

CLAM DATA ANALYSIS

ASSATEAGUE ISLAND NATIONAL

SEASHORE

MARYLAND

Developed under Dr. Terry Bashore

Barrier Island Management

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ABSTRACT

A clam (Mercenaria mercenaria) study was conducted by the Assateague Island National Seashore staff to determine if there is any impact of human predation on the clam population. The island is open for clamming during summer for outdoor recreation. Twelve different sites were established along the Sinepuxent and Chincoteague bayside of Assateague Island. Data were collected from these sites for seven years (summers of 1984 - 1990). Human predation did not affect the clam density and size ($p < 0.05$). The interaction between human predation and years of observation also did not show any significant difference at $p < 0.05$. However, there were highly significant differences at $p < 0.00001$ among the years of observation. Density and size distribution changed every year during the research. In 1985 and 1986 the density and size of the clams decreased and increased respectively, while from 1989 to 1990 the clam density decreased and the size increased. The study indicated that the environment had a more distinct influence on the clam population than human predation did.

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INTRODUCTION

Background

Assateague Island is a barrier island system approximately 58 km in length and averaging 0.8 km in width (Biggs 1970). Assateague is bounded respectively to the north and south by Ocean City and Chicoteague inlets, east by the Atlantic Ocean and west by northern Sinepuxent Bay and southern Chincoteague Bay (Fig.1). The average depth of Sinepuxent Bay ranges from 1 to 1.5 m, with a 2 m channel, and deepens to 5-6 m at Ocean City Inlet. The maximum width of Chincoteague Bay is 11.6 km with the entire back bay system covering an area of 428.9 km² (Biggs 1970). Chincoteague Bay depth ranges from 1 to 3 m, deepening to 28 m at its Inlet. Tom's Cove, is found at the southern end of the island, which is formed by a westward bending sand spit (Fishing Point) and contains the island main body. The average depth of Tom's Cove is 1 m (Counts and Bashore 1991).

The area to the west of Assateague Island was settled by coastal Indians prior to the first European settlers arriving in 1524. Evidence indicates that the Indians used Assateague Island for fishing and hunting only, while more permanent settlements were located to the west (Anonymous 1982). Since that time, both the Indians and Europeans used this island as their recreational area (Jack Kumer, Resource Management Staff, pers. comm.).

