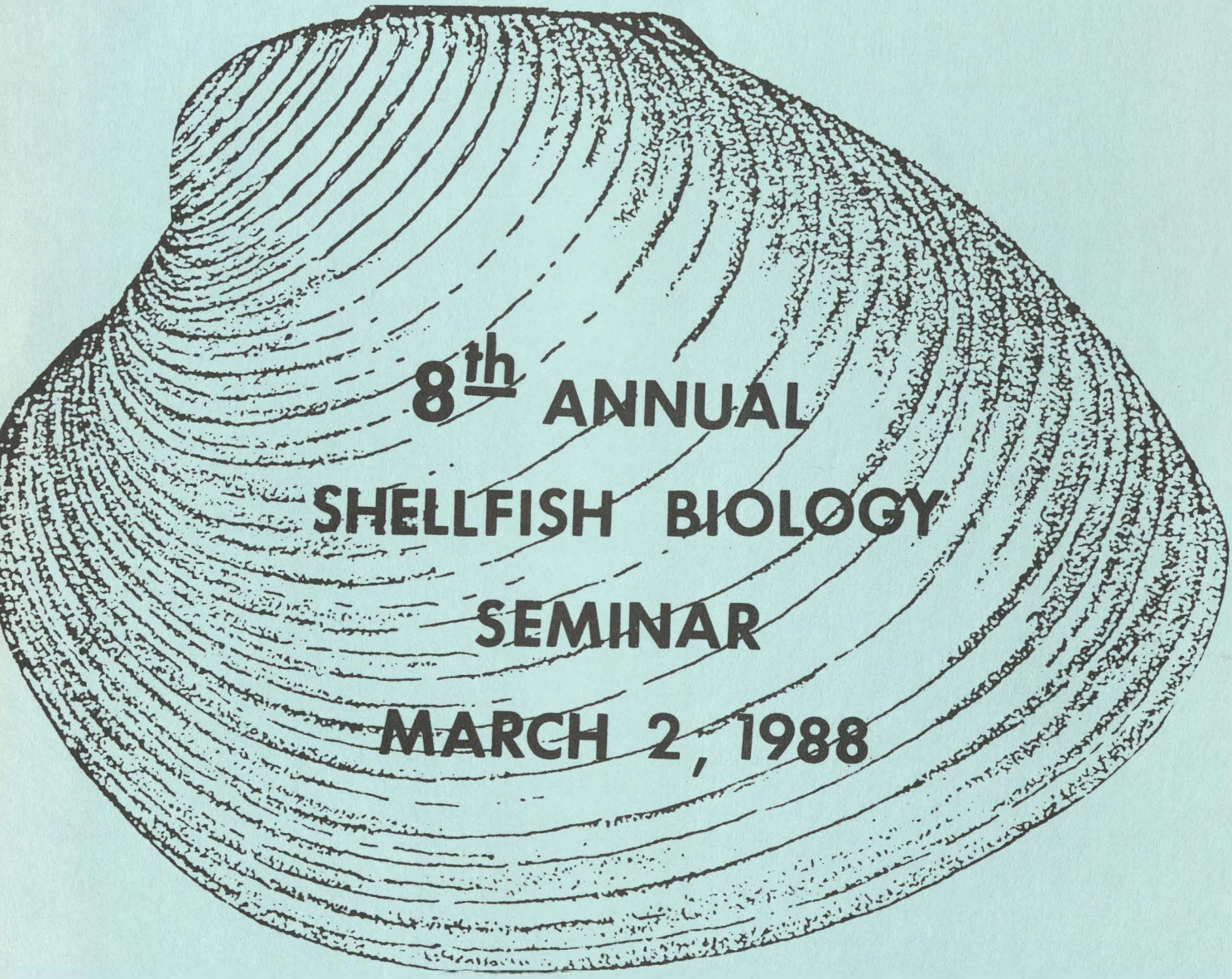

8th ANNUAL SHELLFISH BIOLOGY SEMINAR

MARCH 2, 1988

SPONSORED BY

NATIONAL MARINE FISHERIES SERVICE

NORTHEAST FISHERIES CENTER

MILFORD LABORATORY

8th ANNUAL SHELLFISH BIOLOGY SEMINAR AGENDA, MARCH 2, 1988

National Marine Fisheries Service, Northeast Fisheries Center,
Milford Laboratory
Holiday Inn Ballroom
Milford, Connecticut

