fell below 3.0 ppm, the State's threshold for acute hypoxia. Although most low-oxygen samples were collected on ebb tides, 71% of such samples in the summer of 2010 were collected on flood tides.

The Wequetequock Cove Inlet site was added in 2011 to monitor the effect of Oxecosset Brook and the vineyard. Preliminary results suggest that, although water quality in the brook is very poor, it has generally had a minor effect on the Cove since results at Head and Inlet sites were similar.

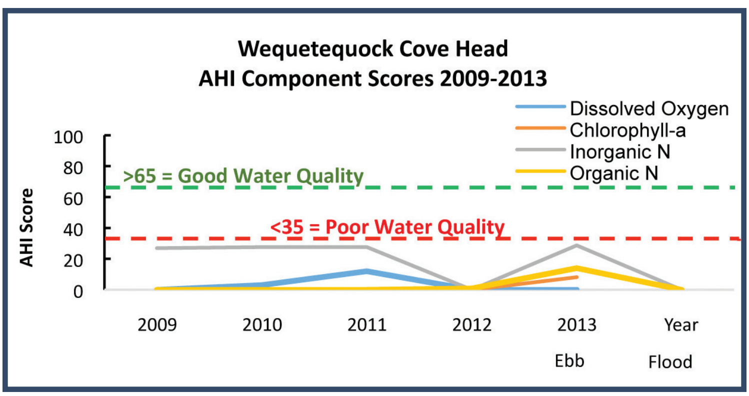
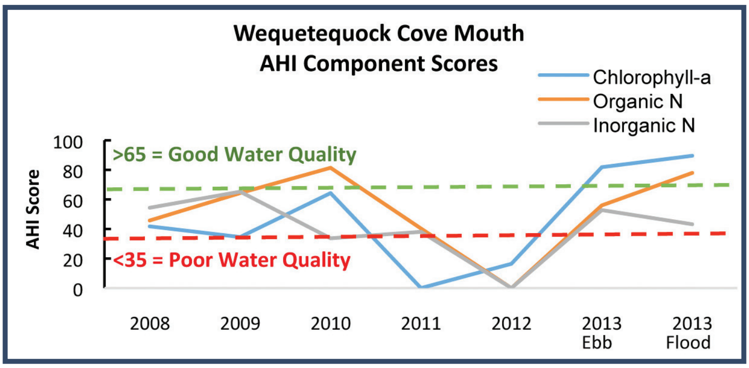


FIGURE 10

WEQUETEQUOCK COVE MOUTH

The Mouth of Wequetequock Cove (2008-2013) lies south of the railroad bridge, at center cove, on the edge of Little Narragansett Bay. In 2011 and 2013, individual samples of fecal bacteria exceeded the limit for safe swimming. As seen in Figure 9, overall annual AHI scores fell abruptly between 2010 and 2012, from an average of 61 (Fair-Plus) to 21 (Poor), then back to 66-69 (Good) in 2013. Figure 11 shows that these changes occurred in all indicators except oxygen, which averaged 76 (Good) throughout the 6-year period.

The apparent improvement in 2013, particularly in chlorophyll-a, may be due in part to a rapidly proliferating infestation of macroalgae (seaweed) throughout the Bay. Dense mats of seaweed can restrict tidal flows and destroy the habitat of bottom-dwelling species such as crabs, shellfish, and shrimp (Lambert, 2012). At the same time, seaweed produces abundant oxygen, crowds out microalgae, and takes up large amounts of nitrogen from the water column--all of which keep indicator scores deceptively high. Continued, expanded, and creative monitoring techniques will be needed to evaluate these changes.



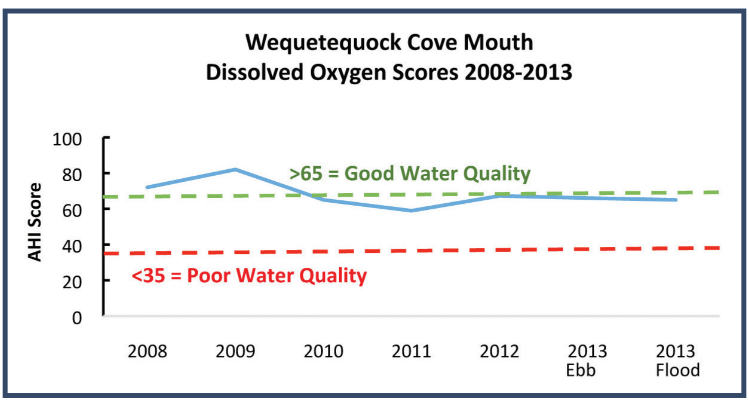


FIGURE 11

POLLUTION SOURCES AND REMEDIES

SOURCES

1. Restricted tidal or freshwater flushing due to man-made or natural obstructions, such as narrow openings in railroad and highway bridges, islands at bay entrances, stream or river dams, and upstream water withdrawals reducing downstream flow.

2. Nutrient sources (Nitrogen) that fuel oxygen-depleting algae blooms, which can be harmful or even deadly to marine life.

3. Uncontrolled stormwater runoff, a major source of water pollution in Long Island Sound. Pollutants from our everyday activities are picked up by uncontrolled stormwater, deposited into storm drains (catch basins), and delivered into local waters. Pollutants may be deposited directly into waterways from clipped lawns or paved surfaces near the shoreline. Contaminants carried in stormwater include:
   - **Chemical fertilizers and pesticides** from lawns, gardens, playing fields, parks, and farms
   - **Pet waste**, including doggy bags deposited in storm drains
   - **Wildlife waste**, especially from geese and swans
   - **Oil and grease** from roadways
   - **Detergents** from washing boats or cars near shore or on paved driveways

4. Major storms and hurricanes, which stir up waters and sediments, wash over land areas, and generally disrupt the marine system, resulting in temporary sharp declines in water quality.

5. Septic systems that are poorly designed—for example, too small or sited on inappropriate soils–or poorly maintained.

6. High impact development lacking stormwater controls.

WHAT WE CAN DO

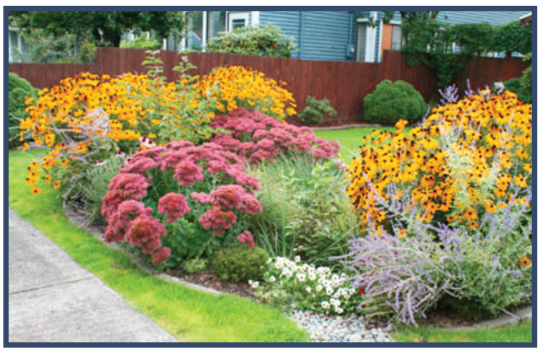
Major storms and natural flow restrictions are out of our control, but many of the contributors to poor water quality are related to our everyday decisions and actions.

Eliminate use of synthetic chemical fertilizers and pesticides. Use organic/natural methods and products.

- **Test your soil**, ask for organic recommendations, and add only as much organic fertilizer as the test results indicate.
- **Mow lawns to no less than 3 inches and leave the clippings.** Roots will grow and watering needs will shrink dramatically.
- **Top dress in the fall** with ¼ inch of high-quality organic compost.
- To improve both soil and plant health, **aerate areas where the soil is packed firmly** (compacted).
- For details and useful links visit www.cushinc.org (click on "Solutions," then on "Sound Friendly Yards").

Manage or eliminate sources of bacteria and nutrient runoff:

- **Monitor and maintain your septic system** or replace it with one of the new, more efficient models (www.uri.edu, enter "septics" in the search window).
- **Clean up after your pet** and dispose of doggy bags in the trash.
- **Do not feed wildlife**, especially geese and swans. In addition to depositing wastes (up to 3 lbs per day), these wildfowl uproot salt marsh grasses as they feed. Feeding also harms the birds themselves by fostering dependency, which can lead to diseases, malnutrition, and disruption of normal migration patterns.
- **Use permeable asphalt** for driveways, parking areas and sidewalks.
- **Capture individual sources of runoff** before they combine into unmanageable streams. (http://www.reducerunoff.org/). Divert roof runoff into rain barrels. Install rain gardens, where water can seep gradually into the ground instead of rushing into a storm drain and then into the nearest ditch or stream. If you live on the water, plant a buffer garden at the shoreline (http://clear.uconn.edu/crlg/index.html).



An example of a rain garden. Photo by David Hymel.

Practice clean boating :

- **Do not discharge holding tanks into the water**; use pumpout facilities. To find a facility, pick up a CUSH clean boating brochure at your marina or visit www.cushinc.org (click on "Solutions," then on "Sound-Friendly Boating"). Remember, Long Island Sound is a No Discharge Area–it's the law!
- **Use biodegradable or non-toxic cleaning materials** and **contain all washings or toxic paint removed** from boat bottoms.
- **Bring all trash back** to port for disposal.

Be an activist:

- **Voice your water-quality concerns to your town and to CT DEEP.** Promote and support Low Impact Development (LID) strategies (www.unh.edu/unhsc) in your town. LID principles can make major contributions to protecting water quality, using approaches such as managing stormwater, preserving open space and natural water flow, and re-evaluating traditional building techniques to support these concepts.

- **Volunteer your time, attend our programs and give your philanthropic support** to help us to continue this important water quality monitoring work.

REFERENCES

Callender, Edward, "The Aquatic Health of Rhode Island's Salt Ponds." Salt Ponds Coalition Newsletter (Spring, 2008), pp. 4-7. www.saltpondscoalition.org. For further details, see www.buzzardsbay.org/eutroindex.htm.

CT DEEP Water Quality Standards, 2011. http://www.ct.gov/deep/lib/deep/water/water_quality_standards/wqs_final_adopted_2_25_11.pdf.

Lambert, Lesley, "Water Quality Impacts on Macroalgae." Narragansett Bay Journal (Summer, 2012), pp. 1-3. Narragansett Bay Estuary Program, www.nbep.org.

US EPA Ambient Water Quality Criteria Recommendations – Rivers & Streams in Nutrient Ecoregion XIV, subregion 59. Document 822-B-00-022, December 2002. http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/upload/2007_09_27_crit eria_nutrient_ecoregions_rivers_rivers_14.pdf.

FOR MORE INFORMATION

RAIN GARDENS:

http://www.ct.gov/deep/lib/deep/water/watershed_management/wm_plans/lid/what_is_a_rain_garden.pdf
http://nemo.uconn.edu/raingardens/index.htm

RAIN BARRELS:

http://www.ct.gov/deep/lib/deep/water/watershed_management/wm_plans/lid/what_is_a_rain_barrel.pdf

SHORELINE BUFFERS:

http://web2.uconn.edu/seagrant/publications/coastalres/riparian.pdf
http://www.ct.gov/deep/lib/deep/long_island_sound/coastal_management/twbufferguidance.pdf

CLEAN BOATING:

http://www.ct.gov/deep/cwp/view.asp?a=2705&q=323526&deepNav_GID=1620

LOW-IMPACT DEVELOPMENT:

http://www.ct.gov/deep/lib/deep/water/watershed_management/wm_plans/lid/what_is_low_impact_development.pdf
http://www.nemo.uconn.edu/tools/publications.htm

STORMWATER RUNOFF:

www.unh.edu/unhsc

CUSH, INC.
CLEAN UP SOUND & HARBORS 2014
WWW.CUSHINC.ORG