Hard Clam Extended Culture Trials
1999-2000

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Including Comparisons to Results of Past Years

Prepared for

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Table of Contents

I. Introduction..... 1

II. Methods and Materials 3

III. Results 5

Figure i – Location Map 6
Figure ii – Water Temperatures 1999-2000 7
Table 1 – Screen Covered Boxes 8
Table 2 – Shellfish Bags, Including Deployment Timing Comparison 10
Table 2a – Shellfish Bags, Density Comparison 14
Table 3 – Screened Plots 16
Table 4 – Potted and Un-potted plots..... 19

IV. Discussion 20

Figure 1a – Annual Survival in Trays and Boxes 1993-2000 25
Figure 1 – Survival in Boxes, One and Two Year Seed 1999-2000 26
Figure 2 – Survival in Shellfish Bags 1999-2000 27
Figure 2a – Survival in Shellfish Bags by Density 1999-2000 28
Figure 2b – Annual Survival in Shellfish Bags 1997-2000 29
Figure 3 – Survival in Screen Covered Plots 1999-2000 30
Figure 4 – Survival in Potted and Un-potted Plots 1999-2000 31
Figure 4a – Crab Catch 1999-2000 32
Table 5 – Labor and Materials Costs and Survival 1999-2000 33
Table 6 – Cost/Survival Ratios and Rankings 36

1999-2000 Extended Culture Trials

Introduction

The East Hampton Town Shellfish Hatchery has been producing clam seed for stocking of public grounds since 1990. Clams are started in the hatchery beginning in late winter, held through the growing season and seeded into natural bottom in the fall. Seeding practice originated with a philosophy of 'reinforcing success', targeting naturally productive areas identified with the help of baymen and elected officials. A portion of seed was also planted in less productive areas to try to establish new beds. The success of seedings has been erratic, but in some years certain areas yielded significant harvests.

Early on, in an attempt to objectively define the seed survival issues, the hatchery began assessing overwinter survival and in some cases subsequent second year survival and growth of yearling seed clams. This experimentation revolved around the size of the seed upon introduction into the sediment, the type of sediment into which the seed was introduced, the timing of the introduction into the receiving sediment (especially with respect to temperature) and the presence or absence of predator protection through the assessment period. Much of the work involving seed size, planting timing and sediment type saw minor differences, but the devastating effect of predators across the board was unmistakable. In addition, bay constables conducted harvest surveys, enabling the identification of more and less successful planting locations and grow-out practices were modified to favor the holding of seed in field grow-out systems in order to yield a larger average seed size for the major fall plantings. All of these efforts were on going and by late 1998 plans were being made for an assessment of the effectiveness of trapping crabs as a means of predator control in large planted plots.

In early 1999 a shellfish hatchery advisory committee was formed consisting of hatchery staff and representatives of the East Hampton Town Board, Town Trustees and commercial and recreational shellfish interests. Critical assessment of the program found as its focus the issue of presumably too few obvious and significant increases in hard clam harvests. Committee discussions led the hatchery to propose four different options as to how it might proceed with its work in the 2000 season and perhaps beyond. Option one involved focusing on oyster seed production only; this being the species most favorably inclined to resource enhancement. Option two would forgo the season's production in an effort to exhaustively assess extended culture of clam seed. Option three would have the hatchery focusing strictly on maximizing seed production while assigning grow out and extended culture to a host of growers in a public/private aquaculture model, and the fourth option would maintain the status quo. Members of the committee returned to their respective boards to discuss these options. They settled on a recommendation that the hatchery pursue normal seed production *and* assessment of extended clam culture in a ratio of effort of sixty to forty percent. A proposal was developed by the hatchery, presented to the committee and accepted. The resulting work forms the basis of this report.

The extended culture assessment effort includes four basic seed planting methods undertaken in five Town harbors and analyzed for survival and growth over a one-year period. Some methods compare early and late planting times using smaller and larger seed respectively. A cost benefit breakdown of each method is also presented. The methods include:

- Small screen covered sediment filled boxes designed to yield continuing background survival data, adding to information collected since 1993-94. In addition, two-year old clam seed is also deployed alongside one-year old seed in order to assess the difference in survival between these two age classes.

- Clam seed deployed in shellfish growing bags is also designed to yield data building on information collected since 1997-98. This method is a modification of commercial practice in Florida.

- Direct bottom plantings into small screen covered plots also builds on findings from 1998-99. This method follows commercial techniques used in Virginia and Massachusetts.

- Large plot field plantings, half of them protected by crab pots assesses typical seeding practices carried out by public shellfish enhancement efforts. In particular, this survey evaluates the advantages afforded by this form of predator elimination.

Methods and Materials

1. 2'X2' Sediment Filled Boxes with 1 Year and 2 Year Old Clams

Set-up and Treatment

- To compare survival of two age classes at end of one year.
- Boxes filled with sediment typical of the deployment location and stocked at 200 clams/box (50 clams/sq. ft.).
- Boxes covered with ¼" screen.
- 10 boxes deployed into each of 3 harbors: Northwest, Three Mile, Lake Montauk, near the screen-covered plots. All deployed late (October).
    1. 5 boxes each with 1 yr. clams.
       5 boxes each with 2 yr. clams (from 98-99 bag experiments).

Sampling

- Survival and growth checked in mid-July, 2000.
    1. All clams counted and measured.

2. Shellfish Growing Bag Culture

Set-up and Treatment

A. Straight Comparison Assessments.

- A total of 33, 1/4" mesh vexar bags (3.5'x2'x3") were deployed for comparisons between harbors and with screen-covered plots.
- Bags stocked at 1000 clams/bag, deployed early (August) and late (October).
- 6 bags deployed into each of 5 harbors near screen-covered plots (see screen plot section for harbors), with 3 additional bags into Skunk's Hole (known soft bottom), Napeague.
    1. 3 bags deployed early: August (15 bags).
    2. 3 bags deployed late: October (15 bags).

B. Stocking Density Assessments and Comparisons.

- A total of 21 bags were deployed for density experiments.
- Bags stocked at 500, 1000, 2000, and 3000 clams/bag.
- 3 bags per stocking density and deployed in October into Fresh Pond (12 bags).
- 3 bags per stocking density and deployed in October into Three Mile Harbor -the bags stocked at 1000 per bag in TMH in October will be covered by bags in A above (9 bags).

3. Screen- covered plots

Set-up and Treatment

- 20’ X 14’ plots, prepared by hand raking and seeded with ± 30,000 clams (stocking density ~100 clams/sq. ft), then covered with ¼” mesh bird netting.
- A total of 10 screen-covered plots were deployed, 2 plots in each of 5 harbors: Northwest Creek, Three Mile Harbor, Accabonac Creek, Napeague Harbor and Lake Montauk.
    1. One plot per harbor seeded early: August (5 plots).
    2. One plot per harbor seeded late: October (5 plots).

Sampling

- Survival and growth checked by suction dredge from late June through mid-July , 2000. Fifteen randomly located 2 sq. ft. samples per plot.

4. Potted and Un-potted Plots

Set-up and Treatment

- 1 acre plots (50,000 sq. ft. or 200’ X 250’). All plots seeded with 250,000 clams (5 clams/sq. ft.) and half the plots additionally seeded with 50,000 oysters (0.5 oysters/ sq. ft.). All plots seeded late (October).
- 4 one acre plots in Three Mile Harbor :
    1. 2 plots each with 32 green crab traps deployed in such a way as to trap crabs both inside and in a perimeter around the plot. The traps were baited with bunker and fished twice a week for two weeks prior to seeding, and fished twice a week until mid-November, then once a week until mid January when ice covered harbor. Resumed potting once a week in March, upped to twice a week in July. One plot located under Sammis beach, and the other on west side of harbor south of Boy’s Harbor.
    2. 2 plots each with no green crab traps located near potted plots described above.

Sampling

- Plots suction dredge sampled in summer/fall of 2000. Survival and growth assessed.
    1. Thirty randomly located 40 sq. ft. samples taken from each plot.
    2. Sampled plots near Sammi’s Beach in late July, 2000.
    3. Sampled plots near Boy’s Harbor in late July, 2000.

Results

Results of the different 1999-2000 treatments by location are cataloged in Tables 1, 2, 2a, 3 and 4. A map of the treatment locations is presented as Figure i and the year's temperature as recorded at the Commercial Dock in Three Mile Harbor is presented as Figure ii. The experimental information is grouped under the general headings of deployment, winter observation and retrieval. Sub-categories include:

Deployment

- Date of deployment.
- Whether the deployment is early or late.
- Water temperature at deployment.
- Depth of water at the test site.
- Average seed size at deployment.
- Age of the seed at the time of deployment.
- Total number of seed deployed in the treatment.
- Planting density of the seed.

Winter Observation

- Date of the observation.
- What the observation was.
- Action taken relative to the observation.

Retrieval

- Date of the retrieval.
- Water temperature at retrieval.
- Condition of gear at retrieval, if applicable.
- Percent of clams recovered where applicable.
- Percent survival of clams in the treatment.
- Average seed size of the live clams at retrieval.
- Average size of dead seed (shell) at retrieval.

