Virginia MARINE RESOURCE BULLETIN

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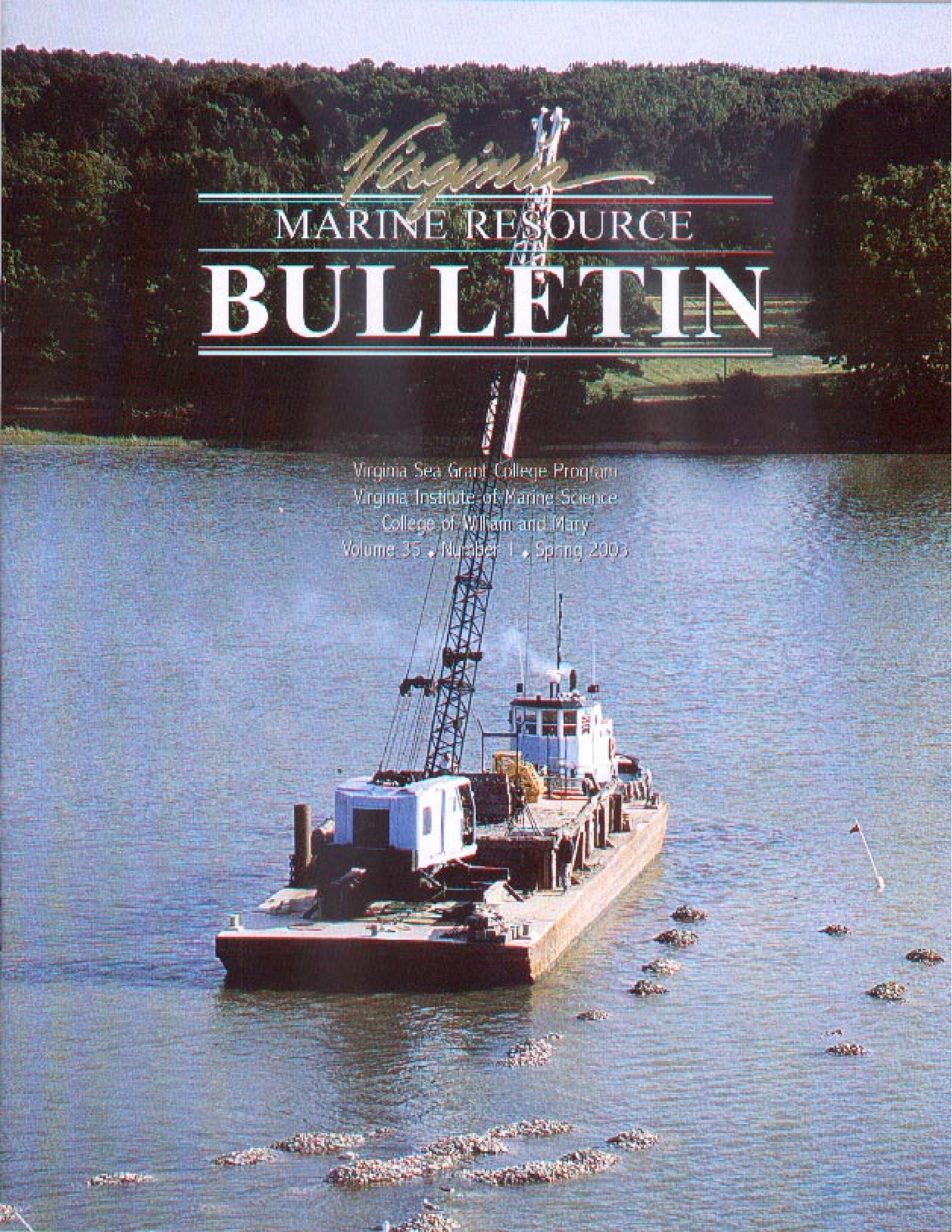

Sea Grant
Virginia

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Sometimes unusual circumstances force us to scrap conventional thinking, to set aside more traditional approaches and do a bit of mental stretching. The current state of the Eastern oyster in the Chesapeake Bay presents just such a challenge to flex our collective brain power and ponder a more radical approach toward jump-starting their return to the estuary.

This edition of the *Bulletin* looks closely at a plan to take a small pool of genetically rehabilitated oyster brood stock – bred for disease resistance – and "ramp up" their numbers while orchestrating their relocation throughout the bay in a series of graduated steps. The plan incorporates state-of-the-art genetics knowledge, and it assumes that such modifications will enable the oyster to resist its arch-nemeses – Dermo and MSX – generation after generation.

Of course this plan is grounded in hypothesis: It represents a pioneering concept that tests new waters. We have no proof that it will work, but our knowledge of local ecosystems where young oysters will first be deployed presents an opportunity to examine this theory. And, we are buoyed by the resolve of many collaborators – resource managers, ecologists, biologists, and watermen – working with the U.S. Army Corps of Engineers, who can provide the engineering prowess and logistical wherewithal to take the plan from research lab to the waters of the bay. Optimism abounds!

On "safer" ground, we look at a recently published inventory of Virginia's dune systems, and two research projects underway to create a more sustainable black sea bass trap fishery. Also inside, we take a nostalgic look at the history of Virginia's barrier islands, with special focus on their recreational offerings at the turn of the century.

As always, we encourage you to pass this edition along to friends or suggest they read it online at www.vims.edu/GreyLit/SeaGrant.html.

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Front Cover:
Oyster reef planting on the lower Yecomico River, Westmoreland County.

TERRAFORMING Chesapeake Bay

By Standish K. Allen, Jr., Robert Brumbaugh, & David Schulte

Conditions for success
"Set the conditions for success." These were the marching orders of Col. David "Hurricane" Hansen, District Commander of the U.S. Army Corps of Engineers in Norfolk, as he prepared his staff for a new assault in the war on oyster diseases. Now, through an extraordinary collaboration among the Virginia Institute of Marine Science (VIMS), the U.S. Army Corps of Engineers (USACE), the Virginia Marine Resources Commission (VMRC), the Chesapeake Bay Foundation (CBF), the Virginia Seafood Council (VSC), and the oyster industry in general, an ambitious 10-year plan is on the table to restore oysters in the bay. There is little doubt that an effort of this magnitude is required if we want our native oyster back: This season will be the worst on record for Maryland harvests, approaching the dismal numbers that Virginia has seen for the past decade.

Authored by the USACE, the plan is scheduled to begin in 2003 with an ambitious escalation of effort over the next decade. Of course, oyster restoration and reef building efforts are not new. The VMRC (with funds and support from the Virginia Coastal Program), CBF, and VIMS have had active programs to construct, stock, and monitor sanctuary reefs for nearly a decade. What is outstanding about this new effort is the degree of coordination among partners and the potential for applying new federal funds to a large, totally integrated plan to give oysters the maximum opportunity for a successful comeback.

The plan focuses upon two primary objectives: (1) increase oyster biomass to restore the ecological functions they provide; and (2) promote disease resistance within such oyster populations. It is fair to say that if we were simply trying to restore oysters without interference from diseases, we would be well on our way to achieving the 2010 goal of increasing biomass ten-fold. In fact, there is evidence that in some smaller, restricted areas, oysters have responded to restoration attempts by re-populating adjacent shores. In general, however, attempts to date have failed to make significant progress at a scale necessary to restore certain ecological functions oysters provide to the bay—and necessary to revitalize the oyster industry. To restore the entire baywide oyster population, and thus turn the devastated oyster fishery around, however, is a formidable task that requires significant financial resources and a long-term commitment from stakeholders. It's an effort that deserves the term, "terraforming," or designing and engineering the reefs as well as the oysters.

To those involved in oyster restoration, it seems pretty clear how to increase biomass. The initial step involves restoring habitat to allow oysters to colonize, aggregate, and reproduce. These activities have been at the core of previous attempts, but in many cases have yielded only short-term successes. For example, in 1996, thousands of bushels of Tangier oysters were transplanted to a reef system in the Great Wicomico River. Over the ensuing spawning season, this artificial aggregation of large adults generated a "wrap-up" set, populating the reef anew as well as surrounding areas where substrate was available. Stocking reefs seems to be critical in the overall strategy for increasing biomass due to low adult oyster population densities in most areas. Significant sets also have accompanied oyster reef construction and seeding of juvenile oysters by CBF in the Lynnhaven, Elizabeth, and Lafayette rivers. Aggregation and reproduction, in fact, are the mechanisms by which oysters maintain population size.

