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EXPLORATIONS

A JOURNAL OF RESEARCH AND PUBLIC SERVICE
AT THE UNIVERSITY OF MAINE

Cover: Brian McLain of New Harbor, measuring a V-notched lobster; slide taken by Robert C. Bayer, University of Maine Professor of Animal and Veterinary Sciences.

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EXPLORATIONS

A JOURNAL OF RESEARCH AND PUBLIC SERVICE AT THE UNIVERSITY OF MAINE

Volume V Winter 1989 Number 2

April is Aquaculture Month

Guest Editorial, by Kathleen Lignell

The cold, clean waters of Maine's 3500-mile coastline provide an ideal setting for the development of aquaculture. Beginning with a research project on *The Culture of Resources in a Cold Water Environment* more than 15 years ago, the Sea-Grant College Program at the University of Maine has been instrumental in introducing shellfish aquaculture to the state. The initial growth studies on the European oyster sparked such immediate interest that several firms were started near the University's marine laboratory, the Ira C. Darling Center in Walpole.

While the oyster culture industry was making a dramatic debut in Maine, the slower-growing mussel culture industry was also getting its start at the Darling Center under the aegis of Sea-Grant's five-year *Cooperative Blue Mussel Project*, which began in 1975. This cooperative effort involved the University of Maine, the University of New Hampshire, the Maine Department of Marine Resources, and Abandoned Farm, Inc., the only commercial mussel culture firm in the United States at that time. With increased marketing efforts and the switch to on-bottom culture techniques in the 1970s, the culturing of mussels has gained a permanent place in Maine's developing aquaculture industry.

The aquaculture industry in Maine continues to be challenged by questions which researchers at the University's Center for Marine Studies seek to answer. By cooperating with the many individuals and organizations devoted to Maine aquaculture, the University will continue to play a vital role in the development of both the state's shellfish and finfish culture industries.

This April, UM's Sea-Grant College Program, in cooperation with Maine Aquaculture Association, Maine Department of Marine Resources, University of Maine's Cooperative Extension Service and its Fisheries and Aquaculture Research Group, will celebrate aquaculture's coming of age with a month-long series of events.

Highlights of this cooperative effort will include open houses at aquaculture hatcheries and facilities throughout the state; workshops and seminars to survey successful aquaculture ventures and discuss ways of resolving conflicts with traditional fisheries; videotape showings; an aquarium aquaculture conference for teachers sponsored by the University's Northeast Marine Education Program; exhibits at the State House in Augusta during Maine Science and Technology Week; and a cultured seafood reception at the University Club.

-- Kathleen Lignell
Sea Grant
Communications
Coordinator

Hospital Project Teams: Gaining Cooperation

by Mary Beth Pinto

To survive in today's competitive marketplace, hospitals are faced with the challenge of becoming more market-driven: they must identify and satisfy the needs of their customers in a manner superior to that of their competitors. Understanding the nature of this new focus on competition has become a matter of life or death for most hospitals because of the rapidly changing nature of the health care environment. In an effort to meet the changing needs of society, hospitals are continually developing new programs and services. For example, the increasing number of elderly in society has created a need for a variety of programs and services including Alzheimer's centers, adult day care centers, and home health care programs. Society's increasing concern about health and wellness has encouraged the development of sports medicine centers, cholesterol screening projects, lifestyle fitness centers, weight reduction programs, and breast evaluation centers.

The marketing function in hospitals has assumed a prominent role in the implementation of these new programs and services. Health care marketing personnel are responsible for targeting appropriate market segments, developing marketing strategies, creating promotional campaigns, and so on. To complete these tasks, the marketing function must work closely with personnel from other functional areas within the hospital (*e.g.*, physicians, nurses, ancillary staff, administration, and finance).

The difficulties hospitals often experience in achieving this cross-functional cooperation are daunting. Personnel from different functional areas approach problems with different goals, conflicting time frames, outlooks, and so forth. The inevitability of conflict often creates difficulty in reaching agreement on integrated programs of action and in the subsequent implementation of the programs and services. As a result, health care managers often look for better methods to facilitate the intrateam efficiency and cooperation of personnel. This article discusses the results of a recent research study intended to help hospital managers better understand the factors critical to achieving cross-functional cooperation and the successful implementation of programs and services.

Mary Beth Pinto is Assistant Professor of Marketing at the University of Maine. She earned her Ph.D. in Business from the Katz Graduate School of Business at the University of Pittsburg and her MBA with a concentration in Health Services Administration from the same institution. Her major research interests include cross-functional cooperation, marketing implementation, and health care marketing.

The Study

The research sample consisted of 131 hospitals from Pennsylvania, Ohio, and New York. The hospitals were chosen from the American Hospital Association Guide (1986). The sample set of hospitals met the following criteria: (1) Accreditated by the Joint Commission on Accreditation of Hospitals (JCAH); (2) Non-government, not-for-profit organization; (3) General, medical, and surgical hospital; (4) 200 - 500 bed size.

Questionnaires were mailed to 299 project team members from 72 hospitals that agreed to participate in the study. A total of 273 responses were received out of the starting sample of 299, indicating an overall response rate of 91.3 percent. Complete or partial survey returns were received from 62 project teams out of the starting sample of 72, indicating a project team response rate of 85 percent.

While a variety of projects were included in the sample, *e.g.*, breast evaluation center, cardiac care program, and back rehabilitation program, each project corresponded to the development of a new program or service in the hospital. The sample included project team members from a variety of functional areas, both clinical and non-clinical. The largest number of respondents, 58 (21.4 percent) project team members, were from the marketing area.

Research Framework

The study empirically examined the effects of four variables (superordinate goals, proximity, accessibility, and rules and procedures) on the attainment of cross-functional cooperation. Further, the effect of cross-functional cooperation on project implementation success was also examined. Figure 1 illustrates the research framework. The following section discusses each component of the research framework.

Superordinate Goals. One frequently overlooked type of goal that is important in the study of cross-functional cooperation is a superordinate goal. Muzafer Sherif originally introduced the notion of superordinate goals during his classic Robber's Cave Experiments in 1954, defining them as *goals which are urgent and compelling for all groups involved, but whose attainment requires the resources and efforts of more than one group* (Sherif 1962, p. 19). The essence of Sherif's theory is that competitive goals cause intergroup conflict, but superordinate goals give rise to intergroup cooperation. In this study, superordinate goals were defined as an overriding purpose, goal, or set of goals that is

shared by members of the project team. For example, one project team in this study that was developing a mobile breast evaluation center had the following superordinate goal: *to offer high quality, convenient, and accessible mammography services to the city and rural community.* Superordinate goals were hypothesized to have a significant positive effect on cross-functional cooperation.

Physical Proximity. Past research has suggested that the physical structure of an organization, *i.e.* the architectural design and physical placement of furnishings, can influence the working relationships of organizational members. In a small building or when a work group is clustered on the same floor, relationships tend to be more intimate since people are physically near each other. As people spread out along corridors, in different buildings or at different sites, interactions may become less frequent or less spontaneous. In these situations, it is harder for employees to interact with members of their own department and/or other departments. Therefore, in this research the physical proximity of project team members was hypothesized to have a significant positive effect on cross-functional cooperation.

Accessibility. Separate from the issue of physical proximity, additional factors can inhibit the amount of interaction that occurs between organizational members, *e.g.*, an individual's schedule, position in an organization, or out-of-office commitments. For example, consider a hospital setting in which an individual from the medical records department is physically located near an individual from the physical therapy department. These individuals, however, rarely interact because of different work schedules, varied duties and priorities, and commitment to their own agendas. These circumstances raise the additional issue of accessibility among members of an organization. In this research, accessibility was hypothesized to have a significant positive effect on cross-functional cooperation.

Rules and Procedures. Rules and Procedures are central to any discussion of cross-functional cooperation because they offer a means for integrating or coordinating activities, particularly those activities that cut across divisional or departmental lines. In this study, rules and procedures referred to the degree to which the activities or tasks of the project team were mandated or controlled. For example, were there established hospital rules and procedures governing who was assigned to specific projects or evaluating a project team's performance? In this research, rules and procedures were hypothesized to have a significant positive effect on cross-functional cooperation.

Cross-Functional Cooperation. Cross-functional cooperation is important in the development and implementation of projects because cooperation has been shown to promote productivity and help individuals perform more effectively. In this research, cross-functional cooperation was defined as the quality of different functional areas working together for the accomplishment of an organizational task. Cross-functional cooperation was hypothesized to have a significant positive effect on project success.

Project Success. In this study, project success was assessed by two components: task outcomes and psycho-social outcomes. Task outcomes referred to factors involved in the actual implementation of the project (time, schedule, and performance) and its subsequent performance. Psycho-social outcomes referred to whether or not the project team members considered the project implementation process to be worthwhile, satisfying, and productive. Previous research on project implementation success has tended to focus strictly on task outcomes, *i.e.*, assessing whether or not an implementation effort achieved what it set out to achieve. Little attention was directed at measuring the succcess or failure of the implementation *process.* Project team members' perception of the implementation process is important because if the process is considered enjoyable, rewarding, and devoid of interpersonal and technical problems, then team members will likely approach future projects with a positive attitude. Likewise, if the project implementation process is fraught with difficulties, project team members may be unwilling to become involved in future projects.

Findings

Several interesting findings surfaced from this research. First, all of the variables, *i.e.*, superordinate goals, proximity, accessibility, and rules and procedures, were found to be important predictors of cross-functional cooperation and subsequently, project success. For example, when project team members agreed on and were committed to the same superordinate goal(s), the team achieved more cooperation. Moreover, the project was more likely a success.

Second, when considering all of the constructs together, superordinate goals was the most powerful predictor of cross-functional cooperation. Consequently, it appears vital for managers to ensure that all project team members (1) *understand* a project's overall goal(s), (2) *agree on* and are *committed to* the same overall goal(s), (3) *utilize* the overall goal(s) to guide their activities.

The next finding pertained to the importance of accessibility and physical proximity in the achievement of cross-functional cooperation. Both of these constructs were important predictors of cooperation when examined independently, but when all of the constructs were considered together, accessibility seemed to be more important than the actual physical location of the project team members in the hospital. In other words, while it helps the project implementation effort when project team members are conveniently located near one another in the hospital, it is paramount that project team members make themselves accessible to each other through team meetings, telephone calls, and/or informal or unplanned discussions in the halls, over coffee, and/or at the copier machine.

Fourth, this research revealed that hospital project teams tend to create their own rules and procedures to facilitate the progress of a project, rather than relying on established hospitalwide rules and procedures. This finding may reflect the fact that many hospitals are relative newcomers to project-based work. It is only recently that they have begun to focus their efforts on a wide variety of new services and programs such as women's care centers and alcoholic treatment centers. Unlike other organizations that are regularly involved in new project development, (*e.g.*, manufacturing organizations), hospital project teams do not always have the luxury of relying on established rules and procedures to assist them with their tasks. Consequently, they are often required to create their own rules and procedures to facilitate the progress of the project.

