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Marine Resource Report No. 84-7

Development of a Hard Clam Seed Hatchery

by William D. DuPaul

The hard clam (Mercenaria mercenaria) supports an important commercial fishery along the Atlantic coast. Virginia production peaked in 1965 at about 2.5 million pounds of meats with a value of 1.4 million dollars; lowest production in recent years occurred in 1978 with 0.5 million pounds of meats harvested with a value of 0.46 million dollars. On a national scale, Virginia's share of the total U.S. production of hard clams declined from 10% in 1970 to 5% in 1980, despite increases in clam prices and the number of harvesters. Further declines in production are projected if the fishery continues in its current fashion.

The Joint Legislative Audit and Review Committee (JLARC) in its 1983 report, "The Economic Potential and Management of Virginia's Seafood Industry," estimated that total hard clam production has the potential of being increased 240% by adopting one of several management options. One options with such potential involves mariculture activities along with revisions in harvesting technology.

Past hard clam culture research and development activities at VIMS Wachapreague Laboratory have detailed procedures for spawning clams for seed production. Additional field grow-out experiments to raise the juveniles to market size have also proven successful. Even though the private sector has expressed interest in these pilot activities and operations, on the whole, clam harvesters have been apprehensive about entering into such a venture on a large scale.

The primary purpose of the proposed facility is the annual production of approximately 100 million hard clam seed of appropriate field planting size (6-8 mm). It is anticipated that between 70-80 private growers utilizing one million seed per year could be supported by these efforts. Once the system is implemented and field grow-out progresses, an annual clam production of 50 million littlenecks could be expected. Considering the price per clam has fluctuated between 10 and 15 cents over the past few years, it is anticipated that the annual gross production would be valued at between 5 and 7.5 million dollars, with three to four years after the facility becomes operational. The grow-out of hard clam seed has proven successful in the intertidal area of the eastern shore with an 85% survival rate. Similar successful operations in waters up to 20 feet in depth remains to be proven.

Major constraints for deepwater hard clam mariculture exist because of the necessity to protect clam beds from predators using large plastic mesh screens. Regulations would be necessary to restrict boating and fishing activity above these beds to prevent the protective screens from being damaged. In addition, changes in harvesting regulations would be needed to make these operations cost efficient. It may be necessary to reconsider the use of mechanical or hydraulic harvesting devices for use on privately leased clam growing areas. It is unrealistic to consider that a clam grower will invest thousands of dollars in clam seed but yet will not be allowed to protect or harvest his crop in an economic manner.

Through such programs, a facility of this magnitude may be able to offset the decline of natural clam production, as well as

stimulate the development of private clam growing enterprises by providing readily available, good quality seed. By these means both traditional harvesters and new individuals could benefit from this project.

We are confident that mariculture operations for clams in the Chesapeake Bay are ready to be developed. In order to insure such operations are cost efficient, changes in harvesting regulations and modifications in bottom leasing policies may have to be considered.

Scientific Management of Virginia's Important Finfish Species

by Herbert Austin

Virginia's finfisheries may be placed into three general categories, Bay and tributaries, coastal, and continental shelf fisheries. Each is managed by a different Commission or Council. These include the Virginia Marine Resources Commission (VMRC in the Virginian territorial waters, the Atlantic States Marine Fisheries Commission (ASMFC) in the coastal waters for interstate migratory species, and the Mid-Atlantic Fisheries Management Council (MAFMC) in the Fisheries Conservation Zone (200 mile limit). Most species migrate through the jurisdiction of two or even three management zones during a single seasonal migration. Most species are both of commercial and recreational value, competitively pursued by commercial and recreational fishermen. There is even competition between commercial gear types. Consequently, management of Virginia's finfish stocks presents several interesting problems.

