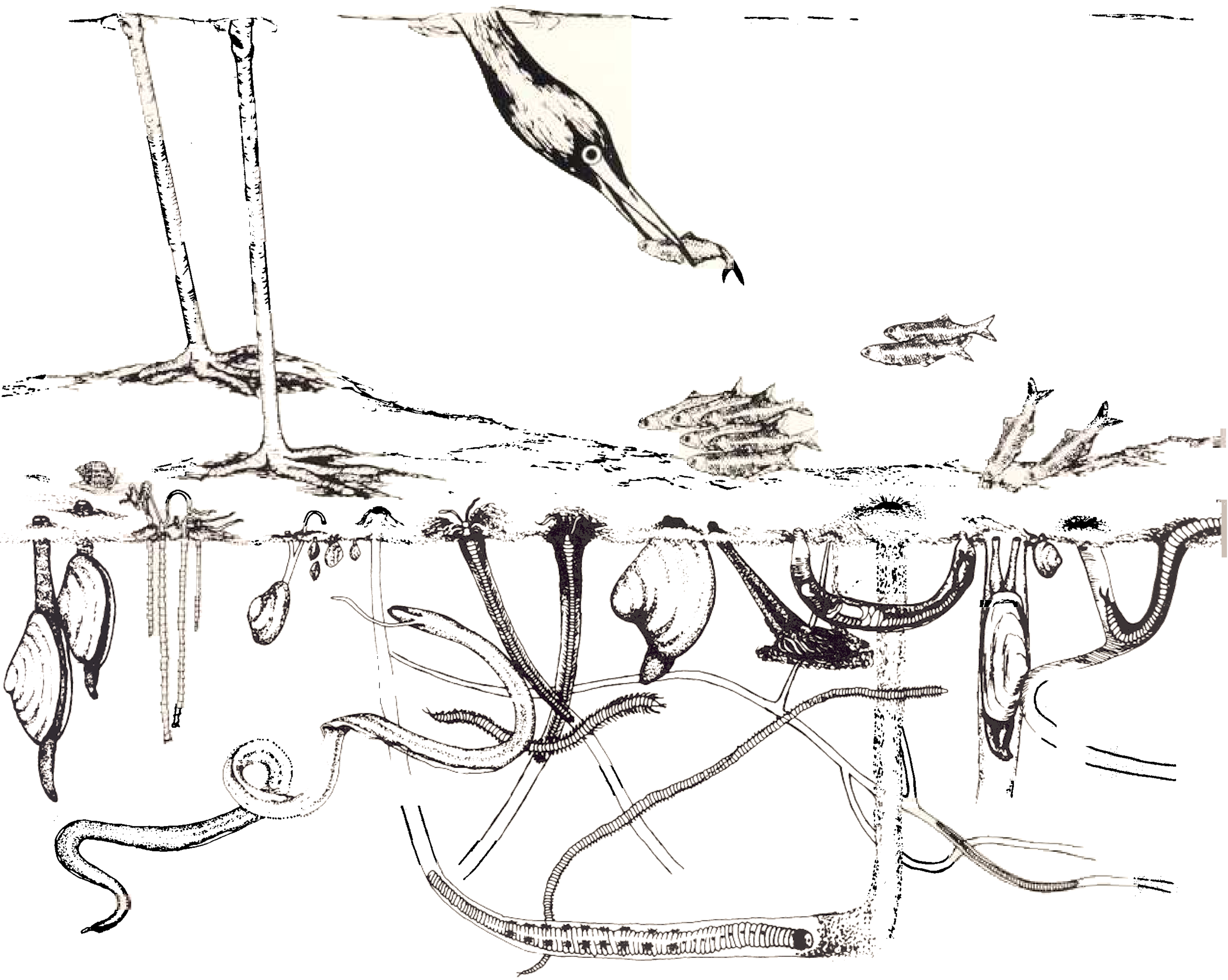
Virginia MARINE RESOURCE BULLETIN



Virginia Sea Grant Program, Virginia Institute of Marine Science
Spring & Summer 1992, Vol. 24, No. 1&2

Virginia MARINE RESOURCE BULLETIN

DR. DENNIS L. TAYLOR
Dean and Director
Virginia Institute of Marine Science

DR. WILLIAM RICKARDS
Director
Virginia Sea Grant College Program

DR. WILLIAM D. DUPAUL
Director
Marine Advisory Program

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10 YEARS OF EXCELLENCE
Virginia Sea Grant College Program

Susan C. Waters, Editor, Writer and Designer
Janet G. Walker, Typography
Kay Stubblefield, Graphics

The Marine Resource BULLETIN is a quarterly publication of Marine Advisory Services of the Virginia Sea Grant College Program which is administered by the Virginia Graduate Marine Science Consortium with members at the College of William and Mary, Old Dominion University, University of Virginia and Virginia Polytechnic Institute and State University. Subscriptions are available without charge upon written request.

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.

Beneath the waves, the currents of the Chesapeake Bay is an ecosystem rarely given much thought by non-scientists. Hidden there is the benthos, the interface between Bay water and the underlying sands and mud.

The benthos, the term used to describe the bottom and the organisms which inhabit it, is as nebulous as one might imagine. Scientists Robert Diaz and Linda Schaffner succinctly describe it as a place filled "with a myriad of organisms and processes, the majority of which are cryptic and not easily observed or understood."

Truly diverse, the benthic ecosystems of the Chesapeake Bay range from intertidal flats to deep channels. Each system is unique and has it own set of organisms and processes.

For all its obscurity, the hidden realm of the benthos is fundamental to many of the fish and crustaceans, both resident and migratory. A square meter of Chesapeake mud can contain thousands of organisms, many of which are a source of food for marine life.

The importance of the benthos is not limited to its value as food. Current scientific thought suggests that ". . .most physical, chemical, geological and biological processes in estuaries are regulated or modified by interactions with the benthic system," according, again, to Diaz and Schaffner. The organisms within the sand and mud are involved in the transfer of energy, nutrient dynamics and even the cycling and fate of toxic chemicals or pollutants.

A concerted effort is currently being conducted by a battalion of scientists from Virginia and Maryland to determine what exactly happens to toxicants once they end up in the Chesapeake Bay system. To do so requires integrating very different types of scientific information and research to arrive, hopefully, at a model.

This issue of the *Bulletin* is meant as an introduction to the shadowy benthic world. A sampler of current research is outlined and a few of the better known benthic organisms—and some of the issues surrounding them—are discussed.

Rarely seen, seldom thought about, the benthos is nevertheless bound to become an area more intently studied as scientists seek to understand the Chesapeake Bay in its entirety.

