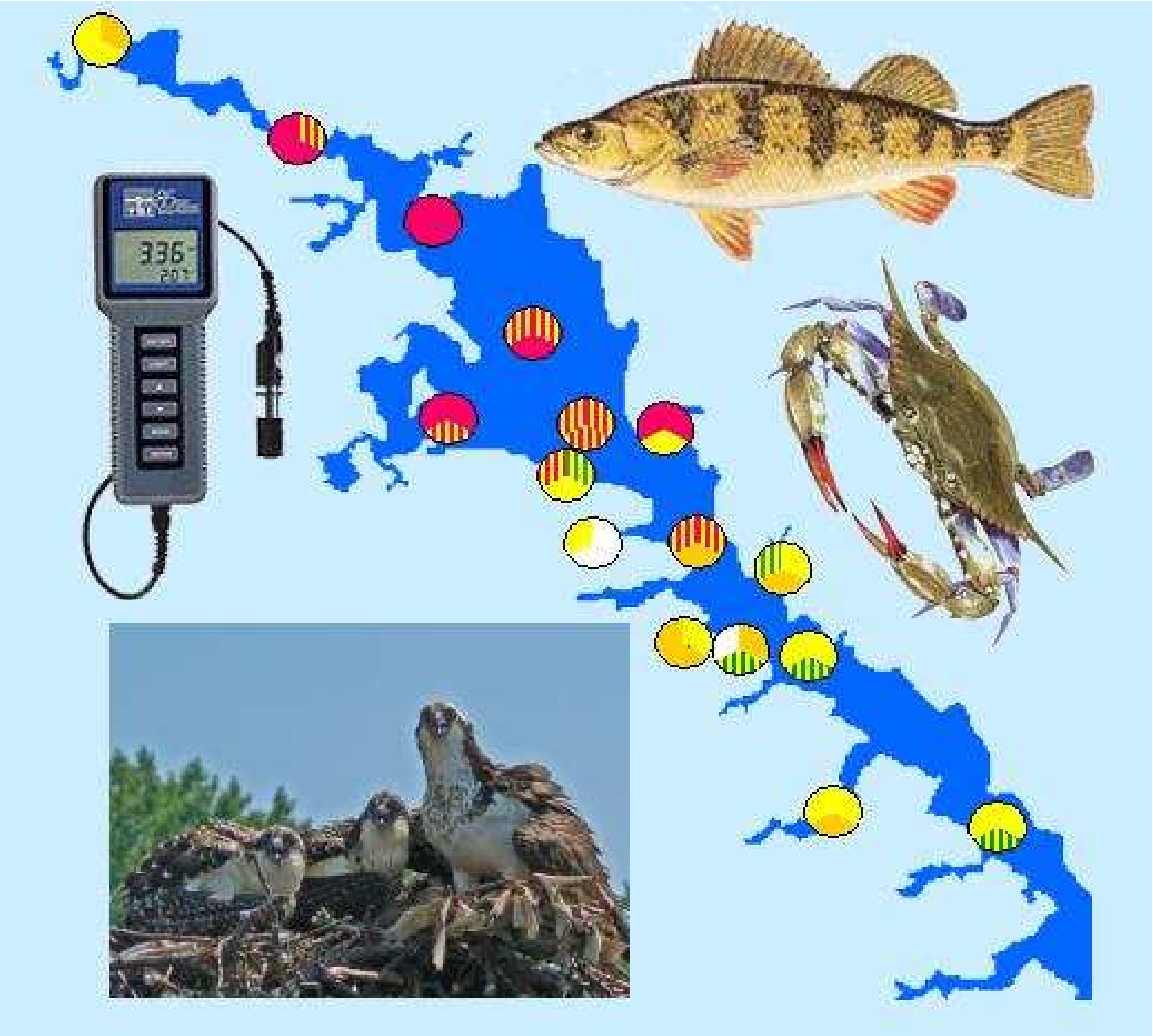
2008 Severn Riverkeeper Monitoring Project

Pierre Henkart



2008 Severn Riverkeeper Monitoring Project

by Pierre Henkart, PhD, Severn Riverkeeper Program

Summary

During the summer of 2008, the Severn Riverkeeper Monitoring Project measured dissolved oxygen, salinity, temperature, and surface water clarity from 15 stations throughout the tidal Severn River at 1-2 week intervals. As expected, dissolved oxygen levels throughout the River diminished with depth, and for the months of June through August, over half the water throughout the tidal Severn was below the Chesapeake Bay Program's "healthy" level of 5 mg/liter. Most strikingly, bottom dissolved oxygen levels in northern Round Bay and the adjacent upper Severn averaged less than 0.5 mg/liter, and hydrogen sulfide was routinely detected in these water samples. Because we have reported similar bottom anoxia in this area in 2006 and 2007, it is clear that a summer "dead zone" regularly forms in this region of the Severn. This dead zone is a thinner and smaller version of the one well described in the deep channel of the Chesapeake, but no other Chesapeake tributary has been shown to have persistent summer bottom anoxia in such shallow (5-7 meter) water. Particular features of the Severn that promote this bottom anoxia were not clearly identified. As in previous years, salinity increased at all stations from 5-6 ppt in June to 11-12 ppt in September, with typical differences of ~1 ppt between surface and bottom readings (confirming the absence of a pycnocline). Similar to the previous two years, the mid Severn/Round Bay region had the best surface water clarity (mean Secchi depths >1.0 meter), correlating with the growth of substantial submerged aquatic vegetation along both shores. Both upper and lower Severn stations had mean Secchi depths <1.0 meter, correlating with little of no submerged aquatic vegetation along their shores. In addition to the above water quality monitoring, we collaborated with Maryland DNR Fisheries and Arlington Echo Outdoor Education Center to monitor yellow perch larvae by plankton tows in the upper Severn in the spring. Using a standard DNR protocol, the spring of 2008 produced the lowest number of these larvae in the last 5 years of measurement.

Background

The Severn Riverkeeper Monitoring Project collected water quality data throughout the summers of 2006 and 2007, and our 2008 season was largely a follow-up on those efforts. To allow for comparison with previous data, the same monitoring stations and the same instruments were used for measurements. The most important result of previous monitoring was the identification of an anoxic "dead zone" at the bottom of upper Round Bay and the adjacent upper Severn, so these stations were monitored with special attention in 2008. The anoxia in this "dead zone" means that bottom-dwelling organisms such as clams, worms, etc., will be absent from this region of the Severn along with crabs and fish that prey on them. However, while this bottom habitat is destroyed, the low dissolved oxygen in water further above the bottom can also be part of a "habitat squeeze" that negatively impacts other desirable fish such as white perch and striped bass. To address this hypoxic habitat squeeze issue, we have added an analysis of the dissolved oxygen depth profiles acquired in the last 3 years so that we can estimate the percent of Severn water with adequate oxygen according to the Chesapeake Bay Program's "healthy" criterion of 5 mg/liter. Overall, we find that only about half the water in the tidal Severn met this standard during the summer. Unfortunately, other Chesapeake tributaries have not been monitored as thoroughly as the Severn, so it is not clear whether this mid-water habitat is worse in the Severn than others.

Methods

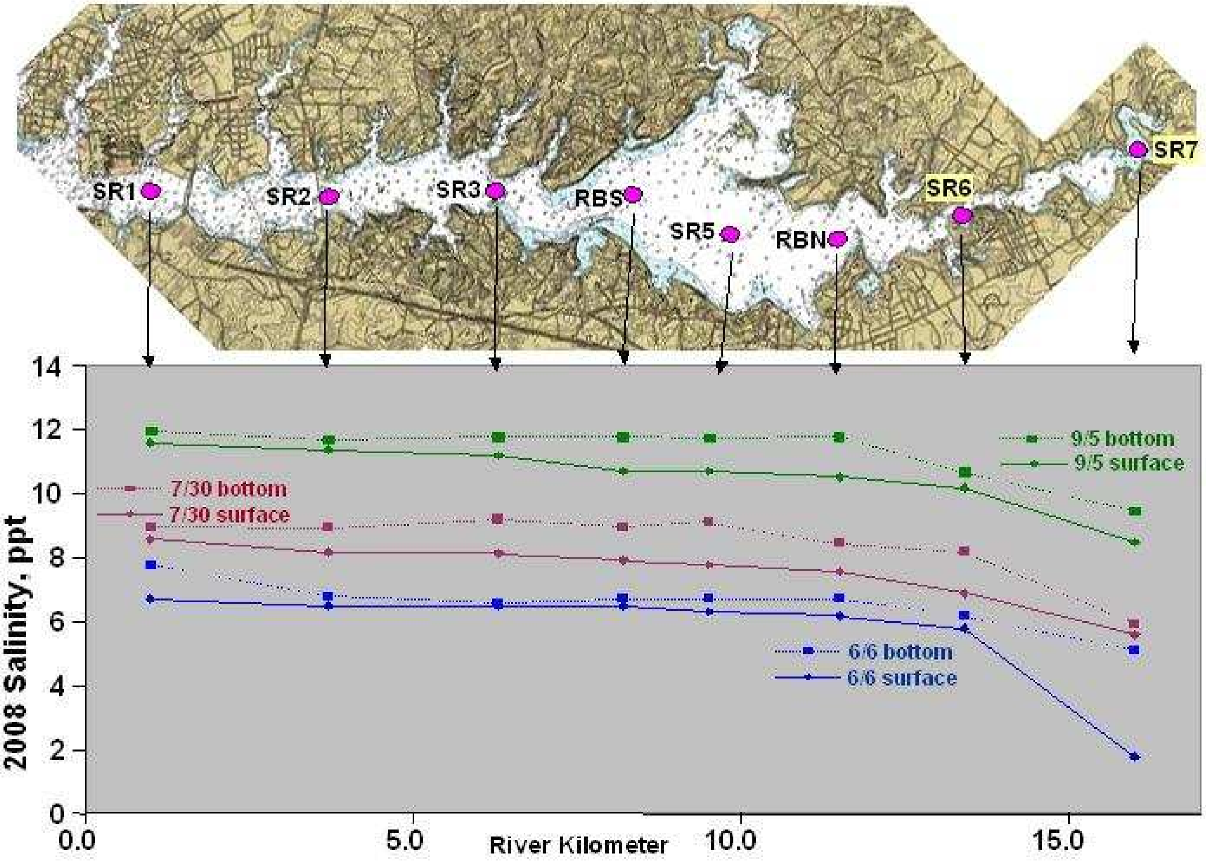
The 2008 Severn monitoring stations are generally the same as those in 2007. One exception is that Martin's Pond in the mid-Severn has a shallow entrance endangering our boat's propeller at low tide, so that station was dropped and was replaced with a station near the tidal head of Brewer's Creek. It was hoped that this new station would reflect current restoration efforts in Howard's Branch, the freshwater stream whose mouth is nearby. As shown on the map, some of our monitoring stations are in the mid-Severn channel, and some are in the tidal creeks of the lower and middle Severn.