AGENDA

8:10	Welcome	Alberta Jagoe Mayor of Milford
8:15 - 8:30	Opening Remarks	Walter Blogoslawski/ Anthony Calabrese NMFS, Milford, CT
8:30 - 8:35	Hard clam recruitment in Long Island Sound- an overview of the cooperative study	Ron Goldberg NMFS, Milford, CT
8:35 - 9:00	Growth and survival of hard clams at various densities in three Long Island Sound locations	James Widman NMFS, Milford, CT
9:00 - 9:30	Hydrographic factors influencing the growth of Mercenaria in LIS	Ron Goldberg NMFS, Milford, CT
9:30 - 9:50	Progress in the evaluation of phytoplankton as potential clam food in LIS	Gary Wikfors NMFS, Milford, CT
9:50 - 10:10	Bacterial ecology of planted Mercenaria mercenaria during recruitment studies at three Long Island Sound stations	Walter Blogoslawski NMFS, Milford, CT
10:10 - 10:30	Shellfish recruitment: What do we know and where do we go from here?	Ron Goldberg NMFS, Milford, CT
10:30 - 10:45	BREAK - Portrait of an Oysterman - Video Tape	Butler Flower F.M. Flower & Sons, Bayville, NY
10:45 - 11:00	A multi-factor, statistical model relating tidal currents seston, and bottom sediments to individual growth of M. mercenaria	Raymond Grizzle Jackson Estuarine Lab Durham, NH

11:00 - 11:30	Submersible assessment of the environmental effects of offshore shellfishing	Steven Murawski NMFS, Woods Hole, MA
11:30 - 12:00	Spatial patterns of predation on hard clams in LIS	Peter Auster NURP, UCONN, Noank, CT
12:00 - 1:15	Luncheon - Ballroom	
1:15 - 1:45	Recruitment into Georgia hard clam populations over time	Randal Walker Univ. of Georgia Savannah, GA
1:45 - 2:15	Temporal and spatial patterns of recruitment of Mercenaria spp. in the Indian River Lagoon, Florida.	Dan C. Marelli State of Florida St. Petersburg, FL
2:15 - 2:45	Overview of clam management and recruitment for the Town of Orleans	Sandra Macfarlane Orleans, MA
2:45 - 3:00	BREAK & Poster - Age determination of hard clams from LIS in 1987	Foyer - John Ropes NMFS, Woods Hole, MA
3:00 - 3:30	Development of a model to seed mussel bottom leases to their carrying capacity: Phase I	Carter Newell Great Eastern Mussel Farm Tenants Harbor, ME
3:30 - 4:00	Reproductive success of LIS Mercenaria:Genetic and viability studies	Sheila Stiles NMFS, Milford, CT
4:00 - 4:40	Use of Thalassiosira weissflogii in the culture of post-set Mercenaria mercenaria	Karen Eno and Craig Strong Bluepoints Co. W. Sayville, NY
4:40 - 5:10	Does pea gravel protect hard clams from predation by all crabs?	Elizabeth A. Day Clemson University Conway, SC
5:10 - 5:20	CONCLUDING REMARKS	Walter Blogoslawski Workshop Chairman

ABSTRACTS

Hard clam recruitment in Long Island Sound - an overview of the cooperative study

Ronald Goldberg, Edwin W. Rhodes,
James Widman and Kathryn Chiba

National Marine Fisheries Service
Northeast Fisheries Center
Milford Laboratory
Milford, Connecticut 06460

