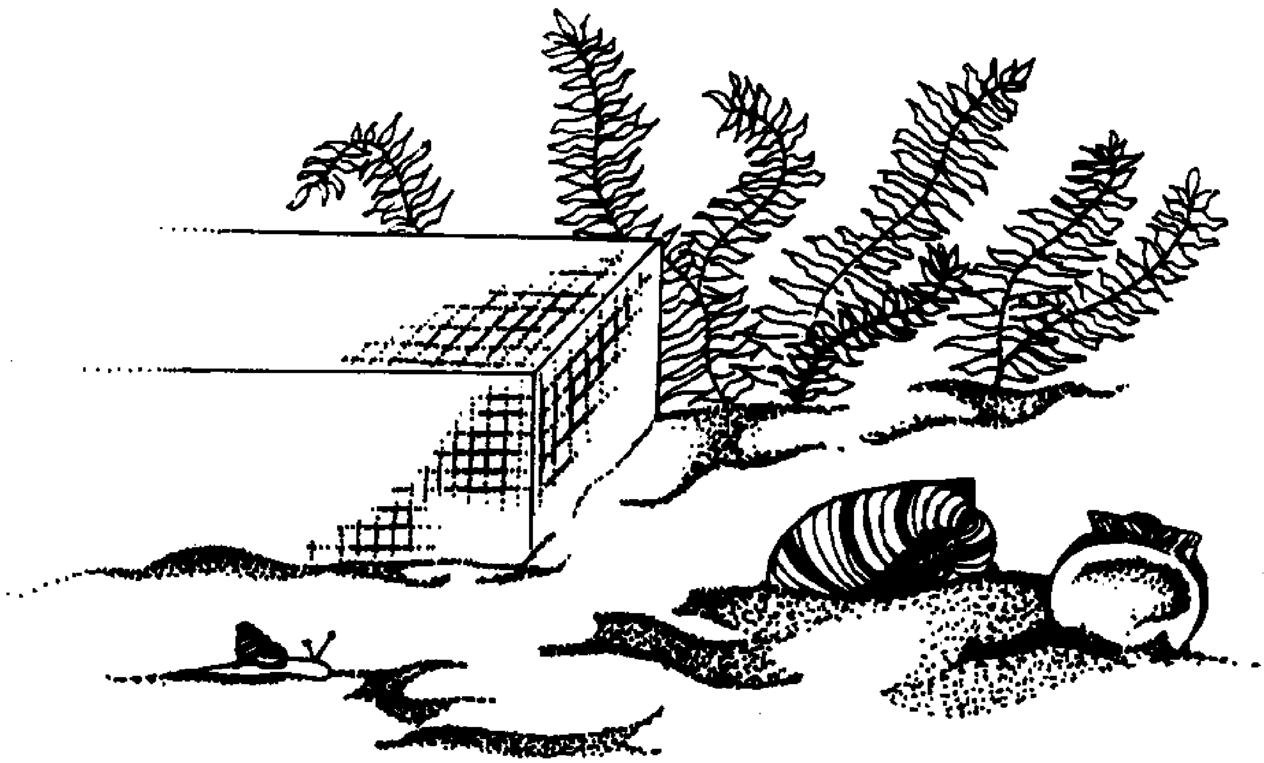
CL.A.M.S.

Climatic Accelerating Maturing System



OCEAN PROJECTS
APRIL 28, 1988

C.L.A.M.S.

Climatic Accelerating Maturing System

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ABSTRACT

In this paper we propose to investigate the feasibility of accelerating the growth rate of the hard clam, Mercenaria mercenaria (Linne) through extension of its growing season. This extension will be accomplished by transporting clams to South Carolina following a single growing season in Massachusetts. Comparison of growth rates between a grow out confined to Massachusetts and a grow out that includes both Massachusetts and South Carolina locations will be made. The feasibility of upscaling our clam operation to 6 million clams is analyzed through two economic scenarios.

From the growth data and the economic forecasts, the grow out utilizing both Massachusetts and South Carolina could be favorable on a large scale. The transportation of clams could be quite successful if accelerated growth rates were achieved and if economic risks were willing to be taken. The grow out confined to Massachusetts could also be profitable on a smaller scale.

INTRODUCTION

The quahog or hard clam, Mercenaria mercenaria is a bivalve mollusk native to the east coast of the United States and Canada. It is found in protected bays and estuaries from the Gulf of St. Lawrence to the Gulf of Mexico, and is most abundant from Massachusetts to Virginia. It is a burrowing organism, found in substrates ranging from soft mud to sand from the intertidal zone to a depths of about fifty feet below mean low water. Generally, Mercenaria mercenaria requires relatively high salinities (greater than 20 ppt) and a temperature range of 8 - 28 C, (46 - 82 F). (Mulholland, 1984)

Mercenaria mercenaria, like other burrowing bivalves, is a filter feeder. It positions itself in the substrate with its muscular foot, and extends its two siphons into the water column. The siphons are essential to feeding, as well as respiration and waste removal. The incurrent siphon is used to pump large volumes of the surrounding water over the gills. These select and sort out food particles through ciliary action. Food particles include phytoplantkon and particulate organic matter (Tiedemann, 1983).

Spawning occurs from spring to fall when the water temperatures are optimum (22 - 28 C). Males and females release gametes into the water column where fertilization takes place. The zygote then develops into a planktonic, unshelled larval stage called the trochophore. A subsequent, shelled larval stage (veliger) occurs within 6 - 12 days and this eventually metamorphoses into a spat stage, and these grow into adult stage upon the bottom. Predation by crabs and carnivorous gastropods often occurs at this point. Maturity is usually attained within 2 to 3 years

(Mulholland, 1984).

Growth in quahogs is a function of both environmental and physiologoical factors. Environmental parameters such as temperature, food concentration, water quality, and current are all important. Quahogs usually experience rapid growth over the first two years of life, and then decrease to a slower but constant growth rate (Manzi, 1988).