Fifth, this research empirically confirmed the relationship between cross-functional cooperation and project success in terms of both task outcomes and psycho-social outcomes: cross-functional cooperation was found to be an important predictor of project success. A project team coordinator noted the importance of cross-functional cooperation in a follow-up interview:

> *The project team members are the only people who can make the project happen. Cooperation among them, no matter what department they are from, where they are located, or what their individual 'turf' issues are, is vital to the implementation of the project.*

Finally, the study verified that there are two equally important components to a project's success: task outcomes and psycho-social outcomes. Traditionally, the notion of project success was measured strictly in terms of whether or not the project team accomplished all the tasks that they set out to accomplish, and further, if the team completed the tasks on time and within budget. This study pointed to an additional, and equally important component of project success, psycho-social outcomes. Psycho-social outcomes are important because how a project team member feels about an implementation effort can affect the job that he or she does on the current project and can have long-term ramifications for his or her involvement in future projects.

Conclusions

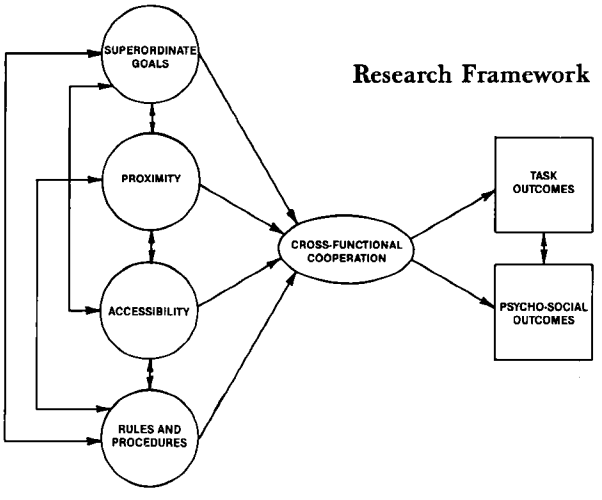
This research has important implications for hospital managers charged with developing and implementing new programs and services. The results demonstrated that when considering all of the constructs together, *superordinate goals and accessibility were the most important predictors of cooperation.* The construct, superordinate goals, in particular, was found to have a powerful effect on the attainment of cooperation, as well as task outcomes.

The implications of these findings for hospital project managers are highly significant. They suggest that hospital project managers need to develop and adopt an overriding purpose or set of goals for the project team in an effort to promote higher levels of interaction and cooperation. Further, it is vital that hospital project managers employ the necessary techniques or protocols to encourage continual accessibility among members from different functional areas. Finally, an additional issue pertains to the powerful role that psycho-social outcomes can have on members of a project team. It is imperative that hospital project managers understand the residual emotional baggage that team members can carry with them from one project experience to the next. If past experiences on projects have been psychologically or professionally damaging, it is unlikely that these personnel will perform their present or future project responsibilities to their full potential. Conversely, positive past experiences on projects would be expected to influence both present and future project-based work. Employing these guidelines should help hospital managers achieve greater levels of cross-functional cooperation as well as ultimate project success.

Reference

Sherif, M. (1962), "Intergroup Relations and Leadership: Introductory Statement," in *Intergroup Relations and Leadership*, M. Sherif, ed., New York, NY: John Wiley and Sons, 3-21.

Research Framework



In the following article, the Maine Lobster Institute is occasionally referred to as the MLI for short. Please note that this acronym usually refers to the Marine Law Institute, University of Maine School of Law. We apologize for any confusion this may create.

The Maine Lobster Institute:
Science and Industry Working Together

by Susan White

I think this may be the first time an actively fished area has been voluntarily closed by its fishermen for scientific research, exclaimed Dr. Robert Steneck as he described his project in the Damariscotta River Thread of Life region. Steneck, a lobster researcher at the University of Maine, worked with fishermen last summer to institute a *trap-free zone* in one of the most productive lobster fishing regions on the northeast coast.

About four dozen lobstermen voluntarily pulled their traps from this area for six weeks during the peak of last year's lobstering season so Steneck could conduct his research on lobster behavior. Arnold Gamage, president of the South Bristol Fishermen's Cooperative, many of whose members participated in Steneck's project, called this study *A breakthrough for a state where a lot of people think that fishermen won't work with scientists.* Preliminary findings indicated that when traps containing lobster bait were removed, the number of lobsters in the area decreased. This could have far-reaching implications for managing the fishery.

Steneck's *Thread of Life project* is just one of many research projects supported or initiated by the recently founded Maine Lobster Institute. The Maine Lobster Institute (MLI) is a cooperative program of research and education between the University of Maine and the lobster industry. Research priorities are determined and policy set for the Institute by a Board of Advisors made up of representatives from the three founding organizations (Maine Lobstermen's Association, Maine Pound Owners Association, and Maine Import/Export Lobster Dealers Association), the Maine Department of Marine Resources (DMR), the Massachusetts Lobstermen's Association, the Atlantic Offshore Fishermen's Association, and members of the Canadian lobster fishery. As Herb Hodgkins, President of the Maine Lobster Pound Association, points out, *Never before have so many individuals from as many factions of the industry been behind something for the good of the whole industry.*

Several events in the past ten years led up to the formation of the Institute. To begin with, the lobster industry, which has never functioned like a traditional industry, has finally become organized. With the steady growth of the Maine Lobstermen's Association, and the formation of the Maine Lobster Pound Association and the Maine Import/Export Lobster Dealers Association, communication has improved both within the organizations and among the three sectors. The Maine Fishermen's Forum, started in 1975 with support from the University's Sea-Grant College Program, also helped effect change in the industry. The Forum brought together fishermen from eastern and western Maine and provided a neutral place for them to talk to each other, discuss their concerns, disagree (many times in heated debates), and approach a better understanding of each others' problems.

Traditionally, the lobster industry has been known to be *strong-willed, independent, and opinionated.* In fact, many have said that the only thing that lobster fishermen, pound owners, and dealers could agree on is that they disagreed! However, when they all started talking to each other, they found they did agree on several points. The most basic one is that they all depend on the lobster for their livelihood and that they need each other for their businesses to survive.

Although lobster landings have remained relatively stable at about 20 million pounds in the last 16 years, the number of traps set has more than doubled. This, and other concerns, have led members of the industry to question how the lobster resource should be managed to ensure its future productivity. Even though few agree on ways to do it, they do agree that the lobster and its environment must be protected, conserved, and enhanced. They also stated that they would stand together to make recommendations on how to manage the resource if they knew what to recommend.

To develop effective management strategies, industry leaders felt that more scientific information was needed about the lobster and the impact that humans have on its environment. This concern is what led directly to the formation of the Maine Lobster Institute.

The MLI identifies problems and seeks solutions through quick response projects and longer-term research programs. Dr. Robert Bayer, lobster researcher at the University of Maine, stressed the importance of industry participation in research. *Through their existing knowledge of the resource and the lobster business overall, they multiply by many times our researchers' ability to identify the important questions, and generate much needed answers.*

The blue lobster experiment is a project that has received

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appreciable publicity lately. This past summer, Aquaculture Specialist Sam Chapman and his research associates at the University's Darling Marine Center released more than 6000 juvenile blue lobsters in the mid-coast area near Damariscove Island and in Pemaquid Harbor. If these lobsters survive for the six or seven years it takes for them to become harvestable size adults, lobstermen should see a lot more blue lobsters turning up in their traps in a few years.

In 1985, researchers at UMaine's Darling Center in Walpole began developing the technology to hatch and release lobsters. In this live culture system, algae are fed to brine shrimp which are then fed to lobsters. In the spring of 1986, the Cutler Marine Hatchery was established in Downeast Maine. Brian Beal, Environmental Resource Coordinator at the University of Maine at Machias, was instrumental in organizing this project. Using feeding techniques developed at the Darling Center, the Cutler Hatchery was the first privately-operated, fishermen-sponsored lobster rearing facility in the United States.

As Beal tells the story, *In 1985, the Maine Legislature passed a bill that allowed a portion of the Seed Lobster Fund to be used to create and support lobster hatcheries. As soon as the bill passed, lobstermen in Cutler organized themselves, and formed a Cutler Marine Hatchery Committee. They contacted Fred Reynolds, President of the University of Maine at Machias, and Fred allowed me the time to assist the folks in Cutler with their plans for a hatchery.*

I had never seen a lobster larva in my life except in an invertebrate zoology text. The first thing I did was to call Sam Chapman. During the summer of 1985, he had been working on a culture method for raising lobster larvae through their three planktonic stages with the ultimate purpose of releasing stage IV individuals into the wild. These were the same goals as the Cutler Hatchery.

A typical Maine lobstering scene.

Beal, with the help of the Committee, wrote a proposal to the DMR to establish a lobster hatchery in Cutler. Out of the five proposals submitted, the Cutler Hatchery project was the only one approved.

At the end of the first season, 20,000 stage IV lobsters had been released from Cutler. After improving the method of collecting larvae released from the female, they produced 85,000 individuals the second year. In 1988, they made further adjustments to the feeding system and released nearly 175,000 juvenile lobsters. As Beal asked *So, now comes the question: Do lobster hatcheries work? Do they function as a viable management tool that results in an increased harvest of lobsters for Maine fishermen?*

Between the Darling Center and the Cutler Hatchery, thousands of lobsters have been hatched, raised, and released in coastal Maine waters over the last three years. Lobstermen provide partial support for the Cutler Hatchery through the state-administered Seed Lobster Fund. Both the state and lobstermen now want to determine whether lobster hatcheries are effective before they expand the program. According to Dr. Irving Kornfield, of the University of Maine's Center for Marine Studies, if three percent of the lobsters released by hatcheries survive until they are of legal size, it is likely that hatcheries will be considered economically feasible for the fishery.

To determine whether hatcheries are effective, lobsters must be marked in some way so that researchers will know how many hatchery-raised animals are trapped. *Color-coded blue lobsters* were chosen as a way to differentiate those that are hatchery-raised from those that develop naturally in the wild. Blue lobsters are ideal because they are very rare (occurring one in four million) and they are easy to spot. However, the question still remains whether blue lobsters survive as well as normal ones.

In addition to the *baby blues* released last summer, Chapman is rearing several hundred juvenile lobsters that resulted from a number of crosses, such as a blue male mated with a normal female and a blue male mated with a bluish-normal female. This will help researchers determine the color ratio of blue or bluish lobsters to normal greenish-brown ones, and to establish the genetics of lobster coloration. One goal of the project is to develop a broodstock of three or four dozen pure, cobalt blue females which will supply the thousands of juveniles needed for future work.