In a natural system, reproduction is usually so successful that oysters compete with each other for space and other resources in a race for survival of the fittest. In the case of the Chesapeake Bay today, however, that race for survival is against diseases, not other oysters. The ultimate effect on new recruits (as new oyster set are called) is rapid mortality, with barely enough adults surviving to reproductive size to breed again. Simply put, they die too soon at the hands of disease to propagate and sustain their biomass. This is what happened in the Great Wicomico River.

Promoting disease resistance in oysters is not as straightforward as simply building sanctuary reefs – a cornerstone of Virginia's restoration programs for some time. Indeed, broadening the restoration effort to include large-scale stock enhancement for the purpose of developing disease resistance is a significant departure from previous restoration efforts. Disease resistance is one of the most sought-after traits in all of agriculture, and more recently, aquaculture. In agriculture, significant efforts have been made to produce disease-resistant and herbicide-resistant varieties by selective (artificial) breeding and genetic modification (gene transfer). At the Aquaculture Genetics and Breeding Technology Center (ABC) of the VIMS, selection for disease resistance in oysters and clams is ongoing, although through selective breeding techniques only (see *VMRB,* Vol. 33, No. 3).

The advantages of developing disease-resistant crops – in this case, oysters – are apparent. They would survive longer and potentially make aquaculture of the *C. virginica* oyster commercially feasible. Less clear is the success that artificially selected, disease-resistant oysters will realize on reefs where populations are less controlled and at the mercy of natural, climatological and ecological events. In fact, propagating domesticated lines of oysters to produce seed for planting on newly created reefs seems a bit artificial for restoration, given that restoration normally strives to obtain a *natural* outcome. Yet planting disease-*susceptible* oysters seems futile, so disease-resistant oysters have been selected for use in public oyster restoration programs like those sponsored by Maryland's Oyster Recovery Partnership (ORP) and CBF. So far, resistant oysters have found homes in the Lynnhaven, Lafayette, Great Wicomico and Piantatank rivers, but still on a relatively small scale.

Genetic rehabilitation

The role of disease-resistant strains in restoration was discussed during a workshop held by ABC in the fall of 2000. Two conclusions from the workshop are notable. First, there seems little value in conducting such restoration programs in the Virginia portion of Chesapeake Bay based primarily on hatchery production from wild brood stock. In Virginia, where disease pressures are acute, oyster longevity becomes a formidable challenge. Stocking wild seed produced in the hatchery has the undesirable effects of both constraining genetic variation as well as multiplying disease-susceptible brood stock.

A second notable conclusion of the workshop was the recognition that, having suffered a number of assaults over the last 50 years, wild oyster populations, were deemed in need of rehabilitation through the use of disease-resistant strains. At this point in time, it's an act of faith that the upside of disease resistance in selectively bred stocks outweighs the downside of decreasing genetic variability through hatchery propagation.

In all systems but the most de-populated, disease-resistant seed used for restoration will eventually lead to hybridization with wild populations. The desired outcome of hybridization is introgression (a form of genetic assimilation) of disease-resistant genes into the natural population. Introgression will have a positive benefit if it contributes to the fitness of oysters in subsequent generations; specifically, disease resistance, which will presumably give rise to increased longevity and higher fecundity. Despite limited understanding of the overall dynamics of genetic rehabilitation, or even its prognosis for success, there was a sense of congruence in the workshop that the so-called wild oyster was in a downward spiral and that trial implementation of a genetic rehabilitation strategy, with selective breeding at its core, was warranted.

The USACE plan fully embraces the concept of genetic rehabilitation and focuses on the logistical details of implementing it in the lower Chesapeake. The logistics are staggering and only possible to overcome through collaborative means. Of course, work only progresses as federal funds, matched by non-federal state and private resources, can be brought to bear on the problem.

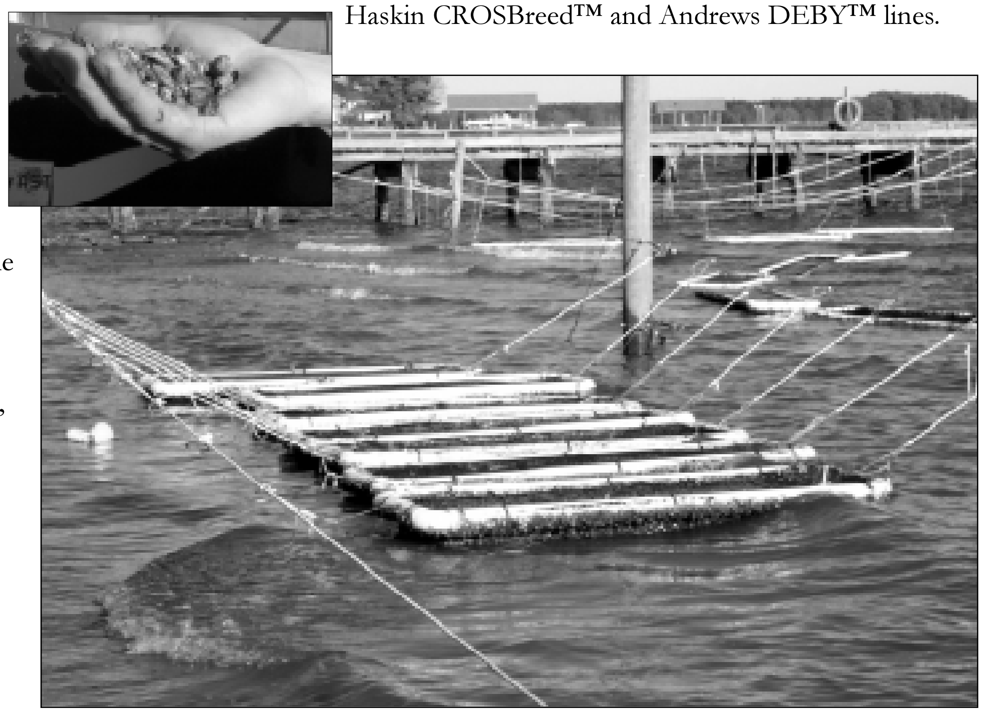
The calculus of biomass accretion

In a genetic rehabilitation strategy, hatcheries will take a primary role in boosting specific stocks with disease resistance. However, at present there are serious limitations on the extent to which disease-resistant strains can be amplified through hatchery propagation; for example, magnified from a few hundred brood stock to a few hundred million or even billions of spat that might be required for "jump starting" populations throughout the lower estuary. It's necessary to conceptualize the amplification of biomass needed for restoration as a step-wise process (see page 7).

1

The process begins when superior brood stock developed in a controlled breeding program is selected for propagation at the breeding station. At this point in time, that breeding station is the ABC hatchery at Gloucester Point. Because it is a research hatchery, a limited number of seed oysters can be produced, and an even more limited number of brood stock can be maintained to adulthood. Nonetheless, expanding from a hundred select brood stock to perhaps 10,000 or so disease-resistant oysters (a total derived from all resistant lines currently under development) is realistic – and represents a hundred-fold amplification.

At present, 6 or 7 disease-resistant strains are under development. Two have been released to hatcheries over the last few years, the so-called Haskin CROSBreed™ and Andrews DEBY™ lines.



Parental strains of disease-resistant oyster are propagated and raised at the oyster farm at VIMS.

These represent decades of effort. The other lines under development have specific attributes, such as Dermo disease resistance imported from Louisiana oysters that were interbred with our own. The process of selective breeding is continuous, but the methods and starting populations necessary for genetic rehabilitation are available today.

2

The second step involves amplification of the disease-resistant brood stock in commercial, public, or public-private hatcheries. This is accomplished by the release of brood stock to hatcheries for spawning and propagation. At present there are a few commercial hatcheries in place to perform this step. It is likely that more capacity is needed, because from the thousands of brood stock that would be available for release, there may be enough demand among oyster restoration partners for 100,000,000 seed. This represents a 10,000-fold increase in biomass over what was received as brood stock.

Seed produced from the hatchery will need to be nurtured to a size adequate to be put onto artificial reefs, constructed by the USACE, VMRC, or other groups. The USACE is presently the lead agent for reef construction because of the release and likely continuation of federal funds allocated for this purpose. There is still a running debate about the most appropriate way to set and nurture hatchery-produced seed oysters destined for reef planting, centered around the use of cultchless or cultched (spat-on-shell) seed. Cultchless seed is produced when oyster larvae are induced to set as single individual oysters, using tricks such as allowing them to set on tiny shell chips. Cultchless set can be handled with great efficiency and put into artificial upwellers, raceways, or even plastic mesh spat bags. The possible downside of cultchless oysters is that they may become snack food for crabs if they are planted too small – generally considered so at less than 40 mm (about 1½").