In 1965, the Assateague National Seashore was established to

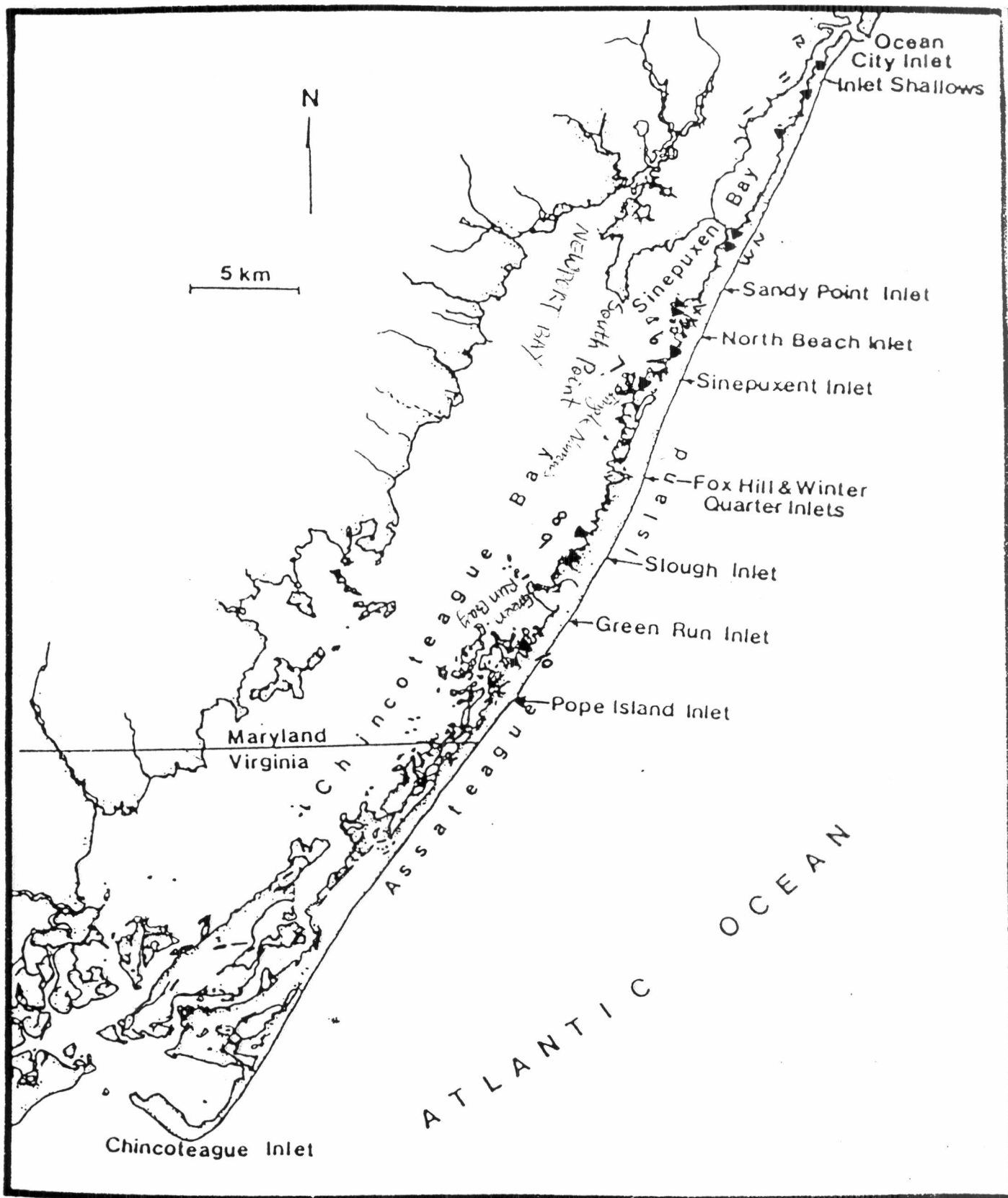


Fig. 1 Assateague Island, Maryland and Virginia, showing the clam survey sites (source: Counts and Bashore 1991).

protect and develop the natural resources of the seashore for public outdoor recreation and enjoyment (Anonymous 1991). In order to continue the traditional events, the National Park Service has annually conducted a very popular 'clam walk' at the coastal bay for seashore visitors. Approximately 4,000 visitors a year enjoy these clam walks. About 14,000 clams per year are removed from approximately 300 acres of the bay bottom by these visitors (Anonymous 1984). The most accessible location to the clam ground is from the Old Ferry Landing. A study done by the National Park Service in 1979 showed that the average densities of clams within 2,000 feet of the Old Ferry Landing was 1.09 clams/100 ft², between 2,000 feet and 3,000 feet the density was 3.78 clams/100 ft², and beyond 3,000 feet only 1-2 clams/100 ft² could be found (Anonymous 1984). More recent data indicated that in 1989 the clam population in this same area was 1.42 clams/100ft² and 1.08 clams/100 ft² in 1990. This locality has consistently been considered one of low clam density, yet one from which at least (90%) of the island's recreational clammers conduct their activities.

The hard clam, Mercenaria mercenaria, is a commercially important bivalve species along the Atlantic coast of the United States (Castagna and Kraeuter 1977). Since the clam population in Assateague Island has shown a decline year by year, the Resource Management Division of Assateague Island National Seashore established a clam monitoring program in 1984 to determine clam density of the island by site in order to find the

effect of clammers on the clam population (Jack Kumer, Resource Management Staff, pers. comm.). This clam survey has been conducted yearly from 1984 to 1990.

Many studies have been done on growth rate of Mercenaria affected by its environment (Ansell 1968; Chanley 1959; Chesnut in Eversole et al. 1986; Grizzle and Morin 1989; Gustafson 1955; Jones et al 1989; Pratt and Campell 1956; Whetstone and Eversole 1981). However, there has been only one ecological population study of this species in the Chincoteague Bay area (Wells 1957).

Objectives

The purposes of this study are:

1. To analyze the data collected by the National Park Service to determine the impact of clamming on the clam population.
2. To determine the environmental effects such as tide, temperature, salinity and dissolved oxygen on the population density.
3. To recommend changes in future sampling technique, clam monitoring, and clamming activity.