Most species are not year round Bay residents. Rockfish, for example, that spawn in the tidal freshwater of the Bay's tributaries, leave the Bay for eight months out of each year. The croaker and spot, on the other hand, spawn in the ocean, use the Bay and tributaries as a winter nursery ground, spend the spring and summer in the Bay, then migrate south of Cape Hatteras each fall. They are only resident in the Bay some five months each year. This means that unilateral management in Virginia is useless. Interstate management plans under ASMFC sponsorship must be developed for those species that migrate across state boundaries. This is

difficult as each state's preceptions, priorities and pressures are different.

There is only one species of fish in the bay that is not sought by both commercial and recreational fishermen. This is the menhaden. All others are common target of both fisheries. A fishery, pursued by only one group, is easier to manage. There is no need to allocate the resource between sport and commercial fisheries. The pie doesn't need to be divided between two competing groups.

Most of Virginia's commercial finfish are pursued by several gear types, each making up their own fishery, for example, the Bay pound net and coastal trawl fishery. Most of these fisheries are "multi-species" fisheries, that is, the gear is non-selective and captures several species indiscriminately. It is difficult to manage a stock or species when it is the target of one fishery, and the by-catch of another; or, it is one of several species that is taken in a single haul. Two examples include the Bay rockfish (striped bass) gillnet and coastal flounder trawl fisheries. A management plan for the rockfish gillnet fishery would necessitate a mesh size that would eliminate the white perch fishery, and the rockfish spawning ground closure impacts the shad fishery. The 4 1/2" mesh size for the coastal trawl fishery for flounder potentially eliminates the croaker and weakfish fishery in the fall as these "thinner" species slip through the meshes. This is true of all fisheries where there is a multi-species catch. Virginia should give careful consideration to management by gear rather than stock.

There are data from Maryland and New York that suggest that the recreational catch of croaker, bluefish and striped bass may be ten times the commercial catch. Yet, data on this critical component are not collected.

Again, only the menhaden is alone. It is pursued only by commercial fisheries, and for the most part primarily by the purse seine.

Fisheries management, particularly the development of fishery management plans, requires biological information on the stocks to be managed. This information includes studies locating the time and location of spawning grounds, the fecundity (number of eggs), age at sexual maturity, growth rates, and on a continuing (monitoring) basis, rate of recruitment and mortality.

The concept of Optimum Yield, as defined in the revised Section 28.1-23.1 (Senate Bill 167) prevents overfishing, while achieving, on a continuing basis, the maximum biological yield, as modified by relevant social and economic considerations. In short, to catch as much as possible, efficiently as possible, without overharvesting the stock or putting anyone out of business. In order to achieve this the recruitment rates must equal, or exceed, the mortality rates. When they don't, a stock declines. The rockfish recruitment rate has not equalled the mortality rate since 1970. Consequently, the stock has declined.

In Virginia, recruitment rates are estimated by VIMS by assessing the abundance and distribution of juvenile finfish (the same is true for blue crab and oyster). This is accomplished by using either an otter trawl or a beach seine to catch and count the

young fish. Different species are abundant in the Chesapeake Bay and its tributaries at different times of the year, consequently the surveys conducted by VIMS go on monthly, year round, and have since 1955. A single, or even short period of years is of little use. Recruitment must be an annual, and an ongoing committed effort. It can be expensive, is unglamorous to most scientists, and is often difficult to interpret due to the affects of the environment, both man-made and natural. It provides however, an index of health and future size of the stock, an early warning of pending fishery decline or failure, and an index of the success of a management plan.

With this is mind, a recruitment index can be the trigger mechanism in a management plan to activate more stringent regulations, in advance of, and possibly heading off, a stock decline. Just as importantly, it can also serve as the indicator to relax the stringent regulations when the stock has recovered.

