Chapter 67
Toward a Sustainable Fishery Management Policy:
An Artificial Neural Network Model for Predicting Bull Shark (*Carcharhinus Leucas*) Presence

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ABSTRACT

This article proposes an Artificial Neural Network (ANN) model to predict neonatal and juvenile bull shark habitat usage in the Sabine Pass, located within the Gulf of Mexico between Louisiana and Texas. Given continuing discussion regarding overfishing of all shark species, including bull sharks, in the northwestern Atlantic and Gulf of Mexico, the research objective was to analyze environmental data proven to be conducive to bull shark early life stages and to use these data in an ANN to predict bull shark presence during late spring and throughout summer months at designated sampling sites. The results of this analysis can both aid decision making in a fisheries context and inform the discussion on bull shark habitat usage in general, thereby contributing to the discussion of whether or not the need exists for conservation efforts to ensure sustainability of the species as part of an effective bull shark management plan.

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1. INTRODUCTION

At the present time there is concern that the increasing demand for ocean resources may result in sustainability issues for the ocean's fisheries through markets ranging from local to global (Roberts & Brink, 2010). Sustainability, as defined by the 1992 U.N. Convention on Biological Diversity is defined as "the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations" (United Nations Environmental Programme, 1992). Yet, it has been expressed that "worldwide, we have failed to manage the ocean's fisheries" (Marra, 2005). Marra predicts that the ability of the ocean to supply the needed fish resources will reach its limit despite attempts at management including environmental restoration and ecosystem-based fisheries management.

For the United States, the Fisheries Conservation and Management Act in 1976 defined the optimal amount of fish that will provide the greatest overall benefit to the nation while taking into account the protection of marine ecosystems, prescribing the maximum sustainable yield (MSY) from the fishery, and providing for rebuilding an overfished fishery to a level consistent with the maximum sustainable yield in such fishery (P.I. 94-265). In 1980, the Gulf of Mexico Fisheries Management Council began developing a shark management plan. An annual quota for recreational fishermen is not included, but these fishermen are limited to 1 shark of at least 4.5 feet in fork length per trip. Commercial fishermen have an annual quota of 1017 metric tons dry weight based on the Maximum Sustainable Yield (MSY), which is the maximum long-term average yield that can be produced by the stock on a continuing basis, however, there is no size limit for the bull sharks (*Carcharhinus leucas*) commercial fishermen are allowed to catch (NMFS, 2006). Since there was concern that the MSY estimates used for the Gulf Coast plan (NFMS, 1999) were developed without adequate knowledge of shark species' population dynamics and habitat usage, subsequent research was used to determine the current levels (NMFS, 2003; 2006). Yet, realistically, there has not been much incentive for fishermen to accept lower catch limits that might allow endangered stocks to recover in future because of the immediate value of staying in business. Due in part to ineffective measures to control fishing, management using MSY has proven difficult, but ecosystem-based management practices also have struggled to compensate for uncertainty inherent in the scientific assessments of fish populations (Roberts & Brink, 2010).

Despite regional efforts, the bull shark population of the United States was considered to be overfished as of September 1998 according to a U.S. Department of Commerce report to Congress. In the most recent fisheries management plan, the large coastal sharks are still considered to be overfished with overfishing continuing unabated (NMFS, 2006). Yet, progress has been made by the study of demographic rates and population modeling of sharks that provide a more accurate representation of some shark populations (Apostolaki et al., 2002; Cortés, 2002; Cortés et al., 2002) most notably to the blacktip shark (*Carcharhinus limbatus*) in the northwestern Atlantic Ocean. There has been considerable debate about whether or not this species or other shark populations actually face extinction in the Northwest Atlantic Ocean and the Gulf of Mexico. Burgess et al. (2005) questioned the findings by Baum et al. (2003) and Baum and Myers (2004) that the collapse of shark populations in these bodies of water was eminent. They argued that methodological flaws in these two studies may have biased the results and thus led to overly pessimistic conclusions. However, Myers, Baum, Shepherd, Powers, and Peterson (2007) and O'Connell, Shepherd, O'Connell, and Myers (2007), continued to affirm that large population declines up to functional elimination suggest that few mature individual bull sharks may actually exist in the Atlantic and Gulf of Mexico (GOM) regions. More recently, research that incorporated multiple