Marine Resources Curriculum: A Tale of Two Schools

A Narrative Documenting Work Done by Teachers at the Lubec Middle School and Shead High School in Eastport

Produced by the Cobscook Bay Clam Restoration Project

About the Cobscook Bay Clam Restoration Project

The Cobscook Bay Clam Restoration Project, started in 1995, seeks to address the decline in the local clam industry by working towards four goals. These objectives are:

- To improve the health of the Bay.
- To increase productivity of the flats.
- To create a regional approach to clam management.
- To increase access to education and training in resource conservation.

Working towards the fourth objective, the Clam Project began documenting the local efforts at marine resource education implemented at the Lubec Middle School and Shead High School in Eastport.

Additionally, the Clam Project has assisted these two schools in implementing a hands-on, sense-of-place, local marine resources curriculum by:

- Working with Shead High School science teacher Mike Tuckett to secure a Shore Stewards Trust Partners in Monitoring grant;
- Working with Mike Tuckett to select water quality monitoring equipment;
- Ordering the water quality monitoring equipment;
- Coordinating a public meeting in Eastport to publicize the water quality monitoring program activities to the community;
- Coordinating University of Maine Cooperative Extension personnel to provide training in water quality testing and analysis to Shead High School students;
- Coordinating Eastport and Lubec student volunteers in a joint reseeding of Lubec flats as part of an AmeriCorps National Day of Service effort in April 1996;
- Providing seed clams and technical assistance for the Lubec reseeding;
- Conducting a moonsnail survey of the Lubec flats that involved area students; and
- Contributing to the purchase of the Shead High School science room computer.

How to Contact the Clam Project

For more information, or to order copies of this narrative, you can contact the Clam Project:

- by writing to Will Hopkins, Project Coordinator, at: 4 Favor Street, Eastport, ME 04631;

A Note to the Reader

This curriculum documentation is divided into two main parts: **Narratives** and **Appendices**.

The **Narratives** section highlights the marine resources curriculum developed at two Washington County schools, the first at the middle-school level (Lubec), and the second at the secondary level (Eastport). This section describes the work done by three teachers.

The **Appendices** section is intended to aid teachers by providing tangible materials: course outlines and proposals, classroom handouts, assessment tools, resource lists, equipment lists, and successful grant applications. Some of the appendices are not referenced in the **Narratives** text. Therefore, it is suggested that readers peruse the List of Appendices and the appendices themselves.

Acknowledgements

The Clam Project would like to thank the following individuals for their assistance with this project: Rose Binda, Marty Mahar, and Mike Tuckett, teachers; Sheila O'Brien and Carrie Hall, Summer 1997 Clam Project interns from the Quebec-Labrador Foundation; Sarah Davis, proofreader; and Dr. Pamela Proulx-Curry, University of Maine at Machias, reviewer.

Table of Contents

Section: Page:

I. Introduction

Give someone a fish and they'll eat for a day;
Teach them how to fish and they'll eat forever.
-Traditional Saying

The sea around us inspired the marine resources curriculum profiled in this document. The marine resources belong to Cobscook Bay in Washington County, Maine, from whose waters residents have derived both sustenance and livelihood for centuries. The work of three teachers is documented here - the team of middle school teachers Rose Binda (science) and Marty Mahar (mathematics) at Lubec Middle School, and science teacher Mike Tuckett at Shead High School in Eastport.

Cobscook Bay is an enormous estuary of the Gulf of Maine, which is a semi-enclosed sea that extends seaward for almost 200 miles. The Bay experiences intense tidal currents and subarctic summer water temperatures. These factors, along with Cobscook's highly convoluted shorelines, contribute to an exceptional diversity of marine habitats, which support the highest density of bottom-dwelling invertebrates on the Atlantic coast north of the tropics.

Characterized by pristine beauty, Cobscook Bay is one of the last undeveloped places along the eastern U.S. seaboard. This beauty, however, is not without its price, as area residents struggle to meet the costs of education for their young people. The economics of place, therefore, comprise part of the context for the development of a marine resources curriculum which stresses sustainable harvesting practices, alternatives such as aquaculture, and stewardship of the environment.

The other part of the context for the marine resources curriculum documented here relates to traditions. For millennia Cobscook Bay has provided its inhabitants with an abundance of natural resources. Today, many of the fisheries in both the immediate and surrounding waters of the Bay have collapsed, or are in danger of collapsing. In response, an aquaculture industry has emerged along Cobscook's shores, including the nation's largest salmon-raising facility and the only U.S. sea farm to grow Nori, the seaweed used to wrap sushi. Traditions, however, persist and one of those traditional activities is the harvesting of soft-shell clams.

During the last several decades, the closures of thousands of acres of clam flats around the Bay have resulted in a loss of millions of dollars from local economies. A lack of conservation and management has also contributed to the dwindling of the soft-shell clam resource, and competition - from other states and provinces - has lowered the price-per-pound of clams harvested in Washington County.

Recently, over 2,000 acres of flats have been reopened to harvest because of the efforts of community organizations, clam harvesters, volunteers, marine biologists, area residents, teachers, and students.

The two schools profiled in this documentation represent two communities sharing the waters of Cobscook Bay. Lubec, the easternmost town in the U.S., is separated by 2.7 miles of water from Eastport, the easternmost city in the U.S. Students in these schools have participated in the kinds of educational activities that relate what they are learning to where they live. This relevancy, termed "authentic" in teaching circles, has resulted in concrete changes for the communities on the shores of Cobscook Bay.

These students have researched the need for shellfish ordinances and were instrumental in implementing a shellfish ordinance in the Town of Lubec. They have participated in water quality monitoring activities that

ultimately led to the opening of closed acreage. They are working with a local shellfish hatchery to plant seed clams and learn which techniques are best to grow out seed stock. They are learning about aquaculture, conducting experiments in marine animal husbandry, developing marketing strategies for under-utilized species, and building aquaculture and community marine resource centers.

To achieve their goals, these students have collected water samples in cold, wet weather. They have used applied mathematics to analyze data. They have cleaned beaches, exchanged ideas with peers in other communities sharing the Gulf of Maine, and written monographs on statewide conservation ordinances. They have cleaned, painted, designed, and maintained. They have assisted one another. Most of all, they have demonstrated that they are capable, passionate stewards who will not only learn how to fish - so they can eat forever - but how to fish in a sustainable way, so that their children and grandchildren may also enjoy the bounty of Cobscook Bay.

II.A.1. Lubec Middle School - Narrative

"For several years we wanted to utilize our coastline as a classroom. Time and money prohibited anything more than an occasional field study. Realizing that it was imperative to teach young people the dynamics of their environment and involve them in the care and wise use of resources, we decided to devote two days per year to cleaning up marine debris. Students collected data and after two years noticed a significant decline in discarded plastics. Encouraged that we were making a difference, teachers, parents, and students began to investigate various grant programs and curriculum designs. After two more years of research and writing the middle school was awarded two grants that enabled [us] to merge math and science studies into an integrated study of our coast."

- From narrative application for the Anheuser-Busch *Promise & A Pledge* environmental award.

Lubec Middle School teachers Rose Binda and Marty Mahar had just celebrated winning an award of $1,000 from the Shore Stewards Trust when they received notification from the GTE Foundation that an application for a $12,000 fellowship had been approved. "We were elated," Binda says. "We really didn't think we had a chance."

In 1993-94, a total of $13,000 in grant monies propelled Lubec Middle School students into what Binda calls "the living classroom." The students embarked on their journey by testing coastal water quality . Sixth-graders monitored Johnson's Bay; the seventh grade tested the Narrows; and eighth-graders sampled the waters at the South Lubec tidal marsh. The project involved all of the 87 middle school students, who recorded temperature, pH, salinity, color, and bottom sediment.

The students' efforts at shore stewardship generated interest in soft-shell clams. Binda noticed that, as students read articles in New England newspapers on the collapse of northeastern fisheries, their awareness grew.

This awareness turned into action. In January 1994 students wrote to Dr. Brian Beal, professor of marine biology at the University of Maine at Machias, asking him what they could do. He suggested they establish a study of a standing population of clams. In turn, the students honed in on an active flat in South Lubec. Then they discussed doing the study with local officials at a town meeting and found out there was no shellfish ordinance.

By June 1994, the students had produced the following:

- A monograph on water quality findings;

- A survey of state shellfish ordinances and shellfish management practices;
- Experiments that looked at how run-off (of fertilizer, oil, and gray water discharge) affects clam growth; and
- A videotaped message to the Town of Lubec about opportunities and alternatives for Lubec's clam flats.