Mortality, on the other hand, the rate at which the stock is harvested or dies a natural death, is generally inferred from the VMRC catch data. This poses a problem as the only catch reported is that generated by the commercial fisheries. For some Bay species the recreational catch is ten times larger. Further, effort data are lacking. Catch needs to be expressed as catch-per-unit-effort (CPUE). Ten thousand tons taken by ten boats in a 100 day season, yields a catch-per-unit-effort of 10 tons/boat/day; but, if 10,000 tons are taken the next year by the same ten boats, fishing 200 days a year, then the catch-per-unit-effort is 5 tons/boat/day, a 50% decline in the stock.

The Chesapeake Bay initiatives, proposed by the Governor, will enchance the VMRC fisheries management and statistics program, such that the necessary data will be available in the time frame, and with the accuracy needed for active fisheries management. The addendum research support provided to VIMS for the 1984-86 biennium will provide funding for scientists in support of studies to understand interannual fluctuations and trends in recruitment, and the decline in James River spatfall. Careful monitoring of the balance between recruitment and mortality will allow Virginia's stocks to be managed for their Optimum Yield.

Summary of Problems

1. Fisheries Management for most species taken in Virginia, or by Virginians in the Fisheries Conservation Zone, must be interstate or regional, with the attendant problems of other states priorities and pressures.

2. Fisheries pursued in a fluctuating environment, by two competing user groups, requires flexible management, capable of altering strategies as recruitment and/or mortality rates change.

3. Catch data are currently inadequate, in spite of efforts by VMRC staff, to provide timely information for management decisions. Effort data are nearly non-existant. Causes for recruitment fluctuations are poorly understood.

Answers

1. VIMS has, and can, provide data and information on the biology of the species for development of Virginia Fishery Management Plans. A population dynamicist is being hired, as well as a fish and oyster biologist. The population dynamicist will be assigned to help VMRC develop FMPs.

2. The size of the "pie" (stock size) available for the users will vary from year to year as recruitment and mortality rates fluctuate. VIMS will assess the size of the "pie" and recommend what slice must remain to provide future recruitment. The remainder will be available for the VMRC to allocate among the users.

3. The Chesapeake Bay Initiatives will provide needed personnel and support for the VMRC Fisheries Management and Statistics programs. VIMS will work in cooperation with them providing recommended recruitment levels for the FMPs, and their annual modifications.

The Repletion Program

by Dexter S. Haven

Beginning in the late 1950's when MSX entered Chesapeake Bay, statewide oyster production declined drastically from about 3.5 million bushels annually to about 1.6 million in 1980. Most of this decline has occurred because of the absence of production from leased bottoms. In contrast, production from the state public bottoms have declined to a lesser extent. However, the absence of production from leased bottoms has imposed an ever increasing harvest pressure on the state's public bottoms.

The reason for the major decline in production from leased bottoms is due in part to the still lingering impact of MSX, however, a major reason for the continued low production is due to outdated laws, regulations and practices which prevent full utilization of the state's still enormous potential.

It is our view that statewide production on public and leased bottoms can and should be increased. Toward this goal the JLARC report gives six basic options for increasing oyster production which are based in part on an earlier report by VIMS.

Options and Methods for Increasing Production

The JLARC report gives six basic options for increasing oyster production. These options were based in part on earlier VIMS studies.

A. Maintain the status quo: (this policy should not be pursued).

Result: A continued decline would occur, and production would stabilize around 8 million pounds annually.

B. Aggressively promote Virginia's oyster products:

Result: Increased consumer demand could increase oyster production on public and private beds by 401,000 lbs. by 1990. This policy is controversial and is not discussed here.

C. Double repletion expenditures on public grounds at a cost of $670,000:

Needed: An increase in funding.

Result: A gain of 500,000 lbs. is projected.

D. Lower the price of seed oysters to increase use on private and private bottoms:

Needed: Changes in traditional laws and policy of the use of seed areas in the James River and a more active management role by the VMRC.

Result: Increased production by 1.7 to 3.0 million lbs. Benefits from this course of action could amount to 2.3 to 4.0 million dollars annually.

E. Manage unproductive public grounds by state planting of seed and shell and allow dreding as a harvest method (only if regulated and if dredged areas are repleted).

