10-23-1995

Fishery independent standing stock surveys of oyster populations in Virginia 1995

Roger L. Mann
Virginia Institute of Marine Science

James Wesson

Report for the period October 1, 1994 - September 30, 1995

submitted to:

The Chesapeake Bay Stock Assessment Committee:
attention: M. Elizabeth Gillelan, Division Chief
NOAA Chesapeake Bay Office
National Marine Fisheries Service
410 Severn Avenue, Suite 107A
Annapolis MD 21403

by

The School of Marine Science and Virginia Institute of Marine Science
The College of William and Mary
Gloucester Point, VA 23062
and
Virginia Marine Resources Commission
P.O. Box 756
Newport News, VA 23607-0756

for the program entitled:

Fishery independent standing stock surveys of oyster populations in Virginia

Investigators: Dr. Roger Mann (SMS/VIMS) and Dr. James Wesson (VMRC).

date of report submission: October 23, 1995

Table of Contents

Acknowledgments: We thank John Register and Calvin Wilson of the Virginia Marine Resources Commission; Reinaldo Morales Alamo, Kenneth Walker, Mark Luckenbach, Jake Taylor, Rudy Cashwell, and Jean King of the Virginia Institute of Marine Science, and numerous students of the School of Marine Science, Virginia Institute of Marine Science for their assistance in the field; Gerry Showalter of the Virginia Marine Resources Commission for assistance with reef mapping; and Chris Bonzek and Robert Harris of the Fisheries Data Management Unit of the Department of Fisheries Science at the Virginia Institute of Marine Science of development of the custom database for field data.

Introduction

History of the Virginia oyster resource and the need for stock assessment

Extensive description of the Virginia oyster resource and history of its utilization has been given by Haven, Hargis and Kendall (1981), and more recently reviewed by Hargis and Haven (1988). These contributions, among many others, describe a state of continuing decline. The James River, Virginia has served as the focal point for the Virginia oyster industry for over a century, being the source of the majority of seed oysters that were transplanted for grow-out to locations within the Virginia portion of the Chesapeake Bay and much further afield in the Middle Atlantic states (Haven et al, 1981). The Rappahannock River in Virginia was, for many years, a source of large and valued oysters for both the shucking and half shell trade. It is surprising that comparatively little effort has been previously expended to estimate standing stock in both the James and Rappahannock Rivers given the acknowledged need for such data in fishery management. Continuing losses of productive oyster reef over the past three decades to Haplosporidium nelsoni, commonly known as MSX, and Perkinsus marinus, commonly known as "Dermo", in the higher salinity regions of both rivers, combined with increased fishing pressure on all remaining stocks, have emphasized the need for working estimates of standing stock. This need has been further exaggerated in the James River by a change in emphasis in the past decade from the harvesting of "seed" oysters to larger "market" oysters, and the reduction in size limit of the latter from three to two-and-one-half inches maximum dimension (although this action was reversed with an increase in minimum market size to three inches for the 1994-1995 season). The fishery continues to exploit the limited remaining broodstock from the James River in order to retain a viable fishery for" market" oysters, while simultaneously threatening the long term future of the river as the only functional seed producing location in the Virginia portion of the Chesapeake Bay.

Intensive, fishery independent estimates are rare but pivotal to examination of spawning capabilities of broodstock supporting commercial fisheries and related requirements for establishment of fishery catch quotas. To facilitate resource management a fishery independent survey was proposed to and subsequently supported by the Chesapeake Bay Stock Assessment Committee in 1993. The first year of activity focused on the James and Rappahannock Rivers and the annual report covering that material was submitted in November, 1994. That report contained commentary on both fishery independent and fishery dependent data as tools to assist oyster fishery management in Virginia. The second year of activity began in the Fall of 1994 with further examination of the James and Rappahannock, but was expanded in the Spring of 1995 to include the resources of the Eastern Shore of Virginia. Both activities are limited to fishery independent assessments. This report describes activity under the 1994-1995 funding year.

Fishery Independent Sampling

The primary objective of the study was to effect a fishery independent study of the standing stock of oysters, both market and seed, in the Virginia portion of the Chesapeake Bay and the Seaside of the Eastern Shore. For the period reported here the focus of activity was on the James and Rappahannock Rivers within the Chesapeake Bay, and the Eastern Shore.

Methods: James River and Rappahannock Rivers

The selection of sample numbers and locations

Spatial variability in distribution of oysters within an oyster reef system, and distribution of reefs in the intertidal and/or subtidal regions complicate fishery independent estimation of standing stock. We designed a quantitative sampling program using a stratified random grid with the documented oyster reefs or rocks in the James River forming the strata. The area surveyed is described in extensive surveys made by VIMS and reported by Haven and Whitcomb (1983), and briefly in the 1993-1994 report of the current investigators. These areas have been subjected to regular survey by VMRC and VIMS personnel for at least two decades by dredge. The limits of the known oyster reef were mapped by the Surveying Engineering Department at VMRC and the grids for sampling set with Loran coordinates (Loran was checked daily when in the field from known markers at both the beginning and end of the day). The James River public oyster grounds (Baylor grounds) currently supporting oyster populations are illustrated in Figure 1 as an overlay of a map of bottom type (oyster rock, shell and mud, shell and sand, sand, and soft mud). The purpose of this figure is to illustrate that the reef systems as identified in the Baylor surveys are not uniform in substrate, and therefore not expected to be uniform in oyster distribution within a single reef.

The reef areas sampled in 1994 - 1995 are illustrated in Figures 2, this being a modification of Figure 2 from the 1993-1994 survey to include new reef areas examined. The legend of Figure 2 identifies the sampled reefs by number. These numbers are often cross referenced with reef names in this report where convenience dictates. Sampling areas 1 through 11 in Figure 2 represent the limits of hard oyster rock strata selected, mapped and sampled within the larger public oyster grounds in those regions. The limits of hard oyster rock strata within sampling areas 12 through 23 were not mapped separately because of the large areas involved; consequently, we knew beforehand that sampling grids selected in areas 12 - 23 would include both oyster rock strata as well as bare sandy or muddy strata. Sampling sites were picked by random numbers within the grids and oysters were sampled with a hydraulically operated patent tong. In this manner a total of 786 stations were occupied on 23 reefs in the James River in 1994-1995 surveys, compared to 825 stations on 19 reefs in 1993-1994.

The sampling protocol for the Rappahannock River was as for the James River and employed a quantitative sampling program using quadrats located in a random grid placed over a map of the known oyster resources. Although once extensive, these are now mostly limited to the upper part of the Rappahannock above Bowlers Rock and Morattico Bar. The only commercially exploited reef of any consequence is Russ' Rock. In 1994-1995 surveys were extended to include reefs below the Rappahannock bridge at White Stone in an area bounded by Mosquito Point and Windmill Point to the north, and Grey Point and Stingray Point to the south. This section of the river lies approximately 15 nautical miles downstream of the region first surveyed in 1993-1994 and resurveyed in 1994-1995. Both regions are illustrated in Figure 3. The reefs were again the basis for stratified random sampling. The area surveyed is described in Haven and Whitcomb (1989). The limits of the

Figure 1: Outline of areas sampled during the 1994-1995 James River oyster stock assessment superimposed over a chart of bottom type modified from Haven et al (1981). Areas in white respresent primarily soft mud.

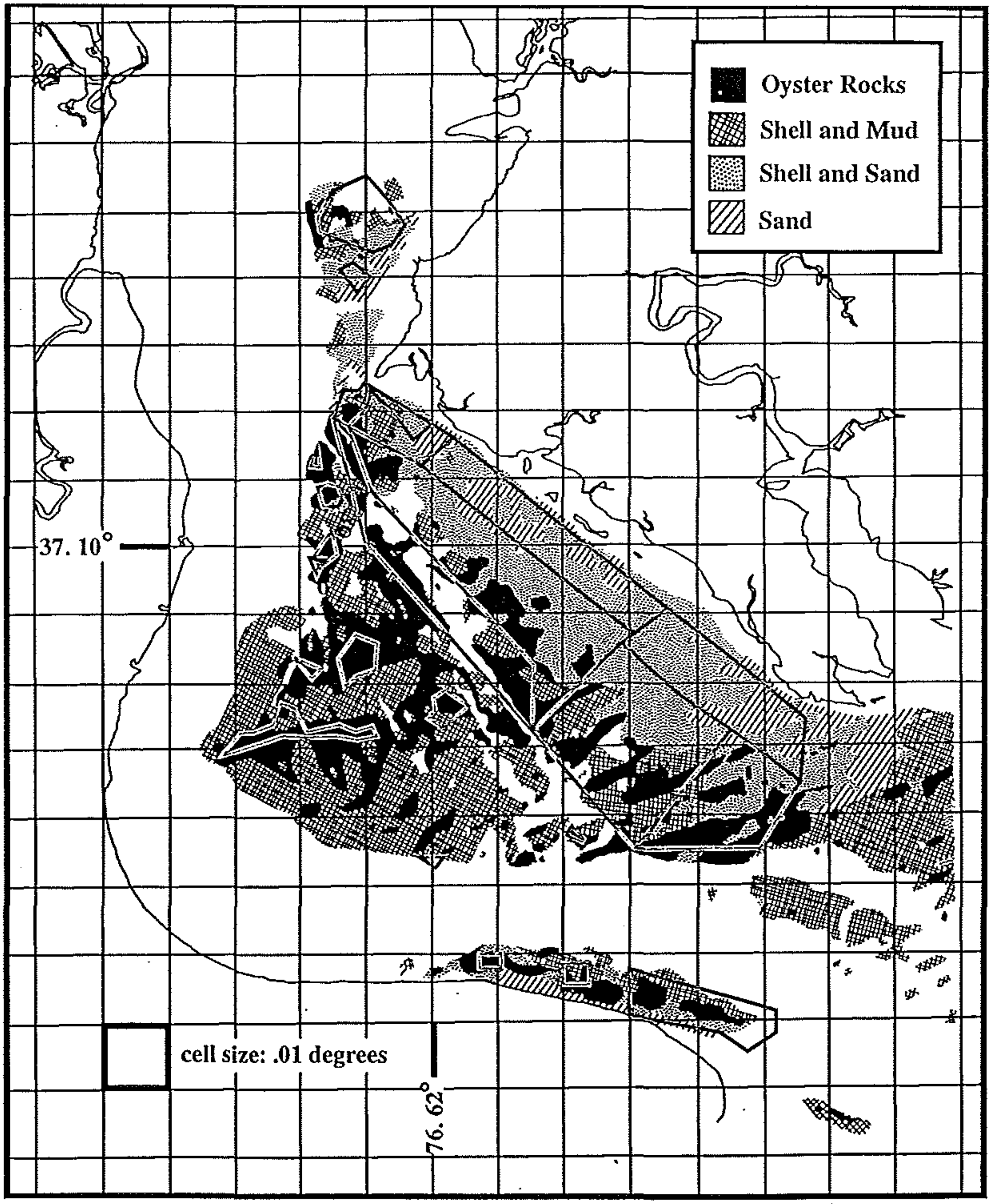
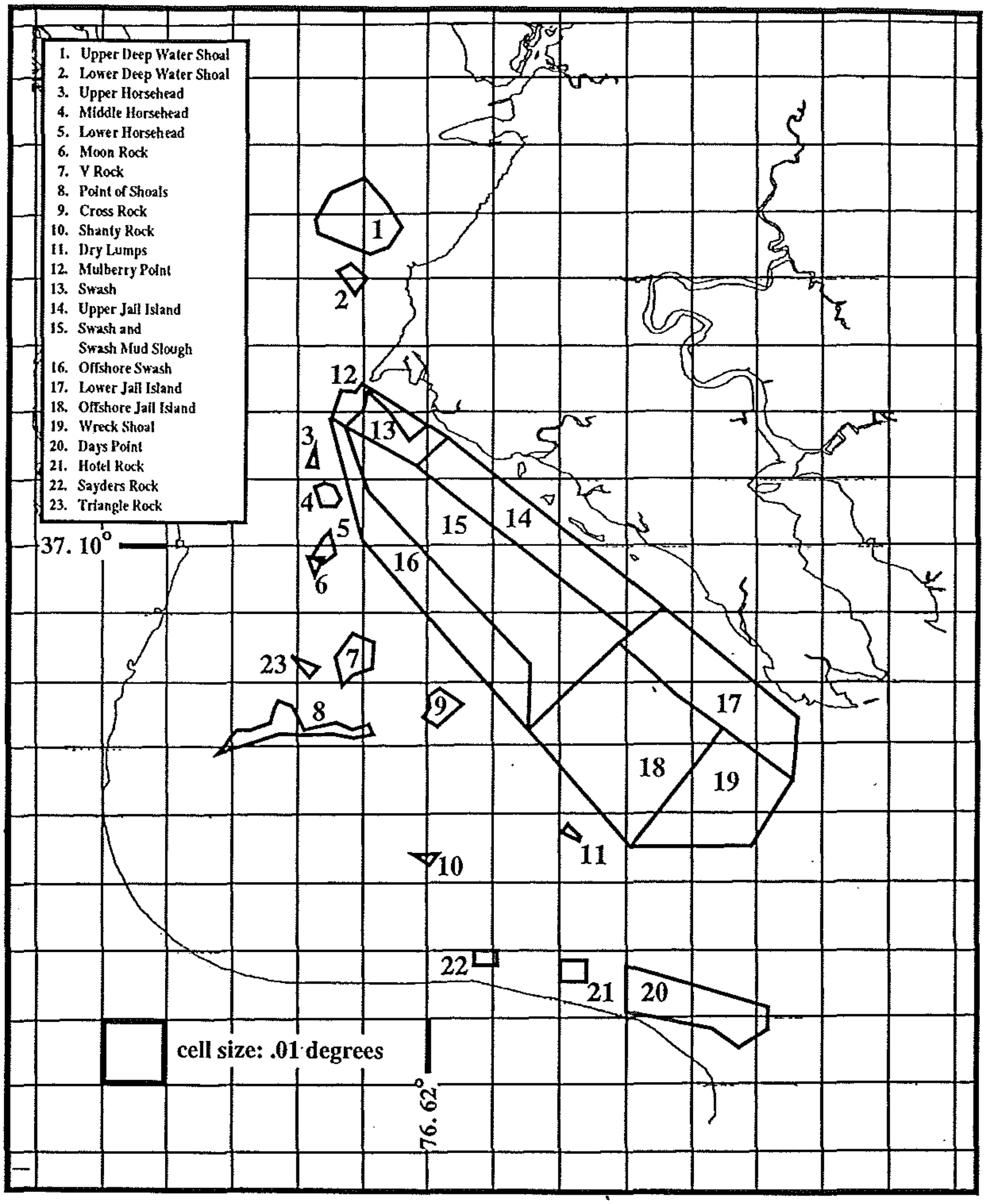


Figure 2: Outline of areas sampled during the 1994-1995 James River oyster stock assessment.