Materials and methods

The Mercenaria mercenaria data used in this study were collected by the staff of Assateague Island National Seashore at the west coast of Assateague Island, MD (at the side of Sinepuxent Bay and Chincoteague Bay) during the summers of 1984-1990.

Methodology

Twelve study areas were set up along the beach (Fig. 1). The study areas of Mystic Harbor, Overwash, Tingle's Island, Jims Gut-D loop, Jims Gut, People's and Lynch study areas had 1 transect; Boathouse North, Boathouse South, Bayside North, and Blind #4 had 2 transects; and Bayside South had 3 transects. The study area markers were established in 1984 and were used as a point to make transects according to given compass bearings towards shore. A 300 foot fiberglass tape was set and marked every 50 feet with fiberglass stakes. A total of six 10'x10' plots were made for each transect. The six plots were labeled A through F, with F the farthest plot from the site marker. A twenty foot marked string (a cord with knots tied at each end and at the 10 foot mark) and 3 stakes were used to established each plot. The plots were located parallel to the transect. The 50 foot interval stakes marked the lower right corner for each plot. The 3 stakes marked the corners of the 100 ft² plot (Fong 1986) (Fig. 2).

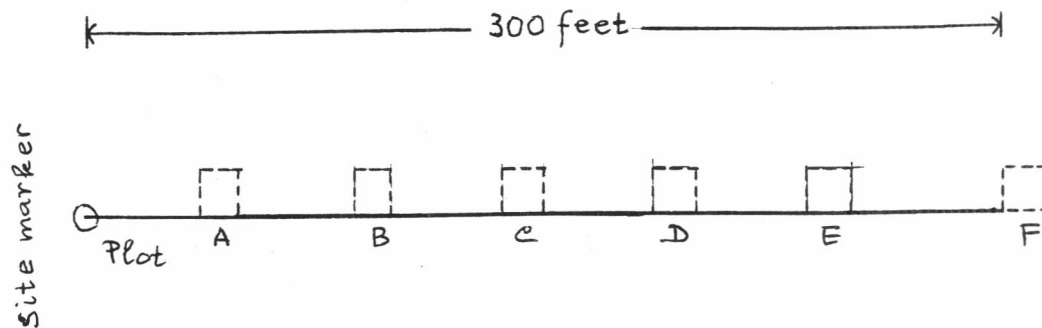


Figure 2. Transect layout.

The clams were collected by using a clam rake. Raking was performed parallel and perpendicular to the transect (Fig. 3).

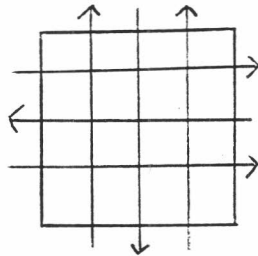


Figure 3. Raking Method

Clam width was measured to the nearest 0.1 mm with vernier calipers (maximum anterior-posterior dimension). The clams were then released to the plot (Fong 1986). Water depth was measured using marked stakes; temperature, salinity, and dissolved oxygen were measured using Hydrolab Surveyer II. Phosphate, Nitrogen, and Chlorophyll a were analyzed by the University of Maryland Horn Point Environmental Lab (Anonymous 1991).

The 12 study areas were grouped according to the degree of

human predation (clamming). The heavy human predation areas were areas 4 to 6 (Bayside North, Bayside South, and Blind #4), moderate human predation areas were areas 1 to 3 and 11 to 12 (Patton's Blind, Boat House North, Boat House South, Overwash, and Mystic Harbor), and light human predation areas were areas 7 to 10 (Tingles Island, Jims Gut-D loop, Jims Gut, and Peoples and Lynch).

Data Analysis

The data from adult M. mercenaria were analyzed using RS/1 (Anonymous 1983) and STAT-Pak (Anonymous 1990) to determine mean and standard deviation of clam density and size. The mean of clam population density and size were analyzed using two way Analysis of Variance (ANOVA) (Sokal and Rohlf 1969) and BMDP (Jennrich et.al. 1983) to see if there were significant differences from site to site over the years from human predation.