In 1987 we finished the second year of research on factors influencing recruitment of the hard clam, Mercenaria mercenaria, in Long Island Sound. This work evolved from our previous aquaculture experience, and uses many of the same experimental approaches. This research was funded by the National Undersea Research Program at the University of Connecticut (NURP-UCAP), and by direct National Marine Fisheries Service (NMFS) funding to the Milford Laboratory. This basic experimental framework was established by the Genetics and Life History Investigation of the Milford Laboratory. It has been strengthened by strong cooperation with the NURP-UCAP program, and the Microbiology and Physiological Ecology Investigations at Milford. NMFS scientists, Jerome Prezioso, (Narragansett) and John Ropes, (Woods Hole) have also made major contributions. Progress in a number of areas has been made and those results will be discussed in subsequent talks.

Growth and survival of hard clams at various densities in three Long Island Sound locations

James C. Widman

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These results are part of a study examining the factors possibly influencing hard clam recruitment in Long Island Sound. Hatchery-reared clams, Mercenaria mercenaria, were held in partially buried, 0.6 X 0.6 X 0.25 m vinyl-coated wire-mesh cages at three sites in Long Island Sound. These were grown in triplicate at densities of 500, 1000 and 3000 m^2, at a depth of 5 m mean low water. At one site, cages were deployed with the clams at five additional densities ranging from 100-5000/m^2. Clams grew from an initial mean shell height of 11.5 mm in April 1987 to final mean shell heights ranging from 17.4 - 24.1 mm by November 1987. Density was not a significant factor affecting

growth at any site. Clams grown in Greenwich were larger than those grown in Milford or Stonington. Survival was not affected by density, although the cages did not completely exclude predators. Survival was lower at the Stonington site.

To test for effects of cages on growth, 4 additional cages, holding clams at 500/m^2, were positioned randomly away from the main cage grid at each site. Growth of these clams was similar to those grown in the density experiment.

Site and hydrographic factors influencing the growth of *Mercenaria mercenaria* in Long Island Sound (LIS)

Ronald Goldberg

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We have characterized the environment at three sites in LIS, chosen to investigate factors affecting settlement and growth of the hard clam, *Mercenaria mercenaria*. The sites, near Greenwich, Milford, and Stonington, CT, were selected to represent diverse ecological conditions within LIS. Age analysis of shells of live clams from the sites indicates an even distribution of all year classes from 0+ to over 50. Sand substrates were similar at all sites, but gravel was heavily interspersed in Greenwich sediment, and shell debris at Milford. Seawater temperature averaged 3°C lower at the Stonington site. Sites at Greenwich and Milford are characterized by low average current flow (0.0-0.5 knots) and high primary productivity (0.5-2.0 fluorescence units). The Stonington site had high average current flow (0.3-1.0 knots), and low levels of productivity (0.1-0.9 fluorescence units). Oxygen levels were close to saturation throughout 1987 at Milford and Stonington. At Greenwich, oxygen levels fell to about 50% saturation (4.2 ppm) between July and August. Measurement of biological oxygen demand (BOD) averaged about 3.0 ppm higher at Greenwich and Milford than at Stonington. The importance of major site and hydrographic conditions are discussed in relation to the growth of caged clams and survival of unprotected clams.

Progress in the evaluation of phytoplankton as potential clam food in Long Island Sound

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During the second year of our hard clam recruitment study, water samples collected at approximately three-week intervals between April and November, 1987, from three Long Island Sound

stations (western, central, and eastern) were evaluated to determine potential food available for hard clams, Mercenaria mercenaria.

Phytoplankton community structure was characterized by identifying microalgal taxa present in whole water samples and estimating the relative abundance of major taxonomic groups. Centric and pennate diatoms were most prevalent in central and eastern stations, respectively, as was observed in 1986. However, unlike 1986, in 1987 a bloom of the dinoflagellate Prorocentrum dominated the phytoplankton at the western site during mid-summer, and this alga remained as a substantial percentage of the assemblage until November.

