Biological Services Program

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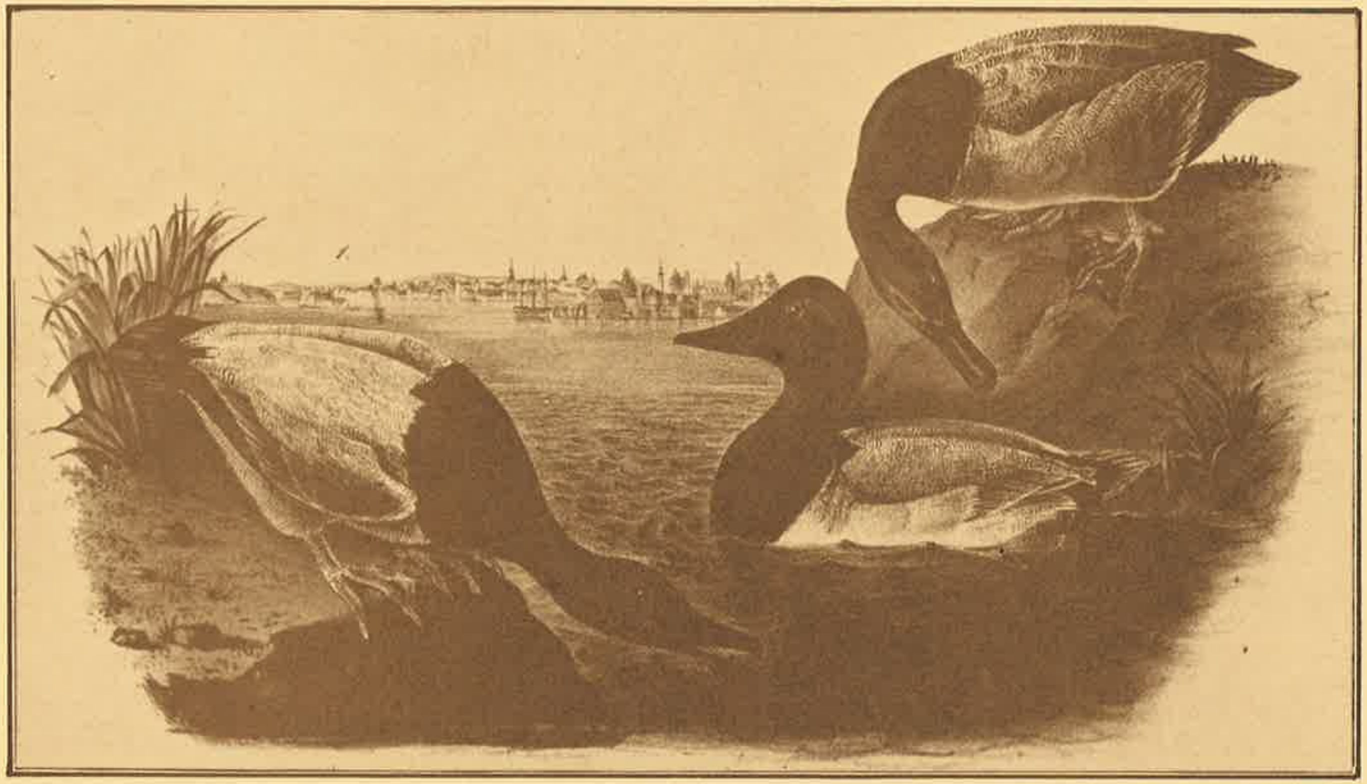

# Decline of Submerged Aquatic Plants in Chesapeake Bay

Maryland Department of Natural Resources, U.S. Environmental Protection Agency and

Fish and Wildlife Service

U.S. Department of the Interior

The Biological Services Program was established within the U.S. Fish and Wildlife Service to supply scientific information and methodologies on key environmental issues that impact fish and wildlife resources and their supporting ecosystems. The mission of the program is as follows:

- To strengthen the Fish and Wildlife Service in its role as a primary source of information on national fish and wildlife resources, particularly in respect to environmental impact assessment.
- To gather, analyze, and present information that will aid decisionmakers in the identification and resolution of problems associated with major changes in land and water use.
- To provide better ecological information and evaluation for Department of the Interior development programs, such as those relating to energy development.

Information developed by the Biological Services Program is intended for use in the planning and decisionmaking process to prevent or minimize the impact of development on fish and wildlife. Research activities and technical assistance services are based on analysis of the issues, a determination of the decisionmakers involved and their information needs, and an evaluation of the state of the art to identify information gaps and determine priorities. This is a strategy that will ensure that the products produced and disseminated are timely and useful.

Projects have been initiated in the following areas: coal extraction and conversion; power plants; geothermal, mineral, and oil-shale development; water resource analysis, including stream alterations and western water allocation; coastal ecosystems and Outer Continental Shelf development; and systems inventory, including National Wetland Inventory, habitat classification and analysis, and information transfer.