In the autumn of 1994, Binda and Mahar entered their students' project, "Coastal H2O Monitoring", into a national contest, the Anheuser-Busch Promise & A Pledge environmental awards. In the narrative application, Binda defined the goals of LMS students as follows:

1) To monitor water quality weekly.

2) To analyze this data and report to the public in an educational forum twice a year.

3) To work with the town shellfish commission [sic] to determine the standing stock of soft-shell clams.

4) To assist the town in developing an innovative management program for the clam flats.

"Coastal H2O Monitoring" garnered the second-place cash prize of $5,000 in the grade 6-8 category. A segment of a videotape produced by LMS students was aired during the awards ceremony, which appeared on national television on June 8, 1994. Schools from all over the United States entered the competition, which recognizes projects that demonstrate a commitment to the preservation and enhancement of natural resources. A total of $100,000 was awarded to 13 entrants.

It was the students, stresses Binda, who wanted to use the award to establish a small, experimental hatchery at the Lubec school. They remembered what Binda had told them she had seen - in particular, the sea urchins - after her visit to a mariculture facility at Woods Hole during a summer training institute in 1993. "The kids were fascinated with watching the life cycle - instead of the slice-and-dice method after the animal is dead," observes Binda.

Objectives for the Lubec aquaculture center included: studying factors that inhibit larval growth in the water column; observing sea urchin brood stock shedding egg and sperm; and watching the fertilization process under the microscope.

In July 1994, Binda and Mahar submitted a formal proposal to the MSAD 19 Board of Directors to use a room in the school as the Lubec Middle School Aquaculture Center. Plumbing and electrical installations were provided at no charge by a local resident. Equipment and supplies were purchased. Students painted the walls and cleaned the room, says Binda, who emphasizes that student ownership was a key element in maintenance.

"If there is magic on this planet, it is in the water," read the Loren Eisley quote above the door to the aquaculture center when it officially opened on December 15, 1994. Housed in the 25' x 15' space at the time were 24 sea urchins, 24 periwinkles, 12 soft-shell clams, six blue mussels, and five minnows. The students used five-gallon plastic buckets instead of glass tanks, explains Binda, because plastic is more porous and allows for better growth. It is also a less expensive method to create a water column, she adds.

At the beginning of 1995 the middle school acquired a 50-gallon seawater tank, which had previously been in the high school. Supervised by Binda and Mahar, students cleaned, sanded, and painted the tank. They sealed it with silicone, and they stripped the motor and installed a new gasket. The purchase of a stand allowed the tank to be raised to eye level, which, Binda stresses, is crucial for observation.

Sea urchins were also placed in the tank. After reading an article in a publication from the National Science Teachers Association about an adapter which enables filming while using a microscope, Binda created her own

adapter using a Styrofoam cup and black paper. This allowed students to observe and film the fertilization of sea urchin eggs.

In January 1995 Binda applied - a second time - for a Toyota Tapestry grant. When her proposal , entitled C.L.A.M.S. (Clams Learning and Management Strategies), was accepted, she earned Lubec Middle School students an additional $8,000. With this funding came an opportunity to engage students in an authentic educational program combining science, mathematics, and a community partnership project in aquaculture.

C.L.A.M.S. is an outline of cooperation between officials of the Town of Lubec, area clam harvesters, Department of Marine Resources biologists, and a local university researcher, Dr. Brian Beal. The main goals of the original proposal included:

- Selecting, maintaining, and using three experimental plots at the South Lubec mudflats to study clam seeding, transplanting, and a combination of both methods;
- Producing a video on the effects of questionable clam harvesting practices;
- Continuing water quality monitoring and initiating coliform screening tests;
- Culturing seed clam and overwintering seed;
- Disseminating findings to Lubec residents and officials in public forums, reporting data to area DMR biologists and local researchers, and sharing this information with other coastal communities in the form of a published monograph.

Binda engaged in the professional development specified in the original proposal - a one-week summer institute in mariculture. In 1995, however, she accepted an offer to teach at a Mount Desert school. "It was hard when she left," says Mahar, "because Rose was pretty much in charge" of the grant writing, implementation, and management for the C.L.A.M.S. project.

The effects of living in what Binda refers to as "the last pristine environment on the east coast" are multiple. Property taxes in Lubec are high because of the town's unparalleled coastal frontage. As mill rates increase, school budgets are carefully scrutinized. The results of such an economy - where natural resources have been depleted, adding to community impoverishment - translated into internal crisis at the Lubec school. This resulted in high administrative and teaching staff turnover and low school morale in general.

Mahar believes these factors contributed to what happened to the middle school water quality testing program in the 1995-96 academic year. "There were safety issues [...] we wanted to eliminate kids from the program, kids who were not responding to these issues. The administration was not supportive so the program was canned."

In 1996-97, however, Mahar relates, the program returned to being "pretty much on track with the original plan." The purchase of 250,000 seed clams from the Beals Island Regional Shellfish Hatchery (BIRSH) provided students with the opportunity to learn about overwintering techniques. Approximately 150,000 of the seed clams were placed in overwintering containers and put out at a Stolt Sea Farms-owned aquaculture lease, says Mahar. The remainder of the seed was overwintered at Mud Hole Cove near Beals Island. Additionally, BIRSH supplied gear and technical assistance to the Lubec Middle School students.

Students also performed internships at the hatchery. They worked in rotating teams, and assisted BIRSH staff with general maintenance tasks. Because of their numbers, observes Mahar, students make a real contribution to hatchery operations at critical times.

II.A.2 Curriculum Particulars

Expectations

"Don't limit expectations for the children, keep smiling, and listen to the young people, old timers, the community," advises Binda. "If you can listen," she maintains, "you can adapt what is being said to the curriculum."

Lubec students, Binda points out, "walk around with the belief that it's all possible. That's a fantastic place to be when you're teaching. People didn't think [the students] could do what the original proposal outlined; they expected the project to be modified and pared down... The kids believe if you work hard enough, you will accomplish it."

Mahar notes, "Once you teach kids how to do water quality testing, or how to care for specimens, they do a good job. Once they learn it, they do it quickly; once they get a handle on it they can do some great things."

As for expectations on a practical level, Mahar smiles. "If you expect a kid to go out on the mud flats and not get dirty, you're crazy."

Student Skills/Teaching Strategies

When students begin the hands-on approach to science and math, says Mahar, they need patience. "Kids want to do things instantly - and they need the ability to listen. They also need to learn organizational skills, so they know the procedures, which groups they're in, where the equipment is, and how to take care of the equipment," he adds. Binda believes that observation skills also need to be developed. She notes, "It takes three months to observe native species in order to adjust and balance everything. Nothing's immediate. It all takes time." To assist students in learning procedures and prepare them to do field work, Binda says she used lectures and demonstrations.

Homework, stresses Mahar, is a key to developing sound academic skills. It can start in kindergarten, he suggests, with a little assignment such as "What did you have for dinner?" When students get older, he says, an assignment could take the form of "How many clams can you dig? How many could your grandfather dig? Kids can see the changes. Then you weave the math in to analyze the data and make comparisons."

Mahar says he likes to see "what kids can and cannot do. I want to see *how* they do it; I don't like being told what a kid can or cannot do. Some of the students doing the water testing had second- to third-grade math skills. Peer educating in groups helped these kids to pick up the math."

Curriculum Integration

Both Binda and Mahar agree that mathematics and science are integrated naturally through a marine sciences curriculum, but teaching both subjects in tandem requires flexibility in scheduling. The Lubec school provided this flexibility, says Binda, who adds that the entire middle school team was "very adaptable."

Mahar likes an application-oriented approach because he feels it makes mathematics relevant to his students. To understand parts-per-million (ppm), a measure used in water quality monitoring, Mahar's students made a million tally marks, a project which took two-and-a-half months to complete. Students then colored in 10 ppm on the tally marks. Because of the concrete nature of such a project, students became aware of what a million really means.

The importance of math, in the context of marine science, was illustrated in a simulation where some of the students acted as lobster fishermen and others played the role of business managers. Each group in the scenario received separate instructions but both had to calculate cost and profit.

Additionally, students generated averages for summaries of analyses for each body of water studied and they graphed their results. This provided hard data for the public forums they conducted, forums which generated community support for the project, and which eventually led to the Town of Lubec adopting a shellfish ordinance.

Evaluation & Assessment

Mahar says that students need to master certain math skills before approaching the next level. "On a day-to-day basis, I like to know how kids are doing."