Figure i

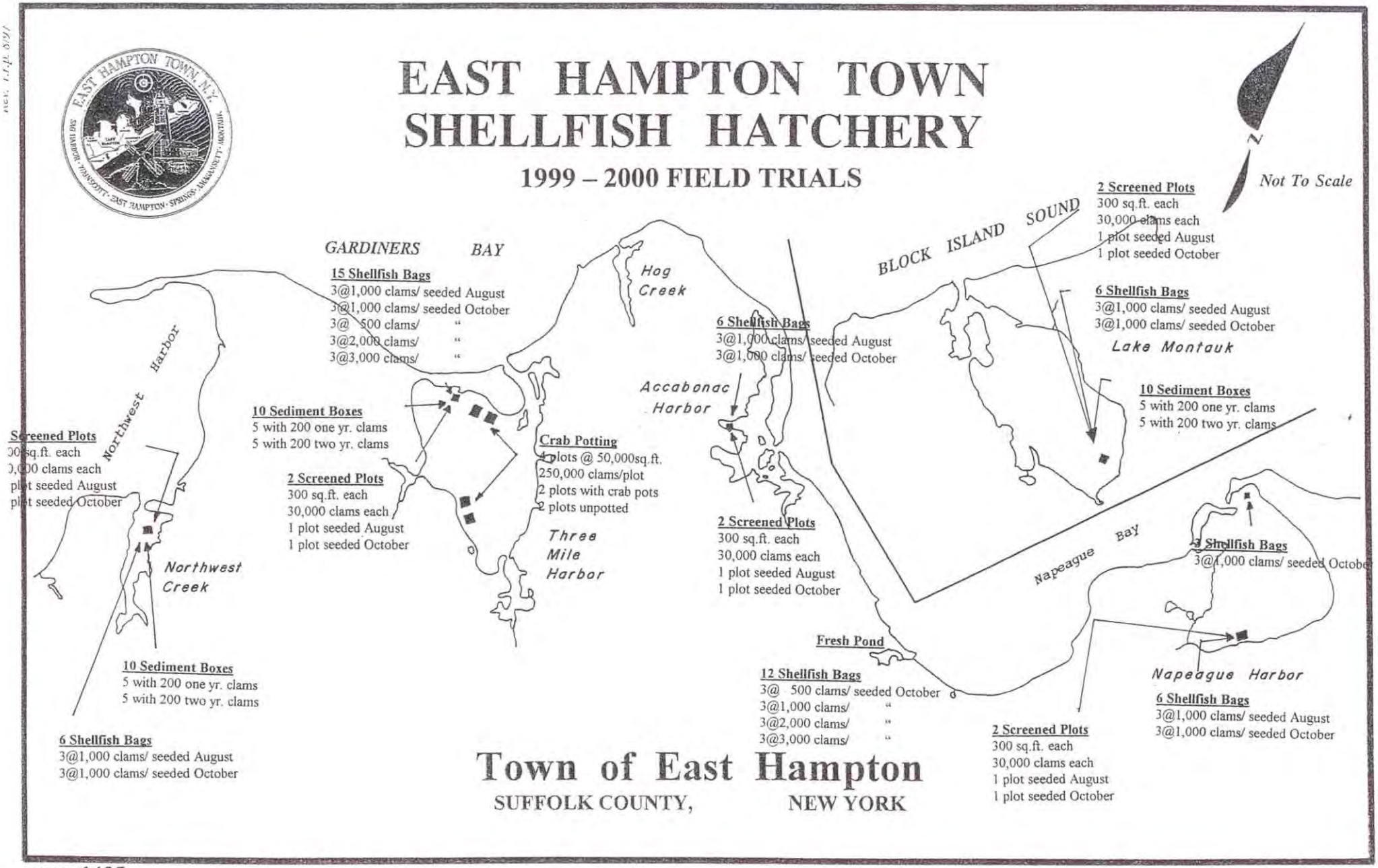

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Figure ii
Water Temperature at Commercial Dock, Three Mile Harbor, 2000

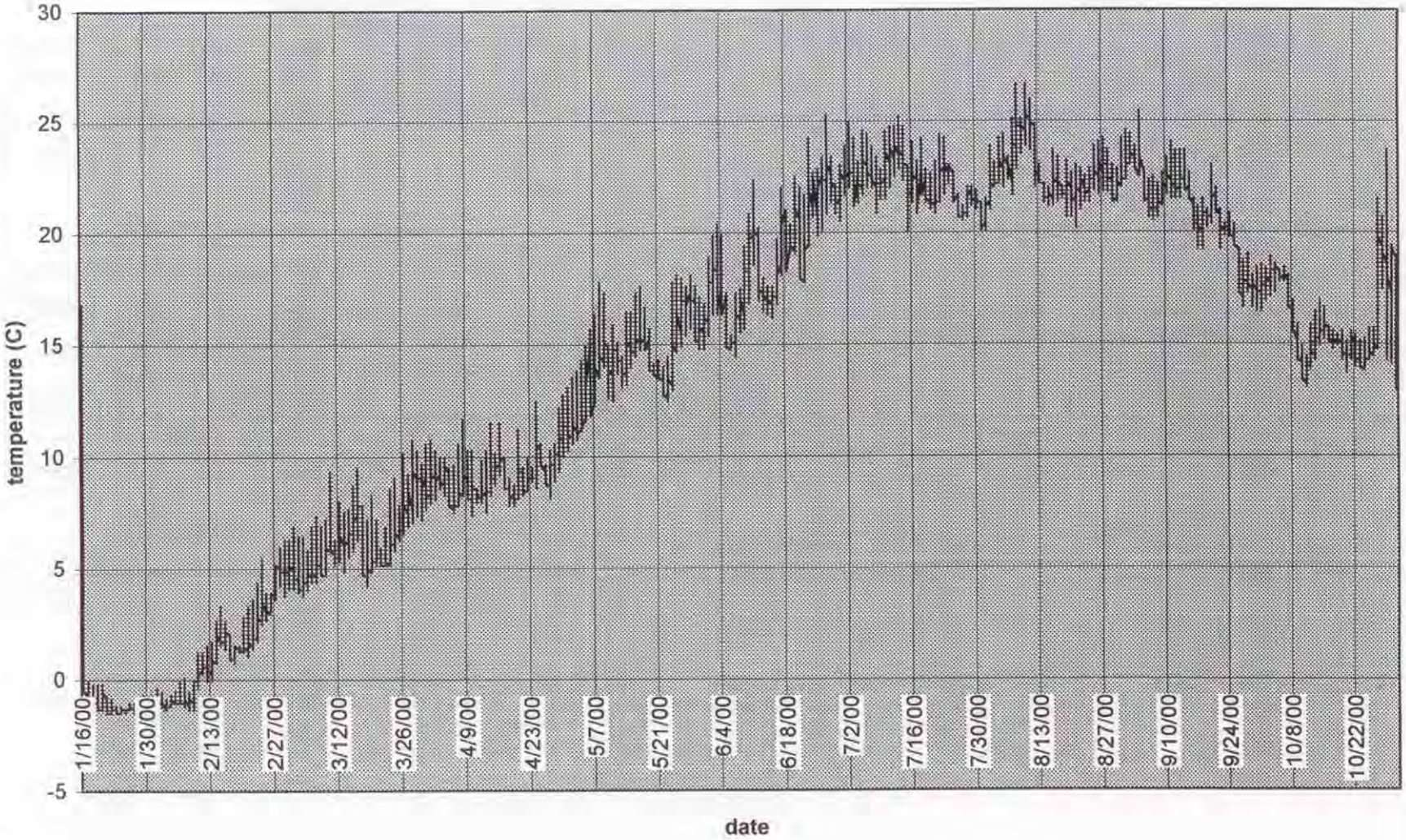

Table 1. Screen-covered Boxes

30, 2' X 2' boxes filled with sediment and covered with 1/4" mesh netting.
10 boxes in each of three harbors; five with first year clams and five with second year clams.

	Deployment									Winter Observation			Retrieval					
location/ description	date of deployment	early/late	temperature (degrees C)	bottom type	depth @ MLW (feet)	average seed size (mm)	age of seed (months)	# of seed	planting density (per sq. ft.)	date	observation	action taken	date	temperature (degrees C)	gear condition	% recovered	% survival	average see live (mm)
Northwest Creek first year clams	10/26/99	L	13	mud/ sand	3.5	15.5	6	200	50	12/04/99 1/17/00 3/02/00 5/08/00	okay ice on harbor okay "	no action " " " " " "	7/11/00	24	screen 25% covered w/ algae	88.2	54.4	24.2
second year clams	10/26/99	L	13	mud/ sand	3.5	22.3	18	200	50	12/04/99 1/17/00 3/02/00 5/08/00	okay Ice on harbor okay "	no action " " " " " "	7/11/00	24	screen 25% covered w/ algae	99.8	97.2	28
Three Mile Harbor first year clams	10/22/99	L	14	sand	3.5	15.5	6	200	50	12/04/99 1/17/00 3/02/00 5/13/00	okay ice on harbor okay "	no action " " " " " "	7/12/00	24	screen 25% covered w/ algae	95.5	71	24.1
second year clams	10/22/99	L	14	sand	3.5	22.3	18	200	50	12/04/99 1/17/00 3/02/00 5/13/00	okay ice on harbor okay "	no action " " " " " "	7/12/00	24	screen 25% covered w/ algae	99.5	95.5	32.1

Table 1. Screen-covered Boxes - continued

	Deployment									Winter Observation			Retrieval					
location/ description	date of deployment	early/late	temperature (degrees C)	bottom type	depth @ MLW (feet)	average seed size (mm)	age of seed (months)	# of seed	planting density (per sq. ft.)	date	observation	action taken	date	temperature (degrees C)	gear condition	% recovered	% survival	average see live (mm)
Lake Montauk first year clams	10/25/99	L	13.5	sand	3.5	15.5	6	200	50	12/04/99	80% wind disturbed	removed 4 boxes	7/14/00	24	screen 5% covered w/ algae	99.5*	47	19
										1/17/00	Ice on harbor	no action						
										2/27/00	okay	" "						
										5/08/00	"	" "						
second year clams	10/25/99	L	13.5	sand	3.5	22.3	18	200	50	12/04/99	40% wind disturbed	removed 2 boxes	7/14/00	24	screen 5% covered w/ algae	103.5**	100.2	35.4
										1/17/00	Ice on harbor	no action						
										2/27/00	okay	" "						
										5/08/00	"	" "						

* Based on 1 recovered box.

