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A study of the hard and soft clam resources of Virginia : annual contract report for the period 1 July 1969 through 30 June 1970, Contract no. 3-77-R-1

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United States
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COMMERCIAL FISHERIES RESEARCH AND DEVELOPMENT ACT

Annual Report

State Virginia

Contract No. 3-77-R-1

Project Title A Study of the Hard and Soft Clam Resources of Virginia

Period Covered 1 July 1969 through 30 June 1970

Prepared by ______________________ Date ________
Dexter S. Haven, Senior Marine Scientist

Approved by ______________________ Date ________

VIRGINIA INSTITUTE OF MARINE SCIENCE

Abstract

Soft clam surveys during the past year have shown the existence of commercial quantities of soft clams in the upper and lower Rappahannock River. Distribution, however, is not continuous and even in favorable firm sand substrate populations were often sparse. Commercial quantities of soft clams do not exist in the York River.

Distribution of juvenile soft clams is not the same as adults since the young are often abundant in the intertidal and subtidal zone of the lower York River. It is thought that crabs and drills kill these small clams before they dig into the bottom.

Growth of soft clams is rapid and they may reach 2 inches in length in about 18 months.

The effects of the hydraulic dredge on sediments within hard and soft clam plots and at varying distances outside were

investigated and results summarized in this report. Results showed that within the plot the character of the bottom is changed. Zostera and other aquatic plants are uprooted and buried shell is raised to the surface of the sediments and silts and clays are washed away. Maximum distance that sediments accumulated was 100 feet from the site of the operation.

The hydraulic escalator can be used to catch commercial quantities of hard clams in Virginia waters. The location of some hard clam areas has been known for many years to patent tongers. However, the present study has documented the extent of the resource.

Questions still must be investigated concerning rates of renewal of clam populations after harvest. Consequently, we are emphasizing several points in this annual report.

1. Hard clams grow slowly in sections of Chesapeake Bay. Off Gloucester Point it may take from 4 to 5 years for clams to reach lengths of 1 1/2 to 2 inches. A 2 1/2 inch clam may be 8 years old. Growth in the James River is more rapid and commercial size may be reached in 4 years. Additional growth studies are now in progress in Hampton Roads and other areas.

2. Many of the clams collected in Chesapeake Bay and in the York and James rivers were large. Most of the clams collected fell between 2 1/2 to 4 inches in length. In contrast, clams from 1 to 2 inches were relatively less abundant.

If large numbers of young clams had been added to the population each year, the small sizes would tend to be more abundant than the larger sizes. This is not the case.

3. The relative abundance of the larger sizes of hard clams and the relative scarcity of smaller sizes suggests that the abundance of the larger clams in many areas is the result of a slow accumulation over a period of 10 or more years. Since we suspect that larval clams do set in many areas, predation or competition may be significant factors in these sparse populations.

In some instances, for example Gloucester Point, only a few young clams appear to be added to the population for many years. However, in other areas, especially in Hampton Roads, young clams are entering the population in considerable numbers.

Generally in populations having low recruitment (few young), the stocks are vulnerable to overfishing and populations may be quickly reduced to low levels. This could mean depletion of the stocks in the area being harvested and result in economic hardship to the operators involved. Recovery of a depleted hard clam area might take 5 or 10 years in certain sections.

Populations of hard clams in areas of moderate or high recruitment may be harvested at higher rates without the danger of depleting the resource.

A STUDY OF THE HARD AND SOFT CLAM RESOURCES OF VIRGINIA

ANNUAL REPORT FOR THE PERIOD 1 JULY 1969 THROUGH 30 JUNE 1970
Contract No. 3-77-R-1

by

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INTRODUCTION

The following report contains results of our studies from 1 July 1969 through 30 June 1970.

Included in this report is a complete summary of all studies related to soft clams. This includes growth rates, recruitment studies, distribution of juveniles, and effects of the dredge on the substrate and on adjacent bottoms.

Hard clam studies reported in this report include studies on growth, recruitment, distribution of young, and effects of the escalator on the bottom.

PHASE I--DETERMINATION OF SOFT CLAM POPULATIONS IN LOWER CHESAPEAKE BAY.

1. Introduction

It was necessary to evaluate soft clam populations in respect to 1) small, recently set clams and 2) adults. The reason for this is that at certain seasons small soft clams are abundant in many areas. In contrast, distribution of the larger adults is much more restricted.

Soft clams set in the upper part of Chesapeake Bay in the vicinity of Solomons Island, Maryland, twice each year. The first period occurs during October, November and December; the second lasts from April through May (Pfitzenmeyer, 1962). Studies at the Virginia Institute of Marine Science show a similar spawning season. Evidence for this is the appearance each year, during the two preceding seasons, of large numbers of juveniles which range in length from about 2 to 20 mm (about 1/10 to 1 inch).

These juveniles or young-of-the-year frequently occur in tremendous numbers in intertidal areas and in shallow water in the Rappahannock, James and York rivers. However, by June of each year few remain. The young during the winter and spring remain at the surface or bury at the most only about 1 inch. Consequently, as soon as the water begins to warm in the spring, they are rapidly consumed by predators such as crabs or gastropods.

In the October to May setting period, the juvenile soft clams may be captured with a Petersen grab. This dredge obtains about 1/15 sq. yd. of bottom substrate to a depth of about 2-3 inches. In this study material obtained by the dredge was screened and all small clams counted and measured. After June, soft clams grow rapidly and bury too deep to be captured by a Petersen grab. Predators collected in the Petersen grab were also tabulated for a limited number of samples.

Clams over 1 inch in length are sampled by the hydraulic escalator dredge.

2. Distribution of Juveniles in Shallow Water

In the York River "set" of juvenile soft clams was studied for three years. Results from the start of the program in 1967 to 30 June 1969 were outlined briefly in the last annual report.

For clarity, the entire program will be reviewed. Stations occupied in the study are shown in Figure 1 and distribution of juveniles is shown in Table 1.

During 1968, large numbers of soft clams occurred in the lower half of the York River from Sandy Point (25) to Gloucester Point (23) at depths from 1 to 2 meters (3 to 6 feet). Maximum concentration within this range was 156/sq. yd. Clams were scarce or absent in deeper water. Few were observed at stations above and below this zone at Purtan Bay (61) and at the Coast Guard Station (19).

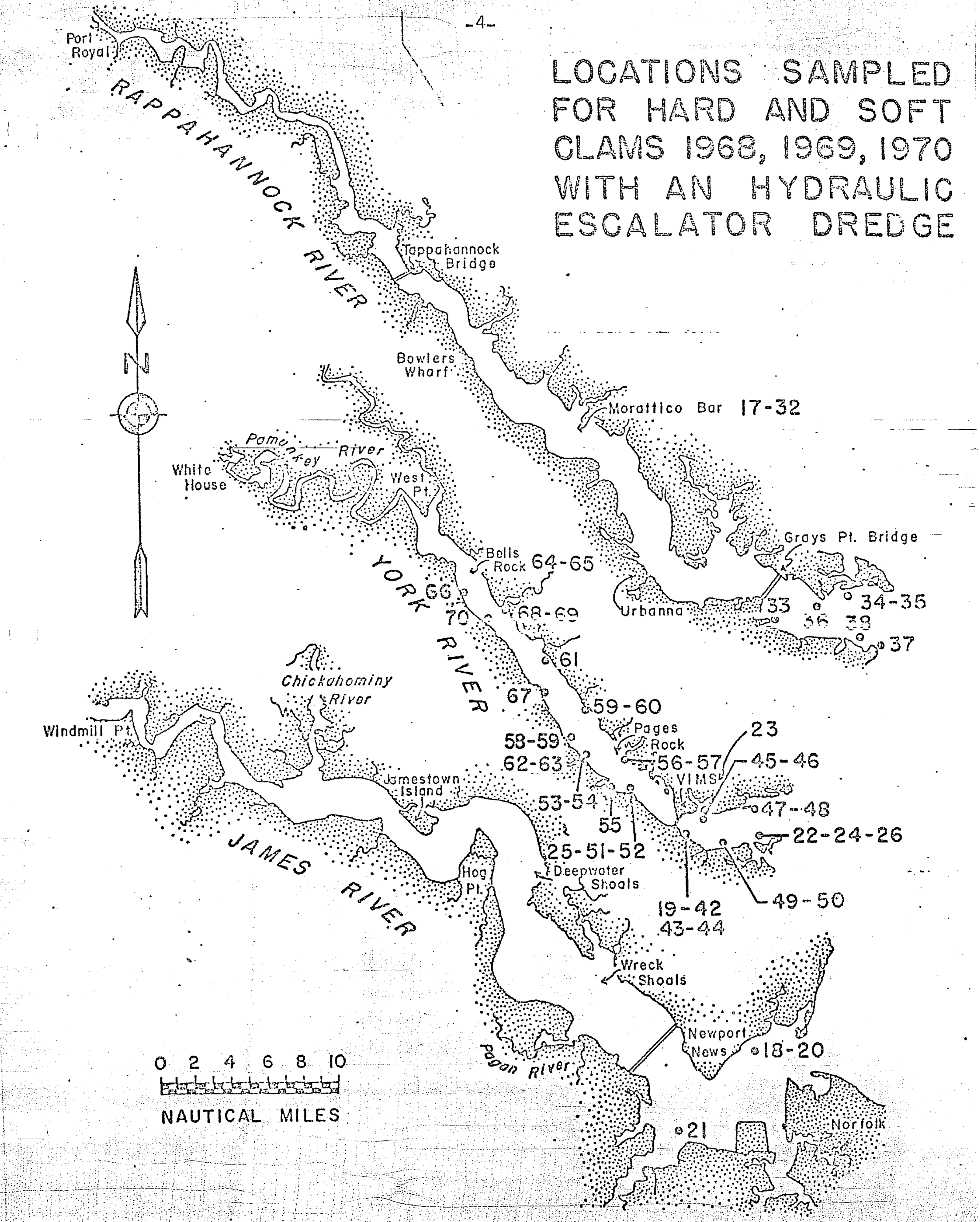
In 1969, soft clams were scarce or lacking at all stations sampled. This was true even at Sandy Point (25) where they were most abundant the previous year.

In 1970, the entire York River was sampled for depths ranging from 1 to 3 meters (3 to 9 feet). Juvenile soft clams were virtually absent in the upper half of the York River above Green Point (56). Below this point they were more abundant than in 1969 but concentrations were scattered and levels were far below those for 1968. Maximum number in 1970 was at Ellen Island (47) where there were 19/sq. yd.

In 1968, at Morattico Bar (17) in the upper Rappahannock River, soft clams were very abundant. Here numbers ranged from 43 to 268/sq. yd. The next year, at these same stations, setting was lower and "set" varied from 0 to 9/sq. yd.

3. Distribution of Juvenile Soft Clams in Intertidal Areas

A limited number of samples was taken for juveniles in the intertidal zone in the vicinity of Gloucester Point (23) in 1968. The zone sampled was largely exposed at low tide. It was not



LOCATIONS SAMPLED FOR HARD AND SOFT CLAMS 1968, 1969, 1970 WITH AN HYDRAULIC ESCALATOR DREDGE

tions occupied in hard and soft clam .

Table 1

Petersen Grab Survey, Hard-Soft Clam Study, 1967-1970

Date	Description	Dist. Upriver	No. Grabs	Depth (m)	Substrate	Total Pelecypods	No. Species	Juvenile Mya	$\bar{x}$ in mm	*Mercenaria mercenaria*	Individuals less than 15.0 mm
12- 5-67	Quarter Pt., York River		6	Equipment and procedure check							
12- 6-67	Goodwin Island	1.0	72	1.7	sand, mud		6	0		1	
12-13-67	Goodwin Island	1.1	32	1.3	sand, mud clay, shell	64	5	0		3	
12-14-67	Goodwin Island	1.1	24	6.3	mud, sand	7	4	0		1	
12-18-67	Quarter Pt., York River	4.1	56	2.8	sand, mud	2	2	0		0	
12-21-67	Yorktown, above Coast Guard Sta.	4.7	56	2.2	sand, mud	9	5	0		3	
2- 9-68	Nun 27, above G. Coleman Bridge	6.0	32	2.0	sand, mud	48	11	1	< 2.0	1	
2-27-68	VIMS	5.5	64	1.1	fine sand, mud, eel-grass roots	204	6	167	4.77	0	
3- 4-68	VIMS	5.5	23	1.5	fine sand, eelgrass roots	16	5	3	4.83	1	
3- 4-68	VIMS	5.5	23	6.0	mud, shell	5	3	0		3	
3- 5-68	Sandy Pt., York River	8.4	23	1.8	sand, mud	269	6	231	5.83	1	

