

*Virginia*  
MARINE RESOURCE  
**BULLETIN**

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Virginia Sea Grant College Program – Virginia Institute of Marine Science – College of William and Mary

Virginia  
MARINE RESOURCE  
BULLETIN

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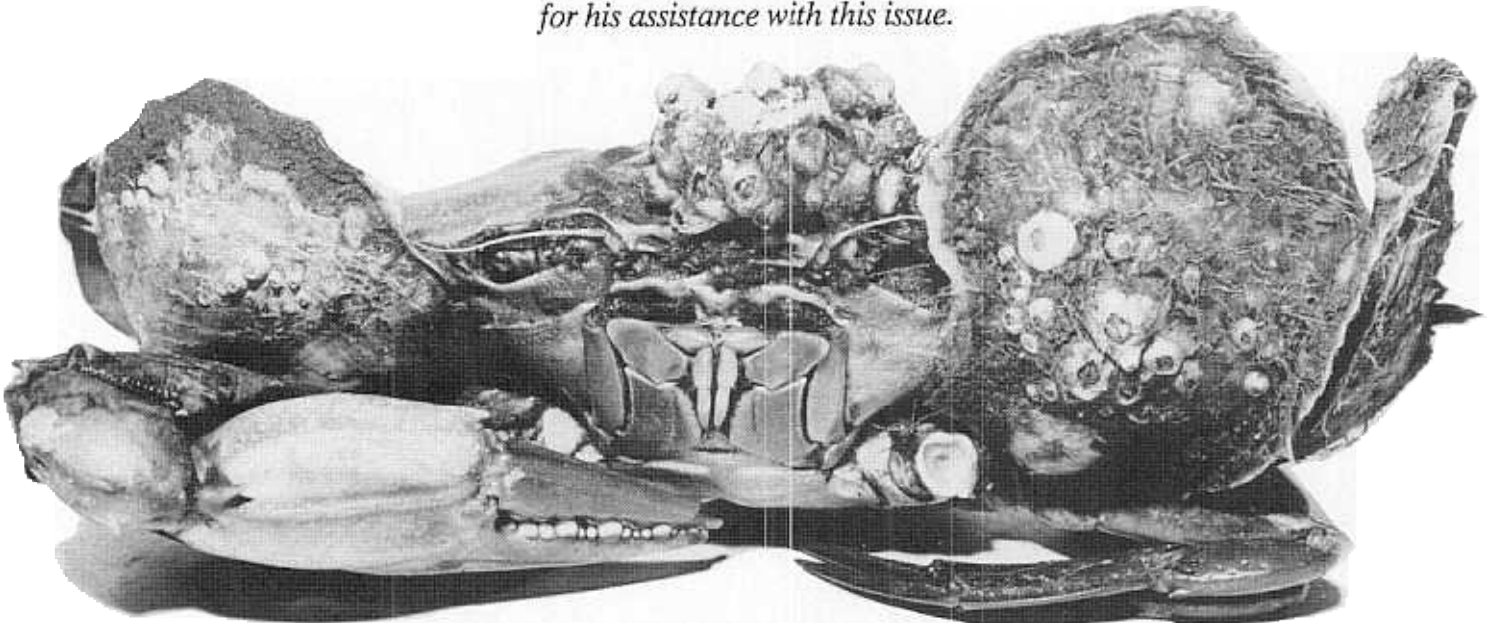
*Sea Grant is a partnership of university, government and industry focusing on marine research, education and advisory service. Nationally, Sea Grant began in 1966 with passage of the Sea Grant Program and College Act.*

**I**n this issue we examine some of the oyster and crab research undertaken at three of Virginia's Sea Grant colleges. Many other research projects are on-going at these and other agencies and institutions in the state. The research described in this issue is representative of the work being performed world-wide related to the many species of crabs and oysters.

The blue crab appears to be one of the hardiest and most abundant animals in the Bay and its tributaries; it must remain so. The oyster has fallen on hard times, primarily due to several diseases which have been particularly virulent during the past few summers. These diseases are not harmful to humans, but do great damage to oyster populations. Oyster diseases, probably spread by man's introduction of oysters from one region to another, are appearing everywhere in the world that the many varieties of oysters grow.

It seems ironic that just as people are discovering the nutritional benefits of seafood and as transportation systems enable the shipment of fresh seafood around the world, much of the world's supply of seafood is in decreasing supply. Sea Grant's commitment to the seafood industry and the dedication of citizens and governments to the Chesapeake Bay will help preserve the resources and the industries. Citizens have the opportunity to comment on finfish and shellfish stock assessments as part of the Chesapeake Bay Agreement. See page 15.

*Special thanks to Rom Lipcius  
for his assistance with this issue.*



# What do you feed a growing crab?

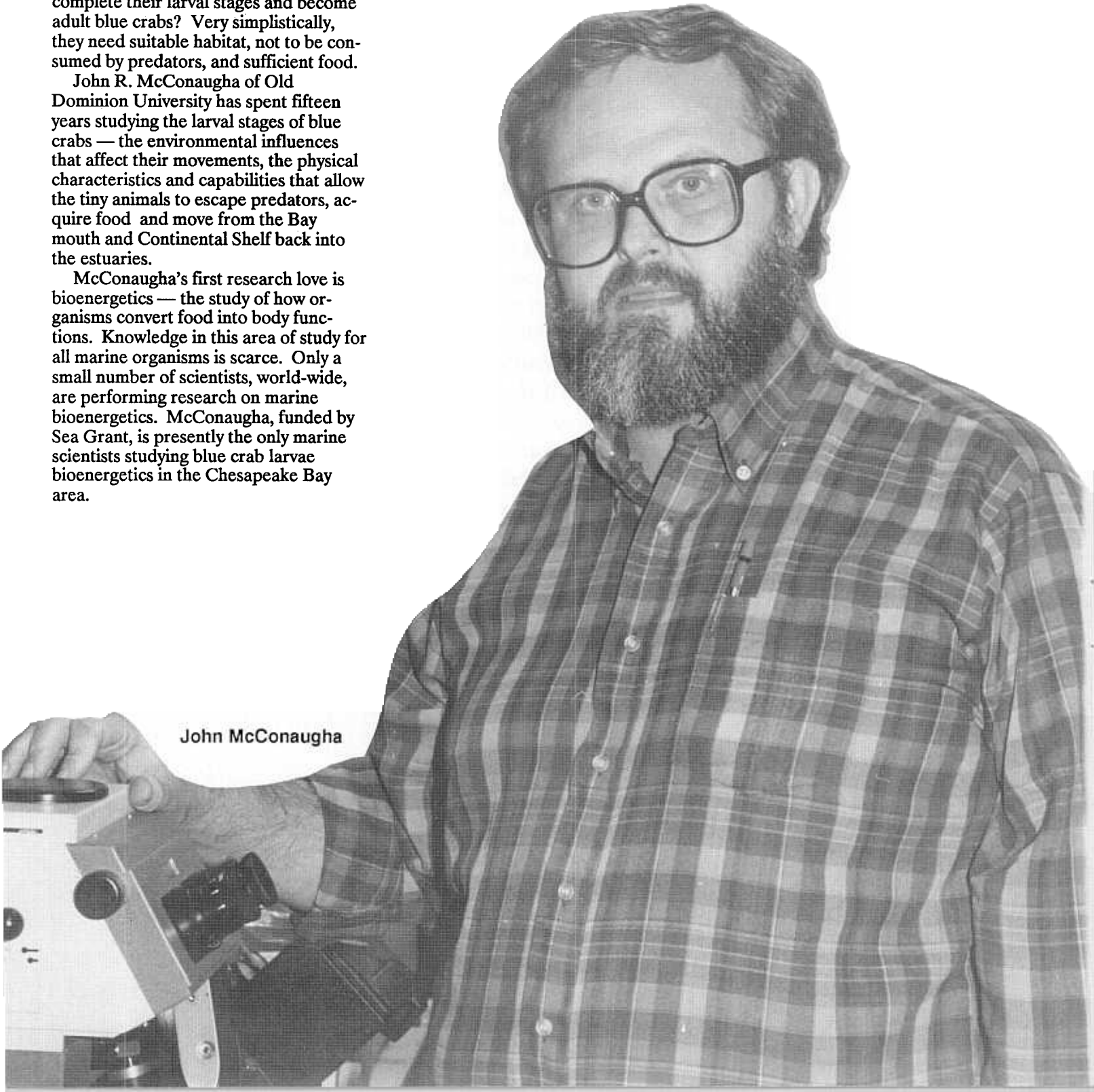
(ODU's John McConaugha has spent 15 years finding out)

**W**hat do blue crabs require to hatch, complete their larval stages and become adult blue crabs? Very simplistically, they need suitable habitat, not to be consumed by predators, and sufficient food.

John R. McConaugha of Old Dominion University has spent fifteen years studying the larval stages of blue crabs — the environmental influences that affect their movements, the physical characteristics and capabilities that allow the tiny animals to escape predators, acquire food and move from the Bay mouth and Continental Shelf back into the estuaries.

McConaugha's first research love is bioenergetics — the study of how organisms convert food into body functions. Knowledge in this area of study for all marine organisms is scarce. Only a small number of scientists, world-wide, are performing research on marine bioenergetics. McConaugha, funded by Sea Grant, is presently the only marine scientist studying blue crab larvae bioenergetics in the Chesapeake Bay area.

John McConaugha



Without this fundamental biological information, it will be impossible to attempt resource management of the blue crab fishery. "Previous studies," McConaugha states, "indicate that management of a fishery under the assumption that replenishment of harvested stocks is unrelated to biological variables, when biological aspects do affect recruitment, can result in the decline or extinction of the population." He becomes very concerned about management decisions that are not based on a thorough understanding of the basic biological systems that affect animals.

Knowledge that is available, indicates that the blue crab larvae use energy from food first for respiration, then for molting, and finally for growth. From his own research and that of others, it is known that many decapod larvae require long chain polyunsaturated fatty acids (called PUFA) in order to complete development through metamorphosis.

Because the larvae can only move vertically in the water column, they must acquire their energy needs from the food around them. The more dense the plankton (single-celled plants and animals), the faster they go through the stages from zoea to megalopae to juvenile. In his laboratory at ODU, McConaugha and assistant Jim Pletl have raised thousands of blue crab larvae. They have learned that inadequate nutrition, particularly lack of PUFA at critical times, can extend the larval stage by several weeks. Since the larvae are relatively helpless, the longer they remain in this stage, the more susceptible they are to predators.

And yet, a large number of blue crab larvae move from the nutrient rich Bay mouth to the nutrient-poor continental shelf. Why?

McConaugha states that, "Other research suggests that estuarine species that have retained a long larval phase and export larvae to the shelf with subsequent return to the rivers, do so for biological benefits." One suggestion is that they move offshore to avoid predators. Perhaps the crabs move offshore, which slows down metamorphosis, but reduces predation. As of yet, no one knows the answer.

To study the energetics of the larvae, the ODU researchers perform complicated and time-consuming series of measurements. The larvae, fed different foods, are measured at different stages in their development. Samples are freeze-dried and ground, then the amount of carbon, nitrogen and total number of calories are measured. Oxygen uptake, an indicator of metabolic rate, is

measured by placing a number of larvae in a tiny respirator chamber for several hours. Even the energy of excretion, exuvia and food organisms must be measured. To do this, they are collected, rinsed with distilled water and measured for caloric content and nitrogen.