Mercenaria mercenaria is of great commerical importance. It is harvested in all fourteen Atlantic coastal states, with the fishery historically centered in southern New England, Long Island, and Chesapeake Bay (Manzi, 1981). In 1986, United States landings for quahogs equalled 1.2x10^6 pounds, with a value of $47 million. Quahogs account for approximately 35% of the value of the total U.S. clam harvest (Anon, 1986).

Quahogs vary in value according to size. Sizes are classified by the names littleneck, cherrystone, and chowder. Littlenecks are the smallest (50.8 - 63.5 mm), cherrystones are medium in size (63.5 - 76.2mm), and chowders are the largest (76.2 + mm). Clams with the greatest commercial value are those within the littleneck range. These clams currently average $0.18 - 0.20 apiece (Tiedemann, 1983).

In recent years clam harvests have been on the decline in traditional areas of production. Overfishing and pollution are largely responsible for the decline. This decreased production, coupled with an increase in demand, have resulted in increased hard clam aquaculture. Mercenaria mercenaria has proven to be a desirable species for aquaculture because it is relatively free from many of the diseases common to other bivalve mollusks. Also, the technology required for its culture is quite simple. As a result, at least 20 corporations are involved in hard clam aquaculture, with the Aquacultural Research Corp. in Dennis, Massachusetts being the largest. Some of the larger corporations devote their efforts to hatchery systems, while others are involved in controlled grow out regimes beyond the hatchery phase. Many smaller, part - time operations exist as well, and are usually engaged in grow out of hatchery raised seed in intertidal and subtidal leased areas. As a result of all these activities, Mercenaria mercenaria has become the most extensively cultured clam species in the U.S. (Burrell, 1983).

The period of time required to raise a quahog to market size (preferrably littleneck) varies from 15 months to 3 years depending upon location of grow out. The fact that grow out to market size takes three years in northern New England can be considered as a major deterrent to potential hard clam aquaculture in this area. It may be possible to achieve a return on such an investment sooner, however, by exploiting Mercenaria mercenaria's different seasonal growing periods in the northern and southern regions of its range. The northern growing period occurs from approximately May to October. In the south, the growing season occurs from October until January and again from March until late May. Transport of clams from north to south in order to take advantage of the southern growing seasons may produce a marketable clam much sooner than an exclusively northern or southern grow out.

The purpose of this project is to investigate the feasibility of accelerating the growth rate of quahogs through extension of its growing season. This extension will be accomplished by transporting clams to South Carolina following a single growing season in Massachusetts. Comparison of growth rates, costs, and returns between a grow out confined to Massachusetts, and a grow out that includes both Massachusetts and South Carolina locations will be made. Results of this comparison will be employed to determine whether growth rates are significantly increased, and subsequently whether transport would be advantageous to a commercial venture.

METHOD AND MATERIALS

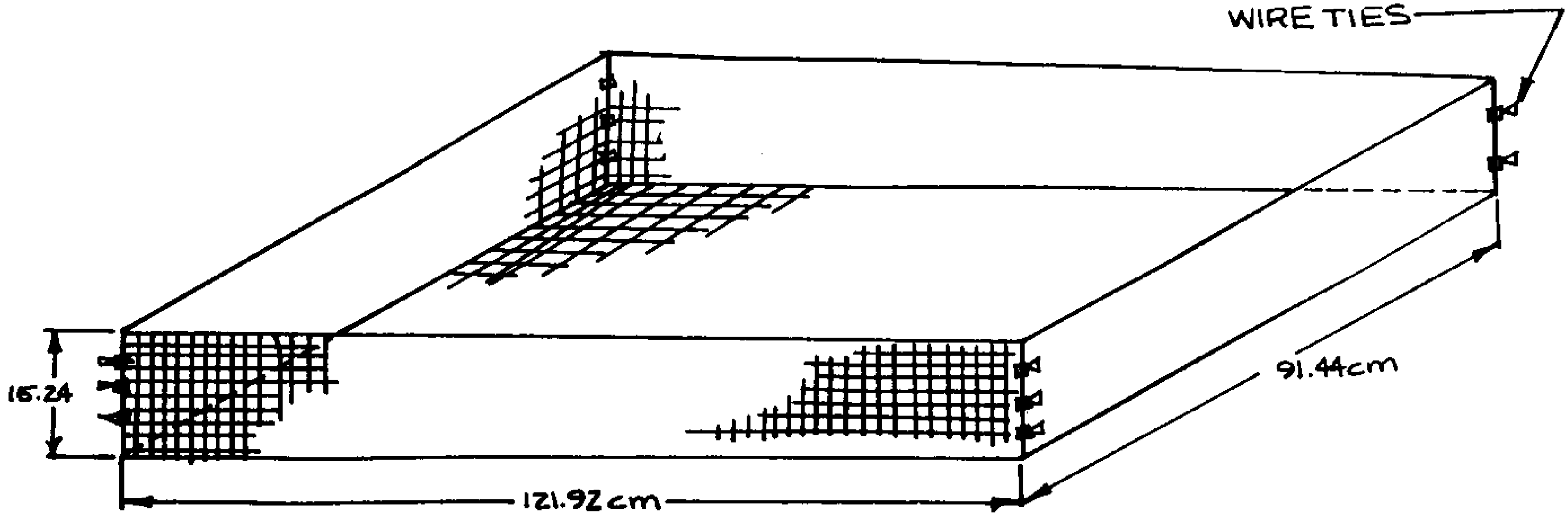
In October 1987, 20,000 seed clams were purchased from the Pleasant Bay Shellfish Farm in Orleans, MA. They had been "planted out" the preceeding May at 1mm in size, and had grown to a mean shell length (anterior to posterior measurement) of 14.8 mm over the six month period. The clams were divided into five predetermined samples of 4,000 clams each, packaged, and transported to South Carolina. There the clams were temporarily held for three weeks suspended in a sluiceway at the Folly Beach Clam Farm. Subsequently four of the samples were taken to the Waddell Mariculture Center in Bluffton, South Carolina after the preparations for their arrival was completed. The fifth sample was left at Folly Beach where it was to be placed in the adjacent estuary.

