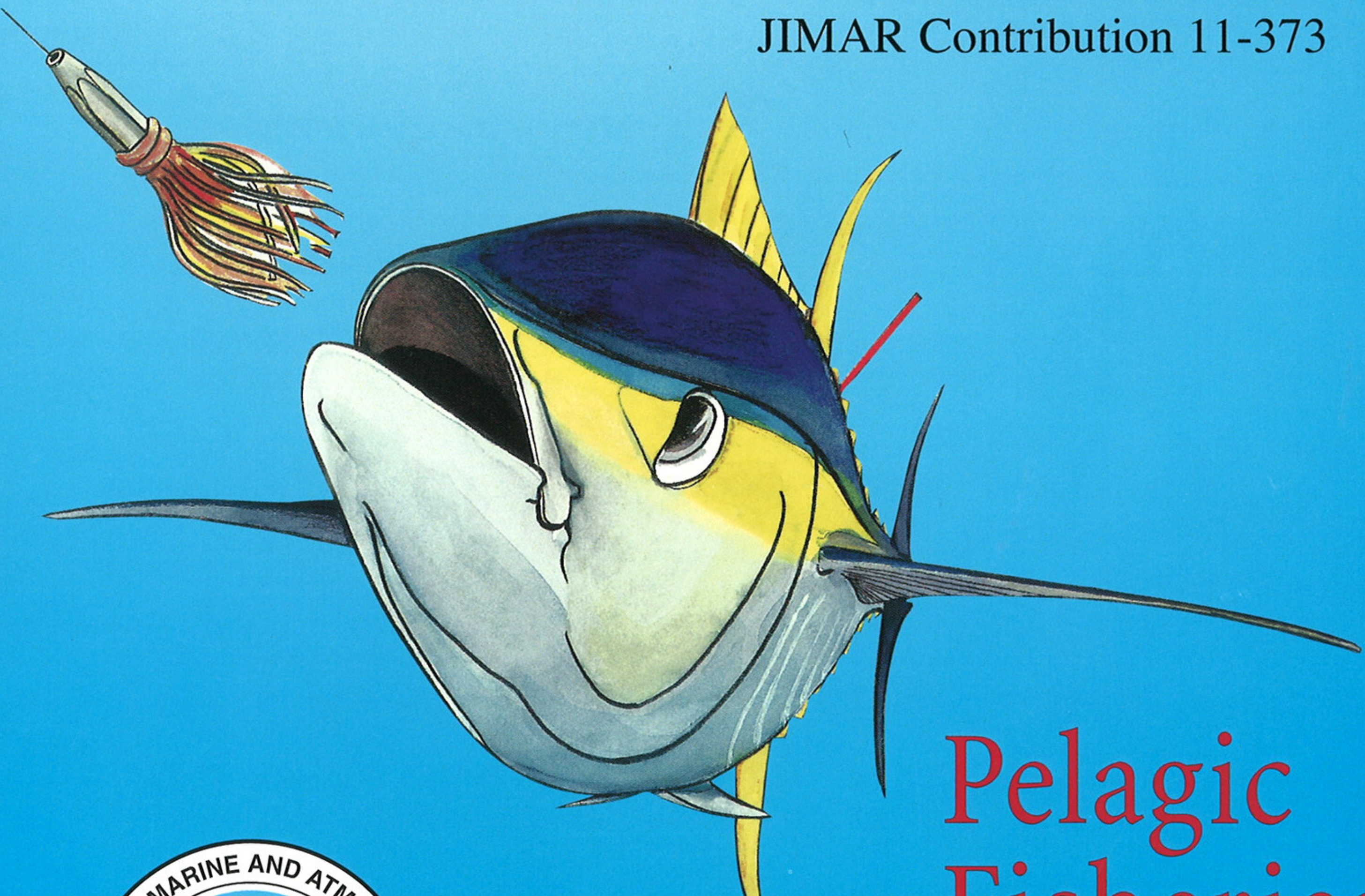
Contribution, Linkages and Impacts of the Fisheries Sector to Hawaii's Economy: A Social Accounting Matrix Analysis

Shawn Arita, Minling Pan, Justin Hospital, and PingSun Leung

SOEST 11-01
JIMAR Contribution 11-373



JOINT INSTITUTE FOR MARINE AND ATMOSPHERIC RESEARCH ~UH-NOAA~ JIMAR

Pelagic Fisheries Research Program

Contribution, Linkages and Impacts of the Fisheries Sector to Hawaii's Economy: A Social Accounting Matrix Analysis

Shawn Arita, Minling Pan, Justin Hospital,
and PingSun Leung

SOEST 11-01
JIMAR Contribution 11-373

Contribution, Linkages and Impacts of the Fisheries Sector to Hawaii's Economy: A Social Accounting Matrix Analysis

Shawn Arita
Joint Institute for Marine and Atmospheric Research and
Dept. of Natural Resources and
Environmental Management
University of Hawaii, Honolulu, HI 96822

Minling Pan, Justin Hospital
Pacific Islands Fisheries Science Center
National Marine Fisheries Service
1601 Kapiolani Blvd., Honolulu HI 96814

PingSun Leung
Dept. of Natural Resources and
Environmental Management
University of Hawaii, Honolulu, HI 96822

SOEST 11-01
JIMAR Contribution 11-373

1. BACKGROUND

In 2005 Hawaii's commercial catch fishery's sector total output was approximately $74 million dollars. Additionally, the onshore/offshore recreational sector and charter sector generated another $500 million dollars. Hawaii's fishery resources are an important source of income for Islanders directly and indirectly dependent upon these resources. However the use of these resources also raises environmental concerns. The impact of the commercial longline industry on endangered species, namely the leatherback turtle, was considered by the courts to be devastating to the species while the bottomfish fishery has been heavily monitored for overfishing concerns.

Decision-making in fishery management often relies on knowledge about the economic contribution, linkages, and impacts of the fisheries sector on the overall economy. For example, a key factor concerning recent regulations over longline fishing in Hawaii is their economy-wide impacts (Leung and Pooley, 2002). Quantitative assessment of the fisheries sector's social and economic contribution is crucial for policymakers to assess the sector's importance. The impacts of fisheries development are not contained within the sector but are transmitted to the rest of the economy. On the other hand, sustainable fisheries development would also rely on the development of other sectors. Input-output (I-O) models provide a useful framework to examine a sector's linkages with other sectors as well as its economy wide impacts.

Previous I-O studies on Hawaii's fisheries have been based on I-O tables that focus only on economic linkages among production sectors. Based on an I-O table, a Social Accounting Matrix (SAM) provides additional information about sectors' linkages through institutional factors such as income distribution, consumption patterns, taxation, and transfer payments. In addition to the traditional inter-industry linkages, these allow a tracing of the linkages between household income and household spending, government revenues and government spending, and savings and investment. The explicit representation of these linkages by the SAM provides a complete picture of the circular flows of goods and money in the economy. As a result, households, governments, and investments can be treated as endogenous variables in SAM models, thus increasing the precision of any impact analysis as well as expanding the analytical details to reflect the income distribution process of the economy.

Hawaii's fisheries operate in a complex environment that is constantly changing due to the varied interest involved with the fishery. The legal issues of sea turtle interactions in the swordfish fishery and the recent mandated closing of the Northwestern Hawaii Islands fishery are examples of how volatile the industry can be. Managers of the fishery have to grapple with not only how much economic activity can be generated but also who are the primary beneficiaries of the fishery. More work is needed to understand the distributional characteristics of the industry. The SAM employed in this report makes it possible to identify the distributional characteristics of the economic impact from the fishery industry and is a useful tool to engage with fishery policy implications.

The first fishery input-output model was built for the year 1992 with an updated version assembled for 1997. This study updates the previous models to 2005 and extends the traditional I-O model to a SAM.

2. OBJECTIVES

The purpose of this research is to 1) provide necessary information on the backward and forward linkages of the fishery sectors to the other sectors of the economy, and the household sector and 2) examine the distributional impacts upon household income. We integrate the most recent cost-earnings information for the various commercial (longline and small boat) as well as the charter/recreational sector into a SAM framework to measure the overall socio-economic contribution of the fishery sector.

Specific objectives are outlined as follows.

1. Extend Hawaii's 2005 I-O table to a fully articulated SAM via including household income distribution and consumption accounts, and government accounts.
2. Build production functions for Hawaii's longline and small boat sectors using recent cost earnings surveys.
3. Incorporate Hawaii's recreational expenditures through using the 2006 Hawaii Marine Recreational Fishing Survey (HMFRS).
4. Integrate detailed fishery sectors into the 2005 SAM.
5. Provide information on forward and backward linkages of fishery sectors through supply driven multipliers.
6. Provide information on the economic importance and value of the various fishery sectors to Hawaii's economy in terms of their contributions to output, value added, state tax revenue, household income, and employment.
7. Assess the fishery sector's distributional impact on household incomes.

3. DIFFERENCES AND IMPROVEMENTS IN THIS MODEL

3.1 Including SAM Accounts (Household and Government Sectors)

The primary difference between this study and previous fishery I-O reports is that this study makes use of a full SAM model.

3.2 Fishery Sectors

The 1997 Fishery I-O Model was originally based on the 1997 Hawaii State I-O model and expanded to include the following 6 fishery sectors.

1. Tuna longline
2. Swordfish longline
3. Commercial small boats
4. Recreation boats
5. Expense boats
6. Charter boats

The SAM model updates the production data with more recent information and includes the six sectors under a slightly different construction.

1. Longline-tuna targeted
2. Longline-tuna and swordfish targeted
3. Small-commercial boat-pelagic
4. Small-commercial boat-non-pelagic

5. Charter
6. Recreational

The setup was changed to be more consistent with the updated data and more relevant to the current structure of the fishery. Two important changes in the 2005 model are that we no longer separate the swordfish sector and we discontinued the use of an expense boat sector. The swordfish sector was consolidated because all longline vessels targeting swordfish also target tuna. These vessels tend to be larger than the vessels exclusively targeting tuna. The use of an expense boat[1] sector was discontinued because differentiating between commercial and expense-boat behavior in the small boat sector was deemed unmanageable in the recent cost-earnings data. This report considered commercial activity to include all fishing activity where the fishermen sold their catch. For the small boat sector that is heavily driven by recreational activity, this raises some modeling issues. We address these issues in later sections of this report.

3.3 Changes in the Industry Sectors

Beyond including additional accounts, the 2005 Fishery SAM has more detail than the previous model. The 1997 model included 20 industry sectors. This paper employs the entire 2005 State I-O table sectors and includes 67 industry sectors.

3.4 Recreational Activity

The previous I-O studies relied on cost earnings data from the small boat sector to estimate recreational activity and only included offshore activity. This report makes use of the Hawaii Marine Recreational Fishing Survey (HMRFS) data, which includes not only offshore but inshore activity. The inclusion of onshore activity significantly increases the size of the sector relative to the previous studies.

3.5 Current Status of the Fishery Industry

Hawaii's fishery industries have undergone many changes since the last time the table was updated, altering its linkages to and role in the local economy. Some of the major changes include the following.

1. Rising fuel costs have dramatically hurt the industry. Fuel takes up approximately 40% of trip expenditure costs, up from 10% about four years ago. These costs have also heavily impacted the costs of all expenditures—everything from bait, gear, to food for crew. This has hurt both the longline and the bottomfish sector.
2. There has been a steady rise in foreign crewmembers for the longline sector. In 2000, it was estimated that approximately half the vessels employed foreign crew (O'Malley and Pooley 2001). In 2005 over 80% of the vessels employed foreign crew. The willingness of foreign crewmembers to accept less compensation for work has allowed vessels to dramatically reduce their overall labor costs.

[1] Expense boat activity refers to quasi recreational/commercial behavior where such fishermen sell their catch primarily to recoup boat expenses..

3. Profits for the longline sector weakened in 2005. Approximately 30% of the boats suffered negative returns, much weaker than the levels received from previous I-O Fishery studies.
4. The last decade has seen a steady rise of imported fish and a decline of overall domestic market share. This has particularly impacted the bottomfish small boat sector, where the increased supply of imports has influenced the price of local catch.

4. DESCRIPTION OF SAM MODELING

A SAM model is a detailed accounting of the purchases of goods and services that maps out the flow of accounts throughout the economy. It is both a data system and a conceptual tool used for policy analysis. It is constructed to be both comprehensive and disaggregated including estimates of transactions among sectors, institutions, and economic agents. Set up as an accounting system, it is designed to be consistent across accounts and complete in that both payments and receipts are properly identified. Like an I-O model, a SAM is constructed as a square matrix with row accounts tracking receipts and column accounts specifying expenditures. However the I-O model can only trace the flow of accounts between production sectors and value added. It is not designed to account for factors of production income flows to institution entities such as government and households, which in return generates demand back onto goods and services. A SAM model captures these flows in detail and clearly shows the linkage between income distribution and economic structure. Additionally the model can also capture the consumption expenditure patterns of socio-economic groups from the production sector.

If a certain number of conditions are met–in particular, the existence of excess capacity and underemployed labor resources–the SAM framework can be used to estimate the effects of exogenous changes and injections, on the entire economy. As long as excess capacity and a labor slack prevail, any exogenous change in supply can be satisfied through a corresponding increase in output without having any effect on prices. The total effect of the supply side increases as the endogenous accounts are estimated through the multiplier process. SAM multipliers are an extension of the classic Leontief I-Ot Model. While the Leontief Model concentrates on inter-industry production linkages, SAM-based models also include consumption linkages. Consumption linkages are included by making households, firms, and government institutions endogenous. The SAM multiplier approach therefore makes use of information on households income and consumption accounts and factor endowments, allowing income distributional analysis.

For example, a reduction in total allowable catch would necessarily result in decreased purchases of bait, ice, and other inputs. This would then decrease the amount of labor required by these sectors. In turn, a significant part of the incremental incomes earned by these socioeconomic groups from providing this work will lead to additional declines of expenditures spent on food demand. The subsequent decrease in food production to satisfy this loss demand leads to further losses of employment and income for these groups, continuing the multiplier process as feedback effects dampen out throughout the process.

4.1 Structure of a SAM

SAM accounts are an extension of traditional input-output accounts whose basic structure follows from the National System of Accounting. The column entries represent expenditures (payments) made by different economic accounts. The row entries represent receipts (income) to agents where total receipts must equal total expenditures. The main components of the SAM include production, factors, institutions, and investment/trade. These main accounts are broken down into several subaccounts and are disaggregated on the basis of requirements and availability of data.

Figure 1 shows the layout of the Fishery SAM model. Below we describe its major components (see Isard et al. 1998 for more details on SAM modeling).

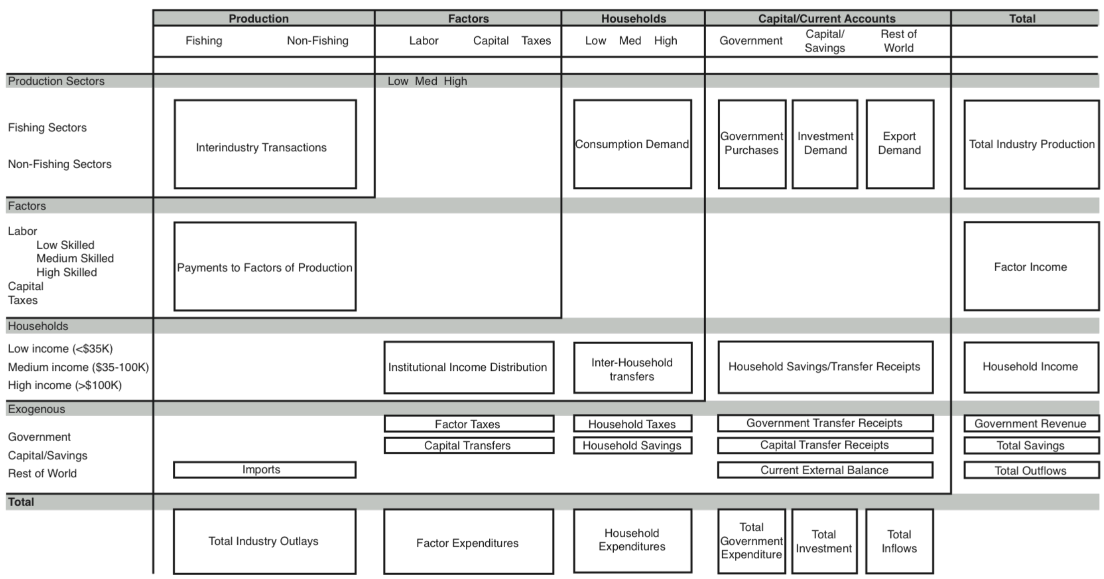


Figure 1. Layout of a SAM

4.1.1 Production Accounts

Production accounts represent industries producing goods and services. It is decomposed into the fishery and non-fishery sectors. The structure of these accounts is the same as a standard input output table. Input-Output/SAM modeling may differentiate between production and commodity accounts; however this layout does not make any distinction between the two. Here it is assumed that a production activity is the same as the corresponding commodity. The rows represent inter-industry sales as well as institutional demand and exports. The columns represent the inter-industry purchases, factor payments, and imports.

