Delaware Inland Bays' Environmental Indicators

Center for the Inland Bays

PROTECTING AND PRESERVING DELAWARE'S INLAND BAYS

Limulus polyphemus

Center for the Inland Bays

Rehoboth Indian River Little Assawoman

A Message from the Chair:

The Center for the Inland Bays, Inc. is an organization on a mission— management of our Inland Bays' precious natural resources under comprehensive watershed management and planning principles.

As a private, non-profit organization, we are uniquely qualified to carry out this mission. Our boundaries are determined by the movement of surface waters and the flooding and ebbing of tides in the Inland Bays, not by political lines. Under the authority of a 1987 amendment to the Clean Water Act, we also function as a National Estuary Program, which has adopted a comprehensive plan to guide not only its own policies, but those of supporting local, state and federal agencies. This plan serves as the blueprint for the management of our Inland Bays as well as the ongoing efforts to restore and protect these magnificent waterways.

Delaware's Inland Bays and its watershed have suffered from past environmental negligence. Over-application of manure from poultry and farming operations has fueled blooms of phytoplankton in our waters. Antiquated holding tanks and failing septic systems have contributed excessive amounts of nitrogen to our ground water. Point source discharges of phosphorus from local sewage treatment plants have led to the growth of nuisance macro algae, such as Sea Lettuce, which collects on our shorelines. A population explosion and advancing development in the watershed have placed stresses on critical wetland and forest habitats necessary for the survival of important estuarine species.

While the legacy of this abuse and neglect remains, we are happy to report that progress has been made with many of these problems. Our agricultural community has made great strides in its efforts to manage the storage, transport, and application of fertilizers. Holding tanks in the watershed have been eliminated and a new compliance and inspection program has been initiated to control pollutants from onsite waste water systems. Strict new regulations concerning point source discharges now prohibit effluent releases to Inland Bays' waters. Finally, local, county and state governments are considering new ways to control growth and minimize harmful impacts to the environment.

Policy makers often ask me if the Inland Bays are "getting better." My answer is both "Yes" and "No". We are making major strides in water quality improvements, but we still have a long way to go. One way to assess our progress is to look at historical trends of a number of factors that have an influence on the bays. This report should help you to see key "environmental indicators" to gauge these trends and thereby, help us all make better plans for the future.

As we continue to implement the Inland Bays Comprehensive Conservation and Management Plan, I believe that our success will depend largely on three factors:

First and foremost, meeting the aggressive milestones and commitments in the plan. We understand that the credibility of our organization depends upon our ability to meet these commitments, and we intend to deliver. We have, thus far, completed a number of important actions and tactics aimed at improving water quality and habitat for Delaware's Inland Bays.

Second, securing adequate resources to meet our future commitments. We are fortunate that the Environmental Protection Agency, the State of Delaware, and numerous supporters have provided significant financial contributions to our program. However, without this continuing financial support, our program will not move forward.

Third, strengthening our partnerships with local and regional communities. Our program will be successful only if it builds upon collaborative efforts to address Inland Bays' issues at the local or regional level. By working with these communities, stakeholders will have the opportunity to seize the initiative to address some of the most critical issues affecting our Inland Bays.

I look forward to working with our staff, partners and supporters to continue to build upon these successes in the coming years.

Rick Eakle, Chair
Board of Directors

FRAMEWORK FOR INLAND BAYS ENVIRONMENTAL INDICATORS

Your vital signs - measures of blood pressure, body temperature and the like - provide indications of your state of health. When you're ill, a physician measures your vital signs, evaluates your symptoms and makes a diagnosis. Often a doctor can even pinpoint the cause of your problem or illness.

Scientists, resource managers and policy makers in estuarine programs around the world use environmental indicators - discreet measures of one aspect of environmental quality or economic impact - in much the same way. Indicators, such as the health of certain species or even the status of legislative actions, can be used alone or in combination with other assessments to paint a comprehensive picture of a water body's condition and its value to the people who use it. For example, indicators based on concentrations of nitrogen and phosphorus in an estuary could be combined with an indicator based on total acreage of submerged aquatic vegetation to tell a story about the effects of water quality on a bay's living resources. As additional indicators are included, the message or story becomes more complete.

The Delaware Inland Bays' environmental indicators were selected and are used for this primary purpose as well as to communicate the health of the Bays and their tributaries to the public. When the members of the Indicators Subcommittee of the Inland Bays Scientific and Technical Advisory Committee selected a suite of indicators, they knew that an indicator was most useful when it addressed numerous questions and met certain criteria. Indicators had to serve to:

1. **Evaluate progress in the Inland Bays restoration effort;**
2. **Monitor environmental condition and environmental response to restoration efforts;**
3. **Provide information needed to establish restoration goals;**
4. **Regularly inform and involve the public in achieving the restoration goals; and,**
5. **Make detailed information and reference data available to others.**

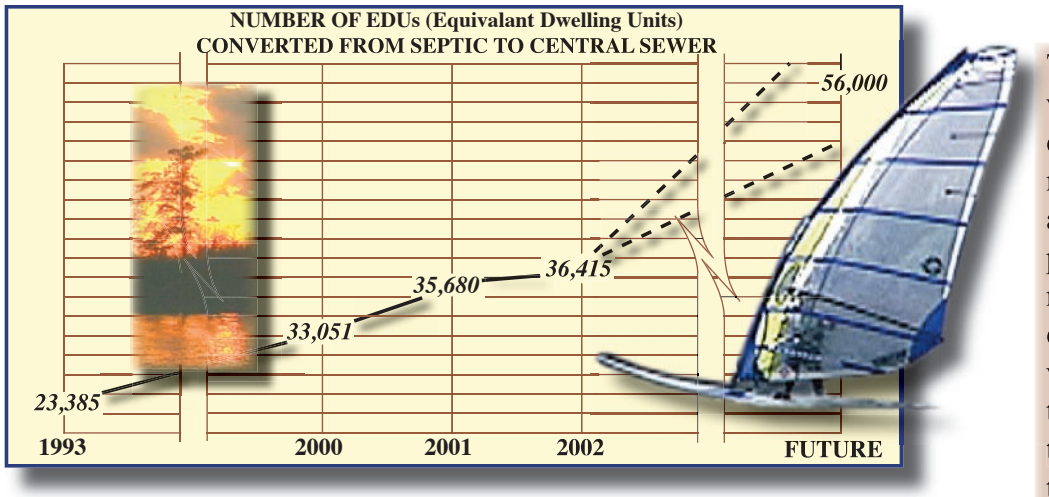
The committee members knew intuitively which indicators to study, but since their intuition is the result of vast experience others lack, they realized they had to be able to articulate the basis for their selection. It was also necessary to relate indicators to each other, so categories into which each can be placed were identified. They are:

1. **Actions by EPA/State Regulatory Agencies;**
2. **Responses of the Regulated and Non-regulated Community;**
3. **Changes in Discharge/Emission Quantities;**
4. **Changes in Ambient Conditions;**
5. **Changes in Uptake and/or Assimilation; and,**
6. **Changes in Health, Ecology, or Other Effects**

The indicators already studied and those for which future reports will be provided can be placed into one of these categories. All the indicators captured in these categories have some value for stakeholders and policy makers. It's hoped that everyone who lives in the watershed or enjoys the Inland Bays will realize that they are the stakeholders. The information in these reports and the story they tell was compiled for them.

The Center for the Inland Bays not only encourages stakeholder participation in its programs and efforts, it depends on this involvment. The Bays will not recover without it. If you would like to discuss this information in more detail or if you have any questions about environmental indicators or the Center for the Inland Bays, please don't hesitate to contact a staff member at (302) 645-7325.

An Indication of Progress Through Government Action:
Converting Septic Systems to Central Sewer



Jim Butch

Jim Butch is an Environmental Scientist in the Region III EPA Environmental Programs Branch office in Philadelphia, PA. He is the fomer program officer for the Delaware Inland Bays Estuary Program.

What is the concern regarding septic systems in the Inland Bays watershed?

The nutrient loadings from septic systems are significant. The Inland Bays watershed currently has more than 16,000 existing septic systems. DNREC estimates that almost 1,000 pounds of nitrogen and as much as 40 pounds of phosphorous may be entering the waters of the Inland Bays on a daily basis from existing and recently eliminated septic systems . Although more than 13,000 septic systems have been replaced by sewer since 1993, these abandoned systems continue to drain nutrients into the ground water, and eventually the Inland Bays for a period of several years.

Why are centralized sewage treatment plants better than septic systems for disposal of human waste?

