Corrosion of Fish Hooks
by
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Background: The U.S. Atlantic pelagic longline fishery targets primarily swordfish and tuna. This fishery also incidentally captures sea turtles, primarily leatherback and loggerhead sea turtles. These turtles may be foul hooked or may ingest the bait (particularly loggerhead sea turtles). Often turtles which take the bait, deeply ingest the hooks. These hooks cannot be dislodged from the turtles upon retrieval of the gear without causing injury. If the fisherman attempts to free the turtle by cutting the gangion, often the hook and trailing monofilament line is left in the throat or gut of the turtle. The hook and trailing line may interfere with feeding and other normal activities of the turtle. This may lead to serious complications and may result in the death of the turtle. Proposed regulations may require that hooks corrode away in a given period of time to mitigate this problem.

The U.S. pelagic longline fishery for swordfish primarily use carbon steel hooks that are electro-plated with rust inhibiting agents. These platings may include tin, nickel, or polyurethane (bronzed). The most common plating is tin. The Mustad hook company calls its tin coating Duratin and Eagle Claw hook company calls its coating Sea Guard. There are some fisheries such as the Hawaiian tuna fishery which use stainless steel hooks. Most hooks in the swordfish fishery are 9/0 size and are typically offset J hooks. An average fishing trip in the northeast distant waters (NED) is 3-5 weeks and the sets may use 800-1000 hooks. Most hooks will be replaced every 15 sets depending on the amount and type of bycatch, particularly sharks.

In the past, it was felt that if hooks were left in a fish (or other marine animal), the hook would corrode away in seawater. Studies conducted by the Maryland Dept. of Natural Resources have shown that contrary to popular thought, hooks do not rust readily even in salinities in excess of 8.0 ppt. The exception was the nickel-plated hooks which showed rapid pitting and breaking with 120 days. It should be noted that this study was not performed in full strength saltwater but rather in Chesapeake Bay where salinities ranged from 8.0-15.0 ppt. The results of this study also suggest that there is at trend where bronze hooks are rejected at a higher rate (1). Italian researchers have shown that sea turtles' occasionally will pass a hook through their digestive system and void the hook through their anus.

Corrodible hooks and crimps have been suggested as a way to reduce mortality of deeply hooked sea turtles. Corrodible hooks seem to be a more feasible mitigation measure. Because crimps are primarily manufactured in Japan, Korea, and Taiwan, there would probably be a greater financial incentive to produce corrodible hooks than crimps. The use of corrodible hooks has also been suggested in the sport fishing community to decrease mortality of released fish. Corrodible hooks have been used in limited applications in the past. Big game sports fishermen tried bronzed hooks at one time but abandoned them because the rust discolored the skirts of their trolling rigs.

Another corrodible fish hook design was created by Joe Cambell in 1987. The design was patented and named the self-destruct fish hook. The design of this hook was to take a conventional steel hook and have it plated with a highly cathodic material (such as gold) but leaving a small area of steel exposed. This may be accomplished by having a small annular band around the hook. The exposed steel would be anodic and when exposed to seawater would set up a galvanic couple causing the anodic area (steel) to corrode rapidly leading to breakage in that area. This exposed steel area could be close to the barb or near the eye of the hook. In a preferred embodiment, a temporary protective coating is provided for at least one member of the couple to delay the onset of corrosion of the steel anodic area. A hook manufactured in this way can retain 100 percent of its strength for a substantial period of usage in seawater before corrosion of the steel body is initiated.

This hook can be modified in a number of ways primarily though coating materials. These modifications can determine when hook breakage will occur. As mentioned before, the majority of the hook will be coated with an cathodic material. This material could be gold, nickel, silver, or graphite. The corrosion rate is controlled by the nobility of the cathode metal and on the ratio between the cathodic and anodic surfaces exposed to seawater. A smaller anodic (steel) area coupled to a larger cathodic (e.g. gold) area immersed in seawater will result in a greatly increased rate of corrosion attack on the anode. Conversely, a small cathode area coupled to a large anode area will have only a minor influence on the rate of corrosion.