At the Waddell Center, each of the four samples were placed in, to 1/4 acre man-made pond. In each pond, the sample was distributed about equally among three trays. The trays were fabricated from a 152 x 122 cm piece of vinyl coated wire mesh. The piece was bent into the shape of a tray by folding up each of the four sides by 15.2 cm (Figure 1). The tray was then fastened together using wire ties. To complete the fabrication of the tray, a section of window screen was placed in the bottom to prevent the small clams from falling through.

The sample which remained at Folly Beach was divided among four cages and placed in the adjacent estuary. The cages were burried approximately 10.2 cm into the mud sediment of the intertidal region. The cages housing these clams were constructed to provide a predator free environment. Construction of these cages consisted of two different methods. The first type of cage which was built used a "shoe - box" design. This method of construction was similar to the making of the trays. A 152 x 122 cm piece was again cut from vinyl coated wire mesh. The four sides were bent up and fastened by wire ties. To complete the cage another 152 x122 cm piece of vinyl coated mesh was cut. This time the four sides were bent 7.6 cm downward, and this piece served as the top of the "shoe - box". It was placed over the constructed cage and fastened with wire ties (Figure 2). The cage's bottom was lined with window screen, and the sides with 1/4 inch vexar mesh. The purpose of the lining was to keep the smaller clams from falling out as well as to prevent predators from getting in.

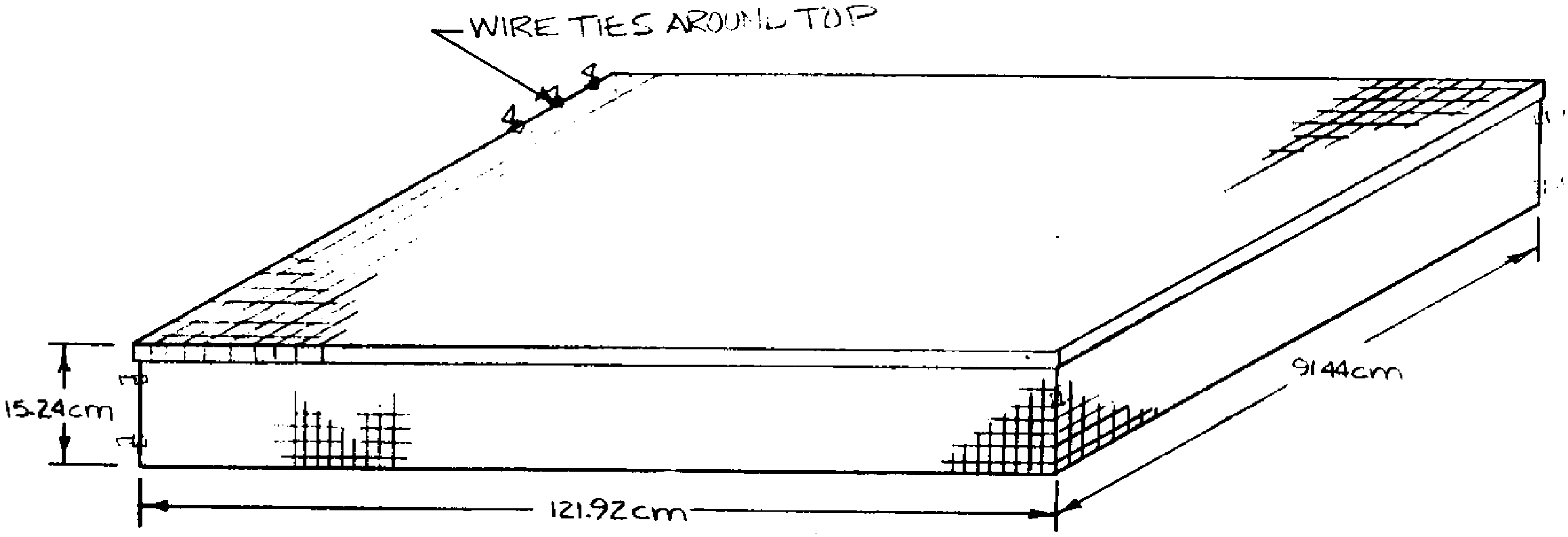
The second method of construction began with a 275 x122 cm piece of vinyl coated wire mesh. This piece was formed into the shape of a rectangular box with the shorter ends left open (Figure 3). The two remaining sides, 25 x122 cm, were then cut and added to the box. This was done by bending in the edges so they would fit into the open ends of the already constructed box. The sides were then fastened with wire ties. For easy access, a fold - up door was cut into the top of the cage. The door, when not in use, was held closed with wire ties. The cages were lined on the bottom with window screen and on the sides with 1/4 inch vexar mesh. Once again this was to prevent the smaller clams from falling out and the predators from getting in.

Anterior to posterior measurement of the clams were made using dial calipers on a monthly basis from January to April, 1988. This procedure was used in measuring approximately 2553 clams. Final measurements were also obtained in April for a control group which remained in Pleasant Bay. Comparison of sizes were made using one way variance of analysis (ANOVA), and when significant differences were found means