4.1.2 Factors of Production Accounts

Factors of production accounts relate to the primary factors that are used in the economy in the production process. They reflect the value added by the production sectors and are used extensively in input-output analysis. The accounts can be disaggregated through different approaches but generally they consist of labor, capital, and tax accounts that receive payment in the form of wages, rent, and factor income from the production activities. These in turn are distributed to the households as labor incomes or the firms as profits. In order to conduct adequate income distributional analysis the labor account needs to be disaggregated further. Previously employed disaggregation approaches include by skill level (Rose et al. 1988) and labor categories (Kening and Thorbecke 1989). In the Hawaii Fishery SAM we have labor factor inputs decomposed by occupational categories.

4.1.3 Institution Accounts

Institution accounts consist of households, firms, and the government. The institution accounts receive factor income from the factors of production accounts and distribute it to the government, household, or capital accounts. The columns of the institution accounts consist of the consumption of household, government, and firms. The rows for households represent gross receipts from labor, proprietor's income, receipts from capital earnings firm enterprises, receipts from government transfers, and earnings from abroad. The households are decomposed by socio-economic groups. SAMs typically decompose these accounts by income levels, skill levels, rural/urban, and farm/non-farm. The disaggregation of the household accounts is crucial to mapping out the income distribution patterns. Unlike the traditional input-output model, institutional income is also distributed to other institutions. They include inter-household transfers, transfers from businesses to households, transfers from people to government, and transfers from government to people. There are also transfers between federal and state and local government and firms.

4.1.4 Capital/Current Accounts

Capital/current accounts include capital investment and change in stocks in the column and savings from households, enterprises, and government as well as the balance of foreign trade on capital account in the row. The savings from enterprises, households, and government accounts are all combined into one row and show the source of capital payments. The trade accounts show the economic linkages with the rest of the world. They include the outflows of goods and services or exports and inflows of money or imports.

4.2 SAM Model

To trace out the linkages of different aspects of the economy and generate economic impact analysis, a SAM model integrates the set of accounts described above and imposes several assumptions. Like an I-O model it uses the fixed coefficients assumption where each of the elements of the accounts are divided by their respective column total resulting in a table of direct input coefficients. For the I-O table, the coefficients represent the production functions for each sector. The model generates its multipliers by assuming that each sector response is a fixed proportion. For the SAM, the fixed input assumption is extended across all endogenous accounts. Thus the coefficients are fixed across the production sectors, as well as institutional expenditures. The result is that in addition to the fixed technical coefficients of the I-O model, the distribution of nominal income between wages and profits must be assumed fixed, along with the distribution of wage and profit income to households, and the sectoral composition of household consumption.

By assuming that the coefficients are fixed, the model can be specified as a system of linear equations. The SAM can then be solved to yield coefficients through which changes in the exogenous accounts are translated into changes in each sectors' supply. Following Holland and Wyeth (1993) and Adelman and Robinson (1986) the matrix of direct coefficients in a demand driven Hawaii SAM model, denoted *S*, can be presented as follows.

$$S = \begin{bmatrix} A & 0 & C \\ V & 0 & 0 \\ 0 & Y & H \end{bmatrix} \tag{1}$$

Where the matrix *S* of direct input coefficients is expressed as the partitioned submatrices of:

A = matrix of technical coefficients that includes intra-industry sales and purchases;

V = matrix of value added coefficients that includes payments from production accounts to factors where factors include disaggregated labor groups;

Y = matrix of value added distribution coefficients that includes factor payments to the institution accounts;

C = matrix of expenditure coefficients that includes household purchases of industry output broken down by socio-economic groups; and

H= matrix of institutional and household distribution coefficients that includes inter-household/institution transfer payments.

The supply and demand balance equations can then be written as follows.

$$\begin{vmatrix} x \\ v \\ y \end{vmatrix} = S \begin{vmatrix} x \\ v \\ y \end{vmatrix} + \begin{vmatrix} ex \\ \\ ey \end{vmatrix} \tag{2}$$

Where:

x = vector of total production output;

v = vector of total value added;

y = vector of total institutional income;

ex = vector of exogenous goods and services demand (from exogenous stimulus measures, government expenditures/investment, export demand, or other exogenous sources of demand); and

ey = vector of exogenous household transfer payments (primarily government transfer payments).

Because SAMs are generally designed to capture transactions and transfers between all economic accounts in a system, the selection of which transactions and transfers are considered to be exogenous for modeling purposes is left to the discretion of the economic planner. Generally production activities, factors of production, and the household accounts are set as endogenous and the rest of accounts as exogenous.

For the Hawaii Fishery SAM, we assume that the government (State and Federal), investment, and trade accounts are exogenous. To estimate the economic impacts originating from the final demand, the demand-driven multipliers obtained from the SAM inverse coefficients can be given by the following.

$$\begin{bmatrix} x \\ v \\ y \end{bmatrix} = (I - S)^{-1} \begin{bmatrix} ex \\ \\ ey \end{bmatrix} \quad (3)$$

The matrix can readily be used to calculate the multiplier effects from an exogenous increase in demand (government, investment, or export demand). However this approach may not be appropriate in the evaluation of a policy reducing supply (i.e., a reduction in TAC). As suggested by Leung and Pooley (2002) in the context of fisheries it is more appropriate to use a supply driven framework.

Here, we will follow the suggestion of Cai and Leung (2004) to use Leontief supply-driven multiplier as a backward-linkage measure and Ghosh supply-driven multiplier as the corresponding forward-linkage measure. These two standard linkage measures provide general and complementary information about inter-sectoral relationship. Sectors with large Leontief supply-driven multipliers have a strong backward linkage, which implies that shocks on these sectors' production would potentially have large impacts on their upstream input suppliers. Symmetrically, sectors with large Ghosh supply-driven multipliers have strong forward linkages, which imply that production shocks on them would potentially have significant impacts on their downstream demanders. While the concept of linkage is straightforward, its measure is nevertheless controversial (Cai and Leung, 2004). [2]

4.2.1 SAM Backward-Linked Multipliers

Following the SAM fishery approaches employed by Fernandez-Macho et al. (2008) and Seung and Waters (2009), a supply driven SAM can be assembled. In a supply driven SAM, the standard demand side model can be partitioned as follows:

$$\begin{bmatrix} x_1 \\ x_2 \\ v \\ y \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ v \\ y \end{bmatrix} + \begin{bmatrix} ex_1 \\ ex_2 \\ \\ ey \end{bmatrix} \quad (4)$$

where the output vector, x is decomposed to two sub vectors, $x = [x_1/x_2]$ and we designate x_1 to include the exogenous fishery sectors; and x_2 to be the vector of output from all other production sectors. To see the impacts of an exogenous change in fishing output on the rest of the economy, the supply driven SAM multiplier can be calculated by solving the following linear equation system.

$$x_2 = (I - S_{22})^{-1} S_{21} x_1 \quad (5)$$

[2] Previous studies (Leung and Pooley, 2002; Cai et al. 2005) have indicated that the Ghosh methodology suffers from a problematic theoretical interpretation of the model, particularly when it is used to explain 'physical' output changes due to 'physical' changes in primary factor inputs, such as labor and capital. Thus the results from the Ghosh model should be interpreted with caution.

The backward linkage supply driven SAM multiplier, $(I - S_{22})^{-1}S_{21}$ gives the measured change in output or income in the endogenous sector resulting from a change in the exogenous fishery sector.

For example, Equation (5) can be used to assess the impacts of a reduction in longline output, Δx_1, and on outputs of all other socio-economic accounts of the economy, Δx_2. In this case Δx_1 would be a predetermined scalar, and Δx_2 is the resulting (n-1) x 1 vector of outputs on all other sectors. Equation (1) assumes that Δx_1 will not affect the direct requirement matrix A of the economy. In other words, production technologies of every sector in the economy are assumed to remain unchanged as a result of Δx_1. By exogenizing each sector in the economy one at a time, supply-driven multipliers can be obtained for all sectors in the economy.

In order to understand magnitudes of SAM multipliers and how they differ from traditional I-O multipliers, it is helpful to explicitly spell out the multiplier mechanism, which results from equation (5). Equation (5) can be written out in the following explicit form (Isard et al. 1998):

$$\begin{aligned}
x_1 &= A_{11}x_1 + A_{12}x_2 + C_1 y + ex_1 \\
x_2 &= A_{21}x_1 + A_{22}x_2 + C_2 y + ex_2 \\
v &= V_1 x_1 + V_2 x_2 \\
y &= Yv + Hy + ey
\end{aligned}$$

These equations can be rearranged so that the endogenous terms yield:

$$\begin{aligned}
x_1 &= [1 - A_{12}]^{-1}A_{12}x_2 + [1 - A_{22}]^{-1}C_1 y + [1 - A_{22}]^{-1}ex_1 \\
x_2 &= [1 - A_{22}]^{-1}A_{21}x_1 + [1 - A_{22}]^{-1}C_2 y + [1 - A_{22}]^{-1}ex_2 \\
v &= V_1 x_1 + V_2 x_2 \\
y &= [1 - H]^{-1}Yv + [1 - H]^{-1}ey
\end{aligned}$$

Given an exogenous increase in the fishery sector $\Delta\overline{x}_1$, the above system of linear equations can be solved simultaneously. We can conceptualize the approximate flow of impacts endogenous sectors x_2, v, and y (again assuming that only the government institutions and trade and investment accounts are exogenous) by decomposing the total impacts through different stages of the SAM.

First, the exogenous increase in supply initiates an additional rise in the output of its backward linked non-fishery sectors through A_{21} and generates a corresponding production increase of activity of $\Delta x_2 = [1 - A_{22}]^{-1}A_{21}\Delta\overline{x}_1$ or "own" multiplier impacts (intra-group) on the endogenous industries. This first stage of multipliers does not include the multiplier effects associated with other sectors such as value added or households, which are usually treated as exogenous. The "own" multipliers measures the total potential change in outputs of all other sectors in the economy due to a change in output of the fishery sector. Here $\Delta x_2 = [1 - A_{22}]^{-1}A_{21}\Delta\overline{x}_1$ is the same measure used for standard supply driven I-O Type 1 multiplier.

Next, the additional factors of production that have to be employed to create the additional output generate a stream of value added $\Delta v = V_1\Delta\overline{x}_1 + V_2\Delta x_2$ that constitutes a factor income in addition to any exogenous factor income received from other regions. This is transmitted to the households, where they receive income $[1 - H]^{-1} Y\Delta v$ based on their income Y and transfers H where $\Delta y = [1 - H]^{-1} Y\Delta v$. This set of flows account for the "open loop" multipliers (or extra-group effects) and records how the effects of exogenous inputs of each type get transmitted to the household sector. These multipliers do not include the feedback effects of those increases (or decreases) in household income on subsequent commodity consumption.

Finally the flow of funds is closed through the pattern of household expenditures on commodities, which translates into new production and a corresponding additional flow of income accruing to production activities equal to $[1 - A_{22}]^{-1} C_2\Delta y$. These "closed-loop" multipliers (or inter-group effects) capture the feedback effects between households and inter-industry transactions. This formulation generalizes the Leontief model by including as one of the elements the effects of income distribution on the consumption pattern of each group of households.

Because a SAM captures the endogenously derived effects of income distribution on consumption, it is apparent that the SAM formulation contains more information and a higher degree of precision. In contrast the open Leontief supply driven multipliers only include $[1 - A_{22}]^{-1} A_{21}\Delta \bar{x}_1$. The derivation, based on the expanded accounting system, explicitly solves for the Type II formulation of induced effects. However the two shortcomings of the I-O accounting structure, inconsistent classification between household income and consumption and the lack of correction from "place of work" to "place of residence" income are both eliminated in the SAM formulation. While the Type II multiple does capture the direct, indirect, and cross effects it does not typically designate capital payments as a source of income endogenously (Miller and Blair 2010). Because high-income households received most of their earnings through capital payments, it is important to include this circular flow of income. The SAM multipliers (also referred as Type III multipliers) are designed to include capital payments to households. In addition to the labor income (which includes proprietors' income), households also receive income from the ownership of capital and property in the form of dividends, interest, and rent. Thus, the total multiplier impact (own, open, and closed) estimated by the SAM is greater than those estimated by the Type II multipliers. Submatrix Y is the key component, describing how gross "place of work" factor receipts are allocated to domestic institutions (net of imported factor services) as "place of residence" income for factor services. The generalized SAM inverse, which incorporates the induced changes in factor incomes and in income levels and, ultimately, the resulting expenditure pattern on commodities, generates much higher multiplier values than the more limited Leontief multipliers (Thorbecke 1989).

4.3 SAM Forward-Linked Multipliers

While the above analysis provides the potential impact only from a backward linkage point of view, a similar framework can be extended to the analysis of forward linkage effects using the Ghosh model (Ghosh 1958). The Ghosh model can be expressed as the following linear system:

$$[X''_1 X'_2] = [X''_1 X'_2]\begin{bmatrix} R_{11} & R_{12} \\ R_{21} & R_{22} \end{bmatrix} + [ew_1 + ew_2]$$

where R is the direct output confidents indicating the level of forward output generated from an increase in the sector. It is formed by dividing each row of the transaction matrix by the respective gross output of that row, as opposed to dividing each column in deriving S. As in the Leontief model, the Ghosh assumes that R is fixed; i.e., the allocation of a sector's output to other sectors is assumed fixed. Solving the linear equation system for X_2 gives us the forward linkage supply driven SAM multiplier $R_{12}(I - R_{22})^{-1}$. The input supply-driven multiplier measures the total change in outputs of all other sectors in the economy from a change in output of the *ith* sector similar to the output supply-driven multiplier, except from a forward linkage point of view. Each element *(i,j)* in this matrix measures the change in output or income in endogenous sector *i,* resulting from an increase in the output or income of exogenous sector *j.*

5. THE HAWAII FISHERY SAM: ASSEMBLY AND CONSTRUCTION

5.1 Specification of the Hawaii Fishery SAM

The 2005 Hawaii Fishery SAM model is based on several different data sources (see Appendix I for more details). The core aspect of the table comes from the 2005 Input-Output model. The State Input-Output table served as the primary foundation of the SAM and includes production activity information for 68 accounts. For detailed information regarding Input-Output models, please refer to The Hawaii Input-Output Study, 2005 Benchmark Report, at the Hawaii State Department of Business, Economic Development, and Tourism at http://www.hawaii.gov/dbedt, or the various Input-Output resource and documentation from the Bureau of Economic Analysis at http://www.bea.gov.

The State model had only one commercial fishing sector, and in building the Fishery Model, that sector was broken down into six sectors: longline tuna; longline tuna/swordfish; small boat pelagic; small boat-non pelagic; charter; and recreational sector (included in the appendix). The charter boat fishing sector was in the sightseeing transportation sector in the State model, and was separated out in the fishery model. Recreation boats were in the personal consumption expenditures (PCE) in the State model.

Data for the additional SAM accounts—factors of production and institution accounts—were retrieved from the IMPLAN data. This data, which relies on household income and expenditure surveys, yields the incomes of various socioeconomic groups. The 528 IMPLAN industry sectors were aggregated into the 68 industry sectors from the Hawaii State Input-Output model. Lastly, to complete the income distribution mapping from the industry sector to the household sector we make use of the Hawaii State Industry Occupational Matrix. Detailed explanations on how these sectors were linked are discussed in the appendix.

Table 1 gives an overview of the industries used in building the Fisheries Input-Output Model. In the 2005 Hawaii Fishery SAM there are a total of 101 accounts—93 endogenous accounts and eight exogenous accounts. The 93 endogenous accounts include five fishery production sectors, 67 non-fishery productive sectors, 12 value added sectors, and nine socioeconomic household accounts. The inter-industry demand for both the production sectors (fishing and non-fishing) and value added accounts are the same accounts employed in the traditional I-O model. In addition to the typical I/O elements, the SAM also includes non-industrial financial flows.

Table 1. Size of Fishery Industry in Relation to Hawaii Economy

Hawaii 2005 Gross State Product	**$54,711 million**	
Industry	**Output ($ million)**	**% of Economy**
Commercial Fishery Sectors		
Tuna Longline	42.36	0.05%
Tuna and Swordfish Longline	18.01	0.02%
Pelagic Small Boat	8.53	0.01%
Non-Pelagic Small Boat	5.01	0.01%
Total Commercial Fishery Sector	**73.91**	**0.08%**
Other Fishery Sectors		
Charter	20.70	0.02%
Recreational Sector	521.85	0.57%
Total Fishery Sectors	**690.38**	**0.67%**
Non-Fishery Sectors		
Agriculture	684.68	0.75%
Mining and Construction	7,307.36	7.97%
Food Processing	1,070.42	1.17%
Other manufacturing	4,094.23	4.47%
Transportation	5,236.90	5.72%
Information	2,195.24	2.40%
Utilities	2,012.41	2.20%
Wholesale	2,808.91	3.07%
Retail Trade	6,221.76	6.79%
Finance and Insurance	4,399.57	4.80%
Real estate and rentals	14,009.94	15.29%
Professional Services	4,011.42	4.38%
Business Services	3,893.33	4.25%
Educational services	934.64	1.02%
Health Services	6,226.94	6.80%
Arts and entertainment	820.34	0.90%
Accommodation	4,891.29	5.34%
Eating and Drinking	3,472.78	3.79%
Other services	2,659.48	2.90%
Government	13,301.83	14.52%
Total	**91,634.22**	**100.00%**

Table 2 shows the data table for the SAM. The sectors are aggregated to larger industries for presentation purposes.[3]

5.2 SAM Modeling to Assess Income Distribution

A SAM includes a comprehensive accounting of regional income and institutional factors that is capable of identifying how different household groups accrue income. Household income is derived from institutions and transfers where institutional income is derived from factors of production. With sufficient decomposition in the factor accounts, distributional linkages can be mapped out to the households.

