# THE STATE OF THE BAY

THE CONDITION

OF THE BAY

OF GREEN BAY

LAKE MICHIGAN

1990

## A CAPSULE VIEW


**PRODUCED BY**

- University of Wisconsin-Green Bay
  Institute for Land and Water Studies
  2420 Nicolet Drive
  Green Bay, Wisconsin 54311-7001

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- Wisconsin Coastal Management Program
  Department of Administration
  P.O. Box 7868
  Madison, Wisconsin 53707

- Wisconsin Department of Natural Resources
  Lake Michigan District
  1125 North Military Avenue
  Green Bay, Wisconsin 54307-0448

- University of Wisconsin-Green Bay

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- Green Bay Remedial Action Plan
  Implementation Committee

- Herbert Fisk Johnson Professorship (H.J. Harris)

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**PROJECT DIRECTOR**

- H.J. (Bud) Harris

**RESEARCH ANALYST**

- Carol Holden

**GRAPHIC DESIGN**

- Steve Martinson
- Tricia Bosse

**TYPOGRAPHY**

- Elizabeth Bassett-Piehl

**ILLUSTRATIONS**

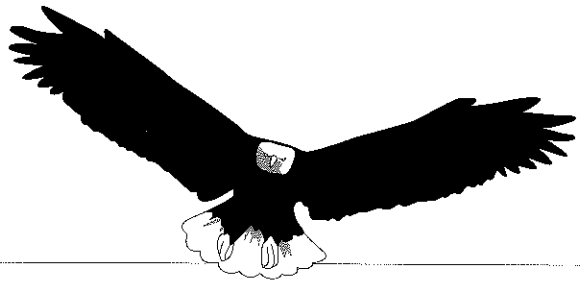
- Steve Martinson
- Monica Von Hoff

**BACK COVER**

- Nicola Yarbrough

**DEDICATED TO**

- This first State of the Bay is dedicated to Dr. Robert Ragotzkie, who, as Director of the Wisconsin Sea Grant Program, first suggested the idea of a State of the Bay report in 1986, and whose support for long term research on Green Bay has been unflagging.



STATE OF THE BAY

# Capsule View

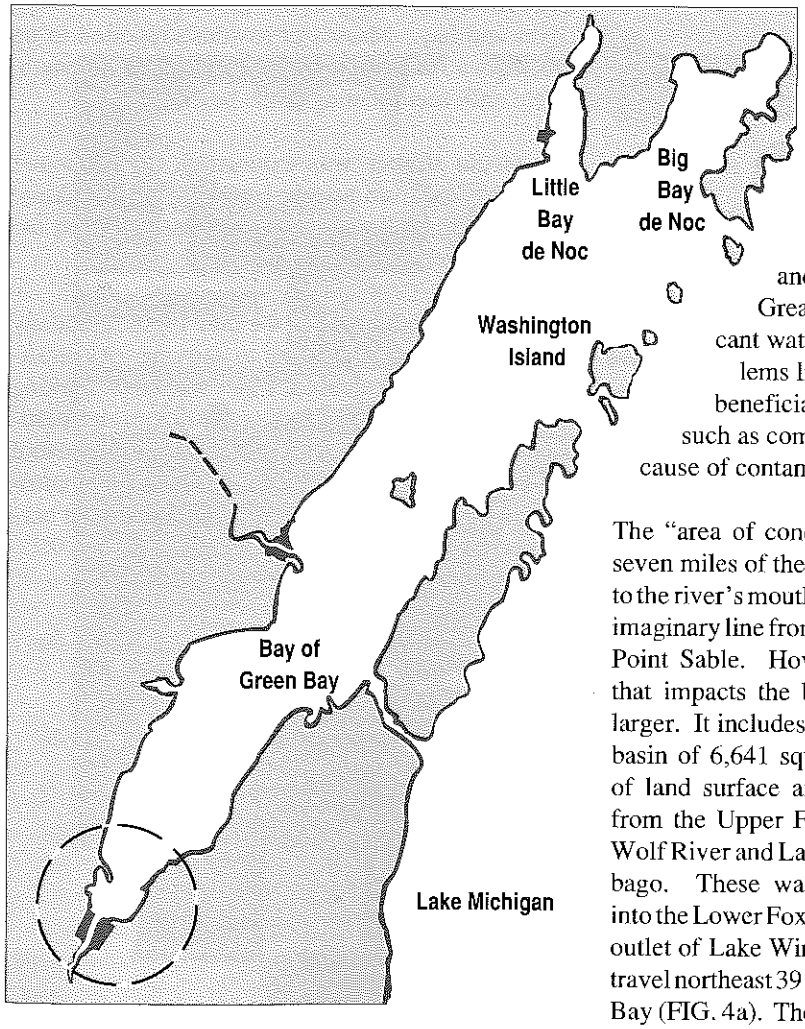
■ The State of the Bay is a capsule of the water quality and condition of water-related resources and uses of Lake Michigan's Green Bay. It is intended to be an easily understandable summary of the overall health of the bay's ecosystem.

A capsule of this kind can not possibly include all the monitoring, research and remedial work that takes place on the bay and Fox River. What appears here are some of the key indicators that tell us something about the ecosystem. This first edition of State of the Bay will provide a "benchmark" upon which future updates can be made.

## WHAT IS THE STATE OF THE BAY?

The objective of the State of the Bay is to measure whether things are getting better, worse or staying the same. It is important to note that conditions of the bay system are naturally fluctuating. This means that from year to year measurements can vary greatly. A subtle effect may go undetected in a given year, but emerge as significant over a longer expanse of time. For this reason limited confidence about measurements and change in any year is something with which we will have to live. Decades may be required before we have dramatic evidence of change.

FIG. 1a




***Bay of Green Bay, Lake Michigan*** *showing area most severely impacted by the Fox River. Insert shows Long Term Monitoring Stations.*

## DESCRIPTION

■ The lower bay ecosystem is a complex, interacting community of people, fish, birds, mammals, and plants and the physical forces acting on it. It includes the lower bay and the Lower Fox River, and is one of 42 areas that Canada and the United States identify in the Great Lakes region as having significant water quality problems. These problems limit fishing, swimming and other beneficial uses. Even less sensitive uses, such as commercial shipping, are limited because of contaminated sediments.

## AREA OF CONCERN

The "area of concern" (AOC) includes the lower seven miles of the Fox River from the De Pere dam to the river's mouth and the lower bay to an imaginary line from Long Tail Point to Point Sable. However, the area that impacts the bay is much larger. It includes a drainage basin of 6,641 square miles of land surface and waters from the Upper Fox River, Wolf River and Lake Winnebago. These waters empty into the Lower Fox River at the outlet of Lake Winnebago and travel northeast 39 miles to Green Bay (FIG. 4a). The Lower Fox basin contains rich farmlands as well as the greatest concentration of pulp and paper mills in the world.

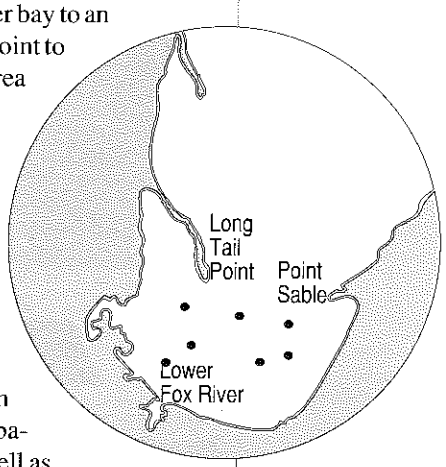


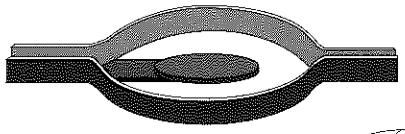

FIG. 1b

# 2

## LOOKING BACKWARDS

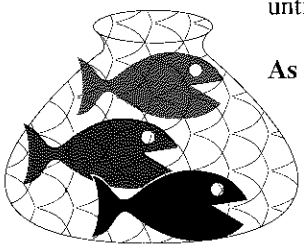
■ To understand the current status of the bay and what its future may be, it is helpful to look to its past. These waters have experienced centuries of exploitation and degradation.

## TRAPPING



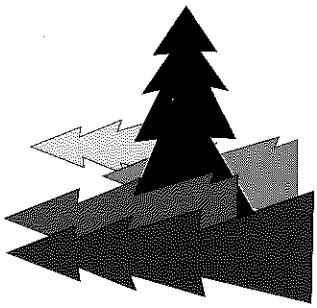
**The fur trade,** the principal industry from the 1600s until the 1830s, set the stage for future exploitation.

## FISHING



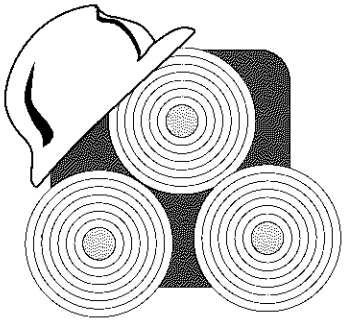
**As early as 1850 the bay's commercial fisheries** were feeling the effects of overharvesting. The loss of wetlands and the introduction of exotic species, such as the German carp planted in the bay in the late 1800s, contributed to the decline and imbalance of the native fishery.

## LOGGING



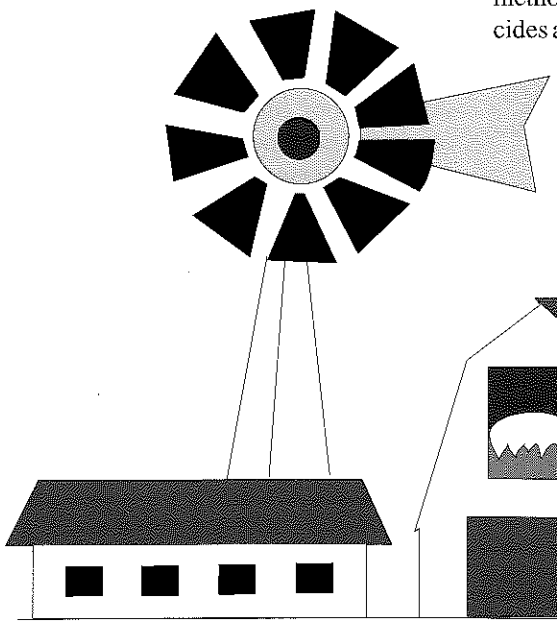
**The timber industry added gross pollution** to the river and bay. Masses of sawdust, reported to be about two miles wide and several miles in length, were once seen floating in the bay.

## PAPER MAKING



**As virgin timber was exhausted**, the economic focus shifted from lumber cutting to papermaking. Fish die-offs followed as pulp wastes reduced the oxygen levels in the waterways.

## AGRICULTURE



**Farming,** which began in the mid-1800s, gradually shifted from wheat growing to dairying. As available farmland decreased, more intensive farming methods were used including fertilizers and pesticides and more livestock per acre. Crop and barnyard runoff sent, and continues to send, nutrients, other chemicals, sediments and bacteria to the waters.

