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Virginia Institute of Marine Science

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NOTES ON
THE OYSTER INDUSTRY OF VIRGINIA AND RELATED TOPICS

List of Titles by Pages

Jay D. Andrews

Virginia Institute of Marine Science
School of Marine Science
The College of William and Mary

October 1992

List of Contents for
Summary Accounts of Oyster Industry and
Oyster Research Programs in Virginia, 1955 - 1984

(Important for history and status of oyster fishery)

Jay D. Andrews

Notes on Seaside Oystering, 13-14 October 1955

J. D. Andrews
Virginia Fisheries Laboratory
Gloucester Point, Virginia 23062

Willis Wharf

There are four shucking houses at Willis Wharf, the operators of which all plant some oysters. Several years ago some of these people were complaining that they couldn't last much longer on Seaside in the oystering business. The answer they came up with was to spread their operations from Chesapeake Bay to Delaware Bay. The trend has been to procure seed from Seaside areas but to grow as much of the market stock as possible away from Seaside. Drill predation is probably the chief cause, although poor oysters may be an additional one. This group, consisting of Ballards, Walkers, Terrys, and Mr. Bowen has come up with one good development in recent years, and that is the oyster cleaning machine or rotating drum with water jets which removes drills. They are now at work on a machine for cleaning the grounds, but do not have a practical model yet. It is a common opinion that oysters are extremely scarce on Seaside, both seed oysters and market oysters. This is attributed to the great demand for seed oysters to go out of the State.

The Walker operation includes moving oysters to Delaware and to Bayside creeks of Eastern Shore. All of their seed is put through the rotary drums and usually hauled by truck to the destination. Earl Walker is running this operation with the help of Fletcher Ewell and this year one of Wade Walker's boys, a physicist, is helping around the plant.

The Ballard operation is conducted by Elmore and John Ballard, who are cousins. They, too, have a rotary drum through which all seed is processed. Their operation consists mostly of moving Seaside seed to the vicinity of Cherrystone Creek on Bayside. They are successful in this because they move the seed to Cherrystone in the spring of one year and harvest it in the fall of the same year, so that the oysters are in the Bay waters only one summer. They make no attempt to produce selects, but aim at shucking their oysters at the earliest possible moment. The Ballards have in the process of construction of a vacuum cleaner type cleaning machine, which is to be a simplification of the northern suction dredges, that is to be used only after all oysters have been harvested by commercial dredge insofar as possible. They contemplate placing three screens on the shaker to catch small drills which they are convinced pass through the northern suction dredges.

Nat and Henry (Buzz) Terry, two brothers, are operating the Terry Shucking House. At present most of their ground is located on Seaside, and they say that it is being gradually restricted so they have nowhere to plant. This is partly drill activity and partly the effects of hurricanes sanding up the grounds. Henry Terry is just now moving to Maryland so that he can culture oysters in Maryland using seaside seed procured by his brother. The Terrys were the first to build a rotary drum machine for cleaning seed oysters and, now they, too, are in the process of building a suction-type dredge for cleaning grounds. Their machine, which uses an ordinary boat screw for an impeller, is to be much cheaper than the

Ballards. At the time we were there, the Terrys were shucking both planted and native oysters brought in from Hogg Island Bay. All of the oysters were poor. Many were being rejected because they were so-called yellow-shelled, native oysters which had grown high up in the tumps of grass and had a yellow color to the meats which made them hard to sell. These oysters were usually poor, too. This yellow also showed on the outside of the oysters. Terry pays his shuckers 10 cents a gallon more to shuck unculled dredged stock, whereas the usual procedure is to pay somebody to cull the material before it reaches the shuckers.

It appears to me that this group at Willis Wharf is the most progressive and the most active in seeking ways to combat drills and to grow oysters on Seaside. The Walkers believe in hand picking drills, the Ballards do not, although their attitudes may not be quite as black and white as this suggests.

Hungar´s Creek

We visited Ralph Clark on Hungar´s Creek, but did not go out on his grounds. He has had serious mortalities, particularly last year, but also again this year. The mortality pattern is quite spotty in Hungar´s Creek, being less as you go up the stream, but sometimes oysters side by side will have quite a different mortality pattern. He has run a shucking house for many years until last year when he did not have enough oysters to remain open. This year he hasn´t opened at all. He does try for barrel stock, which may be one of the reasons he has had losses. Clark was already pretty well sold on the cause of his mortalities being the fungus (Dermo). He was much interested in our belief that North Carolina oysters are the most resistant, native oysters are second, and James River seed or Seasides being the poorest in their resistance to the fungus. He can catch his own local set provided he can procure an adequate amount of shell. He also told us that about three years ago somebody planted a number of loads of South Carolina seed in the creek. So far as he knows, they have done all right. He told us about some green-flected oysters, the green showing up in small spots on the shell and gradually spreading until they coalesced, which almost sounds like some kind of boring algae. I believe from his descriptions that he saw _Thais_ out in the open ocean during the days of his trawling experience some eight or nine years ago. This item is important because several specimens of _Thais_ have been collected within the boundaries of the oyster ground on Seaside and the question arises as to whether this new drill with planktonic larvae is moving into Seaside. Evidently, they have been offshore for many years and may fluctuate back and forth a little without actually invading Seaside.

I also learned from Ralph Clark that Emory Steelman tries to raise barrel stock and I was told that by another source. This also helps to explain the troubles that Emory Steelman has experienced in Cherrystone Creek. The Ballards have not had comparable trouble.

The Seeds of Wrath

A tremendous business in seed oysters has developed on Seaside based upon out-of-state buyers from New Jersey. This has been attended by numerous changes in the industry and an inordinate amount of cheating and sharp deals. In the first place, everything was scraped up and sold to these planters as seed--drills, trash, shucked oysters, and even the shell on the seed bars themselves. Instead of the usual process of picking oysters by hand at low tide, it has been the practice now to tong everything off the bars in many cases. This damages the bars as well as producing an inferior seed. From all accounts no attempt has been made to take the drills out of this seed, but it has been planted directly in Delaware and New Jersey waters. This operation has been extensive for only two seasons.

According to several local oystermen, these New Jersey planters have taken a beating. Part of these losses, I presume were the late summer mortalities of 1954 and some, particularly the drill damage, probably has not been realized yet. Some oystermen tell us that this out-of-state seed industry is about to come to an abrupt halt because of these losses. At least some changes are expected. One planter, Kirkpatrick from Delaware, only last week informed his local supplier that he wanted no more seed. Others have stipulated that it must be cleaned before being delivered to them. These planters demand current-year seed if they can get it, which means that the oysters probably must be held two and three years in Delaware and Jersey waters before marketing. If the fungus is at all active in these waters, they can expect trouble before they harvest their oysters. The species of large drills they have imported may be even more important with this type of seed. Perhaps the seed oyster industry based on out-of-state buyers will take care of itself in the near future.

The Rotating-Drum System of Removing Drills

We were favorably impressed by the rotary drum method of cleaning oysters of drills. We watched Mr. Ballard's machine operate and concluded that it was removing practically all drills of all sizes. I believe only very muddy oysters, which are extremely clumpy, would tend to retain any number of drills. An examination of the seed oysters coming through showed rather infrequent shell injuries of a serious nature. Most of the weak thin-edged bills are knocked off, but I don't think the oysters are damaged. There is a considerable loss of small cinder and seed oysters which go through the approximately one and one-half inch mesh on the drums. Some thought should be given to methods of recovering this seed and cleaning it of drills. The planters will probably work this out themselves. The cost of running seed through these machines is about 10 cents per bushel. Because most of the seed is hauled away by truck, it is simply a matter of placing the machine in the conveyor line and involves no extra handling.

There are three machines at Willis Wharf, two rather elaborate ones, and a smaller simpler one belonging to the Terry brothers. So far as we know, these are the only machines in operation on Seaside. The only other machine we know about is the one on Savage and Mears' wharf. Since there are no patent rights on this machine, we might perform a useful function by spreading the word more widely on Seaside about the use of these machines and their effectiveness. For example, Bill Birch, a young man running the Bunting Company in Chincoteague, spends a lot of money on drill picking, but has given no attention to cleaning the seed before it is planted. Since there is no way of regulating the use of privately grown seed, it would seem important that somebody publicize the two apparent methods of getting relatively drill-free seed. One would be to move the seed in cold weather when the drills are inactive and have crawled down from the tops of the seed bars; the other would be to clean by the machine. Those who have the machines say they will clean it anyway regardless of the season.

Lost Bounty

It appears that any scheme one can devise for paying bounty on drills is bound to fail. In the Willis Wharf area, planters objected to removing the bounty from drills collected on privately owned grounds, even though some of them didn´t believe in handpicking. They argued that most of the tax money paid in comes from their fee payments rather than from licenses. Of course, they would all be happy if the State were to pay $3 a gallon for drills regardless of the source of drills and usefulness of it. However, any system, other than taking a crew to the grounds and paying for the drills that are picked there at that time, seems to be open to some kind of evasion. An increased bounty might possibly work in the upper district around Chincoteague because of the relatively few public grounds and seed grounds. With this exception, it seems that the bounty had better be left alone and as little as possible expended on it. It might be mentioned that we did not seen any live _Eupleuras_ in Seaside during our visit, although I did see them in barrels at Oyster on my previous trip. Also, there were plenty of _Eupleuras_ in Fred Seiling´s catch in Chincoteague Bay. According to Fred, keyhole limpets first appeared in Chincoteague Bay about two years ago and now are quite abundant. We noted limpets at Willis Wharf around the oyster houses and I think Dr. Hewatt's records will show that they have been collected previously.

Clam Scouring

Several years ago a new method of collecting clams was developed in North Carolina which consisted of running boats over shallow grounds and washing the clams out with the propeller. Last year, for the first time, this was done in Chincoteague Bay by crab dredgers. Since there are no laws regulating clamming, the Steelmans have tried to hold clamming operations to the season for crab dredging. The method consists of anchoring to a center pole and running the boats around digging furrows. Huge numbers of clams have been caught at times by this method, and average catch might be 2,200 clams per day. Nat Steelman is concerned because there is no law regulating this industry and he predicts that at least 130 boats will be working in Chincoteague Bay this winter on clams. There are complaints that this clamming method is catching so many clams that the market is being ruined. Also, he is concerned about conservation of clams. We are hardly in a position to suggest seasons or regulations, and yet it may be that such an industry should be regulated. We can get some help from Al Chestnut who has had experience with this method of clamming.

A Report on the Eastern Shore Drill Survey of 13 and 14 October 1955

William J. Hargis, Jr.
Virginia Fisheries Laboratory
Gloucester Point

The following is a cursory and hurried report of the recent survey trip taken by Dr. Andrews and myself to the Eastern Shore of Virginia. During the trip several areas of the Seaside and Bayside of the Eastern Shore were visited and conversations were held with representatives of various oyster planting and packing companies in these areas. In addition, superficial observations were made of the various drill control mechanisms and methods employed by these people. In the following report the areas will be considered separately, and the conversations held with the planters recorded individually.

Willis Wharf, Machipongo River, Seaside

Wade Walker's plant

At WadeWalker'splant we engagedin a round table discussion and underwent a quizzing period with and by Messrs. Earl Walker, Fletcher Ewell, Dr. Walker, a physicist, and another young relative of Mr. Wade Walker, who is employed regularly in drill control work. All of these people seemed very interested in drills and drill control. Apparently they are making extensive efforts at some little cost to the company to overcome their screwborer difficulties. It developed that, although they move seed until freezing time in the fall and after cold weather lets up in the spring, they screen all seedin their rotary drum-type screen. According to Mr. Earl Walker they are convinced that it is very effective and have been using it for a period of six years. Hand picking of rocks has been extensively carried out and evidently Walker's plant has bought about 300gallons, more than any other planter in the area. After harvesting, the grounds are cleaned by dredging and left to fallow for a period of two years. Following this, it is often their practice to plant shell and seed at the end of this two year period using screwborer lines, rings of seed, around these plantings in which it is hoped that migrating drills will be stopped. Evidently the area on either side of these screwborer lines is left clear and dredged regularly. In spite of these elaborate precautions it appears that drills get into the beds. Mr. Earl Walker is of the opinion that wave and current action, particularly during storms, carries drills across the lines. The Walker outfit has bought ground in Delaware in an effort to improve their oyster yield, but so far oysters planted there are poor. However, there is not much mortality. They have even brought the more heavily shelled northern oysters to Virginia and, although the drills are not able to get to them in the beginning, as soon as new growth starts mortality from drilling increases. The Walkers are against restricting the activities of seed moving to cold months because of the increased difficulty of handling and mortality to oysters being moved. Evidently they do most of their seed moving after February 20 and most of these seed are planted intertidally. Mr. Walker contends that screening is as effective as moving during the winter months as a method of drill control. The Walkers are against restricting bounty to public rock. They are in favor of a higher bounty for all rocks. He pays about $2 a gallon now, but feels that most of the smaller ones are not being taken.

Young Dr. Walker suggested that some poison impregnated silicone treatment of the shell might be an effective method of controlling, on the theory that drilling screwborers would ingest the poison shell and thereby be eliminated. Some of the others involved in the discussion pointed out that new growth would not be protected. He countered with the reply that any protection is better than that which they now have.

Mr. Earl Walker says that he personally saw Virginia seed with drills put down in Delaware Bay. He claims that the buyer, Mr. Walker Lehman, buying for Kirkpatrick and Company of Delaware and Rehoboth Bay was taking anything and not screening at either end. He has learned that the Delaware buyers now require that seed be cleaned at the Willis Wharf end before acceptance. However, this cleaning has been going on only ~~in the~~ this past year. Out-of-state seed buying appears to have almost come to an standstill as a result of this transport of screwborers. Mr. Walker also says that the Chincoteague people put down drills with seed.

Ballard's Plant

John and Elmore Ballard are moving Seaside seed to Cherrystone Creek in an effort to escape drills. Apparently they do all right if they take up the oysters the first year, but if these oysters are left for two years, mortality begins. The Ballards have been active in drill control sometime. They employ potting and pay bounty for hand picking. They also move screened seed to drill free areas which have been dredged and fallowed. Since the dredges employed are regular oyster dredges, it is probable that many drills are left on the bottom even after fallowing and dredging. The Ballard plant has been screening seed for several years. We had the good fortune to observe the screen in operation. I was unable to find any drills on clumps and singles picked from the conveyor belt on the screen side even after examining 30 to 40, more or less, samples. The Ballards are now building a large suction dredge which they plan to use to clean ground. They are also going to experiment with flame throwers next spring on their rocks. Mr. John Ballard was against cutting out bounty or restricting it to public ground. He also appeared to find the idea of restricting seed movement to the winter months unfavorable. It was his contention that screening was much less trouble and just as effective. In connection with this, Mr. Elmore Ballard said that when the screening operations were begun some years ago he made an effort to sample the oysters both before and after screening and found that very few, even little ones, were passing through the screening process.

Bowen's Plant

Although we did not meet the owner, Mr. Nat(?) Bowen, because he was out of town, we received information from other sources that he has picked up Thais several times on his rocks. Dr. Andrews examined a specimen which Mr. Bowen had given to Fred Seiling and confirmed the identification.

Terry's House

A long talk held with Mr. Nat Terry disclosed that they are in bad shape, due primarily to drills and shifting sand on their beds. As a result of these difficulties one of them Henry, is planning to move to Maryland so that he can take up grounds there. Evidently they plan to put down 50 to 65 thousand bushels. The Terrys have been potting and picking for some time. They have also regularly dredged and fallowed. They are now being restricted in the latter as a result of recent bottom losses they suffered. They are now constructing a suction dredge of their father's design in order that their grounds can be more effectively cleaned for planting. This dredge is an interesting machine, apparently quite a bit different from others now being used or built. In addition, they are also preparing to use the copper sulphate dip for shells and seed. The Terrys are now dipping some seed for Fred Seiling. He, Seiling, plans to observe the effects on drill populations and they wish to check the effect on oysters and their edibility. All of these measures are being carried out in an effort to get back to raising market oysters on Seaside. The Terrys attribute most of their losses to drills.

Terry contends that out-of-state buyers are affecting the Virginia oyster industry adversely in that too much seed is being removed. The tongers and grubbers are taking everything, even wild marsh and grass oysters. Nat Terry feels that natural spawners are thereby being cut down in numbers. He is certain that he shucks far fewer wild oysters than ever before, because people just can't find them. He claims that their wilds used to be an all winter job.

According to Terry, the Seaside oyster operation is different from Bayside. They handle only the standard grades and rely on big volume because theiroysters are not pretty and cannot be kept too long in the shell.

Mr. Terry says that some of the Delaware planters are now using screens. According to him, perhaps one reason the out-of-state people have stopped buying is that their agent, Mr. Arnold Smith at Willis Wharf, was not set up to screen oysters. Until recently Smith had been buying four thousand bushels a day for Kirkpatrick of Rehoboth. He was buying from tongers and trucking it to Delaware at $1 to $1.20 a bushel. Later on the Delware people cut the price to 20 to 25 cents and then cut him off entirely because of shells and drills. Mr. Terry says the Delaware people make it hard for the local buyers because they are satisfied with grain measure and the local people found it hard to get even measure from the tongers in the face of this competition.

According to Terry Mr. Emory Steelman at Cherrystone is harming himself because he is holding his oysters for the barrel market rather than shucking them before they die. Terry feels that holding oysters for the barrel market is not a wise idea for Bayside growers because of the second year mortality. He also reports that some out-of-staters are planting shell here in an effort to get satisfactory set to be moved later.

Chincoteague

Bunting Planting and Shucking Company. Mr. William B. Birch, the new manager of Bunting, says that his organization has been pitting for eight years and hand picking for two to three years. Bunting Company pays a $3 a gallon bounty. He claims that in spite of this the oyster yields are decreasing and the "screw drivers," as he called them, are increasing. From what we could gather he makes no effort to clean the seed before he plants it. However, he is planning to investigate the effectiveness of a rotary screen to clean his seed in the future. Mr. Birch is in favor of increasing the bounty on public rocks. This bounty is to be paid by the State. For private rocks, one-half is to be paid by the planter and one-half by the State.

Bayside

Clark Planting and Shucking House at Hungar Creek. Mr. Clark has been hard hit for two to three years. Evidently most of his trouble appears to be from Dermocystidium rather than from drills. We learned that he has been attempting to hold for the barrel market rather than shucking, and that his biggest losses have occurred in the second year after planting. According to Dr. Andrews, this follows the Dermocystidium pattern. Mr. Clark reports that some South Carolina oysters have been planted in the creek near his place. They evidently do not suffer the high mortality of his oysters, but are not growing too well. Mr. Clark reported that he has taken Thais while dredging for sea scallops and quohogs at 35 fathoms off Cape Henry. He claims that these drills are the same as those which he saw at Mr. Nat Bowen's plant at Willis Wharf. According to Mr. Clark, Mr. Bowen put some *Thais* in a cage with regular drills to see what would happen.

Discussion

It appears that Mr. Terry, the father, nowdeceased, of the two boys who are running the Terry operation at Willis Wharf, was instrumental in devising the rotary drum-type screen. He also designed a suction dredge.

After checking with Mr. Fred Seiling at Snow Hill, it superficially appears that the ratio of *Eupleura* to *Urosalpinx* is higher in the Maryland area than in the Virginia area. As a matter of fact we sawno *Eupleura* under the screens or on the pilings at Willis Wharf.

Evidently the drill problem is very acute on the Eastern Shore, particularly Seaside. This isparticularly apparent in the efforts and the expenditures of money of the planters in their attempts at drillcontrol. Some of the techniques which they use are potting, or trapping, handpicking, dredging, setting up barriers, fallowing, screening, flaming and seeding new areas. Two of them are now building suction dredges and one is planning to use copper sulphate. Most of the Eastern Shore planters are of the opinion that the out-of-state seed trade has slowed to a standstill and that drills are the cause of it. Several of these planters feel that the out-of-state buyers adversely affect the Virginia planter.

Conversations with Captain Scott and Mr. Clark of the Bayside area of Eastern Shore disclose that the drill problem is not as acute as on Seaside. It appears that they are far more troubled by *Dermocystidium* than other oyster pests.

Conclusions and Recommendations

The drill problem on the Eastern Shore, seaside of Virginia, is very acute. Even though it is now almost impossible for any great portion of the work now being done under the drill contract to be carried out on the Eastern Shore, it is felt that an effort should be made to take regular trips to and surveys of the Seasidearea. This would probably have the effect of improving relations between the Seaside planters and the Laboratory, and the Commission and improving their general business morale. Most of them seemed willing to cooperate and very gratified at being able to discuss their problems. As a matter of fact, we could not have asked for more in the way of cooperation and intelligent discussinn than we received from these people. They are exercisingingenuity and spending large sums of money in their efforts to arrive at a satisfactory method of drill control.

