HINGE-BILL ORIENTATION TECHNIQUES
FOR AUTOMATED OYSTER PROCESSING

by
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ABSTRACT

Title of Thesis: Hinge-Bill Orientation Techniques for Automated Oyster Processing

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The width and thickness dimensions of oysters and an inclined V-shaped trough were studied as means for achieving end orientation. Two series of experiments were conducted on 2,430 oysters sampled from three different locations in the Chesapeake Bay.

Both width and thickness were measured every 0.2 inch along the oyster length from the hinge to the bill end. A width to thickness ratio was found to be the best dimensional combination for distinguishing between the hinge and bill ends. Less than 0.50 percent of all oysters failed the ratio test conditions. Statistical analysis on five width to thickness ratio tests with failure rates between 0.25 and 0.49 percent showed there to be no differences in the percent oyster failure over all bars and across all tests. Results indicate that comparable oyster orienting efficiencies can be attained by width to thickness ratios with orienting points located 0.4 to 1.0 inches in from the oyster ends.

Negative results occurred when an inclined V-shaped trough was used for orienting oysters. There were significant differences in the proportion of hinge and bill leading oysters exiting the trough for each trough loading position over all bars and oyster

axes. The tendency for the oyster axes to behave differently explained some of the differences in the trough's orienting efficiency. However, there were no significant relationships between orienting efficiency and oyster axes.

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CHAPTER 1

INTRODUCTION

Oysters are the most important seafood harvested in Maryland. In 1976, Maryland watermen harvested 15.8 million pounds of oyster meats with a dockside value of 16.4 million dollars (Current Fishery Statistic No. 7183). Maryland, the leading oyster producing state, accounted for 29 percent of the total 1976 United States production of 54.4 million pounds (Current Fishery Statistics No. 7200).

However, the Maryland oyster industry has many serious problems. The method of meat removal from oysters has been essentially unchanged since Colonial days. This hand shucking method is slow and has a potential for injury to the person opening the shellfish because of the difficulty of opening the shell, the dexterity required, and the sharp implement used. Also, persons with the skill required to do this work by hand are rapidly disappearing either because of change to more desirable occupations or because of age. Paparella and Allen (1970) reported that the average age of oyster shuckers in Maryland is about 55.

Because the oyster industry is so dependent on hand labor, labor costs have increased retail product price. In 1950, oyster canners of the South Atlantic region came under minimum wage regulations requiring a minimum wage of 75 cents per hour (Blue Channel Corporation, 1957). The increase in cost caused many oyster processors to look towards mechanical oyster shuckers as an alternative solution. But today, with much higher wages, manual labor still accounts for 60 to 90 percent of the processing costs (Wheaton, 1972). Such has been the success of mechanizing the oyster industry.

Many attempts have been tried to eliminate or reduce the hand labor involved in oyster processing. Unfortunately, the lack of uniformity in size, shape and other physical characteristics of oysters has made purely mechanical systems unworkable. Presently, no suitable automated method has been devised.

Limited success of opening and shucking oysters has been achieved by the use of chemical compounds, electric shock, microwaves, lasers, heating or freezing, and mechanical cutting.

Several attempts have been made to use chemicals in shucking oysters (Prytherch and Koehring, 1936; Welcker and Welcker, 1961; Fehmerling, 1970). Such chemicals attempted to relax the adductor muscle, thus permitting the subsequent release of the meats from the shells. Variations in the time required for the chemical reaction to occur and the efficiency of the chemicals used caused such treatments to fail.

Carpenter (1963) experimented with an electric field. Although it was said to be successful with scallops, it has resulted in partial cooking of oyster meats. Such cooking renders them unsuitable for the raw market trade.

Sprachlin (1971) used microwaves as an oyster shucking assist. Microwaves heated the body tissues causing relaxation of the adductor muscle. The high risk of partially cooking the oyster meat is the main disadvantage of this method. To avoid cooking, microwaves can be used to gape oysters. However, hand shucking is still required.

Singh (1972) utilized a carbon dioxide laser to shuck oysters. Because of high equipment expense and low efficiency, long exposure period, and the need for precise orientation equipment capable of locating the muscle attachment from the shell exterior, this method has been restricted in its use and development.

Evans (1969) and Wheaton (1974a) have attempted to shuck oysters by means of infrared radiation. Intense heat is used to sever the adductor muscle from the shell by destroying the connective adhesive layer between the muscle and the shell. Like microwaves, the temperature produced by infrared radiation may cause the oyster meat to be partially cooked.

Smith (1971) and others employed cryogenic freezing of oysters to sever the bond of both the hinge and the adductor muscle. However, after thawing, bleeding was moderately severe due to cracks on the outer surfaces of processed oysters.

Harris et al (1974) demonstrated the use of mechanical cutting devices for automatically severing both the hinge and adductor muscle attachments. Although this machine has shown promise for shucking some oysters and producing a raw product, it is still in the developmental stage. Damage done to oyster meats by the cutting blades, limitations on conformation of oysters it will handle and low shucking rate has hampered acceptance by oyster processors.

Whatever method is employed to shuck oysters, a series of operations must be performed successfully before an oyster can be considered "shucked". As demonstrated in the last paragraphs, most research has been conducted on the muscle detachment and hinge severing operations. Related operations such as oyster washing, metering and orienting have received less attention. In order for a totally automated shucking machine producing raw oysters to function efficiently all of these operations must be researched.

All raw oyster shucking machines presently under development require the oyster to be correctly oriented before entering the machine (Evans, 1969; Harris et al, 1974; Wheaton, 1974a). Improper orientation results in damaged or destroyed oyster meats, a considerable loss.

Thus, one subsystem of a shucking machine will be an oyster orienting system. Manual orientation can be done, but it is usually expensive and not entirely reliable.

Unfortunately, little documentation exists on orienting oysters. However, orientation is critical in the design of oyster shucking machines. This research will define a methodology usuable in studying oyster orientation problems. In addition, several alternate means of orienting oysters will be explored.

CHAPTER 2

LITERATURE REVIEW

ORIENTATION CONSTRAINTS

Oyster orientation may be defined as: the act of locating and placing a specific physiological point of an oyster at a predetermined location.

According to Boothroyd and Redford (1968) orientation devices fall into two groups: those incorporated into a machine feeder; and those located between the machine feeder and workheads. Devices used within the feeder very often orient by rejection and may be termed passive orienting devices. Items usually enter passive orienting feeders from a hopper containing randomly oriented items. Depending upon the shape of the items, they will rest on the feeder surfaces in certain orientations or attitudes. Orientation in the feeder usually consists of rejecting all objects possessing any but the desired orientation, or only selecting and feeding those items oriented in the desired manner. Only correctly oriented items pass through the device; others fall back into the feed hopper. Rejected items are recycled through the orienting device in an attempt to properly orient them.

Some orienting devices are fitted between the feeder and the automatic workheads. These may be termed active orienting devices. Orientation by rejection is often not possible when using active devices, since items cannot easily be returned to the feeder.

The application of either an active or a passive orienting device depends upon many factors. First, the product must be examined to identify possible orientation characteristics. Product characteristics such as size, weight, shape and material determine what orienting can and cannot be accomplished. For example, if a noticeable weight difference exists between the two end points of a product, then the product can be easily oriented. Because the center of gravity is to one end of the product, it has a natural tendency to feed and be oriented in one direction. Whatever characteristic is chosen, the greater the distinguishing difference exhibited, the easier it is to orient the product. Also, the more uniform the characteristic is from item to item, the easier it is to orient.

While examining the product, it is important to identify its natural resting position. All orienting systems, when bulk feeders are used, must be based upon this characteristic (Tipping, 1969). It is simple to find this property for most products. The resting position of most items can be found by tossing a number of them into the air and allowing them to fall on a flat table. The majority will come to rest in a particular orientation; the natural resting position. All orienting studies should start with this, otherwise one will be working against nature.

The most important factor determining whether an active or a passive orienting device is employed is the number of possible orientations the product can exhibit. Ideally, the product should have the least number of important orientations. For example, using a passive orienting device with a product having eight possible orientations each of which are equally probable, the feed rate of oriented items would be only one eighth of the actual feed rate. Using active orienting devices could increase feed rate considerably. However, one must reconcile the opposing requirements of increased feed rate and percent failure of an active orienting device. Orienting outside the actual feeding device, one usually sacrifices the ability to recycle the product if it cannot be oriented on the first pass.

The feeder can of course be used to do part of the orientation, principally getting the product into a single line or into some other known attitude. Thus, the feeder can reduce the number of possible orientations for some products; which reduces feeding and orienting problems and may increase the number of correctly oriented items. Thus, the efficiency of the feeding device may be improved.

Consistency in the dimensions used to feed and orient a product is essential to proper operation. In manual operations certain dimensions may vary but operators can make adjustments for the variation. Manual operations eliminate the feeders, chutes and slides where jams caused by product variability can occur. Processing machines, on the other hand, are accurate and have dimensional limits on their workheads and chutes. They are also inflexible and cannot learn to cope with products outside specified limits. Many passive orienting devices have dimensional limits on their machine components. Products exhibiting wide variations in dimensions cannot be handled by a single passive orienting device (Tipping, 1969). The product must be sorted or graded before entering a series of feed hoppers and orienting devices.

Bliek (1970) noted that the more dimensional variability exhibited by a product, the more difficult it is in forming distinct orienting points. The result is a "complicated and frequently not interference-free operating orienting contraption". The reliability of such devices is questionable since the freedom from hold-ups does not exist.

Research on oyster orientation equipment is complicated by the fact that it is considered a problem of low priority (Evans, 1969). Many shucking workheads have already been designed with little or no regard to the needs of oyster orientation equipment. Thus, it may be very difficult to design orientation devices around existing shucking machines. Under such circumstances, one must first study the individual operations in an oyster shucking machine before designing the actual orienting device. Information on feed rate, product handling, and operational design are just some of the important variables which must be investigated to properly establish requirements of an orienting device. This data will determine whether a passive or active orienting device is required, and how and where it must be designed into the system.

SYSTEMS ANALYSIS

Holtman et al (1974) defined systems analysis as the technique for determining performance characteristics for a system's interacting components when operating in a specific environment. An automated oyster shucking machine may be considered as a system made up of a number of inter-related subsystems. Each subsystem or operation performs a specific task and must be understood at the outset in order to optimize adjacent subsystems. Thus, the orienting operation must be tailored to fit requirements of its adjacent subsystems. By analyzing the adjacent operations, it is possible to characterize some of the initial problems and design criteria.

The mechanical oyster shucking system developed by Wheaton (1972) involves three principal locations on the shell. Two of these are the points where the adductor muscle attaches to the shell. The third point of interest is the oyster hinge. When all three attachments have been severed, an oyster is considered "shucked". Severing these attachments involves a 3-step combination of infrared heating and a mechanical severing device. Infrared heat is applied to one side of the oyster causing the release of the muscle attachment on one shell valve. A mechanical system then severs the oyster hinge and a similar infrared heating process is used to release the second shell-muscle attachment and free the meat from the shell.

Figure 1 is a simplified flow process chart of Wheaton's (1972) oyster shucking machine. There are five subsystems on the flow chart which are of interest in the design of an orienting mechanism. These subsystems are the washer, clump separator, singulator, first muscle detachment and the shell trimmer (Figure 1). Processing begins by conveying oysters from a storage bin to the washer. Here, the shell stock is washed to remove as much dirt, mud and fouling as possible. Clumps of oysters are then separated into individual oysters by a clump separator. The single oysters pass into a metering device which meters them out one at a time and feeds them into the orienting apparatus. The oysters enter the orienter with either the bill or hinge end leading. The orienter rotates the oyster so that all the hinges are pointing in one direction and all the bill ends are lined up along a line parallel to the direction of travel of the first heating conveyor. Thus, the long axis of the oyster will be perpendicular to the direction of travel of the first heating conveyor. After the first heating operation, the oysters are conveyed to the shell trimmer. Here, the hinge end of all oysters is trimmed, exposing the hinge for later severing.

An apparatus capable of orienting oysters for the above mentioned shucking process must perform two distinct operations: (1) it must first recognize which end of the oyster is the hinge end, and (2) it must then rotate those oysters with incorrect orientations to a correct one.

The design of the Wheaton machine eases orientation problems considerably. Since all oysters are washed prior to entering the orienter, attached debris that may hinder orienter performance is minimized. Orientation is further simplified by the includion of a clump separator. Orientation of oyster clumps is theoretically impossible (Yoos and West, 1965).

An orientation device should utilize the natural resting position of the product in order to maintain

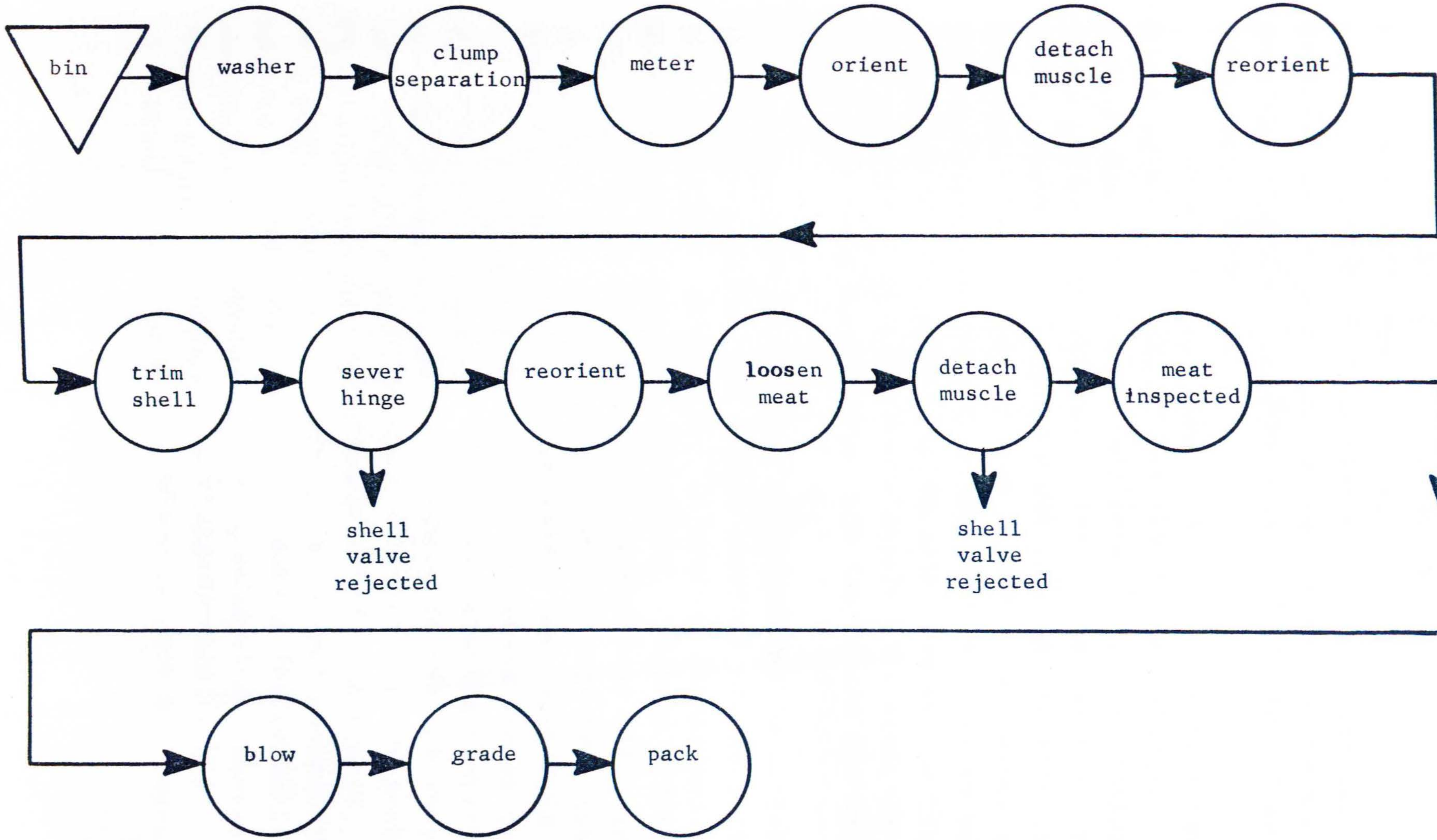

FIGURE 1. PROPOSED FLOW PROCESS DIAGRAM FOR THE WHEATON OYSTER SHUCKER

efficiency, alleviate complexity of design and improve performance. Oysters discharged from the metering device in the Wheaton shucker are positioned with either the left or right valve lying flat on the conveyor belt, a natural resting position. Using the natural resting position of oysters greatly simplifies design of an orientation subsystem.

It would appear that a passive orienting device would be a logical choice for the Wheaton shucker. The natural resting position requirement has been satisfied and there are only two important oyster orientations. Since valve orientation is unimportant only end orientation is required, Thus, it would seem feasible to include a passive orientation device within the feed system where a mechanical filter would discriminate between the hinge and bill ends of oysters. Oysters incorrectly oriented on the first pass would be recycled into the feeder for another trial.

Although orientation equipment may be included in the Wheaton shucker, the oyster physical characteristics pose a problem. Consistency in product dimensions is essential for automatic orientation. Wheaton (1974b) reported that oysters harvested in Maryland will vary in length from 3.0 to 8.0 inches, and in shape from nearly round to long and narrow. In width, they vary from about 1.5 to 6.0 inches, while naximum thickness varies from about 1.0 to 2.5 inches. Since the metering operation does not segregate oysters according to size or shape, the orienting device must handle a very non-uniform product. Multi-staged sorters and feeders could be designed, but at a prohibitive cost. Oyster dimensional inconsistency and the economic constraint of a single feeder limit the usefulness of a passive orienting subsystem. Design of a single passive orienter to efficiently handle the dimensional variability of oysters is probably impossible.

The rapid shucker feed rate (60 oysters per minute) required to meet processors expectations (Wheaton, 1972) favors an active rather than passive orientation systems. Maintaining such a high capacity usually requires a continuous flow process. When oyster dimensional variability and the high continuous processing rate are combined, a simple passive orienting device appears even more unfeasible.

Maintaining the feed rate, preventing interferences at the metering subsystem and eliminating costly multi-staged feeders requires the orienter to be placed outside of the feeder. Failure to do this will downgrade the total shucking system to a costly, non-interference free operation. Based upon these considerations an active orientation device is proposed for the Wheaton oyster shucker. The orienting subsystem will be located after the metering operation and will take advantage of existing adjacent subsystems design criteria. Such a design will optimize the shucking operation.

The proposed active orienter will operate in the following manner. After oysters have been discharged from the metering device such that the long axis of the oyster is placed parallel to the line of travel with the hinge or bill end positioned in a forward direction, they will enter the orienter. A discrimination operation at the orienter will determine whether the hinge or bill end of each oyster is leading. Similar orientation of all oysters will next be accomplished by rotating 180 degrees only those oysters with the hinge in front (or vice versa).

An ideal orienting subsystem for the Wheaton shucker would, in my opinion, possess the following characteristics:

1. be an active type orienting device.
2. be a continuous flow design.
3. be capable of orienting at least 60 oysters oysters per minute.

4. be capable of processing all single oysters regardless of shape, size, or other physical properties.

5. operate with high reliability.

6. would not interfere or impede operation of adjacent machine subsystems.

ECONOMIC ANALYSIS

The fundamental facts necessary for a study of oyster orientation were laid down in the last section. Before proceeding further, it is necessary to define preliminary economic guidelines for any orientation device. It is important to remember that the objective is not to mechanize the process, but to find the most economic processing method. Economic machine requirements include reduction of processing costs and increasing or maintaining return on capital invested.

Indexing devices such as orienting mechanisms which handle complex products (i.e. awkward in shape, size and other characteristics) are treated as pure special purpose devices (Tipping, 1969). These devices are the most difficult to design, develop and manufacture. It is almost impossible to estimate with any degree of accuracy the cost of a special purpose machine unless one prepares a comprehensive feasibility study, eliminating all trouble spots and then doing rough designs to a degree suitable for an estimation. Since this study is in the conceptual stage, accurate cost estimates are unnecessary. The designer during concept formulation is concerned primarily with problem definition; the establishment of operational, economic and product requirements; and the mapping of alternative solutions in the broadest terms. Thus, in this analysis, two alternative solutions to oyster orientation are investigated; manual orientation and mechanical orientation. Using assumed conditions, both solutions will be analyzed and compared with only labor and oyster rejection costs as input. Expected performance of both solutions will be compared to provide a means for estimating the best economic system.

Manual Orientation

Manual end orientation of oysters is a very simple procedure. It involves a two step operation and the senses of sight and touch. An operator can immediately recognize and distinguish between the two ends of an oyster. Then, using his hands, the operator can rotate the oyster to any desired position.

No actual experiments have been published to determine achievable rates of manual end orientation. However, Harris et al (1974) reported that a single operator was able to feed 1200 oysters per hour to his shucking machine. Harris's oyster shucking machine required both end and valve orientation. Theoretically then, a single operator orienting oysters only with regards to their ends could handle more than 1200 oysters per hour. Exactly how many more oysters per hour a single operator could handle would have to be determined by actual tests. However, assuming the 3600 oyster per hour feeding rate required by Wheaton's machine, a single operator to orient all these oysters must handle one oyster every second. It would be impossible for the operator to maintain such a continuous rate over a period of time without interruption. Considering other factors such as job acceptance and operator stress, it would be safe to assume that two operators could efficiently handle 3600 oysters per hour. Thus, with two operators using both hands, it would be relatively easy for each operator to orient one oyster every two seconds.

In determining the feasibility and cost of a manual orientation operation the following assumptions were made:

1. feed rate of 3600 oysters per hour.
2. two orientation operators.
3. the operators will orient all oysters correctly.
4. each operator will be paid $3.00 per hour.
5. based upon present hand shucking, the operators would work 6 hours per day, 4 days per week, 30 weeks per year, for a total of 720 hours per year.

Calculations in Appendix A show that two orienting operators would cost a processor approximately $4,800 per year.

Mechanical Orientation

Control of mechanical efficiency is very important in orienting devices. Since very few special purpose devices operate at 100 percent efficiency, the cost of product loss can be detrimental to total mechanization. Total mechanization of many indexing operations require unrealistic and costly efficiencies just to be comparable to manual operations.

The following assumptions were made in determining the cost effectiveness of mechanical orientation:

1. average gallon of oysters contains 306 oysters.
2. capacity rate of 3600 oysters per hour or 11.8 gallons per hour.
3. oysters have a product value of $10.00 per gallon (lower limit) and $12.00 per gallon (upper limit).
4. the device operates 720 hours per year.

5. all oysters not oriented correctly are considered a total loss.

Based upon these assumptions and the calculations in Appendix A, an orienting device operating at 95 percent efficiency will cost an oyster processor $4,234.00 to $5,080.00 per year in product losses.

Comparison of Alternative Solutions

A mechanical orienter must operate with an efficiency of 95 percent just to be comparable to manual orientation. If machine costs and operating costs are considered, then, the efficiency must be increased by 2 or 3 percentage points. Overall a mechanical orientation device should have an efficiency near 97 percent, just to be comparable to the cost of a manual operation.

Although the economic calculations presented are very basic, several important conclusions regarding oyster orientation can be drawn. Assuming two operators can manually orient 3600 oysters per hour the following can be concluded:

1. Good control of orienting efficiency (97 percent or better) is required for total automation.

2. Unless properly designed, an automated orienting device will be a marginal apparatus when compared with manual operators.

3. Proper design of a mechanical orienter should include small capital investment, low operating costs and long machine life.

STATE-OF-THE-ART

Automated Shellfish Shucking

An initial state-of-art survey of shellfish shucking revealed the development of numerous machines.

Most of these are patented (Appendix B). After studying the Patent Office Classification Definition Manual, it was decided that the one class and five subclasses listed in Table 1 were germane. A complete search was conducted of all patents filed in these categories. Only 39 of the approximately 200 patents on shellfish shucking reviewed could be designated as shucking machines. The remaining patents were considered shucking "assists", since extensive manual labor was still required in many of the shucking operations.

As an aid to future investigators, it should be noted that almost all shucking patents pertaining to bivalves since 1969 have been assigned to either subclass 48 or subclass 74. It should also be noted that most of the other patents reviewed were placed in these two subclasses as cross-reference documents. Thus, any patent search on shellfish shucking should begin with a review of both subclass 48 and 74.

Table 2 presents a chronological listing of the patents considered as automated shellfish shucking machines. Details on the design and operation of these devices can be found in the annotated bibliography of Appendix B.

Twenty of the 39 patents listed in Table 2 relate to the processing of the American oyster (*Crassostrea virginica*). Several different clam and scallop species are covered in 18 patents, One patent relates to mussel processing.

There are 27 different shellfish shucking machines covered in the 39 patents. Sixteen of the machines require some type of orientation. Only two machines provide any mechanical orientation devices with the others depending upon manual orientation.

There are nine separate machines covered in 11 patents for shucking raw oysters. Each machine has

TABLE 1. PATENT REVIEW SUMMARY

Class, Subclass	Description	No. of Shellfish Shucking Patents
17,45	Butchering, Processes	6
17,48	Butchering, Processes, Shelling	15
17,53	Butchering, Marine Animals	2
17,74	Butchering, Marine Animals, Bivalve Opening Means	15
17,76	Butchering, Marine Animals, Bivalve Opening Means, Support and Wedge	1

TABLE 2. LIST OF PATENTED SHELLFISH SHUCKING MACHINES

Patent No.	Year	Author	Principal[1] Bivalve Processed	Bivalve[2] Condition	Orientation Required	Orientation Device
848,608	1907	Torsch and Parker	O	R	X	
848,784	1907	Torsch and Parker	O	R	X	
1,439,181	1922	Mandvill	O	R	X	
1,445,672	1923	Egli	O	R	X	
2,008,820	1935	Doxsee and Cook	C	S		
2,047,688	1936	Jenkins	C	S		
2,102,945	1937	Doxsee and Cook	C	S		
2,337,188	1943	Geldermans and Hond	M	R		
2,608,716	1952	Harris	O	S		
2,652,588	1953	Harris	O	S		
2,818,598	1958	Skrmetta	O	S		
2,823,414	1958	Seal and Harris	O	S		
2,824,005	1958	Strasburger	O	S		
2,832,989	1958	Harris	O	S		

TABLE 2. (continued)

Patent No.	Year	Author	Principal[1] Bivalve Processed	Bivalve[2] Condition	Orientation Required	Orientation Device
2,942,292	1960	Rey	O	R	X	
3,007,801	1961	Lapeyre et al	O	F		
3,037,237	1962	Lapeyre et al	O	F		
3,203,034	1965	Matzer and Seidel	S	R	X	
3,230,578	1966	Marvin and Henderson	C	R	X	X
3,230,580	1966	Marvin and Henderson	C	R	X	X
3,239,877	1966	Lapeyre and Couret	O	F	X	
3,320,631	1967	Brown	S	R	X	
3,417,423	1968	Meyer	S	R		
3,465,382	1969	Meyer	S	R		
3,473,191	1969	Evans	O	R	X	
3,528,124	1970	Wenstrom and Gorton	S	R		
3,562,855	1971	Willis	S	R		
3,564,648	1971	Snow	C	R		

TABLE 2. (continued)

Patent No.	Year	Author	Principal Bivalve Processed[1]	Bivalve Condition[2]	Orientation Required	Orientation Device
3,566,438	1971	Snow	C	R		
3,594,859	1971	Hanks and Grieb	C	R	X	X
3,594,860	1971	Nelson et al	S	R	X	
3,605,180	1971	Harris and Zober	O	R	X	
3,614,806	1971	Henry	O	R	X	
3,619,855	1971	Willis	S	R		
3,683,458	1972	Wenstrom and Gorton	S	R		
3,722,035	1973	Hanks	C	R	X	
3,724,031	1973	Harris	O	R	X	
3,755,855	1973	Ouw and Johnson	O	R	X	
3,828,398	1974	Harris et al	O	R	X	

[1] Clams (C), mussels (M), oysters (O), scallops (S)

[2] Frozen (F), raw (R), steamed (S)

its own distinct orienting requirements. Table 3 outlines the type of orientation for the oyster shucking machines. It is apparent from Table 3 that all machines require at least end orientation and, in most cases, valve orientation.

Except for two devices oyster orientation is critical to the proper operation of the shucking machines. Henry (1971) and Ouw and Johnson (1973) require oyster orientation only to maintain product quality. There is no mechanical orientation requirement for these two machines. The two machines can sever the oyster meats from either or both valves. However, since oysters are being processed for the half-shell trade, the oysters are oriented such that only the top valve is removed; leaving the meat and liquor in the cupped valve. Since both machines will process oysters regardless of shellstock orientation, oyster orientation is not a mechanical requirement. Product quality alone is the determining factor for oyster orientation.

Even though it has been demonstrated that oyster orientation is critical to proper operation of shucking machines, no orientation devices are present in any patented machine. Evans (1969) gives some reasoning for the exclusion of orientation subsystems: "Where the plant in which the machine is used includes a grading step so that substantially uniform sized bivalves can be fed to the machines, automatic delivery equipment can be employed. Otherwise, manual insertion of the bivalves is deemed to be satisfactory." Consistency in the dimensions used to feed and orient a product is a basic premise on which many indexing devices are designed. If this premise cannot be adhered to, then grading is a logical solution to product variability. However, orientation devices can be independent of the feeding and delivery equipment.

TABLE 3. ORIENTATION REQUIRED IN OYSTER SHUCKING MACHINES PRODUCING RAW OYSTERS

Patent No.	Year	Author	Degree of Orientation	
			End	Valve
848,608	1907	Torsch and Harper	X	
848,784	1907	Torsch and Harper	X	
1,439,181	1922	Mandvill	X	X
1,445,672	1923	Egli	X	
2,942,292	1960	Rey	X	X
3,473,191	1969	Evans	X	X
3,605,180	1971	Harris and Zober	X	X
3,614,806	1971	Henry	X	X
3,724,031	1973	Harris	X	X
3,755,855	1973	Ouw and Johnson	X	X
3,828,398	1974	Harris et al	X	X

Evans (1969) looks upon the feeding and grading devices as a means for achieving orientation. However, this should not be taken for granted. Before designing the oyster placing workheads, it must be established whether or not the feeder or grader will deliver correctly oriented oysters. If it cannot achieve this, orientation must be undertaken elsewhere. One must eliminate each problem before moving on, otherwise considerable time and money is wasted.

Orientation devices have been built for clams which do not exhibit the variability in shape and size that oysters do. Thompson (1942) pointed out that for many free-moving bivalves such as clams, an increase in size is not accompanied by any change in shape of the shell. With such a symmetrical and constant shape, orientation of clams is feasible.

Two very similar, yet different devices have been constructed for orienting clams. Marvin and Henderson (1966a, 1966b) built a clam shucker which utilized a passive type orienting mechanism. An active type orienting device was used in the machine proposed by Hanks and Grieb (1971). Although these two machines use different types of orientation devices, both attain the same orientation.

Marvin and Henderson (1966a, 1966b) devised an orienting apparatus by which clams fed from a hopper attained an edgewise position and were then oriented with their hinge ends uppermost. It was found that when a bivalve mollusk such as a clam stands on its mantle edge, its center of gravity is below its thickest portion and spaced substantially away from its hinge. This failure of the center of gravity to coincide with the geometric center provided an excellent means to orient clams. The orienting device consisted of two separate work pieces. Clams from a storage bin are fed into a vibratory hopper containing a pair of converging plates. The plates form an elongated V-shaped trough which is vibrated along its horizontal axis. The trough acts as a mechanical filter, accepting only those clams which enter edgewise. Due to the vibratory action, the on-edge clam is gradually fed into the next portion of the orienting device. The individual clams drop in an edgewise position onto a pair of spaced inclined rollers, rotating in opposite directions. The rotation of these rollers tends to lift the on-edge clam from between them and substantially reduces static friction forces between the clams and the rollers. The rollers are spaced a sufficient distance apart that when a clam is rotated to dispose its mantle edge bottommost, thereby positioning its hinge uppermost, its center of gravity is below its point of contact with the rollers. With this spacing between the rotating inclined rollers, an on-edge clam is in an unstable position except when its mantle edge is disposed bottommost. Thus, clams traveling along the rollers may be in any vertical position. However, because of the relative location of the center of gravity and the roller, the clams rotate upon an imaginary lateral axis until their centers of gravity are in the lowermost position.

The orientation device presented by Marvin and Henderson (1966a, 1966b) is considered a passive type according to the criteria accepted earlier (Boothroyd and Redford, 1968). Passive orienting devices are often incorporated within the feeding mechanism and work on the principle of orienting by rejection. The clams are fed in a bulk random fashion and the V-shaped trough mechanically accepts only those clams in an edgewise position. Clams not able to attain this desired position fall back into the hopper and make a further attempt to pass through the filter.

Hanks and Grieb (1971) proposed an active orienting device which also operated on the failure of the center of gravity to coincide with the geometric center. The orienting mechanism again consisted of two separate work pieces; a V-shaped trough and a pair of rollers rotating in opposite directions. Unlike the previous device, the clams are conveyed singularly by a paneled conveyor from a feed tank to the inclined V-shaped trough. In this case, orientation by rejection is impossible. If one of the pockets in the conveyor happens to pick up two or more clams and drops them onto the V-shaped trough at once, only one clam will pass. The other clams fall out of the system and cannot be recycled.

The device operates in the following manner. Clams are individually conveyed to a pair of spaced and downwardly convergent panels forming a V-shaped trough. Because of their shape the clams assume an edgewise position and fall by gravity onto a pair of inclined rollers rotating in opposite directions. The clam syphon protrudes from the shell and because of this, the movement of clams along the rollers causes them to automatically assume a position with the syphon extending downwardly through the space between the rollers.

For several reasons oyster orientation by either of these techniques does not appear feasible. Unlike the clam, the valves of an oyster are asymmetrical and mis-shapen with deep ridges and valleys. The contour of oyster shells may be either circular or elongated and irregular. Such great variations in gross shell morphology does not lend the oyster to easy orientation by a mechanical filter such as the V-shaped trough. Jamming of the trough is likely due to these irregularities.

Maintaining an on-edge orientation by two counter-rotating rollers is impractical for oysters. Although the maximum thickness of oysters is not highly variable, 1.0-1.5 inches, the location of this measurement on the oyster is variable. Appropriate variations in roller spacing would be required to sustain on-edge orientation. The irregular valve shape makes it impossible to significantly reduce the static friction forces between an oyster and the rollers. Thus, an oyster would not be able to rotate about its lateral axis to attain the desired orientation, hinge end uppermost.