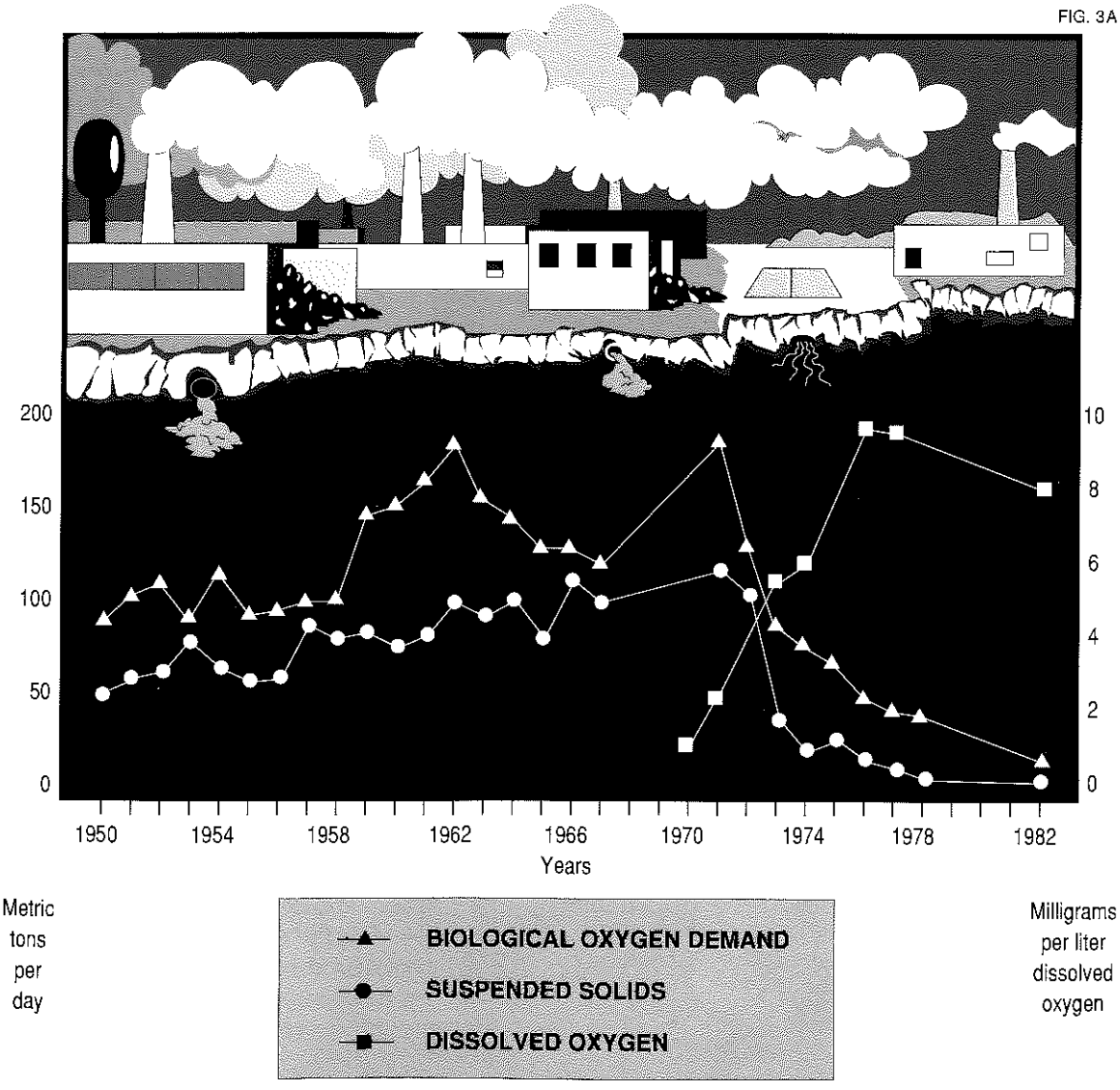
# 3

■ Water quality first became a public issue in the 1920s when people complained of fish kills, gross pollution and obnoxious odors associated with the Fox and East Rivers. Complaints from commercial fishermen of dead fish in their nets led to the bay's first comprehensive study of water quality. That 1938 study showed oxygen depletion to be related to paper mill wastes discharged to the Fox. It also noted "very large quantities" of blue-green algae and only small numbers of immature burrowing mayflys, a pollution-sensitive insect. Bay Beach was closed in 1943 due to high levels of bacteria.

■ The 1972 Clean Water Act enabled the State to respond to water quality problems. During the early 1970s, most of the attention focused on point sources or end-of-pipe discharges. At that time approximately 90 percent of the oxygen-demanding waste was being discharged by the pulp and paper industry with the remainder from municipal sewage plants.

Since 1970, over $300 million has been spent on wastewater treatment facilities by municipalities and industries along the Lower Fox River. Data collected in the bay from 1970 to 1982 revealed a marked increase in dissolved oxygen concentrations and a reduction in oxygen-demanding waste(BOD) dumped into the river. During that same time, some improvement in the abundance and composition of benthic organisms, such as bottom-dwelling worms and immature insects, was observed. Efforts to re-establish the sport fishery were also made during this time.

FIG. 3A




## RESULTS OF PAST POLLUTION CLEANUP ACTIVITIES

# 4

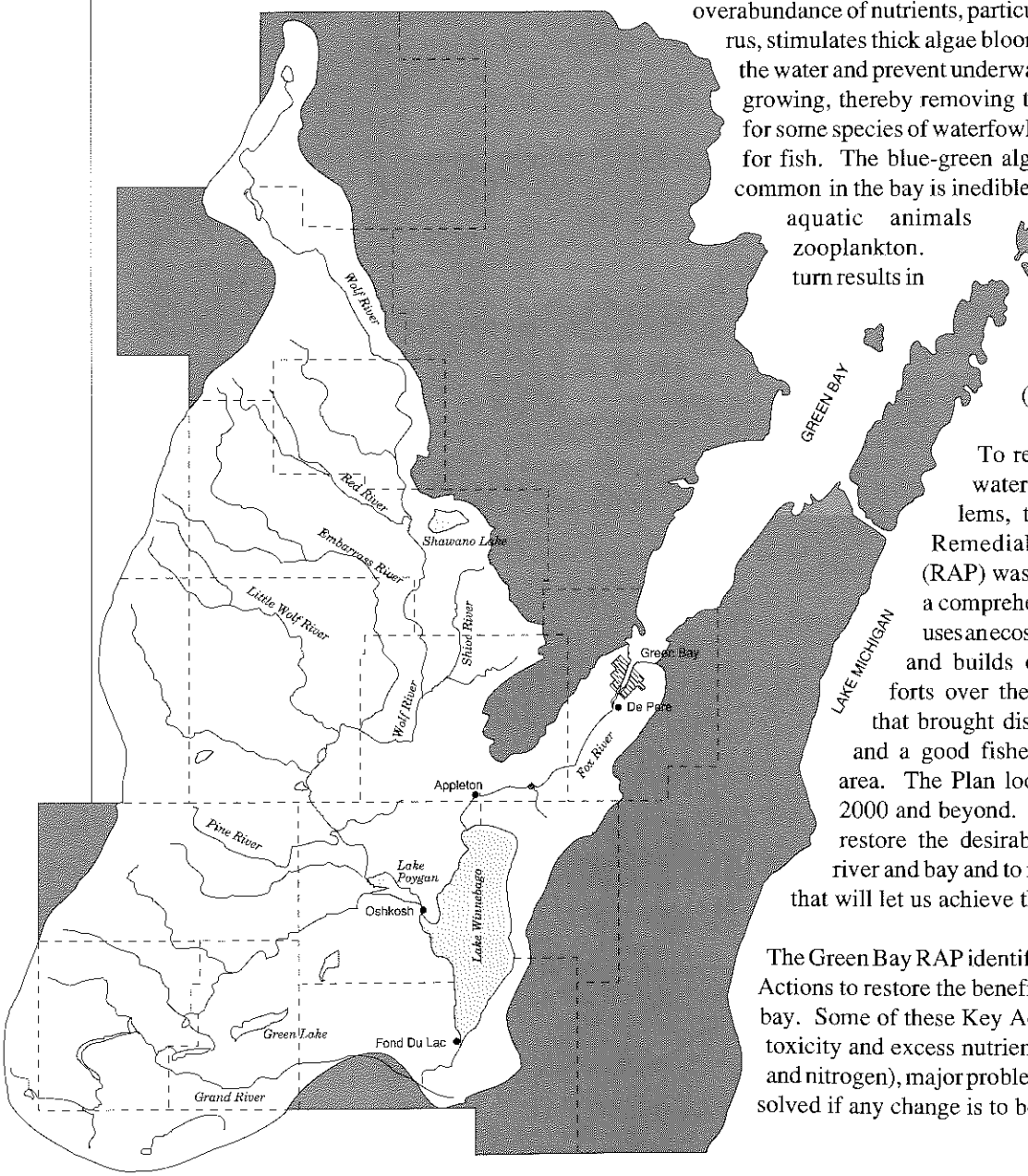
## WHAT ARE THE CURRENT PROBLEMS?

■ Despite past efforts, however, these key problems remain:
- Toxic contaminants are found in fish and in fish-eating birds.
- Excess nutrients continue to cause algae blooms.
- Fish and wildlife habitats have been destroyed.
- Swimming and public access to the water are limited.

Ironically, control of oxygen-demanding waste may have contributed to the problem of toxic pollution from wastewater discharges, air emissions and contaminated bottom sludge. Increased dissolved oxygen in the water means that fish can not only live in the water but can live for longer periods. They are, therefore, exposed to toxics that may increase in concentration in the fish or humans who eat them. More than 100 toxic substances have been detected in the Fox River water and sediments. These include PCBs, dioxins, ammonia and heavy metals.

Another major problem is excess nutrients washing into the bay from urban and agricultural runoff. An overabundance of nutrients, particularly phosphorus, stimulates thick algae blooms which cloud the water and prevent underwater plants from growing, thereby removing the food source for some species of waterfowl and the habitat for fish. The blue-green algae which is so common in the bay is inedible to most small aquatic animals known as zooplankton. This in turn results in a substantially changed ecosystem (FIG. 5b).

FIG. 4a




## GREEN BAY RAP

## FOX–WOLF RIVER BASIN

To respond to these water quality problems, the Green Bay Remedial Action Plan (RAP) was prepared. It is a comprehensive plan that uses an ecosystem approach and builds on cleanup efforts over the past 15 years that brought dissolved oxygen and a good fishery back to the area. The Plan looks to the year 2000 and beyond. Its goals are to restore the desirable uses of the river and bay and to identify actions that will let us achieve these uses.

The Green Bay RAP identifies sixteen Key Actions to restore the beneficial uses of the bay. Some of these Key Actions focus on toxicity and excess nutrients (phosphorus and nitrogen), major problems that must be solved if any change is to be expected.

