

**DEVELOPING PHYSIOLOGICAL AND BIOCHEMICAL  
INDICES OF SURVIVAL IN RELEASED BLUE SHARKS**

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**EXTENDED ABSTRACT ONLY- DO NOT CITE**

Successful management strategies in both sports fisheries and commercial fisheries require information about long-term survival of released fish. Catch-and-release sports fishing and non-retention of commercially caught fish are justifiable management options only if there is a reasonable likelihood that released fish will survive for long periods. All recreational anglers and commercial fisherman who practice catch-and-release fishing hope that the released fish will survive. While it is safe to say that 100% of retained fish will die, it is not known what proportion of released fish will survive. Tag-and-release studies, which have been used broadly within fisheries management, frequently find significant post-release mortality, often days or weeks after release. These tagging programs are vital tools to assessing post-release survival, but they can be difficult and expensive to implement. Conclusions from tag-and-release studies are often difficult to extrapolate to other species. Many factors, such as fish size, water temperature, fight time and fishing gear, could influence survival.

Using funds provided by the Pelagic Fisheries Research Program (PFRP), we have been developing tools that we hope will reduce the need for tagging studies. Whereas tagging studies assess how many fish survive, we are trying to understand *why fish die*. We are developing a set of diagnostic tools to assess the biochemical and physiological status of fish captured on various gear. Our application of these tools is integrated into a comprehensive pop-up archival satellite tag (PSAT) program.

We focused first on the post-release survival of blue sharks, which are frequently by-catch of Pacific long-liners. Using the NMFS vessel *Townsend*

*Cromwell*, we captured blue sharks on scientific long-line gear off the coast of Hawaii. Blood samples were collected from sharks that were fitted with PSATs. The information from the PSAT establishes how long the shark survives. Analysis of the blood sample allows us to evaluate the physiological condition of the shark when it was released. Our goal is to develop predictors of survival based upon analysis of a single blood sample taken just prior to release. Although we focused first on blue sharks, we are anxious to apply this approach broadly to other commercial and recreational fisheries.

#### *Analysis of blood samples*

When a fish is caught, it experiences many different physiological challenges that can affect its long-term survival. Our analysis is similar to that used by doctors examining a patient in an emergency room. A lot of information about animal health can be obtained from a blood sample. Every few seconds each red blood cell passes through the heart, along blood vessels that penetrate the tissues, then back to the heart. When the blood passes through the body, it is changed in many ways that reflect the state of the tissues.

Hooked fish may lose significant amounts of blood. If too much blood is lost, the fish may no longer be able to provide adequate oxygen to its tissues. Blood loss is assessed by measuring *hematocrit*, which reflects the level of blood cells in the circulation. When fish are captured on fishing gear, the vigorous swimming activity can deplete its energy stores. When any animal undergoes extreme exercise, muscle produces high levels of *lactic acid*, which is released into the circulation. Blood lactic acid levels therefore reflect the amount of exercise the animal has experienced. If fish have used too much of its metabolic fuel deposits, it may be unable to recover from the exercise bout<sup>1</sup>. Retaining an ability to swim after exhaustive exercise allows fish to avoid predators, but is critical in large pelagics that ram-ventilate.

Strenuous exercise also results in muscle damage. Other forms of tissue damage, such as heart attacks, kidney failure, liver or brain damage could conceivably arise as a result of capture. These damaged tissues release their intracellular contents into the circulation. Since many cells possess unique cellular markers, the presence of these molecules in the blood can be used as an index of tissue damage. By characterizing the profile of blood proteins, we are able to assess the degree of tissue damage. For example, if you were to suffer a heart attack, heart cells release the proteins creatine kinase and troponin I into the plasma.

Acute liver cell damage results in the release of the proteins alanine aminotransferase and aspartate aminotransferase into the plasma.

We are also using the properties of blood cells themselves to assess the extent of tissue damage. When fish blood experiences hazardous conditions such as high temperature or oxidative stress, it can activate a line of defence that minimizes the damage to the blood cell. This “stress response” is recognized by stimulation of genes that lead to production of a suite of protective proteins called heat shock proteins. Our analysis of heat shock protein synthesis can be used to categorize the extent of the stress experienced by the blood cells<sup>2</sup>. In many cases, the damage to red blood cell can cause them to trigger programmed cell death, as indicated by elevated levels of caspases, DNA fragmentation<sup>3</sup>.

At this point we have completed analysis of the first year of our study. A second set of sharks were sampled and tagged in April.

#### *Outcome of tagging studies*

In recent years, sharks represent about 45% of the catch on long-line research cruises from the Townsend Cromwell. The dominant shark species caught has been blue sharks. In the past 2 years, we have collected blood samples from 46 blue sharks, 31 of which were fitted with PSATs. These tags will provide them with environmental and behavioral details about these animals. They will also provide a record of survival upon release. Blood samples were also collected from blue sharks that were morbid upon capture (4 sharks) or released without tags.

The PSAT data from the blue sharks tagged in 2001 has shown that blue sharks are remarkably resilient animals. Although none of the first 16 sharks we sampled died within a week of release, many of the sharks had clear signs of stress. Six sharks had elevated creatine kinase levels and lactate dehydrogenase levels, which are indicative of muscle damage. Five sharks had very high levels of lactic acid, which is indicative of exhaustive exercise. One shark that was dead when captured showed the signs of experiencing a fatal heart attack. Its blood had high levels of the heart protein troponin I. All the sharks showed some signs of oxidative stress as demonstrated by hsp mRNA blotting.

Following the analysis of blood samples collected in April from 24 blue sharks, we will expand our analysis of stress indicators. These studies will help us understand the factors that cause delayed mortality of sharks and other large

pelagics upon release. We believe these studies can be a valuable tool for fisheries managers. We are anxious to apply the technology to other fisheries.

### **References**

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