ASMFC Habitat Management Series #1

Atlantic Coastal Submerged Aquatic Vegetation:

A Review of its Ecological Role, Anthropogenic Impacts State Regulation, and Value to Atlantic Coastal Fish Stocks

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Introduction

by

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Background

The decision to focus ASMFC's attention on submerged aquatic vegetation was prompted by increasing concerns that the coast-wide health of this valuable resource may be declining, that certain human activities may be adversely affecting SAV, and that the Commission may need to take action in its fishery management plans (FMPs) to protect SAV as valuable fish habitat.

Based on those facts, Habitat Committee Chair Tom Fote (NJ) established the Submerged Aquatic Vegetation (SAV) Subcommittee on May 28, 1996, and made three assignments to them:

1. Prepare a report on the ecological value of SAV, connections between SAV and fish stocks managed by the ASMFC and its member states, adverse effects of human activities on SAV, and existing state programs and policies related to SAV;

2. Compile background materials that will be useful to states and the Commission as they incorporate the ecological importance of SAV in their fishery management programs; and

3. Present a report to the full Committee and Commission at the October 1996 Annual Meeting.

A fourth task evolved as the Subcommittee contemplated how the Commission and states could use the technical information to improve management of Atlantic coastal fish stocks and their habitats. Those efforts led to a proposed Commission policy and several recommendations for implementation at the state level, which are discussed later in this introduction.

The SAV Subcommittee accomplished these four tasks. This report presents a summary of its work and four important technical papers which review the ecological value of SAV, its regulation by the Atlantic coast states, anthropogenic impacts, and the importance of SAV to fish stocks managed by ASMFC.

Scope

The general scope of SAV covered by this report includes rooted, vascular, flowering plants, that, except for some flowering structures, live and grow below the water surface. This includes 13 species of marine seagrasses, as well as 20-30 species of freshwater macrophytes found in tidal freshwater and low salinity areas of Atlantic estuaries.

The technical papers in this report do not all address the same species of SAV. For example, Thayer et al. refers only to seagrasses; some regulations for macroalgae are included in Ernst and Stephan; and Laney includes nontidal freshwater vegetation in addition to the species described above. However, the ecological value of all SAV discussed, with the possible exception of macroalgae, is analogous (Heck and Crowder, 1991; Stevenson, 1988).

Ecological Role

The technical paper by Gordon Thayer, Mark Fonseca, and Judson Kenworthy provides a brief summary of the ecological value of seagrasses. While their discussion focuses exclusively on marine seagrasses and not on all species of submerged aquatic vegetation, many of the ecological roles played by seagrasses have parallels to other vegetation. As noted by Heck and Crowder (1991), all species of submerged vegetation provide a common function in aquatic systems, whether in freshwater or coastal marine ecosystems. As Heck and Crowder conclude from the literature, the high ecological value of SAV is supported by observations that animal abundances in vegetated habitats are often several orders of magnitude greater than in unvegetated areas.

Seagrasses are a vital component of one of the most productive ecosystems in the world. Submerged beds of aquatic vegetation provide chemical cycling, physical stabilization, food, and shelter to valuable nearshore communities. Most importantly to ASMFC, these beds provide direct ecological value to many state-managed species, including striped bass, menhaden, spot, eel, black sea bass, tautog, bluefish, summer flounder, American lobster, weakfish, croaker, red drum, and spotted seatrout. For those species and their prey, healthy SAV beds form the basis for healthy stocks, successful fisheries, and long-term sustainability.

State Regulation

Laura Ernst and Dianne Stephan's paper includes the results of a coastwide review of state regulatory and management programs related to SAV. Their informal survey encompassed all SAV species, including macroalgae and vascular plants. In addition to their basic queries about state activities the authors also asked questions about overall program effectiveness and about any fishing gear restrictions imposed to protect SAV. While limited to the impressions of relatively few respondents, the results do provide a valuable glimpse of state programs. The authors hope that the information in their report will be useful in states considering similar actions or to the Commission as it contemplates an appropriate role in each FMP.

Anthropogenic Impacts

William Goldsborough's summary of SAV health in Chesapeake Bay offers a regional assessment of the effects of human activities on SAV beds. His paper serves two major purposes -- it offers insights to other managers who may be evaluating the health of SAV in their jurisdiction and it provides details for managers contemplating action to address specific human activities. Although research on the direct impacts of fishing activities on SAV is very limited, the author does provide examples of how crab scrapes, haul seines, aquaculture ventures, and other fishing activities may affect SAV.

Value to ASMFC Managed Fish Stocks

Wilson Laney's paper establishes the ecological connection between seagrasses and those fisheries covered by the 20 management plans under Commission jurisdiction, or of special interest to member states. Individual species accounts provide an introduction that can be complimented by reviewing the separate plans. Ecological connections are based on direct relationships or secondary roles such as forage. Even when no direct utilization of SAV species exists, reliance may occur if managed species prey upon resources which utilize SAV. The full range of those primary and secondary connections are discussed in the paper. Although clear connections for numerous species are established, the author acknowledges that further SAV utilization may be apparent in a more complete review of the literature.

Recommendations and Next Steps

The Subcommittee's final report to the Habitat Committee on October 21, 1996, included seven recommendations for immediate action:

1. Develop a model state policy for SAV, drawing as appropriate from existing policies such as the South Atlantic Fishery Management Council and the Chesapeake Bay Program.

2. Work with state and federal water quality agencies to develop water quality criteria to ensure SAV survival and health.

3. Develop a standard protocol for mapping and monitoring, including procedures for determining presence and for follow-up surveys.

4. Collect information on natural variability so states and the Commission can determine the effects of human activities.

5. Offer assistance to the Commission's species boards to apply the findings of this report in the context of each FMP and related research and management initiatives.

6. Prepare a Commission policy or resolution on SAV, communicating the importance of SAV to ecosystem health and fishery productivity.

7. Prepare a special ASMFC report based on the SAV Subcommittee's work and publish for general distribution.

The SAV Subcommittee has progressed on several of these fronts. A policy on SAV conservation has been forwarded to the Commission for review and adoption. The development of water quality criteria to enhance SAV perpetuation, and investigation of a standard mapping protocol are both addressed in the policy. Recommendations for integrating SAV conservation into ASMFC fishery management plans are also addressed in the policy. Finally, the development of this report serves to provide the background information for ASMFC's SAV policy development, as well as supply important information which can be incorporated into ASMFC fishery management plans.

Application to ASMFC Fishery Management

Standard information for each FMP amendment, including connections between SAV ecology and managed species, and the need for management measures to address adverse effects, should be considered. Each FMP would be enhanced with species-specific information. Standard language would help with coast-wide consistency for fishery management, habitat management, and coordination with other agencies (e.g., the U.S. Army Corps of Engineers and their oversight of dredge and fill activities, state agencies regarding mooring fields, U.S. Environmental Protection Agency for dredged material disposal sites, NOAA Fisheries for essential fish habitat determinations).

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Ecological Value of Seagrasses:
A Brief Summary for the ASMFC Habitat Committee's SAV Subcommittee

by

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To establish and address the ecological value of submerged aquatic vegetation (SAV) with an emphasis on marine SAV, we will provide a brief overview of what seagrasses are; what we consider to be the seagrass habitat; information concerning impacts to these systems; and a brief discussion of restoration and mitigation of these fishery habitats. By-and-large, the source material comes from Thayer et al. (1975, 1984b), Kenworthy et al. (1988), Fonseca (1992), Fonseca et al. (1992, 1996) and Hoss and Thayer (1993). Information on the brackish water SAV species can be found in Chesapeake Bay Program (1992, 1995) reports; however, ecological values are considered similar to their estuarine-marine counterparts. The information presented supports and augments the South Atlantic Fishery Management Council's policy statement for the protection and enhancement of marine submerged aquatic vegetation (SAV) habitat of July 1995.

We begin with a pointed statement: Seagrasses are among the most productive ecosystems in the world and perform a number of irreplaceable ecological functions which range from chemical cycling and physical modification of the water column and sediments to providing food and shelter for commercial, recreational as well as ecologically important organisms. This is evident not only by the scientific literature but also by the increasing public notices occurring in newspapers regarding their loss (e.g., Chesapeake Bay, Florida Bay). Their general function and resource value are no longer an issue in developed countries.

Seagrasses occur in all coastal states of the US with the exception of Georgia and South Carolina where freshwater inflow, high turbidity and tidal amplitude combine to inhibit their occurrence. There are a minimum of 13 species of seagrass currently recognized to occur in US waters. In the northern area serviced by the ASFMC, eelgrass (Zostera marina) dominates, with two other species also occurring: Halodule wrightii (Cuban shoalgrass) in North Carolina and Ruppia maritima (widgeon grass) which is cosmopolitan. In Florida, turtlegrass (Thalassia testudinum) and manatee grass (Syringodium filiforme) become dominants along with several species of Halophila, one of which (H. johnsonii) has been proposed for listing by the NMFS as an endangered plant species.

These seagrass species exist in a wide variety of physical settings that lead to different cover patterns, from patchy to continuous. SAV habitat is dynamic, both spatially and temporally. These patches and meadows also move, the rate of which may vary on a scale of days to decades. SAV can occur on rocky to soft bottom habitats (although the former only is observed on the west coast) and from intertidal habitats to depths of 40 meters. They reproduce both sexually (flowering) and asexually (by runners), and some species such as eelgrass can exist either as perennials or annuals. These dynamic aspects are important considerations when discussing seagrass habitats. Seagrass habitats must be recognized as including not only continuously vegetated beds but also patchy SAV environments with the unvegetated area between patches as part of the SAV habitat. In fact, available data show that patchy SAV habitats provide ecological functions similar to those of continuous meadows. A detailed discussion of the importance of scale in defining SAV habitat is provided by Fonseca et al. (1996).

Like all other organisms and habitats in estuarine-near shore environments, seagrasses occur at the end of the pipe and therefore at the end of all watershed inputs: the juncture between riverine inflow and oceanic inputs as well as the juncture between land and sea. They are largely submerged and therefore out of sight of most humans. This situation makes them extremely susceptible to damage by human activities such as nutrient loading, light reduction, propeller scarring and dredge-fill operations.

Seagrasses are subject to natural disturbances such as bioturbation, overgrazing by birds, storm or wave-related scour, ice scour, and disease or disease-associated perturbations as well as man-related impacts. Excessive epiphytic loads and smothering by transient macroalgae, both of which are often associated with eutrophication, can disrupt these systems. Subtidal seagrasses have suffered little damage from oil spills whereas impacts on intertidal beds have been significant. Oil spill-related impacts on the seagrass-associated fauna can range from smothering to lowered stress tolerance, reduced market values and incorporation of carcinogenic and mutagenic substances into the food chain. Other well-known impacts such as dredge and fill operations are no longer a primary cause of major losses of seagrass habitat due to the recognition of their ecological role and vigilance of state and federal regulatory activities relative to permits. This human-related impact, although still present, is now being replaced by that associated with propeller scouring and some fishing gear-related impacts. This physical damage is long-lasting and often results in sediment destabilization and continued habitat loss. The increasing number of small boats plying estuarine and coastal waters has made the prop-scarring impacts more widespread, and there has been a recognized need in some quarters for both enhanced management of these systems and increased awareness by the boating public. One can only wonder what the long term chronic effects of hydrocarbon inputs from these small recreational craft is on these SAV.

Water quality and, in particular, water clarity is now considered among the most critical, if not the most critical, factor in the maintenance of healthy SAV habitats. Work by the Chesapeake Bay Program (1995) is perhaps the only quantitative water chemistry information for managers to evaluate the health of seagrass environments at present but probably only applies to temperate systems. In the past few years it has become increasingly clear that seagrasses generally require light intensities reaching the leaves of 15-25% of the surface light (Kenworthy and Haunert 1991, Bulthuis 1994, and literature cited therein). However, water transparency standards historically have been based on light requirements of phytoplankton which typically require only 1% of surface light. Many factors act to reduce water column transparency, with excess suspended solids and nutrients being considered to be among the most important and most controllable through watershed management practices.

The loss of seagrasses, regardless of the cause, leads to several undesirable, and often difficult to reverse, situations that reflect on SAV ecological values. Literally hundreds of scientific and management articles and thousands of pages have been written on or pertain directly to the ecological values or functional roles of these important fishery habitats. These can be summarized as: (1) the plants have a high rate of leaf growth, and this influences a number of functions; (2) the leaves provide support for large numbers of organisms, both plant and animal; (3) the leaves produce large quantities of organic material which may be consumed by herbivores but which also is important as a base to an active detrital cycle; (4) the root-rhizome complex binds sediments while the leaves baffle waves and currents thereby both trapping water column-borne material and retarding the resuspension of fine particles while enhancing sediment stability; (5) nutrient uptake occurs through both the leaves and the root-rhizome system as well as by the associated epiphytes and macroalgae; (6) roots and leaves provide a vertical and horizontal complexity which, coupled with abundant and varied food resources and physical support provided by the leaves (i.e., #2 above), leads to densities of fauna generally exceeding those of nearby unvegetated habitats. Therefore losses can and have lead to reduced sediment binding and water motion baffling capability of the habitat allowing sediments to be more readily resuspended and moved. The physical ramification includes increased shoreline erosion (e.g., as occurred in some areas after the seagrass die-off in the 1930's) and water column turbidity. The losses of SAV, of course, eliminate all important associated habitat functions of SAV pertinent to fisheries use.

From the standpoint of essential fishery habitat, being submerged most if not all of the time, SAV are available to fishery organisms for extended periods; yet, research emphasis on this habitat has been predominantly directed more at primary rather than secondary productivity. There has been a growth of research on SAV over the past 30 years trying to understand and quantify functional values. There are some general functional relations that are based on experiments and observations of juvenile and adult invertebrates and fishes. Habitat heterogeneity, plant biomass, and surface area enhance faunal abundances. The predator-prey relationships in seagrass beds are influenced by plant biomass, shoot density, and surface area. Blade density interferes with the efficiency of foraging predators and the reduction of light within the leafy canopy further conceals small prey which includes young-of-the-year of many economically valuable species. High density of seagrass shoots and plant surface area can inhibit movement of larger predators. Additionally, some organisms can orient themselves with the seagrass blades to become camouflaged. The food availability within grass beds for young stages may be virtually unlimited. While there is continuing debate and research on whether refugia or trophic functions are most important (when and to which organisms), there is little debate that these are important functions provided by this habitat type.

Perhaps seagrass meadows are best known by the coastal public for their source of attachment and/or protection for the bay scallop (Argopectin irradians) and hard clam (Mercenaria mercenaria). Scientific evidence also indicates that blue crabs (Callinectes sapidus), pink and brown shrimp (Penaeus duorarum, P. aztecus), and lobster (Homarus americanus, Panulirus argus), just to name a few invertebrates, have a strong reliance on seagrass habitats including seagrass-supported trophic intermediaries.

There have been few studies dealing with larval fish settlement and use of seagrass habitats while there have been numerous publications listing juvenile and adult fishes collected in SAV. One might expect, however that some of the same functions described above hold true for larvae. In the lower Chesapeake Bay seagrass beds are important for the brooding of eggs (for example, silverstripe halfbeak, Hyporhamphus unifasciatus) and for fishes with demersal eggs (e.g., rough silverside, Membras martinica). In the Bay, winter-spring spawners lack a seagrass habitat because of its seasonality, but larvae of spring-summer spawners such as anchovies (Anchoa spp.), gobies, (Gobiosoma spp.), northern pipefish (Syngnathus fuscus), weakfish (Cynoscion regalis), southern kingfish (Menticirrhus americanus), red drum (Sciaenops ocellatus), silver perch (Bairdiella chrysoura), rough silverside, feather blenny (Hypsoblennius hentz), and halfbeaks are present and using the seagrass beds. In contrast, northern regions of North Carolina exhibit almost year-round cover of seagrass (eelgrass and Cuban shoalgrass), and larval and early juvenile fishes are present in these beds during much of the year. Lists of these species are presented in referenced literature and policy statements, but it should be pointed out here that larvae and juveniles of important commercial and sport fish such as gag grouper (Mycteroperca microlepis), snapper (Lutjanus griseus), seatrout or weakfish, bluefish (Prionotus saltatrix), mullet (Mugil spp.), spot (Leiostomus xanthurus), Atlantic croaker (Micropogonius undulatus), flounder (Paralichthys spp.), herrings (Clupeidae), and many other species appear in eelgrass beds in spring and early summer. Many of these fish reside only temporarily in the grass bed either to forage, spawn, or escape predation. Some species reside there until the fall when they return to the open coastal shelf waters to spawn. As is noted by the SAFMC's SAV protection policy, economically important species use these habitats for nursery and/or spawning grounds: spotted seatrout, grunts (Haemulids), snook (Centropomus sp.), bonefish (Albulu vipes), tarpon (Megalops atlanticus) and several species of snapper and grouper.

For the most part, the organisms discussed above utilize the grass bed structure and trophic elements associated with the bed, but many species of herbivorous invertebrates (e.g., urchins [Lytechinus variegatus, Tripneustes ventricosus]), birds (e.g., black brant [Branta bernicla]), fishes (e.g., pinfish [Lagodon rhomboides], parrotfish [Sparisoma radians]), the green turtle (Chelonia midas) and the Caribbean manatee (Trichechus manatus) feed directly upon coastal and estuarine seagrasses. Work on green turtles in North Carolina has shown a higher incidence of capture in pound nets set in grass beds than by nets set in unvegetated areas. Grazing can have profound effects on the system, but the consequences are neither uniform nor of similar importance in both tropical and temperate seagrasses. However, areas grazed by large herbivores do provide natural experiments in which to test hypotheses on many functional relations in seagrass meadows. This is discussed in detailed by Thayer et al (1984a).

