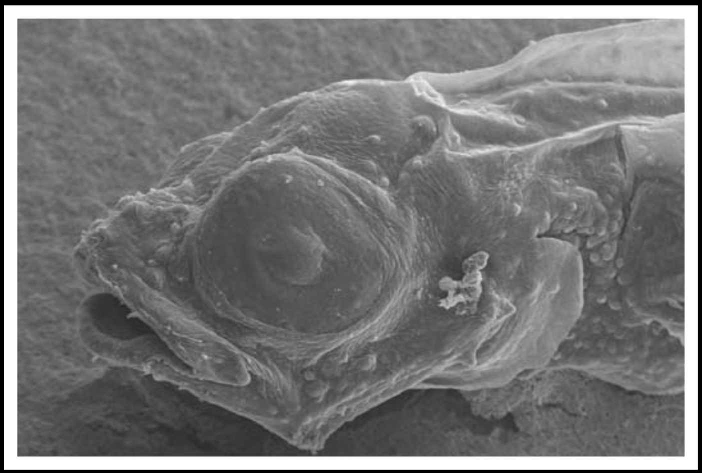
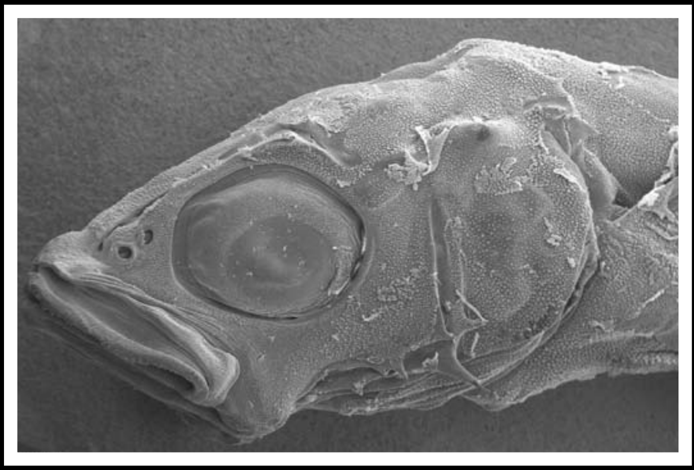
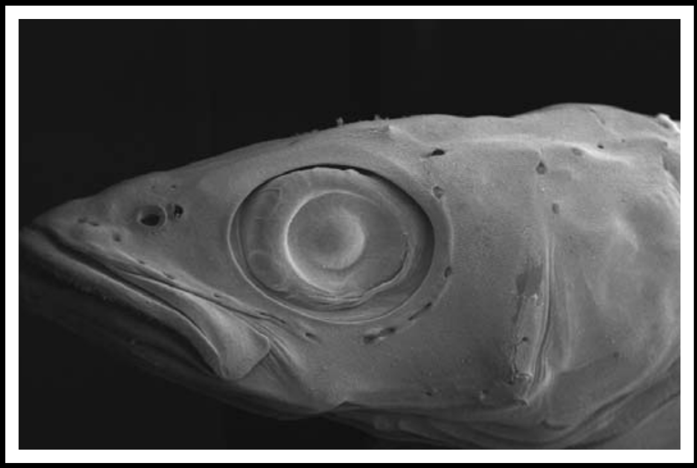
Virginia MARINE RESOURCE BULLETIN







Virginia Sea Grant Program
Virginia Institute of Marine Science
The College of William and Mary
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The *Virginia Marine Resource Bulletin* is a publication of the Marine Advisory Program of Virginia Sea Grant. The magazine is intended as an open forum for ideas, and the views expressed do not imply endorsement, nor do they necessarily reflect the official position of Sea Grant or the Virginia Institute of Marine Science.

COVER: Scanning electron micrographs illustrating changes in larval cobia during development to the juvenile stage. The micrographs show alterations that occur in jaw shape and morphology and complexity of operculum development.
Photo by: Guillaume Salze

FROM THE EDITOR

Along with outreach, communications and education, research is a critical program area for Virginia Sea Grant. In 2007, $1.4 million dollars of federal and state funding went to support research projects across the state.

With funding devoted to research, Virginia Sea Grant supports studies in the areas of economic leadership and coastal ecosystems, with a focus on revitalizing commercial fisheries, developing sustainable aquaculture, improving seafood safety and technology, and maintaining ecosystem health. Research projects often support training for graduate students, educating the next generation of scientists.

Virginia Sea Grant researchers may also compete for National Strategic Investment (NSI) monies. NSI projects have a national focus and are intended to respond to high priority areas. Virginia researchers have been particularly successful in funding projects related to oyster disease research, one of the current priority areas established by NOAA's National Sea Grant Office.

At the state level, program development funds are distributed by the Virginia Sea Grant Program to help support small, well-defined, issue-oriented projects or to provide seed money for initial efforts designed to gather data for a subsequent full proposal.

Virginia Sea Grant is also proud to support research developed and carried out by commercial fishermen through the Virginia Fishery Resource Grant Program (FRGP). Funded by the General Assembly and administered by Virginia Sea Grant, FRGP recognizes the fact that fishermen often generate the best ideas in fisheries research, but may lack the background and resources to carry out a scientific project. FRGP helps bridge the divide between the fishermen and academic researchers, encouraging collaborative projects that enrich the experience of all parties involved in a project.

Included in this issue of the *Bulletin* are three articles featuring Sea Grant funded research. We hope by reading these articles you will gain an appreciation for the depth and breadth of the research we support. If you are interested in learning more about the projects we fund, visit our Web site at *www2.vims.edu/sea-grant/research.htm.*

— *Erin Seiling*

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Cobia research helps aquaculture

Story and photos by: Guillaume Salze

Cobia (*Rachycentron canadum, L.*), a warm-water marine fish found in waters of the Southeastern United States, has recently gained prominence as a research subject and as a potential candidate species for commercial aquaculture. Cobia's valuable characteristics include tolerance of crowding, the ability to reproduce in captivity, a high-quality flesh with an excellent market value, and the species' astonishing growth rates. All of these factors make this species ideally suited for fish farming. According to the FAO[1], cobia is cultured commercially in 23 countries and territories that include China, Mexico, the Philippines, Puerto Rico and Taiwan. In 2005, over 70% of global cobia landings were derived from aquaculture, and in 2007, 22,751 metric tons have been attributed to aquaculture production out of a total volume of 31,840 metric tons reported to FAO. However, in the United States, cobia production was only 74 metric tons in 2005; a figure derived mainly from sportfish landings.

Several bottlenecks constrain the more rapid development of the nascent U.S. cobia industry. One of the most critical of these barriers is the need for a reliable supply of high quality weanlings at sufficient quantities to support a growing industry. Indeed, high rates of mortality occur during larval rearing. Currently, a 30-35% survival rate between hatching and weaning is considered excellent. For other marine species such as flounder, sea bass and gilthead sea bream, survival rates of over 90% are common and achieved at much higher stocking densities than with cobia. These poor survival rates of cobia are unsatisfactory and further research is required to improve production. Important in this respect are broodstock management and, more specifically, broodstock nutrition, genetics, and both larval and post-larval nutrition.

At both the Virginia Tech Aquaculture Center (VTAC, Blacksburg, VA) and the Virginia Seafood Agricultural Research and Extension Center (Hampton, VA), Virginia Sea Grant research focuses on larval rearing and juvenile nutrition. All organisms require an adequate food supply in order to develop and grow normally. In order to optimize production, dietary ingredients must be carefully considered and integrated into practical formulations. When dealing with larvae, nutritional requirements change as the organism matures, just as these requirements change in humans and other animals. Hence, the fundamental question in larval rearing is: When to feed and what?