The Seafood Industry of Eastern Shore

J. D. Andrews

October 1956

On October 14 through the 16, 1956, Bob Bailey and I made a trip to Eastern Shore to collect samples of oysters for Dermocystidium tests. Thirteen samples were taken, four from the Seaside, and the remaining ones from the Bayside and Pocomoke Sound.

In contrast to the past two years, in 1956 the oystermen are comparatively happy. The supply of oysters is short, but the price is good and they are in reasonably good condition and mortalities have been low generally. Although there is no reason to believe that drill activity was less this year than in previous years on the Seaside, the oysters we saw had many fewer boxes than in previous years. There was more complacency about drills than we have seen for many years. We heard of only two cases of serious mortalities; one was on a bed of Nat Terry's, on which there were large numbers of sea urchins or "pincushions", as they call them. Fred Sieling investigated this relationship and has found no evidence so far that the "pincushions" could have been the cause of the mortality. These oysters died nearly one-hundred per cent, although the boxes appeared to me to have been quite old, probably prior to this past summer. Mr. Terry, however, claims they started dying in June of this past summer. The other area of mortality was Cherrystone Creek and, as usual, it is Mr. Steelman who always has trouble on that Creek. The Ballards, who also plant in that Creek, made no mention of losses.

Together with the low mortality, several oystermen had the impression that oysters grew much better this past spring and summer than they had in previous years. Captain Onley showed me some old oysters which had been blunt for two or three years, and suddenly they put on a new bill this past spring.

Condition was only fair in all oysters. The best oysters we saw were from Tom's Cove, but these included some rather fat ones and some rather poor ones. The taste of Tom's Cove and Chincoteague oysters was superior, as usual. I saw little difference between the condition of Seaside and Bayside oysters. The worst ones came from Ralph Clark's ground in Hungar's Creek, where he had collected them on a float for shipment as barrelstock. These were old oysters and while not all the old oysters we saw were poor, they tended to have poor oysters among them. I was struck by the almost complete absence of pea crabs in all groups of oysters this past year. Only one or two oysters were noticed with spawn at this late time.

The drill picture is confusing as usual. Savage and Mears began a little trapping last year and had out several thousand traps this year. They have switched suddenly from a policy of no drill control to one of quite active trapping. I saw no rotary drums in Chincoteague, although there may be some. At Willis Wharf, the rotary drums were not being used in all instances. The Walkers said they were processing all of their seed oysters before planting. The Ballards said they had not processed theirs yet this fall because they were buying some two-thousand bushels each day, and they could not put that much through their rotary drums without delaying the transplanting. The out-of-state buyers who are operating across the Creek from Terry's place were cleaning some of their seed and trucking some directly without passing through the rotary drum. The agent who handles and delivers these oysters to Delaware or New Jersey gets ten cents a bushel for handling and ten cents a bushel for passing them through the rotary drum. The Walkers had a small problem of how to recover singled spat and small oysters that fell through the drum without planting drills with them. The Ballards have the notion that their short period of growing oysters in Cherrystone Creek, usually only about one year, would prevent much drill damage. They claim they have not been seriously bothered at Cherrystone Creek, although there were numerous drills on most of the beds. I found no evidence anywhere of trapping or drill control of any sort on the Bayside. Mr. Acuff has experimented with traps but considers that they are too irregular in catch and not effective enough to justify the cost.

The bounty paid by the State on drills last year was $2.00 a gallon, which was added to by the planters. This was apparently sufficient stimulus to cause a considerable amount of picking and trapping. However, this fall the State bounty has been removed, at least temporarily. There are a number of people who have doubts about the justification for paying private planters for picking drills off their beds. They also claim that the bounty is still too low to induce people to go on public grounds to pick drills.

The seed oyster picture has improved somewhat over last year. The amount of seed shipped out of state last winter was reduced over previous years but is still considerable. The planters complain that the public grounds are being raked up so that nothing is left. This means that they have difficulty in buying seed large enough to mature in one year on their own grounds. There is a firm belief that it is impossible for the planters to produce their own seed on their own grounds in sufficient quantities, yet there is evidence that nearly all planters are striving to get more seed ground, and several independent small planters are shifting to seed-oyster production. The demand for seed oysters is strong and will undoubtedly encourage this tendency further. The set was reported to be unusually good in nearly all areas on both sides of the Eastern Shore peninsula. At Hungar's Creek Mr. Clark failed to get a good set on his shell plants this year; however, Mr. Acuff had quite a satisfactory set, at least on shell strings which were laid on the bottom. This set ran to perhaps six or eight, maybe ten, spat per shell, not heavy, but adequate. A good many oysters are grown in the Bayside Creeks by planting shells and leaving them in place until oysters reach market size.

The methods of growing oysters and procuring seed are quite varied, and a number of changes are occurring in recent years. A relatively small number of seed oysters are planted on Seaside to produce market oysters. For example, the Ballards plant very few on Seaside, most of their stock going to Cherrystone Creek. The Walkers have almost given up planting on Seaside and are developing intensively some grounds in the State of Delaware. The Terry's still depend a lot upon stock planted on Seaside, but they have also procured ground in Maryland for growing oysters. The typical procedure is to buy seed stock from the public grounds, or perhaps in some cases their own grounds, and transplant this to their outlying growing grounds; then the mature oysters are hauled back to the plant for shucking.

The clam industry presents a confused picture and apparently not a very stimulating one to producers. Most of the clams produced on Eastern Shore come from public grounds from which they are procured by hand tongers, more or less the year around. Often in the past, and still to some extent, scows or boats tonging clams will go off into the beds for a week and work that long before they return to the shucking houses for selling. There they are sold to the clam wholesalers, who either ship or replant close to their houses after sorting by size. They can then dig these dense clams on demand without much trouble and in almost any weather. The best market for Cherrystones is in September and October when fall clam bakes are in progress, and many of these occur in the midwest, Ohio and Indiana. Chowders are considered a nuisance, and there is apparently no profit in them at all. Soup companies have worked so hard for low prices that the profit has been squeezed out of this size of clam. Anyway, two or three companies seem to have a monopoly on the clam-chowder business. Even the wholesaling of clams has become more or less monopolized. Burton, who is by far the biggest clam dealer, followed by Savage and Mears, trucks his clams to wholesalers and according to his competitors makes his profit from the trucking rather than from the clams; therefore, Ballard and others have dropped out of the clam business. This is a strange situation, too, because most of the clams are caught in the lower part of the Seaside and yet the market is centered in Chincoteague. We saw a simple and interesting grading machine for clams consisting of two rollers, which turned up in such a way that the clams dropped through whenever they reached a gap wide enough for them. Bob Mears claims that clams fatten very quickly after they spawn, and there is hardly any poor season for them. He does have considerable mortality in his replanted beds, but this may be partly due to crowding, partly to the fact that the clams are held too long under unsuitable conditions before he bought them and not necessarily to any disease or natural mortality. Some of these replanted areas are fenced in with bullfish-tight fences. A school of these fish (cow-nose rays) would soon destroy a bed if they got into it.

Last year Nat Steelman was much perturbed about whether to prevent or to allow winter dredging of clams. The North Carolina method is used in which water of a suitable depth is chosen, a stake is planted, and the boat is run round and round this stake to dig a furrow, and a netted bag behind to catch the clams. The winter crab-dredge fishery was catching a few clams but very few crabs in recent years. The crabbers were anxious to be permitted to take more clams in winter since there was a good market for them. So, last winter Mr. Lankford gave permission for them to go ahead and roughly some one hundred boats worked, if Nat is correct. He expects even more activity this winter. There are conflicting opinions as to what this new fishery is doing to the market and to the supply of clams. Fred Sieling apparently considers it quite destructive of clams since they break a lot and, also, may hurt the market. He points out that they really tear up their propellers and they have quite an expense on their boats; some are getting steel propellers now for this particular work. The depth they work in depends on the size and draft of the boat because they must get the back of the boat down close to the bottom to allow the propeller to dig. Nat tells me that in one certain area they have dredged it year after year and still got plenty of clams. Perhaps by the time the clams are reduced to a non-profitable level, the crab fishery will be back.

In respect to the oyster industry, one conception which we have been slow to realize and take into consideration in our thinking is the rapid growth of "salts" (Seaside oysters). All the oystermen are apparently convinced that "salts" will grow faster than baystocks, and this seems to be so if the timing of their planting and harvesting means anything. Several, including Ralph Clark and the Ballards, were quite interested in South Carolina seed; they believe they can have success with it despite our predictions of mortality trouble in cold winters because they expect to hold oysters only about one year in Virginia waters. They believe they can get seed large enough to mature in that time, provided it grows like our own "salts". The one example of an introduction of South Carolina oysters in Hungar's Creek turned out favorably, and nearly all oysters lived and growth was good. However, this occurred in 1952 and it had favorable winters and summers for comparison with native oysters.

The oystermen of Eastern Shore have been forced to make changes in their oyster operations, and I think it will turn out to their advantage. The mood seems to be more optimistic this year than for some time. For example, Captain Onley, who has not planted in Messongo Creek for two years, began planting again this year. Several are looking around quite vigorously for new sources of seed. The great demand for seed from Delaware and New Jersey oystermen has stimulated seed production, which is probably beneficial to the small growers. The Ballards believe they can introduce South Carolina seed for about the same price as their local seed costs them; however, we saw some wonderful sets in places, such as Hungar's Creek and on Mr. Thornton's ground beside the Chincoteague Road, and by and large it would seem unnecessary to go to South Carolina for seed.

The problem of early fall shucking is still not licked. The distributors insist upon having oysters on the first day of September, and regardless of their condition the oyster processors must supply them. Nat Terry lost a couple thousand gallons of oysters he bought from another firm because of pink yeast. All of this was to insure that no competitors got their brands into his Davenport area; he has furnished the Davenport Fish Company for some twenty or thirty years. This matter of keeping markets sometimes becomes the primary factor in forcing planters and shuckers to operate early in the season.

Copy to [illegible]

Summary of Effects of Channel Dredging on Oyster Production in James River

Jay D. Andrews
28 September 1966

A. Diseases

1. MSX

Salinity does not seem to be as important in regulating MSX as was first thought. We have observed now the patterns of infection by MSX in James River for six years. The first three years were average or slightly wet years and the last three were exceptionally dry. Data for 1966 are not yet available.

There are three seasons of the year when salinity may have limiting effects on the activity of MSX. The first period is in June and July when early-summer infections are occurring. There is some evidence that salinities below about 15 parts per thousand during this period tend to inhibit or reduce the number and intensity of infections. The second period is during the late-summer and fall season when salinities are usually at their highest levels. The effect of low salinity in this period appears to delay development of infections. The third and most important period of the year is in spring, especially April and May, when the lowest salinities of the year occur. During this period in every year of observation, oysters have recovered from MSX infections throughout the seed area with the exception of an area around Brown Shoals.

The usual pattern of MSX activity in James River is for latent infections to occur in June and early July but not to appear clinically until October or November. This delayed development results in light infections which have no chance to develop due to cold weather and therefore, no appreciable death rate. These infections persist apparently at low levels of intensity through the winter and are discarded in April and May, often at temperatures in the vicinity of 10-15°C, but for the most part after oysters have become active in spring. It is now believed that the oysters expel MSX actively rather than salinity being the effective killing agent. However, infections occurring farther up the river may disappear during winter. Only one of the six years monitored have departed from this typical pattern of MSX activity in James River. Apparently as a consequence of relatively high salinities throughout the summer during the infection period, in 1964, oysters began dying about the first of September which is late compared to fully epizootic areas, and caused as much as 30% mortality from Wreck Shoal downriver.

We have learned from various observations that early exposure of young oysters to MSX has an important effect on subsequent survival. If oysters of varied ages are exposed to the same infection pressure of MSX, that is in the same area under essentially uniform conditions, spat will have the fewest infections, yearlings will be next, and older oysters will tend to have the highest levels of disease. Our observations suggest that in discarding or expelling MSX, the order of remission is similar, with spat being most effect in recovery and older oysters being least effective.

There has not been much selection of oysters by MSX through deaths in the seed area. However, it is quite possible that the 1964 yearclass, which set in a year when MSX was most vigorous in the James River, may show some genetic improvement over earlier yearclasses. It is not known whether continuous exposure is necessary to maintain the acquired immunity which seems to protect young oysters in fully epizootic areas.

Our monitoring of MSX prevalences began in 1960 and provided six years of information. MSX invaded the seed area, including the Wreck Shoal area, in all six years. However, only three years showed levels of prevalences which we consider fully epizootic, that is about 30-35% infection. In the other three years, infections were at levels of 5-15%. In three wet years, MSX established epizootic levels of infection in two years, whereas only one of three dry years exhibited these same levels of infection. It appears that salinity is a limiting factor if it is low, but other factors are also affecting MSX infections. The lack of information on the life cycle of MSX makes it impossible to define these factors at present. If there is an alternate host, this may explain variations in prevalences. Probably dosage is involved regardless of the source of infection.

The effects of MSX on usage of James River seed oysters are not as detrimental as was first believed possible. MSX appeared late in James River seed area, but in eight years of MSX activity, losses from transplantation of infected seed appear to be minimal. In the first place, seed oysters were planted almost entirely in low-salinity areas comparable to those in the seed area. Therefore, except for the two years of extreme drought conditions, there were not important losses from use of infected seed. However, where such seed was used in high-salinity areas, infections continued to develop and caused deaths. If James River is to be used as a seed area, it would appear that benefits may arise from early exposure of young small oysters to MSX. Up to the present time, planters have sought to obtain seed from MSX-free areas when possible. This is understandable in view of the general expectation that importation of MSX-infected oysters might cause further spread and increase in activity. There is no evidence in the epizootiology of MSX that this has occurred.

2. Dermocystidium

Our tests of natural oysters in James River indicate that very little Dermocystidium was present in the years 1963 and 1964. There was more Dermo present in 1965, especially in some trays which had been held in James River for several years. The 1966 tests are only now being run. In short, it appears that Dermocystidium has not taken advantage of the prolonged drought to expand its activities significantly in the seed area. I am at a loss to explain why since oyster populations are still relatively densely situated, although not as abundant as they were in pre-MSX days. Furthermore, there have been more larger and older oysters available for infection. Since Dermocystidium is slow to infect small oysters under about two years of age, in normal years when sets are heavy and most oysters are young, one would not expect much infection by the fungus disease. Dermocystidium is inhibited in multiplication by low salinities but it is not as easily discarded as MSX. Once infections are firmly established, they can persist through winter and spring in areas where salinities almost approach $0^{o}/oo$

for a period. However, in such areas Dermocystidium does not proliferate readily, therefore it would not be able to persist through several years even if advanced cases were imported into low-salinity areas.

Conclusions

Seasonal variations in salinities are large in James River, therefore they tend to compensate for annual fluctuations of dry and wet periods. It appears that oysters were capable of expelling MSX during all springs including the drought years of 1963 to 1966. Both 1964 and 1965 had average or better spring runoff, and salinities usually dropped to at least 10 parts per thousand or lower for considerable periods of time at the river level of Wreck Shoal. Therefore, MSX may occur in late fall but it is thrown out by oysters in spring in the James River each year. We have observed the effects of MSX in both wet and dry years and there seemed to be little difference except that deeper penetration of the seed area occurred in dry years. It would appear that changes of the order of 1 to 3 $^{o}/oo$ salinity in summer and fall will not have an appreciable effect upon distribution or intensity of MSX infections. There may be some advantage, when sets are normal and most oysters are young, in having these oysters exposed to MSX at early ages. It is entirely possible that new data on the life cycle of MSX may change this appraisal. In addition to providing minimal levels for MSX to develop and kill oysters, salinities may work indirectly through regulation of the distribution of other hosts or sources of infective materials.

Notes on Mortality Conference & Conflicts with Oxford Biologists
JDAndrews
5 Dec. 67

I have attempted to outline the objectives of the Shellfish Mortality or Pathology conferences in the light of present activities and existing organization.

1. If the purpose is coordination of programs or planning of research aims, this must necessarily be done by senior administrators and/or project directors. It cannot be done in an open meeting of 100 or so people. Furthermore, the BCF has a strong leverage on these aspects of planning thru their control of funding.

2. If the purpose is exchange of information, the meeting has become too diverse and specialized. Papers from finished research to repetitive progress reports and especially rehashes by novices are encountered. I suspect much of the audience is repelled or only slightly interested in epidemiology, histochemistry or ultra structure - to name only a few of the favorite topics. Each group has a better audience available in (organized) present societies. Quarterly reports should keep all informed - but in practice are late or not received to 2 or 4 states.

I find much duplication of materials at various meetings thru the year. I attended only 3 meetings in 1967 and heard one paper at all three of them. Sindermann has named some outlets such as NSA, Invertebrate Pathology Society and Protozoology to which can be added AERS - for specialized papers are given there too.

3. The original purpose of quickly exchanging info on MSX is gone and the atmosphere is charged with jealousy and recriminations- between states as well as with BCF. Very little new information is coming out on the immediate problem of what to do about MSX - infection, culture, even breeding resistant oysters are slow fields at best. The peripheral and more basic disciplines are being pursued. Monitoring areas for MSX have long since been cut and dried and are being abandoned somewhat.

4. I conclude that the principal objective now is that of propaganda- which is important in influencing who gets the money. This aspect is quite apparent in Oxfords approach and they have done a pretty good job of getting lots of people involved and irons in every fire. And Oxford doesn't leave any meeting uncovered e.g. Malacological Society. On the other hand a resolution by NSA for a review symposium on MSX for publication! brought very old "warmed over" talks and so far only one paper - mine. With some 30 to 40 "papers" submitted to NSA for oral presentation only one paper has been received for publication - and the Proc are now published as quickly as most journals.

Again, I doubt that we need another meeting for propaganda purposes.

J. D. Andrews

Objectives in MSX Research

27 December 1967
JDA

1. Continue to compare and select for acquired and innate resistance in Chesapeake Bay oyster "lines."

   a) The first involves discovering the type of exposure or habitat which confers acquired resistance. My best guess now is that it involves exposure during breeding--either of parents or larvae and earliest spat. It seems improbable that larvae are exposed to MSX appreciably during culture but most parents have probably been exposed before breeding without becoming sick or selection occurring. For example, P14 was bred from parents imported in August 1964 and spawned in February 1965 (in lab from 19 November 1964). Since infected oysters stop growing, it is probable that oysters spawned were selected in the sense that they did not obtain late-summer infections. Could the parents have transmitted the ability to produce antibodies to MSX through their eggs? Unfortunately for this tenuous theory, P20 Horseheads were stripped before being placed in York River water.

   The other possible method of acquiring resistance is by low level exposure in Ames Pond although 1966 progeny were exposed at VIMS by 1 October 1966 and had no MSX the following June (including P33).

   b) Early batches of progeny involved several parents usually whereas later ones often involved pairs. By careful selection of parents we may be able to demonstrate innate resistance or susceptibility in lines such as P33 and P10 (this group with 3 years intensive selection and a good record of resistance). This approach projects the program well into the future.

2. Explore further the effects of age and size on MSX activity--in the first 3 years after import.

   a) 1966 Horseheads show half the MSX activity that 1964 Horseheads did in 1967 (both prevalences and death rates). Will this reduced level prevail as the oysters get bigger and older? So far the die seems to be cast for life from the beginning--low, moderate or high death rates. What casts the die?? The how of this procedure of "casting the die" is discussed above in 1.

3. I don't believe it will be easy to demonstrate the effects of 2nd, 3rd, etc. infections on resistance but I should try. It involves selecting sick oysters or populations which must be moved to low-salinity areas (difficult in summer) for clearing then re-exposed, etc. Such a program runs high risk of failure from loss of oysters by human scavengers.

4. Breeding involves more than just selecting the oysters. They must be brought or gotten into breeding condition by feeding, warming, cooling, and other treatments. Also, it will probably be necessary to prepare dozens for every pair bred. Spawning is highly desired but may be impossible. Considerable effort should be expended in recording the characteristics and subsequent history of the parents--in an environment eliminating Dermo and other mortality agents.

5. Continue monitoring at least 1 tray of new susceptibles in at least 3 areas each year. There should be at least 2 at VIMS in the event of accident of unforeseen events. Potomacs are more susceptible but Horseheads are classical and satisfactory controls. Note of the succession of yearclasses should be made in the event susceptibility changes. A tray of Potomacs would be a good check.

6. Patterns of timing of infections and kill are about fully confirmed and multiple imports can be reduced--spring and fall at VIMS but only spring elsewhere.

7. Some efforts at density control are urgently needed but how this can be accomplished in trays or on the bottom without losing identities is not clear yet!

8. Experiments designed to throw light on the method of transmission should be considered. For example, assuming a large motile animal (fish or crabs) is a host, one could fence an area (preferably in a protected body of water) and hold a tray of susceptibles within the enclosure. I predict no effect from this treatment but . . . I could almost certainly eliminate the blue crab from our experience in Ames Pond. I think some more carefully planned comparisons of types of bottom--shelly, sandy, muddy--might be useful. Also, a raft experiment in deep water (Mobjack possibly or rather a protected area) (?) to get away from the bottom is a possibility. Also, I need to search for a high-salinity area without MSX. This would perhaps give a clue to origin of infective particles. A search for additional ponds is in order also.

