Environmental Indicators: A Tool Used to Measure the Health of the Estuary

The Delaware Estuary Program (DELEP) established the first suite of environmental indicators for the Delaware Estuary. Indicators are tools that are used to assess progress toward a particular goal or objective. The environmental indicators for the Estuary are helping DELEP to measure the progress toward enhancing and preserving the diverse ecosystem of the Delaware Estuary, and in maintaining a balance among the Estuary’s many diverse uses. In order to expand our readership’s knowledge of the Delaware Estuary and about some of the issues that DELEP is addressing, we have devoted this issue of Estuary News to the environmental indicators.

The initial suite of environmental indicators includes: American Shad Abundance; Dissolved Oxygen; Suitability of Estuary Waters for Swimming; Geographic Extent of Approved Shellfish Harvesting Areas; Developed Land and Population; Agriculture in the Delaware Estuary; Acres of Parkland; Water Use Efficiency; and Contaminated Sediments in the Estuary.

Although the individual indicators range from land use to water quality, many of them are related. For example, the survival of American Shad is closely tied to dissolved oxygen. An increase in the number of shad, a migratory fish, suggests that water quality and habitat in the Delaware Estuary has improved.

In the past, pollution in the heavily industrialized sections of the River resulted in low dissolved oxygen levels, thus blocking the passage of shad during their migration. However, more recently, improved wastewater treatment and an increase in public consciousness about protecting water quality, has resulted in much higher oxygen levels and improvements in fish passage.

All of us need to think about preserving and maintaining that delicate balance, from habitat for shorebirds, to recreational fishing, to the refining-petrochemical industry. Over the course of the next couple of years, DELEP will be working to expand the number of environmental indicators and to track progress in improvements to the Delaware Estuary.

For more information about the environmental indicators, please call 1-800-445-4935.

Congratulations to the Partnership for the Delaware Estuary’s 2001 Excellence in the Estuary Award recipients who were recognized on September 25, 2001

Stacy Levy / SERE Ltd. for Artistic Impression; Pennsylvania Department of Environmental Protection’s Citizens’ Volunteer Monitoring Program for their continual efforts to encourage and expand Citizen Monitoring of our rivers, creeks, and streams; McNeil Consumer Healthcare for their efforts in Corporate Environmental Stewardship; Cumberland County Planning Board for their efforts in encouraging Ecotourism in Cumberland County, New Jersey; Robert C. Shinn, Jr., Commissioner, New Jersey Department of Environmental Protection for Government Leadership; Fairmount Park Commission’s Natural Lands Restoration & Environmental Education Program and the Riverfront Development Corporation of Delaware for Habitat Restoration; Manomet Center for Conservation Sciences, the Delaware Department of Natural Resources and Environmental Control, the New Jersey Department of Environmental Protection, and the National Oceanic and Atmospheric Administration’s National Ocean Service for their combined efforts in protecting the Living Resources on Pea Patch Island, in Delaware; Delaware Bay Schooner Project for Water Education; and W. Michael McCabe, former Deputy Administrator for the U.S. Environmental Protection Agency, for his Vision in protecting our natural environment.
Tributary Sampling - In order to support the development of a PCB model for the Delaware Estuary, accurate estimates of PCB loadings into the Delaware Estuary are necessary. A collection of water samples will be taken from the mainstem of the Delaware River at Trenton; the Schuylkill River, above the head of tide; and in tributaries to the Delaware River. This will be done during wet and dry weather for the analysis of particulates and dissolved PCBs, solids, and organic carbon. The members of the TAC are reviewing the final draft of the Delaware Estuary Tributary Sampling Plan.

PCB Sampling - Scientists from U.S. Environmental Protection Agency and the University of Delaware have been mapping the Delaware River at the request of the Delaware River Basin Commission and the Delaware Estuary Program. Fitted with side scan and multi-scan sonar, the regional research vessel, Lear, cruised the river in order to provide a detailed sediment map. The map will be used for modeling the sediment transport in the river and will help in the development of a TMDL for PCBs in the Delaware. To date, the team has covered the area between the Betsy Ross and Delaware Memorial Bridges at 100% saturation, and is on-schedule to complete the survey. Only a small area was not covered owing to active dredging operations. The team plans to survey the final reach (Betsy Ross Bridge to the Burlington Bristol Bridge) during the week of October 22, 2001, at which time they will also survey the missed spot.

As a follow-up, core sediment sampling for PCBs will be carried out this fall. The team met in late September to suggest sampling locations. The next full TAC meeting will be in November 12, 2001, at the Delaware River Basin Commission.

Public Participation Implementation Team (PPIT)

The PPIT recently developed a brochure and folder about the Delaware Estuary Program (DELEP) for public distribution. The brochure includes the history of DELEP, the definition of an Estuary, the importance of the Delaware Estuary, a description of the Program, and the Program partners. The folder will be used to package Estuary information and includes a listing of the web sites for all of our Program partners. These outreach materials will be used to promote the Program to not only the general public, but to potential funders, elected officials, and community leaders.

