EXPLORING SCIENCE WRITING

an environmental focus

editors NANCY RIGGS · PEGGY BRITT

Sea Grant

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Introduction For Teachers

The purpose of *Exploring Science Writing: An Environmental Focus* can be stated very simply: to introduce students to writing for the lay public about a few of the many public issues that affect the ecosystems in which we live. *Exploring Science Writing: An Environmental Focus* responds to growing national concerns about student cognitive development and a growing interest in writing across the curriculum. The reader features science writing, an exciting addition to traditional writing curriculums. Science writing, writing about science for the lay public, can be taught through standard rhetorical strategies. This reader offers practical approaches to help students find ideas and develop them in writing. Throughout the reader, students are exposed to award-winning science writing about environmental topics in stories that represent the various styles of individual writers.

In his text, *Best Science Stories,* Robert Gannon defined science writing by first explaining that it is **neither** scientific or technical writing. Gannon, science writer and associate professor of English at Pennsylvania State University, wrote that scientific writing is for a specific audience who is assumed to be familiar with the topic, and that technical writing is for an audience who needs and wants specific information. Science writing, on the other hand, is for a large diverse readership who frequently has no background information and often is unaware that it needs the information.

Events do not occur in isolation but are connected to other events, whether they are sudden events in our daily lives or recurring events affecting ecosystems. In *Interpretative Reporting,* authors Curtis MacDougall, late journalism professor at Northwestern University, and Robert Reid, journalism professor at University of Illinois, noted, "Most early conservationists were hunters and outdoorsmen who perceived that everything is connected . . . ." A crystal clear understanding of the interconnections of events, or occurrences, that affect ecosystems is essential before writers can communicate impacts and potential impacts.

The 21st century will bring expanding public issues as urban sprawl continues, encroaching on rural land and crowding shorelines along every coast. The role of writers in developing any communication piece for the public, whether working as a reporter, educator, scientist or in one of the many other careers that will require writing for the public, is to write in a way that can be easily understood and that will contribute to a better informed reader. *Exploring Science Writing: An Environmental Focus* was developed in response to requests from teachers for resources to help teach students to write clearly about ecosystem issues. The reader was developed by Illinois-Indiana Sea Grant and Michigan Sea Grant in collaboration with secondary teachers, science writers, researchers and outreach specialists and Sea Grant programs representing all U.S. coastal regions.

Reader Organization

The reader has been developed for use not only in writing classes but also across the curriculum. Many of your students will be writing about public issues regardless of the academic and future career paths they may select. Directed primarily to high school teachers, the reader also is applicable to classes in technical schools and other settings. One of the goals of the reader is to encourage further exploration of both public communication and environmental topics.

Part I, Chapter 1, is a self-contained section in which students are introduced to science writing and the importance of accuracy. Accuracy is a tenet of both journalism and science that students will find crucial through higher education and professional careers. In Chapter 1, students learn the difference between basic science and applied science, and three types of

science writing are explained. Part II includes Chapters 2-5 that introduce specific environmental topics, followed by readings illustrating some of the various formats in which science writing is produced. An Appendix contains an extensive list of contacts for more information.

Examples of Readings

Chapter 1 - excerpts from a book about science history
Chapter 2 - a radio script about pollution in the Arctic and a re-write of that script for a print story
Chapter 3 - a news release on zebra mussels, exotic invaders now found in inland lakes, followed by a published story generated by that news release
Chapter 4 - an article focusing on the cultural history involved in managing a contemporary fishpond in Hawaii
Chapter 5 - a travel feature focusing on a natural resource on the shores of Lake Michigan that explains the formation, and natural and human wear and tear on dunes

Assessment of Writing

The writing process consists of five stages: pre-writing, drafting, revising, editing and publishing. *Exploring Science Writing: An Environmental Focus* assignments allow for small group or class collaboration in the first stage, and assignments include writing for publication submission thereby encouraging students to produce their best work.

In addition to traditional writing assessment processes, the organization of the reader will support portfolio development. The organization provides an opportunity for student portfolios to illustrate not only writing competencies but also knowledge of environmental issues. This structure is particularly helpful in writing across the curriculum and encourages multi-disciplinary projects through portfolio development.

Format

The reader has been produced in an 8 ½ x 11 format for easy copying for classroom use. Teacher-developed writing activities provide opportunities for students to develop their own stories based on their readings and on similar situations in their local communities. These activities immediately follow the readings, allowing teachers to easily pick and choose from various sections.

Related Resources

Teachers are encouraged to contact Sea Grant programs and other agencies listed in the Appendix to request supplemental resources on the various topics. Fact sheets and other publications are available free or at minimal cost from Sea Grant, U. S. Environmental Protection Agency and state environmental agencies.

-nancy riggs

Notes for Classroom Use

The future safety of our environment lies in the water and in the air and in effective use of trash bins. The future safety of our ecosystem lies in the informed minds of our youth. When youth understand the need to respect air, water and disposal systems, when they can read, when they can write, when they can understand and inform others why Americans must protect natural resources for present and future generations, their ownership is activated. With that goal in mind for our youth, these notes are provided to help you hammer out your sparks of knowledge and direction for a sound ecosystem and for stimulating your students' interest in public communication. We wish you an excellent teaching experience with this material.

Teaching Model Using Complete Reader
Portfolio Process

Questions and activities follow each chapter introduction and each reading to review, to stir debate, and ultimately to lead to writing articles for publication. Based on questions from the reader or those generated by the instructor, students should write three articles each for chapters two through five. The student will have 12 articles when the reader is completed which should be kept in a portfolio throughout the unit timeframe.

Two of the three entries per chapter may be short, 150 to 300 words, but a third entry of 500 to 600 words is encouraged. This entry should be re-worked to publication quality. Even when using one of the three types of science writing, keep in mind the other categories of sound writing strategies: defining, comparing and contrasting, persuading (an editorial piece) and researching (interviewing and investigating). Interconnections dominate as a theme throughout the ecosystem. A summary paper on these interconnections would synthesize the theme of the reader.

Example

Recently, a fish kill occurred in a lagoon located in a midwestern city park. Several hundred fish died from a seemingly unknown cause. Investigation determined the cause to be a buildup of excessive algae. This occurrence lends itself to science writing. Article suggestions include the folowing.

- Define algae and its effects.
- Contrast composition of water that is pristine to water with algae buildup.
- Persuade readers of the need to consistently monitor lagoon water to prevent recurrence.
- Investigate and explain what city officials are doing to prevent recurrence.

Many excellent articles could be produced with one developed to publication quality through both peer and instructor review. Such articles may be given serious consideration when submitted to local newspapers, and they would have value for a school newspaper, raising the level of consciousness about the environment. Teachers are encouraged to develop specialized school publications for student publishing. (Suggested peer and instructor review sheets are in Appendix.)

Chapter Suggestions

The following chapter suggestions can be used along with teacher-generated ideas to help students develop localized stories.

Chapter 1

This chapter provides guidance for story development.

Chapter 2

Worldwide pollution has collected in the Arctic, contaminating a formerly pristine environment. On a smaller scale, is there a similar environmental concern in your local community? Do winds from a manufacturing or processing plant or an agricultural operation outside your community carry odors through your community? What is the source of the odor? Can the odors be prevented? What are the airborne pollutants? Are pollutants deposited into lakes or streams? Is there a polluted lake or stream in your area? Can the discharges be stopped? What are the costs? What are the tradeoffs? How could your community and an offending business such as a manufacturing or processing plant or an agricultural operation work in concert with each through tax abatements or other inducements to create a cleaner environment and financial success? What are various perspectives on the issue? Could a schemata be drawn to show wind drifts through the city, similar to those used on local weather broadcasts? How has a specific culture in your area been affected by ecosystem changes?

Chapter 3

Every area of the United States has exotic species, species that are not native to the area. What are some of the non-native animals in your area? What are some plants? Were they introduced intentionally or accidentally? Which have been beneficial and which have been detrimental? How have they altered the ecosystem? Are exotic species transported by boat traffic in your area? Does your state have a monitoring program for exotic sightings? Have businesses, farmers and others suffered detrimental effects from exotic species?

Chapter 4

Fishing is conducted in every part of the United States, and in some areas, fish is a major part of traditional diets. How much fish is consumed in your state? Is it a staple for the diets of any particular group of people in your area? Have any fish species been drastically reduced, or disappeared, from your area? What is the dollar contribution of fishing to your state? Is commercial or sportfishing, or both, important to your area?

Chapter 5

Summer is often a time for distant travel, warm breezes and summer sun. Observe the parks, trails and beaches where you travel. Is the terrain cared for or eroded? What can you find out about places that have remained pristine or others that are degraded? How much does tourism contribute to your state's economy? Does your state promote tourism to its natural resources? What has your state done to preserve or maintain natural resources?

Alternate Teaching Model Using Selected Readings

The reader is arranged in a manner to allow you to pick and choose materials that you may wish to include in your current class materials if time does not allow you to teach science writing as a complete unit. Various readings may be selected, along with accompanying assignments, as group or as individual readings. Questions from the above model may be posed to your students to encourage their thinking about ways to write about local concerns, and a summary paper on ecosystem interconnections would synthesize the theme.

-charles herber

Part I Writing Techniques

Chapter 1
Getting Out the Word: Science Writing Techniques

by Robert Hays

More than just about any other topic you might write about, science affects everyone. Science has much to do with the quality of our lives, from the inventions that make our daily existence more comfortable to the safety of the food we eat and the cleanliness of the water we drink and the air we breathe. This means that, while information about science in its basic form may be of somewhat limited interest, information about the applications of science — the way it affects people — is likely to be of wide interest.

Charles Petit, a past president of the National Association of Science Writers, says that science news is in many ways the most genuine form of news. That is, science news concerns ideas and events new to human perception. This relates not only to new scientific discoveries, but also to new ways of applying old discoveries to different problems.

Many scientists are interested mainly in basic, fundamental science. They search for basic knowledge. These scientists may have less regard for the long-term effects of their discoveries. One scientist's research in nuclear physics, for example, might lead others to develop terrible weapons of mass destruction on the one hand or vital treatments for disease on the other. Joseph Henry, a prominent early American scientist and the first director of the Smithsonian Institution, once observed that "the advance of science or the discovery of new truths" was of great importance, regardless of "immediate applications."

Other scientists are more concerned with the applications of scientific discoveries. They especially want to find new ways to make science--either new or old discoveries--work to solve particular problems. This might involve combining long-known scientific principles in ways that lead to improved food processing, for example, or new ways to treat pollution in our lakes and streams.

Science writers write about both kinds of science, basic and applied. They recognize that the kind of science they're writing about makes a great deal of difference in who will be most interested.

Work in basic science may lead to results that are dramatic in terms of the advancement of knowledge. This would be of great interest to scientists. Because of this, writing about basic science is more commonly aimed at scientific journals and other specialized publications that are read primarily by scientists. Average readers, lacking a strong background in science, probably would find this material difficult to understand. They might find it to be of little interest because they don't recognize the potential application of such fundamental scientific discoveries to specific human problems. Clearly, these readers would be more interested in stories about applied science. Science writers who write about applied science therefore are more likely to write their articles for newspapers or magazines or other popular mass media.

There are a number of reasons you might want to write about science. You may be vitally concerned about the environment, and want to inform people about environmental issues. These might include the risks of polluted water or other environmental hazards, for example.

Or, you may feel that it is important for the public to understand the role of science in protecting the environment. Public support of science is critical.

Clean water is important to everyone. This means that when you write about clean water and the science related to it, you know that you are writing about a subject that matters. If you write clearly, you can help inform people on a very important topic.

And don't underestimate what a single article can do. Kenneth Wilson, Nobel Prize winner in physics, cites a single newspaper article as a vital factor in the National Science Foundation's decision to provide $200 million to create major supercomputing centers at four universities. The article quoted scientists who said the funding was needed if the United States was to maintain its edge in supercomputing technology.

You may never write an article that has an effect this dramatic. But you may reach many readers whose opinions are important.

Consider Your Audience

Writers always need to consider their audiences. In writing for a scientific journal, the writer expects her or his readers to have a background in science. Such readers understand scientific jargon and technical terms. But newspaper readers in general, or those who hear news about science on the radio or through television, can't be expected to understand or care much about the technical aspects of science stories. They want to know how the science may affect them or people they know.

Here, our interest is in writing for that general, non-scientist audience. Further, our interest is specifically in writing about water quality and related environmental issues. We can assume that scientists in this field read the relevant scientific journals and have current information. But this is not true of the non-scientists whose knowledge about environmental issues is gained from newspapers or other mass media, or through information passed along by friends. This is the audience we want to reach.

Knowing your audience helps you avoid the first common pitfall in writing: failure to say effectively what you mean to say. Readers will understand what you write only if they understand the meanings of the words you use. This means you need to avoid scientific language and technical jargon not familiar to most readers. Using simple language to convey the meaning you want to communicate to your readers will lead to greater success.

Sometimes, though, you have to use technical terms when you write about science. You've read about "eutrophication." What does it mean? You can't explain it to someone else if you don't understand it yourself.

If you must use technical terms, explain them immediately. Explain the unfamiliar by comparing it with things people know about and understand. Put yourself in the place of your reader. Ask yourself what questions you'd have if you were hearing about this subject for the first time. Then be sure you answer those questions!

Research tells us that people tend to seek out information that interests them. We already have said that science, in terms of the way it affects people, is likely to be of wide interest. While this might seem to indicate that readers are eager for science stories, it doesn't necessarily follow that any given science story will routinely attract readers' attention. In fact, effective communication — actually educating significant numbers of people about changes that may be important to them — may be a slow and difficult process. Increased awareness of public issues such as water pollution certainly is possible, but may require intensive multi-media coverage over a long period of time.

We could look at this two ways. One way would be to throw up our hands and say, "What's the use? This piece I'm writing isn't going to make any difference." But most successful writers would look at the situation another way. They would recognize that any story about science is likely to be seen by some people who will remember the information. These people, in turn, will pass that information along to others. Over time, that single science story may reach a great many people. Scientists themselves understand that their discoveries often are slow to gain wide awareness, even in the scientific community. They recognize that it may be years before the general public knows about their

work. For example, aquatic biologists have known for more than a hundred years that lakes and rivers are complex environments in which organisms are highly dependent upon each other. Yet only in recent years has the general public come to gain some understanding of this fact — even though water pollution affects us all.

Use Focus Structure

Although news stories traditionally are written in an inverted pyramid style with most important facts first, writers often craft their stories using a focus structure. Science writing, like all news stories, should "tell a story." Writers often tell a story through the eyes of one person or by explaining one small part of a broad subject. Few of us can understand the complex implications of pollution statistics and potential health risks, but we can understand the impact of a closed beach due to high levels of *Escherichia coli* bacteria (commonly known as *E. coli*) in water along the shoreline, or the impact of contaminated drinking water in one community.

Telling a story about one scientist's contribution to science is one way to apply the focus structure to science writing. Additional steps include providing a transition to the larger issue, explaining that issue and providing a strong finish. Writers must establish and follow clear objectives when using the focus structure.

Three Types of Science Writing

Three types of science writing may be of interest to you. The first is writing general science news stories. Typically these would be intended for newspapers or broadcast stations. The second is writing about risk. This is a more specific topic area. It might include news reports for newspapers or broadcast stations as well as more comprehensive articles, such as those written for magazines. The third type is writing about science history. You might write about science history in newspaper features or in magazine articles.

Writing General Science News Stories

Most science stories don't involve sensational news. Many attract very little attention. Alton Blakeslee, long-time distinguished science writer for the Associated Press, warned that science stories must compete with all other stories for the reader's eye and ear. Blakeslee urged science writers to push their "enthusiasm button" when beginning a story. "If you are not interested, or interesting, can you interest anyone else?" he asked.

But given your own interest in a science story, how do you approach it? How do you make it interesting enough to attract readers? Blakeslee offered some valuable guidelines, published by the Foundation for American Communications in a briefing paper for journalists. In considering how to begin your story, he suggested, "Think what your story means and how best to tell it." He said it helps to tell someone verbally "what the story is about, what you want to say."

Then, Blakeslee advised, write a first draft that tells "all you want to say, in one place, so you can examine and rearrange" as you re-write the story. This means getting all the facts together, distilling them, and deciding what is important enough to include. But don't drown your reader in minor detail.

All writers have an obligation to be accurate. People who read your story must be able to trust you. So far as your readers are concerned, you, the writer, are the expert.

First, this means that you must be certain of the *facts* in your story. There is a great difference between nine hundred and nine thousand of anything. Before you write that something affects millions of people, be sure that you are correct. You may be the only source of information your reader has.

Second, you have an obligation to make clear, whenever possible, the *meaning* or *significance* of the science you are writing about. You have to base this on the information available to you, not on assumptions. If you're not sure what something means don't pretend to know. Ask questions until you

find out. One of the worst things you can do is write something that you later find out is wrong — after others have read it. Leon Hale, popular columnist for the *Houston Post*, used to tell journalism students, "Jumping off tall buildings and landing on your head is not as bad as being wrong in print!"

If you are to be a successful science writer, you need to pay attention to what makes any information — not just that relating to science — worth readers' attention. News media have well-established guidelines that are helpful. If your science story fits within these, you can be sure *it is* worth your time and effort.

First, to qualify as "news," information must be *timely*. Another qualification is *proximity*. Information about things close to readers or listeners, physically or psychologically, is of greatest interest. Another is *significance*. Does it really matter?

News media also have learned that audiences are more interested in stories that have some element of unusualness or human interest. Unusualness essentially means the unexpected. In the ideal world, clean water would be expected and thus not attract attention. We do not expect water to be polluted, so pollution in our rivers and lakes rates highly in terms of unusualness. Human interest is an appeal to human emotions — anger, joy, sadness, compassion and the like. Stories about situations that have dramatic impact on people are likely to measure up well on this standard.

There are other elements within the news media guidelines, but these are the most important. With a little thought, you can readily judge for yourself whether something you want to write about fits within these guidelines.

Once you start to write, remember that your article or story will be more readable if you use short sentences and short paragraphs. Here, the standard varies according to the type of publication you're writing for. Sentences and paragraphs in this chapter often are too long for use in a newspaper story. Newspaper editors prefer sentences that average no more than 20 words in length, with many shorter than that. (The author, a former reporter, would use a somewhat different writing style if this were written for a newspaper.) Longer sentences are acceptable for a book or a magazine article. Regardless of the medium, though, vary construction of your sentences and paragraphs to avoid monotony.

Nothing helps your writing more than active verbs. Active verbs and sentences written in active voice help keep your writing lively and interesting.

And always plan to write and *re-write*. You can always find ways to improve what you've written. Watch for passive words and sentences and look for sentences that are too long and complex. Use fewer commas and more periods!

Writing About Risk

People often find science stories of particular interest because they fear the dangers of disease or pollution or other things that put human beings at risk. Science writers, in turn, often write about risk. You probably have heard of "investigative" reporting. Writing about risk is one form of this type of journalism.

If you choose to write about risk, your first obligation is to learn as much as you can about the issues involved so that you can explain them accurately and clearly. Your goal should be to increase public understanding. Be prepared for the fact that people may be responding emotionally to what they believe to be risks to their health and wellbeing, beyond the level justified by facts. Such emotional response, termed "outrage" by Dr. Peter Sandman of Rutgers University, may cause people to overreact. Lacking such outrage, they may be less concerned about problems or potential problems than they should be.

Science writers can help readers understand actual levels of risk by providing sound, basic information: How serious is the actual risk? What is being done about it? What can readers themselves do about it? What specific health or environmental standards are in jeopardy? Who is responsible? Are there reasonable alternatives to conditions that pose the risk? What are the tradeoffs (or benefits), if any?

Science writers also need to be alert to the differences between new or sudden risks and long-term risks. People often overestimate the danger of sudden risk situations such as accidental chemical spills

and underestimate the danger of long-term, chronic risks such as those posed by diet or home contaminants such as lead or asbestos. You are more likely to be in a position to affect public opinion regarding chronic risk situations, because these typically involve factors your readers can control.

You can help your readers evaluate the risks they face by giving them comparisons with other risks they may understand better. Such comparisons are most useful when you compare similar risks, compare risks with alternatives, compare risks with benefits, or compare risks with regulatory standards.

Writing About Science History

Science history is likely to be about people — individual scientists, for example — institutions, or situations in which science plays a significant role. All of these may be fascinating to read about. Stories about them also may be very informative to your readers.

Scientists are human beings. Beyond reports of their discoveries are stories about how and why they chose their respective fields of science, the kinds of problems they've encountered in their work, the satisfaction they gain from science and so on. These are *people* stories, and therefore of interest to other people. We all can identify with the pride others feel in their work or disappointments they have suffered. The stories of most great scientific discoveries, at their heart, are stories about people.

Institutions also play vital roles in science. Consider how many scientific advancements have been made possible by great research universities, for instance. This is but one type of institution. The importance of agencies such as the National Science Foundation would be hard to overestimate. Likewise, the Environmental Protection Agency and the National Oceanic and Atmospheric Administration, to cite just two examples of government agencies, are very influential in what happens in science today. The number of institutions, broadly defined, at the national, state, and local levels that have roles in science is truly staggering. You could write important stories about the respective history of virtually any of them.

Finally, stories about science history may well involve the background and development of situations that affect us today or were of great significance in the past. How a particular disease was conquered, how science led to inventions that improved our lives, or ways that science has helped us use our natural resources while preserving our environment — all these are topics you may want to explore as you think about your writing.

Much of the information you need to write articles on science history is readily available in the library. You'll find it fascinating reading. And with a little imagination, you will be able to understand why it is important to all of us today. Once you understand that, you're well on your way to writing interesting science history stories.

Assignments

1. Explain the contrast between basic science and applied science. What is the dilemma regarding the long-term effects of some scientific discoveries?
2. What questions must a writer ask regarding the needs of an audience for whom he or she is writing? What are the three types of science writing?
3. Why are accuracy and meaning so important with science writing? Give the quote of Leon Hale. Briefly explain these terms: timeliness, proximity, unusualness and human interest. List at least three qualities of writing that will make an article more readable.

Following are examples of science history writing by Robert Hays. The first pieces are short excerpts from *State Science in Illinois*. "Wholesome Water in Abundant Supply" is from *The Nature of Illinois*, a science-oriented popular magazine. Each piece demonstrates ways that science history can be used to describe the important work that scientists do. An example of a risk-based story appears on page 27, and a general science story on page 63. Numerous other examples appear throughout the reader.

Excerpts

State Science in Illinois

by Robert G. Hays (copyright, Southern Illinois University Press)

Perhaps more than either of the other two survey chiefs, Arthur Buswell appreciated the threat posed by the careless consumption of the earth's natural resources. He had been profoundly impressed by Fairfield Osborn's book, *Our Plundered Planet*, a compelling exposition of man's destruction of his surroundings. And he knew from a coincidental Water Survey discovery just how fragile the natural environment could be. Field engineers from the survey, running a continuous measurement on a deep well at the University of Illinois airport south of Champaign, had been puzzled by a small but frequent fluctuation of the water level. The disturbance amounted to only about half an inch and was always temporary. But sensitive monitoring equipment recorded it regularly. The well was 169 feet deep and the water level was about 70 feet below the surface.

After observing the phenomenon for some time, the engineers discovered what seemed to be a relationship between the times of the disturbance and the schedule of freight trains on the Illinois Central railroad tracks more than a half mile away. They watched this pattern closely. The relationship was too prominent to be ignored. Finally, with the cooperation of the railroad, a series of experiments was conducted. In addition to the regularly scheduled trains, freight trains of various lengths carrying different weight loads and traveling at different speeds were moved past the well. The experiments bore out the engineers' suspicions. Seventy feet below the surface of the earth, the water level was affected by passing freight trains at a relatively remote distance. The "solid ground" of the Illinois prairie was but a fragile crust!

* * *

The insect problem worsened as the summer progressed, with an unusually severe European corn borer infestation. The tomato russet mite, reported in Illinois for the first time only the previous year, heavily damaged hundreds of acres of commercial canners' crops. In addition, there was more than the usual amount of damage to corn and other crops from wireworms, false wireworms, grape colaspis, billbugs, sod webworms, grasshoppers, corn rootworms and corn root aphis.

Unquestionably, such severe insect outbreaks led to a dramatic increase in the use of chemical insecticides. This led, in turn, to more questions about the effects of insecticide application. By the mid-1950s, Natural History Survey scientists were deeply committed to research on broad problems relating to insecticide use.