Even the basic theory for the operation of these two techniques is questionable for oysters. Although the center of gravity and the geometric center do not coincide for clams, the same may not hold true for oysters. In fact the relative locations of the center of gravity and the geometric center of oysters is very erratic. It is possible for the center of gravity to be closer to the hinge area for some oysters, while for others closer to the bill area. Oysters are sessile organisms and their growth is greatly modified by contact with the substratum upon which they rest. Wide variations in shell morphology, especially shape and weight, is to be expected, since environmental conditions vary in both time and space. Gunter (1938), Newcombe (1950) and Hoffstetter (1965) noted that oysters growing on soft mud are often long, narrow and thin. When the bottom is firm and clean, the oysters develop broad, well cupped shells. Medcof (1961) found that oyster shells are thickest, hardest, heaviest and most cupped when oysters grow in cool-water, seaward areas. Where water is too fresh, as in upper parts of creeks and estuaries, shells are often light, chalky and weak. Thus, it appears that as an oyster grows the center of gravity and the geometric center shift back and forth extensively. So the differences between the center of gravity and geometric center is not a constant and reliable feature for use in oyster orientation.

The techniques employed in orienting clams do not appear to be applicable to oysters. The V-shaped trough used with clams is not advantageous to oyster orientation. Previously, it was shown that feeding oysters edgewise into the trough was impractical. However, by modifying the design and operation of the trough, it may be possible to orient oysters.

It is proposed that an inclined, V-shaped trough be situated after the oyster singulation equipment. The inside angle of the trough is greater than 90 degrees. Instead of being fed edgewise into the trough, the oysters enter with their long axis at a right angle to the trough length. Theoretically, the trough shape should cause each oyster to rotate 90 degrees. Thus, each oyster has an equal probability of exiting hinge or bill end forward. However, due to oyster variability in size, shape and weight a single trough probably cannot orient all oysters with high efficiency. Since the trough dimensions must be set, oysters of different sizes and shapes could behave differently. Lacking data on trough orientation of oysters the proposed application has unknown capabilities and could theoretically work, but because of oyster variability its chances of attaining high orienting efficiencies appears limited. Despite its low success probability the inclined V-shaped trough will be investigated as a secondary solution to oyster orientation, because of its simplicity, ease of fabrication and low cost.

Orientation of Various Products

After studying available orientation devices for agricultural products, it became obvious that there were a limited number of techniques and fundamental principles of operation. Essentially, little formal research has been undertaken to investigate and advance design of orientation machinery.

There is a dearth of information on product orientation in the literature. The initial literature search turned up very common orientation methods which were of no use with oysters. Henderson and Newman (1972) presented a physical and analytical explanation of prolate object orientation on oscillating conveyors. Hammond and Shephard (1973) investigated mechanical orientation of bright leaf tobacco. Leaves were studied for geometric properties, physical dimensions, buoyancy characteristics in water, and aerodynamics of a leaf in air. Failure of the geometric center of the leaf and the center of gravity to coincide was used for orientation. Hook et al (1973) and Dooley et al (1974) considered orienting individual strawberries by a light reflectance technique so the cap could be properly removed. Burkhardt and Mrozek (1974) employed two parallel conveyor belts and a series of rotating wheels to orient prunes along their longest axis.

With the hope of finding a more comprehensive source of information on orientation a second patent search was initiated. Initially this did not prove fruitful. However, the discovery of a report by Shawver and Henderson (1972) documenting present technology in singulation and related areas such as orientation did prove helpful. Shawver and Henderson (1972) examined over 2,000 patents from 1870 through 1969, summarizing each patent with a brief description. A complete review of this compendium was made and from the 2,060 patents reviewed, 239 were directly related to orientation. A broad range of products from screws to prunes were covered, with approximately 60 percent of the patents pertaining to fruit orientation. Such techniques as vibration, stem indent sensors, and molded cups were the primary means for orienting fruit. None of the techniques, however, were applicable to oysters.

Only one device showed any promise for use with oysters. Simmons (1966) constructed an electronic device for determining end orientation of products such as corn, carrots, banana peppers and other products having a longitudinal taper on one end and a blunt shape on the other. The electronic apparatus consisted of a predetermined array of light-sensitive cells and light sources located at the end of a V-shaped conveyor system. The operation of this device may be summarized as follows: When a product, such as an ear of corn, is positioned on the conveyor with the tapered end forward, only one of three light-sensitive cells will be covered by the end of the ear of corn. Since this is the desired orientation, the electronic control circuitry does not respond to this condition and the ear of corn is allowed to proceed. However, if the ear of corn is proceeding from the conveyor with the blunt end first, all three light sensitive cells are covered. The corn in the undesired orientation is shifted to a ramp by an air jet supplied from a nozzle. Nozzle discharge is controlled by a solenoid valve.

Simmons (1966) approach to end orientation can be applied to oysters. Oysters usually exhibit differences in both shape and shell dimensions between the hinge and bill ends. Generally, the hinge end of an oyster has a greater thickness but a smaller width than the bill end (Figure 2). Because of these dimensional differences, an oyster appears to have a narrow pointed end (hinge) and a broad blunt end (bill). It could be feasible to photoelectrically sense this dimensional variation and apply it to orienting oysters. It is possible to improve the latitude of Simmons' (1966) technique by sensing in two dimensions rather than one. Not only can the oyster width dimensions be utilized but also the thickness or a combination of both. Employing two dimensions, improves the probability of finding a suitable orientation method.

The use of photoelectric devices for orientation offers several advantages from the design viewpoint. It is possible to achieve the required orientation rate of 3,600 oysters per hour because photoelectric detection is inherently rapid. Machine wear is minimal since the photoelectric sensor has no moving parts to wear out. Sensing without touching the oyster allows a photoelectric device to be protectively packaged, eliminating the affect on its operation of the corrosive shucking plant environment. The compact size of the sensors and associated electronic circuitry eliminates many installation problems and minimizes changes in the current shucking machine.

Based upon these considerations, an experiment will be conducted investigating the use of oyster dimensions in orienting oysters.

SUMMARY

Orientation devices can be grouped into two types; passive and active. A passive orienter operates on the principle of rejection and is usually situated within the feeder. An active orienter works on a principal not practical for inclusion into the feeder and is thus placed outside of the feeder.

Many factors determine whether a passive or an active orienting device is employed. Orienter selection depends greatly upon the product characteristics, possible product orientations and feed rate. Passive orienters operate best when: (1) the physical product characteristics are quite uniform, (2) the number of important orientations is small, and (3) the feed rate is not rapid. When one or more of these conditions cannot be met, then orientation must be accomplished outside of the feeder. This requires an active orienter.

A systems analysis of the Wheaton oyster shucking machine was conducted. Subsystems important to oyster orientation were analyzed for determining orientation criteria. Based upon the analysis, an active orienter was selected for inclusion into the Wheaton shucker. The two most important factors in this decision were: (1) the rapid feed rate of 3600 oysters per hour and (2) the non-uniformity in the physical characteristics of oysters.

The proposed active oyster orienter must perform two distinct operations: (1) it must first recognize which end of the oyster is the hinge or bill end, and (2) it must then rotate those oysters with incorrect orientations to a correct one.

In order to determine the economic criteria for an active oyster orienter a general cost analysis was done. The cost effectiveness of manual and mechanical orientation was made with only labor and oyster rejection costs as input. Assuming two manual operators can orient 3600 oysters per hour the following conclusions are:

1. A mechanical orienter must have an efficiency of 95 percent just to be comparable to the cost of two manual operators.

2. When machine and operating costs are considered, an orienting efficiency of at least 97 percent is required.

Overall, the economic analysis indicates that an active orientation subsystem is at best a marginal operation when compared to a manual one.

Two proposed means for orienting oysters were chosen from information contained in shellfish shucking and orientation patents. The most promising technique for oyster orientation is a photoelectric device adapted from work by Simmons (1966). The device would sense possible dimensional differences between the hinge and bill ends of oysters. A secondary method for oyster orientation consists of an inclined V-shaped trough. The low cost and simplicity of the trough are the important factors favoring its investigation. The trough method is considered a secondary solution because the probability of it achieving high efficiency is low.

CHAPTER 3

OBJECTIVES

The overall objective of this study is to identify and assess the feasibility of new methods for orienting oysters. In order to achieve the overall objective, several specific objectives have been identified. These objectives are:

1. Develop a method for quickly and efficiently measuring oyster shellstock.

2. Measure physical dimensions of oysters from 3 oyster bars in the Chesapeake Bay and/or tributaries including:

   a. Both single oysters and individual oysters from oyster clumps.

   b. Left handed, right handed and straight axis oysters.

3. Develop a technique which will enable a machine to distinguish between the hinge and bill ends of an oyster.

4. Determine orientation of oysters discharged from a V-shaped trough using 4 known input orientations.

CHAPTER 4

PRELIMINARY EXPERIMENT

INTRODUCTION

Oysters exhibit general dimensional properties. An inverse relationship exists between oyster width and thickness. The width increases from the hinge to the bill end. Oyster thickness decreases from the hinge to bill end (Figure 2). General dimensional characteristics offer only a crude starting point in formulating oyster orientation criteria. It is necessary to identify distinct orienting points on the oyster for application by a mechanical orienter. Specific information is also required on the magnitude of the dimensional differences between the points chosen for use in orienting. The greater the difference the easier it is in distinguishing between the points.

A stepwise procedure is required in determining the feasibility of using dimensional characteristics for orienting. It must first be determined which oyster dimensions or dimensional combinations are suitable for distinguishing between the hinge and bill ends. Then, the specific location of the orienting points must be determined and analyzed with respect to each other to determine favorable dimensions or dimensional combination. Finally, a selection process must be undertaken based upon the magnitude of the differences between chosen orienting points to determine the best orienting combination.

The number of possible orienting points is related to oyster size and dimensional measuring method. If width and thickness dimensions are measured every 0.25 inch along the oyster length then,

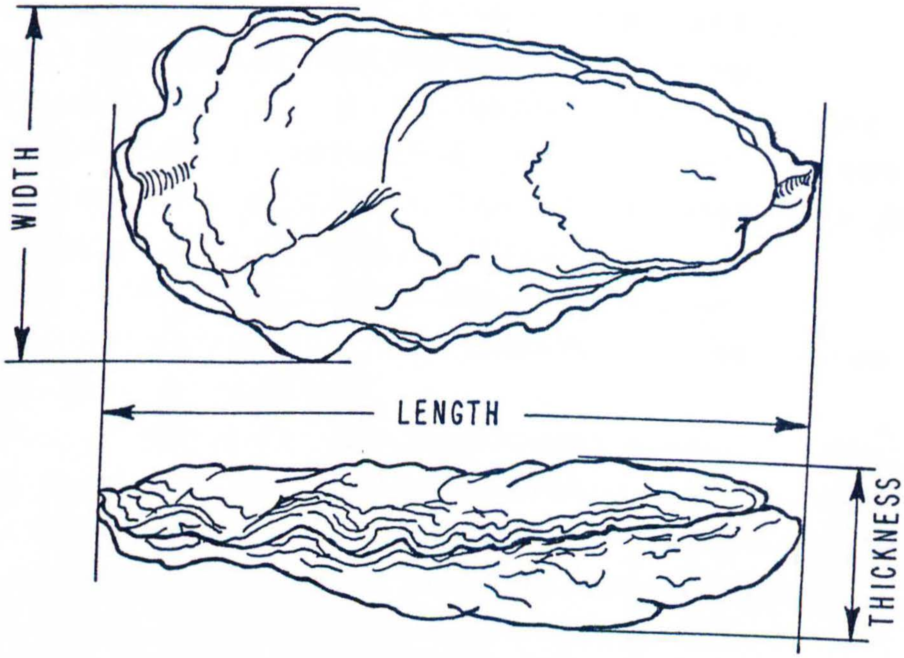

FIGURE 2. DIAGRAM TO REPRESENT DIMENSIONAL TERMS APPLIED TO OYSTERS

Definition of Dimensional Terms (Medcof, 1961)

LENGTH. Length of an oyster is the straight-line distance from the hinge end to the most distant part of the bill end.

THICKNESS. The thickness of an oyster is the distance between the outer surface of the upper shell and outer surface of the lower shell.

WIDTH. The width of an oyster is the edge-to-edge, straight-line distance across the shells at right angles to the length axis.

a 3.0 inch oyster has 12 possible orienting points in each of two dimensions (i.e. width and thickness). A 6.0 inch oyster has 24 possible orienting points. A complete analysis on the orientation feasibility of all points is impractical. The stepwise analysis is complicated further by the possible dimensional combinations which have to be tested. Two orienting points or combination of points can be tested against a certain dimension or dimensional combination. An in depth analysis such as this is impossible in a preliminary experiment. Only pre-selected oyster dimensions and dimensional combinations can be tested at certain orienting points.

The purposes of this experiment were: (1) to determine which oyster dimensions (width and thickness) or dimensional combinations appear to be most suitable for end orientation, and (2) to identify general orienting areas on the oyster.

EQUIPMENT

In order to determine the capabilities of dimensional orientation, it was necessary to record both oyster width and thickness at selected points along the oyster length. These selected points were designated as possible orienting points. The incremental recordings were taken by means of two measuring grids.

Width Measurement

Oyster width was measured with a transparent mylar grid. The grid consisted of 0.25 inch square blocks divided into 28 columns and 16 rows. The grid was dimensioned to accomodate the largest oyster (7 inches long, 4 inches wide). The grid blocks were numbered consecutively from left to right. The numbering helped maintain incremental recording position and sequence. Since the data was recorded manually onto paper, it was very easy to lose the recording position.

The grid was placed between two sheets of 11.0 x 8.0 x 0.25 inch clear plexiglass.[1] This was done for several reasons. The grid was very thin (4 mil) and thus difficult to handle. Oyster shells are very abrasive and when an oyster was placed on top of the grid, the grid scratched badly. Some of the oysters also gaped due to heat from the light source. Released oyster liquor ran over the grid causing a cleaning problem. The plexiglass sheets eliminated these problems.

A plastic straight edge was aligned with the vertical grid marks and cemented onto the left end of the top plexiglass sheet. The plastic straight edge helped in orienting each oyster with respect to the grid and acted as a standardized starting point for the oyster length.

An overhead projector was used to project the grid and oyster image onto a screen. The magnification thus produced facilitated reading grid markings.

Thickness Measurement

A grid similar to the one used for measuring oyster width was fabricated. The grid was attached to an opaque background and fastened to two vertical supports. A moveable plexiglass stand was positioned in front of the vertical grid support and aided proper positioning and aligning of an oyster with respect to the grid.

A slide projector was used to project the oyster image onto the grid. Oyster thickness was then

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[1] Trade name for acrylic plastic

determined by reading the grid at each 0.25 inch increment along the oyster length.

PROCEDURE

Incremental width and thickness were measured by a technique similar in theory to the shadowgraph procedure described by Mohsenin (1970). When an oyster was placed on or against a grid and illuminated with a light source, the incremental measurements were determined by counting the number of darkened blocks. Blocks that were 50 percent or more darkened were counted. Linear measurements were recorded every 0.25 inch along the oyster length. The grid allowed the dimensions to be measured to the nearest 0.25 inch.

Sample Preparation

Two bushels of oysters were brought from a shucking plant on Kent Island. They came from two general localities in the Chesapeake Bay, the Severn River and Eastern Bay. Both bushels were assumed to be a mixture of these two localities plus a mixture of several different oyster bars.

Only single oysters were chosen for use in this experiment. Oyster clumps were discarded for two reasons. First, the number of oyster clumps was very small. Breaking up many of these clumps resulted in damage to the oyster shells. Measuring the dimensions of such oysters would have resulted in biased data. Also, it was evident at the beginning of the experiment that sample size would have to be small, since the measuring technique used was very laborious. Thus, it was felt that the dimensional orientation method could be tested more precisely by using just single oysters. If the method did not work for the more numerous single oysters, there was no cause to investigate clumped oysters.

Oyster clumps were separated from the two bushels. The single oysters were manually washed and brushed to remove as much dirt and fouling as possible. Cleaning helped provide truer dimensional measurements.

After cleaning 111 oysters were randomly chosen to be measured. Only one oyster had to be discarded, due to shell distortions, leaving a study sample of 110 oysters.

Width Measurement

The transparent plexiglass grid was placed on an overhead projector and centered over the light source. Shadows and distorted projections were minimized by maintaining this position.

A single oyster was randomly chosen and placed on top of the grid. The oyster was positioned with its right (flat) valve down, the hinge end in contact with the grid straight edge and the long axis of the oyster disposed at a right angle to the straight edge.

The oyster width image was projected onto a screen. Incremental width measurements were recorded every 0.25 inch along the oyster length; starting from the hinge and proceeding to the bill end. Grid blocks that were 50 percent or more darkened were counted as covered. Grid numbers assigned to each block were used for maintaining recording position.

Initially, width measurement data was recorded twice for each oyster, once with the oyster resting on the left valve and once with the oyster resting on the right valve. Both width dimensions were compared, and for most oysters no differences existed between the same incremental measurements. However, oysters with a strong shell curvature projected different widths for the two valve positions. Oysters placed on their left (cupped) valve had noticeable shadows and distorted projections for the curved portions. Thus, errors due to shell curvature were minimized by placing all oysters on their right valve.

Thickness Measurement

Each oyster was positioned on the moveable stand, duplicating the width measurement orientation. The oysters were disposed on their flat valve in a natural resting position. The thickness measuring grid was suspended vertically from two supports behind the stand. A slide projector, positioned 12 feet in front of the oyster, illuminated the grid with the oyster thickness outline. The plastic stand was moved so that the image of the hinge end of each oyster was aligned on the first vertical grid mark. Thickness measurements were then recorded every 0.25 inch along the oyster length, starting from the hinge and proceeding to the bill end. Grid blocks that were 50 percent or more darkened were counted as covered.

Distortion of the projected image compared with the true dimension was minimized by positioning the light source 12 feet away from the oyster and adjusting the projector lens. This minimized light beam divergence angle, and nearly eliminated magnification of the image. In addition, the oysters were placed in the center of the light beam where lens spherical aberration was negligible.

RESULTS AND DISCUSSION

A selection process was required to determine which dimensions and dimensional combinations were to be tested. The orienting points also had to be selected to make the analysis feasible.

Prior to the data analysis only four dimensional orienting methods were considered. These methods were: (1) comparison of individual width increments and width combinations, (2) comparison of individual thickness increments and thickness combinations, (3) comparison of individual width to thickness ratios and ratio combinations, and (4) comparison of additive combinations of width and thickness.

The comparison of separate width increments and width combinations is not presented. The observed width data was so variable that an analysis was considered worthless. Thus, only three dimensional orienting methods are presented.

The ratio and additive combinations of width and thickness were considered as orienting methods since oyster width and thickness are inversely related. Thus, these combinations may be sensitive to hinge-bill differences.

A limited number of orienting points were selected for testing with each dimensional method, because it was impossible to test all possible orienting points. Only the first six end points for both the hinge and bill were considered as possible orienting points.

<u>Oyster Thickness Orientation</u>

It was previously stated that oyster thickness decreases from the hinge to the bill end. For orientation purposes this means that all hinge orienting points should be greater than all bill orienting points.

Oysters can enter the proposed active orienter with either the hinge or bill end leading. So, the thickness test conditions were: (1) if the first orienting point was greater than the second orienting point, the hinge end was leading, and (2) if the first orienting point was less than the second orienting point then the bill end was leading. Orienting points that had equal values were test failures.

Several separate comparisons between individual thickness increments were carried out. Only equally spaced increments from both oyster ends were compared. The orienting test points were selected from an incremental plot of mean thickness (Figure 3). The distributions of incremental mean thickness are graphically shown for the three most dominant oyster length groupings. The sample sizes of the other length groups were too small for adequate graphical presentation.

The observed difference in magnitude between the thickness of the first end means was too small for successful results (Figure 3). The five orienting points between 0.50 and 1.50 inches in from the ends were selected and compared. The analysis of each comparison was terminated after 50 oysters because of a 10 to 30 percent failure rate. The smallest failure occurred with the orienting points 0.75 and 1.00 inches in from both ends. The largest failure was recorded with the 1.50 inches orienting points. The analysis of Figure 3 substantiates these results, since the largest and smallest differences between computed means occur at these points. The larger the mean differences, the greater the probability of success.

The low success of individual thickness comparisons can be attributed to the variability in the oysters. The plot of incremental mean thickness (Figure 3) obscures this variability. Accuracy of the measuring technique may account for part of the high failure rate, since many of the failures occurred with points of equal value. Success rate of the comparisons might have been increased by more accurate measurements (i.e., using less than 0.25 inch blocks).

Orientation by Dimensional Combinations

Table 4 presents a list of selected dimensional

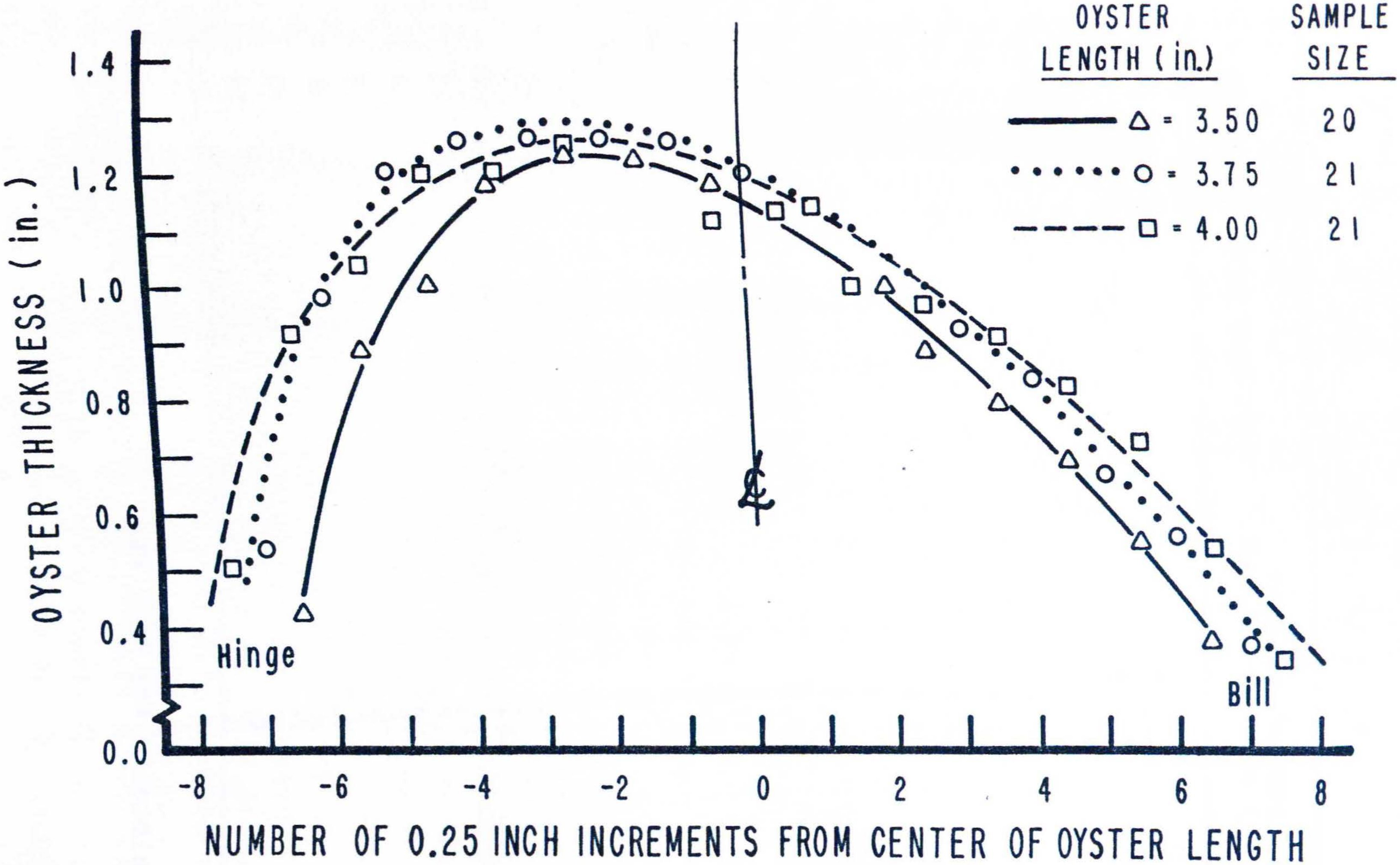

FIGURE 3. MEAN OYSTER THICKNESS EVERY 0.25 INCH ALONG OYSTER LENGTH

TABLE 4. LIST OF TESTED DIMENSIONAL COMBINATIONS OF WIDTH (W) AND THICKNESS (T)

Hinge and Bill Reading[1]	Reading Comparison Percent Failure (N=110)
T1 + T2 + T3	12.0 %
T1 + T2 + T3 + T4	11.1
T2 + T3 + T4	3.6
T3 + T4 + T5	4.5
T4 + T5	4.5
T4 + T5 + T6	4.5
W3 - T3	4.5
W4 - T4	4.5
W5 - T5	7.2
(W3 + W4) - (T3 + T4)	2.7
(W4 + W5) - (T4 + T5)	2.7
W2 / T2	4.5
W3 / T3	1.8
W4 / T4	2.7
W5 / T5	4.5
(W3 + W4) / T3	.9
(W3 + W4) / T4	.9
(W4 + W5) / T3	.9
(W4 + W5) / T2	3.6
(W4 + W5) / T4	.9
(W4 + W5) / T5	2.7
(W4 + W5) / (T2 + T3)	.9
(W4 + W5) / (T4 + T5)	.9

1 Numerical values refer to 0.25 inch end recording position

combinations which were tested over the entire sample. Other combinations are feasible and might provide better results. It should be noted that the lettered numbers in Table 4 refer to 0.25 inch end recording positions. Thus, a value of 4 refers to a 1.0 inch (4 x 0.25 = 1.0) recording position in from both oyster ends.

Failure rates ranged from a low of 0.9 percent to a high of 12.0 percent. More than half of the tested combinations had less than 3.0 percent failure. The best results were attained with width to thickness ratios (Table 4).

The test conditions for using width to thickness ratios were: (1) if the first orienting point was less than the second orienting point the hinge end was leading, and (2) if the first orienting point was greater than the second orienting point then the bill end was leading. Orienting points which had equal values or zero differences were test failures.

The relationship between individual width to thickness ratios is graphically demonstrated in Figure 4. The mean value of each incremental ratio was computed for the predominant oyster length groups and plotted. Generally, the curves follow the known inverse relationship between width and thickness dimensions (Galtsoff, 1964). As expected, the width to thickness ratios bottom out at the hinge areas and peak at the bill areas (Figure 4). The greatest differences will be found by relating orienting width to thickness ratios in the high and low portions of the curves (Figure 4).

The difference in magnitude between the first end means was not great enough for discrimination between the two ends (Figure 4). Orienting points 0.50 to 1.25 inches in from both ends were selected and analyzed based on Figure 4. The largest differences occurred with ratios taken 0.75 inches in from both ends (Table 4). This result was surprising since the 0.50 inch location

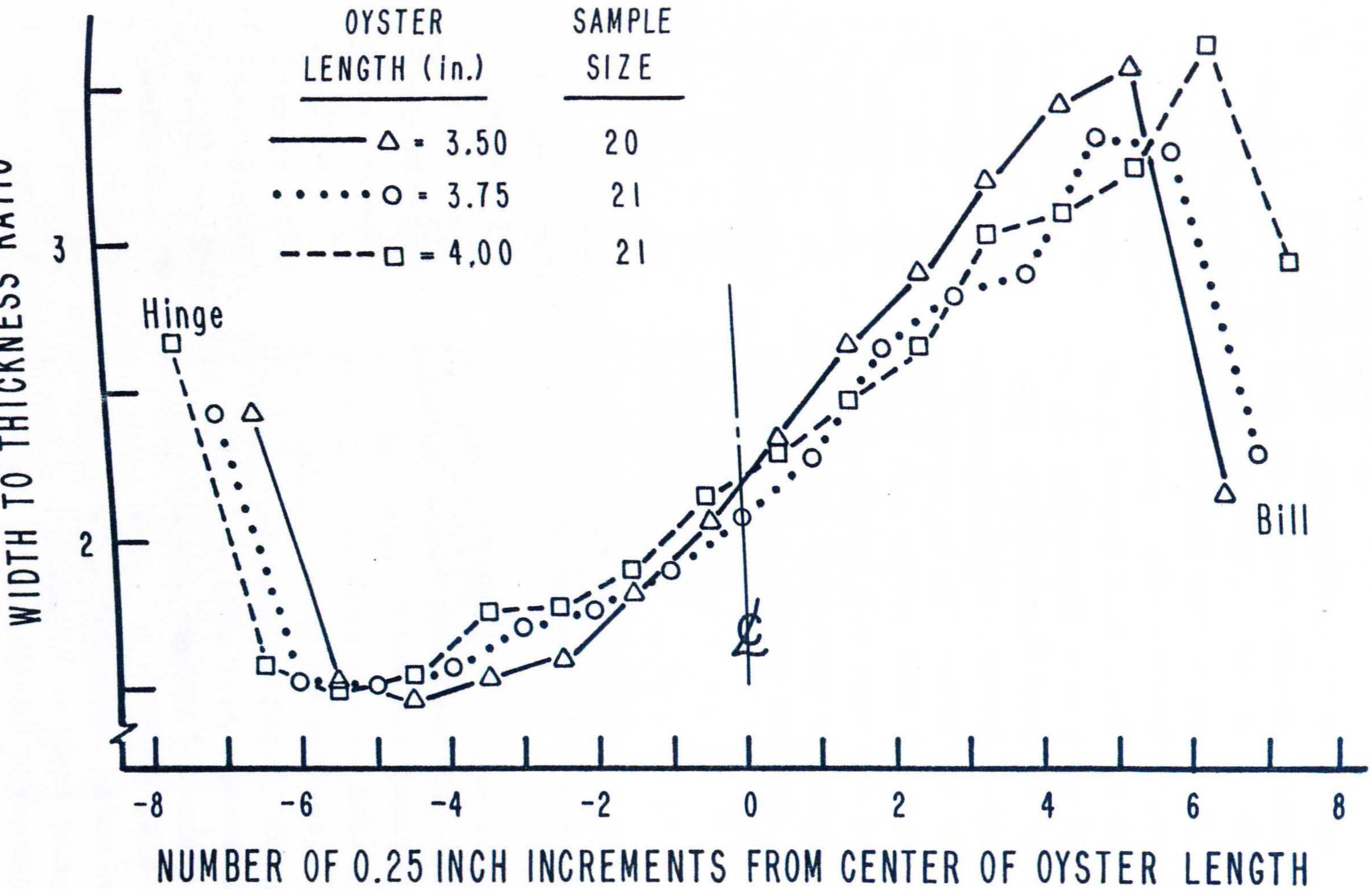

FIGURE 4. MEAN WIDTH TO THICKNESS RATIOS EVERY 0.25 INCH ALONG OYSTER LENGTH

exhibited the greatest mean differences and, theoretically, should have had better results than any other recording position.

The multiple combinations of width to thickness ratios had the lowest failure rates of all combinations tested (Table 4). The lowest failure rate of 0.90 percent was realized with a ratio of additive width to single thickness. The orienting points were located between the 0.75 and 1.25 inch recording positions. Almost all ratios of this form had similar failure rates. These ratios would have to be analyzed further to identify differences between them.

The failure rates of all width and thickness combinations occurred most often when the compared values were equal; accounting for over one half the failures. A more accurate measuring technique could have different, and possible better results.

CONCLUSIONS

The width and thickness dimensions can be used to successfully distinguish between the hinge and bill ends of oysters.

It does not appear feasible to use single recordings of either width or thickness for orientation. The comparisons of individual thickness recordings between 0.50 and 1.50 inches in from both oyster ends resulted in unacceptable failure rates; 10 to 30 percent. Results of preliminary experiments indicate different forms of width to thickness ratios are the best dimensional methods. The orienting points should be located 0.50 to 1.25 inches in from both ends. A failure rate less than 1.00 percent is feasible with different ratio combinations. The low rejection rate is adequate to meet necessary economic requirements for a mechanical orienter.

All of the dimensional orienting methods should be tested again. The small sample size and the accuracy of the measuring technique did not provide adequate means for distinguishing between dimensional methods. Most of the methods had between one and five oyster failures, and most failed under the zero difference test condition. A larger sample size and a more accurate measuring technique is required to distinguish between dimensional orientation methods.

The method for measuring incremental oyster dimensions should be improved. The technique is very slow and laborious. It took, on the average, one hour to measure both the incremental width and thickness of four oysters.

CHAPTER 5

EXPERIMENT 1 : DIMENSIONAL STUDIES

INTRODUCTION

The preliminary experiment suggested oyster shellstock dimensions might be used to distinguish between the oyster hinge and bill ends. Although a width to thickness ratio was considered the best orientation method, measuring grid accuracy and small sample size prevented a definitive decision as to the best dimensional measurement. Thus, an experiment was designed to determine which oyster physical dimensions would provide the best means of orienting oysters. This experiment incorporated a larger sample size and improved dimensional measurement accuracy. Initially, a dimensional measuring device was proposed for automatically recording shellstock dimensions since a very large number of measurements were required. After extensive planning and research, the measuring device had to be terminated because of design problems and economic constraints. An alternative method of recording the data was adopted; consisting of manually recording the data in a prescribed sequence into a tape recorder. The width measuring grid was also changed to facilitate transfer of data.

OBJECTIVES

The objectives of this experiment were to:

1. determine which oyster dimensions or dimensional combinations were most suitable for end orientation.

2. identify specific orienting points for each orientation method.

3. determine for each dimension or dimensional combination tested the orientation efficiency.

4. statistically identify the best dimensional orientation method of those tested.

EQUIPMENT

Width Measurement

Oyster width was measured using a precision inch grid[1] designed for printed circuit artwork. The translucent mylar grid consisted of 0.1 inch square blocks and was partitioned so that incremental width measurements could be recorded at 0.2 inch intervals.

Figure 5 is a top view of the width measuring grid. The grid orienting axis, a heavy horizontal line, divides the grid into two width measuring areas. Every other grid column, in both measuring areas, is numbered consecutively starting from the horizontal line. The grid was divided into two width measuring areas for two reasons: (1) increase data recording rate and (2) decrease recording errors. An oyster positioned on the grid and properly aligned was divided into two width areas; a top and bottom portion. The incremental width was quickly recorded by scanning the edge of one area and recording in sequence the number of the last block darkened at each 0.2 inch interval along the oyster length. The process was repeated for the bottom portion. Maximum recording speed was maintained by the scanning process. Actual width was determined by the computer, thus reducing recording errors.