[3] The full SAM disaggregated sectors are available upon request.

In practice, many SAMs do not adequately capture income distribution linkages. The problem lies in the linking between factor receipts and their disbursement to institutions. Due to data limitations, factor receipts are generally distributed among institutions directly such that the flows are treated with total factor receipts rather than a matrix of factor receipts that varies across industries. For example, in the widely used database source, IMPLAN, the SAM is designed with fixed distribution of factor incomes across households for all industries. While the SAM can capture variations in the factor distribution of income, it cannot capture the size distribution of income among institutions (Alward 1996). Without transition sub-matrices to link sectoral factor incomes to institutions, these impacts cannot examine changes in the size of distribution across households.

The actual process in which income circulates through an economy is very complicated, and the linking of accounts from production sectors to households can be approached from many ways (Marcouiller et al. 1993; Leatherman and Marcouiller 1996). To develop a SAM that can appropriately capture the distribution effects, one must pay particular attention to the mapping of labor income from the production sectors to the household. Determining the income distribution characteristics of different production sectors requires identifying the relationship between aggregate factor income change and its distribution to local households.

In the assembly of the Hawaii Fishery SAM, special attention was given to decomposing the factor payments so that production activities could be reasonably linked towards households. Instead of having production labor compensation payments to the household distributed directly from an aggregated account, we make use of a transition-matrix to decompose labor compensation into different skill levels. The transition matrix instrument we use for this task is the State of Hawaii occupational matrix. The use of this matrix allows us to disaggregate the industry-household linkage according to the composition of skill levels employed by each industry. The mechanism of income flows can be seen more clearly in Figure 2. Here the production sector's labor payments are identified by individual occupations. With the occupation matrix, the inputs are then mapped into appropriately defined skill levels based on the average salary of the occupation (at the State level). The labor income is then mapped into the household sector, where the distribution of skill levels is appropriately mapped to follow the distribution of household socioeconomic groups (see appendix for more details of the mapping procedures employed for both the occupation-skill levels and skill level-household income). Total labor compensation is then combined with capital income to give us total household income.

Table 2. Condensed Hawaii2005 SAM (in $US millions)

	Fishing Sectors	1	2	3	4	5	6	7	8	9	10	11
1	Tuna Longline	2	0	0	0	0	0	0	2	0	0	0
2	Mixed Longline	0	2	0	0	0	0	0	1	0	0	0
3	Pelagic Small Boats	0	0	1	0	0	0	0	0	0	0	0
4	Non-Pelagic Boats	0	0	0	0	0	0	0	0	0	0	0
5	Charter	0	0	0	0	0	0	0	0	0	0	0
6	Agriculture	0	0	0	0	0	65	7	170	11	0	0
7	Mining/Construct.	0	0	0	0	0	2	30	4	4	69	4
8	Food Process.	0	0	0	0	0	5	0	31	15	2	0
9	Other manuf.	10	4	9	2	2	27	360	31	210	416	6
10	Transportation	2	1	0	0	2	15	141	21	88	313	10
11	Information	0	0	0	0	0	2	32	4	23	43	135
12	Utilities	0	0	0	0	0	11	75	13	82	70	7
13	Wholesale	7	3	1	1	0	23	341	42	112	116	16
14	Retail Trade	0	0	0	0	0	3	323	11	31	8	22
15	Finance/Insurance	2	1	0	0	1	7	73	4	37	92	26
16	Real estate	0	0	0	0	0	30	172	11	50	126	45
17	Professional Serv.	0	0	0	0	0	3	476	10	56	128	47
18	Business Serv.	0	0	0	0	1	4	124	54	134	378	41
19	Education	0	0	0	0	0	0	1	0	9	20	7
20	Health Services	0	0	0	0	0	0	0	0	0	1	0
21	Arts/entertain.	0	0	0	0	0	0	3	1	3	2	4
22	Accommodation	0	0	0	0	1	0	6	2	7	3	2
23	Eating/Drinking	1	0	0	0	0	0	33	9	20	59	13
24	Other services	5	1	5	3	0	3	39	9	39	39	16
25	Government	0	0	0	0	0	5	8	3	19	302	5
26	Labor-Low	2	0	1	0	0	170	3	93	40	91	54
27	Labor-Medium	4	1	2	1	7	68	802	104	311	903	407
28	Labor-High	0	0	2	1	0	10	1508	22	131	348	184
29	Proprietor income	-1	1	-17	-7	2	6	382	3	241	127	44
30	Other capital	3	1	2	1	3	187	495	4	-17	281	555
31	Taxes	0	0	0	1	1	-61	67	7	13	231	96
32	Household-Low	0	0	0	0	0	0	0	0	0	0	0
33	Household-Med	0	0	0	0	0	0	0	0	0	0	0
34	Household-High	0	0	0	0	0	0	0	0	0	0	0
35	Federal Gov	0	0	0	0	0	0	0	0	0	0	0
36	State Gov	0	0	0	0	0	0	0	0	0	0	0
37	Investment	0	0	0	0	0	0	0	0	0	0	0
38	Imports	5	3	2	1	1	98	1806	404	2428	1070	450
	Output	42	18	9	5	21	685	7307	1070	4094	5237	2195
	Jobs	202	54	1812	3042	354	13713	44901	6771	11742	31649	12640
	Earnings	5	3	-20	-4	7	231	2368	180	608	1211	589
	Taxes	0	0	0	0	1	18	339	13	39	147	107

(Table 2 continued)

	Fishing Sectors	12	13	14	15	16	17	18	19	20	21	22
1	Tuna Longline	0	0	0	0	0	0	0	0	0	0	2
2	Mixed Longline	0	0	0	0	0	0	0	0	0	0	1
3	Pelagic Small Boats	0	0	0	0	0	0	0	0	0	0	0
4	Non-Pelagic Boats	0	0	0	0	0	0	0	0	0	0	0
5	Charter	0	0	0	0	0	0	0	0	0	0	0
6	Agriculture	0	0	0	0	24	1	1	0	6	1	0
7	Mining/Construct.	133	5	19	12	346	10	13	29	20	4	103
8	Food Process.	0	1	1	0	0	1	0	0	27	0	3
9	Other manuf.	530	40	74	19	141	52	61	18	61	4	18
10	Transportation	12	14	30	22	58	69	38	8	83	4	35
11	Information	3	56	74	118	117	91	94	28	79	8	71
12	Utilities	51	15	79	13	116	21	48	9	96	15	169
13	Wholesale	12	62	23	5	65	44	36	8	102	5	64
14	Retail Trade	6	24	67	5	121	65	59	1	39	1	15
15	Finance/Insurance	15	32	84	666	540	44	41	6	49	5	121
16	Real estate	10	82	611	197	1110	328	160	112	437	30	166
17	Professional Serv.	35	53	105	169	266	275	243	22	214	20	138
18	Business Serv.	25	134	218	154	408	87	186	42	405	18	406
19	Education	14	3	5	12	3	11	7	8	21	3	1
20	Health Services	0	0	0	0	0	0	0	1	36	0	0
21	Arts/entertain.	0	0	0	0	0	0	0	0	0	16	3
22	Accommodation	2	5	9	12	24	21	6	1	17	0	7
23	Eating/Drinking	7	16	27	39	37	30	22	16	64	8	36
24	Other services	1	24	29	37	471	35	35	5	37	8	56
25	Government	6	11	45	29	80	18	25	3	51	9	44
26	Labor-Low	0	55	353	9	101	58	422	104	321	45	373
27	Labor-Medium	119	738	1608	657	329	676	1102	275	1448	222	1241
28	Labor-High	179	131	171	497	173	854	451	101	943	77	116
29	Proprietor income	2	88	193	97	456	504	136	15	317	71	90
30	Other capital	450	301	550	1005	7845	272	346	30	395	121	834
31	Taxes	154	552	1127	136	655	87	72	38	169	69	378
32	Household-Low	0	0	0	0	0	0	0	0	0	0	0
33	Household-Med	0	0	0	0	0	0	0	0	0	0	0
34	Household-High	0	0	0	0	0	0	0	0	0	0	0
35	Federal Gov	0	0	0	0	0	0	0	0	0	0	0
36	State Gov	0	0	0	0	0	0	0	0	0	0	0
37	Investment	0	0	0	0	0	0	0	0	0	0	0
38	Imports	246	367	720	490	524	358	289	54	788	57	399
	Output	2012	2809	6222	4400	14010	4011	3893	935	6227	820	4891
	Jobs	2999	21856	88747	25257	42371	42503	62927	17147	69007	21903	40112
	Earnings	221	900	2071	1087	999	1933	1896	446	2714	380	1629
	Taxes	84	415	1047	229	396	262	266	63	278	35	426

(Table 2 continued)

	Fishing Sectors	23	24	25	26	27	28	29	30	31	32	33
1	Tuna Longline	8	0	0	0	0	0	0	0	0	5	10
2	Mixed Longline	3	0	0	0	0	0	0	0	0	0	0
3	Pelagic Small Boats	2	0	0	0	0	0	0	0	0	1	2
4	Non-Pelagic Boats	1	0	0	0	0	0	0	0	0	1	1
5	Charter	0	0	0	0	0	0	0	0	0	0	0
6	Agriculture	21	1	1	0	0	0	0	0	0	30	77
7	Mining/Construct.	55	18	56	0	0	0	0	0	0	0	0
8	Food Process.	187	2	2	0	0	0	0	0	0	94	198
9	Other manuf.	87	48	33	0	0	0	0	0	0	145	352
10	Transportation	41	28	33	0	0	0	0	0	0	206	604
11	Information	35	49	31	0	0	0	0	0	0	178	451
12	Utilities	87	74	59	0	0	0	0	0	0	188	347
13	Wholesale	158	44	44	0	0	0	0	0	0	181	476
14	Retail Trade	17	41	0	0	0	0	0	0	0	651	1857
15	Finance/Insurance	42	27	12	0	0	0	0	0	0	319	1031
16	Real estate	204	232	39	0	0	0	0	0	0	1621	3864
17	Professional Serv.	107	92	71	0	0	0	0	0	0	105	257
18	Business Serv.	101	148	66	0	0	0	0	0	0	28	105
19	Education	1	4	7	0	0	0	0	0	0	67	344
20	Health Services	0	1	2	0	0	0	0	0	0	1259	2945
21	Arts/entertain.	8	1	0	0	0	0	0	0	0	54	168
22	Accommodation	6	8	5	0	0	0	0	0	0	26	94
23	Eating/Drinking	37	10	17	0	0	0	0	0	0	221	798
24	Other services	28	23	22	0	0	0	0	0	0	256	717
25	Government	19	15	17	0	0	0	0	0	0	143	338
26	Labor-Low	577	202	223	0	0	0	0	0	0	0	0
27	Labor-Medium	525	592	4973	0	0	0	0	0	0	0	0
28	Labor-High	40	143	6029	0	0	0	0	0	0	0	0
29	Proprietor income	33	160	0	0	0	0	0	0	0	0	0
30	Other capital	294	171	1279	0	0	0	0	0	0	0	0
31	Taxes	162	100	-68	0	0	0	0	0	0	0	0
32	Household-Low	0	0	0	3296	0	0	298	482	0	10	30
33	Household-Med	0	0	0	0	17119	0	1493	3092	0	37	104
34	Household-High	0	0	0	0	0	12109	1045	2411	0	18	50
35	Federal Gov	0	0	0	0	0	0	107	1412	418	257	2732
36	State Gov	0	0	0	0	0	0	0	404	3567	133	1206
37	Investment	0	0	0	0	0	0	0	7452	0	477	1312
38	Imports	589	425	348	0	0	0	0	-154	0	1546	4103
	Output	3473	2659	13302	3296	17119	12109	2943	15100	3985	8259	24576
	Jobs	59147	48698	172528								
	Earnings	1057	1010	8032								
	Taxes	143	118	447								

(Table 2 continued)

	Fishing Sectors	33	34	35	36	37	38	Total
1	Tuna Longline	10	5	0	0	0	8	**42**
2	Mixed Longline	0	0	0	0	0	10	**18**
3	Pelagic Small Boats	2	1	0	0	0	1	**9**
4	Non-Pelagic Boats	1	1	0	0	0	0	**5**
5	Charter	0	0	0	0	0	20	**21**
6	Agriculture	77	44	1	2	0	221	**685**
7	Mining/Construct.	0	0	574	424	5370	2	**7307**
8	Food Process.	198	95	11	9	0	387	**1070**
9	Other manuf.	352	172	124	58	90	890	**4094**
10	Transportation	604	365	8	57	193	2738	**5237**
11	Information	451	244	12	27	0	192	**2195**
12	Utilities	347	165	33	166	0	0	**2012**
13	Wholesale	476	247	11	38	194	329	**2809**
14	Retail Trade	1857	1001	5	25	288	1535	**6222**
15	Finance/Insurance	1031	556	0	23	0	541	**4399**
16	Real estate	3864	2077	7	73	33	2184	**14010**
17	Professional Serv.	257	143	226	6	399	342	**4011**
18	Business Serv.	105	70	51	0	0	505	**3893**
19	Education	344	267	4	0	0	117	**935**
20	Health Services	2945	1842	20	0	0	121	**6227**
21	Arts/entertain.	168	115	0	0	0	441	**820**
22	Accommodation	94	71	2	9	0	4546	**4891**
23	Eating/Drinking	798	436	3	0	0	1513	**3473**
24	Other services	717	501	10	99	0	106	**2659**
25	Government	338	194	6979	4874	0	60	**13301**
26	Labor-Low	0	0	0	0	0	0	**3296**
27	Labor-Medium	0	0	0	0	0	0	**17118**
28	Labor-High	0	0	0	0	0	0	**12108**
29	Proprietor income	0	0	0	0	0	0	**2943**
30	Other capital	0	0	0	0	-306	0	**15100**
31	Taxes	0	0	0	0	0	0	**3985**
32	Household-Low	30	56	2505	173	1286	122	**8259**
33	Household-Med	104	197	1924	284	206	121	**24576**
34	Household-High	50	96	375	24	0	32	**16161**
35	Federal Gov	2732	2369	8870	0	9266	43	**25474**
36	State Gov	1206	1017	2074	477	0	31	**8909**
37	Investment	1312	1481	0	1818	265	5660	**18465**
38	Imports	4103	2330	1645	244	1181	2648	**25464**
	Output	24576	16157	25474	8909	18465	25465	
	Jobs							
	Earnings							
	Taxes							

Capital rents are broken up into two components—proprietor's income and other capital costs. Proprietor's income comes from the BEA's personal income series. Other capital costs include corporate profits, consumption of fixed capital, net interest paid, net rental income of individuals, and business transfers and is computed by subtracting proprietor's income. The majority of these accounts flow into household income. Some of the net interest accounts are transferred to the government and consumption of fixed capital is transferred to a separate investment account. Capital income is mapped from the production sector to the household sector with the given IMPLAN data. Note that unlike labor income, capital income is not broken down across production sectors and is assumed constant across all sectors. While capital rent payments to socioeconomic groups varies across industries, we would expect the distribution patterns to vary less than labor income where the rents are already skewed towards the higher-level income groups. Together capital rents and the labor income mappings provide a complete linkage of income distribution from industry accounts to household sectors.

