Loggerhead • Kemp's Ridley • Leatherback

Virginia MARINE RESOURCE BULLETIN

Virginia Sea Grant College Program
Virginia Institute of Marine Science
The College of William and Mary
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Green • Loggerhead • Kemp's Ridley

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This season, the *Bulletin* includes coverage about two icons of the coast: oysters and sea turtles. Both articles illuminate—from different vantage points—the lengthy nature of scientific inquiry.

Yet, championing the importance of taking the long view is perhaps the biggest communications challenge faced by researchers. The pace of scientific discovery inevitably comes into direct conflict with the institutional constructs of management and legal remedies. Those are the constructs dominating the governance of public resources, and therefore, the constructs with which non-scientists are most familiar.

The oyster situation is a perfect example of the agitation that surfaces during such conflict. It is one that calls for private interests to respect the pace of scientific inquiry, and to appreciate the long road that brought us here. But is it also the time for governing bodies to take a more streamlined approach? Should public dollars be more precisely targeted to a directed breeding program for the native oyster? At what point, and at what level, should public funds be diverted toward other options, including the Asian oyster?

Sea turtles illustrate yet another dimension of the management conundrum. Scientists and managers are searching for ways to protect turtles from commercial fishing gear, as anecdotal evidence points to trouble. At the same time, understanding sea turtle behavior well enough to calculate population estimates proves very complicated when working at the scales involved, as demonstrated in the article by Kate Mansfield.

Respecting such scales of distance and time is difficult for humans. We are not known for tremendous reserves of patience. Patience, some would say, is what sets the scientific community apart—what becomes fundamental grounding early in the graduate study process. While the rest of us chafe from not having immediate solutions to contemporary problems, scientists are equally uncomfortable making decisions, or offering advice, before all the answers are in.

We could all benefit from going through the exercise of population analysis on just one turtle species—or modeling all the variables that might influence an oyster to set—and in so doing, learn to appreciate the myriad unknowns that scientists and resource managers must stare down and make judgments upon every day. Such insight may not resolve current conflicts, but it would better prepare us for the even tougher decisions coming our way.

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Front Cover:
A Kemp's ridley equipped with a radio tag (longer antenna to right) and satellite tag (shorter antenna) surfaces off the Virginia Beach coast.

Surfacing for Science

By Katherine Mansfield

Adored by children young and old, sea turtles link us to our deepest past and remain a symbol of constancy in an ever-changing world. These ancient animals are found throughout the world's marine and estuarine habitats. Virginia's waters provide a seasonal home to several species of sea turtles that undertake long-distance migrations of several hundred to a thousand kilometers each year, just to spend a few short months here. The Chesapeake Bay and coastal waters of the state play an especially important role in the life history of two species: the loggerhead (*Caretta caretta*) and Kemp's ridley (*Lepidochelys kempi*) sea turtles.

Scales of distance and time

After hatching from their natal beaches, smaller juvenile sea turtles seek out offshore waters, riding oceanic currents for thousands of miles over a period of several years. As larger juveniles, the turtles will return to coastal and estuarine waters to establish foraging grounds and over-wintering habitats, often migrating between the two seasonally. As adults, females exhibit strong fidelity to a particular nesting beach, and migrate back to it every two to three years to mate and nest.

Depending upon species, researchers have determined that sea turtles take up to 25 years to reach sexual maturity and may survive well over 50 years. This time scale, similar to that of humans, has important implications for sea turtle management and protection.

All sea turtles are federally protected under the Endangered Species Act (ESA) of 1973. Loggerhead turtles are listed as threatened throughout their range. Kemp's ridleys are the most endangered species of sea turtle and ranked *among the most endangered species of animals worldwide*. The ESA states that no part or product of a sea turtle may be taken or possessed within the United States and its territories. Nesting and foraging grounds are also protected by the ESA, and alterations to these critical habitats are prohibited or restricted.

Sea turtles are highly migratory, inhabiting the waters of many different countries within their lifespan. As a result, protecting them becomes an international challenge. Since they may not reach sexual maturity until the third decade of their life, protecting juvenile sea turtles is of utmost importance. Only by allowing these animals to reach sexual maturity are they able to reproduce and add to their population.

Virginia's sea turtle habitat

The Chesapeake Bay is one of the most important seasonal foraging grounds for juvenile loggerhead and Kemp's ridley sea turtles in the western Atlantic. Virginia's in-water sea turtle habitat includes the entire mainstem Chesapeake Bay and its tidal tributaries, and all coastal waters.

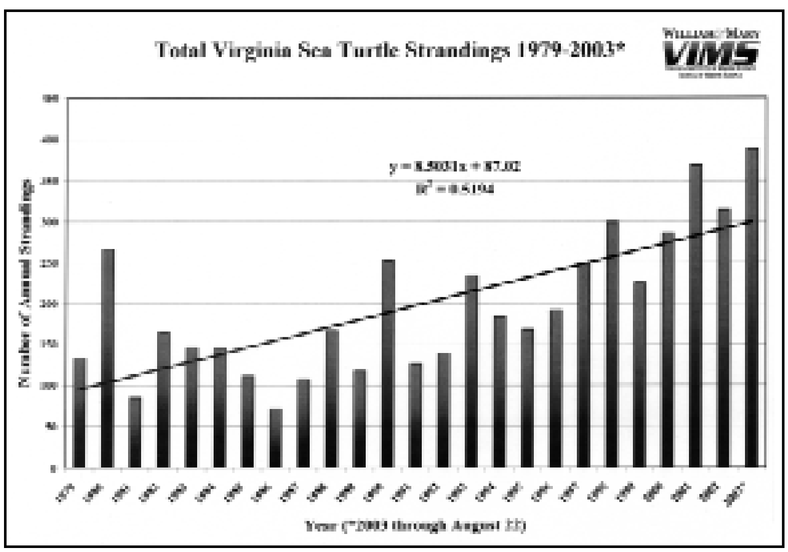
Based on long-term stranding and tagging studies, researchers at the Virginia Institute of Marine Science (VIMS) have estimated that 95% of Virginia's sea turtles are juveniles, with only a small number of adults using state waters and beaches to forage or nest. While Kemp's ridleys are only known to nest along the western shores of the Gulf of Mexico, the northernmost extent of loggerhead nesting along the U.S. East Coast is found in Virginia. Virginia's loggerhead nesting habitat includes the Eastern Shore's coastal beaches and the Virginia Beach oceanfront south to North Carolina.

Since sea turtles are cold-blooded reptiles, sea temperatures strongly influence their movements and behavior. Virginia's estuarine and coastal waters are subject to a wide range in temperature regimes over the course of four seasons. Sea turtles cannot survive Virginia winters and are only resident here between May and October.