The Biological Services Program consists of the Office of Biological Serivces in Washington, D.C., which is responsible for overall planning and management; National Teams, which provide the Program's central scientific and technical expertise and arrange for contracting biological services studies with states, universities, consulting firms, and others; Regional Staff, who provide a link to problems at the operating level; and staff at certain Fish and Wildlife Service research facilities, who conduct in-house research studies.

**Front Cover: Canvasback ducks feeding on submerged aquatic plants. Drawn from nature by J. J. Audubon. Lithograph printed by J. T. Bowen, Philadelphia. Published in 1843. Folio engraved 1836. Reprinted by permission of the Maryland Historical Society, Baltimore.**

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# THE DECLINE OF SUBMERGED AQUATIC PLANTS IN CHESAPEAKE BAY

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## DECLINE OF SUBMERGED AQUATIC PLANTS IN CHESAPEAKE BAY

Since the early 1970's, many people interested in Chesapeake Bay—water-fowl hunters, fishermen, oystermen, ecologists, researchers, and waterfront residents—have been concerned about the apparent decline of aquatic grass beds in the Bay. Many people fear that this decline will force, or has already forced, some species of waterfowl to change their feeding habits and to move out of this region in search of more suitable habitats. Others speculate that the decline of these aquatic plants is an indication of serious deterioration in the "health" of the Chesapeake. Still others feel that the loss of the grasses will affect commercial fisheries in the Bay. In response to these concerns, "Summary of Available Information on Chesapeake Bay Submerged Vegetation" was compiled in August 1978 by the University of Maryland Laboratory Center for Environmental Estuarine Studies at Horn Point, Maryland. This brochure features highlights from that more comprehensive document.

## WHAT PLANTS MAKE UP THE BAY GRASSES?

Although not true members of the grass family, submerged aquatic plants (fig. 1) are often referred to as "grasses." Common names such as eelgrass and widgeongrass have evolved due to their resemblance to true grasses.

Eurasian watermilfoil, with its feathery leaves, is probably the most ubiquitous species, due to its perplexing invasion of the Bay in the 1950's and early 1960's. From 1960 to 1961, it was estimated that the area covered by milfoil doubled, from 50,000 to 100,000 acres.

Two pondweed species are common inhabitants of the Chesapeake Bay. Redhead grass has distinctive oval-shaped leaves that clasp the plant stem at the leaf base. Sago pondweed, though a relative of redhead grass, has long, tapering leaves and closely resembles widgeongrass.

Eelgrass is a common inhabitant of the lower Bay, where salinity is high. It has long, narrow, ribbon-like leaves. Wildcelery is similar to eelgrass, but is found in fresh to slightly brackish waters and has a light-colored center stripe when held to the light.

Horned pondweed is abundant in late spring and again in late summer, producing seeds twice a year. Its leaves are narrow, fairly short, and rise in pairs from each joint of the stem. Waterweed has narrow oval leaves that are arranged by two's and three's at the joints of the stem. This species is familiar to many people, since it is commonly sold for aquariums. Naiads (e.g., bushy pondweed) are common in the Susquehanna Flats and other portions of the Bay with low salinity. They vary in appearance, but tend to have fully branching stems with short, slender, oval leaves. Coontail is usually found only in fresh water at the head of the Bay and its tributaries.

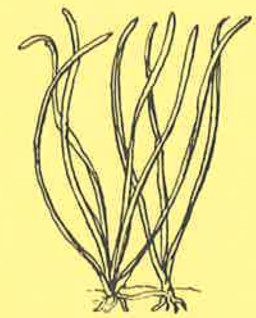
Muskgrass (*Chara* spp.), not illustrated, is an alga, but is included among the Bay grasses because of its importance as a food source for waterfowl and its physical resemblance to other grasses. Muskgrass is commonly found in fresh and brackish areas of the Bay, and is often characterized by a pungent, skunk-like odor.

**Eurasian watermilfoil**
*Myriophyllum spicatum*

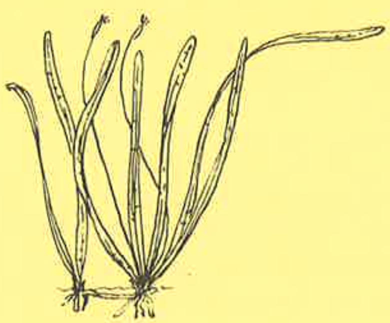
**Redhead grass**
*Potamogeton perfoliatus*

**Sago pondweed**
*Potamogeton pectinatus*

**Widgeongrass**
*Ruppia maritima*



**Eelgrass**
*Zostera marina*



**Wildcelery**
*Vallisneria americana*

**Horned pondweed**
*Zannichellia palustris*

**Waterweed**
*Elodea canadensis*

**Bushy pondweed**
*Najas guadalupensis*

**Coontail**
*Ceratophyllum demersum*

**Figure 1. Submerged aquatic plants found in Chesapeake Bay. Reprinted by permission of The Johns Hopkins University Press, from** *The Chesapeake Bay in Maryland: An Atlas of Natural Resources* **by Alice J. Lippson. 1973.**

## WHY ARE BAY GRASSES IMPORTANT?

**Primary Production.** Aquatic grasses are important primary producers. Using carbon dioxide and inorganic nutrients as raw materials, they can transform the sun's energy into carbohydrates and proteins. This process, called primary production, is of critical importance, since it forms the basis for food webs in the Bay. Some ducks, fishes, shrimp, and snails graze directly on the living grasses, while other animals (e.g., clams and oysters), filter bacteria-laden detritus (dead plant tissue) from the water to obtain nutrients. It appears that primary production in the Bay ecosystem has been drastically reduced in recent years because of the loss of submerged aquatic vegetation.