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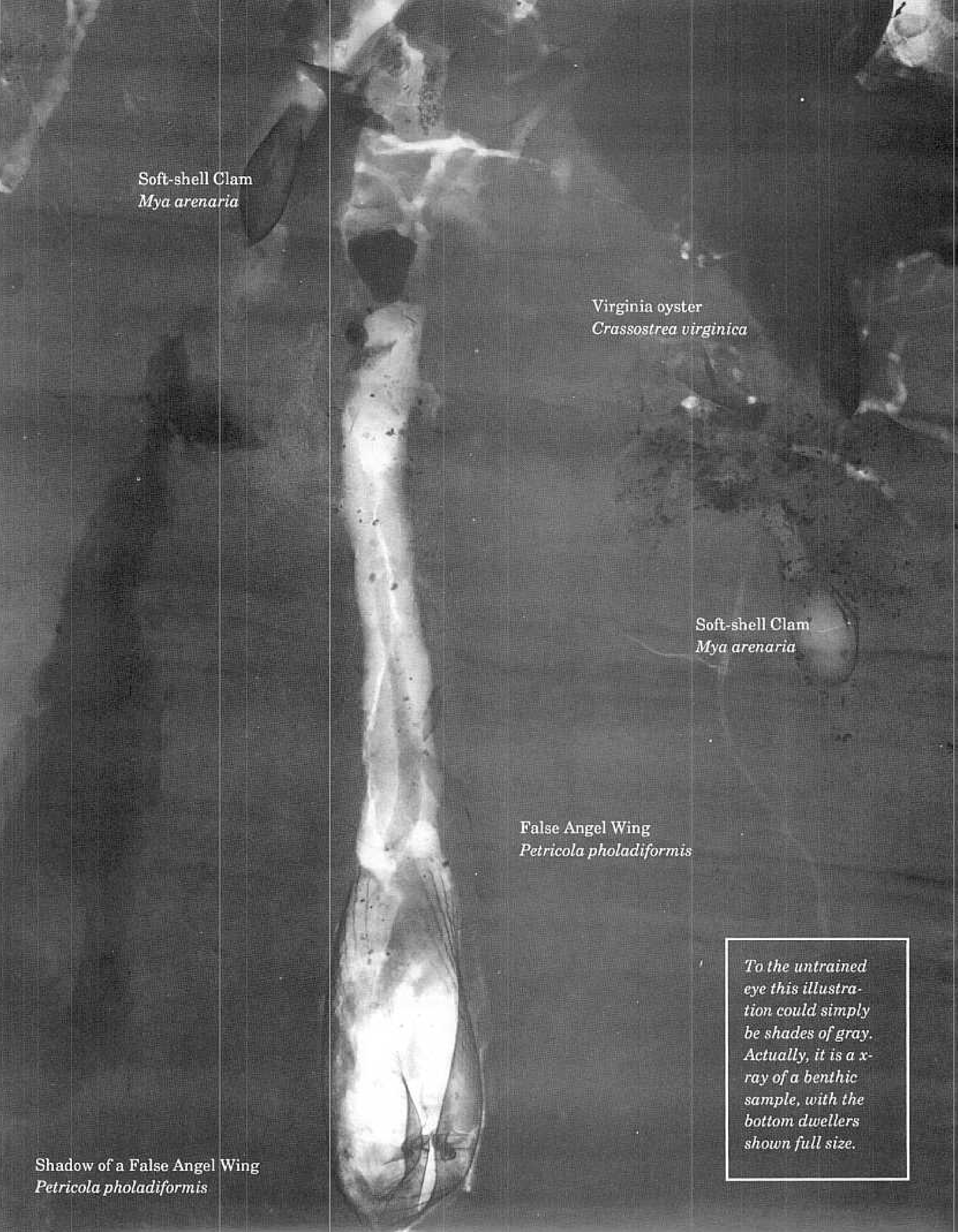
"The benthos is filled with a myriad of organisms and processes, the majority of which are cryptic and not easily observed or understood."



To the untrained eye this illustration could simply be shades of gray. Actually, it is a x-ray of a benthic sample, with the bottom dwellers shown full size.

About the Benthos.

Son

mating dances, the clamworm descends back into the mud.

In terms of biological production, the benthos is analogous to agricultural systems on land; it supports a tremendous amount of life. The benthos, like its terrestial counterpart, is also subject to seasons and the biological production reflects that with high amounts of activity in the summer, low ones in winter.

Not a great deal was known about the benthos until about three decades ago when work on defining geological and biological patterns began in the Chesapeake Bay. Since then, scientists at the Virginia Institute of Marine Science and at Old Dominion University have made significant progress in understanding this hidden world.

To fully comprehend the benthos dictates an interdisciplinary approach, an understanding of the biological, physical and chemical processes and properties and how these elements interface. Unraveling this triad is a formidable undertaking, made intriguing and difficult because the interactions between these three aspects change. For instance, in summer the biological segment of the triad dominates; the benthos is not subject to disruption by frequent storms and the metabolic rates for organisms are high. Conversely, physical processes prevail in winter when storms are frequent and the organisms are inactive. Chemistry, in turn, could take on importance in spring when the freshwater influx is the greatest.

Add to the challenge of benthic ecology just one more variable: the Chesapeake Bay is highly impacted by human activity. Substances which enter the Bay through the air or from run-off are stored in the bottom of the estuary. If the system were static the problem would seem limited; however, like every other ecological system, the benthos is dynamic. The biological processes of benthic organisms—the burrowing, feeding and movements—impact the fate of toxins. In turn, physical and chemical processes also play a part. Thus, toxins are not necessarily buried permanently in the bottom. The benthos can serve as a long-term source of pollutants as they are leached out by physical, chemical and biological processes.❖

Linda Schaffner

Habitat Disruption, Bane or Blessing? Depends on the Site

The impact of mining on benthic resources is a serious consideration, and the Virginia Institute of Marine Science (VIMS) often asseses a site both before and after an operation.

One would tend to think that any disruption of the benthos would be detrimental, but that is not always the case. After a recent beach-sand mining operation the habitat became a haven for blue crabs (*Callinectes sapidus*).

In 1990 the city of Hampton, Virginia, dredged approximately 250,000 cubic yards of sand from Thimble Shoal for use in beach restoration. The impact of the mining project was estimated to be low, yet the Commonwealth needed information on the site recovery to assist in creating a model for future projects. VIMS scientist Linda Schaffner headed the monitoring project.

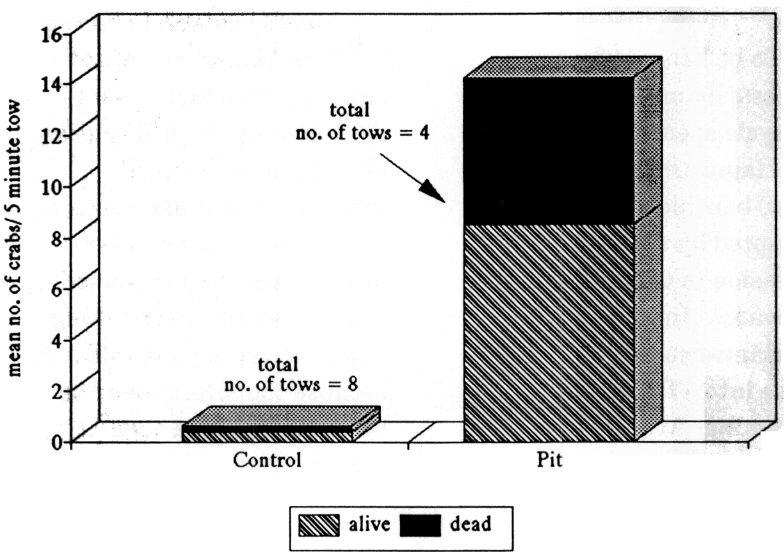
Obviously, dredging and sand mining alter the benthos in a dramatic fashion, removing both surface sediments and benthic organisms.

Before the mining operation began, VIMS scientists exaimed three basic aspects of the site as a resource.

First, researchers evaluated the abundance, composition and diversity of benthic organisms through core sampling and a remotely deployed underwater camera system, the Surface and Profile Imaging System (SPI). The SPI system developed at VIMS combines conventional surface photography and profile photography of the sediment-water interface. The information gleaned from these images include the sediment type; the bedforms; biogenic features such as tubes, burrows and fecal pellets or mounds; and the presence of organisms.

Next, the habitat was assessed for its importance as a habitat for hard clams and overwintering blue crabs. During spring, summer and fall blue crabs are caught throughout the shoal regions of the Chesapeake Bay by commercial fishermen employing crab pots. In winter, blue crabs become less active and sometimes burrow into the bottom.