Mahar believes that students learn more through the hands-on approach. To demonstrate this, he spent nine weeks teaching middle school students how to calculate percentages and solve problems by planning meals using coupons from the newspaper. He asked students questions such as: If you had $35 and four VIPs coming to dinner, what would you do?

Modifications

To accommodate students with different learning abilities, Mahar and Binda incorporated oral assessment techniques, such as an end-of-the-year presentation by groups or individuals. "Writing is important, but so is oral expression," says Mahar.

Group work, he adds, is a strategy particularly useful when support for special needs students is limited. In a group of three, Mahar advises, have "one low, one average, one above-average student" working together. "All kids have their place," he stresses, noting that "the students with the lesser abilities actually turn out to be the best. When they get it right, they feel great."

Student Focus

"Student interest," says Mahar, "grew year by year." He adds that students were "really enthusiastic about clam counts, seeding, and beach clean-ups. The kids who went through the program really had their eyes opened. We didn't have to hold a carrot up, reward them to do something they should do, especially stewardship."

In the Field

- Parental Permission - One form was developed, says Binda, to cover the entire year.
- Weather - When the weather was good, Mahar says, students accompanied teachers to collect water samples. During inclement weather, teachers took the samples and students did the testing. Binda recalls cold temperatures, overcast skies, and students on the mud flats counting clams. "There was no grumbling, no moaning," she recalls.
- Clothing - Mahar suggests that students bring a change of clothing when working in the field. "If they don't have boots, they can wear old sneakers tied tight and a pair of sweats. When it's cold, have plenty of rubber gloves," he advises.
- Transportation - The Lubec school provided Binda and Mahar with a small bus to take students to and from the test sites.

II.A.3. Lubec Middle School - Instructional Foci & Learning Outcomes

---

Instructional Foci: Learning Outcomes:

A = Attitude S = Skill K= Knowledge

Cleaning up local beaches ..... Stewardship (A)

Water quality monitoring ..... Stewardship (A); Handling lab equipment (S); Following instructions (S); Collecting & analyzing mathematical data (S; K); Understanding chemistry involved in water quality monitoring (K); Observing marine environment (S; K); Working cooperatively (S; A)

Reading newspaper articles ..... Relating facts to local area (S; K)

Responding to articles by writing letter to local researcher ..... Synthesizing stewardship attitude & action (A);
Communication via letter-writing (S)

Writing monograph on water quality findings ..... Synthesizing scientific data (S); Communication via writing (S)

Conducting survey of state shellfish ordinances and shellfish management practices ..... Research (S); Understanding local laws & practices (K); Working cooperatively (A)

Conducting experiments on how run-off affects clam growth ..... Handling equipment & marine animals (S); Formulating hypotheses (K); Synthesizing information & data (S;K); Working cooperatively (A)

Making a videotaped message to the town about opportunities & alternatives for Lubec?s clam flats ..... Handling video equipment (S); Stating beliefs (A); Working cooperatively (A)

Instructional Foci: Intended Learning Outcomes:

A = Attitude S = Skill K= Knowledge

Establishing an aquaculture center ..... Handling equipment & marine animals (S); Observing live marine animals (S; K); Sanding, painting, & sealing a 50-gal seawater tank (S); Observing & filming the fertilization of sea urchin eggs (S; K); Maintaining room & caring for specimen animals (A); Working cooperatively (A)

Culturing & overwintering seed clams .... Handling & caring for live marine animals (S; A; K); Working cooperatively (A).

Performing internships at BIRSH ..... Engaging in tasks at hatchery involving algae culture, seed clam feeding, maintenance (S; K; A); Working cooperatively (A).

II.B.1. Shead High School - Narrative

"Just as it is important to have well defined objectives and purposes in doing an activity or lesson, it is equally important to have the activity apply to real-life situations. It is apparent that science and social and industrial life are inseparably linked, and that each in turn causes the other to advance... In my marine resources class we not only study the features of the oceanic ecosystems, we also look at the impact these systems have on the economy of the area."

- Mike Tuckett, from Statement of Educational Philosophy

Context/Beginnings

When Mike Tuckett started teaching science at Shead High School in Eastport in 1989-90, "there was no marine biology course and nothing on marine resources or natural resource ecology." Reflecting on his first several years in Washington County, Tuckett notes, "You don't change the community, you become part of it. I spent two years observing, not forcing. After that, I asked, "Why *don't* we have a marine sciences curriculum??"

In 1992-93, Tuckett began to explore the idea of such a curriculum. He recalls meeting with Julie Early, director of the Quebec-Labrador Foundation's (QLF) Fishnet program, "which was formed to bring marine education to communities like ours." Tuckett relates that he and Early brainstormed ideas. "I told her my vision - that we needed a course that exposes students to all opportunities in marine sciences in the area, fishing, aquaculture, boat building."

Those discussions led to the QLF/Fishnet-funded pilot program in 1993-94, a four-week mini- course that "met every other day for two hours, at the Shead High School lab, at the boat school [Marine Technology Center], wherever the venue took us," explains Tuckett. A no-credit, volunteer elective, the mini-course, he elaborates, "was like a fishing expedition, to see what we could catch. And we caught some really interested students."

The mini-course engaged students in the following activities:

- Finfish aquaculture and the shellfish hatchery - visits were made to local salmon pens, and Dr. Brian Beal, professor of marine biology at the University of Maine at Machias, talked to students about activities at the Beals Island Regional Shellfish Hatchery (BIRSH);
- Students were given an overview of modern and traditional boat building methods;
- Eastport Port Authority personnel discussed the new cargo port at Estes Head in Eastport, the economic benefits expected from the port, and licensing procedures;
- Dave Clifford, the Department of Marine Resources area biologist, talked with students about his work as a marine biologist; and
- A representative from QLF talked to the class about marine ecology and marine habitats.

Between 10 and 12 students - sophomores and juniors - participated in the mini-course. The method of evaluation consisted of a pre- and post-course test (developed by QLF), in which students had to demonstrate their knowledge of the responsibilities required for the position of a DMR Tech II.

The mini-course led to the development of the full-year Marine Resources course, which was offered as an elective in science and attracted almost 20 students (many of them who had taken the mini-course) when it was implemented in 1994-95 . "These were not college-bound kids," notes Tuckett. "It's the whole point of the course. My focus has always been around the creation of jobs."

Objectives/Curriculum

The main objective of the Marine Resources course was, and still is, to investigate the habitats and ecosystems, the fisheries, and the aquaculture methods in the Cobscook Bay/Quoddy area. Prerequisites for enrollment were Algebra I, Earth Science, and Biology. The knowledge and skills gained from the Marine Resources curriculum included:

- Knowledge of the marine environment and marine ecosystems;
- Knowledge of underutilized marine species;
- Knowledge of the chemistry behind water quality;
- Proper handling of equipment used in labs and to conduct water quality monitoring;
- Communication skills, including interviewing techniques and writing skills;
- Marketing skills;
- Skills related to the operation of small water craft; and
- Use of navigational charts.

In the Spring of 1994, Tuckett received a Shore Stewards Trust/Partners in Monitoring grant to begin water quality and fecal coliform testing in Cobscook Bay sites near Eastport. The grant was written in partnership with the Cobscook Bay Clam Restoration Project . Water quality monitoring involves the following activities:

- Gathering 100-ml samples on a weekly basis (in fall and spring);
- Recording water temperature at the sample site;
- Running samples through incubation in a membrane filtration process in order to detect fecal coliform;
- Viewing samples under a microscope and counting fecal coliform colonies; and
- Performing dissolved oxygen tests.

The water quality testing aspect of the curriculum, explains Tuckett, gives students an opportunity to practice science by observing, collecting data, and seeing if there are any changes. "Science is 90% mundane," he stresses. "You have to keep records. You have to be accurate. Then, sometimes, there's the 'aha'. People think they're going to discover something. But look at Mendel: it took him 20 years to figure out the mathematical probabilities of genetics. If you're really sincere about science, it may lead to something."

During the 1994-95 year, another feature to the marine resources curriculum was added, an exchange program with students in Gloucester, Massachusetts. Julie Early of QLF/Fishnet coordinated this effort, which emphasized an exchange of information between the young people of both communities. The experience in Gloucester, Tuckett relates, is that "most of the kids there are better off economically [than Eastport kids], but the fishermen's families there are looking at their lifestyles changing because of a loss of the groundfish fisheries. We lost our fisheries a long time ago. Our students know a lot about aquaculture. Once we got past the barriers, the kids formed a nice connectedness. Friendships developed."

Eight students were selected from Shead High School to go to Gloucester, where they stayed with host families. Activities included visiting the fish processing plants, talking to local fishermen about their ideas, visiting the Woods Hole laboratory facility, and spending a half day in the science classroom. "They got into a nice debate about how different fishing techniques help or harm," recalls Tuckett.

