Marine Resource Bulletin

A Sea Grant Advisory Service of the College of William and Mary

VOL. XII, NO. 2 SUMMER 1980

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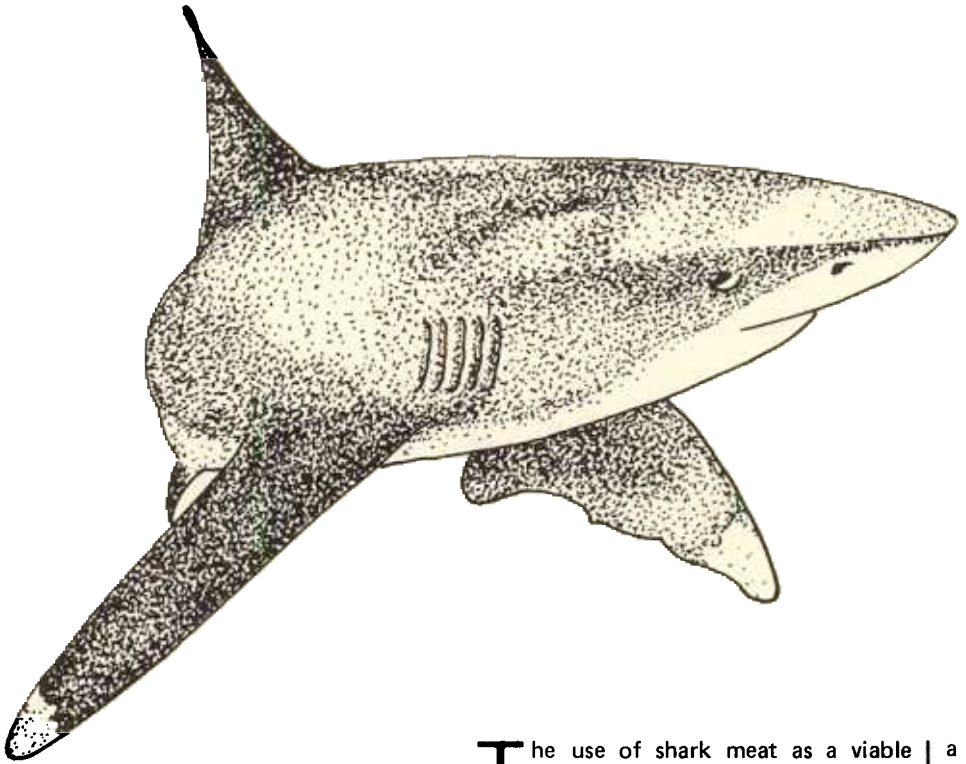


ILLUSTRATION: DICK COOK

The Potential for a Shark Fishery in Virginia

The use of shark meat as a viable food resource is increasing worldwide; and has prompted interest in Virginia to develop a commercial fishery for sharks. In an effort to assess the potential for a commercial shark fishery, John A. Musick and James A. Colvocoresses of the Virginia Institute of Marine Science/College of William and Mary have written a research publication titled "A Preliminary Evaluation of the Potential for a Shark Fishery in Virginia."

The report, partially funded by Sea Grant, is designed to assist resource users and managers in assessing the potential for the development of a commercial fishery for sharks in the mid-Atlantic Bight, where sharks are an abundant but unutilized resource. While sharks are currently considered a nuisance by most local commercial fishermen, large and established fisheries for shark are presently in operation in other parts of the world, particularly Europe. In view of this, the present investigation was undertaken in order to determine the practicality of a commercial shark fishery in Virginia, and if so, to identify those areas requiring future research for the optimal development and management of the fishery.

"The reason why shark fisheries haven't been introduced here before is because they have never been economically practical. Recently, however, prices have risen sharply and sharks are now being exported to Europe for consumption," said Colvocoresses.

Four factors are necessary for the making of a successful fishery. These factors are: the availability of an adequate stock of the target species, a means of harvesting the resource, a suitable method of processing the species into a saleable product and the existence of a suitable market for the product.

Surveys have revealed that the most abundant shark species in the Chesapeake Bay are the sandbar shark *(Carcharhinus plumbus)* abundant in the summer and the spiny dogfish *(Squalus acanthias)* present in Virginia during the winter months. Studies also indicate that the sandbar shark is one of the most abundant large predators on the Chesapeake Bay during the summer and early fall. Although the sandbar shark is available in harvestable quantities, lack of knowledge concerning the sandbar's natural mortality coupled with its low reproductive rates make the sandbar shark questionable as a fishery potential.

Spiny dogfish, which prefer a bottom water temperature of 7° to 13°C., have been the target of numerous commercial fisheries throughout the northern hemisphere in the last 50 years. They are extremely abundant in the Chesapeake Bight from December to April. The spiny dogfish is so abundant during these months that the annual harvesting of even a small portion of the population would support a major fishery. "There are over 100,000 tons of dogfish available in the Chesapeake Bight during the winter months. Just a fraction of that would amount to a large fishery," said Colvocoresses.

Studies of the life history of the Atlantic spiny dogfish have shown that spiny dogfish females produce an average of five young every two years and have a gestation period of 22 months. Females probably mature between seven and eleven years of age and grow to a length of 80 centimeters. Males appear to mature between four and eight years of age at a length of 62 centimeters. The

"Economically, the present market for shark meat is in Europe, not in the United States."

maximum longevity of the Atlantic spiny dogfish is 20 years or more.

In addition to the sandbar shark and the spiny dogfish, several other species may have limited fishery potential in Virginia. Smooth dogfish *(Mustelus canis)* appear briefly, but abundantly, in inshore waters during their migration period. Two species of oceanic sharks, the short-fin mako *(Isurus oxyrhinus)* and the blue shark *(Prionae glauca)* have been taken in offshore longline sets along the continental shelf break.

