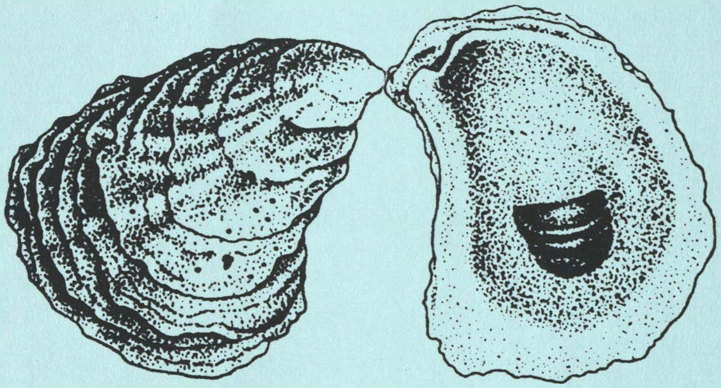
10th ANNUAL SHELLFISH BIOLOGY SEMINAR

FEBRUARY 27, 1990



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10th Annual Shellfish Biology Seminar

February 27, 1990

National Marine Fisheries Service
Northeast Fisheries Center
Milford Laboratory
Harbor Room, Howard Johnson's Lodge
Milford, Connecticut 06460

8:00	Introduction	Walter Blogoslawski Conference Chairman
8:10 - 8:15	Welcome	Fred Lisman Mayor of Milford
8:15 - 8:30	Remarks on Connecticut's Shoreline Environment	Congressman Bruce Morrison 3rd District, New Haven CT
8:30 - 8:50	A review of the effects of algal blooms on shellfish and aquaculture	S. Shumway, Maine Dept of Marine Resources, W. Boothbay Harbor ME
8:50 - 9:10	Spawning delay of *Mercenaria mercenaria* caused by *Aureococcus anophagefferens*	C. Strong, Bluepoints, Inc. W. Sayville NY
9:10 - 9:25	Paralytic toxins in offshore shellfish: The events in 1989 - Future implications	C. Martin NMFS Gloucester MA
9:25 - 9:45	Ecology and toxicity in Long Island waters of *Dinophysis* spp., the suspected causative organisms of diarrhetic shellfish poisoning	A. Freudenthal, Nassau County Dept. of Health Mineola NY
9:45 - 10:10	Use of concentrated bacteria in a clam nursery	M. Castagna VIMS Wachapreague VA
10:10 - 10:30	The role of algal sterols in oyster nutrition: Evidence from Milford feeding studies	G. Wikfors NMFS Milford CT
10:30 - 11:00	BREAK - POSTER SESSION	CHURCHILL ROOM
11:00 - 11:20	Nursery culture of bivalves in Rhode Island marinas	M. Rice URI Wickford RI

11:20 - 11:40	Marina docks as an aquaculture platform	R. DeSanto, Deleuw Cather Co., E. Hartford CT
11:40 - 12:00	Biomonitoring for TBT in Portugal using Crassostrea angulata	H. Phelps, Univ. of District of Columbia, Washington DC
12:00 - 1:15	LUNCHEON	DICKEN'S ROOM
1:15 - 1:35	Ontogenetic changes in trophic relationships and their effects on shellfish recruitment	R. Whitlatch UCONN Groton CT
1:35 - 1:55	Can we culture natural sets of hard clams?	C. MacKenzie NMFS, Sandy Hook NJ
1:55 - 2:15	Bivalve/fish polyculture in the effluent of marine fish ponds in Eilat, Israel	M. Shpigel, VIMS Gloucester Pt. VA
2:15 - 2:25	Seed production in a hatchery/ nursery in Maine	W. Mook Mook Sea Farms Damariscotta ME
2:25 - 2:45	Oyster culture in Virginia: Adaptations of conventional methods	M. Luckenbach VIMS Wachapreague VA
2:45 - 3:00	Survival of juvenile surf clams, Spisula solidissima	A. Desbonnet, URI Narragansett RI
3:00 - 3:30	BREAK - POSTER SESSION	CHURCHILL ROOM
3:30 - 3:40	Policy and rules governing introduction of shellfish to NY and CT state waters	P. VanVolkenburgh, NY DEC Stony Brook NY and J. Volk, Dept. of Agric. Milford CT
3:40 - 3:50	Genetic improvement of the American oyster for growth and disease resistance in the Northeast	S. Ford and H. Haskin Rutgers Univ Port Norris NJ
3:50 - 4:10	Productive performance for three lines of genetically selected American oysters	C. Davis Univ. of Maine Orono ME
4:10 - 4:30	An examination of defense mechanisms in MSX resistant and susceptible oyster stocks held in lower Chesapeake Bay, Maryland	M. Chintala Univ. of Maryland Cambridge MD

4:30 - 4:45	Genetic improvement of cultured Delaware bivalves through hybridization and polyploidy	P. Gaffney Univ. of Delaware Lewes DE
4:45 - 5:00	CONCLUDING REMARKS	W. Blogoslawski Conference Chairman