9. I want to expedite the program I have been talking about for years--special handling of select oysters for optimum growth, shape and quality by eliminating all fouling shell-dwelling organisms, careful stacking, low density, etc. These should be carefully measured, weighed and described regularly.

10. Sampling has become a problem with so many trays. Few gapers are obtained except in winter hence live oysters must be sampled. The precaution that no two trays of oysters are alike (even if same history and station) makes it best to sample the tray being monitored for mortality but death rates are high and number of oysters limited. So I try to sample at critical periods and sometimes overlook groups. Conversely if regular monthly sampling is done, the oysters will soon be depleted. A compromise has been to sample some groups intensively and others more sparingly or to sample duplicate trays alternately.

Problems in Progeny Monitoring

1. Time of transplanting is important--I now have groups moved in 1) early spring, 2) early summer (during highly infective periods) and 3) late summer and fall.

2. Is time of culture important, that is, during or out of infective period?

3. These unknown mortalities 1) mud smothering, 2) pond disease, 3) other diseases are fuzzing the picture badly.

4. Except for P30 and P33, most mortalities which could be caused by MSX are in groups with low prevalences.

5. Mortalities sometimes occur rather late in the fall in resistant progeny--hence a delay is gained but oysters are eventually lost.

6. P34 (VIMS natives) is a group with a good MSX record in 1967 and was moved from pond in April as were 1964 and 1965 progeny.
   P35 same but 6 cases of MSX in August.
   P31 and P32 moved in fall have good record.

Notes on MSX Program

26 December 1967
JDA

1. Why did P1 to P5 moved to VIMS a month after setting not develop full and equal resistance to MSX as later groups left in pond did? Except P5, none ever had more than 7 cases/25 oysters, however.

2. I must look for differences in environmental exposure for variations in prevalences and resistances.

3. Could it be that certain sizes of oysters are more attractive to possible other host or that active (growing) oysters more so than sick ones?
   Why did P9 (Mobjack runts) get out of line--suffer so much MSX kill in 1967? (It occurred too early for Dermo and MSX prevalence was up!)
   P8 seems to have escaped MSX and been killed by Dermo.

4. Should I take a group of 1964 progeny and divide into "large" and "small" oysters and compare mortalities? Save large for breeding. Separate P10's 90 mm and larger into a group not to be sampled (done).

5. Should I measure dead oysters in older lots from now on?

6. Should I weigh some of market size progeny--yes! or volume?

7. P15 offers good support of P14 (same batch) on low MSX activity for late summer 1966 exposure.

8. This year be sure to mix susceptibles and infected lots in the same tray. Also mix progeny and infected lots with control sets.

9. Should I move some P33's (dying Horseheads) to low salinities to remove MSX? (Done) How about some older oysters of good history--move to James River to clean out MSX then back to VIMS about 1 June next year? Should these be susceptible lots which usually continue dying or resistant progeny?

10. It seems probable that unknown diseases are active in young oysters particularly and complicating MSX monitoring.

11. What shall I do with old survivors now that they have Dermo?

12. Should I move old survivors to upper James for a year or two in an attempt to eradicate Dermo? And other condition-inhibiting associates.

13. Could crowding be a factor in MSX? in trays vs. pilings or plantings--really no planned tests of this factor yet!

MEMORANDUM

To: John Wood

From: Jay D. Andrews

Date: March 7, 1968

Subject: "Pond Disease"

I examined a group of oysters (89,592-616) yesterday which had been transplanted from Horsehead to Hampton Bar the middle of April 1967. A sample was taken on 30 June 1967. There are many sick oysters in the group. In fact, most oysters show some evidence of distress. It is possible that MSX has established infections in these oysters although none were seen in the first 16 examined. It is early for MSX to appear, and from past experience it is quite unlikely that the leucocytosis is caused by MSX.

I see in these oysters the same syndrome which we have been calling pond disease. The most characteristic sign is the occurrence of large leucocytes full of granules. The first oyster in the group is a good example of this, and for comparison oyster number two shows some reaction but without the granular leucocytes. Another characteristic of these sick oysters is the condition of the digestive tubules in which they are stressed, distorted, enlarged, and often cilia are sloughed off.

Another characteristic of oysters with this syndrome is serious lysis or disintegration of the connective tissue which we observed also in several lots of oysters held in aquaria for MSX infection experiments. A less common, but perhaps related, sign is phagocytosis which gives the appearance of cell within cell, such as I have sometimes called Mackin's syndrome.

One of the interesting aspects of this disease is its apparent occurrence in low-salinity oysters and sickness or death within a short time after transplanting to higher salinity areas. This we noticed in James River seed some years and not others in a spring mortality. Also, before MSX was discovered, I had noted a June mortality of unexplained cause. Furthermore, at intervals we have rather serious winter mortalities which are spread all over Chesapeake Bay and the oysters have no recognizable pathogen. We experienced the same kind of kill in New Jersey imports in 1964 in June and July. I have also reported that nearly half of the deaths in old survivors is from causes other than MSX or Dermocystidium. Finally, the disease or diseases are accentuated in the pond but appear to kill mostly in the spring and summer.

I do not see any pathogen in these oysters but I do not believe MSX is involved. We have many oysters fixed from these various situations

I have described which could be compared for similarity of the syndrome. I suspect some microbial organism is involved but it is probably very small and you will have to decide how to approach it.

JDA:br

COMMONWEALTH OF VIRGINIA

VIRGINIA INSTITUTE OF MARINE SCIENCE
GLOUCESTER POINT, VIRGINIA 23062

March 18, 1968

Dr. Victor Sprague
Chesapeake Biological Laboratory
Box 38
Solomons, Maryland 20688

Dear Victor:

I have enjoyed reading your final report on the disease-resistant oyster program. It is a good report and I have had much fun testing various concepts I hold concerning MSX and SSO. I think the essential information is available including source, date of import, disease resistance at time of import, death rates and prevalences of diseases in gapers.

I am fully aware that you were not nearly as deeply committed to testing of oysters as we were in Virginia. I therefore rationalize the sizes of your initial populations as being useful if minimal. A fair number of your populations were started with about 100 oysters. This gives a fairly satisfactory picture of seasonal and annual mortalities but can become misleading for short periods and particularly when the population becomes decimated as it was for 1967. I therefore put less reliance on the mortality graphs in 1967 where they become jagged with one period fluctuations in mortalities. We usually begin closing out a population when it declines to 100 oysters by sampling the live oysters out.

This is an exercise in analyzing your report and data for my own purposes. I see no harm in communicating these to you even though I may repeat your own conclusions. My major points are:

1. MSX was only moderately active in 1965 in Chincoteague Bay and virtually absent in 1966 and 1967. This conclusion is based largely on your death rates in susceptible controls and the occurrence of MSX in gapers. + type 2 controls

2. SSO was very active in 1966 but absent or with low activity in 1967. There is no basis for judging 1965 except in the native oysters obtained in the summer of 1964 which showed very little SSO in 1965. Only two of more than fifty gapers in 1967 had SSO. I have no information

about the distribution in time when these gapers were collected but assume it covers the period of mortality which was early summer. I conclude therefore that SSO fluctuates almost as widely as MSX in Chincoteague Bay.

3. There appear~~s~~ to be lots of unexplained mortality in all three classes of oysters reported, particularly in 1967 when neither MSX nor SSO appeared in appreciable numbers of gapers.

4. There is a suggestion that survival of spat from our laboratory cultures which you ~~re~~imported in 1964 indicates ~~provides~~ some acquired resistance to SSO as well as to MSX if transplanted to an endemic area early. There is no breakdown on the causes of deaths in spat to further explain this. Also, I must say that I did not observe this resistance of native Seaside oysters to SSO in my earlier studies. In fact, I suspect that it may be circumstance that has permitted these Egg Island, Mobjack and Potomac River progeny to survive SSO mortalities. They were ~~re~~imported in August 1964 too late for exposure to SSO in that year. By early summer of 1965 they were only one year old, hence from previous experience would be expected to show considerable resistance to infection by SSO. This May-June 1965 period is the one which produced the infections for the heavy 1966 SSO mortality. I see little evidence of strong infection pressure by SSO in the early summer of 1966. Hence, these groups may simply have excaped exposure at the proper age.

most vague 5. Your gaper collection is good and quite informative. Unfortunately, it is vaguest in 1967 when the mortality data are also suspect. However, I consider a good gaper collection essential to sorting the causes of mortalities.

6. I miss live oyster samples taken at critical times which would provide much more input as to the causes of mortalities. I realize that your populations were too small for sampling.

A few further notes may be of interest.

1. The imports from Marumsco Bar in 1964 already had substantial infections of MSX, hence many of the deaths in 1964 and 1965 cannot be charged to infections in Chincoteague. On page 8 under Marumsco, you make the statement that MSX appeared in Pocomoke in 1960 and has been increasing in activity since. My evidence of this and other fringe areas is that there was an early mortality in 1960 and 1961 after which MSX subsided only to reappear again in 1964 and 1965. Since that time I found MSX has again subsided in such areas. Perhaps you have evidence to the contrary for Pocomoke Sound.

2. I am sure you realize that your 1964 imports, the earliest of which were made on 10 August, precluded any MSX mortality in 1965 (except native oysters) and also it precluded any early summer MSX infections in 1964. Late summer infections were possible but winter mortalities do not follow these unless the infective pressure is very intense. Mortality the following June is normal and to be expected.

3. I think your ~~combination~~ comparison of exposed and unexposed groups of oysters for significant differences in mortality levels is not justified in reference to MSX. My view of the mortality graphs indicates that a large proportion of deaths was caused by SSO and neither of these groups was previously exposed to it (again excluding natives).

4. My secondhand information on Long Island does not suggest that there ever has been an epizootic of MSX. I think it has been present all along but in such low levels of activity that one cannot classify the oysters as having had previous exposure.

I am really quite puzzled as to what happened in 1967 in your oysters. On page 38 where you give type 2 control data, it is not clear what groups these refer to. I presume the Horseheads were lot 2 imported the first of May 1965 which indicates that a substantial epizootic of MSX occurred in Chincoteague Bay from infections in 1965. The next group from Beacon I presume to be in lot 2 imported in May 1966 and sampled at the end of September. This confirms the mortality graph picture of essentially an SSO type mortality alone. In fact, gapers with MSX in 1966 could easily be the last of the 1965 infections dying in June and July 1966. The ~~entire~~ last group from Tolchester I would expect to be 1967 imports sampled in September and indicating again no MSX activity in susceptible oysters. However, only one group of Tolchesters is shown in your list of imports in Table 1 and these were imported back in 1964. In short, I conclude that MSX infections were essentially limited to the summer of 1965 and that deaths in 1965 and 1966 were from this one summer of infection.

It is interesting that you continued your infection experiments on the Rattlesnake Landing Pier in 1966 and 1967 with negative results. I rather suspect that a number of explanations could be given for the failure of laboratory infection experiments other than the settling of spores. I think the most important observation for consideration is why MSX and SSO should vary so widely from year to year in Chincoteague Bay and to a lesser extent in lower Delaware Bay. It has done so here too but never to the extent of reducing infections to a low level.

Your experiments with growing and setting larvae using natural food screened through 43-micron filters are most interesting. I hope you will find this can be repeated at other times and other years. I still remain completely baffled by your figures which seem to imply that oyster larvae set at 200 microns or below 250 at least. I realize that you are giving population means with parameters and I can only assume that you had a small proportion of your larvae which were much larger and that these were the ones which set.

I think your final conclusion that Chincoteague Bay is not a good location for testing the resistance of oysters to MSX is valid. The disease is not dependable from year to year and there is too much interference by SSO and other mortality agents. I don't know what to suggest concerning the survivors now that your program has been concluded, at least as far as the contract is concerned. As you know, we have most of the same kinds of oysters and frankly we have more than we can handle now.

Again, I enjoyed your report and I hope you will find my comments useful and a fair indication of the success of your report in reporting information.

Sincerely yours,

Jay D. Andrews

Jay D. Andrews, Ph.D.
Senior Marine Scientist

JDA:br

Notes on MSX Program

3 December 1969

Jay D. Andrews

I am recording some of my plans and concepts, regarding a breeding program to obtain stocks of oysters with genetic resistant to MSX. These plans may require modification when the geneticists reports are received.

A. Breeding - time, stocks, quantity, methods (in and out-cross breeding; also group vs pairs)

1) Time - I much prefer early (April and May) lots of progeny to profit from May and June growth (best of year); to avoid handling small spat during natural oyster setting periods; to avoid prolonged exposure in pond; and to permit MSX selection by end of 2nd summer. Late summer spat are subject to red tide periods winter smothering, poor growth, late exposure to MSX and they are definitely inferior for my program.

2) Stocks - I think three types of stocks should be bred for testing: a) 10 yr. old survivors of all diseases including Dermocystidium; these have yielded our best progeny groups so far; b) successive generations of resistant stocks after several years of MSX selection (often not very rigorous) both inbred (siblings if possible) and out bred (cross of two resistant lots); c) a few highly susceptible lines as controls and to

demonstrate genetic mechanisms - but these on a much smaller scale than resistants.

I do not advocate bringing in exotic species or races of *C. virginica* from other areas for breeding at this time - with the possible exception of Delaware Bay resistant stock. This would only complicate an already complex and difficult breeding program. The culture lab is asking for 30 oysters per lot to insure spawners of both sexes, and this rapidly depletes old stocks and the select specimens of any stock, because they are not saved and returned to their groups. A laboratory-wide system of marking males and females should be adopted. I believe an experienced hatchery technician can determine sex by behavior under stimulation without spawning occurring. Perhaps some efforts in season to spawn whole trays of oysters, as yearlings, to determine and mark sexes would be justified.

I believe that group and pair spawnings should be executed with the same lots of oysters both as a check on larval rearing and subsequent growth and disease resistance. If groups are bred, greater genetic variability will be available from which fast growers can be selected to satisfy the new objectives of growth and large size. Lethal genes may require numerous permutations of pair matings to obtain progeny of strong viability - at least batches of eggs should be held until failure of development is obvious.

3) Number of progeny - Free spat are much easier to handle than those on shell, once they are large enough to hold on window screen in plastic trays (about 2 mm). Growth to a size of 2 mm in the lab has been a real holdup in 1969. The method of obtaining free spat during the first 24 hrs. permits getting easily far more spat per brood than the Mylar method - if the problem of growth of tiny spat in suspension can be ovesrcome. Since we are operating on a mass selection basis for our genetic approach, I would like to have tens of thousands of free spat from each group rather than hundreds. It will be no more trouble to handle these large numbers after 2 mm is reached. In 1969, I handled all the pond tray operations by myself with weekly visits. At least four commercial hatcheries are handling free spat by the millions and undoubtedly from early detachment. Setting spat on small shell fragments facilitates their culture.

B. Nursery operations - Most commercial hatcheries appear to be growing spat to 1/2 inch or larger before they are trayed in open waters. I will accept 2 mm spat as nursery stock unless better growth than at present is eventually attained in the hatchery culture.

I learned by experiences in 1968 and 1969 that two to four weeks is all the time required in the pond to reach a size for good survival in the York River in trays. We have had virtually no mortality of trayed spat (after 5 mm) in the pond or the river as of 1 December 1969.

I expect to begin air drying of all spat groups on a regular scheduled basis to prevent fouling in the York River.

Sorting by size will begin as early and rapidly as manpower permits, and spat will be moved to coarser mesh screens as their size increases. Simple wooden boxes with screen bottoms appear to be satisfactory for pond culture. They fit nicely into our present trays for suspension and are easy to build. A depth of 4 inches provides adequate protection without small-mesh wire tops after a spat size suitable for the York River is attained. No experiments have been conducted on predation because of scarcity of spat.

C. Monitoring and Selection - Our objectives are to obtain disease-resistant oysters with fast growth from genetic strains or lines. This sounds like what we have been doing but it is really quite different. In the past two or three years, our attention has been centered on the practical shortcut of natural immunity acquired by exposure to MSX. Groups have been maintained intact without willful selection and mortality and prevalence of MSX have been the criteria for judging resistance of groups. Now we propose to add the superior oyster criteria of growth and size (L&W) in selection. We intend to select and sort lots into two or more groups and discard those that appear sick or stunted. If we obtain large numbers of progeny from a particular mating, the selection can be more rigorous. We have already demonstrated that we can sort out sick oysters by size alone but we will probably process samples of the sorted groups to confirm our actions.

The approach just described is a *mass selection* program intended to accelerate development of genetically resistant strains. It will permit handling more breeding lots with a minimum number of oysters (after selection). For *progeny testing* of pair breedings, it will be necessary to retain all surviving young with random samples and representative measurements. The mated pairs must be carefully identified and maintained for subsequent breeding. Continued exposure to MSX but protection from *Dermocystidium* may seem irrational, however, experience indicates that many more oysters will survive the sporozoan than the fungus disease.

D. Control of environmental factors _ I see no possibility of rearing large numbers of progeny or brood oysters in controlled environments. We must accept the unfavorable conditions of seasonal changes in temperature, salinity, and food quality, and annual fluctuations too. We may be able to modify or regulate density of oysters, competitors and fouling organisms, and possibly some parasites such as pea crabs. Position of oysters in trays is already randomized by regular handling. We already have standard trays and meshes. In groups where mortality is no longer the major criterion of success, we can use Sevin and salt-brine dips more freely to control pests. We have gambled in 1968 and 1969 on the ability of small current year spat to escape infections of Dermocystidium at VIMS Pier where it is prevalent. It would be much more difficult to attempt to hold small spat offshore.

E. Auxillary experiments - we have already found that progeny bred out of the areas where MSX is prevalent are about as susceptible as unexposed James River controls. All three of the groups tested were bred from parents without known exposure or selection. Two additional groups were obtained in 1969 for monitoring. We hope to get resistant stocks bred in upper bay hatcheries, for import at various ages and subsequent monitoring. We also should exchange progeny lots with Haskin in Delaware Bay and retain sublots for comparisons. Probably current year spat are the best groups to exchange.

Program of Research for J. D. Andrews

30 December 1968
JDA

A. Active Programs

1. Continue MSX grant program if possible with the purposes:
   a) Get 2 or 3 more years monitoring of existing progeny stocks.
   b) Strive to shift the emphasis to genetic studies if methods of 1) conditioning, 2) spawning, 3) free spat handling, 4) <u>and</u> system of observing genetic traits can be developed.
   c) To keep invertebrate breeding lab in operation.
   d) To keep microtechnique lab in strong operation.

2. Reduce the scale of monitoring sharply.

3. Increase the intensity of selection of oysters for growth, quality--in short, intensify control of variables affecting oysters in open waters by treatments, transplanting.

4. Increase the observations on fouling and pest organisms--both qualitative and quantitative efforts--mostly near VIMS.

5. Attempt nursery studies with hard and soft clams--probably mostly by tray methods (including Mike's oyster shell bed method which fits my observations of natural survival of clams--also in the long held belief that blue crabs are the major predators).

6. Begin tray studies of other shellfish--particularly <u>Macoma</u> for causes of deaths and rates (e.g., Dermo in species other than oysters).

B. Catch-up Programs

1. SSO data and slides that are unworked are voluminous.

2. Setting data--not true research but needs to be organized in available form.

3. OJR work--three papers should be prepared; 2 are nearly done but not accepted.

4. Salem Church, Rappahannock Hurricane, James River dredging studies should be given better distribution--to name a few unfinished business items.

5. Growth and underwater weighing vs. disease studies--unpublished.

C. Minor Programs for Students and Occasional Attention

1. Predation of bivalve larvae.

2. Parasites of bivalves, Ostrincola, Mytilicola, Pinnotheres, etc.

Notes on Oyster Diseases,
A Workshop at VIMS
3 & 4 April 1972
J. D. Andrews

I. Delaware Bay

Haskin showed a oyster production chart for Delaware Bay with early catches of 2 million bushels per year in 1930's or earlier. Several factors (overharvesting, salinity increase and drill invasion due to N. Y. taking water, and a power-dredging law (1945)) caused a reduction to about half this level from post-war years to mid or late 50's. These factors, especially power dredging and subsequent set failure, led to depletion of the lower seed beds and by the late 1940's and through 1955 or 56 seed was being imported from Virginia. At first this was James River seed then Virginia passed a law requiring seed to be planted one year in Virginia waters and activity shifted to Seaside where the existing supply of seed and cultch was depleted rather quickly. There followed in the late 1950's set failures on Seaside and in 1958 an extensive mortality never satisfactorily explained but being mostly in Chincoteague Bay may have been caused by MSX (Sieling claimed eel grass smothering at the time and he was located there).