The seasonal patterns of reproduction and development of many temperate fishery species coincide with seasonal abundances of seagrasses. It has been concluded in several papers that, although juvenile fish and shellfish can use other types of habitat, the bulk of the shelter in many estuarine systems is provided by seagrasses, and that the loss or reduction of this habitat will produce concomitant declines in juvenile fish settlement. Thus, this habitat type may be essential to many species of commercial, recreational and ecologically important shellfish and finfish.

The recognition of the ecological role (principally from observations of sediment trapping and presence of invertebrates, fish and use by wading birds) of this habitat type lead to an early consideration of the need to restore these habitats, and more recently to the recognition that impact avoidance (i.e., management) is a less financially costly and environmentally sounder means of protecting and conserving this important resource than mitigation or restoration. None-the-less, seagrass habitats have been and continue to be impacted or lost, and restoration efforts have broadened to include development and evaluation of new approaches to seagrass restoration and measurements of recovery of functional values. In addition, programs are springing up at the local level to plant seagrasses for purposes of sediment stabilization, nutrient uptake, and fishery habitat. These programs and projects, which are often volunteer, consult with experts, utilize scientifically based guidelines, and monitor their transplantation success. Research continues to evaluate current techniques and develop new approaches (e.g., clonal development). However, we have not found a restoration or mitigation project that has returned seagrass habitat equal to that which has been lost. Much has been written on techniques and evaluation of restoration of seagrasses along the Atlantic coast of the U.S. Data are showing that if seagrass transplanting is successful we can expect a similar faunal community to return within a few years (2-4 possibly), depending on the geographic area and rate of development of the transplant.

There are many uncertainties associated with seagrass mitigation and restoration such as impacts of herbivory, but experience is showing that efforts can be successful if the well-founded guidelines available are followed. Perhaps the penultimate document, at least for the near future, has been prepared for the U.S. Department of Commerce, National Ocean and Atmospheric Administration under funding from the NOAA Coastal Ocean Program: "Guidelines for mitigation and restoration of seagrasses in the United States and adjacent waters" by Fonseca, Kenworthy and Thayer (1996).

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The Relationship of Submerged Aquatic Vegetation (SAV) Ecological Value to Species Managed by the Atlantic States Marine Fisheries Commission (ASMFC): *Summary for the ASMFC SAV Subcommittee*

by

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Introduction

The purpose of this summary is to provide information to the Atlantic States Marine Fisheries Commission's Submerged Aquatic Vegetation Subcommittee, a subunit of the Habitat Committee, with regard to the use of SAV by species managed by the ASMFC. The issue was raised initially before the Habitat Committee by former Commissioner Al Goetz, with regard to a specific issue involving striped bass in oligohaline/freshwater SAV habitats in the Upper Chesapeake Bay. Subsequent discussions broadened the scope of the issue and lead to the development of a formal policy on SAV habitats by the ASMFC. This summary establishes an initial scientific basis for the policy, and broadens the initial target audience to include the Commissioners, Technical Committee members and Advisory Panel members, as well as other members of the public who may be interested in the relationship between SAV and ASMFC-managed species.

This summary is a cursory review of the requirements of each of the subject species to ascertain what relationship exists between the species and SAV, conducted using only a few reference sources (Funderburk et al. 1991, Odum et al. 1984, Thayer et al. 1984, Zieman 1982 and species profiles and Fishery Management Plans (FMP) as referenced for the individual species). A more thorough effort to document SAV linkages should be conducted through a comprehensive review of all the literature on each species, as well as through a search of SAV studies which includes faunal inventories.

The Atlantic States Marine Fisheries Commission (ASMFC) currently (April, 1997) is responsible for 24 species for which 20 management plans are either implemented, under preparation, or being amended. Species for which plans are in the implementation phase include: Atlantic croaker (*Micropogonius undulatus*), Atlantic menhaden (*Brevoortia tyrannus*), red drum (*Scianops ocellatus*), Spanish mackerel (*Scomberomorous maculata*), spot (*Leiostomus xanthurus*), spotted seatrout (*Cynoscion nebulosus*), and striped bass (*Morone saxatilis*). Species for which plans are under preparation include: American eel (*Anguilla rostrata*), black seabass (*Centropristis striata*), scup (*Stenotomus chrysops*), and tautog (*Tautoga onitis*). Plans for the following species are currently undergoing amendment: American lobster (*Homarus americanus*), Atlantic herring (*Clupea harengus*), Atlantic sturgeon (*Ocipenser oxyrinchus*), bluefish (*Pomatomis saltatrix*), northern shrimp (*Pandalus borealis*), shad/river herring (includes American shad, *Alosa* *sapidissima*, hickory shad, *Alosa mediocris*, alewife, *Alosa pseudoharengus*, and blueback herring, *Alosa aestivalis*), summer flounder (*Paralichthys dentatus*), weakfish (*Cynoscion regalis*), and winter flounder (*Pleuronectes americanus*).

For the purposes of this discussion, additional species of interest to the ASMFC member states (ME, NH, MA, RI, CT, NY, NJ, PA, DE, MD, the District of Columbia, the Potomac River Fisheries Commission, VA, NC, SC, GA and FL) for which no ASMFC planning activity is currently underway are considered. These include blue crab (*Callinectes sapidus*), gulf and southern flounders (*Paralichthys albigutta*, *P. lethostigma*), white and striped mullet (*Mugil curema, M. cephalus*), rainbow smelt (*Osmerus mordax*), black drum (*Pogonias cromis*), bay scallop (*Argopecten irradians*), and southern shrimp (includes *Penaeus aztecus*--brown shrimp, *Penaeus duorarum*--pink shrimp, and *Penaeus setiferus*--white shrimp).

Many of these species use submerged aquatic vegetation during some or all phases of their life cycle. The term "submerged aquatic vegetation" as used herein includes those species which occur in marine and estuarine ecosystems (commonly called seagrasses) as well as those which occur in the tidal fresh and freshwater portions of estuarine tributaries. The term "seagrass" refers only to the marine and estuarine species as listed by Thayer et al. (1997). Seagrasses include at least 13 species recognized to occur in US waters. Within the zone of ASMFC jurisdiction (ME to FL, seaward to three miles offshore) the dominant species are eelgrass (*Zostera marina*), Cuban shoalgrass (*Halodule wrightii*), widgeon grass (*Ruppia maritima*), turtlegrass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*), and several species of *Halophila*. The first three species occur primarily from NC northward, while the rest occur predominantly in FL (Thayer et al. 1997). Many more species of SAV occur in tidal fresh and freshwater portions of upper estuaries and their tributary rivers on the East Coast (Odum et al. 1984). The diversity of these species increases as salinity decreases (see Table 6, p. 34 in Odum et al. 1984). Some of the more prevalent species include waterweeds (*Elodea* spp.), pondweeds (*Potomogeton* spp.) and watermilfoils (*Myriophyllum* ssp.).

To the extent possible, prey species which may be used by all the above-listed species for forage are also considered in this discussion of species ecological linkages to SAV. Even if no direct linkage to submerged aquatic vegetation (SAV) by a species for which ASMFC has jurisdiction or interest has been documented, secondary linkages may occur if ASMFC species prey upon resources which are SAV-dependent. Several questions were posed hierarchically in the process of assessing each specie's relationship with SAV:

1. Does the geographic, spatial and/or temporal range of the species overlap with (i.e., potentially allow use of) SAV?

2. If the answer to question 1 is yes, which life stages geographically, spatially and/or temporally occur with SAV?

3. Has use of SAV by the life stage(s) of the species been documented in the literature?

4. If no direct use by the life stage(s) of the species has been documented, does it consume prey which use SAV?

5. Is the species consumed by other ASMFC species which are SAV users?

The ecological values of SAV to those species of ASMFC responsibility or interest which are considered for the purposes of this account are those which are established and addressed in Thayer et al.(1997) for seagrasses, which immediately precedes this report. It is presumed that the same functions would apply in SAV beds which occur in freshwater. For the purposes of the matrix tables which summarize the results of this review, those functions are characterized as: refuge (is sheltered in SAV beds), attachment (requires SAV for a substrate), spawning (scatters or attaches eggs in or to SAV), food (direct or detrital consumption), and prey (forages on SAV epifauna, in SAV beds, or on prey which are SAV dependent).

ASMFC Managed Species

Atlantic croaker: Literature reviewed for this account is Lassuy (1983a), Mercer (1987), Odum et al. (1984) and Thayer et al. (1984). It is unclear from the information in these accounts to what extent Atlantic croaker may benefit from SAV. Lassuy (1983a) reports that juveniles were reported to occur abundantly in both open and vegetated shallow marsh areas. Neither Lassuy (1983a) or Mercer (1987) includes SAV in discussions of habitat preferences. Mercer (1987) in fact states that the habitat suitability index model developed for the species assumes that the primary habitats for juvenile croaker are estuarine marshes and estuarine open water areas. However, food habits studies document the presence of vascular plant tissues and invertebrates which may be SAV dependent, therefore some level of use may occur. Odum et al. (1984, p. 138) state that Atlantic croaker are juveniles are locally common in tidal freshwater and feed on some species (copepods) whose abundance may be controlled by the amount of particulate detritus (p. 50). Therefore they may be linked to freshwater and estuarine SAV beds through dependency of their prey on SAV as an indirect food source. Thayer et al. (1984) indicated that croaker were common in SAV and rare in marsh channel habitat in the Newport River (NC) estuary-sound complex (p. 78). Croaker constituted 3.3 percent of total fish taken in SAV. Atlantic croaker feed on a variety of invertebrates, including polychaetes, molluscs, ostracods, copepods, amphipods, mysids, and decapods (Mercer 1987, p. 3). Detritus has been reported as a major component of the diet of juvenile croaker; however it is not clear that ingested plant material is assimilated (Lassuy 1983a, p. 7). Atlantic croaker are preyed upon by bluefish, striped bass, southern flounder, spotted seatrout and weakfish (Mercer 1987, p. 3).

Summary: The range of Atlantic croaker and SAV overlap completely geographically. The spatial and temporal range of post-larval and juvenile croaker overlap with SAV, especially in the Mid-Atlantic (Odum et al. 1984, p. 65). The extent of relationship between Atlantic croaker and SAV is unclear from this review. The Atlantic croaker's reliance on benthic epifauna as prey may dictate use of more open areas, since SAV might interfere with the preferred foraging strategy of diving deeply into the bottom (see Mercer 1987, p. 32). Some Atlantic croaker prey levels may be influenced by SAV-derived detritus. Atlantic croaker juveniles do use SAV beds as indicated by their presence; however they are not a dominant species. Thayer et al. (1997) list this species as one which appears in eelgrass beds in spring and early summer.

Atlantic menhaden: Literature reviewed for this account is Lippson (1991), Odum et al. (1984), Rogers and Van Den Avyle (1989) and Thayer et al (1984). SAV is not mentioned as a preferred or essential habitat for Atlantic menhaden in these reviews. However, Lippson (1991, see p. 7-3) indicates that juvenile Atlantic menhaden readily digest cellulose and vascular plant material, and that detritus of vascular plant origin forms an important component of their diet. To the extent that such detritus originates in SAV beds, this could constitute an important linkage. Larval and juvenile menhaden occupy estuaries where SAV occurs and are seasonally very important components of estuarine fish assemblages, where they consume and redistribute significant amounts of energy and materials (Lippson 1991). Odum et al. (1984) indicated that juveniles are common to abundant in tidal freshwater ecosystems and feed on copepods and small crustaceans, which may be reliant on SAV detritus, which establishes an indirect linkage. Thayer et al. (1984, p. 78) report that menhaden do occur as a common resident of SAV, although they report that the species prefers marsh habitat. Menhaden are one of the most important forage species for striped bass, bluefish, and Spanish mackerel due in part to their schooling behavior.

<u>Summary</u>: The range of Atlantic menhaden and SAV overlap completely geographically. The spatial and temporal range of juvenile menhaden overlaps with that of SAV. Adult habitat range also overlaps temporally, with adults entering estuaries as far inland as the brackish/fresh interface in the spring. Some adults spawn within coastal embayments in the North Atlantic region (Rogers and Van Den Avyle 1989, p. 4). It appears from this review that Atlantic menhaden are not highly reliant upon SAV with the possible exception of use of detrital SAV as a food source by juveniles during their estuarine nursery phase, although adults which spawn in northern coastal embayments could conceivably spawn in or near eelgrass. While they were a common species present in SAV in one study (Thayer et al. 1984), they were not a dominant species.

Red drum: Literature reviewed for this account is Mercer (1984a), Reagan (1985), South Atlantic Fishery Management Council (hereafter SAFMC, 1990), Thayer et al. (1984) and Zieman (1982). Eggs, larvae, postlarvae and small and large juveniles of this species have been documented from SAV beds. Mercer (1984a) reported that red drum eggs were observed in seagrass beds in TX, and that larvae were collected from SAV on the eastern shore of Chesapeake Bay. It was further suggested that observation of gravid adults in estuaries suggested that some spawning may occur there. Postlarvae live among seagrass (Reagan 1985, p. 4). Juveniles were found in grassy areas of estuaries and were more abundant in ecotonal areas between seagrass and nonvegetated areas than in homogeneously vegetated sites (Mercer 1984a, Reagan 1985, p. 11). The SAFMC indicates that one- and two-year-old red drum occur year round in estuaries, including at grass beds behind barrier islands (SAFMC 1990, p. 9). Thayer et al. (1984, p. 79) list red drum as rare in seagrass beds; however Zieman (1982, p. 50) states they are seasonally resident in this habitat. Preadult red drum also feed in SAV. Crustaceans and fishes were the most important diet components of red drum on the Atlantic and Gulf coasts. Important prey items in Atlantic waters were blue crabs, striped mullet, spot, pinfish (*Lagodon rhomboides*) and pigfish (*Orthopristis chrysoptera*). On the Gulf Coast, prey were predominantly fish and crustaceans, including grass shrimp (*Palaemonetes* sp.), blue crabs, penaeid shrimp, anchovies, menhaden and spot (Reagan 1985, p. 9). Many of these species reside in SAV beds.

<u>Summary</u>: Current red drum range overlaps that of SAV geographically, though the species is rare north of NJ. Spatial and temporal range of juveniles and adults overlaps SAV in the southeast states. It appears likely that red drum are very dependent upon SAV during the juvenile stages, especially in the southern portion of their range (FL). Reliance on SAV habitat in the northern part of the range appears less likely since surveys have documented few juveniles in SAV; however, the species is on the edge of its range in any localities north of NC. In those estuaries where seagrasses are absent, oyster reefs may replace seagrasses as an important nursery habitat for red drum. Thayer et al. (1997) list red drum as a species whose larvae use seagrass beds during spring-summer. The SAFMC (1990, p. 22) states that seagrass beds in the Chesapeake Bay and the sounds and bays of NC and FL are critical areas for red drum; however no data are provided to document

this statement. Juvenile red drum have been captured in the inland portions of NC sounds well above the brackish/freshwater interface, near areas where SAV beds are likely to occur (R.W. Laney, J.W. Kornegay and S.W. Winslow, U.S. Fish and Wildlife Service, NC Wildlife Resources Commission and NC Division of Marine Fisheries, unpublished data).

Spanish mackerel: Information on Spanish mackerel was derived from Mercer et al. (1990), which incorporates by reference Godcharles and Murphy (1986). The Atlantic migratory group of Spanish mackerel ranges from the Florida Keys north to NY or southern New England, occasionally straying to the Gulf of Maine. Adults frequently enter tidal estuaries, bays and lagoons during seasonal migrations (Mercer et al. 1990, p. 3). Spawning occurs offshore over the inner continental shelf, larvae being collected from Cape Canaveral, FL to Cape Hatteras, NC, in nearshore shallow water environments (Mercer et al. 1990, p 7).
Spanish mackerel are major predators on small schooling fish such as anchovies (*Anchoa* spp.), menhaden, and Spanish sardines (*Sardinella aurita*) and on shrimp and squid. They also feed on scianids (Mercer et al. 1990, p. 8). Many of the listed prey species depend on estuarine and nearshore areas for survival. Major predators of Spanish mackerel are a number of species of sharks.

<u>Summary</u>: No mention is made in the literature reviewed of any dependence on SAV by Spanish mackerel; however the geographic range of all life stages and the temporal and spatial range of juveniles does overlap that of SAV. The species is not mentioned by Thayer et al. (1984, 1997) as a species which occurs in SAV. However, as noted by Mercer et al. (1990, p. 11), Spanish mackerel are dependent on many prey species which are estuarine dependent, therefore are themselves estuarine dependent. To the extent that prey species are linked to SAV, Spanish mackerel are also.

Spot: Literature reviewed for this account is Homer and Mihursky (1991), Odum et al. (1984), Phillips et al. (1989) and Thayer et al. (1984). Spot have been collected from temperate seagrass beds as adults and juveniles (Thayer et al. 1984, p. 74). Spot also were a dominant species from SAV beds in the lower Chesapeake Bay, but in one study showed a preference for marsh habitats (Thayer et al. 1984, p. 77). The species is stated to use freshwater tidal habitats as a nursery ground (Odum et al. 1984, p. 63). A study in NC documented spot abundance in SAV as well as marsh channel and intertidal flat habitats (Thayer et al. 1984, p. 78). Spot was a dominant species in all three habitats sampled. Homer and Mihursky (1991) do not mention SAV as an important habitat for spot; however they do note its wide distribution and extreme importance in Chesapeake Bay. The mid-Atlantic species profile for spot does not mention any reliance on SAV (Phillips et al. 1989). Spot prey upon plankton as larvae. As juveniles and adults, they prey upon copepods, polychaetes and small molluscs, including bivalve siphons (Homer and Mihursky 1991, p. 11-4; Phillips et al. 1989, p. 6). Larval spot were consumed by silversides (*Menidia* sp.) and striped killifish (*Fundulus majalis*) (Homer and Mihursky 1991, p. 11-5). Juvenile spot were consumed by bluefish, weakfish, striped bass, Atlantic croaker, summer flounder, spotted seatrout, American eel and other species (Homer and Mihursky 1991, p. 11-5; Phillips et al. 1989, p. 8). Spot are preyed upon as adults by striped bass, weakfish and bluefish (Homer and Mihursky 1991, p. 11-4).