Nutrients are composed of proteins, carbohydrates and lipids, the basic organic components of living cells. The polyunsaturated fatty acids described earlier, are a type of lipid, and some research indicates that PUFAs in the blue crab are both an energy source and a trigger which starts the metamorphic process.

McConaugha hopes to determine the minimum concentration of food necessary for survival and the optimal amount needed for successful respiration, growth and metamorphosis. By comparing the success or failure of laboratory specimens with larvae collected from the field, he hopes to develop an index which will assess the success of field-collected larvae.

Although not part of these experiments, the biologist would also like to do field experiments to collect the phyto- and zooplankton that the larvae feed on

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*ODU research of the blue crab's larval stages may help answer many blue crab questions.*

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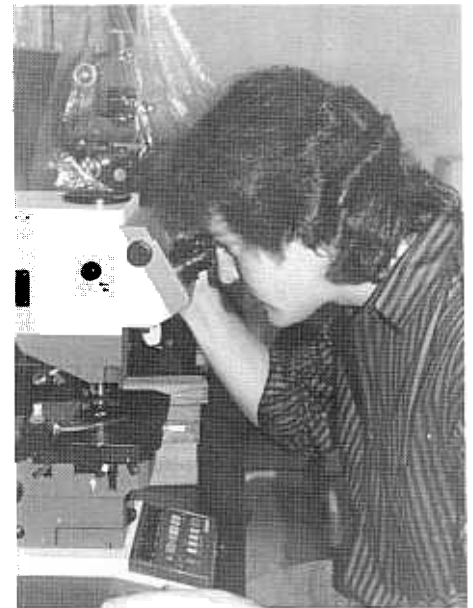
to see exactly what the larvae eat; its size, range and distribution. This would further his increasing knowledge of the developmental energetics of the blue crab.

Jim Pletl, his assistant and a PhD candidate at ODU, plans to make a career of bioenergetics. He is fascinated with the question of why some larvae move to the Shelf and would like to help develop an eventual overall life history of the blue crab.

Both McConaugha and Pletl are also interested in the other species of crabs that live in Virginia waters. Crabs were originally all ocean dwellers; many, such as the rock crab (*Cancer irroratus*), still are. Other species, such as the mud crab (*Rhithropanopeus harrisi*) live in estuaries and have a short larval period; 17 days compared with 35-40 days for the blue crab.

"The blue crab is particularly interesting," says McConaugha, "because it is both an ocean and an estuarine dweller; hatching its eggs in the ocean and then returning to the estuary in the late megalopae stage."

How do the scientists grow the larvae for all their experiments? Pletl explains,



**PhD candidate, Jim Pletl examines some of the thousands of blue crab larvae raised by ODU.**

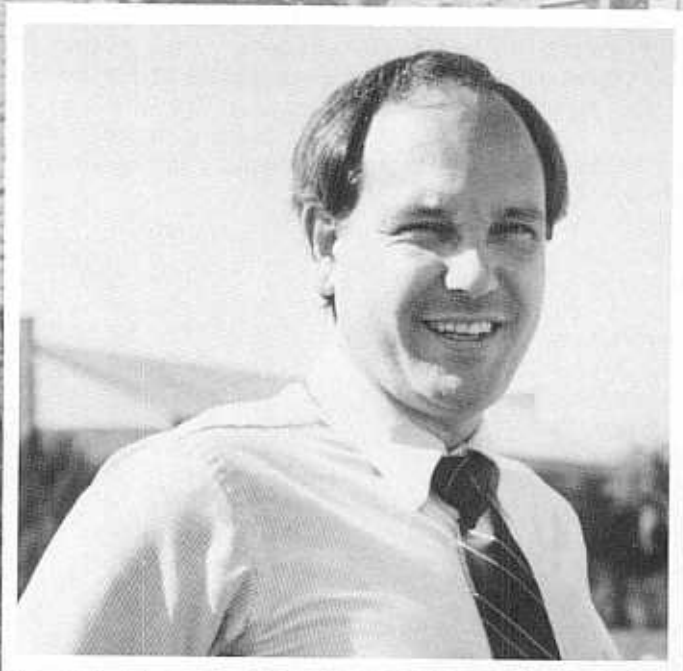
"We remove the black sponge (fertilized eggs ready to hatch), from the female and put them in water on a shaker table. The motion helps aerate the water and by morning the eggs have hatched. The larvae are then collected with pipettes (slender glass tubes) and put in one liter of sea water in an eight inch culture dish with food." Depending on the nutrients the scientists feed the larvae, they may go through the larval stage in four weeks, or take as long as nine weeks.

Scientific research is always a process of fitting one puzzle piece into another. Sometimes a lifetime of work results in a very small puzzle piece. In the case of McConaugha however, the research fills a very large space in the understanding of the most popularly harvested species in Virginia. In addition, the ODU work is essential to resource management.

# Tech Seafood Research for Consumers and Industry

North Americans eat about 1400 pounds of food per person, per year; spending approximately \$485 billion. About 15 percent of their disposable income is used for food (10.8 percent at home and 4.3 percent away from home in 1984). In 1985, food and related products processing was the third leading major industry in employment in Virginia. Nation-wide, the food industry is the largest both in number of individuals employed and in income generated. The industry is growing; so is consumption of seafood.

If these facts and figures lead you to believe that Virginia may be in an ideal position to meet the needs of a growing consumer market; you're right. Virginia is already a national leader in seafood processing which generates approximate-



Cameron Hackney, Superintendent of the Seafood Lab at Hampton helps VPI keep ahead of consumer trends in seafood.

ly \$400 million to the local economy; and Virginia is one of the largest processors of oysters and crabs.

One of Virginia's most important assets in increasing its capability in seafood processing is the Virginia Polytechnic Institute and State University (VPI); Virginia's largest university and home of one of the nation's leading food science and technology programs.

According to Merle Pierson, Head of the VPI Food Science and Technology Department, "Food science and technology is the application of science and technology to the processing, preservation, packaging, distribution and utilization of foods and food products." Food research requires expertise in biochemistry, chemistry, microbiology, physics, engineering and other sciences. Food scientists use this knowledge for the development of new products, processes, equipment and packages; to the selection of proper raw products and ingredients; and to the direction of plant operations so that foods high in nutritive value and quality are economically produced.

In addition to the major research laboratories and facilities on campus in Blacksburg, for 13 years VPI has conducted part of their seafood research at an outreach station in Hampton. The station, situated on the water, is located in the very heart of Virginia seafood harvesting and processing. Over the years, VPI scientists have developed pasteurization techniques for seafood to improve the quality and shelf-life for extended geographical marketing. Researchers have designed product containers and developed computer programs for processing plant operations to help improve market position and efficiency. Scientists are frequently called upon by state or federal government agencies to examine processing methods for product safety standards. Much of their research is funded by private industry to solve specific problems or to design improvements.

A little over two years ago, Cameron Hackney became Superintendent of the Seafood Lab at Hampton. Since his arrival, much of his research has been concerned with oysters. "There's no particular reason for the concentration on oysters," he says, "there just happened to be work that needed doing."

Recently, grants from the National Fisheries Institute have enabled him to study drain weight in oysters. When oysters are processed at packing plants, a variety of methods may be used. All oysters are washed first, but they may be cleaned just with water, or with a combination of air and water called "blow-

ing". Once the oysters are drained, they are packed in jars for distribution. Legally, no additional liquid may be added to the jars; a requirement called "dry-packing."

As the oysters settle in the containers, liquid is slowly released from their bodies — the characteristic oyster "liquor". Over the years, the U S Food and Drug Administration has tried to establish a percentage of liquid to oysters allowable in oyster packing in order to discourage packers from adding liquid. However, those standards were challenged as unacceptable to industry due to the variance in drain weight in oysters.

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### Despite its salty taste, most seafood is low in salt content.

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Two years ago, Hackney and other scientists from East and Gulf Coast oyster producing states began examining differences in the rate and amount of oyster liquid naturally given up by the oysters in packing. In Virginia, Hackney examined both blown and non-blown, dry-packed oysters from initial packing until a maximum of eighteen days after packing. In the fall of last year, David Cook of the Gulf Coast Research Laboratory presented the combined results to the National Shellfish Institute.

"What we learned," Hackney said, "is that a 15 percent standard is probably something we can all live with." Although blown and non-blown oysters give up liquid at different rates initially, within a few days the amounts are equal. "The real differences are in the original harvest location and the season and the length of time on the shelf." One of the major harvesting areas in Florida, for example, will have problems meeting the 15 percent standard because their oysters

naturally give up more liquid. Virginia oysters harvested from the ocean coast in summer may occasionally give up more liquid. Maryland oysters will generally meet the standard at all times.

Much of the work performed by VPI is intended to evaluate and stay ahead of consumer trends. Recent concern about salt content in food products have led to research on oyster and other seafood salt levels. Restaurants and markets which handle raw oysters know that customers prefer the saltier tasting oysters; but many people are concerned about the amount of salt. The good news is that despite its salty taste, most seafood is low in salt content; for blown oysters about 0.2 percent.

Dr. Hackney has developed a fast, inexpensive method for determining salt content of oysters which can be used at the processing plant. Past methods were expensive, time-consuming and required sending samples to a laboratory for analysis. In addition, he continues to examine other elements of nutritional importance such as zinc, potassium, magnesium, iron, chromium and nickel in seafood. More stringent packaging laws are in effect this year for seafood, and Hackney believes nutritional information similar to that printed on other processed food may eventually be required for processed seafood.

Recently the laboratory at Hampton was expanded so that all of the researchers at the facility will have sufficient room and equipment for their work. The importance of the food industry over-all, and the growth of seafood processing in particular, will keep the food scientists busy for a long time to come.

## NOTICE

### *High Salaries, Many Openings*

#### PLEASE APPLY!!!

There is a steady demand for food scientists and technicians; beginning salaries range from \$19,000 to \$30,000. "High school and college students, however, seem unaware of the opportunities or even that the field of study exists," says Merle Pierson, Head of the Food Science and Technology Department at VPI.

Career opportunities will continue to improve well into the future and junior and community colleges offer associate programs which enable young people to enter the field. Anyone interested in information about food science and technology and/or the programs at VPI should contact Dr. Pierson at The Department of Food Science and Technology; VPI; Blacksburg, VA 24061.

# Larval blue crabs . . .

. . . finding the right habitat by chance or by choice?

Nancy J. Chartier

One of the most valuable inhabitants of the Chesapeake Bay is the blue crab, *Callinectes sapidus*. Hard-shelled or soft, it is a popular and important component of Virginia's seafood industry. Its value insures that it is the focus of many scientific research programs. Relatively few studies, however, have centered on the larval, post-larval, and early juvenile stages of the blue crab's life cycle. The cycle begins as eggs of the blue crab hatch into shrimplike larvae (zoea), which are microscopic free-floating animals or zooplankton. This occurs at the mouth of the Chesapeake Bay. In the shelf waters off the coast, the zoea develop into post-larvae (megalopae) which are also predominantly planktonic. Megalopae are more crablike in shape, but with their abdomens still extended, rather than folded underneath the body like those of adult crabs. It is generally believed that blue crabs return to Chesapeake Bay waters in this form.