From about 1952-1955, Delaware Bay seed beds (and all these figures probably exclude Delaware) were producing 300-400 thousand bushels annually and it was estimated that over half the seed planted was "brush" stock from Virginia. According to Haskin production of market oysters had declined farther already before MSX epizootics began. The 2-month sail-dredging season on seed beds was not shortened with the advent of power dredging but there have been shorter seasons and closed ones in the 1950's and 1960's. MSX killed about 50% of the resident stocks in the seed area in 1958 with the kill being heavier on the lower beds and because of changes in drill and setting patterns, the seed catching moved upriver. The drill line moved from Ben Davis Point up to Ship John's lower edge. Seed production was cut to half when MSX scattered throughout the Bay in 1958-1959. MSX has not been a mortality factor at Arnolds, the upper-most seed bed (small) except in mid 1960's with high MSX intensity years (I suspect incipient or sub-clinical infections were common and explains some of the quick infections and mortalities that occurred when moved to the high-salinity waters of Cape May). In summary, overharvesting brought seed production down from 1 million to 350,000 bushels and MSX cut this in half by further reducing brood stock and setting.

Market production dropped finally to about 1% of the 2 million level when MSX wiped out the Seasides and native seed on the lower Bay planting grounds. The seed production now is back to about 250,000 bushels annually with only a handful of planters involved. This is almost equal to James River seed production where without much disease or predator activity, the lower half of the seed area (below Wreck Shoal) is not producing much seed from poor recruitment (sets) and continued harvesting (especially for soups).

The MSX epizootic was discovered in April and May with box counts of 80% at the center of the epizootic and 50% over a wider area. These figures may refer to accumulation figures thru the summer of 1957 for it is quite unlikely that an end-of-winter kill would have been so intensive and if they died the previous summer and fall it would have been discovered for they were harvesting oysters. It does mean that the initial massive infections had to occur in the summer of 1956 -- undoubted late-summer from present knowledge.

Haskin has had crews monitoring plantings on some 8 to 10 beds scattered throughout the lower Bay each year. He reports wide seasonal fluctuations in prevalences which may rise to 80-90% in May-June, then after an early-summer kill drop to 10-20% in late June, and back up in July or August. Our data do not support such wide fluctuations.

Haskin firmly believes that the Delaware Bay seed beds and the small wide-mouthed tributaries on the Jersey shore are a self-contained setting unit and that the tributaries are important in helping to retain or detain larvae in the area. He has studied larval ecology there long and intensively hence I should believe him but I don't. I fully accept the importance of shallow bays and creeks in trapping some larvae, but I can't believe the intensive Cape May larval broods do not penetrate up river in lesser densities. This is not to deny that the seed beds may be of major importance as brood stock for setting throughout Delaware Bay including Cape May shores. Where else did Cape May set come from through the lean years of the early 1960's when there were virtually no stocks of oysters on the planting grounds.

Haskin mentioned a Corps of Engineer plan to build 26 dams on the Delaware River which has been blocked temporarily at least. He mentioned their request for natural flows from April to November to control drills.

Haskin stated that MSX is a significant factor in New Jersey production, but with the relatively high resistance of seed oysters, the industry could live with it if they rotated (harvested) crops on an annual basis. They had relatively good sets in 1966, 1968, 1969, 1970 (counts of 2000-

3000 spat in 1970 on new beds in lower seed area -- now most "important" source). Planters who gambled with Arnold's seed had heavy losses. Haskin describes increasing resistance in seed oysters from upper to lower seed beds but how can this be genetic resistance if the gene pool of the seed area is randomly mixed by larval transport for two weeks? Surely he wouldn't claim that Arnolds produced larvae that set at Arnold's etc. I see this gradation in resistance in James River seed (between Deep Water Shoal and Horsehead stocks as well as Wreck Shoal stocks some 8 to 10 miles downriver), but I don't see how it can be genetic unless there has been selection by MSX (we did have about 25% kill on Wreck Shoal in 1964 but not on other bars and not in other years of recognizable intensity). Haskin states that our James River stock seems to be getting more resistant by Delaware Bay tests but he needs to remember that in 1971 we sent him two lots -- Deep Water Shoals that were dying from prolonged freshwater exposure (these died on him soon after arrival) and Wreck Shoals to insure that he would have some control oysters. I, too, find Wreck Shoal oysters more resistant.

Haskin has never accepted my contention that introducing oysters in the middle of the intensive infection period in June results in higher losses to MSX than if those same oysters were acclimated and given a chance to develop their natural defenses. (His 1971 reports which have just been received exhibit this June import pattern). James River oysters are always poor, and undergo a considerable salinity change when transplanted directly to Delaware Bay. This year for the first time I have persuaded him to accept oysters moved first to VIMS for about 10 days in winter to adjust to higher salinities and then go to N. J. He took about 2000 (2 1/2 bushels) of sorted Horsehead back with him on 4 April 1972.

When Dr. Hargis asked Hal what N. J. scientists had done for the oyster industry, he listed the principle of genetic resistance; they sought and obtained an embargo on susceptible imports which still holds; and scientists were mostly responsible for the changes in seasons and quantities of seed bed working -- there has been no two-month season since 1953 -- some seasons are as short as two weeks and not over three weeks now -- also several closed seasons. The shellplanting program in N. J. has been in the seed area in addition to a percentage of shucked oysters that must go back to seedbeds by law. Shell supplies became very short during the 60's when there was very little harvesting of oysters. There were lots of surf clam shells but I don't know whether they were used except on the Cape Shore. He discussed the oystermen's old argument about needing to work the beds each year to clean shell for setting and he told about a "309" money planting that was late and happened to occur during setting with a dramatic spatfall. Fouling is low in the seed area as it is in James River except for barnacles and sometimes mussels (1971) in the James. I believe *M. recurvus* does not occur in Delaware Bay.

Haskin pointed out that we can test for MSX only in the field but that life cycle, immunity mechanisms, and host parasitic reactions were major objectives at Rutgers so it is not simply a field program. Without the ability to infect under controlled conditions, he has used the ocean side of Cape May as a sanctuary from MSX. This permits him to manipulate oysters into and out of MSX infection pressure and observe the consequences. As a result of these manipulations (mostly with spat I surmise) he sees no evidence that first exposure or infection affects subsequent exposure and infection frequencies. He emphatically states that he does not believe in my acquired resistance theory but he did not challenge my data on resistance of spat versus adult oysters on first exposure. He evidently believes that selection has occurred before my monitoring began.

Haskin mentioned something about low (?) temperatures being unfavorable to MSX (it drops out) but I didn't understand what the circumstances were.

I have always been impressed by Haskin's ability to present a convincing picture of his activities, and I consider his objectives quite sound. I think his long-term objectives are broader and perhaps better delineated than ours in respect to MSX. He does an excellent job of responding to questions and pulling things together. I am sometimes appalled at his data collection methods, however, and his handling of trays and data. He is a long way from the Cape May shore most of the year and depends almost entirely on student help seasonally. His recent reports indicated very extensive interference by Dermo-even in first year imports.

Haskin's conclusions about the status of genetic resistance in Delaware Bay are interesting. He showed the same graph used for years to show that in about two years of monitoring susceptible oysters (Horsehead, Potomac, Navesinks, L. I., etc) reach 80-90% mortalities whereas resistants usually reach 40% or higher. Previously, he has maintained that each subsequent generation has a lower death rate but now he is encountering selected lots (Great South Bay ex.) that do as well as his best Delaware Bay stocks. This is what I have found all along. We apparently agree that it may be difficult to attain higher resistance -- at least without going to progeny testing, pairs and inbreeding in attempts to define resistance and lock it into carefully bred lines. Despite the relatively high losses in Delaware Bay, I'm convinced that Haskin's resistant oysters are as good or better than ours in this respect -- dosage or environment makes the difference. His speculation that resistance may be sex-linked (carried by females) is interesting but premature.

No one from Delaware attended and they indicated they were doing no disease work. Fred Kern has been looking at some old oysters that they moved down from low-salinity areas to Bowers Beach on the Delaware Shore and in successive samplings found 6, 20, and 42% prevalence of MSX. I'm not clear whether they have examined anything from Rehoboth Bay and Indian River, but got the impression that MSX was active there. Also Austin Farley has some *C. gigas* slides from Delaware stock and found no MSX so probably this is the basis for the claims I have heard the *C. gigas* is resistant to MSX. These oysters were held in the canal close to the lab that changes from fresh to 30 ppt each day (?) so were they exposed really? Fred Kern has a haplosporidian in oysters (*C. gigas*) from Taiwan or Korea that has spores exactly the size of *M. nelsoni* in *C. virginica*. He also mentioned a gregarine-like worm found in spat (from where?) which would be most unusual, for *Nematopsis* uses crustaceans for the gregarine stage and mollusks for spores usually.

Austin Farley showed me a table on occurrence of spores in *M. nelsoni* based on over 10,000 live oysters collected from Marumsco Bar in Pocomoke Sound from which they selected over 1000 sick-looking oysters for smearing (and I presume later sectioning) in 1965-67. About 800 of these oysters had MSX and some 70 had spores. This is

10% of sick oysters and 1% of the population. These were Potomac River susceptibles and he believes sporulation occurs in June and October although spores may be found anytime. This about kills my theory that spores were more likely to be found in resistant oysters that could live long enough for the parasite to sporulate (presumably a year as is required for SSO). It appears that marginal areas for MSX may provide enough braking on the pathological effects to allow MSX to sporulate, or Pocomoke Sound is other wise suitable for it, because this is more cases of spores than we have seen in all our slides and much higher occurrence (ours is about 1 per thousand MSX cases).

Aaron Rosenfield reports MSX from Beaufort, N. C. (Neuse River) to Maine now and we wonder if thereare several strains of MSX (another reason for facilities to infect and test under controlled lab conditions). The level of kill in Great South Bay is no more than 15% (all causes) according to Haskin and there is no evidence yet to contradict my theory that high-salinity environments are not suitable for MSX. This is probably why epizootics haven't occurred north or south of Delaware and Chesapeake. Oxford did find SSO in L. I. oysters shipped to California in June hence it has had a chance to establish on the west coast (and it is in L. I.).

II. Oxford and Milford activities

MSX has essentially disappeared from Maryland waters which I would predict with the withdrawal of range in Virginia. We have had rather little MSX in the Piankatank and the Rappahannock rivers in the past several years with imported susceptibles. It is quite confusing in terms of epizootiology to work in border areas where salinities or other factors cause queer activities of pathogens and diseases. Chincoteague Bay is a tricky place to work even though Dermo is absent, because MSX acts pecularily in high-salinity areas. I privately explained to Rosenfield that their paper on Chincoteague Bay epizootiology misinterprets MSX and SSO mortalities.

Although Oxford is out of active studies of the MSX problem in Chesapeake Bay, they have several people working on diseases of invertebrates and Milford and Oxford are forming new teams which I interpret as being stimulated by Carl Sindermann although they may be working under the guise of pollution studies or something. They are receiving regular samples from the west coast (Oregon and Washington) and get casual samples from other areas where oysters get into trouble (as described for Calif.). Bacteriology may also be the new fad that will support their activities. I get the impression that Sindermann may be pushing for discovery and quick publications on as many parasites and diseases as they can find in a whole range of invertebrates. They have Farley who is always seeing new bugs and have hired Gilbert Pauley who is a Sparks-University of California trained pathologist. He is very prolific-usually on one tumor in one oyster type of papers but well trained and able. Then Milford is back in full operation on a much larger scale than before with lots of new people such as Walter Blogaslawski who is studying bacterial diseases of mollusk larvae.

I was rather shocked to learn how out of touch I am with activities in my present field of activity. I don't belong to the Invert. Pathology Society and go only to NSA and occasionally Estuarine meetings. I haven't been to Milford in ten years and only saw the new building once in a quick fly-in and out visit. I need to visit the Milford Lab to

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stimulate my activities on genetics of oysters. I understand Longwell has four several thousand gal. tanks full of oysters -- parents and progeny for her breeding program. Perhaps my comment that we were not effectively doing either mass selection or progeny testing was ill-advised at the meeting, but it was not challenged and perhaps it was the only chance I will have to express my frustration in the breeding program. The present selection program is empirical, uncontrolled and will not yield lasting and basic genetic information for the future -- only a few superior brood stock oysters.

Sara Otto and Mrs. Hammel are working at Oxford preparing and reading slides for Maryland from two annual surveys. They are paid by the state. Since MSX and Dermo are rare, they are working on Ancistrocoma, a gut epithelial ciliate parasite, Nematopis distribution, and Bucephalus. They had charts but never got a chance to talk, I have a couple table summaries of Dermo occurrence in Maryland from 1963 to 1971 from them. They are also interested in "winter kill," a sporadic mortality of unknown cause which occurs in Virginia too.

J. D Andrews
5 Apr 1972

A Program for Moderating the Effects of MSX on the Virginia Oyster Industry

I. History and Introduction

MSX appeared in Virginia in 1959, spread throughout the lower Chesapeake Bay in 1960, and has persisted through 1971 in killing most of our stocks of seed oysters when they were planted within the high-salinity area of distribution of the pathogen. The historical effects of the epizootic were to essentially eliminate planting of James River seed oysters in most of the York River and Mobjack Bay together with Bay grounds off Egg Island and in Hampton Roads. Tributaries of these areas, such as Back River and many creeks were also abandoned as oyster planting areas. In addition to loss of nearly half of Virginia's private rented grounds, public beds in the lower half of the Rappahannock River and parts of the Piankatank and Great Wicomico rivers were forced out of production. Numerous large creeks along Bayside of the Eastern Shore are vitually unused.

At first the James River seed area was not affected, hence there was an oversupply of cheap seed oysters, and scarcity and high prices of market oysters prevailed in low-salinity sanctuaries from MSX. Chief among these areas were the Rappahannock River above Towles Point and the Virginia tributaries of the Potomac River.

Two events in Nature tended to ease and obscure the supply disruptions caused by MSX. Both tongers and processors benefited from these natural events. The first was a drought from 1963 to 1967 which permitted seed oysters in the usually low-salinity James River to become larger and "fatter" than usual. These small, cheap oysters were needed to supply Campbell's three soup plants. Hence, the James River seed area became a source of market oysters with catches eventually almost equaling seed harvests. In recent years, James River oysters reverted to their normal small size and poor condition, but the marketing practices had become well established with watermen and the soup plants.

The second event of Nature that affected oystering in Virginia was a moderate river-wide set in the Potomac River in 1963 -- the best in 25 years of records. The set was only 200 to 300 spat per bushel but it occurred on thousands of acres of bottom. By 1965, tongers had largely abandoned the James River seed area for the bonanza of excellent quality Potomac River oysters. The

1963 yearclass is still contributing in 1972 to the catch although it is declining.

The large supply of seed oysters in the James River provided excellent broodstock but did not prevent a sudden change in the level of setting to about one-tenth the 1940 and 1950 recruitment rates. Setting failed beginning in 1961 and has not improved appreciably through 1971. Meanwhile, total catches in the James River seed area, including soup and seed oysters, have declined to less than one-fourth the two-million bushels annually of the 1950's. Overfishing together with disease (MSX and Dermocystidium) and predator losses during the drought years combined to strongly reduce oyster populations in the lower half of the seed area (below Wreck Shoal). The important implication of these declines is that the seed area is not self sustaining in setting without broodstock contributions of private & public beds of oysters in Hampton Roads that were decimated by MSX.

The situation in Virginia in 1972 is that both seed and market oysters are in extremely short supply. The minor seed areas in the Piankatank and the Great Wicomico rivers were relatively productive in the mid 1960's with unusually good sets, and seed supplies were enhanced by use of dredged shell for cultch. Both setting and cultch supply have declined in recent years. A large portion of soup and market oysters are now obtained from Maryland, and an estimated 60% of that state's production (Sieling, 1972) is trucked to Virginia for processing. Potomac River production is declining and some low-salinity growing areas are hampered by pollution. Setting was generally low throughout Maryland and Virginia seed areas in 1971.

II. Statement of the Problems

The major problem in respect to MSX effects on the industry is to restore seed production. Pollution, political, and economic problems may become more serious but are being mostly put aside for this analysis. Without a dependable seed supply, the industry is doomed. The most important objective is to restore setting and production in the James River -- always the major resource in Virginia.

It would be desirable to restore to production the abandoned grounds in the high-salinity areas of lower Chesapeake Bay, but these are marginal beds with serious problems of predators, smothering, and diseases in addition to MSX. It is much easier biologically to utilize large acreages of public grounds in the Rappahannock River and the vast Potomac River to grow oysters. The problems here are political, and obtaining seed oysters. This account is addressed to a program for increasing seed supplies and avoiding MSX losses.

III. Status and Knowledge of MSX

A. Distribution and intensity of MSX activity

MSX has been continuously active in lower Chesapeake Bay for 12 years. It routinely kills 40 to 65% of James River seed in the first year of exposure and almost as many in the second year. The disease was moderate from 1959 to 1962 when lower bay plantings were destroyed, very intensive from 1963 through 1966 in years of drought, and moderate to heavy from 1967 through 1971. The chief effect of these changes in intensity was expansion of the range or distribution of MSX in the drought years. During the drought years, damage was caused in the lower James River seed area, upper York River, upper Rappahannock River, lower Maryland tributaries such as Manokin River, and Pocomoke Sound. The usual intensity of activity and distribution of MSX is shown in the attached map (Fig. 1). In average years, the areas just mentioned are not affected appreciably.

B. Biology and monitoring

The life cycle of MSX is known only in the oyster. It is highly infective but not contagious from one oyster to another. Infections may be obtained only in Nature and the source of infections is not known. It is not affected by density of oysters or even absence of oysters in an area. The disease actually intensified after large populations of planted oysters in lower Chesapeake Bay were gone. Intensity of disease is monitored in all major rivers of Virginia by placing susceptible seed oysters from upper James River in test trays each year. Native oysters and planted beds are also tested when available as they were in the early years particularly.

C. Resistance to MSX and manipulation of seed oysters

Natural selection for resistance to MSX is progressing very slowly in Virginia. Most present populations of native oysters set and grow in low-salinity sanctuaries where MSX is not active. This is more a consequence of predation than diseases for MSX does not kill young oysters. Most planted seed oysters are grown in low-salinity areas, also beyond the range of MSX.

Natural setting areas where MSX is moderately active are the Mobjack Bay river tributaries and creeks, and the Piankatank-Milford Haven system. Hampton Roads has regular spatfalls but no survival due to drill and flatworm predation. It has been demonstrated that native oysters set and reared in MSX areas have resistance to permit most to survive the disease. Numerous tray experiments, several trial plantings by the State, and one commercial planting of Piankatank seed oysters all withstood MSX exposure in Mobjack Bay and the lower York River. More generally, it has been demonstrated by VIMS that native lower Chesapeake Bay wild sets, if grown from setting in areas of exposure to MSX, will withstand the disease with minor losses. Resistance is enhanced even in susceptible James River seed if transplanted to MSX-infested areas as spat or yearlings. In short, methods of using existing seed supplies to combat MSX have been found but predation prevents their use.

D. Feasibility of hatcheries for restocking resistant oysters

The artificial breeding program at VIMS has shown that broodstocks with high resistance to MSX may be obtained by intensive selection of native stocks by MSX. The feasibility of producing seed oysters or breeding stocks by hatchery and nursery techniques for use in open waters is limited by economics at present. Even if placed in sanctuaries, where removal by the fishery would not occur, it is probable that mixture with large numbers of unselected native oysters would quickly overwhelm and nullify resistance in the gene pool of the hatchery-bred stocks. The technology to manipulate superior lines of broodstocks should be advanced in the event that pollution or failure of wild spatfalls necessitates artificial breeding.

IV. A Biological Program to Reverse MSX-Induced Declines in Oyster Production.

The oyster industry of Virginia has been forced to operate with out-moded political and technological limitations. As long as these persist, biological improvements are limited in scope too. The industry has been increasingly restricted to operations in low-salinity waters and to importing market oysters from such waters in Maryland. Use of low-salinity waters avoids the problems of diseases and predators, and permits longer holding without losses or need for costly transplanting. With the supply of seed oysters low, there can be little justification for planting now in risky high-salinity areas.

The program which follows assumes that status quo will prevail in Virginia in respect to: 1) political philosophy of private and public oyster beds; 2) restriction of harvesting methods to the present inefficient ones; 3) transplantation of public and private seed stocks to MSX-free low-salinity areas for growth and marketing.

The major thrust of these suggestions is to increase seed-oyster supplies but an important objective is to accelerate development of natural genetic resistance to MSX in the broodstocks of the seed areas. Application of hatchery and nursery techniques is not considered feasible at present economic levels, and so long as natural setting persists and may be enhanced by manipulation of shell and seed. If pollution or other factors cause a more rapid decline in supply or increase in costs, artificial techniques may be re-evaluated.

A. Improvement of James River seed area

The James River is a strongly flushed estuary with a relatively steep salinity gradient. It apparently requires a large stock of brood oysters to compensate for flushing of larvae. Setting is typically late for Chesapeake Bay, and it occurs mostly in late August and September -- a trend accentuated in post-MSX years. Seed areas are the most important and valuable of all oyster grounds and they should be used for that purpose alone. The following proposals are biological in purpose and the economic and political arguments against them are well known. To increase seed supply and broodstock and increase resistance to MSX are the objectives.

