WHOI-W-89-001 C3

WHOI-89-35

Woods Hole Oceanographic Institution

Shellfish Closures in Massachusetts: Status and Options

Proceedings of a Sea Grant-Sponsored Workshop held at the
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543
March 22, 1989

Edited by
Alan W. White
and
Lee Anne Campbell

September 1989

Technical Report

Funding was provided by NOAA National Sea Grant College
Program Office, Department of Commerce, under Grant No. NA-86-AA-D-SG090,
to the Woods Hole Oceanographic Institution Sea Grant Program.

WHOI-89-35

Shellfish Closures in Massachusetts: Status and Options

Edited by

Alan W. White
and
Lee Anne Campbell

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

September 1989

Technical Report

Funding for the workshop and preparation of this report was provided by NOAA National Sea Grant Program Office, Department of Commerce, under Grant No. NA-86-AA-D-SG090, Woods Hole Oceanographic Institution Sea Grant Project Nos. M/O-2 and A/S-10-PD.

Reproduction in whole or in part is permitted for any purpose of the United States Government. This report should be cited as: Woods Hole Oceanog. Inst. Tech. Rept., WHOI-89-35.

Approved for Distribution:

David A. Ross

David A. Ross, Chairman
Department of Geology & Geophysics

TABLE OF CONTENTS

ABSTRACT

This report is a summary of a workshop on the problem of shellfish closures due to microbial contamination in Massachusetts. The workshop, sponsored by the Woods Hole Oceanographic Institution Sea Grant Program, was held on March 22, 1989, at the Woods Hole Oceanographic Institution. Its principal aim was to keep the shellfishing community informed about the status of shellfish closures throughout Massachusetts, the results of recent research on microbial contamination of shellfish, and options for shellfisheries in the region in the face of increasing closures of shellfish areas. Topics addressed by invited speakers included 1) the history of shellfish closures in the state, 2) the fecal-coliform standard and why it needs to be modified, 3) alternatives to the standard, and 4) shellfish relay and depuration procedures used in other states. The workshop was attended by more than 160 people, primarily shellfish officers, shellfish biologists, members of town shellfish commissions and shellfishermen from Massachusetts.

MASSACHUSETTS SHELLFISH CLOSURES, MONITORING PROGRAMS, REGULATIONS, AND THE CONCERN OVER THE BACTERIAL STANDARD

J. Michael Hickey
Division of Marine Fisheries
Commonwealth of Massachusetts
18 Route 6A
Sandwich, MA 02563

Status of Massachusetts Shellfish Growing Waters

The overall health and water quality condition of shellfish growing waters in Massachusetts can be characterized by the following alarming account of shellfish closures since 1982 due to bacterial contamination.

In the decade between 1970 and 1980 there was little change in the total amount of open and closed shellfishing area on the South Shore and in southeastern Massachusetts (from the Hull/Cohasset town line to the Massachusetts/Rhode Island state line). A total of 19,891 acres were closed to the harvest of shellfish for public health reasons at the end of 1980. Much of the closed area was in the vicinity of highly urbanized and/or industrialized sections such as the Taunton River/Mt. Hope Bay, New Bedford Harbor/Clarks Cove, Plymouth Harbor, and a number of smaller harbors including Falmouth Harbor, Hyannis Inner Harbor, Cohasset Harbor, and portions of Provincetown Harbor. Numerous smaller areas also added to the total.

The situation remained much the same throughout 1981 and early 1982. However, by the end of 1982 an additional 2,038 acres were closed. By the end of 1984 another 3,469 acres were also closed. Consequently, during that two-year period 5,507 acres (8.6 square miles) of coastal waters were closed to shellfish harvesting due to bacterial contamination. This brought the total area closed to shellfishing to 25,398 acres in the southeast region of our state and represented a 27.7% increase over the 1980 total. These additional closures affected 17 communities and for the most part were in suburban areas not serviced by municipal sewage treatment plants. Over the next two years the trend continued with another 3,340 acres closed, bringing the total to 28,737 acres by the end of 1986. In 1987 another 2,207 acres were closed, and in 1988 another 3,349 acres were closed, bringing the total closed area in the southeastern portion of Massachusetts to 35,078 acres.

In the eight years since the end of 1980, 15,187 acres (23.7 square miles) of coastal waters have been closed to shellfishing, representing a 43% increase over the 1980 total.

On Cape Cod, 5,750 acres have been closed during this period, representing an 88% increase over the 1980 total of 712 acres and bringing the total to 6,462 acres closed (10 square miles). A frightening event was the 1988 closure of 531 acres of open coastal waters along the shores of Cape Cod Bay.

Other major closures have occurred in what were once considered relatively unpolluted areas. In picturesque tidal rivers like the Westport River, 860 acres have been closed; in the North and South Rivers in Marshfield and Scituate, 1,008 acres have been closed. Thirteen years ago, the North River was designated as one of New England's cleanest rivers. Not even the off-shore islands have escaped the trend. In 1980, 617 acres were closed on the islands; in 1988, 2,649 acres were closed, an increase of 2,032 acres or 30%. Much of the recently closed area (1,016 acres) is on Martha's Vineyard in relatively undeveloped tidal salt ponds.

In contrast, on the North Shore and in Boston Harbor the situation is not quite as bleak in terms of new closures. Nonetheless, the present status quo is already worrisome to those concerned about shellfish harvest and public health. For many years all of Boston Harbor has been closed to the harvest of shellfish except in certain areas classified as "restricted." In these areas specially-licensed diggers harvest "moderately contaminated" (with coliform bacteria) soft-shell clams for purification at the state-operated purification plant in Newburyport. The amount of productive shellfish area classified on any given day as "restricted" is about 2,864 acres. In Boston Harbor about 1,826 productive acres are closed (prohibited) at all times. Portions of the 2,864 acres classified as "restricted" may temporarily revert to the prohibited status on a daily basis depending on sewage treatment plant malfunctions and stormwater bypasses. There are no open areas in the Harbor. Consequently, adjacent waters of Boston, Milton, Quincy, Hull, Braintree, Weymouth, Hingham, and Winthrop are closed or restricted. In total, 4,690 productive acres (7.3 square miles) are closed in this area.

Like Boston Harbor, much of the North Shore has been closed for many years. Of the 3,514 productive shellfish areas, 1,576 (44.9%) are prohibited and 514 (14.6%) are restricted. Hence, only 1,424 acres (40.5%) of productive flats are open. The only improvement is that since 1981 some prohibited productive acres have been reclassified as restricted: Newburyport (1981), 77 acres; Ipswich (1982), 124 acres; Gloucester (1983), 56 acres. Still, the combined total productive shellfish flats closed (or restricted) from Boston Harbor northward amounts to 6,781 acres (10.6 square miles).

The foregoing refers to closures of productive areas; that is, intertidal flats with commercial quantities of soft-shell clams. In addition to these areas, there are about 18,000 non-productive acres closed because water quality does not meet shellfish growing area standards. Species of value such as blue mussels, surf clams, and ocean quahogs are found in portions of these 18,000 acres. Taken together, the total area under public health closure on the North Shore and in Boston Harbor amounts to 24,780 acres (38.7 square miles).

The total maximum closed area in Massachusetts in 1988 was 60,078 acres (93.8 square miles) and represents a 34% increase from 44,672 acres closed in 1980.

Of the closed area south of Boston, about 22,290 acres is considered productive since the shellfishery is diverse and not confined to an intertidal soft-shell clam fishery. Quahogs, oysters, soft-shell clams and mussels are found in both intertidal and subtidal waters, while bay scallops, surf clams, and ocean quahogs are harvested in subtidal waters. The estimated annual loss in unharvested shellfish from the areas closed south of Boston is about $14.7 million in landed value, not counting bay scallops. Another $1.2 million of estimated annual landed value is lost from the closed productive areas of Boston Harbor and the North Shore. A conservative multiplier of 4.5 times the landed value can be used to estimate a total economic loss of about $71.1 million annually.

Monitoring Programs

The Division of Marine Fisheries samples each shellfish area at least five times per year according to the requirements of the National Shellfish Sanitation Program (NSSP). In 1988, 6,564 water samples were collected. Shellfish are also sampled for PCBs and metals (mostly mercury) in connection with transplants from contaminated areas. In addition, bioassays for marine biotoxins (paralytic shellfish toxin) are routinely conducted on a weekly basis from mid-March to early December from 18 locations along the coast. In 1988, 556 shellfish samples were examined. Other special studies involve sampling for hydrocarbons and pesticides as required and histopathological examination for shellfish diseases (an animal health issue) such as MSX, SSO, and neoplasia.

Division of Marine Fisheries personnel also conduct sanitary surveys of shellfish growing areas. These surveys involve documentation and evaluation of all actual and potential pollution sources affecting shellfish waters and an analysis of the impact of land use and hydrographic and meteorological factors. These surveys are the basis of shellfish area classification.

Bacterial Standard

Identification of pollution sources together with testing of shellfish growing waters and shellfish meats is generally regarded as a sound concept and sufficient to protect consumers from most diseases of fecal origin. However, the coliform indicator and standard (density value) currently in use was developed during the 1920s when the target disease was typhoid fever, a rare occurrence today, and may be insufficient to detect viruses, particularly the virus causing infectious hepatitis, which is also of fecal origin. The relationship between this and other viral pathogens and the bacterial indicator has not been firmly established, nor has the validity of the standard. The national standard is a fecal-coliform median or geometric mean not exceeding 14 bacteria per 100 ml, and not more than 10% of the samples may exceed an MPN (most probable number) of 43 for a 5-tube decimal dilution test.

The bacterial indicator may exceed the existing water quality standard even when no source of public health risk is present. Fecal-coliform bacteria have been found to survive and multiply in the environment under certain conditions and do not necessarily indicate the presence of human or animal waste. There is some question that the current indicator may be restrictive, resulting in unnecessary closures and preventing the use of safe shellfish.

Research is needed to investigate the current indicator and other potential indicators in terms of their numerical relationship to pathogens. Any change in the indicator or the numerical relationship for classifying growing waters should be accompanied by appropriate changes in the tolerance limits for shellfish, i.e. the current market standard. However, it should be emphasized that the Division of Marine Fisheries is not advocating abandoning the present standard until such time as a new standard can be developed and verified and such standard is adopted by the Interstate Shellfish Sanitation Conference and made part of the NSSP.

POLLUTION SOURCES IN BUTTERMILK BAY: KEEPING IT ALL IN PERSPECTIVE

George Heufelder
Barnstable County Health and Environmental Department
Route 6A
Barnstable, MA 02630

- What do people mean when they say the Bay is too polluted to shellfish in?
- Where is all the pollution coming from?
- What about the marinas; could they be the problem?
- What about the major discharges at sewage treatment plants; are we sure they aren't the problem?
- How can a few dogs walking on the beach be a major pollution problem? Aren't we getting a little carried away?
- Ducks, geese, and swans? How can we control pollution caused by them?
- How about all those septic systems in that major development? They must be the problem! What is being done about them?
- How can stormwater be affecting the Bay? Where does the contamination come from?
- Is the problem too big? What can I personally do?
- What are the state and federal governments doing to resolve the issue of marine water pollution?

Over the past months, residents around Buttermilk Bay and many of our marine embayments have been asking these and other pertinent questions about the "health" of our marine waters. What follows is a summary of our findings in studying Buttermilk Bay and an account of some of the activities presently going on to resolve some of these questions and issues.

Indices of Pollution: How Do We Know an Area is Polluted?

No discussion of pollution in our estuaries can be complete without a clear understanding of two concepts: 1) what do we mean by pollution? and 2) what do we use as an indication that an area is polluted? **Pollution**, broadly defined, **is any activity which prevents a resource from being used for its intended or desired purpose.** In the case of Buttermilk Bay, there are a number of desired uses which have been affected by man's activities. In 1984 the entire Bay was closed to shellfishing due to bacterial contamination. Periodically, certain areas of the Bay have even exceeded that level of bacterial contamination considered safe for contact recreation such as swimming or wading. It is clear that some human activities have been the cause. Determining causal relationships between shoreline development/land practices and bacterial contamination is the subject of continuing study. Although remedial actions and best management practices (BMPs) are being developed and implemented, there are still a number of unanswered questions which require further research.

