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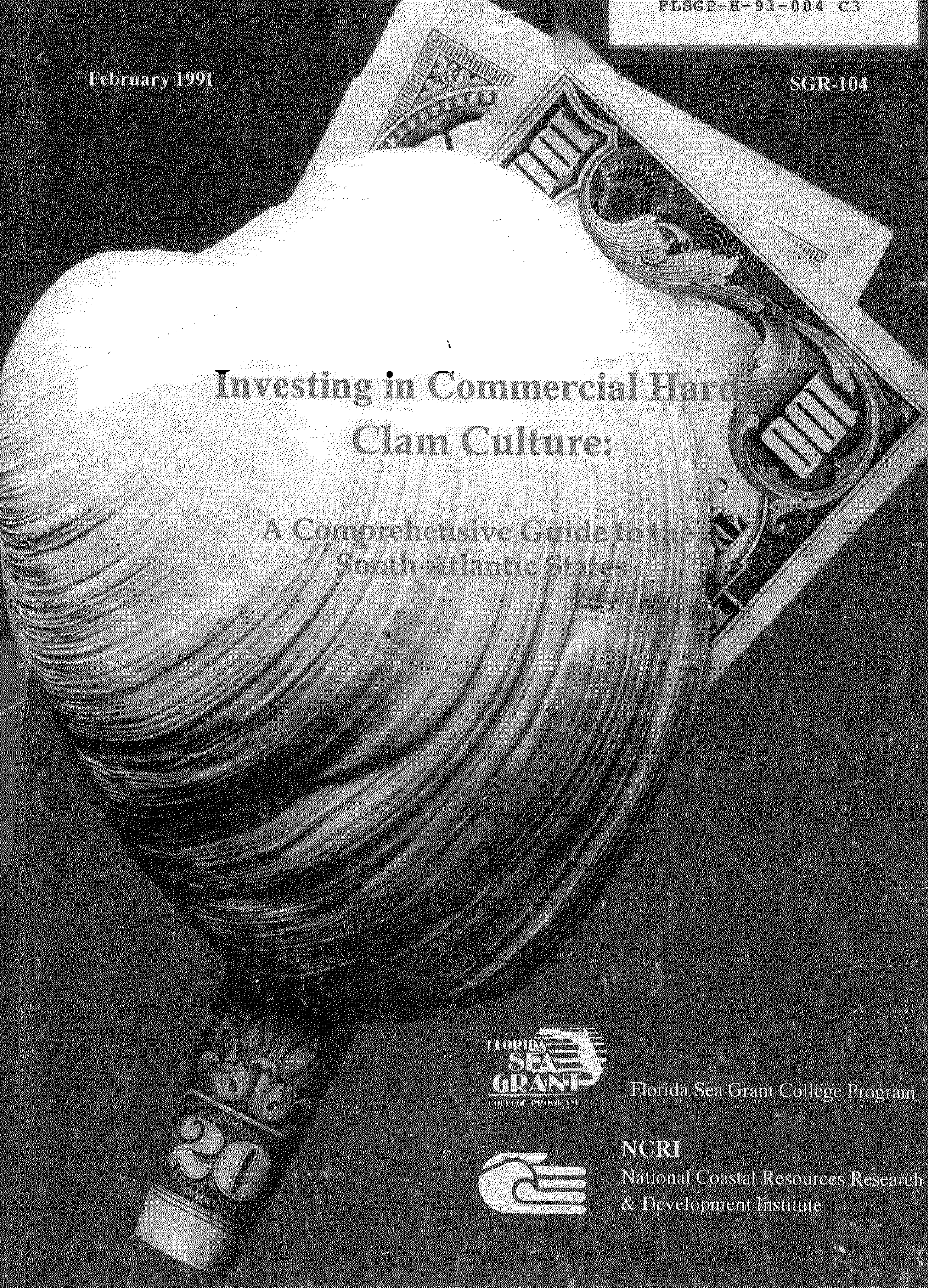

Investing in Commercial Hard Clam Culture:

A Comprehensive Guide to the South Atlantic States

Florida Sea Grant College Program

NCRI
National Coastal Resources Research & Development Institute

INVESTING IN COMMERCIAL HARD CLAM CULTURE: A COMPREHENSIVE GUIDE TO THE SOUTH ATLANTIC STATES

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PREFACE

Per capita consumption of fish and shellfish products in the U.S. has increased almost 25 percent throughout the decade of the '80s. Harvest of wild stocks is not increasing at the same rate because stocks are limited. Average price for hard clam meats has increased nationwide with an even greater increase occurring in the South Atlantic. The potential is now great for rapid development of hard clam culture. It is necessary to further develop commercially viable aquaculture techniques and information so that existing and potential seafood producers can supply the growing demand and the industry can develop.

A substantial amount of biological research has been completed from Virginia through Florida on hard clam culture during the last decade. Clam farmers are beginning to use this technology. However, two of the current major limiting factors to industry development are public education and economic information. This guide focuses on both these factors. Six clam culture biologists and five economists wrote this guide on the economic feasibility of clam culture to provide the basis on which interested persons can make realistic economic decisions on whether to begin a hard clam culture system. Although the guide is intended as a self-help manual for potential clam culturists and investors, the authors themselves and others at their institutions can assist in industry develpment through their public education and Sea Grant extension programs.

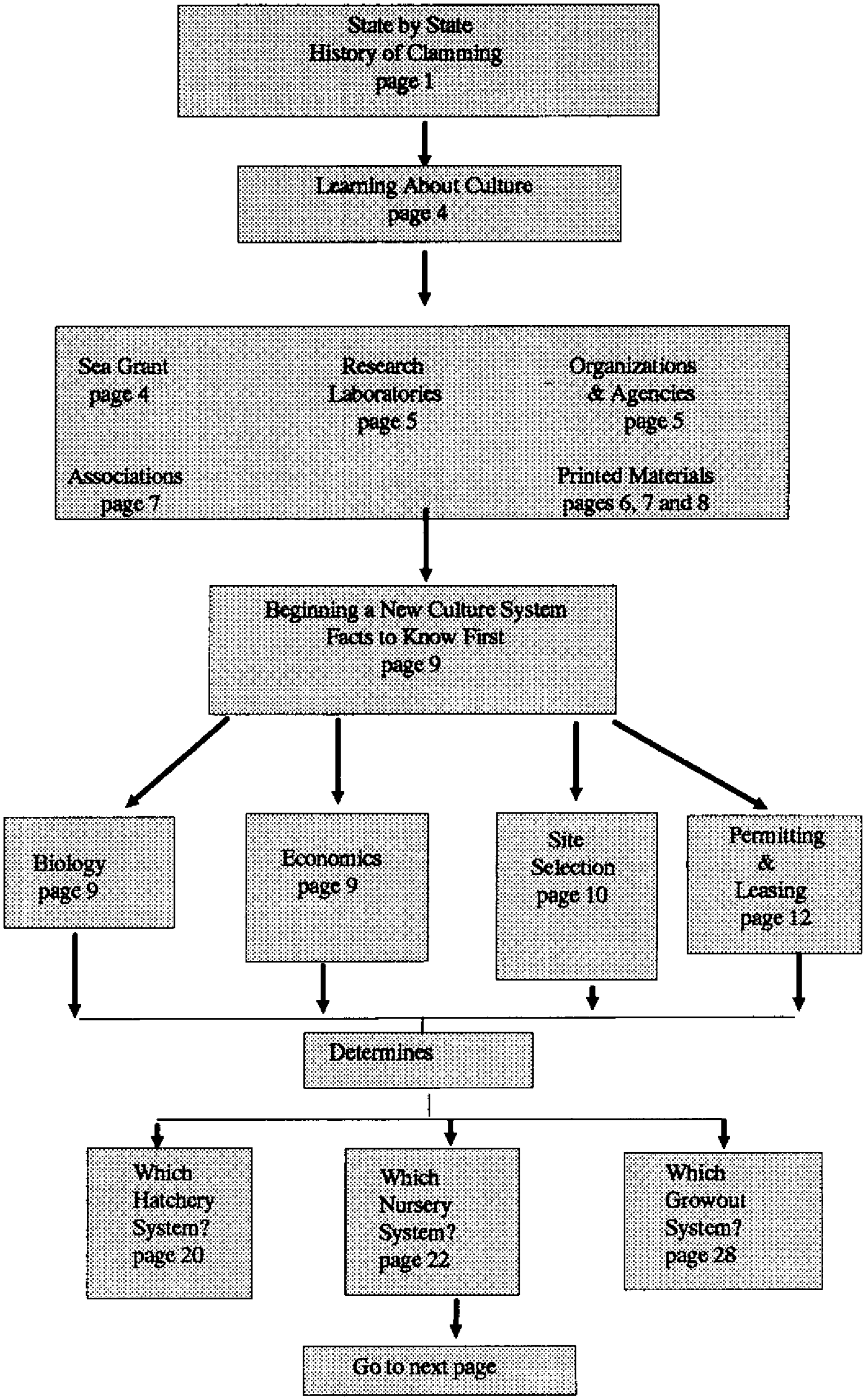
HOW TO USE THIS GUIDE

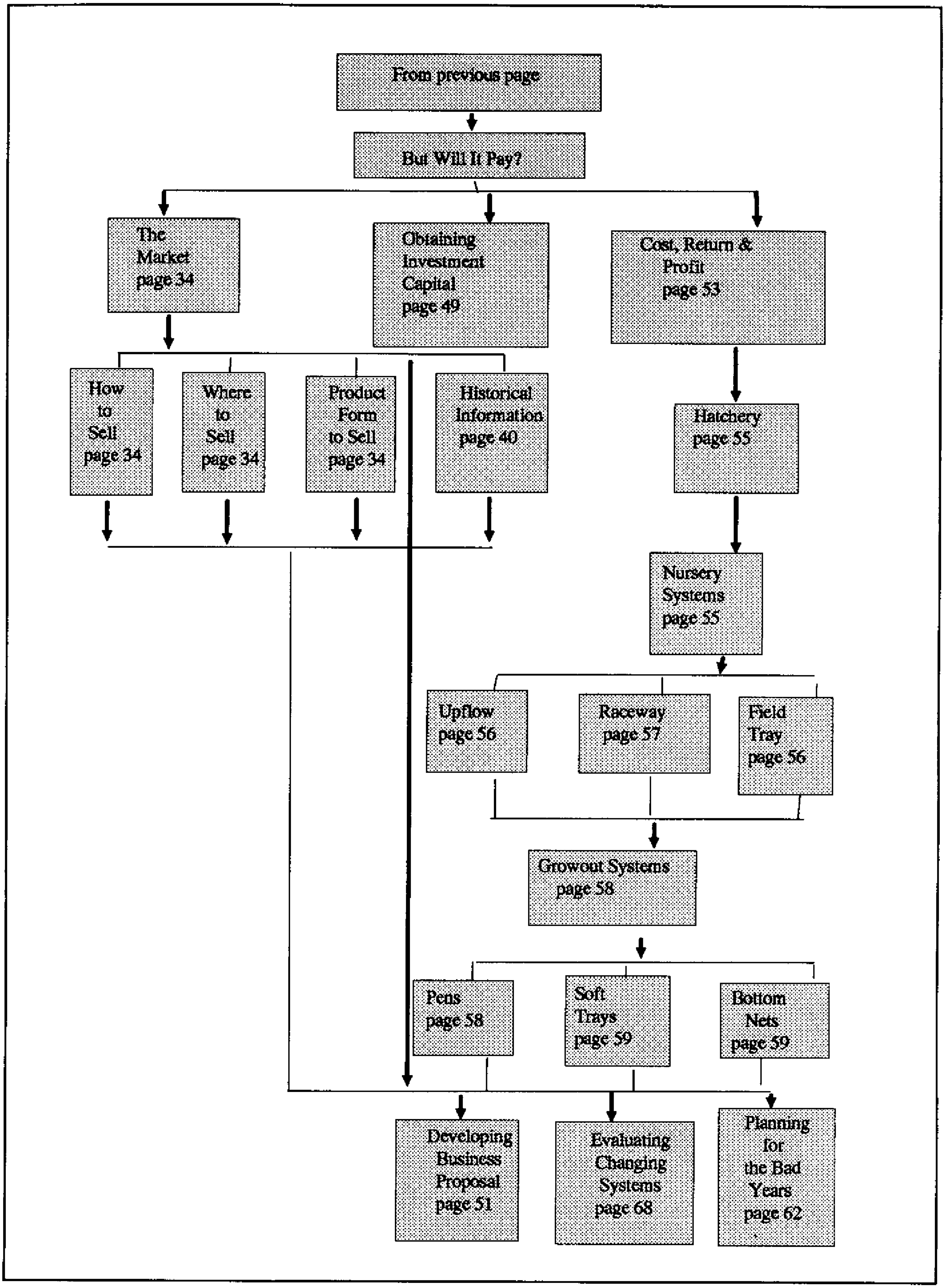
This guide is designed to provide possible investors and hard clam culturists with basic operational and financial information and a method to analyze their own economic potential. Using it should allow making rational decisions about clam culture investment. A major focus of the guide is the presentation of analyses of culture technique components in tabular format. These analyses include investment requirements and sample cost and return budgets for each clam culture stage. Although produced for the South Atlantic region, the guide should be useful in all areas where clam farming has potential.

Potential investors and hard clam culturists are advised to modify the data and economic projections based on their own locations and economic situations. While the authors have made every attempt to produce realistic assumptions and analyses, investors and farmers should use these data at their own risk. The authors and the institutions and agencies they represent are not responsible for the economic consequences of decisions based on this guide.

Some potential investors and farmers may want to read and use each major section as shown in the Table of Contents and flow chart on the next page. The flow chart provides a summary "road map" for the important issues and questions covered in the guide. Other readers may only be interested in certain sections if they are already involved in clam culture. The flow chart (Figure 1) also contains page numbers for each highlighted major section.

Figure 1. Guide Flow Chart

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I. INTRODUCTION

Clam culture in the United States began with the first successful rearing of larval hard clams, Mercenaria mercenaria, by W.F. Wells between 1920 and 1926. Culture methods for larval and juvenile clams were eventually standardized by Victor Loosanoff and his colleagues in the 1950s and early 1960s (Loosanoff and Davis, 1963a, 1963b). A number of commercial hatcheries began toward the latter part of this period. Clam culture in North America, however, was not commercially successful until economical and efficient nursery systems and field growout techniques were developed. Only over the last decade have nursery system and field growout technologies sufficiently evolved to make the controlled culture of the hard clam commercially attractive (Manzi and Castagna, 1989).

The reported landings of hard clams in the United States have decreased steadily from the turn of the century although production over the last decade has been relatively stable (Table 1). The proportion of these landings either directly or indirectly due to culture has been increasing. The data in Table 1 reveal that hard clam culture production has increased from about 140 thousand bushels in 1981 to about one-half million bushels in 1989. This represents an increase in total culture production of about 300 percent in less than a decade. Over this same period, the percent of total hard clam production due to culture has increased from about 6 percent in 1981 to over 43 percent in 1989. Although much of this increase has occurred in the South Atlantic states (Virginia, North Carolina, South Carolina, Georgia, Florida), it may reflect only apparent statistical increases (i.e. state reporting requirements are changing, finally allowing the segregation of cultured and wildstock landings). Total landings have decreased as well, providing an artificial proportional increase in the contribution of cultured product to overall production. The clam culture production statistics are also probably inflated by the inclusion of clams produced by partial culture activity - i.e., seed production, transplanting, replantings and other semiculture performed as part of natural clam harvesting practices.

Historically, with the exception of North Carolina and Virginia, the South Atlantic states have not been major hard clam producers. Recently however, with the advent of mechanical harvesting methods and the increased value of the species, all of the states but Georgia have developed substantial fisheries. Availability of leasable growout areas and the environmental suitability of the region in general for culture have also stimulated considerable interest in commercial hard clam culture.

Virginia

In Virginia, the hard clam has been recognized as an important commodity since the writings of Captain John Smith. The lower portion of Chesapeake Bay including the lower James and York

Table 1. U.S. hard clam landings and clam culture production.

Year	Wildstock Landings	Clam Culture Production	Percent of Landings From Culture
	---- 000 bushels ----		
1981	2,265	140	6.2
1982	1,607	221	13.8
1983	1,773	201	11.3
1984	1,844	211	11.4
1985	2,087	199	9.5
1986	1,474	313	21.2
1987	1,427	437	30.6
1988	1,546	520	33.6
1989	1,160	500[1]	43.1

Data from NMFS (1989), Rhodes (1989) and Anonymous (1990)
[1]Estimate

Rivers with their bays and tributaries and the Eastern Shore are prominent harvesting locations for the wild fishery. Harvesting methods in Virginia vary widely and include treading by foot, clam rake, basket rake, hand tongs, and patent tongs. In recent years, the wild harvest of clams in Virginia has increased as the harvest of oysters has declined. In 1988, the wild harvest of hard clams was valued at almost $4.8 million, making it the sixth most valuable fishery in the state.

Virginia has a long history of both experimental and commercial culture of the hard clam. The first commercial hard clam hatchery in North America opened its doors in 1956 in the town of Atlantic on the Eastern Shore. While the hatchery/nursery portion of this facility met with some success, the field growout aspect was a failure, most likely due to predation. Scientists in Virginia have since developed growout systems that protect small-size clam seed from predators, greatly increasing the potential for successful culture ventures. Virginia now boasts one of the largest commercial clam culture operations on the eastern seaboard and approximately two dozen smaller ones.

North Carolina

Mechanical harvesting has played a significant role in the growth of North Carolina's hard clam fishery. From 1959 to 1979, the average annual ex-vessel value of hard clams was less than $1 million. By 1986 it had increased to about $7.5 million. Most of the harvest before 1976 was by hand (rakes and tongs). The development of more efficient hydraulic dredges and "kicking" mechanical methods paralleled the rapid increase in the relative prices for clams in the 1970s and 1980s. Hydraulic dredges use a water nozzle to dislodge clams from the sediment and a conveyor to bring them to the surface. Dredges operate in water three to about 12 feet deep. Kickers use a metal kicker plate welded to the boat's rudder. The plate deflects the prop wash from the rudder to the bottom where it washes an 8- to 12-foot wide path. A heavy chain net pulled behind the boat catches clams washed out of the bottom sediments. Kickers can harvest in waters three to nine feet deep.

Mechanical harvest allows fishermen to bag more clams and reach deeper beds than by hand, but the advent of mechanical harvesting stirred controversy within the North Carolina fishery. Hand rakers claimed mechanical harvesters were encroaching on their territory, wiping out their fishery. Resource managers felt that kicking damaged grass beds. A study of this problem found indirect evidence that clam kicking reduces subsequent scallop harvests, Hsiao, et al. (1986). In 1987, kicking and dredging were outlawed from grass beds and live oyster rock. Now regulations allow for a mechanical harvesting season for clams from designated public bottoms only during the winter season. Hand harvesting is allowed year round and since mechanical harvesting was curtailed, hand-harvest landings have accounted for almost double those by mechanical methods. There are about 350 kick boats in North Carolina, 25 hydraulic dredges and 12,000 to 15,000 individually licensed hand harvesters. In 1969, only one regulation applied to hard clams, prohibiting their harvest from polluted areas. Since then, regulations have been enacted limiting the number of clams harvested per day, imposing size limits (1-inch thick), requiring culling of undersized clams, limiting mechanical harvest to certain areas and seasons, and prohibiting taking of clams at night.

In North Carolina, commercial hard clam culture has had a small but consistent presence. The state has had at least two commercial hatcheries operating in recent years and three or four commercial nurseries. Recently, a large Massachusetts-based hard clam culture company built a substantial land-based nursery in the state for overwintering seed.

South Carolina

Clams in South Carolina have undoubtedly been harvested both recreationally and commercially since colonial times. Until recently, however, commercial clam harvests have been rather modest. Almost all the clams harvested were consumed locally and the small fishery was centered in the Georgetown area. In 1973, mechanical harvesting (escalator harvesters) was introduced in the Santee Delta and landings increased rapidly over the next few years. The industry became a million-dollar fishery in 1982 and surpassed the value of oyster landings in 1983. At present, landings average over 40,000 bushels per year valued at $1.2 million or about 3 percent of the nation's total average landings and value. The state's landings are derived about equally from mechanical harvesters and hand harvests (primarily rakes and tongs but Self Contained Underwater Breathing Apparatus [SCUBA] has been gaining popularity).

Research on hard clam culture in South Carolina began in the mid-1970's and the state has maintained a strong research effort. State-sponsored research has helped develop technology for upflow nursery systems, recirculating downflow systems for set and postset and intertidal growout technology. Now, the state is involved in a multi-institutional project to produce improved broodstocks for hard clam culture in the South Atlantic. Three small-scale commercial hard clam operations are on-going in the state.

Georgia

Before 1981, annual harvesting of hard clams in Georgia was sporadic and at low production levels. At the turn of the century, a small-clam fishery developed with peak landings of 43,000 pounds of meat in 1908. Clamming continued until 1932 but at low levels of production (1,000 to 2,000 pounds of meat annually). The fishery declined by 1933, presumably because of the economic depression. From 1933 to 1981, clams were reported harvested in only five years. Beginning in 1978, the Georgia Sea Grant Marine Extension Service and the Department of Natural Resources began encouraging fishermen to attempt clamming. In 1981, a company relocated to Camden County, Georgia and began clamming full time. Landings in 1981, primarily due to this company, were 5,855 pounds of meat. Fishermen then realized that there was money in clamming and approximately 60,000 pounds of clam meat were landed in 1988. Georgia fishermen harvest clams in three ways: clam or potato rakes, by hand or tonging. Clamming on the intertidal flats is performed by raking, while rakes and hands are used the small creeks. These two methods account for the majority of harvested clams. Tonging in larger creeks account for only a small percentage of harvested clams.

Molluscan culture research in Georgia showed considerable promise and several small-scale operations were started in the mid-1980s with seed purchased from out-of-state hatcheries. In 1985, however, the Department of Natural Resources found an oyster disease Haplosporidium nelsoni, popularly known as MSX, in an oyster population in Mud Creek, Camden County. In 1986, MSX was found in South Lathram Creek, Glynn County. As a result of the discovery of MSX in coastal Georgia, the Department of Natural Resources banned the importation of any molluscan seed into the state. Since no in-state commercial mollusk hatcheries existed, clam culture in Georgia ceased even though there is no connection between MSX and clam production. In 1990, one small-scale commercial clam hatchery was established.

Florida

Commercial harvesting of clams in Florida dates back to 1900 and averaged only about one million clams per year before to 1980. In the mid-1980s, annual landings increased to between 20 and 50 million clams with a commercial value exceeding $5 million some years. This increase was due to a large natural set of clams occurring on the east coast of Florida in the Indian River Lagoon. Recent declines in landings from that natural set have prompted many Florida clammers to investigate the potential of clam culture as an alternative to fishing natural stocks. The emergence of this new culture industry has brought with it the need for public access to the technology, equipment, seed and leases to be able to culture clams in the state of Florida.

Private marine research laboratories and several state agencies have supported most of the technical support and information transfer to potential clam farmers. One private research institution has operated a commercial-scale hatchery and nursery and sold most of the seed planted in the state, about 25 million seed clams per year. There were about seven hatcheries and 70 clam farms in operation in Florida in the late 1980s. It is predicted that harvests from clam farms in 1989 and 1990 may surpass wild harvest landings. With a growout time of 18-24 months and improved state leasing practices, the future of clam culture in Florida appears favorable.

II. LEARNING ABOUT HARD CLAM CULTURE

Information Sources

This guide can help you decide which method of clam culture might be best for your location and will help you develop numbers for your economic feasibility study. This manual does not, however, provide biological information on how to grow clams. Rather, it's a guide to making economic comparisons among clam culture methods and helping the investor/culturist determine the economic potential of clam culturing.

Most sections of this guide include a description of the production methods but not an in-depth discussion of what you will encounter when you begin clam farming. To help you learn about the "how-to" of clam farming and marketing, there are many sources of information. You should start by contacting one of your state's Sea Grant marine advisory agents, the Cooperative Extension Service, a marine research university or laboratory or a state agency (a listing of these follows). These organizations can give you literature, names of clam farmers and marketing businesses you can visit, as well as initial observations and recommendations.

Clam culturing is unique so the best advice is to begin on a small scale or possibly apprentice with someone already in the business. This way you learn about the complexity of the marine environment so your mistakes will not be as costly as if you were to begin on a large scale without a good feel for marine life and clam culturing. Larger start-up firms will benefit by hiring experienced personnel. The following contacts should all help you.

Sea Grant Marine Advisory Agents

Virginia:

Virginia Sea Grant College Program
Dept. of Marine Advisory Services
Virginia Institute of Marine Science
College of William & Mary
Gloucester Point, VA 23062
(804) 642-7165

Virginia Graduate Marine Science
Sea Grant Consortium
170 Rugby Road
University of Virginia
Charlottesville, VA 22903
(804) 924-5965

North Carolina:

University of North Carolina
Sea Grant College Program
Marine Advisory Specialist
P.O. Box 896
Atlantic Beach, NC 28512
(919) 247-4007

University of North Carolina
Sea Grant College Program
Box 8605
North Carolina State University
Raleigh, NC 27695-8605
(919) 737-2454

South Carolina:

Sea Grant Marine Extension Program
P.O. Drawer 1100
Georgetown, SC 29442
(803) 546-4481

South Carolina Sea Grant Consortium
287 Meeting Street
Charleston, SC 29401
(803) 727-2078

Georgia:

Sea Grant Marine Extension Service
University of Georgia
P.O. Box Z
Brunswick, GA 31523
(912) 264-7268

Georgia Sea Grant
Ecology Building
University of Georgia
Athens, GA 30602
(404) 542-7671

Florida:

Sea Grant Extension Agent
Brevard Service Complex
1515 Sarno Road, Building B
Melbourne, FL 32935-5209
(407) 242-6514

Florida Sea Grant College Program
Building 803
University of Florida
Gainesville, FL 32611
(904) 392-5870

Marine Research Laboratories

Virginia:

Eastern Shore Laboratory
Virginia Institute of Marine Science
College of William and Mary
Wachapreague, VA 23480
(804) 787-5816

North Carolina:

University of North Carolina
Institute of Marine Science
P.O. Drawer 809
Morehead City, NC 28557
(919) 726-6841

Duke University Marine Laboratory
Pivers Island
Beaufort, NC 28516
(919) 728-2111

Georgia:

Shellfish Research Laboratory
University of Georgia
P. O. Box 13687
Savannah, GA 31416
(912) 356-2348

South Carolina:

Marine Resources Research Institute
South Carolina Wildlife and Marine Resources
P. O. Box 12559
Charleston, SC 29412
(803) 795-6350

Waddell Mariculture Center
P. O. Box 809
Bluffton, SC 29910
(803) 837-3795

Florida:

Harbor Branch Oceanographic
Institution
Coastal, Environmental, and
Aquacultural Sciences
5600 Old Dixie Highway
Ft. Pierce, FL 34946
(407) 465-2400

Florida Marine Research Institute
Florida Department of Natural Resources
100 8th Avenue, South
St. Petersburg, FL 33701
(813) 896-8626

Other Organizations and Agencies

Virginia:

Virginia Marine Resources
Commission
P. O. Box 756
Newport News, VA 23607-0756
(804) 247-2200 (leases and licenses)

Virginia Bureau of Shellfish
Sanitation
109 Governor Street
Room 904
Richmond, VA 233219
(804) 786-7937 (sanitation and shipping)

Virginia Department of Agriculture
and Consumer Affairs
Division of Marketing
P. O. Box 1163
Richmond, VA 23209
(804) 371-6094

North Carolina:

North Carolina Division of Marine
Fisheries
P. O. Box 769
Morehead City, NC 28557
(919) 726-7021 or (800) 682-2632
(leases and licenses)

North Carolina Division of
Coastal Management
P. O. Box 769
Morehead City, NC 28557
(919) 726-7021 (CAMA permits)

North Carolina Division of Shellfish
Sanitation
P. O. Box 769
Morehead City, NC 28557
(919) 726-6827 (sanitation and
shipping)

North Carolina Department of
Agriculture
P. O. Box 27647
Raleigh, NC 27611
(919) 733-7125 (permit assistance)

South Carolina:

South Carolina Department of
Wildlife and Marine Resources
Division of Marine Resources
P. O. Box 12559
Charleston, SC 29412
(803) 795-6350

South Carolina Coastal Council
4130 Faber Place, Suite 130
Charleston, SC 29405
(803) 744-5838

South Carolina Department of Health
and Environmental Control
Division of Water Quality and Shellfish
Sanitation
2600 Bull Street
Columbia, SC 29201
(803) 734-5232

Georgia:

Department of Natural Resources
Coastal Resources Division
1 Conservation Way
Brunswick GA 31523-9990
(912) 264-0542 (leases and licenses)

Department of Agriculture
P. O. Box 631
Jesup, GA 31542
(912) 427-3507 (health inspector)

Environmental Protection Division
Department of Natural Resources
Coastal Resource Division
1200 Glynn Avenue
Brunswick, GA 31523-9990
(912) 264-7284 (CAMA permits)

Florida:

State of Florida
Department of Agriculture and
Consumer Services
Mayo Building, Room 422
Tallahassee, FL 32399-0800

Florida Department of Natural
Resources
Division of State Lands
Bureau of Submerged Land
Management
3900 Commonwealth Boulevard
Room 203
Tallahassee, FL 32399
(904) 487-4436 (leases)

Magazines and Periodicals

Fish Farmer
Quadrant Subscription Services
Oakfield House, Perrymount Road
Haywards Heath, Sussex RH 163 DH
England
bi-monthly - $50/yr.

Aquaculture Magazine
by Achill River Corporation
P. O. Box 2329
Asheville, NC 28802
bi-monthly-$15/yr.
Annual Buyer's Guide

Practical Aquaculture and Lake
Management
P. O. Box 1294
Garner, NC 27529
(919) 772-8548
monthly-$12/yr.

Magazines and Periodicals (cont.)

World Aquaculture Magazine
World Aquaculture Society
16 East Fraternity Lane
Louisiana State University
Baton Rouge, LA 70803
(504) 388-3137
quarterly - $30/yr.

Water Farming Journal
by C.T. & A., Inc.
3400 Neyrey Drive
Metairie, LA 70002
(504) 482-9500
monthly - $18/yr.

Canadian Aquaculture
4611 William Head Road
Victoria, British Columbia V8X3W9
Canada
(604) 478-9209
bi-monthly - $18/yr.

Associations

Virginia Shellfish Grower's Association
421 Messick Road
Poquoson, VA 23662
(804) 868-6058

Shellfish Farmers Association
480 River Prado Road
Ft. Pierce, FL 34946
(407) 466-2013
newsletter

World Aquaculture Society
16 East Fraternity Lane
Louisiana State University
Baton Rouge, LA 70803
(504) 388-3137
quarterly journal, quarterly magazine, annual meeting, $45/yr.

Florida Aquaculture Association
P. O. Box 3989
Tallahassee, FL 32315
free subscription with FAA membership $10-$50/yr.
newsletter

National Shellfisheries Association
College of Marine Studies
University of Delaware
Lewes, DE 19958
(302) 645-4060
quarterly NSA newsletter
semi-annual journal
annual meeting

South Carolina Aquaculture Association
South Carolina Department of Agriculture
P. O. Box 11280
Columbia, SC 29211
(803) 734-2200

Brochures and Booklets

Virginia:

Manual for Growing the Hard Clam (Mercenaria)
SRAMSOE No. 249
110 pages - $3.00
Virginia Institute of Marine Science
Sea Grant Communications
Gloucester Point, VA 23062

North Carolina:

Kemp, Phillip F. "Skip" 1991.
Clam Gardening: A Manual for the Small Scale Clam Operation in North Carolina.
UNC-SG-01.
University of North Carolina Sea Grant College Program
Raleigh, NC
$5.00

"Shellfish: North Carolina Aquaculture Regulations"

Clam Conference Video Series
(one-week loan)

All available from:
UNC Sea Grant MAS
P. O. Box 3146
Atlantic Beach, NC 28512

Brochures and Booklets (cont.)

South Carolina:

Economic Analysis of Commercial
Hard Clam Mariculture in
South Carolina
South Carolina Aquaculture Fisheries
and Wildlife Cooperative
Publication #9001
SC Sea Grant Consortium
287 Meeting Street
Charleston, SC 29401

An Interim Guide for Aquaculture Permitting
in South Carolina
SC Sea Grant Consortium
287 Meeting Street
Charleston, SC 29401

Florida:

A Manual for Farming the Hard Shell
Clam in Florida
by D. Vaughan, L. Creswell and M. Pardee
Florida Department of Agriculture and
Consumer Services
Division of Marketing
Mayo Building
Tallahassee, FL 32399-0800

New York:

Small-scale Farming of the Hard Clam on Long
Island, NY
Aquaculture Innovation Program
The NY State Urban Development Corporation
1515 Broadway
New York, NY 10036

Books

Bardach, J.E., J. H. Ryther, and W. O. McLarney. 1972. Aquaculture - The Farming and Husbandry of Freshwater and Marine Organisms. John Wiley & Sons Inc., New York, NY. 868 pp.

Chaston, I. 1983. Marketing in Fisheries and Aquaculture. Fishing News Books, Ltd., Farnham, Surrey, England. 143 pp.

Chaston, I. 1984. Business Management in Fisheries and Aquaculture. Fishing News Books, Ltd., Farnham, Surrey, England.

Financial Management Handbook. 1982. Department of Agricultural Economics, Barre Hall, Clemson University, Clemson, SC 29634.

Huner, J. V. and E. E. Brown. 1985. Crustacean and Mollusk Aquaculture in the United States. AVI Publishers, Inc., Westport, CT.

Manzi, J.J. and M. Castagna, (Eds.) 1989. Clam Mariculture in North America. Elsevier Science Publishing Co. Inc., Amsterdam. 461 pp.

Pomeroy, R. S. and P. J. Rathwell. 1988. Economic Evaluation of Investment Decisions for Aquacultural Enterprises. Department of Agricultural Economics, Clemson University, Clemson, SC. 26 pp.

Quayle, D. B. and G. F. Newkirk. 1989. Farming Bivalve Molluscs: Methods for Study and Development. World Aquaculture Society Press, Baton Rouge, Louisiana.

Shang, Y. C. 1990. Aquaculture Economics. World Aquaculture Society Press, Baton Rouge, Louisiana.

III. BEGINNING A NEW CULTURE SYSTEM

Options

The clam culture process is divided into three stages: hatchery, nursery, and growout. The hatchery produces small seed grown from eggs through larval stages. The nursery grows larger seed for field planting. Growout produces marketable size clams from seed.

The hatchery stage consists of tanks and equipment to (1) condition adult clams into ripeness and spawn or induce release of reproductive cells or gametes, (2) grow and produce cultured algae as a food source for developing clams, and (3) grow early clam stages or larvae into the young clams or "set." The hatchery stage techniques are fairly standard and appropriate for most areas but are fairly complex and expensive. Standard methodology of larval cultivation has been developed (Loosanoff and Davis, 1963a, 1963b) and standard basic methods have been described (Castagna and Kraeuter, 1981).

The nursery stage takes the young clams or "set" and protects, feeds and grows them until they are large enough to plant in final growout conditions. This can be done by using a land-based, field-based or combination system. The land-based system holds clams in tanks or containers and provides food by pumping natural waters or cultured algae. The field-based nursery places juveniles in protected containers planted within the natural protected areas. Field-based nursery systems eliminate the need for pumping, but labor and equipment costs be different from land-based systems. Nursery system design will vary in response to technical capability, equipment availability, predator pressures, cost considerations, land availability, permitting and labor limitations. Each of these must be considered for each locality when evaluating site requirements and available resources.

The growout stage uses the larger seeds which are planted in field conditions until harvest. Using natural phytoplankton as food, seeds can be grown in trays, bags, nets or cages designed to protect the seeds from predators and allow substantial water flow to provide food. Variables for growout to harvest are site specific and affected by predators, fouling, and approved harvesting techniques.

Hatchery, nursery and growout systems may not all be needed at once in order to develop a profitable business. One or two of these may be the best initial strategy for your business plan with additions or full integration possible later. In general, most culturing can become successful through a growout operation begun by purchasing large-size seed and growing them out. Later the farmer can add a nursery after becoming proficient at seed handling or if availability of seed or its cost becomes a limiting factor.