1) Stop all marketing of soup-type oysters from the seed area. Oysters sold as soups would yield 2 to 5 times the volume of meats if transplanted for growth and conditioning. This would ease the demand for seed oysters and permit larger populations of breeders to remain in the river.

2) Build up oyster populations in the lower half of seed area (below Wreck Shoal,or Blunt Pt. to Days Pt. line) where a) production is now low b) MSX exerts some exposure and selection pressure c) salinities favor growth and fattening for maximal spawn release.

   a) Limit harvesting by catch limit, short seasons, and sanctuaries.

   b) Transplant Piankatank and Mobjack tributary seed (April of year after setting with spat counts as low as 500/bu.) to supplement local sets. Warning! This seed may contain drills hence must be carefully monitored and planted only in present drill-infested area on east side of channel near Brown shoal. Drill-free seed should be planted on western side of channel from bridge to Days Pt. and areas closed for at least one full year (subsequent season).

   c) Try winter dredging of plot at Brown Shoal near channel or on Hampton Bar to remove shell, oysters, fouling organisms and drills. Winter dredging to try to smother some drills. Plant clean shell mid-Aug. to 1 Sept., monitor and if set obtained move to seed area immediately (late Sept. or when set justifies earlier). This is costly and experimental but represents an attempt to use known regular setting potential of Hampton Roads.

d) Sprinkle clean shell (100-200 bu/acre) over seed plantings as close to 1 September as possible. Shell planted <u>when</u> oyster larvae are setting often acquire several <u>times</u> as many spat as older shell.

3) Sprinkle a major portion of each year's shells on oyster beds in the upper half of the seed area. The sprinkling should be done in the two weeks straddling 1 September at rates not to exceed 100-200 bu/acre. The objective is to get clean shell on the tops of the best rocks at the optimal time for setting (based on 25 years records). Oyster larvae are attracted to set by presence of other oysters, hence an oyster bed will catch far more spat than a shell bed (demonstrated in James River). This activity is usually opposed by inspectors and oystermen alike for obvious reasons. Late summer spat in the James River usually winter at a size not visible to tongers hence the shells must be culled. A light spatfall in James River will produce more oysters than one several times as intensive in the Piankatank or the Great Wicomico rivers because survival is better (probably silting but possibly flatworm predation or related to time of setting. Sets in the rest of Chesapeake Bay are usually in July—except occasional exceptionally big sets in September. This program is to augment oyster stocks in the part of the seed area now supporting the seed industry, and it has no benefits to MSX resistance, except to relieve pressure on stocks that are being selected and hopefully contributing heavily to breeding.

B. Management of other seed areas

The Piankatank and the Great Wicomico rivers have exhibited higher setting potential than the James River throughout the 1960's. The resulting seed production has been disappointing although they are small rivers. The problems have been many, primarily because of operation as a public fishery for tongers. There has been a trend towards more harvesting or cleaning-up beds by MRC that is more effective.

These estuaries exhibit entirely different larval and setting patterns than the James River. They tend to be rather closed systems with much better retention of larvae which are usually carried upriver in channel tidal currents. Setting is usually more intensive towards the heads of the rivers where oyster grounds are small in size and shallow.

The Piankatank-Milford Haven and Mobjack tributary seed areas are exposed moderately to MSX hence have the best opportunity to develop resistance to MSX. This is the primary reason for suggesting transplanting to the lower James River seed area despite a rather long expensive boat trip. The Piankatank exhibits very poor growth of oysters on thick shell plantings after the spat reach fingernail size. Shell plantings should be thin enough to permit larvae to penetrate to all shells, then moved out completely the following spring. If setting occurs, this river and possibly the Great Wicomico River should be on a one-year rotation whereby a crop of seed oysters is taken out each year and no shells are laying buried and idle. Efforts to use the small bars of the upper reaches should be intensified. The Great Wicomico is not usually exposed to MSX hence should be used as an auxillary seed area for private planters who usually require two-year-old oysters on their rented grounds. It is believed that planting rates for shells should not exceed 5000 bushels per acre and depending upon experience and type of bottom may be less. Rapid turnover is the key to management of seed areas if spat will survive on planting grounds.

C. Private production of seed oysters

When seed oysters become scarce and prices high, private planting of shells increases. There has been considerable activity in the Great Wicomico and tributaries of Chesapeake Bay below its mouth in recent years. Oystermen located up the seed rivers where heavy sets occur find shellbags profitable. When counts are several thousand per bushel, the MRC should consider buying bagged seed for sprinkling on James River seed beds. There is added value if these are caught in the Piankatank River system where MSX selection is a factor. Survival and clumpiness are not serious problems on the rocks of James River where high count is the prime consideration. The MRC should encourage all types of seed production on private grounds as a regular habit, by any advice or help in obtaining shells and equipment in the area.

V. Rehabilitation and Use of High-Salinity Grounds

When MSX decimated large planted populations of James River seed in 1959 and 1960, it was hoped that rehabilitation of the lower Chesapeake grounds could be accomplished soon. Most diseases fade away when their host is gone but MSX did not. The reduction in seed supply was not expected to be so drastic. A method was found whereby MSX could be evaded but its execution was prevented by a shortage of resistant oysters and the cost and inefficiency of transplanting oysters. Resistant seed oysters from the Piankatank River were too small to withstand smothering and drill predation on Mobjack Bay grounds. Transplanting to low-salinity grounds and re-transplanting to Mobjack Bay is not feasible economically.

Mobjack Bay was chosen as a trial area for MSX experiments over Hampton Roads because Dermocystidium is not active there (it is up some of its tributaries) and drills are less abundant. Also MSX is more intensive in Mobjack Bay than in Hampton Roads. It (MSX) is more active in moderate-salinity areas than in high ones.

The Brown Shoals area of the James River seed area exhibits all the mortality agents of Hampton Roads with both diseases (Dermocystidium and MSX) active and drills abundant. These agents do not penetrate very far into the seed area seriously and are essentially absent on the opposite side of the channel where salinities are a little lower.

The only feasible use of the abandoned grounds in lower Chesapeake Bay may be for cleansing and fattening oysters from polluted areas. This would need to be carefully timed to avoid MSX infections of susceptible oysters, and it may be more risk than most planters would take with marketable oysters. All factors considered, there is not much promise for use of public or private beds in high-salinity waters because of unsolved biological and technological problems.

VI. Planning and Monitoring of Rehabilitation Programs

Experience has demonstrated that careful planning and execution of shell and seed transplanting programs is required for adequate evaluation of the success of the operations. Both MRC and VIMS must monitor carefully the seed, the beds and the results. Continuous checking of setting, drill activity, diseases, and timing and location of operations are essential. Failure of programs comes easier than success. There are many details and explanations that are incomplete in this report. There may be field situations of which the writer is not aware. A careful review by all concerned is required. Once a program is launched, cooperation is even more important to success.

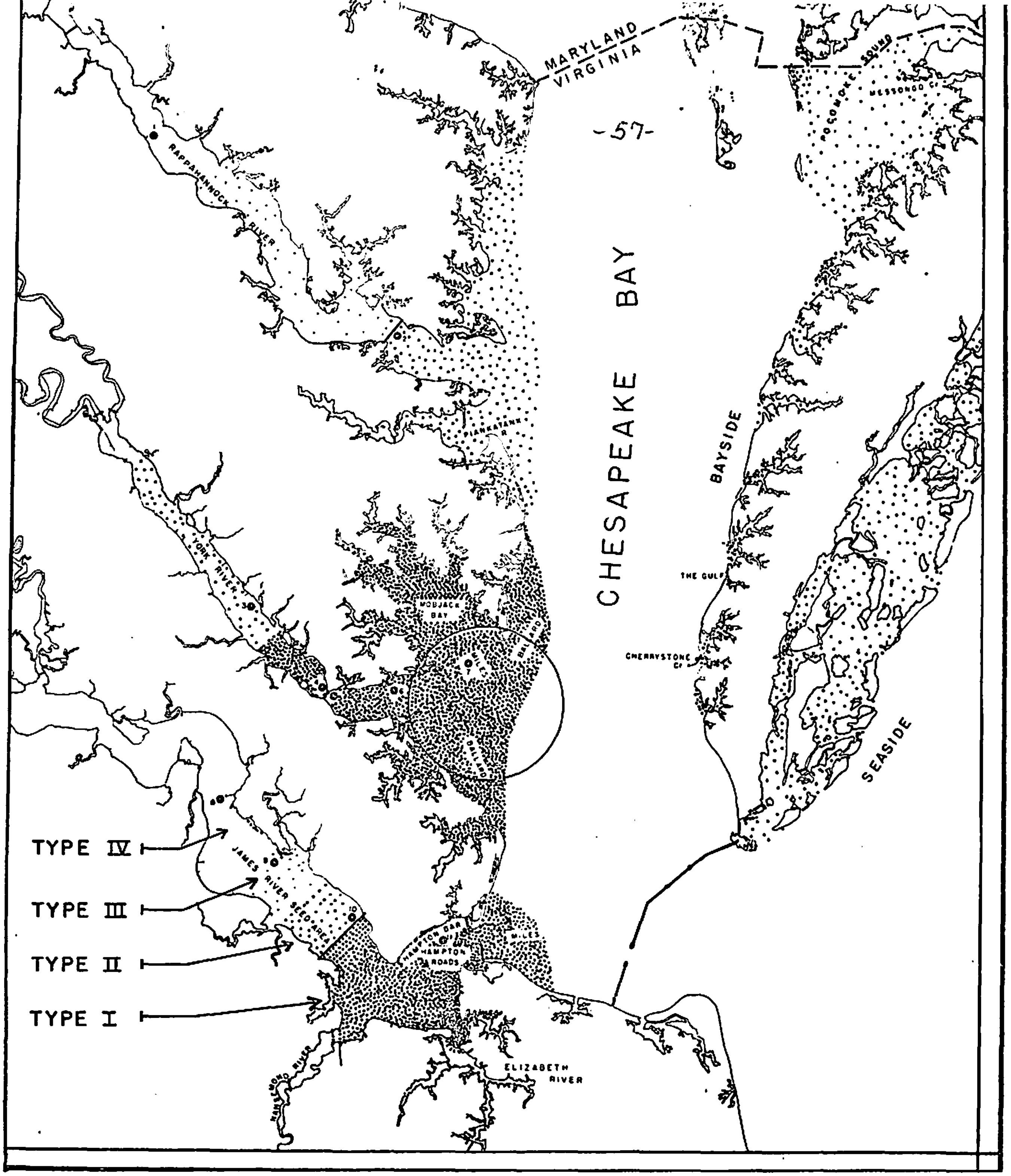

Fig. 1. Classification of Virginia oyster grounds by intensity of MSX activity. Four types of areas are designated by intensity of stippling from fully epizootic MSX activity to none (no stippling). Type I, fully epizootic all years; Type II, activity fluctuates from light to heavy; Type III, light with late infections and often no deaths; IV, absent. Important areas and beds are named. Tray stations are numbered as follows: 1. Bowlers, 2, Hoghouse, 3. Foxes Cr., 4. Tillage's ground, 5. VIMS pier and offshore VIMS, 6. AMOCO Platform, 7. Mobjack Bay, 8. Horsehead, 9. Wreck Shoal, 10. Brown Shoal, 11. Hampton Bar. The circle represents the initial area of mortalities from MSX in 1959. Taken from Fig. 2. of History of MSX in Virginia by Andrews and Wood.

J. D. Andrews
June 30, 1972

Program to Respond to Agnes Flood

Excessive rainfall during the current water year (beginning 1 October 1971) produced background salinity regimes in Chesapeake Bay of unusually low levels before Agnes caused record floods and runoff. Consequently oysters at the heads of oyster regions in the James and the Potomac rivers were already dying from prolonged exposure to fresh- and low-salinity waters and were in extremely weak condition before Agnes passed.

Oyster losses seem almost certain to occur and may be the most serious ever experienced in Chesapeake Bay. The interactions of low salinities, low oxygen from flood detritus and stratification of waters that inhibit wind mixing, and the timing and duration of adverse conditions will determine the extent of oyster losses.

The biological problems posed by Agnes for shellfish management and repletion are: 1) short-term monitoring of time, place, depth, and extent of losses, and the causes, probably ending in a month or two, and 2) long-term population and recruitment studies, and repletion activities, that may stretch into years. Inventories of shellfish predator, fouling organism, and disease stocks before and after the expected damage are necessary for management and repletion decisions. These events (changes) must be related to the physical conditions that cause the damage and the relative roles of mortality agents assessed (freshwater, O_2 depletion and silting). The short-term monitoring of all important oyster stocks, such as the James River seed area, private planted oyster beds in the Rappahannock River and Potomac River tributaries should be done on a daily, semi-weekly and weekly basis until recovery of physical conditions and the fate of shellfish stocks are known.

The long-term job of restoring seed stocks and setting rates -- in short, repopulation of denuded and depleted seed beds may be much more difficult and expensive. For example, the James River seed beds, situated in a low-salinity region normally, where sanctuary from predation and diseases is secured, provides most seed oysters for Virginia and Maryland planters. The upper half, most susceptible to flood damage, now provides a large proportion of the seed oysters. Most biologists agree that this strongly flushing-type river is under-populated now which accounts for the 10-fold decline of setting and the 5-fold reduction in seed production in the 1960's and early 1970's. The first objective of Virginia shellfish management authorities must be restoration of this seed area--for without seed there will be no industry.

The scientist's roles in seed area repletion programs lie in planning, monitoring, and evaluating the necessary activities to restore natural setting. Even with the present unsatisfactory rate of recruitment (natural setting), the James is declining steadily, and if the major brood stocks from Wreck Shoal upriver are killed, it may become completely unproductive.

It is probable that the trap-type minor seed areas in the Piankatank-Milford Haven, the Great Wicomico River, and the Mobjack Bay tributary rivers will be less damaged by Agnes than the James River because of small drainage basins. Also, much smaller brood stock populations are required to produce natural sets. It seems probable that setting potential will be retained in these systems hence may provide the source of brood stock to repopulate the James River seed area. If these contingencies become reality, it will require much more intensive cultching, including artificial techniques such as shellbags on the bottom where sets are most intensive (upriver), and careful monitoring of larval broods and setting to insure maximum spatfalls. Larval monitoring for cultching at optimum times has never been done in Virginia because of cost and extensiveness of setting seasons and areas to be covered. It should not be as difficult in these smaller tributaries where larval broods are more restricted in time of occurrence and the upriver migration is almost certain to be in the channel.

The contingency plan proposed is to cultch these intensive setting, restricted acreage, trap-type rivers intensively with three-dimensional methods and transplant spatfalls to the James within a few weeks of setting. It may be possible to get more than one crop per setting season from the same areas. In addition to monitoring larvae and spatfall, scientists must determine the optimum locations in the James River for growing spawning stock--where oysters will produce the most spawn in the shortest time and contribute effectively to successful recruitment.

Decisions must be made where and what portion of the available seed stocks may be utilized to sustain the oyster industry during this period of crisis. Experience indicates that once planters are out of business and have lost their markets, it usually becomes a permanent situation. It is assumed that the major planting areas in the Rappahannock River and Potomac tributaries will lose much of their present private market stocks to low salinities and low oxygen conditions.

The 1972 setting season is at hand, but fresh waters will prevent survival of larvae even if some spawning occurs. A possible exception is the James River where setting peaks are two months away (1 September), if any brood oysters survive. The unusual hydrography conditions may produce a miracle in larval transport with the great masses of fresh water producing a proportionally vigorous salt water wedge to carry larvae upstream if they can find the right layer.

J. D. Andrews

Budget ~~-~~ for Oysters on Agnes Flood

1972

No decision has been made who would do what and when and how long. Here are a few notes on the projects suggested in my "short" and "long" version of Operation Agnes.

1) Present inventories are qualitative to tell <u>what</u> is happening not how much. A full survey of all major public beds in all rivers should be done before oystering begins this fall. This could be done slowly by ~~2~~ 3 Thunderbird~~s~~ with crew of 3 or quicker with a Pathfinder and power dredge and crew of 3 to 5 plus ship people. At → least 3 man-months and a boat not now available. Tech + Spe 60 day

2) Monitoring of setting weekly should be continued as usual through early October. If Dexter can handle as usual, o.k. (Other organisms should be given special attention this summer to see how recruitment occurs with severely reduced populations--barnacles, mussels, bryozoans, etc.).

3) If and when the state decides to plant shells and shell-bags in trap type rivers to repopulate James River, the operations should be followed by VIMS personnel to determine the results, effects and quality of the operations. Monitoring of larvae need not be too long (2 months probably adequate) but may not be feasible until 1973 (season already here).
--Need nets, pumps, and particularly a larval counter.
May be semi-quantitative and not involve large numbers of samples--not a research project but prediction. Probably need 1 man-year (concentrated in summer). Boats? If qualitative, may use Thunderbird size.

4) The recovery of public seed and market stocks must be followed for several years. I think some intensification of what Dexter now does would be sufficient -- Cost?

Jack

we need a new outboard motor $1500 if any extra running in James.

Also we need water bottles + some diving gear - regulator

Andrews

COMMONWEALTH OF VIRGINIA

VIRGINIA INSTITUTE OF MARINE SCIENCE
GLOUCESTER POINT, VIRGINIA 23062

July 3, 1972

Mr. Russell T. Norris
Regional Director
National Marine Fisheries Service
14 Elm Street
Gloucester, Massachusetts 01930

Dear Ossie:

Pursuant to our conversation of 27 and 28 June and letter of 29 June, I am enclosing a more detailed description of the research and management study proposed by the Institute of the effects of Hurricane Agnes on the fisheries resources and environments in Chesapeake Bay and adjacent waters of the Continental Shelf. At this point in time it is impossible to estimate firmly the total cost of the investigation because we lack firm indications of the duration of effects of the flood. Even so, it is now clear that the program outlined in the enclosure will cost in excess of $150,000. We request the assistance of the National Marine Fisheries Service in funding this urgent research and management opportunity and responsibility. The Commonwealth of Virginia is fully committed to this large scale, broadly interdisciplinary program. We would be grateful for any assistance that the Fisheries Service can render.

With sincere appreciation for your advice and assistance in this matter, I am

Sincerely yours,

Bill

William J. Hargis, Jr.
Director

WJHJr:ja

cc: Mr. Phillip Roedel, Director NMFS

OPERATION AGNES

Investigation of the Impact of a Major Flood on the Fisheries Resources and Environments of the Chesapeake Bay

Proposal

Submitted to

National Marine Fisheries Service

By

Virginia Institute of Marine Science
Gloucester Point, Virginia 23062

William J. Hargis, Jr.
Director

Rainfall resulting from Hurricane Agnes produced the largest flood in the Chesapeake Bay drainage since 1771, and perhaps the largest in recorded history. The passage of this unprecedented volume of fresh water through the estuary will produce changes in the hydrographic, chemical and biological regimes of the system. Most of the changes will be deleterious to the biotic communities on which the fishing industries, both commercial and recreational, are based. There follows a description of a program to evaluate the impact of the flood on the fishery organisms and on the fishing industry and to develop recommendations for preventative, remedial, or restorative measures where feasible.

The Virginia Institute of Marine Science has launched a large-scale program to study the effects of Hurricane Agnes on the physico-chemical aspects of the Chesapeake Bay system. That program, for which funding is being sought from other sources, will provide a thorough description of environmental changes. Parameters being measured are currents, salinity, temperature, dissolved oxygen, various nutrients, silt loads, transparency, siltation rates and others. These data, which are being collected at a large series of stations in the tidal tributaries, in Chesapeake Bay, and in adjacent waters of the Continental Shelf, will provide the basis for interpretation of changes in the biota.

Flood waters from Agnes threaten to decimate oyster populations both on the seed beds and in low-salinity areas of Virginia where the growing areas are now concentrated. The extent of the mortality will depend on how rapidly the fresh water flows out of the system and on weather conditions such as wind velocity and temperature. However, lesser flows of fresh water in 1958 killed over 90% of the oysters in the upper James River seed area, and low oxygen in 1955 killed over two million dollars worth of market-sized oysters in the upper Rapp ~~Potomac~~. The biological problems posed by Agnes for shellfish management and repletion include short-term and long-term programs.

The immediate problem is to monitor time, place, depth and extent of oyster losses and the relative roles of low salinities, oxygen deficiencies, and silting as mortality factors in a period probably ending in a month or two. Frequent inspections (daily during the most critical period) will be required until conditions approach normalcy. Inventories of shell stocks, predators, fouling organisms, and diseases are required before, during and after the catastrophe.

The long-term job of restoring setting rates and seed stocks in depleted and denuded beds will be difficult and expensive. The magnitude of this job is not known yet. Without seed oysters there can be no oyster industry, and the primary source in James River is severely stressed and threatened. Setting declined in the 1960's to one-tenth earlier levels and biologists agree that inadequate brood stock is the probable cause in this strongly-flushed river. The prime objective to save the oyster industry in Virginia is to restock the James River seed area.