Seston samples collected 1M from the bottom were filtered at sea and analyzed in the laboratory for dry weight, protein, carbohydrate, lipid, and photosynthetic pigments. Analyses revealed seston component concentrations and trends similar to those observed in 1986. When protein, carbohydrate, and lipid values, measured as mg/m^3 were summed to calculate an index of "food" (as per Soniat, Ray, & Jeffries, 1984. Contrib. Mar. Sci., 27: 127-141), eastern waters were shown again to contain less potential nutrition for filter feeders than western waters.

Results of seston analyses will be combined with current-speed data (collected concurrently) to investigate how the concept of "food flux" relates to growth of hard clams planted at the study sites. Clam growth and food availability in Long Island Sound will be compared with results of recent laboratory experiments on hard clam nutrition.

Bacterial ecology of planted Mercenaria mercenaria during recruitment studies at three Long Island Sound stations

W. J. Blogoslawski, L.P. Tettelbach,
L.J. Romick, and J.E. Lovatt

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As part of the ongoing hard clam recruitment study in 1986-87, we collected samples of water, sediment and planted clams, as well as water quality data at Connecticut sites near Stonington, Milford and Greenwich. These samples were then plated on bacteriological media to provide total counts of marine heterotrophic bacteria, including Vibrio isolated on thiosulfate-citrate-bile-saccharose agar medium (TCBS).

A total of 639 isolates were selected for identification to genus and bioassay challenge against clam larvae reared at the Milford Laboratory. The genera of bacterial flora found in descending order of concentration were: Vibrio, Pseudomonas, Flavobacterium, Achromobacter, Aeromonas, and Micrococcus. Of these, 67 isolates primarily of genus Vibrio and Pseudomonas

were shown to cause mortality to clam larvae in preliminary laboratory bioassays. Pathogens were not found in clam tissues from Milford or Stonington, but only at the Greenwich site.

Considering the total microbial community, all three sites showed uniformity in bacterial genus composition in spite of significant differences in site-specific characters such as bottom current speed, salinity, dissolved oxygen, nutrients, pollution inputs, sediment type, light, tidal flux, and temperature.

Shellfish recruitment: what do we know and where do we go from here?

Ronald Goldberg

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Milford, Connecticut 06460

A conceptual model was developed to identify major factors affecting hard clam recruitment. Inputs to the model include hydrography, phytoplankton availability, physical habitat, predation, possible population density-dependence, genetics, disease, and anthropogenic effects. These factors influence the bivalve's reproduction, settlement, and growth and ultimately determine whether the population will become self sustaining and available to the fishery.

Our primary approach has been one of manipulative field experimentation and monitoring of ambient conditions. Research we have undertaken tests some components of this model, measuring their relative importance and probable interactions. Research has focused on identifying differences in growth and recruitment at sites representing diverse environments in Long Island Sound. Caged and uncaged hard clams were planted at 3 sites to determine how habitat, hydrography, phytoplankton and predation influence growth. Planted but unprotected clams had greater survival in the presence of gravel or shell which probably reduced predation. Settlement of young-of-the-year clams was detected at all experimental sites. Growth of caged clams was less in Stonington. Growth was not dependent upon population density within the experimental cage units.

Among the factors tested, temperature and food availability have greatest influence on growth. Food flux, food concentration multiplied by the current flow, is discussed as a factor which may determine growth rate. Chemical, biochemical, and microbiological data from the study are reviewed. The strengths and weaknesses of the study are presented and alternative research strategies for the future are proposed.

A multifactor statistical model relating tidal currents, seston and bottom sediments to individual growth of *Mercenaria mercenaria*

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Descriptive/correlative studies at eight sites and a 3 X 3 (3 sites and 3 sediment types: mud, muddy sand, sand) factorial field experiment were carried out in a coastal lagoon in southern New Jersey to determine the relative importance of tidal currents, seston and bottom sediments to individual growth of *Mercenaria mercenaria*. A statistical model that predicts shell growth was developed.

Hatchery-reared clams were used in the experiment, and wild clams (age/growth relations determined by internal shell banding patterns) were used in the descriptive/correlative studies. Sediment characteristics, and near-bottom tidal current velocities and seston parameters were measured at all sites.