POSTERS

The effects of toxic algae on the behavior and physiology of bivalve molluscs	S. Shumway, Dept. of Marine Resources; T. Cucci, Bigelow Lab., W. Boothbay Harbor ME
Aspects of a mussel carrying-capacity model	C. Newell, Great Eastern Mussel Farms, Inc. Tenants Harbor ME and D. Campbell, Dept. of Marine Resources, W. Boothbay Harbor ME
Oysters and toxic algal blooms: Are they immune?	S. Shumway, J. Barter, S. Sherman-Caswell, Dept. of Marine Resources, W. Boothbay Harbor ME
The distribution of hard clams <u>Mercenaria mecenaria</u> in the eastern Great South Bay, New York: Identification, hard clam population dynamics, sediment profile characteristics, bottom morphology	J. Kassner, T. Carrano Div. of Environmental Protection, Brookhaven NY R. Cerrato, Marine Sciences Research Center, SUNY Stony Brook NY
A genetic model of polyploidy and hybridization in shellfish populations	S. Stiles, J. Choromanski NMFS Milford CT
Observations of reduced recruitment of oysters in an estuary with restricted tidal flushing	T. Visel, UCONN Avery Point CT

A Review of the Effects of Algal Blooms on Shellfish and Aquaculture

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and
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Toxic algal blooms occur worldwide and in some areas they are a common and seasonal occurrence. Historically, attention has been focused on blooms of toxic dinoflagellates (e.g. Protogonyaulax tamarensis). More recently, attention has been turned to other species (e.g., Dinophysis, Aureococcus, and Gymnodininum). These blooms often present problems with respect to optimal utilization of the shellfish resources and the magnitude of economic losses can be catastrophic. Nevertheless, successful culture facilities and commercial harvests persist in areas prone to toxic algal blooms.

This paper reviews the literature available on occurrences of toxic algal blooms, the means by which harvesters, managers, and industry cope with the problems associated with toxic algal blooms, and makes recommendations for the most efficient and successful utilization of resources in the face of environmental instability.

Spawning Delay of Mercenaria mercenaria Caused by Aureococcus anophagefferens

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The first recently recognized occurrence of the Aureococcus anophagefferens bloom in the Great South Bay was in 1985, with subsequent major appearances in 1986 and 1988. Although gross physical examination of the hard clam Mercenaria during 1985 and 1986 showed a cessation of shell growth and the production of copious pseudofeces, gonadal development proceeded normally. Eventual bloom decline coincided with M. mercenaria spawning and unusually successful larval production, when compared to non-bloom years. The year 1988, although similar in bloom appearance, does not follow the pattern and shows differences in the timing of spawning related events.

Paralytic Toxins in Offshore Shellfish: The Events of 1989 - Future Implications

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National Marine Fisheries Service
Northeast Fisheries Center
Gloucester Laboratory
Gloucester, Massachusetts 01930

Shellfish toxicity associated with the occurrence of dinoflagellates has been well documented in the coastal waters of eastern Canada and the northeastern United States. Offshore resources have on the whole remained untouched by these events. For the first time, in 1989, areas outside state and provincial jurisdiction (i.e., in the Exclusive Economic Zones of both the United States and Canada) became the focus of attention as reports of toxicity in certain species appeared. Roe-on scallop were placed under special restrictions in Canada following analyses showing elevated levels of paralytic toxins in the roe portion. In mid-summer surf clams from Georges Bank were shown to exceed acceptable standards and a ban was initiated by NMFS. Subsequent analyses have documented the occurrence of toxicity in several offshore species and have raised concerns about the safety of these resources. In order to maintain confidence in offshore shellfish products, monitoring is being contemplated for paralytic shellfish toxins (PSTs), diarrhetic shellfish poison (DSP) and amnesic shellfish poison (ASP) in all important mollusc species. Recent studies on the distribution of toxins in shellfish from Georges Bank and Nantucket Shoals will be described and their implications discussed.

Ecology and Toxicity in Long Island Waters of Dinophysis spp., The Suspected Causative Organisms of Diarrhetic Shellfish Poisoning (DSP)

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Two brief, unplanned surveys were conducted in Long Island waters in response to high counts of the dinoflagellate, *Dinophysis.* Plankton was collected and examined for *D. norvegica* in nearshore oceanic waters in July 1988 and for *D. acuminata* in northshore estuarine waters in August-September 1989. The results from each survey provided some ecological data similar to western European studies: appearance immediately following diatom bloom discolored waters; greater abundance at depth (especially the bottom of the thermocline); and presence with the dinoflagellate *Ceratium* spp. Shellfish samples from the *D. acuminata* waters were analyzed with the new quick test kit which detects okadaic acid (OA), a diarrhetic shellfish poison, by competitive enzyme-linked immunosorbent assay (ELISA). One station showed a toxicity level of approximately 0.5 MU.