On June 25th and 26th the Partnership for the Delaware Estuary and DELEP hosted an Education and Outreach Workshop for the National Estuary Programs (NEPs). During the first day, the fourteen NEPs who attended were provided with the opportunity to present their most successful programs and to share their lessons learned. On the second day, a facilitated brainstorming session was held in which all the attendees discussed potential opportunities for collaboration on regional and/or national initiatives. This workshop has led to a national effort to develop an outreach campaign focused on the theme of estuaries as nurseries for future generations.

During the next couple of months, the PPIT will be developing five fact sheets. The fact sheets will address the following topics: Water Conservation, Horseshoe Crabs & Shorebirds, Nonpoint Source (NPS) Pollution, Conservation Landscaping and Household Hazardous Wastes (HHW). To put your name on a list to receive the fact sheets, please call 1-800-445-4935.

Information Management Advisory Committee (IMAC)

The IMAC met on September 19, 2001 to discuss a proposed scope of work for hosting data from the basin states using an Internet Map Server. Possible funding sources are being investigated. The Committee has identified data layers, including layers specific to the Delaware Estuary. A computer friendly interface will be developed for the user to view geographic information based on responses to specific questions. Much of the information is already available, and if funded, the prototype would be ready by early spring 2002.

The Delaware River Basin Commission also has three Committees that serve in the same capacity as the Implementation Teams:
The Delaware Estuary supports a diverse natural environment, as well as a vital industrial base. The Estuary is home to the largest population of horseshoe crabs in the world and is an integral link in the migratory path of numerous species of birds, including shorebirds and waterfowl. In addition to its natural beauty and habitat value, the Estuary maintains the world’s largest fresh water port, the second largest refining-petrochemical center in the nation, and one of the world’s greatest concentrations of heavy industry. These diverse uses require a delicate balance.

The Delaware Estuary Program (DELEP) is committed to improving and maintaining the state of the environment in the Delaware Estuary. The Estuary extends from the head of tide at Trenton, New Jersey to the mouth of the Delaware Bay and is defined as the area where fresh water from the river mixes with salt water from the sea. To measure progress toward enhancing and preserving this diverse ecosystem, the Delaware Estuary Program has developed an initial suite of nine land and water environmental indicators. Indicators are tools that are used to assess progress toward a goal or objective.

Although the individual indicators range from land use to water quality, many of them are related. For example, an increase in the number of shad (a migratory fish) suggests improved water quality and habitat. The survival of migratory fish is closely tied to dissolved oxygen (fish need oxygen to survive too). In the past, pollution caused low dissolved oxygen levels in the heavily industrialized Philadelphia, Camden and Wilmington reach of the river, thus blocking the passage of fish during their migration. Because of improved wastewater treatment and an increased public consciousness about protecting water quality, oxygen levels are much higher and fish passage has significantly improved.

The indicators we have selected tell us much about the Delaware Estuary Region. The areas used for harvesting shellfish have expanded, which suggests improved water quality. People living in the region are using less water due in part to conservation efforts, even though the population is increasing. On the other hand, the Delaware River continues to have significant water quality issues, such as toxins, in the water column and the sediments. Contributing to these contamination concerns are industrial and municipal discharges (i.e., from sewage treatment plants), and nonpoint sources of pollution including stormwater runoff, air deposition, and water dependant activities such as shipping.

The overall message from this initial set of indicators is encouraging, but also illustrates the complexity of the Delaware Estuary. While the water quality and habitat of the Estuary continues to improve, there is plenty of work still to be done to ensure that this progress continues. Collaborative efforts involving regulatory and voluntary actions are necessary to improve the health of the Delaware Estuary. While work continues through the Delaware Estuary Program, citizens can help by keeping trash away from storm drains, recycling used motor oil, participating in river clean-ups, and getting involved in local watershed restoration activities. For more information about the Delaware Estuary Program, please call 1-800-445-4935.
Between 1982 and 1992, the Delaware Estuary region lost 13.3% or 287,429 acres of agricultural land. Current development patterns have consumed vast amounts of cropland, woodland, pastureland and rangeland, and continues to threaten the Estuary’s rural landscape.

**Importance**

Farmland in our region includes some of the most productive land in the country. Additionally, the agricultural heritage and rural character of the Estuary are essential elements of the region’s image, quality of life and economic stability.

**Economic**

Agriculture contributes to local economies through sales, job creation, support services and businesses, and also by supplying secondary markets such as food processing. The proximity of local farms to major population centers reduces shipping costs and offers fresher products for public consumption. Additionally, distinctive agricultural landscapes may attract tourism.
Knowledge Gaps

Recent changes in the definitions of farmland may prevent comparisons with past data. The U.S. Census Bureau transferred their agricultural data collection to the U.S. Department of Agriculture, which subsequently, transferred this duty to each state. Definitions and time frames for collecting agricultural data vary widely by state.