<u>Summary</u>: The geographic range of spot overlaps that of SAV. The spatial and temporal range of adults and juveniles especially overlaps with SAV. Spot are documented to occur in freshwater as far as 23 miles above the brackish water interface (see Phillips et al. 1989, p. 1). Information from the sources reviewed indicates that juvenile spot may be present in SAV beds in high densities; however it is unclear what functional benefit spot derive from this association. Thayer et al. (1984)

state that the major life history stage of the seasonal SAV fish fauna is juveniles, which use the meadows as a refuge and for food resources (p. 80).

Spotted seatrout: Literature reviewed for this species is Zieman (1982), Lassuy (1983b), Mercer (1984b), Odum et al. (1984), Thayer et al. (1984), and Johnson and Seaman (1986). Spotted seatrout in the southern part of their range prefer brackish shallow water habitats with extensive SAV (turtle grass--*Thalassia testudinum* and shoal grass--*Halodule wrightii*) adjacent to deeper waters (3-6 m) that can be used as a refuge during cold periods (Johnson and Seaman 1986, p. 14). The Fishery Management Plan for spotted seatrout (Mercer 1984) notes the close association of spotted seatrout juveniles and adults with seagrasses (p. 4). Larval seatrout have primarily been collected in tidal passes and the lower portions of estuaries throughout the range (Mercer 1984, p. 19). Spawning occurs in coastal and estuarine habitats and at least sometimes in or over grassbeds, based on acoustic studies and actual observations (Mercer 1984, p. 25; Lassuy 1983, p. 3) and the capture of running ripe fish over grassbeds (Mercer 1984, p. 26; Lassuy 1983, p. 3). Spawning does occur in areas where seagrasses are not present (SC, GA), so the presence of seagrass is not mandatory. The species does occur in tidal freshwaters seasonally (Odum et al. 1984, p. 137). Both young-of-the-year and adult spotted seatrout are usually associated with SAV beds, as reflected by the results of numerous studies (see Mercer 1984, p. 20); however Thayer et al. (1984) indicate only juveniles as having been collected from temperate seagrass beds (see Table 7, p. 74) and NC studies found them present only rarely in seagrass beds (Table 10, p. 78). Most Gulf of Mexico studies concluded that seagrass beds are the preferred habitat of postlarvae, juveniles and adults (Lassuy 1983, p. 10). Zieman (1982, p. 50) states that spotted seatrout are common over seagrass. Spotted seatrout are carnivorous and feed largely on crustaceans and fishes. Dominant food organisms in the diet were penaeid shrimp and crabs. The highest percentage of fish in the stomachs (see Table 12-5 in Mercer 1984, p. 32-33) were anchovies (Engraulidae), Atlantic menhaden, mullet, pinfish (*Lagodon rhomboides*) and silversides. Many of these species reside in or near seagrass beds. Other ASMFC species which prey on spotted seatrout include striped bass, Spanish mackerel, and bluefish.

<u>Summary</u>: The range of spotted seatrout overlaps that of SAV, with maximum abundance occurring in areas where SAV is abundant. The species spawns in SAV and occupies SAV habitats during all life stages. The spotted seatrout is viewed essentially as an estuarine species which prefers the shallower, non-tidal portions of estuaries with extensive SAV cover, where seasonal fluctuations in temperature and salinity rather than daily fluctuations are the controlling factors (Mercer 1984, p. 47). They are highly dependent on SAV in those portions of the range where SAV occurs; however, they do occur in areas where it is absent. Thayer et al. (1997) list spotted seatrout as a species for which SAV is used for nursery and/or spawning grounds.

Striped bass: References reviewed for striped bass include Bain and Bain (1982), Zieman (1982), Fay et al. (1983b), Odum et al. (1984), Thayer et al. (1984), Hill et al. (1989), Setzler-Hamilton and Hall (1991) and ASMFC (1995). The only reference which indicates any direct association between striped bass and seagrasses is Hill et al. (1989), which lists "grass" as a substrate used by adult striped bass in inshore areas. Odum et al. (1984) note the species' reliance on tidal freshwater habitats in the Mid-Atlantic, indicating that it consumes many species which occur in or feed on SAV (amphipods, grass shrimp-*Palaemonetes* spp., mysids, Atlantic menhaden, alewife and blueback herring, see p. 133). None of the other references indicate seagrass beds as a habitat which is used by any life stage of striped bass. The striped bass life cycle restricts the potential interactions of striped bass with seagrass beds, since only juveniles and migrating adults would co-occur with seagrasses. Adult striped bass do forage during spawning migrations in estuarine areas in which seagrasses occur, and juvenile striped bass spend the early years of their existence in estuarine areas where grassbeds may be present. The habitat suitability index model developed by Bain and Bain (1982) for coastal striped bass does include a variable for the extent of salt marsh, but this is related to zooplankton production and not to any cover or foraging relationship (p. 12). Lists of organisms which have been collected from temperate and subtropical seagrass beds do not include striped bass of any life stage (Zieman 1982, Thayer et al. 1984). Where references to preferred juvenile habitat are made, indications are that shallow areas with substrates ranging from sand to rock (Hill et al. 1989, p. 15) or clean sandy bottoms (Bain and Bain 1982, p. 7) are either preferred or exhibit the largest catches, although it was noted in the latter case that differential sampling efficiency may have been responsible. Juvenile striped bass consume a wide variety of prey, including insect larvae, polychaetes, larval fish, mysids and amphipods (Setzler-Hamilton and Hall 1991, p.13-6). Juveniles (to 75 mm, and 76-125) from the Hudson River preferred gammarid amphipods, calanoid copepods, and chironomid larvae, while larger juveniles (116-200 mm) preferred tomcod (*Microgadus tomcod*)(Fay et al. 1983b, p. 19). In other systems (York, James, Delaware Rivers, Chesapeake Bay, see Fay et al. 1983b, p. 19) juveniles fed on a variety of prey, including some species associated with seagrasses. Fish become more important as the juveniles grow. Adult striped bass in Chesapeake Bay are piscivorous, consuming bay anchovy (*Anchoa mitcheli*), Atlantic menhaden, larval and juvenile spot and Atlantic croaker, white perch (*Morone americana*), alewife and blueback herring (Setzler-Hamilton and Hall 1991, p. 13-6). Predators of striped bass include any sympatric piscivorous fish (Hill et al. 1989, p. 15), adult bluefish and weakfish (Fay et al. 1983b, p. 20).

<u>Summary</u>: The geographic range of striped bass overlaps that of SAV. From NC north, the species is migratory and the temporal and spatial range of all life stages intersects that of SAV. One reference reported that striped bass were among the numerically dominant fish species present in tidal freshwater habitats in two Virginia rivers (Odum et al. 1984). However, all of the references reviewed contained only a single passing reference to direct use of seagrasses by striped bass. Some of the prey consumed by juveniles and adult striped bass during residence in estuarine areas do occur in seagrass beds. It appears likely that striped bass do use seagrass beds to some extent in the estuaries where they occur; however how important they may be is unknown. It could be that the lack of information reflects a lack of research to evaluate seagrass use by striped bass. Given the present high density of juvenile striped bass in several estuarine systems, research on this question would be timely.

American eel: Literature reviewed for this document included Odum et al. (1984), Thayer et al. (1984), Van Den Avyle (1984a) and Facey and Van Den Avyle (1987). The life cycle of the American eel dictates that primarily the yellow eel and silver (adult) eel stages are likely to encounter seagrasses. Yellow eels may reside in estuaries for some time after metamorphosis from the elver stage occurs (sometimes for many years). Adults pass through estuaries during migration from inland lakes and rivers to spawning grounds in the Sargasso Sea (central Atlantic Ocean). The probability of encountering seagrasses is highest for yellow eel stages, since that stage has the longest residence time in estuaries. Both species profiles indicate that postlarval eels are bottom dwellers and hide in plant masses, among other types of shelter or the substrate (Van Den Avyle 1984a, p. 13, Facey and Van Den Avyle 1987, p. 18). Thayer et al (1984, p. 77) collected eel in both eelgrass and widgeon grass, but noted that they appeared to prefer marsh habitat. Yellow eels feed on a wide variety of prey and their diet varies with location and season. Eels in lower Chesapeake Bay fed on crustaceans, bivalves and polychaetes, with blue crabs and soft-shell clams (*Mya arenaria*) significant prey (Facey and Van Den Avyle 1987, p. 16). Predators on American eels include striped bass (Van Den Avyle 1984a, p. 12).

Summary: The geographic range of American eel is the same as for SAV. Spatial and temporal overlap occurs for juvenile and adult stages. Yellow eel stages of the American eel occur in SAV beds during the estuarine stage of their life history; however they also use other types of bottom habitats and are probably not obligate SAV users.

Black sea bass: Literature reviewed for this species included Thayer et al. (1984), Mercer (1989a) and Mid-Atlantic Fishery Management Council (1996b). Black sea bass spawn offshore, and the larvae longer than 13 mm presumably become demersal or estuarine near that size (Mercer 1989a, p. 5). Juveniles occur in saline areas of estuaries from FL through MA. Adults in the northern part of the range move inshore during the summer, and some spawning occurs in Buzzards Bay and Nantucket Sound (MAFMC 1996b, p. 14), although no mention is made as to the use of SAV beds. Mercer (1989a) does not list SAV among the habitats occupied by juvenile sea bass (p. 5). Thayer et al. (1984, p. 77) found the species present in both eelgrass and widgeon grass beds. The MAFMC reports, based on responses from state fishery biologists, that black sea bass juveniles throughout the range, and adults in the northern portion of the range, use estuarine and nearshore habitats (MAFMC 1996b, p. 12). Juveniles in NC sounds and in the Chesapeake Bay are reported to use grass beds (MAFMC 1996b, p. 13). Black sea bass juveniles consume shrimp, amphipods and isopods (Mercer 1989a, p. 9).

Summary: Black sea bass occur along the Atlantic Coast predominantly from Cape Cod, MA to Cape Canaveral, FL. Only the juvenile stages co-occur spatially and temporally with SAV. Juvenile black sea bass definitely use seagrasses, but to what extent such use occurs and to what extent the species may be dependent upon SAV for nursery areas is presently unknown. Adult black sea bass in the northern portion of the range are present inshore during the same time of year as SAV beds, but the extent of any use is unknown.

Scup: The only literature reviewed for scup was Mid-Atlantic Fishery Management Council (hereafter MAFMC, 1996a). Scup is a continental shelf species of the northwest Atlantic. It occurs from Cape Hatteras to Cape Cod. Eggs, larvae, juveniles and adults use tidal bays and sounds and nearshore ocean habitats during the warmer months of the year. Spawning occurs in nearshore ocean waters and is also likely to occur in some bays and estuaries. Scup use Chesapeake Bay, Delaware Bay, Indian River and Rehoboth Bays, Sandy Hook Bay, Long Island Sound, Fishers Island Sound, Narragansett and Mt. Hope Bays, Buzzards Bay, Nantucket Sound, and Vineyard Sound as spawning, nursery and feeding areas, based on surveys of state fishery biologists conducted by the Mid-Atlantic Fishery Management Council (1996a). Young of year scup have been collected over eelgrass beds in Narragansett Bay. Scup feed principally on polychaetes, amphipods, other crustaceans and molluscs. Scup was not listed by Thayer et al. (1984, 1997) as a species which occurred in eelgrass beds; however, it occurs north of the area in which their studies were predominantly conducted.

Summary: SAV and scup co-occur from Cape Hatteras, NC north. Scup spawn in nearshore and inshore areas, and eggs, larvae, juveniles and adults occur in tidal bays and estuaries where eelgrass occurs on a spatial and temporal basis. One state report did indicate that scup have been collected as juveniles over eelgrass beds. Given that a principle food of the species is small bivalve molluscs, including blue mussels, the habitat needs and quality for such species may be an important issue in the discussion of scup essential habitat. Since blue mussels occur in eelgrass beds (Thayer et al. 1984), scup may use SAV for foraging. The extent to which scup use SAV does not appear to be well known at this time.

Tautog: References for tautog which were reviewed for this document include Thayer et al. (1984) and Auster (1989). Auster (1989) notes that juvenile and adult tautog use eelgrass beds (see pp. 6, 7 and 10); however such use may be seasonal and limited to the summer. Thayer et al. (1984) indicate that tautog eggs have been collected from eelgrass (p. 74). An additional habitat requirement for tautog is that individual fish be able to remain alongside or under an object for shelter, therefore eelgrass beds may be a secondary habitat used during the day. Preferred prey for juvenile and adult tautog is blue mussel (*Mytilus edulis*).

<u>Summary</u>: Tautog distribution is from ME to SC, with major abundance from Cape Cod to the DE capes. Both juvenile and adults of this species use eelgrass, at least on a seasonal basis, for spawning, foraging and cover. They use other substrates as well; therefore the extent to which they rely solely on SAV is unknown.

American lobster: The only references reviewed for this species were MacKenzie and Moring (1985) and American Lobster Plan Development Team (hereafter ALPDT 1997). Seagrass was listed as a habitat used by juvenile American lobster (ALPDT 1997) as a settling area. Juvenile and adult lobsters are stated to occupy substrates characterized by sand-rock, bedrock-rock, mud-rock, mud-silt and clay-silt (MacKenzie and Moring 1985, p. 13). Highest lobster densities occur on sand substrate with overlying flattened rocks (MacKenzie and Moring 1985, p. 5). Juvenile and adult lobsters are omnivorous and consume benthic invertebrates (crabs, sea urchins, mussels, polychaetes, periwinkles, sea stars) as well as plants and fish (MacKenzie and Moring 1985, p. 10). Preferred prey is crabs. Juvenile and adult lobsters are consumed by many species of bottom feeding fishes, including the ASMFC managed tautog, striped bass, black sea bass and weakfish (MacKenzie and Moring 1985, p. 10).

<u>Summary</u>: The geographic range for American lobster in the US is ME to NC. Spatially and temporally, adults living in nearshore coastal waters and juveniles overlap seasonally with SAV. The profile prepared for this species makes no mention of use of SAV by the species. The Plan Development Team review draft for Amendment #3 to the American Lobster Fishery Management Plan does list SAV as a preferred settling habitat. Given the northern range of the species and its preference for rocky substrates in deeper coastal and nearshore waters below the depth at which SAV grows, it may be that the two simply are largely spatially distinct. However, there must be more documentation somewhere for SAV habitat use by this species, since Thayer et al. (1997) state that "Scientific evidence also indicates that...lobster... [has] a strong reliance on seagrass habitats including seagrass-supported trophic intermediaries."

Atlantic herring: Literature reviewed for this species includes Kelly and Moring (1986) and Atlantic Herring Plan Development Team (hereafter AHPDT, 1993). Atlantic herring spawn in the northeast Atlantic (Gulf of Maine, Bay of Fundy, Gulf of St. Lawrence) at depths of from 0.9 to 100 m (Kelly and Moring 1986, p. 4; AHPDT 1993, p. 21). Spawning habitat is within both the geographic and depth range of eelgrass (see Thayer et al. 1984, pp. 4-5, p. 25); however, none of the literature reviewed reports egg deposition in eelgrass beds. Larval and juvenile herring move into estuarine areas (Kelly and Moring 1986, pp. 6-7; AHPDT 1993, p. 61) but the literature makes no mention of the use of SAV. All life stages are dependent on zooplankton for food, including larval decapods (Kelly and Moring 1986, p. 7). Atlantic herring are consumed by many species, including striped bass (Kelly and Moring 1986, p. 12) and hickory shad (AHPDT 1993, p. 26).
<u>Summary</u>: Atlantic herring range in US distribution from ME to NC, with most abundance north of Cape Cod and least south of NJ. Geographic, spatial and temporal overlap with SAV is slight.

Literature reviewed for this species does not mention any use of SAV or any dependency on that habitat. To the extent that larval and juvenile herring may use SAV during their residence in estuarine or nearshore areas, and to the extent that zooplankton consumed by herring may derive from SAV beds, some level of linkage may exist.

Atlantic sturgeon: Literature reviewed for this species is Gilbert (1989), Odum et al. (1984), Smith and Clugston (In press), Taub (1990), Thayer et al. (1984) and Van Den Avyle (1984b). Spawning, incubation and hatching of Atlantic sturgeon eggs takes place in the inland portions of Atlantic Coast rivers. Early juveniles are presumed to slowly move downriver from spawning sites. Juveniles over 30 cm in length occupy the tidally influenced lower rivers and estuaries (Smith and Clugston, in press, p. 3; Taub 1990, p. 8; Gilbert 1989, p. 15; Van Den Avyle 1984b, p. 5) and may reside in such areas for years (Van Den Avyle 1984b, p. 6), after which they move out to sea. Atlantic sturgeon are omnivorous, opportunistic feeders ingesting a wide variety of benthic invertebrates and small fishes (Taub 1990, p. 4) and feeding indiscriminately throughout life (Gilbert 1989, p. 18). Prey reported consumed included molluscs, polychaetes, gastropods, shrimps, isopods, amphipods and small benthic fishes such as sand lances (*Ammodytes* spp.). Few cases of predation on sturgeon have been documented, and they do not appear to constitute a significant dietary component of any other ASMFC species.

Summary: The US geographic range of the species, as well as spatial and temporal use of estuaries and rivers by adults and juveniles where SAV occurs, indicate that some linkage with SAV may be present, since the yearlings remain in freshwater up to a year and the juveniles in estuaries up to four years (Odum et al. 1984, p. 121. However, literature reviewed suggests that a strong linkage between Atlantic sturgeon and seagrass does not appear to exist. The only life stages which may encounter SAV beds in estuaries are the juveniles during occupation of the nursery areas and adults during migration to upriver spawning areas, but literature reviewed contains no documentation of any collection in or use of SAV beds by this species. In fact, Gilbert (1989, p. 22) states: "In general, however, vegetation does not appear to be an important factor in the life histories of these fishes."

