Assessment of the Regulatory Effects of Summer Flounder Management on the Size Distribution of Catch along the East Coast of the United States.

I. Introduction

The recreational fishery for summer flounder extends from Maine to South Carolina along the east coast of the United States. However, the majority of recreational and commercial landings range between Massachusetts and North Carolina. Recent reports indicate that the summer flounder fishery generates substantial net benefits and economic impacts for the mid-Atlantic region. The commercial fishery reported landings of approximately 12 million pounds valued at $29 million (or $2.42 per pound) in 2013, which is 1% of the total landings that generates value added in 2012 of $6.5 billion for all species landed in the mid-Atlantic region. The recreational fishery reported catches of 4.2 million pounds, which is 9.15% of the total recreational catch from the mid-Atlantic region that supports a recreational fishery of 2.2 million anglers with a value added of $2.4 billion in 2012.[1]

The Mid-Atlantic Fisheries Management Council (MAFMC) and the Atlantic States Marine Fisheries Commission cooperatively manage this fishery since significant landings of summer flounder occur in state waters from shore out to three miles along the middle Atlantic coast, and in federally managed waters of the exclusive economic zone (EEZ) from three to two hundred miles offshore of east coast states. Promulgated regulations by these management bodies are implemented and enforced by the National Marine Fisheries Service (NOAA Fisheries). These management regulations are primarily based on biological stock assessment results that determine the annual catch limit (ACL).

The summer flounder ACL is set to rebuild the fish stock to end overfishing and correct the overfished status of the stock. Once the ACL is determined, sixty percent is allocated to the commercial fishery with the remaining forty percent going to the recreational fishery. The recreational fishery management regulations include size limits, possession limits, and setting the length of the annual fishing season with emphasis placed on the size of fish landed. The fishery management instruments for the commercial fishery used to enforce these allocation levels are fish size class and mesh size limits to protect juvenile fish and the adults that reproduce to repopulate the stock. This allocation scheme was determined to be economically optimal for 2014 in a study conducted by Hicks and Schnier (2017).

With the success of this stock rebuilding management program, summer flounder fishery managers must now contend with the redistribution of these rebuild stocks between commercial fishermen and recreational anglers. For the recreational fishery, allocating catch by one-inch size categories is a function of the management history of the recreational fishery and the abundance of summer flounder determined by an annual stock assessment. Determining the probability that a fish landed by a recreational angler subject to existing or proposed fishery management regulations in state managed waters or the EEZ is based on a model proposed by Bockstael and McConnell (1981). This theoretical household production function model is modified into a qualitative response model given the uncertainty existing with the available data for the recreational fishery. Jointness in production with the commercial fishery is tested for using the commercial price per pound and by accounting for the jointly determined stock abundance estimated in the stock assessment.

This analysis will be undertaken in two parts. The first will be the estimation of a model that predicts the probability that a summer flounder landed is in a specific size category. This probability estimate is used to allocate fish landed into a size class distribution for different historic fishery management regulatory scenarios. The second part will involve the use of household production function theory (Bockstael and McConnell, 1981) to develop a primal model of fish landed as a measure of the quality of a fishing trip and fishing effort in the form of a fishing trip taken by summer flounder anglers. This discussion of the household production function and the probability model methodology are followed by a summarization of the SAS programs that create the database used to estimate these models. The programs developed to actually estimate the relationships and generate results for a fishery

---

[1] www.st.nmfs.noaa.gov/Assets/economics/feus/2012/FEUS2012_MidAtlantic.pdf

management scenario are also summarized. Combing this analysis with the net benefits generated by the commercial fishery should provide an estimate of the total net benefits derived from the summer flounder fishery under different fishery management scenarios. Finally, a summary is provided.

II. Methodology

The principle assumption of this analysis is that participants in the summer flounder fishery interviewed by the Marine Recreational Interview Program (MRIP) behave according to underlying economic incentives. Even though the typical information about individuals is not collected by MRIP in its survey to estimate the number of anglers and catch of fish, the trends in the data remain influenced by the underlying biological, economic, and socio-cultural factors. Therefore, how the fishery management regulations effect landings and catch trends over time can be related back to a utility function derived from the household production function (Bockstael and McConnell, 1981) using the primal approach.

A. Household Production Function

The household production function proposed by Bockstael and McConnell (1981) is an interpretation of how user groups interact with the marine environment. In this case, the quality of a fishing experience (q_i) is a function of the experience of the angler (e_i), the abundance of the stock of fish (S), and the quantity of inputs (w_i) used by the angler to take a trip (x_i) that is a function of the inputs (w_i) used by angler (i); i.e., the catch of fish per trip by the angler. This can be expressed as:

$$q_i = Q[e_i, S(A), x_i(w_i)] \qquad (1)$$

where A is a control variable used by fishery managers to control the size of the stock (S). That is, the decisions made by fishery managers that directly affect stock size and indirectly affect the catch rate of an angler, affecting the quality of their fishing experience.

Similarly, the number of trips (x_i) taken by an angler for a particular species is a function of the catch (q_i), the stock abundance (S) that is influenced by the fishery management regulations (A), and the necessary inputs needed to take the trip (w_i) which is a function of the unit costs of those inputs (p_i):

$$x_i = X[q_i, S(A), w_i(p_i)] \qquad (2)$$

Based on the relationships in equations (1) and (2), a cost function can be derived that is then used to construct a constrained utility function that measures changes in welfare from taking a recreational fishing trip; e.g.,

$$\max_{x,\,q,\,y} U[W(x_i,q_i), y_i]$$

$$\text{s.t. } I = p_y y_i + C(x_i, q_i, p_i, e_i, S(A)) \qquad (3)$$

where y_i is all other goods consumed,
p_y is the price of these other goods and services, and
I is income.

A set of derived demand equations can be derived from equation (3) that can be solved for a set of structural demand equations for trips and the quality of these trips (Bockstael and McConnell, 1981):

$$x_i = X_x[q_i, p_i, e_i, S(A), I] \qquad (4)$$

$q_i = Q_q[x_i(p_i), p_i, e_i, S(A), I]$

The implication of equation (4) is that any change in price (p_i) or fishery management regulation (A) would result in a new equilibrium number of trips (x_i^*) and quality of those trips (q_i^*) as represented by the catch per trip. As a result, the MRIP survey data on trips and catch per trip are based on the individual angler behavior that is represented by equation (4).

Equation (4) is a partial equilibrium analysis in that it holds constant some of the variables that affect catch and trips in analyzing changes in other variables. The general equilibrium analysis utilized in this assessment relaxes this assumption and allows the prediction of trips and catch based on changes in fishery management regulations. This allows other market influences such as income, prices, and costs to adjust to their new equilibrium levels. In addition, joint production exists in this recreational angler experience, since the demand for trips is a function of the quality of that trip in terms of its catch per trip and the quality of the trip is a function of the number of trips, indicating the need for a simultaneous equations estimation approach.

B. The Probability of the Size of a Fish Landed

The discussion of risk and uncertainty concepts in fishery management forums has ranged from a clear understanding of these terms to their use as synonyms. To avoid confusion, how these terms are to be employed in the context of this analysis is needed.

1. Risk and Uncertainty

One of the underlying assumptions of the ideal perfectly competitive market model in economics and hence fisheries economics is that of perfect information about the marketplace. Imperfect information, including information about future events, is considered a market failure or externality that leads to inefficient allocations of scarce resources amongst the unlimited wants of buyers and sellers. This concept is the core of the definition of uncertainty (Dixit and Pindyck, 1994). Risk, or more precisely what is at risk, is that which is wagered to achieve some potential, but uncertain, outcome.

The simplest example of an application of uncertainty involves flipping a coin. The probability of heads being the outcome for a two sided coin in many identical trials of a perfectly balance coin is Prob(H) = 0.5. The probability of a tail is equal to Prob(T) = 1 - Prob(H) = 0.5 as well. While the outcome of the next trial is uncertain, the information about the probability of a head would indicate that in 10 trials, an outcome of heads or tails could be expected 5 times each. Risking one dollar on the outcome of a coin toss to win two dollars is a risk neutral bet since the expected value of the prize is equal to what is being risked over many trials; e.g.,

$\$1 = \text{Prob (H)} * \$2$

A slightly more complicated example of the application of uncertainty involves the throwing of a die, where the probability of getting a number between 1 and 6 is 0.1667. When two dice are thrown, the outcome changes to the probability distribution in Table 1. In this case, the expected value for a given prize is much higher for an outcome of 7 with a probability of 0.1667 than for either a 2 or a 12, which has a probability of 0.0278.