When a megalopa metamorphoses (changes its physical form), it becomes a first stage juvenile crab (shell width < 2.00 mm). Studies on these early phases of the blue crab are essential for providing important information on patterns of settlement and recruitment (becoming part of the Chesapeake Bay blue crab population), behavior, and survival, all of which may lead to a better understanding of changes in the populations of blue crabs.

At the Virginia Institute of Marine Science, biologists Robert J. Orth and Jacques van Montfrans are collaborators on a longterm research project involving the megalopae and early juveniles of blue crabs. "There has been a renewed interest in larval ecology," Orth states. "Our study is geared to examining the relative value of different Chesapeake Bay habitats as settlement sites for megalopae and areas for the growth and

survival of early juvenile blue crabs, once they have entered the Bay." The project, funded by Sea Grant, began in 1985 and has several phases, each trying to address a particular question. Seasonal and annual juvenile blue crab abundances have been estimated from samples collected

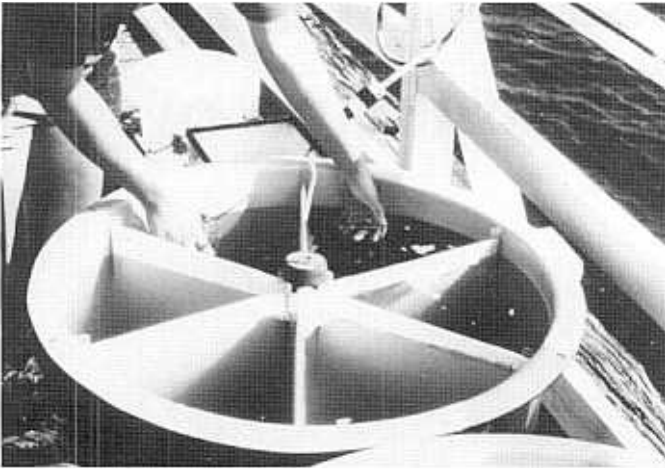
over a period of four years in an intensive sampling program. These samples were taken from a seagrass bed and nearby tidal marsh creek in the lower Chesapeake Bay (Little Monday Creek), using a cylindrical drop net and suction pump. Experimental comparisons show that this



P. Sadler, W. Tease

**Blue crab megalopae are moved from the Bay mouth up the estuaries where, scientists now believe, they may actively search for suitable habitat where they complete the metamorphosis to juvenile crabs.**





Six different substrates, including live eelgrass, oyster shell, and marsh mud, were placed in different sections of this container.

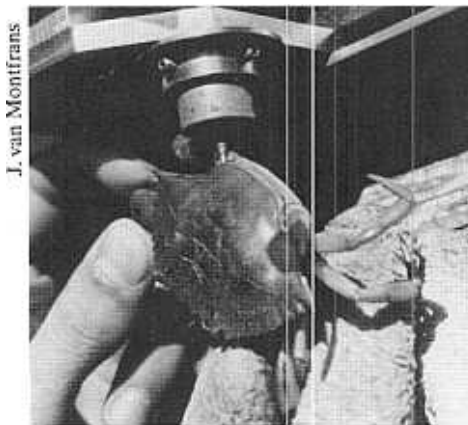
sampling gear is 88% efficient, collecting densities of early stage juvenile blue crabs at least an order of magnitude higher than those collected by conventional trawl gear. In fact, in the initial stages of the sampling program, these unusually high densities were considered "anomalies." When comparisons were made between the densities of megalopae and early juveniles in the seagrass bed and the marsh creek, they found that the concentrations in the seagrass bed were much higher.

With that in mind, van Montfrans and Orth began exploring questions of settlement patterns and habitat selection by megalopae and early juvenile blue crabs. "Megalopae are thigmotactic — they cling to things," explains van Montfrans. Together with Rom Lipcius (also at VIMS), he has been studying more closely the molting pattern of the megalopa. "Complete metamorphosis generally takes several days, depending on environmental conditions such as salinity and food availability." Van Montfrans and Orth observed settlement patterns of megalopae on sets of air conditioning filters sampled daily and found that the greatest deposition of megalopae occurred during a full moon, less so during a new moon, and negligibly at any other time. They also studied settling patterns in marsh creeks, and beds of submerged aquatic vegetation (SAV) or seagrasses. The densities of early juvenile crabs were found to be highest in seagrass beds, indicating the possibilities of habitat preference and selection.

The researchers plan to examine several potential explanations for the differences found in the densities of megalopae and early juvenile crabs between the shallow water habitats. One hypothesis suggests "swarms" of megalopae encountering an eelgrass bed may settle out passively with sediment particles and other debris, influenced by the baffling of the water around the

seagrasses. Another explanation involves differential predation. An eelgrass bed may provide better refuge from predators than a tidal marsh creek, the difference evident in the numbers found. A third possibility is that the megalopae actively select the seagrass beds. Orth and van Montfrans have been researching this latter option in more detail, setting up a laboratory experiment to observe the responses of megalopae to six different substrates. The substrates used were living eelgrass (*Zostera marina*), artificial eelgrass, live oysters, sunbleached oyster shells, bare sand, and marsh mud. Preliminary analysis indicates that, given an opportunity to choose a substrate, the megalopae preferred the living eelgrass.

Using first stage juvenile crabs which metamorphosed from megalopae in the laboratory, van Montfrans and Orth found that these crabs preferred marsh muds and live oysters, demonstrating a possible change in habitat choice as they proceed from one life stage to another. A field experiment on habitat selection



A magnetized tag is injected into the backfin muscle of a blue crab. These tags stay with the crabs for longer periods of time than conventional tags and are easily detected with a magnet.

involved placing plugs of eelgrass, oysters, and marsh mud into a bare sandflat and collecting the newly settled megalopae and first stage crabs from these substrates the following day. The number of megalopae and first stage juveniles were counted and the highest densities of both were found in the eelgrass plugs. "The supposition is that the first stage juveniles found in the eelgrass were megalopae that came in and metamorphosed overnight," says van Montfrans. "The field experiment indicated that active substrate selection by megalopae was not only displayed under laboratory conditions but also occurred under natural conditions."

To determine the role of chemical stimuli in blue crab orientation to a particular habitat, a laboratory experiment was conducted using "chemically conditioned" water samples of living eelgrass, oysters, salt marsh grass, and unconditioned York River water. The water samples were "conditioned" by soaking the substrates in York River water for a minimum of 24 hours. Megalopae were then placed in a central chamber to which four peripheral chambers were connected, each of which received a single filtered water source at the same flow rate. The central chamber contained the "whole soup" of chemical stimuli, while each of the four peripheral chambers contained a single substrate stimulus. The orientation patterns of the megalopae were observed and quantified after four hours. "We felt that there were three possible outcomes to this experiment - confinement to the central chamber would indicate no orientation at all, random distribution among the peripheral chambers would imply influence by current flow, and a concentration in one chamber would indicate orientation to a chemical stimulus. Our preliminary interpretations are that the megalopae closest to metamorphosis may show a preference for eelgrass. There were no significant trends evident among those megalopae that weren't so close to molting," says van Montfrans.

Orth and van Montfrans are innovators in blue crab tagging studies using magnetized microwire tags that are injected into the base of the backfin muscle of the crabs. A laboratory tagging study lasting 51 days showed that the crabs retained their tags through as many as two molts. These injected tags stay with the animals much longer than the conventional external tags. A field tagging study also provided evidence that blue crabs stay within a tidal marsh creek

*continued on page 19*

# Searching for a disease resistant oyster

*A cooperative New Jersey-Virginia  
Sea Grant research project*

**Eugene Burreson  
Marine Scientist**

**M**SX, the common name for *Haplosporidium nelsoni*, is a well-documented oyster pathogen that crippled the oyster industry of the middle Atlantic coast during 1957-1960 by killing 85-90% of the oysters growing in high salinity waters of Delaware and Chesapeake Bays. High mortality from the parasite continues to discourage planting on traditional, private leased grounds in the lower James River and Mobjack Bay and the Virginia oyster harvest remains low. Recent newspaper articles report that only about 15% of the oysters processed in Virginia are actually harvested in Virginia. In addition, presentations at the annual shellfish mortality workshop held recently in Oxford, Maryland, indicate that MSX has caused high mortality in oysters in Connecticut and along the southern shore of Cape Cod, Massachusetts, that 1986 and 1987 were the worst MSX years on record in Delaware Bay and Chesapeake Bay, and that MSX has recently been found in oysters in Georgia. Obviously, the range of the parasite is increasing and its ability to kill is not decreasing.

In my opinion, one of the potential solutions to the MSX problem is the development of resistant oysters — either by inducing acquired resistance or by selective breeding for genetic resistance. Although it is uncertain whether oysters are capable of acquiring resistance to a disease agent through prior exposure, the Sea Grant program provides funding to Dr. Fu-Lin Chu of VIMS to assess acquired resistance in oysters to *Perkinsus marinus*, a pathogen in which infective stages have been identified and can be produced routinely in the laboratory.

Funding from Sea Grant provided during 1984-86 to elucidate the life cycle of MSX was also related, in part, to acquired immunity. When the life cycle is known and the infective stage identified, it will be possible to challenge oysters to MSX under controlled conditions in the

laboratory to investigate acquired immunity. The research is in cooperation with Susan Ford and is continuing through a grant to Rutgers University by the New Jersey Sea Grant Program.

Much research has also been conducted on selection for genetic resistance. Drs. Harold Haskin and Ford, working in Delaware Bay, have developed laboratory-reared MSX-resistant strains by exposing progeny to a 33 month testing period through 5 generations. Fifth generation resistant oysters had a survival rate, after 33 months, of about 72%, compared with 7% for James River MSX-susceptible oysters. Delaware Bay native oysters selected naturally for resistance during the MSX invasion had a survival rate of about 20% after 3 years.

Unlike Delaware Bay where brood oysters were exposed to MSX and thus selected naturally for resistance, large stocks of unselected brood oysters survive in the low salinity regions of the James River according to J.D. Andrews of VIMS. These oysters are only exposed to MSX during years of extreme drought. Oysters surviving the 1960 MSX invasion in Mobjack Bay were bred at VIMS by Dr. Andrews. Survival of over 100 separate lots from various parents were monitored for 2 or 3 years. Results over 15 years indicate between 2 and 5 times greater survival in resistant strains than in James River seed oysters.

Sea Grant funded research on development of oysters resistant to *Perkinsus marinus* was conducted at VIMS between 1979 and 1981. Although evidence was obtained suggesting the development of resistant strains, the lack of a disease-free facility hindered interpretation of laboratory challenge experiments.