Use of Concentrated Bacteria in a Clam Nursery

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Wachapreague, Virginia 23480

Commercially available concentrated bacteria (Aqua-Bacta-Aid[R], ABA) commonly used in fish were tested in a *Mercenaria* nursery system to evaluate effects on growth and survival. In a flow-through seawater system ten troughs were conditioned for 20-days prior to the addition of clams: 5 control troughs received untreated seawater and the remaining 5 received daily 2 ml-doses of ABA. Five hundred thousand newly-set *Mercenaria* were added to each trough and growth and survival were monitored over a 60-day period. After 21-days, survival in the ABA-treated troughs was more than 2 times that in the controls. Growth rate varied between treatments, but were confounded by density-dependent effects. These preliminary results suggest that this bacterial concentrate may be useful in increasing survival of clam seed during the period from post set to planting.

The Role of Algal Sterols in Oyster Nutrition: Evidence from Milford Feeding Studies

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National Marine Fisheries Service
Northeast Fisheries Center
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and

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Previous studies of sterol metabolism in oysters, Crassostrea virginica, have suggested that these mollusks may have a nutritional "functional requirement" for dietary cholesterol. The enzymatic reduction of acetate to mevalonate (a cholesterol precursor) occurs slowly, if at all, in oysters, and may limit growth of oysters when fed a low-cholesterol diet. In this study, we have investigated how various sterols present in microalgae affect the growth of oysters fed known rations of axenically-cultured algae under controlled laboratory conditions. Sixteen algal diets fed to oysters were evaluated for sterol composition semi-quantitatively, with component sterols measured as percentages of total sterol. Appreciable differences in sterol composition were found between algal species. Two aspects of algal sterol structure, 1) the presence of an ethyl rather than a methyl group on carbon 24, and 2) the presence of a double bond at carbon 5 (cholesterol is in this group), showed statistically-significant effects upon oyster growth. A step-wise regression model ($p= 0.025$, $R^2= 0.68$), using results from principal components analysis, identified these two sterol attributes, along with algal lipid, dry weight, protein, and carbohydrate, as accounting for 90% of the differences in oyster growth on the 16 algal diets.

Nursery Culture of Bivalves in Rhode Island Marinas

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In response to numerous constraints on development of traditional aquaculture techniques in Rhode Island, studies were undertaken to assess the possibility of using the non-utilized space under floating docks in small-boat marinas for production of bivalve seed. Three marinas with varying hydrographic and boat use patterns were selected as well as a non-marina control site in waters certified as clean for shellfishing. Growth and survival of quahogs, Mercenaria and bay scallops, Argopecten irradians, suspended in enclosures under the docks were monitored at each site. Water quality variables monitored at each site were temperature, salinity, chlorophyll-a, total and organic seston concentration, Secci turbidity, various heavy metals and total coliform bacteria. Soft-tissue concentrations of the heavy metals were determined in clams maintained for differing time periods in the marinas. Growth of the bivalves varied considerably among sites, and correlated best with organic seston concentration. Input of coliform bacteria in the marinas is shown to be from boats as well as terrestrial non-point source origin associated with rainfall events. Coliform loading from non-point source runoff is quantitatively greater than that of the small-boats at each of the sites. However, coliform levels in the marinas regularly exceeded established levels for shellfishery closure. Clams grown in Ram Point Marina (Upper Point Judith Pond) from May-November 1989 reached average valve lengths of 12-18 mm from an initial 1 mm length. At the end of the growth period, the concentrations of various metals in the soft tissues of the clams were: Cu (20.59; 44.27%) (ug/g dry wt.; % FDA Proposed Alert Level); Zn (85.05; 28.13%); Cr (*2.09; 34.84%); Pb (3.40; 18.28%); Cd (0.25; 10.73%). The growth and tissue trace metal data suggest that small-boat marinas may be a viable areas for the production of shellfish seed. Fecal contaminants in the marinas are of concern and necessitate the relay of seed to certified clean water for final grow-out to marketable size.

Marina Docks as an Aquaculture Platform

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Investigations have been undertaken to study the ecological relationship between marinas and a Connecticut estuary. One aspect has concerned using marina docks as aquaculture platforms. Two prototype docks have been constructed and patented.

They provide a conventional dock for mooring boats in combination with an aquatic life habitat. The habitat is accessible for the seeding, maintenance, and harvesting associated with conventional aquaculture activities.

Investigations have included experiments into the growth rates of oysters (*Crassostrea virginica*), and the bioaccumulation potential of contaminants associated with marinas and urbanization. They are summarized as follows:

One year old oysters (*Crassostrea virginica*) were labeled, weighed and measured at biweekly (±) intervals between June and October at seven stations in estuarine and marina waters. Growth factors ranged from 2.9 to 6.2 for weight, with the fastest and greatest growth in open waters and slowest and least growth in the nearshore marina.

Chemical analyses of cultured and native oysters from Clinton Harbor were compared with commercial (i.e., "certified") oysters from Long Island Sound and Chesapeake Bay. Concentrations of cadmium and zinc in Clinton Harbor oysters were variable but comparable to adult oysters collected away from Clinton Harbor. All levels tested were substantially below Alert Levels proposed by the FDA in the 1973 Proceedings of the Seventh National Shellfish Sanitation Workshop. All oysters tested negative for mercury, chromium, lead, selenium, tin, and DDT.