At the very top and bottom of Figure 5 are a series of consecutive numbers from 12 to 35. These numbers referred to a length class designation which was

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[1] Trade name Accufilm

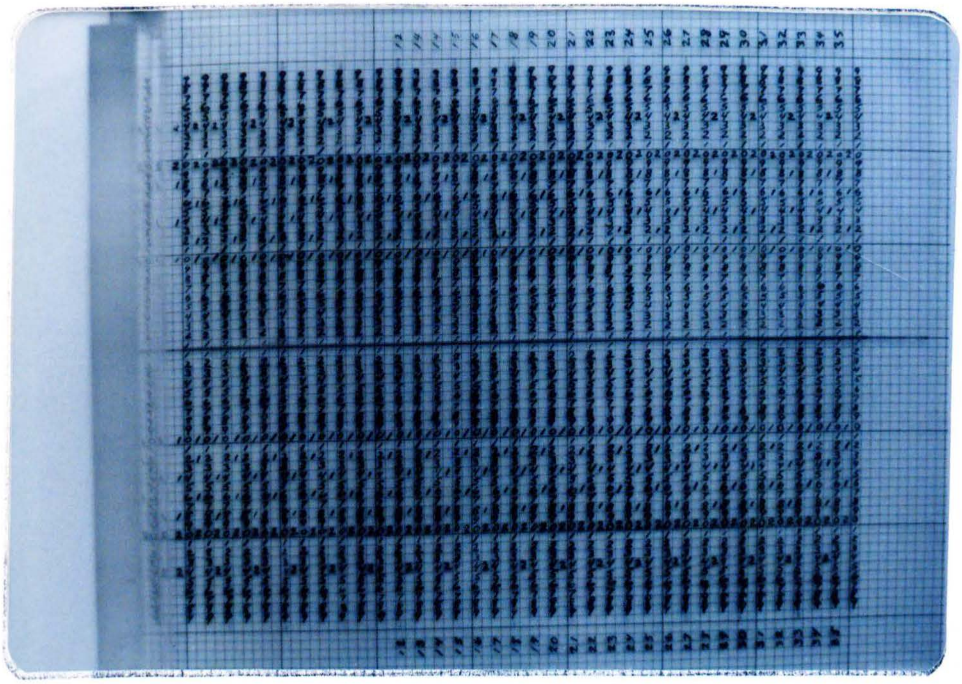

FIGURE 5. OYSTER WIDTH MEASURING GRID

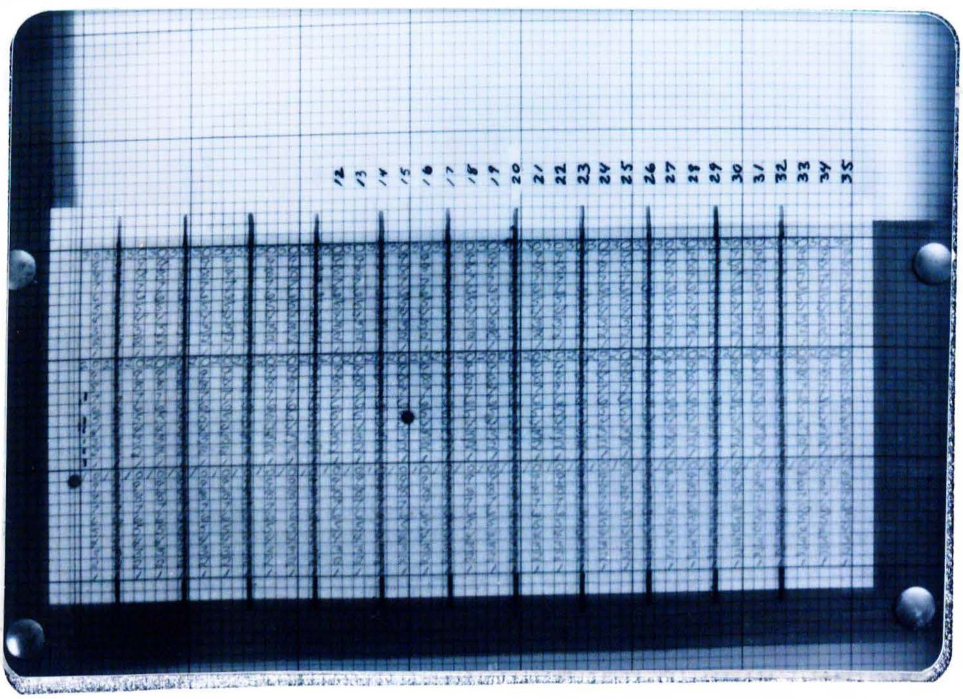

FIGURE 6. OYSTER THICKNESS MEASURING GRID

recorded for each oyster and later used in sorting data.

The grid was constructed of only four parts. The grid was numbered with permanent ink and attached to a plastic base (9.50 x 8.50 x .125 inches) with transparent adhesive tape. A protective plastic shield, approximately 7 mil thickness, was placed over the grid and fastened to the base support with adhesive tape. An acrylic plastic straight edge was then positioned over the shield and grid, and fastened onto the left end of the base (Figure 5) such that the center of the grid column coincided with the 0.1 inch intervals. The straight edge helped orient each oyster with its longest axis directly above the heavy horizontal line on the grid. The intersection between the straight edge and the horizontal line was designated as the standardized starting point for positioning and measuring oysters.

The same overhead projector used in the preliminary experiment was employed in this study. Magnification produced by the projector facilitated reading grid numbers.

Thickness Measurement

The same set up used for measuring thickness in the preliminary experiment was applied in this study except the previous grid was replaced with a grid having 0.1 square inch blocks (Figure 6).

The spaced vertical lines on the grid, Figure 6, helped maintain recording position and sequence. Every other grid column was numbered from top to bottom in ascending order, with the bottom accented by a heavy horizontal line. The grid was attached to the same vertical support employed in the preliminary experiment. A moveable stand was positioned in front of the grid such that the top of the stand was in the same plane as the bottom horizontal line on the grid.

A slide projector was used to project the oyster image onto the grid. Thickness measurements were determined at 0.2 inch intervals by reading the grid along the oyster length.

Data Recording

Both incremental width and thickness data were recorded into a tape recorder (Panasonic RQ-212DAS). Recording malfunctions due to dirt and oyster shell particles were eliminated by placing the tape recorder in a plastic bag. The microphone switch was also covered by an elastic casing: the neck of a rubber balloon.

The handling and transfer of dimensional data was greatly simplified by recording it into a tape recorder. The oral recording allowed a continuous transfer of data, eliminating recording position errors.

PROCEDURE

All incremental measurements were determined by recording the number of the first and last darkened block at each interval from the projected image. Data recordings were made every 0.2 inch along the oyster length by orally transcribing the last block numbers that were 50 percent or more darkened. The 0.1 inch square grid blocks allowed total incremental dimensions to be measured to the nearest 0.1 inch.

In the preliminary experiment, the number of darkened blocks were counted and recorded. However, only the first and last darkened blocks were recorded in this study. This change reduced the time required in recording measurements and reduced computational errors.

Sample Preparation

Three different oyster bars from the Chesapeake Bay were studied. Two of these bars were sampled by personnel from the Chesapeake Biological Laboratory and the Center for Environmental and Estuarine Studies. One of the sample bars was obtained commercially from Buck's Seafood on Tilghman Island.

Table 5 shows the exact location of the three study areas. All bar locations had to be verified since their locations were initially reported only as a bar name and river system. Duplication of bar names is very common in Maryland waters. A bar name location index by Gird and Wheaton (1976) was employed for verifying bar location on Natural Oyster Bar Charts. The index verified bar locations and deciphered one of the reported bar names. Initially, bar 1 was reported as Bar Neck. The official chart name was determined to be Church Hill from a cross listing of common and official bar names in the location index (Gird and Wheaton, 1976).

All oysters were first washed by a spray washer to remove as much dirt and fouling as possible. The oysters were then manually cleaned to remove any remaining mussels and barnacles. During the cleaning process, empty shells and other debris were removed and discarded. The cleaned oysters were counted, reallocated to bushel baskets, and stored in a freezer until needed.

Six bushels of oysters were sampled from each bar location. Since the number of oysters in each bushel varied from 149 to 250, only 135 oysters from each bushel were randomly selected to be measured. Thus, 810 oysters from each of three different oyster bars were measured for a total of 2,430 oysters.

Width Measurement

The translucent grid was centered over the

TABLE 5. LOCATION OF BAR SAMPLES

Sample Number	Bar Name	Date Harvested	Bar Location			
			County	River System	Longitude Latitude	Grid Location[1]
1	Church Hill	9/22/1976	Talbot	Choptank	38-41-25 76-17-30	11C5
2	Prison Point	9/22/1976	Calvert	Patuxent	38-26-30 76-37-00	18C4
3	Buoy Rock	9/27/1976	Kent	Chester	38-59-50 76-13-15	7A4

[1] Gird and Wheaton, 1976

light source of the overhead projector. A single oyster was randomly chosen and positioned on top of the grid with its right valve down, hinge end in contact with the straight edge and the long axis disposed at a right angle to the straight edge. The oyster was then oriented along its longest axis with respect to the heavy horizontal grid line.

The oyster width image was projected onto a screen (Figure 7) and incremental width measurements were recorded first for the top width portion and then the bottom width portion. Width increments were recorded every 0.2 inch along the oyster length starting at the hinge end. The grid number from the last darkened block (50 percent or more darkened) was counted as covered and orally recorded into the tape recorder. This resulted in two series of incremental width points being recorded for each oyster.

Thickness Measurement

The same procedure used for measuring thickness in the preliminary experiment was employed in this study. Each oyster was positioned on the moveable stand; duplicating the width measurement orientation. The grid, fastened vertically to two supports behind the stand, was illuminated by a slide projector positioned 12 feet in front of the grid. The stand was adjusted to align the hinge end of each oyster with the first vertical grid mark.

Two thickness measurements were then recorded every 0.2 inch along the oyster length, starting from the hinge end. The number of the last darkened block was recorded at each interval from hinge to bill end for first the top portion of the thickness image and, then for the bottom portion of the image. Since there was no magnification of the thickness image, vertical grid marks were made at

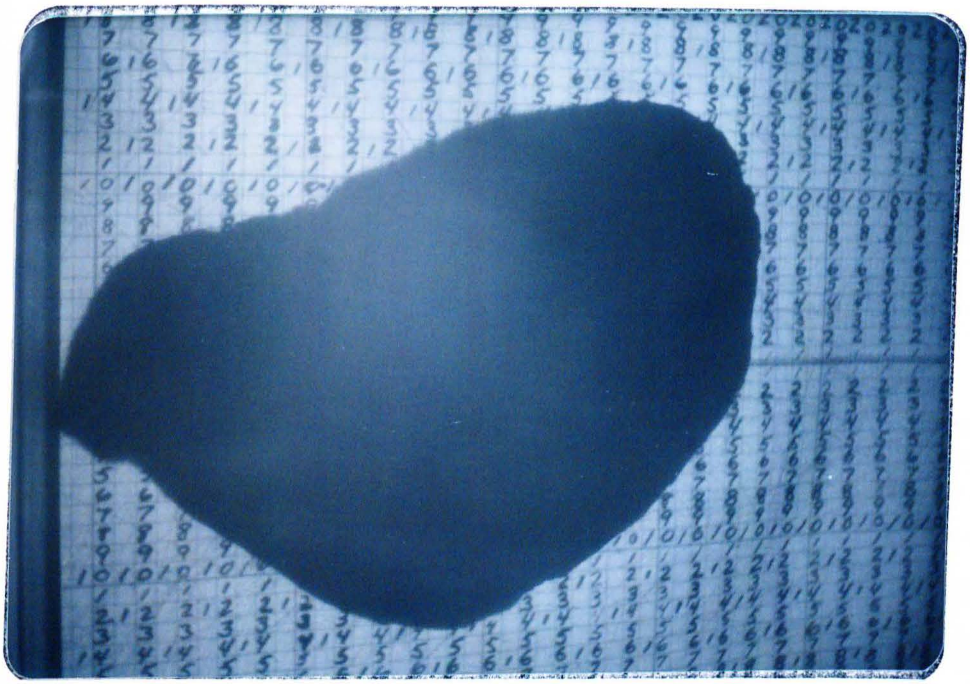

FIGURE 7. PROJECTED IMAGE OF OYSTER WIDTH

every third interval to help maintain recording position.

Data Recording

All incremental data was recorded orally onto a cassette tape recorder using 90 minute tapes. By orally recording the data, it was possible to measure approximately 20 to 25 oysters per hour. It was possible to store both width and thickness data from 40 to 50 oysters on one tape.

The data was recorded in a specific sequence. Since there were four series of incremental recordings, two width and two thickness recordings, a number from one to four was orally recorded. This series number was designated as the "card" number for later computer applications. In addition, each bar, bushel, and oyster were given a number and recorded for proper handling of the data by the computer.

The dimensional increments were recorded in three number sequences from hinge to bill to facilitate later punching of the data onto computer cards.

The dimensional data was punched directly onto cards from the cassette tapes. Each oyster was dimensionally defined by four cards. There was a single card for each top and bottom recording of incremental width and thickness.

After a computer check was made to find any punching errors, the data was combined to form actual width and thickness measurements. Width to thickness ratios were then calculated for each interval point and rounded to the nearest 0.1 inch.

Several comparisons of individual dimensions and dimensional combinations were conducted. Appendix C contains a listing of one of the programs used in making the comparisons. Most of the other programs employed were variant forms of the one listed.

RESULTS AND DISCUSSION

Dimensional Tests

The dimensional tests were conducted by individually comparing selected orienting points along the oyster length. For computational purposes the first orienting points were fixed and consisted of the seven individual measurements, located at 0.2 inch intervals, from 0.4 to 1.6 inches in from the oyster end. Thus, the first orienting points for all oysters were located at the following distances in from the oyster end; 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, and 1.6 inches. The second orienting points depended upon the oyster length and consisted of all other measurements located 0.6 inch from one of the first orienting points. Thus, for a 2.6 inch oyster with the first orienting point at 0.4 inches in from the oyster end comparisons were made with the computed measurements at 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4, and 2.6 inches along the oyster length. The comparisons were then repeated in the above manner between the other six first orienting points.

The individual comparisons were run under two simulated conditions; hinge leading and bill leading oysters. This meant that the first set of fixed orienting points for the hinge area were run and compared. Then, the first set of fixed orienting points for the bill area were run and compared. The hinge leading and bill leading comparisons were then compiled under a test hypothesis that satisfied both simulated conditions. In order to run one dimensional method over all oysters 600,000 comparisons had to be made and compiled.

Tables 6 through 9 summarize the best orientation results for different dimensional methods over all oysters.

TABLE 6. SUMMARY OF THICKNESS ORIENTATION TESTS WITH SMALLEST PERCENT FAILURE OVER ALL OYSTERS

Orientation Method[1]	Distance from Ends (inches)		Total Number Oysters Failed[4]	Percent Failure (N=2430)
	First Reading[2]	Second Reading[3]		
Individual Thickness	0.4	0.4	264	10.86
	0.6	0.6	203	8.35
	0.8	0.8	198	8.15
	1.0	1.0	106	4.36
Thickness Summation	0.4+0.6	0.2+0.4	54	2.22
	0.6+0.8	0.4+0.6	69	2.84
	0.8+1.0	0.6+0.8	82	3.37

[1] The test hypothesis is: If the first reading is greater than the second reading then the hinge end is leading. If the first reading is less than the second reading the bill end is leading.

[2] First reading is the distance in from leading end, hinge or bill.

[3] Second reading is the distance in from trailing end, hinge or bill.

[4] Calculated on two-tailed test conditions of both hinge and bill leading criteria.

TABLE 7. SUMMARY OF WIDTH ORIENTATION TESTS WITH SMALLEST PERCENT FAILURE OVER ALL OYSTERS

Orientation Method[1]	Distance from Ends (inches)		Total Number Oysters Failed[4]	Percent Failure (N=2430)
	First Reading[2]	Second Reading[3]		
Individual Width	0.4	0.4	56	2.30
	0.6	0.6	46	1.89
	0.8	0.8	48	1.98
	1.0	1.0	72	2.96
Width Summation	0.4+0.6	0.2+0.4	274	11.28
	0.6+0.8	0.4+0.6	149	6.13
	0.8+1.0	0.6+0.8	119	4.89

[1] The test hypothesis is: if the first reading is less than the second reading then the hinge end is leading. If the first reading is greater than the second reading then the bill end is leading.

[2] First reading is the distance in from leading end; hinge or bill.

[3] Second reading is the distance in from trailing end, hinge or bill.

[4] Calculated on two-tailed test conditions of both hinge and bill leading criteria.

TABLE 8. SUMMARY OF WIDTH TO THICKNESS RATIO TESTS OVER ALL OYSTERS

Distance From Ends Second reading (inches)	Distance From Ends First Reading (inches) 0.4	0.6	0.8	1.0	1.2	1.4	1.6
0.2	* (1.69) ** ±.51	(2.06) ±.56	(2.59) ±.63	(3.09) ±.69	(4.53) ±.83	(6.87) ±1.01	(8.81) ±1.13
0.4	(0.37) ±.24	(0.49) ±.28	(0.62) ±.31	(0.95) ±.38	(1.65) ±.51	(2.76) ±.65	(4.57) ±.83
0.6	(0.49) ±.28	(0.25) ±.20	(0.25) ±.20	(0.45) ±.27	(0.99) ±.39	(1.98) ±.55	
0.8	(0.62) ±.31	(0.25) ±.20	(0.25) ±.20	(0.41) ±.25	(0.99) ±.39		
1.0	(0.95) ±.38	(0.45) ±.27	(0.41) ±.25	(0.49) ±.28			
1.2	(1.65) ±.51	(0.99) ±.39	(0.99) ±.39				
1.4	(2.76) ±.65	(1.98) ±.55					
1.6	(4.57) ±.83						

* Total percent failure (N=2,430)

** Confidence limits for percent failure. Computed from Zar (1974).

TABLE 9. SUMMARY OF BEST WIDTH TO THICKNESS RATIO METHODS OVER ALL BARS WITH SET ORIENTING POINTS

Distance From End[1] (inches)		Total Number Oysters Failed[2]	Percent Failure (N=2430)
First Reading	Second Reading		
0.4	2.4	78	3.21
0.4	2.6	61	2.51
0.6	2.4	56	2.30
0.6	2.6	47	1.93
0.8	2.4	55	2.26
0.8	2.6	47	1.93
1.0	2.4	46	1.89
1.0	2.6	40	1.65
1.2	2.4	55	2.26
1.2	2.6	50	2.06
1.4	2.4	89	3.66
1.4	2.6	86	3.54
1.6	2.4	148	6.09
1.6	2.6	121	4.98

[1] Both readings are distances from the same end.

[2] Calculated for both hinge and bill leading criteria.

Thickness comparisons. Comparisons of both individual thickness increments and thickness summations resulted in unacceptable failure rates (Table 6). The smallest failure for individual comparisons was achieved with orienting points located equal distances in from both oyster ends. Orienting points located 1.0 inch in from both ends had the lowest failure of 4.36 percent for all oysters. Comparisons of thickness summations yielded lower failure rates; but they were still unacceptable (Table 6).

A third dimensional test was conducted utilizing total thickness measurements. Each oyster was bisected equally along its length into hinge and bill areas, and the thickness increments summed and compared. The comparison of hinge and bill thickness areas resulted in an unacceptable failure of 5.5 percent over all oysters.

Width comparisons. Individual width comparisons yielded better results than individual thickness comparisons (Table 7). Orienting points located 0.6 inch in from both ends showed the smallest failure of 1.89 percent. Width summation comparisons produced higher failure rates compared to thickness summations (Table 7). The smallest failure of all dimensional width tests, 1.3 percent, was achieved with a comparison between hinge and bill width areas. The acceptable failure rate of 1.3 percent was achieved over all oysters. When each bar was analyzed, an unacceptable test failure of 2.3 percent occurred with bar 2, Prison Point.

Width to thickness ratio comparisons. Only individual comparisons of width to thickness ratios were conducted. The excellent results achieved in the individual comparisons eliminated any need for testing ratio summations or combinations.

Table 8 shows the distribution of oyster failure for individual comparisons of width to thickness ratios at different orienting points. All comparisons between orienting points 0.4 to 1.0 inches in from both oyster ends yielded very low failure rates. Only 0.25 to 0.95 percent of all oysters failed within this range of orienting points. The smallest failure of 0.25 percent occurred with orienting points 0.6 and 0.8 inches in from both ends. The results of individual comparisons of width to thickness ratios agree with the findings from the preliminary experiment. In the preliminary experiment, the lowest failure rate for individual ratio comparisons was with orienting points 0.75 inches in from both ends.

Table 9 summarizes a set point method utilizing width to thickness ratios. In all the other previous dimensional comparisons, the location of orienting points was dependent upon oyster length. The distance between the two points increased as the oyster length increased. The distance between orienting points is the same, regardless of oyster length, in a set point method. A set point method may be important in future applications since a length sensor is not required in the orienting system.

The two orienting points for the best set point ratio method are 1.0 and 2.6 inches in from the oyster end (Table 9). Even though the failure rate of 1.65 percent is unacceptable for a totally automated orienting device, such a scheme may be found useful in later development of an oyster shucking machine.

Set point schemes for the other dimensional methods were investigated but failed. The best hope for the other dimensions are the so called split set point schemes. Instead of setting the orienting points across all oysters, the orienting points are set for certain oyster lengths. Split set point schemes were analyzed to only a limited degree. Thus, no definite conclusions were reached with this technique.

Selection of tests. Using percent failure as the test selection criteria, width to thickness ratios produced the lowest failure rates of all techniques examined. There were 12 different orienting point combinations for the ratio method with failures less than 1.0 percent (Table 8). Only five of these combinations with a failure between 0.25 and 0.49 percent were selected to be analyzed to test for differences between bars. The five tests were selected from Table 8 on the basis that they were vertically bounded by other ratio tests with the least percent failure. It was also important to obtain a range of different orienting point combinations so that the ratio method could be adequately tested.

Table 10 shows the five selected width to thickness ratio tests. The original bar and bars total data for these tests is found in Appendix D. An examination of Table 10 revealed noticeable differences in failure rates over both tests and bars. Church Hill had the largest failure rates across four of five tests. Buoy Rock had the lowest failure rates over all bars and tests. The width to thickness ratio tests responded quite differently from bar to bar with the lowest failure rates occurring in tests three and four. These differences in percent failure could be due to the different size oysters from each location. Table 11 is a bar summary of the oyster length distributions. Buoy Rock is definitely skewed to the left compared to the other two bars. The lowest failure rates for Buoy Rock (Table 10) could be due to the larger number of smaller oysters. This means that the five ratio tests could be biased for smaller oysters. Further statistical analysis should reveal if there are any significant differences between bars for the ratio tests.

TABLE 10. AVERAGE PERCENT FAILURE OF SELECTED DIMENSIONAL ORIENTATION TESTS FOR EACH BAR SAMPLE (ORIGINAL DATA)

Orientation Test	Test[1]	Distance From Ends (inches)		Bar Failure (Percent)			
		First Reading	Second Reading	Church Hill	Prison Point	Buoy Rock	Bars Total
1	W/T RATIO	0.4	0.4	0.99	0.12	0	0.37
2	W/T RATIO	0.4	0.6	1.11	0.25	0.12	0.49
3	W/T RATIO	0.6	0.8	0.37	0.25	0.12	0.25
4	W/T RATIO	0.8	0.8	0.25	0.37	0.12	0.25
5	W/T RATIO	1.0	0.8	0.49	0.49	0.25	0.41

[1] Width to thickness ratio symbolized by W/T.

TABLE 11. LENGTH DISTRIBUTION OF OYSTERS OVER EACH BAR SAMPLE

Oyster Length Class (inches)	Bar Sample Size			Total
	Church Hill	Prison Point	Buoy Rock	
2.6 - 2.7	2	4	36	42
2.8 - 2.9	18	11	96	125
3.0 - 3.1	26	32	149	207
3.2 - 3.3	72	61	142	275
3.4 - 3.5	108	89	121	318
3.6 - 3.7	125	136	103	364
3.8 - 3.9	128	122	65	315
4.0 - 4.1	120	113	39	272
4.2 - 4.3	98	94	31	223
4.4 - 4.5	41	71	15	127
4.6 - 4.7	35	29	4	68
4.8 - 4.9	22	23	8	53
5.0 - 5.1	6	11	0	17
5.2 - 5.3	4	7	1	12
5.4 - 5.5	4	5	0	9
5.6 - 5.7	1	1	0	2
5.8 - 5.9	0	1	0	1
Total	810	810	810	2430

Statistical Analysis

The five selected dimensional orientation tests (Table 10) were analyzed with a repeated measurements (split plot in time) design because the same observations were made on the same oysters (Steel and Torrie, 1960). The bar effects were analyzed as fixed effects since the purpose of the analysis was to test differences between bars for the dimensional tests. All dimensional tests were previously selected and thus fixed.

The basic set up for the repeated measurements design is shown in Table 12. The bars represented whole units and dimensional tests represented subunits within each whole unit. The whole-unit design was a completely random design with six replicates (bushels). The number of oyster failures were calculated for each unit from bar-bushel tables similar to those in Appendix D.

The valid application of the analysis of variance required that basic assumptions be met: (1) The data must have been obtained randomly from a normal distribution, (2) the experimental errors must have been independently distributed with a common variance, and (3) the effects of factor levels were assumed to have been additive. Since the data dealt with success and failure (Table 12) the arcsine transformation was applied to meet these required assumptions (Table 13).

Results of the analysis of variance on the transformed data are shown in Table 14. Both main effects were non-significant while the interaction was significant (.01<P<.025). Because of significant interaction effects, a simple statement of preference for any dimensional test could not be made until the patterns of response to changes in bars and tests

TABLE 12. NUMBER OF OYSTER FAILURES FOR SELECTED ORIENTATION TESTS (ORIGINAL DATA)

Bar Location	Bushels	Test 1	2	3	4	5	Totals
Church Hill	1	1	0	0	0	1	2
	2	0	0	0	0	0	0
	3	2	3	1	1	0	7
	4	2	3	0	0	0	5
	5	2	2	1	1	1	7
	6	1	1	1	0	2	5
Totals		8	9	3	2	4	26
Prison Point	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	1	1	1	2	5
	4	1	1	1	1	1	5
	5	0	0	0	1	1	2
	6	0	0	0	0	0	0
Totals		1	2	2	3	4	12
Buoy Rock	1	0	0	0	0	0	0
	2	0	1	1	1	1	4
	3	0	0	0	0	1	1
	4	0	0	0	0	0	0
	5	0	0	0	0	0	0
	6	0	0	0	0	0	0
Totals		0	1	1	1	2	5
Test Totals		9	12	6	6	10	43

TABLE 13. ARCSINE TRANSFORMATION OF PERCENT FAILURE FOR SELECTED DIMENSIONAL ORIENTATION TESTS

Bar Location	Bushels	Test 1	Test 2	Test 3	Test 4	Test 5	Totals
Church Hill	1	4.94	0	0	0	4.94	9.88
	2	0	0	0	0	0	0
	3	6.99	8.57	4.94	4.94	0	25.44
	4	6.99	8.57	0	0	0	15.56
	5	6.99	6.99	4.94	4.94	4.94	28.80
	6	4.94	4.94	4.94	0	6.99	21.81
Totals		30.85	29.07	14.82	9.88	16.87	101.49
Prison Point	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	4.94	4.94	4.94	6.99	21.81
	4	4.94	4.94	4.94	4.94	4.94	24.70
	5	0	0	0	4.94	4.94	9.88
	6	0	0	0	0	0	0
Totals		4.94	9.88	9.88	14.82	16.87	56.39
Buoy Rock	1	0	0	0	0	0	0
	2	0	4.94	4.94	4.94	4.94	19.76
	3	0	0	0	0	4.94	4.94
	4	0	0	0	0	0	0
	5	0	0	0	0	0	0
	6	0	0	0	0	0	0
Totals		0	4.94	4.94	4.94	9.88	24.70
Test Totals		35.79	43.89	29.64	29.64	43.62	182.58

TABLE 14. ANALYSIS OF VARIANCE FOR REPEATED MEASUREMENTS EXPERIMENT

Source of Variation	df	SS	MS	F	
Bars	2	99.28	49.64	2.41	$P < .1$
Error (a)	15	308.39	20.56		
Whole-unit Total	17	407.67	23.98		
Tests	4	11.11	2.78	.87	$P < .25$
Bar x Tests	8	68.11	8.51	2.65	$.01 < P < .025$
Error (b)	60	192.86	3.21		
Subunit Total	72	272.08	3.78		
Total	89	679.75			

TABLE 15. AVERAGE PERCENT FAILURE OF SELECTED DIMENSIONAL ORIENTATION TESTS FOR EACH BAR SAMPLE (TRANSFORMED DATA)

Orientation Test	Test[1]	Distance From Ends (inches)		Bar Failure (Percent)			
		First Reading	Second Reading	Church Hill	Prison Point	Buoy Rock	Total
1	W/T RATIO	0.4	0.4	5.14	0.82	0	1.98
2	W/T RATIO	0.4	0.6	4.85	1.65	0.82	2.44
3	W/T RATIO	0.6	0.8	2.47	1.65	0.82	1.65
4	W/T RATIO	0.8	0.8	1.65	2.47	0.82	1.65
5	W/T RATIO	1.0	0.8	2.81	2.81	1.65	2.42

[1] Width to thickness ratio symbolized by W/T.

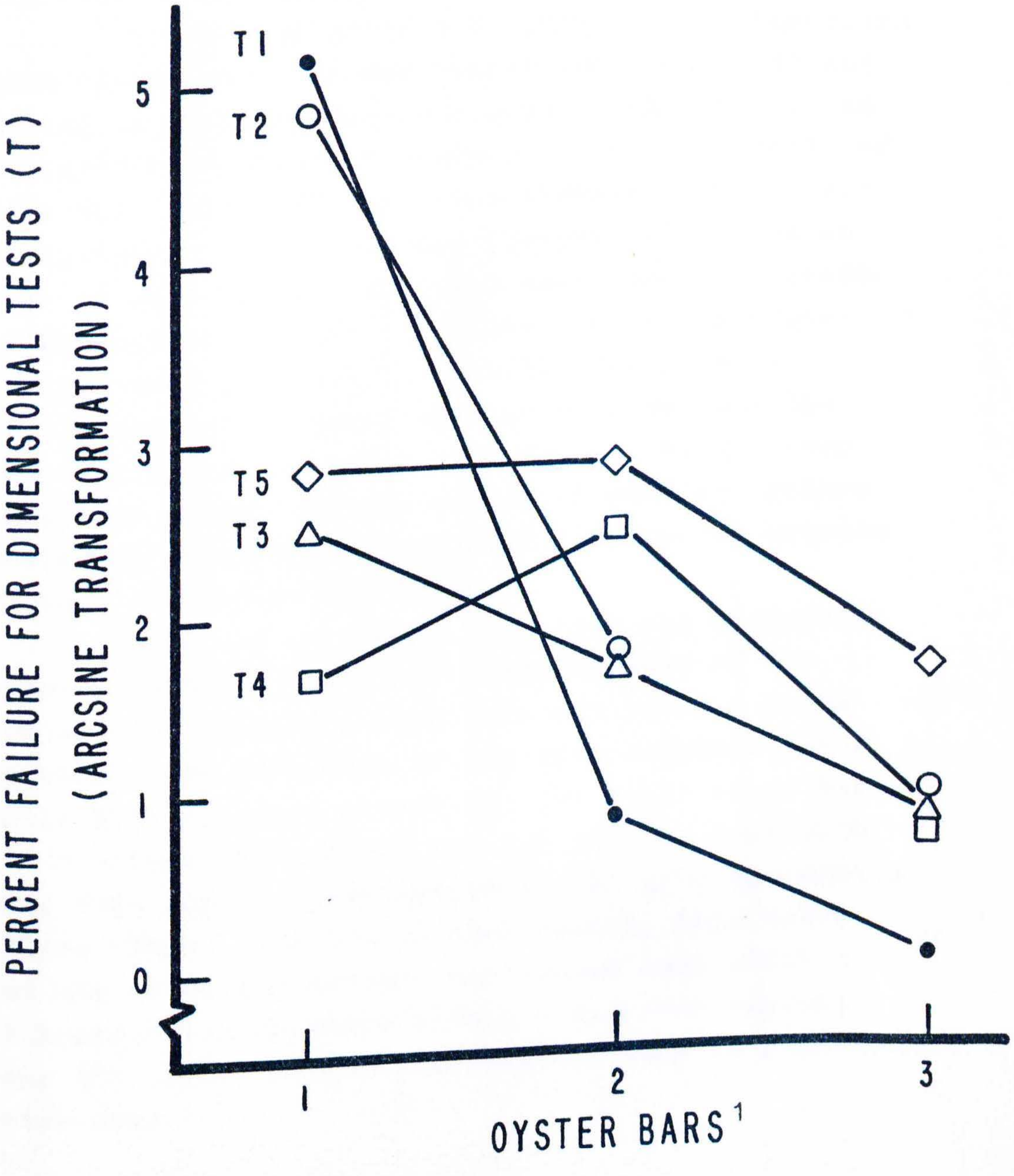

FIGURE 8. RESPONSE GRAPH OF PERCENT FAILURE FOR DIMENSIONAL TESTS ACROSS OYSTER BARS

[1]Bar 1 - Church Hill
Bar 2 - Prison Point
Bar 3 - Buoy Rock

were understood. Consequently, it was necessary to graphically describe separate response graphs for the five orientation tests.

The average percent failure of the dimensional tests across each bar was calculated (Table 15) and plotted as separate response graphs (Figure 8). An examination of Figure 8 revealed that the effects of tests were not consistent over different bars. For bar 1, tests 1 and 2 had the highest failure rates while on bars 2 and 3 the same tests had the lowest failure rates. Across all tests, bar 1 had higher failure rates than bar 3. Overall, no general differences can be found between bars because the tests did not respond the same for all bars. Even though bar 3 had a larger number of smaller oysters (Table 11) there were no general differences between the bars for any of the tests.

There was no single test that was uniformily superior over all the other tests because of the inconsistent effects across bars and tests. Since the confidence intervals of the five selected tests (Table 8) overlapped almost all the other ratio tests with readings between 0.4 and 1.0 inch in from both ends, then any of these ratios should give comparable failure rates. For future application, this means that the orienting sensors can record each width to thickness ratio anywhere within a 0.6 inch segment along the oyster length starting 0.4 inch in from both oyster ends.