An important early study conducted in the spring and summer of 1954 was related to a concentrated effort to control a Japanese beetle outbreak. About fifteen hundred acres of central Illinois farmland received heavy applications of dieldrin insecticide, some of the land sprayed and some treated with granules. Members of the survey study team made extensive daily field observations to compare animal populations on treated and untreated fields, fencerows, and roadsides. They also made chemical analyses on dead animals to determine if dieldrin was the cause of death. Their

findings were startling. Birds and ground squirrels, normally plentiful in the region, were virtually eliminated from the treated area. Muskrats along creek banks were killed by the spray; rabbits died in the fields. Only small field mice appeared to be unaffected. The study thoroughly substantiated the need for increased awareness of environmental problems caused by chemical insecticides.

Wholesome Water in Abundant Supply

by Robert G. Hays (copyright, The Nature of Illinois Foundation)

Turn-of-the-century fishermen on the Illinois River near Havana grew accustomed to a curious houseboat, towed by a 25-foot steam launch named *Illini*. In all likelihood, what went on aboard the vessel remained a mystery to most of them. And even if they had known, they could not have been expected to appreciate fully the importance of what was taking place.

This lumbering craft was no ordinary pleasure boat. It was a carefully designed scientific laboratory, complete with scientists' office, a library, kitchen, and laboratory space. The investigations carried out from this floating biological field station marked the beginning of the scientific study of water pollution in Illinois — almost 100 years ago.

Scientists and students aboard the houseboat during the summer of 1894 collected water samples regularly at six points on the Illinois River and three points on connected lakes. They studied their samples methodically, carefully identifying and recording minute specimens of plant and animal life. Then they sent the samples to the University of Illinois for analysis in the laboratory of Professor Arthur Palmer. Professor Palmer was confident that contaminated water was a major factor in the typhoid epidemics that had devastated the nation in 1893. He was especially eager to gain more extensive information on the quality of drinking water in his home state. Water samples from the Illinois would allow him to commence his urgent quest.

Pioneering a New Science

Arthur Palmer was a chemist — for a time the entire chemistry faculty of the university. He was well ahead of many of the scientists of his day in his understanding of the importance of clean water. Even so, he faced a formidable challenge. Because modern methods of bacteriological investigation had not yet been developed, Palmer could not identify conclusively the origin of outbreaks of typhoid and other dangerous diseases. At the same time, Illinois had few large population centers and had scarcely begun to notice serious sanitation problems. Health hazards that today seem obvious went unrecognized; there was no great public outcry from citizens worried about polluted waters.

But Professor Palmer enjoyed two advantages that significantly influenced his perspective. First, he had done graduate study in Europe, where the movement had gained a great deal more momentum than it had in the United States. And second, Palmer was a protege of Stephen A. Forbes, whose understanding of aquatic biology and the complex relationships of natural environments probably was unparalleled in late nineteenth-century America.

Forbes was both State Entomologist and director of the State Laboratory of Natural History. But more important, so far as Professor Palmer was concerned, Forbes also was dean of the University of Illinois College of Science and, therefore, Palmer's boss. That relationship would propel Arthur Palmer into the mainstream of scientific activity.

Dean Stephen Forbes was nationally known and respected as a scientist. In Illinois, he was remarkably influential. It was Forbes who founded the Havana field laboratory, a joint undertaking of the university and the State Laboratory of Natural History, and it was Forbes who initiated Palmer's work testing Illinois River water.

In 1895, Forbes succeeded in gaining a special $5,000 appropriation from the state legislature to support intensified chemical analyses of the state's water supplies. Professor Palmer undertook the studies in September. He and an assistant, toiling in the university's cramped chemistry laboratory, analyzed nearly 1,800 water samples from 68 Illinois counties over the next 15 months.

Galesburg's city health commissioner sent samples from a number of shallow wells in that western Illinois community. Professor Palmer's analyses showed that the water was contaminated. Subsequent study revealed that most or the wells received drainage from animal refuse. From Jacksonville, where typhoid had been prevalent, samples showed that very few wells provided water the scientists could consider safe. Similar situations were found in Joliet, Rock Falls, and other communities around the state.

Funding a New Agency

At the end of December 1896, Professor Palmer recommended not only that the water study be continued, but also that it be expanded in scope. He knew he was doing important work. The legislators in Springfield responded favorably.

This time, however, the funds appropriated by the legislature were separate from those committed to the general budget of the university. The appropriation bill called for a systematic chemical and biological survey of the waters of Illinois "to the end that the potable waters of the State may be better known, and that the welfare of the people of various communities may thereby be conserved." A State Water Survey now existed as an institution created by the Illinois General Assembly.

The early work of Professor Arthur Palmer and his assistants was in many respects pioneering. Theirs was an exciting, if somewhat uncertain, scientific period. Most of the water samples analyzed during 1896 were from home water supplies in communities where typhoid and diphtheria had been all too common. The chemical tests performed in Professor Palmer's laboratory were extensive but, he readily admitted, still speculative to some degree. "The precise relationship between the content of nitrates and the dissemination of disease by use of the water in which they are contained, is not definitely known," Palmer explained in his first published *Bulletin*. But he said that scientists in many instances "have found great quantities of nitrates in waters used by families in which several deaths from typhoid have occurred . . . ." He knew his scientific detective work held immense promise.

As knowledge of the new State Water Survey's work spread, demand for its services increased. More than 6,500 water samples had been analyzed by the end of 1899, a third of them sent to the laboratory by individual citizens who wondered about the safety of the wells and cisterns from which they and their families drank.

Professor Palmer still was interested in surface water, too, and undertook limited studies of the Mississippi, Des Plaines, Kankakee, Peoria, and Spoon rivers and the Illinois and Michigan Canal. And he had not forgotten the Illinois River. For nearly four decades, sewage from Chicago had been carried by the Illinois and Michigan Canal into the Des Plaines River and then to the Illinois. Nor was Chicago the only recognized source of Illinois River pollution. At the turn of the century, Palmer reported, sewage from some 25,000 people in Peoria, 10,000 in Pekin, and 8,000 in various smaller communities was flowing directly into the Illinois.

Added to the human waste was the refuse from Peoria and Pekin feedlots where 40,000 to 50,000 cattle had been fed on distillery slops. At the same time, glucose and strawboard factories in these same cities dumped more than 200 tons of organic waste into the river every day. For one as knowledgeable of the dangers of polluted water as Arthur Palmer, these must have been distressing realities.

It is easy to speculate that Arthur Palmer might have become an eminent figure in American science if fate had granted him that opportunity. But Professor Palmer died in early 1904 of "a physical weakness" said to have been brought on by overwork. He left his successors a clear mandate, however, and it was an appropriate legacy. He had grown adamant in his determination that the citizens of Illinois should enjoy "an abundant supply of wholesome drinking water" and he had gathered indisputable evidence that most of the state's surface water supplies, like its wells, were polluted. And polluted water, Professor Palmer wrote in that first *Bulletin*, offered "a most potent means of developing and spreading disease."

Samuel Parr, a fellow member of the university's chemistry faculty, succeeded Palmer as Water Survey director. He served as something of a caretaker administrator of the growing agency during the next 18 months. (Parr gained recognition for his studies in the use of Illinois coal, an area of applied

chemistry in which he came to specialize.) Then Edward Bartow assumed the directorship. Bartow would guide the Water Survey for the next 15 years, with time out for a stint of active military duty during World War I. He picked up immediately where Arthur Palmer had left off.

Expanding the Mandate

Under Bartow's leadership, the Survey saw rapid expansion of its bacteriological studies. The new director was particularly concerned about small communities that he knew did not have the technical capabilities of the cities when it came to water system management. He moved to make Survey scientists readily available to help. But Director Bartow also believed that the Water Survey should be doing more than simple testing. He felt strongly that water treatment and conservation as well as pollution control ought to be included within the range of the agency's activities.

After a period of lean budget years, Bartow was able to obtain increased funding for 1911 to provide for field engineers to make on-site inspections of municipal water supplies. Their early reports mark the beginning of a water supply data base that continues today as one of the state's valued assets.

Public water supplies in Illinois still were in comparatively primitive condition if gauged by modern standards. Effective methods of chemical purification had been developed in Europe, but these still were rare in the American Midwest. Municipal water systems that pumped raw, untreated water into the homes of citizens were common in Illinois. Clearly, keeping the water clean in the first place would be an important accomplishment, but the Water Survey had no real authority to correct even the most blatant cases of pollution. Pointing out the sources of contamination often proved to be of little consequence. Residents, who were quick to raise their voices in alarm when Survey scientists and engineers pointed out flaws in their communities' water-supply systems, commonly showed little concern about the dangers their own untreated sewage and industrial wastes posed for neighbors downstream.

The need for an intensified attack on pollution was critical. Many of the state's surface water supplies had grown seriously contaminated. Along the shore of Lake Michigan north of Chicago, there were more than 20 sewer outlets along a stretch of shoreline where there also was a score of waterworks intakes. "The frequent outbreaks of typhoid fever along the north shore have made very apparent the dangerous character of this pollution," Bartow reported in a 1913 Water Survey *Bulletin*. The majority of communities drawing their water from reservoirs were making little or no effort to protect them, the report noted, citing the example of one instance where "several private sewers were until recently permitted an outlet in the city reservoir." With very few exceptions, it said, "there are no sources of surface water supply in Illinois that are entirely free from possible contamination of a dangerous character."

Industrial wastes also continued to be a serious and growing menace to the state's waters. Water Survey engineers were dismayed by the condition of the Sangamon River below Decatur, where the stream was heavily contaminated not only by sewage but also by wastes from a corn products factory. Factory waste, said to be six to eight times as strong as normal domestic sewage, was flowing into the Sangamon at the rate of a million gallons a day. In low-water periods especially, pollution from Decatur left the river in a condition of obvious filth for miles downstream.

Early Pollution Control Efforts

Director Bartow had lost patience with the legal limitations on the Water Survey's authority to go to war with polluters. He finally discovered an effective solution. The recently-created Rivers and Lakes Commission had ample power, through hearings and abatement orders, to take action in cases of pollution. But the commission, for a variety of reasons including the lack of funds to hire investigators, had rarely exercised its authority. Bartow jumped at this obvious opportunity. The Rivers and Lakes Commission readily accepted a proposal under which the Water Survey could investigate cases of pollution and report its findings to the commission for legal action. Polluters no longer would be allowed to thumb their noses at his agency. The struggle to clean up Illinois water, though barely beginning, at least was under way.

Near the end of his tenure, Edward Bartow defined a two-pronged attack on water problems that he foresaw as the future challenge of the State Water Survey. He told a gathering of the American Public Health Association in Florida that agencies such as his should be concerned not only about the *quality* of water available, but also the *quantity*. The latter element of that dual charge would become critically important for the State Water Survey in years to come.

Professor Palmer, Edward Bartow, and all those who were to follow in molding the Water Survey into the agency it is today, merely extended the original guiding philosophy of Dean Stephen Forbes. On the opening of the Havana biological field station in 1894, Forbes told the University of Illinois Board of Trustees that the university had a special obligation to "stand in the closest possible relation to the general public welfare."

The field station was to carry out a mission of "pure science," Dean Forbes said. But he recognized a broader mission, as well — one best illustrated by the role he assigned Arthur Palmer. In order to serve the public welfare, the institution would have to "work out in every direction the application of the results of its investigations."

That application, ably begun by Professor Arthur Palmer before the turn of the century, continues in the State Water Survey today.

Assignments

1. Science history is often about people. Summarize one of the stories explaining how one person (like Arthur Palmer) or group of people changed the prevalence of disease for an entire state.
2. Consider yourself a science writer. Consider the work done in your own community by one person or group of people. Discuss the issue with your science teacher (air or water issue in your community, tree planting program, recycling in your school or community, air quality in your school etc.), plan questions, conduct interviews and write an article for submission to your school and/or local newspaper.

Part II Environmental Topics

Chapter 2
Water Quality: A Measure of Health

by Nancy Riggs

The term water quality may carry various meanings for different people. Safe water is essential not only for drinking but also for wildlife habitat, recreation, manufacturing and other economic development that is dependent on water. Economic development expansion or decline plays a critical role in the quality of life in coastal communities. Water quality affects the fish species that can survive and the safety of fish for eating. Water quality is a measurement of just how clean — or unclean — a body of water is, and whether or not it is safe for human consumption, habitation and recreation.

From the wetlands of Louisiana and the lagoons of Texas to the waters of the Great Lakes and the Arctic region, water quality issues are diverse. When European settlers first arrived, they found abundant, pristine water resources. Fish and game provided sustenance for the rapidly growing colonies, and soon the waters became highways for a young nation to expand. The oceans served as highways bringing more settlers to the New World, and inland waters took settlers into what is now known as the Midwest, a vast region of rich crop land. As the nation expanded westward, transportation and agriculture relied heavily on water resources.

Population growth around coastlines, both ocean and Great Lakes, became more and more concentrated, placing stress on these resources. Although seemingly unlimited to a young nation, these coastal resources began showing negative effects of burgeoning populations and an industrial revolution. Pollution from large urban areas included both human and industrial waste and street runoff. Agriculture changed dramatically during the 1900s, creating agricultural runoff pollution. Some native aquatic species began disappearing, and with ever-increasing waste materials dumped into waters, serious problems have surfaced.

Beginning with the Rivers and Harbors Act of 1899, regulatory attempts have been made to limit the pollution entering U. S. and Canadian waters. In response to an increasing dependence on oil, the Oil Pollution Control Act of 1924 prohibited discharge of oil into navigable waters. As early as the 1940s, evidence was presented that water pollution created a health hazard and damaged beaches, leading to passage of the Water Pollution Control Act in 1948. An increased environmental awareness of the 1970s, spurred in no small part by Rachel Carson's *Silent Spring*, led to passage of a Federal Water Pollution Control Act of 1972, commonly known as the Clean Water Act. The Safe Drinking Water Act followed in 1974, and amendments have expanded the scope of both. These acts are complemented by a number of other legislative programs and agreements, all directed toward improving and restoring the quality of water resources. Major progress has been made, but many concerns remain.

Some of today's major water quality concerns are contaminants, pathogens and eutrophication.

- Contaminants have the potential to increase risk of cancer, birth defects and genetic mutations. Examples include PCBs, dioxins and mercury (not a complete list).
- Pathogens can cause bacterial, viral and parasitic diseases through both drinking and direct body contact such as in swimming. Miroorganisms which are water quality indicators are actually surrogates for the presence of pathogenic or disease causing organisms. Examples include *Escherichia coli* (*E.coli*), an indicator in fresh water and *Enterobacter sp.*, an indicator in salt water. Bacterial pathogen examples include staphylococcus and aeromonas (not a complete list) that may cause infections in individuals with weakened immune systems or in elderly or very young people. Viral pathogens include the polio virus, hepatitis and protozoa (not a complete list).
- Eutrophication is the overenrichment of nutrients in lakes and estuaries that generally leads to poor water quality. Heavy loading, or overenrichment, of nitrogen and phosphorus compounds in aquatic ecosystems can occur naturally but is accelerated through human activities such as land clearance, atmospheric deposition from manufacturing and power production plants, and automobile exhaust. In effect, these nutrients overfertilize waters which can lead to excessive growth of algae, the single-celled plants at the base of the food chain. While extremely important, too many algae can cause severe water problems; because they go uneaten, they eventually die and are degraded by bacteria in processes that deplete water of its oxygen. A healthy body of water is usually home to popular sportfish species such as lake trout, whitefish and others that require cold, high-oxygen waters. In the Great Lakes, these fish normally eat invertebrates such as mayfly larvae (young) and freshwater shrimp that thrive in clean waters. Waters that have been heavily depleted of oxygen, however, lead to the loss of invertebrates and fish species that cannot tolerate these degraded conditions. These fish often are replaced by species that can tolerate those conditions. For example, carp and catfish, less popular for sportfishing, often replace the more sought-after species.

Aquatic problems are universal and are not limited to one locale such as the Great Lakes, Gulf, Pacific, Atlantic or Arctic. Public awareness and understanding have been paramount in spurring improvement and restoration of water resources. Whether information is disseminated by mass media, education and research institutions or agencies that address water quality, clear communication is essential. Explaining complex issues in clear, easy-to-understand language requires not only an understanding of the issues but also the ability to translate those complex issues into everyday language. Readers can more readily understand complex issues if they relate to topics they know and understand.

Writing About Water Quality

Although the array of water quality issues that may arise is unlimited, certain concepts help in explaining these issues. Two concepts are writing about conflicting studies and using concentration analogies.

Conflicting Studies: Research results sometimes seems contradictory. For example, chlorine is added to water to kill harmful bacteria in our drinking water. On the other hand, some research indicates that chlorine can be harmful to humans and aquatic species. Answers come slowly, and it's essential that you explain information clearly to indicate that research results are sometimes actually conflicting, and in other instances, that answers simply are not yet available.

Concentration Analogies: When it is necessary to include statistics about water pollution, presenting concentration analogies can help your readers understand the statistics. Although some examples may seem extraordinary, they can help your readers grasp the significance of concentration levels.

- One part per million
  - one automobile in bumper-to-bumper traffic from Cleveland to San Francisco
  - one pancake in a stack four miles high
  - one cent in $10,000
- One part per billion
  - one silver dollar in a roll of silver dollars stretching from Detroit to Salt Lake City
  - one second of time in 32 years
  - one kernel of corn in a 45-foot high, 16-foot diameter silo
- One part per trillion
  - one square foot floor tile on a kitchen floor the size of Indiana
  - one square inch in 250 square miles
  - one drop of detergent in enough dishwater to fill a 10-mile long string of railroad tank cars

Assignments

1. Using poster board, develop a timeline format, tracing the history of attempts to control aquatic damage.
2. Using poster board, draw a sketch of a coastal area showing population centers.
3. Write a story explaining the Clean Water Act and at least one impact in your area.

"The tide rolls on," by Jim Hiney, was published in Sea Grant's *Texas Shores* magazine, Spring 1997, to educate the public about brown tide and to convey frustration that its continued existence causes in the scientific, regulatory and sportsmen communities. This piece was one of three stories that, combined, received a 1998 CASE Special award for general writing collection.

Excerpts

The Tide Rolls On

by Jim Hiney, Texas Sea Grant

There is no other way to say it. Phyllis Ingram loves the Laguna Madre.

From the moment she first saw the "Mother Lagoon," it beckoned to her. Its crystal clear waters, lush sea grass meadows and abundant sea life lured her away from her office work in San Antonio and sat her right where she says she belongs, at the controls of her boat as a professional fishing guide.

There is nothing like cruising along the 120 or so miles of the Laguna Madre. On calm, clear days it's like skimming across a glass-topped table, looking down on nature's living collage of plants and animals.

Pristine. That's what the Laguna Madre is.

Or was.

"I was traveling along the Gulf Intracoastal Waterway, about a mile or two south of the John F. Kennedy Causeway," Ingram recalls. "I was in clean water and then I crossed a dark line. It was like chocolate coffee soup. I was totally dumbfounded. I thought to myself, 'My God, what is this stuff?'"

That was Ingram's introduction to brown tide, and it was seven years ago.

Brown tide is a mass of microscopic plants that dominates the Laguna Madre's ecosystem and perplexes the surrounding human population. Researchers believe it is the longest continual algal bloom in known history. Try as they might, researchers don't know why the brown tide won't go away.

It has become the battle of science vs. The biological Energizer Bunny.

At one time or another, the brown tide and resulting "rancid" water, as Ingram characterizes it, has been all the way from Galveston Bay to at least halfway down the Mexican coast.

Whether brown tide does much more than turn the Laguna Madre's once sparkling waters into varying shades of unpleasant brown is the subject of some heated debate among researchers, state officials and those who live and work on Laguna Madre. Brown tide kills seagrasses, which are critical habitat for spawning an raising most forms of sea life that call the Laguna Madre and Gulf of Mexico home. As the grasses die, so do small life forms. Fish larvae in particular appear to be plagued not only by the lack of seagrasses but also by the brown tide itself. Laboratory experiments show the brown tide has a lethal effect on fish larvae, though it has no effect on juvenile or adult fish.

Other zoo plankton that also float through the Laguna Madre virtually disappear as the brown tide mass grows. If you liken the food web to the ladder, brown tide is working its way from the bottom up, destroying rungs as it goes. Unlike red tide, brown tide isn't flashy about what it does. It doesn't cause large fish kills or cause human physical discomfort, like red tide does. Brown tide is more secretive and deliberate about its work.

"What's bad about brown tide is that brown tide is not an acute harmful bloom, it's a chronic harmful bloom," says Dr. Paul Montagna, a brown tide researcher at the University of Texas Marine Science Institute (UTMSI) in Port Aransas. "In other words, it's not a heart attack, it's kind of like cancer. It's something that might take 10 years to kill you. But that doesn't make it any less lethal."

Brown tide doesn't appear to hurt people, that is if frustration doesn't count as harm. Researchers and state officials are frustrated by the lack of solutions to the problem. Many of those who make their living from the Laguna Madre, primarily fisherman and guides, are frustrated as what they perceive as inaction and possibly indifference by the state towards brown tide. That indifference, they claim, because the brown tide hasn't hurt enough pocketbooks.

"As far as I'm concerned, when it comes to brown tide, the Texas Parks and Wildlife Department (TPWD) has dropped the ball miserably and they don't seem like they are interested in picking up the ball," fumes Walt Kittelberger, a professional fishing guide based in Port Mansfield. "It's like they are kicking it out of bounds. They want to pass this one on. I think it's not because they don't want to deal with it, it's because they, through counsel, have come to the conclusion that, 'Ain't nothing we can do about it.' Parks and Wildlife, in my opinion, is showing a great deal of insensitivity to the fishing public by underwhelming us with its resources in this area."

* * *

The brown tide was born in Baffin Bay in late 1989 of an environmental "car wreck," as Montagna puts it. "It's not one thing. Not every fish kill, not every freeze, not every drought period by itself will cause something like brown tide," says Montagna. "What we had in December 1989 was a unique confluence of events which was why I said it's like a car wreck. You can't have a car wreck unless two cars are at the intersection at the same time. We were going on the second or third year of drought. The salinities at Baffin Bay were very, very high. When the salinity is high, the ecosystem gets unstable. What I mean by unstable is that lots of things can't withstand the high salinity so lots of things are dying out. So the diversity in the bay was very low. And at all levels, there were only a few kinds of animals in the mud, there were only a few kinds of things in the water and it was basically a disturbed environment.

Now you know what happens if a farmer plows his field?" asks Montagna. "You have a disturbed environment. And what pops up? A weed."

On top of the drought there was a hard freeze in late 1989 that caused a huge fish kill. The freeze not only killed fish, it also killed many of the tiny invertebrates that had survived the saltier-than-normal-water. Some of those fed on the brown tide organism and helped keep it in check. When those invertebrates died the brown tide organism was left without many predators. As the freeze victims decomposed they released huge amounts of nitrogen , the brown tide's favorite food. The effect was the same as a gardener putting liquid plant food on a garden.

"Basically it fertilized this entire disturbed system," says Montagna. "So now you have an opening and this little weed took hold and had plenty of nutrients to grow on, plenty of open space to grow into because there was very little else living there at the time and it just flourished."

* * *

At one time or another, virtually all of the Laguna Madre has had a brown tide presence. Copano, Corpus Christi and Nueces bays have all had brown tide blooms. Copano was particularly hard hit during 1990. The biggest difference between those blooms and the one in Laguna Madre is that the other blooms went away.

The brown tide is a bit fickle. It doesn't coat the Laguna Madre like a blanket. It tends to sit in patches and those patches change. An area covered by brown tide at 8 a.m. may be clear by 2 p.m., notes Walt Kittelberger, who is also chairman of the Lower Laguna Madre Foundation, a citizen group formed to "act as an advocate to protect and preserve the resources of the Lower Laguna Madre."

Baffin Bay remains the only spot from which the brown tide has never completely disappeared.

* * *

Eventually there will be no brown tide in the Laguna Madre. No one knows whether that will be sooner or later, but the answer will determine what will be left behind in the Laguna Madre.

If the brown tide ends sooner, common thinking is that the Laguna Madre ecosystem will recover. The sea grasses will probably recolonize the meadow areas lost to the brown tide and fish will return to normal spawning habitats, though total recovery may take many years. A persistent brown tide will

mean "gradual death in terms of the bay system as we know it," foresees Bob Wallace, past president of the Coastal Bend Bays Foundation. The type of fish communities in the Laguna Madre will shift from seatrout, redfish and croaker to the drum and mullet populations that dominated the area years ago, Wallace predicts.