TRAY DESIGN

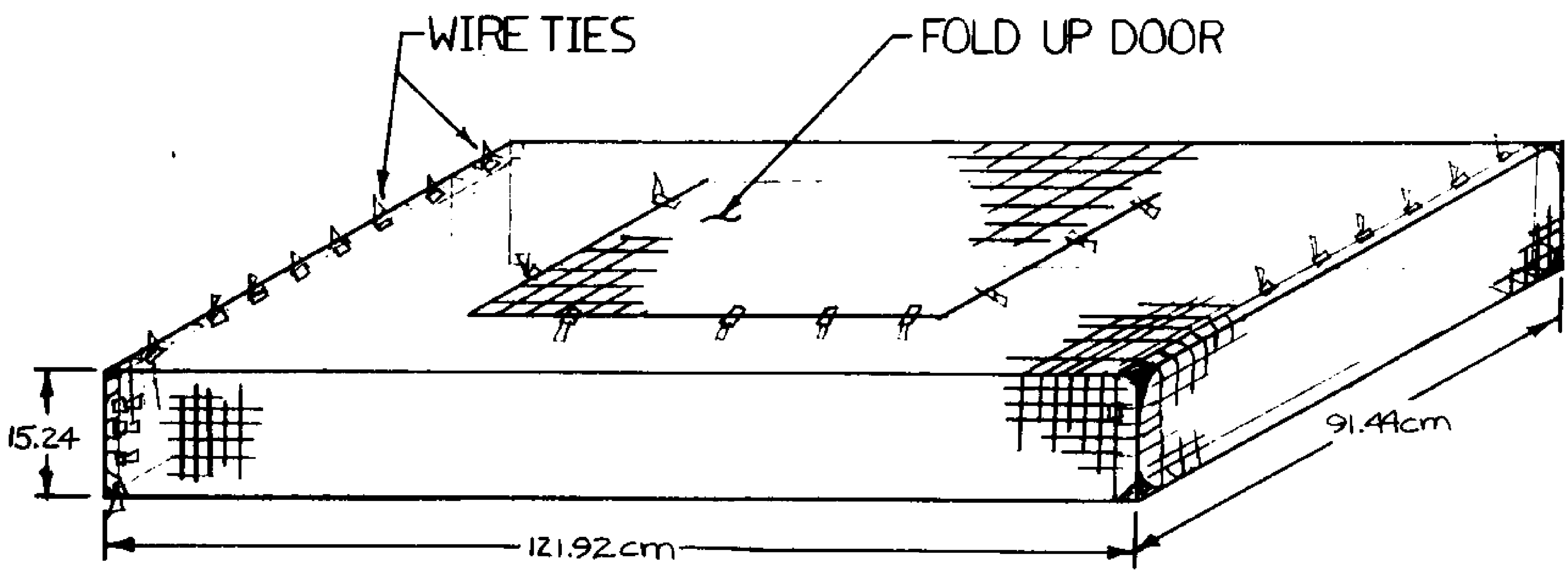
FIGURE 1



FIRST CAGE DESIGN

NOTE: WIRE TIES AROUND DOOR MUST BE REPLACED AFTER USE

FIGURE 2



SECOND CAGE DESIGN

NOTE: WIRE TIES AROUND DOOR MUST BE REPLACED AFTER USE

FIGURE 3

were compared using Student-Newman-Keuls Posterior Test (Sokal and Roholf, 1969).

Results

The initial (October) mean sizes of the clams stocked into the five different locations in South Carolina ranged from 13.54 to 15.16mm (Table 1). There was no significant difference in initial mean size between locations (p >0.05) except that the initial mean sizes of those stocked into pond 11 was significantly smaller (p,0.05) than that of other locations (Table 1).

Mean sizes of M. mercenaria in South Carolina and Cape Cod over the following six months appear in Table 1 and Figs. 4-9. Comparisons of instantaneous growth rates (mm/day) indicate that while growth occured in all locations, it was greatest in the ponds, followed by the estuary, and then Cape Cod (Table 2, Fig.10). The actual increase in mean size of the clams in the South Carolina ponds and estuary and Cape Cod were 26%, 21%, and 03% respectfully.

By the end of the experiment (April), the mean size of the clams in Cape Cod (16.20mm) was significantly smaller than the mean sizes of clams in all locations in South Carolina ($p<0.05$). At the same time, the clams located in the South Carolina estuary were significantly smaller than those in the ponds ($p<0.05$). Some differences were also seen between ponds. Clams in pond 5 were significantly larger than those in pond 8 ($p<0.05$), however those in pond 2 were not different in size from either pond 5 or pond 8.

Table 1: Mean (+/-1 SD) sizes (mm) of M. mercenaria on different dates in different locations. SC = South Carolina.

Location	Date Sampled				
	October	January	February	March	April
Cape Cod	15.08+/- 1.9	----------	----------	----------	16.20+/-2.3
Pond 2, SC	15.16+/-3.1	18.64+/-3.1	19.01+/-3.8	20.02+/-4.3	20.00+/-3.9
Pond 5, SC	15.08+/-1.9	19.20+/-2.8	19.86+/-2.5	20.17+/-2.9	20.61+/-2.9
Pond 8, SC	14.37+/-2.5	17.54+/-2.6	17.64+/-3.0	17.97+/-3.9	19.49+/-3.6
Pond 11, SC	13.54+/-2.0	15.72+/-3.0	14.93+/-3.2	16.17+/-3.0	19.51+/-2.8
Estuary, SC	14.71+/-1.8	17.40+/-2.4	16.10+/-2.5	16.66+/-2.6	18.63+/-2.4

Table 2: Growth rates (mm/day) in M. mercenaria from October 1987 to April 1988 in all Locations. SC = South Carolina.

Location	Growth (mm)	Time (days)	Rate (mm/day)
Cape Cod	1.12	181	0.007
Pond 2, SC	4.84	181	0.027
Pond 5, SC	5.53	181	0.031
Pond 8, SC	5.12	181	0.028
Pond 11, SC	5.97	181	0.033
Estuary,SC	3.92	181	0.022

FIGURE 4: Mean (+/- 1 SD) Sizes of M. mercenaria on Different Dates in South Carolina Estuary