Biomonitoring of Tributyltin in Portugal Using *Crassostrea angulata*

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Tributyltin (TBT) presence in Portuguese estuaries was studied using the Shell Thickness Index of the native Portuguese oyster, *Crassostrea angulata.* In 1988-89, oysters and oyster shells were collected and measured from three estuaries. The Sado estuary oysters had recently ceased reproduction and the remaining oysters showed severe shell thickening. Young hatchery-reared oysters (1 - 3 cm) were placed in cages in several estuaries, and growth and shell thickness index measured at two and four months. Some control cages had panels painted with International Cruise Co-Polymer (TBT) Paint. Growth was greatest in northern estuaries and vivieros. The shell thickness index was independent of growth, and by two months indicated significant TBT impact in two major estuaries being considered for aquaculture development. Cages placed only a few yards apart showed different TBT impact depending on hydrographics. Spat placed in the Sado estuary showed growth inhibition and/or shell thickening relating to proximity to a large ship-painting industry. In the absence of TBT-containing paint legislation in Portugal it would be advisable to conduct this two-month oyster spat placement test at all locations being considered for aquaculture projects, as the TBT concentrations could impact other aquaculture organisms. This project was funded by the Luzo-American Foundation and the Instituto Nacional de Investigacao das Pescas.

Ontogenetic Changes in Trophic Relationships and Their Effects on Shellfish Recruitment

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The trophic relationships between many benthic species change drastically as individuals progress through life-history stages. For example, to a setting shellfish larva, a resident suspension-feeder can be a predator. If the larva can successfully recruit that same resident may have no initial trophic interaction with it. However, with growth and a potential change in diet, the recruit and older resident may compete actively for food resources.

We have been conducting field and laboratory experiments to test how such ontogenetic changes in trophic relationships affect populations of the American oyster. In particular, we examined how this species' changing relationships with a variety of common marine, sessile invertebrate species affects its settlement, post-settlement growth and survivorship, and resultant recruitment success and abundance. The nature of the effects varied among the sessile species, but all exhibited ontogenetic changes in their relationship to the oysters.

We have found that the cumulative effect on a cohort of life-stage dependent trophic relationships is fairly predictable. In addition, we modelled the effects of changing trophic relationships on mixed life-stage populations and found that effects were highly variable and influenced by the relative density-dependence of the different trophic interactions on the temporal pattern of colonization by the interacting species. Our qualitative model also provides a basis with which to compare management strategy alternatives for enhancing oyster population abundance.

Can We Culture Natural Sets of Hard Clams?

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Few attempts have been made to culture natural sets of hard clams in natural bays, as is done with oysters in Long Island Sound. The advantages of doing so are that larger areas would be involved, more fishermen would benefit and perhaps clams would be cheaper than those produced in hatcheries. Although setting densities of hard clams may be lower than those in oysters and mussels, abundances of natural sets might be enhanced through predator control. To the known list of predators which consume juvenile hard clams, we can add two amphipods, two shrimps and juvenile mud crabs. In the 1960s, two examples of predator control showed 6- and 8-fold increases in hard clam abundances in Connecticut and Long Island. One means proposed to provide juvenile clams with cover from predators is by spreading broken clam shells over their beds. A quarter million bushels of surf clam and ocean quahog shells produced each year in New Jersey might be used for this purpose.

Bivalve/Fish Polyculture in Warm Water Ponds in Eilat, Israel

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The feasibility of integrated fish/bivalve polyculture was studied at the National Center for Mariculture, Eilat, Israel. Seawater from the Gulf of Eilat (Red Sea) was pumped to three fish ponds stocked with Gilthead Seabream (*Sparus aurata*) which were fed a 35-40% protein diet. Inefficient utilization of the diet, coupled with intense solar radiation produced dense phytoplankton blooms. The outflow water of the three fish ponds drained to a common setting pond and then passed through tanks stocked with edible bivalves (*Crassostrea gigas* and *Tapes semidecussatus*). Both bivalve species reached commercial size in about 14-18 months. *C. gigas* spawned between May to August while *T. semidecussatus* has ripe gonads during much of the year. Summer mortality in both species ranged between 20-40%. Despite relatively high water temperatures during the summer, and high salinity (41 ± 1%) throughout the year, the ability of both species to grow, undergo gametogenesis, and spawn under local environmental conditions demonstrated their adaptability indicating a favorable potential for polyculture. For Israel, with 60% of its area desert, using seawater for mariculture provides an important additional source of employment and income.

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Seed Production in a Hatchery/Nursery in Maine

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Mook Sea Farm is a commercial hatchery/nursery located in mid-coast Maine on the Damariscotta River. The facility is on the upper portion of the estuary where salinity and temperature conditions allow year round hatchery production of six bivalve species. Seed sales are to commercial shellfish growers and municipal management programs, primarily on the east coast.