** Based on 3 recovered boxes.

Table 2. Shellfish Growing Bags- Early and Late Deployment Comparison

4' X 2', 1/4" mesh shellfish bags stocked with 1000 clams per bag.
3 bags deployed early and 3 bags deployed late in each of six harbors.*

	Deployment									Winter Observation			Retrieval					
location/ description	date of deployment	early/late	temperature (degrees C)	bottom type	depth @ MLW (feet)	average seed size (mm)	age of seed (months)	# of seed	planting density (per sq. ft.)	date	observation	action taken	date	temperature (degrees C)	gear condition	% recovered	% survival	average see live (mm)
Northwest Creek early	08/30/99	E	20	sand to mud	3.5	14.2	4	1,000	125	12/04/99 1/17/00 3/2/00	On sediment surface ice on harbor okay	no action " " " "	7/18/00	23	bags 25% covered w/ algae	87.4	24.1	21.2
late	10/16/99	L	14	sand to mud	3.5	16.4	6	1,000	125	12/04/99 1/17/00 3/2/00	On sediment surface ice on harbor okay	no action " " " "	7/18/00	23	bags 25% covered w/ algae	77.4	5.9	22.9
Three Mile Harbor early	08/6/99	E	20	mud	6	14.2	4	1,000	125	12/04/99 1/17/00 2/27/00 5/13/00	Buried, mesh visible ice on harbor Not visible " "	no action " " " " " "	7/13/00	23	bags 50% covered w/ algae	100.8	92.2	20.2
late	10/15/99	L	14.5	mud	6	16.4	6	1,000	125	12/04/99 1/17/00 2/27/00 5/13/00	On sediment surface ice on harbor Not visible " "	no action " " " " " "	7/13/00	23	bags 50% covered w/ algae	94	51.2	20.3

Table 2. Shellfish Growing Bags- Early and Late Deployment Comparison - continued

	Deployment									Winter Observation			Retrieval					
location/ description	date of deployment	early/late	temperature (degrees C)	bottom type	depth @ MLW (feet)	average seed size (mm)	age of seed (months)	# of seed	planting density (per sq. ft.)	date	observation	action taken	date	temperature (degrees C)	gear condition	% recovered	% survival	average see live (mm)
Accabonac Creek																		
early	8/30/99	E	20	mud	5	14.2	4	1,000	125	12/04/99 1/17/00 2/27/00 5/08/00	Not visible ice on harbor Not visible " "	no action " " " " " "	7/17/00	23	bags 25% covered w/ algae	94.8	83.6	17.6
late	10/15/99	L	14.5	mud	5	16.4	6	1,000	125	12/04/99 1/17/00 2/27/00 5/08/00	On sediment surface ice on harbor On sediment surface Not visible	no action " " " " " "	7/13/00	23	bags 25% covered w/ algae	94	51.2	18.4
Fresh Pond																		
late	10/27/99	L	14	mud	6	15.5	6	1,000	125	1/17/00 3/03/00	ice on harbor Not visible	" " " "	7/18/00	23	bags 15% covered w/ algae	106.6	72.4	21.4

* Fresh Pond had no bags deployed early and 3 bags deployed late.

Table 2. Shellfish Growing Bags- Early and Late Deployment Comparison - continued

	Deployment									Winter Observation			Retrieval					
location/ description	date of deployment	early/late	temperature (degrees C)	bottom type	depth @ MLW (feet)	average seed size (mm)	age of seed (months)	# of seed	planting density (per sq. ft.)	date	observation	action taken	date	temperature (degrees C)	gear condition	% recovered	% survival	average see live (mm)
Napeague Harbor early	8/31/99	E	20	silt under sand	0.5	14.2	4	1,000	125	12/04/99 1/17/00 2/27/00 5/08/00	1 bag buried ice on harbor On sediment surface 1 bag missing	no action " " " " " "	7/17/00	23	bags 25% covered w/ algae	76.4	18.9	23.1
late	10/15/99	L	14.5	silt under sand	0.5	16.4	6	1,000	125	12/04/99 1/17/00 2/27/00 5/08/00	15% buried ice on harbor On sediment surface okay	no action " " " " " "	7/17/00	23	bags 15% covered w/ algae	88.2	12.4	20.6
Skunk's Hole late	10/27/99	L	14	mud	10	16.4	6	1,000	125	12/04/99 2/27/00 5/08/00 7/17/00	Not visible " " " " no marker buoy	no action " " " " no action	8/17/00	22	bags filled w/ sediment	109.8	0.2	18.5

*Napeague Harbor received 3 bags deployed early and 6 bags deployed late. Three of the six late bags were deployed in a mud bottom in Skunk's Hole.

Table 2. Shellfish Growing Bags- Early and Late Deployment Comparison - continued

	Deployment									Winter Observation			Retrieval					
location/ description	date of deployment	early/late	temperature (degrees C)	bottom type	depth @ MLW (feet)	average seed size (mm)	age of seed (months)	# of seed	planting density (per sq. ft.)	date	observation	action taken	date	temperature (degrees C)	gear condition	% recovered	% survival	average see live (mm)
Lake Montauk																		
early	8/31/99	E	20	silty sand	8	14.2	4	1,000	125	12/04/99	Not visible	no action	7/13/00	23	bags 25% covered w/ algae	82.9	19.2	19
										1/17/00	Ice on harbor	" "						
										2/27/00	Not visible	" "						
										5/08/00	" "	" "						
late	10/15/99	L	14.5	silty sand	8	14.2	6	1,000	125	12/04/99	Not visible	no action	7/13/00	23	bags 25% covered w/ algae	59.3	4	19.3
										1/17/00	Ice on harbor	" "						
										2/27/00	Not visible	" "						
										5/08/00	" "	" "						

Table 2a. Shellfish Growing Bags- Density Comparison

4' X 2', 1/4" mesh shellfish bags stocked with 500, 1000, 2000, 3000 clams per bag.
3 bags deployed per density treatment in Three Mile Harbor and Fresh Pond.

	Deployment									Winter Observation			Retrieval					
location/ description	date of deployment	early/late	temperature (degrees C)	bottom type	depth @ MLW (feet)	average seed size (mm)	age of seed (months)	# of seed	planting density (per sq. ft.)	date	observation	action taken	date	temperature (degrees C)	gear condition	% recovered	% survival	average see live (mm)
Three Mile Harbor																		
500	10/25/99	L	14	mud	6	15.5	6	500	62.5	12/04/99	On sediment surface	no action	7/13/00	23	bags 75% covered w/ algae	94.1	44.1	22.4
										1/17/00	ice on harbor	" "						
										2/27/00	Not visible	" "						
										5/13/00	" "	" "						
1000	10/15/99	L	14.5	mud	6	16.4	6	1,000	125	12/04/99	On sediment surface	no action	7/13/00	23	bags 50% covered w/ algae	94	51.2	20.3
										1/17/00	ice on harbor	" "						
										2/27/00	Not visible	" "						
										5/13/00	" "	" "						
2000	10/25/99	L	14	mud	6	15.5	6	2,000	250	12/04/99	On sediment surface	no action	7/13/00	23	bags 50% covered w/ algae	99.9	59.5	20.2
										1/17/00	ice on harbor	" "						
										2/27/00	Not visible	" "						
										5/13/00	" "	" "						
3000	10/25/99	L	14	mud	6	15.5	6	3,000	375	12/04/99	On sediment surface	no action	7/13/00	23	bags 30% filled w/ sediment	97.5	57.8	18.4
										1/17/00	ice on harbor	" "						
										2/27/00	Not visible	" "						
										5/13/00	" "	" "						

Table 2a. Shellfish Growing Bags- Density Comparison - continued

location/ description	Deployment									Winter Observation				Retrieval					
	date of deployment	early/late	temperature (degrees C)	bottom type	depth @ MLW (feet)	average seed size (mm)	age of seed (months)	# of seed	planting density (per sq. ft.)	date	observation	action taken		date	temperature (degrees C)	gear condition	% recovered	% survival	average see live (mm)
Fresh Pond																			
500	10/27/99	L	14	mud	6	15.5	6	500	62.5	1/17/00	ice on harbor	"	"	7/18/00	23	bags 50% covered w/ algae	117.1	81	21.2
										3/03/00	Not visible	"	"						
1000	10/27/99	L	14	mud	6	15.5	6	1,000	125	1/17/00	ice on harbor	"	"	7/18/00	23	bags 15% covered w/ algae	106.6	72.4	21.4
										3/03/00	Not visible	"	"						
2000	10/27/99	L	14	mud	6	15.5	6	2,000	250	1/17/00	ice on harbor	"	"	7/18/00	23	bags 15% filled w/ sediment	99.9	72.4	20.1
										3/03/00	Not visible	"	"						
3000	10/27/99	L	14	mud	6	15.5	6	3,000	375	1/17/00	ice on harbor	"	"	7/18/00	23	bags 30% filled w/ sediment	94.5	75.9	17.6
										3/03/00	Not visible	"	"						

Table 3. Screened Plots

Ten, 20' X 14' plots covered with 1/4" mesh netting. Two plots per harbor.

	Deployment									Winter Observation			Retrieval					
location/ description	date of deployment	early/late	temperature (degrees C)	bottom type	depth @ MLW (feet)	average seed size (mm)	age of seed (months)	# of seed	planting density (per sq. ft.)	date	observation	action taken	date	temperature (degrees C)	gear condition	% recovered	% survival	average see live (mm)
Northwest Creek early	8/06/99	E	23	sand	3	12.5	4	30,000	100	12/04/99 1/17/00 3/02/00	okay ice on harbor screen 10% ice scoured	no action " " screen back in place	7/10/00	24	screen 100% covered w/ algae	80.2	65.4	21.5
late	10/07/99	L	14	sand to mud	3.5	15.2	6	30,000	100	12/04/99 1/17/00 3/02/00	okay ice on harbor screen 10% ice scoured	no action " " screen back in place	7/11/00	24	screen 100% covered w/ algae	57.5	55	25.7
Three Mile Harbor early	8/6/99	E	23	mud/ sand/ pebble/ shell	3.5	12.5	4	30,000	100	12/04/99 1/17/00 2/27/00 5/08/00	okay ice on harbor okay "	no action " " " " " "	6/28/00	24	screen 100% covered w/ algae	125.9	80.2	16
late	10/5/99	L	16	sand/ pebble/ shell	1	15.2	6	30,000	100	12/04/99 1/17/00 2/27/00 5/08/00	okay ice on harbor screen 20% ice scoured "	no action " " screen back in place " "	6/28/00	24	screen 0% covered w/ algae	25	18.2	20.8

Table 3. Screened Plots - continued

	Deployment									Winter Observation			Retrieval					
location/ description	date of deployment	early/late	temperature (degrees C)	bottom type	depth @ MLW (feet)	average seed size (mm)	age of seed (months)	# of seed	planting density (per sq. ft.)	date	observation	action taken	date	temperature (degrees C)	gear condition	% recovered	% survival	average see live (mm)
Lake Montauk																		
early	8/10/99	E	23	sand	3.5	12.5	4	30,000	100	12/04/99	okay	no action	6/29/00	25	screen 100% covered w/ algae	48.8	19	17.2
										1/17/00	Ice on harbor	" "						
										2/27/00	screen 5 % covered by sediment	" "						
										5/08/00	okay	no action						
late	10/06/99	L	14	sand	3.5	15.2	6	30,000	100	12/04/99	okay	no action	6/29/00	25	screen 25% covered w/ algae	69.4	39.6	22.5
										1/17/00	Ice on harbor	" "						
										2/27/00	screen 80 % covered by sediment	" "						
										5/08/00	okay	no action						