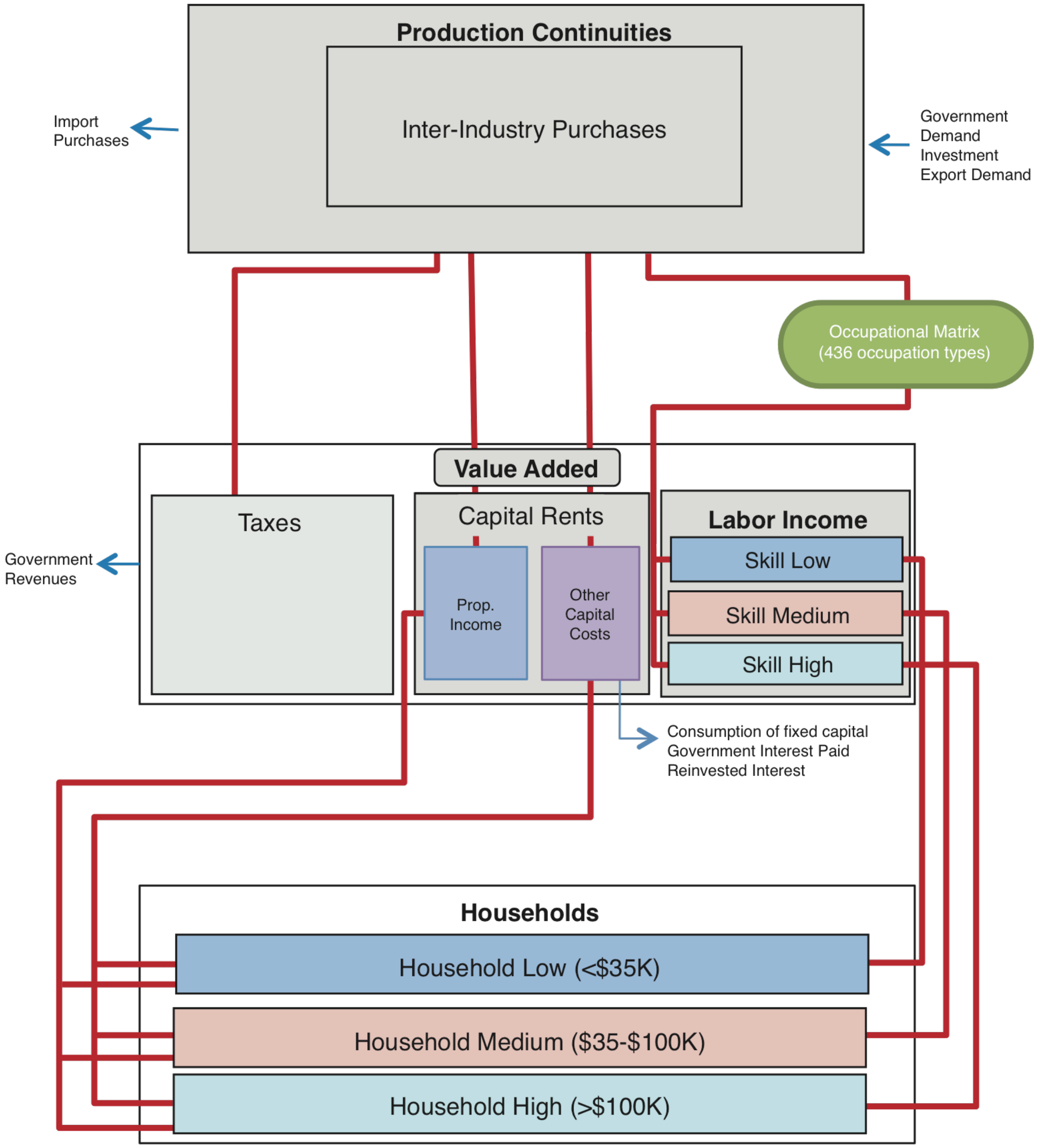


Figure 2. Income Distribution from Production Sectors to Households

Overall this mapping gives us a high level of precision in identifying skill intensive industries versus unskilled intensive industries. Without our occupation transition matrix, the only way to distinguish different distributional impacts of the sectors would be from the differential intensities between the industries contribution to capital payments relative to labor payments. Our approach provides explicit linkages between the distributions of income from the production sector to the household.

5.3 The use of SAM analysis to Assess Fisheries

The Magnuson-Stevens Fishery Conservation and Management Act of 1976 requires a comprehensive economic analyses of any new fisheries management regulations, within the context of conservation objectives, from both economic and social perspectives. Consequently, the analysis of economic and welfare implications of fishery regulations has become an essential part of public policy formulation.

While many studies have applied I-O models in determining the overall economic value of fisheries, only recently have SAM models been employed. Fernandez-Macho et al. (2008) used a supply driven SAM model to measure the impacts of a TAC reduction in the Galician hake fishery. They found that for a 979 million euro industry (2001), a 54% drop (value of 108 million euros) in the TAC would have a backward linked economic impact of over 150 million euros on the backward linked production sectors and over 80 million euro for the households. Seung and Waters (2009) used a similar approach to examine the backward and forward linkage effects of Alaska fisheries. Their results showed that a 10% reduction in the pollack harvest would decrease total impact by \$110.7 million (direct and backward linkage effects); with household income falling by \$17.6 million. However their analyses did not include disaggregated labor income groups that could link the distributional impacts from production activity to the household sectors, thus mitigating the ability to conduct distributional analysis.

6. ESTIMATION OF ECONOMIC CONTRIBUTIONS AND LINKAGES OF HAWAII'S FISHERIES

In the Hawaii fishery SAM model, backward linkage effects occur because an increase (decrease) in output of an exogenous sector will increase (reduce) the sector's demand for intermediate inputs purchased from other sectors, and for primary factors of production, such as labor and capital. In turn, the industries that provide inputs to the exogenous sector will increase (reduce) their own demand for intermediate inputs from other upstream industries. Also, the increased (reduced) demand for the labor and capital will lead to further increases (reductions) of factor income. This will increase (reduce) household expenditures, leading to other series of effects.

6.1 Differences between SAM and IO multipliers

Before we present the supply driven multipliers, we first briefly examine the demand driven SAM multipliers, $(I - S)^{-1}$. Examination of these multipliers allows direct comparison with traditional I-O output multipliers generated by the *2005 State of Hawaii Input Output Model* (DBEDT 2008). The output multipliers are presented in condensed form[4] in Table 3. The demand driven multipliers reflect the impact effects of increasing a sector's final demand by one unit. The final-demand output multipliers for each column sector are derived by summing the corresponding column entries of the production impacts across sectors (not including the value added and household accounts). The SAM output multipliers for the five exogenous fishery sectors and 29 endogenous sectors are shown in the first few columns of Table 3. The multipliers are broken down by total

[4] The SAM demand multipliers for the disaggregated sectors are available upon request.

industry impact, factors of production, and household. For example, the total industry output multiplier for the tuna longline sector is 2.59, suggesting that a $1 increase in final demand of tuna longline products, would generate a total economic impact of $2.59 on the production sectors of the economy while factors of production and households would be both impacted separately with a multiplier of 0.97 and 0.71. Comparing the industry output multipliers we notice that on average the commercial fishery sectors generate higher multipliers than the non-fishery sectors (2.72 compared 2.16). However the impacts on household income are lower (0.30 compared to 0.90).

Table 3. Condensed SAM Demand Driven Multipliers

		SAM Multipliers			I-O Multipliers	
		Total Industry	**Factors of Production**	**Household**	**Type 1***	**Type 2***
1	Tuna Longline	2.59	0.97	0.71		
2	Tuna-Swordfish Longline	2.55	0.96	0.71		
3	Pelagic Small Boats	3.26	-0.55	-0.76		
4	Non-Pelagic Boats	2.82	0.23	-0.20		
5	Charter	2.40	1.34	1.02		
Fishery Sector Average		2.72	0.59	0.30		
1	Commercial Fishery Sector*				1.61	2.24
2	Agriculture	2.30	1.29	1.00	1.43	1.97
3	Mining/Construct.	2.12	1.08	0.85	1.42	1.96
4	Food Process.	2.18	0.87	0.69	1.57	1.98
5	Other manuf.	1.70	0.56	0.45	1.32	1.61
6	Transportation	2.27	1.09	0.83	1.56	2.05
7	Information	1.92	1.15	0.80	1.25	1.66
8	Utilities	2.10	0.96	0.63	1.59	1.88
9	Wholesale	1.96	1.22	0.80	1.28	1.77
10	Retail Trade	2.04	1.26	0.83	1.34	1.83
11	Finance/Insurance	2.22	1.26	0.88	1.49	1.96
12	Real estate	1.97	1.25	0.69	1.40	1.61
13	Professional Serv.	2.32	1.38	1.09	1.42	2.13
14	Business Serv.	2.35	1.44	1.14	1.38	2.11
15	Education	2.43	1.43	1.12	1.47	2.19
16	Health Services	2.29	1.33	1.05	1.42	2.08
17	Arts/entertain.	2.14	1.41	1.04	1.27	1.92
18	Accommodation	2.24	1.34	0.95	1.42	1.98
19	Eating/Drinking	2.28	1.18	0.87	1.51	2.04
20	Other services	2.26	1.25	0.95	1.46	2.06
21	Government	2.18	1.62	1.37	1.05	1.79
Non-Fishery Average		2.16	1.22	0.90	1.40	1.93

**From the 2005 State Input-Output Study For Hawaii, DBEBT (2008)*

The SAM multipliers can be compared against the *2005 State of Hawaii Input Output Model* Type I and Type II Input Output multipliers. Note that the State's model does not decompose the fishery sectors. The Type I multipliers are estimated using only production accounts and does not include the SAM "open loop" and "closed loop". This Type I multiplier is equivalent to the SAM "own" multiplier (as demonstrated in the earlier conceptual decomposition of the SAM multiplier). The multipliers generated are expected to be equivalent given that the 2005 Fishery SAM was extended from the *2005 State of Hawaii Input Output Model*. There are some slight deviations from the two multipliers, but this is due to minor adjustments in numbers that were necessary in assembling and balancing the SAM.

The Type II I-O multiplier is generated by endogenizing the household sector into the I-O model and attempts to capture elements of the "open loop" and "closed loop". Its ability to capture the induced impacts depends upon the accounts included in the household earnings account. Traditional Type II multipliers are generated by endogenizing the household sector by incorporating labor income. For the *2005 State of Hawaii Input Output Model*, the endogenized household earnings account includes wage and salary income, proprietor income, director fees, and health insurance and excludes contributions to social insurance. The inclusion of proprietor income incorporates additional elements beyond labor income. However the Type II multipliers do not account for other capital income payments such as corporate profits and net interest that bring forth additional induced impacts. The total SAM industry multiplier includes such payments and is expected to be larger. Comparing the SAM total industry multiplier to the I-O multipliers, we do indeed observe that the SAM generates the largest multipliers followed by the Type II and then Type I I-O multipliers. The average SAM industry multipliers for the non-fishery sectors is 2.16 compared with 1.93 for the Type II and 1.40 for Type I multipliers. The inclusion of the additional capital payments and the further precision offered by the SAM adds a significant increase in overall impacts.

As discussed in the previous section, without complete accounting information of the institutional accounts, the I-O model cannot fully link the flow of payments. Given the shortcoming of the I-O accounting structure in linkage the value added/household income accounts and the consumption accounts, the SAM is able to capture a more comprehensive mapping of the flows. A more detailed assessment of the differences between the SAM multipliers and the original *2005 State of Hawaii Input Output Model* are given in more detail in the appendix.

6.2 Estimated Backward Linkage Multipliers

The supply-driven SAM backward multipliers for the five exogenous fishery sectors are given in Table 4. The multipliers are decomposed between their "own", "open loop", and "closed loop" effects in additive terms[5]. As discussed in the previous section the own multiplier effects are equivalent to the traditional supply driven I-O multipliers $[1 - A_{22}]^{-1} A_{21} \Delta \overline{x_1})$. The open loop and closed group effects can then be decomposed (in additive terms[6]) from the total SAM multipliers, $(I - S_{22})^{-1} S_{21} x_1$, by subtracting out the impacts on the value added/institution accounts and feedback impacts on the production sectors.

6.2.1 Longline Sector

For the Hawaii Tuna Longline sector, a $1 increase in supply has a resulting additional direct impact of increasing the non-fishery sectors by $0.87 (own multipliers). Sectors with high levels of linkages include the other manufacturing (primarily petroleum

[5] See Pyatt and Round (1979) and Stone (1985). Pyatt and Round use a multiplicative decomposition, while the additive version is given by Stone.

[6] The decomposition of additive multipliers was first proposed by Stone (1985). Multipliers decomposed in multiplicative terms have been derived by Stone (1985).

production) and the wholesale sector ($0.25 and $0.19, respectively). The open loop multipliers impact the household sector by increasing household income by an additional $0.67. Of the different socio-economic groups, the medium household group (incomes between $35,000 and $100,000) is most impacted at $0.41 for every additional dollar of tuna longline revenue. Lastly the additional higher income feedbacks into the production sector with a closed loop impact of an additional $0.57 for the production sector. This last induced impact affects the real estate sector and the health service sector the most intensely ($0.14 and $0.08). A $1 million increase in the tuna sector is expected to result in an additional $1.44 million increase in production on the other non-fishery sectors. The multipliers for the tuna/swordfish longline sector are similar in magnitude to the tuna sector. This is expected given the very similar technologies employed by the two sectors.

Due to the relatively input intensive nature of the industry, we find that the backward linkages of the longline sector are quite high.[7] The magnitudes of the backward linkage found in the longline sector are significantly higher than the linkages found in previous Hawaii Fishery economic impact study estimates. Cai et al. (2005) (using the *1997 Fishery Input Output Model*) found a Type I supply side multiplier of 1.42 for the tuna sector and 1.44 for the swordfish sector. This compares much lower in magnitude to the longline sector's own multipliers of 1.87 and 1.77 which, given the same technology structure, should be similar in magnitude to the I-O Type I multipliers. The increase in multipliers reflects the change in the overall production structure of the longline industry. Chief among these factors is the rise in fuel costs. While fuel accounted for approximately 7% of gross revenues for longliners in 1993, it accounted for more than 23% for 2005 (Pan 2009, Hamilton et al. 1996). Table 4 shows that for the longline sector, the sector with the highest backward linkages is the other manufacturing sector. This is mainly attributed to fuel purchases, which are included in the other manufacturing sector, and are one of the primary inputs for the longliners that would lead to overall higher own group multipliers.

The level of net income also changed in the recent years. Compared to previous years, the overall return to owners dropped significantly. The high rise in fuel costs significantly hurt the profit margins of vessel owners. This combined with the fact that most labor compensation is leaked outside the economy through foreign migrant worker payments; the longline sector contributes less personal earnings in the local economy, generating a smaller induced impact of increased income.

Examining Table 3 we can perceive that the impact of the longline sector on the value added and household sectors is relatively smaller than the other non-fishing sectors. The longline sectors have an impact of approximately $0.7 on the households while the rest of the sectors have an average of $0.90 per a $1 increase. This may be reflected by the heavy usage of foreign crewmembers for labor. While domestic crew payments amounted to over 20% of gross revenue in 1993 it accounted for less than 5% of sales in 2005 (Pan 2009, Hamilton et al. 1996). Overall most of the multipliers accruing in the economy are through direct or indirect effects on the backward linked industries. The appendix goes over the differences between the 1997 and 2005 fishery multipliers in more detail.

6.2.2 Small Commercial Boat Sector

[7] Cai et al. (2005) have found that fishing sectors have relatively strong backward linkages.

Examining the multipliers for the small commercial boat sector, we find strong overall backward linkages. These strong multipliers are partially attributed to the quasi-recreational nature of the sector. The commercial value of fishes caught by these boats is usually not sufficient to cover the expenses they spend in catching fishes. While the own multipliers for the other production sectors brings in an additional $2.61 for the pelagic fishery ($1.77 for the non-pelagic) for each generated dollar of increased activity, it leads to reductions of overall household income—$0.70 for the pelagic and $0.19 for non-pelagic. The corresponding subsidization of losses leads to negative induced impacts, which lowers consumption on the other sectors by $0.58 for the pelagic and $0.15 for non-pelagic thus diminishing the overall multiplier effect. Nonetheless, the SAM multipliers indicate that after accounting for the household and value added impacts, the generated total impacts are fairly high.

6.2.3 Charter Sector

The magnitude of the linkages of the charter sector is comparably smaller than the commercial sectors. A $1 increase in activity generates an additional $0.54 on inter-industry production, stimulates $0.86 in induced activity, and brings in an additional $1.02 household income.

6.3 SAM Forward Linkage Multipliers

Forward linkages are based on the fact that a reduction in the level of output will influence the level of activity of the sectors that take fish as an input. This expected reduction of production in other sectors will generate a series of induced effects. Decreased production in downstream sectors will also reduce income earned by primary factors of production, resulting in decreased household expenditures, and generating a series of additional effects throughout the economy.

Table 5 shows the magnitude of the longline forward linkages. The traditional Ghosh multipliers are slightly less than the SAM forward multipliers. We noticed that the traditional I-O multipliers are relatively similar in magnitude across commercial sector. The SAM driven multipliers are slightly larger. The multipliers for the tuna/swordfish sector are smaller than the tuna sector reflecting its higher levels of exports. However, the overall forward impacts must be interpreted with caution. Hawaii does not have much of a fish processing sector where the primary forward linked sectors include eating and drinking establishments, and government sectors. Many of these sectors could feasibly substitute their fish products from imported sources where the overall economic forward impact is likely to be biased upwards.