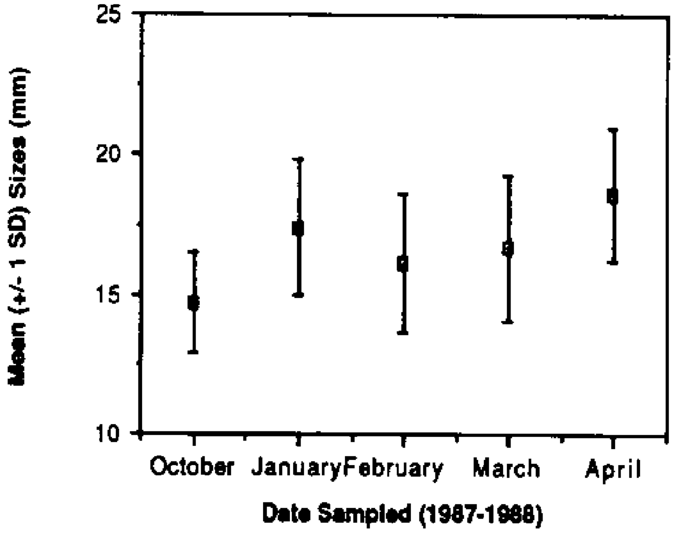


FIGURE 5: Mean (+/- 1 SD) Sizes (mm) of M. mercenaria on Different Dates in Pond 11

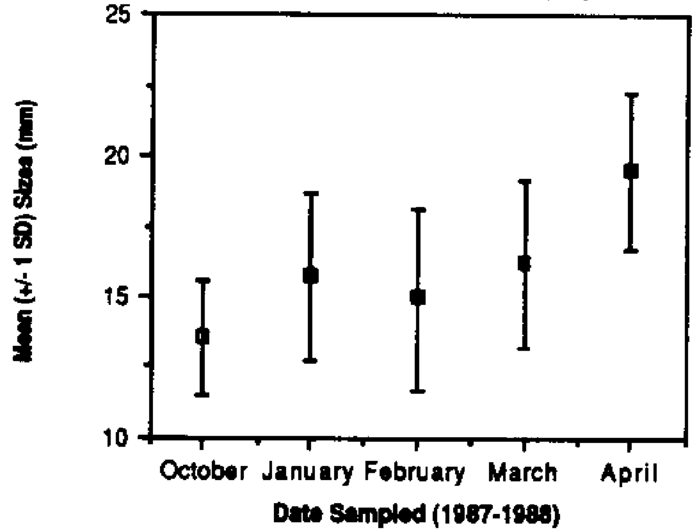


FIGURE 6: Mean (+/- 1SD) Sizes (mm) of M. mercenaria on Different Dates in Pond 8

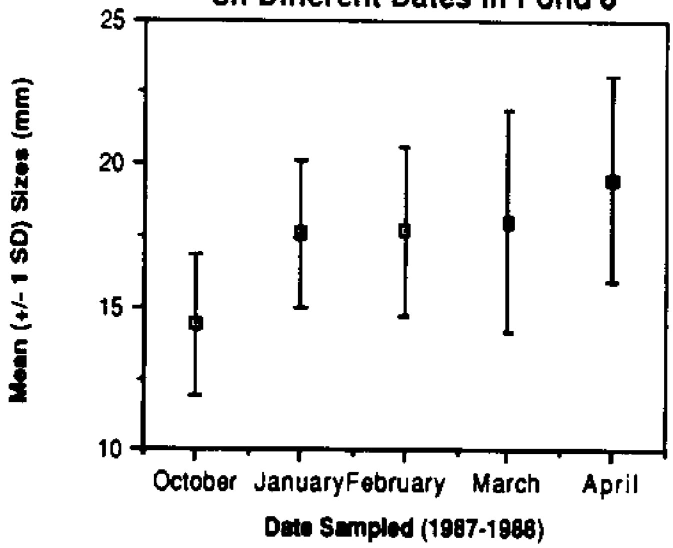


FIGURE 7: Mean (+/- 1SD) Sizes (mm) of M. mercenaria on Different Dates in Pond 5

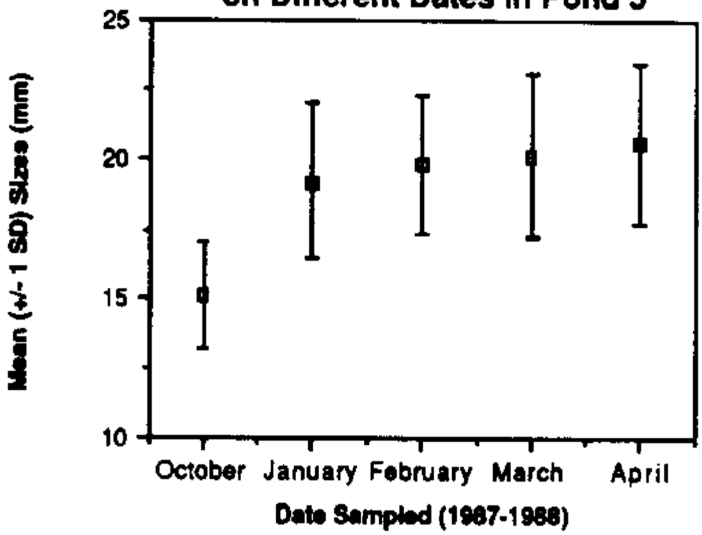


FIGURE 8: Mean (+/- 1 SD) Sizes (mm) of M. mercenaria on Different Dates in Pond 2

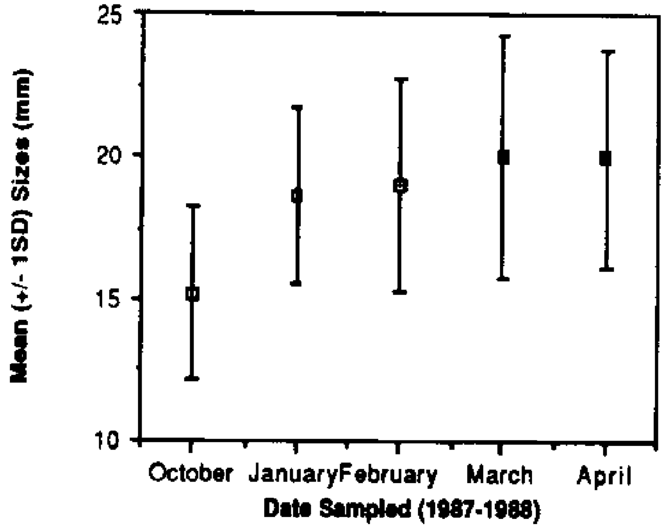


FIGURE 9: Mean (+/- 1 SD) Sizes (mm) of M. mercenaria on Different Dates in Cape Cod