Result: Increase state production by 3.4 million lbs. and by 4.7 million dollars annually.

Needed: Legislative action to allow such policies.

F. Lease portions of the state Baylor Grounds:

Result: If 1,000 acres were leased, production could be increased by up to 4. 6million lbs. annually. The benefits could equal 4.6 million dollars annually.

Needed: Legislative action.

Available: A VIMS survey of most Baylor Grounds, along with an evaluation of their extent, productivity, spatfall potential, shell reserve, salinity, etc.

Considerations

It goes without question that the goal should be to increase statewide production so we are no longer dependent on imports to meet Virginia's need. However, if options C-F are implemented, many changes are needed. These include changes in administrative policies and laws relating to the management and use of the public oyster grounds so full advantage may be taken of their potential. Long range management plans must be developed based on available biological data and on good management practices. Needed to achieve this goal is a good exchange of information between VMRC, VIMS and other state agencies.

Some Biological Considerations to Increase Production

A. Utilize to a much greater extent the still enormous productive potential of the James River seed areas.

1. Permit dredging in certain areas if the area is repleted.
2. Use cost effective gear to transport and replant seed.

3. Allow limited direct use in specific areas by private interests under VMRC supervision.

4. Continue and expand research in the James River to determine why spatfall has declined since 1960 and where the best areas are for optimum spatfall on shell substrate. Already a fund of information exists and an intergrated study of this estuary was begun July 1, 1984.

B. Lower cost of shell cultch.

1. Exploit instate buried shell deposits for the sole use by the state. Needed is a study of the state's buried shell resources and an engineering study of how this resource may be economically harvested, transported and planted.

2. Use substrates other than oyster shell for cultch, for example, surf clam shells or shale.

3. Many areas with a smooth bottom are underlain with shell deposits (1-12 inches deep). These deposits may be raised by mechanical means and reused.

C. Much improvement has been made by the VMRC in the last four years in respect to planting shell at the optimum time and place and in planting seed in the best growing areas. VIMS is now in a position to provide a historical guide as to the optimum time to plant shell in each estuary.

Badly needed by the VMRC is a program to systematically evaluate the results of their repletion efforts and a system (computer) to store such information.

Conclusions:

1. The basic problem is low statewide oyster production.

2. Long range plans need to be developed to increase production on public as well as leased bottoms.

3. To achieve realistic goals, changes in laws and regulations are needed as well as changes in traditional methods of management.

4. In the formulation of future management plans, close cooperation is indicated between VIMS, which has a large store of biological information, and the VMRC, which must manage the resource.

Comments on Water Quality/DO-Nutrient Enrichment Aspects

by Bruce Neilson

Over the past decade there have been significant improvements in water quality in general as a result of higher levels of treatment for both municipal and industrial wastewaters. At present most water quality problems in Virginia's tidal waters are of a local nature. However, trends in population growth suggest that the tidal freshwater portions of both the Potomac River and the James River will continue to be stressed and that those stresses could become quite severe within the next decade.

Despite water pollution control measures reputed to have cost a billion dollars, the upper Potomac estuary experienced severe blooms of blue-green algae in the summer of 1983. The ecological consequences of these blooms are not well-known, but the algal types involved are believed to be less desirable as food sources for the zooplankters, that are a food source for finfish. The blooms also represent an unstable situation which could result in a crash of the algal population, which in turn would reduce dissolved oxygen levels and possibly cause fish kills.

During the summer of 1983 chlorophyll levels in the upper tidal James River reached levels on the order of 50 to 60 micrograms per liter, not bloom levels but ones indicative of an enriched system. Anticipated increases in wastewater loads to the upper James suggest that within the next decade substandard dissolved oxygen levels will occur and that the additional nutrient enrichment

might result in algal blooms comparable to those recently observed in the Potomac.