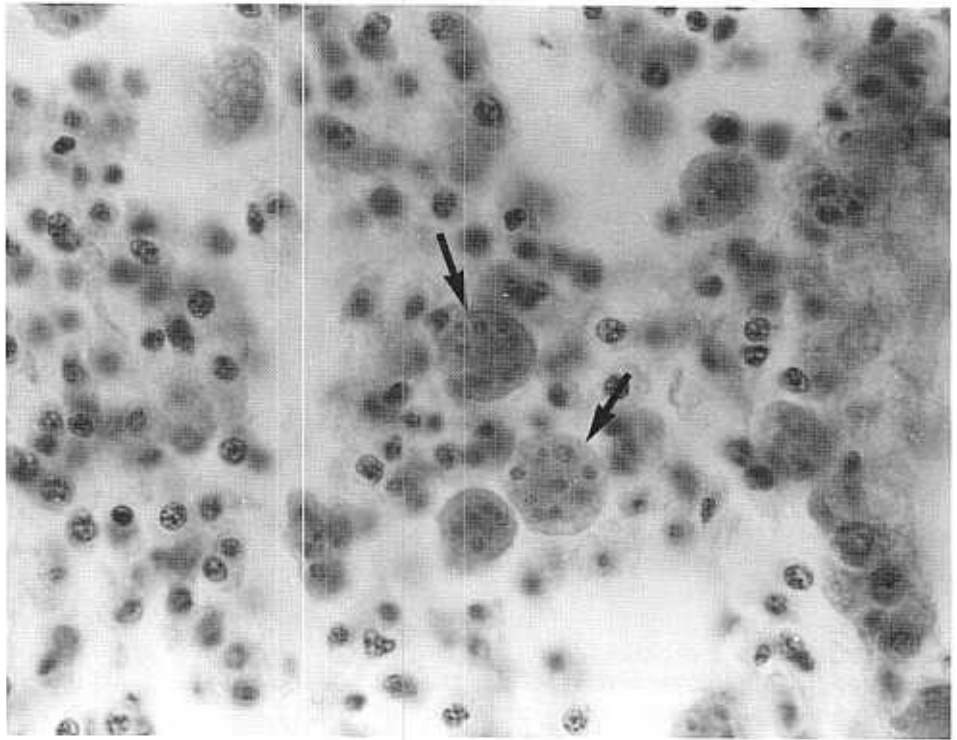
During 1984 and 1985 VIMS monitored 500 native oysters from Mobjack Bay for MSX-induced mortality. These oysters were provided by local watermen who had experienced very low

Eugene Burreson holds Mobjack Bay oysters which he hopes may be disease resistant.



C. Plummer

**Close-up of a killer. MSX,**  
*Haplosporidium nelsoni*.



mortality in Mobjack Bay, an MSX endemic area. These oysters have been naturally selected for MSX resistance since the 1960 episode and our studies showed less MSX prevalence and greater survival each year in these oysters than in James River seed oysters held in an adjacent tray. (See table 1 below)

These studies clearly demonstrate that genetic resistance to disease can be enhanced in laboratory-bred oysters and also that natural selection for MSX resistance has occurred in Delaware Bay and possibly Mobjack Bay in the Chesapeake.

The new VIMS oyster hatchery allows for large scale production of progeny from MSX-resistant brood oysters. The goal of the hatchery is to provide large numbers of eyed-larvae to oystermen who will remote-set them on shell. If the larvae are progeny of MSX-resistant brood stocks, then their subsequent susceptibility to the disease will be much lower than James River seed oysters. Therefore, it may become economically feasible to once again utilize the traditional private grounds in the lower James River and elsewhere for oyster production. This utilization has the potential to greatly increase the oyster harvest in Virginia, but it is important to realize that problems of smothering and predation of the spat will continue to be a problem. It is also important to realize that laboratory breeding of MSX-resistant oysters is not an attempt to influence the gene pool of brood oysters in the James River. The large number of unselected oysters in the upper James River insures that the natural set will always be highly susceptible to the disease.

The purpose of our latest research which began in January is to determine

the level of resistance and the growth rate of progeny from two groups of potentially MSX-resistant oysters compared to progeny from susceptible James River seed oysters. Harold Haskin and Susan Ford of Rutgers University have agreed to provide VIMS with oysters from their highly resistant strains, but it is necessary to demonstrate MSX-resistance and adequate growth in these oysters in Chesapeake Bay conditions. There is some evidence that progeny from Delaware Bay oysters do not grow as rapidly in Chesapeake Bay as progeny from native stock, according to Dr. Andrews. Oystermen will be reluctant to use progeny from potentially resistant oysters from either Delaware or Chesapeake Bay unless resistance and adequate growth have been recently demonstrated in VIMS hatchery-bred oysters.

The overall objectives of our latest research project is to determine the annual mortality for three years due to MSX disease in progeny from three groups of brood oysters — Delaware Bay resistant, Mobjack Bay resistant, and James Rivers susceptible — and to determine annual growth rate in each group. The three year period was chosen because experience has shown that after three years mortality of oysters in trays caused by *Perkinsus* (which is very slow to move through a population of oysters), becomes high and rapidly eliminates live oysters.

The VIMS oyster hatchery was developed to augment the natural set of larvae in the James River. If progeny of Delaware Bay resistant oysters grow well and demonstrate significantly MSX resistance, both based upon reduced mortality in comparison to James River non-resistant oysters, then full-scale hatchery production can begin incorporating MSX resistant brood stock. Production of MSX-resistant larvae should, based upon known resistance level in brood stock, make it economically feasible for oystermen to plant oysters on traditional grounds in MSX-endemic areas. These grounds have been out of production since 1960. Harvest from these areas would increase substantially the total dollar value of the oyster industry in Virginia by reducing or eliminating the need for processors to import oysters from other regions of the country.

**Table 1**

| Date    | Source      | No. Examined | No. MSX (%) | Monthly Mortality (%) |
|---------|-------------|--------------|-------------|-----------------------|
| Sept 84 | James River | 25           | 4 (16)      | 6                     |
| Sept 84 | Mobjack Bay | 21           | 0           | 1                     |
| Sept 85 | James River | 24           | 11 (40)     | 13                    |
| Sept 85 | Mobjack Bay | 25           | 3 (12)      | 7*                    |

\**Perkinsus* (Dermo) prevalence 28% and this parasite probably responsible for much of the mortality. *Perkinsus* prevalence 0 in James River seed.

# Blue Crab and A Habitat and

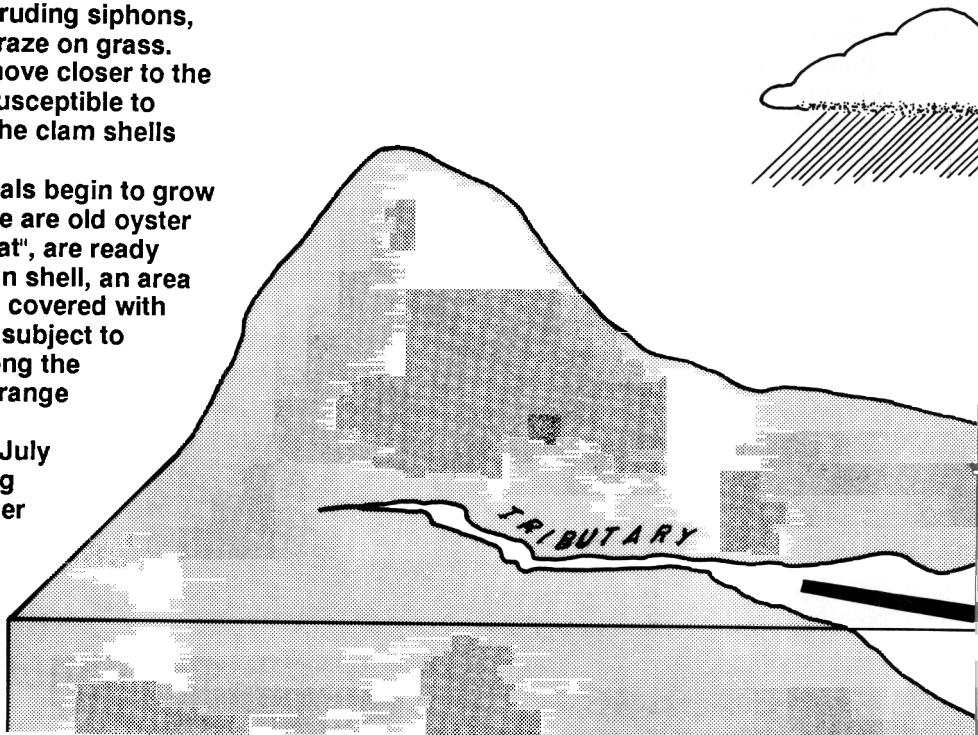
Activity in the Bay and its sub-estuaries and tributaries increases each spring as water temperature rises.

Winter dormant crabs begin to forage, as do fish returning to the Bay from the ocean. Bottom-dwelling animals such as clams are ready prey for the first arrivals. These molluscs are filter feeders which siphon food from water and sediments by tubes which stick up through the soft bottom. Fish such as spot, croaker and hogchoker graze the protruding siphons, nipping off the ends; much the way cattle graze on grass.

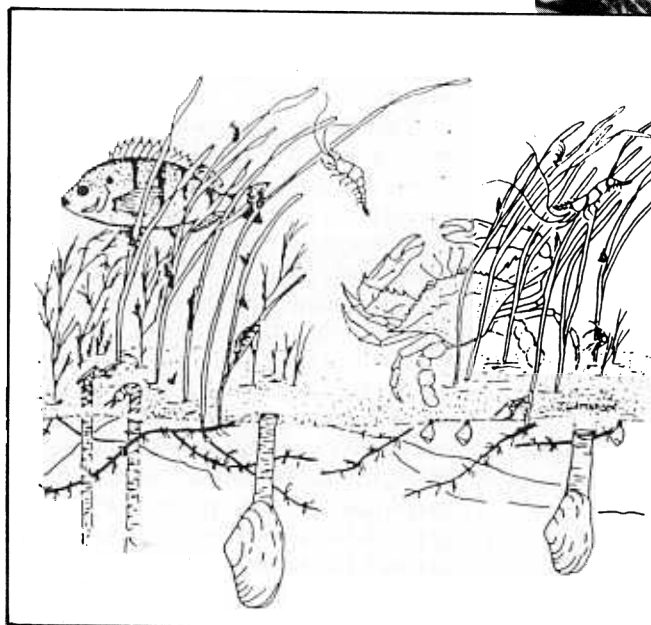
In order to continue feeding, the clams move closer to the surface of the bottom and, there, become susceptible to predation by crabs which are able to open the clam shells with their powerful claws.

As the water warms, tiny plants and animals begin to grow on any bottom surface; particularly desirable are old oyster shells. When the oyster's young, called "spat", are ready to settle, they must search for a spot of clean shell, an area not already inhabited by other organisms or covered with sand and mud. The young oysters are also subject to predation by crabs which not only feed among the oyster shells, but through their activity re-arrange the shells.

Once the water becomes warmest in late July and August, activity reaches its peak. Young animals are foraging in competition with older animals; plant and animal life is most abundant; and the flora and fauna are at their metabolic peak.



## SOFT SEDIMENT HABITAT

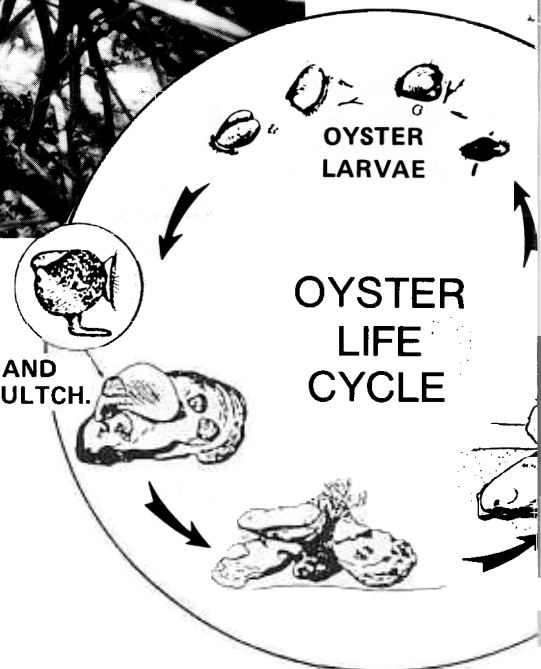


Eelgrass meadows provide habitat for crab megalopae, juvenile crabs and mating and molting adults. Bottom-dwelling fish and adult crabs prey on soft-shell clams and other infaunal organisms.



