MARYLAND
Research, Education, Outreach
September-October 1998
MARINE NOTES

SPOTLIGHT ON AQUACULTURE RESEARCH

Spawning Stripers on Demand

Basic Research — Real World Uses

By Merrill Leffler

Aquaculture in the United States may have grown rapidly over this last decade, says Yonathan Zohar, "but it is still lagging 20 years behind the rest of the world." Zohar is Director of the University of Maryland Center of Marine Biotechnology (COMB) and a scientist who has pioneered research on the molecular basis of fish reproduction — his is not just a scientist's view. Josh Goldman, president of AquaFuture, one of the nation's leading striped bass growers, has spoken of the aquaculture industry's "extraordinary gains" — he has also referred to it as "technologically primitive."

With only one finfish species, catfish, has U.S. aquaculture reached world class production harvest levels. From 1984-1986, for example, growers averaged some 230 million pounds a year, primarily in ponds in the southeastern states; over the last three years, they have doubled harvests to more than 450 million pounds annually.

Though production of striped bass, the species of special interest in the Mid-Atlantic, is only 8 million pounds annually, that figure represents a 600 percent growth in five years, according to the U.S. Striped Bass Growers Association. In 1985, the industry did not even register on the U.S. Department of Agriculture's charts. Many in the industry and in research labs, says Reginal Harrell, are confident that those figures can be kicked up significantly over the next decade. USDA has forecast a consumer market for some 50 million pounds of stripers annually, if prices could be moderately reduced.

Increasing production while reducing costs will require a number of research breakthroughs that the industry can begin putting into operation, says Harrell, finfish specialist for the Maryland Sea Grant Extension Program and a scientist at the University's Center for Environmental Science (UMCES). To begin with, the industry needs year-round availability of seed fish, he says. "It also needs domesticated broodstock that can be bred for particular traits, such as faster growth and disease resistance." (See "Domes-

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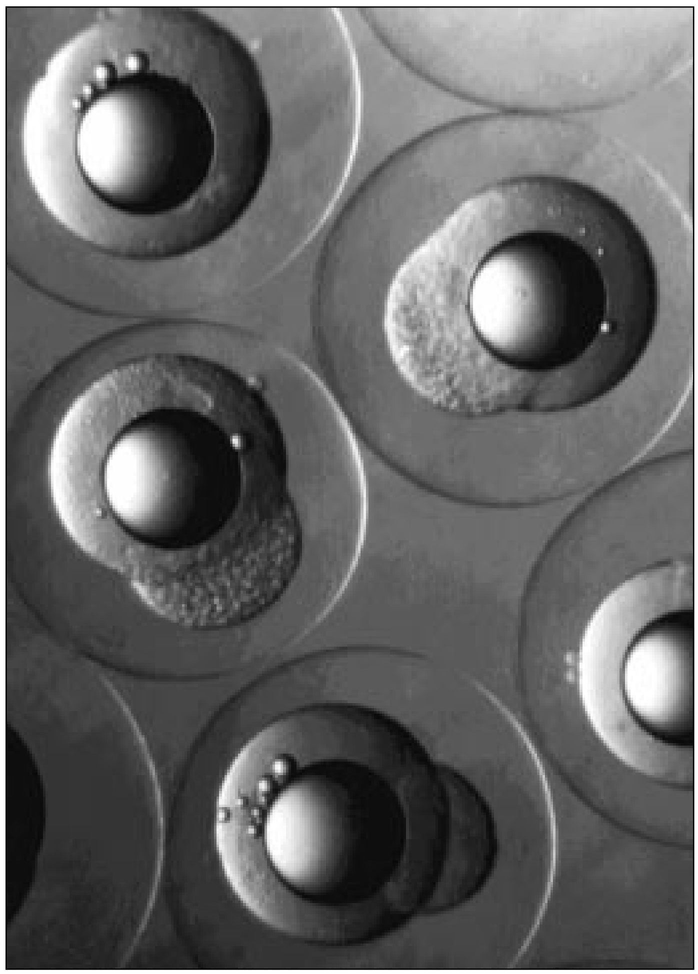


Reginal Harrell

Above: Striped bass eggs shortly after they have been fertilized and before cell division.