Environmental

Farmland makes up the largest percentage of open space in the region. Farms offer habitat for wildlife, and if managed properly, can protect soil and water resources and help to prevent flooding. Farmland also absorbs and filters wastewater and provides groundwater recharge.

Social

Farmland provides a rural lifestyle and plays an important role in contributing to a sense of place. Farmland maintains scenic, cultural and historic landscapes. It offers beautiful views and managed open space, which can provide opportunities for hunting, horseback riding, fishing and other recreational activities. Farms create an identifiable and unique rural community character and add to our quality of life.
American Shad

Things to Think About
There are several factors that influence the dynamics of the spawning run. Temperature and stream flows are key factors. The temperature of the water directs when the adults enter the river to spawn, where and when spawning occurs, and when the juveniles migrate to the ocean. With regard to stream flow, high flows tend to deter the movement of the adults. These environmental factors can affect the results that are obtained when trying to count shad in a given place at a given time.

Knowledge Gaps
It is difficult to assess the progress with regard to recovery of this resource. The data on juvenile shad shows significant swings in apparent abundance; adult shad numbers had shown an increase, but variability is also apparent.

TREND
While the numbers of shad have shown some improvement since 1975, they are well below their pre-1900 abundance. The 1999 adult data collected, indicating a steep decline, may be cause for further assessment of the actual recovery of this resource. However, the preliminary assessment of the adult spring 2000 data (only for the month of April) shows a return of 350,000 shad, similar to the level reached in 1998.

IMPORTANCE
American shad is an anadromous species, meaning that it hatches in fresh water, migrates to the ocean, where it spends much of its growing years, and returns to fresh water to spawn. Shad migrate to the ocean in the fall where they live for 3 to 6 years before returning to their natal river to spawn in the spring.
One theory is that, with water quality improving, spawning is able to occur in the lower reaches of the river, resulting in fewer shad in the upper reaches where sampling has been undertaken. Alternatively, there are numerous possibilities for anomalous events, such as weather patterns or “incidents at sea,” which could also account for variability. The results obtained could also be an artifact of sampling design, or a combination of several factors.

One of the reasons to count both adult and juvenile shad is to have some basis to judge the relationship between the two. It could be hypothesized that 3 to 6 years after a strong showing of juveniles, a large run of adults could be expected. However, the data do not show a good correlation between adult and juvenile estimates. The relationship between adult numbers and juvenile numbers and the degree to which other factors, including the effect of sampling design, are responsible for declines in estimates of population and are areas where additional study is needed.

The abundance of American shad in the Delaware Estuary is legendary. At one time, the Delaware River supported the largest American shad fishery along the Atlantic Coast. During the early 1900s the population of shad began to sharply decline. This decline was attributed primarily to water quality degradation, but other causes included over fishing, habitat destruction, damming of tributaries, entrainment and impingement at intakes, and dredge and fill activities.

As the result of significant water quality improvements, the number of adult shad returning over the past two decades has shown gradual improvement. There remains significant fluctuation in the indicators of abundance for adults and juveniles.

**ECONOMIC**

With the improvement in numbers in the 1980’s, shad fishing had been restored as the most popular springtime fishery on the Delaware River. Shad and its roe are also caught and marketed commercially, with the annual harvest amounting to $30,000 to $150,000 (dockside value) from 1980-89 (Sutton et al., 1996).

**ENVIRONMENTAL**

The environmental effects on shad that resulted in the population crash around 1900 must be viewed in the context of natural environmental stresses. The effects of these factors are beyond our control; thus the need to reduce the loss of shad due to human activities in the Estuary is critical. This reduced loss would include ensuring availability of habitat for spawning by providing for fish passage in tributaries that have been dammed, maintaining water quality suitable for spawning in the river system, and implementing resource management efforts to prevent over fishing. The stresses experienced by shad are also important because they are shared by other anadromous and semi-anadromous species such as herring, striped bass, and sturgeon.

**SOCIAL**

Recreational fishing is an important pastime and part of our heritage. Shad fishing was especially important to the Lenni Lenape Indians as well as to colonial Americans.

To respond to the decline of the fishery compared to its historic levels, “A Management Plan for the American Shad in the Delaware River Basin” was prepared for the Delaware Basin Fish and Wildlife Management Cooperative in 1982. This plan is currently being reassessed by the Cooperative.
While population growth within the Delaware Estuary has remained relatively slow, residential development has drastically increased. Between 1970 and 1990, the Estuary region witnessed a population increase of 1.2%. Population forecasts for the region predict a modest growth of 10.9% from 1990 to 2020. During this same time period, however, developed land within the Estuary increased by 19.6%. Forecasts for developed land predict a substantial increase of 36% or almost 275,000 acres between 1990 and 2020.

As the Delaware Estuary looks towards 2020, it is the distribution of jobs and people together with the location of new development that will determine the impacts on the environment and water quality. Development patterns could transform many rural communities into low-density suburbs comprised of single-family detached residential developments, office parks and corporate centers. The Estuary’s
species, habitats and ecosystems are under considerable stress from development pressures and are becoming less resilient.