What Do We Use For an "Index" of Pollution?

There are scores of bacterial and viral pathogens associated with human sewage which could make their way into the marine environment. Because it is too difficult and expensive to test for all of these pathogens, "indicator" species have been used since the 1920s in an attempt to assess the possibility that viable human pathogens are also present. **An indicator organism is an organism which, by its presence, suggests the concurrent occurrence of other organisms.** In the case of shellfish harvesting and contact recreation waters, **coliform are presently used to assess the degree of public health threat.** Coliform bacteria are present in the fecal material of warm-blooded animals in large numbers. When a certain concentration of fecal coliform is reached (14 fecal coliform per 100 milliliters (ml) of sample in the case of shellfish areas, and 200 fecal coliform per 100 ml in the case of swimming areas), the area is considered unsafe for these purposes. The fecal coliform indicate that fecal material from warm-blooded animals is present and that human pathogens could also be present. For the most part, the bacteria of the fecal-coliform group are not pathogenic in themselves; however, their presence is associated with other organisms which cause disease in humans. Shellfish harvesting areas are presently classified based on the interrelationship between various sources of pollution, bacteria levels in the water, and the association between fecal coliforms and human pathogens.

This Sounds Good, So What's the Problem?

As simple and straightforward as the previous concept may sound, there are some fundamental problems. Does the presence of fecal coliform always suggest a public health threat? If it can be shown that the fecal coliform being measured originated from human sewage or wastes, most would agree that a health risk is indicated. The problem, however, is that numerous warm-blooded animals (dogs, birds, horses, rodents, etc.) also carry and defecate fecal coliforms. The health risk and implication of the presence of fecal coliform originating from non-human sources has not been determined. **In the absence of this information, and due to the inability to determine the origin of the fecal coliform observed in monitoring samples, we must assume the health risk is the same as if the fecal coliform were of human origin.**

Sources of Pollution: Keeping Them All in Perspective

Now that we have a basic understanding of what constitutes pollution and how we measure it, the next step is to determine where it all comes from. Regarding bacterial pollution, there are a number of sources: failing septic systems, stormwater runoff, sanitary waste discharges from marine craft, municipal wastewater discharges, various point source discharges, waterfowl and wildlife. What follows is a discussion of each of these sources and how they have been determined to affect Buttermilk Bay.

Failing Septic Systems

During the course of the "Buttermilk Bay Study," a number of failing septic systems, as evidenced by discharge on top of the ground, were discovered, and local health officials ordered their repair. These types of failures are the most immediate threat to the public health, especially in situations where the overflow has a surface route to the water. Present regulation (Title 5 of the Massachusetts Environmental Code) gives full authority to the local Boards of Health to require failing septic systems to be repaired.

In addition to these "overt" types of septic system failures, the potential for pathogen transport to the Bay through groundwater was also investigated. Analyses of groundwater near the Bay containing discharge from septic systems supports the contention that, generally, the soils in the area are effective in removing enteric bacteria from wastewater after a few yards of passage through the soil. Although properly functioning septic systems (no observed overflow) were generally found not to contribute to the indicator bacteria levels in the Bay, there is still much concern that viral pathogens, which are much smaller and hence less filtered by the native soils, may reach the Bay undetected in certain cases. This contention is based on a review of published studies from Long Island where entrainment of viruses in groundwater occurred, and viruses were found at distances up to 200 feet from the source. These studies are particularly relevant to our area since the soil types in the Long Island studies were similar to those in Buttermilk Bay.

In addition to viruses, the nutrient inputs to the Bay from septic systems may be causing increased bacteria levels by supplying direct and secondary nutrients. A final report on our findings relative to septic systems will be submitted to the Environmental Protection Agency (EPA) for review in the coming months.

Stormwater Runoff

At least three years of site-specific data from Buttermilk Bay, as well as data produced nationwide, have pointed to stormwater as a major source of bacterial contamination. Over 22 discharge points into Buttermilk Bay were investigated. No illegal sanitary hookups to stormwater pipes were found. However, during rain events the stormwater pipes were found to discharge significant amounts of bacteria. Because the shellfish sanitation program mandates sampling be performed during "adverse pollution conditions," the effect of stormwater discharge containing high levels of bacteria is acutely felt.

Where do the coliform in stormwater come from? We should keep in mind that paved roads, connected to the Bay through drainpipes, allow surface-deposited wastes new pathways to the Bay. Pet wastes, bird wastes, wastes from overflowing septic systems once remote to the Bay, now find a surface route into the Bay causing contamination.

Under a grant from the EPA, two of the main "offending" drains will no longer flow directly into the Bay. In the case of the Electric Avenue discharge pipe, a structure, much in appearance like a large septic system, will receive the stormwater flow and discharge it to the ground adjacent to the Bay. Monitoring wells will be installed near the discharge points to determine the effectiveness of this method. Using a similar principle, the Red Brook drain in Wareham will be diverted into a ponding area where the water can percolate naturally through the soil before it reaches the Bay. If these methods prove effective, other drains in the Bay can be corrected by local effort. Recent allocation of funds through the Transportation Bond Issue may soon allow towns to apply for funds to correct some of these drainage problems. This funding source, as well as funds which may become available through the state's Non-Point Source Pollution Program, augmented by each town's efforts, can make a difference.

Discharge From Marine Craft

In many encounters with residents of the Bay area, the issue of sanitary wastes from boats and marina operations has come up. This issue has received considerable attention by both the Barnstable County Shellfish Advisory Committee and the Cape Cod Marine Water Quality Task Force. A survey, recently published by the Task Force, indicated that there are less than five pump-out facilities servicing the entire Barnstable County. In response to letters from the Shellfish Advisory Committee and others, the State Executive Office of Environmental Affairs (EOEA) has recently formed its own task force to resolve the issue. A document recently compiled by the EOEA has underscored the complexity of the issue both politically and technically. Our efforts in this area will be to "dog the heels" of the state task force and make sure that the effort toward resolving the issue of proper disposal of marine sanitary wastes will not wane.

The question of the actual impact of present discharge practices from marine craft on embayments is a difficult one. The magnitude of the problem is obscured primarily by its intermittent nature. It is generally felt, however, that the immediate goal should be to investigate all avenues that will help provide boat owners with a method and incentives for disposing of sanitary wastes in an environmentally sound manner. In the case of Buttermilk Bay, the marinas do not contain boats large enough to be a problem.

Wastewater Discharges

Of primary concern to Buttermilk Bay area residents has been the sanitary discharge from the Massachusetts Maritime Academy (MMA). In 1985 the Division of Water Pollution Control (Department of Environmental Quality Engineering) sampled the discharge from this facility extensively and found areas of non-compliance. Since that time, the facility has made a number of recommended improvements both in equipment and sampling. The state reports that MMA has been in compliance since the fall of 1986. Study by the Food and Drug Administration (FDA) (Carr, 1987) has indicated that contamination from this source could reach the entrance to Buttermilk Bay in the event of a plant failure. In response to numerous inquiries regarding this discharge, we will be attempting, in the coming months, to verify the proper treatment of wastes from this facility.

In addition to the discharge from MMA and other businesses and industry, Buzzards Bay receives the effluent from five municipal wastewater discharges. Periodically, the Division of Water Pollution Control monitors the discharge of these plants as part of the requirements of the Federal Clean Waters Act, determining whether compliance with appropriate regulations is attained.

Waterfowl, Wildlife and Pets on the Beach: Where Will it all End?

We should clearly understand that animal wastes in the water closely equate to human wastes. Animals produce fecal coliform, indistinguishable from one another and from those produced by humans. Since the possibility of human origin of fecal coliform in our monitoring samples can not be discounted, the conservative approach of assuming a public health threat, when certain levels are reached, has been adopted.

What can we do? Regarding pet waste, a simple measure of collecting and disposing of our pet wastes properly will help. Our study in Buttermilk Bay has confirmed that animal wastes on the beach does have an effect. This effect is increased when the wastes become entangled in the wrack weed that washes up on the beach. A number of towns have adopted a "pooper scooper" law which is designed to encourage pet owners to be responsible for their pet's waste. Regarding waterfowl and wildlife, there is a certain component we can do nothing about. However, studies have shown them to be a significant contributor of bacteria and fecal matter. The recent regulations passed in some towns that prohibit the feeding of waterfowl are designed to minimize man's interference with the natural migration of Canada geese and other waterfowl, and discourage their congregating in recreational areas.

Is the Whole Marine Pollution Problem Too Big? What Can I Do?

A famous cartoon character once said, "We have met the enemy, and they are us!" We have indeed, by our love of the water and desire to live near it, become the problem. The ability of our marine environment to handle the wastes we produce and discharge into it is being exceeded. It is not too late to "turn the tide." While we are, indeed, the problem, we are also the solution. Behind each door, small successive steps toward the solution can be taken. Proper maintenance of septic systems, proper handling of pet wastes and observance of local by-laws and regulations pertaining to control of surface water pollution all move toward the solution. Singularly and collectively, citizen participation in forums and workshops as well as political involvement make a difference.

While individual responsibility plays a major role in reclaiming clean waters, some of the problems can only be solved by a commitment of resources. Stormwater treatment systems, upgrading of municipal wastewater treatment systems, pump-out facilities for marine craft, personnel to monitor compliance, etc. all require money and political resolve. As citizens, we can stay involved, informed and interactive with our representatives in local, state and federal government. It is neither too big of a problem, nor too late to correct our past mistakes. Together we can make the difference and have clean waters for now and the future.

NON-POINT SOURCE POLLUTION AND ITS REMEDIATION: EVALUATION FACTORS FOR MANAGEMENT ALTERNATIVES

Virginia T. Treworgy and Marc J. Garrett
GHR Engineering Associates, Inc.
109 Rhode Island Road
Lakeville, MA 02347

Introduction

Pollution impacts on both groundwater and surface water resources have become a paramount public concern. Point sources, those easily identified industrial, wastewater and sewage discharges, have been regulated through a variety of regulatory controls (e.g. National Pollutant Discharge Elimination System (NPDES) program). Public awareness regarding the critical nature of point sources of pollution has provided the catalyst for cleanup projects which have improved national water quality. Unfortunately, these successes have only scratched the surface of the water pollution problem we presently face.

Non-point source pollution (pollution from stormwater drainage, overland runoff, groundwater discharge and airborne fallout) was not generally recognized until the late 1960s (Novotny and Chesters 1981). Consequently, it is now being realized that significant water pollution problems are more far-reaching than the remediation of those traditional point source discharges. Statistically, non-point source pollution accounts for more than 50% of the total water quality problem today.

Non-point source pollution occurs in several unobtrusive and insidious ways. Its impacts are only now being identified and addressed by the environmental regulatory community. Unfortunately, the present responsibility of remediating these problems has been left to fiscally constrained state and local authorities or non-profit citizens' groups. This approach has led to limited successes in confined water bodies such as lakes, ponds, and impoundments, where the extent of the waterbody can be easily defined, as can its associated interest group. Shorelines, bays, rivers and streams do not provide the same opportunity for defining a public interest. This public interest or coalition support is a key ingredient required by any interested party (i.e. shellfishermen) in attempting to address these water pollution issues.

Background and Statement of Problem

The issue of non-point source pollution concerns coastal as well as inland water resources. However, for the purposes of this paper, we will deal specifically with the problem as it relates to shellfish and estuaries.

Current management of shellfishing in coastal areas of Massachusetts is based primarily on the quality, with regard to bacteria, of the overlying water. In recent years, there has been a significant increase in the number of shellfishing area closures due to elevated bacteria levels in the overlying waters. These closures are mandated under Massachusetts General Law, Chapter 130, Sections 17A, 74 and 74A. These regulations use fecal-coliform bacteria levels as the indicator organism for monitoring water quality and managing the coastal shellfishery, and they incorporate standards established by the U.S. Food and Drug Administration as part of the National Shellfish Sanitation Program (NSSP).

The recent increase in shellfish area closures is the result of a number of factors, including changes in land use and land management practices, increased development in coastal areas and a stepped up and more sophisticated monitoring program by the Department of Environmental Quality Engineering (DEQE) and the Division of Marine Fisheries (DMF) which has focused on testing in areas likely to be contaminated. This last factor has accelerated closure actions, generated a public perception that coastal water quality has deteriorated rapidly in the past five years, and increased public awareness of the sensitivity of shellfishing areas to bacterial pollution.