Similarly, a distribution can be constructed from the MRIP recreational data for the probability that a fish landed (Type A fish), caught (Type A + B1 fish), or discarded (including the Type 9 records) by an angler will fall within a predetermined size category, given that it is a particular species of fish based upon the historical data available (Table 2).

Even as the outcome of an actual coin toss depends on the revolutions per minute imparted to the coin and the height of the toss, the probability distribution related to the landing of an individual fish by an angler is dependent on the economic, biological, and regulatory environment that exists at a point in time. Since the regulatory objective is to increase the size of the fish stock, the associated risk given the uncertainty of achieving this goal is the value of the fish given up in previous time periods to increase the likelihood of landing a larger fish in some future time period when a larger biomass level exists.

Figure 1 taken from (Ward, 1990), which is based on the Gordon (1954) – Schaefer (1957) – Copes (1970) model of a fishery, demonstrates the level of risk associated with a potential increase in landings from a fishery after the biomass has been rebuilt to a sustainable level of yield. The initial equilibrium point (a) has a yield of Y1 as a result of a fished stock that is overfished (X1). This represents a long-run equilibrium since the open access supply function (S_{oa}) is equal to both the demand and the stock constant supply function (S_{x1}). The net benefits corresponding to this equilibrium are equal to areas A+B in Figure 1.

Correcting the overfished fish stock status requires setting an ACL that causes a loss in net benefits equal to area A in Figure 1. The ACL limit on yield allows the stock to grow to the precautionary size (X2) that results in a shift in the stock constant supply function to (S_{x2}). The S_{oa} and S_{x2} are in equilibrium at point b where yield has increased to Y2 and net benefits are equal to areas A+B+C+D+E+F. Unfortunately, stock constant supply (S_{x2}) is equal to demand at point c in Figure 1, which is an unsustainable point for the fishery; i.e., achieving and maintaining yield at point b has an extremely low probability of success.

In the context of fisheries managers evaluating proposed regulations to correct the overfished fishery problem, the risk, equal to the foregone net benefits from setting the ACL, represented by area A, should be at least equal to the expected value of the promised outcome; i.e., the probability of success of achieving point b multiplied by the increase in net benefits (the area equal to A+B+C+D+E+F). This concept of risk, what could potentially be given up, and uncertainty, the probability associated with an unknown future event, are employed to assess the changes in fish landed, caught, and discarded using the MRIP data set.

2. The Uncertainty Model

The summer flounder fishery consists of both commercial fishermen (fishermen) and recreational anglers (anglers) who respectively maximize profits and satisfaction from fishing. These two consumptive user groups are linked through the fish stock populations that act as a constraint on the maximum achievable by either group; i.e.,

$$\text{Max } H = \int e^{-rt}\,\Pi\, dt + \int e^{-\partial t}\,\mu\, dt \qquad \text{s.t. } dS/dt = S[G(S) - M - F_c - F_r] \qquad (5)$$

where

Π is commercial profits,
μ is recreational satisfaction,
e^{-rt} is the commercial discount factor,
$e^{-\partial t}$ is the recreational discount factor,
G(S) is the growth rate of the fish stock,
M is natural mortality, and
F is fishing mortality from commercial (F_c) and recreational (F_r) fishing.

The effect of this nonseparability in production assumption is that changes in demand for the in situ living marine resource by fishermen has an indirect impact on the angler supply of fish via the stock constraint and vice versa. For example, an increase in the ex-vessel price of fish in the commercial market from, for example, a decline in harvest level from a decline in stock abundance would reduce the number of fish available to the recreational sector, which would result in a negative coefficient on price in an analysis of the recreational sector. Solving for the derived demand for fish in the recreational sector

(q_i) reveals that the solution is a function of the variables representing both the maximization of profit and satisfaction as well as abundance:

$$q_i = Q(\pi, \mu, S)$$

Derived for each size class of fish (X_k) is a separate functional form that is a function of the variables representing each user groups' maximization objective as it is influenced by the regulatory environment;

$$X_k = f_k(\pi, \mu, S, R) \qquad k = 1, \ldots, K \text{ size classes.}$$

While these theoretical relationships are well understood (Clark, 1976), data collection programs for both the recreational and commercial sectors have primarily focused on the fish stock population dynamics. This has resulted in imperfect information about the structural equations (equation 4) that influence these relationships that determine the size class of each fish landed.

Imperfect information is the core element of uncertainty (Dixit and Pindyk, 1993). The uncertainty in this analysis is that which is associated with the size class of the next fish landed. Fortunately, interviewers collect the size, species, and weight of each landed fish (type A) for use in estimating the number of recreational fishing trips for use in the stock assessment. This information recorded in the MRIPs database provides a set of data that ranges from 1981 to 2017. Information from additional data sets, such as ex-vessel summer flounder prices, national population, fuel prices, discount rates, regulatory measures that have been adopted over time, and biomass abundance levels are added to this data set.

While data has been collected on the size and weight of recreationally caught fish, the subsequent estimates of numbers and pounds of fish caught by state do not include their distribution by size class. This shortcoming is addressed using historic recreational interview data to determine the probability that a landed fish falls within a given size category. This probability distribution is then use to redistribute the state level estimates of numbers of landed fish into each size class. These estimates of landed, caught, and discarded fish can then be used to estimate the total number of fish in each size class for each state based on a proposed set of fishery management regulations.

Logistic regression analysis (Agresti, 2002, Allison, 1999, Collett, 2003, Cox and Snell, 1989, Hosmer and Lemeshow, 2002, Stokes, Davis, and Koch, 2000) is the methodology of choice when the relationship between a discrete response, such as the size class of a landed fish, and a set of explanatory variables is being investigated. In this case, these variables include the regulatory environment, the biological conditions existing in the marine environment, and the economic conditions existing in the recreational fishing marketplace. This model where multiple possible outcomes exist can be extended to a multinomial model referred to as a generalized or baseline-category logit model (McFadden, 1974) in the form:

$$\mathrm{Log}(\Pr(Y=i|x)/\Pr(Y=k+1|x)) = \alpha_i + \beta'_i x \qquad i = 1, \ldots, k$$

where Y is the categorical variable,

α_i are the intercept parameters,

β_i is the vector of the slope parameters, and

X is a vector of exogenous variables,.

III. SAS Database Programs

Marine recreational fisheries statistics queries are available at:

www.st.nmfs.noaa.gov/recreational-fisheries/data-and-documentation/queries/index from 1981 to present. Both SAS and CSV formatted data files are available for down load. The SAS data files are downloaded in ZIP format and are expanded once saved on the local computer system. The SAS files are directly available for use in the programs used to estimate parameters to allocate fish into specific size classes. As a result, many of the earlier problems associated with building a usable database by merging SAS and CSV formatted files are no longer an issue. As a result, many of the earlier SAS programs needed to build the database are no longer necessary.

Commercial ex-vessel price information is available at:

http://www.st.nmfs.noaa.gov/commercial-fisheries/index

Formatted, annual and monthly data by species and state for landings and value for commercial fishing operations is readily available and easily downloaded from this website. Specific species can be identified by name on this site and downloaded for use in updating this summer flounder assessment.

This data is inflated by the producer price index for fish (commodity code 0223) to a base year of 2011, which is available from the Bureau of Labor Statistics. Their website at:

http://www.bls.gov/news.release/pdf/ppi.pdf

provides detailed instructions for accessing this information on their website and provides updated information concerning its availability and any problems that may have developed over time with the time series. This is also the source for the fuel cost data included in the summer flounder size class assessment. The producer price index for fuel (commodity code 057303) was used as a proxy for fuel cost.

National population size is found at the Bureau of the Census at:

http://www.census.gov/services/sas/historic_data.html

The prime rate, which is used as a proxy for capital costs, is taken from the Wall Street Journal website:

http://www.bankrate.com/rates/interest-rates/wall-street-prime-rate.aspx

All other variables and data used in this summer flounder assessment are calculated as part of the analysis using the accompanying SAS programs.

