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Developing a Multi-Regional Social Accounting Matrix (MRSAM) for Southwest Alaska Fisheries

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ABSTRACT

Most traditional regional economic models developed for North Pacific fisheries depict either the whole state (i.e., Alaska) or a large sub-region (e.g., the Southeast region). While these models are well suited to calculate impacts of fishery management actions on those relatively large regions, they may not as accurately represent impacts on smaller “fishing communities”, or fishing-dependent areas such as individual boroughs and census areas (BCAs). Therefore, results from traditional models may be less useful for fishery managers, policy makers and other entities interested in examining impacts on specific communities, especially ones with very unique, fishing-dependent economic structures. No existing study has yet developed models designed to estimate impacts on individual fishing-dependent communities in Alaska.

Recently, Alaska Fisheries Science Center (AFSC) collected regional economic information (including employment and expenditures) for six BCAs in the Southwest Alaska (SWAK) region from surveys of fish harvesting vessel owners and interviews with key informants, including seafood processors and local input supply businesses. In a follow-up project, AFSC constructed a multi-regional social accounting matrix (MRSAM) incorporating the data mentioned above and other supplementary information. This MRSAM will serve as the baseline dataset from which regional economic models for SWAK fisheries will be developed. This report describes the data and procedures used to construct the MRSAM and provides guidelines for those interested in building similar datasets for fishing-dependent communities in Alaska, other U.S. regions, or other countries.

CONTENTS

1. INTRODUCTION

Most regional economic models developed for North Pacific fisheries are tailored to depict either the whole state (i.e., Alaska) or an administrative region (e.g., the Southeast region). While these models are well-suited to compute the impacts of fishery management actions on relatively large regions, they may not as accurately represent impacts on smaller, fishing-dependent areas such as boroughs and census areas (BCAs) or "fishing communities." Therefore, results from these large models may be less useful for fishery managers, policymakers and other parties interested in illustrating impacts on specific communities, especially ones with very unique economic structures. No existing study has yet developed models designed to estimate impacts on individual BCAs or fishing-dependent communities in Alaska.

The information needed to develop BCA-level models includes (i) IMPLAN data, (ii) landings data by port or community in the BCAs, (iii) data on expenditures by harvesters and fish processors for the BCAs, and (iv) indicators of linkages among harvesters, processors and local input suppliers. IMPLAN provides the local-level (BCA-level) economic data needed as the foundation for BCA-level models. However, seafood sector data in IMPLAN are too aggregate to be useful at this level (IMPLAN Group LLC).

Recently, Alaska Fisheries Science Center (AFSC) obtained regional economic information (including employment and expenditures) for six BCAs in Southwest Alaska (SWAK) region via a survey of fish harvesting vessels and from interviews of key informants among seafood processors and local support businesses. The six SWAK BCAs were Aleutians West Census Area (AWCA), Aleutians East Borough (AEB), Lake and Peninsula Borough (LPB), Bristol Bay Borough (BBB), Dillingham Census Area (DCA), and Kodiak Island Borough (KIB). The regional economic information collected included data on the expenditures and employment for (i) fishing vessels making landings in SWAK ports, (ii) shore-based processors in SWAK BCAs, and (iii) local suppliers selling inputs to the fishing vessels and processors operating in the SWAK region. The data collection also included gathering information on the geographical distribution of input expenditures and residence of fishing and seafood processing sector employees.

In a follow-up to the data collection, the Alaska Fisheries Science Center (AFSC) constructed a 10-region multi-regional social accounting matrices (MRSAM) using the above-mentioned data, basic regional economic data for each BCA derived from IMPLAN, and other supplementary information. This MRSAM will serve as a baseline dataset upon which regional economic models for SWAK fisheries will be built.

This report describes the procedures followed to construct the 10-region MRSAM. The 10-regions in the MRSAM include the six SWAK BCAs plus the rest of Alaska (RAK), West Coast [Washington, Oregon and California (WOC)], the rest of the U.S. (RUS), and a "region" representing at-sea catcher-processors and motherships operating in SWAK-region waters (Western Bering Sea, Aleutian Islands and Gulf of Alaska). Specifically, this report (i) provides a short overview of SAM and SAM models, (ii) explains data requirements for developing an

MRSAM, (iii) briefly describes the data collected for SWAK fisheries and other data used to construct the MRSAM, (iv) describes in detail how BCA-level fisheries information is estimated from regional (i.e., SWAK)-level information, and (v) explains how the MRSAM will be used in a follow-up project to develop regional economic models such as MRSAM models and multi-regional computable general equilibrium (MRCGE) models. Results from these models to be developed based on the MRSAM data will be useful for fishery managers and others who are interested in understanding the economic impacts of fishery management actions or natural exogenous shocks (such as climate change) on fishing-dependent communities in the SWAK region and elsewhere.

2. SOCIAL ACCOUNTING MATRIX (SAM)

2.1 Single-region SAM

A social accounting matrix (SAM) is a matrix that comprises expenditure and income (revenue) accounts, and shows a snapshot of an economy at one point in time. Numbers in the rows show incomes or revenues flowing to economic agents whereas the numbers in the columns show the expenditures or payments by the economic agents. The sum of the elements in a row for an account (i.e., the total revenue for the account) is equal to the sum of the elements in the corresponding column for the same account (i.e., the total expenditures). SAM is an extension of an input-output (IO) table. Thus, to construct a SAM, one starts with the IO accounts that show detailed industry, commodity, factor, and final demand transactions. In addition to these flows and transactions, 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. These accounts are balanced to reflect market-level equilibrium, as well as the aggregate income-expenditure equilibrium. Because a SAM includes these flows, a model based on a SAM can assess the distributional effects of policies, which an IO model cannot evaluate. See King (1985) and Pyatt and Round (1985) for a more detailed discussion of a SAM. The structure of a SAM is presented in Table 1 (2004 Alaska SAM). The SAM has accounts for industries, value added sectors (employee compensation, proprietary income, other property income, and indirect business tax), households, the combined state and local government, the federal government, capital (savings and investment), and the rest of the world (ROW) account. An economic impacts model built off of a SAM is called a SAM model.

2.2 Multi-regional SAM (MRSAM)

A regional economic model based on a single-region SAM can calculate only the economic impacts of a certain policy that transpire in the region for which the SAM is specified and may miss a large fraction of the economic impacts that occur in the regions with strong economic ties with the first region. In order to address the inter-regional effects, one needs a multi-regional SAM (MRSAM) model, and needs to construct a MRSAM. The basic structure of a MRSAM is presented in Table 2 that shows a three-region MRSAM for Alaska, West Coast, and the RUS. In the table, the diagonal elements in the table represent intra-regional transactions among economic agents within a region whereas the off-diagonal elements represent interregional transactions. Table 3 presents a more detailed structure of the 10-region SWAK MRSAM. For more details about MRSAM, see, for example, Seung (2017) and Seung and Miller (2018).

3. DATA ISSUES IN ECONOMIC IMPACT ANALYSIS OF ALASKA FISHERIES

Economists carrying out economic impact analyses using IO, SAM, and computable general equilibrium (CGE) models often rely on IMPLAN data to develop the models. However, there are several problems with fishery data (and Alaska fishery data, in particular) in IMPLAN datasets.

First and foremost, IMPLAN data assumes that the production technology for an industry in a region is the same as that for the national average production technology for the industry. For many non-seafood industries, this assumption may not be problematic. However, the national average production technology may not accurately describe the production “recipe” for regional fish harvesting and processing industries in Alaska. Therefore, to specify correctly the production or expenditure functions for the Alaska seafood industries, it is advisable to obtain primary data on earnings and costs for the categories of industries in question.