Table 3. Screened Plots - continued

	Deployment									Winter Observation			Retrieval					
location/ description	date of deployment	early/late	temperature (degrees C)	bottom type	depth @ MLW (feet)	average seed size (mm)	age of seed (months)	# of seed	planting density (per sq. ft.)	date	observation	action taken	date	temperature (degrees C)	gear condition	% recovered	% survival	average see live (mm)
Accabonac Creek																		
early	8/09/99	E	23	thin mud layer over hardpan	1.5	12.5	4	30,000	100	12/04/99 1/17/00 2/27/00 5/08/00	okay ice on harbor screen 5% ice scoured okay	no action " " screen back in place no action	6/30/00	26	screen 100% covered w/ algae	1	0.5	15.1
late	10/07/99	L	14	thin mud layer over hardpan	1.5	15.2	6	30,000	100	12/04/99 1/17/00 2/27/00 5/08/00	okay ice on harbor screen 15% ice scoured okay	no action " " screen back in place no action	6/27/00	25	screen 100% covered w/ algae	4.1	1.1	17.7
Napeague Harbor early	8/06/99	E	23	sand	1	12.5	4	30,000	100	12/04/99 1/17/00 2/27/00 5/08/00	okay ice on harbor okay "	no action " " " " " "	6/30/00	26	screen 80% covered w/ algae	79.1	62.7	20.1
late	10/06/99	L	16	sand	1	15.2	6	30,000	100	12/04/99 1/17/00 2/27/00	okay ice on harbor screen 100% ice scoured	no action " " not able to relocate plot	NA	NA	NA	NA	NA	NA

Table 4. Potted and Unpotted Plots

Four, one acre plots. Two potted for crabs, two not potted.

	Deployment									Winter Observation			Retrieval					
location/ description	date of deployment	early/late	temperature (degrees C)	bottom type	depth @ MLW (feet)	average seed size (mm)	age of seed (months)	# of seed	planting density (per sq. ft.)	date	observation	action taken	date	temperature (degrees C)	gear condition	% recovered	% survival	average see live (mm)
Three Mile Harbor North potted	10/12/99	L	17	sand	3	clams 15.2	6	250,000	5	1/17/00	ice on harbor	no action	7/21/00	23	NA	NA	clams 0.4	22.5
	11/02/99	L	14	"	"	oysters 35	8	50,000	1	2/27/00	ice gone	removed pots				NA	oysters 42	43.9
										3/09/00		returned pots to plot						
unpotted	10/07/99	L	14	sand	3 to 4	clams 15.2	6	250,000	5	1/17/00	ice on harbor	no action	7/13/00	23	NA	NA	clams 0.8	25.5
	11/01/99	L	14	"	"	oysters 35	8	50,000	1	2/27/00	ice gone	no action				NA	oysters 40	46.2
										3/09/00		no action						
Three Mile Harbor South potted	10/12/99	L	17	pebble/ sand to mud	1 to 9	clams 15.2	6	250,000	5	1/17/00	ice on harbor	no action	7/28/00	23	NA	NA	clams 0.6	22.4
										2/27/00	ice gone	removed pots						
										3/09/00		returned pots to plot						
unpotted	10/09/99	L	17	pebble/ sand to mud	1 to 9	clams 15.2	6	250,000	5	1/17/00	ice on harbor	no action	7/27/00	23	NA	NA	clams 1.6	21.9
										2/27/00	ice gone	no action						
										3/09/00		no action						

Discussion

1. Sediment Filled Boxes

The sediment filled boxes were deployed for two reasons. 1. As a measure of continuity of 1999-2000 survival with past observations from 1993 to 1998 using the same method. Figure 1a represents survival data using this method from 1993 through 2000. Survival results in boxes over the 1999-2000 period seem to fall within the range seen in this treatment over past years. 2. We wanted to document differences in one and two year old seed survival in more than one location. Figure 1 represents these results, clearly showing greater survival of two year old seed across the test range, with similar disparities from location to location.

Seed clams do not seem to be largely immune from non-predator related winter mortality until they have survived their first overwintering.

2. Shellfish Growing Bags

Figure 2 represents 1999-2000 survival results in the six harbors in which this treatment was located. The first thing that stands out is the variability of survival with relation to location. The second is the consistently higher survival rate in seed planted earlier as opposed to later in the season and that this difference carries across the range of sites in a fairly proportionate way.

Some of the survival differences by location seem explainable. The generally lower survival rates in Napeague Harbor and Lake Montauk possibly resulted from a harder sandy bottom into which the bags had more difficulty settling, allowing in less sediment for the clams to burrow into. The Napeague location was also quite shallow and subject to extremes such as ice. The low survival rates in Northwest Creek and the Napeague mud site are puzzling. The Northwest sediment seemed to be well suited to this type of overwintering, and in fact, clams planted in screen-covered plots nearby survived fairly well. Curiously, just the opposite phenomenon was observed in the Accabonac Harbor site; where clams in bags survived well and those in screen covered plots poorly (see also Figure 3). Since we expected there might be problems at the primary Napeague Harbor site, the mud site at Skunk's Hole was picked specifically as a back up, expected to produce results similar to the muds of Fresh Pond, with which we had much experience. The almost total die-off there was a surprise. Perhaps higher salinity due to the site's deep water and proximity to Napeague Bay or the nature of the sediment, a fine-grained sulfurous mud, possibly quite anoxic, might explain the problem.

Stocking density comparisons in two locations are represented in Figure 2a. While results differed between locations, the survival rates across the range of densities in each location were fairly proportionate. This gives us some confidence that higher stocking densities are not detrimental.

Information gleaned from the 1999-2000 survival trials was compared with past years trials, somewhat as with the box assessments, in order to identify anomalies. Figure 2b shows survival percentages at different stocking densities (except in one instance) for three years. What is interesting here is the fact that while survival rates seem to differ from year to year and location to location within a given year, the relative survival rates are fairly consistent across the range of densities.

3. Screen Covered Plots

Data relating to the survival of clams seeded early and late into screen-covered plots is presented in Figure 3. Despite considerable variability between sites, the early seedings fared better than later ones.

The very low survival of clams at Accabonac Harbor is difficult to understand considering the good survival of clams overwintered in bags nearby (see also Figure 2). Bottom type at this site was different from all other sites. It consisted of a surface layer of silty mud above a layer of hardpan about two inches below the surface.

The low survival of the late seeding in Three Mile Harbor probably was accentuated by its location in very shallow water. The screen on this plot was disturbed by ice more than any in the series except the one lost completely in Napeague Harbor. This screen was also the only one in the series to contain no fouling when it was removed in the summer. This leads us to believe that it may have been subject to air exposure at very low tides, which probably would have put more stress on the animals, especially during the period of the freeze.

The Lake Montauk plots were the only ones in the series to have had portions of the screens covered with sediment, as was seen in the winter observation and on removal in the summer. The fine sands and exposure of this site to strong northwesterly winds over a several mile fetch could explain this finding, and may have contributed to the relatively low survival.

4. Potted and Un-potted Plots

Potting for crabs using the methods we employed did not increase survival relative to the un-potted plots in the northern and southern Three Mile Harbor locations. In addition, survival of oyster seed distributed into the northern plots was not enhanced in the potted plot either. These results, represented in Figure 4, call into question the effectiveness of this method of seed protection. If the costs of the method are factored in, its attractiveness diminishes further, as will be seen.

Crab catch data over the experimental period (Figure 4a) shows a falloff in catch from the fall to the spring. However, some of the spring catch data is artificially low, since pots were generally tended once a week (as opposed to twice a week in much of the fall period) and some crabs were probably leaving the pots as the bait was eaten up. This seems to be confirmed by the short period toward the end of the experiment during which

we switched to twice-a-week pot tending and experienced a corresponding increase in catch. Nevertheless the catch seems to be diminished in this period, despite warm water temperatures. This may be a natural phenomenon and have nothing to do with our efforts, but if not it may suggest a long term benefit to crab removal, although much more investigation would be needed to demonstrate this in any reliable way.

This particular set of experimental results should not imply disappointing survival of freely planted seed in every instance. Among other things, predator makeup and density will highly influence the impact on a given seeding area. Through sampling and harvest surveys, we have identified areas in Town in which unprotected clam seed have survived well enough to improve the harvest, sometimes significantly.

5. Labor and Materials Costs vs. Survival of Clam Seed in Extended Culture Work

Table 5 summarizes the factors contributing to a cost/benefit analysis of each extended culture experimental treatment. These include the cost of a particular culture effort both in labor and capital outlay and the survival of clam seed seen in the various treatments. The table also carries an explanation of labor calculations based on experiences over the period. It should be kept in mind that these figures and the analysis performed are specific to the findings of these experimental trials and any conclusions drawn from them must be correspondingly limited. It should also be noted that figures represent efforts over two growing seasons, factoring in subsequent retrieval and re-seeding of clams held in shellfish bags. In the case of screen covered plots, retrieval and re-seeding would be a costly option which was not considered in these comparisons.

Figure 6, basically the heart of the cost/benefit analysis, begins by apportioning a cost per clam for each method of protection, while standardizing the number of clams introduced as seed. Shellfish growing bags are calculated based on a stocking density of 2,000 seed per bag; in-bottom plantings reflect experimental densities. A proportional cost ranking is then assigned to each method. The method demonstrating lowest cost is assigned a value of one; each of the other values being proportionally greater by the factor derived from the formula:

$$\frac{\text{Method of Lowest Cost (\$0.00006/clam)}}{1} = \frac{\text{Cost of Method B,C etc.}}{x}$$

The values represented by x reflect the relative cost of each method of protection (as practiced over the period) regardless of success in advancing overwinter survival. By this account, screened plots, shellfish growing bags and crab potting of a free planted plot are respectively 40, 45 and 83 times more costly than seeding with no extended protection, the most inexpensive treatment. Next, survival of seed is factored in using results based on the five harbors comparisons and a cost/survival ratio is established for each treatment. Each of these figures is assigned a proportional ranking relative to one another using the same basic formula as above. Here we see screened plots, shellfish growing bags and crab potting as requiring 1.4, 1.6 and 200 times more effort relative to achieved survival than no protection, which still showed the lowest cost/survival ratio.

6. Comments, Recommendations and Proposals:

While the survival of freely planted seed seems erratic and site specific, on whole screen covered plots and shellfish growing bags each yield about fifty percent survival through the second year if the understandable failures can be factored out. The requirements for deployment and treatment of each method are very different, however.