Table 1 continued

Date	Description	Dist. Upriver	No. Grabs	Depth (m)	Substrate	Total Pelecypods	No. Species	Juvenile Mya	$\bar{x}$ in mm	*Mercenaria mercenaria*	Individuals less than 15.0 mm
3- 6-68	Sandy Pt., York River	8.4	24	1.2	coarse sand, shell	131	8	106	6.80	1	
3- 6-68	York River channel off VIMS	5.2	16	12.1	soft mud, few shells	18	4	0		4	
3- 8-68	Purtan Bay, York River	17.9	31	1.4	mud, shell	4	2	3	5.0	0	
3-19-68	Morattico, Rappahannock River 1	23.8	23	1.5	sand, shell frags	168	3	101	5.43	0	
3-20-68	Morattico, Rappahannock River control (a)	23.8	48	1.5	sand, shell frags	891	4	860		0	
3-21-68	Garrett's Private Ground, Rappahannock River	28.4	31	1.5	sand, light clay	196	4	89	6.83	0	
2-13-69	VIMS	5.5	24	1.6	sand, eel-grass	25	4	1	3.8	3	
2-14-69	VIMS	5.5	24	2.6	sand, eel-grass	6	4	0		3	
2-17-69	VIMS	5.5	24	1.8	sand, mud eelgrass	33	5	0		5	14.4
2-26-69	VIMS	5.5	24	6.5	mud	2	2	0		1	
3- 5-69	VIMS	5.5	16	8.0	mud, sand	1	1	0		0	

ble 1 continued

Date	Description	Dist. Upriver	No. Grabs	Depth (m)	Substrate	Total Pelecypods	No. Species	Juvenile *Mya*	$\bar{x}$ in mm	*Mercenaria mercenaria*	Individuals less than 15.0 mm
-19-69	Quarter Pt., York River	4.1	24	2.3	sand, eel-grass	8	3	0		2	12.8
- 5-69	Yorktown, York River 3	4.7	56	2.2	sand, mud	52	4	0		4	control
- 6-69	Yorktown, York River A	4.7	48	2.2	sand, mud	7	3	0		1	Post-escalation
- 4-69	Yorktown, York River A	4.7	96	2.2	sand, mud	3	2	1	not meas.	0	
2-24-69	Sandy Pt., York River	8.4	24	2.0	sand, mud, shell frags.	11	4	0		0	
4-28-69	Sandy Pt., York River	8.4	7	1.3	sand, mud, fossil shells, no tubes	7	3	4	9.5	0	
3-25-69	Morattico, Rappahannock River Control (a)	23.8	24	1.8	sand, shell fragments	78+	5	14	17.7	0	
6-25-69	Morattico, Rappahannock River 1	23.8	40	1.8	sand, shell	64	3	6	13.8	0	
6-26-69	Morattico, Rappahannock River control (b)	23.8	64	2.2	sand	69	6	0		0	
2-19-69	Yorktown, above Coast Guard Sta.	4.7	4	3.0	sand, mud	0					
1-28-70	Gaines Pt., York River	3.7	4	1.0	old oyster bed, sand, mud, eelgrass	6	2	2	5.9	0	

le 1 continued

Date	Description	Dist. Upriver	No. Grabs	Depth (m)	Substrate	Total Pelecypods	No. Species	Juvenile Mya	$\bar{x}$ in mm	*Mercenaria mercenaria*	Individuals less than 15.0 mm
-28-70	Gaines Pt., York River	3.7	4	3.0	old oyster bed, sand, mud, eelgrass	3	2	1	15.7	0	
- 4-70	Ellen Island	2.1	4	1.0	old oyster bed, sand, mud	10	5	5	9.3	2	2
- 6-70	Ellen Island	2.1	4	3.0	old oyster bed, mud, eelgrass	8	4	3	12.8	0	
2-18-70	York River, below refinery	2.3	4	1.0	subtidal, sand, clay, eelgrass	0					
2-18-70	York River, below refinery	2.3	4	3.0	subtidal, sandy	2	2	1	7.5	0	
2-24-70	Sandy Pt., York River	8.6	4	1.0	sand shoal, sand, mud	1	1	0		0	
2-25-70	Sandy Pt., York River	8.6	4	3.0	subtidal, mud	0					
2-27-70	Queens Creek, York River	12.0	4	1.0	planted oyster bed, mud	1	1	0		0	
3- 2-70	Queens Creek, York River	12.0	4	3.0	planted oyster bed, mud	2	2	0		0	

le 1 continued

ate	Description	Dist. Upriver	No. Grabs	Depth (m)	Substrate	Total Pelecypods	No. Species	Juvenile Mya	$\bar{x}$ in mm	Mercenaria mercenaria	Individuals less than 15.0 mm
9-70	Green Pt., York River	10.1	4	1.0	subtidal, sand, eelgrass	1	1	1	11.6		
-10-70	Green Pt., York River	10.1	4	3.0	old oyster bed, shell	6	2	3	12.3	3	
-23-70	Leigh's Ground, York River	13.2	4	1.0	old oyster bed, sand, mud	0					
-24-70	Walker's Ground, York River	13.7	4	1.0	old oyster bed, sand	0					
-25-70	Walker's Ground, York River	13.7	4	2.0	old oyster bed, mud	0					
- 1-70	Above Allmondsville Light, York River	17.4	4	2.0	planted oyster bed, mud	29	1	0		0	
- 3-70	Leigh's Ground, off Camp Peary, York River	14.9	4	1.0	subtidal, mud	12	1	0		0	
- 3-70	Leigh's Ground, off Camp Peary, York River	14.9	4	2.0	subtidal, mud	40	1	0		0	
-13-70	Bell Rock, York River	24.4	4	1.0	planted oyster bed, mud	45	2	1	10.1	0	
-13-70	Ware Creek, York River	23.3	2	1.0	subtidal, mud	69	2	0		0	
5-15-70	Skimino, York River	17.0	2	2.0	subtidal, mud	165	1	0		0	

ble 1 continued

Date	Description	Dist. Upriver	No. Grabs	Depth (m)	Substrate	Total Pelecypods	No. Species	Juvenile Mya	$\bar{x}$ in mm	*Mercenaria mercenaria*	Individuals less than 15.0 mm
-14-70	Poropotank, York River	20.9	2	1.0	old oyster bed, mud, sand	57	2	0		0	
-15-70	Mt. Folly, York River	21.5	2	2.0	subtidal, mud	106	1	0		0	
5-18-70	VIMS	5.5	100	3.0	mud, sand, eelgrass	9	6	2	7.5	1	1
5-19-70	Yorktown plot # 1	4.7	100	4.0	subtidal, mud, sand	9	1	0		9	5
5-21-70	Yorktown plot # A	4.7	100	3.0	mud, sand, eelgrass	7	3	0		4	2

sampled extensively since it was thought that surveys offshore in the shallow water would be more indicative of the estuary as a whole.

Results did show extensive populations as high as 1,000/sq. yd. in early May 1968 which was much higher than was found slightly offshore (Table 2). Numbers present in the area declined rapidly; none remained by August of that year.

4. Predators of Juvenile Soft Clams

As stated previously, during the October-May period soft clams range from about 2 to 20 mm long and during this period individuals do not bury, or, if they do, they are covered with a thin layer of sediment. During this period when the water is cold, most of the predators which might kill them are inactive. However, beginning about 1 May, when the water begins to warm, predators become active, and by June large numbers of soft clams which occur in the intertidal zone are killed.

Quantitative data were not obtained on numbers of soft clams destroyed by predators; however, observations of the intertidal flats, exposed during low tide, showed that gastropods and crustaceans eat tremendous numbers of small clams. That is, wide areas of intertidal flats may contain from 500 to 1,000 clams/sq. yd. in March-April. However, by the last of June none may be found (Table 2). It is thought that most, if not all, are eaten by predators.

Predators observed by the author ingesting small soft clams were the blue crab *Callinectes sapidus*, mud crabs, the two oyster drills *Urosalpinx cinerea* and *Eupleura caudata*, two species of mud snails *Nassarius vibex* and *Nassarius obsoletus*, and the conch *Busycon canaliculata*.

Table 2

Distribution of juvenile *Mya arenaria* in the intertidal area at Gloucester Point, Virginia, 1968

Date	Clam Density Number per sq. yd.	Average Length in mm
March-April	500-1,000	8-10
May	300-500	12-17
June	200-700	13-18
August	none	-
November	none	-

All the preceding predators were observed in Petersen grab samples at one time or another in the lower York River during 1968, 1969 and 1970 during January, February or March (Table 3). Drills were not collected in the single year (1970) when samples were collected in the upper York River. Mud snails and crabs were absent or scarce from the upriver stations in 1970; however, they did exist in that location.

Only the upper Rappahannock at Morattico Bar (17) was sampled for predators. Oyster drills do not occur in this region. Gastropods and crabs were not collected during the winter months; however, they do occur.

5. Distribution of Adult Soft Clams

Surveys for adult soft clams with the hydraulic escalator showed that soft clams occur in commercial quantities at locations in the upper and lower Rappahannock River. However, distribution within this range is not continuous and the presence of many producing oyster grounds in the river made sampling of intervening areas impractical.

Commercial quantities were obtained in the vicinity of Morattico Bar (17, 31, 32) (Fig. 1). In this area during September 1968, 37.8 bushels of soft clams were taken in a half-acre plot in 7.8 hours of operation. Clams ranged in length from 1 3/4 to 3 1/2 inches. A resurvey of the same area in September 1969 again found large quantities with the dredge capturing 34.1 bushels in a half-acre plot in 12.8 hours of operation (Table 4).

In the lower Rappahannock River at the mouth in the vicinity of stations 34, 35, 36, 37 and 38, extensive sampling showed

Table 3

Petersen Grab Predator Survey, 1967-1970

Location	Date	Depth (m)	No. Grabs	Gastropods and Crustaceans	No. Individuals	Substrate
Goodwin Island	12-13-67	1.3	32	*Urosalpinx cinerea* *Eupleura caudata* *Nassarius vibex*	22 4 33	predominantly sand and mud, some shell and clay
Goodwin Island	12-14-67	6.3	3	None		mud, sand
Quarter Point, York River	12-18-67	2.8	4	Mud crabs	1	sand, mud
Yorktown, above Coast Guard Sta.	12-21-67	2.6	2	None		sand, mud
Nun 27, above G. Coleman Bridge	2- 9-68	2.0	1	*Nassarius vibex*	1	muddy with sand
VIMS	2-27-68	1.1	1	*Urosalpinx cinerea* *Nassarius vibex* Mud crabs	4 5 2	sand with mud and eelgrass
VIMS	3- 4-68	1.5	1	Mud crabs	1	sand with eelgrass
VIMS	3- 4-68	6.0	1	None		mud, shell
VIMS	3- 5-68	1.8	1	None		sand, mud
Sandy Point, York River	3- 6-68	1.2	1	None		coarse sand, shell
York River, off-shore from VIMS	3- 6-68	12.1	1	None		mud, shell

Table 3 continued

Location	Date	Depth (m)	No. Grabs	Gastropods and Crustaceans	No. Individuals	Substrate
Purtan Bay, York River	3- 8-68	1.4	1	None		mud, shell
Morattico Flats, Rappahannock River	3-19-68	1.5	1	None		sand, shell fragments
Garrett's Private Ground, Rappahannock River	3-21-68	1.5	1	None		sand, light clay
VIMS	2-13-69	1.6	24	Callinectes, < 2" Urosalpinx cinerea Mud crabs Nassarius vibex Libinia	12 50 10 14 2	sand, eelgrass
VIMS	2-14-69	2.6	24	Callinectes Nassarius vibex	1 7	sand, eelgrass
VIMS	2-17-69	1.8	24	Callinectes, < 2" Urosalpinx cinerea Eupleura caudata Nassarius vibex Mud crabs	28 14 2 32 26	sand, mud, eelgrass
VIMS	2-26-69	6.5	24	Eupleura caudata Busycon canaliculata	4 1	mud
VIMS	3- 5-69	8.0	16	Nassarius vibex Mud crabs	2 1	mud, sand (less than 10%)
Quarter Point,	2-19-69	2.3	24	Callinectes, < 2" Nassarius vibex Eupleura caudata Urosalpinx cinerea Nassarius obsoletus Mud crabs	6 6 1 1 1 3	sand, eelgrass

Table 3 continued

Location	Date	Depth (m)	No. Grabs	Gastropods and Crustaceans	No. Individuals	Substrate
Yorktown, York River	6- 5-69	2.2	56	None		sand, mud
Sandy Point, York River	2-24-69	2.0	24	*Callinectes*, < 2" *Eupleura caudata* *Nassarius vibex* Mud crabs	4 2 1 2	sand, mud, shell fragments
Sandy Point, York River	4-28-69	1.3	7	*Nassarius vibex*	2	
Morattico Flats, Rappahannock River	3-25-69	1.8	24	None		sand, shell fragments
Morattico Flats, Rappahannock River	6-25-69	1.8	40	None		sand, shell
Morattico Flats, Rappahannock River	6-26-69	2.2	64	None		sand
Yorktown, above Coast Guard Sta.	12-19-69	3.0	4	None		sand, mud
Gaines Point, York River	1-28-70	1.0	4	*Urosalpinx cinerea* *Nassarius vibex*	1 4	olf oyster bed, sand, mud, eelgrass
Gaines Point, York River	1-28-70	3.0	4	*Urosalpinx cinerea*	1	old oyster bed, sand, mud, eelgrass
Ellen Island, York River	2- 4-70	1.0	4	*Callinectes*, < 2" Mud crabs	1 3	old oyster bed, sand, mud
Ellen Island, York River	2- 6-70	3.0	4	*Callinectes*, < 2" *Eupleura caudata* *Nassarius vibex*	1 1 1	old oyster bed, mud, eelgrass