CONCLUSIONS

1. A width to thickness ratio produced the lowest oyster failure of all techniques tested.

2. The effects of orientation tests were not consistent over different bars.

3. Over all the bars tested the percent oyster failure was the same for the selected width to thickness ratio tests.

4. The width to thickness ratio tests had the same oyster failure across all bars.

5. Comparable oyster orienting efficiencies can be attained by width to thickness ratios with orienting points located 0.4 to 1.0 inch in from the oyster ends.

CHAPTER 6

EXPERIMENT 2: TROUGH STUDIES

INTRODUCTION

It was proposed earlier that an inclined, V-shaped trough be tested for orientation capabilities. Oysters entering with the long axis at a right angle to the trough length will be rotated 90^{o} by the trough such that they will exit with either the hinge or bill end leading.

The key to trough success is the change in initial oyster orientation. It is hypothesized that oysters will reorient themselves on the trough in a consistent manner such that only one oyster end (hinge or bill) exits the trough first. Consistent oyster reorientation will depend upon trough design and the effect of certain oyster variables. The orienting efficiency of the trough may be low because of the unknown relationships between trough design and oyster variables. However, trough simplicity and low cost are important enough factors to explore its possibilities further.

OBJECTIVES

The objectives of this experiment are:

1. to determine trough orientation efficiency
2. to identify the relationships between one trough design and oyster variables as they affect orientation efficiency.

STUDY VARIABLES

The trough studies were conducted simultaneously with the dimensional orientation experiment. Each oyster was subjected to a series of trough trials after the incremental dimensions were recorded. Because of the large number of trials required to test a trough, only one trough design was tested.

Several oyster variables were identified. These variables were: (1) oyster type, (2) trough loading position, (3) oyster axis, and (4) oyster-trough behavior.

Oyster Type

Oysters were classified into three types: (1) cultchless, (2) clumped, and (3) cultched. The type designations referred to oyster attachment condition. Oysters showing no past or present evidence of physical attachment were classified as cultchless. The evidence of prior attachment consisted of visually examining the oyster hinge area. Any noticeable deformations to the shell exterior were considered evidence of previous attachment. Oysters attached to other shell material or showing physical signs of being previously attached were called cultched oysters. Two or more live oysters attached together were designated as clumped.

Oyster attachment condition was considered a variable because the general shape and deposition of shell material is affected by how an oyster is attached to an object. If the left of lower valve of an oyster is restricted by a solid object, the valve will follow the contour of that object (Quayle, 1969). Hanks (1966) and Budge and Donald (1973) showed how oyster shell deposition and shape were restricted by proper placement on artificial substrates. Hanks (1966) developed a cultch material having inwardly tapered recesses. The cultch shape caused individual oysters to grow with narrow pointed hinge ends and broad bill ends. The restricted cultch recesses alleviated shell curvature and caused most of the shell material to be deposited in the bill region. Budge and Donald (1973) cemented individual oysters onto vertical screens suspended below the sea water surface. The oysters were arranged in a predetermined pattern and spaced such that they grew to a larger size without deforming each other. The cemented valves followed the contour of the screen and because of proper spacing were well rounded.

How an oyster is attached and how long it remains attached can effect shape and shell deposition. The three attachment conditions account for some of this affect and may help in understanding oyster orientation in the trough.

Trough Loading Position

Oysters can enter the proposed trough orienter only with the long axis at a right angle to the trough length (Figure 10). Figure 10 shows one of four possible orientations; right valve down, hinge end left. The four trough loading positions repeated for each oyster were:

1. right valve down, hinge end left
2. left valve down, hinge end left
3. right valve down, hinge end right
4. left valve down, hinge end right

Loading position is important because of its relationship with valve placement. Both oyster valves exhibit general differences in weight and shape. The left valve is usually thicker and heavier than the right valve (Galtsoff, 1964). The left valve generally is cupped while the right valve tends to be flat. These differences in valve shape and weight could affect which oyster end exits from the trough. Depending upon the loading position, valve shape and weight could affect oyster rotation on the trough.

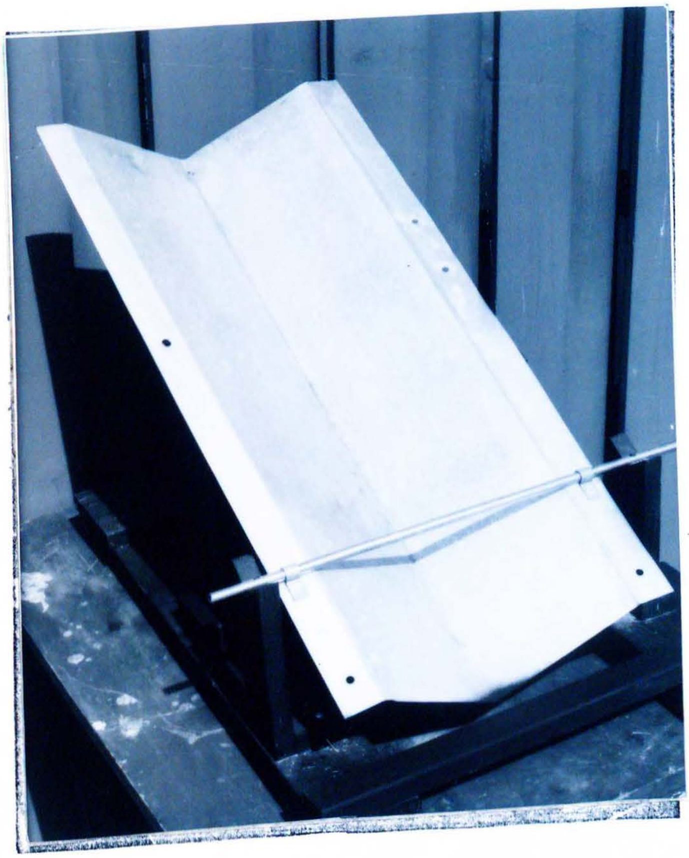

FIGURE 9. INCLINED V-SHAPED TROUGH

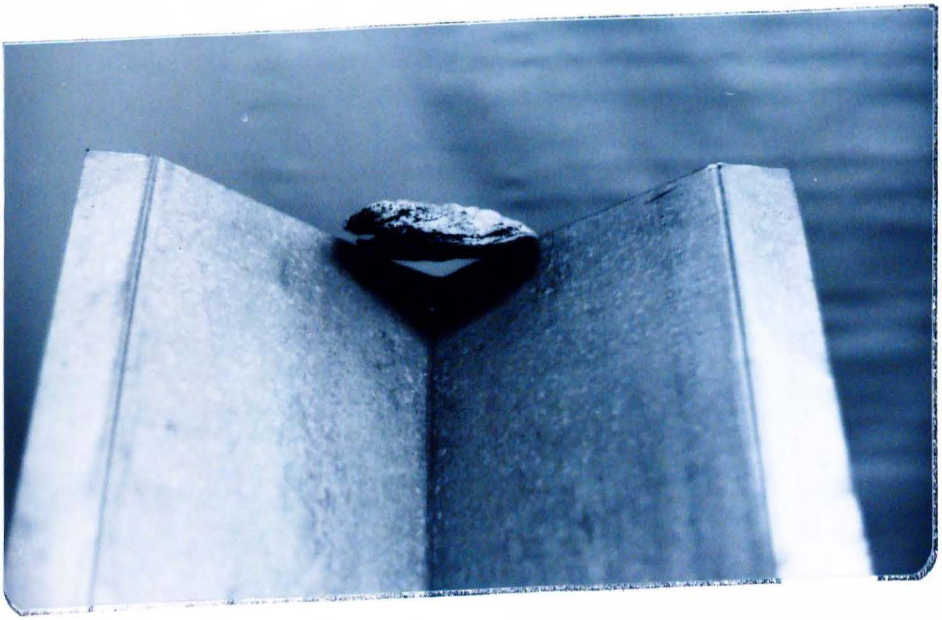

FIGURE 10. TROUGH LOADING POSITION

Oyster Axis

Oyster axis is the direction of shell curvature. Three different axes were defined according to Galtsoff's criteria (Galtsoff, 1964). These axes were: (1) right handed, (2) left handed, and (3) straight axis. Oyster axis or shell curvature direction was determined by placing each oyster on its left valve with the hinge end pointing away from the observer. A left handed oyster, positioned in the above manner, curved to the left. A right handed oyster curved to the right. Oysters showing no curvature were called straight axis oysters.

The importance of shell curvature is related to trough loading position and the differences in valve shape and weight. A left handed oyster positioned in the orientation shown in Figure 10, has its shell curvature directed in towards the trough. Assuming that the long axis of the oyster is at a right angle to the trough length, the bill end should be displaced in a more forward direction than the hinge end. One might expect the bill end to exit the trough first because the heavier left valve, positioned upwardly, would cause rotation in this forward direction. The same oyster positioned with the same valve direction but hinge right, would tend to exit hinge leading. This is because the shell curvature is directed away from the trough placing the hinge end in a more forward direction.

Theoretically, left handed and right handed oysters are mirror images in terms of shell curvature. The oyster ends exiting the trough should then be opposite for the same loading position. A straight axis oyster should be independent of end orientation because of negligible shell curvature. Loading positions with the same valve orientations but different end orientations, should have no affect upon which end exits the trough first.

There appears to be a possible relationship between shell curvature direction and trough loading position. The trough orienting efficiency can be adversely affected if these relationships prove to be true.

Oyster-Trough Behavior

A trial run of the trough was conducted to determine the appropriate trough inclination angle and the behavior of oyster reversal. Oysters either rotated 90 degrees or tumbled valve over valve as they went down the trough. Initially, no specific differences in trough behavior could be identified for either oyster type, oyster axis or loading position.

The reversal behavior, tumble or rotate, was recorded for each of the four loading trials in the final trough study.

EQUIPMENT

Trough

Figure 9 shows the experimental trough unit. A 30 by 15 inch length of 23 gauge galvanized sheet metal was cut and bent parallel to the 30 inch dimension to form a V-trough with a 120 degree inside angle. A piece of pipe, 14 inches long and 0.5 inch O.D., was attached at the lower trough end by two clamps (Figure 9) riveted to opposite sides of the trough. The pipe section was positioned through the clamp openings and fastened to two wooden lateral supports. The pipe allowed the trough to be swiveled up and down thereby changing the trough inclination angle.

A wooden wedge-shaped base was placed under the trough for support.

Data Recording

Trough data was recorded onto the same tape recorder (Panasonic RQ-212DAS) used previously in the dimensional orientation studies.

PROCEDURE

A trial run was conducted to determine the necessary trough inclination angle. The trough was set at inclination angles of 20, 25, and 30 degrees. A number of oysters were then positioned and dropped onto the trough from a height of about 2 to 3 inches from the trough surface. Many of the oysters did not exit the trough at the 20 and 25 degree settings. Almost all small oysters, less than 3.5 inches in length, stopped half-way down the trough. All test oysters slid completely down the trough when it was set at the 30 degree angle. A second trial run was conducted with approximately 200 oysters to verify the 30 degree trough inclination angle. The second trial run verified this setting and all the trough studies were conducted with the trough set at an inclination of 30 degrees.

Trough Studies

Each oyster was first physically examined to identify the specific oyster type and axis. The four trough trials were then carried out in the following order:

1. right valve down, hinge left
2. left valve down, hinge left
3. right valve down, hinge right
4. left valve down, hinge right

For each trial, the oyster was held 2 to 3 inches above the trough entrance with the correct valve up and the long axis of the oyster at right angles to the trough length. The oyster length was then centered over the trough entrance and the oyster dropped. Figure 10 shows the oyster position for Trial 1 (right valve down, hinge left).

The reorientation process occurred as the oyster moved down the trough. Oyster behavior (rotate or tumble) during the reorientation process was noted and recorded as was the oyster end exiting the trough first.

The same procedure was followed for each oyster and trial.

<u>Data Recording</u>

The recorded variables had to be properly ordered and numerically keyed on the recorder so that they could be efficiently transferred onto computer cards. Each variable was given a specific recording position and a numerical abbreviation.

The data was collected and abbreviated in the following order:

1. oyster type (1 digit position)
   - A. cultchless = 1
   - B. clumped = 2
   - C. cultched = 3
2. oyster axis (1 digit position)
   - A. left handed = 1
   - B. right handed = 2
   - C. straight axis = 3
3. trough trials (2 digit position repeated sequentially 4 times)
   - A. first digit: end exiting trough
     1. hinge end = 1
     2. bill end = 2
   - B. second digit: oyster behavior
     1. rotate = 1
     2. tumble = 2

The number of variables required 10 data points to be recorded for each oyster. Since it was impossible to remember and record all 10 points at once, the data was sequenced into 3 parts and recorded. The oyster axis and type were first recorded. Then, trial 1 and trial 2 of the trough studies were conducted and the results numerically recorded. Finally, trial 3 and trial 4 were carried out and the results recorded.

The key variable names were recorded for each data position to assure that correct and proper sequencing of recorded data was maintained.

RESULTS AND DISCUSSION

Two variables, oyster type and oyster-trough behavior, were not analyzed for trough orientation effects. Each bushel contained between 4 to 19 clumped oysters prior to random sampling. After sampling, the number of clumped oysters was even smaller, thus making an analysis of this type impractical. The three oyster type designations were further complicated by a biased sample from bar 1; Church Hill. This sample, obtained commercially from Bucks Seafood on Tilghmans Island, was sorted and declumped prior to sale making it impossible to distinguish between cultched and clumped oysters.

Only two forms of oyster-trough behavior were characterized during the trial runs; rotate and tumble. A third form of behavior became evident during the last part of the critical trough experiment. Many left and right handed oysters "flipped" or rotated one-half turn about their long axis in addition to the above described behavior when positioned on the left valve. Since left and right handed oysters accounted for almost 67 percent of the total sample (calculated from Appendix E, Table E-4), and since trough behavior was not characterized correctly for the two left valve trials, a significant portion of the data was not taken. Failure to appreciate the significance of "flipping" behavior made analysis of oyster-trough behavior data worthless.

Statistical Analysis

Counts of hinge and bill leading oysters exiting the trough were analyzed for four different loading positions and three oyster axes. The purpose of the analysis was to determine whether there were any differences in the oyster ends exiting the trough for the different loading positions and oyster axes.

The enumeration statistical method employed consisted of arranging the data in Appendix E into contingency tables and analyzing the tables with the chi-square statistic. Analysis of the bar and axis data tested the hypothesis that the proportion of hinge and bill leading oysters was independent of loading position. The 5 percent significance level (s. = significant) determined the chi-square critical value for all contingency table analysis.

Since the enumeration data was being tested on two variables, loading position and oyster end exiting the trough, a series of 4 by 2 and 2 x 2 contingency tables were set up and analyzed according to procedures by Steel and Torrie (1960) and Zar (1974).

Table 16 shows an example of one of the 4 by 2 contingency tables. The procedure used in Table 16 required an estimate be made of the observed probability associated with one category for each row of the table. Estimates of these observed probabilities are symbolized by "pA" where "p" is the observed proportion associated with hinge leading oysters for each loading position, and "A" is the number of hinge leading oysters. The total observed proportion of hinge leading oysters for all loading positions is denoted by "P".

Tables 17 and 18 summarize the results for a series of contingency tables conducted on the bar and axis data (Appendix E). Initially, the analysis was carried out on all four loading positions and in each case resulted in a large chi-square, indicating a lack of independence of the variables. The procedure for locating causes of significance was conducted according to Steel and Torrie (1960). The procedure consisted of

TABLE 16. OYSTER END EXITING TROUGH FOR CHURCH HILL BAR WITH FOUR TEST ORIENTATIONS

Oyster Orientation	Hinge Lead(A)	Bill Lead	Total	p	pA
1. Right valve down, hinge left	307	503	810	.379	116.353
2. Left valve down, hinge left	296	514	810	.365	108.040
3. Right valve down, hinge right	491	319	810	.606	297.546
4. Left valve down, hinge right	253	557	810	.312	78.936
Totals	1347	1893	3240		600.875
			P=1347/3240=.416		560.352

$$\text{Chi-square} = \frac{600.875 - 560.352}{.416\ (1-.416)} = 166.760 \text{ with 3 d.f., s.}$$

degrees of freedom (d.f.) = (rows-1) (columns-1) = (4-1) (2-1) = 3

TABLE 17. SUMMARY OF CHI-SQUARE VALUES FOR CONTIGENCY TABLES ON EACH OYSTER BAR

Comparisons[1]	Bar 1 Church Hill	Bar 2 Prison Point	Bar 3 Buoy Rock	Bar Total
1, 2, 3, 4	166.8 s. P<.001	219.8 s. P<.001	378.5 s. P<.001	585.2 s. P<.001
1, 2, 4	8.8 s. .01<P<.025	153.8 s. P<.001	363.5 s. P<.001	360.9 s. P<.001
1, 2	.33 n.s .50<P<.75	34.8 s. P<.001	164.5 s. P<.001	114.4 s. P<.001
3, 4	141.1 s. P<.001	178.9 s. P<.001	164.2 s. P<.001	459.4 s. P<.001
1, 3	81.9 s. P<.001	45.0 s. P<.001	55.3 s. P<.001	172.0 s. P<.001
2, 4	3.9 s. .025<P<.05	159.3 s. P<.001	316.1 s. P<.001	351.4 s. P<.001

[1] Comparisons numerically keyed:
1 = right valve down, hinge left
2 = left valve down, hinge left
3 = right valve down, hinge right
4 = left valve down, hinge right

TABLE 18. SUMMARY OF CHI-SQUARE VALUES FOR CONTIGENCY TABLES ON EACH OYSTER AXIS OVER ALL BARS

Comparisons[1]	Left Handed Oysters	Right Handed Oysters	Straight Axis Oysters	Bar Total
1, 2, 3, 4	896.8 s. P<.001	76.3 s. P<.001	42.9 s. P<.001	585.2 s. P<.001
1, 2, 4	449.3 s. P<.001	10.8 s. .001<P<.005	42.6 s. P<.001	360.9 s. P<.001
1, 2	105.6 s. P<.001	3.4 n. s. .05<P<.10	11.3 s. P<.001	114.3 s. P<.001
3. 4	791.2 s. P<.001	72.1 s. P<.001	6.9 s. .01<P<.005	459.4 s. P<.001
1, 3	350.9 s. P<.001	28.4 s. P<.001	1.4 n. s. .10<P<.25	172.0 s. P<.001
2, 4	410.6 s. P<.001	2.0 n. s. .10<P<.25	36.8 s. P<.001	351.2 s. P<.001

[1] Comparisons numerically keyed:
1 = right valve down, hinge left
2 = left valve down, hinge left
3 = right valve down, hinge right
4 = left valve down, hinge right

eliminating the rows which appeared to be the cause of the significance and running a new test of significance on the reduced data. In almost every new test significant results occurred indicating that the proportion of hinge and bill leading oysters was not the same for the loading positions.

In order to explain the significant differences between loading positions and the oyster orientation exiting the trough, it was necessary to investigate theorized trough behavior.

<u>Oyster bars</u>. Analysis of the bar results yielded little information in explaining the action of the trough. The most significant finding from Table 17 was that the proportion of hinge and bill leading oysters was significantly different over each bar for the four trough loading positions ($P<.001$) This proves the inefficiency of an inclined V-shaped trough in orienting oysters since efficiency was dependent upon bars and loading positions.

<u>Left handed oysters</u>. The very large chi-square values in Table 18 can be partially explained by the previously stated theory of a mirror image effect for left handed oysters. When all left handed oysters are considered, the ratio of bill to hinge leading oysters is 2 to 1 for the first right valve position while for the second right valve position, the ratio is 1 to 2 (Table E-1, Appendix E). The mirror image effect is still evident on individual bar results, but the proportion between hinge leading and bill leading oysters varies widely. Although individual bar ratios are too heterogeneous to justify a significant mirror image over all bars and oysters, the trend towards a mirror image effect is a possible cause of the large chi-square value for the comparison between right valves (Table 18).

The data in Table E-1, Appendix E shows no likelihood of a mirror image effect for left handed oysters positioned on the left valve. The great orientation differences between right and left valve positioning may be attributable to the unrecorded "flipping" associated with left handed oysters positioned on the left valve.

<u>Right handed oysters</u>. Trough orientation results for right handed oysters did not agree with expectations. For any hinge left loading position, there were no significant differences ($.05<P<.10$) between the proportion of hinge and bill leading oysters (Table 18). This means that for all right handed oysters the proportion of hinge and bill leading oysters was the same regardless of valve positioning. Theoretically, results for right handed oysters should be the reverse of left handed oysters. This reversal is seen in only two instances from the data in Appendix E. The bar results show a reversal for the two oyster types with right valve positioning (Table E-1 and E-2, Appendix E). Over all bars, only the second right valve loading position displays the reversal (Table E-4, Appendix E).

<u>Straight axis oysters</u>. Earlier, it was theorized that trough orientation of straight axis oysters was independent of loading positions when the same valve orientation was used, because shell curvature is lacking in straight axis oysters. If the theory was correct, trough results should be identical for both right valve loading positions and for both left valve loading positions. There appears to be a tendency for straight axis oysters to follow the theory, but the hinge and bill leading proportions vary too much from one loading position to another to support independence of loading position (Table E-3, Appendix E).

Over all bars straight axis oysters had the smallest chi-square value in comparing the proportion of hinge and bill leading oysters for all four loading positions (Table 18). Although there are significant differences in the proportions between each loading position (P<.001), the smaller chi-square may indicate a tendency for straight axis oysters to follow proposed theory.

The proportion of straight axis hinge leading and bill leading oysters was the same over all oysters for right valve down positions (Table 18). This significant result does verify proposed theory, but it is not statistically justified. The individual bar data was too heterogeneous to justify pooling and computing a chi-square (Table E-3, Appendix E).

The tendency for the three oyster axes to behave differently explains some of the differences in the trough's orienting efficiency. However, there were no significant relationships between orienting efficiency and oyster axes.

CONCLUSIONS

1. An inclined V-shaped trough operating under set conditions is not efficient in orienting oysters.

2. There are significant differences in the proportion of hinge and bill leading oysters exiting the trough for each trough loading position over all bars and oyster axes.

3. There does appear to be a tendency for specific oyster axis types to orient in some known manner on a V-trough, but this tendency is not statistically significant.

4. Within all bars, there are no mirror image effects for both left and right handed oysters.

CHAPTER 7

CONCLUSIONS

The conclusions of this research were:

1. A width to thickness ratio produced the lowest oyster failure of all dimensional orienting methods; less than 0.50 percent.

2. Over all the bars tested the percent oyster failure was the same for the five different width to thickness ratio tests.

3. The width to thickness ratio tests had the same oyster failure across all three bars.

4. Comparable oyster rejection rates can be attained by width to thickness ratios with orienting points located 0.4 to 1.0 inches in from the oyster ends.

5. Oysters from different bars result in different rejection rates using the same orienting method for several methods tested.

6. The inclined V-shaped trough was not efficient in orienting oysters.

7. Significant differences existed in the proportion of hinge and bill leading oysters for each trough loading position over all bars and axes.

8. Within all bars tested, no mirror image effects existed for both left and right handed oysters.

9. Only 20 to 25 oysters per hour could be handled using the oral recording technique.

CHAPTER 8

RECOMMENDATIONS FOR FUTURE STUDY

1. The magnitude of the differences between each pair of orienting points for the five width to thickness ratio tests should be calculated and compared. The greater the difference the easier it is in distinguishing between the oyster ends.

2. Actual tests should be conducted with a photoelectric device to determine if dimensional orientation results are applicable.

3. Investigation should be initiated to develop a re-orienting device for rotating oysters 90 degrees.

4. Width to thickness ratio data should be investigated as a means for quantifying oyster shape.

5. All dimensional data should be compiled as a reference source on the dimensional properties of oysters.

6. Develop automatic oyster dimensional measuring device.

7. Additional research into the design of oyster shellstock washing and singulation equipment should be undertaken. The investigation should include a patent search on shellstock washing and an appraisal of the work by Shawver and Henderson (1972) for singulation purposes.

8. A method for dimensionally determining the location of the adductor muscle spot from the shell exterior should be investigated. If the location of the adductor muscle can be dimensionally defined, the operation can be combined with the orientation subsystem.

APPENDIX A

ECONOMIC ANALYSIS

I. Calculation of Number of Oysters Per Average Gallon (Wheaton, 1972)

No. oysters/gal = (No. oysters/gal standards) (% standards) + (No. oysters/gal selects) (% selects) + (No. oysters/gal extra selects) (% extra selects) + (No. oysters/gal counts) (% counts)

= 400(.5) + 225(.4) + 185(.05) + 140(.05)

= 306 oysters/average gal

II. Assumptions of Manual Orientation

1. Feed rate of 3600 oysters per hour.
2. Two orientation operators.
3. Each operator will be paid $3.00 per hour.
4. The operators will orient all oysters correctly.
5. Operators will work 6 hours per day, 4 days per week, 30 weeks per year, for a total of 720 hours per year.

From these assumptions, 2 operators will earn each year:

earnings = (2 operators) (720 hrs/yr) ($3.00/hr)

earnings = $4,320 per year

With fringe benefits (11% of base pay) it would cost a processor:

cost = (earnings) + (earnings) (.11)

cost = $4,795.20 per year

Therefore a processor will have to pay $4,795.20 per year to maintain a manual orienting operation.

III. Assumptions of Mechanical Orientation

1. Average gallon of oysters contains 306 oysters.
2. Capacity rate of 3600 oysters per hour or 11.76 gallons per hour.
3. Oysters have a product value of $10.00 per gallon (lower limit) and $12.00 per gallon (upper limit).
4. The device operates 720 hours per year.
5. All oysters not oriented correctly are considered a total loss.

Calculation of product value loss with an orienting device operating at 95 percent efficiency.

at \$10/gal:

Product value loss/yr = (% failure) (no. gal/hr) (no. hrs/yr) (cost/gal)

= (.05) (11.76) (720) (10)

= \$4,233.60

at \$12/gal:

Product value loss/yr = (.05) (11.76) (720) (12)

= \$5,080.32

APPENDIX B

ANNOTATED BIBLIOGRAPHY OF U.S. SHELLFISH SHUCKING PATENTS

1. Torsch, E.L., and J.H. Parker.
1907. Process of shucking oysters. U.S. Pat. No. 848,608.

Raw oysters are manually fed to a machine consisting of a rotating wheel with oyster grippers and grinding wheels attached to it. The grippers automatically pick up the oysters and carry them past successive grinding wheels for removing the hinge portion. Two hook like mechanisms then enter the ground-off-ends of the oysters and spread the valves apart. Flexible knives enter between the shell spreaders, follow the interior contour of the shells, and sever the adductor muscles. Thereafter, the oyster is inverted to discharge the meat from between the blades.

Orientation desired: horizontal position on the oyster loading station with hinge end facing the operator.

Orientation device: manual.

2. Torsch, E.L., and J.H. Parker.
1907. Machine for shucking oysters. U.S. Pat. No. 848,784.

Same as U.S. Patent No. 848,608.

3. Mandvill, A.P.
1922. Oyster opening machine. U.S. Pat. No. 1,439,181.

Oysters are fed from a funnel shaped hopper onto an intermittently moving conveyor belt. The belt consists of a number of connected links with every other link having a vertical flange on one side. Attached perpendicular to the flange is a block containing a clamping finger which holds the oyster. As oysters are fed from the hopper, an operator places the oysters left valve uppermost with the hinge end disposed against the flange and under the spring fingers. After an oyster has been properly positioned, it is conveyed to two wedge shaped knives. The first blade enters from the bill end between the two halves of the shell and pries the shell apart. At the same time, the blade cuts the oyster loose from the bottom portion. The top part of the shell and attached meat is then carried by a lever arm to the second knife. The lever arm is fixed with spring clips at its end which engage the remaining top shell and position it for the final muscle cutting.

Orientation desired: horizontal position, left valve (cupped) uppermost with the hinge or dorsal end perpendicular to the direction of flow.

Orientation device: manual.

4. Egli, H.
1923. Oyster shucking machine. U.S. Pat. No. 1,445,672.

Raw oysters are processed on a horizontal rotating table. Several mechanisms for positioning the oysters, opening the shells, severing the adductor muscles, and then extracting the meats from between the shells are mounted on the table. As a preliminary step before shucking, the edge of the bill is broken off so that the shell spreaders and muscle knives can operate properly. After the bill has been broken, an operator places an oyster in a vertical position, hinge end uppermost, under a holding clamp. At the same time, the operator aligns the bill such that a wedge, in the shape of an inverted "V", enters the broken bill. The wedge is composed of two sections and spreads the valves apart where two knives then enter from beneath the table and sever the adductor muscles. Once the oyster shell is opened and both ends of the muscles severed, an extractor moves radially outward, between the parted shells, carrying on its serrated edge the oyster meat. The meat is then deposited in a receptacle.

Orientation desired: vertical position, hinge end uppermost.

Orientation device: manual.

5. Doxsee, J.H.,Jr., and W.H. Cook.
1935. Apparatus for shelling mollusks. U.S. Pat. No. 2,008,820.

This device is a tumble-separator for steamed clams. Clams are conveyed by a bucket elevator to a steam box where they are heated for about 20 minutes. The clams are first steamed to open the shells and loosen the meats from the shells. From the steam box, the clams are transferred by a chute onto a pair of conveyor belts arranged side by side. Mounted one inch from the surface of the belts are three diverting barriers for agitating the clams. The interaction of the clams on the barriers separates the meats from the shells. As the clams are deposited onto the first conveyor, they come in contact with the first barrier. Any meats which become separated at this point pass under the barrier and remain on the belt, while the empty shells and the shells still containing meats are diverted by the barrier onto the second belt. The shells and meats are again agitated by another barrier raised one inch above the belt. At the second barrier, the shells are diverted through an opening and fall off the belt. The meats pass under the second barrier and come in contact with the third barrier. The third barrier is placed flush with the belt and diverts the meats back onto the first belt where all the meats fall off into a receptacle.

Orientation desired: none, batch process.

Orientation device: none.

6. Jenkins, M.B.
1936. Method of processing edible bivalves. U.S. Pat. No. 2,047,688.

This invention is directed to the continuous processing of small clams, the particular species being _Donax laevigate_. The process comprises cooking the bivalves to open the shells, tumbling the cooked bivalves to free the meats, and separating the meats by flotation. The apparatus is divided into the following major elements: a rotary screen, a sorting conveyor, a cleaning tank, a rotary cooker, an extractor, and a separator. Clams are fed from a hopper into a rotary screen that is perforated peripherally. Two spray nozzles direct a stream of water onto the clams, separating sand from the bivalves. The sand passes through the screen perforations into a drain pan and discarded. The clams drop from the rotary screen onto a sorting conveyor where rocks and other foreign matter are manually removed. After being sorted, the clams enter the cleaning tank where they are brushed and rinsed. Within the cleaning tank is a belt made up of an endless series of interlinked brushes having steel bristles. The bottom of the tank is corrugated so that the clams are turned over a number of times to be cleaned on all sides. The clams are then rinsed to remove debris resulting from the brushing operation. The clams enter a rotary cooker composed of a long horizontally displaced cylindrical shell. A series of burners extends longitudinally under the cooker. Within the shell is a spiral plate extending its entire length which moves the clams through the cooker. The meats are loosened from the shells by means of a horizontal rotating drum. Within the drum is a number of radially inwardly extending spikes which agitate the clams as they are being tumbled. After the meats have been freed from the shells, the product enters the separator. Here a ribbed conveyor belt carries the meat-shell products under a water spray. The shells are caught by the ribs and the water carries the meats off the belt into a strainer.

Orientation desired: none, batch process.

Orientation device: none.

7. Doxsee, J.H.,Jr., and W.H. Cook.
1937. Method of shelling mollusks. U.S. Pat. No. 2,102,945.

This method consists of a tumble-separator for steamed clams. The present invention is similar in design and theory of U.S. Patent No. 2,008,820. Unlike the previous patent, this invention characterizes the dual belt-barrier system in much more explicit detail.

Orientation desired: none, batch process.

Orientation device: none.

8. Geldermans, J.E., and A. Hond.
1943. Process of separating shells and meats of bivalve shellfish. U.S. Pat. No. 2,337,188.

Mussels are supplied from a feed container onto a conveyor belt and pass through an oven where they are subjected to a temperature of about 1100° C. for 8 seconds. The mussels exit from the oven and fall 7 feet upon a rotating cylinder. The impact of the heated shellfish upon the cylinder causes the meats to be separated from the shells. The uncooked meats are then separated from the shells in a flotation tank containing a solution of common salt. The flotation tank is mounted beneath the rotating cylinder. For a heating temperature of a 1100 C. and a heating time of 4 seconds, the average temperature of the meats on leaving the oven is 48 C. and, at a heating time of 15 seconds, 55 C.

Orientation desired: none, batch process.

Orientation device: none.

9. Harris, S.G.
1952. Method for recovering oysters. U.S. Pat. No. 2, 608,716.

Steamed oysters are processed in a tumble and spray separator. Oysters are preliminarily washed and then steamed at a temperature of 240 F. for 9 minutes. The oysters are then fed into an inclined rotating drum 10 feet long, 4 feet in diameter, rotating at 20 to 22 r.p.m. The wall of the drum is constructed of spaced longitudinal pipes with openings such as to pass the oyster meats while holding back the shells. Within the drum are a plurality of baffles for raising the oysters. The fed oysters are picked up by the baffles, raised to near the top of the drum, and then allowed to fall. The resulting impact separates the meats from the shells. A water pipe extending lengthwise within the drum directs jets of water upon the oysters, facilitating separation of meats from the shells. The meats fall into a collecting pan beneath the drum. The meats are transferred to a flotation tank where any shell fragments are removed.

Orientation desired: none, batch process.

Orientation device: none.

10. Harris, S.G.
1953. Apparatus for recovering oysters. U.S. Pat. No. 2,652,588.

Steamed oysters are processed in a tumble and spray separator. This device is the same as the apparatus described in U.S. Pat. No. 2,608,716.