Relative organic production by submerged aquatic plants and phytoplankton in the Chesapeake Bay before and after the decline of the 1970's is shown in figure 2, along with the recent production of North Carolina sounds. At present, the amount of carbon (a measure of primary production) produced by the grasses is relatively small—only 6% of the combined production by submerged aquatic vegetation and phytoplankton. In 1963, when the grasses were more wide-spread, they accounted for over 40% of this total. In contrast, researchers estimate that submerged aquatic plants are responsible for 70% of the primary production in the estuarine sounds of North Carolina, where grass production has not appeared to decline.

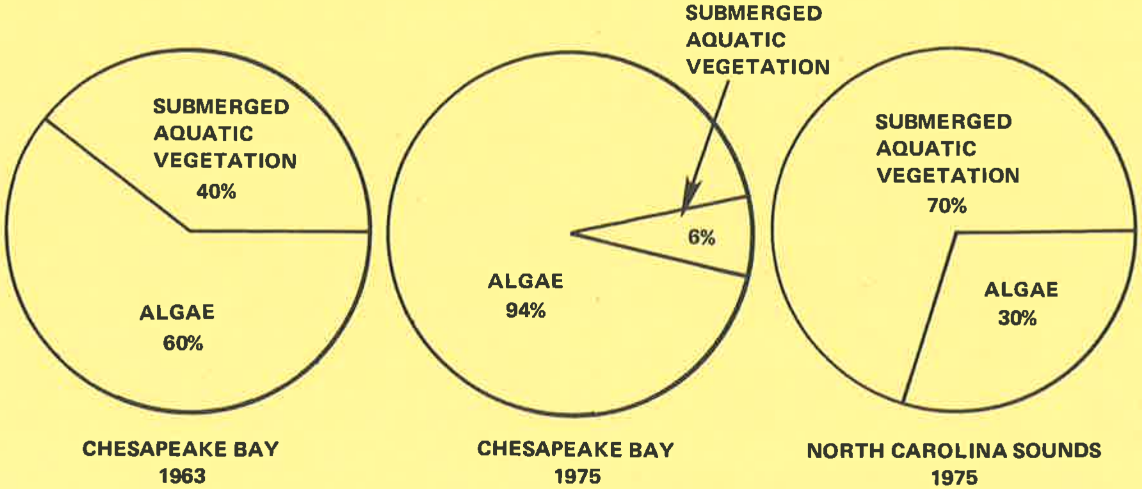



**Figure 2. Relative net primary production of submerged aquatic vegetation and algae (phytoplankton) in Chesapeake Bay and North Carolina sounds.**

The change in the ratio between the grasses and phytoplankton may affect the fish species present in Chesapeake Bay. Fishes that feed on phytoplankton, such as the adult Atlantic menhaden (*Brevoortia tyrannus*), have been harvested in increasing numbers (fig. 3). Bluefish, which feed heavily on forage fishes, including menhaden, have also increased in numbers. Large invasions of bluefish may eventually out-compete species such as rockfish (striped bass), whose numbers have been declining in the Bay. Increased catches of menhaden and bluefish have not economically offset the reduced harvest of rockfish, shad, and herring. The economic effects of grass decline may become even greater in the future if the populations of commercially valuable fishes continue to be affected.

**Habitat.** The grasses provide important habitats for many animal species. Investigators at the Virginia Institute of Marine Science found up to 33,000 animals among the submerged aquatic vegetation in lower Chesapeake Bay. In experiments when artificial grasses were substituted for living plants, the animal community which developed on the leaves was similar to that found in living grass beds, indicating that these particular animals depended on the grasses for the habitat it offered.

The variety of structure that grass beds offer, compared to unvegetated bottom, provides estuarine-spawning fishes (e.g., shad, herring, and rockfish), and their offspring with protection from predators. The shelter provided by the submerged aquatic plants may also be important to blue crabs that are especially vulnerable to predators during molting because of their soft shells and sluggish activity.

**Sediment.** By baffling currents and reducing wave action, grass beds reduce the velocity of water flow and cause suspended sediments to settle out of the water, reducing turbidity. The growth of the grasses is enhanced both by lower levels of turbidity and by the accumulation of rich organic sediment. Conversely, a loss of aquatic grasses increases the amount of turbidity in the estuary. This is similar to the dust bowl effect which occurred when vegetation was lost in the midwest prairie regions in the 1930's. As vegetation is lost, the dust (or turbidity, in this case), increases, which then buries the remaining plants and cuts down light needed for growth, which in turn results in greater losses of vegetation.