To adequately answer these critical questions, the digestive system of cobia larvae requires further examination. First, it is essential to determine how the various organs involved in feeding and nutrition develop and when they become fully functional, which can be established by sampling cobia larvae at regular time intervals during their rearing and then undertaking histological and morphological investigations. When combined with biochemical research, the functionality of the digestive organs can also be assessed. This can be accomplished by examining the appearance and

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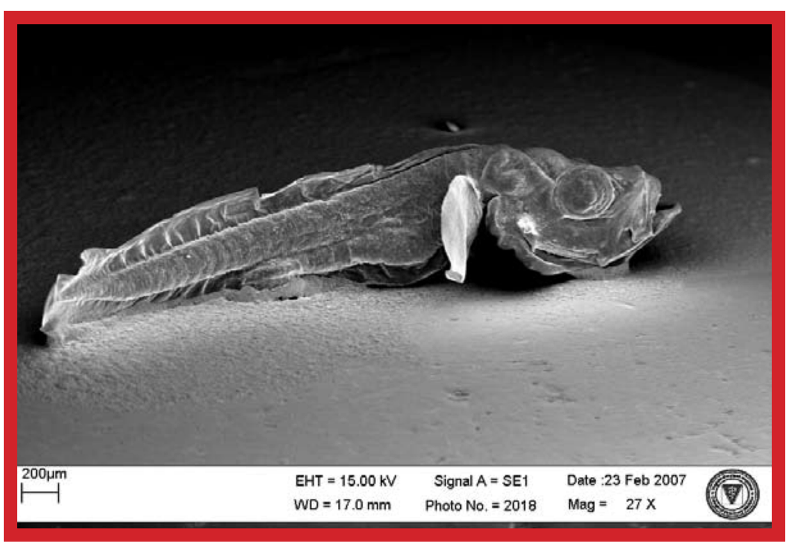
[1] FAO, 2007. Cultured aquatic species information programme. Rachycentron canadum (Linnaeus, 1766). *www.fao.org/fi/website/FIRetrieveAction.do ?dom=culturespecies&xml=Rachycentron_canadum.xml.*

activities of enzymes involved in food digestion and absorption.

Similar to other marine fish at hatching, the gastrointestinal (GI) tract of a larval cobia is a straight tube. It is also agastric, meaning that cobia larvae do not develop a stomach for over a week after hatching. However, at hatch, the intestine already exhibits differences at the cellular level between the anterior and the posterior portions, indicating regional specialization for the absorption and handling of diverse nutrients, such as proteins and lipids. The mouth and rectum of cobia larvae remains closed until three days post-hatch (dph). Until the larvae are able to capture prey, they rely on their yolk-sac for sustenance. As soon as the mouth and rectum open, the larvae start feeding on live food items. By using Scanning Electron Micrographs (SEM), we can clearly see developing sensory cells on the fish's head and body even at 3 dph: the larvae is then able to process information from its surrounding environment, including the presence of food. Analyses of some enzymes involved digestion show that lipase, amylase, and trypsin activities, while relatively low, are detectable. This indicates that when the larvae initiate feeding, they are able to digest and assimilate food as soon as their gastrointestinal tract opens. As the larvae grow, their feeding abilities develop more aggressively. The SEM reveals the formation of the lateral line system, which is a complex series of sensory cells, organized in a partially closed canal that runs from the tip of the snout to the base of the caudal fin on each side of the animal. Similarly, the nostrils, which were but mere bowl-shaped patches of olfactory epithelium at three dph, undergo an impressive transition, evolving into two paired pits with a sleek hydrodynamic shape.

Larval feeding experiments have revealed that dietary additives, such as taurine and mannan oligosaccharides (MOS), improve larval growth and survival. The free amino acid taurine is believed to help larval cobia osmoregulate. When we enriched live feeds with supplemental taurine as feed for cobia larvae, we observed an increase in GI enzyme activities when compared to control fish. The taurine-supplemented larvae had significantly higher growth rates. The challenge in rearing larvae can essentially be described as a race for early weaning. Weaning is the transition from live feeds to a prepared feed and the sooner a larval cobia can be weaned, the greater its potential for survival. Cobia larvae, just like other carnivorous marine fish larvae, must be fed live prey (zooplankton) or they starve to death. Production of live prey (e.g., rotifers, Artemia) is difficult, time consuming and particularly costly. However, artificial formulated feeds are relatively easy to manage and distribute, while remaining stable and of reasonable cost. The nutritional value of formulated feeds can also be more precisely controlled. Once weaned, the incidences of mortalities that occur during larval development disappear. Thus, aquaculturists always aim to wean their fish as early as possible. However, marine fish larvae appear unable to digest and assimilate formulated feed before the development of



LEFT: *Early larval state of cobia.*

the full suite of digestive enzymes. Therefore, increased knowledge and understanding of the mechanisms that control the onset of enzyme activity will be critical to help assist in the design of better rearing protocols, as well as weaning diets for larval cobia. Attempts to wean fish before they are ready to digest a formulated feed generally result in poor growth and ultimately in death, even though observation may show that the gut is full of food. Taurine, together with MOS, which is a natural cell-wall extract derived from yeast, may be able to help promote more rapid and successful weaning. Taurine and MOS-supplemented live feeds were found to promote the development of the intestine and may have aided in the development of the larvae's immune system as well.

Another important issue in regard to larval nutrition is the selection of live prey or dry feed of the optimal size and shape. Proper size selection is vital to ease food capture and assimilation by the larvae. A greater understanding of the developmental process of the mouth of cobia larvae can greatly influence this decision-making process. Morphometric analysis of the larval head, which consists of taking multiple measurements between discrete points, allows us to conclude that most of the changes in the cobia larval cranium result from developmental alterations in the jaw-line. This information may assist in estimating maximum jaw gape and therefore, the largest particle size that cobia can accept at various stages of development, which could prove crucial to increasing overall survival through weaning.

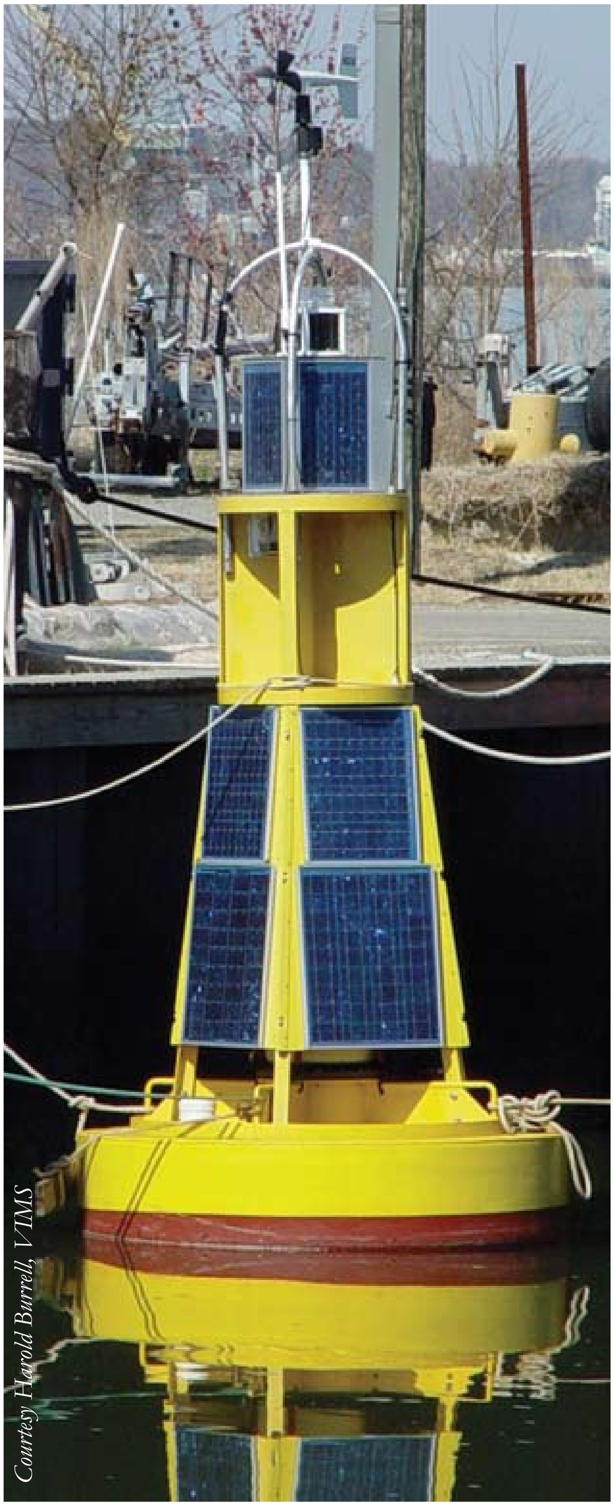
There is still a tremendous amount of work to be done with cobia larval development and nutrition. The research at the VTAC, combined with the findings of others, emphasizes the need for much more research to fully elucidate the numerous relationships between nutrition and biology in this rapidly growing species. In the post-genomic era, researchers are only beginning to explore the impact of nutrition on gene expression and regulation in fish. When integrated with more traditional physiological methods, molecular techniques will certainly shed greater light on the inter-relationships between nutrition and growth in the development of larval cobia, as well as that of other marine fish larvae.