Minor seed areas of the trap-type, such as the Piankatank River-Milford Haven system, the Great Wicomico River and the Mobjack Bay tributaries, probably will be damaged less and they require much smaller brood stock populations to produce natural setting. The systems may provide sources of brood stock to repopulate the James River by intensive three-dimensional cultching with shell bags and other artificial methods in addition to shell planting. Extra larval monitoring is proposed in these trap-type estuaries to insure maximum catches and perhaps more than one crop a year.

Also to be considered is the feasibility of repopulating decimated beds with hatchery-reared spat of superior genetic quality. Strains having disease resistance and other desirable traits are available at the Institute for propagation.

Determination of optimum locations for planting brood stock in James River to gain maximum larval production, retention and setting is critical. Monitoring extent of mortality and rate of return of predators, diseases, and fouling organisms after the expected destruction of oyster bed communities should be done.

The catastrophe may provide the need and impetus to advance markedly methods of planting seed oysters and shell in both private and public sectors of the industry. A portioning of surviving seed stocks to planters for keeping the industry "alive" and to build back the supply of seed and market oysters must be considered carefully.

Two ongoing monitoring programs will provide information of direct value to the industry. VIMS and the Marine Resources Commission monitor each week the oyster spatfall at 45 locations throughout the oyster growing area. Timely information about spatfall will be especially valuable in 1972 because it will be necessary to make the best use of available spat. Meat quality of market-sized oysters is also monitored frequently at 14 locations. This information is valuable both as an indicator of the yield of shucked meats per unit of shellstock and as an indicator of the general health of oysters at a given locality.

Hard clams and soft clams, like oysters, are susceptible to damage from the flood. Having censused beds of these molluscs in many places in the tributaries and Chesapeake Bay in recent years, VIMS is in a good position to assess the damage from the current catastrophe by repeating the census program on representative beds. The census will provide information about the resources remaining to sustain the industry. Such information is of value not only to the industry but also to the public management authorities.

One immediate response by the public health authorities to the influx of flood waters was to prohibit harvest of clams and oysters in most productive areas. Not known as of this time is the length of time these beds must remain closed. Also unknown is the bacteriologically-based need for closure and for the spatial and temporal extent of closure. Since immediate harvesting and processing is one defense against floodwater-induced loss, unnecessary closure is to be avoided. On the other hand, since it is vital to protect the health of shellfish consumers, justification for leaving beds open to harvesting must be sound. Clearly, direct knowledge of the true bacteriological situation is essential. One phase of the work involves bacteriological sampling.

To obtain better indicators of stress and the likelihood of death of molluscs and crabs we propose to measure certain serum and tissue constitutents at various periods during stress and recovery. Development of physiological indicators of degree of stress would be of value both to the fishing industry and to public managers. Such an indicator could be used for example, to determine whether or not it would be necessary to move oysters to avoid a kill.

Constituents to be measured are amino acids, sodium, potassium, calcium, and magnesium. In addition the heavy metals (zinc, copper, lead, mercury, and cadmium) will be measured both as physiological indicators and pollution indicators as well as indicators of potential public health hazards.

The flood waters flushed large numbers of larval fish and other planktonic organisms from the nursery grounds as is demonstrated by the samples collected in plankton nets throughout the period of high runoff. We propose a quantitative and qualitative analysis of these plankton samples to ascertain the impact of the flushing on the productivity of the nurseries. Larvae of river herring, shad, and striped bass in addition to others of less direct recreational and commercial importance are presumed to be affected.

The nurseries will be censused in late summer and again in midwinter to ascertain production of young. (These two census operations are funded by Anadromous Fish Act projects. They are mentioned here not as a request for additional monies, but to show that the plankton data will be integrated with a broader census program.) Catch statistics will serve as an index of the size of the parental population. Plankton samples will indicate losses by flushing, while subsequent censuses will indicate production of young. Data from censuses of previous years will provide a comparison.

Influences of the flood on adult fishes will be less readily detectable than on sessile species such as oysters. Fish are highly mobile, most of the estuarine forms tolerate wide changes in salinity, and numerical baseline data are generally weak. Furthermore the qualitative and quantitative changes in fish populations resulting from seasonal migrations cause uncertainties in attributing causes to observed changes. Therefore, we propose only to document the extent of displacement of fish from their usual habitats and the rate of return to normal, and to sample with sufficient quantitative accuracy to detect a major change in population if one should occur. Although adult fishes would seem likely to be less affected by the flood than many other organisms, it would seem unwise to ignore the possibility of some change. Data on distribution and numbers will be compared with similar data from previous years.

The blue crab spawning season began in mid-June this year and will continue through mid-October. Floodwaters are sweeping through lower Chesapeake Bay during the first third of the spawning season. Since this spawning ground produces somewhat more than half of the total catch of blue crabs in the U. S., the impact of the flood is of considerable economic concern.

The response of the plankton community is of equal importance to understanding the effects on the ecosystem. VIMS has been sampling the plankton and associated hydrographic and chemical parameters and measuring primary productivity, heterotrophic potential, and chlorophyll a at monthly intervals on a series of stations in lower Chesapeake Bay and the York River for more than a year. We propose to increase the frequency of sampling from monthly to weekly during the 4 to 6 weeks that these various parameters can be expected to change rapidly in order to determine the fate of the plankton, including crab larvae. These data will be integrated with an intensive examination of flux of materials through the mouth of Chesapeake Bay.

Census of blue crabs will be continued by the methods which have led to reasonably accurate predictions of the quantity which will become available to the fishery several months in the future. We are requesting support for the additional sampling and analysis that must be added to this ongoing program to fully and quickly evaluate the effects of the flood. The information is needed by the seafood industry and by public managers.

OPERATION AGNES OBJECTIVES

J. D. Andrews

16 July 1972

I. Long-Term Program

It is too early to assess the losses and status in oyster populations of Chesapeake Bay (the short-term objective between now and 1 October 1972), but it seems probable that the supplies of seed and market oysters will be reduced for a few years. The supply of market oysters in Maryland, upon which Virginia packers are so dependent may also be reduced and limited. Vigorous management, monitoring and manipulation programs must be instituted to restore the industry to even recent levels of production. In the following restorative programs, it is assumed that the MRC will manage and execute and that VIMS will monitor, advise and evaluate results and progress. These industry-oriented programs will require closer cooperation of the two agencies than ever before.

Program 1. To restore seed oyster supplies and insure maximum utilization of natural sets and enhance both.

Present economics of the oyster industry almost require use of natural sets for recruitment and seed production. The James River is the major seed source but is declining steadily and it is assumed that brood stock must be built up to improve setting levels. The seed area has been squeezed by predators and diseases on the lower end, and over-harvesting and fresh water on the upper end. Several changes in policies and activities are listed here and are discussed in a position paper relating to MSX in May 1972.

A. Repletion Measures

a) Stop all harvesting of public oysters in the James River except for planting as seed - regardless of size and condition of oysters or economic needs of the industry.

b) With drills gone from Agnes flood waters, plant shell and seed oysters in the best setting and growing areas from Brown Shoal to Wreck Shoal.

c) Close the public oyster beds below the level of Wreck Shoal for several years to build brood stocks.

d) Sprinkle clean shells on the tops of the best rocks each year beginning the last week of August thru the middle of September.

e) Transplant seed oysters from Piankatank and G. Wicomico rivers to sanctuary zone described in "C".

f) Give priority in use of repletion funds to buying shell-bags (1/2 bu or more) with 1000 spat per bag at $1 per bag. MRC to advertise in advance that it will buy them (fall or spring). Plant in lower James R. where survival is excellent.

g) Plant as much shell in trap-type estuaries, particularly the proven Piankatank and G. Wicomico rivers as budget will permit. Use three-dimensional methods and small beds at heads of estuaries where larvae concentrate.

h) Plan to move all seed and shell from trap-type estuaries each year even with low counts (300 per bushel).

i) Establish incentive plans (seed-buying credit) to encourage planters and processors to plant shell, move seed, and contribute shell stocks and boat services at <u>optimum</u> times, <u>not</u> their convenience.

j) Request law declaring that all shells harvested from Virginia waters are State property to be conserved for use in seed production. Include incentive for improved use~~d~~s such as successful three-dimensional seed production (free shells), Virginia is shell poor!

k) Permit short-term use of public seed beds by private firms that utilize three-dimensional cultching.

e) Make theft of oysters more difficult and a more serious crime by holding seller, buyer, and organized oystermen's groups responsible for reporting and policing.

B. Biologists Role (VIMS)

The new or intensified activities that VIMS must carry out to advise and monitor seed production activities include:

a) Plan, monitor and evaluate seed and shell plantings as to times, rates per acre, types of bottoms, survival rates, and yields for all state plantings. Biologists should be present as observers and monitors for all activities of repletion officers of MRC.

b) VIMS should provide counting, measuring, and record keeping services for all shell and seed planting and moving operations to both public and private interest upon request.

c) VIMS biologists should be responsible for population, condition, setting, mortality, predation, and other biological oriented activities for all managed public beds.

d) Biologists and helpers should be stationed locally on each of the important seed areas to monitor larvae, make daily reports, and follow spatfalls through the three to four weeks that setting usually continues each year.

e) Larval monitoring programs should utilize transect methods of collection designed to show relative abundance of larvae (particularly mature ones) and their distribution - a service modeled after West Coast methods - not basic research on transport methods.

f) Observations should not rely upon old crude methods of tongs and dredges but should include much SCUBA diving and efficient mechanized harvesters eg. hydraulic dredges for sampling.

C. Premises of Seed Production Program (1)

The seed program is based on certain long-term observations and derived assumptions about place, time and use of setting potentials. These working assumptions may be refined as experience justifies.

1) Only 3 or 4 estuaries (systems) are now suitable for seed production - James River, Great Wicomico River, Piankatank River, and Mobjack Bay tributaries - in order of importance.

2) All but James River exhibit typical July (early season) setting, and a six week period from last week in June thru first week of August usually covers the significant setting period. Occasional late (Sept) sets are very intensive and replenish whole rivers (examples York in

-81-

Sept. 1971, Rapp. in 1944 and 1954).

3) In the James River late setting is typical with August and September about equally important but in the 1960's usually confined to last week of August and first two weeks of September. Thus shell-planting activities of MRC, planters and VIMS may be carried out in trap-type estuaries before James River needs attention.

4) Planting cultch just before (days) or during setting will increase spatfall severalfold and intensive efforts of biologists and cultching operations should be organized to utilize this situation. Weak sets on pre-season shells can be made into commercial ones by this intensive effort and correct timing.

5) Spatfalls may be increased several-fold by placing shell off the bottom (most practical method is shellbags stacked on bottom)

6) Survival of spat is far greater in the James River than in the other systems. The reasons are uncertain but are probably more related to lack of silting and superb oyster "rocks" rather than predation (occurs in absence of drills but presence of Stylochus).

7) Growth of oysters in all seed areas is slow but the James River has large areas and yields more desirable seed. Planters cannot use (or will not use) small seed from trap-type estuaries, hence to produce annual crops these spat should be moved to James no later than April of Year after setting. Seed in Piankatank and G. Wicomico rivers has typically sold for about half the price of James R. seed thereby offering about $1 per bushel in value to offset cost of transplanting.

8) In the 1960's the two trap-type estuaries exhibited much higher setting potential (on testshells but often not realized on shell plantings) than the James River. Agnes may accentuate this difference by reducing the broodstock supply in James River whereas size of broodstock appears relatively unimportant in trap-type setting areas. The Piankatank and G. Wicomico are expected to retain their setting potential after Agnes, whereas the James River has been quite marginal for eleven years.

9) The distribution of oyster drills is expected to be severely restricted after Agnes (probable elimination from Rappahannock River, Piankatank River and lower James River seed area, possibly including Nansemond Ridge and parts of Hampton Roads). After drill surveys, advantage should be taken of this "flushing job" to utilize greater setting potential of lower James over upper and particularly the lower Rappahannock River. Laws and surveillance to prevent reintroduction should be instituted immediately.

SUMMARY OF SEED-OYSTER REHABILITATION PROGRAM

Jay D. Andrews

16 July 1972

Virginia's seed and market oyster supplies have become increasingly inadequate to meet demand since 1960. Agnes threatens to destroy a large share of existing private stocks, particularly of market oysters in the Rappahannock River, and Potomac River tributaries. Restocking will be costly and perhaps debilitating to the James River. Without seed oysters there can be no oyster industry in Virginia! First priority must be given to management, rehabilitation, and manipulation of seed areas.

A program to use the James River as a sanctuary and nursery area for all Virginia seed resources is outlined. The major premises are: 1) that the James River seed area will not improve in recruitment until spawning stocks are increased, (2) that the trap-type seed estuaries will retain their setting potential after Agnes, 3) that the high setting potential in trap-type estuaries must be exploited by intensive cultching methods, and that crops be removed annually 4) that growth, quality, and area problems in these small trap-type seed estuaries do not favor direct use by private planters, hence should be moved early to spacious James River beds for survival and quality of seed oysters, 5) that increased volume and value of shellstrike imported to James River will pay for transplanting and concurrently help the broodstock problem 6) that seed oysters shall no longer be used for any other purpose (stop use as soup oysters), 7)that the lower half of the James River be declared a sanctuary for a

[illegible]
JDA

few years, 8) that post-Agnes distribution of drills be given full consideration in planting shell and seed oysters, 9) that all shell from Virginia waters be declared a state resource and that it be planted carefully as to time, place, and quantities, (rates) 10) that trap-type seed areas be monitored intensively for larvae by biologists to insure optimum planting times and localities, and to encourage three-dimensional cultching (shellbags).

This program involves numerous biological evaluations, more intensive monitoring of larvae, spatfalls, and transplanting, and studies of times, rates, and places of planting shell and seed. More effective methods and gear for estimating population fluctuations are urgently needed. The situation demands more efficiency and cooperation in management of oyster resources by MRC and VIMS. The objectives must be clearly defined and adhered to by all involved in the industry if it is to survive.

OYSTER DISEASE TAKES A HOLIDAY IN 1972

(MSX fails in 13th year)

J. D. Andrews

In the thirteenth year of its history, MSX failed to cause an appreciable loss of susceptible oysters in Chesapeake Bay. The relief may be quite temporary. Hurricane Agnes which killed so many oysters in the upper parts of the bay and its tributary streams with freshened waters, also reduced salinities in Virginia rivers where MSX is usually active. Low salinities prevented new infections and permitted oysters to overcome those already initiated.

In 1959, a new disease of oysters appeared in lower Chesapeake Bay caused by a protozoan organism called MSX or Minchinia nelsoni. For twelve consecutive years, MSX killed each year about 50% of James River seed oysters planted in the lower bay or held in trays. Large acreages of private beds have not been planted for over ten years because of this disease. Most oysters are now grown in low-salinity areas where the disease does not occur. Susceptible oysters are imported in trays to MSX areas for estimating disease activity each year.

VIMS scientists are awaiting the summer of 1973 expectantly to see if the unknown sources of MSX infective material have also been affected. Expectations are not too great, for a few late cases of MSX appeared in the fall of 1972 when salinities were approaching normal levels.

One important change in the behavior of MSX offers some hope of improvement in the future. Beginning in 1968, MSX failed to produce late-summer infections, hence the infection period was reduced from five to about two months. If this pattern persists, it would allow oystermen to plant in MSX areas in August or September and get about 10 months of growth before June infections occur.

The other alternative is for planters to obtain scarce selected seed from MSX areas, or grow resistant oysters from hatchery seed. VIMS has MSX-resistant breeding oysters but they must be spawned and reared in hatcheries to a suitable size for planting. Hatchery seed is more expensive than wild seed oysters at present, hence not readily available.

The other major disease of oysters caused by the fungus <u>Dermocystidium</u> is still active in most high-salinity areas. It persists in infected oysters even in low salinities although it does not kill them. The fungus increased in abundance during the two consecutive warm falls of 1970 and 1971. It kills oysters only during the warm summer months whereas MSX causes death throughout the year.

Oysters imported to monitor MSX and <u>Dermocystidium</u> in Virginia's rivers were exceptionally good in condition or "fatness" when sampled in December. Sick oysters are easily seen in shucked specimens by poorness except during the summer spawning season. The ~~lower~~ Rappahannock River, the York River at Gloucester Point, and Hampton Bar showed no sick oysters in 1973 and most lots were estimated to shuck about a gallon per bushel. Condition indices for Rappahannock, Piankatank, and York river lots were 13.0, 13.3 and 10.9 respectively in

December. All the oysters were Horsehead, James River seed imported as disease-free stocks in the spring of 1972. Oyster diseases do not affect the edibility of the shellfish except that sick oysters are low in stored glycogen or food reserves.

Criteria for Closing Out Oyster Trays

J. D. Andrews

17 February 1972

I. Control Lots (susceptible imports)

1) Usually carry one full year--providing heavy mortalities and intensive sampling do not deplete well below 100 oysters.
2) Usually import replicate lots (spring and fall) but they need not be on same bed near Gloucester Point. These lots may usually be combined when necessary.
3) Not usually desired for breeding.!
4) When Dermo appears, an incentive is added to discard!

II. Progeny Lots (Resistant only - handle susceptibles as in I.)

1) Are they likely to be used as breeders? (If not, discard after 1 or 2 years exposure to MSX--not including year of setting).
2) Do they exhibit special attributes that are desirable for breeding--hold as long as possible even if Dermo is serious?
3) Are they sibling lots, inbred, advanced generation number? Hold as breeding lines.
4) Dermo is a cause for attempted isolation but not discarding if desirable attributes including age are involved.
5) Avoid combining distinctive lines (Mobjacks, Egg Islands, P10's, etc.) until small numbers (<10) dictate holding as merely "old oysters".

6) Never lose identity of known pair parents! Never discard while alive. Expect to get small circular trays for these!

7) Death rates are usually unreliable when oysters drop below 100 in a lot but sampling is okay until last oyster for disease prevalences.

8) Changes in status (location, selection, Dermo appearance, growth evaluations, and both desirable traits and undesirable ones) should be entered in the history concurrently--also disposal and hopefully a brief summary history (by me). For example, P69 was deliberately exposed to heavy selection by Dermo in 1970 and 1971 and this should be noted on its history page.

9) When possible, close out trays at definitive times in the year--at points of change from active to passive disease--usually in cold season.

POST-AGNES STATUS OF OYSTER PREDATORS

J. D. Andrews

3 January 1973

No one wishes for Hurricane Agnes to be repeated, but new opportunities have arisen for increased oyster production as a result of uncontrollable flood waters. The two species of oyster drills were eradicated or greatly reduced in abundance in large areas of Virginia estuarine rivers. This opens the possibility of increased survival of natural wild spatfalls in the lower sectors of the three major rivers. These are open-type rivers from which most larvae tend to be flushed by tidal flows.

The Rappahannock River is the greatest potential beneficiary from this eradication of drills. These predators, which normally occur from the mouth to about the level of Urbanna, could not be found there in the fall of 1972. This removal of drills from the lower river was a major objective of biologists by "controlled floods" if the Salem Church Dam was ever built. The job was done by Agnes at a high price. This sector of the river has exhibited light to medium natural oyster sets (200 to 1000 per bushel) over a period of 25 years with regularity. Brood stocks have been supplied by the most extensive in the upper sector above Urbanna plantings of private oyster beds in Virginia. It is hoped and expected that regular setting will resume after the 1972 failure. Bridge and pier pilings are covered with the young oysters that escaped predation in 1971 whereas oysters on the bottom are scarce.

The York and James rivers have exhibited ~~also~~ heavier setting of oyster spat in the lower sectors, but the spat are quickly killed by predators. In these rivers, drills were severely reduced to the river mouths but not eliminated. For a few years, until drill populations recover, there should be increased survival of wild spatfalls. A few spat were seen in the fall of 1972 despite almost complete failure of setting.

The short supply of seed oysters in Virginia, mostly from failure of natural setting in the James River seed area above the bridge at Newport News, makes selection of shell-planting areas urgent and critical. Both public and private plantings should be made in the places and at the times that past experiences have shown to be most promising.

Another predator must be watched carefully if increased spat survival is to occur. The oyster "leech", a tiny wafer-like flatworm, was not noticeably affected by the fresh waters of Agnes. The young of these flatworms settle on cultch with newly-set spat and quickly decimate the tiny oysters. Later, full-grown leeches up to an inch long may kill spat of about equal size. This has occurred on laboratory-reared spat at Gloucester Point in the fall of 1972.

Continuous monitoring of drill abundance and distribution in Virginia will be carried out by VIMS in the next few years. Meanwhile all people involved in oyster culture should take advantage of this unprecendented opportunity to grow, culture, and sell seed oysters in areas not usually available because of predation. Both public and private interests should exercise extreme care not to reintroduce drills into now free areas by careless transplanting. Call VIMS if there is any question about presence of drills in seed oysters and learn to identify them from the common mud snails that occur everywhere. It is believed, but not fully proven, that drills do not occur above New Point Comfort in the Western Shore tributaries of Virginia now.