"That isn't to say that nature is not right, that it's not time to make a shift," he interjects. "It's just not what the people of this community want, me included.

Montagna shares Wallace's pessimistic view of the Laguna Madre's future.

"When brown tide first started, everyone was convinced that all we needed was one good rain event and it would be gone-flushed right out. Well, we had an amount of rain in 1992 that was equivalent to a major hurricane, and you want to know what? It just made the brown tide thicker," Montagna chuckled, "So I am not convinced anymore that a hurricane will solve the problem. And if a hurricane doesn't solve the problem and there is no way for it to be naturally controlled by other organisms in the Laguna Madre, I don't know what is going to solve it, except a very long period of time.

* * *

"Brown tide is sort of like the common cold of the Laguna Madre. There are no easy fixes without changing other things. There are a lot of things you can't do, like poison it. We could poison it, I'm sure there is a way we could do it, but I'm sure nobody would like the results, ultimately, because it would kill everything else, too. For instance, we know we can kill brown tide with copper, but the amount of copper needed to kill brown tide is 20 times that which will kill other plankton. So we've killed everything 20 times before we've killed brown tide." Dr. Terry Whitledge, UTMSI researcher

* * *

In the end, hope may be all we have. Hope that the brown tide will end soon, hope that nature knows what she's doing, hope that the Laguna Madre will survive, and even hope that a hurricane will blow through and make everything better.

"I have a love for this area. It's very sad for me to see what used to be pristine waters suffer through all of this," sighs Phyllis Ingram. "But I guess I have a positive attitude and I hope it will recover completely."

Assignments

1. Using poster board, draw a water schemata illustrating pristine water and brown tide. Using the chart as supportive detail, show how brown tide affects the type of fish that inhabit the different waters.
2. Explain why the writer compares brown tide to cancer rather than to a heart attack.
3. Write a story about brown tide.

"WETLAND LOSS . . . As People See It," by Marilyn Barrett, was published in Louisiana Sea Grant's *Coast & Sea*, Summer 1994, to help people understand the various viewpoints on wetland loss. The story focuses on the impacts upon quality of life and the relationship to the land shared by Louisiana residents. Barrett included statistical information on several of the many facets of this controversy and went on to quote credible experts in explaining impacts on people.

WETLAND LOSS . . . As People See It

By Marilyn Barrett, Louisiana Sea Grant

Conservation is a popular word today and much effort by individuals as well as by nonprofit organizations and government agencies is devoted to it. But saving one resource sometimes involves using another, and a conflict can result. The deterioration of some of the most ecologically valuable land in our country, the wetlands of Louisiana, has stimulated an outcry for conservation, while provoking strong emotion because wetland conservation means different things to different people.

Louisiana's coastal area, encompassing 40 percent of the nation's wetlands, has experienced 80 percent of the nation's total wetland loss. Since about 75 percent of the U.S. population lives within 50 miles of a coast, the majority of Americans apparently value these areas in some way. Most coastal residents earn at least a part of their incomes in coastal areas and use them for recreation. The rich marshes serve as home and nursery to a vast variety of wildlife, and coastal areas and barrier islands protect inland areas from Gulf of Mexico storms. According to the U.S. Fish and Wildlife Service (USFWS), only about 47 percent of the wetlands remain that existed in the contiguous United States during colonial times. About 45 square miles of Louisiana's coastal wetlands are being lost or significantly altered annually.

The largest of these U.S. coastal areas is the complex of marshes, lakes, and estuaries situated in south Louisiana adjacent to the Gulf of Mexico. Within this region, the U.S. Environmental Protection Agency has established the Barataria-Terrebonne Estuary Program, a special designation for a management unit covering about 6,000 square miles that includes all of the water bodies, woodlands, swamps, marshes, agricultural lands, and settlements within 15 Louisiana parishes (counties). The human population of this region is concentrated in somewhat isolated communities occupying narrow ridges adjacent to bayous, and in communities along the Mississippi and Atchafalaya rivers. Although most coastal parishes like Lafourche and St. Mary are inhabited primarily along one main ridge or levee, Terrebonne Parish's communities occupy five ridges, radiating like fingers from the city of Houma. Only about five feet above sea level at most, these ridges are the elevated spots in the coastal wetlands.

Together this four-million-acre area, housing a comparatively small population, contributes nearly $1 billion annually to the U.S economy in commercial seafood, sport fishing, and hunting. At least 19 percent of the nation's estuarine-dependent commercial fisheries spend part of their life cycles here. Most of the offshore oil and gas drilling activity in the United States is serviced from or located here.

Some say human activities — industry, development, technological/physical alterations to waterways and coastlines — are causing wetland deterioration. Others blame natural occurrences — saltwater intrusion, shoreline erosion, and subsidence. Actually all of these have contributed to the shoreline retreat at a rate of 2-4 square meters annually of eight of the nine hydrologic basins in Louisiana which empty into the Gulf of Mexico. Only the ninth, the Atchafalaya, is building new wetlands at its mouth.

Most individuals have noticed one or more changes that affect survival: disappearing and dying plants and animals, increased flooding, reduced commercial fish catch, and job loss leading to reduced personal incomes and smaller local economies. Some point to their own backyards. disappearing from coastal erosion or subsidence.

"When I was 18, I used to walk in marsh grass that was taller than me," said Kirby Verret of the United Houma Indian Nation at Isle de Jean Charles. "Today three feet of water covers that area." Verret is now 46.

"People used to drive cattle out to the (barrier) islands to graze," said Robert Jones, Terrebonne Parish Engineer. "Today you can't get there without a boat." Statistics indicate that Terrebonne Parish has been subsiding about one inch in every 20 years. "For those living along Bayou Grand Caillou or Bayou de Jean Charles, that means that a house that used to be high and dry now has water in the backyard about 20 percent of the year," Jones said. Some houses have raised wooden walkways from the road to the door.

Many of those living and working in Louisiana's coastal areas have shared their observations on changes in their coastal environments with Dr. Shirley Laska of The Environmental Institute at the University of New Orleans. By conducting telephone surveys and direct interviews, the institute assembled data that are being used by federal, state, and local governments to try to decide on a method to conserve Louisiana's diminishing coastlands.

In their survey responses, the people don't all see coastal changes the same way. In most cases, residents attributed the coastal changes to natural causes while public officials attributed them to human activities. For example, residents explain that erosion or habitat loss near home was caused by last year's flood, excessive rain, or sea level rise. "The rising saltwater killed the cypress," Verret said. Public officials like Jones attribute changes to human projects, especially the Corps of Engineers projects to control the flow of the Mississippi River. People from both groups blame industry or technology, unless it directly provides a source of livelihood. They don't blame technology that puts food on the table, concluded Laska and her team.

A large number of the surveyed residents expressed helplessness, saying that the problem is much bigger than they are. They describe *temporary* adjustments they have made in lifestyle — downscaling to match a reduced budget, taking second job, sending the wife to work, encouraging children to select a vocation different from that of their parents. Some are so sure that these circumstances are temporary that they accept these adjustments rather than look for a more permanent method of conservation or restoration. They make small changes and tolerate inconveniences like periodic flood or erosion.

"People will start responding seriously (to diminishing wetlands) when they get tired of wearing boots to go from the house to the car or truck," observed Rod Emmer, an independent planning consultant and adjunct professor at UNO's College of Urban and Public Affairs.

The surveys make clear that the general public and public officials define wetland conservation as lifestyle retention. The lifestyles of these tightly knit, south Louisiana communities of large, extended families are supported by the coastal environment — primarily through commercial fishing or the offshore oil patch. Wetlands shelter these communities on those narrow north-south ridges, isolated east and west by water and deteriorating marsh. "Because of wetland deterioration, some of these people now live 30 percent of the year under subhuman conditions," said Reggie Dupre, chairman of the Terrebonne Parish Council. Although erosion and subsidence threaten human habitat and lifestyle, the people consider the coastal wetlands to be home.

Whenever the wind blows from the southeast and the single road into the community of Isle de Jean Charles is flooded by the tide, the people living there stay home. Even if the road is eventually unusable, Verret emphasized that no one in his community would consider relocating. "If we have to, we'll use a boat."

Residents' Conservation Efforts

Residents' conservation efforts are careful and slow; they resist any method that might disrupt their lifestyles. "Humans first ignore a threat, then they pay attention. Then they tend to apply technological skill to it," explained Dr. Laska. "They try to diffuse its impact, in this case with flood insurance. As the problem becomes more serious, they may make major technological or 'engineered' efforts, like building levees. Once it appears that these engineered structures will not stop the change, they may begin some conservation measures like building homes of materials that can be restored easily after a flood, or constructing new homes on pilings to reduce the damage when the inevitable floods or storms come. Relocating is considered by all to be the final phase, the last resort."

These stages can be seen in Terrebonne Parish where some houses and mobile homes stand on pilings 8-10 feet off the ground. The parish government, the only local government in the entire parish, has spent millions on engineered projects called *forced drainage*. "New Orleans has 17 forced drainage systems and we have 55," said Jones. In these, the residential communities are surrounded by man-made levees along those fingers of high ground. During and after rains, pumps force the accumulating water over the levees into the bayous and marshes.

Preservation of lifestyle is so important that the people are willing to tax themselves to achieve it. Terrebonne voters passed four taxbills in 1992 to raise funds to correct drainage and road problems. Two were sales taxes, and two renewed drainage, road, and bridge bond issues. "Win or lose the wetlands fight, the people have drawn the line. They are not moving north (out of their coastal homes)," emphasized Jones.

Public Officials' Solutions

The Environmental Institute's surveys show that public officials do not share residents' feelings of helplessness or their perceptions that coastal change is temporary. For instance, Terrebonne Parish is carefully encouraging the development of two regional medical facilities at Houma to supplement the wetland-dependent seafood- and oil-related economic base. Tourism is being encouraged. The surveys show that they are also in favor of engineered projects to mitigate or slow erosion and that they plan to seek state and federal financial assistance for these.

But only about 50 percent of the public officials would support relocating people in order to conserve wetlands. Most, like the general public, seek technological solutions that will preserve the existing lifestyle.

"Our culture is washing away with our land," said W. Clifford Smith, president of T. Baker Smith & Son, Inc., of Houma. This firm has been involved in south Louisiana wetland surveying, exploration, and mapping for three generations. Although he supports local government efforts to diversify the economy, Smith emphasizes the need to conserve the coastal areas in order to preserve the lifestyle intimately associated with south Louisiana's unique culture.

"When the levees on the (Mississippi and Atchafalaya) rivers stopped the annual flooding, our coastal areas stopped receiving the natural delta-building silt needed to perpetuate the wetlands. Eventually, our coastal areas began deteriorating. But the U.S. *had* to build the dams and levees (to protect upstream midwestern and Louisiana communities from flooding)," he said. In that case, midwestern lifestyle had to be preserved. Similarly, engineering projects that provide jobs and protect coastal Louisiana homes are contributing to coastal deterioration. But the canals dredged under the direction of engineers through the marshland also assisted oil exploration, a major employer for wetland residents; engineer-designed forced drainage systems protect coastal homes while they reroute natural freshwater flow.

Although some environmental groups would like to stop all use of wetlands and preserve what is left, neither residents nor public officials agree. To them, the value of the wetlands lies with the people who live there.

Public officials and the general public are interested in working with environmentalists to restore Louisiana's barrier islands as a step toward stopping wetland deterioration. Eroding at rates of 5-20 meters per year, barrier islands form a natural storm buffer for the wetlands, explained Lou Schober,

who does research and development at T. Baker Smith & Son, Inc. Hurricanes have eroded these islands from offshore, and cold fronts from inshore. The most recent assault from Hurricane Andrew in 1994 took about 100 feet off East Island. Although barrier island restoration would entail a great deal of engineering and expense, all agree that the resulting protection for the marsh would significantly reduce the annual marsh shoreline retreat.

To survive, wetlands must have a steady supply of new sediment. Terrebonne officials believe that the logical source for it is the Atchafalaya. The Old River Control Structure diverts 23-35 percent of the water, silt, and nutrients from the Mississippi River into the Atchafalaya, which in turn, deposits it primarily in the Atchafalaya Bay in St. Mary Parish. Terrebonne officials have developed a plan to capture some of that fresh water and silt by relocating the Terrebonne segment of the Gulf Intracoastal Waterway (GIWW) farther to the south in the coastal estuaries. Dupre, Smith, and Jones fear that this huge engineering solution is not likely to happen. Lamenting the federal red tape that is necessary to secure a permit for their forced drainage projects (one underway at present took 17 years to secure approval), they fear that relocating this trade route would be even more difficult because all parties — residents who might have to relocate, environmentalists who would be concerned about lost habitat, commercial fishermen who fear loss of estuary, sportfishermen who fear loss of fishing grounds, oil companies whose operations might be curtailed or disturbed — might object.

The Big Picture

Many separate efforts are being made to save portions of the wetlands. Among them: The South Terrebonne Parish Tidewater Management and Conservation District has several hurricane and estuary protection projects under construction. The U.S. Army Corps of Engineers maintains hurricane protection levees in Lafourche and St. Mary parishes, as well as other projects along the Mississippi and Atchafalaya. On the basis of research such as this done by the Environmental Institute, the Barataria-Terrebonne Estuary Program plans to propose management and conservation measures. This program is part of the EPA's National Estuary Program. There are many other state and federally funded programs as well.

No one believes that land already lost can be completely restored but everyone understands that conservation efforts are the best way to salvage what remains of the wetlands. The path that is taken depends upon whether the motive is preserving a lifestyle, saving American geographical heritage, or protecting the American economy. This means that the major thrust of all public and private conservation efforts can include preserving the land as it is now, building more structures to prevent further erosion or subsidence, planting or encouraging the development of new wetland areas, or even releasing the Mississippi River from man-made control. It can mean preserving only a portion of our wetlands because the expense of total restoration is too high.

The data from The Environmental Institute make clear that the people who live in the wetlands want, above all, to preserve their lifestyle. They apparently believe forced drainage is essential to the solution. Although many public officials agree with Jones that forced drainage is only a part of the solution and that it sometimes costs more to maintain an area than the value of the dwellings therein, these projects will continue because the people want them, believe they solve the problem, and are willing to pay for them.

"*Objective* reality is less important than *perceived* reality," Laska explained. "People don't respond to the existing situation; they respond to their perceptions of it." The people perceive conservation of wetlands as conservation of the existing lifestyle.

At the same time, some environmental groups see wetland conservation from a completely nature-based standpoint. Removing the cause of deterioration, which they perceive as man and his technology, is at the base of their efforts.

Those who look at the national picture note the value of petroleum and gas exploration to the American economy and defense efforts. They point to seafood as a cornerstone of the food and entertainment industries. The loss of either will have significant economic impacts on American lives from Atlantic to Pacific. These lifestyles too must be preserved.

"But change is coming," Laska said. "The country can't afford to continue to absorb these losses." Which losses — land, lives, marine life, jobs, oil — is an unanswered question.

Assignments

1. Draw an illustration showing the loss of wetlands in one Louisiana basin, revealing the loss of plants, animals and shoreline.
2. Form wetland debate groups. Using posters to demonstrate evidence, one side will defend the wetlands, striving to restrict and reduce development. The other side will raise objections and forestall wetland protection.
3. Write a list, stating what scientists and dwellers give as causes of coastal changes in the Louisiana basin.
4. Write a story explaining ways that inhabitants of the Louisiana basin cope with loss of their economic security. Cite quotes from authorities and inhabitants that reveal the struggle by inhabitants to remain in a basin where the biota is rapidly deteriorating.

"Viewing a Phaseout From Different Vantage Points," by Nancy Riggs, was carried in Illinois-Indiana Sea Grant's *The HELM*, Spring 1996. The article was published to raise awareness of the issue of chlorine discharge into the Great Lakes. To avoid any possible misinterpretation of the source of information, a forum format was selected to present the information. "Viewing a Phaseout From Different Vantage Points" earned a 1996 ACE Gold Award in Writing.

Chlorine: Viewing a Phaseout From Different Vantage Points

by Nancy Riggs, Illinois-Indiana Sea Grant

Panoramic scenes appear very differently from different vantage points. The chlorine issue has various vantage points, and the view from each is somewhat different. The call by the International Joint Commission (IJC) for a phaseout of chlorine discharge into the Great Lakes has generated heated debates among supporters and opponents. The stakes are high, and the debate centers around whether or not chlorine-containing compounds should be treated as one chemical or evaluated on an individual basis.

The U.S. Environmental Protection indicated that more study is needed, and Environment Canada noted a lack of scientific basis for a phaseout. Some proponents of the phaseout point out that individual assessments are not realistic. Opponents, on the other hand, argue out that chlorine provides essential benefits.

Sea Grant is committed to providing unbiased information to help people make more informed decisions. Within that context, this issue of *The HELM* includes a forum that carries views from both proponents and opponents of the phaseout. Contributing organizations include the IJC, National Wildlife Federation, Chlorine Chemistry Council and the Council of Great Lakes Industries.

Guest Views on Chlorine

Responsible Choices . . . Responsible Stewardship

by Grace Wever, Vice President, Council of Great Lakes Industries

Today, thanks to the efforts of many, the Great Lakes are not in crisis. Over a decade ago, their problems were highly visible. But two decades of intervention by governments and the public and private sectors have done much to alleviate this through improved treatment, tighter standards, and voluntary pollution prevention addressing both conventional and toxic pollutants. Data from both Canada and the United States indicate that such point source programs have been highly effective. Discharge levels of chemicals have been drastically reduced, and in turn, their levels have dropped in fish tissues, in sediments, and in the water column. Concerns remain, however, about a small subset of chemicals that are persistent, bioaccumulative, and toxic. Nonpoint sources are by far the greatest contributors of these materials. For example, air deposition contributes 9 per cent of the mercury entering the lakes, and residual chemicals are still found in sediments and landfills. While many programs have been established by both Canada and the U.S. to address nonpoint sources, the issue still begs for better coordination of both point and nonpoint source programs. Cost-effective barriers to the use of these methods need to be removed.

Far more controversial is the topic of human health effects of bioaccumulative persistent toxic chemicals. Definitive data needs to be gathered that established where risks are real, and where they are perceived or phantom in nature. Several studies are underway that will provide sound science for

decision-making. While this issue awaits resolution however, we are not standing still, nor are we slipping backward. Tighter discharge standards and ongoing pollution prevention programs continue to diminish point source discharges of these materials. Some have proposed broad-brush chemical bans for whole classes of chemicals. This clearly is not a viable solution. Removing chemicals such as chlorine, for example, from commerce would rapidly lead to very real (not phantom) effects on both the region's economy as well as its underlying social systems. Today approximately 40 per cent of all U.S. jobs and income depends on chlorine chemistry, including the synthesis of 85 per cent of all pharmaceutical products. The safety of drinking water supplies has been ensured since chlorine disinfection was adopted. Regional leaders need to find consensus on a more rational, science-based approach to such issues, that includes analysis of such risks, benefits, and costs as a part of the decision making process.

If the region truly intends to adopt and ecosystem-based approach to environmental management, then it will need to expand its vision beyond a single parameter such as chemicals to effective analysis and management of all factors that affect the well-being of its natural resource base, including biodiversity, exotic species, land-use and other issues. We will need to adopt a more integrated approach to plan for the sustainability of both our natural resource base and the economic system that underwrites the stability and health of our social systems as well.

Position of the International Joint Commission on Chlorine

by Thomas Baldini, United States Section Chairperson

Under the 1978 Great Lakes Water Quality Agreement, the International Joint Commission is requested to advise the Governments of the United States and Canada about matters relating to Great Lakes water quality including strategies for controlling and preventing the input of persistent toxic substances. Agreement programs are intended to virtually eliminate the input of these substances to protect human health and that of living aquatic resources. The philosophy adopted by the Governments for this purpose is zero discharge.

There is increasing evidence that a number of persistent toxics, particularly chlorinated organic chemicals, entering the Great Lakes ecosystem are harmful to various species including humans. Considering the advice of its technical boards and other sources over several years, and the lack of action on general recommendations for toxics management strategies, the Commission reached the following conclusions:

- Great Lakes ecosystem integrity and specifically human health are being compromised contrary to the intent of the Great Lakes Water Quality Agreement.
- The implications are sufficiently serious that a precautionary approach is needed, based on a weight or preponderance of evidence, in contrast to delayed remedial action after cause and effect have been proven for each specific chemical after the fact.
- The customary approach of allowable-input thresholds and risk management should not apply to chemicals that persist and/or bioaccumulate in the ecosystem.
- The customary regulatory approach of controlling one chemical at a time, while still needed, is inadequate to deal with the thousands of chemicals and their uses, and thus a broad preventive approach that addresses classes of substances is preferred.
- The onus in determining which chemicals should be allowed in commerce should rest with the proponent to prove safety rather than with governments to prove harm.
- Technology exists or can be developed for safer replacement products/processes.

The International Joint Commission has recommended the planned phasing-out or "sunsetting." of a number of substances now in commerce, beginning with the eleven Critical Pollutants first proposed in 1985. A majority of these, and many other known persistent toxics, are chlorine compounds. Many other chlorinated chemicals have either characteristics similar to those with known deleterious effects, or as yet unknown effects. Their generation as by-products, especially in the environment, cannot always be fully controlled. Thus, the Commission recommended to the Governments of Canada and the United States that, to ensure virtual elimination of persistent toxic

substances, they discuss with industry and other interest the sunsetting of chlorine and chlorine compounds as industrial feedstocks. The Commission recognized uses, e.g. pharmaceuticals and water treatment, that may presently be unavoidable, and also that the timing of the need technological transition must take into account socio-economic as well as public health considerations.

A Key to Pollution Prevention

by Wayne Schmidt, Research Manager, National Wildlife Federation Resource Center

"Are humans and our environment in danger from persistent toxic substances now? Are future generations in danger? Based on a review of scientific studies and other recent information, we believe the answer to both questions is yes."

Do you agree? How you feel about these conclusions of the International Joint Commission (IJC) will affect your opinion about chlorine.

I think there *is* something fundamentally wrong in our environment. The Great Lakes' eagles, lake trout and otters that suffer reproductive problems are telling us something important. I believe that our current uses of chemicals are harming our children and their yet-to-be born children.

We have two basic choices: (1) keep doing what we're doing or (2) do something different.

The problem with the first choice is that it's what got us into this mess. Dancing housewives and chickens sang "DDT is good for me-e-e!" in 1940s pesticides advertising. Dioxins aren't that bad, chemical makers argued in the 1970s. And for nearly 50 years PCBs, now the scourge of the Great Lakes environment, were marketed for everything from electrical ballasts to paint on Navy ships — all told, some 700,000 tons in the United States alone.

Today, the same industry, in fact, the very same companies responsible for some of these global catastrophes are saying: "Trust us. That was then. We're smarter now."

But the most modern tests, performed one chemical at a time using the arcane science of risk assessment, may give only a peek at a chemical's effects. Our real exposures are to *mixtures* of chemicals, which may have unpredicted effects. Risks to an adult are different than to a developing fetus. Individual susceptibility may depend on gender, age, hormonal factors, diet, pre-existing diseases, genetics, lifestyle and possible ethnic differences. Risk assessment captures none of the subtleties. Nor does current testing adequately deal with emerging concerns about potential damage from pollution to endocrine and immune systems.

So, then, how do we chart a new path to do something different? How do we start *preventing* the most troublesome classes of chemicals from getting out of control?

That's where chlorine comes in. About half the persistent toxic chemicals in the Great Lakes and half the chemicals known to damage endocrine systems are chlorinated. So the *class* of chlorinated chemicals is a great place to start looking for ways to prevent pollution.

That does not mean banning the use of chlorine for bleaching our socks, making pharmaceuticals or even disinfecting water. It does, however, mean taking some easy steps — where better alternatives already exist — to phase out industrial uses of chlorine, such as bleaching of paper, and manufacturing some popular consumer products, such as PVC plastics used in packaging.

PVC is by far the largest single use of chlorine in the United States. Dioxins are produced inadvertently throughout the life cycle of PVC, especially when PVC plastics are burned with trash. For example, the biggest source of dioxins in the Great Lakes is from medical waste incinerators in Illinois, especially the Chicago metropolitan area, according to recent research by Dr. Barry Commoner.

Our ignorance of biological complexities demands humility and great caution in the used and release of chemicals to our environment. Phasing out key industrial uses of chlorine, especially when alternatives are readily available, makes sense.