11. Skrmetta, R.Q.
1958. Oyster shucking machine. U.S. Pat. No. 2,818,598.

This device is a tumble-separator for steamed oysters. In its broadest scope, this invention primarily consists of passing oysters through a plurality of impact members which serve to dislodge the meat from the shells. Since three forms of the apparatus are described, only the preferred form of the device will be reviewed. Steamed oysters are conveyed to the top of a vertical tower where they fall onto a series of impact members. Each impact member or rotor consists of a number of elongated blades fastened to two end plates. The rotors are spaced longitudinally in the tower and revolve in such a direction as not to impede the vertical flow of oysters. Adjacent to each rotor is an inclined vibrating screen and water spray. Any meats dislodged from the shells by the impact of the blades of the first rotor, fall through the screen and are washed down a discharge chute into a collecting trough. The separating action is repeated by a series of rotors until the oysters reach the bottom of the tower where they are screened once more and the emptied shells are removed by a discharge conveyor.

Orientation desired: none, batch process.

Orientation device: none.

12. Seal, R.D., and S.G. Harris.
1958. Apparatus for recovering the meats of bivalves. U.S. Pat. No. 2,823,414.

Steamed oysters are processed in a tumble and spray separator. After oysters have been preliminarily processed by steaming, they are fed into a rotating cylindrical drum. The wall of the drum is constructed with continuous circumferential openings of a width such as to pass the meats while holding back the major portion of the shells. Within the drum are a plurality of baffles for raising the oysters and allowing them to fall as the drum rotates. The baffles lie at an angle of about 30^{o} to the drum axis, so that oysters are advanced along the drum each time they are lifted and dropped. Mounted within the upper part of the drum is a water pipe which discharges jets of water to facilitate the movement of the meats through the drum openings. A collecting pan of sheet metal is mounted such that it extends along the sides and bottom of the drum. As the drum rotates, oyster meats are separated from the shells and are discharged through the drum openings upon the inner surface of the pan. The meats slide down the pan to pass through a discharge opening in the bottom of the pan and enter a liquid tank. They are then removed from the tank by a belt conveyor for packaging.

Orientation desired: none, batch process.

Orientation device: none.

13. Strasburger, L.W.
1958. Method of recovering the meats of bivalves. U.S. Pat. No. 2,824,005.

In this invention, a method is related of producing steamed oysters for later canning. After the oyster shellstock has been washed, the oysters are packed in steel crates and transferred to a heated brine tank. The bivalves are soaked for a period from 3 to 8 minutes in a brine solution at about 60° F. The solution is heated to a temperature ranging from 110° F. to 160° F. by a pipe coil on the bottom of the tank supplied with steam. The soaking of the oysters in the hot brine causes the oysters to gape and open. The salt brine enters the shells, changes the density of the oyster liquor, and causes the adductor muscles to become weakened. Following the soaking, the oysters are cooked in a standard steam box or retort by exposing them to a temperature from 235° F. to 260° F. for a period from 4 to 20 minutes. The pressure of the steam box ranges from 8 lbs. to 20 lbs. The crates of oysters are then removed from the steam box and the separation of the meat from the shells is completed by agitation, as by use of a rotary drum of the Harris Patent 2,652,588.

Orientation desired: none, batch process.

Orientation device: none.

14. Harris, S.G.
1958. Method of recovering meats of bivalves. U.S. Pat. No. 2,832,989.

Whole oysters are fed into a rotating cylindrical drum where they are simultaneously washed and mechanically shocked. The application of the shock weakens the hinge ligament and the adherence of the adductor muscles, so that subsequent opening of the shells is facilitated. The oysters are then steamed for a period of 4 to 25 minutes at a temperature from about 220°F. to 260°F. at 2½ to 20 lbs. pressure. The cooked oysters are then discharged onto a perforated belt submerged in a brine flotation tank. Some of the meats, which are wholly released from their shells, float free to the surface; while others, which are still connected to their shells, are carried into the brine. As the oysters travel along the belt, the belt is subjected to agitation from beneath by action of mechanical beaters, causing the shells to bounce up and down. Such agitation releases any meats adhering to the shells. The shells are discharged as the belt rises out of the brine, and the meats are collected at an overflow opening in the flotation tank.

Orientation desired: none, batch process.

Orientation device: none.

15. Rey, H.D.
1960. Method of opening oysters. U.S. Pat. No. 2,942,292.

Oysters are manually placed onto a conveyor formed from two spaced roller chains. Attached to one chain are a number of angle pieces having horizontal ledges. The other chain has vertical pieces of metal attached to it. An oyster is placed flat valve down with its bill resting on the horizontal ledge and its hinge supported by the vertical pieces. Between the two conveyor chains is an elongated electrical heating rod situated such as to heat the adductor muscle area at a temperature from 1000°F. to 1500°F. for about 10 to 20 seconds. After one of the muscle attachments has been released, the oyster is manually placed in an edgewise position onto a lever actuated wedge. As the lever is depressed, a conical point is forced between the shell valves, forcing the valves apart. Once the valves are opened, a knife is manually inserted from the hinge end and the remaining adductor muscle is severed.

Orientation desired: For the conveyor unit, oysters are placed with their right valves down; all bills placed on the horizontal ledges of the angle pieces. At the lever actuated shell spreader, oysters are placed in a vertical position with the hinge end uppermost.

Orientation device: manual.

16. Lapeyre, F.S., J.M. Lapeyre, L.E. Demarest, and R.F. Couret.
1961. Process for the recovery of oyster meats. U.S. Pat. No. 3,007,801.

Frozen oysters are processed in a tumble-separator. In the principal form of the invention, oysters are conveyed to a rotary inclined drum affixed with spiral vanes. Extending lengthwise near the bottom of the drum is a central anvil fastened to an oyster meat recovery flume. Constructed around the drum is a brine flotation tank. As oysters enter the drum, the spiral vanes lift the oysters, dropping them upon the anvil, thus breaking apart the shells. The frozen meats collect in the flume and are discharged out of the tank. The shells are conveyed from the bottom and discarded.

Orientation desired: none, batch process.

Orientation device: none.

17. Lapeyre, F.S., J.M. Lapeyre, L.E. Demarest, and R.F. Couret.
1962. Machine for shucking oysters. U.S. Pat. No. 3,037,237.

A division of U.S. Patent No. 3,007,801. Similar in theory and design.

18. Matzer, R.F., and E. Seidel.
1965. Material handling apparatus. U.S. Pat. No. 3,203,034.

Cupped fingers pick up and convey calico scallops (<u>Aequipecten gibbus</u>) past a series of gas burners. The direct flame contact on predetermined zones of each shell causes a release of the adductor muscles. A pair of cooperating rollers having mating cavities receive the bivalves and the shearing action of the rollers separates the valves. The meat is then separated from the shells in a brine flotation tank.

Orientation desired: unclear.

Orientation device: unclear.

19. Marvin, J., and T. Henderson, Jr.
1966. Apparatus for recovering flesh from bivalve mollusks. U.S. Pat. No. 3,230,578.

Clams are fed through a mechanical filter, where they attain an on-edge position, onto a pair of inclined rollers. The rollers, rotating in opposite directions, convey the clams hinge end uppermost past a pair of gas burner pipes. The direct flame contact causes the clams to open draining the juices, and thus preventing overcooking. The clams are then dropped onto a second pair of inclined rollers and gas pipes. Direct flame contact releases the meat from the shell and a vacuum nozzle gathers the meat.

Orientation desired: vertical position, hinge end uppermost.

Orientation device: vibrating V-shaped trough and a pair of inclined rollers rotating in opposite directions. The V-shaped trough acts as a mechanical filter accepting only those clams which enter edgewise. The vibration causes the on-edge clams to be fed to the pair of rollers. The rotation of these rollers in opposite directions tends to lift the clam from between the rollers and reduces the static friction forces between the clams and the rollers. The rollers are spaced a sufficient distance apart that when the clam is rotated to dispose its mantle edge bottommost, thereby positioning its hinge uppermost, its center of gravity is below its point of contact with the rollers. Thus, initially clams traveling along the rollers may be in any vertical position, but because of the location of the center of gravity relative to the rollers, the clams roll upon an imaginary lateral axis until their centers of gravity are in their lowermost position.

20. Marvin, J. and T. Henderson, Jr.
1966. Method for recovering flesh from bivalve mollusks. U.S. Pat. No. 3,230,580.

A division of U.S. Patent No. 3,230,578. Similar in design and theory.

21. Lapeyre, J.M., and R.F. Couret.
1966. Process and machine for opening bivalves.
U.S. Pat. No. 3,239,877.

Oysters are processed by first immobilizing both valves of an oyster, then rotating the lower valve to break the hinge joint between the valves and to sever the adherence of the adductor muscle from one of the valves. Frozen oysters are placed onto a conveyor comprised of spaced chains affixed with pallets. Each pallet is provided with a group of holes in number and position corresponding to the upstanding pins of an oyster clamping member located beneath the conveyor. Located above the conveyor is another clamping member with shell grasping pins. Once an oyster is positioned between both clamping members, the lower valve is contacted by the rising pins which deform to cavity patterns of the oyster shell. The rising pins lift the bivalve from the pallet to an elevation where the downwardly projecting pins of the upper clamp engage the upper valve. On the final upward movement of the lower clamp member, the bivalve is tightly clamped. After the locking operation, the handle of a twist valve is thrown so as to admit fluid under pressure and rotate the lower clamp member. This rotation will effect corresponding rotary movement in the lower valve while the upper valve is immobilized to the upper clamp member. The result is severing of the hinge joint and the adductor muscle from the top valve. The oyster is then freed from the clamping operation and a knife is manually employed to sever the adductor muscle from the lower valve.

Orientation desired: horizontal position, right valve (flat) uppermost, bill pointing in direction of flow.

Orientation device: manual.

22. Brown, C.T.
1967. Apparatus for removing scallops from their shells.
U.S. Pat. No. 3,320,631.

Scallops are manually loaded onto pivoted feeding trays on a rotatable vacuum head. After the trays have been heated electrically for 6 seconds to cause release of the bottom valve, a lever flips the scallops against suction cups of the vacuum head. A foot lever is depressed to rotate the head at a speed from about 1200 to 2000 r.p.m. for a few seconds. Centrifugal force throws the heated shells and viscera against sloping walls of the head from where they pass down a chute to a debris receptacle. Recessed heaters in the suction cups are then energized for about 2 seconds to loosen the scallop muscle on the remaining half shell. The vacuum head is again rotated to separate the meats. The vacuum is cut off and the shells pass into the debris receptacle.

Orientation desired: horizontal position, all hinges placed against the loading tray lip.

Orientation device: manual.

23. Meyer, L.
1968. Means for processing scallops for the market. U.S. Pat. No. 3,417,423.

Whole scallops are delivered from a chute onto a wire screen conveyor belt. The randomly spaced bivalves travel under a series of perforated steam pipes. The steam rapidly heats the shells of the scallops causing them to open. The heated yet raw scallops fall from the conveyor onto a meshed vibrating screen where the meats are separated from the shells. The mesh is too small to permit passage of the shells but large enough to pass the meats to an eviscerator. The viscera is removed from the meats by means of a rotating cylindrical brush.

Orientation desired: none, batch process.

Orientation device: none.

24. Meyer, L.
1969. Means for processing scallops for the market. U.S. Pat. No. 3,465,382.

A division of U.S. Patent No. 3,417,423. Similar in theory and design.

25. Evans, L.A.
1969. Apparatus for shucking bivalves. U.S. Pat. No. 3,473,191.

There is provided in this invention an apparatus for shucking bivalves, principally raw oysters. The shucking machine consists of an electrically heated tunnel type oven and a conveyor track attached with individual bivalve holder arms. Associated with the holders are shielding elements for protecting the hinge and bill portions of the bivalves from being burned. Oysters are manually placed in the holder arms in a vertical position, bill end uppermost. After the holder automatically closes on one of the valves, the operator pulls the upper shield assembly over the bill. The holders move on into the oven where the oysters are exposed not only to the hot atmosphere in the chamber but also the radiant heat of the chamber walls. Depending upon oyster size, age and locality of waters taken, the oven is heated to a temperature of between 1200°F. and 2000°F. for between 14 and 25 seconds. Before the oysters exit from the oven, they are subjected to a vertical shaking motion which causes the meat to peel away from the shell. Upon emerging from the oven, each oyster is sprayed with water from a nozzle. Coincident with the spray step, the shield assembly of the bill is released by the engagement of an actuator element. Thus, the shell is free to open under the action of the hinge ligament, together with the action of the water spray. The holder arms then begin to turn in a downward direction as they are conveyed on the track. Half-way through the turn, a downward thrusting motion is generated to the holder arms, causing the meat to be ejected out of the shells into a wash tank. The holder arms automatically open, dropping the empty shells for disposal.

Orientation desired: vertical position; bill end uppermost. Also the left valve of the oyster is placed such that it faces the left or dorsal side of the bivalve holder arm.

Orientation device: manual.

26. Wenstrom, R.T., and T.S. Gorton,Jr. 1970. Method of shucking shellfish. U.S. Pat. No. 3,528,124.

Combination of a two step shocking operation and immersion in a hot water bath for separating raw scallops. Calico scallops (Aequipecten gibbus) are carried on a paneled conveyor belt to the first shocking station. In one form of the first shocking station, the bivalves are dropped 20 to 60 feet down a vertical chute onto a metal baffle plate. In another form, the bivalves are subjected to a blow by rotating paddles (400 to 600 r.p.m.) mounted in a chamber on a central rotary shaft. After the scallops have been shocked, they are immersed in a hot water bath (150° to 212°F.) for a period from about 3 seconds to 20 seconds. The immersion process assists in separating the meat from the enclosed shells. Scallops are then conveyed to the second shocking operation similar to the first. At the second station, the shells are broken and the meat-shell products fall onto a vibrating screen. Here the meats fall through to an eviscerator where the edible muscle is removed. The eviscerator consists of a series of contiguous rollers geared so that adjacent rollers rotate in opposite directions. The eviscerator is arranged at an incline and provided with a water spray above and below the rollers. The viscera is gripped between the rollers, peeled from the meat and dropped beneath the rollers to a pan. The remaining muscles are progressively advanced to different pairs of adjacent rollers to be rotated and turned for further cleaning.

Orientation desired: none, batch process.

Orientation device: none.

27. Willis, E.D.
1971. Scallop processing. U.S. Pat. No. 3,562,855.

Calico scallops (Aequipecten gibbus)are discharged from a feed hopper onto an open mesh conveyor belt where they are washed by an overhead spray unit. The conveyor discharges the scallops onto a chute which is inclined to drop the bivalves between a pair of drum rollers. The rollers are driven to counter-rotate to mechanically shock the scallop muscle. The scallops are dropped into a hot water bath (180°- 200°F.) for a period from about 6 to 9 seconds. The immersion process lessens the adhesion of the adductor muscle to the shell. They are then conveyed from the tank to another pair of rollers and shocked. The scallops are dropped onto a vibrating shaker which separates the meat from the shell. The vibrating shaker includes an inclined perforated plate which is sized to allow only the passage of the muscle and attached viscera. The meats and viscera pass into a brine flotation tank where any shell fragments are removed. The scallop meats are then conveyed to an eviscerator consisting of a plurality of inclined rollers and an overhead water spray. The rollers exert a frictional pulling force on the viscera in a downward direction through the nip of the rollers while at the same time restraining movement of the scallop muscle in that direction.

The overhead spray unit impedes the movement of the muscles down the inclined path to facilitate further cleaning. Scallop muscles after traversing the length of the roller path, fall into a collecting pan.

Orientation desired: none, batch process.

Orientation device: none.

28. Snow, H.F.
1971. Shucking of bivalves. U.S. Pat. No. 3,564,648.

Sea clams are fed in random-spaced arrangement onto an open-mesh wire conveyor belt. The bivalves travel through a heat cell (800°F. or higher) for a period from about 45 seconds to about 3 minutes. Each bivalve is completely enveloped about its circumference by a concentrated bed of heat. It has been found that by enveloping the bivalve in this heated stream and effecting release of the muscle with the subsequent springing open of the shells has tended to prevent cooking of the meat within the interior of the shell. The liquid passes out during the heat treatment in the form of vapor, thereby cooling the meat and obviating premature cooking. The heat cell has a number of propane gas conduits, spaced 12 inches apart, positioned beneath the conveyor belt. The nozzle orifices on each conduit are spaced 1½ inches apart and are positioned in a horizontal plane about 8 inches beneath the conveyor. Gas pressures are from about 1 p.s.i. to 3 p.s.i. Interposed between the nozzles and the conveyor are a series of metal interference rods, one rod parallel to and lying in the same plane as each conduit. The interference rods produce a uniform level of flame for the several parallel conduits. Above the conveyor is a refractory layer comprising of several spaced heat-reflective planks made of ceramic. The planks reflect downwardly any heat which passes through the belt. The spaces between the planks permit the escape of exhaust gases to a single exhaust fan.

Orientation desired: none, batch process.

Orientation device: none.

29. Snow, H.F.
1971. Shucking of bivalves. U.S. Pat. No. 3,566,438.

This apparatus is similar to U.S. Patent No. 3,564,648. Sea clams are fed in a random-spaced arrangement onto an open-mesh wire conveyor belt. The bivalves travel through a heat cell (600° to 1200°F.) for a period from about 30 seconds to 120 seconds, and are then crushed and separated in a flotation tank. In the heat cell, mounted above and perpendicular to the belt, are a series of electric coils or heating rods. These heating rods impart the necessary heat to completely envelop the clam shell. Mounted between the rods are a series of fans which rotate in such a direction as to draw the air in the interior of the cell in an upward direction. Such an arrangement maintains a constant stream of heat on the bottom face of the bivalves. After the clams have been heated to separate the muscle attachments, the shells are crushed into sections less than 2 inches by a toothed rotating cylinder. The meat and broken shells are conveyed into a flotation tank. A bubble system supplies gas under pressure to the solution to agitate the shell-meat products and assists in separating the meats. The meats are then skimmed off the top.

Orientation desired: none, batch process.

Orientation device: none.

30. Hanks, F.,Jr., and W.C. Grieb,Jr. 1971. Method and apparatus for removing meat from the shells of bivalve mollusks. U.S. Pat. No. 3,594,859.

This patent discloses a spray separator for soft shell clams (<u>Mya arenaria</u>). Clams are immersed in two successive water baths, a warm water bath (80°F.) and a cold water bath (35°F.), in order to extend the clam syphon and immobilize the clam in this position. Clams are transported singularly by a paneled conveyor to a syphon cutting station. A pair of inclined rollers carries clams, syphons extending downwardly, past two series of spray nozzles. Low pressure nozzles (40 to 200 p.s.i.) mounted above the rollers, hold the clams in an on-end position for syphon cutting. Syphons are severed by spray nozzles (900 p.s.i.), mounted beneath the rollers on both sides of the syphon. Clams are then subjected to a hot water spray (212°F.) to open the shells, and the meat is removed by another series of high pressure spray nozzles (900 p.s.i.).

Orientation desired: syphon extending downwardly so that the longitudinal axis of the clam is in a vertical direction.

Orientation device: pair of inclined rollers (4"d.), spaced 4 3/4" apart, rate of rotation 36 r.p.m. Rotation of rollers cuases clams to attain an on-end position since center of gravity does not coincide with geometric center when syphon is extended.

31. Nelson, R.W., R.F. Mackin, and W.I. Tretsven. 1971. Method for shucking and eviscerating bivalve mollusks. U.S. Pat. No. 3,594,860.

This process consists of an oxygen-acetylene burner and spray separator for raw bivalves, particularly scallops. Scallops are transported on a series of L-shaped trays mounted on a continuous belt. The belt forms an inverted triangle with the horizontal belt passing around three wheels. The long base leg of each tray is aligned with the direction of the belt travel and a scallop is manually positioned such that the hingelike portion faces the upright leg of the tray. As the scallop advances along the belt, it passes under a water cooled burner with a supply of oxygen and acetylene. The burner, with an array of flame-directing tips, is positioned such that an even temperature is produced over the adductor and catch muscle area. The scallop is heated for a period of approximately 1 second at a temperature from about 5800°F. to 6000°F. Once the muscles are severed from the top shell gaping occurs and the scallop proceeds to a station where the upper and lower shells are separated by breaking them apart. A pair of spaced right angle channels are positioned around the periphery of the inverted portion of the belt forming an interior track. As the gaped scallop enters the track, the top valve strikes a U-shaped bracket mounted on top breaking it from the lower valve. The half-shell scallop proceeds in an inverted position to an eviscerating station. The inverted scallop is submerged in a water bath where jets of water from two inclined nozzles loosen the viscera. A suction intake nozzle receives the viscera for discharge into a waste receptacle. After evisceration, the scallop is conveyed along the track and lifted in an inverted position onto a second conveyor. The second conveyor travels in a horizontal plane, carrying the scallop beneath a second water jet and burner for severing the muscle from the remaining half-shell. Open spaces in the belt allow the muscle to fall into a chute for further processing.

Orientation desired: horizontal position, bill forward in direction of travel.

Orientation device: manual.

32. Harris, S.G., and B.P. Zober.
1971. Apparatus and method for shucking oysters. U.S. Pat. No. 3,605,180.

The shucking device consists of four processing stations arranged along a straight horizontal conveyor rack. The four shucking stations are the feeder assembly, shell cutting operation, spreading of shells and adductor muscle cutting, and shell release. Prior to being processed, the oysters are washed and the shell fluid entrapped between the two shells is drained off to prevent damage to the oyster stomach by the saw blade. An oyster is placed manually, hinge end uppermost, into a clamp of a carriage assembly and secured by compressible spring loaded spikes that conform to the exterior contours of the shells. The oyster is automatically conveyed along the rack to the shell cutting mechanism. A diamond edge saw, cutting in a horizontal plane, removes the top (hinge) portion of the oyster. It is then moved to the shucking station where the tops of the shells are spread apart. The spikes holding the oyster in the clamp are relaxed and a pair of hook-like arms spread the opened shells apart. Two spade shaped blades are then introduced from the top of the shells which follow the interior contour of the shells and sever the adductor muscles. The blades then force the shells apart at their bottoms and the oyster meat drops out of the shells into a container. The empty shells are then carried to a final position where the clamps are opened and the shells are discarded.

Orientation desired: vertical position, hinge end uppermost, left valve (cup) facing right hand side of clamp assembly.

Orientation device: manual.

33. Henry, M.T.
1971. Method for shucking shellfish. U.S. Pat. No. 3,614,806.

Microwaves and an oxy-acetylene heat treatment is used for shucking raw oysters on the half shell trade. Oysters are conveyed with their

flat valve uppermost under a series of oxy-actylene torches, exposing the shell to a temperature from about 3000°F. to about 6300°F. for a period from 5 to 10 seconds per oyster. After the meat has been detached from the flat valve, the oyster is opened by microwave heat treatment. A microwave oven operating at a frequency of 2450 megacycles at a power of 2 kw. for a period from 20 to 30 seconds per oyster is used.

Orientation desired: right valve (flat) uppermost with the bill ends placed forward and parallel to the flow.

Orientation device: manual.

34. Willis, E.D.
1971. Scallop processing. U.S. Pat. No. 3,619,855.

A division of U.S. Patent No. 3,562,855. Similar in theory and design.

35. Wenstrom, R.T., and T.S. Gorton,Jr.
1972. Apparatus for shucking shellfish. U.S. Pat. No. 3,683,458.

Same as U.S. Patent No. 3,528,124. Similar in theory and design.

36. Hanks, F.
1973. Method for removing meat from the shells of bivalve mollusks. U.S. Pat. No. 3,722,035.

Clams are heated sufficiently to obtain partial opening of the shells and the release of one of the adductor muscles. The bivalves are then transferred to a flotation tank containing two stainless steel conveyor belts and a compressed air device. Compressed air is supplied to cause upward turbulence and thus separate the bivalve meats from the shells. The meats float upwardly to be skimmed from the top by a conveyor. The shells fall to the bottom of the tank and a second conveyor removes the shells.

Orientation desired: none, batch process.

Orientation device: none.

37. Harris, S.G.
1973. Method of shucking bivalves. U.S. Pat. No. 3,605,180.

Same as U.S. Pstent No. 3,605,180. Similar in theory and design.

38. Ouw, W.B.G., and A.L. Johnson. 1973. Method for opening shell fish. U.S. Pat. No. 3,755,855.

A concentrated beam of infra-red light is applied to the oyster adductor muscle attachment area of the flat valve to assist in later hand shucking. A forced-air-cooled, 1 3/4 inch focal length, 1000 watt infra-red lamp having an ellipsoidal focusing reflector and a beam width of 5/16 inch diameter at the focal length is used. Oysters were treated from about 2.5 seconds to about 20 seconds per oyster. Maximum rates of up to 24 oysters per minute were achieved.

Orientation desired: horizontal position, right valve (flat) uppermost.

Orientation device: manual.

39. Harris, S.G., J.D. Smith, D.D. McCall, G.S. Moore, W.P. Hidden, and N. Svendsen. 1974. Method and apparatus for shucking bivalves. U.S. Pat. No. 3,828,398.

Similar in theory and design to U.S. Patent No.'s 3,605,180 and 3,724,031. However, the present invention presents a number of improvements over previous designs. Unlike the horizontal conveyor rack used previously, a vertical work carrier is employed. The work carrier consists of two tables, rotating about a vertical axis. The first table includes six stations, five of which are active in operation. These stations include a load station, three vibration stations, and a transfer station. The second table has four stations; a transfer position, saw position, shucking position and a shell discharge position. In general, the operation of this device is similar to the device described previously. Several modifications have been made. Two major modifications are the inclusion of a proportional sensing device and an oyster vibrator. The proportional positioning device is sensitive to the maximum width of the oysters and is employed so that the muscle centers will be directly under the centers of the fixed knives. Thus, precision and accuracy of shucking can be achieved regardless of oyster size. The oyster vibrating mechanism settles the meat between the shells and insures that it occupies the space left free by the removal of the liquid between the shells. Use of the vibratory mechanism eliminates damage to the oyster stomach by the saw blade. As the machine is designed to operate at the rate of an oyster every three seconds, and as it has been found that as much as 4 seconds of vibration is desirable, three vibration positions each giving about 1 1/3 seconds of vibration time are used in order to allow for indexing time between stations.

Orientation desired: hinge end uppermost, left valve (cup) facing right hand side of clamp assembly.

Orientation device: manual.