Aerial surveys and telemetry studies conducted by VIMS researchers have shown that turtles migrate north into the bay during the spring as sea temperatures reach between 18º and 22º C. The turtles will remain here until the fall, feeding on a variety of benthic species, including blue crabs (*Callinectes sapidus*), horseshoe crabs (*Limulus polyphemus*), channel (*Busycotypus canaliculatus*) and knobbed whelk (*Busycon carica*), and some species of fish. When temperatures drop in late September or October, the turtles begin a southern migration to their over-wintering grounds. Over-wintering habitat for Virginia's turtles is found from waters south of Cape Hatteras to the waters off the South Carolina, Georgia, and Florida coasts, extending to the Gulf of Mexico.

Sea turtle mortality in the Commonwealth

The Virginia Institute of Marine Science has served as the center for the National Marine Fisheries Service Sea Turtle Stranding and Salvage Network in Virginia for nearly 25 years. Each year, between 200 and 400 juvenile sea turtle stranding deaths are recorded within Virginia waters and, as shown here, over the past ten years these stranding mortalities have been on the rise.



These data represent total annual sea turtle strandings (all species) recorded in Virginia since 1979. A simple regression line fitted to these data indicates a trend toward increased annual strandings over time. The 2003 stranding data in this graph represents all strandings through August 22, 2003. As of mid-September, the total has exceeded 400 turtle mortalities.

Historically, 50-60% of annual strandings occur in the spring of the year, within the first two to three weeks of residency. This annual peak in strandings typically takes place sometime from mid-May to early June when sea temperatures reach at least 18º C and turtles are beginning to arrive in the bay. These annual mortalities may be attributed to many different causes, including but not limited to: entanglement in different fishing gears, exposure to cold water temperatures, injuries sustained from boat collisions and channel dredging, ingestion of foreign objects, and the energetic costs of long migrations. However, the majority of stranded turtles exhibit no signs of illness, fishery interaction, or other human-induced mortality.

Given historic population estimates and the recent increase in turtle strandings, the primary question for managers is: Does the recent increase in sea turtle mortalities in Virginia simply reflect an increase in the turtle population?

Virginia's sea turtle populations

One of the primary missions of the VIMS Sea Turtle Research Program is to determine relative abundance and seasonal distribution of sea turtles found in the Chesapeake Bay and coastal waters via aerial population surveys, and to examine any changes in relative abundances over time. Since sea turtles can take up to 25 years to mature and Virginia waters serve as an important habitat during juvenile development, a census of Virginia's juvenile loggerheads (6-12 years of age) may be the best indicator of the effectiveness of conservation efforts initiated 10-30 years ago on loggerhead nesting beaches. Understanding trends in Virginia's juvenile population will, in turn, help identify what will happen to the entire Atlantic loggerhead population as these juveniles mature into adults.

Population estimates are based on aerial surveys conducted by trained observers. A pattern of transect lines has been established over the Chesapeake Bay, broken down into two

(cont. on page 6)

Left, Capt. Charles Machen and former VIMS graduate student Dr. Joanna Gascoigne prepare to release a juvenile loggerhead sea turtle south of the Chesapeake Bay Bridge-Tunnel. The turtle was outfitted with sonic and radio telemetry tags and tracked by Kate Mansfield for 24 hours post release.

Above, VIMS graduate student Kate Mansfield tracks a sea turtle in the mouth of the Chesapeake Bay, using radio telemetry and hydrophone receivers.

SEA SCALLOPS & SEA TURTLES

Sea turtles are sometimes taken as bycatch in scallop dredges, and scientists are working closely with the industry to minimize the impacts of commercial fishing vessels on these marine reptiles. While early education efforts specifically targeted captains and vessel operators, it became apparent that scallop gear modifications were a necessary component of strategies to protect sea turtles.

In cooperation with the National Marine Fisheries Service and the scallop industry, VIMS and Sea Grant initiated a gear testing program. According to Dr. William DuPaul, one of two paired dredges towed by scallop vessels was modified in this experiment to prevent the capture of sea turtles. To date, 14 trips covering 150 days at sea have tested the modified gear on vessels from Virginia and Massachusetts. During the gear trials, all vessels had a VIMS observer on board.

Because the observers would spend an unusual amount of time at sea, special educational programs in sea turtle biology and vessel safety were initiated. About a dozen observers took part in a workshop conducted by sea turtle researchers and learned how to identify various species as well as assess and properly respond to injuries if a turtle is taken onboard as bycatch. The workshop included a study of turtle anatomy and a review of the correct steps of turtle resuscitation. While observers are specifically prohibited from handling a turtle, their knowledge can ultimately help a crewmember, who is mandated by law to properly return the animal to its ocean habitat.

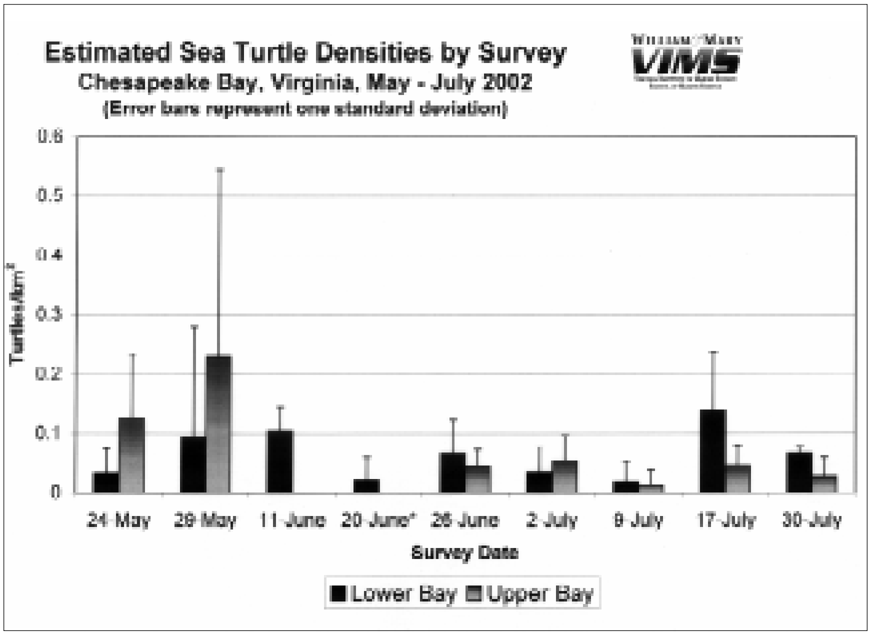
The *Vessel Safety Program* is conducted by Sharon Miller at VIMS. Modeled after a curriculum established by the Alaska Marine Safety Education Association, training is designed to increase safety awareness and survivorship while working onboard vessels. "Hands on" experience in the use of survival equipment and drills that reinforce procedures to employ during vessel emergencies fortify classroom instruction. Participants get an opportunity to test their knowledge by performing exercises in the William and Mary campus pool, including donning an immersion suit within 60 seconds, abandoning ship, and deploying and boarding a life raft. Understanding the seven steps of survival forms the backbone of Miller's program. Students learn the framework to prepare for survival when a vessel no longer provides the safest shelter.