Chlorine: Essential to Public Health and Safety

by Clifford T. "Kip" Howlet, Vice President and Managing Director Chlorine Chemistry Council, A Council of Chemistry Manufacturers Association

Concerns have been raised over possible health and environmental effects of the widespread use of chlorine-based products. Some have called for a ban on chlorine and the practice of chlorine chemistry. Taking such precipitous action without a rigorous, science-based evaluation of the pros and cons of such a ban would very likely create many more problems than it would solve.

Chlorine and chlorine-based disinfectants provide safe drinking water in nearly all U.S. public water systems. Chlorine chemistry is critical to the manufacture of 85 per cent of all medicines, and it is involved in the production of 96 per cent of all crop-protection chemicals. It is the basis for all things made from vinyl plastic and is essential to production and performance of thousands of other products that we use each and every day of our lives.

Yet in April, 1992, the International Joint Commission (IJC) of the United States and Canada recommended the "sunsetting" of chlorine and chlorinated compounds as industrial feedstocks. The chemical industry was extremely disturbed and disappointed by this recommendation because, among other problems, the IJC report was selective in its use of scientific data. The U.S. Environmental Protection Agency (EPA) and Environment Canada apparently agreed; both rejected the IJC's recommendation in the fall of 1993.

Many of the objections to chlorine revolve around sweeping generalizations that equate all chlorinated compounds with a problematic few that have been shown to cause adverse effects on wildlife. In fact, chlorinated chemicals have differing chemical and physical properties which govern not only their value to society, but their potential behavior in and effect on the environment, which vary widely.

A number of respected organizations recognize this fact. The American Medical Association, American College of Preventive Medicine and American College of Occupational and Environmental Medicine all have called for a scientifically grounded process to assess chlorinated compounds. In June 1994, the Michigan Environmental Science Board (MESB), in a report prepared for Gov. John Engler, concluded that products containing chlorine are not inherently dangerous. In fact, the report states, science has shown the opposite to be true: many chlorine compounds not only are safe, but also make significant contributions to our economy *and* protect the environment.

The most comprehensive scientific review ever undertaken on the subject of chlorine chemistry, published in *Regulatory Toxicology and Pharmacology* (August, 1994) and underwritten by the Chlorine Chemistry Council, notes that "the mere presence of chlorine in a molecule does not necessarily confer unique toxic properties or bioaccumulative potential . . . ." This report was prepared under the direction of a panel of independent experts in toxicology, ecotoxicology, epidemiology, carcinogenicity and environmental chemistry.

Creating public policy based on broad generalizations about chlorine could lead to loss of products that improve the quality of life with a comparable benefit to human health and the environment. Therefore, evaluations should include risk-benefit analysis of potential alternatives, as well as the risks of not having chlorine available to society. Taking any other path would defy logic and common sense.

Chlorine Update — The *HELM* Winter 1997-98

New U. S. Environmental Protection Agency (U. S. EPA) rules issued in November will reduce dioxins in affected waterways by 96 percent, according to that agency. Bleached paper-grade kraft mills will have to replace chlorine gas used in the bleaching process with chlorine dioxide to meet emission standards. The rules were scheduled for publication in the Federal Register in January and will take effect after a 60-day period for Congressional review. Mills that discharge directly into U. S. waters must be in compliance when permits are reissued. Mills that discharge into municipal systems will have three years to comply. The new rules were issued as part of U.S. EPA cluster rules affecting both water and air emissions. Remaining segments of the cluster rule affecting pulp and other mills are expected to be finalized by the U. S. EPA later.

Assignments

1. Analyze the chlorine issue and persuade an audience reading your article which action is best to take at this time. Name the audience that you plan to target as that will reflect the form of persuasion taken.
2. Which guest contributors support a ban and which ones oppose a ban? List at least two reasons that each cites.
3. Defend your side. Imagine yourself a corporate lawyer or a lawyer representing an environmental group. Write a persuasive brief taking a position on this question: Which losses can American no longer afford: land, lives, marine life, jobs or oil?
4. Write a story about chlorine discharge. Be sure to write a balanced story.

"Pollution Goes Up, Comes Down in the Arctic," is a radio script for "Arctic Science Journeys," produced by Doug Schneider, Alaska Sea Grant. This 1998 broadcast script highlights science, culture and the Arctic environment. A re-write for a print story follows illustrating the differences in writing for broadcast and for print. "Arctic Science Journeys" has won numerous awards including first place 1998 Alaska Press Club Awards and second place 1998 ACE Award for features and specials.

Pollution Goes Up, Comes Down in the Arctic

Arctic Science Journeys Radio Script

Writer/Producer Doug Schneider, Alaska Sea Grant

INTRO: Scientists say a commonly used pesticide is polluting a famous lake in Canada. Debra Damron has more, coming up next on Arctic Science Journeys.

STORY: Novelist Robert Service's gritty stories about the far north have made places like Lake LaBerge in Canada's Yukon Territory famous. The stories reflect a time when the Arctic was a pristine land. Now scientists say the lake is polluted and its fish tainted. Mark Palmer is with the Canadian Department of Indian and Northern Affairs.

PALMER: "It sorta caught everyone in the Yukon off guard, that all of a sudden there's this chemical, toxaphene. Nobody knew what it was, it was never used around that lake, why is it in our fish. Everybody was sort of thinking the Yukon was pristine, and there're no problems here. All of a sudden, wham! We got hit with this."

Toxaphene is a pesticide once used extensively on cotton and soybean crops in the United States. Banned in the United States since the 1970s, it's still commonly used in many developing countries. Although such countries are thousands of miles from the Arctic, toxaphene is making its way to the Arctic by hitchhiking aboard global air currents. Mark Palmer explains.

PALMER: "Chemicals like toxaphene are quite volatile. As soon as it warms up it evaporates into the atmosphere. And when it cools, it'll come back down in rain or snow. When it warms up, the cycle will repeat. Some people refer to it as the 'grasshopper effect' because everything sort of bounces north and gets stuck up here."

Toxaphene becomes trapped in the Arctic because it's too cold much of the year for evaporation to occur. As a result, the pesticide accumulates first in the lakes and later in the organs of fish. Indians and Eskimos consider fish kidneys and livers a delicacy. But health officials have warned against the practice.

PALMER: "The levels of toxaphene are so low they don't mean a thing in the drinking water. But once they get into the fish, they're actually at quite high levels. As a result, Health Canada advised people not to consume the livers of burbot and only eat limited quantities of lake trout."

Scientists say toxaphene and other chemicals pose a danger in only a few of the territory's thousands of lakes. To keep it that way, Mark Palmer says Arctic nations will have to lobby countries far from the Arctic to stop using dangerous chemicals.

OUTRO: For Arctic Science Journeys, this is Debra Damron reporting from Fairbanks, Alaska.

Pollution Goes Up, Comes Down in the Arctic

by Doug Schneider, Alaska Sea Grant

Novelist Robert Service's gritty stories about the far north have made places like Lake LaBerge in Canada's Yukon Territory famous. His stories reflect a time when the Arctic was a pristine land. Now scientists say the lake is polluted and its fish are tainted. Mark Palmer, a scientist with the Canadian Department of Indian and Northern Affairs is leading the effort to understand the extent of the pollution.

"It sorta caught everyone in the Yukon off guard," says Palmer. "All of a sudden there's this chemical called toxaphene. Nobody knew what it was. It was never used around that lake. So why is it in our fish? Everybody was sort of thinking the Yukon was pristine, and there're no problems here. All of a sudden, wham! We got hit with this."

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"Chemicals like toxaphene are quite volatile," explains Palmer. "As soon as it warms up it evaporates into the atmosphere. And when it cools, it'll come back down in rain or snow. When it warms up again, the cycle will repeat. Some people refer to it as the "grasshopper effect" because it sort of bounces in and out of the atmosphere. But once it reaches the Arctic it tends to get stuck up here."

Toxaphene gets trapped in the Arctic because it is too cold much of the year for evaporation to occur. As a result, the pesticide accumulates first in the lakes and later in the organs of fish. Indians and Eskimos consider fish kidneys and livers a delicacy. But health officials have warned against eating those organs.

"The levels of toxaphene are so low that they don't mean a thing in the drinking water," says Palmer. "But once they get into the fish, they're actually at quite high levels. As a result, Health Canada advised people not to consume the livers of burbot and only eat limited quantities of lake trout flesh."

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Assignments

1. Define the grasshopper effect, and explain how toxaphene, used in the southern United States in the 1970s, is now collecting in Arctic lakes.
2. Explain how the radio script and print story differ in technique.
3. Write a story about pollution in a nearby lake or stream.

Chapter 3
Exotic Species: Unwelcome Intruders

by Peggy Britt and Joyce Jukubiak

For as long as people have traveled, they've transported plants and animals to new locations. Sometimes this was done deliberately to enhance the quality of life; other times new species were accidentally introduced. Today these newcomers are known as exotic, or nonindigenous, species. Exotic species are organisms introduced into habitats outside their native range.

Even though exotic species may sometimes be ecologically harmless or even beneficial (for example, some houseplants, vegetables and birds), others have had a detrimental impact. These are known as invasive or nuisance species. With no natural predators, parasites or competitors to keep their numbers in check, nuisance species overrun their new homes and crowd out native species — sometimes to extinction. These exotic species can rarely be eliminated once they're established and are a major reason for the loss of biological diversity throughout the world.

Aquatic exotic species have had profound effects in the oceans, lakes and streams from the San Francisco Bay to the Atlantic Ocean and from the Great Lakes to the Gulf of Mexico. In the Great Lakes, for example, more than 140 new species have been introduced since the 1800s, according to the Michigan Department of Environmental Quality. Some species were introduced intentionally and have had positive effects. Coho salmon from the Pacific Ocean were introduced into the Great Lakes decades ago where they now support a thriving recreational fishery. However, more than one-third of the nonindigenous species in the Great Lakes arrived after the St. Lawrence Seaway opened in the 1960s, which allowed ocean freighters to reach the Great Lakes. One of the most detrimental intruders to hitch a ride in the ballast water of an ocean freighter has been the zebra mussel. Zebra mussels are small striped mussels native to the Caspian Sea region of Asia. Scientists discovered the creature in Lake St. Clair (between Lake Erie and Lake Huron) in 1988. Since its discovery, the tenacious mussel has adapted quickly to its new home — multiplying rapidly and attaching itself to everything from water intake pipes to native clams — and has permanently altered the ecosystem. In the last decade, zebra mussels have spread to inland lakes and streams in 19 states and two Canadian provinces, and they cost millions each year to control.

One West Coast study found that more than 230 exotic species have invaded the San Francisco Bay, and researchers estimate that a new organism shows up every 15 weeks. As in the Great Lakes, many of these creatures arrive in the ballast water of ships traveling to the United States from foreign countries. Ocean freighters take on ballast water for stability during the ocean crossing and often dump this water — and everything it — when they pick up their loads in port. In addition to accidental introductions from ballast water, exotic species are sometimes brought into the country for aquaculture, research projects and aquariums. These exotic species sometimes escape or are released into the wild. Goldfish, for example, have become an exotic nuisance species in eastern Washington.

Although many accidental introductions of exotic species occur, people sometimes intentionally bring nonindigenous species into the country to control the spread of another exotic. These introductions are called biological control. The grass carp is one example of a species introduced to control unwanted aquatic plants. Unfortunately, the fish also feeds on native plants and has become a nuisance itself. In this case, the introduction was intentional but the results were unintentional.

Today, legislation regulates the purposeful introduction of exotic species, and efforts are being made to limit accidental introductions. Ballast water is a primary concern. Guidelines dictate, for example, that ships from European freshwater ports exchange their ballast water at sea before arriving in a Great Lakes port. Research also continues on methods of filtering and chemical control of ballast to kill foreign organisms.

Numerous regional efforts attempt to control exotic species.

- In the South, millions are spent each year to remove aquatic weeds, such as Hydrilla, that choke waterways and hinder boating.
- In the Great Lakes region, control of zebra mussels is expected to cost more than $500 million by the year 2000. Public education programs also teach boaters and anglers how to prevent the spread of this troublesome creature.
- In Maryland, some local governments pay fisherman to collect bushels of the exotic green crab (which are then composted) in an effort to control their numbers and boost the population of native crabs.

Control of exotic species can be extremely costly, but these efforts are necessary to preserve the health and biological diversity of native ecosystems.

Writing About Exotics

When writing about exotic species, it's important to remember that the long-term impact of some aquatic invaders may not be well understood — even by scientists. Underwater impacts are not as easy to assess as the impact of some nuisance exotics on land. Yet the impacts are equally profound. For example, zebra mussels' ability to filter water, which improves clarity, might be viewed as beneficial. Yet by filtering zooplankton and other microorganisms, zebra mussels have reduced food for some native species — an impact that could have evolutionary consequences. In writing about exotics, one of the challenges is to explain to readers the potential long-term impacts, the importance of biological diversity and how an exotic species might disturb this balance. Writers should find out what native species are directly or indirectly affected by the introduction of an exotic species, which may compete with native species for food or habitat. It's important to consult credible scientific sources for evaluations of potential impacts.

If native species are affected by an exotic invader, writers should find out if any of these native species are harvested commercially. An exotic species might have an impact on the local economy. Method of introduction: Some exotic species are deliberately brought to new locations. In these situations, writers should find out if there have been any unintentional impacts. If arrival is accidental, writers should explain how it happened and what legislation might help prevent similar accidental introductions.

Assignments

1. Nuisance species can bring great harm to an ecosystem. Explain the negative impacts on the Great Lakes.
2. What is the projected cost by the year 2000 to keep zebra mussels in check?
3. What has been the advantage of the international introduction of the coho salmon to the Great Lakes? What was the original home of the coho salmon?
4. How do nuisance species manage to get into new bodies of water?
5. Write a story about a non-native species in your state.

"An Endless Invasion? Green Crabs, New England Intruders Move West," by Michael Fincham, uses focus structure in the story of one fisherman to explain the general problem of invasive exotic species to the general public. The story, published in Maryland Sea Grant's *Marine Notes*, March/April 1996, is based on research for a documentary video, "Alien Ocean," that won a third place award at the U.S. International Film and Video Festival.

An Endless Invasion? Green Crabs, New England Intruders, Move West

by Michael W. Fincham, Maryland Sea Grant

On Martha's Vineyard, the new scallop season opened with high skies, bouncing sunlight and blustery winds but only modest hopes that a good harvest would be had this winter out of the harbors, bays and tidewater ponds of this picturesque island.

So Mike Picciandra spent the windy first morning fishing for scallops — and in the afternoon he went fishing for green crabs. Picciandra has a daily limit on scallops: as soon as he catches three bushels he has to quit. On a good day he may get $8 a pound for his scallops.

On green crabs, however, he has no season, no limits — just as green crabs have no season, no daily limit on scallops: they keep eating scallops all day, every day. And that's one reason Picciandra goes out after green crabs. The other reason is money: the green crab is so unpopular up here, it carries a price on its head. "The town puts a bounty on these crabs," he explains, "and I as a bounty hunter, I go out and catch the crabs." He'll only get 40 cents a pound for his green crabs, and most of them will end up on a compost pile, but he reasons that by the end of the day there'll be fewer 40 cent crabs eating up $8 scallops.

Only four years ago, the scallop fleet that motored out of Edgartown harbor on opening day numbered more than 100 boats. This year the winds are so high and the hopes are so low that the "fleet" totals less than 20 boats. For several weeks, Picciandra and other fisherman had been motoring out to Cape Pogue Bay and Edgartown Harbor and Sengekontacket Pond to check on this year's crop, and by opening day the word has gone round the island: another off year for scallops.

An Unwanted Bounty

Green crabs are probably not the primary culprit in the scallop decline — but they stand accused as accessories to the crime. Most scallop fisherman think of the green crab as a local pest, but few of them realize this small green predator is an immigrant into these coastal waters, a transplant from European seas like the North Sea and the Baltic.

For marine scientists, green crabs are a prime example of yet another successful invasion of American waters by an exotic species. That makes them an instructive case study for the developing science of "invasion ecology."

Green crabs may be exotics, but you catch them much the same way you catch blue crabs, their larger, more popular cousins. Picciandra uses a technique familiar to any Chesapeake Bay waterman: he builds pyramid-shaped wire mesh traps, baits them with fish and sets them in the water attached to crab buoys. Every two or three days, he checks his pots and makes his haul. "I weigh them up, tag them, and then once a week I submit a voucher to the town treasurer and they pay me."

That bounty on the green crab is paid by the town of Edgartown, the scenic village on Martha's Vineyard where Hollywood filmed the blockbuster movie *Jaws* 20 years ago. In the epic, a great white

shark slid around eating hapless swimmers and hard-drinking fisherman. In Edgartown today, green crabs are leaving people alone, but they are attacking scallops and other native shellfish.

"Green crabs are a problem in our ponds because they eat soft shell clams, quahogs and oysters — as well as scallops," explains Paul Bagnall, the shellfish biologist for Edgartown and the man responsible for putting a bounty on green crabs. He wants to protect the scallop fishing in Sengekontacket Pond, a two-mile saltwater embayment shared by Edgartown and the neighboring town of Oak Bluffs.

Over the last year, he placed more than a quarter million seed scallops in the pond from the town's small shellfish hatchery. He hopes most of those scallops are caught by fisherman rather than the green crabs.

Bounty programs are somewhat controversial as a predator control technique. Proponents like Paul Bagnall make this simple argument: every time you catch a crab, you save a number of scallops, clams and oysters. Opponents to bounties argue that crab populations in a tidewater pond reach a steady state equilibrium. Every time you catch a crab, you simply open up space for another crab to move in. The bounty is wasted money and effort.

The arguments for and against are largely theoretical, the evidence mostly anecdotal. As a result, a number of New England towns have sporadically tried bounties in hopes of protecting their shellfish beds. And most have abandoned them without knowing whether they worked or not.

Good evidence might come from the work of Greg Ruiz, an ecologist who has been setting a lot of traps for green crabs along the Atlantic coastal marshes of Connecticut and along the Pacific coastal bays north of San Francisco. As a graduate student, Ruiz worked with Jim Carlton, one of the country's leading researchers in invasion ecology, and his early research centered on San Francisco Bay, this country's hottest site for invasive exotics. Now with the Smithsonian Environmental Research Center on Maryland's Chesapeake Bay, Ruiz has been studying the history and pattern of green crab immigrations. His question: can we predict the ecological impacts of future invasions?

Claws II

According to Ruiz, there have been two major green crab invasions of American waters: one on the east coast, one on the west coast. The green crabs of Martha's Vineyard are descendants of the first influx that began more than 150 years ago. Their ancestors reached the Atlantic coast under sail, riding along in the dry ballast of wooden ships or clinging to the mossy crevices of heavily fouled outer hulls.

Those green crabs first found suitable habitat in coastal embayments from New Jersey to Cape Cod. In the early 1900s, they began spreading northwards, ranging up through Maine and the maritime provinces of Canada, all the way to Cape Sable, Nova Scotia. Their arrival in Maine in the 1950s coincided with dramatic declines in the soft clam fishery, setting off an earlier search for predator control strategies.

The second great invasion of green crabs was discovered as recently as 1989 in San Francisco Bay. First a fisherman found a large male crab in his gill net. The next summer bait trappers began finding green crabs in lagoons along the west side of the bay. Since scientists were able to track this west coast episode nearly from the start, this second invasion has revealed much more about the green crab's migratory strategy.

These recent immigrants probably arrived as stowaways in the ballast water of big commercial ships hauling televisions, truck and cars —and the oil to run them. According to Jim Carlton, now an ecologist with Williams College, there are also a number of other less obvious routes. Green crabs, like their ancestors, could also be hanging onto the fouling found in seawater pipes of big ships. Or they could have come west directly from New England, tucked in with the seagrass and kelp used for packing and shipping Maine lobsters and Atlantic bait worms.

On the Western Front

The green crab invasion, according to Ruiz and Carlton, works something like this. Young green crabs thrive best in fairly protected coastal ponds and lagoons and embankments. There they eat molluscs, crustaceans, polychaetes and green algae. Though they have trouble cracking a hard clam, they can dig out soft clams buried six inches deep. In these food-rich coves and ponds and marshes they can grow and reproduce in sufficient numbers to create a "beachhead population." On the west coast, green crabs took three years to establish a beachhead in San Francisco Bay.

Their first major foray beyond the Golden Gate came in 1993 when they reached Bodega Harbor 75 miles north. According to Ruiz, it was not grown crabs but crab larvae, offspring of the beachhead crabs, that made the trip, gliding northwards at five miles a day on the current. These excursions probably occurred during short windows of opportunity lasting five to fifteen days when the normal northerly winds die down. Since 1993, green crabs have been building up a new beachhead in Bodega Harbor from where a new crop of larvae can travel north towards Oregon, Washington and Canada.

On the Global Front

As the entire globe becomes a free trade zone and shipping traffic continues to increase, green crabs will invade other estuaries — and so will other species. "What we've seen over the last few decades is really an explosion in the amount of commercial traffic that is bringing in ballast water to different parts of the world," explains Ruiz, "At an any one time, there may be tens of thousands of vessels moving around the world carrying ballast water. The effect has really been to open up a conduit for the transfer of species from one part of the world to another part of the world."

Whether bounty programs work remains an open question. In Edgartown, Paul Bagnall claims his bounty program is helping green crabs, scallops and fisherman coexist. " We have removed over 15,000 pounds of green crabs over the last five months from this pond," he says. We have reaped the benefit of this by having a scallop harvest up here this year. It isn't the best the pond has ever seen, but there are certainly plenty of nice healthy scallops to be harvested."

Will Edgartown — beset by green crabs and a growing population — ever see great scallop harvests again? Picciandra, for one, says it could happen — but only if the town deals with problems like reseeding, redredging, rising nitrogen levels, spider crabs, green crabs and the influx of yet another non-native species: *Codium fragile*, a bottom-rooting alga that locals call Japanese grass. In many parts of the pond Japanese grass is replacing the eelgrass beds that new scallops like to set on.

Though the threat of more invasions looms large with the approach of every tanker and container ship across the horizon, marine exotics remain a small, nearly invisible blip on the environmental radar screens of most Americans. "Look at the problems it is causing us," laughs Picciandra, the bounty hunter. "I'm killing this green crab for two years, and seeing it all around — and I didn't know that it didn't belong here."

Assignments

1. How much do scallops bring fishermen per pound? How much do green crabs bring per pound? Why are fishermen out to destroy the green crab?
2. Because of the green crab, how many boats are no longer in the business of fishing?
3. Using poster board, develop a timeline that shows the development of the green crab in this nation.
4. What is ballast water?
5. Write a story explaining how ballast water has been the source for the spread of invasive species.

The following press release from Michigan Sea Grant was part of an ongoing citizen project to monitoring for zebra mussels. Written by Carol Swinehart, the release illustrates one way that information is disseminated to media with both writer and specialist contacts listed. The story that follows, "Volunteers Catch Zebra Mussels in the Act," by Sea Grant intern Jeffrey Cooke, is from Spring 1998 issue of *The Communicator*, an employee newsletter published by the Michigan State University Extension system. The story is based on the press release and illustrates the use of a press release to localize a story.

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February 23, 1998

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NINETEEN MORE MICHIGAN LAKES INFESTED WITH ZEBRA MUSSELS

EAST LANSING, Mich. — Nineteen more Michigan lakes are now infested with zebra mussels (*Dreissena polymorpha*), according to Michigan Sea Grant.

Three of the 19 new infestations reported in 1997 were found by citizen volunteers participating in the Sea Grant Zebra Mussel Monitoring Program, which supported sampling on 21 lakes last year. The other 16 reports came from miscellaneous sources on other lakes. The 1997 results bring to 65 the total of confirmed infested Michigan lakes found since 1993. Over the last four years, MSG has received 244 reports on 118 lakes.

Resource managers consider some of the state's lakes to be at greater risk of infestation than others. Inland lakes with a high level of transient recreational boating activity due to their large size and public access and those in close proximity to infested waters are particularly vulnerable. Zebra mussels can contaminate lakes when boatersand anglers unknowingly transport the clinging veligers from infested waters via boats, trailers, and fishing equipment.

Begun in the spring of 1993 as a joint effort between the Michigan Department of Natural Resources (MDNR), the Michigan Lake and Stream Associations, Inc. (MLSA), and the Michigan Sea Grant College Program (MSGCP), volunteer monitoring was designed to verify predictions of the dispersal mechanisms, direction, and rate of spread of zebra mussels to Michigan's inland waters.