Second, IMPLAN understates the employment level in the commercial fishing sectors. IMPLAN relies on state unemployment insurance program data. But the state program excludes “uncovered” employees such as self-employed and casual or part-time workers. A large portion of the employment on fish harvesting vessels is composed of self-employed, seasonal and part-time workers. Therefore, the employment and earnings of many crew members in the commercial fishing sector are not adequately captured in the IMPLAN data.

Third, fish harvesting sector data in IMPLAN are highly aggregated. Models based on highly aggregate data will not be able to evaluate the economic impacts of fishery policies affecting individual species or individual harvesting and processing sectors. Estimation of the economic impacts on the individual seafood sectors is possible only if the seafood sectors in IMPLAN are disaggregated into subsectors by vessel and processor type. This necessitates collecting information on employment, revenues and expenditures (intermediate inputs) by participating vessels and processors.

Fourth, Alaska fisheries are unique in that a large proportion of harvesting vessels and processing facilities is owned and operated by non-Alaskan residents. For example, many of the harvesting vessels operating in Bristol Bay are owned and crewed by residents of Washington and Oregon. This means that much of the capital income (vessel owners’ income) earned by these vessels is likely to leak from Alaska. Similarly, many of the crew members and processing workers are in Alaska fisheries are non-Alaskan residents. Therefore, a large fraction of labor income generated in Alaska seafood industries also leaves the region. In general, it is difficult to identify the residence of economic agents using existing data.

Fifth, Alaska fisheries, like some other Alaska industries, import a large amount of intermediate inputs, much by way of Washington State. Therefore, it is important to estimate the source of imported goods and services used as intermediate inputs in order to correctly estimate the regional impacts of fishery management actions on Alaska and other regions.

Although critical to correctly analyzing regional economic impacts of fishery policies, available published data generally do not provide detailed and reliable information mentioned above. Thus, AFSC implemented a data collection project to obtain the necessary data for analyzing SWAK fisheries. The next section details the types of data that AFSC collected.

4. DATA COLLECTION FOR SHORE-BASED SWAK FISHERIES

We conducted a voluntary, mail-out survey in 2016 of five different categories of fishing vessels delivering to SWAK shore-based processors – Trawl, Hook and Line, Groundfish Pot, Salmon Gillnet, and Other Gear. SWAK crab fishery vessels were excluded from the survey because economic data are already being collected for this sector by the Crab Rationalization Economic Data collection program for the BSAI crab Economic Data Report (EDR). For each vessel category, the survey elicited information on employment and expenditures for vessels participating in SWAK fisheries. Information on 13 vessel operating expenditure categories was elicited, including crew payments and expenditures for intermediate inputs such as fuel, repairs, and other goods and services. Surveyed vessel owners provided information on the number and residency of skippers, crew members and owners who worked on the vessel. The survey also collected information on the geographic distribution of expenditures made in the six SWAK BCAs, RAK, WOC, and RUS. The expenditure categories for which information was obtained from fish harvesting vessels are listed in Table 5a. We mailed out a total of 1,590 survey questionnaires, which resulted in 550 returned surveys with useable data with a response rate of 34.6% (Cascade Economics 2016).

Economic information was elicited from shore-based seafood processors operating in the SWAK region via key informant interviews. This information included product cost components (labor, other variable costs and fixed costs) for the major seafood products produced by SWAK processors, numbers and region of residence of processing employees, the distribution of processors' costs among listed expenditure categories, and the geographic distribution of expenditures made in SWAK BCAs and elsewhere. We collected additional economic data via key informant interviews with suppliers of intermediate inputs used in fish harvesting and processing for SWAK fisheries. For details about the data collected from seafood harvesters, shore-based seafood processors and input suppliers, including survey methods and results, see Cascade Economics (2016).

Data on the total volume and ex-vessel revenues from landings of each species were summarized from AKFIN data extracts. These data included information on the weight and ex-vessel value of fish landings by BCA, species and gear type. Data on total net weight and first wholesale value of fisheries products processed in each BCA by SWAK shore-based processors were summarized from Commercial Operator's Annual Report (COAR) data extracts.

5. STEPS FOR CONSTRUCTING SWAK BCA MRSAM

5.1 Developing SWAK-level Expenditure Function for Shore-based Processors

To develop SWAK-level expenditure functions for the shore-based processing industry, we first identified three different SWAK processor types based on the range of species processed and seasonality of operations. The three processor types are (1) Bristol Bay / Salmon type, characterized by almost exclusive reliance on relatively short-seasonal salmon harvests (Bristol Bay, Dillingham, Lake and Peninsula), (2) BSAI type, characterized by diversity of species processed, including large volumes of crab (Aleutians West, Aleutians East), and (3) Kodiak type, characterized by diversity of species processed, but relatively low volumes of crab (Kodiak Island). For each processor type, we tabulated representative expenditure share data from estimates derived from the processor primary data collection effort plus insights provided by the McDowell Group.[1]

Next, we associated the activity of several inshore floating processors with their respective BCA of operation based on estimates derived from AKFIN and COAR data feeds.[2] This was done in order to include activities of these inshore floating processors with the shore-based processors whose activities they were supporting rather than classifying them as at-sea floating processors (See Section 5.7). In 2014 (and 2015) there were three such inshore floating processor vessels whose activities that we associated with nearby shore-based floating processor operations. Finally, we mapped the estimated shore-based processor expenditure categories onto IMPLAN commodity sectors (based on FEAM[3] relationships for shore-based processing activities, updated to be consistent with IMPLAN's current 536 industry sectoring scheme), and mapped the processor expenditures by IMPLAN sector onto the aggregated MRSAM industry/commodity sectors, plus payments to labor and net income. Expenditure categories for which information was obtained from shore-based processors are listed in Table 5a.

5.2 Developing SWAK-level Expenditure Function for Shore-based Harvesting Vessels

Based on the response data for vessel expenditures by five vessel types (Groundfish Trawl, Groundfish Pot, Groundfish and Halibut Hook and Line, Salmon Gillnet, and "Other Gear" [mostly seine, jig and setnet gear]) from SWAK vessel survey (Cascade Economics 2016), we estimated the average SWAK-level expenditure function for each vessel type. To estimate vessel expenditures for the BSAI crab sector, we used the average expenditure data from the

[1] Personal communication.
[2] AKFIN and COAR data for in-shore floating processors were summarized by Northern Economics, Inc.
[3] FEAM (Fisheries Economic Assessment Model) was developed by William Jensen and Hans Radtke in the early 1980s to estimate contributions of commercial and recreational fishing to the economies of coastal regions. FEAM is a production-oriented model designed to estimate the impacts of supply-side (harvesting sectors) changes assuming perfectly elastic demand for outputs. FEAM consists of two sub-models. The first sub-model estimates revenues and expenditures of businesses involved in fish harvesting and processing activities which are then applied to a second sub-model derived from IMPLAN. Regional economic impacts are calculated by multiplying estimated changes in fishery-related expenditures by income multipliers derived from a corresponding regional IMPLAN model.

Crab EDR supplemented with survey data collected for SWAK Groundfish Pot harvesting vessels and estimates provided by the McDowell Group.[4] Next, we mapped the vessel expenditure data onto corresponding IMPLAN commodity sectors (based on updated FEAM relationships), and mapped the expenditures by IMPLAN sector into the aggregated MRSAM industry/commodity sectors, plus payments to labor and net income. Expenditure categories for which information was obtained from shore-based harvesters are listed in Table 5b.