Guillaume Slaze is a student in the department of large animal clinical sciences at the Virginia Maryland Regional College of Veterinary Medicine, Virginia Polytechnic Institute and State University.

ABOVE: *The developmental sequence of cobia larvae from egg through totally weaned juvenile fish at 27 days post-hatch (dph).*

Reality Science

By: Erin Seiling



ABOVE: *An ocean observing buoy is held at the VIMS boat basin before deployment.*

Every now and then, you'll hear an old-timer predict the winter weather by looking at the width of the brown stripe on the wooly caterpillar. A few gardeners may still time their planting based on advice found in the *Farmer's Almanac*, a trusted weather guide for over 200 years. But by and large, weather forecasting has gone the way of Doppler radar and satellite imaging.

Local news stations provide accurate daily and weekly forecasts, helping us plan our wardrobe and activities for the week. National weather information is available as well, allowing us to monitor El Niño events or approaching storm systems. However, predicting long-term changes such as drought or warming average temperatures remains difficult and inexact, but scientists hope the Global Ocean Observing System (GOOS) will soon change that.

GOOS, created by the International Oceanographic Commission in 1991 is a network of observing platforms that measure and collect data on the state of the oceans. The primary task of GOOS is to monitor the oceans, using collected data to monitor and predict climate change. Ocean monitoring also helps increase the safety of maritime operations, improve the effectiveness of cleanup following oil spills and makes possible the sustainable use of marine resources.

The GOOS system also delivers a wealth of real-time data to scientists, educators and the general public. Recreational fisherman can get a look at current patterns and water conditions before setting out for a fishing trip. Weather enthusiasts can monitor how wind and wave patterns change during storm events — weather prediction has come a long way from the wooly caterpillar and the *Farmer's Almanac*.

Evolution of Ocean Observing

The voyage of the HMS *Challenger* is often credited with laying the foundation of nearly every branch of oceanography we know today. The *Challenger* expedition, conducted between 1872 and 1876 is still considered the most comprehensive single oceanographic voyage ever undertaken. The vessel, loaded with specimen jars and alcohol for preserving samples, microscopes, trawls and dredges, thermometers, water sampling bottles and equipment to collect sediment from the bottom, recorded oceanographic data in the Atlantic, Pacific and Arctic Oceans.

This simple sampling gear is still widely used in science classrooms and by citizen scientists to gather basic information on water quality. Though seemingly rudimentary, the data collected from these instruments is enough to provide an idea of how water quality changes over time.

But there is a complex array of technology going far beyond thermometers and water bottles that supplies the data necessary for monitoring the state of our oceans. And the user group that needs such data is composed of more than scientists and researchers.

Emergency managers and city planners find long-term oceanographic data beneficial in setting up storm preparedness and response plans. Historic data from storm events is incorporated into inundation prediction maps that graphically predict how rising sea level or storm surge during major storm events could affect low-lying coastal areas. Maps exist for much of coastal Virginia and are available on the Virginia Department of Emergency Management Web site.

Power companies can monitor wind speed during storm events to pinpoint areas likely to experience power outages. Having this information early speeds up response time as they are able to deploy trucks and crews as soon as danger passes.

K-12 educators are another group likely to benefit from reliable real-life data provided by GOOS. To many teachers on a limited budget, trying to keep classes interesting can be a challenge. GOOS data, being quality assured, is a free resource of nearly limitless data streams students can use to create charts, graphs and research projects.

To help guide teachers through the process of integrating GOOS data into their lesson plans, Chris Petrone, Virginia Sea Grant educator, led a three day workshop explaining the history and future of ocean observing and challenging teachers to think creatively about ways to use the data.

Technology and Gadgets

After a brief history of ocean observing, Petrone launches into an overview of the "cool stuff" — the gadgets. The technology and hardware are part of the excitement for Petrone, who describes ocean observing as a science for "the kids who never grew up."

Buoys are perhaps the most familiar and most basic instrument used in the GOOS system. The number of U.S. buoys is estimated to be in the mid- to upper-hundreds. Buoys take observations above and below the water surface, measuring wind speed and direction, air temperature, water temperature, salinity, wave height and current information. Most buoys are tethered to the ocean floor. Data recording instruments are hooked to the tether line and suspended in the water column. Additional instruments can be mounted to the top of the buoy platform. The limitation of buoys, therefore, is the amount of instruments they can accommodate. Buoys are outfitted with solar panels which power the instruments. The disadvantage of relying on solar power is that during major storm events, such as hurricanes, solar power is unavailable, meaning the instruments aren't online to record some of the most sought-after data.

A bird's eye view of the oceans is provided by remote sensing satellites. These satellites pass over the ocean surface at given intervals, providing data to map changes over time. The colorful images of water temperature sometimes shown on local news stations are an example of the data produced by remote sensing satellites. The obvious limitation of remote sensing satellites is they can only interpret changes at the surface of the ocean. Dense cloud cover prevents observation, again, limiting their usefulness during storm events.

Autonomous Underwater Vehicles (AUVs) fill the niche for uninterrupted ocean observation during storm events. AUVs are small, battery operated submersible vehicles capable of recording and relaying oceanic data. They can run for several days on one charge, meaning they can be deployed before a storm and stay out during the event, recording conditions when other ocean observing systems are inactive. Submersible up to 6,000 meters, AUVs map subsurface temperature and salinity profiles along the entire water column. Once the battery is spent, the AUV floats to the surface and relays its location so it can be retrieved, recharged and redeployed.

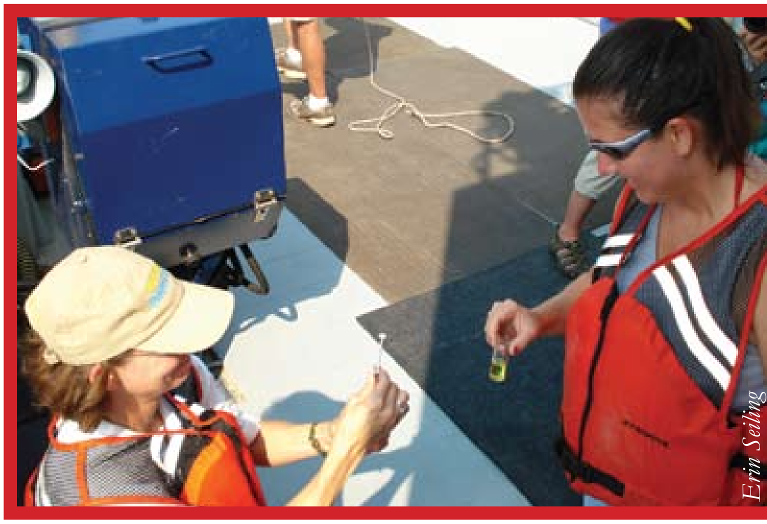
Erin Seiling

ABOVE: *Workshop participants got hands-on experience outfitting and steering the AUV Fetch, designed by VIMS' own Mark Patterson.*

If the ocean floor were outfitted with electrical outlets and wireless internet connections, AUVs could recharge and transmit their data back to the laboratory without being hauled in. Developing technology is starting to establish grids of power cables and fiber-optic communication systems on the seafloor. Such a system will reduce the down-time between deployments and allow researchers to quickly change the path of deployed AUVs to monitor areas of interest.

