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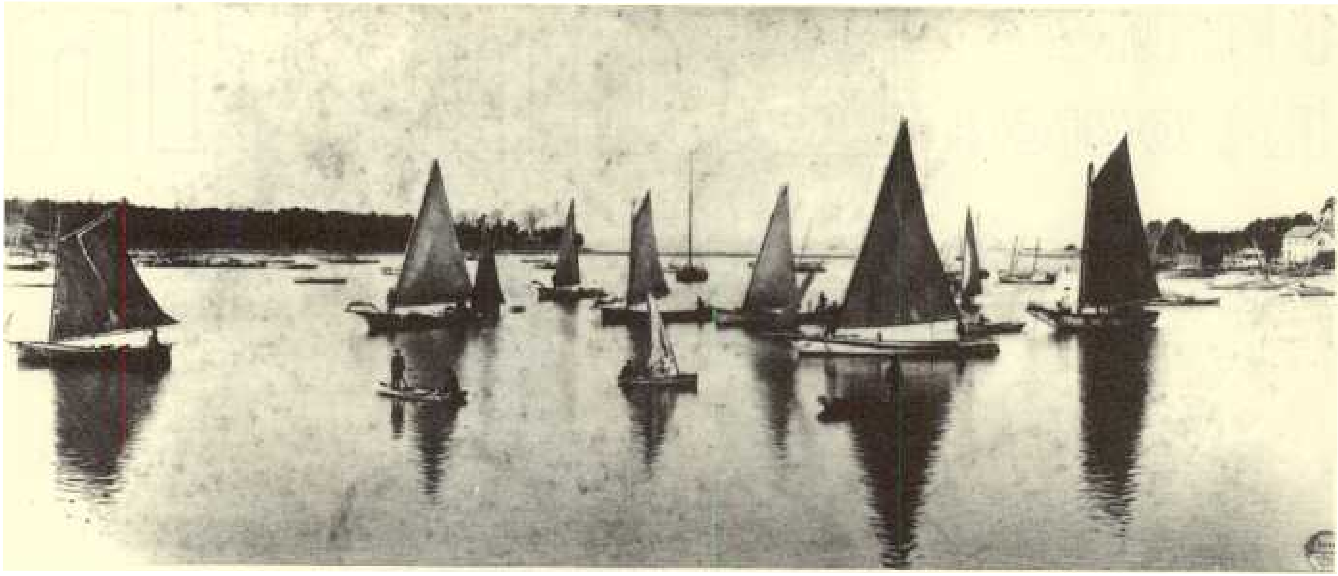
JAMES RIVER
SEEDBEDS
OYSTER DISEASE



James River Seedbeds

by Susan Schmidt

The first English ship into the Chesapeake Bay surprised a party of Indians roasting oysters on Cape Henry. Jamestown settlers survived starvation by eating oysters within sight of their fort. Seventeenth century ship captains had to navigate around great living mounds of oyster rocks in the James River.

The James River oyster bars have been bountiful for more than three and a half centuries. Despite disease, storms and pollution, the American oyster, *Crassostrea virginica,* continues to be a major fishery in the state which is its namesake. For almost a century Virginia has regulated the once-great, now-declining oyster industry.

After Lt. James Baylor surveyed Virginia oyster grounds in 1894, the state claimed all productive bottoms for public harvest. In the James River the Baylor grounds start about a mile below the James River Bridge and extend upstream to Deep Water Shoals near Fort Eustis.

What makes a good oyster bar?

Simply, oysters grow where there are other oysters. To set, oyster larvae require clean, hard bottom, such as old oyster shells. Oyster bars can be intertidal, like on the Seaside of the Eastern Shore, or 25 feet deep. Oysters occur in salinities between 5 and 35 parts per thousand (ppt). In saltier waters above 15 ppt, predators like oyster drills and MSX disease can wipe out whole oyster bars.

A good bar is not smothered by silt or fouled by organisms like algae or barnacles. There is enough food; not too much pollution, predation, or disease. To be a seedbed, an oyster bar must also have estuarine circulation which allows larvae to set or "strike" in the river.