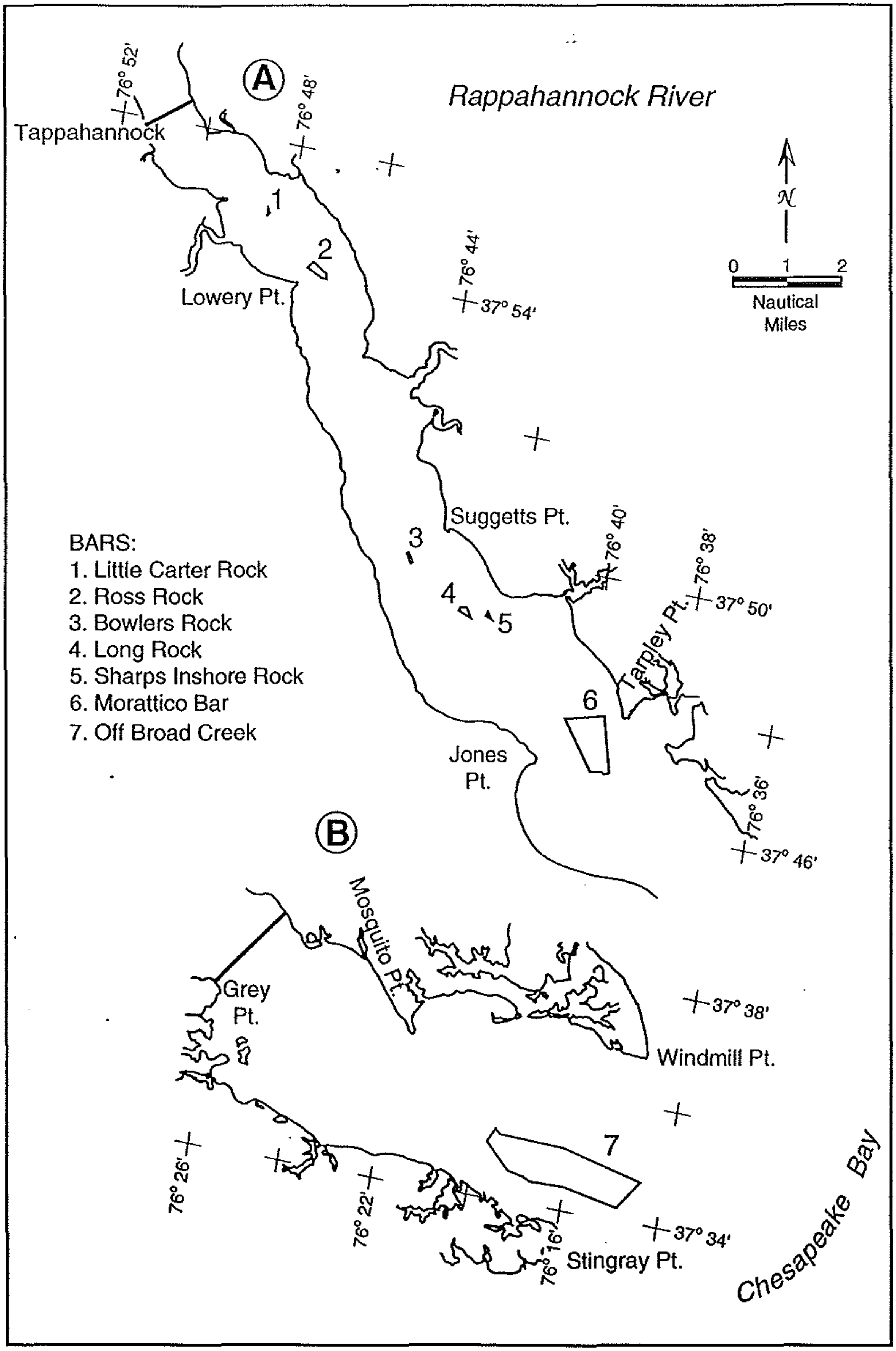


Figure 3 Location of oyster bars sampled during 1993 and 1994 stock assessment surveys in two segments of the Rappahannock River, Va. Approximately 15 nautical miles between segments A and B not included in this figure.

known oyster reef were mapped by the Surveying Engineering Department at VMRC and the grids for sampling set with Loran coordinates. Loran was, again, checked daily when in the field from known markers at both the beginning and end of the day. Sampling sites were picked by random numbers within the grids. 193 stations on 7 reefs were occupied in the Rappahannock in 1994-1995 compared to 47 stations on 5 reefs in 1993-1994.

Sampling gear

Both tongs and dredges are commonly used to examine oyster populations; however, only the former are good quantitative tools (see Chai et al, 1992). In 1993-1994 we examined a standard patent tong of known area; however, tests proved this to be an unpredictable sampling tool in that penetration into the hard bottom on the reef surface was inconsistent resulting in high variability in replicate samples on the same site. We replaced the tong with an hydraulically operated tong which separates the closing actions of the tong from the retrieval action. This has proven to be vastly superior in providing consistent penetration of the bottom and replication sampling and was retained as the only sampling tool for both rivers in 1994-1995. The hydraulic tong was installed on the VMRC vessel R/V Baylor. This vessel was used in all survey work described herein.

Data collection

The open dimensions of the tong were such that it sampled one square meter. Upon retrieval the sample was washed on the cull board and processed for counts of live oysters as spat (young of the year), small oysters (less than 3 inches), and market (greater than 3 inches) oysters. In addition, the opportunity was taken to collect data on dead oysters with paired valves (boxes, indicating recent mortality). The volume of shell retrieved in each tong was also recorded as an index of the quantity of cultch material present at each station. Between six and nine people were on board on each day of sampling, and all were trained to avoid inconsistency in categorization of oysters. This process was labor intensive, with between 30 and 60 samples being processed each day depending on weather conditions, crew size and the time required to wash and separate samples. Sampling of the James and Rappahannock Rivers was completed in December of 1994.

Data reduction and archiving

A custom database program for field data was developed by the Fisheries Data Management Unit in the Department of Fisheries Science at the School of Marine Science and Virginia Institute of Marine Science. Size distribution data was archived and analysis effected using commercial spreadsheet software (Microsoft Excel). Archived material is available in either hard copy or digital form on request.

Methods: Seaside of Eastern Shore of Virginia

The selection of sample locations, numbers and sampling gear

The shallow intertidal reef systems of the Seaside if the Eastern Shore of Virginia represent a much different sampling problem to the subtidal reefs of the Chesapeake Bay. The Seaside reefs are vast in number but generally small in size - many are in the range of less than one acre to two acres. Many exist as fringing regions of reef as the reef progresses into high marsh grass regions. Few have been adequately surveyed. The shallow reef systems are found along the entire Virginia shoreline from Chincoteague in the north to Fisherman's Island at the southern tip of the DelMarVa peninsula. Given the limited resources in time and personnel available to us we determined that the optimum approach to the task of stock assessment was to select identified reefs in five areas of the coastline. From north to south

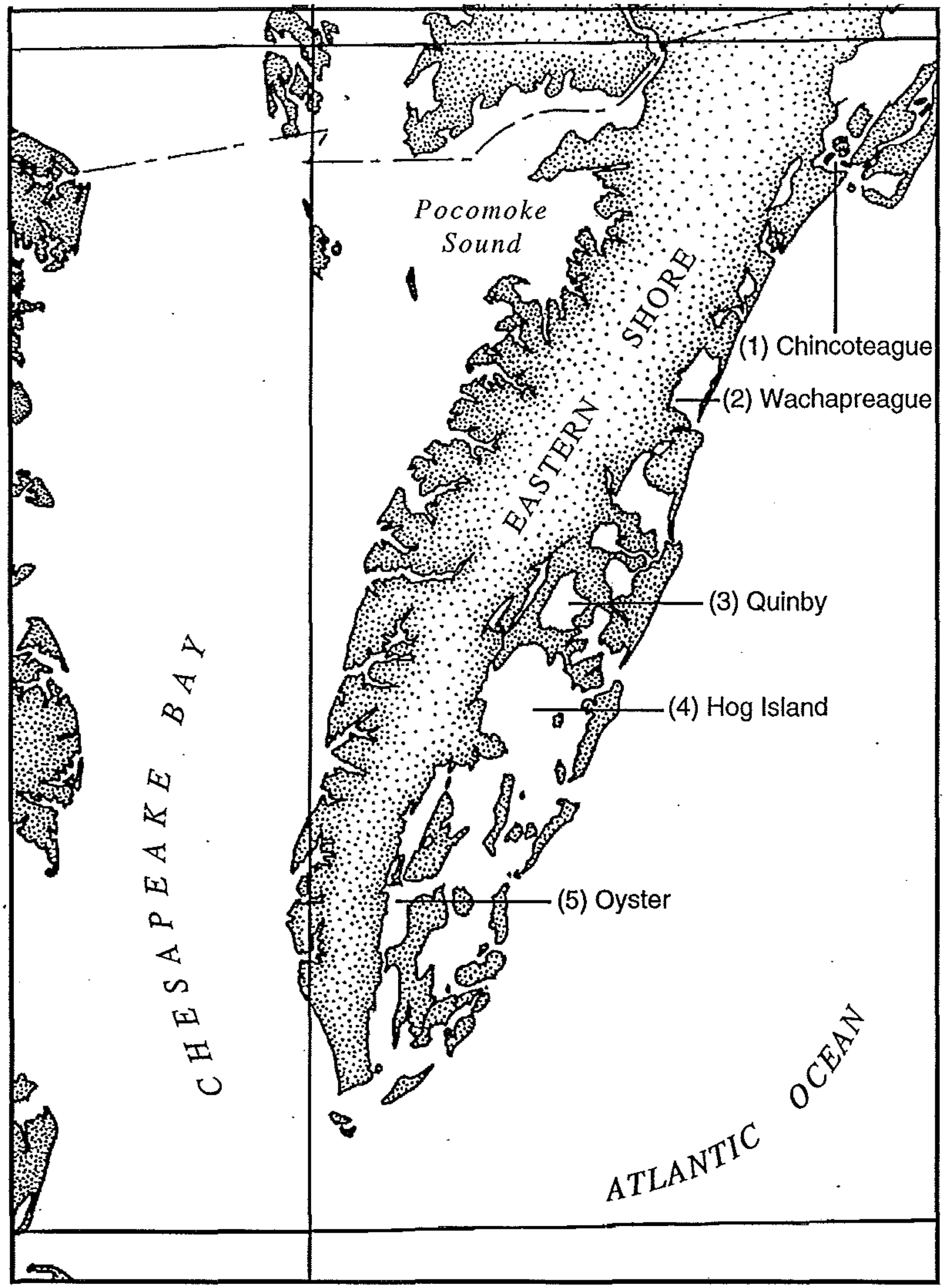


Figure 4 Location of the five areas sampled during the 1994-95 stock assessment survey of oyster bars on the seaside of the Eastern Shore peninsula of Virginia. A list of the individual oyster bars in each area is given on Table 1 .

Table 1: Area and Station Locations for oyster reefs surveyed during the 1994 -1995 stock assessment on the Seaside of the Eastern Shore of Virginia (see Figure 4 for area locations)

Area (1) Chincoteague:
Watts Bay high
Watts Bay low

Area (2) Wachapreague
Bradford Bay shell plant 93-94
Bradford Bay turnover east 93
Bradford Bay turnover west 93
North Hummock shell plant 93 and 94
North Hummock turnover 93 & shell plant 94
South Hummock shell plant 93
South Hummock turnover 93

Area (3) Quinby
Barge Point 93 high shell plant
Barge Point 93 low shell plant
Cockle Creek 92 shell plant & 93 turnover
Major Midhole shell plant 93
Middle Gap South 93 turnover
Middle Gap North shell plant 93
Middle Gap North turnover 93

Area (4) Hog Island
Upper Draft shell plant 93 high
Upper Draft 93 turnover
Upper Draft shell plant 93 low
Upper Draft bagless dredge

Area (5) Oyster
Brockenberry shell plant 92
Brockenberry shell plant 93
Narrow Channel S.W. shell plant 92
Narrow Channel S.W. 93
Narrow Channel East 93 turnover
Narrow Channel turnover west
Pointer Rock shell plant 93 high
Pointer Rock shell plant 93 low
Pointer Rock turnover 93
Rams Horn shell plant
Rams Horn turnover 93

these were Chincoteague, Wachapreague, Quinby, Hog Island, and Oyster. These locations are illustrated in Figure 4. In each area reefs were chosen based on recent (1992 and subsequent) replenishment activity by the VMRC Shellfish Replenishment Program. Thirty one reef systems were identified. These are listed by area in Table 1. Initial attempts to survey these reefs to provide "overlays" for random sampling proved difficult, time consuming and to all intents impractical, so we resorted to haphazard sampling. This consisted of sampling at low tide with a quarter meter square quadrat. The quadrat was literally thrown haphazardly into the air above the reef and the sampling location determined by where it landed. All material in the quadrat was collected in mesh bags (one bag per quadrat) and returned to the VIMS Wachapreague laboratory for examination. Protocols for sample evaluation were as for samples collected in the James and Rappahannock Rivers: market, small and spat size oysters, mortality estimates from "boxes", and residual shell volumes. Seven quadrats were collected from each reef sampled for a total of 217 samples.

Results and Discussion: James River and Rappahannock River

Data analysis

In the initial stages of data analysis of the 1993-1994 data sets for estimation of standing stock questions relating to sampling design and adequacy were addressed, mostly because of a lack of previous quantitative assessment data for this resource. Although thorough discussions of these questions were a component of the 1993-1994 annual report a brief recapitulation is appropriate here for completeness. The two primary questions addressed were:

1. Are there strata reasonable? The background behind this question is that recent surveys by Haven and Whitcomb (1983, 1989) illustrate varying bottom type within the chosen strata - from mud to hard shell bottom. This could present a significant sampling problem in that strata are sufficiently heterogeneous to be of limited ecological and statistical value.

2. Assuming 1 (above) is not a problem, are there sufficient samples to adequately represent the strata and allow estimates of abundance per unit area and, subsequently, total standing stock.

Bros and Cowell (1987) offer a good discussion of methods of estimating sample size in situations where minimum detectable difference cannot be specified a priori, as is the case in this situation. Their proposed method incorporates use of resolving power as a primary factor and sampling feasibility (an issue here with time and cost) as a secondary factor. They suggest the standard error of the mean be used as a measure of appropriate sampling effort. We have adopted their suggestion. Questions 1 and 2 above were primarily addressed by a single analysis in which data were examined collectively within each strata. A plot was generated of mean number of oysters per patent tong (one square meter) sample and standard error of the mean versus number of samples included in the calculation. This calculation was repeated ten times for data within a strata with samples being chosen at random from those available. Random sampling eliminated any bias that resulted from sequential data entry in accordance with sampling in the field sampling (the latter may have resulted, inadvertently in temporally focused sampling on a particular substrate type). In a regime where variability with bottom type was high and the sample size was low then the mean would not stabilize, and where sampling was insufficient the standard error of the mean would not demonstrate a **stable** trend of decreasing value - remembering of course that the standard error value will eventually continue to decrease with increasing number of samples included in the calculation because the standard error is inversely proportional to the square root of the number of observations of the mean. Increasing sample size will eventually solve both these problems, but the number of samples required might be very large. The same criteria were applied in sampling in 1994-1995 as in 1993-1994.

General summary of population sizes

Stock assessment estimates for the James and Rappahannock Rivers are given in Tables 2 and 3, with Table 2 providing information on live oysters by size class and Table 3 providing information on boxes and residual shell. Table 4 provides a comparison of small and market oyster standing stock in the James River by reef for both the Fall 1993 (funding year 1993-1994) and Fall 1994 (funding year 1994-1995) surveys.

There remains a high variability in mean oyster density among the sampled reefs in the James River. Horsehead, V-Rock, Point of Shoals and Shanty Rock all maintain populations in excess of 100 oysters per sq. m. Understandably, these reefs support the major fishery for market oysters. The remaining reefs support modest mean oyster densities, although market oysters densities in these locations are typically below 5 per sq. m. Small oysters, generally an indicator of future potential harvest, are not exceptionally abundant on reefs other than those listed above, suggesting that the fishery will not expand onto new reefs in the immediate future. In addition to the above reefs modest spat densities were recorded on Hotel Rock and Dry Lumps, but these are very small reefs and represent a very small total resource. The number of both old and new boxes at all stations in the James were a relatively low percentage of the total number of live oysters present, typically around 10% in the more densely populated reefs. An elevated value was recorded at Dry Lumps, again a rather small reef. The shell resource on all reefs in the James remains a source of concern. Ten liters of shell uniformly spread over the surface of one sq. m represents a layer one centimeter thick - or about a single layer of shells. Only one of the sampled reefs in the James, Low Horsehead, had a mean shell volume in sampling in excess of 10L per sq. m. Earlier in this document we emphasized that none of the sampled reefs was uniform with respect to bottom type and therefore shell coverage, and that reefs numbered 1 through 11 in the James represented a uniformly better bottom type for oyster growth. Despite this qualification, consideration of a mean value of 6.56 L shell per sq. m of bottom on Point of Shoals suggest that even if only 25% of the reef area were oyster shell covered then this shell layer would still only be about one inch (2.5 centimeters) thick! The necessity to maintain shell replenishment on the productive reefs, not around them, cannot be understated.