There are many potential sources of bacterial pollution in coastal areas. These include runoff from roads, farms and private developments; groundwater discharges from septic systems and other sources (e.g., leaching catch basins); boat bilges and holding tanks. Pollution sources may be located adjacent to shellfishing areas or many miles inland along rivers and streams which eventually discharge into coastal embayments.

Proximity of the source to the shellfishery is but one of many physical factors affecting the distribution and subsequent dissipation of contamination. The geological setting is also important in determining transport pathways, with soil types, surface and bedrock topography and groundwater flow patterns playing a major role. The layout of man-made systems such as roads, storm drains, sewers and all manner of buildings frequently alters the natural drainage patterns. Residential/recreational land-use patterns such as vacation versus year-round habitation can also affect pollution patterns in coastal areas. Where runoff and/or other non-point sources contribute to bacterial loading, weather and rainfall patterns can play a central role in predicting and potentially mitigating contamination episodes. Finally, current and circulation patterns in the coastal and estuarine environments affect the capacity of the receiving area to dissipate pollutants.

Development of sound management programs must also take into account new advances in monitoring techniques and in regulatory criteria used for managing shellfishing and other sensitive uses of water resources along the coast. Advances in indicator test procedures and virology are likely to result in changes in the regulatory standards for managing shellfish water quality at some time in the next five years.

Economics of Non-Point Source Pollution Remediation

The major issue that confronts the shellfishing community when trying to address the problem is whether the solution of any specific non-point source pollution problem is cost effective and accepted by the citizenry. Every water resource has its own economic value to a specific community or interested group. The reality is that the loss of a specific resource must represent a significant economic hardship to justify the costs associated with its restoration. Generically, economics is the science that deals with the production, distribution and consumption of wealth or resources while contending with the problems of cost. Economic strategies or plans are generated to maximize use and consumption while minimizing cost and impact. This holds true in finance as well as non-point source assessment and remediation. Management plans, financial or ecological, are designed to address this concept. For the purposes of this paper, the term economics will refer to all forms of use, production and consumption placed on estuaries. Therefore, value placed upon a resource does not have to represent a dollar value, only an intrinsic one.

The loss of a specific shellfishery, of course, presents economic impacts easily equated with dollar values to the community of concern. The present rate of closures has reached an alarming pace, and, in some instances, this has meant critical economic hardship for certain communities. Not only are hardships directed toward the commercial fishing community, but also to the recreational fishermen. These interests can, in several coastal communities, provide the basis for popular support of these non-point source issues. This support must be utilized to force local agencies to consider the remediation of non-point source problems as a critical need. At present, GHR Engineering Associates, Inc. (GHR) has been involved in several such projects at both the state and local levels. Locally, boards of health, watershed associates, and citizen action committees have sought help and expertise in addressing their own local concerns. Of course, economics is just one factor to be considered in developing alternatives for non-point source management. Our approach in the identification of non-point source problems and evaluation of proper and feasible alternatives has been accepted and included in the DEQE Final Draft Non-Point Source Management Plan (1988). The following section summarizes the technical approach as included in this reference.

Evaluation of Alternatives for Non-Point Source Management

The identification and evaluation of remedial alternatives proceeds in several steps. A diagnostic process must take place to identify pollution sources and pathways for bacterial loading. Restoration and management options, for both watershed and instream application, must then be screened to identify the remedial actions that most effectively address site problems and meet general goals and objectives. Remedial alternatives for consideration at a given site include a wide range of options as shown in the following table:

TABLE 1.

TECHNOLOGY ALTERNATIVES FOR NON-POINT SOURCE MANAGEMENT

WATERSHED APPLICATIONS	INSTREAM APPLICATIONS
Zoning/land use planning	Macrophyte harvesting
Sanitary sewers	Biocidal treatment
Stormwater diversion	Water level control
Maintenance and upgrade of outdated disposal systems	Habitat management
Detention basins	Hypolimnetic aeration or withdrawal
Bank and slope stabilization	Dredging
Increased street sweeping	Bottom sealing or sediment treatment
Minimum lawn fertilizer use	Dilution and flushing
Eliminate garbage disposal units	Nutrient inactivation
Eliminate phosphate detergents	
Restrict boating activity	

A key consideration in the screening of technologies is the ability of an alternative to meet the general goals and objectives for any non-point source project which are:

1. Slow or reverse the bacterial loading process.
2. Restore or maintain the general aesthetic quality of water bodies at study locations.
3. Assure a minimal water quality of either primary or secondary recreational contact water.
4. Design a remediation plan which can be easily applied to other areas within the watershed.

Meeting any of these objectives, to a greater or lesser extent, will largely be determined by cost, by ease of operation of the controls, and by agency and public input. In order to factor all of the variables affecting remedial alternative screening and selection, a detailed evaluation model must be developed for technology screening. Standardization is important so that experience gained through case studies and individual non-point source projects can have wider application throughout a watershed or state.

The following criteria have been developed at GHR to assess the technology alternatives discussed above.

1. Technical Evaluation
    a. Performance
    b. Reliability
    c. Implementability
    d. Safety considerations

2. Institutional Evaluation
    a. Applicable or relevant and appropriate regulatory requirements
    b. Ability or alternative to attain water quality standards
    c. Public education and community awareness

3. Environmental Impact Evaluation
    a. Beneficial effects of the alternative
    b. Adverse effects of the alternative

4. Cost Evaluation
    a. Capital costs
    b. Operation and maintenance costs
    c. Present worth analyses

Detailed evaluations will provide the basis for regulatory agency and public review of remedial actions which could be applied to a given site. The evaluation screening will result in a hierarchical rating of management practices. This hierarchical rating becomes the basis for important agency decisions regarding a successful non-point source study. Whatever remedial action or alternative is selected, however, the key factor is economics. An example of the application of this process to a real case is GHR's experience in the Westport River. A description of the case study follows.

East Branch Westport River Bacteriological Evaluation: A Case Study

The primary objective of this project was to observe the patterns of bacterial contamination in the estuary both seasonally and following rainfall events. This effort was undertaken to establish a data base which could be used to assess the feasibility of instituting conditional opening of shellfishing areas which have been closed due to the presence of fecal-coliform bacteria in densities exceeding the established maximum levels. The town's consideration of conditional openings was based on the local economic hardship created by the unconditional closure by the DEQE.

The East Branch was divided into geographical areas according to physical features and current shellfishing status. The A-Zone included upstream areas where the estuary is relatively narrow and bacteria levels have consistently exceeded acceptable levels for shellfishing. The B-Zone included the middle portion of the estuary where it is generally wide and shallow and where bacteria levels fluctuate above and below acceptable shellfishing levels. The C-Zone included the lower estuary where the morphology is similar to the B-Zone and shellfishing is still permitted. The D-Zone included the Westport Harbor below the Route 88 bridge where monitoring was limited to one station at the bridge to measure outflow from the study area.

The pattern of bacterial contamination in the estuary clearly indicated that the primary sources are located in the upper estuary and that the lower reaches of the estuary serve as a dilution/dispersion area. The impact of runoff from tributary streams draining the lower areas is localized and short-lived due to the small drainage areas and flows of these streams in relation to the upstream drainage area. It was clear from both the data generated during this investigation and other recent studies in the watershed that rainfall and subsequent overland stormwater flow from agricultural areas initiated episodes of bacterial contamination in the estuary. A review of the data presented in the study (GHR 1987) dramatically demonstrates the decrease in fecal-coliform levels throughout the estuary following a rainfall event. The study also identified an incompatibility between certain agricultural land uses, existing drainage infrastructure and shellfishing.

Conclusion

When developing a high-payoff program to combat pollution from non-point sources, it is vital to aim the control strategy and supporting resources at those watersheds, and the land areas within them, where pollutants are most likely to be effectively and efficiently controlled. This targeting has four basic aspects:

1. Determine the priority water bodies within a jurisdiction for which the source of the existing or potential water quality problem is "non-point."
2. Of those priority water bodies identified, decide which ones should receive concentrated attention.
3. Establish which land-use activities within the watershed are responsible for delivering pollutants to the water body.
4. Design a system of BMPs that will best control the delivery of pollutants to the water bodies in the watershed.

The first two targeting mechanisms identify the water bodies toward which efforts should be directed. The last two fine-tune the controls and the specific locations and activities at which they should be aimed. The outcome of these determinations will lay a good foundation for the institutional framework chosen for management of the program.

References

Division of Environmental Quality Engineering. 1988. Non-Point Source Management Plan; Final Draft, Division of Water Pollution Control.

Novotny, V. and G. Chesters. 1981. Handbook of Non-Point Pollution: Sources and Management. New York, NY: Van Nostrand Pemhold Env. Eng. Series, 555 pp.

USDHH. 1986. Sanitation of Shellfish Growing Areas- Part I. Center for Food Safety and Applied Nutrition, Washington, DC.

ALTERNATIVE INDICATORS FOR THE SANITARY QUALITY OF SHELLFISH RESOURCES

Robert A. Duncanson
Water Quality Laboratory
Town of Chatham
Chatham, MA 02633

and

Dale L. Saad
Town of Barnstable Health Department
Hyannis, MA 02601

The use of bacterial species as indicators of the sanitary quality of water had its origins in the early part of this century. The indicator concept was begun as a protective measure for potable water supplies in response to widespread outbreaks of waterborne diseases such as typhoid and cholera. The use of bacterial indicators in the shellfish arena began in the 1920s following several outbreaks of typhoid linked to oysters. Since the introduction of bacterial standards for both shellfish growing waters and market samples, the incidence of shellfish-borne disease has declined. The question thus becomes why should consideration be given to a change in the indicator system which appears to have been working adequately for over 60 years?

The answer to the question posed above is multifaceted. Although the incidence of classical shellfish-borne diseases (typhoid and cholera) have declined, there are increasing numbers of disease outbreaks attributed to shellfish. This would indicate that the pathogenic agents involved in these more recent outbreaks are not the classical pathogens which the original indicator system was meant to warn of. Indeed, in many recent outbreaks other bacteria, such as Aeromonas hydrophila, Vibrio parahemolyticus and V. vulnificus, have been the cause. This, combined with advances in microbiological techniques and a greater understanding of microbial ecology, has opened to question some of the early assumptions upon which usage of the current indicator is based.

Indicator Characteristics

In order to evaluate the current indicator and any potential alternative, it is necessary to understand what the indicator should be doing. As commonly defined, a water quality indicator (potable, recreational or shellfish) "should indicate the possible presence of more serious pathogens." This definition implies a relationship between the indicator and the pathogen. A "good" indicator is said to have the following characteristics: 1) it should be consistently and exclusively associated with the source of the pathogen(s), 2) it should be present in numbers, relative to the pathogen, high enough to reflect accurately the potential presence of the pathogen, 3) it should approach the resistance to environmental stress and disinfection of the most resistant pathogen, 4) it should not multiply in the aquatic environment, and 5) it should be countable by easy, inexpensive methods with precision, accuracy and specificity. It is becoming evident that the currently used indicator system for shellfish sanitation may be flawed in meeting one or more of the above requirements.

The Current Indicator

The current standards for the sanitary safety of shellfish rely on the use of the fecal-coliform indicator. Fecal coliform is a group comprised of at least two bacterial species, Escherichia coli and Klebsiella spp. Until recently it was assumed that the fecal-coliform test, as recommended, measured organisms whose origin was the fecal material of warm-blooded animals. However, studies have shown that some Klebsiella spp. can multiply to high levels in carbohydrate-enriched waters in the absence of fecal wastes. Other studies have shown that the resistance of coliforms to disinfection and environmental stress may be much lower than that of the pathogens, especially the viruses. There is also mounting evidence that some coliforms may multiply in, or at least survive for extended periods in, some aquatic environments such as marshes and sediments. This limited discussion of some of the potential problems with the current indicator system should result in at least an examination of potential alternatives.

Probably the simplest solution for determining the sanitary quality of water would be to look for the pathogen(s) of concern. Currently this is not done for several reasons. Fecal waste may contain an increasing list of potential pathogens depending on the population contributing and advances in laboratory techniques. At least 114 types of human enteric viruses have been identified in sewage. A further problem is that many of the pathogens of concern can only be detected by time-consuming, expensive and labor-intensive methods. Many of the viral agents have yet to be identified and others can not be grown in the laboratory.