A. Program I

Once a complete set of interview data has been down loaded by wave for each year, this program creates a SAS data set for a particular species. Three variables are created to determine if it is a primary or secondary targeted or non-targeted fish species; i.e., DPrim1, DPrime2, and NTPrim2. It also creates one-inch size classes by converting fish lengths from centimeters to inches and assigning fish to one inch ranges; i.e., dsz1 to dsz110. This program also generates a frequency distribution by size class for each year and provides a set of statistics for the data set.

B. Program II

The previously created annual data file is combined into the 1981 to 2012 SAS work.one data set. The abundance variable (SSB) and the total summer flounder landings variable (TotSFL) are incorporated by this program into the final data set for summer flounder.

C. Program III

The summer flounder regulatory history is incorporated into the SAS work.one data set in terms of quantitative variables representing ACLs, size limits, and catch limits by state and over time. States codes, party size, hours fished, gear type, disposition of the catch, and days fished (for 2 and 12 day trips) are labeled. Commercial landings and values are included to test for jointness in production. The prime rate (PR), as a proxy variable for capital invested, national population levels (NP), as a demand indicator, and the fuel producer price index (FPPI), to represent costs of a recreational trip, are included.

IV. Analytical Programs

The SAS work.one data file is utilized by a set of SAS programs to estimate the probability that a fish landed or caught fits within a specified size class given that it is a summer flounder. This probability is then applied to the universe of summer flounder landed or caught to determine how many summer flounder are in any specific size class. The universe of summer flounder is provided by the stock assessment or can be estimated using a set of trip and catch equations solved simultaneously for a given set of fishery management regulations at a point in time.

A. Logistic Model

The probability that a fish landed or caught falls within a specific size category given that it is a summer flounder is estimated. The SAS logistic procedure is used to estimates a multinomial model for each size category based on variables representing the regulatory history, recreational fishing effort, and also includes commercial fishery landings and values. It also adds a discard variable (Discard = 1) if the variable Num_typ9 > 0. The final stage of this program saves the estimated coefficients to a file named work.betas.

B. ProbEstimate I and II

The estimated coefficients saved in the work.betas file are used in the SAS programs ProbEstimate I and II to estimate the probability that a fish landed or caught is in a given size category for a proposed fishery management scenario. The probability distribution for different fishery management scenarios can be compared and utilized to determine the change in the distribution of fish that will be landed or caught in each size category based on the total number of fish landed or caught. ProbEstimate I provides labels to each variable used in the estimation of numbers of fish in ProbEstimate II. A set of macros at the beginning of the latter program is used to specify the state of landing and the regulations that will be analyzed. A macro variable (MaxSize) has been included to represent a maximum fish size limit that prevents caught fish greater than the maximum size limit from being landed in a counter factual analysis of proposed slot limit fishery management regulation. This variable effect can be set to estimate 100% compliance or include some level of noncompliance up to 0% (CL = 0 to 1). The results of each state run are stored in an output program that is utilized to construct regional estimates of numbers of fish landed or caught by size class.

C. Regional

The regional model summarizes the state size class data set into three regional estimates of numbers of fish caught or landed. The north Atlantic region consists of Maine to Rhode Island. The middle Atlantic region consists of the states between New York and Virginia; inclusive. The south Atlantic region consists of the states south of Virginia. The program is easily manipulated to change the regional state designations or include new states of interest.

D. CBAModel

The total number of fish utilized by ProbEstimate II to estimate the number of fish by size category can be provided by a stock assessment or it can be estimated using the CBA model program. This program uses MRIP survey data to estimate the number of trips for summer flounder and the number of summer flounder landed using a model, based on general equilibrium theory applied to the household production function recreational model, solved simultaneously using three stage least squares.

E. PolicyModel

The policy model estimates costs and benefits for a user specified set of fishery management regulations relative to a base case. It develops an estimate of the number of trips and, most importantly, the level of landings for a user specified set of fishery management regulations.

V. Contract Deliverables

Task 1. Model Simplification

Part I. The statistical model parameters have been identified and labeled, and the data source of each exogenous variable is identified in each SAS program. Each variable acronym has been labeled and is listed on the logistic program output.

Part II. The distribution of individual summer flounder by size category in Table 2 corresponds to a normal distribution with most of the observations falling within the medium size classes. The statistical analysis of the global fit of the logistic model in Table 3 indicates that the model is significant at the alpha = 0.05 level using the Chi-square test for the log likelihood ratio, score, and wald tests with 115 degrees of freedom. The correlation coefficient (R-squared) in Table 3 indicates that the estimated model in Table 4 explains at least 81 percent of the variation in the data set. The individual parameter estimates are listed and labeled in Table 4. Most of these estimated parameters are significant at the alpha = 0.10 level. Some classifications of the class variables were set to zero by the program as statistical theory would expect since these classifications were perfectly collinear with other variables used in the analysis.

Part III. An extensive analysis was conducted to convert the state level model to a regional level model. The north Atlantic region consisted of Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut. The mid-Atlantic region consisted of New York, New Jersey, Delaware, Maryland, and Virginia. The southern Atlantic region was North Carolina, South Carolina, Georgia, and the east coast of Florida. Unfortunately, analyses of numerous regional combinations of states did not converge in the SAS logistic procedure. Instead, the state level analysis was retained and a regional aggregation model (Regional program) was used to create regional estimates of harvest and catch by size class (Table 5).

A few parameters that are not statistically significant at the alpha = 0.10 level remain in the model for their latter use in the policy analysis of proposed management regulations. Also, all presently existing regulatory variables will be retained in the simplified model; including season lengths, bag limits, size limits, and slot limits.

Part IV. A slot limit analysis is incorporated into the statistical model estimation to determine proposed regulatory effects on the estimated probability of a fish being in a bounded range of size classes. A number of statistical approaches were statistically insignificant according to the statistical criteria. Instead, a counterfactual analysis was conducted based on the assumption that an upper size limit would not affect the catch of fish by anglers, but would increase the discarding of fish larger than the upper size limit. Since minimum size limits do not prevent landings according to the survey data sets, a compliance level is also included in the slot limit counterfactual analysis. This can be set by expert opinion, a survey of recreational fishermen about compliance with recreational fishery management regulations, or the compliance level of anglers who retain undersized fish can be assumed to be the compliance level for oversized fish as well. This analysis is conducted on the state level and is then aggregated into the regional level table.

Task 2. Recreational Policy Assessment Model

A recreational policy assessment base case is based on the simplified statistical model estimated in Task I. The recreational fishery policy to be evaluated consists of an 18-inch size limit on summer flounder landed, a four fish possession limit, a 153-day fishing season, and a spawning stock biomass index level of 41,524. It assumes a fuel price index of 305.3, a prime rate 3.25, and a national population size of 316,128,839. The maximum size limit for a slot limit analysis is set at a nonbinding 107 inches and the compliance level is set at zero to correspond to full compliance.

Part V. The recreational policy assessment computer simulation model predicts the probability of a fish landed being in a particular size class by region and under different management scenarios. The estimated coefficients in Table 4 are used to estimate the probability that a landed fish is in a specific size class as a function of the fishery management regulations in place in any specific year. The intercept terms in Table 4 indicate that the first twelve size class coefficients are not significantly different from zero. Beginning with intercept 13 and all subsequent size classes, the estimated coefficient Wald Chi-squared values reject the null hypothesis that the estimated coefficient values are equal to zero. The variables representing weight and abundance are significant at the alpha = 0.10 level. This is consistent with the abundance constraint in equation (5), linking the commercial and recreational fisheries. Federal management regulations are also statistically significant in their effect on the estimated probability of a fish landed being in a specific size class. State effects are particularly important in estimating regional differences in landed sizes except for Maine and North Carolina that are not statistically different from probabilities estimated for the base case of Virginia.

Part VI. These estimated probabilities are used to estimate the numbers of fish in each size class for comparison to a predetermined status quo base case. The actual regulations to be assessed will include season length, bag limits, size limits, slot limits, and any combination of the above to be determined by the Mid-Atlantic Fishery Management Council Staff. This assessment could not be preformed at this time as the MAFMC has not had the opportunity to develop an alternative set of proposed regulations to evaluate. The estimated number of fish by size class for the base case is provided in Table 5 based on the proposed regulations list above. This information is summarized into north, mid, and southern region estimated number of fish by size class in Table 6.