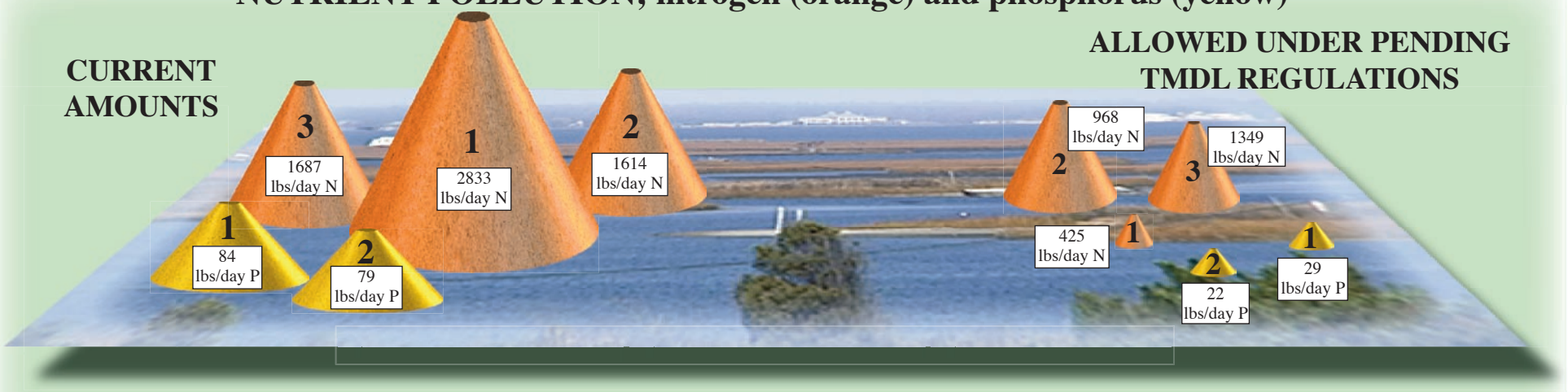
Public sewer systems provide a valuable service by providing higher treatment levels for both domestic and commercial sewage, thereby reducing the levels of nutrient pollution to the Inland Bays. Although treating sewage is an important way to reduce nutrient pollution loading to the bays, some treatment plants still discharge their treated waters into the bays. Efforts are underway to phase out these muncipal sewage treatment plant discharges over the next several years. This is important because this phase-out step will further reduce nutrient contributions to the Inland Bays.

Typical domestic wastewater comes from showers, baths, toilets, washing machines, dishwashers and sinks. Nitrogen and phosphorous are contaminants of public health and environmental concern in wastewater. If wastewater cannot be discharged to sanitary sewers for treatment at a centralized wastewater treatment plant, it must be treated where it originates. Systems for onsite treatment are referred to as "septic systems" or "onsite wastewater systems." An acceptable individual septic system in the county is one consisting of a house sewer, septic tank, distribution system, and an adsorption area. Sewage flows from the household into the septic tank where the heavier solids settle to the bottom forming a sludge deposit. Lighter solids, such as grease, float to the top and form a scum layer. The liquid flows from the septic tank to an adsorption system where it soaks into the soil. This entire process provides treatment of the sewage by gravity settling and skimming, biological decomposition, and soil filtration.

"Sussex County maintains an aggressive strategy to eliminate holding tanks and failing septic systems in the Inland Bays watershed. Council continues to make progress in these efforts through wastewater treatment facility upgrades and service expansions. Sussex County plans to spend $171 million in the next five years towards this effort."

Bob Stickels, County Administrator

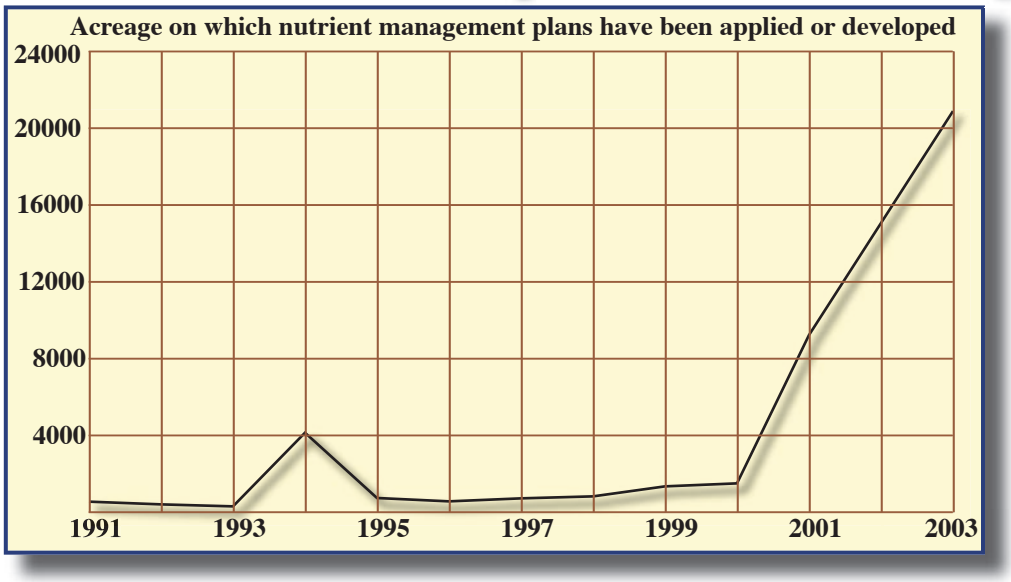
NUTRIENT POLLUTION; nitrogen (orange) and phosphorus (yellow)



Of the 4,447 pounds of "non-point source" nitrogen that enter the Indian River and Rehoboth Bays from the Upper Indian River (cone 1) and all other tributaries (cone 2), 988 lbs are believed to come from existing and recently eliminated septic systems. Cone 3 represents the amount of nitrogen from the atmosphere that enters the bays daily.

An Indication That Improvements Are Being Implemented:

Nutrient Management Planning



Nutrient management planning is a type of best management practice or "BMP" used by farmers to control the amount, form, timing and placement of plant nutrients on crops. Plant nutrients, such as nitrogen and phosphorus, fertilize crops and help them grow. This type of practice allows farmers to supply adequate plant nutrients to meet crop production requirements while minimizing entry of nutrients into surface water and ground water. Excessive contributions of nutrients in Inland Bays waters may lead to undesirable growth of aquatic plants such as Sea Lettuce or blooms of harmful algae. A concerted effort to increase agricultural acreage under nutrient management planning has been ongoing since the passage of the Delaware Nutrient Management Law in 1999.

Ed Lewandowski

Ed Lewandowski has been the Education and Outreach Coordinator with the Center for the Inland Bays since 1998. He was appointed by the Delaware House of Representatives to the Delaware Nutrient Management Commission in the Spring of 2002.

What are the nutrient management requirements for the Inland Bays watershed?

The Delaware Nutrient Management Law affects persons who operate an Animal Feeding Operation in excess of eight animal units (1animal unit = 1,000 pounds) and/or those persons who control or manage property in excess of 10 acres on which either organic or commercial nutrients are applied. These persons are required to develop and implement a nutrient management plan, maintain records, submit an annual report and become certified. The certification deadline was January 2003 and other deadlines are phased in starting January 2003 and ending in January 2007.

How do the bays benefit from proper nutrient management activities?

Proper nutrient management planning in combination with other efforts such as the development of alternative uses for poultry manure (eg. pelletizing) will result in decreased contributions of both nitrogen and phosphorus to our waterways. Less nutrients mean a decrease in the rapid and abundant growth of nuisance plants such as Sea Lettuce and other algal blooms, which results in healthier waterways.

What trends in nutrient management do you foresee?

Acreage under mandatory nutrient management planning has increased steadily since the passage of the Delaware Nutrient Management Law and it should continue to increase through the mandated 2007 deadline.

"Nutrient management isn't a new concept to most farmers. Our farm has been practicing it for years because it's cost-effective and good for the environment."

Ken Walsh, poultry farmer

Ken Walsh (on the right) has been growing poultry in the Inland Bays watershed for seventeen years. Ken believes that nutrient management planning is a tool that can be used to increase crop productivity while reducing the chances of over application of fertilizer such as poultry manure. As a local contract poultry grower, Walsh was an "early cooperator" and brought his agricultural operation under nutrient management planning well before mandated deadlines.

An Indication of Changes In Discharge & Emissions:

Total Nutrient Loads From All Point Sources Into The Indian River & Rehoboth Bays		Flow in Millions of Gallons / Day From Wastewater Treatment Plants			
	lbs / day Nitrogen	***lbs / day Phosphorus***	***Georgetown***	***Lewes***	***Millsboro***	***Rehoboth***
1990	**537**	**68**	**.45**	**.45**	**.36**	**1.0**
2000	**710**	**72**	**.46**	**.57**	**.43**	**1.14**
Increase	**32%**	**6%**	**2%**	**27%**	**19%**	**14%**

Hassan Mirsajadi

Hassan Mirsajadi is an Environmental Engineer with DNREC's Watershed Assessment Section who has worked extensively on point source discharge issues.

What is the nutrient contribution to the bays from point source discharges?