With adjusted (for original length, ANCOVA) shell growth as dependent variable, the experiment showed a significant (P=0.0014) "site" effect, P=0.0616 for "sediment" effect, and P=0.1258 for "site by sediment" interaction effect [(x_1) (X_2) term in model below]. Differences in mean horizontal seston fluxes (a product of current velocity x seston concentration, units: $mg/cm^2/s$; X_1 term in model) best explained the "site" effect, and fluxes were positively related to growth. Slowest growth was in mud and fastest in sand (sediment characteristic = X_2 in model). Descriptive/correlative studies showed that the positive relation between seston fluxes and growth changes to negative at some flux rate [$(X_1)^2$ in model with negative coefficient B_2]. These findings were used in multiple regression analyses of the wild clam shell growth and environmental data to develop a model of the general form:

$$\text{Growth} = B_0 + B_1 (X_1) + B_2(X_1)^2 + B_3 (X_2) + B_4 (X_1) (X_2) + E$$

Highest growth rates are predicted (and occurred) in sandy sediments and moderate seston flux regimes.

Submersible assessment of the environmental effects of offshore shellfishing

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National Marine Fisheries Service
Northeast Fisheries Center
Woods Hole, Massachusetts 02543

During the summers of 1986 and 1987 we evaluated, in situ, the operating characteristics and subsequent effects of shellfish dredging on the Northeast continental shelf. The project involved two research submersibles (Johnson Sea Link II, and Delta) and nine commercial fishing and research surface vessels. Research focused on four major issues (1) survival of small sea scallop, ocean quahog, and surf clam culled from catches as not meeting minimum size regulations, (2) efficiency of commercial and research dredges (both hydraulic clam and scallop dredges), (3) effects on shellfish encountered on the bottom by the dredges, but not brought to the surface, and (4) effects on nonharvestable animals and plants, and on sediment structure.

This paper discusses preliminary research results, based on photographic, video, and observational data, as well as the results of field experimentation. Results of the project will be of importance in assessing the probable impacts of various harvest regulations for the species.

Spatial relationships of crustacean predators with an infaunal prey species (Mercenaria mercenaria)

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National Undersea Research Program
The University of Connecticut at Avery Point
Avery Point, Groton, Connecticut 06340

Direct underwater observations of the behavior of crustacean predators, searching for infaunal prey, suggested interactions occur at a variety of spatial scales. Using hard clams (Mercenaria mercenaria) as a model infaunal prey item, we conducted manipulative field and laboratory experiments to test hypotheses concerned with: (1) the effects of prey patch size and density on mortality, (2) the effect of heterogeneous diel predator distributions on the spatial patterns of prey mortality, and (3) the short-term effects of non-consumptive handling of prey by predators. This paper will discuss the results of these investigations in terms of impacts on recruitment in natural populations as well as artificial seeding for population enhancement programs.

Recruitment into Georgia hard clam populations over time

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The age structure of 40 hard clam, Mercenaria mercenaria (L.) populations throughout the coastal waters of Georgia was studied. Clams (N=2072) were aged according to shell sectioning techniques. Clams were aged to 40 years with clams less than 10 years of age accounting for 60% of the harvested animals. Clams 11 to 20, 21 to 30 and those greater than 30 years accounted for 25%, 13% and 2% respectively. Successful recruitment, as defined here, means surviving clams into the next year class. Actual recruitment per year per population is unknown. Overall, (N=40 populations) some successful recruitment has occurred every year for the past 40 years; however, successful recruitment per population varied greatly. Factors such as population growth rate, density, and reproductive biology are discussed in terms of recruitment in the coastal waters of Georgia.