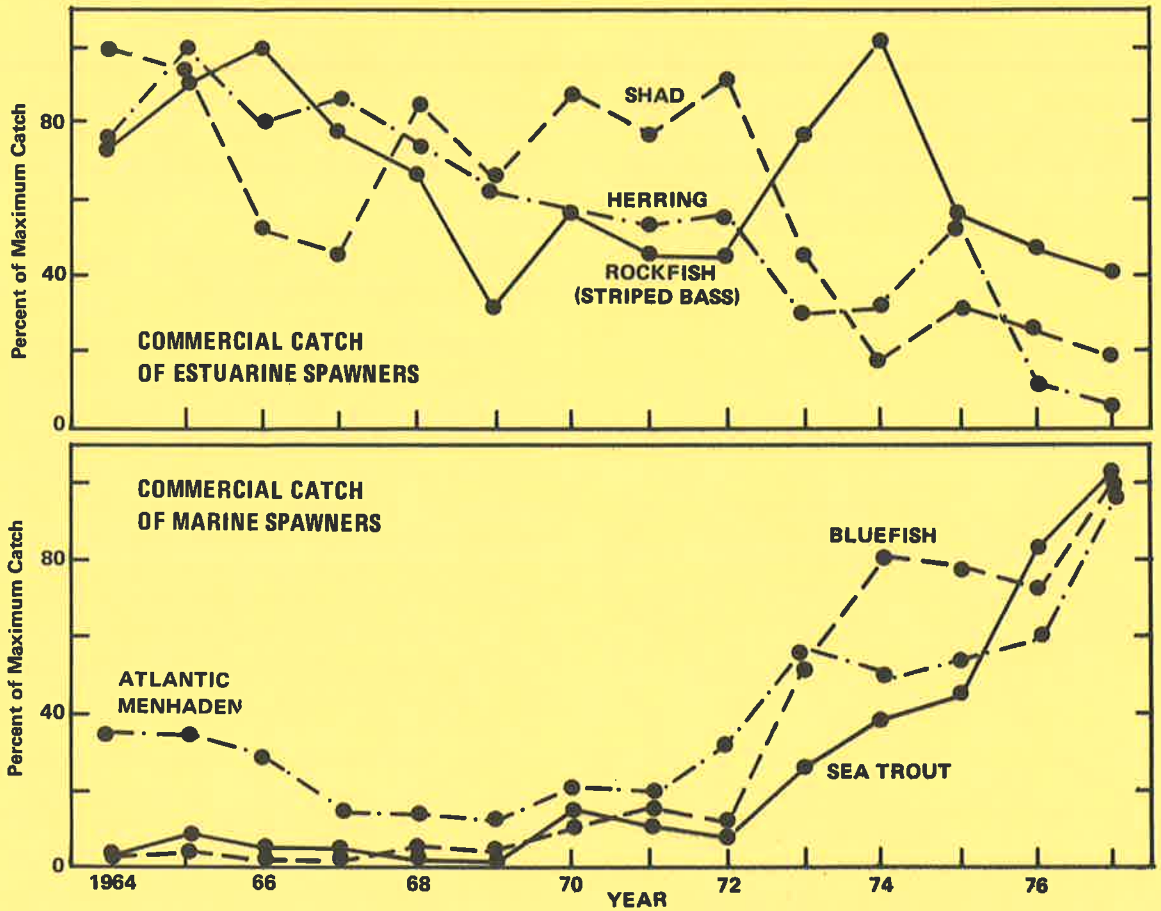


**Figure 3. Commercial catch of some fishes associated with Chesapeake Bay.**

**Nutrient buffering.** Submerged aquatic plants can affect the water quality of Chesapeake Bay by utilizing dissolved nitrogen and phosphorus for their growth. By withdrawing the nutrients from the water, they make them unavailable for use by algae, which often reach pea-soup concentrations in summer in rivers that flow into the Bay. The grasses then convert these nutrients into plant tissue, which eventually is incorporated into Chesapeake Bay food webs by animals that consume live plants or detritus. The grasses thus act as a 'nutrient pump,' recycling nitrogen and phosphorus from the sediments to the Bay and the animals in it. When a large portion of the Bay bottom is covered with grass beds, this process may simultaneously increase the Bay's productivity and decrease nuisance levels of algae. Some researchers speculate that submerged aquatic plants further diminish algal populations by secreting chemical inhibitors into the water. It appears that submerged grasses may have been subtly controlling the algae—both by competition for nutrients and by chemical inhibition.

**Economic uses.** In previous times, the colonists used estuarine grasses as mattress filling, bedding for domestic animals, cattle forage, insulation, fertilizer, mulch, and fuel. Even today, the seeds of eelgrass are harvested from the Gulf of California by the Seri Indians and used to prepare a gruel. Several species of submerged aquatic plants might serve as important renewable natural resources.

## DECLINE OF THE BAY GRASSES

The U.S. Fish and Wildlife Service Migratory Bird and Habitat Research Laboratory (MBHRL) and the Maryland Department of Natural Resources have monitored the occurrence of aquatic grasses in Maryland waters from 1971 to the present. These surveys constitute the main body of information on Chesapeake Bay grasses. By combining data from over 600 sampling stations in 26 areas, they found that the percent of stations with grasses decreased from about 28% at the start of the survey in 1971 to about 10% in 1978 (fig. 4).