Always the most productive oyster seed area in Virginia, the James River seedbeds now supply 77% of state seed oysters, according to Dexter Haven in his widely-acclaimed treatise *The Oyster Industry in Virginia* (1981). The Great Wicomico and Piankatank rivers and the Seaside supply the balance. Slow growth is typical of a seed area; however, the James River is not just a seedbed. It also produces most of the state's "soup" oysters, which are under three inches.

"You used to be able to walk across Deep Creek on oyster boats. There were 700 tongers; now there are 50. There were 50–60 buy boats; now there are two..."

Individual watermen work 243,000 acres of Baylor grounds; private planters lease 107,307 acres of less productive bottom from the state. The private oyster industry transplants young "seed" oysters to better growing areas for several years before harvesting them for market.

Private planters cultivated extensive oyster beds in the saltier lower James until MSX arrived in the Bay in 1960. At the same time there was a drastic reduction in spatfall in the entire James River after 1960. MSX killed no oysters above Brown Shoal, but oysters killed in the lower James could have been broodstock.

According to data from the National Marine Fisheries Service and from the Virginia Marine Resources Commission (VMRC), oyster seed harvest in the James River declined 62-63% between 1963-1975. Total state seed production peaked at more than 3 million bushels in 1955 and fell to less than 400,000 in 1975.

The harvest could be down either because there are fewer oysters on the bottom to be harvested or because planters demand fewer seed oysters. Before 1960, private production was 4-5 times greater than public harvest; now private and public harvest are almost equal.

James River oysters also suffered from freshwater runoff in big storm events like hurricane Hazel in 1954 and tropical storm Agnes in 1972. Chlorine from sewage treatment plants can kill oyster larvae, and chemicals from industry and agriculture can destroy oysters or their food. More construction means more siltation; as filter-feeders, oysters need clear water. Excessive nutrients in the water can cause overgrowth of fouling organisms. Any of these factors may compound the others so that weaker oysters are more susceptible to predation or disease.

Biological and physical scientists at the Virginia Institute of Marine Science (VIMS) are now studying how to enhance the natural productivity and to prevent further deterioration of the James River seedbeds.

Spatfall monitoring since 1960 illustrates a major decline in set, as well as wide variation in annual setting patterns and survival rates. However, no data clarify initial attachment rates, intensity of set, or the cause of mortality during the first growing season. Working in the James River and in the lab at VIMS, biologists Reinaldo Morales-Alamos and Jim Whitcomb are quantifying oyster mortality from fouling and predation. They are considering fouling by mussels, barnacles, bryozoans, and worms and predation by snails, flatworms, mud crabs, and blue crabs.

VIMS scientists continue to survey James River seed rocks for survival of yearling and older oysters. VMRC provides catch data on the number of older oysters per bushel of cultch, or shell substrate. After locating and counting adult oysters in the James, scientists will measure successful gamete production from separate seedbeds to identify the richest broodstocks.

River circulation determines how far larvae float in two weeks from the broodstock where they are spawned. Little is known of small-scale circulation patterns in the James River. Bruce Neilson at VIMS is directing a team of physical oceanographers investigating the circulation and water quality of the James.

Over short and extended time periods these scientists will measure direction and speed of currents, tidal cycles, and water mass interfaces. They will study exchanges between up and downriver, north and south shores, surface and bottom waters, channels and shoals. A hydraulic model will project the transport of oyster larvae within the James River, between the river and the Chesapeake Bay and between the river and its tributaries. The model can also estimate how much pollution reaches the broodstock and seedbeds from sewage treatment plants, the shipyard, and Elizabeth River.