For the next stage of this research, Chapman and his associates will sample the sites where the blue lobsters were released, try new release sites along the coast, and *develop more color-coded lines from rare yellow and red lobsters.*

Another MLI-supported project is the *Inshore/Offshore Lobster Genetics Study*, funded primarily through the University of Maine Sea-Grant College Program and conducted by Dr. Irving Kornfield. Through his research, Kornfield will determine the extent to which offshore lobster populations con-

tribute to inshore production and larval recruitment. Preliminary findings have shown that inshore lobsters in the Gulf of Maine are not genetically different (they do not possess distinct mitochondrial DNA's) from offshore lobsters. However, there may be genetic differences between inshore and offshore females as well as differences between inshore and offshore males. By expanding this study to include an examination of variations in nuclear DNA between male and female lobsters in inshore and offshore populations, researchers will be able to determine whether offshore male lobsters are contributing to inshore production through movement.

An important benefit obtained from using molecular biology techniques to study lobster populations is that a new class of genetic markers will be identified. These markers could be used for tagging juvenile lobsters produced in hatcheries to find out how many of them survive after they are released into the ocean. This will help hatcheries, such as the one in Cutler, evaluate more accurately the success of their programs.

Another study conducted by Dr. Robert Steneck has demonstrated that lobsters are very discriminating creatures in choosing a place to live. According to Steneck, lobsters decide where to live depending on their size and the bottom characteristics of the habitat. In his main study site at the mouth of the Damariscotta River, Steneck discovered that there is a close relationship between the number of shelter spaces in a given area and the number of lobsters living there. Also, the size of the spaces is directly related to the size of the lobsters that inhabit them.

Small lobsters [less than 1½" carapace length (CL)], called Early Benthic Phase lobsters, live mainly in shallow waters where there is a small rock or cobble bottom. These lobsters depend on the small shelters created between cobbles which protect them from predators. Adolescent Phase lobsters (1½" to 3½" CL) live in areas with larger boulders, remain under cover during most of the day and go foraging at night. Reproductive size (greater than 3½" CL) adult lobsters appear to be less shelter-dependent than the other two phases. They usually inhabit deeper water and can migrate long distances.

Steneck points out that shelter space can be limited for Adolescent Phase lobsters even though empty spaces of the right size are available. This is because these lobsters are highly competitive and aggressive. When shelters are too close together or face each other, lobsters compete, with dominant lobsters forcing subordinate individuals from their territory. Thus, the number of empty shelter sites depends on their spacing as well as on the aggressiveness of the lobsters in the area.

Where lobsters live, their population densities, and food availability are factors which contribute to the carrying capacity of the lobster habitat. Over the past several years, Steneck has been studying how these factors affect the carrying capacity, so that future studies can determine the impact of human activities on it.

Next summer, Steneck is proposing, with support from Sea-Grant and the Maine Lobster Institute, to study the impacts of dragging (a method of harvesting scallops, *etc.*) on lobster populations and the carrying capacity of their habitats. He will again use the *Thread of Life* area for his study site where lobsters and shelter spaces are most abundant, and the population is stable. Questions he will address include: *Does dragging kill lobsters in areas where they are abundant? What impact does dragging have on their food? What is the impact of dragging on bottom characteristics and other factors which determine the carrying capacity?*

Another problem identified by the MLI has led to a study of ghost traps. This project could help answer the question that has been plaguing lobstermen, researchers and resource managers for decades: *Do lost traps continue to trap lobsters which eventually starve to death or can the lobsters escape?*

Dr. Robert Bayer, of the University of Maine's Animal and Veterinary Sciences Department, along with graduate student George Kupelian, and fishermen from Islesford, have designed an experiment to find out just what happens in the watery depths from a lobster's point of view. Last summer, they installed an underwater video surveillance system off the Cranberry Islands. The system, developed by Mike Manuzza, graduate student in Agricultural Engineering, and Kupelian, monitors lobster activity in and around a series of traps.

The experiment was designed to determine whether lobsters can escape from traps once they're inside, as well as answer other research questions about lobster behavior. At the end of the study, the video footage will be edited and condensed into a 20-minute segment showing lobster behavior that researchers found was the most interesting and informative.

After observing hours of video footage, Bayer and Kupelian agree that it appears that lobsters can get out of traps, but only from the *kitchen or forward compartment.* Also, it seems more likely that once lobsters are inside the kitchen, there is a greater possibility that they will wander into the parlor section than leave the trap. According to researchers, *Once the lobsters in their study entered the parlor area, no one got out.*

Video observations showed that when lobsters first discovered they were trapped, they probed around and tried very hard to escape. However, after a while they gave up and settled down in the corners of the trap. Another interesting observation was that lobsters entered traps even after the bait was gone.

An offshoot of this project is another video system, designed by Kupelian, which will be implemented at Conary Cove Lobster Pound in Deer Isle. The purpose of this study is to observe lobster behavior over a 24-hour period and to study their feeding habits. If affordable underwater video systems can be developed, pound owners could use them to determine when pounded lobsters have eaten and to monitor the lobsters' health.

Both of these studies are being conducted by the Fisheries and Aquaculture Research Group (FARG) of the Maine Agricultural Experiment Station, with help from the MLI in locating the fishermen who are participating in the project. The equipment was funded through the University's Center for Marine Studies.

Lobster Band Testing was another problem-solving project suggested by the MLI. For years, keeping bands on lobster claws has been a problem for the lobster industry, especially for pound owners. Dr. John Riley, along with other researchers in the Agricultural Engineering Department, tested existing lobster claw bands for elasticity and deterioration, and are working on a better banding system. The project was funded by the Maine Agricultural Experiment Station through its Fisheries and Aquaculture Research Group.

The Maine Lobster Institute has also conducted workshops and conferences throughout New England and the Maritime Provinces. At the annual Fishermen's Forum held in March in Rockland, the Institute held four workshops in which the University's research faculty shared the results of their work. The MLI also co-sponsored (with the Maine Lobster Pound Association and the Maine Import/Export Lobster Dealers Association) a Lobster Dealers and Pound Operators Workshop held last April.

Through its Information and Public Education Program, the MLI publishes a quarterly **Lobster Bulletin** which covers current research and other topics of interest to the lobster industry. The book **Lobsters Inside-Out**, written by Dr. Robert Bayer and his wife Juanita, was initially funded through the Sea-Grant College Program. However, the book is now being distributed by the MLI and is in bookstores throughout Maine. According to Bayer, the book *answers the simplest questions in the simplest fashion. Everyone will learn from this handy guide for teaching both children and adults about Maine's most popular crustacean.*

A Lobster in Every Pot: More Than Just a Cookbook, is also being coordinated by the Institute. Representing the coast of Maine from Kittery Point to Beals Island, sixteen women of the lobster industry have joined forces with the MLI to produce the book. It will contain not only recipes of the many delicious ways to prepare lobster, but also interesting and humorous lobster-related anecdotes, photographs and illustrations. In addition, interspersed throughout the book will be facts about the history of lobstering, lobster biology and behavior, harvesting, storage, handling, shipping, economic importance, and nutritional value. In effect, the book will attempt to answer *everything you ever wanted to know about lobsters — and more!* Proceeds from the book will be used to support the research and educational programs of the Institute.

The Maine Lobster Institute is definitely off and running. If the success of its first year of operation is any indication of the future, it appears that the Institute will be around for many years to come. As Ed Blackmore, President of the Maine Lobstermen's Association stated, *The idea behind the Institute is to get more people involved in lobster problem-solving and to keep them talking to one another. We all need each other, and there's plenty for all of us to do if we expect to continue to have a viable lobster industry in Maine.*

Lobsterpot of gold?

It has been 20 years since Garrett Hardin published his landmark article the Tragedy of the Commons. During that time, the theory has been elevated to the status of scientific law. The idea that resources owned in common are subjected to unusual abuses seems obvious. In the early 1970s, some anthropologists noted that the theory appeared to work in some societies, but not in others. Scholars in other disciplines ranging from ecology to psychology also debated the dilemma of the commons. Dr. Acheson's interest in the theory stems from his years at the fisheries service. In 1983, he teamed up with Dr. Bonnie McCay of Rutgers to sponsor a symposium on common property resources at the International Congress of Anthropological and Ethnological Sciences held in Quebec City. They organized another in 1984 in Toronto, and with the support of the University of Maine and Rutgers sea-grant programs, a workshop was held in the summer of 1984 at the Darling Center, the University of Maine's marine laboratory. The result of this effort is The Question of the Commons, *published in 1987 by the University of Arizona Press. The 475 page volume contains articles by 18 authors (primarily anthropologists) who have worked in various parts of the world on questions of resource management. The book puts the theory of the commons in cross-cultural perspective. It demonstrates that Hardin's assertions about resources and property rights hold only in some cases. Its larger role is to push forward this body of theory which has become a keystone for resource managers.*

The Theory of Common Property Resources: Scientific Law or Myth?

by James M. Acheson

During the last half of the Twentieth Century, we are becoming increasingly aware of the damage that human beings have done to their environment. Newspapers in the United States routinely feature stories on overfishing, acid rain, toxic waste seepage, nuclear reactor safety, air pollution, and problems with the ozone layer. Developing countries have serious problems with soil erosion, depletion of fish and animal resources, and deforestation. In developing countries, resource depletion results in health problems and death. Evidence is quickly mounting that people in industrialized nations are not immune.

The most commonly accepted explanation for the overexploitation of resources is the theory of Common Property Resources, which has become one of the most influential theories guiding the management of resource management policy in the world today. Essentially, the theory argues that publicly owned resources are inevitably subject to overexploitation. Such *common property resources are owned by no one*, and thus, it is no single person's interest to protect them. Moreover, the people using common property resources are caught in a situation in which it is only logical that they increase their exploitive efforts without limit. Why should one fisherman, for example, conserve the fish stocks when the fish he does not take will simply be caught by someone else within a few hours? Under these circumstances a fisherman is only being sensible to catch all the fish possible as quickly as possible.

Resources owned privately are not subjected to this kind of abuse. After all, it is in an owner's best interest to avoid damaging his or her own property.

This theory attained international prominence due to the work of Garrett Hardin whose article in **Science** entitled *The Tragedy of the Commons* received widespread attention and some notoriety. Hardin, who was very interested in the population problem, argued that untrammelled freedom to produce children would result in disaster for the world. The parable he used, however, was that of a group of shepherds using a common pasture. A first, the herders do no damage to the pasture, but as they add more animals, overgrazing occurs. However, as Hardin points out, it is rational for shepherds to continue to add animals to herds. The reason is that each shepherd gains the full benefit of each sheep added, while the costs are born by all of the shepherds jointly. The gain in meat and wool belongs to the individual shepherd, but each does not pay for the pasture eaten by his or her sheep. The result

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is depletion of the pasture and erosion. Nevertheless, when resources are limited and held in common it is rational for each individual to overexploit them even though this behavior ultimately results in tragedy for the group. *Each man is locked into a system that compels him to increase his (share) without limit—in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all*; (Hardin 1968: 1244).