Table 4. Condensed SAM Backward Multipliers (Supply Driven)

	SAM "Own" Multipliers					SAM "Open Loop" Multipliers				
	Tuna Longline	Tuna & Swordfish Longline	Pelagic Small Boat	Non-Pelagic Small Boat	Charter	Tuna Longline	Tuna & Swordfish Longline	Pelagic Small Boat	Non-Pelagic Small Boat	Charter
Small Longline	1.00									
Big Longline		1.00								
Pelagic Small Boat			1.00							
Non-Pelagic Small Boat				1.00						
Charter					1.00					
Agriculture	0.00	0.00	0.01	0.00	0.00					
Mining and Construction	0.00	0.00	0.01	0.01	0.00					
Food Processing	0.00	0.00	0.01	0.00	0.02					
Other manufacturing	0.25	0.23	1.15	0.47	0.12					
Transportation	0.05	0.04	0.06	0.06	0.10					
Information	0.02	0.02	0.03	0.03	0.02					
Utilities	0.01	0.01	0.05	0.03	0.01					
Wholesale	0.19	0.19	0.12	0.17	0.03					
Retail Trade	0.02	0.02	0.05	0.04	0.01					
Finance and Insurance	0.08	0.06	0.10	0.08	0.08					
Real estate and rentals	0.03	0.03	0.11	0.09	0.02					
Professional Services	0.03	0.03	0.07	0.06	0.02					
Business Services	0.04	0.03	0.10	0.08	0.05					
Educational services	0.00	0.00	0.01	0.00	0.00					
Health Services	0.00	0.00	0.00	0.00	0.00					
Arts and entertainment	0.00	0.00	0.00	0.00	0.01					
Accomodation	0.00	0.00	0.01	0.00	0.04					
Eating and Drinking	0.02	0.01	0.04	0.03	0.01					
Other services	0.12	0.09	0.66	0.60	0.00					
Government	0.01	0.01	0.02	0.01	0.01					
Labor-Low						0.09	0.07	0.13	0.12	0.05
Labor-Medium						0.34	0.30	0.57	0.51	0.55
Labor-High						0.10	0.09	0.31	0.27	0.11
Proprietor's income						0.03	0.09	-1.90	-1.23	0.15
Other capital costs						0.27	0.24	0.32	0.26	0.36
Taxes						0.09	0.09	0.06	0.29	0.11
Household-Low (<$35k)						0.10	0.09	-0.05	0.00	0.08
Household-Med ($35-100k)						0.41	0.40	-0.33	-0.06	0.71
Household-High (>$100k)						0.16	0.17	-0.32	-0.13	0.22
Total Industry Impact	1.87	1.77	3.61	2.77	1.54					
Total Value Added Impact						0.83	0.79	-0.57	-0.07	1.23
Total Household Impact						0.67	0.65	-0.70	-0.19	1.02

(Table 4 continued)

	SAM "Closed Loop" Multipliers					SAM Total Multipliers				
	Tuna Longline	Tuna & Swordfish Longline	Pelagic Small Boat	Non-Pelagic Small Boat	Charter	Tuna Longline	Tuna & Swordfish Longline	Pelagic Small Boat	Non-Pelagic Small Boat	Charter
Small Longline						1.00				
Big Longline							1.00			
Pelagic Small Boat								1.00		
Non-Pelagic Small Boat									1.00	
Charter										1.00
Agriculture	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01
Mining and Construction	0.01	0.01	-0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Food Processing	0.01	0.01	-0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.03
Other manufacturing	0.02	0.02	-0.02	-0.01	0.03	0.28	0.25	1.13	0.46	0.16
Transportation	0.02	0.02	-0.02	-0.01	0.03	0.07	0.07	0.04	0.06	0.13
Information	0.02	0.02	-0.02	-0.01	0.03	0.04	0.04	0.01	0.02	0.05
Utilities	0.02	0.02	-0.02	0.00	0.02	0.03	0.03	0.03	0.03	0.03
Wholesale	0.02	0.02	-0.02	0.00	0.03	0.21	0.20	0.10	0.16	0.06
Retail Trade	0.05	0.05	-0.05	-0.01	0.08	0.07	0.07	0.00	0.03	0.09
Finance and Insurance	0.04	0.04	-0.04	-0.01	0.06	0.12	0.10	0.05	0.07	0.14
Real estate and rentals	0.14	0.13	-0.14	-0.03	0.21	0.17	0.16	-0.03	0.06	0.23
Professional Services	0.02	0.02	-0.02	-0.01	0.03	0.05	0.05	0.05	0.05	0.05
Business Services	0.02	0.02	-0.03	-0.01	0.04	0.06	0.06	0.08	0.07	0.09
Educational services	0.01	0.01	-0.01	0.00	0.02	0.01	0.01	-0.01	0.00	0.02
Health Services	0.08	0.08	-0.08	-0.02	0.12	0.08	0.08	-0.08	-0.02	0.12
Arts and entertainment	0.00	0.00	-0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.02
Accomodation	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.05
Eating and Drinking	0.02	0.02	-0.02	-0.01	0.04	0.04	0.04	0.02	0.03	0.04
Other services	0.03	0.03	-0.03	-0.01	0.04	0.14	0.12	0.63	0.59	0.05
Government	0.01	0.01	-0.01	0.00	0.02	0.02	0.02	0.00	0.01	0.03
Labor-Low						0.09	0.07	0.13	0.12	0.05
Labor-Medium						0.34	0.30	0.57	0.51	0.55
Labor-High						0.10	0.09	0.31	0.27	0.11
Proprietor's income						0.03	0.09	-1.90	-1.23	0.15
Other capital costs						0.27	0.24	0.32	0.26	0.36
Taxes						0.09	0.09	0.06	0.29	0.11
Household-Low (<$35k)						0.10	0.09	-0.05	0.00	0.08
Household-Med ($35-100k)						0.41	0.40	-0.33	-0.06	0.71
Household-High (>$100k)						0.16	0.17	-0.32	-0.13	0.22
Total Industry Impact	0.57	0.55	-0.58	-0.15	0.86	2.44	2.33	3.03	2.63	2.40
Total Value Added Impact						0.83	0.79	-0.57	-0.07	1.23
Total Household Impact						0.67	0.65	-0.70	-0.19	1.02

6.4 Summary of Economic Linkages

Table 6 reports the overall summary of backward and forward linkages for the fishery sector on Hawaii's economy. These impacts only include the endogenous effects and do not include the direct impacts of the exogenous increase. For the longline sectors, most of the linkages fall upon inter-industry purchases and sales. The total backward linkage impact on industries is $1.4 million for the tuna sector and $1.3 million for the tuna/swordfish sector. The forward linkages are comparable for the tuna sector ($1.3 million) but are much lower for the tuna/swordfish sector ($0.62 million) due to the high export rate for swordfish. Reflecting the input-intensive nature of the industry, there is less of a linkage to value added accounts where the backward linked totals are $0.7-$0.9 million and the forward linked total is $0.2 (tuna/swordfish) and $1.3 million (tuna). Overall, the backward linkages on the households are felt strongest by the medium households for the longline sector. The forward linkage impacts have slightly smaller industry impacts than the backward linkages. However, the income impacts across the households are larger than the backward linkages.

Given the smaller size of the small boat sector, we estimate the economic impact of $100,000. We notice that given this exogenous increase in supply, the backward linkages on the industry range from $160,000-$200,000. The forward linkages on output are relatively in the same magnitude. We notice that the backward linkages generate substantial losses throughout the economy. The net loss of the sector trickles down into the household income through reduced expenditure with an overall household income reduction of $70,291 and $18,644 for the pelagic and non-pelagic sectors, respectively. However, increased activity results in positive forward economic linkages and increased expenditures result in gains of household income of over $100,000.

Table 6 also reports the SAM state tax and job multipliers. State tax multipliers measure the economic impact of changes in an industry's supply in terms of changes in state tax revenues. Entries in the supply driven multipliers are converted to state tax equivalents by multiplying each row of the total requirements table by the ratio of state taxes to output for the corresponding row industry. A similar treatment is given for the employment multipliers. Job creation is relatively low for the longline sectors. For a million dollar increase in supply we find that the tuna longline and tuna/swordfish longline sectors generate another 12 and 11 jobs respectively through its backward linkages. The forward linkages are higher for the tuna sector (15), but less for the tuna/swordfish sector (seven). The amount of taxes generated through backward linkages is $89K (tuna) and $84K (tuna/swordfish). This amount is higher than the amount generated through forward linkages. With a $100,000 increase in commercial activity, the estimated additional job impact for the small boat sector is approximately two jobs for the small boat sector.

Table 5. Condensed SAM Forward Multipliers (Supply Driven)

	SAM "Own" Multipliers					SAM "Open Loop" Multipliers				
	Tuna Longline	Tuna & Swordfish Longline	Pelagic Small Boat	Non-Pelagic Small Boat	Charter	Tuna Longline	Tuna & Swordfish Longline	Pelagic Small Boat	Non-Pelagic Small Boat	Charter
Small Longline	1.00									
Big Longline		1.00								
Pelagic Small Boat			1.00							
Non-Pelagic Small Boat				1.00						
Charter					1.00					
Agriculture	0.00	0.00	0.00	0.00	0.00					
Mining and Construction	0.00	0.00	0.00	0.00	0.00					
Food Processing	0.05	0.05	0.05	0.05	0.00					
Other manufacturing	0.00	0.00	0.00	0.00	0.00					
Transportation	0.00	0.00	0.00	0.00	0.00					
Information	0.00	0.00	0.00	0.00	0.00					
Utilities	0.00	0.00	0.00	0.00	0.00					
Wholesale	0.00	0.00	0.00	0.00	0.00					
Retail Trade	0.00	0.00	0.00	0.00	0.00					
Finance and Insurance	0.00	0.00	0.00	0.00	0.00					
Real estate and rentals	0.00	0.00	0.00	0.00	0.00					
Professional Services	0.00	0.00	0.00	0.00	0.00					
Business Services	0.00	0.00	0.00	0.00	0.00					
Educational services	0.00	0.00	0.00	0.00	0.00					
Health Services	0.01	0.01	0.01	0.01	0.00					
Arts and entertainment	0.00	0.00	0.00	0.00	0.00					
Accommodation	0.05	0.05	0.05	0.05	0.01					
Eating and Drinking	0.20	0.20	0.19	0.19	0.00					
Other services	0.00	0.00	0.00	0.00	0.00					
Government	0.00	0.00	0.00	0.00	0.00					
Labor-Low						0.08	0.02	0.09	0.09	0.00
Labor-Medium						0.22	0.06	0.26	0.26	0.01
Labor-High						0.29	0.08	0.33	0.33	0.02
Proprietor's income						0.05	0.01	0.06	0.06	0.00
Other capital costs						0.11	0.03	0.12	0.12	0.01
Taxes										
Household-Low (<$35k)						0.20	0.05	0.23	0.23	0.01
Household-Med ($35-100k)						0.32	0.09	0.37	0.37	0.02
Household-High (>$100k)						0.39	0.12	0.45	0.45	0.02
Total Industry Impact	1.34	1.34	1.33	1.33	1.01					
Total Value Added Impact						0.75	0.21	0.86	0.86	0.04
Total Household Impact						0.91	0.25	1.05	1.05	0.05

(Table 5 continued)

	SAM "Closed Loop" Multipliers					SAM Total Multipliers				
	Tuna Longline	Tuna & Swordfish Longline	Pelagic Small Boat	Non-Pelagic Small Boat	Charter	Tuna Longline	Tuna & Swordfish Longline	Pelagic Small Boat	Non-Pelagic Small Boat	Charter
Small Longline						1.00				
Big Longline							1.00			
Pelagic Small Boat								1.00		
Non-Pelagic Small Boat									1.00	
Charter										1.00
Agriculture	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.00
Mining and Construction	0.07	0.02	0.08	0.08	0.00	0.07	0.02	0.08	0.08	0.00
Food Processing	0.01	0.00	0.01	0.01	0.00	0.06	0.05	0.06	0.06	0.00
Other manufacturing	0.02	0.01	0.03	0.03	0.00	0.02	0.01	0.03	0.03	0.00
Transportation	0.05	0.01	0.06	0.06	0.00	0.06	0.02	0.06	0.06	0.00
Information	0.02	0.01	0.02	0.02	0.00	0.02	0.01	0.02	0.02	0.00
Utilities	0.01	0.00	0.02	0.02	0.00	0.02	0.01	0.02	0.02	0.00
Wholesale	0.03	0.01	0.03	0.03	0.00	0.03	0.01	0.03	0.03	0.00
Retail Trade	0.06	0.02	0.07	0.07	0.00	0.07	0.02	0.08	0.08	0.00
Finance and Insurance	0.05	0.01	0.05	0.05	0.00	0.05	0.02	0.06	0.06	0.00
Real estate and rentals	0.12	0.03	0.13	0.13	0.01	0.12	0.04	0.14	0.14	0.01
Professional Services	0.05	0.01	0.06	0.06	0.00	0.05	0.02	0.06	0.06	0.00
Business Services	0.05	0.02	0.06	0.06	0.00	0.06	0.02	0.06	0.06	0.00
Educational services	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.02	0.02	0.00
Health Services	0.08	0.02	0.09	0.09	0.00	0.08	0.03	0.10	0.10	0.00
Arts and entertainment	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.00
Accommodation	0.06	0.02	0.07	0.07	0.00	0.11	0.07	0.11	0.12	0.01
Eating and Drinking	0.04	0.01	0.04	0.04	0.00	0.24	0.21	0.24	0.24	0.00
Other services	0.03	0.01	0.04	0.04	0.00	0.03	0.01	0.04	0.04	0.00
Government	0.21	0.06	0.24	0.24	0.01	0.21	0.06	0.24	0.24	0.01
Labor-Low						0.08	0.02	0.09	0.09	0.00
Labor-Medium						0.32	0.09	0.37	0.37	0.02
Labor-High						0.19	0.06	0.21	0.21	0.01
Proprietor's income						0.05	0.01	0.06	0.06	0.00
Other capital costs						0.11	0.03	0.12	0.12	0.01
Taxes						0.00	0.00	0.00	0.00	0.00
Household-Low (<$35k)						0.20	0.05	0.23	0.23	0.01
Household-Med ($35-100k)						0.47	0.13	0.54	0.54	0.03
Household-High (>$100k)						0.25	0.07	0.29	0.29	0.01
Total Industry Impact	0.99	0.28	1.14	1.14	0.06	2.33	1.62	2.46	2.47	1.07
Total Value Added Impact						0.75	0.21	0.86	0.86	0.04
Total Household Impact						0.91	0.25	1.05	1.05	0.05

Table 6. Summary of Economic Linkages

	Longline ($1 million dollar increase in Activity)		Small Commercial Boats ($100,000 increase in activity)	
	Tuna	Tuna & Swordfish	Pelagic	Non-Pelagic
Backward Linkage Impact (in US $, not including direct effects)				
Total Impact on Industries	1,440,000	1,326,000	203,000	163,000
Value Added	828,000	792,000	-57,000	-7,000
Labor-Low	89,000	67,000	13,000	12,000
Labor-Medium	336,000	300,000	57,000	51,000
Labor-High	102,000	94,000	31,000	27,000
Proprietor's income	35,000	91,000	-190,000	-123,000
Other capital costs	266,000	240,000	32,000	26,000
Household Income	673,000	651,000	-70,000	-19,000
Household-Low (<$35k)	102,000	85,000	-5,000	0
Household-Med ($35-100k)	412,000	399,000	-33,000	-6,000
Household-High (>$100k)	159,000	167,000	-32,000	-13,000
Jobs	12	11	2	2
Tax Revenue	89,000	84,000	7,000	8,000
Forward Linkage (in US $, not including direct effects)				
Total Impact on Industries	1,327,000	618,000	146,000	147,000
Value Added	750,000	211,000	85,000	85,000
Labor-Low	79,000	19,000	9,000	9,000
Labor-Medium	325,000	92,000	37,000	37,000
Labor-High	187,000	55,000	21,000	21,000
Proprietor's income	52,000	15,000	6,000	6,000
Other capital costs	107,000	30,000	12,000	12,000
Household Income	912,000	254,000	106,000	106,000
Household-Low (<$35k)	197,000	49,000	23,000	23,000
Household-Med ($35-100k)	466,000	132,000	54,000	54,000
Household-High (>$100k)	249,000	73,000	29,000	29,000
Jobs	15	7	2	2
Tax Revenue	74,000	35,000	8,000	8,000

7. HOUSEHOLD INCOME DISTRIBUTION ANALYSIS

Besides economic efficiency, equity is also an important issue in public policy. Information about the distributional impacts of proposed policies is critical for policy makers. This section assesses in more detail how the commercial fishery sector has impacted income distribution of Hawaii households.

7.1 Distributional Analysis with the Hawaii SAM

To conduct distributional analysis the Hawaii SAM has the household accounts disaggregated by three household income groups (nine for the disaggregated SAM). Table 7a reports the breakdowns across households. In 2005 there were 430,007 households in the State of Hawaii. The median household income was $58,112.[8] The condensed SAM aggregates the household income groups as follows: the low-income group[9] includes households with less than $35,000 (121,992 households or 28.4% of Hawaii households); the medium income group includes households in the $35,000-$100,000 range (210,017 households or 48.8% of Hawaii households); and the high-income group includes all households above $100,000 (97,998 households or 22.8% of Hawaii households).