Alternative Indicators

This, then, brings us back to the need for an indicator of the potential presence of the pathogen. Alternatives to the current indicator system can be divided into four categories: bacteria, yeasts, phage/viruses and chemicals.

Included in the bacteria list are organisms such as E. coli which was the original indicator of the 1900s. Methodological problems forced tests for E. coli to be broadened into the total coliform and fecal-coliform groups. E. coli, the only coliform exclusively associated with the gastrointestinal tract, thus had its effectiveness as a fecal-waste indicator lessened by being grouped with organisms which had non-fecal sources. Recent advances have produced rapid, easy, inexpensive and specific methods for enumeration of E. coli. E. coli, along with Enterococci, a more fecal-specific component of the fecal streptococci, have recently been recommended by the Environmental Protection Agency (EPA) as the indicators of choice for recreational waters because they correlate with illness better than do total or fecal coliforms.

The fecal coliform/fecal streptococci ratio gained a lot of attention as a potential indicator system when it was shown that human fecal waste produced a ratio greater than 4.0 while other warm-blooded animals produced ratios less than 0.7. Unfortunately, further research showed that the fecal waste of gulls, frequent inhabitants of shellfish waters, often produced ratios in excess of 4.0.

Several anaerobic bacteria have potential as indicators. One, which has been used extensively as a conservative tracer of sewage sludge, is Clostridium perfringens spores. Its usefulness as an indicator of recent pollution and the presence of pathogens is limited due to the extended survival of the spores. Other anaerobic bacteria which may be useful alternatives are Bifidobacteria spp. and Bacteriodes fragilis. The former has a specific association with the fecal waste of mammals, and the latter has been detected in 100% of the human fecal samples examined. Problems with methodology must be overcome before these species can be properly evaluated as indicators.

Other potential bacterial indicators include Vibrio parahemolyticus, Aeromonas hydrophila and Pseudomonas aeruginosa. V. parahemolyticus is a normal inhabitant of marine waters. Although this organism appears to respond to nutrient loading resulting from sewage disposal, its ability to grow in the marine environment limits its use as an indicator of pathogens. Aeromonas responds to nutrient loading in freshwaters and, like Pseudomonas, can multiply in aquatic environments, thus limiting its usefulness. Pseudomonas is used in some areas as an indicator of the sanitary quality of swimming pools and hot tubs.

Candida albicans, a member of the yeast group, has also been studied as a sewage indicator. Initial results are not promising as it has been detected in significant numbers in pristine areas and not found in areas known to be impacted by sewage.

The phage/virus group contains three classes of potential alternative indicators: Bacteriophages (bacterial viruses), Coliphages (bacterial viruses which specifically infect E. coli) and the Enteroviruses themselves. The problems with the latter group have been discussed earlier. By being viral in nature, the first two overcome one of the major arguments against bacterial indicators, i.e., they may not behave like the viral pathogens. More research is needed to see how well phages simulate enteric viruses. Several methods have been developed for the phages which will allow these organisms to be evaluated as indicators.

The final potential alternative indicator to be discussed is the chemical coprostanol. This compound is present in human fecal material and has been utilized as a tracer of sewage sludge. However, as an indicator for routine use, several problems must first be overcome. The methodology is expensive and time consuming. There are also concerns over some natural sources of coprostanol in the environment.

Summary

In summary, there are several potential alternatives to the currently used fecal-coliform indicator system for the sanitary quality of shellfish growing waters and the shellfish themselves. The current indicator system will not change quickly since all of the alternatives have important questions which must be answered. Information must be collected on: a) the human fecal specificity of any alternative, b) some correlation, preferably positive, between the alternative indicator and the risk of human disease transmission from consumption of the product, c) the potential for disease transmission via the shellfish route from sources other than human fecal waste (i.e. waterfowl) and whether the alternative will protect against that risk, d) the survivability and transport characteristics of the alternative relative to the pathogen(s) of concern.

A final point for consideration is that a change in the existing indicator system to one which overcomes some of the current problems may not result in major changes in the way the shellfish sanitation program operates or its impact on the resource.

SHELLFISH BAG RELAYING SYSTEMS IN CONNECTICUT

Timothy C. Visel[1], Nancy E. Follini[2], Joseph J. Gilbert[2], and Lance L. Stewart[3]

[1] Connecticut Sea Grant Marine Advisory Program
University of Connecticut
Avery Point, Groton, CT 06340

[2] Briarpatch Enterprises, Inc.
Stonington, CT 06378

[3] National Undersea Research Center
University of Connecticut
Avery Point, Groton, CT 06340

Abstract

In Connecticut, container relaying has been an approved method to cleanse oysters of bacterial contaminants for more than ten years. Oysters are relayed in nylon-mesh bags attached to a bottom longline. With modifications, this method has been used to relay hard clams (quahogs) in VEXAR bags with equal success. Bag relaying continues to be an effective way for shellfishermen to reduce normal relay losses and utilize a resource that formerly was wasted in many Connecticut shoreline towns.

Introduction

The relaying of oysters and hard clams (quahogs) from closed areas to certified waters for purification is an important industry procedure in Connecticut. Historically, the transplanting of shellfish such as seed oysters from areas deemed unsafe for direct shellfishing to deeper, cleaner waters has been an accepted industry practice. Many of these procedures originated when shallow grow-out areas (such as The Beach in West Haven, Connecticut) were closed in 1918 due to pollution. Later, adult shellfish were transplanted, to allow them to cleanse themselves of bacteria in shorter time periods. Such relays relied upon the storm protection of shore features such as islands in the western section of Long Island Sound. Areas suitable for relays were quickly leased, and the remaining potential sites were closed to commercial shellfishing.

In spite of the success of the relay process, losses do occur . The process varies from site to site, and losses occur through predation, breakage in the harvesting process, and poor retrieval procedures. In Connecticut, it is estimated that up to 40% of the relayed stock can be lost to the industry as a result of the above factors, especially for short relays of less than 180 days. The shellfish industry has expanded rapidly (leasing has increased 90% in state waters) in eastern Connecticut where environmental conditions such as deep water, strong tides and storm losses make open water relay recovery difficult, if not impossible. A new relay method for clams and oysters was developed in 1978 incorporating large mesh bags on a longline (Visel, 1978). Initial results of this relay system reduced losses to less than 10%.

Bag Relay Studies

To our knowledge, the first bag relay occurred on August 7, 1978 (Visel, 1980). After receiving permission from the Connecticut Department of Health Services (DOHS) and the local Madison Shellfish Commission, 15 bushels of oysters were relayed in mesh bags in 10 feet of water off the shore of Madison, Connecticut, using a longline trawl similar to that traditionally used for lobster pot trawls.

Equipment and Deployment Methods

In the 1978 Madison relay, oysters were loosely packed (1/2 bushel) in one-bushel capacity nylon mesh bags. Mesh bags were cut from a rectangular sheet of nylon two-inch mesh number 21 thread seine webbing. The sheet of webbing was then folded in half and laced along one side and the bottom edge, creating a bag approximately 40 inches across and 40 inches deep.

To complete the bag, a nylon drawstring was passed through the top meshes, creating a continuous loop when tied end to end. Utilizing this drawstring, mesh relay bags were attached to a lobster trawl line. The longline consisted of 5/16-inch polypropylene lobster pot rope. Bights (loops) of line six inches in diameter were placed approximately every 10 feet with a single overhand knot. Two trawls 150 feet long, each containing 15 relay bags, were used with lobster pot buoys at each end to mark recovery. No additional weight other than the oysters themselves kept the trawls on the bottom. In setting the trawl, each bag drawstring was drawn tight and tied to the bight of line with half hitches. It took approximately 30 minutes to set each trawl.

Relay Procedures

The bag relay procedures utilized by Briarpatch Enterprises, Inc., of Stonington, Connecticut, can be applied to most bag relay operations. Briarpatch Enterprises, Inc. has been bag relaying hard clams, Mercenaria mercenaria, and oysters, Crassostrea virginica, since August 1985. In the summer of 1986, Briarpatch redesigned its depurating bag, replacing disposable VEXAR with reusable nylon webbing.

A water temperature of 50° F or above for both harvest and transplant sites is required for all relay operations in Connecticut, according to NSSP guidelines (1988 revision) and DOHS regulations. (Water temperatures below 50° F have been shown to inhibit purification of relayed shellfish.)

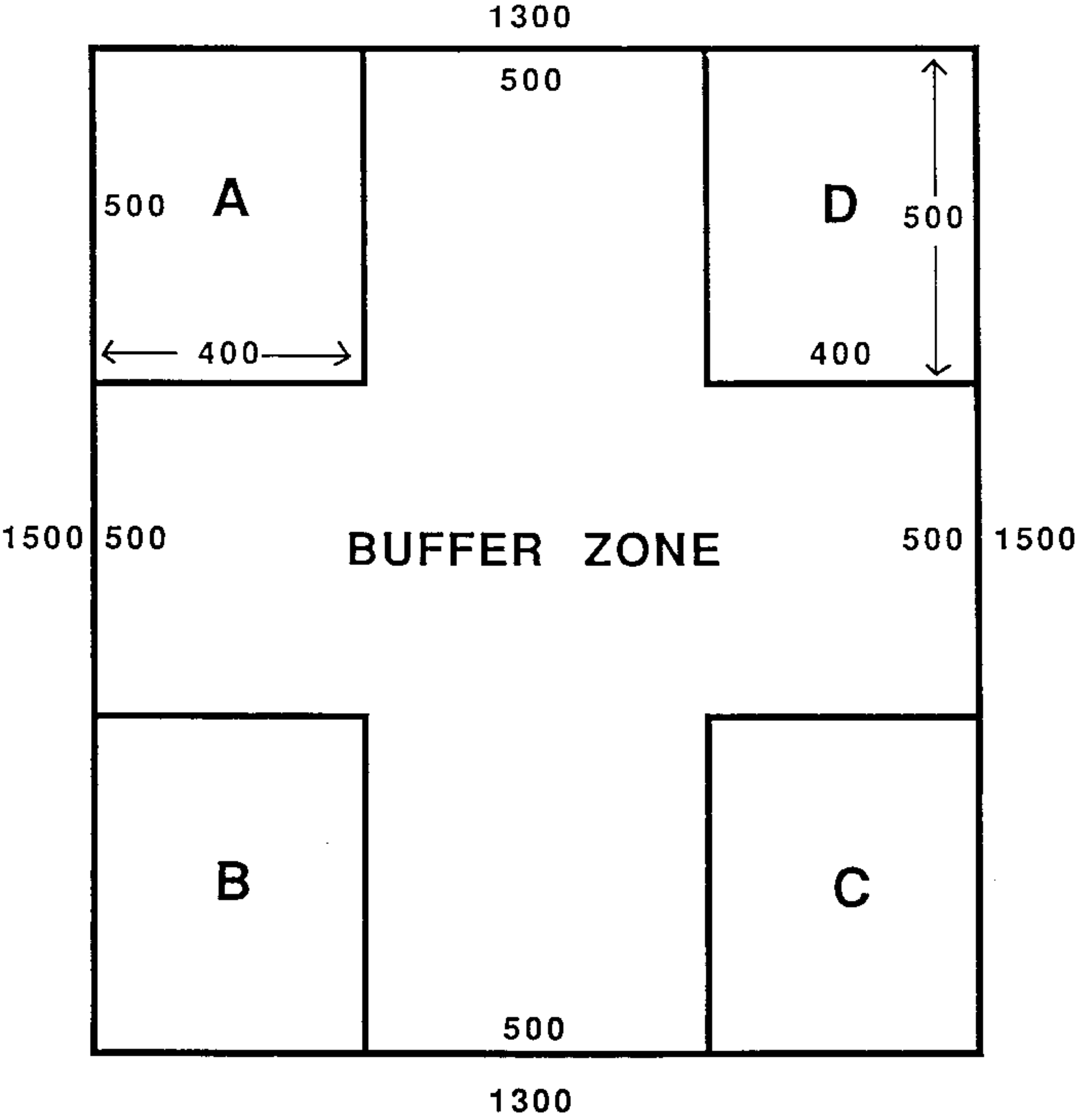
The first step in the process is the identification of an exploitable population of shellfish. The sources of contaminated shellfish vary; Briarpatch Enterprises has processed product from Pawcatuck River, Mystic River, Tom's Creek, Neck River, East River, Indian River, and Housatonic River. When a suitable source is located, a sample from each source is provided to the DOHS at the start of the transplanting operation for bacterial examination.