There are several other modifications that can delay or hasten the onset of corrosion. One modification, is to cover the anodic area (steel) with an intermediate metallic layer somewhat more passive than steel to provide temporary protection for the steel anodic area. For example, where gold is the cathodic outer plating, a thin layer of copper, nickel, bronze, or tin can provide temporary protection for the underlying steel anodic area. The period of protection provided by the intermediate plating depends on the relative passivity of the metal used and the thickness of the plating.

Protection of the steel anodic area can also be provided by covering the cathode with a temporary coating, either inorganic or organic, which deteriorates within a few days of hook use in seawater. Possible mechanisms for deterioration of the temporary cathode covering include galvanic interaction, dissolution in seawater, or by means of mechanical disruption or chemical reaction after being embedded in bone or flesh. One method for delaying the onset of corrosion of the anodic area is to provide a relatively fragile plastic sleeve to cover the shaft of the hook, including at least a portion of the cathode area, thus blocking the seawater path of the galvanic cell. When the hook becomes embedded in a turtle the fragile plastic sleeve is stripped away or otherwise disrupted by mechanical agitation, or by chemical reaction with the turtle tissue, so that the circuit is completed to allow corrosion of the anodic area. As a further advantage, as long as the temporary cathode covering is intact, the point of the fish hook can be re-sharpened without concern that it will subsequently corrode at an abnormal rate through galvanic coupling with the cathode.

As an alternative to the use of an electroplated intermediate layer for temporarily protecting the steel anodic area, other protective coatings can be used. For example, a fragile plastic sleeve covering the anodic area can be used to delay the onset of corrosion until it is mechanically or chemically disrupted when the hook is embedded in fish bone or tissue. Whatever the method to provide temporary protection for the underlying steel anodic area, the fisherman can easily recognize the onset of corrosion from the familiar color of iron oxide (rust). Additionally more than one small anodic area can be designated so that an abandoned fish hook immersed in seawater will eventually break at those locations.

Fishermen often prefer to sharpen the point of a fish hook before use. Whenever a conventional steel fish hook is plated with gold or nickel is sharpened, the point is stripped of its protective covering, and when immersed in seawater corrosion (rust) will concentrate on the exposed steel point. In the practice of this invention, the hook can be well sharpened when manufactured and the hook point protected with a piece of easily removed plastic until used, so that further sharpening may be unnecessary. However, if the hook is re-sharpened during use, the point can be pressed into a cake of beeswax to provide temporary wax coating and protection from rust for at least several hours of fishing before the process might need repeating.

One advantage to the use of a temporary covering over the cathode area to delay the onset of the anodic area is that it would also protect the point of a re-sharpened hook from accelerated corrosion as long as the cathode covering remained essentially intact. If the point end of the hook is anodic and the shank cathodic, and the point end is plated with a sacrificial metal (i.e. anodic to steel in seawater) such as cadmium, the re-sharpened (exposed steel) will be protected from rust by the adjacent small area of exposed sacrificial metal as long as the cathode remains covered. Therefore, one preferred practice of the invention includes a non-bonding (easily stripped) fragile plastic covering, or a thin plastic (e.g. latex) dip coating, covering the shank of the hook, including the cathode surface.

This self-destruct fish hook could be highly beneficial to the sea turtle, particularly if the breaking point is near the barb this might allow the majority of the hook (except the barb) to dislodge from the throat or gut of the turtle and be expelled from the digestive tract. Alternatively if the breaking point were near the eye of the hook the trailing line may be pulled back out of the mouth and/or digestive tract. There are many questions to be answered as to how long the hook should last before breakage and what the best coatings for the hook might be. Considering that the fishery normally replaces hooks on a regular basis, this could be a gear modification which may have minimal effect on the fishery, while decreasing the mortality rates of turtles which are captured and released with deeply swallowed hooks. Another problem that has to be considered before designing and mandating corrodible hooks is the effect that the corroding materials may have on the sea turtles.

(1) An Analysis of the Effect of Hooks on Striped Bass (Morone saxatilis) When Left Embedded in the Pharyngeal or Gastric Region Maryland Dept. of Natural Resources - Tidewater Administration- Fisheries Div. Eric B. May