Because Michigan has more than 10,000 inland lakes, resource managers can can monitor only a few lakes and collect a limited number of samples. However, citizen participation in sampling and monitoring has greatly increased the number of lakes surveyed, providing early detection of zebra mussel populations and saving valuable time and resources, according to Sea Grant Extension Associate, Mike Klepinger. This early warning allows lake managers and citizen groups to erect signs at boat launches and develop volunteer programs for boat inspections and cleanings.

"The early detection of zebra mussel infestation helps prevent damage to boats, beaches, and, most importantly, the ecosystem of Michigan's inland lakes," says Klepinger.

The citizen monitoring program provides the training and equipment necessary for individual citizens, public officials, school teachers, lakefront owner groups, and industrial site managers to detect the mussel in its larval (veliger) stage using a plankton sampling method. Sampling is performed boatside and must be done in water more than 18 feet deep. The procedure takes roughly one hour and is repeated twice during the summer season to ensure accurate results. The plankton samples, which may contain microscopic mussel spawn, are sent to a laboratory where biologists determine whether the water is infested.

During the past two years, volunteers have been trained for veliger sampling through Sea Grant's award-winning instructional video that demonstrates the procedure. An accompanying illustrated handbook assists monitors in preparing samples while aboard their vessels. Both the video and handbook are included in the 15 sampling kits that Michigan Sea Grant has distributed on long-term loan throughout the state.

Michigan Sea Grant is a cooperative program of Michigan State University and the University of Michigan in Great Lakes and marine research, education and outreach.

In 1997 zebra mussel populations were confirmed in the following lakes:

County	Lake
Allegan	Allegan
Cass	Magician
Genesee	Fenton
Gladwin	Wixom Lake
Hillsdale	Baw Beese
Jackson	Columbia
Leelanau	Leelanau
Livingston	Strawberry
Manistee	Tippy
Mecosta	Blue
Mecosta	Mecosta
Mecosta	Round
Oakland	Lakeville
Oakland	Maceday
Oakland	Pine
Oakland	Union
Oakland	Upper Straits
Oakland	White
VanBuren	Gravel

Volunteers Catch Zebra Mussels in the Act

by Jeffrey Cooke, Michigan Sea Grant

Lea VanRenterghem suspected the possibility of a burgeoning zebra mussel (*Dreissena polymorpha*) population in Oakland County's Pine Lake several years ago, but county researchers could not substantiate the infestation. She was especially concerned because the Eurasian native had invaded other Oakland County inland lakes like a plague.

"We citizens wanted to know ourselves," says Lea. "Someone else suggested we might possibly have zebra mussels."

Determined to find the answer, Lea and other concerned Pine Lake citizens contacted Michigan Sea Grant Extension Associate Mike Klepinger for a diagnosis. Klepinger introduced them to the Michigan Sea Grant (MSG)Zebra Mussel Monitoring Program.

The program provides the training and equipment necessary for individual citizens, public officials, school teachers, lakefront owner groups, and industrial site managers to detect the mussel in its larval (veliger) stage using a plankton sampling method.

Sampling is performed boatside and must be done in water more than 18 feet deep. The procedure takes roughly one hour and is repeated twice during the summer season to ensure accurate results. The plankton samples, which may contain microscopic mussel spawn, are sent to a laboratory where biologists determine whether the water is infested. The samples VanRenterghem drew from Pine Lake confirmed her suspicions: zebra mussels were present.

Volunteer monitoring was designed to verify predictions of the dispersal mechanisms, direction, and rate of spread of zebra mussels to Michigan's inland waters. Because Michigan has over 10,000 inland lakes, resource managers can collect only a very limited number of samples, and therefore few lakes can be monitored. However, local citizen participation in sampling and monitoring has greatly increased gains in data and knowledge and saved valuable time and resources, according to Klepinger.

The lakes selected for study in the Sea Grant program are primarily those thought by resource managers to be at high risk of infestation. Like Pine Lake, they have a high level of transient recreational boating activity due to their large size and public access and are close to already infested waters. Zebra mussels contaminate lakes when people unknowingly transport the clinging veligers from infested waters via boats, trailers, and fishing equipment.

Until 1996, citizens received sampling method training hands-on from field biologists. Today, volunteers are effectively trained for veliger sampling through an award-winning instructional video which demonstrates the sampling procedure. An accompanying illustrated handbook assists monitors in sample preparation while on their vessels. Both the video and handbook are included in the 15 sampling kits that Michigan Sea Grant has distributed on long-term loan throughout the state.

The kits are often shared among citizens. Ryan Cousineu of Upper Long Lake shared his with VanRenterghem. Citizen networking is another benefit of the program. Not only is it cost effective, it continues to be successful, Klepinger says. Seven of the 17 infestations in 1997's 47 lake survey were reported by volunteer lake monitors. MSG has received 242 reports on 116 lakes over the last four years of the study. These results bring the cumulative total of verified infested Michigan lakes to 63.

The program begun in the spring of 1993 as a joint effort between lake biologists and communication specialists from the Michigan Department of Natural Resources (MDNR), the Michigan Lakes and Streams Associations, Inc. (MLSA), and the Michigan Sea Grant College Program (MSGCP). Since its inception, the volunteer program has increased the number of lakes participating, therefore providing early detection of zebra mussel populations.

This early detection has given the citizens that live and play on the waters of Oakland County time to inform boaters and anglers about the alien invader and to promote prevention of its spread to other inland lakes. It allows lake managers to erect signs at boat launches and develop volunteer programs for boat inspections and cleanings.

"The early detection of zebra mussel infestation is essential in preventing damage to boats, beaches, and, most importantly, the ecosystem of Michigan's inland lakes," says Klepinger. "Volunteer monitoring provides a way for concerned residents to participate in the preservation and improvement of that ecosystem."

Assignments

1. How has Michigan tried to fight the invasion of zebra mussels?
2. What damage is caused when zebra mussels filter the water?
3. What does one successful program, involving citizens, teachers and students, do to prevent the spread of zebra mussels?
4. Are zebra mussels in waters in your state? Write a story explaining control measures, or, if they are not in your state, identify another nuisance species and explain introduction, problems and control.

"Tiny Weevil Shows Big Potential to Control Eurasian Watermilfoil," from the May 1997 *Seiche,* Minnesota Sea Grant's newsletter, was written to inform Minnesota citizens of a publicly-funded research project and to inform other scientists of the report. The article generated 14 documented print and broadcast news stories for combined audiences of 1.8 million. The *Seiche* received a most improved award from the National Association of Government Communicators in 1997.

Tiny Weevil Shows Big Potential to Control Eurasian Watermilfoil

By Marie Sales, Minnesota Sea Grant

Sea Grant researchers think a tiny freshwater weevil (*Eubrychiopsis lecontei*) shows promise as a possible control for Eurasian watermilfoil. The exotic watermilfoil plant continues to slowly spread in Minnesota, usually due to accidental transport by boaters.

Susan Solarz and Ray Newman conducted experiments at the University of Minnesota using a native weevil that normally eats northern watermilfoil — a usually benign native relative of Eurasian watermilfoil. Solarz and Newman found that weevils introduced to Eurasian watermilfoil in a lab setting prefer to lay eggs on the Eurasian variety over native varieties.

The weevil lays its eggs on the tips of the milfoil plant. Once they hatch, the young eat their way down the stem, slowing the milfoil's growth. Under the right environmental conditions, the weevils could provide a chemical-free control method.

"Their results show that the weevils are definitely worth looking into as a control method and that additional research is necessary," said Chip Welling, coordinator of the Minnesota Department of Natural Resources' Eurasian watermilfoil program.

Eurasian watermilfoil has infested North American waters since the late 1940s. It can form dense mats of vegetation that crowd out native aquatic plants, clog boat propellers and make water recreation difficult. Eurasian watermilfoil is currently found in 40 states and three Canadian provinces. In Minnesota, it has spread to 75 lakes, primarily in the Twin Cities area, and to four rivers and streams.

Eurasian watermilfoil is controlled through harvesting and applying chemicals. However, both methods are costly and labor-intensive. Chemical treatments can cost between $200 and $300 per acre of water. Combinations of the two methods can run considerably more.

A frequently-cited example of high control costs is Lake Minnetonka, a popular, large multi-bay lake west of Minneapolis. Control costs there have run as high as $250,000 per year. Nationally, the U.S. Army Corps of Engineers estimates controlling Eurasian watermilfoil costs taxpayers millions of dollars each year.

"Finding a natural way to inhibit Eurasian watermilfoil is important," said Newman." Although it is unlikely the weevils will eradicate Eurasian watermilfoil infestations, under certain conditions they can reduce the amount of the plant that spreads across the water's surface, which can provide major benefits, especially for boaters.

"While chemical control may still play a role in specific settings such as near crowded lake accesses and to clear navigational channels, natural controls have advantages," said Newman. "First, these weevils are already here; there isn't the danger of adding a new exotic pest. Second, the weevil specifically targets Eurasian watermilfoil, reducing the risk that native plants will be harmed in the process. Third, effective biological controls may result in long-term declines at a relatively low cost. This reduces the need for repeated treatments usually required with chemical and mechanical controls."

Solarz and Newman also discovered that weevils reared on the Eurasian watermilfoil in the lab spend more time looking for it if it is removed, instead of simply switching to the native plant. The weevils can eventually switch, but they have long coexisted with the native plants. Solarz and Newman published their results in *Oecologia*, an international peer-reviewed journal. Reprints of this article, "Oviposition Specificity and Behavior of the Watermilfoil Specialist, Euhrychiopsis lecontei," are available from Sea Grant.

Newman and colleagues continue their research with the weevil. They seek to determine where weevil control will work and what conditions are optimal for success. Researchers in Wisconsin, Vermont and Washington State are also investigating use of the weevil to control Eurasian watermilfoil.

Assignments

1. How may a native weevil help control water milfoil?
2. Why is water milfoil harmful?
3. Name the three advantages of the weevil as a control measure.
4. Learn what non-chemical control measures are used in your area, and write a story explaining an example.

Chapter 4
Fisheries: Resources at Risk

by Peggy Britt and Joyce Jakubiak

A significant portion of the food that humans eat today comes from the world's oceans and Great Lakes. The United Nations Food and Agriculture Organization (FAO) estimates that fish account for about 16 percent of the animal-protein supply for the world. Globally, the United States is the sixth largest producer of seafood, according to the National Marine Fisheries Service (NMFS). Not only are fish and shellfish harvested commercially for food, they also support recreational fisheries in many areas of the country including the Great Lakes.

As the world's population has grown, however, so too has the fish harvest. In 1996, the world fish catch was five times as much as it was in 1950. The bad news is that many species of fish have not kept pace with this rate of harvest, and populations have crashed. Overfishing is a critical fisheries issue, with many fish species now facing an uphill battle for long-term survival. These species include some of the country's most valuable fish and shellfish, such as cod, Atlantic sea scallops, Gulf shrimp, Atlantic bluefin tuna, swordfish, Pacific salmon, oysters, and Alaska king crab. In 1994, for instance, fish declines off the Massachusetts coast caused a fishery to close — an industry worth $200 million per year. In the Great Lakes, the trend is similar for some fish. In 1997, for example, lake management organizations in the four states bordering Lake Michigan drastically restricted commercial and recreational yellow perch fisheries following a steady 10-year decline.

Restricting fishing, however, is a touchy issue. Managing fish populations to keep them sustainable — or reproducing successfully — is a balancing act that involves biological, political, economic and social issues. In the United States, the National Marine Fisheries Service is the organization ultimately responsible for the sustainability of marine life. In addition, there are eight fishery management councils that govern specific regions of the country. Fisheries management is a primary concern in each region. Management decisions affect not only the health of the oceans and Great Lakes, but they also affect people. For example, it's extremely difficult to assess fish populations, and scientific research reflects this difficulty. Many fish population estimates are imprecise, and there is simply no data for some species. This lack of knowledge makes it difficult for management councils to set accurate commercial and recreational fishing limits to maintain sustainable populations. Unnecessary fishing restrictions may cause economic hardship for some people, while fish population estimates that are too high may ultimately cause an entire fishery to collapse due to overfishing. Making matters worse, endangered mammals and countless other fish are harmed when they end up in fishing nets by accident. This collection of unwanted sea life is known as bycatch. In the Gulf of Mexico, for example, for every one pound of shrimp caught, the nets snag four pounds of other fish — most of which die when they're thrown overboard. On the bright side, the commercial fishing industry has made progress in the last few years in creating devices that limit bycatch.

Another common fishery problem is competing interests. Several groups of people may find themselves fishing in the same location — a situation that has led to disputes between

commercial and recreational fishermen and between inshore and offshore fishermen pursuing the same species. Disputes have even arisen over the method of fishing, such as longliners versus trawlers. In some regions, conflicts are escalating between aquaculturists and commercial fishermen who compete for market share. Skirmishes between countries have also occured. Tuna, for instance, migrate through waters governed by different countries. Sometimes it's not clear who has the right to fish for these migratory species.

Because many countries share these marine resources, they are also jointly responsible for managing them. For some species (such as Pacific halibut) state, federal and international agencies may be involved in management. In the Great Lakes, state, federal, tribal and Canadian governments have management authority. Sometimes the responsibilities of these organizations overlap, and successful management becomes a challenge.

Another important issue identified by the National Marine Fisheries Service concerns fish that currently have no commercial value. These fish populations may be abundant, while more popular species are continually depleted. In some cases, the species harvested is market-driven and depends upon social change.

There are many other fishery issues not mentioned here such as habitat loss due to development and pollution. Contaminants, for example, have contributed to declines in some fish populations and have led to fish advisories in the Great Lakes. Nonindigenous species are also a problem in some areas, particularly where they prey on native species or take over prime habitat. The subject of "fisheries" is extremely broad and encompasses a wide range of issues.

Writing About Fisheries

Complexity: Articles on fisheries can be written from any number of angles depending on the situation. Economic, political, social and biological issues all come into play. While writers might choose a human-interest angle (for example the social effects of fishing restrictions on a single town), writers should also include the scientific research that led to the relevant management decisions and the legislation that governs the region. Language: Any discussion of fisheries involves many scientific terms such as bycatch and sustainability. When using these terms, writers should explain them in language readers will understand.

Assignments

1. What percent of the world's animal-proten food is supplied by fish?
2. Why is bycatch a problem?
3. Learn whether commercial or sportfishing contributes to your state's economy. Write a story on the economic contribution of one or the other.

The following *Nor'easter Magazine* article, Spring/Summer 1995, was written to give voice to the various points of view in the environmental issue — environmentalists, scientists and resource managers, commercial fishers, thus providing understanding of differing views to help different groups work together to solve the problem. *Nor'easter Magazine* is produced by the Northeast Sea Grant Programs.

BYCATCH — Whose Issue Is It Anyway?

by Tony Corey and Erik Williams, Rhode Island Sea Grant

The numbers are very much in contention. The very existence of the problem is a matter of debate. Even the definition of the term is open to interpretation.

BYCATCH — the inadvertent capture of nontarget species — is a factor in commercial and recreational fisheries: That much is agreed. Consensus is elusive, however, when it comes to particulars.

Is bycatch part of the cost of getting marketable fish to shore, as many fishermen believe? Is it the lake of unintended species in amounts that sometimes equal or exceed targeted catch, as scientists and regulators have noted? Is it indiscriminate harvesting of sea life that depletes desirable stocks by taking juveniles, as conservationists contend?

Bycatch is not a new issue. References to the concept go back at least as far as the Bible: "...The Kingdom of heaven is like a net that was thrown into the sea and caught fish of every kind; when it was full, they drew it ashore and put the good into baskets but threw out the bad" (Matthew 13:47-48). What brings the issue so emphatically to the forefront now, according to Rolland Schmitten, director of the National Marine Fisheries Service (NMFS), is a recent proliferation of sensational media articles. Focusing in the most dramatic bycatch incidents, and quoting numbers that are disputed by fishermen, such sensational press "misleads the public and polarizes the constituencies," Schmitten says. Negative misperceptions are especially hard on an industry already taking it on the chin for overfishing and stock depletion.

It is not just bycatch but also excess directed fishery efforts that have left the legacy of depleted stocks, suggests Eleanor Dorsey, Conservation Law Foundation staff scientist. But fishing captain James Lovgren of the Pt. Pleasant Fisherman's Cooperative in New Jersey is quick to point out that overfishing is not the sole cause of fishery collapse, as evidenced by the failure of eastern Canadian cod stocks to recover despite closure of the fishery. And Madeleine Hall-Arber, anthropologist and marine liaison for the Massachusetts Institute of Technology (MIT) Sea Grant, asserts that bycatch isn't even considered a problem when stocks are in good shape.

These different perceptions of the bycatch problem illustrate the diversity of opinion that characterizes this issue. Solving the problem first requires determining exactly what it is — a tricky matter, given a concept so elusive that the word itself isn't in the dictionary. Even the simplest working definition of bycatch as "everything fisherman catch by mistake" presents the difficulty of defining "mistake." From fishery to fishery, one fisherman's mistake is another's stock-in-trade. For example, the cod taken as incidental bycatch in a Gulf of Maine shrimp trawl was once a boon to the shrimper, who could keep and sell it with his target catch. But this retained bycatch was then lost to another fisherman for whom cod was the target species. In some cases, as when the bycatch is underaged or undersized, or protected by regulation, it has to be returned to the water, and thus becomes "discard." If discard survives the handling and exposure — and only 40 percent does, according to Steve Murawski, chief of population dynamics studies at the NMFS Northeast Fisheries Science Center — it may reproduce and contribute to stock replenishment. If it does not, it becomes the "wasted dead fish" that Nelson

Beideman, executive director of the longtime fishery's Blue Water Fisherman's Association, speaks of as bycatch's "definition and problem all in one."

Discard is a particularly sensitive issue, in part because of the public perception of it as profligate waste. While some catch is discarded as a matter of preference — for example, unmarketable species caught by commercial fishermen or unpalatable fish caught by anglers — much commercial discard is a matter of regulation. An example is the small-mesh mixed-trawl fishery on the East Coast. During the summer flounder (fluke) season, mixed-trawl fishermen are allowed to keep and sell their catch of fluke, up to a certain amount. Anything is excess of this amount must be thrown overboard. When the fluke season is closed, this fishery continues to operate, but all fluke must be discarded.

Many fishermen see such management efforts as contributing to a new bycatch problem. Lovgren calls it "government bycatch" — marketable fish that have to be discarded because of quotas, closed seasons, or mesh-size restrictions. "Bycatch of any kind is not desired," Lovgren says, "but watching cod, fluke, swordfish, or other such fish go overboard dead is a crime. It's certainly not conservation."

Fishermen suggest alternatives, such as giving the regulated bycatch to food banks, rather than risk wasting it as discard. But resource managers, looking at fish populations, landings, and bycatch rates, contend that the primary concern has to be rebuilding stocks. Fishermen worry that this ultimately means shutting then down. They concede that bycatch and declining fish populations are concerns, but they take issue with statistics that have been used to dramatize the problems. For example, the Southern shrimp trawl fishery, which admittedly produces one of the highest bycatch rates, has been blamed for finfish bycatch up to 10 times above targeted catch. But Walter Shaffer, chairman of the Gulf & South Atlantic Fisheries Development Foundation's bycatch steering committee, insists, "There's no evidence that the shrimp fishery is affecting fish stocks. There's been no change in the fish stocks over the past 20 years." Shaffer vehemently disputes the 10-to-1 ratio, and recent research supports his stance: both foundation and NMFS studies place the ratio at closer to 3.5 to 1.

Numbers alone don't tell the whole story. "There's a tendency to look at just the bycatch, but you have to look at the numbers in relation to the population," explains Lee Alverson, president of the Seattle-based consulting firm Natural Resources Consultants, which conducts research in North Pacific and international fisheries. Depending on the life history of a given species, "high bycatch rates may have a relatively low impact, especially among abundant species," Alverson says. "On the other hand, low rates can have significant impact." For example, in the Pacific pollock fishery, bycatch of 200 million animals represents less than half of 1 percent of the population. Yet, among harbor porpoises in the Gulf of Maine sink gill-net fishery, bycatch of 1,400 animals is cause for alarm in light of the small population and low birthrate."

Technological Remedies

Catch quotas, days-at-sea limits, fishing grounds closures, restrictions on gear, and other regulatory responses to bycatch and depleted stocks are bitter medicine, yet even fisherman acknowledge that such measures are necessary. Of the remedies available, perhaps the easiest to swallow is gear modification, which at least allows fisherman to keep fishing.

Initially, fishermen resisted gear regulations as costly, cumbersome, and even ineffective. For example, the turtle excluder device (TED), a grate-like device inserted in a fishing net to deflect endangered sea turtles out of the net, was met with resentment when mandated for the Southern shrimp industry. Yet, a more refined cousin of the TED, the Nordmore grate, was introduced into the Gulf of Maine shrimp fishery with success. Functioning like a sieve, the grate allows shrimp to pass through its bars into the net's cod end while blocking the larger finfish and forcing them out through an opening in the net. A crucial attribute of the Nordmore grate is its control of finfish bycatch without significant reduction in shrimp catch. Of course, as New Hampshire fisherman David Goethel points out, the grate works well "as long as what you want to keep is smaller than what you want to keep out."

Use of the Nordmore grate is now required by regulation for Northern shrimp trawlers. The easier acceptance of this equipment than of the TED demonstrates fishermen's general readiness to embrace something that works — especially if they have a role in its implementation. It was fisherman, in fact,

who came up with the most successful bycatch control technology to date: escape modifications for lobster pots. In a proactive effort to preserve their fishery by reducing the take of juvenile lobsters, lobstermen developed traps with variable spaced laths, or slats, so small or juvenile crustaceans lured into the traps could crawl back out.

For lobster fishermen, forgoing a portion of the catch has a stronger element of self-interest than it might for finfishermen. Lobstermen can be fairly certain that this year's discard will survive and grow to be next year's catch. For finfishermen, however, the greater likelihood is that the discard will die, and if not, that it will be caught by another fisherman. But tools like the Nordmore grate and even large-mesh net help prevent discard by limiting the bycatch that comes on board in the first place. "It doesn't behoove us to bring 15,000 pounds on deck and then throw 5,000 pounds over the side," is the way Point Judith, R.I., fisherman Fred Mattera sees it. For Mattera, using larger-mesh nets last winter meant catching 25 to 30 percent less whiting than similar vessels caught, but it also meant retaining 90 percent of what he did catch.

As these examples suggest, success in controlling bycatch is often a matter of fishing industry initiative. Another recent encouraging step toward control of bycatch comes with just-completed "pinger" experiment in the Gulf of Maine.

Pinger Power

Like many fishermen, Bob MacKinnon is carrying on a generations-old tradition by making his living from the sea. Like many fishermen, he fears the loss of that tradition, livelihood, and lifestyle with the stroke of a legislative pen.

MacKinnon, president of the Massachusetts Gillnetters Association, is a sink gill-net fisherman. His gear works by creating a wall of mesh that traps fish by tangling their fins or gills. He chose this fishery for its advantages, including size selectivity that allows undersized and nontarget small fish to pass through the mesh, and passive collection that doesn't rough up the ocean bottom. The primary disadvantage, however, is that gill nets occasionally entangle marine mammals and other creatures along with targeted species. It is this aspect of the fishery that captured public attention: Turtle bycatch promoted a Florida gill-net ban and overtures toward a ban in North Carolina.

Fearing the gill-net ban would work its way up the coast to Massachusetts, MacKinnon joined forces with an ad hoc assemblage that would become the Harbor Porpoise Working Group. Harbor porpoise entanglement is a major bycatch issue in the Gulf of Maine, where MacKinnon fishes. To prevent the problem from overwhelming the gill-net industry, the fishermen, researchers, managers and environmentalists of the Harbor Porpoise Working Group confronted it collaboratively.

This was an unlikely alliance, given the different agendas of the constituencies. With environmentalists petitioning for "threatened" status for harbor porpoises under the Endangered Species Act, fishermen fighting for their livelihoods, and regulators debating bycatch control measures, participants had to agree to disagree and move on to the job at hand, explains Roland Barnaby, Maine/New Hampshire Sea Grant marine educator and associate investigator on the pinger project. "We decided not to worry about whether gill nets are good or bad, not to worry about population assessments, but to focus on the common goal — reducing the harbor porpoise take with minimum impact on the fisherman.