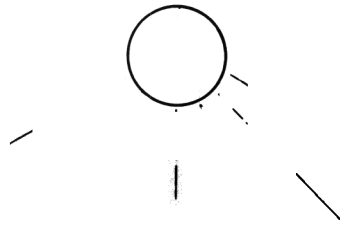
*Zostera marina*  
(Eelgrass)

SPAT SETTLE AND ATTACH TO CULTCH.



OYSTER  
LIFE  
CYCLE

# American Oyster Life Cycles

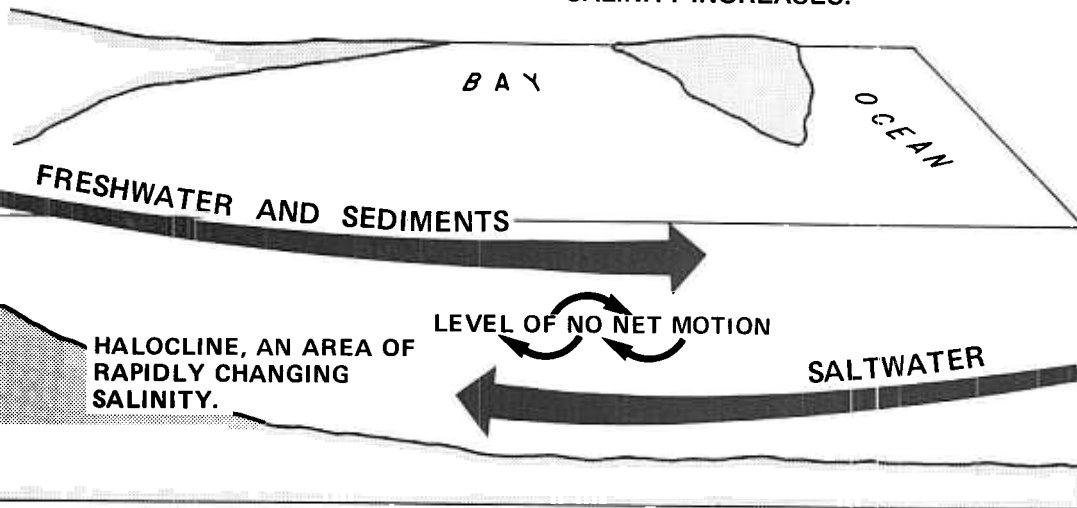


If spring rains have been light, or little freshwater runoff has diluted the oceans' saltier water, salinity increases and a variety of oyster diseases are spread throughout the system. Although these diseases have no adverse effects on humans, they can devastate the oyster population.

The interrelationships between physical factors such as sediment movement, currents, climatic events, chemical factors and the organisms must be understood and then factored with studies of the organisms and their relationships. Finally, scientists add the effects of man's activities on this already complex environment.

The complexities of this system are enormous. Life histories of many species are still not fully understood.

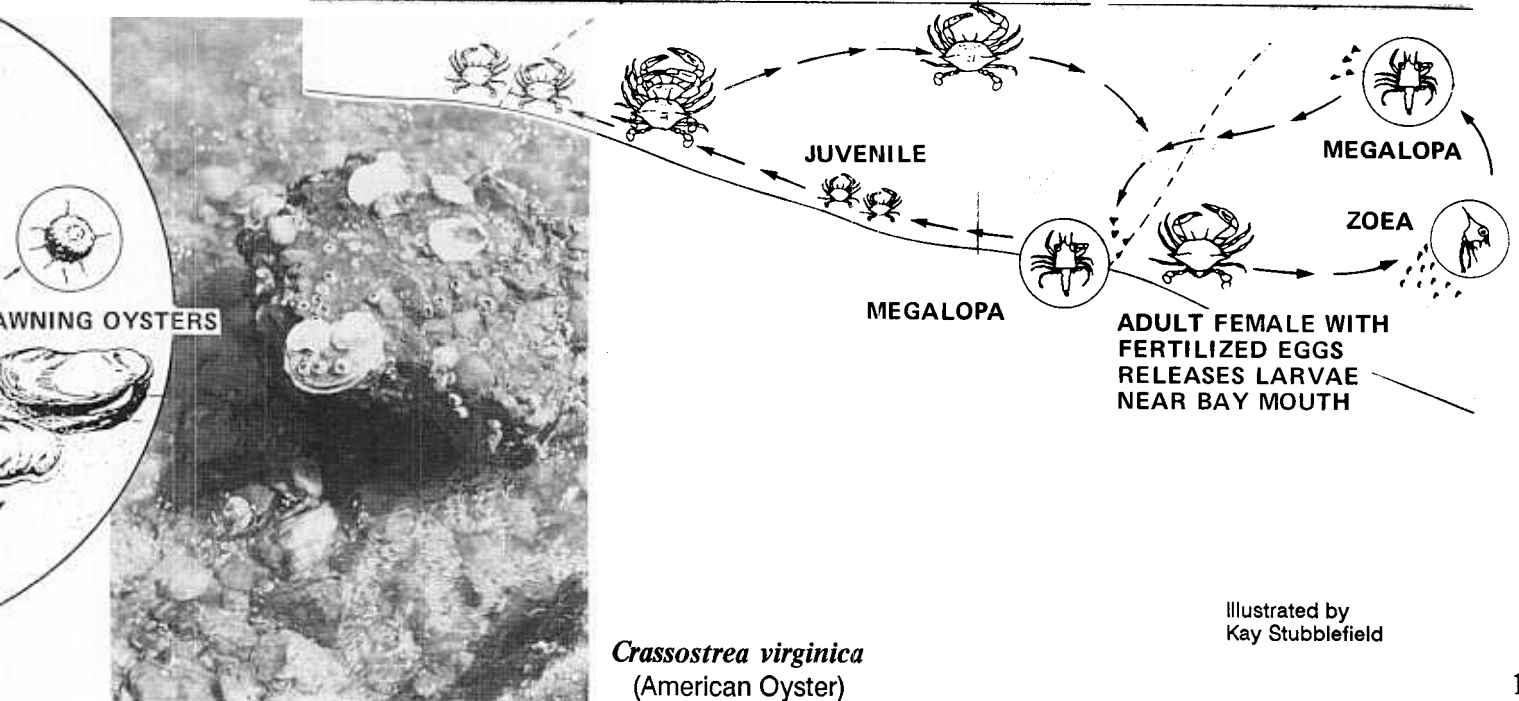
THE INCIDENCE OF MSX AND *Perkinsus* INCREASES AND SPREADS WHEN SALINITY INCREASES.



### Average water temperatures

|        |    |
|--------|----|
| April  | 55 |
| May    | 66 |
| June   | 74 |
| July   | 79 |
| August | 80 |

## BLUE CRAB LIFE CYCLE



*Crassostrea virginica*  
(American Oyster)

Illustrated by  
Kay Stubblefield

## Harvesting the Best

Wanda Cohen

*The Terry family of Willis Wharf has been harvesting Virginia oysters for 85 years.*

C. Plummer



Since 1903, when H. M. Terry first harvested oysters from Sewansecott Creek, an ocean-side estuary on Virginia's Eastern Shore, the family has been captivated by the allure of the oyster. Today, Terry's two sons and two grandsons operate a fully-integrated business including nursery and grow-out beds, boats, shucking houses and processing facilities.

"Harvesting and processing oysters hasn't changed much in the past eighty years," according to Wec Terry who operates the shore-side of the family business while his brother, Pete, and Uncle Buzz manage the water-side. Equipment that is economically feasible has not been developed, so planting, transplanting, and tending beds as well as harvesting and processing are still done primarily by hand.

Empty shells generated during each shucking season are planted in nursery beds. Mature oysters left in the beds release huge numbers of sperm and eggs. Fertilization occurs at random in the water and the larvae swim with the tide for a couple of weeks (the only time the oyster will be mobile in his entire life). After this brief period of activity, the larvae excrete a concrete-like substance and "set", or attach themselves to a hard surface where they will remain permanently at home. Oyster shells are their first choice for a home; however, they will also attach to rocks or other debris beneath the water.

Generally, nursery beds are located in relatively shallow tidal areas where they will be flooded at least twice a day. The growth rate is phenomenal during the first few months; oysters may increase as much as 30 times in size in the first few weeks after setting. When the young oysters, now called "spat", reach one to two inches in size, they are moved by

**Edward Fisher fills Sewansecott brand containers with freshly shucked oysters.**

hand from the nursery beds to grow-out beds in four to ten foot waters. Here they will siphon approximately 100 gallons of water a day for nutrients. During the winter months, oysters firmly close their shells, do not feed, their heart rate and metabolism drops and they essentially hibernate. Allowed to fully mature, American oysters can reach 10-12 inches.

Terry describes the business as "much like farming, except you can't see damage or loss" to the crop; therefore, spot checking the beds is an important part of the daily routine. Droughts or heavy rainy seasons which affect the salinity of the water also affect the growth rate, taste and texture of oysters. In addition, naturally-occurring algae, which also responds to water temperature and salinity changes, can also affect oyster growth.

While the oyster truly sits and minds his own business, two predators have developed ingenious ways to obtain the delicate meat. The oyster drill, a small marine snail that looks like a periwinkle, simply drills through the oyster shell for a satisfying meal. Starfish are the oysters other natural enemy. The tenacious starfish wraps its tentacles around the entire oyster and applies steady pressure until the oyster tires and opens its shell. Infestation by starfish can be devastating to the crop because oystermen have no really effective method to rid waters of starfish.

Although oysters are found in waters all over the world, their taste, texture, color and consistency are determined by their local environment. Thus, an oyster found in New England or British waters will not taste the same as an oyster found in Virginia. (And, of course, anyone with discriminating taste knows that the world's best oysters come from Virginia.)

On-shore operations are straight line, efficient and expedient. Within an hour a load of oysters is processed and packaged for transportation. Bushels of oysters are deposited in the shucking house where shuckers deftly insert narrow knives to pry the shell open and remove the meat. While most of us would starve if we had to open enough oysters to survive, the shuckers not only accumulate a very respectable pile of

shells in a surprisingly short period of time, they also separate the oysters by grade into appropriate containers, laugh and chat with co-workers and still keep ten fingers.

The oysters are then washed under cool water and placed in 18-gallon metal aeration tanks. During this fifteen-minute process, air is forced through gently agitating water to remove any grit or shell from the oysters. Foam that accumulates on the top during the aeration process is removed and the oysters are placed on a metal strainer table. Here they undergo one final inspection under the experienced eye of Wec Terry before being packed by hand into various sized containers for marketing.

Oysters are handled much like other seafood products for transportation to distributors and retailers. The plastic and glass containers are placed in heavy cardboard boxes surrounded by ice to maintain internal temperatures just above freezing which preserves the texture and consistency of the product.

Processors are routinely inspected by various state and federal regulatory agencies. The FDA periodically inspects plants to insure that health and safety standards relating to the production of food for human consumption are met. They check for bacterial counts, coliform counts and water contamination levels. Other agencies like the Shellfish Sanitation Board and the State Water Control Board conduct routine spotchecks on temperature controls in the plant and bacterial levels in waters where oysters are harvested.