According to Miller, "There is a direct correlation between surviving and familiarity with safety equipment. Training affects your attitude and how you respond to an emergency situation."

An essential component of the vessel training program includes an onboard safety orientation to discuss safety concerns. Here, Dr. William DuPaul explains dredge gear aboard a scallop boat.

The modified dredge shown above is designed to to keep sea turtles out.

Participants in the safety training learn how to keep an injured man afloat.



These data represent estimated sea turtle densities (uncorrected for behavior) recorded during aerial surveys conducted in the spring of 2002. A peak in sea turtle densities was recorded in the lower bay during the early spring as turtles first migrated into state waters and the first strandings were recorded. This peak is consistent with density peaks recorded in the mid-1980s.

NOTE: The standard deviation represents the uncertainty in the measurement representing the actual state of things. If, conceptually, the experiment could be repeated different counts of turtles would have been obtained and correspondingly different esimates of density. (If you toss a coin ten times, it may come up three heads and seven tails; if you toss it again ten times you will probably get a different result.) The "true" turtle densities are very likely to lie twice the standard deviation of the observed density.

study regions: the upper bay and lower bay. Four lines are randomly chosen from each region, and surveys are flown along those transects regularly during and immediately following the stranding season. Two observers, one on each side of the plane, scan the sea surface and record any observed sea turtles or fishing activity.

Minimum densities of turtles are calculated by dividing the total number of turtles observed by the area surveyed (where area includes the width and length of the surveyed transect). That number is then extrapolated out for the entire survey area—in this case, either the lower or upper Chesapeake Bay.

These estimates must also be adjusted to reflect the turtles' respiratory behavior. Sea turtles are air breathers and must come to the surface to breathe. Due to the murkiness of the bay, sea turtles are only visible to aerial observers when swimming within the top meter of the water column. But since turtles are known to dive throughout the *entire* water column and forage on bottom dwelling organisms, those counted at the surface represent only a fraction of the overall population. A correction factor is used to account for turtles that cannot be seen. This correction factor is determined based on the percentage of time turtles spend *at* the surface versus time they spend *below* the surface, expressed by the ratio: for every one turtle observed at the surface, there are 'x' number of turtles swimming below the surface.

The ratio historically used was determined in the 1980s via radio telemetry, based on the respiratory behavior of foraging sea turtles. Sea turtles were outfitted with radio tags, released in the Chesapeake Bay, and tracked by boat for several days or weeks post release. Radio transmitters only transmit a signal when exposed to air, so the amount of time turtles spend at the surface is determined by the percentage of time radio transmissions are heard.

Aerial surveys conducted by VIMS researchers between the years 1982-1985 and 1991-1992 indicate that maximum population estimates range between 6,500 and 9,700 turtles for Virginia waters within any given season. Importantly, the highest turtle densities were observed during the spring of the year, implying that the greatest numbers of sea turtles visit Virginia waters during springtime. However, the correction factor used to account for turtles below the observable surface was based on summer and fall foraging behavior. No data were collected for respiratory behavior during the spring when turtles are first migrating into the bay and aerially observed sea turtle densities are highest.

If there is a difference in the percentage of time sea turtles spend at the surface in the spring of the year versus later in the residency season, historic population estimates may be thrown into question. For example, if sea turtles spend *more* time at the surface in the spring versus the summer, they are more likely to be observed and counted during aerial surveys. If this is the case, it is possible that historic aerial assessments *overstate* sea turtle abundance.

Current studies

Sea turtle abundances for the Chesapeake Bay have not been consistently quantified in over ten years due to lack of available funding. Surveys were reinstated during the 2001-2003 seasons. Those surveys indicate that the highest turtle densities also occur during the spring months in the lower bay, corresponding to the time when turtles first appear in Virginia. Using the historic respiratory correction factor, maximum population estimates seasonally range between 3,900 and 8,100 turtles in the bay.

Given historic springtime peaks in observed sea turtle densities, the next question to ask is: Are sea turtles spending a greater amount of time within warmer surface waters in the spring and, thus, more likely to be counted by aerial surveys?

Refining population estimates

Radio tracking work conducted by VIMS researcher Richard Byles in the 1980s established that loggerheads spend 5.3% of their time at the surface while foraging in the bay during summer months—or, for every one turtle observed at the surface, there are approximately 18-19 turtles below. Sea turtle researchers have determined, however, that turtles may spend 10-20% of their time at the surface when migrating long distances—or, for every turtle observed at the surface, there are 5-10 below the surface. These longer surfacing times are due to the metabolic costs of migration that result in greater oxygen intake.

Since sea turtles are cold-blooded reptiles, temperature may also play a role in the amount of time turtles spend in different parts of the water column. To explore this idea and improve estimates of regional abundance, sea turtles were tracked using radio and satellite telemetry during the spring months of 2002 and throughout their residency in 2003. Among four juvenile loggerheads tracked in 2002, the percentage of time these individuals spent at the surface ranged from 7.07-12.7%. The mean time spent at the surface was 9.91%—higher than Byles' findings. These preliminary data imply that turtles are spending more time at the surface during the spring months and therefore are more likely to be counted during aerial surveys. For every turtle observed at the surface, there are ten turtles below the surface.

(over)

Good Sources of Information

Websites:

- www.vims.edu/bridge (*link to Spotlight on a Scientist)
- www.seaturtle.org (*link to satellite tracking project)

Books:

- Musick, J. A. 1988. *The Sea Turtles of Virginia.* Virginia Institute of Marine Science, Gloucester Point, VA.
- Lutz, P. L. and J. A. Musick (eds.). 1997. *The Biology of Sea Turtles.* CRC Press, Boca Raton, FL.

When extrapolating data for an entire survey area (thousands of square kilometers), using the earlier correction factor of 1:18 throws into question historic population estimates. If this is the case, turtle populations have been overestimated in the past.