The hatchery consists of two large fiberglass greenhouses. Microalgae (6-7 different species) are grown in 23 gallon kelwall tubes containing pasteurized filtered seawater. Broodstock, larvae, and young juveniles are grown in 100 to 2000 gallon tanks filled with heated filtered seawater which is changed on a regular basis.

Beginning early in the spring, seed from the hatchery is grown in three types of nurseries. Two land-based upflow nurseries, one located at the hatchery and the other located on Cape Cod, have a total capacity of 82 silos, each 18 inches in diameter. There are also two tidal-powered upflow nursery rafts each with 16- 19" X 19" bins, and approximately 800- 3' X 4' floating nursery trays on a 5 acre lease site upriver from the hatchery.

Oyster Culture in Virginia: Adaptations of Conventional Methods

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Oyster culture is a well developed practice in some regions of this country and the world. In the Chesapeake Bay and the coastal waters of Virginia several factors - biological, physical, and socioeconomic - interact to create an environment in which variation in developed approaches are required. Foremost among the special considerations in this area is the prevalence of the parasites Haplosporidium nelsoni and Perkinsus marinus and the devastating effects which they can have on both cultured and wild stocks of oysters. Together with other factors, including heavy fouling, limited tidal range, water use conflicts and market conditions, these factors necessitate modification of traditional approaches. We present preliminary data from experimental culture of oysters in Virginia waters. Our results suggest several avenues for future investigations of oyster culture in this region.

Survival of Juvenile Surf Clams, Spisula Solidissima

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The surf clam, *Spisula solidissima,* supplies one of the largest commercial bivalve fisheries nationwide, yet juvenile life history traits, important for determining distribution and establishment of adult populations, remain unknown. This study presents the results of investigations on the survival of juvenile surf clams.

Clams of 3, 5, 10, 15 and 20 mm length were planted in the field at densities from 5 to 320 clams per 0.25 m^2 and sampled 21-days later. All mortality could be attributed to crustacean predators.

In general, survival decreased as size increased. Three millimeter clams showed greater survival at high densities (<80), a trend not observed for larger clams. Some survival occurred for all size classes at decreased densities, suggesting a low density refuge from predation. Inefficiency of foraging predators at low prey densities, and increased efficiency at greater prey sizes and densities may account for these observations.

Increased survival of 20 mm clams relative to other size classes suggests a size refuge from predation. Subsequent work has proven this false up to 40 mm clam length. Winter survival of 20 mm clams was enhanced, showing individuals that survive post-set predation have a 60% probability of surviving into their second growing season.

Control Over Introductions of Shellfish and Other Organisms to New York's Marine and Estuary Environments

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The legal basis for controlling importations and exportations of shellfish ("oysters, scallops, and all kinds of clams and mussels") is provided in New York State's Fish and Wildlife Law. The Law specifically requires a permit for transplantation of shellfish or importing shellfish for transplanting purposes; the Law provides for the permitting of activities of marine hatcheries and the cultivation of marine species; the Law allows the Department of Environmental Conservation to make regulations relative to importing, exporting or otherwise trafficking in shellfish.

The only importation/introduction requests presently handled by the Division have related to the cultivation of shellfish; written approval is required. Inspections relative to proposed importations are not required by statute or by regulation. "Traditional" importation sources of recent years are generally considered to be acceptable; candidate sources located in areas with a known history of problems or with considerably different flora and fauna or from hatcheries additionally cultivating unwanted species are considered to be unacceptable. The acceptable sources are currently limited to New England states, with some specific areas excluded. New York State has very little capability to inspect proposed importations; administrators in the source state are consulted for history of the source area or hatchery, and, if the need for inspection is indicated, an approved "expert" (e.g., NMFS Oxford Lab) examines a sample of the proposed importation. The Atlantic States Marine Fisheries Commission recently adopted a "Shellfish Transport Plan" aimed at multi-state control over introductions and recommended that individual states develop trained personnel to inspect shellfish proposed for transfer between states.

New York State's authority to control the importation, exportation and movement of marine organisms between ecosystems is incomplete in that some types of organisms apparently are not included under the law; additionally, the department has not fully strengthened its administrative position through the authorized development of regulations. Fortunately, current interest in importations is essentially limited to those shellfish species for which permitting is required by statute, but increased interest in the potential for cultivating a variety of marine species suggests that attention to the control question should not be delayed. Present laws should be amended and/or new laws should be enacted in New York State to expand coverage so that the introduction of <u>all</u> types of living organisms to the State's marine and estuarine environments is controlled, and specifics of policies and procedures governing the administration of the control program should be spelled out in regulation.

Connecticut Laws and Practices Concerning the Transfer and Introduction of Molluscan Shellfish

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The Connecticut laws relating to shellfisheries specifically prohibit the introduction into the State's waters of any shellfish infected with harmful parasites, pests and diseases. Additionally, no introductions are allowed of any oyster species other than Crassostrea virginica.

Regulatory authority is provided by law to the Commissioner of Agriculture for setting standards and procedures for the transport and importation of shellfish. This authority includes access to vessels, gear and structures used in shellfish operations to determine compliance. Anyone desiring to deposit shellfish in any of the tidal waters of Connecticut must provide notification of intent to the Commissioner.