Bluefish: Sources for information on bluefish were Oliver et al. (1989), Pottern et al. (1989) and Thayer et al. (1984). Two stocks of bluefish occur off the Atlantic coast: a spring spawning stock which spawns at the margin of the Gulf Stream in the South Atlantic between Cape Hatteras and northern Florida; and a late summer spawning stock which spawns in continental shelf waters in the middle Atlantic region (Cape Cod to Cape Hatteras) (Oliver et al. 1989, p. 3). Larval development for both groups takes place offshore. Maturation to the juvenile stages also occurs offshore beyond the distribution of eelgrass; however, juveniles do move inshore and use estuarine areas. Juveniles from the spring spawning stock move into estuaries between Cape May, NJ, and Long Island, NY. Juveniles from the summer spawning stock remain at sea, migrate south of Cape Hatteras in early fall, spend the winter offshore, and appear in the NC sounds during the following spring (Oliver et al. 1989, p. 7). Adults and older juveniles inhabit inshore areas, including bays and inlets, subsequent to spawning and also during their southerly migration in fall and winter (Oliver et al. 1989, pp. 5-6). Geographic, temporal and spatial distribution of the species' juvenile and adults life stages overlaps that of seagrass. Neither of the species profiles reviewed mentions seagrass as a bluefish habitat; however Thayer et al. (1984) list the species as occurring in SAV during juvenile and adult life stages, and as a common species in SAV. Juvenile bluefish consume species which occur in SAV beds, including shrimp (*Penaeus* sp.), squid (*Loligo* sp.), pinfish and silversides. Adult bluefish are predominantly piscivorous, feeding on other bluefish, butterfish (*Peprilus* *triacanthus*), harvestfish (*Peprilus alepidotus*), anchovies, seatrout, spot and Atlantic menhaden. Adult bluefish are consumed by only the largest of pelagic predators.

Summary: Bluefish occur throughout the geographic range of SAV in the US. Juveniles are the only life stage which spatially and temporally co-occur on a regular, prolonged basis with SAV. Bluefish juveniles and adults commonly occur in estuarine areas during the period of the year when eelgrass is present and prey on species which are associated with SAV. Some degree of linkage is likely, but given the extent to which the life cycle of bluefish occurs offshore outside the range of SAV, it is probably less than for other species.

Northern shrimp: Literature reviewed for norther shrimp was McInnes (1986). The stock for which ASMFC is responsible resides in the Gulf of Maine. Northern shrimp reside offshore for much of their life cycle; however, egg-bearing females migrate into inshore nursery areas, where hatching occurs and larvae ultimately metamorphose into bottom-dwelling juveniles. Juveniles remain in inshore nursery areas until the end of their second summer, when they migrate offshore and mature into males. Males remain offshore, where they ultimately transform into females and return to inshore areas to complete the life cycle. Northern shrimp eat primarily molluscs and crustaceans (McInness 1986, pp. 9-10). They are preyed upon heavily by four species of hake and two species of flounder. Northern shrimp are not mentioned in Thayer et al. (1984, 1997) as a species which occurs in SAV beds.

Summary: The limited geographic, spatial and temporal distribution of northern shrimp in US waters insure that linkage to SAV is minimal. Northern shrimp eggs (during attachment to females), larvae, juveniles, and female adults use inshore areas in the Gulf of Maine where SAV occurs. None of the literature reviewed states that any association between northern shrimp and SAV beds occurs. Given the overlap in geographic, spatial and temporal distribution of northern shrimp with SAV in the Gulf of Maine, some limited use of SAV by the species appears likely, especially since it is a benthic organism.

Shad/river herring--American shad: Literature reviewed to assess use of SAV by American shad included Rulifson et al. (1982), Odum et al. (1984), MacKenzie et al. (1985), Facey and Van Den Avyle (1986), Weiss-Glanz et al. (1986), and ASMFC (1988). Adult American shad reside offshore in the Atlantic Ocean. They ascend Atlantic Coast rivers from northern FL through Canada during the spring and summer to spawn. Eggs are deposited and larval development occurs in the inland, freshwater portions of rivers. Juvenile American shad were recorded as numerically dominant in studies of fish communities in widely separated rivers along the Atlantic Coast (Hudson River, NY; Pamunkey River, VA; Savannah River, GA; see p. 61 in Odum et al. 1984). Juveniles form schools and move downriver, using the tidally influenced freshwater zones and estuaries as nursery habitat. Juveniles in southern rivers emigrate in the fall, but juveniles in northern systems may spend their first winter in rivers and estuaries (Rulifson et al. 1982, Facey and Van Den Avyle 1986). Older juveniles and adults remain offshore (MacKenzie et al. 1985, p. 5). During their riverine/estuarine phase, juvenile shad consume primarily insects and crustaceans, but also eat small fish such as anchovies (Facey and Van Den Avyle 1986, p. 12). After emigrating to sea, juveniles and adults feed on a variety of small benthic crustaceans (MacKenzie et al. 1985, p. 11). American shad are preyed upon as juveniles by American eels and striped bass (Facey and Van Den Avyle 1986, p. 12), and adults are likely consumed by a variety of offshore predators including sharks, tunas and porpoises.

Summary: Geographic distribution of the species in US waters overlaps that of SAV, as does the spatial and temporal distribution of early juveniles. American shad adults during the spawning migration and juveniles during their estuarine residence phase likely encounter SAV. None of the literature reviewed states that SAV is used directly by American shad. Given the limited amount of time spent by these life stages in estuaries or nearshore areas where SAV occurs, any great use of SAV appears unlikely. However, further study or literature review could establish linkages during the early life stages which occur in freshwater and estuarine habitats, including SAV.

Shad/river herring--hickory shad: Literature reviewed for hickory shad was Rulifson et al. (1982), Odum et al. (1984) and Thayer et al. (1984, 1997). Hickory shad range along the Atlantic Coast from FL to the Bay of Fundy. Like American shad, the adults live in the ocean and undertake spawning migrations to Atlantic Coast rivers. Spawning is assumed to occur in river swamps and larger tributaries of mainstem rivers, which it does based on current ongoing studies in the Roanoke River (U.S. Fish and Wildlife Service and National Marine Fisheries Service, unpublished data). Adults apparently do use shallow areas for spawning and could conceivably spawn in or near freshwater SAV beds. Larval and early juvenile development occurs in the freshwater portions of rivers, but juveniles apparently move rapidly to estuarine areas and thence to the ocean (Odum et al. 1984, p. 57). Juvenile food habits are unknown. Adults are primarily piscivorous, but also consume squid, fish eggs, small crabs and pelagic crustaceans in addition to silversides, anchovies, small clupeids and minnows (Cyprinidae).

Summary: Although hickory shad have a relatively broad geographic distribution, the center of their abundance occurs in VA and NC. Linkage to SAV appears very limited in view of the very limited amount of time which this species spends in areas with SAV habitat present. There is a scarcity of information regarding hickory shad life history. Adults and juveniles occur in areas where SAV is located during the spawning migration and subsequent downstream migration. None of the references reviewed listed SAV as a habitat for hickory shad; however, co-occurrence of juvenile and adult life stages in areas where SAV exists provides an opportunity for some level of use. As with American shad, the amount of time spent by these life stages in areas where SAV occurs is limited and any great use of SAV appears unlikely.

Shad/river herring--alewife: Alewife life history and habitat requirements were reviewed in Rulifson et al. (1982), Fay et al. (1983a), Odum et al. (1984) and Mullen et al. (1986). Alewife occur from Newfoundland in Canada to South Carolina. Adults live offshore during most of the year, ascending coastal rivers in the spring to spawn. Alewives use streams, rivers and coastal ponds with connections to tidal waters for spawning. Eggs are adhesive when initially laid and may adhere to vegetation in shallow areas. After development to the juvenile stage, juveniles move upstream initially prior to emigration from rivers and estuaries during the fall of the year. Juvenile alewife were among the numerically dominant fishes in tidal freshwater habitat in the Woodbury Creek, NJ, and Pamunkey River, VA (Odum et al. 1984, p. 61). Juvenile alewives consumed ostracods, insect eggs and insect parts (Fay et al. 1983a, p. 15). Adult alewives are thought to be zooplanktivores. Juvenile alewives are preyed upon by bluefish, striped bass and weakfish.

Summary: Adults during the spawning run and juveniles during the estuarine residence phase are geographically, spatially and temporally present in areas occupied by SAV. Thayer et al. (1984, 1997) do not list alewife as a SAV user. It is likely that this species is not highly dependent upon SAV, unless there is documented use of SAV for spawning purposes.

Shad/river herring--blueback herring: Blueback herring life history requirements were reviewed in Rulifson et al. (1982), Fay et al. (1983a), Odum et al. (1984) and Mullen et al. (1986). Blueback herring occur on the Atlantic Coast from Nova Scotia, Canada, to the St. Johns River, FL. As with alewives, blueback herring adults spend most of their lives at sea, returning to coastal rivers only to spawn. Blueback herring prefer spawning sites with fast currents and associated hard substrates. Odum et al. (1984, p. 62) report that blueback herring spawn in both the shallows and channels or shoals in tidal freshwater. Juveniles of blueback also exhibited apparent upstream movement initially, followed by downstream movement and emigration from rivers and estuaries during the fall. Blueback herring were numerically dominant in tidal freshwaters in the Hudson River, NY, Woodbury Creek, NJ, and the Rappahannock and Pamunkey Rivers, VA (Odum et al. 1984, p. 61). Some juveniles in northern estuaries may overwinter there rather than emigrating to the ocean. Juvenile blueback herring fed upon copepod life stages and adults, as well as dipteran larvae (Fay et al. 1983a, p. 15). Adult blueback herring are thought to be zooplanktivores. Blueback herring are consumed by bluefish, striped bass and weakfish.

<u>Summary</u>: The species overlaps with SAV distribution geographically and adults during the spawning run and juveniles during the estuarine residence phase are present in areas occupied by SAV. Thayer et al. (1984, 1997) do not list blueback herring as a SAV user. It is likely that this species is not highly dependent upon SAV, unless it is documented that it deposits eggs on SAV during spawning activities.

Summer flounder: Literature reviewed for summer flounder includes Rogers and Van Den Avyle (1983), Odum et al. (1984) and Thayer et al. (1984, 1997). Summer flounder range from Nova Scotia, Canada, to south FL. Adults spend warmer months in nearshore coastal waters and coastal embayments. Spawning occurs offshore during late fall, winter or early spring in continental shelf waters at depths of 30 to 200 m. Larval development occurs offshore, and juveniles move into estuarine nursery areas in late winter and spring. Juvenile summer flounder use SAV beds in NC sounds and in Chesapeake Bay (Rogers and Van Den Avyle 1983, p. 5; Thayer et al. 1984, 1997). Juveniles emigrate from estuarine nursery areas during the second fall of life in the south, and perhaps earlier in the north. Juveniles feed on mysid shrimp and small fish initially and shifted to decapod crustaceans and larger fish as they grew. Odum et al. (1984, p. 139) indicates that the species is rarely recorded from tidal freshwaters, thus it is unlikely to use freshwater SAV. Adults north of Cape Hatteras feed on fish and large invertebrates.

<u>Summary</u>: Geographic distribution of the species overlaps SAV distribution, and juveniles and adults are spatially and temporally distributed with seagrasses. Grass beds are important to summer flounder juveniles and adults, and any loss of these areas along the Atlantic seaboard may affect stocks (Rogers and Van Den Avyle 1983, p. 8).

Weakfish: Literature reviewed for weakfish was Mercer (1985, 1989b), Odum et al. (1984) and Thayer et al. (1984, 1997). Weakfish range from southern FL to Massachusetts Bay and occasionally to Nova Scotia and the eastern Gulf of Mexico. Weakfish spawn in the inshore and estuarine areas after the spring inshore migration. Spawning areas include the NC sounds, Chesapeake Bay and Delaware Bay. Juveniles emigrate from estuaries by December. Odum et al. (1984) indicate that juveniles of the species are present in tidal freshwaters to some degree (p. 137) and are present in estuaries during spring, summer and fall. In northern areas, a greater portion of adults spend the summer in ocean waters rather than estuaries. Young weakfish feed mostly on mysid shrimp and anchovies. Adults feed primarily on juvenile clupeids. Weakfish are documented as important top carnivores in SAV habitats in Chesapeake Bay (Mercer 1989b, p. 10).

Adults foraging along the edge of SAV consumed high percentages of blue crabs and spot. SAV beds are apparently not significant for weakfish spawning (Mercer 1985, p. 68).

Summary: The geographic, spatial and temporal distribution of weakfish overlaps that of SAV. Weakfish may be an SAV-dependent species in those areas where SAV occurs, although they occur in areas (SC, GA) where SAV is not present in estuaries. Both juveniles and adults forage in or adjacent to SAV beds.

Winter flounder: Literature reviewed for winter flounder was Howell et al. (1992). Winter flounder range from Labrador to GA along the Atlantic Coast. Adults move into estuaries during fall prior to spawning, and to deeper estuarine areas or offshore in late spring and summer. Winter flounder spawn preferentially among the filaments of mat-formed diatoms. No eggs were found in eelgrass or algal beds (Howell et al. 1992, p. 77). Juveniles in one study were captured near eelgrass beds (Howell et al. 1992, p. 78). Both juveniles and adults make diurnal migrations into intertidal zones to feed. Prey includes polychaetes and soft-shelled clams (*Mya arenaria*). Juvenile diets also included crustaceans, annelids and other molluscs. Adults consumed polychaetes, molluscs, amphipods, hydroids, sea anemones and isopods, as well as plant material. Growth experiments indicated that growth rates were lower in eelgrass beds than over sand flats with sea lettuce mats. Predators of juveniles include summer flounder, bluefish, striped bass, and spiny dogfish.

Summary: The geographic, spatial and temporal distribution of this species would limit its potential use of SAV to seagrasses. Winter flounder are heavily dependent on estuaries for spawning, nursery and adult habitat. They do not spawn in SAV, and growth rate in SAV appears lower than in other available habitats. However, in at least one study, juveniles were captured near eelgrass beds, which suggests that foraging may occur in or near eelgrass.

Other Species of Interest

Blue crab: Literature reviewed for this account was Odum et al. (1984), Van Den Avyle and Fowler (1984), Hill et al. (1989) and Van Heukelum (1991). Mid- and south-Atlantic species profiles for blue crab indicate that the species inhabits all areas of estuaries, but do not specifically mention SAV as a preferred or essential habitat. The profiles do note that the blue crab diet has been found to include SAV, specifically eelgrass (*Zostera*) and ditch grass (*Ruppia*). Odum et al. (1984) indicates that the species does use tidal freshwaters. Van Heukelum (1991) indicates that grass beds are important nursery habitats for juvenile blue crabs, especially for smaller size classes (< 11 mm) and juveniles. Densities in grass beds were 10 times higher than those in nearby marsh creek habitat (Van Heukelem 1991). SAV beds in the lower Chesapeake Bay were deemed important nursery habitats for blue crabs. In other studies cited, eelgrass beds were found to provide important refuges from predation for blue crabs; hosted higher densities of crabs during periods of greater abundance, but were no different from other estuarine habitats during low abundance; provided protection from overwintering mortality (eelgrass root masses and debris); provided shelter during molting; and shelter more females than marsh creek habitat. Despite these linkages to blue crab nursery use, it is noted that estuaries in SC, DE and NJ harbor substantial blue crab populations, but are almost devoid of seagrasses. Also, during the major seagrass decline in Chesapeake Bay from 1965 through 1980, commercial blue crab landings did not reflect a concurrent decline (see Van Heukelem 1991). Many invertebrate species consumed by juvenile blue crabs are SAV-dependent. Juvenile blue crabs are consumed by American eel, Atlantic croaker, adult blue crabs, black drum, red drum, striped bass, spotted sea trout, and weakfish, all of which may forage in or near SAV beds.

Summary: The geographic, spatial and temporal range of the blue crab entirely overlap that of SAV. Blue crabs do include seagrasses in their diet, and in areas where SAV is present, do use SAV beds as nursery habitat and as shelter for molting adults.

Southern flounder: Literature reviewed for this species was Thayer et al. (1984, 1997) and Reagan and Wingo (1985). The species profile (Reagan and Wingo 1985) does not mention any use of SAV by this species. It is noted that the juveniles are present in estuaries in the spring, summer and fall (at least in the Gulf of Mexico). Both adults and juveniles tolerate low salinity, and indications from some studies are that postlarval southern flounder may grow faster at lower salinities (Reagan and Wingo 1985, p. 7). Thayer et al. (1984, 1997) note that the species has been collected commonly as adults and juveniles in temperate zone seagrass beds (1984, pp. 74, 78). Small juveniles prey on invertebrates, predominately mysids. Larger flounder preyed on primarily fish, chief among which were anchovies, fat sleepers, menhaden, striped mullet and scianids, but also consumed palaemonid and penaeid shrimp and blue crabs.

Summary: The geographic range of the southern flounder is from NC to TX, therefore it overlaps the range of SAV in the southern portion of the ASMFC jurisdiction. The life stage most likely to use SAV is the juvenile, since it uses estuarine areas as a nursery habitat, and is present spatially and temporally when SAV is present.

Striped mullet: Literature reviewed for white mullet information included Zieman (1982), Thayer et al. (1984, 1997), Collins (1985a), and Zieman and Zieman (1989). Striped mullet spawn offshore and the larvae develop there, migrating to inshore waters and estuaries once they reach about 20 millimeters in length. Juveniles tolerate salinities of 0 to 35 parts per thousand, and spend the first year of their lives in coastal waters, salt marshes, and estuaries. Large numbers of them may overwinter in estuaries. Larval mullet eat primarily microcrustaceans. As they mature, the percentage of plant material in the diet increases, so that juvenile mullet over an inch long consumed 80 percent plant material. The major food of adult mullet is epiphytic and benthic microalgae, macrophyte detritus, or inorganic sediment particles, the latter of which may be enriched by adsorbed micro-organisms (Collins 1985a, p. 7). Thayer et al. (1984, 1997) reported striped mullet as an abundant component of seagrass fish communities in NC. Adult striped mullet derive epiphytic prey from the surface of SAV, both seagrasses and freshwater species. Major predators of mullet include sharks and spotted seatrout.