Because of the continued decline of seed production and reduced commercial landings, VMRC has recognized the need to manage the oyster industry. Using information provided by VIMS scientists, VMRC will begin to develop an oyster management plan this year.

people
on the water

A dredger replants oysters in Eastern Bay, below. Right, a tonger is reflected in Tilghman Creek. Aubrey Bodine photographed Chesapeake Bay watermen for the Baltimore **Sun** *magazine from 1920 to 1970. His pictures have been collected in* **My Maryland, Chesapeake Bay and Tidewater,** *and* **The Face of Virginia.** *These photographs appear courtesy of The Mariners Museum in Newport News, Va., which has a collection of Bodine negatives.*

"You used to be able to walk across Deep Creek on oyster boats. There were 700 tongers; now there are 50. There 50 to 60 buy boats; now there are two," Steve Perok said.

At his dock in Menchville on Deep Creek, Steve Perok unloads seed oysters harvested in the James River seedbeds.

"Ever think what a paradise this used to be," Perok asked. "You could not starve. It doesn't cost the taxpayer a cent; Mother Nature does it all--provides food and a living."

Since 1946 David Insley of Poquoson has tonged in the James River, from sunrise to sunset, from October to June.

"It gets in your blood," Insley said. "Sure it's cold; February, we'll break ice to get out of the creek to work."

Tongs are 16-24 foot poles crossed like scissors with heavy metal-toothed baskets on the ends. Insley lowers the poles and opens and closes the teeth on an oyster rock. He knows the feel of the bottom and lifts the tongs when they're full. In a balancing act on the washboard of his boat, *Miss Shirley,* Insley swings the basket above water and empties oysters on a culling table.

Tongers come in when they have loaded 100 bushels of seed oysters. Their boats line up at the Menchville dock where conveyor belts load oysters on planters' trucks.

Like four generations before him, Skipper Garrett plants James River seed oysters on private grounds he leases in the Rappahannock River.

As in farming, Garrett uses a mechanized seed sprayer to sow oyster seeds. In a good year Garrett plants 1,000 bushels of seed oysters per acre on one-third of the 1,000 acres he leases from the state.

Inspectors for the Virginia Marine Resources Commission (VMRC) patrol the tonging fleet in the James River seedbeds. After midday when loaded boats start heading in to Deep Creek, inspectors watch tongers unload their harvest on buy boats on the dock.

At 67 Herb Sadler has worked on the James River seedbeds for 50 years. He started as a tonger at 17, bought seed oysters for 8 years, and has been an inspector for VMRC for 24 years.

"The James River is the goose that lays the egg," Sadler said. "Through the years-storms, pollution, MSX, channel dredging, chemicals washed down the river--everything has happened to the James River, it still goes on and on." –S.S.

Oyster Disease:
Trying to find the cause or cure

Several diseases kill oysters in Virginia and other mid-Atlantic states. In the 1950's *Perkinsus marinus* (Dermo) was the primary cause of oyster deaths in mid-salinity waters of the Chesapeake Bay. In 1959 *Haplosporidium costalis* (SSO) was discovered infecting oysters on the Seaside of the Eastern Shore. Since 1959-60 *Haplosporidium nelsoni* (MSX) has been a major cause of oyster deaths in Virginia waters.

From 1957-60 MSX killed 85% of oysters in high salinity waters in Delaware and Chesapeake Bays. VIMS scientists, Dexter Haven and Jay Andrews monitored the impact in Virginia as MSX eliminated oyster culture in regions above 15 ppt salinity. MSX infected 71% of the acreage of private leases and 58% of public bottoms. Andrews estimated that James River oysters, over the past 25 years, have suffered losses greater than 50% the first year after transplantation and 75-80% the second year.

The life cycle of Dermo, a coccidium, is well-known, and its stages can be cultured in a lab. The life cycles of MSX and SSO are unknown and have not been cultured. Scientists cannot artificially infect oysters with SSO or MSX. Therefore, it is impossible to conduct experiments to study how to combat these two protozoan parasites.

Two scientists at VIMS are studying these oyster diseases, either to discover the cause or to develop a cure. This research is funded by the Virginia Sea Grant College Program. Dr. Eugene Burreson wants to crack the mystery of the life cycle of SSO and, by correlation, MSX. Dr. Fu-Lin Chu is investigating whether oysters can acquire immunity to Dermo.