Taking its cue from experiments in which Jon Lien, Memorial University of Newfoundland animal behavior professor, studied effects of acoustical devices on whale behavior, the working group recruited Lien to help design a device for its purposes. Lien consolidated his work with that of Ken Baldwin, associate professor of mechanical engineering and director of the Center for Ocean Engineering at the University of New Hampshire (UNH). From their efforts came pingers, devices that are attached along gill nets to emit sounds that warn harbor porpoises away.

In two years of experiments with the devices, only one harbor porpoise was caught in the alarmed, or "pingered" nets, while 42 were caught in control nets, Barnaby reports. But because these initial trials were considered too small for the results to be statistically significant, the group pushed for, and ultimately won, funding to conduct a third experiment. With the National Fish and Wildlife

Foundation footing the bill, and with Scott Kraus, associate director for research at the New England Aquarium, joining the team as principal investigator, the group ran a double-blind experiment that was "as scientifically correct as possible," Barnaby states. The results: 25 porpoises trapped in control nets; two caught in alarmed nets.

While these results have the strength of scientific credibility behind them and are certainly heartening, researchers are cautious, as well as enthusiastic, in their assessments of pingers. "Occasionally technological fixes work," Kraus observes. "In this case, it looks like this one does." Concurring with Barnaby's reference to pingers as a tool rather than a solution, Kraus cautions that success in this situation "doesn't mean [pingers] will work in all cases and with all species."

Too Efficient

In part, the problem of bycatch is one of efficiency: More efficient gear means more abundant catch. But efficiency without selectivity may also mean more bycatch. These issues had some bearing on the pair-trawling fishery in New England. Pair trawling, which involves two boats pulling a net between them, began in the 1970s as a bottom-trawl fishery, targeting herring, cod, and other groundfish. It evolved into mid-water, targeting swordfish and tuna, in the early 1990s, according to Clifford Goudey, project director for the Center for Fisheries Engineering Research at MIT. But by 1993, Goudey explains, concerns about the status of the stocks prompted the restriction of large pelagic pair trawling to an experimental fishery and the outright banning of groundfish pair trawling.

The experimental fishery, while intentionally limiting participation, offers opportunities for data collection and, potentially, resumption of the tuna pair-trawling fishery. Hence Goudey's research in midwater, or pelagic, pair trawling. His results — a marine mammal bycatch mortality ratio of one per 123 tows — suggest that pair trawling may be "cleaner" than other traditional commercial tuna fishing methods. For a much maligned fishery, says Goudey, "it would be nice if it were recognized for the virtues it does have." Apart from preventing bottom habitat destruction, pelagic pair trawling presents a potential for selectivity: Midwater species tend to be schooling fish, and a large haul of pelagic swordfish is likely to have less bycatch than a net full of bottom-swimming herring. The latter, as Goudey observes, "are hard to target when they're in a school of cod."

Selectivity in fishing gear has been pursued as a way to curtail destruction of undersized fish since the early 1900s. More recent research has tackled gear selectivity from the angle of fish behavior. Joseph DeAlteris, Rhode Island Sea Grant researcher and University of Rhode Island (URI) fisheries, animal, and veterinary science professor, and his staff use a low-light, underwater camera mounted to active otter trawls to analyze fish behavior around this type of gear. Otter trawling, which involves dragging a funnel-shaped net along the ocean bottom, is the single most important fishing method in the Northeast. But it generates noticeable bycatch. Pinpointing the response of, say, whiting, to this equipment will help researchers develop gear for "species-specific behavior instead of one-style-fits-all," as DeAlteris puts its.

The species-specific focus for now is on whiting because this fishery risks closure if its bycatch problem isn't brought under control, says Henry Milliken, URI fisheries research assistant. Because whiting requires small-mesh gear, bycatch of juvenile flatfish is hard to avoid. As a possible solution, URI researchers have come up with modifications in the sweep rigging of the otter trawl that allow flatfish to slip under the net while whiting are retained. Testing of modifications like this one are becoming simpler with the completion of the new fish behavior lab at URI. The tank-equipped lab allows simulation of responses to different types of gear, thus speeding up the time frame between hypothesis and application.

Industry Must Lead

Whatever the ultimate solution to the bycatch problem, it will come about through the cooperative efforts of resource managers, conservationists, scientists, and fisherman. The sometimes incompatible interests of these constituencies have hindered consensus in the past, but necessity has recently become a potent spur to negotiation. Providing a forum for this negotiation was the purpose

of the East Coast Bycatch Conference held in Rhode Island this spring. The conference was initiated by DeAlteris, Williams, and assistant Chris Gagnon, and sponsored by NMFS, participating East Coast Sea Grant programs, the commercial fishing industry, and others "to get everyone at the table so we're all talking together," says DeAlteris. As a step toward resolving the bycatch issue, this conference and similar communication and education efforts allowed stakeholders to clarify their positions and recognize their roles as allies, rather than adversaries, in a common struggle.

The most critical effort, all constituencies agree, is that of the fishing industry itself. Brad Warren, National Fisheries Conservation Center director and *National Fisherman* magazine field editor, states bluntly, "The fisheries have the ability to solve their own problems. If the fishermen don't want to or don't get heard, solutions don't happen."

From the inside, as Maine fisherman Ted Ames makes clear, the situation looks pretty basic: "The bottom line is, there aren't enough fish. The quickest way to have more is to reduce or eliminate juvenile bycatch. If the fish reproduce at least once before they're caught, the crop will be right there, growing fatter for next year." Summing up progress so far, Ames concludes, "We've got large-mesh nets; we've got the Nordmore grate; and now we've got pingers. These allow us to keep fishing and at the same time protect the species we're after."

Assignments

1. What is bycatch?
2. What Biblical reference is made in the story about bycatch ?
3. Form a debate group. One side must defend the position that overfishing causes fishery collapses with the other side insisting that bycatch is not a problem.
4. Give an example of bycatch control technology. How might bycatch devices really be worthwhile?
5. Research a fishing issue in your state, and write a story.

"Yellow Perch: Once Not Profitable Enough for Commercial Catch, Now Mainstay of Lake Michigan Fisheries," by Nancy Riggs, explains the dilemma of commercial fishermen in southern Lake Michigan. The story also highlights regulations and research on the plight of yellow perch. The story was carried in Illinois-Indiana Sea Grant's *The HELM*, Fall/Winter 1996.

Yellow Perch: Once Not Profitable Enough for Commercial Catch, Now Mainstay of Lake Michigan Fisheries

by Nancy Riggs, Illinois-Indiana Sea Grant

Nowhere can one see more clearly illustrated what may be called the sensibility of such an organic complex — expressed by the fact that whatever affects any species belonging to it, must speedily have its influence of some sort upon the whole assemblage." S. A. Forbes, from "The Lake As A Microcosm," The Scientific Association, 1887, Illinois Natural History Survey

When Lawrence Schweig's grandfather started commercial fishing operations in southern Lake Michigan in 1922, yellow perch were plentiful. The southern Lake Michigan fishery, or fishing ground, would yield more than a century of abundant harvests. These tasty fish, however, weren't sought by commercial fishermen in the 1920s. "Yellow perch weren't very important then because there were so many of them. They were cheap and were popular for Friday night fish fries," Schweig said.

Today, though, yellow perch represent a significant portion of the business at Joe's Fisheries, operated by Schweig and son Larry in Chicago, that includes commercial fishing, a processing plant and a restaurant. Commercial fishermen in southern Lake Michigan depend on yellow perch and chubs, where the approximately 11 million people along the lake's southern shorelines are a major consumer market. Yellow perch are also important to sports fishermen.

Although the reasons aren't clear, worldwide fish populations have declined since a peak commercial catch of 86.1 metric tons in 1989, nearly five times the catch of 1950. In 1994, declines off the Massachusetts coast led to a fishery closing, shutting down an annual $200 million industry. This trend has occurred in the Great Lakes, too. Following a steady decline in yellow perch in Lake Michigan, lake management organizations in the four Lake Michigan states have issued stringent fishing limitations. Both commercial and sports fishermen are displeased because their livelihoods are threatened with fisheries closures and catch limits.

Schweig, who also is president of the Illinois Seafood Consumers Council, an organization of commercial fishermen, expressed concern about maintaining a yellow perch market. "We have businesses to operate, and building a market is difficult. If the fish that consumers develop a taste for isn't available, they will switch to another product, and regaining that market is very difficult. We feel very strongly that consumers have first claim on yellow perch. We want it to be available at the lowest cost."

Indiana commercial fishermen face additional challenges if they are not able to catch yellow perch, noted Jim Francis, Lake Michigan biologist with the Indiana Department of Natural Resources. "Indiana lies at the southern tip of Lake Michigan where the waters are more shallow. Chubs, the only other species available as commercial catch, are a deep-water fish, and are very limited here," Francis said.

The sportfishing industry, too, faces economic hardships attributed to the yellow perch decline. John Vadas, president of Illinois-Indiana Perch America, a sportfishing organization, started Vets Bait

and Tackle Shop, in Chicago in 1951 upon his return from military service. "We're a stone's throw from Lake Michigan," Vadas said. "Since 1985, business has been steadily downhill, and the past couple of years it's really dropped off. We had about 25 bait and tackle shops in Chicago, and now we're down to five or six. The years between 1975 and 1985 were peak years, not only for yellow perch but also for salmon. My business now is about 50 percent of that."

Early Commercial Fishing

"In earlier years, the productivity of commercial fisheries in Illinois waters of the lake was significant, with more than one million pounds caught annually," said Rich Hess, Lake Michigan fisheries biologist with the Illinois Department of Natural Resources. "The commercial fishery has changed considerably over time because Lake Michigan has been in a state of flux for the last 100 years or so."

Tremendous population growth and subsequent increased fishing in the southern Lake Michigan region, coupled with the invasion of nonindigenous species, or exotics, had a major influence upon the fishery. Early fishermen harvested Lake Michigan fish to meet the needs of the burgeoning population. Coming from the East, this population brought their European taste for fish to the Great Lakes region, creating a market for a southern Lake Michigan's commercial fishing industry. Chicago's population increased from approximately 50 in 1830 to 1.7 million people by 1900. Fishing practices of early commercial fishermen weren't so different from the fishing practices of Native Americans of the southern Lake Michigan region, who fished to provide sustenance, primarily in the shallow bays and tributaries along the shoreline.

Pollution and Technology Influences on Fishery

Pollution and technology are usually associated with recent decades, but both played important roles in southern Lake Michigan's commercial fishing operations. As early as the mid-1800s, shoreline commercialization was beginning to create pollution in shallow waters where seine fishing was rapidly growing, and some species of fish were already becoming scarce or nonexistent. The growing markets of an increasing population center in the lower lake region encouraged increased commercial fishing efforts. The mid-1800s saw development of the gill net, with its tiny threads not easily seen by fish, allowing fishing on or near the lake bottom to obtain larger catches than with seine fishing. The steam-powered gill-net lifter followed closely on the heels of the gill net, allowing fishermen to bring in many more nets daily than in the past.

Fish Conservation Legislation

During most of the 1800s, commercial fishing was virtually unregulated in the Great Lakes with only token attempts to control annual catches. In 1872, the first Illinois fish conservation law limited net size but included no harvest limits. When Indiana began regulating commercial fishing in the early 1980s, commercial fishing licenses fees were $20 to $50, depending on boat size. Lake Michigan fishing is regulated by state departments of natural resources in both Illinois and Indiana.

Commercial catch in Illinois waters during the 1930s averaged about 1.3 million pounds annually and was primarily chubs, perch, lake trout and lake herring. Commercial catches of yellow perch in the 30-year span between 1934 and 1964 fluctuated, ranging between 100,000 and 600,000 pounds, according to Illinois DNR.

"Commercial harvest is not necessarily a reflection of availability," Hess pointed out. "A number of other factors contribute to catch with market choices being a primary factor. Prior to the 1950s, the commercial fishery was multispecies. Commercial fishing responded to market price and demand."

Increased Pressures on the Fishery

Expanded harvests to meet demand during World War II reduced the lake trout. Nonindigenous species including sea lamprey, alewife and smelt would soon affect the fishery. Sea lampreys initially attacked lake trout, then moved onto other species including yellow perch. Continuing technology

provided the diesel-powered gill net tug, and more efficient nylon twine replaced cotton mesh, allowing increasingly larger commercial harvests. Lake trout were re-producing in smaller numbers, and within two decades, lake trout and herring disappeared from Lake Michigan. Multispecies fishing was only a memory, and chubs and yellow perch became southern Lake Michigan fishery mainstays.

Beginning in the 1960s, salmon and trout stocking efforts encouraged a strong sportfishing industry in southern Lake Michigan. By the early 1980s, sport fishermen spent more than 3.5 million fishing days on Illinois waters of Lake Michigan, and about 85 percent of the number of fish caught are yellow perch. Between 1980 and 1985, Indiana sport fishing total catch of all species averaged 193,000 fish.

Regional Response to Lakewide Problem

Yellow perch supports sport fisheries in all four states; commercial fisheries in Wisconsin, Illinois and Indiana; and a tribal fishery in Michigan. In response to studies indicating that yellow perch have declined significantly since 1989, the Yellow Perch Task Group was formed in 1994 by the Lake Michigan Committee of the Great Lakes Fishery Commission, with representation from the four Lake Michigan states and the tribal fishery. A 1994 public meeting brought about three recommendations: 1) implement more restrictive harvest regulations; 2) conduct research to address causes of the yellow perch decline; and 3) increase enforcement of harvest regulations. Recently, the task force has prioritized research needs and will soon make recommendations to management agencies.

Management agencies have responded to declining fisheries with varying degrees of regulation. In 1975, in response to a decline in bloater chubs, Illinois set new standards for commercial fishing licensees, reducing the number of licensees from 44 to 3. That number was increased to five in 1995.

In the early 1980s, Indiana commercial fishing licenses were classified into Class 1, 2, and 3, with fees of $1,000, $2,000 and $3,000, and the state currently has 13 commercial licensees. Gill net fishing was banned In 1988, and trap net limits were established. Francis noted, "Salmon and trout were getting caught in the gill nets and dying. Yellow perch are bottom dwelling and will swim into the trap nets while salmon and trout won't."

Illinois commercial harvest of yellow perch for 1995 and 1996 was limited to 24,000 per licensee, 35 percent of the 1994 quota of 68,000 per licensee. The 1995 Indiana limit of 360,000 pounds, 35 percent of the 1994 catch of one million pounds, was divided among the three licensee classes. Further reductions in the 1996 catch allowed only 160,000 pounds. According to Francis, Indiana DNR weigh-in checkpoints indicated that commercial fishermen were complying with limits. Wisconsin and Michigan also set 1995 limits at 35 percent of the 1994 catch. Illinois, Indiana and Wisconsin set sport fishing daily bag limits at 25-fish per person, and Michigan reduced its sport fish limit of 100 to 50 per day. Lake Michigan fisheries were closed in the month June. In October 1996, Wisconsin banned commercial yellow perch fishing and set a sport fish limit of five per day.

Challenges at Hand

Illinois DNR data indicates that mature perch six to eight years of age made up 86 to 89 percent of the catch at two annual assessment locations. These statistics indicate a dramatic decrease in the number of young perch, and consequently a drastic decline in perch population. Zebra mussels may be at least partly responsible for this decrease because they siphon the water, removing plankton, microscopic plants and animals. Young perch feed on plankton in open waters before moving to the lake bottom for their food as they grow.

New concerns are surfacing with the arrival of other nonindigenous species. Ruffe are expected to arrive in Lake Michigan soon and likely will be major competitors with perch for food. Gobies are now in Lake Michigan, but their potential impacts are not clear, according to Sea Grant researcher Ellen Marsden.

Illinois-Indiana Sea Grant currently is funding research addressing the potential effects of ruffe and zebra mussels on the Lake Michigan ecosystem. Phillip Pope, Illinois-Indiana Sea Grant director, said, "Yellow perch are important to the southern Lake Michigan ecosystem. A wide range of efforts are

underway to determine the reasons for the perch decline. Once an understanding is reached, the aim is to reverse the population decline. Time is short, however, if we are to save the present commercial perch fishery."

Some commercial fishermen believe that management agency studies do not accurately reflect the yellow perch in Lake Michigan, and some question assessment methods. Schweig said, "There are similar concerns about yellow perch depletion in both Lake Michigan and Lake Erie. We don't understand how on Lake Erie, Canadian agencies increase yellow perch quotas while in the United States, regulatory agencies in states bordering Lake Erie decrease quotas. Fish do not recognize international borders."

Conversely, some sport fishermen believe further limitations and more effective enforcement of commercial fishing regulations are needed. Vadas noted, "Some of these commercial fishermen are out here long after they're supposed to be and are taking salmon and trout as well."

Management agencies, commercial fishermen, sport fishermen, and consumers all are stakeholders in this significant issue. Continued cooperation and a thorough investigation of all options to salvaging yellow perch — perhaps the last Lake Michigan species that can support a southern Lake Michigan commercial fishery — are essential.

Assignments

1. The yellow perch story highlights the problems involved in an entire ecosystem. Support one of the two following positions:
   1) The demise of the yellow perch does not matter. If they become extinct, they become extinct. We should let matters take their natural course.
   2) We must find some way to defend the yellow perch. Explain what has been accomplished so far and why all this effort is so necessary. Your ability to come up with supporting details to strengthen your argument determines the validity of your position.
2. Write a story about fishing concerns in your area.

"Multispecies Management in the Chesapeake Bay — A Far Future?" by Merrill Leffler was published in Maryland Sea Grant's *Marine Notes,* September/October 1995, to inform people about problems of managing the many species in Chesapeake Bay. The writer included not only current information on problems but also background, highlighting a symposium that addressed multispecies management.

Multispecies Management in the Chesapeake Bay — A Far Future?

by Merrill Leffler, Maryland Sea Grant

Ten years ago, Maryland banned the taking of striped bass from its portion of Chesapeake Bay — at least until clear signs indicated the fishery was recovering, Maryland's controversial action was part of a Congressionally backed restoration plan that required states from Maine to North Carolina to make major changes in striper fishing in their coastal waters. Those changes included raising the minimum catch sizes — in some cases from 18 inches to 32 inches — and reducing the daily creel limit. The aim was to allow striped bass to mature so they could return to their native rivers in the Bay to spawn. And they have.

Today striped bass are back, and the state has declared the fishery recovered. A rare success story — and a heartening one at a time when the Chesapeake's oyster fishery has been nearly eliminated and concern is mounting over a possible decline of blue crabs. Only recently, however, have questions been asked about the implications of the striper recovery for the productivity of the Bay ecosystem as a whole, for the abundance of other popular species, bluefish and weakfish, for example. Does the increasing abundance of stripers mean anything with respect to the prey they all go after — anchovy and menhaden and crabs, for that matter?

Some fishermen have speculated that diminishing crab stocks — if in fact they are decreasing — could have more to do with voracious predation by stripers than human predators. This conjecture was based on large numbers of small crabs found in the stomachs of some striped bass.

There has not yet been evidence to support the argument that stripers have put a dent in the crab population, at least according to studies by the Maryland Department of Natural Resources and the Virginia Institute of Marine Science. Though those studies are probably right, says Ed Houde, a fisheries scientist at the Chesapeake Biological Laboratory, part of the University of Maryland Center for Environmental Science (UMCES). "Historically, you would guess that they [stripers] had little impact," he says. But sea grass habitats have been disappearing in the Bay for years, and young crabs rely heavily on those grasses. Crabs may now be more vulnerable to predation, perhaps far more than they would have been."

Whether or not further research turns up a significant relation between striped bass and crabs, the issue raises a question that offshore fisheries managers from Georges Bank to the Bering Sea have been struggling to answer for years — namely, does a boom for one species mean a bust for others? How does the harvesting of one fish species affect the abundance and dynamics of other species? And do we need to account for such interactions in fishery management plans in the Chesapeake?

Multispecies Management

Ed Houde and Tom Miller, also at UMCES's Chesapeake Biological Lab, have undertaken a literature review and synthesis to ask just that question. With support from the Chesapeake Bay Program's Scientific and Technical Advisory Committee (STAC), they are focusing on the multispecies

nature of Bay fisheries and possible interactions. "The goal," says Miller, "is to ask whether there is even compelling evidence that we need to adopt a multispecies approach in the Chesapeake."

Some years ago, Harley Speir of the Maryland Department of Natural Resources examined a set of sportfishing data collected in the same location to see if he could detect an inverse relation between striped bass and bluefish catches. If bluefish catches were up, he asked, were striped bass down or vice versa? He found no such connection. For the most part, though, such investigations in the Bay have been cursory, mostly localized, and they've played on part in fisheries management. "We've primarily considered the effect of removal rates of one species on the abundance of that species," says Speir. "We've never examined to see if removal of that species will affect other ones." Until now, no multispecies studies, let alone management practices based on multispecies models, have been undertaken in major estuaries like the Chesapeake. Most research has been done in offshore fisheries, for example, Georges Bank and the North Sea. In the North Sea multispecies models—such as the Multispecies Virtual Population Analysis — have had an impact on how quotas are set. (That commercial fisheries have been collapsing is not a shortcoming of multispecies models, says Miller, as much as the general failure of management practices — simply too many fish being caught.)

"What a multispecies approach should presumably allow you to do," Miller says, "is to modify the catches of individual species based upon the removal of other components in the food web." Are there ecosystems where these ideas are firmly in practice? Not fully, says Miller, who points out that trophic food webs are extraordinarily complex and depend not only on predation and competition among species for a variety of prey, but a host of other factors — climatic conditions, physical properties, let alone human issues of commercial and sportfishing, together with their political implications.

A symposium on multispecies management several years ago in The Hague pointed to these problems directly. From a fishery manager's perspective, while species-interaction models may be conceptually more realistic than managing single species alone, their complexity and the results they produce may run counter to conventional wisdom. As Ed Houde points out, multispecies analysis in the North Sea shows clearly "that most fish are killed by other fish" through predation and that "how you manage" top predators such as cod and whiting can have major impacts on other fish in the system. "Multispecies models," however, often lack sufficient data, so as realistic as they may be conceptually, they may not adequately represent the ecosystem because of their incompleteness. In the North Sea, for instance, the multispecies model considers only nine species and then only from the post-larval stage — meanwhile, the model treats the North Sea itself as a single box.

Nevertheless, what makes the idea of multispecies management attractive, says Houde, is its taking into account interactions among species and the effect of fishing on relative abundance, predator — prey relationships and competitive relationships among species. For example, the harvest of a top predator (like striped bass or bluefish) may allow numbers of its prey species (like menhaden) to increase, affecting populations not only of prey species, but also of species it consumes in the food chain, what ecologists call a cascade effect.

If multispecies management has a future for the Chesapeake, the review and synthesis by Houde and Miller could provide a stepping stone. The two researchers will scour historical records in trying to detect trends over the years among important popular and commercial species, among them, striped bass, bluefish, flounder, sea trout, croaker and blue crab. They will be looking for cycles of abundance and occurrences of explosive growth and collapse. "We will look to see if there are clear indications of variations in abundance between species that suggest predator-prey interactions," says Miller. "For instance, if bluefish are abundant, are menhaden less abundant?"

Menhaden and anchovy are major prey of bluefish, striped bass, weakfish and other finfish — they are the two most abundant fish in the Bay and on the whole east coast. Unlike anchovy, which travel in small schools and for which there is no commercial fishery, menhaden are the major commercial finfishery in the entire Chesapeake, some 200,000 tons a year.

Bay harvests of menhaden have remained steady, though there are no limits on those harvests — on the other hand, bluefish landings along the east coast have declined sharply in recent years. Is there any relationship? Right now, it is impossible to say.

Teasing out underlying causes is an important goal of their study, says Miller: "Can we find something in the data that suggests we need to consider them in unison rather than in isolation — if not for the whole Bay ecosystem, at least for key components?"

For example, he asks, do we see variations in catch related to phytoplankton productivity of the Bay if it is a particularly wet or dry year? "Certain things we can factor in quantitatively, he says, "like the runoff, seasonal water temperature, estimates of productivity and sea grass coverage over time." In other words, not all shifts in abundance will be due to multispecies effects of fishing, predation and competition. "We're" not trying to find a single smoking gun," Miller says.

One problem he and Houde face is that the historical data they will be using — records of abundance, for example — weren't collected with their interests in mind. While there are statistics on commercial landings, landings are a measure of catch, not necessarily of abundance. Furthermore, the records on recreational catch are poor to nonexistent. "We will have to assume fishing effort [the total fishing gear in use over a period of time] was constant or, in scaling, somehow, convert catch statistics to species abundance."