The solution to all tragedies of the commons is repressive governmental action. Hardin concludes that we cannot ask people voluntarily to restrain their use of any commons: *coercion is necessary. The coercion should be mutually agreed upon* (1968: 1247), *but it need not be just* (1977: 275). *The alternative of the commons is too horrifying to contemplate. Injustice is preferable to total ruin.*

Hardin sees world population as a common property issue. The costs of breeding do not ostensibly fall on those who have additional children, but are passed on to the society as a whole (Hardin 1968: 1346). Hardin sees only famine and tragedy for developing countries because he does not believe that the governments of those countries can develop effective curbs on population growth. He has advocated abolishing foreign aid and not establishing an international food bank. He has also advocated strict immigration controls, denigrated the *Green Revolution* which would raise agricultural output in those countries, and called for restrictions on immigration. All of the strategies which Hardin opposes would, in his view, merely pass on the costs of overpopulation to rich countries and future generations (Hardin 1977: 262-277). Hardin's willingness to let the people of developing countries starve caused no minor furor. I suspect that the interest in Hardin's work is due in great part to the fact that he articulated solutions to problems that others had at least thought about.

Although Hardin was strongly interested in overpopulation, his theory has been applied primarily in resource management. Hardin is not alone in suggesting that resources that lack a private owner are prone to problems. Several resource economists have suggested the same thing. Their prescriptions for a solution differ markedly. Hardin sees authoritarian governmental action as the answer to common property problems. The economists argue that if it is a lack of a sole owner that causes the problem, the solution is to establish ownership rights. As a result, they have proposed to manage commonly owned resources through such policies as taxation, limited entry legislation, licensing, gear restrictions, quota permits and other strategies that simulate property rights (McCay and Acheson 1987: 5-6).

The theory of Common Property Resources has been soundly criticized by a number of scholars on a variety of grounds (Acheson 1988). None of these critiques attacks what I see as the most serious weaknesses in the theory—namely that it rests on very questionable assumptions and is highly culture-bound. The theory does not hold true crossculturally and is not even applicable to all situations in the United States.

Tragedies of the commons certainly do exist. There are many cases, particularly in industrialized countries, where open access resources have been overexploited. The Gulf of Maine was overfished by fleets of factory ships from European countries in the 1960s and the stocks of herring, cod, and haddock have not recovered yet. The extermination of the massive buffalo herds in the 1860s and 1870s affords still another example. However, the *conditions that produce such tragedies are not universal* by any means.

Behind the theory of common property resources developed by both Hardin and the economists run four presuppositions:

1. The users of common property resources are individualistic profit-maximizers, who are driven by economic goals to overexploit the resources on which their livelihood depends despite the best interests of the society as a whole.
2. The users of these resources have the technical capacity to exceed the maximum rate of renewal of the resources. (That is, any resource has a natural rate at which it renews itself, and the definition of the problem implies that the users of these resources are able to exceed that renewal rate, and are motivated to do so.)
3. Those using common property resources and their communities cannot and will not erect institutions to protect those resources.
4. Collectively owned resources can only be protected by the institution of private property or government action.

As we shall see, these presuppositions hold true only under certain conditions or are wrong.

Conservation Institutions Around the World

One of the most important contributions of anthropologists to the study of property rights has been to demonstrate that in large numbers of societies people have generated effective institutions to limit exploitation rates. The near universality of such institutions needs to be stressed. There are very few societies or even local level communities where there are no restrictions on the use of resources. In writing about fisheries, Fikret Berkes says *These assets are almost never truly open-access* (Berkes 1985: 204). The same is true for pasture, farmland, forests, *etc.* Contrary to what the common property model assumes, the institution of private property and government control are not the only mechanisms to conserve resources. There is a middle way: rules developed at the local level. The wide variety of such conservation institutions is important to note.

Private property arrangements are very common in peasant and industrialized societies. But communally owned property is also very common and exists in a wide variety of forms. Communally owned property is especially common in tribal societies in which there is little personal property, and land is held typically in some kind of group tenure, usually by kinship units of one kind or another (Erasmus 1977: 79). In peasant societies, communal property is also relatively common. In societies ranging from Japan to the Andes and Europe some areas and forests in villages and municipalities have been owned communally, and access to that property has been limited. In Europe the co-owners of the common grazing areas can use them only during certain hours and during certain seasons. If there is a shortage of space or forage, then each owner is assigned a quota, called *stinting.*

In the common property literature, it is assumed that oceans are always common property and open to all comers. This is not true. In large numbers of societies around the world, ocean areas and fisheries are owned. In many fishing societies, rights to fish in particular areas are held by individuals. This is true among the Indian tribes of the northwest coast, the lobster fishery of the Yucatan Peninsula and some Swedish coastal fisheries. In even more societies, fishing rights are owned by groups. In the Maine lobster fishery, fishermen from each harbor jointly own lobster fishing rights in the waters adjacent to their own harbors (Acheson 1972, 1988). In the Inland Sea of Japan, peasant villages possess exclusive fishing rights (Ruddle 1985; 157 ff). Group rights are held by the raft fishermen of Brazil (Forman 1970), in the beach seining fishery in Sri Lanka (Alexander 1980: 102-03), and all throughout Oceania (Johannes 1978: 350-351).

Property rights are not the only mechanisms used to control access to ocean resources. In many societies, there are informal quotas. In one New Jersey community, the cooperative manager sets a quota daily based on the amount of fish he can sell at a reasonable price. The catches of all boats are pooled and the proceeds are shared jointly by all boats regardless of what they actually caught. This reduces incentives to overfish (McCay 1980). Another conservation device is limits placed on new, and more efficient, technology. In the Chesapeake oyster fishery, boats must be propelled by sail and only hand tongs can be used to take oysters.

Fishermen in many preindustrial societies have also developed mechanisms to protect marine resources. In the Pacific, R.E. Johannes has stated that *(The islanders) devised and practiced almost every basic form of modern marine fisheries conservation measure centuries ago, long before the need for marine conservation was even recognized in western countries* (1982: 259). These conservation methods included size limitations, limits on access to the fishery, seasonal restrictions to protect the spawning fish, quotas, closed areas, catch limits, and gear restrictions (Johannes 1978 352-54; Klee 1980: 253-255).

Property Rights and Conservation

One of the tenets of the Theory of Common Property Resources is that private property rights conserve. Is this true? There is a good deal of disagreement on this point, and even less hard evidence. Hardin and the economists have stated that private property rights do conserve, but they have appealed more to logic than data.

In some societies operating under certain circumstances, property rights do seem to conserve. Johannes, for example, argues strongly that property rights over reefs and lagoons control access and lower fishing pressure. In this regard, he says: *Marine tenure systems in Oceania are designed to enable the islanders to control the types and degrees of exploitation of their waters and thereby protect them against impoverishment. The mechanism is simple. Where fishing rights exist it is clearly to the advantage of those who control them to fish in moderation, for this ensures the future productivity of their fishing grounds* (Johannes 1977: 122). The forests of Germany have been managed very well for centuries by strictly controlling access. In the lobster fishery of Maine, there is strong quantitative evidence that the territorial system cuts exploitive effort, which results in a larger stock of lobsters and a larger breeding stock (Acheson 1988: Appendix 1). Another example is afforded by the Cree, who have a system of family owned trapping territories. Berkes argues that *the trap line system is good management* because families that conserve the animals on their lines and leave an adequate breeding stock gain in the future in increased catches (1981: 169).

It is also important to note that in all of these cases, communally owned property is involved. It is not just privately owned property that can conserve resources. Resources owned by groups or communities have owners too, and those co-owners can be very effective conservators in some cases.

In other well-known instances, private property has gone hand in hand with irresponsible use of resources (Gilles and Jamtgaard 1982). In the United States, the dust bowl conditions of the 1930s were caused by irresponsible soil management practices, and students of Maine history are aware that the 19th Century saw lumber barons run through whole counties of pine and spruce forests with no thought of the future. In these cases, private owners were less responsible than the users of communally owned property have been.

In still other instances, it has been argued that private property rights have actually increased exploitive effort on natural resources. For example, throughout New Guinea the object of owning property is to give it away with prestige and power in mind. James Carrier points out that in the Ponam area the object of fishing was *not to accumulate fish, but to be as generous as possible with one's own and one's lineage property* (1987). Private ownership rights here do not automatically conserve in stark contrast to the theory.

Local Level and Government Relations

In the absence of private property, according to the theory, abuse of resources is inevitable unless the government takes over management activities. A look at the ethnography shows this to be a very simplistic and inaccurate view of the situation.

Perhaps most important, contrary to Hardin's assertion, open access resources are so rare as to be almost nonexistent. The resources of the world are either managed by governments or by local level communities or a combination of both. The relationships between local level communities with their resource management devices and the governments of nation-states are complicated and highly variable.

Local level management systems exist in great numbers and in many different variations. In some out-of-the-way places in developing countries, where the power of the central government is rarely felt, local people manage their own resources. But it should be pointed out that these situations are becoming increasingly rare as modernization and communications expand to influence even the most isolated parts of the globe. More often, these local level management systems are influenced to one degree or another by government. They are what anthropologist F.G. Bailey (1969: 144ff) has called encapsulated systems (one system inside another). They are not truly independent political systems.

Sometimes management is practiced by the national government with little or no local involvement. Oftentimes, anthropologists have discovered, government intervention into resource management is far less effective than Hardin would have us believe. In west Malaya, for example, the rules the central government set up, which were not adequately enforced, contributed to massive overfishing by a modernized trawler fleet with subsequent hardship for owners of small, in-shore vessels (Anderson 1987: 329-30). A small war resulted between these two fleets. Still another example is afforded by the New England groundfishery. In the late 1970s the Federal Government attempted to regulate this fishery by imposing quotas. When the quotas were enforced, it was the largest and best equipped boats that caught the largest share of the fish. If others were to remain in business, they had to get bigger and better equipped boats. The result of this attempt at management was *a quota race—increased competition for the fish and a fleet far more capable of overfishing than the one that had existed previously* (Acheson 1984: 325-327).

In the case of fisheries, the failures of government action appear to be due to the fact that management by government typically attempts to simulate property rights through such management schemes as quotas, licenses, gear and seasonal regulations, *etc.* The problem is that such simulated property rights set up *disharmonious incentives* (Townsend and Wilson 1987: 319). That is, no one has any incentive to maintain the rules and all the motivation to cheat or innovate their way around them. Rules limiting the length of a boat can be circumvented by building faster boats or putting larger engines in them. Quotas can be avoided by selling fish caught over the limit to other boats, or by misreporting catches. Townsend and Wilson believe that fisheries management would be furthered if managers abandoned *the property model, which does not have the beneficial effects envisioned by the common property economists, and imposes expensive and basically pointless regulations on the fishery.* They recommend developing policies which would reinforce the normal tendency of fishermen to switch away from declining stocks to more abundant species (Townsend and Wilson 1987: 323).