**ECONOMIC**

Sprawl causes the dispersal of land uses rather than encouraging investment within existing communities and appropriate growth areas. Sprawl contributes to the inefficient movement of people and goods and causes traffic congestion resulting from the increased number of single-occupancy vehicles. Sprawl adds a great deal to infrastructure costs such as roads, schools, sewer and other utilities, which leads to higher taxes. Sprawl may over-concentrate both tax exempt properties and regional financial obligations in urban areas.

In terms of eco-tourism, there is an economic loss associated with sprawl. Sprawl can result in decreased fish and wildlife abundance due to degradation of water quality and loss of natural habitat. This decreased abundance of wildlife can result in lost revenue from fishing and hunting licenses, and eco-tourism dollars.

**ENVIRONMENTAL**

Maintaining the current pace and type of development in the Delaware Estuary into the future will cause dramatic changes in the landscape. Over the past twenty years, the Estuary has witnessed a significant loss of open space and farmland as new development has pushed further into the suburban and rural fringe. Urban areas have seen little or no growth, and in some cases significant population losses. Urban areas and older suburbs are generally fully developed, and have tended to lose population recently. As land is transformed from natural cover to impervious surfaces, increased loadings of pollutant-laden stormwater and reduced absorption and filtration occur. Subsequently, stream hydrology is affected, as more water flows into streams during storm events and less water is available for groundwater recharge and maintenance of stream base flows. Moreover, inefficient land management fragments natural habitat, creating small, less ecologically valuable parcels.

**SOCIAL**

The challenge facing residents of the Delaware Estuary is to change the way in which our communities are created. New development must be sensitive to the critical natural resources of the Estuary in addition to improving the linkage between land use and transportation. Inefficient land uses tend to concentrate poverty and accelerate the socio-economic decline of cities, towns and older suburbs. Sprawl may diminish the quality of life by creating a lack of affordable suburban housing where job growth is greatest.
From 1990 to 1996 the volume of potable water supplied by the Delaware River Basin decreased while the population in the basin slightly increased. It is believed that this decrease in demand for potable water is a result of conservation practices.

**IMPORTANCE**

In 1996, the Delaware River Basin was the source of potable water for approximately 17.46 million people. Potable water includes water supplied by purveyors for public consumption as well as self-supplied rural domestic water use, and includes both ground water and surface water. Surface water constitutes 80 percent, and ground water 20 percent, of the potable water supplied by the Basin. While the majority of the ground water and surface water withdrawals for potable water are used within the basin to supply 7.48 million people, approximately 40 percent of the potable water withdrawn is exported to New York City and northeast New Jersey.

Things to Think About

Drought warning declarations have become commonplace in the Delaware River Basin. Since 1980, there have been ten warnings. Fortunately, water supply has been sufficient to meet demand during these periods, in part due to the efforts of effective water resource management.

In 1993, water utilities in the Basin reported approximately 215 million gallons of water per day was unaccounted for, representing over 17% of the
average daily demand. Unaccounted for water typically results from leaking water distribution systems, unmetered water use, or under-registering of metered water use.

Flows in the Delaware River are regulated to prevent salt water from migrating upstream. This helps protect fresh water supplies for Philadelphia and other municipalities on the river and reduces corrosion control costs. During dry periods, up to 60% of the flow in the Delaware River at Trenton is from releases from upstream reservoirs.

Knowledge Gaps

Potable water provided by public water suppliers includes all uses of water (i.e. residential, commercial, industrial and other). Knowing how much of the potable water is used by each sector would allow us to separate the data by use categories and more accurately evaluate water use trends. In addition to potable water use, ground water and surface water are withdrawn for industry, power generation, and irrigation. Data is being compiled to evaluate water use trends.

suppy 9.97 million people. New York City alone derives approximately 50 percent of its water from the Basin.

There are many factors which influence water usage, including population; types of industries; income levels; the cost of water; and climate. The volume of potable water withdrawn from the Delaware River Basin ranged from approximately 688,000 million gallons in 1990 to 637,000 million gallons in 1996. This represents an average decrease of 6 percent over the seven-year period. During this same period of time, however, the population served has gradually increased by approximately one percent.

Decreasing potable water use during this period of increasing population is a positive indication that water resources are being managed more effectively. One of the goals of water resource management is efficient water use, and one of the ways to facilitate this is through water conservation. Effective water conservation practices include repair of leaking public water distribution systems and the use of water saving plumbing fixtures such as low flush toilets and restricted flow shower heads. Another goal of water resource management is insuring that there is sufficient supply to meet demand.

**ECONOMIC**

Water conservation can reduce or delay the need for developing new water supply systems or enlarging existing systems. These systems consist of costly infrastructure including drinking water and sewage treatment plants, pumping stations, reservoirs, and distribution systems. Efficient water use can lead to savings in capital and operating costs by reducing the volume of water which must be processed through distribution and wastewater treatment systems.