Sonic tags that provide real-time data on a turtle's depth and the ambient temperatures within the water column were used in 2003. Coincidentally, an unusual phenomenon in the coastal zone this past summer helped shed more light on sea turtle behavior. A widely reported "upwelling" event took place throughout the Mid-Atlantic Coast, bringing colder bottom waters closer to the sea's surface. Two juvenile turtles were tracked with sonic tags near the mouth of the bay and offshore of Virginia Beach through the area of coastal upwelling. Water temperatures at the surface were 23-24º C. Two to three meters below the surface, temperatures dropped to 18º C, and bottom temperatures dipped between 9-11º C. Preliminary analyses of the turtles' sonic tracks indicate a clear preference for the warmer water. In fact, these turtles spent over 30% of their time at the surface!

Implications for research and management

These preliminary findings collectively suggest that: 1) turtles spend more time at the surface in the spring versus later in the summer (when warmer waters range deeper in the water column), and 2) turtles exhibit a preference for warmer surface waters when swimming through waters with a large vertical range in temperatures. These data also indicate that historic attempts to quantify population size may have overestimated turtle abundance in Virginia waters during the spring of the year.

To answer the two questions posed, more turtles need to be tracked in the spring of the year. This will enable researchers to better understand whether the mean ratio of surface to submergence time for loggerhead juveniles in the spring is significantly different from the summer and fall ratio that was established in the 1980s. If this turns out to be the case, then future work will include recalculating all sub-population data derived from aerial surveys, incorporating spring surfacing behavior for local sea turtles.

On a management level, these data will help determine appropriate "take limits" for local fisheries that are known to harvest turtles as bycatch. Allowable sea turtle take limits for Virginia's commercial fisheries have not yet been established. As such, under the ESA it is assumed that no turtle takes are allowed, and local fisheries have been subjected to blanket closures as a result. The economic consequences of such closures on Virginia fishermen are well known. However, overestimating turtle populations may encourage managers to *relax* turtle bycatch limits in culpable fisheries, undoing years of sea turtle conservation efforts in Chesapeake Bay and western Atlantic waters. This would ultimately harm turtle populations and may result in more stringent fishery management actions down the road.

To report a sea turtle stranding in Virginia, please call:

- For turtles north of the James River north to the Potomac:
Virginia Institute of Marine Science—toll-free stranding hotline (24-hr.)
1-(866) 493-1085
- For turtles south of the James River to the NC border & the Eastern Shore:
Virginia Marine Science Museum—24-hr. stranding hotline
1-(757) 437-6159

To report strandings in Maryland, please call:

- 1-(410)-408-6633 (to report live strandings)
- 1-(800)-628-9944 (to report a dead stranding)

VIMS SEA TURTLE STRANDING & RESEARCH PROGRAM

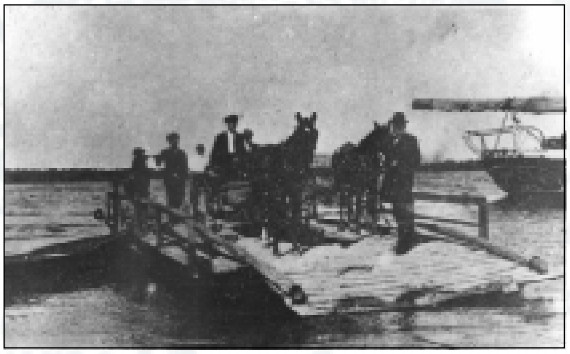
Katherine Mansfield is a Ph.D. candidate at VIMS working under the tutelage of Dr. Jack Musick, who founded the state's sea turtle stranding network in 1979.

WHERE RAIL AND WATER MEET:
A Look Back in Time at the Town of West Point

Narrative by Billy Mills

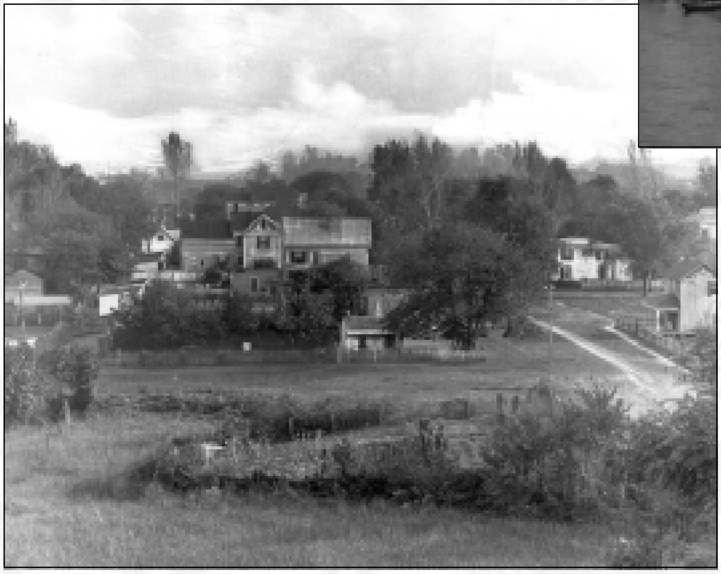
The Town of West Point's history as a strategically positioned port, railway terminus, shipbuilding and manufacturing center began with a complex of Native American settlements scattered across a peninsula once known as Pamunkey Neck. It was at "Cinquoteck," home of Chief Powhatan's brother Opechancanough, that the first extensive contact between English settlers and the Powhatan people was launched following a visit from Captain John Smith in late 1607.

Today, the Town of West Point is often called the "Gateway to the Middle Peninsula," and it remains a vital port. A pending highway project to modernize its bridges and roads, coupled with a new master plan for the town, suggests that yet another chapter in West Point's maritime history is about to unfold.



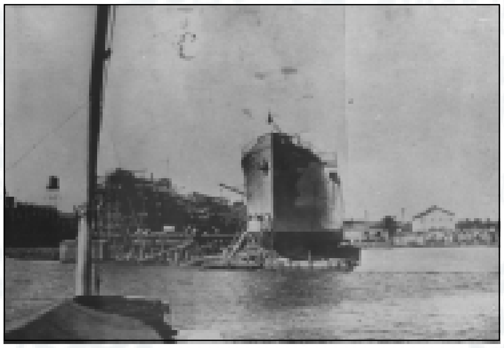
Before bridges delivered reliable and safe, permanent river crossings, chain or rope ferries such as this one that departed from Shephard's Warehouse for West Point from King & Queen County provided vital connections for people and their vehicles.

Richardson's Oyster House provided a West Point terminus on the Pamunkey River for the ferry connecting travelers to New Kent County at Plum Point until the 1920s when the Pamunkey River Bridge was finally constructed.



West Point's 1914 downtown landscape didn't look all that different from much of the surrounding countryside, with its unpaved roads and muddy intersections.

The Model-T Ford parked in front of the impressive State Bank building in 1914 was a sure sign that modern times had come to West Point. Ultimately, State Bank merged with the Citizen's Exchange Bank and became the Citizens and Farmers Bank in that same building.