In 1995, eight Gloucester students came to Eastport. They toured local aquaculture pens, visited Peacock's processing plant in Lubec, the Waponahki Museum at Sipayik, and spent a half day in the science classroom. "A lot of the Gloucester kids couldn't believe how small, rural, and beautiful it is here or how friendly the kids in this area are," says Tuckett. Unfortunately, when the Gloucester science teacher left in 1996, the exchange program stopped.

During the 1994-95 and 1995-96 academic years, a major emphasis in the marine resources program at Shead was on water quality monitoring. "We were finding that the places the DMR was testing - Half Moon Cove and Carrying Place Cove - had the same results, good water quality," notes Tuckett. However, points out Clam Project Coordinator Will Hopkins, Shead students were also testing water between DMR sampling sites. "In doing so," he notes, "they were able to pick up on a septic system that malfunctioned only during periods of high rains. The students alerted the Clam Project to this problem."

In 1996, Shead students began to work with BIRSH, participating in clam flat reseedings in both Eastport and Lubec and assisting the staff at the facility with a variety of tasks. "The curriculum hasn't really changed that much," Tuckett observes. "There are a lot of things we don't cover because of budget, for example, boat building, more of the hands-on type stuff. In the future, I think that will be more possible."

Assessment

Tuckett has used a variety of evaluation tools, including tests, quizzes, labs and lab reports, final presentations, and portfolios.

One of the projects that Tuckett used the first year of Marine Resources (and used throughout the implementation of the course) involved under-utilized species. Students research a species they choose, design an advertising campaign around its use, and cook a dinner .

By 1995-96, says Tuckett, "I was fine-tuning the curriculum. We were doing the same things but doing them differently." As an example, he cites the under-utilized species project. The first year, "I let students pick the species," notes Tuckett, laughing, "but some of them picked fish like salmon. Now I pick the species."

In 1996-97, instead of papers, for midterms, student groups made oral and visual presentations on different marine environments . During this academic year, Tuckett added a unique assignment to his range of assessment tools, "The Cell Project." For this project, students had a choice of five options, from writing a short story or play about a town as a cell, to designing a cell game, to building a three-dimensional model (edible or inedible) of a cell. The edible cell option, he notes, was the most popular.

In 1995-96, after attending a workshop on portfolio assessment with former Shead High School English teacher Andrew Lopez, Tuckett introduced portfolio assessment into his Marine Resources class . He notes that the more experienced students are with alternative evaluation such as portfolios, the better they do. "I would like to see [portfolios] used as early as second or third grade," stresses Tuckett.

Referring to portfolios as "another tool in the bag of tricks you have as a teacher, which gives you a handle on how the curriculum works and how students work," Tuckett notes that time to critique the evaluation process, as well as parameters for its setup, are crucial.

Tuckett says he is "pushing for students to decide on the method of assessment." First, however, Tuckett feels that a school needs to determine what it considers the knowledge of most worth for its students. "There are two diplomas you can get," he elaborates, "one for outcomes and one that says you're here for four years. We have to decide what we want as a school. The mark of a good school is when you can combine skills and be creative."

Perhaps the most evidence for authentic assessment concerns the transferability of the skills and knowledge gained through the Marine Resources program at Shead. Tuckett notes, "When I moved up here, two students went on to major in oceanography or marine sciences. Within the last two years, nine to ten are majoring in something that has to do with the ocean, simply because they saw the importance of studying the environment around them. It's the little pebble you throw in the pond that makes the ripple. Science doesn't just take place in the science class," he stresses. "You need people who can build things, communicate the right way."

Expansion

Because of high student interest in 1995-96, a Marine Resources II class was started in 1996-97, a semi-independent format course in which students study marine resources at a more advanced level. In the first year of implementation, the Marine Resources II students audited a Maine Maritime Academy course, which was offered through Interactive Television (ITV) at Shead High School.

Additionally, Marine Resources II students were involved in getting the Seaview Project, a community marine resources center, off the ground. These students were responsible for choosing the closed tank system and evaluating the project as it progressed. They worked closely with construction technology teacher Scott Fraser to design the renovation of an unused Special Education trailer on the elementary school grounds. Schoolwide involvement in the project resulted in construction technology students performing some remodeling tasks and art students painting murals. Tuckett envisions curricular integration around Seaview, with English classes reading literature related to marine topics and social studies projects that involve interviewing and videotaping local individuals with marine knowledge.

The Seaview Project will serve a two-fold purpose. "We want to try to raise salt-water species and conduct experiments to see what the best conditions are to raise fish," says Tuckett. The other goal of the center is to provide a resource to the community, including a space for Shead students to present their findings, and an area for elementary school students to learn about local marine species.

II.B.2. Shead High School - Curriculum Particulars

Skills

Tuckett notes that equipment-handling skills improved from the first year of water quality monitoring activities to the second. By year two, students "were right on target" with DMR water quality scores.

In the Field

Safety - Preparation for hands-on activities such as collecting water samples and doing labs followed Tuckett's maxim that "Safety is always the first thing in science." To ensure student safety, Tuckett used safety contracts and reviewed safe procedures. When introducing new equipment, he always demonstrated how to use it and how *not* to use it.

Sample Collection Procedure - Tuckett used the manual, *Clean Water: A Guide to Water Quality Monitoring*, developed by Esperanza Stancioff of the University of Maine Cooperative Extension.

Parental permission - One form was developed for students participating in the water quality monitoring program.

Student Perceptions

Tuckett says students completing the Marine Resources course gained insight into the variety of marine-related employment opportunities. Prior to taking the class, students' conceptions about aquaculture jobs, for example, centered on shoveling feed and gutting fish. By looking at the scientific aspects of aquaculture within the context of the course, students "now see the ocean as full of vast wealth and opportunity," says Tuckett.

Fine-tuning

- Scheduling Marine Resources I and II classes at the same time resulted in too many students at once. In the 1997-98 academic year, the classes will be separate.
- When using portfolios as an assessment tool, Tuckett notes, make expectations clear and set deadlines at each stage to ensure that students are progressing with their projects.

II.B.3. Shead High School - Instructional Foci & Learning Outcomes

Instructional Foci: Intended Learning Outcomes:

A = Attitude S = Skill K= Knowledge

Field trip to local salmon pens ..... Learning about local aquaculture techniques (K)

Guest speakers making presentations on: clam culture, boat building methods, port construction & shipping economy;
work of a DMR area biologist; marine ecology & habitats ..... Learning about local employment opportunities around marine resources & importance of marine environment to the local economy (K)

Water quality monitoring ..... Stewardship (A); Handling lab equipment (S); Following instructions (S); Collecting & analyzing mathematical data (S; K); Understanding chemistry involved in water quality (K); Observing marine environment (S; K); Working cooperatively (S; A)

Marketing campaign around under-utilized species ..... Knowledge of underutilized species (K); Interviewing (S); Writing (S); Marketing (S)

Operating small water craft ..... Understanding of water safety (K; A); Boat handling (S; K); Understanding water and wind factors (K; S); Using navigational charts (S; K)

Gloucester exchange program: visiting another community; talking to local fishermen; field trip to Woods Hole lab..... Sharing information with peers (K); Representing own community in another community (A; S); Interviewing (S); Learning about marine lab facility (K)

Seeding local clam flats ..... Handling live marine animals (S); Participating in local stewardwhip effort (A); Working cooperatively (S; A)

Instructional Foci: Intended Learning Outcomes:

A = Attitude S = Skill K= Knowledge

Portfolio Assessment ..... Organization & selection (S); Reflective process (S; K)

Seaview Project: planning & executing renovation; monitoring progress ..... Architectural design (S; K); Construction technology (S; K); Using applied mathematics (S);

Reflection on project's progress (S); Maintenance of facility (A; S)

II.B.4. Overview of Enrollment for Marine Resources Classes ? Shead High School

Marine Resources Mini-Course (1993-94):

Twelve students - sophomores and juniors - enrolled (entire student body = ± 180 students)

Marine Resources (1994-95):

Nineteen students (9-10 who had taken the mini-course) enrolled (entire student body = ± 180 students).

15 students finished the course; four went on to study marine-related topics (26%) and are still somewhat involved in the field.

Marine Resources (1995-96):

Twelve students enrolled (entire student body = ± 180 students)

Five students (42%) went on to Marine Resources II class in 1996-97

Six of the students (50%) went on to work in marine-related fields

Marine Resources I (1996-97):

Twenty students enrolled (entire student body = ± 180 students). Presently, most of them are still at Shead High School.