There is still another possibility not mentioned by Hardin or the economists interested in common property issues: the idea that the government and local level communities could jointly manage resources. Yet in a surprising number of cases co-management does exist. The fisheries of Iceland, for example, are managed exclusively by the Icelandic government, but government policy is strongly influenced by the fishermen and others in the fishing industry (Durrenberger and Palsson 1987: 372). Another example is afforded by the salmon fishing industry of British Columbia. The Province has a good many regulations on salmon fishing, including a limitation on licenses. Local communities have successfully lobbied the Provincial government for regulations they believed in the best interests of the stocks. They have also passed and enforced their own local regulations. One Indian community pressured the Provincial government to close an area to fishing to protect the stocks; it also prohibited fishing in its own local area for a number of years (Pinkerton 1987: 364-65). Still another example is afforded by the lobster industry in Maine. In the past year, the Maine Lobstermen's Association, and State and Federal Agencies and the Legislature have negotiated a far-reaching set of regulations which gives both the fishermen and the agencies the kinds of regulations both think are essential to preserve the lobster stocks.

In some instances local communities and governments exist in an antagonistic relationship, one in which they are ceaselessly trying to wrest control of the resource away from each other. But in others, local groupings have not only accommodated the government, but have been able to use the power of the central government for their own purposes. When an Irish community was offered control over its own salmon fishery, it refused reasoning that it could not develop its own management and enforcement system without monumental conflict. *The river would run red with blood*, they said. Instead, community members preferred to fish for salmon illegally (the finest local sport), and forced the government officers to do the onerous job of enforcing the conservation laws. The Irish situation is not unique (Taylor 1987: 295ff). Enforcement of norms is always difficult. It is not an accident that in most advanced societies, norms are enforced by paid moral guidelines: the police.

In stark contrast to what is suggested by the theory of common property resources, local level management has proven so effective in so many cases and management by governments has proven so costly, that there are increasing calls for community level management of natural resources. To begin to get the benefits of community level management means that governmental managers must stop thinking of resource users as bent on putting themselves out of business (they are well indoctrinated in the tragedy of the commons) and start

thinking of mechanisms to buttress community level rule structures if they are effective in conserving resources (Berkes 1987: 22). (This is not to argue that all resource management can be handled effectively at the local level. In some cases, local level management institutions do not exist and cannot be developed).

The Political Economy of Resource Depletion

The common property model sees the overexploitation of natural resources as rooted in the property system. This is an oversimplification and ignores the role of other socioeconomic factors. Many of the problems which are laid at the door of open access property rights are more closely related to issues of population growth, industrialization, and the expansion of international markets.

Any given area on earth has a maximum amount of renewable resources that can be harvested without damaging the reproductive capacity of the animals and plants that inhabit the landscape. That amount is variously called the *replacement rate* or the *maximum sustainable yield* or *biological maximum*. Societies with small populations operating with a low level of technology and local markets will rarely overexploit resources. The amounts of food and resources they need to sustain themselves do not approach the replacement rate, and they have no need to extract large amounts to sell to international markets. Even if they wanted to produce more, they could not because of technological limitations. If populations are increased, the rate of output rises and can exceed the replacement rate, even if the technology remains at a low level. If markets expand, perhaps because it becomes possible to sell goods on the international market, and the technology increases as well, it may also be possible to exceed the natural replacement rate of resources, even if populations remain small. If populations expand, along with markets and technology, a tragedy may be inevitable in spite of any property rights system involved. Many social scientists are convinced that this combination of factors has led to many resource problems in diverse places in the world. The problems in the Sahel area of Africa have been blamed on the irresponsible expansion of cattle herds which have damaged the range. This is due to an expansion of the human population in combination with increased markets for cattle (Franke and Chasin 1980: 121ff). Another example is afforded by Central America where the number of cattle has increased 80 percent in 20 years due to the high profits that can be gained exporting beef to the United States (DeWalt 1983: 21-22).

Expansion of markets has led to problems for other resources as well. In the past 20 years, Panamanian shrimp stocks have begun to be overfished due to the opening of the U.S market which has stimulated use of efficient large vessels and modern packing technology. In Micronesia, commercialization of fisheries not only led to overexploitation, but even worse, the decline in traditional resource management systems (Johannes 1978: 356-7). In both the case of Panama and Micronesia, population increases also were a contributing factor in resource decline.

If this point of view is accurate, overpopulation in combination with technological advance and the opening of international markets are the primary causes of resource depletion, not flaws in property rights systems.

Modifying the Theory

Given the work of anthropologists, the theory of common property resources needs to be extended and modified in several ways. Virtually all of the basic axioms on which the model is based are flawed in one way or another. Let us examine those axioms in view of what anthropologists have learned about resource use and conservation in our own and other cultures.

First, the common property model assumes that in the absence of private property rights, individuals are driven to achieve economic goals by overexploiting the resources on which their livelihood depends. In reality, individual rights are subordinate to community rights. In virtually all societies, there are controls on access to resources and various kinds of rules and institutional arrangements to limit exploitive activities. Individuals are not allowed to seek their short-term goals at the expense of the society. In many industrialized or overpopulated societies, tragedies of the commons do exist, but this is not due to the fact that societies generally abandon their resources to anyone who wants to exploit them. Perhaps this axiom can best be phrased: *In most societies, individual rights to resources are subordinate to those of the community.* In a minority of instances individuals are free to overexploit essential resources.

The second assumption of the common property theorists is that those using such resources have the technical capacity to overexploit them and the motivation to do so. In fact, in many technologically undeveloped societies, particularly those with small populations and no access to large-scale markets, people have neither the ability nor the motive to overexploit natural resources. It is very difficult, for example, for a small hunting and gathering band to wipe out a clam population digging them with their bare hands, and they would have little reason to do so since they cannot sell them and can only eat so many themselves. This axiom might be rephrased: *Natural resources are more likely to be overexploited in technologically advanced societies, with large populations where resources are sold in large international markets.*

The third presumption of the common property theorists is that individuals using common property resources can not and will not erect effective institutions to protect those resources. As we have seen, most societies have generated some kind of institutions to control exploitive efforts ranging all the way from various kinds of controls on access, to limits on types of exploitive gear that can be used. In some societies, both

primitive and modern, a good many such mechanisms have been developed. Private property is one such mechanism, but another that is very commonly used is community or joint ownership arrangements. (Again, this is different than open access.) Once some kind of property rights are established, other rules restricting the use of resources may be established. While there is some debate on the effectiveness of property rights in conserving resources, there is evidence from a few studies that they do help to conserve (*e.g.* the Maine lobster industry).

Fourth, the common property theorists assume that collectively owned resources can only be managed by either the institution of private property (the economist's solution) or by governmental action (Hardin's solution). Both private property and the government can conserve resources under some conditions, but private property does not always result in conservation, and government management is not always effective. More importantly, this axiom ignores the existence of a wide range of mechanisms that can conserve resources, including a large number of norms and institutions erected at the local level. In addition, many cases of co-management exist, in which local level and government units work jointly to manage the resource. This presupposition can be restated: *resources can be managed by privatization, government action, a wide variety of local level institutions or co-management.* None of these solutions is effective in every case.

There are strong managerial implications in some of these findings, especially the fourth axiom. In the words of Jere Gilles, *For years people were saying that you essentially had to choose between this public or private approach to resources; otherwise you would go to hell in a handbasket. There is a middle way that has been overlooked* (Jarmul 1987: 3). One type of intermediate solution is the many local level management strategies that have been evolved by hundreds of societies over the course of centuries. Does this mean that the solution to resource problems of the world is to hand over control of resources to the grass roots or small communites? In some cases that might work. But the power of national states, multinational corporations, *etc.*, is such that local communities in many areas could not maintain their own management regimes for long. A better solution in most cases would be co-management in which the traditional norms and strategies of local communities are reinforced by officials of nation-states in management plans.

REFERENCES CITED

Acheson, James
1972 The Territories of the Lobstermen. Natural History 81:60-69.
1984 Government Regulation and Exploitive Capacity: The Case of the New England Groundfishery. Human Organization 43(4):319-329.
1988 The Lobster Gangs of Maine. University Press of New England.

Alexander, Paul
1980 Sea Tenure of Southern Sri Lanka. In Maritime Adaptations: Essays on Contemporary Communities. Pittsburgh: U of Pittsburgh Press.

Anderson, Eugene N.
1987 A Malaysian Tragedy of the Commons. In The Question of the Commons. Eds. Bonnie McCay and James Acheson. Tucson: University of Arizona Press.

Bailey, F. G.
1969 Strategems and Spoils: The Social Anthropology of Politics. New York: Schocken.

Berkes, Fikret
1981 The Role of Self-regulation in Living Resource Management in the North. In Renewable Resources and the Economy of the North. MMR Freeman Ed. Ottawa: ACUNS/MAB.
1985 Fishermen and the "Tragedy of the Commons" Environmental Conservation 12(5): 199-205.
1987 Common Property Resource Management and Cree Indian Fisheries in Subarctic Canada. In The Question of the Commons, Bonnie J. McCay and James Acheson, eds. Tucson: University of Arizona Press.

Carrier, James
1987 Marine Tenure and Conservation in Papua New Guinea. In The Question of the Commons. Eds. Bonnie McCay and James Acheson. Tucson: University of Arizona Press.

DeWalt, Billie R.
1983 The Cattle Are Eating the Forest. Bulletin of the Atomic Scientists 39(1): 18-23.

Durrenberger, Paul, and Gisli Palsson
1987 "The Grassroots" and the State: Resource Management in Icelandic Fishing. In The Question of the Commons. Eds. Bonnie McCay and James Acheson. Tucson: University of Arizona Press.

Erasmus, Charles J.
1977 In Search of the Common Good: Utopian Experiments Past and Future. London: Collier Macmillian Publishers. 424 pp.

Forman, Shepard
1970 The Raft Fishermen. Bloomington: Indiana U.P.

Franke, Richard W. and Barbara H. Chasin
1980 Seeds of Famine: Ecological Destruction and the Development Dilemma in the West African Sahel. Montclair, N.J.: Allenheld, Osmun.

Gilles, Jere Lee and Keith Jamtgaard
1982 Overgrazing in Pastoral Areas: The Commons Reconsidered. Nomadic Peoples No. 10:1-10.

Hardin, Garrett
1968 The Tragedy of the Commons. Science 162: 1243-1248
1977 Living on a Lifeboat. In Managing the Commons. Eds. Garrett Hardin and John Baden. pp. 275-276.

Hardin, Garrett and John Baden

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What do Seedless Watermelons and Triploid Oysters have in Common?

by Mary Lee

"The Oyster Lover" found in *The Illustrious Oyster Illustrated* by Robert H. Robinson. Copyright 1983 Sussex Prints Inc., Georgetown, DE.