The end of World War I witnessed a late call from the U.S. government for a massive fleet of wooden vessels like the *R. L. Newman*, a 3,500-ton-class ship constructed in 1919 in West Point by the York River Shipbuilding Corporation.

The Southern Railway terminus on the Pamunkey came to be a bustling transportation hub for the region, boasting not only train and steamship service connections for long-distance travelers and freight, but also taxi cab and bus service for local travelers. *(Photo courtesy of Joseph Staniuf)*

When West Point's popular Beach Park burned in the summer of 1910, the town's heyday as one of the few and famed "wet" communities in the region came to an abrupt end. This post-fire photograph records all that remained of one of the town's celebrated over-the-water bars and oyster houses just after the conflagration.

Well into the 1930s and 1940s, schooners like the *Charles A. Conway* still plied the Chesapeake Bay and her rivers. Only with the advent of increasingly reliable roads, steam power, and alternative motor freight haulers were the schooners finally dislodged from their prominence at West Point docks and wharves.

By the mid-1930s, West-Point-based Chesapeake Corp. owned leasing rights to some 1, 200-plus acres of oyster grounds above Clay Bank Wharf and had planted or acquired 140,000 bushels of oysters. Returning previously harvested oyster shell to the grounds on the York River bottom was both necessary and difficult work for local watermen, as depicted in this photograph.

In the late 1930s and early 1940s, Chesapeake Corp. initiated an oyster growing enterprise named Sea-Rac, which resulted in a 3-year intensive experiment in which oysters were cultured to market size in wire baskets in a concerted effort to reduce the impacts of heavy silt. Marketed under the Sea-Rac name, Chesapeake's "fancy half-shells" met with success in the better hotels and restaurants of the East Coast, selling for as high as $12 a barrel. Here, men are thinning out the Sea-Rac oysters at low tide at their Queen Creek site, which extended over 3 shoreline miles.

Unless otherwise noted, all photos are from **York River Yesterdays: A Pictorial History** *by Alonzo Thomas Dill, 1984. Used with permission of the Donning Company Publishers of Virginia Beach, Va.*

High Stakes, High Hopes

By Pauli Hayes

Despite the many research advances that have made their way into the oyster restoration field, an extremely difficult challenge remains in attempting to restore sustainable populations in the Mid-Atlantic of native oysters that can be cost-effectively reared for harvest. An attractive alternative to many in the oyster industry and in politics is the non-native oyster *Crassostrea ariakensis,* which has become a focal point for heated discussions of its potential benefits–and risks–if introduced to Mid-Atlantic waters.

The ariakensis issue was a common thread woven through numerous discussions during an oyster research and restoration meeting held in Annapolis in September. The meeting, hosted by the Virginia and Maryland Sea Grant programs and the NOAA National Sea Grant Office, brought together scientists, resource managers, industry representatives and others to assess the overall progress of oyster research and then to develop a set of research objectives building on the foundation in place.

What about *C. ariakensis?*

The hopeful are ready to invest in large-scale field trials–if not introductions–of the Asian oyster *Crassostrea ariakensis*. In small-scale trials conducted with sterile animals over the past several years under the auspices of the Virginia Institute of Marine Science, the animal proved to be remarkably resistant to the oyster diseases Dermo and MSX that have decimated native populations, fast growing and just as tasty as the native oyster, *Crassostrea virginica*.

After more than a year of study, and after these initial trials, the National Academy of Sciences advocated a similarly cautious and carefully regulated approach to the introduction of ariakensis to the bay. Because little is known about the environmental risks, the study suggests stringently controlled aquaculture experiments with sterile animals. This compromise could help the desperate local industry while allowing time for further controlled scientific study.

The controlled experiment

Maintaining this cautious approach already taken by VIMS, the third phase of a controlled field experiment began in late September, when 800,000 sterile Asian oysters were distributed among eight Virginia growers for a trial in which the oysters will be raised to market size–confined in mesh bags within wire cages to prevent an accidental introduction of animals to the Chesapeake.

Stakes are high for the sponsoring Virginia Seafood Council and for the commercial farmers and processors who received their oysters in this third stage of the trial. High hopes mixed with apprehension fuel the growers who believe the project–if successful–could conceivably herald a comeback of the industry that once supported whole communities.

Because the impacts of a wholesale release of *C. ariakensis* are entirely unknown, however, extra safeguards are in place to ensure that the non-native oysters stay isolated in their cages until watermen harvest them at market size within a year. The wire containers in sites scattered around the bay are anchored to stakes, and in severe weather growers are required to move the oysters out of open water and onto the safety of docks or pilings.

Additional requirements have been handed down from the Virginia Marine Resources Commission following recommendations by

VIMS, the National Academy of Sciences and the Chesapeake Bay Program. Oysters must be sterile with a tolerance of one normal, reproductive oyster among 1,000 sterile ones. Sterility is achieved when oysters are genetically modified to have three sets of chromosomes (triploidy) instead of two (diploidy). While deployed, oysters must be monitored regularly and removed from their growing sites within a year to ensure that animals won't have enough time for genetic reversion that could render them fertile.

In the thick of the ongoing experiment is Stan Allen, professor of marine science and director of the Aquaculture Genetics and Breeding Technology Center at VIMS. Allen's work in selective breeding, along with that of co-worker Dr. Ximing Guo now at Rutgers University, resulted in the technique for growing the sterile oysters used in this experiment. The criteria are exacting. Allen destroyed an initial batch of selectively bred 1 million larvae this summer after 4 in 3,000 spat proved to be fertile. The second batch of 1 million met the stringent criteria for distribution – only half the earlier batch, or two in 3,007, were found to be fertile.

These juvenile seed oysters, about three-quarters of an inch in size, are expected to grow two to three times faster than the native oyster, *C. virginica,* and reach roughly three inches in size when they're ready for market–possibly as early as next summer. "This is really a test of the whole concept of replacing oyster resource through aquaculture," says Allen. "Technology will play a key role in reducing the risk to the lowest humanly possible."

Questions and concerns

Despite the promise illustrated by this large-scale field trial, however, large questions and uncertainties remain in the minds of scientists and industry members alike. Will the Asian oyster grow and thrive in the bay–or will it too succumb to diseases, known or unknown? Will it have negative impacts on beneficial species or outcompete the native oyster? How might it affect oysters in other states? Under what conditions might sterile animals revert to reproductive? If fertile animals are introduced to the bay, or if triploid animals become wild, will they colonize and build reefs?