Striped Bass, continued

ticating Striped Bass Broodstock".)

The research to meet these needs is underway in both university and industry labs, Harrell points out, "and we are beginning to see achievements that could make stepped-up production a reality in the next several years." First and foremost is the reproductive issue: researchers have been working to develop methods to reliably spawn striped bass year round in captivity — and they are getting close.

The Problem of Spawning

A number one need, says Josh Goldman, "is having large numbers of juvenile fish throughout the year." That is not the case now: virtually all striped bass seed (eggs and fry) depends on collecting wild fish from their spawning grounds. In the few states that do not have restrictions, hatchery operators collect gravid fish (females ready to spawn whose eggs are near full development), transport them to the hatchery and, with a combination of skill and luck, says Harrell, maintain them until their eggs are mature. They generally need to inject the fish with a hormone (human chorionic gonadotropin) to induce spawning — the eggs are then physically removed for fertilization.

The industry's dependence on collecting wild broodstock that are near spawning has been one of the major limits to its expansion. The difficulty of maintaining captive broodstock in hatchery raceways or tanks with the expectation that they will produce fully developed eggs has been immense.

"Broodstock stripers are just too finicky when it comes to spawning them," says Scott Lindell of AquaFuture. Captive stripers rarely undergo final egg development, let alone spawn. Consequently, the striped bass industry is really a hybrid one, in most cases making use of crosses between female white bass and male stripers — these fish are referred to as sunshine bass.

Unlike stripers which may travel coastal waters for six years before returning to their natal areas to spawn, white bass are not migratory; they are also considerably smaller. For these reasons, they are not as sensitive when it comes to egg maturation and spawning — they are much easier to manipulate, says Lindell.

The striped bass industry's dependence on wild broodstock for fry and fingerlings has hindered its growth

While white bass reach maturity at one to three pounds, pure striped bass first reach maturity at 6 to 10 pounds, though many run from 15 to 50 pounds on the spawning grounds; it can take numbers of white bass to produce as many eggs as one or two large female stripers. Some years ago, research by Ed Houde at the UMCES Chesapeake Biological Lab showed that in addition to considerably more eggs per pound, larger striped bass produced higher quality eggs.

Houde's findings were for wild stripers. Studies of captive striped bass by Yonathan Zohar showed that when spawning for the first time, striped bass generally do not produce good quality eggs. "They have low fertilization if any," says Zohar, "or they just do not hatch." The reasons have to do with a lack of full maturity of the endocrine systems.

In addition, white bass eggs and newly hatched fish are initially smaller, which can make the feeding of young hybrids more expensive and difficult: while growers must raise rotifers to feed the white bass fry, striper fry can be fed with freshly hatched commercially available brine shrimp. Potentially, with pure striped bass, raising fry could be simpler, says Steve Mitchell of Kent Sea Farms.

Don Merritt

To provide the industry with striped bass seed, hatchery operators depend on collecting gravid striped bass from the wild, usually by electroshocking.

Even if wild stripers were more easily captured and spawned successfully, there are still disadvantages to relying on them, says Harrell. "You are dependent on the fish you happen to collect — they may produce high quality eggs, they may not. You just don't know. It's totally random." "Furthermore," he says, "you can only get viable eggs at the time of natural spawning, a period of some four to six weeks." Consequently, all production for the year depends on that narrow window of time — the same, of course, goes for white bass females. Currently, to harvest fish all year round, growers like AquaFuture and Kent Sea Farms "cold bank" them — that is, they lower temperatures to slow fish metabolism, growth and egg maturation.