Temporal and spatial patterns of recruitment of Mercenaria spp. in the Indian River Lagoon, Florida

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From late 1986 through the summer of 1987, a quarterly recruitment survey was conducted in the Indian River lagoon, Florida. The survey consisted of sampling substrates at fifty stations in each of two shellfish bodies in the lagoon. Of these fifty stations, fifteen each were randomly located in eastern, middle, and western portions of areas open to harvesting in each shellfish body, and five more in the western portion of each body were in areas closed to shellfishing. Information on depth and sedimentary characteristics was collected at each station, and then a 0.25 sq. meter circular quadrant was worked into the substrate to a depth of approximately 10 cm. The quadrant was cleared of large clams by raking with a hand rake, and the top 5 cm of substrate was removed with a water powered, venturi driven, suction dredge. Material removed was collected in a mesh bag with 2 mm sub-circular openings. All Mercenaria spp. retained in the bag, as well as all clams raked, were preserved and subsequently counted and measured as to maximum shell length.

Recruitment in the northern lagoon was extremely low, averaging 0.16 recruits per sq. meter across all dates and stations. Not enough data were collected to allow for comparisons of areas within the northern lagoon, or between seasons.

Densities of Mercenaria spp. recruits in the southern lagoon averaged 2.64, 4.72, 2.72, and 2.32 per sq. meter, for the fall, 1986, winter, spring, and summer 1987 respectively. Recruitment was significantly higher during the winter of 1987. Wide variation was seen between stations, but differences between areas were not significant. Recruitment to areas closed to shellfishing was significantly higher than to open areas.

Current research is focusing on monthly recruitment of Mercenaria spp., in four areas of the lagoon, and its relation to reproductive stages of adults in the population. Monthly recruitment will also be related to levels of larval abundance, physico-chemical parameters and chlorophyll. A semi-annual suction dredge survey will be conducted so that the pattern of recruitment in the natural population can also be determined.

Overview of clam management for the Town of Orleans

Sandra L. MacFarlane

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Shellfish-Harbormaster Department
Orleans, Massachusetts 02653

Because Massachusetts has a system of shellfish management whereby each coastal community manages its own shellfish resources, components of any management program such as propagation, transplants, regulations and enforcement are all handled directly by the individual municipality. Orleans is fortunate to have three separate and very different embayments within its borders providing prime habitat for bay scallops (Argopecten irradians), blue mussels (Mytilus edulis), soft shell clams (Mya arenaria), and quahaugs (Mercenaria mercenaria).

Quahaugs are the species with which we have done the most work. The town has been committed to a seed propagation program since 1975, a program that has utilized bottom and raft culture as well as hatchery rearing and upwellers for nursery culture. In addition to seed plantings, we have also planted hundreds of bushels per year of adult spawning stock, usually greater than 3", obtained from relatively deep water in Cape Cod Bay. Our objective in these programs has been to augment the natural supply of quahaugs with planted stock.

Currently, the town is using the upweller technique almost exclusively to raise one million seed from one to two millimeters to eight to fifteen millimeters in a growing season. The seed is kept in the facility until the water temperature drops to less than 10^{o}C at which time they are broadcast into the water. Survival in the culture facility averages about 97%; field

survival is estimated to be about 50%, but quantitative information is extremely difficult to obtain because of a variety of factors.

Age Determination of hard-shelled clams from Long Island Sound 1987

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As part of a study of natural recruitment of hard-shelled clams, Mercenaria mercenaria, at Milford, Greenwich, and Stonington sites in Long Island Sound, valves from 177 individuals collected during June 1987 were prepared for age determination. Acetate peels from radially sectioned valves revealed the various types of growth breaks that have been identified for hard-shelled clams. Freeze shock breaks, resulting from the lowest winter temperatures, seemed to occur with a regular periodicity. An annual deposition of such breaks was supported by examination of hard-shelled clams that had been cultured from larvae, raised as juveniles in an upwelling system until planting in the field, and finally dug up 3-1/2 years after larval settlement. The freeze shock breaks in these and the Long Island Sound clams appear to have continuity with growth breaks in a cardinal tooth. These breaks were sometimes more distinct and easier to enumerate than those in the valve.