Specific equipment and techniques used in the nursery and growout phases of clam culture common to each state along the South Atlantic coast are described in: Virginia (Kraeuter and Castagna, 1985); North Carolina (Kemp, 1991); South Carolina (Manzi and Whetstone, 1981); Georgia (Walker, 1984) and Florida (Vaughan, Creswell and Pardee, 1989). Regional variability requires equipment, techniques, and planting strategies used in nursery and growout stages to be specialized by site requirements, environmental and biological conditions and economic constraints. A summary of important guidelines is given below in general order of priority.

<u>SITE SELECTION</u> is the most important step in establishing a clam farm. Be thorough in your examination of a site and remember that biological, environmental, sociological and operational factors all interact. Trial plots and experiments with equipment are recommended before a large-scale operation is established.

<u>ECONOMIC</u> considerations include a range of operational variables affected by environmental and biological conditions. Culture methods, equipment, labor and financial assessments may vary because of site specificity. Adequate initial investment capital is needed to offset negative annual profits which may occur during the first four to five years of operation. Year-to-year cash needs will be an additional financial burden during the start-up years and you must clearly understand the timing and magnitude of all costs and earnings.

<u>LEASING, PERMITTING AND REGULATION</u> requirements should be researched and all permits, licenses and notifications be made to proper authorities before starting your operation. Remember that water classifications, leasing, and harvesting regulations may change frequently.

MARKET considerations should include local and national demand, seasonality and consistency of supply. Historical landings of wild harvest may not reflect culture-product market potential.

BIOLOGICAL background of the species under cultivation should be understood when evaluating techniques, seed sources, growth problems and conditions for enhancing clam growth.

PREDATION is a major cause of mortality in a clam operation. Sufficient exclusion techniques must be incorporated into farming methods to ensure profitable survival rates.

HARVESTING regulations of permitted equipment and techniques as well as shellfish sanitation surveys of harvestable waters should be researched for present and future status for a specific area.

FIELD NURSERY AND GROWOUT TECHNIQUES vary in design and efficiency for each site. Experiment with modifying various methods and improve procedures to best suit your location.

RECORD KEEPING is an important factor in effective evaluation and organization of any farm operation. Maintain accurate records to establish patterns and trends that can help you modify and improve in delinquent areas as needed.

SECURITY is a vital component of any clam farm venture. Be sure that you have effective methods to protect your crop from theft. It may be necessary to include 24-hour surveillance near or on the field growout site.

Site Selection

Site selection is the primary consideration for potential clam farmers. The criteria for evaluating an appropriate growout site include ecological, resource use, and operational factors and their interaction. These considerations will influence clam growth and survival as well as equipment and methods. This greatly effects capital and labor and, therefore, profit. A small test plot of clam seed may be the best way to evaluate a site.

Ecology

Ecology of the site greatly affects clam growth and survival. Important biological factors include the living organisms that contribute to the food, fouling, predation, disease and water classification. Food (algae or phytoplankton) is a major factor contributing to clam growth. This is controlled by both the quantity (species density) of food as well as the quality (species diversity) of food available. How fast clams grow can be analyzed from old shell-growth lines, living clam shell-growth lines and seed-planting experiments.

Fouling organisms can affect water and food flow through protective equipment and can inhibit growth and lower product value. Fouling can vary seasonally and greatly affect equipment and labor costs. Fouling organisms may compete for the same food organisms as the clams, thus greatly affecting clam growth rates.

Clam predators are one of the most important aspects to consider in site selection. Their type and abundance need to be accounted for in deciding what equipment and methods are used for protection.

Other microorganisms may also be important if they are abundant enough to be a pest or contribute to diseases, shell deformities or degradation of water quality.

Other environmental factors include weather, wave and bottom conditions, clam survival, equipment needs and operational constraints. These conditions include geographic and seasonal variation in salinity, temperature, water quality and flow, bottom sediment characteristics, tidal range and wind and wave action.

The optimal salinity range is between 25 and 35 parts per thousand (ppt). Salinities much above or below this range for more than short periods may result in slow growth or even death. Optimal temperature range is between 20-28° C (68-82° F) but this may vary depending on geographic location in the South Atlantic. Clams can survive in higher and lower temperatures but growth rates are affected.

Protection from wind and wave action must be considered in site selection. Exposed areas to prevailing winds can cause sediment movement and working-condition problems. Although clams can grow in most sediment types and at most depths, the latter two will affect the equipment, methods and working conditions.

Resource Use

The way resources are currently used will affect the leasing of a site if existing or adjacent fisheries production areas exist or are perceived. Adjacent landowners and public opinion can greatly affect getting a lease or expanding an operation. Alternate uses by fisherman and boaters as well as residential aesthetics and future development should be considered. Potential sources of pollution and conflicts with other users need to be considered as well.

Operations

Upland access and its contribution to field operations, boat launching, equipment storage, harvesting and security is a major component of how well a clam farm operates. Site construction constraints, ability to expand, permitting and availability of utilities need to be addressed for all upland facilities. Plans for handling security should also include upland and field sites, as well as access between them.

IV. PERMITTING REQUIREMENTS AND CONDITIONS FOR OBTAINING A SHELLFISH LEASE

Shellfish growers operate in an environment that comes under the jurisdiction of a variety of public agencies. In some South Atlantic states shellfish growers deal primarily with a single regulatory agency, usually a department of marine resources or department of natural resources. However, usually a grower will need a permit or license for an activity under the jurisdiction of another regulatory agency. The discussion below outlines the permitting requirements and conditions for obtaining a shellfish lease in the states considered in this manual. The reader is cautioned that the rules and regulations regarding shellfish leasing and permitting are subject to change. The section below, therefore, is intended to be a general overview. Potential hard clam investors should thoroughly examine all relative rules and regulations.

Conditions for Obtaining a Shellfish Lease

Any clam culture operation that includes a growout phase will need to obtain a shellfish lease. This lease is not unlike that on business property. A shellfish lease is a legal agreement between the lessee and the lessor detailing the authorized use and restrictions on specified property or asset. Each state along the South Atlantic coast has similar conditions that each lease applicant and application must meet. Table 2 provides a state-by-state summary of these conditions. Note that in Florida, the shellfish lease referred to in this document is called an aquaculture lease and in South Carolina it is called a mariculture permit. However, the term shellfish lease will be used for convenience.

Eligible Grounds

Each state delineates between shellfish bottoms reserved for public access and those available for private lease subject to the approval of the water quality and safety for shellfish growing purposes. Although the method by which public bottoms are delineated differs by state, the public areas not available for lease are well documented. Clam-growing bottoms eligible for a new lease include all those within the territorial waters of a state exclusive of those areas designated as public and those approved areas not already assigned under an existing lease agreement.

Residency

The lease applicant must be a resident of the state to which the application is being made except in Georgia. Applications made under the name of a business or corporation follow similar rules in that the business or corporation must be chartered in the state to which application is made. Corporations may also be subject to the additional requirement that at least a majority of its shareholders be state residents. In Georgia, preference is given to state residents but residency is not a precondition for obtaining a lease.

Acreage Limits

In all states except Georgia, there exists a maximum amount of acreage that any one individual or business may be assigned on any single application. The maximum acreage for each state is in Table 2. Note also that in some states there are limits on the amount of leased bottom any one individual may hold in aggregate. For example, Virginia allows an individual up to 3,000 acres leased in his or her name. The maximum acreage that will be considered for any one lease application is 250 acres. The 3,000-acre limit applies to waters not more than 15 feet deep. In waters exceeding 15 feet the limit is 5,000 acres. In Florida, leases in Franklin County are restricted to no more than one acre. In some states larger lease sizes may be awarded provided the lessee demonstrates the ability to manage a larger area.

Lease Duration

In all states except Georgia, leases are granted for a fixed time. In Georgia, lease assignments are largely negotiated between the lessee and the state. Thus, many of the terms and conditions, including the duration of the agreement, are products of that process. In all other states the lease period is fixed by law but is renewable subject to satisfaction of all terms and conditions of the expiring lease.

Table 2. Conditions that must be met to acquire a shellfish lease in five South Atlantic states.

Conditions	Virginia	South Carolina	North Carolina	Georgia	Florida
Eligible grounds a = any approved state bottom not assigned or designated as public.	a	a	a	a	a
Residency R = required NR = not required	R	R	R	NR	R
Acreage limits NR = no restrictions	250	500	5	NR	5
Years of lease R = renewable N = negotiable	10 R	5 R	10 R	N	10 R
Application fee	$25	$25	$100	$50	$200
Survey a = required at application b = required upon approval	a	b	b	b	b
Public notice R = public notice required	R	R	R	R	R
Management plan NR = not required R = required	NR	NR	R	R	R
Lease fee (acre/yr) M = market value	$1.50	$5.00	$5.00	M	$15

Application Process

In all states formal lease applications must be filed. Although the agency with which the application must be made differs by state, application contents and process are similar. The following discussion indicates the essential elements that must accompany the lease application state by state.

Application Fee

Each lease application must be accompanied by payment of a nonrefundable fee, ranging from $25 in Virginia and South Carolina to $200 in Florida (Table 2). In Virginia, however, a variable recording fee must also be paid, depending upon the nature and duration of the application process.

Survey

In addition to a written description of the proposed lease site, a formal site survey must be conducted. In some instances the survey must be included at the time of application. In other cases the survey need not be submitted until application approval. The survey fee may be separate from the permit fee in some states and could be substantial.

Public Notice

In all states public notification of a lease application must be given. In all states except Georgia, the public review process allows time for objections and comments. In Georgia, the public review process precedes a public bid for the lease. Thus, in Georgia, the lease may not necessarily be granted to the individual who initiated the application. In some states public objection may substantially delay approval or cause a lease application to be denied.

Management Plan

In all cases when the lease application is made, the applicant must give a written description of the proposed use of the submerged lands. In Florida, North Carolina and Georgia, however, a management plan must be submitted. Information that may be required is the crop to be produced, production methods, harvest methods, and a timetable for development of leased bottoms.

Lease Fee

Each state requires an annual lease fee. In all states except Georgia the lease fee is the same regardless of the area being leased. In Georgia the lease fee depends on the shellfish production potential of the leased bottom. Thus, bottoms of low productivity would be assigned a lower lease fee than those of relatively greater production potential.

Lease Restrictions

The previous sections described basic considerations and requirements for obtaining a shellfish lease. In addition to these, each state may restrict lease use. A summary of the various types of restrictions and how each state deals with them is in Table 3.

Right to Fish

In all states, traditional uses of the water column for navigation or fishing may not be excluded by the holder of a shellfish lease. In principle, the holder of a shellfish lease has exclusive rights to the product of his or her own efforts but the holder does not have the right to exclude other uses of the water surface as long as they do not infringe on the shellfish-growing activity.

Restricted Use

In all states, acquisition of a shellfish lease does not carry all the rights and privileges accorded to private property. A shellfish lease is granted under the condition that the bottoms be used for no other purpose than the production of shellfish. Applicants should also check on the transferability or sub-leasing of leases to third parties. This may be very important in obtaining funds from a financial institution.

Harvestable Size

In some states, shellfish growers must adhere to the same harvestable-size restrictions imposed on shellfish harvested from wild stocks. In Virginia, the same rule applies; however, no minimum size limits have been set. In South Carolina, on the other hand, culture operations are exempted from any size restrictions. In Florida, any in-state shipment of clams must meet a 1" minimum size. Under certain conditions, however, out-of-state shipments of cultured clams are exempt from size restrictions.

Table 3. Restrictions or special requirements for a shellfish lease in five South Atlantic states.

Restrictions or Special Requirements	Virginia	South Carolina	North Carolina	Georgia	Florida
Right to fish R = right to fish applies	R	R	R	R	R
Restricted use R = restriction applies	R	R	R	R	R
Harvest size limits A = size limit applies but none currently set B = size limit applies C = aquaculture exempted D = aquaculture exempted for out-of-state shipment only	A	C	C	B	B,D
Condemnation R = restriction applies	R	R	R	R	R
Harvest time S = no Sunday harvest N = no night harvest	S,N	N	N	S,N	N
Harvest gear HD = hydraulic dredge prohibited MP = mechanical harvest allowed with permit	HD,MP	MP	MP	MP	MP
Water column NR = no restriction subject to navigation special permit requirements	NR	NR	NR	NR	NR

Condemnation

In all states, all shellfish grounds can be condemned by state health authorities because of bacterial or chemical contamination of shellfish-growing waters.

Harvest Times/Season

In all states, shellfish-culture operations are exempt from seasonal restrictions on harvest. However, in Virginia and Georgia, nighttime and Sunday harvest is prohibited. In North Carolina only nighttime harvest is prohibited while in Florida and South Carolina, nighttime harvest is allowed with a special-use permit.

Harvest Gear

In all states, all methods of hand harvesting are permitted with proper licenses or permits. However, each state differs in its treatment of mechanical harvesters. With some exceptions each state permits all means of mechanical harvesting with proper permits. In Virginia however, hydraulic dredges are expressly prohibited although other forms of mechanical harvest are not.

Water Column

In all states, a leaseholder may be allowed to use the water column for production purposes as long as such activity does not impede navigation. However, with the exception of Virginia, a special water-column permit must be obtained. Further, with the exception of North Carolina, water-column leases are subject to the same terms and conditions as a bottom lease. In North Carolina, water-column permits require an annual fee of $500 per acre, are renewable on a two-year basis, and carry a minimum production requirement of 100 bushels per acre. Note also that in North Carolina a water-column lease is required for <u>any</u> production system that extends into the water column including pens, bags, trays, and cages. Only artificial beds and bottom nets can be used in North Carolina without a special water-column permit. In Florida only areas not designated as aquatic preserves are eligible for a water-column lease.

Other Permitting Requirements

Acquisition of a shellfish lease is equivalent to a clam production permit. In most states, however, permits may also be required to buy and sell clams, transfer seed clams or ship clams. Also, for operations including a land-based hatchery or nursery system, special permits may be required to pump sea water through the system and discharge wastes. A regulations summary for selling and land-based operations is in Table 4.

Selling Clams

The type of licenses required for selling clams depends on whether the harvested clams are to be sold directly to a registered wholesaler or dealer or whether the clam culturist acts as his or her own wholesaler. In Virginia and North Carolina, no license other than that required to harvest is necessary if the clam culturist sells directly to a qualified buyer. Florida, Georgia, and South Carolina, however, require a license to land and sell any clams harvested in waters of those states in addition to the license required for harvesting gear. Any clam culturist planning to become a wholesaler or distributer must be licensed. Virginia, South Carolina and Georgia require only an application for a wholesalers license. In Florida and North Carolina, however, there are special provisions for wholesalers.

North Carolina requires a shell-stock shippers license for any clams shipped live in the shell. If shucked clams are to be shipped, a shucker-packer license is required. Any clam dealer required to have a shell-stock <u>and</u> a shucker-packer license must be inspected and certified by the North Carolina Shellfish Sanitation Division. In Florida, one of two licenses is required depending upon the clams' destination. A Wholesale County Dealer license permits the licensee to buy and sell clams only within the county registered on the license. A Wholesale State Dealer license permits the licensee to buy and sell clams anywhere within the state inclusive of the county in which the dealer is located. In all states, anyone shipping clams out of state is subject to federal interstate-shipping regulations and must obtain a special shippers license.

Special Provisions for Seed

There is considerable concern among the South Atlantic states for the integrity of natural wildlife and ecosystems. Consequently, most states have special provisions regarding the import of seed stock from out of state. In Virginia, all non-native species are prohibited. In North and South Caro-

Table 4. Dealer licensing and land-based permit requirements for shellfish leases in five South Atlantic states.

Requirements	Virginia	South Carolina	North Carolina	Georgia	Florida
Sale to buyer only NL = no license required other than harvest LS = landing and selling permit required	NL	LS	NL	LS	LS
Wholesaler WL = wholesaler license required SS = shell-stock shippers license required SH = shucker-packer license required WC = wholesaler county license required WS = wholesaler state license required	WL	WL	SS,SH	WL	WC,WS
Seed stock NS = non-native species prohibited ES = exotic-species permit required for non-native species IS = all out-of-state seed prohibited	NS	ES	ES	IS	NS,ES
Pump/discharge permits PRV = permit required, reviewed on case-by-case basis PR = permit required	PRV	PR	PR	PR	PRV

lina, an exotic-species permit may be obtained to import non-native species. All out-of-state seed is prohibited in Georgia. A special permit must be obtained to import non-native seed to Florida waters even though the species may be native to the region.

Pumping/Discharge Regulations

Any land-based hatchery or nursery system will require pumping of seawater and discharge of waste. North Carolina, South Carolina and Georgia require a permit to pump or discharge water. In Georgia, application for such a permit must be made to the Division of Natural Resources, while in North Carolina, permit applications are to the North Carolina Coastal Commission. At present, South Carolina is making its permitting rules consistent with those of the federal government. Once completed, culture operations with limited flow rates will be exempt from the discharge-permitting requirements. Virginia has similar rules to those of North Carolina and Georgia, except that the type of discharge permit required depends on the water volume to be used. In Florida, permitting for pumping and discharging water from culture facilities is reviewed case by case. There is considerable concern, however, over the effluent volume and content pumped through clam culturing systems in the state. Consequently, rules and regulations regarding pumping and discharge permitting are currently being examined.

Federal and Local Considerations

Besides specific state regulations, federal, regional or local regulations may affect the siting or operation of a clam culture business. For example, there are large areas in Georgia suitable for clam culture that are located on federal lands. Although it is possible to lease these areas, applications must be made to the Department of Interior and specific guidelines governing the use of the site must be followed. In other instances, the regulatory requirements of the U.S. Army Corps of Engineers, the Environmental Protection Agency, and other federal agencies may affect a hard clam culture business.

In addition to federal concerns, local government regulations or decisions may affect clam culture businesses. In all cases, a lease application must be subjected to a public notice within the county or municipality adjoining the lease site. At that time, the lease application must satisfy local regulations and is subject to objections from specific individuals that may be adversely affected. In most instances, local and federal regulations will be location or operation specific and cannot be addressed in this guide. Anyone interested in investing in hard clam culture must be aware that federal and local regulations may affect his or her business plans and the time investigating the potential impacts of these regulations would be well spent. A summary of permitting-agency addresses in each state is in Table 5.

Table 5. Shellfish culture permitting agencies in five South Atlantic states.

Lease Application	Licenses	Discharge Permits
Virginia		
Virginia Marine Resources Commission P. O. Box 756 Newport News, VA 23607	Virginia Marine Resources Commission P. O. Box 756 Newport News, VA 23607	Virginia Water Control Board 2107 North Hamilton Street Richmond, VA 23230
North Carolina		
North Carolina Division of Marine Fisheries P. O. Box 769 Morehead City, NC 28557	North Carolina Division of Marine Fisheries P. O. Box 769 Morehead City, NC 28557	North Carolina Division of Coastal Management P. O. Box 769 Morehead City, NC 28577
South Carolina		
Aquaculture Permit Facilitator South Carolina Department of Agriculture P. O. Box 11280 Columbia, SC 29211-1280	Aquaculture Permit Facilitator South Carolina Department of Agriculture P. O. Box 11280 Columbia, SC 29211-1280	Aquaculture Permit Facilitator South Carolina Department of Agriculture P. O. Box 11280 Columbia, SC 29211-1280
Georgia		
Dept. of Natural Resources Coastal Resources Division 1 Conservation Way Brunswick, GA 31523	Dept. of Natural Resources Coastal Resources Division 1 Conservation Way Brunswick, GA 31523	Dept.of Natural Resources Environmental Protection Division 1 Conservation Way Brunswick, GA 31523
Florida		
Division of State Lands Dept. of Natural Resources 3900 Commonwealth Boulevard Tallahassee, FL 32399	Division of Marine Resources Dept. of Natural Resources 3900 Commonwealth Boulevard Tallahassee, FL 32399	Dept. of Environmental Regulation Twin Towers Office Building 2600 Blair Stone Road Tallahassee, FL 32399

V. CULTURE TECHNIQUES

Brood Stock Collection and Reproductive Conditioning

Brood stock for hatchery production of larvae should be collected from local sources. Clams are easier to condition if collected before their natural spawning period(s). For South Atlantic clam populations, spring is the major spawning period. Although it is possible to recondition clams after spawning, it takes 8 to 10 weeks. By collecting clams before natural spawning, only days to a few weeks of conditioning may be required. Listed in Table 6 below are reports on the reproductive cycle of hard clams in the South Atlantic states.

Spawning

To initiate spawning, clams are placed in a spawning table containing sea water heated 28 to 30° C. Clams should remain in the table until at least half begin siphoning. The water temperature in the table is then lowered to 20 to 22° C by adding chilled sea water. At 30-minute intervals, the water temperature is alternated between 20 to 22° C and 28 to 30° C. If the clams are well-conditioned, spawning should begin after three or four cycles. If not, a male may be sacrificed, stripped of sperm and a sperm suspension added to the water. If this fails, chemical serotonin may be injected into the clam to induce spawning. Gibbons and Castagna (1984) contains information such as dosage rates for serotonin.

Table 6. Information sources on reproductive cycle of hard clams in five South Atlantic states.

Area	Spawning Period	Source
Virginia	Spring-Fall	Castagna & Kreauter (1981)
North Carolina	Spring-Fall	Porter (1964)
South Carolina	Spring-Fall	Eversole et al. (1980); Manzi et al. (1985)
Georgia	Spring-Fall-Winter[1]	Pline (1984); Heffernan et al. (1989)
Florida East Coast	Spring-Fall	Hesselman et al. (1989)
Florida West Coast	Spring-Fall-Winter[1]	Dalton and Menzel (1983)

[1] Although winter spawning has been documented, it is dependent on environmental factors and may not occur every year. (See Heffernan et al. 1989).

These studies should be consulted for approximate spawning times in the specific geographic area of interest. However, spawning cycles may vary from year to year. That is, a warmer-than-normal winter may result in an earlier-than-normal spawning and a colder-than-normal winter may delay spawning.

After collection clams should be washed and scrubbed to remove other organisms from their shells. Clams are placed in holding tanks containing chilled sea water (18 to 24° C) with sufficient food for conditioning, both of which should be replaced daily.

Larval Culture

After spawning, eggs are collected, counted and placed in larval growing tanks. Eggs are collected by draining the water from the spawning table through two sieves. The top sieve (180 to 400 micron) filters out the debris, mucus, feces and pseudofeces, while allowing the eggs to pass through. The bottom sieve (25 micron) retains the eggs, which are washed into a precalibrated container, stirred well, and a one ml sample obtained. The sample is transferred to a Sedwick-Rafter counting cell placed under a compound microscope and the number of eggs per ml determined by direct count. By multiplying the number of eggs per ml sample, times total number of ml per container, the total number of eggs can be estimated. Eggs are placed in larval tanks containing 5 micron filtered sea water at 26 to 30 ppt salinity at 25 to 30° C. After two days, larval tanks are drained down through a 44-micron sieve. Trochophore larvae are counted and returned to a new growing tank at a density of 15 larvae per ml. Until setting, which occurs between 8 to 14 days, larvae should be collected, counted and placed into new tanks every two days. Castagna and Kraeuter (1981) provide an excellent detailed description of hatchery procedures.

Post-set Growout

Once larvae have set, there are three basic means of maintaining the post-set clams: traditional, downweller, and upweller methods as described in Manzi and Castagna (1989). The traditional method requires leaving the larvae and set animals in the larval tanks and adding large amounts of cultured algae daily. Larval tank water is changed daily. Post-set larvae may also be placed in raceways containing static water. After a week, filtered, ambient temperature sea water is added at very slow flow rates. Flow rates are gradually increased with growth of animals as reported in Castagna and Kreauter (1981). Table culture requires large amounts of space and is very labor intensive in areas of heavy silt, as compared to the other methods.

Downweller units may be as simple as a cylinder with a mesh screen attached to the bottom suspended within a recirculating reservoir. Post-set clams are placed in the cylinder and sea water with cultured algae is pumped via airflow or direct flow from the reservoir by the recirculating pump into the top of the cylinder. Excess water is forced down through the clams and out the bottom mesh. Reservoir tanks should be changed daily, or supplemental feeding from a common reservoir can be used during working hours and continuous ambient-flow through can be used during nonworking hours. The ambient flow flushes out waste products and unused algae, but complete tank cleaning should be done weekly. In upweller units, water circulates up through the bottom mesh, through the clams and exits in an opening near the top of the cylinder. The cylinder is in a reservoir. Water is driven by airlifts within the cylinder, drawing water from within the cylinder and forcing it back into the reservoir. Manzi and Castagna (1989) provide details.

Algal Production for Feeding Clam Larvae and Juveniles

Hatchery production of single-celled algae species for consumption by bivalve larvae and juveniles has developed from two basic methods: the Glancy Method (Glancy, 1965; Castagna and Kreauter, 1981; Castagna and Manzi, 1989) and the Milford Method (Loosanoff and Davis, 1963a,b; Davis, 1969). The Glancy Method is the simplest way to grow algae, but the Milford Method is presently the preferred culture system among hatchery operators. The Glancy Method involves filtration by continuous centrifuging and filtering of raw sea water through bag filters, or wound-core filters., Filters are usually of 3, 5, 10, and 25 micron in size. Filtered water stands for 48 hours in slowly aerated tanks exposed to sunlight or artificial light. Tanks may be outdoors, but are generally in a greenhouse or solarium to prevent contamination by other algal species from salt spray. Fertilizers will produce heavy blooms generally dominated by a single species. A major problem with this method is its dependence upon natural phytoplankton blooms. Whatever is blooming in the river (a desirable or non-desirable species) is what you will be culturing.

The Milford Method is a much more labor-intensive and technical means of culturing algae (see Castagna and Manzi, 1989). This method generally starts with unialgal culture. Cultures are generally started in sterile sea water in small 250-ml flasks in which culture media such as Guillard's F/2 nutrients have been added (Guillard, 1983). Sterilization of the sea water may be achieved by autoclaving or by the addition of hypochlorite (2 percent solution). Chlorine is then neutralized by sodium thiosulfate. Flask cultures then inoculate 18-liter carboys to inoculate Kalwall tubes (see Castagna and Manzi, 1989) or tanks of various sizes. Culture vessels are aerated to supply CO_2 and mix the culture. They may be supplied with additional CO_2 from gas cylinders at various intervals to help maintain an optimal pH for best algae growth. Cultures are placed under natural light, fluorescent, halide lamps or a wide spectrum light source. This method produces a constant high-quality food source that is not dependent upon environmental fluctuations as is the Glancy Method.

VI. CLAM NURSERY SYSTEMS

Commercial hard clam culture systems rely primarily on final-growout procedures that use the natural environment. The large majority of field growout techniques presently used by commercial culturists require clam-seed stock of considerable size. In the South Atlantic states, field growout techniques include intertidal pens and trays, subtidal trays, soft trays and bottom plants - all of which require an initial seed size of at least 7-10 mm. Because it is not economically feasible to raise seed to this size in hatcheries, some form of intermediate growout is necessary to produce planting-size seed. Nursery systems are the link between hatcheries and field growout operations, providing the intermediate growth necessary to bring hatchery seed to field-planting size. A comparison of critical factors that determine which type system is best is in Table 7. Three types of nurseries for hard clam seed have evolved; field trays, raceways and upflow nurseries (Manzi and Castagna, 1989).

Field Nurseries

Field nurseries were the first to evolve and took several forms including rafts, intertidal and subtidal cages, trays and bottom plants using aggregate and/or plastic mesh netting for predator protection. Subtidal and intertidal trays have emerged as primary methods of field-nursery culture. Plastic trays are lined with fine netting. Gravel and/or sand is a protective substrate. The trays are placed in protected natural areas in either the low intertidal zone or on shallow subtidal bottoms. Although initially used with very small seed (1 mm), the intensive maintenance required with smaller mesh netting to provide good water exchange generally precludes the use of field-nursery culture systems for seed smaller than 3-4 mm. Recent standard practice with field nursery systems consists of planting 3-4 mm seed at high densities (1,000-1,500 seed/ft^2) in mesh covered plastic trays often containing a pea-gravel substrate.

Recently, bottom-bag systems and oyster-belt systems have been developed and used as field nurseries for hard clam seed (Vaughan et al., 1989). Bottom bags are basically soft cages of plastic mesh attached to the substrate by a lead line or other anchoring system (e.g. rebar). Flotation is attached to the bags to allow them to "tent," for sediment deposition. The oyster belt is a flexible belt system using a pair of parallel polypropylene lines, supporting mesh bags between the lines (Figure 2). The method has had good initial results and substantially less maintenance than other subtidal tray or cage systems (Vaughan et al., 1989).

Land-based Nurseries

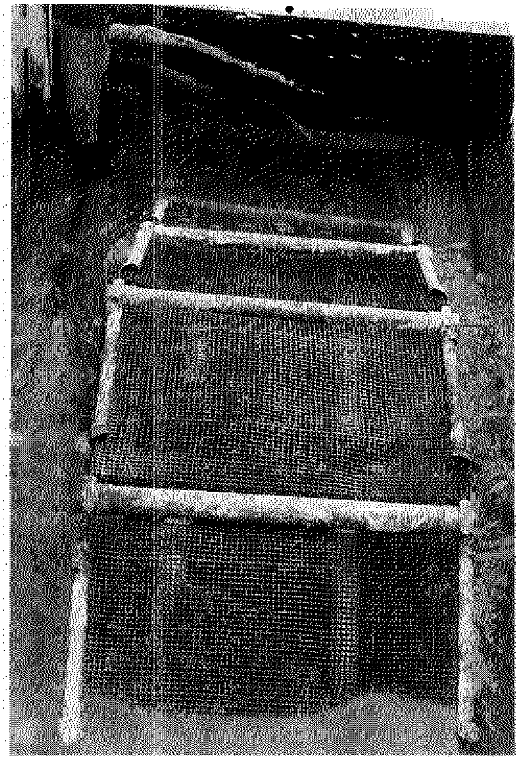
Raceways have been the traditional land-based nurseries for bivalve culture. They are generally long shallow tanks or troughs, or tiers of shallow trays, constructed of epoxy or resin-coated wood, fiberglass, plastic or concrete. Raw seawater is pumped from an adjacent source, delivered to one end of the raceway and directed to flow horizontally along the raceway to drains at the opposite end. In shallow raceways, seed is spread over the bottom in a single layer with water just covering the sand. This provides good water mixing and efficient water use. In deeper raceways, racks or tiers of trays are used to take three-dimensional advantage of water depth. In deep raceways, baffles are also commonly used to provide mixing within the horizontal water flow.

The use of land-based upflow nurseries was revived in the United States in the early 1980s. Upflow nurseries use ambient seawater, pumped from an adjacent source, to produce a vertical water flow directed up through a seed mass, rather than a horizontal flow across the seed as in raceways. Three upflow nursery systems are in common use; one recirculating system and two flow-through nursery systems. The recirculating system was developed for the production of clam post set and is used primarily in hatcheries. Normally a battery of recirculating (upflow and downflow) units are in a single reservoir tank and airlift pumps recirculate algal-enriched water among the units and the reservoir (Figure 3). Setting clams are introduced to the recirculating units and the resultant sets continue to be reared in the system until they are large enough to go into flow-through nurseries (one mm).

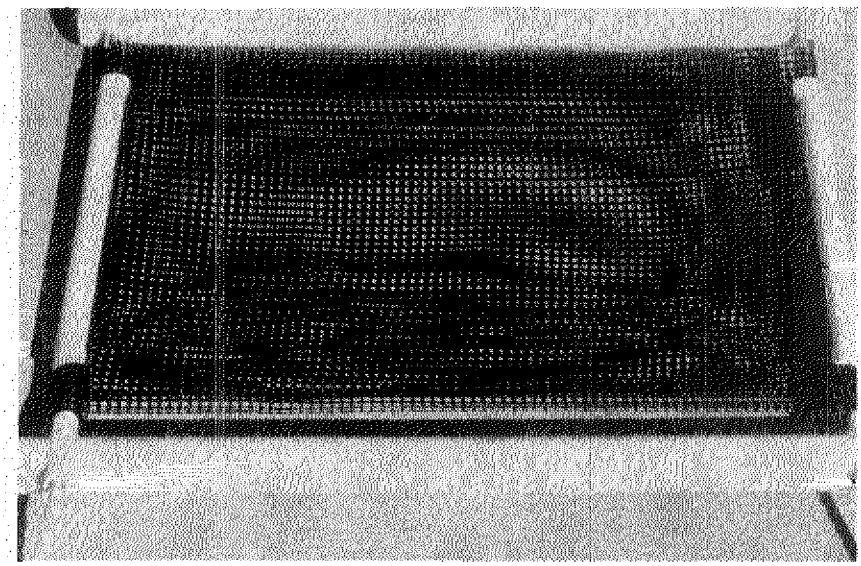
The two flow-through upflow nurseries using unsupplemented ambient seawater are (1) the active flow system that forces water at high velocity up through a seed mass and (2) the passive flow system which "pulls" water at low velocity up through a layer of seed. More simply, active or forced flow systems use water under pressure for the velocity necessary to initiate a slow fluidization of the seed mass. This is necessary for small seed (less than 3 mm) that tend to pack tightly resulting in a situation

Table 7. Comparison of critical factors that determine the appropriate hard clam nursery culture systems.