Cultched seed is made by allowing larvae in the hatchery to attach to some form of hard material or substrate. Seed produced in this way has the advantage that it initially grows faster and is partially protected from predators by the cultch itself. The best cultch is oyster shell, although other materials have been tried with varying degrees of success. Larval oysters set on the cultch and grow rapidly because they essentially only have to build one shell. Moreover, they can be planted when they are about 25 mm (about 1") instead of 40 mm because surrounding cultch material protects them from predators, and it is more difficult for a crab to manipulate an oyster shell and prey upon the attached spat. The major downside to cultched seed is that bulk handling is necessary for nurturing the seed until it reaches 25 mm. That is, besides the seed, the cultch itself has to be moved several times. Compared to the seed itself, cultch is thousands of times more voluminous.

The decision to use cultchless oysters or spat-on-shell for brood stock enhancement for any given project will be based on the ecological return for the economic investment. In all likelihood, some of both will find their way onto the terraformed bottom.

One idea that might be considered at this scale is barge culture. Conceptually, the entire process of setting, nurturing, and delivering seed could be accomplished in one efficient step. The idea is to put a retrofitted barge (or fleet of them) into the restoration scheme. A barge would contain bags of shell, stacked in a configuration for receiving eyed larvae – the stage at which they are competent to settle. Oyster larvae are easily transported vast distances at the end of their larval cycle for setting in areas distant from the hatchery, a process called remote setting. Eyed larvae then would be transported to the restoration barge, which would be flooded with water filtered from the bay by onboard filters. (Filtration is necessary to eliminate predators until larvae can settle.) Larvae released into the hopper of the barge would set on the shell after several days. At that point, pumps would engage to keep a constant circulation of raw water flowing over the newly settled spat. The spat would grow in the barge to the appropriate size for planting. Finally, the barge could be towed to the reef site and dumped directly onto the reef. The economics of this idea need to be considered, because the logistics are potentially elegant.

3

The seed amplified by hatcheries and purchased and nurtured by nurseries will ultimately be planted on artificial reefs. In this new approach of coupling broodstock enhancement with genetic rehabilitation, the first reefs the young oysters are bound for are called "incubator reefs." This is where some of the most important science in reef restoration comes in, relying on the Institute's long-standing expertise. Sites for incubator reefs are intentionally chosen in water bodies known as trap estuaries, where larval recruitment is generally retained within the system. Estuaries that act as traps include the Great Wicomico River, Piankatank River, and Lynnhaven River, among others. Several of these systems are well studied and will be employed for the genetic rehabilitation strategy.

By stocking incubator reefs with disease-resistant seed from commercial or public hatchery programs, the rivers become places where distinct strains of oyster are amplified in situ. An incubator reef becomes, in effect, a "natural hatchery" based within a natural system. One advantage of using natural systems in this way is their capacity for providing enormous numbers of next-generation oysters from selected stocks through so-called wrap-up sets in the surrounding estuary. A disadvantage of natural systems is that they are far less predictable than man-made hatcheries. Nonetheless, the potential exists for incubator reefs to accomplish the next round of amplification of disease-resistant stocks.

For genetic rehabilitation, areas surrounding the incubator reefs must be managed by placement of 2-dimensional reefs of fresh cultch material to catch the set. If successful, this round of biomass amplification will take us from millions of hatchery seed to hundreds of millions of natural hatchery seed, or perhaps more depending on Mother Nature.

Just as in step two, step three provides an economic opportunity for participation by the commercial oyster industry. Two-dimensional reefs built around incubator reefs to catch seed could be privately or publicly held. Either way, the attached seed are useful for the next step in the process. When they reach suitable size, they can be harvested and used to plant additional reefs located in other rivers, creeks, or the main stem of the bay. No need for the cultch versus cultchless debate here. This approach is an obvious way to obtain very large quantities of oysters set on cultch if genetic rehabilitation, with nature's help, works as intended. Taking up seed and moving it throughout the bay is an activity that commercial oystermen have been doing for generations. Essentially, instead of planting oysters for eventual harvest and sale to restaurants and shucking houses, watermen will be planting them for genetic rehabilitation. In this scheme, they will be paid for their work immediately instead of moving seed on speculation for later harvest – an activity that recently has been extremely unprofitable. Initial estimates of payment for this work range around $12 per bushel.

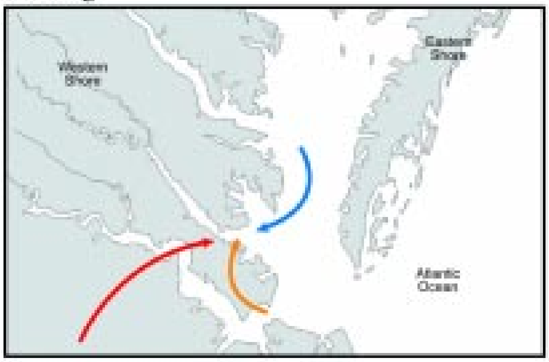
One intriguing potential for using incubator reefs has to do with the way they could be managed over the long haul. First, only a few incubator reef systems are needed because it is the seed *from* these reefs that will become the bulk of the planting programs for reefs that are built in other parts of the bay. Second, a series of incubator reefs located in specific tributaries could be managed separately for propagating distinct genetic stocks. For example, one might be managed for a disease-resistant stock that excels in Dermo resistance but not MSX. Seed from that reef could be used for one particular zone of the bay. Seed from another strain that might be more suitable for dual disease resistance could be used for another zone of the bay, and so on. In this way, costly seed produced in hatcheries (step 2) would be more appropriately applied to the more predictable incubator reefs and not the less predictable ones in the main stem of the bay. For the immediate future, it seems wise to plan on stocking incubator reefs continually with hatchery seed to best assure the constant flow of disease-resistant seed from these trap systems. Additionally, superior strains of disease-tolerant native oysters are likely to be developed in the future. Continual stocking will be necessary to incorporate these more robust genes into the native oyster population.

4

The final step in genetic rehabilitation is the movement of seed from the perimeter of incubator reefs to other, newly built reefs located in larger systems like Tangier and Pocomoke sounds or the lower Rappahannock River, where we are less certain about the circulation patterns and retention of spat. Presumably, a steady flow of seed from the incubator reefs will repopulate these reefs with disease-resistant progeny, interbreed with wild to make a more fit oyster, or hopefully, both. Ultimately, it is hoped that the reefs in these larger systems also will become productive and contribute more hearty seed to surrounding areas through higher oyster reproduction within those systems, thus completing the final phase of genetic rehabilitation. In this step, oyster stocks would grow from hundreds of millions to billions.

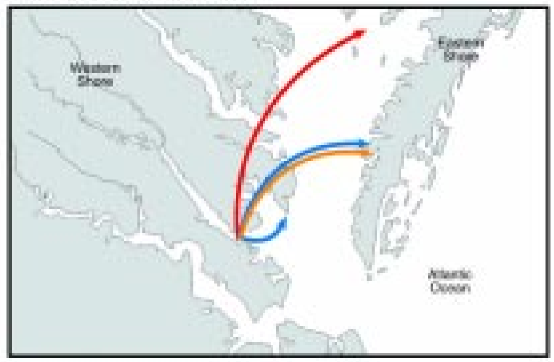
Six-step Program for Genetic Rehabilitation of Oysters

Breeding



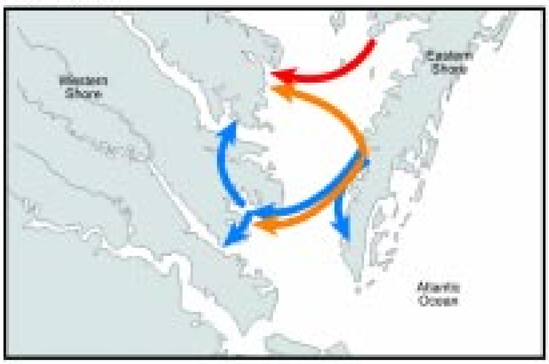
1) Natural stocks or varieties already developed are housed, selected, and propagated at the ABC Gloucester Point hatchery.

Brood Stock Distribution



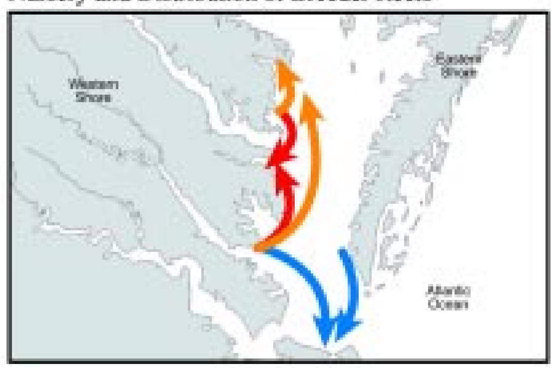
2) Select brood stock are distributed to commercial hatcheries for raising seed.