Also using immunological techniques, Burreson wants to find the intermediate hosts which probably harbor SSO and MSX and then to follow their life cycles. Scientists suspect that these haplosporidians use an intermediate host, an organism where a parasite develops and multiplies before infecting the main host.

An intermediate host may explain why uninfected oysters are not infected from exposure to free parasite spores or infected oysters. Also, MSX or SSO may not originate in oysters. Dr. Jay Andrews at VIMS transplanted uninfected oysters to areas of high salinity around the Bay and found oysters are killed by MSX even when there are no other oysters nearby.

It is likely that an intermediate host would probably be large enough to ingest spores of MSX and small enough to be ingested by oysters. However, the initial infection of MSX occurs on the oyster's gills instead of in the gut as might be expected if the spore is transmitted from an organism the oyster ingests. Therefore, Burreson hypothesizes that an intermediate host probably ingests spores and releases them in a free-living stage.

By solving the life cycle of SSO, Burreson can elucidate the developmental stages of the other haplosporidian, MSX. Burreson believes the starting point for unraveling the life cycle mystery is the spores produced by the disease organisms. In nature SSO spores are more readily availiable than MSX spores. However, since the haplosporidian spores are small, they need to be labeled for earlier observation. Burreson originally used a flourescent marking, but found it faded with time.

As a more permanent label, Burreson has tested an enzyme-immunoassay technique used

Eugene Burreson studies a magnified slide of SSO disease spores infecting oyster tissue, marked as black clusters by an enzyme-immunoassay label.

Susan Schmidt

routinely in human medicine for diagnosis of bacterial disease. As a first step Burreson injects SSO into a rabbit. The rabbit's immune system recognizes the parasite is foreign and makes an antibody to kill it. Antibodies made in mammals will attach to the parasite or antigen.

Burreson mixes rabbit anti-SSO serum and a goat enzyme. The enzyme link will attach to SSO in infected oyster tissues. The tiny parasites, otherwise very difficult to see, are marked as black clusters seen under a microscope. By feeding SSO spores to the main predators of dead oysters-- amphipods, crabs and other crustaceans, Burreson can tag SSO in a possible intermediate host. It would otherwise be too time-consuming to screen the broad range of organisms associated with oysters for the parasite.

If a species ingests and changes the spores, then it is a possible intermediate host. If there is any sign of spore digestion, Burreson will focus on that species. If he detects developmental stages, then Burreson will begin to piece together the SSO life cycle by analyzing sectioned tissues histologically.

In another Sea Grant project, Fu-Lin Chu is testing acquired resistance to disease by immunizing oysters with virulent and avirulent concentrations of Dermo zoospores. Like Burreson, Chu uses oysters collected from upstream bars of James River seedbeds where little or no infection occurs.

Her two methods of immunization are individual inoculation and osmotic infiltration. Osmotic infiltration, or immersion of oysters in water containing antigen, is more effective than individual injection to protect large populations in a laboratory or hatchery.

Chu has observed that oysters can take up both soluble and particulate antigens through osmotic infiltration. The uptake is positively correlated to the concentration of antigen in the water in which the oysters are immersed and to the pumping rate of the oysters. Although warmer water increases the rate at which oysters pump it, warmer water does not appear to increase antigen uptake.

For use in immunization Chu inactivates spores of Dermo by heat or formalin, homogenizes the spores and then centrifuges them to produce soluble and particulate antigens.

Chu will soon test the persistence or memory of the immune response in three groups of oysters immunized at different rates for different time periods. After long-term immunization, Chu will expose experimental oysters to virulent spores and will monitor rate of infection and mortality.

Susan Schmidt

Fu-Lin Chu shows a tray of oysters that have been inoculated intermuscularly.

Chu is investigating two types of disease resistance--phagocytosis, where a cell engulfs a parasite, and humoral, where the blood stream contains an antibody-like substance.

To test humoral resistance, Chu will monitor whether fluid and tissue from oysters inhibit the growth of disease spores in glass dishes. Chu also wants to know whether oyster blood cells can engulf and thereby inactivate disease spores. After separating non-ingested spores from blood cells, she can count number of ^{14}C - labelled spores that are engulfed by measuring the radioactivity of the blood cells.