Critical Factors	System Type: Raceways	Upflows	Cages/Trays
Location	Land-based and adjacent to high quality seawater source	Land-based and adjacent to high quality seawater source	Field-based in low intertidal or shallow subtidal protected estuarine areas
Recommended initial seed size	1 mm	1 mm	3 mm
Maximum production seed size	8-10 mm	8-10 mm	10-20 mm
Recommended rates	0.5-1.0 gal/ft^2 2.0-4.0 $liters/0.1m^2$	0.05-0.08 $gal/inch^2$ 30-50 mls/cm^2	NA
Recommended densities	$70\text{-}600/inch^2$ $10\text{-}100/cm^2$	$125\text{-}2{,}500/inch^2$ $20\text{-}400/cm^2$	$1{,}000\text{-}1{,}800/ft^2$ ($1\text{-}2/cm^2$)
Maintenance requirement	High	Low	Moderate to High (site specific)
Initial capital costs	High	High	Low
Replacement costs	Low	Low	Moderate to High
Energy requirement (utilities)	High	High	Low
Survival rates	High	High	Low to Moderate
Permitting	Depending on size, may need NPDES permit and others for discharge and intakes	Depending on size, may need NPDES permit and others for discharge and intakes	Need state lease or permit for field location



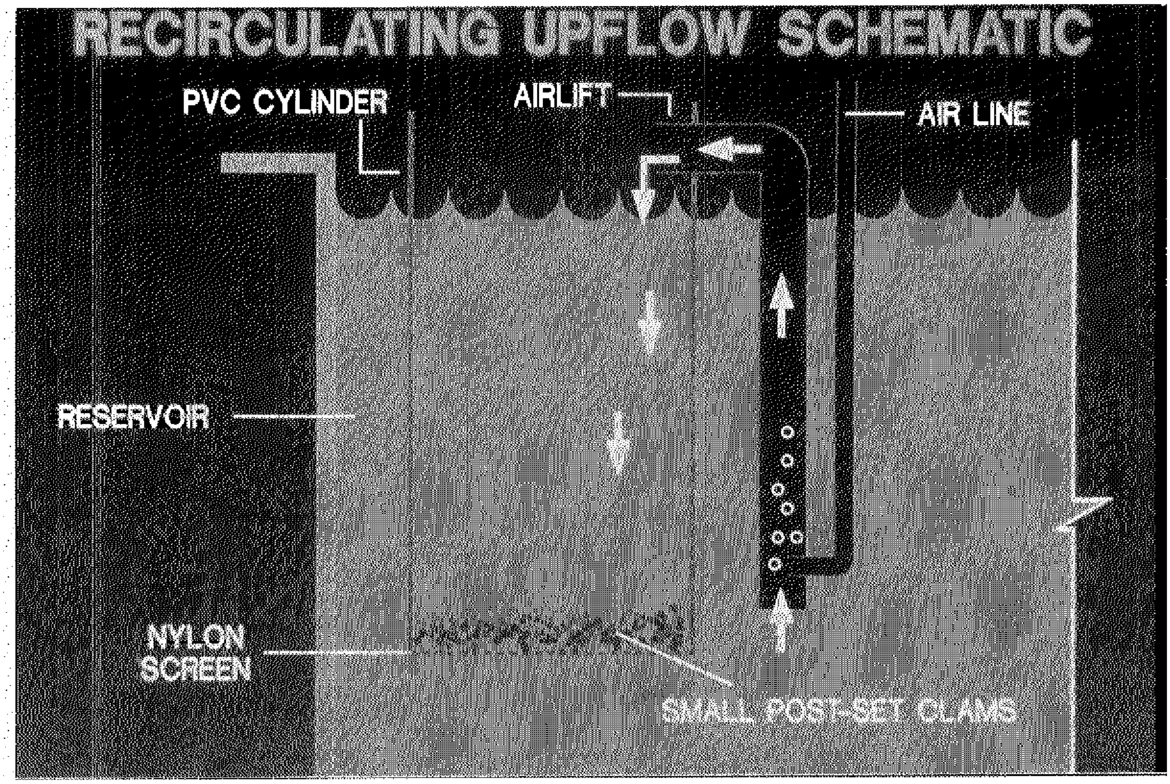
(a) Flexible belt system supporting nursery bags of clams (Patent No. 4896626)



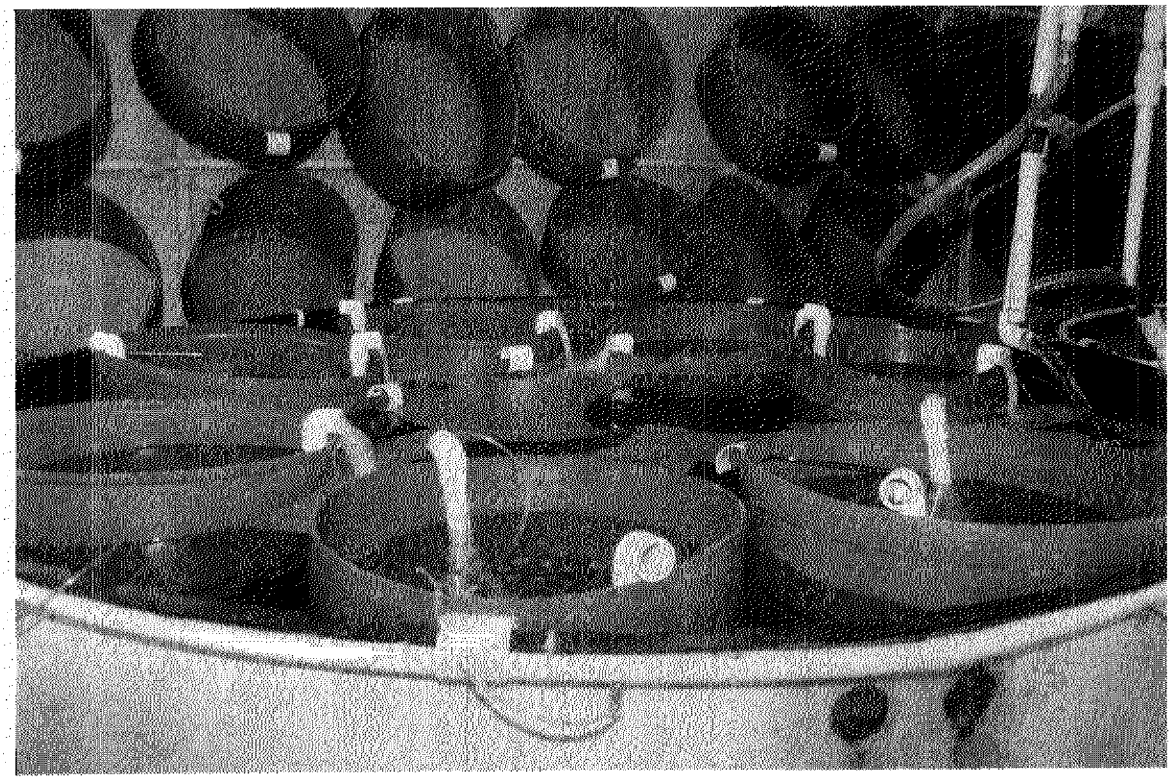
(b) Individual component of belt.
Figure 2.

that would channelize lower velocity water flows. The slow fluid motion of water through the seed in an active flow column insures that all seed are serviced by the incoming water. Forced upflows normally consist of closed-bottom, small-diameter, PVC cylinders with an intermediate, positioned plastic screen supporting the seed mass. Water enters the closed cylinder below the screen and is forced up through the seed mass to an overflow near the cylinder top (Figure 4). Passive upflows are normally large-diameter, open-ended PVC cylinders suspended in a reservoir. Each cylinder uses an appropriate-size mesh screen to form the bottom and support the seed mass. Water entering the reservoir can exit only through drains positioned in each cylinder's upper end, and is thus drawn up through the seed mass to the drains (Figure 5). If flow rates in a passive upflow are correct, wastes and silt are swept through the seed mass and settle as a loose layer at the seed-mass surface.

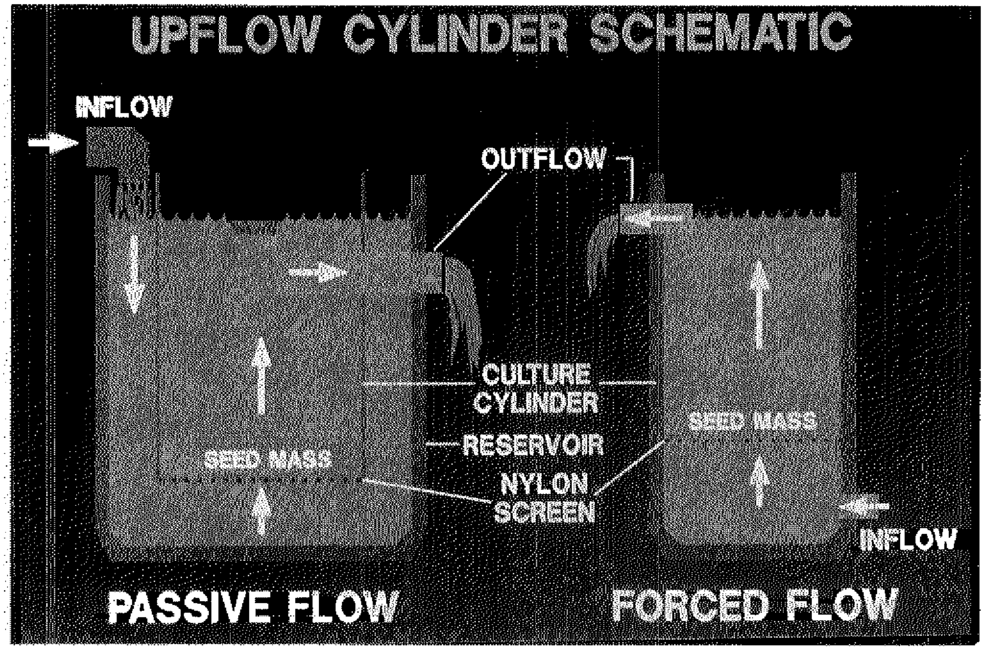
Field nurseries and land-based nurseries each have advantages and disadvantages. Field trays are simple, low-energy systems that have relatively low operational costs. They do, however, require significant maintenance and harvest labor. They also suffer from incomplete predator protection, limited inspection access, and susceptibility to environmental perturbations, vandalism and theft. In contrast, land-based nurseries provide maximum protection and predator control, easy access and low maintenance but require an appreciable energy input. Field nurseries generally have less expensive capital costs than land-based systems but replacement costs may be higher in certain instances. Finally, location may play a distinct role in the efficacy of a particular nursery system. Climate and permitting considerations may exclude either land-based or field-based nurseries from certain areas. As with all culture operations, site selection is the most important thing for successful nursery systems so the culturist must select the system appropriate for the location.



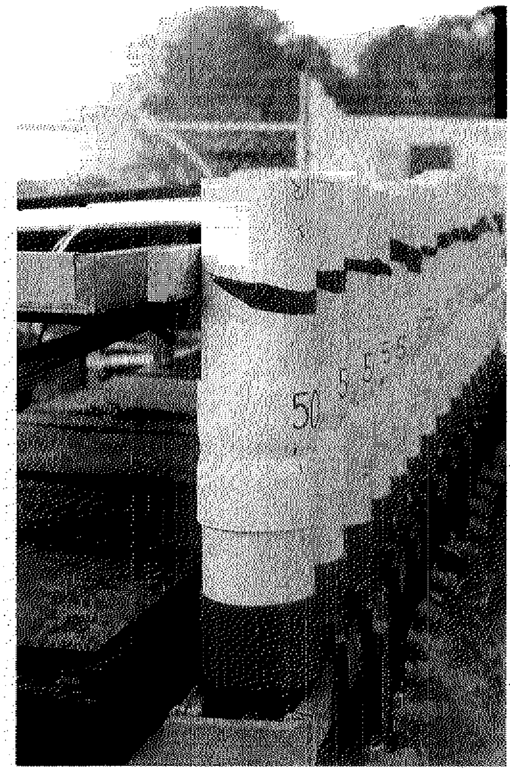
(a) Schematic of recirculating upflow/downflow nursery system.



(b) Recirculating upflow nursery for recent hard clam post set.
Figure 3.

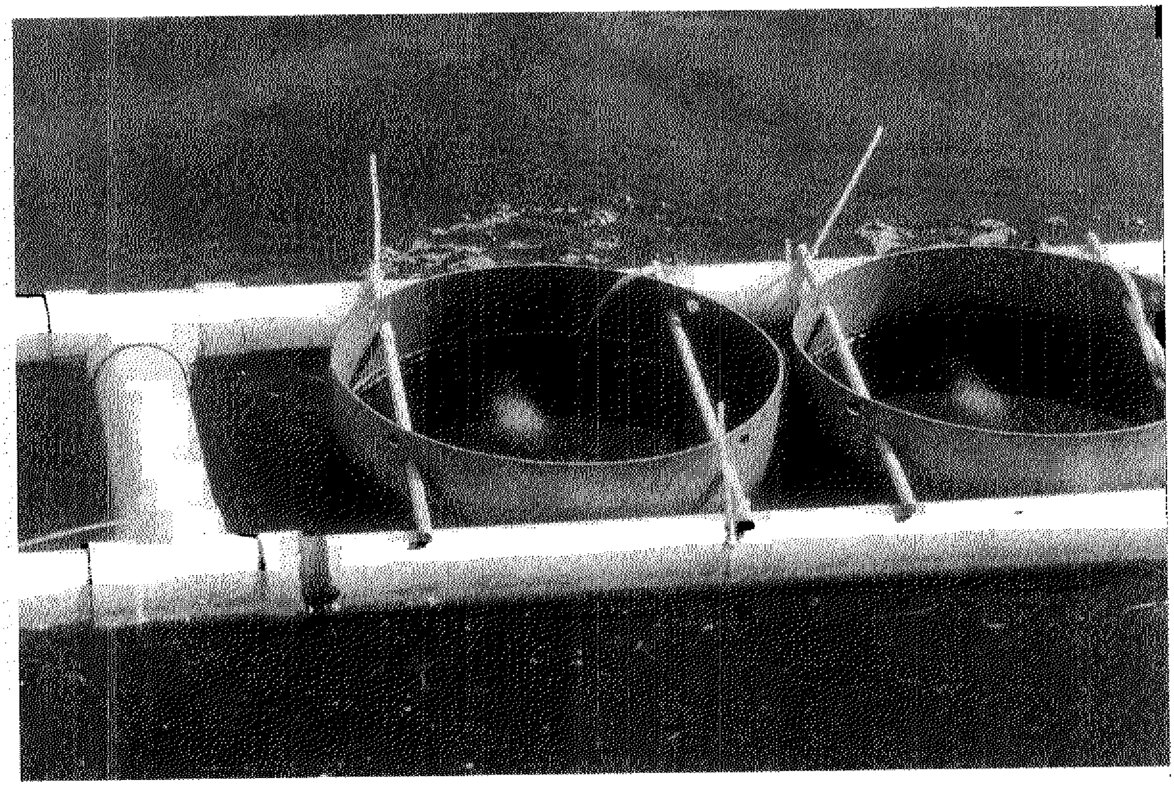


(a) Schematic of passive and forced (active) upflow nurseries for bivalve mollusc seed.



(b) Forced (active) upflow nursery for young clam seed.
Figure 4.

(a) Commercial-scale passive upflow nursery for hard clams.

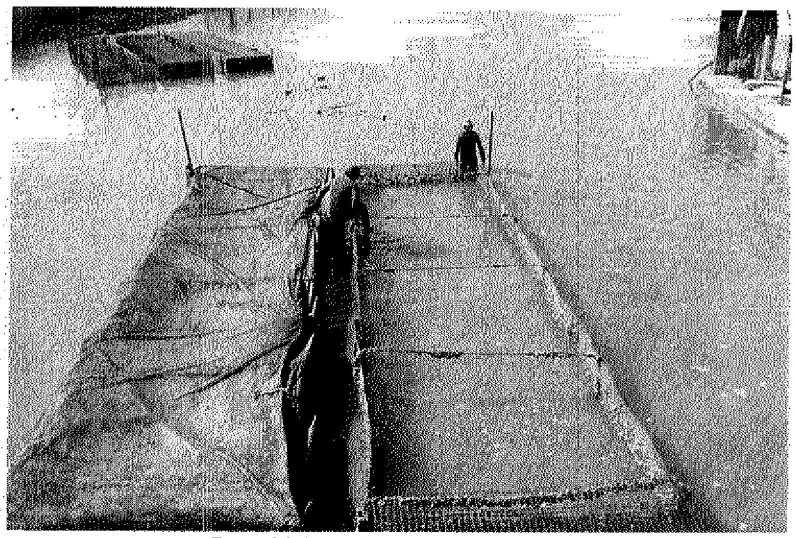


(b) Floating upflow nursery for hard clam seed (modification of land-based passive nursery system).
Figure 5.

VII. GROWOUT METHODS

Field Growout

Growout techniques can vary greatly from land-based systems to simple field broadcasting of seed onto the bottom without protection. Although complex land-based systems may be economically feasible in the future, only a few field growout techniques will be summarized. Most growout methods use pens, trays or nets. Many variations of size, material and handling techniques are used and may all produce harvestable clams, but differ in structure, labor, material cost, and yield. The lease area required to grow clams to harvestable size varies greatly from site to site. In general, about a million clams can be grown on one acre. Rarely is 100 percent of a lease possible to plant. Considerations for working areas, anchoring, grass beds and unusable bottom substrates may necessitate larger lease areas to accommodate usable planting areas. About 100 clams per square foot can be used as an upper density for planting, but much less than this may be required at some site locations. Survival rates are highly specific to planting methods and experience and may vary greatly. About 50 percent survival is a good general rate for most growout methods with experienced field management personnel and practices. Critical factors that determine the selection of growout methods are in Table 8.



Intertidal pens for hard clam culture.
Figure 6.

Pens

Pens (cages or corrals) are box-like structures which allow water flow from all sides but inhibit predator access with mesh (Figure 6). The pens are constructed with support frames and mesh. Supporting frames are usually made of rebar metal rods or PVC piping. Rigid mesh materials are used to support vertical and horizontal positions off the sediment and in the water column. These can be made of vinyl-coated wire or high-density polyethylene mesh. Connections to the support framing are made of nylon ties, hog rings, or monofilament line. A box-like structure is made that will accumulate natural substrate, prevent access from predators and leave enough room for clam growth without sediment reaching the top of the pen. Intertidal placement or construction allows for low-tide tending and alleviates many fouling organism problems. Most pens are large enough so large numbers of clams can be planted with little routine maintenance. Harvesting is by removal of a lid or partial disassembly of the top layer. Clams are hand or rake harvested and may be assisted by water hose removal of sediments or concentration of harvestable products in one area. Pens can be mechanically harvested by suction in some states. Pens have to be rigid enough to withstand currents and are usually limited to intertidal use because of fouling.

Trays

Trays have been used effectively for growout systems for a long time. Trays have proven reliable and productive in terms of clam growth and survival if they are monitored and maintained properly. Trays consist of material that protects clams from predation and incorporate a sediment substrate. The growing container also allows for clam retrieval at harvest.

Trays can be made of all sizes and materials. Most have plastic,

Table 8. Comparison of critical factors that determine appropriate hard clam growout systems.

Critical Factors	Pens	Trays	Nets
Location	Intertidal	Intertidal, Subtidal	Subtidal
Sediment	Soft bottoms Mud	Hard bottoms Sand	Hard bottoms Sand
Maintenance requirement	Moderate	Moderate to high (soft or hard tray)	Low
Capital costs	High	High	Low
Labor to harvest	Moderate	Low	High
Effort to access and inspect	Low	Moderate	High
Special permits (in addition to lease)	Most states	Some states	No states
Recommended method by state			
Virginia		X	X
North Carolina		X	X
South Carolina	X	X	
Georgia	X	X	
Florida		X	X

fiberglass, or wooden sides and bottom with mesh covering (Figure 7). Wooden trays were the first used and can be made of boards and plywood. Although these materials are locally available and inexpensive, they are more cumbersome and susceptible to deterioration. With rigid or hard trays, a lifting device must be used to hoist them because these units are very heavy. Boring clams and wood rot are persistent problems in wooden trays. Trays may be fouled externally with barnacles, oysters, etc., that need to be scraped off.

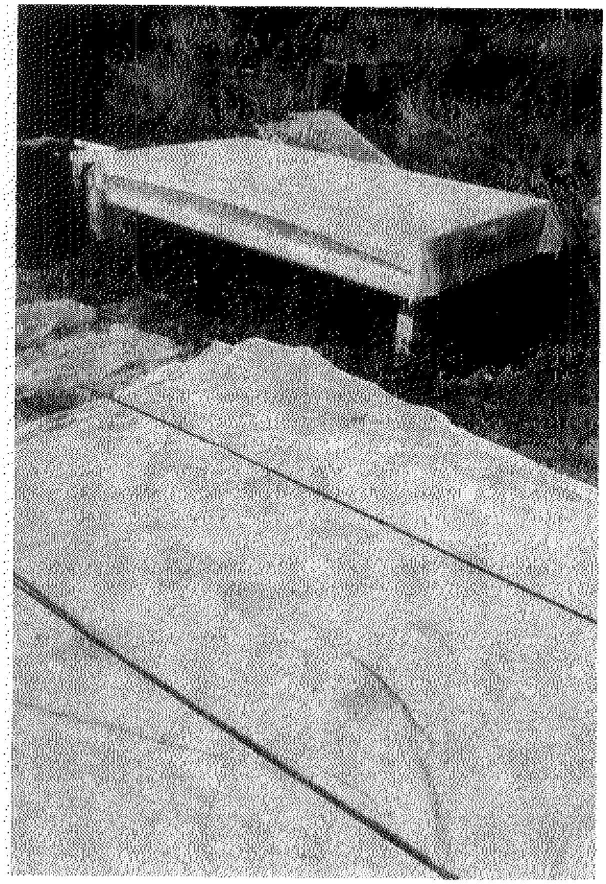
The soft tray was designed as a hybrid of tray-and bottom-net culture. The soft tray is made of flexible mesh such as nylon and made into a flat box (Figure 8). It has the properties of tray culture in that it provides both top and bottom protection but uses existing or naturally accumulating sediments. When lifted or harvested, all sediments remain on the bottom with only the clams and mesh lifted.

The soft tray can be made of woven nylon mesh and formed into bags of four x four feet or four x eight feet, which will take one or two people to handle. A float may be attached in the center of the bag to facilitate siltation. After an adequate amount of sediment has been deposited in the bag, however, the float should be removed. If the soft tray remains tented for an extended period, the net is more susceptible to fouling.

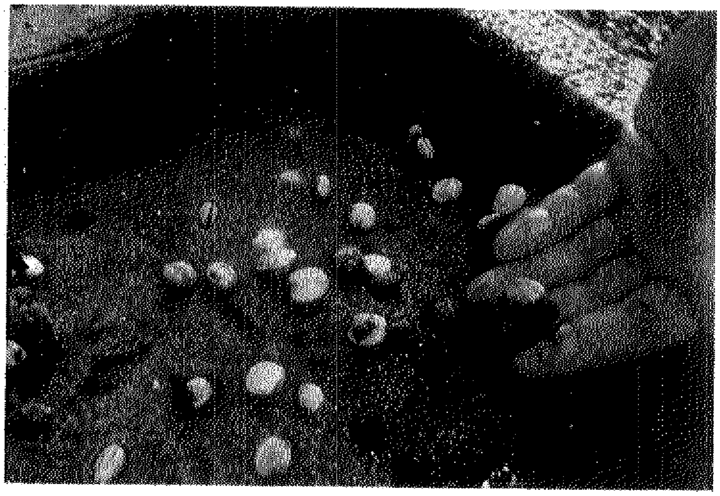
Fouling can be controlled by removing the float and/or by flipping the tray so that the upper surface is now on the bottom, and the fouling organisms are suffocated in the sediment. The clams should be rearranged and spread evenly in the bag as much as possible. A regular schedule of checking for rips or tears in the mesh is suggested.

Nets

Nets are the least expensive of growout culture techniques, both in material cost and maintenance labor. There are

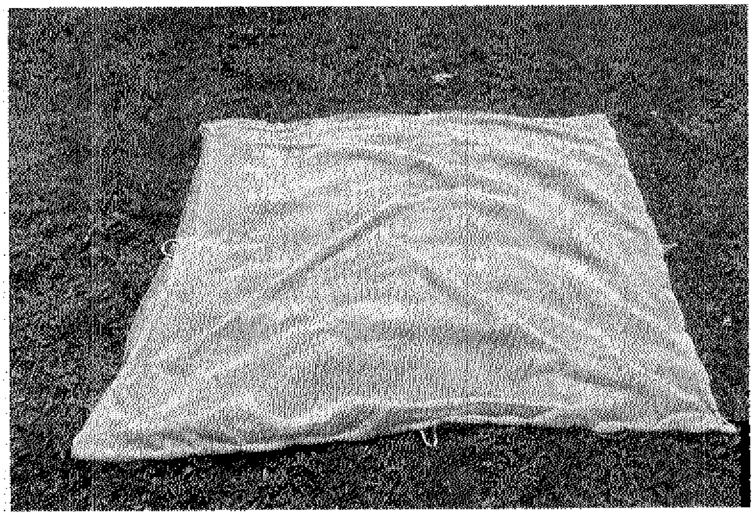


(a) External view of growout tray made of wood and netting.



(b) Internal view of growout tray filled with sand and clams.

Figure 7.



Growout tray made out of nylon netting (soft tray) in four-foot square size.
Figure 8.

Maintenance consists of periodic checks to ensure that the net has not become buried from the accumulation of sand or silt. Some sand (1/4") covering the net is beneficial as it will decrease fouling. Clams may be easily suffocated beneath a sinking net if they are too small or weak to raise it on their own. In waters with a high silt loading, floats or poles can be placed beneath the nets to avoid excessive siltation. If heavy fouling or destruction occurs, nets should be removed, repaired and replaced.

different types of bottom-net methods commonly used, but a nylon mesh weave netting has been fairly effective in predator control. A less expensive plastic mesh netting may also be used in areas where predation pressures are lower (Figure 9a).

Nets consist of netting (six x four mm mesh) with a weighted line attached to the sides. The net is staked to the bottom with metal stakes fabricated from rebar. Netting is made in rolls of 8-12 feet widths and variable lengths. The weighted line is fastened to the net approximately six inches from the outer edges to provide a protective "skirt" that will be buried vertically in the sand when the stakes are in place. The weighted line is attached with stainless wire hog rings. The completed net is rolled onto a length of pipe to facilitate planting. Some farmers also attach a line down the center of the net with loops to aid in lifting the net when it begins to sink beneath the silt. Growout nets range in length from 25 to 50 feet, although smaller sizes are not uncommon (Figure 9b).

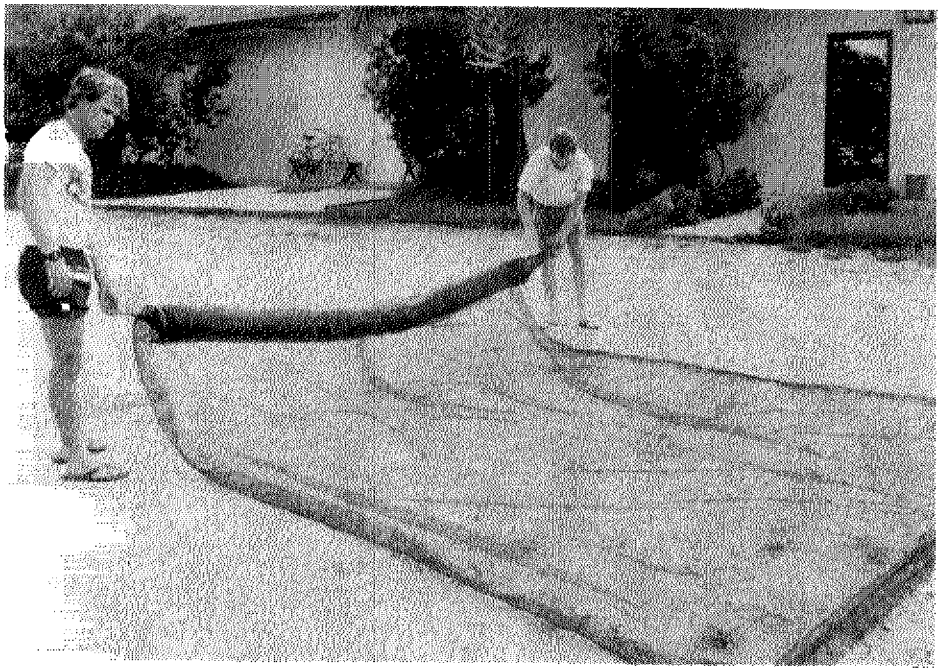
To plant the clams, the nets are unrolled and secured over the top of seed that is broadcast on the natural sediment. A weighted line and stakes secure the net in the substrate along the edges. Other variations include sandbags along the sides of the net or a rebar frame buried around the plot perimeter over which the net is stretched.

Although the bottom-net system is easy to plant, predators may access the net from the sides and sedimentation may be a problem. Harvesting is also restricted to normal allowable bottom-harvesting techniques.

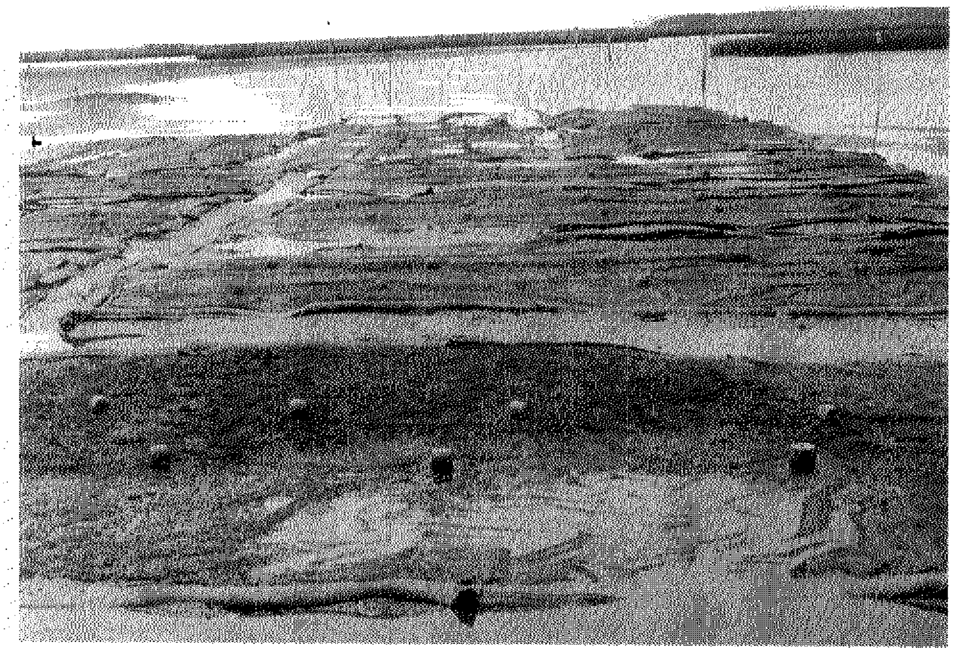
Harvesting Methods

An important consideration in designing a plan for clam culturing is how the clams will be harvested. For production systems in which the clams are grown in containers that can be lifted, specialized methods can offer the advantage of several thousand clams harvested in a single haul. Special lifting equipment may be required and each system dictates the amount of time and staff required.

In systems where the container is too large to lift (pens) or does not surround the bottom (nets), the harvest method required may be similar to that used for wild commercial fisheries. This would include hand harvesting, SCUBA, clam rake, clam tongs, dredge or other mechanical harvesting techniques. Mechanical harvesters such as the hydraulic dredge, escalator dredge and suction harvesters offer the greatest labor efficiency and speed. The speed and ease of harvesting can also affect which marketing plan you use. Because of resource regulations and environmental concerns, many states severely restrict the use of mechanical harvesters. Some may allow special permits for culture use. In this regard, the choice of growout methods should



(a) Growout net rolled out on land.



(b) Growout net in intertidal zone.
Figure 9.

not be made without considering the allowable harvesting methods available to you now and in the future.

VIII. MARKET FOR HARD CLAMS

Clams are generally marketed piece-rate, i.e., by count container, or individual clam, particularly for the premium-size category of littlenecks. The three market categories generally recognized are littlenecks, cherrystones and chowders. As pointed out below, littlenecks are the smallest-size category and command the highest prices. This clam is generally 1 3/4 - 2 1/2 inches (Brown and Folsom, 1983) measured by its largest shell dimension, though some states allow harvest based on different shell measurements. As the smallest size clam is the most valuable, the grower is only concerned with achieving minimum size clams to market as littlenecks, and not with larger size, less valuable clams.

Minimum sizes for harvesting are in Table 9. Note some differences in minimum-allowed harvest sizes from private (leased) beds compared to public beds (e.g., Florida). Discussion is underway in several states to exempt harvests off private, or culture, beds from minimum harvest size regulations. Obviously, it is in no grower's interest to harvest a size too small to market.

One of the problems in analyzing markets and recent clam harvests is that landings data report values in pounds of meat. These values result from harvest of all size clams and represent an average value for all three market categories. Thus, average landing values (for cultured and wild harvest) are less appropriate to the clam grower who markets only littlenecks. Because these data are all that exist, however, they are discussed below.

Products and Market Structure

Many clam products are distributed locally to restaurants and retail markets. The predominant product form for littlenecks is live (in shell). Chowders are largely marketed as shucked meat. Cherrystones are marketed both live (in shell) and as meats. As noted by Vondruska (1988), hard clams ". . . have the lowest percentage of landings converted into fresh and frozen shucked meats, 4-28 percent in 1975-84, because hard clams are marketed largely in the shell."

Brown and Folsom (1983) reported that from 1979-83, Fulton Market in New York marketed about 10 percent of total U.S. hard clam landings. Allowing for some sales through other wholesale markets, the bulk of hard clam landings are still marketed through distributors. A survey by Adams and Busby (1986) found that 76 percent of Florida's east coast 1985 hard clam harvest was distributed through wholesaler/distributors. Similar distribution probably occurs in the other large clam-producing state, North Carolina.

Potential investors should talk with clam and seafood dealers and distributors in their area. Culturists should also talk to producers about their marketing programs and production practices. Other producers can give valuable information about markets and services of local distributors.

Table 9. Minimum hard clam legal harvesting size for five South Atlantic states [1]

	Measure of Shell Thickness	
State	Wild Harvest	Culture
Virginia	None	None
North Carolina	1"	1"
South Carolina	1"	None
Georgia	1"	1"
Florida	1"	1" within state 7/8" out of state

[1] Effective early 1990. Discussions underway in several states for changes.
For most recent size regulations, check with state's regulatory agency.

Potential investors considering marketing their own harvests should explore early local markets such as retail establishments and restaurants. Do not overlook the costs of marketing and distribution if you decide to "do it yourself." These costs can be significant, particularly when individual customers purchase relatively small quantities.

Between 1979 and 1986, U.S. hard clam landings have fluctuated between about 12 million pounds (meat weight) and 18 million pounds (Fig. 10). Landings have declined to a range of 11-12 million pounds in the 1986-88 period. Landings appear to have become more variable from the mid-1970s to the present, compared with those in 1960 through the mid-1970s (see Table 10). During this earlier period, landings were relatively stable at 14-16 million pounds per year. Also note in Table 10 that landings of both ocean quahogs and surf-clam meats have exceeded those of hard clams since 1977 (surf-clam landings have historically exceeded hard clam landings). Imports of various clams and clam products have increased significantly since the mid-to-late 1970s, but comprise only about 10 percent of total supplies in 1986-88.

Potential

Assessing the potential for expanded clam culture is somewhat risky, as investors know. Aside from production risks associated with water quality, predation and potential diseases, projecting long-term prices is itself uncertain at best. There are factors, however, that influence expected future prices, discussed below.

First, and perhaps most important, are the potential effects on prices from increases in production. Increased production may originate from increased culture and growout on leased bottom, from increased depuration of clams grown on polluted, public bottom, and perhaps from stock-augmenting state agency management of public bottoms. Predicting the future supplies of each is again risky business, but we can speculate.

Future supplies of clams may be increased from depuration, holding of shellfish in clean water to allow bacteria purging and other pollutants. However, depuration requires extra handling, whether done on shore, or "relayed" to cleaner water in bays before harvesting. Some price advantage for depurated clams or regulation may result in more depuration in the future. This increased quantity of clams could have future price effects, but we do not know the level of these potential quantities. However, larger scale relay or shore depuration would result in significantly higher production costs. While we might expect some increase in the near future in South Atlantic supplies of hard clams from depuration, it is unclear just how large they will be.

Growout on leased bottom does serve a storage/speculative function as well as a production function (Agnello and Donnelley, 1975; Easley, 1982). This advantage is not generally available to the fishermen harvesting from public bottom due to the open access/common property nature of the fishery. Given significant price fluctuations through any given year (discussed later), this advantage may be important, since clams can be held in protected natural conditions until prices are favorable.

As production grows, what are the likely consequences on prices for clam producers? While this question cannot be definitively answered with the existing knowledge of clam markets and data, there are several studies that bear on the question. First, evidence suggests that marketing Florida clams to northeastern markets enhanced harvesters' prices in 1978-85 (Adams and Busby, 1986). Given the relatively high-valued product, it is not surprising that shipments occur across states and regions in response to higher prices.

The characteristics of the demand for hard clams largely determines price effects from increased production. Brown and Folsom (1983) estimated that the wholesale price of littlenecks would fall by .56 percent if landings increased by 1 percent, holding other factors constant, such as income. With this estimated effect, gross revenues to the industry would increase with small increases in output. However, since it is not known how costs respond, it is difficult to predict the effect on industry net revenue. It does appear reasonable to speculate that expansion in culturing output could be accomplished at relatively constant marginal costs. This may not be true of increased output from naturally-occurring wild stocks.

North Carolina hard clam producers were found to be "price takers" relative to the U.S. market during 1960-82 (Hsiao, Johnson and Easley, 1986). North Carolina quantities landed did not exert the expected negative effect on the state's

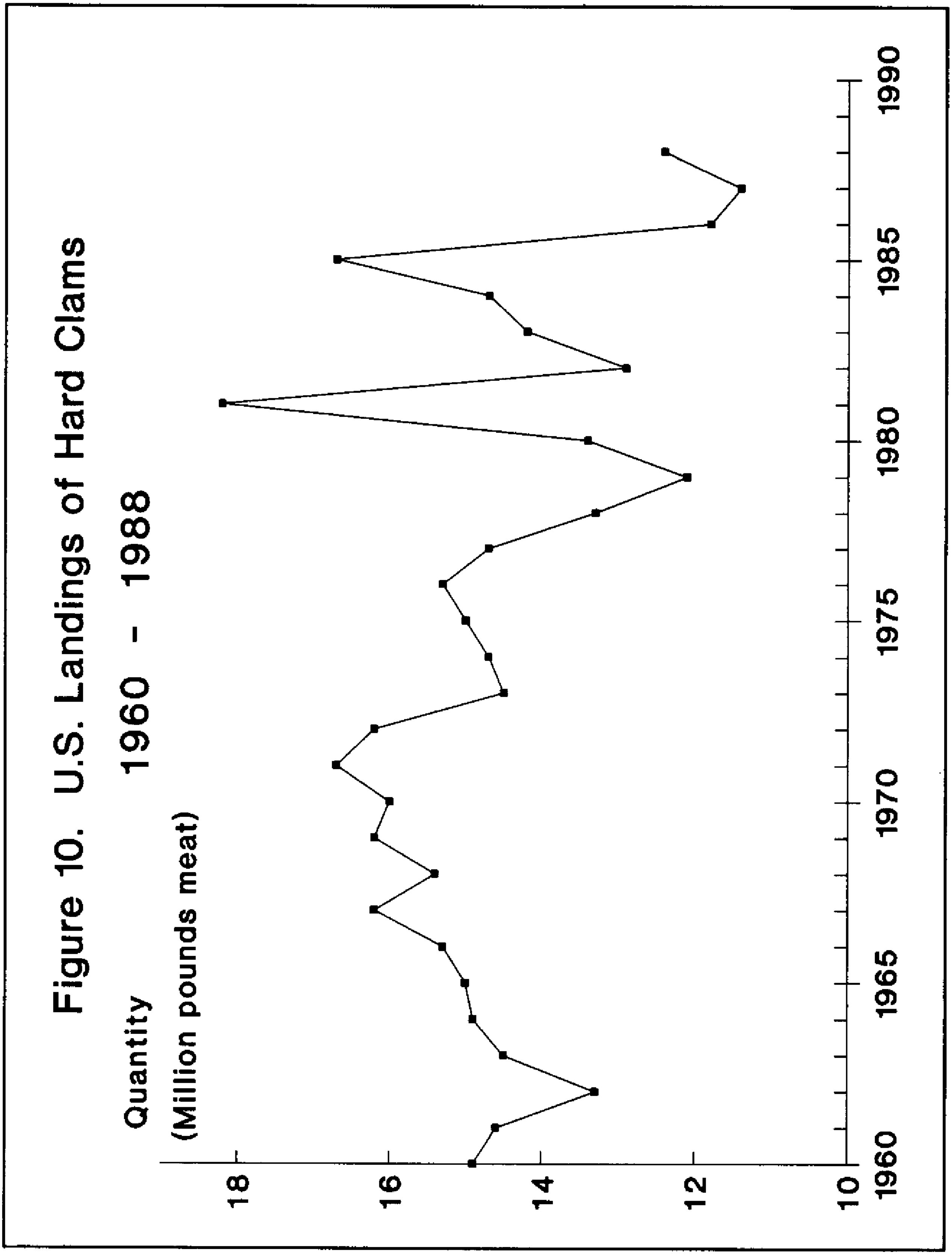


Figure 10. U.S. Landings of Hard Clams
1960 - 1988

Table 10. U.S. landings, imports and apparent consumption of hard clams, 1960-1988.