Summary: Striped mullet range geographically concurrent with SAV throughout the entire ASMFC jurisdiction. Their ability to ascend freshwater rivers to the fall line also exposes them to freshwater species of SAV. Because they feed on epiphytes of SAV and possibly on SAV directly, and use areas occupied by SAV as nursery habitat, they appear to be closely linked to SAV.

White mullet: Literature reviewed for white mullet information included Zieman (1982), Thayer et al. (1984, 1997), Collins (1985b) and Zieman and Zieman (1989). White mullet occur throughout the range of ASMFC jurisdiction, from MA to FL, but adults occur predominantly in FL and are uncommon north of there. Like striped mullet, white mullet spawn offshore and the juveniles move inshore and into estuaries during the spring, summer and fall of their first year. Thayer et al. (1997) indicate that they appear in eelgrass beds in spring and early summer. Young white mullet migrate southward along the coast to FL or further during their first fall. White mullet apparently feed on the same food at the same times as striped mullet. White mullet are preyed upon by weakfish, bluefish and red drum.

Summary: The geographic range of white mullet encompasses that of SAV; however, north of NC, predominantly juveniles occur. White mullet apparently prefer higher salinities than striped mullet, therefore they are more likely to be linked with seagrasses than with freshwater SAV.

Rainbow smelt: The only source of information reviewed for rainbow smelt was Buckley (1989). Rainbow smelt occur from eastern Labrador and the Gulf of St. Lawrence south to the Delaware River. They are anadromous, with adults living in estuaries and coastal waters and returning to freshwater streams to spawn. Spawning occurs in the spring, and typically occurs over gravel, but Buckley (1989) also reports that eggs have been deposited on SAV (p. 4). Larval smelt move downstream and ultimately mature to the juvenile stage in the lower estuary or nearshore coastal waters. Juveniles have been observed in eelgrass beds. Both adults and juveniles overwinter in estuaries. Juvenile smelt feed on copepods and other planktonic crustaceans. Larger juveniles and adults feed on euphausiids, amphipods, polychaetes, and fish. Fish species preyed upon include small mummichogs, cunner, anchovies, sticklebacks, Atlantic silversides and alewives. Predators on smelt include bluefish and striped bass.

Summary: Rainbow smelt occur only in the northern portion of ASMFC jurisdiction, from MA to DE. Their range overlaps spatially and temporally with eelgrass, to which their eggs may be attached and in which the juveniles may reside.

Black drum: Literature reviewed for information on black drum included Odum et al. (1984), Thayer et al. (1984, 1997), and Sutter et al. (1989). Black drum range from the Bay of Fundy to Argentina. They are common from the Chesapeake Bay south to FL and in the Gulf of Mexico, where they are abundant along the TX coast. Black drum spawn in tidal passes and in open bays and estuaries. Spawning begins in February and March in southern areas and may occur as late as June or July. Eggs are pelagic. Larvae are transported into estuaries by tidal currents. Juvenile black drum prefer shallow, nutrient rich and relatively muddy waters. They can tolerate a wide range of salinities and have been taken in freshwater. Odum et al. (1984) report that young have been collected in tidal creeks at salinities from 0-6 ppt. Adults through age 4 occupy estuarine areas. Older adults, at least in the Gulf of Mexico, migrate to offshore areas. Black drum larvae feed largely on zooplankton. Juveniles consume marine annelid worms, soft crustaceans, small fishes, amphipods and mollusks. Larger drum consumed primarily mollusks, crabs, shrimp and aquatic vegetation (Sutter et al. 1989, p. 5). No predators of black drum were reported in the literature reviewed.

Summary: Black drum geographically, spatially and temporally overlap with SAV, primarily seagrasses. The only mention of direct use of SAV was for consumption. Based on the literature reviewed, they do not appear to be heavily reliant on SAV.

Bay scallop: Information on the bay scallop was found in Fay et al. (1983), Thayer et al. (1984, 1997) and Zieman and Zieman (1989). Bay scallops range from the north shore of Cape Cod, MA to Laguna Madre, TX. They have a relatively short life, surviving on average 12 to 16 months, with a maximum of 26 months. Spawning times vary considerably across the range, with northern populations (MA, CN, RI) spawning in June and July, and southern ones (NC, FL) spawning between August and December as water temperatures decline. Fertilized eggs result in juveniles in about 14 days. Juveniles may use a variety of substrates for attachment during settlement, including stones, seaweeds, oyster shells, rope, and filamentous algae; however, eelgrass (in northern populations) or turtlegrass (FL) is the preferred substrate. Adult scallops can also attach to substrates, but they seldom do so. They prefer quiet waters which are protected from high winds, storms and tides. Preferred depths range from 0.3 to 10 meters, but they have been reported to 18 meters. The primary food of bay scallops is benthic diatoms, which are strained from the water while resting on the bottom or slightly burrowed. Principal predators of the bay scallop are crabs, including the green crab (*Carcinides maenes*) and the blue crab. In deeper waters, several species of starfish (*Asterias* and *Marthasterias* spp.) also prey on scallops.

Summary: The geographic, temporal and spatial distribution of the bay scallop closely overlaps that of seagrasses. Adults prefer to reside in seagrass beds, and juveniles prefer them (if not too dense) for settlement. Since scallop growth is higher at lower current speeds (Fay et al. 1989, p. 13) the sheltering effect of seagrass beds is likely beneficial in this regard as well. This species, of all those in this summary, is the closest to being an obligate SAV resident; however, as with several other species, populations of bay scallops do exist in areas without SAV as well.

Southern shrimp--brown shrimp: Literature reviewed for brown shrimp information was Zieman (1982), Lassuy (1983), Thayer et al. (1984, 1997), Larson et al. (1989) and Zieman and Zieman (1989). Brown shrimp occur from Martha's Vineyard, MA to the Florida Keys within the ASMFC jurisdiction. They are most abundant in NC, and less so through SC and FL. Spawning occurs offshore from NC through FL during most of the year, with adults apparently dying after spawning. Eggs are demersal, and hatch and develop through 11 larval stages offshore. After metamorphosis to postlarvae, transportation by currents carries the small shrimp into estuaries. Peak numbers moving into estuaries occur in March through June in NC, March and April in SC, and March to June in GA and FL. Highest recruitment occurs in areas adjacent to intertidal marshes and seagrass beds (Lassuy 1983, p. 10). Thayer et al. (1984, 1997) report that brown shrimp are strongly reliant on seagrass habitats. Community profiles on FL seagrasses (Zieman 1982, Zieman and Zieman 1989) did not indicate that brown shrimp were an important faunal component of seagrass beds in FL. Juveniles occupy estuarine nursery grounds from March through July, eventually moving to deeper more saline waters to mature. Adult and juvenile brown shrimp apparently prefer loose peat and sandy mud substrates, although they do occur on other substrate types such as sand, silt or clay mixed with rock fragments. Availability of cover, usually in the form of intertidal vegetation, is an essential component of brown shrimp nursery areas. Brown shrimp do use seagrass beds in the southern part of their range (Lassuy 1983, p. 4). Brown shrimp are omnivorous and consume detritus, plants, small invertebrates and fish. Many predators, primarily carnivorous fish and crustaceans, have been documented as consuming brown shrimp.

Summary: Brown shrimp co-occur with SAV beds in estuarine nursery areas in the southeastern portion of ASMFC jurisdiction. Juvenile recruitment rates are high near seagrass beds, and SAV is viewed as an important habitat for the species, but the species is clearly not an obligate SAV user since the highest commercial catches (NC) occur in areas where SAV is not presently abundant (e.g. Pamlico Sound).

Southern shrimp--pink shrimp: Literature reviewed for pink shrimp was Zieman (1982), Bielsa (1983), Thayer et al. (1984, 1997) and Zieman and Zieman (1989). Pink shrimp occur from lower Chesapeake Bay south to FL and into the Gulf of Mexico. Spawning occurs throughout the year in oceanic waters. Egg development, hatching, and larval development are similar to that of brown shrimp. Postlarvae enter estuarine nursery grounds at smaller size than brown shrimp, with peaks of abundance in the spring and late fall. Pink shrimp are highly reliant on seagrass beds as a nursery habitat. In fact, pink shrimp dispersion in nursery areas may be limited by the geographical distribution of seagrasses within estuaries (Bielsa et al. 1989, p. 13). Inshore fisheries for the species do not occur in areas without seagrass, although in NC, decomposing forest litter may provide an acceptable substitute in the absence of seagrass (Bielsa et al. 1989, p. 14, citing Williams (1955). Adult pink shrimp move to deeper areas and eventually offshore. Juvenile pink shrimp forage in seagrass beds and like brown shrimp are omnivorous, consuming dinoflagellates, foraminiferans, nematodes, polychaetes, ostracods, copepods, mysids, isopods, amphipods, caridean shrimps and their eggs, and mollusks. Pink shrimp display a preference for coarser substrates that either brown or white shrimp. Adult pink shrimp also are omnivorous, feeding on a variety of small mollusks, crustaceans, worms, small fishes and plant material. Pink shrimp are a major prey item for carnivorous fish such as snook (*Centropomus undecimalis*), spotted seatrout and many other species, as well as marine mammals and aquatic birds.

Summary: Pink shrimp occur in the southeastern portion of ASMFC jurisdiction. Juveniles are highly reliant on seagrasses as a nursery habitat and are not abundant where seagrasses are absent. Based on the literature reviewed, this species can legitimately be characterized as an obligate seagrass user.

Southern shrimp--white shrimp: Literature reviewed for white shrimp information was Muncy (1984). White shrimp occur from Fire Island, NY to Saint Lucie Inlet, FL, along the Atlantic Coast. They also occur in the Gulf of Mexico. The center of abundance within ASMFC jurisdiction is from NC south to FL. Adult white shrimp reside in the ocean and spawn from March through November, with peak spawning occurring from April to October. Offshore development of the egg and larval stages is similar to the other two species, with postlarvae moving inshore as they are carried by currents. Entrance into coastal estuaries in NC, SC and GA occurs during June through September. Juvenile white shrimp tend to move further upstream than either brown or pink shrimp, and prefer muddy substrates. Juvenile white shrimp have been collected as far as 270 kilometers from the mouth of the St. Johns River, FL. Juvenile and adult white shrimp are benthic omnivores, and consume items such as detritus, parts of annelids and mollusks, fish, bryozoans, sponges, corals, algae and vascular plant stems and roots. White shrimp, as with the other two species, are heavily preyed upon by many species of estuarine fish.

Summary: White shrimp distribution in the southeastern portion of ASMFC jurisdiction overlaps that of SAV. The species is not cited in the literature as being particularly reliant on SAV. This may be attributable to the fact that it is more tolerant of lower salinities, in which seagrasses do not occur. It is associated with intertidal vegetation. The fact that juveniles do move further upstream than the other species could place it near freshwater SAV; however, Odum et al. (1984) specifically note that it is not a significant component of tidal freshwater communities. The species appears to be one which does not rely heavily on SAV.

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Table 1.Life stage(s) of Atlantic States Marine Fisheries Commission species of responsibility/interest and documented (no question mark) or potential (question mark indicates that species overlaps SAV geographically, temporally and/or spatially, but no documentation of use was found in the literature) function which SAV provides (Documentation from Thayer et al. 1984, 1997 and other literature as referenced in the individual species' accounts

	SUBMERGED AQUATIC VEGETATION FUNCTION			
SPECIES/LIFE STAGE[1]	**REFUGE[2]**	**ATTACHMENT[3]**	**SPAWNING[4]**	
Atlantic croaker	L,J,A			
Atlantic menhaden	L,J,A			
Red drum	L,J		A?	
Spanish mackerel	J?			
Spot	L,J,A			
Spotted seatrout	J,A		A	
Striped bass	J?			
American eel	J			
Black seabass	J			
Scup	L,J,A?		A?	
Tautog	J	E?	E,A	
American lobster	J?			
Atlantic herring	L?,J?			
Atlantic sturgeon	J?			
Bluefish	J			
Northern shrimp	E?,J?,A?	L?,J?	A?	
American shad	J?			
Hickory shad	J?			

[1] Life stage abbreviations: E = eggs; L = larvae; J = juveniles; and A = adults.
[2] The species resides in SAV but is not physically attached.
[3] The species uses SAV as a site of physical attachment.
[4] The species deposits eggs in SAV beds or on SAV.
[5] The species consumes SAV directly (herbivore) or secondarily (detritivore).
[6] The species feeds on prey which reside in or are attached to SAV.

	SUBMERGED AQUATIC VEGETATION FUNCTION			
SPECIES/LIFE STAGE[1]	**REFUGE[2]**	**ATTACHMENT[3]**	**SPAWNING[4]**	
Alewife	J?			
Blueback herring	J?			
Summer flounder	J,A			
Weakfish	L,J,A		A?	
Winter flounder	J?,A?			
Southern flounder	J,A			
Striped mullet	J,A			
White mullet	L,J,A		A?	
Rainbow smelt	J,A?			
Black drum	L?,J?,A?		A?	
Bay scallop	E?,L?,J,A	E?,J	A?	
Brown shrimp	J,A			
Pink shrimp	J,A			
White shrimp	J?,A?			
Blue crab	J,A			

[1] Life stage abbreviations: E = eggs; L = larvae; J = juveniles; and A = adults.
[2] The species resides in SAV but is not physically attached.
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[6] The species feeds on prey which reside in or are attached to SAV.

Human Impacts on SAV - A Chesapeake Bay Case Study

by

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A large scale decline in submerged aquatic vegetation (SAV) occurred in Chesapeake Bay in the late 1960's and early 1970's that affected all major species and reduced overall abundance by 90% (Kemp et al., 1983). Although there has been some modest recovery in recent years, SAV abundance in Chesapeake Bay is still near historic low levels (Chesapeake Bay Program, 1992). This loss has meant that the ecological functions provided by SAV have been curtailed or severely impaired.

A wide range of possible decline causes, both anthropogenic and natural, has been investigated including natural cycles, animal foraging and grazing, storm events, disease, chlorine, industrial pollutants, physical disturbance, agricultural herbicides, sedimentation and nutrient enrichment (Stevenson and Confer, 1978). The primary causative factor identified for Chesapeake Bay is reduced penetration of light to rooted aquatic plants as a result of nutrient enrichment and sedimentation (Kemp et al., 1983; Hurley, 1991). Other factors are believed to be significant locally or in combination with these effects.

Nutrient enrichment stimulates excessive growth of phytoplankton, causing increased water column turbidity and reduced light penetration (Chesapeake Bay Program, 1995a). Similarly, direct shading of leaf surfaces occurs when nutrients enhance the growth of epiphytic algae. The primary sources of nutrients are fertilizers from farm fields and lawns, sewage treatment plant effluent, and acid rain. Suspended sediments also contribute to increased water column turbidity and can cause direct shading when they settle on leaf surfaces (Chesapeake Bay Program, 1995a). The primary source of sediment is land runoff from farms and construction sites.

Channel dredging in shallow water can remove existing SAV and dramatically alters SAV habitat (Stevenson and Confer, 1978). The increased water depth reduces light penetration to the bottom and discourages SAV recolonization. Dredging and dredged material disposal can also increase turbidity and negatively impact surrounding SAV (Hurley, 1991). While seasonal and area restrictions are in place to minimize direct effects on existing SAV beds, there is little protection in place for areas of suitable SAV habitat which formerly supported SAV and are targeted for restoration (Chesapeake Bay Program, 1995b). Shoreline development (Stevenson and Confer, 1978) and stabilization (Chesapeake Bay Program, 1995b) can result in the loss of suitable SAV habitat primarily by reducing the ability of shorelines to absorb wave energy.

Among toxic pollutants, agricultural herbicides have received the most attention as factors in the decline of SAV (Kemp et al., 1883). Originally considered a likely cause of the decline (Stevenson and Confer, 1978), herbicides were found only in sublethal concentrations in Chesapeake Bay except in certain, localized circumstances (Kemp et al., 1983). Periodic storm events following herbicide application could have detrimental effects on SAV, but these effects would be local (Hurley, 1991). Similarly, a major role for industrial pollutants in the SAV decline in Chesapeake Bay is unlikely given the absence of any correlation between the two (Kemp et al., 1983). Fluctuations in ambient water pH due to industrial discharges or other causes would have to be extreme to affect SAV and have not been documented for Chesapeake Bay (Stevenson and Confer, 1978).

Boating and fishing activities can impact SAV through direct damage and sediment resuspension. Prop scar from boating activity is thought to be growing in significance with the increase of boating (Hurley, 1991). In addition, significantly increased turbidity due to propeller-induced turbulence has been observed for vessels typical of Chesapeake Bay (Gucinski, 1978). Commercial fishing activities of concern include clam dredging, crab scraping, haul seining and aquaculture (Chesapeake Bay Program, 1995b). Crab and oyster dredging generally do not occur in SAV habitat. When hydraulic clam dredging occurs in SAV beds, it uproots all vegetation in a 75 to 90 cm path (Stevenson and Confer, 1978). The extent and permanency of the physical effects of clam dredging probably depend on the particular SAV species. Those that reproduce primarily by vegetative means would be less affected, but those dependent on sexual reproduction could be virtually wiped out (Stevenson and Confer, 1978). Clam dredging can also significantly increase local turbidity with negative impacts on SAV (Chesapeake Bay Program, 1995b). The turbidity is more extensive and persistent in silt or clay than it is on sandy substrates.