For now, that's the best they can do.

Fisheries Management and Ecosystem Stability

There is another view to multispecies management beyond predator-prey and competitive relationships among fish, one that has to do with the effects of fisheries on the health or the stability of the ecosystem itself. Just how important is the ecological role of certain species — of oysters, for instance; perhaps of menhaden? Such multispecies management considerations are a first step on a long road that could lead to ecosystem-based management of our fisheries.

We have already learned much, in the past two decades, about the interconnectedness of the Chesapeake Bay ecosystem. The widespread decline of underwater grasses and an increase in summer depletion of oxygen in bottom waters, for example — both attributed to excessive nutrients entering the Bay — have meant the loss of healthy habitat for young crabs, oysters and other species. Heavy nutrient oading has overfertilized these waters and led to explosive algal growth far beyond the Bay's assimilative capacity. Consequently, a major goal in the cleanup of the Chesapeake Bay is the reduction of nutrients by 40 percent — such reductions, it is hoped, will significantly lower algal production and such consequences as oxygen depletion.

The Bay's poor assimilative capacity, some have argued, may also be due to the near-elimination of oyster stocks and oyster reefs. Several years ago, Roger Newell of the UMCES Horn Point Lab estimated that oyster stocks in the late 19th century could have filtered, on average, the entire Chesapeake Bay in three to five days; in 1988, it would have taken more than a year. With the further decline of oysters since then as reflected in lowered harvests and monitoring, such filtering comparatively would like even longer. Newell's estimates helped catalyze concern over the oyster's ecological role — and while oysters continue to be managed primarily for commercial use, for the first time resource managers have begun to acknowledge and take into account the oyster's ecological importance.

Menhaden may also have an important ecological role in the Bay by sequestering nitrogen in the enormous amounts of phytoplankton they consume: since they move out into coastal waters, they become potential exporters of nitrogen. A number of UMCES scientists have argued that menhaden could sequester and export much more nitrogen by limiting the commercial catch to fish aged at least three to four years. (Menhaden generally do not reach sexual maturity until age two; the largest menhaden on record, at three pounds, was eight years old.) That is not the case now. "In the lower part of the Bay," says Ed Houde, "a commercial fishery is hammering on them at most of the ages, from juvenile stages through age one and two."

We are still a long way from using commercial and recreational landings as a tool for managing nutrient levels or other measures of Bay health. The complexity of trophic food webs, let alone the political and social issues at stake, may make that more an ideal than a reality. But before they can become practical tools, such issues as multispecies and ecosystem-based management must first become part of the ongoing conversation — and that has begun. The far future may hold surprise connections between striped bass and crabs, between oysters and menhaden that we cannot yet foresee.

Assignments

1. Briefly, explain the problem of multispecies management.
2. Most fish are killed by other fish. Explain these terms: food chain. catch statistics. species abundance. How are they related?
3. Write a story on the most prevalent catch in your area.

This article was published in Hawai'i Sea Grant's newsletter, *Makai*, July 1997, to help modern fish farmers apply ancient knowledge to restoration efforts. "Fishpond Study Reveals Ancient Know-How" explores science writing as an art form while disseminating research information. By explaining a Hawaiian renaissance and the need for economic diversification, this article demonstrates the necessity of the restoration of ancient fishponds.

Fishpond Study Reveals Ancient Know-How

by M.E. Weidenbach, Hawai'i Sea Grant

A resurgence of interest in the history, culture and traditions of ancient Hawai'i has also inspired inquiry into traditional methods of agriculture and aquaculture. Now, with aquaculture technologies expanding worldwide in response to the increasing need for alternative food sources, Hawai'i's aquacultural traditions are also becoming a focus of scientific inquiry.

"Salt water ponds seem to be unique to the Hawaiian islands," says Professor Cengiz Ertekin of the UH Department of Ocean Engineering whose recent pilot study of fishponds, undertaken with Sea Grant support, utilized computer technology in simulating the relationship between fishpond design and water circulation characteristics.

Historically evolving out of Hawai'i's wetland agricultural tradition, a variety of responses to fresh, brackish and saltwater environments were developed to produce a thriving aquacultural tradition that had been flourishing for several centuries prior to foreign contact. Ertekin and his students' study, transforms on-site conditions into computer simulations, opening a high-tech window to a variety of scenarios that, in essence, allow researchers a glimpse at the experience of generations past.

The project was undertaken with the assistance of Robert Howerton, Sea Grant Extension Agent, and Dean Fujii, Executive Director of the Molokai Community Development Corporation. An initial survey of pond sites along the southern coast of Moloka'i was undertaken to identify potential sites for restoration while searching for a candidate pond suitable for a tidal circulation study. Ertekin and his students, Hari Sundararaghavan and Sander van Stiphout, selected One Ali'i fishpond as the best site to initiate the pilot study.

One Ali'i pond is of the loko kuapa (fishpond made by building a wall on a reef) type with a permeable wall structure with two makaha, or gates, one of which is currently remaining. The makaha provide an opening of slightly more than eight feet in a wall enclosure containing a pond of approximately 27 acres. Wall thickness is fairly uniform at four feet with a height slightly higher. Current conditions find the pond waters silted and its walls overgrown with mangroves extending in from the pond perimeters.

Initial survey measurements were obtained for water depth variations in and outside of the pond, overall pond geometry and tidal elevations. These were used in a computer simulation of those conditions.

The hydrodynamic model used in the simulations is based on continuity and momentum equations for liquids affected by varying conditions. The model is completed by identifying the boundary conditions, in this case, the pond walls and water depths in relation to tidal flow variations.

By taking depth measurements at strategic points inside and outside the pond, hard data are translated into the abstract and integrated with specially developed computer programs. Originally developed for use in a waste water flow study by Sundararaghavan, the model simulates water flow and transport phenomena translated into numerical equivalents. "The problems involved are inherently three-dimensional and are quite complex," Ertekin said.

The information is first digitized to prepare a computer grid simulation. A triangular mesh is generated from a program called TRIGRID. The result is adjusted to accurately describe boundaries and physical characteristics of the actual pond site. From this, researchers can create a variety of scenarios combining tidal factors and design conditions for a simulated pond. The action of tides can be mimicked, variations in makaha placement can be explored, and water flow and sediment transport can be simulated.

In using the data from One Ali'i pond, Ertekin and his research staff, calculated relative flow patterns for various pond designs within a full range of tidal movements and resulting water levels. What they discovered from the One Ali'i pond simulation, was complex dynamics of flow variables.

Using the computer simulation for One Ali'i pond, the researchers developed two different scenarios. The first replicated site conditions with one open makaha in the southern portion of the wall. In the second simulation, the southern as well as the western makaha was opened. Water circulation improved dramatically after the simulated opening of the second makaha.

Using this system, it becomes possible to calculate the placement and number of makaha necessary to achieve the most efficient water circulation for a specific pond design within a full range of tidal variations.

The aquaculture systems of ancient Hawai'i were developed over a long period of time through the careful observation and experience of generations. Modern understanding of their technology is yet to be fully realized. Basic questions remain to be answered. How and why did the Hawaiians decide to place the makaha where they did? The answers may remain unclear, but after the study of fishponds on Moloka'i, Ertekin has no doubt, "They were well thought out choices."

Now with the help of computer simulations, it may be possible to rediscover these design choices and provide a resource to assist modern farmers in the further development of Hawai'i's aquaculture tradition.

"We are trying to show that if you have problems with sediment or problems related to water dynamics, we can provide a resource," Ertekin said. "It will be possible to apply the present numerical method to other fishponds and make recommendations on ways to reduce sediment accumulation, one of the stumbling blocks to the economic viability of fishponds."

Ertekin is looking forward to the development of a database that will consolidate general information from all sources as well as specific data for each fishpond. The researchers hope to provide a resource that would make it possible to utilize computer simulations for the development of efficient pond designs and the further expansion of a potentially viable aquaculture industry.

"Hawai'i's fishponds are unique," Ertekin said. Yet the breakdown of Hawai'i's cultural traditions that followed the arrival of Captain Cook in 1778 and the abolition of the kapu system in 1819 led to an environment in which Hawai'i's aquacultural tradition had become little more than a curiosity for historians by the beginning of the nineteenth century. "Current studies have continued to focus on the historical aspects of Hawaiian fishponds," Ertekin said. "Our project is motivated by the possibility of revitalization."

Assignments

1. Why was the study of fishponds undertaken by the University of Hawai'i?
2. How are computers helping modern farmers develop aquaculture following traditional Hawaiian methods?
3. Write a story about fish farming in your area or in a nearby area.

Chapter 5
Coastal Economic Development: A Balancing Act

by Nancy Riggs

From the cornfields outside Chicago to the Eastern Shore off the coasts of Maryland and Virginia, and along the Pacific and Gulf coasts, urban sprawl has encroached onto previously unpopulated areas. Coastal populations are growing at rapid rates along the Great Lakes and the Atlantic, Pacific and Gulf coasts. Since 1980, approximately 60 percent of population growth has been in coastal counties. More than 151 million people are expected to live in coastal counties by 2010, according to the National Sea Grant College Program. This population growth brings with it special needs for infrastructure and other human needs, and it brings competing interests for scarce coastal resources.

Coastal economic development has been important to the overall U.S. economy since the earliest settlers arrived. Waterways transported people, raw materials and manufactured goods. Manufacturing, shipping, fishing, and logging are a few examples of industries that developed along ocean and Great Lakes coastlines. The Erie Canal completed in 1826 was the critical link that facilitated the flow of people and goods through the Great Lakes system, followed by the Illinois and Michigan Canal in 1848, creating a waterway link to the Mississippi and the Gulf of Mexico. Throughout the 1800s, coastal development continued to support a growing population, and coastal infrastructure in major cities encouraged continued growth. The Great Lakes became a steel industry giant primarily because iron ore, coal and limestone could be carried on the lakes from mines to steel mills. Paper mills, logging and commercial fishing expanded at a rapid rate, and giant ports on Atlantic, Pacific and Gulf of Mexico coasts supported international trade. The St. Lawrence Seaway was completed in 1959, the last in a long line of waterway improvements that facilitated Great Lakes trade to Europeon ports.

Early in the industrial age, waterways and shorelines became popular recreational sites. Major shoreline communities sprang up for the wealthy, particularly on the East Coast as the Industrial Revolution created a whole new and rapidly growing middle class. This new economic reality, in conjunction with a number of labor law reforms, produced a new American emphasis on recreation and nature. Tourism has now become a major contributor to the U.S. economy, and future growth is anticipated.

Coastal populations and industrial development continued to support a burgeoning economy. By the 1970s concerns were growing about harm to the environment caused by pollution from industrial and human waste. Declining natural resources and habitat threatened biodiversity, and water quality deteriorated significantly. In conjunction with the Clean Water Act and through cooperative efforts of all concerned, improvements have been made, particularly in the reduction of point-source discharges. These improvements have come at a high cost to society. Costly remediation remains for sites with contaminated sediments affecting harbors; toxic deposition of heavy metals and other industrial chemicals continue to find their way into waters from atmospheric deposition; and discharges from

animal wastes create pathogen problems. For example, *E. coli* bacteria threatens the safety of Great Lakes beaches, and toxic algal blooms threaten shorelines in Atlantic and Gulf coast communities.

The mix of coastal industries is changing rapidly. For example, manufacturing, commercial fishing and seafood processing have declined. Coastal communities are attempting to diversify their economies. Infrastructure improvements are necessary to support the growing coastal populations. Many interests are coming together to work toward the improvements needed. Coastal businesses such as tourism, port operations and marine trades must contend with declining natural resources and increased environmental and public safety regulations. Community revitalization must take into account coastal cultural heritage and economic and social values derived from marine and coastal resources.

Assessing integrity of marine structures, and keeping them in good working condition are essential to the continued success of coastal communities. Daniel Burnham's 1909 Plan of Chicago envisioned a shoreline where "not a foot should be appropriated by individuals to the exclusion of the people." This shoreline, with one of the most accessible shorelines in the United States, hosts more than 60 million visitors annually who contribute significantly to the state's economy. Many major shoreline structures were built in the 1930s and over the years have deteriorated, necessitating a need for major repair costing hundreds of millions of dollars. Chicago represents but one example of shoreline economies that must be continually upgraded to support coastal development.

Wildlife habitat is becoming increasingly scarce as urban sprawl continues to grow. A number of issues develop along crowded shorelines as competing interests vie for scarce natural resources to support manufacturing, human population and wildlife habitat. Public access to shorelines becomes a major issue in areas where a large percentage of the land is in private ownership. As coastal populations continue to grow, these shorelines concerns will also continue to grow. Collaborative efforts among the public and private sector with an emphasis on increased research to find new solutions will be necessary to solve the complex problems.

Writing About Coastal Economic Development

Economic-related stores often include statistics. Writers should carefully check statistics to be sure they are from reliable sources such as federal and state agencies. Although public information need not always be source-attributed, writers should be aware of the possible need to back up their stories. Because published statistics sometimes conflict, source attribution is sometimes a good idea, particularly on a controversial topic. Explaining background and potential impacts often is necessary when writing about economic development. The relationship among various issues is important and should be included.

Assignments

1. What percent of population growth has been in coastal counties since 1980?
2. Why did the Great Lakes become a steel industry giant?
3. What did Daniel Burnham envision for Chicago? Why do you think he included this statement in his formal Plan of Chicago?
4. Write a story explaining a conflict in your community between human and and wildlife habitat needs.

"Armoring the Coast: Beachfront Battles Over Seawalls," by John Tibbetts, was published in South Carolina's Sea Grant's *Coastal Heritage*, Fall 1997. The story was written to inform readers about the conflict between people who want access to beaches and people who want to protect their property from erosion by building seawalls, which further erode beaches. *Coastal Heritage* has received a number of awards including a 1995 CASE award for external newsletters, a 1993 Silver Wing Award from South Carolina Public Relations Society of America, and a 1992 National Governmental Communicators Award.

Armoring the Coast: Beachfront Battles Over Seawalls

by John Tibbetts, South Carolina Sea Grant

As many beaches erode, houses and businesses along the nation's shoreline are increasingly threatened by rising seas during storms. Now some oceanfront homes could be damaged or destroyed by storm waves if property owners are not allowed to build protective seawalls. New seawalls, however, are banned in South Carolina because they destroy public beaches. How can South Carolina balance preservation of beaches against the rights of private landowners?

While shorebirds graze nearby, bulldozers have been scraping up sand near the water's edge at the Isle of Palms, a barrier island near Charleston. Since September 1996, bulldozers have dug shallow holes where the low-tide beach grows out in an unusual, curving bulge near the northeastern tip of the island. Then the machines have rumbled along for a quarter-mile or so, following the eroding shoreline.

Where the beach disappears at high tide, the bulldozers have dumped sand into eight-foot protective dunes in front of as many as 17 houses and condominiums at the Wild Dunes resort. Despite the dunes, though, a storm could knock the buildings off their pilings or undermine foundations. The houses and condominiums "are sitting ducks, really," says Bill Eiser, S.C. Ocean and Coastal Resource Management (OCRM) oceanographer.

Now six of the properties are the focus of a lawsuit, *Elsie Jerozal v. S.C. Department of Environmental Control-Ocean and Coastal Resources Management*. In August 1996, the landowners wanted to protect their property from erosion by piling truck-sized 6,000-pound sandbags on the public beach. But the state denied the permit request, because giant sandbags would be an "erosion-control structure" or a seawall.

Seawalls were banned under the S.C. Beachfront Management Act, passed in 1988, because they drown beaches. Seawalls allow waves to scour away sand, preventing beaches from naturally migrating inland. Soon the beachfront disappears underwater.

If a new seawall were built at Wild Dunes, long stretches of the beach would be gone during high tides, regulators say. High tides would cover the beach with two feet of water, making it difficult to walk on the public shoreline for several hours a day.

Yet oceanfront landowners could lose their homes to storms and erosion if they cannot build seawalls. So now South Carolina faces the challenge of balancing the public's right to walk along the beachfront against the rights of private landowners to protect their property.

The *Jerozal* lawsuit awaits a court date in the Charleston Court of Common Pleas. A similar case involving giant sandbags and a Daufuskie Island eroding beachfront is now awaiting a court date in Beaufort County. And in June 1997, Summer House condominiums at Wild Dunes and three neighboring landowners requested permits to put up giant sandbags.

The condominiums likely would be destroyed by rough seas coming ashore with high waves if a hurricane roared offshore this summer, says Dick Johnson, a resident of Summer House. "We don't even need a direct hit; if a hurricane goes by us, we're in trouble."

The problem, however, is that people are building permanent structures on land that periodically washes away. South Carolina regulators made this argument during a landmark case heard by the U.S. Supreme Court in 1992, *David H. Lucas v. S.C. Coastal Council* — a case with broad influence on the state's shoreline policies.

In 1987, Lucas, a local developer, paid about $1 million for two oceanfront lots at Wild Dunes near the Jerozal properties when the beach was hundreds of feet wide. His aim was to build a single-family home on each lot. History, however, showed that dramatic erosion along this shoreline occurred about every five to 10 years; twice in the last 40 years, the lots had been completely underwater.

The S.C. Beachfront Management Act prohibited permanent structures from oceanfront areas likely to erode within 40 years. As a result, Lucas could not build on his lots, though homes existed on adjacent properties.

If regulators prevented him from building, Lucas said, his property would be worthless, or "taken" unconstitutionally, so he must be compensated. Lucas eventually won the case, the state buying the lots in a settlement of $1.6 million. The case made national headlines and energized the growing property-rights movement.

"In the guise of environmental protection, (some) want no growth," says Lucas. "There's a group of people who like the beaches kept pristine, who don't want any development. But we stopped them."

The state resold the disputed lots to John and Robert Gwynn, developers in Columbia, the resale including special permits to build on both lots. So far, one of these lots has been developed with a single-family home, which is threatened by severe erosion, just as regulators had warned. The undeveloped lot, moreover, is cut in half by erosion, without enough land on which to build a house.

Eroding Beaches

Over the past century, as sea levels have risen, most Gulf and Atlantic coastal beaches have migrated landward at an average rate of one or two feet per year, though local conditions can vary greatly, says Robert Dean, University of Florida coastal engineer. In some areas, the annual erosion rate can be more than 20 feet annually. Other areas, though, are relatively stable or accreting.

Today, several developed beaches in South Carolina have "hotspots" of erosion. Edisto Beach, North Myrtle Beach, Garden City, Debidu, Daufuskie Island, Hilton Head, Folly Beach, Sullivans Island and, of course, Isle of Palms all have areas with chronic or severe erosion.

For generations erosion was not much noticed, because most U.S. beaches were undeveloped. But as more homes and businesses were built on the oceanfront, landowners began installing seawalls and other erosion-control structures to protect their property from high water.

In the 1960s, starting in New Jersey, the nation's shoreline became increasingly armored. Today, 50 percent of New Jersey's beaches are now covered with revetments, breakwaters, bulkheads, and seawalls and other hard erosion-control devices.

"There was a free-for-all, with people putting up any kind of shore protection they could afford," says Sea Grant researcher Tim Kana, president of Coastal Science & Engineering, Inc., based in Columbia.

Now twenty-seven percent of South Carolina's developed shoreline is armored, as is 70 percent of Virginia's and 80 percent of Georgia's.

So coastal managers began searching for alternatives to armoring. The options, though, proved limited. Communities can nourish beaches, though nourishment is short-term and expensive. Most replenishments are designed to last several years, but in many cases they don't last that long.

Second, states can establish a policy of retreat from the ocean, requiring that buildings be set back from the ocean, and prohibiting new seawalls and repair of old ones. But only two states, North Carolina and South Carolina, have attempted this strategy.

The Lucas case, though, altered the state's policy of retreat. South Carolina's regulators once enforced strict rules requiring residental structures to be set back from shoreline areas expected to wash away within 40 years. "Before *Lucas*, we had a prohibition against building houses in certain (erosional) areas; now, after Lucas, we don't," says Steve Moore, OCRM director of permitting.

A property owner can get a special permit to build up to a 5,000-square-foot house on land likely to erode within 40 years. But if the shoreline indeed washed away and the structure ended up on the public beach, the landowner would have to remove the building.

Further, a seawall cannot be rebuilt if 60 percent of the structure is destroyed by a storm. (By 2005, the ceiling lowers to 50 percent.) If seawalls disappear, then some beaches will migrate inland, knocking some structures down and leaving others on the public beach, in which case they would have to be removed.

Inlet Vagaries

The *Lucas* and *Jerozal* cases emerged from a single stretch of beach for several reasons. Most of the Isle of Palms shoreline is accreting — that is, growing. The northeastern portion of the shoreline, however, is extremely volatile because it is near an inlet. It is "always going to be a very dynamic shoreline with hundreds of feet of accretion or erosion" every six or seven years, says Eiser.

Inlets are natural or manmade channels connecting the coastal ocean to rivers and estuaries, with strong currents caused by tides and river flows. Inlet currents build up supplies of sand, called shoals, just inside or outside inlet channels.

Some inlets cause rapid erosion as they travel down the coast. Other inlets indirectly cause localized erosion when waves push shoals from inlet channels onto barrier islands.

A few years ago, a large shoal was located just offshore between the Isle of Palms and Dewees Inland to the north. But waves very slowly pushed a portion of the shoal south and west toward the Isle of Palms. The migrating shoal added sand to the barrier island, but it also created narrow channels for waves and strong currents to strike portions of the beach, washing sand away, creating extreme erosion in some areas.

But once the shoal comes ashore, "attaching" to the shoreline and spreading out, the beachfront will grow out, and the former Lucas lots will once again have a surplus of sand.

The sand won't stay there, though. While the Isle of Palms has an overall growing trend, some portions will continue to have periodic, dramatic losses of sand caused by migrating shoals. In 1963, for example, the former Lucas lots were entirely underwater, and 10 years later they were partially covered by tidal ponds. Half of each Jerozal lot has been underwater 15-30 percent of the time since 1949, says Jones.

"The land at issue in *Lucas* is virtually a mirage," writes Richard Lazarus, Georgetown University law professor, in the May 1993 Stanford Law Review.

Not true, says Lucas. The high land on his former lots will return, he says, and will likely remain free of erosion for several years.

Management Decisions

In 1992, the U.S. Supreme Court sent the *Lucas* case back to the S.C. Supreme Court with instructions. If the state's prohibition against Lucas' building on his lots indeed made his land worthless, then the regulation had "taken" his property unconstitutionally, Lucas would be due compensation, the U.S. Supreme Court said.

But a big loophole existed. If constructing a home in a hazardous place were considered a nuisance or a public hazard in South Carolina, then the regulation would not be a taking.

"Government can deny development for clear public safety reasons," says Gus Bauman, an attorney with Beveridge & Diamond, in Washington, D.C., who has argued property-rights cases before the U.S. Supreme Court.

So South Carolina was instructed to search through its common law — its historical judicial decisions — to discover whether its courts had ruled that building in hazardous areas was indeed a nuisance or threat to public safety. South Carolina could find no precedent that building on the beachfront could harm others, so the state settled the case.

State regulators, therefore, believe that they cannot prevent people from building homes in hazardous areas. "As long as you have high ground property to build on, it doesn't really matter what the erosion history of your land is, you'll get a permit" for a residential structure, says Eiser of OCRM. "While it's high ground, we can't deny (residential) property owners the right to build. Just because it's in a high-risk area is not enough justification to say that you can't build there."

But unlike houses, seawalls do harm the public beach by increasing erosion. Therefore, the strongest portion of the state's beachfront protection law is the seawall provisions, regulators say. The effect of the seawall provisions, however, is that many more oceanfront homes probably will be lost to storms and erosion. And as oceanfront homes disappear, regulators expect that property owners will try pressuring the state legislature to change the law.

"It will not be a good day when structures end up on the beach, and we have to order them removed," says Moore of OCRM. "But very likely it's going to happen."

Assignments

1. Why is the *Lucas* case a complicated issue?
2. Would you want to build your home on a shoreline?
3. How much of South Carolina's developed shoreline is armored?
4. What does the S. C. Beachfront Management Act prohibit? In a brief article, explain why you would or would not want to build beachfront property on land affected by this Act.

"Indiana Dunes National Lakeshore Good Choice For Getaway," by Nancy Riggs, encourages tourism in the southern Lake Michigan region and raises awareness of the need to continually protect these important natural resources. The story was carried in the spring of 1997 in several local and regional newspapers including the Mattoon (IL) *Journal Gazette* and the Champaign-Urbana (IL) *News Gazette*.