Callinectes sapidus
February 19, 1991



A comparison of crab densities before and after a mining operation. The pit made by dredging afforded a more favorable habitat for crabs.

Dredge surveys indicated the site was not significant for either overwintering crabs or hard clams.

The third segment of the pre-mining evaluation determined how heavily the site was utilized by demersal fish. Trawl surveys and analysis of fish feeding habits allowed scientists to evaluate the importance of the site for support of commercial species.

When it was determined that the site had, relatively speaking, a low resource value, the project proceeded. The pit left from mining operations was ideal, at least from a blue crab's point of view. Wave energy, which was high in the area, was far less in the pit, and the fine sediment made it easier for *Callinectes sapidus* to burrow. The graph to the left illustrates just how dramatically the crab densities were before and after the project.

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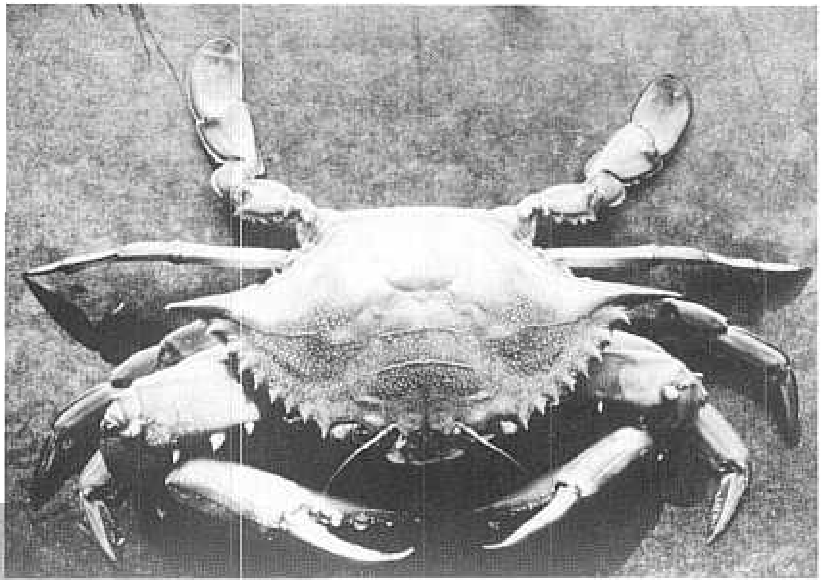
The Benthos as Temporary Home

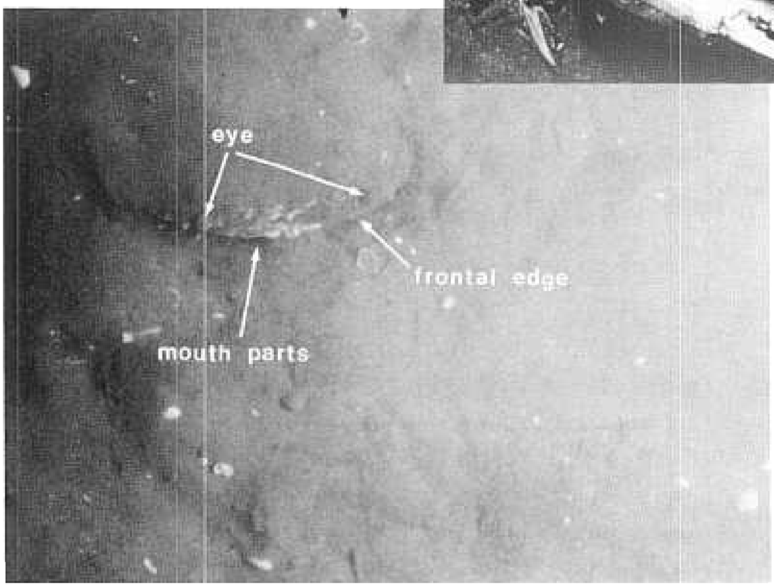
It has long been known that many blue crabs overwinter in Chesapeake Bay sediment, and sand. Even so, the winter distribution patterns in the lower Bay have been delineated only fairly recently.

A study, conducted by scientists Linda Schaffner and Robert Diaz, related the distribution patterns to these different environments: high energy, wave and tide-dominated spits and shoals; moderate energy, tide-dominated basins; and variable energy, tide-dominated or quiescent channels. A total of 17 habitat-stratum combinations were examined.

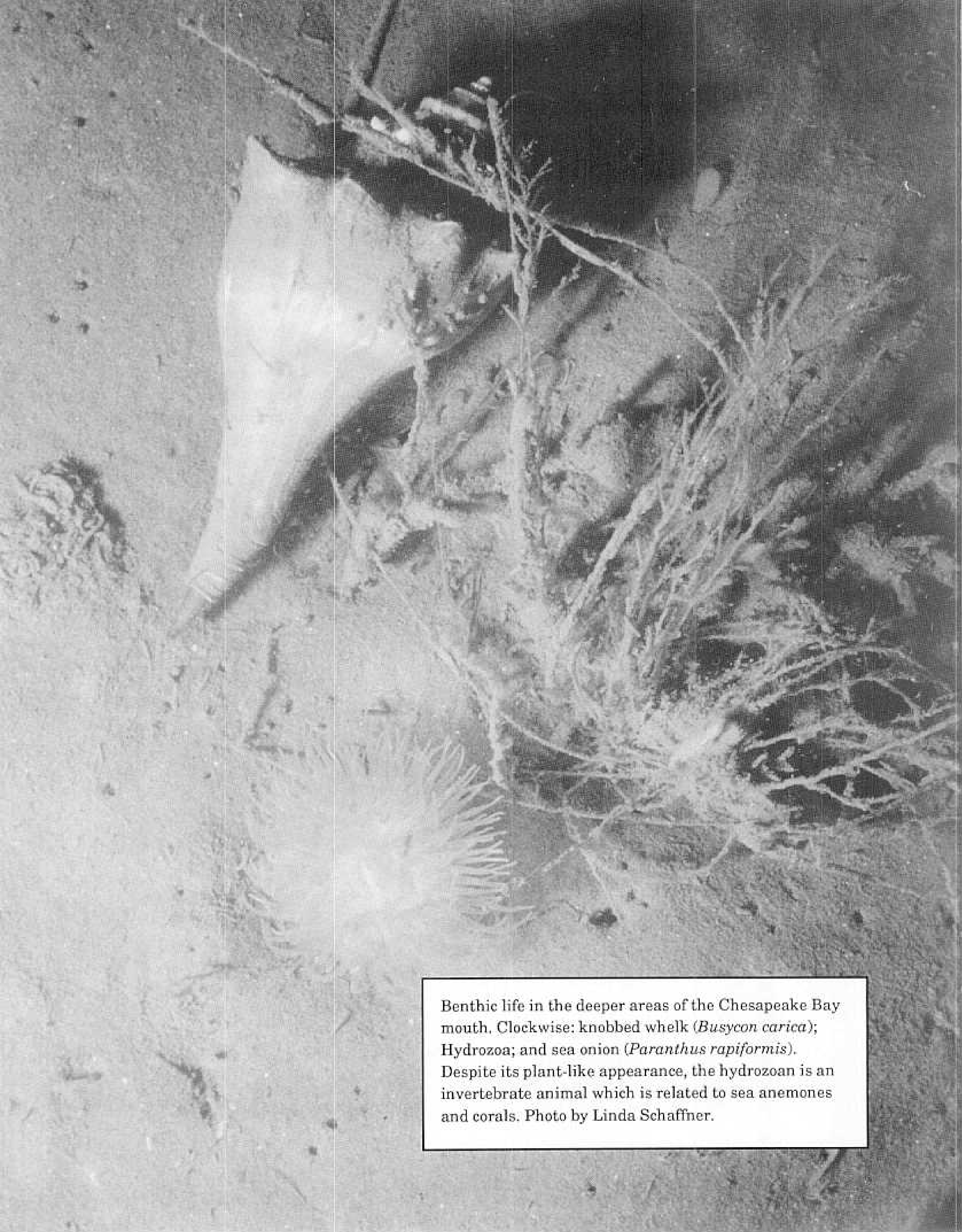
Greatly simplified, the study results indicated that crabs were found most in the basin habitat, and least in the shoal and spit environments. A high percent of sand—between 41 and 60—



was favored, especially at depths exceeding 9 meters. Mature females were found predominately, and then in areas characterized by moderate energy regimes and fine, but sandy sediments. ❖



Callinectes sapidus in full view and incognito during the winter months.