Year	Beginning stocks	Landings: Hard	Landings: Ocean quahog	Landings: Soft	Landings: Surf	Landings: Other	Landings: Total	Imports (product weight): Fresh & frozen clams	Imports (product weight): Canned Razor clams	Imports (product weight): Canned Other clams	Imports (product weight): Canned Chowder & juice	Imports, total, meat weight equiv.	Total supply	Exports frozen	Ending stocks	Apparent consumption: Total	Apparent consumption: Per person (pounds)	Population (Million persons)
	(thousand pounds, fresh shucked meat weight, except as noted)																	
1960	NA	14,877	186	8,579	25,071	859	49,572	969	72	1,023	6	1,408	50,980		NA	50,980	0.286	178.1
1961	NA	14,604	124	7,363	27,502	737	50,330	1,119	75	1,724	8	2,123	52,453		NA	52,453	0.290	181.1
1962	NA	13,295	67	9,396	30,854	557	54,169	640	5	1,454	5	1,614	55,783		NA	55,783	0.304	183.7
1963	NA	14,529	104	9,754	38,586	430	63,403	469	60	1,447	37	1,600	65,003		NA	65,003	0.349	186.5
1964	NA	14,925	113	11,030	38,144	252	64,464	411	27	1,403	3	1,495	65,959		NA	65,959	0.349	189.1
1965	NA	15,044	93	11,308	44,088	316	70,849	573	57	1,319	47	1,523	72,372		NA	72,372	0.378	191.6
1966	NA	15,324	91	11,919	45,113	304	72,751	703	14	1,924	52	2,099	74,850		NA	74,850	0.387	193.4
1967	NA	16,182	45	9,823	45,054	396	71,500	708	12	1,664	74	1,864	73,364		NA	73,364	0.376	195.3
1968	NA	15,426	225	10,368	40,552	675	67,246	749	0	1,850	37	2,031	69,277		NA	69,277	0.351	197.1
1969	NA	16,154	639	13,481	49,575	896	80,745	1,087	5	2,618	123	2,911	83,656		NA	83,656	0.420	199.1
1970	NA	16,015	1,747	12,908	67,318	1,216	99,204	1,720	0	4,568	66	4,956	104,160		NA	104,160	0.516	201.9
1971	NA	16,666	2,032	12,652	52,535	604	84,489	3,072	5	3,169	12	4,184	88,673		NA	88,673	0.433	204.9
1972	NA	16,153	1,401	9,078	63,471	586	90,689	2,994	5	4,219	7	5,128	95,817		NA	95,817	0.462	207.5
1973	NA	14,505	1,457	8,627	82,370	581	107,540	2,167	0	3,654	5	4,267	111,807		2,115	111,807	0.533	209.6
1974	2,115	14,665	838	9,590	96,110	490	121,693	1,602	5	4,589	0	4,913	128,721		2,484	126,237	0.597	211.6
1975	2,484	14,995	1,296	9,174	86,956	966	113,387	1,436	0	1,997	10	2,435	118,306		1,933	116,373	0.544	213.8
1976	1,933	15,251	5,602	10,467	49,158	2,054	82,532	2,132	2	6,286	14	6,705	91,170		2,391	88,779	0.411	215.9
1977	2,391	14,690	17,743	10,275	51,421	3,210	97,339	2,989	6	7,752	41	8,423	108,153		4,452	103,701	0.475	218.1
1978	4,452	13,295	22,965	10,091	39,237	2,123	87,711	4,315	35	4,701	3	6,131	98,294		4,486	93,808	0.425	220.5
1979	4,486	12,058	34,724	8,585	34,912	1,771	92,050	4,524	27	5,803	137	7,273	103,809		4,629	99,180	0.445	223.0
1980	4,629	13,370	33,832	8,948	37,737	1,482	95,369	4,558	116	5,321	94	6,908	106,906		4,525	102,381	0.454	225.6
1981	4,525	18,118	36,107	8,072	46,100	12,234	120,631	8,316	22	6,617	63	9,520	134,676		3,885	130,791	0.575	227.7
1982	3,885	12,855	34,792	8,021	49,720	2,917	108,305	9,435	41	7,846	45	11,122	123,312		4,840	118,472	0.515	229.9
1983	4,840	14,186	35,232	8,460	55,938	1,589	115,405	10,150	77	7,391	3	11,006	131,251		2,555	128,696	0.555	232.0
1984	2,555	14,749	38,812	7,919	70,243	1,198	132,921	9,544	49	7,791	15	11,113	146,589		3,053	143,536	0.611	234.8
1985	3,053	16,697	51,964	7,865	72,520	1,505	150,551	9,645	33	9,765	26	12,979	166,583	1,044	5,227	160,312	0.676	237.0
1986	5,227	11,793	45,383	5,887	78,749	3,581	145,393	10,189	88	13,622	175	16,879	167,499	1,335	8,407	157,757	0.659	239.4
1987	8,407	11,418	50,255	7,469	60,744	4,471	134,357	12,373	141	13,352	481	17,641	160,405	1,244	7,151	152,010	0.629	241.5
1988	7,151	12,371	46,310	6,814	63,545	2,700	131,740	12,008	229	10,387	652	14,872	153,763	1,568	2,973	149,222	0.612	243.9

Source: NMFS, Fishery Statistics of the United States, Frozen Fishery Products, Imports and Exports of Fishery Products, and Fisheries of the United States. Imports converted to meat weight using the following factors: 0.40, in shell or shucked; 0.93, canned clams; 0.30, canned chowder or juice. Landings for 1978 onward subject to revision.

NOTE: Reproduced from Vondruska (1988).

prices. Changes in hard clam landings in other states did negatively affect North Carolina prices, and to a lesser degree, so did landings of soft and surf clams (possible substitutes). North Carolina price was estimated to rise 1.13 percent in response to a 1 percent decrease in other states' hard clam landings.

These studies, as expected, suggest a negative effect on price for increased clam landings. However, both Brown and Folsom (1983) and Hsiao, Johnson and Easley (1986) found large positive effects on price for income increases. Over time as income increases, the demand for clams increases, resulting in higher prices. Hsiao, Johnson and Easley (1986), for example, found that North Carolina prices were bid up by 3.36 percent for a 1 percent increase in U.S. real per capita income. Thus, even if increased production reduces prices in the short run, increased income over time more than offsets this through a demand increase. Future prices may largely depend upon the relative sizes of these two opposing effects.

Observations on early growers' experiences suggest that growth in demand has been at least as great as growth in supplies. Some producers are contracting for prices year round that may exceed wild-harvest prices much of the year. Consistency in supplies and high-quality products appear to be motivations behind buyers in such contracts.

Clams are now being marketed in new areas. Markets have historically been the eastern coastal states. Future efforts to expand beyond traditional markets suggest that larger quantities (exact level not known) can be marketed without adverse price effects.

Another factor that will affect long-run profitability in the industry as quantities produced (and consumed) expand is the cost at which growout firms can be replicated. If this cost is fairly constant, long-run real prices may not increase a condition similar to what occurred in the catfish industry. However, if new entrants enter the industry with successively higher costs, early entrants may well earn above-normal returns.

Recent U.S. Prices

Clams are marketed by size, with the smallest market-size clams commanding the highest prices. Size categories according to Brown and Folsom (1983) are decided by the clam's largest dimension, and are: littlenecks, 1 3/4 - 2 1/2 inches; cherrystones, 2 1/2 - 3 inches; and chowders, over 3 inches.[1] Average wholesale prices at New York for 1988 for a bushel of live clams by size were: littlenecks,[2] $104.52; cherrystones, $31.75; and chowders, $16.82. Such a price structure reflects consumer size preference, and supplies by size classes. Much stronger preference for the small clam is of obvious importance to the culturist, as growout time to the littleneck size is much shorter than for the larger classes.

Figure 11 presents recent wholesale prices for littlenecks and cherrystones.[3] Several points are worth noting. First, there is significant variability in wholesale prices through the year, with major peaks occurring each winter. This may be due to some seasonality in demand, but is also affected by reduced supplies from northeastern states during the winter months (Brown and Folsom, 1983). South Atlantic producers with small acreages may take advantage of these large variations by timing harvests during periods of higher price. Larger producers, however, may have to harvest year-round and are less able to fit production to periods of high prices.

Other points worth noting from Figure 11 are

1 Florida uses even larger numbers of size classes, with three categories within the littleneck, (personal communication, Mr. Stu Kennedy, Florida DNR), including littleneck, middleneck, and topneck. Other Florida grades are cherrystone, chowder and ungraded, employed in pricing harvests at the vessel level.

2 Littlenecks are 480 count per bushel.

3 Prices by these size categories are not available at the vessel (or fisherman) level. State-level prices (presented later) represent a blend price for all sizes harvested. They not only reflect higher-level market prices, but also differences in the proportion of harvests made up of the different size classes. Thus vessel-level prices may not provide potential investors with as much information as wholesale littleneck prices adjusted for mark-ups and transportation costs from the reader's region.

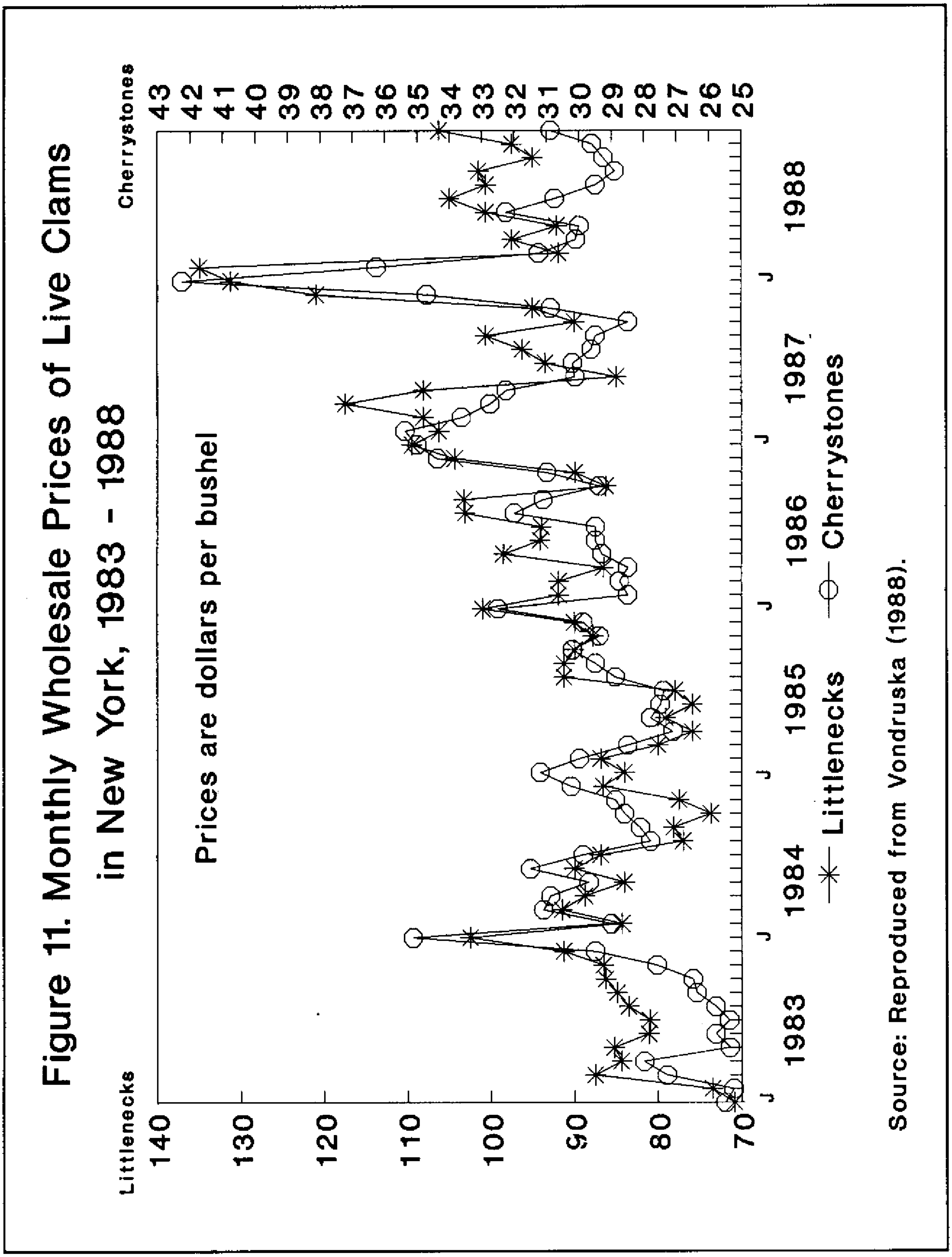


Figure 11. Monthly Wholesale Prices of Live Clams in New York, 1983 - 1988

that prices of the different-size clams tend to move together, perhaps reflecting the fact that all size classes are harvested simultaneously from public waters and may be substitutes in consumption. There also appears to be an upward trend in prices during the six-year period beginning in 1983. These are nominal prices, however, and reflect general inflationary forces as well as changes in clam-market forces. Figure 12 presents deflated wholesale prices (deflated by the producer price index for finished consumer goods) for live clams. Real prices for littlenecks have increased significantly over time, particularly from the mid-1960s through the early 1970s, the late 1970s, and 1985-87.

Hard clam prices in recent years have risen significantly relative to other shellfish. Table 11 presents recent exvessel price indexes for hard clams and total edible shellfish (which also includes clams). Note that average prices for 1989 for hard clams are 45 percent higher than in the base year of 1982. The final column in Table 11 shows the ratio of the hard clam index to the total edible shellfish index. This ratio of indexes shows that hard clam exvessel prices have risen relative to shellfish in general. The probable explanation for this is that the demand for hard clams has been increasing more rapidly than has the demand for all shellfish.

Historical Price Overview by State

While landings of hard clams were relatively stable during the 1960s and early 1970s, they have been lower in the late 1980s (Table 10). Regional landings for Virginia through Florida, on the other hand, have increased from about 1.5 million pounds of meat in the mid-1970s, to 3.5 to 4.0 million pounds in the mid-to-late 1980s. Table 12 presents landings by state for the region. U.S. landings have gone down since the late 1960s-early 1970s and South Atlantic landings have risen. The share of total U.S. landings accounted for by South Atlantic landings has increased significantly. Regional landings accounted for about 10 percent of total U.S. landings in 1975-76, and had increased to just over 30 percent in 1986-87 (see Table 12).

Increased landings have resulted in large part from increased clam prices. Higher prices may be due to several factors, including population and income growth in the region and stable-to-downward landings elsewhere in the country.

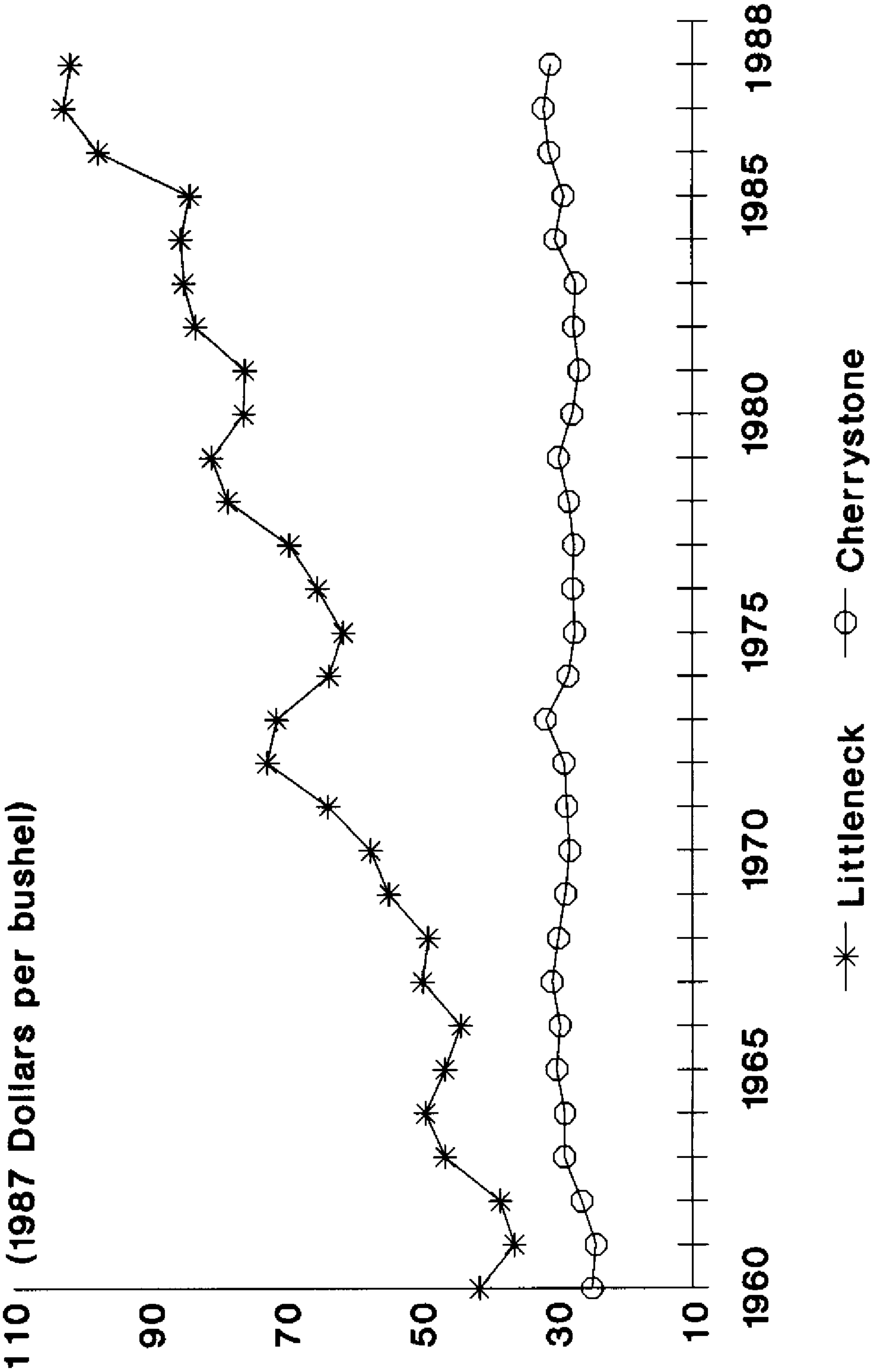
Figures 13-17 present nominal (current dollar) and real prices (adjusted to remove general inflationary effects) for 1973-88. Note large increases in the real, or adjusted, prices from 1976-78, and 1985-87. Both these periods coincided with reduced landings in other regions. Real prices fell in Virginia, North Carolina and South Carolina from 1980 - 81. This may be due to a relatively large

Table 11. Indexes of exvessel prices for hard clams and total edible shellfish, 1980-89.
(1982 = 100)

Year	Hard Clams	Total Edible Shellfish	Hard Clams x 100 / Total Edible Shellfish
1980	79	68	116
1981	85	78	109
1982	100	100	100
1983	89	98	91
1984	101	96	105
1985	92	92	100
1986	119	108	110
1987	130	109	119
1988	164	113	145
1989	145	108	134

Source: NMFS, Fisheries of the United States, various issues, U.S. Government Printing Office, Washington, D.C.

Figure 12. Real Wholesale Prices of Live Clams in New York, 1960 - 1988



Source: Reproduced from Vondruska (1988).

Table 12. Hard clam landings for five South Atlantic states, 1973-88.

Year	Virginia	North Carolina	South Carolina	Georgia	Florida	Total	Share of U.S.
		------ Thousand pounds of meat ------					Percent
1973	1,354	380	119	6	139	1,998	13.8
1974	1,419	288	155	0	94	1,956	13.3
1975	1,088	285	178	0	74	1,624	10.8
1976	893	306	169	11	61	1,440	9.4
1977	1,021	739	199	0	148	2,107	14.3
1978	497	892	205	0	126	1,720	12.9
1979	620	1,455	194	0	72	2,341	19.4
1980	753	1,542	296	0	62	2,653	19.8
1981	1,116	1,458	258	6	117	2,955	16.3
1982	698	1,702	527	10	145	3,082	24.0
1983	1,177	1,342	340	3	145	3,007	21.2
1984	739	1,388	393	3	1,377	3,900	26.4
1985	716	1,393	221	7	1,655	3,992	23.9
1986	920	1,356	250	17	1,148	3,691	31.3
1987	1,004	1,207	186	34	1,194	3,625	31.8
1988	1,308	940	272	61	686	3,267	26.4

Source: Various state fishery statistical programs.

increase in U.S. landings in 1981. Real prices also fell in several South Atlantic states from 1987-88.

Some care should be exercised in interpreting changes in vessel-level prices by state. These prices represent composite or average prices across the size classes harvested. As noted earlier, there are very large price differences between littlenecks and chowders, for example. Thus, a year-to-year change in average clam prices for a state may reflect real market forces at work, or reflect a change in the composition of landings. For example, an increase in price from one year to the next might be explained by an increase in the share of landings of smaller and higher-priced clams, with no change in overall market demand.

Similarly, variation in annual prices across states may be due largely to changes in the size composition of landings. A good example of this effect may be the comparison of Virginia and North Carolina prices. Real prices are reasonably similar from 1973-77, with Virginia prices higher in three of the five years. But since 1978, North Carolina prices have exceeded those in Virginia by a significant margin. The Virginia industry includes soup /chowder producing plants, which may prefer the larger and lower-priced chowders, whereas the North Carolina industry does not include such plants. Thus, marketing related to different sizes and prices of clams influences average or composite vessel-level prices.

Seasonal Price Variation

Price variation through a year (or seasonal variation) is important to the timing of harvest by a lease-holder unless the grower is selling at a contracted price. As noted earlier, the lease provides growers the opportunity to time their harvests for higher prices, because they have property rights to the clams and control access (unlike the fisherman who harvests off public bottom). Also noted earlier, there is significant variability in wholesale prices through the year (recall Figures 11 and 12). Much of the wholesale price variability is translated into vessel-level price variability.

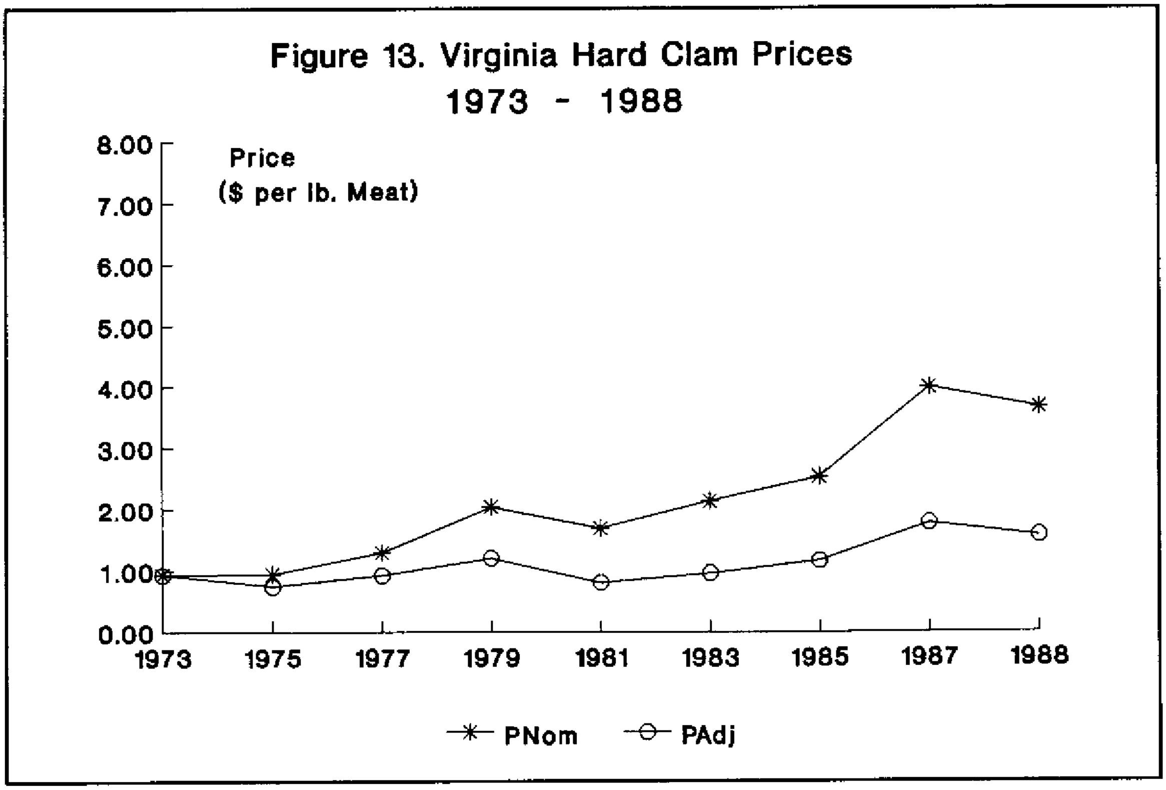


Figure 13. Virginia Hard Clam Prices
1973 - 1988
Price
($ per lb. Meat)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1973
1975
1977
1979
1981
1983
1985
1987
1988
PNom
PAdj

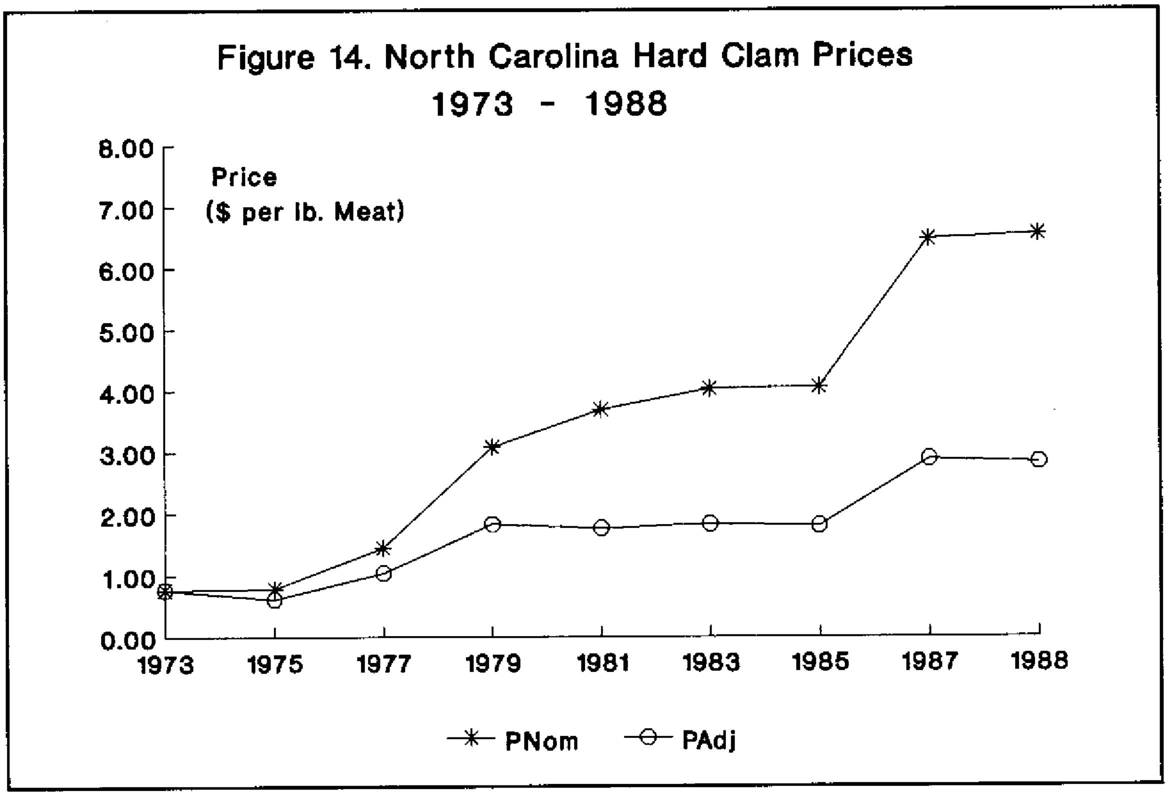


Figure 14. North Carolina Hard Clam Prices
1973 - 1988
Price
($ per lb. Meat)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1973
1975
1977
1979
1981
1983
1985
1987
1988
PNom
PAdj

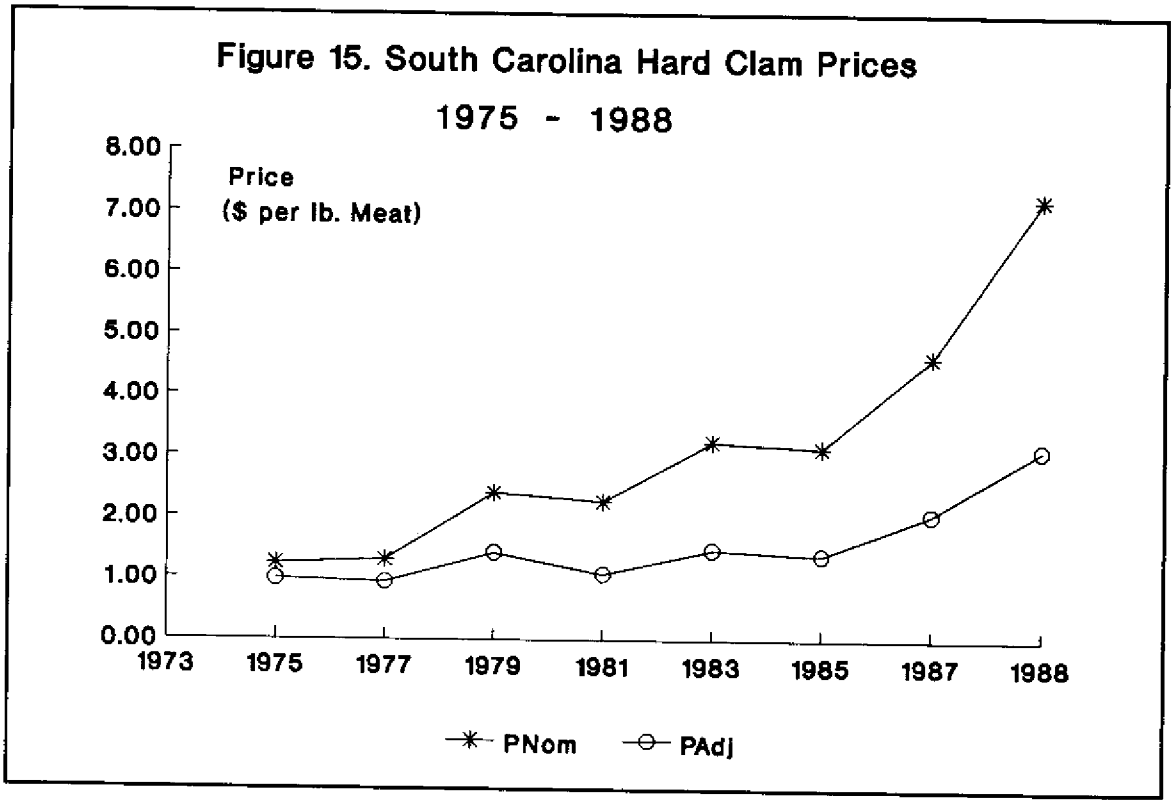


Figure 15. South Carolina Hard Clam Prices
1975 - 1988
Price
($ per lb. Meat)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1973
1975
1977
1979
1981
1983
1985
1987
1988
PNom
PAdj

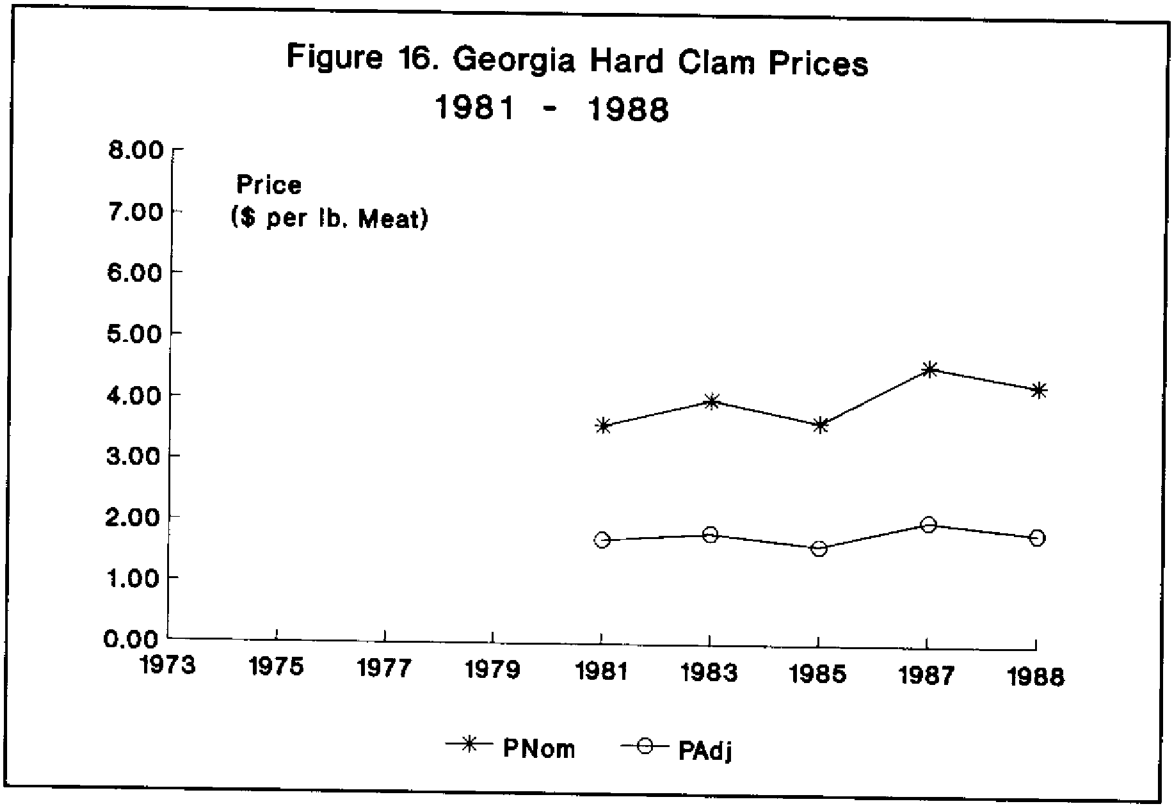
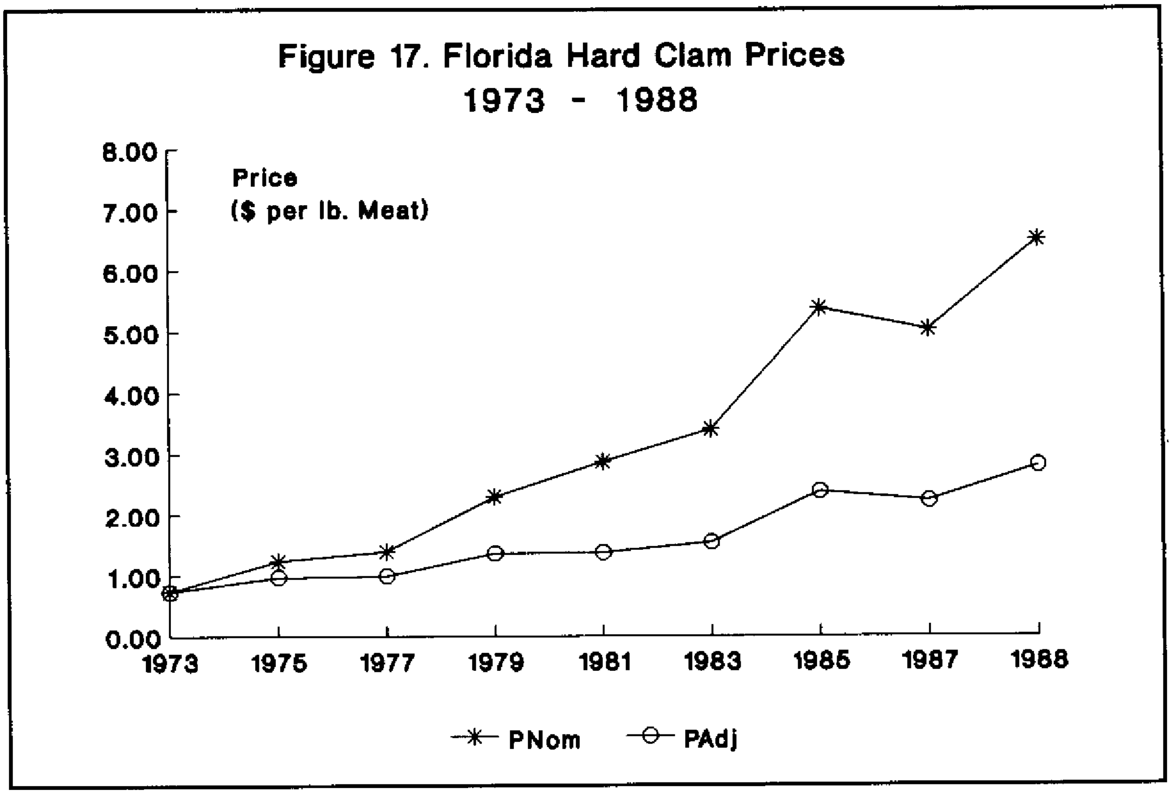


Figure 16. Georgia Hard Clam Prices
1981 - 1988
Price
($ per lb. Meat)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1973
1975
1977
1979
1981
1983
1985
1987
1988
PNom
PAdj



Figures 18-20 contain monthly vessel-level prices for two recent years for Virginia, North Carolina, and Florida, the three largest clam-producing states along the South Atlantic. Note that those shown for Florida are for the East Coast which accounts for 90 percent or more of the state's landings.

