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Hampton Roads tunnel corridor survey report for the Virginia Department of Highways

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Hampton Roads Tunnel Corridor Survey Report

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by

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INTRODUCTION

A survey of a proposed bridge tunnel corridor across Hampton Roads from Newport News to Portsmouth was undertaken by the Virginia Institute of Marine Science at the request of the Virginia Department of Highways. The objective was the estimation of the densities of hard clams, oysters and bottom shell.

SUMMARY

1. The occurrence of oysters was extremely low and not of economic concern. A future economic potential for this natural resource, in the absence of MSX or the development of a strain of oysters resistant to the disease, remains in the realm of probability but, of course, cannot be evaluated at this time.
2. Submerged aquatic vegetation, such as Zostera and Ruppia which provide shelter for small motile organisms and are a source of attachment for sissile ones, were absent in the deeper water stations. Both species though present, were very sparsely represented in the shallow water stations (nos. 7 and 18).
3. Hard clam density was mostly confined to the norhtern half of the corridor from the Newport News shore area to a little beyond the Middle Ground area. Southward to the Portsmouth shore, the density of hard clams was very sparse. The substrate in the latter area was unstable and composed of soft mud and/or silt, often overlying the shell of old oyster beds; the substrate of the former area was firm due to its sand-mud-shell complex.

4. The overall estimate of hard clams was approximately 200,000 bushels. Based on the prices paid the patent tong fisherman, the value of this standing crop is about $821,000.
5. The relatively high percentage of Littleneck and Cherrystone clams (71% combined) is indicative of good recruitment to the population.

MATERIALS AND METHODS

To obtain the desired estimates the overall corridor was divided into eight areas (Figure 1). These areas differed in depth or substrate type, or both. A brief description of each area follows:

Area 1: Hampton Roads (south)
Depth: 10-18 feet MLW
Substrate: Soft mud
Surface area: 1.76 sq. mile (nautical)

Area 2: Hampton Raods (anchorage)
Depth: 19-27 feet MLW
Substrate: Soft mud to hard sand
Surface area: 2.23 sq. miles

Area 3: Newport News Middleground
Depth: 14-18 feet MLW
Substrate: Hard sand
Surface area: 0.14 sq. mile

Area 4: Newport News Channel
Depth: 40-45 feet MLW
Substrate: Soft mud over hard clay
Surface area: 0.17 sq. mile

Area 5: Newport News Bar
Depth: 6-12 feet MLW
Substrate: Hard sand
Surface area: 0.46 sq. mile

Area 6: Newport News Bar
Depth: 13-18 feet MLW
Substrate: Hard sand
Surface area: 0.16 sq. mile

Area 8: Newport News Shore
Depth: 1-5 feet MLW
Substrate: Soft mud
Surface area: 0.25 sq. mile

Area 7: Portsmouth Shore
Depth: 1-11 feet MLW
Substrate: Soft mud
Surface area: 0.76 sq. mile

A grid overlay and a table of random numbers were used to establish sampling stations in each area (Figure 1, triangles in areas 1-6, crosses in areas 7 and 8). The number of stations in each area is approximately proportional to its size. Areas 1-6 were sampled by a chartered patent-tong operator; because of the shallow depth, areas 7 and 8 were sampled from an open skiff with hand tongs. Hand tongs sample a volume about one-sixth that of patent tongs, therefore, the number of sample stations was increased accordingly in these two areas. In the initial proposal submitted on 29 February, 1972, it was suggested that five bottom samples be taken at each station. Patent tong sampling, however, proceeded faster than expected and it was possible to obtain 20 samples at each station. Hand tong sampling was a relatively slow procedure and it was possible to collect only five samples per station by this method.