According to a US Army Corps of Engineers estimate, during the 1988-1990 period, 8.1% of the nitrogen load and 29.4% of the phosphorous loads to the Inland Bays originated from point sources. In 1990, the thirteen point source discharge facilities contributed 537 lbs/day of nitrogen and 68 lbs/day of phosphorous. By the year 2000, four facilities had been eliminated resulting in a reduction of 7.7 lbs/day of nitrogen and 0.7 lbs/day of phosphorous.

So, does that mean the overall contribution of nutrients from point sources decreased between 1990 and 2000?

Even though four discharge facilities were eliminated, the overall point source loads increased over the ten-year period. In 2000, the point source load of nutrients reached 710 lbs/day of nitrogen and 72 lbs/day of phosphorous. This increase was the result of increases in discharge flows from four larger municipal wastewater treatment facilities in the watershed. DNREC continues to work with wastewater facilities to reduce nutrient contributions to the Inland Bays.

Will all the point source discharges be removed from the Inland Bays?

There may be some instances for which removal of the discharge is not feasible. For example, Pinnacle Foods (VLASIC) in Millsboro has retained their permit to continue discharges, however, by using "pollution trading" the company was able to reduce nutrient contributions elsewhere, which offset the nutrients entering the waterways from their its effluent.

Removal of Direct Discharges Into The Bays:

Point source discharges (those that come directly from a pipe), such as effluent from sewage treatment plants, contribute pollutants and nutrient loads to the Inland Bays and have a significant impact on water quality. Considering water quality impairments caused by nutrient overenrichment of the Inland Bays, a state TMDL (Total Maximum Daily Load) regulation seeks "systematic removal of all point source discharges of nutrients to the Inland Bays." In 1990, thirteen point source discharge facilities were in operation in the Inland Bays' watershed. During the last several years, seven of the thirteen discharges have been eliminated. Efforts are currently underway to eliminate all remaining point source discharges of nutrients in the watershed through a timely and cost-effective manner.

Providing safe, clean and fun recreational activities at Delaware Seashore State Park is the responsibility of Ken Farrall and his qualified staff from the Division of Parks and Recreation. Two of the most popular activities at Delaware Seashore State Park are camping at the Indian River Inlet campsite and fishing in the inlet's waters. For years, the treated wastewater from the campground was discharged directly into the inlet on the outgoing tides. In 1999, a new pumping station was constructed, which allowed the park to eliminate its point source discharge and begin pumping waste to the South Coastal Treatment Plant. Following the State's lead, five other point source discharges to the Inland Bays were eliminated.

"Delaware Seashore State Park is a major attraction for millions of visitors who enjoy the large variety of water-related activities available along Delaware's coast. Eliminating our campground's discharge to Indian River Inlet in 1999 demonstrated our commitment to improving and maintaining our waterways for their significant ecological and recreational value. "

Ken Farrall, Park Administrator

An Indication of Change in the Environment:

Nutrient Pollution & Dissolved Oxygen

Eutrophied Bay Non-Eutrophied Bay

"Solar Bee" aeration system

Small amounts of nutrients (nitrogen and phosphorus) and sediments enter the bays naturally in runoff from fields, forest, and wetlands. Many more nutrients are contributed by human activities and can lead to eutrophication, a condition where excess nutrients stimulate rapid and abundant plant growth. This plant growth is commonly referred to as an algal bloom. When the algae begins to die and decay, the bacteria that break down the algae use up the oxygen in the water and can cause low oxygen or hypoxia. The low oxygen can cause fish kills and harm other animals living in the bays. High levels of algae are generally indicated by increased levels of chlorophyll, the plant pigments used for photosynthesis.

Kent Price

Kent Price is the chair of the Center for the Inland Bays Scientific and Technical Advisory Committee. He was a professor at the College of Marine Studies, University of Delaware, in the Marine Biology and Biochemistry department for 33 years before retiring. He began research on the bays in 1968.

What human activities lead to eutrophication?

Sewer and septic systems, application of fertilizers by farmers and homeowners, pet and animal waste, and emissions from vehicles or power plants all lead to eutrophication through nutrients entering the bay.

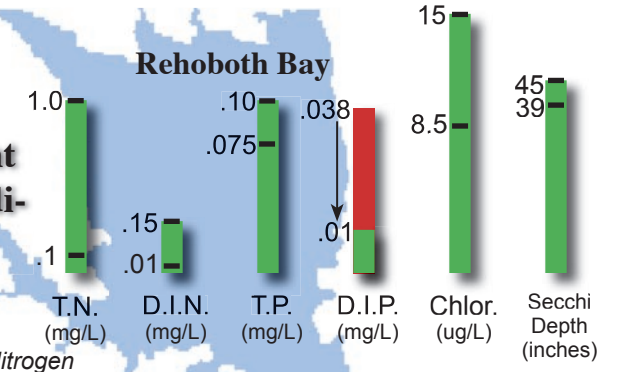
How do nutrients enter the bays?

Nutrients can enter the bays through runoff from land in the watershed during a storm. Some nutrients enter the bays through groundwater because nutrients can percolate through the soils and reach the groundwater. The groundwater will then reach the bays. The atmosphere also contains some nutrients that may be deposited in the bays. Nutrients from all of these sources can lead to eutrophication in the bays.

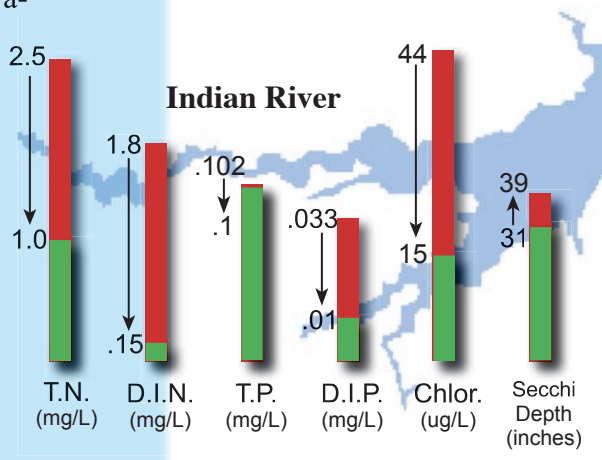
What can we do to help alleviate the problem?

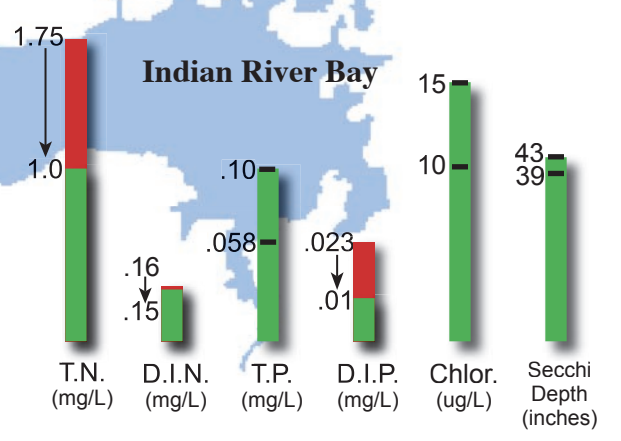
We can begin to reduce the amount of nutrients that we use in the watershed. Emission controls on vehicles and power plants can greatly reduce nitrogen emissions to the atmosphere. Advanced wastewater treatment technology (such as Biological Nutrient Removal) can remove most of the nutrients from wastewater and proper maintenance of septic systems reduces the amount of nutrients released into groundwater as well. Best management practices for farming can be applied to greatly reduce the amount of sediment and nutrient runoff from farms. Homeowners can reduce residential nutrient runoff by carefully following dosage and application recommendations when applying fertilizers to lawns and gardens. Sediment control techniques greatly reduce sediment runoff from construction sites. Natural, vegetated buffers (strips of land and marshes bordering waterways) can filter many nutrients and sediments from surface runoff and groundwater. Everyone has a role in nutrient reduction.

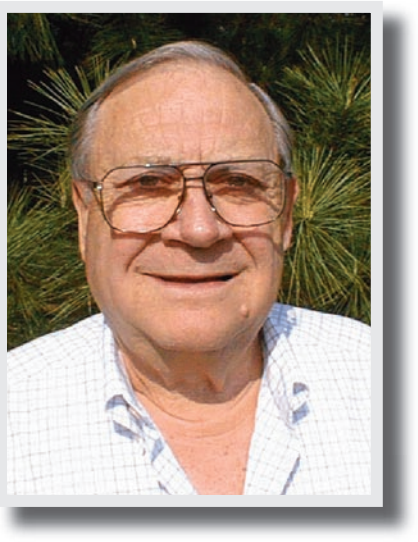
The two values in each vertical bar are the current level and the goal. Red indicates "goal not attained".