Would you eat a reproductively sterile oyster? The answer may be *yes* if you were to sample the local fare at a sushi bar in downtown Seattle. Here you might find yourself eating sterile triploid Pacific oysters. Unless someone told you, you wouldn't realize your oysters were triploids or that your oysters weren't completely sterile. But if it were summer and you had your choice between a plateful of diploids or the triploids before you, you'd probably choose the sweeter-tasting, firmer-fleshed triploids.

If you were to ask for triploid American oysters at a sushi bar on the east coast or triploid Sydney rock oysters in Australia your request would probably be met with blank stares. Although triploidy was first induced in shellfish ten years ago, it has only found commercial application in the Pacific oyster. The future utility of triploidy will depend on shellfish species, geographic location, and the health and direction of the shellfish industries.

The American oyster (*Crassostrea virginica*) has a reproductive capacity so robust that it strains credibility. Fully grown females have been known to release 100,000,000 eggs in one spawning. For many, a statistic like this doesn't have much impact. A better way to grasp a number of this magnitude is with a comparison that invokes everyday life. For instance, there are approximately a million seconds in 12 days. So, it would take about 3 years and 2 months for 100 million seconds to tick away.

Given a new feel for the magnitude of this number one may ask why an oyster would bother to spend so much energy producing so many gametes. The answer lies in the species' reproductive strategy. Spawning American oysters simultaneously broadcast their eggs and sperm into the surrounding water. Many gametes are necessary to ensure that some survive to reproductive age.

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American and Pacific oysters (*Crassostrea gigas*) are species of an oviparous oyster genus. That is, the eggs of both species are discharged into the water and fertilized outside the organism. Larviparous species of oysters (*e.g.* the European oyster, *Ostrea edulis*) are incubatory. Fertilization takes place in the gill cavity, and the larvae are incubated, then discharged, after having reached an advanced stage of development. This more conservative reproductive strategy makes a lower fecundity possible. And in fact, in comparison to the American and Pacific oysters, the fecundity of the larviparous European oyster is rather low, (approximately ten times less fecund).

In order to accumulate so many gametes, oysters spend much of the warm months of the year producing them. American oysters from northern latitudes (*e.g.*, Maine) have a single annual reproductive season of shorter duration than oysters from southern latitudes (*e.g.*, Chesapeake Bay) which often have several gonad forming and spawning cycles over a longer season.

So what does this mean to a major two-legged oyster predator, the *Homo sapiens* seafood connoisseur? Some may be familiar with the axiom that warns of eating oysters in months lacking an *R*. The expression dates to 1599 to an English parson named William Butler. He found the European oysters *unseasonable and unwholesome* in months lacking an R. For most oysters the R-less months (May through August) are reproductive season months. The tendency for an oyster to be unpalatable during this time depends on the species, the location and on personal preference. As the expression pertains to the European oyster, the clergyman was right. Since these oysters brood their larvae in the summer, eating one at this time is like eating sand. Their inedible appearance resulted in the expressions *white sick* and *black sick*, terms that correspond, respectively, to the early and late stages of larval incubation.

For the oviparous oysters, this rule of thumb doesn't always hold true. First, the commercial quality of oviparous oysters is not as adversely affected by reproductive development as the larviparous European oyster. Although gonadal develop-

ment does affect the flavor and texture of oviparous oysters they are by no means unwholesome or inedible. The rapid proliferation of sex cells in the gonad exhausts glycogen reserves so that by the end of the reproductive cycle (immediately after spawning) the amount of glycogen is at a minimum. Glycogen, which imparts a sweet flavor and creamy color to oyster meat, is converted during sexual maturation to less flavorful products. Oysters also become soft when reproductive tissues form throughout the body. After they spawn oysters are trimmed down and watery in texture.

Second, the R-less month rule doesn't hold true for all oviparous oyster species. Summer market quality varies among the species. For instance, sexually mature Pacific oysters are inferior products for marketing in the summer whereas gonadal development in American oysters cultured in Maine doesn't significantly detract from their market value.

Third, reproductive seasons vary in length depending on latitude. The R-less month rule may apply to some regions but not to others. Within their natural geographical range, American oysters from colder waters (*e.g.* Maine) may have breeding seasons as short as four weeks. In oysters from the warmer waters of the south (*e.g.* Chesapeake Bay) gonadal formation and spawning continue for several months. If you're picky about the quality of your oysters, here the R-less month rule may provide a fairly accurate guideline.

Finally, regardless of species and location, summer reproductive development doesn't deter some oyster connoisseurs who may consider this the best time to eat them. Such is the case with Sydney rock oysters (*Crassostrea commercialis*). Although there's a decrease in meat quality during the warmer months, Australians enjoy Sydney rock oysters year-round.

So it appears with some species, locations and markets, reproductive sterility may be beneficial to the commercial shellfish grower. Triploidy is one way sterility can be produced. Most sexually reproducing animals have cells with two sets of chromosomes and so are called diploids. *Triploid animals have three sets of chromosomes.* The process of meiosis (gamete production) reduces chromosome number by one-half (haploid) in order to keep the chromosome number from doubling with each generation (haploid egg + haploid sperm = diploid zygote). In diploids, meiosis involves an intricate pairing of the two chromosome sets, but the presence of a third chromosome set in triploids disrupts that pairing. As a result triploids are usually sterile due to their inability to produce viable gametes successfully.

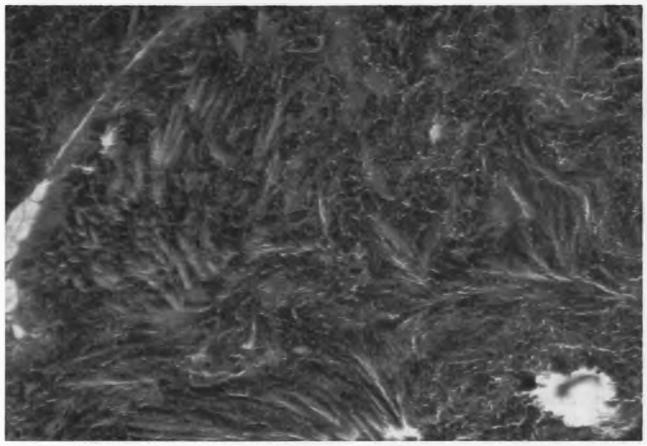
The University of Maine has been a forerunner in triploid shellfish research. Since a small project began in 1978 to induce triploidy in the American oyster, knowledge of triploid bivalves has expanded to produce triploid bay scallops, soft-shell clams (steamers) and hard-shell clams (quahogs). The idea for developing triploid oysters arose from work being done at the University of Maine to produce sterile landlocked Atlantic salmon. In this case triploidy was used for its ability to induce reproductive sterility. After triploid American oysters were produced, the first concern in the evaluation of this technique was its effect on growth. Triploidy is not expected to produce a size differential in animals of determinate growth due to a compensatory reduction in overall cell number. But because shellfish have indeterminate growth (no final adult size) triploid oysters were expected to be larger than ordinary diploids. Indeed triploid American oysters were found to be larger and to grow faster than their diploid siblings.

At first increased growth in American oysters was attributed to increased heterozygosity (genetic diversity) due to the presence of a third chromosome set. But further research on triploid shellfish indicated that reproductive sterility may also be significant. Triploids may show a growth advantage over diploids after sexual maturity due to a diversion of reproductive energy to growth. A comparison of energy budgets for diploid and triploid soft-shell clams suggested growth is enhanced in triploids due to retarded gametogenesis (gamete production) rather than to an increase in metabolic efficiency brought on by heterozygosity.

Sterility doesn't necessarily mean a total lack of gametes. Sterility can also be a result of the production of functional gametes in greatly reduced numbers or the production of gametes that are sub-optimal in their ability to fertilize. The benefits of triploid sterility may not be as alien to everyday life as you may think. Some may be familiar with seedless watermelons. Unlike seedless grapes, seedlessness in watermelons is produced through triploidy. If you've ever had the chance to eat one you may have noticed they're not completely seedless. The Burpee seed company produces a seedless watermelon variety described as having a *few small soft seeds* which are *completely edible.* Either one of the definitions of sterility may apply. By their description the seeds are probably not functional, and if they are, they're produced in such reduced numbers as to make the watermelon fundamentally sterile.

A similar degree of *seedlessness* is found in triploid shellfish. A visual inspection of triploid bay scallops during their reproductive season revealed greatly retarded gamete production. Microscopic examinations of triploid soft-shell clams, Pacific oysters and American oysters indicated profoundly altered reproductive physiology. The author's investigation of gametogenesis in triploid American oysters showed male sterility to be a result of a total lack of gametes (Figure 1a; right). Although female triploids produced some gametes (oocytes) their numbers were so greatly reduced as to render them essentially sterile (Figure 1b; right).

In both sexes some energy is diverted to the development of early gametogenic cell stages but this is probably not significant. Absolute sterility is not essential for triploids to be valuable commercially. As is the case with Pacific oysters, reduced gamete production is sufficient for marketing during the summer. Gamete production diverts a great deal of energy from other physiological functions, such as growth and hardiness. Sterile triploids would have increased energy reserves and probably reduced physiological stress during times



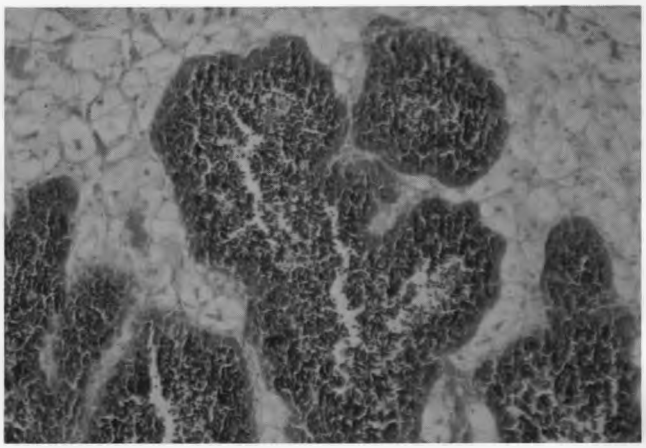
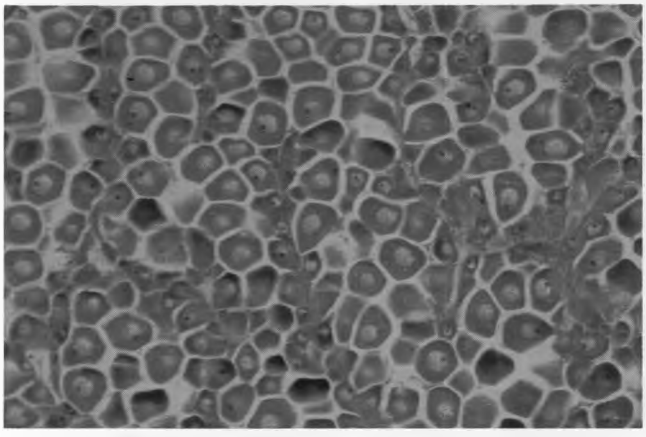
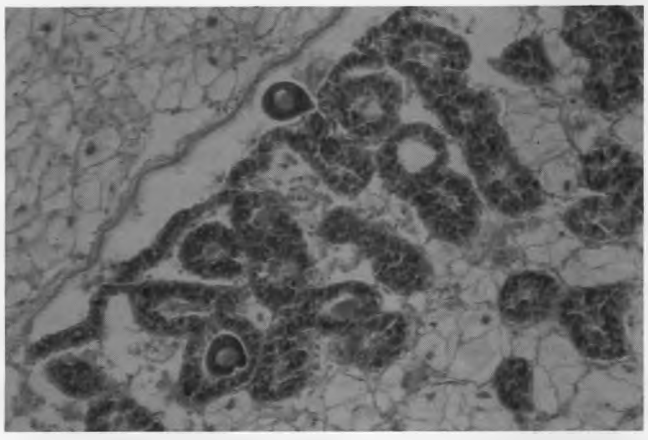