She will compare the effects with immunized and unimmunized oysters, one- and two-year-old oysters, and two immunization techniques.

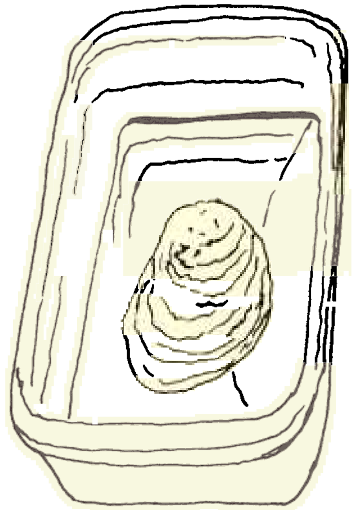
If Chu discovers immunization can induce disease resistance, spat from seedbeds and seed from hatcheries can be immunized prior to transplantation. Osmotic infiltration is an immunization technique that is feasible for large scale application. If Burreson finds the intermediate host for MSX, then the study of the oyster disease can really begin. Scientists cannot control MSX or SSO until they can infect oysters in a laboratory.

-S.S.

Marine Schoolhouse Series No. 23

by Mary Sparrow
Sea Grant Marine Educator

The Great American Oyster



Walk along the beach, and you will surely find oysters, common shells on estuarine shorelines. The oyster shell may not be pretty, but it is the home of an organism important to Virginia's fisheries economy.

How much can you learn about the oyster? Like a marine biologist, begin your study by observing the shell, the oyster itself, and its behavior. Remember, an observation is made by using one or more of your five senses. From your observations, make inferences or educated guesses about how the oyster lives.

You will need the following materials: an empty oyster shell; a live oyster in its shell (from the beach, a restaurant, or seafood market); a knife; forceps (tweezers); a hand magnifying glass or microscope; scales; food coloring; a jar; and bay water (17 ppt salinity). List your observations and compare them with the following questions.

- How much does the empty oyster shell weigh? Are the two shells the same size? Are they the same shape? How would you describe the shape of each shell?

- How would you describe the appearance of the outside of the shell? How does it feel? Are there any markings on the inside of the shell? The outside?

Use the following questions as a guide to list your inferences.

- Normally, the two shells of the oyster are joined together. If yours are not, how do you think they were connected and at what location on the shells?

- What are the circular rings or layers on the outside of the shells? How were they made?

- How does an oyster eat? What does it eat? In what ways does it move? How? Of what material do you think the shell is made? From where does this material come?

- Does the oyster have any natural enemies? The shell is the external protection for the oyster.

What do you think the body of the oyster looks like? In what ways does the shell protect the oyster?

- Do you think the oyster has a top or bottom? A right or left? If so, which shell is the top, which is the bottom? Right? Left? In what position does the oyster lie in the estuary? Why?

To observe behavioral characteristics, place the live oyster shell in a jar of salt water. Allow the oyster to sit for an hour or so undisturbed to give it time to adjust to its new environment. Place a drop of food coloring in the jar of water near one end of the shell. What happens? Why do you think this happens? Replace the salt water and place a drop of food coloring near the other end of the oyster. What happens?

Next, open the living oyster by placing it in the refrigerator for awhile, then use a knife to pry the shells apart. Observe the soft body of the oyster. Complete your list of observations. Can you decide which of the inferences you made were accurate?

Probably one of the most interesting facts about the oyster is that it changes its sex within its lifetime. Most oysters start life as males. Each winter, however, oysters absorb their reproductive organs, and males may emerge with female organs the next spring. As oysters increase in age and size, most become females.

Spawning (reproduction) takes place usually from June to October. The female releases eggs into the water and the male releases sperm. The fertilized eggs become free-swimming larvae. After 10-14 days of mobility, a larva begins to search for a hard surface to which it will attach itself. This stage of the oyster is called the spat, and the attachment to substrate is called the "strike" or "set".