Aside from the large-scale import of Chesapeake Bay oysters into Long Island Sound which occurred during the early nineteenth century, Connecticut historically served as a source of oyster seed for neighboring New England states. Presently, however, most seed produced in Connecticut is now cultivated and marketed from the State's own waters. Because of relatively good recruitment of native populations of hard clams and oysters in Connecticut, there has been no pressing need for importations. As a member of the Atlantic States Marine Fisheries Commission, Connecticut participated in the development of the document: A Procedure to Control Interjurisdictional Transfers and Introductions of Shellfish (ASMFC Fisheries Management Report No. 13, October 1989). Effort is made to work closely with New York's Department of Environmental Conservation in review of acceptable sources of imports into Long Island Sound and avoidance of areas with known problems.

Because of the potential severe consequences of indiscriminate shellfish transport and introductions, good communication, cooperation and understanding is a must between the scientific community, the shellfish industry and regulatory agencies.

Genetic Improvement of the American Oyster for Growth and Disease Resistance in the Northeast

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In 1988, the United States Department of Agriculture, through the Northeastern Regional Aquaculture Center, began funding a project that included testing MSX-resistant oyster strains, developed at Rutgers University, in several locations in the northeast. To date, seven strains have been tested and compared with local controls. Four of these have been maintained to market size (approximately 70-80 mm shell height) at two sites on Cape Cod MA; at Deal Island (Chesapeake Bay) MD; and in lower Delaware Bay NJ.

In 1988, when MSX was prevalent, MSX-resistant strains outperformed other stocks at all sites. Survival was two to three times better than local controls. This was true in the Chesapeake, even though "Dermo" disease, as well as MSX, is a problem there. In 1989, however, MSX pressure was light everywhere and losses were negligible, except at the Chesapeake site, where the prevalence of "Dermo" was high and caused significant mortality. In this case, there was no evidence that the MSX-resistant stocks survived better than the local control.

Growth rates were site-specific and, in general, resistant strains grew better than controls when MSX pressure was heavy. Otherwise, there was no difference. Following a pattern that we have documented over a number of years, a Long Island resistant line showed faster growth than a Delaware Bay resistant line in all locations except the Chesapeake.

This is NJAES Publication No. K-32901-3-89, supported by state funds.

Productive Performance for Three Lines of Genetically Selected American Oysters, *Crassostrea virginica* (Gmelin, 1791)

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In 1986 the University of Maine commenced a selective breeding program for genetic improvement of the American oyster. This work is now part of a regional effort toward improving shellfish stocks through genetic manipulations as coordinated by the Rutger's University Shellfish Laboratory, and sponsored by the U.S. Department of Agriculture's Northeast Regional Aquaculture Center.

A random sample of broodstock was taken from 3 lines of oysters and subdivided into "control" and "select" groups. These lines had been evaluated for pure line performance at 18 months of age in the fall of 1987. The control group was composed of animals representing an equal distribution of all weight classes based on whole wet weight at 18 months of age. The select group consisted of the remaining animals from the top 20% of the population. Animals were spawned in April or July, 1988, and reared for two growing seasons in floating, screened trays in the Damariscotta River, Maine. The mean maximum summer temperature at the growing site was 21^{o} C.

At 18 months of age, the Milford NMFS "High Line" select group had a mean whole wet weight (29.3g) 10.2% greater than the control line (26.6g). The groups were significantly different at the $t_{.05}$ level. The Rutger's University "MSX-resistant" select line (36.6g) showed a significant 66.4% gain compared to the control group (22.0g). This large difference may be due to the high (82%) natural mortality incurred in the control group. Although the "Flowers" select line had a numerically greater mean weight (9.6g) than the control (8.9g), it was not significantly different at the $t_{.05}$ level. A final assessment will be made following the third growing season.

An Examination of Defense Mechanisms in MSX-Resistant and Susceptible Oyster Stocks Held in Lower Chesapeake Bay, Maryland

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Two stocks of oysters, one a Delaware Bay stock laboratory-selected for resistance to MSX (Haplosporidium nelsonii) at Rutgers University and the other a local MSX-susceptible stock, were held at Deal Island, MD in the lower Chesapeake Bay during 1988-89. In vitro measurements of the hemocyte capacity to regulate salinity, to spread to an amoeboid shape and to locomote showed no differences between the stocks. However, each stock exhibited temporal changes as seen in earlier studies. Lysozyme and protein concentrations were measured since lysozyme is generally presumed to be involved with host defense and digestion, and could indicate the physiological condition of the animal. The susceptible stock tended to have higher protein and lysozyme concentrations; however, this was only statistically significant during May 1989 (protein) and July 1989 (lysozyme). Bacterial agglutination of Vibrio cholerae was used to measure serum lectins. Both stocks exhibited a decrease temporally in lectin titer, however during the summer the lectin titers of the resistant stock were significantly greater than for the susceptible stock. Previous studies reinforce these results. Serum lectins may act defensively by recognizing and opsonizing nonself material in the hemolymph, and differences between the two stocks could play a role in their ability to recognize and bind parasites for phagocytosis.