High Frequency (HF) Radar arrays on land compliment the assortment of devices in the ocean. Currently, there are 100 HF Radar arrays along the U.S. coastline collecting continuous, real-time data on ocean currents and waves. HF Radar is limited in that it can only measure surface conditions, but the technology has proved itself immensely helpful in search and rescue efforts. Incorporating the speed and direction of surface currents into search plans, rescue teams are able to more accurately pinpoint a search area. Since incorporating HF Radar in search and rescue efforts, the U.S. Coast Guard has noted an increase in successful rescues.

Despite the sophisticated technology available, there are still vast expanses of open ocean that researchers know very little about. As the saying goes, you can't be everywhere at once — and the ocean is a big place. The constraints of time and expense may prevent research vessels from crossing the ocean on a regular basis, but there are other types of ships that are out there daily — cargo and cruise ships. It is relatively simple and inexpensive to outfit such vessels with monitoring equipment. So-called "Ships of Opportunity," these retrofitted vessels are used to monitor water conditions, validating data gathered by other means and collecting data in remote areas. There are 4,000 Ships of Opportunity globally; 1,000 are in the U.S. program. In some ways, ocean observing has come full circle from the days of the *Challenger*.



Erin Seiling

ABOVE: *Virginia Sea Grant educator Vicki Clark (left) helps find the dissolved oxygen content of a water sample.*

Teaching the Teachers

The education staff of Virginia Sea Grant specializes in developing ways to integrate marine science topics into K-12 classroom curricula. Public schoolteachers are locked into state learning standards and find it difficult to deviate from their set syllabus, says Petrone.

"In many cases, topics and concepts in ocean sciences, including ocean observing systems, can be used to demonstrate the mandated concepts in a standards-based curriculum. While ocean sciences and GOOS integrate easiest into earth science, they can also be used in chemistry, biology and physics classrooms," explains Petrone.

Each year, the Virginia Sea Grant education staff host a series of workshops focused on a specific ocean science topic to help participating teachers develop ways of incorporating ocean science into their classroom.

Ocean Observing Systems are being covered through the CBIBS Inside & Out project. The two-year project is presented by the Virginia Sea Grant Marine Advisory Program educators and funded by the NOAA Chesapeake Bay Office Bay Watershed Education and Training (BWET) grant program.

Teachers participate in two teacher institutes (June 2007 and 2008) and complete water quality monitoring with their students during the 2007-2008 and 2008-2009 school years. During the June 2008 teacher institute, 2007 participants will bring a "buddy" teacher from their school or district to double the potential students taking part in water quality monitoring.

To get the teachers thinking about possible field activities, the three day institute features hands-on field work. Day two of the short course was spent aboard the R/V *Pelican*, one of two large research vessels located at the Virginia Institute of Marine Science (VIMS).

The field day begins with Captain Charles Machen mooring the *Pelican* off the end of the research pier at VIMS. Todd Nelson, senior electronics technician at VIMS, joins the group for the day's activities and to take advantage of time aboard the *Pelican* to repair a weather station and solar panel damaged during storm events.

While the boat is moored, the teachers pull out water sampling gear they have received as part of the GOOS workshop. Each of the participating teachers has new GPS units, water

BELOW: *Virginia Sea Grant educator Chris Petrone takes water readings with a digital handheld probe.*

Erin Seiling

quality backpacks, anemometers (for measuring wind speed), waterproof notebooks and HOBO data loggers (which measure air temperature and light intensity) to use with their students in the upcoming year. The teachers take the opportunity to test out their new equipment in the field while the Virginia Sea Grant education staff are on hand to provide guidance and answer questions.

Once the repairs to the weather stations are complete, Nelson points out a bright yellow buoy just off the stern of the *Pelican*. The buoy and weather stations on the pier are part of the Virginia Estuarine and Coastal Observing System. The buoy houses instruments that record water temperature, salinity, dissolved oxygen, turbidity, fluorescence, waves and water velocity in the York River.

A second buoy near the mouth of the York River, records similar data further offshore. This larger Nomad Buoy is also part of the Virginia Estuarine and Coastal Observing System. The platform of the Nomad is much larger than the buoy near the pier, meaning it can accommodate more ocean observing instruments, says Nelson. The two buoys communicate with VIMS through HF radio modems. Once the incoming data from the buoys is processed for accuracy, it is uploaded to the VIMS Web site.

Seeing the various ocean observing equipment in action reinforced the classroom instruction led by Petrone.

What do we do with all this data?

Back in the classroom at VIMS, the teachers spend some time brainstorming ways to incorporate ocean observing data into their classroom. The participants agree that the biggest challenge is there are only three weeks of oceanography allotted in environmental science classes. Teachers have to get creative to think of ways to use data all year.

Since the teachers that attended were from all over the state, someone suggested those residing within the same watershed could monitor how water quality changes throughout the system. Such a collaborative project would reinforce the lesson that pollution events upstream can have far-reaching impacts down river and into the bay.


Erin Seiling

ABOVE: *Workshop participants spend time brainstorming ways to incorporate GOOS data into standard K-12 curricula.*

Another idea was to tie the data into real-life situations that would interest the students. A good example would be to set-up at "CSI" (crime scene investigation) case and have students try to solve the case using oceanographic data.

For those students more mechanically inclined, the Monterey Advanced Technology Education (MATE) Center in California coordinates regional ROV competitions. The competition is open to middle, high school and college students. Each team must build and operate a remotely controlled AUV able to perform certain tasks. As part of the competition the teams must also submit technical reports, present engineering information and develop a poster display.

The teachers left the workshop energized and eager to introduce GOOS in their classrooms and field activities. Perhaps the data or the field exercises will inspire some of their students to become the next generation of ocean observers.

Visit The Bridge online at: www.vims.edu/bridge/. Find real time buoy data on the VIMS Web site at www.vims.edu/realtime/.

Sizing Up An Oyster Adversary:
The Asian Oyster Parasite *Bonamia*

Story and photos by Ryan Carnegie

The decline of native oyster *Crassostrea virginica* populations in Chesapeake Bay over the last century due to overharvesting and associated habitat destruction, and more recently environmental degradation and disease, is a story familiar to residents throughout the bay region. Familiar also to coastal communities has been the ripple effects of this decline: watermen have left the water, shucking houses have closed, an oyster packing industry has nearly vanished. As early as the 1980s, Virginia began experimenting with non-native oyster species as commercial alternatives to native *C. virginica*. The Pacific oyster *Crassostrea gigas*, so important to global aquaculture production, failed to impress in early Virginia trials and was abandoned as a candidate for introduction. By the late 1990s, experimentation was underway with *Crassostrea ariakensis*, another Asian oyster species. Promising initial results with *C. ariakensis* fueled commercial interest and introduction on a larger scale is being considered today.