Part VII. The methodology to expand survey data to estimated data using the Coastal Household Telephone Survey (CHTS), the for-Hire Survey (FHS), and the Access Point Angler Intercept Survey (APAIS) is explained on pages 47 to 51 in the Marine Recreational Information Program Data User Handbook.[2] In its essence, the catch per trip is calculated for a wave using the APAIS, which are then weighted using the FHS and CHTS and the frequency of use of a fishing site. Although the APAIS collects the length and weight of landed (type A) fish, the resulting weighting factors do not take these into account when estimating total catch (A, B1, and B2).

A second use of a weighting factor is used in the summer flounder stock assessment. This estimates the missing weight variable on summer flounder that the APAIS interviewers were unable to directly access even though length estimates were provided by anglers. These fish weight estimates are based on a statistically estimated weight-length relationship; i.e., weight in kilograms = a(Length in centimeters)^B.

The estimation of these weight factors has changed over the years that the APAIS has been conducted. A historical listing of these weighting factors is not readily available. Also, the method of calculating total catch based on these weighting factors is conducted at the wave level and does not include a breakdown by size or weight of fish.

Part VIII. The comparison of two management scenarios requires a metric to show improvement or degradation relative to the status quo of the fishery. This metric is developed based on the cost – benefit ratio derived from the household production function model (Bockstael and McConnell, 1981). The trip and quality equations are estimated using the primal approach in the CBAModel program and the estimated coefficients are used in the PolicyModel program to estimate the specified status quo and alternative case fishery management regulations. Since a specific alternative set of management regulations have not been specified, the results for the base case are contained in Table 7. These estimates are based on the mean values of variables in the data set. The resulting estimates are for the average fishing trip.

[2] www.st.nmfs.noaa.gov/recreational-fisheries/MRIP-Handbook/MRIP_handbook.pdf

VI. Summary

Fisheries management is a complex, convoluted process that rarely results in data collection procedures providing the information needed to address new problems facing fishery managers. Fortunately, the application of economic and biological theory can be used to interpret existing data bases to provide an indication of how changes in fishery management regulations will affect catch rates, trips, and the distribution of fish in a fishery. In this case of summer flounder fisheries management, the effect of changes in recreational regulations are predicted for catch rates and size class distributions in future time periods for each state and subregion in the mid-Atlantic fisheries management region based on past angler behavior. The estimated net benefits for each of these proposed or existing fishery management regulations can also be estimated to determine if the long-run quality of a fishing experience is improving or declining.

VII. Reference

Abbott, Joshua and James Wilen (2009). "Regulation of Fisheries Bycatch with Common-Pool Output Quotas." Journal of Environmental Economics and Management, 57:195-204.

Agresti, A. (1984), *Analysis of Ordinal Categorical Data*, New York: John Wiley & Sons.

Agresti, A. (1990), *Categorical Data Analysis*, New York: John Wiley & Sons.

Agresti, A. (1992), "A Survey of Exact Inference for Contingency Tables," *Statistical Science*, 7, 131–177.

Agresti, A. (2002), *Categorical Data Analysis*, Second Edition, New York: John Wiley & Sons.

Aitchison, J. and Silvey, S. (1957), "The Generalization of Probit Analysis to the Case of Multiple Responses," *Biometrika*, 44, 131–140.

Albert, A. and Anderson, J. A. (1984), "On the Existence of Maximum Likelihood Estimates in Logistic Regression Models," *Biometrika*, 71, 1–10.

Allison, P. D. (1982), "Discrete-Time Methods for the Analysis of Event Histories," in S. Leinhardt, ed., *Sociological Methods and Research*, volume 15, 61–98, San Francisco: Jossey-Bass.

Allison, P. D. (1999), *Logistic Regression Using the SAS System: Theory and Application*, Cary, NC: SAS Institute Inc.

Anderson, Lee G. (1986). The Economics of Fisheries Management. Johns Hopkins University Press, Baltimore, 296 pp.

Ashford, J. R. (1959), "An Approach to the Analysis of Data for Semi-Quantal Responses in Biology Response," *Biometrics*, 15, 573–581.

Bartolucci, A. A. and Fraser, M. D. (1977), "Comparative Step-Up and Composite Test for Selecting Prognostic Indicator Associated with Survival," *Biometrical Journal*, 19, 437–448.

Bockstael, Nancy E. and Kenneth E. McConnell (1981). "Theory and Estimation of the Household Production Function for Wildlife Recreation." Journal of Environmental Economics and Management, 8:199-214.

Breslow, N. E. (1982), "Covariance Adjustment of Relative-Risk Estimates in Matched Studies," *Biometrics*, 38, 661–672.

Breslow, N. E. and Day, N. E. (1980), *Statistical Methods in Cancer Research, Volume I: The Analysis of Case-Control Studies*, IARC Scientific Publications, No. 32, Lyon, France: International Agency for Research on Cancer.

Brier, G. W. (1950), "Verification of Forecasts Expressed in Terms of Probability," *Monthly Weather Review*, 78(1), 1–3.

Burnham, K. P. and Anderson, D. R. (1998), *Model Selection and Inference: A Practical Information-Theoretic Approach*, New York: Springer-Verlag.

Clark, CW (1976). Mathematical Bioeconomics, the Optimal Control of Renewable Resources. John Wiley, New York.

Collett, D. (2003), *Modelling Binary Data*, Second Edition, London: Chapman & Hall.

Cook, R. D. and Weisberg, S. (1982), *Residuals and Influence in Regression*, New York: Chapman & Hall.

Copes, P. (1970). "The Backward-Bending Supply Curve of the Fishing Industry." Scottish Journal of Political Economy, 17(1):69-77.

Cox, D. R. (1970), *The Analysis of Binary Data*, New York: Chapman & Hall.

Cox, D. R. (1972), "Regression Models and Life Tables," *Journal of the Royal Statistical Society, Series B*, 20, 187–220, with discussion.

Cox, D. R. and Snell, E. J. (1989), *The Analysis of Binary Data*, Second Edition, London: Chapman & Hall.

DeLong, E. R., DeLong, D. M., and Clarke-Pearson, D. L. (1988), "Comparing the Areas under Two or More Correlated Receiver Operating Characteristic Curves: A Nonparametric Approach," *Biometrics*, 44, 837–845.

Dixit and Pindyck (1994). Investment Under Uncertainty. Princeton University Press.

Draper, C. C., Voller, A., and Carpenter, R. G. (1972), "The Epidemiologic Interpretation of Serologic Data in Malaria," *American Journal of Tropical Medicine and Hygiene*, 21, 696–703.

Finney, D. J. (1947), "The Estimation from Individual Records of the Relationship between Dose and Quantal Response," *Biometrika*, 34, 320–334.

Firth, D. (1993), "Bias Reduction of Maximum Likelihood Estimates," *Biometrika*, 80, 27–38.

Fleiss, J. L. (1981), *Statistical Methods for Rates and Proportions*, Second Edition, New York: John Wiley & Sons.

Freeman, D. H., Jr. (1987), *Applied Categorical Data Analysis*, New York: Marcel Dekker.

Furnival, G. M. and Wilson, R. W. (1974), "Regression by Leaps and Bounds," *Technometrics*, 16, 499–511.

Gail, M. H., Lubin, J. H., and Rubinstein, L. V. (1981), "Likelihood Calculations for Matched Case-Control Studies and Survival Studies with Tied Death Times," *Biometrika*, 68, 703–707.

Gordon, H. Scott (1954). "The Economic Theory of a Common-Property Resource: The Fishery." Journal of Political Economy, 62:124-42.

Hanley, J. A. and McNeil, B. J. (1982), "The Meaning and Use of the Area under a Receiver Operating Characteristic (ROC) Curve," *Radiology*, 143, 29–36.

Harrell, F. E. (1986), "The LOGIST Procedure," *SUGI Supplemental Library Guide, Version 5 Edition*.

Heinze, G. (1999), *The Application of Firth's Procedure to Cox and Logistic Regression*, Technical Report 10/1999, update in January 2001, Section of Clinical Biometrics, Department of Medical Computer Sciences, University of Vienna.