**ENVIRONMENTAL**

Water conservation can have a stabilizing effect on the rate of water withdrawals, ultimately helping to maintain flows in rivers and streams, and reducing the potential for over-pumping of groundwater. In addition, water conservation practices directly leads to reduced volumes of wastewater, which must be treated and discharged, back into the environment. Water conservation therefore directly affects the Estuary as well as upstream portions of the Basin.

**SOCIAL**

Efficient water use can have major environmental, public health, and economic benefits by helping to improve water quality, maintain aquatic ecosystems, and protect drinking water resources.
Although public parkland has increased by more than 33,000 acres, or by 14.1% between 1990 and 1999, development pressures on the Estuary’s remaining undeveloped open spaces may limit the ability to protect habitat and the natural resource values of these areas or to secure these areas for future recreational use.

**IMPORTANCE**

Adequate parkland is an important component in enhancing the Estuary’s image and the region’s quality of life. Parkland not only provides aesthetic, environmental and sporting benefits, but also encourages an overall sense of community.

**ECONOMIC**

Throughout the Delaware Estuary, parkland is playing an increasingly important role in today’s mobile and information-based economy. Natural landscapes and recreational opportunities that parklands offer drive tourism, one of the leading industries in the Estuary. In addition, property values have been shown to increase...
Knowledge Gaps

This indicator does not provide data for Berks, Lebanon, Lehigh or Schuylkill counties in Pennsylvania. In order to gain a complete picture of parkland within the Estuary, an assessment of privately owned and protected open space must be undertaken as well. There are many private park-like areas such as golf courses and schools that have an impact on the environmental, economic and social composition of the Estuary. It will also be important to assess the future recreational needs in the Delaware Estuary so we can develop strategies to identify and preserve needed park areas.

when in proximity to parkland. This in turn leads to more prosperous communities.

■ ENVIRONMENTAL

Parkland within the region encompasses woodlands, steep slopes, wetlands, streams, rivers, lakes, pine barrens, and flood plains - all intricately inter-connected elements of the Estuary’s ecosystem. All these areas drain to, and therefore impact, the Estuary. Parkland provides a scenic refuge for people, cleanses air and water, and provides habitat for wildlife.

■ SOCIAL

Parkland plays an important role in defining communities throughout the Delaware Estuary. It helps to establish our communities’ boundaries and landscapes while creating a sense of place with which people can identify. Parkland also provides a focal point for socializing.
Dissolved Oxygen in the Delaware Estuary

**TREND**

Dissolved Oxygen in the Estuary has made a dramatic increase over the past 35 years, and has returned to levels that will sustain a fish population.

**IMPORTANCE**

Essentially all life in the river and bay requires dissolved oxygen. In the past, the oxygen demand from municipal and industrial effluents was so large that a long stretch of the urban river (about 30 miles) was almost devoid of oxygen in the warmer summer months. The oxygen demand is from reduced components in the water (organic matter and ammonium nitrogen) that are oxidized by bacteria in the water. Natural systems have some oxygen demand, but municipal and industrial effluents greatly increase the demand. Although mixing of water with the air will replenish oxygen, prior to 1965 the biochemical oxygen demand (BOD) from the effluents in the water was so great that it was impossible for equilibration with the air to keep up. Decreased effluent BOD allows a fairly stable healthy level today.

Things to Think About

The Delaware River in the Philadelphia area was once one of the most polluted estuarine regions in the country. A primary sign of the poor water quality, low dissolved oxygen, was especially bad in the summer. Water quality is better now due to improved effluent controls over the past several decades. The much improved water quality has brought back more fish populations, birds and humans that feed on the fish. However, centuries of contaminants in the bottom of the river and in waste sites along the
There has been a large increase in dissolved oxygen values between Trenton, NJ (river mile 130) to the lower bay (river mile 30) in the summer when the oxygen is the lowest (Figure 1). Although the oxygen content in the upper river and lower bay were not low in the past, there was an “oxygen sag” in the urban river that is much smaller today. Average low summer dissolved oxygen for the river region from Cherry Island to Ben Franklin Bridge (river miles 70-100) was very low in the past (as recently as the 1960s, average for summer < 2 mg/L with individual values of zero). Average summer concentrations in this reach have been above the target of 3.5 mg per liter since the mid-1980s (Figure 2). After a progressive increase, the oxygen content appears to have reached a relatively constant level since 1994. With regulations under the Clean Water Act being met, we have reached the limits of improvement. We now recognize that some effluent and sedimentary oxygen demand will always be present.

**Knowledge Gaps**

Greatly decreased BOD, especially from sewage effluents, have given rise to the improved oxygen content that brought us above the 3.5 mg/L minimum standard around Philadelphia and Camden by the mid-1980s. However, the current level of 5 to 6 mg/L was achieved by the mid-1990s and there has been no further significant improvement. Have we achieved the maximum summer dissolved oxygen content that we can or are further improvements possible? Can we maintain the current level of oxygen or will there be increased BOD from other sources as we continue to clean up the Estuary?