Marine Resources II (1996-97):

Five students enrolled. All went on to study or work in marine resource-related fields (100%).

III.B Lubec Middle School - Funding Narrative

Shore Stewards Trust Grant - 1993 - $1,000

Binda learned of the Shore Stewards Trust grant program by reading a local newspaper. The item about the award "was buried in the paper," notes Binda, stressing the need to look everywhere for resources.

Binda and Mahar used the $1,000 grant to purchase the following water quality monitoring supplies:

- Water sampling & measurement kit for Marine Studies;
- Oceanography field test kit;
- Bacterial pollution kit;
- Thermal and sewage pollution detection kits.

MSAD 19 provided $650 for professional development and Lubec's local-access cable channel provided $50 for videotaping expenses and assistance in editing and broadcasting the forum prepared by students on water quality.

GTE Foundation GIFT (Growth Initiative For Teachers) Fellowship - 1993 - $12,000

Binda learned of this prestigious grant program while watching a television program for science teachers, *Scientific American Frontiers* .

Awarded to in-service teachers showing innovation in the integration of math and science, the $12,000 fellowship was awarded in 1993 to 60 teams. Binda and Mahar were the only winners from Maine that year, reports Barbara Townsend Donino, the GTE Foundation GIFT Program Contributions Assistant. "They did a really good job," she recalls, adding that fewer than 250 teams applied in 1993.

The two Lubec Middle School teachers were "elated, absolutely tickled," says Binda. "We felt very affirmed that we were going in the right direction." Mahar relates that his colleague pulled him off the court during a basketball game to tell him the news. "I felt a great deal of pain because Rose pounded me so hard," he jokes.

Upon receiving the fellowship, Binda, Mahar and members of the other winning teacher teams spent three days in Boston, where they visited GTE's facilities and MIT's cyberlab. The next four days were spent in Washington, D.C., where the emphasis was on networking with government officials and private foundations. GTE personnel "set up the appointments and delivered you to them," says Binda. "Senator Mitchell came off the Senate floor to meet with us; he made the time to see us," adds Mahar, noting, "Olympia Snowe did the same thing. It was quite an experience."

"We stayed in the finest hotels and ate the finest meals," says Binda, who comments that she is still in touch with some of the team members she encountered during that week. "We were treated like professionals," comments Mahar. "The more you do as a teacher, the more you're expected to do. Teachers *should* be thanked. GTE treated us like kings and queens. They thought what we were doing was worthwhile."

GTE's Donino says many teachers in the GIFT program comment about their being treated like professionals. "It was an eye-opener to us, a revelation" she comments, "because we didn't realize that they weren't being treated professionally."

For Binda, one of the best features of the award concerns its use for professional development. When applying for the fellowship, Binda budgeted $2,500 to the following professional development activities:

- A one-week Marine Science Institute for Teachers at the Huntsman Marine Laboratory in St. Andrews, New Brunswick (Summer 1993);
- A one-week course in Marine Environments/Coastal Ecology at the Massachusetts Maritime Academy in Cape Cod (Summer 1993);
- A one-semester, 3-credit course in Basic Oceanography at the University of Maine at Orono (Fall 1994);
- A one-semester, 3-credit course in Curriculum Organization of Middle Schools at the University of Maine at Machias (Spring 1994);
- A one-semester, 3-credit course in Staff Development for Educators at the University of Maine at Machias (Spring 1994).

She completed all these activities, with the exception of Basic Oceanography, which was canceled due to lack of enrollment. Binda substituted this course with:

- A one-semester, 3-credit course in computer training at the University of Maine at Machias (Fall 1993).

Additionally, Binda was able to engage in the following activities:

- Individual computer tutorials (a total of 10-12 hours of instruction) with local computer consultant Jon Bragdon; and

- A grant-writing course at University of Maine at Augusta (1994).

When applying for the fellowship, Mahar budgeted $2,500 for the following professional development activities:

- A one-week Marine Science Institute for Teachers at the Huntsman Marine Laboratory in St. Andrews, N.B. (Summer 1993);
- A one-semester, three-credit course in Introduction to Statistics for Business and Economics at the University of Maine at Orono (Fall 1993);
- A one-semester, three-credit course in Introduction to Oceanography at the University of Maine at Machias (Spring 1994);
- A one-week Marine Ecology Institute and a one-week Marine Ocean Habitats Institute at the West Quoddy Marine Biological Station (Summer 1994);
- Memberships to the National Middle School Association, the National Math Teachers Association, and the National Science Teachers Association.

Because of course cancellations, the closure of the West Quoddy Marine Biological Station, and a busy family life, Mahar was unable to complete all of his professional development funds and had to return $1100 of the $2500 earmarked for training. Reflecting on alternatives to professional development and local human resources, Mahar notes, "My neighbor, however, is a marine biologist and I spent half the summer learning from her."

The remainder of the fellowship - $7,000 - was used for the following:

Equipment and Supplies for Water Quality Monitoring:

- 3 marine water sampling kits;
- 3 oceanography field tests;
- 1 CD ROM Drive;
- 1 LCD Magnaview for overhead projector with RGB "Y" cable;
- 1 3M 900 Series Overhead Projection;
- 4 bacterial pollution kits;
- 3 thermal sewerage detection kits;
- Various reagents, chemicals, growth medium, bacteria, plankton, kelp cultures, glassware;
- Miscellaneous computer materials (3.5 diskettes, tapes, acetate print for overhead projections);
- Videotape materials, printing, and postage.

Transportation to Test Sites

Field Trips to:

- Beals Island Regional Shellfish Hatchery;
- Moosehorn National Wildlife Refuge;
- Huntsman Marine Laboratory

Anheuser-Busch Promise & A Pledge Environmental Prize - 1994 - $5,000

Every September Anheuser-Busch sends a mailing to American schools notifying educators of their Promise & A Pledge award for environmental work. "It ended up on my desk," says Binda, who notes that the application consists of a "narrative, with no budget, no strings attached."

Binda and Mahar were notified a week before April vacation that the Lubec Middle School was going to receive an award. However, they did not know until the presentation in Florida, aired on national television in June, that they would win the second-place, $5,000 cash prize.

"This was a competition," she stresses. "That this school, these kids, were going to get national recognition was a trip. The whole school was charged. There was a lot of pride in the community."

The $5000 cash prize was used to establish an aquaculture center at the Lubec school. This project became reality on December 15, 1996, when middle school students hosted an open house at their mariculture facility.

Toyota Tapestry Grant - 1994 - $8,000

"It took me two years to get the Toyota grant," Binda says, referring to a 1993 application which was turned down. "It's a really competitive grant," she explains, "you have to use very tight language, there can be no fuzziness, nothing wasted. Their readers are very precision-oriented." Binda adds that of all the grant applications she has written, the Toyota grant "was the most time-consuming. I spent three weeks writing it because it's so competitive. It was the best technical writing I had ever done. I worked really hard and it paid off. The grant-writing course really helped a lot."

The Toyota Tapestry program awards 20 environmental and 20 physical science grants, up to $10,000 each, annually. In 1994 there were 8,000 applicants. Binda notes that the focus for the environmental grants is sustainability. This year, she says, Toyota is also offering 20 grants in mathematics.

The awards ceremony in 1994 was held at the four-day National Science Teachers Convention in Philadelphia. "We were guests of Toyota," says Binda. "They wined and dined us."

"I only applied for what I needed," notes Binda of the Tapestry grant. Of her $8,000 budget, $6,400 was earmarked for the following equipment and supplies:

- Calipers
- Clam hoes
- Metric trundle wheels
- Culture incubator for coliform
- Micro-video unit
- Netting
- Culture jars
- Float tray materials
- Reagent for water testing
- Glassware
- Seed clams
- Video tape and data storage disks
- Printing and postage

The $1,600 in remaining monies was used to fund professional development, specifically, training in seed clam production and care at the Darling Marine Research Center at the University of Maine at Orono.

III.C. Funding Particulars

Locating Resources

Rose Binda's success in grant writing captured a total of $23,000. For small schools in economically depressed rural areas, such funding not only allows implementation of an innovative curriculum, it boosts school and community esteem.

Locating resources is a matter of paying attention to professional journals, newspapers, and networking with businesses, corporations, and foundations, explains Binda, who suggests that educators peruse their content-area publications. For example,

the National Science Teachers Association publishes a newspaper every two months, which includes three pages of grant listings. There are state, federal, and private foundation grants listed in this and other professional publications.