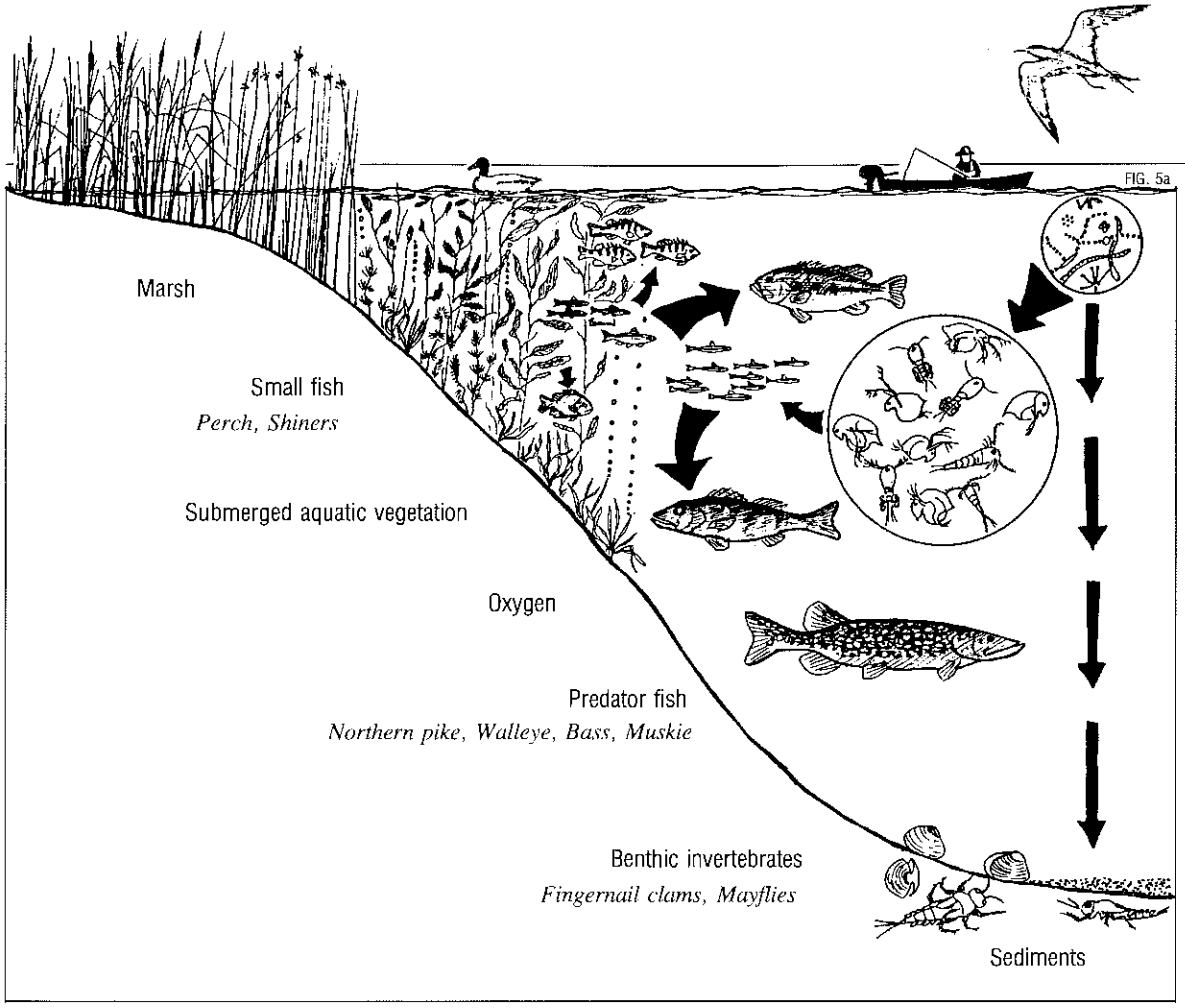



FIG. 5a

**LOWER GREEN BAY: DESIRED FUTURE STATE**

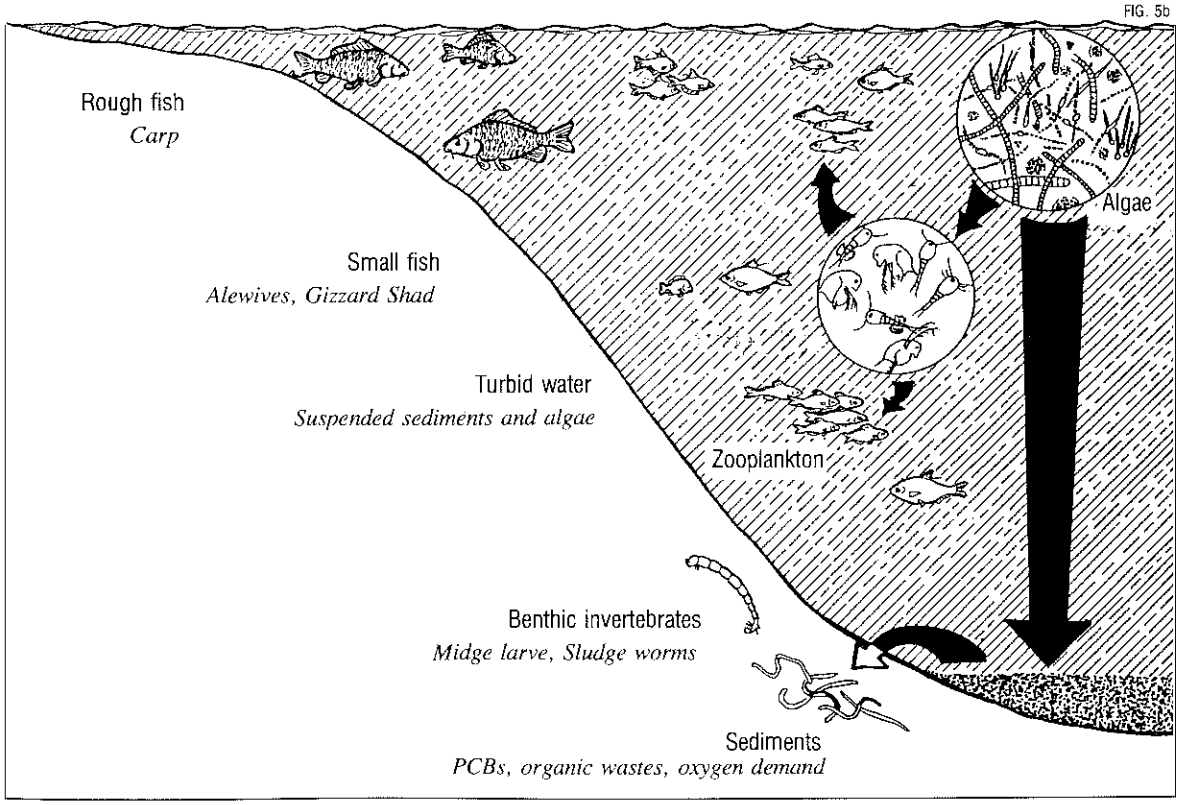



FIG. 5b

**LOWER GREEN BAY: PRESENT STATE**

# 6 Physical and Chemical Indicators

Certain physical conditions and chemical substances in the water serve to gauge the health of the Green Bay ecosystem. Phosphorus, water clarity, dissolved oxygen and toxic contaminants are some of the things measured.

## PHOSPHORUS

■ Phosphorus is an essential element for all life forms. It is particularly important as a plant nutrient. However, excess phosphorus in the bay is responsible for its highly enriched or overfertilized (hypereutrophic) condition. Phosphorus comes from fertilizers washed off farmers' fields and urban residents' lawns and gardens. Phosphorus is in the discharge from sewage treatment plants. The natural decay of algae releases phosphorus that stimulates more algae growth — an internal cycle. The Wolf River, Upper Fox River and Lake Winnebago drainage basins (FIG.4a) send a great deal of phosphorus to the bay - perhaps as much as 60 percent of the total phosphorus load.

The data reveal a trend of decreasing concentrations of phosphorus since the early 1970s. Most of the decrease can be attributed to reduced phosphorus loads from improvements to sewage treatment plants required by the Clean Water Act.

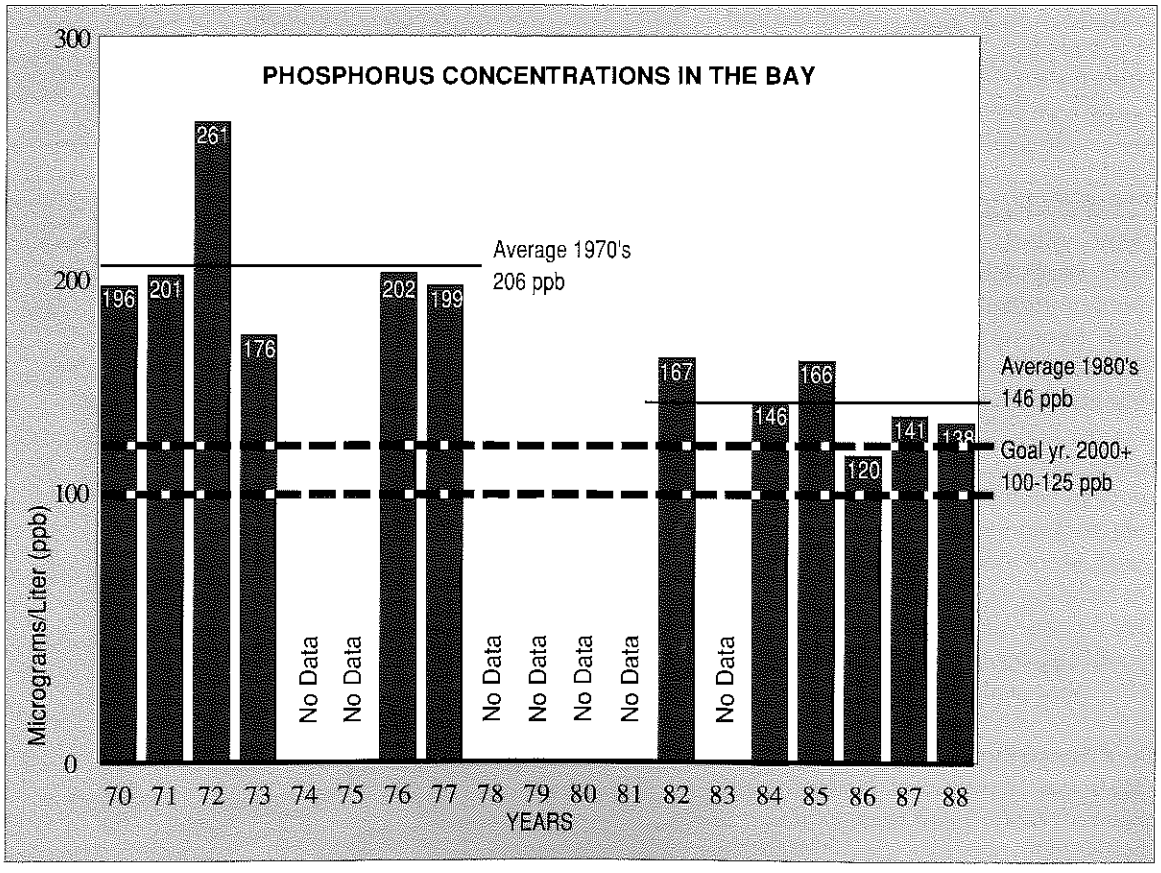
The reductions in phosphorus, however, are not enough. The bay remains hypereutrophic and nuisance algae blooms are common. The average summer total phosphorus concentration for the 1980s was 146 micrograms per liter or parts per billion (ppb). This average appears considerably lower than the 1970s average. It was influenced by the years 1986 through 1988 which had lower phosphorus concentrations than previous years. This is a good sign.

An objective of the Green Bay RAP is to reduce this concentration to a range of 100-125 ppb. Scientists estimate that to reach this level will require a 40-50 percent annual reduction in the amount of phosphorus entering the bay. This will not be easy to achieve. It will likely require further reductions of phosphorus from sewage treatment plants along with significant reductions from rural and urban runoff.

## DATA FROM

*Paul Sager of the University of Wisconsin-Green Bay, 1970-1984 and John Kennedy, Green Bay Metropolitan Sewerage District, 1985-1988*

FIG. 6a




The data represent the average concentration of all measurable forms of phosphorus, known as total phosphorus, collected from eight stations in the inner bay during spring and summer months.

# 7

## WATER CLARITY

■ The waters of lower Green Bay, particularly the area of concern, are notoriously turbid and cloudy. Particles of algae, wood fibers and clay suspended in the water cause this condition. Turbidity has far reaching detrimental effects. For example, it

- prevents desirable submergent plants from growing,
- favors fish such as carp and not the desirable predator fish,
- decreases available duck food,
- adds further nutrients to the water,
- covers fish spawn and decreases hatchability,
- inhibits swimming, and
- is aesthetically unsightly

(see present state, page 5).

A simple and standard measure of water clarity is called Secchi disc depth. It is the depth at which a black and white disc, when lowered in the water, disappears from sight. Secchi disc depths at several sites in the lower bay were recorded and averaged over the growing season in the early 1970s by Dr. Paul Sager, University of Wisconsin-Green Bay. The monitoring results were 0.4 to 0.5 meters (1.25 to 1.7 feet). Similar averages, measured in meters, collected by John Kennedy of the Green Bay Metropolitan Sewerage District during the late 1980s were:

| | | | |
|---|---|---|---|
| **1986** | **0.71** | **1988** | **0.66** |
| **1987** | **0.63** | **1989** | **0.53** |

The average for these four years was 0.63 meters (about 2 feet).

There appears to be a very weak trend toward an increased Secchi disc depth but it is not great enough to have much, if any, significance. The target Secchi disc depth for the AOC in the Green Bay RAP is 0.7 to 1.3 meters (2.3 to 4 feet). This level of clarity is obtained north of Long Tail Point where submergent plants, particularly wild celery, are now becoming re-established (see page 13).

Water clarity will likely not improve until nutrients and sediments from nonpoint sources are significantly reduced.

## DISSOLVED OXYGEN

■ Levels of dissolved oxygen remain an important measure of water quality. The acceptable level needed to maintain a quality sport fishery is five milligrams per liter or parts per million (ppm).

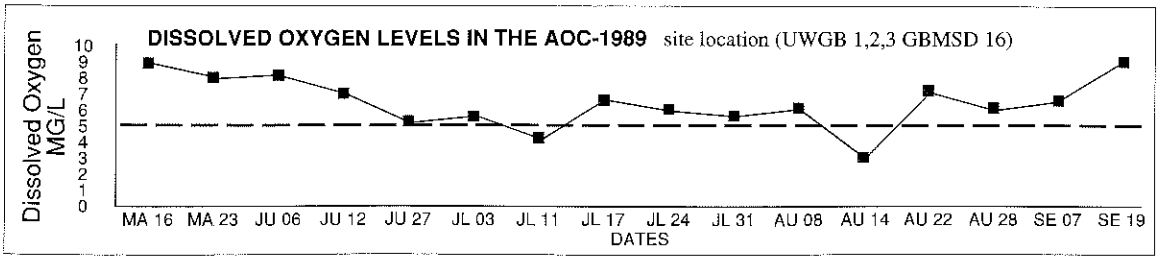
Since the cleanup of conventional pollutants in the late 1970s, the average dissolved oxygen levels in the AOC have generally met the desired standard of five ppm. There are times, however, when the oxygen concentration drops below this level. The average oxygen concentration over the growing season for the last four years, measured in parts per million, are:

| | | | |
|---|---|---|---|
| **1986** | **8.1** | **1988** | **7.8** |
| **1987** | **7.6** | **1989** | **7.9** |

Averages tell something, but as far as the organisms are concerned, it is the extreme conditions that make life difficult. For example, 1989 data collected for the Green Bay Metropolitan Sewerage District monitoring program show that on July 11 and August 14 the oxygen levels were below standard at the interface of the river and bay (FIG. 7a).