Table 3 continued

Location	Date	Depth (m)	No. Grabs	Gastropods and Crustaceans	No. Individuals	Substrate
York River, below refinery	2-18-70	1.0	4	*Nassarius vibex*	4	sand, clay, eelgrass
York River, below refinery	2-18-70	3.0	4	*Callinectes*, < 2" *Nassarius vibex*	1 1	subtidal, sandy
Sandy Point, York River	2-24-70	1.0	4	None		sand shoal, sand, mud
Sandy Point, York River	2-25-70	3.0	4	None		subtidal, mud
Queens Creek, York River	2-27-70	1.0	4	None		planted oyster bed, mud
Queens Creek, York River	3- 2-70	3.0	4	None		planted oyster bed, mud
Indian Field Creek	3- 6-70	1.0	4	*Callinectes*, < 2"	2	planted oyster bed, mud
Green Point, York River	3- 9-70	1.0	4	*Nassarius vibex*	3	subtidal, eel-grass, sand
Green Point, York River	3-10-70	3.0	4	None		old oyster bed, shell
Leigh's Ground, York River	3-23-70	1.0	4	*Nassarius vibex*	3	old oyster bed, sand, mud
Walker's Ground, York River	3-24-70	1.0	4	*Nassarius vibex*	1	old oyster bed, sand
Walker's Ground, York River	3-25-70	3.0	4	None		old oyster bed, mud

Table 3 continued

Location	Date	Depth (m)	No. Grabs	Gastropods and Crustaceans	No. Individuals	Substrate
Above Allmondsville Light, York River	4- 1-70	2.0	4	None		planted oyster bed, mud
Leigh's Ground off Camp Peary, York River	4- 3-70	1.0	4	None		subtidal, mud
Leigh's Ground off Camp Peary, York River	4- 3-70	2.0	4	None		subtidal, mud
Bell Rock, York River	5-13-70	1.0	4	None		planted oyster bed, mud
Ware Creek, York River	5-13-70	1.0	2	None		subtidal, mud
Skimino, York River	5-15-70	2.0	2	None		subtidal, mud
Poropotank, York River	5-14-70	1.0	2	None		old oyster bed, mud, sand
Mt. Folly, York River	5-15-70	2.0	2	None		subtidal, mud
VIMS (oyster drills only)	5-18-70	3.0	100	_Urosalpinx cinerea_ (drills tab.)	3	mud, sand, eel-grass
Yorktown, Plot #5 (oyster drills only)	5-19-70	4.0	100	_Eupleura caudata_ (drills tab.)	1	subtidal, mud, sand
Yorktown, Plot #1 (oyster drills only)	5-21-70	3.0	100	No oyster drills		mud, sand, eel-grass

Table 4

Catch per unit of effort of *Mya arenaria* captured with an escalator harvester in 1968, 1969 and 1970 in various locations.

Coll. No.	River and Location	Month and Year	Depth (ft)	Effort (hrs)	Total Catch (bu) in half-acre	Catch/bu/hr Total	Catch/bu/hr First 2 hours	$\bar{x}$ no. bu.	$\bar{x}$ wt. bu. (lbs.)
17	R-Morattico #1	9/68	10	7.8	37.8 =13/m²	4.8		833	57.3
18	J-Hampton Bar	1/69	9	16.8	0				
19	Y-Yorktown	7/68	6	6.0					
20	J-Hampton Bar #2	7/68	8	4.5	0				
21	J-Nansemond Ridge	2/69	8	6.0	193 Clams				
22	Y-Goodwin Island #1	3/69	4-6	7.5	76 Clams				
23	Y-Gloucester Point	3/69	6	9.0	34 Clams				
24	Y-Goodwin Island #2	3/69	4-6	2.0					
25	Y-Sandy Point	4/69	4-6	1.0	16 Clams				
26	Y-Goodwin Island	4/69	4-6	3.5	4 Clams				
27	ES-Cobb Island #1	5/69	4	1.3	0				
28	ES-Cobb Island #2	5/69	4	2.0	0				
29	ES-Terry's Ground	5/69	4	0.3	0				
30	ES			0.8	0				
31	R-Morattico #1	7/69		6.3	3.3 =1/m²			1550	
32	R-Morattico #2	9/69	10	12.8	34.1 =12/m²	2.7		855	53.4
33	R-Parrotts Island	8/69	4-8	12.7	19.3 =6.5/m²	1.5		626	54.8
34	R-Deep Hole Point	8/69	4-8	4.0	1.0 =0.3/m²	0.2		1484	51.0
35	R-Deep Hole Point	8/69	4-8	2.3	0.5 =0.17/m²			1128	55.8
36	R-Mosquito Point	8/69	4-8	2.5	1.8 =0.6/m²			1510	53.8
37	R-Deltaville	9/69	4-8	1.0	171 Clams				
38	R-Broad Creek	9/69	4-8	1.0	298 Clams				
42	Y-Yorktown	10/69	4	2.0					
43	Y-Yorktown	10/69	6	2.0					
44	Y-Yorktown	10/69	9	24.5					

Procedure of sampling changed. Clams sampled in 12-foot circular path inside half-acre.

Table 4 continued

Coll. No.	River and Location	Month and Year	Depth (ft)	Effort (hrs)	Total Catch (bu) in Circle	Catch/bu/hr Total	Catch/bu/hr First 2 hours	$\bar{x}$ no. bu.	$\bar{x}$ wt. bu. (lbs.)
45	Y-Gains Point	1/70	4	2.5					
46	Y-Gains Point	1/70	9	2.5	0				
47	Y-Ellen Island	2/70	4	5.0					
48	Y-Ellen Island	2/70	9	6.4	0				
49	Y-Below AMOCO	2/70	4	2.0	0				
50	Y-Below AMOCO	2/70	9	5.5	0				
51	Y-Sandy Point	2/70	4	6.0	2 Clams				
52	Y-Sandy Point	2/70	9	0.8	0				
53	Y-Queens Creek	2/70	4	1.5	4 Clams				
54	Y-Queens Creek	2/70	9	3.5	94 Clams				
55	Y-Indian Field Creek	3/70	4	2.5	16 Clams				
56	Y-Green Point	3/70	4	2.0	4 Clams				
57	Y-Green Point	3/70	9	3.0	0				
58	Y-Aberdeen Creek (Leigh's)	3/70	14	2.0	360 Clams				
59	Y-Camp Peary (Walker's)	3/70	4	2.5	81 Clams				
60	Y-Camp Peary (Walker's)	3/70	6	1.0					
61	Y-Allmondsville Wharf	4/70	1	2.5	113 Clams				
62	Y-Camp Peary (Leigh's)	4/70	4	0.5	0				
63	Y-Camp Peary (Leigh's)	4/70	6	0.5	0*				
64	Y-Bell Rock (inshore)	5/70	4	0.5	0				
65	Y-Bell Rock (offshore)	5/70	4	0.5	0				
66	Y-Ware Creek	5/70	4	0.5	0				
67	Y-Skimino Creek	5/70	4	0.5	0				
68	Y-Poropotank Creek (inshore)	5/70	4	1.0	1**				
69	Y-Poropotank Creek (offshore)	5/70	4	1.0	0***				
70	Y-Mt. Folly	5/70	4	0.5	0				

* 1 juvenile on belt.
** 80 juveniles on belt.
*** 402 juveniles on belt.

scattered beds of small soft clams (1 to 1 1/2 inches) which were not at that time large enough to be sold commercially. However, at one location near Parrotts Island (33) a large bed of commercially saleable soft clams was located. In this location 19.3 bushels were taken in a half-acre plot in 12.7 hours of operation. Rate of catch during the first 2 hours of operation was approximately 15 bushels an hour.

Quantities captured in the upper and lower Rappahannock were comparable to catches in Maryland.

In Maryland in newly discovered beds, an operator often catches 50 to 75 bushels per day. In the Patuxent River when first dredged commercially in 1954, one operator averaged 4.3 bushels per hour. On the Eastern Shore of Maryland after the fishery had been established for five years, the catch per unit of effort has been stabilized at 2 to 3 bushels per hour (Manning and Dunnington, 1955).

It was thought that the York River might be a source of soft clams since intertidal concentrations have been noted in the past near the mouth and intertidally at scattered locations over the length of the river. These intertidal beds have been observed by biologists and by local residents in the 1960-1966 period. However, in the last four years there has been a drastic decrease in numbers. Scattered intertidal beds now exist inshore of stations 47-48, 45-46, 52, 59, 60 and 61. Surveys by the hydraulic escalator failed to obtain commercial quantities of soft clams along the entire length of the York River at depths ranging 4 to 14 feet. However, at most stations a few clams were taken (Table 4).

It was previously pointed out that distribution of juveniles as shown by the Petersen grab study was not similar to that of adults. For example, juvenile soft clams were very abundant in 1968 at Gloucester Point (23) and at Sandy Point (25). However, in 1970 adults were not obtained at Gloucester Point, and in 1969 and 1970 only a very few were seen at Sandy Point.

Conclusions

1. Heavy sets of small soft clams occur in the upper Rappahannock in 1968 and 1969. In 1968 in the lower York, there was a heavy set in certain locations in moderate depths. Set was low in 1969 and slight in 1970.

2. Commercial quantities of soft clams exist in the upper and lower Rappahannock, but distribution is not continuous.

3. Commercial quantities of soft clams were not found in the York River in spite of the fact that juveniles did appear on occasion in large numbers. It is thought that crabs or gastropods eat most of these juveniles before they become adults.

PHASE II--DETERMINE HOW RAPIDLY SOFT CLAMS WILL REPOPULATE A DREDGED AREA.

1. Introduction

In the management of soft clam resources, it is necessary to determine how rapidly an area will become repopulated after an existing crop is removed. This will depend on the annual set and the rate of growth and mortality. A second aspect to the problem is: Will the operation of a hydraulic dredge result in an increase in numbers of clams "setting" on the bottom during the following year? In relation to this last question, it has been suggested that the mixing of the bottom sediments by the dredge would in some manner result in a heavy strike or set the following year.

Experiments related to these problems have been in progress for several years and are now completed. The general design of the studies has been outlined in previous reports but will be briefly outlined again for clarity.

2. Methods

Half-acre plots were established in soft clam areas and marked with stakes. Numbers of clams within the staked areas was determined by a Petersen grab and with the hydraulic escalator.

1. A small dredge (Petersen grab) was first used to collect bottom sediments within the marked area. That is, it sampled clams too small to be captured by the hydraulic escalator (see Phase I). All clams collecting on the screen were counted and measured.

2. Following collection of the Petersen grab samples, the hydraulic escalator was used to harvest the larger clams in the half-acre plot. During harvest a 1/4 inch mesh belt was used on the escalator to facilitate collection of the smaller individuals. One year later the entire process was repeated and changes noted.

3. A basic aspect of this recruitment study was that the half-acre plot was harvested prior to the soft clam setting season. That is, it was harvested in late fall prior to the setting season which occurred in the October through May period.

4. Growth of soft clams in the York River at Gloucester Point was studied in sediment-filled boxes over a three-year period. Clams for this study came from a natural strike which occurred in the intertidal area each year. Small clams ranging from about 3 to 25 mm (1/10 to 1 inch) were sieved from the sediments, numbered, measured, weighed, and the clams were placed in screened sediment-filled boxes which rested on the bottom. Growth of each lot was measured twice each year during the period from 1968 to 1970.

3. Growth of Soft Clams

Five groups of soft clams were studied (Table 5). Two groups (5 and 5A) spawned during the 1966-67 season were placed in the York River in May 1967. Initial length was 20.8 mm (about 7/8 inch). One year later mean lengths ranged from 42 to 44 mm (about 1 3/5 inches). By May 1969 (third year) mean sizes were 51 and 52 mm (2 inches). In May 1970, mean size of both groups was 58 mm (2 3/10 inches).

Table 5

Data on growth of soft clams *Mya arenaria* in boxes at Gloucester Point, Va. Mortality is shown as the per cent dead since the last examination.

Lot 5

	1967 May	1967 Nov	1968 Apr	1968 Oct	1969 May	1969 Nov	1970 May
Winter-Spring 1966-67 set							
$\bar{x}$ length mm	20.8		44.2	46.8	52.1	56.2	58.1
$\bar{x}$ weight g	1.7		13.4	16.5	25.9	31.2	37.1
Number alive	100		88	79	67	56	56
% mortality during period			12	10	15	16	0

Lot 5A

	1967 May	1968 Apr	1968 Oct	1969 May	1969 Nov	1970 May
Winter-Spring 1966-67 set						
$\bar{x}$ length mm	20.8	42.3	45.5	51.3	55.5	58.0
$\bar{x}$ weight g	1.7	12.1	15.7	22.8	28.3	36.9
Number alive	100	44	35	35	35	35
% mortality during period		56	20	0	0	0

Lot 6

	1968 Apr	1968 Nov	1969 May	1969 Nov	1970 May
Winter-Spring 1967-68 set					
$\bar{x}$ length mm	13.3	28.9	47.5	53.0	57.8
$\bar{x}$ weight g	0.3	3.2	15.8	21.9	33.0
Number alive	205	43	41	23	23
% mortality during period		79	5	44	0

Lot 7

	1969 May	1969 Nov	1970 May
Winter-Spring 1968-69 set			
$\bar{x}$ length mm	20.3	44.5	52.3
$\bar{x}$ weight g		10.4	22.2
Number alive	58	44	42
% mortality during period		24	4

Table 5 continued

	Lot 8		
	1969 May	1969 Nov	1970 May
Winter-Spring 1968-69 set			
$\overline{x}$ length mm	21.8	42.9	50.9
$\overline{x}$ weight g		9.2	19.4
Number alive	127	103	101
% mortality during period		19	2

Lot 6 spawned in the 1967-68 season grew more rapidly than the two preceding groups. Its initial mean length was only 13 mm in April 1968 (about 1/2 inch) but by April 1969 it reached 48 mm (1 9/10 inches). By May 1970 (third year) mean length was 58 mm (2 3/10 inches).