Like others in the industry, the Terry's are concerned about the future of the oyster in Virginia. Although remarkably adaptable over the centuries, the sedentary oyster is defenseless and vulnerable to the changes man has introduced. If we are to continue to enjoy one of nature's most delightful gastronomical treats, oyster management programs will have to become more sensitive to the needs of the industry. Wec Terry is extremely active in these efforts, having served as Chairman of the Board of the Virginia Seafood Council and currently serving as Chairman of the Virginia Marine Products Board.



C. Plummer  
**Wec Terry talks oysters with clients who stop by the Terry family business in Willis Wharf.**

# Blue crab prey, predators and habits

**R**om Lipcius of the Virginia Institute of Marine Science (VIMS) and Anson Hines of the Smithsonian Environmental Research Center (SERC) in Maryland are collaborating on a combination of laboratory and field studies of interspecies relationships. Specifically, they are examining several marine animals as both predators and prey during varying seasons and in different environments. The work is funded by the National Science Foundation.

The laboratory work will be performed at VIMS and SERC and the field work will take place in the Rhode River, a subestuary of the central Chesapeake Bay located on the western shore just south of Annapolis, Maryland. Lipcius and Hines have chosen to look at the relationships among three types of bottom feeding fish, two species of clams and the blue crab.

Spot, Atlantic croaker and hogchoker enter estuarine areas and creeks to feed during warmer months. The overall abundance of each of these fish varies significantly from year to year and varies by species and location. The fish consume great numbers of clam siphons — tube-like structures which enable the clam to siphon water and food particles while it remains buried in the bottom. The fish also consume other organisms living in the soft-bottom areas.

Although the fish generally do not feed on whole adult clams, they appear to have a major effect on a soft-shelled

clam, *Macoma balthica*, by eating the ends of the clam's siphons, which may subsequently affect the clam's growth, reproductive output and ability to survive. Survival may be reduced if clams with nipped siphons have to move closer to the sediment surface where they may be susceptible to predation by blue crabs.

The blue crab is a dominant omnivore found throughout diverse shallow mud and sand habitats. In Chesapeake Bay, the blue crab is abundant and actively foraging from late spring through autumn, after which it buries to overwinter in deep channels. The blue crab consumes whole clams and a variety of other organisms, making it a predator with numerous interactions.

Previous research by Lipcius and Hines suggests that predation by blue crabs and demersal fish is a significant regulatory factor of clam abundance. However, although there were major increases in abundance of the clams during the spring and fall recruitment periods, the populations underwent rapid declines each summer to levels approximately the same as in most years. These summer declines coincided with the arrival of predatory blue crabs and fish.

The predators and prey exhibit distinct and discordant cycles of abundance, with peak prey abundances crashing in the summer when those of the predators increase dramatically, suggesting cause-effect relationships. The significance of their study will be the ability to describe community dynamics in a relatively simple predator-prey system.

Dr. Lipcius is involved in a body of work with blue crabs which relates primarily to the crab and its interactions with other animals and the environment. The blue crab research program at VIMS, now headed by Lipcius, was begun by Willard A. Van Engel in the 1940s. Professor Van Engel is now a Professor Emeritus with VIMS and continues to be involved in blue crab projects, particularly in relation to analyzing population changes.

Lipcius also directs the work of several students, including Eugene Olmi who is the first recipient of the Willard A. Van Engel Fellowship. The Fellowship was established in 1986 to offer an opportunity to individuals of outstanding ability to do crustacean research in the Chesapeake Bay region, particularly on the blue crab, while pursuing graduate studies.

Olmi, of Charleston, South Carolina, began doctoral studies in crustaceology in 1986. He is studying the processes which return crab post-larvae into estuaries. The postlarval (megalopal) stage reinvades estuarine nursery grounds from the continental shelf outside the mouth of Chesapeake Bay 2-4 weeks after being hatched as a larval stage by egg-bearing female blue crabs. Beginning in July of last year, Olmi took samples once or twice a week from the York River to determine when the megalopae began arriving.

From August 6 through the end of November, Olmi sampled every day. The highest density of megalopae and thus the optimal sampling time is during the maximum flood tide, generally very late at night or very early in the morning.

Using paired plankton nets, 100 x 50 cm with a 0.75 mm mesh, Olmi samples from the top 80 cm in the York River, along the northern shore. Although he has just begun his field work, Olmi's sampling showed larvae moving up the estuary in measurable numbers later in the season than was previously believed to occur. This year, he will sample from different depths and have additional samples taken simultaneously at other locations in the River.

When it is time to analyze the data, the scientist will be looking for any repetitious patterns, such as lunar or semi-lunar. He will also examine wind patterns and tidal flow rate. Olmi's hypothesis is that the megalopal and juvenile stages of blue crab are not randomly moving in the estuary, but actually have behavioral characteristics which aid in their transport from the mouth of the estuary to the nursery grounds. If he is correct, large numbers of megalopae should be found at predicted times.

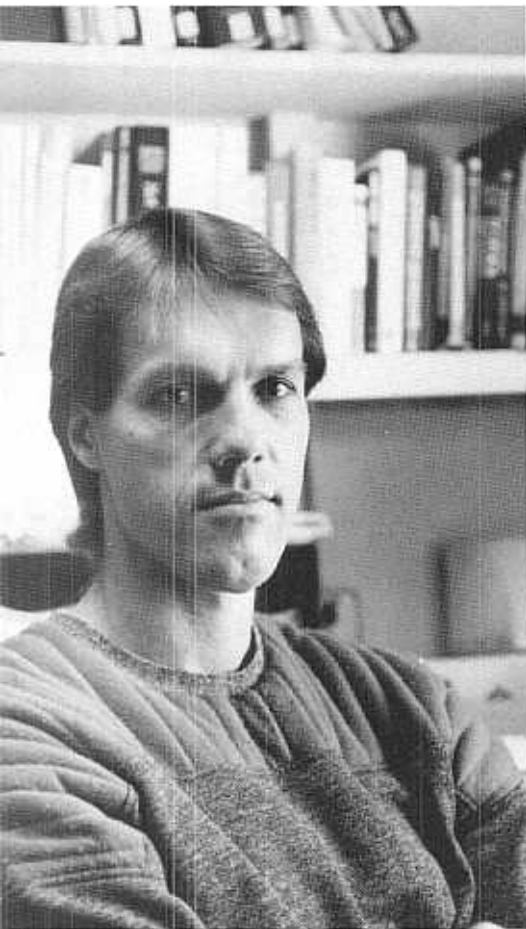
Another doctoral student, Randa Mansour, is working on the annual blue crab trawl surveys financed by the Commonwealth, and under the direction of

W. Jenkins



Professor Emeritus Willard A. Van Engel and Gino Olmi.





C. Plummer

Rom Lipcius heads the blue crab research program at VIMS.

Dr. Lipcius is examining the predator-prey relationship between blue crabs and clams. In particular, she is attempting to discern the effects that blue crabs have on each other when feeding on the soft-shell clam, *Mya arenaria*. For instance, a solitary blue crab may be very effective at feeding on clams, whereas two or more crabs feeding in the same locality may interfere with each other through aggressive interactions. The consequences of such behavior are a reduced feeding efficiency for groups of blue crabs and enhanced survival for the clams. Mansour will conduct laboratory experiments at VIMS and field experiments utilizing ultrasonic telemetry at the Smithsonian's Rhode River site. This work is also a part of the joint effort by Hines and Lipcius funded by the National Science Foundation, Smithsonian Institution, and VIMS.

## Bay Plan Citizens' comments sought

*Here's your chance to comment on stock assessment*

A draft, Bay-wide plan that proposes new means for monitoring and assessing stocks of finfish and shellfish in Chesapeake Bay will be available for public review after April 18, 1988. The Bay-wide Stock Assessment Plan is being developed by the state/federal Chesapeake Bay Stock Assessment Committee (CBSAC), sponsored by NOAA's Estuarine Programs Office. The 1987 Chesapeake Bay Agreement calls for the adoption of this plan by July, 1988.

Recommendations will include improved ways to collect commercial and recreational catch and effort data, which are consistent Bay-wide and which will provide better information for stock assessment. Also, a Bay-wide data collection effort will be outlined for collecting biological data (age, length, sex, weight, etc.) from commercially, recreationally, and selected ecologically valuable species of finfish and shellfish. These data would be collected from landings (fishery-dependent) and through research surveys (fishery-independent) to ensure complete population estimates for all age groups of important species and for all regions of the Bay and its tributaries. These new efforts should provide basic, long-term data that are essential for stock assessment.

Virginia members of CBSAC include Dr. Herb Austin, VA Institute of Marine Science; Dr. Erik Barth, VA Marine Resources Commission; and Dr. John McConaughy, Old Dominion University. For more information about the plan contact Dr. Barth, in Richmond, at 804-247-2236, or Bess Gillelan, NOAA Estuarine Programs Office, in Washington, D.C., at 202-673-5243.

The Chesapeake Bay Agreement was signed in December 1987, by the Chesapeake Executive Council, consisting of the Governors of Maryland, Virginia, Pennsylvania, along with the Mayor of the District of Columbia, the chairman of the Chesapeake Bay Commission, and the Administrator of the

US Environmental Protection Agency, representing all the federal agencies involved in the Chesapeake Bay Program. The Agreement contains commitments dealing with six areas of concern: Living Resources; Water Quality; Population Growth and Development; Public Information, Education, and Participation; Public Access; and Governance. Commitments require the development, adoption, and implementation of plans, strategies, or policies for accelerating the restoration and protection of living resources in the Bay.

Living resources commitments include the Bay-wide assessment plan, described above, as well as six others:

- The adoption of habitat requirements guidelines by January 1988 (completed, and being revised for Jan. 1989).
- A schedule for developing resource management strategies by July 1988.
- The development of management plans for oysters, blue crabs, and American shad by July 1989, and the initiation of plans for other commercially, recreationally, and selected ecologically valuable species by 1990.
- The development of a Bay-wide tidal and non-tidal wetlands policy by December 1988.
- Improvements of waterways to restore natural passage for migratory fish.
- The development of a Bay-wide living resources monitoring plan, by July 1988.

The Living Resources Subcommittee of the Chesapeake Bay Executive Council's Implementation Committee, is chaired by Verna Harrison, MD Dept. of Natural Resources, and it has the lead responsibility for making sure these commitments are met. For complete information on these and other commitments in the Agreement, contact Carole Barth or Jean Jones, Citizens Program for Chesapeake Bay, 903 9th Street Office Building, Richmond, VA 23219, 804-225-4355.

# Oyster & Crab RESEARCH

## Helping oyster growers outwit the blue crab

**H**ow do crabs open an oyster? Using their strong claws to chip away at the thin shell edges of oyster spat or crush the shells, the crabs work to attain the soft meat inside. Another tactic is to puncture the hinge of the shells to break open the oyster. All of these predatory methods leave distinct "crab signatures" on the oyster shells.