Everyone agrees that such dependence is unacceptable. For some time, researchers have been trying to "trick" striped bass into developing and spawning eggs by maintaining them in tanks with simulated environmental conditions — especially daylight and temperatures, as well as

Continued on page 4

Domesticating Striped Bass Broodstock

BY MERRILL LEFFLER

Striped bass aquaculture, while growing, is still only a tiny portion of the U.S. seafood economy. Limiting that growth is an inability to spawn the fish year round as is done with other more valuable aquaculture species. The fact that growers must depend on collecting fish from the wild restricts the amount of fish they can spawn. What we need, says Reginal Harrell, a scientist at the University of Maryland Center for Environmental Science, is "domesticated, not captive broodstock." He has focused his research career on the culture and genetics of striped bass and its hybrids. In a current project, he and John Jacobs have been comparing the growth characteristics of striped bass juveniles from five different regions of the east coast in order to determine if some strains reach harvest size substantially faster than others.

Reginal Harrell

While their findings will be of interest to growers, there are limitations, he says, to just how applicable the results are — that is because Harrell has to evaluate the offspring of broodstock captured in the wild. There is no baseline to the broodstock stripers from Florida, South Carolina, Maryland and Canada — they all came to maturity under different conditions in their regions. Different temperatures, different salinities, different nutrition. In other words, says Harrell, we don't know whether our results of juvenile growth to harvest size were the result of inherent differences in those strains or if they were due to the environmental conditions the fish experienced before we captured and spawned them.

The only way to derive conclusive comparisons would be to have broodstock fish that were first reared, then bred in the hatchery. But domesticated striped bass broodstock have been very slowly coming — that means rearing juvenile striped bass to maturity, perhaps four to six years or so, then spawning them; that second generation is then raised to maturity, then spawned, and so on. The ability to do this has been nearly impossible (see "Spawning Stripers on Demand"). And yet, without such domesticated broodstock, it is next to impossible to compare different strains, let alone breed fish for different traits, as agriculturalists have bred animals for centuries.

Over the last 15 years, though, University of Maryland researcher Curry Woods has quietly been doing just that: breeding striped bass at the Crane Aquaculture Facility. And he has begun to have success — small, but significant success, says Harrell — that holds exciting promise for the future farming of striped bass and its hybrids.

"Some of Curry's work," says Jim Carlberg, president of Kent Sea Farms in San Diego, one of the nation's largest striped bass producers, "is the only such work of its kind in the world."

Breeding Selective Stock

"We have been slowly developing a domestic population of pure striped bass," says Woods — "we're now into the fourth filial generation removed from the wild." This is a domestic population, he points out, rather than an acclimated captive one. "It's a distinction" he says "that's not often made."

Woods's operation at Crane, in Baltimore City, has produced the first selectively bred stocks, namely superior males and superior females. "We have a database on each fish. We know what we have to choose from," he says, with regard to growth. In a recent field trial, he compared the progeny produced by third generation striped bass with a first generation sunshine bass (a hybrid cross between a white bass female and striper male). "Our fish are growing 40 percent faster," he says.

With domesticated broodstock whose characteristics are known, growers can selectively breed for those characteristics, whether they are faster growth, better disease resistance, or higher feed conversion efficiency. "We already have examples of how you can breed for growth," Woods says. "It took us six years to get the first females to produce; we've gotten third generation stripers to reach maturity in three years."

"We're still in a research phase," Woods is quick to point out. "If you cannot provide the exact environmental cues that fish experience in the wild, you reach hurdles that can only be overcome by hormonal induction therapies, such as Yonathan Zohar has been developing." Ninety-five percent of the time, he says, "our fish will not spawn without such assistance."

But maybe five percent of the time they do, which means that some individual fish in some families are getting the correct environmental signals. Woods points out, however, that he cannot get domestic fish to spawn with regularity. "Without hormonal therapies," he says, "we would be unable to continue our program." That's why his research is focusing on understanding just what kind of stress broodstock fish undergo. "Stress physiology is one area that we have to quantify with science," he says. Such quantification involves understanding the roll of diet.