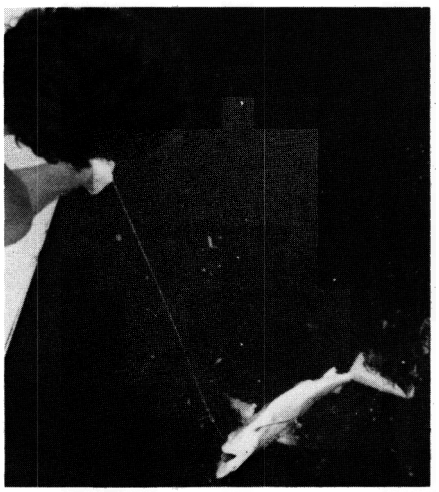
Harvest methods play a very important role in the development of a fishery. Sharks are usually harvested by using one of three methods: longlines, gill nets and trawls. The methods used may vary according to the species, local bottom conditions and the economic capabilities of the fishery.

Gill nets are effective for the capture of virtually any size shark. Trawling is often the most efficient method for the capture of small sharks. Since most of the larger sharks are capable of avoiding trawls, longlines and gill nets are employed. Due to the abundance of spiny dogfish during the winter months in Virginia, any of the three harvest methods would be successful.

Although trawling is the most cost-effective method for large-scale harvesting of the spiny dogfish, trawling operations must be conducted with caution. If the net is fished for an excessive amount of time, it may become so filled with dogfish that the catch cannot be brought aboard without damage to the trawling gear. Because sharks tend to damage harvest gear, they are often considered a nuisance by fishermen. "Usually sharks are considered nuisances by commercial fishermen because they consume other commercial fish and damage gear by either tangling in or tearing nets," explained Colvocoresses.

The processing of a shark depends on the product(s) which may be the most profitable. In general, small sharks are found to have the greatest value when processed for food. Larger sharks are valued for their hides and fins. Exceptions to the rule are the mako and porbeagle sharks. These large sharks are highly sought after as food.

Colvocoresses states that even though the present domestic market for steaks of large sharks is small, it is growing very slowly. "The taste of shark meat would be a pleasant surprise for most people, but it's going to take a while for the public to accept it."



PHOTOGRAPH: KEVIN GRAY

Longlining for shark.

"Economically, the present market for shark meat is in Europe, not in the United States," states Musick. "It will be difficult to get people here to accept shark as a food. We will have to re-educate the public toward accepting shark as a food, which could be costly and time consuming."

Sharks to be processed for food, as is the case of the spiny dogfish, must be carefully handled to avoid spoilage. During the processing of the spiny dogfish, the head, fins, skin and entrails are removed, leaving the flesh which is wrapped and quickly frozen. Sharks to be processed for hides and fins must be skinned within 24 hours after the shark is dead. Unprocessed sharks are virtually unmarketable.

Shark liver oils, which are used in small quantities by textile, tanning, cosmetic and pharmaceutical industries also hold some value. However, the largest potential market for sharks is as food. Fresh shark steaks and fillets are presently being sold at fish markets in many areas of the United States. "In Florida, large sharks are sought after as food," said Colvocoresses.

With the exception of dogfish there is little export demand for shark meat. In southern England, dogfish are virtually the only species used in England's "fish and chips" trade. In West Germany, spiny dogfish belly flaps are very strong in import demand.

European dogfish have been heavily exploited and overfished during the past few decades. As a result, the price of spiny dogfish in Europe has risen and an import market for dogfish has developed. On the West German market dogfish, which was 17 cents a pound in 1967, is now 65 cents a pound. The price of belly flaps has risen from 30 cents a pound in 1967 to $1.50 a pound in early 1980.

Musick believes the problem of overfishing can plague U.S. fisheries if careful steps aren't taken. "Even though dogfish are abundant, they can be overfished quickly. Some are taken prematurely and these fish have to grow to a certain size before they can reproduce. Overfishing must be controlled." said Musick.

Colvocoresses and Musick state that the long-term development of shark meat as seafood looks bright; however they point out that no dramatic increase in the domestic demand for shark meat appears eminent unless a major producer of prepared food products decides to use shark meat.

There appears to be little doubt that a Virginia fishery for sharks has the potential to expand within the next few years, but just how much depends on demand. "The key to the ultimate success of the fishery is local demand," points out Colvocoresses, "Based solely on exports the fishery will develop, but slowly. When shark meat becomes popular here, that's when the fishery will take off."

According to Musick, developments of the shark export fishery should begin to take place within about a year, however, problems concerning economics and mechanized processing must be combated. "The success of the fishery depends on the value of the dollar, cost of fuel necessary for fishermen to trawl for dogfish, cost of labor for processing and how much money the German buyers will be willing to pay for dogfish," said Musick. "If the shark fishery becomes profitable, it will fly."

Copies of "A Preliminary Evaluation of the Potential for a Shark Fishery in Virginia," SRAMSOE No. 234, are available upon written request from Sea Grant Publications, VIMS, Gloucester Point, VA 23062. The first copy is free to Virginia residents; all other copies are $1.00.