5.3 Developing Regional SAMs

In order to develop SWAK BCA-level SAMs and SAMs for the non-SWAK regions in the MRSAM, we used the following procedures.

a) Obtain 2014 IMPLAN data for Alaska, Washington, Oregon, California and the U.S. The Alaska IMPLAN data set included borough-level data for all Alaska BCAs.
b) Generate the regional economic datasets using 2014 IMPLAN data for the following regions: (i) Aleutians West Census Area, (ii) Aleutians East Borough, (iii) Lake and Peninsula Borough, (iv) Bristol Bay Borough, (v) Dillingham Census Area, (vi) Kodiak Island Borough, (vii) RAK (remaining 23 BCAs in the State of Alaska), (viii) WOC, and (ix) the entire U.S.
c) In IMPLAN, generate industry by commodity (IxC) detailed SAMs for each region and export that data to GAMS 26 file format.
d) Run GAMS 'IMPLAN Social Accounting Matrix - Construction and Check' routines to assemble IMPLAN GAMS 26 file format data for "import-ridden" SAMs (commodity purchases from commodity accounts include components produced outside the region) and "import-purged" SAMs (purchases from producing industry accounts exclude commodities produced outside the region) for each region. Each raw SAM comprises up to 40 rows and 40 columns, including: 14 aggregated industry accounts, 14 aggregated commodity accounts, four factor payment accounts (employee compensation, proprietors' income, other property income, and indirect business taxes), three aggregated household accounts, one state and local government account, one federal government account, one savings-investment account, one foreign trade account (foreign imports and foreign exports), and one domestic trade account (domestic imports and domestic exports).
e) Subtract corresponding elements of the six SWAK BCA SAMs, RAK SAM, and WOC SAM from the entire U.S. SAM to derive the RUS SAM (i.e., the entire U.S. economy minus the other regions enumerated in the MRSAM). The nine regional economies included in the MRSAM at this point were therefore: (i) Aleutians West Census Area, (ii) Aleutians East Borough, (iii) Lake and Peninsula Borough, (iv) Bristol Bay Borough, (v) Dillingham Census Area, (vi) Kodiak Island Borough, (vii) RAK (remaining 23 BCAs in the State of Alaska), (viii) WOC, and (ix) RUS.

[4] Personal communication.

f) Simplify regional SAM industry, commodity, and institutional accounts for all regional SAMs by zeroing-out IMPLAN-estimated non-industrial commodity supplies (inventory change, government sales, household sales, etc.), inter-household financial transfers, and financial transfers between exogenous accounts. We did this to make the resulting SAM, MRSAM, and CGE models more tractable.
g) Conduct preliminary balancing of the regional SAMs by adjusting other property income (to balance industry accounts), domestic imports (to balance commodity accounts), and institutional net savings and transfers (to balance household and state and local government accounts).

5.4 Commercial Fishing and Seafood Processing Sectors in the Augmented Regional SAMs

5.4.1 *General Procedures*

Once the initial nine regional SAMs were developed as described in Section 5.3 above, the IMPLAN commercial fishing and seafood processing sectors in the six SWAK SAMs were replaced by data constructed for the regional fishing industries. We followed the following steps to augment the SWAK BCA SAMs with the constructed fishing industry data.

a) Bifurcate the employee compensation and proprietors' income accounts in each SWAK BCA SAM into payments to labor and proprietors associated with (1) commercial fishing and seafood processing-related activity, and (2) activities of all other industry sectors. We did this to distinguish the effects of household income received from seafood industries from the effects of income from other sources. Conventional SAM or CGE models for fisheries generally do not distinguish between labor income sourced from different industries. Bifurcating the employee compensation and proprietors' income into seafood industry and non-seafood industry components will enable investigation of household income distributional effects.
b) Replace the single IMPLAN commercial fishing industry account with harvesting vessel expenditure coefficients for relevant fishing vessel sectors in each BCA derived in Section 5.2 above and scaled by applying total ex-vessel values for each relevant harvesting vessel sector in each BCA derived from AKFIN data (tabulated from data provided by The Research Group). For details on how the BCA-level expenditure functions for different vessel types were derived based on the SWAK-level expenditure functions, see Sections 5.4.2 and 5.4.3 below.
c) Replace the elements of the IMPLAN commercial fishing sector Make matrix for each BCA with total ex-vessel value for each of 11 aggregated species "commodities" [1. Tanner Crab (Tanner crab and snow crab), 2. King Crab (mostly Bristol Bay red king crab but also includes brown king crab and blue king crab), 3. Other Crab (mostly Dungeness crab), 4. Pacific cod, 5. Pollock, 6. Sablefish, 7. Rockfish, 8. Flatfish, 9. Salmon, 10. Halibut, and 11. All Other Spp. (mostly herring in 2014)]. Ex-vessel values are derived from AKFIN data (tabulated from landing and ex-vessel value data provided by The Research Group).

d) Reconfigure the IMPLAN seafood processing industry account with seafood processor expenditure coefficients derived in Section 5.1, above, for each BCA and scaled by applying total processed seafood first wholesale value for each BCA. First wholesale values are derived from COAR data (tabulated from seafood product net weight and first wholesale value data provided by The Research Group).
e) Replace seafood processing industry purchases of raw fish inputs in each BCA with ex-vessel value totals for landings of each relevant species "commodity" landed in the BCA (tabulated from data provided by The Research Group).
f) Replace the element of the IMPLAN processed seafood Make matrix in each BCA with total processed seafood "commodity" first wholesale value data (tabulated from data provided by The Research Group).

SAMs for each of the remaining regions (RAK, WOC and RUS) were constructed using a single commercial fishing sector account based on IMPLAN sector #17, and a single seafood processing sector account based on data from IMPLAN sector #93. No additional commercial fishing or processing data were applied to IMPLAN estimates for those sectors.

5.4.2 *Procedures to Derive BCA-level Expenditure Functions from SWAK Expenditure Functions*

The data collected for each harvesting vessel sector reflected activities in the SWAK region as a whole but also included information on the source of input purchases and location of crew and owner residence in individual SWAK BCAs and elsewhere. To develop a BCA-level MRSAM, the regional data must be disaggregated to the BCA-level. This section describes in detail how the BCA-level vessel expenditure functions were derived from the regional-level information. Derivation of BCA-level expenditure functions was based on two implicit assumptions. First, when deriving the BCA-level cost information, it is assumed that costs for a given vessel sector do not vary with the fish species caught. Second, the geographical distribution of expenditures is the same regardless of where (which SWAK BCA) vessels in a given sector land their fish.

First define some notations as follows:

v (v = 1, 2, ..., V) denotes harvesting vessel sector (e.g., trawler sector, hook and line sector, etc.) where V = 6.

s (s = 1, 2, …, S) denotes fish species caught by the vessel sectors where S = 11.

f (f = 1, 2, ..., F) denotes expenditure categories including intermediate inputs (e.g., fuel, bait, etc.) and primary factors of production (e.g., labor and proprietors' services), where F = 15 (13 expenditure categories for intermediate inputs and two value added components including fishing labor income and fishing proprietor income).

a (a = 1, 2, ..., A) denotes borough or census area of landing and processing (BCA) where A = 6 for this project.

b (*b* = 1, 2, …, B) denotes area/region where vessel expenditures are made, where B = 9 (6 SWAK BCAs and 3 non-SWAK regions including RAK, WOC, and RUS). Here *a* is a subset of *b*.

EXV_SW(*v*) is the total ex-vessel value of all landings by sector v vessels landing at all SWAK ports. This information is available from AKFIN data.

EXV(*v,a*) is the value of all the landings by sector v vessels landing at *a*, and is the output level of vessel sector *v* in area *a*'s portion of the MRSAM.

EXV_S(*v,s,a*) is the value of landings of species *s* by sector *v* vessels landing at *a*, and is the element in the "Make matrix" in vessel sector *v*'s row and the column for species (commodity) *s* in area *a*'s portion of the MRSAM.

COST_SW(*v,f*) denotes total cost of *f* for all vessels in sector *v* landing fish at SWAK regardless of at which SWAK BCA they landed. This information is estimated based on the survey results.

COST(*v,f,a*) denotes total expenditure on *f* made by all vessels in sector *v* landing at *a*.

COST_B(*v,f,a,b*) denotes total expenditure on f made in *b* by all vessels in sector *v* that landed fish at *a*.