This likely reflects cumulative effects of upstream organic waste and algal production, sediment oxygen uptake and bay water interactions. So while the general oxygen picture looks good, the available data reveal that it can be marginal. High phosphorus loads and excess algae production contribute to this problem.

FIG. 7a




NOTE: Results reflect station averages of vertical profiles collected at one meter intervals.

# 8

## TOXIC CONTAMINANTS

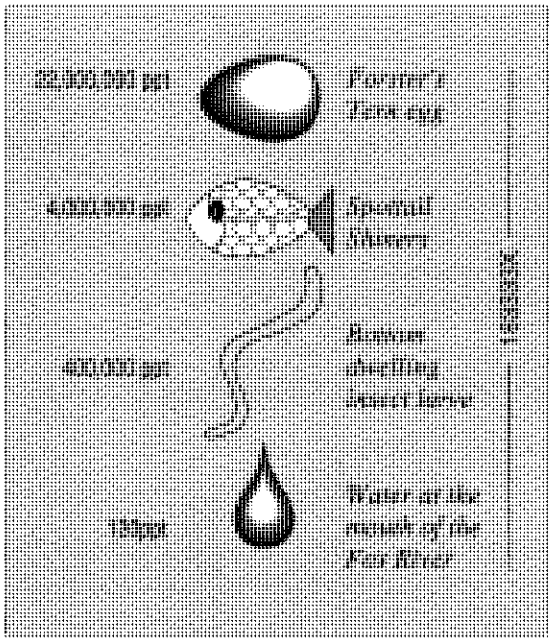
■ Toxic substances and their effects on living organisms and public health in the Great Lakes region are major concerns of scientists, environmentalists and several federal, state and provincial agencies responsible for environmental protection.

The Green Bay AOC is seriously contaminated with both persistent and conventional toxic substances. Persistent toxic substances, primarily chlorinated hydrocarbons like PCBs (FIG. 9a), are particularly problematic because they do not decompose readily and they become more concentrated as they move up the foodchain (FIG. 8a).

## BIO-MAGNIFICATION OF PCBs IN GREEN BAY

Prior to 1988

FIG. 8a



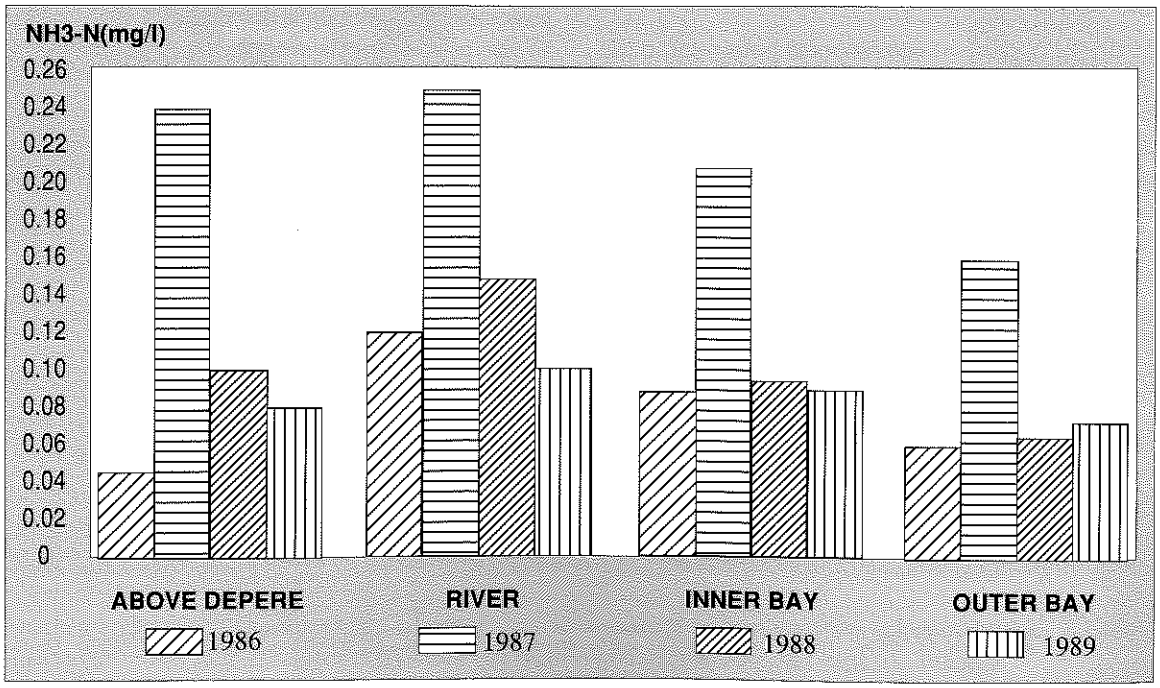
A nonpersistent toxic substance, ammonia, was recently found to exert significant toxic effects on bottom dwelling organisms in the Lower Fox River and Green Bay. Ammonia is naturally generated from decomposing organic material, such as sewage, paper fibers or algae, and can be eliminated by reducing the amount of these materials. Unacceptably high levels of ammonia have been found in Green Bay waters several miles from the mouth of the Fox River. This ammonia likely arises from both point and nonpoint sources (FIG. 8b).

Most of the PCBs and some other chlorinated organic materials contaminating the Green Bay ecosystem came from paper recycling operations. Unlike ammonia, these materials do not decompose and remain attached to sediment particles. Consequently, sediments are now a main source of PCBs. Significant amounts of PCBs and mercury are coming from sediment deposits above the De Pere Dam–some as far away as Little Lake Butte de Morts. Because of high levels of PCBs, health advisories are in effect for most fish, except perch, in the AOC.

## TOTAL AMMONIA

Lower Fox River and Green Bay

FIG. 8b



**TOXIC CONTAMINANTS** continued

Considerable evidence exists connecting reproductive and growth abnormalities in Forster's terns with PCB and PCB-like compounds in the area of concern. A study of Forster's tern populations in 1988 showed an increase in reproductive success when compared to a similar study in 1983. It is too early, however, to conclude that this increase is a result of decreased persistent toxicants.

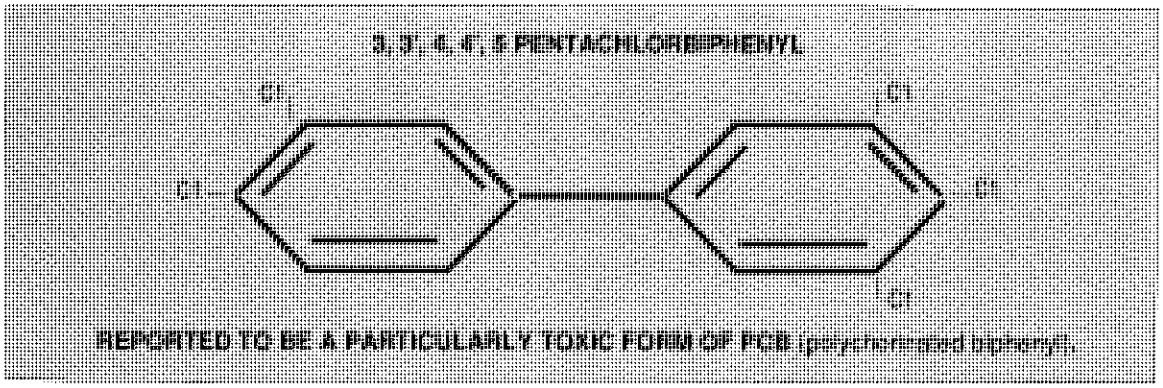
The lack of good "trend data" on PCBs in fish makes statements regarding the change in PCBs since the 1970s tenuous. One statistical test measured the average PCB level in the fillets of white suckers from the Fox River in 1977 as compared to the PCB level in 1988. It revealed a significant decline from 2.9 ppm to 0.60 ppm after the data were normalized for fat content. These numbers are consistent with data on Lake Michigan fish that show declines in PCBs in salmon and trout and an 80 percent decline in dioxins from the 1970s to the late 1980s.

While the PCB contaminant levels in Green Bay fish appear to have fallen slightly, we are a long way from being "out of the woods". The Fox River-Green Bay toxics situation must be classified as serious with tenuous signs of improvement. Ultimately the contaminated sediments may need to be removed or treated, an extremely expensive proposition.

New toxic rules are now in place for discharges of wastewater, and paper companies have significantly reduced the amount of PCBs in their waste effluent. Meanwhile, continued efforts must be made to virtually eliminate any toxicity associated with municipal and industrial waste discharges. New treatment facilities at the Green Bay Metropolitan Sewage Treatment Plant should alleviate some of the ammonia toxicity problem in the area of concern.

The problem of persistent toxic substances remains largely unresolved although significant progress is being made in defining its extent and magnitude.

FIG. 9a




**PROBLEM DEFINITION**

■ An unprecedented effort is being made by EPA Great Lakes National Program Office and Wisconsin DNR to determine the fate of PCBs in Green Bay. This so-called Mass Balance Study will ultimately guide efforts to eliminate the toxic effects of the chemicals.

While the study is incomplete we now know that once PCBs reach the bay, they become evenly distributed in the sediments at low concentrations and are thus unmanageable. Removal of upstream sediment and point sources is the key to reduced contamination.

# 10 Biological Indicators

The following sections examine the status of bottom dwelling organisms (benthos), the yellow perch, the Forster's tern and a plant called wild celery.

■ Some organisms or groups of organisms serve as a telltale for the larger system. These organisms may or may not be of direct public use, but their presence, absence or abundance is of major significance regarding the health of the ecosystem. For Green Bay, organisms were selected based on two factors: 1) whether sufficient data exist from which to examine trends, and, 2) whether there is adequate knowledge to know what those trends mean.

## BENTHOS

■ Benthos or bottom dwelling organisms are important food for fish and waterfowl. They are also important as processors of organic particles. Generally, a greater variety of organisms, or "richness", is consistent with a healthier environment. In the area of concern the number of species of benthos more than doubled from 1978 to 1988 on both the west and east shores.