By this time, the oyster has already started to form its two-part calcium shell. The two shells are connected by a strong muscle at the pointed end of the shell. As the oyster grows each season, it adds a layer of shell (similar to a tree's growth rings).

This shell helps to protect the oyster from some of its natural enemies, like crabs, starfish, some fish, and snails. It is not a complete protection, however, since each predator species has developed the means to enter the shell. For example, the oyster drill and some sponges simply drill a hole through the shell to get to the soft-bodied organism inside. The shell retains moisture if the oyster is exposed to the air at low tide.

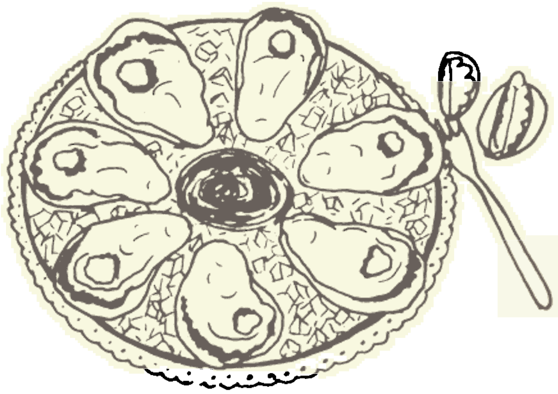
Lying immobile on its left or bottom shell (the cupped side), the oyster now depends on the currents to carry oxygen and nourishing plankton to it. By lying on the cupped side, the oyster keeps the edges or lips of the shells above the substrate to reduce the chance of clogging the gills.

A filter feeder, the oyster strains phytoplankton (plants) and zooplankton (animals) from sea water. The plankton are trapped by the mucous covering on the gills and are transferred to the mouth by five hair-like structures called cilia. The oyster expels water and unwanted material by the sudden closing of the shells. An oyster may filter as much as 100 gallons of water in a 24-hour period.

In Virginia's portion of the Chesapeake Bay, an oyster may reach its adult size in five years or so. However, the growth rate depends on the salinity of the water and the presence of predators and diseases.

This type of information took many years of observation by many scientists to collect. Making observations is a skill that must be practiced and is a means of easily developing a sizeable body of information about whatever subject you wish to learn.

Oysters



VIRGINIA HAM AND OYSTER PIE

1 pint shucked oysters, drained
1/4 pound cooked Virginia ham, cubed
3 T butter or margarine
2 cups sliced fresh mushrooms
1/2 cup chopped onion
1/2 cup chopped green onion
1/4 cup flour
1/2 tsp salt
1/4 tsp cayenne pepper
1/4 cup chopped parsley
2 T lemon juice
Biscuit Topping
1-1/2 cups flour
2-1/4 tsp baking powder
1/4 tsp salt
3 T margarine or butter
1/2 cup milk

Preheat oven to 400°. Dry oysters between absorbent paper. Fry diced ham in butter or margarine until heated through. Remove ham and drain. Add mushrooms, onions, and green onion to butter and ham drippings in the frying pan. Cover and simmer 5 minutes or until tender. Blend in flour, salt, and pepper. Stir in oysters, ham, parsley, and lemon juice. Grease a 9-inch pie plate. Turn oyster mixture into pie plate. To make biscuit topping, sift flour, baking powder, and salt together. Cut in butter until mixture is like coarse crumbs. Add milk all at once. Mix just to a soft dough. Turn onto lightly floured surface. Knead gently 5 to 6 strokes. Shape into a ball. Roll out to a 9-inch circle to fit on top of pie plate. Cover oysters with biscuit topping. Score biscuit topping. Bake for 20 to 25 minutes or until topping is lightly browned. Serves 6.

*From The Great Taste of Virginia Seafood published by the Virginia Marine Products Commission. During Seafood Month each September, the Commission sponsors a Governor's Tasting of native seafood and a Seafood Recipe contest. The cookbook selects 1982 and 1983 winning recipes for fish, clams, crabs, as well as oysters. Edited by Mary Reid Barrow and Robyn Browder, it can be ordered for $10.95 from GB Publishing, P. O. Box 7359, Hampton, VA 23666.