MAT(*v,f,b*) is a matrix of the shares of geographical distributions of the expenditure on f for sector v where $\sum_b MAT(v,f,b) = 1$, that is, the sum across b's of the elements of any row in the matrix equals one.

$MAT_k(v,f,b)$ is the matrix of geographical distributions (in %) of the expenditure on f made by the k^{th} unit in the response sample of vessels in sector *v*. Here k = 1, 2, … , K (K = the number of respondents in the survey).

$EXV\_SW_k(v)$ is the ex-vessel value of the k^{th} vessel in the response sample for sector *v*.

Then the following equations hold:

$$\sum_a EXV(v,a) = EXV\_SW(v) \qquad \text{Eq. (1)}$$

$$\sum_s EXV\_S(v,s,a) = EXV(v,a) \qquad \text{Eq. (2)}$$

$$\sum_f COST\_SW(v,f) = EXV\_SW(v) \qquad \text{Eq. (3)}$$

Equation (3) states that the summation of all the costs exhausts the ex-vessel revenue for *v*. Here *f* consists of all intermediate inputs including payments to labor (crew and skipper's shares) and capital (owner's profit).

$$\sum_b COST\_B(v,f,a,b) = COST(v,f,a) \qquad \text{Eq. (4)}$$

$$MAT(v,f,b) = \sum_{k=1}^{K} MAT_k(v,f,b) \frac{EXV\_SW_k(v)}{\sum_{k=1}^{K} EXV\_SW_k(v)} \quad \text{Eq. (5)}$$

That is, we estimate MAT(*v,f,b*) using weighted average of the geographical distributions (in % from survey) for the vessels in the response sample with weights calculated by the ex-vessel values of the vessels in the response sample. Note that it is implicitly assumed here that we have the same MAT(*v,f,b*) regardless of at which area a vessels in a given sector land fish. In other words, for a given vessel sector, the geographical distributions of vessel expenditures are the same in all BCAs' portions of the MRSAM.

$$COST(v,f,a) = COST\_SW(v,f) \frac{EXV(v,a)}{EXV\_SW(v)} \quad \text{Eq. (6)}$$

This states that, to calculate COST(*v,f,a*), we allocate COST_SW(*v,f*) across six different BCAs in SWAK in proportion to the ratios of vessel sector *v*'s ex-vessel values from landings at different BCAs to the sector's total ex-vessel value. Note that COST(*v,f,a*) is vessel sector (industry) *v*'s total cost for *f* in the area a's portion of the MRSAM.

$$COST\_B(v,f,a,b) = COST(v,f,a)\, MAT(v,f,b) \quad \text{Eq. (7)}$$

This equation states that COST_B(*v,f,a*) is derived by allocating COST(*v,f,a*) across different areas using MAT(*v,f,b*). Note that in the area a's portion of the MRSAM, COST_B(*v,f,a,a*), which denotes the amount of input f purchased from the region where raw fish were landed (*b*=*a*), will be the element in the column for industry (sector) *v* and the row for input *f*. Note also that the imports by area a from all the other regions are computed as $\sum_b COST\_B(v,f,a,b) - COST\_B(v,f,a,a)$.

$$\sum_{b,f} COST\_B(v,f,a,b) = \text{EXV}(v,a) \quad \text{Eq.(8)}$$

This equation states that the sum of geographic distributions of *all* costs (all *f*'s) is equal to the total sales of sector *v* in the area *a*'s SAM.

5.4.3 *Example*

In this section, we show an example of how to derive BCA-level expenditure functions based on SWAK-level survey information. Suppose that the harvesting sector of interest is sector v, the sector lands fish at three regions (a1, a2, and a3), uses two inputs (f1 and f2), and purchases inputs from four regions (b1, b2, b3, and b4, where b4 may be thought of as the combined region of RAK, WOC, and RUS). We assume that a1 = b1, a2 = b2, and a3 = b3.

Suppose further that the following information is provided from the AKFIN landings and vessel survey data:

EXV_SW(v) = 2000
EXV(v,a1) = 500
EXV(v,a2) = 700
EXV(v,a3) = 800
COST_SW(v,f1) = 1600
COST_SW(v,f2) = 400.

Finally, suppose that MAT(*v,f,b*) matrix for a vessel sector v is given as follows:

input\region	**b1**	**b2**	**b3**	**b4**	**Total**
f1	0.1	0.2	0.1	0.6	1
f2	0.2	0.3	0.2	0.3	1

Given these numbers, COST(*v,f,a*) and COST_B(*v,f,a,b*) can be calculated using the formulas in Equations (6) and (7) above:

COST(v,f1,a1) = 1600*500/2000 = 400
COST(v,f1,a2) = 1600*700/2000 = 560
COST(v,f1,a3) = 1600*800/2000 = 640

COST(v,f2,a1) = 400*500/2000 = 100
COST(v,f2,a2) = 400*700/2000 = 140
COST(v,f2,a3) = 400*800/2000 = 160

COST_B(v,f1,a1,b1) = 400*0.1 = 40
COST_B(v,f1,a1,b2) = 400*0.2 = 80
COST_B(v,f1,a1,b3) = 400*0.1 = 40
COST_B(v,f1,a1,b4) = 400*0.6 = 240

COST_B(v,f1,a2,b1) = 560*0.1 = 56
COST_B(v,f1,a2,b2) = 560*0.2 = 112
COST_B(v,f1,a2,b3) = 560*0.1 = 56
COST_B(v,f1,a2,b4) = 560*0.6 = 336

COST_B(v,f1,a3,b1) = 640*0.1 = 64
COST_B(v,f1,a3,b2) = 640*0.2 = 128
COST_B(v,f1,a3,b3) = 640*0.1 = 64
COST_B(v,f1,a3,b4) = 640*0.6 = 384

COST_B(v,f2,a1,b1) = 100*0.2 = 20
COST_B(v,f2,a1,b2) = 100*0.3 = 30
COST_B(v,f2,a1,b3) = 100*0.2 = 20
COST_B(v,f2,a1,b4) = 100*0.3 = 30

COST_B(v,f2,a2,b1) = 140*0.2 = 28
COST_B(v,f2,a2,b2) = 140*0.3 = 42
COST_B(v,f2,a2,b3) = 140*0.2 = 28
COST_B(v,f2,a2,b4) = 140*0.3 = 42

COST_B(v,f2,a3,b1) = 160*0.2 = 32
COST_B(v,f2,a3,b2) = 160*0.3 = 48
COST_B(v,f2,a3,b3) = 160*0.2 = 32
COST_B(v,f2,a3,b4) = 160*0.3 = 48

Based on these numbers, we can derive the components of sector *v*'s expenditure function as presented in Table 6.

5.5 Developing Species-specific Industry Expenditure Functions

5.5.1 *Shore-based Harvesting Sectors*

The expenditure functions estimated for the seafood industries above are defined for fish harvesting sectors designated by gear type and main target species. With these expenditure functions incorporated in a regional economic model, the economic impacts of, for example, a change in TAC for a given species can be calculated in terms of the apportioned changes in harvesting activities (and associated multiplier effects) of *all* the harvesting sectors that catch the species. With gear-based expenditure functions, however, it is somewhat complicated to estimate the economic impacts of the TAC change on only that portion of a harvesting sector's activity that is associated with that particular species. Therefore, after generating the SWAK BCA-level expenditure functions which show expenditures by each harvesting sector (e.g., Trawlers), we also derived species-specific expenditure functions. A species-specific expenditure function is defined for a particular species group, rather than by gear type, and shows the estimated value of intermediate inputs used by a hypothetical sector dedicated to producing (catching) only that particular species.