Although no comparable survey has been conducted in Virginia, spot measurements of submerged grass beds by the Virginia Institute of Marine Science reflect a similar decline.

Some areas around the Chesapeake Bay show dramatic evidence of this decline (fig. 5). At the head of the Bay where the Susquehanna River enters, the lush grasses that long provided a prime feeding ground for waterfowl virtually disappeared after 1971. In the nearby Sassafras River, seven species of grasses were documented in the late 1960's, but only two have been found so far in the 1970's. Further down the Bay, the Patuxent River supported at least eight species in the 1960's, but only four have been found in the 1970's. Around Curtis and Cove Points near Calvert Cliffs, four species were documented from 1930 to 1970, but survey teams found no grasses from 1971 to 1976. The Choptank River on the Eastern Shore had only one station with grasses in 1975. Before and after 1975, there were several grass beds west of the town of Secretary to the mouth of the river. In the 1960's, surveys by the Maryland Department of Natural Resources reported many grass beds upriver from this point, but these no longer exist. At Bloodsworth and South Marsh islands, near the Virginia border, submerged aquatic vegetation was severely affected in 1976, when many other areas were improving. Estimates of total coverage of submerged grasses in the York River, Virginia, show a decrease of 865 acres from 1971 to 1974. During the same period of time, grass coverage in the Rappahannock River decreased from 1,730 acres to about 10 acres.