<u>Genetic Improvement of Oysters through Hybridization and Polyploidy</u>

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The continuing decline of the American oyster industry in the mid-Atlantic region has kindled interest in alternatives to the culture of undomesticated wild stock. Proposed alternatives range from the use of genetically improved varieties of *Crassostrea virginica* to the introduction of other oyster species such as *C. gigas.* Several approaches to the development of genetically improved varieties of American oyster are now in various stages of application, ranging from traditional mass selection to the production of interspecific polyploid hybrids.

The potential advantages of polyploid oysters, particularly triploids, have been well illustrated by the commercial use of triploids in the Pacific Northwest. It remains to be seen whether viable tetraploid oysters can be produced. Autotetraploids would be invaluable as broodstock for routine production of monospecies and hybrid triploids; allotetraploids would be in essence true-breeding novel species which might combine favorable elements of both parent species.

Interspecific hybrids have been reported for a number of *Crassostrea* species, including *C. virginica.* However, to date there has been no unequivocal genetic evidence of hybridization. Electrophoresis of putative *virginica* x *gigas* hybrids produced in several laboratories showed all offspring to resemble one of the parental species; hybrid genotypes were not present. Similar results have been reported in studies of hybridization among several species of pearl oyster. Although the data available at present suggest that interspecific fertilization may result in gynogenetic or androgenetic offspring (i.e., uniparental zygotes), conclusive results have yet to be obtained.

The Effects of Toxic Algae on the Behavior and Physiology of Bivalve Molluscs

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It has long been believed that toxic dinoflagellates and other toxic algal species have little or no effect on the well-being of marine molluscs. Despite some data to the contrary, many authors have perpetuated the myth that these alga species are harmless to molluscs. Studies in our laboratory during the past 5 years have indicated that toxic dinoflagellates can elicit various responses by the host molluscs. Responses are species-specific and have been shown to vary according to geographic locations. Responses to the presence of the toxic dinoflagellate, _Alexandrium (Protogonyaulax) tamarenses,_ include shell-valve closure and or siphon retraction (_Mya arenaria, Mytilus edulis, Geukensia demissa),_ cessation of feeding (_Mercenaria),_ increased rates of particle selection (_Ostrea edulis),_ production of mucus (_M. edulis_ from Spain and Rhode Island, _Placopecten magellanicus, G. demissa),_ mortalities (_M. edulis_ from Spain); transient cardiac inhibition (_M. arenaria),_ long-term decrease in heart rate (_O. edulis),_ varied inhibition of cardiac activity (_G. demissa, M. edulis);_ inhibition of byssus production (_M. edulis_ and _G. demissa);_ increased rates of oxygen consumption (_M. arenaria,_ some _M. edulis),_ decreased rates of oxygen consumption _P. magellanicus, Spisula solidissima)_ and mortalities (_M. edulis_ from Spain). _Modiolus_ has thus far exhibited no response to the presence of _A. tamarenses._ These data are compared with other molluscan species' responses to the presence of toxic algal species.

Aspects of a Mussel Carrying-Capacity Model

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The bottom culture of blue mussels, *Mytilus edulis*, is a new industry along the Maine coast which has generated the need for more scientific and technical information upon which production and management decisions can be based. We have developed a model that can be used to estimate the mussel seeding densities that will result in optimum production of mussel meat and shell on various lease sites along the Maine coast. The critical processes associated with food and feeding of mussels on the lease site are the import of food onto the lease site, the transfer of food from surface waters to the bottom boundary layer, and the mussel feeding process. We made four simplifying assumptions as follows: (1) Food from all sources is aggregated into a single state variable; (2) No allowance is made for on site carbon production; (3) Negative effects of high seston concentrations on mussel feeding were not considered; (4) Mussel reproduction is not separated from growth.

Food supply to the mussels is controlled by the flux onto the lease site and the transfer of food into the bottom boundary layer through turbulent mixing. The horizontal flux of food onto the site is determined by the tidal exchange volume and the food concentration difference between water on the site and water offshore. Flux of food into the boundary layer is a function of the average tidal current velocity and bottom roughness. Bottom roughness in turn is a function of mussel length. This model was able to reproduce growth rates of meat and shell and shell lengths found on one of the Great Eastern Mussel Farm lease sites. Sensitivity analysis of the model showed that a 50% increase in food supply caused a 63% increase in meat weight, a 39% increase in shell volume and a 75% increase in the POM flux to the mussels. Various mussel seeding densities were evaluated in the model which resulted in accurate prediction of the mussel size and shell volume reductions that were observed at very high seeding densities. Over the range of mussel densities from 300 to 4500 m^{-2} the average weight of an individual mussel varied by 82% while mussel length varied by only 22%. We conclude that mussel seeding density is a critical and controllable factor determining meat and volume yield which, if properly adjusted on individual lease sites, can result in substantial additional profits for the mussel bottom culture industry.