Table 7b reports the distributional impacts on high, medium, and low-income households. These impacts reflect the production linkages to household income stemming from the increased production of the sector as well as the feedback effects between households and inter-industry transactions resulting from induced effects of increased production. The table reports both the absolute household income multiplier as well as its percentage of total household impact on a single socioeconomic group. Because low labor input intensive sectors have lower overall total household income multipliers than sectors with high labor input usage, examination of the percentage of the decomposed household income multiplier to the total household multiplier may better gauge the relative distributional impact a sector has on a socioeconomic group.

Comparing the household multipliers across income groups we estimate that for the non-fishery sector, a $1 exogenous increase in demand will result in an increase in a total household income of $0.90. The majority of this impact is linked to the middle-income group, which gains $0.49 or 55% of the total household linkage. The high impact on the middle-income group is expected given that the group accounts for the largest proportion of Hawaii households. While the high-income group has a smaller proportion of the non-fishery sector's overall linkage to income ($0.28), it is more than twice that of the lower income group ($0.13). This skewed linkage occurs despite the fact that the low-income group accounts for a far larger share of the population.

Comparing the linkages across sectors, we can assess which sectors have higher linkages across different socio-economic groups. The absolute multipliers (reported in bold) indicate that the professional services and government sectors have the strongest linkages to the high income groups. This is reflected by the skill intensive nature of these sectors as well as, possibly, their low level of input usage. We see that the agriculture

[8] The average household size in Hawaii for the year 2005 was 2.88

[9] For a family of 4 the Poverty guideline for the State of Hawaii was $22,260 for 2005 (http://aspe.hhs.gov/poverty/05fedreg.htm).

and eating and drinking sectors have the strongest linkages to the low-income groups reflecting the relatively low skill nature of the occupations employed by the sectors.

Table 7a. Hawaii Socio-Economic Breakdowns

	Household-Low (<$35k)	Household-Med ($35-100k)	Household-High (>$100k)	Total
Number of households	121992	210017	97998	430007
% of households	28%	49%	23%	100%
2005 Total Group Income (in $US millions)	8,259	24,576	16,157	48,992

Table 7b. SAM Household Income Multipliers

	Household-Low (<$35k)		Household-Med ($35-100k)		Household-High (>$100k)		Total
	Household Multiplier	% of total Household Income Multiplier	Household Multiplier	% of total Household Income Multiplier	Household Multiplier	% of total Household Income Multiplier	
Tuna Longline	0.11	15%	0.44	61%	0.17	24%	0.71
Tuna-Swordfish Longline	0.09	13%	0.44	61%	0.18	26%	0.71
Pelagic Small Boat	-0.06	8%	-0.36	48%	-0.34	45%	-0.76
Non-Pelagic Small Boat	0.00	-1%	-0.07	33%	-0.14	68%	-0.20
Charter	0.08	8%	0.71	70%	0.22	22%	1.02
Agriculture	0.34	34%	0.44	44%	0.22	22%	1.00
Mining and Construction	0.06	7%	0.41	48%	0.38	45%	0.85
Food Processing	0.19	27%	0.35	51%	0.15	22%	0.69
Other manufacturing	0.05	11%	0.26	58%	0.14	31%	0.45
Transportation	0.08	10%	0.49	58%	0.26	32%	0.83
Information	0.08	10%	0.46	58%	0.25	32%	0.80
Utilities	0.05	8%	0.32	51%	0.26	41%	0.63
Wholesale	0.08	10%	0.52	65%	0.20	25%	0.80
Retail Trade	0.11	14%	0.52	63%	0.19	23%	0.83
Finance and Insurance	0.07	8%	0.49	55%	0.33	37%	0.88
Real estate and rentals	0.08	11%	0.37	54%	0.25	35%	0.69
Professional Services	0.09	9%	0.55	50%	0.45	41%	1.09
Business Services	0.18	16%	0.63	55%	0.33	29%	1.14
Educational services	0.19	17%	0.63	56%	0.31	28%	1.12
Health Services	0.13	12%	0.57	54%	0.35	34%	1.05
Arts and entertainment	0.13	12%	0.61	58%	0.30	29%	1.04
Accommodation	0.15	15%	0.58	61%	0.23	24%	0.95
Eating and Drinking	0.24	27%	0.45	51%	0.19	22%	0.87
Other services	0.15	15%	0.55	58%	0.25	27%	0.95
Government	0.08	6%	0.67	49%	0.63	45%	1.37
Non-Fishery Averages	0.13	14%	0.49	55%	0.28	31%	0.90

7.2 Distributional Analysis of Longline Sectors

Now we examine the distributional impacts on the commercial fishery sector. Beginning first with the longline sector we see that compared to the non-fishery sector, the longline sector has a smaller overall impact on the household income gaining \$0.71 for every additional \$1 increase in demand (for both tuna and tuna/swordfish sector). This reflects the high level of input use required from the sector and the low level of labor inputs. Comparing its linkages across household groups the multipliers suggest that an increase in demand for the longline sector would primarily leak into the middle-income groups with the lower and higher income groups receiving modest levels of increased income. With a household impact multiplier of \$0.17 (\$0.18 for the tuna/swordfish target) for the high-income group, we see that the longline linkages are relatively small. With a household impact \$0.11 and \$0.09 for the tuna and tuna-swordfish longline sectors, there is a relatively mild impact on the lower income group sector. This is small relative to the agricultural sector (\$0.34), but it is roughly in line with the other sectors.

For the lower and middle-income groups, the longline fishery sectors have a household income multiplier that is comparable to but slightly lower than the non-fishery sectors. However given that the fishery is an input intensive sector, these impacts on the household sector are smaller across the board. To gauge their relative distributional impacts across socioeconomic groups, we can compare the percentage of their total household impact. We see that with a linkage of 24%-26% of total household income, the longline sector has a relatively light impact on the high-income groups (compared to the 31% non-fishery average). The percentage impacts on middle income groups is 61%, which is above the non-fishery averages (55%), while the impacts of the low income group is 14%, which is approximately in line with the non-fishery averages (14%).

Overall we can assess that while the fishery sector in general has a small household income multiplier (relative to the non-fishery sectors), the distribution of income is mostly tied to the middle-income groups with the lower income groups gaining a relatively fair amount of linkages. The relatively smaller linkage to the high-income group reflects the weak net revenue received throughout the longline sector in 2005. Generally for the high-income group, a large proportion of their overall income received comes from proprietor income. However for the commercial longline sector, the weak returns (negative for the tuna vessels) for these boats would be reflected in negative levels of proprietor income, reducing the net income impact on higher income households.

7.3 Including Foreign Crew Members in Longline Sector

The SAM model was designed so that foreign crewmember payments were accounted as imported inputs rather than labor income (see appendix). Normally foreign workers who live in the local economy have local consumption expenses, and their foreign remittances would typically not be treated as imported inputs. However, foreign crews in the Hawaii longline fishery operate under a uniquely restrictive arrangement such that while they are in Hawaii they are prohibited from leaving the vessel or pier area (see Allen and Gough 2006). Because by law they are not allowed to leave the boat, the vessel owners provide their housing and the vast majority of their food and living expenses. While many foreign crew members are likely to have some of their income spent in Hawaii (through local friends that help them at the pier), virtually all of their money gets sent back home. In this regard, their role is more similar to imported inputs rather than traditional guest workers.

The distributional impacts discussed earlier only include domestic crew member income in the factor payments accounts. The household linkages to the lower income groups would be higher if foreign crew member earnings were included in the employee domestic compensation.[10] To assess how the results would change had we included the foreign crew members as part of the local economy, we now attempt to treat their labor inputs similarly to the domestic crew inputs. Table 8 reports summary statistics and analysis of the foreign crew sector. We can see that the crew members are predominately foreign. For the tuna sector there was 295 foreign hired crew members compared with 109 domestic crew members. For the Tuna/Swordfish there was 113 foreign hired crew and 23 domestic crew members. With approximately 75% of the crew foreign the total labor compensation increases significantly after accounting for these crew members.

Table 8. Longline Economic Impact on Household Income with Foreign Crew

	Tuna Longline		Tuna-Swordfish Longline		
	Without Foreign Crew	**With Foreign Crew**	**Without Foreign Crew**	**With Foreign Crew**	
Number of Crew jobs	109	295	23	136	
Total Crew Compensation (in $)	1,657,083	5,289,154	403,408	1,985,745	
Household Income Multipliers					Non-Fishery Average
Household-Low Multiplier	0.11	0.19	0.09	0.18	0.13
%	15%	24%	13%	22%	14%
Household-Medium Multiplier	0.44	0.43	0.44	0.43	0.49
%	61%	54%	61%	54%	55%
Household-High	0.17	0.17	0.18	0.19	0.28
%	24%	22%	26%	23%	31%

Household Income changes in response to changes in $10 million dollars (in million $)

Household-Low (<$35k)	1.02	1.78	0.85	1.62
Household-Med ($35-100k)	4.12	4.05	3.99	3.95
Household-High (>$100k)	1.59	1.61	1.67	1.70

Comparing the multipliers with and without foreign crew members we see that the household income linkages to the lower socio-economic group become much stronger after their inclusion. A $1 increase in demand for the sector leads to an increase of

[10] Foreign crew member earnings ranged from $5000 to $12,000 a year. This is far less than the poverty level in the United States but is well over double that of the average earnings of a Filipino family back in the Philippines.

$0.18-$0.19 of overall income for the low income households. This impact is approximately twice the level found without including foreign crew members. The linkage to the sector is now significantly greater than the linkage found in the non-fishery sector ($0.13) and its percentage of overall household income rises to approximately 22-24% of total household impact. This share of income to the low-income group is roughly equal in magnitude to the high-household group. Following a $10 million dollar increase in supply they both receive approximately $1.6-1.8 million dollars in additional income. These levels of impacts on the low-income groups are relatively high compared to other sectors where the high-income groups generally receive a disproportionate share of the household income linkages.

7.4 Distributional Analysis on the Small Boat Sector

For the small boat sector we see a reduction in household earnings across income groups following an increase in fishing activity. Table 7b shows that the overall household income falls by $0.76 for the pelagic boats and $0.20 for the non-pelagic boats for every $1 increase in activity. This once again reflects the recreational nature of the activity, were households subsidize their utility from fishing by taking net losses. This reduction in household income mostly falls on the higher income groups, where their share in the reduction of income is 45% and 68% of the pelagic and non-pelagic small boat sectors. The negative impact on income resulting from the net losses of the sector, dominates any other feedback effects from the feedback effect of increased purchases, leading to an overall negative impact on household income. Unlike the longline sector, the lower income groups are very little impacted by increases of fishing activity. We see that increases in activity will result in fairly large reductions in household income.

8. CONCLUDING REMARKS

The purpose of this study was to build a SAM model that could assess the socio-economic impacts of Hawaii's fishery sectors on the rest of its economy and its distributional effects on households. Expanding a traditional I-O model, a SAM allows the complete tracing of the circular flows of goods and money in the economy. The SAM model assembled combines the State of Hawaii 2005 I-O table and expands the value-added and household accounts to incorporate the complete flow of production and money in the economy. Economic multipliers that include "own", "open loop", and "closed loop" impacts were estimated to map out a more comprehensive analysis of socio-economic linkages.

Previous fishery studies employing SAM modeling have not adequately examined the distributional impacts of income distribution impacts. The mapping of income distribution from industry to household requires labor payments to the household sector to be disaggregated by employee types. The assembled Hawaii SAM includes transition matrices that map industry labor inputs from Hawaii's input-output table to the state level occupational matrix before linking it to household institutional flows. This allows a complete mapping of income distribution from industry accounts to household sectors. Combining this data with cost-earnings data of Hawaii's commercial fishing vessels, we analyzed how the fishing sector impacts household incomes across different socioeconomic categories.

The SAM developed for Hawaii found relatively strong backward linkages between the fishery sectors and the rest of the economy highlighting the relatively input-intensive structure of the sector. The high increases in fuel costs and subsequent decrease in profits over the recent years are the leading forces increasing these economic multipliers. The distributional analysis of the SAM indicated that the longline sectors impacts the middle income groups most significantly with modest linkages to the lower income groups and relatively low linkages to the high income groups. The impacts on the low-income household groups strengthen significantly after including foreign crew member labor compensation. For the small boat sector, there was a strong negative net impact on households, which reflects the high recreational nature of the sector. This reduction in incomes was most impacted on the higher income groups who are the chief participants of the industry.

The interpretation of the estimated impacts drawn from this report must take into account the general limitations of SAM analysis. All the shortcomings of the I-O framework—fixed technology coefficients, fixed prices, and full factor employment—apply to SAM modeling. Thus for large exogenous supply changes—where the assumptions of factor immobility and fixed prices effects are unlikely to hold—will lead to estimates that are biased upwards. However given the smallness of the region and modest shocks, the distributional patterns shown in this analysis should be robust, and at least may be interpreted as upper bound estimates.

The 2005 Hawaii Fishery SAM Model is a step forward in understanding and analyzing the socio-economic impacts of the fishery in Hawaii. This present study constitutes the first attempt to construct a SAM for the State of Hawaii. This report demonstrated the capability of using the model in assessing the socio-economic impacts of the fishery sector. Potential policy applications of the model include socio-economic impact estimates from reductions in total allowable catch for the bigeye tuna sector and fishery closures from hitting the sea turtle bycatch cap. Future studies interested in income distribution in Hawaii may also apply the model to other sectors of interest such as tourism and energy.

APPENDICES

1. Construction of the Hawaii SAM

In this appendix we outline our methodology for constructing the 2005 Fishery SAM model. This section will first go over the procedures used to assemble the basic SAM for the State of Hawaii. Section II describes the steps to include the fishery sector.

1.1 Data Sources

The 2005 Hawaii SAM is based on three database sources. First, and most importantly, the 2005 Hawaii State Input-Output Model was used to provide information on the production activities, factor payments, and final demand aggregate accounts. The State Input-Output table served as the primary foundation of the SAM and all other accounts and information were linked and made to be consistent with this table.[11] The State I-O includes production activity information for 68 accounts. One of these sectors is the commercial fishery sector that we decompose into the six fishery sub-sectors.

Second, data for the additional SAM accounts—value added and institution accounts—were retrieved from the 2006 IMPLAN data.[12] This data, which relies on household income and expenditure surveys, yields the incomes of the various socioeconomic groups.[13] The 528 IMPLAN industry sectors were aggregated into the 68 industry sectors from the Hawaii State Input-Output model. To adjust the accounts to be consistent with 2005 Hawaii State Input-Output model accounts, we relied on the purchase coefficients to relate it to the I-O output accounts.

Third, to complete the income distribution mapping from the industry sector to the household sector we make use of the 2006 Hawaii State Industry Occupational Matrix.[14]

1.2 Linking SAM Accounts

With the aim of outlining our own data construction process, we will not review the details of the construction of these data sources here. Readers interested in these details can refer to the primary sources cited in this report. We will now describe how the various SAM accounts are linked.

Institution Accounts. IMPLAN provides data to expand the I-O accounts to include household, firm, and government payments and receipts. The SAM assumes the government sector to be exogenous. IMPLAN disaggregates the household income sector into nine socio-economic categories. For presentation purposes these sectors are re-aggregated to three income categories: low (less than $35,000); medium ($35,000-$100,000); and high ($100,000+). In our SAM we use the personal consumption

[11] Details of *the 2005 State Input-Output Study for Hawaii,* can be found at the Hawaii State Economic Development, and tourism at http://hawaii.gov/dbedt/info/economic/data_reports/2005_state_io/2005-input-output-study.pdf.

[12] Details on the construction of IMPLAN data can be found at http://implan.com.

[13] IMPLAN provides a comprehensive level of all accounts that includes all the accounts available in the Hawaii State IO. However many of the accounts provided by IMPLAN's is based off of national averages. The State-IO table is based off of locally constructed data, and is far more reliable in nature than IMPLAN. In the construction of the SAM, we relied on the State-IO data whenever possible.

[14] This data can be accessed at http://www.hiwi.org/cgi/dataanalysis/AreaSelection.asp?tableName=Iomatrix.

expenditures provided by the 2005 Hawaii State I-O, but we disaggregate the expenditures by the socio-economic classes based off of the proportions given by IMPLAN.

We use Institution percentage shares from IMPLAN inter-institutional accounts (intra-household and inter-household-government accounts) and apply it to the institution levels given by the State-I-O to assemble the inter-institution accounts. Because these accounts are not given by the Hawaii State-I-O, the values need to be adjusted to remain consistent with the rest of the SAM matrix.

Value Added. Both the Hawaii State Input Output table and IMPLAN provide four factor payment accounts.

1. Employee compensation
2. Proprietary income
3. Taxes
4. Other property income/capital costs

IMPLAN provides information for factor distribution payments to the household and government institution accounts where the income distribution payments are based off constant proportions.[15] It is important to note that these four components do not provide adequate mapping of income distribution from the industry sector to the household sector. The IMPLAN data first maps the industry sector to the value added sector, and then remaps the value added sector to the institution sectors off constant proportions. But beyond the intensity spread across the four aggregate components, the factor payments from the industry sector to households are based off of aggregate proportions. Normally this is standard treatment in SAM exercises; however because the employment compensation account is not broken down, the IMPLAN dataset offers very few linkages between industry output and income distribution.