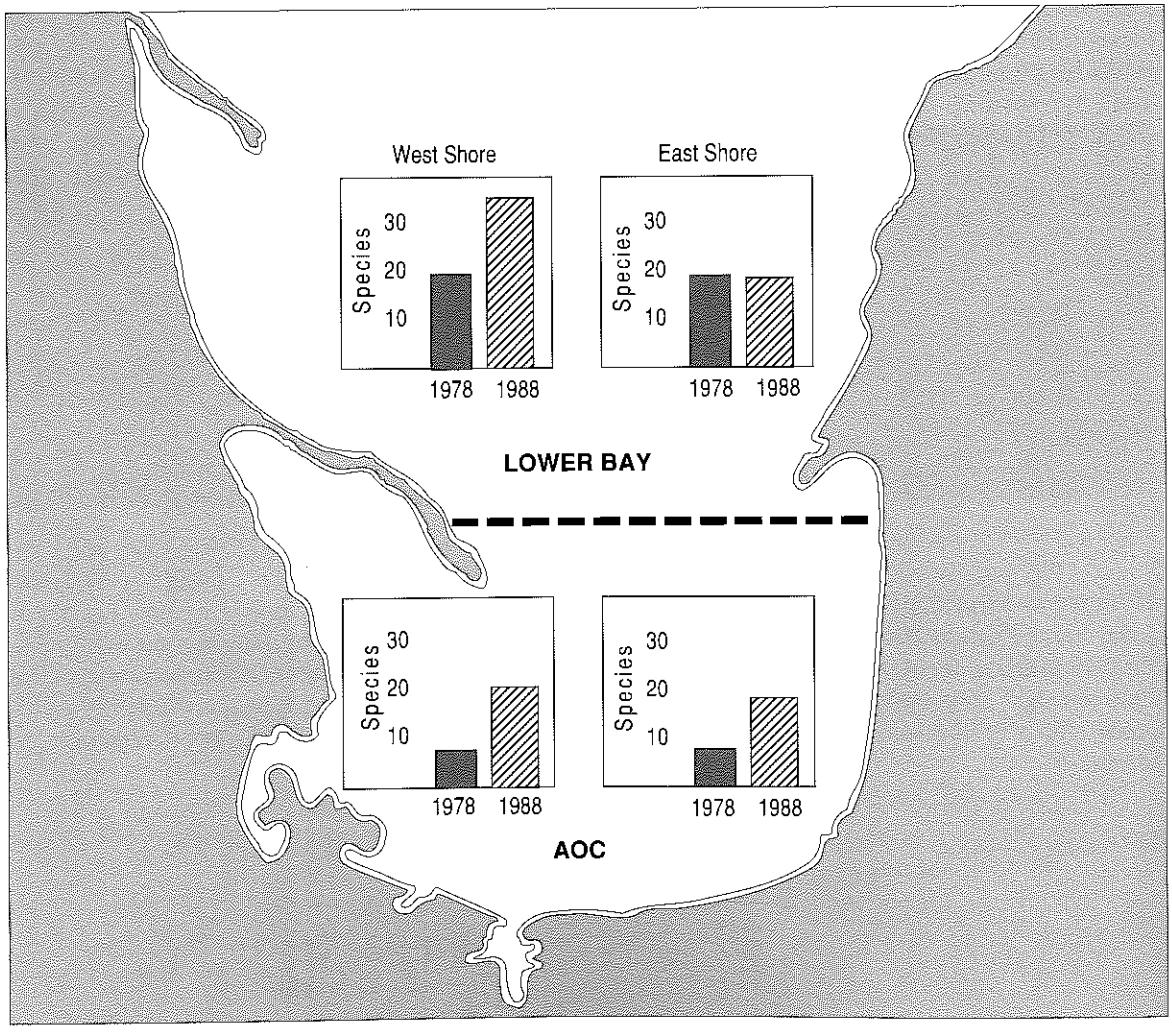
In the lower bay north of the area of concern, diversity on the west shore area increased substantially but the same increase was not seen on the east shore. This suggests that the benthos on the east shore are still being influenced by Fox River water which flows up the east shore. Other factors–such as whether the bottom is mud, sand or some other type may also be involved.

The increase from 1978-1988 is good news and represents progress. The no-change condition on the east shore of the lower bay and the relatively low diversity in the AOC is the bad news; it means further improvements in water quality are needed.

The number of species of benthos for the area of concern and the lower bay are shown on the map below.

FIG. 10a

## CHANGE IN THE NUMBER OF KINDS OF BENTHOS IN THE AOC AND LOWER BAY FROM 1978 TO 1988




*Data from Dave Rades Integrated Paper Services, Appleton, Wisconsin.*

# 11

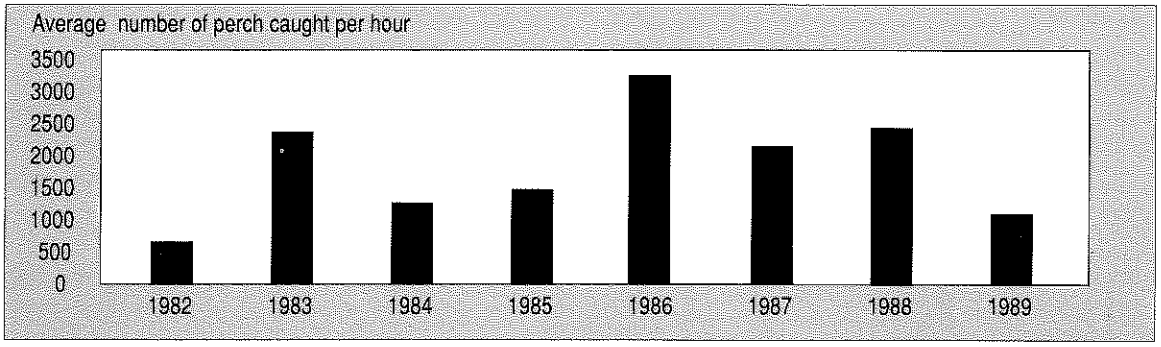
## PERCH

■ Yellow perch are the mainstay of the local commercial and sport fishery. The amount of perch harvested commercially over the years varied from 2.25 million pounds in the 1940s to less than 0.25 million pounds in the 1960s and 1970s. In 1982 the Wisconsin Department of Natural Resources (DNR) implemented regulations designed to improve the failing fishery. Commercial and sport harvests were sharply restricted, changes were made in the timing of the open season, and spawning sanctuaries were created.

DNR monitoring of the fishery began in 1980. Using shore netting for young of the year and trawling for adult perch, the relative abundance of species and their growth rates were assessed. The trawling index, expressed as the average number of perch caught per trawling hour, reveals an increase in numbers from 1982 through 1988 (FIG.11a). The decline in 1989 may reflect a location change for a portion of the perch population or an actual decline in numbers. A leveling of growth rates during the late 1980s suggests that the population size may be as much as can be sustained by the present system (FIG.11b). Sport and commercial catch is now about even with the commercial catch set at 475,000 pounds (FIG.11c). This limit is being reconsidered.

The future challenge will be to maintain the present harvest level of the fishery and to insure that contaminant levels are well within the acceptable health standards.

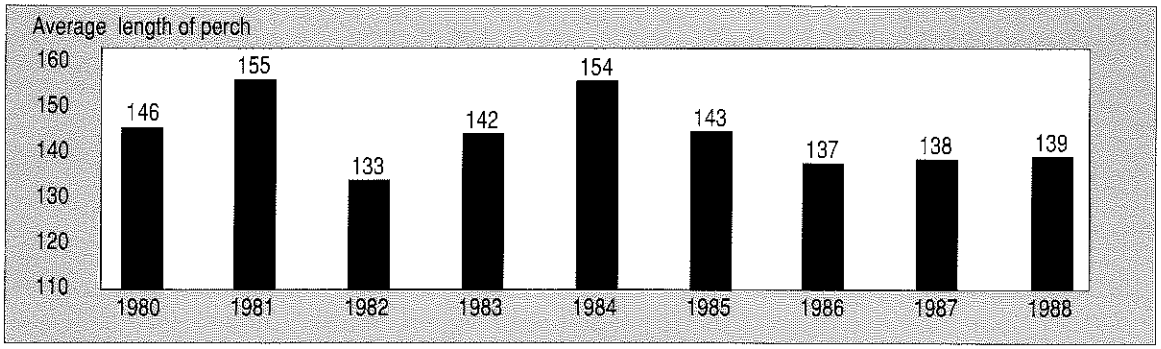
FIG. 11a




**TRAWLING INDEX YEARLING & OLDER YELLOW PERCH**

*Data from Brian Belonger DNR Marinette Office*

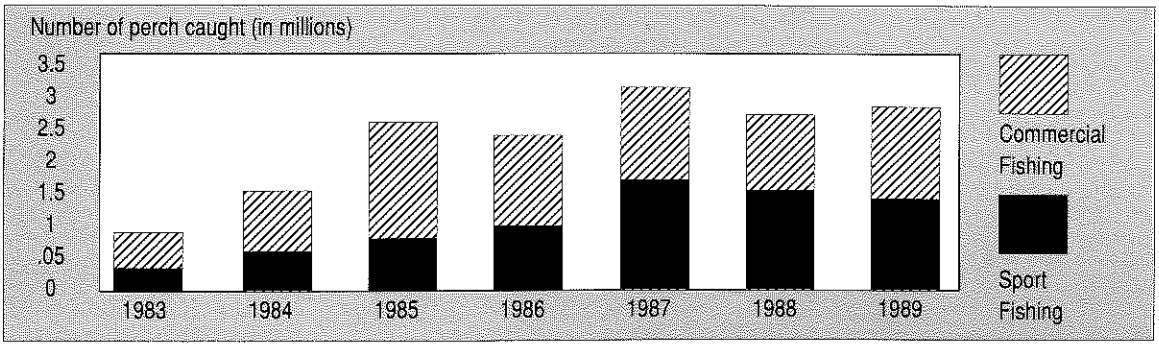
FIG. 11b




**AGE 1+ YELLOW PERCH**

*Data from Brian Belonger DNR Marinette Office*

FIG. 11c




**YELLOW PERCH HARVEST COMPARISON NUMBER CAUGHT**

*Data from Brian Belonger DNR Marinette Office*

# 12

## FORSTER'S TERN

■ The Forster's tern (see back cover) serves as a telltale of the ecosystem in two ways. First, its diet consists almost entirely of fish and thus it serves as a monitor for persistent toxic substances in the system. Second, as a marsh nesting species it has reflected the conditions of marshes in Green Bay.

The number of pairs of nesting Forster's terns has been monitored periodically since the late 1960s, primarily on the west shore of Green Bay as far north as Oconto (FIG. 12a). The relatively low number of nesting terns from the mid-1970s until 1986 is believed to be related to two factors causing low survival of young:

1) Lake Michigan and Green Bay water levels prior to and during this period made the marshes and nesting conditions within the marshes far from optimum. This is part of the natural high- and low-water level cycles common to Green Bay and a phenomenon to which the terns must adapt.

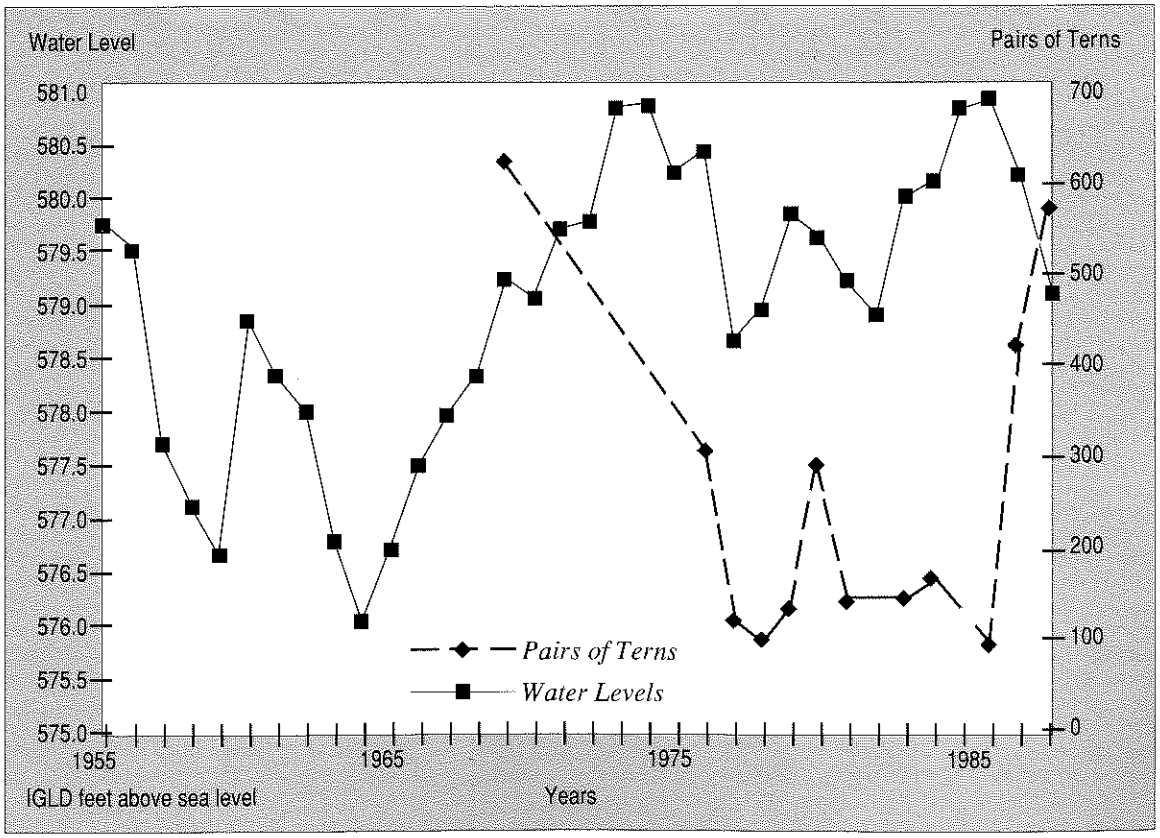
2) Studies conducted in 1983 show quite convincingly a link between persistent toxic substances and impaired reproduction in the Forster's tern.