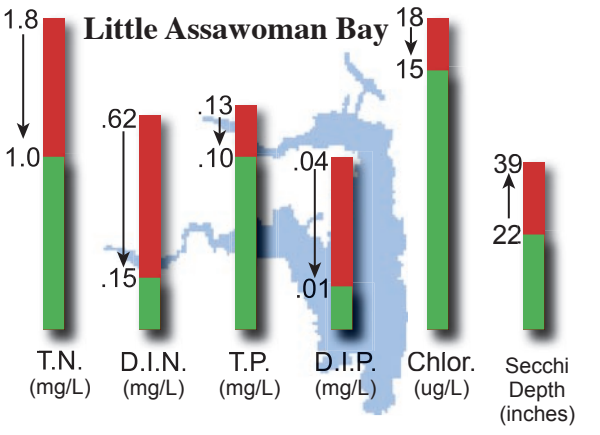


T.N.-*Total Nitrogen* D.I.N.-*Dissolved Inorganic Nitrogen*
T.P.- *Total Phosphorus* D.I.P-*Dissolved Inorganic Phosphorus*
Chlor.-*Chlorophyll a* Secchi Depth-*water visibility*





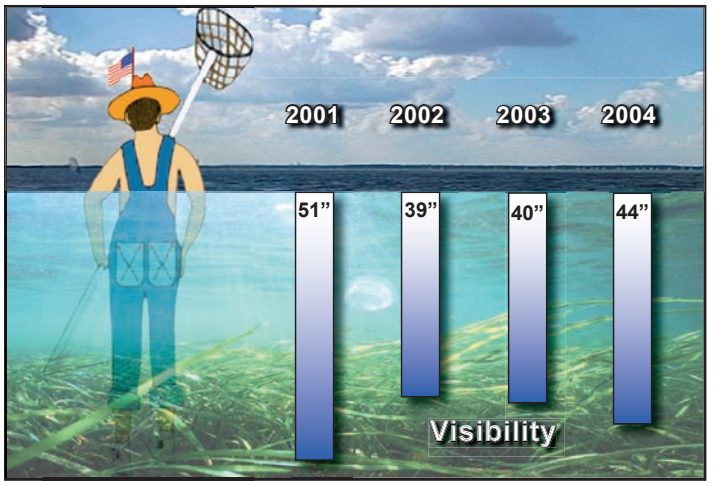




"I have experienced the effects of eutrophication first-hand. I live on a dead-end canal where algal blooms frequently occur during the summer."

Al Goldfarb, Sussex County resident

An Indication of Change in Water Clarity: The Sneaker Index



Water transparency is a quick and easy measurement that tells scientists a lot about water quality. First, it indicates the amount of light penetration into a body of water. Second, water transparency provides an indirect measure of the amount of suspended material in the water (turbidity), which in many cases is an indication of the amount of algae in the water. The Sneaker Index is a low-tech method for measuring water transparency or turbidity that also raises public awareness about water quality and the bays. The measurement is established each year during the annual Governor’s Wade-In Event.

Sergio Huerta

Sergio Huerta, M.D. is the Administrator of the Environmental Laboratory at DNREC and chairs the Inland Bays Environmental Indicators Subcommittee.

How did the concept of the sneaker index originate?

Maryland Sen. C. Bernard (Bernie) Fowler coined the name Sneaker Index. As a young man in the 1940s. Fowler would wade into Maryland’s Patuxent River to harvest crabs and shellfish and clearly see his sneakers while standing in chest deep water. In the mid 1980s, Sen. Fowler became deeply concerned about the future of the Patuxent. To evaluate the condition of the river water, he began to measure how deep be could wade into the water and still see his sneakers, thus came the Sneaker Index. People understood this form of assessment very easily. Consequently, the public accepted it and in 1987, the first annual event to measure water clarity took place in Maryland.

Does the sneaker index have any basis as a scientific measurement?

Fr. Pietro Angelo Secchi, scientific advisor to the Pope, first lowered a white disk from the papal yacht into the Mediterranean Sea on April 20, 1865 to assess water clarity. Secchi used the ambient light which reflected off the white disk to determine how far he could see into the waters of the Mediterranean. The “Secchi disk” now serves as the basis for water clarity measurements. The “Sneaker Index” is similar to a Secchi disk measurement and has been adopted by the CIB as an official environmental indicator.

What trends for water quality do you foresee for our Inland Bays?

The Sneaker Index depends on a number of variables including tides, wind-driven turbulence, suspended sediments and water temperature. For example, our 51” reading in 2001 may be attributed to a few days of onshore breezes which created an upwelling effect in the waters of eastern Rehoboth Bay. The turbid, “murky” waters were blown to the western side of the bay and replaced at the wade-in site by clearer ocean water. Although waters were more turbid in 2002 - 2004, water clarity should improve in the years ahead as we continue to reduce sediment and nutrient contributions to our Inland Bays.

“The annual Governor’s Wade-In Event is a great opportunity for our residents and visitors to learn more about water clarity and ongoing efforts to restore one of the Diamond States most precious gems - its Inland Bays.”

Governor Minner

Governor Ruth Ann Minner established the first “Sneaker Index” measurement at 51 inches in June, 2001.

Governor Minner is no stranger to the waters of our Inland Bays. As a child, she spent countless hours crabbing the still waters with her family or raking in the shallows for a bounty of delicious hard clams. Since becoming Governor four years ago, Minner has made the Inland Bays a critical component of her *Livable Delaware* initiative. She believes that improving the quality of water in the bays, including turbidity, will require assistance from many organizations and programs. Essential to this effort is balancing consideration for the environment with the need for local growth and development.

GOVERNOR’S WADE-IN
Second Saturday in June beginning at 11 a.m.
Towers Road Beach (bay side) Delaware Seashore State Park

An Indication of Risk To Public Health:

Shellfish Growing Area Closures

Jack Pingree

Jack Pingree is the program manager for the Shellfish and Recreational Water Branch of DNREC.

Why are coliforms measured in the water?

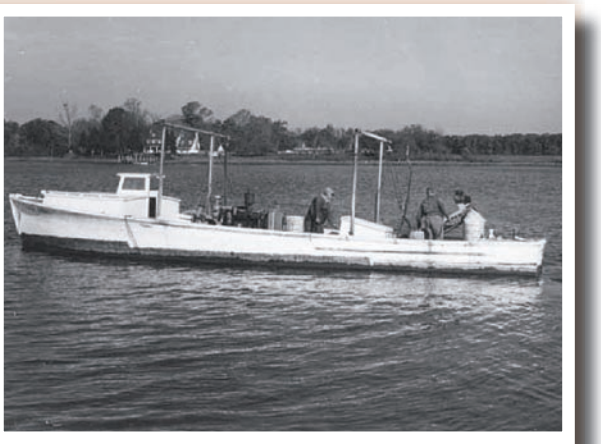
Bacteria are measured at 45 locations in our Inland Bays, and are an indicator of the potential for shellfish-borne human illness, which may include death or serious illnesses, such as hepatitis A; but more typically indicate Norwalk-like viruses, which are generally not life-threatening; but cause extreme gastrointestinal symptoms.

Why are coliforms used to determine shellfish closure areas?

Total coliform standards are time-tested indicators, going back to work conducted by the U.S. Public Health Service in 1925 - in the wake of a series of shellfish-borne disease outbreaks in the U.S. in the 1920s. Clams can filter up to 1 gallon of water per hour. This can also cause clams to concentrate bacteria, pollutants and toxins, so shellfish areas must be monitored to ensure human health.