To do this transformation, we computed commodity (species) composition ratios derived from each BCA's Make matrix (fraction of species *s* caught by gear sector *g* in BCA *b*), and applied these to each gear-based fish harvesting sectors' expenditure functions to derive species-specific harvesting sector expenditure functions for each SWAK BCA. So instead of each individual species being potentially harvested by up to six gear-based harvesting sectors, following this transformation, harvest of each species in each BCA is fully accounted for by a single species-specific harvesting sector expenditure function.

5.5.2 ***Shore-based Processing Sectors***

The procedure for deriving species-specific processing expenditure functions was identical but simpler because there is only a single shore-based processing sector associated with each BCA. To derive species-specific processing expenditure functions, we used the fraction of total estimated first wholesale revenue associated with each species processed to apportion total expenditures for intermediate inputs and factors of production among the individual species processed in each BCA. In a few cases adjustments were made for certain species so that estimated first wholesale revenue was consistent with ex-vessel revenue.[5] Following this transformation, processing of each species in each BCA is accounted for by a unique, species-specific processing expenditure function.

5.6 Multiregional Commodity and Factor Trade Flows in SWAK BCA SAMs

Commodities produced in a region include goods and services used locally and those exported to other regions. Similarly, factor income generated in a region during production includes portions paid to regional residents as well as to residents of other regions. Together these commodity and factor income flows determine the amount of interregional economic linkages in a MRSAM.

The starting points for modeling interregional commodity trade flows in the MRSAM were estimates of domestic exports (i.e., goods and services purchased by buyers in other U.S. regions), foreign exports (goods and services purchased by ROW buyers) generated by the underlying IMPLAN regional models, and factor income generated in a region and paid to residents in other U.S. regions (domestic payments) and elsewhere (ROW payments). Unfortunately, while IMPLAN provides estimates of total commodity exports and total factor payments, it provides little insight regarding the distribution of commodity and factor income flows among individual regions in the MRSAM.[6]

So the main task in estimating interregional commodity and income flows is mapping IMPLAN's total domestic exports and total domestic income payments to the receiving regions in the MRSAM.[7] The regional distributions of input expenditures estimated for SWAK fisheries and processing sectors served as lower bounds on the volume of interregional commodity and factor income trade between SWAK BCAs, the other five BCAs in the SWAK region, and the other three domestic regions in the MRSAM (RAK, WOC and RUS). The SWAK data collection

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[5] Annual reports of whole weights and ex-vessel values of fish caught are not necessarily correlated with net weights and first wholesale values of corresponding products manufactured due to potential time lags between catch, delivery, production, and final sales.

[6] While IMPLAN Pro can be used to provide estimates of commodity trade flows between two or three regions, it was not able to estimate interregional flows between the nine domestic regions in the MRSAM.

[7] Note that commodity exports from a given region are imports in the receiving region (i.e., exports are shipped in return for payment from the receiving region), while factor income payments to non-residents are analogous to export earnings in the receiving region (i.e., the income flows augment available funds in the receiving region).

effort provided estimates of SWAK fisheries sectors' interregional commodity and factor flows, namely (1) harvesting vessels' expenditures for commodity inputs by MRSAM region based on tabulated responses to a vessel cost survey question (region of expenditure for vessel input purchases), (2) SWAK vessels' factor income payments by residence region of crew, skippers and owners based on tabulated responses to a vessel cost survey question (region of crew, skipper and vessel owner residence) (See Section 5.2), and (3) SWAK shore-based processors' expenditures for intermediate inputs and payments of labor and ownership income by MRSAM region based on data gleaned from the SWAK processors' interview responses and McDowell Group estimates (see Section 5.1).[8]

In cases where IMPLAN's estimates of total domestic commodity exports exceeded the amounts that could be mapped based on results from the collected fisheries sector data, we mapped "excess" commodity flows to destination regions (i.e., other SWAK regions, RAK, WOC and RUS) based on the relative gross regional product (derived from IMPLAN) of each potential destination region in the MRSAM, with IMPLAN estimates of total domestic commodity exports and total domestic commodity imports for each region serving as upper bounds on potential interregional trade in the MRSAM. Employing this assumption means that the larger a regional economy the more likely it is to receive commodity exports from other regions in the MRSAM, and *vice versa*. Note that this method was also used to estimate all commodity flows between the non-SWAK regions in the MRSAM.

We employed methods similar to those used to estimate commodity flows to estimate flows of "excess" factor income (i.e., employee compensation and proprietors' income payments exceeding those that could be mapped using results from the SWAK fisheries sector data collection) between regions in the MRSAM. That is, "excess" interregional factor income flows were estimated in proportion to relative gross regional product and bounded by estimated total payments and receipts of domestic factor income flows for each region (derived from IMPLAN). For simplicity, we assumed that all interregional flows of other property income estimated by IMPLAN as generated by non-fishery-related industries in SWAK BCAs were distributed to owners in the RUS region.[9]

In general using the assumptions and methods outlined in this section means that (1) estimated interregional flows of commodities and factor income payments were roughly proportional to 15the relative gross regional products of the purchasing regions, and (2) except for cases identified in the survey of harvesting vessels or from interviews with shore-based processors, estimated commodity flows and factor income payments between the six SWAK BCAs were very small or nil.

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[8] McDowell Group's estimates of processor expenditures and payroll were derived from prior work plus seafood processors' workforce residency data provided by Alaska Department of Labor and Workforce Development.

[9] All returns to ownership in SWAK fisheries-related sectors (including processors) were distributed to owners via each BCA's fisheries proprietors' income account.

5.7 Including At-Sea Catcher-Processor and Mothership Sectors

We estimated production expenditure totals for the at-sea Catcher-Processor (CP) and Mothership floating processor (MS) sectors operating in Bering Sea, Aleutian Islands and western Gulf of Alaska waters using catch, ex-vessel revenue, net product weight and first wholesale revenue data summarized from AKFIN and COAR data extracts. The lack of consistent catch and production data for certain species, including the absence of ex-vessel revenue data (value of raw fish inputs) for CPs, necessitated the estimation of values for ex-vessel revenue and first wholesale revenue that are consistent with corresponding values for species caught and processed in SWAK shore-based fisheries. Therefore, we estimated ex-vessel revenue equivalent values and corresponding product first wholesale revenues for the at-sea sector using average ex-vessel prices, yields and first wholesale prices that are consistent with procedures used in Fissel et al. (2018).

We adapted expenditure functions (sector and geographical distributions of input purchases) for the at-sea fishery sectors from prior empirical work on the Amendment 80 trawl head and gut fleet (Waters et al. 2014). For that work, activities by CP vessels were bifurcated into harvesting and processing functions, with transfers of raw fish occurring from the harvesting function to the processing function. This two-function harvesting and processing structure was used to model the at-sea CP sector in the MRSAM. We used the expenditure function (sector and geographical distributions of input purchases) estimated for the CP processing function to represent the MS at-sea processing sector. Finally, we used the expenditure function developed from SWAK shore-based trawl vessel survey responses to represent activities of CVs delivering to at-sea MS processors.

Note that a total of six MS floating processor vessels operated in SWAK fisheries in 2014 (and 2015), three of which operated in at-sea fisheries and three that operated inshore in association with shore-based processors. We excluded from the at-sea sector in the MRSAM all operations of the three MS vessels that operated inshore, but included them with the shore-based landing and processing activities in those vessels' primary BCAs of operation.

Negligible direct interaction was modeled between the at-sea sector participants and SWAK BCAs, with the exception of AWCA and KIB, which we assumed provided small quantities of the services, commodity inputs and labor purchased by at-sea sector vessels. Based on findings from the Amendment 80 study cited above, we assumed the largest share of inputs used by the at-sea sector originated from WOC (which includes Seattle).

For lack of more definitive data on the distribution of processed seafood sales by the at-sea sector, we assumed that 10% each of total "seafood" commodity produced by at-sea CPs and Mothership processors was exported to WOC and RUS while the remainder (80%) to ROW[10].