Seed Sales



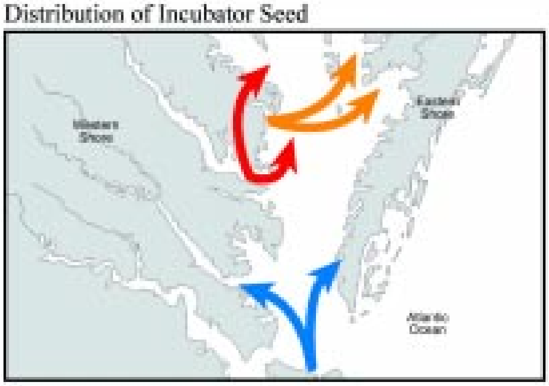
3) Seed raised at hatcheries is too small for deployment on reefs and must be distributed to commercial nurseries.

Nursery and Distribution of Breeder Reefs



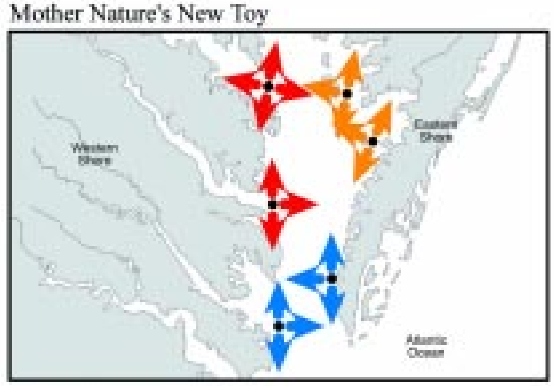
4) Once the seed obtain refuge size, they can be distributed to targeted breeder reefs. Each reef receives only one strain.

Distribution of Incubator Seed



5) Once spawning and settlement from breeder reefs have occurred, the new generation of seed can be harvested and moved to larger reef assemblages by the industry.

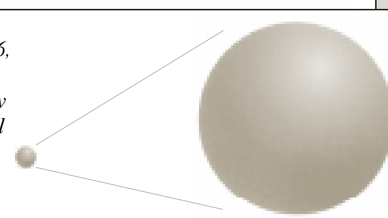
Mother Nature's New Toy



6) At this point, it is Mother Nature's role to distribute, via larval dispersal, the enhanced stocks to surrounding areas.

Note: Arrow colors represent different lines of oysters.

Between Step 1 and Step 6, the volume of oyster biomass increases roughly from the size of a golf ball to the size of a 12-foot-diameter sphere.



Overall, starting with the few hundred selectively bred brood stock distributed to hatcheries in step 1, we (hypothetically) have amplified the number of oysters by about six orders of magnitude – that is to say, one-million-fold! In fact, the figure on page 7 illustrates the actual scale of this increase – from golf-ball size to a 12-foot-diameter sphere. The final step depends primarily on nature, and accounts for 90% of the gain in this process. Yet, billions of oysters in the bay is not an unrealistic expectation based upon what researchers believe must have been out there at one time. Even now, at what many would consider the nadir of oyster resource in the bay, the standing stock in Virginia may range from about 5 billion to as many as 600 billion, although scientists contend that almost 80% of those are below market size (76 mm, or 3").

Summary

Through new federal funding initiatives, the USACE in collaboration with many partners has been given the opportunity to "terraform" the bay. An integrated plan involves the expertise of nearly all constituent groups. Perhaps most importantly, there is ample opportunity for the commercial sector to be involved in the process. Like any big picture idea, it will be essential to keep all elements working together with an appropriate dedication of resources to the project.

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-Dr. Robert Brumbaugh is a fisheries scientist with the Chesapeake Bay Foundation.

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See page 21 for references cited.

With what oyster?

What would we be doing differently now if it were trying to introduce the non-native oyster instead of restoring the native one? The simple answer is: not much. Bringing back a native oyster whose populations are low is just about the same as introducing a non-native oyster whose population is zilch. The two approaches reveal more parallels than differences.

Parallels

·We need to bring in the right stocks of non-natives (or "select" the right stocks of natives).
·We still have to use hatcheries as the first amplification step.
·We still have to nurse either species to a size that predators won't devastate them – past hors d'oeuvre size for crabs.
·We still need to seed reefs that are built in strategic locations to foster recruitment, and leave them as sanctuaries.
·Both species need to have substrate to settle on – a commodity in short supply in the bay. So reefs of both incubator type and 2-D settlement areas must be built.
·It will still take nearly a decade to bring non-native populations up to the levels where they will be self-sustaining, and at least that long for natives.
·Probably the most unappreciated parallel between native restoration and non-native introduction is there is no guarantee either of them will work.

We can hail the virtues of the Asian oyster all we want, but the bottom line for the biology of the critter is that it needs to find the climate of the mid-Atlantic suitable for timely reproduction (e.g., spawning when phytoplankton are available for their larvae). It needs to have oceanographic conditions in the bay suitable for recruitment (i.e., larval behavior and circulation patterns have to match). It needs to have recruits hearty enough or with settlement patterns sufficiently cunning to evade the plethora of predators in the Chesapeake. It needs to have gregarious settlement patterns that foster communities that then can form breeding assemblages.

The uncertainties that makes regulators jittery about the unknown effects of introduction are the same uncertainties affecting the likelihood of a successful introduction.

Differences

The major difference between restoration of the native and introduction of the non-native is the scope of activity that industry would choose. For the native, industry is, for all intents and purposes, done with taking chances with their money. For non-natives, however, it is likely that industry would reinvest in their grounds, equipment, and infrastructure to mount minor industries throughout the bay. But for the first 5 or so years – and maybe 10 – the industry will be completely reliant on hatchery production to jump-start their systems.

It seems industry is destined to embrace aquaculture of oysters no matter how you cut it. With non-natives the option now exists to raise triploid sterile oysters in controlled aquaculture, an option not available for native oysters because of their disease susceptibility. Based on this, terraforming the Bay to accommodate natives is, in a sense, a precursor for non-native introduction in the event that *C. virginica* just can't make it. So it all comes down to the question: With what oyster?

An Outpost for Hunting and Fishing

By Charlie Petrocci

Defining coastal culture

A lone surf fisherman stands vigil while waves crash before him. Knee-deep with rod held high, he anticipates the strike. He continually digs his boot heals in as the sand shifts beneath his feet with each receding wave. Foam appears and disappears around him, with each passing exposing tumbling shells, portals of unseen creatures, and chunks of ancient marsh rooted out by an ever-changing beach.

Shorebirds are busy here. With spindly legs they perform a ballet of run, feed, run between recoiling waves. The angler seeks spring red drum, but he comes for other reasons too. He makes this pilgrimage each year to not only enjoy the visuals and drink in the smells, but to experience the isolation. His urban job is far away and his world gets smaller each time his line clears the breakers. But this shadow has been cast here before, by layers of generations, attracted for the same reasons. For many it was escape and others, an annual rite of passage.

Along the coast of Virginia there is a long thread of islands, stretching from Assateague Island at the Virginia-Maryland line south to Fisherman's Island, located at the gateway to the Chesapeake Bay. These 18 ever-changing spits of land, known as barrier islands, stretch for over 70 miles, hugging back coastal bays and running parallel to the mainland of the Eastern Shore. They are remote, isolated, and wildly beautiful. Few people visit them, yet at one time several of these islands hosted wealthy sportsmen and tourists from across the country.