-Kevin Gray

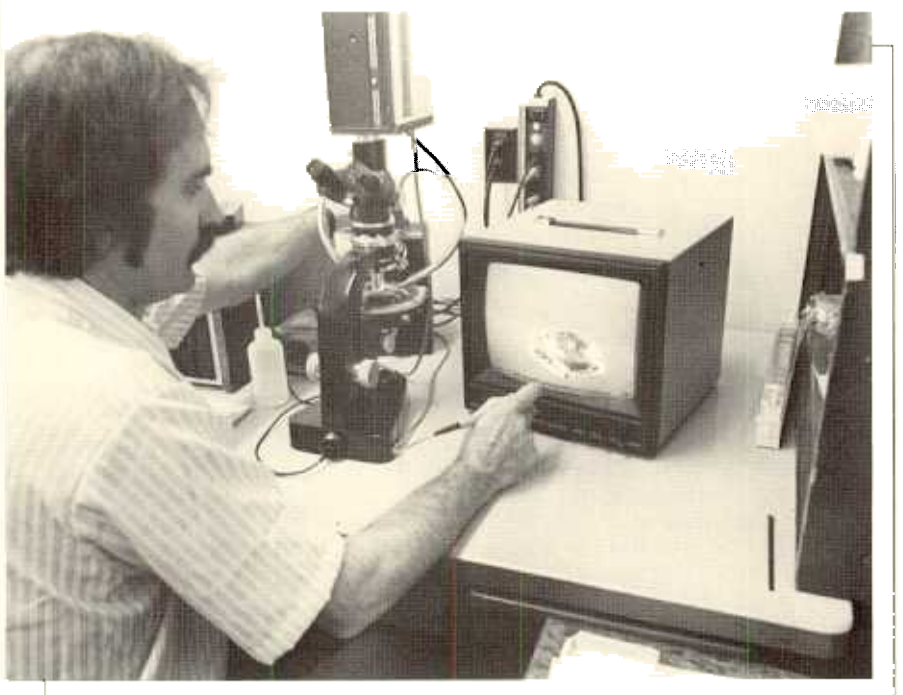
Fourier Analysis of Quartz Grains

a new method of interpreting sediment movement

Scientists at the Virginia Institute of Marine Science/College of William and Mary are studying sediment movement in the lower Chesapeake Bay by analyzing the shape characteristics of ordinary quartz grains with a new procedure called Fourier Grain Shape Analysis. This two-year research project, funded by Sea Grant and the National Science Foundation, maintains that quartz grains carry a definite shape 'signature' which can identify a sediment's source and history of movement. An understanding of the complexities of sediment movement is fundamental to investigating shoaling in channels, wandering barrier islands, beach erosion and the shifting of offshore dump sites.

Through the Fourier Analysis of quartz grains it may be possible to distinguish between sands entering the Chesapeake Bay from the continental shelf and sands that have come from rivers or an eroding shoreline. This analysis would provide data to make decisions regarding dredging, waste disposal, and containment of harmful contaminates introduced into Bay sediments. This research may also provide an effective means for investigating sedimentary problems on a local scale incuding erosion, beach nourishment and shoreline protection.

Quartz grains, which comprise 90% of marine sediments, have identifiable shapes because quartz is born into igneous rock as a secondary mineral. This means that quartz enters igneous rock after the rock is formed, thus taking on an identifiable print of the original 'parent' rock. This shape information in quartz grains can identify not only the origin of the grain, but also its history of movement during which some aspects of its original shape are modified through abrasion. The fact that it is virtually impossible for two collections of grains from different sources to have the same shape signature provides an unprecedented capability of tracing massive quantities of coastal sediments.



PHOTOGRAPH: KYM YOUNG

Dr. John D. Boon studies magnified quartz grain image on television monitor.

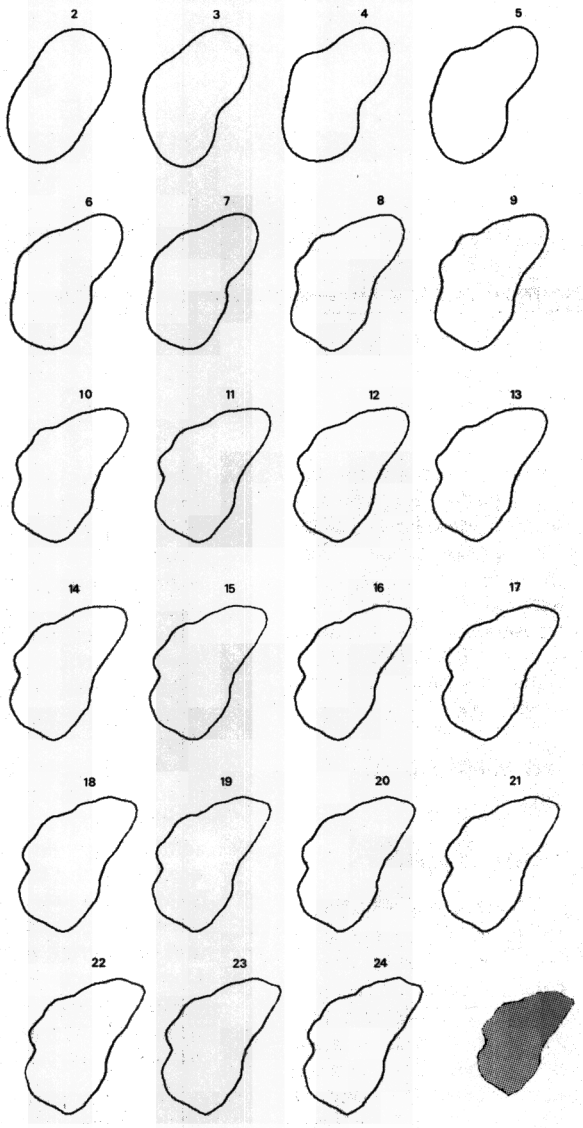
"A body of sand that can be 'tagged' in this way can be traced," said principal investigator Dr. John D. Boon, Associate Marine Scientist in the VIMS Department of Geological Oceanography. "This would be a very useful capability when it comes to practical problems such as identifying the source and pathway of sediment moving into an area of rapid shoaling or finding out where spoil material goes when it is dumped on the bottom."