The increase in numbers from 1987 through 1989 are not totally explainable. Several factors may contribute to this increase. Populations began nesting on Renard Isle when marshes were unavailable and, because the island is always above water level, there is no mortality from the nest flooding that naturally occurs in marshes. Second, for reasons unknown, there has been an increase in the reproductive success of the terns (see section on toxic contaminants). Third, the Green Bay population is experiencing an increase in the movement of terns from a very successful colony on Lake Poygan.

Past and present population changes of this bird are a result of environmental conditions under which it lives. The amount of suitable wetlands available for nesting and the presence of toxic contaminants appear to remain a problem for this species. As the quality of the environment improves, the population may vary less than it has in the past two decades.

FIG. 12a

**GREEN BAY WATER LEVEL AND BREEDING PAIRS OF FORSTER'S TERNS**




*Tern data from Dr. Harris, T. Erdman and Joel Trick, UWGB*

# 13

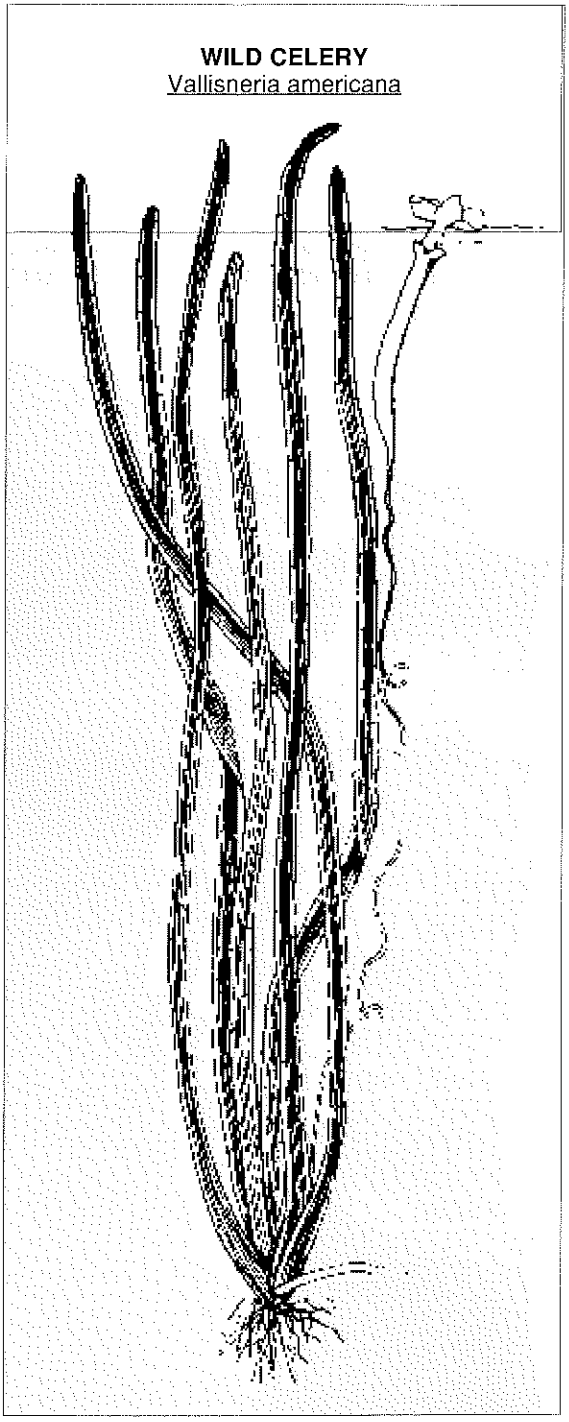



FIG. 13a

*Wild Celery Illustration provided by the Illinois Department of Conservation*

## WILD CELERY

■ Plants are good indicators of local conditions. After all, they can't escape from adverse conditions the way animals do. Because plants are autotrophic (carry on photosynthesis) they are dependent on adequate light. Animals are not so restricted.

## WATERFOWL FOOD

A plant called wild celery (Vallisneria americana), known to be prevalent in the AOC and lower bay area in the 1960s, is a favorite food for waterfowl. It also serves as habitat for forage fish and provides spawning areas for northern pike and perch. Wild celery has been absent from the lower bay and AOC for the past 20 years. The recorded reappearance of this plant approximately four years ago north of Long Tail Point and inside of Little Tail Point suggests that water clarity in this area has increased enough that light is no longer limiting the growth of the plant. There may be factors other than light involved which we do not yet know. The reestablishment of healthy beds of this and other submergent plants will positively affect fish and wildlife but may eventually cause concern to boaters. It is yet another indication that the bay is gradually regaining a healthier state.

## F ISH HABITAT

## LIGHT STUDIES

■ Graduate student Lynne McAllister at UWGB is conducting an intensive study of this plant's distribution in the bay. She is also attempting to predict the level of light required for the successful establishment of this submergent plant. The importance of this plant for the rehabilitation of Green Bay cannot be overstated.

# 14 People-Related Activities

The condition of the bay is both affected by and reflective of how it is used. The following section focuses on key recreational uses, such as sport fishing, boating, "swimability", and economic trends in the area of concern.

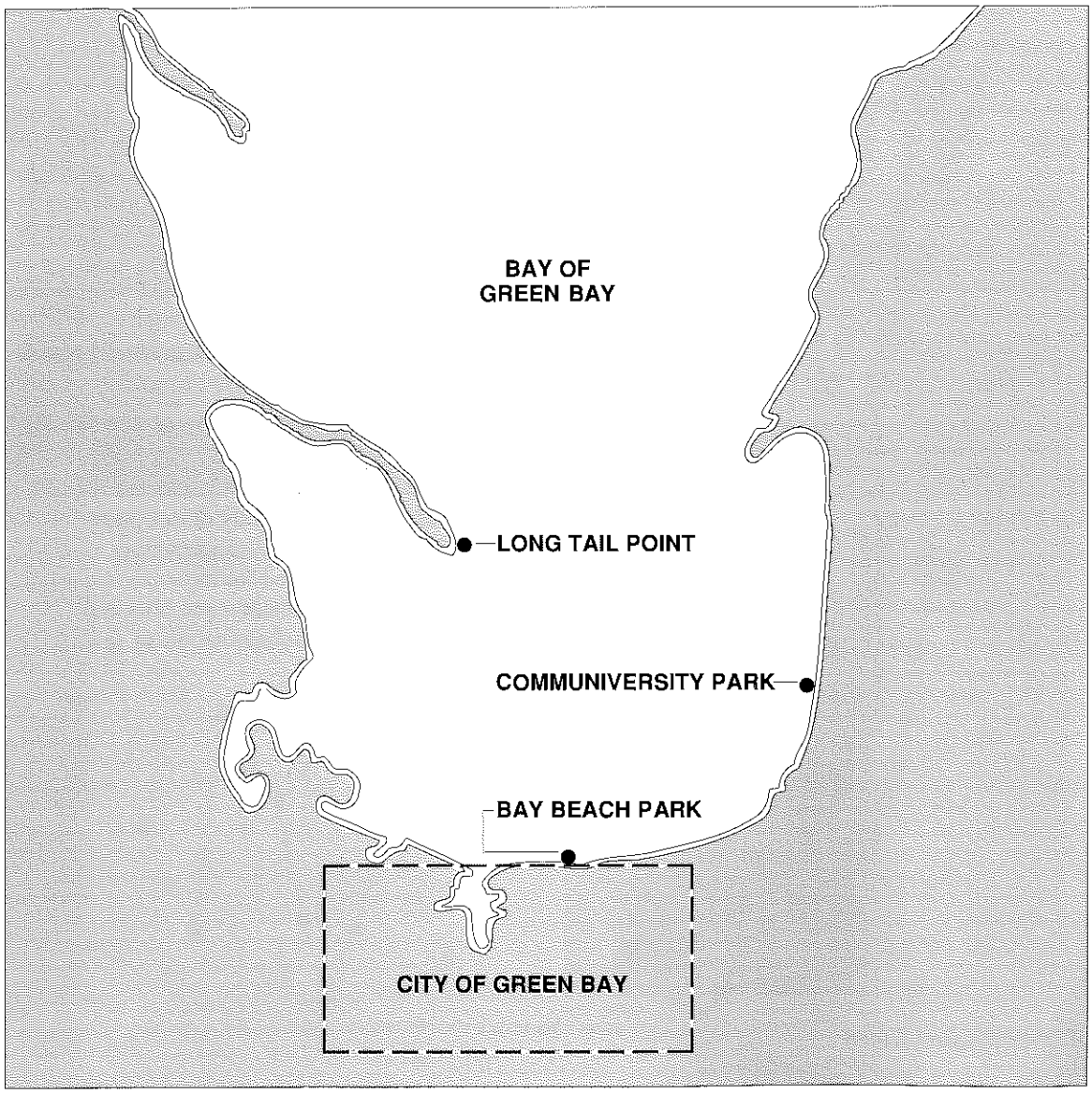
## SWIMABILITY

■ Water quality that meets recreational swimming standards and the siting of a swimming beach in the area of concern are goals of the Green Bay RAP. There has not been an approved swimming beach in the area of concern since Bay Beach was officially closed in 1943. A few sites, however, are now used informally for swimming, wading or other recreational water sports.

Monitoring results from Long Tail Point, Bay Beach Park and Communiversity Park (see map below) were analyzed as indicators of swimability. These indicators include water clarity, as measured by Secchi disc depth (see Water Clarity section) and bacteria levels measured as the number of times the standard for fecal coliform is exceeded.* Fecal coliform are normal bacteria in the intestines of warm-blooded animals that indicate that illness or disease-causing (pathogenic) bacteria and viruses may be present.

## MONITORING POINTS

FIG. 14a




*Fecal coliform bacteria counts must be less than 200 in 100 milliliters (ml) or about one-half cup of sample water. Ten percent of the total samples in any 30 day period cannot exceed 400 per 100 mls.

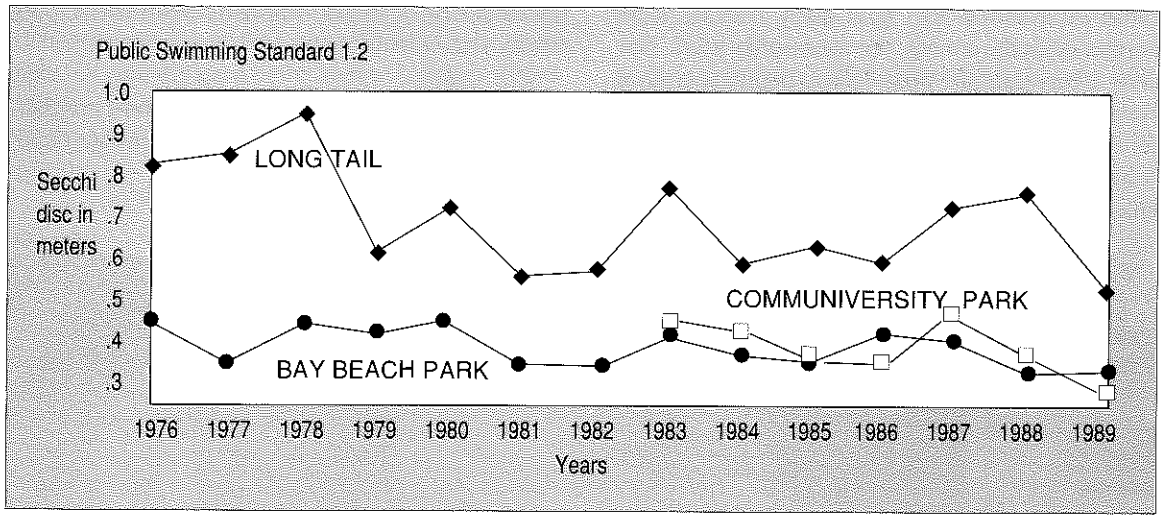
## SWIMMABILITY CONTINUED

The data collected by the Green Bay Health Department, show that none of the three sites met recreational water quality standards for water clarity (FIG. 15a ). Measurements taken in the bay 50-100 feet off Bay Beach since 1976 show an average Secchi disc depth of 0.4 meters (1.25 feet) for the months of June, July and August. The data show little variation from year to year. All measurements were well below the standard of 1.2 meters (4 feet) that is considered acceptable for public swimming.