APPENDIX C
COMPUTER PROGRAM

```
C**** PROGRAM MAD,MAIN
C
C**** COMPARES ONE DIMENSIONAL INCREMENT TO A SERIES OF OTHER
C     DIMENSIONAL INCREMENTS FOR DESIGNATED TEST HYPOTHESIS. RESULTS OF
C     COMPARISONS ARE PRINTED BY OYSTER LENGTH CLASS FOR EACH BUSHEL,
C     SUMMED FOR EACH BAR AND SUMMED FOR ALL BARS.
C     THE NUMBER OF OYSTER FAILURES ARE PRINTED FOR EACH COMPARISON
C     ON SIMULATED HINGE AND BILL LEADING CONTITIONS. TOTAL FAILURE
C     COMPUTED ON AN 'OR' BASIS.
C
C**** DATA MUST BE SORTED BY LENGTH CLASS FOR EACH BAR BUSHEL. THE
C     FOLLOWING SORT FUNCTIONS WERE USED :
C
C     1. FOR THICKNESS DATA (CARD7) AND WIDTH DATA (CARD6)
C           @SORTSDF CARD6.,CARD6.,2500,80,KEY/8/2.A,KEY/2/2.A
C
C     2. FOR WIDTH TO THICKNESS RATIO DATA (CARD8)
C           @SORTSDF CARD8.,CARD8.,2500,132,KEY/8/2.A,KEY/2/2.A
C
C**** VARIABLE DEFINITIONS
C
C       IB     = BAR NUMBER
C       IBU    = BUSHEL NUMBER                IBART  = BAR TOTAL TABLE COUNTER
C       IRATIO = DIMENSIONAL DATA             HDG    = BAR NUMBER AND NAMES
C       IB1    = BUSHEL ID COUNTER            IEND   = LAST INCREMENT COMPARED
C       IENT1  = BUSHEL COUNTER               NUM    = NUMBER OF COMPARISONS
C       IENT2  = BAR COUNTER                  JJ     = STARTING TABLE COLUMN
C       IBUS   = BUSHEL TABLE COUNTER         II     = STARTING TABLE ROW
C       IBAR   = BAR TABLE COUNTER            ICOMPF = FORWARD COMPARISONS
C                                             ICOMPB = BACKWARD COMPARISONS
C
C        VALUE = DISTANCE FROM HINGE OF FIRST ORIENTING POINT
C       ISTART = LOCATION OF  VALUE IN DATA SET
C       NOYSTR = NUMBER OF OYSTERS IN LENGTH CLASSES FOR BUSHELS
C       SUMBAR = NUMBER OF OYSTERS IN LENGTH CLASSES. BAR COUNTER
C       BARTOT = NUMBER OF OYSTERS IN LENGTH CLASSES. BAR TOTALS COUNTER
C       IBEG   = FIRST VALUE TO BE COMPARED
C       IC     = DISTANCE FROM BILL OF FIRST ORIENTING POINT
C
      INTEGER SUMBAR,BARTOT
      DIMENSION IBUS(25,51),IBAR(25,51),IBART(25,51),ICOMPF(30),ICOMPB(3
     10),IRATIO(30),NOYSTR(17),SUMBAR(17),BARTOT(17),HDG(3,2)
C
C**** INITIALIZE LENGTH CLASS COUNTERS.
C
      DO 5 I=1,17
```

```
      NOYSTR(I)=0
      SUMBAR(I)=0
5     BARTOT(I)=0
C
C**** INITIALIZE ALL TABLE COUNTERS
C
      DO 10 J=1,25
      DO 10 I=1,51
      IBUS(J,I)=0
      IBAR(J,I)=0
10    IBART(J,I)=0
C
C**** INITIALIZE BUSHEL ID NUMBER,BUSHEL AND BAR COUNTERS.
C
      IB1=1
      IENT1=0
      IENT2=0
C
C**** READ IN SINGLE VALUE OF FIRST ORIENTING POINT AND STARTING COLUMN
C     FOR FIRST POINT. VALUES WERE .4,.6,.8,1.0,1.2,1.4,1.6 .
C     CORRESPONDING STARTING COLUMNS WERE 3,4,5,6,7,8,9
C
      WRITE (6,100)
      READ (5,105) VALUE
      WRITE (6,110)
      READ (5,105) ISTART
C
C**** READ BAR NUMBER,BUSHEL NUMBER,LENGTH CLASS AND DIMENSIONAL DATA.
C
15    READ (10,115,END=45) IB,IBU,LC,(IRATIO(I),I=1,30)
C
C**** CHECK BUSHEL CHANGE. IF NEW BUSHEL,PRINT TABLE.
C
      IF (IBU.NE.IB1) GO TO 45
C
C**** DEFINE LAST DATA INCREMENT TO COMPARE
C
20    IEND=LC+1
C
C**** DEFINE STARTING COLUMN OF TABLE
C
      JJ=(LC-13)*3+1
C
C**** INITIALIZE COMPARISON STRINGS. FORWARD COMPARISONS SIMULATE HINGE
C     LEADING OYSTERS. BACKWARD COMPARISONS SIMULATE BILL LEADING
C     OYSTERS.
```

```
C
      DO 25 I=1,30
      ICOMPF(I)=1
25    ICOMPB(I)=1
C
C**** EXECUTE FORWARD COMPARISONS(HINGE TO BILL)
C
      IBEG=ISTART+3
      DO 30 I=IBEG,IEND
      II=I-ISTART-2
30    IF(IRATIO(ISTART).GE.IRATIO(I))ICOMPF(II)=0
C
C**** EXECUTE BACKWARD COMPARISONS(BILL TO HINGE)
C
      IBEG=LC-1-ISTART
      NUM=IBEG
      IC=LC-ISTART+2
      DO 35 I=1,NUM
35    IF(IRATIO(IC).LE.IRATIO(IBEG-I+1))ICOMPB(I)=0
C
C**** COUNT NUMBER OF FAILURES FOR ONE LENGTH CLASS AND ONE BAR BUSHEL
C
      DO 40 I=1,II
      IF(ICOMPF(I).EQ.0)IBUS(I,JJ)=IBUS(I,JJ)+1
      IF(ICOMPB(I).EQ.0)IBUS(I,JJ+1)=IBUS(I,JJ+1)+1
40    IF(ICOMPF(I).EQ.0.OR.ICOMPB(I).EQ.0)IBUS(I,JJ+2)=IBUS(I,JJ+2)+1
C
C****CONTINUE COUNTING AND STORING FAILURES FOR ONE BAR BUSHEL
C
      IB1=IBU
      GO TO 15
C
C**** PRINT BUSHEL TABLE ONCE BUSHEL NUMBER CHANGES. READ NUMBER OF
C     OYSTERS IN LENGTH CLASSES.
C
45    IF (IENT2.NE.0.OR.IENT1.NE.0) GO TO 60
      DO 50 J=1,2
      DO 50 I=1,3
50    HDG(I,J)='    '
      DO 55 I=1,3
      WRITE (6,120) I
      READ (5,125) (HDG(I,J),J=1,2)
55    CONTINUE
60    READ (11,130) (NOYSTR(I),I=1,17)
      CALL PRINT (IBUS,HDG,IENT2+1,IENT1+1,NOYSTR,1,VALUE,ISTART,LC,IENT
C
```

```
C**** COUNT NUMBER OF BUSHELS. SUM NUMBER OF OYSTERS IN LENGTH CLASSES
C     FOR BAR TOTAL.
C
     12)
      IENT1=IENT1+1
      DO 65 I=1,17
65    SUMBAR(I)=SUMBAR(I)+NOYSTR(I)
C
C**** SUM BUSHEL RESULTS INTO TABLE FOR BAR TOTALS AND INITIALIZE BUSHEL
C     TABLE.
C
      DO 70 J=1,25
      DO 70 I=1,51
      IBAR(J,I)=IBAR(J,I)+IBUS(J,I)
70    IBUS(J,I)=0
C
C**** ALL BUSHELS ANALYZED. IF YES, PRINT BAR TOTALS FOR BAR 1
C
      IF (IENT1.EQ.6) GO TO 75
      IB1=IBU
      GO TO 20
75    CALL PRINT (IBAR,HDG,IENT2+1,IENT1+1,SUMBAR,2,VALUE,ISTART,LC,IENT
     12)
C
C**** INITIALIZE BUSHEL NUMBER COUNTER. COUNT NUMBER OF BARS ANALYZED
C     SUM NUMBER OF OYSTERS IN LENGTH CLASSES INTO BAR TOTAL COUNTER.
C     INITIALIZE BAR COUNTER.
C
      IENT1=0
      IENT2=IENT2+1
      DO 80 I=1,17
80    BARTOT(I)=BARTOT(I)+SUMBAR(I)
      DO 81 I=1,17
81    SUMBAR(I)=0
C
C**** SUM BAR RESULTS INTO TABLE FOR TOTAL BARS
C     AND INITIALIZE BAR TOTALS.
C
      DO 85 J=1,25
      DO 85 I=1,51
      IBART(J,I)=IBART(J,I)+IBAR(J,I)
85    IBAR(J,I)=0
C
C**** ALL BARS ANALYZED. IF YES PRINT TABLE FOR
C     TOTAL BARS AND STOP
C
```

```
      IF (IENT2.EQ.3) GO TO 90
      IB1=IBU
      GO TO 20
90    CALL PRINT (IBART,HDG,IENT2+1,IENT1+1,BARTOT,3,VALUE,ISTART,LC,IEN
     1T2)
95    STOP
C
100   FORMAT (1X,'FIRST READING ?')
105   FORMAT ()
110   FORMAT (1X,'COLUMN OF FIRST READING (ISTART)?')
115   FORMAT (1X,I1,I1,4X,I2,1X,30(I4))
120   FORMAT (1X,'NAME OF BAR',1X,I1,1X,'?')
125   FORMAT (2A6)
130   FORMAT ()
      END


C
C
C**** PROGRAM MAD,PRINT
C
C**** NEW VARIABLE DEFINITIONS
C
C        ICHEK    = PAGE HEADINGS
C        ARD      = LENGTH CLASS LIMITS
C
C        NUM      = NUMBER OF OYSTERS IN LENGTH CLASS
C        IC       = NUMBER OF LAST FULL LINE
C        NUMIND   = INDEX NUMBER OF THE ELEMENT IN OYSTER NUMBER VECTOR
C                   THAT CORRESPONDS TO THE LENGTH CLASS
C        ITABLE   = ARRAY IN WHICH THE TABLE TO BE PRINTED IS STORED
C        KK       = LAST LENGTH CLASS TO BE PRINTED ON ONE PAGE
C        IDIST    = COLUMN TO PRINT LINE
      SUBROUTINE PRINT (ITABLE,HDG,IB,IBU,NUM,ICHEK,VALUE,ISTART,LC,IENT
     12)
      DIMENSION ITABLE(25,51),HDG(3,2),NUM(17),ARD(25)
C
C**** PRINT APPROPRIATE HEADING
C
      GO TO (5,10,15), ICHEK
C
C**** HEADING FOR BUSHEL TABLE
C
5     WRITE ( 6,130) IB,(HDG(IB,J),J=1,2),IBU
      GO TO 20
```

```
C
C**** HEADING FOR BAR TABLE.
C
10     WRITE ( 6,135) IB,(HDG(IB,J),J=1,2)
       GO TO 20
C
C**** HEADING FOR BAR TOTALS.
C
15     WRITE ( 6,140)
C
C**** INITIALIZE COUNTERS
C
20     IBEG=1
       NUMIND=1
       IPAGE=1
       IEND=12+IBEG-1
       IC=13-ISTART-1
       IFIN=IC+3
C
C**** WRITE TABLE HEADING.
C
       WRITE ( 6,145)
       WRITE ( 6,150)
       WRITE ( 6,155) ,(NUM(I),I=1,4)
C
C**** DETERMINE THE LENGTH CLASS LIMITS
C
       DO 25 I=1,25
25     ARD(I)=VALUE+0.6+(I-1)*0.2
C
C**** PRINT ONE PAGE OF THE TABLE.
C
       WRITE ( 6,160)
26     DO 125 J=1,IFIN
       IF (IPAGE.EQ.5) GO TO 95
       IF (J.GT.IC) GO TO 30
       WRITE ( 6,165) VALUE,ARD(J),(ITABLE(J,I),I=IBEG,IEND)
       GO TO 125
30     IDIST=J-IC
       GO TO (35,40,45), IDIST
35     IBEG=IBEG+3
       WRITE ( 6,170) VALUE,ARD(J),(ITABLE(J,I),I=IBEG,IEND)
       GO TO 125
40     IBEG=IBEG+3
       WRITE ( 6,175) VALUE,ARD(J),(ITABLE(J,I),I=IBEG,IEND)
       GO TO 125
```

```
45    IBEG=IBEG+3
      WRITE ( 6,180) VALUE,ARD(J),(ITABLE(J,I),I=IBEG,IEND)
      IF (J.EQ.IFIN) GO TO 50
      GO TO 125
50    IF(IPAGE.EQ.4)GO TO 125
      GO TO (55,60,65), ICHEK
55    WRITE ( 6,130) IB,(HDG(IB,K),K=1,2),IBU
      GO TO 70
60    WRITE ( 6,135) IB,(HDG(IB,K),K=1,2)
      GO TO 70
65    WRITE ( 6,140)
70    WRITE ( 6,145)
      GO TO (75,80,85), IPAGE
75    WRITE ( 6,185)
      GO TO 90
80    WRITE ( 6,190)
      GO TO 90
85    WRITE ( 6,195)
90    NUMIND=NUMIND+4
      KK=NUMIND+3
      WRITE ( 6,155) ,(NUM(I),I=NUMIND,KK)
      WRITE ( 6,160)
      GO TO 125
95    IF (J.NE.1) GO TO 120
      GO TO (100,105,110), ICHEK
100   WRITE ( 6,130) IB,(HDG(IB,K),K=1,2),IBU
      GO TO 115
105   WRITE ( 6,135) IB,(HDG(IB,K),K=1,2)
      GO TO 115
110   WRITE ( 6,140)
115   WRITE ( 6,145)
      WRITE ( 6,200)
      NUMIND=NUMIND+4
      WRITE ( 6,205) NUM(NUMIND)
      WRITE ( 6,210)
120   WRITE ( 6,215) VALUE,ARD(J),(ITABLE(J,I),I=IBEG,IEND)
125   CONTINUE
C
C**** RETURN IF LAST PAGE IS PRINTED. OTHERWISE INITIALIZE THE
C     COUNTERS AND GO TO A NEW PAGE.
C
      IF (IPAGE.EQ.5) RETURN
      IC=IC+4
      IFIN=IC+3
      IEND=IEND+12
      IBEG=IBEG+3
```

```
      IPAGE=IPAGE+1
      IF(IPAGE.EQ.5)IFIN=IC
      IF(IPAGE.EQ.5)IEND=IEND-9
      GO TO 26
C
130   FORMAT (1H1//////////////////////50X,'BAR',I1,' - ',2A6,3X,'BUSHEL N
     1UMBER  ',I1)
135   FORMAT (1H1//////////////////////50X,'BAR',I1,' - ',2A6,3X,'BUSHEL T
     1OTALS')
140   FORMAT (1H1//////////////////////64X,'BAR TOTALS')
145   FORMAT (/58X,'WIDTH-THICKNESS RATIO'//47X,'NUMBER OF OYSTERS FAILE
     1D OVER OYSTER LENGTH')
150   FORMAT (//26X,'DISTANCE FROM END  2.6-2.7 INCHES   2.8-2.9 INCHES
     1   3.0-3.1 INCHES    3.2-3.3 INCHES')
155   FORMAT (30X,'(INCHES)',9X,4('(N=',I3,')',10X))
160   FORMAT (26X,'FIRST         SECOND',3X,4('HINGE BILL',7X)/26X,'READING
     1    READING',2X,4('LEAD  LEAD TOTAL  ')//)
165   FORMAT (26X,F3.1,8X,F3.1,6X,4(I3,3X,I3,2X,I3,3X))
170   FORMAT (26X,F3.1,8X,F3.1,23X,3(I3,3X,I3,2X,I3,3X))
175   FORMAT (26X,F3.1,8X,F3.1,40X,2(I3,3X,I3,2X,I3,3X))
180   FORMAT (26X,F3.1,8X,F3.1,57X,I3,3X,I3,2X,I3,3X)
185   FORMAT (//26X,'DISTANCE FROM END  3.4-3.5 INCHES   3.6-3.7 INCHES
     1   3.8-3.9 INCHES    4.0-4.1 INCHES')
190   FORMAT (//26X,'DISTANCE FROM END  4.2-4.3 INCHES   4.4-4.5 INCHES
     1   4.6-4.7 INCHES    4.8-4.9 INCHES')
195   FORMAT (//26X,'DISTANCE FROM END  5.0-5.1 INCHES   5.2-5.3 INCHES
     1   5.4-5.5 INCHES    5.6-5.7 INCHES')
200   FORMAT (//26X,'DISTANCE FROM END  5.8-5.9 INCHES')
205   FORMAT (30X,'(INCHES)',9X,'N=',I3)
210   FORMAT (26X,'FIRST         SECOND',3X,'HINGE BILL'/26X,'READING   READ
     1ING',2X,'LEAD  LEAD TOTAL  '//)
215   FORMAT (26X,F3.1,8X,F3.1,6X,I3,3X,I3,2X,I3)
      END
```

APPENDIX D
DIMENSIONAL ORIENTATION TESTS

PART A
BUSHEL TOTALS

Note: Only bar 2, Prison Point, has table for oyster length class 5.8 - 5.9 inches. There were no oysters in this length class for the other bars.

BAR1 - CHURCH HILL BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 2)			2.8-2.9 INCHES (N= 18)			3.0-3.1 INCHES (N= 26)			3.2-3.3 INCHES (N= 72)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	0	0	0	5	2	7	7	7	13	15	4	18
.4	1.2	0	0	0	3	0	3	5	4	9	12	4	15
.4	1.4	0	0	0	2	0	2	5	2	7	7	2	9
.4	1.6	0	0	0	1	0	1	4	1	5	4	2	6
.4	1.8	0	0	0	1	0	1	1	1	2	4	0	4
.4	2.0	0	0	0	0	0	0	0	0	0	3	1	4
.4	2.2	0	0	0	0	0	0	0	0	0	2	0	2
.4	2.4	0	0	0	0	0	0	0	0	0	1	0	1
.4	2.6	0	0	0	0	1	1	0	0	0	1	1	1
.4	2.8				2	1	3	0	1	1	1	1	1
.4	3.0							1	4	4	0	1	1
.4	3.2										6	10	14

BAR1 - CHURCH HILL   BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		3.4-3.5 INCHES (N=108)			3.6-3.7 INCHES (N=125)			3.8-3.9 INCHES (N=128)			4.0-4.1 INCHES (N=120)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	35	15	46	35	23	52	56	27	71	50	38	71
.4	1.2	29	9	37	24	18	38	39	24	54	39	29	57
.4	1.4	20	3	23	20	11	30	26	12	35	30	20	45
.4	1.6	19	1	20	12	11	22	17	5	20	26	15	38
.4	1.8	13	0	13	7	4	11	9	5	13	19	11	29
.4	2.0	7	0	7	3	1	4	4	3	7	11	7	18
.4	2.2	4	0	4	3	1	4	5	2	7	8	3	11
.4	2.4	0	0	0	0	0	0	1	3	4	6	2	8
.4	2.6	0	0	0	0	0	0	1	1	2	5	2	7
.4	2.8	0	0	0	1	0	1	2	1	2	4	2	6
.4	3.0	0	0	0	0	0	0	2	1	2	3	2	5
.4	3.2	0	2	2	0	0	0	2	1	2	4	1	5
.4	3.4	5	17	21	0	3	3	2	2	2	3	1	3
.4	3.6				4	13	17	3	3	5	4	4	4
.4	3.8							14	15	26	5	6	9
.4	4.0										12	19	28

BAR1 - CHURCH HILL BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		4.2-4.3 INCHES (N= 98)			4.4-4.5 INCHES (N= 41)			4.6-4.7 INCHES (N= 35)			4.8-4.9 INCHES (N= 22)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	44	22	54	22	18	31	15	18	27	9	6	14
.4	1.2	27	20	42	15	16	25	13	15	24	6	6	11
.4	1.4	22	17	36	10	12	19	8	13	20	6	6	10
.4	1.6	14	8	21	8	9	15	9	11	19	5	5	8
.4	1.8	12	6	17	6	8	12	7	8	14	3	5	8
.4	2.0	9	4	13	4	4	8	6	5	11	3	3	6
.4	2.2	9	4	13	3	4	7	5	3	8	3	3	6
.4	2.4	5	4	9	2	4	6	3	2	5	1	2	3
.4	2.6	4	2	6	1	3	4	1	2	3	1	2	3
.4	2.8	1	3	4	1	1	2	0	0	0	1	2	3
.4	3.0	1	1	2	1	0	1	0	0	0	1	1	2
.4	3.2	1	2	3	1	0	1	0	0	0	1	1	2
.4	3.4	1	0	1	1	0	1	0	0	0	0	0	0
.4	3.6	1	0	1	1	0	1	0	0	0	0	0	0
.4	3.8	1	1	1	1	0	1	0	0	0	0	0	0
.4	4.0	1	4	4	0	0	0	0	0	0	0	0	0
.4	4.2	15	16	26	1	1	2	0	0	0	0	0	0
.4	4.4				9	6	13	0	2	2	0	0	0
.4	4.6							4	7	9	0	0	0
.4	4.8										3	2	5

BAR1 - CHURCH HILL BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		5.0-5.1 INCHES (N= 6)			5.2-5.3 INCHES (N= 4)			5.4-5.5 INCHES (N= 4)			5.6-5.7 INCHES (N= 1)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	4	2	5	2	2	3	2	2	3	0	0	0
.4	1.2	3	3	5	1	1	2	1	2	3	0	0	0
.4	1.4	2	2	4	1	1	2	0	2	2	0	0	0
.4	1.6	2	1	3	2	1	3	0	1	1	0	1	1
.4	1.8	2	1	3	1	1	2	0	1	1	0	1	1
.4	2.0	2	1	3	0	1	1	0	1	1	0	1	1
.4	2.2	2	1	3	0	1	1	0	1	1	0	1	1
.4	2.4	2	0	2	0	1	1	0	1	1	0	1	1
.4	2.6	2	0	2	0	1	1	0	1	1	0	1	1
.4	2.8	2	0	2	0	0	0	0	1	1	0	1	1
.4	3.0	2	0	2	0	0	0	0	1	1	0	1	1
.4	3.2	2	0	2	0	0	0	0	1	1	0	1	1
.4	3.4	0	0	0	0	0	0	0	1	1	0	1	1
.4	3.6	0	0	0	0	0	0	0	1	1	0	1	1
.4	3.8	0	0	0	0	0	0	0	1	1	0	1	1
.4	4.0	0	0	0	0	0	0	0	1	1	0	0	0
.4	4.2	0	0	0	0	0	0	0	1	1	0	0	0
.4	4.4	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.6	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.8	0	1	1	0	0	0	0	1	1	0	0	0
.4	5.0	1	2	3	0	0	0	0	0	0	0	0	0
.4	5.2				0	0	0	0	0	0	0	0	0
.4	5.4							0	1	1	0	0	0
.4	5.6										0	0	0

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 4)			2.8-2.9 INCHES (N= 11)			3.0-3.1 INCHES (N= 32)			3.2-3.3 INCHES (N= 61)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	1	0	1	0	0	0	1	1	2	5	7	12
.4	1.2	0	0	0	0	0	0	0	1	1	4	4	8
.4	1.4	0	0	0	0	0	0	0	0	0	2	2	4
.4	1.6	0	0	0	0	0	0	0	0	0	1	2	3
.4	1.8	0	0	0	0	0	0	0	0	0	1	2	3
.4	2.0	0	0	0	0	0	0	0	0	0	1	1	2
.4	2.2	0	0	0	0	0	0	0	0	0	0	1	1
.4	2.4	0	0	0	0	0	0	0	0	0	0	1	1
.4	2.6	0	0	0	0	0	0	0	0	0	1	1	1
.4	2.8				0	1	1	0	0	0	0	0	0
.4	3.0							0	3	3	0	0	0
.4	3.2										0	3	3

BAR2 - PRISON POINT   BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		3.4-3.5 INCHES (N= 89)			3.6-3.7 INCHES (N=136)			3.8-3.9 INCHES (N=122)			4.0-4.1 INCHES (N=113)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	11	12	22	8	33	39	20	24	38	18	22	36
.4	1.2	8	9	17	8	18	25	14	16	26	10	20	27
.4	1.4	5	6	11	5	15	20	9	13	20	6	13	17
.4	1.6	3	4	7	5	10	15	5	7	12	4	7	10
.4	1.8	1	0	1	4	5	9	2	4	6	3	5	8
.4	2.0	0	0	0	3	5	8	1	4	5	1	2	3
.4	2.2	0	0	0	3	3	6	0	3	3	0	2	2
.4	2.4	0	0	0	3	0	3	0	2	2	0	2	2
.4	2.6	0	0	0	0	0	0	0	1	1	0	2	2
.4	2.8	0	0	0	0	0	0	0	1	1	0	1	1
.4	3.0	0	0	0	0	0	0	0	0	0	0	0	0
.4	3.2	0	0	0	0	0	0	0	0	0	0	0	0
.4	3.4	0	10	10	0	0	0	0	0	0	0	0	0
.4	3.6				1	10	11	0	0	0	0	0	0
.4	3.8							1	10	11	0	0	0
.4	4.0										0	14	14

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		4.2-4.3 INCHES (N= 94)			4.4-4.5 INCHES (N= 71)			4.6-4.7 INCHES (N= 29)			4.8-4.9 INCHES (N= 23)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	27	31	48	9	25	33	10	12	17	6	8	12
.4	1.2	17	29	40	6	24	30	3	10	11	5	5	9
.4	1.4	11	24	33	7	18	24	4	9	12	5	7	11
.4	1.6	7	14	20	3	15	18	3	4	7	4	6	10
.4	1.8	6	10	15	1	10	11	2	4	6	4	3	7
.4	2.0	4	6	10	1	10	11	2	3	5	3	3	6
.4	2.2	3	5	8	0	8	8	1	2	3	2	2	4
.4	2.4	3	3	6	0	7	7	1	1	2	1	1	2
.4	2.6	1	2	3	1	5	6	0	1	1	1	0	1
.4	2.8	0	1	1	0	3	3	0	1	1	0	0	0
.4	3.0	0	4	4	0	1	1	0	1	1	0	0	0
.4	3.2	0	1	1	0	1	1	0	0	0	0	0	0
.4	3.4	0	1	1	0	1	1	0	0	0	0	0	0
.4	3.6	0	0	0	1	1	1	0	0	0	0	0	0
.4	3.8	0	0	0	1	1	1	0	0	0	0	0	0
.4	4.0	0	1	1	1	1	1	0	0	0	0	0	0
.4	4.2	1	17	18	1	0	1	0	0	0	0	0	0
.4	4.4				1	9	10	0	0	0	0	0	0
.4	4.6							1	7	7	0	1	1
.4	4.8										2	4	6

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		5.0-5.1 INCHES (N= 11)			5.2-5.3 INCHES (N= 7)			5.4-5.5 INCHES (N= 5)			5.6-5.7 INCHES (N= 1)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	3	7	8	3	3	5	3	3	4	0	0	0
.4	1.2	1	6	7	2	3	4	3	3	4	0	0	0
.4	1.4	1	6	7	3	2	4	2	2	4	0	1	1
.4	1.6	1	6	7	3	1	3	1	2	3	0	0	0
.4	1.8	0	4	4	3	1	3	1	1	2	0	0	0
.4	2.0	0	3	3	1	0	1	0	1	1	0	0	0
.4	2.2	0	3	3	1	0	1	0	1	1	0	0	0
.4	2.4	0	3	3	1	0	1	0	1	1	0	0	0
.4	2.6	0	2	2	1	0	1	0	1	1	0	0	0
.4	2.8	0	2	2	1	0	1	0	0	0	0	0	0
.4	3.0	0	2	2	0	0	0	0	0	0	0	0	0
.4	3.2	0	2	2	0	0	0	0	0	0	0	0	0
.4	3.4	0	1	1	0	0	0	0	0	0	0	0	0
.4	3.6	0	0	0	0	0	0	0	0	0	0	0	0
.4	3.8	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.0	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.2	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.4	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.6	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.8	0	1	1	0	0	0	0	0	0	0	0	0
.4	5.0	1	5	5	0	1	1	0	0	0	0	0	0
.4	5.2				0	1	1	0	1	1	0	0	0
.4	5.4							1	3	4	0	0	0
.4	5.6										0	1	1

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES) FIRST READING	SECOND READING	5.8-5.9 INCHES N= 1 HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	0	1	1
.4	1.2	0	1	1
.4	1.4	0	1	1
.4	1.6	0	1	1
.4	1.8	0	1	1
.4	2.0	0	0	0
.4	2.2	0	0	0
.4	2.4	0	0	0
.4	2.6	0	0	0
.4	2.8	0	0	0
.4	3.0	0	0	0
.4	3.2	0	0	0
.4	3.4	0	0	0
.4	3.6	0	0	0
.4	3.8	0	0	0
.4	4.0	0	0	0
.4	4.2	0	0	0
.4	4.4	0	0	0
.4	4.6	0	0	0
.4	4.8	0	0	0
.4	5.0	0	0	0
.4	5.2	0	0	0
.4	5.4	0	0	0
.4	5.6	0	0	0
.4	5.8	0	0	0

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 36)			2.8-2.9 INCHES (N= 96)			3.0-3.1 INCHES (N=149)			3.2-3.3 INCHES (N=142)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	1	1	2	4	11	15	7	14	21	16	18	34
.4	1.2	1	1	2	2	7	9	2	8	10	10	7	17
.4	1.4	1	0	1	2	0	2	0	3	3	7	2	9
.4	1.6	1	0	1	0	0	0	1	4	4	3	1	4
.4	1.8	0	0	0	0	0	0	1	2	2	0	1	1
.4	2.0	0	0	0	0	0	0	0	1	1	0	0	0
.4	2.2	0	0	0	0	0	0	0	0	0	0	0	0
.4	2.4	0	0	0	0	0	0	0	0	0	0	0	0
.4	2.6	0	6	6	0	0	0	0	0	0	0	0	0
.4	2.8				0	10	10	0	0	0	0	0	0
.4	3.0							3	18	21	0	1	1
.4	3.2										2	18	20

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		3.4-3.5 INCHES (N=121)			3.6-3.7 INCHES (N=103)			3.8-3.9 INCHES (N= 65)			4.0-4.1 INCHES (N= 39)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	16	27	40	16	17	32	9	16	22	10	9	19
.4	1.2	9	17	26	9	12	20	7	10	14	7	7	14
.4	1.4	5	9	14	6	7	12	3	5	8	4	5	9
.4	1.6	4	5	9	3	2	5	3	4	6	1	3	4
.4	1.8	2	2	4	2	1	3	1	1	2	0	2	2
.4	2.0	2	1	3	1	1	2	0	2	2	0	1	1
.4	2.2	1	1	2	0	0	0	0	1	1	0	1	1
.4	2.4	1	2	3	0	0	0	0	0	0	0	1	1
.4	2.6	0	1	1	0	0	0	0	0	0	0	1	1
.4	2.8	0	1	1	0	0	0	0	0	0	0	0	0
.4	3.0	0	0	0	0	0	0	0	0	0	0	0	0
.4	3.2	1	2	2	0	0	0	0	0	0	0	0	0
.4	3.4	2	25	27	0	0	0	0	0	0	0	0	0
.4	3.6				4	19	23	0	0	0	0	0	0
.4	3.8							1	13	14	0	0	0
.4	4.0										1	6	7

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		4.2-4.3 INCHES (N= 31)			4.4-4.5 INCHES (N= 15)			4.6-4.7 INCHES (N= 4)			4.8-4.9 INCHES (N= 8)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	5	6	9	4	6	9	2	0	2	3	3	5
.4	1.2	4	5	8	3	5	8	0	1	1	3	3	5
.4	1.4	3	5	7	2	4	6	0	0	0	3	3	5
.4	1.6	1	4	5	1	4	5	0	0	0	2	2	4
.4	1.8	1	2	3	0	2	2	0	0	0	1	2	3
.4	2.0	1	1	2	0	2	2	0	0	0	1	2	3
.4	2.2	0	1	1	0	1	1	0	0	0	0	1	1
.4	2.4	0	1	1	0	1	1	0	0	0	0	1	1
.4	2.6	0	0	0	0	1	1	0	0	0	0	1	1
.4	2.8	0	0	0	0	0	0	0	0	0	0	0	0
.4	3.0	0	0	0	0	0	0	0	0	0	0	0	0
.4	3.2	0	0	0	0	0	0	0	0	0	0	0	0
.4	3.4	0	0	0	0	0	0	0	0	0	0	0	0
.4	3.6	0	0	0	0	0	0	0	0	0	0	0	0
.4	3.8	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.0	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.2	2	7	8	0	0	0	0	0	0	0	0	0
.4	4.4				4	5	7	0	1	1	0	0	0
.4	4.6							0	1	1	0	0	0
.4	4.8										1	0	1

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		5.0-5.1 INCHES (N= 0)			5.2-5.3 INCHES (N= 1)			5.4-5.5 INCHES (N= 0)			5.6-5.7 INCHES (N= 0)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	0	0	0	0	1	1	0	0	0	0	0	0
.4	1.2	0	0	0	0	1	1	0	0	0	0	0	0
.4	1.4	0	0	0	0	0	0	0	0	0	0	0	0
.4	1.6	0	0	0	0	0	0	0	0	0	0	0	0
.4	1.8	0	0	0	0	0	0	0	0	0	0	0	0
.4	2.0	0	0	0	0	0	0	0	0	0	0	0	0
.4	2.2	0	0	0	0	0	0	0	0	0	0	0	0
.4	2.4	0	0	0	0	0	0	0	0	0	0	0	0
.4	2.6	0	0	0	0	0	0	0	0	0	0	0	0
.4	2.8	0	0	0	0	0	0	0	0	0	0	0	0
.4	3.0	0	0	0	0	0	0	0	0	0	0	0	0
.4	3.2	0	0	0	0	0	0	0	0	0	0	0	0
.4	3.4	0	0	0	0	0	0	0	0	0	0	0	0
.4	3.6	0	0	0	0	0	0	0	0	0	0	0	0
.4	3.8	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.0	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.2	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.4	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.6	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.8	0	0	0	0	0	0	0	0	0	0	0	0
.4	5.0	0	0	0	0	0	0	0	0	0	0	0	0
.4	5.2				0	0	0	0	0	0	0	0	0
.4	5.4							0	0	0	0	0	0
.4	5.6										0	0	0

BAR1 - CHURCH HILL   BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 2)			2.8-2.9 INCHES (N= 18)			3.0-3.1 INCHES (N= 26)			3.2-3.3 INCHES (N= 72)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	0	0	0	3	2	5	6	4	10	17	5	21
.6	1.4	0	0	0	1	0	1	5	1	6	12	2	14
.6	1.6	0	0	0	1	0	1	5	1	6	5	1	6
.6	1.8	0	0	0	1	0	1	1	0	1	3	1	4
.6	2.0	0	0	0	0	0	0	0	0	0	1	0	1
.6	2.2	0	0	0	0	0	0	0	0	0	1	0	1
.6	2.4	0	0	0	0	0	0	0	0	0	1	0	1
.6	2.6	0	0	0	1	1	2	0	0	0	1	1	1
.6	2.8				4	1	5	0	2	2	1	1	1
.6	3.0							2	5	6	0	3	3
.6	3.2										7	13	18

BAR1 - CHURCH HILL BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		3.4-3.5 INCHES (N=108)			3.6-3.7 INCHES (N=125)			3.8-3.9 INCHES (N=128)			4.0-4.1 INCHES (N=120)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	30	8	37	31	21	47	32	26	53	39	31	57
.6	1.4	23	6	29	23	14	36	21	12	32	29	21	43
.6	1.6	14	2	16	17	10	27	14	8	21	20	15	32
.6	1.8	7	0	7	9	3	12	7	6	12	16	11	26
.6	2.0	4	0	4	6	3	9	5	3	8	8	5	12
.6	2.2	1	0	1	4	2	6	0	1	1	4	2	6
.6	2.4	0	0	0	1	0	1	0	4	4	1	1	1
.6	2.6	0	0	0	0	0	0	0	2	2	1	1	1
.6	2.8	0	0	0	0	0	0	1	1	2	0	0	0
.6	3.0	0	0	0	0	0	0	1	1	1	0	1	1
.6	3.2	0	2	2	0	0	0	1	1	1	1	1	1
.6	3.4	4	15	19	1	3	4	1	2	2	1	1	1
.6	3.6				5	11	16	2	5	6	1	3	3
.6	3.8							11	19	29	1	7	8
.6	4.0										10	23	29

BAR1 - CHURCH HILL BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		4.2-4.3 INCHES (N= 98)			4.4-4.5 INCHES (N= 41)			4.6-4.7 INCHES (N= 35)			4.8-4.9 INCHES (N= 22)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	25	23	45	14	13	21	10	11	19	6	7	12
.6	1.4	19	21	38	11	10	17	6	9	15	6	8	12
.6	1.6	15	11	26	7	9	15	6	8	14	4	10	13
.6	1.8	9	7	16	4	5	9	2	3	5	3	8	10
.6	2.0	6	6	12	4	5	9	1	2	3	3	7	9
.6	2.2	5	6	11	2	3	5	1	1	2	2	6	7
.6	2.4	3	1	4	1	3	4	1	1	2	1	5	6
.6	2.6	2	2	4	1	2	3	0	1	1	1	2	3
.6	2.8	0	1	1	0	1	1	0	0	0	1	2	3
.6	3.0	0	0	0	0	0	0	0	0	0	1	1	2
.6	3.2	0	0	0	0	0	0	0	0	0	1	0	1
.6	3.4	0	0	0	0	0	0	0	0	0	1	0	1
.6	3.6	0	0	0	0	0	0	0	0	0	2	0	2
.6	3.8	0	1	1	0	0	0	0	0	0	1	0	1
.6	4.0	0	3	3	0	1	1	0	0	0	0	0	0
.6	4.2	14	16	26	0	1	1	0	0	0	0	0	0
.6	4.4				8	6	12	0	2	2	0	0	0
.6	4.6							3	7	8	0	1	1
.6	4.8										2	3	5

BAR1 - CHURCH HILL BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		5.0-5.1 INCHES (N= 6)			5.2-5.3 INCHES (N= 4)			5.4-5.5 INCHES (N= 4)			5.6-5.7 INCHES (N= 1)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	3	2	4	0	1	1	0	3	3	0	1	1
.6	1.4	2	2	3	1	0	1	0	2	2	0	0	0
.6	1.6	1	1	2	1	0	1	0	1	1	0	1	1
.6	1.8	1	1	2	0	0	0	0	1	1	0	1	1
.6	2.0	1	1	2	0	0	0	0	1	1	0	1	1
.6	2.2	1	1	2	0	0	0	0	1	1	0	1	1
.6	2.4	1	0	1	0	0	0	0	1	1	0	1	1
.6	2.6	1	0	1	0	0	0	0	2	2	0	1	1
.6	2.8	1	0	1	0	0	0	0	1	1	0	1	1
.6	3.0	1	0	1	0	0	0	0	1	1	0	1	1
.6	3.2	0	0	0	0	0	0	0	1	1	0	1	1
.6	3.4	0	0	0	0	0	0	0	1	1	0	1	1
.6	3.6	0	0	0	0	0	0	0	1	1	0	1	1
.6	3.8	0	0	0	0	0	0	0	1	1	0	1	1
.6	4.0	0	0	0	0	0	0	0	1	1	0	0	0
.6	4.2	0	0	0	0	0	0	0	1	1	0	0	0
.6	4.4	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.6	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.8	0	1	1	0	0	0	0	0	0	0	0	0
.6	5.0	1	1	2	0	0	0	1	0	1	0	0	0
.6	5.2				1	0	1	0	0	0	0	0	0
.6	5.4							0	1	1	0	0	0
.6	5.6										0	0	0

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 4)			2.8-2.9 INCHES (N= 11)			3.0-3.1 INCHES (N= 32)			3.2-3.3 INCHES (N= 61)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	0	0	0	0	0	0	1	1	2	5	5	8
.6	1.4	0	0	0	0	0	0	0	0	0	2	3	5
.6	1.6	0	0	0	0	0	0	0	0	0	1	2	3
.6	1.8	0	0	0	0	0	0	0	0	0	2	1	2
.6	2.0	0	0	0	0	0	0	0	0	0	2	1	2
.6	2.2	0	0	0	0	0	0	0	0	0	1	1	1
.6	2.4	0	0	0	0	0	0	0	0	0	1	1	1
.6	2.6	0	0	0	0	0	0	0	0	0	1	1	1
.6	2.8				0	2	2	0	0	0	1	1	1
.6	3.0							0	3	3	1	1	2
.6	3.2										1	5	6

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		3.4-3.5 INCHES (N= 89)			3.6-3.7 INCHES (N=136)			3.8-3.9 INCHES (N=122)			4.0-4.1 INCHES (N=113)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	8	9	17	10	20	29	13	22	32	18	21	33
.6	1.4	5	5	10	9	14	23	5	16	21	10	16	24
.6	1.6	3	1	4	7	7	14	2	6	8	7	11	18
.6	1.8	0	1	1	6	2	8	0	5	5	5	4	9
.6	2.0	0	1	1	4	0	4	0	3	3	3	3	6
.6	2.2	0	1	1	3	0	3	0	1	1	2	1	3
.6	2.4	0	0	0	2	0	2	0	1	1	2	1	3
.6	2.6	0	0	0	0	0	0	0	1	1	1	1	2
.6	2.8	0	0	0	0	0	0	0	1	1	0	0	0
.6	3.0	0	0	0	0	0	0	0	0	0	0	0	0
.6	3.2	0	0	0	0	0	0	0	0	0	0	0	0
.6	3.4	0	13	13	0	1	1	0	0	0	0	0	0
.6	3.6				2	11	13	0	0	0	0	0	0
.6	3.8							1	11	12	0	0	0
.6	4.0										0	17	17

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		4.2-4.3 INCHES (N= 94)			4.4-4.5 INCHES (N= 71)			4.6-4.7 INCHES (N= 29)			4.8-4.9 INCHES (N= 23)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	18	28	43	12	26	33	5	11	14	6	8	12
.6	1.4	11	26	35	9	20	27	6	12	15	6	9	13
.6	1.6	5	14	18	6	17	21	3	9	12	4	7	10
.6	1.8	3	11	14	5	16	20	2	8	10	4	5	9
.6	2.0	2	8	10	3	12	15	2	6	8	1	3	4
.6	2.2	1	7	8	3	9	12	0	4	4	1	2	3
.6	2.4	1	4	5	2	7	9	0	2	2	1	0	1
.6	2.6	0	3	3	1	5	6	0	2	2	1	1	2
.6	2.8	0	1	1	0	3	3	0	1	1	0	0	0
.6	3.0	0	4	4	0	2	2	0	1	1	0	0	0
.6	3.2	0	0	0	0	1	1	0	1	1	0	0	0
.6	3.4	0	0	0	1	1	1	0	1	1	0	0	0
.6	3.6	0	0	0	1	1	1	0	0	0	0	0	0
.6	3.8	0	0	0	1	1	1	0	0	0	0	0	0
.6	4.0	1	0	1	1	1	1	0	0	0	0	0	0
.6	4.2	2	18	20	1	0	1	0	0	0	0	0	0
.6	4.4				4	10	14	0	0	0	0	0	0
.6	4.6							2	3	4	0	1	1
.6	4.8										2	4	6