Two probe-based YSI 85 meters capable of measuring dissolved oxygen, temperature and salinity, successfully used in 2007, were used again in 2008. One has a 25- foot cable that was useful for all stations except the deep SR3 station in the middle of the Severn off Joyce. The other meter with a 50-foot cable was used at all stations. Virtually all dissolved oxygen measurements reported are an average of two meter readings, made by different observers in the bow and stern of the monitoring boat. Assessment of the presence of hydrogen sulfide by olefaction was carried out using a water sampling device to confirm anoxia when low (DO<0.2 mg/l) meter readings were obtained. Surface water clarity was measured with a standard Secchi disk; results reported are the average of two independent readings at each station.

Each monitoring station was located by maneuvering the boat using visual line-ups of shore-based landmarks from a photo-based guide established in 2006. The boat was anchored at the designated position, and the monitoring probes were lowered to ~.5 meter off the bottom using a lead weight suspended under the probe. Readings of dissolved oxygen percent saturation, mg/liter dissolved oxygen, salinity and temperature were made at 1-2 meter depth intervals to the surface, with care taken to keep the probe moving via a jigging motion as required for accurate readings by the oxygen electrode. Data were recorded by a second person using a clipboard, and subsequently transferred to an Excel spreadsheet, normally within one day.

Salinity--Results

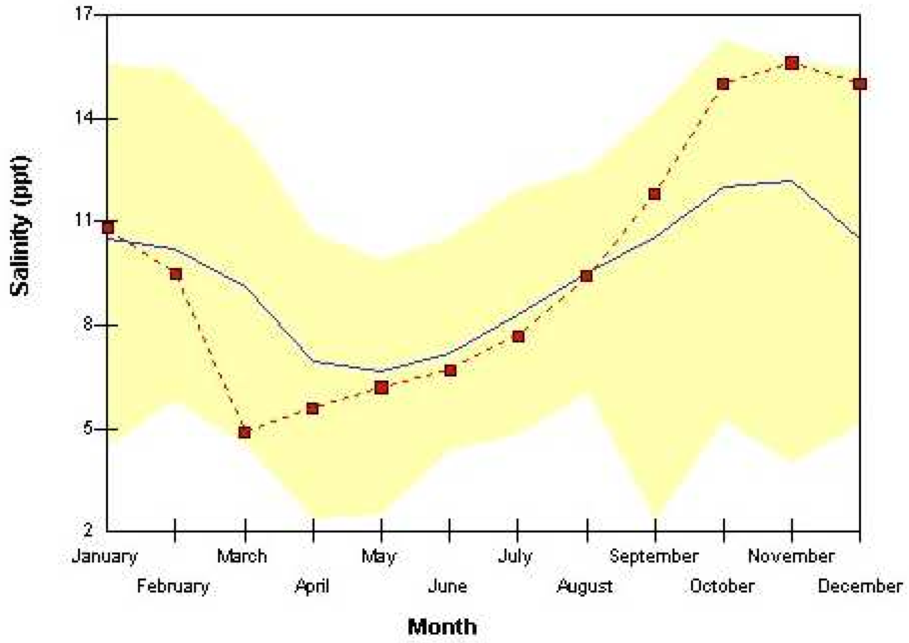
Salinity results are presented first because they reveal a fundamental but little-appreciated aspect of the Severn's relationship to the Chesapeake. As we found in previous years, the Severn's salinity was surprisingly constant throughout the16 kilometer length of the tidal Severn. The figure below shows 2008 salinity data from three monitoring days spread over the summer. The Severn chart at the top has been rotated so that it aligns with the graph, with Annapolis at the left. While the uppermost monitoring station (SR7) shows significant fresh water influx, mainly at the surface, the salinity change from Annapolis to the Severn Narrows station (SR6) is generally less than 10%. In most cases, there is only a small difference (<2ppt) between surface and bottom salinities at one station. The above figure also shows the salinity increasing over the course of the summer.



Although not shown in the above figure, the Severn tidal creek stations had salinities very similar to the nearby mainstem stations, with little or no local freshwater inflow detected. However, we did not schedule monitoring to detect freshwater inflows resulting from rain events.

Salinity--Discussion

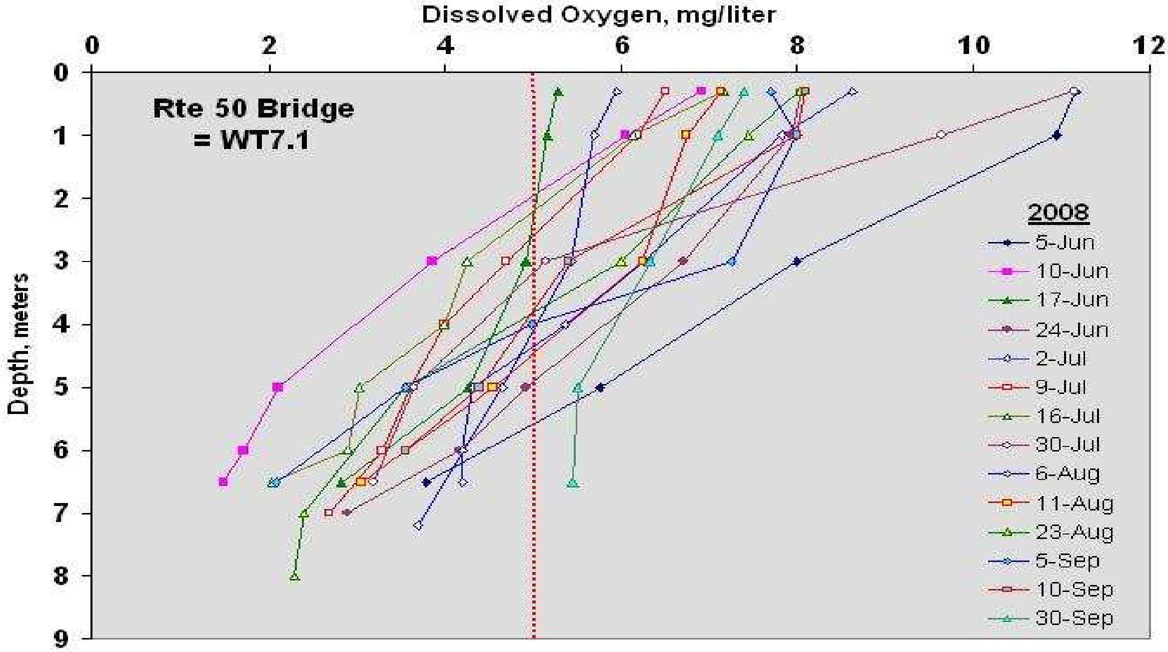
The Severn's salinity during the summer months of 2008 was rather typical when compared to historical records, as can be seen from the DNR's "Eyes on the Bay" data from the Route 50 Bridge monitoring station reproduced here. The 6-7 ppt levels we found at the start of the summer are in the range of the normal minimum salinity in the Severn, reflecting high fresh water inflow from the Susquehanna in the spring. While it is tempting to look at a map of the Severn and think of it as a flowing river or a subestuary with its own salinity gradient, our salinity measurements throughout the Severn indicate a rather uniform salinity from Annapolis to the tidal head of the Severn. The freshwater inflow after a rainfall is detectable at the uppermost stations, but is a relatively minor and temporary influence on the overall Severn water mass. Our previous monitoring data (2006) showed that high freshwater inflows from the Susquehanna come down the Bay and rapidly lower the Severn's salinity starting at Annapolis and working up the Severn. Data presented on the DNR's "Eyes on the Bay" website (http://mddnr.chesapeakebay.net/eyesonthebay/april_salinities.html) suggest this occurs every spring. This interesting and perhaps unexpected phenomenon is readily explainable by a density-driven water exchange at the mouth of the Severn in response to the changing salinity of the upper portion of the adjacent Chesapeake.

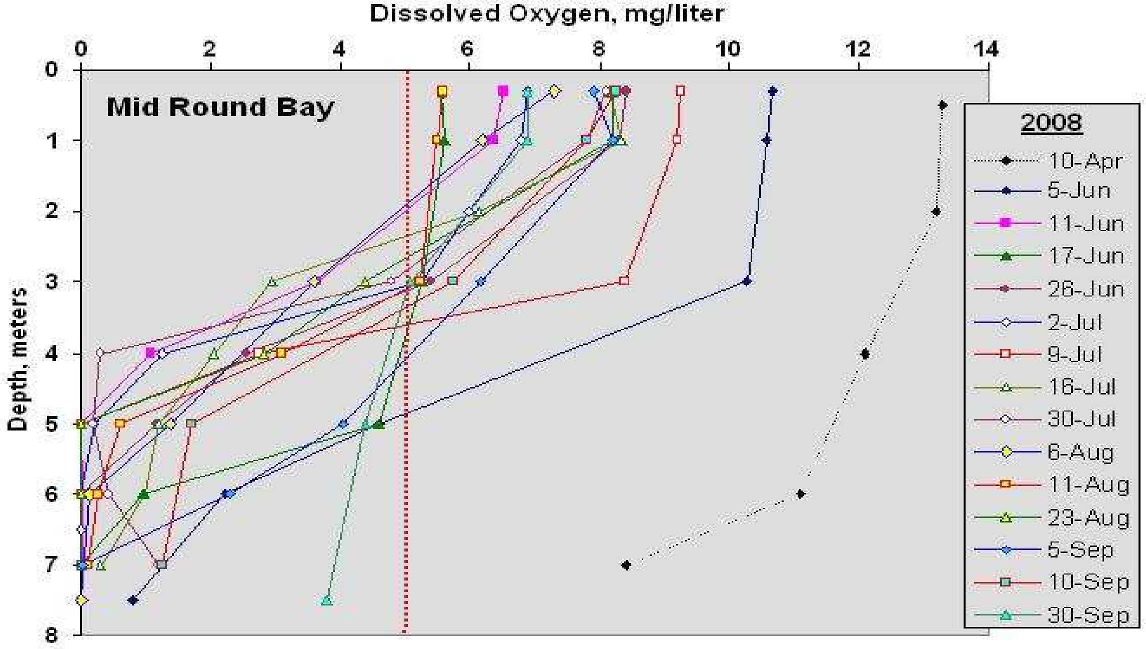


Although local rainfall was normal during the first half of the summer, the Susquehanna's flow decreased considerably more than usual starting in June. This allowed salty water from the ocean to move further up the Bay, pushing the lighter, fresher water in the Severn out into the Bay. The continued lower-than-normal Susquehanna flow throughout the summer and fall was responsible for unusually high Severn salinities from October through December. It is possible that these higher salinities could be detrimental to oyster restoration efforts in the Severn, as such salinities favor the reproduction of the devastating oyster pathogen, Dermo. However, press reports in the winter of 2008 indicated that oyster infection by Dermo was less than expected.

Dissolved Oxygen--Results

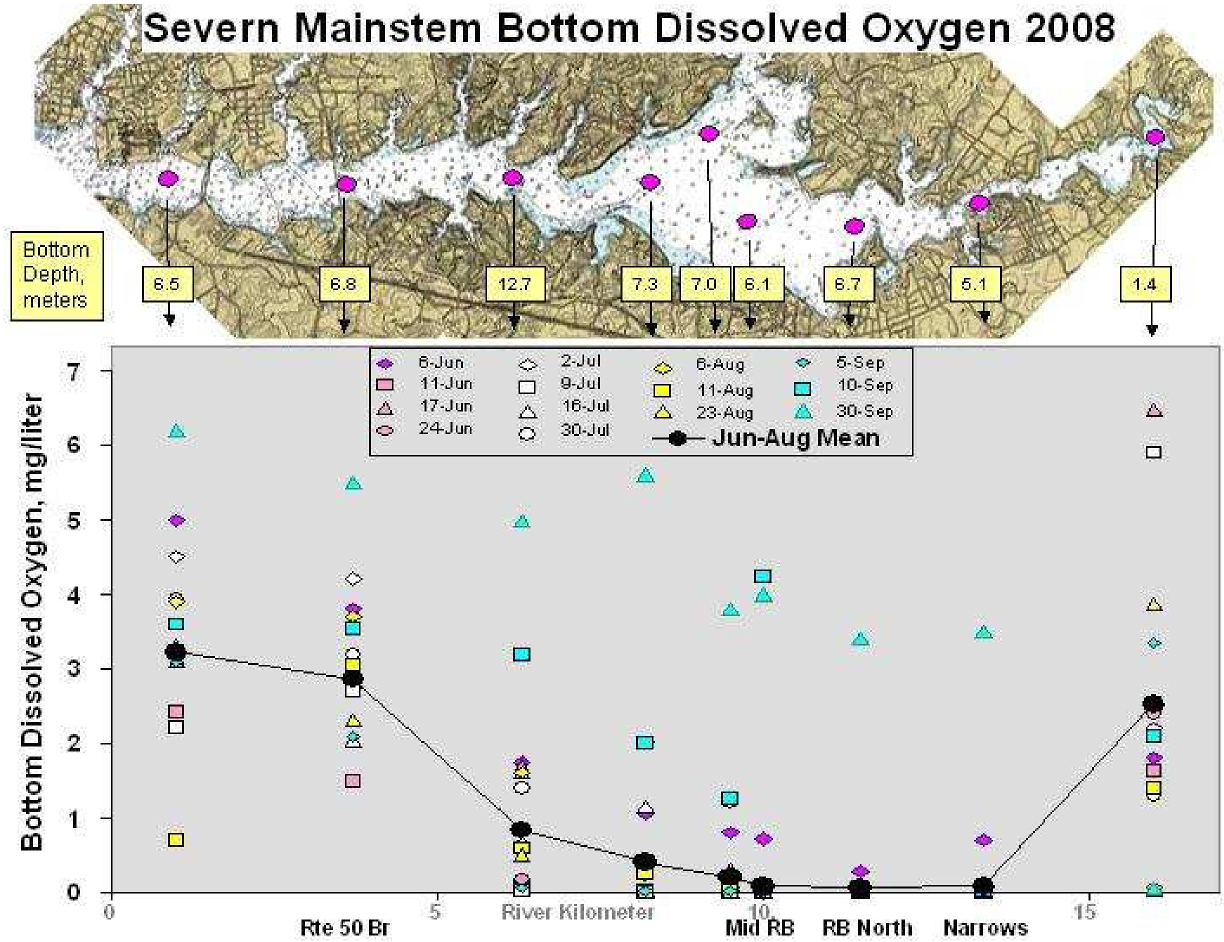
Our 2008 monitoring data revealed low levels of dissolved oxygen (DO) in the Severn, similar to our results from the summers of 2007 and 2006. Water with dissolved oxygen levels below 3-5 mg/liter is considered hypoxic, and this condition compromises two different kinds of organisms: fish and crabs swimming throughout the Severn, and also organisms restricted to the bottom, such as worms, clams, and oysters that are adapted to moderate hypoxia. The Severn's DO problems can best be understood by examination of the DO vs depth profiles generated from our monitoring data. Oceanographers plot such profiles with the vertical axis representing the depth going down from the surface, as if the observer were a diver looking horizontally in the water. The upper plot shows DO depth profiles at our Rte 50 bridge station and the





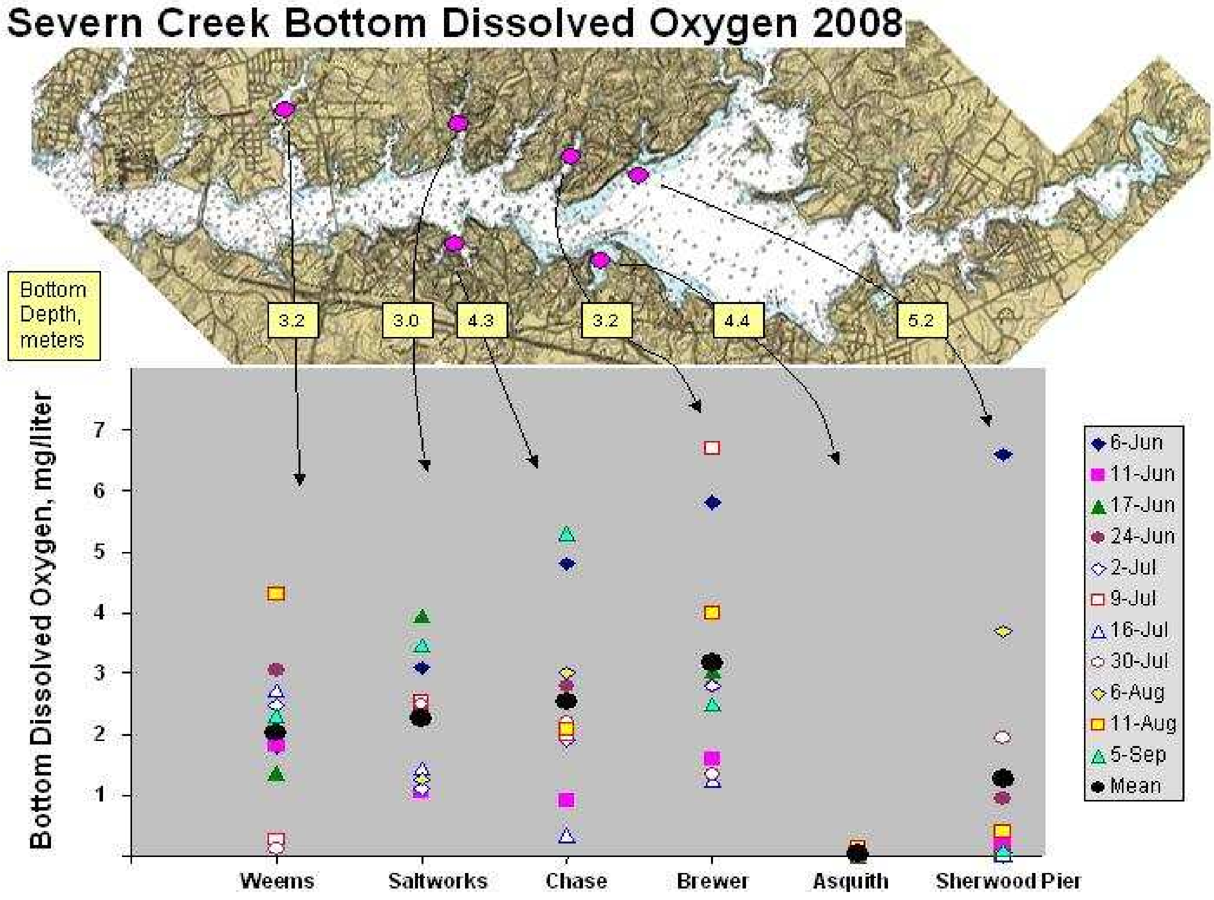
lower one our mid-Round Bay station. Examination of these plots shows that dissolved oxygen levels are maximal at the surface, as expected where the water is in contact with atmospheric oxygen. DO diminishes with increasing depth, and almost all profiles show minimal DO levels at the bottom. These minimal DO levels range between 1 and 6 mg/liter at the Rte 50 Bridge, but are much lower at the mid-Round Bay station (summer levels between 0 and 1 mg/liter). The hot summer weeks have the lowest DO levels, and unfortunately this is a maximal growth period for bottom-dwelling organisms like clams and worms. They typically require at least 1 mg/liter of dissolved oxygen, so our data suggest that they have enough oxygen at the Rte 50 bridge, but they are not expected to survive in the middle of Round Bay.

The figure below shows our bottom DO data for all our stations in the Severn mainstem. Our stations at the US Naval Academy and at the Rte 2 bridge have a wide range of bottom DO readings, but average about 3 mg/liter. The next station up, off Joyce Point, is almost 40 feet deep and has a mean bottom DO level of about 1 mg/liter. Entering Round Bay, bottom DO drops further, with summer means of 0.2 mg/liter or less at the mid-Round Bay, Round Bay North, and Severn Narrows stations. The shallow top-most Severn station had predictably higher bottom DO levels. The very low bottom DO levels from mid-Round Bay up into Severn Narrows are indicative of anoxia, a condition more extreme than hypoxia, corresponding to conditions where multicellular organisms rapidly die. To confirm anoxia at these stations, we used a water sampling



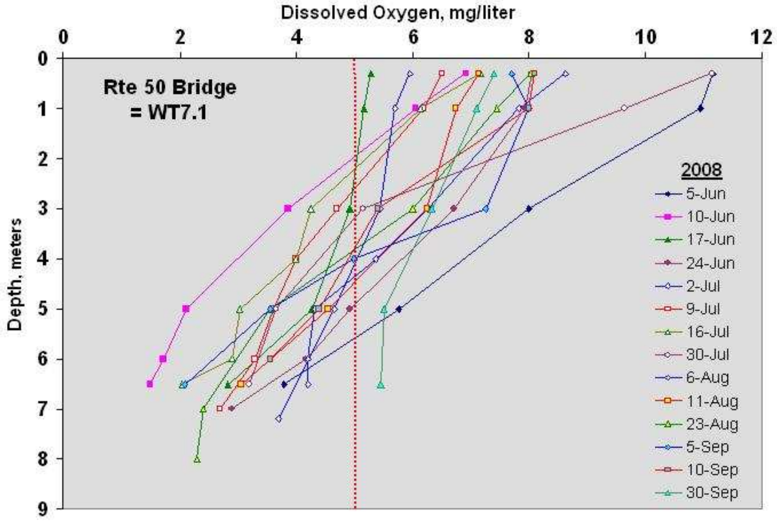
device to obtain bottom water, which clearly smelled of hydrogen sulfide whenever the metered bottom DO level was less than 0.2 mg/liter. Hydrogen sulfide is a toxic gas, unstable in the presence of oxygen, and its presence shows that a persistent “dead zone”.clearly exists in this substantial area of the Severn.

The next figure shows that the Severn’s tidal creeks showed varying levels of bottom hypoxia, with no clear geographic pattern. The most striking result was the anoxia seen in Asquith Creek, where the mean DO level was 0.05 mg/liter and near-bottom water samples smelled strongly of hydrogen sulfide. This is the only Severn creek where we have detected persistent anoxia. The figure above also shows the results for our station off the end of the Sherwood Forest pier, near the Round Bay shoreline. We observed severe hypoxia there, compatible with its proximity to the anoxia of central Round Bay, but its shallower depth and proximity to the shoreline probably allow better mixing of bottom water with oxygen-rich surface water.

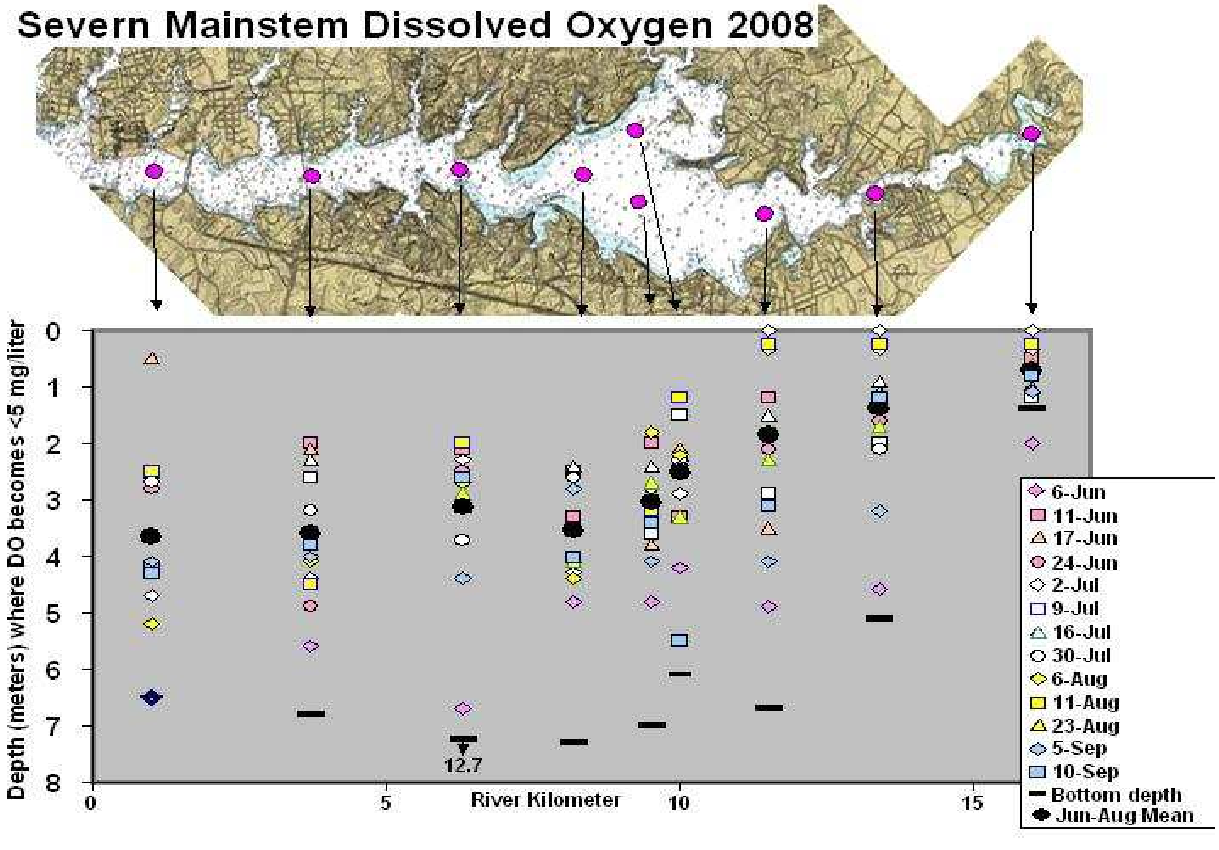


The above description of dissolved oxygen at the bottom reflects the condition of the habitat for bottom-dwelling organisms such as clams and worms. However, the Severn also is the home of crabs and various fish species that move freely from top to bottom, and they will swim toward the surface to avoid deeper areas where oxygen levels are low. Different fish species have different tolerances for hypoxic water, but will typically avoid water with DO levels between 2-5 mg/liter. This has been described as a “habitat squeeze” that forces fish in the upper portion of the water column, limiting their interactions with the benthic organisms that are better adapted to lower oxygen levels. In order to quantitate this habitat squeeze, we have used the Chesapeake Bay

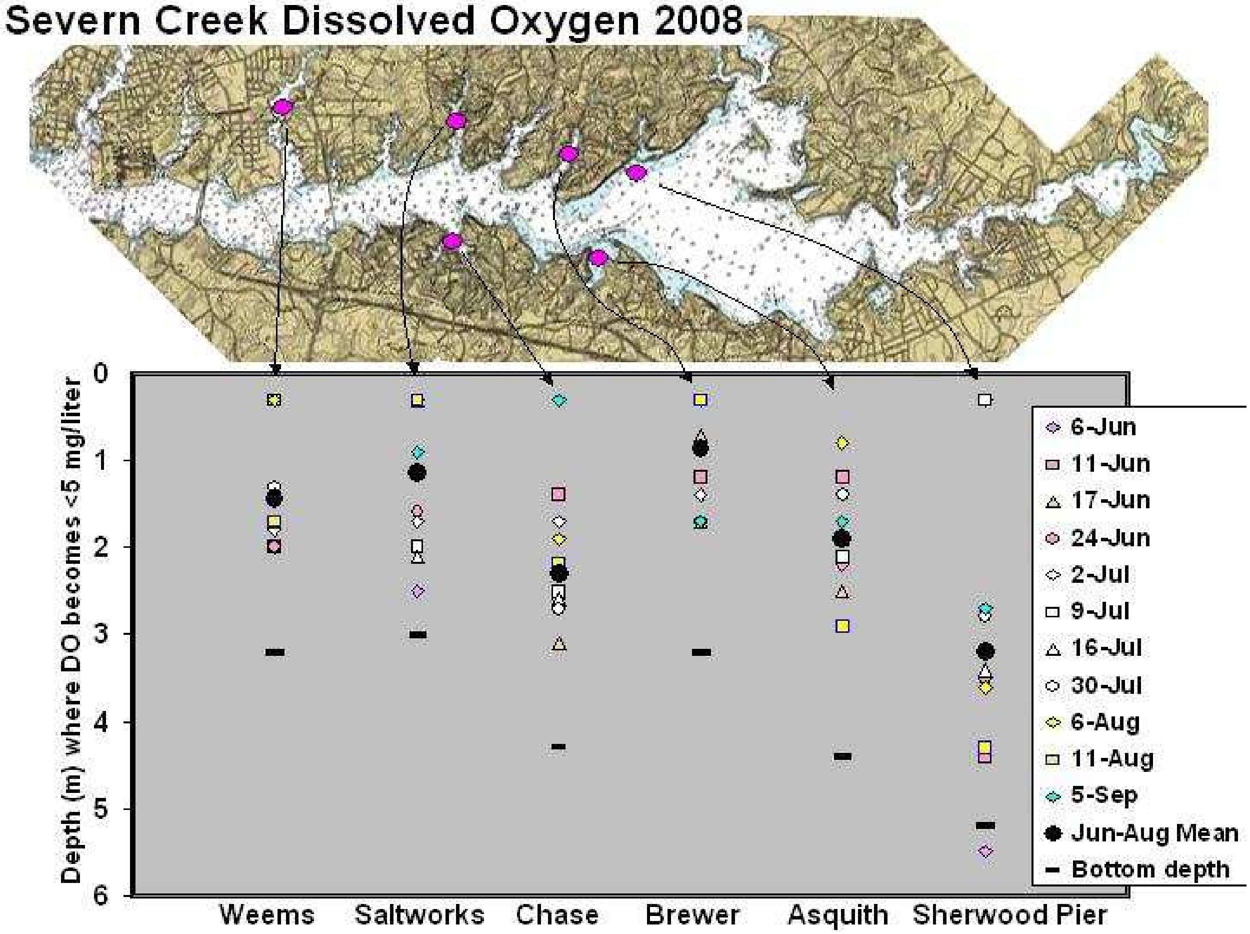
Program’s “healthy” DO cut-off of 5 mg/liter to calculate how much of the vertical water column is suitable fish habitat, and thus to estimate the habitat squeeze inflicted by hypoxia.