"Consortiums of schools can apply for big money," stresses Binda, who suggests subscribing to the publication *Grants for School Districts*, an $80 annual investment.

Some Practical Grant-Writing Tips:

- "You have to write like a venture capitalist," states Binda.
- Large corporations have their own foundations; these are easier grants to write. Furthermore, these foundations are flexible in terms of how money is used, especially in regards to technology advances.
- Read articles about others who get grants, contact these people directly and get information.
- Local companies "are quiet about grants unless it's something of interest to them," notes Binda. Sometimes their resources could be in the form of in-kind donations, for example, refrigeration units or cleaning supplies. "There's a lot of stuff kicking around, especially in closed businesses and restaurants. Write to distributors."
- U.S. Government surplus offers very affordable equipment, says Binda, citing the purchase of a 486 computer for $5.
- Groups stand a better chance of obtaining funding.
- Funders appreciate proposals with acronyms for names; i.e. Binda called her Toyota Tapestry grant proposal C.L.A.M.S., which stands for Clams Learning and Management Strategies.
- Use three-ring binders to keep track of spending; it makes the process of reporting and accounting more manageable and less time-consuming.
- Report any changes in project status and/or other funding received in order to avoid conflict.

III.D. Lubec Middle School - Aquaculture Center Equipment List

---

Physical Space

A 6' X 4' area is the minimum space necessary to set up an aquaculture center similar to that at LMS. Running water, she notes, "would be convenient but is not necessary." Without running water, maintenance requires hauling 25 gallons of salt water per day and 5 gallons of fresh water.

Specimen Holding Facilities

Binda and Mahar used a plastic "kiddie" wading pool placed on a wooden pallet. Five to six white plastic buckets (to hold the animal specimens) were placed inside the pool. Binda and Mahar used five-gallon drywall or blueberry buckets.

Approximate cost:

- The kiddie pool cost approximately $8.
- The wooden pallet was donated by local merchants.
- Similar buckets are sold through scientific supply companies for approximately $10 a piece. Binda notes that blueberry buckets are available for $4-$5 each. However, she suggests waiting until mid-September, when used blueberry buckets are available at local hardware stores for $1-$2 each.

Preparation:

To prepare used buckets, Binda advises washing them with water and letting them air out for 48 hours so any contaminants can leach out of the plastic.

Environmental Regulation - Equipment

- **Aquachiller** - Needed to circulate and chill marine water (the water must be maintained at 45°F). Ideally, notes Binda, the aquachiller's capacity should be expandable to 700 gallons per hour. The unit requires a 120-volt, grounded outlet. No special wiring is needed.
  Approximate cost: $1,700-$2,000.
- **Two Hoses** - These serve as intake and outtake hoses and are connected to the aquachiller.
  Approximate cost: $2/eight-foot hose
- **Calcified Gravel** - A 1 1/2" layer of gravel is placed inside the holding containers and the pool. For a facility like the LMS aquaculture center, Binda says a 50-lb. bag lasts 1-2 years. "The key is keeping it clean," she stresses.
  Approximate cost: $20
- **Air Stones** - Provides oxygen; one is needed per holding container.
  Approximate cost: $12/package of 12
- **Aerator Filter** - One aerator filter per holding container is needed to keep water from getting murky.
  Approximate cost: Less than $5 each.

Specimen Animals

- Fifteen mature **soft-shell clams** and approximately two dozen mature **blue mussels** were donated by a local, licensed shellfish harvester. **Green sea urchins** were donated by a local dragger. **Lobsters** were acquired from Carolina Biologic.
  Approximate cost: The only cost was for the lobsters. Carolina Biologic's lobster kit includes a submersible pump and 10 lobsters, which are released back into the wild. The entire kit costs $99.

Microalgae

- **Native Microalgae** - Needed to start active algal cultures used to feed shellfish. Available from scientific supply distributors .
  Approximate cost: $50-100 for a year?s supply
- **Glassware** - Beakers, test tubes, etc. Needed for algal culture.
  Approximate cost: Binda budgeted $400 for culture jars (non-consumable) and $300 for glassware

(beakers & testtubes) in her Toyota Tapestry grant application. Catalog prices on glassware varies according to capacity and number.

- **Grow Lights and Timer** - Needed to cultivate algae. Binda notes that regular fluorescent bulbs, covered with violet-purple cellophane, can also be used. The timer is used in conjunction with the lights.
  Approximate cost: Average price for light bulbs in a science supplier catalog is $50 for four 48" 40 watt fluorescent bulbs. The price on timers ranges from $30-$50.
- **Lab Table** - Used as a base on which to attach grow lights.
  Approximate cost: $600-$800
- **Steam Autoclave** - Used to test for bacteria and to prepare fertilizer for algae.
  Approximate cost: $350-$635 depending on capacity (9-liter and 14-liter prices listed here, respectively, from Aquatic Ecosystems, Inc.)
- **Refrigeration** - Needed to store algal cultures.
  Approximate cost: Price per unit at local dealer; this is an item that might be donated.

Cleaning Supplies

- **Bleach** - Used in daily maintenance procedure to kill any organisms. Binda says approximately 1 1/2 gallons per week are needed.
  Approximate cost: Price per case at local grocer's; this is an item that might be donated.
- **Other Cleaning Supplies** - Sponges, mops, brooms, rubber gloves, etc. are needed for regular maintenance of the aquaculture center room.
  Approximate cost: Price per item at local grocer's; some of these supplies might be donated.

III.E. LMS Aquaculture Center - Maintenance Procedures

Daily Procedures

Binda reports that the students performed these daily tasks on a rotating schedule:

- **Cleaning** - Draw off 1/3 of the water and remove all waste from each tank. Replace water that has been removed with new water.
  ± 20 minutes/day.

- **Feeding** - Fresh seaweed and potato peelings are fed to urchins every morning. Clams and mussels are fed 500 ml. microalgae. Young lobsters are given a brine shrimp pellet; mature lobsters can eat raw fish, clams, etc.
  ± 20 minutes/day.

- **Set up of Autoclave** - Binda says this task was performed during regular class time.
  ± 20 minutes/day

Weekly/Biweekly Procedures:

- **Pumps & Filtration Systems** ? Take all pumps and replenish filtration systems. Clean air stones. Strip big pump and clean it.
  ± 2 hours

- **Calcified Gravel** ? Every two weeks gravel needs to be removed and rinsed. Binda says this task was performed when water was being changed. Binda notes that she vacuumed the gravel every other day.
  ± 1-2 hours to remove and rinse gravel; ± 15 minutes to vacuum gravel

- **Cleaning of Room -** Walls and floors are washed (by students).
  ± 1-2 hours

Twice a Year

- Strip big pump and clean it.
  ± 1 hour

Miscellaneous Maintenance Procedures

- As glassware is used: Clean it, dry it, and sterilize it before next use.
  Time involved depends on the number of glassware items used.

III.F. Appendix: Resources for Teachers

NOTE: This Appendix is included with the narrative documentation in order to provide some resources to readers. Other Appendices, listed in the section "List of Appendices," are actual documents, the majority handouts used in the classroom, and are housed in two separate binders, both located at the office of the Cobscook Bay Clam Restoration Project. For more information about these Appendices, contact Clam Project Coordinator Will Hopkins by writing to: 4 Favor Street, Eastport, ME 04631.

Print Resources

Handbooks

Clean Water. A Guide to Water Quality Monitoring by Esperanza Stanicoff, Maine/New Hampshire Sea Grant Advisory Program, University of Maine, Orono.

The Monitor's Handbook, LaMotte Company, Chestertown, MD. (Excerpts in Binder 1 of Appendices).

Field Manual for Water Quality Monitoring by William Stapp, Tomsom-Shore, Inc., Dexter, MI. (Excerpts in Binder 1 of Appendices).

The Tapwater Tour (Test Kit), LaMotte Company, Chestertown, MD.

Water Systems

The Estuary Book, Maine Coastal Program, State Planning Office, Augusta (FREE)

The Gulf of Maine by Spencer Apollonio, Maine Books, Rockland, ME.

"Water," *National Geographic* Special Edition, November 1993.

Groundwater, Department of the Interior, U.S. Geological Survey.

The Oceans by Don Groves, Wiley & Sons, New York, NY.

Marine Aquaria and Aquaculture

Marine Aquarium Keeping by Stephen Spotte, Wiley & Sons, New York, NY.

The Marine Aquarium by C.W. Emmens, TFH Publications, Neptune City, NJ.

Aquarium Aquaculture, Brody & Patterson, UMaine Sea Grant, Orono. ($3.00; details how to set up an aquarium on a shoestring budget; in Binder 1 of Appendices).