RESULTS

Data analysis indicated the human impact (clamming) on population density and size in the waters surrounding Assateague Island (Table 1 and 2) during the seven years of observation. The impact of high, medium, and low clamming activities (stated as USE in both tables) to the clam population were not significantly different at $p < 0.05$. The same results were obtained for the interaction between year and human predation

(stated as YU). However, both clam density and size were significantly different at $p < 0.00001$ over the years of the observations (stated as YEAR).

Table 1. ANOVA of clam (Mercenaria mercenaria) density found in waters surrounding Assateague Island during 1984 to 1990.

Source	Sum of squares	Degrees of freedom	Mean square	F	Tail prob.
Mean	341.2147	1	341.2147	34.23	0.0006
USE	41.3299	2	20.6649	2.07	0.1963
1 Error	69.7698	7	9.9671		
YEAR	28.0931	6	4.6822	8.13	0.0000***
YU	8.1235	12	0.6770	1.18	0.3312
2 Error	24.1902	42	0.5760		

*** significant difference at $p < 0.00001$

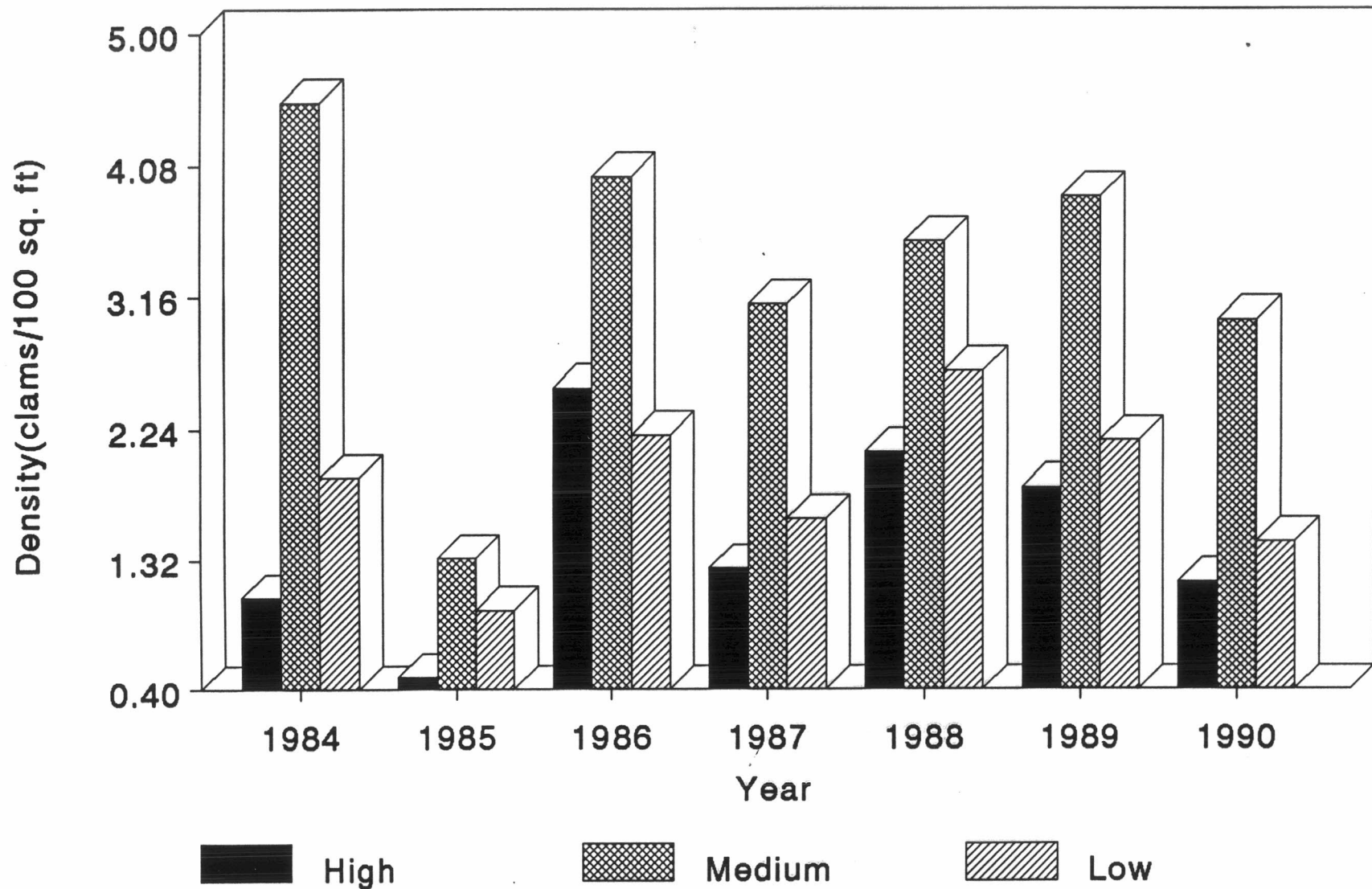
Table 2. ANOVA of clam (M. mercenaria) size found in waters surrounding Assateague Island during 1984 to 1990.