Sediment research is currently active in the Chesapeake Bay and extensive collections of bottom samples are being made available to the VIMS quartz grain analysis study. Sediment samples from the Environmental Protection Agency's Chesapeake Bay Study Program and the National Ocean Survey's basic hydrographic surveys of the Bay's entrance and nearshore areas are routinely collected and transferred to VIMS. Besides Boon, VIMS scientists involved in the quartz grain study are co-principal investigator Dr. David A. Evans, head of the Department of Data Processing and Statistical Services, Dr. John M. Ziegler, Assistant Director of Physical Science and Ocean Engineering, and Harold Hennigar, a graduate student working towards his Ph.D.

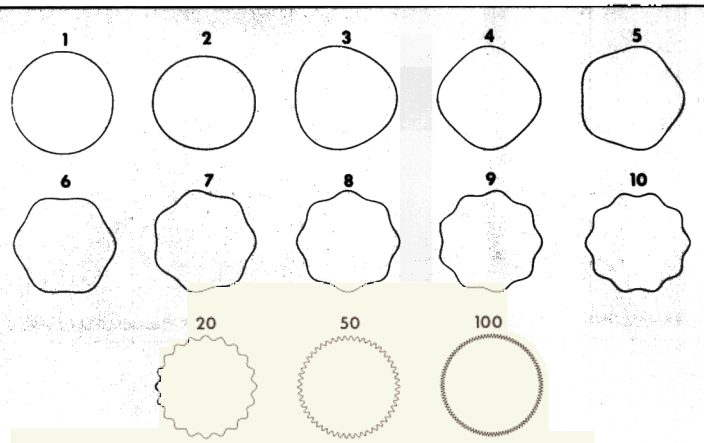
"The only thing that has held us back from this type investigation in the past," Boon said, "is the lack of a means of acquiring numerical data on literally thousands of grains of sand. Now that mini-computers have entered the researcher's lab, it is very easy to acquire the data we need and to transfer it to a central computer where the mathematical calculations necessary for Fourier Analysis are done."

Fourier analysis is a method used to analyze two-dimensional particle shape. Even quartz grains with a very irregular shape profile can be easily represented by a few simple trigonometric terms (harmonics) added together in a Fourier series. The Fourier series is named after Baron Fourier, a well-known 19th century French mathematician.

Sediment samples are initially washed to remove salts, then sieved to extract the grain sizes selected for analysis. Quartz grains are identified, separated, washed, dried and mounted on glass slides. A petrographic microscope with



(Figure 2) Reconstruction of a typical grain shape by the addition of successive harmonics.



(Figure 1) Shape of individual harmonics when added to a unit circle.

The method used to analyze two-dimensional particle shape is called Fourier Analysis. Even sand grains with a very irregular shape profile can be easily represented by a few simple trigonometric terms (harmonics) added together in a Fourier series.

"To illustrate," said Boon, "Imagine an earth covered entirely by water. In two dimensions its undisturbed surface would be a smooth circle, like the face of a clock. Now if we choose to add some simple waves to this surface, we might begin with a long wave having a low at 12, a high at 3, another low at 6, another high at 9, and finally a low again at 12. This kind of circular wave with two highs and lows would be called a second harmonic (Harmonic 2, Figure 1). Like the hours on the clock, it repeats the same sequence without end. The third harmonic would have three highs and lows, the fourth four highs and lows, and so on, each with sucively shorter wavelengths so that they 'fit' the circle.

"We can represent virtually any shape (Figure 2) by adding the appropriate number of harmonics with the correct amplitude and phase (phase gives the position of the high relative to the origin in use). The combination for a given shape is unique, so that Fourier analysis applied to any particle yields only one amplitude and one phase for each harmonic."

a computerized television camera attachment electronically scans the quartz grains and projects a magnified grain image on a television monitor. A minicomputer then converts the image into an array of electronic 'dots' and selects all points lying on the grain's edge. These points are stored in the computer's memory, ready to be used for Fourier Shape Analysis.

"Before, minicomputers'" said Boon, "we would have had to use a special drawing attachment on the microscope and trace the projected image of the sand grain by hand on paper, then try to get the boundary coordinates by scaling and finally enter the numbers on punched cards. An impossible task, really, considering the large number of grains that have to be analyzed in each and every sample we have."

Geologists and soils engineering scientists have long utilized information on the general size characterisitcs of sediments, but only in the last few years has anyone attempted to analyze the very detailed patterns contained in the shape of individual particles. Using the Fourier method to analyze shapes of sand grains is a new concept initiated by Dr. Robert Ehrlich of the University of South Carolina's Department of Geology. Previous methods of grain shape emphasized sphericity and roundness, concepts that do not achieve the desired result of extracting all essential information contained in quartz grains, which are non-symmetric and irregular. Fourier analysis can be made to fit a grain shape as precisely as possible, and is a much more useful method of analyzing quartz grains.

Fourier Grain Shape Analysis is a more direct and inexpensive method of tracing sediment movement than early attempts using flourescent dyes to 'tag' sand. The amount of dyed sand used in these cases is usually small in comparison to the area under study and tends to become buried or removed, making accurate interpretations of longterm sediment movement difficult.

The utility of information available through Fourier Grain Shape Analysis has great potential and has only begun to be exploited in field studies. This new method of particle shape analysis deserves singular consideration in its application to real world problems and may become a problem- solving tool within the Chesapeake Bight.

"A demonstration of the technique would be very valuable in its own right." said Boon, "But, in doing so, we contend that some very basic questions about sediment movement on continental shelves may be answered. *-Kym Young*

BULLETIN

Transporting Eelgrass Offers Hope

Many watermen and sport fishermen, as well as soft crabbers wading the shoreline are acutely aware of the disappearance of eelgrass in the Chesapeake Bay. Its absence affects not only the availability of peeler and soft crabs but also finfish, especially major predator fish such as trout, flounder, rockfish, and the fish these predators feed on.