Seldom is *C. ariakensis* mentioned by proponents of a mid-Atlantic introduction without "disease-resistant" included as an adjective to describe it. Perception of disease resistance, along with documented fast growth to "market" size forms the basis of commercial interest in this oyster species. Work in Virginia waters since 1998 by the Shellfish Pathology Laboratory at the Virginia Institute of Marine Science (VIMS) and its collaborators has done little to dispel this myth. We have found that *Perkinsus marinus*, the agent of dermo disease in native *C. virginica*, infects the Asian *C. ariakensis*, but generally causes little serious disease. We have found little evidence that *Haplosporidium nelsoni*, the cause of MSX disease in *C. virginica*, infects *C. ariakensis* at all. The major pathogens of native *C. virginica* pose just a minor threat to this non-native oyster, seemingly making *C. ariakensis* a good candidate for introduction.

Observations in North Carolina, however, have revealed a chink in the armor of *C. ariakensis*. They have shown *C. ariakensis* to be "disease-resistant" in a narrow sense alone, with respect only to *P. marinus* and *H. nelsoni*. In doing so, they have cast doubt on the ultimate usefulness, and promise, of future introduction of the species to our waters.

While initial deployments of sterile, triploid *C. ariakensis* in Virginia as well as North

LEFT: *Map showing current and potential future distrubution of Bonamia. Confirmed cases of Bonamia have been observed in areas from Fort Pierce, Fla., north to Cape Hatteras, NC (area indicated by hash marks). Favorable environmental conditions and availability of a host could extend its range to New Jersey (area indicated by dots).*

Carolina were characterized by low oyster mortality, very high mortality was observed in small *C. ariakensis* deployed to Morehead City, North Carolina, in 2003. Of *C. ariakensis* delivered to this site on Bogue Sound in early July 2003, just 15% were alive five weeks later. Of *C. ariakensis* deployed in mid-August, only 10% remained alive by mid-September. Only *C. ariakensis* shipped to Bogue Sound in early October, after temperatures began to cool, were spared mortality — most of this final shipment survived through the following summer.

A primary cause of the 2003 mortality and similar outbreaks in subsequent years, we now know, was a *Bonamia* parasite, a member of a genus of oyster pathogens notorious for their impacts around the world. Relatives include *Bonamia ostreae*, partly responsible for the collapse of flat oyster (*Ostrea edulis*) populations and industries in Europe; *Bonamia roughleyi*, a contributor to winter mortality in the Sydney rock oyster, *Saccostrea glomerata*, in southeastern Australia; and *Bonamia exitiosa*, a cause of serious mortality in dredge or Bluff oysters, *Ostrea chilensis*, in the Foveaux Straight region of southern New Zealand. Each of these *Bonamia* species infects oyster hemocytes, or blood cells, and may be passed directly from oyster to oyster in dense natural and aquaculture populations.

Since 2003, we have worked with colleagues at the University of North Carolina Institute of Marine Sciences in Morehead City and others from the University of North Carolina Wilmington, Maryland Department of Natural Resources, University of Maryland, Harbor Branch Oceanographic Institution, and South Carolina Division of Natural Resources to better understand this parasite and its potential to impact both *C. ariakensis* and native oyster species. The products of this effort, supported by the NOAA Chesapeake Bay Office, the Sea Grant programs of Virginia and North Carolina, and the Maryland Department of Natural Resources can be organized as five primary findings.

First, *Bonamia* may be an introduced pathogen, but it is here to stay. Analysis of the DNA sequences from *Bonamia*, points to a close relationship with southern hemispheric *Bonamia* species. This contrasts sharply with a second *Bonamia* species, *Bonamia perspora*, which we discovered infecting the native crested oyster, *Ostrea equestris*, an oyster occurring in coastal waters south of Cape Hatteras. *B. perspora* is more closely related to the northern hemispheric *Bonamia* species, *B. ostreae*, and may be a native local parasite species. Proximity of the initial outbreak of *C. ariakensis* to the North Carolina State Port, an international marine shipping terminal in Morehead City, suggests an avenue of introduction of the parasite. While *Bonamia* may not necessarily be a recent arrival to our waters — its distribution at least as far south as Fort Pierce, Florida, suggests it may have been here a while — it is not likely to leave, even if *C. ariakensis* culture and experimentation is discontinued. *Bonamia* has acquired a local host in *O. equestris*, which it infects apparently without causing much serious disease, at least in adult individuals.

Second, *Bonamia* parasitism primarily impacts seed *C. ariakensis*. Highest levels of disease and mortality have been observed in *C. ariakensis* under 50 mm in size. Oysters over 50 mm in size do develop *Bonamia* infections, but parasite prevalence and oyster mortality is reduced. The good news is that we have no evidence of a *Bonamia* impact on native *C. virginica.*

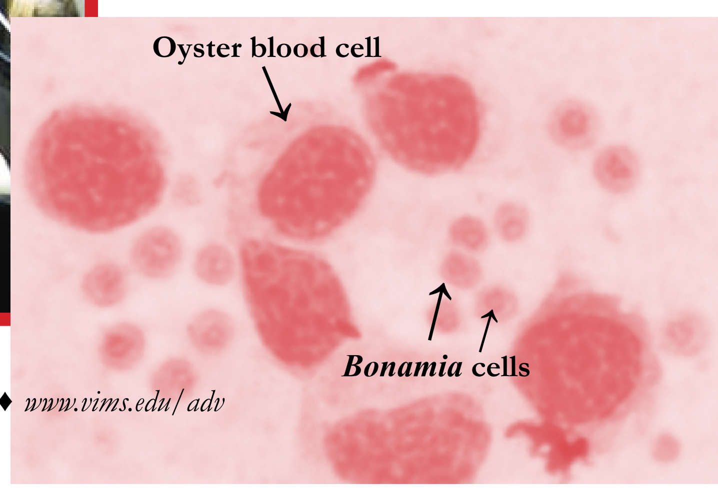
Third, *Bonamia* impacts are greatest in waters of higher salinity. Field and laboratory evidence suggests that waters of 20 ppt salinity will accommodate *Bonamia* activity, with disease impacts greatest at 25 ppt and above. Salinities of 18 ppt and lower appear to favor oyster defenses against this parasite. In drought years, most Virginia waters, with the exception of the middle and upper James and Rappahannock Rivers, can be characterized by periods of salinity 20 ppt and higher. *Bonamia* impacts, therefore, may be chronic within coastal lagoons, and may occasionally extend to waters of lower Chesapeake Bay.

Fourth, *Bonamia* outbreaks are associated with peak summer temperatures. In North Carolina, *Bonamia* prevalence and oyster mortality increase sharply as water temperatures approach 25°C and remain high as long as temperatures exceed 20°C. Like *P. marinus*, *Bonamia* becomes nearly undetectable in North Carolina in late winter and spring. *Bonamia* is, therefore, an agent of summer oyster mortality. As windows of warm summer water temperatures narrow with increasing latitude, risk of *Bonamia* outbreaks should decrease with distance north. Waters as far north as New Jersey, however, are characterized by several weeks of summer water temperatures exceeding 25°C, so *Bonamia* activity could extend substantially further north than it does now.

Finally, oysters *C. ariakensis* and *O. equestris* are the most likely environmental *Bonamia* reservoirs. Favorable temperatures and salinities alone will not assure a *Bonamia* outbreak if there is no local parasite source. Experimental evidence suggests that direct transmission among neighboring *C. ariakensis* is possible, so infected *C. ariakensis* may function as a reservoir from which *Bonamia* may be transmitted. The only other species in which *Bonamia* infections have been observed is *O. equestris* — native crested oyster populations — hundreds of kilometers from the nearest *C. ariakensis* transplants have been found to harbor this parasite. While direct transmission from *O. equestris* to *C. ariakensis* has not been demonstrated experimentally, *O. equestris* is the most plausible environmental source, given 1) the apparent strict association of *Bonamia* species with oysters, and 2) the absence of evidence of *Bonamia* infection in *C. virginica*. While *O. equestris* populations do not currently persist north of Cape Hatteras, a northward range expansion by this oyster species, as for myriad other organisms, could accompany

LEFT: *Bonamia infections are deadly in small C. ariakensis.*

BELOW: *Bonamia infections are confirmed microscopically.*



regional climate warming. There is no assurance that *Bonamia* activity will be permanently restricted to waters south of Cape Hatteras.