Next, a depuration site in certified water with a hard bottom is selected and the lot is designed. The depuration lot designed by Briarpatch Enterprises is divided into four sublots (A, B, C, and D), separated by 500-foot buffer zones and so staked (see Figure 1).

Next, proper town and state harvest permits are obtained, sublot A is officially closed, and a DOHS transplant permit is obtained in preparation for receiving shellfish.

Shellfish are removed from closed areas, using a hydraulic clam dredge, a bull rake, or oyster dredge. The product, hard clams or oysters, are sorted from the culling table directly into the depurating bags. The capacity of each bag is controlled by using a bottomless five-gallon bucket as a measure. The bucket is inserted into the mouth of a bag, filled to capacity, and then lifted so as to funnel shellfish into the bag.

Figure 1 Diagram of Four Depuration Lots
(all measurements in feet)



Note: All corners are buoyed.

Full bags are stacked forward of the work area until harvest operation is suspended. Enroute from the contaminated area to the depuration lot, the full bags are spread out in straight lines on the clear area of the work deck. The bags are tied on polypropylene floating lines at 12-foot intervals with up to 30 bags per string. Upon reaching the lot, the vessel is positioned on a starting point by the use of ranges, position is recorded, and strings of bagged shellfish are deployed off the stern while the vessel moves slowly forward. Each bag must be handled to evenly distribute the shellfish as it is dropped. A finishing point position is recorded and the procedure is repeated for each string. When several days' product has been relayed to lot A, the lot is closed, the transplant permit is cancelled; a transplant permit is obtained for lot B, and the procedure is repeated. Hard clams are relayed on the same day they are removed from the closed area.

Relaying procedures are the same for clams and oysters, except for the difference in time from harvest to relay. Oysters are usually harvested with hand equipment, in lesser volumes which do not merit daily deposition to a depurating lot. Therefore, one or two days' catch may be consolidated before being bagged and relayed.

When a depuration lot's transplant permit is canceled and the lot is closed, the depurating countdown, usually 14 days, begins. During this time, security is achieved in several ways. All strings of bagged shellfish are set blind (without buoys) and are thus not visible. The 12-foot spacing of bags on the line makes retrieval without power equipment very difficult in 15- to 20-feet of water. The weight of the bags of shellfish is sufficient to resist being lifted by the occasional rod and reel drift fisherman who happens to snag one. (Reports of broken fishing lines found tangled in the equipment are common.) In addition, Briarpatch representatives and other fishermen observe their depuration lot many times per day during periods of activity.

When sufficient time passes, usually 14 days, sampling takes place in the presence of a disinterested party acting in an official capacity. Random samples of 12 shellfish are bagged, sealed, marked, and refrigerated for transport to the state laboratory. These samples are compared to the original sampling from the source bed. When satisfactory results are reported, the DOHS issues a harvest permit for the appropriate sublot.

Harvest begins with grappling along the recorded coordinates and hauling several strings of bagged shellfish aboard the vessel. The bags are removed from the line and washed with a high-pressure seawater hose to remove silt and algae from the shellfish. When washing is complete, shellfish are sorted as to shape, size, and species, then bagged and tagged for market. Product mortality is assessed for predation, cracked shells and mud clams, and recorded in the back of the shellfish log book. The log book is also a record of the source and quantity of shellfish harvested and to whom they were sold.

Upon arrival at the dock, shellfish are transferred into refrigerated vehicles for transport or onto pallets in a refrigerated area to await transport vehicles. After harvest, the lot is closed, the harvesting permit is cancelled, a new transplant permit is issued by the DOHS, and the cycle continues.

Results and Discussion

Some of the questions about bag relaying that had to be addressed were the causes and extent of mortality, the condition of the product, the configuration of the bags on the bottom, and, of course, demonstrable reduction of bacterial contamination. All bag relay programs are permitted and monitored by the Connecticut DOHS under guidelines issued on April 26, 1988.

Mortalities differ according to bottom type. Bag relays realize substantially lower mortalities than open-water relays and subsequent recovery. Stewart (1988) found that 1.5-bushel nylon bags with one-inch mesh approved by the Connecticut DOHS for hard clams at no time experienced more than one percent mortality in depuration (relay) times of one to two-and-a-half months. The product was clean, sand-free, and highly marketable in the restaurant trade.

Filling the bags to 1/3 to 1/2 capacity ensures that proper respiration posture is assumed. Underwater observations conducted by Stewart (1988) using scuba revealed that the bags flatten out on the bottom and the majority of contained hard clams bury in sediment and assume normal siphon feeding/respiration posture. Depuration grounds which allow ebb and flood bottom current achieve thoroughly adequate circulation and no restrictions are obvious. Gilbert and Follini (1989) reported that bag relay mortalities for oysters have been less than five percent. Fifty percent of the mortality is due to starfish predation, the remainder to cracked or damaged shells. Visel (1980) reported that mortalities for oysters can vary according to bottom types, with lowest mortalities, four to eight percent, occurring in hard sand bottoms, and up to 20-percent mortality in soft mud bottoms. Underwater observations of bag shape by Gilbert and Follini (1989), using scuba equipment, have helped to refine bag design to its present form which deploys very well on the bottom. Observations have shown that hard clams are able to spread out and actually dig into the bottom. Oysters were observed to be evenly distributed through the bags, in layers not more than two oysters deep.

Analysis of ten years of data compiled by Malcolm C. Shute (unpublished), Principal Environmental Sanitarian of the Connecticut DOHS, shows that bacteria levels are reduced substantially in the bag relaying process. Examples of before-and-after bacterial examinations obtained from Mr. Shute are included in Table 1.

Table 1. Bacterial Examination of Oyster and Clam Meats
Connecticut State Department of Health
Laboratory Division, Hartford, Connecticut

Date	Location (source)	Coliform organisms MPN/100 grams	Fecal organisms MPN/100 grams	Standard plate count per gram	Relay period
9/9/78	Hammonasset River oysters	3500	170	900	8/26/78
9/19/78	BED 101	78	<18	100	9/19/78
8/5/85	Tom's Creek oysters	54,000	170	8,600	7/25/85
8/5/85	BED 101	110	<18	720	8/5/85
4/27/87	Thames River hard clams	11,000	490	3,400	4/27/87
5/11/87	BED 4-A	<18	<18	1,100	5/11/87
5/18/87	Thames River hard clams	3,300	1,300	3,000	5/18/87
5/31/87	LOT A-2	130	<18	7,900	5/31/87
6/9/87	Thames River hard clams	3,300	78	22,000	6/9/87
6/21/87	LOT A-1	20	<18	680	6/21/87
4/2/88	Neck River oysters	490	330	N.A.	4/2/88
5/23/88	BED 413-D	170	45	500	5/23/88
6/16/88	Gulf Pond oysters	490	45	500	5/2/88
6/15/88	BED 413-D	4,600	<18	4,400	6/14/88

Conclusion

Research to date has shown bag relaying to be an effective and economic way for small-scale shellfishermen to cleanse polluted shellfish. The authors feel that for independent baymen, the opportunity to relay with minimum loss can sustain fisheries in areas closed to shellfishing. The limiting factor, of course, is suitable water temperatures required for relaying, and therefore relaying must be considered a supplemental or seasonal fishery.

Acknowledgement

This research was supported by the University of Connecticut Sea Grant College Program, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. The authors wish to thank Mr. Malcolm Shute, Principal Sanitarian of the Department of Health Services, Shellfish Unit, for his comments and assistance in the preparation of this report. A special thanks to Margaret Van Patten for assistance in the preparation of the manuscript, figure, and table, and to Dolores Chambers and Eleanor Minik for final reviews.

References

Gilbert, Joseph J. and Nancy E. Follini. 1989. "A Report on the Procedures for Bag Relaying." Unpublished. 6 pp.

National Shellfish Sanitation Program Manual of Operations for Sanitation of Shellfish Growing Areas, 1988 revision.

Shute, Malcolm C. 1982. "Were the Shellfish You Just Ate Safe?" Connecticut Health Bulletin, Vol. 96, #4. pp 188-191.

State of Connecticut Department of Health Services, Preventable Diseases Division. 1988. "Shellfish Container Relay Operations Special Requirements." April 26, 4 pp.

Stewart, Lance L. Correspondence to Malcolm Shute. October, 1988, 3 pp.

Visel, Timothy C. Personal correspondence to Malcolm Shute, August, 1978, 2 pp.

Visel, Timothy C. 1980. "Bag Relaying and Depuration." (paper presented at FDA Relaying and Depuration Workshop, December, 1980.) Unpublished. 8 pp.

STATUS OF CONTROLLED PURIFICATION OF SHELLFISH

Santo A. Furfari
Northeast Technical Services Unit
Shellfish Sanitation Branch
Food and Drug Administration
CBC Base - Building S26
Davisville, RI 02852

Introduction

The intent of controlled purification of shellfish (also known as depuration), under current technology, is to allow shellfish to cleanse themselves of microbiological pollution. The process is short term; i.e., a minimum of two days, during which the shellfish release the microorganisms through natural processes. Longer purification times of three or four days have been needed on occasion for a variety of reasons related to the biology of the species and the seawater environment in which the shellfish are placed. Economically, it is not desirable to extend the process beyond two or three days.

Briefly, the process takes place in tanks sized and designed according to the recommendations of the National Shellfish Sanitation Program (NSSP). Seawater suitable for the shellfish is treated to kill microbes of sanitary concern. The seawater is supplied either as flow-through or recirculated. Recirculation is most prevalent.

Controlled purification is practiced intensely by industry in England, Spain, and Australia. Purification is practiced less intensely in the United States, Canada, France and New Zealand. Other countries with a history of use are Portugal, Japan, and the Philippines.

Over the past 20 years controlled purification has taken place in Maine, Massachusetts, New York, New Jersey, Delaware, Virginia, South Carolina, Florida and California. About 30 different depuration plants have been involved. At present the most active states are Maine, Massachusetts, New Jersey, and Florida, with about 12 plants operational. The reasons for the sporadic use of the process involve shellfish marketing, shellfish yield from the areas, and the nature of the shellfish industry.

The species being purified include oysters, soft clams and hard clams in the United States and mussels in other countries. A great deal of research on the process has been done to show the feasibility of purification within reasonable limits.

Problems With Start-Up

The problems getting industry started in controlled purification of shellfish usually involve the following:

1. Legal authority - Only if a state has sufficient regulations can purification plants be built and operated.
2. Industry acceptance - The local shellfish industry must be willing to accept the process as a way of doing business.
3. State acceptance - Some states cannot accept a scenario for purification because of the lack of resources to monitor the process.
4. Laboratory requirements - The NSSP requires certain laboratory testing as quality control. There is an economic factor involved. The options are:
    a) state subsidy,
    b) private laboratory,
    c) payment to a state or local laboratory, or
    d) build a laboratory and hire a part-time qualified laboratory technician.

NSSP Requirements

Most states which have regulations on depuration, or are in the process of developing them, will follow the NSSP Manual of Operations, Part II, Section I. The basic elements of the requirements include:

1. Plant sanitation
2. Designation of suitable harvest areas
3. Development of the process plan
4. Verification of process effectiveness
5. Continual monitoring of the process
6. Adequate design, construction, and operation
7. Proper shellfish handling

The requirements are technically feasible. The major economic problems consist of 1) an adequate supply of shellstock to maintain full tanks, 2) electrical power for lighting, refrigeration, seawater system, seawater treatment, etc. and 3) laboratory testing. The size of the plant will determine whether manual labor or machinery will be needed to move the shellfish. Shellfish are handled several times in the process; e.g., in basketing, washing, culling, loading into tanks, unloading, re-washing and culling, bagging and storing.

Harvest areas suitable for controlled purification have water which is only moderately polluted. The median coliform count may not exceed 700/100 ml or the median fecal-coliform count may not exceed 88/100 ml. These values may seem very restrictive, but they are necessary in view of what the process is expected to do.