Covering bottom plots with screening requires an area with relatively firm bottom and quite shallow water, since people must be able to work around the plots while setting up and maintaining the screens. Because they are exposed to quite a lot of sunlight, the screens foul quickly and require at least one and possibly two cleanings or replacements over the course of a twelve month period, more if clams would be held into the spring or early summer of their third year. We did not experiment with cleaning the screen in place; they might need more constant attention if this is the method chosen to deal with the fouling. To employ screened plots efficiently, they should be large but manageable (in the neighborhood of 50 feet long by the width of the screen, or 14 feet) and clustered in one general area, seeded as heavily as possible and the clams left in their beds until deemed harvestable. This would necessitate a highly managed situation through the entire life of the screening process (the necessary length of which is uncertain), and in order to avoid chaos, probably a managed harvest as well. Gales, hurricanes and ice would likely be of great importance in the success of these plantings; key would be their placement relative to a particular event. Using this method one million clams would be able to be seeded into an area less than one acre. If a commitment could be made to the concept of long term intensive clam culture and this method's management needs were met, harvest yields would be expected to increase.

Overwintering seed in shellfish growing bags presumes the clams are taken out of their protected situation at some point and freely planted, a significant expenditure of labor. The method requires an extensive area of soft bottom, preferably in some depth of water to limit fouling and protect against ice damage. The bottom characteristics are important in that some mud bottom types can prove fatal either due to an anoxic or some other noxious condition and too soft a mud might not support the bags. While single season survival and growth data for this technique is available for a few locations (in one case over a several year period), it is not certain how this would translate in an expanded effort nor how long the seed should be held before it is taken out and exposed to unprotected conditions. An area of about two acres would likely be needed to overwinter one million seed using this method. We have taken steps to budget money in 2001 for overwintering one million seed in this way and hope to utilize a portion of Fresh Pond for the work.

One unanticipated experimental observation, the apparent superiority of early deployments of smaller seed, may have ramifications when considering both extended culture and free plantings of year old seed. When considering extending seed culture beyond one year, protected situations may be set up as soon as seed comes to a pre-determined size, allowing plots or fields of shellfish bags to be set up over a period of time, making the work load manageable. However, free planting year old seed at a

smaller average size earlier in the growing season may yield no worse survival than the current practice of seeding larger seed later in the season. If this assumption is true, grow out systems would immediately be capable of increased production due to the smaller seed stocking the gear and the protracted dissemination schedule that would result. In effort expended vs. rate of return, this increased output potential, while still subject to high predation rates, may be competitive with the additional labor required of extended culture. More work clearly needs to be done to investigate the merits of this hypothesis, but it seems at least worthwhile to try to determine if earlier plantings of smaller seed into unprotected bottom yield no worse results than later plantings of larger seed later in the season. To this end, we have begun preliminary discussions with other Long Island towns involved in shellfish enhancement and representatives of the Marine Sciences Research Center at SUNY Stony Brook, NY Sea Grant and Cornell Cooperative Extension of Suffolk, Marine Program. It is our hope that a region wide assessment can be funded that would answer this question definitively.

Figure 1a
Overwinter Survival of Clams Held in Sediment Filled Trays and Boxes, 1993 through 2000

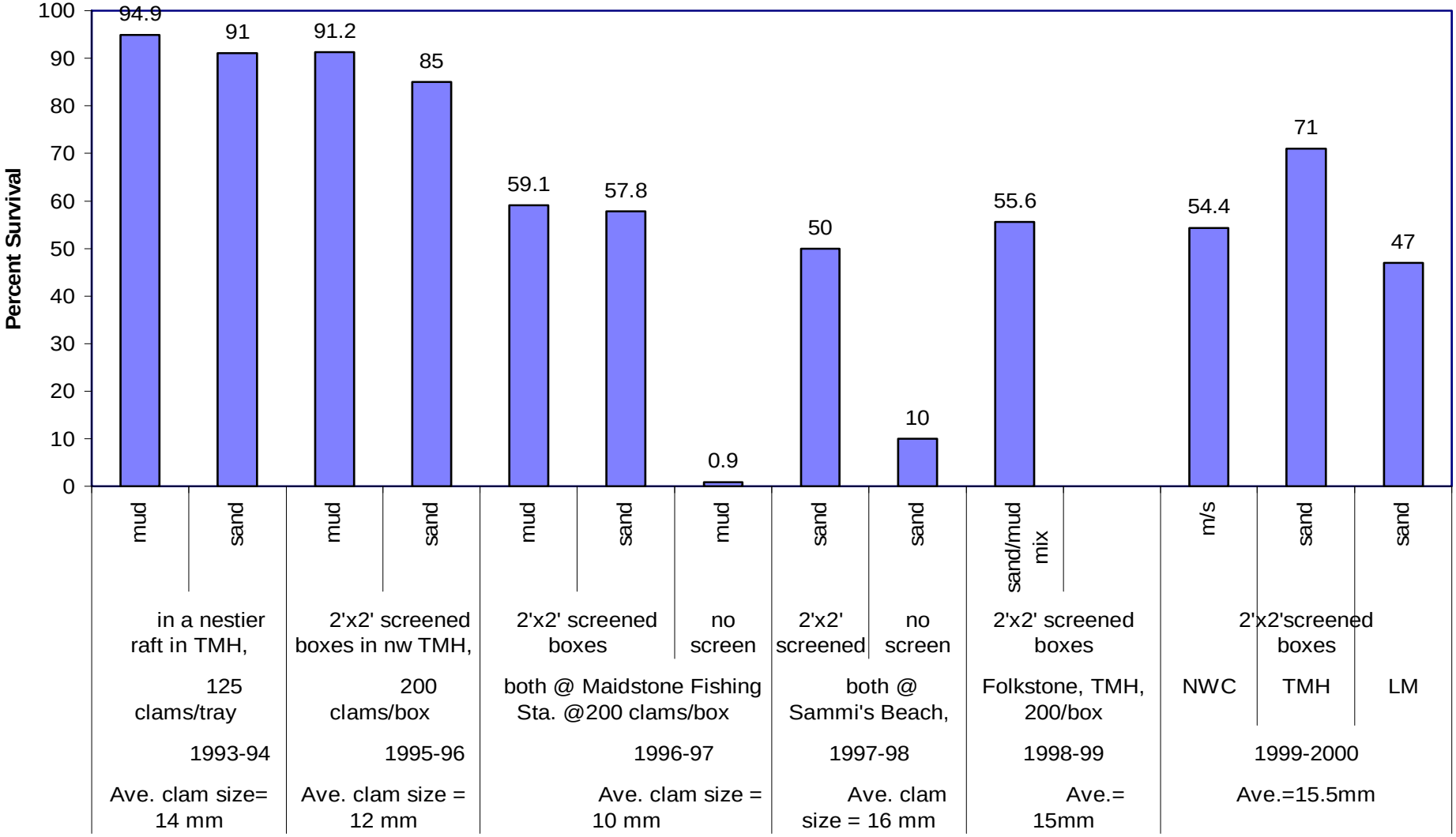

Figure 1
Percent Survival of First and Second Year Clams Seeded into 2'x2' Screen-covered Boxes and Overwintered in Northwest Creek, Three Mile Harbor and Lake Montauk. 1999-2000

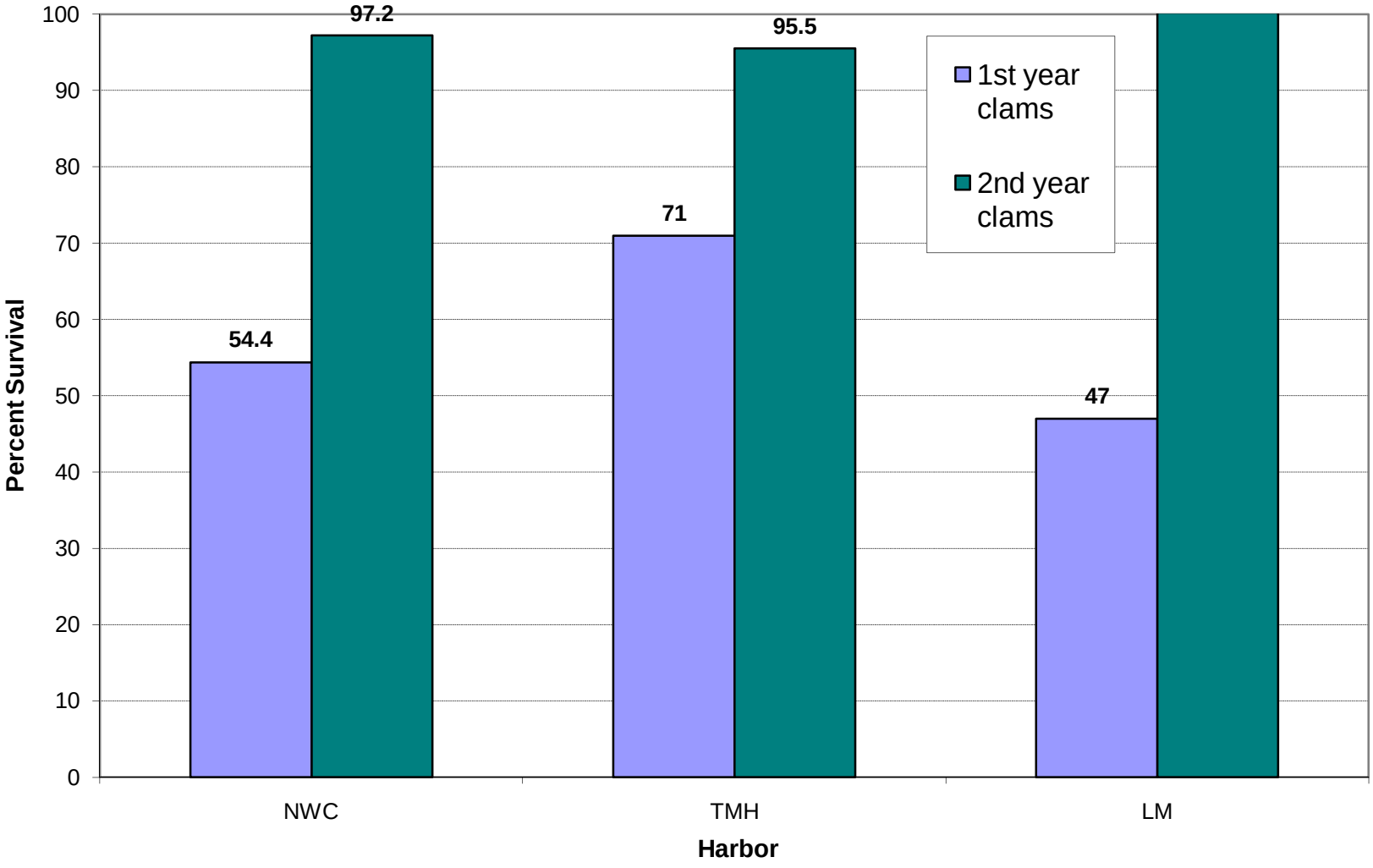

Figure 2
Percent Survival of Clams in Shellfish Growing Bags Overwintered in Northwest Creek, Three Mile Harbor, Accabonac Harbor, Fresh Pond, Napeague and Lake Montauk.
1999-2000