[10] These percentage distributions are determined based on personal communication with Ben Fissel (REFM-AFSC) and industry (At-sea Processors Association).

We developed species-specific expenditure functions representing the activities of at-sea harvesting and processing sectors using the same procedures outlines in Section 5.5.

5.8 Final Assembly and Balancing of the MRSAM

A SAM is composed of different types of sectors or accounts. These include “commodities” (the goods and services produced and purchased), “industries” or “activities” (producers of commodities), “value added” (employee compensation, proprietors’ income, other property income, and indirect business taxes paid by industries), “households” (purchasers of commodities and receivers of factor income and transfer payments), “governments” (tax collectors, commodity purchasers and makers of transfer payments), a “capital account” (savings-investment balancing), and “trade” (commodity and factor payment import and export balance) accounts.

Once all the SAM elements for nine regions plus the at-sea sector region had been constructed as described above, we assembled the individual SAM components into a 10 × 10 array of intra- and inter-regional transactions matrices. The 10 regional transactions matrices comprise the principal diagonal of the 10 × 10 MRSAM array. Each of the six SWAK BCA component matrices consists of up to 53 endogenous accounts (rows and columns) in the gear-based harvesting sector version, or 68 endogenous accounts in the species-specific fishery industries version. The at-sea sector region consists of up to 34 endogenous accounts in the gear-based harvesting sector version, or 52 endogenous accounts in the species-specific fishery industries version. Each of the three component non-SWAK regional matrices (RAK, WOC, and RUS) consists of 38 endogenous accounts (rows and columns) in both the gear-based and species-specific fishery industries versions. There are also four exogenous accounts that help balance the MRSAM (savings-investment account, federal government revenue and spending account, foreign trade [imports and exports] account, and trade-balancing financial flows account).

The endogenous commodity and factor flows estimated in Sections 5.6 and 5.7 above were mapped onto the corresponding off-diagonal multi-regional trade matrices in the MRSAM array (i.e., representing exports from the region of origin and imports to the receiving region). Finally, we used the exogenous savings-investment and foreign trade accounts to reconcile any remaining unbalanced accounts in the MRSAM, as applicable.

5.9 Sectors in the Final MRSAM

The completed MRSAM has placeholders for a total of up to 466 endogenous accounts (34 in at-sea sector region + 53 × 6 BCA regions + 38 × 3 non-BCA regions) in the gear-based fishery industries version, or 574 endogenous accounts in the species-specific fishery industries version (52 in at-sea sector region + 68 × 6 + 38 × 3). Note that some of these accounts are zero in some regions.

In the gear-based fishery industries version, endogenous accounts in each of the six SWAK BCA regions include up to 19 industries, 24 commodities, six value-added accounts (fisheries labor income, non-fisheries labor income, fisheries proprietors' income, non-fisheries proprietors' income, other property income, and indirect business taxes), three household accounts (low-, medium-, and high-income households),[11] and a combined state and local government account. Industry accounts (Table 4) include up to seven fisheries industries (6 harvesting industries and 1 processing industry) and 12 other industries. The commodity accounts include up to 11 fish species: one processed seafood commodity and 12 non-seafood commodities.

In the species-specific fishery industries version, endogenous accounts comprising each SWAK BCA region include up to 34 industries, 24 commodities, six value-added accounts (fisheries labor income, non-fisheries labor income, fisheries proprietors' income, non-fisheries proprietors' income, other property income, and indirect business taxes), three household accounts (low-, medium-, and high-income households), and a combined state and local government account. Industries include up to 22 seafood industries (11 harvesting industries and 11 processing industries) and 12 non-seafood industries. Commodity accounts include up to 11 raw fish species: one processed seafood commodity and 12 non-seafood commodities.

The 38 endogenous accounts comprising each of the three non-SWAK regions are the same in both the gear-based and species-specific fishery industries MRSAM versions and include 14 industries, 14 commodities, six value-added accounts (fisheries labor income, non-fisheries labor income, fisheries proprietors' income, non-fisheries proprietors' income, other property income, and indirect business taxes), three household accounts (low-, medium-, and high-income households), and a combined state and local government account. The 14 industries include 2 seafood industries (1 harvesting industry and 1 processing industry) and 12 non-seafood industries. The 14 commodities include one raw fish commodity: one processed seafood and 12 non-seafood commodities.

The six fishery harvesting industries in the gear-based fishery industries MRSAM version are 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 gillnet or setnet caught salmon), Other harvesters (harvesting vessels that do not fall into any of the above vessel categories). There is a single shore-based processing industry in each region in this MRSAM version.

The 11 fish species included in both MRSAM versions are: Tanner Crab (Tanner crab and snow crab), King Crab (mostly Bristol Bay red king crab but also includes brown king crab and blue king crab), Other Crab (mostly Dungeness but there's not much of this in SWAK), Pacific cod, Pollock, Sablefish, Rockfish, Flatfish, Salmon, Halibut, and All Other Species (mostly herring in 2014).

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[11] Low-, Medium-, and High-income households are aggregations of the nine household categories in IMPLAN. In the MRSAM 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 IMPLAN had not updated its nine household income brackets for some time as of the 2014 data year.

The species-specific fishery industries MRSAM version includes a unique, shore-based processing sector dedicated to processing each of the 11 fish species, so there are up to 11 total seafood processing sectors in each SWAK BCA.

Both MRSAM versions include four overall exogenous accounts that help balance the MRSAM (savings-investment, federal government revenue and spending, foreign trade [imports and exports], and trade-balancing financial flows).

For the at-sea sector region, all industry inputs including factors of production are imported from other regions in the MRSAM. There are only four industry accounts in the gear-based fishery industries version (Catcher Processor harvesting, Catcher Processor processing, Mothership processing, and catcher vessels delivering to Motherships). Other endogenous accounts in the gear-based fishery industries version include 18 non-zero commodities (eight non-zero fish species, one processed seafood commodity, and nine non-zero non-seafood commodities), and three non-zero value-added accounts (fisheries labor income, fisheries proprietors' income, and indirect business taxes).

In the species-specific fishery industries MRSAM version, endogenous accounts comprising the at-sea sector region include 8 non-zero industries (one for each fish species category caught, 18 non-zero commodities (eight non-zero fish species, one processed seafood commodity, and nine non-zero non-seafood commodities) and three non-zero value-added accounts (fisheries labor income, fisheries proprietors' income, and indirect business taxes).

Since all value-added generated by the at-sea sector industries is transferred to other regions in the MRSAM, there are no endogenous household or state and local government institutional accounts associated with the at-sea sector region. Likewise the at-sea sector region has no non-fisheries related value-added accounts.

6. EMPLOYMENT ESTIMATION IN THE MRSAM

6.1 Non-fisheries Sector Employment

In addition to regional industry transactions and value-added data, IMPLAN produces employment estimates for each regional industry. We used IMPLAN employment estimates (number of jobs) for all non-fisheries industries and government sectors in each region of the MRSAM. These are considered to be broad estimates of employment, calculated as the total number of "jobs", including full-time, part-time, temporary employees, and proprietors. To estimate employment in the RUS region, we subtracted employment in each corresponding sector in the six SWAK BCAs, RAK and WOC regions from the IMPLAN U.S. employment total for that sector.

6.2 Fisheries Sector Employment

Employment in SWAK BCA seafood industries was estimated based on the average number of fish harvesting crew and skippers per harvesting vessel, and fish processing workers per shore-based processor, that are required to operate a particular type of vessel or processor during its annual activities. Unlike employment in IMPLAN sectors which is defined as the annual average number of full- and part-time jobs during a year, employment in SWAK seafood industries is not adjusted for relative length of the fishing or processing season during the year. For example, suppose there are 10 vessels in Gillnet sector and the average number of crew members per vessel is four. Then total employment in the 10-vessel Gillnet sector during the year is estimated to be 40 jobs (= 4 × 10 vessels).