SUPER OYSTER STEW

2 pints fresh oysters with liquid
2 potatoes, diced
1/4 pound butter
1 cup chopped sweet onion
1/4 cup chopped celery
1/2 cup chopped green pepper
3 pints half and half
1 can evaporated milk
1 tsp salt
1/2 tsp white pepper
1 T Worcestershire sauce
1/8 tsp thyme
1/4 tsp sweet basil
1/4 tsp chives
red pepper

Drop oysters in two cups of salted boiling water. Leave no longer than 5 minutes. Remove oysters and cook potatoes in same liquid. Saute onions, celery, and green peppers in butter in a large sauce pan. Add oysters, half and half, evaporated milk, potatoes with their liquid, Worcestershire sauce and the rest of the seasoning. Simmer briefly; DO NOT BOIL. Let stand to blend flavors. When ready to serve, heat until hot but NOT BOILING. Seasonings may be adjusted to taste. Serves 8 - 10.

*Mike Oesterling, Sea Grant commercial fisheries specialist at VIMS, offers his own oyster recipe. Oesterling won the 1980 National Fisherman recipe contest.

More Sea Grant Research

More people living on the coast require more sewage treatment plants. Pathogens in sewage can be harmful to humans, and chlorine to treat sewage can kill oyster larvae. The Shellfish Sanitation Office of the State Health Department allows no shellfish harvesting where they find fecal bacteria in the water from treatment plants, septic tanks or pastures. However, the state allows oysters from polluted grounds to be relayed to clean waters to depurate for 15 days before harvest.

Under Sea Grant funding Howard Kator and Martha Rhodes at VIMS are measuring the relative survival time of indicator bacteria and pathogens in different temperatures. Kator is concerned that salmonella virus could survive longer than the indicator bacteria (*Escherichia coli*) when temperatures drop. He expects that rates of elimination vary according to environmental factors like degree of pollution, temperature, salinity, rainfall and oyster metabolism.

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With Sea Grant funding, Bruce Neilson and Gary F. Anderson have compiled an Index of Potential Productivity. Using existing data within several state agencies, they have rated all oyster beds in Virginia on salinity, temperature, disease prevalence, setting pattern and bottom type. This index can be used to predict the harvest on private grounds or to locate a hatchery.

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In another Sea Grant project with practical applications, Lehman Ellis has been investigating techniques for cryopreservation (freezing) of the gametes and larvae of oysters and clams. Frozen larvae could be available economically yearround for aquaculture. Ellis, an Iowa State University professor, working with Michael Castagna of VIMS, intends to control the rates of freezing and thawing of larvae and then to measure subsequent larval growth.

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Do customers prefer their oysters - fresh, frozen, canned, breaded or smoked? Would the state ever consider "breaking Baylor," or leasing public grounds to private planters? Economists at the Virginia Polytechnic Institute (VPI), under Sea Grant funding, are evaluating market strategies to increase the demand for Virginia oysters and are evaluating management options to increase oyster harvest on public grounds.

Oral Capps, Leonard Shabman, and Charles Coale are developing econometric models with which to advise the state. Policy options include raising retail prices, increasing the budget for cultch and seed repletion, reducing seed prices, and renting public grounds to private planters. By reviewing customer preferences, they can better design merchandising of oysters.

• •

Virginia now imports oyster shell from Maryland for cultch in repletion programs. Using seismic probing and coring, Carl Hobbs, III, will soon begin mapping reserves of oyster shells in the Rappahannock River. This Sea Grant search will satisfy basic and applied research needs. Geologists will learn more about the sedimentary history of the Chesapeake Bay. For practical purposes, the search may reveal closer sources of shell for cultch to save transportation costs for oyster managers. If Hobbs does find fossil oyster reefs, an environmental impact assessment would precede any underwater mining.