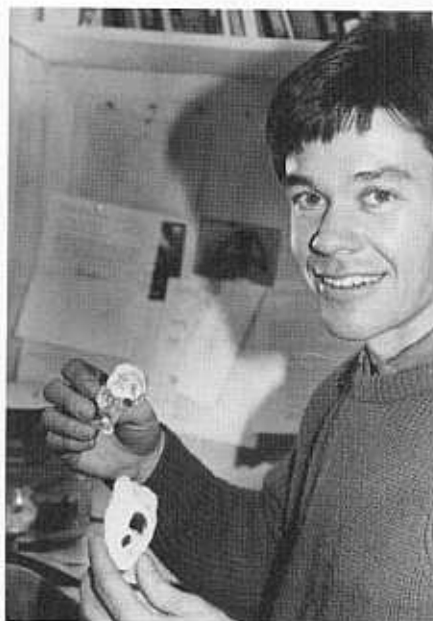
It is estimated that crabs may be responsible for a significant number of first year oyster deaths. David Eggleston is a graduate student interested in the ability of young-of-the-year oysters to survive, particularly from crab predation. Working at the Milford Haven Virginia Marine Resources Commis-

David Eggleston holds oyster shells with characteristic "crab signatures."

sion shell plant off Gwynn's Island, he took samples of oyster shells, measured the spat on them, marked the shells and replaced them on the bottom in their natural densities. After three weeks, Eggleston recaptured his samples and examined them for dead spat. Causes of mortalities implicated by this "mark-recapture" technique were listed as either "due to crabs" or "unknown." Crab predation was quantified by recording the number of spat mortalities exhibiting the "crab signatures."

Eggleston also conducted laboratory experiments to study crab predation on oysters, to see if the resulting data supported his field observations. The key factors influencing the intensity of the crab predation were the size and density of the young oysters, and water temperature.

His preliminary findings indicate that oysters become relatively safe from crab predation at a spat length of about 30.0 mm. The amount of "handling



C. Plummer

time" required by a crab to crush the shell of an oyster is an important factor in determining this "safe size." A crab will benefit the most energetically from an oyster of an optimal size (most meat for the least amount of work). Smaller spat may be easier to open but provide less meat, while spat larger than 30.0 mm are even less profitable in terms of meat yield, because of the time required to get the shells open. Decreasing water temperature appeared to have two effects on predation; depressing the crab feeding rates, and at low spat densities, reducing the number of "encounters" a spat had with crabs. When published, findings from Eggleston's study may be employed by planters to minimize their losses due to crab predation by manipulating both spat size and temperature at the time of outplanting. The results of this study may also be applied to mathematical ecology models which can be used to predict seasonal spat mortality losses due to crab predation in the field. *NJC*

Roger Mann has over-all responsibility for the oyster research program at the Virginia Institute of Marine Science. A biologist, Mann studied in England and Wales before moving to the Woods Hole Oceanographic Institution in 1975.

Dr. Mann believes strongly that research must return to combined laboratory and field work. "Neither is sufficient alone," he says, "what is observed in the field must be proven in the lab and vice versa. We cannot continue with a trend of 'lab-only' scientists who have lost all sight of the real environment; nor can we afford the field observer who never tests hypotheses in a controlled environment."

Mann has been guiding major and long-term research projects at VIMS for three years, attracting funding, researchers and students.



W. Jenkins

## Measuring shell fouling

Each summer the Virginia Marine Resources Commission (VMRC) plants clean oyster shells on selected public oyster beds throughout the Commonwealth's tributaries of the Chesapeake Bay to increase seed oyster production by increasing the amount of suitable substrate on which oyster larvae can attach. Similar plantings are done in the Potomac River by the Potomac River Fisheries Commission (PRFC).

The timing of the shell planting could be crucial to the success of spatfall on those shells. Shell surfaces and their aggregation offer an ideal surface for attachment of oyster small plants and animals; they also trap sediments and detritus. Oyster larvae settling on the shells must compete for use of the available space with those other biotic and abiotic components.

Aware of this competition, the VMRC and PRFC attempt to plant the clean shell as close as possible to the expected maximum peak in setting of oyster larvae in each of the locations where shell is planted. Until recently, however, no studies

had been undertaken in the natural environment to examine the timing and extent of shell fouling by the other competitors for space.

Roger Mann and his associates, Rick Rheinhardt and Ray Morales, began quantifying shell fouling in some of the most productive seed oyster beds of the James and Potomac rivers two years ago. To obtain their data, the scientists removed samples of the planted shell throughout the season and quantified the various fouling components. Their studies in the James River have been completed and examination of data from the Potomac River study is underway at present.

It was discovered that the maximum settlement of oyster larvae in the James River in 1985 occurred in late July and early August, while fouling reached its peak at the time of highest water temperature in mid-August. The most important fouling components of shells on oyster beds, the researchers learned, were detritus and sedimentation. Thus, the progression of fouling on each of the shell plantings reflects primarily the increased rate of detritus and

sediment accumulation on the bottom, and secondarily, the setting patterns of fouling organisms.

The studies also suggested that physical factors (such as disturbance of the beds by fish and crabs and extreme water turbulence) and biological factors (such as natural mortality, predation and competition) may prevent fouling from completely covering all shell surfaces which would deny oyster larvae any space for attachment.



R. Rheinhardt and R. Morales measure the amount of fouling on newly planted oyster shell.

## Decline in James River Spat Settlement

Since the onset of the oyster disease MSX (*Haplosporidium nelsoni*) in the late 1950's, the number of newly set oysters or "spat" settling on the James River oyster beds has been declining. Concerns over this decline have prompted several graduate students at the Virginia Institute of Marine Science to become involved with research projects that may help discover what is going wrong with the oyster set. Under the supervision of Roger Mann, they are studying egg production and the survivability of the oyster larvae, including their means for staying within the seed area despite the tides.

How does spawning affect the physiology of an oyster? In preparation for the spawning season in early

summer, an oyster stores up energy reserves in its tissues and becomes "fat." By September, the spawning season is over and the oyster's tissues are watery and thin. Graduate student Carrollyn Cox is studying these changes in oysters by counting the number of eggs produced by female oysters throughout the spawning season and using a condition index to estimate the physiological state of the oysters. A condition index is a ratio of the numerical values of certain characteristics of an organism. Relative changes of these values (and therefore the characteristics) over time can then be measured and assessed. One of the goals of her study is to try to relate a condition index to the average number of eggs

produced per female oyster at different public oyster reefs in the James River.

Cox is also comparing condition indices and numbers of eggs produced over time at four locations along a salinity gradient in the James River seed area. She is looking to see what effects different salinities have on the physiological condition of an oyster and the number of eggs produced. Another aspect of her work involves trying to establish a correlation between the number of eggs produced by an oyster and its shell length. Overall, her main objective is to try and establish what factors affect the production of eggs in the James River seed areas.

*continued on page 18*

# Oyster & Crab RESEARCH

## Oysters in the air

**T**he area of the coast defined by the range of high and low tides is called the intertidal zone. Here, air, water, and land influences combine to produce a complex, ever-changing physical environment. Organisms living in this environment are uniquely suited to cope with these changes; those that can not have been excluded. Graduate student Curtis Roegner is studying the growth and survival of oysters living in the intertidal zone, to see how the periodic exposure to air affects them. Observations of distinct zones of oysters on river pilings have led him to try and discover whether oyster larvae prefer to settle intertidally.

To study the growth and survival of intertidal oyster spat, Roegner allowed larvae to settle on porcelain tiles. These tiles were then placed on racks at various depths in the intertidal zone, each depth experiencing a different amount of exposure to air. Periodically, photographs were taken of each tile to document growth and mortality patterns of the spat. These photographs provided sequential images of each tile for time periods up to 80 days. Preliminary examinations of the photographs using a computerized image analyzer indicate that there were differences in spat growth rates and survival, depending on their location in the intertidal zone. Interactions with other fouling organisms (i.e. algae and barnacles) and the influences of sedimentation also differed by zone. Roegner plans to continue the study this summer, extending the time frame to 3-4 months.



Another aspect of this study has involved examining the distribution of oyster larvae as they settled in the intertidal zone. To do this, larvae were contained in open-ended, mesh-covered tubes placed vertically in the intertidal zone. The concentrations observed in the settlement patterns of the spat indicate that there may be some preference for intertidal settlement by oyster larvae.

Roegner hopes that, ultimately, the results of his research project will be applicable to practices in mariculture by providing an alternative method for reducing the number of oyster spat deaths. Mortality due to predation is inversely related to spat size, decreasing as the spat grow. An ability to maxi-

**Famous Chincoteague oyster beds, laid down so that oysters are regularly exposed to the air. (Historic VIMS photo, circa 1950s).**

mize spat growth would be extremely beneficial. Placing newly-set oysters intertidally may minimize the effects of predation and competition from other fouling organisms; the limiting factor being the periodic exposure to air. However, oysters in the intertidal zone would also be affected by this exposure and could sustain diminished growth rates by not being able to feed continuously. The ideal solution is to find a balance of exposure and inundation times which maximize the growth and survival of the oysters. *NJC*

**Spat**  
*continued from page 17*

**W**here do oyster larvae in the James River come from? Do they stay in the seed area? If so, how do they overcome the tidal forces? Graduate student Kevin McCarthy is exploring the mechanisms by which oyster larvae might remain in an estuarine river despite tidal action. This work requires a basic understanding of the circulation patterns of a river like the

James. Simplistically, fresher, lighter river water flows seaward over denser, more saline seawater moving upstream from the Chesapeake Bay and Atlantic Ocean. Where the two layers of water meet vertically, mixing occurs, and an area of rapidly changing salinity or halocline results. Theoretically, there is a layer of water directly above the halocline that has no net motion up or down the river.

McCarthy is breaking new scientific ground by examining the responses of

oyster larvae to a choice of salinities. He theorizes that the larvae may be attracted to the halocline. Slight movements up or down within this region by the larvae, vertical swimmers, could result in passive horizontal movement up or down the river. McCarthy further speculates that it is possible that upward-swimming larvae could move into the water layer of no net motion, thereby enabling them to stay within the river despite the tides. *NJC*

## The best of the crab and oyster recipes from the Seafood Seminars

Susan Gammisch and Donna Soul Boone are definitely experienced when it comes to Seafood Education Seminars. The VIMS Sea Grant Educator and the VPI Sea Grant Extension Agent have given 5 series containing a total of 30 classes attended by over 900 participants.

The only complaint the two women ever hear is that the seminars are filled too quickly. The series is so popular, in fact, that during the earliest recorded snow storm in the coastal area in November this past year, only one couple were unable to attend.

Here are some of their favorite oyster and crab recipes from the seminars. *Hint from the pros: baking crab cakes instead of frying them cuts down on calories and carbohydrates; and seminar participants said the resulting taste was just as good, if not better.*

For information about the seminars, contact either Susan Gammisch 804/642-7169, VIMS' Advisory Services, Gloucester Point, VA 23062 or Donna Soul Boone 804/247-2061, VA Tech Agricultural Seafood Experiment Station, P. O. Box 369, Hampton, VA 23669.

Notices of upcoming seminars are sent to individuals on the mailing list; so call now to be included in the next mailing.