Oyster populations remain low in density throughout the Rappahannock, and although the cumulative total for the areas sampled exceeds 10,000 bushels of combined market and seed oysters, the mean density of all oysters combined never exceeds 50 per sq. m. on the sampled rocks.

The commercial fishery in the James River in the 1993-1994 season was modest, and the data of Table 4 suggest that the combined losses to the fishery, diseases and other mortality was generally balanced by growth in the resident population. The estimates of mean numbers of bushels of small oysters increased (although the 95% confidence intervals for the two years overlap) from 465,357 bushels to 532,004 bushels. The inclusion of four other reefs in the 1994-1995 survey increased the latter value to 561,095 bushels. In contrast the market oyster values fell from 258,869 bushels to 205,441 bushels for the original 19 reef region. It should be underscored here that the 1993-1994 survey used a 2.5 inch separation for small versus market oysters, whereas the 1994-1994 survey used a three inch separation. This would result in moving animals formerly in the market class (from 2.5 to 3 inches) to the small oyster class, and probably accounts for the greater part of the discrepancy in the values for the size classes in respective years. The mean estimates for all

Table 2: James River and Rappahannock River Stock Assessment: Fall 1994.

Oyster spat (per sq. m), small and market oyster density (per sq. m, bushels on reef and bushels per acre) for each reef

n = number of samples collected for identified reef.

REEF #	REEF NAME	n	SPAT per sq. m	SMALL per sq. m	MARKET per sq. m	SML+MKT per sq. m	SMALL bushels	bu /acre	MARKET bushels	bu/acre	SML+MKT bushels	bu/acre
JAMES RIVER												
1	Up D Wtr Shl	72	5.32	40.51	9.21	49.72	34866	149	24214	104	59080	253
2	Low D Wtr Shl	8	2.8	11.9	8	19.9	871	44	1792	90	2663	134
3	Up Horsehead	6	30	192.17	26.17	218.33	2127	707	885	294	3012	1001
4	Mid Horsehead	11	53.8	194.6	11.9	206.5	13938	716	2606	134	16544	850
5	Low Horsehead	10	104.5	280.2	26.7	306.9	20068	1031	5843	300	25911	1331
6	Moon Rock	7	187.3	310	26.7	336.7	4505	1140	1186	300	5691	1441
7	V-Rock	20	79.17	154.55	15.35	169.9	40969	569	12433	173	53402	741
8	Pt of Shoals	32	61.05	138.69	25.31	164	73923	561	26984	205	100907	766
9	Cross Rock	10	77	69.3	8.4	77.7	255	9354	94	3464	349	12818
10	Shanty Rock	7	44	102.9	3.6	106.4	1490	416	103	29	1594	445
11	Dry Lump	7	35.7	54.9	0.4	55.3	1197	202	29	5	1225	207
12	Mulberry:upriver	10	8	30	3.4	33.4	10544	121	2390	28	12934	149
13	Mulberry & Swash	28	2	12.7	3.3	15.9	8466	51	4340	26	12806	78
14	Upper Jail Is	62	1.17	13.68	4.31	17.98	30785	50	29618	48	60403	99
15	Swash Mud	122	5.85	24.25	3.03	27.23	122151	98	30558	25	152709	123
16	Offshore Swash	64	12.92	31.55	1.97	33.52	72713	116	13866	22	86579	138
17	Lower Jail Is	63	1.05	8.73	2.38	11.11	20200	32	16833	27	37034	59
18	Offsh.Jail Island	101	7.12	14.33	2.23	16.55	53615	53	25473	25	79088	78
19	Wreck Shoal	52	8.43	8.98	0.94	9.92	19321	33	6194	11	25515	44
20	Days Point	73	7.73	21.04	0.32	21.36	23223	77	1063	4	24286	81
21	Hotel Rock	7	25.86	40.43	1.57	42	2012	149	239	18	2251	166
22	Snyders	7	14.71	19.86	0.86	20.71	770	73	102	10	872	83
23	Triangle Rock	7	23	114.43	17.14	131.57	3086	421	1413	193	4498	614
RAPPAHANNOCK RIVER												
1	Ross Rock	8	0	3	0.4	3.4	387	12	97	3	484	15
2	Carters Rock	7	0	0	0	0	0	0	0	0	0	0
3	Bowlers Rock	7	0.1	2.4	1.9	4.3	58	10	88	15	146	25
4	Long Rock	7	0	1.9	2.7	4.6	116	8	338	22	454	29
5	Sharps Inshore	7	0.6	7.9	2	9.9	78	32	40	66	118	48
6	Morattico Bar	42	0	0	0.2	0.2	222	0	1773	2	1995	2
7	Mouth	115	0.9	1.8	0.3	2.1	8443	7	2586	2	11029	10

Table 3: James River and Rappahannock River Stock Assessment: Fall 1994.
Oyster mortality as indicated by old and new boxes (articulated valves) and shell resource (volume in L)
n = number of samples collected for the identified reef. Values include mean, 95% confidence interval, minimum and mean for a sq. m. sampling area

REEF #	REEF NAME			OLD BOX					NEW BOX					SHELL VOL
			n	mean	mean+CI	mean-CI	min	max	mean	mean+CI	mean-CI	min	max	mean
JAMES RIVER														
1	Up D Wtr Shl	3-8-Nov-94	72	1.51	2.1	0.93	0	11	0.76	1.08	0.45	0	8	4.29
2	Low D Wtr Shl	7-Dec-94	8	0.8	1.9	0	0	3	0.5	1.1	0	0	2	2.9
3	Up Horsehead	2-Nov-94	6	7.17	12.7	1.64	1	16	11.33	18.75	3.92	0	21	9.33
4	Mid Horsehead	2-Nov-94	11	5.5	8.34	2.75	3	17	6.7	9.21	4.25	2	13	5.2
5	Low Horsehead	3-Nov-94	10	12.7	19.2	6.2	3	32	6.4	10.6	2.2	0	14	17.9
6	Moon Rock	3-Nov-94	7	7.3	12.1	2.5	2	15	1.9	3.8	0	0	5	7
7	V-Rock	2-Nov-94	20	4.8	6.43	3.17	1	12	9.6	12.32	6.88	1	21	7.55
8	Pt of Shoals	14-Nov & 1-Dec-94	32	6.19	8.12	4.25	0	25	1.88	2.68	1.07	0	8	6.56
9	Cross Rock	3-Nov-94	10	15.2	23.8	6.6	0	33	6	13.2	0	0	29	7.4
10	Shanty Rock	1 & 7 Dec-94	7	21.3	27.3	15.3	13	34	17.1	23.3	11	11	30	7.3
11	Dry Lump	7-Dec-94	7	22	46.3	0	2	81	14.7	39	0	0	74	15
12	Mulberry:upriver	14-Nov-94	10	1.4	3.09	0	0	7	0	0.65	0	0	1	2.1
13	Mulberry & Swash	14-Nov-94	28	0.8	2	0	0	12	0.1	0.2	0	0	1	0.4
14	Upper Jail Is	16-Nov-94	62	1.56	2.16	0.97	0	11	0.21	0.41	0.01	0	5	1.92
15	Swash Mud	6 & 7 Dec-94	122	2.7	3.28	2.12	0	15	0.97	1.25	0.68	0	9	2.44
16	Offshore Swash	30-Nov & 1-Dec-94	64	4.38	5.96	2.79	0	26	2.33	3.15	1.51	0	14	3.11
17	Lower Jail Is	16-21-Nov-94	63	3.37	4.82	1.91	0	40	2.15	2.57	1.74	0	13	1.57
18	Offsh.Jail Island	28&29-Nov-94	101	4.69	5.94	3.45	0	33	2.46	3.12	1.79	0	20	4.12
19	Wreck Shoal	29 & 30-Nov-94	52	5.17	7.25	3.1	0	42	2.04	2.82	1.26	0	13	7.05
20	Days Point	28-Nov & 7-Dec 94	73	4.88	6.6	3.15	0	49	6.63	8.84	4.42	0	47	6.72
21	Hotel Rock	7-Dec-94	7	10.43	21.28	0	0	34	8.14	15.43	0.85	0	19	8.86
22	Snyders	7-Dec-94	7	3.71	6.11	1.32	0	9	4.14	6.79	1.5	0	10	4.86
23	Triangle Rock	7-Dec-94	7	4.43	7.84	1.02	0	9	0.71	1.17	0.26	0	1	5.29
RAPPAHANNOCK RIVER														
1	Ross Rock	20-Dec-94	8	0.5	1.2	0	0	2	0	0	0	0	0	8.4
2	Carters Rock	20-Dec-94	7	0.1	0.5	0	0	1	0	0	0	0	0	2.7
3	Bowlers Rock	20-Dec-94	7	0.7	1.7	0	0	3	0	0	0	0	0	6.1
4	Long Rock	20-Dec-94	7	0.1	0.5	0	0	1	0	0	0	0	0	10.6
5	Sharps Inshore	20-Dec-94	7	0.4	0.9	0	0	1	0	0	0	0	0	10.4
6	Morattico Bar	20-Dec-94	42	0.1	0.3	0	0	3	0	0.1	0	0	1	5.1
7	Mouth	19-Dec-94	115	0.5	0.1	0	7	0.1	0.1	0	0	3	3	0.03

Table 4

James River Stock Assessment: Fall 1993 and 1994. Estimates of small and market oyster standing stock for defined reefs.

Values given as mean number of bushels with 95% CI for whole reef

JAMES RIVER REEF #	REEF NAME	ACRES	1993 Small oysters mean	1993 Small oysters mean+CI	1993 Small oysters mean-CI	1994 Small oysters mean	1994 Small oysters mean+CI	1994 Small oysters mean-CI	1993 Market oysters mean	1993 Market oysters mean+CI	1993 Market oysters mean-CI	1994 Market oysters mean	1994 Market oysters mean+CI	1994 Market oysters mean-CI	1993 Total mean	1993 Total mean+CI	1993 Total mean-CI	1994 Total mean	1994 Total mean+CI	1994 Total mean-CI
1	Up D Wtr Shl	234	46472	61252	31692	34866	47309	22423	37579	49240	25918	24214	34181	14248	84051	110492	57610	59080	81490	36670
2	Low D Wtr Shl	20	798	1089	508	871	1598	143	1371	1773	969	1792	3749	-165	2169	2862	1477	2663	5347	-21
3	Up Horsehead	3	3588	6747	429	2127	3248	1007	1348	2594	101	885	1577	194	4936	9341	530	3012	4824	1201
4	Mid Horsehead	19	16877	22083	11671	13938	17286	10590	1158	1795	521	2606	4053	1159	18035	23878	12192	16544	21339	11749
5	Low Horsehead	19	19963	24487	15439	20068	23136	17000	2954	4729	1179	5843	8086	3600	22917	29216	16618	25911	31222	20599
6	Moon Rock	4	3948	6152	1744	4505	5898	3112	791	1360	223	1186	1992	381	4739	7512	1967	5691	7890	3492
7	V-Rock	72	45950	52120	39780	40969	46849	35088	11842	13906	9777	12433	15855	9011	57792	66026	49557	53402	62704	44099
8	Pt of Shoals	132	55906	68893	42919	73923	95581	52265	25463	31617	19309	26984	34631	19337	81369	100510	62228	100907	130212	71602
9	Cross Rock	37	11151	15252	7050	255	299	211	2329	2972	1685	94	100	89	13480	18224	8735	349	397	301
10	Shanty Rock	4	471	909	32	1490	1823	1157	65	160	0	103	195	12	536	1069	32	1594	2018	1170
11	Dry Lump	6	360	578	142	1197	2522	0	40	90	0	29	75	0	400	668	142	1225	2597	0
12	Mulberry:upriver	87	6436	9899	2973	10544	23998	0	3937	5633	2240	2390	4654	126	10373	15532	5213	12934	28652	126
13	Mulberry & Swash	165	2356	4052	657	8466	21613	0	1687	2989	385	4340	11607	0	4043	7041	1042	12806	33219	0
14	Upper Jail Is	612	13560	19624	7497	30785	44347	17224	27578	43337	11818	29618	42113	17122	41138	62961	19315	60403	86460	34346
15	Swash Mud	1245	104703	125738	83669	122151	147733	96568	56092	66346	45838	30558	37574	23542	160795	192084	129507	152709	185308	120110
16	Offshore Swash	627	62175	89705	34644	72713	102150	43277	28911	60710	0	13866	19737	7994	91086	150415	34644	86579	121887	51271
17	Lower Jail Is	629	23571	37856	9286	20200	32102	8297	24936	33768	16104	16833	25479	8188	48507	71624	25390	37034	57582	16485
18	Offsh.Jail Island	1017	31884	42626	21141	53615	68034	39195	20117	26343	13890	25473	34672	16275	52001	68969	35031	79088	102706	55470
19	Wreck Shoal	585	15188	23107	7269	19321	26358	12283	10671	15716	5625	6194	10120	22668	25859	38823	12894	25515	36478	14552
20	Days Point					23223	30717	15729				1063	1658	467				24286	32375	16196
21	Hotel Rock					2012	3656	369				239	418	60				2251	4074	429
22	Snyders					770	1140	400				102	163	40				872	1302	441
23	Triangle Rock					3086	4537	1634				1413	2296	529				4498	6834	2163
	TOTAL																			
	REEFS 1-19 INC	5517	465357	612169	318542	532004	711884	359840	258869	365078	155582	205441	290450	143781	724226	977247	474124	737446	1002332	483222
	REEFS 1-23 INC					561095	751934	377972				208258	294985	144877				769353	1046917	502451