Process verification requires an intense sampling program prior to approval for marketing. This may involve two or more weeks and several depuration runs with proof of effectiveness by data analysis by the state agency. During this period proper plant operation should be stressed. Samples of water and shellfish are taken from various phases of the process. This sampling will be more intense than during routine operations. The shellfish must meet final process requirements of the NSSP.

The design of the system should be reviewed by the state agency to forestall construction problems. Although seawater systems are quite common, there are some special features particular to a depuration plant. These involve sanitation and cleanliness.

The operations and shellfish handling must be planned carefully, since it would be intolerable to mix up polluted and treated shellfish.

Summary

Although controlled purification of shellfish is not widely practiced in the United States, the process is accepted by the NSSP, the technology is available, many states have the necessary regulations in place, and the practice may be a viable alternative for the industry in certain situations. The industry will have to weigh the advantages and disadvantages and determine how to minimize the costs of the process on a case by case basis.

OPTIONS FOR MASSACHUSETTS SHELLFISHERIES

H. Karl Rask
Cape Cod Extension Service
Deeds and Probate Building
Barnstable, MA 02630

Introduction

Non-point source fecal-coliform contamination has been responsible for many shellfish closures in every coastal state. In Massachusetts recent closures of large expanses of marshes and other undeveloped areas have raised questions about the possible sources of coliform bacteria and the extent of the actual public health significance associated with them.

Pros and Cons of the Current Standard

In Puget Sound (Washington) efforts were made to identify and repair failing septic systems within the watershed, as well as to improve small farm drainages which were thought to be significant coliform sources. After these sources were cleaned up, only minor improvements were detected in water quality. This led to testing of the sediments and stream waters flowing into the estuary, which were found to contain high concentrations of bacteria. Furthermore, the bacteria were reproducing in these areas. Sediment samples collected from one of the streams discharging into the estuary averaged over 100,000 fecal coliforms per 100 ml (the federal standard for shellfish growing waters is 14 coliforms per 100 ml).

This research showed that once there is a coliform source somewhere in an estuary, salt marsh, or feeder stream, the bacteria counts can and do reach levels above and beyond the federal standards. Whether the "source" is human or otherwise has not been determined. The actual public health significance is also unknown, since the indicator does not actually measure the presence or absence of pathogens. The standard was developed in the 1920s, under the assumption that the presence of coliform bacteria would mean that disease-causing organisms could also be present in the water. While this might be true, it is not always the case. At present, however, elevated counts in rural and undeveloped areas will result in closures in the same way as in developed, urbanized areas.

Although this standard is so conservative that it is effective, we are probably closing many areas that could remain open with no public health threat. Many of our undeveloped marsh systems are a case in point; these areas are frequently closed, but have not been significantly altered since they were last open to shellfishing.

Despite these drawbacks, the existing standard is effective. It has controlled shellfish-borne diseases since it was first implemented. Not only is this a federal standard, but it is also used by Canada and many other countries as well. Thus, any proposed changes will take a long time to implement.

In the meantime, all other states are experiencing increased shellfish closures. They have realized that a federal standard cannot be changed right away, but that they have the ability at the state level to utilize the shellfish resources in the closed areas. This is being done primarily through relay/transplant programs, through utilizing the closed areas as nursery grounds for aquacultural production, and through a limited number of privately-operated depuration facilities.

In Newburyport, Massachusetts there is a state-operated depuration facility for soft-shell clams, but depuration is not allowed in the private sector. There are municipal relay/transplant programs in which the towns can purchase contaminated shellfish for their own propagation efforts. These shellfish must be in the water for at least one spawning cycle, and are most often used for the recreational shellfisheries. Such relay programs also are not allowed in the private sector, although most shellfish specialists clearly agree that the relay method is safe and workable. The main problem cited is the "lack of enforcement ability," among others.

Because of the Massachusetts state budget situation, there are several other problems to tend to before this one gets resolved. These include transportation for the staff to and from the sampling areas, completion of the sanitary surveys by September, and the establishment of a statewide water quality monitoring program. However, with that in mind, the following is a description of some of the programs that do exist in other states.

FLORIDA: Depuration and relay of hard clams are permitted, but only from conditionally approved areas. Depuration and relay from restricted or prohibited areas are not allowed. Recently a demonstration plant for oysters has been constructed. Relays are for 14-15 days in clean water sites. Harvest is on day 15, but if it rains, the count automatically goes back to day one. After 14 days of dry weather, the oysters can be harvested. No meat counts are required prior to harvest. In general, relays are labor intensive, there is less control over the environment, and good weather is the limiting factor (it would be a very bad year if it rained every 10 days).

LOUISIANA: Depuration plants exist for oysters, using ultraviolet- and ozone-treated water.

SOUTH CAROLINA: A relay program is jointly run by the Department of Marine Resources (DMR) and the Department of Health and Environmental Control. Oysters and clams (quahogs) can be taken from restricted or conditionally approved areas for relay to clean (approved) areas. The permit process goes through both agencies; permits are first reviewed by the DMR from a resource management perspective, and, if approved, are next reviewed by the Department of Health. The applicant must go to each agency separately. Relays are for 14 days, provided temperatures are suitable, and sometimes stretch to 16-20 days. Enforcement-monitoring personnel (state-funded) must be on the relay site at all times.

One depuration plant is also licensed to operate (clams only). Plants are privately operated, but very rigorously controlled by the Department of Health, and becoming more so. The operation season is from December 15 - March 15.

NORTH CAROLINA: There is a relay program similar to that in South Carolina, but the relay period is 21 days. Depuration plants are not allowed.

VIRGINIA: There is a similar relay program in Virginia. It is very strictly monitored by the state Marine Resources Commission. The relay time is 14 days. Basket relay has recently been instituted for hard clams, as mortality is low, but this is not yet allowed for oysters. Depuration plants are not allowed.

MARYLAND: In Maryland aquacultural production of shellfish is permitted in closed waters. These shellfish can be moved from one aquaculture grant to another (clean) one under the supervision of Environmental Police Officers. Thus, closed areas can be used as nursery grounds. Grant holders have their license fee returned if the area becomes prohibited.

NEW JERSEY: New Jersey has a state-sponsored relay program administered by the Department of Environmental Protection (DEP). Relays for clams (quahogs) are conducted in a three-stage system. Shellfish are planted on lot A for 30 days, and then the lot is closed. For the next 30 days, shellfish are planted on lot B. During the following 30 days, shellfish are planted on lot C, while those on lot A are harvested, and so on. Clams can be planted all winter, but the 30-day countdown does not start until water temperatures rise above 50 ° F. Lease fees go to the DEP to help pay for enforcement, but they do not cover the total bill. A problem with expanding the program is "lack of enforcement ability" cited by the DEP, although many of the closed areas would be suitable.

A few comments about this program should be noted. If a relay schedule is for 14 or 15 days, there is less reason to bypass the system than if it is 30-60 days. It would be helpful to know what the actual cleansing time for transplanted quahogs is; perhaps seven days would be as adequate as 14, or perhaps there really is a reason for 30 days. In addition, while bacteria and stomach contents are purged in a very short time, contaminants like metals and fat-soluble pollutants such as PCBs are not. This raises another set of issues, but emphasizes the need to classify areas from which shellfish can be moved (for example, remote salt marshes with elevated bacteria counts don't have these other pollutants).

Regarding depuration in New Jersey, there is now one plant (two have closed) for depurating soft-shell clams and quahogs. Obtaining a permit for a new plant is very difficult.

NEW YORK: State-run, municipal, and private relay/transplant programs exist in New York. Town programs hire commercial diggers to move stock to management areas, which are later opened. For the private relay operations, permit holders doing the transplants are required to pay the salary of Department of Environmental Conservation enforcement personnel needed for supervision (including benefits, overtime, etc.). This can represent over $800/week. The minimum time that shellfish are required to remain in clean water is 21 days, but town transplants are usually longer. Although the price paid to harvesters is generally about half the market value, there are no catch limits.

CONNECTICUT: Connecticut has an oyster transplant program for aquaculture purposes. There is, also, a bag relay program for oysters and hard clams (quahogs) as described earlier in this report by Timothy Visel.

RHODE ISLAND: Rhode Island has a rain closure system for conditionally-approved areas.

MAINE: In Maine permit holders may culture shellfish taken from closed areas. They may culture shellfish within either an authorized area or a closed area. Also, they may ship shellfish from a closed area to an authorized area, to another closed area, or between authorized areas. This process is enforced by the Department of Marine Resources (DMR).

Regarding relays, meat counts are taken from the shellfish beforehand in the closed area, and the water quality in the open area is tested. Shellfish cannot be moved to within 500 feet of an area that is currently being harvested commercially. Shellfish must be in the open area for not less than 14 days, when the water temperature is above 50° F. Before shipping (after the 14 days), shellfish must be approved by the DMR after meat count testing.

Maine has outlined the criteria for the controlled depuration of shellfish in a physical plant (DMR Chapter 20). These include performance specifications, plant requirements, plumbing, etc. In these systems, all the seawater used is sterilized with ultraviolet light. The depuration time is 48 hours at a minimum. Areas from which shellfish can be harvested for depuration must be approved by the DMR. The entire process is spelled out, in terms of who harvests, from where, how shellfish are shipped and handled, what happens to shellfish at the plant, how the plant should be set up, how it must be run, etc.

Conclusions

In sum, then, there are many options already in place for utilizing shellfish from closed areas. A conference similar to this one was held in 1984 in Hyannis. The predominant view then was "there are problems with this and problems with that." Indeed, there are problems, but it seems that most other states have worked around them and found solutions. We are not at that stage yet in Massachusetts.

The main problem in Massachusetts at this time is budgetary. With the Division of Marine Fisheries as the new regulatory agency for shellfish, more testing is being done now, with fewer people, than previously. DMF is also responsible for conducting statewide sanitary surveys of all shellfish growing areas by September, 1989. If these surveys are not completed, the areas that have not yet been surveyed must be closed automatically (under NSSP guidelines each state has to conduct such a survey every 12 years). Without the budget to do these surveys first, most other ideas will have to wait.

Perhaps this is not the best time to be developing a new state program. On the other hand, it was not an opportune time five years ago either. Nothing was done then, and it looks as if nothing is going to happen now, even though additional closures are expected in the future.

Further, the more that sampling is done, the more that closures will be necessary. The shellfish industry in general will suffer as a result. The shellfish industry, as well as aquaculture, will continue to suffer until some shellfish utilization policy is created.

A statement often made about depuration is that it is no substitute for cleaning up contaminated areas. This is true, but somewhat beside the point of this discussion. The ability to depurate or relay obviously is not a panacea. Even if the shellfish can be utilized, the contaminated areas cannot be allowed to deteriorate further. On the other hand, there are certain areas that very likely will never be opened again. Some of these are so foul that shellfish should not be taken from them under any circumstances. Other areas are not as bad and could be cleaned up. However, the process may take years, and, in the meantime, usable shellfish stocks are simply waiting to be harvested. Moreover, there are areas where the natural levels of bacteria exceed the standard. These areas are usually salt marshes, and can be located several miles from the nearest human sources of contamination. They may have counts not only above the standard, but in some cases, several orders of magnitude higher. For example, George Heufelder mentioned this morning the problems of Buttermilk Bay. Despite the fact that Buttermilk Bay is surrounded by houses and roads and subject to road runoff, people walking dogs along the water, a sizable waterfowl population, and somewhat limited tidal exchange, the bacteria counts there are not as high as they are in some marshes. Clean up sounds like the solution, but in this situation, there is nothing in the marshes to clean up. Further, these are often very productive areas. They will remain closed until some aspect of the federal regulations are improved to recognize these differences in shellfish areas.

Most other states do have seemingly workable programs in place. The risk of illegal harvesting under any of these programs is no greater than currently exists in Massachusetts. A legal and controlled outlet for shellfish would seem preferable to the uncontrolled outlet we have at present.

When Massachusetts reaches the stage where most shellfish waters are closed, it may take a long time to implement policies, even if all agree (at that time) to make use of the resource. For example, today policy makers cannot even agree on the characteristics of a "good" depuration facility. Should Massachusetts adopt criteria from other states? How will they be enforced? To minimize the time lag, we need a set of criteria that describe how new shellfish programs ought to operate, even if the process is not legalized immediately.