The most rapid growth of all was shown by lots 7 and 8 which came from the 1968-69 set. These were placed in the York River in May 1969 with mean lengths of 20.3 and 21.8 mm. One year later mean lengths ranged from 50.9 to 52.3 mm (about 2 inches).

The preceding data show variability in growth between years and it is not known if this reflects experimental conditions or variability due to differences in food, etc., between the years.

4. Mortality of Large Soft Clams

Data on mortality in the present study are only indicative of conditions in the field. However, certain trends are indicated in Table 5. It is suggested that mortalities are initially high when clams are small. Also indicated is a higher mortality during the warmer months. Mortality during the colder months appears low and ranged from 0 to 15%.

5. Conclusions Related to Growth

Analysis of the data shows that soft clams in our study area reached a mean length of from 1 3/5 to 2 inches one year after the end of the setting season. This would be an average period of about 18 months. The rate of growth found in this study appears to be about the same for the Solomons Island, Maryland, since it was reported that soft clams grow to about 2 inches in length in about 18 months (Manning and Dunnington, 1955).

In respect to commercial production, soft clams are saleable at 2 inches. Consequently, if growth in trays is typical of natural bottoms, a crop might be harvested on productive ground every two years.

6. Repopulation of a Dredged Soft Clam Area

The recruitment study for soft clams was conducted at Morattico Bar in the upper Rappahannock River. In this area three half-acre plots were established (stations 17, 31, 32) (Fig. 1). The bottom was firm sand with much buried oyster shell 2 or 3 inches below the surface.

A. In 1968 two half-acre plots were established (#1 and a control). Initial studies consisted of a Petersen grab study for juveniles on March 19 and 20, 1968 (Table 1). On the test area (plot #1) 23 grabs collected 101 small soft clams or 66/sq. yd. In the control (a) 48 grabs obtained 860 soft clams (286/sq. yd.) (Table 1). Clams obtained with the grab were small with an average size of 5.4 mm and had been spawned during the 1967-68 season.

Six months after collection of the samples in September 1968 and prior to the spawning season, the hydraulic dredge was operated on the test plot. A total of 37.8 bushels of soft clams was harvested in 7.4 hours (coll. no. 17, Table 4). Clams were about 2 inches long (commercial size) and counted 833 per bushel. The juveniles noted the preceding spring were not collected in any abundance. It is probable that they passed through the mesh of the belt on the escalator.

B. 1969--The same two half-acre plots were studied for recruitment in 1969. On June 25, 1969, plot 1 which had been harvested the preceding year had a very low density of juveniles spawned the preceding winter. Forty grabs with the Petersen dredge collected only 6 juveniles (2/sq. yd). On June 26, 1967, the control (plot 1) also showed a large decrease over the previous year and in 24 grabs only 14 small clams were collected (2.5/sq. yd.).

After the Petersen grab samples were collected, plot 1 was harvested in July 1969 (coll. no. 31) with the hydraulic escalator (Table 4). A total of 3.3 bushels of soft clams was collected in 6.3 hours. Clams were all small and "counted". 1,550 per bushel (Table 4). The large number of small clams is thought to represent those sampled with the Petersen grab the previous year.

An area adjacent to plot 1 (coll. no. 32) which had never been harvested was harvested on September 10 and 12.8 bushels of commercial soft clams were taken in 12.8 hours.

Conclusion: Harvest of the soft plots did not result in an increase in set over the control area.

PHASE III--EFFECTS OF HYDRAULIC DREDGING ON SUBSTRATE AND ON ADJACENT BOTTOMS.

Effects of the hydraulic escalator dredge were evaluated in four detailed studies. One was conducted in the lower York using a hard clam head, two in the lower James with the hard clam head, and one in the upper Rappahannock with the soft clam head. Bottom substrate at each station was sand with a small quantity of silt-clay.

The general plan of each study was similar and has been described in previous reports. A review will be given, however, of the important points. At each station a half-acre plot was outlined with stakes. Divers placed small square wooden pegs in the bottom leading away from each of the four sides at 10-foot intervals for 100 feet and then at 50-foot intervals. Each peg was driven into the bottom so that exactly 2 inches projected above the sediment surface.

After placing pegs in position, cores of the bottom sediment were collected by divers in four locations inside each test plot and at varying distances along each of the four rows of pegs. After these preliminary preparations, the hydraulic dredge was operated in each plot until nearly all clams were harvested. After dredging was completed, divers again measured distance from the top of each peg to the sediment surface. Bottom cores were collected again in the same locations as they were prior to dredging.

Details of all sediment studies have been analyzed in respect to depths of material deposited at varying distances from the place where the dredge was operated. Sediment cores on all plots have yet to be analyzed.

Operation of a hydraulic dredge changes the appearance and texture of the bottom. Aquatic plants, such as Zostera (eelgrass), are uprooted. Invertebrate "holes" are eliminated and the per cent composition of bottom deposits is modified. Shallow trenches are left in the dredged area 6-8 inches deep. These tend to fill in in a month or two, leaving a smooth bottom.

Changes in per cent composition of the bottom are shown for the Morattico test area in Tables 6, 7, 8 and 9. Prior to escalation the test area showed a mean of 2.4% silt-clays, while a nearby control area showed a mean of 2.0%. After escalation the silt-clay fraction inside the escalated area was only 0.6%. This influence did not extend far from the test area. Seventy-five feet from the escalated area the pre-harvest silt-clay content had a mean of 3.1%, while the post-dredging content was 2.9%. At 150 feet, the pre- and post-escalation mean values for silt-clay were 2.2 and 2.0, respectively. It was concluded that beyond 75 feet there was measurable change in the character of bottom sediments.

A major influence of dredging is that buried shells are brought to the surface. Frequently, bottoms which appeared to be smooth sand were changed by escalation so that up to 20% of the bottom was covered by shell. In many localities this effect might be considered beneficial.

Measurements of quantities of sediments deposited in the test areas of the Rappahannock, York and James rivers are shown in

Table 6

Morattico Flats Experimental Area
The Effects of the Escalator Harvester

Cores	Control		Test Area: Prior to harvest		Test Area: After harvest	
	% silt-clay	% sand	% silt-clay	% sand	% silt-clay	% sand
1	2.9	97.1	1.3	98.7	0.8	99.2
2	2.2	97.8	1.8	98.2	0.3	99.7
3	1.6	98.4	4.2	95.8	0.4	99.6
4	0.6	99.4	2.1	97.9	0.8	99.2
5	0.7	99.3				
6	1.9	98.1				
7	3.3	96.7				
8	2.8	97.2				
	$\bar{x}$ = 2.0		$\bar{x}$ = 2.4		$\bar{x}$ = 0.6	
	Range 0.6-3.3		Range 1.3-4.2		Range 0.3-0.8	

Data are based upon analysis of 6-inch cores.

Table 7

Morattico Flats Experimental Area
The Effects of the Escalator Harvester

Analysis of Sand Fraction

Pre-harvest

	Core 1	Core 2	Core 3	Core 4
Total dry weight of sand fraction (gms)	66.61	61.90	49.93	64.32
% on 1000 micron screen	7.3	18.0	10.8	7.5
% on 500 micron screen	28.5	29.3	27.5	30.5
% on 250 micron screen	45.2	39.6	43.5	44.8
% on 125 micron screen	17.5	12.4	17.7	16.9
% on 63 micron screen	0.5	0.3	0.4	0.4

Post-harvest

	Core 1	Core 2	Core 3	Core 4
Total dry weight of sand fraction (gms)	48.63	68.28	46.66	64.03
% on 1000 micron screen	7.2	21.4	16.2	13.9
% on 500 micron screen	28.3	26.8	29.9	28.5
% on 250 micron screen	47.3	37.5	41.4	41.6
% on 125 micron screen	16.7	13.7	12.5	15.2
% on 63 micron screen	0.5	0.7	0.3	0.5

Table 8

Morattico Flats Experimental Area
The Effects of the Escalator Harvester

75 feet outside test area

Transect	Pre-harvest % silt-clay	Pre-harvest % sand	Post-harvest % silt-clay	Post-harvest % sand
Upriver	4.1	95.9	3.5	96.5
Downriver	1.7	98.3	3.3	96.7
Inshore	3.2	96.8	2.3	97.7
Offshore	3.5	96.5	2.6	97.4
	$\bar{x}$ = 3.1		$\bar{x}$ = 2.9	

Table 9

Morattico Flats Experimental Area
The Effects of the Escalator Harvester

150 feet outside test area

Transect	Pre-harvest % silt-clay	Pre-harvest % sand	Post-harvest % silt-clay	Post-harvest % sand
Upriver	3.7	96.3	2.7	97.3
Downriver	1.3	98.7	0.4	99.6
Inshore	2.1	97.9	3.6	96.4
Offshore	1.6	98.4	1.3	98.7
	$\bar{x} = 2.2$		$\bar{x} = 2.0$	

Tables 10, 11, 12 and 13. Measurable quantities of sediments were deposited up to 75 feet from the edges of the dredged areas. There was, however, no measurable accumulation 75 feet or more from the plots. Accumulations of up to 1 inch around the sediment stakes were occasionally observed within the first 75 feet of each transect. However, even in this zone quantities deposited were frequently not measurable. Shells dredged from the plot were also occasionally observed within the first 50 feet.

Beyond 75 feet, measurements often showed 0 accumulation. Measurements showing a loss of up to 3/4 inch of sediment were about as frequent as those showing a similar accumulation. Divers swimming over the bottom in the areas of the sediment stakes observed small sand ridges or ripples 3 to 4 inches from crest to crest and up to 1 1/2 inches high. These ripples are commonly found on any sandy area subject to currents. They are constantly being formed or eroded and may appear or disappear in any one spot in a matter of hours.

Oysters located at 75 to 150 feet from the dredged area were not injured or covered by the action of the hydraulic dredge.

Conclusions

Deposition of sand about the stakes beyond 100 feet in this study was thought to be due to natural effects of the current.

It was concluded that 100 feet was a reasonable limit to set for detectable influence of dredging by a hydraulic escalator on oysters.

Table 10

Morattico Test Area

Accumulation and erosion of sediment (in inches) around test stakes immediately after harvest. Plot last harvested 23 September 1968. Measurements made 25 September 1968; two measurements at each stake.

Distance from test area (ft)	Test Upriver	Test Downriver	Test Inshore	Test Offshore
0	1 , 3/4	1/8 , 0	1/16, 0	1/8, 1/8
10	1/8, 0	0 , 0	0 , 0	-1/8, 0
20	1/8, 0	0 , 0	-1/8 , 0	0 , 3/8
30	-5/8, -3/8	0 , 0	0 , 0	1/16, 1/2
40	-3/8, -7/8	0 , 0	0 , 3/8	0 , 0
50	-1/8, 3/8	0 , 1/8	-1 , 0	0 , 0
60	3/8, 0	0 , 1/8	-3/8 , -3/8	3/8, 0
70	1/4, 0	0 , -1	0 , 0	0 , 0
80	-1/2, M	0 , 0	0 , 0	0 , 3/8
90	0 , M	0 , 0	1/4 , -1/2	0 , 0
100	-3/4, 0	1/8 , 0	-5/8 , -3/8	-1/4, 0
140	0 , 1/8	1/8 , 1/8	-1/8 , -1/2	1/8, 0
150	1/16, 0	0 , 1/4	-1/4 , 0	0 , 0
160	3/4, 0	1/16, 1/16	1/16, -1/4	-1 1/2, -1/8

One hundred oysters at 75 feet on each transect; none killed; all covered with thin film of sand 1/16 inch thick, except on downriver transect where it was 1/32 inch thick.

Scattered trenches on plot 6 inches deep. Humps and scattered Mya and oyster shell on surface common all over plot. Shell extended 10-30 feet outside plot.

Control: 0; -1 3/4; -3/4; -1/4.

M = Stake missing.

Table 11

Hampton Roads Test Plot No. 1

Accumulation and erosion of sediment (in inches) around stakes immediately after harvesting a half-acre plot. Area last harvested 29 July 1968. Measurements made 2 August 1968; two measurements at each stake.