Eelgrass, the dominant type of submerged aquatic vegetation in the lower Bay, began its dramatic decline in the early 1970's. Today the shallows of the entire Rappahannock River, major sections of the York River, the Piankatank River and the Potomac River are essentially devoid of eelgrass.

Scientists throughout the Bay continue to work on understanding what caused the twentieth century record decline of eelgrass and VIMS scientist Dr. Robert J. Orth and his associates have determined the grass can be successfully transplanted. This means the few remaining areas with eelgrass can potentially serve as reservoirs for re-establishing grass beds in denuded areas.

Orth has found that the successful growth of transplanted plugs of eelgrass largely depends on the time of year transplanting occurs. The greatest survival and growth of eelgrass plugs occurs when transplanting is done in the fall (September and October). Within six months, plugs produce a visible grass patch on the bottom twice to three times the area of the original planting. The success with spring-initiated transplants has not been as dramatic.

Water turbidity, water temperature and biological activities of snails and crabs attracted to the new plugs seem to affect the survival and growth of the transplants. It is hoped that the effects of light and shade on transplants can be more thoroughly examined in the near future.

This work has the potential for restoring the important eelgrass beds to the Bay's shallows, and Orth hopes to conclusively demonstrate whether a transplanting program will restore the once luxurious and critically important eelgrass resource.

Persons interested in learning more about the transplanting program should contact Dr. Orth at 804/642-6131, Ext. 164. A non-technical overview of the Submerged Aquatic Vegetation Program and Orth's eelgrass transplanting results appears in the Citizens Program for the Chesapeake Bay Newsletter (May-June 1980 Chesapeake Citizen Report, No. 13). This is available from the EPA Chesapeake Bay Program Office, 2083 West Street, Baltimore, MD 21401.
-Jon Lucy

Handicapped Students Tour VIMS

Twenty-five 15-20 year old handicapped students from areas across the country made a recent visit to VIMS as part of a five-week study of marine science. The students, sponsored by the National Science Foundation program for Academically Excellent Handicapped Students, were selected by the Marine Science Consortium in Wallops Island, Va., to participate in the course. The Consortium is the only program in the country which allows the handicapped to visit research institutions while receiving classroom instruction in the marine sciences.

At VIMS, students visited the remote sensing, crustaceology, pathology, ichthyology, and physical oceanography laboratories. VIMS scientists lectured, demonstrated techniques, and answered questions. Consortium directors signed (interpreted lectures with sign language) for the deaf students.

The tour was conducted by Marine Education specialists with the VIMS Sea Grant Advisory Services.

Paul Gerdes (r) with the VIMS Crustaceology Lab addresses a group of Academically Excellent Handicapped Students studying marine science.

PHOTOGRAPH: KYM YOUNG

Chesapeake Bay Data Gathering Study

In an effort to provide a basis for a Bay-wide monitoring system of the Chesapeake Bay's 'health' and to improve guidelines for federal and state agencies to base their decisions, the Virginia Institute of Marine Science in cooperation with the Environmental Protection Agency will continue its study of the Chesapeake Bay until 1981.

In a project spearheaded by the Environmental Protection Agency's Chesapeake Bay Program seven research institutions including VIMS along with numerous state and federal agencies conducted a simultaneous data gathering study designed to provide data on water movement, temperature, salinity, pigment, dissolved oxygen, suspended sediment and nutrients for the entire Chesapeake Bay, July 9-16. VIMS has conducted studies of the Chesapeake Bay since 1978.

Studies conducted by VIMS include: measurement of organic chemicals in the Bay, distribution of fluid mud and its behavior, animal-sediment relationship, submerged aquatic vegetation, distribution of sediment, sediment location maps, maps of the Chesapeake Bay and ecosystem analysis.

According to Dr. John Ziegler, assistant director, division of Physical Science and Ocean Engineering at VIMS, all field and lab studies of the Chesapeake Bay will conclude in 1981. "Our goal is to provide a baseline to which all future studies will be related," said Ziegler. "After our studies we will have better guidelines for state and federal agencies to base their decisions."

Financiers, Watermen Meet at Seminar

Financiers met with watermen August 21st at the Chamberlin Hotel in Hampton, Virginia, at a conference entitled "Lending Opportunities in the Seafood Industry."

Targeted primarily for Virginia's banking institutions, the program served to familiarize the state's various financial institutions with Virginia's diverse seafood industry and its investment climate. The program provided an overview of Virginia's seafood harvesting, processing and marketing sectors, as well as a look at various federal government associated financial assistance programs available to the industry. Over 65 participants attended the successful seminar.

The seminar was jointly sponsored by the Virginia Banker's Association and the VIMS Sea Grant Program under contract with the Coastal Plains Regional Commission.

Striped Bass Spawning Study

The serious decline in striped bass (rockfish) stocks along the entire East Coast has stimulated Congress to authorize appropriations of nearly $5 million in research funds. Aimed at pinpointing the causes for the decline, these funds will permit the U.S. Fish and Wildlife Service and The National Marine Fisheries Service to complement state research programs on striped bass over the next three years.

This spring at the Virginia Institute of Marine Science, in conjunction with Maryland researchers, VIMS planktologists Dr. George C. Grant and John E. Olney began sampling Chesapeake Bay tributaries for striped bass eggs and larvae as well as the microscopic food organisms on which the larvae feed.

Another group of researchers, headed by VIMS ichthyologist C. E. Richards, is tracking the survival of the spring spawned fish with beach seine sampling surveys in tributaries.

