AN ANALYSIS OF THE EFFECT OF HOOKS ON STRIPED BASS (*Morone saxatilis*) WHEN LEFT EMBEDDED IN THE PHARYNGEAL OR GASTRIC REGION

Prepared by: The Maryland Department of Natural Resources

Tidewater Administration

Fisheries Division
Mr. William P. Jensen
Director

INTRODUCTION:

In 1989 the National Oceanic and Atmospheric Administration/National Marine Fisheries Service in cooperation with the Maryland Department of Natural Resources produced a video entitled "Keeping Score", which advocated catch and release methods of sport fishing for Striped Bass (Morone saxatilis). The video was an exceptionally positive production in approach and suggested an alternative to utilization of the resource in favor of more conservation-wise practices for sport fishing. The video suggested one way to improve the chances of hooked striped bass survival was to simply cut the line and leave the hook embedded. This would not create significant damage which usually resulted from removing the hook when embedded in the gill, gullet or stomach. This process also reduces the amount of time the fish is out of the water or in a situation where it would be adversely affected. Both scientists involved in the production as well as managers raised questions as to the impact of the hook on the fish when it remains embedded. In reviewing the available literature the answer is unfortunately not available. Further, concepts such as rapid rusting out and minimal effects are not backed by any definitive data, rather they are based on common beliefs or accepted practices.

No studies on striped bass (Morone saxatilis) are available and no studies on other fish have been completed.

As a result the Maryland Department of Natural Resources through the Fisheries Division conducted initial trials to see if we could resolve this question to management's satisfaction. In this study, hooks designated as Mustad® #1 and 2 9146 model or similar styles were used. The coating or electroplating finishes were bronze, steel, and tin/cadmium. Groups of 20 fish were subjected to hooking by artificial insertion with the tip of the hook embedded at the level of the rear pharyngeal plates. The initial results from this study suggested that expulsion or loss of hooks (hook rejection) was high in bronze coated hooks (greater than 50%), and low in the rest of the groups. In addition, behavioral responses were seen on fish which had tin/cadmium coated hooks implanted: The responses were lethargy, and lack of feeding in all fish with this particular style of hook.

The study was, however considered faulty as the study groups were held in separate tanks, one of which was not similar to the other two (450 versus 1,000 gallon), and water delivery systems were somewhat different. In addition, no randomization of groups was attempted and thus, we could sort out the effect of tank or study conditions from the actual impact of hooks or rejection rates. In addition, the hook styles were not as comparable as we would have liked.

In the late summer and fall of 1990 the study reported herein was reinitiated with marked refinement of methodology and expansion of objectives. The current study randomized and mixed treatment fish, insured a standardization of hook style, and added on additional

plating to cover all possible combinations currently used by hook manufacturers.

The intent of this study was to look at the impact of hooks on survival (short term and long term), and to determine if a method for assessment could be established that would be useful in future development of hooks (electroplating methods), and shape.

NEED:

It is common opinion that leaving the hook in fish, particularly striped bass, does not harm the fish, and that it would rust out within a very short period of time. Data collected from 1989 and 1990 would suggest that the assumption that rapid rust rates occur is invalid and in addition, there may be an effect of the hook composition or finish on the survival of striped bass.

With increased emphasis on catch and release methods of sport fishing the number of fish being exposed to this particular situation will increase. Thus, whether or not leaving hooks in fish has adverse effect on important sport fish needs addressing. In addition, increased awareness on the part of the public for more humane methods of treatment suggests that we should provide assurances that current practices and hook styles are not going to cause slow and debilitating diseases.

MATERIALS AND METHODS:

Husbandry:

Wild striped bass were obtained from populations at stations located at the Kent Narrows and the Chesapeake Bay Bridges. All fish were obtained using hook and line methods. These methods were designed to insure that only fish caught in the snout were used, and that any fish appearing to be sick or unduly hurt by the process were not used in the study. All fish were loaded into either 450-gallon (small fish) or 1,000-gallon (large fish) tanks held on board chase boats which were aerated and agitated depending on circumstance.

All fish were transported to the facilities at the Cooperative Oxford Biological Laboratory, Oxford, Maryland on trucks equipped with 450-gallon tanks (small fish) and 1,000-gallon tanks(large fish). The total time of holding for both large and small fish was less than six hours from the time the last fish was taken. Fish were separated into two size designations, those under 56 cm (small fish) and those over 57 cm (large fish).

The small fish were placed in open water net pens three weeks prior to introduction to smaller tanks where the tests would be conducted. At the end of two weeks fish were transferred to 550-gallon tanks at which time they were randomized by size, checked for health, and begin to be fed a conversion diet. They were held an additional two weeks prior to actual test implementation to insure proper acclimation to tank conditions.