Source	Sum of squares	Degrees of freedom	Mean square	F	Tail prob.
Mean	287693.7500	1	287693.7500	780.09	0.0000
USE	1818.3817	2	909.1909	2.47	0.2006
1 Error	1475.1852	4	368.7963		
YEAR	820.2383	6	136.7064	9.27	0.0000***
YU	244.0146	12	20.3345	1.38	0.2419
2 Error	353.8087	24	14.7420		

*** significant difference at $p < 0.00001$

Fig. 4 shows clam density by human predation level and year of observation. Generally, the marginal (columns: total mean according to human predation; rows: total mean per year) clam density showed a specific pattern (Table 3). The highest density

Figure 4. Density of clam 1984-1990



was at the medium human predation area (3.84 clams/100 ft²) followed by intermediate density at low human predation area (1.86 clams/100 ft²) and smallest density at high human predation area (1.49 clams/100 ft²). There was no significant difference ($p < 0.05$, Table 3).

Table 3. Mean density (clams/100 ft²) of clam (*M. mercenaria*) found in waters surrounding Assateague Island during 1984 - 1990.

Year/Use	High	Medium	Low	Marginal
1984	1.05	4.53	1.92	2.44
1985	0.48	1.33	0.96	0.93
1986	2.53	4.00	2.20	2.84
1987	1.27	3.11	1.62	1.96
1988	2.08	3.56	2.66	2.75
1989	1.33	3.87	2.17	2.57
1990	1.16	3.00	1.46	1.83
Marginal	1.49	3.84	1.86	2.19

The marginal clam density was decreased in 1985 (0.93 clams/100 ft²), and from 1988 to 1990 (2.76 , 2.58 , 1.83 per 100 ft² respectively). The same pattern was also reflected by the changing of density at high, medium, and low human predation areas during the observation years (Fig. 4 and Table 3). The difference between years was significantly different ($p < 0.00001$).

The clam size distribution according to human predation and observation years is presented in Fig. 5 and Table 4. The largest marginal average size was found at the low human predation area (83.73 mm), while the intermediate marginal size

Table 4. Mean of clam (*M. mercenaria*) size (mm) found in waters surrounding Assateague Island during 1984 - 1990.

Year/Use	High	Medium	Low	Marginal
1984	76.62	86.51	87.81	84.05
1985	65.63	72.57	77.60	72.02
1986	58.10	80.42	82.94	74.77
1987	78.58	83.70	83.25	79.25
1988	65.56	80.02	80.35	75.98
1989	72.96	81.36	86.18	80.33
1990	75.55	84.93	87.97	83.12
Marginal	69.00	81.36	83.73	78.50