Important policy and management questions remain unanswered as well. Will large growers dominate the commercial landscape, pushing out the mom-and-pops if only triploid ariakensis are allowed for farming? Will funds dwindle for more conventional restoration projects for

Employees of Accomac Aquafarms prepare to place a tray of C. ariakensis *into Folly Creek on the Eastern Shore. Ultimately, 100,000 of the Asian oysters (shown to the left) will be tested at this site.*

C. virginica if *C. ariakensis* succeeds? And, centrally, can a traditional fishery realistically be brought back?

Although the oyster industry is pinning its hopes on rejuvenating the nearly extinct fishery–creating millions of dollars in sales and successfully competing with growers in Louisiana and on the West Coast–the prognosis is anything but clear.

> "The question is what threshold of uncertainty we are willing to accept."
>
> —*Dr. Mark Luckenbach*

On the bright side, the earlier trials of Asian oysters in the bay showed not only disease resistance and rapid growth, but also enthusiasm from consumers. On the down side, a recent experiment with Asian oysters in North Carolina ended in the deaths of many animals apparently due to a worm infestation. Although this has not been the case in Virginia, unforeseen die-offs remain an unsettling possibility.

The introduction issue

Virginia's cautious approach–proceed slowly and see what develops–varies significantly from the more aggressive stance adopted by Maryland. There, scientists and politicians are awaiting permission from the Army Corps of Engineers to distribute fertile–not sterile–animals for experiments in the upper bay. Although a date of next summer is admittedly optimistic, the fact remains that reproductive animals will likely enter the bay–if they haven't already.

Karen Oertel, an Eastern Shore restaurateur and champion of commercial growers large and small, is adamant about getting oysters before the industry collapses. "Time's running out, guys," she says. "Industry needs solutions right now. We don't have two years to wait." She also notes the possibility that an introduction of a non-native oyster has already occurred, perhaps even inadvertently by watermen conducting independent experiments.

Clearly, the issue is highly charged, with livelihoods and ways of life at stake. Significant risks, however, accompany significant potential benefits for a future introduction of a non-native species.

Addressing some of these issues firsthand is Dr. Mark Luckenbach, professor of marine science and director of the VIMS Eastern Shore Laboratory. During a recent trip to China, he found that the Asian oyster is not faring so well even in its home waters there and in Japan. Ariakensis is declining in its native Ariake Sea in Japan–apparently a victim of multiple stressors from disease, predation and environmental changes.

Although the animal thrives principally through aquaculture, the status of natural populations is murky, perhaps because natural populations have been widely exploited already in favor of aquaculture. This lack of certainty, says Luckenbach, significantly affects our ability to assess potential benefits as well as risks on the U.S. East Coast. For example, will it thrive here or will it prove a mythical quick fix that creates false promises and hopes? If it does adapt and thrive, how long could this process take? Are there different strains, species or variants, and if so, which should be introduced? All of these considerations have huge implications for assessing success and risk, he says.

Beyond these specific concerns, numerous political, social and environmental issues are at stake. Among these are widespread geographic concerns. Regions outside the introduction area must be considered regardless of jurisdictional ability to "just do it," and ecological concerns must influence the economic values of individual states.

Luckenbach, echoed by other scientists, advocates establishing reasonable goals, prioritizing research needs, and creating carefully designed experiments. "The process," he says, "must be informed by science–so we've got to get out and do the work."

"The decision will be made in the face of uncertainty," he concludes. "The question is what threshold of uncertainty we are willing to accept."

Pauli Hayes coordinates the communications program for Virginia Sea Grant from her office at UVA.

MASTER *of the* Reef

By Charlie Petrocci

Black sea bass *(Centropristis striata)* extend from Massachusetts south to Florida, with good concentrations in the Mid-Atlantic region. Here, sea bass migrate offshore in the fall and over-winter in waters 40 to 500 feet deep. Come spring, they reverse their movement and migrate back inshore to shallow coastal habitats. Considered temperate reef fish, adults spawn during the summer in areas around natural anomalies or wrecks. Adult sea bass will readily consume barnacles, fish, crabs, mussels, and other benthic organisms. Feeding slows down during the height of the summer spawning season.

Spawning can be protracted and takes place in the Mid-Atlantic at ocean depths around 60-150 feet. Beginning in early June and peaking around August, the fish spawn in water temperatures ranging between 65-68° F. Females will lay between 30,000 to 280,000 free-floating eggs. After hatching, the young go through a planktonic stage. Young sea bass up to an inch in size then begin to migrate toward coastal bays and estuaries. Juveniles are aggressive feeders and will eat anything that looks edible, including crab, clam, worms and other small fish.

Sea bass have robust bodies covered with large scales colored from dusky brown to black in patterns with definitive vertical streaks. They also have the ability to change color to match their bottom habitat. Slow growers, it can take up to five years for a sea bass to reach one pound in the wild. They are also very territorial and may fiercely protect a piece of structure as small as a submerged soft drink can.

But perhaps the most interesting aspect of the natural history of the sea bass is that they are protogynous hermaphrodites. In other words juvenile sea bass start out as females and later some transform into males. The size and age of the sex reversal varies, but it is believed most fish change sex when they reach approximately 7-10 inches and between 2-5 years of age. Females are more abundant than males because they dominate the younger, smaller class of fish. But there is evidently no fixed rule with regard to sexual reversal, as mature males and females can be found in all age classes.

Sex reversal usually takes place between August and April, indicating that reversal takes place after spawning. Research has shown that many of the fish that are larger than 11 inches and older than 5 years in age are males. Sea bass can reach up to 24 inches in length, weigh over 8 pounds, and live upwards to 20 years. They reach sexual maturity between one and four years old.

Commercial fishery

Because of their migratory behavior, sea bass are jointly managed by state and regional authorities. At one time there was an active commercial sea bass fishery along the Mid-Atlantic coast. Though it still occurs in many areas, harvesting by offshore trawl nets and wooden or wire box traps is declining. This is due primarily to erratic species movement, small harvest sizes, loss of gear, and challenging seasonal regulations. Since 1978, VIMS has conducted bottom trawl surveys to index young of year and juvenile sea bass. This ongoing research has been instrumental in determining their population status.

"The predominant gear types used in the commercial sea bass fishery are otter trawls and fish pots, along with a limited amount of hand line activity. There is also bycatch from lobster pots, trap nets, and pound nets," says Bob Fisher, a commercial fisheries specialist for VIMS. Otter trawl landings are primarily the result of bycatch from summer flounder and squid fisheries.

"The bulk of this fishery occurs during the winter months, while the traditional pot fishery occurs, depending on current regulations, from April until November," he adds.

Wood pots are very similar in construction to lobster slot traps. Usually several hundred pots are set near wrecks, reefs, and rough open bottom, and fished on a rotational basis every few days. Sea bass are caught in these dark un-baited traps, seeking shelter and territory. Bycatch includes starfish, hake, eels, and rock crabs.