We are not aware of any studies that have demonstrated that nutrient enrichment has directly impacted the finfish populations in an estuary. However, we do know that dissolved oxygen levels do affect virtually all aquatic organisms - for example, crab jubilees result from low DO situations. We also know that the phytoplankton are the primary producers in the system and substantive changes at this base level are likely to be felt further up the food chain.

It is recommended that constant attention be given to these two water bodies to insure that water quality is protected to the greatest extent possible. Research on the effects of nutrient enrichment on finfish would help to define the water quality criteria which are necessary and beneficial to this resource. I would note that these problems are not static. Inter-basin transfers and other diversions, consumptive uses of water such as irrigation of agricultural lands, and other uses could exacerbate the problems. On the other hand the Governor's Initiatives, for example implementation of best management practices on agricultural lands, will reduce the problem over the long haul.

A related problem is bottom water anoxia. Generally speaking, the areas with experienced oxygen depletion tend to lie in the upper portion of Chesapeake. Parts of the lower bay and the lower portions of the Rappahannock and York estuaries do regularly experience episodes of depressed DO. It is our recommendation that a limited monitoring effort be developed to follow these episodes in Chesapeake Bay. Additionally research should be undertaken to

determine how and why density stratifications vary, and how stratification affects water quality, especially oxygen levels. It is our opinion that the data base for the lower York River is far superior to that for any other estuary in Virginia, and consequently we believe that initial research efforts should be focused on the York.

The linkages between water quality and marine resources are more clearly defined for shellfisheries. In order to address various water quality and management issues, since 1980 VIMS has been working with VMRC, the SWCB, and the Health Department on the Interagency Task Force for Shellfish Resources. One general outcome of that work has been the realization that management of this resource would be improved if each agency had access to the other agencies' data sets and that access were rapid and easy. Accordingly, the Task Force has been working to define the various data sets and the needs of such a shellfish data base system.

It is almost certain that every fishery would benefit from a coordinated data management system. VIMS can contribute greatly to efforts of this type because the Institute collects much of the data that is generated, has computer capabilities, has staff trained in the statistical and other mathematical skills necessary, and has the fisheries scientists who can guide the analysis and interpretation of the data.

It is recommended that the Commission make known its desires regarding coordinated data bases, so that these can be incorporated in the work to be done under the Governor's Initiatives for Chesapeake Bay. Because the Shellfish Task Force has worked on this

for several years, perhaps organization of an oyster data base should be a high priority under the initiatives.

Toxic Chemicals

by Robert J. Huggett

Virginia is not without its problems relating to toxic chemicals. Marine resources can be damaged by toxic chemicals in two ways: (1) the first is by their presence in water or sediment at concentrations which cause biological damage to the resource. This damage may be acute, causing death, or chronic, causing lower rates of recruitment and/or growth; and (2) the other avenue of damage may be brought about by the animals concentrating the chemicals to such levels that they are potentially hazardous for humans to consume or they taste bad.

This afternoon I will very briefly review three specific areas of concern with toxic chemicals. The first deals with the continuing problem of Kepone.

1. The Institute has conducted extensive laboratory and field studies with Kepone. These studies have shown that marine life in the James River and Chesapeake Bay are most probably not damaged biologically due to the presence of Kepone. Although damage does occur at levels tested in the laboratory, these levels are far above those found in the river. For example, levels necessary to kill animals in the laboratory are 100 to 1,000 times higher than those found in the river and concentrations causing chronic effects are 10 to 100 times higher than found in the river. However, Kepone concentrations in some species are still above those considered safe for consumption by health experts. Levels are declining in most species tested as Kepone-laden sediments in the river are covered

with clean sediments. Processes which might disrupt sediments and potentially redistribute Kepone, e.g., major storms, need to be watched very carefully if they occur.