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		5.0-5.1 INCHES (N= 11)			5.2-5.3 INCHES (N= 7)			5.4-5.5 INCHES (N= 5)			5.6-5.7 INCHES (N= 1)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	3	8	10	3	2	5	1	2	3	0	1	1
.6	1.4	2	6	8	4	1	5	1	2	3	0	1	1
.6	1.6	1	5	6	3	0	3	0	2	2	0	1	1
.6	1.8	1	4	5	2	0	2	0	1	1	0	0	0
.6	2.0	0	3	3	2	0	2	0	1	1	0	0	0
.6	2.2	0	1	1	2	0	2	0	0	0	0	1	1
.6	2.4	0	2	2	1	0	1	0	0	0	0	0	0
.6	2.6	0	1	1	1	0	1	0	0	0	0	0	0
.6	2.8	0	1	1	0	0	0	0	0	0	0	0	0
.6	3.0	0	1	1	0	0	0	0	0	0	0	0	0
.6	3.2	0	0	0	0	0	0	0	0	0	0	0	0
.6	3.4	0	0	0	0	0	0	0	0	0	0	0	0
.6	3.6	0	0	0	0	0	0	0	0	0	0	0	0
.6	3.8	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.0	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.2	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.4	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.6	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.8	0	1	1	0	0	0	0	0	0	0	0	0
.6	5.0	1	3	3	0	0	0	0	0	0	0	0	0
.6	5.2				0	1	1	0	1	1	0	0	0
.6	5.4							1	3	4	0	0	0
.6	5.6										0	1	1

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES) FIRST READING	SECOND READING	5.8-5.9 INCHES N= 1 HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	0	0	0
.6	1.4	0	0	0
.6	1.6	0	0	0
.6	1.8	0	0	0
.6	2.0	0	0	0
.6	2.2	0	0	0
.6	2.4	0	0	0
.6	2.6	0	0	0
.6	2.8	0	0	0
.6	3.0	0	0	0
.6	3.2	0	0	0
.6	3.4	0	0	0
.6	3.6	0	0	0
.6	3.8	0	0	0
.6	4.0	0	0	0
.6	4.2	0	0	0
.6	4.4	0	0	0
.6	4.6	0	0	0
.6	4.8	0	0	0
.6	5.0	0	0	0
.6	5.2	0	0	0
.6	5.4	0	0	0
.6	5.6	0	0	0
.6	5.8	0	0	0

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 36)			2.8-2.9 INCHES (N= 96)			3.0-3.1 INCHES (N=149)			3.2-3.3 INCHES (N=142)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	1	0	1	2	5	7	4	7	11	9	16	25
.6	1.4	1	0	1	0	1	1	1	3	4	5	7	12
.6	1.6	1	0	1	0	0	0	0	2	2	1	6	7
.6	1.8	0	0	0	0	0	0	0	0	0	0	0	0
.6	2.0	0	0	0	0	0	0	0	0	0	0	0	0
.6	2.2	0	0	0	0	0	0	0	0	0	0	0	0
.6	2.4	0	0	0	0	0	0	0	0	0	0	0	0
.6	2.6	0	5	5	0	0	0	0	0	0	0	0	0
.6	2.8				0	14	14	0	0	0	0	0	0
.6	3.0							3	23	26	0	1	1
.6	3.2										3	27	30

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		3.4-3.5 INCHES (N=121)			3.6-3.7 INCHES (N=103)			3.8-3.9 INCHES (N= 65)			4.0-4.1 INCHES (N= 39)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	14	17	28	10	11	21	10	10	17	4	4	8
.6	1.4	7	8	15	3	8	11	4	8	11	2	4	6
.6	1.6	3	7	10	1	3	4	2	4	5	0	2	2
.6	1.8	1	3	4	0	2	2	1	3	4	0	2	2
.6	2.0	1	1	2	0	0	0	1	1	2	0	2	2
.6	2.2	0	1	1	0	0	0	1	0	1	0	2	2
.6	2.4	0	1	1	0	0	0	0	0	0	0	1	1
.6	2.6	0	1	1	0	0	0	0	0	0	0	0	0
.6	2.8	1	1	1	0	0	0	0	0	0	0	0	0
.6	3.0	1	0	1	0	0	0	0	0	0	0	0	0
.6	3.2	1	3	3	0	0	0	0	0	0	0	0	0
.6	3.4	4	29	32	0	2	2	0	0	0	0	0	0
.6	3.6				8	25	31	0	0	0	0	0	0
.6	3.8							1	14	15	0	0	0
.6	4.0										2	8	10

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		4.2-4.3 INCHES (N= 31)			4.4-4.5 INCHES (N= 15)			4.6-4.7 INCHES (N= 4)			4.8-4.9 INCHES (N= 8)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	6	6	11	3	5	7	0	0	0	4	3	6
.6	1.4	5	6	9	2	3	4	0	0	0	4	3	6
.6	1.6	3	5	8	2	2	4	0	0	0	3	2	4
.6	1.8	1	3	4	2	1	3	0	0	0	1	2	3
.6	2.0	0	1	1	1	1	2	0	0	0	1	2	3
.6	2.2	0	1	1	1	0	1	0	0	0	0	1	1
.6	2.4	0	0	0	0	0	0	0	0	0	0	1	1
.6	2.6	0	0	0	0	0	0	0	0	0	0	1	1
.6	2.8	0	0	0	0	0	0	0	0	0	0	0	0
.6	3.0	0	0	0	0	0	0	0	0	0	0	0	0
.6	3.2	0	0	0	0	0	0	0	0	0	0	0	0
.6	3.4	0	0	0	0	0	0	0	0	0	0	0	0
.6	3.6	0	0	0	0	0	0	0	0	0	0	0	0
.6	3.8	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.0	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.2	2	8	9	0	0	0	0	0	0	0	0	0
.6	4.4				4	5	7	0	1	1	0	0	0
.6	4.6							0	2	2	0	0	0
.6	4.8										1	1	2

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		5.0-5.1 INCHES (N= 0)			5.2-5.3 INCHES (N= 1)			5.4-5.5 INCHES (N= 0)			5.6-5.7 INCHES (N= 0)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	0	0	0	0	1	1	0	0	0	0	0	0
.6	1.4	0	0	0	0	0	0	0	0	0	0	0	0
.6	1.6	0	0	0	0	0	0	0	0	0	0	0	0
.6	1.8	0	0	0	0	0	0	0	0	0	0	0	0
.6	2.0	0	0	0	0	0	0	0	0	0	0	0	0
.6	2.2	0	0	0	0	0	0	0	0	0	0	0	0
.6	2.4	0	0	0	0	0	0	0	0	0	0	0	0
.6	2.6	0	0	0	0	0	0	0	0	0	0	0	0
.6	2.8	0	0	0	0	0	0	0	0	0	0	0	0
.6	3.0	0	0	0	0	0	0	0	0	0	0	0	0
.6	3.2	0	0	0	0	0	0	0	0	0	0	0	0
.6	3.4	0	0	0	0	0	0	0	0	0	0	0	0
.6	3.6	0	0	0	0	0	0	0	0	0	0	0	0
.6	3.8	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.0	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.2	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.4	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.6	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.8	0	0	0	0	0	0	0	0	0	0	0	0
.6	5.0	0	0	0	0	0	0	0	0	0	0	0	0
.6	5.2	0	0	0	0	0	0	0	0	0	0	0	0
.6	5.4	0	0	0	0	0	0	0	0	0	0	0	0
.6	5.6	0	0	0	0	0	0	0	0	0	0	0	0

BAR1 - CHURCH HILL BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 2)			2.8-2.9 INCHES (N= 18)			3.0-3.1 INCHES (N= 26)			3.2-3.3 INCHES (N= 72)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	0	0	0	1	1	2	5	3	8	12	0	12
.8	1.6	0	0	0	1	0	1	5	2	7	6	0	6
.8	1.8	0	0	0	1	0	1	1	0	1	3	0	3
.8	2.0	0	0	0	0	0	0	0	0	0	2	0	2
.8	2.2	0	0	0	0	0	0	0	0	0	2	0	2
.8	2.4	0	0	0	0	0	0	0	0	0	1	1	1
.8	2.6	0	0	0	1	2	3	0	0	0	0	1	1
.8	2.8				3	1	4	0	2	2	0	1	1
.8	3.0							3	7	9	0	4	4
.8	3.2										7	14	19

BAR1 - CHURCH HILL BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		3.4-3.5 INCHES (N=108)			3.6-3.7 INCHES (N=125)			3.8-3.9 INCHES (N=128)			4.0-4.1 INCHES (N=120)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	21	6	25	23	13	36	23	15	37	24	20	37
.8	1.6	10	3	13	15	8	23	17	4	20	18	15	30
.8	1.8	7	1	8	9	5	14	9	2	11	14	12	24
.8	2.0	5	1	6	2	3	5	4	2	6	5	4	9
.8	2.2	1	1	2	2	2	4	0	1	1	1	1	2
.8	2.4	0	0	0	1	0	1	0	3	3	0	1	1
.8	2.6	0	0	0	0	0	0	0	1	1	1	1	2
.8	2.8	0	0	0	0	0	0	0	0	0	0	1	1
.8	3.0	0	0	0	0	0	0	1	1	1	0	1	1
.8	3.2	0	3	3	0	1	1	1	1	1	0	0	0
.8	3.4	6	18	24	1	4	5	1	2	2	1	1	1
.8	3.6				8	14	22	2	6	7	1	4	5
.8	3.8							13	22	34	1	7	8
.8	4.0										12	23	32

BAR1 - CHURCH HILL BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		4.2-4.3 INCHES (N= 98)			4.4-4.5 INCHES (N= 41)			4.6-4.7 INCHES (N= 35)			4.8-4.9 INCHES (N= 22)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	27	18	44	12	14	23	10	12	20	5	14	16
.8	1.6	15	12	26	7	9	16	7	9	16	5	13	14
.8	1.8	7	9	16	6	7	13	4	5	9	3	10	11
.8	2.0	5	6	11	2	3	5	3	3	6	2	9	10
.8	2.2	3	5	8	3	4	7	3	2	5	2	6	7
.8	2.4	2	4	6	1	3	4	2	2	4	1	5	6
.8	2.6	1	1	2	0	2	2	0	1	1	1	4	5
.8	2.8	1	1	2	0	0	0	0	1	1	1	2	3
.8	3.0	0	1	1	0	0	0	0	0	0	1	1	2
.8	3.2	0	0	0	0	0	0	0	0	0	1	1	2
.8	3.4	0	0	0	0	0	0	0	0	0	1	1	2
.8	3.6	0	0	0	0	0	0	0	0	0	0	1	1
.8	3.8	0	1	1	0	0	0	0	0	0	0	0	0
.8	4.0	2	4	6	0	1	1	0	0	0	0	0	0
.8	4.2	14	18	30	0	1	1	0	0	0	0	0	0
.8	4.4				8	6	12	0	2	2	0	0	0
.8	4.6							3	9	10	1	1	2
.8	4.8										2	3	5

BAR1 - CHURCH HILL BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		5.0-5.1 INCHES (N= 6)			5.2-5.3 INCHES (N= 4)			5.4-5.5 INCHES (N= 4)			5.6-5.7 INCHES (N= 1)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	1	2	3	2	0	2	1	1	2	0	0	0
.8	1.6	1	2	3	2	0	2	1	1	2	0	1	1
.8	1.8	1	2	3	1	0	1	1	1	2	0	1	1
.8	2.0	1	2	3	1	0	1	1	1	2	0	1	1
.8	2.2	1	0	1	0	0	0	1	1	2	0	1	1
.8	2.4	1	0	1	0	0	0	1	1	2	0	1	1
.8	2.6	1	0	1	0	0	0	1	1	2	0	1	1
.8	2.8	1	0	1	0	0	0	0	1	1	0	1	1
.8	3.0	1	0	1	0	0	0	0	1	1	0	1	1
.8	3.2	0	0	0	0	0	0	0	1	1	0	1	1
.8	3.4	0	0	0	0	0	0	0	1	1	0	1	1
.8	3.6	0	0	0	0	0	0	0	1	1	0	1	1
.8	3.8	0	0	0	0	0	0	1	1	2	0	1	1
.8	4.0	0	0	0	0	0	0	0	0	0	0	1	1
.8	4.2	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.4	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.6	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.8	0	1	1	0	0	0	0	0	0	0	0	0
.8	5.0	1	1	2	0	0	0	0	0	0	0	0	0
.8	5.2				1	1	2	0	0	0	0	0	0
.8	5.4							0	1	1	0	0	0
.8	5.6										0	0	0

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 4)			2.8-2.9 INCHES (N= 11)			3.0-3.1 INCHES (N= 32)			3.2-3.3 INCHES (N= 61)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	0	0	0	0	0	0	1	0	1	5	4	9
.8	1.6	0	0	0	0	0	0	0	0	0	3	3	6
.8	1.8	0	0	0	0	0	0	0	0	0	3	1	4
.8	2.0	0	0	0	0	0	0	0	0	0	3	1	3
.8	2.2	0	0	0	0	0	0	0	0	0	1	1	1
.8	2.4	0	0	0	0	0	0	0	0	0	1	1	1
.8	2.6	0	0	0	0	0	0	0	0	0	1	1	1
.8	2.8				0	2	2	0	0	0	1	0	1
.8	3.0							0	3	3	1	1	2
.8	3.2										2	6	7

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		3.4-3.5 INCHES (N= 89)			3.6-3.7 INCHES (N=136)			3.8-3.9 INCHES (N=122)			4.0-4.1 INCHES (N=113)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	5	5	10	18	10	27	16	15	29	13	19	29
.8	1.6	1	2	3	10	5	15	8	10	18	9	12	21
.8	1.8	0	0	0	6	3	9	3	7	10	5	6	11
.8	2.0	0	1	1	2	1	3	4	6	10	4	5	9
.8	2.2	0	0	0	2	0	2	2	2	4	1	1	2
.8	2.4	0	0	0	1	0	1	2	1	2	1	1	2
.8	2.6	0	0	0	0	0	0	2	1	2	0	1	1
.8	2.8	0	0	0	0	0	0	2	2	2	0	1	1
.8	3.0	0	0	0	0	0	0	1	1	1	0	0	0
.8	3.2	0	0	0	0	0	0	0	0	0	0	0	0
.8	3.4	1	13	14	0	1	1	0	0	0	0	0	0
.8	3.6				2	14	16	0	0	0	0	0	0
.8	3.8							2	13	14	1	1	2
.8	4.0										0	18	18

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		4.2-4.3 INCHES (N= 94)			4.4-4.5 INCHES (N= 71)			4.6-4.7 INCHES (N= 29)			4.8-4.9 INCHES (N= 23)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	13	20	29	12	23	33	6	11	14	6	10	14
.8	1.6	8	12	18	4	16	20	4	6	9	4	7	11
.8	1.8	4	9	13	4	14	18	3	5	7	3	4	7
.8	2.0	2	6	8	3	9	12	2	4	6	1	2	3
.8	2.2	1	5	6	2	6	8	0	2	2	1	4	5
.8	2.4	1	1	2	1	6	7	0	2	2	1	2	3
.8	2.6	0	2	2	2	4	6	0	2	2	1	2	3
.8	2.8	0	0	0	0	1	1	0	1	1	0	0	0
.8	3.0	0	2	2	0	0	0	0	1	1	0	0	0
.8	3.2	0	0	0	0	1	1	0	0	0	0	0	0
.8	3.4	0	0	0	0	1	1	0	0	0	0	0	0
.8	3.6	0	0	0	1	1	1	0	0	0	0	0	0
.8	3.8	1	0	1	1	1	1	0	0	0	0	0	0
.8	4.0	2	0	2	1	1	1	0	0	0	0	0	0
.8	4.2	3	17	20	1	0	1	0	0	0	0	0	0
.8	4.4				5	12	17	0	0	0	0	0	0
.8	4.6							2	5	6	0	1	1
.8	4.8										1	4	5

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		5.0-5.1 INCHES (N= 11)			5.2-5.3 INCHES (N= 7)			5.4-5.5 INCHES (N= 5)			5.6-5.7 INCHES (N= 1)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	0	4	4	3	3	5	2	1	3	0	1	1
.8	1.6	0	4	4	2	2	3	2	2	3	0	0	0
.8	1.8	0	3	3	2	1	3	2	1	3	0	0	0
.8	2.0	0	2	2	0	1	1	0	1	1	0	0	0
.8	2.2	0	2	2	1	0	1	0	0	0	0	0	0
.8	2.4	0	2	2	0	0	0	0	0	0	0	0	0
.8	2.6	0	2	2	0	0	0	0	0	0	0	0	0
.8	2.8	0	2	2	0	0	0	0	0	0	0	0	0
.8	3.0	0	0	0	0	1	1	0	0	0	0	0	0
.8	3.2	0	0	0	0	1	1	0	0	0	0	0	0
.8	3.4	0	0	0	0	0	0	0	0	0	0	0	0
.8	3.6	0	0	0	0	0	0	0	0	0	0	0	0
.8	3.8	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.0	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.2	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.4	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.6	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.8	0	0	0	0	0	0	0	0	0	0	0	0
.8	5.0	0	0	0	0	0	0	0	0	0	0	0	0
.8	5.2	0	0	0	0	0	0	0	0	0	0	0	0
.8	5.4	0	0	0	0	0	0	0	1	1	0	0	0
.8	5.6	1	2	3	0	2	2	1	3	4	0	1	1

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES) FIRST READING	SECOND READING	5.8-5.9 INCHES N= 1 HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	1	0	1
.8	1.6	0	0	0
.8	1.8	0	0	0
.8	2.0	0	0	0
.8	2.2	0	0	0
.8	2.4	0	0	0
.8	2.6	0	0	0
.8	2.8	0	0	0
.8	3.0	0	0	0
.8	3.2	0	0	0
.8	3.4	0	0	0
.8	3.6	0	0	0
.8	3.8	0	0	0
.8	4.0	0	0	0
.8	4.2	0	0	0
.8	4.4	0	0	0
.8	4.6	0	0	0
.8	4.8	0	0	0
.8	5.0	0	0	0
.8	5.2	0	0	0
.8	5.4	0	0	0
.8	5.6	0	0	0
.8	5.8	0	0	0

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 36)			2.8-2.9 INCHES (N= 96)			3.0-3.1 INCHES (N=149)			3.2-3.3 INCHES (N=142)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	1	0	1	3	2	5	3	5	8	4	9	13
.8	1.6	1	0	1	0	0	0	0	2	2	1	8	9
.8	1.8	0	0	0	0	0	0	1	0	1	0	0	0
.8	2.0	0	0	0	0	0	0	0	0	0	0	0	0
.8	2.2	0	0	0	0	0	0	0	0	0	0	0	0
.8	2.4	1	0	1	0	0	0	0	0	0	0	0	0
.8	2.6	0	6	6	0	0	0	0	0	0	0	0	0
.8	2.8				0	14	14	0	0	0	0	0	0
.8	3.0							5	24	29	0	1	1
.8	3.2										4	32	35

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		3.4-3.5 INCHES (N=121)			3.6-3.7 INCHES (N=103)			3.8-3.9 INCHES (N= 65)			4.0-4.1 INCHES (N= 39)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	8	9	17	6	9	15	5	5	10	1	5	6
.8	1.6	4	6	10	3	2	5	3	4	6	0	4	4
.8	1.8	3	3	6	1	1	2	0	2	2	0	2	2
.8	2.0	2	1	3	0	0	0	0	2	2	0	2	2
.8	2.2	0	1	1	0	0	0	0	1	1	0	1	1
.8	2.4	0	1	1	0	0	0	0	0	0	0	0	0
.8	2.6	1	1	1	0	0	0	0	0	0	0	0	0
.8	2.8	1	0	1	0	0	0	0	0	0	0	0	0
.8	3.0	1	0	1	0	0	0	0	0	0	0	0	0
.8	3.2	1	2	3	0	0	0	0	0	0	0	0	0
.8	3.4	5	32	36	0	3	3	0	0	0	0	0	0
.8	3.6				9	29	36	0	0	0	0	0	0
.8	3.8							1	16	17	0	0	0
.8	4.0										2	8	9

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		4.2-4.3 INCHES (N= 31)			4.4-4.5 INCHES (N= 15)			4.6-4.7 INCHES (N= 4)			4.8-4.9 INCHES (N= 8)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	4	6	10	3	3	5	1	1	2	1	2	3
.8	1.6	2	6	8	3	2	5	0	0	0	1	2	3
.8	1.8	1	3	4	2	3	5	0	0	0	1	2	3
.8	2.0	0	2	2	1	1	2	0	0	0	1	1	2
.8	2.2	0	1	1	1	0	1	0	0	0	0	1	1
.8	2.4	0	0	0	0	0	0	0	0	0	0	1	1
.8	2.6	0	0	0	0	0	0	0	0	0	0	0	0
.8	2.8	0	0	0	0	0	0	0	0	0	0	0	0
.8	3.0	0	0	0	0	0	0	0	0	0	0	0	0
.8	3.2	0	0	0	0	0	0	0	0	0	0	0	0
.8	3.4	0	0	0	0	0	0	0	0	0	0	0	0
.8	3.6	0	0	0	0	0	0	0	0	0	0	0	0
.8	3.8	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.0	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.2	2	8	9	0	0	0	0	0	0	0	0	0
.8	4.4				4	6	8	0	1	1	0	0	0
.8	4.6							0	2	2	0	0	0
.8	4.8										1	0	1

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		5.0-5.1 INCHES (N= 0)			5.2-5.3 INCHES (N= 1)			5.4-5.5 INCHES (N= 0)			5.6-5.7 INCHES (N= 0)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	0	0	0	0	1	1	0	0	0	0	0	0
.8	1.6	0	0	0	0	1	1	0	0	0	0	0	0
.8	1.8	0	0	0	0	0	0	0	0	0	0	0	0
.8	2.0	0	0	0	0	0	0	0	0	0	0	0	0
.8	2.2	0	0	0	0	0	0	0	0	0	0	0	0
.8	2.4	0	0	0	0	0	0	0	0	0	0	0	0
.8	2.6	0	0	0	0	0	0	0	0	0	0	0	0
.8	2.8	0	0	0	0	0	0	0	0	0	0	0	0
.8	3.0	0	0	0	0	0	0	0	0	0	0	0	0
.8	3.2	0	0	0	0	0	0	0	0	0	0	0	0
.8	3.4	0	0	0	0	0	0	0	0	0	0	0	0
.8	3.6	0	0	0	0	0	0	0	0	0	0	0	0
.8	3.8	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.0	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.2	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.4	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.6	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.8	0	0	0	0	0	0	0	0	0	0	0	0
.8	5.0	0	0	0	0	0	0	0	0	0	0	0	0
.8	5.2				0	0	0	0	0	0	0	0	0
.8	5.4							0	0	0	0	0	0
.8	5.6										0	0	0

BAR1 - CHURCH HILL BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 2)			2.8-2.9 INCHES (N= 18)			3.0-3.1 INCHES (N= 26)			3.2-3.3 INCHES (N= 72)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	0	0	0	2	2	4	5	1	6	9	2	11
1.0	1.8	0	0	0	2	2	2	1	1	2	4	1	5
1.0	2.0	0	0	0	0	1	1	0	0	0	2	1	2
1.0	2.2	0	0	0	0	1	1	0	0	0	1	1	1
1.0	2.4	0	0	0	0	1	1	0	0	0	0	2	2
1.0	2.6	0	0	0	1	2	3	0	0	0	0	1	1
1.0	2.8				4	5	7	0	2	2	0	2	2
1.0	3.0							4	7	10	0	7	7
1.0	3.2										8	17	23

BAR1 - CHURCH HILL BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		3.4-3.5 INCHES (N=108)			3.6-3.7 INCHES (N=125)			3.8-3.9 INCHES (N=128)			4.0-4.1 INCHES (N=120)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	12	4	16	18	7	25	19	8	26	22	15	33
1.0	1.8	10	2	12	10	5	15	10	6	16	14	12	24
1.0	2.0	5	1	6	4	3	7	5	3	8	10	4	14
1.0	2.2	2	1	2	2	3	5	1	2	3	3	2	5
1.0	2.4	0	0	0	0	1	1	0	3	3	1	1	2
1.0	2.6	0	0	0	0	0	0	0	2	2	1	0	1
1.0	2.8	0	0	0	0	0	0	1	1	1	1	0	1
1.0	3.0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.2	0	5	5	0	0	0	1	1	2	1	0	1
1.0	3.4	7	19	26	2	6	8	1	2	2	1	0	1
1.0	3.6				11	18	29	1	6	6	2	3	5
1.0	3.8							16	24	38	1	6	7
1.0	4.0										13	24	33

BAR1 - CHURCH HILL BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		4.2-4.3 INCHES (N= 98)			4.4-4.5 INCHES (N= 41)			4.6-4.7 INCHES (N= 35)			4.8-4.9 INCHES (N= 22)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	15	12	26	8	8	16	8	10	17	5	11	13
1.0	1.8	7	6	13	5	5	10	6	4	10	4	11	14
1.0	2.0	2	5	7	5	3	8	4	4	8	3	6	9
1.0	2.2	3	2	5	2	3	5	2	3	5	3	5	7
1.0	2.4	1	0	1	1	2	3	1	1	2	1	3	4
1.0	2.6	1	1	2	1	0	1	0	0	0	0	2	2
1.0	2.8	1	1	2	0	0	0	1	0	1	0	2	2
1.0	3.0	1	0	1	0	0	0	0	0	0	0	1	1
1.0	3.2	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.4	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.6	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.8	2	1	3	0	0	0	0	0	0	0	0	0
1.0	4.0	2	5	7	0	1	1	0	0	0	0	0	0
1.0	4.2	15	21	34	0	1	1	0	0	0	0	1	1
1.0	4.4				6	7	12	0	2	2	0	0	0
1.0	4.6							3	9	10	1	1	2
1.0	4.8										2	3	5

BAR1 - CHURCH HILL BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		5.0-5.1 INCHES (N= 6)			5.2-5.3 INCHES (N= 4)			5.4-5.5 INCHES (N= 4)			5.6-5.7 INCHES (N= 1)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	1	3	4	3	0	3	1	1	2	0	1	1
1.0	1.8	2	1	3	1	0	1	0	1	1	0	1	1
1.0	2.0	1	0	1	1	0	1	1	2	2	0	1	1
1.0	2.2	1	0	1	0	0	0	1	2	2	0	1	1
1.0	2.4	1	0	1	0	0	0	1	1	2	0	1	1
1.0	2.6	1	0	1	0	0	0	0	2	2	0	1	1
1.0	2.8	1	0	1	0	0	0	0	1	1	0	1	1
1.0	3.0	1	0	1	0	0	0	0	1	1	0	1	1
1.0	3.2	0	0	0	0	0	0	0	1	1	0	1	1
1.0	3.4	0	0	0	0	0	0	0	1	1	0	1	1
1.0	3.6	0	0	0	0	0	0	0	1	1	0	1	1
1.0	3.8	0	0	0	0	0	0	0	1	1	0	1	1
1.0	4.0	0	0	0	0	0	0	0	0	0	0	1	1
1.0	4.2	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.4	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.6	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.8	0	1	1	0	0	0	0	0	0	0	0	0
1.0	5.0	1	2	3	0	0	0	0	0	0	0	0	0
1.0	5.2				1	1	2	0	0	0	0	0	0
1.0	5.4							0	1	1	0	0	0
1.0	5.6										0	0	0

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 4)			2.8-2.9 INCHES (N= 11)			3.0-3.1 INCHES (N= 32)			3.2-3.3 INCHES (N= 61)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	0	0	0	1	0	1	0	0	0	3	3	6
1.0	1.8	0	0	0	1	1	1	0	0	0	4	1	4
1.0	2.0	0	0	0	0	0	0	0	0	0	3	1	3
1.0	2.2	0	0	0	0	0	0	0	0	0	1	1	1
1.0	2.4	0	0	0	0	0	0	0	0	0	1	1	1
1.0	2.6	0	0	0	0	0	0	0	0	0	1	1	1
1.0	2.8				0	2	2	0	0	0	1	0	1
1.0	3.0							0	3	3	1	1	2
1.0	3.2										2	6	7

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES) FIRST READING	SECOND READING	3.4-3.5 INCHES (N= 89) HINGE LEAD	BILL LEAD	TOTAL	3.6-3.7 INCHES (N=136) HINGE LEAD	BILL LEAD	TOTAL	3.8-3.9 INCHES (N=122) HINGE LEAD	BILL LEAD	TOTAL	4.0-4.1 INCHES (N=113) HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	7	3	10	13	3	15	15	10	24	11	15	25
1.0	1.8	3	0	3	8	1	9	8	7	15	7	6	13
1.0	2.0	1	0	1	4	1	5	4	5	9	3	5	8
1.0	2.2	0	0	0	2	2	4	4	1	4	2	3	5
1.0	2.4	0	0	0	2	2	3	2	1	2	2	1	3
1.0	2.6	0	0	0	0	0	0	2	2	2	0	2	2
1.0	2.8	0	0	0	0	0	0	2	2	2	0	0	0
1.0	3.0	0	0	0	0	0	0	2	2	2	0	0	0
1.0	3.2	0	0	0	0	0	0	1	0	1	0	0	0
1.0	3.4	1	16	17	0	2	2	1	0	1	0	0	0
1.0	3.6				3	17	20	0	0	0	0	0	0
1.0	3.8							2	13	15	1	1	2
1.0	4.0										1	21	22

BAR2 - PRISON POINT BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		4.2-4.3 INCHES (N= 94)			4.4-4.5 INCHES (N= 71)			4.6-4.7 INCHES (N= 29)			4.8-4.9 INCHES (N= 23)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	9	10	18	9	19	26	3	5	7	4	5	9
1.0	1.8	6	7	13	4	6	9	1	5	6	3	2	5
1.0	2.0	2	4	6	2	5	7	1	5	6	1	1	2
1.0	2.2	2	2	4	2	5	7	0	4	4	1	1	2
1.0	2.4	1	1	2	1	5	6	0	1	1	0	1	1
1.0	2.6	0	1	1	1	3	4	0	1	1	1	1	2
1.0	2.8	0	0	0	1	2	3	0	0	0	0	0	0
1.0	3.0	0	1	1	0	1	1	0	0	0	0	0	0
1.0	3.2	0	0	0	0	2	2	0	0	0	0	0	0
1.0	3.4	0	0	0	1	1	1	0	0	0	0	0	0
1.0	3.6	0	0	0	1	0	1	0	0	0	0	0	0
1.0	3.8	1	0	1	1	1	1	0	0	0	0	0	0
1.0	4.0	1	2	3	1	0	1	0	0	0	0	0	0
1.0	4.2	3	17	19	2	0	2	0	0	0	0	0	0
1.0	4.4				5	13	18	0	0	0	0	0	0
1.0	4.6							2	7	8	0	1	1
1.0	4.8										3	4	6

BAR2 - PRISON POINT   BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		5.0-5.1 INCHES (N= 11)			5.2-5.3 INCHES (N= 7)			5.4-5.5 INCHES (N= 5)			5.6-5.7 INCHES (N= 1)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	0	2	2	2	2	3	1	1	1	0	0	0
1.0	1.8	1	2	3	2	1	3	1	1	2	0	0	0
1.0	2.0	0	3	3	1	0	1	0	1	1	0	0	0
1.0	2.2	0	3	3	1	0	1	0	0	0	0	0	0
1.0	2.4	0	2	2	1	0	1	0	0	0	0	0	0
1.0	2.6	0	0	0	0	0	0	0	0	0	0	0	0
1.0	2.8	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.2	0	0	0	0	1	1	0	0	0	0	0	0
1.0	3.4	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.6	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.8	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.2	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.4	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.6	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.8	0	0	0	0	0	0	0	0	0	0	0	0
1.0	5.0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	5.2	0	0	0	0	0	0	0	0	0	0	0	0
1.0	5.4	0	0	0	0	0	0	0	1	1	0	0	0
1.0	5.6	1	3	4	0	2	2	1	3	4	0	1	1

BAR2 - PRISON POINT   BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES) FIRST READING	SECOND READING	5.8-5.9 INCHES N= 1 HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	0	0	0
1.0	1.8	1	0	1
1.0	2.0	1	0	1
1.0	2.2	1	0	1
1.0	2.4	0	0	0
1.0	2.6	0	0	0
1.0	2.8	0	0	0
1.0	3.0	0	0	0
1.0	3.2	0	0	0
1.0	3.4	0	0	0
1.0	3.6	0	0	0
1.0	3.8	0	0	0
1.0	4.0	0	0	0
1.0	4.2	0	0	0
1.0	4.4	0	0	0
1.0	4.6	0	0	0
1.0	4.8	0	0	0
1.0	5.0	0	0	0
1.0	5.2	0	0	0
1.0	5.4	0	0	0
1.0	5.6	0	0	0
1.0	5.8	0	0	0

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 36)			2.8-2.9 INCHES (N= 96)			3.0-3.1 INCHES (N=149)			3.2-3.3 INCHES (N=142)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	1	1	1	0	0	0	4	2	6	7	5	11
1.0	1.8	0	1	1	0	0	0	1	2	3	4	1	4
1.0	2.0	0	1	1	0	0	0	0	0	0	2	1	2
1.0	2.2	0	1	1	0	0	0	0	0	0	1	1	1
1.0	2.4	0	0	0	0	0	0	0	0	0	0	0	0
1.0	2.6	1	8	8	1	0	1	1	0	1	0	0	0
1.0	2.8				2	20	21	0	0	0	0	0	0
1.0	3.0							7	33	40	0	3	3
1.0	3.2										7	39	45