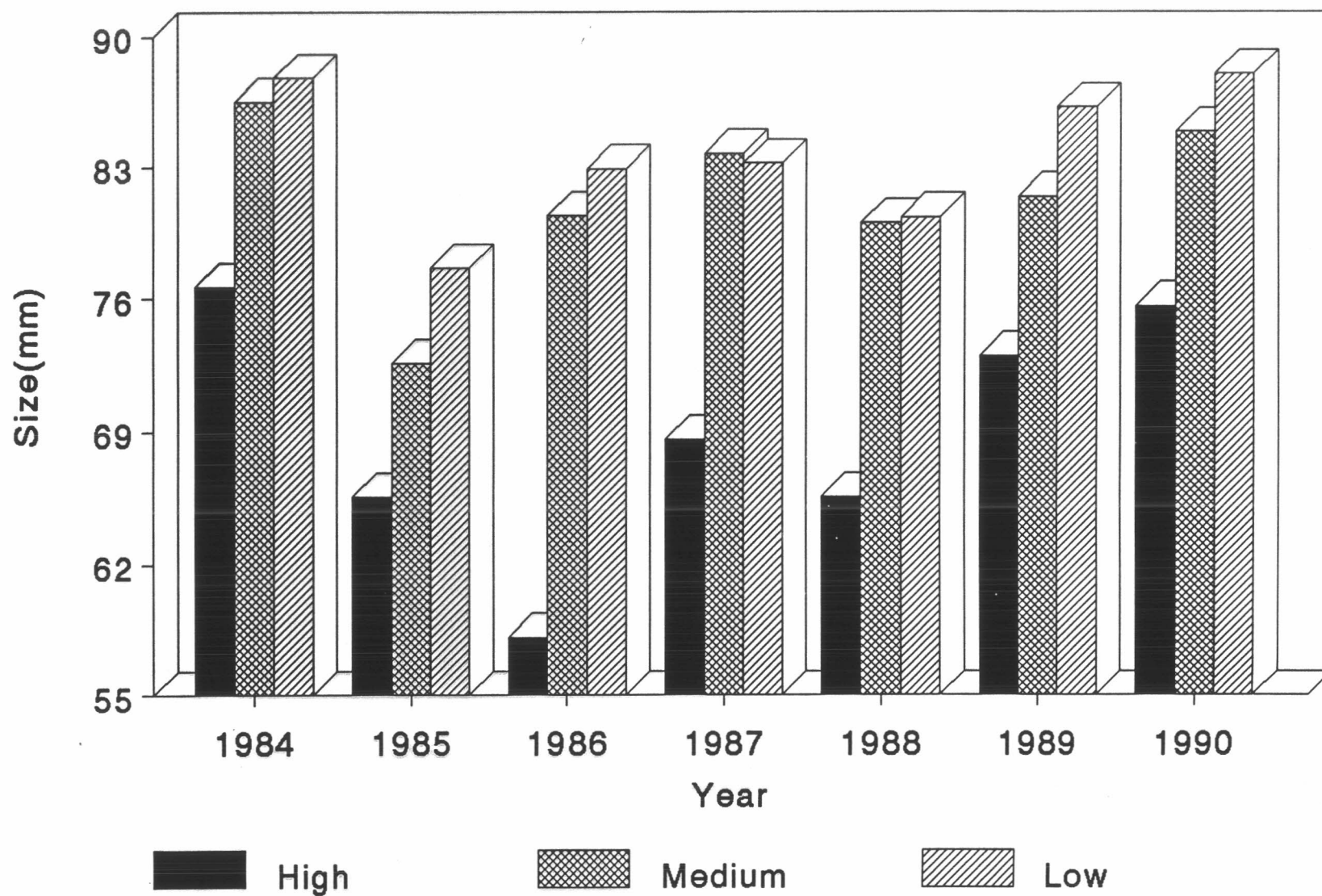
at the medium human predation area (81.36 mm), and the smallest marginal size at the high human predation area (69.00 mm).

However, these three size groups were not significantly different at $P < 0.05$ (Table 2).

There was no specific pattern of size distribution during observations. In 1985 and 1988 the clam size was low, while in 1986 to 1987 and 1989 to 1990 the size of the clam was higher. This pattern existed both in the marginal group and the human predation group (Fig. 5 and Table 4). In the marginal group, the clam sizes in 1985 and 1988 were 72.02 mm and 75.98 mm; while in 1986 to 1987 and 1989 to 1990 the clam sizes were 74.77 mm, 79.25 mm, 80.34 mm, and 83.12 mm respectively. These clam sizes were highly significantly different across the years of observation.

Both clam density and size were low in 1985, and were higher in 1986 but opposite pattern exist in the last two years of observation. From 1989 to 1990 the clam density was low, while

Figure 5. Mean size of clam 1984-1990



the clam size was high (Figs. 4 and 5; Tables 3 and 4).

DISCUSSION

The results of this study cannot be compared to the results of Wells (1957) because of different sampling techniques and equipment. Every commercial-sized clam (length ≥ 3.81 cm) was remove in Wells' (1957) study. The clams were collected from the intertidal zone to depths of 7.5 feet by a clam rake, with 27.5 mm between the teeth, and oyster tongs, with 51 mm between the teeth of each side bar. While the clams used in this study were commercial-sized (> 3.81 cm), and were collected from shallow water (≤ 3 feet). A clam rake with about 50 mm between the teeth was the only equipment used to obtain the samples.