The major reason for presenting these prices is to illustrate some of the variability from month to month and through the year. Note that there is little consistency in monthly price patterns among the years presented. However, given the variability, the clam producer will want to pay close attention to local prices in timing harvests, especially in states that have important wild harvests.

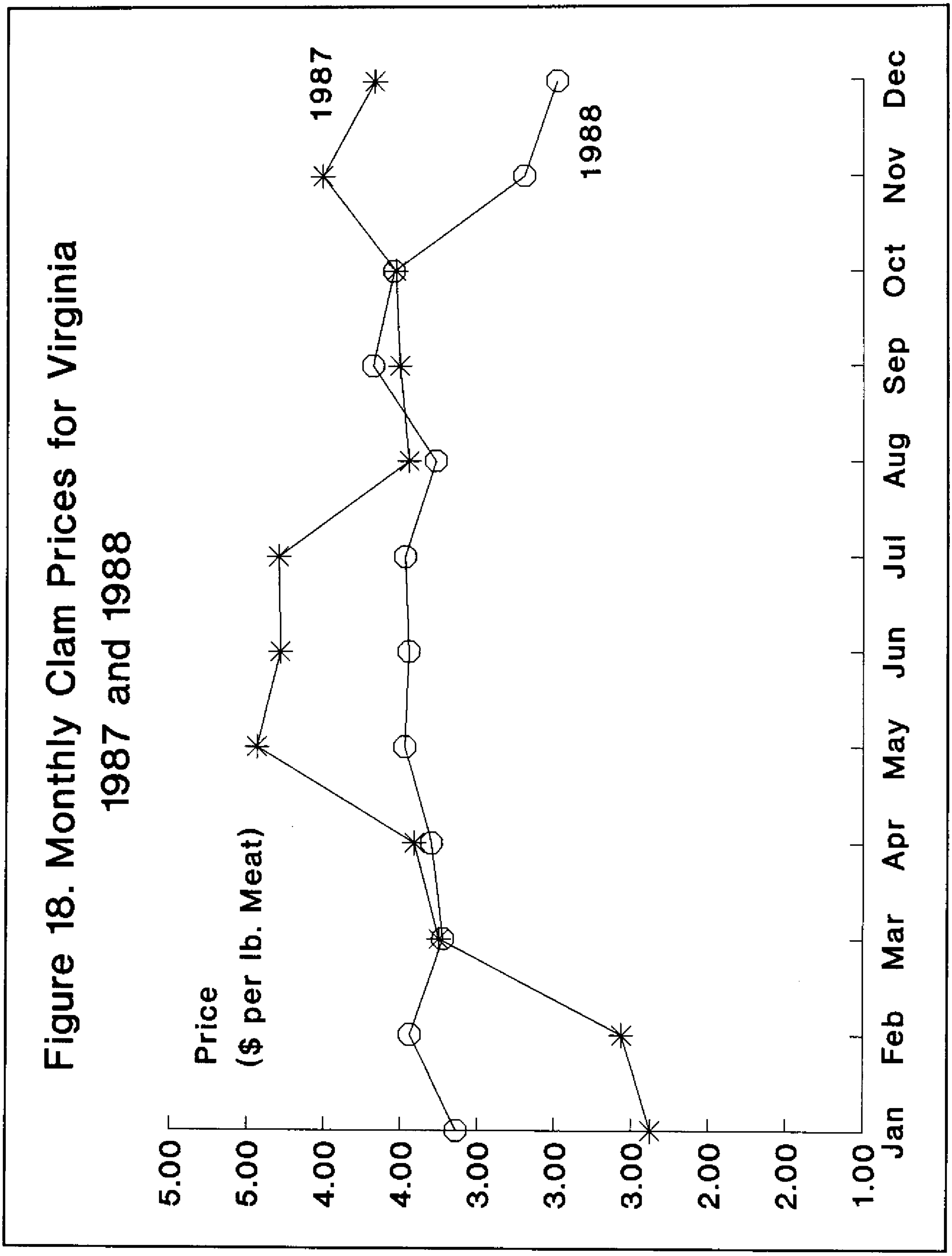


Figure 18. Monthly Clam Prices for Virginia
1987 and 1988

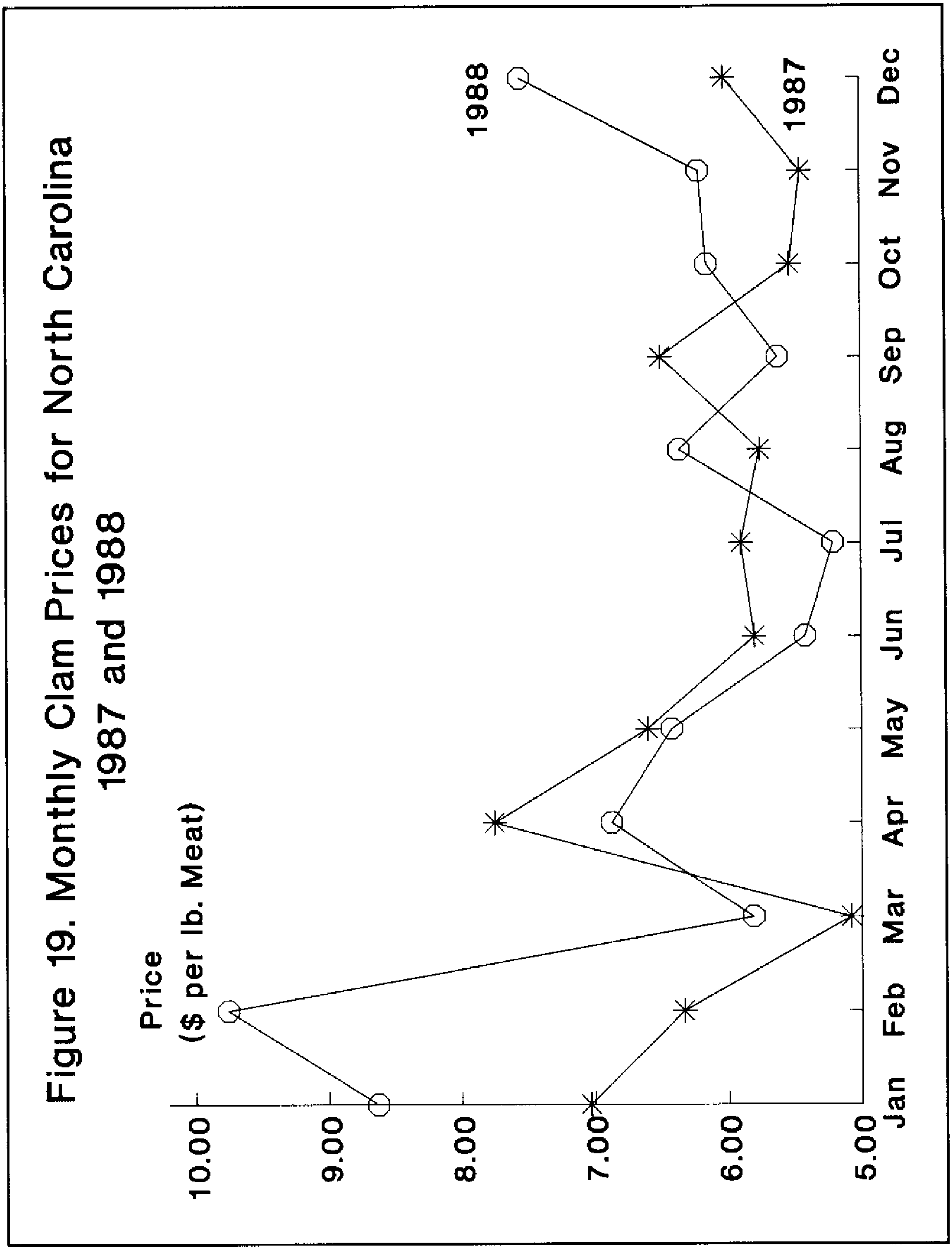
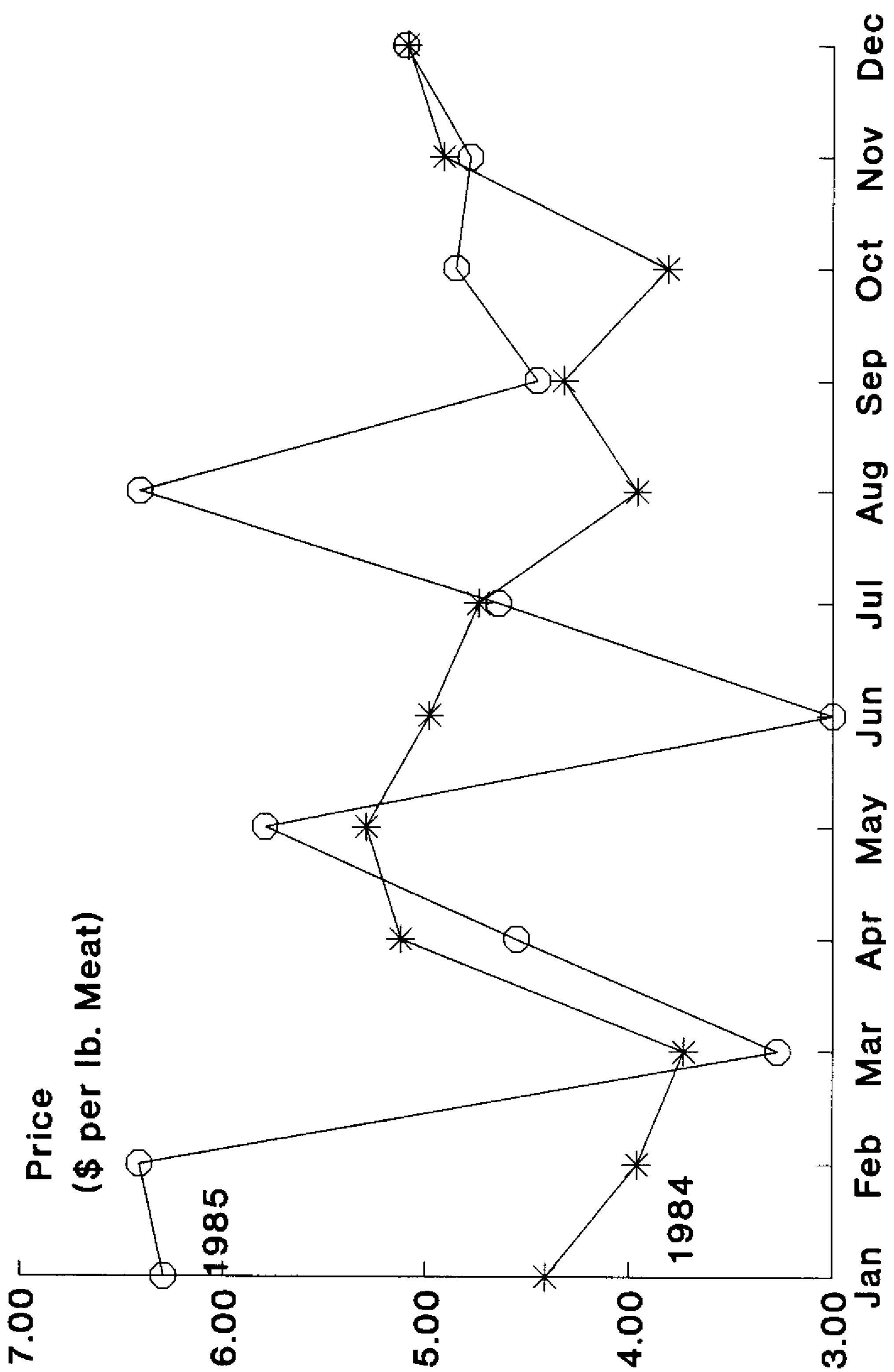


Figure 19. Monthly Clam Prices for North Carolina 1987 and 1988

Figure 20. Monthly Clam Prices for Florida East Coast 1984 and 1985



IX. FINANCING THE CLAM CULTURE VENTURE

Obtaining capital for clam culture can be a formidable task for current and prospective culturists. Major problems are the perceived high risk and high investment and low return on investment associated with clam culture.

Individuals considering commercial hard clam culture should be financially sound because the capital investment can be higher than for most other agricultural or aquacultural enterprises. Prospective producers should not start hard clam production undercapitalized or unsure of funding sources. Unexpected cash flow or capital equipment needs may cause failure.

Most lenders are unfamiliar with hard clam farming and will have made very few loans to clam culturists. In areas where hard clam culture is unproven or a successful track record has not yet been established, lenders are usually cautious with new operations and financing may be difficult to obtain. The clam culturist should educate the lender about production, financial and marketing factors.

Lending criteria and requirements for aquaculture credit are generally varied. Profits and return on investment, while important, are not the only criteria that influence the decision-making process. Aquaculture and individual risks are also considered. Other factors include the borrower's character, repayment capacity, collateral and equity capital, as well as the nature of the enterprise.

The prospective borrower should have adequate collateral for the loan requested. The borrower must provide current accurate financial statements and supporting records, professionally prepared. A balance sheet, with supporting schedules and inventories, is essential. A projected income statement and a projected cash flow for the business are needed. A five-to-ten-year projected cash flow period may be required. Use realistic figures that represent average values rather than inflated figures unlikely to be obtained. The financial analysis should reflect the specific farm situation. The borrower must provide a marketing plan explaining to whom, at what price, and how the hard clams will be marketed. Letters of reference from professionals or seafood brokers or other market customers supporting the business can be helpful. Any actual experience producing hard clams commercially or participation in hard clam culture educational programs should be noted. The character of the principals in the business is of major interest to the lender. The producer must be willing to keep records, inform, listen to and work with the lender.

Once credit is obtained, properly managing it becomes a major challenge. Three basic financial statements - balance sheet, income statement and cash flow statement - are used to monitor the financial strength of your business. A successful business must exhibit strength in repayment ability and capacity, liquidity and solvency, profitability and financial efficiency.

Credit is available for hard clam culture from a variety of sources and for a variety of purposes including farm ownership and facility construction and for operating or producing the hard clam. A loan may be a direct, insured loan or a guaranteed loan. Sources of credit for aquaculture include:

1) Farm Credit System (funds typically used for operating loans, to purchase or improve real estate or refinance debt),

2) Bank for Cooperatives (loans to agricultural and agribusiness cooperatives)

3) Commercial banks (operating, non-real estate and real estate loans)

4) Farmers Home Administration (farm operation and ownership, limited resource, economic emergency, business and industrial)

5) Small Business Administration (guaranteed and direct loans)

6) Life insurance companies (first mortgage real estate loans)

7) Savings and loans associations (first mortgage real estate loans)

8) Merchants and dealers (agribusiness firms provide credit to purchase inputs and equipment)

9) Individuals (real estate purchases and operating loans)

10) Venture capitalists and equity capitalists (venture financing for growth companies)

11) Private companies/consulting firms (private agricultural and agribusiness companies and consulting firms are providing technical services and loans for emerging companies)

12) State assistance programs (credit for new aquaculture enterprises)

X. DEVELOPING A CLAM CULTURE BUSINESS PROPOSAL

Developing a clam culture business proposal can be difficult. For culturists searching for start-up capital or simply organizing their approach to a new venture, proposal preparation can be tedious and cumbersome. Many areas of business expertise are required to properly organize a proposal so that a particular idea may be evaluated and acted upon. For the greatest chance of success, a logical, conscientious effort from idea to proposal should be used.

Readying a proposal for presentation to a financial institution requires several steps:

1) An idea becomes the business desire of the principal(s).

2) Idea is converted into long - and short-term goals.

3) Goals lead to the formation of a basic plan of action to be analyzed, producing various alternatives for goal attainment.

4) Decision is made for the best alternative depending on the principal's(s') particular circumstances.

5) Financing proposal is written with an organized purpose and logical plan of action.

Long- and short-term goals set the direction by which the culture venture can become a reality. Long-term goals are accomplished over several business cycles, while short-term goals create a path to the attainment of the former, and are accomplished in a shorter time period.

An example of long - and short-term goals for a clam farmer may be:

Long-term goal number 1: Hard Clam Inc. proposes to own and operate a commercial hard clam growout operation.

Short-term goals:

1. Site research and selection by July 1.

2. Analysis of alternate growout systems by August 1.

3. Selection and design of growout system by October 1.

4. Seek financing for operation by February 1.

5. Startup activities by June 1.

6. Begin operation by October 1.

Long-term goal number 2: This operation is to pay back the initial investment within seven years after operation begins.

Short-term goals:

1. First three operational years, 20% paid back.

2. Fourth year, 40% paid back.

3. Sixth year, 80% paid back.

Long-term goal number 3: The owner-operator would like to make a salary of $45,000 per year.

Short-term goal:

1. Same as long-term goal.

Once goals are set, a basic plan, including alternatives, is developed. All alternatives should be evaluated using criteria developed from the goals. The analysis of the alternatives should be consistent for comparisons ("apples to apples") and should produce one or two "best" plans. Types of alternatives are highly dependent on the nature of the culture activity (i.e., location, scale, level of integration, technology).

After identifying various alternatives, set criteria by which they can be compared. Because most goals are financially oriented, one set of criteria is financial statements (other criteria, such as production goals, should also be considered). Pro forma financial statements include cash flow, income statement, balance sheet, and the statement of changes in financial position. Specific criteria, such as internal rate of return, payback period, and financial ratios, can be adopted from these statements. These criteria can then be used by the principal(s) to select one or two "best" plans from the alternatives.

General environmental and industrial factors, which are external to, but nonetheless impact on, the proposal, must also be considered. The general environment can be viewed through cultural, economic, government, technology, and international issues. The industry can be examined by competitive forces affecting market performance.

The following general outline is useful as a guide for the contents of the proposal. Specific sections and tables from this guide of use in preparing the business plan are shown in parentheses.

- Title Page
- Table of Contents
- Statement of Purpose
- Executive Summary
- The Business
  - Industry Status (I) - current status of the business and organization
    - Operations (location, facilities, production cycle, permits) (III, IV, V, VI, VII)
  - Market (VIII)
  - Marketing (VIII)
  - Competition and Risks (I, III, VIII)
  - Management
  - Personnel
  - Research and Development
  - Financing Arrangements and Ownership (IX)
  - Development Schedule
  - Summary
- Financial Plan (XI)
  - Sources and Use of Funds (IX)
  - Capital Equipment List (Tables 14, 18, 22,26, 30, 34, 38, 42,46,47, 48, 49, 54)
  - Break-even Analysis (Tables 58, 59, 60)
  - Pro Forma Balance Sheet
  - Pro Forma Income Statement (Tables 17, 21, 25, 29, 33, 41, 45, 53, 57)
  - Pro Forma Cash Flow (Tables 16, 20, 24, 28, 32, 36, 40 44, 52, 56)
  - Historical Financial Statements
  - Equity Capitalization (Tables 16, 20, 24, 28, 32, 36, 40, 44, 52, 56)
  - Debt Capitalization
- Supporting Documents

XI. FINANCIAL FEASIBILITY ANALYSIS FOR HARD CLAM CULTURE SYSTEMS

Introduction

Interest in the culture of hard clams has caused the development of technology resulting in a variety of hatchery, nursery, and growout systems. Understanding the differences in these is important to a potential hard clam culture investor. Further, a potential investor wants to understand how the economic performance of each technology differs. Current clam culturists may also increase the efficiency of existing production systems using this information. The following discussion focuses on the systems' economic and financial characteristics.

Baseline Assumptions

A wide variety of production systems are currently used for hard clam culture in the South Atlantic region. This analysis attempts to emphasize those systems recognized as especially technologically and financially promising. Therefore, only a select set of hatchery, nursery, and growout methods are examined, with respective harvest capacities, as follows:

- Hatchery: Milford method (24 million)
- Nursery: Upflow method (12 million)
  Raceway system (1 million)
  Raceway system (12 million)
  Field-tray method (12 million)
- Growout: Pens (1 million)
  Soft trays (1 million)
  Bottom nets (1 million)

Each method is examined independently. In addition, two integrated systems (i.e. hatchery, nursery, and growout) are assessed. These integrated systems include specific combined technologies (at a harvest capacity of six million each) and are described as follows:

- Milford hatchery
  Upflow nursery
  Pens

- Milford hatchery
  Upflow nursery
  Soft trays

Each system is assessed under a specific set of descriptive, operational, and financial baseline assumptions. These assumptions will be covered before discussing each respective system. A more general set of assumptions applying to the overall analysis follows:

Production

- All hatchery and nursery systems are in production only six months of each year.

- Planting occurs yearly with increasing acreage seeded until year three. First harvest is in year three and each year thereafter.

- Mortality is assumed to be 50 percent at each production level, with the exception of the field-tray nursery (refer to that section).

- Growout systems are stocked at a density of 100 seed clams per square foot.

- Growout harvest size is 45-50 mm (longest dimension of shell).

- Harvested clams are assumed to all be of a given size (i.e. growout systems produce only littlenecks).

- Operation size will be measured in terms of annual output goals from the growout stage of the operation. Excess capacity has been built into the hatchery and nursery stages of the operation for system expansion and sale of seed. Annual production goals from each stage of the operation are shown below:

Production Schedule (Millions of Clams)

	Year of Operation							
	1	2	3	4	5	6	...	10
Hatchery	24	24	24	24	24	24	..	24
Nursery	12	12	12	12	12	12	...	12
Stand Alone								
Growout								
Plant	2	2	2	2	2	2	...	2
Harvest	-	-	1	1	1	1	...	1
Integrated								
Growout								
Plant	12	12	12	12	12	12	...	12
Harvest	-	-	6	6	6	6	...	6

Financial

- Harvest volumes, revenues, and operational expenses for each system are assumed to be constant across years (costs and prices are for 1990).

- All loans (i.e. capital and operational) are at 12 percent.

- Capital loans are for 10 years.

- Initial start-up capital loans assume 65 percent of cost financed (i.e., 35 percent owner financed). Capital asset loans required for capital replacement assume 100 percent borrowed capital.

- Owner equity is defined as the sum of owner financing (i.e., 35 percent initial capital requirements) and any start-up costs, which may include permitting fees, legal costs, consultant fees, survey costs, etc.

- The opportunity cost of owner equity (i.e., the next best investment alternative) is defined to be a 12 percent annual rate.

- Capital assets are depreciated using the straight-line method. Salvage value is zero for all capital assets.

- An operating loan covers all cash shortfall (zero minimum cash balance).

- Each system is managed by an owner-operator, whose cost of management skills is not included. Therefore, final returns are to owner-operator's management and risk. Additional labor requirements for each system are presented later.

- Returns are before taxes (i.e. state and federal income and property tax). This is necessitated due to the variability in applicable income and property tax rates.

- Because of the extreme variability in cost likely encountered for acquiring waterfront property within the South Atlantic region, the cost of land has not been included in the analysis.

- The discount rate for net present-value computations is 15 percent.
- The stream of values used for the internal rate of return and net present value computations is the "ending cash balance" contained in the cash flows.

Other

Pomeroy and Manzi (1990) served as the basis for some of the assumptions regarding the computation of labor and salaried benefits, repair and maintenance costs and derivation of certain other production, salary and wages, and overhead costs. These include:

- Annual maintenance costs for pens, nets, and trays are assumed to be 5 percent of total initial investment. These costs may be higher in different locations under different conditions.

- Annual maintenance costs for trucks, boats, trailers and motors are assumed to be 10 percent of total initial investment.

- Electricity costs for pumps are computed on the basis of 24-hour pump use at a given horsepower rating, where one KWH = one HP @ $0.063 per KWH.

- Labor was included at $5.00 per hour, given a six-day week (i.e. 48 hrs.).

- General manager salary is assumed to be $32,000 per year.

- Technician salary is assumed to be $16,000 per year.

- Benefits on hourly labor and salaried personnel are computed as 10 and 13.5 percent, respectively, of the total annual charge.

- Miscellaneous costs are included to cover other minor costs and are assumed to be 3 percent of operating costs. This value includes annual lease fees, which may be a negligible cost on a per-acre basis.

Financial Statements

The financial statements used in this analysis include a statement of operational expenses, initial capital investment requirements, capital asset addition schedule, annual cash flow (10 years), and an income statement (year five). These financial statements are presented for the hatchery, each nursery, and each growout system, as well as for the two integrated systems. In addition, enterprise budgets for year five are presented for each of the stand-alone growout systems.

A reference guide useful in locating the financial analyses for each system is provided in the Appendix in Table 13 along with all the financial analysis tables. This table cross-references the financial analysis tables with the production system of interest. Also, a brief description of the kinds of financial information contained within each table is provided.

Finally, several terms are used repeatedly in the discussion of the financial analyses. Brief definitions of each of these terms are below (Beierlein, Schneeberger and Osburn, 1986):

Opportunity cost - what the owner could have earned with the available equity in the next best investment alternative.

Net present value (NPV) - the difference between the current value of an investment's annual incomes and the current value of annual costs.

Internal rate of return (IRR) - the discount rate that makes the current value of annual incomes equal to the current value of annual costs. Projects that have an internal rate of return greater than the opportunity cost of an investment will have a positive net present value.

Hatchery System

The hatchery system employs the Milford method for producing required seed quantities. The system is designed to produce 24 million seeds of one mm size. The facility is assumed to be in operation six months per year. The total "annual" production quantity is, therefore, 24 million seeds.

The capital investment requirement for start-up is significant. Total initial investment required shown in Table 14 is $242,474. (Recall that only 65 percent of this total will actually be financed through a lending institution.) The most costly individual items are the required building, support lab, and heat exchanger. The building may have to meet FEMA flood zone standards. If this is the case it may result in higher construction costs. Pumps, seawater transmission systems, and water treatment systems also represent a major component. The system also requires investment in equipment for brood-stock maintenance, algal culture, larval culture, and post-set maintenance. Timely reinvestment in some of these and other capital items dictates a constant debt burden. Approximately one-half acre of shore-side property is required, the cost of which is not included in the analysis.

A major production-cost category is utilities (Table 15). The requirement for water movement necessitates using many pumps, resulting in a large utility cost for these pumps. Instead of purchasing algae, this proposed system is assumed to produce all needed algae. For the sake of simplicity, however, all algal production costs are lumped into one production cost category (Pomeroy and Manzi, 1990). Algal costs for brood-stock maintenance and larval culture represents another major expense, as do general supplies and heat exchanger costs. Labor costs are the single largest operational expense. The system is assumed to require two full-time technicians and a general manager (one-half year each). Total annual operating expense (the sum of production costs, salaries and wages, and overhead costs) is $70,751.

The anticipated selling price for one mm seed is assumed to be $0.003 each. Therefore, annual revenue for the system is $72,000. Given the assumptions regarding initial investment, reinvestment needs, magnitude of operating expenses and production capacity, the system remains in a negative cash flow position over the entire 10-year planning horizon (Table 16). The inability of the system to generate a positive cash-available value necessitates an operating-loan to be advanced each year. However, since the cash available position remains negative, the operating-loan debt cannot be retired and the operating loan interest accumulates. The income statement for year five further demonstrates the inability of the system to produce a positive net return, particularly when non-cash expenses such as depreciation and the opportunity cost of owner capital are considered (Table 17).

Nursery Systems

Three nursery methodologies are examined in this report: upflow, raceway and field tray. All nursery systems are assumed to be in production for only six months per year. Labor and salaried workers are included on a full-time basis, but only for six months per year. In addition, all nursery systems require one-half acre of shore-side property, whose cost is not included in the analysis.

Upflow Method

The upflow nursery uses a combined forced/passive upweller system. The operation is assumed to purchase one mm seed from a hatchery and grow the seed to eight mm. Annual production capacity is 12 million seeds. Given that assumed mortality is 50 percent, the annual purchase of 24 million one mm seed is required.

The major capital investment requirements for the upflow nursery include the passive-flow systems, pumps, building and pad (Table 18). In addition, a small dock and pump house are needed to place the required pumps over water. The total initial investment for the system at the stated capacity is $171,150. A major reinvestment every three years is required for the main pumps. Replacement of other capital equipment within the first 10 years is also required.

The acquisition of seed clams represents the largest share of the total operating expenses (Table 19). Given the 50 percent mortality rate, 24 million seed clams one mm in size must be purchased at $0.003 each at a total cost of $72,000. Electricity for pumps, as well as labor and salary, represent other major operational costs. Additional personnel (other than the owner/operator) are assumed to be one laborer and technician. Note that interest payments on an operating loan are paid for years one and two. These payments reflect an operating loan taken within each of the first two years to cover preproduction costs. The loans are phased out over the two-year period. These interest payments are included as operational expenses. Annual operational expenses total $102,097 for year three and beyond.

The system generates an annual revenue of $240,000, resulting from the sale of 12 million seed clams (8 mm) at an anticipated price of $0.02 each. Given the assumed magnitude of operational expenses and debt retirement obligations, a positive cash flow results beginning with year one and through the 10-year planning horizon (Table 20). With the ability to produce a positive value for available cash at the end of each year, no operational loan is required. NPV for the upflow system is $2.3 million, while IRR is 121 percent. The income statement for year five indicates a favorable net-earnings ability under the given set of assumptions (Table 21). After accounting for non-cash depreciation "charges" of $28,057, the net returns for year five total $97,586. However, when the opportunity costs of investing the owner's initial equity elsewhere is considered, net returns fall to $90,398.

Field Tray

Initial capital investment requirements for the field-tray system are substantially less than those for the upflow system (Table 22). Whereas capital expenditures for the upflow system were for shore-side facilities (without accounting for the cost of land), the majority of the capital expenses for the field tray are boats for tray maintenance and harvesting on the bottom lease. Major capital requirements include the trays (2.5' x 4'), barge/shaker, and dock. The barge must be big enough to accommodate temporary storage of trays and gravel/sand, as well as have enough deck space for a mechanical shaker for sorting. The dock must be large enough for movement of trays and equipment on and off the barge during harvesting, including a front-end loader to move gravel/sand from on-shore storage sites. A total of 550 trays are required for stocking the initial 24 million seed. Initial investment requirements are $80,250. Significant capital replacement is also required for the boat, motor, and trailer needed to tend the trays in the field.

The operational expenses for the field-tray system are approximately twice as large as those estimated for the upflow system (Table 23). Differences include costs of operation and maintenance of the barge, boat, and motors, as well as additional labor for tending and harvesting the trays. The system is assumed to require three full-time laborers and a technician for six months, in addition to the owner-operator. However, the major operational expense is the cost of seed-clam acquisition. Instead of stocking one mm seed in shore-side upwellers for the upflow nursery, the field-tray system is assumed to stock three mm seed. However, because the seed is stocked at a larger size, anticipated mortality is reduced to only 25 percent. Therefore, only 16 million seed clams are required for the target output of 12 million clams. The price for three mm seed clams is assumed to be $0.01

each, annually totaling $160,000. Total annual operating expenses are estimated at $206,525 for year three and beyond.

The field-tray system is assumed to produce 12 million seed clams. The seed clams are larger (15 mm) than those produced by the upflow system, as they are stocked in the trays at a larger beginning size. The anticipated price for the 15 mm seed clams is $0.03 each, resulting in an annual total revenue of $360,000. Given the assumptions regarding operating expenses and debt retirement, this relatively large annual revenue produces a positive cash position for every year in the 10-year plan (Table 24). As with the upflow system, no operating loan is required. NPV for the field-tray system is approximately $3 million, while IRR is estimated to be 23.8 percent. The income statement for year five further indicates a positive net return after depreciation and opportunity costs of $133,138 (Table 25). This high IRR reflects "favorable" conditions resulting from the set of base assumptions. The result of less-than-favorable conditions is discussed later.

Raceway (one million seed output)

The raceway system consists of four-tier wooden racks, with each tier consisting of a 4' x 20' raceway about six inches deep. Water is pumped shore-side through main PVC pipes from pumps in a pump house on a small catwalk over the water. The water is distributed to each four-tier rack and then further distributed via a PVC piping system to each raceway at a rate of 40 gpm. The effluent is channeled through PVC pipes down from each raceway to a small aluminum culvert for drainage back to the water source. The raceways are stocked with about 1,000 seed clams per square foot.

Initial capital investment for this relatively small-scale facility is $27,200 (Table 26). The largest capital expenditures are for the wooden-rack systems, a truck and the PVC seawater system. Trays and racks are assumed to have a six-year life. Therefore, replacement costs associated with the wooden racks, as well as a new truck, are major items.

The raceways are stocked with 2 million one mm seed clams. At $0.003 each, seed-clam acquisition is the major operational expense (Table 27). Others include electricity for pumps and fuel for the truck. No labor cost is charged since the owner/operator is assumed to supply the system's manpower. Total annual operating expense is $11,395 in year three and beyond.

A positive cash position is achieved for every year in the planning horizon (Table 28). No operating loan is required, because sufficient cash is generated to cover operational expenses and retire long-term debt obligations. NPV for the raceway system is $69,768, while IRR is about 48.8 percent. The values reflect the assumed favorable conditions. The income statement indicates a net return of $2,078, after depreciation (Table 29). Again, recall that this represents returns to owner/operator capital, management, and risk. Accounting for opportunity costs (i.e. subtracting from net returns what the owner/operator could earn in the "next best" investment alternative) results in a true economic loss of only $28.

Raceway (12-million-seed output)

The 12-million-seed output raceway is simply a scaled-up version of the previously discussed system. Note that the initial investment reflects virtually a linear scale-up from the smaller-size facility (Table 30). Total initial investment is $246,386. The major cost items are the wooden racks and pumps. In addition, the seawater transmission system, consisting of large quantities of various sizes of PVC pipe, valves, and "fittings" represents a sizeable investment. Due to continuous use in a seawater environment, the pumps are only given a three-year life, so capital replacement costs will be high.