Heinze, G. (2006), "A Comparative Investigation of Methods for Logistic Regression with Separated or Nearly Separated Data," *Statistics in Medicine*, 25, 4216–4226.

Heinze, G. and Schemper, M. (2002), "A Solution to the Problem of Separation in Logistic Regression," *Statistics in Medicine*, 21, 2409–2419.

Hirji, K. F. (1992), "Computing Exact Distributions for Polytomous Response Data," *Journal of the American Statistical Association*, 87, 487–492.

Hirji, K. F., Mehta, C. R., and Patel, N. R. (1987), "Computing Distributions for Exact Logistic Regression," *Journal of the American Statistical Association*, 82, 1110–1117.

Hirji, K. F., Mehta, C. R., and Patel, N. R. (1988), “Exact Inference for Matched Case-Control Studies,” *Biometrics*, 44, 803–814.

Hirji, K. F., Tsiatis, A. A., and Mehta, C. R. (1989), “Median Unbiased Estimation for Binary Data,” *American Statistician*, 43, 7–11.

Hosmer, D. W., Jr. and Lemeshow, S. (2000), *Applied Logistic Regression*, Second Edition, New York: John Wiley & Sons.

Howard, S. (1972), “Discussion on the Paper by Cox,” in *Regression Models and Life Tables*, volume 34 of *Journal of the Royal Statistical Society, Series B*, 187–220, with discussion.

Hurvich, C. M. and Tsai, C. (1993), “A Corrected Akaike Information Criterion for Vector Autoregressive Model Selection,” *Journal of Time Series Analysis*.

Izrael, D., Battaglia, A. A., Hoaglin, D. C., and Battaglia, M. P. (2002), “Use of the ROC Curve and the Bootstrap in Comparing Weighted Logistic Regression Models,” in *Proceedings of the Twenty-seventh Annual SAS Users Group International Conference*, Cary, NC: SAS Institute Inc., available at www2.sas.com/proceedings/sugi27/p248-27.pdf.

Lachin, J. M. (2000), *Biostatistical Methods: The Assessment of Relative Risks*, New York: John Wiley & Sons.

Lamotte, L. R. (2002), personal communication, June 2002.

Lancaster, H. O. (1961), “Significance Tests in Discrete Distributions,” *Journal of the American Statistical Association*, 56, 223–234.

Lawless, J. F. and Singhal, K. (1978), “Efficient Screening of Nonnormal Regression Models,” *Biometrics*, 34, 318–327.

Lee, E. T. (1974), “A Computer Program for Linear Logistic Regression Analysis,” *Computer Programs in Biomedicine*, 80–92.

McCullagh, P. and Nelder, J. A. (1989), *Generalized Linear Models*, Second Edition, London: Chapman & Hall.

McFadden, D. (1974), “Conditional Logit Analysis of Qualitative Choice Behaviour,” in P. Zarembka, ed., *Frontiers in Econometrics*, New York: Academic Press.

Mehta, C. R., Patel, N., and Senchaudhuri, P. (1992), “Exact Stratified Linear Rank Tests for Ordered Categorical and Binary Data,” *Journal of Computational and Graphical Statistics*, 1, 21–40.

Mehta, C. R., Patel, N., and Senchaudhuri, P. (2000), “Efficient Monte Carlo Methods for Conditional Logistic Regression,” *Journal of the American Statistical Association*, 95, 99–108.

Mehta, C. R. and Patel, N. R. (1995), “Exact Logistic Regression: Theory and Examples,” *Statistics in Medicine*, 14, 2143–2160.

Moolgavkar, S. H., Lustbader, E. D., and Venzon, D. J. (1985), “Assessing the Adequacy of the Logistic Regression Model for Matched Case-Control Studies,” *Statistics in Medicine*, 4, 425–435.

Murphy, A. H. (1973), “A New Vector Partition of the Probability Score,” *Journal of Applied Meterology*, 12, 595–600.

Naessens, J. M., Offord, K. P., Scott, W. F., and Daood, S. L. (1986), “The MCSTRAT Procedure,” in *SUGI Supplemental Library User’s Guide, Version 5 Edition*, 307–328, Cary, NC: SAS Institute Inc.

Nagelkerke, N. J. D. (1991), “A Note on a General Definition of the Coefficient of Determination,” *Biometrika*, 78, 691–692.

Nelder, J. A. and Wedderburn, R. W. M. (1972), “Generalized Linear Models,” *Journal of the Royal Statistical Society, Series A*, 135, 370–384.

Pregibon, D. (1981), “Logistic Regression Diagnostics,” *Annals of Statistics*, 9, 705–724.

Pregibon, D. (1984), “Data Analytic Methods for Matched Case-Control Studies,” *Biometrics*, 40, 639–651.

Prentice, P. L. and Gloeckler, L. A. (1978), "Regression Analysis of Grouped Survival Data with Applications to Breast Cancer Data," *Biometrics*, 34, 57–67.

Press, S. J. and Wilson, S. (1978), "Choosing between Logistic Regression and Discriminant Analysis," *Journal of the American Statistical Association*, 73, 699–705.

Santner, T. J. and Duffy, E. D. (1986), "A Note on A. Albert and J. A. Anderson's Conditions for the Existence of Maximum Likelihood Estimates in Logistic Regression Models," *Biometrika*, 73, 755–758.

SAS Institute Inc. (1995), *Logistic Regression Examples Using the SAS System*, Cary, NC: SAS Institute Inc.

Schaefer, Milner B. (1957). "Some Considerations of Population Dynamics and Economics in Relation to the Management of the Commercial Marine Fisheries." Journal of the Fisheries Research Board of Canada, 14(5):669-681.

Stokes, M. E., Davis, C. S., and Koch, G. G. (2000), *Categorical Data Analysis Using the SAS System*, Second Edition, Cary, NC: SAS Institute Inc.

Storer, B. E. and Crowley, J. (1985), "A Diagnostic for Cox Regression and General Conditional Likelihoods," *Journal of the American Statistical Association*, 80, 139–147.

Venzon, D. J. and Moolgavkar, S. H. (1988), "A Method for Computing Profile-Likelihood Based Confidence Intervals," *Applied Statistics*, 37, 87–94.

Vollset, S. E., Hirji, K. F., and Afifi, A. A. (1991), "Evaluation of Exact and Asymptotic Interval Estimators in Logistic Analysis of Matched Case-Control Studies," *Biometrics*, 47, 1311–1325.

Walker, S. H. and Duncan, D. B. (1967), "Estimation of the Probability of an Event as a Function of Several Independent Variables," *Biometrika*, 54, 167–179.

Ward, J.M. (1994). "The Bioeconomic Implications of a Bycatch Reduction Device as a Stock Conservation Management Measure." Marine Resource Economics, 9(3):227-240.

Williams, D. A. (1982), "Extra-binomial Variation in Logistic Linear Models," *Applied Statistics*, 31, 144–148.