How do these observations bear on the commercial introduction of *C. ariakensis* to mid-Atlantic waters? *C. ariakensis* culture in Virginia and Maryland may continue to be lightly impacted by parasitic disease in the short term, given this oyster's relative resistance to local parasites *H. nelsoni* and *P. marinus*. Long-term prospects, however, may not be as bright. Culture in the higher salinity coastal sounds of the seaside Eastern Shore would not be without risk of *Bonamia* parasitism, and sporadic *Bonamia* outbreaks are possible in waters of lower Chesapeake Bay. *C. ariakensis* aquaculture may be most promising and advantageous, over the long term, in a narrow range of mesohaline salinities, from 12 to 20 ppt, where *C. ariakensis* maintains a growth and survival advantage over *C. virginica* but where salinities are too low to support *Bonamia* outbreaks.

Questions are still unanswered concerning the risk of a *C. ariakensis* introduction with respect to *Bonamia* and native oyster species. Will *C. ariakensis* amplify *Bonamia* levels in the environment such that the crested oyster, *O. equestris*, is more seriously impacted by this parasite? And what of *C. virginica*? Molecular evidence continues to point to some association of *Bonamia* with *C. virginica*, with *Bonamia* detection increasing with decreasing oyster size, though histological documentation of actual infections remains elusive — that is, we cannot confirm *Bonamia* infections of *C. virginica* microscopically. The impact of *Bonamia* on both *C. virginica* and *O. equestris* at very early life stages remains an open question.

Introduction of an alien oyster species has often been likened to opening a Pandora's Box, for the unanticipated and not necessarily positive consequences that might follow. Such has been the case with the Pacific oyster, *C. gigas*, which, while an essential aquaculture species worldwide, has become a problem invasive species in northern Europe, along the North American west coast and in southeastern Australia. It is impossible to predict with any certainty what the possible negative consequences of a *C. ariakensis* introduction will be with respect to *Bonamia* or to other ecological concerns. It is just as difficult to fully gauge the potential economic benefits. The emergence of *Bonamia* in *C. ariakensis* does remind us, however, that the unexpected may well follow a non-native oyster introduction. It reminds us too that reality, in this case with respect to the disease resistance of *C. ariakensis*, does not always match hype. *C. ariakensis* may well play a future role as oyster aquaculture in our region continues to develop, but native *C. virginica*, particularly as its disease issues are beginning to be overcome, should continue to be the cornerstone of this industry.

ABOVE: *VIMS Shellfish Pathology Lab staff collect oyster samples from Bogue Sound, NC.*

Tastes Like Chicken

Sea Grant Funded Research Examines Alternative Crab Bait

Story and photos by: Erin Seiling

Sitting near the kitchen during the holiday season can be torturous. The smells of roasting turkey, fresh baked breads and desserts waft out of the oven for hours before you ever sit down to eat. Waiting in anticipation of the delicious meal to come, I am reminded of the old cartoons where the aromas take the shape of fingers and tantalize the nose of the main character. You know how it goes: the character is lulled into a trance-like state, follows the smell of food into the kitchen, only to discover that for some reason, he can not get to the source of the delicious smell. A humorous skit generally follows, with the character employing all sorts of zany schemes to get to the food. Though my daydreams often feature a famous cat and mouse cartoon duo, a more appropriate character may be the blue crab.

Blue crabs are nearly blind. Living in murky bottom habitats, blue crabs rely on other senses to navigate and locate prey. When searching for food, they rely on chemoreceptors — or organs that are highly sensitive to smell. Detecting chemical cues produced by prey, blue crabs follow the smell to find food — kind of like those wafting aromatic fingers in the cartoons.

Crab potters take advantage of the predatory habits of blue crabs, baiting their crab pots with odiferous clams or fishes that blue crabs seem to find irresistible. The smell emanating from the bait lures crabs into the pots, where they climb in and become trapped trying to reach the aromatic smorgasbord inside.

In the early spring and summer, crabbers in the bay bait their pots with razor clams. As the weather warms, crabbers switch to menhaden bait. Older crabbers swear by the small, oily fish known locally as "bunker," seldom if ever trying different bait. But increasing regulations in the menhaden fishery may force crabbers to find alternate baits in the near future.

Menhaden have supported the Virginia economy since the 1800s. While other East Coast states have closed their commercial menhaden fisheries, Virginia still allows industrial harvest, concentrating fishing effort in the Chesapeake Bay. According to Governor Kaine's office, 95,300 metric tons of menhaden were harvested from the bay in 2004. Menhaden are processed into fish meal for livestock feed and heart-healthy omega-3 fish oil used as a dietary supplement. Menhaden serve an important ecological role in the bay as well. As filter feeders they help lower nutrient and pollution levels in the bay. They are also an important prey species, supporting larger commercially and recreationally valuable fisheries such as rockfish.

Though the Atlantic States Marine Fisheries Commission (ASMFC) lists menhaden along the Atlantic coast as not over fished, there is concern that Virginia stocks may be depleted due to concentrated fishing pressure. In 2006, ASMFC accepted a proposal from Governor Kaine that caps menhaden harvest in the bay at approximately 109,020 metric tons annually through 2010. As demand for heart-healthy products in the consumer market increases, crabbers worry that one day, there will be no menhaden available as bait in the crab fishery.

Lynn Haynie is one crabber who is doing more than worry about what the future may hold — she's doing something about it. Haynie received funding from the Virginia Fishery Resource Grant Program (FRGP) to test alternative baits for the crab pot fishery. The Fishery Resource Grant Program, funded by the Virginia General Assembly and administered by Virginia Sea Grant, funds collaborative research projects involving the fishing industry and academic researchers.

A resident of Reedville, Virginia, Haynie knows how important fishing has been to her community. During the late 1800s and early 1900s, Reedville residents made their fortunes from the profitable menhaden fishery centered near the town. Main Street, also known as "Millionaires Row," boasts several Victorian-era mansions built by fishing boat captains and menhaden factory owners. But times have changed and local fishermen now worry about the future of the once-profitable menhaden industry and the other fisheries — such as crabbing — that menhaden support.

The crab pot industry is of particular interest to Haynie, whose family has been involved in the crabbing industry for generations. Her father worked the water his entire life and still fishes crab pots and runs a shedding house for soft crabs. Haynie and her brother started working on the water with their father when they were young. Her brother now owns and operates a seafood business in Reedville. Though she works fulltime as the manager of a shipyard in Weems, Haynie still holds a waterman's card and works with her brother and father when she has time.

The shipyard where Haynie works is owned by American Proteins, Inc., a leading processor of poultry byproducts. AmPro produces chicken meal which is used extensively in pet food and livestock feed. Haynie saw an opportunity to use poultry byproducts as bait in the crab pot fishery. The idea isn't far-fetched either, as chicken necks are a popular bait choice for recreational crabbers.

AmPro got onboard with the idea, supporting Haynie's project by donating product and the time of an engineer to help develop bait formulas. They started by trying three formulas for molded bait. The first formula was ground product frozen in a mold, the second was unground product frozen in a mold and the third was product held together by edible glue, "like a granola bar," explains Haynie.

After developing possible bait formulations, Haynie field tested them. They were searching for a formula that would slowly dissolve when submerged in water. They settled on the granola-like brick and made up a batch for Haynie to take home and test in her crab pots.