Research has been underway to clarify the nutritional requirements stripers at different stages must have. For example, what are the amino acid requirements, the fatty acids that larvae, juveniles, or mature females need? "We are trying to develop effective diets for broodstock fish," he says, "so that they can make great gametes." These are major challenges. If commercialization is to really take off, says Woods, it will need an integrated operation.

"Domestication is the key," he reiterates. "Simply bringing in captive fish will not do it." Through domestication, he says, we'll have individual stripers that will enable us to provide more uniformity — "we won't have to catch wild fish, hoping they don't die on the way to the hatchery. We won't have to play Russian roulette anymore."

Spawning, continued

salinities — that they experience in the wild. Over this last decade, studies have shown that it is possible to spawn striped bass under such artificial photothermal cycles, says Craig Sullivan of North Carolina State University. However, he adds, the problem has been "the poor quality of the eggs or embryos."

This summer, though, Zohar and his group at COMB achieved a breakthrough: they spawned eggs from captive striped bass six months before the fish would naturally do so. They produced some three-quarters of a million fry from those eggs, fry that appear to be healthy, says Zohar. Many of the fish have been given to growers and researchers so they can track growth to harvest size.

This achievement by Zohar and his colleagues could represent a milestone for the industry. While the findings need to be replicated consistently and then refined for commercial use, Zohar says, hatchery operators could soon apply these techniques for producing striped bass or white bass seed year-round. In the long run, they would no longer have to depend on running out to the spawning grounds during a short period in April or May. Much like agriculture, they could better plan their production.

David Harp

Yonathan Zohar and John Stubblefield remove eggs from an anesthetized striper to determine if the fish is ready to receive a hormonal implant that will stimulate spawning.

Research advances on out-of-season spawning could have a major benefit for the striped bass industry

The Biochemistry of Spawning

Researchers have tried different methods for manipulating photoperiod, temperature and salinity in order to stimulate egg development and ovulation. The approach that Craig Sullivan and others have taken is to compress a year's cycle into six or nine months. Zohar's approach, based on earlier success with a number of other farmed fish, has been to expose fish to a phase shift that imitates exactly a year in the life of a fish. In other words, he simulates what a broodstock striped bass would experience over a year's coastal migration to the freshwater spawning grounds but shifts it by two, three, four, five months. Phase shifting in itself is not enough, says Zohar. "In the hatchery, stripers reach a certain stage of development and then stop."

The intriguing scientific questions for Zohar have had to do with the biochemical processes that prevent captive striped bass from producing viable eggs. "We knew that some hormonal failures were responsible," he says, "and though we had clues from previous work I had done on sea bream, we just didn't know."

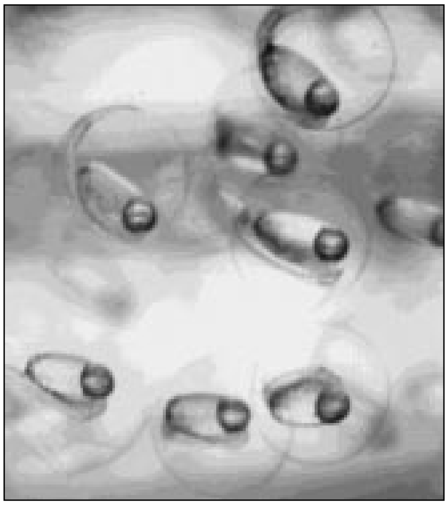
In the early 90s, Zohar began comparing the endocrine make-up of captive striped bass in tanks with gravid females captured on their spawning grounds. "Doing this," says Zohar, "we confirmed our hypothesis that the reason for failure of spawning is found in the brain."

There is a hormone — it is key, he says — that starts the whole chain of reproductive events: in the wild, the striper's biology responds to environmental cues by making the brain's gonadotropin-releasing hormone (a peptide referred to as GnRH); the GnRH induces the pituitary to release gonadotropins which induce egg development and spawning. In captive stripers, Zohar says, the gonadotropins are in the pituitary but the GnRH in the brain is somehow dysfunctioning — either it is not released or not synthesized. Consequently the gonadotropins are not released.