Figure 1. The microscopic examination of gametogenesis in triploid American oysters revealed profoundly altered reproductive physiology. a. Late season gonadal development in diploid and triploid males. The micrograph of the diploid male on the left (100X) shows a fully developed (ripe) spermary filled with spermatozoa (male gametes). The micrograph of the triploid male on the right (100X) exemplifies the maximum degree of gonadal development found in triploid males. The spermary in this individual is filled with primary spermatocytes (an early reproductive cell stage prior to meiosis).





1b. Late season gonadal development in diploid and triploid females. The micrograph of the diploid female on the left (100X) shows a fully developed (ripe) ovary filled with primary oocytes (female gametes). The micrograph of the triploid female on the right (100X) typifies the gonadal development found in late season triploid females. Only two well developed oocytes are visible.

of reproduction. The production of sterile triploids may help to avoid problems associated with sexual maturity and physiological stress. For example, triploid sterility may find a role in combating oyster disease. The disease organism *Minchinia nelsoni* (MSX) is responsible, in part, for the sharp decline in the Chesapeake Bay oyster fishery. The disease has assumed great regional importance with recent commercial MSX disease kills as far north as Cape Cod. Since this disease is most virulent during periods of oyster reproduction, it is possible that triploids will be more resistant to MSX than diploids due to their summer vigor.

In some species triploidy may be beneficial for its ability to induce sterility while in others triploidy may be best used for its effect on growth. For example, although seedlessness is useful in watermelons, it is not important in apples since the core wouldn't be eaten even if seedless. Nevertheless, sterile triploid Baldwin apples were once very popular and sought after in New England for their large size. Similarly, the next application of triploidy may concern growth.

If not for sterility, triploidy may still find a use in the production of larger faster growing shellfish. The larger body size is of obvious significance to aquaculturists. A faster growth rate is valuable as it would also decrease the time necessary to grow a shellfish to market size. Currently it takes 2 to 3 years to grow an oyster to market size. In comparison it only takes 7 weeks to grow a day old chick to broiler size. A reasonable goal for the oyster industry would be to produce a marketable oyster in 18 months. Improvements should be forthcoming as the University of Maine has undertaken

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Technology and the Competitive Edge

by John Field and Eric Beenfeldt

Maine is home to a number of companies which compete in international markets. To maintain and increase their market share, these companies' products must have competitive prices and capabilities. One way to achieve these goals is to keep up-to-date on the latest technology.

The following article describes how members of the Electrical/Computer Engineering faculty at the University of Maine helped one Maine company, the Reece Corporation of Gorham, to upgrade one of their product lines through the use of microprocessors.

The Reece Corporation

The Reece Corporation was founded in Waltham, Massachusetts, in the late 1800s. Their corporate headquarters are still located there, but the engineering and manufacturing operations of the company were moved to Gorham, Maine, in 1974. Reece is a worldwide marketer of equipment for the apparel industry; for example, it manufactures industrial sewing machines for specialized functions such as sewing buttonholes or sewing pockets on trousers and jackets. It also manufactures machinery for automatically enclosing or bagging clothes in plastic so that the clothes are protected during shipping or storage. It is this latter product, called an automatic bagger, that was upgraded by Electrical/Computer Engineering faculty with the use of microprocessors.

The Automatic Bagger

It may seem strange, but it is true, that there is a worldwide market for a machine that can automatically enclose or bag clothes in plastic. This machine operates as a sort of carousel. A conveyor is used to deliver garments on hangers to the left side of the bagger, where, one at a time, they are taken off and sent around to a bagging position where a continuous tube of plastic is taken from a large roll and pulled down over the garment. When the garment is completely enclosed in the tube, a heated blade cuts and seals the top of the tube, forming a bag for the garment. The bagged garment then continues on to an unloading conveyor on the right rear of the bagger. In full operation, the bagger can process as many as 1,050 separate garments in an hour with little human intervention. The operator needs only to replace the roll of plastic tubing when it is expended and restart the operation if a garment is improperly bagged for some reason.

The bagger uses a large number of sensors to determine answers to questions such as *What position is the bagger in? Is there a garment to be bagged? Is there plastic on the roll?* The answers to these and many other questions are used to control the bagger's several systems of motors, brakes, and clutches. All the various systems must work in perfect synchronism for the bagger to operate correctly.

Old versus New Technology

To achieve this synchronism the old bagger design used electronic circuitry based on discrete components and small-scale integrated circuits. There were so many of these devices that seven circuit boards were required to accommodate them all. The large number of components and boards, in turn, resulted in high manufacturing and assembly costs as well as more difficulty in locating faults should the circuitry not work.

While the circuit was entirely appropriate when it was first designed 20 years ago, Reece recognized that a redesign using large-scale integrated circuits, such as microprocessors, would eliminate or at least ameliorate many of the problems listed above. However, they lacked the special equipment and expertise necessary for microprocessor-based design. They turned to the University of Maine for advice and were referred to Electrical/Computer Engineering faculty members Eric Beenfeldt and John Field. Working through the University's Department of Industrial Cooperation, directed by Professor Richard Hill, a project was established to develop a microprocessor-based automatic bagger.

Features of the Microprocessor-Based Bagger

The new bagger was required to appear to operate in exactly the same way as the old bagger. This way, customers who were familiar with the original bagger could buy a new one and not need to retrain their operators. At the same time, Reece did want to incorporate new safety features as well as a self-testing capability that would aid with field repair work. All this had to be done *using fewer electronic components, improving the reliability of the electronic controls, reducing the manufacturing costs, and,* if possible, *fitting all the components on one printed circuit board* instead of the seven used in the old machine.

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Eric Beenfeldt is a Lecturer in Electrical Engineering at the University of Maine and earned his M.S. degree in Electrical Engineering from that institution. His interests include microprocessor applications.

Work on the project began when an operational 12-foot high, 1500-pound bagger was delivered to Barrows Hall in June, 1986. A forklift truck was needed to move it from the delivery truck to the building's loading dock.

The first step was to analyze the bagger to determine exactly what it was doing. Once the detailed steps for a bagging cycle were understood, the electronics of the old machine were removed and work was started on the hardware and software that would operate the new machine. A Zilog Z80 microprocessor was chosen for the design because it was inexpensive, sufficiently powerful, and was already used in some equipment Reece was marketing. The operator controls for the machine remained essentially the same except for the addition of a 1-digit 7-segment display and a 2-digit thumbwheel.

With these few external changes, software and hardware were designed which duplicated the operation of the bagger and also included a number of safety and convenience features. At 19 points during the bagging cycle, checks are made to make sure that operations that should have taken place did take place. If the failed operation could be related to the safety of the operator or possible damage to the bagger, the machine would be shut down and the 7-segment display would flash a number indicating what type of failure occurred. If the failed operation related to the normal function of the machine, *e.g.*, running out of plastic tubing, the machine would simply stop and display a number indicating what was wrong and wait for the operator to remedy the situation. In addition to aiding in day-to-day operations, the error indications have also reduced field repair calls by allowing the operator to distinguish more easily between serious and nonserious faults.

The flexibility gained by operating the bagger with a microprocessor allowed a self-test feature to be added. Software for the machine was written in two parts. One part would operate the machine in its normal bagging mode. But, by changing a switch setting on the printed circuit board the second part of the software would take over control and allow the bagger to be tested. Field repair people can now individually test every switch, motor, hydraulic actuator, and clutch that is used in the bagging cycle. Previously these items were wired together in such a way that it was impossible, without dismantling the machine, to test them independently.

While initially thought of as a field repair aid, the self-test feature had an unexpected bonus on the manufacturing floor. The technicians who assemble the bagger found that they were more efficient because they could isolate and test individual components while the machine was being assembled. Using the machine to test itself decreased the assembly time and also allowed critical adjustments to be made more accurately.

SUMMARY

The automatic bagger has been marketed for well over a year now. It has resulted in the expected lower manufacturing costs and has also drastically reduced field repair calls. This project demonstrates the benefits that can be derived from the application of new technology. It is also one example of how University of Maine facilities and expertise are being made available to aid Maine industries.

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1977 Managing the Commons. San Francisco: W. H. Freeman and Co.

Johannes, R. E.

1977 Traditional Law of the Sea in Micronesia. Micronesia: 13:121-127.

1978 Traditional Marine Conservation Methods in Oceania and Their Demise. Annual Review of Ecology and Systematics 9:349-64.

1982 Traditional Conservation Methods and Protected Marine Areas in Oceania. Ambio 11(5):258-261.

Jarmul, David

1987 Common Property Resources in the Developing World. National Research Council News Report. March issue. pp. 2-5.

Klee, Gary

1980 Oceania. In World Systems of Traditional Resource Management. Ed. Gary A. Klee. New York: John Wiley and Son. pp. 245-281.

McCay, Bonnie J.

1980 A Fishermen's Cooperative, Limited Indigenous Resource Management in a Complex Society. Anthropological Quarterly 53-29-38.

McCay, Bonnie, and James Acheson

1987 Capturing the Commons: an Introduction. In The Question of the Commons. Eds. Bonnie McCay and James Acheson. Tucson: University of Arizona Press.

Pinkerton, Evelyn

1986 Intercepting the State: Dramatic Processes in the Assertion of Local Co-Management Rights. In The Question of the Commons. Eds. Bonnie McCay and James Acheson. Tucson: University of Arizona Press.

Taylor, Lawrence

1987 "The River Would Run Red with Blood": Community and Common Property in an Irish Fishing Settlement. In The Question of the Commons. Eds. Bonnie J. McCay and James Acheson. Tucson: University of Arizona Press.