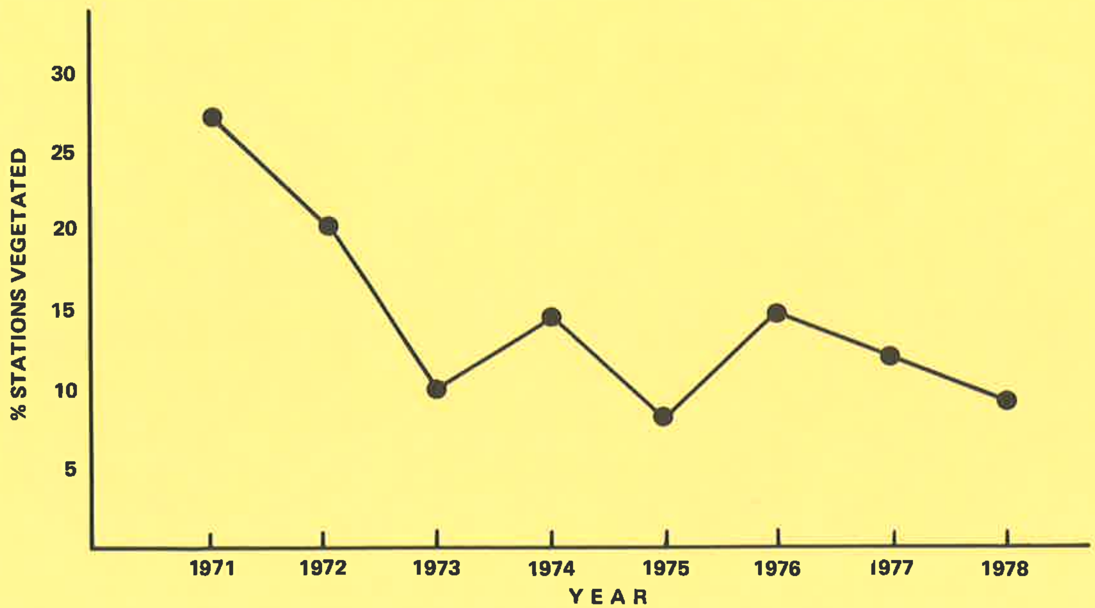



**Figure 4. Percent of stations vegetated with submerged aquatic plants.**

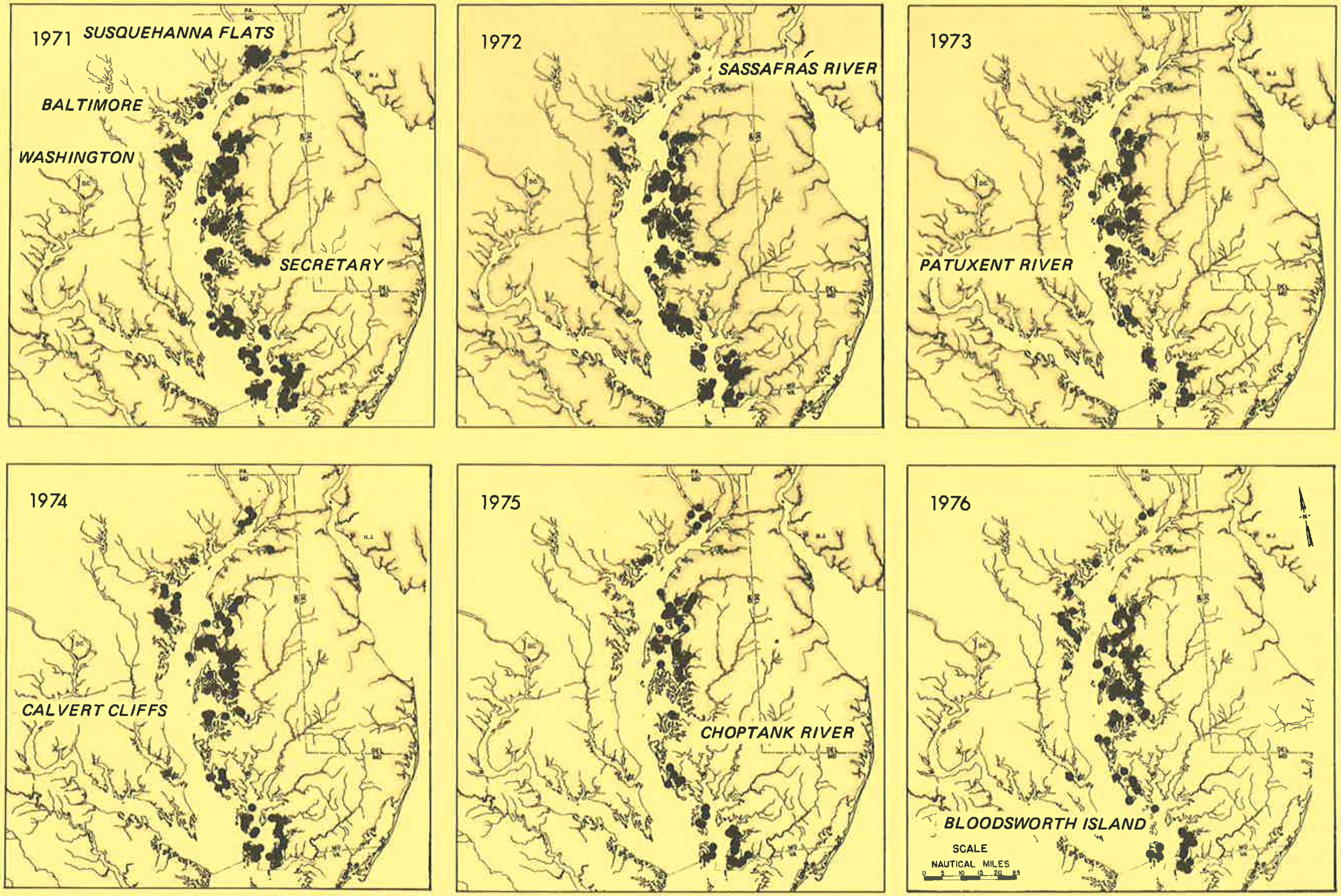



**Figure 5. Distribution of all submerged aquatic plant species in the upper Chesapeake Bay.**

These surveys (along with accounts of naturalists and watermen), clearly indicate that there has been a Bay-wide decline in grasses. Furthermore, there is evidence that all species have declined rather than a single species, with the exception of Eurasian watermilfoil which has increased in nuisance proportions. Although eelgrass alone declined in the 1930's, (possibly due to a disease), it is improbable that ten species would decline simultaneously due to any natural cause. The only other comparable accounts in the scientific literature of large-scale grass losses involve stresses imposed on the system. These stresses involve pollution by man, salinity, or substrate modifications.

## WHY ARE THE BAY GRASSES DECLINING?

Various factors have been suspect in the decline of Bay grasses, but little direct scientific evidence is available. With present knowledge, hypotheses can be formulated, but no one cause can be definitely proven. The first issue of importance is whether natural or man-induced perturbations are more likely to have caused the loss of these plants. Among the most likely natural stresses on the grass system are overgrazing by animals, the effects of Hurricane Agnes, warming trends of Bay waters, and natural diseases. Man-induced stresses include the introduction of pollutants into Bay waters.



**Rockfish (striped bass), an important Bay resource.**

*Photo Credit: C. Boyd Pfeiffer*

**Overgrazing by animals.** European carp, cownose rays, and mute swans have all been accused of damaging aquatic plant beds. Carp and rays uproot plants in search of hard-shelled mollusks and crustaceans. The mute swan consumes the plants at an estimated rate of 10 lb/day. Although the feeding habits of fish and waterfowl are responsible for localized reductions of aquatic vegetation, it is unlikely that they are the cause of Bay-wide grass declines. Carp and rays are not new to the Bay and their populations have shown no noticeable increases in the 1970's. The mute swan, although a newcomer, is limited mainly to Eastern Bay and to the Little Choptank, Choptank and Chester rivers. Considering this localized population (between 200 and 300 birds—June 1977 count by the Maryland Wildlife Administration) and evidence that Eastern Bay and Chester River submerged grasses are luxuriant compared to many other parts of the Bay, it is unlikely that swans (or any other grazers) represent a threat serious enough to decimate the submerged aquatic plants throughout the Bay.