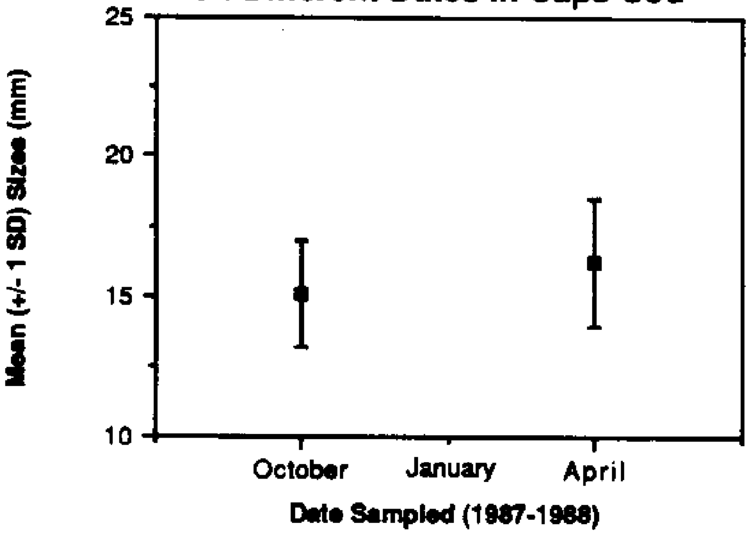
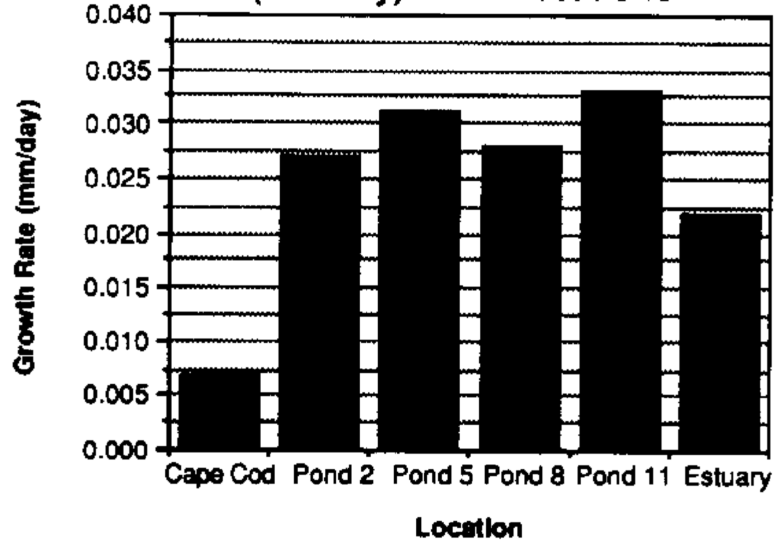


Figure 10: Comparison of Growth Rates (mm/day) in All Locations



ECONOMIC ANALYSIS

"THE COST AND BENIFITS OF TRANSPORTING QUAHOGS"

Scenario #1: Growth of Mercenaria mercenaria from 8-10mm to market size including transport of clams to and from South Carolina and New England.

Six million 8-10mm quahogs will be purchased in April of each year. Clams will be planted out over a five day period in a 1/2 acre New

England intertidal bottom grant. They will then be covered with panels of 1/4 inch vexar overlain by a grid of 3/8 inch lead core line which will decrease mortality from predation. Based on research literature, the clams will be stocked at a density of 3000/m^2 (275/ft^2). At the end of the first growing season in October the clams will be harvested over a five day period and trucked to South Carolina.

The clams will be planted out in a leased six acre shrimp pond which will have been lined over a one acre area with 1/4 inch vexar mesh. The purpose of the transport is to extend the growing period of the clams so that they will reach a harvestable size over a shorter elapsed time. In April, the clams will again be harvested and returned to New England for their final grow out. For the final grow out the clams will be distributed over the two acre portion of the grant while the next group of 6 million clams are planted. When clams have been reached the desired size, they will be harvested over a 12 week period in the fall when prices are assumed to be the highest. Harvesting will be accomplished by hand or bull raking by ten employees, using a boat and barge for transport purposes. Assuming that the required growth takes place, each qroup will be fully harvested at the end of each 30 month period. Labor and supervision will be taken care of by two full time employees. Extra labor will be hired as needed for planting and harvesting.

Scenario #2: Growth of Mercenaria mercenaria from 8-10mm to market size in New England.

Six million 8-10mm quahogs will be purchased in April of each year.

Clams will be planted out over a five day period in a 2 acre New England intertidal bottom grant. They will then be covered with panels of 1/4 inch vexar overlain by a grid of 3/8 inch lead core line which will decrease mortality caused by predation. Based on research literature, the clams will be stocked at a density of 750/m^2 (70/ft^2) .

The clams will remain under the predator netting for 2 years. After 2 years the vexar and lead line will be removed and placed over the newly planted seed. The clams will remain in the two acre area until they are harvested. The clams will be harvested over a 12 week period in the fall when prices are assumed highest. Harvesting will be accomplished by hands or bull raking by ten employees. This will be done using a boat or a barge for mainly transport purposes.

Labor and supervision will be taken care of by two full time employees. Extra labor will be hired as needed for planting and harvesting.

ASSUMPTIONS AND EXPLANATIONS

1. A pickup truck is used for all general transportation needs. The refrigerator insert is used to transport market size clams to buyers during the twelve week harvest period.
2. A work boat and barge are used in the estuarial waters of New England for transport, planting, and harvesting.
3. A trailer office can be used in New England and South Carolina for all management and labratory purposes.
4. The half acre piece of land will be purchased in New England near the clam flats in order to provide room for the office, work shed, and other equipment.

5. The cost of clam flats in New England are $25/acre.

6. All estimated costs are rounded up to the nearest one hundred dollars.

7. Cost of extra labor: $8/hour for routine labor

$15/hour for harvesting market clams

8. All planting and harvesting for transport will be accomplished over a five day period to minimize time clams are out of their natural environment.