Indiana Dunes National Lakeshore Good Choice For Getaway

by Nancy Riggs, Illinois-Indiana Sea Grant

Summer vacationers often look for one-day or weekend destinations. For most midwesterners, a trip to Lake Michigan will fit into today's busy schedules. The southern Lake Michigan shoreline lays claim to the 14,000-acre Indiana Dunes National Lakeshore. Visitors can walk the beaches at this park and envision the dunes area before humans came along.

"The dunes are important to the region's growing tourism industry," said Phillip E. Pope, Illinois-Indiana Sea Grant director. "Historically, Illinois-Indiana Sea Grant has supported tourism and recreation in the southern Lake Michigan region. Currently, we are supporting research and outreach in sustainable economic development in both Illinois and Indiana. Public access to natural areas adjacent to Lake Michigan as this development occurs continues to be an important consideration."

The dunes, left by the Ice Age, are ever changing. They begin as tiny sand grains, rolled along by the wind into what becomes the foredunes, those dunes nearest the beach. When wind velocity is sufficiently high, sand grains bounce along in a movement known as saltation. Soon a ridge is formed, gradually growing into a dune that ranges from only a few feet to more than 100 feet, with its stability enhanced by the growth of grass, shrubs and trees. Marram grass, with wind spray providing cementing moisture, provides the root system important to dune building around the Great Lakes. An underground system of stems supports most of its growth. Cottonwood trees, also important to the dune building process, need sheltered spots to sprout but with early growth, they, too, can survive sand buildup. Steep-sided valleys called blowouts are cut into the dune by the wind that strips away vegetation, creating a depression.

Moving landward, next comes the interdunal area with ponds, marshes and dunes whose forms are dictated by the vegetation that includes juniper, poison ivy and bluebells. White pines, and jack pines at their southernmost site, also grow here. Once foredunes, these dunes protect the still older dunes, the backdunes, where dense vegetation grows and includes black oaks, white oaks, elms and sassafrasses.

Glaciers, wind and water have combined to form these unique dunes that Illinois and Indiana now lay claim to. The bogs, swamps and lakes that are part of the Dunes are important to the Great Lakes ecosystem. The significance of plant diversity in this region was highlighted by researcher Henry Cowles in the early part of this century. Cowles examined the changes in dunes as new plants crowd out native growth.

Natural processes of longshore currents and simple wave action sometimes cause destruction of one beach while creating adjacent beaches. This erosion balance, however, can be altered by human actions. This altered environment is evident in the plants visible in blowout areas as heavy human use wears away protective vegetation.

Even before World War I, efforts were begun to preserve the Dunes. Delayed by national priorities that included three more wars and economic ups and downs, federal action was slow to come. With U.S. Senator Paul Douglas of the neighboring state of Illinois as spokesman, concerned citizens continued to push for Dunes preservation. Indiana Dunes National Lakeshore was approved by Congress along with the Port of Indiana as a package deal in 1966. In 1972 the Lakeshore was designated the first urban park of the U.S. Department of the Interior. In addition to the Indiana Dunes National Lakeshore, dunes are preserved within the boundaries of Indiana Dunes State Park and Illinois Beach State Park. Indiana shoreline includes 14 miles of dunes, with seven miles on the Illinois shoreline.

Assignments

1. Explain how dunes are formed.
2. What two states were directly involved in passing federal legislation that preserved Indiana Dunes?
3. Identify a natural resource in your area that has tourism value. Write a story explaining its formation and benefits.

Originally carried as "Coastal Salmon: The Scientific Background" in the January 1995 issue of *Restoration,* an Oregon Sea Grant quarterly publication about salmon, watersheds and people, this story by Joseph Cone was written to provide scientific background to nonspecialist readers about a region-wide endangered species problem. Cone has won numerous awards for his science writing for print and broadcast. His 1991 book, *Fire Under the Sea,* was named by Booklist and Library Journal as one of the top science books of the year.

Coastal Salmon Decline in the Pacific Northwest

by Joseph Cone, Oregon Sea Grant

For most fish biologists and managers and other government officials, the "wake-up call" about today's salmon crisis came courtesy of a professional report published in 1991. The report, "Pacific Salmon at the Crossroads," was written by three experienced biologists who were members of the endangered species committee of the American Fisheries Society.

The biologists had undertaken a review that — strange as it may seem in retrospect — no one had done before. They wanted to collect information about the status of wild salmon populations throughout the Pacific Northwest. (A simple, though incomplete, definition of "wild" salmon is that they are local fish spawned naturally — as opposed to in fish hatcheries.) As the biologists spoke with others who were knowledgeable about the fish in their own areas of the region, a disturbing overall pattern began to emerge.

More than one hundred local populations, or "stocks," had become extinct during the last century. Two hundred fourteen other stocks faced definite risks of extinction.

Using standards established by the National Marine Fisheries Service, the "Crossroads" biologists said that of the 214 stocks, 101 were at high risk of extinction and would probably qualify for "endangered" status under the Endangered Species Act. Fifty-eight stocks were at moderate risk and would probably qualify for "threatened" status, and the remaining stocks merited "special concern" to prevent them from becoming threatened or endangered.

About two-thirds, 138, of the 214 stocks were native to coastal waters from the Canadian border to southern California. Of those 138, 58 stocks were native to the Oregon coast. They included populations of chum, chinook, and coho salmon, and also steelhead and sea-run cutthroat trout.

The list of causes of the decline was long and was led by "habitat loss and damage, and inadequate passage and flows caused by hydropower, agriculture, logging, and other developments."

According to the authors serious factors contributing to the decline of many populations are overfishing, competition and hybridization with fish raised in hatcheries. The authors also recognized that poor survival in the ocean was an additional important factor. Poor survival can result from such conditions as ocean temperature extremes and the increased presence of predators such as seals and sea lions.

Because the causes are so numerous, varied, and often interrelated, improving the condition of salmon populations will require more than piecemeal actions, the "Crossroads" authors noted. Integrated and comprehensive efforts are called for, as recovery plans already developed for Columbia and Snake River salmon by both the Northwest Power Planning Council and the National Marine Fisheries Service outline in some detail.

Watersheds Key to Freshwater Improvements

Restoration of salmon is such a challenge because the fish live in so many different environments during the course of their lives. There's not much that people can do about conditions

in the ocean, but during the last decade the recognition has grown that something can be done to improve conditions in the freshwater ecosystem that salmonids inhabit at various times. Attention, accordingly, has turned to watersheds.

Attention to the effects of timber management on salmonids in coastal watersheds is not exactly new. In the late 1950s, cooperative studies began in the Alsea, Oregon, watershed. However, it was not really until 1992 that watersheds first became the focus of widespread public attention. The attention resulted from a report prepared for Congress that year by a group of government scientists led by Jack Ward Thomas, now Chief of the U.S. Forest Service. The scientists, the so-called "Gang of Four," had been asked to propose options for management of old-growth and other mature ("late-successional") federal forests in the range of the northern spotted owl. The report identified 137 "key watersheds" — generally those in the best condition — and specified improvements in their management that would protect and aid in the restoration of salmonid populations.

Although the "Gang of Four" report did not lead to new legislation in 1992, it did set the framework upon which President Clinton's forest plan was developed a year later, with many of the principal scientists again involved. The aquatic species conservation elements of Clinton's plan was again built around "key" watersheds, this time 164 of them totalling more than 9 million acres of federal forest land in western Oregon, Washington and northern California.

While federal agencies are devoting attention to protecting and restoring salmonid habitat in certain watersheds, so too are the efforts of state government focused on watersheds.

The mood now about salmon is somber. On the one hand, a great deal of the salmon legacy of the Northwest has been irretrievably lost. On the other, efforts to restore salmon will not be successful without economic costs. However, knowledge about restoration is available, and if a public commitment can be found — not only to fund restoration, but to engage in a long-term task — at least some people believe that some of the once-numerous salmon runs can be restored.

Assignments

1. How many wild salmon stocks were native to the Oregon coast?
2. Why is salmon restoration so challenging?
3. Write a story about a native restoration project in your state.

Although published more than a decade ago in 1986, in Delaware Sea Grant's *Reporter*, "Trash into Treasure . . . Chitin Chemists Make Sutures from Shells" is included here to illustrate the potential for exposure of good science reporting. Following Sea Grant publication, the story was picked up by several national media from the *Washington Post Business Week* reaching a large audience with what was then a new and exciting breakthrough for the seafood industry.

Trash into Treasure . . . Chitin Chemists Make Sutures from Shells

By Tracey Bryant, Delaware Sea Grant

After playing the shell game for a dozen years, Dr. Paul Austin and his associates at the University of Delaware Sea Grant College Program have finally won.

Over a decade ago, the scientists discovered a way to dissolve chitin — a component of the shells of blue crabs that resembles stale, whitish cornflakes — and extrude it into filaments for surgical sutures. The information was patented, and now, after several years of optioning those patents from the university, Unitika Ltd., a major Japanese textile fiber and hospital supply firm, is licensing them for use in a process they have developed for surgical sutures.

With blue crab shells becoming so useful (and blue crabs represent only a small source of chitin — it's also found in all other marine crustaceans, as well as insects, fungi, and yeast), seafood processors throughout the nation may soon find entrepreneurs more than willing to help solve a dilemma facing many processors in recent years.

The seafood industry on the Delamarva Peninsula annually processes nearly two million pounds of crabmeat alone — leaving behind almost 21 million pounds of crab waste, including the shells. After the Environmental Protection Agency halted the processors' former practice of dumping shells back into the waters they came from, the processors began hauling the waste to landfills. But the sheer volume and foul smell of the crab waste soon prompted some landfill operators to close their sites to shell dumping, thus forcing the processors to find other means of disposal.

"Quite a few years ago a crab processor in Crisfield called me and told me about the industry's dilemma," Dr. Austin says, "so we began working to alleviate their headache by making the waste into something of value. We estimated that from all of that crab waste could be extracted more than a million pounds of chitin."

Recently, a crab meal fertilizer plant called Hosho-Somerset, Inc., near Crisfield, Maryland, began accepting tons of crab waste from crab packers in Crisfield and neighboring Deal Island. Through contacts with Austin and his colleague Dr. John Castle, plant manager Dr. Michael Mau says his company will begin producing chitin for market this fall.

Delaware's Chitin Story

Although Paul Austin's chitin project marked a first for the University of Delaware Sea Grant College Program twelve years ago, he was far from a newcomer to the field. "We were working on chitin at DuPont back in '36," he says. "But then another polymer — nylon — was discovered, and it was recognized as a tremendous opportunity. It immediately drew in all personnel."

According to Austin, a few chemical corporations continued to conduct research on chitin, but with little success. No one could find a suitable solvent to transform the whitish flakes into more useable form. "That is where we've made our contribution — making chitin soluble," Austin says.

In 1975, Austin working with then graduate students Frank Rutherford and Charles Brine, discovered a lithium chloride/dimethylacetamide solvent for chitin. And that important discovery led to another: chitin could be made into sutures. How? Through a series of simple experiments in his laboratory in the College of Marine Studies, Austin demonstrates the process.

"What you do when you want to make a fiber is get a syrupy solution about as thick as honey," he says, as he adds some of the solvent to a flask containing chitin flakes, closes it, and begins shaking it. "I could do this in my sleep," he says, grinning.

"Now, when it's pretty thick, you can put this stuff in a hypodermic syringe, extrude it through the needle, run it out through a coagulating solvent like alcohol or acetone, and it will come out as a filament — a suture-like material. Then you cold-draw it," Austin says, as he pulls next from his briefcase a polyethylene ring used to join cans of beverages into six-packs.

"Chitin is an organic, crystalline polymer — and it's this crystalline material that makes it wonderful. By cold-drawing this material, you further order the molecules and make the resulting fiber stronger. Think of bricks dumped off a truck into a big pile, with each brick a molecule," he explains. "The bricks don't amount to much until you put them into a wall," he says. "Making that wall is precisely what you do to make nylon, Dacron, and polyethylene fibers, and can do to make sutures from chitin."

Austin then takes one of the polyethylene rings and pulls steadily on it. The ring elongates and feeds off the middle until it is a slender, but unbreakable filament. "There's your wall," Austin says. "Cold drawing is one of the most phenomenal things discovered in the textile industry. And now we can do it with chitin."

Chitin sutures should be welcomed by the medical profession. According to Austin, they are absorbable — a trait presently shared by only a few of a dozen different suture materials (catgut, and polymers of polylactic and polyglycolic acids). They are nonallergenic — producing essentially no tissue reaction compared to some degree of reaction with other materials. They possess somewhat mysterious wound-healing properties, which, Austin notes, "can only mean a plus." And chitin sutures are stable under alkaline conditions. "Most absorbable sutures don't retain their strength under such conditions," Austin says. "So these will probably be used in the urinary tract and the pancreas."

Other Chitin Products

Yet surgical sutures may be only one of a myriad of products that can be produced from chitin. Currently, at the Marine Studies Complex in Lewes, Dr. John Castle is experimenting with microcrystalline chitin (chitin in powder form from acid treatment and high-speed shearing) to develop an ointment and other specialty products. Tests have shown that chitin promotes the healing of wounds and reduces scar tissue.

University of Delaware Sea Grant researchers have already proven that chitin can be combined with another waste product — whey — to produce animal feed. Although whey contains 55% of milk's nutrients and most of its vitamins, millions of pounds of it are discarded by the dairy industry every year because it contains so much lactose that neither humans nor animals can digest much of it. However, Dr. John Zikakis in the College of Agricultural Sciences found that when chitin is added to whey, it promotes production of enzymes that enable animals to digest lactose.

In laboratory tests, Zikakis found that chicks fed a diet consisting of commercial feed, 20% whey, and 2% chitin grow faster and contain less fat than chicks fed solely commercial feed. And according to Zikakis, use of the chitin-whey substitute could eventually reduce feed costs to chicken growers. Zikakis and the rest of the team are currently working to interest industry in the production of feed from the two wastes.

In the Food Science Department, Dr. Dietrich Knorr has made significant progress with a derivative of chitin called chitosan. Soluble in acid of vinegar strength, chitosan can be used to clarify the waste water produced by food processing plants much as an egg white added to coffee acts to knock down any grounds to the bottom of the pot.

Typically, the waste water from food processing plants contains some protein, starch, and other nutrients. Through treatment of the water with chitosan, however, this nutritious material can be culled out and recycled. In laboratory experiments thus far, Dr. Knorr has used chitosan to increase the efficiency of recovering protein from tomato seeds by 15 percent.

"The amount of protein present in waste water produced by the tomato canning industry alone in the U.S. could fulfill the minimum daily requirements of five million people for a year," Knorr says. "Thus chitin and its derivatives could make a very real contribution in recycling such food wastes in this country."

Currently, however, Knorr and his colleagues are studying chitosan's role in facilitating recovery of such commercially valuable substances as waxes, gums, pigments, flavorings, fragrances, pharmaceuticals, and other products from plant cell cultures. According to Knorr, if chitosan were applied to cell cultures of the Venus Flytrap, for example, it would promote the release of enzymes that are used in meat tenderizing and leather ripening, and for such medical applications as the removal of tumors.

From sutures to flavorings — all of these chitin products serve to remind Dr. Austin that the work he began at the University of Delaware more than a decade ago is far from over. To further tap the natural polymer's potential, the 79-year-old scientist says he wants to, in a way, go back to the drawing board.

"I keep hoping to find a better chitin solvent since the one we have now is really pretty nasty," he explains. So far, he has tested hundreds of different solvents, each printed carefully in his laboratory notebook.

"Day after day, I go into the lab — but no, I don't find it. But maybe the next day, I'll be successful," he says. "It doesn't disturb me to be unsuccessful, you see. I expect it. And it's fun," he adds, smiling. "Otherwise, I wouldn't be here."

Assignments

1. How many pounds of crabmeat are produced on the Delmarva Peninsula?
2. How many pounds of crab waste are left behind?
3. Research and cite other examples of uses of waste material.
4. Write a story explaining one use of waste material in your area.

Appendix

Information Sources

Sea Grant Contacts

Nancy Riggs, Illinois-Indiana Sea Grant
217 333-8055; http://ag.ansc.purdue.edu/il-in-sg

Peggy Britt, Michigan Sea Grant
734 763-1437; http://www.engin.umich.edu/seagrant

National Sea Grant College Program
National Oceanic and Atmospheric Administration
1315 East-West Highway
Silver Spring, Maryland 20910
Phone: 301/713-2431
http://www.mdsg.umd.edu/seagrantmediacenter/
(Contact National Sea Grant for nearest Sea Grant program)

Other Information Sources

National Oceanic and Atmospheric Administration
U.S. Department of Commerce
14th Street & Constitution Ave., NW, Room 6013
Washington, DC 20230
202 482-6090; http://www.noaa.gov/

U. S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460
202 260-2090 http://www.epa.gov
(Individual state environmental agencies can be found in the government section of most phone directories.)

Center for Environmental Journalism (CEJ)
University of Colorado
Campus Box 287
Boulder, CO 80309-0287
303 492-4114; cej@colorado.edu;
http://campuspress.colorado.edu/cej.html

High School Journalism Institute
Indiana University School of Journalism
Ernie Pyle Hall, Room 200J
Bloomington, IN 47405
812 855-0895
http://www.journalism.indiana.edu/HSJI/webpage.html

Poynter Institute for Journalism Training
81 Third Street South
St. Petersburg, FL 33701
813 821-9494; http://www.poynter.org

Web Sites

• Professional Organizations

Agricultural Communicators in Education (ACE)
http://AGCMOO2@UNLBM.UNL.EDU

National Association of Science Writers
http://www.nasw.org/

Society of Environmental Journalists (SEJ)
http://www.seg.org/

North American Association of Environmental Education
http://naaee.org

• Special Interest Professional Organizations

Asian American Journalists Association
http://www.aaja.org

Journalism and Women Symposium
http://www.jaws.org

National Association of Black Journalists
http://www.nabj.org/

National Association of Hispanic Journalists
rpetro@nahj.org
http://www.nahj.org/

National Lesbian and Gay Journalists Association
nlgja@aol.com
http:www.nlgja.org

Native American Journalists Association
http://www.medill.nwu.edu/naja/

• Other Useful Web Sites

Directory of Great Lakes Educational Materials
http://www.ijc.org/comm/dglem.html

Great Lakes Information Network (GLIN)
http://www.great-lakes.net/

GreenCom Environmental Education Resource Library
http://eelink.net/eepro/html/reslib/html

Science and the Environment
http://www.cais.com/publish/voyage.htm

Science/Nature for Kids
The Mining Company - online publishing for kids
http://kidscience.miningco.com/

EE-Link
National Consortium for Environmental Education and Training
http://eelink.net

Reporter.org
http://www.reporter.org/
Provides links to various journalistic organizations, newspapers, etc.

Environmental News Network
http://www.enn.com/aboutenn/welcome.asp

Pulitzer Board
http://www.pulitzer.org/year/

(Many newspapers have websites; a web search will lead to local sites.)

Print Resources

A Field Guide for Science Writers. Deborah Blum and Mary Knudson, editors, 1997.
National Association of Science Writers
P.O. Box 294
Greenlawn, NY 11740.
http://nasw.org/

The Art of Science Writing. Worsley and Mayer, 1989.
Teachers and Writers Collaborative
5 Union Square West
New York, NY 10003

Communicating Science News.
The National Association of Science Writers, 1998
National Association of Science Writers
attn: Diane McGurgan
P.O. Box 294
Greenlawn, NY 11740

The Complete Book of Feature Writing. Leonard Witt, ed., 1991.
Writers Digest Books
1507 Dana Avenue
Cincinnati, Ohio 45207

Computer Assisted Research, Nora M. Paul, 1997 (3rd Edition).
Poynter Institute
81 Third Street South
St. Petersburg, Fl. 33701
813 821-9494
http://www.poynter.org

Environmental Writer Newsletter
National Safety Council, U.S. Environmental Health Center.
1025 Connecticut Avenue NW, Suite. 1200
Washington, DC 20036
202 293-2270 ext. 469
http://www.nsc.org/ehc/publicat.htm

Journalism and Mass Communication Educator Newsletter
University of Tennessee School of Journalism
Room 330 Communication Building
Knoxville, TN 37996-0330
615 974-5155; Jim-Crook@utk.edu

Meeman Archives
Michigan State University
517 353-9479; Detjen@pilot.msu.edu
The Reporter's Environmental Handbook. West, Sandman, Greenberg, eds., 1995.
Rutgers University Press
109 Church Street
New Brunswick, NJ 08901

Reporting on Risk: A Journalist's Handbook on Environmental Risk Assessment. M. Kamrin, D. Katz, and M. Walter, 1995.
Available from Michigan Sea Grant
2200 Bonisteel Blvd.
Ann Arbor, MI 48109
734 764-1138; msgpubs@engin.umich.edu

"Speaking, Listening, and Media Literacy Standards for K through 12 Education"
National Communication Association
5105 Backlick Road, #F
Annandale, VA 22003
mrandall@natcom.org

-information sources list compiled by peggy britt

Peer Evaluation Sheet

An artist begins shading a drawing only after the design is complete. The craft of writing is practiced similarly. Follow suggestions below to improve quality of writing.

- Re-write all sentences that begin with "there" or "here."
- Remove all verbs using "get" and find a more effective verb.
- Remove most adverbs.
  (Adjectives should be used sparingly, and adverbs even more sparingly.)
- Read the story carefully and correct any of the following errors in grammar or punctuation.

  -fragments
  -run-ons
  -comma splices
  -colons
  -semicolons
  -commas
  -pronoun-antecedent agreement
  -subject-verb agreement
  -apostrophe
  -end punctuation
  -capitalization
  -spelling/homonyms

Instuctor Evaluation Sheet

The following key points should be addressed by the instructor after student and/or peer editor does effective re-write.

- Does the lead capture the main essence of the story?
- Is the story written as briefly as possible while still covering essential facts and primarily answering the following questions: Who, What, When, Where?
- Does the lead pull the reader into the rest of the story?
- Is the key point of the story in the lead?
- Are strong verbs and nouns used in the lead?
- Do paragraphs flow smoothly one to the other, using some form of transition?
- Are the questions of "why" and "how" clearly answered in the body of the text?
- Does the story have clear attribution for all assertions?
- Does the story have sufficient supporting evidence for all claims?
- Does the story have balance, giving both sides of controversy?
- Is the story accurate?
- Is the story written in good taste, even if difficult topics are covered?

-evaluation points developed by charles herber

About the editors and contributors

Nancy Riggs is a communicator in the Illinois-Indiana Sea Grant College Program. She is a former newspaper reporter, public relations writer and magazine writer. She held public information positions with American Red Cross and has taught writing at the University of Illinois at Springfield and at Richland Community College. She holds B.A. and M.A. degrees in journalism from the University of Illinois at Springfield. She has written for several daily newspapers and for a number of magazines that include *Prairie Farmer, Turf Magazine* and *The Landscape Contractor.*

Peggy Britt is assistant director of the Michigan Sea Grant College Program. She also served as assistant director of the National Consortium for Environmental Education and Training, president of the Environmental Education Association of Washington, and held various environmental specialist positions. She holds a B.S. degree in biology from Cornell University and an M.S. degree in environmental studies from The Evergreen State College. She authored a guide on designing and evaluating community education programs and co-authored and edited a ten-volume handbook on integrating environmental education into the K-12 curriculum.

Robert Hays teaches journalism at the University of Illinois. He is a former newspaper reporter, public relations writer and magazine editor. He also served three years as an assistant scientist in the Illinois scientific surveys (Natural History, Geological and Water). He holds B.S. and M.S. degrees in journalism and an interdisciplinary Ph.D., all from Southern Illinois University. He is author, co-author or editor of five books, including *State Science in Illinois.* His articles have appeared in a number of academic journals, magazines and newspapers such as *Chicago's American* and the *St. Louis Post-Dispatch.*

Joyce Jakubiak is an editor in the Michigan Sea Grant College Program. She holds a B.A. degree in English from Western Michigan University and an M.A. degree in journalism from the University of Wisconsin. She has been an editor for research publications and has written articles for *Traverse Magazine.*

Charles Herber teaches English and journalism at Jefferson High School in Lafayette, Indiana, and has taught in his field since 1966. He holds a B.A. degree in English from St. Joseph's College, an M.A. degree in English, and an M.S. in counseling from Purdue University. He has edited proceedings for Purdue University School of Engineering, presented workshops on special issues in publishing and coordinated Upward Bound programming. His articles appear in educational newsletters.

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