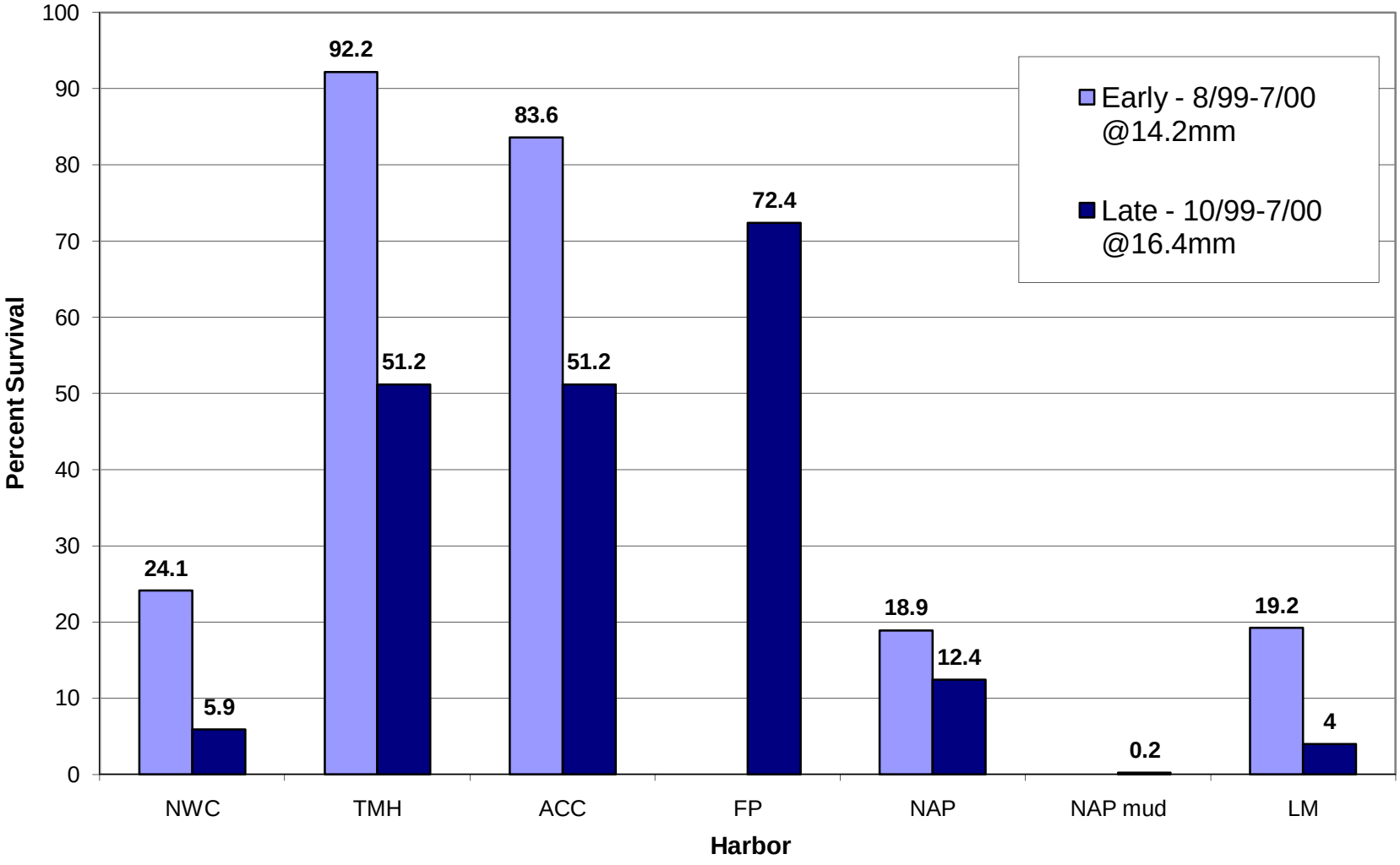

Figure 2a
Percent Survival of Clams in Shellfish Growing Bags Stocked at Four Densities and Overwintered in Three Mile Harbor and Fresh Pond.
1999-2000

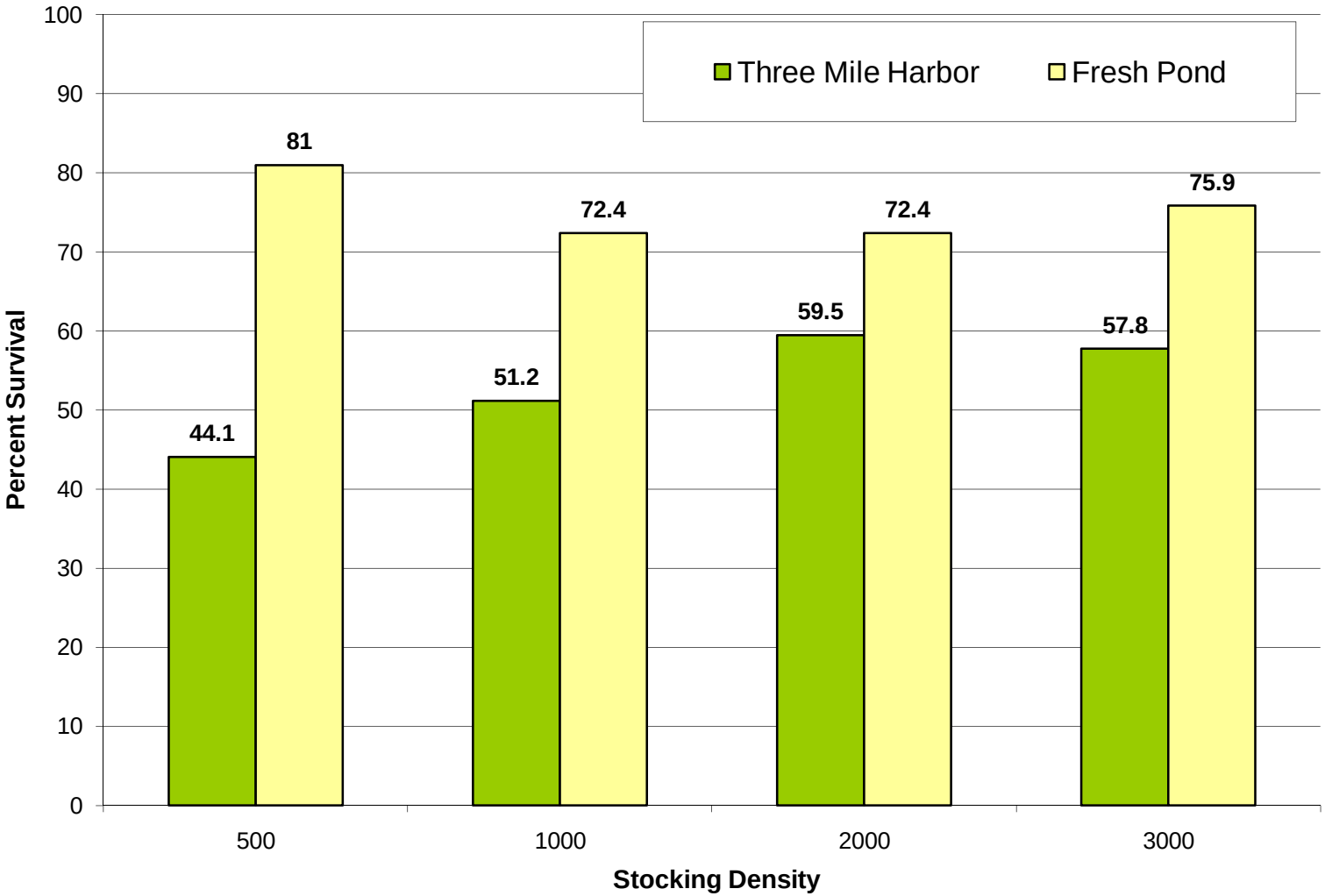

Figure 2b
Percent Survival of Clams in Shellfish Growing Bags Overwintered in Three Mile Harbor and Fresh Pond, 1997-2000.