Figure 5

Upper Deep Water Shoal: live oyster size frequency distribution, 1993 and 1994

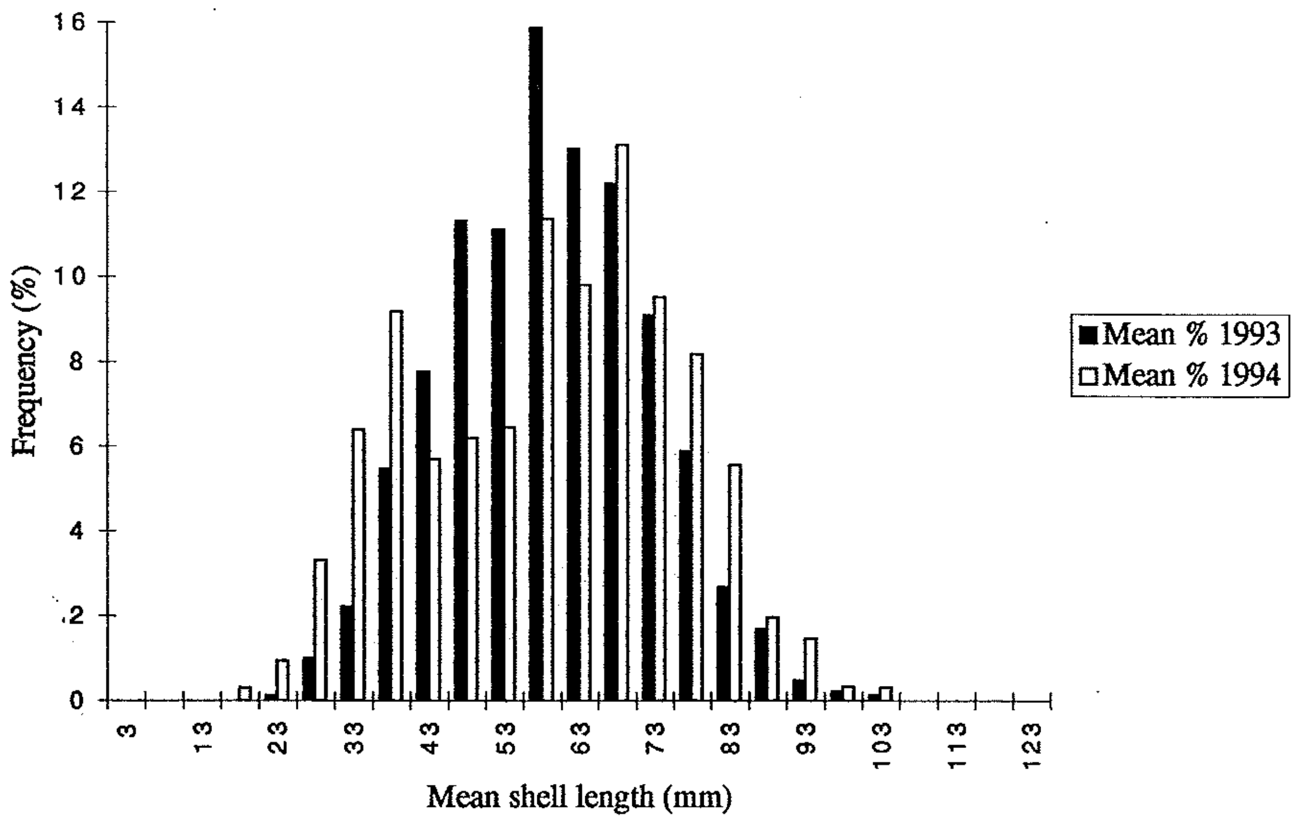


Figure 6

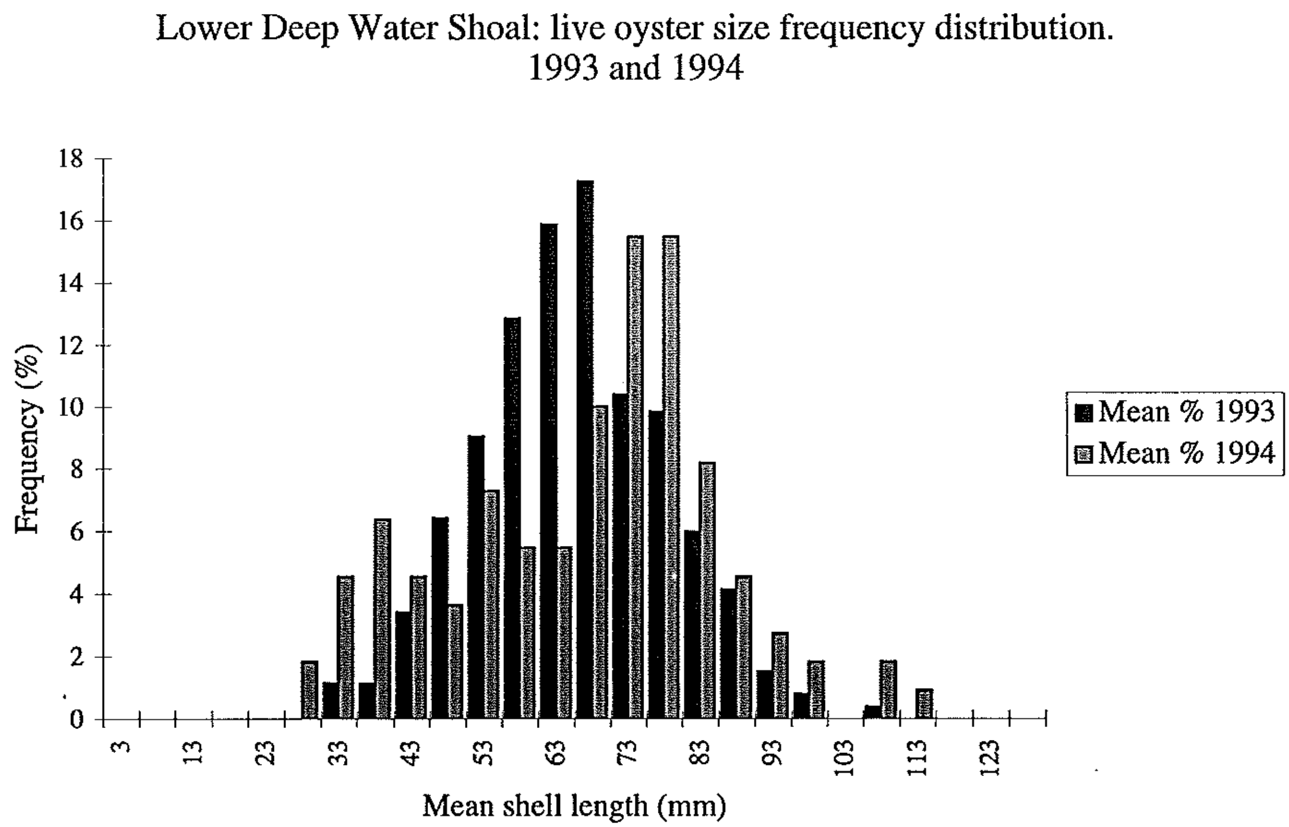

Lower Deep Water Shoal: live oyster size frequency distribution.
1993 and 1994
Frequency (%)
0
2
4
6
8
10
12
14
16
18
3
13
23
33
43
53
63
73
83
93
103
113
123
Mean shell length (mm)
Mean % 1993
Mean % 1994

Figure 7

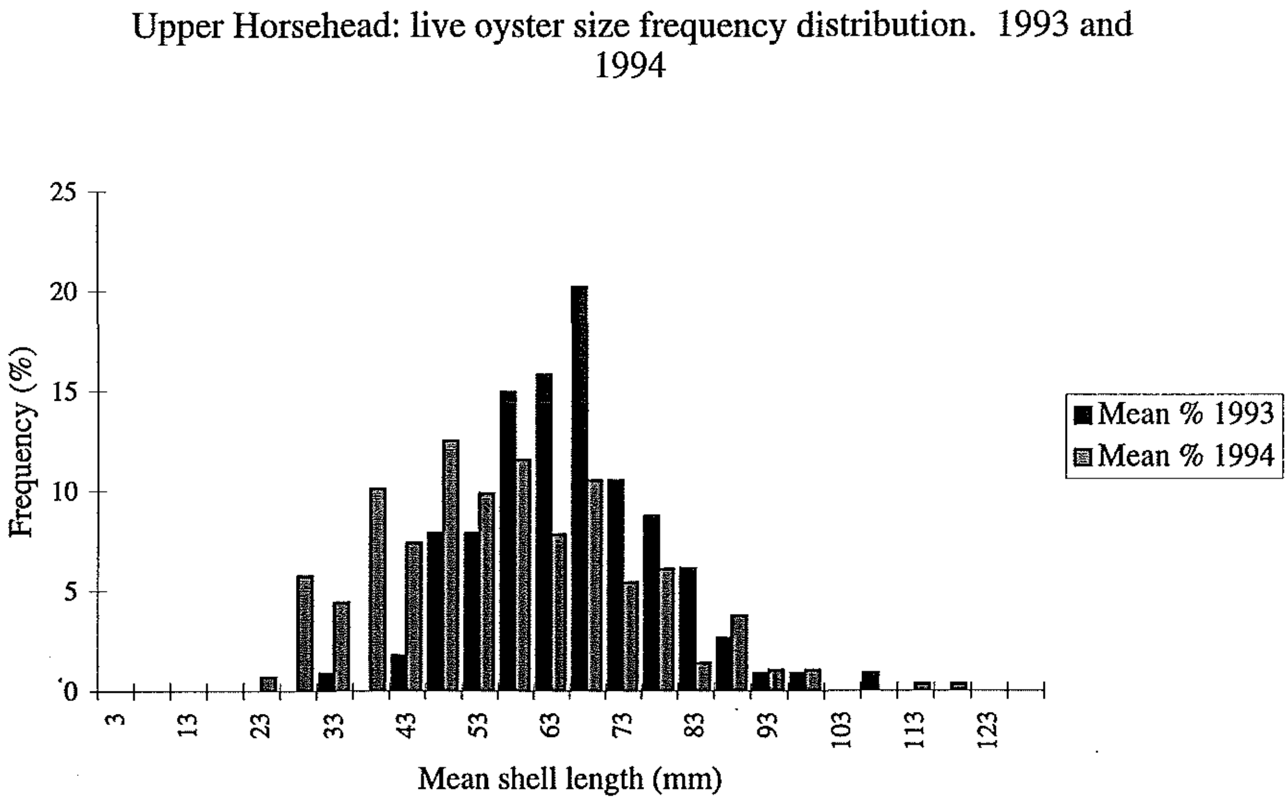
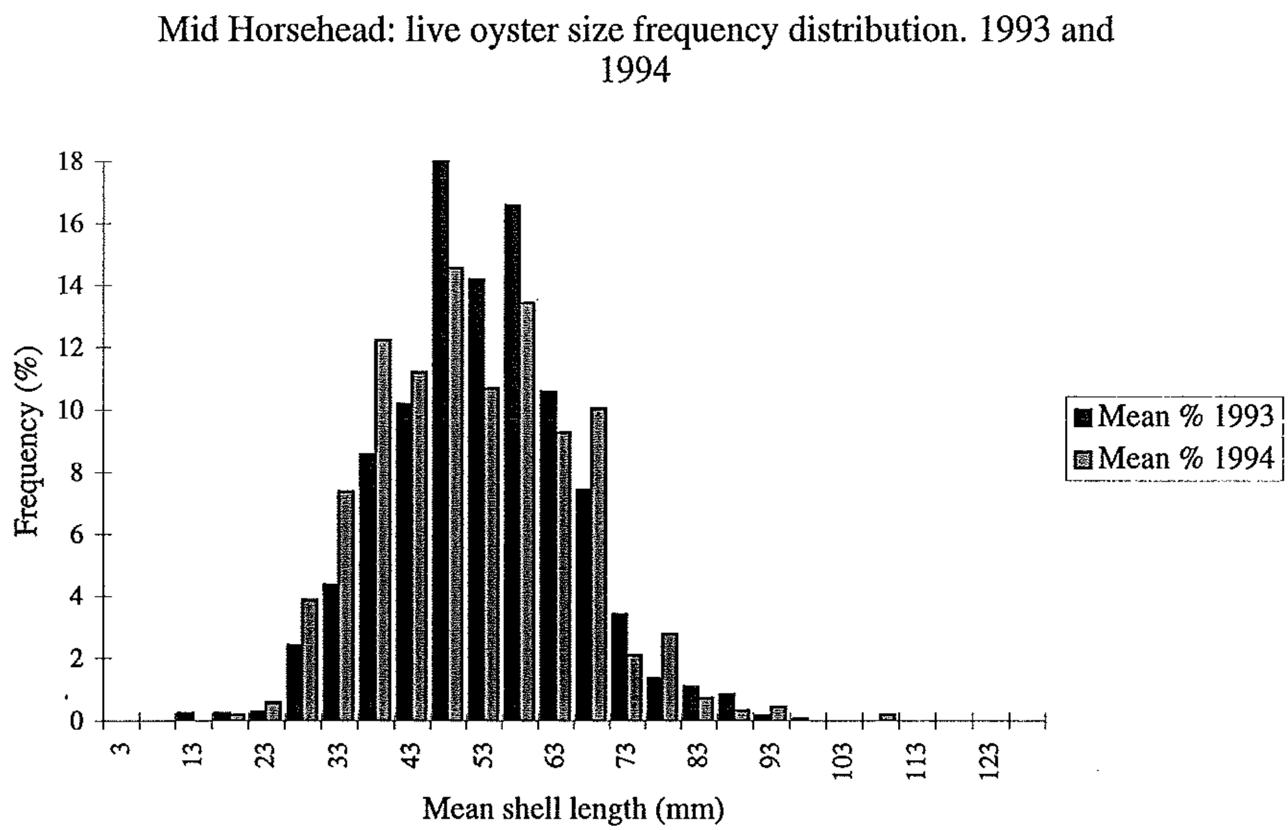
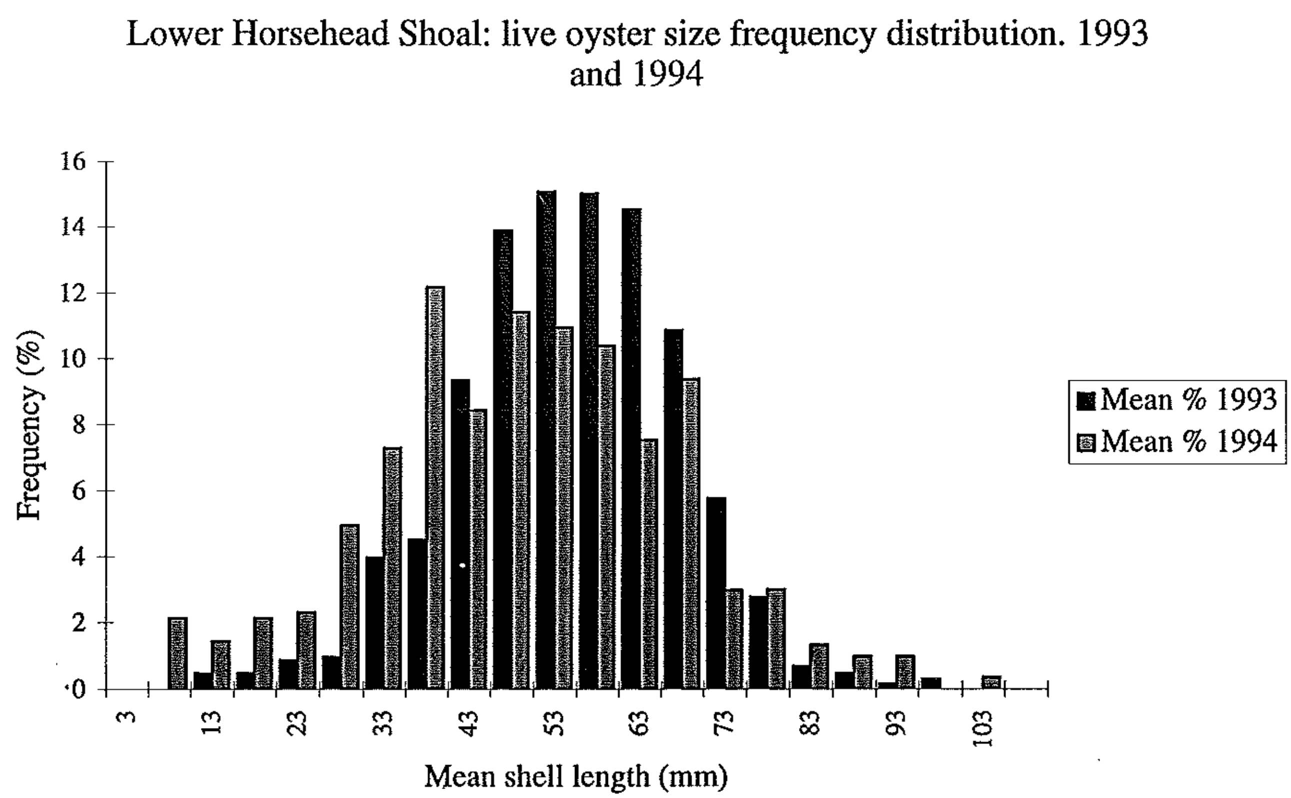

Upper Horsehead: live oyster size frequency distribution. 1993 and 1994
Frequency (%)
25
20
15
10
5
0
3
13
23
33
43
53
63
73
83
93
103
113
123
Mean shell length (mm)
Mean % 1993
Mean % 1994

Figure 8



Mid Horsehead: live oyster size frequency distribution. 1993 and 1994
Frequency (%)
18
16
14
12
10
8
6
4
2
0
3
13
23
33
43
53
63
73
83
93
103
113
123
Mean shell length (mm)
Mean % 1993
Mean % 1994

Figure 9



Lower Horsehead Shoal: live oyster size frequency distribution. 1993 and 1994
Frequency (%)
16
14
12
10
8
6
4
2
0
3
13
23
33
43
53
63
73
83
93
103
Mean shell length (mm)
Mean % 1993
Mean % 1994