Townsend, Ralph and James Wilson

1987 An Economic View of the "Tragedy of the Commons": from Privitization to Switching. In The Question of the Commons. Eds. Bonnie McCay and James Acheson. Tucson: University of Arizona Press.

Growing Our State Tree Faster: Fertilizing White Pine

by Robert Shepard and M.W. Blumenstock

For 300 years, until well after the turn of the present century, White Pine was unrivaled as a timber-producing tree. Perhaps no other tree in the world has had so momentous a career. Certainly, no other has played so great a role in the life and history of the American people.

— Donald Culross Peattie, *Natural History of Trees of Eastern and Central North America*, Houghton Mifflin Company, 1950

Early voyagers exploring the coast of Maine hundreds of years ago were duly impressed with Maine's forests and recognized the potential uses for the abundant white pine. Earliest uses of that species for ships' masts soon gave way to its exploitation as a source of lumber, a major use which continues today.

The spontaneous forest is disappearing.

Forest managers interested in increasing the growth of white pine are managing their stands as a crop requiring many growing seasons to reach harvestable maturity. This forest crop responds to cultural practices, some of which are being closely studied by the University of Maine's Cooperative Forestry Research Unit.

One study deals with the growth response of white pine to fertilization with nitrogen and some of the factors that may control the magnitude of the response. The findings of this research are currently being distributed to forest scientists, researchers, and interested forest owners. The UMaine Cooperative Extension Service is assisting with this distribution through one of its forestry education programs, *Yankee Woodlot*, which began as a television series in 1982 and was co-produced with the Maine Public Broadcasting Network of the University of Maine System.

White pine values are increasing in the State of Maine. Acreage in seedling and sapling white pine stands in the State of Maine is decreasing.

The decrease of a natural resource and its simultaneous increase in value is the type of challenge often faced by scientists at the University of Maine.

What do they do? — Find effective answers. How do they do it? —Through research and study, and through the crucially important dissemination of study results to the Maine people who can apply those results to solve concrete problems. And that is exactly what research scientists at the University of Maine are doing to help solve the dichotomy of the State's white pine.

Eastern white pine is the most valuable conifer in Maine. The average statewide stumpage price in the Fall of 1988 was $90 per thousand board feet (Maine Forest Service, 1988). It ranged from $113 in York, Cumberland, and Androscoggin Counties to $88 in southern Washington and Hancock Counties. An individual sale of $190 per thousand board feet was reported.

While white pine values are increasing, the acreage in seedling and sapling white pine stands in Maine is decreasing. The most recent forest survey of Maine (Powell and Dickson, 1984) reported that these size classes of young trees decreased from 368,000 acres in 1971 to 61,000 acres in 1982. The area in sawtimber stands increased by about 325,000 acres during the same period, and acreage in poletimber stands remained about constant. Because of the reduction in area of young stands it appears that a shortage of white pine sawtimber may ultimately occur.

One way of moderating a future white pine shortage is to stimulate growth of existing stands. Because many white pine stands are growing on sites that are nutrient deficient, especially in nitrogen, fertilization with nitrogen may be one way to increase stand growth on these sites. A commercial nitrogen fertilizer such as urea could be used on all sites. On those sites where regulatory guidelines permit, papermill or municipal secondary sludge, both of which are relatively high in nitrogen, might be used.

The Role of Research

A white pine fertilization study currently in progress in the UMaine College of Forest Resources indicates that both stand volume and value may be increased considerably by adding nitrogen. The work is concentrating on the effects of soil (divided into till and outwash soils), nitrogen application rate, stand density, and individual tree size on growth response.

A response function, incorporating the variables listed previously, was developed to predict four-year growth of individual stands. The most favorable application rate was 100 pounds of nitrogen per acre; results presented here are for application rates of 0 and 100 pounds per acre. Results are presented in terms of sawtimber volume and value.

Dr. Robert Shepard is Associate Professor in the College of Forest Resources at the University of Maine and scientist in charge of the research project described in this article.

M.W. (Bud) Blumenstock is with the University of Maine Cooperative Extension Service, a Cooperating Professor in Forest Resources and associated with the Yankee Woodlot Program.

Stand Volume Increase

Volume growth was much greater on the till soils than on the outwash soils (Table 1). This held true both with and without fertilization and is likely due primarily to more favorable moisture conditions on the till soils. Volume growth on the till soils was greater without fertilization than on the outwash soils with fertilization.

The average increase over the four-year period on the till soils due to fertilization was 1226 board feet per acre, or 12.26 board feet per pound of nitrogen. On the outwash soils the four-year increase with fertilization was 776 board feet per acre, or 7.76 board feet per pound of nitrogen. The relative increase on the till soils was 23 percent; on the outwash soils it was 20 percent.

Table 1. Four-year volume growth of white pine sawtimber stands on till and outwash soils in Maine fertilized with nitrogen at 0 and 100 pounds per acre (eight stands per soil group).

Application Rate (pounds per acre)	Soil Group: Till	Soil Group: Outwash
	— board feet per acre —	
100	6551[a.] (4567 to 7995)[b.]	4577 (3061 to 5983)
0	5325 (3752 to 6339)	3801 (2545 to 4928)

a. Mean
b. Range

There were large differences in response among stands on both groups of soils. On the till soils increases ranged from 815 to 1656 board feet per acre, whereas on the outwash soils the improvement was from 516 to 1055 board feet per acre. On each group of soils the stand that showed the smallest increase in growth without fertilization also showed the smallest increase with fertilization, and the stand that showed the largest increase without fertilization also showed the largest increase with fertilization.

Stand Value Increase

There were two important aspects to the increase in sawtimber value (stumpage price = $100 per thousand board feet) (Table 2).

1. The average per acre increase was greater on till soils than on outwash soils. At an application of 100 pounds of nitrogen per acre the value increased $122 for till soils and $78 for outwash soils. It is evident that the potential for earning a favorable return on fertilization is much greater in stands on the till soils than in stands on the outwash soils.

2. The range of increased values due to fertilization was wide on both till and outwash soils, but considerably greater on the till soils. For example, till soils had a range of $82 to $166 per acre, while outwash soils exhibited a range of $52 to $105 per acre. Thus, a small gain is more likely and a large gain less likely on the outwash soils than on the till soils.

Table 2. Four-year increase in sawtimber value (at a stumpage price of $100 per thousand board feet) for white pine on till and outwash soils in Maine fertilized with nitrogen at 0 and 100 pounds per acre (eight stands per soil group).

Application Rate (pounds per acre)	Soil Group: Till	Soil Group: Outwash
	— dollars per acre —	
100	655[a.] (457 to 800)[b.]	458 (306 to 598)
0	533 (375 to 634)	380 (255 to 493)

a. Mean
b. Range

Summary

Nitrogen fertilizer was applied to plots in white pine stands on glaciated soils (both till and outwash) in Maine. Four-year results indicated a 23 percent increase in board foot volume on till soils and a 20 percent increase on outwash soils at an application rate of 100 pounds per acre. Volume growth increase was greater on till soils with no fertilization than on outwash soils with fertilization. Value increases, when measured in dollars per thousand board feet, showed commensurately greater improvements for till soils over outwash soils.

Literature Cited

Maine Forest Service. 1988. Stumpage prices - fall 1988. Mgmt. and Util. Div., Augusta. 15 p.

Powell, D.S. and D.R. Dickson. 1984. Forest statistics for Maine 1971 and 1982. USDA For. Serv., NE For. Exp. Stn. Resour. Bull. NE-81. 194 pp.

Terms Defined

***Board Foot** A unit for measuring wood volumes equaling 144 cubic inches,

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Versatile and valuable, white pine probably grows better on a wider variety of sites than any other tree species native to Maine. It is found on droughty outwash soils and on poorly drained till soils. The best stands generally occur in southwestern Maine. Two stands are shown here. The largest trees in these stands are approximately 20 inches in diameter (measured at 4.5 feet above the ground) and 110 feet tall.

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commonly used to measure and express the amount of wood in a tree, sawlog, or individual piece of lumber. For example, a piece of wood 12 inches by 12 inches by 1 inch, or a piece measuring 12 inches by 2 inches by 6 inches — both contain 1 board foot of wood.

Outwash Soil A soil that has developed in sand and gravel deposited by fast-flowing water discharged from melting glaciers.

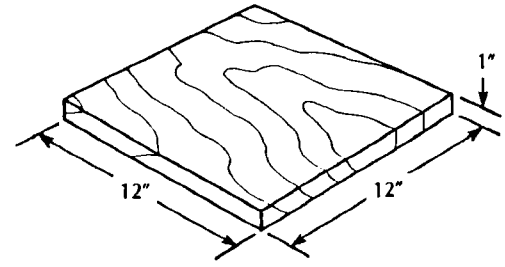
***Pole Timber** A stand of trees whose diameters (at 4.5 feet above ground level) range from approximately 5 to 9 inches.

***Saw Timber** A stand of trees whose diameters are large enough to produce a sawn product — usually about 10 inches in diameter.

***Stumpage** The monetary value of a tree or group of trees as they stand in the woods uncut (on the stump).

Till Soil A soil that has developed in unstratified glacial drift deposited directly by ice, and that consists of intermingled clay, silt, sand, gravel, and boulders.

*Adapted from Terminology for Forest Landowners by Donald P. Hanley, Donald R. White, David L. Adams and David M. Baumgartner. Washington State University, Pullman. Publication EB 1353. 1983.



Board Foot

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a long-term selective breeding program for the genetic improvement of growth rate in American oysters. (See **Explorations** Volume III, Number 3, p. 10-16. 1987 *The Quest for the Eighteen Month Oyster.*)

While the benefits of triploidy can be realized more quickly than those of selective breeding, the two are not mutually exclusive. Triploids can be produced in wild broodstocks or genetically distinct lines. Since triploidy has been shown to improve growth rate in unselected (wild) American oysters, additional improvement can be expected from genetically selected, pure-line (unmixed broodstock) triploids. Further, cross-line (mixed broodstock or hybrid) triploids may show an additive effect over either the cross-line diploids or the pure-line triploids. Since genetically selected lines of MSX resistant oysters already exist, a sterile triploid, MSX resistant oyster is also possible.

In conclusion, seedless watermelons and triploid oysters have triploid sterility in common. Although neither are completely seedless, absolute sterility is not essential for these triploids to be commercially valuable. Unlike triploid watermelons, triploid shellfish may have advantages that go beyond seedlessness. If not for reproductive sterility, triploidy may prove to be instrumental in realizing *the quest for the eighteen month oyster* and may prove to be vital in the war against *MSX - the AIDS of the American oyster industry.*

Triploid Pacific oysters now represent 50 percent of the total oyster production of commercial hatcheries in the Pacific Northwest. Perhaps one day we'll see the commercial use of triploidy on the east coast and abroad. When that time comes, maybe you'll find yourself eating reproductively sterile triploid oysters. Bon appetite!

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