While scientists knew of two GnRHs, Zohar's group discovered much to their surprise a third GnRH — they refer to it as sbGnRH — that turns out to be the most relevant for regulating egg development and spawning. "Our laboratory, as well as most of the scientific community," he says, "overlooked the most important form of gonadotropin-releasing hormones."

In using the techniques of biochemical engineering, the researchers designed superpotent versions, or analogs, of the native gonadotropin-releasing hormones for administering to captive fish. Zohar knew, however, that simply injecting these superpotent GnRHs would not be sufficient — that is because they release an initial surge of gonadotropin for one or two days that is then broken down or eliminated by the striper.

If the gonadotropin-releasing hormones were to make a difference in stimulating the pituitary, they would need to be released over a much longer period of time. To do that, Zohar's group adapted a "delivery system" that would provide sustained re-



Reginal Harrell

leases of GnRHs: made of a biodegradable polymer, says Zohar, it is in the form of implants or microspheres. It can release GnRHs for periods of three to six weeks.

The implant technology for such sustained release of GnRHs is widely used in commercial aquaculture," Zohar says. "It is employed in more than 20 species of farmed fish throughout the world."

Zohar is excited about the future of this GnRH technology for striped bass culture and for other species. "We did the same thing for sea bream and sea bass some years ago," he says. "Based on the technology we developed, sea bream eggs are now being produced 365 days a year in different parts of the world — we are getting close to being able to do the same thing for striped bass."

The uniqueness of the research for striped bass growers, says Steve Mitchell, is that everyone in industry and university labs is cooperating on their findings. "We're all working together," he says. "Broodstock manipulation is an example — having fingerlings all year round is the goal. Once we have the most effective techniques, we don't have to think about getting the information out." That is Zohar's view as well: "I want to understand the fundamental processes of what is going on," he says, "but my approach is that it should work for the industry."

Sea Grant Program Directory Available

Maryland Sea Grant has just published a program directory that gives a plain language overview to its research, outreach and education programs for 1998-99. Included are summaries of major program areas, including coastal ecosystem health, economic leadership, outreach and education, as well as short summaries of each project funded. In addition, there is a description of program facilities, budget information and a directory of researchers, extension and administrative personnel.

Sea Grant supports research by scientists at institutions throughout the state, including the University of Maryland's Center for Environmental Science; University of Maryland Biotechnology Institute's Center of Marine Biotechnology; the University of Maryland, College Park; the Maryland Department of Natural Resources; The Johns Hopkins University; the Smithsonian Environmental Research Center; and the Academy of Natural Sciences Estuarine Research Center.

For a copy, call (301) 405-6376 or send an e-mail request to connors@mdsg.umd.edu. Summaries of the research projects listed in the directory are also available on the web at www.mdsg.umd.edu/MDSG/Research/index.html.

Skip Brown

The photograph above, featured on the cover of the new Maryland Sea Grant program directory, shows Don Meritt, Merrill Leffler and students from the Living Classrooms Foundation loading spat-covered shell in the Choptank River in an effort to restore Bay oyster reefs. This project represents broad cooperation among a number of groups, including the University of Maryland Center for Environmental Science, the Maryland Sea Grant College, the Oyster Recovery Partnership, the Living Classrooms Foundation and the Maryland Watermen's Association.

Maryland Sea Grant Request for Proposals

Maryland Sea Grant will begin shortly to seek innovative proposals in marine research for the two-year funding period beginning February 1, 2000. The Request for Proposals (RFP) will be issued in December, both as a printed booklet and on the worldwide web. Projects are sought in a range of areas, from environmental studies to aquaculture and biotechnology. For details on research priorities and submitting a proposal, consult the online RFP at www.mdsg.umd.edu/MDSG/Research/RFP or request a copy of the printed RFP booklet by calling (301) 405-6371 or e-mailing Ellen Lundgren, lundgren@mdsg.umd.edu.