NOTES ON SHELLFISH CONVENTION

New Orleans, June 25-28, 1973

J. D. Andrews

I roomed with Neil Bourne and learned quite a lot more about B.C. and Canadian shellfish work. He did an experiment with manila clams in B.C. from seed obtained from Budge. The clams were placed in meter (?) square boxes inside log frame shellstring floats and floated on the surface with window-screen bottoms. Later black plastic covers were placed on all but one of a series. The open one became fouled with algae. They were looked at monthly. Manila clams inhabit rather high intertidal zone and *Mya* on west coast is also strictly intertidal. There is a small persistent colony of *C. virginica* in B.C. (Boundary Bay?). Budge owns property there and spent an evening with Neil--some vague explanation that he wanted to set up an oyster culture operation there--perhaps seed in Pendrell? Budge is now getting requests to set seed on shell because oystermen can't handle his 2-3 mm spat. Budge said that *C. gigas* was a little harder to breed than *C. virginica*.

Budge got oysters (*C. commercialis*) from Australia but found out they would not let anything in. In contrast, France is importing from everywhere--B.C., Budge and mostly from Japan. In recent years, imports to the west coast from Japan have declined drastically and the oyster growers have depended largely on Dabob Bay and Pendrell Sound as seed areas. Some 100,000 cases of Pacific seed have been flown to France this year at a cost of $100 per case. It is hoped that

C. gigas will be confined to the C. angulata area by low temperatures. Since many scientists have speculated that C. gigas and C. angulata are the same species or only races with C. angulata introduced in historical times, they will probably interbreed quite frequently.

I learned that Pendrell Sound seed receives rough handling and perhaps only one-third of the set survives transplanting. Since a minimum of five spat per shell is needed, the set in recent years has not always been adequate. Dabob Bay has some nine seed producers of which John Glude's brother-in-law, Steele, is perhaps the best but he doesn't wish to enlarge his operation.

On the west coast there has been a continuous effort to prevent drills from spreading by requiring permits for transplanting and it has been fairly successful.

I learned that the Prince Edward Island hatchery is considered a White Elephant by many in Canada and that it and another hatchery 20 miles away built by Anderson for commercial production (now owned by Govt.) are not operating as planned. A pair of geneticists from Halifax are running a basic genetic study on diversity of characters using 20 half sib matings (same male to several females in pairs) and they are being grown in large tanks with controlled food (artificial) and environment (except can't heat or cool?). Some 2 million larvae are started in each of 14 larval tanks and several thousand are set on cement coated cardboard ring bands. The wooden setting bands are labelled and stacked or suspended in the tanks. There seems to be a trend to close out Ellerslie on P.E.I. Roy Drinnan sold the idea of lab breeding and built the hatchery. He is reported to have some 20 projects in progress that he is supervising. Roy has a much better reputation in the U.S. than in Canada. Carl Medcof had a growth removed from his nose that was cancerous so he resigned the next day and is spending a year in Australia. Logie is stymied in Ottawa by a minister Jackie Davis who dislikes him intensely. A young man, Jack ________, is doing nutrition studies on the lab-reared clutches of oysters. He is the son of a famous biochemist.

Pendrell Sound is 100 fathoms deep and it takes some know-how to anchor the oyster shell string rafts. Someone was doing some interesting experiments with plastic bags made from 6x6 or 6x12 sheets of polypropylene netting. Some were attached to a "hard back" 2x4 on top of 1/4 cm of polystyrene and the bags tied at intervals to prevent shifting of oysters. These were put out in 4 ft. lengths hinged in groups of 3 boards. A better way was to pile oysters in center of plastic net, add pieces of polystyrene on top, tied with nylon, anchored with cinderblock (wire around cinderblock) and a surface marker float. Density did not appear to be a factor in growth but 1/2 inch mesh was best because oysters did not grow in to mesh as with 1 and 2" mesh. No appreciable reduction in growth by small mesh and limited fouling. Kept 1' or more off bottom.

Haskin reported that the upper half of Delaware seed area had been getting the best surviving set and carrying the industry but with the decline of drills past 3 or 4 years the lower sector with larger beds has become the big producing area. There is no ready explanation of the decline of drills before wet years of '71 and '72. MSX was extremely heavy in Delaware in 1972 despite the wetness (Cape Shore, I presume). George Valiulis reported some resistance to Dermo along with MSX resistance (related) in Cape Shore progeny stocks (paper given last year but I have forgotten the details). Haskin has finally gotten into surf clams and he talks like the offshore beds are seriously overfished. He is plugging for restrictions on smaller clams that comprise the inshore population for brood stock.

I am always amazed at the rather high levels of MSX kills in Delaware in the first two years of exposure among the most resistant progeny (third generation). They run 40 to 50% and began with fall infections of current year spat (brought from ocean storage in early October). Why is MSX more infectious and more virulent in Delaware Bay than in Chesapeake Bay?

Changing Usage of James River Seed-Oyster Area

by

J. D. Andrews

Virginia Institute of Marine Science
Gloucester Point, Virginia 23062

5 January 1979

The supply of seed oysters is nearly always critical in Chesapeake Bay. The James River seed area in low salinity waters has always been the major source of seed oysters. Prior to 1960, about 2 million bushels of seed were harvested annually from these natural beds, designated as public grounds, for planting on private beds in Virginia and Maryland. Recruitment was regular and dependable. Spat and small oysters were abundant (2000/bu.), slow growing, and cheap ($1-$2/bu.).

In 1959-60, a new disease caused by Minchinia nelsoni (MSX) destroyed 80 to 90% of all planted oysters in high-salinity waters ($>15^{o}$/oo) in lower Chesapeake Bay. Planting of these private beds has not been resumed after 18 years--indeed seed oysters to plant these large acreages (nearly half of 150,000 acres of rented grounds in 1960) are not available now.

After 1960, setting in the James River was reduced to about one-tenth the level of the 1950's. This has been attributed to absence after 1960 of large stocks of oysters formerly planted on private beds on Hampton Bar and near the mouth of James River. From

1963 to 1966, a long dry period increased salinities throughout Chesapeake Bay. This allowed MSX to penetrate far up the Bay and its rivers, greatly restricting the use of seed oysters. There was a glut of seed oysters following the drastic reduction of planted acreage which occurred abruptly after 1960. Reduced populations and increased salinities allowed oysters in the seed area to grow larger and fatter than usual. Beginning in 1962 and increasingly rapidly to over half the catch in 1965, oysters were marketed directly from the James River seed area. Most went to steaming plants for soup stock at $2-$3 per bushel. These small oysters would have doubled in size and meat yield in one year if planted on growing grounds outside the James River.

The return of normal low-salinity conditions to the seed beds did not stop sale of soup oysters despite the return to poor meats. A period of wet years (1971-74) took its toll of winter-spring deaths from low salinities, and recruitment failed also. Oyster processors got most of their oysters from Maryland and even as far away as Louisiana and Texas, in the shell. The demand for seed had declined to one-fifth or less of the level harvested in the 1950's. The states of Maryland and Virginia bought and planted seed oysters during winter gluts of the market. Shell-planting in the Great Wicomico and Piankatank rivers in the drought years of 1963-66 temporarily increased the supply of seed oysters. A single good spatfall in the Potomac River in 1963 relieved tonging pressure on the James River as oystermen worked on superior quality market oysters from 1965 to 1968 or later from this one set. Then in 1975, the toxic pesticide Kepone was discovered in James River. No oysters have been marketed directly from the river since that discovery. Seed oysters moved to clean areas soon cleanse themselves of the chemical, but no forseeable harvesting from James River is to be expected.

It is ironic that proper usage of James River oysters as seed for transplanting should depend on pollution of the river. Seed oysters from the James River are high in quality for use on marginal (soft or sandy) grounds for growth to market size. Slow-growing, thick-shelled, single oysters or small clumps produce fat well-shaped marketable stock in one or two years. Usually the oysters in James River are free of diseases and pests and grow well after transplanting. In the James River they remain poor and small.

Seed areas free of predators and diseases are rare, and they are the most valuable beds to the industry. Regular setting in Chesapeake Bay and more northern waters is found only in a few places and must be recognized as a natural resource not to be misused by early marketing.

Oyster Setting Gradients in Virginia Estuaries

J. D. Andrews

6 July 1984

Summary of Results

Natural and artificial cultches were used to estimate annual spatfalls on oyster beds in Virginia major rivers. Natural cultch varies greatly in quality, because of fouling organisms and in size of shells. Therefore, artificial cultch consisting of clean three-inch valves was suspended in wire bags or strung on wires face down and called shell strings. These were exposed weekly, monthly or for the duration of the setting season (1 July to 1 October) each year.

Weekly patterns of setting revealed that a gradient of declining spatfall with increasing distance of oyster beds from the river mouth (large rivers only! reverse pattern in coastal plains estuaries) prevailed. These patterns are presumed to reflect the relative abundance of mature larvae over respective oyster beds during weekly periods of cultch exposure. The effects of pheromones on larval aggregation were not determined although all stations were on natural beds with adult oysters. Survival of spat was highest on up river beds in low salinities, presumably due to scarcity or absence of predators (flatworms and crabs predominantly). It is known from other studies that a high proportion (up to 90%) of initial spatfall is lost (dies) during the first week or two.

A cross-river gradient also occurs despite similar salinity, predator and cultch conditions. It is probably a reflection of greater duration of flood tides on the left shore (east) and longer ebb tides on the right shore.

The concurrence of changes in setting rates (higher or lower) at all stations in the seed area suggests that weekly larval broods (continuous setting for three months) became distributed throughout the oyster growing area of James River during 10 to 14 days of planktonic life. Density of larvae was obviously greater in the lower river than over up river beds. This indicates that larvae are more dependent upon wind and tidal currents than on their own ability to select favorable strata for upriver migration such as occurs in fish and crab larvae. Umbo and late-stage larvae do select deeper strata when they are fortunate enough to remain in channel waters, but most oyster beds in the James River are $<$ 10 ft in depth which in general results in predominance of ebb-flow currents.

Only in the James River seed area was setting high enough in intensity and long enough in duration to show repeated occurrence of setting gradients. Spat were counted on weekly bags and strings of shells only on the inside face of clean, flat shells. Shell strings usually caught more spat per shellface than bags of shells or natural cultch because the horizontal angle of the substrate favors spatfall.

Postscript on the Corrotoman River as a seed-oyster area

17 August 1984

J. D. Andrews

The Corrotoman River is one of the main tributaries of the Rappahannock River. It joins the Rappahannock River just below Towles Point near the middle of the oyster-growing zone of the parent river. During the 1940's and 1950's the oyster zone above Towles Point had both private and public beds that exhibited excellent growth but low recruitment (setting) most years. Because predators and diseases were nearly absent in this growth zone, occasional intensive spatfalls resulted in oysters that lasted many years for harvest on public beds. Setting was usually lighter inshore on private grounds where planters used James River seed oysters. Only rarely were seed oysters from private beds in the upper Corrotoman moved out into the Rappahannock River for better growth.

During these early years after World War II, the transport and distribution of planktonic oyster larvae was not understood. It may have been presumed that broodstock, larvae and spatfall in the Corrotoman River were more or less independent of the Rappahannock River. Now it seems probable that the Corrotoman is dependent on the larger river for its larval supply. Sets did seem higher than in the Rappahannock River above Towles Point, but in fact were usually quite similar in intensity to those at Drummond Ground near the mouth of the Corrotoman River. Occasionally, very intensive sets occurred in the upper Corrotoman River similar to those that occurred in the Piankatank and the Great Wicomico rivers.

Spatfall intensity has declined over the past two decades in the Rappahannock River and its tributaries. The causes are not certain, but oyster stocks on both public and private beds have declined drastically. Since 1972, when Hurricane Agnes killed many oysters, particularly on public beds, planters have been reluctant to plant James River seed oysters because of predation by cow-nose rays and possibly fear of MSX. The wet years of the 1970's caused large declines in stocks of natural-set mannose (Mya arenaria) which were the natural food of rays. It appeared that the rays searching for soft-shell clams (Mya) in oyster and eel grass beds destroyed both communities and became accustomed to eating oysters when Mya were scarce. Finally, the shortage of public bed oysters became so severe in the area below Towles Point that patent tongers were allowed to work upriver on the more shallow beds above Towles Point and depleted them. The broodstock populations in the Rappahannock River are probably far lower than they have ever been before. Furthermore, nutrient pollution and natural tendency for deep, channel waters to become anaerobic each summer have interfered with survival of larvae during transport upstream.

Therefore, the Corrotoman River no longer has potential as a seed-oyster river because of low rates of spatfall. Even in the 1940's the level of setting was marginal for a seed area, unless off-bottom methods of cultch exposure such as shell bags were used. The natural public beds are small in area in the Corrotoman River, but almost the whole river could be used if artificial cultch such as shell bags were used. The Corrotoman River can no longer be considered as a potential seed area.

EXPANDING SEED-OYSTER PRODUCTION IN THE RAPPAHANNOCK RIVER AREA
(Seed-Oyster Potential of the Corrotoman River)

J. D. Andrews
Virginia Fisheries Laboratory
Gloucester Point, Virginia

Spring, 1950

I. An Evaluation of the Utilization of the Corrotoman River

A. Problems of the oyster industry

Nearly every year, reports are received from some localities in Virginia telling of oysters dying or failing to fatten in certain waters. Sometimes the losses are due to oyster drills, parasites, pollution, or silting, but more often the causes are unknown. These mortalities and losses are of tremendous importance to oystermen, but even if the causes could be determined, it appears that their control would be extremely difficult in open waters.

B. Most promising approach for improving the industry

A more promising way of helping the oyster industry is to increase the supply of seed-oysters. The knowledge and resources needed to do this are available now and await application. More seed-oysters can be grown by (1) establishing new seed grounds in suitable areas, and (2) intensifying production on existing seed grounds. Several potential seed areas will be discussed together with the reasons for and against such use.

C. Great demand for seed-oysters

The demand for seed-oysters has increased greatly since World War II. With labor and equipment available again, oystermen have been able to use their grounds more fully, and many new bottoms have been leased from the State. Leased oyster bottoms now total 97,785 acres (13 April 1949) which is a considerable increase over the 60,000 acres in 1928 and the 75,803 acres in 1945. While rented ground has nearly doubled in acreage, the crop of seed-oysters available to stock these grounds has remained the same for 15 years, fluctuating around 1,000,000 to 1,200,000 bushels per year. From 1930 to 1935, over 2,000,000 bushels of seed-oysters were produced each year, with a maximum production of nearly 3,000,000 bushels in 1934. These are some of the factors which have caused seed-oysters to be in such great demand. In recent years a large portion of the seed stock was sold for 60 to 70 cents per bushel, to which must be added hauling charges. Only a few years ago 50 cents was considered an exceptionally good price, and many seed-oysters sold for as little as 25 cents per bushel. To insure a reasonable supply and price of seed-oysters for Virginia oystermen, the Virginia Commission of Fisheries, acting in accordance with state law, has found it necessary to exclude the out-of-state market for the past two years.

D. Present sources of seed-oysters

Most seed-oysters planted in Virginia are taken from the public "rocks" of the James River. Seaside of Eastern Shore produces its own seed, and a few planters grow part of their own supply, specially in the James River area. The areas of rented grounds suitable for production of seed-oysters are quite limited, but public grounds in several rivers show promise. The key factor is adequate level of setting on a regular basis.

E. Requirements for a good seed-oyster area

A seed-oyster area should meet several requirements to produce satisfactory seed. Consistent annual spatfalls (set or strikes) is the most important characteristic of a seed area. Seed stock is usually considered worth transplanting if there is an average of one spat on each shell or a count of 400-600 spat per bushel (400-500 shells or valves per bushel). The seed stock must be free of drills. Drills cannot survive in salinities lower than 12-15 parts per thousand of salt. They are quite generally distributed in all Chesapeake waters with suitable salinities, but transplanting drills with seed oysters is inviting disaster. The seed stock should also be relatively free of diseases, boring sponge and other fouling organisms which may interfere with normal growth. These conditions are best achieved in low-salinity waters.

F. Classification of public oyster grounds for management purposes

Each fall the Virginia Fisheries Laboratory surveys throughout Virginia a large number of natural oyster bars to determine setting rates, growth rates, condition of meats and abundance of predators and fouling organisms. The purpose is to determine the characteristics of bars so that they can be placed in one of three management categories, namely: 1. seed-oyster beds, 2. self-sustaining grounds, 3. growing and conditioning beds. The management operations required for efficient operation of beds in these three categories are basically quite simple. Seed-oyster beds require a new supply of cultch every year or two and removal of cultch with spat attached to growing bars as soon after the strike as feasible. Self-sustaining bars are those having a moderate set and good growth so that application of cultch every three or four years is the only management activity necessary.

Growing bars are those lacking set but exhibiting rapid growth; therefore, seed-oysters must be planted on these beds to produce oysters. Records must be obtained for many more years before a full understanding of the category of each area is possible, but information gained in a few years suggests that certain areas can be used for seed-oyster production. These areas include all or part of the Corrotoman, Piankatank, and Great Wicomico rivers and numerous minor tributaries and creeks in Mobjack Bay, e.g. for which data are lacking. The Corrotoman River is a promising seed area that will be discussed in detail in this paper.

G. Analysis of annual setting records from the Corrotoman River, a potential seed area

The annual set in the Corrotoman River for several years is shown in Table 1. This is an example of the type of information being collected on oyster bars in all the important rivers in Virginia. "Natural cultch" is a term used to describe all substrates including oysters, shells, and fragments of shells which are available for oyster larvae to set upon. Natural cultch is often covered with barnacles and other fouling organisms, resulting in a low rate of oyster setting. The wire bags containing test shells lay on the bottom but project enough above the bottom to cause a large amount of water to percolate through them. As a result, these test shells receive much higher sets than those found on shells planted loose on the bottom. Fig. 1 shows that natural cultch usually failed to obtain a set of 400-600 spat per bushel in the Corrotoman River, whereas test shells in wire bags got a set far greater than necessary. Commercial plantings of clean shell in June just before setting begins can be expected to obtain sets at a rate intermediate between old natural cultch and test shells. It is important that clean cultch be planted at the right time each year. If inspection after the first setting season reveals that the cultch has failed to get an adequate set for seed-oyster purposes, then it must be left another year to insure seed stock with a spat count of 400-600 per bushel.

In the Corrotoman River where setting seems to be similar in intensity throughout the river, the public grounds can probably be managed as a unit. However, in the Great Wicomico and Piankatank rivers, bars in the upper parts of the river appear to be more suitable for seed-oyster production.

H. Economic advantages of using Corrotoman River as a seed area

For optimum efficiency, a seed-oyster bed should be located near the growing grounds that are used. The Corrotoman River is ideally located to supply seed for private planters in the Rappahannock River area. Use of the Corrotoman as a source of seed-oysters would benefit the industry as follows:

1. It would increase the total supply of seed oysters. The acreage of private grounds rented from the State has increased rapidly since the war, but nothing has been done to increase the supply of seed-oysters to stock these grounds. The price of seed-oysters has risen rapidly with the increase in demand. Competition has forced planters to buy seed-oysters when and where they can without much regard for the needs of their management programs.
2. It would afford optimum use of state-planted shells. Shells are of little value on public grounds unless they obtain a set of young oysters. Good-setting areas, such as the Corrotoman, offer the best change for regular sets year after year.

3. It provides added diversification to the oyster industry in the Rappahannock River area. In the early summer of 1949, a large percentage of oysters in the Rappahannock River above Towles Point died from unknown causes (an aerobic condition on deep public beds caused by excessive freshwater discharge during fall and spring of 1948-49 -- "black bottom"). During the oyster season which followed, tongers were forced to quit or go to other areas to oyster. Shuckers were forced to seek market oysters outside the area. The development of seed beds in the Rappahannock area would have allowed tongers more flexibility in their choice of work.
4. It results in lower labor and transportation costs due to shorter hauls of seed oysters. Proximity of the seed grounds would allow "buy-boats" (haul-boats) to move more oysters in a season with lower labor costs. Weather would be less inhibiting because tongers could work in the protected Corrotoman River when it is too windy on the Rappahannock River.

I. Biological advantages of the Corrotoman River as a seed area

The biological advantages include:

1. Early sets in July which result in large spat by fall. By November spat set the previous July average about one inch in length, whereas James River sets occur largely in late August and September, resulting in spat of fingernail size or less. These early sets enable oystermen to see spat the first fall after setting occurs and to convince them that the seed stock is worth moving. Oystermen are accustomed to buying James River seed stock

for the one- or two-inch and older oysters present, and they disregard tiny spat which are much more numerous.