The dissolved oxygen proflies shown here were analyzed by obtaining the depth at which the dissolved oxygen level becomes less than 5 mg/liter (dotted vertical line). The graph shows that this threshold value was crossed each monitoring date except September 30, when even near the bottom the DO level was above 5 mg/liter. Some days (e.g., June 5) there was little DO habitat squeeze, while just a few days later (June 10) it was substantial, as most of the water had unacceptably low DO. Using this approach, we have calculated the DO habitat squeeze from all the DO profiles at the stations we monitor, as shown in the figure below.

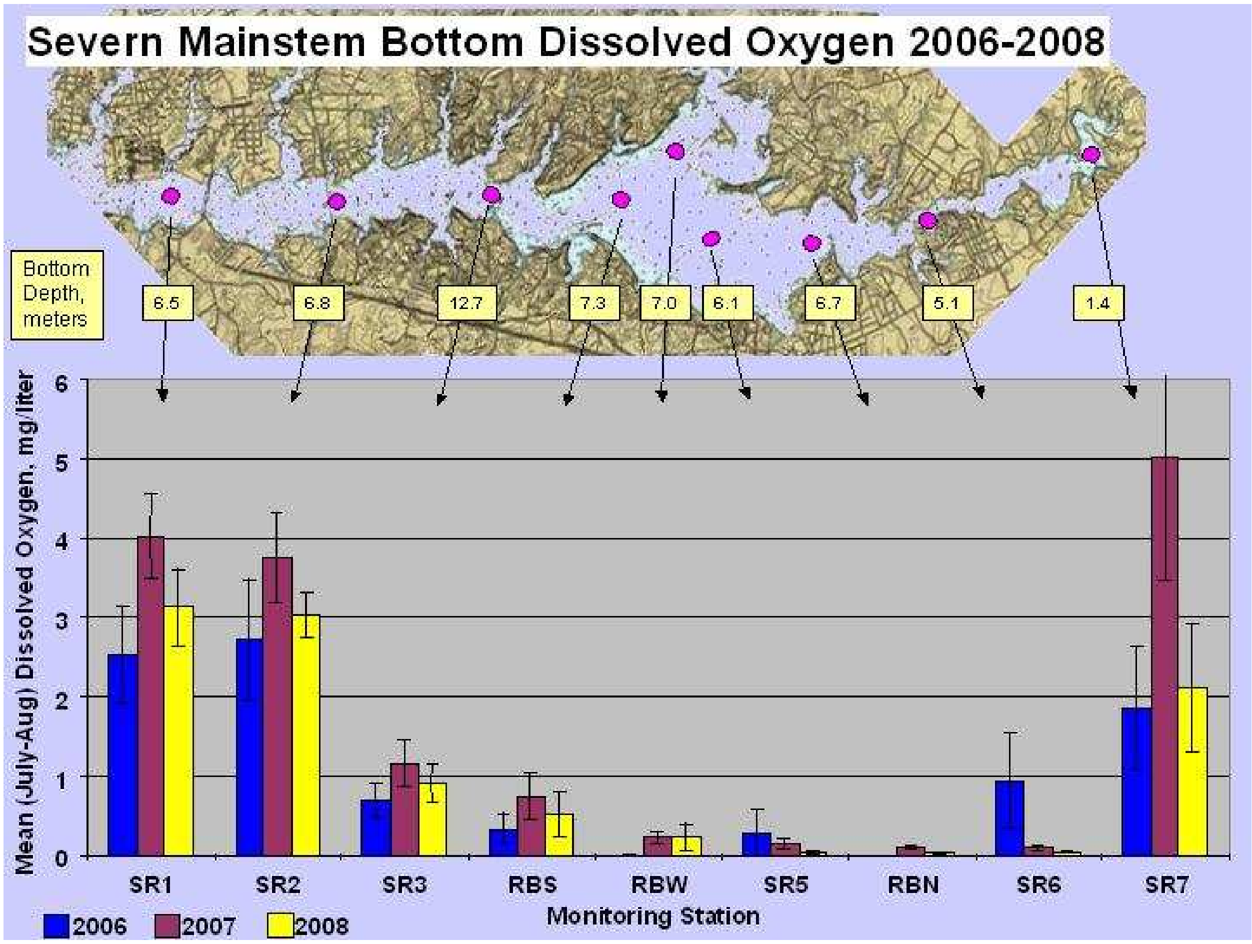


This figure shows that on average only the top 3-4 meters of water in the lower Severn has “healthy” DO levels, and in the upper Severn it is more like the top 2-3 meters. DO in the Severn's creeks is similarly impaired, as shown by the figure below. The depths below which hypoxia started were higher in the creeks than in the deeper mainstem waters, but this corresponds to their shallower depth.



Dissolved Oxygen--Discussion

We have analyzed our DO monitoring data to assess the impact of oxygen levels on two biological habitats: that of benthic organisms that live in or on the bottom, and that of freely swimming organisms that utilize all of the vertical water column. Our most important finding was the persistent presence of anoxic bottom water in and above northern Round Bay, confirming observations we made in the summers of 2006 and 2007. A graphical summary of Severn bottom DO levels over these three summers is shown in the figure on the next page. We conclude that a "dead zone" regularly forms and persists throughout the summer in this substantial area of the Severn. While the Chesapeake's summer "dead zone" has been well described and is the subject of a major monitoring effort by the Chesapeake Bay Program, the Severn's "dead zone" is significantly different and is not connected to the one in the Chesapeake. The anoxic portion of the Severn is a relatively thin layer along the bottom, in 5-7 meters of water. In contrast, the Chesapeake's anoxic zone is associated with its deep trench corresponding to the ancient Susquehanna, where oxygen disappears at ~15 meters, continuing to the bottom at 20-40 meters. The Chesapeake's "dead zone" is associated



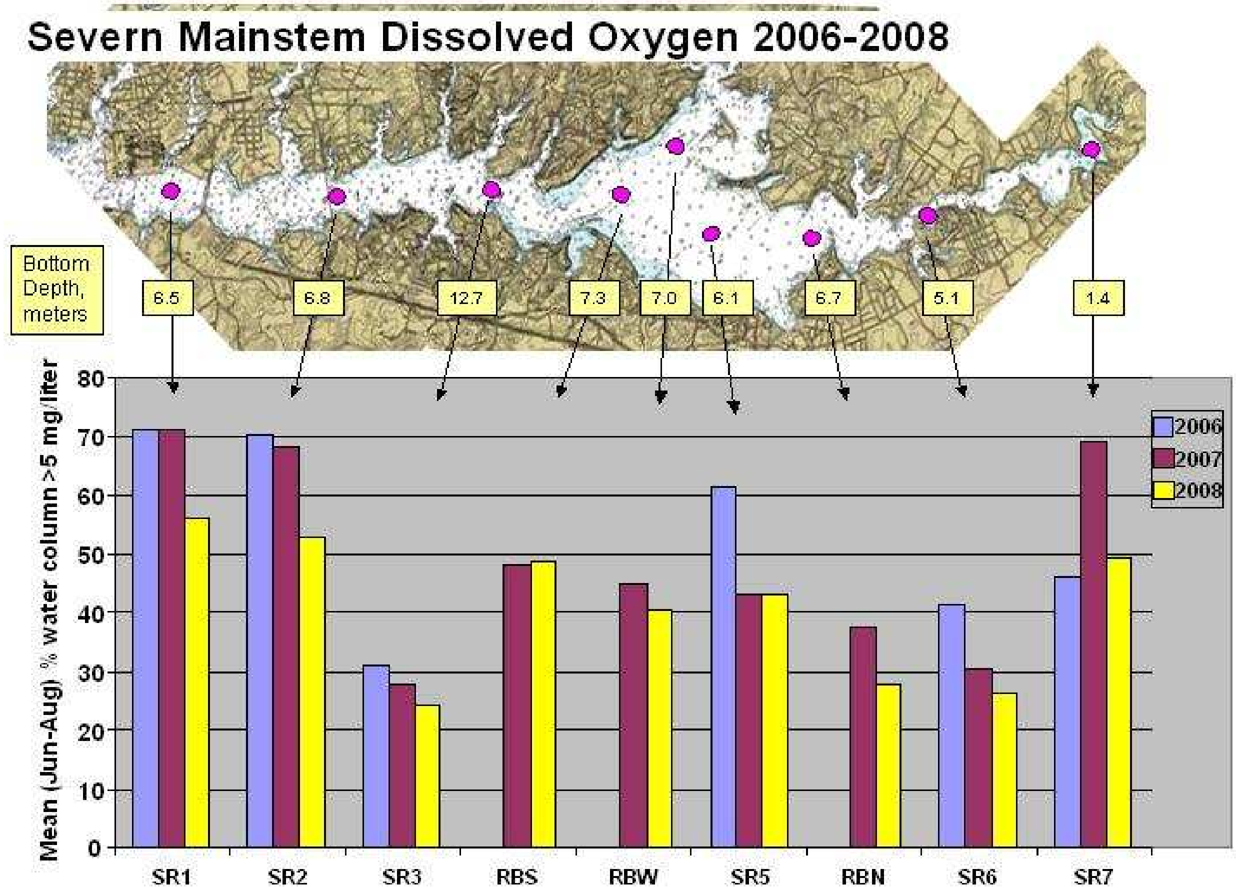
with the pycnocline, which is the sharp density gradient in the Chesapeake's boundary between saltier bottom water and fresher surface water. The pycnocline provides a natural barrier to vertical mixing, thus cutting off oxygen from the denser bottom layer. Our monitoring shows that the Severn has no pycnocline, and it is surprising that vertical mixing is apparently so limited in parts of the Severn that truly anoxic water exists only 4-5 meters from the surface in Round Bay and less than that in Asquith Creek. Similar shallow "dead zones" persisting throughout the summer have not been described previously in Chesapeake tributaries. Such persistent shallow anoxia is distinct from the temporary anoxic episodes associated with fish kills that occasionally occur at the head of tidal creeks in the Chesapeake and elsewhere. These occur when algal blooms consume oxygen during the night, leading to temporary anoxia and the death of fish that cannot escape from the creek. Such an event occurred in June 2007 in the Severn's Weems Creek, which is 5 miles distant from Round Bay's anoxic area. From a biological point of view, the persistent anoxia in Round Bay eliminates multicellular organisms confined to the bottom, and this in turn compromises organisms such as crabs and several fish species that utilize such benthic animals as part of their food resources. This biological impact is distinct from the habitat squeeze hypoxia imposes on the freely swimming crabs and fish, since benthic animals are adapted to hypoxia and would still be available as food sources during water column hypoxia.