Large fish were held in a 4,000-gallon tank for four weeks total prior to the initiation of the test. During this time they were acclimated to test diets, and at test initiation were transferred to a second, but identical tank during the course of treatment.

All tanks received flow through water taken directly from the Tred Avon River. Flow rates were set such that eight complete changes per day were achieved.

Small fish were fed an acclimation diet of live minnows, which gradually was changed to clam snouts over a period of three weeks during acclimation. They were then converted exclusively to clam snouts during the two week tank acclimation period. Feeding was discontinued 24-hours prior to treatment, and the fish were left off feed seven days after treatment. Feeding was resumed using clam snouts ad libitum. Active feeding continued until water temperatures fell below 60^{0}C, at which time feeding was discontinued.

Large fish were fed in similar fashion as the small fish, however, during the study trials they were converted to a combination of clam snouts and cut fish owing to their larger size.

Physical parameters during the study were: pH steady at 7.2, dissolved oxygen ranged from 6.0 to 8.0 ppm, salinities ranged from 9.0 to 15.0 ppt, and temperatures ranged from 15.0 to 2.3^{0}C.

TEST GROUPS:

The studies reported herein will involve all three trials each with separate objectives in mind.

HOOK COATING STUDIES:

Hook styles designated as Mustad R #2 9174 were utilized for this experiment. The hooks were finished with bronze/lacquer coatings (bronze), nickel plating (nickel), tin/cadmium plating (tin/cad), and unfinished steel (steel). Each group consisted of 30 fish per hook plating style, and 30 controls. Fish were randomized into tanks such that each tank contained five each of bronze, nickel, tin/cad, stainless, and control fish. A total of twenty-five fish per tank made up of a single test unit. Six replicates were present, however they were not considered as true replicates in that analysis was based on comparisons of hook style as total groups of 30 rather than true replicates which would be comparisons of five, which would not be statistically accurate.

Insertion was effected by removing the fish, laying them on their left side, taking a hook with needle-nosed pliers and pushing the hook to level of the rear pharyngeal plates, pulling such that the hook embedded into the mucosa (we attempted to penetrate mucosa with barb forced to a level of the submucosa), and then pulling to insure complete embeddment of the hook such that it would not be inadvertently expelled. We felt that this would mimic conditions of being hooked. Figure 1 shows the apparatus for this study which consisted of a hook, snelled 25-pound test line, a color tag, and a number tag. The color designation were for visual identification of the fish and judgement as to any behavioral changes associated with test conditions. Bronze received yellow tags, nickel red, tin/cad orange, stainless white, and controls did not have any tags. The end of the tag had a number designation for record keeping such that we could track the treatments by their numbers as well as size designations. (Note: an error occurred here in that we should have provided tags on control fish as it was found out later that the lack of these tags when other fish had rejected their hooks confused our ability to make judgments as to affect on control or not. As such all results are reported only when both the number and the color was clearly known and thus the reports are valid).

HOOK RUST STUDIES:

To determine the rate of rust O. Mustad Incorporated provided a series of #2/0 hooks directly from their factory in Sweden. These hooks were constructed such that they were bright steel, bright steel coated with bronze, and bright steel coated with bronze lacquer finish. Hooks were inserted in a fashion as described before except that instead of needle-nosed pliers a dowel was used to gauge depth as well as allow for control in the positioning of the hook. The hook was positioned such that the apex and barb of the hook projected sufficiently to allow it to be caught by the

mucosa. The hook was then inserted such that the apex of the curve pushed against the pyloric terminus of the stomach with the dowel pressed upward removed and then the line pulled such that the hook embedded itself into the submucosa of the stomach to a level approximating that of the muscularis. The apparatus used is similar to that as before (Figure 1) except that no color code was provided, and a 1/4 ounce lead weight was attached so that if the hook rusted out, the entire apparatus would drop to the bottom of the tank for retrieval.

BARBED HOOKS VERSUS BARBLESS:

This part of the study was designed to determine if the lack of barb had any affect on rejection rates. Since the style which was being used were not designed with barbless hooks available we created the barbless condition by crimping the with a pair of pliers thus eliminating the barb on Mustad R #2 9174 bronze lacquer hooks. Two groups were used, those without crimped (barbed) and those with crimped (barbless) barbs. The groups consisted of 20 barbed and 20 unbarbed, randomized by size and conditions into two tanks with each tank containing 10 barbed and 10 barbless. Hook insertion was at the level of the pharyngeal plate as before, and the hook apparatus was identical to that used for the coating study with the exception no color coding was provided.