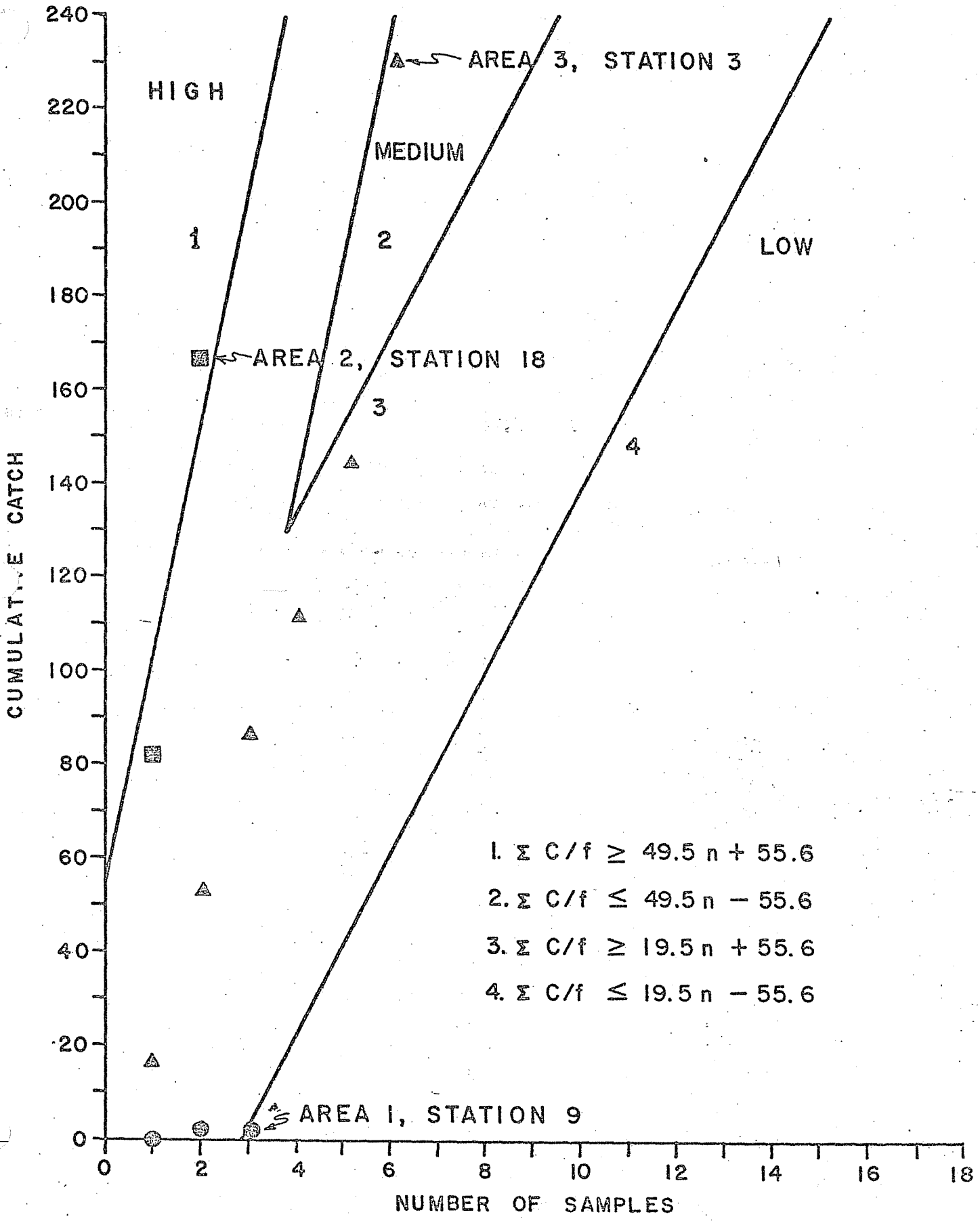
The R/V Mar-Bel, equipped with a hydraulic tow dredge, was also employed for sampling at selected stations in areas 1, 2, 3, 5 and 6. It was used as a check on the patent tong results because its catch characteristics are better known to the authors. The number of tows at each station was not predetermined but, instead, was a function of the ratio between cumulative catch and number of tows. This is a sequential sampling procedure; its explanation is too lengthly to present here, but the interested reader is refered to Wald (1945) and Statistical Research

Group, Columbia University (1947). In essence, the procedure permits qualitative probability statements about abundance, i.e., the classification of a station in this study as one of high, medium or low abundance. The procedure is presently applicable to only hard clams in this study. Graphical examples are presented in Figure 2. When the limits of the graph are exceeded, tow number (n) and cumulative catch (c/f) are substituted into the inequalities. Sampling continues until the plot of cumulative catch verses number of tows occurs on a line or within a designated area of abundance, this, also, results in one of the inequalities being satisfied.