**Economic**

Commercial and recreational fisheries were effectively destroyed in the urban portion of the tidal river and above because of low oxygen. Fish could not migrate up into the fresh water of the upper river to spawn and the once large shad and sturgeon populations plummeted around the turn of the last century. Aesthetically undesirable conditions also drove away people and jeopardized commercial activities. With increasing oxygen content in the past decade, migratory fish populations are improving and people are moving closer to the river to live and to participate in recreational activities. Light industry and other commercial activities are also moving closer to the river today.

**Environmental**

Important migratory fish, benthic (bottom-dwelling) animal and resident fish populations are increasing in the Estuary. However, the river in the Philadelphia region has been negatively altered by human activities over three centuries. We are now trying to return it to a more natural environment and preserve this condition. The most basic environmental requirement in the river is dissolved oxygen. With increased oxygen, the river is potentially more habitable.

**Social**

For many decades the population of the Delaware Estuary has not looked upon the river and bay as a valuable natural resource, but more often as a sewer conduit and shipping lane. With proper management, our Estuary can serve for waste disposal, shipping, and as a sustainable natural resource.
Contaminated Sediments in the Estuary

**BENTHIC TOXICITY**

<table>
<thead>
<tr>
<th>Toxic Score</th>
<th>% Survival</th>
</tr>
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<tbody>
<tr>
<td>Low</td>
<td>69-100%</td>
</tr>
<tr>
<td>Medium</td>
<td>17-68.9%</td>
</tr>
<tr>
<td>High</td>
<td>2-16.9%</td>
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* For Benthic Toxicity (amphipod toxicity), toxic scores were set up using 100 divided by the percent survival. An arbitrary score of 0 to 1.25 would have a rank of 0; 1.25 to 5.0 would have a rank of 1; 5.1 to 10.0 would have a rank of 2; and 10.1 to 100.0 would have a rank of 3. Low on the graphic is 0-3, Medium is 3.1-6, and High is 6.1 to 50.

**ORGANIC CONTAMINANTS TOXICITY**

**An arbitrary score was set up for Organic contaminants, with A Benzo(a) pyrene equivalents of 0 to 60 having a score of 0; 61 to 100 having a score of 1; 101 to 500 having a score of 2; and 501 to 1500 having a score of 3. On this graphic 0-1 is Low, 1.1 - 2 is medium and 2.1-3 is High.**


**TREND**

At this time, the only information that exists on contaminated sediments for the Estuary is baseline, therefore it is impossible to detect a trend.
IMPORTANCE

Assessment of aquatic sediments is an important component to gauge the health of natural systems. Sediments act as an indicator to characterize the estuarine system. This is because past pollution activities, which contaminate sediments, can take many years to be removed from the system. Sediments can also act as a source through which contaminants can re-enter the system. This in turn can frustrate pollution control efforts.

In 1997, sediment investigations in the Delaware Estuary and selected tributaries were performed by the federal government, and supported by Delaware, New Jersey and the Delaware River Basin Commission. In this study, ninety-one stations were evaluated for a number of factors including toxic effects to bottom organisms. Standard testing was performed with crustaceans (relatives of crabs) called amphipods to determine the toxic impact of contaminated sediments. The map of benthic toxicity above shows the location of sediments that are considered highly toxic, slightly toxic, and not toxic. The second map shows the location of sediments that contain high, medium and low levels of chemical contaminants related to the toxicity of Benzo(a)pyrene. Benzopyrenes are organic chemicals originating from petroleum products or combustion sources.

ECONOMIC

Contaminated levels and toxicity of pollutants in aquatic sediments directly affect the types of organisms and plants that can live there, as well as the commercial and recreational harvesting that takes place. Uptake of pollutants from aquatic sediments by organisms can drastically affect the quality of shellfish and finfish resources in the Estuary, as well as the commerce and tourism industries to which they depend. Clean sediments reduce the cost of disposal of dredged sediments.

ENVIRONMENTAL

Maintaining good marine sediment quality is essential to protecting the diversity of life in the Estuary, and in concert with water quality, is a good indicator of the Delaware Estuary’s health.

SOCIAL

Clean aquatic sediments provide for safe recreational activities in the Estuary, such as wading in its waters.

Knowledge Gaps

The effect of downstream movement of contaminated sediments in the Delaware Estuary is not well understood. The effects of dredging and ship scour may affect the migration and uptake of contaminated sediments by aquatic organisms.

Things to Think About

Sediments represent a long-term memory of the “insults” aquatic systems receive over time. Sediments can reflect long-term levels of contaminants. Continued sediment sampling for contaminants is worth doing to evaluate long-term improvements in the system. Sediment toxicity is an important aspect of these contaminated materials.
Improved water quality in the Delaware Estuary has resulted in an upgrading of additional harvesting acreage.