Data for Communiversity Park and Long Tail Point have not been collected as consistently as for Bay Beach, but are worthy of note. The Communiversity Park site is about the same as Bay Beach—about 0.4 meters. Long Tail Point, which is often used for swimming by recreational boaters, averaged 0.64 meters (about 2 feet), still well below public swimming standards.

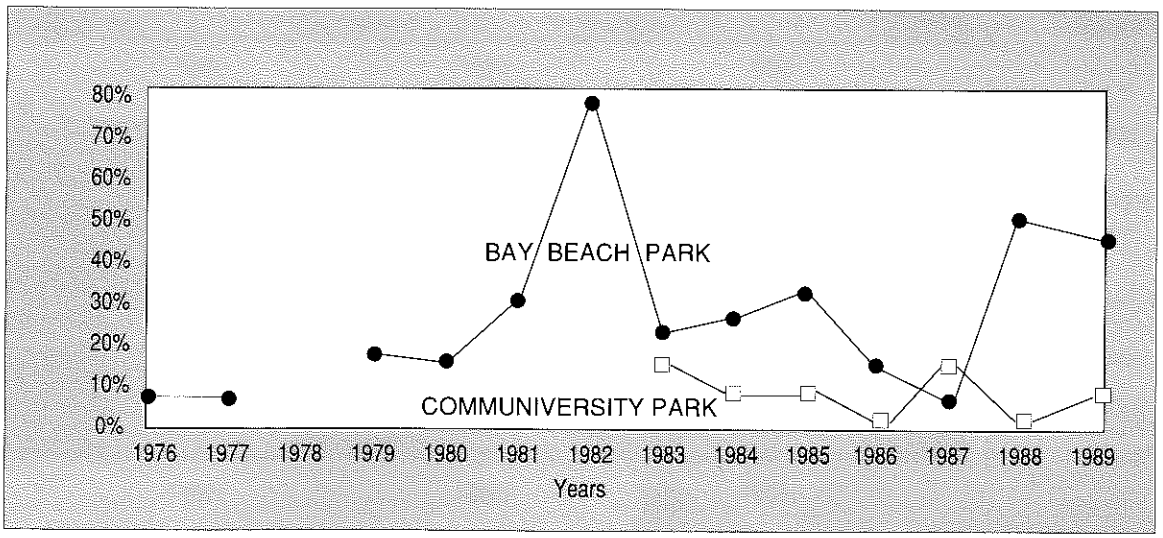
The fecal coliform standard is exceeded regularly at Bay Beach (FIG. 15b). The two other sites had a very low rate exceeding the standard. Communiversity Park averaged six percent for the sample years 1980 to 1989. Long Tail Point never exceeded the standard in the sample years 1978 to 1989. The average for the Bay Beach site (25%) is influenced by an increase in fecal coliform levels for the years 1982, 1988 and 1989. Data are not readily available to explain whether the increase could be due to weather, animal waste, discharges or a combination of sources.

FIG. 15a




**WATER CLARITY**
*Data from Green Bay Health Department.*

FIG. 15b




**% OF TIMES FECAL COLIFORM EXCEEDS ACCEPTABLE LIMITS**
Long Tail Point equals 0

*Data from Green Bay Health Department.*

# 16

## SPORT FISHING

■ Fishing has been a popular sport on the bay for a long time. In recent years that popularity has spread to portions of the Fox River as well. Increases in dissolved oxygen in the water and a walleye stocking program by the Wisconsin DNR helped establish a fishery that now attracts large numbers of anglers.

Determining the actual numbers of people who fish in the area of concern is difficult. While creel census, or angler catch data are collected each year, the data base is not extensive or consistent enough to be used at this time.

A general indication of sport fishing trends was obtained from fishing license information compiled annually for the state and county by the DNR. License information tells how many licenses were purchased in the county, not necessarily used. Nor does it represent the total fishing population since certain segments— children under 16, adults over 65 and the disabled—are not required to purchase fishing licenses. The information can be used, however, to compare license sales trends over time.

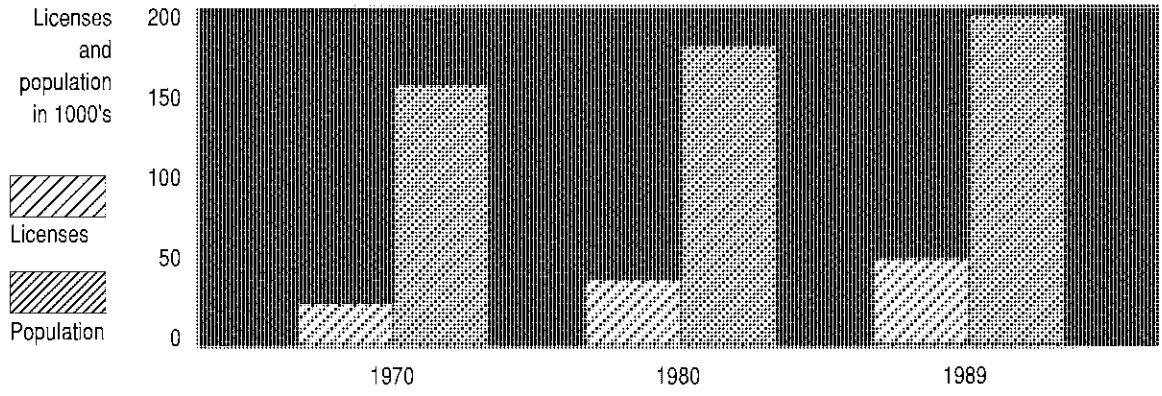
Data from 1970, 1980 and 1989 show a significant upward trend from 19 thousand licenses purchased in Brown County in 1970 to 51 thousand in 1989. That's a 176 percent increase in the Brown County fishing population compared to a 48 percent increase in the Wisconsin fishing population for the same years. Figures provided by the Green Bay Planning Department show that the general population of Brown County increased 23 percent from 1970 to 1989 while the general population of Wisconsin increased ten percent for the same years.

In recent years fishing license sales in Brown County increased at a slower rate than for previous years and declines in sales have been reported statewide for certain years. This downward trend is reflected nationwide and may be due to increased urbanization, a change in leisure time activities and changing family structure.

Despite recent data, however, the popularity of fishing among Brown County residents appears to remain strong.

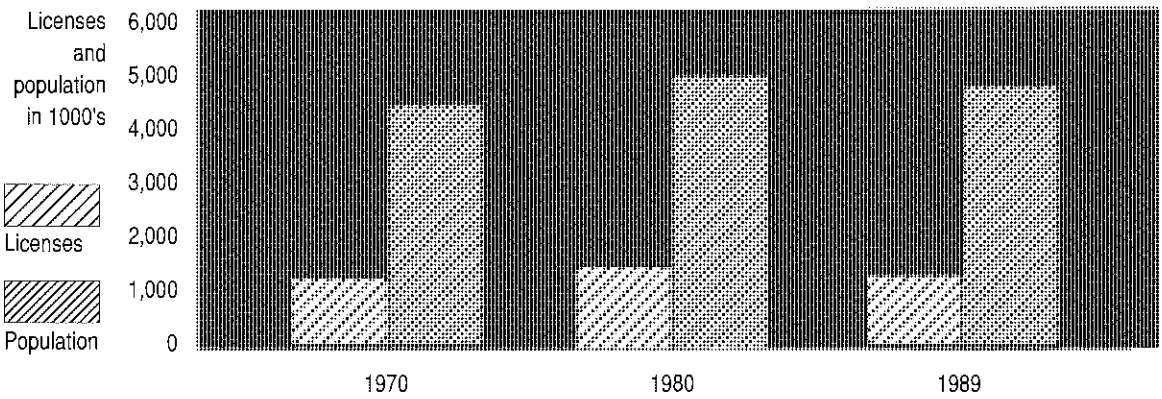
**CHANGE IN THE NUMBER OF FISHING LICENSES AND POPULATION FOR BROWN COUNTY**

FIG. 16a




**CHANGE IN THE NUMBER OF FISHING LICENSES AND POPULATION FOR STATE OF WISCONSIN**

FIG. 16b



# 17

## RECREATIONAL BOATING

■ Boating on the Lower Fox River and bay is a popular form of recreation. As soon as the weather warms, long lines of fishing boats and pleasure craft can be seen almost any weekend at area launch sites. Just how popular is boating in the area of concern?

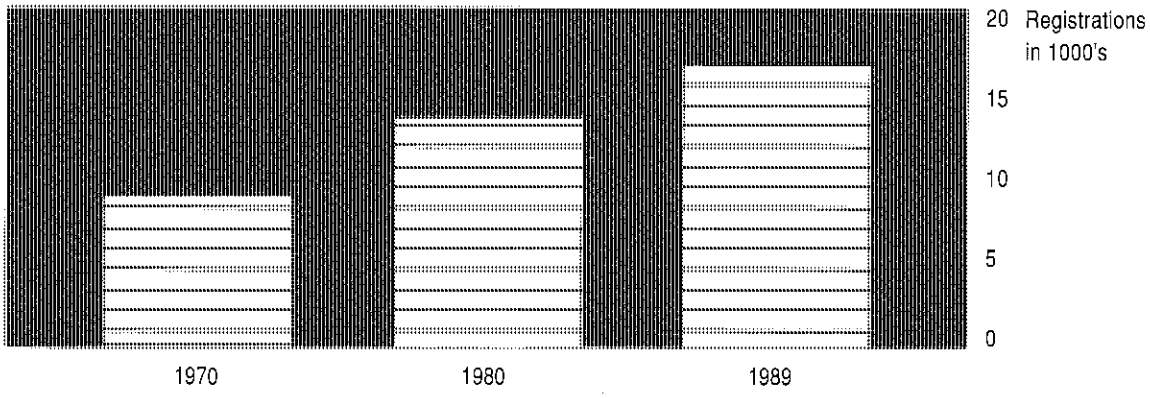
According to Wisconsin Department of Natural Resources figures, 17,817 boats were registered to Brown County residents in 1989, or 107 percent more than in 1970. That compares to a 54 percent increase in the state boating population for the same years. The general population increased at a much more modest rate in both Brown County and Wisconsin during that same time (see FIG. 16a and FIG. 16b).

A boat license is valid for two years and entitles the owner to use the boat anywhere in the state. Boat registration figures, therefore, do not indicate how many boats are actually used in the area of concern. Other measures can be used to get a better idea of boat usage.

For instance, 1989 was the first complete year that launch fees were collected at six sites managed by the City of Green Bay, City of De Pere and Brown County. Daily pass receipts totaled 17,163. In addition, 2,079 seasonal passes were sold that allow unlimited access at any of the sites. These figures may be conservative since not all launch sites have full time attendants.

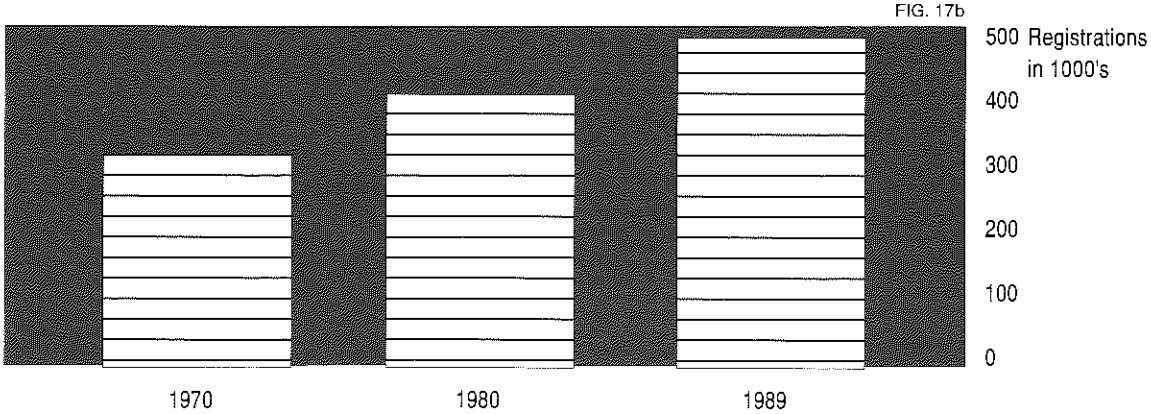
What these numbers mean is that more people perceive the river and bay as places for recreation. This growing enthusiasm for local waterways is encouraging. The challenge will be to balance the demand for recreational access with the environmental constraints of the ecosystem.