9. One man can harvest 10,000 market size clams in per day.

10. All costs and survival rates were estimated from information provided by Biosphere, Aquaculture Research Corp. (ARC) and other industry sources.

11. Large tractor - trailor refrigerator truck is used for transportation of clams to South Carolina and back to New England, as well as the transport to market.

12. All estimated administrative costs are considered necessary due to the large scale of production.

13. Purchase price of the clams is $30/1000 clams when they are 8 - 10 mm. Selling price of the clams is $0.20/clam when they are 50mm. Prices are based on current prices and are subject to change.

14. Sales costs are estimated at 3% of selling price for marketing equipment and materials.

15. The cost of the 1/4 inch polyethlene vexar netting is $46/200 ft^2 as quoted from ADPI Enterprises Inc..

16. Federal , state, and local income tax has been taken as 50%.

17. Seed is always bought in the spring (around April 15). Market size clams are always harvested in the fall (September, October, and November).

18. Clams to be transported will be initially planted at a density of 3000/m^2 (275/ft^2) for the reason of growth (Walker, 1984).

19. Clams that be will grown out to full size without being moved will be planted at a density of 750/m^2 (70/ft^2).

20. An acceptable density of1800/m^2 (170/ft^2) has been chosen for the ponds, considering the size of the clams at that time.

21. Depreciation is considered to be linear over the estimated lifetime.

22. The fiscal year begins on April 15.

23. The analysis period is 5 years.

24. Once the clams are over 25mm in length, they no longer need the predator netting.

25. The cost of the lead core line is $40/100 ft. It is stretched over the vexar in a 10 x 10 ft^2 mesh pattern.

26. As a result of the data, the clams for both scenarios are not harvestable until the third fall season (30 months).

INITIAL INVESTMENTS

	SCENARIO 1	SCENARIO 2
1. EQUIPMENT		
TRUCK-PICKUP WITH REFRIGERATOR BODY INSERT (FOR FINAL HARVEST)	30,000	30,000
WORK BOAT	5,000	5,000
WORK BARGE	5,000	5,000
TRAILER OFFICE	25,000	25,000
KEVAR 1/4 inch	13,100	40,100
LEAD CORE LINE 3/8 INCH	900	7,200
MISC. EQUIPMENT, ETC..	7,000	7,000
SUBTOTAL 1:	**86,000**	**119,300**
2. LAND PURCHASE- NEW ENGLAND		
SHORE LOT (1/2 ACRE)	150,000	150,000
WORK SHED	15,000	15,000
SUBTOTAL 2:	**275,000**	**306,300**

3. <u>LAND IMPROVEMENTS</u>		
ROAD, DOCK, GRADING, ULITITIES	20,000	20,000
4. LICENSES, LEGAL FEES, INCORPORATION PAPERS	4,000	2,000
<u>TOTAL:</u>	**273,000**	**277,000**

ANNUAL DEPRECIATION

	SCENARIO 1	2
1. TRUCK (5 YEARS)	6,000	6,000
2. WORK BOAT (5 YEARS)	1,000	1,000
3. BARGE (5 YEARS)	1,000	1,000
4. TRAILER OFFICE (7 YEARS)	3,600	3,600
5. MISC. EQUIPMENT, FURNITURE, ETC... (7 YEARS)	1,000	1,000
6. LAND IMPROVEMENTS (10 YEARS)	2,000	2,000
7. WORK SHED (10 YEARS)	<u>1,500</u>	<u>1,500</u>
<u>TOTAL</u>	**16,100**	**16,100**

ANNUAL OPERATING COSTS

	SCENARIO 1	SCENARIO 2
1. LAND LEASING AND RENTAL		
NEW ENGLAND - $25/ ACRE	200	200
SOUTH CAROLINA LEASE-SHRIMP POND	6,000	-----
SUBTOTAL 1:	**6,200**	**200**
2. PERSONAL-LABOR		
TWO PROFESSIONAL CLAM FARMERS (FULL TIME)	50,000	40,000
EMPLOYEE BENEFITS (20%)	10,000	8,000
PART TIME LABOR		
NEW ENGLAND - LAY SEED (5 DAYS , 3 TO 4 PEOPLE)	1,000	1,300
NEW ENGLAND - LAY CLAMS FROM SOUTH CAROLINA (5 DAYS, 2 PEOPLE)	700	-----
NEW ENGLAND - HARVEST FOR TRANS. (5 DAYS, 10 PEOPLE)	3,200	-----
SOUTH CAROLINA - LAY CLAMS FROM NEW ENGLAND (5 DAYS, 4 PEOPLE)	1,300	-----
SOUTH CAROLINA - HARVEST FOR TRANS. (5 DAYS, 5 PEOPLE)	1,600	-----
SUBTOTAL 2:	**67,800**	**49,300**

	SCENARIO 1	SCENARIO 2
3. SUPPLIES, EQUIPMENT AND SEED		
COST OF SEED ($30/1000)	180,000	180,000
FUEL - TRUCK, BOAT, BERGE, PUMPS	3,000	2,000
REFRIGERATOR TRUCK RENTAL N.E - S.C. (1 WEEK FOR TRACTOR 3 WEEKS FOR TRAILER)	10,000	-------
RAKES, SMALL TOOLS, POWER TOOLS	1,000	1,000
ONION BAGS	100	100
MISC. MATERIALS	2,000	1,000
SUBTOTAL 3:	**196,100**	**184,100**
4. ADMINISTRATIVE		
GENERAL MANAGER, SALES MANAGER CONSULTANT (1/2 TIME)	30,000	30,000
ACCOUNTANT FEES	3,000	3,000
TRAVEL, TELEPHONE, COPYING	12,000	8,000
LIVING COST IN S.C. FOR 2 PEOPLE SIX MONTHS	6,000	------
ALL INSURANCE EXPENSES	5,000	4,000
SUBTOTAL 4:	**56,000**	**45,000**
TOTAL	**326,100**	**278,600**