To estimate total employment on shore-based harvesting vessels in each SWAK BCA we used average employment results for each vessel type from the survey of harvesting vessels multiplied by the number of vessels in each category that made deliveries to shore-based processors in each SWAK BCA in 2014. To avoid double-counting, each vessel was assigned a unique harvesting vessel category. For employment by SWAK shore-based processors, we used average employment estimated by the McDowell Group based on data provided by Alaska Department of Labor and Workforce Development. For employment in fisheries harvesting and processing sectors in the RAK, WOC and RUS regions that we used the employment estimates for IMPLAN sector 17 “Commercial fishing” and sector 93 “Seafood product preparation and packaging”, respectively.

To estimate total employment in at-sea fishing and processing sectors, we used the total numbers of vessels operating in at-sea fisheries in SWAK region waters (Catcher-processors, Motherships and catcher vessels delivering to Motherships), estimates of average employment per vessel gleaned from Economic Data Reports (EDR) for Amendment 80 catcher-processors, and the average number of crew and skippers per Trawl harvesting vessel from results of the survey of SWAK shore-based harvesting vessels. For total employment on Catcher-processors, we used the average number of Amendment 80 combined fishing and processing employees per vessel multiplied by the estimated number of Catcher-processors operating in at-sea fisheries in SWAK region waters. Total employment on Catcher-processors was divided into harvesting positions and processing positions based on the average ratio calculated from the 2008-2010 Amendment 80 EDR. For total employment on Mothership floating processors, we used the average number of processing employees per vessel from the Amendment 80 EDR multiplied by the estimated number of Mothership floating processors operating in at-sea fisheries in SWAK region waters. For total employment on catcher vessels delivering to at-sea Motherships we used the average number of crew and skippers per Trawl harvesting vessel from the survey of SWAK harvesting vessels multiplied by the estimated number of catcher vessels that delivered to Motherships operating in at-sea fisheries in SWAK region waters.

7. FUTURE WORK

For this project, we constructed a 10-region MRSAM representing economic interactions between SWAK commercial fishing activities and other regions. The MRSAM provides the dataset needed to develop economic impact models such as SAM models for individual or aggregated SWAK BCAs, MRSAM models that include some or all of the 10 regions, and static and dynamic versions of CGE and MRCGE models. The resulting models will provide more specific and accurate measures of impacts for fishery managers, policymakers and other parties interested in understanding the effects of fishery policies and environmental shocks on fishing dependent communities in Alaska and other regions.

We plan to develop user interface software based on the MRSAM model. The software will be made available for use by social scientists and economists at AFSC, Alaska Regional Office, and the NPFMC for conducting regional economic analyses for Alaska fisheries.

Models can also be developed for analyzing the effects on U.S. regions of external economic conditions. For example, one can use the MRSAM to develop static MRCGE models of Alaska fisheries to estimate impacts of changes in exchange rates, trade policies (such as imposition of tariffs on seafood), or shifts in world demand for Alaska seafood. Dynamic CGE models could also be developed to examine the temporal and accumulated economic and welfare impacts of climate change effects on fisheries.

In developing these models, analysts can aggregate the regions depending on the purpose of the analysis. For example, if policymakers want to focus on the economic impacts of a policy on the non-SWAK U.S. region as a whole, the three non-SWAK regions can be aggregated into a single region. If the analyst wants to develop a single region dynamic CGE model for SWAK to examine the dynamic effects of climate change, all seven SWAK BCA and at-sea sector regions can be aggregated into a single region while the three non-SWAK US regions can be aggregated into another region.

In addition to the usual types of impact analysis that investigate the economic impacts of policy changes or exogenous shocks affecting seafood industries, one can use models (i) to conduct structural path analysis that elucidates the detailed channels through which economic impacts occur, and (ii) to perform linkage analysis that measures the importance or role of seafood industries via examining the backward and forward economic linkages.

The MRSAM built via this project can also be extended to develop a multi-country, multi-region MRSAM. This SAM can include as separate regions, for example, Alaska, West Coast, rest of U.S., Korea, China, Japan, European Union, and rest of the world (all the other countries combined). The resulting model can be used to evaluate the effects of external economic shocks to Alaska or U.S. fisheries, such as changes in exchange rates or tariff policies. Extending this project to multi-country MRSAM project may involve using and modifying the world MRSAM data provided by Global Trade Analysis Project (GTAP).

8. CONCLUDING REMARKS

The purpose of this report is to describe the procedures, we followed to construct the 10-region MRSAM, and to provide guidelines for analysts planning to assemble regional economic datasets starting from primary data collected for Alaska fisheries or fisheries of other U.S. or international regions.

Alaska commercial fisheries are relatively diverse and complex in that large volumes and values of a variety of groundfish, shellfish, salmon and other species are harvested throughout the year in both federal and state waters by a range of vessels using an assortment of gear types. Commercially available regional economic data for Alaska fisheries or from other regions of the U.S. generally do not provide sufficient information needed to develop a dataset for regional economic analysis of fisheries industry impacts. Obtaining regional economic data for many Alaska fisheries is difficult because of the reliance on voluntary surveys which attract low response rates and are expensive and time consuming to administer.[12] Even after primary data have been collected and tabulated, it takes a significant amount of time and effort to complete the dataset needed to develop regional economic models. Starting with recent SWAK-level data collected from a previous project, and augmented with fisheries data summarized from mandatory EDRs (e.g., Crab Rationalization and Amendment 80), this project constructed a dataset for developing BCA-level economic models, including linkages with other SWAK BCAs and other regions. This study is among the first to develop a set of models able to estimate economic impacts on individual fishing-dependent communities or BCAs in Alaska.

Very little data are available regarding the interregional flows of commodity inputs (including services) and labor among SWAK BCAs (AWCA, AEB, LPB, BBB, DCA and KIB), between SWAK BCAs and the rest of Alaska (RAK), and between Alaska regions and elsewhere (WOC, RUS and ROW). This project and the associated prior primary fisheries economic data collection effort provided useful estimates of certain variables, however estimates of many interregional commodity and income flow parameters remain unknown. The assumptions that we used to fill in those gaps likely created some bias that is unknown in both magnitude and direction. Certain assumptions, such as those described in Section 5.6 which scale commodity and factor income flows (and thus economic linkages), according to relative GRP, likely underestimate interregional linkages between SWAK BCAs and RAK. Our hope is that the framework that we outlined here may provide a structure for researchers to develop similar economic models and help fill in more of the data gaps over time.

[12] Mandatory economic data collection programs exist for certain Alaska fisheries such as BSAI Crab and Amendment 80 catcher-processors, among others, but these programs have not been coordinated to provide consistent economic data suitable for conducting regional economic analysis, especially at the BCA-level.

9. ACKNOWLEDGMENTS

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Table 1. -- Structure of the 2004 Alaska SAM (Example of structure of the component Regional SAMs)

	ENDOGENOUS ACCOUNTS					EXOGENOUS ACCOUNTS			
	INDUSTRIES	FACTORS	INDIRECT BUSINESS TAX	HOUSEHOLD	STATE /LOCAL GOV'T	FEDERAL GOV'T	CAPITAL	REST OF WORLD	TOTAL
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 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 U.S. (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 U.S. (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 depiction of the 10-Region SWAK MRSAM structure.