But, the first batch of bait bricks smelled so bad, Haynie worried crabbers wouldn't use them. And crabbers are used to using smelly bait. Crabs are enticed into crab pots by pungent odors, so crabbers fish with bait that isn't exactly food-grade seafood. To say the first

RIGHT: *Concerned about the future of the menhaden bait market, Lynn Haynie is working to develop an alternate crab pot bait composed of chicken byproduct.*

batch of chicken bricks was too smelly is saying a lot.

Haynie and the engineer went back to the drawing board – tinkering with the formula to reduce the offensive odor and adding pheromones they hoped would attract crabs. Then, it was back to the field to test how effectively the bait bricks caught crabs.

Aside from the extra-smelly initial formulations, Haynie had trouble with her bait-bricks during the spring.

"They weren't dissolving well in the cold water and didn't attract many crabs," she says. In the spring, local crabbers use clams to bait their pots. Haynie and other crabbers agree that the clams seem to work better than anything as bait, so aside from the bricks not dissolving well, Haynie is not sure if the pheromones in the chicken bricks are as attractive as the crab-pleasing aroma of decaying clams.

Typical Testing Day

We join Haynie on a warm summer day. As she pulls away from her family's boat dock, she points out the abandoned menhaden processing plants lining the waterway.

"There used to be 30 processors just on Cockrells Creek," says Haynie, "now, Omega Protein is the last processor on the entire East Coast."

Haynie approaches the first line of pots and begins describing the crab pot fishery. As the water warms during summer months, crabbers move their pots out of the creeks and further offshore, following the movement of the crabs. They also switch to "bunker" or menhaden as their primary bait. Haynie's project is designed to mimic the fishing techniques of traditional crab potters. So, this summer she followed suit, moving her pots offshore and alternately baiting the control pots with bunker and the test pots with the chicken bait brick.

Pulling crab pots is hard work in itself, but Haynie's experiment added additional time to the typical fishing day. Haynie kept a list of each pot in her line. Every time she went out, she recorded what type of bait was in each pot — bunker or chicken bait — and the total number of crabs caught per pot. She still sorted crabs like any other crabber, tossing undersized crabs back overboard and sorting the keepers into wooden bushel baskets. After putting in a day's work at the ship yard, Haynie spent time crunching the numbers she recorded on the water. She averaged the number of crabs caught in bunker-baited pots and the number of crabs caught in chicken-baited pots to compare the efficiency of each bait type.

When the water is warm enough, the chicken bricks perform nearly as well as the bunker pots, reports Haynie. There are some days the bait bricks even have a higher average than bunker, she says.

The bricks offer some advantages over traditional bait. Crab pots are divided into a top and a bottom with the bait chamber suspended

between. Crabs crawl into bottom and move into the top to feed on the bait where they remain until the pot is pulled. Several of the chicken-baited pots Haynie pulls still have bait remaining. In these pots, there are almost as many crabs in the bottom "entry" chamber as in the top chamber.

"That means it's still attracting and catching crabs after being out for two days," she explains. Pots that have stopped catching will have all of the crabs in the top chamber and none in the bottom. Such is the case with most of the menhaden-baited pots. Nearly all of the pots she baited with menhaden have empty bait chambers after two days of "soak-time" and are no longer catching crabs. Several of the pots baited with chicken-bricks have enough bait remaining that Haynie empties the crabs and tosses the pot back overboard without adding additional bait.

The bait bricks have been shown to persist for up to five days in the water, says Haynie. Longer-lasting bait could equate into monetary savings for crabbers. If the chicken bricks can actively catch crabs for several days at a time, crabbers could leave their pots out longer between pulls, reducing their gas expenses. Generally, crabbers pull their pots every other day during summer months when warm water temperatures rapidly attract crabs and other scavengers to baited pots.

The engineer working with Haynie estimates that with mass production, the cost of the bait bricks would be comparable to the cost of menhaden bait. But the bait-bricks could come out cheaper in the end if crabbers are able to stretch each brick further than the two-day soak time typical of menhaden.

LEFT: *Haynie's experimental bait bricks dissolve slowly over several days, an advantage over traditional bait such as menhaden (shown in the basket on the right). The menhaden fishery once supported a thriving economy in Reedville.*

With each trip out to pull pots, crabbers must estimate how much menhaden bait is needed to refill their pots. Too little bait means some pots are not fished, too much bait means some of it is wasted. The bait bricks can be stored in the freezer and Haynie can vouch for them lasting over winter. At the end of the fall 2006 crabbing season, Haynie had leftover bricks. She froze them over winter and used them during the early 2007 season without noticing a drop in catch rate. Storing bait for several months will reduce driving time for the crabbers who now must purchase fresh menhaden bait several times per week.

Haynie hopes the next step will be expanding the field tests of the bait brick. She is looking for crabbers willing to test the product in other areas of the Commonwealth, or even outside of Virginia, to be sure the formulation works well under various water conditions. Haynie also believes the product could have uses beyond the crab pot fishery.

"The bricks could be ground into chum. Or I could also see it working in the Maryland trotline fishery because the bricks hold together so well," she says. Haynie also suggests it could be considered as bait in the conch fishery, another fishery where the traditional bait — horseshoe crabs — is imperiled.

Haynie knows she will need to prove the performance and advantages of the bait-bricks before she can convince other crabbers to try them.

"Most of these guys are set in their ways and I know it's going to be hard to get them to try the bait," admits Haynie. She is hoping the success of the bait in the FRG project will speak for itself. The results, coupled with Haynie's optimistic personality will likely win over a few skeptics. She hopes others will become believers as the bricks prove their success over time.

For more information on the Virginia Fishery Resource Grant program, visit the Web at www.vims.edu/adv/frg/index.html.

A Marine Challenge for the Discovery Channel

By: Ewen McLean

Every year across the nation 60,000 school children enter projects into various science and engineering fairs. Of these, 10% are selected to compete in the Discovery Channel Young Scientist Challenge — a spirited competition with rigorous judging. From the 6,000 entrants are selected 400 semi-finalists who are judged on their ability to communicate their findings in writing, orally and visually. The competition attracts a varied crop of projects with titles that range from assessing facial recognition through to examining the effects of parachute shape on descent time. This year, the Commonwealth of Virginia harvested nine semifinalist positions in the competition. One of these was Karl Sorensen of Blacksburg, who was in the 8th Grade when he undertook his project. Karl has always had an interest in marine biology and keeps tropical fishes and invertebrates in his home aquarium. One question that he wanted to answer was whether it was possible to put sick fish to sleep to make medication easier. He decided that this would be a good science fair project.

An obvious starting point for Karl to develop his assignment was to visit the Virginia Tech Aquaculture Center (VTAC). The Center has received Sea Grant funding in support of its internationally recognized research program on cobia since 2005. After meeting with VTAC Director, Dr. Ewen McLean, Karl designed a study that examined the effects of different anesthetics on juvenile cobia. Since little was known about the effects of anesthesia on this candidate aquaculture species, Karl decided to investigate the dose-response relationship and physiological impact of different treatments. He selected three anesthetics to study: MS-222 which, other than carbon dioxide, is the only legally applied anesthetic for food fishes in the US; clove oil, which is generally recognized as safe and is presently being evaluated for use by American fish farmers; and for comparative purposes, a chemical called 2-phenoxyethanol, which is sometimes used as an anesthetic by fish hobbyists.

Results from Karl's research project yielded many interesting findings as well as illustrating classical physiological effects of anesthesia on cobia. His conclusions will be useful to commercial cobia farmers around the world since the fish responded differently to anesthesia than reported for other marine species. The study is being prepared for presentation at an upcoming international meeting as well as for submission to the peer-reviewed literature. An added bonus for all of Karl's efforts and hard work was selection as one of only 40 finalists, or 0.07% of the starting total, for the Discovery Channel Young Scientist Challenge.