Obviously the methods in this study allowed the escape of young clams between the teeth and thus may have affected the density and population size value. The young clam data is necessary to predict the population recruitment rate which, in turn, reflects the "pressures" affecting population growth rate. However, a combination of Wells (1957) and our study methods may obtain specimens from the entire population range and the real population dynamic can then be predicted. There will be still several clams lost, especially young ones.

Population growth and size structure were not done properly in this study since adequate data were not available.

Consequently, the clam size data obtained cannot tell the "goodness" of its environment, harvesting pressures, and/or predation pressures.

The highest density of clams was found at the medium human predation areas (sites 1,2,3 and 12) which were located in Sinepuxent Bay and around the Ocean City inlet. In summer, salinity decreases towards the inlets, and increases during winter and spring months (Sieling 1954). Summer 1989 salinities ranged from 27 to 29 ppt in Sinepuxent Bay, the highest salinity being measured near the inlets, and from 24 to 25 ppt in Chincoteague Bay because of high rainfall than usual (Counts and Beshore 1991). The high salinity in Sinepuxent Bay and inlet areas are suitable for hard clams (Carriker 1961). Mercenaria mercenaria prefer to live in these areas rather than in Chincoteague Bay, and consequently the clam density was high.

In summer months, water temperature is cooler at the inlets and warmer in the shallow bays. In winter, this pattern is reversed and the bays will occasionally be covered with ice (Sieling 1954). The temperature in the inlets ranges from 20°C to 28°C (Anonymous 1991) and is suitable for clams when the optimum temperatures for growth and spawning are reached (Ansell 1968 and Carriker 1961). In Chincoteague Bay, the water temperature changes drastically compared with Sinepuxent Bay and the inlet, especially in 1989 where the water temperature was 11°C in April and 29.5°C in July in Chincoteague Bay (Anonymous 1991). Water temperatures below 9°C and above 31°C stop the growth of the clam,

and, therefore, the growth and sexual maturity of this species in Chincoteague Bay were not good. This may have caused the low density of clams in the Chincoteague Bay study sites (7, 8, 9, and 10), although low harvesting pressures were applied. The large clams found in these sites did not reveal the "goodness" of that area. The clams can still survive but growth at a low rate.

The tidal amplitudes are not dramatic, being approximately 1.00 m at the inlets and 0.33 m in the bays. The currents of the Chincoteague and Sinepuxent Bays are mostly independent of non-tidal oceanic currents. Water flows away from the inlets at Ocean City and at Chincoteague as the tides rise (Pellenbarg and Biggs 1970). According to Sieling (1954), currents in the bays may have some influence on shellfish larval distribution, although of no great magnitude. The high of tide also affects the distribution of M. mercenaria larvae (Carriker 1961).

Therefore, the average density of clams was low at sites 4 to 10 which lie in the bay where the current was insignificant; the average density was high where current velocity was great, i.e. at sites 1, 2, 3, 11, and 12. The same results were found by Wells (1957).

The dissolved oxygen (DO) in Chincoteague Bay, Sinepuxent Bay and inlet waters were good, i.e. 7.89 ppm, 7.65 ppm, and 7.37 ppm respectively. These DO levels are not below the code of Maryland Regulations (COMAR 26.08.02), i.e. 5 ppm, and can support a healthy, diverse fish population including clams (Anonymous 1991).

Wells (1957) studied clam densities versus different types of bottom and found a clear correlation of clam densities with bottom types in the Chincoteague Bay area. He pointed out that shell bottoms were accompanied by high densities, sandy bottoms had medium densities and mud bottoms held low densities. The shell bottom were located in some areas in the western part of Chincoteague Bay. These areas are locally formed "Oyster rocks", or it might be more accurately referred to as oyster beds. The accumulated shells of oysters and associated organisms have formed a characteristic substrate which supports a wide variety of fauna. There are extensive areas of sand bottom in Chincoteague Bay. In Assateague Island, these sandy bottom areas are located between Green Run Bay and Tingles Island and continue northward to South Point (Wells 1957). Sites 7, 8, 9, and 10 are located in these areas. Sandy bottom areas are also located in Sinepuxent Bay and around Ocean City inlet, and most of these areas supported high or medium densities (Wells 1957). Sites 12, 11, and 1 of the clam survey are located in these areas, and showed high densities.