2. Chlorine - Environmental problems arising from the discharge of chlorinated effluents into marine, estuarine and fresh water have been recognized for over 10 years. In 1972 the Institute determined that fish mortalities in the James River were due to high levels of chlorine. Subsequent to this incident VMRC and VIMS worked together to develop methods to deal with potential chlorine problems in estuarine areas. Over the last 8 years we have conducted a number of bioassay studies to better define the levels of chlorine toxic to marine life. The most recent of these studies using oyster larvae and chlorinated sewage effluent have just been completed. In late 1982 the SWCB established a task force to recommend limits for chlorine residuals in Virginia waters. Although the specific limits to be adopted have not been established, the Institute will recommend that bioassays be used to set the limits in estuarine areas where oyster spawning occurs. These tests are deemed necessary, since the latest studies indicated that oyster larvae, in a stage not previously tested, were very sensitive. Plans to reduce chlorine discharges to estuarine and fresh waters are part of the Chesapeake Bay initiative and implementation of these plans should result in improved water quality for both estuarine and freshwater organisms.

3. PAHs - Fish from the Elizabeth River have skin lesions, fin rot and abormalities of the gills and liver. Most striking, in one area of the river, is the presence of cataracts in almost 100%

of the fish collected. The causative agent of these abnormalities appears to be a group of toxic chemicals called polynuclear aromatic hydrocarbons. The Elizabeth River may contain the highest levels of these compounds of any estuary in the world. But concentrations in the Bay and other tributaries are likely increasing as people move to its shores and more fossil fuels are burned. In light of the problems observed in the Elizabeth we must ask ourselves:

(A) At what point will the fisheries of the Bay become impacted?

(B) What other toxic chemicals are entering the system?

(C) What types of actions can be taken to lessen potential problems?

These and other questions need timely answers. We notified Secretary Diener and other agency heads of the potential problem in the Elizabeth well over a year ago. We are now actively engaged in research which will provide management agencies, particularly VMRC, with advice concerning what will likely happen if major dredging activities, such as those associated with harbor deepening, occur in the Elizabeth. Some of the studies being conducted include:

(A) Surveys to define the mass of PAHs in the Elizabeth;

(B) A study to determine the loss of sediments and PAHs during the release of dredged material in the rehandling basin;

(C) Biological studies to determine the effects of PAHs on fish, oysters and benthic animals; and

(D) Surveys of toxic organics in other tributaries systems. These investigations are ongoing and may indicate problem areas thus far unknown.

As the results of these and other studies relating to toxic chemicals become available or as other potential problems arise, we will keep VMRC informed.

Wetlands Management in Virginia:
Status, Research Needs and Recommendations

by Gene Silberhorn

The complete interdependency of fisheries management and habitat management is often overlooked conceptually by many who are involved with the resources of Chesapeake Bay. Fortunately, the General Assembly has seen the connection clearly and placed with the Marine Resources Commission the responsibility for managing both fisheries and the habitat which supports them.

Effective habitat management requires not only clear policies but also thorough development of the scientific basis for the policies and adequate technical support for management process. The Virginia Institute of Marine Science is charged with provision of both supporting research and technical assistance in the Virginia management process. These tasks are accomplished primarily by the Wetlands Ecology Department of the Institute.

Current Status

The desire for shoreline development and alteration has increased significantly in Virginia over the last decade despite restrictions and regulations. The number of shoreline permit applications passing through the regulatory process has more than doubled during this period. Simultaneously, reductions in the level of federal participation, under the "New Federalism" concept, have placed increasing importance on the Commonwealth's habitat management program.

At the present time, Virginia's program of combined state and local management of wetland resources has been in place for approximately twelve years. In general the system seems to be meeting the objectives of the General Assembly. With the exception of non-tidal wetlands, the majority of important habitat areas fall under the purview of either the VMRC or local wetlands boards. Shortcomings in the system result primarily from the need to constantly update and enhance the basis for management decisions.

Needs

Experience over the last several years indicates several aspects of the current resource management program which are weakest. These include continuing research in support of management questions, development and upgrading of technical support materials, and formal review of the management scheme efficacy. While each of these items is currently pursued at very restricted levels of effort, the overall program's development is making a vigorous pursuit of each essential.