Announcements

Southeast Virginia Underwater Expo (SeaVUE '85) is scheduled for April 20, 1985, at the Chamberlin Hotel in Hampton, Va. The daylong sport diving education program will consist of seminars, numerous equipment exhibits and quality door prizes. Award-winning underwater cinematographer Stan Waterman will host the SeaVUE film festival. Sponsors of SeaVUE '85 are VIMS Sea Grant Marine Advisory Services and SeaVUE, Inc., a nonprofit diving education organization. For more information, contact Jon Lucy, Sea Grant MAS, VIMS, Gloucester Point, VA 23062 (804/642-7166).

A 1983 regional study of the mid-Atlantic recreational marlin-tuna fishery from New York to Virginia is now available. "Survey of Recreational Tuna and Marlin Fishing in the Mid-Atlantic, 1983" documents the importance of catches and expenditures associated with the offshore sport fishery. The report is available from Sea Grant Communications, VIMS, Gloucester Point, VA 23062.

SEA GRANT PUBLICATIONS

The publications listed in this section are results of projects sponsored by VIMS Sea Grant Marine Advisory Services. Order publications from Sea Grant Communications, Virginia Institute of Marine Science, Gloucester Point, VA 23062. Make checks payable to: VIMS Sea Grant.

FEASIBILITY OF CRAB MEAL PROCESSING IN THE CHESAPEAKE BAY REGION: II. An Integrated Economic Analysis for Hampton/Newport News, Virginia. Phillip R. Grulich and William D. DuPaul. SRAMSOE No. 273, 41 pages. First copy free to Va. citizens; $2 to others.

SPLIT WINCH-COMBINATION NET REEL ALLOWS GREATER VARIETY OF FISHING. Philip Cahill. Advisory No. 26. 50 cents.

SQUID NETS OF THE MID-ATLANTIC. Philip Cahill and W. E. Mansfield. Advisory No. 27. Free to Va. citizens; $1 to others.

A REPORT TO THE OYSTER INDUSTRY OF VIRGINIA ON THE BIOLOGY AND MANAGEMENT OF THE COWNOSE RAY (*Rhinoptera bonasus, Mitchill*) IN LOWER CHESAPEAKE BAY. John V. Merriner and Joseph W. Smith. SRAMSOE No. 216, 33 pages. $1.00

THE PRESENT AND POTENTIAL PRODUCTIVITY OF THE BAYLOR GROUNDS IN VIRGINIA (Vols. I and II). Dexter S. Haven, James P. Whitcomb and Paul C. Kendall. SRAMSOE No. 243; Vol. I, 167 pages. Vol. II, 154 pages plus 64 charts. $10.00 for both volumes.

THE OYSTER INDUSTRY OF VIRGINIA: ITS STATUS, PROBLEMS AND PROMISE. Dexter S. Haven, William J. Hargis, Jr., and Paul C. Kendall. Special Paper in Marine Science No. 4, 1078 pages. $16.00

THE OYSTER INDUSTRY OF VIRGINIA: ITS STATUS, PROBLEMS AND PROMISE: EXECUTIVE SUMMARY. Dexter S. Haven, William J. Hargis, Jr., and Paul C. Kendall. SRAMSOE No. 168, 149 pages. $2.00

COMMERCIAL FISHING NEWSLETTER. A free subscription to this quarterly newsletter may be obtained by written request. Recent back issues are available.

TIDE GRAPHS FOR HAMPTON ROADS, VIRGINIA and TIDE GRAPHS FOR WACHAPREAGUE, VIRGINIA. Published quarterly. Free subscription obtained by written request.

Marine Resource Bulletin
A Sea Grant Advisory Service

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Dr. Frank O. Perkins . . . . . Dean/Director, Virginia Institute of Marine Science
Dr. William Rickards . . . . Director, Virginia Sea Grant
Dr. William D. DuPaul . . . . Director, Marine Advisory Services

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. Address inquiries and comments to the editor.

Susan Schmidt. . . . . Editor

Cover Note

Tongers still harvest seed oysters in the James River and unload them in Deep Creek as they did in this 1905 picture. The cover is a blow-up of the panorama of Deep Creek on page 2. These pictures appear courtesy of The Mariners Museum, Newport News, Va.

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