**Importance**

A direct connection exists between the consumption of shellfish harvested from contaminated areas and human illness.

In the Delaware Estuary, the States of Delaware and New Jersey test the marine waters to ensure that the shellfish resources within the Bay remain a wholesome food product. In addition, the continuous monitoring of shellfish growing waters provides an effective environmental yardstick to assess pollution abatement trends.
example, the shellfish industry provides $20 million directly to the state’s economy through the sale of seafood. In addition, other support services to the fishermen and recreational activities contribute considerable money to the local and state economies. This is all a result of improved water quality.

Knowledge Gaps

There is a need for more frequent and consistent monitoring across the three Estuary states to assess the quality of shellfish beds.

In specific areas of the Estuary, rules have been established by the states prohibiting the harvesting of shellfish for human consumption. This has been done to avoid danger to human health.

Although improved water quality has opened up more acreage for shellfish growing areas, there are certain areas that as a precautionary measure, will always be prohibited. These include areas adjacent to sewage treatment plants and stormwater outfalls. These areas are a very small percentage of the total, and are not depicted in the graphic above.

**Economic**

Marine resources are important to Delaware and New Jersey’s economy. Both states have a vibrant commercial fishing industry, of which shellfish are an important component.

By making more areas available for shellfish harvesting in the Estuary, consumers of shellfish benefit from increased ability to purchase a fresh, locally raised product.

The commercial and sport fishing industries rely on clean water just as much as the shellfish industry.

**Environmental**

Maintaining marine water quality and habitat is essential to protecting the diversity of life in the ocean. As bottom dwellers and filter feeders, shellfish are a good indicator species for the quality of the water and the health of the marine ecosystem.

**Social**

Clean beaches and water provide safe opportunities for recreation and tourism in our coastal communities. Trips to the shore, and the opportunity to eat fresh seafood, are timeless leisure activities for many people and are an important part of our region’s heritage.
Suitability of Estuary Waters for Swimming

**Things to Think About**

By the end of the 19th century, fisheries were declining due partially to over fishing and pollution. In many places drinking water was contaminated, and pollution (primarily from sewage) caused outbreaks of typhoid fever. The industrialization of the waterfront, and water borne diseases led to decreased recreational use on the Delaware River.

**TREND**

The urbanized region of the Delaware Estuary shows much improved water quality with most of the samples showing bacteria counts below the level of concern. As recently as ten years ago, levels were considerably higher. Currently, however, many of the Estuary’s tributaries show levels that are too high.

**IMPORTANCE**

Today, the urban reaches of the Delaware Estuary do not meet swimmable criteria as established by the U.S. EPA. As the demands for recreational, residential, and commercial opportunities along the banks of the river expand, improving water quality to attain swimmable status has become imperative.
Knowledge Gaps

Swimming beaches in the Delaware Estuary are monitored for bacterial contamination. However, swimming also takes place in areas that are not monitored. Coverage for bacterial testing should be expanded to include as many of these “unregulated” areas as possible.

Monitoring programs conducted at the state and federal level evaluate water quality to determine if bacterial indicators are at levels that would cause infection or disease. The data that are used to judge the suitability of ambient water for swimming include fecal coliform, total coliform and enterococcus bacteria. Each state that borders the Delaware Estuary, as well as the Delaware River Basin Commission, has water quality standards for swimming. These standards are based on bacterial counts of fecal coliform and enterococcus colonies. Counts below a certain level are interpreted as being of no concern, while those exceeding this level indicate a potential risk to human health. These criteria set levels for the above pathogens so that ingestion during recreational activities will not cause illness. As the levels rise and criteria are exceeded, the probability of human illness increases.

- **ECONOMIC**

Within the Estuary, recreational water contact is very important to the states of Delaware, Pennsylvania and New Jersey. The assessment of bacterial levels in the system affects not only recreational opportunities, such as swimming, fishing and boating, but commercial fishing, as well as other marine industries.

- **ENVIRONMENTAL**

Bacterial levels in the Delaware Estuary are an important indicator to measure trends in water quality, resource harvesting and recreational opportunities.

- **SOCIAL**

Low levels of pathogens in the waters of the Delaware Estuary are an important aspect to ensure safe opportunities for recreation and tourism.
Upcoming Delaware Estuary Events and Happenings

Exploring Native Plant Communities
Saturday, October 20, 2001
Bristol Marsh and Delhaas Woods
Bristol, Pennsylvania
A tour, guided by the staff of the Bowman’s Hill Wildflower Preserve, will explore Bristol Marsh, a freshwater tidal marsh; and Delhaas Woods, home to a wet meadow, wet forest, and a marsh. For more information or to register, please call the Preserve at (215) 862-2924.

Fourth Annual Wetlands Regulatory Workshop
October 29 – November 2, 2001
Holiday Inn on the Boardwalk
Atlantic City, New Jersey
The purpose of this workshop is to investigate contemporary wetland regulatory issues, and to increase dialogue and foster partnerships between federal, state, and local regulatory agencies, non-governmental organizations and the regulated community. For more information, please call (215) 814-2718.