Culturing Algae by Daniel James, Carolina Biological, Burlington, NC. (brochure; in Binder 1 of Appendices)

Marine Aquarium Laboratory, Jewel Supply, Chippewa Falls, WI. (brochure)

General Interest

The Seaside Naturalist, Coulombe, Prentice Hall, New York.

Herons, Frogs, Cranberry Bogs by J. Pottle, Walch Co., Portland, ME.

The Marine Biology Coloring Book. Harper & Row. (Excerpts in Binder 1 of Appendices)

At the Sea's Edge. Introduction to Coastal Oceanography. William Fox, Prentice Hall.

Curricular Materials

Estuarine Studies. An Activities Text for Maine Schools. Fisheries Education Unit #16. Maine Department of Marine Resources Education Division, Augusta, ME., rev. ed., 1990. (In Binder 2 of Appendices).

Saltwater News - Free newsletter with activities & facts for all grade levels. Request from the Maine Department of Marine Resources Education Division, 207-624-6578.

"Free Materials and Services Available for Use in Schools" Resource List produced by the Maine Department of Marine Resources Education Division, Augusta, ME. (In Binder 2 of Appendices). Includes videos, print resources, field trips, workshops. Call 207-624-6578.

Charting Our Course. An Activity Guide for Grades 6-12 on Water Quality in the Gulf of Maine. Maine State Planning Office, Maine Coastal Program, 1989. To order, call 207-287-3261. Includes a bibliography and a section on further reading for teachers. Also includes a section, "Appendix D: Educational Resources," that lists audio-visual materials, curriculum materials, annual coastal/marine events, in-school programs, resource listings, and teacher workshops. (This resource list is included in Binder 2 of Appendices).

Fundy Issues. The Gulf of Maine Council on the Marine Environment, Autumn 1996. Series of 10 reproducible informational sheets, which can be used for teacher background information or handouts (high school level). Call 902-532-7533.

Scientific American "Frontiers" videotapes - 1-800-315-5010. Note: "Frontiers" is a weekly PBS series funded by the GTE Corporation. Educators are granted permission to tape shows for use in the classroom and to copy curricular materials linked to the series from the weekly teaching guide. "Frontiers" also has a web site at http://www.pbs.org/saf/ that features online activities.

Living in Water. An Aquatic Science Curriculum for Grades 5-7. National Aquarium in Baltimore, 3rd ed., 1997. A total of 50 activities, most of them hands-on in nature, with reproducible materials. This is an excellent resource, recommended by Rose Binda, and used in all 50 states and 8 foreign countries. $23.95 + shipping & handling. To order, call 1-800-228-0810. (Promotional flyer/order form in Binder 1 of Appendices).

Voyage of the MIMI, multidisciplinary program of video, software, and texts. Produced by Bank Street College; distributed by Holt, Rinehart, and Winston, 338 Madison Avenue, NY, NY 10017.

Earth the Water Planet by Gartrell, Crowder, and Callister, National Science Teachers Association.

Physical Oceanography. National Science Teachers Association.

Computer Software & Textbook Suppliers

Cambridge Development Laboratory, Inc.
P.O. Box 605
Newton, MA 02162
Long list of software
No phone number listed

Collamore Educational Publishing
(D.C. Heath and Co.)
125 Spring Street
Lexington, MA 01273
Software and texts
617-862-6650

Educational Materials and Equipment Co.
Old Mill Plain Road
P.O. Box 2805
Danbury, CT 06813-2805
Software
No phone number listed

MECC
3490 Lexington Avenue North
St. Paul, MN 55126
Software
1-800-685-6322

Networks & Associations

Coastlinks. A Resource Guide to Maine's Coastal Organizations. Maine State Planning Office, Maine Coastal Program, November 1994. Excellent guide to aquaria, museums, historical societies, parks & refuges, land trusts, and environmental, planning, marine trade, and state organizations. A revised edition is due to be released in June 1998. Call 287-3261 to order.

National Marine Educators? Association
P.O. Box 130
Kure Beach, NC 28449
Produces a newsletter and journal; network of teachers, aquarium, museum, and Sea grant educators.
No phone number listed

Computers in Marine Education
c/o Skip McLamb
316 Angus Road
Chesapeake, VA. 23320
A network of educators using computers in marine education; produces bibliographies and descriptions of curriculum.
757-549-0192

National Science Teachers Association
1742 Connecticut Avenue NW
Washington, DC 20009

Publishes *Science and Children* (elementary level) and *Science Scope* (middle level) as well as booklets on science education and classroom animal and plant safety information.
703-243-7100

National Wildlife Federation
1412 Sixteenth Street NW
Washington, DC 20036-2266
Publishes *NatureScope*, a quarterly magazine of natural history activities for grades K-7; each issue covers a single topic.
202-797-6800

Equipment and Animal Suppliers

NOTE: For a comprehensive list of suppliers of equipment and software, check the January issue of *Science and Children* each year.

Accent! Science
P.O. Box 1444
Saginaw, MI 48605
Field biology catalog; nets and water samplers.
517-799-8103

Aquarium and Science Supply Co.
P.O. Box 41
Dresher, PA. 19025
215-643-1111

Aquatic Ecosystems, Inc.
1767 Benbow Ct.
Apopka, FL 32703
Excellent supplier, according to Rose Binda
1-800-422-3939

Carolina Biological Supply Co.
2700 York Road
Burlington, NC 27215
Living materials, aquarium supplies & equipment; computer software, slides, filmstrips.
1-800-334-5551

Center for Multisensory Learning
Lawrence Hall of Science
University of California
Berkeley, CA 94720
SAVI (Science Activities for Visually Impaired students)/SELPH (Science Enrichment for Learners with Physical Handicaps) equipment and curricula; OBIS outdoor biology materials. The MARE program at Lawrence Hall has hands-on science curricular materials.
510-642-8941; web site: www.lhs.berkeley.edu\foss\foss.html

Connecticut Valley Biological Supply Co. Inc.
P.O. Box 326
82 Valley Road
Southampton, MA 01073

Living materials, aquarium supplies and equipment.
1-800-628-7748

Damon
Instructional Systems Division
80 Wilson Way
Westwood, MA 02090
Balances, syringes, and other equipment.
1-800-860-3812

Delta Education, Inc.
P.O. Box M
Nashua, NH 03061-6012
Curricula and equipment for hands-on science; replacement parts for Silver Burdett, Charles E. Merrill, Holt, and other science curricula, as well as OBIS, ESS, SAPA II and SCIS II materials.
1-800-258-1302

Forestry Suppliers, Inc.
205 West Rankin Street
P.O. Box 8397
Jackson, MS 39204
Field supplies, including some equipment for aquatic sampling gear.
1-800-346-6939

Harcourt Brace Janovich
School Department Sales
Eastern Region
5 Sampson Street
Saddle Brook, NJ 07662
Balances, scales, and other science equipment; replacement parts catalog for HBJ Learning Boards for Science.
1-800-237-2665

LaMotte Chemical Co.
P.O. Box 329
Chestertown, MD 21620
Kits and replacement parts for water testing.
1-800-344-3100

Nasco Educational and Agricultural Supplies
901 Janesville Avenue
Fort Atkinson, WI. 53538
Scales, balances, volumetric measures; replacement parts catalog for SciQuest.
1-800-558-9595

Schoolmaster Science
745 State Circle
Box 1941
Ann Arbor, MI 48106
Scales, balances, glassware, and other equipment.
313-761-5072

Science Kit, Inc.
777 East Park Drive
Tonawanda, NY 14150
General science equipment.
1-800-828-7777

Teachers' Laboratory
214 Main Street
P.O. Box 6480
Brattleboro, VT 05301-6480
Equipment and curricular materials for elementary science.
No phone number listed

Programs for Students

Note: The Maine State Planning Office, Maine Coastal Program publications, *Charting Our Course* and *Coastlinks*, listed above, contain a wealth of information on educational programs for students and educators.

Cobscook Bay Marine Institute
Suffolk University Friedman Laboratory
Week-long summer program open to all teachers, junior & senior high school students, and college students.
Call 207-726-4749 for information.

Bigelow Laboratory High School Merits Program
For juniors interested in marine science.
Call 207-633-9600
Prospectus and sample application in Binder 2 of Appendices.