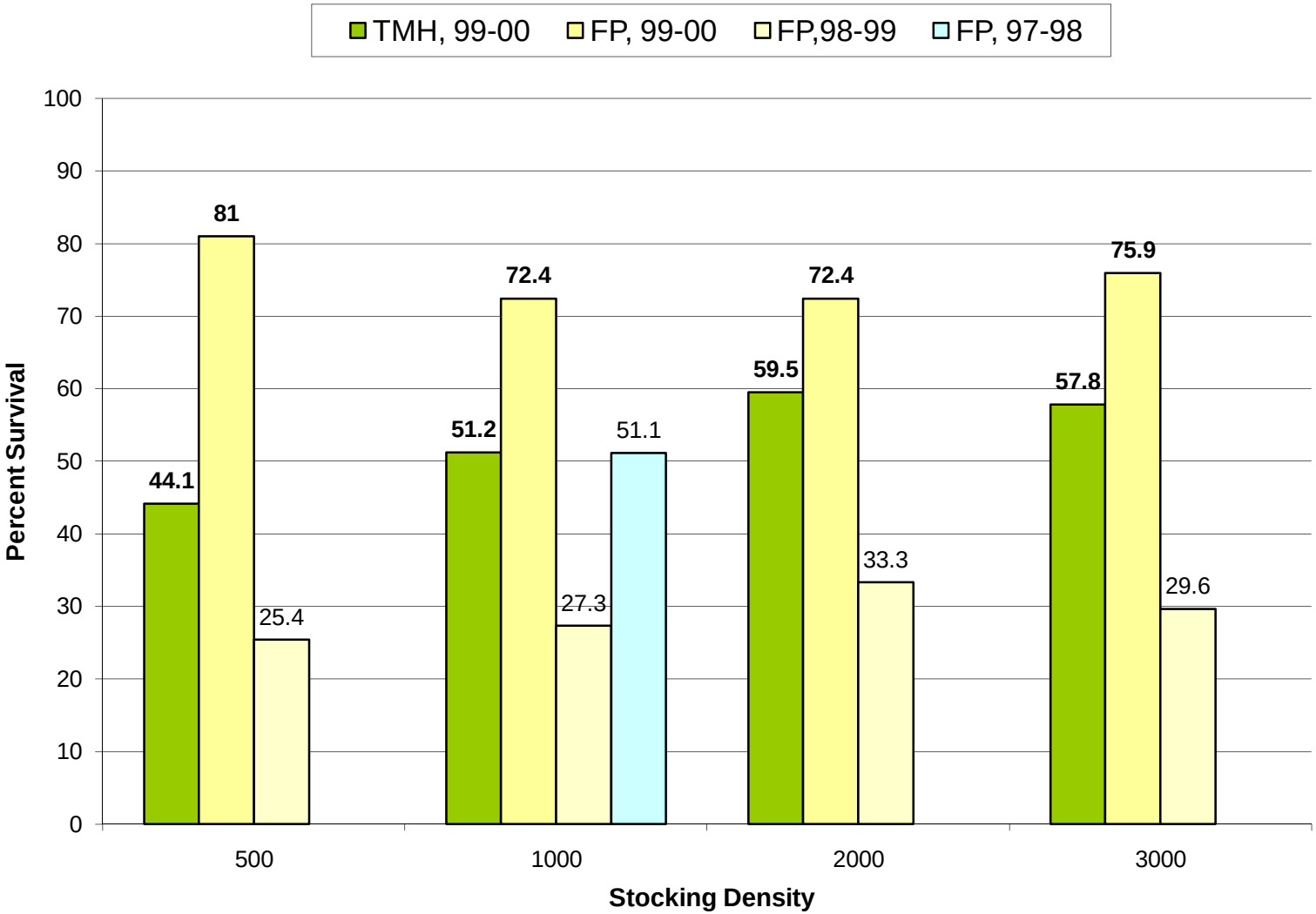

Figure 3
Percent Survival of Clam Seedings in Screen-covered Plots Deployed Early and Late and Overwintered in Northwest Creek, Three Mile, Accabonac, Napeague and Lake Montauk Harbors. 1999-2000.

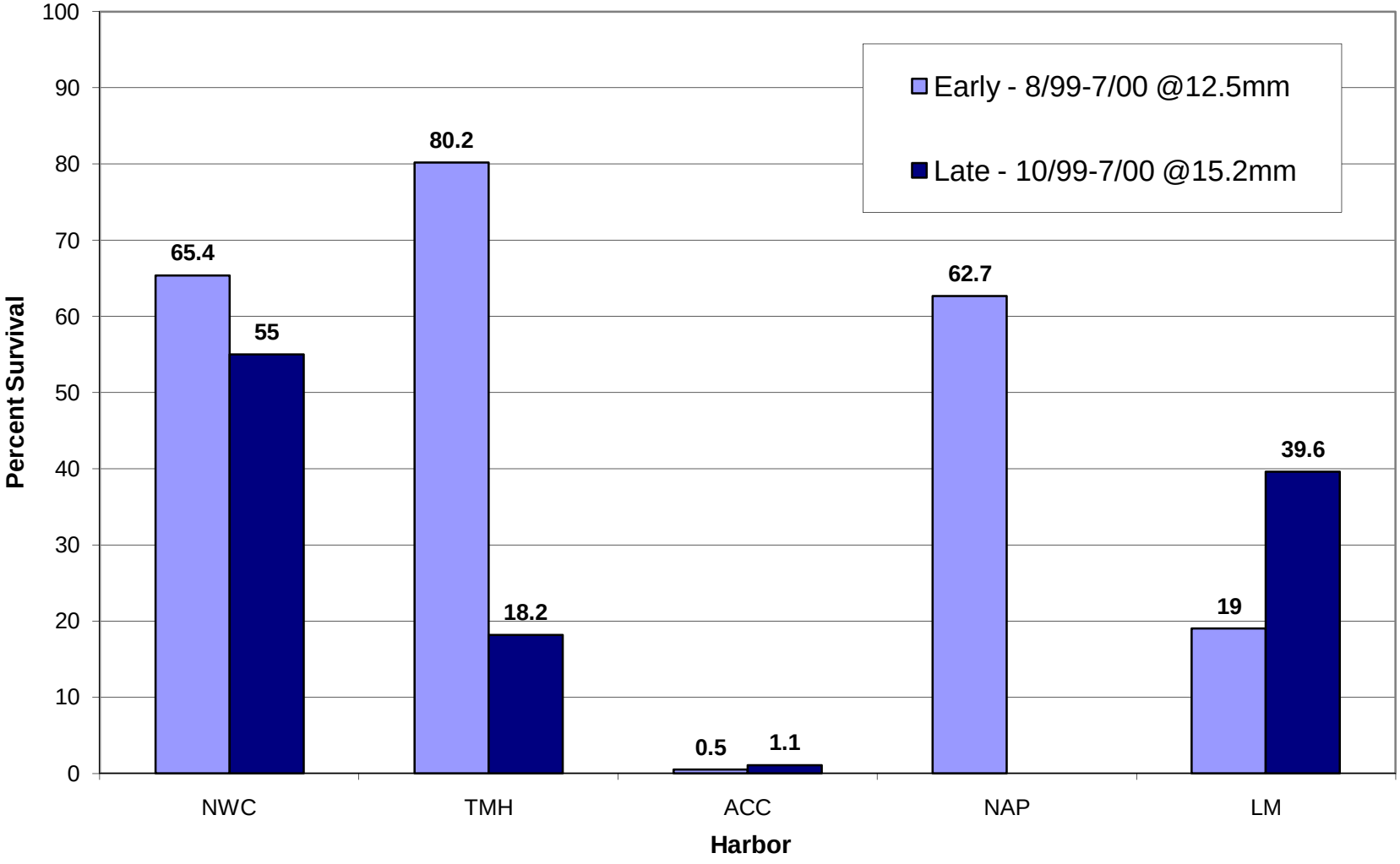

Figure 4
Percent Survival of Seedings in Potted and Unpotted Plots Overwintered in North and South Sites in Three Mile Harbor (Oysters were not seeded in south plots)**.**
1999-2000

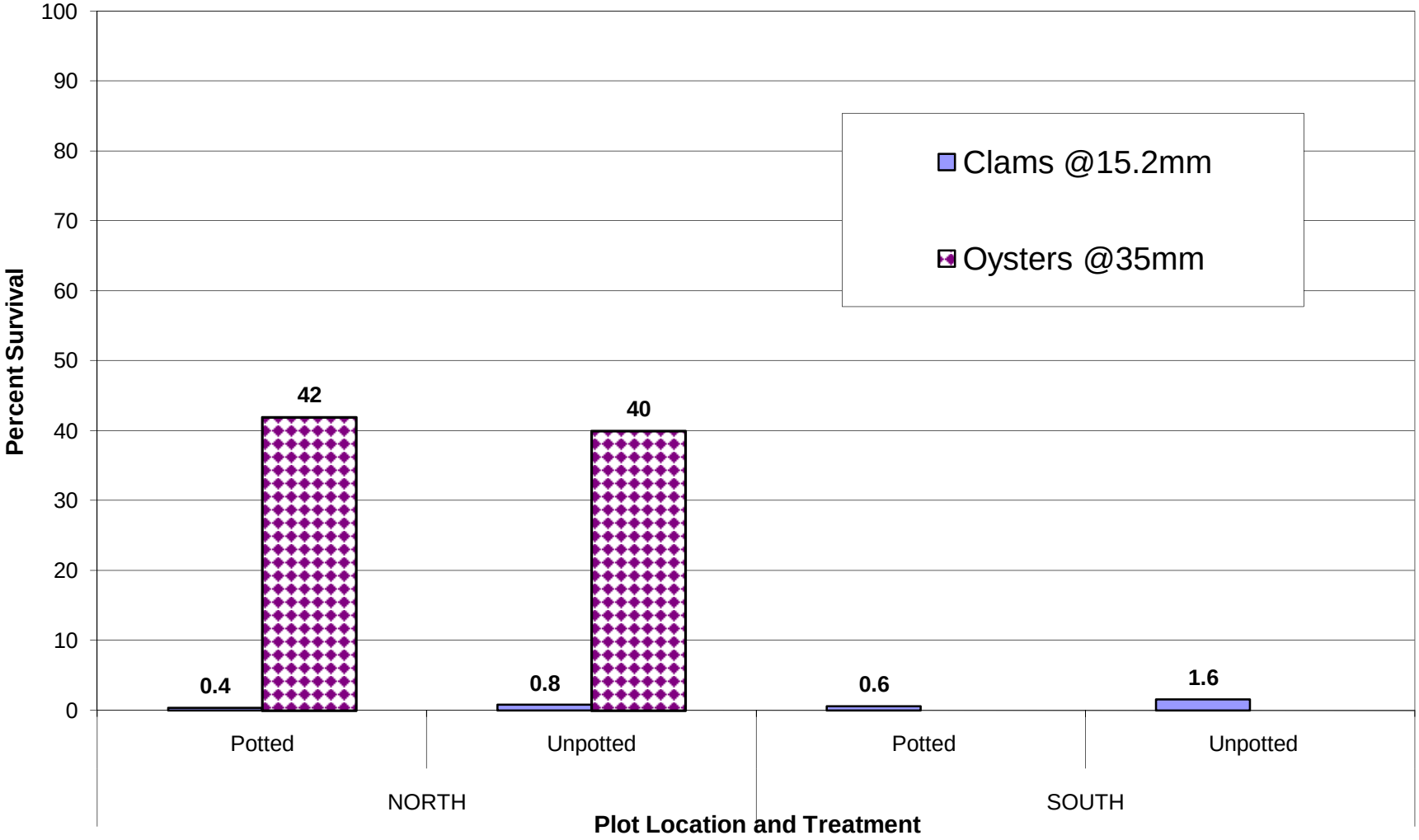

Figure 4a
All Crabs Caught in 'Green Crab Traps' at Two Sites in Three Mile Harbor.
September, 1999 to July, 2000.