In contrast to capital expenditures, operating expense increases do not represent a linear scale-up from the smaller raceway system. In fact, expenses increase by a larger order of magnitude than does output. The most important categories are electricity for the pumps, seed cost, and labor/wages (Table 31). Five 30-hp pumps (including one additional back-up) must run 24 hours a day to provide adequate water exchange, resulting in an annual utility cost of $40,824. Twenty-four million one mm seed are required for initial stocking. The anticipated price of these seed clams is $0.003 each, resulting in an annual seed cost of $72,000. Four full-time laborers and one technician are required for six months to properly maintain the raceways and constantly clean the seawater transmission system pipes, incurring $36,580 annually. Total annual operating costs for the scaled-up version of the raceway system is $168,523 for year three and beyond.

The system will produce 12 million seed clams annually. The anticipated market price for 8 mm seed is $0.02 each. Thus, annual revenues are $240,000. Given assumptions regarding operating expenses, initial capital investment, and debt retirement, the system produces an ending cash balance of $33,021 in year one (Table 32). The system continues to produce a positive and increasing ending cash balance for the remainder of the planning horizon. Only an operating loan to cover preproduction costs is required. These positive results, however, can be misleading. Although the system produces a positive cash position for each year, annual net returns are somewhat less (Table 33). In fact, net returns in year five are estimated to be -$8,088 as compared to a cash available position of $178,728. This results from large non-cash cost recovery (depreciation) for capital replacement, particularly for pumps and the opportunity cost associated with the large initial owner-equity requirement. After accounting for these non-cash costs, the system produces negative true economic profit. This particular scaled-up raceway system may not be justified because it isn't profitable enough for its size, investment and capital replacement. NPV for the system is $419,472, while IRR is about 40.4 percent. The values reflect the favorable base assumptions.

Growout Systems

The analyses assume that the growout systems are stand-alone facilities, i.e. hatchery and nursery systems are not in the operation. Therefore, seed clams are purchased for stocking. The three systems analyzed include pens, bottom nets, and soft trays. For each system, the growout period is 24 to 36 months, with an average of 30 months. None of the growout systems receive income until their third year. Production is assumed to be 1 million clams which are 45-50 mm in size (littlenecks). The anticipated selling price for these is $0.17 each for unsorted clams. Thus, annual gross revenue for each system for year three and beyond is $170,000. Each system assumes plantings during years one, two and three to maintain constant production levels for year three and beyond. Because the pens, bottom nets, and soft trays will increase during years one, two and three, operating expenses will also rise during these years. For each system, two million 8 mm seed clams are purchased for stocking each year at $0.02 each, costing $40,000 annually. Seed-clam purchase is the largest single production cost for each of the growout systems. Boat/truck and growout system maintenance, fuel/oil for the boat and truck, and insurance represent other major production costs for each system. Annual operating expenses increase up to year three due to planting and harvesting more seed as production phases up to a consistent level. The following discussion focuses on year three when operating expenses will stabilize. Annual production for each system is one million clams. Note it is assumed only the owner/operator handles each system, therefore, no labor cost is in the analysis. Additional labor may be required during planting and harvesting. These potential costs are not included but should be noted. All net returns are to owner/operator management and risk. No shore-side facilities are required, except a suitable location to launch a small boat for site maintenance and harvesting. Each system requires a three-acre bottom lease. Security can be a potential problem in certain locations. The owner/manager should be aware security needs to be considered in the siting and management of the clam lease. Providing security can cause additional operational costs. These costs are not included in the following analysis.

Pens

Total investment cost for 115 pens to allow harvest of one million clams is $46,600 (Table 34). The major initial capital investment is for the ground plants or pens, which are 24' x 8' and made of a PVC frame with plastic mesh. Additional pens are purchased in years two and three for $27,600, to maintain a constant yearly production level. The pens have a useful life of six years. In addition, a boat, motor and trailer to manage the pens are required.

Annual operating expenses for year three and beyond total $47,720 (Table 35). Seed-clam purchase (two million eight mm seed clams at $0.02 each) is the largest single expense. Fuel and oil for truck and boat, as well as maintenance for the truck, boat, motor, and pens, represent another large cost.

The first harvest, and thus income for the operation, does not occur until year three. An operating loan is required to carry the operation during the first two years (Table 36). The receipts from harvest in year three are used to retire the operating debt. Therefore, the first positive ending cash balance occurs in year four and for every remaining year in the planning horizon. The pen system generates NPV of $853,083 over the ten-year planning horizon, with IRR of 76.9 percent. These values reflect the favorable base assumptions. The income statement for year five indicates a net return of $99,045 after depreciation and opportunity cost of owner equity (Table 37).

Bottom Nets

Initial capital investment required for bottom nets is substantially less than pens (Table 38). Total capital outlay in the first year is $20,470. To achieve a constant annual level of production, a complement of nets is put into production during years two and three. The initial cost of bottom nets is substantially less than that for the pens, as the former are simply 50' x 8' reinforced plastic nets placed over the bottom and staked down. Twenty-five bottom nets are needed. The major capital investment is the boat, motor, trailer and truck. The nets are given a three-year life and therefore represent a significant replacement cost every year.

Operating costs for year three and beyond total $46,352. As for the pen system, the largest single cost is seed clams (Table 39). Fuel and oil for the boat and truck, as well as insurance and miscellaneous overhead costs, are also sizeable expenses. Repair and maintenance costs are reduced in comparison to the pens due to the nets' simple and inexpensive construction.

The operation produces a positive ending cash balance of $8,235 in year three, one year earlier than the pen system. This value remains positive and increases in remaining years in the planning horizon (Table 40). An operating loan is also used to cover costs incurred in years one and two, before revenue generation. The bottom-net system generates NPV of approximately $1.1 million, with IRR of 115.2 percent. These values reflect the favorable base assumptions. The net returns in year five total $114,570 (Table 41), significantly greater than the pen system. This is primarily due to reductions in operating costs and debt retirement.

Soft Trays

The initial capital investment required for the soft-tray system is $38,037, which is less than that required for the pen system, but more than for the bottom-net system. The major capital expense is for the 4' x 4' soft trays or bags made of plastic mesh (Table 42). A specific mesh size is required to grow the clams from 8 mm to 15 mm, while another is required to grow the clams from 15 mm to 50 mm. A total of 156 small and 1,250 large mesh bags is needed for this size operation. As for the other two growout systems, a constant level of production is attained by putting an additional complement of trays into production in year two and three. A boat, motor and trailer are required for tray maintenance and harvest. The trays are also given only a three-year life. The replacement of the trays, due to damage from handling and predators, result in a significant annual cost for year four and beyond.

Total operating expenses for the system are $47,250 in year three. As for the other two growout systems, the acquisition of seed for stocking is the largest single production cost (Table 43). Fuel, oil and maintenance costs represent additional significant production costs. The operating costs for the soft-tray system are only slightly exceeded by those of the pen system.

A positive ending cash balance occurs for years four and beyond (Table 44). Returns above the operating costs for year three are not enough to sufficiently retire the operating loans incurred during years one, two and three. Positive net cash flow improves during years four through ten. The soft-tray system produces a 10-year NPV of $876,261, with estimated IRR of 84.3 percent. These values reflect the favorable base assumptions. Returns above operating costs, debt, depreciation and opportunity cost for year five are $96,814 (Table 45).

Integrated Systems

The integrated systems include: a hatchery producing 24 million one mm seed clams, a land-based upflow nursery producing 12 million 8 mm seed clams, and either a pen or soft-tray growout system, each producing six million market size (45-50 mm) clams. When integrating these various systems, common use of some capital such as pumps, piping, trucks, buildings, etc. can be realized. The capital and operational costs of the hatchery and nursery systems in Tables 14 through 33 reflect the shared use of some of the required capital. The values presented in these tables describe the hatchery and nursery operations common to both integrated systems. It is assumed that all seed clams produced in the hatchery and nursery are used for growout; therefore, no seed clams are for sale. The growout systems differ from those previously discussed in that production is scaled up to six million clams, rather than one million produced by the stand-alone systems. In addition, note that a cost for full-time security is provided. The specific form of protection against vandalism and poaching may vary. The cost included in this analysis covers a houseboat on location. Finally, although the hatchery is not profitable (at the scale used in this analysis), it is included. The hatchery provides a consistent source of seed stock for the nursery system, thereby insulating as much as possible the integrated system from fluctuations in availability, quality, inappropriate size, and price changes for seed clams. Each integrated system requires a three-quarter acre of shore-side property, with at minimum an 18-acre bottom lease.

It should be noted that total project costs may be increased by up to 10 percent due to additional startup costs such as permitting, legal fees and engineering consultation. These startup costs were not included in this analysis.

An additional cost category found for the integrated growout is for depuration, purging, or some form of market preparation. The volume of clams produced by the integrated pen system, and therefore the revenue generated, is assumed to justify the necessary expense for product quality and safety assurance (Otwell, Rodrick and Martin, 1990). In the future, this form of product handling may be required by state or federal agencies.

Integrated Hatchery/Nursery/Pen Growout System

The total capital investment cost of the integrated pen operation is $611,674. The hatchery comprises seven percent or $44,524 of this total (Table 46). The nursery is 15 percent or $93,150 (Table 47). Associated support facilities (building, seawater transmission system, water treatment) are 41 percent or $253,200 (Table 48), and the growout is 36 percent or $220,800 of the total (Table 49). The principal difference between the stand-alone hatchery and nursery systems and those for the integrated system is the seawater transmission system supplying both the hatchery and nursery systems. The ground plants (pens) make up the single largest investment cost in the growout operation.

The largest operational expenses in the integrated hatchery and nursery are labor and algae (Table 50). Total annual operating costs for the hatchery/nursery are $132,341. An additional full-time hourly laborer is required to operate and maintain the support facilities. Cost categories for the integrated pen growout differ from those for the stand-alone pen growout in that labor cost is included. The largest operating cost for the growout component is also labor (Table 51). Personnel requirements for the 6-million clam capacity growout system are one full-time technician and three full-time hourly laborers. Total operating costs for the growout system in year three and beyond are $56,300.

Similar to the stand-alone growout systems, the first harvest of market-sized clams occurs in year three, with the same level of production occurring for every year beyond year three (Table 52). Therefore, no income is received until the third year in the planning horizon. Annual revenues are $1,020,000, assuming a per-market-size clam price of $0.11. The actual price received for the market-sized clam may depend on a number of factors, some of which may be influenced by the seller. These include targeted market (i.e. retail, wholesale, broker, etc.), scale of operation, current market conditions, and others. For example, a small-scale operation may be at the mercy of a market dominated by a few large producers. However, a small-scale firm may be better able to engage in local, low valued, direct marketing to receive a more favorable price. Direct marketing, however, may erode management time and increase account receivable problems. Prices may also vary in time, such that forward contracting may be useful. The convenience of dealing with wholesale buyers alternatively, may result in a lower average price. The importance of developing a marketing strategy should be clear.

Operating loans are obtained in year one and two to cover cash flow needs. The operating loans are repaid by the fourth year. A positive ending cash balance is obtained by the integrated-pen system in the fourth year of operation. The 10-year NPV is estimated at $5.3 million, with IRR of 59.2 percent. Net returns for year five are $602,695 (Table 53).

Integrated Hatchery/Nursery/Soft Tray Growout System

Initial capital investment for the hatchery and nursery of the integrated soft-tray system are the same as those for the integrated pen system. However, capital costs associated with the growout component are less. Total capital investment cost for the 6-million clam capacity soft-tray growout system is $165,722, significantly less than for the pen system (Table 54). The trays need to be replaced every three years, resulting in a sizeable and constant capital reinvestment cost for years four and beyond. Total initial capital investment in the integrated soft-tray system is $556,596.

Variable costs for the hatchery and nursery also remain the same as the integrated system. Operating costs for the growout component, however, are reduced somewhat to $65,199 in year three for the soft-tray system (Table 55). The largest single operating cost is labor, representing approximately 75 percent of the total variable and overhead costs. Annual depuration costs total $1,900. This estimate includes only the operational costs of electricity and maintenance, and does not include labor, costs of capital, loss due to handling, etc. Depuration can be a very complex process. A more complete discussion of the costs associated with depuration can be found in Roberts, Supan and Adams (in press). Personnel requirements for the six million clam capacity growout system are one full-time technician and two full-time hourly laborers.

The integrated soft-tray system generates a positive cash flow in years three and beyond (Table 56). An operating loan is needed in years one and two to cover cash shortfalls, but is retired by year three. Production begins in year three, under the same assumptions regarding anticipated price for sorted and depurated market-sized clams. Total operating expenses for the fully integrated soft tray system are $197,540. Beginning with year three, the ending cash balance is positive and increases through the remaining years of the planning horizon. NPV for the 10-year planning horizon is estimated to be $5.8 million, with IRR of 64.9 percent. Net returns for year five are estimated to be $612,136 (Table 57). As with the other systems included in the analysis, these net returns are to owner/operator management and risk.

Enterprise Budgets

General enterprise budgets are compiled for each stand-alone growout system, describing the costs, earnings, net returns, and other values of financial interest. The values pertain only to the activity (or enterprise) under consideration, while disregarding any other production activity with which the firm may be involved. For example, if a firm is engaged in oyster <u>and</u> clam culture, a <u>clam</u> enterprise budget would examine <u>only</u> the costs and earnings associated with clam production. Examining the activities of the whole firm would involve both oyster and clam production enterprises. Thus, an enterprise budget provides a more focused view of the financial potential of a single economic activity.

Compiled for the pens, bottom nets, and soft trays (Tables 58, 59, and 60), the enterprise budgets apply to year five in the planning horizon. These budgets provide a more detailed view of the income statement. However, additional information is also provided. Note that the cost per clam, margin per clam, and break-even survival rate are presented. The cost per-clam is simply the total cost of producing the number of harvested clams on a per-clam basis. For the pen system (Table 58), the total cost of production is $65,719 (i.e., total fixed cost plus total variable cost). Given that one million clams were harvested, the total cost per clam is 6.8 cents. Note also that the cost per clam is equal to the break-even price per clam required for sale. The margin per clam is simply the difference between price received and production costs. This value (i.e., 10.2 cents is the pen system example) must at least cover taxes and the opportunity of the owner/operator's capital, management, and risk. Break-even survival rate is also presented. This value indicates the minimum survival rate, given the current market prices for clams and input costs, which would allow the operation to just cover expenses. Any increase in survival would generate positive net returns. The break-even survival rate for the pen system, for example, is approximately 20 percent.

The budgets are constructed so that readers can insert values more specific to their given situation. The various cost categories and revenues may be changed or deleted as necessary. Additional cost categories may be included. The resulting budget provides an assessment of the profitability of a more specific operation.

Sensitivity Analysis

Assumptions regarding such items as clam selling prices, survival rate and growout period in these budgets may be considered "favorable." Findings presented in previous tables suggest that hard clam culture can be profitable under these favorable conditions. However, "real world" market and environmental conditions may cause prices and survival rates to vary considerably. Allowing these parameters to vary around the assumed levels will provide some insight into how sensitive the profitability of hard-clam culture is to changes in market and environmental conditions. A sensitivity analysis was performed on each of the three stand-alone growout systems - pens, bottom nets, and soft trays. The analysis examines the effect of varying product price, survival rate, and growout period from the baseline assumptions mentioned earlier. The baseline scenario for output price assumes a price of $0.17 for a 45-50 mm clam. This was varied to $0.13, $0.15, $0.19, and $0.21, while holding all else constant. The base scenario for survival assumes a rate of 50 percent from planting to harvest. This assumption decreases to 30 and 40 percent, and increases to 60 and 70 percent, while holding all else constant except for packaging costs. The baseline assumption for growout length assumes a period of three years. This is varied to a two- and four-year growout period. To accommodate this latter change, however, allowances are made for associated changes in certain costs (discussed in detail below). The results of the sensitivity analysis are presented in an income statement for year five of the planning horizon.

Price Changes

A $0.02 (13 percent) change in price from the baseline assumption results in an approximate $20,000, or 20 percent, change in net returns for each system (Table 61). Operating expenses, long-term debt interest, and depreciation remain constant as price varies. Also, no operating loan is required by year five regardless of whether price increases or decreases. In all cases for each system, the income statement indicates positive net returns. Note, however, that available cash (ending cash balance) is more sensitive to changes in market price. For the pen system, ending cash balance changes by approximately 67 percent as market price changes by $0.02 from the baseline assumption price of $0.17. This apparent greater sensitivity reflects the cumulative effect on cash surplus as market price changes.

Changes in Survival Rate

As the survival rate increases and decreases from the baseline assumption of 50 percent and the price per clam holds constant, the number of clams harvested and the gross returns increase or decrease, respectively (Table 62). A 10 percent change in survival results in a change in the number of clams harvested of 200,000 (recall that 2 million clams were stocked initially). The operating expenses are adjusted due to needing more bags to package and ship the harvested clams. Long-term debt and depreciation, as well as other variable costs, remain the same in each scenario. No operating loan is required during year five except for the pens and soft-tray system when a 30 percent survival rate is used. For those two systems, a decrease in survival of 20 percent below the baseline 50 percent reduces the ability to meet cash needs of the operation. In all cases for each system, the income statement in year five indicates positive net returns. A 10-percent change in survival (and conversely mortality) results in an approximate 34 percent change in net returns. A 20-percent reduction in survival, however, reduces net returns by 71 percent. As with changes in market price, ending cash balance is more sensitive to changes in survival rate than are net returns. For example, a 10 percent change in survival rate from the baseline assumption of 50 percent changes ending cash balance by approximately 40 percent for the bottom-net system.

Changes in Growout Period Length

The growout period is decreased to two years and increased to four years. Each case requires altering the harvest and revenue generation pattern realized under the baseline assumption of a three-year growout period (Table 63). Recall that under the baseline scenario, consistent production is achieved by rotating planting (P) 2 million clams in years one (P1), two (P2) and three (P3). In addition, harvesting (H) occurred in years three (H1), four (H2), and five (H3). This is then repeated. Since the purpose of a sensitivity analysis is to examine the effect of changes on a given operation design, this planting strategy was preserved under both the two- and four-year growout period lengths. As a result:

Two-year growout period - Production of one million clams (and thus revenue of $170,000) occurred in years two, three, five, seven and nine and is $340,000 for years four, six, eight and 10 (Table 63). Production costs for each system design are increased in year two to equal year three costs, while costs for years four, six, eight and 10 are increased by doubling all costs other than seed cost.

Four-year growout period - Initial production occurs in year four, with no production in year seven (Table 63). Production costs remained the same as under the baseline assumption three year growout period scenario.

The relative impact on year five net returns is greater for a one-year increase in the growout period than that realized from a one-year decrease in growout period (Table 64). For example, net returns for the pen growout system under the assumption of a three-year growout period are $99,995. However, as the growout period increases by one year, net returns in year five decrease by approximately $16,000 to $98,379, primarily due to an increase in short-term cash needs. As the growout period length is decreased to two years, net returns in year five remain at $99,995. Similar findings, with the exception of the requirements for an operating loan when the growout period is increased, are seen for each system design. Note the dramatic increase in ending cash balance for all systems as the growout period is reduced by one year. This reflects the doubling of revenue in year four and production occurring in year two under the two-year growout period assumption. Cash balance decreases by approximately 50 percent as the growout period is increased from three to four years. The scale-up strategy pursued to achieve consistent production will likely be modified to match the assumed growout period length. For example, the scale-up strategy would be used only in years one and two for an assumed two year growout period length. This would provide for consistent levels of production, rather than the doubling of production for every other year as seen in the above example. In addition, a four year grow-out period length may require planting in year four to avoid the absence of production which occurs in year seven.

Sensitivity Comparisons

The sensitivity analysis examines changes in per-clam selling price, survival rate, and growout period. The findings indicate that for unit changes in each of these parameters, while holding the others constant, net returns are more sensitive to changes in survival rate. Therefore, a prudent manager may experience greater returns to management and risk by reducing mortality by 10 percent, than by focusing on increasing selling price by 10 percent.

The Cumulative Effect of Less Than Favorable Conditions

Before the sensitivity analysis, the baseline assumptions maintain favorable conditions in the hard clam culture operation for every year of the planning horizon. That is, yearly fluctuations in market conditions, environmental factors, and management skills, which most likely would occur in a "real world" setting, are assumed to be absent. The sensitivity analysis allows for such change to happen, but only for one factor at a time, while all others are still maintained at favorable levels. In reality, several of these factors will be changing at the same time, resulting in a cumulative effect on the profitability of hard clam culture which may vary from year to year. This cumulative effect may have a significant impact on how financially promising hard clam culture appears to a prospective investor.

Many variable factors can have an impact on a hard clam culture operation's ability to achieve commercial feasibility. These include permitting, market conditions, personnel loss and attrition, poaching and vandalism, equipment changes and the inability to sell old specialized capital, insufficient financing, environmental conditions, availability of seed clams, catastrophic crop failure and current difficulty of acquiring clam-crop insurance, inflation, size distribution of harvested clams, and others. Probably one of the most important factors is the time required to achieve the necessary skills and knowledge to successfully operate and manage the hard clam culture process and business. Achieving these skills is often referred to as "getting up on the learning curve." In fact, several years may be required before management and staff have gained enough experience and knowledge to minimize overall mortality, maximize harvest efficiency, establish successful market contacts, and gain good business sense. Achieving these skills allows one to move farther up the "learning curve." Before having these skills, profitability of the business may be constrained. As a result, the ability to pay back loans, meet necessary cash obligations, and, in general, operate the business in a profitable and commercial manner may be limited.

The learning curve demonstrates the importance of both management experience and ability in achieving improved survival rates. Two different learning curves are shown (Figure 21) with time measured on the horizontal axis and survival rate on the vertical axis (adapted from Thunberg and Adams, 1990). Assuming experience is gained with time, the difference between the two curves may be attributable to management ability. Thus, the curve labeled SLOW might represent average manager ability to adapt with experience while the curve labeled FAST might represent an individual with above average management ability. How differences in management ability translate into cost and returns is shown in Figure 22.

The annual net return to management and risk under two hypothetical managers can be substantially different. With the better manager, net returns are positive by the end of year four and continue to increase. Under the less-able manager the hypothetical business does not earn a positive net return until the end of year seven. During each year in which net returns are positive, the business with the better manager also earns a significantly greater return. Thus, the value of hiring a qualified and experienced manager or the time spent in learning about the production aspects of hard clam aquaculture <u>before</u> making the investment may be well worth the expense.

To demonstrate the cumulative effect of less-than-favorable conditions on the profitability of hard clam culture, variations in several key factors are imposed on the pen growout system. Specifically, (1) a "learning curve" effect is included, such that clam survival begins at 10 percent in year three and increases to 50 percent in years five and seven, (2) operating expenses are allowed to increase five percent each year due to inflation, (3) a catastrophic loss of clams occurs in year eight, with clam survival declining to 10 percent that year and increasing only to 40 percent by year ten, (4) due to the catastrophic loss in year eight, additional capital costs are incurred as a number of pens need to be rebuilt, and (5) market prices for littlenecks increase from \$0.17 in year three to \$0.18 in year four, but then decrease to \$0.15 in year five before stabilizing at \$0.17 for years six and seven. Prices increase to \$0.20 in year eight, in partial response to the local decline in clams (remember...a catastrophic event!), but then decline to \$0.18 by year ten.

When these less-than favorable conditions prevail, the impact on the revenue generation ability of the pen growout system is dramatic (Table 65) as compared to the performance under favorable conditions (Table 66). A positive cash flow does not occur until year four, which necessitates that an operating loan be obtained for years one through three. Repayment of these operating notes contributes to a zero ending cash balance until year seven. Note that operating expenses are increasing each year as inflation takes its toll. Also, the catastrophic loss in year eight reduces total cash receipts to only \$40,000. This value actually would have been less than the \$34,000 received in year three had it not been for the higher market price received for the remaining clams during year eight. NPV for the cash flow is \$10,400, with IRR of 17.9 percent. These are considerably less than NPV (\$853,083) and IRR (76.9%) found under the "favorable" conditions.

The above examples take into account a number of assumptions reflecting less-than-favorable conditions and how this affects the economic condition of the business. Experience has shown that with beginning clam culturists, the "disaster scenario" may create an economic setback from which recovery is difficult. In some cases an "early" disaster may be so economically devastating that first harvest is never reached. It is worth demonstrating this potential with another hypothetical illustration (adapted from Thunberg and Adams, 1990). For this example (Figure 23), year five was arbitrarily selected as the year in which there is 100 percent clam mortality.

The 100 percent mortality requires complete replanting of all seed. Thus, no receipts from clam sales are received until year seven. The disaster analysis indicates that the hypothetical clam business can withstand a major setback and remain financially feasible. However, what is not shown is that the recovery indicated in year seven would only be possible if the owner were able to obtain substantial operating loans to cover the period over which cash receipts are zero. Thus, maintaining a reliable source of credit and a good credit record should be a part of a potential investor's business plan.

Figure 21. Learning Curve for Average and Above Average Management Ability.

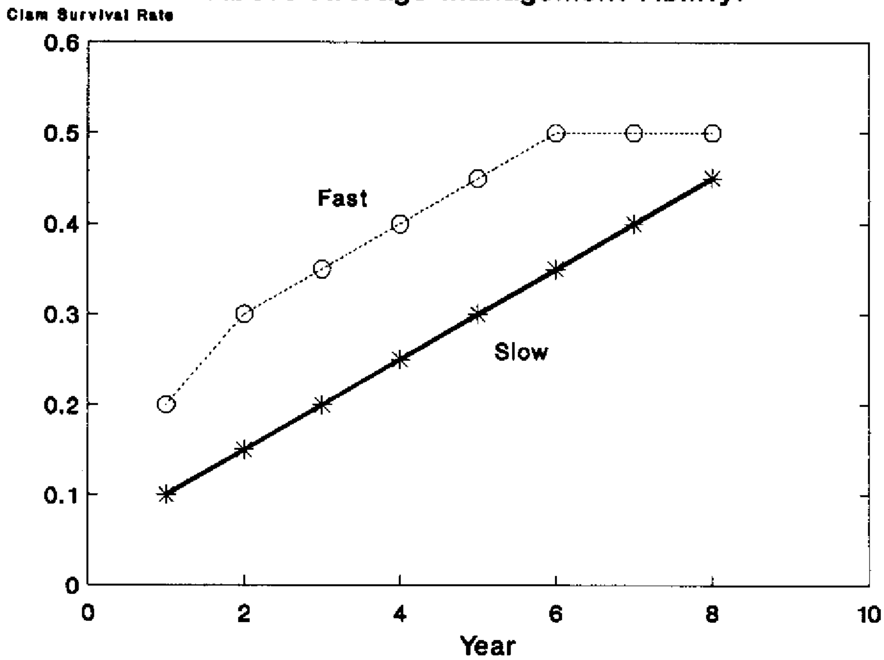


Figure 22. Net Return to Management and Risk for Different Learning Curves.

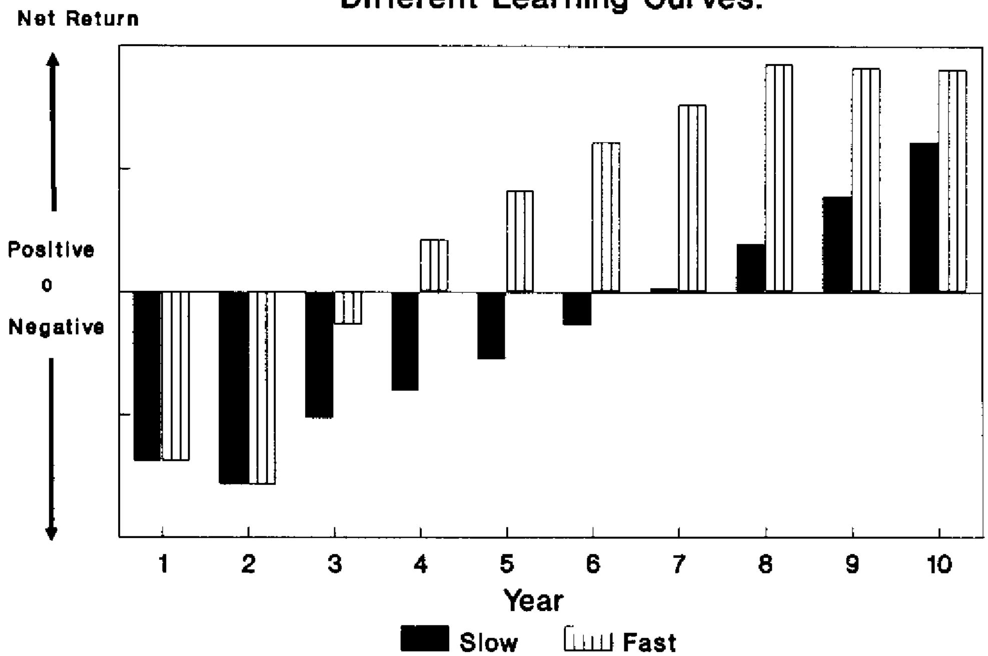
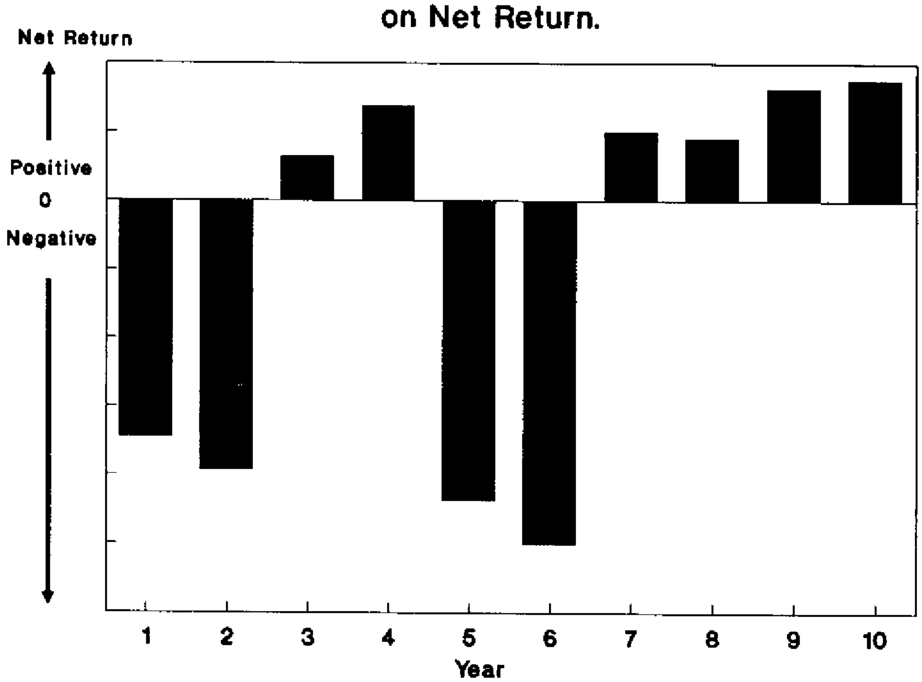


Figure 23. Effect of 100 Percent Clam Mortality on Net Return.



This discussion should make it clear that a potential investor in hard clam culture should approach such an opportunity with caution. Under favorable conditions, hard clam culture appears very promising from a financial perspective. However, the very real possibility of changes in key market, environmental, and managerial factors can have a dramatic negative cumulative effect on profitability. Only those businesses that can quickly progress up the learning curve, and remain there, will be successful.

Summary and Limitations

This section has presented findings regarding the financial feasibility of hard clam culture in the southeastern U.S. The analyses provide considerable detail regarding the cost of capital (cash and non-cash), annual operating costs, anticipated net returns, and cash-flow characteristics for stand-alone and integrated hard clam hatchery, nursery and growout systems. The findings indicate that these costs and returns can vary with facility design and size. In addition, the financial performance of these production systems can be significantly altered by integrating the hatchery, nursery and growout processes. For example, while a stand-alone hatchery is not financially feasible, combining a hatchery with a nursery and growout operation contributes to a financially feasible integrated system. The reader should further note that all net returns have not accounted for owner management costs (i.e. living expenses or salary) start-up expenses, production risk, and cost of land. Including these factors in the analysis would decrease net returns, NPVs, and IRRs below the levels presented.

Table 66 provides a brief summary of key financial information for the various production systems examined. Although a variety of information is presented for each system, the "cost per clam" may be one of the most informative. For example, the cost of producing 1,000 seed clams with the hatchery system is $4.61, well above the average current market price per thousand for one mm seed clams of $3.00. This supports the findings that the stand-alone hatchery system, or at least this study's design and scale, is not financially feasible. Also, the upflow nursery system will produce 8 mm seed clams at a cost significantly below that for the raceway systems. Both raceway systems operate at a net loss, with the cost per clam at or near current market selling price, without any room for profit margin. Therefore, investing in stand alone hatchery and raceway nursery systems at the scale examined in this study may not be advisable.

Several additional caveats should be mentioned regarding the analysis. The scale (i.e., harvest capacity) of operation (i.e., 24 million for the hatchery, 12 million for the nursery, and 1 million for the growout systems) was selected from what appeared to be realistic sizes. Further study is required to identify the scale of operation that maximizes production efficiency and profits. The appropriate scale of operation may vary due to local market and environmental conditions. Given that the hard clam culture industry is currently in a development stage, the systems examined in this study are basically hypothetical, yet based on information applicable to currently existing operations (although of different scale). As emphasized in the sensitivity analyses, input costs (i.e. labor, fuel, maintenance, clam seed, etc.) and selling prices for clams were assumed (under ideal conditions) to be constant over time and scale of operation. In reality, these costs and prices will be changing over time due to general inflation and market shifts. For example, the selling prices for clams, either for the seed or retail markets, will likely be affected by changes in local supplies. Whether or not these local prices will be stable under the production levels analyzed in this study is not known. Further studies on the nature of consumer demand for hard clams are needed.

Finally, this analysis initially examines financial, or economic feasibility. Financial feasibility analyses typically assume that the inconsistencies and vagaries of the consumer and supply markets do not exist. A business is commercially feasible if sufficient profits can be maintained over time, taking into consideration these real world changes. The importance of understanding how these real world changes can impact profitability cannot be over emphasized. This analysis does not attempt to sufficiently demonstrate commercial feasibility.

XII. CHANGING FROM ONE PRODUCTION SYSTEM TO ANOTHER

The economic budgets presented in this manual provide existing or potential investors and farmers in hard clam culture a useful guide in making the investment decision. Two basic decisions must be made. First, how much will it cost to enter the hard clam farming business, and second, how much profit can be made? The interested farmer and investor can go to extension agents, other clam farmers, equipment suppliers, etc., and the various sources mentioned earlier to get equipment investment costs for the current year. These can then be used to develop current capital costs which are specific to a given production system, location, etc.

Clam farmers who are already in the business might be considering a change in culture methods or expansion. To evaluate the economic consequences of this change, rather than estimate the entire investment requirements and cost and returns budget, the clam farmer would only want to analyze revenues and costs that would change with making the new investment or change in operations. To answer the questions, "will it pay to make the conversion?" the technique of partial budgeting can be used.

The partial budgeting technique analyzes only the costs and revenues that change. Losses occur from any increases in clam farming costs and decreases in income. Economic gains occur from decreases in costs and increases in income. If the gains are larger than the losses, the change is economically feasible. To analyze the changes:

Increased Costs	Decreased Costs
+	+
Decreased Income	Increased Income
=	=
Loss Effect	Gain Effect

Gain Effect	+
Loss Effect	-
	____

Net Profit From Change

An example can be used to see how partial budgeting may be used. Consider a clam culturist who is currently operating a stand-alone, wooden pen, growout system. Further, assume that the culturist is operating at the scale described earlier in the discussions of growout systems (i.e., total initial investment costs of $47,720 and annual operating costs of $46,770). The culturist wishes to double expected production beginning in year five. The additional pens needed to double production will be constructed of a new plastic composite. The existing wooden pens will also be replaced with the new plastic pens as they are retired. The plastic pens last three times as long as the wooden pens. Fixed costs will increase (i.e., capital outlay, debt retirement, and depreciation), as will some annual operating expenses (i.e., seed costs, labor, supplies, fuel, harvest/packaging expenses, overhead, etc.). Repair and maintenance costs, however, will decrease. These values will vary with each individual system, so the manager must carefully estimate the timing and magnitude of each of these costs.