Figure 10

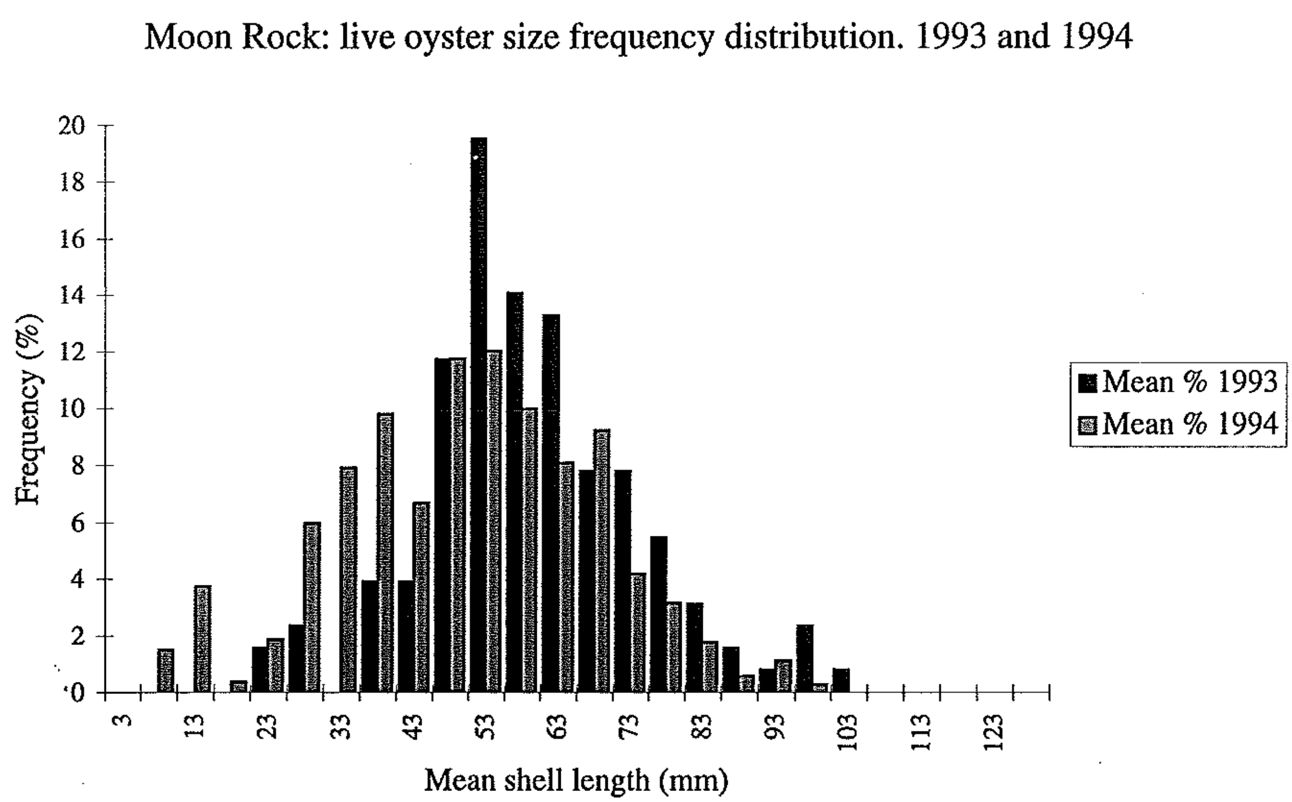
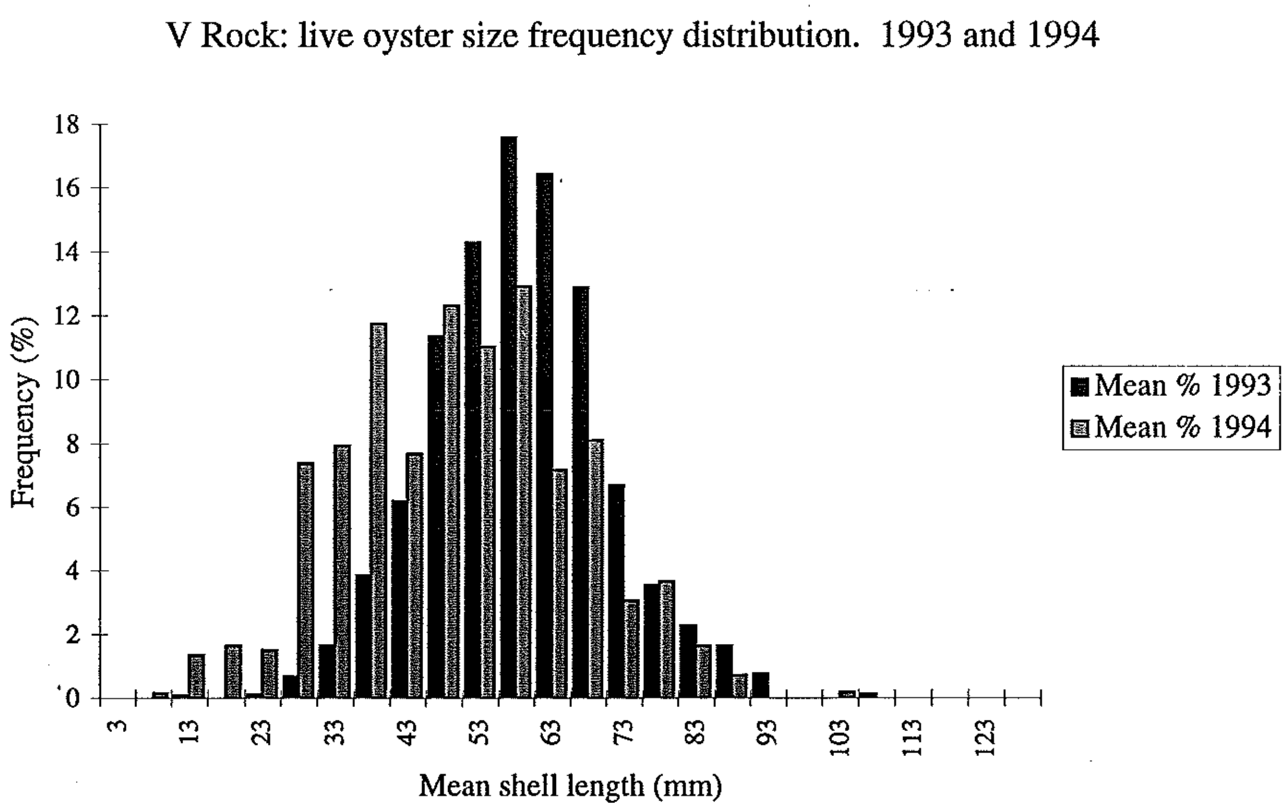
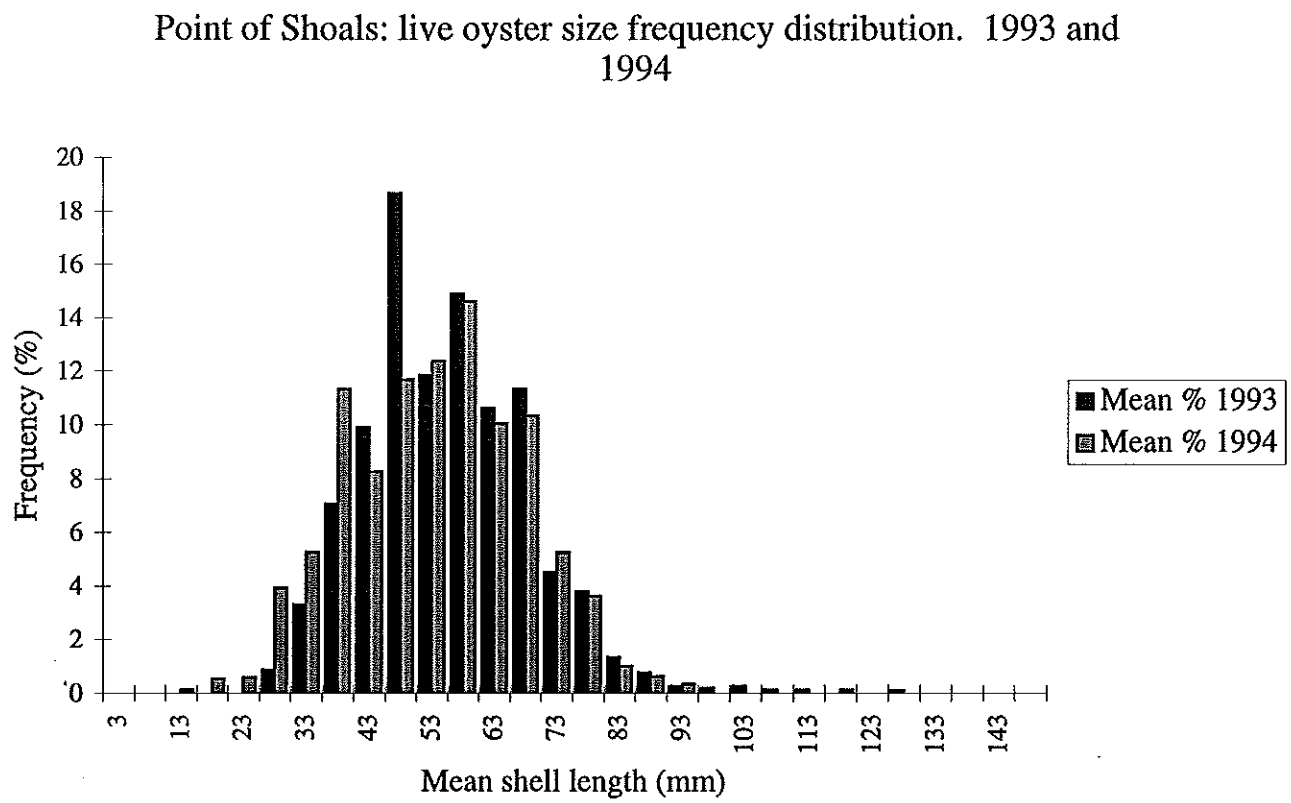

Moon Rock: live oyster size frequency distribution. 1993 and 1994
Frequency (%)
20
18
16
14
12
10
8
6
4
2
0
3
13
23
33
43
53
63
73
83
93
103
113
123
Mean shell length (mm)
Mean % 1993
Mean % 1994

Figure 11



V Rock: live oyster size frequency distribution. 1993 and 1994
Frequency (%)
18
16
14
12
10
8
6
4
2
0
3
13
23
33
43
53
63
73
83
93
103
113
123
Mean shell length (mm)
Mean % 1993
Mean % 1994

Figure 12



Point of Shoals: live oyster size frequency distribution. 1993 and 1994
20
18
16
14
12
10
8
6
4
2
0
Frequency (%)
3
13
23
33
43
53
63
73
83
93
103
113
123
133
143
Mean shell length (mm)
Mean % 1993
Mean % 1994

Figure 13

Cross Rock. Live oyster size frequency distribution: 1993 and 1994

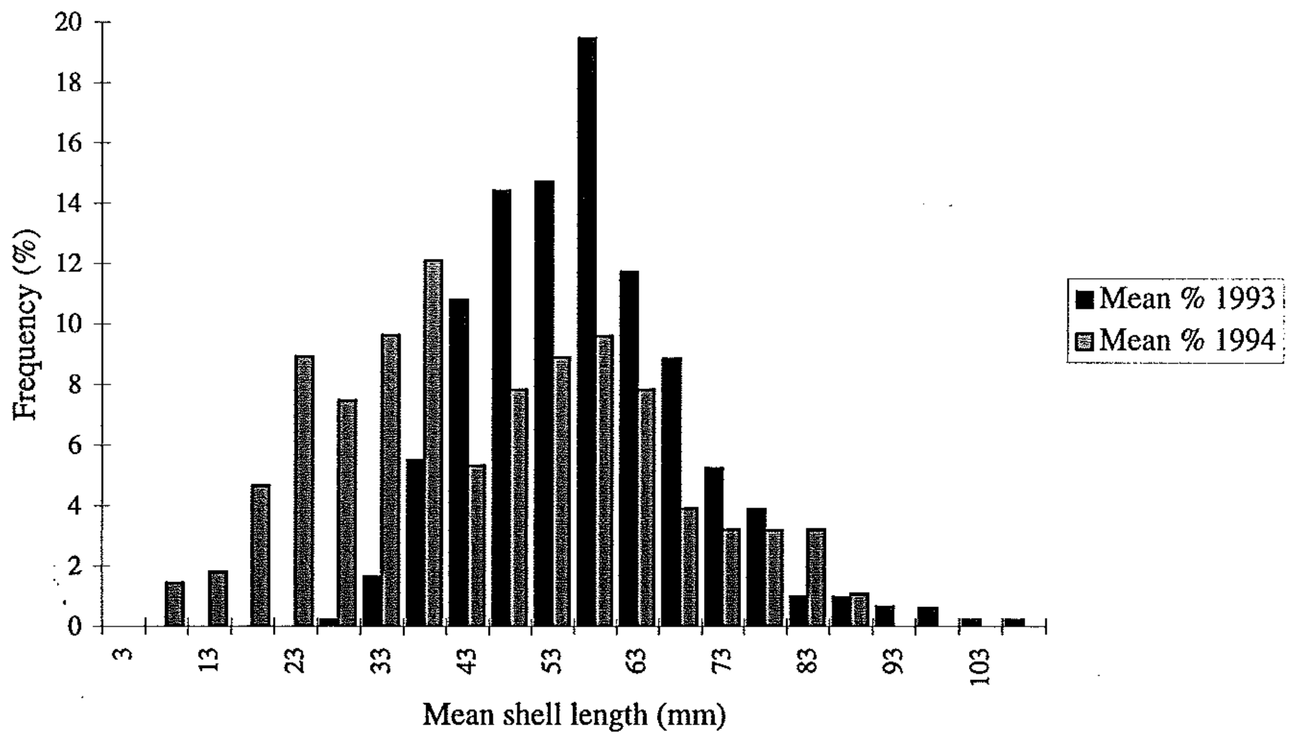


Figure 14

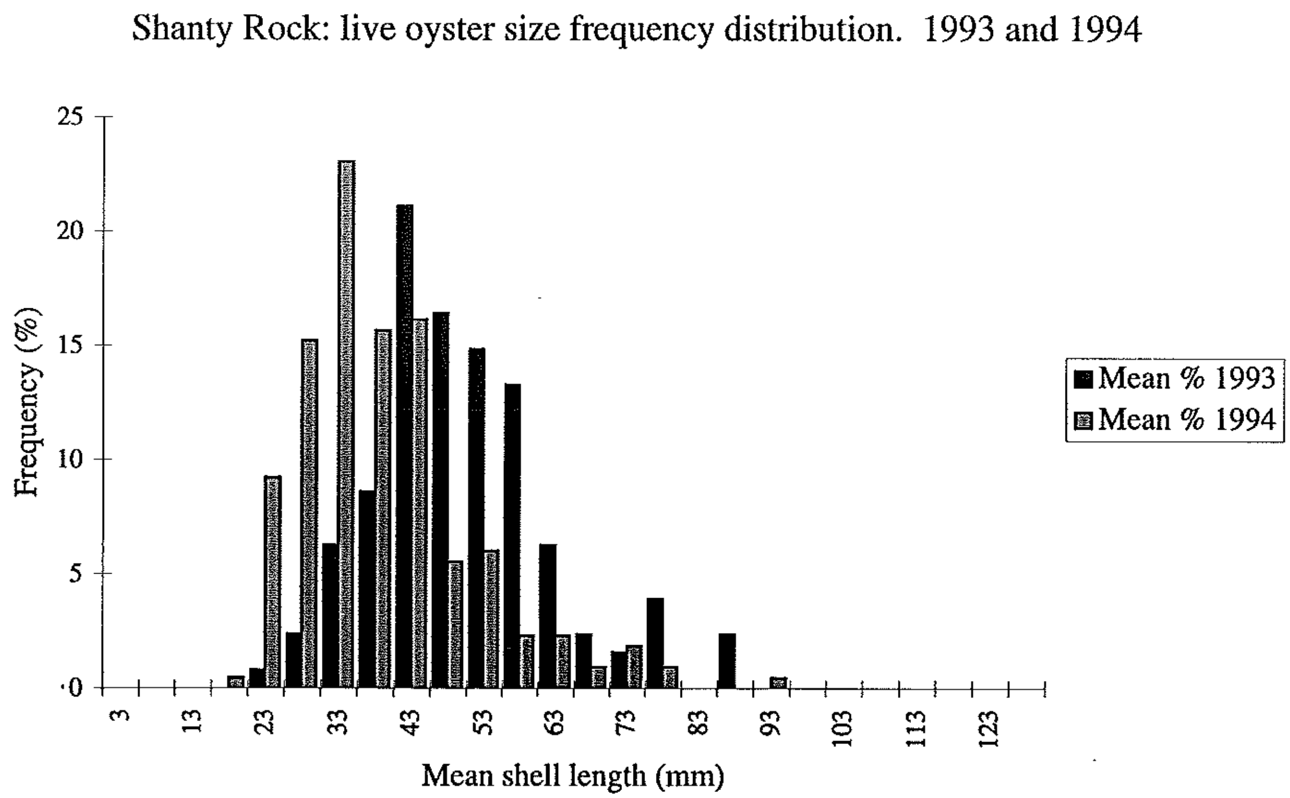

Shanty Rock: live oyster size frequency distribution. 1993 and 1994
Frequency (%)
25
20
15
10
5
0
3
13
23
33
43
53
63
73
83
93
103
113
123
Mean shell length (mm)
Mean % 1993
Mean % 1994