Figure 1: Risk and Uncertainty

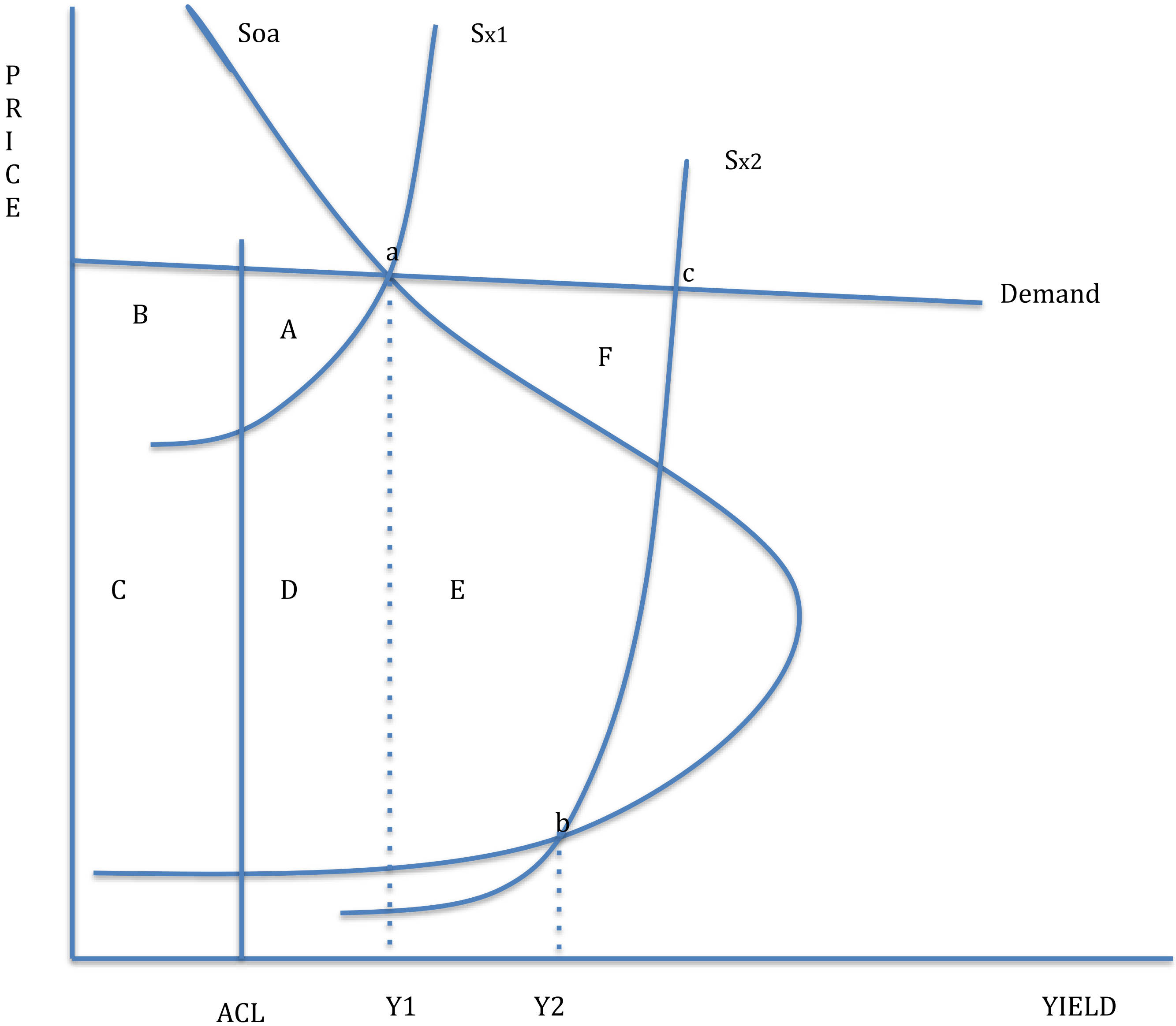

Table 1: Probability Distribution of Thrown Two Dice

Outcome	Frequency	Probability
2	1	0.0278
3	2	0.0556
4	3	0.0833
5	4	0.1111
6	5	0.1389
7	6	0.1667
8	5	0.1389
9	4	0.1111
10	3	0.0833
11	2	0.0556
12	1	0.0278
Total	36	1.0000

Table 2. Summer Flounder Size Class Probability Distribution (2011)

Size Class MidPt (inches)	Frequency (in number of fish landed)	Percent
1	1	0.00095
2	5	0.00475
3	1	0.00095
4	5	0.00475
5	7	0.01
6	110	0.10
7	188	0.18
8	278	0.26
9	494	0.47
10	903	0.86
11	1177	1.12
12	2811	2.67
13	6257	5.94
14	11406	10.83
15	17131	16.27
16	14156	13.45
17	12730	12.09
18	11158	10.60
19	9116	8.66
20	5877	5.58
21	4067	3.86
22	2468	2.34
23	1596	1.52
24	844	0.80
25	706	0.67
26	239	0.23
27	161	0.15
28	123	0.12
29	125	0.12
30	278	0.26
31	142	0.13
32	50	0.05
33	118	0.11
34	43	0.04
35	19	0.02
36	39	0.04
37	159	0.15
38	119	0.11
39	14	0.01
40	5	0.0047494
41	29	0.03
42	17	0.02
43	67	0.06
44	1	0.00095
45	31	0.03
54	3	0.0028496
67	1	0.00095
107	2	0.0018998
Total	105277	1.00

Appendix A

Allocation of Recreational Catch by Size Category: A Users Guide

Introduction

Operationalizing the concepts of risk and uncertainty for this particular type of fisheries management problem requires the use of a series of computer programs written in the SAS data set language and utilizing a number of SAS procedures. The remainder of this section provides step-by-step instructions that explain the use of these programs that accesses the MRFSS and MRIP data files to estimate the probability that a fish landed by an angler falls within a certain size category given that it is of a particular species, which in this case is summer flounder. Uncertainty theory is applied to determine the impact on the probability of landing or catching a fish in a certain size class from a change in the existing fishery management infrastructure in the presence of insufficient information. Once this probability is estimated, it can be applied to the total number of fish landed or caught in each state estimated by a stock assessment to determine the distribution of catch by size category for a given set of proposed regulations.

Program Steps

The first three programs are necessary to create the permanent SAS data set for a particular species, updates that data set when additional data becomes available, and creates the final database for use in the subsequent statistical analysis. The SAS program Logistic Model estimates the ratio of the odds that a specific summer flounder will be in a specific size category. ProbEstimate I and II converts the ratio of the odds into the probabilities for a given set of conditions in the fishery from which the final numbers of fish by size category are predicted. The program Regional converts these size category estimates into regional summaries.

The program CBAModel estimates the total number of fish landed and fish caught using a simultaneous equation model for use in developing an index of costs and benefits for a proposed change in fishery management regulations. The program PolicyModel estimates the costs and benefits for comparison to a user specified base case. The estimated parameters in CBAModel that are used to estimate the number of fish landed or caught in each state could also be used in ProbEstimate II to predict the numbers of fish in each size category.

I. Program I.

Temporary data files for each wave within a year can be downloaded directly from the NMFS recreational data website as SAS formatted data sets. Program I creates an annual data set for a particular fish species by combing the wave data sets. In the process, three variables are created to determine if a fish is targeted, nontargeted, or a secondary targeted fish for the recreational angler based on a SAS variable prim1 or prim2; respectively. One-inch size categories are also created from fish length variable measured in millimeters. A frequency distribution for each year is estimated as output from this program.

The initial stage of this program identifies where the permanent SAS data file will be saved on the PC, using the libname statement. Next, are the macro commands that identify the permanent SAS output data file (`%Let A = sasout.i2011;`) and the temporary SAS input data files (`%Let B = i2011wave1;`). These wave files created downloaded from the NMFS website are combined into a single data file for a specific year (sasout.i2011). Once this data file has been created using the set statement, the if statement limits the data in the file to summer flounder by selecting on species code 88570301; that is, it selects summer flounder as the species that will be contained in the permanent SAS data file:

```
libname sasout 'c:\Users\John Ward\My Documents\My SAS Files(32)';
%Let A = sasout.i2011;
%Let B = i2011wave1;
%Let C = i2011wave2;
%Let D = i2011wave3;
%Let E = i2011wave4;
%Let F = i2011wave5;
%Let G = i2011wave6;
data &A;
      set &A &B &C &D &E &F &G;
            if sp_code = 8857030301;       *Summer Flounder;
              run;
```

From this point forward the data set consists exclusively of the species selected by the

```
if sp_code = 8857030301;
```

command.

The next stage in this program is a set of commands that determine whether the selected species is the primary target of the fishing trip (DPrim1= 1), is a secondary target of the fishing trip (DPrim2 = 1), that is, an incidental catch; or is not a target of the fishing trip (NTPrim1 = 1); that is, no fish species was identified as the target of the fishing trip.

Beginning with the comment:

```
*---------Establishment of Size Class-------------------------------;
```

is a set of commands that converts the fish length in millimeters to one inch size classes.

The program ends with a proc chart command that creates a series of histograms that displays the distribution of number of fish by size class and state of reported landing for this specific year and fish species. A proc means command provides the total number of fish reported landed for the interview data. This total number of fish is used in the next step as a variable in the estimation of the probability of a fish being landed in a certain size class.