Wooden pots are weighed down by bricks or cement liners. Each pot by law provides an escape slot for juvenile fish, currently defined as less than 11 inches. The pots are strung out 20 to a line, about 60 feet apart, which is considered standard for the fishery. Some watermen use smaller wire pots, 2 ft. by 2 ft., which are baited with either squid or bunker. These are usually set right on the reef structure and fished daily.

Markets

During the last decade, there has been considerable demand for sea bass. The fish is favored by Italian and Greek restaurateurs, possibly because it resembles the Mediterranean sea bream. But because of a large growing Asian population which has embraced the sea bass, many non-traditional markets have now developed in Philadelphia, Washington, and New Jersey. In the last few years, Asian chefs have preferred small live fish.

"I can sell as many sea bass as I can get my hands on, but regulations limit my resource availability. It's getting tighter every year and it hurts my market sales," states Red McDonald, owner of Chincoteague Fisheries on Chincoteague Island. Packed out in 50-lb. boxes, sea bass are shipped from his dock to New York, Philadelphia, and North Carolina.

Draggers such as these located in Chincoteague, often harvest black sea bass (left) as bycatch while targeting other offshore species.

"Fish are graded out as small, medium, large, and jumbo. It seems most of the small- and medium-sized fish go to southern buyers with the large and jumbo sea bass going to northern markets," he adds.

Watermen are paid anywhere from 1 to 4 dollars a pound, depending on size and market demand. In 2001, sea bass averaged $1.50/lb. Sea bass are an excellent eating fish, yielding firm white flesh. Fish are usually marketed in the round, headed and gutted, or as fillets if large enough. In 2001 over 660,000 pounds were commercially harvested in Virginia with a value of approximately 3.8 million dollars.

Sport fishery

For decades sea bass have been a favorite target species for recreational anglers. Beginning in the early spring, and again in the fall, Virginia sportfishing boats target sea bass over offshore wrecks or artificial reefs. The objective is to locate a wreck site, mark it, and then anchor up. Baits such as squid, clam and cut bait are most often used. Metal jigs are also becoming very popular. Some charter boat captains reported this past year was some of the best sea bass fishing they have seen since the late 1970s. One captain reported that on several trips his anglers were catching sea bass on bare hooks!

Current size limits for sea bass in Virginia are a 12-inch minimum, with a 25-per-day bag limit. Most recreational caught fish average 2-4 lbs. Sportfishing boats from Virginia Beach, Wachapreague, and Chincoteague all participate in an active offshore sea bass fishery. Black sea bass are an important recreational species, with the greatest proportion of catches taken in the middle Atlantic states (New Jersey to Virginia).

Aquaculture

Because of the growing demand for sea bass in urban centers, especially along the eastern seaboard, aquaculturists have been pioneering efforts into commercialization of sea bass farming. Considered a relatively new culture program, the first successful spawning of sea bass occurred in 1997 in a Connecticut lab.

Using photoperiod and temperature manipulation, marine aquaculturists have been making strides in year-round spawning of captive, wild caught sea bass. The larvae hatch 1-5 days after fertilization and are fed a diet of rotifer and artemia for 5 weeks, eventually being weaned onto pelleted foods.

Growth rates of juveniles are fairly rapid, approximately 5 mm a week. Grow-out time of hatchery reared fingerlings is currently being explored, with preliminary findings suggesting that it may take up to 18-24 months for cultured sea bass to reach a desired market size of 1.5-2 lbs. Little is known about the nutritional and environmental requirements of black sea bass, which is critical for optimizing survival, growth, and efficiency in production. With continued efforts, sea bass may one day prove to be a viable cultured product, entering the traditional markets and taking the pressure off wild caught fish.

Artificial reefs

A large portion of Virginia's coastal bottom consists of soft mud or shifting sand. This relatively stark, featureless environment doesn't attract and hold great numbers of fish. Sport fishermen know that fish congregate around shipwrecks, ocean debris and natural anomalies like mussel beds and exposed rocks. Organisms such as barnacles, mussels and tube worms attach themselves to hard surfaces and thus become the foundation of the "food chain." Other benthic organisms such as crabs, shrimp and small fish are also attracted to the structure. Gamefish, like sea bass, lured by the abundance of food and protection of underwater structure, soon become seasonal residents.

Virginia's artificial reef program goes back to the 1950s when sportfishing groups pioneered efforts to get new reefs on the bottom. During the 1970s, concrete pipes, ships, and automobile tires were frequently used. Today, Virginia's Artificial Reef Program manufactures tetrahedron-shaped "igloos" and uses them along with military hardware and even subway cars to create the state's newest reefs. Possibly no other commercially and recrea-tionally important fish has benefited more from Virginia's successful artificial reef program than the black sea bass.

Collectively, these efforts spell good news for a fish that remains economically important to Virginia.

Experiments are underway to test trap modifications designed to prevent the taking of undersized juveniles.

Education Corner

Note from Website Editor, Susanna Musick:
Housed at the Virginia Institute of Marine Science, the BRIDGE website www.marine-ed.org/bridge is a collection of on-line ocean science resources for teachers. This year, the BRIDGE sponsored two Teacher Reviewers of On-Line Learning (TROLLs) at the National Marine Educators Association annual conference in Wilmington, North Carolina. The BRIDGE staff is proud of our sponsored TROLLs and would like to share their conference experiences with you.

"By now most marine educators are familiar with the helpful, educational and well designed website known as "The Bridge." Well, what fun would a bridge be without a couple of trolls? That's where Marilyn and I came in!

As Teacher Reviewers of On-Line Learning (TROLLs) we were chosen to attend and participate in this year's NMEA conference. What an experience! Among our many adventures during the week, as a reward for our reviewing efforts, we were provided with an incredible opportunity to show conference attendees how to get the most use out of the Bridge website based on their individual needs. This was a fun idea exchange and we met some really creative people from all academic walks of life. We enjoyed spending time with our new friends over a fantastic "dinner with the fishes" in the aquarium. But we were never too full to dive in to some serious beach combing and we even got to volunteer at a sea turtle hospital one day!

. . . We will both begin school this fall with fond memories of the conference, email addresses of many new friends, and some really great lessons! Thanks so much to all of the folks at VIMS who made this amazing opportunity available to Marilyn and me!"

—Kimberly Williams

"A gift usually comes with pretty paper and a bow or one of those cute gift bags. However this summer I received a gift without a box, paper or bow. The gift was sponsorship to attend the National Marine Educators Association conference, *Taking Marine Education by Storm,* held at the University of North Carolina at Wilmington. This conference was the highlight of my summer, and because of the Bridge, I will be able to share important information about the ocean environment and many exciting lesson ideas with my students and the teachers with whom I work.