The need for active research in support of the management program is virtually self-evident. Research describing the structure and functioning of wetlands led to the development of management programs in the late 1960's. As management efforts become more intense and more sophisticated it is essential that basic research continue to provide rationale for decision makers. To that and, there are several research topics of great importance to the current wetlands management efforts.

1. Describe and evaluate tidal freshwater ecosystems of Virginia's major rivers. These resources serve as primary spawning and nursery sites for anadromous fishes such as striped bass, shad and river herring as well as a source of nutrients and detrital food for estuarine plants and animals, respectively. Requests for impact evaluations of water diversion and impoundment proposals involving these systems have already been submitted to VIMS.

2. Describe and evaluate non-tidal wetlands, often found associated (as a continuum) with freshwater marshes and swamps. These wetland types are mainly bottomland hardwood swamps. They seldom receive the attention of coastal resource managers, yet they often exhibit values simliar to tidal wetlands. There has been limited research conducted on the ecological links between non-tidal and adjacent tidal freshwater ecosystems. Preliminary studies indicate that bottomland hardwood forests in concert with associated tidal freshwater wetlands contribute detritus and nutrients necessary to sustain anadromous fish spawning areas.

3. Evaluate wetland mitigation and compensation. Development pressures have brought about the concept of wetland compensation; where a wetland being displaced by construction is exchanged for the creation of a new marsh at another location. There are many arguments pro and con on this 'trade off' concept. Research in this area is virtually nonexistant and is sorely needed if we are to continue to make sound judgements within State wetlands program.

4. Describe and evaluate the role of submerged aquatic vegetation beds (SAV). A preliminary study at VIMS has recently

demonstrated that SAV are prime blue crab nursery and shedding sites. Studies of this type needed in concert with other works that pursue other aspects or factors affecting life cycle of this commercially important species.

Along with an active research program, the wetlands management efforts of the Commonwealth require substantial technical support including: advisors to interpret current research findings; trainers to educate non-professionals about environmental considerations in resource management; and source materials for reference in decision making. The Institute currently works to supply all three of these needs, but a critical need remains in the development of source materials. Specifically, the Wetlands Inventories, initiated in response to the 1972 Wetlands Act, must be completed and routinely updated. The inventories have proven very useful in areas where they are completed. Routine updating would make them even more useful as they would form a long-term data base facilitating both management decisions and evaluations of the management program. In order to undertake this task in a meaningful way additional manpower and financial resources will be needed. The inventorying methodology and mechanics of promulgation have all been satisfactorily established, so nothing other than additional resources are necessary.

The final need existing in the Commonwealth's wetland management program is development of a formal evaluation of the program's efficacy. The Virginia system has been implemented to varying degrees over the last twelve years. The experience gained during that time and the relative uniqueness of the state's

management scheme argue strongly for an analysis of the system. This is not to imply anything is critically wrong with the system, but the evolving nature of both the understanding and the management of wetlands nationwide necessitate periodic reviews. This effort should be designed to evaluate the effectiveness of Virginia's wetlands management program with respect to its goals and objectives for related resources, such as fisheries.

Recommendations

The continued effective management of the Commonwealth's wetland resources will require three specific undertakings over the next several years. First, a conscientious effort to expand and enhance the scientific understanding of all of Virginia's wetlands is essential. This effort must address basic knowledge in areas previously not studied (such as tidal freshwater systems) and applied problems (such as evaluation of mitigation efforts). Second, source materials available to the management system must be enhanced (specifically the wetlands inventories). Third, a thorough review of the management system should be undertaken to assume that it remains appropriate to the Commonwealth's resource management objectives.

All of these needs can only be addressed by increasing available resources (funding and manpower). None of these efforts will require massive new commitments, but none can be adequately met by reallocation of existing resources.