Several local features of the Round Bay area may help explain the poor vertical mixing of its water that promotes bottom anoxia. For one, there is limited tide-induced horizontal water flow because the vertical lunar tidal range in northern Round Bay is 0.7

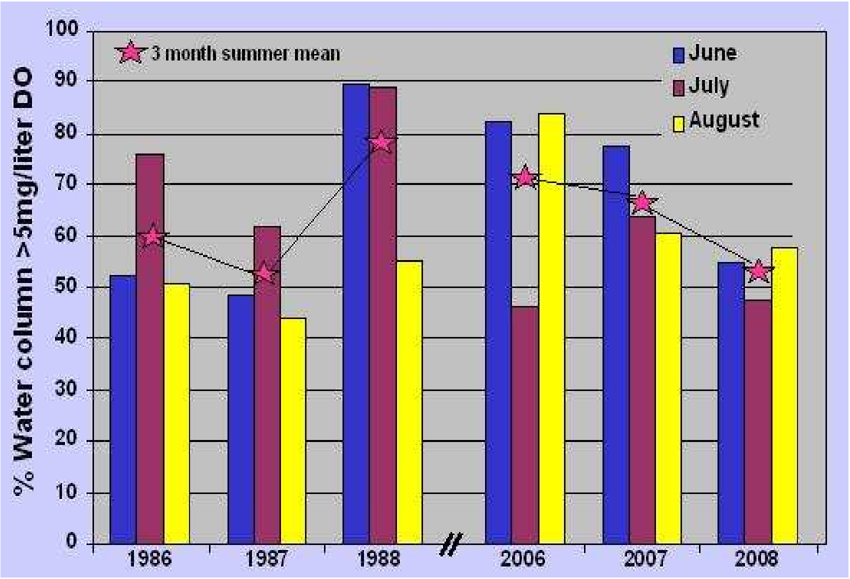
feet, the lowest of anywhere in the Chesapeake (http://www.co-ops.nos.noaa.gov/tides06/tab2ec2c.html#50). Secondly, during the summer months, the Severn normally experiences few strong wind events that drive horizontal water flows. Third, as discussed above, Severn salinity profiles show minimal estuarine characteristics, so that turbulence-inducing horizontal water flows promoting vertical mixing may be insignificant in Round Bay. The clear prolonged bottom anoxia we find in Asquith Creek may provide insight into the much larger Round Bay "dead zone." Asquith Creek is the only Severn creek where we find hydrogen sulfide and undetectable DO in bottom water. Asquith Creek is different from the others in that there is a shallow underwater bar across its entrance to the Severn, and a dense bed of submerged aquatic vegetation grows on that bar. There is a narrow, 0.5 km-long, ~2m deep dredged channel leading to Asquith Creek behind the bar, so that water exchange between Asquith Creek and the adjacent Severn is impaired. The mouths of the other Severn c reeks we monitor all have much more open connection to the Severn mainstem. Thus, it seems likely that limited horizontal water exchange may contribute to the formation of shallow water "dead zones."

It is possible that the Severn's apparently unique anoxia problems derive from excess nutrients that drive eutrophication to higher levels than is found in other Chesapeake tributaries. The older communities along the southwestern shore of the Severn and up into the northwestern portion of its watershed all rely on septic systems that release considerable amounts of nitrogen nutrients into ground water and thence into the Severn. It is possible that such nutrient input leads to higher phytoplankton growth and subsequent oxygen depletion in the Severn than elsewhere. Due to technical limitations, our monitoring program did not monitor chlorophyll a levels (a measure of phytoplankton) or nutrient levels, so we can only speculate on this possibility. However, our monitoring trips along the shorelines of the communities dependent on septic systems did not reveal evidence of higher nutrient levels—visible growth of macroalgae or phytoplankton blooms. SAV beds along the mid-Severn's southwestern shores have been healthy for years, and are reasonably similar to those on the opposite northeast shore where communities are connected to sewers (see SAV map on p.14). Finally, over the last few years, measurements of nitrogen nutrients by the Maryland DNR at the Severn's Route 50 bridge are similar to those found at the DNR's Magothy River station, and persistent bottom anoxia has not been reported in the Magothy. Thus, while no firm conclusions are possible at this time, it is possible that the major nutrients fostering phytoplankton growth driving the Severn's bottom anoxia are derived from the Chesapeake, entering the Severn predominantly during the spring surge of fresh water.

Our DO monitoring revealed that, in addition to the anoxic bottom water around Round Bay, a significant percent of the overall water volume of the Severn in the summer is hypoxic. Hypoxia is sometimes defined as DO <5 mg/liter and sometimes as DO < 3mg/liter, but in either case the biological significance is a "habitat squeeze" resulting from fish and crabs moving away from oxygen-poor water near the bottom up towards the surface which is better oxygenated. As discussed above, we have quantitated the habitat squeeze by calculating the depth below which oxygen levels are less than 5 mg/liter, but a more general appreciation of the problem is given by calculating the percentage of the water volume with "healthy" levels of 5mg/liter, as shown by the graphs on the next page. The hypoxic habitat squeeze is less severe in the lower Severn near Annapolis, but for most of the Severn less than half the water can

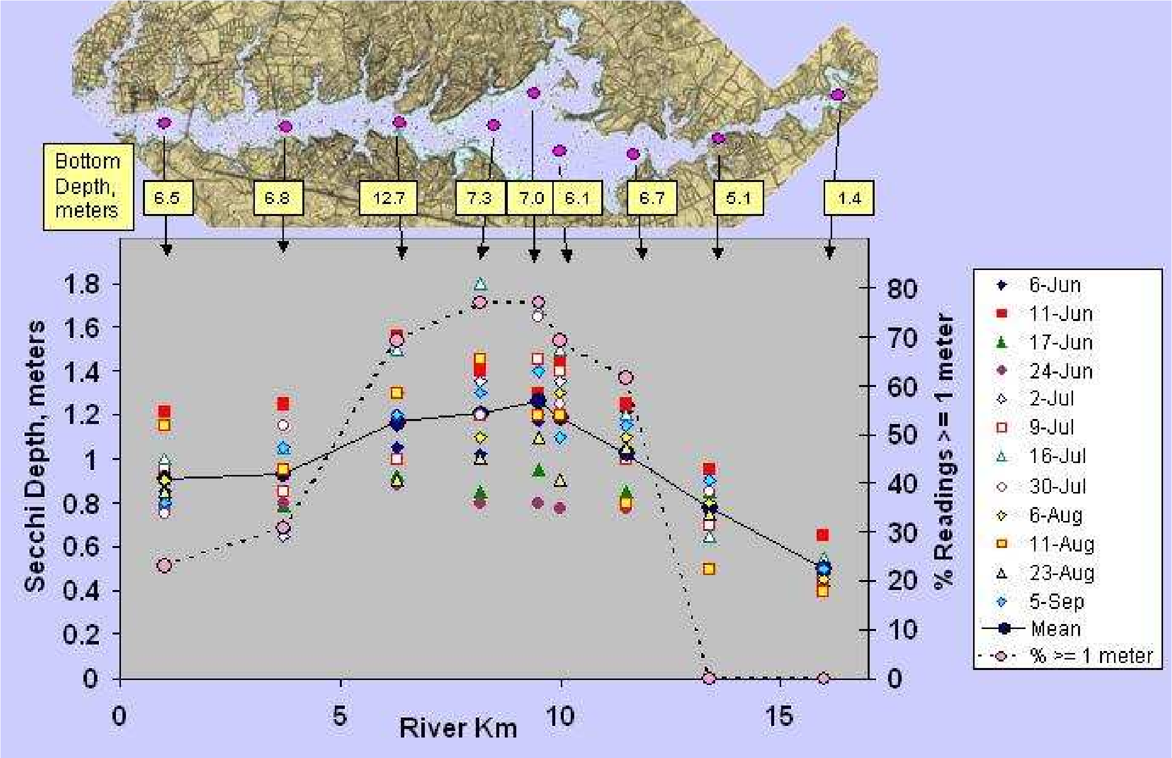


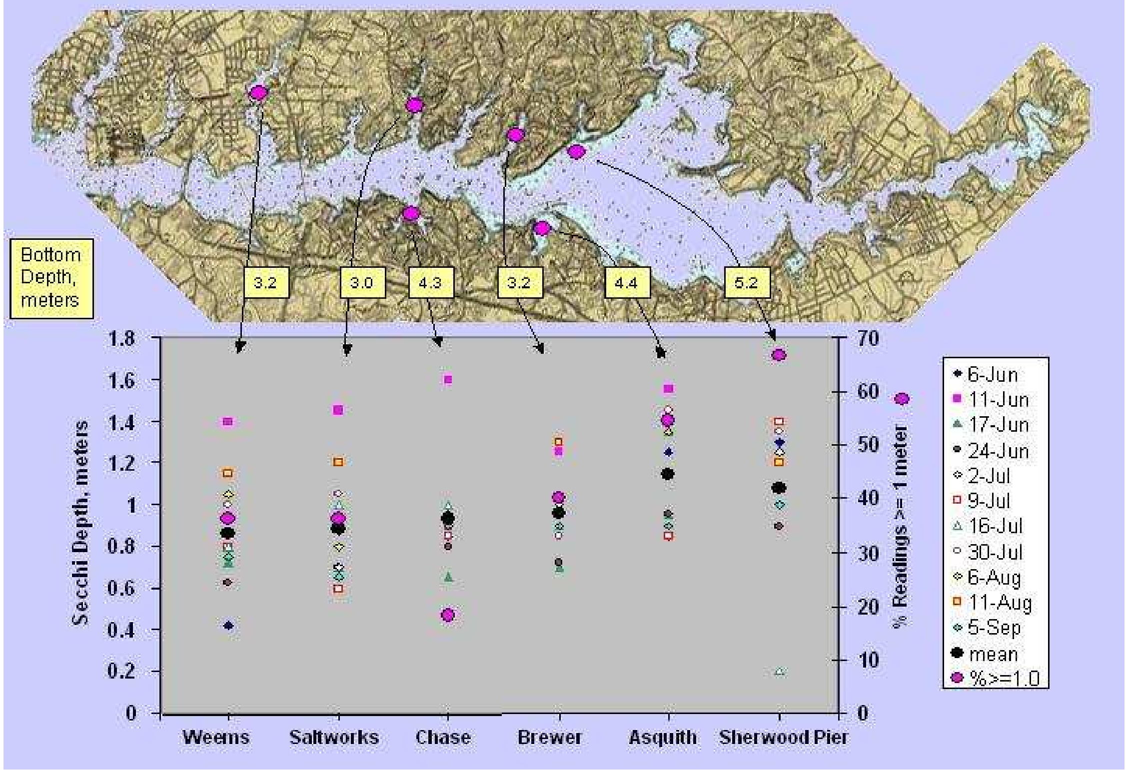
be considered healthy. This condition has been seen in each of the last three summers. The hypoxic habitat squeeze at most stations appears more pronounced in 2008 than in the previous two years, but it is unclear if this is significant. To see if longer term changes in this hypoxic squeeze could be detected by monitoring, we analyzed older DNR data at the SR2/WT7.1 monitoring station and compared it with our recent data. As shown at the left, there does not appear to be any clear change in the summer hypoxic squeeze over the last twenty years, at least in the lower Severn. This appears to reflect the Chesapeake Bay Program's results for the Chesapeake as a whole, in which it is generally considered that restrictions on nutrient enrichment have largely been counteracted by increasing growth and development of the Chesapeake watershed.