Patent tong catch data are reported in terms of the average catch per grab determined from 20 grabs. Hand tong data is reported as the average catch per grab determined from five grabs. Tow dredge data is reported as the average catch per 100 linear feet of tow. All data may be converted to catch per square foot by making the following adjustments: a) Patent tong catch $\div$ 10.5; b) Hand tong catch $\div$ 1.75; and c) Tow dredge catch $\div$ 125. Care must be used in interpreting the tow dredge catch data in absolute amounts. An outstanding feature of sequential sampling is the reduction in sampling effort, i.e., the number of samples needed to classify data. However, this reduction in sampling efforts, while maintaining a high confidence level for qualitative statements, may introduce a degree of inaccuracy, when replication of tows is very low, which is compounded when the data is quantified and extrapolated. This qualitative sampling scheme complemented the quantitative patent tong sampling procedure.

In estimating the number of clams and shells per acre in each area,

Figure 2. Examples of sequential sampling method.



and the total number of clams and shells in each area, the following conversion factors were used:

Hard clams per bushel = 300
Hard clam shells per bushel = 600
Oyster shells per bushel = 500
Other small shells and fragmented shells per bushel = 900

Hard clam size categories:
Littleneck: ≤ 60 mm (≤ 2.4 inches)
Cherrystone: 61 mm (2.4 inches) to 80 mm (3.1 inches)
Chowder: > 80 mm (> 3.1 inches)

Acre = 4.35×10^4 square feet
1 nautical mile = 6076 feet
1 square nautical mile = 848.68 acres

Shell catch is reported in totals for hard clams, oysters and all other molluscan shells and fragmented shells.

Analysis of variance was employed to determine statistically if the estimated bushels of hard clams per acre differed among areas.

RESULTS AND DISCUSSION

The average catch data of hard clams, oysters and shell at each station are presented in Tables 1, 2 and 3.

It is obvious by inspection of the data tables that the occurrence of oysters was relatively rare and that they are not of economic importance in the overall area under consideration. These results were expected because the Hampton Raods area is one in which the disease MSX causes near total mortality in adult oysters. Similarly, eelgrass (Zostera and Ruppia) was present only in Areas 7 and 8. Although its occurrence was somewhat more frequent at the latter station than at the former, at best is was spotty and negligible.

Hard clam densities varied from low to high and are discussed by

areas in a non-numerical sequence that is related to the common nature of the substrates in some areas and the observed distribution pattern of clams and shells.

AREA 1: Very few hard clams were present in this area. The overall average catch for 380 patent tong grabs was 0.02 clams per grab, an estimate of less than a half-bushel per acre (Table 1). Shell was also scarce with the exception of catches at Stations 1 and 13. Area 1 was once oyster grounds where shell was planted. Old shell in a firm bottom generally has well established hard clam populations. The shell at this station, however, is now buried under a heavy silt layer which inhibits the successful setting of bivalve larvae because of the instability of the substrate. This silted condition was probably caused by the creation of the Craney Island disposal area which caused the area immediately upriver to function as a sediment trap.

Tow dredge catch data support the above conclusion of low density. The average tow dredge catch ranged from zero to 0.7 clam per 100 feet (Table 3).

AREA 7: This area is located directly inshore of Area 1. Hard clam catch was higher than in the latter area but was also low. The overall average clam catch was 0.13 per grab for 145 hand tong grabs for an estimate of 11 bushels per acre (Table 2). The substrate was somewhat firmer, ranging from mud to sand, though mostly the former. Wave action in this shoal area probably precludes a silt buildup.

AREA 2: This area was the most non-homogeneous (with respect to catch) of all the areas sampled. The dash line in Figure 1 separates

that portion of Area 2 (Station 5, 6, 7, 8, 9, 10, 12 and 15) which appears to be an extension of the conditions found in Area 1. The substrate at these eight stations was mud, and the overall average catch for 160 patent tong grabs was approximately 0.09 clam per patent tong grab for an estimate of 1 bushel per acre. Immediately beyond these stations along an axis formed by Stations 11 and 18 there is an area of rapid transition from low to high hard clam abundance. The estimated abundance at these two stations is 12 and 11 bushels per acre derived from catches of 0.9 and 0.8 clam per grab, respectively (Table 1). Beyond this, toward the Middle Ground, the average catch of hard clams rose to 3.4 clams per grab or 47 bushels per acre at Station 19 and 4.2 clams per grab or 58 bushels per acre at Station 13. The estimates of hard clams for the remaining nine stations in Area 2 range from 88 to 185 bushels per acre and have a combined average catch of 9.6 clams per grab for an estimate of 133 bushels per acre. The density of clams, in general, increased as the substrate changed from mud to sand. The average catch is reduced to 4.59 clams per grab or about 63 bushels per acre when all 21 stations in the area are considered.