Program II

Program II creates the final database by combining the annual permanent SAS data files into a final combined permanent SAS data file called sasout.SF8112. This file name indicates that data from 1981 to 2012 have been combined into one database. Some additional record type errors are corrected following the creation of the annual dataset. A series of if then do statements are used to add abundance (SSB) and the total number of summer flounder landed (TotSFL) in a specific year to the sasout.SF8112 database for summer flounder.

This program can be easily modified to allow the database "sasout.SF8112" to be updated when 2013 and 2014 to present data becomes available:

```
data sasout.SF8112;
  set sasout.SF8111 sasout.i2013 sasout.i2014;
run;
```

Program III

Additional information needed to estimate the probability that a fish caught is in a given size class is added in Program III. To delete discarded fish from the temporary data file, the third line of the program can be used:

```
if Num_typ9 > 0 then delete;
```

Some additional information is included in the database prior to the estimation of the probabilities since both fishermen and anglers exploit summer flounder. This information reflects U.S. population size, price per pound of commercially harvested summer flounder, the prime rate on capital investment, the fuel producer price index, and the summer flounder fisheries management history. The fishery management history is included as specific changes in area, possession, and size limits as well as the dates of adoption for specific amendments to the management plan. While these FMP and amendment qualitative variables were dropped from the model statement since they were not statistically significant once the specific size and possession limits were incorporated into the analysis, they remain as part of the program in the event that conditions in the fishery change at some point in the future. State variables are also formatted in this program.

Logistic Model

The ratio of the odds that a fish is in a given size class is estimated in the program Logistic Model. Based on the data contained in the SAS work data file data one in line two of the program. The final stage of this program saves the estimated coefficients to a file named betas.

ProbEstimate I and II

The coefficients saved in the work.data file betas are used to calculate the probability that a fish landed or caught is in a given size category for a proposed fishery management scenario. ProbEstimate I formats the variables and summarizes the data into the necessary values with which the probabilities the created.

ProbEstimate II estimates the probabilities for each size class. These probabilities are then used to estimate the number of fish that will be landed or caught in each size category. A set of macro at the beginning of Program II set the conditions that are used to estimate the numbers of fish by size class. The first two macros set the year and state for which the probabilities are estimated. The next set of macros are used to determine the number of fish per size category. The macro corresponding to the state identified in the second macro is uncommented in this set of macros. Following that, the individual regulations to be analyzed are specified. The slot limit is determined by setting MaxSize at the upper size limit and the CL variable at the level of compliance; 1 for no compliance, 0 for full compliance, and partial compliance is a value between 0 and 1.

Regional

The output from the state level model in ProbEstimate II is saved in a SAS work file named Done. Once all state level analyses are complete, this file is used in the Regional SAS program to create a table of regional number of fish landed by size class. This program aggregates state level numbers of fish by size class into North Atlantic, Mid Atlantic, and South Atlantic regions.

CBA Model

The estimated probabilities need a total number of fish caught or landed to determine the number of fish in each size category for a particular state. These total numbers of fish can be derived from another source or can be estimated using the CBA Model program.

This program uses the MRFSS and MRIP survey data to estimate the number of trips for summer flounder and the number of summer flounder landed using a model based on the household production function recreational model (Bockstael and McConnell, 1983) solve simultaneously using three stage least squares; e.g.,

```
proc syslin data = onec outest=a2 3sls converge=0.0001 maxit=500;
endogenous
LnTotSflLnd2 lnTtrip;
instruments
 Lnwgt LnSSB LnSSBsfldp LnSSBFPPI LnSSBPr LnSBBYear Lnparty Lnffdays12 Lnffdays2 LnHrsf
LnminsLm Lnminslmi LnPoslmt LnPoslmti LnminsLm81-lnminslm99 LnminsLmi81-lnminslmi99
LnPoslmt81-Lnposlmt99 LnPoslmti81-Lnposlmti99 LnminsLm00-lnminslm12 dyr81-dyr99 dyr00
dyr01-dyr12 LnminsLmi00-lnminslmi12 LnPoslmt00-Lnposlmt12 LnPoslmti00-Lnposlmti12
FedAlloc LnOpenSea LnARecTrgt Lnsfldp LnFPPI Lnpr Lnnp npd omega3 Dprim1 NTPrim1 Dprim2
stME stNH stMA stRI stNY stNJ stDE stMD stVA stNC;


Trips: model lnTtrip  =  LnTotSflLnd2 Lnwgt Lnparty Lnffdays12 Lnffdays2 LnHrsf LnminsLm
Lnminslmi LnPoslmt LnPoslmti LnminsLm81-lnminslm99 LnminsLmi81-lnminslmi99 LnPoslmt81-
Lnposlmt99 LnPoslmti81-Lnposlmti99 LnminsLm00-lnminslm12 LnminsLmi00-lnminslmi12
LnPoslmt00-Lnposlmt12 LnPoslmti00-Lnposlmti12 FedAlloc LnOpenSea LnARecTrgt Lnsfldp
LnFPPI Lnpr Lnnp npd Dprim1 NTPrim1 Dprim2 stME stNH stMA stRI stNY stNJ stDE stMD stVA
```

```
stNC dyr81-dyr99 dyr00 dyr01-dyr12;

SFldLnd2: model LnTotSflLnd2 = lnTtrip Lnwgt LnSSB LnSSBsfldp LnSSBFPPI LnSSBPr LnSBBYear
Lnparty Lnffdays12 Lnffdays2 LnHrsf LnminsLm Lnminslmi LnPoslmt LnPoslmti LnminsLm81-
lnminslm99 LnminsLmi81-lnminslmi99 LnPoslmt81-Lnposlmt99 LnPoslmti81-Lnposlmti99
LnminsLm00-lnminslm12 LnminsLmi00-lnminslmi12 LnPoslmt00-Lnposlmt12 LnPoslmti00-
Lnposlmti12 FedAlloc LnOpenSea LnARecTrgt Lnsfldp LnFPPI Lnpr Lnnp npd Dprim1 NTPrim1
Dprim2 stME stNH stMA stRI stNY stNJ stDE stMD stVA stNC;
```

The trips and quality of the trip measured in terms of the number of fish landed are estimated with the coefficients stored in an output file (a2).

Policy Model

The program Policy Model develops an estimate of the number of trips and the level of landings for a user specified set of fishery management regulations. The lines 3 to 6 in the program create a data set for each state and year.

```
Data NoFish;
set onec;
   if wgt > 0 and wgt ne . and stNC = 1 and Year = 2011;
                                      *Individual State Predictions;
   run;
```

The proc means procedure is used to determine the average values for the variables used in the estimation equation; these values are output into a data file named a1m. The mean values for the qualitative variables represent the percent of total observations that have a value for the attribute described by the variable. These percentages are used to weight the estimated parameters for those qualitative variables. This weighted value for the set of attributes described by the qualitative variable returns an average effect of that variable on the probability that a fish landed or caught falls in a particular size class.

The coefficients from the three stage least squares simultaneous equation estimation of the trip demand equation and the trip quality equation from data set a1 are added to the tripEst data set using:

```
Data tripEst;
      set a1; if _type_ = "3SLS" and _Model_ = "TRIPS";
      drop _TYPE_;
run;
```

These coefficients are merged with the mean variable values in data set alm into the data set test:

```
data test;
      merge tripest a1m;
```

This data statement also sets missing values of various variables equal to zero to enable the estimation of numbers of trips and fish for proposed fishery management regulations.

The status quo and proposed regulations are specified following the comment:

```
*------------State Variables--------------------------------;
```

First, a year is specified using the variable

dyr??var =1;

where the ?? is a two digit designation for the year; e.g., 11.

Next, the state is designated from the list:

```
    stMEvar = 0;
    stNHvar = 0;
    stMAvar = 0;
    stRIvar = 0;
   *stCTvar = 0;  *Base case;
    stNYvar = 0;
    stNJvar = 0;
    stDEvar = 0;
    stMDvar = 0;
    stVAvar = 0;
    stNCvar = 1;
    stSCvar = 0;
```

where Connecticut (stCTvar = 0) is the base case. All other states are designated by setting the state variable equal to 1; e.g., stNCvar= 1;

The proposed regulations are listed next:

```
/*----------------------Proposed Regulations-------------------------;
      Poslmtvar = 4;     LnPoslmtvar = log(Poslmtvar);
      Poslmtivar = 4;    LnPoslmtivar = log(Poslmtivar);
      minslmvar = 16;    Lnminslmvar = log(minslmvar);
      minslmivar = 16;   Lnminslmivar = log(minslmivar);
      OpenSeavar = 365; LnOpenSeavar = log(OpenSeavar);
      ARecTrgtvar = 0.947848101; LnARecTrgtvar = log(ARecTrgtvar);
--------------------------------------------------------------------*/;
```

where Poslmtvar is the federal possession limit,
Poslmtivar is the state possession limit,
minslmvar is the federal minimum size limit,
minslmivar is the state minimum size limit,
OpenSeavar is the length of the open fishing season, and
ARecTrgtvar is the recreational target harvest level in millions of pounds.

Following these commands are the status quo fishery regulations in existence for each state in the year that is being evaluated; e.g.,

```
*--------------------Status Quo Regulations----------------------------;
            * CTvar is base case - All state var = 0;
            Poslmtvar = 5;          LnPoslmtvar = log(Poslmtvar);
            Poslmtivar = 5;         LnPoslmtivar = log(Poslmtivar);
            minslmvar = 18;         Lnminslmvar = log(minslmvar);
            minslmivar = 18;        Lnminslmivar = log(minslmivar);
            OpenSeavar = 128;       LnOpenSeavar = log(OpenSeavar);
            ARecTrgt = 5.534680851; LnARecTrgtvar = log(ARecTrgt);
                  LnPoslmt11var = LnPoslmtvar*dyr11var;
                  LnPoslmti11var = LnPoslmtivar*dyr11var;
                  Lnminslm11var = Lnminslmvar * dyr11var;
                  Lnminslmi11var = Lnminslmivar * dyr11var;
```

Following the specification of these proposed and status quo regulation values, the trip demand equation is used to estimate the number of trips for this set of regulations in each state. This procedure is then repeated for the number of fish that these trips will generate in each state.

The final equation estimates the net benefits from the demand for trips equation.

```
*--------------------Cost Benefit Estimate-------------------------;
```

The difference in value calculated for the status quo and proposed regulations can be used to create an index of the change in benefits net of costs for the two scenarios.

V. Example

Beginning with Table 1, the MRFSS/MRIP data maintained by NOAA is accessed to determine the level of estimated recreational harvest of summer flounder; specifically the level of harvest based on the A+B1 records from the survey of anglers; i.e., Total Harvest (A+B1). This provides a level of harvest for each state for a particular year. That is 269,220 summer flounder were harvested in Connecticut in 2013 according to the NOAA estimate in Table 1.

Table 2 provides an estimate based on the MRFSS/MRIP survey data of estimated

Table 1. MRFSS/MRIP Estimates

Estimate Status	Year	State	Common Name	Total Harvest (A+B1)	PSE
FINAL	2013	CONNECTICUT	SUMMER FLOUNDER	269,220	18.7
FINAL	2013	DELAWARE	SUMMER FLOUNDER	54,072	14.6
FINAL	2013	FLORIDA	SUMMER FLOUNDER	3,490	52.7
FINAL	2013	GEORGIA	SUMMER FLOUNDER	6,755	96.4
FINAL	2013	MARYLAND	SUMMER FLOUNDER	51,140	22.9
FINAL	2013	MASSACHUSETTS	SUMMER FLOUNDER	29,848	26.9
FINAL	2013	NEW JERSEY	SUMMER FLOUNDER	1,220,806	14.9
FINAL	2013	NEW YORK	SUMMER FLOUNDER	443,312	15.9

FINAL	2013	NORTH CAROLINA	SUMMER FLOUNDER	44,941	17.2
FINAL	2013	RHODE ISLAND	SUMMER FLOUNDER	118,374	27.8
FINAL	2013	SOUTH CAROLINA	SUMMER FLOUNDER	786	32.8
FINAL	2013	VIRGINIA	SUMMER FLOUNDER	187,638	31.6

Table 2. Estimated Status Quo Regulation Expansion Factor

State	Expansion Factor	SFLD Harvest Estimate	Trip Estimate	Net Benefits
CONNECTICUT	78394.48833	3.43417	1.83091	8.89499
DELAWARE	1352.570965	39.9772	2.73396	66.4582
FLORIDA				
GEORGIA				
MARYLAND	11085.98904	4.61303	2.42569	19.3565
MASSACHUSETTS	5965.16192	5.00372	2.47831	1.41897
NEW JERSEY	23908.35437	51.0619	3.55238	86.4916
NEW YORK	13933.88108	31.8154	3.23197	67.5602
NORTH CAROLINA	1246.411861	36.0563	3.02685	21.8872
RHODE ISLAND	11311.20284	10.4652	2.41066	59.1792
SOUTH CAROLINA				
VIRGINIA	5864.677164	31.9946	3.09693	48.2929

Table 3. Estimated Proposed Regulation Harvest Level

State	Est.Harvest	SFLD Harvest Estimate	Trip Estimate	Net Benefits	Benefit/Cost Ratio
CONNECTICUT	245853.7388	3.13611	1.67613	8.12297	91.32073223
DELAWARE	51858.11184	38.3404	2.61016	63.7371	95.90554664
FLORIDA					
GEORGIA					
MARYLAND	50780.25966	4.58058	2.30632	19.2204	99.29687702
MASSACHUSETTS	39000.70584	6.53808	2.40165	1.85409	130.6644961
NEW JERSEY	1509948.856	63.1557	3.28631	106.977	123.6848434
NEW YORK	453897.5695	32.5751	2.96664	69.1733	102.3876483
NORTH CAROLINA	59621.61283	47.8346	2.99326	29.0369	132.6661245
RHODE ISLAND	182086.6123	16.0979	2.08545	91.0314	153.8233028
SOUTH CAROLINA					
VIRGINIA	188904.1838	32.2105	3.11627	48.6188	100.6748404

harvest (SFLD Harvest Estimate) for the regulation in place for the year of interest. This SFLD Harvest Estimate from Table 2 and the Total Harvest (A+B1) estimate from Table 1 are used to calculate an Expansion Factor for each state (Table 2). A new set of SFLD Harvest Estimates are calculated based on the proposed fishery management regulations in Table 3. The Expansion Factors in Table 2 are used to generate an estimated harvest (Est.Harvest) for each state with the difference between the harvest in Table 1 and Table 3 due solely to the change in regulations. For example, in Table 1, NOAA estimated a total harvest (A+B1) of 269,220 summer flounder for Connecticut. The change in regulations resulted in an estimated harvest (Est.Harvest in Table 3) of 245,854 for Connecticut.

The simultaneous equation model used to estimate harvest of summer flounder also estimated the number of trips by anglers for summer flounder. These estimates of number of trips are used to calculate the net benefits from recreationally fishing for summer flounder under the two sets of management regulations (status quo and proposed). The ratio of the proposed to status quo net benefits is reported in Table 3. Again using Connecticut as an example, there is an 8.7 percent decline in net benefits for recreational anglers due to the proposed regulations adoption in that state. This decline is not typical across states with, for example, New Jersey receiving a 32.7 percent increase in net benefits due to the adoption of the proposed regulations relative to the status quo.

Finally, the change in the distribution of size categories of the harvest due to the change in regulations can also be estimated. An example of this analysis is attached as Summer Flounder Reallocation Affects SZCLS.xlsx.

V. Summary

While the concepts underlying this analysis are relatively simple, their application is more complex. This report is intended to explain the steps necessary to develop both estimates of state landed or caught fish and their distribution across fish size categories for different regulatory scenarios.

Steps I to IV only need to be used when information for a new year becomes available. The programs in and after step III can be used if the existing data set is to be modified for another species of recreationally harvested fish. These steps will update the database needed to estimate a new sets of coefficients for use in a policy analysis of any existing or proposed fishery management regulations.

In the event that a stock assessment has been conducted for landed or caught fish in each state, only the programs ProbEstimateI and ProbEstimateII need to be used to decompose the state totals into their expected size categories. Where these independent estimates of landed fish by state do not exist, the programs CBAModel and PolicyModel can be used to estimate the total landed fish by state for use in regulatory analysis to determine the size distribution of a fish landed.