Figure 15

Dry Lumps: live oyster size frequency distribution. 1993 and 1994

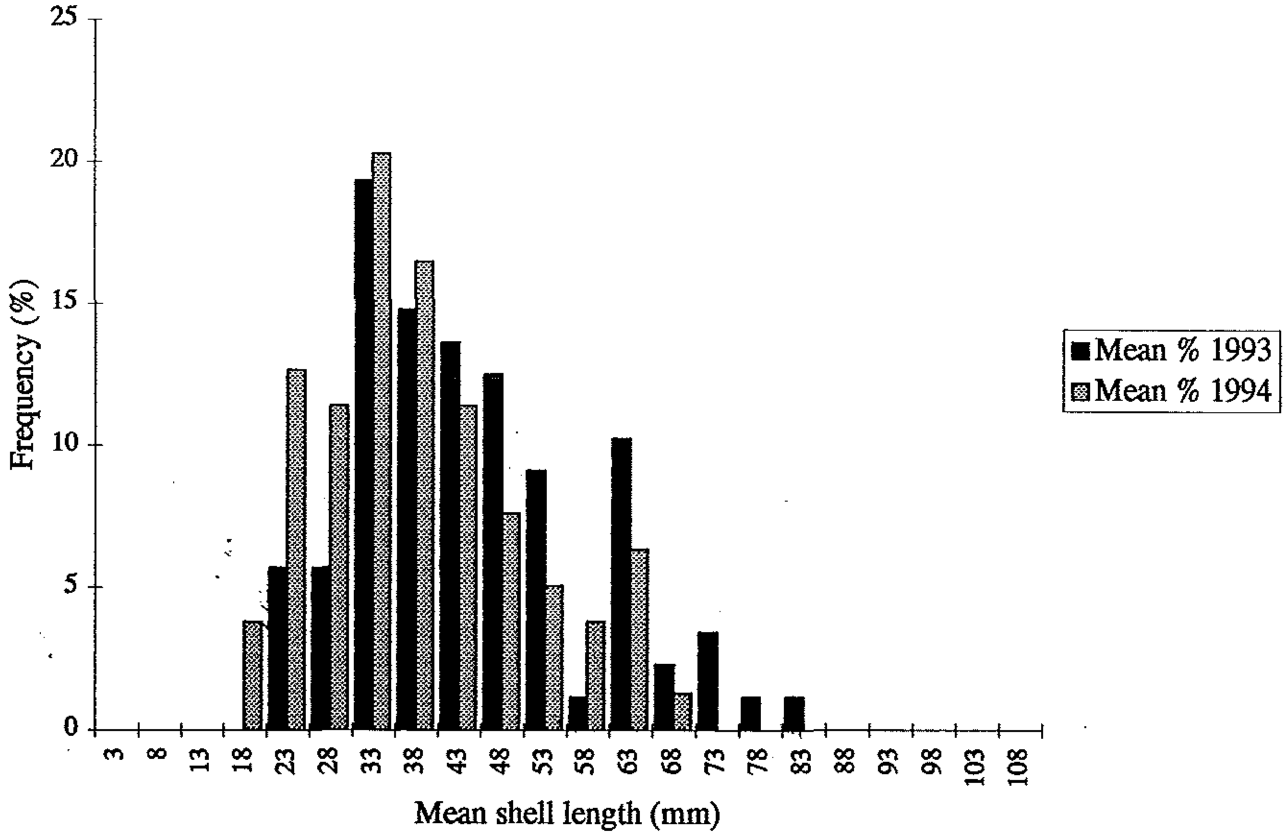
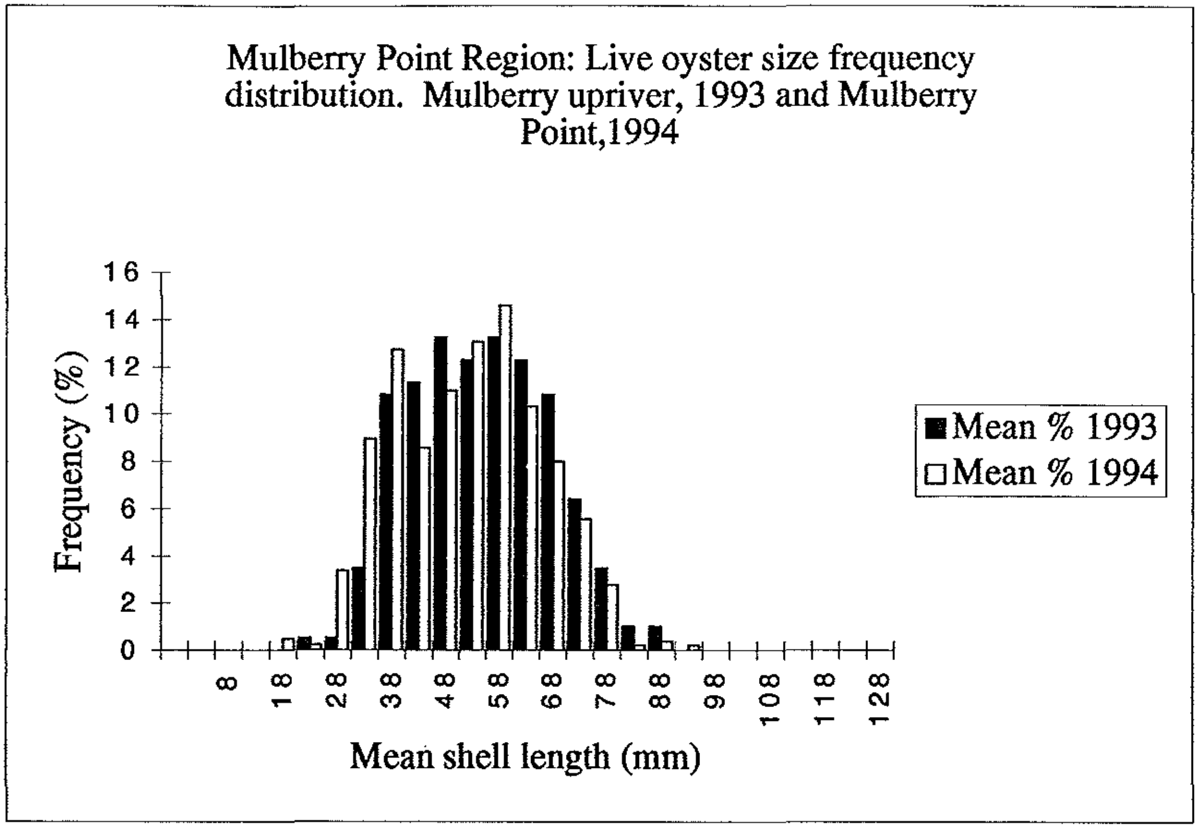


Figure 16


Mulberry Point Region: Live oyster size frequency distribution. Mulberry upriver, 1993 and Mulberry Point,1994
Frequency (%)
0
2
4
6
8
10
12
14
16
8
18
28
38
48
58
68
78
88
98
108
118
128
Mean shell length (mm)
Mean % 1993
Mean % 1994

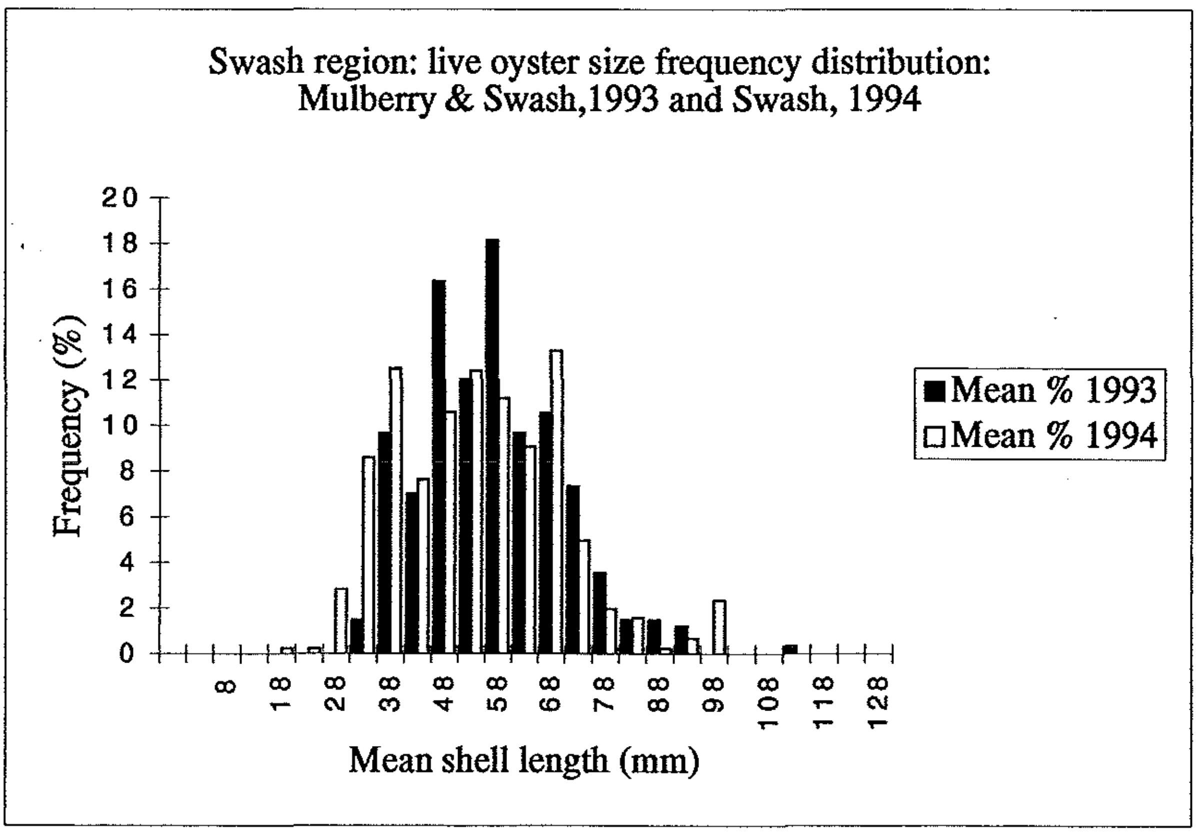

Swash region: live oyster size frequency distribution: Mulberry & Swash,1993 and Swash, 1994
Frequency (%)
0
2
4
6
8
10
12
14
16
18
20
8
18
28
38
48
58
68
78
88
98
108
118
128
Mean shell length (mm)
Mean % 1993
Mean % 1994

Figure 17

Swash slough 1993 (= Swash mud 1994): live oyster size frequency distribution.

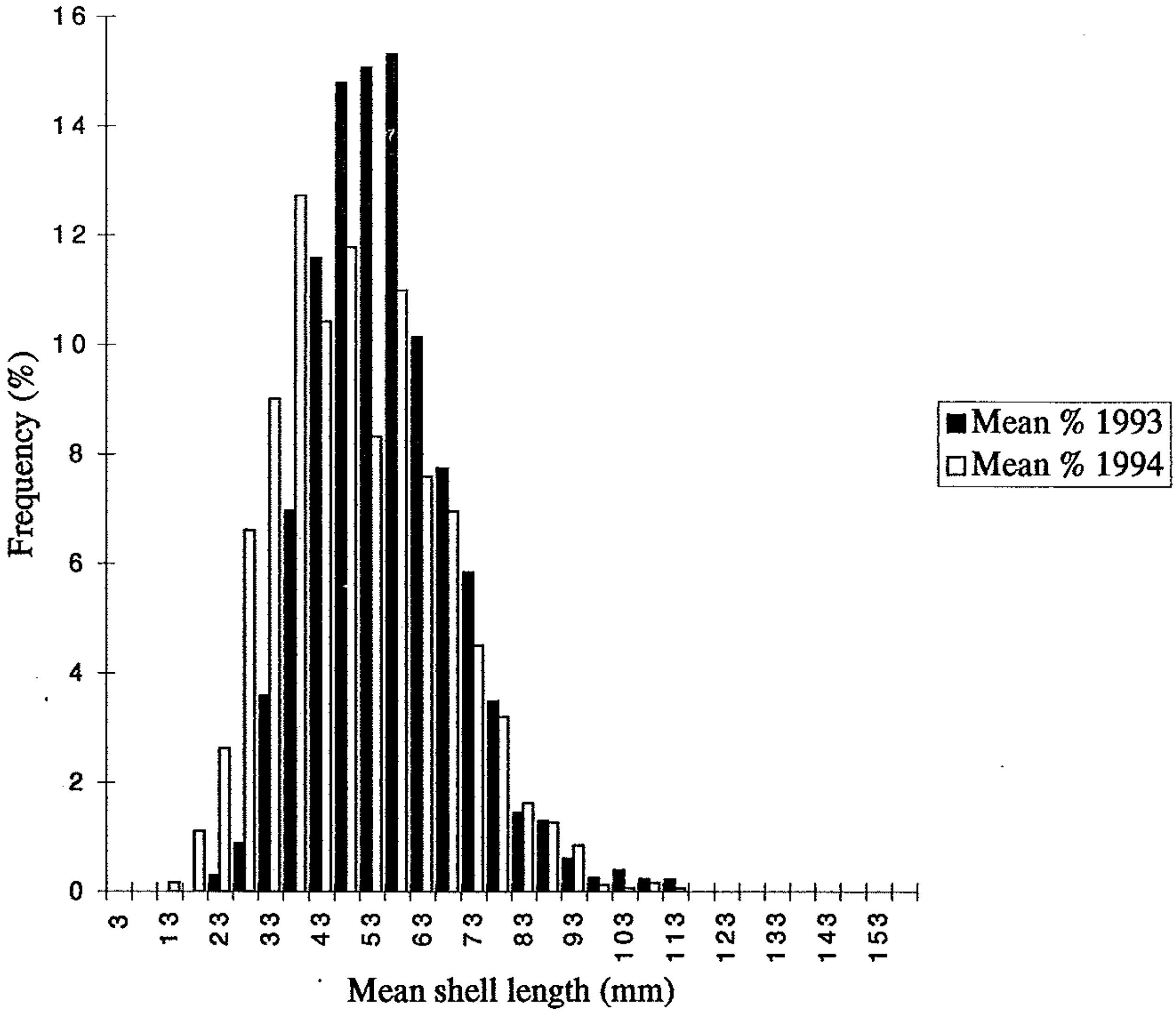
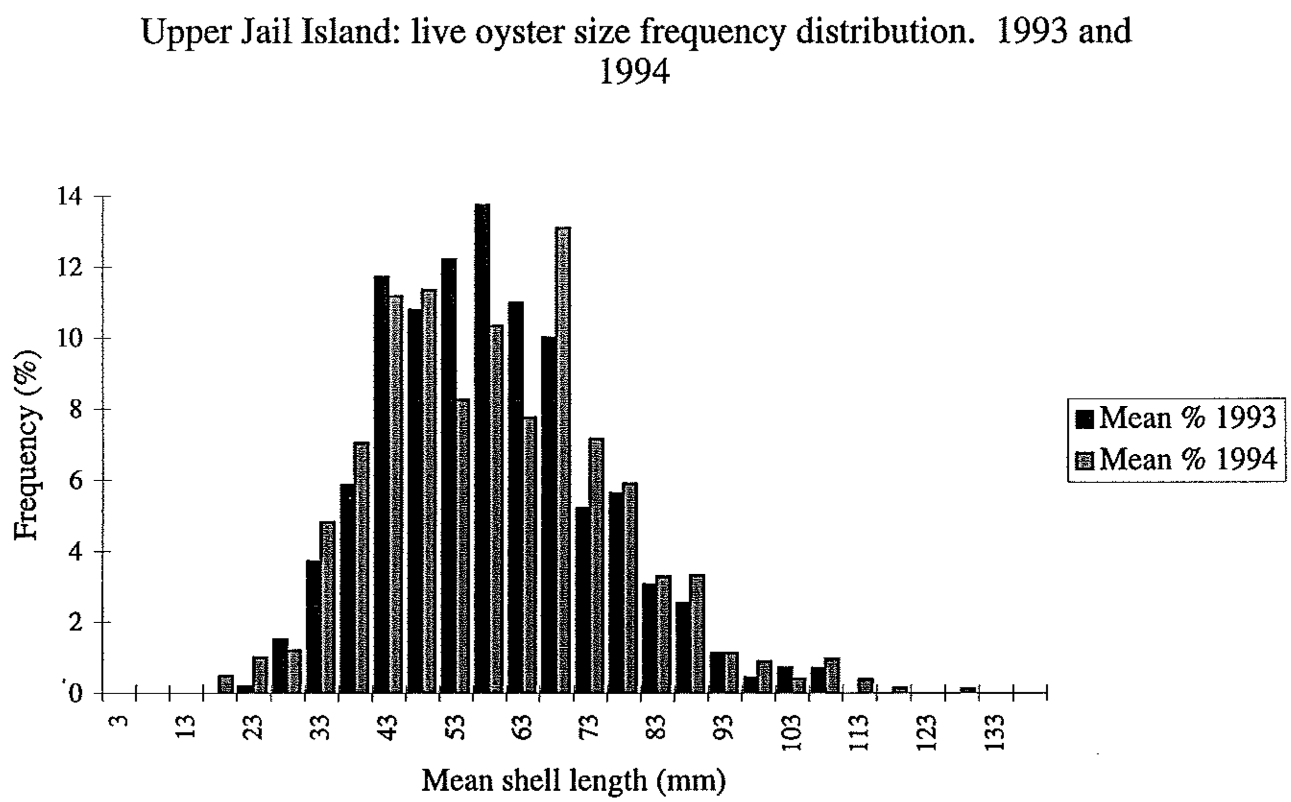