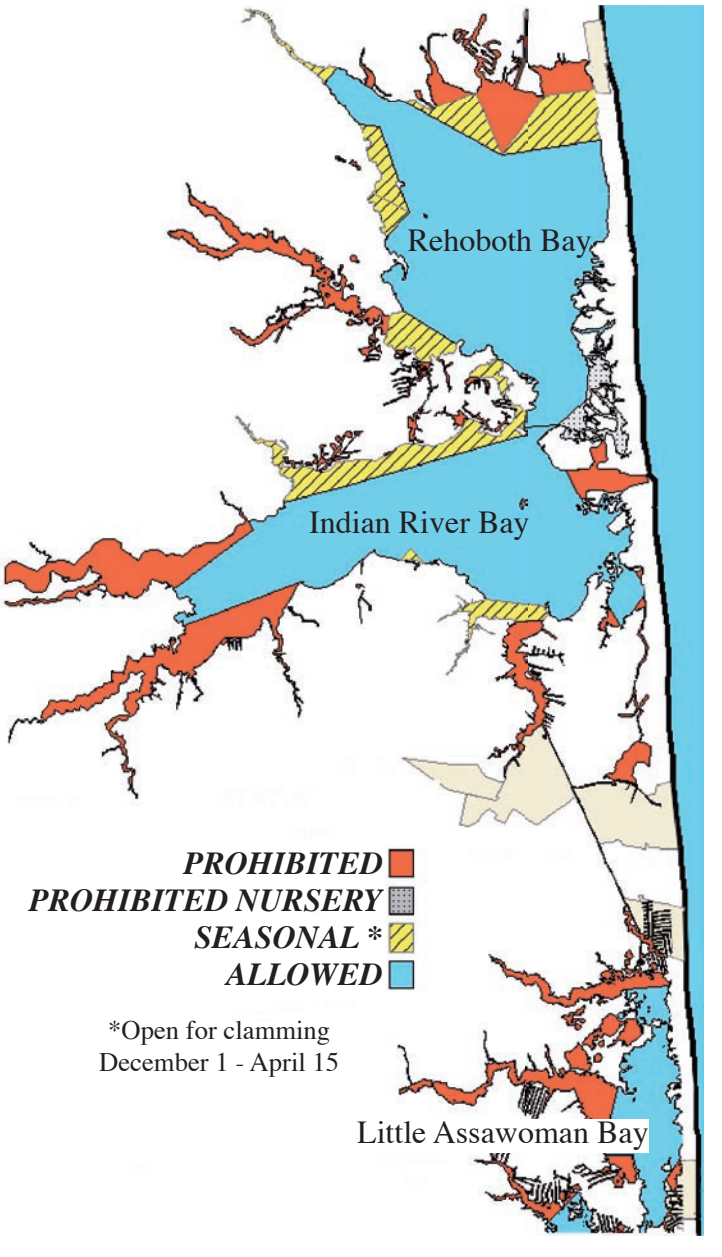
What level do the bacteria have to reach before areas are closed to shellfishing?

Harvest of shellfish is closed when the average number of bacteria exceeds 70 total counts in 100 milliliters of water. In addition, no more than 10% of the samples may exceed 330 total counts per 100 ml.

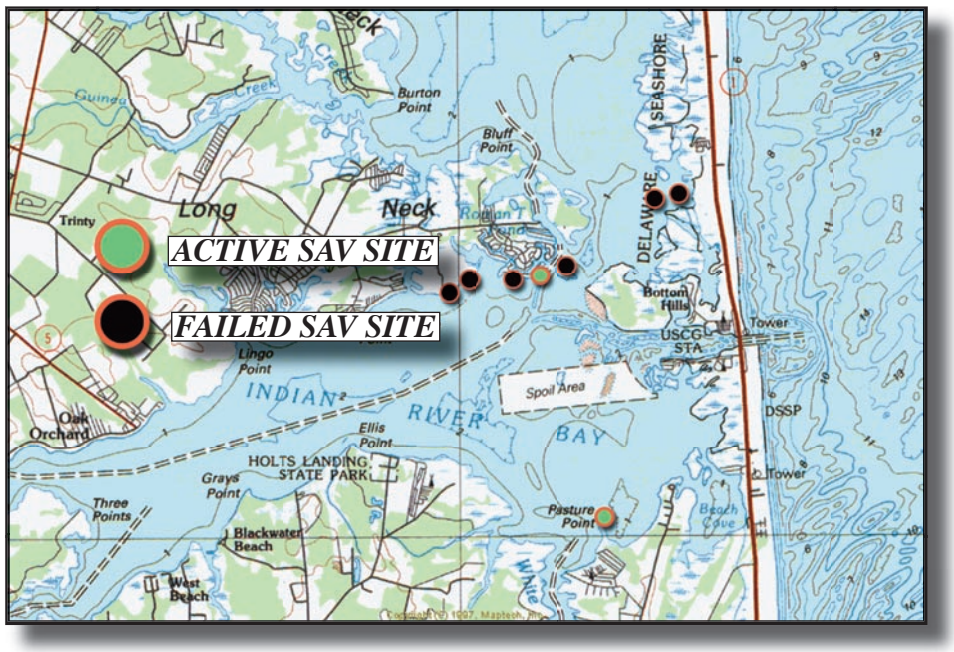


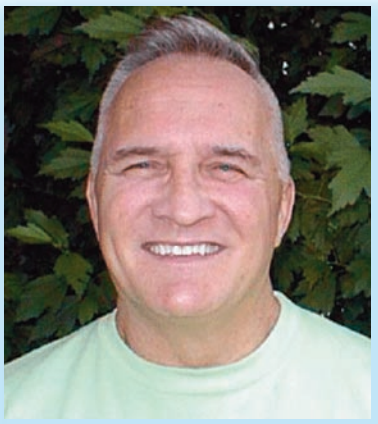
The Department of Natural Resources and Environmental Control conducts water sampling throughout Delaware, encompassing over 275,000 acres of State waters. Waters are classified on the basis of the suitability of the shellfish in those waters for human consumption. This is based on total coliform levels, but primarily on a qualitative assessment of actual and potential pollution sources. Both these protocols, and bacteriological monitoring, are specified and mandated by the National Shellfish Sanitation Program, as assessed under the auspices of the U.S. Food and Drug Administration. The Shellfish Program has collected bacteriological data since 1957. Today, samples are collected at 45 stations throughout Rehoboth Bay and Indian River Bay.

Disease causing bacteria and viruses can be introduced into the water from both point and non-point sources of pollution. Rain can cause run-off of the bacteria and viruses into the water. Septic systems and sewage can also introduce harmful organisms to the bays, although these sources are decreasing due to increases in central sewage treatment plants. It is therefore necessary to monitor shellfish areas to ensure that shellfish in those areas are safe to consume. The coliform tests indicate the likelihood for potentially harmful bacteria or viruses to be in the water. Similar coliform tests are used to monitor waters for recreational swimming and to determine the need for beach closures.



A Fundamental Indicator:
Submerged Aquatic Vegatation - SAV





Ben Anderson

Ben Anderson works for the Delaware Department of Natural Resources and Environmental Control (DNREC). He is part of the Watershed Assessment Branch of the Division of Water Resources.

Why is SAV so important to the Inland Bays?

SAV provides food and habitat for fish, shellfish and invertebrates. The grass beds serve as a nursery ground for juvenile fish, such as spot and striped bass, and provide a hiding place for crabs.

How much and where is SAV found in the Bays watershed?

DNREC has a restoration program which has produced over three acres of eelgrass growing and reproducing in the Inland Bays. All of it is centered in the eastern portion of Indian River Bay where water is of sufficient quality to support the low nutrient requirements of the plant. Unfortunately, the majority of the Bays' area will not support eelgrass due to excessive nutrient loading from agriculture and other man made sources. Hopefully, as the proposed nutrient pollution guidelines are put into effect, additional area will, over time, improve and again support eelgrass and other SAV as they did historically.

Widgeon grass, another SAV, is found in many of the small tidal wetland ponds that ring the bays. A variety of fresh water SAV, such as Wild Celery, are found in the tributaries and ponds that feed into the Inland Bays.

What is in the future for SAV in the Inland Bays watershed?

Restoration programs are a must to jump-start and continue the successful recovery of eelgrass and other selected SAVs in the watershed. Mapping current and future SAV locations within the Bays will give us a yardstick, a measurable quantifiable method, to gauge the success of our nutrient control strategy. Using SAV as a long-term indicator of nutrient levels is a strategy that has worked well and been proven in other estuaries, including the Chesapeake Bay. We also need to protect the existing SAV and reduce nutrients so more can become established. Signs are currently helping protect the beds by alerting boaters and clammers about their location. For those ignoring the signs, regulations with enforcement may be the next step to try to ensure SAV survival and its continued existence in the Bays.

widgeon grass

Bay grasses, or Submerged Aquatic Vegetation (SAV), are the best living natural indicator of the nutrient condition of the Inland Bays. There are many different species of SAV found in the Inland Bays, covering a range of salinity from freshwater to full strength marine saltwater. SAV species are the proverbial 'canary in the coal mine' when it comes to indicating aquatic health and fish habitat. All SAV that grow in the Mid-Atlantic region require relatively clear water with low nutrient levels so submerged vegetation act as an excellent indicator of water quality with respect to eutrophication (nutrient enrichment). If healthy and reproducing SAV are abundant then ambient nutrient water quality conditions are generally considered good. One of the most widely valued of the sea grasses in the North Atlantic is eelgrass (Zostera marina).