Professional Development Opportunities for Teachers

see listing for Cobscook Bay Marine Institute, above

University of Maine at Machias
Ongoing courses in Marine Biology, Marine Ecology; Teacher Education; Kit & Caboodle Academy (summer institute focused on networking local teachers and developing kits aimed at fostering hands-on math & science activities)
207-255-1200

University of Maine, Orono
Ongoing courses in Marine Biology; Marine Ecology; Teacher Education
207-581-1110

Ira Darling Marine Research Center
University of Maine, Orono
207-563-3146

University of Maine System Interactive Television Network (ITV)
Contact UMM's ITV coordinator, Marjorie Stark, at 255-1200 or the Calais Center at 454-8670

Huntsman Marine Laboratory Marine Science Institute for Teachers
St. Andrews, N.B.
506-529-1200

Massachussets Maritime Academy
Cape Cod, MA.
508-792-0177; 508-830-5000

III.G. List of Bound Appendices

I. Lubec Middle School

A. General Documents:

1. 1994-95 Proposals for Science/Math Studies

2. Form for Parental Permission to Participate in Water Quality Monitoring Activities

3. Course Outlines for Lubec Middle School: 6th, 7th, and 8th grade science

4. Resources List

5. Math and Science in Water Quality Monitoring

6. Scientific American Frontiers Teaching Guide

7. Promotional flyer/order form for *Living in Water*, 3rd. ed., National Aquarium in Baltimore

B. Curricular Materials - Handouts:

1. WP Press Handouts:

a) "Ocean Currents"

b) "Ocean Fish"

2. Teacher-Generated Handouts on Water Quality:

a) "Turbidity"

b) "Temperature"

4) "Dissolved Oxygen"

5) "Carbon Dioxide"

6) "Algae"

3. Michigan Department of Natural Resources Handouts:

a) "Nutrients"

b) "Transparency"

4. Handout from Field Manual for Water Quality Monitoring: "Nine Water Quality Tests. What They Mean and How to Do Them"

5. Lamotte Company Handouts:

a) "Why Monitor?"

b) "Site Selection"

c) "Temperature"

d) "Dissolved Oxygen"

e) "Phosphate"

f) "Water Analysis Report Form"

g) "Algae in Water"

h) "Turbidity in Water"

i) "Phosphate in Water"

j) "Alkalinity"

k) "Total Calcium & Magnesium Hardness"

6. "Summary of Johnson's Bay"

7. Carolina Biological Supply Company, Culturing Algae

8. Michael J. Brody & Barbara P. Patterson, An Illustrated Guide for Teachers. Aquarium Aquaculture

9. "Experiment 1 - Fertilization and Development in Sea Urchins"

10. "Models of Chemical Weathering" (Teacher-generated assignment)

11. Scott, Foresman and Company Life Science and Earth Science Study & Activity Sheets:

a) "The Fish"

b) "Glacial Movement"

c) "Erosion and River Systems"

d) "Groundwater and Water Table"

e) "Mitosis and Meiosis"

f) "Comparing Mitosis and Meiosis"

g) "Using Punnett Squares"

h) "Fossils"

i) "Natural Selection"

j) "Pollutants in the Environment"

k) "Use of the Environment"

12. Handouts:

a) "Introduction to the Ocean"

b) "Phytoplankton"

c) "Zooplankton"

d) "Meroplankton Match-Up"

e) "Pressing Seaweed"

f) "Echinoderms"

g) "Life Cycle of Echinoderms"

13. *Marine Biology Coloring Book* Handouts:

a) "Tides"

b) "Tidal Zonation Patterns"

c) "Characterization: Rocky Shores"

d) "Characterization: Tide Pool"

e) "Characterization: Coastal Wetlands"

f) "Characterization: Pelagic Zone"

g) "Molluscan Diversity: The Bivalves"

h) "Bony Fish Diversity: Mid-Water and Deep-Sea Fishes"

i) "Introduction to Echinoderms"

j) "Meiosis and Fertilization"

k) "Animal Development: I

l) "Animal Development: III"

m) "Echinoderm and Chordate Development"

n) "Reproduction in Echinoderms: Echinoderm Life Cycles"

C. Curricular Materials - Teacher-Generated Tests

1) "9-Week Test - Basic Science"

2) "Science - 9-Week Test"

3) "9-Week Test - Earth Science"

4) "Life Science - Heredity"

5) "Nine-Week Test - 7th Grade

6) "Life Science - 9-Week Test ? 7th Grade"

7) "9-Week Test - Life Science"

8) "Science Review - Grade 6"

D. Funding Documents

1. Shore Stewards Trust Grant Application

2. GTE GIFT Fellowship Application

3. Anheuser-Busch Promise and a Pledge Award Application

4. Toyota Tapestry Grant Application (C.L.A.M.S.)

5. GTE GIFT Application Packet/Guidelines

II. Shead High School

A. General Documents - Background & Visions

1. Educational Philosophy - Mike Tuckett

2. Teacher Resumé - Mike Tuckett

3. Letter of recommendation for Mike Tuckett

4. Shead High School Marine Resource Center Overview

5. Marine Resources Education at Shead High School

6. Restructuring of the Science Department

7. Permission Slip for Water Monitoring Program

8. Meeting Notice (April 1995) Regarding Water Quality and Clams in Cobscook Bay

9. Meeting Notice (September 1995) Regarding Marine Resource Education

B. Curricular Materials - General

1. Applied Marine Resources Mini-Course Aquaculture Curriculum

2. Marine Science - English Unit

3. Marine Resources Outcomes

4. Tentative Syllabus for Marine Science

5. Course Outline for Marine Resource I/Aquaculture

6. Course Outline for Science II - Applied Biology/Chemistry

C. Curricular Materials - Background Information for Teachers/Student Handouts

1. Maine Maritime Academy, Introduction to Ocean Science:

a) "Lab Manual"

b) "Temperature, Salinity and the Density of Water"

c) "A Temperature and Salinity Section of Castine Harbor"

d) "Organisms in the Marine Environment. Collection and Identification"

e) "Introduction to Marine Chemistry"

f) "Dissolved Oxygen in Penobscot Bay"

g) "Biogeochemistry of Deep Ocean Waters"

h) "Lab: Tide Cycles and Seiching"

i) "Lab: Waves and Seiches"

2. Teacher Lecture Notes - Oceanography

3. Stancioff, Esperanza, *Clean Water. A Guide to Water Quality Monitoring for Volunteer Monitors of Coastal Waters* (University of Maine Cooperative Extension & Maine/New Hampshire Sea Grant Marine Advisory Program, November 1992).

4. The Education Division, Maine Department of Marine Resources, *Estuarine Studies. An Activities Text for Maine Schools* (Fisheries Education Unit #16, 1990).

5. Marine Education Division, Maine Department of Marine Resources, "Free Materials and Services Available for Use in Schools" (Lists field trip opportunities, in-classroom demonstration programs, slide shows, videos, and other curricular materials and services offered at no cost to Maine schools).

6. 1995 Bigelow Laboratory High School Merits Program Prospectus & Application

7. Maine State Planning Office, Maine Coastal Program, "Appendix D: Education Resources," from *Charting Our Course. An Activity Guide for Grades 6-12 on Water Quality in the Gulf of Maine* (Valuable resource list).

D. Curricular Materials - Assessment:

Individual Projects

1. Marine Resources Exam: Portfolio Assessment

2. Marine Resources "Life of the Sea Book"

3. Marketing Underutilized Species of Fish

4. The Cell Project

5. Marine Resources Term Paper and Presentation

6. Presentation Rubric

7. Presentation - Quality Rating Sheet

Group Projects/Activities

8. Interdisciplinary Marine Science - English Unit

9. Grading Criteria for Lab Reports

10. Lab Report Rubric

11. Calculation of the Score for an Individual from the Group Score

12. Peer Assessment Guidelines

13. Carrying Capacity of the Ocean (Game)

Homework/Study Worksheets

14. Chemical Factors of Water

15. Composition of Seawater

16. Composition of Seawater

17. Chemical Factors of Water and Composition of Seawater

18. The Oceans

19. Fisheries

20. Limits of Tolerance

21. Marine Ecology

22. Marine Ecology

23. Marine Ecology

24. Protists

25. Algae: Plantlike Protists

Teacher-generated quizzes

26. Marine Ecology Terms: Quiz I

27. Biology Quiz: The Microscope

E. Funding Documents

1. Eastport, Chatham, Gloucester Exchange Program

2. Shore Stewards Trust Partners in Monitoring 1994/95 Application Package

3. Partners in Monitoring Award Letter

4. Partners in Monitoring Cooperative Agreement

5. Annenberg Rural Challenge Grant Application - Seaview Project: Work Plan, Description, and Architectural Renderings

6. Other Sources of Money for the Seaview Project

7. GTE Gift Grant Proposal

8. Every Science Every Year Mini-Grant Proposal