There have been some closures in the past, but most areas were open and available to fishermen. As more areas continue to become closed (and these are some of our most productive areas), some type of depuration, relay, or other system must be established if we are going to maintain a viable shellfish or aquaculture industry.

Some initial steps are to decide:

1. Do we want depuration or relay programs? Which methods should we use? Depuration would be a marketing safeguard, regardless of where the shellfish come from - even from clean waters. Depuration would provide a quality control system for the producer. At some point there may be a mandatory requirement for depuration. If this happens, we should have the criteria established, in place, and ready to go. Depuration or relay would allow the use of shellfish from mildly contaminated (conditionally-approved) areas that are now closed. Relays are much less costly than depuration, and relay regulations that seem to work already exist.

2. Would the regulations from another state be appropriate? The criteria for depuration from the Maine DMR, for example, are comprehensive. Depuration there has proven to be something that can be done safely and in a regulated way. Relays are being run successfully in almost all states, and the aquacultural use of closed areas is also allowed. These systems make use of otherwise unused resources, not only in terms of shellfish, but also in terms of space for aquaculture.

3. How do we implement such programs, and how do we fund them? The latter question is of prime importance. The financial issue has to be resolved first. It is clear that the agency in charge has to be funded adequately to do what it has to do. It was hoped that the situation would improve under the recent reorganization. Actually it has, but the DMF is still trying to reorganize from the last 10 years during which the shellfish water quality program was run by a different agency. This will take some time. In the meantime, are there any predictions for how much of the Cape will be closed this summer? In view of the gloom and doom we heard earlier in this workshop, some alternatives should be made available soon.

GENERAL DISCUSSION

Following the presentations by invited speakers, the workshop was opened to a general discussion, which revolved primarily around the two questions below.

1) How long will it take to make substantial progress in developing and adopting a new, sanitary standard for shellfish?

The present standard of 14 fecal-coliform bacteria per 100 ml in water overlying shellfish areas was developed many years ago. It is now firmly entrenched in national and international regulations pertaining to the commercial use of shellfish. In view of the increasing evidence of the conservative and, in some cases, misleading results of this standard in terms of indicating shellfish wholesomeness, a close examination into changing the standard is warranted. Modifying or changing the standard (as, for example, to a specific test for E. coli) would require years of comparative study and testing to be sure of the implications for public health. Options such as this are now being pursued in other countries (particularly in Europe). The new, $20 million, National Shellfish Indicator Act will help support the wide-ranging studies necessary to develop an alternative standard test. A realistic time scale for having a sound alternative would seem to be about five years. Assimilation and implementation of the standard into routine shellfish practice would likely require another five years or so.

2) What are the major obstacles for making better use of shellfish from closed areas in Massachusetts?

Other states facing shellfish closures because of microbial contamination have developed innovative schemes to utilize shellfish from closed areas through relay, depuration or aquaculture operations. In many of these instances, the private sector has provided the initiative. In Massachusetts, however, legislative restraints and policy conflicts between state and local governments thwart progress in this regard. Existing legislation expressly prohibits the operation of depuration facilities in Massachusetts by private concerns. Shellfish aquaculture operations can be licensed only by cities and towns; the state is strictly prohibited from this. Further, cities and towns have authority over approved shellfish areas, but once the areas become closed (contaminated) then the state has authority. Thus, towns are unable to license aquaculture in closed areas, but neither is the state because existing statutes permit only the towns to issue aquaculture licenses. Bills have been submitted to the legislature for the past four years to straighten out this dilemma, but so far without results. A similar sort of impasse hinders development of innovative shellfish relay schemes. In short, the major hurdle in utilizing shellfish from closed areas and involving the private sector in shellfish relay and depuration is the lack of legislation enabling local and state authorities to work together in this regard, rather than at cross purposes.

The need was identified for educating the public about what shellfish closures really mean. It was felt that the general public often perceives shellfish closures to mean that the shellfish are seriously and grossly contaminated, which is often not the case. The public tends to consider shellfisheries in closed areas to be dead and the industry finished. The danger here is that once public interest and confidence in shellfisheries starts to dwindle, then it becomes difficult to rejuvenate the fisheries, as was learned over the past 40 years in Connecticut. It was generally agreed that there is a need to make the public aware that there are viable options for utilizing shellfish from certain closed areas.

Finally, many shellfish areas in Massachusetts face closure next fall unless they pass a sanitary survey test prescribed by the federal Food and Drug Administration. This requirement puts a tremendous burden on the Massachusetts Division of Marine Fisheries in terms of personnel to sample and test each shellfish area in the state. In an attempt to meet the deadline of September 1, 1989, DMF is now training town shellfish officers in sanitary survey techniques. But even with this additional help, it appears that some shellfish areas may not be surveyed by the deadline and may have to be closed.

Shellfish Contamination Workshop Participants

Ken Alfieri
Biologist
Sealand of Cape Cod
Route 6A
West Brewster MA 02631

Theresa Almeida
Laboratory Technician
New Bedford WWTP
763 Kempton Street
New Bedford MA 02740

R.F. Andres
240 Oak Street
W. Barnstable MA 02668

Andrew Ayer
Shellfish Constable
Quincy Health Dept.
1120 Hancock Street
Quincy MA 02169

Kendall Ayers
Barnstable Conservation Commission
367 Main Street
Hyannis MA 02601

Paul Bagnall
Asst. Shellfish/Marine Biologist
RFD 520-B
Edgartown MA 02539

Patricia Ballo
Assistant Health Agent
Town of Orleans
19 School Road
Orleans MA 02653

Tom Barlow
Selectman
Town of Bourne
24 Perry Avenue
Buzzards Bay MA 02532

Brad Barr
MCZM
100 Cambridge Street
Boston MA 02202

Dave Basler
32 Prospect Street
Ludlow MA 01056

Emily Beebe
Health Agent
Town of Provincetown
260 Commercial Street
Provincetown MA 02657

Susan Beede
U.S. EPA, National Estuary Prog.
WQM 2103
JFK Federal Building
Boston MA 02203

Molly Benjamin
Cape Cod Times
115 Bradford Street
Provincetown MA 02657

Bruce Bennett
Cotuit Oyster Company
PO Box 563
Cotuit MA 02635

Richard Blundell
693 West Street
Duxbury MA 02332

Sue Boehler
Division of Marine Fisheries
Shellfish Technical Assistance Program
18 Route 6A
Sandwich MA 02563

Diane Boretos
DEQE Wetlands
Lakeville Hospital
Lakeville MA 02347

Ted Bosen
56 River Street
Plymouth MA 02360

Deborah Boswell
Laboratory Technician
Shellfish Purification Plant
Northern Boulevard
Plum Island
Newburyport MA 01950

Shellfish Contamination Workshop Participants

Bradford Bourque
New Bedford Shellfish Dept.
1200 Purchase Street
New Bedford MA 02740

Phil Brady
Division of Marine Fisheries
Shellfish Technical Assistance Program
18 Route 6A
Sandwich MA 02563

Wedge Bramhall
c/o John Crane
13 Esta Road
Plymouth MA 02360

Robert Bullis
Microbiologist
Lab. for Marine Animal Health
Marine Biological Laboratory
Woods Hole MA 02543

Walter Burr
Chairman Dennis Shellfish Commission
PO Box 682
Dennis MA 02638

William Burt
Asst. Nat. Resource Officer
Town of Eastham
2500 State Highway
Eastham MA 02642

Bernard Cambra
New Bedford Board of Health Lab
100 Brock Avenue
New Bedford MA 02744

Lee Anne Campbell
Communicator
Sea Grant Program
Woods Hole Oceanographic Institution
Woods Hole MA 02543

David Carignan
Falmouth Health Department
59 Town Hall Square
Falmouth MA 02540

David Carlson
Biologist
Sealand of Cape Cod
Route 6A
West Brewster MA 02631

Wayne Castonguay
Bacteriologist
Cat Cove Marine Laboratory
92 Fort Avenue
Salem MA 01970

David Chadwick
Senior Marine Fisheries Biologist
Shellfish Purification Plant
Northern Boulevard
Plum Island
Newburyport MA 01950

Billy Chapman, Jr.
Town of Wellfleet, Shellfish Dept.
RR#1 Main Street
Wellfleet MA 02667

John Chatham
Town of Wellfleet, Shellfish Dept.
RR#1 Main Street
Wellfleet MA 02667

Robert Chausse
DEM - Law Enforcement
37 Alderberry Lane
East Falmouth MA 02536

Neil Churchill
Division of Marine Fisheries
Shellfish Technical Assistance Program
18 Route 6A
Sandwich MA 02563

Toni Chute
Martha's Vineyard Shellfish Group
PO Box 1552
Oak Bluffs MA 02557

Jack Clark
MCZM
100 Cambridge Street
Boston MA 02202

Shellfish Contamination Workshop Participants

Cynthia Coffin
Bourne Board of Health
24 Perry Avenue
Buzzards Bay MA 02532

Haydon Coggeshall
Bourne Board of Health
24 Perry Avenue
Buzzards Bay MA 02532

Orrin Connor
Cape Cod Oyster
262 Bridge Street
Osterville MA 02655

Joseph Costa
MCZM, Buzzards Bay Project
2 Spring Street
Marion MA 02738

Tina Coughanour
Geologist
Horsley Witten Hegemann
PO Box 7
Barnstable MA 02630

Farah Courtney
MCZM, North Shore
159 Main Street
Gloucester MA 01950

Amelia Coyne
c/o Emily Beebe
Health Department
Town of Provincetown
260 Commercial Street
Provincetown MA 02657

John Crane
Beach Conservation/Shellfish Officer
Town of Plymouth
13 Esta Road
Plymouth MA 02360

Beth Creech
Naturalist
Cape Cod Museum of Natural History
Drawer R, Rt. 6A
Brewster MA 02631

Stephanie Cunningham
Marine Biologist
Shellfish Purification Plant
Northern Boulevard
Plum Island
Newburyport MA 01950

Thomas Dallaire
Mass Division of Water Pollution Control
Westview Bldg
Lyman School Grounds
Westborough MA 01581

Paul DeOrsay
242 East Falmouth Highway
East Falmouth MA 02536

Bill Dias
12 Highland Street
South Dartmouth MA 02748

Richard Dickey
Town of Wellfleet, Shellfish Dept.
RR#1 Main Street
Wellfleet MA 02667

Robert Duncanson
Director
Water Quality Laboratory
Town of Chatham
549 Main Street
Chatham MA 02633

Lawrence Edwards
USFDA
One Montvale Avenue
Stoneham MA 02180

Tom Fantozzi
c/o Gary Sherman
PO Box 313
Westport Point
Westport MA 02791

Tracy Flagg
Director Public Health
Town of Danvers
8 Harbor Street
Danvers MA 01923

Shellfish Contamination Workshop Participants

John Fletcher
PO Box 747
East Orleans MA 02643

June Fletcher
PO Box 747
East Orleans MA 02643

Santo Furfari
Deputy Chief, Northeast Technical Services
Shellfish Sanitation Branch, FDA
CBC Base, Building S26
Davisville RI 02852

Mark Galkowski
Conservation Officer
Town of Sandwich
Town Hall Annex
145 Main Street
Sandwich MA 02563

Seth Garfield
1076 Horseneck Road
Westport MA 02790

Marc Garrett
Director of Environmental & Regul. Affairs
GHR Engineering Associates
109 Rhode Island Road
Lakeville MA 02347

Frank Germano
Division of Marine Fisheries
18 Route 6A
Sandwich MA 02563

Joseph Giarrusso
City of Haverhill
58 Marblehead Street
North Andover MA 01845

Anne Gibbons
c/o David Carignan
Falmouth Health Department
59 Town Hall Square
Falmouth MA 02540

Daniel Gilmore
Director, Dept. of Natural Resources
Town of Wareham
54 Marion Road
Wareham MA 02571

David Goulart
New Bedford Shellfish Dept.
1200 Purchase Street
New Bedford MA 02740

Joe Grochowski
Environmental Technology Alternatives
3656 Whitney Avenue
Hamden CT 06518