Decades ago, as nutrients increased in Delaware's Inland Bays, eelgrass started to decline in vitality and range. By the late 1960s to early 1970s, it was completely gone and much of the other SAV in the saline portions of the Bays had almost completely died out. Delaware currently has the unenviable distinction of being the only state within the home range (North Carolina to Nova Scotia) of eelgrass in which its complete state-wide population were presumed extinct. When water quality in the Indian River Bay in the late 1980s reached a level that could support sea grasses, restoration could begin; however, since no plant propagules or seeds existed in the Bays, a natural recovery was impossible. Therefore, it was necessary to move out of state to get propagules to start founder SAV colonies in the Inland Bays.

wild celery

eelgrass

Ecological Role of SAV

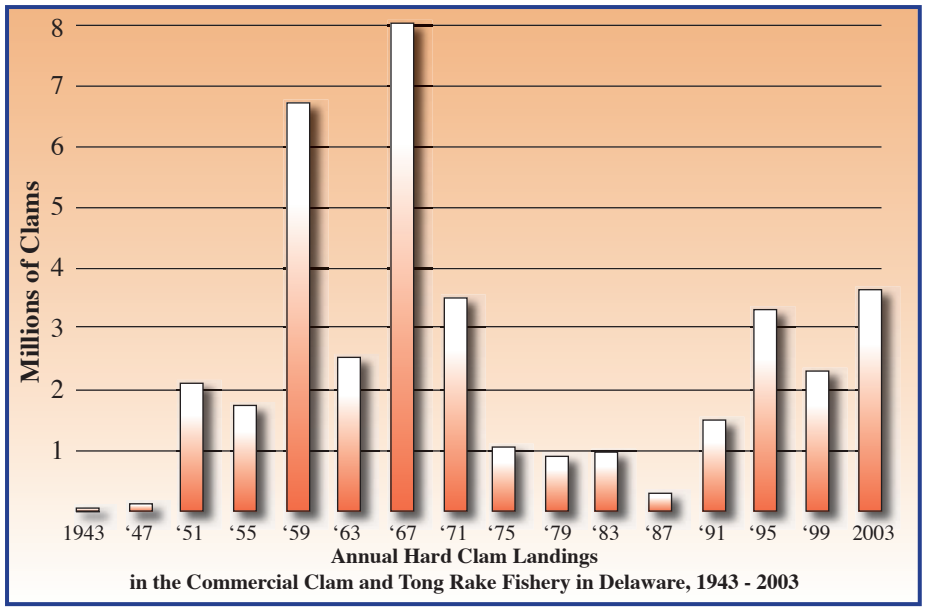
SAV plays an important ecological role to the Bays' aquatic environment by:

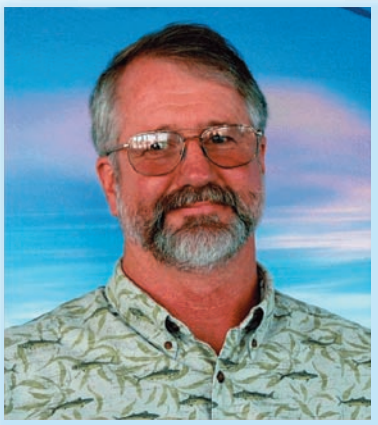
- Providing food and habitat for waterfowl, fish, shellfish and invertebrates; the grasses serve as nursery habitat for many species of fish, such as young spot and striped bass, which seek refuge from predators in the grass beds; additionally, blue crabs are known to hide in bay grasses after molting, while still soft.
- Producing oxygen in the water column as part of the photosynthetic process;
- Filtering and trapping sediment that can cloud the water and bury bottom-dwelling organisms, such as oysters;
- Protecting shorelines from erosion by slowing down wave action; and
- Removing excess nutrients, such as nitrogen and phosphorus that could fuel unwanted growth of algae in the surrounding waters. Bay grasses require such nutrients for growth and reproduction.

Habitat conditions that influence the Bays' grasses distribution

- Temperature, salinity and nutrient levels.
- Light penetration which is affected by suspended sediments and phytoplankton concentration.
- Water depth (range: below low tide line to about 1- 2 meters in depth).
- Water currents and wave action.
- Bottom sediment type.

An Indicator of Value:





Jeff Tinsman

Jeff Tinsman is a fisheries scientist with DNREC's Division of Fish and Wildlife. He has extensive experience with shellfish and Delaware's Artificial Reef Program.

Why were hard clam landings chosen as an indicator?

Clams are the most important commercial fishery in the Inland Bays and we have a record of the number of clam landings from 1943 to the present. Clams are also one of the most abundant benthic species found in the bays.

Why are clams so important in the Inland Bays?

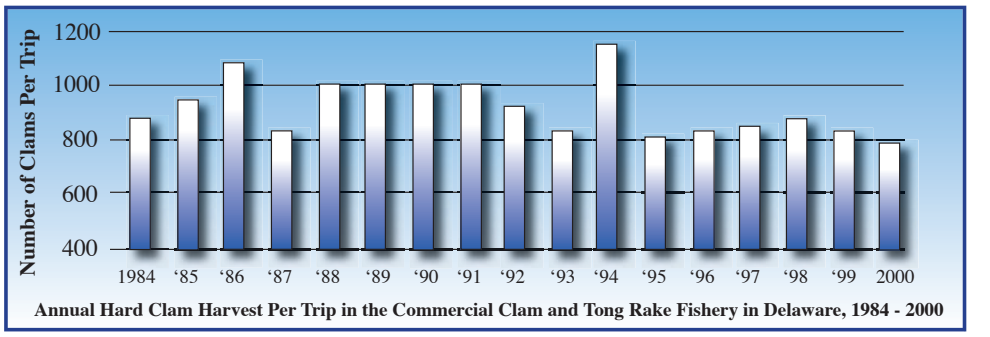
Clams are economically important because recreational harvest of clams stimulates tourism and clams provide a commercial industry. Clams can filter about one gallon of water per hour through two short siphons. Clams can therefore help improve water quality in the bays by catching and eating suspended particles in the water, making the water more clear.

Are hard clam landings increasing or decreasing in the Inland Bays?

In recent years, the number of landings and the effort expended to catch clams has been increasing. The substantial rise in the percentage of "necks", the smallest size class, indicates stronger and more regular recruitment. This may indicate improved water quality that benefits the fragile larval stages. The improved water quality is probably due to the continued scouring of the Indian River Inlet, which leads to increased flushing.

Hard Clam Landings

The hard clam (Mercenaria mercenaria) is the most important commercial and recreational shellfish species in the Inland Bays. Hard clams are the only shellfish species that have a higher value at younger life stages ("necks") and lose value as size and age increase. The clam population in Delaware's Inland Bays is primarily made up of many older and larger individuals numbering in the tens of millions. Because of this large standing stock of clams, a dramatic increase in landings is possible at any time with an increase in effort. Hard clams usually are found in sandy bottoms. They are approximately 1 to 4 inches in size.

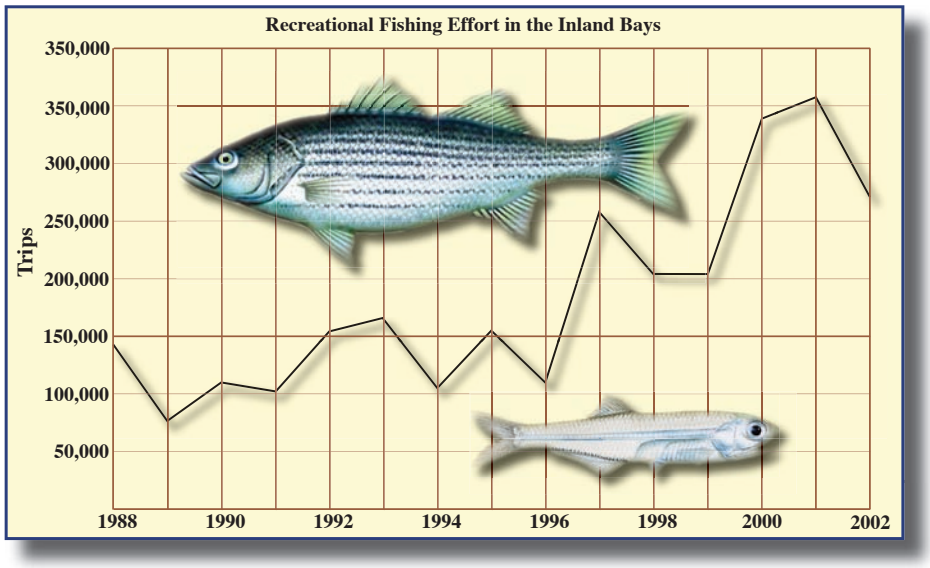


"We have been clamming in the Inland Bays for 36 years. Clamming is getting worse because of all of the buildings. There is more pollution because of the building and no area is left untouched. Now, there are more buffer zones where people cannot go clamming. There are still lots of clams out there but they aren't as thick as they were in the 1960s. They are down so deep that you can't reach them with the rake. The bays are also changing due to the increased boat traffic."

Mr. and Mrs. Copp, Copp's Seafood

An Indicator with Broad Public Appeal:

Recreational Fishing



Fishing in the Inland Bays is a major recreational activity for thousands of Delawareans and visitors. It's a good indicator of the condition of the Bays because the success of the recreational fisherman is directly linked to the ability of the Inland Bays to support a large number of fish. Recreational fishing in the Inland Bays is pursued from shore, private boats and head boats. The bays have many access points for recreational anglers, including numerous public and private boat ramps, and several fishing piers.