Full Moon Festival
Thursday, November 1, 2001, 6:30 p.m. – 8:00 p.m.
Delaware National Estuarine Research Reserve
Dover, Delaware
Join the staff of the St. Jones Reserve for a bonfire complete with s’mores and story telling. Learn how the full moon is essential to the life cycles of numerous animals. For more information or to register, please call (302) 739-3436.

Revitalizing the North Delaware Riverfront
Friday, November 2, 2001, 7:45 a.m. – 10:30 a.m.
Pennsylvania Environmental Council
Philadelphia, Pennsylvania
Find out what redevelopment and conservation activities are envisioned for the Delaware riverfront north of Penn’s Landing from Fishtown to Bucks County. For more information, please call (215) 563-0250.

Harvest of Wildcrafts
Friday, November 2, 2001, 10 a.m. – 12 noon
Nature Center of Cape May
Cape May, New Jersey
This is the best time for creating with nature’s bounty. Get some really great decorating ideas for indoors and out. For more information, please call (609) 898-8848.

Monoshone Watershed Appreciation Day
Saturday, November 3, 2001, 12 noon – 4:00 p.m.
Historic RittenhouseTown
Philadelphia, Pennsylvania
This third annual event, which celebrates the Monoshone Creek, as a source of power for America’s first paper mill, will feature exhibits and displays from more than 25 of the areas environmentally related groups and institutions, walking and bus tours of the watershed, and activities such as water testing. For more information, please call (215) 438-5711.

Fall Tree Care for the Home Gardener
Thursday, November 8, 2001, 12:00 noon – 1:00 p.m.
Pennsylvania Horticultural Society
Philadelphia, Pennsylvania
ISA certified arborist, Lou Giroud, will discuss the keys to healthy trees, including selecting the right tree for your landscape, detecting signs of tree problems, and coping with insects and disease, and pruning. For more information, please call (215) 988-8800.

Oyster Fest 2001
Saturday, November 10, 2001
Everett P. Marino Conference Center
Bridgeton, New Jersey
If you ever wondered why oystering was once a multi-million dollar industry in South Jersey, join the Delaware Bay Schooner Project for an evening of traditional music, food, and a silent auction. Proceeds from the event will help to continue the Schooner Project’s environmental education programs. For more information or to reserve a ticket, please call (856) 785-2060.

Wilmington’s Waterfront
Wednesday, November 14, 2001, 7:00 p.m. – 8:30 p.m.
Ashland Nature Center
Hockessin, Delaware
Join Sally O’Byrne, co-author of Wilmington’s Waterfront, for a slide lecture and discussion of Wilmington, Delaware’s riverfront industrial history and present-day redevelopment activities. For more information, please call (302) 239-2334.

Early Winter Arrivals
Saturday, November 24, 2001, 9:00 a.m. – 11:00 a.m.
The Nature Conservancy of New Jersey
Cape May, New Jersey
Keith Seager will lead participants on a leisurely stroll through the Cape May Migratory Bird Refuge to find the birds that make these meadows their winter home. For more information, please call (609) 861-0600.

Green Space Symposium
Thursday, November 29, 2001, 8:30 a.m. – 4:00 p.m.
Schuylkill Center for Environmental Education
Philadelphia, Pennsylvania
This symposium entitled “The Ecological Enhancement of Urban/Suburban Green Space” will include speakers and panelists from Rutgers University, USDA Forestry Service, and New York University as well as regional ecologists and educators, and urban green space designers. For more information, please call (215) 482-7300 x 118.
The Estuary News encourages reprinting of its articles in other publications. Estuary News is published quarterly by the Partnership for the Delaware Estuary, Inc., under an assistance agreement (CE-993985-03-0) with the U.S. Environmental Protection Agency (EPA). The purpose of this newsletter is to provide an open, informative dialogue on issues related to the Delaware Estuary Program. The viewpoints expressed here do not necessarily represent the views of the Partnership or EPA, nor does mention of names, commercial products or causes constitute endorsement or recommendation for use. For information about the Delaware Estuary Program, call 1-800-445-4935.

What is the Delaware Estuary Program?
The Delaware Estuary Program (DELEP) is a partnership of governmental agencies, nonprofits, the private sector, and citizens working together to restore and protect the Delaware Estuary. It was established in 1988 and is one of 28 national estuary programs around the nation. The estuary region extends from Trenton, New Jersey to the mouth of the Delaware Bay. To learn more about DELEP activities, visit www.delep.org.

WHO IS THE PARTNERSHIP?
The Partnership for the Delaware Estuary, Inc. is a private, nonprofit organization established in 1996. The Partnership promotes the estuary as a regional resource through public outreach and education. It also serves as the education, outreach, and fundraising arm for the Delaware Estuary Program. To find out how you can become one of our partners, call the Partnership at 1-800-445-4935 or visit our website at www.DelawareEstuary.org.

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