Dr. Amer Cnaani

LEFT: Karl Sorensen catching cobia from one of Virginia Tech Aquaculture Center's recirculating life-support systems.

News from the Point...

Grant Money Available

Virginia Sea Grant is accepting applications to compete for approximately $200,000 as part of the Virginia Fishery Resource Grant Program (VFRGP). The Virginia Legislature created the Fishery Resource Grant Program to "protect and enhance the Commonwealth's coastal fishery resource through the awarding of grants."

Basic to the program is the belief that people in the commercial fishing industry often have valid ideas to enhance and protect fisheries, but may lack the financial resources to experiment with innovations. The Fishery Resource Grant Program invests in such ideas generated by the fishing public through fair and competitive methods.

Four priority areas for funding have been established. They include: new fisheries equipment and gear, environmental pilot studies, aquaculture/mariculture, and seafood technology and utilization.

To be considered for funding in this solicitation, a signed application must be received no later than January 18, 2008. Mailed copies must be postmarked no later than January 18, 2008. Mailed copies should be sent to: VFRGP Manager, Virginia Sea Grant Program, Virginia Institute of Marine Science, P.O. Box 1346 Gloucester Point, Virginia 23062.

For further information, contact Tom Murray 804-684-7190, or visit the Web site at *www.vims.edu/adv/frg/index.html.*

Chefs' Seafood Symposium Attracts Crowd

The 16th annual Chefs' Seafood Symposium attracted over 140 members of the Virginia culinary community to the Virginia Institute of Marine Science on October 16, 2007. Participants included professional chefs as well as 70 students and instructors from five high schools and culinary colleges. The event was co-sponsored by Virginia Sea Grant and the Virginia Chefs Association.

The program combined presentations by VIMS scientists on current seafood topics, including sea scallops, shrimp aquaculture and the Virginia native whelk fishery.

ABOVE: Chefs Goodier and Parziale share a moment during the Seafood Cooking Challenge.

The keynote presentation was provided by Chef Frits Huntjens, owner and executive chef of 1 North Belmont Restaurant in Richmond, Virginia. Chef Huntjens demonstrated flatfish fillet techniques followed by a classic preparation of Dover sole. The program culminated in the popular "Seafood Cooking Challenge," an informal competition between VCA officers Chef Winslow Goodier and Reynolds Parziale.

This educational event for culinary professionals is certified by the American Culinary Federation.

VIMS To Host 10th Annual Art Show and Auction

The Virginia Institute of Marine Science will present its 10th annual art show and auction — *Scenes from the Seas* — featuring renowned wildlife artist Dr. Guy Harvey. Dr. Harvey is a unique blend of scientist, conservationist, explorer, diver, angler and artist. He has been a friend and contributor to VIMS for many years.

The two day event begins on Friday April 25th at 6:30 p.m. in Chesapeake Bay Hall on the VIMS campus. There will be an art show, book signing and autograph session with Dr. Harvey. Light hors d'oeuvres and a cash bar will be available. At 7:30 p.m., Dr. Harvey will narrate his dramatic billfish films in McHugh Auditorium in Watermen's Hall.

On Saturday, ticketed guests are invited to a dinner and silent auction featuring a selection of items from regional artists and crasftsmen. In addition, there will be a live auction of a Guy Harvey oil painting. A limited number of tickets to Saturday evening's event are available for $100 per person. Proceeds from the event support the research of VIMS graduate students.

More information about the event can be found on the VIMS Web site at *www.vims.edu.*

Virginia Schools to Compete in the 11th Annual Blue Crab Bowl Competition

Sixteen schools from across Virginia are slated to participate in the 11th Annual Blue Crab Bowl on February 23, 2008. This academic quiz-bowl competition promotes ocean literacy and allows students to demonstrate their mastery of marine science topics. As the Virginia regional competition of the National Ocean Sciences Bowl (NOSB®), the Blue Crab Bowl is administered and co-hosted by the Old Dominion University (ODU) and the Virginia Institute of Marine Science. VIMS' Virginia Sea Grant Marine Advisory Program has played a key role in the Blue Crab Bowl from its inception in 1998, providing key staffing and funding for the annual event. Officials for the competition are drawn from the faculty, staff and graduate students of both VIMS and ODU, as well as their colleague agencies.

At this year's contest, approximately 80 high school students and their 16 teacher-coaches will assemble at Old Dominion University. In a high-energy atmosphere, teams face off to answer multiple-choice, short-answer, and long- answer analytical questions drawn from scientific and technical ocean science disciplines. The winning Blue Crab Bowl team advances to the National finals in April where they will face the top teams from 24 other regions in Seward, Alaska.

The Blue Crab Bowl is a great VIMS and Virginia Sea Grant tradition that inspires the next generation of marine scientists. The success of the Bowl depends on the expertise and enthusiasm of more than 60 volunteers. For more information about the Blue Crab Bowl – including how to participate as a volunteer – contact Carol Hopper Brill at *chopper@vims.edu* or visit the bowl website at *www.vims.edu/bcb.*

ABOVE: Participants in the 2007 Blue Crab Bowl collaborate to answer a team challenge question.

Virginia Aquaculture Conference

The Virginia Aquaculture Conference attracted over 150 individuals interested in commercial aquaculture to Williamsburg, November 16 and 17, 2007. Sponsored by the Virginia Sea Grant Program, Virginia Department of Agriculture and Consumer Services, Virginia Farm Bureau, Virginia Aquaculture Association, along with the Virginia Institute of Marine Science/College of William and Mary, Virginia Polytechnic Institute and State University (Virginia Tech) and Virginia State University, the conference provided an opportunity to learn about current and upcoming issues, new developments in culture technology, and interact with others with similar interests.

FROM LEFT: *Dr. John Wells, Dean & Director of VIMS, Secretary Robert Bloxom, Dr. Alma Hobbs, Dean of the School of Agriculture and Forestry at Virginia State University, Petersburg and Mike Oesterling of Virginia Sea Grant enjoy the aquaculture products featured during the conference banquet.*

Over the day and a half conference, attendees heard from industry leaders, regulatory personnel and scientists, on both freshwater and saltwater aquaculture topics. Two keynote presentations set the tone for other sessions. The first keynote by Dr. Gary Jensen, USDA-CSREES provided an overview of developmental issues facing the U.S. aquaculture industry. Mr. Dick Jones from the H.E. Butt Grocery Company of Texas, offered insight into how seafood fits into the retail food sector. Updates were provided on culture activities of various freshwater species, with information on basic production techniques. On the saltwater side, special sessions on spat-on-shell oyster culture and presentations on shellfish regulatory changes, insurance issues and best management practices rounded out the conference.

A highlight of the conference was the Gala Aquaculture Reception where Virginia Secretary of Agriculture and Forestry, Robert Bloxom, along with Commissioner Todd P. Haymore of the Virginia Department of Agriculture and Consumer Services welcomed attendees to the conference. The reception featured all Virginia-cultured seafood products including, hard clams, oysters, tilapia, mountain trout, hybrid striped bass, cobia, catfish, and freshwater prawns.

VIRGINIA CLEAN MARINA

New Web site Launched

Virginia Clean Marina Program, managed by Virginia Sea Grant at the Virginia Institute of Marine Science, has launched an all new Web site. The improved site features facts on the program as well as links to numerous regulatory sites and current news targeted to marina operators. A frequently asked questions page will encourage users to submit questions which will be answered weekly on the site.

Downloadable forms make it easy to find information on how to become a clean marina or clean boater. Clean marina and clean boater are voluntary programs promoting the wise and sustainable use of our public waterways. The new site also includes links to the state's certified clean marinas, making it easy for boaters to locate participating facilities.

The goal is for the Web site to become a one-stop shop for marina owners providing information to help them run their business. Visit the new site at *www.virginiacleanmarina.com*.

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