John Clark

John Clark works for Delaware Division of Fish and Wildlife at DNREC.

What are the current trends in recreational fishing in the Inland Bays?

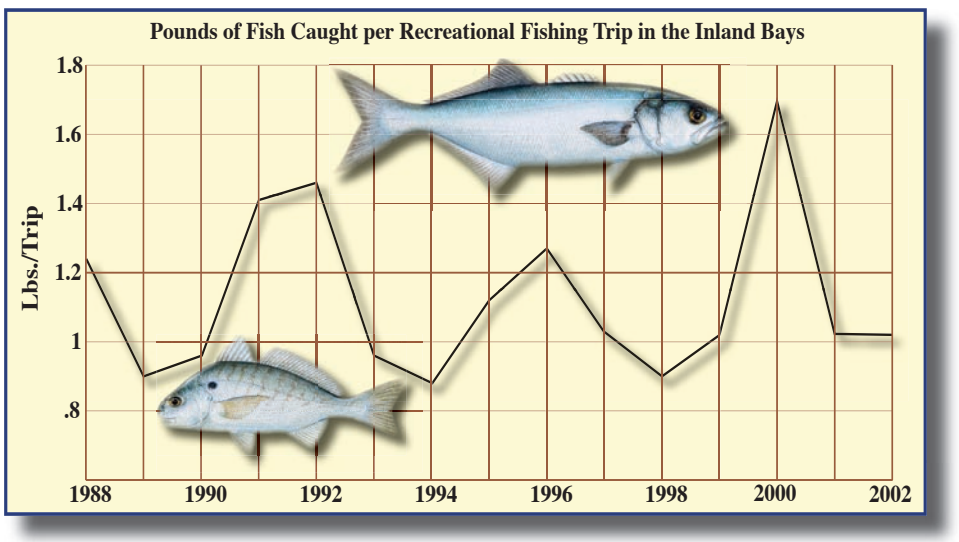
The number of fishing trips per year increased during most of the years between 1988 and 2002 and number of trips per year now is much higher than it was in 1988.

Are recreational fishermen still catching the same amount of fish?

The pounds of fish caught per recreational fishing trip have stayed fairly steady from 1988 till now, despite increasing effort and changing regulations. This suggests that the Inland Bays are capable of supporting the current level of fishing pressure. It is important to monitor this indicator because a drop in either pounds caught per trip or in number of trips could indicate deteriorating conditions for fish in the Inland Bays.

What are the common sport fish caught in the Inland Bays?

Sea trout, summer flounder, striped bass and bluefish are all common in the Inland Bays.



"Recreational fishing is very strong. It's stronger now than it's ever been. The awareness of the recreational fisherman towards conservation and protection of the bays has also increased. Fishermen have an interest in keeping the bays clean and they are looking at what resources will be available for their grandchildren."

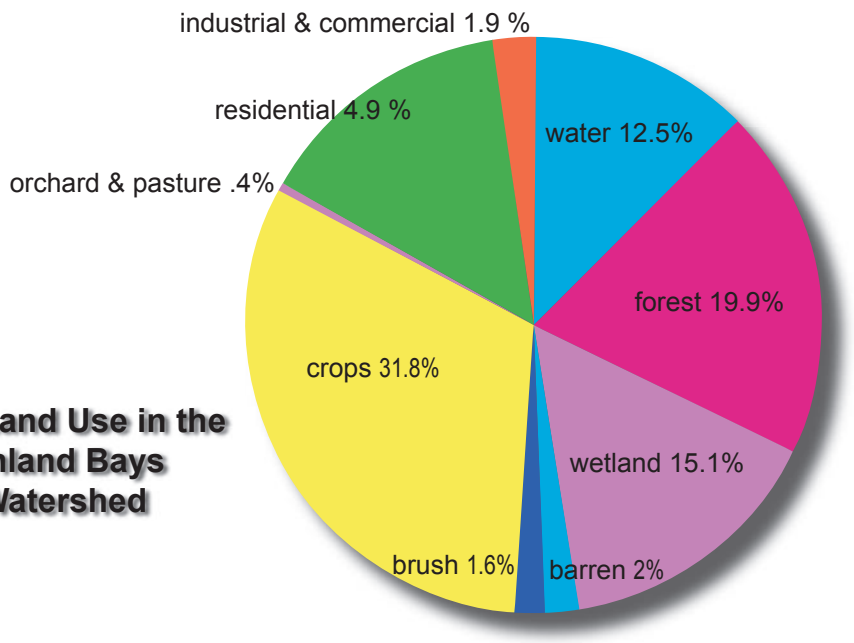
Captain Bill Baker

Species Found in the Rehoboth and Indian River Bays During Delaware Division of Fish & Wildlife 16-foot Bottom Trawl Survey (1986-98)

Bay anchovy	Smoth dogfish	Green goby	Spotfin butterflyfish
Spot	Spotted hake	Etropus spp.	Cownose ray
Weakfish	American eel	Harvestfish	Spiny butterfly ray
Atlantic croaker	Windowpane	Clearnose skate	Yellow Stingray
Silver perch	Striped cusk-eel	Threespine stickleback	Cunner
Atlantic herring	Fourspine stickleback	Bluegill	Atlantic spadefish
Atlantic silverside	Tautog	Rainwater killifish	Banded rudderfish
Atlantic menhaden	Striped bass	Planehead filefish	Red hake
Striped anchovy	Crevalle jack	Pollock	Striped killifish
Hog choker	Blueback herring	Rough silverside	Sandbar shark
Summer flounder	Blackcheek tonguefish	American shad	Smooth puffer
Northern pipefish	White mullet	Feather blenny	King mackerel
Winter flounder	Pinfish	Striped blenny	Grey snapper
Butterfish	Lined seahorse	Orange filefish	Cobia
Mummichog	Spanish mackerel	Smallmouth flounder	Striped-bass hybrid
Northern kingfish	Striped searobin	White perch	Bluntnose stingray
Bluefish	Pigfish	Conger eel	Brown bullhead
Black seabass	Atlantic moonfish	Northern stargazer	White catfish
Naked goby	Gizzard shad	Alewife	Striped burrfish
Scup	Northern searobin	Fringed flounder	Striped mullet
Oyster toadfish	Yellow perch	Little skate	Grubby
Northern puffer	Black drum	Silver hake	
Inshore lizardfish	Lookdown	American sand lance	

An Indication of Increased Stress:

Population Growth



Land Use in the Inland Bays Watershed

The consequences of population growth for the Inland Bays watershed span three areas: changes in land use, increases in pollutants released to the environment and depletion of natural resources. As population increases, this expanded growth begins to distort our environment, leaving what scientists call an ecological footprint. This concept draws upon the idea that each person has certain basic needs such as land, water and energy use. As these resources are used, wastes are generated and disposed. Thus, the extent of resource exploitation, waste generation and environmental damage in the Inland Bays watershed is dependent upon how we plan for growth and its impact on our resources.

Ed Lewandowski

Ed Lewandowski is the Education and Outreach Coordinator with the Center for the Inland Bays.

What is the current population of the Inland Bays watershed?

The exact number of people who live year-round in the watershed isn't really known because census data isn't obtained by watershed area. However, a 1999 study by Cassell and Meals demonstrated that the year-round population in the Inland Bays watershed was about 36,000 residents. Year 2000 census data shows that Sussex County grew by about 38% during the 1990's, with a current population estimated to be approximately 171,000 individuals. The bulk of that growth occurred along the coast, where the population grew by 59 percent and density now averages 257 people per square mile, according to an analysis by the University of Delaware's Sea Grant College Program. That compares with a population density of 132 people per square mile in central Sussex.

How does population growth affect land use?

As an example, between 1974 and 1984, permanent population in Sussex County's unincorporated areas grew by 16,400 individuals from 87,400 to 103,800, or about 18.8 percent. It is estimated that approximately 6,614 acres of land was converted during this period to accommodate the increase in population.A closer look at the data from this period reveals that for every net one acre gain in residential land, 6.43 acres of land underwent a change in use. This clearly demonstrates that developing residential land required the additional development of commercial, industrial, transportation, and utilities, which accounts for this conversion.

What trends in population growth do you forsee for our area?

Sussex County's population is projected to reach more than 180,000 people by the year 2020. If this projection is indicative of the future, we can expect stresses on our Inland Bays and natural resources to increase as well which may result in greater non-point source pollution impacts.

Sussex County Population

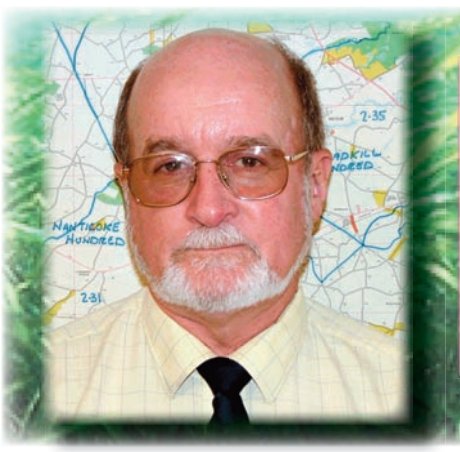
2004 = 171,835 (est.)