Distance from test area (ft)	Upriver	Downriver	Inshore	Offshore
0	3/8, -1/4	3/8, 0	0 , -2	1/8, S
10	1/4, 1/4	1/2, 1/4	0 , 1/2	1/8, S
20	0 , 1/2	0 , 0	0 , 0	1 , 1/8
30	0 , 0	0 , S	0 , 0	0 , 1/4
40	-1/2, 1/4	0 , 1/4	0 , 0	-1/2, 3/8
50	0 , 1/2	1/16, 1/2	1/2, 1/4	0 , 0
60	1/8, -3/8	M , 1/2	0 , 0	1/4, 1/8
70	1/8, 0	1/4, 1/4	1/8, 0	1/2, 1/2
80	0 , 0	0 , 1/4	1/4, 0	0 , 3/8
90	1/4, 0	0 , S	1/8, 0	1/4, 0
100	0 , 0	1/8, 1/8	1/4, 1/8	0 , 0
150	0 , 3/8	0 , -7/8	3/8, 3/4	0 , 0

One hundred oysters at 75 and 150 feet on all four transects; all normal and slightly moved by predators; only slight film of sediment.

Scattered trenches on plot up to 4 inches deep. Bottom uniform sand and shell. No live clams on surface. Shells scattered 30 feet off plot.

Control: 0; 0; 0; 0.

S = Shell; M = Stake missing.

Table 12

Hampton Roads Test Plot No. 2

Accumulation and erosion of sediment (in inches) around stakes immediately after harvesting a half-acre plot. Area last harvested 13 January 1969. Measurements made 15 January 1969; two measurements at each stake.

Distance from test area (ft)	Upriver	Downriver	Inshore	Offshore
0	3/4 , 1/3	1 , M	1 , 1 1/8	1/16 , 1/4
10	1/8 , 0	5/16, 1/4	-1/4 , 1/16	-3/16 , 0
20	1/8 , 1/16	1/4 , 1/8	-1/2 , -3/8	-7/16 , -5/16
30	1/16, 1/16	1/2 , 3/16	-3/8 , 1	-11/16, -1/2
40	1/16, -1/8	-1/16, 0	0 , 1/8	-3/8 , M
50	-3/16, -3/16	1/8 , -1 1/8	3/8 , 3/16	3/16 , 1/8
60	-5/8 , 1/8	1/8 , -1/4	-9/16, 0	-7/16 , 0
70	1 , 0	-1/2 , -3/16	-3/16, -5/16	0 , -3/8
80	3/4 , -1/3	0 , 1/8	1/4 , -3/16	-9/16 , 0
90	1/2 , 3/4	-3/16, 0	-1/4 , 5/16	-1 1/8, -1
100	5/8 , -11/16	3/16, 1/4	-1 , -1/2	-1/2 , -3/8
140	M , M	M , M	5/16, 0	M , M
150	1/2 , -1/8	-1/4 , -3/16	3/8 , 0	-1/4 , -3/16
160	1/2 , -3/4	M , M	-3/8 , 0	M , M

Shell distributed on surface in large patches inside half-acre plot; 10-15% coverage in some areas. Shells extended 10-20 feet outside plot.

Control: -1/2; -9/16; -1/4; 0.

Ripple marks on bottom 3-4 inches crest to crest; 1 to 1½ inches deep outside test square.

M = Stake missing.

Table 13

Yorktown Test Area

Accumulation and erosion of sediment (in inches) around test stakes immediately after harvesting a half-acre plot. Area last harvested 1 July 1968. Measurements made 9 July 1968; two measurements at each stake.

Distance from test area (ft)	Upriver	Test Downriver	Inshore	Offshore
0	0 , M	-1/2 , 0	M , M	0 , 0
10	3/4, 3/8	3/16, 3/8	M , M	3/4, 3/8
20	M , 0	3/16, 3/16	3/8 , 1	0 , 0
30	M , M	0 , 0	0 , 0	0 , 0
40	M , M	7/8 , 1/4	7/16, 0	0 , 0
50	1/4, 1/16	0 , 0	0 , 0	0 , 0
60	1/8, 0	0 , 0	0 , 0	0 , 0
70	0 , 0	0 , 0	1/8 , 0	0 , 0
80	0 , 3/16	0 , 1/2	1/8 , 0	0 , 0
90	0 , 0	0 , 0	0 , 0	0 , 0
100	0 , 0	0 , 0	1/8 , 0	0 , 0

Oysters at 75 and 100 feet on inshore and upriver; oysters at 75 feet on offshore transect; siltation about 1/64 inch; no mortality.

Scattered trenches on plot about 6 inches deep. Bottom shell-sand; no eelgrass or burrows.

M = Stake missing.

PHASE IV--RELATION BETWEEN BOTTOM TYPE AND OCCURRENCE OF SOFT CLAMS.

Cores of sediment have been collected at various stations occupied during the soft clam study. At Morattico Bar in the Rappahannock River where soft clams were abundant (stations 17, 31, 32), the bottom contained from 97.1 to 98.7% sand (Table 7). In the lower Rappahannock at Parrots Rock stations 19, 42, 43 and 44 where soft clams were also abundant, cores have not been analyzed but data obtained ~~during~~ the survey also showed a firm sand bottom with a slight clay content. To date, soft clams have not been found in a soft mud bottom.

Cores in the York River and the lower James have not been studied.

PHASE V--POPULATIONS OF HARD CLAMS AND TIME REQUIRED TO REPOPULATE A DREDGED AREA.

In this phase three aspects of the problem were studied: 1) hard clam growth; 2) distribution of juvenile and adult hard clams; 3) how rapidly hard clams repopulate a dredged area. Aspects of these have been discussed previously in the last annual report. The present discussion will attempt to summarize all data collected pertinent to these points with the exception of material related to deep water hydraulic tow dredging.

1. Growth Study

Data for the estimation of hard clam (*Mercenaria mercenaria*) growth in lower Chesapeake Bay were obtained by two methods. First, groups of hard clams, each containing specimens from the smallest size practical for marking through the larger sizes (approximately 30 to 90 mm), were measured, code-marked and planted in the substrate at several locations. Secondly, juveniles spawned at this laboratory and too small to be marked were kept in sediment trays which were placed in the York River adjacent to the laboratory.

Analysis of mean length data of the laboratory spawned hard clams (Table 14) after one year's growth indicated a significant difference (Table 15). Multiple mean analysis by the method of Scheffé (1959) indicated differences in growth among years but not between average lengths of trays groups in a given year. If it is assumed that the only variables are naturally occurring

Table 14

Mean lengths (mm) of one-year-old hard clams grown in sediment trays at Gloucester Point, Va. Years observed: 1967-68 (trays A and B); 1968-69 (trays C and D); and 1969-70 (tray E).

	1967-68		1968-69		1969-70	
	A	B	C	D	E	Totals
No. clams	18	200	12	30	123	383
Mean length	9.3	8.6	10.8	11.7	7.8	8.7
Variance	6.5	3.9	1.5	6.2	2.8	4.9
Confidence interval	8.0-10.6	3.8-3.9	10.0-11.6	11.6-11.8	6.8-8.7	8.0-9.4

Table 15

Analysis of variance of first year's growth of hard clams in experimental tray plantings. Years observed: 1967-68, 1968-69 and 1969-70.

Source	df	SS	MS	F
Among years	2	418.84	209.42	55.25*
Within years	380	1440.45	3.79	
Total	382	1859.29		

* Indicates significance at the 99 per cent confidence level.

environmental conditions affecting growth, the overall mean length (8.7 mm) is the best estimate of the length of one-year-olds for an "average" growing year in the Gloucester Point area.

Two-year-old hard clams attained an average size of 25.9 mm (Table 16). The data appear similar to those of one-year-olds, i.e., there is a larger difference between years than between trays in a given year. This apparent difference, however, cannot be statistically substantiated (Table 17).

Presently, data obtained from two plantings of clams in the lower James River at Hampton Roads and from single plantings in the lower York River in the vicinities of Yorktown and Gloucester Point have been analyzed with respect to growth. Each group was arbitrarily divided into 5 mm length intervals, except for the extreme sizes which required larger intervals to increase representation. The average increment in growth for each interval was, of course, obtained by differences one year after planting. Haskin (1954), using per cent increment in weight as an estimator of growth, constructed relative growth curves similar to Figure 2A for areas along the New Jersey coast. From these curves and knowledge of one- and two-year-old weights of laboratory spawned clams, he constructed cumulative growth curves for each planting area. The per cent increase in growth is predicted from the Y-axis at the point where the 'X' value (present size) intercepts the free-hand curve. When the average size of one age class is known and the time interval is one year, the cumulative curve is shifted to the point where the 'X' and 'Y' coordinates intercept

Table 16

Mean length (mm) of two-year-old hard clams grown in sediment trays at Gloucester Point, Va. Years observed: 1968-69 (tray A) and 1969-70 (trays C and D).

	1968-69	1969-70		
	A	C	D	Totals
No. clams	15	12	29	56
Mean length	28.6	25.3	24.8	25.9
Variance	78.2	37.7	27.9	44.4
Confidence interval (.95)	23.7-33.5	21.4-29.2	22.8-26.8	23.8-28.0

Table 17

Analysis of variance of second year's growth of hard clams in experimental tray plantings. Years observed: 1968-69 and 1969-70.

Source	df	SS	MS	F
Between years	1	147.95	147.95	3.48
Within years	54	2292.03	42.44	
Total	55	2439.98		

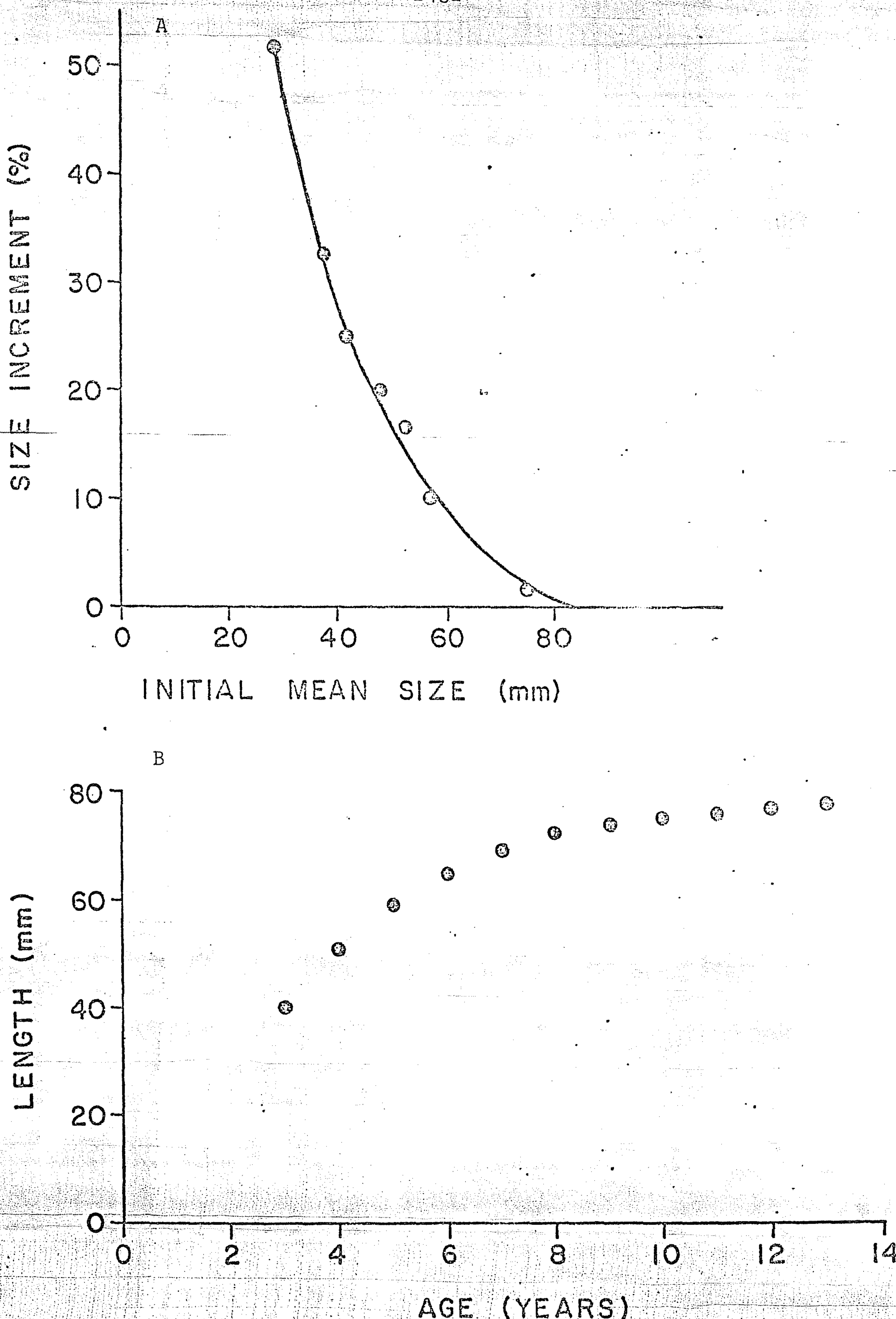


Figure 2. Relative (A) and cumulative (B) growth curves constructed

the growth curve. Figure 2B is such a cumulative curve constructed from the Hampton Roads 1968-69 growth increments. It is based on the assumption that a hard clam at the end of its third year of growth is about 40 mm.

The above method, however, is not considered applicable to this present study. The average size of hard clams of known age (laboratory spawned) has been estimated for only the Gloucester Point area. Varying environmental conditions in the lower Chesapeake Bay region prohibit assuming homogeneous growth.