Oysters and Toxic Algal Blooms: Are they Immune?

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A literature survey has indicated that various species of oysters exhibit very low levels of toxicity when exposed to toxic algal blooms. A study was begun in 1988 when oysters *Crassostrea virginica* and *Ostrea edulis,* were suspended in cages with mussels, *Mytilus edulis,* in Boothbay Harbor, Maine. Samples were taken of all species on a bi-weekly basis to assess the level of toxicity due to accumulation of the toxic dinoflagellate, *Alexandrium (Protogonyaulax) tamarense.* While mussels reached high levels of toxicity, oysters showed only slight levels of toxicity. Further, oysters did not become toxic until approximately 2 weeks after the toxin appeared in *Mytilus.* Both oysters and mussels released the accumulated toxin with 2-4 weeks after peak toxicity levels were reached. Comparison of these data with those from the literature indicate that there is a general trend for oysters to accumulate less toxin than mussels when simultaneously exposed to toxic algae. There is also some indication that oysters can rid themselves of the toxins more quickly than many other species of molluscs.

The Distribution of Hard Clams Mercenaria Mercenaria in the Eastern Great South Bay, New York: Identification, Hard Clam Population Dynamics, Sediment Profile Characteristics and Bottom Morphology

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The distribution of hard clams (Mercenaria mercenaria) in the eastern Great South Bay, New York, can be characterized as distinct and stable areas of high hard clam abundance interspersed with areas of low hard clam abundance. To identify factors that may be responsible for this pattern: the areas of high and low hard clam abundance were statistically defined; hard clam population dynamics of a high and a low hard clam density area were determined; REMOTS (Remote Ecological Monitoring of the Seafloor) sediment profile photographs were taken along transects traversing high and low density areas; and, side-scan sonar was used to identify and map the morphologic features of bay bottom characteristic of high and low abundance areas.

High and low abundance areas were best defined using stratification based on mean hard clam abundance. Comparison of population characteristics in the high and low density areas revealed no difference in ontogenetic growth or the abundance of harvestable size hard clams, but the abundance of sub-harvest size hard clams was an order of magnitude greater and the recruitment to the fishery was 7 times greater in the high density areas. It is not evident if the increased recruitment is due to greater settlement or survival to age one. Analysis of the sediment profile photographs suggested that high hard clam density areas have greater sediment grain size, greater sediment compactness, rougher surface relief and shallower depth to RPD (Redox Potential Depth) and generally had small shell fragments dispersed throughout the sediment. The bottom characteristics suggest that high hard clam abundance may be associated with reduced biogenic reworking of the bottom, the presence of shell fragments and/or greater bottom stability. The side-scan sonar mapping showed the high and low abundance areas to have distinctive morphologic features and that the transition in morphology was relatively sharp.

A Genetic Model of Polyploidy and Hybridization in Shellfish

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Triploidy, hybridization, introduction, and transfer of non-indigenous oysters are currently topics of considerable attention because of recent decimation through disease of American oyster (Crassostrea virginica) populations in the Chesapeake and Delaware Bays. A model was developed showing various cytogenetic outcomes of treatment of shellfish oocytes to induce triploidy. This model is based on a series of experiments, and on direct cytological examination of embryo cells. The ploidy level of early embryos developed from treated eggs and/or sperm ranged from haploidy through tetraploidy to pentaploidy. This depended on the female, experimental conditions, and whether or not the sperm were genetically inactivated. Some embryos were chromosomal mosaics, and some were aneuploid. Additional information was collected from trial induction of triploidy in interspecific crosses of the American and Japanese oyster, and from research on other interspecific crosses. These results should be considered in regard to suggestions that polyploid or hybrid oysters be used to rehabilitate fisheries devastated by disease.

Observations of Reduced Recruitment of Seed Oysters in an Estuary with Restricted Tidal Flushing

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The Pattagansett River estuary in East Lyme, Connecticut, has a history of both natural and cultivated (commercial) oyster production. Declines in productivity led to the abandoning of the industry prior to 1940. The present-day population of oysters in the Pattagansett River is limited to a small bed in an area of high current south of a road causeway. The bed was surveyed in 1984 and consisted of very large adult oysters, buried shell-bases and no evidence of recent oyster setting. Historical information indicated that the oyster resource had significantly declined. Efforts were made in cooperation with the local shellfish commission to prepare the shell base for oyster spatfalls, and the Connecticut Department of Agriculture-Aquaculture Division to plant 400 bushels of shell cultch over the bed to restore oyster setting to the area. Three attempts to restore oyster setting were unsuccessful. The construction of the railroad causeway may have altered the tidal flushing of the estuary, which helped sustain previous oyster populations. Upon closer examination of the river bottom and the existing oyster bed with underwater photography, heavy sedimentation on the cultch and adult oysters was indicated. In addition, a survey of the river adjacent to the railroad causeway revealed the existence of buried oyster beds. Observations of buried oyster populations and present-day conditions are reviewed in relation to oyster setting and the habitat required for oyster growth.