INCOME AND ADDITIONAL COSTS (HARVEST AND SALES) FOR YEARS OF HARVESTING MATURE QUOHOGS

	SCENARIO 1	SCENARIO 2
1. INCOME FROM 80% SURVIVAL ($0.20/ QUOHOG)	960,000	960,000
2. COST OF HARVESTING (12 WEEKS, 10 PEOPLE, $15/HR.)	-72,000	-72,000
3. SALES COST (3%)	-28,800	-28,800
TOTAL	**859,200**	**859,200**

DURING YEARS OF SALES

	SCENARIO 1	SCENARIO 2
1. GROSS PROFIT	533,100	580,600
ANNUAL DEPRECIATION	16,100	16,100
2. TAXABLE INCOME	517,000	564,500
3. TAXES: STATE, FEDERAL, LOCAL (50%)	258,500	282,250
4. NET PROFIT	258,500	282,250
5. CASH FLOW NET PROFIT AND DEPRECIATION	274,600	298,350

CASH FLOW TABLE FOR
ENTIRE ANALYSIS PERIOD (5 YEARS)

YEAR	SCENARIO 1	SCENARIO 2	
0	-273,000	-277,000	- FIXED COST
1	-326,100	-278,000	- OPERATION COST
2	-326,100	-278,000	- OPERATION COST
3	+274,600	+298,350	- CASH FLOW-PROFIT
4	+274,600	+298,350	- CASH FLOW-PROFIT
5	+274,600	+298,350	- CASH FLOW-PROFIT
	ROR = -4%	ROR = 1.25%	

DISCUSSION

According to Eldridge et al, (1976, 1979) and Menzel (1963), M. mercenaria grow year round in the Southeastern United States with fastest growth occuring in fall and spring. In Massachusetts, growth in quahogs occurs primarily in summer months. (Belding, 1931) The purpose of this study was to show that by transporting clams from Cape Cod to South Carolina , it would be possible to decrease the time that it takes clams to grow to market size. This would be done by allowing clams to grow year round under optimum conditions associated with growth periods of the two regions.

The results of final mean size (mm) of clams indicated that clams in Cape Cod were significantly smaller than those in South Carolina (p <05). These findings imply that transport to South Carolina would increase growth over the winter months.

Another objective of this experiment was to show that transport would increase growth in clams to enable a commerical size (50mm) to be obtained in 15 months, The growth rate of clams in South Carolina was determined at .66 to 1.00 mm/month. Based on the growth observed in this study, it would take substantially longer to reach the 50mm size than was desired. A study by Walker and Humphrey (1984) found that different Massachusetts clam stocks responded variably to growth in southeastern United States waters. In comparison to this study Walker and Humphrey (1984) and Manzi and Hadley (1984) observed growth rates of 1.3 to 2.3 mm/month for Massachusetts clams transported south. A growth rate of 2.3 mm/month would enable the desired 15 month period to be met. If they remained in South Carolina.

Comparisons of other studies have shown varying degrees of growth based on initial size and density of planting. In a study by Eldridge etal. (1979) seed clams (13mm) planted out at low densities (290/m^2) in South Carolina attained sizes of 45mm in 19 months. Clams (11mm) planted out in South Carolina at varying densities (380,760,1520, and 3040 clams/m^2) reached 40mm in 13 months but final densities were essentially identical due to mortality (Manzi et al., 1980). Walker (1984) in an experiment with clams (6mm) planted in Georgia at low densities (509/m^2) reguired only 18 months to become 49mm. These studies indicate that it would be potentially feasible to grow commerical sized little necks in 15 months in South Carolina.

In this study, there were several factors which could have been related to the inhibition of growth in these clams. The clams were transported to South Carolina in mid October, 1987 for planting. The ponds at the Waddell Center however were not ready for the arrival of our clams due to delays in cleaning. For this reason, the clams were held under crowded conditions at the Folly Beach Clam Farm for a period of four weeks before planting. After being planted the clams were not fed or supplied with any water circulation because of other experiments in these ponds. Based on these conditions, the clams were probably under considerable stress during this experiment. Furthermore, a study by Walker (1984) has indicated that clams sampled monthly (which this study's were) will grow considerably slower than those sampled seasonally. This is related to stress which the clams must endure while being sampled. Interpretation of the testing environment of this experiment and the results of other studies (Eldridge etal., 1979; Manzi etal., 1980; Walker 1984; Walker and Humphrey, 1984; and Manzni and Hadley, 1984) indicate that under better conditions growth could be significantly increased.

In the statistical analysis of data, pond 11 was not considered because the initial size of these clams was significantly smaller than all other locations ($p<.05$). Table 2 shows, however that the clams in pond 11 had the highest growth rate of all locations. By the end of the experiment these clams had also achieved a size comparatively equal to all the others (table 1).

The growth results of this experiment were used in determining the economic feasibility of a commerical scale-up to 6 million clams. The cash flow table for the analysis period shows the net dispursements as negative and the net receipts as positive. With the dispursements being the funds invested, the rate of return can be calculated from this table.

The fixed costs at year =0 are nearly the same for both scenarios. The operational costs seen at year 1 and 2 are higher for scenario 1 due to the extra labor and transport costs. During the years of sales (years 3, 4, and 5) the cash flow for scenario 2 is higher due to the lower operating costs.

With both scenarios based on the experimental growth, scenario 2 can be seen as the better investment. This is because of all of the extra capital needed in scenario 1. The extra growth during the winter months did not allow the clams to be harvested a year earlier as originally expected.

The result is a 1.25% rate of return with no transporting and a -4% rate of return with the transporting. If, however, growth over the winter months could be improved in South Carolina, the clams could be harvested a year earlier. This would effectively inceases the rate of return for scenario 1 to 23.5%.

The value of accelerating clam growth can be recognized from this example. The feasibility of this study is very sensitive to whether or not the clams can be harvested a year early with the aid of transportion to South Carloina.

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