Given the planned changes to the current system, the increases and decreases in income and costs are shown in the example on the next page. Therefore, the "Loss Effect" is the sum of increased costs and decreased income, which is $62,330 + 0 = $62,330. The "Gain Effect" is the sum of decreased costs and increased income, which is $1,200 + $170,000 = $171,200. The net profit from changing the expected production to 2 million clams is the Gain Effect, minus the Loss Effect, which is $171,200 less $62,330 or $108,870. This value represents the net change in returns to owner/management and risk or profit. Careful examination of this net change may reveal more information than simply the change in profit. For example, note that a doubling of expected production (going from 1 million to 2 million clams) more than doubles profit! This is because costs associated with the added income (or clam production) is reduced through "economies of size." That is, as additional clams are produced, the cost to produce them goes down on a per-clam basis because of excess capacity in current equipment and labor.

The clam culturist should also consider a number of other factors before making the change. Can outdated equipment be sold? Is enough capital available to make the investment? Will changes and pressures on the labor force cause problems? Are other culturists considering expansion which might cause a oversupply of clams on the market? All factors such as these, in addition to the anticipated profit increase, merit serious consideration before making any change.

Example partial budgeting use

Increased Costs		Decreased Costs	
operating expenses	$48,165	repair and maintenance	$ 1,200
depreciation	$ 4,750		
opportunity costs	$ 2,176		
interest	$ 7,239		
TOTAL	$62,330		
Decreased Income		Increased Income	
none	$ 0	additional clams	$170,000
Loss Effect	$62,330	Gain Effect	$171,200

Gain Effect	+ $171,200
Loss Effect	- 62,330
Net profit from change	$108,870

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XIV.

Appendix

of

Financial Tables

Table 13. Reference guide to financial analysis tables for baseline production systems.

Production System	FINANCIAL STATEMENT			
	Capital Investment (equipment cost, life of equipment, number needed, and replacement)	Operating Expenses (annual cost of seed clams, labor, fuel, repair, overhead, etc.)	Cash Flow (timing and magnitude of all receipts and costs, including loan repayment)	Income Statement (revenue over all cash and non-cash costs)
Hatchery	Table 14 (Pg.75)	Table 15 (Pg. 77)	Table 16 (Pg. 78)	Table 17 (Pg. 79)
Nursery:				
Upflow	Table 18 (Pg. 80)	Table 19 (Pg. 81)	Table 20 (Pg. 82)	Table 21 (Pg. 83)
Field tray	Table 22 (Pg. 84)	Table 23 (Pg. 85)	Table 24 (Pg. 87)	Table 25 (Pg. 87)
Raceway (1 mill.)	Table 26 (Pg. 88)	Table 27 (Pg. 89)	Table 28 (Pg. 90)	Table 29 (Pg. 91)
Raceway (12 mill.)	Table 30 (Pg. 92)	Table 31 (Pg. 93)	Table 32 (Pg. 94)	Table 33 (Pg. 95)
Growout:				
Pens	Table 34 (Pg. 96)	Table 35 (Pg. 97)	Table 36 (Pg. 98)	Table 37 (Pg. 99)
Bottom nets	Table 38 (Pg. 100)	Table 39 (Pg. 101)	Table 40 (Pg. 102)	Table 41 (Pg. 103)
Soft trays	Table 42 (Pg. 104)	Table 43 (Pg. 105)	Table 44 (Pg. 106)	Table 45 (Pg. 107)
Integrated:				
Pens	Table 46-49 (Pg. 108-111)	Table 50,51 (Pg. 112-113)	Table 52 (Pg. 114)	Table 53 (Pg. 115)
Soft trays	Table 54 (Pg. 116)	Table 55 (Pg. 117)	Table 56 (Pg. 118)	Table 57 (Pg. 119)

Table 14. Initial investment and capital assets addition schedule for hard clam hatchery system–Milford method (24 million harvest capacity).

Systems/Equipment	Years of Life	No.	Initial Investment in Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Land	–	1/2ac	–	–	–	–	–	–	–	–	–	–
Building (studwall type construction, cement, floor, plumbing, electrical, heat/ air conditioning)	25	2,500sq ft	$100,000	–	–	–	–	–	–	–	–	–
Cold room	12	250sq ft	2,500	–	–	–	–	–	–	–	–	–
Air handling system compressed air	6	3hp	1,000	–	–	–	–	–	1,000	–	–	–
Support lab	10	–	35,000	–	–	–	–	–	–			
Back-up generator	10	1	7,500	–	–	–	–	–	–	–	–	–
Security system	20	–	3,000	–	–	–	–	–	–			
Water intake structure	15	–	2,500	–	–	–	–	–	–	–	–	–
Seawater transmission system												
Main pump	3	2/7.5hp	5,000	–	–	5,000	–	–	5,000	–	–	5,000
PVC Pipe - 4"	15	–	2,500	–	–	–	–	–	–	–	–	–
Valves, fittings, screen	8	–	2,000	–	–	–	–	–	–	–	2,000	–
Water treatment												
Rapid sand filtration	10	1	3,000	–	–	–	–	–	–	–	–	–
UV system, industrial size	5	1	1,500	–	–	–	–	1,500	–	–	–	–
Microfiltration system	10	1	7,500	–	–	–	–	–	–	–	–	–
Heat exchanger/boiler	7	1	12,500	–	–	–	–	–	–	12,500	–	–
Sea water reservoir	10	1/3000gal	2,500	–	–	–	–	–	–	–	–	–
Pump/fixtures	5	1/1hp	200	–	–	–	–	2,500	–	–	–	–
Pick-up truck	5	1	8,000	–	–	–	–	–	8,000	–	–	–
Misc. equipment	3	–	1,750	–	–	1,750	–	–	–	–	–	1,750
Brood stock maintenance												
Multipurpose batch tank	25	2/2500L	2,000	–	–	–	–	–	–	–	–	–
Water chiller	2	2	1,100	–	1,100	–	1,100	–	1,100	–	1,100	–
Peristaltic pump	2	1	900	–	900	–	900	–	900	–	900	–
Miscellaneous equipment	2	–	250	–	250	–	250	–	250	–	250	–

Continued

Table 14. (Continued)

Systems/Equipment	Years of Life	No.	Initial Investment in Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Algal culture												
Environmental chamber	10	1	3,500	–	–	–	–	–	–	–	–	–
Inoculation hood	10	1	1,500	–	–	–	–	–	–	–	–	–
Erlenmyer flask	3	16/250ml	80	–	–	80	–	–	80	–	–	80
Carboy system	3	8	834	–	–	834	–	–	834	–	–	834
Kalwall tube system	5	8	800	–	–	–	–	800	–	–	–	–
Air pumps/aerator	2	2/1hp	400	–	400	–	400	–	400	–	400	–
Settling tank	25	2/2000L	500	–	–	–	–	–	–	–	–	–
Autoclave	8	1	2,500	–	–	–	–	–	–	–	2,500	–
Batch culture	10	4/3000L	2,000	–	–	–	–	–	–	–	–	–
Miscellaneous equipment	2	–	400	–	400	–	400	–	400	–	400	–
Metal halide lights	10	6	715	–	–	–	–	–	–	–	–	–
Algae reservoirs	10	2/2000L	1,000	–	–	–	–	–	–	–	–	–
Peristaltic pumps	2	2	1,200	–	1,200	–	1,200	–	1,200	–	1,200	–
Larval culture												
Spawning table/fixtures	10	1/2000L	600	–	–	–	–	–	–	–	–	–
Larval containers/fixtures	10	8/3000L	8,000	–	–	–	–	–	–	–	–	–
Miscellaneous equipment	2	–	500	–	500	–	500	–	500	–	500	–
Settling tank	10	2/15000L	10,000	–	–	–	–	–	–	–	–	–
Post-set maintenance												
Downweller tanks	10	3/4000gal	1,535	–	–	–	–	–	–	–	–	–
Downwellers	10	150	1,500	–	–	–	–	–	–	–	–	–
Water system: motor/pumps/fixtures	2	2/.5hp	350	–	350	–	350	–	350	–	350	–
Water temperature treatment: water chiller	2	1	735	–	735	–	735	–	735	–	735	–
Fixtures	5	–	500	–	–	–	–	500	–	–	–	–
Miscellaneous equipment	2	–	300	–	300	–	300	–	300	–	300	–
Feeding reservoir	10	1/2000L	825	–	–	–	–	–	–	–	–	–
TOTAL-HATCHERY			$242,474	0	6,135	7,664	6,135	5,300	21,049	12,500	10,635	7,664

Table 15. Annual operating expenses for hard clam hatchery system - Milford method (24-million-seed harvest capacity).

Production Costs	
Electricity	
Water chiller	$ 530
Peristaltic pump	165
Seawater pump	2,000
Small pumps	400
UV	220
Microfiltration	250
Building	3,750
Seawater reservoir pump	275
	$ 7,590
Clean seawater delivery pipes	500
Lab supplies	1,600
Site/bldg. maintenance	350
Freshwater	150
Brood stock	50
Supplies/expendables	6,000
Algae	10,950
Heat exchange-fuel oil	2,140
Silo replacement	40
Sand	200
Truck fuel	800
Repair/maintenance	1,000
Salaries and Wages	
Technician/manager salaries	32,000
benefits	4,320
Overhead Costs	
Insurance	1,000
Miscellaneous costs	2,061
TOTAL	$70,751

Table 16. Annual cash flow for hard clam hatchery system - Milford method (24 million harvest capacity)

	Year 1	2	3	4	5	6	7	8	9	10
Beginning cash balance	$ 0	0	0	0	0	0	0	0	0	0
Total cash receipts	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000
Total cash outflow:										
Operating expenses	70,751	70,751	70,751	70,751	70,751	70,751	70,751	70,751	70,751	70,751
Long-term loan payment										
Principal	8,981	10,059	11,616	13,446	15,409	17,885	20,875	24,092	27,589	31,336
Interest	18,913	17,835	17,364	16,890	16,013	15,484	15,113	14,108	12,494	10,103
Total	98,645	98,645	99,731	101,087	102,173	104,120	106,739	108,951	110,884	112,190
Cash available	(26,645)	(26,645)	(27,731)	(29,087)	(30,173)	(32,120)	(34,739)	(36,951)	(38,834)	(40,190)
New operating loan	26,645	26,645	27,731	29,087	30,173	32,120	34,739	36,951	38,834	40,190
Operating loan payment:										
Principal	0	0	0	0	0	0	0	0	0	0
Interest	0	0	0	0	0	0	0	0	0	0
Ending cash balance	0	0	0	0	0	0	0	0	0	0
Summary of debt Outstanding:										
Long-term debt balance[1]	148,626	144,702	140,751	133,440	129,030	125,945	117,570	104,113	84,188	52,851
Operating debt balance	26,645	56,488	90,997	131,004	176,898	230,245	292,614	364,379	447,274	541,137
Interest on operating debt	3,197	6,779	10,920	15,720	21,228	27,629	35,114	43,761	53,673	64,936

[1] Initial long-term loan balance - $157,608.

Table 17. Income statement (year five) for hard clam hatchery system - Milford method (24 million harvest capacity).

Revenues	$72,000	
Operating expenses	70,751	
Long-term loan payment: Interest	16,013	
Operating loan payment: Interest	0	
Depreciation	23,799	
Net returns to owner's capital, management & risk		(38,563)
Opportunity cost of initial owner equity	11,144	
Net returns to owner's management & risk		($49,707)

Table 18. Initial investment costs and capital asset addition schedule for hard clam nursery system - upflow method (12 million harvest capacity).

Systems/Equipment	Years of Life	No.	Initial Investment in Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Land	–	1/2ac	–	–	–	–	–	–	–	–	–	–
Building	25	500 sq ft	$ 15,000	–	–	–	–	–	–	–	–	–
Back-up generator	10	1	7,500	–	–	–	–	–	–	–	–	–
Security system	20	–	3,000	–	–	–	–	–	–	–	–	–
Dock/pump house	20	–	12,000	–	–	–	–	–	–	–	–	–
Seawater transmission system:												
Main pumps	3	2/30hp	20,000	–	–	20,000	–	–	20,000	–	–	20,000
PVC pipe - 8"	15	–	6,000	–	–	–	–	–	–	–	–	–
Valves, fittings, screen	8	–	5,000	–	–	–	–	–	–	–	5,000	–
Pick-up truck	5	1	8,000	–	–	–	–	8,000	–	–	–	–
Miscellaneous equipment	3	–	1,000	–	–	1,000	–	–	1,000	–	–	1,000
1. Passive flow system (cylinders, reservoir, drain pipes, inflow pipe, standpipes, bag filters)	8	24/10cyl tanks	60,000	–	–	–	–	–	–	–	60,000	–
2. Pad (1,000 sq. ft.) (Drainage, site preparation, electricity lights, freshwater source)	50	1	20,000	–	–	–	–	–	–	–	–	–
Corrugated Roof, 1/2 of pad	15	–	2,500	–	–	–	–	–	–	–	–	–
3. Forced active flow system (cyclinder, screen, inflow pipe, overflow pipe, cap, PVC manifold)	8	120	6,000	–	–	–	–	–	–	– 6,000	–	
4. Rack system	10	3	3,500	–	–	–	–	–	–	–	–	–
5. Standard screens for culling	10	12	900	–	–	–	–	–	–	–	–	–
6. Miscellaneous equipment	2	–	750	–	750	–	750	–	750	–	750	–
TOTAL NURSERY			$171,150	0	750	21,000	750	8,000	21,750	0	71,750	21,000

Table 19. Annual operating expenses for hard clam culture nursery system-upflow method (12 million seed output capacity).

Production Costs	
Electricity	
Lights	$ 200
Seawater pumps	6,242
Clam seed (24 mm @ $.003)	72,000
Freshwater	100
Supplies/expendables	1,500
Repair/maintenance	2,000
Fuel/oil/truck	800
Repair/maint.-truck	800
Salaries and Wages	
Labor	6,250
Benefits	625
Technician	8,000
Benefits	1,080
Overhead	
Insurance	1,000
Miscellaneous Costs	3,000
TOTAL	$102,097

Table 20. Annual cash flow for hard clam nursery system - upflow method (12 million harvest capacity).

	Year 1	2	3	4	5	6	7	8	9	10
Beginning cash balance	$ 0	112,087	227,239	345,320	459,684	573,916	686,732	795,698	904,665	1,000,933
Total cash receipts	240,000	240,000	240,000	240,000	240,000	240,000	240,000	240,000	240,000	240,000
Total cash outflow:										
Operating expenses	108,223	105,100	102,097	102,097	102,097	102,097	102,097	102,097	102,097	102,097
Long-term loan payment										
Principal	6,339	7,100	7,995	10,151	11,412	13,237	16,065	17,993	24,240	28,346
Interest	13,349	12,589	11,827	13,388	12,260	11,850	12,872	10,944	17,395	17,006
Total	127,912	124,849	121,919	125,636	125,768	127,184	131,034	131,034	143,732	147,448
Cash available	112,087	227,239	345,320	459,684	573,916	686,732	795,698	904,665	1,000,933	1,093,484
New operating loan	0	0	0	0	0	0	0	0	0	0
Operating loan payment:										
Principal	0	0	0	0	0	0	0	0	0	0
Interest	6,126	3,063	0	0	0	0	0	0	0	0
Ending cash balance	112,087	227,239	345,320	459,684	573,916	686,732	795,698	904,665	1,000,933	1,093,484
Summary of debt										
Outstanding:										
Long-term debt balance[1]	104,909	98,559	111,564	102,163	98,751	107,264	91,199	144,956	141,716	113,370
Operating debt balance	0	0	0	0	0	0	0	0	0	0
Interest on operating debt	6,126	3,063	0	0	0	0	0	0	0	0

[1] Initial long-term loan balance - $111,248.

Table 21. Income statement (year five) for hard clam nursery - upflow method (12 million harvest capacity).

Revenues	$240,000	
Operating expenses	102,097	
Long-term loan payment: Interest	12,260	
Operating loan payment: Interest	0	
Depreciation	28,057	
Net returns to owner's capital, management and risk		97,586
Opportunity cost of initial owner equity	7,188	
Net returns to owner's management and risk		$90,398

Table 22. Initial investment and capital asset addition schedule for hard clam nursery system - field-tray method (12 million harvest capacity).

Systems/Equipment	Years of Life	No.	Initial Investment in Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Land	–	1/2 ac	–	–	–	–	–	–	–	–	–	–
Shed (10' x 20')	15	1	$ 800	–	–	–	–	–	–	–	–	–
Trays	10	550	13,750	–	–	–	–	–	–	–	–	–
Barge/mechanical shaker	10	1	18,000	–	–	–	–	–	–	–	–	–
Pump	1	5 hp	500	500	500	500	500	500	500	500	500	500
Boat	8	1	7,000	–	–	–	–	–	–	–	7,000	–
Motor	3	1	4,000	–	–	4,000	–	–	4,000	–	–	4,000
Trailer	3	1	1,000	–	–	1,000	–	–	1,000	–	–	1,000
Wet suits	2	4	1,200	–	1,200	–	1,200	–	1,200	–	1,200	–
Dock	20	1	16,000	–	–	–	–	–	–	–	–	–
Pick up	5	1	8,000	–	–	–	–	8,000	–	–	–	–
Front-end loader	10	1	9,000	–	–	–	–	–	–	–	–	–
Miscellaneous equipment	3	–	1,000	–	–	1,000	–	–	1,000	–	–	1,000
TOTAL NURSERY			$80,250	500	1,700	6,500	1,700	8,500	7,700	500	8,700	6,500

Table 23. Annual operating expenses for hard clam nursery system - field-tray method (12 million seed output capacity).

Production Costs	
Lights	$ 200
Clam seed (16 mill. 3mm @ $.01 ea.)	160,000
Supplies & expenditures	1,000
Tray repair & maintenance	700
Repair & maintenance	
Truck	800
Boat & motor	1,200
Barge & shaker	1,800
Front-end loader & pump	950
Fuel and oil	
Truck	1,000
Boat & motor	750
Front-end loader	500
Packaging materials	1,000
Salaries and Wages	
Technician salary	8,000
Benefits	1,000
Labor	18,750
Benefits	1,875
Overhead	
Insurance	2,000
Miscellaneous costs	5,000
TOTAL	$206,525

Table 24. Annual cash flow for hard clam nursery system - field-tray method (12 million harvest capacity).

	Year									
	1	2	3	4	5	6	7	8	9	10
Beginning cash balance	$ 0	131,850	269,809	413,663	556,366	698,768	839,667	979,202	1,118,649	1,256,555
Total cash receipts	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000
Total cash outflow:										
Operating expenses	218,917	212,721	205,525	206,525	206,525	206,525	206,525	206,525	206,525	206,525
Long-term loan payment										
Principal	2,972	3,358	3,857	4,691	5,351	6,476	7,692	8,645	10,178	11,769
Interest	6,260	5,963	5,763	6,081	5,722	6,100	6,247	5,384	5,390	4,949
Total	228,149	222,042	216,146	217,297	217,597	219,102	220,464	220,533	222,093	233,243
Cash available	131,850	269,809	413,663	556,366	698,768	839,667	979,202	1,118,649	1,256,555	1,393,312
New operating loan	0	0	0	0	0	0	0	0	0	0
Operating loan payment:										
Principal	0	0	0	0	0	0	0	0	0	0
Interest	12,392	6,196	0	0	0	0	0	0	0	0
Ending cash balance	131,850	269,809	413,663	556,366	698,768	839,667	979,202	1,118,649	1,256,555	1,393,312
Summary of debt outstanding:										
Long-term debt balance[1]	49,690	48,033	50,675	47,685	50,834	52,057	44,864	44,920	41,242	29,473
Operating debt balance	0	0	0	0	0	0	0	0	0	0
Interest on operating debt	12,392	6,196	0	0	0	0	0	0	0	0

[1] Initial long-term loan balance - $52,163.

Table 25. **Income statement (year five) for hard clam nursery - field-tray method (12 million harvest capacity).**

Revenues	$360,000	
Operating expenses	206,525	
Long-term loan payment: Interest	5,722	
Operating loan payment: Interest	0	
Depreciation	10,044	
Net returns to owner's capital, management & risk		137,709
Opportunity cost of initial owner equity	4,571	
Net returns to owner's management & risk		$133,138

Table 26. Initial investment and capital asset addition schedule for hard clam nursery system - four-tier raceway (1 million harvest capacity).

Systems/Equipment	Years of Life	Initial Investment No.	in Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Four-tier wooden raceway (32" x 30') per tier[1]	6	3	$6,000	–	–	–	–	–	6,000	–	–	–
Pumps	2	3/5.0hp	1,200	–	1,200	–	1,200	–	1,200	–	1,200	–
Back-up generator	10	1/7 hp	2,000	–	–	–	–	–	–	–	–	–
Land	-	1/2ac	——	–	–	–	–	–	–	–	–	–
Drainage	25	-	200	–	–	–	–	–	–	–	–	–
Gravel	5	-	500	–	–	–	–	500	–	–	–	–
Plyboard covers	6	-	1,000	–	–	–	–	–	1,000	–	–	–
Shed (10' x 20')	15	1	800	–	–	–	–	–	–	–	–	–
Security fence	25	-	3,000	–	–	–	–	–	–	–	–	–
Water intake structure (rack plumbing, valves, tees, etc.)	15	-	1,000	–	–	–	–	–	–	–	–	–
Seawater transmission system (main lines, fitting and valves, drain	15	-	2,000	–	–	–	–	–	–	–	–	–
Truck	5	-	8,000	–	–	–	–	8,000	–	–	–	–
Miscellaneous equipment (includes culling screens and other supplies)	3	-	1,500	–	–	1,500	–	–	1,500	–	–	1,500
TOTAL			$ 27,200	0	1,200	1,500	1,200	8,500	9,700	0	1,200	1,500

[1] Includes: wood, screens, nails, pipestrapping, caulk, PVC plumbing, adhesives & fiberglass resin for raceway and support rack.

Table 27. **Annual operating expenses for hard clam - four-tier raceway nursery system (1 million harvest capacity).**

Production Costs	
Utilities	
Electricity pumps (19940 KWH @ 6.3¢ KWH)	$1,225
Water	100
Clam seed (2 mill. 1 mm. @ $.003 each)	6,000
Supplies & expendables	200
Repair & maintenance	
Trays & racks	300
Seawater transmission system and water intake structure	150
Repair & maintenance	
Truck	800
Pumps	120
Fuel & oil	1,000
Packaging materials	200
Salaries and Wages	0
Overhead	
Insurance	1,000
Miscellaneous fees	300
TOTAL	**$11,395**

Table 28. Annual cash flow for hard clam nursery system - raceway method (1 million capacity)

	Year									
	1	2	3	4	5	6	7	8	9	10
Beginning cash balance	$ 0	4,792	9,926	15,189	20,187	24,973	28,254	29,819	31,384	32,736
Total cash receipts	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Total cash outflow:										
Operating expenses	13,079	11,737	11,395	11,395	11,395	11,395	11,395	11,395	11,395	11,395
Long-term loan payment										
Principal	1,007	1,128	1,332	1,577	1,835	2,540	3,397	3,805	4,329	4,935
Interest	2,122	2,001	2,009	2,029	1,984	2,784	3,643	3,008	2,923	2,583
Total	15,208	14,866	14,736	15,002	15,214	6,719	18,435	18,435	18,648	18,913
Cash available	4,792	9,926	15,189	20,187	24,973	28,254	29,819	31,384	32,736	33,822
New operating loan	0	0	0	0	0	0	0	0	0	0
Operating loan payment:										
Principal	0	0	0	0	0	0	0	0	0	0
Interest	684	342	0	0	0	0	0	0	0	0
Ending cash balance	4,792	9,926	15,189	20,187	24,973	28,254	29,819	31,384	32,736	33,822
Summary of debt Outstanding:										
Long-term debt balance[1]	16,672	15,544	15,780	15,479	22,230	28,286	25,065	22,657	20,048	15,360
Operating debt balance	0	0	0	0	0	0	0	0	0	0
Interest on operating debt	684	342	0	0	0	0	0	0	0	0

[1] Initial long-term loan balance - $17,680

Table 29. Income statement (year five) for hard clam nursery system - raceway system (1 million harvest capacity).

Revenues	$20,000	
Operating expenses	11,395	
Long-term loan payment: Interest	1,984	
Operating loan payment: Interest	0	
Depreciation	4,543	
Net return to owner's capital, management & risk		2,078
Opportunity cost of initital owner equity	2,106	
Net returns to owner's management & risk		($ 28)

Table 30. Initial investment and capital asset addition schedule for hard clam nursery system - four-tier raceway method (12 million harvest capacity).

Years of Systems/Equipment	Life	Initial Investment No.	in Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Four-tier wooden raceway (32" x 30') per tier)	6	63	$126,000	–	–	–	–	–	126,000	–	–	–
Pumps	3	6/30 hp	60,000	–	–	60,000	–	–	60,000	–	–	60,000
Back-up generator	10	1	10,000	–	–	–	–	–	–	–	–	–
Land	-	1 ac	—	–	–	–	–	–	–	–	–	–
Plyboard covers	6	-	5,000	–	–	–	–	–	5,000	–	–	–
Gravel	5	-	2,000	–	–	–	–	2,000	–	–	–	–
Shed (15' x 30')	15	1	2,000	–	–	–	–	–	–	–	–	–
Electricity/water	15	-	1,500	–	–	–	–	–	–	–	–	–
Security fence	25	-	5,000	–	–	–	–	–	–	–	–	–
Dock/pumphouse	15	-	3,000	–	–	–	–	–	–	–	–	–
Sea water transmission system	15	-	16,136	–	–	–	–	–	–	–	–	–
Water intake system	15	-	3,250	–	–	–	–	–	–	–	–	–
Truck	5	1	8,000	–	–	–	–	8,000	–	–	–	–
Miscellaneous equipment	3	-	1,500	–	–	1,500	–	–	1,500	–	–	1,500
Aluminum drainage culverts	25	2	3,000	–	–	–	–	–	–	–	–	–
TOTAL			$246,386	0	0	61,500	0	10,000	192,500	0	0	61,500

Table 31. Annual operating expenses for hard clam nursery system - four-tier raceway method (12 million harvest capacity).

Production Costs	
Utilities	
Electricity pumps (648000 KWH @ 6.3¢ KWH)	$ 40,824
Water	1,200
Clam seed (24 mill. 1 mm. @ $.003 ea.)	72,000
Supplies & expenditures	1,500
Repair & maintenance	
Trays & racks	6,300
Seawater transmission system & water intake structure	969
Repair & maintenance	
Truck	800
Pumps	600
Fuel & oil	1,000
Packaging materials	1,000
Salaries and Wages	
Labor	25,000
Benefits	2,500
Technician	8,000
Benefits	1,080
Overhead Costs	
Insurance	1,000
Miscellaneous fees	4,750
TOTAL	$168,523

Table 32. Annual cash flow for hard clam nursery system - raceway method (12 million harvest capacity).

	Year									
	1	2	3	4	5	6	7	8	9	10
Beginning cash balance	$ 0	33,021	71,099	114,231	146,480	178,728	209,206	205,615	212,024	198,433
Total cash receipts	240,000	240,000	240,000	240,000	240,000	240,000	240,000	240,000	240,000	240,000
Total cash outflow:										
Operating expenses	178,634	173,579	168,523	168,523	168,523	168,523	168,523	168,523	168,523	168,523
Long-term loan payment										
Principal	9,126	10,221	11,448	16,326	18,285	21,049	34,534	38,690	43,333	52,037
Interest	19,218	18,123	16,896	22,903	20,944	19,949	40,523	36,378	31,735	33,915
Total	206,978	201,923	196,867	207,752	207,752	209,522	243,591	243,591	243,591	254,475
Cash available	33,022	71,099	114,231	146,480	178,728	209,206	205,615	202,024	198,433	183,958
New operating loan	0	0	0	0	0	0	0	0	0	0
Operating loan payment:										
Principal	0	0	0	0	0	0	0	0	0	0
Interest	10,111	5,056	0	0	0	0	0	0	0	0
Ending cash balance	33,021	71,099	114,231	146,480	178,728	209,206	205,615	202,024	198,433	183,958
Summary of debt outstanding:										
Long-term debt balance[1]	151,025	140,804	190,856	174,530	166,245	337,695	303,151	264,461	282,629	230,592
Operating debt balance	0	0	0	0	0	0	0	0	0	0
Interest on operating debt	10,111	5,056	0	0	0	0	0	0	0	0

[1] Initial long-term loan balance - $160,151.

Table 33. Income statement (year five) for hard clam nursery - raceway method (12 million harvest capacity).

Revenues	$240,000	
Operational expense	168,523	
Long-term loan payment: Interest	20,944	
Operating loan payment: Interest	0	
Depreciation	47,313	
Net returns to owner's capital, management & risk		3,220
Opportunity cost of initial owner equity	11,308	
Net returns to owner's management & risk		($8,088)

Table 34. Initial investment and capital asset addition schedule for hard clam pen growout (1 million harvest capacity).

Systems/Equipment	Years of Life	No.	Initial Investment in Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Pens	6	115	$ 27,600	27,600	27,600	–	–	–	27,600	27,600	27,600	–
Portable water pump	1	1/5hp	500	500	500	500	500	500	500	500	500	500
Wet suit	2	1	300	–	300	–	300	–	300	–	300	–
Boat	8	1	6,500	–	–	–	–	–	–	–	6,500	–
Motor	3	1	2,000	–	–	2,000	–	–	2,000	–	–	2,000
Trailer	3	1	1,000	–	–	1,000	–	–	1,000	–	–	1,000
Cart	3	1	100	–	–	100	–	–	100	–	–	100
Pick-up truck	5	1	8,000	–	–	–	–	8,000	–	–	–	–
Miscellaneous equipment	2	-	600	–	600	–	600	–	600	–	600	–
TOTAL			$ 46,600	28,100	29,000	3,600	1,400	8,500	32,100	28,100	35,500	3,100

Table 35. Operating expenses for hard clam pen growout (1 million harvest capacity).

	Year					
	1	2	3	4	5	6
Production Costs						
Seed (8 mm)	$40,000	40,000	40,000	40,000	40,000	40,000
Supplies/expendables	100	120	140	140	140	140
Fuel/oil:						
Boat	700	800	900	900	900	900
Truck	600	800	1,000	1,000	1,000	1,000
Maintenance						
Boat/truck	950	950	950	950	950	950
Pens	1,400	1,400	1,400	1,400	1,400	1,400
Harvest						
Bags	0	0	1,000	1,000	1,000	1,000
Salary and Wages	--	--	--	--	--	--
Overhead						
Insurance	1,000	1,000	1,000	1,000	1,000	1,000
Miscellaneous costs	1,310	1,320	1,330	1,330	1,330	1,300
TOTAL	$46,060	46,392	47,720	47,720	47,720	47,720

Table 36. Annual cash flow for hard clam pen growout (1 million harvest capacity).

	Year									
	1	2	3	4	5	6	7	8	9	10
Beginning cash balance	$ 0	0	0	0	82,410	188,338	292,762	391,505	485,275	573,712
Total cash receipts	0	0	170,000	170,000	170,000	170,000	170,000	170,000	170,000	170,000
Total cash outflow:										
Operating expenses	46,060	46,390	47,720	47,720	47,720	47,720	47,720	47,720	47,720	47,720
Long-term loan payment										
Principal	1,726	3,534	5,611	6,490	7,348	8,714	11,589	14,581	18,354	20,761
Interest	3,635	6,800	9,856	9,614	9,003	9,142	11,948	13,929	16,440	14,669
Total	51,421	56,724	63,187	63,824	64,072	65,576	71,257	76,231	81,563	82,200
Cash available	(51,421)	(56,724)	106,813	106,176	188,338	292,762	391,505	485,275	573,712	661,511
New operating loan	51,421	56,724	0	0	0	0	0	0	0	0
Operating loan payment	0	0	106,813	23,766	0	0	0	0	0	0
Ending cash balance	0	0	0	82,410	188,338	292,762	391,505	485,275	573,712	661,511
Summary of debt Outstanding:										
Long-term debt balance[1]	28,562	53,130	76,519	73,628	67,681	67,467	87,977	101,496	118,642	101,481
Operating debt balance	51,421	114,315	21,220	0	0	0	0	0	0	0
Interest on Operating Debt	6,171	13,718	2,546	0	0	0	0	0	0	0

[1] Initial Long-term loan balance - $30,290.

Table 37. Income statement (year five) for hard clam pen growout (1 million harvest capacity).

Revenues	$170,000	
Operating expenses	47,720	
Long-term loan payment: Interest	9,003	
Operating loan payment: Interest	0	
Depreciation	8,996	
Net returns to owner's capital, management & risk		104,281
Opportunity cost of initial owner equity	5,236	
Net returns to owner's management & risk		$ 99,045

Table 38. Initial investment and capital asset addition schedule for hard clam bottom-net growout (1 million harvest capacity).

Systems/Equipment	Years of Life	No.	Initial Investment in Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Bottom net (50' x 8')	3	25	$ 1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250
Floats	1	300	120	120	120	120	120	120	120	120	120	120
Boat	8	1	6,500	--	--	--	--	--	--	--	6,500	--
Motor	3	1	2,000	--	--	2,000	--	--	2,000	--	--	2,000
Trailer	3	1	1,000	--	--	1,000	--	--	1,000	--	--	1,000
Scuba/wet suit	2	1	1,100	--	1,100	--	1,100	--	1,100	--	1,100	--
Harvest equipment	3	-	200	--	--	200	--	--	200	--	--	200
Pick-up truck	5	1	8,000	--	--	--	--	8,000	--	--	--	--
Miscellaneous equipment	2	-	300	--	300	--	300	--	300	--	300	--
TOTAL			$ 20,470	1,370	2,770	4,570	2,770	9,370	5,970	1,370	9,270	4,570

Table 39. Operating expenses for hard clam bottom-net growout (1 million harvest capacity).

	Year					
	1	2	3	4	5	6
Production Costs						
Seed (8 mm)	$40,000	40,000	40,000	40,000	40,000	40,000
Supplies/expendables	100	120	140	140	140	140
Fuel/oil						
Boat	700	800	900	900	900	900
Truck	600	800	1,000	1,000	1,000	1,000
Maintenance						
Boat/truck	950	950	950	950	950	950
Nets	62	62	62	62	62	62
Harvest						
Bags	0	0	1,000	1,000	1,000	1,000
Salary and Wages	--	--	--	--	--	--
Overhead						
Insurance	1,000	1,000	1,000	1,000	1,000	1,000
Miscellaneous costs	1,270	1,280	1,300	1,300	1,300	1,300
TOTAL	$44,682	45,012	46,352	46,352	46,352	46,352

Table 40. Annual cash flow for hard clam bottom-net growout (1 million harvest capacity).

	Year									
	1	2	3	4	5	6	7	8	9	10
Beginning cash balance	$ 0	0	0	8,235	127,986	247,247	364,850	481,397	597,701	712,364
Total cash receipts	0	0	170,000	170,000	170,000	170,000	170,000	170,000	170,000	170,000
Total cash outflow:										
Operating expenses	44,682	45,012	46,352	46,352	46,352	46,352	46,352	46,352	46,352	46,352
Long-term loan payment										
Principal	758	927	1,196	1,600	1,950	2,718	3,385	3,869	4,861	5,705
Interest	1,597	1,670	1,891	2,296	2,436	3,327	3,717	3,475	4,123	4,088
Total	47,037	47,609	49,440	50,248	50,739	52,397	53,454	53,696	55,337	56,146
Cash available	(47,037)	(47,609)	120,560	127,986	247,247	364,850	481,397	597,701	712,364	826,218
New operating loan	47,037	47,609	0	0	0	0	0	0	0	0
Operating loan payment	0	0	112,326	0	0	0	0	0	0	0
Ending cash balance	0	0	8,235	127,986	247,247	364,850	481,397	597,701	712,364	826,218
Summary of debt Outstanding:										
Long-term debt balance[1]	12,548	12,991	14,564	17,534	27,354	25,005	27,590	25,091	29,501	28,365
Operating debt balance	47,037	100,291	0	0	0	0	0	0	0	0
Interest on operating debt	5,644	12,035	0	0	0	0	0	0	0	0

[1] Initial long-term loan balance - $13,306.

Table 41. Income statement (year five) for hard clam bottom-net growout (1 million harvest capacity).

Revenues	$170,000	
Operating expenses	46,352	
Long-term loan payment Interest	2,436	
Operating loan payment Interest	0	
Depreciation	4,717	
Net returns to owner's capital, management & risk		116,495
Opportunity cost of initial owner equity	1,925	
Net returns to owner's management & risk		$114,570

Table 42. Initial investment and capital asset addition schedule for hard clam soft-tray growout (1 million harvest capacity).