Major University Funding for *Pfiesteria* Research

Two federal programs have recently announced substantial research awards to University System of Maryland scientists for wide-ranging studies on the *Pfiesteria*-complex of organisms. The two federal programs are ECOHAB (Ecology and Oceanography of Harmful Algal Blooms) and NIEHS (National Institute of Environmental Health Sciences). ECOHAB is a consortium of six federal agencies. Led by the National Oceanic and Atmospheric Administration, it includes the National Science Foundation, the Environmental Protection Agency, the Office of Naval Research, the Department of Agriculture and the National Aeronautics and Space Administration. NIEHS is part of the National Institutes of Health.

ECOHAB Awards

■ University of Maryland Center for Environmental Science (UMCES). A five-year, $4.5 million grant will support research on *Pfiesteria*-related org anisms in terms of their physical environment, the types of nutrients which may lead to their growth, and their interaction with other organisms. Maryland's Department of the Environment, is providing $400,000 and the University of Delaware with the Delaware Center for the Inland Bays is adding $50,000 in matching funds for instrumentation. First year funding from ECOHAB for the portion of the research conducted by UMCES totals $613,899 with the remainder provided based on availability of federal funds and scientific progress.

"We will be studying the nontoxic as well as the toxic stages of the organism in both heavily impacted areas and minimally impacted areas," says principal investigator Patricia Glibert of the UMCES Horn Point Laboratory. As part of the UMCES research, scientists from Maryland, Delaware, North Carolina and South Carolina will collect and compare field data from areas where *Pfiesteria* blooms have occurred. Researchers include Diane Stoecker, Michael Roman, Bill Boicourt, Larry Sanford, Reginal Harrell, Raleigh Hood, Xinsheng Zhang and Rodger Harvey of UMCES; JoAnn Burkholder, North Carolina State University; Alan Lewitus, University of South Carolina; Craig Cary and David Hutchins, University of Delaware.

■ University of Maryland Biotechnology Institute, Center of Marine Biotechnology (COMB). Funding of $1 million for the first two years of a five-year grant will enable COMB to accelerate its study of the molecular biology of *Pfiesteria* and related microorganisms. The Maryland Department of the Environment will provide matching funds of $295,000. COMB's research will focus on answering fundamental questions regarding identification of the *Pfiesteria*-complex of dinoflagellates, the role of bacterial interactions, and factors leading to toxin production.

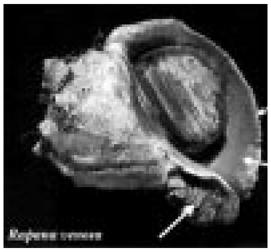
Of central importance is COMB's Dinoflagellate Culture Core Facility, which will maintain the microorganisms and provide cells to researchers in individual COMB projects and to scientists nationwide in the ECOHAB community. Molecular probes to be developed will have the potential to detect the presence of *Pfiesteria*-complex dinoflagellates, distinguish between the numerous species, and determine both in the wild and in the laboratory whether their toxins are present. The COMB team includes Principal Investigator and COMB director Yonathan Zohar and Gerardo Vasta, Robert Belas and Allen Place.

■ University of Maryland School of Medicine and the Institute of Human Virology. Funding of $710,00 will enable researchers to develop rapid and specific DNA analysis tests to detect *Pfiesteria*-like organisms in estuarine waters. The Maryland Department of the Environment will match a portion of federal funds with a $52,500 contribution. The studies will adapt tools of molecular virology for measuring the numbers of organisms in affected waterways and to overcome some of the problems in getting rapid and definitive identification of *Pfiesteria*-related dinoflagellates. Once the methods for detecting genetic sequences from these organisms are perfected, the researchers will adapt the DNA assays for field use. David Oldach, of the School of Medicine, is co-Principal Investigator with Park Rublee of the University of North Carolina at Greensboro and Kjetill Jakobsen from the University of Oslo. Other team members includes JoAnn Burkholder and Howard Glasgow, NC State University; Charles Delwiche, UM College Park, Richard Lacouture, Academy of Natural Sciences and M. Allen Northrup, Cepheid, Inc