The Bay is believed to be the major spawning and nursery ground for the entire East Coast striped bass population. Scientists at VIMS began their studies in the York River this year and plan to conduct identical studies in the James and Rappahannock Rivers in subsequent years.

By determining the level of spawning activity, the availability of planktonic food for the larvae and the survival of small fish through their first year, the scientists feel they will have the information necessary to determine whether the decline of the seventies is natural or caused by man's influence on the Chesapeake Bay.

Studies on the effects of pollutants on the various life stages of the striped bass are underway at the U.S. Fish and Wildlife Service labs. Coordinated research efforts on social and economic problems facing commercial and sport fishermen as a result of the striped bass decline are being tackled by Sea Grant programs in Maryland, North Carolina, and Virginia.

-Jon Lucy

The Atlantic Blue Crab

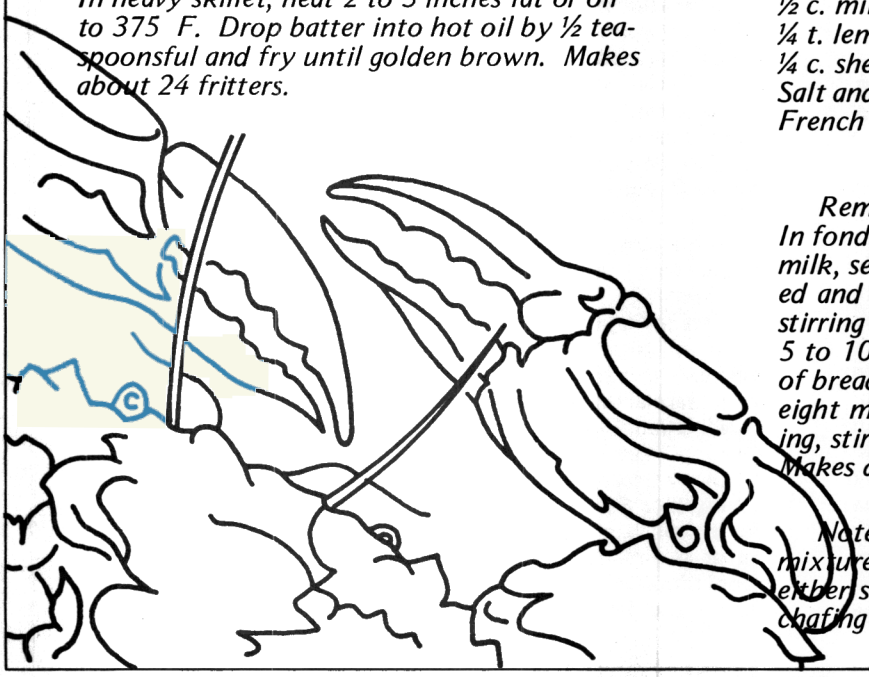
There is no mistaking the distinctive flavor of the Atlantic Blue crab, recognized throughout the nation as an epicurean treat. This shellfish is abundant in the Chesapeake Bay and its tender meat is well worth the extra effort to "pick" from the shell. Remember that any whole, fresh crab should be alive at time of cooking, or cooked immediately after cleaning. Immersing the crabs in cold water after boiling tends to prevent meat from adhering to the shell.

The meat from all kinds of crabs may be used in these delicious recipes - dishes fit for any captain's table!

Crab Fritters

½ lb. (8 oz.) crabmeat
1 egg
¼ c. milk
1 c. all-purpose biscuit mix
Juice of 1 whole lemon
1/8 t. garlic salt
¼ t. salt
½ t. lemon and pepper seasoning
½ t. parsley flakes
6 drops Worcestershire sauce
Fat or oil for frying

Remove all cartilage from crabmeat. In a bowl, beat egg, add milk; stir in biscuit mix. Add seasonings and crabmeat and mix gently. In heavy skillet, heat 2 to 3 inches fat or oil to 375 F. Drop batter into hot oil by ½ teaspoonsful and fry until golden brown. Makes about 24 fritters.



Crab Newburg

1 lb. crabmeat
1/3 c. butter or other fat
3 T. flour
½ t. salt
½ t. paprika
Dash cayenne pepper
1½ c. coffee cream
3 egg yolks, beaten
2 T. sherry
Toast points

Remove any shell or cartilage from crabmeat, being careful not to break the meat into small pieces. Melt butter, blend in flour and seasonings. Add cream gradually and cook until thick and smooth, stirring constantly. Stir a little of the hot sauce into egg yolk; add to remaining sauce, stirring constantly. Add crabmeat; heat. Remove from heat and slowly stir in sherry. Serve immediately on toast points. Serves 6.

Crab Fondue

1 lb. crabmeat
1 8-oz. package cream cheese
1 6-oz. package Guyere cheese, grated
½ c. milk
¼ t. lemon and pepper seasoning
¼ c. sherry
Salt and pepper, to taste
French bread cut into 1-1½ in. cubes

Remove all cartilage from crabmeat. In fondue pot, set on low, combine cheeses, milk, seasonings and sherry. Stir until blended and smooth. Add crabmeat and heat, stirring occasionally, until hot and bubbly, 5 to 10 minutes. For serving, spear cubes of bread with fondue fork and swirl in figure-eight motion. If fondue thickens on standing, stir in a little additional milk or sherry. Makes about 4 cups fondue.

Note: If you do not have a fondue pot, mixture may be made in a double boiler and either served from that or transferred to a chafing dish.