A Walford "transformation" (Walford, 1946), as modified by Linder (1953), was utilized in this analysis. Linear representation of the growth rate of each group of hard clams was obtained by plotting length at time 't' against length at time 't + 1' for each individual clam (Figure 3). A strong degree of mutual linear relationship is suggested by the high correlation coefficients (r) obtained. The slope (k) of each regression line is an estimate of:

$$k = e^{-K}$$

where 'K' estimates the average rate of length increment (Ricker, 1958). An estimate of average maximum length, generally referred to as asymptotic length (L_∞), can be calculated from the Y-axis intercept. The latter can be equated to $L_\infty(1-k)$. The values necessary for the solution are obtained from the estimated line in which:

$$Y = a + kX$$

where 'X' and 'Y' are length at time 't' and 't + 1' respectively;

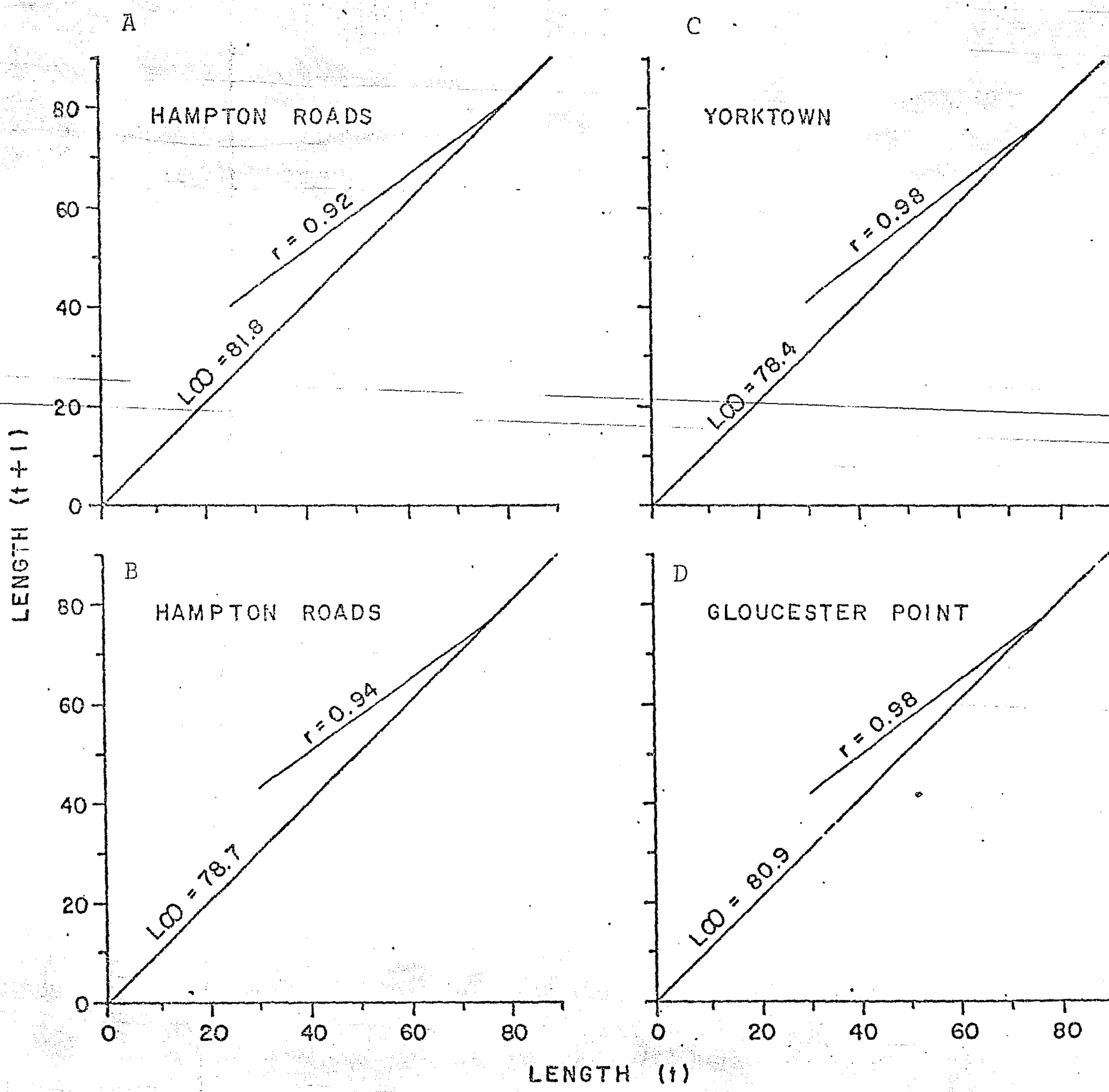


Figure 3. A Walford transformation of growth data for marked hard clams after one year's growth in the lower James River (A and B) and the lower York River (C and D).

'k' equals the slope of the Walford line and 'a' is the Y-axis intercept. Therefore:

$$L_\infty = a/(1-k)$$

Walford also showed that asymptotic size may be estimated from the intercept of the regression line and a line drawn at 45° through the zero point.

Analysis of covariance indicated no significant difference in the growth patterns of two experimental groups in the Hampton Roads area in 1968-69 (Table 18). These data were, therefore, combined. Analysis of the Hampton Roads, Yorktown and Gloucester Point data indicated a significant difference among the Walford lines (Table 19). Accordingly, treatment (group) means were again contrasted by the multiple mean method of Scheffe. The results indicated no difference between Yorktown and Gloucester Point plantings but their growth was significantly different than that exhibited at Hampton Roads. The lower York River data were also combined and the common regression for it and the lower James River are, respectively:

$$Y = 17.581 + 0.782 \quad X$$

and

$$Y = 22.375 + 0.717 \quad X$$

where in both cases 'X', 'Y', 'b' and 'a' are as explained above.

These regression lines indicate the rate of growth increment (K) to be approximately 1.4 times faster in the lower James River than in the lower York River (Table 20). The predicted size of one-year-old hard clams in the lower James River, based on the above ratio and the observed size (8.7 mm) of one-year-olds in

Table 18

Analysis of covariance of growth increments between two experimental plantings of hard clams at Hampton Roads, Va. Year observed: 1968-69.

Source	N-1	Σx^2	Σxy	Σy^2	SS	N-2	MS
Lot 1	368	84522.10	60833.75	49587.69	5803.34	367	15.81
Lot 2	130	24393.14	17767.70	15215.54	2273.74	129	17.62
Pooled					8077.08	496	16.28
Reg. Coeff.					1.42	1	1.42
Common	498	108915.24	78601.44	64803.23	8078.50	497	16.25
Adjusted					38.41	1	38.41
Total	499	115365.83	82744.40	67464.08	8116.91	498	

Comparison of slopes: $F = 0.09$

Comparison of elevations: $F = 2.36$

Table 19

Analysis of covariance of adult hard clam growth increments among Hampton Roads, Yorktown, and Gloucester Point plantings. Year observed: 1968-69.

Source	N-1	Σx^2	Σxy	Σy^2	SS	N-2	MS
Yorktown	155	40975.28	31408.32	25284.68	1209.61	154	7.85
Gloucester Point	116	28047.03	22567.67	19090.20	931.43	115	8.10
Hampton Roads	499	115365.86	82744.43	67464.13	8116.94	498	16.30
Pooled					10257.98	767	13.37
Reg. Coeff.					205.38	2	102.69
Common reg.	770	184388.18	136720.42	111839.01	10463.36	769	13.61
Adjusted					190.30	2	95.15
Total	772	184555.22	136751.91	111984.22	10653.65	771	

Comparison of slopes: F = 15.35*

Comparison of elevations: F = 13.99%

Table 20

Estimated growth parameters of the Walford transformation for experimental hard clam plantings in the lower James and York rivers.

	L_∞	k	K	Ratio (K_j/K_y)
James River	79.9	0.717	0.33	1.375:1
York River	80.8	0.782	0.24	

the Gloucester Point region, is about 12 mm. Cumulative growth curves (Figure 4) were constructed by substituting one-year-old size into the appropriate regression equation to obtain an estimate of the size of two-year-olds; the latter estimate was then entered to estimate three-year-old size, and so on. These estimates with respect to age may also be made from the graphic display of the regression line (Figure 5).

Analysis of data presented in Figures 4 and 5 gives the following data for growth in the lower York and lower James rivers:

Year	Length (mm) James	York
1	12.0	8.7
2	31.0	24.4
3	44.6	36.6
4	54.3	46.2
5	61.3	53.7
6	66.3	59.6
7	70.0	64.2

Walford (1946) states that his method may be used to distinguish between races which have different growth patterns. It is tempting to draw such a conclusion in this present case since the estimated values of 'K' and '$L\infty$' are different. However, caution must be exercized because adult growth is based on one year's observation and tray studies indicate that yearly growth patterns may vary. Observations are needed for a number of successive years to obtain an estimate of the "average growth rate." Continued observations would detect any trend in growth rate change, reflecting, of course, environmental changes. The value of the above analysis, besides giving an initial estimate of growth, is in demonstrating the applicability of the Walford transformation to hard clams. This

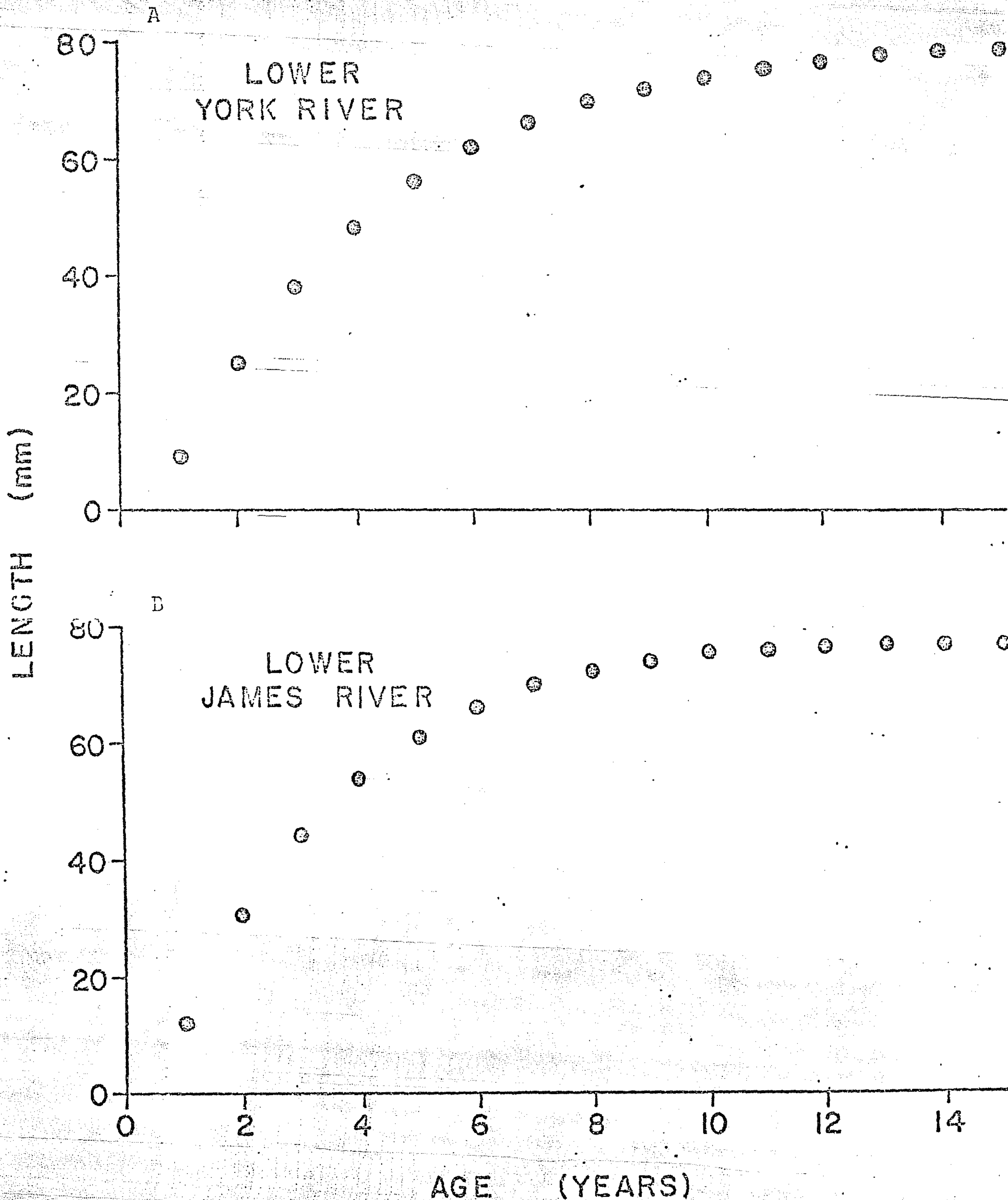


Figure 4. Cumulative growth curves for hard clams in the lower York River (A) and the lower James River (B) derived from the regression lines of the Walford transformations.