2000 = 157,430

1990 = 113,230

1984 = 103,800

1974 = 87,400



"Our coastal resort area has always been considered a great place to vacation. People have now discovered it is also an ideal place to live."

Lawrence Lank,
County Planning Director

Lawrence Lank has witnessed firsthand the population explosion in the Inland Bays watershed. As the Planning Director for Sussex County, Lank is responsible for local oversight of the development process. He believes the Inland Bays area is at a crossroads. As the area's population continues to expand, traditional land uses such as agriculture are threatened by development pressures, such as the establishment of infrastructure to service new residents. Sussex County's Comprehensive Land Use Plan, which is updated every five years, does consider projected population growth and hopes to manage growth issues to protect and conserve the environment.

An Indication of a Changing Landscape:

Land Use

Bob Scarborough

Bob Scarborough is the Research Coordinator for the Delaware National Estuarine Research Reserve

How are the land use percentages determined for the watershed?

Approximately every five years, the entire state of Delaware is overflown and photographed. These photos are then digitized and entered into a Geographic Information System (GIS) database. One of the items derived from these photos is the breakdown of land use in the state. Land use is categorized into over fifty classifications; however; for ease of interpretation, the classifications have been combined into six categories. Prior to 1992, a 10-acre resolution was used for interpretation. Currently, the land use is based on four-acre resolution increments which provides much higher definition; however, that invalidates any comparisons with data obtained before 1992. The data used for this indicator is from 1992, 1997 and 2002.

Besides the Sussex Land Trust, is the state or others doing anything to protect Inland Bays' resources?

The land that is protected by either government agencies or non-profit conservancy groups can also indicate land use practices. As more land is protected, the better the long-term chances for preservation of quality habitat in the area along with preventing increased nutrient and pollutant loads to the waterways. As of July 2000, either state/local governments or conservancy groups owned over 20% of the total land area in the Inland Bays watershed. Combined with agricultural preservation districts and recent land purchases by the Sussex Land Trust, more than one fourth of the watershed area is now protected from development.

Changes in land use can show potential trends of the environmental quality of the region. Increases in urban acreage, for example, indicate increased human impacts to the area, which can cause reduced ground water recharge from increased impervious areas, along with higher storm water runoff due to channeling and collection from paved areas and roofs. There can also be elevated pollutant loading from homeowner practices and street runoff. As forested land is destroyed, the nutrient uptake and natural purifying of the surface and ground water is decreased along with the shading of streams and ditches that keeps the water cool. Decreases in open areas also mean less habitat for native wildlife in the Inland Bays watershed.

Dennis Forney is the publisher of the Cape Gazette, a weekly newspaper based in Lewes, Delaware. Over the years, Forney has reported extensively on land use and environmental changes that have been occurring in coastal Sussex County. He has been active in efforts to educate the citizenry on land use issues and more recently Forney has been influential in the creation and development of the Sussex Land Trust. The Land Trust was organized to protect and preserve open space in the fragile coastal area through land acquisition. Since its inception in 2003, the Sussex Land Trust has invested more than $2 million towards the purchase and preservation of natural lands in the county.

Inland Bays Watershed Land Use Trends

	1992 (acres)	*1997*	*2002*	*acres ± in 10 yrs*	*% change in 10 yrs*
agriculture	74,572	72,245	70,312	**- 4,260**	**-6 %**
barren	5,033	4,042	3,068	**- 1,965**	**-39 %**
forest	43,535	40,312	37,714	**- 5,821**	**-13 %**
range	1,559	3,323	4,120	**+ 2,561**	**+264 %**
urban	26,158	30,899	35,098	**+ 8,940**	**+34 %**
water	24,270	24,349	24,427	**+ 157**	**+1 %**
wetlands	34,026	33,915	34,417	**+ 391**	**+1 %**

"The long-term economic health of Sussex County, and the quality of life enjoyed by current and future generations of residents and visitors, depends on wise land use decisions. Sussex County Land Trust believes that protection and preservation of open spaces represents a vital land use component. Such preservation provides direct quality of life benefits for humans and wild flora and fauna, helps mitigate expensive infrastructure needs in the short term, and ensures and enhances healthy property values and economic strength in the short and long term. Sussex County Land Trust is working to harness the economic strength of rapid growth to leverage the purchase of carefully identified open space parcels."

Dennis Forney - Cape Gazette Publisher

Up until the 1960s, the Inland Bays watershed was typified by a development pattern that resembled a series of villages of concentrated settlements (e.g. Rehoboth) with proportionately larger areas of farmland and open space. The concentration of development and relatively large household size resulted in smaller per capita environmental costs.

As interest in the coastal resort area increased during the seventies and eighties, so did the expansion of development throughout the watershed. If new development had proceeded in the unincorporated areas as it had in Rehoboth, using the resort village model, the impact would have been less. Instead, the addition of subdivisions, mobile home parks, and resort communities became more typical. Unfortunately these kinds of communities occupy more land, require more infrastructure and therefore have greater impact on the Bays than higher density development.

For every acre in new residential land, over six acres of land underwent a change in use. This demonstrates that the sort of residential development that took place required additional development for commercial and industrial property as well as land for transportation and utilities. It's exactly the kind of development that has come to be known as "sprawl".

Glossary

Best Management Practices (BMPs) – procedures, methods and management practices that are determined to be most effective at reducing pollution from non-point sources; examples farmers can employ include countour and no-till plowing, composting, water control structures, proper timing of manure applications and vegetative buffers; Delaware's Department of Agriculture lists fifty-three such practices at http://www.state.de.us/deptagri/nutrients/bmp.htm

Coliform – rod shaped bacteria that are relatively harmless in their natural habitat, the intestines of humans and other warm-blooded animals, but harmful to water quality; the presence of coliform bacteria in water bodies makes them unfit for human contact and shellfish that live in those water bodies are usafe for consumption

Chlorophyll a – green pigment that plants use for photosynthesis

Ecological footprint – the land needed to support the resource demands and absorb the wastes of a given population

Eutrophication – a condition in an aquatic ecosystem where high nutrient concentrations produce excess plant growth commonly manifested by blooms of algae

Geographic Information System (GIS) – an organized computer system for displaying and analyzing geographic information using a series of maps and data layers

Harmful algal bloom (HAB) – a HAB is an unusually large algal population, a bloom, that has deleterious effects on plants, animals or humans, often due to the production of natural toxins

Hypoxia – conditions of low oxygen in the water that can kill fish and other animals

Land use – a classification of the way that land is used for things such as agriculture, residential areas, industrial areas and forests; this information can be entered as a layer in a GIS to display uses of land on a map

Non-point source pollution – pollution that enters a water body through runoff or groundwater seepage from diffuse land sources such as parking lots or fields

Nutrient – a substance taken in by living things for growth and development; nitrogen and phosphorus are the major nutrients needed for plant growth

Nutrient management planning – the practice of managing the amount, source, placement, form and timing of the application of nutrients and soil amendments; such planning is an attempt to reduce nutrient pollution and improve water quality [defined by the USDA Natural Resources Conservation Service (NRCS) Standard (590)]

Photosynthesis – the process whereby plants use sunlight, carbon dioxide and water to generate energy

Point Source Discharges – specific locations where nutrients are released directly into a water body, such as through a discharge pipe

Pollution trading – a pollution reduction practice in which one polluter receives credit for reducing the pollution of another

Restoration – man's efforts to return a degraded system back to a more natural state

Secchi disk – solid white or white and black disk that is lowered into the water to measure turbidity; the depth at which the disk is no longer visible is recorded and it indicates the clarity of the water

Sprawl – low density development originating from the edge of cities or towns, the result of poor planning of development and less efficient use of land

Submerged Aquatic Vegetation (SAV) – sea grasses that live on the sea floor and grow entirely underwater; SAV provides a good habitat for fish and crabs

Total maximum daily load (TMDL) – a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources; it is the sum of the allowable loads of a single pollutant from all contributing point and non-point sources [defined by the US Environmental Protection Agency]

Turbidity – the cloudiness of the water as affected by things such as suspended sediments, phytoplankton in the water; measured by determining how far light can penetrate in the water

Vegetative Buffers – zones where trees and other plants are along the bank of a stream to reduce the amount of nutrients entering the stream from runoff; ideally, buffer zones of at least 50 feet should exist along streams

Watershed – the land that drains into a body of water

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Your membership will strengthen the Center for the Inland Bays and help us to protect and preserve this magnificent natural resource. As the smallest of the 28 National Estuary Programs, we need your support and assistance to accomplish the many tasks necessary to improve the Inland Bays' condition.

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