WAVELETS

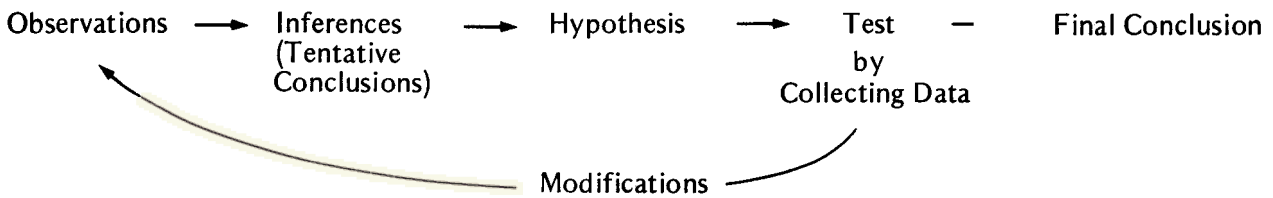
Marine Schoolhouse Series No. 10
by Elizabeth A. Cornell

CUT ALONG DOTTED LINE

Steps to a Better Science Fair Project

VIMS-Sea Grant marine education specialists often serve as judges at science fairs and encounter countless students of all ages who are interested in learning more about the marine environment by doing a project. We are often asked, "What kind of project should I do, and how do I do it?" Our belief is that you learn science by doing science, by actually handling marine materials (e.g., water, sand, fish or anything from the marine environment as long as what you do is not harmful to you or the environment), making observations and experimenting.

Scientists employ the following model to investigate the unknown, whatever that may be.



You can follow the same steps to create an exciting, award-winning piece of investigative research which also happens to be fun! After reading the following outline and example, discuss this article with your teacher. Ask him/her to explain any aspects you do not understand. Then "turn to" and "carry on" mate!

STEPS TO A BETTER SCIENCE FAIR PROJECT – Part I

1. Make observations about environments familiar to you; e.g., backyard, kitchen and school yard. Expand your hobby into a scientific investigation. Think of questions to ask which are based on your observations. For example, what influences the environment, the reactions of plants or behavior of animals? Making observations and making inferences are the hardest exercises for any investigator, scientist or student. Once you learn how to ask questions, you have conquered your biggest obstacle.

"What do I do for a project?" Any questions which involve testing variables can be the basis for a science fair project. Practice making observations and making inferences before you design a project. These are basic skills for conducting a scientific investigation. For more information and suggestions about making observations and inferences write to the Marine Education Center at VIMS, and we will send you helpful guidelines.

2 An investigative project begins when you are able to state a hypothesis (a prediction about the environment or a system) or make inferences (draw tentative conclusions) based upon your observations. You must be able to clearly state the problem and be able to express exactly what you are trying to find out and how you plan to find out. Your teacher will help you design an appropriate hypothesis after you make your observations and inferences.

3 A literature search should not be the project; it should supplement the investigation. In other words, once you have decided upon a problem to investigate and formulated a testable hypothesis, a literature search gives you background information about your area of investigation. "Is my question original or has it been answered before?" "Who else has done similar research and what have they found?" "What additional questions may I ask based on research already conducted?"

4 You are then ready to design and select experiments and equipment which will answer your question(s). The concept of collecting data which will resolve the problem (test the hypothesis) is not always well understood or obvious to you the student or to the scientist. Here are some things to keep in mind.

a Measuring and quantifying results are preferable to describing in words only.
b Identifying variables (identifying what influences the results) is basic to any scientific investigation.
c Controlling variables enables you to identify which variable influenced which result without confusing several causes and effects. This includes establishing a control and testing only one variable at a time.
d Often the least exciting aspects of experimenting are repeating tests to see if the results are the same or similar each time(thus reducing the probability that the results reflect chance occurences instead of the influence of the variable) and recording the data immediately after doing the experiment (thereby eliminating confusion and memory lapses).

5 You may feel your project is complete once you obtain any results at all, or what you may perceive to be the "correct" results. This is the time to ask how the results relate to the hypothesis. Are the results conclusive or should the hypothesis be modified and retested? If you are justifiably satisfied with the results, then the next step is to refine and reduce the data. For example, construct tables and charts with clearly labeled columns and rows. Some tables and charts of numbers are better presented as graphs with clearly labeled axes (trends are easier to detect). Elementary statistics may be calculated (mean, average, range) where appropriate. Show your results to your teacher and discuss what you plan to do next. See if he/she follows your train of thoughts, agrees or has suggestions.

6 Based on your results with regard to the stated problem and hypothesis you should (1) clearly state a conclusion, (2) relate your study to other similar studies, and (3) suggest other variables or factors which could be tested.

7 An orderly and accepted format for present ing a research project is:

a. An Introduction briefly states the hypothesis, how it was tested, the results and conclusions (usually not more than one page in length);
b. The Methods and Materials section describes the materials and/or apparatus and procedure employed to test the hypothesis;
The Results section contains only results (no conclusions) which may include descriptions, tables, graphs, charts and statistical analysis;
d. The Discussion contains the conclusions, literature review and suggestions for further investigations;
e. The References and Resources section should be an indication that you did not work in a vacuum but did read additional material and consult other individuals. This list need not be lengthy.

This is the first of a two-part series. Look for Wavelet's "Steps to a Better Science Fair Project - Part II" in the Fall 1980 Marine Resource Bulletin.

Wavelets is a project of the VIMS Sea Grant Marine Advisory Services Education program.

Sea Grant Publications

The publications listed in this section are results of projects sponsored by VIMS Sea Grant Marine Advisory Services. Publications can be ordered from Sea Grant Marine Advisory Services, Publications Office, Virginia Institute of Marine Science, Gloucester Point, VA 23062.