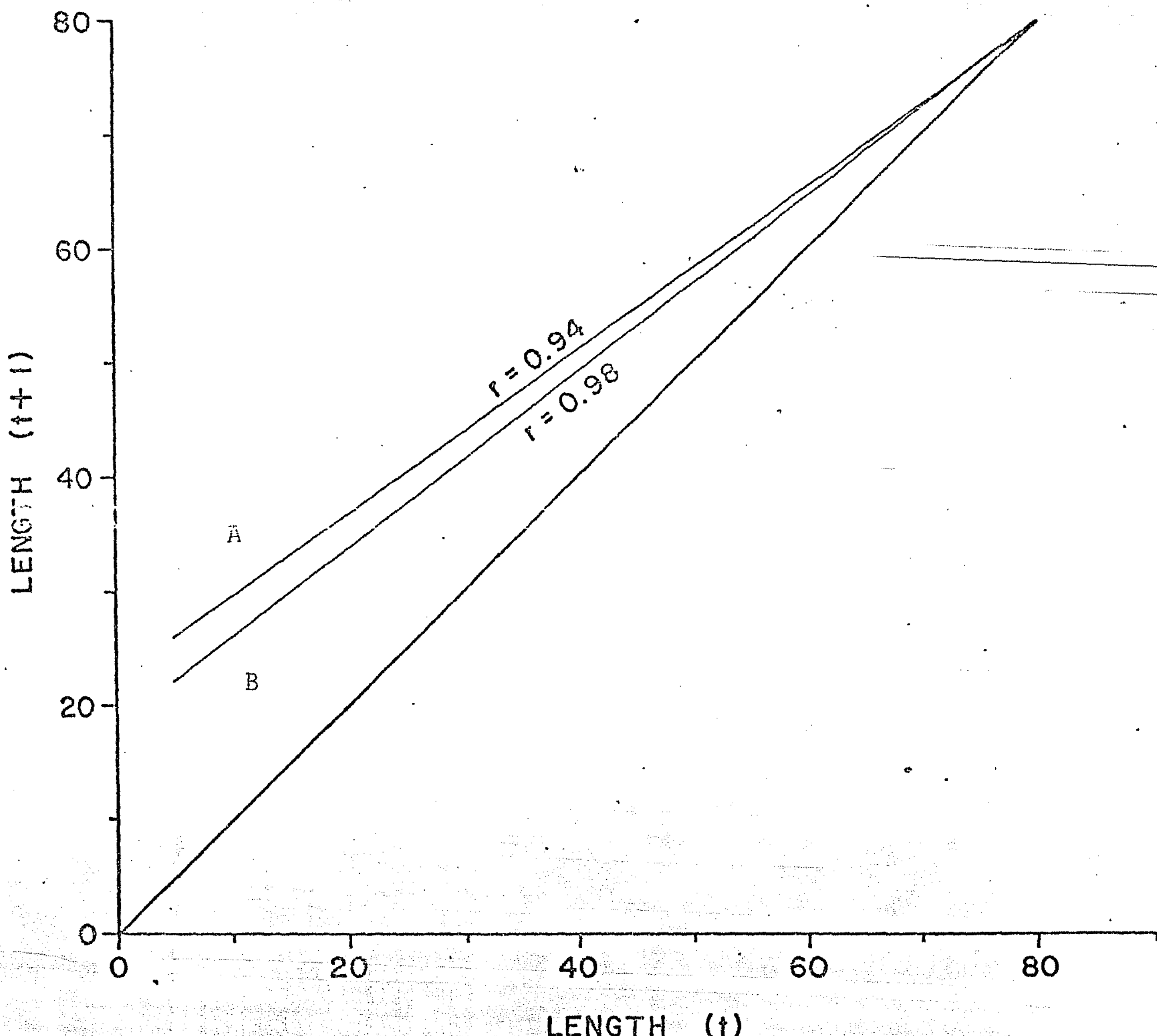


Figure 5. Walford transformations of the combined growth data for marked hard clams after one year's growth in the lower James River (A) and the lower York River (B).

eliminates the subjectivity of free-hand curve drawing and permits relatively easy statistical linear comparisons.

Conclusions for Growth

1. Growth of hard clams is variable from one river to another with the fastest rate in the lower James River.

2. In Virginia clams reach saleable size as littlenecks when they range from 48 to 62 mm (1 9/10 to 2 2/5 inches) in length. That is, clams will be saleable from the Hampton Roads between their third and fourth year. In the York they will be first saleable between their fourth and fifth year.

2. Distribution of Hard Clams in Virginia

Over fifty stations have been occupied by the hydraulic escalator during the hard clam study. All stations reported in this section were made with the hydraulic escalator in shallow water within half-acre plots as outlined in Phase I for the soft clam study. That is, areas were surveyed for juveniles with the Petersen grab and also with the hydraulic escalator.

Distribution of Juveniles--During the Petersen grab study for juvenile soft clams reported in Phase I, observations were also made for juvenile hard clams.

Growth studies presented in the preceding section show that hard clams reach a size of about 12 mm when one year old and from 24 to 31 mm when about two years old. In the present study any individual less than 15 mm long was classed as a juvenile. As in the study conducted on soft clams (Phase I), the Petersen grab was used to obtain juvenile hard clams. However, in respect to hard clams, this gear collected both juveniles and adults. Studies with the Petersen grab covered the York and the lower James and from 1968 to 1970. Preliminary results are reported in the last annual report but the entire program including unreported information is included here.

During the Petersen grab study, 57 large adult clams were collected but only 11 individuals less than 15 mm long. In most instances number collected was zero. Maximum density was less than 1/sq. yd. (Table 1).

Conclusion for Juveniles--Density of juvenile clams was low in all areas sampled. It was concluded that rates of recruitment or annual set were low. It was also concluded that if concentrations of juveniles noted in this study were typical, concentrations of adults were the result of a slow accumulation over a period of years.

Distribution of Large Hard Clams--The distribution of large hard clams has been studied since the start of the project in 1967 and a summary of the distribution in deep water was given in the last annual report. This report summarizes distribution to date in shallow water as indicated by surveys with the hydraulic escalator.

In the York River hard clams were present from the mouth about one-third of the total distance upriver in the vicinity of Camp Peary (60) (Fig. 1). Within this range they were captured by the dredge in commercial quantities at scattered locations from Green Point (57) to the mouth of the river. Catch varied from 0.3 to 3.5 bushels per hour for the first two hours with each bar containing from about 206 to 320 clams per bushel (Table 21). Average length varied from about 2 1/2 to 3 1/2 inches. Length varied with the station. Clams under 50 mm (about 2 inches) were scarce at Goodwin Island (49), Yorktown (19), and VIMS (23). The smaller sizes, however, were relatively more numerous at Sandy Point (25) and Green Point (56) (Figures 6 and 7).

Total numbers of bushels of clams per acre in the York were measured through October 1969 with about 48.2 bushels/acre at Yorktown (44). There was a change in sampling procedure in January 1970 and density has not been calculated. However, estimates indicate that as many as 100 bushels per acre may occur in the vicinity of Ellen Island (45, 46, 47, 48).

In the lower James River clams occurred in commercial quantities at Hampton Bar and at Nansemond Ridge. Catch per hour for the plots ranged from 3.6 to 9.7 bushels/hour. Number of clams per bushel ranged from 265 to 354 per bushel. Clams averaged from 2 1/2 to 3 1/2 inches in length. However, at Nansemond Ridge (21) and Hampton Roads (18) sizes under 2 inches were present (Figure 7). In respect to small clams at Sandy Point (25) and Nansemond Ridge (21), the question of dwarfing must be considered.

Conclusions

More studies are needed to establish distribution over wider areas. However, hard clams are available and may be taken by the hydraulic escalator in commercial quantities in the lower York and lower James rivers.

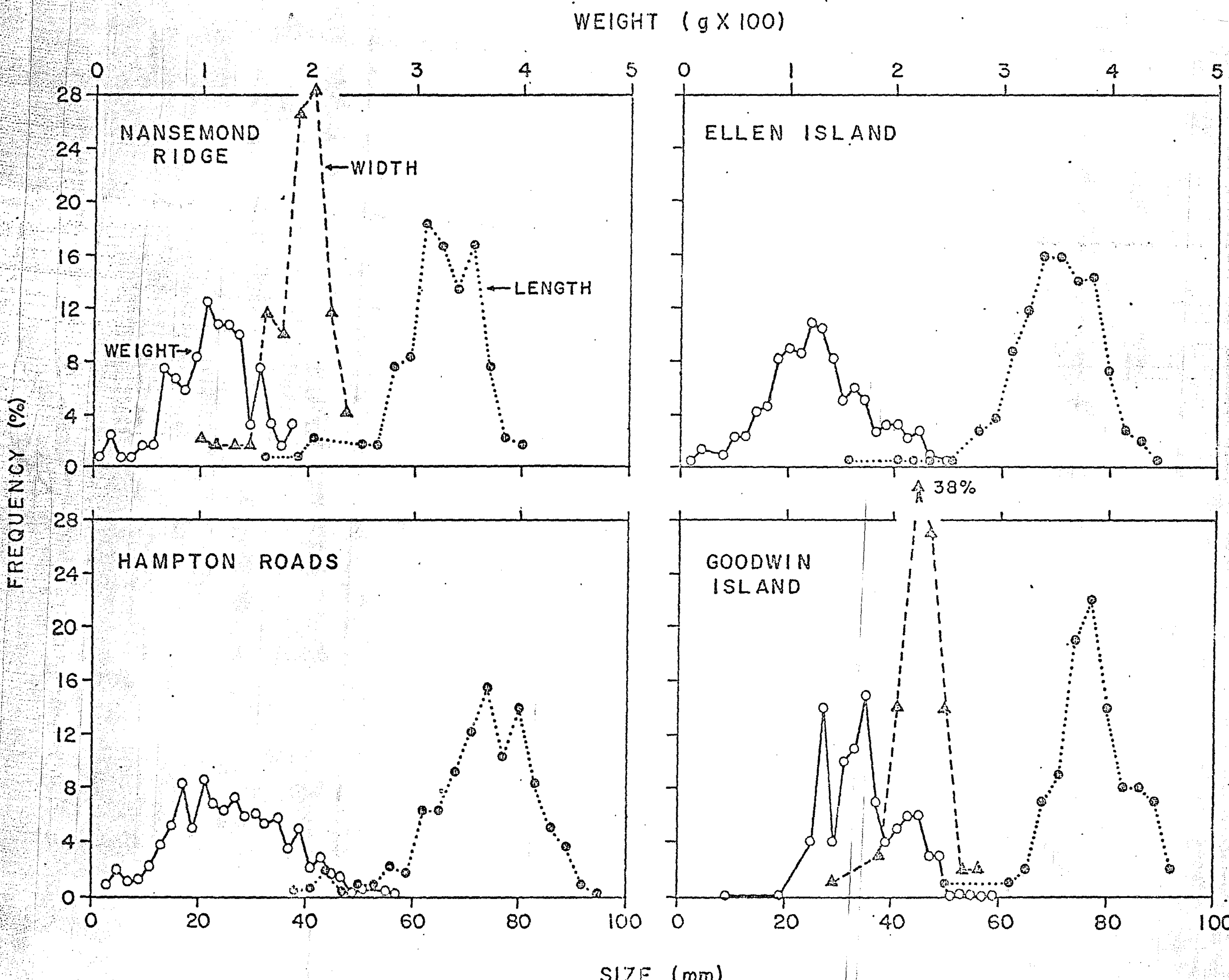


Figure 6. Length frequency of hard clams captured at various locations by the hydraulic escalator dredge.