1.3 Linking Production Activity to Income distribution

To sufficiently map out industry to household income distribution we need to decompose employee compensation and stratify it appropriately before linking it to the household sector. The stratification of the employee compensation can be done in many ways. The use of skill/education levels, occupations types, geography (urban vs. rural), and demographics are potential ways of decomposing labor. We approach this task by first mapping employment compensation from the production sector to the 2006 Hawaii State Industry Occupational Matrix. The use of the occupational matrix allows us to break down the labor inputs by occupation categories that can generate comprehensive differentiation among the labor groups necessary to link employee compensation to socioeconomic classes. The State Hawaii occupational matrix contains labor inputs for 436 Standard Occupational Classification (SOC) categories.

Next, we use the average 2005 Hawaii wage/salary level of each occupation (Hawaii Department of Labor & Industrial Relations Data) to rank occupations into skill levels based on the income earned. This allows us to assign each occupation into one of nine skill levels (in the condensed SAM this is aggregated into three skill levels). Note that these skill levels actually reflect wages earned. For methodological convenience, the size

[15] The factor payments information given by IMPLAN is based off of National Income and Product Accounts (NOPA) constructed by the Bureau of Economic Analysis

of the skill level groups is set so that they match the distribution of household income groups in the IMPLAN data. This allows a direct one to one mapping from the labor compensation accounts (nine skill levels) to the household accounts (nine socioeconomic groups). Because the socioeconomic classes are categorized at the household level and the occupations at the employee level, the factor payments are mapped to the households by matching the distribution of Hawaii wage/salary compensation data to the IMPLAN employee compensation income payments.[16]

This transformation provides crucial linkages between the industries and household income payments. For example, an exogenous increase in the skill-intensive industries, which employ larger shares of better compensated occupations, will have a more significant impact on households in the higher income socioeconomic categories than the lower income households. If we only use the data afforded by IMPLAN this same impact would capture the differential industry income distribution effects only through the level of intensity difference between the employee compensation vs. proprietary/property income mechanism.

1.4 Matrix Rebalancing

Our fully articulated SAM consists of 97 separate accounts: five fishery subsectors; 67 non-fishery production sectors; 12 value added sectors; nine endogenous household sectors; and eight exogenous accounts (government, investment, and current/capital accounts). The different accounts were assembled to remain as consistent to the Hawaii State Input Output table as possible. Thus the production and value added accounts were kept virtually equivalent to the original State I-O while the expanded accounts were adjusted so they could be well integrated with the original core accounts. This required some slight adjustments with the expanded accounts and efforts were made to minimize changes from the original data sources. Nevertheless tying in different sources of data makes it virtually impossible to keep the SAM balanced. The procedure for incorporating the fishery subsectors also relied on different sources of data and we were forced to use matrix balancing techniques to derive a matrix with equal receipts and payments. We dealt with this task by employing the RAS technique. This led to some slight adjustments in numbers between the SAM model and the original I-O table.

2. Construction of Fishery Sectors

2.1 Commercial Longline Sector (Tuna and Tuna/Swordfish Sectors)

The data for the longline sectors came from the 2005 cost-earnings survey of longline fisheries (Pan 2009). The longline sectors were broken up between tuna targeted vessels and tuna and swordfish targeted vessels.[17]

---

[16] Note that the other factor income distribution accounts—proprietary income and other property income—will be mapped separately. We do not breakdown these accounts further, and rely on the fixed proportions provided by IMPLAN. These income distribution accounts are likely to be less dependent upon industry.

[17] Previous Hawaii fishery I-O tables had the longline data broken up by tuna and swordfish sectors. However since all swordfish-targeting vessels also target tuna it is more appropriate to breakdown the sectors between "Small Longline" vessels which only target tuna and have on average smaller vessels and "Big Longline" which target both swordfish and tuna and have on average bigger vessels.

a. Production Function

The process of building the production function involves several steps. First, an initial production function is made by allocating the average costs of goods and services purchased into the appropriate industries in the model. The cost-earnings survey sampled 98 vessels of a total population of 124 (93 tuna, 31 tuna/swordfish) in operation in 2005. The total sector purchases were simply extrapolated from the sample averages.

The data from the variable costs, labor costs, and fixed costs are based off the averages found in the survey. The annual sales cost is the 10% fee charged by the wholesale sector.[18] The depreciation costs were calculated by writing off a 3.3% expense off the purchase price of the boat. In Hawaii the excise tax is a standard 0.5% charge off the gross revenue.

b. Margins

All transactions in an I-O model are valued at producer's prices where only the margin on a merchandise resale is considered the output of the selling industry. Separate margins need to be calculated for the wholesale, retail, and transportation sectors. The margins are adopted from the previous *1997 Hawaii Fishery Input-Output* model and the *2005 Hawaii State Input-Output Model.*

c. Total Expenditure Allocations across Industry Sectors

With the production functions and their producer margins, we can assign the total sector purchases to their appropriate industrial sector using standard NAICS industrial classifications. However it is less straightforward to assign whether or not the good and services was produced in Hawaii or imported. Because there is very little manufacturing in Hawaii, most of the purchased goods were assigned as imports. Following procedures taken in previous Hawaii Fishery I-O studies, all of the fuel[19] and ice were assumed to be produced locally; half of the food was assumed to be produced locally and half imported; and the rest of the gear, equipment, and other goods were assumed to be imported. The bait was assumed to be procured from the sector itself.

The fixed costs were assigned to the relevant industries. Mooring fees and miscellaneous fixed costs were assigned to support activities for transportation; bookkeeping fees and insurance were assigned to insurance and other professional services; repair costs were assigned to the general repair and maintenance sector; and loan payments were considered as part of *other capital costs* (value added sector).

d. Proprietor's Income

After accounting for the depreciation and tax expenses we find that the net return for the longlining vessels is relatively low. The average tuna-targeted vessels suffered a slight negative return (almost breaking even).

e. Labor Compensation

The annual labor costs per a vessel are given in category C and provides information on both the captain and crew shares. For the tuna (tuna/swordfish) longline sector the average captain is compensated with an annual salary of \$46,349 (\$49,564), average

---

[18] Longline vessels sell their catch through the United Fishing Agency where they are charged a 10% wholesale fee.

[19] Procured from local oil refineries.

domestic crew costs was $17,818 ($13,013), and the average foreign crew cost was $39,055 ($51,403). We include the domestic crew payments into the employee compensation accounts; the foreign crew costs are included as input costs (see next section for further details).

To incorporate their employment compensation into the flow of payments to the institution sector in the SAM this labor component of the value added sector has to be assigned to the appropriate socio-economic income class. In the SAM, labor inputs are mapped into occupation categories before being assigned into household income categories. Thus the salary levels have to be assigned so that their distributions match the household income distribution given by IMPLAN.[20] This is done by having the fishing salaries scaled up to match the relevant household income category and then ranking the fishermen's salary within the rest of Hawaii's salary distribution and relating it to the household income distribution.

f. Foreign Crew Payments

In the longline sector, the crew members are predominately foreign. For the tuna sector there was estimated to be 295 foreign hired crew compared with the estimated number of 109 domestic crew For the tuna/swordfish there was an estimated 113 foreign hired crew and 23 domestic. With crews that are approximately 75% foreign, it is critical that we correctly integrate the foreign crew compensation accounts appropriately. One way to do this would be to consider foreign crew payments as factor trade/remittances. Under this scheme, the flow of account payments would be from longline sector (production) to employee compensation (value added) with transfer payments from employee compensation to the foreign trade (import account). However the problem here is that the two-step mapping of accounts lumps all the factor trade flows (employee compensation to foreign remittances) together and thus would not effectively capture the linkage between changes in longline output and foreign crew remittances. Having the foreign payments redirected from the employee compensation accounts to the foreign trade accounts, would only increase the overall percentage leakages. Because the remittances are not industry-specific, any exogenous output change cannot discriminate which sectors are more remittance intensive than others. While the longline sector is remittance intensive, under this SAM setup any supply driven change will capture the remittances only by the aggregate level percentages.

An alternative approach would be to include all the foreign crew labor costs flows directly from the longline production sector to the foreign trade account. Under this scheme, foreign labor costs are seen as more similar to imported inputs for the production sector. Normally foreign workers who live in the local economy have local consumption expenses and their foreign remittances could typically not be treated similarly to imported inputs. However, the foreign crew in the Hawaii Longline Fishery operates under a uniquely restrictive arrangement such that their permission to be in Hawaii is strictly tied to their presence on the vessel and pier. The foreign crew members are not traditional migrant workers: by law they are required to stay on the boats, and are not allowed to go outside of the pier (see Allen and Gough 2006). The boats provide their housing, and the owners provide the vast majority of their food and living expenses. While many of them are likely to have some of their income spent in Hawaii (through local friends that help

[20] IMPLAN's income distribution comes from the U.S. Census.

them at the pier), virtually all of their money gets sent back home. In this regard, their role is more similar to imported inputs rather than traditional guest workers.

g. Sales of Sector

The total sales of the sector are based off of extrapolating the gross sample averages to the known level of longlining vessels. While export data gives accurate figures on how much fish leaves the state, little is known about inter-industry fish sales. For the Longline sector alongside all the other 4 sectors, the breakdown of total sales is assigned by employing the ratios used in the *1997 Hawaii Fishery Input Output Model*.

h. Jobs

Only domestic jobs are included in the job multipliers. While the average vessel had about 4-6 crew members, a typical boat carried approximately one local crew member and one local captain, thus generating approximately two local jobs per vessel.

2.2 Small Commercial Boats (Small Boat-Pelagic and Small Boat-Non-Pelagic Sectors)

The small boat commercial sector is decomposed into a pelagic and non-pelagic small boat sectors. The production functions were built primarily with data from the small boat cost-earnings survey done in 2007-2008 (Hospital 2009). The process of building the production functions for the SAM for the small boat sector was not as straightforward as the longline sector. First, the small boat sector operates multiple gear types that target various pelagic and non-pelagic species. Each vessel engages with different fish-targeting trips whose trip expenditures need to be allocated to its relevant sector. Second, the small commercial boat sectors are characterized by a quasi-commercial structure where a significant portion of the fishing is motivated by recreational pursuit. Lastly, unlike the longline sector, where we had a very comprehensive survey of vessels, the data for the small boat sector comes from a sample from a much smaller percentage of vessels. The exact number of small commercial boats is unknown and we have to use an indirect procedure to calculate the total purchases for the sector. Below we discuss how this sector was incorporated.

a. Fishing Trip Types

A total of 343 interviews were completed for vessels that engaged in seven basic categories of fishing. This was primarily trolling (66%) and bottomfish (22%). We simplified the analysis by breaking down the categories to two main types: 1) pelagic (trolling, akule/opelu, palu ahi, ika shibi); and 2) non-pelagic (bottomfish, reef fishing). Mixed gear types of fishing were reallocated to the two categories based on proportional trip percentages. Naturally each type of fishing reflects different production and sales structure, but this categorization captures the general nature of the trip types.

b. Production Function

Variable expenditures. The variable cost data is broken down by trip level expenditures. Knowing the average number of trips taken a year, we can extrapolate the annual variable expenditures. While this can help us construct a basic production function, the lack of data for the population of small commercial vessels requires us to estimate the total purchases. We do this by basing the total level of activity according to the total commercial landings caught by each sector.[21] We can then relate the average gross vessel revenues (which are provided by the 2007 survey) to the total value of the commercial landings and then apply the cost-earnings proportions to calculate the total variable purchases. The resulting procedure translates the average variable expenditure values reported in the survey into aggregate numbers.

Fixed Costs. The fixed costs are attributed according to vessels and have to be distributed across pelagic and non-pelagic sectors. Because the small boat vessels were employed across different targeting trips, the fixed costs had to be allocated appropriately. This was done by allocating the cost according to the proportion of trips. A certain percentage of trips (5.3%) employed mixed gear. Their fixed cost allocations were broken down by the overall pelagic vs. non-pelagic proportions.

c. Total Expenditure and Sales Industry Sector Allocations

Completing the production function was done using the same general methods as the longline fisheries: constructing a preliminary production function; converting to producer prices; aggregating the sample data to population level purchases; and assigning the appropriate industry. The allocation of receipt accounts followed the same proportions. The depreciation and excise taxes were calculated at the same rates (5% and 0.5%, respectfully). The wages were based off of crew share information from Hamilton and Huffman (1997).

d. Quasi-Commercial Activity

As mentioned previously, the small boat sector is characterized by a dual commercial-recreational behavioral structure. Many of the commercial fishermen do not sell their entire catch—in many cases, they keep most of the catch for themselves and are driven by recreational behavior. Thus, even though all purely recreational fishermen—those who do not sell any fish—are excluded from this sector (they are accounted for in the recreational fishing sector), we still have a significant portion of our commercial activity being driven primarily by recreational motivations.

Previous reports made attempts to disaggregate commercial between genuine full time fishermen and fishermen who sold enough fish to cover their expenses; however this practice contains several technical problems and it was determined that the sub-grouping of commercial and expense boat activity is unfeasible.[22] Furthermore from the standpoint of management and regulatory issues for the State of Hawaii small boat sector, the grouping of commercial and quasi-commercial activity is appropriate because all such fishermen would have to adhere to the policies established by the fishery management

---

[21] This data was retrieved through the NOAA Pacific Islands Fisheries Science Center at http://www.nmfs.hawaii.edu/wpacfin/hi/dar/Pages/hi_data_3.php. Catch volumes were subtracted from the longline sectors were subtracted from the totals to account for just the small boat sector.

[22] Hamilton (1997) employed a Commercial vs. Expense vs. Recreational categorization. Expense boats consisted of fishermen whose fishing activity covered 50% of their personal activity. However this categorization is tenuous. The 50% threshold is arbitrarily set and its designation is self-declared. The use of self-designations made the categorizations susceptible to inconsistencies in which fishermen reported themselves. Some fishermen considered themselves to be commercial fishermen even though they didn't catch any fish the entire previous 12 months.

plan. The quasi-commercial structure of the sector is evident in the negative profit earnings for both sectors.

e. Labor Compensation

The total wage compensation was based off of catch shares that have been assumed from previous studies for the crew members and captains. Beyond these catch shares is the net income generated by each boat, which is considered proprietor's income. In many cases the captain of the boat is also the owner and therefore his/her income can be considered as proprietor income. However, the total values of these two value-added sectors are distributed separately. Using the average household income and distribution information for small boat fishing owners, we can map labor compensation into the relevant skill level categories.

2.3 Charter Boats

The charter boat sector was based on information used to construct the 1997 Hawaii Fishery Output model. No recent survey has been done since then. We extrapolated the same sale/purchase information from this source to 2005 data.

3. SAM Fishery Multipliers vs. Original Hawaii State I-O Multipliers

Table 9 compares demand driven output multipliers generated by the SAM Fishery Model and the traditional I-O output multipliers generated by the original 2005 State Input-Output Table.[23] To gain more insight between the differences of the two models, we decompose the SAM multipliers between their intra and total group impacts (details of this decomposition procedure can be found in Pyatt and Round [1979] and Miller and Blair [2010]). By definition the SAM own multipliers and the Type I I-O multipliers are expected to be equivalent. The own multipliers generated by the SAM are shown to be approximately equivalent to the Type I multipliers generated by the State Input Output table. The SAM model was constructed to be consistent with(?) the State's 2005 Input Output table but slight differences exist between the multipliers due to minor discrepancies between the SAM table and the State I-O table.[24]

As discussed in this report, the Type II total industry output multipliers should be closer in magnitude to the SAM multipliers but smaller due to their non-accounting of several capital payment elements. For the Hawaii State I-O, the Type II multipliers are generated by including wage and salary income, proprietor income, director fees, and health insurance, and excludes contributions to social insurance. This is supposed to account for all income that is received by households from the production of regional goods and services and that are available for spending on goods and services. However through the use of IMPLAN's data, we are able to include additional capital payment accounts such as corporate profits, and net interest accounts that are not included in the traditional SAM. If we compare the State I-O Type II output multipliers to SAM output multipliers, is the State multipliers (?) are an order of magnitude smaller (about 0.10-0.30

[23] We present demand driven multipliers to make it comparable with the Hawaii State I-O multipliers.
[24] As discussed in Appendix I, the SAM was designed to be consistent with the State I-O. However small adjustments were necessary to incorporate the expanded institutional accounts.

or 10%). This is despite the fact that the SAM table has been constructed to be consistent with the State IO table (the direct SAM multipliers are equal to the State Type I multipliers).

Given the shortcomings of the I-O accounting structure in linking (?) the value added/household income accounts and the consumption/PCE accounts, the SAM multipliers are likely to provide a more precise in mapping out of the necessary flows.