NIEHS Award

■ The University of Maryland Biotechnology Institute's Center of Marine Biotechnology (COMB), the University of Maryland School of Medicine (SOM) and the Johns Hopkins University School of Medicine. A five-year, $6.3 million grant will support a group of projects at COMB on the biology of *Pfiesteria*, e.g., life cycle, mechanisms of toxin production, and medical studies at SOM on neuropsychology and neurotoxicology. COMB research is expected to provide methods for determining the relationships between toxins and specific impairments in human learning and memory. SOM studies will focus on defining the nature and extent of learning and memory impairments in affected persons, and will concentrate on examining responses to toxin preparations in tissue culture and animal models. Principal investigators are Yonathan Zohar (COMB) and J. Glenn Morris (SOM). Researchers at COMB include Gerardo Vasta, Robert Belas and Allen Place; at SOM, Lynn Grattan and Christopher Bever (neurocognitive studies), Ellen Silbergeld, Amira Eldefrawi, Edson Albuquerque (neurotoxicologic studies) and at Johns Hopkins, Patricia Charache.

Exotic Mollusc Found in Virginia Waters



A non-native gastropod mollusc, the rapa whelk (*Rapana venosa*), was found during a routine Virginia Institute of Marine Science (VIMS) trawl survey on the lower James River this past summer. The gastropod, a large snail, is a native of Japanese waters, but was introduced into the Black Sea in the 1940s, probably via ballast water. Within a decade it had spread along the Caucasian and Crimean coasts and to the Sea of Azov. Between 1959 and 1972, its range extended into the northwest Black Sea to the coastlines of Romania, Bulgaria and Turkey. *R. venosa* is thought to be very fertile and tolerant of low salinities, water pollution and oxygen deficiency. In the Black Sea, it is responsible for significant changes in the ecology of bottom-dwelling organisms.

VIMS researchers are interested in any sightings of this large snail in Virginia and Maryland waters; these reports will aid scientists in developing a model that will define potential impacts of the mollusc. The rapa whelk is visually similar to native whelks (*Busycon carica*, *B. sinistrum*, *Busycotypus canaliculatus*), so VIMS has produced a fact sheet with photographs of the different types of whelks and a list of characteristics to help in identifying the rapa whelk. To request a copy of the fact sheet, contact Vicki Clark, Marine Education Specialist, Sea Grant Marine Advisory Program, Virginia Institute of Marine Science, P.O. Box 1346, 1208 Great Road, Gloucester Point, VA 23062, phone (804) 684-7169, fax (804) 684-7161, e-mail vclark@vims.edu.

Information on the whelk and how to identify it are also available on the web: www.vims.edu/fish /oyreef/rapven.html.

End Notes

Publications

■ ***Molecular Technology and* Pfiesteria *Research: A Scientific Synthesis.*** This 34-page publication is a workshop report from a national meeting in October 1997 at the Center of Marine Biotechnology, covers issues of *Pfiesteria*-complex biology, taxonomy, toxins and human health implications. It is available from Maryland Sea Grant — call (301) 405-6376, or on the Sea Grant website, along with related information, at: www.mdsg.umd.edu /fish-health/ pfiesteria/

■ ***Aquafarmer.*** This quarterly from the Maryland Sea Grant Extension Program begins its 15th year of publication this winter. Each issue carries articles of importance to those with interests in current research, outreach and educational efforts related to aquaculture, water quality and seafood issues. The current issue, for example, includes articles on the striped bass strain research that John Jacobs and Reginal Harrell have been doing at the University of Maryland Center for Environmental Science Horn Point Laboratory and the expansion of the oyster hatchery at Horn Point by Don Meritt. You can subscribe to Maryland Aquafarmer by calling (301) 405-6374 (e-mail: connors@mdsg.umd.edu) or you can read it on the Sea Grant website: www.mdsg.umd.edu/MDSG/ Extension/Aquafarmer/index.html.