Systems/Equipment	Years of Life	No.	Initial Investment in Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Bags												
small mesh (4' x 4')	3	156	$ 2,262	2,262	2,262	2,262	2,262	2,262	2,262	2,262	2,262	2,262
large mesh (4' x 4')	3	1250	15,813	15,813	15,813	15,813	15,813	15,813	15,813	15,813	15,813	15,813
Floats	1	1406	562	562	562	562	562	562	562	562	562	562
Wet suit/scuba	2	1	1,100	–	1,100	–	1,100	–	1,100	–	1,100	–
Boat	8	1	6,500	–	–	–	–	–	–	–	6,500	–
Motor	3	1	2,000	–	–	2,000	–	–	2,000	–	–	2,000
Trailer	3	1	1,000	–	–	1,000	–	–	1,000	–	–	1,000
Bag cleaning tank	3	-	200	–	–	–	–	–	–	–	–	–
Pick-up truck	5	1	8,000	–	–	–	–	8,000	–	–	–	–
Miscellaneous equipment	2	-	600	–	600	–	600	–	600	–	600	–
TOTAL			$ 38,037	18,637	20,337	21,637	20,337	26,637	23,337	18,637	26,837	21,637

Table 43. Operating expenses for a hard clam soft-tray growout (1 million harvest capacity).

	Year					
	1	2	3	4	5	6
Production Costs						
Seed (8 mm)	$40,000	40,000	40,000	40,000	40,000	40,000
Supplies/expendables	100	120	140	140	140	140
Fuel/oil						
Boat	700	800	900	900	900	900
Truck	600	800	1,000	1,000	1,000	1,000
Maintenance						
Boat/truck	950	950	950	950	950	950
Trays	900	900	900	900	900	900
Harvest						
Bags	0	0	1,000	1,000	1,000	1,000
Salary and Wages	--	--	--	--	--	--
Overhead						
Insurance	1,000	1,000	1,000	1,000	1,000	1,000
Miscellaneous costs	1,300	1,330	1,360	1,360	1,360	1,360
TOTAL	$45,550	45,900	47,250	47,250	47,250	47,250

Table 44. Annual cash flow for hard clam soft tray (1 million harvest capacity).

	Year 1	2	3	4	5	6	7	8	9	10
Beginning cash balance	$ 0	0	0	0	95,155	199,203	298,536	393,739	485,644	572,799
Total cash receipts	0	0	170,000	170,000	170,000	170,000	170,000	170,000	170,000	170,000
Total cash outflow:										
Operating expenses	45,550	45,900	47,250	47,250	47,250	47,250	47,250	47,250	47,250	47,250
Long-term loan payment										
Principal	1,409	2,640	4,116	5,842	7,702	10,145	12,692	15,277	18,639	22,109
Interest	2,957	5,034	7,158	9,260	11,000	13,272	14,855	15,568	16,956	17,315
Total	49,926	53,574	58,524	62,353	65,952	70,667	74,797	78,095	82,845	86,674
Cash available	(49,926)	(53,574)	111,476	107,647	199,203	298,536	393,739	485,644	572,799	656,125
New operating loan	49,926	53,574	0	0	0	0	0	0	0	0
Operating loan payment	0	0	111,476	12,492	0	0	0	0	0	0
Ending cash balance	0	0	0	95,155	199,203	298,536	393,739	485,644	572,799	656,125
Summary of debt Outstanding:										
Long-term debt balance[1]	23,315	39,319	55,533	71,329	83,963	100,455	111,100	114,460	122,658	122,186
Operating debt balance	49,926	109,491	11,154	0	0	0	0	0	0	0
Interest on operating debt	5,991	13,139	1,338	0	0	0	0	0	0	0

[1] Initial long-term loan balance - $24,724.

Table 45. Income statement (year five) for hard clam soft-tray growout (1 million harvest capacity).

Revenues	$170,000	
Operating expenses	47,250	
Long-term loan payment: Interest	11,000	
Operating loan payment: Interest	0	
Depreciation	10,860	
Net returns to owner's capital, management & risk		100,890
Opportunity cost of initial owner equity	4,076	
Net returns to owner's management & risk		$ 96,814

Table 46. Initial investment and capital asset addition schedule for integrated hard clam culture operation - hatchery (24 million harvest capacity).[1]

Systems/Equipment	Years of Life	No.	Initial Investment in Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Brood stock maintenance												
Multipurpose batch tank	25	2/2500 l.	$ 2,000	–	–	–	–	–	–	–	–	–
Water chiller	2	2	1,100	–	1,100	–	1,100	–	1,100	–	1,100	–
Peristaltic pump	2	12	800	–	–	–	–	–	–	–	–	–
Miscellaneous equipment	2	–	250	–	250	–	250	–	250	–	250	–
Algal culture												
Environmental chamber	10	1	3,500	–	–	–	–	–	–	–	–	–
Inoculation hood	10	1	1,500	–	–	–	–	–	–	–	–	–
Erlenmeyer flask	3	16/250 ml.	80	–	–	80	–	–	80	–	–	80
Carboy system	3	8	834	–	–	834	–	–	834	–	–	834
Kalwall tube system	5	8	800	–	–	–	–	800	–	–	–	–
Air pumps/aerator	2	2/2 hp	400	–	400	–	400	–	400	–	400	–
Settling tank	25	2/2000 l.	500	–	–	–	–	–	–	–	–	–
Autoclave	8	1	2,500	–	–	–	–	–	–	–	2,500	–
Batch culture	10	4/2000 l.	2,000	–	–	–	–	–	–	–	–	–
Miscellaneous equipment	2	-	400	–	400	–	400	–	400	–	400	–
Metal halide lights	10	6	715	–	–	–	–	–	–	–	–	–
Algal reservoirs	10	2/3000 l.	1,000	–	–	–	–	–	–	–	–	–
Peristaltic pumps	2	2	1,200	–	1,200	–	1,200	–	1,200	–	1,200	–
Larval culture												
Spawning table/fixtures	10	1/2000 l.	600	–	–	–	–	–	–	–	–	–
Larval containers/fixtures	10	8/3000 l.	8,000	–	–	–	–	–	–	–	–	–
Miscellaneous equipment	2	-	500	–	500	–	500	–	500	–	500	–
Settling tank	10	2/15000	10,000	–	–	–	–	–	–	–	–	–
Post-set maintenance												
Downweller tanks	10	3/4000 l.	1,535	–	–	–	–	–	–	–	–	–
Downwellers	10	150	1,500	–	–	–	–	–	–	–	–	–
Water system motor/pumps/fixtures	2	2/5 hp.	350	–	350	–	350	–	350	–	350	–
Water temperature treatment:												
Water chiller	2	-	735	–	735	–	735	–	735	–	735	–
Fixtures	5	-	500	–	–	–	–	500	–	–	–	–
Miscellaneous equipment	2	1/2000 l.	300	–	300	–	300	–	300	–	300	–
Feeding reservoir	10		825	–	–	–	–	–	–	–	–	–
TOTAL HATCHERY			$44,524	0	5,235	914	5,235	1,300	6,149	0	7,735	914

[1] This hatchery is a component of an integrated system which also includes a nursery, support facility and growout operation.

Table 47. Initial investment and capital asset addition schedule for integrated hard clam culture operation - upflow nursery (12 million harvest capacity).[1]

Systems/Equipment	Years of Life	No.	Initial Investment in Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Passive flow systems (cylinders, reservior, drain pipe, control drain, inflow pipe, standpipe, bag filters)	8	24 cyl. tanks	$60,000	–	–	–	–	–	–	–	60,000	–
Pad (10,000 sq. ft.) (Drainage, site preparation electricity, lights, freshwater source)	50	1	20,000	–	–	–	–	–	–	–	–	–
Corrugated roof pad	15	-	2,500	–	–	–	–	–	–	–	–	–
Forced active flow system (cylinder, screen, inflow pipe, overflow pipe, cap, PVC manifold)	8	120	6,000	–	–	–	–	–	–	–	6,000	–
Rack system	10	3	3,000	–	–	–	–	–	–	–	–	–
Standard screens for culling	10	12	900	–	–	–	–	–	–	–	–	–
Miscellaneous equipment	2	-	750	–	750	–	750	–	750	–	750	–
TOTAL NURSERY			$93,150	0	750	0	750	0	750	0	66,750	0

[1] This nursery is a component of an integrated system which also includes a hatchery, support facility and growout operation.

Table 48. Initial investment and capital asset addition schedule for integrated hard clam culture operation - support facility.[1]

Systems/Equipment	Years of Life	No.	Initial Investment in Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Land	–	3/4 acre										
Building (studwall type) Construction, cement floor, plumbing, electrical, heat/air conditioning	25	2,500 sq ft	$100,000	–	–	–	–	–	–	–	–	–
Coldroom	12	250 sq ft	2,500	–	–	–	–	–	–	–	–	–
Air handling system												
Compressed air	6	3 hp	1,000	–	–	–	–	–	1,000	–	–	–
Support lab	10	–	35,000	–	–	–	–	–	–	–	–	–
Backup generator	20	1	7,500	–	–	–	–	–	–	–	–	–
Security system	20	–	4,000	–	–	–	–	–	–	–	–	–
Dock/pumphouse	20	–	16,000	–	–	–	–	–	–	–	–	–
Seawater transmission system												
Main pumps	3	3/25 hp	24,000	–	–	24,000	–	–	24,000	–	–	24,000
PVC pipe 8"	15	–	7,500	–	–	–	–	–	–	–	–	–
Valves, fittings, screens	9	–	6,000	–	–	–	–	–	–	–	6,000	–
Water treatment												
Rapid sand filtration	10	1	3,000	–	–	–	–	–	–	–	–	–
UV system, industrial size	5	1	1,500	–	–	–	–	1,500	–	–	–	–
Microfiltration system	10	1	7,500	–	–	–	–	–	–	–	–	–
Heat exchange/boiler	7	1	12,500	–	–	–	–	–	–	12,500	–	–
Seawater reservoir	10	1/3000 gal	2,500	–	–	–	–	–	–	–	–	–
Pump fixtures	5	1/1 hp	200	–	–	–	–	200	–	–	–	–
Pick-up truck	5	2	16,000	–	–	–	–	16,000	–	–	–	–
Miscellaneous equipment	3	–	2,000	–	–	2,000	–	–	2,000	–	2,000	–
Office equipment	10	–	4,500	–	–	–	–	–	–	–	–	–
Total			$253,200	0	0	26,000	0	17,700	27,000	12,500	8,000	24,000

[1] This support facility is a component of an integrated system which also includes a hatchery, nursery and growout operation.

Table 49. Initial investment and capital asset addition schedule for integrated hard clam culture operation - pen growout (6 million harvest capacity).[1]

Systems/Equipment	Years of Life	No.	Initial Investment in Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Ground plants (pens)	6	690	$165,600	165,600	165,600	–	–	–	165,600	165,600	165,600	–
Portable water pumps	1	3/5 hp	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Wet suits	2	4	1,200	–	1,200	–	1,200	–	1,200	–	1,200	–
Boat	8	2	13,000	–	–	–	–	–	–	–	13,000	–
Motor	3	2	4,000	–	–	4,000	–	–	4,000	–	–	4,000
Trailer	3	1	1,000	–	–	1,000	–	–	1,000	–	–	1,000
Cart	3	2	200	–	–	200	–	–	200	–	–	200
Miscellaneous equipment	2	–	2,000	–	2,000	–	2,000	–	2,000	–	2,000	–
Clam sorter	5	1	4,000	–	–	–	–	4,000	–	–	–	–
Depuration system												
Tank	15	1	5,000	–	–	–	–	–	–	–	–	–
UV system, industrial	5	1	7,500	–	–	–	–	7,500	–	–	–	–
Pump	4	1/1hp	300	–	–	–	300	–	–	–	–	300
Racking system	7	1	500	–	–	–	–	–	–	500	–	–
Security	15	1	15,000	–	–	–	–	–	–	–	–	–
TOTAL			$220,800	167,100	170,300	6,700	5,000	13,000	175,500	167,600	183.300	7,000

[1] This growout operation is a component of an integrated system which also includes a hatchery, nursery, and support facility.

Table 50. Operating expenses for integrated hard clam culture operation-hatchery, nursery, support facility.

	Year					
	1	2	3	4	5	6
Production Costs						
Electricity						
Hatchery	$1,840	1,840	1,840	1,840	1,840	1,840
Nursery	200	200	200	200	200	200
Building equipment	5,000	5,000	5,000	5,000	5,000	5,000
Seawater pumps	7,803	7,803	7,803	7,803	7,803	7,803
Freshwater	250	250	250	250	250	250
Clean seawater delivery pipes	500	500	500	500	500	500
Laboratory supplies	1,600	1,600	1,600	1,600	1,600	1,600
Brood stock,	50	50	50	50	50	50
Algae	10,950	10,950	10,950	10,950	10,950	10,950
Heat exchanger/fuel oil	2,140	2,140	2,140	2,140	2,140	2,140
Silo replacement	40	40	40	40	40	40
Sand	200	200	200	200	200	200
Fuel/oil truck	1,600	1,600	1,600	1,600	1,600	1,600
Supplies/expendables	7,500	7,500	7,500	7,500	7,500	7,500
Repair/maintenance						
Trucks	1,600	1,600	1,600	1,600	1,600	1,600
Site/building	500	500	500	500	500	500
Equipment/pumps	3,000	3,000	3,000	3,000	3,000	3,000
Salary and Wages						
Hatchery	32,000	32,000	32,000	32,000	32,000	32,000
Nursery	14,250	14,250	14,250	14,250	14,250	14,250
Support	26,250	26,250	26,250	26,250	26,250	26,250
Benefits	9,568	9,568	9,568	9,568	9,568	9,568
Overhead						
Insurance	3,000	3,000	3,000	3,000	3,000	3,000
Miscellaneous costs	2,500	2,500	2,500	2,500	2,500	2,500
TOTAL:	$132,341	132,341	132,341	132,341	132,341	132,341

Table 51. Operating expenses for integrated hard clam culture operation - pen growout (6 million harvest capacity).

	Year					
	1	2	3	4	5	6
Production Costs						
Supplies/expendables	$2,500	2,500	2,500	2,500	2,500	2,500
Fuel/oil						
Boats	1,700	1,700	1,700	1,700	1,700	1,700
Water pumps	1,000	1,000	1,000	1,000	1,000	1,000
Truck	1,200	1,200	1,200	1,200	1,200	1,200
Maintenance/repair						
Boat/truck	1,750	1,750	1,750	1,750	1,750.	1,750
Pens	8,000	8,000	8,000	8,000	8,000	8,000
Harvest bags	0	0	6,000	6,000	6,000	6,000
Depuration						
Electric	1,500	1,500	1,500	1,500	1,500	1,500
Repair/maintenance	400	400	400	400	400	400
Salary and Wages						
Wages	53,400	53,400	53,400	53,400	53,400	53,400
Benefits	5,904	5,904	5,904	5,904	5,904	5,904
Overhead						
Insurance	2,000	2,000	2,000	2,000	2,000	2,000
Miscellaneous costs	1,630	1,630	1,630	1,630	1,630	1,630
TOTAL:	$81,024	81,024	81,024	81,024	81,024	81,024

Table 52. Annual cash flow for integrated hard clam culture operation - hatchery, nursery, pen growout.

	Year 1	2	3	4	5	6	7	8	9	10
Beginning cash balance	$ 0	0	0	0	621,408	1,282,691	1,938,310	2,556,709	3,143,234	3,682,861
Total cash receipts	0	0	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000
Total cash outflow										
Operating expenses	219,491	216,428	219,365	219,365	219,365	219,365	219,365	219,365	219,365	219,365
Long-term payment										
Principal	22,656	34,897	49,181	56,999	64,516	74,081	94,955	116,612	145,705	165,123
Interest	47,711	65,044	82,118	80,250	74,837	70,935	87,281	97,498	115,303	101,888
TOTAL	289,858	316,369	350,665	356,614	358,717	364,381	401,600	433,475	480,373	486,376
Cash available	(289,858)	(316,369)	669,335	663,386	1,282,691	1,938,310	2,556,709	3,143,234	3,682,861	4,216,485
New operating loan	289,858	316,369	0	0	0	0	0	0	0	0
Operating loan payment	6,126	3,063	669,335	41,978	0	0	0	0	0	0
Ending cash balance	0	0	0	621,408	1,282,691	1,938,310	2,556,709	3,143,234	3,682,861	4,216,485
Summary of debt outstanding										
Long-term debt balance[1]	374,932	507,135	635,139	611,753	559,123	517,042	632,386	696,247	815,154	683,946
Operating debt balance	289,858	641,010	48,595	0	0	0	0	0	0	
Interest on operating debt	34,783	76,921	5,831	0	0	0	0	0	0	0

[1] Initial long-term loan balance - $397,588

Table 53. Income statement (year five) for integrated hard clam culture operation - hatchery, nursery, pen growout.

Revenues	$1,020,000	
Operating expenses	219,365	
Long-term debt interest	74,837	
Operating debt interest	0	
Depreciation	81,102	
Net returns to owner's capital, management & risk		644,696
Opportunity cost of initial owner's equity	42,001	
Net returns to owner's management & risk		$602,695

Table 54. Initial investment and capital asset addition schedule for integrated hard clam culture operation - soft-tray growout (6 million harvest capacity).

Systems/Equipment	Years of Life	No.	Initial Investment in Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Bags -												
Small mesh	3	936	$ 13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572	13,572
Large mesh	3	7500	94,878	94,878	94,878	94,878	94,878	94,878	94,878	94,878	94,878	94,878
Floats	1	8436	3,372	3,372	3,372	3,372	3,372	3,372	3,372	3,372	3,372	3,372
Wet suit/scuba	2	4	1,200	–	1,200	–	1,200	–	1,200	–	1,200	–
Boat	8	2	13,000	–	–	–	–	–	–	–	13,000	–
Motor	3	2	4,000	–	–	4,000	–	–	4,000	–	–	4,000
Trailer	3	1	1,000	–	–	1,000	–	–	1,000	–	–	1,000
Bag cleaning tank	20	2	400	–	–	–	–	–	–	– –	–	
Clam sorter	5	1	4,000	–	–	–	–	4,000	–	–	–	–
Miscellaneous equipment	2	–	2,000	–	2,000	–	2,000	–	2,000	–	2,000	–
Depuration system												
Tank	15	1	5,000	–	–	–	–	–	–	–	–	–
UV system, industrial	5	1	7,500	–	–	–	–	7,500	–	–	–	–
Pump	4	1/1hp	300	–	–	–	300	–	–	–	300	–
Racking System	7	1	500	–	–	–	–	–	–	500	–	–
Security	15	1	15,000	–	–	–	–	–	–	–	–	–
TOTAL			$165,722	111,822	122,022	116,822	123,322	123,322	120,022	112,322	135,322	116,822

Table 55. Operating expenses for integrated hard clam culture operation - soft-tray growout (6 million harvest capacity).

	Year 1	2	3	4	5	6
Production Costs						
Supplies/expendables	$1,500	1,500	1,500	1,500	1,500	1,500
Fuel/oil						
Boat	1,700	1,700	1,700	1,700	1,700	1,700
Truck	1,200	1,200	1,200	1,200	1,200	1,200
Maintenance/repair						
Boat/truck	1,750	1,750	1,750	1,750	1,750	1,750
Bags	2,000	2,000	2,000	2,000	2,000	2,000
Harvest bags	0	0	6,000	6,000	6,000	6,000
Depuration						
Electric	1,500	1,500	1,500	1,500	1,500	1,500
Repair/maintenance	400	400	400	400	400	400
Salary and Wages						
Wages	40,960	40,960	40,960	40,960	40,960	40,960
Benefits	4,656	4,656	4,656	4,656	4,656	4,656
Overhead						
Insurance	2,000	2,000	2,000	2,000	2,000	2,000
Miscellaneous costs	1,533	1,533	1,533	1,533	1,533	1,533
TOTAL	$59,199	59,199	65,199	65,199	65,199	65,199

Table 56. Annual cash flow for integrated hard clam culture operation - hatchery, nursery, soft-tray growout.

	Year									
	1	2	3	4	5	6	7	8	9	10
Beginning cash balance	$ 0	0	0	76,956	768,560	1,438,575	2,083,382	2,700,788	3,296,102	3,854,355
Total cash receipts	0	0	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000	1,020,000
Total cash outflow										
Operating expenses	191,540	191,540	197,540	197,540	197,540	197,540	197,540	197,540	197,540	197,540
Long-term payment										
Principal	20,616	29,462	39,944	52,928	66,244	82,303	101,002	120,235	146,596	172,395
Interest	43,414	54,359	65,453	77,908	86,221	95,350	104,053	106,911	117,612	117,304
TOTAL	261,697	278,424	302,937	328,376	350,005	375,193	402,594	424,686	461,747	487,240
Cash available	(261,697)	(278,424)	717,063	768,580	1,438,575	2,083,382	2,700,788	3,296,102	3,854,355	4,387,115
New operating loan	261,697	278,424	0	0	0	0	0	0	0	0
Operating loan payment	6,126	3,063	640,107	0	0	0	0	0	0	0
Ending cash balance	0	0	76,956	768,560	1,438,575	2,083,382	2,700,788	3,296,102	3,854,355	4,387,115
Summary of debt outstanding										
Long-term debt										
Balance[1]	341,171	423,531	505,494	596,301	652,264	712,283	766,102	770,690	833,501	805,142
Operating debt										
Balance	261,697	571,524	0	0	0	0	0	0	0	0
Interest on operating										
Debt	31,404	68,583	0	0	0	0	0	0	0	0

[1] Initial long-term loan balance - $361,787

Table 57. Income statement (year five) for integrated hard clam culture operation - hatchery, nursery, soft-tray growout.

Revenues	$1,020,000	
Operating expenses	197,540	
Long-term debt interest	86,221	
Operating debt interest	0	
Depreciation	89,216	
Net returns to owner's capital, management & risk		647,023
Opportunity cost of initial owner's equity	34,887	
Net return to owner's management & risk		$612,136

Table 58. General enterprise budget (year five) for hard clam pen growout system (1 million harvest capacity).

		Estimated Value	Your Value
Revenues			
1 million 45-50 mm @ $0.17 ea.		$170,000	____
Operating expenses			
Variable costs:			
Seed clams (2 mill. 8 mm @ $0.02 ea.)	$40,000		____
Supplies & expendables	140		____
Fuel/oil			
Boat	900		____
Truck	1,000		____
Maintenance			
Boat/truck	950		____
Pens	1,400		____
Harvest bags	1,000		____
Labor	0		____
Total variable costs		45,390	____
Fixed costs:			
Overhead			
Insurance	1,000		____
Miscellaneous costs	1,330		____
Long-term debt interest	9,003		____
Operating debt interest	0		____
Depreciation	8,996		____
Total fixed costs		20,329	____
Net returns before tax to owner/operator capital, management, and risk		104,281	____
Opportunity cost of initial owner equity		5,236	____
Net returns before tax to owner/operator management and risk		99,045	____
Cost per clam and break-even price[1]		$0.068	____
Margin per clam[2]		$0.102	____
Break-even survival rate[3]		20%	____

[1]The sum of total variable and fixed costs divided by number of clams harvested (i.e., 1 million)

[2]Difference between break-even price and actual selling price (i.e., 17¢)

[3]The sum of total variable and fixed costs divided by selling price, then divided by initial number of clams stocked (i.e., 2 million)

Table 59. General enterprise budget (year five) for hard clam bottom-net growout system (1 million harvest capacity).

		Estimated Value	Your Value
Revenues			
1 million 45-50 mm @ $0.17 ea.		$170,000	____
Operating expenses			
Variable costs:			
Seed clams (2 mil. 8 mm @ $0.02 ea.)	$40,000		____
Supplies and expendables	140		____
Fuel/oil			
Boat	900		____
Truck	1,000		____
Maintenance			
Boat/truck	950		____
Nets	62		____
Harvest bags	1,000		____
Labor	0		____
Total variable costs		44,052	____
Fixed costs:			
Overhead			
Insurance	1,000		____
Miscellaneous costs	1,360		____
Long-term debt interest	2,436		____
Operating debt interest	0		____
Depreciation	4,717		____
Total fixed costs		9,453	____
Net returns before tax to owner/operator capital, management, and risk		6,495	____
Opportunity cost of initial owner equity		1,925	____
Net returns before tax to owner/operator management and risk		114,570	____
Cost per clam and break-even price[1]		$0.054	____
Margin per clam[2]		$0.116	____
Break-even survival rate[3]		16%	____

[1]The sum of total variable and fixed costs divided by number of clams harvested (i.e., 1 million)

[2]Difference between break-even price and actual selling price (i.e., 17¢)

[3]The sum of total variable and fixed costs divided by selling price, then divided by initial number of clams stocked (i.e., 2 million)

Table 60. General enterprise budget (year five) for hard clam soft-tray growout system (one million harvest capacity).

		Estimated Value	Your Value
Revenues			
1 million 45-50 mm @ $0.17 ea.		$170,000	____
Operating expenses			
Variable costs:			
Seed clams (2 mill. 8 mm @ $0.02 ea.)	$40,000		____
Supplies and expendables	140		____
Fuel/oil			
Boat	900		____
Truck	1,000		____
Maintenance			
Boat/truck	950		____
Trays	900		____
Harvest bags	1,000		____
Labor	0		____
Total variable costs		44,890	____
Fixed costs:			
Overhead			
Insurance	1,000		____
Miscellaneous costs	1,360		____
Long-term debt interest	11,000		____
Operating debt interest	0		____
Depreciation	10,860		____
Total fixed costs		24,220	____
Net returns before tax to owner/operator capital, management, and risk		100,890	____
Opportunity cost of initial owner equity		4,076	____
Net returns before tax to owner/operator management and risk		96,814	____
Cost per clam and break-even price[1]		$0.069	____
Margin per clam[2]		$0.101	____
Break-even survival rate[3]		20%	____

[1]The sum of total variable and fixed costs divided by number of clams harvested (i.e., 1 million)

[2]Difference between break-even price and actual selling price (i.e., 17¢)

[3]The sum of total variable and fixed costs divided by selling price, then divided by initial number of clams stocked (i.e., 2 million)

Table 61. Sensitivity analysis of varying per clam market price for hard clam growout systems (year five income statements).

I. Pens:					
Price/Clam	.13	.15	.17	.19	.21
Revenues	130,000	150,000	170,000	190,000	210,000
Operating expenses	47,720	47,720	47,720	47,720	47,720
Long-term debt interest	9,003	9,003	9,003	9,003	9,003
Operating debt interest	0	0	0	0	0
Depreciation	8,996	8,996	8,996	8,996	8,996
Net Returns[1]	64,281	84,281	104,281	124,281	144,281
Opportunity cost	5,236	5,236	5,236	5,236	5,236
Net returns[2]	59,045	79,045	99,045	119,045	139,045
Ending cash balance	63,251	125,938	188,338	250,738	310,885
II. Bottom nets:					
Price/Clam	.13	.15	.17	.19	.21
Revenues	130,000	150,000	170,000	190,000	210,000
Operating expenses	46,352	46,352	46,352	46,352	46,352
Long-term debt interest	2,436	2,436	2,436	2,436	2,436
Operating debt interest	0	0	0	0	0
Depreciation	4,717	4,717	4,717	4,717	4,717
Net returns[1]	76,495	96,495	116,495	136,495	156,495
Opportunity cost	1,925	1,925	1,925	1,925	1,925
Net returns[2]	74,570	94,570	114,570	134,570	154,570
Ending cash balance	123,436	185,836	247,247	307,247	367,247
III. Soft trays					
Price/Clam	.13	.15	.17	.19	.21
Revenues	130,000	150,000	170,000	190,000	210,000
Operating expenses	47,250	47,250	47,250	47,250	47,250
Long-term debt interest	11,000	11,000	11,000	11,000	11,000
Operating Debt Interest	0	0	0	0	0
Depreciation	10,860	10,860	10,860	10,860	10,860
Net returns[1]	60,890	80,890	100,890	120,890	140,890
Opportunity cost	4,076	4,076	4,076	4,076	4,076
Net returns[2]	56,814	76,814	96,814	116,814	136,814
Ending cash balance	74,403	136,803	199,203	260,541	320,541

[1]Net returns to owner's initial capital, management and risk.

[2]Net of opportunity cost of capital.

Table 62. Sensitivity analysis of varying survival rates for hard clam growout systems (year five income statements).

I. Pens:

Survival	30%	40%	50%	60%	70%
No. clams	600,000	800,000	1,000,000	1,200,000	1,400,000
Price/clams	.17	.17	.17	.17	.17
Revenues	102,000	136,000	170,000	204,000	238,000
Operating expenses[1]	46,750	46,760	46,770	46,780	46,790
Long-term debt interest	9,003	9,003	9,003	9,003	9,003
Operating debt interest	3,355	0	0	0	0
Depreciation	8,996	8,996	8,996	8,996	8,996
Net returns[2]	33,896	71,241	105,231	139,221	173,211
Opportunity cost	5,236	5,236	5,236	5,236	5,236
Net returns[3]	28,660	66,005	99,995	133,985	167,975
Ending cash balance	38,898	85,253	191,302	295,705	397,675

II. Bottom nets:

Survival	30%	40%	50%	60%	70%
No. clams	600,000	800,000	1,000,000	1,200,000	1,400,000
Price/clams	.17	.17	.17	.17	.17
Revenues	102,000	136,000	170,000	204,000	238,000
Operating expenses[1]	45,382	45,392	45,402	45,412	45,422
Long-term debt interest	2,436	2,436	2,436	2,436	2,436
Operating debt interest	0	0	0	00	
Depreciation	4,717	4,717	4,717	4,717	4,717
Net returns[2]	49,465	83,455	117,445	151,435	185,425
Opportunity cost	1,925	1,925	1,925	1,925	1,925
Net returns[3]	47,540	81,530	115,520	49,510	183,500
Ending cash balance	52,231	145,151	250,247	352,067	454,037

III. Soft trays

Survival	30%	40%	50%	60%	70%
No. clams	600,000	800,000	1,000,000	1,200,000	1,400,000
Price/clams	.17	.17	.17	.17	.17
Revenues	102,000	136,000	170,000	204,000	238,000
Operating expenses	46,280	46,290	46,300	46,310	46,320
Long-term debt interest	11,000	11,000	11,000	11,000	11,000
Operating debt interest	1,868	0	0	0	0
Depreciation	10,860	10,860	10,860	10,860	10,860
Net returns[2]	31,992	67,850	101,840	135,830	169,820
Opportunity cost	4,076	4,076	4,076	4,076	4,076
Net returns[3]	27,916	63,774	97,764	131,754	165,744
Ending cash balance	37,018	96,149	202,323	305,451	407,451

[1]Change in costs of harvest bags.
[2]Net returns to owner's initial capital, management and risk.
[3]Net of opportunity cost of capital.

Table 63. Planting/harvest schedule for two-, three-, and four-year growout period scenarios.[1]

Production Scenario	Production Rotation	Year 1	2	3	4	5	6	7	8	9	10
Two-year	1	P1	H1	P1	H1	P1	H1	P1	H1	P1	H1
Growout period	2		P2	H2	P2	H2	P2	H2	P2	H2	P2
	3			P3	H3	P3	H3	P3	H3	P3	H3
Three-year	1	P1		H1	P1		H1	P1		H1	P1
Growout period (Base assumption)	2		P2		H2	P2		H2	P2		H2
	3			P3		H3	P3		H3	P3	
Four-year	1	P1			H1	P1			H1	P1	
Growout period	2		P2			H2	P2			H2	P2
	3			P3			H3	P3			H3

[1] P = Planting (occurs at beginning of year)
H = Harvest (completed by end of year)

Table 64. Sensitivity analysis of varying growout period length for hard clam growout systems (year five income statement).

I. Pens			
Growout period years	2	3	4
Revenues	170,000	170,000	170,000
Operating expenses	46,770	46,770	46,770
Long-term debt interest	9,003	9,003	9,003
Operating debt interest	0	0	1,616
Depreciation	8,996	8,996	8,996
Net returns[1]	105,231	105,231	103,615
Opportunity cost	5,236	5,236	5,236
Net returns[2]	99,995	99,995	98,379
Ending cash balance	544,277	191,302	106,878

II. Bottom nets			
Growout period years	2	3	4
Revenues	170,000	170,000	170,000
Operating expenses	45,402	45,402	45,402
Long-term debt interest	2,436	2,436	2,436
Operating debt interest	0	0	0
Depreciation	4,717	4,717	4,717
Net returns[1]	117,445	117,445	117,445
Opportunity cost	1,925	1,925	1,925
Net returns[2]	115,520	115,520	115,520
Ending cash balance	600,632	250,247	120,211

III. Soft trays			
Growout period years	2	3	4
Revenues	170,000	170,000	170,000
Operating expenses	46,300	46,300	46,300
Long-term debt interest	11,000	11,000	11,000
Operating debt interest	0	0	0
Depreciation	10,860	10,860	10,860
Net returns[1]	101,840	101,840	101,840
Opportunity cost	4,076	4,076	4,076
Net returns[2]	97,764	97,764	97,764
Ending cash balance	554,530	202,323	104,998

[1]Net returns to owner's initial capital, management and risk.

[2]Net of opportunity cost of capital.

Table 65. Annual cash flow for a hard clam pen growout system[1] under a learning curve with fluctuating market and environmental conditions.

	Year									
	1	2	3	4	5	6	7	8	9	10
Beginning cash balance	0	0	0	0	0	0	0	80,301	26,179	17,495
Total cash receipts	0	0	34,000	108,000	150,000	170,000	170,000	40,000	95,000	140,000
Total cash outflow										
Operating expenses	46,060	48,693	51,408	53,978	56,677	59,511	62,486	65,611	68,891	72,336
Long-term loan payment										
Principal	1,726	3,534	5,611	6,490	7,348	8,714	11,589	14,581	18,354	20,761
Interest	3,635	6,800	9,856	9,614	9,003	9,142	11,948	13,929	16,440	14,669
Total outflow	51,421	59,027	66,875	70,082	73,029	77,367	86,023	94,121	103,684	107,766
Cash available	(51,421)	(59,027)	(32,875)	37,918	76,971	92,633	83,977	94,121	103,684	107,766
New operating loan	51,421	59,027	32,875	0	0	0	0	0	0	0
Operating loan payment	0	0	0	37,918	76,971	92,633	3,676	0	0	0
Ending cash balance	0	0	0	0	0	0	80,301	26,179	17,495	53,729
Summary of debt outstanding										
Long-term debt balance[2]	28,562	53,130	76,519	73,628	67,681	67,467	87,977	101,496	118,642	101,481
Operating debt balance	51,421	116,618	163,487	145,188	85,639	3,282	0	0	0	0
Interest on operating debt	6,171	13,994	19,618	17,423	10,277	394	0	0	0	0

[1]System designers for 1 million clam harvest capacity.

[2]Initial long-term loan balance - $30,290.

Table 66. Summary of financial information for alternative hard clam production systems.

System	Total Initial Investment[1]	10-Year NPV[2]	10-Year IRR (%)	Year 5 Operating Expense[3]	Year 5 Net Returns[3]	Year 5 Ending Cash Balance	Year 5 Cost Per Clam[4]
Hatchery	$242,474	0	n/a[5]	$ 70,751	$(49,707)	0	$4.61[6]
Nursery							
Upflow	171,150	2,319,942	121.0	102,097	90,398	573,916	0.012[7]
Field tray	80,250	2,980,054	237.7	206,525	133,138	698,768	0.019[8]
Raceway (1 mill.)	27,200	69,768	48.8	11,395	(28)	24,973	0.018[7]
Raceway (6 mill.)	246,386	419,472	40.4	168,523	(8,088)	178,728	0.020[7]
Growout							
Pen	46,600	853,083	76.9	47,720	99,045	188,338	0.068[9]
Bottom-net	20,470	1,121,872	115.2	46,352	114,570	247,247	0.054[9]
Soft-tray	38,037	876,261	84.3	47,250	96,814	199,203	0.069[9]
Integrated pen	611,674	5,297,167	59.2	219,365	602,695	1,282,691	0.063[9]
Integrated soft-tray	556,596	5,822,262	64.9	197,540	612,136	1,438,575	0.062[9]
Less than favorable pen	46,600	10,400	17.9	56,677	59,811	0	0.085[9]

[1] Includes initial owner equity and financed capital.
[2] Discount rate of 15 percent. Initial flow includes initial owner equity and financial capital. Income stream used is ending cash balance.
[3] Values taken from income statements.
[4] Defined as in enterprise budget.
[5] Due to zero cash available for each year.
[6] Cost per 1000 1 mm seed clams.
[7] Cost is per 8 mm seed clam.
[8] Cost is per 15 mm seed clam.
[9] Cost is per 45-50 mm littleneck clam.