Benthic life in the deeper areas of the Chesapeake Bay mouth. Clockwise: knobbed whelk (*Busycon carica*); Hydrozoa; and sea onion (*Paranthus rapiformis*). Despite its plant-like appearance, the hydrozoan is an invertebrate animal which is related to sea anemones and corals. Photo by Linda Schaffner.

Budgeting the Benthos

Difficult, certainly, is quantifying the amount of benthic life needed to sustain resident or migratory fish and crustaceans in the Chesapeake Bay. The following table can be viewed as a budget of sorts, assigning a numerical value to what resides in the mud. Scientists Robert Diaz and Linda Schaffner are estimating the benthic biomass (the dry weight of living matter, here in metric tons) required to support the yield of major bottom-feeding species, or to support maximum sustainable yields (MSY). *Important to note: these are the estimated requirements for a few of the species which inhabit the Chesapeake Bay.*

Species	Annual recreational average, 1960-1979 [328]	Annual commercial average, 1970-1977 [188]	MSY [340,341]	Benthic biomass (in metric tons) needed for average year
Benthic predators				
Blue crab		28,000		10-200 - 13,200
			29,500	
Maryland	14,200 *			5,200 - 6,700
Virginia	7,100 **			2,600 - 3,300
Total				18,000 - 23,200
Spot		1,000		360 - 470
			1,400	
	3,500			1,300 - 1,600
Total				1,660 - 2,070
Croaker		900		320 - 420
	1,800			650 - 850
Total				970 - 1,270
White perch		500		180 - 230
			1,400	
	1,430			520 - 670
Total				700 - 900
Flounder		130		50 - 60
			1,400	
Total				50-60
Grand total commercial and recreational				21,400 - 27,500
Grand total commercial				11,100 - 14,400
Grand total recreational				10-300 - 13,100
Grand total maximum sustainable yield				12,200 - 15,900
Benthic herbivores ***				
Oyster				
			13,600	
Hard clam		400		
Soft clam		1,200		
			27,300	
Grand total commercial				950
Grand total maximum sustainable yield				3,720

* Averaged landings, 1983-1984 (Maryland DNR 1989).

** Assumed to be 50% of Maryland landings.

*** Fisheries yield is assumed to be a minimum estimate of annual production.

Management Implications for The Benthos Far Reaching

The 1987 Chesapeake Bay Agreement has underscored the need for sound management of all Bay resources. If this task is to be accomplished, the entire Bay must be perceived as a single functioning ecosystem. Effective management of living resources and their habitats requires knowledge of what affects these resources, both positively and negatively, and how they function within the ecosystem. Because the benthic subsystem (the entire benthic boundary layer) is the final focus for pollutants and is integrally connected to every other Bay subsystem, reliable detection and interpretation of habitat conditions require adequate understanding of benthic function.

Any management plan for Chesapeake Bay living resources needs to start with the recognition of the Bay as a single ecosystem. From this perspective a detailed plan or model can be produced that will allow for identification of key flows and controls. Preliminary attempts to model the Chesapeake Bay confirm how complex and interconnected the system is. This level of complexity requires that managers more clearly focus their attention, consider ecosystem-level implications, and set limits to management goals. This response would improve communication with scientists, who are asked to provide data necessary to determine whether management strategies have been or would be successful.

—Robert Diaz & Linda Schaffner, Benthic Ecologists at the Virginia Institute of Marine Science

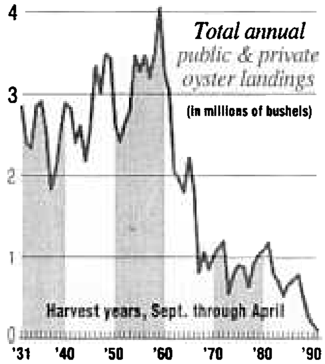
If the benthos is to be understood from a scientific point of view, research needs must be identified and addressed. Listed below are a few areas of concern to scientists:

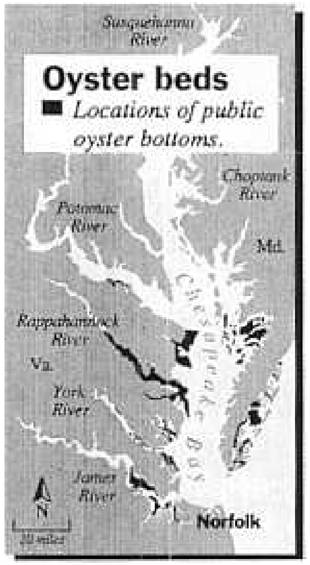
- *How closely coupled are fishery yields and benthic production?*
- *What are the relationships between toxicants and benthic organisms that control the uptake and fate of toxicants?*
- *Does the spatial arrangement of various benthic habitats (i.e. bare sand, mud, marshes, seagrass beds, oyster bars) play an important role in benthic function?*
- *How do long-term changes in climate affect benthic function, and are there any long-term periods?*
- *What role do episodic events (i.e. large storms, dredge material disposal) play in restructuring benthic habitats?*

The Oyster Bar: A cluster of life for the Chesapeake Bay

A sampling of the variety of life found in and around oyster beds; plus how oysters help clean the Bay

OYSTER WOES

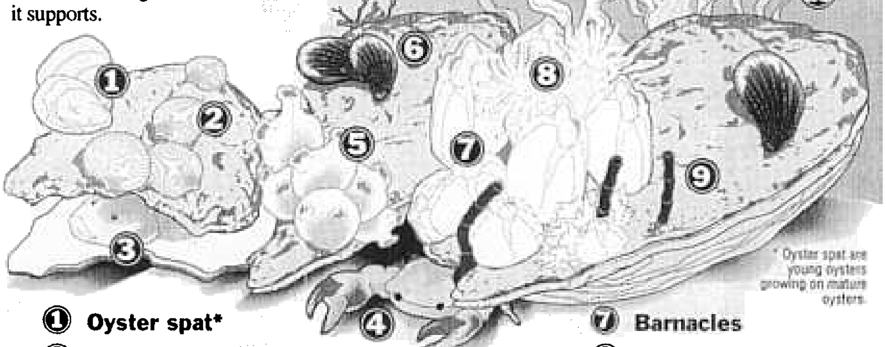




Most people think of oysters only as appetizers. The watermen who harvest them and the consumers who eat them certainly do. And the decline of the oyster population in the Bay has tremendously affected the economic impact. But if the oyster is lost, the Bay may lose more than just its most famous occupant. The American oyster, *Crassostrea virginica*, grows in clusters in the shallow waters on the edge of the Bay. The clusters provide food and protection for a wide variety of aquatic life. The loss of this habitat could have devastating effects on the life it supports.