Tow dredge catch data indicates a similar diversity in abundance. No hard clams were taken in three tows at Station 10 (Table 3). Station 18 was classified as having a high density of hard clams, but the patent tong catch, however, was relatively low at this station. This station is in the transition zone and the apparent discrepancy probably reflects a minor location difference when the station was separately sampled with each collection gear. The highest tow dredge catch was taken at Station 17 which was also the site of the largest patent tong catch.

AREA 3: Patent tong catches in this area indicated a medium abundance of hard clams. Average catches ranged from 3.7 to 4.9 clams per grab for an estimate of 51 to 68 bushels per acre; for the three stations combined, the average catch was 4.20 clams per grab or 58 bushels per acre (Table 1).

Tow dredge sampling again complemented the patent tong results. Six tow samples averaging 38.5 clams per 100 linear feet classified the station as one of medium abundance (Table 3).

AREA 4: Hard clams were scarce in this area; the average catch, derived from 60 patent tong grabs, was 0.36 clams per grab or an estimated 6 bushels per acre (Table 1). The lack of hard clams in this area was expected because it is a dredged, deep-water channel.

The depth of this channel precluded the use of the hydraulic tow dredge.

AREA 5: The estimated abundance of hard clams in this area ranged from medium to high, with an overall catch average of 5.65 clams per patent tong grab or an estimated 78 bushels per acre (Table 1).

Tow dredge sampling indicated Stations 1 and 2 had a high density of hard clams (Table 3). This is in agreement with the patent tong results for Station 1 but not for Station 2. This may, again, reflect minor location differences in sampling which results in different estimates of abundance because of the contagious nature of hard clam distributions.

AREA 6: Average patent tong catches in this area ranged from zero to 4.7 clams per grab with an overall estimate of 32 bushels of hard clams per acre (Table 1).

A statistical decision of relative abundance had not been made at Station 2 when tow dredge sampling terminated. The cumulative catch at this time indicated a medium or high abundance of hard clams.

AREA 8: Average catch at this shoal water area ranged from zero to 3.2 clams per hand tong grab (Table 2). The overall estimate of hard clam abundance was 58 bushels per acre. This estimate for Area 8 is considerably higher than at Area 7 (the opposite shore) and is most likely related to the difference in substrates. The abundant shell in latter area was mostly overlaid by mud while in the former area the substrate ranged from sand-mud to hard packed sand.

Areas 1 and 4 were obviously different and not included in the statistical analysis to determine if the derived estimate of the number of bushels per acre varied among areas (Table 4). Areas 7 and 8 were also omitted because the sampling gear (hand tongs) was different. The catch data was best described by a negative binomial distribution and, accordingly, the transformation, log (X+1), was applied prior to analysis. Analysis of variance indicated that a highly significant difference existed among these areas with respect to the average catch (Table 4). Subsequent multiple mean tests (Scheffe, 1959) indicated that four of the six possible contrasts of means were significantly different. The data indicated that the large catch variation was responsible for the inability to find significant differences in the other two contrasts; all catch averages were considered discrete and were used to construct Table 5. Column 5 of this table lists the size of each area in square nautical miles. Columns 6 and 7 are an estimate of the total number of bushels of hard clams and bushels of shell,

respectively. The abundance of hard clams in their natural distribution generally has a positive correlation with the amount of shell and the firmness of the substrate. The correlation coefficient for the abundance of clams and shells in the present data is very low (r=0.53) because of the thick mud and silt cover over some heavily shelled substrate. It is evident from the data in Table 5, however, that the denser concentrations of hard clams was associated with a firm bottom composed of a sand-shell matrix.

Length measurements were made of 1,974 hard clams obtained from the sample catches and the percentages of Littlenecks, Cherrystones and Chowders were 14%, 57% and 29%, respectively. Patent tong fishermen are paid $0.015 for each Littleneck and Cherrystone clam, and $0.01 for each Chowder clam. Based on the above percentage distribution of size and the estimate of total abundance, the standing crop of hard clams in the areas sampled is approximately $821,000 (Table 6). If 20 percent of the standing crop were harvested annually, the dockside value would exceed $160,000. The overall value, inturn, would increase as the resource is passed to wholesalers and retailers. Because of the abundance of the smaller Littleneck and Cherrystone clams in this area, it is reasonable to assume that annual mortality (both natural and fishing) is balanced by recruitment. Thus the estimate of approximately 200,000 bushels should be a relatively constant density year to year.