Water Clarity—Results

As in previous years, water clarity was measured at the surface by using a Secchi disk at each station throughout the monitoring period; the result reported is a mean of two independent measurements of the maximum depth at which the disk can be seen from the surface. This crude but widely used standard measure of water



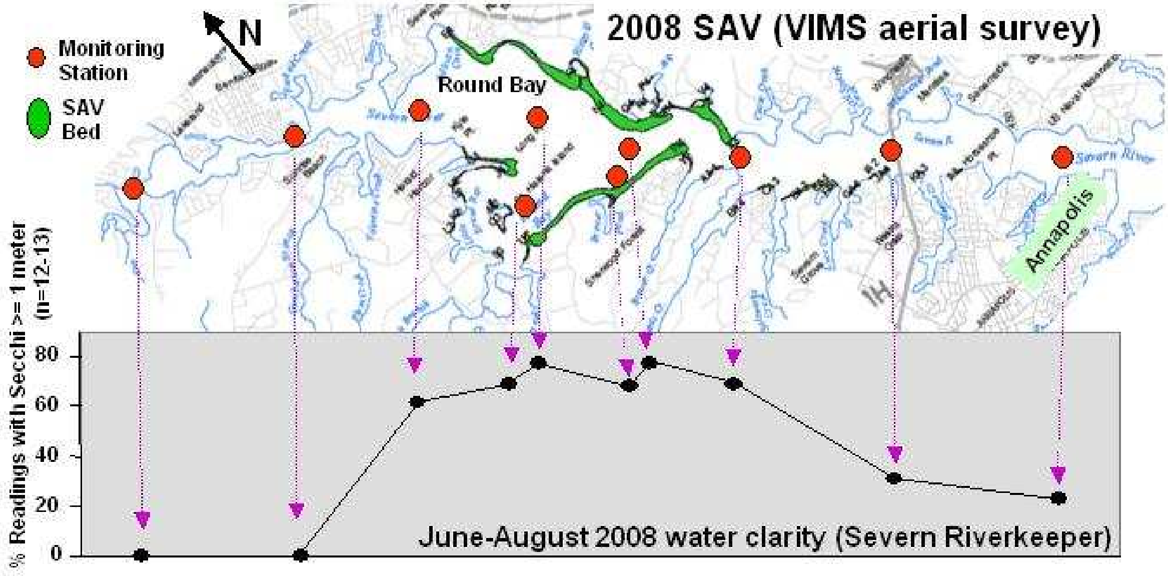


clarity reflects both light scattering by living and non-living particles in the water, and light absorbance due to dissolved pigments. The water clarity patterns we found in the Severn in 2007 were largely repeated in 2008. As can be seen in the figure, there is considerable variation in Secchi measurements at any one station over the course of the summer, but no clear temporal trend was seen. The worst clarity was found near the tidal head of the Severn, where sediment and nutrient input from Severn Run is pronounced. The best water clarity was seen throughout Round Bay, and a decline in clarity was observed in the lower Severn, The creeks off the lower Severn had similar clarity to the adjacent mainstem, and Asquith Creek had better clarity similar to adjacent parts of Round Bay. As shown in the figure, different locations in the Severn typically showed only relatively small differences in the mean Secchi depths, but a metric based on the percent of observations that were one meter and above showed much greater variation.

Water Clarity—Correlation with Growth of Submerged Aquatic Vegetation (SAV)

We have not attempted to analyze the factors compromising water clarity in the Severn. Candidates are phytoplankton, sediment washed into the tidal Severn from the watershed, sediment entering the Severn from the Chesapeake, sediment resuspended from the bottom by turbulence, and soluble pigments. However, analyzing the contribution of these possible factors is beyond the means of our program.

Poor water clarity can limit the growth of SAV because light must penetrate into the water to allow energy production by photosynthesis. By comparing SAV growth In the Severn as measured by the Virginia Institute of Marine Science's aerial surveillance program with our measurements of water clarity, we found a correlation between water clarity and SAV growth in 2007. As shown below, a very similar result was obtained in 2008. Both SAV growth and water clarity were similar in 2008 to what was found in 2007. The figure shows that water clarity is markedly better in the Round Bay area where there are major SAV beds than in the upper and lower Severn where SAV beds are sparse or lacking. This correlation between SAV growth and water clarity is not perfect: the northern part of Round Bay lacks SAV while its water clarity is good, and SAV growth diminishes going south from Round Bay before the water clarity declines. Nevertheless, a reasonable interpretation of this data is that poor



water clarity limits SAV growth in both the upper and lower Severn (although other factors may contribute).

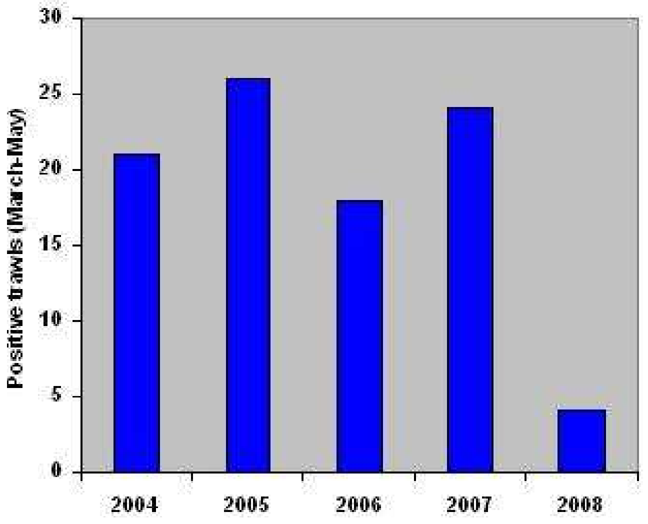
Yellow Perch—Results and Discussion

In the spring of 2008, the Severn Riverkeeper Monitoring Project collaborated with the Fisheries Division of the Maryland DNR and the Arlington Echo Outdoor Education Center to conduct a program of plankton tows to monitor larval yellow perch abundance in the upper Severn. The monitoring protocol used is one developed and used by DNR Fisheries biologists for years, so our data can be compared with previous results.

Yellow perch are a fresh water fish that are adapted to estuarine habitats, and this species has traditionally been a favorite target of anglers in the Severn as well as other low salinity areas. However, yellow perch abundance has declined dramatically in the Severn and neighboring Chesapeake tributaries in recent years, leading the DNR to ban fishing for this species in the Severn in 1989. Although adult yellow perch still spawn in Severn Run, larval viability has been low for reasons that have been difficult to identify. This issue was addressed in a 2005 DNR study by DNR biologists, in which they concluded that a combination of increasing salinity in the upper Severn, and low dissolved oxygen were likely responsible.

The monitoring protocol calls for a series of ten two-minute plankton tows in each of 10 standard routes throughout the upper Severn, carried out twice per week from late March until late April or whenever no more larvae are found. Larvae are detected visually at the end of each tow, and the standard metric is the total number of positive tows per season. As can be seen in the graph comparing results in recent years, 2008 was a notably poor year for the production of yellow perch larvae in the Severn.

. Environmental conditions such as rainfall, temperature, etc., were relatively normal in the spring of 2008, so it is not clear why we found so few larval yellow perch. However, neighboring tributaries such as the South River, monitored by DNR, had a similarly poor success in 2008, so the cause of this problem is probably not due to a local condition.



Improving the Severn's Water Quality—Discussion

Our monitoring has been focused on a major problem with the Severn's water quality, low dissolved oxygen levels in the summer. This problem results from the excessive growth of phytoplankton, a problem affecting the Chesapeake as a whole, and coastal waters world-wide. Because measurements of phytoplankton levels (based on chlorophyll content) are not simple technically, we have not tried to measure this, although the Maryland DNR measures chlorophyll monthly at the Rte 50 monitoring station. The Severn is not included in the Chesapeake Bay Program phytoplankton monitoring program, which identifies species present and their abundance. However, phytoplankton densities can vary rapidly, and it is often hard to analyze the responsible factors. It is well known that the excessive phytoplankton growth results from an overabundance of nitrogen- and phosphorous-based nutrients in the water, and considerable study has been devoted on the sources of these nutrients for the Chesapeake as a whole. Focusing on the Severn, an open question is how much of the relevant phytoplankton nutrients are derived from the local watershed and how much come into the tidal Severn from the adjacent Chesapeake. It seems likely that where there is a major fresh water influence (areas like Ben Oaks), nutrients will be largely derived from the local watershed. However, for areas like Round Bay, it is not simple to identify the dominant source.

Phytoplankton growth in estuaries is controlled by the amount of available sunlight and the levels of nitrogen and phosphorous nutrients. In the Severn, phytoplankton growth increases in the spring with its longer days and more overhead sunlight, along with increasing fresh water input containing nutrients. It is not known whether nitrogen or phosphorous is limiting to the phytoplankton growth causing the Severn's oxygen problems. In general, phytoplankton growth in fresh water tends to be limited by phosphorous, while marine phytoplankton are limited by nitrogen-based nutrients. Some modeling studies have suggested that in the Severn, phytoplankton growth is limited by phosphorous in the spring when the water is fresher, and later in the summer there is a switch to nitrogen limitation. Whether this is actually the case, and which nutrient limits the growth of the phytoplankton responsible for the Severn's serious hypoxia is not known. Bottom anoxia can increase nutrient recycling from sediment, so the Severn's nutrient budget may differ from neighboring tributaries.