Oyster bar sampler

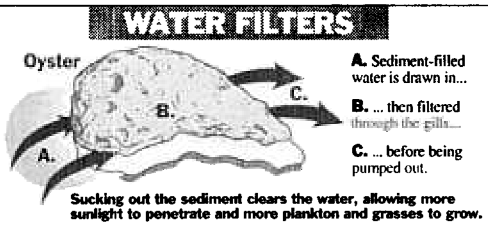
Some of the typical life found in and around oyster beds



1. Oyster spat*
2. Cockles
3. Skilletfish
4. Mud crab
5. Sea squirts
6. Hooked mussels
7. Barnacles
8. Sea Anemone
9. Fan worms
10. Enteromorpha

WATER FILTERS

Oysters help clean the Bay by filtering water through their shells. They feed on phytoplankton and deposit their wastes on the bottom. They clean sediment and plankton blooms, while returning nutrients back to the Bay.



Cleaning rates:
An oyster can filter water through its gills at rates up to 2 gallons an hour. The pre-1870 stocks of oysters are estimated to have filtered a volume of water equal to the entire Chesapeake Bay every few days. Today's stocks would take almost a year.

SOURCES: VIMS, Rethinking the Bay, Life in the Chesapeake Bay, Ecology and Field Biology, The Audubon Society Field Guide to North American Seashore Creatures

Bill Pitzer/ Staff
The Virginian Pilot

There seems to be no end to the way life invents a place for itself within an ecosystem. An oyster bar would seem to be mostly for oysters, right? Not so, at least not entirely. Oysters share space with sea squirts, boring sponges, mollusks, worms and a throng of other marine life. Skilletfish and blennies use dead oyster shells for egg laying. The pea or oyster crab actually takes up residence within a live oyster. A pea crab "invades" as a larva and grows, utilizing food filtered by the oyster. A reef is a haven for smaller organisms—much more than a flat area; the dense collection of shells significantly multiplies the surface area, provides convenient niches for other forms of life.

An oyster bar forms when new, young oysters, also called "spat" attach to existing oyster shells, both living and dead. The new generation builds literally on the last. Left alone, an oyster bar could attain some height. Colonial Americans recorded accounts of ships stranded on oysters bars—at least until the next tide. Even now, hundreds of years later, any oyster bed can be a prominent physical feature of the benthos, influencing patterns of sedimentation within an estuary.

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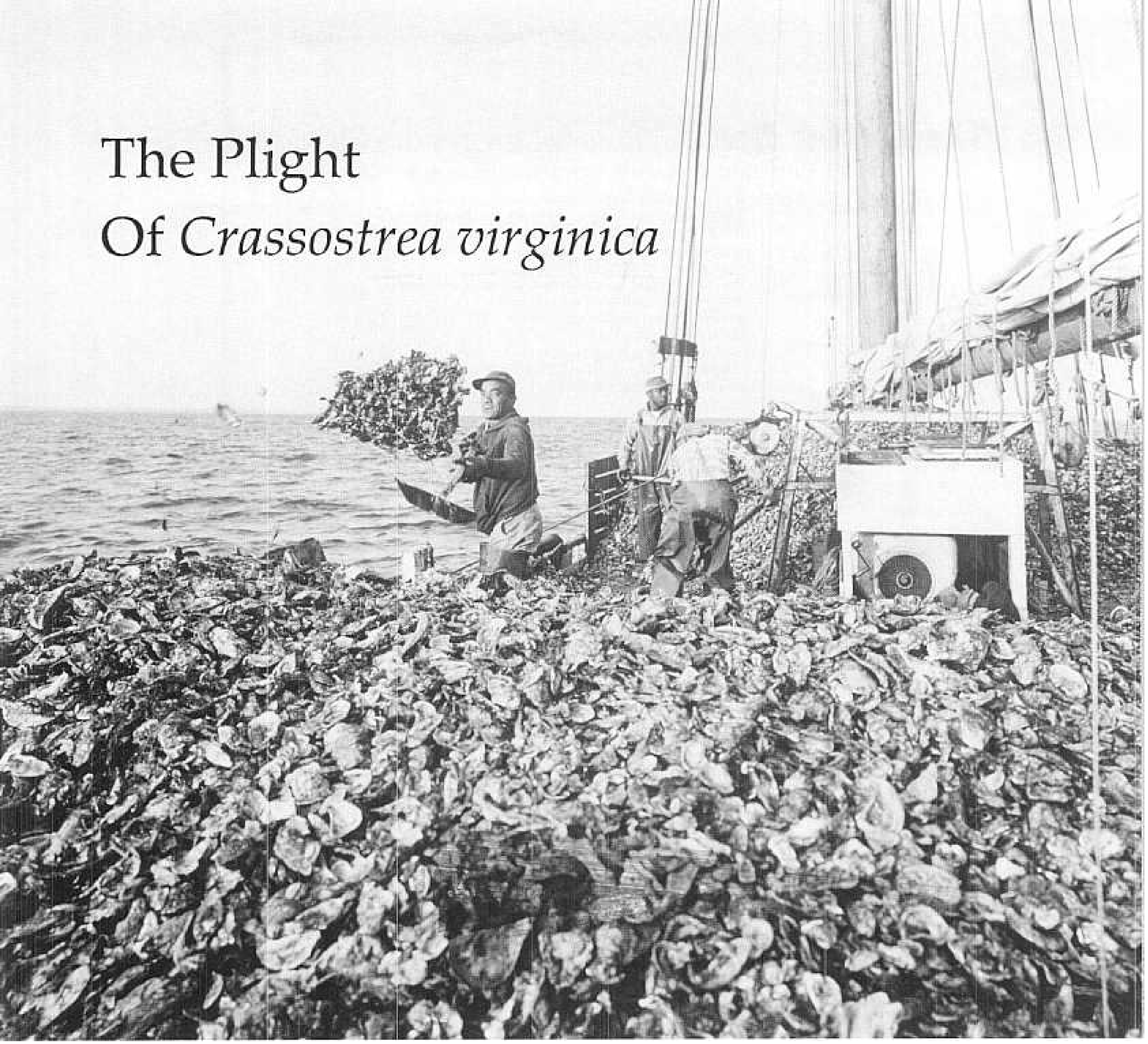
The Plight Of *Crassostrea virginica*



This historical photo by Aubrey Bodine may seem to hark back to the heyday of the Virginia oyster, *Crassostrea virginica*, but it really typifies the type of harvesting pressure put on the oyster resource. As early as the 1890s scientist William Brooks warned that without close management the fishery could collapse. When his advice was not heeded the Johns Hopkins professor said, in exasperation, “We have wasted our inheritance by improvidence and mismanagement and blind confidence.” During Brooks' time oysters were being harvested at what now seems like an astounding rate: 17 million bushels in 1875. In this century Virginia's average of 3-4 million bushels during 1955-60 was high, especially when contrasted with Virginia's average landing during 1990-

91. . . approximately 112,000 bushels.

Even though scientists and managers differ about ways of reviving *virginica*, they do tend to agree that the sad state of the native oyster is due to a combination of disease, environmental stresses and fishing pressure.

Environmental stresses come in many forms. *Haplosporidum nelsoni* (MSX) and *Perkinsus marinus* (Dermo), the two pervasive oyster diseases of Virginia, often take their toll early, leaving few oysters to harvest. Environmental stress, in the form of toxicants, may make oysters more susceptible to disease. Plus, some researchers suspect that the fishing pressure, which has lowered the height of reefs, could be viewed as stress; when oysters are lower, nearer the bottom, they may expend more energy as they sort through inorganic material.