2. More uniform size and age of seed stock. If the set is adequate, seed stock would be moved out each winter and spring and a new supply of cultch planted. This would result in most seed-oysters attaining market size earlier and at the same time. In contrast, James River seed stock includes oysters of three or more different yearclasses, and there may be considerable delay before the smallest oysters reach market size.
3. Reduction of losses in transit from freezing and overheating. Short hauls would allow more flexibility in moving oysters both during hot and cold weather without losses.
4. Adaptability of local seed to salinity and water conditions of the area. There is no proof that local seed is better than that from distant places. However, the evidence suggests there may be some advantages specially as regards introduction of pests and predators.
5. Better growth of oysters not subjected to two or three years of stunted growth in seed areas such as the James River.

J. Use of current-year spat in drill-free areas as seed oysters

Seed stock taken from the James River consists of oysters of three or more age groups, including current year spat, yearlings, and older oysters. Seed oysters grow very slowly in the James, but they do develop thicker shells for their size as they get older. Planters with drill-infested grounds want these larger, thicker-shelled oysters to reduce losses from predation. However, current-year spat can be used in relatively drill-free areas such as the Rappahannock River. This would make it possible to grow a new crop of seed-oysters each year. A merchant must get a higher percentage of profit on items which have a slow rate of turnover as compared to those that sell fast. An oysterman who buys 2-year old seed and leaves it on his growing grounds for 2 1/2 or 3 years is not only tying up his grounds and capital for an excessive period, but he also runs greater risks of mortalities and poor condition with 5-year old oysters. It seems feasible that in areas without drills oystermen could utilize current-year spat as seed stock both to increase the number of crops of seed oysters obtained from seed beds and to get seed oysters on fast-growth grounds as quickly as possible and thereby shorten the growth period before harvest. The combination in the Corrotoman-Rappahannock river system offers an opportunity for more efficient culture.

K. Limitations of Corrotoman as a seed area

It must be realized that oyster strikes in the Corrotoman River are not comparable to those occurring annually in the James, and there is a possibility of partial failure some years which would necessitate leaving shells for another year. Because the count in the Corrotoman is near the minimal requirement for seed-oyster stock, it would be essential that clean shells be planted at the optimum time for spatfall each year. There is a limited amount of fouling by sponges and other organisms that may retard growth somewhat.

L. Present use of public oyster grounds of the Corrotoman River

These potential seed grounds in the Corrotoman are now being used to grow market oysters. In Chesapeake Bay, seed areas seem to occur in small, low-salinity and rather enclosed rivers where oysters grow slowly; therefore, they must be left an extra long time to reach market size or to be sold as undersize stock. In summary, such areas are ideally suited for setting of oysters free of diseases and predators but poorly adapted for growing market oysters.

M. Why not try the Corrotoman as a seed area?

A public meeting was held in 1948 at Kilmarnock, Virginia, to discuss a proposal by the Virginia Fisheries Laboratory to open two small public bars in the Corrotoman River as seed-oyster grounds. The tongers rejected the recommendations on the grounds that undue hardship would fall upon a few local tongers and shuckers in the river. Probably their real fear was that "outsiders" would find seed tonging profitable and compete with local oystermen for the bounty of the Corrotoman. The Commission of Fisheries is quite willing to plant shell in the Corrotoman each year. This should make it possible for tongers to harvest a crop of seed-oysters each year in contrast to the sparse crop of undersized market oysters now being caught. If catch and price were favorable, tongers would probably come from other areas just as they do in the James River seed area, but the small size of the Corrotoman River would probably result in a short season and eventually the local tonger would find himself in a favorable position to benefit most. Furthermore, a public natural resource should be developed for the good of the industry and all people rather than for those few in a limited locality.

Opening the Corrotoman River as a seed area would provide more work for tongers, more oysters for planters, and optimal use for state-planted shells. The Virginia Fisheries Laboratory recommends that the Corrotoman River be tried as a seed area for a few years. If this proves unsatisfactory, it can be allowed to go back into its present state of meager production of runty market oysters.

Procurement of seed-oysters is a difficult problem in states north of Virginia because setting is limited and erratic. In Virginia, areas of natural setting are available to supply seed-oysters not only to Virginia planters but also to supply the Maryland market. With an abundant and regularly available supply of seed oysters, Virginia oystermen have an advantage in their competition with other oyster-producing areas.

TABLE 1. Annual spatfall on natural cultch in the Corrotoman River
(Spat per bushel)

Location	1944	1945	1946	1947	1948	1949	1950		Average by bars
Corrotoman Pt.	376	574		300	56	328	166	=	300
Middle Ground		344	564	164		140	138	=	270
Island Bar				360	280	290	196	=	282
Black Stump	132	248		324	268	288		=	252
Bar Point				160	260	284		=	210
Sheltons Point	212	272		368	244	316	62	=	246
Average by years	240	360		279	222	274	167	=	260
Grand average for 7 years									260

TABLE 2. Spatfall on shells in wirebags on the bottom, Corrotoman River
(Spat per bushel)

Location	1931* (10 Sep)	1948 (29 Oct)	1949 (14 Dec)	1949 (7 Nov)	1950 (1 Nov)
Drummond Ground	2,390				600
Corrotoman Point	3,455				570
Middle Ground	2,800			2,775	1,770
Island Bar	3,114	1,912	1,317	2,256	
Sheltons Point	4,850				1,450

* Loosanoff 1932. The dates when June-planted shellbags were recovered is given under the years.

The Status of the Oyster Industry in Virginia, 1985

Jay D. Andrews

Virginia Institute of Marine Science
Gloucester Point, Virginia 23062

5 March 1985

History of James River Seed Area

Virginia oyster production increased to its peak after World War II and during the 1950's when 3 to 4 million bushels were marketed each year. The increase was due primarily to planting of James River seed oysters on private beds. Harvest of seed oysters averaged 2,600,000 bushels per year from 1950 to 1959, most of which came from the James River (Haven et al., 1978). Spatfall was regular, moderate in intensity, and produced thick-shelled oysters 1 to 3 years old that resisted predation and smothering on marginal leased grounds (Andrews, 1951, 1954, 1982). Counts of seed oysters ranged from 2 to 4 thousand per bushel of which 1 to 2 thousand were two-inch oysters. Spatfalls on major beds usually averaged 1,000 to 2,000 per bushel annually.

The invasion of the disease caused by *Haplosporidium nelsoni* (MSX) into high-salinity areas of lower Chesapeake Bay in 1959-1960 had a crippling effect on the Virginia oyster industry. Nearly half of Virginia's leased beds were not replanted for 25 years after 1960. Oysters were grown thereafter in areas with late-summer salinities no higher than 18 to 20°/oo. A prolonged drought from 1963 to 1967 increased salinities and allowed MSX to spread throughout Virginia and into Maryland. An over supply of seed oysters occurred in the early 1960's which encouraged Campbell Soup Company to use the larger seed oysters for soup stock. Seed oysters sold for $.75/ to $1 per bushel and eventually climbed to $2 per bushel. The drought allowed James River seed oysters to grow larger and to develop more glycogen which yielded larger catches for tongers and more meat for Campbell Soup Co. at $2.50 to $3.00 per bushel. The soup company used seed oysters until 1975 when discovery of Kepone forced them out for public relations reasons. After the drought, James River seed oysters returned to their typical poor condition which did not concern the soup company; such oysters transplanted to growing areas in higher salinities would have produced 2 or 3 times the volume of quality meats after a year's growth. During 1964-1965, over half the oysters harvested in the seed area were marketed as fresh-shucked oysters or sold to Campbell Soup Company. These unjustified uses of seed oysters stabilized the market when tongers lacked markets from planters. The states of Virginia and Maryland bought seed oysters during winters of some years to plant on public growing beds.

A more persistent problem that followed the MSX invasion was reduction in setting levels in the seed area to an average of about one-tenth the 1950's sets. Private beds below the James River Bridge were not replanted after 1960 and the beds soon became silted over so that no shells could be seen by SCUBA survey. Beds on Hampton Bar, Willoughby Bank, off Ocean View, and the Nansemond River were heavily planted with James River seed oysters through the 1950's where domestic pollution ensured excellent growth and fatness.

Setting in the James River continued for 90 to 100 days during the 1940's and 1950's, with gradual increases to maximum rates about 1 September; after 1960 during some years setting failed and in others had only 1 to 3 weeks of erratic light setting. A further stress on recruitment of oyster populations was a generally wet decade during the 1970's, and higher mortalities from freshwater exposure in the upper seed area during

Tropical Storm Agnes in June 1972. Loss of broodstock in the lower James River is one premise for the decline in setting rates in the seed area.

Auxiliary Seed Areas

The Virginia Marine Fisheries Commission, based on recommendations from VIMS about setting potential, began planting fossil shells recovered by a hydraulic dredge in 1963 but the program ran out of shells in 1965. Shells were purchased from Maryland in subsequent years. The Piankatank and Great Wicomico rivers have intensive spatfalls throughout the estuaries in some years but setting fails in others. Shell plantings of 10,000 bushels per acre in these rivers from 1963 to 1965 had good sets on surface shells; the rivers were opened for seed harvest in 1965 and 1966, thereby providing some relief to the James River from over-harvesting. An intensive spatfall occurred in these new seed areas in 1983, but MSX, *Perkinsus marinus* and flatworms (Stylocus) destroyed most oysters including spat before seed oysters could be harvested. These low-flow, coastal-plain estuaries should be designated seed areas because of slow growth of oysters to market size and prevalence of *P. marinus* which flourishes when oyster populations in high densities are grown on shallow beds. Early harvesting of seed oysters and use of annual shellbags for spatfall collection would minimize mortalities. Attempts to grow market oysters result in high mortalities and sustain disease intensity. These small estuaries do not have enough fresh-water discharge in spring to allow oysters to discharge MSX infections as they do in the James River. A salinity $<10^{o}/oo$ is required.

Mobjack Bay and its tributaries have moderate setting of oysters some years. This reproductive capacity is important because Mobjack Bay and the lower York River are the only high-salinity areas in Chesapeake Bay where native oysters have developed resistant to MSX after 25 years of selection.

These stocks of native oysters are being grown on private beds on small-scale, pilot operations that could be important in rehabilitating Hampton Roads with broodstock for reproduction in the James River seed area. In Hampton Roads, drills and P. marinum remain problems when substantial populations of oysters are grown to maturity in high-salinity waters; therefore, regular harvesting and rotation or fallowing of beds will be necessary.

Production of Oysters in Virginia

Production of oysters in Virginia has been documented with tables and graphs by Haven et al., 1978. The data are based primarily on tax records and they do not distinguish catches by areas or sources out of state until 1963 when the Virginia Marine Resources Commission began reporting harvests of seed and market oysters from tax records. Seaside of Eastern Shore is excluded from this discussion because it is essentially a self-contained industry both for seed and market oysters with limited interaction with the oyster industry on the western shore of Chesapeake Bay.

During the 1950's, 80% of market oysters came from private grounds. Production peaked in 1959 at 4 million bushels for Virginia. Seed oyster production peaked in the mid-1950's at 3 million bushels; yields of market oysters were slightly over 1 bushel for each bushel of seed oysters planted (Haven et al, 1978). About 80% of the seed oysters came from the James River. A few oysters were imported from the Potomac River for shucking in Virginia but none from other sources. Market oysters were priced at $3 to $4 a bushel when seed oysters were $1 to $1.50 per bushel.

Importations of Oysters to Virginia

Sources of oysters and patterns of marketing changed abruptly when the largest Virginia planters were forced to abandon culture in the lower Bay after 1960. Although prices of market oysters did not increase until inflation occurred about 1975, demand for market oysters was strong and seed oysters were in over supply. About 1965 when demand and catch of seed oysters had declined drastically, oysters from a light, riverwide spatfall that occurred in 1963 began to reach market size in the Potomac River. Natural cultch averaged <200 spat per bushel which decreased with distance up the river, although the potential was much higher if clean shells had been available (Beaven and Andrews, 1964). It was the last general set in the Potomac River, and it demonstrated the potential this river has for oyster production where survival is high when predators and diseases are absent in low-salinity waters.

Tongers left the James River to tong high-quality market oysters in the Potomac River in 1966-67. Unfortunately, the Potomac River is restricted to public oyster grounds only and there is no regular supply of seed oysters available from Virginia or Maryland. During those mid-1960's years, setting was excellent in small estuaries near the Potomac River, but only a limited quantity could be bought with public funds available. The St. Mary's River, Smith Creek, the Great Wicomico and Piankatank rivers all had large supplies of seed oysters which should have been transplanted to the Potomac River, a natural fast-growth river with thousands of acres of barren bottoms. Nearly 2 million bushels of oysters were harvested from the Potomac River over 13 years; most were derived from the 1963 spatfall plus transplantations from two seed areas near the mouth at Point Lookout. Most of the Potomac River oysters were processed on the Virginia shore; when the 1963 yearclass catch began declining by 1968-69, over half all Maryland oysters were shucked in Virginia and this has continued into recent years.

Virginia processors, still not able to supply the 3 million bushel market established in the 1950's, began importing oysters in their shells from states on the Gulf of Mexico about 1963. This biologically dangerous practice has increased greatly in recent years as private plantings continued to decrease in Virginia waters. The latest trend in marketing of oysters in Virginia is that of unconfirmed reports that hundreds of thousands of gallons of Pacific oysters imported from the West Coast were sold wholesale over the country in 1984.

Decline of Oyster Culture in Virginia

Inflation seems to have dealt the Virginia oyster industry another serious problem. Seed oyster prices have remained low at $2 per bushel (increased to $2.50 in 1984); but market oysters have risen to $12 to $16 per bushel and as high as $24 per bushel for selected Potomac River oysters for raw-bar use. Only low demand for seed oysters and low quality (low counts) saved the James River seed area from being over-harvested. Reductions in the number of hand-tongers has been steady as seed oysters remained low in price and as tongers got older, and as catches tended to decline. During the 1940's and 1950's, some 700 to 800 regular tongers caught oysters in Virginia. Adjacent creeks exhibited many rows of tonging boats 15 to 20 deep at night. Some 10 to 15 buy boats used for transport and planting of seed oysters could be seen anchored in the James river as buying stations. Now, the major oyster buyer for Rappahannock River planters reports only 60 to 70 active tonger boats and nearly all oysters are transported by large trucks to a special barge mechanically designed for achieving uniform planting rates. The scarcity of tongers limits the quantity of seed available for purchase and planting. There are complaints when counts of oysters are less than 1,000 per bushel; low counts make the risks higher because by numbers typically 80% of oysters planted die before harvest even on predator- and disease-free beds.

There are other risks to consider during a two-year period required to grow stunted James River oysters to marketable size. Dry years may allow MSX to move upbay to kill oysters into usually safe areas. Extreme weather conditions occur all too commonly in the forms of drought, excessive rainfall or hurricanes. Both extreme dry and wet periods have occurred already in the 1980's and caused damage to oysters in Chesapeake Bay. There is the added risk of high interest rates that discourage planting where high-value per acre is involved with intensive oyster plantings. A moderate rate of planting of 500 bushels per acre may cost $1,500 per acre when costs of transport and planting are included. Only high prices of market oysters and a wide price spread between seed and market oysters make the risks acceptable. In 1972 Hurricane Agnes, the last major tropical storm, was rated the worst in a century for excessive discharge of fresh water. It disrupted and displaced downbay populations of <u>Mya arenaria</u> by killing clams upbay in Maryland and causing heavy sets and high survival downbay in Virginia, ~~which~~ soft-shell clams are the natural food of cow-nose rays. The rays destroyed eelgrass and some oyster beds which contained dense populations of clams. Sporadic destruction of oyster beds by rays has continued for over a decade after the storm. A large school of rays can destroy acres of oysters in one day or night.

Comments on Dredging of Shell Deposits

J. D. Andrews
21 February 1963

The wise use of any natural resource requires a program for replenishing the resource or substitution for it. Even with a rapid recycling resource like water, overuse can lead to serious consequences. The replenishing rate for shells can be assumed to be virtually nil in comparison to the rate of use in Chesapeake Bay. The important information then is what quantities are available and how long will shell be needed.

In the absence of data, my impression is that shell is far less abundant in the Chesapeake area than sand and gravel hence will require more active conservation, I further suspect that the under-water sources of shell are less in Virginia than in Maryland whereas the reverse is probably true of land deposits in coastal plains areas of the two states. The demand need for shell in the Chesapeake area does not seem to be great at present, judging from the remarks of representatives of the two dredging companies. However, the Radcliffe Co. is large, handles a large share of the world's shell supply and is actively seeking markets. There has been the suggestion that a promise of a shell processing plant in Tidewater Virginia is a part of the unwritten background to the Virginia contract. If such a plant were established in Virginia, the value of processed shell might greatly offset the costs of distant transportation and substantially increase the demand for Virginia shell. It is interesting that the Virginia contract is an open one with respect to amount of shell which may be dredged and sold, whereas the Maryland contract has fixed limits. Once an area is approved by us and the Commission, all the shell in that area can be removed by Radcliffe at their discretion.

The period of need for shells for oyster repletion is an open question. Pollution may stop oyster culture in 20 years but we can't plan on this. We can always fall back on land-buried shell and artificial cultch but this will undoubtedly be more expensive. I think we should plan on a minimum of 100 years supply.

Although the contract would seem to commit us to a policy of conservation by reserving certain areas of shells for oyster repletion work only, this may fail because adequate supplies in other areas for inducement of dredging may not be available. The basic philosophy of the present contract seems to be one of producing revenue for repletion work. This may make long-term planning impossible.

As I understand it, the cost of transporting and planting shells is negotiable and distance is an important factor in the total cost of shells. For this reason I think we would be wise to have two categories of dredging areas- one for oyster repletion solely and the other for commercial dredging of shells. This need not prevent us from using shells for repletion from the latter areas if it is feasible.

Despite all these complications in planning long-term use of our shell resources, the most urgent need is for a careful statewide survey with shell lenses carefully surveyed and plotted. Although I have not been told so, I gather from a letter that we intend to ask for money from the State to do this survey. I don't think the Commission will be willing to divert their royalities to this purpose although, it may be possible to divert 10 per cent to us for surveys and research by legislative action as was done for the Maryland soft clam.

Until such surveys have been completed, I would be very cautious about approving areas for dredging. In fact, at this point, I would limit the authorization to the Craney Island-Pig Point area. Our greatest need for repletion shell is in James River. While shell from shucking houses costs more, we will probably be obligated to buy it for a few years at least. We can procure most of our shell needs for the Rappahannock River area from local shucking houses. Not much sentiment exists for planting in Pocomoke Sound for lack of setting. Seaside is our biggest problem unless local sources and means of recovery are found. The Rappahannock River shell deposit seems unnecessary toopen now and I have reservations about the status of the deposits in Pocomoke Sound in regard to "living" oyster reefs.

I would urge that we put in our policy early ~~as~~ a permanent prohibition on taking of shells from upper James River in the vicinity of our seed beds.

I would urge that we explore the meaning of the "open" contract and the philosophy of the shell mining operation.

I would suggest that we explore further the intentions of Radcliffe, preferably with the "boss" rather than local field men. I am particularly interested in their plans for creating markets, the degree of limitation imposed by transportation distances and costs, whether a lime or chicken-feed plant is contemplated, what volume they must handle to maintain an operation in Chesapeake, how they defend their contract in comparison to Maryland's (the best I can figure out from Ralph Hammer's statements is that they get 5¢ a bushel royality and we get 1¢ - this doesn't make sense), whether they can dredge ahead and store shell feasibly.

Radcliff Problem
J. D. Andrews
6 Jan. '63

I have very little faith that Radcliff will provide enough information to satisfy our demands for protection of a natural resource. I think they have already exhibited deliberate intent to circumvent us and will continue to do so through the Commission and its desire for income.

From what I know of their survey methods--aluminum poling at present--I think they are doing no more than finding large deposits of shell probably without definite boundaries or depths and perhaps with no more survey than locating themselves on the charts.

The use of oyster inspectors to avoid producing beds is necessary but subject to whims and collusion plus the fact that nothing but verbal contacts are made hence no written record.

The areas are much larger than I had thought. I had the impression the first area was quite small but with addition of a block around Craney Island, they now have a substantial portion of Hampton Roads under committment.

The shells which can be dredged at present prices may not be as extensive as we imagine--that is after the high-quality, large-area beds are dredged, it may be necessary all too soon to dig small and shallow beds of mixed mud and shell. I still have no idea whether we are dealing with a 10 year or 100 year program.

I suggest:

1. That we ask Layfield to come up and discuss their plans and surveys with us before 15 Jan. He hasn't been here in over a year.

2. That we ask Commission of Fisheries for expenses to put our man (a new one) on survey boats with Radcliff so that he can make

written reports of what goes on.

3. That a survey with coordinates be required for any area requested as a reserve. These small scale charts indicate gross definition of area to me.

4. Negotiate with Radcliff to see what they can and will provide from their crude surveys and when and if they intend to do detailed surveys with special boat and equipment as they have done in the Gulf.

5. That contact be made with Gulf state's authorities to see how negotiations and allottments are done in an area of long experience.

Jay D. Andrews