Figure 18



Upper Jail Island: live oyster size frequency distribution. 1993 and 1994
Frequency (%)
14
12
10
8
6
4
2
0
3
13
23
33
43
53
63
73
83
93
103
113
123
133
Mean shell length (mm)
Mean % 1993
Mean % 1994

Figure 19

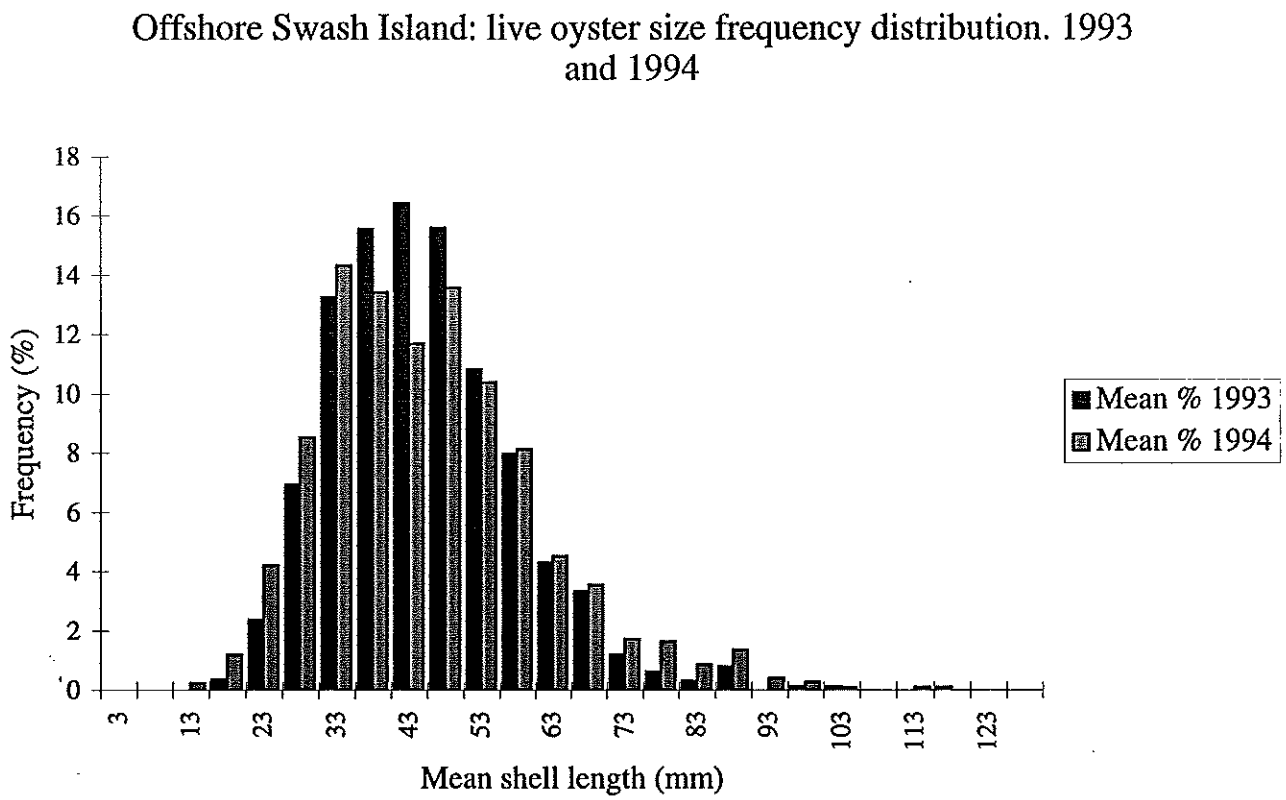

Offshore Swash Island: live oyster size frequency distribution. 1993 and 1994
18
16
14
12
10
8
6
4
2
0
Frequency (%)
3
13
23
33
43
53
63
73
83
93
103
113
123
Mean shell length (mm)
Mean % 1993
Mean % 1994

Figure 20

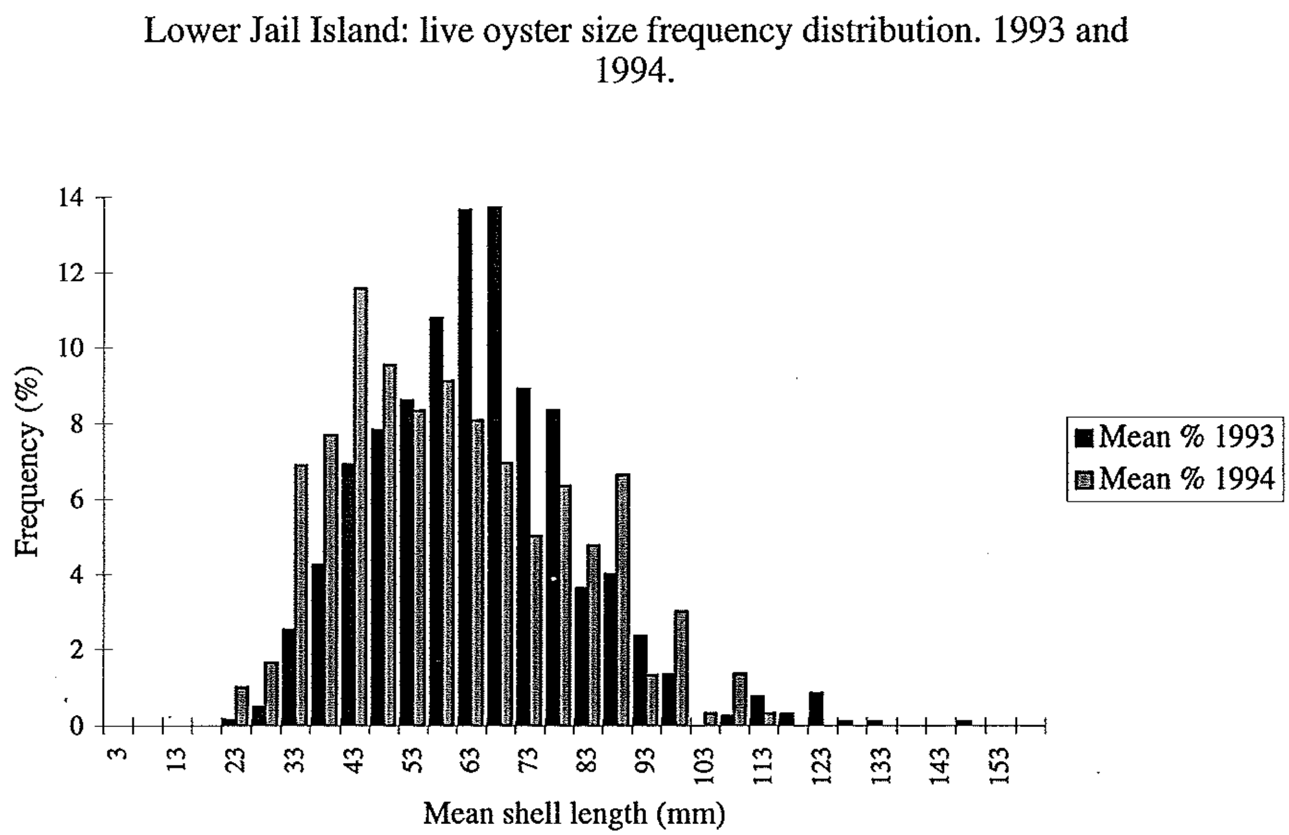

Lower Jail Island: live oyster size frequency distribution. 1993 and 1994.
Frequency (%)
0
2
4
6
8
10
12
14
3
13
23
33
43
53
63
73
83
93
103
113
123
133
143
153
Mean shell length (mm)
Mean % 1993
Mean % 1994

Figure 21

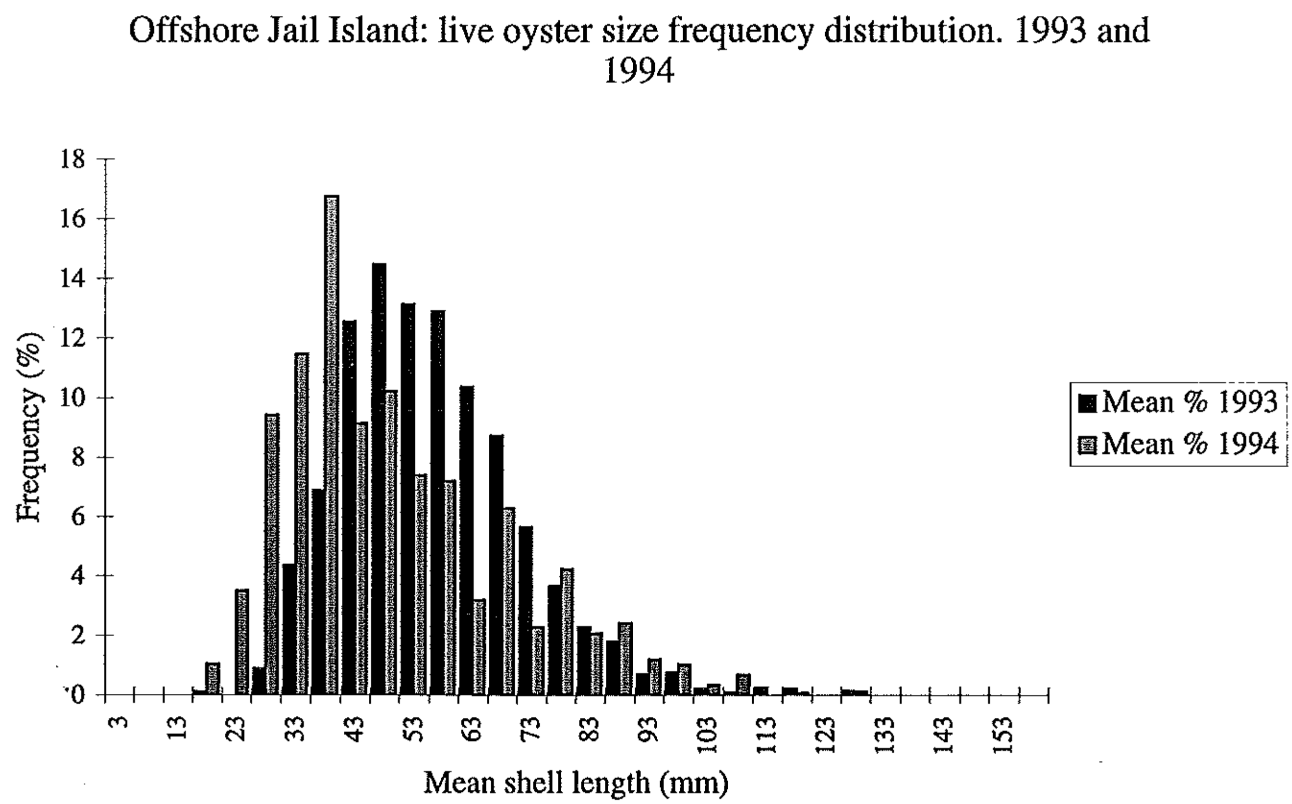
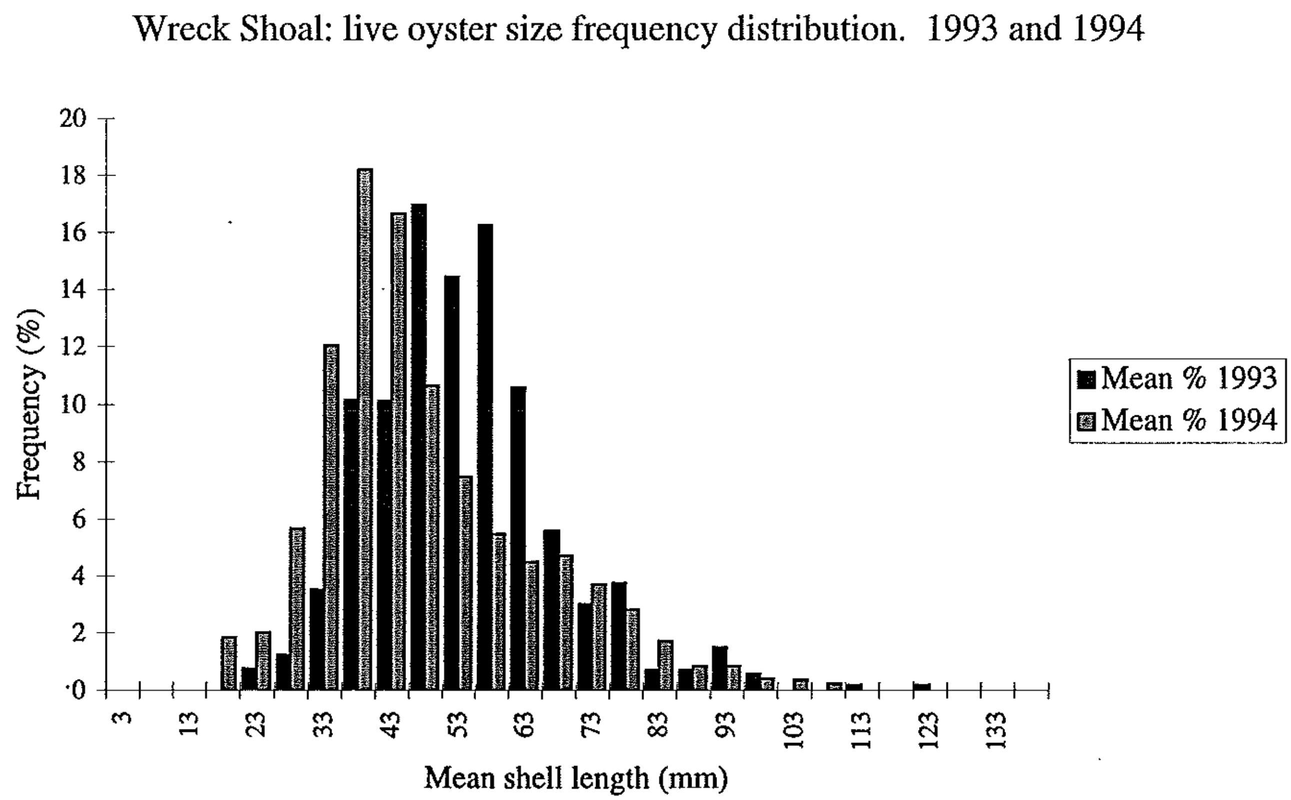

Offshore Jail Island: live oyster size frequency distribution. 1993 and 1994
Frequency (%)
0
2
4
6
8
10
12
14
16
18
3
13
23
33
43
53
63
73
83
93
103
113
123
133
143
153
Mean shell length (mm)
Mean % 1993
Mean % 1994

Figure 22



Wreck Shoal: live oyster size frequency distribution. 1993 and 1994
20
18
16
14
12
10
8
6
4
2
0
Frequency (%)
3
13
23
33
43
53
63
73
83
93
103
113
123
133
Mean shell length (mm)
Mean % 1993
Mean % 1994

size classes for the two years for the 19 reef comparison show remarkable concordance: 724,226 bushels in 1993-1994 and 737,446 bushels in 1994-1995 or less than a 2% discrepancy between the years.