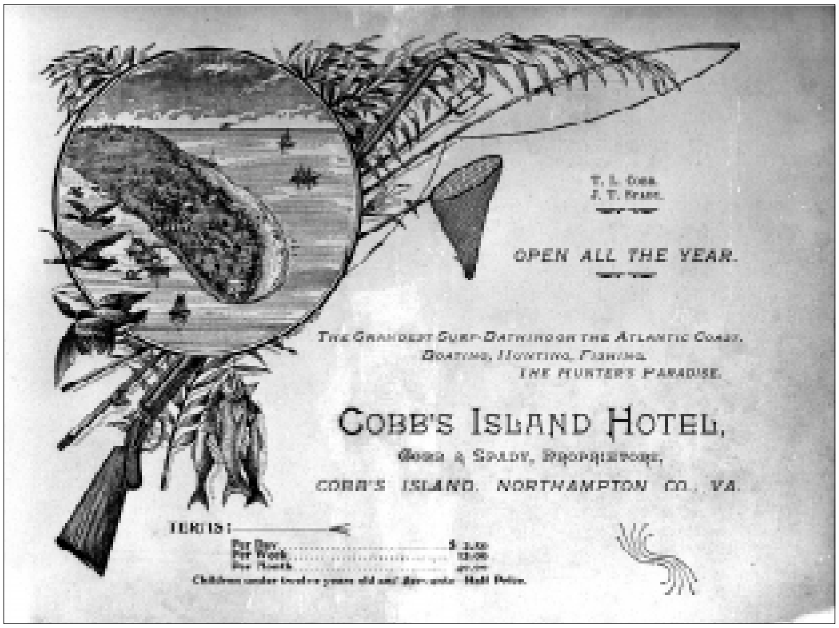
These islands, made of sand, brush, and upland maritime forest, have fortunately changed little over the centuries. They continue to withstand the onslaught of a relentless ocean, complete with tidal surges and hurricanes. The human footprint is shallow here, with only bare visible remnants of intrusion from the past. Like they have for centuries, these islands teem with life, both in the sea and air. And it is for this reason these beautiful yet inhospitable places have always attracted man.

Most other barrier islands found along the Atlantic Coast have become major tourist destinations complete with hotels, boardwalks and noisy arcades. Many had the same land use origins as Virginia's Eastern Shore islands, but their development accelerated before a guiding hand could be put in place. Virginia's barrier islands, though, fared a better fate. Through the efforts of conservation-minded people and the Nature Conservancy, the islands have remained undeveloped and now are protected. But these places have had a human presence before, including not only Native Americans, but cash-laden tourists who paid handsomely to experience these wild and isolated land forms while seeking both solitude and recreation.

The human footprint

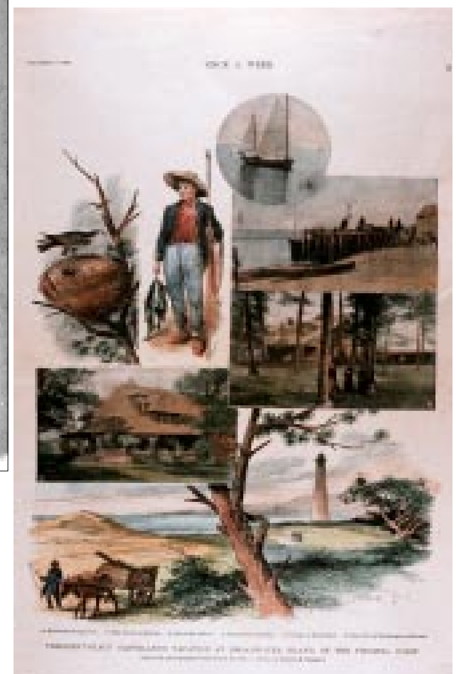
The Eastern Shore has long been isolated from the rest of Virginia both politically and economically, thus evolving its own unique cultural identity. Human habitation on the islands was sparse at best.


CHESAPEAKE BAY
ATLANTIC OCEAN
VIRGINIA EASTERN SHORE
The Nature Conservancy



Cobb Island, like most resorts of its day, advertised in publications that attracted the sportsman. Courtesy of The Nature Conservancy.

President Grover Cleveland, an avid outdoorsman, visited Hogg Island in 1892. He enjoyed vacations along Virginia's coast. Courtesy of the Eastern Shore Library.



Native Indians used the land for seasonal subsistence, since the islands were inhospitable and lacked fresh water. In the late 16th and early 17th centuries salt works appeared. As tobacco waned as a principal crop, animal husbandry increased, and the barrier islands became prime pasture land for sheep, goats and cattle. During the Revolutionary War the islands were used by the Americans as a lookout and by the British as a rest and supply area for privateers. Few people lived year-round here.

From its earliest beginnings in the 1620s, the foundation was laid for a colonial outpost embracing and exploiting the abundant natural resources found in the area. Maritime trade quickly developed with the mainland, along with several other far reaches of the British empire, including Bermuda and Barbados. This in turn initiated industrial development in shipbuilding, lumber, agriculture, fisheries, animal husbandry, and commerce. The islands were used primarily for subsistence activities and also for salt making, an important trade commodity in the 17th century. It was salt taken from shallow pans and dried that cured the fish headed for export markets. Fish and shellfish harvested for local and regional trade helped island residents get by.

Native Americans were displaced early in the settlement of the area, but many original place names have been kept and are still in use today. Several of the barrier islands – Assawoman, Assateague, and Metompkin – for example, continue to remind us of the history of the first peoples of this region.

African Americans, initially brought here as slaves, played an important role in the success of the colony through agricultural support and construction contributions. These artisans also brought with them design and brick masonry skills that were soon evidenced in the elegant homes that graced the landscape. Others channeled their talents into decoy carving or used their knowledge to become hunting guides.

Small villages come and go

After the Revolution, small villages began to emerge such as those on Hog, Cobb and Assateague. Most of these island folk depended on the bounty of the island waters for subsistence and marketable products. They were primarily livestock farmers and fishermen, who were intricately tied to the land. But because of this, nature determined their fate. After years of storms and unforgiving tidal surges, one by one the islands were abandoned. By the 1930s most of the islands were void of permanent habitation. Leaving was hard for some residents, but those of Hog and Assateague simply lifted up their houses and barged them over to the mainland, where some of those structures still survive today.

Connections to the outside world

Since the 1870s the Delmarva region, including the Eastern Shore, was promoted as a tourist destination for the leisure elite and the sportsman from surrounding metropolitan areas such as Washington, Baltimore, New York, and Philadelphia. Many came to forget the misery and loss associated with the recent Civil War, while others came to escape the crowded cities that hosted crime, sickness, and poverty. Since that early foundation, area tourism, sometimes driven by recreation such as hunting and fishing, developed into an important element of the culture and economy of the region. There was a need for diversion and the isolated waterfront areas of the Eastern Shore offered that. Tourism began to grow and travel links such as ferries, trains and roads grew with it.

The extensive natural resources of the barrier islands provided steady seasonal subsistence and employment to both watermen and market hunters, but also attracted sportfishermen and sport hunters as well. These outsiders drove the economic machine to develop lodging and entertainment, as well as guide services for the growing industry of outdoor recreation.

Though many of the islands hosted lighthouses, gun clubs, home sites, and lifesaving stations at one time or another, three islands are most noted for the tenacity of their residents. These were Hog, Assateague and Cobb islands. On Hog there were several prosperous gun clubs, a lighthouse, and the little village of Broadwater. During the Civil War, in fact, Union soldiers came to guard the lighthouse, but were driven away by mosquitos, which proved more daunting than Confederate bullets. In the 1920s there were over 160 people living on this island. Grover Cleveland, an ardent sportsman, visited the island twice. Assateague village, complete with a one-room schoolhouse and church, grew under the shadow of its lighthouse, but economics and land disputes forced the inhabitants to flee to Chincoteague, its prosperous sister island.

In 1943 the land came under the domain of the U.S. Department of the Interior. And on uninhabited Cobb's Island, the Cobb family created a resort based on recreation and solitude for the traveling sports-

The Cobb Island Hotel was one of the most popular island resorts in the Mid-Atlantic region for sportsmen and the leisure elite.

man. Cobb Island is unique in that it offers us a glimpse into how an island embraced, developed, and then lost its tourism foothold over a century ago.

The Cobb legacy

Cobb Island is six miles long, defined with little high ground and scarce vegetation. In 1833 Nathan Cobb, a Cape Cod shipbuilder, decided to leave New England with his family for a warmer climate. First settling in the village of Oyster, he operated a ship salvaging operation from wrecks that occurred along the barrier islands. In 1839 he bought "Great Sand Shoal Island" from William "Hardtime" Fitchett and moved his house, wife, and three sons over to the island. He then dutifully renamed it Cobb's Island.

Nathan Cobb continued his salvage operation and, along with his sons, hunted, fished, and sold his excess harvest to local markets. Soon word spread of the great gunning to be had on the island and the Cobbs began to take out hunting parties, mostly made up of wealthy urban northerners seeking adventure. The business grew.

Luck was with them when the ship *Bar Cricket*, sailing from Rio de Janeiro with a cargo of coffee, grounded on the shoals of Cobb Island. The Cobb family rescued the crew, the ship, and its goods and were awarded $18,000 for their efforts. This literally found money was then invested in a new hotel and the island became a resort in the coastal wilderness.