	At-Sea	Aleutians West Census Area	Aleutians East Borough	Lake and Peninsula Borough	Bristol Bay Borough	Dillingham Census Area	Kodiak Island Borough	Rest of Alaska	Washington, Oregon and California	Rest of the U.S.	*Exogenous Accounts / ROW*
At-Sea	**AS**	*Exports: AS to AWCA*	*Exports: AS to AEB*	*Exports: AS to LPB*	*Exports: AS to BBB*	*Exports: AS to DCA*	*Exports: AS to KIB*	*Exports: AS to RoA*	*Exports: AS to WOC*	*Exports: AS to RUS*	*Exports: AS to RoW*
Aleutians West Census Area	*Imports: AWCA to AS*	**AWCA**	*Exports: AWCA to AEB*	*Exports: AWCA to LPB*	*Exports: AWCA to BBB*	*Exports: AWCA to DCA*	*Exports: AWCA to KIB*	*Exports: AWCA to RoA*	*Exports: AWCA to WOC*	*Exports: AWCA to RUS*	*Exports: AWCA to RoW*
Aleutians East Borough	*Imports: AEB to AS*	*Imports: AEB to AWCA*	**AEB**	*Exports: AEB to LPB*	*Exports: AEB to BBB*	*Exports: AEB to DCA*	*Exports: AEB to KIB*	*Exports: AEB to RoA*	*Exports: AEB to WOC*	*Exports: AEB to RUS*	*Exports: AEB to RoW*
Lake and Peninsula Borough	*Imports: LPB to AS*	*Imports: LPB to AWCA*	*Imports: LPB to AEB*	**LPB**	*Exports: LPB to BBB*	*Exports: LPB to DCA*	*Exports: LPB to KIB*	*Exports: LPB to RoA*	*Exports: LPB to WOC*	*Exports: LPB to RUS*	*Exports: LPB to RoW*
Bristol Bay Borough	*Imports: BBB to AS*	*Imports: BBB to AWCA*	*Imports: BBB to AEB*	*Imports: BBB to LPB*	**BBB**	*Exports: BBB to DCA*	*Exports: BBB to KIB*	*Exports: BBB to RoA*	*Exports: BBB to WOC*	*Exports: BBB to RUS*	*Exports: BBB to RoW*
Dillingham Census Area	*Imports: DCA to AS*	*Imports: DCA to AWCA*	*Imports: DCA to AEB*	*Imports: DCA to LPB*	*Imports: DCA to BBB*	**DCA**	*Exports: DCA to KIB*	*Exports: DCA to RoA*	*Exports: DCA to WOC*	*Exports: DCA to RUS*	*Exports: DCA to RoW*
Kodiak Island Borough	*Imports: KIB to AS*	*Imports: KIB to AWCA*	*Imports: KIB to AEB*	*Imports: KIB to LPB*	*Imports: KIB to BBB*	*Imports: KIB to DCA*	**KIB**	*Exports: KIB to RoA*	*Exports: KIB to WOC*	*Exports: KIB to RUS*	*Exports: KIB to RoW*
Rest of Alaska	*Imports: RoA to AS*	*Imports: RoA to AWCA*	*Imports: RoA to AEB*	*Imports: RoA to LPB*	*Imports: RoA to BBB*	*Imports: RoA to DCA*	*Imports: RoA to KIB*	**RoA**	*Exports: RoA to WOC*	*Exports: RoA to RUS*	*Exports: RoA to RoW*
Washington, Oregon and California	*Imports: WOC to AS*	*Imports: WOC to AWCA*	*Imports: WOC to AEB*	*Imports: WOC to LPB*	*Imports: WOC to BBB*	*Imports: WOC to DCA*	*Imports: WOC to KIB*	*Imports: WOC to RoA*	**WOC**	*Exports: WOC to RUS*	*Exports: WOC to RoW*
Rest of the U.S.	*Imports: RUS to AS*	*Imports: RUS to AWCA*	*Imports: RUS to AEB*	*Imports: RUS to LPB*	*Imports: RUS to BBB*	*Imports: RUS to DCA*	*Imports: RUS to KIB*	*Imports: RUS to RoA*	*Imports: RUS to WOC*	**RUS**	*Exports: RUS to RoW*
Exogenous Accounts / ROW	*Imports: RoW to AS*	*Imports: RoW to AWCA*	*Imports: RoW to AEB*	*Imports: RoW to LPB*	*Imports: RoW to BBB*	*Imports: RoW to DCA*	*Imports: RoW to KIB*	*Imports: RoW to RoA*	*Imports: RoW to WOC*	*Imports: RoW to WOC*	

Table 4. -- IMPLAN Industries in the 2014 SWAK MRSAM.

IMPLAN SECTORS (536 Industries)	**AGGREGATED INDUSTRIES in MRSAM**
Sector 17 (Replaced with estimated data)	At-Sea Catcher-Processor (CPs, harvesting)
Sector 17 (Replaced with estimated data)	CVs delivering to At-Sea Mothership Processors
Sector 17 (Replaced with estimated data)	Trawlers delivering to Shore-based Processors
Sector 17 (Replaced with estimated data)	Longliners delivering to Shore-based Processors
Sector 17 (Replaced with estimated data)	Crabbers delivering to Shore-based Processors
Sector 17 (Replaced with estimated data)	Salmon Netters delivering to Shore-based Processors
Sector 17 (Replaced with estimated data)	Other Harvesters delivering to Shore-based Processors
Sector 93 (Replaced with estimated data)	At-Sea Catcher-Processors (CPs, processing)
Sector 93 (Replaced with estimated data)	At-Sea Mothership Processors (MS)
Sector 93 (Replaced with estimated data)	Shore-based Processors
Sectors 1-16, 18-40	Agriculture and Mining
Sectors 41-51, 519, 522 and 525	Utilities
Sectors 52-64	Construction
Sectors 65-92 and 94-105	Other Food Processing
Sectors 106-394	Other Manufacturing
Sector 395	Wholesale Trade
Sectors 396-407	Retail Trade
Sectors 408-416	Transportation
Sectors 417-440, and 442-517	All Other Services
Sectors 441, and 527-530	Miscellaneous
Sectors 521, 523-524, 526, and 531-534	State and Local Government Services
Sectors 518, 520, and 535-536	Federal Government Services

Table 5a. -- List of expenditure categories in the 2014 survey of SWAK Processors.

Fish purchases from harvesting vessels
Other fish purchases
Processing labor
Line workers
Supervisors and support staff
Administrative staff
Packaging, materials, supplies, and freight
Fish taxes and landings tariffs
Fishery quota purchases
Energy, utilities, and waste disposal
Insurance
Other business costs and expenses
Owners' net income (before income tax)

Table 5b. -- List of expenditure categories in the 2014 survey of SWAK Harvesting Vessels.

Total Payments for fishing trip-related labor *(Note: this item is the total of three rows below)*
Payments to hired crew members
Payments to hired skippers
Payments to owners for fishing-related labor on the vessel
Vessel/engine/gear repair or replacement
Fuel and lubricants (including amounts paid by crew)
Food, supplies, ice, and bait (including amounts paid by crew)
Management fees, monitoring, and observer costs (including amounts paid by crew)
Vessel insurance
Interest payments (short-term liabilities)
G&A overhead, including recruitment and training
Purchase or lease of quota (annualized cost)
Other expenditures (including amounts paid by crew)

Table 6. -- Illustration of sector v's production/expenditure functions for areas a1 and a2 .

Area a1		Area a2	
input f1 purchased from a1 (=b1)	40	input f1 purchased from a2 (=b2)	112
input f2 purchased from a1 (=b1)	20	input f2 purchased from a2 (=b2)	42
input f1 purchased from b2	80	input f1 purchased from b1	56
input f1 purchased from b3	40	input f1 purchased from b3	56
input f1 purchased from b4	240	input f1 purchased from b4	336
TOTAL f1 from ROW	360	TOTAL f1 from ROW	448
input f2 purchased from b2	30	input f2 purchased from b1	28
input f2 purchased from b3	20	input f2 purchased from b3	28
input f2 purchased from b4	30	input f2 purchased from b4	42
TOTAL f2 from ROW	80	TOTAL f2 from ROW	98
Total cost = Total output = EXV(v,a1)	40+20+360 +80 =500	Total cost = Total output = EXV(v,a2)	112+42+448 +98 = 700

U.S. Secretary of Commerce
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