### BAKED OYSTERS WITH SPINACH AND CHAMPAGNE GLAZE

Serves 4

16 plump select oysters  
1/2 c. dry champagne

3 tbsp. minced shallots (split in two parts - one part for spinach, other part for buerre blanc)  
4 oz. unsalted butter  
4 oz. fresh spinach leaves  
2 c. buerre blanc  
1/2 c. freshly whipped cream

1. Saute oysters for seconds on each side in warm butter. Season and remove. Place on paper towel.
2. Saute minced shallots in warm butter. Add clean leaves spinach and wild spinach for seconds. Season and put aside.
3. Make butter sauce:  
Remainder of shallots  
1/2 c. champagne  
1/2 tsp. crushed white peppercorn  
2 tbsp. white wine vinegar  
4 oz. cold unsalted butter

In small heavy saucepan combine shallots, pepper, vinegar, champagne and oyster liquid. Cook over low heat until liquor is reduced. Add butter a few pieces at the time and cook over medium heat until creamy. Set aside. Whip heavy cream in cold stainless steel bowl fairly stiff. Fold carefully in butter sauce.

To serve: Place spinach in small casserole or on a small plate. Place oysters on spinach. Cover oysters with glaze and place in hot oven or under broiler for a few seconds to glaze. Sprinkle with a little cayenne pepper.

Hans Schadler, C.E.C.  
Williamsburg Inn

### CRABCAKES

1 lb. backfin crabmeat  
3 heaping tbsp. fresh chopped parsley  
1/3 c. chopped pimento

Mayonnaise Mix:

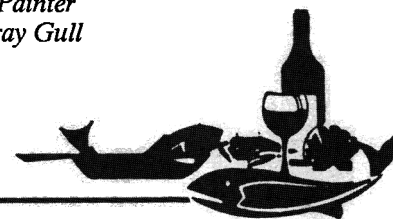
6 oz. mayonnaise  
1 tsp. Old Bay  
Juice from 1/2 lemon  
1/2 tsp. hot sauce  
1/2 tbsp. Worcestershire sauce

2 slices white bread crusts removed and finely diced

1. Carefully pick 1 lb. crabmeat to remove shells while leaving lumps intact.
2. Add parsley and pimento to crabmeat.
3. Separately mix together mayonnaise, old bay, lemon juice, hot sauce and worcestershire.
4. Add mayonnaise mix to crabmeat and gently fold together.
5. Add bread cubes to mixture and fold together again.
6. Scoop into well greased pan and bake at 350° for 8 minutes or until golden brown.

Makes 6 four ounce cakes

Susan Painter  
The Gray Gull



### Larval crabs

*continued from page 7*

for longer periods of time (more than 66 days) than previously believed.

The research will continue, looking for more answers to more questions about these early stages of the blue crab. Orth and van Montfrans plan to explore the role of predation in determining crab densities in the habitats they have examined. "Another area we'd like to research is the possibility of an eelgrass bed situated in front of a tidal marsh

creek having a 'filtering' effect on the megalopae, thereby reducing the numbers found in the creek itself as opposed to a tidal marsh creek without an eelgrass bed," says Orth. "Overall, the blue crab population may depend upon the supply rate of recruits, and the amount of submerged aquatic vegetation available to those recruits. We believe that the megalopae are the principal settlers. They appear to be settling out mostly in the lower Bay which has seen

the least decline in seagrass beds compared to the upper Bay in the last two decades." Van Montfrans adds, "The contribution of eelgrass beds to blue crab populations may be very high, even though they comprise only a small proportion of the potential habitats for the crabs. However, if comparisons are made that consider both animal density and the total area of available habitat, then the contribution of marsh creeks may be more significant."

# Marine Notes

## 1988 Tidal Extreme Highs and Lows

So many readers called or wrote to request the 1988 tidal extremes that John Boon has agreed to prepare them for you each year. Excerpted below is the relative section from Dr. Boon's article on storm surge and high tides in the MRB Vol. 19, No. 1, Spring 1987.

"The media often give you the calculated height of storm surge, but it is up to you to add the predicted astronomical tide for the time at which the forecast surge is to occur.

"Fortunately, in preparing for an approaching storm, precision is not essential and a property owner can judge approximately where the highest possible water mark will extend. The high water extreme is

what matters most to you. Although the tide table predictions of high water for our area are given in feet above mean low water, it is easy to convert to a height above mean high water in only two steps:

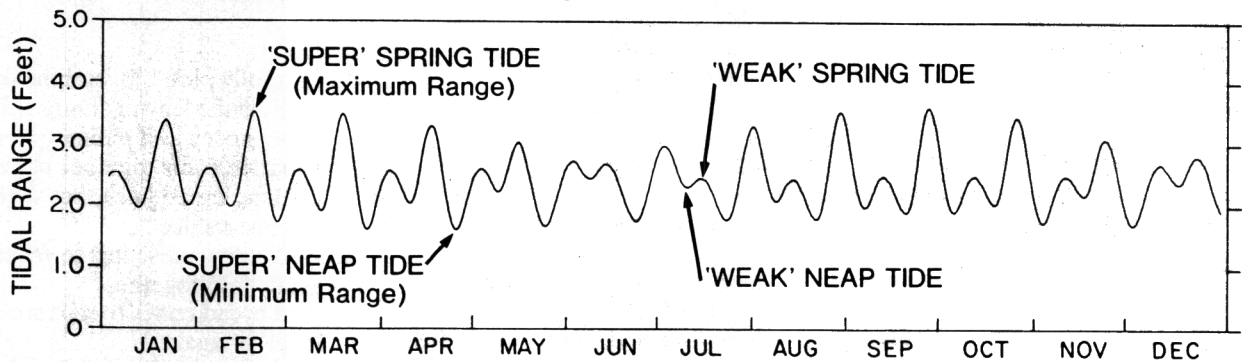
- 1) Find the mean range of tide stated in feet for the location nearest you listed in the tide tables or in the range chart below, and

- 2) Subtract the mean range from each predicted high water height obtained from the tables.

"You will then have the corresponding high water height predicted in feet above mean high water. Like predicted low water heights, the numbers may turn out to be slightly negative at times.

"Once you have a predicted high water height given in feet above mean high water, you add the forecast storm surge height and compare the result to the approximate high water mark on your property which you will have to determine in advance from your own observations. (One way to do this is to observe the high water mark on several occasions when weather is normal and the high water height above MHW is predicted to be near zero.)

"About six of these super-range events occur each year (on different days each year), and those falling due in the winter season should be marked on your storm watch calendar."



From Northeasters and High Tides

Hampton Roads, VA.

## D.C. Fisheries Program Underway



Marta Nammack holds a striped bass gillnetted during the anadromous fish survey for D.C. waters. Photo by Rupert Bonner, USFWS.

The District of Columbia established a Fisheries Management Program in 1985. Supervised by the Department of Consumer and Regulatory Affairs, the program was initiated by Jack Buckley (now with Massachusetts Fish and Game). The main purpose of "D.C. Fisheries" is to manage the aquatic resources in the rivers and streams of the District of Columbia. Impetus for the development of the program came from the Chesapeake Bay Agreement, signed by the mayor in 1984.

The program currently employs six fishery biologists, and there are plans to increase that number in the near future. Two VIMS alumni, Marta Nammack and Steve Smith, and one VIMS master's candidate, Jean Fulton, are presently working in the program as fishery biologists. While a student at VIMS,

Nammack's work on spiny dogfish was funded by Sea Grant.

Some of the projects currently underway include resident and anadromous fish surveys, an aquatic resource education program, an artificial reef study, and creel surveys (to estimate recreational catches and fishing effort). Future plans include an aquatic education center and a boat ramp. Funding for these projects is provided in part by NOAA through the Chesapeake Bay Stock Assessment Committee (CBSAC) and Fish America.

Written reports are available upon request, including resident and anadromous fish surveys, an aquatic education booklet, and a guide to the identification of D.C. fishes. For more information, contact D.C. Fisheries, 5010 Overlook Avenue S.W., Washington, D.C. 20032 or call (202) 767-8422. NJC

## Wanted: Artificial Reef and Wreck Fishermen



John Lucy, Sea Grant Recreational Specialist, looks over wreck charts with graduate assistants Nancy Chartier and Charles Barr.

A study of fishing success rates on Virginia's artificial reefs is entering its second year. Researchers at the Virginia Institute of Marine Science (VIMS) will continue to conduct random telephone interviews with fishermen who fish artificial reefs in Chesapeake Bay and offshore waters. The catch and fishing effort information obtained will be used by the Virginia Marine Resources Commission in evaluating the state's artificial reef program. Encouraged by the results of 1987, VIMS will expand its interviews with fishermen in 1988 to obtain better coverage of the reef fishery. Fishermen who fish these reef sites at least a few times a year are asked to contact Mr. Jon Lucy, Coordinator, Artificial Reef Study, Sea Grant Marine Advisory Services, Gloucester Point, VA 23062 or call (804) 642-7166. Charts with LORAN coordinates of the reef sites and nearshore wrecks can be obtained by contacting Lucy.

### FISHERIES DEVELOPMENT & UTILIZATION

#### Financing Aquaculture and Mariculture Projects

April 20, 1988  
Virginia Institute of Marine Science  
Gloucester Point, Virginia

**Focus of the workshop:** This workshop will educate the lending community, seafood producers, fish farmers, fishermen and investors about the potential of aquaculture as a profitable economic activity; provide realistic financial risk assessment guidelines for aquaculture projects, and educate entrepreneurs about the requirements of the financial community related to such projects.

- Overview of production processes
- Critical restraints on production
- Management requirements
- Production estimates
- Market strategies
- Commercial banking programs
- FHA lending program
- The venture capital view
- Budget and cash flow analysis techniques

Sponsored by: Virginia Sea Grant Marine Advisory Program; and Virginia State University Cooperative Extension Service

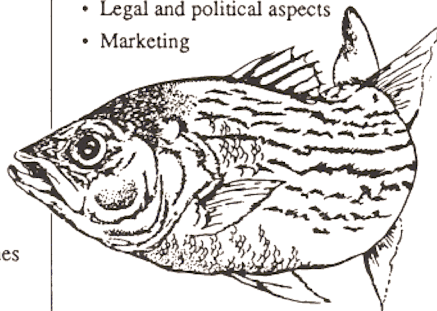
\$20.00 registration fee includes lunch and materials.

#### Culturing Striped Bass and Its Hybrids

April 21, 1988  
Virginia Institute of Marine Science  
Gloucester Point, Virginia

**Focus of the workshop:** This workshop will provide potential fish farmers with technological and management information related to the culturing of striped bass.

- Production technology
- Pond construction and culture
- Cage culture
- Trends in resource management
- Legal and political aspects
- Marketing



Sponsored by: Virginia Sea Grant Marine Advisory Program and Virginia State University Cooperative Extension Service and the Agricultural Research Station

\$20.00 registration fee includes lunch and materials.

### Pre-Publication Announcement

A report summarizing annual catches, fishing effort, and the economic value of Virginia's offshore recreational fishery will be available in April 1988. Entitled "An Analysis of Virginia's Offshore Sport Fishery, 1983-1986," the study gives an overview of the entire fishery and focuses on bluefin and yellowfin tuna, white and blue marlin, and dolphin. Boat owners and captains who have participated in the offshore study will receive a free copy upon publication. Anyone else wishing to reserve a copy of this report should contact: Offshore Sport Fishery Report, Sea Grant Communications, Virginia Institute of Marine Science, Gloucester Point, VA 23062.

**Cover Photo:**

Photo editor, Bill Jenkins arranged a coastal cornucopia of Virginia products — oysters, crabs and Virginia wine. A little eel grass drapes the basket.

**Spring issue:**  
Water Quality in Virginia's coastal areas.

**Sea Grant Communications  
Virginia Institute of Marine Science  
Gloucester Point, Virginia 23062**

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