Considerable recent concern in Anne Arundel County has addressed the need for moderating local stormwater runoff, especially for older areas built up before current regulations were put in place. It seems clear that nutrients and sediment from local stormwater runoff are major contributors to the water quality problems we have identified in the upper Severn and in the tidal creeks. Modern methods of stormwater control can reduce both nutrients and sediment, and their implementation would have a beneficial effect. While regulations for new construction in the County include such controls, much of the problem in the Severn watershed is attributable to older development, and improvements in water quality may be unlikely until runoff from these areas is addressed.

One major source of phytoplankton nutrients for the Chesapeake is from fertilizers in agricultural areas. While the Severn watershed has almost no agriculture, it has considerable acreage in suburban lawns, many of which are heavily fertilized. Lawns on waterfront property are striking to those of us who monitor the Severn from the water, but lawns throughout the watershed potentially contribute to nutrient enrichment. We are unaware of studies addressing whether restricting lawn fertilizer usage would significantly reduce overall nutrient influx and phytoplankton growth in the tidal Severn.

Acknowledgments

This project was initiated and funded by the Severn Riverkeeper Program, and first in line to be thanked is Riverkeeper Fred Kelly. Fred was a major resource for this project, from directly participating in monitoring, maintaining the boat, helping supervise monitoring personnel, and inspiring donors to help fund our efforts. In additional to numerous individual donating to the Severn Riverkeeper Program, funds for this project were provided by the Chesapeake Bay Trust, the ERM Foundation and the Severn 1000 Club.

Allison Albert, Riverkeeper Program Director deserves much credit for the success of this monitoring project. She was instrumental in writing the grants that funded the project, she directed many of the actual monitoring trips, and organized the various components needed to provide reliable data for the project. Riverkeeper Program interns Christine Sandvik and Brooke Warrington manned the boat, read the meters, and recorded data. Their efforts have made this the most comprehensive water quality monitoring effort in the Severn. Student assistants Nate Frankoff and Aaron Canale played equally vital roles in monitoring and boat handling throughout the summer.

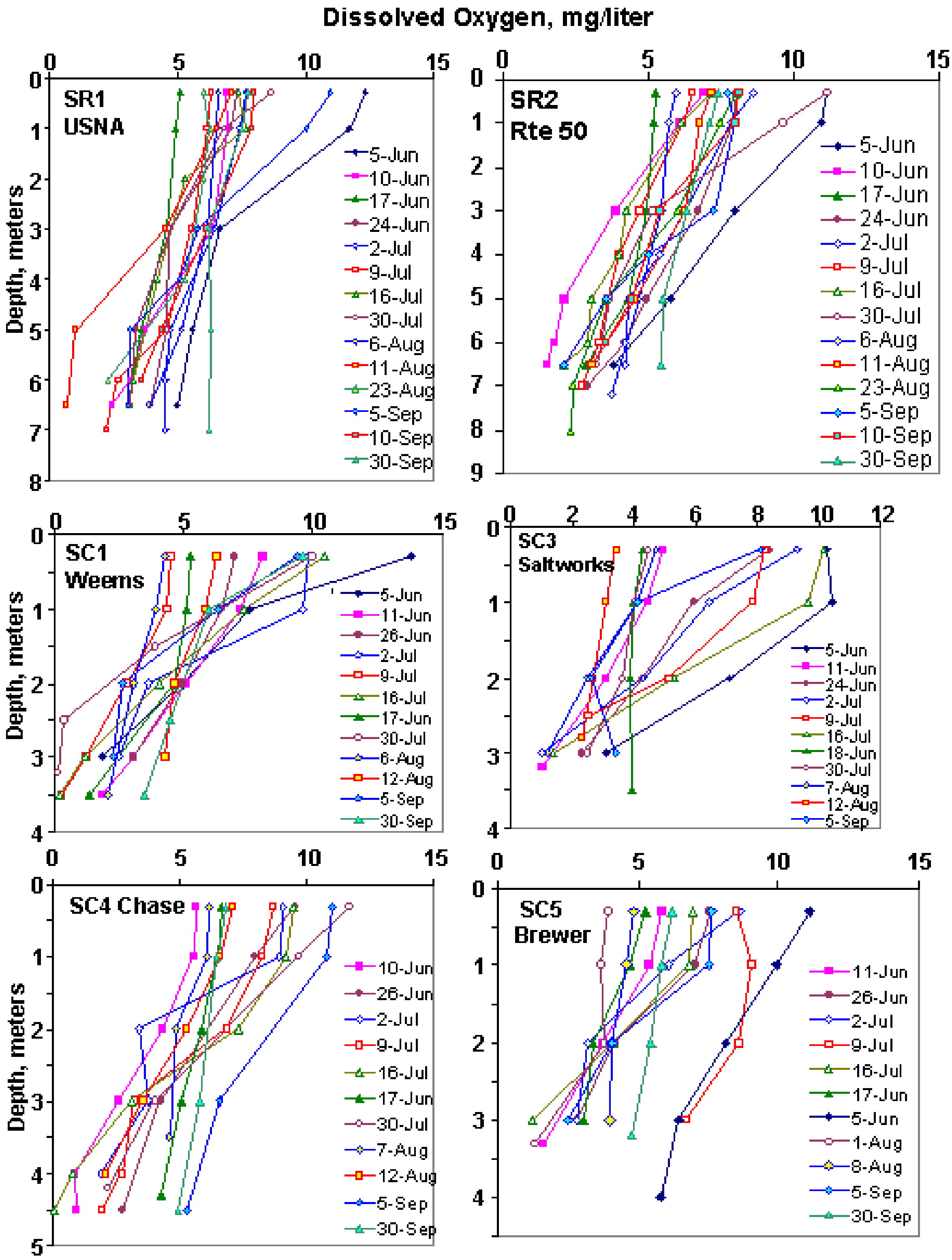
The Yellow Perch monitoring project was carried out in collaboration with the Arlington Echo Outdoor Education Program and the Maryland Department of Natural Resources. In particular, Steve Barry provided Arlington Echo's boat and personnel, which were vital to this effort.

Volunteers Catherine Stirling and PJ Klavon regularly participated in monitoring efforts, and their help is greatly appreciated.

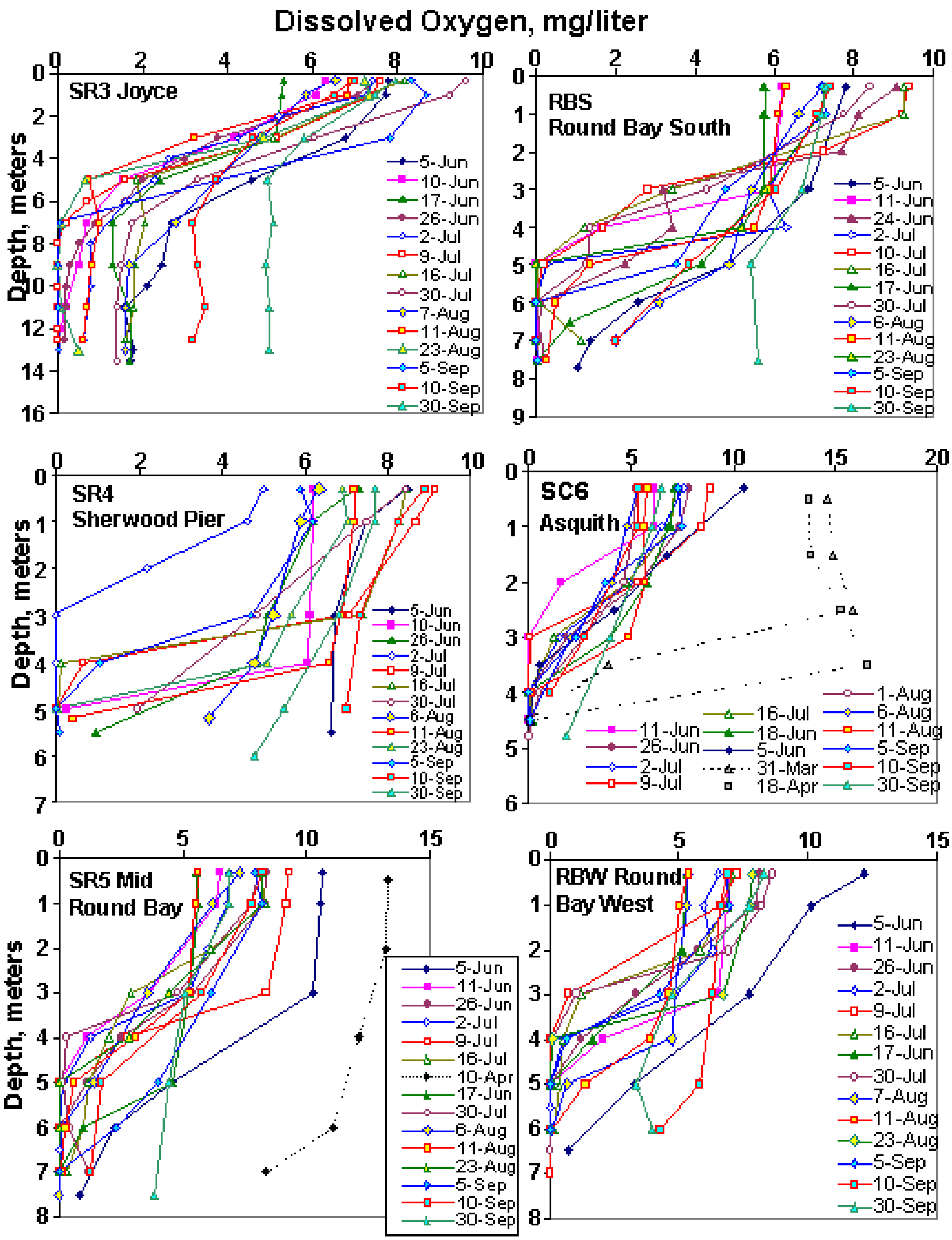
Since 2006, this monitoring project has greatly benefitted from expert advice from NOAA's Dr. Peter Bergstrom. His experience with instruments and methods of data reporting, as well as his expertise in submerged aquatic vegetation, have greatly aided our efforts and are much appreciated.

Danalee Henkart's editorial assistance improved this report and is greatly appreciated.

Appendix: 2008 Dissolved Oxygen Profiles, Lower Severn



Appendix: 2008 Dissolved Oxygen Profiles, Mid- Severn



Appendix: 2008 Dissolved Oxygen Profiles, Upper Severn