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gigas versus *virginica*

During the course of research, scientists Eugene Burreson, Bruce Barber, and Roger Mann found *Crassostrea gigas*, the Japanese oyster, more resistant than the native oyster to *Perkinsus marinus* (Dermo). The marine scientists are now trying to discover the mechanism which makes the Virginia oyster more susceptible, a factor which could assist in projects to produce disease-resistant oysters.*

In a new project, Barber and Mann will produce experimental groups of the Virginia and Japanese oysters under controlled conditions at the oyster hatchery at the Virginia Institute of Marine Science. Both oyster species will be exposed to the parasite Dermo. Researchers hope to create a model indicating how a Virginia oyster's vital life processes are affected by Dermo, discovering at the same time, the mechanism which makes the Japanese oyster less susceptible.

*Projects focusing on selective breeding, fast growing (oysters would ideally reach market size before contracting diseases); and Sea Grant research to develop disease-resistant strains were detailed in the 1991 Spring/Summer issue of the Bulletin.

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The Chesapeake Bay, in terms of diseases, is in an unlucky geographic position. Both MSX and Dermo are pervasive in the region.

Environmental Stress Disease Susceptibility??

Logic would certainly suggest that a living organism under environmental stress would be more susceptible to diseases. However, the true relationship of pollutants to the onset of disease in the Virginia oyster (*Crassostrea virginica*) has not been fully established. In most cases, toxic substances in low doses do not cause the immediate death of an organism. Instead, they may stress biota by interfering with normal physiological functions or by depleting energy or other crucial reserves.

In a number of studies analyzing the effects of sublethal amounts of pollutants, various responses have been observed, including structural alteration of cells in the digestive and reproductive systems. Pollutants have additionally been found to interact with enzymatic and detoxification systems of the organism. Determining whether pollution is actually a factor in the spread of infectious diseases in the Eastern oyster is valuable information as scientists and managers seek ways to revive the oyster population.

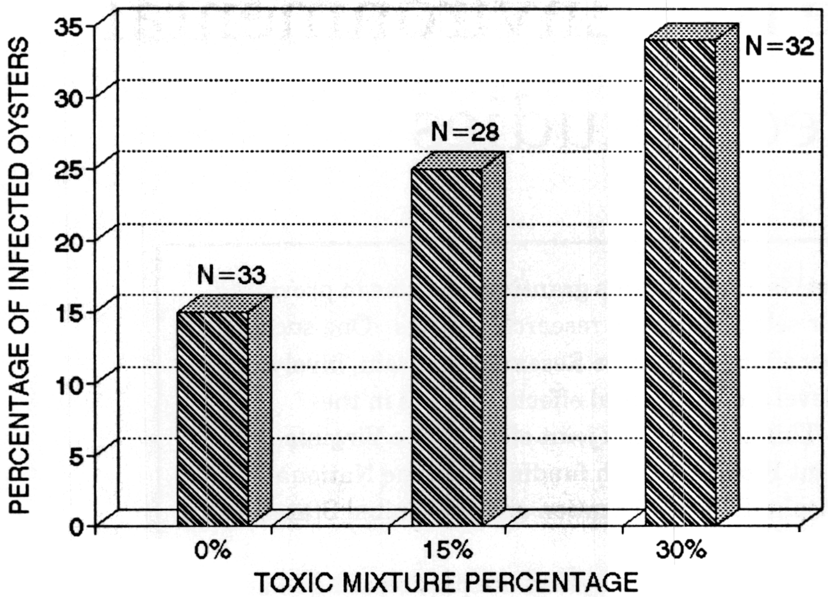
The exceptionally high levels of disease-related mortalities in recent years led Chu and Hale to suspect that environmental pressures—natural or caused by humans—may be contributing to the demise of the Virginia oyster by disease.

Fu-Lin Chu and Robert Hale, researchers at the Virginia Institute of Marine Science (VIMS) challenged oysters with pollutants derived from sediments of the Elizabeth River in Virginia.* In the experiment, sediment and estuarine water were mixed, the particulates allowed to settle, and the remaining water filtered. The filtered water, which contained a suite of compounds similar to those expected to occur in polluted waters, was then further diluted and used in subsequent experiments. Thus, oysters were exposed to pollutants actually found in the environment, as opposed to ones which may or may not be found in significant quantities. Most previous studies of this kind examined the effects of toxins on aquatic biota using single compounds dissolved in the water at predetermined nominal doses. Sea Grant researchers believed it would be more meaningful and realistic to expose oysters to a pollutant-mixture that could be found within an actual system.

Chu and Hale's interest in the relationship between environmental stress and disease was piqued by several factors. Recently, several major disease outbreaks in seals and dolphins were in observed in marine and estuarine environments. Speculation is that environmental pollution may have weakened the immune system of the organisms, permitting infection by indigenous microorganisms and resulting, ultimately, in the death of the mammals.

Another factor which led to this Sea Grant research

* This research is part of the Chesapeake Bay Environmental Effects Studies, a joint Virginia and Maryland Sea Grant effort, with funding from NOAA and the EPA.



Percentage of infection (prevalence) in oysters exposed to zero, 15 and 30% of toxic mixture derived from contaminated sediments. Number of oysters is indicated on the top of each bar.

was the severe and continuing incidence of Dermo (*Perkinsus marinus*) and MSX (*Haplosporidium nelsoni*) in the Chesapeake Bay. Historically, infections of MSX have been more intense than those of Dermo; however, in the last three years significant increases of mortalities have been caused by Dermo. In the past, areas of low salinity were a refuge for oysters, but no longer are to the same degree. Those same areas are in close proximity to locations where pollutants from human activity are probable. The exceptionally high levels of disease-related mortalities in recent years led Chu and Hale to suspect that environmental pressures—natural or caused by humans—may be contributing to the demise of the Chesapeake Bay oyster by disease.

Results of the Sea Grant research demonstrated a change in the the hemocyte, a cellular element of blood cells. Hemocytes play a significant role in an oyster's ability to ward off disease. A disruption of the normal functioning of a hemocyte signals a diminished capacity to combat infection. In one experiment the oysters were immediately exposed to Dermo and then the toxicant mixture. The oysters' shells were notched, Dermo was injected and then the oysters were exposed for approximately a month, each set to a toxicant/water solution of zero, 10 or 25 percent. In another segment of this project, oysters were exposed first to the toxicant (zero 15 and 30%) and then to Dermo. Basically, the results were similar: the more the organism was stressed, that is exposed to toxins, the more susceptible it was to disease (see figure).

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Chesapeake Bay Environmental Effects Studies

Virginia Sea Grant often joins granting agencies in providing support for selected marine research projects. One such cooperative effort, the Toxics Research Program, involves studying system-level environmental effects of toxics in the Chesapeake Bay. This program is a joint effort of the Virginia and Maryland Sea Grant Programs, with funding from the National Oceanic and Atmospheric Administration and the United States Environmental Protection Agency.

Scientists from Virginia and Maryland are participating in a multi-year, inter-disciplinary and inter-institutional research program, which addresses the transport, fate and effects of toxicants in the Bay. Projects which involve the benthos and which are by Virginia investigators are listed below.

Particle-Reactive Pollutants in Southern Chesapeake Bay: Accumulation, Resuspension and Flux into the Bottom (1990-1992)

Researcher:

Donald Swift
Department of Oceanography
Old Dominion University
Norfolk, Virginia

The dispersal of toxics in the Bay is, in part, controlled by the natural cycle of fine sediment transport between the water column and the sea floor. A basic requirement for modeling the movement of particle reactive pollutants is the estimation of their residence time in the Bay floor and the rate of passage into the zone of permanent burial. This requires knowledge of the behavior of particle-reactive pollutants, and the hydraulic patterns and biological activity that may affect them. Using radionuclides as proxies, this research will develop methods to estimate the potential flux of contaminants into the shallow sea bed. These estimates will be used to model toxic pollutant dispersal and predict consequences of environmental changes or management strategies.