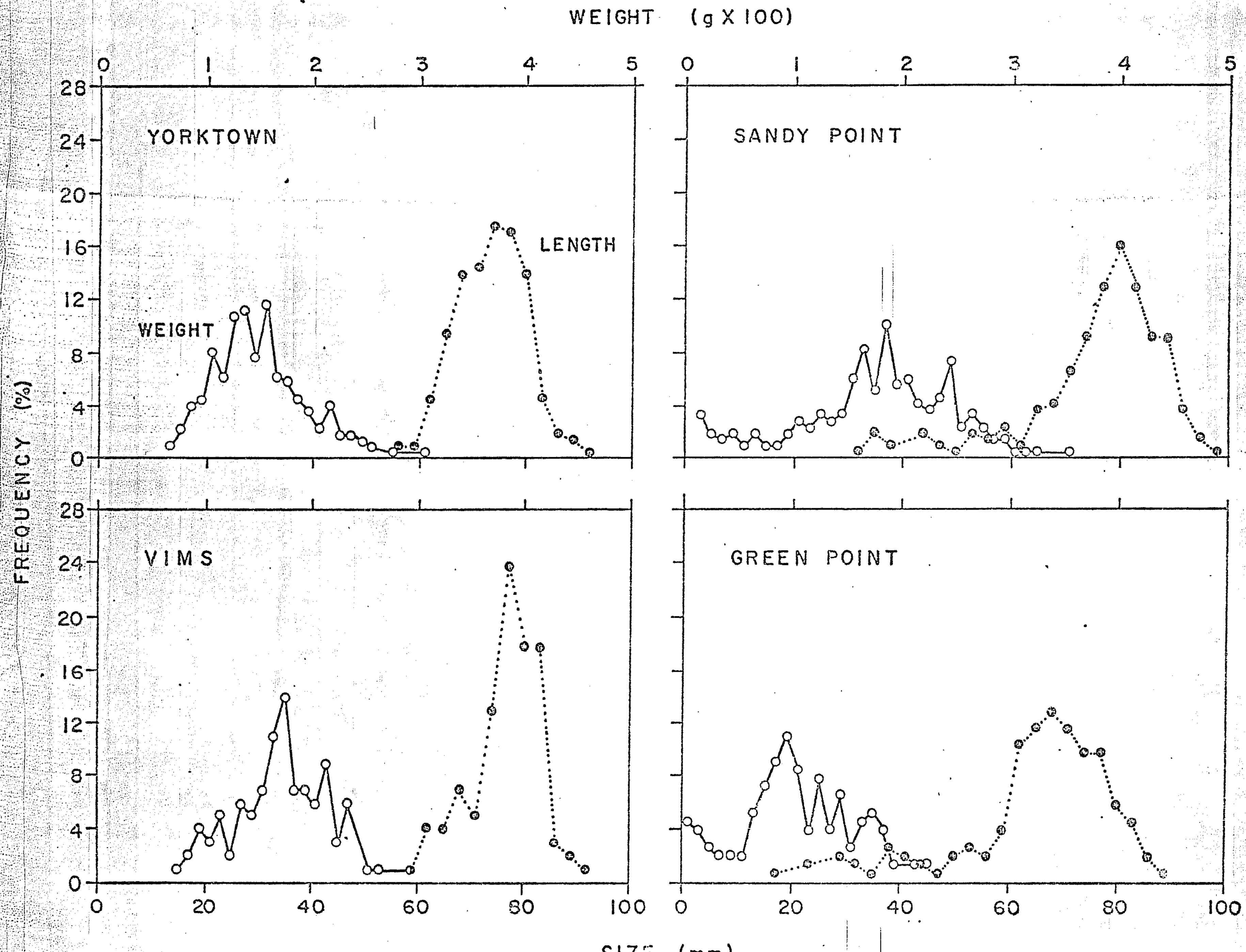


Figure 7. Length frequency of hard clams captured at various locations by the hydraulic escalator dredge.

Estimates of possible gross returns are possible from the present data. Assuming a catch of 3.6 bushels/hour with counts of 354 clams per bushel in the lower James, calculations show the escalator would capture 1,274 clams/hour (3/6 x 354) or 1,274 x 8 = 10,192 clams in an 8-hour day. At 2¢ each, this would be a gross of $203 per day.

3. Determine How Rapidly Hard Clams Will Repopulate A Dredged Area

As outlined for soft clams in Phase II, it is necessary to determine how rapidly an area will become repopulated after an existing crop is removed. This will depend on annual set, the rate of growth and mortality. A second aspect is: Will the operation of a hydraulic dredge result in an increase in set of hard clams the following year?

Two aspects of this problem have been discussed and preliminary answers are possible.

1. Annual set is very light in the locations investigated to date.

2. It will take about 4 or 5 years in the James and York, respectively, for clams to grow large enough to be sold commercially.

3. Mortality data have been collected but are not presented in this report. However, results indicate that once hard clams reach a size of 12 mm, mortality is very low.

The remaining question is related to effect of the escalator on set during the following year.

The basic design of studies to test effects of the escalator on set the following year was previously outlined but will be repeated for clarity.

Half-acre plots were established in the lower York River and populations estimated as outlined in Phase II with a Petersen grab and the hydraulic escalator. A basic difference from soft clam studies was that plots were sampled and escalated in early spring since hard clams spawn during June and early July. Two areas were studied in the aspect of the study, one at Yorktown (19) and the second at Gloucester Point (23) (Fig. 1).

1. Yorktown hard clam area, York River, Va. (Fig. 1, 19-42).

The Yorktown test area was located about 1 mile downriver from Yorktown on an old oyster growing area. The bottom was sand or firm mud-sand with oyster shell buried 2 or 3 inches below the surface. It was just outside an eelgrass zone. Depth varied from 6 to 12 feet MLW.

A. 1968--Three half-acre plots were studied in this area which are designated as plots 1, 3 and 5. The hydraulic escalator was used to remove nearly all the larger clams from plot 1 between the dates of 5 to 17 June. This was prior to the spawning period. Total catch was approximately 15 bushels during 12 hours. Clams were all large, averaging about 75 mm (3 inches) long. Few, if any, were 2 inches or smaller in length.

Plot 5, coll. no. 19, was harvested between 28 June and 1 July 1968 (during the spawning period). Total harvest was 14 1/2 bushels of hard clams in 6 hours (Table 21). Clams were

Table 21

Catch per unit of effort of *Venus mercenaria* captured with an escalator harvester in 1968, 1969 and 1970 in various locations.

Coll. No.	River and Location	Month and Year	Depth (ft)	Effort (hrs)	Total Catch (bu) in half-acre	Catch/bu/hr Total	Catch/bu/hr First 2 hours	$\bar{x}$ no. bu.	$\bar{x}$ wt. bu. (lbs.)
	Y-Yorktown #1	6/68	6-8	12.0	15		1.5		
17	R-Morattico #1	9/68	7	7.3	0				
18	J-Hampton Bar #1	1/69	9	16.3	78.5	4.7	8.0	285	83.1
19	Y-Yorktown #5	7/68	6	6.0	14.5	2.4	2.5	223	75.6
20	J-Hampton Bar #2	7/68	8	4.5	43.8	9.7	9.5	265	82.0
21	J-Nansemond Ridge	2/69	8	6.0	21.5	3.6	6.0	354	83.1
22	Y-Goodwin Island #1	3/69	4-6	7.5	12.5	1.7	2.0	224	83.6
23	Y-Gloucester Point	3/69	6	9.0	17.0	1.9	3.0	218	82.7
24	Y-Goodwin Island #2	3/69	4-6	2.0	3.7	1.8	1.8	223	84.2
25	Y-Sandy Point	4/69	4-6	1.0	0.7	0.7	0.9	255	86.0
26	Y-Goodwin Island	4/69		3.5	3.4	0.9	0.9	255	86.0
27	ES-Cobb Island #1	5/69	4-6	1.3	1.0	0.8	1.0	612	97.8
28	ES-Cobb Island #2	5/69	4	2.0	2.0	1.0	1.0	330	83.1
29	ES-Terry's Ground	5/69	4	0.3	0.2	0.6			
30	ES			0.3	0.5	0.7		304	86.9
	Y-Yorktown #1	6/69	6-8	2.8	0.8		0.3		
17	R-Morattico #1	7/69	7	6.3	0				
32	R-Morattico #2	9/69	10	12.8	0				
33	R-Parrotts Island	8/69	6-8	12.7	0				
34	R-Deep Hole Point	8/69	4-8	4.0	0				
35	R-Deep Hole Point	8/69	4-8	2.3	22 Clams				
36	R-Mosquito Point	8/69	4-8	2.5	101 Clams				
37	R-Deltaville	9/69	4-8	1.0	46 Clams				
38	R-Broad Creek	9/69	4-8	1.0	9 Clams				
42	Y-Yorktown, adjacent	10/69	4	2.0	1.2	0.6	0.6	236	90.0
43	Y-Yorktown, adjacent	10/69	6	2.0	2.3	1.2	1.2	206	85.5
44	Y-Yorktown #3	10/69	9	24.5	24.1	1.0	2.5	232	87.5

Procedure of sampling changed. Clams sampled in 12-foot circular path inside half-acre.

Table 21 continued

Coll. No.	River and Location	Month and Year	Depth (ft)	Effort (hrs)	Total Catch (bu) in circle	Catch/bu/hr Total	Catch/bu/hr First 2 hours	$\bar{x}$ no. bu.	$\bar{x}$ wt. bu. (lbs.)
45	Y-Gains Point	1/70	4	2.5	7.0	2.8	3.1	275	89.0
46	Y-Gains Point	1/70	9	2.5	4.7	1.9	2.0	306	86.5
47	Y-Ellen Island	2/70	4	5.0	10.0	2.0	1.8	320	85.0
48	Y-Ellen Island	2/70	9	6.4	17.6	2.8	3.5	298	91.9
49	Y-Below AMOCO	2/70	4	2.0	0.5	0.3	0.3		
50	Y-Below AMOCO	2/70	9	5.5	3.4	0.6	0.4	205	
51	Y-Sandy Point	2/70	4	6.0	2.4	0.4	0.6	221	86.2
52	Y-Sandy Point	2/70	9	0.8	8 Clams				
53	Y-Queens Creek	2/70	4	1.5	199 Clams				
54	Y-Queens Creek	3/70	9	3.5	134 Clams				
55	Y-Indian Field Creek	3/70	4	2.5	104 Clams				
56	Y-Green Point	3/70	4	2.0	332 Clams				
57	Y-Green Point	3/70	9	3.0	12.5	4.2	5.2	300	88.3
58	Y-Aberdeen Creek (Leigh's)	3/70	14	2.0	144 Clams				
59	Y-Camp Peary (Walker's)	3/70	4	2.5	1.7	0.7	0.8	335	90.6
60	Y-Camp Peary (Walker's)	3/70	6	1.0	2 Clams				
61	Y-Allmondsville Wharf	4/70		2.5	0				
62	Y-Camp Peary (Leigh's)	4/70	4	0.5	0				
63	Y-Camp Peary (Leigh's)	4/70	6	0.5	0				
64	Y-Bell Rock (inshore)	5/70	4	0.5	0				
65	Y-Bell Rock (offshore)	5/70	4	0.5	0				
66	Y-Ware Creek	5/70	4	0.5	0				
67	Y-Skimino Creek	5/70	4	0.5	0				
68	Y-Poropotank (inshore)	5/70	4	1.0	0				
69	Y-Poropotank (offshore)	5/70	4	1.0	0				
70	Y-Mt. Folly	5/70	4	0.5	0				
19	Y-Yorktown #5	5/70	6	1.0	0.8 (205 clams)				
23	Y-Gloucester Point	5/70	6	1.5	0.5 (88 clams)				
	Y-Yorktown #1	5/70	6-8	1.0	0.2 (47 clams)		0.2		

all large with a mean length of 75.5 mm. Small hard clams less than 25 mm (1 inch) were not collected.

Petersen grab samples were not taken on either plot in 1968.

B. 1969--Plot 1 was investigated again on 4 and 6 June 1969 by taking 144 Petersen grab samples. There had been little, if any, recruitment since the plot was harvested in 1968 since only one small hard clam and one small soft clam were recovered in all the samples (Table 1). Following the collection of samples with the Petersen grab, the hydraulic escalator was again operated in the half-acre plot (plot 1) between 10-11 June for 2.8 hours. Total catch was 0.8 bushel of large hard clams.

Plot 5 was not sampled in 1969.

On 5 June an adjacent half-acre plot (3) was investigated as a "control." At this location 56 samples with the Petersen grab collected only 4 large hard clams. No juvenile hard or soft clams were obtained which had set during the preceding year (Table 1). Afterwards the escalator was operated for 24.5 hours with a catch of 24.1 bushels.

C. 1970--Plot 1 was sampled for the second time in 1970 with a Petersen grab on 21 May. In 100 Petersen grabs only 2 small hard clams (0.3/sq. yd.) spawned the preceding year were collected (Table 1). One hundred grabs on plot 1 on 19 May obtained 5 juvenile hard clams (0.7/sq. yd.). Total lengths of the clams were 10, 8, 6, 5, 5 mm. Small soft clams spawned the preceding year were not obtained on either plot. Following sampling with the grab, plot 1 was harvested for the third year in succession in May. Only 47 large hard clams were taken in 1 hour. On plot 5 one hour of escalation resulted in 205 large clams. No small hard clams less than 25 mm (1 inch) long were taken by the hydraulic dredge.

2. <u>Gloucester Point hard clam area.</u>

This area is located 800 feet downriver from the short pier at the Virginia Institute of Marine Science. The bottom is 7 feet deep MLW. The substrate is firm sand with an occasional patch of eelgrass.

A. 1969--One half-acre plot was harvested with a hydraulic escalator during mid-March 1969 (coll. no. 23, Table 21). Seventeen bushels of clams were obtained in 9 hours of operation. Clams were all large. Petersen grab samples were not taken.

B. 1970--One year after the initial survey on 18 May, 100 Petersen grab samples were taken on this same plot. One hard clam 10 mm long (about 1/2 inch) spawned during the previous year was collected (0.2/sq. yd.) (Table 1).

After the Petersen grabs were collected in May 1970, the escalator harvester was operated on the plot for 90 minutes. Only 88 large hard clams were obtained during this period (Table 21).

It was concluded that escalation on the plot did not increase the set of hard clams during the following year and that recruitment on the Gloucester Point plot during 1969 was very low. Calculations similar to that for the Yorktown area show a per acre density of young clams of 0.2/sq. yd. or about 968 per acre.

Data from the two plots permitted several conclusions.

1. Annual set in the Gloucester Point area was low.

2. "Working" the bottom with the hydraulic escalator did not measurably increase the set of hard clams in the area.

3. The Yorktown area had slightly higher maximum rate of recruitment with maximum annual set of hard clams being 0.7 clams/sq. yd./year. Therefore, maximum density on the sampling date was square yards in one acre (4,840) x 0.7 or 3,388 juvenile clams per acre.

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