Crab scraping is practiced directly in SAV beds in pursuit of blue crabs that use the beds for cover while shedding. Observations of crab scraping suggest that the activity removes the upper parts of the plants without digging up the critical roots and rhizomes (Chesapeake Bay Program, 1995b). The epicenter of this activity in Chesapeake Bay is the Tangier and Pocomoke Sounds area which continues to be the region of greatest density for SAV. The apparent sustainability of this practice there is probably due to the dominance in this area of eelgrass (Zostera marina), an SAV species with a basal meristem morphology. The plant parts removed for this type of species would consist primarily of old or dying tissues. Crab scraping would be more limiting for apical meristem plants which include most other Chesapeake Bay species (Chesapeake Bay Program, 1995b).

Haul seining is known to sometimes occur in SAV beds or on their periphery in Chesapeake Bay. Concern about possible impacts on SAV from haul seining in the Susquehanna flats area of upper Chesapeake Bay led to the introduction of legislation to ban the practice in this area in 1996. The legislation was tabled while a study was conducted by the Maryland Department of Natural Resources during the commercial haul seining season in the summer of 1996. A three part study involving experimental seining, observations of commercial operations, and aerial photography concluded there were no detectable effects from seining on plant height, plant density, or species composition (Sadzinski et al., 1996). This gear must skim the bottom to be effective, but underwater video revealed that seines rode easily over stands of SAV with little or no effect. Aerial photographs taken before and after seining also showed no discernible effect. Loose SAV regularly observed floating, settled on the bottom, and accumulated in windrows on the shore were assumed to be the result of wave action by boats and wind, rooting activity by carp, and natural stem die-off.

Aquaculture activities involving raft or on-bottom rack culture in shallow water can have a detrimental effect on SAV through direct shading and possibly through nutrient enrichment effect (Chesapeake Bay Program, 1995b). Although this form of aquaculture is not widely practiced in Chesapeake Bay at this time, it is growing in popularity, especially for shellfish culture, and may pose a significant problem for SAV in the future.

Natural factors such as climate, disease, grazing and foraging are unlikely to be of more than occasional and local importance for SAV in the Chesapeake (Kemp et al., 1983). One exception to this rule may be major climatic events like Hurricane Agnes in 1972 which resulted in a nearly complete loss of SAV in the upper Chesapeake Bay (Chesapeake Bay Program, 1992). Notwithstanding this dramatic effect, the lack of regrowth is probably the result of increasing background levels of turbidity resulting from nutrient enrichment.

SAV loss in Chesapeake Bay is primarily the result of large scale water quality problems, particularly nutrient enrichment and sedimentation (Hurley, 1991). Activities such as fishing and dredging which physically disturb the bottom may be significant locally and can have a direct effect when they occur in SAV beds, but they are unlikely to be major problems for SAV on a baywide scale. However, when these activities resuspend bottom sediments they reinforce the primary mechanism of SAV loss, the reduction of light reaching the plants. Relatively small scale impacts such as these can be more significant when SAV is regionally diminished due to larger scale factors. The small scale impacts viewed as important because of their widespread nature and the pressure to compromise (Chesapeake Bay Program, 1995b). Accordingly, they are recognized inherently in official government policy which states that, "only in rare circumstances will losses of submerged aquatic vegetation be considered justified"(Chesapeake Executive Council, 1989).

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State Regulation and Management of Submerged Aquatic Vegetation Along the Atlantic Coast of the United States

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Introduction

In order to summarize the state regulations protecting submerged aquatic vegetation (SAV, specifically seagrasses) along the Atlantic Coast, relevant state agencies were canvassed by telephone. SAV was considered to include marine and brackish water seagrasses; however, some state contacts also provided information on the management of macroalgae. Information provided by state contacts was summarized in the *General Overview* section for each state. If copies of the regulations were provided, they are indicated in the *References and Literature Cited* section.

In a followup survey, state contacts were asked to characterize the effectiveness of these regulations, by answering the following questions:

1. Are state regulations extremely effective at protecting SAV [no SAV is lost, or any that is lost is effectively mitigated (replaced)]?
2. Are state regulations highly, somewhat or not effective at protecting SAV from physical disturbance?
3. Are state regulations highly, somewhat, or not effective at protecting water quality necessary for SAVs?

As evidenced by this procedure, effectiveness characterization for each state was based solely on the opinion of that state contact.

State contacts were asked to describe any fishing gear restrictions in place to protect SAV, and any long-term and/or recent trends in SAV abundance. Finally, state contacts were asked to describe any mapping efforts which are being planned or underway, and to estimate the percentage of area currently mapped. Information on regulation effectiveness gathered during the followup survey is summarized in Table 1. Coastal mapping programs are summarized in Table 2.

State Programs

Maine

Contact: Seth Barker Maine Department of Marine Resources P.O. Box 8
West Booth Bay Harbor, ME 04575 (207)633-9507 Phone (207) 633-9579 FAX

General Overview

The Maine Coastal Program in the Maine State Planning Office completed a project to determine whether 12 common species of marine benthic vegetation (eelgrass, kelps, and rockweeds) should specifically be protected in Maine, and to develop management guidelines if protection was warranted (Wippelhauser, 1996). The document entitled "Ecology and Management of Maine's Eelgrass, Rockweeds, and Kelps," identifies threats and recommends management options for conservation.

The Natural Resources Protection Act of Maine requires permits to be issued by the Department of Environmental Protection for any dredging, bulldozing, removal of material, draining or dewatering, filling, and construction, repair or alteration of any permanent structure that affects coastal wetlands. Coastal wetlands are defined as all tidal and subtidal lands, and other regulated areas. Applicants for permits must demonstrate that there will be "no meaningful loss of the wetland function and values based on the nature of the activity (Wippelhauser, 1996). SAVs are not addressed by species in any of these regulations.

Nonpoint sources of pollution are indirectly addressed through state laws that are administered by the Department of Environmental Protection (Site Location of Development Act, Natural Resources Protection Act), and by municipalities (Municipal Subdivision Law and Land Use Regulation Act). Recommendations for reducing nonpoint sources of pollution have been made in the Maine Coastal Nonpoint Source Control Program Plan, which was submitted to NOAA and EPA for approval. The program calls for the implementation of Best Management Practices in all towns that have land areas draining directly into coastal waters (Wippelhauser, 1996).

Effectiveness of Regulations and Recent Trends in SAV Abundance

Maine regulations are considered by the state contact to be somewhat effective at protecting SAV from physical disturbance, and at protecting the water quality needed by SAVs. Maine's regulations are effective for larger projects that would physically disturb eelgrass, because permits require compliance checks to assess effectiveness. Under Maine's reduced review procedure, smaller projects (e.g. pile-supported piers) are permit-by-rule. The presence of eelgrass is not considered and the permits do not include compliance checks. Maine regulation does not consider the impact of physical disturbance on macroalgae.

For larger projects that would impact water quality (e.g. outfall pipes), the effect on eelgrass (but not macroalgae) would probably be considered. However, water quality standards are geared toward the protection of animal life (e.g. dissolved oxygen) rather than plant life (e.g. no turbidity standards). There is no historical data with which to estimate long or short-term trends in SAV abundance.

Fishing Gear Restrictions to Protect SAVs

There are no fishing gear restrictions to protect SAVs in Maine.

SAV Mapping

Mapping of eelgrass by the Maine Department of Marine Resources is currently underway, and should be completed for the entire coast of Maine by 1998. In a cooperative project between DMR and the Nature Conservancy, existing geological maps and groundtruth surveys are being used to map macroalgae in Cobscook Bay.

New Hampshire

Contact: Bill Ingham New Hampshire Fish and Game 2 Hazen Drive
Concord, N.H. 03301 (603)271-2461 Phone (603) 271-2461 FAX

General Overview

New Hampshire manages and regulates wetlands under the N.H. Department of Environmental Services Wetland Program. There is a Wetlands Bureau which acts on matters relating to resources of the state, including but not limited to excavating, dredging, or filling in and/or adjacent to waters of the United States (N.H. Department of Environmental Services Wt 103.01, 1996). The regulations mandate that no person shall excavate, remove , fill, dredge or construct any structure in or on any bank, flat, marsh, or swamp in and/or adjacent to any waters of the state without a permit from the Wetlands Bureau (482-A:3, 1992). Although the regulations do not specifically identify SAV in the definitions, the Wetlands Bureau has jurisdiction, and regulations apply "wherever the tide ebbs and flows, including those areas within 100 feet of the highest observable tide line which border on tidal waters, including but not limited to, banks, upland areas, bogs, salt marsh, swamps, meadows, flats or other lowlands subject to tidal action" (New Hampshire Code of Administrative Rules, Chapter 482-A:4, 1992).

In addition, New Hampshire has regulations for fill and dredge in wetlands which protect wetland areas for the benefits they provide as habitat to fish and wildlife. The language specifies that it is found to be for the public good and welfare of the state to protect and preserve its submerged lands under tidal and fresh waters and its wetlands, (both salt water and fresh), from despoliation and unregulated alteration, because such despoliation or unregulated alteration will adversely affect the value of such areas as sources of nutrients for finfish, crustacea, shellfish and wildlife of significant value, will damage or destroy habitat and reproduction areas for plants, fish and wildlife of importance, etc.

Effectiveness of Regulations and Recent Trends in SAV Abundance

Regulations in New Hampshire are considered by the state contact to be extremely effective at protecting SAV. In recent years, eelgrass abundance seems to have been increasing because of what appears to be a decline in wasting disease.

Fishing Gear Restrictions to Protect SAVs

New Hampshire does not have any regulations in effect to protect SAV from harm caused by fishing gears. There are regulations which limit the amount of SAV that can be harvested for subsistence, and prohibit the commercial harvest of SAV.

SAV Mapping

University of New Hampshire researchers have completed mapping eelgrass in Great Bay and Little Harbor, and incorporated it into GIS format. Eelgrass in the Piscataqua River was mapped in conjunction with Maine Department of Marine Resources. Studies to map offshore areas and the Hampton Estuary are on hold because of funding needs.

Massachusetts

Contact: Paul Caruso Massachusetts Division of Marine Fisheries 50 A Portside Drive Pocasset, MA 02559 (508) 563-1779 X-107 (508) 563-5482 FAX

General Overview

The Massachusetts Department of Environmental Protection has specific regulations under the code of Massachusetts regulations (310 CMR 10.00), which are applied when land under the ocean or nearshore areas of land under the ocean are found to be significant to the protection of marine fisheries, protection of wildlife habitat, storm damage prevention or flood control. Non-water dependent projects cannot have adverse effects on marine fisheries habitat or wildlife habitat caused by:

- alterations in water circulation;
- destruction of eelgrass (Zostera marina) or widgeon grass (Ruppia maritima) beds;
- alterations in the distribution of sediment grain size;
- changes in water quality, including, but not limited to, other than natural fluctuations in the level of: dissolved oxygen, temperature or turbidity, or the addition of pollutants;
- alterations of shallow submerged lands with high densities of polychaetes, mollusks or macrophytic algae.

When a saltmarsh is determined to be significant to the protection of marine fisheries, the prevention of pollution, storm damage prevention, or ground water supply, then a proposed project in a salt marsh, on lands within 100 feet of a salt marsh or in a body of water adjacent to a salt marsh shall not destroy any portion of the salt marsh and shall not have an adverse effect on the productivity of the salt marsh (310 CMR 10.32).

Effectiveness of Regulations and Recent Trends in SAV Abundance

Regulations are considered by the state contact to be very effective at protecting SAVs from physical disturbance, but not effective at protecting the water quality needed for SAVs to flourish. The significant amount of eelgrass lost over the last few years is generally attributed to poor water quality, especially nutrient loading.

Fishing Gear Restrictions to Protect SAVs

Some areas of the south shore of Cape Cod are closed to mobile gear including all trawls and sea scallop dredges in order to protect eelgrass.

SAV Mapping

Approximately 90% of seagrasses and macroalgae in the state of Massachusetts have been mapped by the Department of Environmental Protection. The data are available in GIS format, and are expected to be complete by June 1997.

Rhode Island

Contact: Jim Boyd R.I. Coastal Resources Management Program
Oliver Stedman Government Center Wakefield, RI 02873
(401)277-2476 Phone (401) 277-3922 FAX

General Overview

The State of Rhode Island Coastal Resources Management Program (RICRMP) as amended, requires a Category B application for major activities in tidal and coastal pond waters, on shoreline features and their contiguous areas. The Category B application requires several steps which may directly and/or indirectly protect SAV, although SAV is not addressed on a species basis. The applicant must describe the boundaries of the coastal waters and land area that are anticipated to be affected; demonstrate that the alteration or activity will not result in significant impacts on the abundance and diversity of plant and animal life; demonstrate that the alteration will not result in significant impacts to water circulation, flushing, turbidity, and sedimentation; and demonstrate that there will be no significant deterioration in the quality of the water in the immediate vicinity as defined by the Department of Environmental Management (R.I. CRMP, Section 300.1, Category B Requirements).

Effectiveness of Regulations and Recent Trends in SAV Abundance

Regulations are considered by the state contact to be very effective at protecting water quality, and at protecting SAVs from physical disturbance. Once SAV beds are identified, the regulations minimize disturbance to SAV, and water qualtiy is maintained through several state programs. Anecdotal information suggests that eelgrass losses are occurring; however, the amount lost is currently unknown.

Fishing Gear Restrictions to Protect SAVs

There are no fishing gear restrictions in Rhode Island to protect SAVs.

SAV Mapping

Approximately 3% of Rhode Island's seagrasses have been mapped through a number of programs. This inventoryof seagrasses is currently limited to the salt ponds on the south shore (Thorne-Miller et al., 1983) and portions of Narragansett Bay (Boyd, personal communication, 1996). *Save the Bay* and the Rhode Island Department of Environmental Management are teaming up under the Naragansett Bay Program to complete the inventory of seagrasses in Narragansett Bay by late 1997. This effort is supported by the Pew Charitable Trusts.

Connecticut

Contacts: Ron Rozsa and Sue Mickolyzck CT Department of Environmental Protection,
Office of Long Island Sound Programs 79 Elm Street Hartford, CT 06106-5127
(860)424-3034 Phone (860) 424-4054 FAX

General Overview

The water chemistry of Long Island Sound is polyhaline and the dominant SAV is eelgrass (Zostera marina). Once present in the shallow waters and coves throughout the Sound, eelgrass today only occurs along the eastern third of Connecticut's shore and is absent from New York's portion of Long Island Sound. The long term decline of eelgrass is believed to be a result of nitrogen enrichment, which is also responsible for hypoxia in central and western Long Island Sound. To further quantify water quality characteristics, the Office of Long Island Sound Programs initiated a coastwide volunteer Secchi Disk program in 1995. Sampling stations were expanded in 1996. Current research focuses on the past and present distribution of eelgrass and the evaluation of its minimum water quality requirements.

A related but separate SAV initiative is the development of baseline data for the lower Connecticut River, which has been designated as a "Wetland of International Importance" under the Ramsar Convention. This includes the Connecticut River estuary and tidal river below Portland/Cromwell, which supports a diverse assemblage of tidal fresh and tidal brackish SAV. The Nature Conservancy was provided with funding from the Department of Environmental Protection's (DEP) Long Island Sound Research Fund to develop a GIS based seagrass database using airphoto interpretation and field surveys with GPS. Final maps and digital data should be available in winter 96/97.

The Connecticut Coastal Management Act (CMA) establishes a single set of policies, standards and criteria for actions at all levels of government. Eelgrass is specifically referenced in the Policy for Coves and Embayments: "...to manage estuarine embayments so as to insure that coastal uses proceed in a manner that assures sustained biological productivity, the maintenance of healthy marine populations and the maintenance of essential patterns of circulation, drainage and basin configurations; to protect, enhance and allow natural restoration of eelgrass flats except in species limited cases, notably shellfish management, where the benefits accrued through alteration of the flat may outweigh the long-term benefits to marine biota, waterfowl, and commercial and recreational finfisheries [Connecticut General Statutes Sec. 22a-92(c)(2)(A)]. Furthermore, the CMA defines unacceptable adverse impacts. Most notably, activities that destroy eelgrass would have the adverse impacts of "degrading or destroying essential wildlife, finfish or shellfish habitat through significant alteration of the composition, migration patterns, distribution or breeding or other population characteristics of the natural species or significant alteration of the natural components of the habitat" [C.G.s. 22a-93(15)(G)].

Effectiveness of Regulations and Recent Trends in SAV Abundance

Connecticut regulations are considered by the state contacts to range from extremely effective to very effective at protecting SAV. Direct impacts to SAV from activities such as dredging, filling and construction of docks are regulated under the Structures and Dredging and Filling Law. Such activities must be designed to either avoid impacts to SAVs or mitigate them. No quantitative records have been generated to record the actual permitted SAV losses, but they are expected to be on the order of less than 0.25 acres per year.

Connecticut has only recently documented significant long term declines of eelgrass, which are probably the result of nitrogen enrichment from sewage treatment plants. The states of New York and Connecticut have begun to implement a nitrogen reduction program for Long Island Sound, which should benefit eelgrass in the long term. Improved water quality will provide for spontaneous restoration of eelgrass, or restoration assisted by man through transplantation or seed disbursement.

There are incidental impacts to eelgrass from a variety of activities that are known to exist but which have never been quantified such as propeller scour, shellfish harvest, and blowouts from jet skis.

Fishing Gear Restrictions to Protect SAVs

Connecticut does not have any fishing gear regulations which were designed to protect SAVs. In order to keep fishing vessels away from recreational beaches, trawling is prohibited inside the 18 foot contour line, which may result in some protection for SAVs from physical disturbance.

SAV Mapping

Final GIS mapping of SAV in the lower Conencticut River by the Nature Conservancy should be finished by the winter of 1996/97. A Sound-wide eelgrass mapping project was completed in 1996. A team of University of Connecticut researchers equipped with a GPS, SCUBA gear, and a small boat surveyed over 800 potential eelgrass locations during 1993-1995 field seasons. With technical assistance from DEP's Long Island Sound Resource Center, the field work was incorporated into an ARC/INFO GIS database. This project was funded by the state's Long Island Sound Research Fund.