Richard Haigh
406 Quissett Avenue
Falmouth MA 02540

George Hampson
Research Specialist
WHOI
Woods Hole MA 02543

Al Haven
Town of Wellfleet, Shellfish Dept.
RR#1 Main Street
Wellfleet MA 02667

Ardy Hennemuth
c/o Tammy Race
PO Box 374
Monument Beach MA 02553

Truman Henson
Shellfish Constable
Orleans Shellfish Department
Town Hall
19 School Road
Orleans MA 02653

George Heufelder
Environmental Program Manager
Barnstable County Health & Environ. Dept.
Route 6A
Barnstable MA 02630

J. Michael Hickey
Chief Marine Biologist
Division of Marine Fisheries
Commonwealth of Massachusetts
18 Route 6A
Sandwich MA 02563

Shellfish Contamination Workshop Participants

Russell Hodgdon
Shellfish Constable, Town of Rowley
134 Hillside Street
Rowley MA 01969

Albert Hollander
473 Popponesset Island Road
Mashpee MA 02649

Catherine Hood
9 Carter Street
Concord NH 03301

George Jennings
Harbormaster/Shellfish Officer
2 Spring Street
Marion MA 02738

Morris Johnson
Shellfish Constable
Town of Yarmouth, Dept. Nat. Res.
597 Forest Road
South Yarmouth MA 02664

Stephen Jones
Research Scientist
Jackson Estuarine Laboratory
RFD2, Adams Point
Durham NH 03824

Rick Karney
Martha's Vineyard Shellfish Group
PO Box 1552
Oak Bluffs MA 02557

Jeffrey Kennedy
Marine Fisheries Biologist
Shellfish Purification Plant
Northern Boulevard
Plum Island
Newburyport MA 01950

Philip Kent
Shellfish Constable
Town of Ipswich
Town Hall, Shellfish Dept.
Ipswich MA 01938

Margaret Kien
62 Locust Street, Apt. #234
Falmouth MA 02540

Carol Kilbride
EPA Region I, Buzzards Bay Project
WQP 2103
JFK Federal Bldg.
Boston MA 02203

Mark King
76 Wollcott Avenue
North Dartmouth MA 02747

Robert Knowles
Shellfish Constable
13 Woodward Avenue
Gloucester MA 01930

Susan Kuenster
New England Fisheries Development Found.
280 Northern Avenue
Boston MA 02210

Richard Langan
Jackson Estuarine Laboratory
RFD 2, Adams Point
Durham NH 03824

Dale Leavitt
WHOI, Coastal Research Center
Woods Hole MA 02543

Henry Lind
Natural Resource Officer/Shellfish Constable
Town of Eastham
2500 State Highway
Eastham MA 02642

Sandra MacFarlane
Town of Orleans Shellfish Dept.
Town Hall
19 School Road
Orleans MA 02653

Nancy Maciolek
MCZM
100 Cambridge Street
Boston MA 02202

Scott MacKinnon
Lloyd Center for Environ. Studies
PO Box 7037
S. Dartmouth MA 02748

Shellfish Contamination Workshop Participants

Howard Mallowes Jr.
PO Box 155
Marion MA 02738

Jim Manning
NMFS
Woods Hole MA 02543

Robert Mant
Brewster Shellfish Dept.
Town Hall
Brewster MA 02631

Alan Marcy
Shellfish Constable
Town of Dennis
PO Box D
485 Main Street
South Dennis MA 02660

Charles McCloskey
Harbormaster/Shellfish Constable
Green Street
Kingston MA 02364

John Mendes
Division of Marine Fisheries
Shellfish Technical Assistance Program
18 Route 6A
Sandwich MA 02563

Charles Merritt
Natural Resource Officer
Department of Natural Resources
Town of Bourne
24 Perry Avenue
Buzzards Bay MA 02532

Clarence Merritt
Director
Department of Natural Resources
Town of Bourne
24 Perry Avenue
Buzzards Bay MA 02532

David Merry
Asst. Shellfish Constable
Martha's Vineyard Board of Health
PO Box 26
West Tisbury MA 02575

Charles Millen
Director Natural Resources
Town of Barnstable
1189 Phinney's Lane
Centerville MA 02632

Fin Miller
PO Box 178
Chilmark MA 02535

Mitchell Mondino
206 Old Barnstable Road
East Falmouth MA 02536

Susan Moore
Southeast Regional Coordinator
MCZM
Town House
2 Spring Street
Marion MA 02748

Paul Noonan
191 Main Street
Cotuit MA 02635

Brian Nunes
Shellfish Warden
Town of Mattapoisett
16 Main Street
Mattapoisett MA 02739

Jim O'Connell
MCZM
100 Cambridge Street
Boston MA 02202

Meghan O'Connor
Lloyd Center for Environ. Studies
PO Box 7037
S. Dartmouth MA 02748

Daniel Ostrye
GHR Engineering Associates
109 Rhode Island Road
Lakeville MA 02347

John Pavlos
Town of Yarmouth, Dept. Nat. Res.
597 Forest Road
South Yarmouth MA 02664

Shellfish Contamination Workshop Participants

Wayne Perry
New Bedford Board of Health Lab
100 Brock Avenue
New Bedford MA 02744

Donald Pipatti
Town of Yarmouth, Dept. Nat. Res.
597 Forest Road
South Yarmouth MA 02664

John Powers
Martha's Vineyard Board of Health
PO Box 26
West Tisbury MA 02575

Irving Puffer
Shellfisherman
Cape Cod Sea Farms
PO Box 1020
Wellfleet MA 02667

Tammy Race
PO Box 374
Monument Beach MA 02553

H. Karl Rask
Regional Marine Resource Specialist
Cape Cod Extension Service
Deeds and Probate Building
Barnstable MA 02630

Diane Regan
Bacteriologist
Shellfish Purification Plant
Northern Boulevard
Plum Island
Newburyport MA 01950

Gordon Rice
Director
Aqua Test
PO Box 526
West Chatham MA 02669

John Richards
Chatham Shellfish
Box 205
West Chatham MA 02669

Mark Richardson
Biologist
Sealand of Cape Cod
Route 6A
West Brewster MA 02631

David Roach
Marine Biologist
Shellfish Purification Plant
Plum Island
Northern Boulevard
Newburyport MA 01950

Donald Robello
Falmouth Department of Natural Resources
750 Main Street
Falmouth MA 02540

Mark Robinson
Compact of Cape Cod Conservation Trusts
PO Box 7
Barnstable MA 02630

Bruce Rosinoff
MCZM
Marion Town House
2 Spring Street
Marion MA 02738

David Ross
Coordinator
Sea Grant Program
Woods Hole Oceanographic Institution
Woods Hole MA 02543

John Ryther
WHOI
ESL
Woods Hole MA 02543

Dale Saad
Coastal Health Resource Coordinator
Board of Health, Town of Barnstable
Town Hall
367 Main Street
Hyannis MA 02601

Craig Saunders
Environmental Consultant
RID 372A
Vineyard Haven MA 02568

Shellfish Contamination Workshop Participants

Greg Sawyer
Division of Marine Fisheries
Shellfish Technical Assistance Program
18 Route 6A
Sandwich MA 02563

Mark Schaffel
Mann Farms
620 Head of the Bay Road
Buzzards Bay MA 02532

Donald Schall
IEP
PO Box 1840
90 Route 6A, Sextant Hill
Sandwich MA 02563

Gary Sherman
Shellfish Constable
PO Box 313
Westport Point
Westport MA 02791

Lynn Sherwood
Division of Marine Fisheries
Shellfish Technical Assistance Program
18 Route 6A
Sandwich MA 02563

Bev Singleton
Consultant
PO Box 560
South Orleans MA 02662

Sherrill Smith
PO Box 218
Orleans MA 02653

Anne Smrcina
MCZM
100 Cambridge Street
Boston MA 02202

Ira Somerset
Regional Shellfish Specialist
USFDA
One Montvale Avenue
Stoneham MA 02180

Paul Somerville
Shellfish Constable
Mashpee Shellfish Dept.
PO Box 1108
Mashpee MA 02649

Edith Souza
114 Acapesket Road
East Falmouth MA 02536

George Souza
114 Acapesket Road
East Falmouth MA 02536

Jeanne Spalding
Wareham Board of Health
54 Marion Road
Wareham MA 02571

Judith Stetson
Conservation Commissioner
261 Quissett Avenue
Falmouth MA 02540

Boyd Steven
WHOI
226 Redfield
Woods Hole MA 02543

Joseph Strazdes
Shellfish Constable, Town of Scituate
342 Central Avenue
Marshfield MA 02050

Lori Thayer
South Shore Regional Coordinator
MCZM
100 Cambridge Street
Boston MA 02202

John Thomas
Assistant Shellfish Officer, Scituate
PO Box T
Humarock MA 02047

Virginia Treworgy
GHR Engineering Associates
109 Rhode Island Road
Lakeville MA 02347

Shellfish Contamination Workshop Participants

Bruce Tripp
WHOI, Coastal Research Center
Woods Hole MA 02543

John Valois
Department of Marine Resources
Marine Biological Laboratory
Woods Hole MA 02543

William Vanderhoop
Shellfish Constable
RFD Box 127
Gay Head MA 02535

Timothy Visel
Advisory Agent
Connecticut Sea Grant, Marine Advisory Service
University of Connecticut
Avery Point
Groton CT 06340

Bob Wallace
c/o Irving Puffer
PO Box 1020
Wellfleet MA 02667

Dennis Walsh
Aquacultural Research Corp.
PO Box AC
Dennis MA 02638

Craig Whitcomb
PO Box 471
Harwich MA 02645

Alan White
Marine Science Advisor
Sea Grant Program
Woods Hole Oceanographic Institution
Woods Hole MA 02543

Everett Whorton
Martha's Vineyard Aquaculture
PO Box 1062
Edgartown MA 02539

Alan Wilder
PO Box 172
Cuttyhunk Island MA 02713

John Winslow
PO Box 1376
Orleans MA 02653

Bill Wood
53 Belmont Street, #2
Cambridge MA 02138

DOCUMENT LIBRARY

July 5, 1989

Distribution List for Technical Report Exchange

Attn: Stella Sanchez-Wade
Documents Section
Scripps Institution of Oceanography
Library, Mail Code C-075C
La Jolla, CA 92093

Hancock Library of Biology &
Oceanography
Alan Hancock Laboratory
University of Southern California
University Park
Los Angeles, CA 90089-0371

Gifts & Exchanges
Library
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, NS, B2Y 4A2, CANADA

Office of the International
Ice Patrol
c/o Coast Guard R & D Center
Avery Point
Groton, CT 06340

Library
Physical Oceanographic Laboratory
Nova University
8000 N. Ocean Drive
Dania, FL 33304

NOAA/NESDIS Miami Library Center
4301 Rickenbacker Causeway
Miami, FL 33149

Library
Skidaway Institute of Oceanography
P.O. Box 13687
Savannah, GA 31416

Institute of Geophysics
University of Hawaii
Library Room 252
2525 Correa Road
Honolulu, HI 96822

Library
Chesapeake Bay Institute
4800 Atwell Road
Shady Side, MD 20876

MIT Libraries
Serial Journal Room 14E-210
Cambridge, MA 02139

Director, Ralph M. Parsons Laboratory
Room 48-311
MIT
Cambridge, MA 02139

Marine Resources Information Center
Building E38-320
MIT
Cambridge, MA 02139

Library
Lamont-Doherty Geological
Observatory
Colombia University
Palisades, NY 10964

Library
Serials Department
Oregon State University
Corvallis, OR 97331

Pell Marine Science Library
University of Rhode Island
Narragansett Bay Campus
Narragansett, RI 02882

Working Collection
Texas A&M University
Dept. of Oceanography
College Station, TX 77843

Library
Virginia Institute of Marine Science
Gloucester Point, VA 23062

Fisheries-Oceanography Library
151 Oceanography Teaching Bldg.
University of Washington
Seattle, WA 98195

Library
R.S.M.A.S.
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149

Maury Oceanographic Library
Naval Oceanographic Office
Stennis Space Center
NSTL, MS 39522-5001

Marine Sciences Collection
Mayaguez Campus Library
University of Puerto Rico
Mayagues, Puerto Rico 00708