In the original data records it was noted that the bottoms of sites 4, 5, and 6 are sandy with slight silt. The densities of these three sites showed the lowest average of all sites. One possible explanation is that sites 4, 5, and 6 are located at southwestern Chincoteague Bay. Well's (1957) study found that much of western Chincoteague Bay--- from the shallow area of the head of Newport Bay to a small area in Sinepuxent Bay, most of

St. Martin River, several creeks, and the head of Assawoman Bay are characteristically of mud bottom. These mud bottom exhibit reach the lowest average clam densities of all bottom types. The eastern part of Sinepuxent Bay, east of Kelly Point, and a few areas around the islands in the southwestern portion of Chincoteague Bay also have a mud substrate and hold intermediate clam densities compared with other bottom types.

One reason why the clam density is low is predation by human and other animals. Wells (1957) stated that man was an important predator of the adult clam. Sieling in Counts and Bashore (1991) noted that the mud crab (Panopeus herbstii) and blue crab (Callinectes sapidus) are the most important predators of young clams, while the clam borer, conch, and cow-nosed ray are important adult clam predators. In Georgia waters, the main predators of clams were whelks, drills, rays, and crabs (C. sapidus and P. herbstii). The blue crab was the dominant predator (Walker et al 1980; Walker and Humphrey 1984). They caused low clam survival during the first year. Other studies have also found that juvenile blue crabs were frequently found in the cages and shell fragments characteristic of blue crab predation were abundant (MacKenzie 1977, Krantz and Chamberlain 1978). Crabs entered cages as postlarvae or small juveniles. After a period of time they could grow to sufficient size to prey upon the clams (Walker and Humphrey 1984). To be safe from crab predation, seed clams must reach 20 mm length. Landers also (1967) indicated that infestation of the hard clam, M. mercenaria

by the polychaete worm cause a severe shell damage, and weaken the victims and make them more susceptible to disease or predation.

The human predation did not affect the clam density and size, neither did the interaction between human predation and years of observation ($p < 0.05$). However, the clam density and size during the years of observation showed highly significant difference at $p < 0.00001$. Therefore, the environment had a more distinct influence on the clam population than human predation did. To get more accurate effects of human predation and environment stress, proper sampling techniques and monitoring programs should be conducted.

RECOMMENDATION

Several sampling techniques, clam monitoring programs, and clamming activity can be recommended for the future:

1. The available data were inadequately taken. Almost all clams below the rake size used in the research were not caught. This data did not reflect the real population size and dynamic, and therefore cannot indicate clam recruitment. Changing clam recruitment is very important as an indicator that there are environmental (such as physical and chemical factors, predators, disease, etc.) and/or human activity (such as over-harvesting) impact on that population. To measure the recruitment, adequate data are needed from proper sampling techniques. In this study, core sampling techniques applied randomly in the sampling sites can be suggested.
2. Data collected from "similar environmental conditions" (in this case: same water and substrate quality) is highly recommended to avoid or reduce bias and error. Then, different levels of human activity can be applied in this area and get valid results. In this study, data were taken from many different places with different environmental conditions (different substrate, salinity, temperature and current). It makes the data collected difficult to analyze.
3. More accurate, detailed study is needed. Data should be collected on water quality, substrate analysis of the sampling sites, and the number of people involved in clamming. This

may reveal the exact effect causing the decline in the clam population.

4. Samples can also be used for further studies, such as survivorship, growth rate, and age structure. The results show relationships with the degree of clamming pressure (Walker 1989).
5. The statistical analysis did not reveal a significant difference due to degree of clamming pressure and thus could not explain the decline of the clam population. The data show that the smallest density was found in the high human predation area. Besides that, the density significantly decreased during the last three years of observation. However, the clam size increased during the last two observation years which should indicate a "good year". This means that in a "good year", the clam density can also decline. However, if unlimited clamming activity was still allowed, the density of clams will eventually decrease due to this pressure. Therefore, limited clamming activity is recommended in this area.

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