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		3.4-3.5 INCHES (N=121)			3.6-3.7 INCHES (N=103)			3.8-3.9 INCHES (N= 65)			4.0-4.1 INCHES (N= 39)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	6	6	12	2	3	5	5	3	8	1	2	3
1.0	1.8	2	3	5	2	1	3	3	2	5	1	1	2
1.0	2.0	3	2	4	0	0	0	2	1	3	1	3	4
1.0	2.2	2	1	3	0	0	0	1	0	1	0	1	1
1.0	2.4	1	1	1	0	0	0	0	0	0	0	0	0
1.0	2.6	1	0	1	0	0	0	0	0	0	0	0	0
1.0	2.8	1	0	1	0	0	0	0	0	0	0	0	0
1.0	3.0	2	1	3	0	0	0	0	0	0	0	0	0
1.0	3.2	1	3	4	0	0	0	0	0	0	0	0	0
1.0	3.4	7	35	40	0	4	4	0	0	0	0	0	0
1.0	3.6				9	32	39	1	0	1	0	0	0
1.0	3.8							3	17	19	0	0	0
1.0	4.0										2	9	11

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		4.2-4.3 INCHES (N= 31)			4.4-4.5 INCHES (N= 15)			4.6-4.7 INCHES (N= 4)			4.8-4.9 INCHES (N= 8)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	2	4	6	2	3	5	0	0	0	1	3	4
1.0	1.8	2	4	6	2	2	4	0	0	0	1	1	2
1.0	2.0	0	0	0	0	0	0	0	0	0	1	1	2
1.0	2.2	0	0	0	1	0	1	0	0	0	0	1	1
1.0	2.4	0	0	0	0	0	0	0	0	0	0	0	0
1.0	2.6	0	0	0	0	0	0	0	0	0	0	0	0
1.0	2.8	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.2	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.4	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.6	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.8	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.2	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.4	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.6	0	0	0	0	0	0	0	1	1	0	0	0
1.0	4.8	2	8	9	4	6	8	0	3	3	1	2	3

BAR3 - BUOY ROCK BUSHEL TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		5.0-5.1 INCHES (N= 0)			5.2-5.3 INCHES (N= 1)			5.4-5.5 INCHES (N= 0)			5.6-5.7 INCHES (N= 0)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	0	0	0	0	0	0	0	0	0	0	0	0
1.0	1.8	0	0	0	0	0	0	0	0	0	0	0	0
1.0	2.0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	2.2	0	0	0	0	0	0	0	0	0	0	0	0
1.0	2.4	0	0	0	0	0	0	0	0	0	0	0	0
1.0	2.6	0	0	0	0	0	0	0	0	0	0	0	0
1.0	2.8	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.2	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.4	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.6	0	0	0	0	0	0	0	0	0	0	0	0
1.0	3.8	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.2	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.4	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.6	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.8	0	0	0	0	0	0	0	0	0	0	0	0
1.0	5.0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	5.2				0	0	0	0	0	0	0	0	0
1.0	5.4							0	0	0	0	0	0
1.0	5.6										0	0	0

APPENDIX D

DIMENSIONAL ORIENTATION TESTS

PART B

BAR TOTALS

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 42)			2.8-2.9 INCHES (N=125)			3.0-3.1 INCHES (N=207)			3.2-3.3 INCHES (N=275)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	2	1	3	9	13	22	15	22	36	36	29	64
.4	1.2	1	1	2	5	7	12	7	13	20	26	15	40
.4	1.4	1	0	1	4	0	4	5	5	10	16	6	22
.4	1.6	1	0	1	1	0	1	5	5	9	8	5	13
.4	1.8	0	0	0	1	0	1	2	3	4	5	3	8
.4	2.0	0	0	0	0	0	0	0	1	1	4	2	6
.4	2.2	0	0	0	0	0	0	0	0	0	2	1	3
.4	2.4	0	0	0	0	0	0	0	0	0	1	1	2
.4	2.6	0	6	6	0	1	1	0	0	0	2	2	2
.4	2.8				2	12	14	0	1	1	1	1	1
.4	3.0							4	25	28	0	2	2
.4	3.2										8	31	37

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		3.4-3.5 INCHES (N=318)			3.6-3.7 INCHES (N=364)			3.8-3.9 INCHES (N=315)			4.0-4.1 INCHES (N=272)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	62	54	108	59	73	123	85	67	131	78	69	126
.4	1.2	46	35	80	41	48	83	60	50	94	56	56	98
.4	1.4	30	18	48	31	33	62	38	30	63	40	38	71
.4	1.6	26	10	36	20	23	42	25	16	38	31	25	52
.4	1.8	16	2	18	13	10	23	12	10	21	22	18	39
.4	2.0	9	1	10	7	7	14	5	9	14	12	10	22
.4	2.2	5	1	6	6	4	10	5	6	11	8	6	14
.4	2.4	1	2	3	3	0	3	1	5	6	6	5	11
.4	2.6	0	1	1	0	0	0	1	2	3	5	5	10
.4	2.8	0	1	1	1	0	1	2	2	3	4	3	7
.4	3.0	0	0	0	0	0	0	2	1	2	3	2	5
.4	3.2	1	4	4	0	0	0	2	1	2	4	1	5
.4	3.4	7	52	58	0	3	3	2	2	2	3	1	3
.4	3.6				9	42	51	3	3	5	4	4	4
.4	3.8							16	38	51	5	6	9
.4	4.0										13	39	49

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		4.2-4.3 INCHES (N=223)			4.4-4.5 INCHES (N=127)			4.6-4.7 INCHES (N= 68)			4.8-4.9 INCHES (N= 53)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	76	59	111	35	49	73	27	30	46	18	17	31
.4	1.2	48	54	90	24	45	63	16	26	36	14	14	25
.4	1.4	36	46	76	19	34	49	12	22	32	14	16	26
.4	1.6	22	26	46	12	28	38	12	15	26	11	13	22
.4	1.8	19	18	35	7	20	25	9	12	20	8	10	18
.4	2.0	14	11	25	5	16	21	8	8	16	7	8	15
.4	2.2	12	10	22	3	13	16	6	5	11	5	6	11
.4	2.4	8	8	16	2	12	14	4	3	7	2	4	6
.4	2.6	5	4	9	2	9	11	1	3	4	2	3	5
.4	2.8	1	4	5	1	4	5	0	1	1	1	2	3
.4	3.0	1	5	6	1	1	2	0	1	1	1	1	2
.4	3.2	1	3	4	1	1	2	0	0	0	1	1	2
.4	3.4	1	1	2	1	1	2	0	0	0	0	0	0
.4	3.6	1	0	1	2	1	2	0	0	0	0	0	0
.4	3.8	1	1	1	2	1	2	0	0	0	0	0	0
.4	4.0	1	5	5	1	1	1	0	0	0	0	0	0
.4	4.2	18	40	52	2	1	3	0	3	3	0	0	0
.4	4.4				14	20	30	0	15	17	0	0	0
.4	4.6							5			0	1	1
.4	4.8										6	6	12

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		5.0-5.1 INCHES (N= 17)			5.2-5.3 INCHES (N= 12)			5.4-5.5 INCHES (N= 9)			5.6-5.7 INCHES (N= 2)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	7	9	13	5	6	9	5	5	7	0	0	0
.4	1.2	4	9	12	3	5	7	4	5	7	0	0	0
.4	1.4	3	8	11	4	3	6	2	4	6	0	1	1
.4	1.6	3	7	10	5	2	6	1	3	4	0	1	1
.4	1.8	2	5	7	4	2	5	1	2	3	0	1	1
.4	2.0	2	4	6	1	1	2	0	2	2	0	1	1
.4	2.2	2	4	6	1	1	2	0	2	2	0	1	1
.4	2.4	2	3	5	1	1	2	0	2	2	0	1	1
.4	2.6	2	2	4	1	1	2	0	2	2	0	1	1
.4	2.8	2	2	4	1	0	1	0	1	1	0	1	1
.4	3.0	2	2	4	0	0	0	0	1	1	0	1	1
.4	3.2	2	2	4	0	0	0	0	1	1	0	1	1
.4	3.4	0	1	1	0	0	0	0	1	1	0	1	1
.4	3.6	0	0	0	0	0	0	0	1	1	0	1	1
.4	3.8	0	0	0	0	0	0	0	1	1	0	1	1
.4	4.0	0	0	0	0	0	0	0	1	1	0	0	0
.4	4.2	0	0	0	0	0	0	0	1	1	0	0	0
.4	4.4	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.6	0	0	0	0	0	0	0	0	0	0	0	0
.4	4.8	0	2	2	0	0	0	0	1	1	0	0	0
.4	5.0	2	7	8	0	0	0	0	0	0	0	0	0
.4	5.2				0	1	1	0	1	1	0	0	0
.4	5.4							1	4	5	0	0	0
.4	5.6										0	1	1

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		5.8-5.9 INCHES N= 1		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL
.4	1.0	0	1	1
.4	1.2	0	1	1
.4	1.4	0	1	1
.4	1.6	0	1	1
.4	1.8	0	0	0
.4	2.0	0	0	0
.4	2.2	0	0	0
.4	2.4	0	0	0
.4	2.6	0	0	0
.4	2.8	0	0	0
.4	3.0	0	0	0
.4	3.2	0	0	0
.4	3.4	0	0	0
.4	3.6	0	0	0
.4	3.8	0	0	0
.4	4.0	0	0	0
.4	4.2	0	0	0
.4	4.4	0	0	0
.4	4.6	0	0	0
.4	4.8	0	0	0
.4	5.0	0	0	0
.4	5.2	0	0	0
.4	5.4	0	0	0
.4	5.6	0	0	0
.4	5.8	0	0	0

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 42)			2.8-2.9 INCHES (N=125)			3.0-3.1 INCHES (N=207)			3.2-3.3 INCHES (N=275)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	1	0	1	5	7	12	11	12	23	31	26	54
.6	1.4	1	0	1	1	1	2	6	4	10	19	12	31
.6	1.6	1	0	1	1	0	1	5	3	8	7	9	16
.6	1.8	0	0	0	1	0	1	1	0	1	5	2	6
.6	2.0	0	0	0	0	0	0	0	0	0	3	1	3
.6	2.2	0	0	0	0	0	0	0	0	0	2	1	2
.6	2.4	0	0	0	0	0	0	0	0	0	2	1	2
.6	2.6	0	5	5	1	1	2	0	0	0	2	2	2
.6	2.8				4	17	21	0	2	2	2	2	2
.6	3.0							5	31	35	1	5	6
.6	3.2										11	45	54

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		3.4-3.5 INCHES (N=318)			3.6-3.7 INCHES (N=364)			3.8-3.9 INCHES (N=315)			4.0-4.1 INCHES (N=272)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	52	34	82	51	52	97	55	58	102	61	56	98
.6	1.4	35	19	54	35	36	70	30	36	64	41	41	73
.6	1.6	20	10	30	25	20	45	18	18	34	27	28	52
.6	1.8	8	4	12	15	7	22	8	14	21	21	17	37
.6	2.0	5	2	7	10	3	13	6	7	13	11	10	20
.6	2.2	1	2	3	7	2	9	1	2	3	6	5	11
.6	2.4	0	1	1	3	0	3	0	5	5	3	3	5
.6	2.6	0	1	1	0	0	0	0	3	3	2	2	3
.6	2.8	1	1	1	0	0	0	1	2	3	0	0	0
.6	3.0	1	0	1	0	0	0	1	1	1	0	1	1
.6	3.2	1	5	5	0	0	0	1	1	1	1	1	1
.6	3.4	8	57	64	1	6	7	1	2	2	1	1	1
.6	3.6				15	47	60	2	5	6	1	3	3
.6	3.8							13	44	56	1	7	8
.6	4.0										12	48	56

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		4.2-4.3 INCHES (N=223)			4.4-4.5 INCHES (N=127)			4.6-4.7 INCHES (N= 68)			4.8-4.9 INCHES (N= 53)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	49	57	99	29	44	61	15	22	33	16	18	30
.6	1.4	35	53	82	22	33	48	12	21	30	16	20	31
.6	1.6	23	30	52	15	28	40	9	17	26	11	19	27
.6	1.8	13	21	34	11	22	32	4	11	15	8	15	22
.6	2.0	8	15	23	8	18	26	3	8	11	5	12	16
.6	2.2	6	14	20	6	12	18	1	5	6	3	9	11
.6	2.4	4	5	9	3	10	13	1	3	4	2	6	8
.6	2.6	2	5	7	2	7	9	0	3	3	2	4	6
.6	2.8	0	2	2	0	4	4	0	1	1	1	2	3
.6	3.0	0	4	4	0	2	2	0	1	1	1	1	2
.6	3.2	0	0	0	0	1	1	0	1	1	1	0	1
.6	3.4	0	0	0	1	1	1	0	1	1	1	0	1
.6	3.6	0	0	0	1	1	1	0	0	0	2	0	2
.6	3.8	0	1	1	1	1	1	0	0	0	1	0	1
.6	4.0	1	3	4	1	2	2	0	0	0	0	0	0
.6	4.2	18	42	55	1	1	2	0	0	0	0	0	0
.6	4.4				16	21	33	0	3	3	0	0	0
.6	4.6							5	12	14	0	2	2
.6	4.8										5	8	13

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		5.0-5.1 INCHES (N= 17)			5.2-5.3 INCHES (N= 12)			5.4-5.5 INCHES (N= 9)			5.6-5.7 INCHES (N= 2)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	6	10	14	3	4	7	1	5	6	0	2	2
.6	1.4	4	8	11	5	1	6	1	4	5	0	1	1
.6	1.6	2	6	8	4	0	4	0	3	3	0	2	2
.6	1.8	2	5	7	2	0	2	0	2	2	0	1	1
.6	2.0	1	4	5	2	0	2	0	2	2	0	1	1
.6	2.2	1	2	3	2	0	2	0	1	1	0	2	2
.6	2.4	1	2	3	1	0	1	0	1	1	0	1	1
.6	2.6	1	1	2	1	0	1	0	2	2	0	1	1
.6	2.8	1	1	2	0	0	0	0	1	1	0	1	1
.6	3.0	1	1	2	0	0	0	0	1	1	0	1	1
.6	3.2	0	0	0	0	0	0	0	1	1	0	1	1
.6	3.4	0	0	0	0	0	0	0	1	1	0	1	1
.6	3.6	0	0	0	0	0	0	0	1	1	0	1	1
.6	3.8	0	0	0	0	0	0	0	1	1	0	1	1
.6	4.0	0	0	0	0	0	0	0	1	1	0	1	1
.6	4.2	0	0	0	0	0	0	0	1	1	0	0	0
.6	4.4	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.6	0	0	0	0	0	0	0	0	0	0	0	0
.6	4.8	0	2	2	0	0	0	0	0	0	0	0	0
.6	5.0	2	4	5	0	0	0	1	0	1	0	0	0
.6	5.2				1	1	2	0	1	1	0	0	0
.6	5.4							1	4	5	0	0	0
.6	5.6										0	1	1

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BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES) FIRST READING	SECOND READING	5.8-5.9 INCHES N= 1 HINGE LEAD	BILL LEAD	TOTAL
.6	1.2	0	0	0
.6	1.4	0	0	0
.6	1.6	0	0	0
.6	1.8	0	0	0
.6	2.0	0	0	0
.6	2.2	0	0	0
.6	2.4	0	0	0
.6	2.6	0	0	0
.6	2.8	0	0	0
.6	3.0	0	0	0
.6	3.2	0	0	0
.6	3.4	0	0	0
.6	3.6	0	0	0
.6	3.8	0	0	0
.6	4.0	0	0	0
.6	4.2	0	0	0
.6	4.4	0	0	0
.6	4.6	0	0	0
.6	4.8	0	0	0
.6	5.0	0	0	0
.6	5.2	0	0	0
.6	5.4	0	0	0
.6	5.6	0	0	0
.6	5.8	0	0	0

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 42)			2.8-2.9 INCHES (N=125)			3.0-3.1 INCHES (N=207)			3.2-3.3 INCHES (N=275)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	1	0	1	4	3	7	9	8	17	21	13	34
.8	1.6	1	0	1	1	0	1	5	4	9	10	11	21
.8	1.8	0	0	0	1	0	1	2	0	2	6	1	7
.8	2.0	0	0	0	0	0	0	0	0	0	5	1	5
.8	2.2	0	0	0	0	0	0	0	0	0	3	1	3
.8	2.4	1	0	1	0	0	0	0	0	0	2	2	2
.8	2.6	0	6	6	1	2	3	0	0	0	1	2	2
.8	2.8				3	17	20	0	2	2	1	1	2
.8	3.0							8	34	41	1	6	7
.8	3.2										13	52	61

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		3.4-3.5 INCHES (N=318)			3.6-3.7 INCHES (N=364)			3.8-3.9 INCHES (N=315)			4.0-4.1 INCHES (N=272)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	34	20	52	47	32	78	44	35	76	38	44	72
.8	1.6	15	11	26	28	15	43	28	18	44	27	31	55
.8	1.8	10	4	14	16	9	25	12	11	23	19	20	37
.8	2.0	7	3	10	4	4	8	8	10	18	9	11	20
.8	2.2	1	2	3	4	2	6	2	4	6	2	3	5
.8	2.4	0	1	1	2	0	2	2	4	5	1	2	3
.8	2.6	1	1	1	0	0	0	2	2	3	1	2	3
.8	2.8	1	0	1	0	0	0	2	2	2	0	2	2
.8	3.0	1	0	1	0	0	0	2	2	2	0	1	1
.8	3.2	1	5	6	0	1	1	1	1	1	0	0	0
.8	3.4	12	63	74	1	8	9	1	2	2	1	1	1
.8	3.6				19	57	74	2	6	7	1	4	5
.8	3.8							16	51	65	2	8	10
.8	4.0										14	49	59

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		4.2-4.3 INCHES (N=223)			4.4-4.5 INCHES (N=127)			4.6-4.7 INCHES (N= 68)			4.8-4.9 INCHES (N= 53)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	44	44	83	27	40	61	17	24	36	12	26	33
.8	1.6	25	30	52	14	27	41	11	15	25	10	22	28
.8	1.8	12	21	33	12	24	36	7	10	16	7	16	21
.8	2.0	7	14	21	6	13	19	5	7	12	4	12	15
.8	2.2	4	11	15	6	10	16	3	4	7	3	11	13
.8	2.4	3	5	8	2	9	11	2	4	6	2	8	10
.8	2.6	1	3	4	2	6	8	0	3	3	2	6	8
.8	2.8	1	1	2	0	1	1	0	2	2	1	2	3
.8	3.0	0	3	3	0	0	0	0	1	1	1	1	2
.8	3.2	0	0	0	0	1	1	0	0	0	1	1	2
.8	3.4	0	0	0	0	1	1	0	0	0	1	1	2
.8	3.6	0	0	0	1	1	1	0	0	0	0	1	1
.8	3.8	1	1	2	1	1	1	0	0	0	0	0	0
.8	4.0	4	4	8	1	2	2	0	0	0	0	0	0
.8	4.2	19	43	59	1	1	2	0	0	0	0	0	0
.8	4.4				17	24	37	0	3	3	0	0	0
.8	4.6							5	16	18	1	2	3
.8	4.8										4	7	11

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES) FIRST READING	SECOND READING	5.0-5.1 INCHES (N= 17) HINGE LEAD	BILL LEAD	TOTAL	5.2-5.3 INCHES (N= 12) HINGE LEAD	BILL LEAD	TOTAL	5.4-5.5 INCHES (N= 9) HINGE LEAD	BILL LEAD	TOTAL	5.6-5.7 INCHES (N= 2) HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	1	6	7	5	4	8	3	2	5	0	1	1
.8	1.6	1	6	7	4	3	6	3	3	5	0	1	1
.8	1.8	1	5	6	3	1	4	3	2	5	0	1	1
.8	2.0	1	4	5	1	1	2	1	2	3	0	1	1
.8	2.2	1	2	3	1	0	1	1	1	2	0	1	1
.8	2.4	1	2	3	0	0	0	1	1	2	0	1	1
.8	2.6	1	2	3	0	0	0	1	1	2	0	1	1
.8	2.8	1	0	1	0	0	0	0	1	1	0	1	1
.8	3.0	1	0	1	0	1	1	0	1	1	0	1	1
.8	3.2	0	0	0	0	1	1	0	1	1	0	1	1
.8	3.4	0	0	0	0	0	0	0	1	1	0	1	1
.8	3.6	0	0	0	0	0	0	0	1	1	0	1	1
.8	3.8	0	0	0	0	0	0	1	1	2	0	1	1
.8	4.0	0	0	0	0	0	0	0	0	0	0	1	1
.8	4.2	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.4	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.6	0	0	0	0	0	0	0	0	0	0	0	0
.8	4.8	0	1	1	0	0	0	0	0	0	0	0	0
.8	5.0	2	3	5	0	0	0	0	0	0	0	0	0
.8	5.2				1	3	4	0	1	1	0	0	0
.8	5.4							1	4	5	0	0	0
.8	5.6										0	1	1

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES) FIRST READING	SECOND READING	5.8-5.9 INCHES N= 1 HINGE LEAD	BILL LEAD	TOTAL
.8	1.4	1	0	1
.8	1.6	0	0	0
.8	1.8	0	0	0
.8	2.0	0	0	0
.8	2.2	0	0	0
.8	2.4	0	0	0
.8	2.6	0	0	0
.8	2.8	0	0	0
.8	3.0	0	0	0
.8	3.2	0	0	0
.8	3.4	0	0	0
.8	3.6	0	0	0
.8	3.8	0	0	0
.8	4.0	0	0	0
.8	4.2	0	0	0
.8	4.4	0	0	0
.8	4.6	0	0	0
.8	4.8	0	0	0
.8	5.0	0	0	0
.8	5.2	0	0	0
.8	5.4	0	0	0
.8	5.6	0	0	0
.8	5.8	0	0	0

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		2.6-2.7 INCHES (N= 42)			2.8-2.9 INCHES (N=125)			3.0-3.1 INCHES (N=207)			3.2-3.3 INCHES (N=275)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	1	1	1	3	2	5	9	3	12	19	10	28
1.0	1.8	0	1	1	3	3	3	2	3	5	12	3	13
1.0	2.0	0	1	1	0	1	1	0	0	0	7	3	7
1.0	2.2	0	1	1	0	1	1	0	0	0	3	3	3
1.0	2.4	0	0	0	0	1	1	0	0	0	1	3	3
1.0	2.6	1	8	8	2	2	4	1	0	1	1	2	2
1.0	2.8				6	27	30	0	2	2	1	2	3
1.0	3.0							11	43	53	1	11	12
1.0	3.2										17	62	75

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES)		3.4-3.5 INCHES (N=318)			3.6-3.7 INCHES (N=364)			3.8-3.9 INCHES (N=315)			4.0-4.1 INCHES (N=272)		
FIRST READING	SECOND READING	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL	HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	25	13	38	33	13	45	39	21	58	34	32	61
1.0	1.8	15	5	20	20	7	27	21	15	36	22	19	39
1.0	2.0	9	3	11	8	4	12	11	9	20	14	12	26
1.0	2.2	4	2	5	4	5	9	6	3	8	5	6	11
1.0	2.4	1	1	1	2	3	4	2	4	5	3	2	5
1.0	2.6	1	0	1	0	0	0	2	4	4	1	2	3
1.0	2.8	1	0	1	0	0	0	3	3	3	1	0	1
1.0	3.0	2	1	3	0	0	0	2	2	2	0	0	0
1.0	3.2	1	8	9	0	0	0	2	1	3	1	0	1
1.0	3.4	15	70	83	2	12	14	2	2	3	1	0	1
1.0	3.6				23	67	88	2	6	7	2	3	5
1.0	3.8							21	54	72	2	7	9
1.0	4.0										16	54	66

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES) FIRST READING	SECOND READING	4.2-4.3 INCHES (N=223) HINGE LEAD	BILL LEAD	TOTAL	4.4-4.5 INCHES (N=127) HINGE LEAD	BILL LEAD	TOTAL	4.6-4.7 INCHES (N= 68) HINGE LEAD	BILL LEAD	TOTAL	4.8-4.9 INCHES (N= 53) HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	26	26	50	19	30	47	11	15	24	10	19	26
1.0	1.8	15	17	32	11	13	23	7	9	16	8	14	21
1.0	2.0	4	9	13	7	8	15	5	9	14	5	8	13
1.0	2.2	5	4	9	5	8	13	2	7	9	4	7	10
1.0	2.4	2	1	3	2	7	9	1	2	3	1	4	5
1.0	2.6	1	2	3	2	3	5	0	1	1	1	3	4
1.0	2.8	1	1	2	1	2	3	1	0	1	0	2	2
1.0	3.0	1	1	2	0	1	1	0	0	0	0	1	1
1.0	3.2	0	0	0	0	2	2	0	0	0	0	0	0
1.0	3.4	0	0	0	1	1	1	0	0	0	0	0	0
1.0	3.6	0	0	0	1	0	1	0	0	0	0	0	0
1.0	3.8	3	1	4	1	1	1	0	0	0	0	0	0
1.0	4.0	3	7	10	1	1	2	0	0	0	0	0	0
1.0	4.2	20	46	62	2	1	3	0	0	0	0	1	1
1.0	4.4				15	26	38	0	3	3	0	0	0
1.0	4.6							5	19	21	1	2	3
1.0	4.8										6	9	14

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES) FIRST READING	SECOND READING	5.0-5.1 INCHES (N= 17) HINGE LEAD	BILL LEAD	TOTAL	5.2-5.3 INCHES (N= 12) HINGE LEAD	BILL LEAD	TOTAL	5.4-5.5 INCHES (N= 9) HINGE LEAD	BILL LEAD	TOTAL	5.6-5.7 INCHES (N= 2) HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	1	5	6	5	2	6	2	2	3	0	1	1
1.0	1.8	3	3	6	3	1	4	1	2	3	0	1	1
1.0	2.0	1	3	4	2	0	2	1	3	3	0	1	1
1.0	2.2	1	3	4	1	0	1	1	2	2	0	1	1
1.0	2.4	1	2	3	1	0	1	1	1	2	0	1	1
1.0	2.6	1	0	1	0	0	0	0	2	2	0	1	1
1.0	2.8	1	0	1	0	0	0	0	1	1	0	1	1
1.0	3.0	1	0	1	0	0	0	0	1	1	0	1	1
1.0	3.2	0	0	0	0	1	1	0	1	1	0	1	1
1.0	3.4	0	0	0	0	0	0	0	1	1	0	1	1
1.0	3.6	0	0	0	0	0	0	0	1	1	0	1	1
1.0	3.8	0	0	0	0	0	0	0	1	1	0	1	1
1.0	4.0	0	0	0	0	0	0	0	0	0	0	1	1
1.0	4.2	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.4	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.6	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4.8	0	1	1	0	0	0	0	0	0	0	0	0
1.0	5.0	2	5	7	0	0	0	0	0	0	0	0	0
1.0	5.2				1	3	4	0	1	1	0	0	0
1.0	5.4							1	4	5	0	0	0
1.0	5.6										0	1	1

BAR TOTALS

WIDTH-THICKNESS RATIO

NUMBER OF OYSTERS FAILED OVER OYSTER LENGTH

DISTANCE FROM END (INCHES) FIRST READING	SECOND READING	5.8-5.9 INCHES N= 1 HINGE LEAD	BILL LEAD	TOTAL
1.0	1.6	0	0	0
1.0	1.8	1	0	1
1.0	2.0	1	0	1
1.0	2.2	1	0	1
1.0	2.4	0	0	0
1.0	2.6	0	0	0
1.0	2.8	0	0	0
1.0	3.0	0	0	0
1.0	3.2	0	0	0
1.0	3.4	0	0	0
1.0	3.6	0	0	0
1.0	3.8	0	0	0
1.0	4.0	0	0	0
1.0	4.2	0	0	0
1.0	4.4	0	0	0
1.0	4.6	0	0	0
1.0	4.8	0	0	0
1.0	5.0	0	0	0
1.0	5.2	0	0	0
1.0	5.4	0	0	0
1.0	5.6	0	0	0
1.0	5.8	0	0	0

APPENDIX E

TROUGH ORIENTATION DATA

TABLE E-1

BAR SUMMARY
AXIS 1 - LEFT HANDED OYSTERS

OYSTER ORIENTATION : V-SHAPED TROUGH RESULTS
OYSTER END EXITING TROUGH : NUMBER(#) AND PERCENT(%) OF OYSTERS

BAR NUMBER	SAMPLE SIZE		TRIAL 1- HINGE LEFT: RIGHT VALVE DOWN, HINGE LEAD	TRIAL 1- HINGE LEFT: RIGHT VALVE DOWN, BILL LEAD	TRIAL 1- HINGE LEFT: LEFT VALVE DOWN, HINGE LEAD	TRIAL 1- HINGE LEFT: LEFT VALVE DOWN, BILL LEAD	TRIAL 2- HINGE RIGHT: RIGHT VALVE DOWN, HINGE LEAD	TRIAL 2- HINGE RIGHT: RIGHT VALVE DOWN, BILL LEAD	TRIAL 2- HINGE RIGHT: LEFT VALVE DOWN, HINGE LEAD	TRIAL 2- HINGE RIGHT: LEFT VALVE DOWN, BILL LEAD
1	576	#	213	363	212	364	404	172	161	415
		%	37.0	63.0	36.8	63.2	70.1	29.9	28.0	72.0
2	383	#	142	241	201	182	286	97	39	344
		%	37.1	62.9	52.5	47.5	74.7	25.3	10.2	89.8
3	494	#	115	379	330	164	287	207	28	466
		%	23.3	76.7	66.8	33.2	58.1	41.9	5.7	94.3
TOTAL	1453	#	470	983	743	710	977	476	228	1225
		%	32.3	67.7	51.1	48.9	67.2	32.8	15.7	84.3

TABLE E-2

BAR SUMMARY
AXIS 2 -RIGHT HANDED OYSTERS

OYSTER ORIENTATION : V-SHAPED TROUGH RESULTS
OYSTER END EXITING TROUGH : NUMBER(#) AND PERCENT(%) OF OYSTERS

			TRIAL 1- HINGE LEFT				TRIAL 2- HINGE RIGHT			
			RIGHT VALVE DOWN		LEFT VALVE DOWN		RIGHT VALVE DOWN		LEFT VALVE DOWN	
BAR NUMBER	SAMPLE SIZE		HINGE LEAD	BILL LEAD	HINGE LEAD	BILL LEAD	HINGE LEAD	BILL LEAD	HINGE LEAD	BILL LEAD
1	41	#	25	16	21	20	11	30	17	24
		%	61.0	39.0	51.2	48.8	26.8	73.2	41.5	58.5
2	88	#	35	53	46	42	14	74	54	34
		%	39.8	60.2	52.3	47.7	15.9	84.1	61.4	38.6
3	38	#	10	28	20	18	1	37	29	9
		%	26.3	73.7	52.6	47.4	2.6	97.4	76.3	23.7
TOTAL	167	#	70	97	87	80	26	141	100	67
		%	41.9	58.1	52.1	47.9	15.6	84.4	59.9	40.1

TABLE E-3

BAR SUMMARY
AXIS 3 -STRAIGHT AXIS OYSTERS

OYSTER ORIENTATION : V-SHAPED TROUGH RESULTS
OYSTER END EXITING TROUGH : NUMBER(#) AND PERCENT(%) OF OYSTERS

			TRIAL 1- HINGE LEFT				TRIAL 2- HINGE RIGHT			
			RIGHT VALVE DOWN		LEFT VALVE DOWN		RIGHT VALVE DOWN		LEFT VALVE DOWN	
BAR NUMBER	SAMPLE SIZE		HINGE LEAD	BILL LEAD	HINGE LEAD	BILL LEAD	HINGE LEAD	BILL LEAD	HINGE LEAD	BILL LEAD
1	193	#	69	124	63	130	76	117	75	118
		%	35.8	64.2	32.6	67.4	39.4	60.6	38.9	61.1
2	339	#	99	240	146	193	108	231	60	279
		%	29.2	70.8	43.1	56.9	31.9	68.1	17.7	82.3
3	278	#	53	225	78	200	28	250	36	242
		%	19.1	80.9	28.1	71.9	10.1	89.9	12.9	87.1
TOTAL	810	#	221	589	287	523	212	598	171	639
		%	27.3	72.7	35.4	64.6	26.2	73.8	21.1	78.9

TABLE E-4

AXIS SUMMARY

OYSTER ORIENTATION : V-SHAPED TROUGH RESULTS
OYSTER END EXITING TROUGH : NUMBER(#) AND PERCENT(%) OF OYSTERS

AXIS NUMBER	SAMPLE SIZE		TRIAL 1- HINGE LEFT				TRIAL 2- HINGE RIGHT			
			RIGHT VALVE DOWN		LEFT VALVE DOWN		RIGHT VALVE DOWN		LEFT VALVE DOWN	
			HINGE LEAD	BILL LEAD	HINGE LEAD	BILL LEAD	HINGE LEAD	BILL LEAD	HINGE LEAD	BILL LEAD
1	1453	#	233	1220	872	581	1041	412	261	1192
		%	16.0	84.0	60.0	40.0	71.6	28.4	18.0	82.0
2	167	#	85	82	51	116	41	126	126	41
		%	50.9	49.1	30.5	69.5	24.6	75.4	75.4	24.6
3	810	#	136	674	231	579	249	561	220	590
		%	16.8	83.2	28.5	71.5	30.7	69.3	27.2	72.8
TOTAL	2430	#	454	1976	1154	1276	1331	1099	607	1823
		%	18.7	81.3	47.5	52.5	54.8	45.2	25.0	75.0

TABLE E-5

BAR SUMMARY

OYSTER ORIENTATION : V-SHAPED TROUGH RESULTS
OYSTER END EXITING TROUGH : NUMBER(#) AND PERCENT(%) OF OYSTERS

			TRIAL 1- HINGE LEFT				TRIAL 2- HINGE RIGHT			
			RIGHT VALVE DOWN		LEFT VALVE DOWN		RIGHT VALVE DOWN		LEFT VALVE DOWN	
BAR NUMBER	SAMPLE SIZE		HINGE LEAD	BILL LEAD	HINGE LEAD	BILL LEAD	HINGE LEAD	BILL LEAD	HINGE LEAD	BILL LEAD
1	810	#	307	503	296	514	491	319	253	557
		%	37.9	62.1	36.5	63.5	60.6	39.4	31.2	68.8
2	810	#	276	534	393	417	408	402	153	657
		%	34.1	65.9	48.5	51.5	50.4	49.6	18.9	81.1
3	810	#	178	632	428	382	316	494	93	717
		%	22.0	78.0	52.8	47.2	39.0	61.0	11.5	88.5
TOTAL	2430	#	761	1669	1117	1313	1215	1215	499	1931
		%	31.3	68.7	46.0	54.0	50.0	50.0	20.5	79.5

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