New York

Contact: Art Newell New York State Department of Environmental Conservation,
Bureau of Marine Resources 205- No. Belle Meade Road East Setauket, NY 11733 (516) 444-0430 Phone (516) 444-0434 FAX

General Overview

The New York Department of Environmental Conservation, Division of Marine Resources manages areas where SAV occurs under the Tidal Wetlands Land Use Regulations (6 NYCRR Part 661). There are no regulations specific to the protection of SAV, but New York regulations for protecting the littoral zone extend out to 6 feet at mean low tide and include all lands under tidal waters which are not included in any other category (6 NYCRR Part 661.4).

Effectiveness of Regulations and Recent Trends in Abundance

According to the state contact, regulations are somewhat effective at protecting SAVs from physical disturbance, and at protecting the water quality necessary for SAVs to thrive. New York State water quality standards, which are administered through water quality programs, are probably protective of SAVs. However, turbidity standards are difficult to enforce, especially if the turbidity is not a result of a point source discharge. Nonpoint source nutrient input control programs are in their infancy, and probably still not effective. Anecdotal information suggests that eelgrasses have been declining in New York waters.

Fishing Gear Restrictions to Protect SAVs

There are no fishing regulations to protect SAV in New York waters.

SAV Mapping

Seagrasses are being documented through aerial photography by the State Bureau of Marine Resources. This information is being archived for future use; however, data analysis has not been planned.

New Jersey

Contact: Bruce Halgren New Jersey Department of Environmental Protection,
Division of Fish, Game and Wildlife CN 400 Trenton, NJ 08625-0400 (609) 292-2083 Phone
(609) 984-1414 FAX

General Overview

The New Jersey Department of Environmental Protection's Land Use Regulatory Program (LURP) specifies that submerged vegetation of the state's estuarine waters serve important functions as suspended sediment traps, important winter forage for migratory waterfowl, nursery areas for juvenile finfish, bay scallops and blue crabs, and by nourishing fishery resources through primary biological productivity through detrital food webs in a similar manner to salt marsh emergent Spartina cord grasses. LURP's SAV regulations (7:7E-3.6) aim to protect SAV as a resource. The state identifies areas where SAV grows or has been known to grow, as habitat areas which currently or potentially could support SAV. New Jersey maps the distribution of some species of SAV and provides a method of delineation. Regulated activities in SAV beds are prohibited under the New Jersey regulations except as specifically noted (i.e. trenching for utility pipelines and submarine cables in the public interest, new dredging of State and Federal navigation channels, provided that there is no practicable or feasible alternative and mitigation is required, etc.)

Effectiveness of Regulations and Recent Trends in Abundance

New Jersey regulations are considered by the state contact as very effective at protecting SAVs from physical disturbance, and at protecting water quality. Ongoing studies suggest that eelgrasses have been declining in the Barnegat Bay - Little Egg Harbor complex because of plant disease. High volume boat traffic may contribute to increased turbidity, and negatively impact SAVs.

Fishing Gear Restrictions to Protect SAVs

New Jersey does not have any regulations that specifically address SAVs and gear. The Division of Fish, Game, and Wildlife, however, takes into consideration the impact that different gear types may have on SAVs when considering new or modified regulations. Requests for the use of certain gear types have been denied in the past, based in part on their potential impact to SAVs.

SAV Mapping

Seagrasses in New Jersey were mapped in 1980 by the Department of Environmental Protection. In 1988, seagrasses in Barnegat Bay and Little Egg Harbor were mapped by the Division of Fish, Game and Wildlife.

Delaware

Contact: Bill Moyer   Delaware Department of Natural Resources and Environmental Control
89 King Highway P.O. Box 1401 Dover, Delaware 19903
(302)739-4691 Phone (302) 739-3491 FAX

General Overview

Delaware has adopted the standards used in the Chesapeake Bay for water quality goals to meet in the Inland Bays (Ben Anderson, Personal Communication, 1996). This pollution control strategy includes restoration of SAV as water quality parameters permit.

Delaware has authority for SAV under regulations for subaqueous lands and wetlands. Although SAV is not specifically mentioned, the definition of subaqueous lands includes submerged lands and tidelands. Submerged lands means lands lying below the line of mean low tide in the beds of all tidal waters within the boundaries of the state together with the beds of navigable rivers, streams, lakes, bays and inlets within the boundaries of the state. Since areas of submerged lands and tidelands includes areas where SAV are found, the Department of Natural Resources and Environmental Control, Division of Water Resources (Department) can require permits to deposit material or remove materials from submerged lands or tidelands. The Secretary of the Department can place reasonable limits on the use and development of private subaqueous lands (72 Del. Laws. §7202).

The Delaware Wetlands Statutes recognize that much of the wetlands of the state have been lost or despoiled by unregulated dredging, dumping, filling and like activities, and that the remaining wetlands of the state are in jeopardy of being lost or despoiled by such activities (The Wetlands Act 7 Del.C. 1953 §6602). The statutes also recognize that wetlands are valuable to finfish, crustacea and shellfish of significant economic value. Under the 1994 Department of Natural Resources and Environmental Control Wetland regulations, specific species of aquatic vegetation are included in those areas considered as wetlands [e.g., Eelgrass (<u>Zostera marina</u>), Widgeon Grass (<u>Ruppia maritima</u>)].

The water quality of Delaware's Inland Bays does not meet the requirements for SAV. Although there is a heightened awareness of the water quality problems, restoration activities are complicated by recreational and commercial clamming. Recreational clammers rake in SAV beds which just get established from restoration efforts, and commercial fisherman complain because areas are fenced off while state biologists are trying to restore beds.

Effectiveness of Regulations and Recent Trends in Abundance

Regulations in Delaware are not effective at protecting SAVs from physical disturbance, according to the state contact. Regulations for protecting water quality necessary for SAVs are somewhat effective; however, nonpoint source pollution is not being effectively controlled. Anecdotal information suggests that seagrasses in Delaware have been declining. Expermimental plantings are underway to determine whether improvements in water quality in Delaware Inland Bays will make SAV growth feasible.

Fishing Gear Restrictions to Protect SAVs

There are no fishing regulations to protect SAV in Delaware waters.

SAV Mapping

Seagrasses in Delaware have not been mapped.

Maryland

Contact: Nancy Butowski Maryland Department of Natural Resources
580 Taylor Avenue Annapolis, MD 21401 (410)974-2242 Phone (410) 974-2600 FAX

General Overview

Virginia and Maryland signed The Chesapeake Bay Program (CBP)Agreement Commitment Report entitled "Submerged Aquatic Vegetation Policy for the Chesapeake Bay and Tidal Tributaries," in 1989. The states agreed to work together to implement the assessment of the distribution and abundance of SAV, develop protection and restoration guidelines, and implement an education component to increase public awareness of the value for the resource (Chesapeake Bay Program 1989). The CBP Submerged Aquatic Vegetation Work Group developed a guidance document for protecting SAV from physical disruption in 1995 (Chesapeake Bay Program 1995). The Guidance focuses on impacts of shallow water dredging and construction activities on SAV and SAV habitats. The document gives an excellent summary of existing regulations, guidelines and policies of regulatory and commenting agencies regarding activities affecting SAV. (See Attached Table 3).

Effectiveness of Regulations and Recent Trends in Abundance

Maryland regulations are extremely effective at protecting SAVs from physical disturbance, and maintaining the required water quality, according to the state contact. Seagrasses in Chesapeake Bay increased in abundance from 1991-1993, and decreased in 1994.

Fishing Gear Restrictions to Protect SAVs

The use of crab scrapes in SAV beds is limited to toothless scrapes.

SAV Mapping

Seagrasses in Chesapeake Bay are mapped annually by the Virginia Institute of Marine Sciences. The 1995 update will be available in December, 1996.

Virginia

Contact: Randy Owen Virginia Marine Resources Commission P.O. Box 756
Newport News, VA 23607-0756 (804)247-2200 Phone (804) 247-8062 FAX

General Overview

Virginia and Maryland signed The Chesapeake Bay Program (CBP)Agreement Commitment Report entitled "Submerged Aquatic Vegetation Policy for the Chesapeake Bay and Tidal Tributaries," in 1989. The states agreed to work together to implement the assessment of the distribution and abundance of SAV, develop protection and restoration guidelines, and implement an education component to increase public awareness of the value for the resource (Chesapeake Bay Program 1989). The CBP Submerged Aquatic Vegetation Work Group developed a guidance document for protecting SAV from physical disruption in 1995 (Chesapeake Bay Program 1995). The Guidance focuses on impacts of shallow water dredging and construction activities on SAV and SAV habitats. The document gives an excellent summary of existing regulations, guidelines and policies of regulatory and commenting agencies regarding activities affecting SAV. (See Attached Table 3).

Effectiveness of Regulations and Recent Trends in Abundance

Virginia regulations are very effective at protecting SAVs from physical disturbance, and maintaining the required water quality, according to the state contact. Seagrasses in Chesapeake Bay increased in abundance from 1991-1993, and decreased in 1994.

Fishing Gear Restrictions to Protect SAVs

The use of crab scrapes in SAV beds is limited to toothless scrapes.

SAV Mapping

Seagrasses in Chesapeake Bay are mapped annually by the Virginia Institute of Marine Sciences. The 1995 update will be available in December, 1996.

North Carolina

Contact: Mike Street North Carolina Division of Marine Fisheries P.O. Box 769 Morehead City, NC 28557 (919)726-7021 Phone (919)726-7222

General Overview

Under North Carolina state law and the public trust doctrine, the North Carolina Division of Marine Fisheries (DMF) comments on dredge and fill projects (Mike Street, Personal Communication, 1996). The Marine Fisheries Commission rules protect SAV with fishing gear restrictions which prohibit mechanical shellfish harvest and trawling which uses propeller wash and weighted trawls. Coastal Resources Commission rules generally prohibit dredging or filling of SAV and are effective. The DMF is currently mapping estuarine bottoms with a stratified random sampling method.

Effectiveness of Regulations and Recent Trends in Abundance

North Carolina regulations are very effective at protecting SAVs from physical disturbance, and somewhat effective at maintaining the water quality required by SAVs, according to the state contact. High salinity seagrasses such as Zostera and Halodule abundances are stable or increasing. Low salinity species such as Ruppia and wild celery have suffered losses, but are beginning to recover in Pamlico Sound.

Fishing Gear Restrictions to Protect SAVs

Mechanical shellfishing and bullraking are prohibited in seagrass beds.

SAV Mapping

Most high salinity SAVs have been mapped by the National Marine Fisheries Service. Portions of estuarine areas have been mapped by the NC Geodetic Survey. The DMF is mapping estuarine bottom types and shellfish beds for the entire coast, excluding the open waters of Pamlico Sound. This project is estimated to be completed by 2001. There are not any plans to map seagrasses in the open waters of Pamlico Sound.

South Carolina

Contact: Rob Dunlap South Carolina Department of Natural Resources P.O. Box 12559 Charleston, SC 29412 (803)762-5067 Phone   (803) 762-5007 FAX

South Carolina does not have SAV in tidal waters because of high tidal amplitude and very turbid waters. There are some herbaceous species of aquatic vegetation but the state lumps their regulation under intertidal wetlands (Rob Dunlap, Personal Communication, 1996).

Georgia

Contact: Stuart Stevens Georgia Department of Natural Resources 1 Conservation Way Brunswick, GA (912)264-7218 Phone   (912) 262-3143 FAX

Georgia does not have SAV in tidal waters because of high tidal amplitude and very turbid waters.

Florida

Contact: Leonard Nero Department of Environmental Protection 3111 B13 Fortune Way Wellington, FL 33414 (407)791-4042 Phone (407) 791-4722 FAX

General Overview

Florida has the authority to regulate SAV under statutes in the Sovereignty Submerged Lands Management, State Parks and Preserves, Florida Aquatic Preserves, and the 1994 supplement to Florida Statutes of 1993. Under Chapter 373.414, additional criteria for activities in surface waters and wetlands, criteria which must be considered when determining whether an activity is contrary to the public interest, include whether the activity will adversely affect the conservation of fish and wildlife, including endangered or threatened species, or their habitats; and whether the activity will adversely affect the fishing or recreational values or marine productivity in the vicinity of the activity.

Chapter 253.034, which pertains to state lands, requires that the state manage state-use lands primarily for the maintenance of essentially natural conditions, the propagation of fish and wildlife, and public recreation, including hunting and fishing, where deemed appropriate by the managing agency. Chapter 253.12, Title to tidal lands vested in the state, requires the Board of Trustees of the Internal Improvement Fund (Board) to determine the extent to which the sale of islands or submerged lands would interfere with the conservation of fish or marine productivity, including, but not limited to, destruction of marine habitats, grass flats suitable as nursery or feeding grounds for marine life, and established marine soils suitable for producing plant growth of a type useful as nursery or feeding grounds for marine life. The Board cannot sell the lands if it would result in the destruction of oyster beds, clam beds, or marine productivity, including, but not limited to , destruction of natural marine habitats, grass flats suitable as nursery or feeding grounds for marine life, and established marine soils suitable for producing plant growth of a type useful as nursery or feeding grounds for marine life.

Florida Aquatic Preserves, Chapters 18-20, refers to management of SAV in several places. In part, the preserves are supposed to be managed in accordance with several goals including to preserve, promote, and utilize indigenous life forms and habitats, including but not limited to submerged grasses. There are special stipulations for marinas located in aquatic preserves, including the siting of docking facilities to take into account the access of the boat traffic to avoid marine grassbeds, and prohibition in Resource Areas where SAV is located (Chapter 18-20.004). Under the statutes of the State Parks and Preserves, aquaculture activities are permitted, but only in those areas which will not destroy grassbeds and commercial docking facilities cannot have adverse impacts on marine resources (Chapter 258.42).

The object of the Sovereignty Submerged Lands Management statutes are to "manage, protect, and enhance sovereignty lands so that the public may continue to enjoy traditional uses including, but not limited to navigation, fishing, and swimming." (Chapter 18-21.001). By definition, sovereign submerged lands include benthic communities where grass beds occur. Activities which would result in significant adverse impacts to sovereignty lands and associated resources cannot be approved unless there is no reasonable alternative and adequate mitigation is proposed. Activities are supposed to be designed to minimize or eliminate any cutting, removal, or destruction of wetland vegetation, and shall be designed to minimize or eliminate adverse impacts on fish and wildlife habitat. Included under these statutes are the Florida Keys Marina and Dock Siting Policies and Criteria, where special attention and consideration shall be given to eliminating any adverse impacts on wetland or submerged vegetation or benthic communities, and requiring adequate water depths to avoid dredging and other bottom disturbance (Chapter 18-21.0041).

Effectiveness of Regulations and Recent Trends in SAV Abundance

Florida regulations to protect SAV from physical disturbance are considered by the state contact to be somewhat effective, as are those that protect water quality. The long term trend in SAV abundance in Florida has been one of significant decline. Recognition of the problem and subsequent efforts at regulation and protection have substantially reduced the direct loss of SAV. However, rapid population growth continues to result in chronic secondary and long term indirect perturbation and loss of SAV. The ecosystem management initiatives of the new Department of Environmental Protection are anticipated to result in the integrated protection, enhancement, and restoration of SAV.

Fishing Gear Restrictions to Protect SAVs

Florida does not have any regulations that limit the use of fishing gear in order to protect SAVs.

SAV Mapping

All of Florida's seagrasses have been mapped at one time or another by a myriad of agencies, including the various water management districts, the state Department of Environmental Protection (DEP), the US Fish and Wildlife Service, and the National Marine Fisheries Service. The DEP is in the process of developing a GIS database including all seagrass mapping efforts. This database will be continually updated as time and funding permit.

Table 1. Recent trends in seagrass abundance in Atlantic coastal states, and qualitative estimates of regulation effectiveness based on opinions of state contacts. The effectiveness of regulations at protecting seagrass from physical disturbance, and ensuring the necessary water quality, are ranked on the numerical scale given below. Regulations addressing fishing gear impacts are also summarized.

STATE	RECENT TRENDS	PHYSICAL DISTURBANCE	WATER QUALITY	FISHING GEAR REGULATIONS
ME	unknown	3	3	none
NH	>	1	1	none
MA	<<	2	4	trawls and seas scallop dredges prohibited on areas of south shore of Cape Cod to protect *Zostera.*
RI	<	3	3	none
CT	<	1	2	none
NY	<	3	3	none
NJ	<	2	2	some gears have been prohibited in part because of impacts to SAV
DE	<	4	3	none
MD	=	1	1	crab scrapes must be toothless
VA	=	2	2	none
NC	<	2	3	mechanical shellfishing and bullraking prohibited in SAV
FL	<	3	3	none

Recent Trends:

- << - severe declines
- < - decline
- > - increase
- = - stable

Physical Disturbance/Water Quality Ranking:

- 1 - extremely effective
- 2 - highly effective
- 3 - somewhat effective
- 4 - not effective.

Table 2. SAV mapping efforts occurring in Atlantic coastal states, including agency or organization implementing project, estimated percentage complete, and expected completion date.