It wasn't long before sportsmen from all over the country came to Cobb Island to fish for red drum or weakfish, or hunt the seemingly endless string of shore birds and waterfowl. And many returned annually. It seems the island visitors were as much enamored by the recreation as they were by the unsophisticated Cobb family running the lodge. In 1908 writer Alexander Hunter, who frequented Cobb Island, recorded the following in his book, *The Huntsman in the South*. "I happened to be there at the opening, and it made a greater impression upon me than any seaside resort I ever visited. The attempt of three simpleminded, honest fishermen to run a watering place, without the remotest idea of anything outside their storm tossed isle, was certainly unique and rare." He added, " It was certainly ludicrous, these untutored, unimaginative wreckers catering to the wants of the delicate, refined pleasure seekers. Well, the balance was about even; these Norsemen did not understand their guests, and the guests did not comprehend their landlords." But evidently the match worked, because from the 1860s until the late 1880s the resort prospered and grew in fame.

But time soon caught up with the resort and the ill health of patriarch Nathan Cobb caused the buildings to fall into disrepair. A series of owners took over and kept it alive. But nature's power was ever vigilant and several storms, including those of 1896, finally destroyed many of the buildings. By the turn of the century most of the buildings were gone and with them, the outpost and dream of Nathan Cobb, who through the eyes of Hunter had created the most famous hunting and fishing resort in America.

Other lodges hung on and hunting continued on Cobb Island until the 1930s, with the Cobb Island Clubhouse hosting sportsmen of the day. Grandson George Cobb continued guiding hunting parties on the island until he drowned in the famous 1933 hurricane. He was one of the last Cobb Island residents and the last of the Cobbs to carry on the hunting tradition. The site of the fabled Cobb hotel now sits buried beneath the Atlantic Ocean.

Today the legacy of the Cobb family name lives on. Through stories, photographs, and the remnants of their trade, the name Cobb is familiar among collectors, historians, and sportsmen. And there is no better proof of that legacy than in the decoy world.

The sons of Nathan Cobb were excellent hunting guides and decoy carvers. Using flotsam, discarded wood, and parts of shipwrecks – including the masts – these unassuming hunters carved beautiful working decoys. More than likely, they learned their carving skills from their father who was a master craftsman. Today the carved decoys of Nathan Cobb, Jr., his son Elkanah, and grandson Arthur are in high demand. It's not uncommon to hear of unique Cobb decoys being auctioned for almost $200,000 by collectors!

For decoy collectors and folklorists, Cobb decoys represent a bygone era that won't return. They are the only tangible evidence of a time when life was simple and these remote islands attracted the wealthy, who were drawn there as much by a pursuit of recreation as they were by the islands' rough-hewn beauty.

Vanishing Dunes of the Chesapeake

By C. Scott Hardaway, Jr.

Shown here is the extensive dune system between Pond Drain and Pickett's Harbor along the southern end of Northampton County on Chesapeake Bay. The dune profile includes (from R to L) the beach, primary dune (at location of level and tripod), secondary dune, and maritime forest.

Invaluable Sand Deposits Becoming Scarce

Virginia's dune systems represent a unique and valuable component of its coastal landscape. By their very nature, coastal dunes protect inland areas from the ravages and flooding associated with periodic storms as well as the day-to-day assault of wind and wave action. Dunes also serve as critical habitat to a wide assortment of plants and animals – some rarely seen by the casual visitor.

Primary dunes and beaches are protected by the *Coastal Primary Sand Dunes Protection Act* (the "Dunes Act"), a Virginia law passed in 1980. But until recently – in 1998 – the exact extent of existing dune systems in Virginia's coastal region remained unknown. Two studies completed by researchers at VIMS, reveal and classify the location and extent of primary and secondary dunes and dune fields in the eight coastal jurisdictions covered by the Dunes Act. The authors discovered approximately 40 miles of shoreline still supporting dune systems – a mere "grain of sand" in the 5,000-plus miles of marine shoreline found in the Commonwealth – making them a rare habitat indeed. Funding for the studies was provided by Virginia's Coastal Zone Program.

Values of dune systems

Dune systems are generally identified by the mounds of sand covered in vegetation, and are best known for the buffering action they provide during storm surges and seasonal weather events. Yet the remarkable thing about these mounds is the connection they have to the greater sand ecosystem which extends well into the littoral zone in the form of a sand bar or shelf that is regularly inundated by salt water. This underwater zone is in many cases blanketed by submerged aquatic vegetation.

Such areas perform a variety of vital functions beyond their storm buffering attribute—not the least of which are the nursery and hiding areas they provide small crustaceans and finfish. But a host of coastal life – including ground-nesting shorebirds (such as the piping plover), arthropods, and sea turtles also spend time in this "edge" environment at some point during their life cycle. Horseshoe crabs use the base of the dune, where high water infrequently washes over, to lay their eggs each spring; the endangered tiger beetle lives just above the water line; migrating sea turtles come ashore the Atlantic and lower Chesapeake Bay coasts to deposit eggs during spring high tides; and ghost crabs and other arthropods live within several inches of the beach surface. Foxes, rabbits, deer, and rodents are frequent visitors to beaches and dunes, seeking refuge and food. During both spring and fall, neotropical migrants – songbirds of the most spectacular colors – use Virginia beaches and dune systems as a primary flyway. It is in the dunes that they stop to rest, prey upon insects, or dine upon berries and other herbaceous vegetation available in this scrub environment.

The plants and shrubs that support life here are a hearty bunch. They are probably familiar to you: sea oats, American beach grass, seaside goldenrod, sea rocket, saltmeadow hay, and on slightly higher ground, bayberry, groundsel tree, and others. These enduring specimens withstand the extremes of temperature, wind, and salt spray, and in the process enable the accretion of more sand, which serves to stabilize the entire habitat.

Baseline for the future

Publication of these reports not only quantifies this important coastal ecosystem in its current state, but also creates a baseline of information for the future. A digital inventory of Virginia's coastal dune systems will shed insight into future analyses of morphological change throughout Virginia's shores.

Such a monitoring effort is now underway to assess the details of morphological change across nine selected dune sites scattered along the bay. It is apparent that beaches and backshore areas tend to accrete during quiescent wave periods, with corresponding increases in foredune and primary dune elevations (as there has not been a significant storm event since Hurrican Floyd in September, 1999). Although shoreline hardening by bulkheads and stone revetments has created a sand deficit from shoreline erosion, man-made structures like jetties and groins have been responsible for areas of sand accretion and dune growth. The net effect, however, appears to be a loss of beach and dune features over the past 60 years.

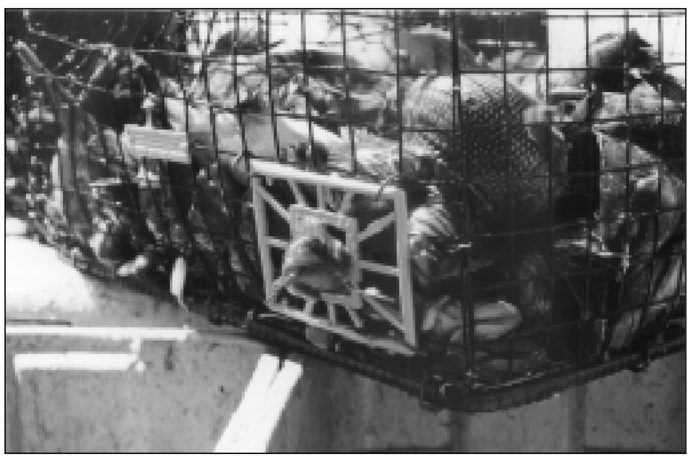
Armed with this information, VIMS researchers have been instrumental in proposing shoreline management schemes for waterfront property owners that include creation of more beaches and dunes as part of overall shoreline protection plans.

Reducing Discards from Black Sea Bass Traps

By Robert Fisher

In the early 1990s stock assessments for black sea bass *(Centropristis striata)* indicated that the species was becoming over-exploited. Amendment 9 to the Mid-Atlantic Fishery Management Council (MAFMC) "Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan" was enacted in 1996, implementing new management measures for black sea bass trap fishermen which included minimum fish size and the use of an escape vent. The basis for these measures was to reduce fishing mortality and allow for stock rebuilding.

Estimates on commercial black sea bass discard mortality are limited and contradictory. Fish traps are widely used in the black sea bass fishery, which has accounted for 45% of the commercial landings in the Mid-Atlantic since 1990 (NEFSC 1997). Traps are fished at depths to 40 meters and quickly hauled to the surface with pot-pullers.