The overall area considered in this study is defined as polluted and the clams purchased from the patent tong fishermen during the open season in this area (1 May to 15 August) are replanted on private holding grounds. A limited number of men are employed at a later date in the reharvest of these clams. They are paid from $0.40

to $1.00 per hundred clams; the pay is inversely proportional to the density of clams on the holding ground, i.e., they are initially paid the lowest price when clams are dense and the price rises as recapture becomes more time consuming. The value of the clams when shipped to market depends upon the time of year and the particular market; both of these factors affect the size ranges defining Littleneck, Cherrystone and Chowder clams, and the value associated with each category. Presently, summer prices on the New York wholesale market are about $26, $11 and $5 per bushel for Littleneck, Cherrystone and Chowder clams, respectively.

Aerial observations by this Institution indicate that approximately 25 patent tong boats harvest clams in the Hampton Raods area during the open season. Records of their catch, however, are not available.

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Table 1

Hampton Roads-Craney Island patent tong catch data.
Station data are averages determined from 20 grabs per station.

		Mollusks		Shell Number		
Area	Station	Hard Clam	Oyster	Hard Clam	Oyster	Total
1	1	0.1	0.1	0.1	17.5	17.6
	2	0	0	0	0	0
	3	0	0	0	0.1	0.1
	4	0	0	0.2	0	0.2
	5	0	0	0	0.1	0.1
	6	0	0	0	0	0
	7	0	0	0.1	0	0.1
	8	0	0	0.1	0.3	0.4
	9	0	0	0.1	0	0.1
	10	0.1	0	0.1	0.2	0.3
	11	0	0	0	0.3	0.3
	12	0	0	0	0.2	0.2
	13	0	0	0	11.0	11.0
	14	0	0	0	0.2	0.2
	15	0	0	0.1	0.2	0.3
	16	0	0	0	0.4	0.5
	17	0	0	0	0.1	0.6
	18	0.1	0	0	0.1	0.2
	19	0.1	0	0	0.2	0.2
Overall Average		0.02 = 0.3 bu/acre	0.00	0.04	1.54	1.62
2	1	11.6	0	6.4	0.1	6.7
	2	7.0	0	5.2	0.2	5.4
	3	10.6	0.1	6.7	0	6.8
	4	6.4	0.1	5.8	23.2	29.0
	5	0	0	0	0.3	0.5
	6	0.1	0	0	0	0.4
	7	0.1	0	0	0	0.3
	8	0.2	0	0	0.1	0.7
	9	0	0	0.1	0.1	0.8
	10	0	0	0	0	0.3
	11	0.9	0	0.1	0.1	1.6
	12	0	0	0	0.2	0.3
	13	4.2	0	0.6	0	1.7
	14	7.7	0	0.8	0	1.2
	15	0.3	0	0	0.1	1.7
	16	9.2	0	0.9	0	1.8
	17	13.4	0	1.4	0	3.5
	18	0.8	0	0.1	0.1	1.1
	19	3.4	0	1.3	0.1	3.2
	20	11.3	0	6.2	0.3	7.6
	21	9.4	0	4.6	0	4.8
Overall Average		4.59 = 63 bu/acre	0	1.91	1.18	3.78

Table 1 (Contd.)

Average Catch Per 20 Grabs

		Mollusks		Shell Number		
Area	Station	Hard Clam	Oyster	Hard Clam	Oyster	Total
3	1	4.0	0.15	0.3	0.1	0.4
	2	4.9	0	0.6	0	1.2
	3	3.7	0.2	1.8	0.1	2.2
Overall Average		4.20 = 58 bu/acre	0.11	0.90	0.06	1.26
4	1	0.7	0	0.5	0.2	1.0
	2	0.3	0	0.3	1.8	2.5
	3	0.1	0	0.1	0.1	0.2
Overall Average		0.36 = 5 bu/acre	0	0.30	0.70	1.23
5	1	8.8	0	18.2	72.8	91.0
	2	4.0	0	13.2	52.6	65.8
	3	5.1	0.1	31.6	126.6	158.2
	4	3.8	0.1	17.1	68.3	85.4
	5	5.6	0.2	19.3	77.3	96.6
	6	6.6	0	29.7	118.7	148.4
Overall Average		5.65 = 78 bu/acre	0.06	21.51	86.05	107.56
6	1	2.4	0.1	2.4	0.7	3.3
	2	4.7	0	9.8	39.2	49.0
	3	0	0	2.0	7.8	9.8
Overall Average		2.36 = 33 bu/acre	0.03	4.73	15.90	20.70

Table 2

Hampton Roads-Craney Island hand tong catch data.
Station data are averages determined from five grabs.