Dynamics of Sediment Resuspension: Bay-Stem Plains of the Lower Chesapeake Bay (1990-1992)

Researchers:

L. Donelson Wright
John D. Boon
Jerome P.-Y. Maa
Linda C. Schaffner
Department of Geological and Benthic Oceanography
Virginia Institute of Marine Science

A thorough understanding of the processes of sediment deposition and resuspension in the Bay will permit improved predictions of the fate and exposure of toxic chemicals. This study will support the companion study by D. Swift aimed at modeling the exchange of particles between the water column and the Bay floor. Resuspension increases residence time of particle-associated toxic chemicals in the water column, slows the burial process, allows for an increased exchange between the dissolved and particulate phases, and may result in the transport of toxics to regions far from their sources.

To obtain quantitative measures of particle fluxes in the southern Chesapeake Bay, researchers will use an instrument array equipped with flow meters, pressure sensors, sediment concentration sensors and data recorders. Specifically, this instrument will obtain data on particle resuspension, lateral advection, and burial, thus allowing researchers to determine the relative contribution of physical processes to particle/toxic dynamics. This information will permit improved prediction of the fate and exposure of chemicals in the Bay.

Role of Benthic Communities in Sediment-Associated Toxic Organic Chemical Fate and Transport in the Lower Chesapeake Bay (1991-1992)

Researchers:

Linda C. Schaffner
Rebecca M. Dickhut
Virginia Institute of Marine Science

As indicated by recent studies of sediment transport and the stratigraphic record preserved in near-surface sediments, benthic communities have major impacts on sediment dynamics in the Chesapeake Bay. Thus, benthic organisms have a high potential to influence toxic chemical fate as well as the transport and recycling within the Bay's estuarine system. In particular, estimates of rates of bioturbation and patterns of toxicant storage within the sediment are essential for modeling transport probabilities in this environment and in other habitats where biological reworking of bottom sediments exceeds physical reworking. This study will provide information necessary to predict the relative importance of biological versus physical controls on the fate and transport of toxicants.

—Beth Hens

Of all the life buried in, actually burrowing through the soft mud and sand of the Chesapeake Bay, the hard clam is the most commercially valuable.

In Virginia, *Mercenaria mercenaria* ranks among the top ten in terms of the wild harvest. Preliminary data from the Virginia Marine Resources Commission indicates that 1,068,243 pounds of hard clams were harvested in 1991 with a value of $4,063,696. In 1990 1,559,108 pounds were harvested at a value of $5,695,741. Impressive as they might be, these figures only represent the wild harvest. Aquaculture operations in the Commonwealth are believed to contribute substantially—close to half—of the total U.S. commercial hard clam aquaculture harvest. Approximately 20 million cultured clams were produced last year in the state of Virginia.

The Virginia Institute of Marine Science (VIMS) has had a long involvement with culturing hard clams. VIMS's role has been to perform research at its Wachapreague lab, and to gather existing information for further dissemination to aquaculturists. Much of the work at the Wachapreague lab has been pragmatic; every attempt was made to adapt materials an aquaculturist might have on hand or access to—as opposed to designing new, expensive technology which might be well beyond the fiscal means of watermen. The methods and information provided by the Wachapreague lab have been highly successful. Many of the commercial operations on the East Coast have sent employees to the annual VIMS clam culture workshop. Over the years, technicians have come from as far away as Mexico, Venezuela, Chili, Argentina, Ireland and the Philippines to learn methods.

Over a period of many years, Virginia Sea Grant has sponsored workshops and produced a number of publications about hard clam culture and economics. Recently, the National Coastal Resources Research and Development Institute produced a fiscal guide to hard clam culture, *Investing in Commercial Hard Clam Culture: A Comprehensive Guide to the South Atlantic States.* The guide—written by a team of Sea Grant economists and biologists from Virginia, North Carolina, South Carolina, Georgia and Florida—is intended as a self-help manual for potential clam culturists and investors. The book focuses on economic analysis and investment guidelines. Topics reviewed include: basics of hard clam culture; beginning a new culture system; permitting and leasing conditions; culture techniques; nursery systems; growout methods; marketing the clams; financing a clam culture operation; and financial feasibility. A limited number of copies are still available. Virginia residents can order a free copy by writing Virginia Sea Grant Marine Advisory Service, Virginia Institute of Marine Science, Gloucester Point, VA 23062. If you are not a Virginia resident, contact the Sea Grant program in your state. ❖

A Not Entirely Sedentary Existence

Mercenaria mercenaria, the hard clam, belongs to the massive invertebrate grouping of mollusks, a phylum which includes clams, oysters, scallops and snails.

Life starts for the would-be hard clam in spring or early summer when sperm is released by the male into the surrounding water. This triggers the release of eggs by the female. The fertilized eggs soon become veliger larvae which swim and feed while drifting with the water currents. The two outer shells form and finally the clams, made heavy by the shells, drift down to the bottom. At first the young clam attaches itself to the bottom by producing a byssus thread. It later loses the ability to produce this thread and at this point uses its foot to secure its place on the bottom. By alternately extending, swelling and contracting the foot, the clam pulls its body into the mud or sand.

Hard clams are normally near the surface of the bottom and their siphons are exposed. One siphon brings in water that carries oxygen for respiration and food in the form of microscopic algae. Some of this food is retained and the rest, along with foreign particles and filtered water, are expelled through the other siphon. To escape predators, hard clams will burrow deeper. Juvenile or small clams are fare for a number of predators, including blue crabs, conchs, sting rays, horseshoe crabs and moon snails.

Harvesting methods differ quite a bit from state to state. Patent tongs are used extensively in Virginia, but hand tongs are also employed. On a recreational level, clams are uncovered with a rake or by "treading," by locating clams with one's bare feet.

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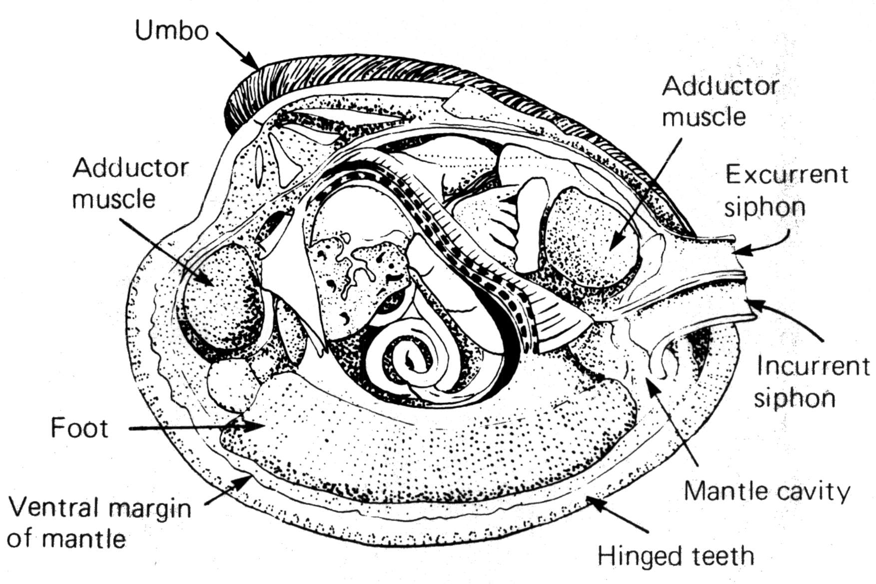