This was a conference of firsts for me, including sponsorship at a national meeting devoted to the ocean environment, participating in a hands-on field trip at the Karen Beasley Sea Turtle Hospital, learning from scientists and colleagues from museums and aquariums and Sea Grant offices, and helping in the exhibit booth. Helping at the Bridge exhibit provided an opportunity to talk individually with scientists and colleagues about information given in presentations. Those topics explored climate and weather, technology in ocean science, maritime heritage, marine protected areas, and marine science in elementary education.

At times it is difficult to view myself as a marine science educator while teaching in the elementary school, but attending NMEA solidified that for me. The marine environment as a classroom topic provides a unique teaching opportunity by integrating separate subjects and helping students be good stewards of the environment.

. . . Attending a conference that included classroom, museum and aquarium educators and scientists made it easy to see the partnership that we all share in teaching about the oceans and aquatic environments. This conference also helped me renew my commitment to the marine environment and teaching environmental stewardship to young children."

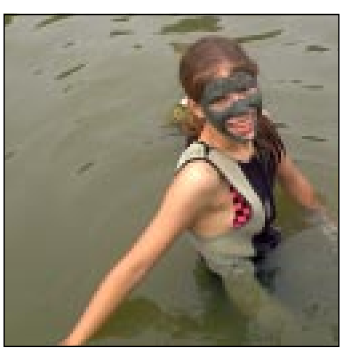
—Marilyn Cook

(A) Sea grasses provide great habitat for juvenile crabs, explains VIMS researcher Dr. Rochelle Seitz at last summer's teacher workshop.

(B) VIMS crustacean ecologist Jacques van Montfrans shares with teachers his concern about the decreasing size of mature blue crabs in Chesapeake Bay.

(C) VIMS fisheries biologist Dr. Richard Brill explains the unique external and internal adaptations of a tuna to high school teachers.

(D) New BRIDGE TROLLs Kimberly Williams (L) and Marilyn Cook (R), featured on previous page, enjoy a field trip at the NMEA conference this past summer.



(E) A Governor's School intern makes a fashion statement while sampling and counting the marsh snail Littoraria irroratta.

(F) Teachers in the 2003 summer graduate course, Marine Fisheries Science and Management, *analyze fish stomach contents with VIMS scientist, Dr. Robert Latour.*

News from the Point

INTRACOASTAL WATERWAY PROPOSED FOR STUDY

Sea Grant supported a series of workshops to discuss the operational status and economic impact of the Atlantic Intracoastal Waterway. Sponsoring partners included BoatU.S., the U.S. Army Corps of Engineers, the Atlantic Intracoastal Waterway Association (AIWA), and local trade groups. The "town meetings" held along its path between Norfolk and Miami included presentations and fact findings by federal, state, and local decision makers. Among related issues, discussion focused on the importance of undertaking a Sea Grant regional economic assessment of the waterway. Additional workshops, including one in Norfolk, will be held at a date to be determined.

WELCOME, Virginia's Newest Clean Marinas!

- Bell Haven Marina in Alexandria
- Deltaville Yachting Center in Deltaville
- Tidewater Yacht Agency in Portsmouth
- Washington Sailing Marina in Alexandria
- Wormley Creek Marina in Yorktown
- Bluewater Yachting Center in Hampton
- Leeward Marina in Newport News

Some of Virginia's finest culinary masters once again gathered for the annual Chefs' Seafood Symposium, hosted by Virginia Sea Grant, VIMS, and the Virginia Chefs Association on October 13th.

NEW TAGGING REPORT OUT

The Virginia Game Fish Tagging Program works with trained anglers to improve our understanding of fish movement throughout Chesapeake Bay and adjacent coastal waters. A cooperative effort between the institute and the VMRC, the program's *2002 Annual Tagging Report* summarizes tag-recapture results from 10 targeted species, including red and black drum, flounder, cobia, black sea bass, and tautog.

Results include:

- the observation of sporadic, often rapid migration (sometimes within 2-7 days of tagging) of juvenile black and red drum from the Chesapeake Bay to North Carolina waters from late August to November;
- the recapture of 2- and 3-year-old flounder tagged at fishing piers and other structures (some multiple times) at the same site over 2- to 15-week periods; and
- the observation of 35- to 47-inch cobia tagged during previous summers in the Chesapeake returning to bay spawning grounds 1 to 4 years later, after migrating as far south as Florida.

The *2002 Annual Tagging Report* is available for free from the Sea Grant publications program by calling (804) 684-7170.

FIRST CULTURED COBIA RELEASED INTO YORK RIVER

The cobia *(Rachycentron canadum)* is one of the most conspicuous and sought-after big game fish during summertime in Chesapeake Bay. These seasonal visitors support a large recreational fishery throughout their range along the southeastern coast and the Gulf of Mexico. Cobia is also a highly prized food fish that commands premium prices in upscale restaurants, when available. These are the primary reasons that VIMS scientists have been investigating the aquaculture potential of cobia for the past several years.

Initially, the aquaculture project concentrated on cobia's potential as a food fish. In 2000, the first successful domestic spawning and culture of cobia beyond the larval stage was accomplished by VIMS scientists. This success led to expanded research by a consortium of scientists and, ultimately, the first truly commercial production in the U.S. of cultured cobia in 2003. With commercial production rapidly developing, attention of the program at VIMS has shifted toward answering stock enhancement questions, due to the cobia's popularity among recreational anglers.

As a first step, the VIMS program tagged and released its first cohorts reared in captivity. These one-year-old fish, weighing between 2 and 4 pounds, were cultured at VIMS and released into the York River during early July, 2003. Of interest was whether or not the 120 cultured fish would be able to adapt to life in a natural environment. Also of interest was information on movement patterns that could be gleaned from reported recaptures.

Despite the small number of fish released, tagged cobia have been caught by both commercial and recreational fishermen. These early returns are beginning to provide valuable information that could potentially be used by fisheries managers for future stock enhancement projects. To date, 17 fish (or 14%) have been recaptured. These tagged cobia have dispersed throughout the lower bay, as demonstrated by their recapture points: at the Hampton Roads Bridge-Tunnel, in the Mobjack Bay system, along the eastern side of Chesapeake Bay near the popular fishing site known as "the cell," and elsewhere. In one instance, a certified Virginia Game Fish Program tagger measured a recaptured fish. This fish had grown 6.4 cm (or 2.5 inches), representing a 13% increase from its length at tagging, after just 33 days of freedom.

The returns thus far demonstrate that cultured fish will forage in the wild and travel over a wide area. These early returns, however, do not answer questions regarding seasons and pathways of migration, or site fidelity. It is hoped that future projects will address these questions.

For additional information, contact Mike Oesterling at 804-684-7165.

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.

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