Size distribution data

Figures 5 through 22 illustrate mean size frequency distributions of oysters on the sampled reefs in the James River in the 1994-1995 funding year. Each figure corresponds to a single reef in numerical order as listed in Figure 2 and Tables 2 and 3 with one exception. Figure 16 illustrates data for both the Mulberry Point and Swash regions in two graphics because the boundary between these two adjacent reef areas was moved slightly between the 1993-1994 and 1994-1995 surveys with the transfer of the easterly section of the 1993-1994 Mulberry upriver sampling area (12 in Figure 2) to Swash (13 in Figure 2) in 1994-1995. The transferred section more closely resembles the bottom type in the new sampling area.

Some growth of the 43-63 mm size class of 1993 is seen in the 1994 larger sizes at Upper Deep Water Shoal. Similarly the presence of 73-83 mm oysters in 1994 can be related to a strong 59-68 mm representation in the preceding year. Both locations are upstream and closed to market oyster fishing for much of the public season; they are, however, open to seed oystering for a limited period. This area is not generally subject to disease related losses - the salinity is too low - and the combined data illustrate that oysters can survive and grow in this location in the absence of commercial harvest. Horsehead (Figures 7-9), Moon Rock (Figure 10), V Rock (Figure 11), and Cross Rock (Figure 13) are open to market oyster exploitation throughout the public season and demonstrate harvest pressure in that the size frequency data for 1994 is suppressed compared to 1993. Point of Shoals (Figure 12) illustrates essentially a stable size frequency distribution for both years with harvest and disease losses (which can be small but none the less present here) in balance with growth and recruitment. Shanty Rock (Figure 14) illustrates marked depression in all size classes above 43 mm in 1994. This is also of concern at Dry Lumps (Figure 15). Both Shanty Rock and Dry Lumps are in a down stream location and more susceptible to disease than reefs with numerical identifiers from 1-9 on Figure 2. The Mulberry Point region illustrates a stable size frequency (Figure 16, upper graphic), whereas the 48 and 58 mm size classes of 1993 at Swash (Figure 16, bottom graphic) may be closely related to the 68 mm size class of 1994 at that sampling area. Swash slough illustrates depressed abundance in 1994 in all size classes above 43 mm (Figure 17), although some marginal gains in these >68 mm size classes at Upper Jail Island (Figure 18) may be related to a strong 1993 representation in the 43-63 mm size classes. Offshore Swash (Figure 19) illustrates interannual stability in frequency distribution; however, general depression in frequency of the larger size classes (48 mm and above) is observed at both Lower and Offshore Jail Island (Figures 20 and 21) and Wreck Shoal (Figure 22). Again, these last three sampling areas are all subject to disease related mortality in elevated salinity conditions.

Results and Discussion: Seaside of Eastern Shore of Virginia

Data analysis

Unlike surveys in the James and Rappahannock Rivers the sampling of the seaside was limited in statistical rigor by the choice of a haphazard sampling protocol with a fixed number of samples per sampling area. No attempt was made to investigate optimal sample numbers per sampling area prior to sampling, although modest standard deviations in the resultant groups suggest representative coverage. Also, the small size of the sample area and the large number of areas to be sampled dictated an efficiency in effort at each location.

Table 5

Seaside of Eastern Shore of Virginia Oyster Stock Assessment: Spring 1995

Values for oysters are the mean number per sq. m (based on seven collections from randomly deployed 0.25 sq. m quadrats)

Residual shell volume values are in liters

Area and Station Location	Oysters				Boxes			Shell
	Spat	Small	Market	Total	New	Old	Total	Residual
(1) Chincoteague								
Watts Bay high	18.3	133.7	33.1	185.1	3.4	8.6	12.0	9.1
Watts Bay low	4.6	1.7	0.0	6.3	0.0	6.9	6.9	19.4
(2) Wachapreague								
Bradford Bay shell plant 93-94	4.6	129.7	4.6	138.9	13.7	8.6	22.3	16.6
Bradford Bay turnover east 93	1.7	45.1	2.3	49.1	10.3	9.7	20.0	27.4
Bradford Bay turnover west 93	0.6	40.6	0.6	41.7	6.9	16.0	22.9	22.9
North Hummock shell plant 93 and 94	11.4	9.7	0.0	21.1	1.7	0.0	1.7	18.3
North Hummock turnover 93 & shell plant 94	16.6	9.7	0.0	26.3	1.7	4.0	5.7	13.1
South Hummock shell plant 93	2.9	219.4	2.3	224.6	5.1	4.6	9.7	12.6
South Hummock turnover 93	14.3	353.1	10.3	377.7	20.0	34.3	54.3	24.6
(3) Quinby								
Barge Point 93 high shellplant	8.0	406.3	2.9	417.1	16.6	4.6	21.1	4.3
Barge Point 93 low shell plant	0.6	46.9	0.0	47.4	6.3	1.1	7.4	4.0
Cockle Creek 92 shell plant & 93 turnover	1.1	358.3	55.4	414.9	20.0	14.9	34.9	8.0
Major Midhole shell plant 93	24.0	176.6	2.9	203.4	9.1	12.0	21.1	14.9
Middle Gap South 93 turnover	24.0	276.6	1.7	302.3	21.7	50.9	72.6	27.4
Middle Gap North shell plant 93	19.4	66.3	2.3	88.0	27.4	30.9	58.3	14.0
Middle Gap North turnover 93	3.4	95.4	8.0	106.9	12.0	4.6	16.6	8.6
(4) Hog Island								
Upper Draft shell plant 93 high	145.1	393.1	0.0	538.3	37.7	16.6	54.3	24.6
Upper Draft 93 turnover	115.4	72.0	0.0	187.4	17.7	17.1	34.9	21.7
Upper Draft shell plant 93 low	23.4	81.1	0.0	104.6	17.1	2.9	20.0	20.0
Upper Draft bagless dredge	30.9	54.9	0.0	85.7	9.1	16.0	25.1	32.3
(5) Oyster								
Brockenberry shell plant 92	82.3	117.7	2.3	202.3	13.7	84.6	98.3	14.3
Brockenberry shell plant 93	27.4	506.3	8.6	542.3	60.0	45.7	105.7	2.1
Narrow Channel S.W. shell plant 92	31.4	243.4	4.0	278.9	26.3	44.6	70.9	10.9
Narrow Channel S.W. 93	30.3	77.7	1.1	109.1	13.7	7.4	21.1	15.7
Narrow Channel East 93 turnover	11.4	6.3	0.0	17.7	1.7	6.3	8.0	20.0
Narrow Channel turnover west	5.1	0.0	0.0	5.1	0.0	4.0	4.0	29.1
Pointer Rock shell plant 93 high	26.9	128.6	0.6	156.0	11.4	11.4	22.9	11.6
Pointer Rock shell plant 93 low	26.9	125.7	3.4	156.0	22.3	25.7	48.0	4.6
Pointer Rock turnover 93	24.6	197.1	0.0	221.7	39.4	23.4	62.9	18.6
Rams Horn shell plant	34.3	125.1	1.1	160.6	14.9	52.0	66.9	9.1
Rams Horn turnover 93	41.1	31.4	0.6	73.1	14.9	42.9	57.7	12.9

General summary of population sizes

A range of oyster densities was observed from essentially absent at Narrow Channel turnover west in Area 5 to over 500 oysters per sq. m. (Table 5) Numerous stations had oyster densities in excess of 100 oysters per sq. m. in all Areas, values comparable with or even exceeding the highest values recorded at Horsehead, Moon Rock, V Rock and Point of Shoals in the James River. Despite these high oyster densities market oysters were present in substantial numbers only at Watts Bay high (33. 1 per sq. m) and Cockle Creek. Modest densities of market oysters were present at South Hummock turnover, Middle Gap North turnover, and Brockenberry shell plant 92. The vast majority of the oysters are represented in the small oyster category. The high oyster densities are a indicator of the value of careful replenishment activity; however, the variability between spatially adjacent stations (compare for example Watts Bay high and low in terms of all size classes, or Barge Point high and low shell plant) can be very high and tidal related. Indeed, careful observation of these reef systems at low tide illustrate that oysters optimally inhabit a very narrow depth range in the intertidal. As in all observation sets there are the exceptions, and virtually identical oyster populations were observed at Pointer Rock high and low shell plants in Area 5.

The majority of replenishment activity on the Seaside has consisted of shell planting and bagless dredging; however, this has more recently been supplemented with "turnover"; effective exhumations of deeper buried shell than would typically be exposed by bagless dredging. "Turnover" is effected with a device similar to a garden tiller, and is cost comparable with shell planting in areas where buried shell resource is abundant (which applies to numerous sites on the Seaside that have recently been inundated with finer sediments. Also, the use of a "turnover" approach minimizes the cost associated with logistics of large shell volumes, small barge movement and tides that dominate activity in the Seaside reef and marsh systems. When used in combination with shell planting at Cockle Creek this approach produced the highest oyster densities observed at any stations in the entire 1994-1995 surveys. When used as the single replenishment activity at Middle Gap, Upper Draft, and Pointer Rock (Area 3, 4 and 5 respectively) oyster densities were still very high (100-300 oysters per sq. m range), at the last location exceeding that of adjacent shell plants. Only at Narrow Channel (Area 5) was the turnover approach both unsuccessful and notably poorer than adjacent shell plant stations.

The estimates of mortality in these populations from articulated shells (boxes) suggest this to be slightly higher in terms of percentage than that observed at the more productive James River reefs, but still not exceptionally high. Of particular note in the Seaside data is the consistently higher values for residual shell in samples compared with James River data reflecting the choice of active repletion sites in the Seaside survey.

Conclusions and recommendations

Even though this survey represents only the second year of fishery independent surveys in the James and Rappahannock Rivers, surveys effected in the absence of any prior intensive quantitative surveys, several factors of note have already emerged. The concordance of total standing stock and component estimates for the two years lends support to the soundness of the survey design. The disparity in estimates of small and market oysters between the years is very much accounted for the by the change in the dividing size limit from 2.5 to 3 inches (63 to 76 mm) and further supported by the extensive size distribution data. The general commitment in resource management to "No Net Loss" as recommended by the Haskell - Pruitt Blue Ribbon Panel can be achieved IF AND ONLY IF FISHERY INDEPENDENT STANDING STOCK ESTIMATES ARE RESPECTED AND USED

SENSIBLY BY MANAGEMENT AGENCIES. In spite of our best efforts, and the approval of our studies by peers in the scientific community, we have yet to attain an acceptable equilibrium situation with active fishery managers. We must redouble our efforts in this educational process. The data are adequate to effect sensible and sustained exploitation of these resources.

The lack of shell resource on the James River and Rappahannock River reefs remains a great concern. Again, education must prevail. Replenishment activity must focus on low density shell supplementation of extant reef, NOT on misguided attempts to extend reefs into areas where they have not developed over recent geological time. This is metaphorically pouring good shell after bad in a near time frame mode. This shell, an already valuable and increasingly costly resource, will rapidly bury and require further shell application. The long employed methods of large scale shell planting which allow only minimal control of the thickness of application are arguably overdue for general replacement with methods that effect controlled shell application at lower density. The increase in cost will more than be offset by the increased shell substrate IN THE OPTIMUM AREA FOR SETTLEMENT AND SURVIVAL.

It would be inappropriate to conclude discussion concerning the James River resource without comment on the substantial mortalities associated with storm related fresh water run -off in the summer of 1995. Had such run-off occurred in the winter months the effect would probably have been negligible in that oyster physiological rate is low in the winter months and their ability to remain closed for extended periods is high; however, at high summer temperatures the limits on extended closure are small as dictated by respiratory needs, and once opened at low salinities the oysters are doomed by a combination of stress from both osmotic and respiratory needs. To add insult to this injury, preliminary data indicate that the summer of 1995 was one of the worst on record for oyster diseases in the James. The extended period of low rainfall has resulted in generally low river flows and salinity intrusions into the last remaining oyster populations in the upper James. More than ever the data of fishery independent stock assessment should be heeded in establishing management directives to stabilize and rebuild the oyster resource. Sensible minds must prevail against a "lets take 'em before they die anyway" attitude that so pervades the fishery interest. As this report is completed we are beginning our third year of fishery independent surveys in the James River. This year, the final year of our agreed effort with CBSAC support, could be more critical than ever in providing stock estimates for long term planning of resource rehabilitation.

The Seaside of the Eastern Shore of Virginia has generally received secondary attention in terms of replenishment activity. A recent (past five years) increase in the status of this area has been driven by the conviction that there exists untapped potential for an oyster fishery on the Seaside. Certainly, the results of this limited survey are very encouraging, with a number of site showing large numbers of small oysters that should reach market size in the Fall of 1995 and 1996. Continued development of the Seaside reefs would appear prudent.

Literature cited

Bros, W. E. and B. C. Cowell. 1987. A technique for optimizing sample size (replication). J. Exp. Mar. Biol. Ecol. 114: 63-71.

Chai, A-L, M. Homer, C-F. Tsai and P. Goulletquer. 1992. Evaluation of oyster sampling efficiency of patent tongs and an oyster dredge. North American Journal of Fisheries Management 12: 825-832.

Hargis, W. J. Jr. and D. S. Haven. 1988. The imperilled oyster industry of Virginia. VIMS Special Report NUmber 290 in Applied Marine Science and Ocean Engineering. 130p.

Haven, D. S., W. J. Hargis, Jr. and P Kendall. 1981. The present and potential productivity of the Baylor Grounds in Virginia. Va. Inst. Mar. Sci., Spec. Rep. Appl. Mar. Sci. Ocean. Eng. No. 243: 1-154.

Haven, D. S. and J. P. Whitcomb. 1983. The Origin and Extent of Oyster Reefs in the James River, Virginia. J. Shellfish Res. 3(2):141-151

Haven, D. S. and J. P. Whitcomb. 1989. The Location and Topography of oyster reefs in the Rappahannock River Estuary, Virginia. J. Shellfish Res. 8:105-116