Development of a model to seed mussel bottom leases to their carrying capacity: Phase I

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An attempt was made to determine realistic inputs for a model in which optimal mussel seeding density is calculated for each least section. Model predictions and field data indicate that as much as 25% of the available food can be removed from the benthic boundary layer above a mussel bed path length of 1 meter at current speeds of 5 cm/sec. Mussels sampled from the middle of large (over 10 m diameter) patches grew 43-48% less in meat weight and 34-36% less in volume than those sampled from the edge. Overseeding was identified as the major cause of density-dependent growth effects. In a 500 m transect across three seeded sections on the flood tide at a low-current area, food availability was lower in the inner vs outer sections (44.2% less phytoplankton cells, 31.9% fewer chlorophyll particles as estimated with the flow cytometer, 32.3% less carbon and 21.5% less nitrogen). Mussel feeding selectivity accounted for 40% greater filtration rates on chlorophyll vs non-chlorophyll

particles, but there appeared to be a threshold of % chlorophyll cells for feeding selectivity to occur. Highest mussel feeding rates (.17 ug chlorophylla/min/g dry flesh weight) occurred during the fall phytoplankton bloom, and lowest rates (30-fold less) were correlated with periods of low food availability during the summer.

Flume experiments and direct measurements of mussel height off the bottom were used to determine bottom roughness in a mixing model. Development of a computer model with further refinements is proposed in Phase II of the research, along with detailed examination of mussel seeding technology and mussel feeding thresholds.

Hard clam reproductive success: Genetic and viability studies

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Cytogenetic and viability analyses of early life stages of hard clams collected from five sites in Long Island Sound indicate that water quality varied by site at the time of sampling. Significant differences were evident as early as Metaphase I of meiosis, the stage at which bivalve eggs are spawned. Chromosomal aberrations, cytotoxic stickiness of dividing chromosomes, and pycnotic nuclei were also observed in embryos and larvae. The frequency of these cytopathological conditions varied in embryos and larvae cultured in water collected from various sites and used for laboratory spawning of the clams, as well as for fertilization, meiotic, and developmental assays of the eggs.

Cytological findings and mutagenic events generally were consistent with morphological abnormality and mortality of larvae. Overall frequency of meiotic and mitotic chromosomal aberrations in clam eggs and embryos was similar to that of the mass-spawned eggs of another bivalve, the American oyster. Results demonstrate that bivalves could be used as models for evaluating water quality and genotoxic effects of environmental pollution on reproduction.

Use of Thalassiosira weissflogii in the culture of post-set Mercenaria mercenaria

Karen Eno and Craig Strong

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Thalassiosira weissflogii is a relatively large diatom generally used for bioassay purposes. Data showing its high uptake by scallops led to a study challenging it against several known bivalve foods used in Mercenaria culture. Results of this preliminary study indicate that this diatom makes a significant nutritional contribution to the growth of post-set Mercenaria. Based on this study, T. weissflogii has been included in the Mercenaria post-set diet through both pulse and drip feeding systems.

Does pea gravel protect hard clams from predation by all crabs?

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The use of pea gravel has been suggested to reduce crab predation on hard clams, Mercenaria mercenaria, however, the results of some field plantings suggest that gravel does not always provide the expected protection to hard clams. Planting juvenile hard clams in substrates not preferred by crabs should inhibit crab predation on clams. The effect of predatory risk should also be greatest in their non-preferred substrates. However, substrate preferences may not be the same for all crab species. The xanthid mud crabs, Neopanope sayi, Panopeus herbstii, and Eurypanopeus depressus, preferred broken oyster shell most and sand least when offered shell, mud, small gravel, large gravel, and sand in binary combination. Neopanope sayi predation on juvenile hard clams was at least 64.8% lower in sand than when this substrate was combined with gravel substrates. Addition of the toadfish, Opsanus tau, caused more than a 91.5% reduction in predation on clams by crabs. This lowered predation was primarily a result of depressed crab activity, not direct crab mortality. The results of these experiments, coupled with field observations by other researchers, indicate that clams planted in crabs' least preferred substrate survive best, especially when predatory fish are present.