4. Differences Between 1997 Hawaii Fishery Model and 2005 SAM Model

The procedures used in constructing the fishery sector for the 2005 SAM model attempted to follow the previous practices employed by the *1997 Hawaii Fishery Input-Output Model* (Peterson 2005)[25]. However due to structural changes in the fishery and data availabilities, several changes were required. As discussed in previous sections, the 1997 model had the longline sectors strictly divided between tuna and swordfish. Following the temporary ban and later resumption of swordfish catches, the swordfish-targeting longliners modified their boats to be able to target both swordfish and tuna. Given that all of the swordfish targeting longliners now also target tuna, it was more appropriate to decompose the sectors between tuna and mixed (tuna/swordfish) sectors for the 2005 SAM model. The decomposition between the small commercial boat sectors was also modified. Instead of the previous small commercial/expense/recreation boat sectors, the 2005 SAM decomposed these sectors into pelagic and non-pelagic boats. This approach was taken to make the small commercial boat sector more in line with the cost earnings data provided for these sectors. Because no updated Charter boat data was available, the 2005 SAM model used the same data as the 1997 Fishery Model.

Due to differences in individual fishery sector composition, assessing the differences between the 2005 SAM multipliers and the previous 1997 Hawaii Fishery Input-Output Model (Peterson 2005) can only be done with limitations. Table 10 compares the multipliers generated between the fishery sectors in 1997 and 2005. Comparison[26] between the own SAM multipliers and the I-O Type I multipliers generated from the 1997 fishery input-output reveal much higher multipliers for the more recent model. If the underlying structure of the sectors has not been changed, these two multipliers are supposed to be equivalent. One possible explanation for the increase in multipliers is that the fishery sectors have become more input intensive. The rise in fuel costs has significantly increased the levels of inputs required to operate the vessels and decreased profits. Secondly for the longline sectors, the increased usage of foreign workers has also decreased the percentage of value added to the sector. While the small boat sectors are less comparable across the two models, we can see that the multipliers have risen significantly as well. Only the charter boat industry looks roughly the same. This is expected given that charter cost-earnings data had not been updated, and the SAM model was required to use the same data.

[25] The first Hawaii Fishery Model was designed by Sharma et al. (1999).

[26] For comparison purposes, the demand driven multipliers of the SAM have been displayed.

Table 9. Comparison between 2005 SAM Fishery Multipliers and 2005 Hawaii State I-O Multipliers

		SAM Total Multipliers			Traditional IO (State of Hawaii 2005)	
	Sector	Own Multipliers	Total (Own/Open/ Closed Effects)		Type I Multiplier	State IO Type II
1	Small Longline	1.98	2.53			
2	Big Longline	1.94	2.50			
3	Pelagic Small Boat	3.84	3.05			
4	Non-Pelagic Small Boat	2.96	2.73			
5	Charter	1.56	2.43			
6	Other Crops	1.28	2.18		1.28	1.81
7	Vegetables	1.59	2.30		1.58	2.06
8	Other Fruits	1.44	2.27		1.43	1.95
9	Pineapples	1.40	2.32		1.40	2.03
10	Flowers and Nursery Products	1.48	2.34		1.47	2.02
11	Sugarcane	1.31	2.21		1.31	1.83
12	Animal Production	1.45	2.18		1.45	1.90
13	Forestry and Logging	1.46	2.38		1.46	2.15
14	Support Activities for Ag	1.35	2.29		1.34	2.01
15	Mining	1.72	2.47		1.72	2.39
16	Electricity	1.60	2.06		1.60	1.85
17	Gas Production/Distribution	1.61	2.08		1.61	1.87
18	Single Family Construction	1.40	2.08		1.40	1.92
19	Other Construction	1.43	2.14		1.43	1.98
20	Heavy Construction	1.44	2.17		1.44	2.01
21	Maintenance and Repairs	1.40	2.09		1.40	1.93
22	Food Processing	1.57	2.17		1.57	1.97
23	Beverage Manufacturing	1.52	2.04		1.51	1.85
24	Apparel and Textile	1.25	1.93		1.24	1.81
25	Other Manufacturing	1.33	1.96		1.33	1.88
26	Petroleum Manufacturing	1.31	1.50		1.30	1.43
27	Wholesale Trade	1.28	1.95		1.28	1.77
28	Air Transportation	1.62	2.26		1.61	2.06
29	Truck/Rail Transportation	1.40	2.26		1.40	1.99
30	Water Transportation	1.74	2.31		1.73	2.12
31	Passenger Transportation	1.50	2.24		1.50	2.01
32	Scenic/Support Transport	1.19	2.12		1.19	1.94
33	Couriers And Messengers	1.22	2.00		1.22	1.72
34	Warehousing And Storage	1.31	2.22		1.31	1.97
35	Retail Trade	1.34	2.04		1.34	1.84
36	Publishing	1.07	1.93		1.07	1.63
37	Motion Picture	1.21	1.79		1.20	1.55
38	Broadcasting	1.29	1.95		1.29	1.74
39	Telecommunications	1.28	1.89		1.29	1.64

(Table 9 continued)

	Sector	SAM Total Multipliers			Traditional IO (State of Hawaii 2005)	
		Own Multipliers	Total (Own/Open/ Closed Effects)		Type I Multiplier	State IO Type II
40	Other Information Services	1.47	2.03		1.47	1.90
41	IT/Data Processing	1.38	2.00		1.38	1.85
42	Credit Intermediation	1.41	2.12		1.41	1.82
43	Other Finance And Insurance	1.38	2.26		1.38	2.12
44	Insurance	1.64	2.37		1.64	2.18
45	Real Estate	1.42	2.00		1.42	1.68
46	Rental And Leasing and Others	1.51	2.20		1.51	1.92
47	Legal Services	1.35	2.27		1.35	2.10
48	Other Professional Services	1.52	2.36		1.52	2.18
49	Architectural/Engineering	1.37	2.26		1.37	2.08
50	Computer Services	1.42	2.40		1.42	2.29
51	R&D	1.37	2.17		1.37	2.02
52	Management	1.45	2.40		1.45	2.22
53	Administrative	1.29	2.30		1.29	2.06
54	Travel Services	1.50	2.34		1.50	2.13
55	Waste Management	1.46	2.18		1.45	1.99
56	Other Educational Services	1.47	2.41		1.47	2.20
57	Higher Education	1.47	2.41		1.47	2.19
58	Ambulatory Services	1.17	2.17		1.17	1.97
59	Hospitals	1.65	2.36		1.65	2.19
60	Nursing	1.38	2.25		1.38	2.09
61	Social Assistance	1.35	2.28		1.35	2.05
62	Arts and Entertainment	1.27	2.13		1.27	1.92
63	Accommodation	1.42	2.22		1.42	1.97
64	Eating and Drinking	1.52	2.29		1.52	2.05
65	Repair and Maintenance	1.39	2.12		1.39	1.99
66	Personal/Laundry Services	1.54	2.34		1.54	2.14
67	Organizations	1.43	2.26		1.43	2.05
68	Federal Gov. Civilian	1.14	2.17		1.14	1.89
69	State And Local Gov.	1.10	2.17		1.10	1.86
70	Federal Gov. Military	1.00	2.14		1.00	1.70
71	Owner-Occupied Dwellings	1.34	1.87		1.34	1.47
72	Aquaculture	1.56	2.23		1.55	1.96

Table 10. 1997 vs. 2005 Fishery Multipliers

	Backward Multipliers		Forward Multipliers
	SAM own multipliers	SAM Total Multipliers (own, open, and circular)	IO Ghosh Driven Multipliers
2005			
Tuna Longline	1.87	2.43	1.34
Tuna and Swordfish Longline	1.77	2.32	1.34
Pelagic Small Boat	3.61	3.03	1.33
Non-Pelagic Small Boat	2.77	2.62	1.33
Charter Boats	1.54	2.41	1.01
1997	I-O Type I Multipliers*	I-O Type II Multiplier*	IO Ghosh Driven Multipliers**
Tuna Longline	1.42	1.94	1.33
Swordfish Longline	1.44	1.84	1.04
Small Commercial Boats	1.49	2.16	1.33
Expense Boats	2.26	2.45	1.33
Charter Boats	1.52	2.09	1.01

** from SMS research (2004)*
*** from Cai et al. (2005)*

We note that the SAM multipliers are larger than the Type II multipliers of the 1997 Fishery Model. If the I-O model endogenizes the household earnings to include all capital payments, these two multipliers are supposed to be roughly equivalent. Given that the original I-O table links the factor payments and household consumption differently, the resulting SAM generated larger multipliers for the fishery sectors. However after accounting for the larger differences in the own multiplier/Type I effects (the other sectors were the same), the differences are not that large. This is in contrast to the non-fishery sectors where the differences in the I-O multipliers and the 2005 SAM multipliers were exclusively from the induced impact. With the relatively small net profits or negative profits generated by the fishery sectors there is a much smaller induced effect, and the higher multipliers are being driven mostly by the higher levels of input costs.

5. Recreational Sector

The recreational fishing sector also provides an important contribution to Hawaii's economy. In 2005 the recreational sector was over $521 million. While the recreational sector does not generate direct income/value added to the economy, its expenditures have backward linkages that indirectly impact the economy. These expenditures include fishing inputs (rods, reels, tackle, gear, bait), boat expenditures (vessel, motors, parts), as well as vehicles and other equipment.

Using recreational expenditure data from the "Economic Contribution of Marine Angler Expenditures in the United States, 2006" report produced by the National Marine Fisheries Service (NMFS) we can use the SAM to evaluate the backward linkages of the recreational sector. The expenditure information from this report is based on an intercept survey from both on site marine anglers and also mailed home surveys from shore, private/rental, and party/charter modes of fishing[27] that collected expenditure information for over 40 different types of trip and equipment expenditures.[28] The respondents of the survey were weighted and estimates of the full population of recreational activity and purchases were calculated. Following methods employed in the construction of the other sectors (accounting for margins and excluding the estimated amount of goods and services that were imported, and adjusting the 2006 data into 2005 activity) we can integrate the recreational data into the SAM. To close the recreational account, the expenditures (This sentence is complete. Delete?)

Table 11 reports the SAM multipliers (demand driven) generated by recreational sector for the aggregate sector. We see that for a $1 increase in demand, there is a total industry multiplier of $2.01. Examining the own multipliers we see that the wholesale and transportation sector is impacted most significantly. For every $1 increase in recreational demand there a direct economic impact of $0.18 and $0.11, respectfully. Assessing the open loop multipliers we see that there is a small impact on the household incomes. Because the recreational sector does not generate any value added, all of the increased income comes from its backward linked sectors that generate indirect income. Lastly in the close-loop multipliers we see that the real estate sector and health services receive the most from the cross feedback induced effect.

The bottom of the table shows the predicted impacts resulting from a $10 million dollar increase in recreational fishing activity. We see that the SAM estimates a total industry impact of $20.1 million dollars. Household income is expected to rise by $4.1 million and the medium income households are most impacted. Through the backward linkages increases in economic activity, total jobs will rise by approximately 90 workers and tax revenues are expected by rise by $3 million dollars. While these overall impacts are slightly smaller in proportion to the other fishery sectors, given the overall weight of the recreational sector (which is more than five times larger than all the other commercial sectors combined), the overall economic impact can be quite large.

[27] Party/charter modes of fishing only includes for non-commercial activity.
[28] Vehicle use and secondary homes related to fishery use were not included.

Table 11. Recreational Backward Linkages

	SAM Total Multipliers	SAM Own Multipliers	SAM Open Loop Multipliers	SAM Closed Loop Multipliers
Tuna Longline	0.00	0.00		0.00
Tuna-Swordfish Longline	0.00	0.00		0.00
Pelagic Small Boats	0.00	0.00		0.00
Non-Pelagic Small Boats	0.00	0.00		0.00
Charter	0.00	0.00		0.00
Recreational Sector	1.01	1.00		0.01
Agriculture	0.00	0.00		0.00
Mining/Construct.	0.01	0.00		0.00
Food Process.	0.01	0.00		0.00
Other Manuf.	0.07	0.05		0.01
Transportation	0.12	0.11		0.01
Information	0.02	0.01		0.01
Utilities	0.02	0.01		0.01
Wholesale	0.20	0.18		0.01
Retail Trade	0.10	0.06		0.03
Finance/Insurance	0.05	0.02		0.03
Real Estate	0.11	0.03		0.08
Professional Serv.	0.03	0.02		0.01
Business Serv.	0.06	0.05		0.02
Education	0.01	0.00		0.01
Health Services	0.05	0.00		0.05
Arts/Entertain.	0.03	0.03		0.00
Accommodation	0.01	0.01		0.00
Eating/Drinking	0.03	0.02		0.01
Other Services	0.03	0.02		0.02
Government	0.04	0.03		0.01
Labor-Low	0.04		0.04	
Labor-Medium	0.20		0.20	
Labor-High	0.08		0.08	
Proprietor Income	0.04		0.04	
Other Capital	0.15		0.15	
Taxes	0.08		0.08	
Household-Low	0.05		0.05	
Household-Med	0.25		0.25	
Household-High	0.12		0.12	

For a $10 Million increase in Recreational Activity	
Total Impact on Industries (not including direct effect)	$10,090,147
Household Income	$4,124,127
Household-Low	$461,098
Household-Med	$2,476,244
Household-High	$1,186,784
Jobs created	91
Tax Revenue	$3,040,000

REFERENCES

Allen, S., and A. Gough, 2006. A sociocultural assessment of Filipino crew members working in the Hawaii-based longline fleet U.S. Dept. Commer., NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-6, 54 pp.

Alward, G., 1996. *Deriving SAM Multiplier Models Using IMPLAN* (Minneapolis, MN).

Cai, J., P. Leung, M. Pan, and S. Pooley, 2005. Economic linkage impacts of Hawaii's longline fishing regulations, *Fish. Res.*, 74, 232-242.

Fernández-Macho, J., C. Gallastegui, and P. González, 2008. Economic impacts of TAC regulation: A supply-driven SAM approach, *Fish. Res.*, 90, 225-234.

Hamilton, M., R. Curtis, and M. Travis, 1996. Cost-earnings study of the Hawaii-based domestic longline fleet, SOEST Publication 96-03, JIMAR Contribution 96-300*,* 59 pp.

Hamilton, M., and S. W. Huffman, 1997. Cost-earnings study of the Hawaii's small boat fishery, SOEST Publication 97-06, JIMAR Contribution 97-314*,* 102 pp.

Holland, D., and P. Wyeth, 1993. SAM multipliers: Their interpretation and relationship to input-output multipliers, *Microcomputer-Based Input-Output Modeling: Applications to Economic Development*, p. 181-197.

Hospital, J., 2009. Hawaii small boat fishery economic expenditure data report, Pacific Islands Fishery Science Center, Internal Report 09-038.

Isard, W., I. J. Azis, M. P. Drenna, R. E. Miller, S. Saltzman, and E. Thorbecke, 1998. *Methods of Interregional and Regional Analysis* (Ashgate).

Keuning, S., and E. Thorbecke, 1989. *The Impact of Budget Retrenchment on Income Distribution in Indonesia: A Social Accounting Matrix Application* (OECD).

Leatherman, J., and D. Marcouiller, 1996. Income distribution characteristics of rural economic sectors: implications for local development policy, *Growth Change*, 27, 434-459.

Leung, P., and S. Pooley, 2002. Regional economic impacts of reductions in fisheries production: A supply-driven approach, *Mar. Resour. Econ.*, 16.

Marcouiller, D., D. F. Schreiner, and D. K. Lewis, 1993. Constructing a Social Accounting Matrix to Address Distributive Economic Impacts of Forest Management., *Regional Analysis & Policy*, 23, 2, p. 60-90.

Miller, R., and P. Blair, 2010. *Input-Output Analysis: Foundations and Extensions* (Cambridge University Press).

O'Malley, J., and S. Pooley, 2003. Economic and operational characteristics of the Hawaii-based longline fleet in 2000, SOEST Publication 03-01, JIMAR Contribution 03-348*,* 31 pp.

Pan, M., 2009. Costs and earnings status of the Hawaii longline vessels in 2005, Pacific Islands Fishery Science Center Internal Report. Internal Report 09-033.

Peterson, A., 2005. 1997 Hawaii fishery input-output model and methodology, SOEST Publication 05-02, JIMAR Contribution 05-356.

Pyatt, G., and J. Round, 1979. Accounting and fixed price multipliers in a social accounting matrix framework, *Econ. J.*, 850-873.

Research and Economic Analysis Division, Department of Business Economics Development, and Tourism, 2008. *The 2005 State Input-Output Study for Hawaii* (Honolulu).

Rose, A., B. Stevens, and G. Davis, 1988. *Natural Resource Policy and Income Distribution* (Johns Hopkins University Press).

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.

Sharma, K., A. Peterson, S. Pooley, S. Nakamoto, and P. Leung, 1999. Economic contributions of Hawaii's fisheries, SOEST 99-08, JIMAR Contribution 99-327, 40 pp.

Stone, R., ed., 1985. *Journal* (World Bank, Washington DC).

Thorbecke, E., 1989. *The Social Accounting Matrix Framework to Capture the Interdependence between Domestic and Foreign Variables* (National Center for Super Computing Applications, University of Illinois).