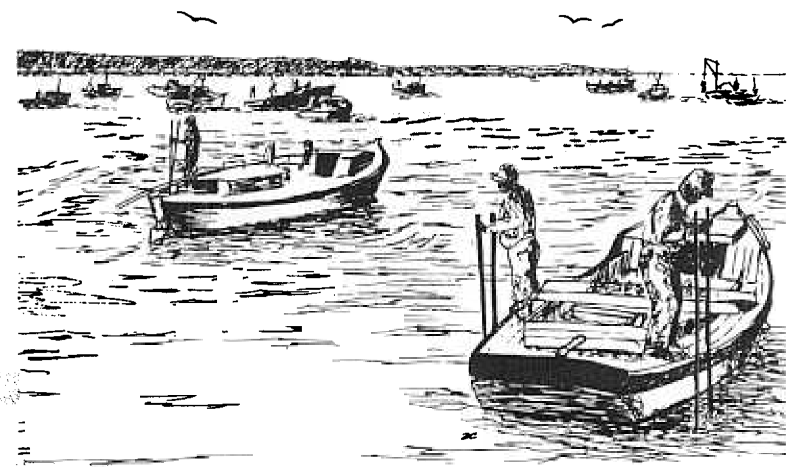
The Hard Clam

Delaware Sea Grant

Information in this article was adapted from a Delaware Sea Grant publication, "The Hard Clam." It can be obtained by writing University of Delaware Marine Communications Office, 263 East Main St., Newark, DE 19716. A similar publication, "Bountiful Bivalve, The Hard Clam," is available from Virginia Sea Grant, Virginia Institute of Marine Science, Gloucester Point, VA 23062.

Cream of Garden Herbs With Poached Oysters in Champagne

1/2 oz. fresh herbs (chives, fennel, dill, chervil, tarragon, basil)
1/2 oz. chopped onions
1/4 cup unsalted butter
1/4 cup minced carrot, celery and leek
1 1/2 qt. chicken stock
1 pt. heavy cream
6 ea. plump oysters
6 ea. sprigs of basil
1 cup champagne (or dry wine)
salt
pepper
1 tbsp. carrots, celery, leeks, diced fine



Method:

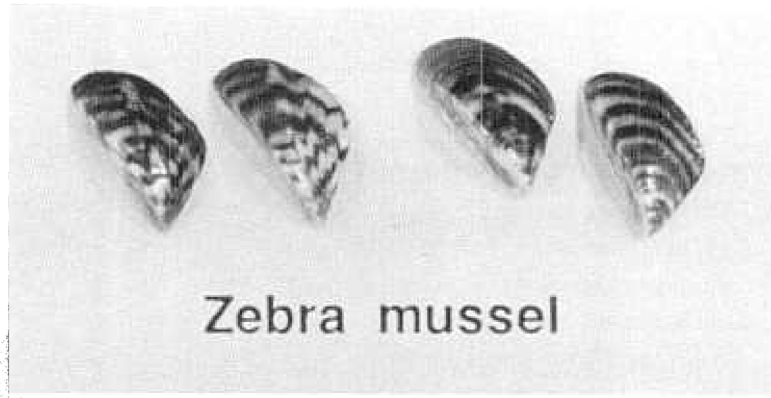
Pick herb leaves from stems, save stems.
Sweat onions, celery, carrots and leek.
Add chicken stock, salt, pepper and herb stems.
Simmer for about 20 minutes.
Puree soup through strainer or food processor.
Add cream slowly.
In saute pan, saute fine minced vegetables, add herbs until tender, add to soup.
Poach oysters in champagne for a few seconds.
Place oysters in soup bowl.
Finish soup with juice and butter.
Ladle soup over oysters and garnish with sprig of basil.

Serves 4-6

Recipe by Hans Schadler, Williamsburg Inn, Williamsburg.

Marine Notes

Dreissena polymorpha, The Unwelcome Colonizer



Zebra mussels (*Dreissena polymorpha*) have been a prodigious source of problems since their unintentional introduction into the Great Lakes. They arrived in the U.S. via a European ships's ballast water.

In the last six years the thumbnail-size, freshwater bivalves have cost industries and municipalities millions of dollars. All of the Great Lakes have been colonized by zebra mussels and they have also been collected near the Tennessee River and the Susquehanna River near the New York-Pennsylvania border.

The zebra mussels's small size belies its power to cause difficulties. The bivalves grow in clusters and can become so numerous that they clog the intakes of power generating plants, waterworks and other facilities. Zebra mussels average one-half inch in length but can grow to two inches during their five-year life span.

The damage caused by zebra mussels is not just economic. The freshwater shellfish can compete with small fish and native mussels for small, suspended food particles. High densities of zebra mussels can quickly deplete the food resources that are essential to the survival of native fishes and other aquatic animals.

A great deal of research is being conducted by the national Sea Grant network as scientists seek information to mitigate the problem. The zebra mussels' ability to rapidly expand has prompted a host of Virginia agencies, including the Fisheries Division of Game and Inland Fisheries and Virginia Sea Grant, to initiate public awareness programs.

How to Identify

Zebra mussels are small, usually less than an inch long, with shells having dark and light bands. They are the only freshwater mussels attached in clusters to submerged objects.

Here are a few measures which can be taken to prevent the spread of zebra mussels:

Don't bring them to Virginia

- ☐ Zebra mussels can be accidentally transported to Virginia by boaters and anglers travelling between waterways. If you are in infested waters, check your boat and trailer for attached adults. Inspect live wells, bait buckets, trailer and tires, and all boat parts. Leftover bait or water should not be transported.

- ☐ Drain all water from boat and hose off boat and trailer. Washing is important even if adults cannot be detected. Allow boat and trailer to dry 2-4 days, preferably a week. Adult zebra mussels can live up to 7 days without water.

- ☐ Don't throw them back. If you find a zebra mussel or cluster, scrape off and save in alcohol for biologists to identify. Place the rest in a bag, crush, and dispose of in trash. Do not leave any on the ground where they can wash back into the water.

Report all suspected sightings to the Fisheries Division of Virginia Department of Game and Inland Fisheries at (804) 367-1000.

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Estuaries Day 1992

September 19th
10 a.m. – 5 p.m.
York River State Park
Taskinas Creek National Estuarine Research Reserve
Croaker
804/566-3036

Join us for a day of fun-filled educational activities about our estuaries. We will offer hikes, canoe trips, water quality testing aboard the research vessel *Bay Eagle*, exhibits, a marsh cleanup, and terrific theatrical performances by the life-sized puppets of New York's acclaimed Arm-of-the-Sea Theater. Estuaries Day is part of a three-week celebration of our nation's coastal habitats.

Directions: From Interstate 64 west of Williamsburg, take Croaker Exit 231B (old Exit 54B) and follow the brown signs for York River State Park. The address is 5526 Riverview Road.

Fees: $2 per car; $8 per bus. Groups should register by June 30. Call 804/566-3036.

On the cover:

The cover art is an adaptation of an illustration from *Life in the Chesapeake Bay*, a book by Alice Jane and Robert Lippson. *Life in the Chesapeake Bay* is an excellent guide for both the curious observer and the serious student of estuarine ecology. The book is published by Johns Hopkins University Press, 701 West 40th Street, Baltimore, Maryland 21211.

The Lippsons also conduct tours of the Bay and its tributaries. The firm name is Chesapeake Bay Nature Cruises and Expeditions, P.O. Box 833, St. Michaels, Maryland 21663.

Adaptation by Dianne Bowers.

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

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