REJECTION EVALUATION:

All tanks were examined daily for evidence of hooks either at the bottom or wrapped around the central standpipe. This was done by visual inspection, vacuuming of the bottom using a siphon set-up which flowed through a small mesh net capable of trapping any hooks, or in the case of the 4,000-gallon tank a combination of the above as well as a set of magnets which when drawn through the water would attract the hooks and pick them up.

RESULTS:

HOOK REJECTION:

For hook coating studies the results are depicted in Table 1 showing the rejection rates at 30, 60, 90 and 120 days post treatment. In addition, because of an observation that nickel-plated hooks appeared to be breaking at a significant rate this was included in Table 1 as rust/break rates for nickel-plated hooks counted at 30, 60, 90 and 120 days. From the table it can be seen that a relationship exists in rejection rates where bronze is the highest followed by stainless, tin/cad and nickel respectively. In addition, the nickel-plated hooks exhibited rusting and breaking where none of the other hooks behaved in a similar fashion. Preliminary analysis would suggest that the level of rejection is not significant when compared between groups however, it does show a trend. On the other hand it is considered a significant difference in terms of nickel breaking as compared to other hooks.

For hook rust rates it was found that within 20 days following insertion of the hook into the stomach 31 of 33 fish rejected their hooks completely. Due to the degree and rapidity of this rejection no differential rate of rusting based on coating style could be determined. It does however suggest that embeddment in the stomach may not pose a significant threat to the fish. Two of the hooks remain in place and have remained there now for 120 days.

For the barbed versus barbless hooks, Table 2 shows the rejection rates, again presented as rates at 30, 60, 90 and 120 days. A trend again, is seen where barbless do reject the hooks at a higher rate, however there is no significant difference between barbless and barbed.

MORTALITY RATES:

A disturbing aspect of this study were the observed mortalities, which were not seen in previous studies.

For studies related to the hook coating Table 3 presents mortality rates at 30, 60, 90 and 120 days. It is clear that a significant difference exists for the tin/cadmium plated hooks where 6 fish out of 30 died as opposed to 1 for bronze and nickel. No mortalities were recorded in stainless steel coated hooks. Necropsy information suggests extensive necrosis of the anterior kidney that extends from the area where the hook entered. In addition, marked edema is seen around the area. Histological evaluations, and microbiological analysis will be reported at a later date. Concurrently, serum analysis will be performed to determine any organotropic effect, as well as determine concentrations of metal in the serum.

For hook rust rate studies no mortalities were experienced during the course of the study.

In the barbed versus barbless study Table 2 also presents mortality rates at 30, 60, 90 and 120 day intervals. The barbed hooks appeared to produce a significantly higher rate of mortality than barbless. It is not clear why this rate is higher than in the other bronze test group.

RUST CHARACTERISTICS:
Cadmium/Tin plated hooks. Size #2.

Hooks that were rejected were studied for decomposition. Decomposition of the hook usually begins with the loss of the plating in various spotty locations, usually on the shank of the hook. Rust begins at these sites, becoming heavier until pitting is evident. Pitting seems to only occur on locations on the shank of the hook, usually 1/3 to 1/2 of the way down the shank from the eye of the hook.

Nickel plated hooks. Size #2.

Rust usually begins at several locations, and then a spot will occur where the integrity of the plating fails. Once pitting starts it is very active and usually only occurs at one site, it appears to be of a electrolysis nature. Several of the hooks that were recovered after being rejected by the fish, were almost pitted all the way through. The hook piece remaining in the fish after the tag end fell away, was recovered at a later date at the bottom of the tank.
Bronzed hooks. Size #2

After 30 days the bronzed hooks start to show heavy rust on the shank of the hook, about 1/2 way down from the eye. This is the most common location for pitting to occur.

Stainless steel hooks. Size #2.

Hooks in most cases show no effect from being inside the fish. Some hooks showed a slightly dulled finish.

DISCUSSION:

In our approach to fisheries management it has always been clear that any activity, be it catch and release, or other style of fishing may have long term and protracted impacts. In the case of hook retention we have advised people that the cutting of hooks is appropriate procedure however, no definitive studies exist to date which support this advice. This study represents the first real attempt to determine the effects on hooks on striped bass subjected to hook implantation and one of only two studies ever performed. Clearly this work shows that such studies are needed as the data indicates an effect is seen and in some cases provides assurances that in promoting hook and release, catch and return fishing we are not adversely impacting fish provided we use appropriate hook designs.