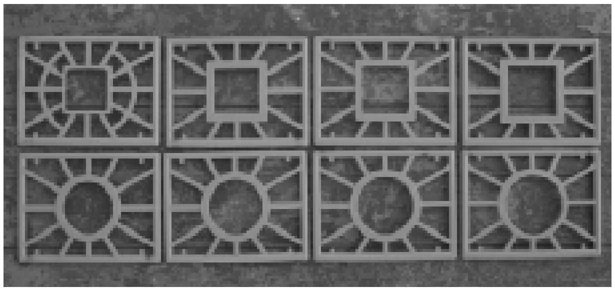


A black sea bass trap with a just-legal size fish caught in the escape vent, blocking the exit for smaller, sub-legal fish.

Actual discard mortality associated with the bass trap fishery is thought to be even more variable since not all sub-legal fish released are able to survive. This is largely due to internal damage from pressure changes during trap hauling. Black sea bass, like other reef-dwelling fish as grouper, tile fish and tautog, have a gas filled internal organ called a swim bladder that enables them to control their buoyancy, thereby allowing them to position themselves at different depths. When these fish are brought up from the bottom quickly, the trapped gas in the swim bladder expands due to reduced atmospheric pressure and can burst the bladder, expelling gases into the fish's body cavity. The resulting internal pressure is sufficient to push the stomach out through the mouth and the intestine out through the anus, and create bulging of the eyes. Discarded fish that are released in this condition are not able to dive until they are able to control their buoyancy, leaving them floating on the surface and highly vulnerable to predators.

Prior to Amendment 9, most black sea bass traps were fished without an escape vent. The use of cull rings and escape panels or vents to facilitate the escape of undersized animals within trap fisheries is well documented. However, information specific to black sea bass has been lacking.

Research conducted by MAFMC specific for the sea bass trap fishery, which formed the basis of Amendment 9 vent policy, demonstrated a significant reduction of sub-legal bass caught in traps with a rectangular vent (MAFMC 1996). However, no work was performed to determine the selectivity of traps using circular or square vents, although a large proportion of black sea bass trap fishermen in the Mid-Atlantic use either circle or square vents. Proposed – and later mandated – dimensions for a circular and square vent were derived from black sea bass body length/depth relationships (Weber and



Escape vents tested in the black sea bass habitat trap fishery (baitless, placed near a structure). Vent openings ranged from 1-7/8" to 2-1/4" (square) and 2-1/4" to 2-5/8" (circle) in diameter.

Briggs 1983). Implementation of an escape vent within the trap allows for the release of undersized fish while on the bottom or during the initial stage of haul-back, before the damaging effects of pressure changes are experienced.

In 2002, the MAFMC approved fishery management measures, which include an increase in minimum fish size from 10" to 11", and vent sizes of 2-3/8" circular, 2" square, and 1-3/8" x 5-3/4" rectangular. Research on the effectiveness of size selectivity between different vent designs widely used throughout the industry as well as testing of alternative trap designs that target discard reduction are needed to address mortality specific to the black sea bass trap fishery and enable MAFMC to make sound management recommendations.

Project designs

Currently, two research projects are underway to look at discard reduction in the black sea bass pot fishery. The first study was designed to evaluate fish size selectivity of various vent sizes of both circular and square vent types, and their effectiveness in reducing discards is being analyzed.

In a coordinated effort between scientists and fishermen, 15 commercial fishing trips were conducted, providing data from 2,099 traps totaling 30,658 measured fish. Fishing occurred from March through December 2002 in waters 25 to 55 miles offshore between Currituck Light, North Carolina, and Hog Island, Virginia. Fishing depths ranged from 60 to 150 feet. Fishing activity mimicked commercial practices of Mid-Atlantic black sea bass trap fishermen, including trap deployment, soak time, trap haul-back, and fish culling and discard methods. Catch from each trap was measured and recorded, including all by-catch. Comparative analysis is currently underway for size selectivity and relative efficiency of tested vents.

This project was made possible through set-asides from the black sea bass fishery. A small percentage of the "total allowable catch" (TAC) is contributed as part of an innovative approach to funding research. Funds are administered by the NOAA National Marine Fisheries Service.

A second research project tests the efficiency of an alternative trap, designed by a commercial fisherman, in reducing sub-legal discards of black sea bass. When a single vent is used in a trap, the likelihood of that opening being blocked by near-legal size fish, especially during the initial stage of haul-back, exists. Once the vent is blocked, escape by other fish is prevented.

This study is being conducted within the baited traps fishery (drop-pots), which typically results in a larger density of fish per trap. If more avenues for escape are available, more sub-legal fish can passively exit the trap when larger ones enter or hurriedly exit the trap during haul-back, thereby resulting in less mortality associated with discard.

The proposed project is designed to evaluate the effect that a single 2" (legal) square vent has on black sea bass discard compared to an experimental trap design with the entire parlor section of trap constructed of 2" mesh. The effectiveness of the two gear types in allowing fish to escape prior to trap retrieval will be tested.

Approximately one-third of the research trips have been completed; 148 traps have been fished and 5,420 fish have been measured. Preliminary results from the data generated to date show the "legal" traps (those with a single vent) retaining 30% of the undersized fish (<28 cm) while the experimental traps are only retaining 5%. Comparative analysis will be conducted on the complete data set for size selectivity and relative efficiency of tested trap designs.

Support for this study was provided by the Fisheries Resource Grant Program administered by Virginia Sea Grant.

For a complete copy of this technical report, including trap specifications and data analaysis, contact Robert Fisher at (804) 684-7168, or <rfisher@vims.edu>.

News from the Point

WORKSHOP SERIES TARGETS CHARTER BOAT OPERATORS

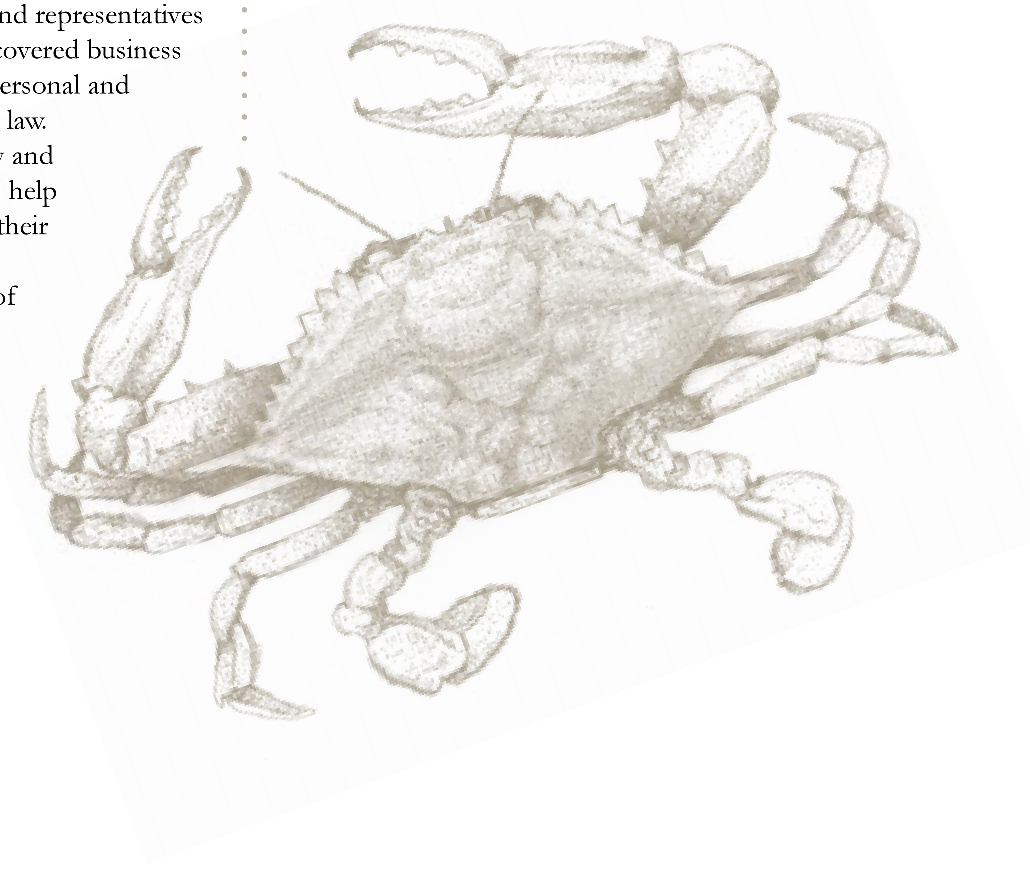
The Mid-Atlantic Sea Grant programs (representing the states of North Carolina, Virginia, Maryland, Delaware, New Jersey, and New York) hosted a series of workshops for the charter boat industry, aimed at helping operators succeed in a changing business environment. The workshops were held from the Virginia-North Carolina border to Long Island, New York, during February and March when operators were most available to participate.

