A BIOECONOMIC MODEL FOR INVESTIGATING THE PUBLIC HEALTH IMPACTS OF FISH CONTAMINATION

A Preliminary Look at Mercury Contamination in Gulf of Mexico and South Atlantic King Mackerel

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BACKGROUND

Fish is an important component of a healthy diet: high in protein, low in saturated fat, and a source of omega-3 fatty acids that current research has linked with a variety of health benefits such as protecting against coronary heart disease and stroke, and aiding in the neurological development of children (U.S. EPA 2004; IOM 2006). At the same time, the presence of mercury in the fish supply is a growing public health concern to seafood consumers. Mercury can build up in the food chain to harmful levels and has been associated with irreversible damage to the brain, kidneys, and developing fetus (Figure 1; U.S. EPA 2004). This concern has prompted the issuance of consumption advice such as that found in the 2004 U.S. EPA and FDA joint federal advisory for mercury in fish (Figure 2).

Figure 1: Health Effects of Mercury

Figure 2: EPA-FDA Joint Advisory for Mercury in Fish

MOTIVATION

- Consumer reaction to consumption advice is unpredictable
- Dynamics of bioaccumulation imply mercury contamination can vary significantly by size/age class
- A more directed, size-based management of marine fisheries that accounts for the economic dynamics of optimal harvesting in the presence of contamination could lead to public health improvements by limiting the amount of mercury that reaches consumers

OBJECTIVE

This research examines the economic feasibility of a size-based management regime to reduce consumer exposure to mercury using a bioeconomic model of the South Atlantic and Gulf of Mexico king mackerel (*Scomberomorus cavalla*) fishery.

KING MACKEREL FISHERY OVERVIEW

King mackerel is a coastal pelagic that is distributed in the western Atlantic and in the Gulf of Mexico and Caribbean Sea, with substantial commercial and recreational catches occurring in U.S. waters. The fishery, which is essentially a single stock with mixing, is currently managed as two independent migratory groups (Gulf Migratory Group and Atlantic Migratory Group; Figure 3) through quotas, possession and trip limits, size limits, and seasonal closures. Mercury levels are high in king mackerel and it is recommended that women and young children avoid eating king mackerel (U.S. EPA 2004).

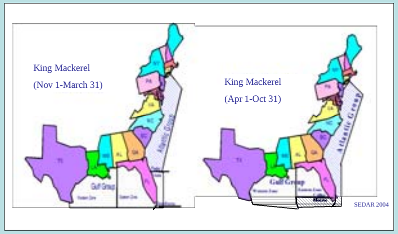

Figure 3:King Mackerel Migratory Groups & Seasonal Boundaries

METHODOLOGY

A multiple cohort bioeconomic model of the fishery will be developed. Key features of the model include the relevant biological characteristics of the fishery, the presence of methylmercury in the fish, the potential health costs and benefits associated with fish harvesting, and the temporal and technological patterns of harvesting (Figure 4). This bioeconomic model is linked to a U.S. FDA exposure simulation model that relates consumption levels to blood levels of mercury in U.S. fish consumers. The exposure simulation results are then used to determine the net health impact of several health endpoints associated with mercury and fish consumption. The model will be used to examine the impact of alternative regulatory and market-based management scenarios, including size, gear, and time restrictions or taxes.

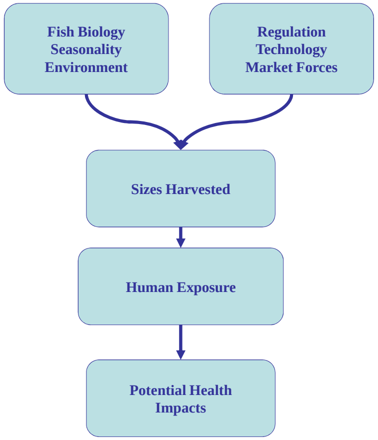

Figure 4: Conceptual Model

BIOECONOMIC FRAMEWORK

The biological submodel is based on a dynamic, age-structured population model with multiple cohorts that are distinguished by age in years. A recent stock assessment (SEDAR 2004) provided estimates of the initial stock size, natural mortality, fishing mortality, von Bertalanffy growth parameters, biomass, and recruitment. Figure 5 compares preliminary simulation results for the Gulf of Mexico king mackerel fishery with observed catch from 1981-2001. A simulation model for the South Atlantic stock is currently in development. Once completed, the biological models will be linked to an economic model of the fishery.

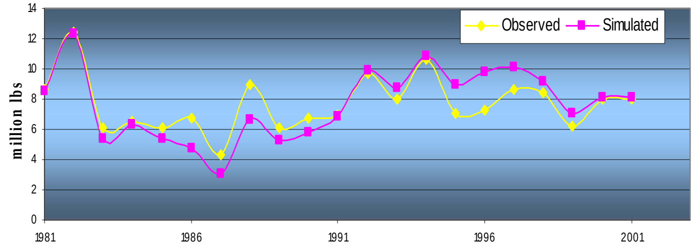

Figure 5: Gulf King Mackerel: Simulated and Observed Catch

INCORPORATING HEALTH IMPACTS

Potential risks and benefits of fish consumption depend on many factors:

- frequency of consumption
- serving size
- contaminant concentration
- bodyweight
- gender
- age

To account for these factors, a model for mercury exposure developed by Carrington and Bolger (2002) is used.

EXPOSURE SIMULATION MODEL

The model relates seafood consumption to levels of methylmercury (MeHg) in the blood and hair of consumers, and utilizes consumption data from the FDA's Continuing Survey of Food Intake for Individuals (Figure 6).

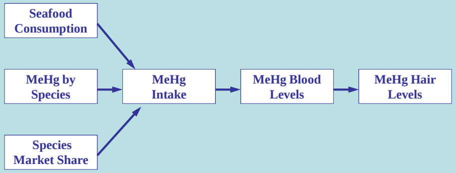

Figure 6: Carrington and Bolger (2002) Exposure Assessment Structure

MeHg intake for individual consumers is estimated over one-year period using distributions for short-term seafood consumption, MeHg concentrations in various species, and per capita consumption of individual species. The intake estimates can then be used with established dose response relationships to determine health risks and benefits from fish consumption measured in probability of a health impact from a given exposure for an individual. The exposure assessment model is linked to the bioeconomic model through the relationship between fish size and mercury concentration (Figure 7 illustrates this for king mackerel in the Gulf of Mexico). This relationship will be used to generate distributions of mercury concentration by age class.

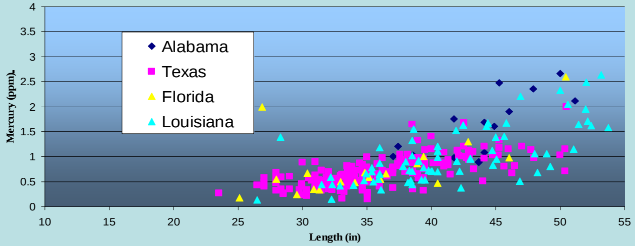

Figure 7: Length-Mercury Relationship for Gulf of Mexico King Mackerel

DISCUSSION

The model will be used to examine alternative management scenarios along with the use of potential regulatory and market-based policy instruments including size, gear, and time restrictions or taxes. General conditions under which optimal management of a fish species may occur given the objectives of maximizing the present value of the fishery while limiting potential negative public health impacts will be determined. The completed bioeconomic model will provide the opportunity to demonstrate how public health risks can be incorporated into harvest management strategies to minimize adverse health impacts, and recommend specific approaches to optimal fisheries management in the presence of size and/or age-based chemical contamination.

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ACKNOWLEDGEMENTS: