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**U.S. DEPARTMENT OF COMMERCE**
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
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# Regional Economic Analysis for North Pacific Fisheries

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## ABSTRACT

Although there are many studies of economic impacts of Alaska fisheries conducted by the Alaska Fisheries Science Center (AFSC) Economic and Social Sciences Research (ESSR) group, none of the models used for these studies have been utilized by the economists and social scientists in Alaska Regional Office (AKRO), North Pacific Fishery Management Council (NPFMC), and other agencies who are tasked with evaluating the economic impacts of proposed fishery management policies. There are several reasons for this. First, there is a gap between the time when the analysts need the economic impact analysis for the policies at hand and the time when the model development is completed by ESSR and available for AKRO or Council analyses. Second, even when the models are available to the analysts, they may not be familiar with the structure of the models, and therefore, find it difficult to implement the models and interpret the results.

In order to address these issues, AFSC and AKRO economists launched a project to develop a web-based software application that the analysts, without in-depth knowledge of regional economic models, can be used to estimate the economic impacts of fishery management actions or environmental shocks. This project resulted in user-friendly software and a user manual. This report is intended for those analysts in ESSR, AKRO, and NPFMC who are not familiar with regional economic modeling but will use this software. This report (i) introduces the basics of the regional economic models that are often used for economic impact analyses for fisheries, and (ii) provides a description of the model used in the software, called the Adjusted Demand-driven Multi-regional Social Accounting Matrix (MRSAM) model. Appendix B contains a user manual that provides step-by-step instructions on how to use the regional economic analysis web-based application software to model impacts of commodity-based shocks, industry-based shocks, or a combination of the two shocks.

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# INTRODUCTION

Federal laws governing U.S. marine fisheries require that an analysis of regional or community economic impacts from a proposed fishery management action be conducted. These laws include, among others, the Magnuson-Stevens Fishery Conservation and Management Act (MSA, reauthorized in 2006), National Environmental Policy Act (NEPA), and Executive Order 12866. National Standard 8 (MSA Section 301[a][8]), for example, mandates that, to the extent practicable, fishery management actions minimize economic impacts on fishing communities. To satisfy the National Standard 8, fishery managers must take into account the economic impacts arising from management actions on various stakeholder groups (e.g., fishermen, processors, and fishing-dependent communities).

In an effort to meet these requirements, the Economic and Social Science Research (ESSR) group in the Alaska Fisheries Science Center (AFSC) has conducted a myriad of studies of Alaska fisheries using different types of regional economic models. These studies examined the regional economic effects of potential fishery management actions and environmental shocks such as climate change. For example, Seung and Waters (2009) computed the economic impacts on Alaska of a hypothetical reduction in pollock TAC in terms of output, employment, value added, and household income. Seung and Waters (2013) evaluated the regional economic impacts of Steller sea lion protection measures for Alaska.

Although there are many studies of economic impacts of Alaska fisheries conducted by ESSR, none of the models used for these studies have been utilized by the analysts (economists and social scientists) in Alaska Regional Office (AKRO), North Pacific Fishery Management Council (NPFMC), and other agencies who are tasked to evaluate the economic impacts of proposed fishery management policies. There are several reasons for this. First, there is a gap between the time when the analysts need the economic impact analysis for the policies at hand and the time when the model development is completed by ESSR. It usually takes an enormous amount of time to develop a regional economic model designed to address a specific proposed fishery management action. In contrast, the analysts are usually tasked with completing the impact analysis in a relatively short time frame. Second, even when the models are available for the analysts, the AKRO and Council analysts may not be familiar with the structure of the models and, therefore, find it difficult to implement the models and interpret the model results.

To address these issues, AFSC and AKRO economists launched a project to develop a web-based software application that analysts lacking in-depth knowledge of regional economic models can use to estimate the economic impacts of fishery management actions or environmental shocks. This project was completed in 2018, resulting in user-friendly software, the user manual, and this report (the present document). This report is intended for those analysts in ESSR, AKRO, and NPFMC who are not familiar with regional economic modeling, but may have a need to use this software to estimate regional economic effects of proposed fishery management actions. This report introduces the basics of the regional economic models that are often used for economic impact analyses for fisheries, and describes the model used in the software, called the Adjusted Demand-driven Multi-regional Social Accounting Matrix (MRSAM) model. A multi-regional economic impacts such as the one used in the software is particularly useful for analysis of Alaska fisheries that depend heavily on the economies of other U.S. states, especially Washington State. Appendix B contains a user manual for the web-based application software that provides step-by-step instructions on how to use the regional economic analysis software.

## Alaska Fisheries and Economy

In 2016, fish harvest from waters off Alaska accounted for about 58% by weight of the total U.S. commercial fish harvest [National Marine Fisheries Service (NMFS) 2017]. This constituted about 5.9 billion pounds of fish and shellfish with an ex-vessel value of about $1.6 billion. Harvest of groundfish generated about 50.7% of this ex-vessel value, followed by salmon (25.9%), shellfish (15.7%), halibut (6.9%), and herring (0.4%). Commercially, pollock is the most valuable among the groundfish species caught in Alaska waters. In 2016, the pollock harvest was 1.53 million metric tons (t) or 67% of the total groundfish catch. The ex-vessel value from the pollock harvest was $433.8 million, accounting for 50% of the total ex-vessel value for groundfish. Other commercially important groundfish species are Pacific cod, sablefish, and several species of flatfish [North Pacific Fishery Management Council (NPFMC) 2017]. In the same year, the Alaska seafood industry directly accounted for about 2.8% of total state employment of 332,138 jobs, and about 2.6% of $17.7 billion total state earnings (Alaska Department of Labor and Workforce Development, http://live.laborstats.alaska.gov/qcew/ee16.pdf).

The Alaska economy depends to a large extent on the economies of the rest of United States, via importing large amounts of factors of production and input commodities from the rest of the United States. This means that a significant portion of the economic impact from fishery and non-fishery policies for Alaska leaks out of the state. First, a large proportion of workers in many Alaska industries are non-residents. In 2015, non-Alaskan residents made up about 21.3% of total private and state and local government employment in Alaska. As a result, about 16.0% of the total labor earnings from the private and the state and local government sectors leaked out of the state. The seafood processing sector suffers the largest leakage of labor income (64.6%), followed by agriculture, forestry, and fishing and hunting (50.2%, mostly fishing); mining (33.3%); accommodation (32.4%); arts, entertainment, and recreation (23.9%); and the transportation and warehousing (23.6%) sectors (Alaska Department of Labor and Workforce Development 2017). Second, a large amount of capital used in Alaska industries (fishing vessels and processing plants in the case of seafood industries) is owned by non-Alaskan residents, which implies that much of the capital income generated in the state flows to the other states. Third, many of the goods and services used by Alaska seafood and non-seafood industries and by households are imported from other states. A previous study (Seung 2014a) indicates that, in 2008, the total value of imports of all commodities to Alaska ($15.9 billion) from non-Alaskan U.S. states is about 31% of the total value of production ($51.2 billion) in the state.

## Regional Economic Models

### Input-Output Models

In an Input-Output (IO) model, multipliers are derived from the relationships among different industries in an economy. Analysts use the multipliers to compute the economic impacts from a change in final demand which is usually estimated outside of the model. Since Wassily Leontief developed an IO model of the United States in the 1930s, IO models have been a basic tool for regional economic impact analysis. Applications of the models have been wide-ranging; the models have been used in analyses of regional economic development, resource management problems, and environmental issues. For fisheries, analysts have used the models to assess the economic impacts from commercial and recreational fisheries. This section provides a short overview of the fundamental features of single-region IO models, based on Miller and Blair (1985) and Seung and Waters (2005). For a discussion of interregional and multiregional IO models, see, for example, Miller and Blair (1985) and Hewings and Jensen (1986). Richardson (1985) provides a survey of IO studies conducted before 1985. For a review of IO studies for fisheries, see Andrews and Rossi (1986) and Seung and Waters (2006).

**Input-Output Model Basics**

Suppose a regional economy consists of *n* sectors. Let sector *i*'s total output and total final demand for sector *i*'s product be denoted $X_i$ and $Y_i$, respectively. Then, the following relationship holds:

$$X_i = Z_{i1} + Z_{i2} + \ldots + Z_{ii} + \ldots + Z_{in} + Y_i,\ i = 1, 2, \ldots, n, \qquad \text{Eq. (1)}$$

where $Z_{ij}$ are dollar value of interindustry purchase by sector *j* from sector *i*. The *j*th equation in the above equation system describes how sector *j*'s output is distributed to the other sectors (industries) and the final users. The elements in the *i*th column on the right-hand side of the equation system above are $[Z_{1i}, Z_{2i}, \ldots, Z_{ii}, \ldots, Z_{ni}]$. These elements represents sector *i*'s purchases of *n* different products from the *n* different sectors. These products are used as inputs in sector *i*'s production. These inputs are called intermediate inputs. A fundamental assumption in IO models is that the flows of the intermediate input from *i* to *j* depend entirely and exclusively on the level of total output of sector *j*. Thus, a technical coefficient or input-output coefficient ($a_{ij}$) is defined as the ratio of the flow of input from *i* to *j* ($Z_{ij}$) to sector *j*'s output ($X_j$):

$$a_{ij} = \frac{Z_{ij}}{X_j} \text{ or } Z_{ij} = a_{ij}X_j\ . \qquad \text{Eq. (2)}$$

Substituting Equation (2) into Equation (1) and rearranging the terms yields,

$$
\begin{aligned}
&(1-a_{11})X_1 - a_{12}X_2 - \ldots - a_{1i}X_i - \ldots - a_{1n}X_n = Y_1 \\
&-a_{21}X_1 + (1-a_{22})X_2 - \ldots - a_{2i}X_i - \ldots - a_{2n}X_n = Y_2 \\
&. \\
&. \\
&-a_{i1}X_1 - a_{i2}X_2 - \ldots + (1-a_{ii})X_i - \ldots - a_{in}X_n = Y_i \\
&. \\
&. \\
&-a_{n1}X_1 - a_{n2}X_2 - \ldots - a_{ni}X_i - \ldots + (1-a_{nn})X_n = Y_n. \qquad \text{Eq. (3)}
\end{aligned}
$$

Expressing the system of equations in (3) in matrix terms,

$$\boldsymbol{(I\text{-}A)X = Y} \qquad \text{Eq. (4)}$$

or

$$\boldsymbol{X = (I - A)^{-1}Y,} \qquad \text{Eq. (5)}$$

where $\boldsymbol{I}$ is an $n \times n$ identity matrix; $\boldsymbol{A}$ is an $n \times n$ input-output coefficient matrix of $a_{ij}$'s; $\boldsymbol{X}$ is a column vector of $X_i$'s (industry outputs); and $\boldsymbol{Y}$ is a column vector of $Y_i$'s (final demand for commodities). Here, $\boldsymbol{X}$ is a vector of endogenous variables and $\boldsymbol{Y}$ a vector of exogenous variables. $\boldsymbol{(I\text{-}A)^{-1}}$ is often referred to as Leontief inverse whose elements represent total impacts on individual sectors (industries) when there is an exogenous change in final demand *by one unit*. So Equation (5) can be used to calculate the total impact on output ($\boldsymbol{X}$) in the different sectors of the economy when there is a change in final demand ($\boldsymbol{Y}$).

The final demand ($\boldsymbol{Y}$) for a sector's product in Equation (5) comprises household demand, government demand, investment demand, and exports. Households spend their labor income to purchase goods and services for their final consumption. The amount of their purchases depends on their labor income, which they earn in return for their labor services to production processes.

Therefore, their labor income depends on the level of output of each of the production sectors. Because household expenditures make up a major fraction of the final demand in most economies and because the level of household income (labor income) is determined by the level of industry output in an economy, one could make the household sector an endogenous sector. This is known as closing the model with respect to households. Hence the model closed with respect to households is called a "closed model" while the model in Equation (5), where only production sectors are endogenous, is called an "open model."

**Direct, Indirect, and Induced Effects**

There are three types of effects calculated in an IO model – direct, indirect, and induced effects. Direct effects refer to the initial changes in the final demand. Indirect effects represent the effects transpired by iteration of changes in industries' purchases from other industries in response to the direct effects. Induced effects are the additional changes caused by the change in household income and spending which is generated by the direct and indirect effects.

Total effects are the sum of direct and indirect effects in an open IO model while, in a closed IO model, the total effects are the sum of all the three types of effects above. Multipliers are obtained simply by dividing the total effects by the direct effects. Depending on which of the two models (open or closed model) is used, two types of multipliers are computed – simple multipliers and total multipliers. The former is derived using only direct and indirect effects (from an open model) while the latter is calculated using all the three types of effects (from a closed model). To calculate the multipliers, the Leontief inverse in Equation (5) is used; the multiplier for an industry is derived by summing the elements in the column representing the industry in the Leontief inverse.

**Backward Linkage and Forward Linkage**

In regional economic impact analysis, there are two broad categories of inter-industry linkages that need to be considered, depending on the direction the impacts that occur – backward linkage and forward linkage. Backward linkage refers to the relationship between an industry and the industries from which the first industry buys the inputs needed to produce its output. So an exogenous change in the first industry will generate backward-linkage effects on the industries that supply inputs to the industry. The IO model in Equation (5) is designed to capture only the backward-linkage effects. Forward linkage is the relationship between an industry and the industries to which the first industry sells the outputs needed to produce outputs in the industries that buy the first industry's output. So an exogenous change in the first industry will produce forward-linkage effects on the industries that depend on the first industry for its output, however these forward linkages are not included in IO models.

**Social Accounting Matrix Models**

A social accounting matrix (SAM) is a matrix consisting of expenditure and income accounts, and it is a useful way of representing an economy at one point in time. Rows record incomes or receipts to economic agents and columns record expenditures or payments by the economic agents. The matrix is a balanced matrix, meaning that total receipts (the sum of the elements in a row for an account) are equal to total expenditures (the sum of the elements in the column for the account). SAM accounts are an extension of traditional IO accounts. To build a SAM, one starts with specifying the IO accounts. IO accounts show detailed industry, commodity, factor, and final demand transactions. These accounts are balanced to reflect market-level equilibrium, as well as the aggregate income-expenditure equilibrium. In addition to these IO accounts, a SAM has the accounts showing non-market financial flows such as tax payments by households and firms and fund transfers between households or institutions. See King (1985) and Pyatt and Round (1985) for a more detailed discussion of a SAM. Table 1 presents the structure of a regional SAM (2004 Alaska SAM), which is the basis for the multi-regional social accounting matrix (MRSAM) model used in the web-based software application.

While an IO model is developed using an IO table, a SAM model is constructed based on a SAM. IO models capture a major source of linkages in an economy by including the transactions of intermediate inputs among industries. However, one limitation of IO models is that the models fail to capture the flows from producing sectors to factors of production (value added), and then on to institutions such as households and government, and finally back to demand for goods and services. Because SAM models capture these flows, the models enable assessment of the distributional effects of policies by allowing one to examine the distribution of income between wages and profits and the distribution of wages and profits between various types of households. Discussion of the structure of SAM models below is based on Adelman and Robinson (1986), Holland and Wyeth (1993), and Seung and Waters (2013).

The Alaska SAM in Table 1 has a total of 52 endogenous accounts or sectors which include 38 industries, 4 value-added accounts (employee compensation, proprietary income, other property income, and indirect business tax), 3 household accounts (low-, medium-, and high-income households), and a state and local government account. There are three exogenous accounts in the SAM. They are the federal government account, capital account (savings and investment), and the rest of the world (ROW) account recording imports of goods from, and exports of goods to, both non-Alaska U.S. states and foreign countries.

The first step in developing a SAM model using a SAM is to divide each element in a column by the sum of the elements in the column. This yields a matrix of coefficients. Next, to obtain the matrix of SAM direct coefficients, the coefficients in the columns and rows for the exogenous accounts are removed. The matrix with the remaining coefficients is the matrix of SAM direct coefficients denoted **S**, which is shown below:

$$\mathbf{S} = \begin{bmatrix} \mathbf{A} & \mathbf{0} & \mathbf{0} & \mathbf{C} & \mathbf{GD} \\ \mathbf{V} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{IBT} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{F} & \mathbf{0} & \mathbf{IHT} & \mathbf{STR} \\ \mathbf{0} & \mathbf{SF} & \mathbf{BTS} & \mathbf{HTX} & \mathbf{IGT} \end{bmatrix}, \qquad \text{Eq. (6)}$$

where:

***S*** = matrix of SAM direct coefficients.

***A*** = matrix of technical coefficients.

***V*** = matrix of primary factor payments coefficients.

***IBT*** = matrix of indirect business tax coefficients.

***F*** = matrix of coefficients showing factor payments to households.

***SF*** = matrix of state and local factor tax coefficients.

***BTS*** = matrix of state and local indirect business tax coefficients.

***C*** = matrix of household consumption coefficients.

***IHT*** = matrix of inter-household transfer coefficients.

***HTX*** = matrix of coefficients showing household tax payments to state / local government.

***GD*** = matrix of state and local government demand coefficients.

***STR*** = matrix of state and local government transfer coefficients.

***IGT*** = matrix of intergovernmental transfers.

In an IO model, which is built using the IO technical coefficients, the only endogenous sectors are the industries shown in the matrix of technical coefficients (**A**). Compared to an IO model, a SAM model, which is constructed based on a SAM, has additional endogenous accounts or sectors. For example, the matrix of primary factor payments coefficients (V) accounts for how income from producing sectors is distributed to different factors of production. The matrix of coefficients showing factor payments to households (F) represents how the factor income is distributed to different types of households. By adding these additional endogenous accounts in the SAM, the SAM model below can address the distributional effects of policies, which is not possible within an IO model.

The SAM model can be represented as follows:

$$\begin{bmatrix} \mathbf{Q} \\ \mathbf{V} \\ \mathbf{IBT} \\ \mathbf{H} \\ \mathbf{SG} \end{bmatrix} = \mathbf{S} \begin{bmatrix} \mathbf{Q} \\ \mathbf{V} \\ \mathbf{IBT} \\ \mathbf{H} \\ \mathbf{SG} \end{bmatrix} + \begin{bmatrix} \mathbf{eq} \\ \mathbf{ev} \\ \mathbf{et} \\ \mathbf{eh} \\ \mathbf{eg} \end{bmatrix} \qquad \text{Eq. (7)}$$

or $$\begin{bmatrix} \mathbf{Q} \\ \mathbf{V} \\ \mathbf{IBT} \\ \mathbf{H} \\ \mathbf{SG} \end{bmatrix} = (\mathbf{I}-\mathbf{S})^{-1} \begin{bmatrix} \mathbf{eq} \\ \mathbf{ev} \\ \mathbf{et} \\ \mathbf{eh} \\ \mathbf{eg} \end{bmatrix}, \qquad \text{Eq. (8)}$$

where:

***Q*** = vector of industry regional output (endogenous).

***V*** = vector of total primary factor payments (endogenous).

***IBT*** = indirect business tax payments (endogenous).

***H*** = vector of total household income (endogenous).

***SG*** = total state and local government revenue (endogenous).

***eq*** = vector of exogenous demand for regional output.

***ev*** = vector of exogenous factor payments.

***et*** = exogenous indirect business tax payments.

***eh*** = vector of exogenous federal transfers to households.

***eg*** = federal transfers to state and local government.

Here $\mathbf{(I\text{-}S)^{-1}}$ is called the SAM multiplier matrix or matrix of SAM inverse coefficients.

In Equation (8) above, the elements in ***Q***, ***V***, ***IBT***, ***H***, and ***SG*** are endogenous variables. The exogenous variables are the elements in vectors ***eq***, ***ev***, ***et***, ***eh***, and ***eg***. Vectors ***eq***, ***eh,*** and ***eg*** are non-zero exogenous demand vectors. Vector ***eq*** is the final demand vector whose elements include investment demand, federal government demand, and export demand. Elements of ***eh*** include federal government transfers to households and financial returns from capital holdings outside Alaska. The components of ***eg*** include (i) federal government transfers to state and local government, (ii) income from leases, trusts, and investments, and (iii) taxes paid by non-residents to Alaska. Injections of income into the region are represented by final demand components in ***eq*** and extra-regional payment components in ***eh*** and ***eg***. Leakages of income occur through factor income payments to nonresident factor owners, taxes paid to the federal government, savings, and payments for imports of goods and services.

## Single Region Versus Multiregional Models

The IO and SAM models presented above are single-region models which focus on the economic impacts of a policy that occurs only in the region for which an initial policy shock is introduced and, therefore, ignore the effects occurring in the regions whose economies are linked to the economy of the first region. However, if a strong economic linkage exists among these regions, single-region models will miss a portion of the economic impacts transpiring in the regions with strong economic ties with the first region as well as an additional effect on the first region.

Generally, two different types of inter-regional or multi-regional effects are produced when a policy shock is introduced for a region – spillover effects and feedback effects. Spillover effects refer to the effects transpiring in the other regions because these other regions will have to increase (decrease) production of goods and services and their exports to the first region in order to meet the increased (decreased) industry production in the first region caused by the policy. Feedback effects are additional effects occurring in the first region because the first region will need to increase (decrease) the production of goods to satisfy the increased (decreased) production in the other regions. To capture these multi-regional effects, one will need a multi-regional model.

The economies of regions within the United States (such as state economies) are inter-connected. Large amounts of goods and services are traded between U.S. regions, and factors of production (labor and capital) are highly mobile among them. Multi-regional models are particularly useful for economic impact analysis of Alaska fisheries. A distinctive feature of Alaska fisheries is that the fisheries depend to a large extent on imports of goods and services and factors of production from other states (especially states on the U.S. West Coast). Large shares of the fishing vessels, crew, and intermediate inputs used in these fisheries are supplied from distant West Coast ports. Therefore, single-region models for Alaska would not be able to capture the additional impacts occurring in these other states. Alaska's dependence on the imports is not limited to seafood industries. Large proportions of the goods and services used in non-seafood industries and by households in Alaska are from other states.

Therefore, a multi-regional SAM (MRSAM) model is used for the software. The model will enable analysts to examine the economic effects of fishery management policies not only on the state of Alaska (AK) but also on West Coast (WC), which include Washington, Oregon, and California, and the rest of the United States (RUS).

## Alaska Multi-Regional Social Accounting Matrix (MRSAM) Model

This section relies on Seung (2014b) and Seung (2017).

### Model Structure

The web-based application software uses an MRSAM model constructed for three regions in the U.S., Alaska, WC, and RUS, based on the 2004 MRSAM. This section provides a description of the MRSAM model. The structure of the MRSAM is similar to those in Round (1985). Table 2 presents a simplified diagram of the MRSAM used for the software while Table 3 displays a somewhat more detailed schematic of the MRSAM.

The MRSAM model can be represented as follows:

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} Z_{11} & z_{12} & z_{13} \\ z_{21} & Z_{22} & z_{23} \\ z_{31} & z_{32} & Z_{33} \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} + \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}, \qquad \text{Eq. (9)}$$

where $\boldsymbol{y_i}$ and $\boldsymbol{x_i}$ denote the column vectors of endogenous and exogenous accounts, respectively, for region *i* and $\boldsymbol{Z_{ii}}$ is a submatrix containing coefficients showing the intra-regional transactions and $\boldsymbol{z_{ij}}$ a submatrix containing coefficients showing inter-regional transactions, respectively. All the coefficients in $\boldsymbol{Z_{ii}}$ and $\boldsymbol{z_{ij}}$ are derived by dividing the elements in the columns in the MRSAM by the column totals. Alternatively, Equation (9) can be written as:

$$Y = (I - S)^{-1} X, \qquad \text{Eq. (10)}$$

where $Y = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix}$, S= $\begin{bmatrix} Z_{11} & z_{12} & z_{13} \\ z_{21} & Z_{22} & z_{23} \\ z_{31} & z_{32} & Z_{33} \end{bmatrix}$, and $X = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$. ***S*** is the matrix of direct MRSAM coefficients and $(I - S)^{-1}$ is called the MRSAM multiplier matrix or the matrix of MRSAM inverse coefficients.

$\boldsymbol{y_i}$ is a column vector for region *i* consisting of the following endogenous sub-vectors:

$\boldsymbol{A_i}$ = vector of regional industry output.

$\boldsymbol{Q_i}$ = vector of regional commodity output.

$\boldsymbol{V_i}$ = vector of total primary factor payments.

$\boldsymbol{IBT_i}$ = indirect business tax payments.

$\boldsymbol{H_i}$ = vector of total household income.

$\boldsymbol{SG_i}$ = total state and local government income or revenue.

$\boldsymbol{Z_{ii}}$ for region *i* is as follows:

$$Z_{ii} = \begin{bmatrix} 0 & M_i & 0 & 0 & 0 & 0 \\ U_i & 0 & 0 & 0 & C_i & GD_i \\ V_i & 0 & 0 & 0 & 0 & 0 \\ IBT_i & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & F_i & 0 & 0 & STR_i \\ 0 & 0 & SF_i & BTS_i & HTX_i & IGT_i \end{bmatrix}$$

where:

$\boldsymbol{U_i}$ = matrix showing the use of commodities by industries in production.

$\boldsymbol{V_i}$ = matrix of primary factor payments coefficients.

$\boldsymbol{IBT_i}$ = matrix of indirect business tax coefficients.

$\boldsymbol{M_i}$ = market share matrix (i.e., elements in make matrix[1] divided by total output).

$\boldsymbol{F_i}$ = matrix of factor payment to household coefficients.

[1] Make matrix shows the quantities of different commodities produced by an industry.

$SF_i$ = matrix of state and local factor tax coefficients.

$BTS_i$ = matrix of state and local indirect business tax coefficients.

$C_i$ = matrix of household consumption coefficients.

$HTX_i$ = matrix of state and local government direct household tax coefficients.

$GD_i$ = matrix of state and local government demand coefficients.

$STR_i$ = matrix of state and local government transfer coefficients.

$IGT_i$ = matrix of intergovernmental transfers.

$z_{ij}$ is as follows:

$$z_{ij} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & IM_{ij} & 0 & 0 & 0 & 0 \\ 0 & 0 & LK_{ij} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

where $IM_{ij}$ is matrix of imports from region *i* to *j* and $LK_{ij}$ is matrix of leakage of factor income from region *j* to region *i*. $x_i$ is a column vector consisting of the following exogenous sub-vectors:

$ea_i$ = vector of exogenous demand for regional industry output.

$eq_i$ = vector of exogenous demand for regional commodity output.

$ev_i$ = vector of exogenous factor payments.

$et_i$ = exogenous indirect business tax payments.

$eh_i$ = vector of exogenous federal transfers to households.

$eg_i$ = federal transfers to state and local government.

There are three non-zero exogenous demand vectors – $\mathbf{eq_i}$, $\mathbf{eh_i}$ and $\mathbf{eg_i}$. The elements of $\mathbf{eq_i}$ are components of final demand for commodities including federal government demand, investment demand, and export demand. The elements of $\mathbf{eh_i}$ include federal government transfers to households and remittances from ROW to households. The components of $\mathbf{eg_i}$ include federal government transfers to state and local government. Injections of income into a region occur through final demand components in $\mathbf{eq_i}$ and extra-regional payment components in $\mathbf{eh_i}$ and $\mathbf{eg_i}$. Leakages include taxes paid to the Federal government, savings, and payments for commodities imported from ROW.

## Sectors in the MRSAM

There are different types of sectors or accounts in the MRSAM model. These sectors include "industries" (producers of goods and services), "commodities" (goods and services produced by the industries), "value added" accounts, "households" (that earn income and purchase the commodities), "governments" (that collect taxes, make transfer payments, and purchase commodities), "capital account" (savings and investment), and "trade" (imports and exports outside U.S.) accounts.

These sectors can be bifurcated into two broad categories of accounts, endogenous accounts and exogenous accounts. The endogenous accounts are the economic engine of a region that is driven by the exogenous accounts, which inject money into the regional economic system mainly through exports, federal government demand, federal transfer payments to the region, and remittances from foreign households. Injections from these exogenous accounts are often called the economic base (or export base).

In the MRSAM model, each region has 97 endogenous accounts, meaning that there are a total of 291 (97 × 3) endogenous accounts in the model. For each region, the 97 endogenous accounts consist of 42 industries, 48 commodities, three value-added accounts (labor income, capital income, and indirect business tax), 3 household accounts (low-, medium-, and high-income households)[2], and a combined state and local government account. The 42 industries (Table 4) include 9 seafood industries (6 harvesting industries and 3 processing industries) and

[2] Low-, medium-, and high-income households are aggregations of the nine types of households in IMPLAN. The low-income category includes households with income up to $25,000; the medium-income category includes households with income from $25,000 to $75,000; and the high-income category includes households with incomes in excess of $75,000. Note that these income brackets are based on 2004 IMPLAN data. These cutoffs increased with inflation over time.

33 non-seafood industries. The 48 commodities include 14 fish species, 1 processed seafood commodity, and 33 non-seafood commodities.

The six harvesting industries are Catcher-Processors (harvesting)[3], Trawlers (harvesting vessels whose majority of revenue comes from trawl gear), Longliners (harvesting vessels with a majority of revenue from longline gear), Crabbers (harvesting vessels with a majority of revenue from the crab species group), Salmon Netters (harvesting vessels with a majority of revenue from salmon caught with net or other gear), Other harvesters (harvesting vessels that do not belong to any of the above vessel types). The three processing industries are Catcher-Processors (processing), Motherships (non-stationary floating processors), and Shorebased Processors. The 14 fish species include Pacific whiting, Atka mackerel, flatfish, Pacific cod, pollock, rockfish/other, sablefish, crab, halibut, herring, other finfish, other invertebrates, other shellfish, and salmon/other.

The MRSAM model has four exogenous accounts – federal government, capital account, an account to handle international trade and financial flows, and an account balancing between the three regions and the rest of the world (ROW).

**Dealing With Exogenous Output Change**

The IO and SAM models discussed above are often called Leontief demand-driven models because change in final demand "drives", or is applied as an initial shock to, the models and the models calculate the economic impacts. However, in some cases, government policies directly change the output (supply) level of an industry. An example is an exogenous decrease in the TAC for a fish species triggered by the low level of the stock. If Leontief demand-driven models are used to compute the effects of the exogenous change in output (e.g., a change in the TAC for a fish species) the model results could be biased. This is because, in the Leontief demand-driven model, the final demand shock in the amount equal to the exogenous change will generate

[3] Catcher-processors engage in both fish harvesting and fish processing. In the MRSAM, catcher-processing sector is divided into two separate activities, harvesting and processing activities.

impacts that are larger than the exogenous change (specified as a final demand shock in the model) due to its indirect effects on the industry whose output is exogenous.

Due to this problem, some studies (e.g., Leung and Pooley 2002, Johnson and Kulshreshtha 1982, Eiser and Roberts 2002) contend that it is more appropriate to use a mixed endogenous-exogenous (MEE; Miller and Blair 1985) version of IO models when output level is directly altered. Examples of the MEE version of SAM models include Roberts (1994), Marcouiller et al. (1995), and Seung and Waters (2009).

Studies that use the MEE approach either ignore the forward-linkage effects because the effects are negligible or use the Ghosh approach (Ghosh 1958) to estimate forward-linkage effects (e.g., Eiser and Roberts 2002, Leung and Pooley 2002). However, the Ghosh approach has a serious theoretical problem. Economists have severely criticized the approach because of its fundamental assumption that sales from industry *i* to the industries that buy from industry *i* are proportional to the industry *i*'s output (i.e., fixed output allocation coefficient assumption). This assumption is neither intuitive nor economically valid. Consequently, results from the Ghosh models should be interpreted with caution. In particular, it is advisable that the backward-linkage effects from original MEE approach (Miller and Blair 1985) and the forward-linkage effects from the Ghosh approach should not be added together to determine the total economic impacts.

To overcome the weaknesses of these previous approaches to computing the impacts of exogenous shocks to output level, an adjusted demand-driven model is used. The model is labeled as an "adjusted demand-driven model" because the model is adjusted in the sense that, when running the model, (i) the exogenous changes in output are treated as final demand shocks, and (ii) the regional purchase coefficients (RPCs) are set to zero for the outputs of all the directly impacted industries and the forward-linked industries. Setting RPCs for these industries is equivalent to setting the row elements for these industries in the matrix of direct SAM coefficients (**S** matrix above). Zero RPCs for the directly impacted industry prevent the regional industries from buying output from the directly impacted industry and thereby avoid the biased results that are typically encountered when the unadjusted demand-driven models are used to approximate the effects of exogenous changes in output. In addition, the adjusted demand-driven model overcomes (avoids) the problems of the Ghosh approach by setting RPCs to zero for the output of all the forward-linked industries and by running the model with exogenously specified changes in the output of the forward-linked industries given as initial shocks to the model. This type of approach was used in several previous studies (e.g., Tanjuakio et al. 1996; Steinback 2004). More details on this approach can be found in Seung (2014b) and Seung (2017). The next sub-section details how this approach is applied to Alaska fisheries within the MRSAM framework.

**Adjusted Demand-driven MRSAM Model for Alaska Fisheries**

This section describes how the original MRSAM model was adjusted to yield an adjusted demand-driven MRSAM model for Alaska fisheries that are used in the software. Suppose that pollock harvest is reduced due to a lowered TAC or an environmental shock. To calculate the economic impacts, one should first estimate the decrease in the ex-vessel value of the directly impacted seafood commodity (raw pollock) and the resulting decrease in the first wholesale value of the forward-linked commodity (processed pollock). Then, the MRSAM model is run with these changes as final demand shocks with zero RPCs for all the commodities produced in all the seafood industries in all the three regions,[4] resulting in an adjusted demand-driven MRSAM model.

Note that one should estimate the change in the output of the forward-linked commodity exogenously (i.e., outside the MRSAM model), before running the model, using available information. This change is given as an initial shock to the model along with the change in the directly impacted commodity. By treating both (i) the change in the directly impacted commodity (pollock) and (ii) the change in the forward-linked commodity (processed seafood) as initial shocks to the model, there is no need to calculate endogenously the forward-linkage

[4] The section titled "Example scenario" below provides an example scenario where Alaska pollock TAC was curtailed, hypothetically, by 10%, and the results are presented.

effects on processed seafood of change in pollock TAC, and thus avoids the problem of Ghosh approach.

Setting RPCs for the seafood commodities to zero is equivalent to setting the row elements for the commodities to zero in the matrix of direct MRSAM coefficients (**S** matrix above). The zero RPCs prevent the fish processing industries from purchasing more raw fish from fish harvesting industries (due to indirect and induced effects) than is needed to achieve the exogenously specified change (i.e., direct effect) in harvest. RPCs can be applied to either commodities or industries. In the MRSAM model in which industries and commodities are separately identified, the RPCs are set to zero for all the commodities produced by all seafood industries.

For a single-region model (e.g., for Alaska), the zero RPCs for the seafood commodities (raw fish) technically mean that a change in the intermediate demand by the fish processing industries for the raw fish is met by imports of the raw fish from outside of the region (including all non-Alaska U.S. states and ROW) rather than by regional harvest. However, this technicality does not distort the model results because the initial change in the output of the regional fish harvesting industries has already been incorporated into the direct impact vector. Since the RPCs for the non-seafood commodities are not set equal to zero, the demand by fish harvesting and processing industries for the non-seafood commodities (inputs) is satisfied by regional production and/or imports as in an unadjusted demand-driven model.

The idea of zero RPCs can be similarly applied to a multi-regional model. In the adjusted demand-driven MRSAM model, the RPCs for all the seafood commodities (species) harvested by all the seafood industries <u>in all three regions</u> are set to zero. This means technically that the change in Alaska's demand for imports of two commodities (pollock and processed seafood in the present case) from the other two regions, which arises due to the exogenous shock in Alaska, is not met by the additional production of these commodities in the two regions but is satisfied by imports from ROW. With zero RPCs for all regions, the adjusted demand-driven MRSAM model guarantees that the seafood industry output in the other two regions is not affected at all by policies altering fish harvest levels in Alaska. This is a reasonable assumption because, in all

U.S. fisheries, the annual harvests of most species are set by the fishery managers through TACs. Therefore, a change in TAC for a species caught in Alaska waters will not alter the harvest levels of the other species (commodities) in Alaska and those of all the species in the other two regions.

**Direct, Indirect, and Induced Effects in MRSAM Model**

In this example case above where pollock TAC is curtailed, the direct effects (initial shocks) include the exogenous changes in two commodities; that is, the change in TAC for pollock and the change in the quantity of processed seafood arising from the change in the TAC. As mentioned above, impacts on the forward-linked commodity (processed seafood) are not calculated endogenously within the model but are estimated exogenously outside the model.

Next, the model transforms the direct effects into changes in industry output through the market share matrix (or “make” matrix). Indirect effects are the effects generated from a change in intermediate demand for non-seafood industries’ output caused by the direct effects. However, in the adjusted demand-driven MRSAM model which is designed to avoid double-counting, the indirect effects do not include the indirect effects of the exogenous change in processed seafood on raw pollock and other species because the direct effects on pollock (a negative number) and other species (zeroes) are already specified as exogenous shocks as above.

Induced effects in the MRSAM model are the additional impacts resulting from the direct and indirect changes in household income and state and local government revenue. That is, a decrease in fish harvesting and processing output (direct effects) in Alaska will result in a reduction in intermediate demand for non-seafood industries’ output via backward linkage (indirect effect). This will in turn lead to a decrease in value added, indirect business taxes, household income, and state and local government revenue, thereby resulting in a further reduction in consumption of commodities by households and state and local governments in all regions (induced effect).

Unlike in a single-region model, the MRSAM model generates these indirect and induced effects in the two non-Alaska regions (spillover effects) as well as in Alaska region because the economies of the three regions are dependent on each other. Total effects are computed simply as the sum of all three effects.

## Data

The Alaska portion in the MRSAM was assembled using 2004 data and software from IMPLAN (IMpact analysis for PLANning, Minnesota IMPLAN Group, Inc. 2004). In developing the MRSAM, the IMPLAN data for fish harvesting and processing sectors were not used due to the data for these sectors being not reliable. Instead, these sectors were constructed based on information garnered from informal interviews with key industry contacts as well as data from government and other available sources. The information obtained through the informal interviews was used to ground-truth the industry cost estimates. The Research Group (2007) has more details on the seafood sectors' data for the Alaska portion of the MRSAM model.

In building the WC portion of the MRSAM, the IO model for Pacific Coast Fisheries (IO-PAC), developed by the Northwest Fisheries Science Center (NWFSC), was very useful. The WC portion of the MRSAM was built based on the data on industry, commodity, and employment in IO-PAC model. The IO-PAC model was constructed using IMPLAN data and detailed data about fishery-related industries and commodities. The fishery data used in the IO-PAC model were collected via economic surveys of vessels engaging in WC fisheries, and are for year 2006 (Leonard and Watson 2011).

The RUS part of the MRSAM was collated based on 2008 IMPLAN data. The IMPLAN data for RUS fisheries was supplemented with 2008 NMFS landings data because these data included only basic information about RUS commercial fisheries sectors. Additionally, due to lack of information on the expenditures by RUS fisheries sectors, it was assumed that the expenditure functions of the RUS fisheries sectors were identical to those of the corresponding Alaska and WC fisheries sectors.

Because the three different regional datasets had different data years (2004 for Alaska, 2006 for WC, and 2008 for RUS), GDP price deflator series was used to match the data years by adjusting the WC and RUS portions of the MRSAM to 2004 levels. To estimate the commodity trade flows among the three regions, IMPLAN version 3 was utilized. Non-commodity flows (factor income, transfer payments, and financial flows) among the three regions and ROW were also estimated. For the Alaska SAM, the information about non-resident labor in seafood and other Alaska industries was useful. However, no data was available on the origin or destination of interregional transfer payments and financial flows. Therefore, these interregional flows had to be estimated based on fairly crude assumptions and the analysts' knowledge.

The MRSAM was constructed by collating the three price-deflated SAMs as above. As a final step, the MRSAM thus constructed was balanced by adjusting exogenous accounts until row totals equaled column totals.

## Operating the Model in the Software

This section provides a brief description of the steps to follow to operate the adjusted demand-driven MRSAM model in the software. See the user manual (Appendix B) for detailed step-by-step guidance and instructions on how to use the software.

### GDP Deflator Adjustment of Baseline Data

The adjusted demand-driven MRSAM model allows the users to choose a GDP deflator to adjust the baseline data before computing the economic impacts associated with an industry or commodity shock. Recall that the baseline data was compiled from three different regional datasets with different data years (2004 for Alaska, 2006 for WC, and 2008 for RUS), and that the GDP price deflator series was used to match the data years by adjusting the WC and RUS portions of the MRSAM to 2004 levels. Thus, if a shock is to be entered based on dollar values from a later year then the base data should be adjusted to that same year using the deflator for that year.

The GDP deflators appear in the application as a pulldown menu and were derived based on GDP current dollars and chained 2009 dollars for U.S.[5] The GDP deflator is set to one for year 2004 (base year for the MRSAM). However, if a policy change occurred in a different year, for example in 2016, the user can choose the deflator for the year (1.25044777 for 2016) and the application will adjust the base data. It should be noted, the shock caused by the policy is entered in actual (nominal) reported dollar values in the year in which the shock occurs. Note that if a shock is entered and then the deflator is changed it will not change the impacts on non-employment variables (such as output, value added, and household income) because the relationship (represented by MRSAM coefficients) does not change due to a change in the deflator. However, the baseline data will change as the deflator is changed, while holding a shock constant, thus affecting the impacts from shocks as a percentage of the base data. As a result, tables A, C, and E all change, while tables B and D (quantity impacts) do not change as the deflator is changed when shock(s) remain constant.

**GDP Deflator Effect on Employment Impacts**

Recall that the MRSAM assumes that the level of employment, by region, does not change from the base year of 2004. Further, impacts to employment from a shock are calculated using the ratio of employment to output and this ratio will change as the deflator is changed. For example, suppose that the output of an industry (call it Industry A) in 2004 is 1,000 and its employment is 50. The employment to output ratio for the industry is 0.05. Suppose further that the initial shock (to whichever industry, call it Industry B) is 100 and the impact on the output in the first industry (Industry A) is 60. Then the impact on employment in Industry A will be 60*0.05 = 3. Now if we apply the deflator of 1.12208653 for year 2009, the output of the industry in 2009 is now equal to 1,000*1.12208653 =1,122.09. Thus, in 2009, the employment to output ratio for the industry will be 50/1,122.09 = 0.045, which shows how the employment to output ratio in Industry A decreases as the deflator is increased. The impact of the same shock to Industry B (100) on the output of Industry A is the same (60). Then, the impact on Industry A's

[5] Bureau of Economic Analysis (BEA). Current-dollar and "real" gross domestic product: annual and quarterly series online spreadsheet. http://www.bea.gov/national/xls/gdplev.xls.

employment from the same shock (100) will be 60*0.045 = 2.67 in 2009, which is smaller than the employment impact that will be obtained if the same shock is given in 2004.

The software lists the GDP deflators for years 2004-2016; 2016 was the most recent year in the current- and chained-dollar GDP series (http://www.bea.gov/national/xls/gdplev.xls) when the web-based software was developed. Therefore, there will be three cases when the users may not want to use one of the deflators in the list but want to choose "Custom" and enter the deflator of their choice before running the model. First, they may not agree to the deflator given in the list. Second, the users need to calculate the economic impacts of a fishery management policy implemented in a year (e.g., 2018) which is not in the list of GDP deflators in the software when they use the software but for which the GDP series is updated at the BEA website. In this case, the users can calculate the GDP deflator for the desired year by dividing the GDP for the desired year in the current-dollar series by the GDP in the chained-dollar series and rescaling it for the year 2004. Third, the users may want to assume a value for the GDP deflator for a future year (e.g., 2020) if the fishery management policy under consideration will be implemented in a future year. They may assume a GDP deflator value for that future year based on the previous year's GDP deflator or based on experts' opinion.

**Industry- and Commodity-based Shocks**

The seafood industries (vessel sectors and processing sectors) in the MRSAM model used in the software includes nine seafood industries (six harvesting sectors and three processing sectors). The seafood commodities (species or processed seafood) include 15 commodities (14 raw fish species and one processed seafood). The initial shocks applied in the model can be either (i) the changes in the ex-vessel values of landings of individual species (commodity-based shock), (ii) changes in the ex-vessel values of individual harvesting or processing sectors (industry-based shock), or (iii) both. For example, if the TAC of a certain species is increased, the users may want to use the commodity-based shock. But if there is a change in the total amount of catch by a certain vessel sector (e.g., Trawlers) regardless of the species that the vessel sector catches, the users may want to use the industry-based shock. In some (rare) cases, the users may need to evaluate the economic impacts from a fishery policy that involves applying shocks to both commodities and industries such as change in TAC for a species and restrictions placed on the activity of a vessel sector (fishing industry). In this case, the users may choose to use both types of shocks simultaneously.

Typically, each type of shock involves entering more than one number in the input section in the software. For example, in case of commodity-based shock, if pollock TAC has been increased, the users need to enter both the change in the ex-vessel value of pollock and the estimated resulting change in the first wholesale value of the processed pollock. Similarly, in case of the industry-based shock, if the landings by Trawlers has been decreased, the users need to enter both the decrease in ex-vessel value of the vessel sector and the resulting reduction in the first wholesale value of Shoreside processors. This is how the use of the adjusted demand-driven MRSAM model is different from the use of a typical demand-driven model. While in a typical demand-driven model only one number (i.e., change in final demand for a commodity) is entered to calculate the impacts, in the adjusted demand-driven MRSAM model, the users should enter both the change in the final demand sector (e.g., processed seafood) and its backward-linked commodity (e.g., pollock). The reason for using this method is to avoid the double-counting problem as discussed above.

Therefore, in order to calculate the economic impacts of certain fishery management actions, the users need to have ready the estimates of both the change in the ex-vessel value of species (or vessel sector in case of industry-based shock) and the change in the first wholesale value of the processed fish (or processing sector in case of industry-based shock). In a special case where there is a change in total first wholesale value in the CP sector due to some management change, the change needs to be divided into two components – harvesting and processing activities – before applying shocks. For example, if the change in the first wholesale revenue for the CP sector is $100 and if the change in the implicit ex-vessel revenue from the raw fish processed in the sector is estimated to be $30, the two shock numbers to be entered are $30 and $70 (= 100-30) for CP-harvesting and CP-processing sectors, respectively.

Once the model inputs are entered, the software calculates the economic impacts automatically. For more details about how to use the software, see the User Manual in Appendix B.

## Example Scenario

This section presents results from an example scenario in a previous study (Seung 2014b) where pollock TAC is reduced, hypothetically, by 10%, in 2004. The impacts were calculated using the software. Estimates of the initial reductions in the outputs of the two commodities (raw pollock and processed seafood) are based on The Research Group (2007). These reductions were estimated to be $33.71 million and $114.42 million, respectively. The model accepts these two numbers as the initial shocks.

Tables 5, 6, and 7 present the results, and are from the output files from the software. Table 5 presents baseline values of important regional economic variables which include output, employment, value added, household income, and state and local government revenue. Tables 6 and 7 present the economic impacts for the variables in quantity (in $million or the number of jobs) and in percentage changes, respectively. These two tables show that the total Alaska harvesting industry output decreases by $34.25 million (or 2.82% ) while the total Alaska processing industry output decreases by $113.88 million (or 3.96%), resulting in a total decrease of $148.13 million (or 3.62%) in the total seafood industry output. The total non-seafood industry output for Alaska decreases by $92.82 million (or 0.20%).

Results also indicate that the 10% reduction in pollock TAC in Alaska does not affect the seafood industry output for WC and RUS (Table 6). This is an anticipated result because of the way the model is constructed. However, the shocks in Alaska do produce spillover effects on non-seafood industries in the two regions because, with non-zero RPCs set for non-seafood commodities for all regions, the change in economic activity in Alaska induced by the initial shocks will lead to a change in imports of non-seafood commodities from the two regions. The model estimates that total non-seafood industry output decreases by $28.74 million and $104.29 million in WC and RUS, respectively. Table 6 also presents the distributional impacts of the reduced TAC on the income of different types of households and the state and local government revenue. For some additional example scenarios, see the user manual (Appendix B).

## Concluding Remarks

This report is intended for the economists and social scientists who need to undertake economic impact analyses for Alaska fisheries. To help them understand the model used in the software, this report, among other things, provides the fundamentals of regional economic analysis by introducing several regional economic models such as IO and SAM models, and explains the MRSAM model used in the software.

Although the model itself in the software is very useful, the data used in the model is somewhat outdated. The model was constructed based on 2004 data. Therefore, GDP deflators were used in the software to run the model for years other than the base year (2004). Recently, AFSC completed a data collection for Southwest Alaska fisheries. AFSC is now implementing a project that compiles the data which will be used to construct a new MRSAM for six Southwest boroughs and census areas (BCAs), rest of Alaska, West Coast, and the rest of United States. Once the new MRSAM construction is completed, AFSC will develop a new MRSAM model for Alaska fisheries, possibly updating the software.

The MRSAM model used in the software is for commercial fishing only. Recreational fishing is also a very important sector in Alaska and fishery managers are concerned with the economic impacts from recreational fishing. A future work will be to develop a similar model and software to assess the economic impacts from recreational fishing. On a longer time horizon, this project can be extended to develop similar software for each non-Alaska regional fishery Science Center across the United States and software for the United States as a whole. These software products, once developed, will serve as a very useful tool set for estimating the economic impacts of regional and national fishery management policies.

## CITATIONS

Adelman, I., and S. Robinson. 1986. U.S. agriculture in a general equilibrium framework: Analysis with a social accounting matrix. Am. J. Agricult. Econ. 68: 1,196-1,207.

Alaska Department of Labor and Workforce Development. 2017. Non-residents working in Alaska, 2015. Alaska Department of Labor and Workforce Development, Juneau, AK.

Andrews, M., and D. Rossi. 1986. The economic impacts of commercial fisheries and marine related activities: a Critical review of northeastern input-output studies. Coast. Zone Manage. J. 13: 335-367.

Eiser, D., and D. Roberts. 2002. The employment and output effects of changing patterns of afforestation in Scotland. J. Agricult. Econ. 53: 65–81.

Ghosh, A. 1958. Input-output approach to an allocative system. Economica 25 (1):58–64.

Hewings, G., and R. Jensen. 1986. Regional, interregional, and multiregional input-output analysis. Handbook of Regional and Urban Economics. P. Nijkamp (ed.), Amsterdam: Elsevier.

Holland, D., and P. Wyeth. 1993. SAM multipliers: their decomposition, interpretation, and relationship to input-output multipliers. Research Bulletin XB 1027, College of Agricultural and Home Economics Research Center, Washington State University.

Johnson, T., and S. Kulshreshtah. 1982. Exogenising agriculture in an input-output model to estimate relative impacts of different farm types. W. J. Agricult. Econ. 7: 187-198.

King, B. 1985. What is a SAM? Pyatt, G. and J. Round (ed.), Social Accounting Matrix, World Bank.

Leonard, J., and P. Watson. 2011. Description of the input-output model for Pacific Coast fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-111, 64 p.

Leung, P., and S. Pooley. 2002. Regional economic impacts of reductions in fisheries production: a Supply-driven approach. Mar. Res. Econ. 16: 251-262.

Marcouiller, D., D. Schreiner, and D. Lewis. 1995. Distributive economic impacts of intensive timber production. Forest Sci. 41: 122-139.

Miller, R. E., and P. D. Blair. 1985. Input-Output Analysis: Foundations and Extensions. Englewood Cliffs, NJ: Prentice Hall Inc.

Minnesota IMPLAN Group, Inc. 2004. IMPLAN Pro User's Guide.

National Marine Fisheries Service (NMFS) (2017). Fisheries of the United States, 2016. U.S. Department of Commerce, Office of Science and Technology, Fisheries Statistics and Economics Division, Silver Spring, MD.

North Pacific Fishery Management Council (NPFMC) (2017). Stock assessment and fishery evaluation report for the groundfish fisheries of the Gulf of Alaska and Bering Sea/Aleutian Island Area: Economic Status of the Groundfish Fisheries off Alaska, 2016. North Pacific Fishery Management Council, Anchorage, AK.

Pyatt, G., and J. I. Round. 1985. Social Accounting Matrices: A Basis for Planning. Washington, D.C.: The World Bank.

Richardson, H. 1985. Input-output and economic base multipliers: Looking backward and forward. J. Reg. Sci. 25: 607-661.

Roberts, D. 1994. A modified Leontief model for analysing the impact of milk quotas on the wider economy. J. Agricult. Econ. 45(1): 90-101.

Round, J. 1985. Decomposing multipliers for economic systems involving regional and world trade. Econ. J. 95 (378): 383-399.

Seung, C. and E. Waters. 2005. A review of regional economic models for Alaska fisheries. AFSC Processed Rep. 2005-01, 119 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle WA 98115.

Seung, C. and E. Waters. 2006. A review of regional economic models for fisheries management in the U.S. Mar. Res. Econ. 21(1): 101-124.

Seung, C., and E. Waters. 2009. Measuring the economic linkage of Alaska fisheries: a Supply-driven social accounting matrix (SDSAM) approach. Fish. Res. 97: 17-23.

Seung, C., and E. Waters. 2013. Calculating impacts of exogenous output changes: Application of a social accounting matrix (SAM) model to Alaska fisheries. Annals Reg. Sci. 51 (2): 553-573.

Seung, C. 2014a. Measuring spillover effects of shocks to the Alaska economy: an Inter-regional social accounting matrix (IRSAM) model approach. Econ. Syst. Res. 26: 224–238.

Seung, C. 2014b. Estimating effects of exogenous output changes: an Application of multi-regional social accounting matrix (MRSAM) method to natural resource management. Reg. Sci. Pol. Pract. 6(2): 177-193.

Seung, C. 2017. A Multi-regional economic impact analysis of Alaska salmon fishery failures. Ecol. Econ. 138: 22-30.

Steinback, S. 2004. Using ready-made regional input-output models to estimate backward linkage effects of exogenous output shocks. Rev. Reg, Studies 34 (1): 57-71.

Tanjuakio, R., S. Hastings, and P. Tytus. 1996. The economic contribution of agriculture in Delaware. Agricult.  Res. Econ. Rev. 25 (1): 46-53.

The Research Group. 2007. Estimating economic impacts of Alaska fisheries using a computable general equilibrium model – Data acquisition and reduction task documentation. Prepared for the Alaska Fisheries Science Center. Corvallis, Oregon.

Waters, E., C. Seung, M. Hartley, and M. Dalton. 2014. Measuring the multiregional economic contribution of an Alaska fishing fleet with linkages to international markets. Mar. Pol. 50 (Part A): 238-248.

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Table 1. -- Structure of the 2004 Alaska SAM.

| | ENDOGENOUS ACCOUNTS | | | | | EXOGENOUS ACCOUNTS | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| | INDUSTRIES | FACTORS | INDIRECT BUSINESS TAX | HOUSEHOLD | STATE /LOCAL GOV'T | FEDERAL GOV'T | CAPITAL | REST OF WORLD | |
| INDUSTRIES | Interindustry demand | | | Household demand | S & L gov't demand | Federal gov't demand | Investment demand (gross business investment) | Exports | Total industry output |
| FACTORS | Payments to factors | | | | | | | | Total factor receipts |
| INDIRECT BUSINESS TAX | Indirect business tax payments | | | | | | | | Total indirect business tax |
| HOUSEHOLD | | Factor payments to households | | Interhousehold transfers (interest payments) | S&L gov't transfers to households | Federal transfers to households | Household dissavings; financial returns from capital holdings outside Alaska | | Total household income |
| STATE/ LOCAL GOV'T | | S & L gov't factor taxes | Indirect business tax to S & L gov't | S&L gov't taxes (property tax and other taxes) | Inter-government transfers | Federal transfers to S&L gov't | S&L gov't borrowing; income from leases, trusts & investments, taxes paid by non-residents to Alaska | | Total S&L gov't revenue |
| FEDERAL GOV'T | | Federal factor taxes | Indirect business tax to fed. gov't | Federal income tax | | Intra-government transfers | Federal gov't borrowing, Federal income tax paid by non-residents | | Total federal gov't receipts |
| CAPITAL | | Payments to enterprises; Capital consumption allowances | | Household savings | S&L gov't savings | Federal gov't savings | Net inventory change, retained earnings | External savings | Total savings |
| REST OF THE WORLD | Imports<br><br>Leakage of factor income for seafood industries | Leakage of factor income for non-seafood industries | | Imports | Imports | imports | Imports | | Total ROW receipts |
| TOTAL | Total industry outlays | Total factor payments | Total indirect tax payments | Total household payments | Total S&L gov't payments | Total federal gov't payments | Total investment payments | Total ROW expenditure | |

Source: Seung and Waters (2013).

Table 2. -- Basic MRSAM structure (Waters et al. 2014).

| | Alaska (AK) | West Coast (WC) | Rest of United States (RUS) | Rest of the World (ROW) |
|---|---|---|---|---|
| Alaska (AK) | Alaska Economy | WC Purchases from AK | RUS Purchases from AK | AK Exports |
| West Coast (WC) | AK Purchases from WC | West Coast Economy | RUS purchases from WC | WC Exports |
| Rest of United States (RUS) | AK Purchases from RUS | WC Purchases from RUS | RUS Economy | RUS Exports |
| Rest of the World (ROW) | AK Imports | WC Imports | RUS Imports | |

Table 3. -- More detailed MRSAM structure (Waters et al. 2014) (See the next page for descriptions of acronyms and abbreviations).

| | | **AK (incl H&G)** | | | | **WOC** | | | | **RUS** | | | | **ROW** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ind** | **Com** | **VA** | **Inst** | **Ind** | **Com** | **VA** | **Inst** | **Ind** | **Com** | **VA** | **Inst** | **Fed** | **Invest** | **Exports** |
| **AK (incl H&G)** | **Ind** | | Make | | | | | | | | | | | | | |
| | **Com** | Ind Use | | | Consump | | imp from AK | | | | imp from AK | | | fed demand | inv demand | ROW exports |
| | **VA** | fac inc & IBT to AK | | | | fac inc paid to AK | | | | fac inc paid to AK | | | | | | |
| | **Inst** | | | reg fac income | | | | | | | | | | transfers | remitt | |
| **WOC** | **Ind** | | | | | | Make | | | | | | | | | |
| | **Com** | | imp from WOC | | | Ind Use | | | Consump | | imp from WOC | | | fed demand | inv demand | ROW exports |
| | **VA** | fac inc paid to WOC | | | | fac inc & IBT to WOC | | | | fac inc paid to WOC | | | | | | |
| | **Inst** | | | | | | | reg fac income | | | | | | transfers | remitt | |
| **RUS** | **Ind** | | | | | | | | | | Make | | | | | |
| | **Com** | | imp from RUS | | | | imp from RUS | | | Ind Use | | | Consump | fed demand | inv demand | ROW exports |
| | **VA** | fac inc paid to RUS | | | | fac inc paid to AK | | | | fac inc & IBT to RUS | | | | | | |
| | **Inst** | | | | | | | | | | | reg fac income | | transfers | remitt | |
| **ROW** | **Fed** | | tariffs | fac tax | inc tax | | tariffs | fac tax | inc tax | | tariffs | fac tax | inc tax | | | fed borrow |
| | **Savings** | | | | | | | | | | | | | fed saving | | |
| | **Imports** | | imp from ROW | | | | imp from ROW | | | | imp from ROW | | | | | |

Descriptions of acronyms and abbreviations in Table 3

| | |
|---|---|
| MRSAM | : multi-regional social accounting matrix |
| AK | : Alaska |
| WOC | : West Coast |
| RUS | : rest of United States |
| ROW | : rest of the world |
| Ind | : industry |
| Com | : commodity |
| VA | : value added |
| Inst | : institutions |
| Fed | : federal government |
| Invest | : investment |
| Ind Use | : industry use matrix |
| fac inc & IBT | : factor income and indirect business tax |
| Make | : make matrix |
| imp from | : imports from |
| reg fac income | : regular factor income |
| fac tax | : factor tax |
| Consump | : consumption |
| inc tax | : income tax |
| fed demand | : federal government demand |
| fed saving | : federal government savings |
| inv demand | : investment demand |
| remit | : remittances |
| fed borrow | : federal government borrowing |

Table 4. -- Industries in the MRSAM model.

| IMPLAN SECTORS | INDUSTRIES in MRSAM |
|---|---|
| Sector 16 (Replaced with estimated data[a]) | Catcher-Processor (CPs, harvesting) |
| Sector 16 (Replaced with estimated data[a]) | Trawlers |
| Sector 16 (Replaced with estimated data[a]) | Longliners |
| Sector 16 (Replaced with estimated data[a]) | Crabbers |
| Sector 16 (Replaced with estimated data[a]) | Salmon netters |
| Sector 16 (Replaced with estimated data[a]) | Other harvesters |
| Sector 71 (Replaced with estimated data[a]) | Catcher-Processor (CPs, processing) |
| Sector 71 (Replaced with estimated data[a]) | Mothership (MS) |
| Sector 71 (Replaced with estimated data[a]) | Shorebased processor |
| Sectors 1-15, 17, and 18 | Agriculture |
| Sector 19 | Oil and gas extraction |
| Sectors 20-26 | Other mining |
| Sectors 27-29 | Mining services |
| Sectors 30-32, 495, and 498 | Utilities |
| Sectors 33-45 | Construction |
| Sectors 112-123 | Wood products |
| Sectors 46-70 and 72-84 | Other food manufacturing |
| Sectors 85-111, 124-141, and 143-389 | Other manufacturing |
| Sectors 142 and 396 | Refined petroleum |
| Sector 390 | Wholesale trade |
| Sector 391 | Air transportation |
| Sector 393 | Water transportation |
| Sectors 392, 394, 395, and 397-400 | Other transportation |
| Sector 405 | Food and beverage stores |
| Sectors 401-404 and 406-412 | Other retail |
| Sectors 413-424 | Information |
| Sectors 425-430 | Finance and insurance |

Table 4. -- Cont.

| | |
|---|---|
| Sectors 431-436 | Real estate, renting, and leasing |
| Sectors 437-450 | Professional- scientific and technical services |
| Sector 451 | Management of companies |
| Sectors 452-459 | Administrative support services |
| Sector 460 | Waste management and remediation services |
| Sectors 461-463 | Educational services |
| Sectors 464-470 | Health service and social assistance |
| Sectors 471-478 | Arts, entertainment, and recreation |
| Sectors 479-480 | Accommodations |
| Sector 481 | Food services and drinking places |
| Sectors 482-486 | Repair and maintenance |
| Sectors 487-494 | Other services |
| Sectors 496, 497, 499-502, and 507-509 | Government and non-NAICS |
| Sectors 503 and 504 | State and local government services |
| Sectors 505 and 506 | Federal government services |

a The estimated data for seafood industries is from The Research Group (2007).

Table 5. -- Baseline Data.

| Industry | Alaska | West Coast | Rest of U.S. |
|---|---|---|---|
| INDUSTRY OUTPUT ($million) | | | |
| Harvesting | | | |
| Catcher/processor-harvesting | 287.4 | 10.1 | 0.0 |
| Trawlers | 232.3 | 64.3 | 226.8 |
| Longliners | 247.7 | 22.3 | 0.0 |
| Crabbers | 145.5 | 136.1 | 95.5 |
| Salmon netter | 179.8 | 18.0 | 0.0 |
| Other harvesters | 124.1 | 178.5 | 1002.5 |
| TOTAL HARVESTING | 1216.8 | 429.2 | 1324.8 |
| Processing | | | |
| Catcher/processor-processing | 902.4 | 46.3 | 0.0 |
| Motherships | 227.7 | 32.3 | 0.0 |
| Shorebased processors | 1749.1 | 2883.8 | 7903.6 |
| TOTAL PROCESSING | 2879.2 | 2962.4 | 7903.6 |
| SEAFOOD TOTAL | 4096.0 | 3391.7 | 9228.4 |
| NON-SEAFOOD TOTAL | 47143.6 | 3781915.7 | 20664328.8 |
| TOTAL ALL INDUSTRIES | 51239.6 | 3785307.4 | 20673557.2 |
| EMPLOYMENT (# of jobs) | | | |
| Harvesting | | | |
| Catcher/processor-harvesting | 2652 | 93 | 0 |
| Trawlers | 966 | 838 | 2956 |
| Longliners | 5340 | 759 | 0 |
| Crabbers | 2062 | 3210 | 2254 |
| Salmon netter | 1782 | 2169 | 0 |
| Other harvesters | 4592 | 6347 | 35643 |
| TOTAL HARVESTING | 17394 | 13416 | 40853 |
| Processing | | | |
| Catcher/processor-processing | 8328 | 428 | 0 |
| Motherships | 4616 | 655 | 0 |
| Shorebased processors | 15030 | 9565 | 15261 |
| TOTAL PROCESSING | 27974 | 10648 | 15261 |
| SEAFOOD TOTAL | 45367 | 24064 | 56113 |
| NON-SEAFOOD TOTAL | 419077 | 26775760 | 148987754 |
| TOTAL ALL INDUSTRIES | 464445 | 26799824 | 149043867 |

Table 5. -- Cont.

| | | | |
|---|---|---|---|
| VALUE ADDED ($ million) | | | |
| Labor income | 17788.5 | 1155478.6 | 5999015.5 |
| Capital income | 10707.1 | 754136.5 | 4067330.9 |
| Indirect business tax | 2080.1 | 151950.3 | 778993.4 |
| TOTAL VALUE ADDED | 30575.7 | 2061565.4 | 10845339.7 |
| HOUSEHOLD INCOME ($ million) | | | |
| Low | 2154.7 | 198187.8 | 974913.2 |
| Medium | 9515.2 | 714172.9 | 3433828.1 |
| High | 10942.2 | 852913.7 | 4840387.9 |
| TOTAL HOUSEHOLD INCOME | 22612.2 | 1765274.4 | 9249129.3 |
| GOVERNMENT REVENUE ($million) | | | |
| STATE AND LOCAL GOV'T REVENUE ($million) | 7787.9 | 466024.7 | 2765307.5 |

Table 6. -- Economic impacts from shocks to commodities (quantity change).

| Industry | Alaska | West Coast | Rest of U.S. |
|---|---|---|---|
| .INDUSTRY OUTPUT ($million) | | | |
| *HARVESTING* | | | |
| Catcher/processor-harvesting | -14.8 | 0.0 | 0.0 |
| Trawlers | -18.8 | 0.0 | 0.0 |
| Longliners | -0.1 | 0.0 | 0.0 |
| Crabbers | -0.1 | 0.0 | 0.0 |
| Salmon netter | -0.2 | 0.0 | 0.0 |
| Other harvesters | -0.2 | 0.0 | 0.0 |
| Total harvesting | -34.3 | 0.0 | 0.0 |
| *PROCESSING* | | | |
| Catcher/processor-processing | -35.7 | 0.0 | 0.0 |
| Motherships | -9.0 | 0.0 | 0.0 |
| Shorebased processors | -69.2 | 0.0 | 0.0 |
| Total processing | -113.9 | 0.0 | 0.0 |
| SEAFOOD TOTAL | -148.1 | 0.0 | 0.0 |
| NON-SEAFOOD TOTAL | -92.8 | -28.7 | -104.3 |
| TOTAL ALL INDUSTRIES | -241.0 | -28.7 | -104.3 |
| EMPLOYMENT (# of jobs) | | | |
| *HARVESTING* | | | |
| Catcher/processor-harvesting | -137 | 0 | 0 |
| Trawlers | -78 | 0 | 0 |
| Longliners | -3 | 0 | 0 |
| Crabbers | -2 | 0 | 0 |
| Salmon netter | -2 | 0 | 0 |
| Other harvesters | -8 | 0 | 0 |
| Total harvesting | -230 | 0 | 0 |
| *PROCESSING* | | | |
| Catcher/processor-processing | -329 | 0 | 0 |
| Motherships | -183 | 0 | 0 |
| Shorebased processors | -594 | 0 | 0 |
| Total processing | -1106 | 0 | 0 |
| SEAFOOD TOTAL | -1336 | 0 | 0 |
| NON-SEAFOOD TOTAL | -761 | -205 | -727 |
| TOTAL ALL INDUSTRIES | -2097 | -205 | -727 |

Table 6. -- Cont.

| VALUE ADDED ($ million) | | | |
|---|---|---|---|
| Labor income | -58.7 | -14.7 | -30.4 |
| Capital income | -39.1 | -7.9 | -22.4 |
| Indirect business tax | -5.4 | -1.3 | -4.4 |
| TOTAL VALUE ADDED | -103.2 | -23.9 | -57.1 |
| HOUSEHOLD INCOME ($ million) | | | |
| Low | -2.9 | -1.0 | -1.9 |
| Medium | -24.4 | -6.5 | -12.9 |
| High | -31.9 | -8.7 | -21.6 |
| TOTAL HOUSEHOLD INCOME | -59.2 | -16.2 | -36.4 |
| GOVERNMENT REVENUE ($million) | | | |
| STATE AND LOCAL GOV'T REVENUE ($million) | -8.9 | -2.4 | -7.3 |

Table 7. -- Economic impacts from shocks to commodities (percentage change).

| Industry | Alaska | West Coast | Rest of U.S. |
|---|---|---|---|
| INDUSTRY OUTPUT | | | |
| HARVESTING | | | |
| Catcher/processor-harvesting | -5.2 | 0.0 | 0.0 |
| Trawlers | -8.1 | 0.0 | 0.0 |
| Longliners | -0.1 | 0.0 | 0.0 |
| Crabbers | -0.1 | 0.0 | 0.0 |
| Salmon netter | -0.1 | 0.0 | 0.0 |
| Other harvesters | -0.2 | 0.0 | 0.0 |
| Total harvesting | -2.8 | 0.0 | 0.0 |
| PROCESSING | | | |
| Catcher/processor-processing | -4.0 | 0.0 | 0.0 |
| Motherships | -4.0 | 0.0 | 0.0 |
| Shorebased processors | -4.0 | 0.0 | 0.0 |
| Total processing | -4.0 | 0.0 | 0.0 |
| SEAFOOD TOTAL | -3.6 | 0.0 | 0.0 |
| NON-SEAFOOD TOTAL | -0.2 | 0.0 | 0.0 |
| TOTAL ALL INDUSTRIES | -0.5 | 0.0 | 0.0 |
| EMPLOYMENT | | | |
| HARVESTING | | | |
| Catcher/processor-harvesting | -5.2 | 0.0 | 0.0 |
| Trawlers | -8.1 | 0.0 | 0.0 |
| Longliners | -0.1 | 0.0 | 0.0 |
| Crabbers | -0.1 | 0.0 | 0.0 |
| Salmon netter | -0.1 | 0.0 | 0.0 |
| Other harvesters | -0.2 | 0.0 | 0.0 |
| Total harvesting | -1.3 | 0.0 | 0.0 |
| PROCESSING | | | |
| Catcher/processor-processing | -4.0 | 0.0 | 0.0 |
| Motherships | -4.0 | 0.0 | 0.0 |
| Shorebased processors | -4.0 | 0.0 | 0.0 |
| Total processing | -4.0 | 0.0 | 0.0 |
| SEAFOOD TOTAL | -2.9 | 0.0 | 0.0 |
| NON-SEAFOOD TOTAL | -0.2 | 0.0 | 0.0 |
| TOTAL ALL INDUSTRIES | -0.5 | 0.0 | 0.0 |

Table 7. -- Cont.

| | | | |
|---|---|---|---|
| VALUE ADDED | | | |
| Labor income | -0.3 | 0.0 | 0.0 |
| Capital income | -0.4 | 0.0 | 0.0 |
| Indirect business tax | -0.3 | 0.0 | 0.0 |
| TOTAL VALUE ADDED | -0.3 | 0.0 | 0.0 |
| HOUSEHOLD INCOME | | | |
| Low | -0.1 | 0.0 | 0.0 |
| Medium | -0.3 | 0.0 | 0.0 |
| High | -0.3 | 0.0 | 0.0 |
| TOTAL HOUSEHOLD INCOME | -0.3 | 0.0 | 0.0 |
| GOVERNMENT REVENUE ($million) | | | |
| STATE AND LOCAL GOV'T REVENUE | -0.1 | 0.0 | 0.0 |

## Appendix A: Glossary

Adjusted demand-driven model
An adjusted demand-driven model is used to assess the economic impacts of an exogenous shock to the output or the productive capacity of an industry. The model is run with the regional purchase coefficients (RPCs) set to zero for the relevant industries / commodities and with the initial shock treated as a final demand shock.

Backward linkage
The relationship between an industry and the industries from which the first industry buys its inputs needed to produce its output.

Capital income
Non-labor income that includes business profits (dividends), interest income, and rental income. In the case of fisheries, capital income includes the profits of the owners of vessels and processing firms.

Demand-driven model (or Leontief demand-driven model)
An IO or SAM model that is "driven by" final demand. In a demand-driven model final demand is applied as an initial shock to the model and the model calculates the economic impacts endogenously.

Direct effects
The initial impacts introduced to an economy, typically specified as a direct final demand change.

Direct input coefficients
See Input-output coefficients

Economic impact analysis
An economic impact analysis estimates the change in economic activity arising from a policy or a project. Economic impacts are typically measured in terms of industry output/sales, employment, household spending, and government revenue. Economic impact analysis is different from benefit-cost analysis (BCA) which estimates the *value* of a project by comparing its benefits and costs. When calculating the costs, BCA considers the opportunity cost of a project (i.e., what must be given up to realize the benefits of the project) while an economic impact analysis does not.

Feedback effects
Feedback effects refer to the additional effects that transpire in the region where a policy or a shock is introduced. These effects are caused by the spillover effects occurring in the other regions that arise from the effects in the first region.

Final demand
Demand for goods and services sold to final users. The final demand includes household demand, government demand, investment demand, and exports, but excludes the demand for the goods and services by industries that are used as intermediate inputs.

Forward linkage
The relationship between an industry and other industries to which the first industry sells its output that is used to produce the outputs in these other industries.

GDP deflator
The GDP deflator (also called GDP Price deflator or GDP Implicit Price Deflator) gauges the price level of all domestically produced final goods and services within an economy. It accounts for changes in the average price level for the economy, and therefore, is often used to measure inflation.

IMPLAN
IMPLAN (IMpact analysis for PLANning) provides regional economic data for all counties and states in US, and is also a software used to run IO models with these data.

Indirect business tax
Indirect business taxes include sales taxes, property taxes (levied on businesses), and other fees, fines, licenses, and permit fees, but excludes corporate income tax.

Indirect effects
The impacts caused by iteration of changes in industries' purchases from other industries in response to the direct effects.

Induced effects
The additional impacts transpired due to the change in household spending from a change in household income generated by the direct and indirect effects.

Input-output coefficients (also called Technical coefficients or Direct input coefficients)
Coefficients showing how many dollars of inputs from industries are needed to produce a dollar's worth of output in an industry. The coefficients are derived by dividing the elements in a column in the IO table by the total output of the industry represented by the column.

Input-output table (or transaction table)
A table or matrix showing the transactions among different industries. Columns represent purchasing sectors and rows selling sectors.

Intermediate demand
Industries' demand for goods and services that are used as intermediate inputs in industry production.

Labor income

Labor income consists of (i) employee compensation and (ii) proprietor income. Employee compensation is the total payroll cost paid by the employers, which includes wages, salaries, and all employer-provided benefits (such as social insurance contributions, health care, and retirement). Proprietor income is the income that proprietors pay themselves for their labor in managing their businesses.

Leontief inverse

A matrix showing the total economic impacts on the outputs of all the industries in an economy generated per unit change in the final demand for an industry's output. The sum of the elements in a column (industry) measures the multiplier for that industry.

Make matrix

A matrix showing the quantities of different commodities that an industry produces.

Market share matrix

A matrix showing the proportions of different commodities produced by an industry. The elements in the matrix are derived by dividing the elements in the make matrix by total output of an industry.

Matrix of SAM inverse coefficients

See SAM multiplier matrix

Multiplier

Total impacts generated per unit change in final demand. In the Leontief inverse, the multiplier for an industry is calculated as the sum of the elements in the column representing the industry. Here, total impacts are the sum of direct, indirect, and induced effects. Multipliers may be calculated for industry output, employment, and other variables.

Regional purchase coefficient (RPC)

The fraction of the total demand for a commodity by all users (household, industries, and government) in a region that is supplied by the producers within the region. An RPC of 0.7 for a commodity, for example, means that the producers in the region supply 70% of its total demand with the remainder (30%) satisfied by imports.

Social Accounting Matrix (SAM)

A matrix showing both transactions of commodities and non-market financial flows among industries, value added accounts, households, and governments. It is an extension of IO table because a SAM adds to the IO table accounts recording non-market financial flows from and to sectors like value added sectors, households, and governments. The column entries in a SAM represent expenditures or payments made by the economic agents. The row entries represent receipts or income to agents.

SAM Model
An economic impact model constructed based on a SAM, and overcomes the limitation of input-output model by addressing the distributional effects on, for example, factor owners, households, and government.

SAM direct coefficients
Coefficients showing how the total receipt for an account is spent on commodities or allocated /distributed to non-industry sectors. The coefficients are derived by dividing the elements in a column in a SAM by the column sum. SAM direct coefficients are similar to IO coefficients, but include coefficients for non-industry accounts as well as industry accounts.

SAM multiplier matrix (or Matrix of SAM inverse coefficients)
A matrix showing the total impacts on sectors (including industries, value added accounts, households, and government) generated by a unit change in the exogenous demand for a sector (final demand in case of industries). The sum of the elements in a column, which represent an industry or a non-industry sector, measures the multiplier for the industry or the sector.

Spillover effects
Suppose that economic impacts occur owing to a policy change or a shock in a region. Spillover effects refer to the effects occurring in other regions that have economic linkages with the region where the initial economic impacts transpire.

Supply-determined (or supply-driven model)
An IO or SAM model that is "driven by" industry output or productivity capacity. In a supply-driven model, exogenous change in industry output is applied as an initial shock to the model and the model calculates the economic impacts endogenously.

Supply- driven model
See Supply-determined model

Technical coefficients
See Input-output coefficients

Transaction table
See Input-output table

Use matrix (absorption matrix)
A matrix showing the quantities of different commodities used by each industry in producing the industry's output.

Value added
The difference between an industry's total output value and its payment for the intermediate inputs used in production. Value added consists of labor income, capital income, and indirect business taxes.

# Appendix B: User Manual

**National Marine Fisheries Service**
**Alaska Fisheries Science Center/**
**Alaska Regional Office**

# Regional Impact Analysis User Manual

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## Contents

# User Manual for the Regional Impact Analysis Web Application

The Regional Impact Analysis web application was developed to assist economists and social scientists working with Alaska fisheries in estimating the economic impacts of changes in fishery policies. This web-based application runs a Multi-Regional Social Accounting Matrix (MRSAM) model. This manual (i) briefly describes the model used (MRSAM model), (ii) outlines the regions and sectors used in the model, (iii) provides useful resources that will be helpful in understanding the model, (iv) gives an overview of the web application, and (v) introduces some example scenarios to guide the users in using the application.

# Multiregional Social Accounting Matrix (MRSAM) Model Introduction

Input-output (IO) models are a fundamental tool for regional economic impact analysis, and calculate the total economic impacts of a change in the final demand. Although IO models are useful, the models cannot evaluate the distributional impacts (on value added, household income, and regional government revenue). Social accounting matrix (SAM) models are an extension of IO models, and overcome this limitation of IO models by evaluating the distributional impacts of policy changes. A SAM is a stylized representation of transactions between accounts or "sectors" in an economy.

An example of a SAM model developed for Alaska fisheries is Seung and Waters (2005). However, this SAM model is a single-region model that can calculate the economic impacts for Alaska only, and therefore, was later extended to develop a multi-regional SAM (MRSAM) model for Alaska fisheries in order to examine multiregional effects of changes in Alaska fisheries on the economies of Alaska, the U.S. West Coast (WC), the rest of the US (RUS) [Seung 2014a; Seung 2014b]. We use this MRSAM model for this web application.

A simplified diagram of an MRSAM table is shown in Fig. A1 while a somewhat more detailed schematic of the MRSAM used for this software is shown in Fig. A2. Sectors making purchases or payments appear in the columns. Sectors selling goods and services or receiving payments are shown in the rows. Transactions occur at the intersections of the columns and rows. Note that each sector in the SAM is represented by both a row account and column account, underlining the fundamental principle of SAM that receipts equal expenditures for each account or sector and for the economy overall.

Types of accounts represented in the MRSAM include: "industries" (producers), "commodities" (goods and services produced), components of "value added" (labor income, capital income and indirect business taxes (IBT)), "households" (income earners and consumers of commodities), "governments" (taxes, transfer payments and purchasers of commodities), "capital account" (savings and purchases of capital goods), and "trade" (imports and exports) accounts.

In defining a SAM model, the accounts are bifurcated into “endogenous” and “exogenous” accounts. Endogenous accounts are the economic machinery of a region and are assumed to be driven by the “exogenous” accounts, which inject money into the region chiefly via demand for exports and investment goods, payments from the federal government, and remittances from foreign households. In an MRSAM, each region includes a similar set of economic accounts, and endogenous transactions occur not only between accounts in the same region but also between accounts in different regions. For more details on regional economic impact modeling for Alaska fisheries, see Seung and Miller (2018).

| | Alaska (AK) | West Coast (WC) | Rest of United States (RUS) | Rest of the world (ROW) |
|---|---|---|---|---|
| Alaska (AK) | Alaska Economy | WC purchases from AK | RUS purchases from AK | AK Exports |
| West Coast (WC) | AK purchases from WC | West Coast Economy | RUS purchases from WC | WC Exports |
| Rest of United States (RUS) | AK purchases from RUS | WC purchases from RUS | RUS Economy | RUS Exports |
| Rest of the world (ROW) | AK Imports | WC Imports | RUS Imports | |

Figure A1. -- Basic MRSAM structure (Waters et al. 2014).

| | | AK (incl H&G) | | | | WOC | | | | RUS | | | | ROW | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ind** | **Com** | **VA** | **Inst** | **Ind** | **Com** | **VA** | **Inst** | **Ind** | **Com** | **VA** | **Inst** | **Fed** | **Invest** | **Exports** |
| **AK (incl H&G)** | **Ind** | | Make | | | | | | | | | | | | | |
| | **Com** | Ind Use | | | Consump | | imp from AK | | | | imp from AK | | | fed demand | inv demand | ROW exports |
| | **VA** | fac inc & IBT to AK | | | | fac inc paid to AK | | | | fac inc paid to AK | | | | | | |
| | **Inst** | | | reg fac income | | | | | | | | | | transfers | remitt | |
| **WOC** | **Ind** | | | | | | Make | | | | | | | | | |
| | **Com** | | imp from WOC | | | Ind Use | | | Consump | | imp from WOC | | | fed demand | inv demand | ROW exports |
| | **VA** | fac inc paid to WOC | | | | fac inc & IBT to WOC | | | | fac inc paid to WOC | | | | | | |
| | **Inst** | | | | | | | reg fac income | | | | | | transfers | remitt | |
| **RUS** | **Ind** | | | | | | | | | | Make | | | | | |
| | **Com** | | imp from RUS | | | | imp from RUS | | | Ind Use | | | Consump | fed demand | inv demand | ROW exports |
| | **VA** | fac inc paid to RUS | | | | fac inc paid to AK | | | | fac inc & IBT to RUS | | | | | | |
| | **Inst** | | | | | | | | | | | reg fac income | | transfers | remitt | |
| **ROW** | **Fed** | | tariffs | fac tax | inc tax | | tariffs | fac tax | inc tax | | tariffs | fac tax | inc tax | | | fed borrow |
| | **Savings** | | | | | | | | | | | | | fed saving | | |
| | **Imports** | | imp from ROW | | | | imp from ROW | | | | imp from ROW | | | | | |

Figure A2. -- More detailed MRSAM structure (Waters et al. 2014) (See the next page for descriptions of acronyms and abbreviations).

Descriptions of acronyms and abbreviations in Figure A2

| | |
|---|---|
| MRSAM | : multi-regional social accounting matrix |
| AK | : Alaska |
| WOC | : West Coast |
| RUS | : rest of US |
| ROW | : rest of the world |
| Ind | : industry |
| Com | : commodity |
| VA | : value added |
| Inst | : institutions |
| Fed | : federal government |
| Invest | : investment |
| Ind Use | : industry use matrix |
| fac inc & IBT | : factor income and indirect business tax |
| Make | : make matrix |
| imp from | : imports from |
| reg fac income | : regular factor income |
| fac tax | : factor tax |
| Consump | : consumption |
| inc tax | : income tax |
| fed demand | : federal government demand |
| fed saving | : federal government savings |
| inv demand | : investment demand |
| remit | : remittances |
| fed borrow | : federal government borrowing |

# Regions and Sectors in the MRSAM

In the MRSAM model, the Alaska fisheries industry was represented by eight aggregated components defined using 2004 revenue data sourced from the Alaska Fisheries Information Network (AKFIN, 2013): “Catcher-Processors” (including American Fisheries Act (AFA) pollock CPs, Freezer Longliners, and Amendment 80 (A80) non-pollock trawl CPs), “Trawlers” (catcher vessels with a majority of revenue from trawl gear), “Longliners” (catcher vessels with a majority of revenue from longline gear), “Crabbers” (catcher vessels with a majority of revenue from the crab species group), “Salmon netters” (catcher vessels with a majority of revenue from salmon caught with net or “other” gear), “Other harvesters” (harvesting vessels not falling into any of the prior vessel categories), “Shorebased Processors”, and “Motherships” (non-stationary floating processors). The fish species caught by the CPs and catcher vessels above consists of all major species in Alaska including Atka mackerel, flatfish, Pacific cod, pollock, rockfish, sablefish, crab, halibut, herring, salmon, other finfish, other invertebrate, and other fish.

West Coast (WC) region fisheries were similarly grouped into eight aggregated industry categories encompassing harvesters and processors engaged in federal- and state-managed regional fisheries for the 13 species caught in Alaska fisheries above plus Pacific whiting. The raw fish caught is processed in

CPs, Motherships, and Shorebased processors. Fisheries in the rest of the US (RUS) region were much more compactly aggregated into only four industry components: “Trawlers”, “Crabbers”, “Other harvesters” and “Shorebased Processors”

In the MRSAM constructed for this study, each region includes 33 endogenous non-fisheries industry sectors, 33 corresponding commodity sectors, three value added accounts, three types of households, and a state-local government account, for a total of 219 (73 × 3) endogenous non-fisheries accounts.

Exogenous accounts that drive economic activity in the model include: demand for foreign exports, demand for investment goods, remittances to regional households, and federal government spending. A more detailed technical description of the MRSAM model is provided in Seung and Miller (2018). The complete sectoring scheme with the detailed MRSAM account structure is available upon request.

# Regional Economic Modeling Resources

The MRSAM, and this application tool, are intended to provide socioeconomic analysts with a tool that can be used to evaluate how Alaska fishery policy actions or other exogenous (environmental or market) shocks will affect the economies of the three regions (Alaska, WC, and RUS). The model will map exogenous shocks through economic pathways to estimate regional economic impacts on industry output (sales), value-added, household income, employment, and the combined state and local government revenue. The base modeling structure of the MRSAM does, however, have several limitations. First, the model captures expenditure patterns for the base year (2004) for which the data set was created. Therefore, users may have to rely on GDP deflator adjustments to estimate impacts in subsequent years. Second, the model uses a fixed commodity input structure based on that present in the base year. Therefore, the analyst must be cognizant that major changes in fishery structure within a fishing sector would necessarily alter expenditure patterns in the present time frame and the model output must be interpreted with care in such cases. For more details on the limitations of the model, see Seung and Miller (2018).

It is expected that analysts that use this tool will first familiarize themselves with pertinent literature (see recommended reading list below). However, one does not need to be an expert in the development of regional economic models to use this tool. Several examples are provided here showing real case scenarios as they may be applied in the model application, along with some of the model output one would generate. It is also recommended that analysts confer with either Chang Seung, an economist at the Alaska Fisheries Science Center, or with Scott Miller, an economist at the Alaska Regional Office of the National Marine Fisheries Service for assistance with developing impact scenarios appropriate to the policy issue or exogenous shock in question as well as with assistance in using the model and interpreting model output.

Recommended Reading List

The following resources from the literature are recommended reading to help analysts utilize this tool:

Holland, D. and P. Wyeth (1993). SAM multipliers: their decomposition, interpretation, and relationship to input-output multipliers. Research Bulletin XB 1027. College of Agricultural and Home Economics Research Center, Washington State University.

King, B. 1985. What Is a SAM? Pages 17-51 in Pyatt, G. and J. Round. (eds.), Social Accounting Matrices: a Basis for Planning, The World Bank.

Seung, C. and E. Waters. 2005. A review of regional economic models for Alaska fisheries. Alaska Fisheries Science Center Processed Report 2005-01. https://www.afsc.noaa.gov/Publications/ProcRpt/PR%202005-01.pdf

Seung, C., and E. Waters. 2005. The role of the Alaska seafood industry: a social accounting matrix (SAM) model approach to economic base analysis. The Annals of Regional Science 40 (2), 335-350.

Seung, C. 2014a. Measuring spillover effects of shocks to Alaska economy: An interregional social accounting matrix (IRSAM) model approach. Economic Systems Research 26(2):224-238.

Seung, C. 2014b. Estimating effects of exogenous output changes: An application of multi-regional social accounting matrix (MRSAM) method to natural resource management. Regional Science Policy and Practice 6(2): 177-193.

Seung, C. and S. Miller. 2018. "Regional Economic Analysis for North Pacific Fisheries." NOAA Technical Memo. (in preparation)

Waters, E., C. Seung., M. Hartley., and M. Dalton. 2014. Measuring the Multiregional Economic Contributions of an Alaska Fishing Fleet with Linkages to International Markets. Marine Policy 50: 238-248.

# Regional Impact Analysis Web Application Overview

The MRSAM model allows the user to input a series of shock vectors based on species and/or fishery sector, then view and export the resulting effects on fishery and non-seafood industry sales, employment estimates, and other variables. This section gives an overview of the following:

1. Accessing the application
2. Viewing the documentation
3. Executing the MRSAM model
4. Choosing the types of shock
5. Viewing the data results
6. Exporting the data results

For questions or concerns with regards to the Regional Impact Analysis web application, please contact Chang Seung at chang.seung@noaa.gov or Scott Miller at scott.miller@noaa.gov.

# Accessing the Application

The Regional Impact Analysis web application can be run in any HTML5 compatible browser which includes Microsoft Edge, Microsoft Internet Explorer, Google Chrome, Mozilla Firefox, or Safari (MacOS and iOS). Once downloaded to the client machine, the application can run even when disconnected from the Internet.

1. Navigate to the Regional Impact Analysis web application at:  https://nwecon.psmfc.org


# Viewing the Documentation

To view the Regional Impact Analysis User Manual, select the appropriate link from the application Home page.

1. Select the **here** link under the menu option "Click **here** to read the user's manual".


The user manual will open in a .pdf format.

# Executing the MRSAM Model

To open the Regional Impact Analysis and execute the MRSAM model, select the appropriate link from the application Home page.

1. Select the **here** link under the menu option "Click **here** to access the application".


This takes the user to the application page.


The application allows a run of the model based on the:

- Commodity-Based Shock
- Industry-Based Shock
- Combination of both the Commodity-Based Shock and the Industry-Based Shock

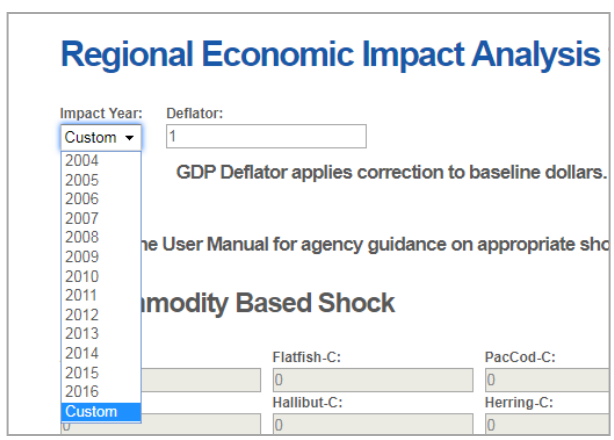
In the commodity-based shock, the initial shock is applied to commodities (fish species or processed fish). The initial shock in this case is specified as the change in the ex-vessel revenue and the change in first wholesale revenue, for one or more species, resulting from a change in harvest of the species. In the industry-based shock, the initial shock is given to industries (fish harvesting and processing sectors). The initial shock in this case is specified as the change in the ex-vessel revenue for a fish harvesting sector (e.g., Trawlers) and the change in first wholesale revenue for a fish processing sector (e.g., Shorebased processors), resulting from a change in the harvest by the fish harvesting sector. The combined commodity and industry shock is used when computing the economic impacts of a fishery management policy that involves changes to both species and fishing sectors.

An overview of each will follow.

1. To begin the model run, select the **Impact Year** for which you want to run the model. The year the user chooses will affect the GDP Deflator applied to the base data prior to executing the model.

The user may select one of the pre-calculated GDP deflators for the years, or select **Custom** and insert their own GDP Deflator value in the **Deflator** text box.

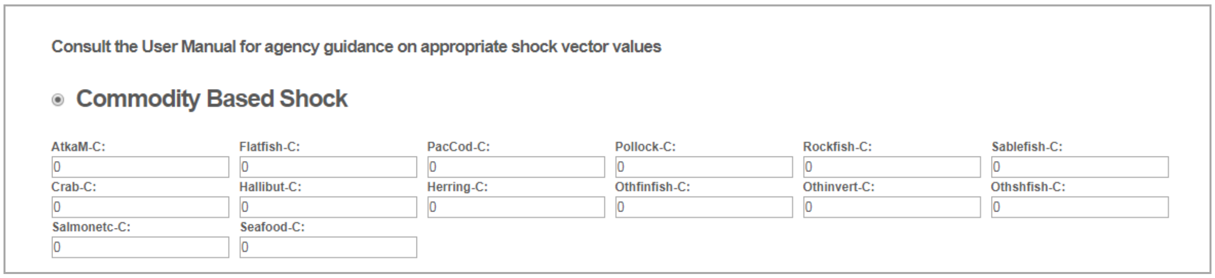
**NOTE: the user must check that the correct GDP deflator is selected prior to EVERY new scenario entered into the application.**



### Executing the Commodity-Based Shock

1. To execute the MRSAM model using a commodity-based shock (i.e., change to the value of the fish species caught), select the radio button to the left of **Commodity-Based Shock**.

Note that when doing so, the text boxes for AtkaM-C, Flatfish-C, etc. turn from gray to white, allowing the user to edit the values.




2. For the **Commodity-Based Shock**, enter ***both*** the desired change to the ex-vessel value of the species (e.g., Pollock-C) catch and the desired change to the first wholesale value of the processed fish (**Seafood-C**).

Commodity-based shocks are created exogenously, or externally, to the model. This means that the users of the software need to estimate the magnitudes of these shocks before running the model. The commodity-based shocks could include such things as a reduction in the Total Allowable Catch (TAC) of a species group due to a decline in the stock. Similarly, a change in allocation of TAC to multiple species groups due to shifting TAC under a harvest cap, such as the 2 million metric ton cap in the Bering Sea and Aleutian Islands (BSAI) groundfish fisheries, could be applied as a commodity shock to each of the affected commodity (species) groups. Alternatively, the effect of a harvest constraint, such as a Prohibited Species Catch cap that results in a species group not being fully harvested, could be analyzed provided the forgone harvest quantity can be estimated.

Commodity shocks are generally composed of two separate shock parameters (numbers). The first is the species group shock (e.g., Pollock-C) and the second is the processed seafood shock. The first shock is measured in terms of the change in total ex-vessel harvest value of the species group. This information may be obtained via a custom query to one or more data repositories within NMFS, the Council, AKFIN, or the State of Alaska, or, in some cases, via published information sources such as the annual Economic SAFE report prepared by the Alaska Fisheries Science Center.

The species group shock, measured at the ex-vessel level, is easily obtained from ex-vessel landings values for catcher vessels delivering to shoreplants due to the ex-vessel transaction being recorded. However, the ex-vessel portion of the commodity shock is not as easily obtained for catcher processors because there is no ex-vessel transaction. In such cases one can apply the catcher vessel ex-vessel prices per metric ton to estimate a proxy for ex-vessel value to obtain the ex-vessel species shock in the catcher processor sector.

The second shock is the impact to the processed seafood (Seafood-C), and is measured as the change in the first wholesale value arising from change in catch. Estimating this shock requires an estimate of the price of the processed fish per retained round metric ton for the species in question and for the processing sector. The price estimate is multiplied by the change in the quantity in tons of the species caught to obtain the value of the change and that value is entered into Seafood-C. If the shocks are negative to one species group but positive for another, the shock to the processed seafood (Seafood-C) must be a net of the two. For complicated scenarios it is advisable to consult with the AFSC and/or AKRO economists.

Note that the shocks are in millions of dollars. A shock could be a negative impact or a positive impact, as a reduction in TAC in one commodity group in the BSAI may result in an increase in TAC in another commodity group. Both effects can be input into the application. However, there is a potential complication to such a scenario.

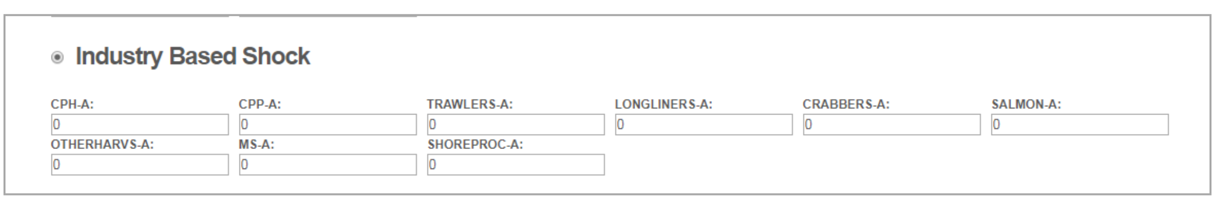
It is important to understand that the model calculates only state-level (i.e., the entire State of Alaska) impacts, and does not, at this time, provide sub-state impacts such as the impacts on boroughs and census areas or cities/communities. This is due to data constraints. The analyst may apply commodity shocks for a specific fishing region, such as the Gulf of Alaska (GOA) or BSAI, by estimating a shock specific to the region and inputting the shock(s) to the model application. However, the results calculated from these shocks will represent the impacts to the entire State of Alaska economy, as well as to the U.S. West Coast, and the rest of the U.S. economies but not at the sub-regional or community level. In other words, a commodity shock (e.g, a change in the TAC for a BSAI fishery) in the model will not provide the economic impacts to the individual communities that depend on the BSAI fishery, but rather the economic impacts to the entire State of Alaska, WC, and RUS.

The model will be executed as soon as the user hits Enter, tabs off the active text box, or uses their mouse to scroll down to view the model results.

### Executing the Industry-Based Shock

1. To execute the MRSAM model using the industry-based shock vectors (i.e., using changes to the harvesting or processing industries), select the radio button to the left of **Industry-Based Shock**.

Note that when doing so, the text boxes for each industry sector turn from gray to white, allowing the user to edit the values.




2. For the **Industry-Based Shock**, the user needs to enter both the change to the ex-vessel value of a harvesting industry (e.g., Trawlers-A) and the change to the first wholesale value of the processing

industry (motherships-MS-A and shore processors-SHOREPROC-A if those vessels deliver to both motherships and shoreside processors). In case of catcher-processors, the change in the “estimated” ex-vessel value is applied to CPH-A and the change in the first wholesale value to CPP-A, respectively.

As in the case of commodity-based shocks, industry-based shocks require the users to estimate the magnitudes of the shocks before running the model. In commodity-based shock cases, the analysts enter the changes in ex-vessel and first wholesale values for certain species. In comparison, in the industry-based shock case, the analysts need to enter the values for relevant fish harvesting and processing industries.

If there is a change in the ex-vessel value of a fish harvesting industry (Trawlers, Longliners, Crabbers, Salmon Netters, or Other Harvesters), the users need to enter the change into the application. In addition, since the change in landing of raw fish by a fish harvesting industry means a change in the processing activity and the first wholesale value for the processing industries [motherships (MS-A) and shoreside processors (SHOREPROC-A)], the users also need to enter these values for the processing industries. The users of the software need to estimate the changes to the fish harvesting and processing industries before running the model. Users may rely on Commercial Operators Annual Report data to get estimates of both the ex-vessel and first wholesale values of the annual harvest of, for example, pink salmon.

Special care should be taken when applying shocks to catcher processor sector. The Catcher Processor sector is composed of two different activities – a harvesting component and processing component. The MRSAM model treats these two activities separately (CPH-A and CPP-A) and so the model application needs the shock to the sector to be split out for harvesting (or ex-vessel value) and processing (or first wholesale less ex-vessel value to capture the net value accounted for by processing activity). For example, if the change in the first wholesale value for the CP sector is $100 and if the change in the “estimated” ex-vessel value of the raw fish processed in the sector is $30, the two shock numbers are derived as $30 for shock to CPH-A and $70 (=100-30) for shock to CPP-A, respectively. The users will need to enter these two numbers.

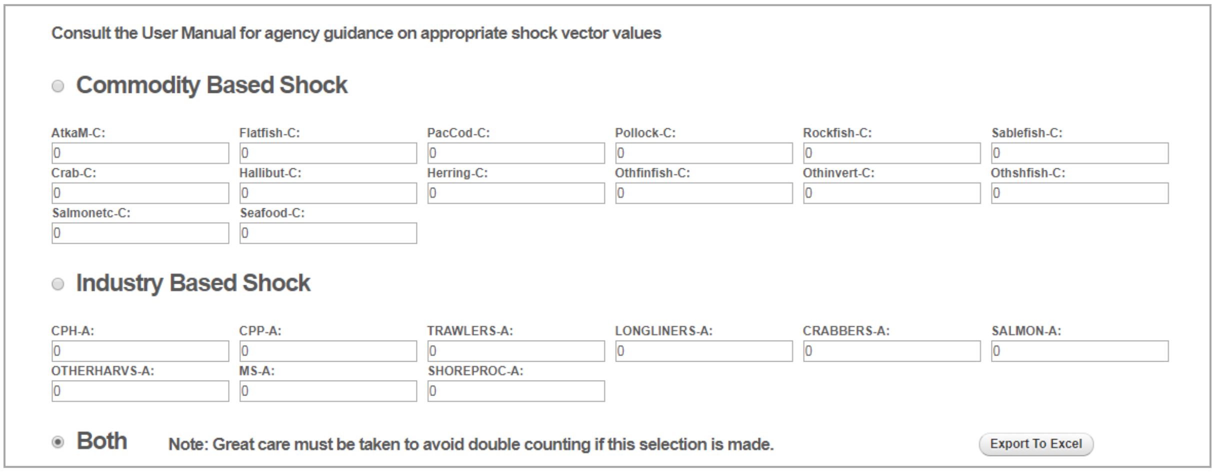
3. The model will be executed as soon as the user hits Enter, tabs off the active text box, or uses their mouse to scroll down to view the model results.

### Executing the Combination Commodity/Industry-Based Shock

In some cases, the users may need to evaluate the economic impacts from a management policy that involves applying shocks to both commodities and industries (such as change in TAC for a species and restrictions placed on the activity of a fishing industry). In this case, the users may choose to use the both types of approaches simultaneously.

1. To execute the MRSAM model based on the combination of commodity and industry-based shock vectors, select the radio button to the left of **Both.**

Note that when doing so, the text boxes for the Commodity-Based Shocks (AtkaM-C, Flatfish-C, etc.) and the Industry-Based Shocks (CPH-A, CPP-A, etc.) turn from gray to white, allowing the user to edit the values.




2. For the **Combination Shock**, the user must enter:

a. Changes in the ex-vessel values of one or more species
b. Overall change in the first wholesale value of the processed fish (Seafood-C)
c. Changes in the ex-vessel values of one or more sectors or industries
d. Changes in the first wholesale values of one or more processing industries (CPP-A, MS-A, and SHOREPROC-A)

***Warning: Great care must be taken to avoid double counting when performing the combination Commodity/Industry-Based Shock.***

3. When applying both commodity-based and industry-based shocks, the users must make sure that any commodity shock cannot be also modeled as an industry sector shock because that would double count the impacts.

The model will be executed as soon as the user hits enter, tabs off the active text box, or uses their mouse to scroll down to view the model results.

In reality, however, there are not many fishery management policies that require using the combined commodity and industry-based shock. For a complicated scenario that involves implementation of a combined commodity- and industry-based shock, it is advisable to consult with the AFSC and/or AKRO economists.

# Choosing the Types of Shock

Users can choose between commodity-based, industry-based, and the combined commodity and industry shocks, depending on several factors. If, for example, the fishery management policy directly alters the amount of harvest of a species caught by different fish harvesting industries, they may want to use commodity-based shock approach. On the other hand, if the management action directly changes the level of fishing activity of a certain fish harvesting industry, which may change the catch of more than one species, the users may want to use industry-based shock approach.

Choosing one or the other type of shocks depends also on how reliable the initial shock estimates are. Suppose that, for a certain policy, the users have estimated two different sets of shocks – one for commodity-based shocks and the other for industry-based shocks. Then, if the users believe that the commodity-based shock estimates are more reliable than industry-based shock estimates, they may want to use the former to get more reliable impact results and vice versa. An important caveat is that the MRSAM model assumes that a fixed percentage of the total harvest of a species (i.e., the harvest by all fishing industries or vessel types) is caught by a fish harvesting industry, and that the amount of a fish species caught by a fish harvesting industry is a fixed percentage of the industry's total catch. These percentages are given in the MRSAM which is based on 2004 data.

# Viewing the Data Results

As noted, the model is executed as soon as the user removes focus from the text boxes. Then, all data tables pertaining to the following impact results are displayed by default:

a. Baseline Data
b. Economic Impacts on industry output and employment to the seafood Industries
c. Economic Impacts on industry output and employment to the non-seafood Industries
d. Economic Impacts on value added, household income, and state and local government revenue

However, the user has the ability to toggle the screen view of these data tables by selecting and de-selecting the displayed sources. The image below illustrates active check boxes located just above Table A (Baseline Data), and Table B (Impacts), indicating that all data tables are turned on for viewing. The user may turn any of these output tables off by unchecking the check boxes.

Display: ☑ Baseline ☑ Economic Impact ☑ Nonseafood Impact ☑ Nonseafood Employment

Table A Baseline Data

| Industry | Alaska | West Coast | Rest of US |
|---|---|---|---|
| INDUSTRY OUTPUT ($million) | | | |
| HARVESTING | | | |
| Catcher/processor-harvesting | 287.4 | 10.1 | 0.0 |
| Trawl CVs | 232.3 | 64.3 | 226.8 |
| Longliners | 247.7 | 22.3 | 0.0 |

Table B Economic impacts from shocks to commodities (quantity change)

| Industry | Alaska | West Coast | Rest of US |
|---|---|---|---|
| INDUSTRY OUTPUT ($million) | | | |
| HARVESTING | | | |
| Catcher/processor-harvesting | -19.8 | 0.0 | 0.0 |
| Trawl CVs | -6.4 | 0.0 | 0.0 |
| Longliners | -2.1 | 0.0 | 0.0 |

Depending on the shocks selected, the tables displayed and exported will differ somewhat. The following tables are available:

- **All Shocks**
  - Table A: Baseline Data
  - Table A.1: Baseline Non-seafood output by industry
  - Table A.2: Baseline Non-seafood employment by industry
- **Commodity-Based Shocks**
  - Table B - Economic Impacts (quantity change)
  - Table C - Economic Impacts (percent change)
  - Table B.1 - Economic Impacts on Non-seafood Output by industry (quantity change)
  - Table B.2 - Economic Impacts on Non-seafood Employment by industry (change in # of jobs)
- **Industry-Based Shocks**
  - Table D - Economic Impacts (quantity change)
  - Table E - Economic Impacts (percent change)
  - Table D.1 - Economic Impacts on Non-seafood Output by industry (quantity change)
  - Table D.2 - Economic Impacts on Non-seafood Employment by industry (change in # of jobs)
- **Combination of Commodity- and Industry-Based Shocks (Both)**
  - Table F - Economic Impacts (quantity change)
  - Table G - Economic Impacts (percent change)
  - Table F.1 - Economic Impacts on Non-seafood Output by industry (quantity change)
  - Table F.2 - Economic Impacts on Non-seafood Employment by industry (change in # of jobs)

# Exporting the Data Results

The users have two options for acquiring the results from the Regional Impact Analysis web application:

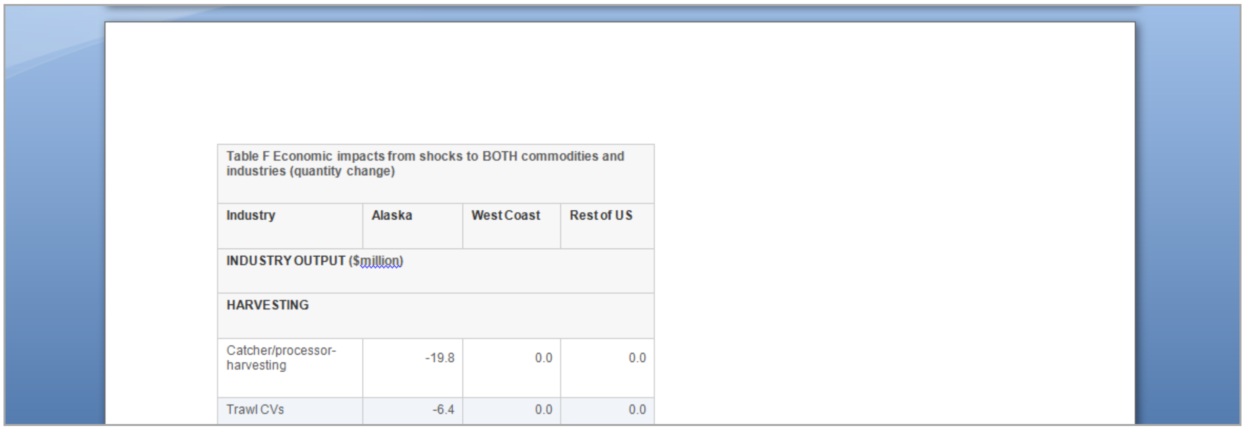
1. Copy and paste the table from the web application screen directly into their document
2. Export the results to an unformatted MS Excel document for further manipulation

## Copying and Pasting the Tables

Once the MRSAM model has been executed and the results viewed in the application, the users can copy and paste the formatted tables one-by-one into their MS Word or other document for use in their analyses.

1. Execute the MRSAM Model
2. Locate the desired table in the web application and highlight the table using your mouse or keypad
3. Right-click and select **Copy**

4. Navigate to document
5. Right-click and **Paste**



| Table F Economic impacts from shocks to BOTH commodities and industries (quantity change) | | | |
|---|---|---|---|
| Industry | Alaska | West Coast | Rest of US |
| INDUSTRY OUTPUT ($million) | | | |
| HARVESTING | | | |
| Catcher/processor-harvesting | -19.8 | 0.0 | 0.0 |
| Trawl CVs | -6.4 | 0.0 | 0.0 |

The above image is a partial example of the copy/paste that inserts a formatted version of the table directly into an MS Word document. One could also use a snipping tool to capture output and paste it to MS Word. Full table output will be shown in the examples below.

### Exporting the Data Tables to Excel

After the results have been executed and the results viewed in the application, the user can export all of the relevant data tables to a non-formatted MS Excel file. For the list of relevant data tables exported by applied shock, see ***Viewing the Data Results***.

1. Execute the MRSAM Model
2. Select **Export to Excel** triggering the browser download
3. Open and view the downloaded file in MS Excel

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Impact Ye | 2004 | Deflator: | 1 | | Note: We assume that the employment in each industry has not changed since 2004. However, all the values (in million dollars) in the initial MRSAM table are adjusted | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | |
| 3 | | AtkaM-C | Flatfish-C | PacCod-C | Pollock-C | Rockfish-C | Sablefish- | Crab-C | Halibut-C | Herring-C | Othfinfish | Othinvert- | Othshfish- | Salmonetc | Seafood-C |
| 4 | Shock Vec | 0 | 0 | 0 | -70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -30 |
| 5 | | | | | | | | | | | | | | | |
| 6 | Table A Baseline Data | | | | | Table B Economic impacts from shocks to commodit | | | | | Table C Economic impacts from shocks to commodities (percentage change) | | | | |
| 7 | Industry | Alaska | West Coa | Rest of US | | Industry | Alaska | West Coa | Rest of US | | Industry | Alaska | West Coa | Rest of US | |
| 8 | INDUSTRY OUTPUT ($million) | | | | | INDUSTRY OUTPUT ($million) | | | | | INDUSTRY OUTPUT ($million) | | | | |
| 9 | HARVESTING | | | | | HARVESTING | | | | | HARVESTING | | | | |
| 10 | Catcher/p | 287.4 | 10.1 | 0 | | Catcher/p | -30.8 | 0 | 0 | | Catcher/p | -10.7 | 0 | 0 | |
| 11 | Trawl CVs | 232.3 | 64.3 | 226.8 | | Trawl CVs | -38.8 | 0 | 0 | | Trawl CVs | -16.7 | 0 | 0 | |
| 12 | Longliners | 247.7 | 22.3 | 0 | | Longliners | -0.1 | 0 | 0 | | Longliners | -0.1 | 0 | 0 | |
| 13 | Crabbers | 145.5 | 136.1 | 95.5 | | Crabbers | 0 | 0 | 0 | | Crabbers | 0 | 0 | 0 | |
| 14 | Salmon ne | 179.8 | 18 | 0 | | Salmon ne | -0.1 | 0 | 0 | | Salmon ne | 0 | 0 | 0 | |
| 15 | Other har | 124.1 | 178.5 | 1002.5 | | Other har | -0.3 | 0 | 0 | | Other har | -0.3 | 0 | 0 | |
| 16 | TOTAL HAF | 1216.8 | 429.2 | 1324.8 | | TOTAL HAF | -70.1 | 0 | 0 | | TOTAL HAF | -5.8 | 0 | 0 | |
| 17 | PROCESSING | | | | | PROCESSING | | | | | PROCESSING | | | | |
| 18 | Catcher/p | 902.4 | 46.3 | 0 | | Catcher/p | -9.4 | 0 | 0 | | Catcher/p | -1 | 0 | 0 | |
| 19 | Mothersh | 227.7 | 32.3 | 0 | | Mothersh | -2.4 | 0 | 0 | | Mothersh | -1 | 0 | 0 | |
| 20 | Shorebase | 1749.1 | 2883.8 | 7903.6 | | Shorebase | -18.1 | 0 | 0 | | Shorebase | -1 | 0 | 0 | |
| 21 | TOTAL PRC | 2879.2 | 2962.4 | 7903.6 | | TOTAL PRC | -29.9 | 0 | 0 | | TOTAL PRC | -1 | 0 | 0 | |
| 22 | | | | | | | | | | | | | | | |
| 23 | SEAFOOD | 4096 | 3391.7 | 9228.4 | | SEAFOOD | -100 | 0 | 0 | | SEAFOOD | -2.4 | 0 | 0 | |
| 24 | | | | | | | | | | | | | | | |
| 25 | NON-SEAF | 47143.6 | 3781916 | 20664329 | | NON-SEAF | -76.8 | -23.3 | -85.4 | | NON-SEAF | -0.2 | 0 | 0 | |
| 26 | | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | | |
| 28 | TOTAL ALL | 51239.6 | 3785307 | 20673557 | | TOTAL ALL | -176.8 | -23.3 | -85.4 | | TOTAL ALL | -0.3 | 0 | 0 | |
| 29 | | | | | | | | | | | | | | | |
| 30 | EMPLOYMENT (# of jobs) | | | | | EMPLOYMENT (# of jobs) | | | | | EMPLOYMENT (# of jobs) | | | | |
| 31 | HARVESTING | | | | | HARVESTING | | | | | HARVESTING | | | | |
| 32 | Catcher/p | 2652 | 93 | 0 | | Catcher/p | -284 | 0 | 0 | | Catcher/p | -10.7 | 0 | 0 | |
| 33 | Trawl CVs | 966 | 838 | 2956 | | Trawl CVs | -161 | 0 | 0 | | Trawl CVs | -16.7 | 0 | 0 | |
| 34 | Longliners | 5340 | 759 | 0 | | Longliners | -3 | 0 | 0 | | Longliners | -0.1 | 0 | 0 | |

MRSAM Model Output.xlsx

The above image is an example of the downloaded MRSAM Output opened in MS Excel. Note that the MS Excel file also includes the impact year and GDP deflator, along with the values for both the commodity and industry shock vector inputs.

## Example Scenario of a Commodity-Based Shock

The total economic value of Alaska seafood production is determined within a world market where prices are directly affected by trade volume, inventory, supply, demand, as well as exchange rates and events in the world banking systems. In 2008, Pacific cod prices were, by some accounts, at an all-time high with strong outlook for even higher prices in 2009. However, late in 2008, a series of banking failures in the U.S. and subsequently in Iceland affected the cod markets negatively. European buyers could not get financing to purchase new inventory and cod prices fell by over 50%.

The 2009 price collapse in cod market resulted in dramatic declines in the landed value of Alaska caught Pacific Cod. Total ex-vessel value, all regions and all gear types combined as reported in the 2010 Economic SAFE report, dropped from $275.6 million to $127 million or a negative shock to the Pacific cod commodity group of $148.6 million. The reported total first wholesale value of that catch was $458.7 million in 2008 but had fallen to $281.4 by 2009. That decline represents a drop in first wholesale value of $177.3 million. Therefore, the two numbers to be entered for the commodity-based shock are -$148.6 million and -$177.3 million for PacCod-C and Seafood-C, respectively. The tables below show the model estimates of impact due to these shocks. Model output within the application also includes base data and percentage impacts. However, what is shown here are the actual numerical impacts.

**Caveat**: IO and SAM (or MRSAM) models assume that prices are fixed, and that the relationship among all the economic variables is linear, meaning that a change in industry output always leads to a proportional change in the use of an input. First, the assumption of fixed prices implies for economic impact analysis of fisheries that a reduction in TAC for a certain species means an equivalent reduction in the ex-vessel value (which is the initial shock given to the model) when the price of the species is normalized to one. Second, regarding the proportionality of input use, a decline in the ex-vessel (or first wholesale value) arising from lowered price of a species may not necessarily decrease the use of inputs proportionally or may not decrease input use at all if the TAC is fixed at a pre-specified level. This is because the use of inputs is proportional to the quantity of fish caught, not to its ex-vessel value. Therefore, when a change in the ex-vessel value is not caused by a change in TAC or the quantity of fish caught but by a change in the price of a species as in the above example, the model results should be interpreted with care. Specifically, the impacts calculated for this example are overestimated to some extent. Users need to be aware of this caveat whenever they simulate shocks that involve changes in the ex-vessel or first wholesale value caused by a price change.

Table B, Economic impacts from shocks to commodities (quantity based), is shown below for this shock scenario. One can see how the shocks affect the harvesting and processing sectors in terms of industry output in millions of dollars. It is important to note that, in the base year, a very small portion of Seafood-C is produced (processed) by non-processing (fish harvesting) industries (trawlers, longliners, crabbers, salmon netters, and other harvesters). So the impacts on the harvesting industries are slightly more than the initial commodity shock because these industries produce some processed seafood in addition to harvesting.[6] On the other hand, the impacts on the processing industries are slightly less than the initial shock to Seafood-C. This difference occurs because the initial shock is commodity-based but the results are reported in terms of industry output. Adding 148.6 to 177.3 equals 325.9, and is equal to the shock sum of 149.4 and 176.5. That is, the sum of initial commodity shocks is the sum of the initial industry impacts. This difference only occurs when applying a commodity shock and does not occur when the shock is exclusively industry-based. Following the output impacts are impacts to employment, value added, household income, and state and local government revenue. The tables also provide the impacts to Alaska, the West Coast, and the Rest of the United States.

As discussed previously, the model will provide a series of other output tables. Table C would convert the output of Table B to percent of base data format. Table A1 provides baseline non-seafood industry output, and table A2 provides base line non-seafood industry employment data. Table B1 provides the economic impacts on non-seafood industry output, by sector, from shocks to commodities, while table B2 provides those impacts in terms of employment. As with all output tables the model output includes impacts to Alaska, the West Coast, and the Rest of the United States, as the three regions in the multiregional SAM. Sample output for tables B, B1, and B2 is shown below.

---

[6] The harvesting sectors' production of processed seafood represents the direct sales of processed fish by harvesting vessels to consumers.

**Table B. -- Economic impacts from shocks to commodities (quantity change).**

| Industry | Alaska | West Coast | Rest of US |
|---|---|---|---|
| **INDUSTRY OUTPUT ($million)** | | | |
| **HARVESTING** | | | |
| Catcher/processor-harvesting | -89.1 | 0.0 | 0.0 |
| Trawl CVs | -28.7 | 0.0 | 0.0 |
| Longliners | -9.3 | 0.0 | 0.0 |
| Crabbers | -8.3 | 0.0 | 0.0 |
| Salmon netter | -2.7 | 0.0 | 0.0 |
| Other harvesters | -11.4 | 0.0 | 0.0 |
| **TOTAL HARVESTING** | -149.4 | 0.0 | 0.0 |
| **PROCESSING** | | | |
| Catcher/processor-processing | -55.3 | 0.0 | 0.0 |
| Motherships | -14.0 | 0.0 | 0.0 |
| Shorebased processors | -107.2 | 0.0 | 0.0 |
| **TOTAL PROCESSING** | -176.5 | 0.0 | 0.0 |
| **SEAFOOD TOTAL** | -325.9 | 0.0 | 0.0 |
| **NON-SEAFOOD TOTAL** | -226.1 | -69.8 | -253.6 |

**Table B. -- Economic impacts from shocks to commodities (quantity change).**

| Industry | Alaska | West Coast | Rest of US |
|---|---|---|---|
| **TOTAL ALL INDUSTRIES** | -552.0 | -69.8 | -253.6 |
| | | | |
| **EMPLOYMENT (# of jobs)** | | | |
| **HARVESTING** | | | |
| Catcher/processor-harvesting | -733 | 0 | 0 |
| Trawl CVs | -106 | 0 | 0 |
| Longliners | -178 | 0 | 0 |
| Crabbers | -105 | 0 | 0 |
| Salmon netter | -24 | 0 | 0 |
| Other harvesters | -376 | 0 | 0 |
| **TOTAL HARVESTING** | -1,522 | 0 | 0 |
| | | | |
| **PROCESSING** | | | |
| Catcher/processor-processing | -455 | 0 | 0 |
| Motherships | -252 | 0 | 0 |
| Shorebased processors | -821 | 0 | 0 |
| **TOTAL PROCESSING** | -1,528 | 0 | 0 |
| | | | |
| **SEAFOOD TOTAL** | -3,050 | 0 | 0 |

| Table B. -- Economic impacts from shocks to commodities (quantity change). | | | |
|---|---|---|---|
| **Industry** | **Alaska** | **West Coast** | **Rest of US** |
| **NON-SEAFOOD TOTAL** | -1,634 | -442 | -1,575 |
| | | | |
| | | | |
| **TOTAL ALL INDUSTRIES** | -4,685 | -442 | -1,575 |
| | | | |
| **VALUE ADDED ($million)** | | | |
| Labor income | -139.5 | -35.3 | -74.1 |
| Capital income | -106.5 | -19.7 | -54.9 |
| Indirect business tax | -12.8 | -3.1 | -10.5 |
| | | | |
| **TOTAL VALUE ADDED** | -258.8 | -58.1 | -139.6 |
| | | | |
| **HOUSEHOLD INCOME ($million)** | | | |
| Low | -7.0 | -2.3 | -4.7 |
| Medium | -59.9 | -15.8 | -31.4 |
| High | -78.1 | -21.0 | -52.8 |
| | | | |
| **TOTAL HOUSEHOLD INCOME** | -145.0 | -39.1 | -88.9 |
| | | | |
| **STATE AND LOCAL GOV'T ($million)** | | | |
| **TOTAL STATE AND LOCAL GOV'T REVENUE** | -21.1 | -5.7 | -17.7 |

**Table B.1 -- Economic Impacts on Non-seafood Industry Output from Shocks to Commodities ($million, quantity change).**

| Industry | Alaska | West Coast | Rest of US |
|---|---|---|---|
| AGRI-A | -1.1 | -0.4 | -1.0 |
| OIL_GAS-A | -20.1 | -0.3 | -3.7 |
| OTHMIN-A | -0.5 | -0.0 | -0.8 |
| MINSERVS-A | -0.5 | -0.0 | -0.1 |
| UTILITIES-A | -7.4 | -1.5 | -3.5 |
| CONSTR-A | -2.7 | -0.8 | -2.9 |
| WOOD-A | -0.2 | -0.2 | -0.6 |
| OTHFOOD-A | -0.0 | -0.0 | -0.1 |
| OTHMANU-A | -7.0 | -11.6 | -51.1 |
| REFINED-A | -26.5 | -3.2 | -6.2 |
| WHOLESALE-A | -7.5 | -2.8 | -16.7 |
| AIRTRAN-A | -1.8 | -0.2 | -1.1 |
| WATERTRAN-A | -0.4 | -0.1 | -0.2 |
| OTHTRAN-A | -4.9 | -1.3 | -5.0 |
| FOODST-A | -3.0 | -0.6 | -1.5 |
| OTHRETAIL-A | -20.3 | -4.3 | -10.4 |
| INFO-A | -7.5 | -5.5 | -14.0 |

| **Table B.1 -- Economic Impacts on Non-seafood Industry Output from Shocks to Commodities ($million, quantity change).** | | | |
|---|---|---|---|
| **Industry** | **Alaska** | **West Coast** | **Rest of US** |
| FIN_INS-A | -20.3 | -5.2 | -39.9 |
| REALEST-A | -12.1 | -4.6 | -13.3 |
| PROFSERVS-A | -12.8 | -6.8 | -16.3 |
| MGTSERVS-A | -1.0 | -0.9 | -6.0 |
| SUPPORT-A | -3.1 | -2.0 | -7.7 |
| WASTEMGT-A | -0.3 | -0.3 | -0.6 |
| EDUSERVS-A | -1.3 | -0.6 | -2.9 |
| HEALTHSERV-A | -16.7 | -4.3 | -14.4 |
| ENTSERVS-A | -2.1 | -1.0 | -2.5 |
| LODGING-A | -1.5 | -0.5 | -1.3 |
| EAT_DRINK-A | -6.3 | -1.6 | -5.3 |
| REPAIRSERV-A | -7.6 | -1.1 | -3.7 |
| OTHSERVS-A | -5.5 | -1.4 | -4.2 |
| MISC-A | -16.2 | -4.9 | -11.1 |
| SLGOVI-A | -8.0 | -2.0 | -5.6 |
| FEDGOVI-A | 0.0 | -0.0 | 0.0 |
| **NON-SEAFOOD TOTAL** | -226.1 | -69.8 | -253.6 |

| **Table B.2 -- Economic Impacts on Non-seafood Industry Employment from Shocks to Commodities (change in # of jobs).** | | | |
|---|---|---|---|
| **Industry** | **Alaska** | **West Coast** | **Rest of US** |
| AGRI-A | -3 | -4 | -8 |
| OIL_GAS-A | -26 | -1 | -4 |
| OTHMIN-A | -3 | -0 | -2 |
| MINSERVS-A | -2 | -0 | -0 |
| UTILITIES-A | -11 | -1 | -4 |
| CONSTR-A | -18 | -5 | -22 |
| WOOD-A | -1 | -1 | -4 |
| OTHFOOD-A | -0 | -0 | -0 |
| OTHMANU-A | -26 | -24 | -112 |
| REFINED-A | -11 | -0 | -1 |
| WHOLESALE-A | -49 | -14 | -86 |
| AIRTRAN-A | -7 | -1 | -4 |
| WATERTRAN-A | -1 | -0 | -0 |
| OTHTRAN-A | -30 | -10 | -46 |
| FOODST-A | -46 | -8 | -22 |
| OTHRETAIL-A | -293 | -50 | -152 |
| INFO-A | -27 | -15 | -34 |

| Table B.2 -- Economic Impacts on Non-seafood Industry Employment from Shocks to Commodities (change in # of jobs). | | | |
|---|---|---|---|
| **Industry** | **Alaska** | **West Coast** | **Rest of US** |
| FIN_INS-A | -101 | -21 | -167 |
| REALEST-A | -72 | -24 | -75 |
| PROFSERVS-A | -121 | -48 | -110 |
| MGTSERVS-A | -6 | -4 | -25 |
| SUPPORT-A | -48 | -32 | -129 |
| WASTEMGT-A | -2 | -1 | -3 |
| EDUSERVS-A | -26 | -10 | -47 |
| HEALTHSERV-A | -195 | -44 | -163 |
| ENTSERVS-A | -44 | -14 | -28 |
| LODGING-A | -17 | -4 | -13 |
| EAT_DRINK-A | -103 | -29 | -94 |
| REPAIRSERV-A | -47 | -11 | -34 |
| OTHSERVS-A | -117 | -27 | -83 |
| MISC-A | -42 | -8 | -13 |
| SLGOVI-A | -139 | -31 | -89 |
| FEDGOVI-A | 0 | -0 | 0 |
| **NON-SEAFOOD TOTAL** | -1,634 | -442 | -1,575 |

## Example Scenario of an Industry-Based Shock

### Pink Salmon Disaster of 2016

In 2016, a projected large run of pink salmon did not materialize in Alaskan waters. Impacts were felt statewide with COAR data (ADF&G) showing a decline of $92.18 million in ex-vessel harvest value from 2015 to 2016. Further, first wholesale value declined by a total of $377.7 million. These shocks ($92.18 million and $377.7 million) were entered into the SALMON-A and the SHOREPROC-A shocks, respectively, and the output of that simulation is provided below.

These shocks, when carried through the model, result in impacts to all seafood and non-seafood sectors in Alaska of $712 million, while total impacts on the West Coast and Rest of US are approximately $88 million and $308 million, respectively (Table D). There is a loss of 731 Alaska harvesting jobs, all in the salmon netter sector, and another 2,595 jobs are lost in the Alaska shorebased processing sector. Additionally, 508 jobs are lost in the West Coast non-seafood sector, and another 1,713 jobs are lost in the Rest of US.

Impacts to value added (labor income, capital income, and indirect business taxes) totals $319 million in Alaska, $75 million in the West Coast, and $167 million in the Rest of the US. Household income fell by $192 million in Alaska, with an additional loss of $52 million and $107 million in the West Coast and Rest of the US, respectively. State and local government revenue declined by $25 million in Alaska, by $7 million in the West Coast region, and $21 million in Rest of the US.

**Table D -- Economic impacts from shocks to industries (quantity change).**

| Industry | Alaska | West Coast | Rest of US |
|---|---|---|---|
| **INDUSTRY OUTPUT ($million)** | | | |
| **HARVESTING** | | | |
| Catcher/processor-harvesting | 0.0 | 0.0 | 0.0 |
| Trawl CVs | 0.0 | 0.0 | 0.0 |
| Longliners | 0.0 | 0.0 | 0.0 |
| Crabbers | 0.0 | 0.0 | 0.0 |
| Salmon netter | -92.2 | 0.0 | 0.0 |

| Table D -- Economic impacts from shocks to industries (quantity change). | | | |
|---|---|---|---|
| **Industry** | **Alaska** | **West Coast** | **Rest of US** |
| Other harvesters | 0.0 | 0.0 | 0.0 |
| **TOTAL HARVESTING** | -92.2 | 0.0 | 0.0 |
| **PROCESSING** | | | |
| Catcher/processor-processing | 0.0 | 0.0 | 0.0 |
| Motherships | 0.0 | 0.0 | 0.0 |
| Shorebased processors | -377.7 | 0.0 | 0.0 |
| **TOTAL PROCESSING** | -377.7 | 0.0 | 0.0 |
| | | | |
| **SEAFOOD TOTAL** | -469.9 | 0.0 | 0.0 |
| | | | |
| **NON-SEAFOOD TOTAL** | -242.0 | -88.4 | -308.1 |
| | | | |
| | | | |
| **TOTAL ALL INDUSTRIES** | -711.9 | -88.4 | -308.1 |
| | | | |
| **EMPLOYMENT (# of jobs)** | | | |
| **HARVESTING** | | | |
| Catcher/processor-harvesting | 0 | 0 | 0 |
| Trawl CVs | 0 | 0 | 0 |
| Longliners | 0 | 0 | 0 |
| Crabbers | 0 | 0 | 0 |

| **Table D -- Economic impacts from shocks to industries (quantity change).** | | | |
|---|---|---|---|
| **Industry** | **Alaska** | **West Coast** | **Rest of US** |
| Salmon netter | -731 | 0 | 0 |
| Other harvesters | 0 | 0 | 0 |
| **TOTAL HARVESTING** | -731 | 0 | 0 |
| | | | |
| **PROCESSING** | | | |
| Catcher/processor-processing | 0 | 0 | 0 |
| Motherships | 0 | 0 | 0 |
| Shorebased processors | -2,595 | 0 | 0 |
| **TOTAL PROCESSING** | -2,595 | 0 | 0 |
| | | | |
| **SEAFOOD TOTAL** | -3,326 | 0 | 0 |
| | | | |
| **NON-SEAFOOD TOTAL** | -1,770 | -508 | -1,713 |
| | | | |
| | | | |
| **TOTAL ALL INDUSTRIES** | -5,096 | -508 | -1,713 |
| | | | |
| **VALUE ADDED ($million)** | | | |
| Labor income | -199.6 | -47.5 | -90.1 |
| Capital income | -104.8 | -23.7 | -64.7 |
| Indirect business tax | -14.9 | -4.0 | -12.5 |
| | | | |
| **TOTAL VALUE ADDED** | -319.2 | -75.2 | -167.4 |

| Table D -- Economic impacts from shocks to industries (quantity change). | | | |
|---|---|---|---|
| **Industry** | **Alaska** | **West Coast** | **Rest of US** |
| **HOUSEHOLD INCOME** ($million) | | | |
| Low | -9.2 | -3.1 | -5.7 |
| Medium | -79.0 | -20.9 | -38.0 |
| High | -103.3 | -27.7 | -63.5 |
| **TOTAL HOUSEHOLD INCOME** | -191.5 | -51.6 | -107.2 |
| **STATE AND LOCAL GOV'T** ($million) | | | |
| **TOTAL STATE AND LOCAL GOV'T REVENUE** | -25.3 | -7.4 | -21.2 |

Table D1, below, provides the impacts of these shocks on non-seafood industry output in each of the three regions. The non-seafood industries in Table D1 are based on sectors that are defined within the model. See Table 4 of Seung and Miller (2018) for definitions of each seafood and non-seafood industry sector. The web application has a list of non-seafood industries. What is perhaps most striking in this output is that impacts to the rest of the US of $308 million are larger than those for Alaska and the West Coast, and that those impacts are largest in the other manufacturing ($69 million) and financial/insurance ($46 million) sectors.  This is not surprising for two reasons. First, a large percentage of the inputs used in Alaska fisheries (including salmon fisheries) are from the Rest of US. Second, the Rest of US economy is much larger than the Alaska economy, which means that the multiplier effects occurring in the rest of US are much larger. For example, about 45% of the other manufacturing commodity used in Alaska industries, including the salmon netter industry, is obtained from the rest of US while about 48% of finance/insurance commodity used in Alaska industries is from the rest of US.

Table D.2 provides these impacts in terms of jobs lost and shows that Alaska based non-seafood sector jobs decline by 1,770, while the rest of the US jobs decline by 1,713. The greatest impacts to employment in non-seafood sectors in Alaska occurred in Other Retail (342) and Health Services (231). The greatest impacts to employment in Other Retail is due primarily to the fact that the commodity from Other Retail is the third most important (in value) input used in Salmon Netter industry and the employment to output ratio for the industry is relatively high. The result that Health Services suffers the second largest decrease in employment among Alaska industries due to the pink salmon disaster indicates the importance of using a SAM model such as the MRSAM model in this application. This result would not be obtained if an input-output model were used. Base year data indicate that the Salmon Netter industry does not use any Health Services directly. Health Services are consumed by the household sector, the income of which consists mainly of factor income derived from labor income and capital income from both seafood industries (including Salmon Netter industry) and non-seafood industries. Base-year data from the MRSAM indicates that households in Alaska spend the largest percentage (17%) of their disposable income on Health Services. An input-output model fails to capture the effects of a change in an industry activity (here, the pink salmon disaster) on factor income and the effects of the change in factor income on household income and expenditures, such as the expenditures on Health Services. Because the MRSAM model used in this application captures the effects on household expenditures, the model produced the result that the pink salmon disaster decreases household expenditures on Health Services and therefore reduces the employment in the Health Services sector significantly.

**Table D.1 -- Economic Impacts on Non-seafood Industry Output from Shocks to Industries ($million, quantity change).**

| Industry | Alaska | West Coast | Rest of US |
|---|---|---|---|
| AGRI-A | -1.3 | -0.5 | -1.2 |
| OIL_GAS-A | -10.5 | -0.3 | -3.6 |
| OTHMIN-A | -0.7 | -0.0 | -1.0 |
| MINSERVS-A | -0.2 | -0.0 | -0.1 |
| UTILITIES-A | -11.4 | -1.9 | -4.4 |
| CONSTR-A | -3.0 | -1.0 | -3.4 |
| WOOD-A | -0.2 | -0.3 | -0.8 |
| OTHFOOD-A | -0.0 | -0.0 | -0.1 |
| OTHMANU-A | -10.1 | -15.8 | -68.5 |
| REFINED-A | -10.5 | -2.6 | -6.0 |
| WHOLESALE-A | -7.6 | -3.7 | -18.8 |

**Table D.1 -- Economic Impacts on Non-seafood Industry Output from Shocks to Industries ($million, quantity change).**

| Industry | Alaska | West Coast | Rest of US |
|---|---|---|---|
| AIRTRAN-A | -2.4 | -0.3 | -1.3 |
| WATERTRAN-A | -0.5 | -0.1 | -0.2 |
| OTHTRAN-A | -5.7 | -1.6 | -6.0 |
| FOODST-A | -3.0 | -0.7 | -1.8 |
| OTHRETAIL-A | -26.3 | -5.6 | -12.8 |
| INFO-A | -9.6 | -7.0 | -17.2 |
| FIN_INS-A | -22.7 | -6.5 | -46.2 |
| REALEST-A | -11.8 | -5.6 | -15.4 |
| PROFSERVS-A | -13.5 | -8.0 | -19.3 |
| MGTSERVS-A | -1.1 | -1.2 | -7.3 |
| SUPPORT-A | -3.5 | -2.5 | -9.2 |
| WASTEMGT-A | -0.4 | -0.3 | -0.7 |
| EDUSERVS-A | -1.7 | -0.7 | -3.7 |
| HEALTHSERV-A | -22.0 | -5.6 | -17.8 |
| ENTSERVS-A | -2.7 | -1.2 | -3.0 |
| LODGING-A | -1.8 | -0.7 | -1.6 |
| EAT_DRINK-A | -8.2 | -2.1 | -6.5 |

| Table D.1 -- Economic Impacts on Non-seafood Industry Output from Shocks to Industries ($million, quantity change). | | | |
|---|---|---|---|
| **Industry** | **Alaska** | **West Coast** | **Rest of US** |
| REPAIRSERV-A | -11.8 | -1.6 | -4.9 |
| OTHSERVS-A | -6.5 | -1.8 | -5.1 |
| MISC-A | -21.4 | -6.4 | -13.5 |
| SLGOVI-A | -9.6 | -2.6 | -6.7 |
| FEDGOVI-A | 0.0 | -0.0 | 0.0 |
| **NON-SEAFOOD TOTAL** | -242.0 | -88.4 | -308.1 |

| Table D.2 -- Economic Impacts on Non-seafood Industry Employment from Shocks to Industries (change in # of jobs). | | | |
|---|---|---|---|
| **Industry** | **Alaska** | **West Coast** | **Rest of US** |
| AGRI-A | -3 | -4 | -9 |
| OIL_GAS-A | -12 | -0 | -4 |
| OTHMIN-A | -4 | -0 | -2 |
| MINSERVS-A | -1 | -0 | -0 |
| UTILITIES-A | -15 | -1 | -5 |
| CONSTR-A | -19 | -6 | -24 |
| WOOD-A | -1 | -1 | -4 |

| Table D.2 -- Economic Impacts on Non-seafood Industry Employment from Shocks to Industries (change in # of jobs). | | | |
|---|---|---|---|
| **Industry** | **Alaska** | **West Coast** | **Rest of US** |
| OTHFOOD-A | -0 | -0 | -0 |
| OTHMANU-A | -34 | -30 | -135 |
| REFINED-A | -4 | -0 | -1 |
| WHOLESALE-A | -45 | -16 | -87 |
| AIRTRAN-A | -8 | -1 | -4 |
| WATERTRAN-A | -1 | -0 | -0 |
| OTHTRAN-A | -31 | -11 | -50 |
| FOODST-A | -42 | -9 | -24 |
| OTHRETAIL-A | -342 | -59 | -168 |
| INFO-A | -31 | -17 | -37 |
| FIN_INS-A | -101 | -24 | -174 |
| REALEST-A | -63 | -26 | -78 |
| PROFSERVS-A | -115 | -51 | -117 |
| MGTSERVS-A | -6 | -5 | -27 |
| SUPPORT-A | -49 | -35 | -138 |
| WASTEMGT-A | -2 | -1 | -3 |
| EDUSERVS-A | -31 | -11 | -53 |

| Table D.2 -- Economic Impacts on Non-seafood Industry Employment from Shocks to Industries (change in # of jobs). | | | |
|---|---|---|---|
| **Industry** | **Alaska** | **West Coast** | **Rest of US** |
| HEALTHSERV-A | -231 | -52 | -181 |
| ENTSERVS-A | -51 | -16 | -31 |
| LODGING-A | -19 | -4 | -14 |
| EAT_DRINK-A | -120 | -35 | -102 |
| REPAIRSERV-A | -65 | -14 | -41 |
| OTHSERVS-A | -125 | -31 | -89 |
| MISC-A | -50 | -9 | -15 |
| SLGOVI-A | -149 | -36 | -96 |
| FEDGOVI-A | 0 | -0 | 0 |
| **NON-SEAFOOD TOTAL** | -1,770 | -508 | -1,713 |

Many more comparisons can be made using the outputs from the model. This discussion of impacts simply provides a flavor of what an analyst might wish to cover and could be similarly developed for the commodity-based shock shown above. In addition, the analyst may wish to work with these numbers in the excel output file to facilitate development of bar charts to compare the magnitude of these impacts. Impacts in percentage terms can be displayed in pie charts as well. It is up to the analyst to use the output to create analytical documents to describe scenarios of shocks within the model.

For further assistance with model operation and interpretation you may contact either Scott Miller (scott.miller@noaa.gov; 907-586-7416) or Chang Seung (chang.seung@noaa.gov; 206-526-4250).

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<u>AFSC-</u>

379 GANZ, P., S. BARBEAUX, J. CAHALAN, J. GASPER, S. LOWE, R. WEBSTER, and C. FAUNCE. 2018. Deployment performance review of the 2017 North Pacific Observer Program. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-378, 68 p. NTIS number pending.

378 M. M. MUTO, V. T. HELKER, R. P. ANGLISS, B. A. ALLEN, P. L. BOVENG, J. M. BREIWICK, M. F. CAMERON, P. J. CLAPHAM, S. P. DAHLE, M. E. DAHLHEIM, B. S. FADELY, M. C. FERGUSON, L. W. FRITZ, R. C. HOBBS, Y. V. IVASHCHENKO, A. S. KENNEDY, J. M. LONDON, S. A. MIZROCH, R. R. REAM, E. L. RICHMOND, K. E. W. SHELDEN, R. G. TOWELL, P. R. WADE, J. M. WAITE, and A. N. ZERBINI. 2018. Alaska marine mammal stock assessments, 2017, 272 p. NTIS number pending.

377 RICHWINE, K. A., K. R. SMITH, and R. A. MCCONNAUGHEY. 2018. Surficial sediments of the eastern Bering Sea continental shelf: EBSSED-2 database documentation, 48 p. NTIS No. PB2018-101013.

376 DORN, M. W., C. J. CUNNINGHAM, M. T. DALTON, B. S. FADELY, B. L. GERKE, A. B. HOLLOWED, K. K. HOLSMAN, J. H. MOSS, O. A. ORMSETH, W. A. PALSSON, P. A. RESSLER, L. A. ROGERS, M. A. SIGLER, P. J. STABENO, and M. SZYMKOWIAK. 2018. A climate science regional action plan for the Gulf of Alaska, 58 p. NTIS No. PB2018-100998.

375 TESTA, J. W. (editor). 2018. Fur seal investigations, 2015-2016, 107 p. NTIS No. PB2018-100966.

374 VON SZALAY, P. G., and N. W. RARING. 2018. Data Report: 2017 Gulf of Alaska bottom trawl survey, 266 p. NTIS No. PB2018-100892

373 ROONEY, S., C. N. ROOPER, E. LAMAN, K. TURNER, D. COOPER, and M. ZIMMERMANN. 2018. Model-based essential fish habitat definitions for Gulf of Alaska groundfish species, 370 p. NTIS No. PB2018-100826.

372 LANG, C. A., J. I. RICHAR, and R. J. FOY. 2018. The 2017 eastern Bering Sea continental shelf and northern Bering Sea bottom trawl surveys: Results for commercial crab species, 233 p. NTIS No. PB2018-100825.

371 RODGVELLER, C. J., K. B. ECHAVE, P-J. F. HULSON, and K. M. COUTRÉ. 2018. Age-at-maturity and fecundity of female sablefish sampled in December of 2011 and 2015 in the Gulf of Alaska, 31 p. NTIS No. PB2018-100824.

370 GUTHRIE, C. M. III, HV. T. NGUYEN, A. E. THOMSON, K. HAUCH, and J. R. GUYON. 2018. Genetic stock composition analysis of the Chinook salmon bycatch samples from the 2016 Gulf of Alaska trawl fisheries, 226 p. NTIS number pending.