FIG. 17a




**CHANGE IN THE NUMBER OF BOAT REGISTRATIONS IN BROWN COUNTY**

FIG. 17b




**CHANGE IN THE NUMBER OF BOAT REGISTRATIONS IN WISCONSIN**

# 18

## ECONOMIC TRENDS

*Data assembled by Dr. James Murray, regional economist, University of Wisconsin-Green Bay*

■ A pervasive view in the recent past has been that there must be a trade-off. The trade-off has been between economics and ecology; that is "you can either have ducks or jobs, but not both."

It is evident there has generally been a positive change in the environmental quality of Green Bay over the past twenty years. It's logical, then, to ask how the economy has done.

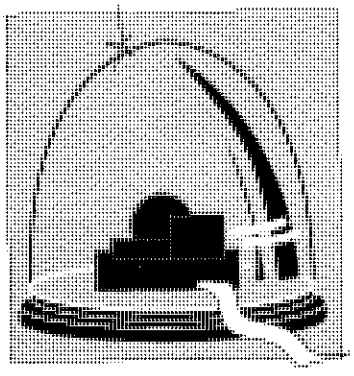
The health of the ecosystem cannot be predicted by one or a few ecological indicators. Similarly, no single indicator can serve as a measure of the well-being of the Green Bay economy. Nonetheless, employment changes from 1969 to 1989 are revealing. It was during this period that Brown County doubled its employment from about 44 thousand in 1969 to about 88 thousand in 1989.

Since 1969, environmental restrictions on the paper, food and power industries have been significant. It is interesting to note, therefore, that all of the affected industries in Brown County have not only increased in employment, but have outperformed the nation and the state in this respect, capturing larger shares of both markets. In fact, the industries that have lost shares of national markets (e.g. health services, real estate, general contractors, etc.) are generally industries that are relatively unaffected by environmental restrictions.

It must be said that the employment composition in some of these industries has changed and some of this change is the result of environmental regulations. The most obvious example is the employment in pulp mills which has declined by about 250 persons in the past five years largely as a result of the closing of the pulp mill at the Proctor and Gamble (P & G) facility. Employment in pulp mills will decline further in the next two years as James River Paper Company brings its recycling operation on line and closes its pulp operation. In the case of P & G, all displaced employees were employed in other activities in the firm. In the case of James River, the recycling operation is expected to employ at least as many persons as the pulp operation.

In addition, there is a very recent increase in employment in recycling in Brown County. Twenty years ago the large cheese firms were disposing of their whey by land applications. When this was prohibited, the technology for recovering protein from whey was perfected. Whey protein concentrates are now an important and critical source of profit for any large cheese producer. A firm employing about 50 persons, which will process waste products from Fort Howard's paper mill into a variety of absorbent products for the market, began operations in 1989. There are now two plastics recycling firms in Brown County. One started during the early 1980s and now employs about 150 persons and a second opened in 1990.

Predicting future economic conditions is beyond the scope of this publication. But the analysis of past and present information shows that the economy of Brown County has remained strong over the past 20 years despite increases in environmental regulation.



# So... Where Are We 19

■ By the "impaired use" criteria of the International Joint Commission of the Great Lakes, the Green Bay ecosystem remains seriously degraded. Toxic substances have captured our attention. There are, however, more impaired uses associated with excess nutrient and sediment loading than there are from toxic substances (FIG. 19a). For example, sediment toxicity appears to be caused, to a significant degree, by ammonia generated from the decomposition of organic matter, primarily algae. The algae, in turn, results from excess nutrients, mainly phosphorus.

Sediment toxicity likely prevents establishment of large populations of desirable organisms that inhabit the sediments and provide food for fish and waterfowl.

- This impoverishes the food supply available to fish and waterfowl.
- Excess nutrients have affected fish and waterfowl habitats by not allowing enough light to produce desirable underwater plants.
- Algae also contribute significantly to turbidity which prevents the waters from meeting the requirements for swimming.
- The algae also create excess cost for wet industries because the water must be cleaned up before being put to some particularly demanding uses.
- Algae "blooms" detract significantly from the aesthetic character of the bay.

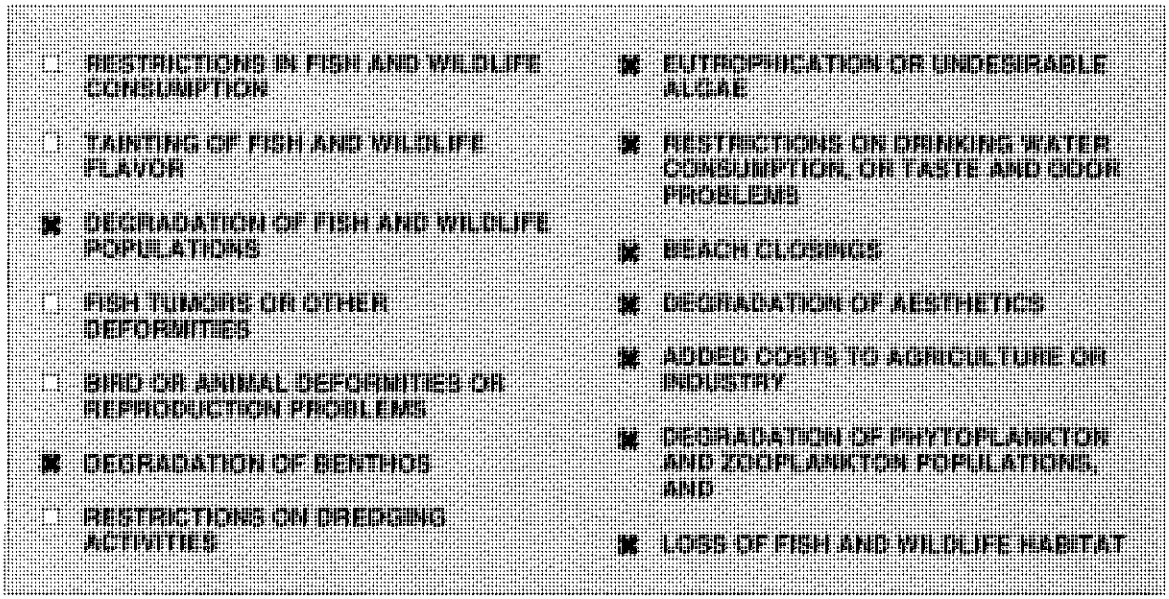
Consequently, excess nutrients can, directly or indirectly, affect wet industries. It can similarly effect those who fish, hunt waterfowl and swim, and those who are interested in land development or simply wish to enjoy the water.

Toxic substances are, indeed, a serious problem. Nevertheless, if the system is to regain its "health", we must guard against too narrow a focus and we must maintain a more encompassing ecosystem approach. Clearly nutrient reduction must be one of the priority actions if beneficial uses are to be restored.

In sum, changes occurring over the past 20 years are indeed in the right direction and evidence that the system will respond to remedial actions. There is every reason to believe that in the next five years there will be continued improvement. Our challenge is to create the political will to bring about the desired changes and restore beneficial uses for us and for our children.

FIG. 19a

**IMPAIRED USES**




✖ indicates nutrient impaired use

# 20 What Lies Ahead?

■ What can we say about the condition of the bay five years from now? Ten years? Not much with a high degree of confidence. There are still too many unknowns about the bay and conditions and stresses on the bay are constantly changing. It's like shooting at a target that takes on a different identity and is always moving in an erratic manner.

Enough is known, however, about the bay to suggest a general model of rehabilitation. Because the bay is affected by multiple stresses, the recovery of a healthy state (ecosystem integrity) will likely take place in a stair step fashion. This will occur as we continue to remove or abate particular stresses (FIG. 20a). Right now we are on step one (BOD reduction) and heading for step two (removal of ammonia discharge). Steps three and four (excess nutrients and persistent toxic substances) will not likely be much changed in 1995 but could be significantly reduced by 2000.

Meanwhile, we are more than likely in for a few "surprises." For example, the number of white perch, another exotic species from Europe, could change conditions by altering foodchains or competing with the yellow perch. Yet, another introduced species, the zebra mussel (Dreissena polymorpha) could have profound ecological, let alone economic, effects. This species, although not yet known to be reproducing in Green Bay, has become firmly established in Lake Erie. This very small clam-like creature is a "filter feeder" which filters algal particles from the water. It can occur in outrageously enormous numbers (20 to 30 thousand per square yard) and some ecologists suspect that it is changing the whole ecology of the western basin of Lake Erie by reducing the algae and thus increasing the water clarity by as much as four feet. Along with this are changes in the food chain which could eventually reduce the walleye population, a not so desirable outcome.

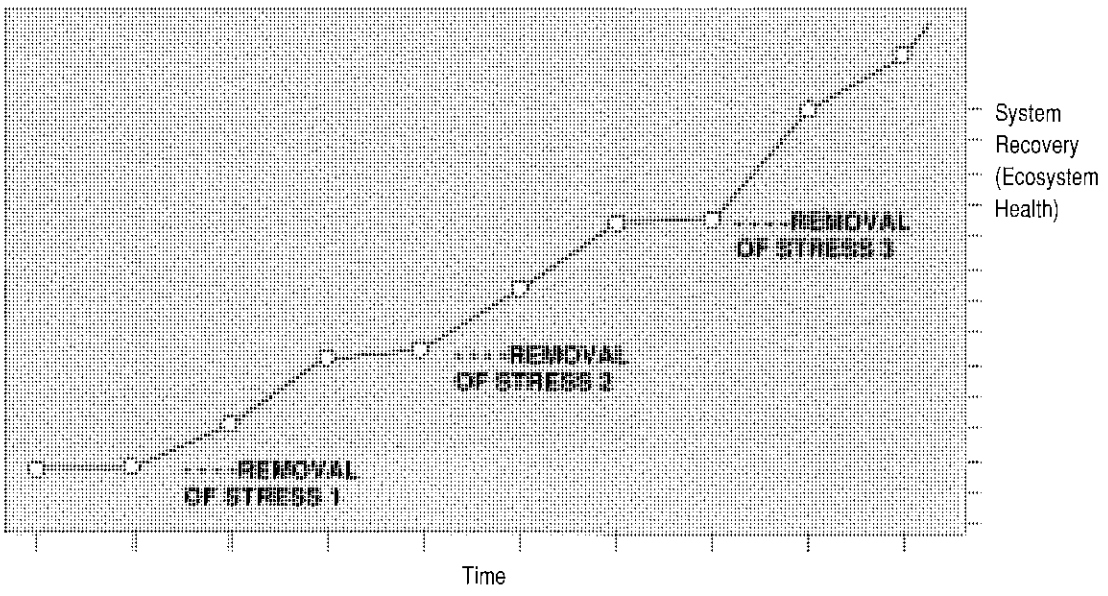
Changes in natural conditions can create some unexpected outcomes as well. If the water level continues to fall in Lake Michigan and Green Bay reaching a low similar to the early 1960's, then submergent aquatic vegetation may once again become super abundant (good news for duck hunters, bad news for sail boaters).

These changes are perhaps trivial in view of the potential atmospheric and global changes associated with the so-called "greenhouse" effect that may occur in the next century.

So with all this uncertainty, what can we plan on? We can and must plan for change! As we go about the business of rehabilitating Green Bay, care must be taken not to create short term solutions which will become the next generation's problems. The key is to maintain and restore as best as possible the ecological integrity of Green Bay. This is a formidable but not impossible task.

**HYPOTHETICAL RECOVERY OF AQUATIC ECOSYSTEM AFFECTED BY MULTIPLE STRESSES**

FIG. 20a



Financial assistance provided by the Wisconsin Coastal Management Program, State of Wisconsin, Division of Energy and Intergovernmental Relations, Department of Administration and the Coastal Zone Management Act of 1972, as amended, administered by the Office of Ocean and Coastal Resources Management, National Oceanic and Atmospheric Administration.

The Wisconsin Coastal Management Program was established in 1978 to direct comprehensive attention to the state's 820 miles of Lake Michigan and Lake Superior coastline. The WCMP analyzes and develops state policy on a wide range of Great Lakes issues, coordinates the many governmental programs that affect the coast, and provides grants to stimulate better state and local coastal management. Its overall goal is to preserve, protect and develop the resources of Wisconsin's coastal areas for this and succeeding generations.

*Terns...Harbingers of the bay*