STATE	AGENCY	ESTIMATED % COMPLETED	COMPREHENSIVE SURVEY COMPLETION DATE
ME	ME Dept. Mar. Res. & Nature Conservancy	in progress	6/98
NH	University of New Hampshire	unknown	no comprehensive survey planned
MA	MA Dept. of Environmental Protection	90% -- in progress	6/97
RI	Naragansett Bay Program	3%	no comprehensive survey planned
CT	University of CT	100%	1996
NY	NY Bureau of Marine Resources*	0%*	no comprehensive survey planned
NJ	NJ Dept. of Environmental Protection	100%	1980, 1988 update in areas
DE	none	0%	no comprehensive survey planned
MD	VA Institute of Marine Sciences	100%	annual updates
VA	VA Institute of Marine Sciences	100%	annual updates
NC	National Marine Fisheries Service, NC Division of Marine Fisheries	30%	no comprehensive survey planned
FL	National Marine Fisheries Service, FL Dept. of Environmental Protection	100%	continuous updates

* aerial photographs are being archived; no plans for data interpretation at this time

Table 3. Summary of existing regulations, guidelines and policies of regulatory and commenting agencies regarding activities affecting submerged aquatic vegetation in Chesapeake Bay.[1] *Excerpted from Guidance for Protecting Submerged Aquatic Vegetation in Chesapeake Bay from Physical Disruption by Chesapeake Bay Program, August 1995.*

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Appendix 2

SAFMC Policy for Protection and Enhancement of Marine Submerged Aquatic Vegetation (SAV) Habitat

South Atlantic Fishery Management Council
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The South Atlantic Fishery Management Council (SAFMC) and the Habitat and Environmental Protection Advisory Panel have considered the issue of the decline of Marine Submerged Aquatic Vegetation SAV (or seagrass) habitat in Florida and North Carolina as it relates to Council habitat policy. Subsequently, the Council's Habitat Committee requested that the Habitat Advisory Panel develop the following policy statement to support Council efforts to protect and enhance habitat for managed species.

Description and Function:

In the South Atlantic region, SAV is found primarily in the states of Florida and North Carolina where environmental conditions are ideal for the propagation of seagrasses. The distribution of SAV habitat is indicative of its importance to economically important fisheries: in North Carolina, total SAV coverage is estimated to be 200,000 acres; in Florida, the total SAV coverage is estimated to be 2.9 million acres. SAV serves several valuable ecological functions in the marine systems where it occurs. Food and shelter afforded by SAV result in a complex and dynamic system that provides a primary nursery habitat for various organisms that is important both to the overall system ecology as well as to commercial and recreationally important fisheries. SAV habitat is valuable both ecologically as well as economically; as feeding, breeding, and nursery ground for numerous estuarine species, SAV provides for rich ecosystem diversity. Further, a number of fish and shellfish species, around which is built several vigorous commercial and recreational fisheries, rely on SAV habitat for a least a portion of their life cycles. For more detailed discussion, please see Appendix 1.

Status:

SAV habitat is currently threatened by the cumulative effects of overpopulation and consequent commercial development and recreation in the coastal zone. The major anthropogenic threats to SAV habitat include:

(1) mechanical damage due to:
- (a) propeller damage from boats,
- (b) bottom-disturbing fish harvesting techniques,
- (c) dredging and filling;

(2) biological degradation due to:

(a) water quality deterioration by modification of temperature, salinity, and light attenuation regimes;
(b) addition of organic and inorganic chemicals.

SAV habitat in both Florida and North Carolina has experienced declines from both natural and anthropogenic causes. However, conservation measures taken by state and federal agencies have produced positive results. The National Marine Fisheries Service has produced maps of SAV habitat in the Albemarle-Pamlico Sound region of North Carolina to help stem the loss of this critical habitat. The threats to this habitat and the potential for successful conservation measures highlight the need to address the decline of SAV. Therefore, the South Atlantic Council recommends immediate and direct action be taken to stem the loss of this essential habitat. For more detailed discussion, please see Appendix 2.

Management:

Conservation of existing SAV habitat is critical to the maintenance of the living resources that depend on these systems. A number of federal and state laws and regulations apply to modifications, either direct or indirect, to SAV habitat. However, to date the state and federal regulatory process has accomplished little to slow the decline of SAV habitat. Furthermore, mitigative measures to restore or enhance impacted SAV have met with little success. These habitats cannot be readily restored; the South Atlantic Council is not aware of any seagrass restoration project that has ever prevented a net loss of SAV habitat. It has been difficult to implement effective resource management initiatives to preserve existing seagrass habitat resources due to the lack of adequate documentation and specific cause/effect relationships. (for more detailed discussion, please see Appendix 3)

Because restoration/enhancement efforts have not met with success, the South Atlantic Council considers it imperative to take a directed and purposeful action to protect remaining SAV habitat. The South Atlantic Council strongly recommends that a comprehensive strategy to address the disturbing decline in SAV habitat in the South Atlantic region. Furthermore, as a stepping stone to such a long-term protection strategy, the South Atlantic Council recommends that a reliable status and trend survey be adopted to verify the scale of local declines of SAV.

The South Atlantic Council will address the decline of SAV, and consider establishing specific plans for revitalizing the SAV resources of the South Atlantic region. This may be achieved by the following integrated triad of efforts:

Planning:

- The Council promotes regional planning which treats SAV as a integral part of an ecological system.

- The Council supports comprehensive planning initiatives as well as interagency coordination and planning on SAV matters.

- The Council recommends that the Habitat Advisory Panel members actively seek to involve the Council in the review of projects which will impact, either directly or indirectly, SAV habitat resources.

Monitoring and Research:

- Periodic surveys of SAV in the region are required to determine the progress toward the goal of a net resource gain.

- The Council supports efforts to
  (1) standardize mapping protocols,
  (2) develop a Geographic Information System databases for essential habitat including seagrass, and
  (3) research and document causes and effects of SAV decline including the cumulative impacts of shoreline development.

Education and Enforcement:

- The Council supports education programs designed to heighten the public's awareness of the importance of SAV. An informed public will provide a firm foundation of support for protection and restoration efforts.

- Existing regulations and enforcement need to be reviewed for their effectiveness.

- Coordination with state resource and regulatory agencies should be supported to assure that existing regulations are being enforced.

SAFMC SAV Policy Statement
(Appendix 1)

DESCRIPTION AND FUNCTION

Worldwide, Submerged Aquatic Vegetation (SAV) constitutes one of the most conspicuous and common shallow-water habitat types. These angiosperms have successfully colonized standing and flowing fresh, brackish, and marine waters in all climatic zones, and most are rooted in the sediment. Marine SAV beds occur in the low intertidal and subtidal zones and may exhibit a wide range of habitat forms, from extensive collections of isolated patches to unbroken continuous beds. The bed is defined by the presence of either aboveground vegetation, its associated root and rhizome system (with living meristem), or the presence of a seed bank in the sediments, as well as the sediment upon which the plant grows or in which the seed back resides. In the case of patch beds, the unvegetated sediment among the patches is considered seagrass habitat as well.

There are seven species of seagrass in Florida's shallow coastal areas: turtle grass (Thalassia testudium); manatee grass (Syringodium filiforme); shoal grass (Halodule wrightii); star grass (Halophila engelmanni); paddle grass (Halophila decipiens); and Johnson's seagrass (Halophila johnsonii) (See distribution maps in Appendix 4). Recently, H. johnsonii has been proposed for listing by the National Marine Fisheries Service as an endangered plant species. Areas of seagrass concentration along Florida's east coast are Mosquito Lagoon, Banana River, Indian River Lagoon, Lake Worth and Biscayne Bay. Florida Bay, located between the Florida Keys and the mainland, also has an abundance of seagrasses, but is currently experiencing an unprecedented decline in SAV distribution.

The three dominant species found in North Carolina are shoalgrass (Halodule wrightii), eelgrass (Zostera marina), and widgeongrass (Ruppia maritima). Shoalgrass, a subtropical species has its northernmost distribution at Oregon Inlet, North Carolina. Eelgrass, a temperate species, has its southernmost distribution in North Carolina. Areas of seagrass concentration in North Carolina are southern and eastern Pamlico Sound, Core Sound, Back Sound, Bogue Sound and the numerous small southern sounds located behind the beaches in Onslow, Pender, Brunswick, and New Hanover Counties (See distribution maps in Appendix 4).

Seagrasses serve several valuable ecological functions in the marine estuarine systems where they occur. Food and shelter afforded by the SAV result in a complex and dynamic system that provides a primary nursery habitat for various organisms that are important both ecologically and to commercial and recreational fisheries. Organic matter produced by these seagrasses is transferred to secondary consumers through three pathways: herbivores that consume living plant matter; detritivores that exploit dead matter; and microorganisms that use seagrass-derived particulate and dissolved organic compounds. The living leaves of these submerged plants also provide a substrate for the attachment of detritus and epiphytic organisms, including bacteria, fungi, meiofauna, micro- and marcroalgae, macroinvertebrates. Within the seagrass system, phytoplankton also are present in the water column, and macroalgae and microalgae are associated with the sediment. No less important is the protection afforded by the variety of living spaces in the tangled leaf canopy of the grass bed itself. In addition to biological benefits, the SAVs also cycle nutrients and heavy metals in the water and sediments, and dissipate wave energy (which reduces shoreline erosion and sediment resuspension).

There are several types of association fish may have with the SAVs. Resident species typically breed and carry out much of their life history within the meadow (e.g., gobiids and syngnathids). Seasonal residents typically breed elsewhere, but predictably utilize the SAV during a portion of their life cycle, most often as a juvenile nursery ground (e.g., sparids and lutjanids). Transient species can be categorized as those that feed or otherwise utilize the SAV only for a portion of their daily activity, but in a systematic or predictable manner (e.g., haemulids).

In Florida many economically important species utilize SAV beds as nursery and/or spawning habitat. Among these are spotted seatrout (Cynoscion nebulosus), grunts (Heaemulids), snook (Centropomus sp.), bonefish (Albulu vulpes), tarpon (Megalops atlanticus) and several species of snapper (Lutianids) and grouper (Serranids). Densities of invertebrate organisms are many times greater in seagrass beds than in bare sand habitat. Penaeid shrimp, spiny lobster (Panulirus argus), and bay scallops (Argopecten irradians) are also dependent on seagrass beds.

In North Carolina 40 species of fish and invertebrates have been captured on seagrass beds. Larval and juvenile fish and shellfish including gray trout (Cynoscion regalis), red drum (Sciaenops ocellatus), spotted seatrout (Cynoscion nebulosus), mullet (Mugil cephalus), spot (Leiostomus xanthurus), pinfish (Orthopristis chrysoptera), gag (Mycteroperca microlepis), white grunt (Haemulon plumieri), silver perch (Bairdiella chrysoura), summer flounder (Paralichthys dentatus), southern flounder (P. lethostigma), blue crabs (Callinectes sapidus), hard shell clams (Mercenaria mercenaria), and bay scallops (Argopecten irradains) utilize the SAV beds as nursery areas. They are the sole nursery grounds for bay scallops in North Carolina. SAV meadows are also frequented by adult spot, spotted seatrout, bluefish (Pomatomus saltatrix), menhaden (Brevortia tyrannus), summer and southern flounder, pink and brown shrimp, hard shell clams, and blue crabs. Offshore reef fishes including black sea bass (Centropristis striata), gag (Mycteroperca microlepis), gray snapper (Lutianus griseus), lane snapper (Lutjanus synagris), mutton snapper (Lutianus annalis), and spottail pinfish (Displodus holbrooki). Ospreys, egrets, herons, gulls and terns feed on fauna in SAV beds, while swans, geese, and ducks feed directly on the grass itself. Green sea turtles (Chelonia mydas) also utilize seagrass beds, and juveniles may feed directly on the seagrasses.

SAFMC SAV Policy Statment
(Appendix 2)

STATUS

The SAV habitat represents a valuable natural resource which is now threatened by overpopulation in coastal areas. The major anthropogenic activities that impact seagrass habitats are: 1) dredging and filling, 2) certain fish harvesting techniques and recreational vehicles, 3) degradation of water quality by modification of normal temperature, salinity, and light regimes, and 4) addition of organic and inorganic chemicals. Although not caused by man, disease ("wasting disease" of eelgrass) has historically been a factor. Direct causes such as dredging and filling, impacts of bottom disturbing fishing gear, and impacts of propellers and boat wakes are easily observed, and can be controlled by wise management of our seagrass resources (See Appendix 3). Indirect losses are more subtle and difficult to assess. These losses center around changes in light availability to the plants by changes in turbidity and water color. Other indirect causes of seagrass loss may be ascribed to changing hydrology which may in turn affect salinity levels and circulation. Reduction in flushing can cause an increase in salinity and the ambient temperature of a water body, stressing the plants. Increase in flushing can mean decreased salinity and increased turbidity and near-bottom mechanical stresses which damage or uproot plants.

Increased turbidity and decreasing water transparency are most often recognized as the cause of decreased seagrass growth and altered distribution of the habitats. Turbidity may result from upland runoff, either as suspended sediment or dissolved nutrients. Reduced transparency due to color is affected by freshwater discharge. The introduction of additional nutrients from terrigenous sources often leads to plankton blooms and increased epiphytization of the plants, further reducing light to the plants. Groundwater enriched by septic systems also may infiltrate the sediments, water column, and near-shore seagrass beds with the same effect. Lowered dissolved oxygen is detrimental to invertebrate and vertebrate grazers. Loss of these grazers results in overgrowth by epiphytes.

Large areas of Florida where seagrasses were abundant have now lost these beds from both natural and man-induced causes. (This is not well documented on a large scale except in the case of Tampa Bay). One of these depleted areas is Lake Worth in Palm Beach County. Here, dredge and fill activities, sewage disposal and stormwater runoff have almost eliminated this resource. North Biscayne Bay lost most of its seagrasses from urbanization. The Indian River Lagoon has lost many seagrass beds from stormwater runoff has caused a decrease in water transparency and reduced light penetration. Many seagrass beds in Florida have been scarred from boat propellers disrupting the physical integrity of the beds. Vessel registrations, both commercial and recreational, have tripled from 1970-71 (235, 293) to 1992-93 (715,516). More people engaged in marine activities having an effect on the limited resources of fisheries and benthic communities, Florida's assessment of dredging/propeller scar damage indicates that Dade, Lee, Monroe, and Pinellas Counties have the most heavily damaged seagrass beds. Now Florida Bay, which is rather remote from human population concentrations, is experiencing a die-off of seagrasses, the cause of which has not yet been isolated. Cascading effects of die-offs cause a release of nutrients resulting in algal blooms which, in turn, adversely affect other seagrass areas, and appear to be preventing recolonization and natural succession in the bay. It appears that Monroe County's commercial fish and shellfish resources, with a dockside landing value of $50 million per year, is in serious jeopardy.

In North Carolina total SAV coverage is estimated a 200,000 acres. Compared to the state's brackish water SAV community, the marine SAVs appear relatively stable. The drought and increased water clarity during the summer of 1986 apparently caused an increase in SAV abundance in southeastern Pamlico Sound and a concomitant increase in bay scallop densities. Evidence is emerging, however, that characteristics of "wasting disease" are showing up in some of the eelgrass populations in southern Core Sound, Back Sound, and Bogue Sound. The number of permits requested for development activities that potentially impact SAV populations is increasing. The combined impacts of a number of small, seemingly isolated activities are cumulative and can lead to the collapse of large seagrass biosystems. Also increasing is evidence of the secondary removal of seagrasses. Clam-kicking (the harvest of hard clams utilizing powerful propeller wash to dislodge the clams from the sediment) is contentious issue within the state of North Carolina. The scientific community is convinced that mechanical harvesting of clams damages SAV communities. The scallop fishery also could be harmed by harvest-related damage to eelgrass meadows.

SAFMC SAV Policy Statement

(Appendix 3)

MANAGEMENT

Conservation of existing SAV habitat is critical to the maintenance of the living resources that depend on these systems. A number of federal and state laws require permits for modification and/or development in SAV. These include Section 10 of the Rivers and Harbors Act (1899), Section 404 of the Clean Water Act (1977), and the states' coastal area management programs. Section 404 prohibits deposition of dredged or fill material in waters of the United States without a permit from the U.S. Army Corps of Engineers. The Fish and Wildlife Coordination Act gives federal and state resource agencies the authority to review and comment on permits, while the National Environmental Policy Act requires the development and review of Environmental Impact Statements. The Magnuson Fisheries Conservation and Management Act has been amended to require that each fishery management plan include a habitat section. The Council's habitat subcommittee may comment on permit requests submitted to the Corps of Engineers when the proposed activity relates to habitat essential to managed species.

State and federal regulatory processes have accomplished little to slow the decline of SAV habitat. Many of the impacts cannot be easily controlled by the regulations as enforced. For example, water quality standards are written so as to allow a specified deviation from background concentration, in this manner standards allow a certain amount of degradation. An example of this is Florida's class III water transparency standard, which defines the compensation depth to be where 1% of the incident light remains. The compensation depth for seagrass is in excess of 10% and for some species is between 15 and 20%. The standard allows a deviation of 10% in the compensation depth which translates into 0.9% incident light or an order of magnitude less than what the plants require.

Mitigative measures to restore or enhance impacted areas have met with little success. SAV habitats cannot be readily restored; in fact, the South Atlantic Council is not aware of any seagrass restoration project that has ever avoided a net loss of seagrass habitat. It has been difficult to implement effective resource management initiatives to preserve seagrass habitat due to the lack of documentation on specific cause/effect relationships. Even though studies have identified certain cause/effect relationships in the destruction of these areas, lack of long-term, ecosystem-scale studies precludes an accurate scientific evaluation of the long-term deterioration of seagrasses. Some of the approaches to controlling propeller scar damage to seagrass beds include: education, improved channel marking restricted access zones, (complete closure to combustion engines, pole or troll areas), and improved enforcement. The South Atlantic Council sees the need for monitoring of seagrass restoration and mitigation not only to determine success from plant standpoint but also for recovery of faunal populations and functional attributes of the essential habitat type. The South Atlantic Council also encourages long-term trend analysis monitoring of distribution and abundance using appropriate protocols and Geographic Information System approaches.

SAFMC SAV Policy Statement

(Appendix 4)

(SAV Distribution Maps in SAFMC 1995)

SAFMC. 1995. Amendment 3 to the fishery management plan for coral, coral reefs and live /hard bottom habitats of the South Atlantic region. South Atlantic Fishery Management Council, 1 Southpark Cir., Ste 306, Charleston, S.C. 29407, 237 pp.