Panel discussions focused on four theme areas that are important to charter boat captains, as gleaned from an industry-wide market survey conducted last fall. A fisheries management panel discussed stock assessments and management plans as they relate to federal and state regulations and permits. The U.S. Coast Guard and representatives of the insurance and legal fields covered business considerations related to safety, personal and business insurance, and admiralty law. Another panel discussed everyday and alternative marketing strategies to help small business operators expand their customer base. The workshops ended with a final "roundtable" of industry representatives talking about their experiences, and providing feedback from earlier discussions.

ATTENTION SECONDARY-LEVEL TEACHERS

The Virginia Sea Grant Marine Education Program at the Virginia Institute of Marine Science will host the third annual *Species of Special Concern* workshop in early July 2003. This one-day teacher workshop will focus on blue crab biology and ecology. Featuring presentations from VIMS scientists and marine educators, the workshop will provide teachers with information and activities to use in middle and high school classrooms. Workshop highlights will include general information sessions on blue crabs, laboratory and field activities, and computer activities.

For more information, contact Lisa Ayers Lawrence at <ayers@vims.edu>.



PUBLIC ACCESS AUTHORITY BEING CONSIDERED

An effort to preserve, protect, and manage public access to waters of the Middle Peninsula continues to move forward. Middle Peninsula localities are considering a proposal to join the Middle Peninsula Chesapeake Bay Public Access Authority. Lewie Lawrence, Director of Regional Planning, has been appearing before Middle Peninsula governing bodies over the past six months to inform them of the opportunity to formally structure such an entity. He reports that, to date, King William, Mathews, and Essex counties as well as the towns of Tappahannock and West Point have taken action to join the Authority.

Enabling legislation for the formation of the Access Authority (reported in the *Bulletin,* Summer/Fall 2001 edition) was approved by the General Assembly during its 2002 session. The Middle Peninsula Chesapeake Bay Public Access Authority Act, HB 619, from the 2002 session can be viewed at http://leg1.state.va.us/ and choosing the 2002 session.

For more information about the Access Authority, contact Lewis Lawrence, Director of Regional Planning, at 804-758-2311.

VMRC RULES IN FAVOR OF *C. ARIAKENSIS* EXPERIMENT

At its February 25 Commission meeting, the VMRC approved a request by the Virginia Seafood Council to deploy one million triploid Suminoe oysters in Virginia waters. Approval was granted, but not without significant modifications to the proposal based on comments from The National Academies panel and the Chesapeake Bay Program's ad hoc Non-Native Species Panel.

To learn more about the non-native oyster, *C. ariakensis,* and ongoing research efforts at VIMS, see <www.vims.edu/abcCA.html>.

OYSTER SUMMIT SNOWED OUT

A conference originally scheduled for February 17-18 in Annapolis to summarize oyster fisheries efforts over the past decade and develop proactive strategies for future directions was cancelled due to inclement weather. The meeting has been tentatively rescheduled for late May/early June, 2003 at the same location.

An announcement will be posted on the VIMS web site when the actual dates are chosen.

CONGRATULATIONS TO YOUTH CONTEST WINNERS!

MPRA, the Mattaponi and Pamunkey Rivers Association, announces that 40 entries by local area students were submitted for inclusion in the national "River of Words" arts and poetry contest.

The river association hosted a local version of the contest, and recognized 7 student winners at its annual membership meeting on March 21. The River of Words contest served as a kick-off event for MPRA's 2003-2004 "Schools of Shad" intiative, an outreach effort that will include issue-specific teaching tools, classroom grow tanks for shad and underwater grasses, and a public arts campaign to raise awareness of the plight of shad and herring fisheries in Virginia.

For more information, call 804-769-0841, or send an e-mail to: <billy@mpra.org>.

The Virginia Outdoor Writers Association wishes to congratulate the winners of the 2002 youth writing competition:

- First Place, Matt Craig
- Second Place, Christopher Siess
- Third Place, Matthew Biggs

Winners and their family members were treated to a luncheon in their honor at the annual membership meeting held in Charlottesville, March 20.

The Mid-Atlantic Sea Grant educators and their colleagues in the Mid-Atlantic Marine Education Association (MAMEA) are busy this spring planning a major education event. MAMEA and the University of North Carolina at Wilmington will host the annual conference of the National Marine Educators Association (NMEA) July 20-24. NMEA, a professional organization established in 1979, has an international membership of classroom teachers, college and university faculty, educators from museums, aquariums, and natural resource agencies, scientists, writers, artists, and others who teach about the aquatic environment. Annual NMEA conferences provide exciting opportunities for members and others to share their expertise as well as learn new science and teaching methods from scientists and other educators.

The event will be held on the UNCW campus in the port city of Wilmington, North Carolina. The conference theme, "Taking Marine Education By Storm," was chosen to reflect not only the event's energy and excitement, but also to acknowledge the historically hurricane-prone conference locale. The stormy theme will be enhanced by keynote speaker Dr. Steve Lyons, the Weather Channel's expert on tropical weather. Dr. Lyons will provide an in-depth analysis of the challenges facing scientists who predict and track tropical storms. A second keynote address by geologist Dr. Stan Riggs, Distinguished Research Professor from East Carolina University, will explore the impact of rapid coastal growth, climate change, and rising sea level on our dynamic barrier islands and estuaries.

The opening reception features Blackbeard the pirate and an exhibit from the N.C. Maritime Museum highlighting the excavation of the wreck of the Queen Anne's Revenge, presumed to be Blackbeard's. Other events include a tour of the newly-renovated North Carolina Aquarium at Fort Fisher and a guided natural history cruise on the Cape Fear River aboard the riverboat Henrietta III. The annual Stegner concert, which celebrates ocean-inspired music and art, will feature "King Mackerel & The Blues Are Running: Songs & Stories of the Carolina Coast," a lively stage production by nationally-recognized artists Don Dixon, Bland Simpson, and Jim Wann.

Field trips will offer explorations of this semi-tropical region, including a boat trip to Masonboro Island National Estuarine Research Reserve, a visit to the Green Swamp, home to numerous species of insectivorous plants, including Venus's-flytrap, sundew and pitcher plants; and a marine fossil dig at a local quarry.

For registration information and regular updates on conference events, see the NMEA 2003 web site: <www.marine-ed.org/nmea2003>.

THOMAS JEFFERSON TAKES BLUE CRAB BOWL CHAMPIONSHIP

Congratulations to the team from Thomas Jefferson High School for Science and Technology, who won the 6th annual Blue Crab Bowl! All team members were new to this event and took the championship in spite of having little preparation time (courtesy of a major snow storm in the Mid-Atlantic the week prior). The team now travels to La Jolla, California, to compete in the National Ocean Sciences Bowl in late April.

Pictured here from L to R: Coach Lisa Wu, Rachael Mongold, Amy Freitag, Veronika Bath, captain Kay Aull, and Chris Brigled

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Back Cover:
Looking north up the Potomac River, this photograph shows how the dune system has accreted on both sides of the Smith Point jetty, which was built during the 1930s to stabilize the entrance into the Little Wicomico River.

SEEKING READER INPUT

The Virginia Sea Grant College Program developed its initial long-range strategic plan three years ago in preparation for an overall program review by the National Office of Sea Grant. The program is scheduled for a similar program evaluation in 2004. To prepare for that evaluation, we will conduct a review of our strategic plan during 2003.

The plan identifies program priorities related to the following topical areas: aquaculture, commercial fisheries, seafood technology, coastal economic development, coastal ecosystem health, and fostering an environmentally and scientifically informed citizenry.

At this time, we invite public comment on the strategic plan, its priorities and its directions. If you feel that a marine or coastal issue or problem or opportunity has been overlooked, please let us know what you believe should be added to (or removed from) the strategic plan.

We welcome comments from any interested individual, and we will consider all input that is provided to us.

You can learn about the Virginia Sea Grant College Program by accessing our website – <www.virginia.edu/virginia-sea-grant> and clicking on "About Us." The strategic plan can be viewed by scrolling down and clicking on "Virginia Sea Grant Strategic Plan."

Comments can be mailed to Director, Virginia Sea Grant College Program, 170 Rugby Road, Charlottesville, VA 22903; faxed to 434-982-3694, or e-mailed to: wlr4z@virginia.edu. Please include your name and address as well as a brief description of your connection to Virginia's coastal and marine resources and/or environments.

Sea Grant
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