■ ***Restoring Oysters to U.S. Coastal Waters: A National Commitment.*** This report from the National Sea Grant College Program features articles that spotlight scientists working to reverse the impact of Dermo and MSX disease on eastern oyster populations in the Mid-Atlantic, juvenile oyster disease (JOD) in the northeast and summer mortality in the Pacific oyster on the west coast.

Among the topics of discussion are techniques for breeding dual disease-resistant strains, which have gone from the hatchery to the field; new molecular tools for diagnosing disease rapidly in the field; and computer models for helping to better monitor around disease. This 24-page publication was produced jointly by the Maryland Virginia sea grant programs for the National Sea Grant College Program. For a copy, call (301) 405-6376 or send an e-mail request to connors@mdsg.umd.edu. The publication will also be available on the Maryland Sea Grant web site: www.mdsg.umd.edu/MDSG

Lab Seeks Volunteers

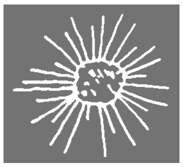
■ ***The Academy of Natural Sciences Estuarine Research Center*** in St. Leonard, Maryland is seeking volunteers to assist with preparations for the 62nd Annual Maryland House and Garden Pilgrimage to be held Saturday, May 8, 1999. The Estuarine Research Center's "Bayscapes" demonstration landscapes will have their public debut at this event, and the lab needs help getting ready. For more information, call Julie Allinson Hatch at (410) 586-9715 or send an e-mail message to hatch@acnatsci.org

Web Sites of Interest

■ ***Voyage to Puna Ridge,*** a new web site, follows the daily activities of scientists aboard the University of Washington's R/V *Thompson* on a cruise off Hawaii to study the underwater aspects of Hawaii's Kilauea volcano. The scientists post daily updates and teachers are invited to bring their classroom along for the adventure. The site, www.punaridge.org, also includes "science factoids," learning activities, and a media gallery of images. The chief scientist on the cruise is Debbie Smith, a geologist at Woods Hole Oceanographic Institution (WHOI) who also wrote the proposal to create the web site. The site is funded by WHOI, NSF and the Hawaii Department of Education.

Calendar

December 10-11 — *Pfiesteria* and the Environment



Georgetown University, Washington, DC. "*Pfiesteria* and the Environment: Convergence of Science and Policy" will bring together academia, government, industry, environmentalists and concerned citizens to look at developments in the science of *Pfiesteria piscicida* and examine how this understanding can improve current and future policy initiatives. The organism has been implicated in several fish kills and human health disorders in the rivers draining Maryland's Delmarva Peninsula. For registration information, call The Center for Food & Nutrition Policy, (202) 965-6400 or e-mail ceres@erols.com.

January 24-27 — Marine Bioinvasions

Cambridge, Massachusetts. The First National Conference on Marine Bioinvasions, to be held at MIT, will focus on the incidence, effects and management of exotic species in coastal, estuarine and marine ecosystems. Topics will include ballast water research and management, ecological and genetic consequences of invasions, patterns of invasions in time and space, transport vectors, status of control factors and predictive options for assisting managers, and economic impacts.
For more information, check the conference website: massbay.mit.edu/exoticspecies/conference.html, or contact Judy Pederson, MIT Sea Grant, jpederso@mit.edu, phone (617) 252-1741 or fax (617) 252-1615.

Maryland Marine Notes
Volume 16, Number 5
September-October 1998

Maryland Marine Notes is published six times a year by the Maryland Sea Grant College for and about the marine research, education and outreach community around the state.

This newsletter is produced and funded by the Maryland Sea Grant College Program, which receives support from the National Oceanic and Atmospheric Administration. Managing Editor, Sandy Rodgers; Contributing Editors, Jack Greer and Merrill Leffler. Send items for the newsletter to:

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Maryland Marine Notes (current and back issues since 1995) is also available on the web at www.mdsg.umd.edu/MDSG/Communications/MarineNotes

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