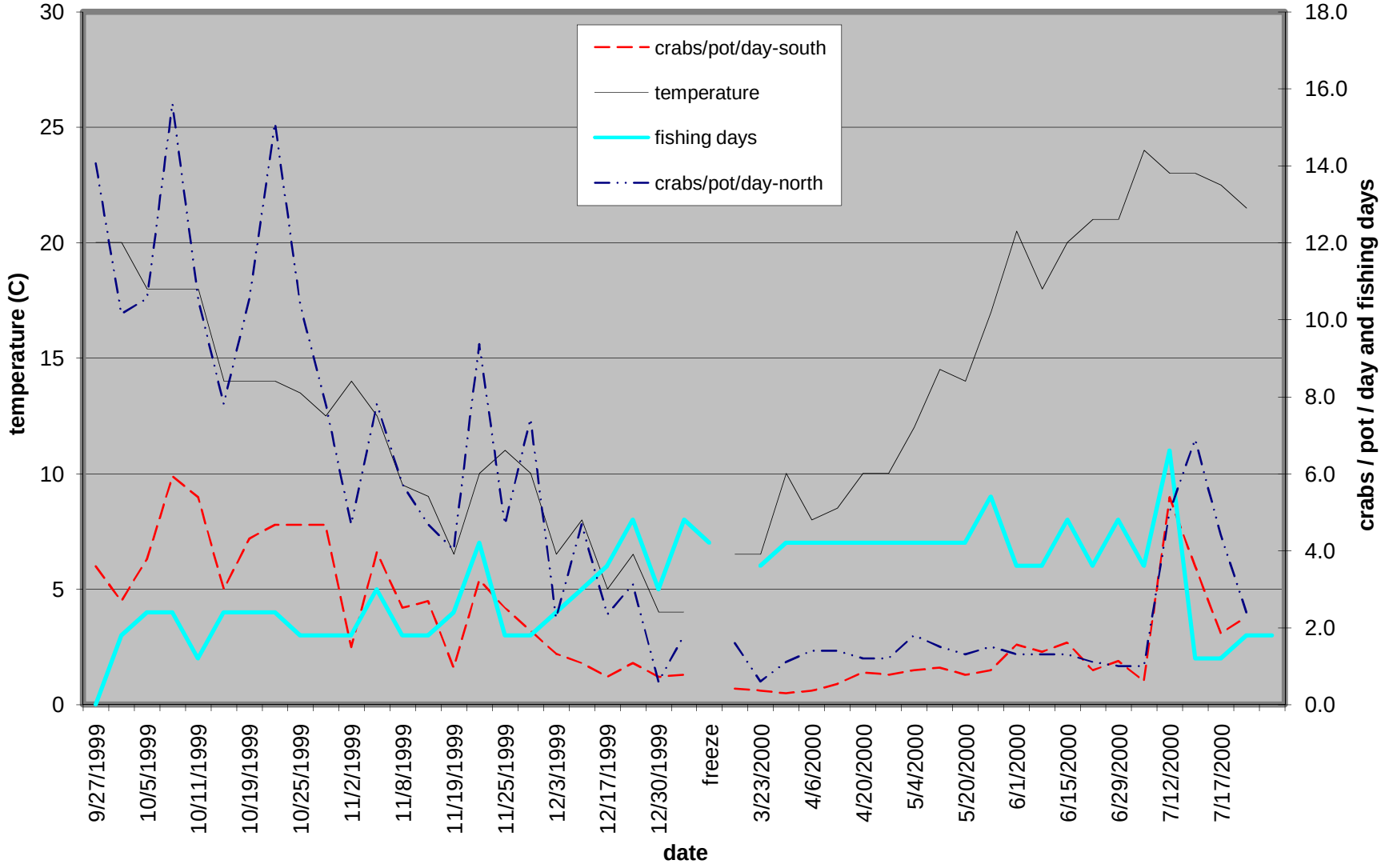

Table 5. Relationship of Actual Effort and Cost to Observed 1999-2000 Overwinter Survival

	Overwinter Survival			Labor Costs per Year					Gear Costs per Year		
Method of Overwintering	Number of clams seeded	Estimated # of clams surviving	Percent Survival	Time (hours) required to: fabricate method	deploy/ maintain	retrieve/ gear	Total (hours)	Cost of labor per plot @$15/hour	Type of Gear Used		Cost of Gear per plot
Unpotted Plots	250,000	2000	0.8	0	1	0	1	$15	none		$0.00
	250,000	4000	1.6								
	Total:		Average:								
	500,000	**6000**	**1.2**								
				Total for 2 unpotted plots:				**$30**	**Total for 2 unpotted plots:**		**$0.00**
Potted Plots	250,000	1000	0.4	2*	62	0	64	$960	Crab pots*, etc.	32 pots/plot	$67.00
	250,000	1500	0.6						Trawl lines*	4, 300' lines	$15.00
									Bait		$200.00
	Total:		Average:							Total:	$282
	500,000	**2500**	**0.5**								
				Total for 2 potted plots:				**$1920**	**Total for 2 potted plots:**		**$564.00**
				*based on ten year life of pot					*assuming pots/line last 10 yrs.		
Screened Plots	30,000	19620	65.4	1**	2*	0.5	3.5	**$52.50**			
	30,000	16500	55						Rebar*		$3.50
	30,000	24060	80.2						Screen**		$15.00
	30,000	5460	18.2							Total:	$ 18.50
	30,000	150	0.5								
	30,000	330	1.1								
	30,000	18810	62.7								
	30,000	0	0								
	30,000	5700	19								
	30,000	11880	39.6								
	Total:		Average:								
	300,000	**102,510**	**34.2**								
				Total for 10 screened plots:				**$525**	**Total for 10 screened plots:**		**$185.00**
				*see Table 6					*assuming rebar lasts 10 yrs.		
				**based on one year life of screen					**assuming screen lasts 1 yr.		

Table 5. Relationship of Actual Effort and Cost to Observed 1999-2000 Overwinter Survival - continued

	Overwinter Survival			Labor Costs per Year					Gear Costs per Year	
Method of Overwintering	Number of clams seeded	Estimated # of clams surviving	Percent Survival	Time (hours) required to: fabricate method	deploy/ maintain	retrieve/ seed	Total (hours)	Cost of labor per 3 bags @$15/hour	Type of Gear Used	Cost of Gear per three bags
Shellfish Growing Bags	3,000	723	24.1	0.1**	0.275*	0.5	0.875	$13.62	Growing bags*	$2.40
	3,000	177	5.9						Clips/line**	$0.38
	3,000	2766	92.2						Total:	$ 2.78
	3,000	1536	51.2							
	3,000	2508	83.6				Cost of Labor per bag:	$4.54	Cost of Gear per bag:	$0.93
	3,000	1536	51.2							
	3,000	567	18.9				**Total for 36 shellfish bags:**	**$164**	**Total for 36 shellfish bags:**	**~$34.00**
	3,000	372	12.4							
	3,000	6	0.2							
	3,000	576	19.2							
	3,000	120	4							
	3,000	2172	72.4							
	Total:		**Average:**							
	36,000	**13,059**	**36.3**							

*see Table 6

**Based on five year life of bag

*assuming bags last 5 yrs.

**assuming clips/line last 10 yr.

Definitions/Explanations of Labor Cost Terms used in Table 5

Method	Time (hours) required to:			Total (hours)	Cost of labor @$15/hour
	fabricate method	deploy seed/gear maintain gear overwinter	retrieve seed and/or gear		
Unpotted Plots	no cost	Seeding clams on to plot ~ 1 hr/plot No gear to maintain.	no seed or gear retrieval	**1 hr/plot**	**$15/ plot**
Potted Plots	Making 4 trawl lines/plot Making 30 snoods/plot Tying snoods to 30 crab traps ~10 hours/plot once every ten years= 1 hr/plot	Seeding clams on to plot ~ 1 hr/plot Setting 30 traps on to a plot Baiting traps, removing crabs as per 99-00 crab catch log. ~60 trips/plot over course of experiment. @1 hr/trip/plot = 60 hrs/plot	No seed retrieval Removng traps ~1 hr/plot	**63 hrs/plot**	**$945/ plot**
Screened Plots	Attatching screen to rebar 1 hr/ screen every year	Seeding clams on to plot, covering plot w/ screen and stapling screen into bottom ~ 1 hr/plot Checking plots, monthly, over the winter and restapling screens that have been moved by wave/ice action. Observed ~15% movement of screen overwinter 99-00. Assume all screened plots in one harbor. ~ 1 hr/plot	No seed retrieval Removing screen from plot ~ 0.5 hr/plot	**3.5 hrs/plot**	**$52.50/ plot**
Shellfish Growing Bags	Attatching weights to 3 bags. Making 3 snoods and attatching to bags. Making trawl lines. ~0.5 hr/3 bags once every 5 years= 0.1 hr/ 3 bags	Deploying seed into 3 bags. Putting bags on bottom ~0.25 hr/ 3 bags Checking bags, monthly, over the winter. Assume all bags in one harbor. ~0.025 hr/ 3 bags	Removing 3 bags from bottom. Removing clams from bags, and seeding clams ~0.5 hr/3 bags	**0.875 hrs/ 3 bags** or **0.292 hrs/ bag**	**$13.12/ 3 bags** **$4.38/ bag**

Table 6. Projected Cost/Survival Ratios for Carrying 500,000 Clams Through Two Years:

Projected Labor + Gear Costs for Carrying 500,000 Clams Through Two Years:

* Labor to maintain screened plots and shellfish growing bags is extrapolated from 1999-2000 labor costs, assuming the method is deployed in one harbor.

Method	Labor + Gear Costs / Clams Seeded	= Cost	Proportional Cost Ranking	Observed 2000 Survival (percent)	Cost/Survival Ratio	Proportional Cost : Survival Ranking
Unpotted Plots 5 clams/sq. ft.	$30 + $ 0 / 500,000 clams =	**$0.00006/clam**	**1**	**1.2**	**0.00005**	**1**
Potted Plots 5 clams/sq. ft.	$1920 + $564 / 500,000 clams =	**$.005/clam**	**83**	**0.5**	**.01**	**200**
Screened Plots 100 clams/sq. ft.	$875 + $308.33 / 500,000 clams =	**$.0024/clam**	**40**	**34.2**	**0.00007**	**1.4**
Shellfish Growing Bags 250 clams/sq. ft.	$1135 + $233 / 500,000 clams =	**$0.0027/clam**	**45**	**36.3**	**0.000074**	**1.6**