In a 1989 there was a clear difference in the rate of rejection between bronze and other hook styles. This study however, fails to confirm the results of the earlier study but does suggest that there is a trend where bronze hooks were rejected at a higher rate. While differential rates were not substantial the trend would suggest validity in current claims by advertisers that in fact, certain styles are more likely to be rejected than others. The same can be said for barbed versus barbless where barbless hooks do show a tendency to be rejected at a higher rate, however, again, the differential between the two rates is not significant.

Of real significance is the mortality rates seen particularly amongst tin/cadmium plated hooks and barbed hooks. Exactly why such mortalities were seen amongst tin/cadmium treated fish is not known. However, cadmium has been shown to have pronounced affects on immune response and on cellular survival which would be a basis for the observed damage. Whether this is in fact a manifestation of a toxic response or a localized injurious response is not known and further evaluation needs to be undertaken.

The barbed hook mortalities is confusing in that the style of hooks and size of fish were identical between this study and those fish used in the coating study discussed previously. Since two different types of tanks were used it is possible that this is a reflection of husbandry rather than any real concern with regard to bronze hooks.

Studies on rust rates would indicate a degree of rust is present in all hooks. However, contrary to popular opinion, hooks do not rust readily even in salinities in excess of 8.0 ppt. Therefore the effect of leaving hooks in the fish must be considered from two perspectives:

First, the effect of the hook on the fish given the fact that exposure to metal coating will continue for a period greater than 120 days. Attempts were made to look at hooks floating free in salt water, however, due to encrustation by algae and other

organisms this was abandoned and will be approached in an entirely different fashion in succeeding years. It is however, clear that even when exposed to water through respiration the hooks only minimally rusted with the exception of the nickel-plated hooks. The nickel-plated hooks, likely due to a combination of oxidation and electrolysis showed rapid pitting and breaking within the 120 days as compared to other styles however, still, 22 of the 30 hooks did not break suggesting that there is still a potential for response to the metal composition.

Second, position of the hook may have a profound effect on rejection rates, as seen with stomach embedded hook versus those embedded at the pharyngeal plates. Anecdotal information suggests that hook rejection may be the function of another feature and that is feeding behavior. Based on observations the rate of rejection increased during times immediately following feeding. Since the positioning of the hooks were at a level of the pharyngeal plates and that the pharyngeal plates will move as a result of both respiratory and feeding behavior such results are not unexpected. Due to the consistency of these observations it is clear that further experimentation needs to be done to verify these observations.

The results of this study do indicate a relationship with hook composition and rejection rates, mortality rates, and at least in one case rust rates. From the authors standpoint, there is a clear need to further elucidate the relationship between hook position, degree of damage and rejection rates. This aspect was not addressed in this study and will need to be addressed in future work.

CONCLUSIONS:

1. A correlation between the external code and rejection rates exists.

2. A strong significant relationship exists between external coat and mortality.

3. Different plated hooks show a significant rate of pitting and breakage.

4. Insertion of hook into stomach appears to enhance rate of rejection for reasons unknown.

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Sincerely,

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Dr. Eric B. May
Coordinator Fish Health Disease Programs

Project Leader

Table 1: Rejection Rates for # 2 Hooks Using 4 Styles of Material

Start date - 10/23/90

Lowest column shows those hooks rusted through.

Study group size - 30 fish for each hook style

Hook	<30 days	<60 days	<90 days	<120 days	Total
Stainless Steel n=30	5	2	0	0	7
Cadnium Tin Plated n=30	4	2	0	0	6
Bronzed n=30	6	3	0	0	9
Nickel Plated n=30	3	2	0	0	5
Nickel Plated/ Rusted off	4	4	0	0	8

Table 2: Crimped and Uncrimped Hook Barb Study

Start date - 10/29/91

2 bronzed hook

Study group size - 20 fish each hook style

Hook	<30 days	<60 days	<90 days	<120 days	Total
Crimped Hook Rejection n=20	8	0	0	0	8
Crimped Hook Mortality n=20	1	0	0	0	1
Uncrimped Hook Rejection n=20	4	1	0	0	5
Uncrimped Hook Mortality n=20	1	3	1	0	5

Table 3: Fish Mortality for 4 Styles of Hooks

Start date - 10/23/90

Study group size - 30 fish each hook style

Hook	≤30 days	≤60 days	≤90 days	≤120 days	Total
Stainless Steel n=30	0	0	0	0	0
Cadnium Tin Plated n=30	1	2	1	2	6
Bronzed n=30	0	1	0	0	0
Nickel Plated n=30	0	1	0	0	0