**Hurricane Agnes.** The force with which Hurricane Agnes hit the Bay in June 1972 was comparable to the record storm that occurred in August 1933. In both instances, extensive damage resulted from heavy rainfall with subsequent drastic lowering of the salinity of the Bay. Further monitoring in the 1970's indicated depressed salinity levels (due to a variety of reasons besides Agnes), even as late as 1976. However, most of the Bay grasses can survive lowered salinities and in some cases, germination and growth rates actually increase. For example, following the 1933 storm, which had more severe winds and wave action than Agnes, vegetation was reported to have returned to prior levels within two or three years. Under normal conditions, the same response would have been expected after Agnes, since bodies of water such as the Chesapeake Bay are naturally resilient to storms. However, the expected recovery did not occur. The submerged grasses are still significantely reduced compared with the pre-Agnes level (fig. 4). The only long-term effect of Agnes was noticeable in the Susquehanna Flats area where large quantities of sediment buried the submerged grasses. After 6 years, however, the lack of grass recolonization in this area raises suspicion that other factors have prevented the return of the grasses.

**Warming trend.** There is evidence that eelgrass declined along the North American and Danish coasts in the 1930's when water temperatures increased over several years. A similar hypothesis has been proposed in explaining the recent eelgrass declines in the lower portion of the Chesapeake Bay. Since the Chesapeake Bay is close to the southernmost extent of the eelgrass range, temperature fluctuations, especially warm winters, might adversely affect its growth and reproduction. Water temperatures recorded at Solomons and Baltimore, Maryland, indicate less significant warming trends in the late 1970's than those which occurred in the 1930's. The relatively cold winters of 1977 and 1978 have not been accompanied by increases in the submerged aquatic vegetation; instead, further decreases have occurrred (fig. 4). In addition, the ten species in the upper Bay which declined in the 1970's all have ranges extending farther south. So warmer temperatures, which may have contributed to the eelgrass decline, cannot be regarded as a leading factor in the overall decline of the grasses in Chesapeake Bay.

**Natural diseases.** Upon examining dead plants after a conspicuous die-off of submerged aquatic grasses, plant pathologists have isolated a number of pathogenic organisms (i.e., bacteria, fungi, and viruses). The slime mold, *Labyrinthula,* was often cited as the reason for the eelgrass decline in the 1930's, but subsequent attempts to infect healthy plants with the isolated pathogen were generally unsuccessful, suggesting that this organism was only a secondary cause of infections. Researchers in Australia found that *Labyrinthula* was normally associated with healthy eelgrass as well as with 'diseased' plants. Therefore, disease seems an unlikely explaination in the Chesapeake Bay decline—especially since a very wide-spectrum pathogen would be necessary to attack ten different species of submerged grasses.

**Pollution — point and nonpoint sources.** Because the grasses grow near shore in shallow water, they are especially vulnerable to pollutants from adjacent land areas. Pollutant sources can be classified into two general categories: point sources, involving discharge from specific outlets (usually industrial or municipal sewage treatment plants); and nonpoint sources such as failing septic systems, runoff from agricultural lands (including sediment, fertilizer, and herbicides), or runoff from urban-suburban development.

Sparrows Point, an industrial area near Baltimore, is a current location of some point-source pollutants in the Bay.

Dip netting for blue crabs is a favorite Bay pastime.
*Photo Credit: Maryland Division of Tourist Development*

Point-source pollutants are most concentrated around large cities associated with manufacturing and include nutrients from sewage, chlorine (used to control pathogenic organisms), heavy metals, and organic toxins, (e.g., kepone). To determine whether point sources were more important than nonpoint sources in the decline of submerged aquatic plants, the locations of submerged grasses in 1971 to 1976 were plotted on maps to detect whether the losses were in progressively radiating concentric rings around major point-source epicenters. The analysis revealed no obvious pattern. Furthermore, Baygrass populations were intact in the Patapsco River downstream from Baltimore's large industrial center at Sparrows Point. Oyster-producing areas in the Chester River affected by industrial discharge had healthy grass populations. It is more probable that the overall grass decline is attributable to numerous nonpoint sources, rather than to individual point sources. Chlorine represents a special case which involves both nonpoint and point sources.

Chlorine enters Chesapeake Bay from sewage and water-treatment facilities, electric power plants, and, sometimes, from nonpoint sources, (bound with agricultural pesticide runoff). Based on data from Martin Marietta Corporation, approximately 29.2 million pounds of chlorine entered Chesapeake Bay in 1973. It is estimated that at least 3% of this amount could produce persistent by-products—chlorinated hydrocarbons. These substances, in concentrations of less than one part per billion, are known to kill shrimp. Substantial yearly increases in chlorine loading correlate with the grass declines from 1971 to the present. Recent work by the Ecological Services Laboratory of the National Park Service indicates that elodea, wildcelery, and sago pondweed show symptoms of growth retardation, loss of chlorophyll, and collapse when grown in tanks with total chlorine levels ranging from 0.05 to 0.125 parts per million, levels which are commonly found in the upper Potomac River. Until further research has been done, the possibility that chlorine is a causal factor in the Bay-wide decline cannot be discounted.