A PRELIMINARY EVALUATION for a SHARK FISHERY in VIRGINIA. *SRAMSOE No. 234.- J. A. Colvocoresses and J. A. Musick. First copy free to Virginia residents, all other copies $1.00.*

(See story p. 2)

LOCATION of FOREIGN FISHING VESSELS HARVESTING SQUID in the MID-ATLANTIC REGION of the UNITED STATES: 1970-1976. *SRAMSOE No. 235.- J. Zaborski. First copy free to Virginia residents, all other copies $1.00.*

In recent years, there has been considerable discussion about the potential for the development of a squid fishery in the Mid-Atlantic. However, knowing where to locate commercial quantities of squid has been a major obstacle. To assist Mid-Atlantic fishermen locate potentially productive areas, the VIMS Marine Advisory Service has compiled and published the monthly distribution of the foreign squid fleet between 1970 and 1976. This summary of foreign squid fishing activities is intended to be used as a tool to help fishermen determine the seasons and areas which might prove most productive.

COMMERCIAL FISHING NEWSLETTER. *Quarterly. Subscriptions available without charge.*

Summer 1980 marked the first issue of the quarterly Commercial Fishing Newsletter. This newsletter is designed to highlight important events and provide information of interest to the commercial fishing industry.

CHART of FISH HAVENS OFF CAPE HENRY, VIRGINIA. *18" X 36" chart, $1.00.*

Chart shows wrecks, obstructions, and rocky bottom areas commonly known as 'fish havens' - off Cape Henry, Virginia. This chart was designed to be used in conjunction with traditional charts as an aid for sportfishermen. Shows true bearings to shipwrecks from well-known points of reference. Not to be used for navigational purposes.

The chart was prepared by VIMS Sea Grant Marine Advisory Services and the Artificial Reef Program of the Virginia Marine Resources Commission. Adapted from National Ocean Survey charts 12200 and 12221. Portions of information on chart furnished by NOAA's Atlantic Marine Center in Norfolk, Virginia.

THE CHESAPEAKE: a BOATING GUIDE to WEATHER. *J. Lucy, T. Ritter and J. LaRue. Educational Series. $1.00.*

THE ECONOMIC IMPACT and STATUS of VIRGINIA'S OFFSHORE FISHING INDUSTRY. *SRAMSOE No. 225.- W. DuPaul and S. Baker. First copy free to Virginia residents, all other copies $1.00.*

ILLUSTRATION: DICK COOK

THE MARINE TURTLES of VIRGINIA.- *J. A. Musick. Field guide. $1.00.*

TIDAL WETLAND PLANTS of VIRGINIA.- *Gene Silberhorn. Booklet. $3.00.*

SENSING THE SEA.- *Ellen Odell-Fisher and Ronald N. Giese. Curriculum guides, grades K-One (OR) Two-Three. $2.00 each.*

VIRGINIA MSD PROBLEMS and OPTIONS.- *Jon Lucy. Advisory No. 19. Free.*

THE ECONOMIC IMPACT of the SEA SCALLOP *(Placopecten magellanicus)* **FISHERY in VIRGINIA.** *SRAMSOE No. 222.- W. DuPaul and S. Baker. First copy free to Virginia residents, all other copies $1.00.*

A REPORT to the OYSTER INDUSTRY of VIRGINIA on the BIOLOGY and MANAGEMENT of the COWNOSE RAY *(Rhinoptera bonasus,* Mitchill) **in LOWER CHESAPEAKE BAY.** *SRAMSOE No. 216.- J. Merriner and J. Smith. First copy free to Virginia residents, all other copies $1.00.*

OFFSHORE PIPELINE CORRIDORS and LANDFALLS in COASTAL VIRGINIA, Vol. I and II. *SRAMSOE No. 190.- A. Rooney-Char and R. Ayres. $5.00 for both volumes.*

Marsh Exploration by Canoe

The Chesapeake Bay Foundation (CBF), in cooperation with the Virginia Institute of Marine Science/College of William and Mary Sea Grant Program, the Citizens Program for Chesapeake Bay, and the Virginia Environmental Endowment is offering a series of field trips to 500 Virginia public school students and teachers during the academic year 1980-81. The program is available to any public school class in the state from 7th grade up.

The trips emphasize the natural history of the Chesapeake, concentrating primarily on marsh plants, fish, birds, invertebrates, and physical transport processes. They will be conducted with CBF's mobile canoe rig, nine 17 foot canoes on a trailer, using appropriate waterways throughout Virginia's tidewater region. All trips will be led by CBF's Field Trip Director, John Page Williams, who has six years' experience running these trips all over the Bay. He is fully licensed and insured, and emphasizes safety afloat. All participants are required to wear life jackets, and all equipment is carefully maintained.

The normal cost of such a trip is $12.50 per person per day, with a minimum of 18 participants. But through a grant from the Citizens Program and the Virginia Environmental Endowment, the cost for Virginia schools is reduced to $6.50 per person per day. All participating teachers will be required to attend a one-day workshop in the winter, to familiarize them with the canoe rig and to help them work on ways to integrate the trips into their curricula.

Early reservations are suggested, as space is limited, and the canoe rig's spring schedule is usually fully booked by early January. For further information, contact Lee Lawrence, Department of Advisory Services, Virginia Institute of Marine Science, Gloucester Point, VA 23062; 804/642-2111, Ext. 298.

Virginia Institute of Marine Science
School of Marine Science of the
College of William and Mary

Marine Resource Bulletin
A Sea Grant Advisory Service

VOL. XII SUMMER 1980

Kym Young .....Editor

The Marine Resource Bulletin is produced by the Virginia Institute of Marine Science of the College of William and Mary as a Sea Grant Marine Advisory Services project. Subscriptions are available without charge upon written request to the editor.

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Maurice P. Lynch .....Sea Grant Director
William D. DuPaul.....Head,Advisory Services

COVER NOTE:

Storm clouds gather over Brown's Bay near Severn, Virginia.

Photograph: Kym Young.

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