		Mollusks		Shell		
Area	Station	Hard Clam	Oyster	Hard Clam	Oyster	Total
17	1	0	0	0	0	0.2
	2	0	0	0	0.6	2.2
	3	0.2	0	0	0	0.6
	4	0.2	0	0	0	0
	5	0	0	0	0	0
	6	0.2	0	0	0.2	3.2
	7	0.2	0	0.4	0	2.2
	8	0.2	0	0	0	0
	9	0	0	0	0	1.0
	10	0	0	0	0	0
	11	0	0	0	0	0
	12	0	0	0	0	0.6
	13	0	0	0	0	1.0
	14	0	0	0	0	0
	15	0	0	0	0	1.0
	16	0	0	0	0	1.4
	17	0.2	0	0	1.0	3.2
	18	1.2	0	0	9.2	9.2
	19	0.2	0	0	0.4	0.4
	20	1.0	0	0	2.8	2.8
	21	0.2	0	0.4	0	0.4
	22	0	0	0.4	0	0.4
	23	0.2	0	0	0	0
	24	0	0	0	0.2	0.6
	25	0	0	0	0	0.2
	26	0	0	0	0	1.4
	27	0	0	0	0	0.6
	28	0	0	0	0	0
	29	0	0	0	0	0
Overall Average		0.13 = 11 bu/acre	0	0.04	0.49	1.12
18	1	1.0	0	0	0	0
	2	0	0	0.8	0	0.8
	3	0	0	0	0	3.2
	4	1.0	0	0.8	0.2	1.4
	5	1.2	0	0.6	0	3.2
	6	0.8	0	0.4	0.4	2.2
	7	0	0	0.4	0	0.4
	8	0.4	0	0.4	0.2	1.4
	9	3.2	0	0	0	0
	10	1.0	0	0	0	1.2
	11	0.2	0	0	0	0
	12	0.4	0	0	0	0
	13	0	0	0	0.2	2.4
Overall Average		0.70 = 58 bu/acre	0	0.20	0.07	0.93

Table 3

Hampton Roads-Craney Island tow dredge catch data.
Average catch data adjusted to a distance of 100 linear feet. L, M or H indicates estimates of low, medium or high abundance for hard clams.

Area	Station	No. Tows	No. of Molluscs Hard Clam	Oysters	Shell (Bushels)
1	9	3	0.7 (L)	0	0.8
	12	3	0 (L)	0	< 0.1
	19	3	0 (L)	0	< 0.1
2	10	3	0 (L)	0	< 0.1
	18	2	83.0 (H)	0	1.0
	17	1	580 (H)	0	1.0
3	3	6	38.5 (M)	0	0.2
5	1	3	86.7 (H)	0	4.1
	2	1	128 (H)	0	4.0
6	2	2	71.0	0	0.6

Table 4

Analysis of variance for the catch data of Areas 2, 3, 5 and 6.

Source of Variation	Degrees Freedom	Sum of Squares	Mean Square	Critical Ratio (F)
Among areas	3	43.2	14.4	14.9*
Within areas	656	631.9	0.963	
Total	659	675.1		

* Probability that the observed difference could be due to chance is less than 1 in 1000.

Table 5

Total abundance of hard clams and shell determined from the average patent tong and hand tong catches.

Area	Clams/acre (Bushels)	Shell/acre (Bushels)	Substrate Type	Area Size (Naut. miles^2)	Totals/area (Bushels) Hard Clam	Shell
1	0.3	13	Mud-silt	1.76	448	19,418
2	63	27	Mud-silt to hard sand	2.23	119,231	57,099
3	58	8	Mud-sand	0.14	6,891	950
4	6	1	Clay	0.17	866	144
5	78	772	Sand	0.46	30,451	301,383
6	32	149	Sand	0.16	4,345	20,232
7	11	42	Mud	0.25	2,334	8,911
8	58	30	Sand	0.76	37,410	19,350
Total				5.93	201,976	421,487

Table 6

Estimated number of Littleneck, Cherrystone and Chowder clams and their value (Littlenecks and Cherrystone @ $0.015; Chowder @ $0.01).

Size Category	Occurrence (%)	Number Bushels	Value (Dollars)
Littleneck	14	28,277	127,246
Cherrystone	57	115,126	518,067
Chowder	29	58,573	175,719
Total		201,976	821,032