**Turbidity.** Increasing levels of turbidity in shallow waters have long been regarded as a factor inhibiting growth of submerged aquatic plants. Turbidity negatively affects plant growth through the reduction of light. Based on field data collected in the plant survey from 1972 to 1978, there is no indication that turbidities have increased significantly in the upper Bay.Some areas, such as the Honga, Manokin, Severn, and Patapsco Rivers, show increases in turbidity over the 5 years covered by the survey. Other areas, for example, the Chester, Choptank, and Nanticoke rivers and Susquehanna Flats show turbidity decreases. Maryland Water Resources data for 1968 to 1976 corroborate turbidity decreases in the Chester, Nanticoke, and Choptank rivers. Even though decreases in turbidity have been documented in these watersheds, all rivers have experienced a decline in their grass populations during the 1970's. Since reduced light is a fundamental problem for submerged grasses, turbidity is probably an important contributing factor in the plant loss in some areas.

**Excessive nutrients.** The upper Potomac River provides an example of the effects of nutrient loading on a river. Since shortly after the turn of the century, water quality in the upper Potomac River has been continually degraded by untreated or partially treated municipal wastewater associated with increasing population in the Washington metropolitan area. Wastewater discharges resulted in high levels of phosphorus and nitrogen, and low levels of dissolved oxygen in the river, promoting the growth of large nuisance populations of blue-green algae that produce unpleasant odors and affect the recreational uses of the area.

In the 1920's, the Potomac River, as well as other areas in Chesapeake Bay, was infested with an undesirable plant, water chestnut (*Trapa natans*). During the 1950's, the Potomac was overrun by dense beds of Eurasian watermilfoil. Heavy growths of water chestnut and milfoil competed with other aquatic plants for light and nutrients and often crowded out other plant species. Since 1960, the upper Potomac River has been experiencing massive summer blooms of algae (*Anacystis*), promoted by high levels of phosphorus and nitrogen. Excessive blooms effectively shade out submerged grasses, and may be part of the reason why the upper Potomac River no longer supports dense grass beds.

**Herbicides.** Herbicide usage has increased dramatically in the Bay area as land use patterns and agricultural practices have changed. Herbicides can adhere to soil particles which may then be washed into nearby streams during spring and summer thunderstorms. Herbicides either become dissolved in water or adsorbed onto bottom sediments, becoming available for uptake by submerged grasses. Since herbicides are specifically designed to kill a broad spectrum of plant species, they might be expected to have an adverse effect on aquatic grasses. Laboratory studies concerning herbicide effects upon redhead grass indicate that one in ten parts per million of the herbicide atrazine can be toxic. Further conclusions cannot be drawn until an extensive survey of atrazine and other herbicides in the Bay is conducted.

**Petrochemicals.** Petrochemicals enter Chesapeake Bay from tankers, refineries, municipal and industrial effluents, boats, and urban and land runoff. Approximately 47% of this amount comes from urban and river sources; municipal and industrial sources account for about 44%. The remaining petrochemical inputs come from oil spills, ship-generated wastes, and boats.

The impacts of oil and oil-contaminated sediments on submerged vegetation are largely unknown. Oil may coat plants, blocking nutrient assimilation and gas exchange. The relatively low incidence of oil pollution in Chesapeake Bay would suggest that it is not a major factor in the recent demise of the submerged grasses, however, more information is necessary about the biological impact of petrochemicals in an estuarine environment.

**Dredging and boat traffic.** Dredging, either for the purpose of harvesting clams or increasing channel depths, is known to physically disrupt or destroy existing grass beds. The immediate physical effects are generally confined to the area of dredging, but downcurrent turbidity and disposal of spoil in open water reduce the light needed by the grasses for growth. Boat traffic can also constitute a significant threat to aquatic grasses. In shallow areas, boat propellers physically damage plants and disrupt bottom sediments, causing turbidity. Excessive boat traffic may be involved in grass declines, but not all areas that are showing declines are popular with boaters. It is unlikely that this particular activity is responsible for Bay-wide vegetation losses, although it may contribute to the problem in isolated areas.

**Future prospects for bay grasses.** The future status of submerged aquatic plants in Chesapeake Bay has been given a high priority by the EPA Cheapeake Bay Program. Accordingly, a number of studies have been funded to seek answers for the recent decline of the Bay grasses.

As results of these studies become available, the interrelationships among water quality, the grasses and other aspects of the Bay ecosystems may be determined.

The submerged grasses are credited with a key role in maintaining the health of the Bay. A better understanding of this role through research and protection of existing grasses through management, are vital to ensuring that the Chesapeake Bay ecosystems will continue to provide man with the benefits which he has enjoyed in the past.

**Some sailing vessels like this skipjack also work the Bay waters.**
*Photo Credit: Maryland Conservationist Magazine*



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**A hydraulic dredge gathers Bay clams.**

*Photo Credit: Maryland Division of Tourist Development*

**The Annapolis waterfront is a center for Bay activities.**
*Photo Credit: M. E. Warren*

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Copies of this brochure, as well as the report on which it is based (Summary of Available Information on Chesapeake Bay Submerged Vegetation, FWS/OBS-78/66), may be obtained from: Information Transfer Specialist; U.S. Fish and Wildlife Service; NASA-Slidell Computer Complex; Slidell, LA 70458.